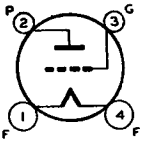
RCA-00-A

DETECTOR

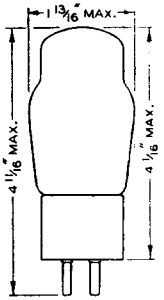
The 00-A is a three-electrode storage-battery tube of the gas-filled type for use as a sensitive grid-leak detector.



RCA-01-A

DETECTOR, AMPLIFIER

The 01-A is a three-electrode storage-battery tube for use as a detector and as an amplifier. Base connections are same as for the 00-A.



CHARACTERISTICS

	00-A	01-A		
Filament Voltage (D. C.)	5.0	5.0		Volts
Filament Current	0.25	0.25		Ampere
Plate Voltage	45 *max.*	90	135 *max.*	Volts
Grid Voltage	0	−4.5	−9	Volts
Plate Current	1.5	2.5	3.0	Milliamperes
Plate Resistance	30000	11000	10000	Ohms
Amplification Factor	20	8	8	
Transconductance	666	725	800	Micromhos
Grid-Plate Capacitance	8.5	8.1		$\mu\mu$f
Grid-Filament Capacitance	3.2	3.1		$\mu\mu$f
Plate-Filament Capacitance	2.0	2.2		$\mu\mu$f
Bulb	S-14	ST-14		
Base	Medium 4-Pin Bayonet	Medium 4-Pin Bayonet		

INSTALLATION AND APPLICATION

The base pins of the 00-A and 01-A fit the standard four-contact socket which should be installed to hold the tube in a vertical position.

As a detector, the 01-A may be operated either with conventional grid leak and condenser or with grid bias. For grid-bias detection, plate voltages up to the maximum value of 135 volts may be used with the corresponding negative grid-bias voltage (13.5 volts approximately, at 135 volts).

These two types are used principally for renewal purposes.

from RMA registration #135,
April 15, 1938

OA4-G

GAS-TRIODE

Cold-Cathode Starter-Anode Type

The OA4-G is a cold-cathode, glow-discharge tube. The discharge can be initiated with a very small amount of electrical energy supplied to the starter-anode circuit. This feature makes it practicable to obtain remote control of line-operated electrical devices by means of an electrical impulse generated at radio frequencies and transmitted over the same power line. The OA4-G may also be used as a voltage regulator or as a relaxation oscillator.

TENTATIVE DATA

MAXIMUM OVERALL LENGTH	4-1/8"
MAXIMUM DIAMETER	1-9/16"
BULB	ST-12
BASE	Small Shell Octal 6-Pin

CHARACTERISTICS

PEAK ANODE BREAKDOWN VOLTAGE (Starter-anode tied to cathode)	225 *min.*	Volts
PEAK POSITIVE STARTER-ANODE BREAK-DOWN VOLTAGE	70 *min.* 90 *max.*	Volts Volts
STARTER-ANODE CURRENT (For transition of discharge to anode at 140 volts peak)	100 *max.*	Microamperes
STARTER-ANODE DROP	60 *approx.*	Volts
ANODE DROP	70 *approx.*	Volts

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

Relay Service

PEAK CATHODE CURRENT	100 *max.*	Milliamperes
D-C CATHODE CURRENT	25 *max.*	Milliamperes
TYPICAL OPERATION WITH A-C SUPPLY:		
Anode-Supply Voltage (RMS)	105-130	Volts
A-C Starter-Anode Voltage (Peak)	70 *max.*	Volts
R-F Starter-Anode Voltage (Peak)	55 *min.*	Volts
Sum of A-C and R-F Starter-Anode Voltages (Peak)	110 *min.*	Volts

INSTALLATION and APPLICATION

The *base* pins of the OA4-G fit the standard octal socket which may be installed to hold the tube in any position. Socket connections are shown on page 4.

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RCA Manufacturing Co., Inc.

As a *relay tube*, the OA4-G should be operated according to the conditions given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

A schematic circuit showing the use of this type is given on page 4. In this circuit, full line voltage is applied between anode and cathode. The starter-anode is maintained at a potential just below that required for breakdown by means of the bleeder consisting of R_1 and R_2. The inductance L and the condenser C constitute a tuned circuit in series with the line. When a carrier having the frequency of the tuned circuit is impressed on the power line, a resonant voltage appears across L and C. The effect of the voltage across the condenser C is to increase the negative potential peaks on the cathode and thus to increase the potentials between cathode and starter-anode. These peaks start a discharge between cathode and starter-anode. This discharge produces free ions which enable the discharge to transfer to the anode if circuit values are such that sufficient starter-anode current flows. After the discharge occurs between cathode and anode, current flows through the relay S to close the contact of a local circuit. Because a.c. is supplied to the anode, the OA4-G ceases to discharge when the carrier is removed.

If the OA4-G is to be operated from a d-c power line, it will be necessary to provide means for reducing the anode voltage to a value under 60 volts (extinction voltage). This can be conveniently done by opening the anode circuit.

It will be noted that most of the voltage on the starter-anode required to cause breakdown is supplied by the bleeder circuit. As a result, the tuned circuit is required to supply only the difference between breakdown voltage and applied a-c voltage. Precautions should be taken in the design of equipment so that at the highest line voltage, the a-c voltage applied to the starter-anode will not be sufficient to cause the OA4-G to break down; and so that at the lowest line voltage, the carrier voltage will be high enough to make up for low line voltage. It is recommended, therefore, that provision be made to supply an r-f starter-anode voltage having a minimum peak value of 55 volts.

Typical breakdown characteristics of the OA4-G are shown in Fig.1, for conditions where the starter-anode and anode are either positive or negative, respectively. The tube is designed to be operated so that the discharge takes place when the starter-anode and anode are both positive (first quadrant). For purposes of illustration, values are also shown in the other quadrants for other polarity combinations. Operation in these quadrants is unstable.

In the first quadrant, it will be noted that the OA4-G breaks down between cathode and starter-anode when the starter-anode voltage reaches 85 volts approximately. This discharge initiates a discharge between cathode and anode, provided the anode potential is adequate. The required anode potential is a function of the current

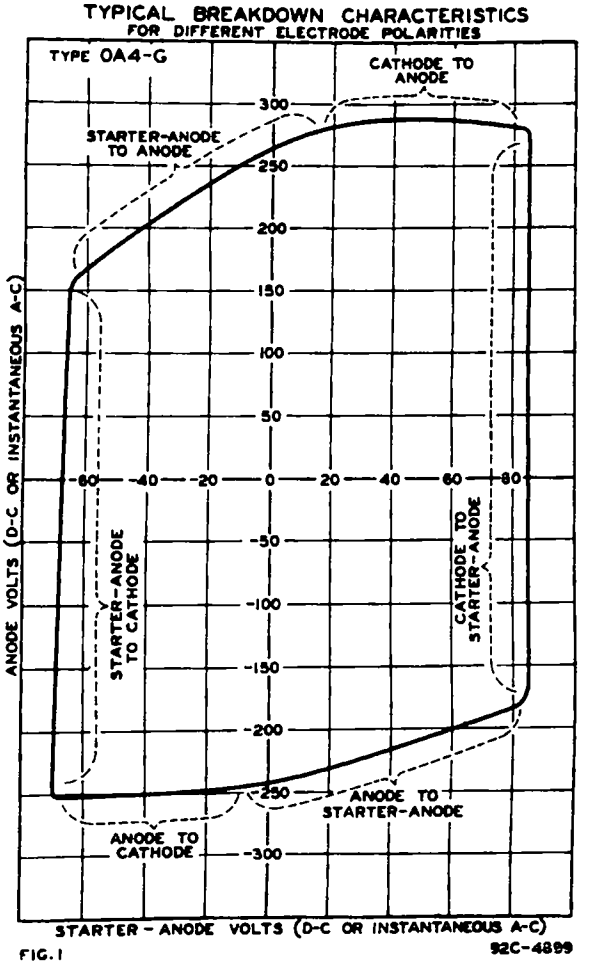


FIG. 1 92C-4899

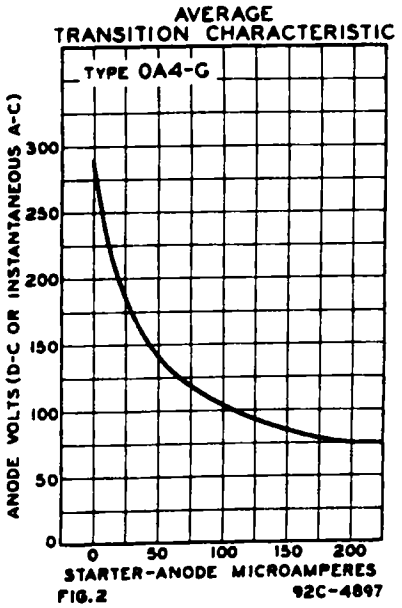


FIG. 2 92C-4897

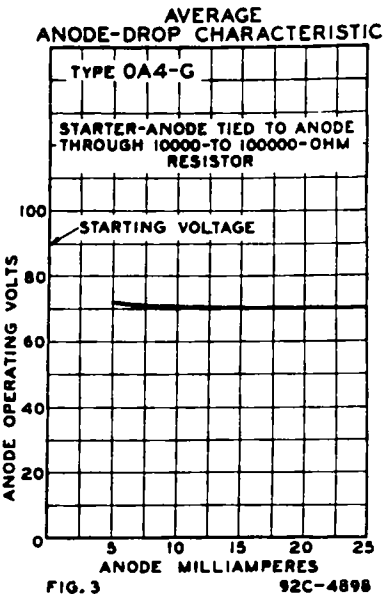


FIG. 3 92C-4898

flowing in the starter-anode circuit. The relationship between anode voltage and starter-anode current is shown in Fig.2. In practice, it is desirable to have a current of at least 200 microamperes flowing to the starter-anode.

READING LIST

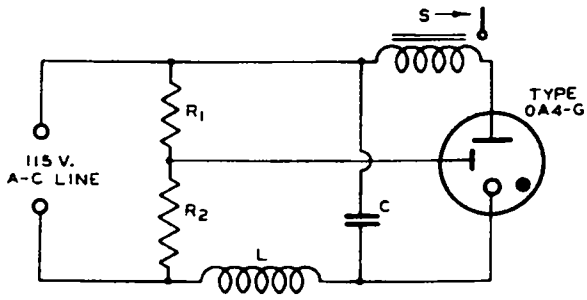
Darrow, K.K. *Electrical Phenomena in Gases.* Williams and Wilkins, Baltimore, Md.

Dow, Wm. G. *Fundamentals of Engineering Electronics.* John Wiley and Sons, Inc., New York, N.Y.

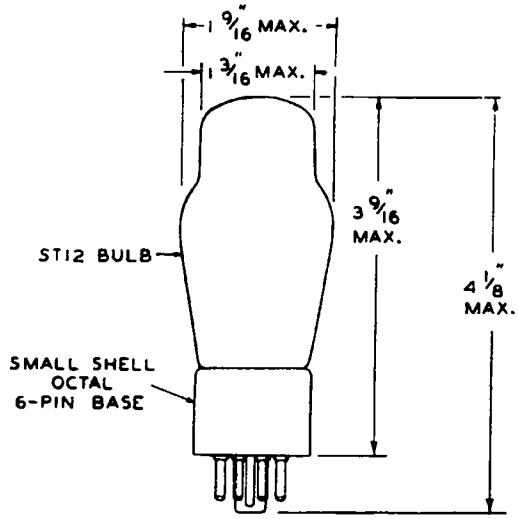
Thomson, J.J. *Conduction of Electricity through Gases.* Cambridge University Press, Oxford, England.

Townsend, J.S. *Electricity in Gases.* Claredon Press, Oxford, England.

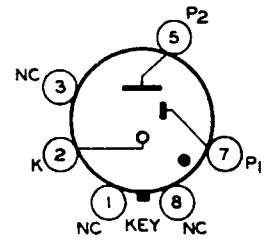
SCHEMATIC RELAY CIRCUIT USING TYPE 0A4-G
A-C OPERATION



C, L = HIGH-Q TUNED CIRCUIT FOR R-F SIGNAL
R_1 = 15000 OHMS (½ WATT)
R_2 = 10000 OHMS (½ WATT)
S = RELAY — CHOSEN FOR DESIGN REQUIREMENTS
● = GAS TUBE TYPE

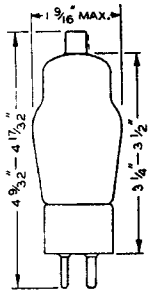


BOTTOM VIEW
OF SOCKET CONNECTIONS



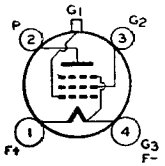
G-4V

P_1 = STARTER-ANODE
P_2 = ANODE
K = CATHODE
NC = NO CONNECTION



RCA-1A4

SUPER-CONTROL R-F AMPLIFIER PENTODE



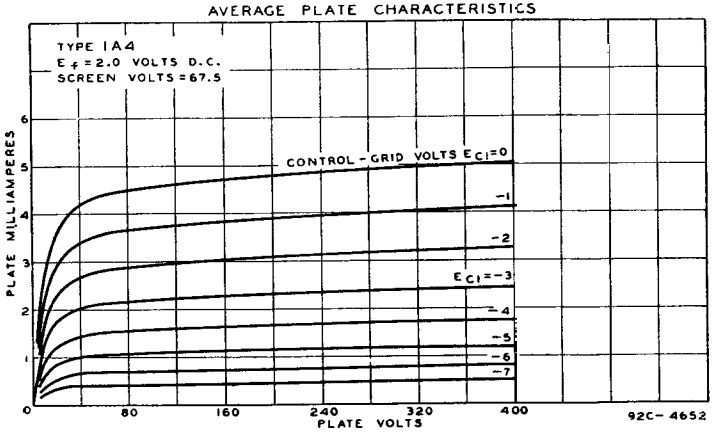
The 1A4 is a super-control pentode of the filament type. It is useful as a radio-frequency amplifier or intermediate-frequency amplifier in battery-operated receivers. The 1A4, although similar in application to type 34, is constructed in a smaller bulb **and,** because of its less remote cut-off characteristic, requires less B-battery power.

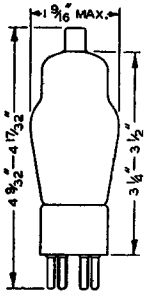
CHARACTERISTICS

Filament Voltage (D. C.)		2.0	Volts
Filament Current		0.060	Ampere
Plate Voltage	90	180 *max.*	Volts
Screen Voltage (Grid No. 2)	67.5 *max.*	67.5 *max.*	Volts
Grid Voltage (Grid No. 1)	−3 *min.*	−3 *min.*	Volts
Plate Current	2.2	2.3	Milliamperes
Screen Current	0.9	0.8	Milliampere
Plate Resistance (Approx.)	0.6	1.0	Megohm
Amplification Factor	425	750	
Transconductance	720	750	Micromhos
Transconductance (At −15 volts bias)	15	15	Micromhos
Grid-Plate Capacitance (With shield-can)		0.007 *max.*	*μμf*
Input Capacitance		5	*μμf*
Output Capacitance		11	*μμf*
Bulb			ST-12
Cap			Small Metal
Base			Small 4-Pin

INSTALLATION AND APPLICATION

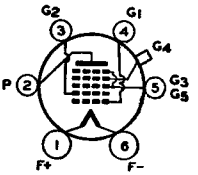
For INSTALLATION and APPLICATION, refer to type 34.





RCA-1A6

PENTAGRID CONVERTER



The 1A6 is a multi-electrode type of vacuum tube designed to perform simultaneously the function of a mixer tube and of an oscillator tube in superheterodyne circuits. Through its use, the independent control of each function is made possible within a single tube. The 1A6 is designed especially for use in battery-operated receivers. In such service, this tube replaces the two tubes required in conventional circuits and gives improved performance. For general discussion of pentagrid types, see Frequency Conversion, page 31.

CHARACTERISTICS

Filament Voltage (D. C.)	2.0	Volts
Filament Current	0.060	Ampere
Direct Interelectrode Capacitances (Approx.)		
Grid No. 4 to Plate (With shield-can)	0.25	μμf
Grid No. 4 to Grid No. 2 (With shield-can)	0.2	μμf
Grid No. 4 to Grid No. 1 (With shield-can)	0.1	μμf
Grid No. 1 to Grid No. 2	0.8	μμf
Grid No. 4 to All Other Electrodes (R-F Input)	10.5	μμf
Grid No. 2 to All Other Electrodes (Osc. Output)	6	μμf
Grid No. 1 to All Other Electrodes (Osc. Input)	5	μμf
Plate to All Other Electrodes (Mixer Output)	9	μμf
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

Converter Service

Plate Voltage		180 *max.*	Volts
Screen Voltage (Grids No. 3 and 5)		67.5 *max.*	Volts
Anode-Grid Voltage (Grid No. 2)		135 *max.*	Volts
Anode-Grid Voltage Supply*		180 *max.*	Volts
Control-Grid Voltage (Grid No. 4)		−3 *min.*	Volts
Total Cathode Current		9 *max.*	Milliamperes
Typical Operation			
Plate Voltage	135	180	Volts
Screen Voltage	67.5	67.5	Volts
Anode-Grid Voltage	135	135	Volts
Anode-Grid Voltage Supply	135	180*	Volts
Control-Grid Voltage	−3	−3	Volts
Oscillator-Grid Resistor (Grid No. 1)	50000	50000	Ohms
Plate Current	1.2	1.3	Milliamperes
Screen Current	2.5	2.4	Milliamperes
Anode-Grid Current	2.3	2.3	Milliamperes
Oscillator-Grid Current	0.2	0.2	Milliampere
Total Cathode Current	6.2	6.2	Milliamperes
Plate Resistance	0.4	0.5	Megohm
Conversion Conductance	275	300	Micromhos
Conversion Conductance (At −22.5 volts on Grid No. 4)	4	4	Micromhos

* Applied through 20000-ohm dropping resistor, by-passed by 0.1 μf condenser.

The transconductance of the oscillator portion (not oscillating) of the 1A6 is 425 micromhos under the following conditions: Plate voltage, 135 to 180 volts; screen voltage, 67.5 volts; anode-grid voltage (no voltage-dropping resistor), 135 volts; and zero oscillator grid volts. Under these same conditions the anode-grid current is 2.3 milliamperes.

INSTALLATION

The **base** pins of the 1A6 require the use of a standard six-contact socket which should be installed to hold the tube in a vertical position.

The coated **filament** of the 1A6 may be operated conveniently from dry-cells, from a single lead storage-cell, or from an air-cell battery. For dry-cell operation, a filament rheostat may be used together with a permanently installed voltmeter to insure the proper filament voltage. For operation from a 2-volt lead storage-cell, the 1A6 requires no filament resistor. Operation from an air-cell battery requires a fixed resistor in the filament circuit. This resistor should have a value such that with a new air-cell battery, the voltage applied across the filament terminals will not initially exceed 2.15 volts.

Series operation of the filament of the 1A6 with those of other two-volt battery types is permissible provided certain precautions are observed. It is essential that shunt resistors be employed across certain filaments to carry the plate current returning from other tubes through these filaments. The shunt resistors should be adjusted to maintain the filament voltage of each tube at its rated value of 2.0 volts under operating conditions. It is obvious that the shunt resistor can also be used to adjust for a difference in filament current ratings. Series-parallel operation of two-volt types is not recommended because failure of one tube may cause excessive voltage across other tubes. Socket terminal No. 1 (see socket connections) should be connected to the positive battery terminal.

Complete **shielding** of the 1A6 is generally necessary to prevent intercoupling between its circuit and those of other stages.

APPLICATION

As a **frequency converter** in superheterodyne circuits, the 1A6 can supply the local oscillator frequency and at the same time mix it with the radio-input frequency to provide the desired intermediate frequency. For this service, design information is given under CHARACTERISTICS. It is important to note that the anode-grid voltage and the plate voltage must each be higher than the screen voltage.

For the oscillator circuit, the coils may be constructed according to conventional design, since the tube is not particularly critical for frequencies up to 10 megacycles. For higher frequencies the 1C6 should be used. However, it should be noted that the 1C6 requires additional filament current. The voltage applied to the anode-grid (No. 2) of the 1A6 should not exceed the maximum value of 135 volts, but should always be higher than the screen (grids No. 3 and No. 5) voltage. The anode-grid voltage may be obtained from a suitable tap on the B battery or from the plate-supply tap through a voltage-dropping resistor of 20000 ohms shunted by a by-pass condenser of 0.1 μf. The size of the resistor in the grid circuit of the oscillator is not critical but requires design adjustment, depending upon the values of the anode-grid voltage and of the screen voltage. Adjustment of the circuit should be such that the cathode current is approximately 6 milliamperes. *Under no condition of adjustment should the cathode current exceed the recommended maximum value of 9 milliamperes.*

The bias voltage applied to grid No. 4 can be varied over relatively wide limits to control the translation gain of the tube. For example, with 67.5 volts on the screen (grids No. 3 and No. 5), the bias voltage may be varied from −3 to plate current cut-off (approximately −25 volts). With lower screen voltages, the cut-off point is proportionately less. The extended cut-off feature of the 1A6 in combination with the similar characteristics of super-control tubes can be utilized advantageously to adjust receiver sensitivity.

Since the capacity between grid No. 4 and plate is in a parallel path with the capacity and inductance of the plate load, it is important to use a load capacity of sufficient size to limit the magnitude of the r-f voltage built up across the load. If this is not done, r-f voltage feed-back will occur between plate and grid No. 4 to produce degenerative effects. For this reason, the size of the load condenser in the plate circuit should be not less than 50 $\mu\mu$f.

Converter circuits employing the 1A6 may easily be designed to have a translation gain of approximately 40. A typical circuit which provides exceptionally uniform oscillator output over the entire grid-bias range is shown under type 1C6. For details of oscillator coil assemblies, refer to type 2A7.

RESTRICTED

RESTRICTED

1B25

PROTECTIVE TUBE

(TENTATIVE DATA)

The 1B25 is designed for use as a protective tube. Normal variations in ambient temperature have negligible effect on the tube's performance.

INTERELECTRODE CAPACITANCE (Approx.)	1.35 μμf
DIMENSIONS	See *OUTLINE DRAWING*
MOUNTING	Special
MOUNTING POSITION	Any
TERMINALS	Cap and Flange

Maximum Rating Is Design-Center Value

MAXIMUM RATING

D-C CONDUCTION CURRENT	30 max. Ma.

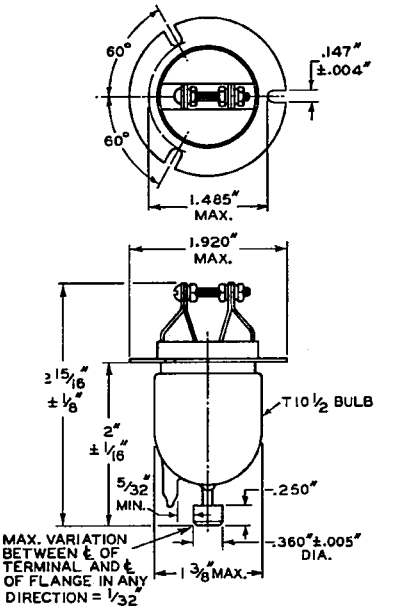
TEST CHARACTERISTICS

D-C BREAKDOWN VOLTAGE (Tube cold)*	160 max. Volts
TUBE VOLTAGE DROP**	120 Volts

* A somewhat higher supply voltage will be required for breakdown when a steep voltage front is used.

**With d-c conduction current of 30 ma.

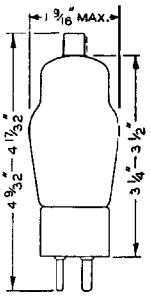
NOTE: The energy dissipated in the tube should not be sufficient to establish a sustained arc.



92C-6332

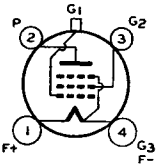
RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA. HARRISON, NEW JERSEY

Photolithographed in U.S.A.



RCA-1B4

R-F AMPLIFIER PENTODE



The 1B4 is a pentode of the filament type. It is recommended for use primarily as a radio-frequency amplifier or detector in battery-operated receivers. The 1B4 is similar in application to type 32 but is constructed in a smaller bulb.

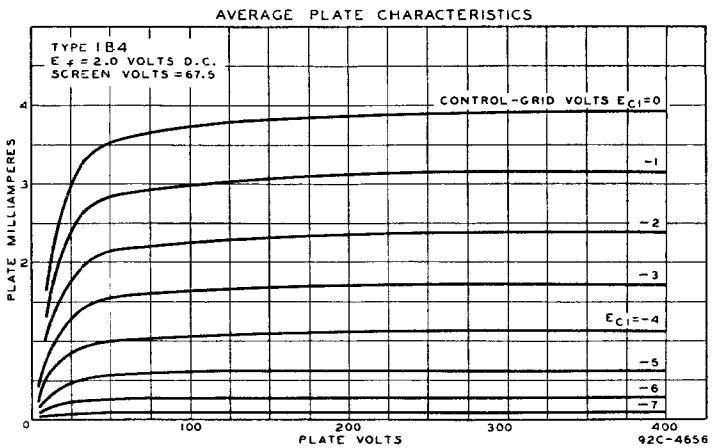
CHARACTERISTICS

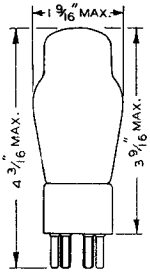
Filament Voltage (D. C.)	2.0		Volts
Filament Current	0.060		Ampere
Plate Voltage	90	180 *max.*	Volts
Screen Voltage (Grid No. 2)	67.5 *max.*	67.5 *max.*	Volts
Grid Voltage (Grid No. 1)	−3	−3	Volts
Plate Current	1.6	1.7	Milliamperes
Screen Current	0.7	0.6	Milliampere
Plate Resistance	1	1.5	Megohms
Amplification Factor	550	1000	
Transconductance	600	650	Micromhos
Grid Voltage* (Approx.)	−8	−8	Volts
Grid-Plate Capacitance (With shield-can)	0.007 *max.*		μμf
Input Capacitance	5		μμf
Output Capacitance	11		μμf
Bulb			ST-12
Cap			Small Metal
Base			Small 4-Pin

* For plate current cut-off.

INSTALLATION AND APPLICATION

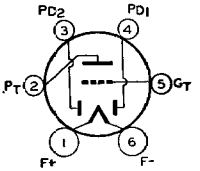
For INSTALLATION, refer to type 34; for APPLICATION, refer to type 32.





RCA-1B5/25S

DUPLEX-DIODE TRIODE



The 1B5/25S is a filament type of tube containing *two diodes* and a *triode* in a single bulb. It is recommended for use as a combined detector, amplifier, and automatic-volume-control tube in battery-operated receivers. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

Filament Voltage (D. C.)	2.0	Volts
Filament Current	0.06	Ampere
Grid-Triode Plate Capacitance	3.6	μμf
Grid-Filament Capacitance	1.6	μμf
Triode Plate-Filament Capacitance	1.9	μμf
Bulb		ST-12
Base		Small 6-Pin

Triode Unit—As Class A_1 Amplifier

Plate Voltage	135 *max.*	Volts
Grid Voltage	−3	Volts
Plate Current	0.8	Milliampere
Plate Resistance	35000	Ohms
Amplification Factor	20	
Transconductance	575	Micromhos

Diode Units

The two diodes and the triode are independent of each other except for the common filament. Diode plate No. 1 is located at the negative end of the filament; diode plate No. 2 is located at the positive end. Because of this arrangement, diode plate No. 1, when the diodes are used for different purposes, should be used for detection to avoid signal delay effects. Operation curves for the diode units are given under type 6B7.

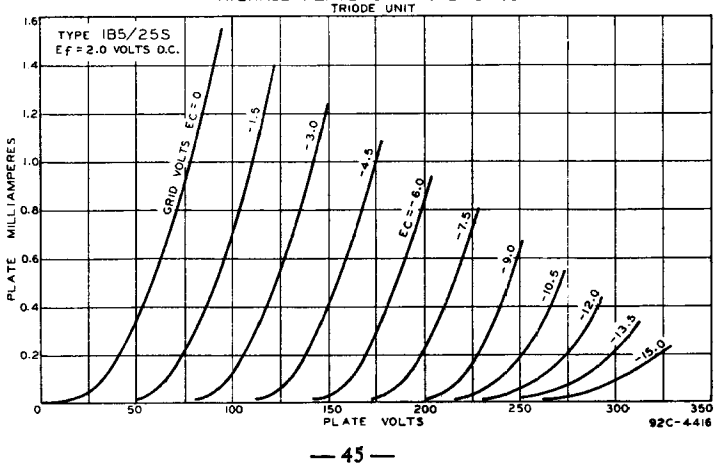
INSTALLATION AND APPLICATION

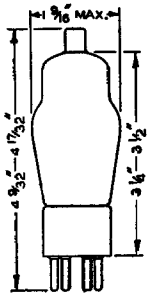
The base pins of the 1B5/25S require the use of a standard six-contact socket which should be installed to hold the tube in a vertical position.

For filament operation and shielding, refer to type 1A6.

The 1B5/25S is similar in application to the type 6R7.

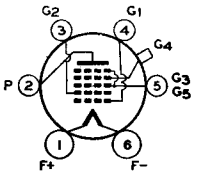
AVERAGE PLATE CHARACTERISTICS
TRIODE UNIT





RCA-1C6

PENTAGRID CONVERTER



The 1C6 is a multi-electrode type of vacuum tube designed to perform simultaneously the function of a mixer tube and of an oscillator tube in superheterodyne circuits. Through its use, the independent control of each function is made possible within a single tube. The 1C6 is designed especially for use in battery-operated receivers. In such service, this tube replaces the two tubes required in conventional circuits and gives improved performance. It is especially useful in multi-range receivers which are often designed to cover frequencies as high as 20 megacycles. For general discussion of pentagrid types, see FREQUENCY CONVERSION, page 31.

CHARACTERISTICS

FILAMENT VOLTAGE (D. C.)	2.0	Volts
FILAMENT CURRENT	0.120	Ampere
DIRECT INTERELECTRODE CAPACITANCES (*Approx.*):		
Grid No. 4 to Plate (With shield-can)	0.3	μμf
Grid No. 4 to Grid No. 2 (With shield-can)	0.3	μμf
Grid No. 4 to Grid No. 1 (With shield-can)	0.15	μμf
Grid No. 1 to Grid No. 2	1.5	μμf
Grid No. 4 to All Other Electrodes (R-F Input)	10	μμf
Grid No. 2 to All Other Electrodes (Osc. Output)	6	μμf
Grid No. 1 to All Other Electrodes (Osc. Input)	6	μμf
Plate to All Other Electrodes (Mixer Output)	10	μμf
BULB		ST-12
CAP		Small Metal
BASE		Small 6-Pin

Converter Service

PLATE VOLTAGE		180 *max.*	Volts
SCREEN VOLTAGE (Grids No. 3 and 5)		67.5 *max.*	Volts
ANODE-GRID VOLTAGE (Grid No. 2)		135 *max.*	Volts
ANODE-GRID VOLTAGE SUPPLY*		180 *max.*	Volts
CONTROL-GRID VOLTAGE (Grid No. 4)		−3 *min.*	Volts
TOTAL CATHODE CURRENT		9 *max.*	Milliamperes
TYPICAL OPERATION			
Plate Voltage	135	180	Volts
Screen Voltage	67.5	67.5	Volts
Anode-Grid Voltage Supply	135*	180*	Volts
Control-Grid Voltage	−3	−3	Volts
Oscillator Grid-Resistor (Grid No. 1)	50000	50000	Ohms
Plate Current	1.3	1.5	Milliamperes
Screen Current (Approximate)	2	2	Milliamperes
Anode-Grid Current	2.6	3.3	Milliamperes
Oscillator-Grid Current	0.2	0.2	Milliampere
Total Cathode Current (Approx.)	6.5	7	Milliamperes
Plate Resistance	0.55	0.75	Megohm
Conversion Conductance	300	325	Micromhos
Conversion Conductance (At −14 volts on Grid No. 4)	4	4	Micromhos

The transconductance of the oscillator portion (not oscillating) of the 1C6 is 1000 micromhos under the following conditions: Plate voltage, 135 to 180 volts; screen voltage, 67.5 volts; anode-grid voltage (no voltage-dropping resistor), 135 volts; and zero oscillator grid volts. Under these same conditions, the anode-grid current is 4.9 milliamperes.

* Applied through 20000-ohm dropping resistor, by-passed by 0.1 μf condenser.

INSTALLATION

Refer to INSTALLATION on type 1A6.

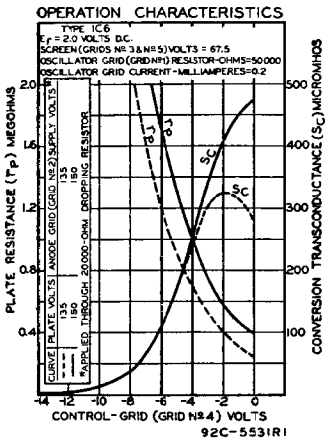
APPLICATION

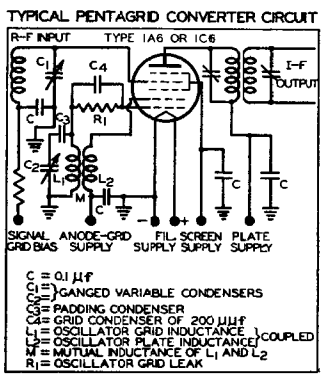
As a **frequency converter** in superheterodyne circuits, the 1C6 can supply the local oscillator frequency and at the same time mix it with the radio-input frequency to provide the desired intermediate frequency. For this service, design information is given under CHARACTERISTICS. It is important to note that the anode-grid voltage and the plate voltage must each be higher than the screen voltage.

For oscillator circuit information, refer to APPLICATION on type 1A6. Final adjustment of the 1C6 circuit should be such that the cathode current is approximately 6.5 milliamperes. *The cathode current should never exceed 9 milliamperes under any condition of adjustment.*

This tube, which is similar to the 1A6 although not directly interchangeable with it, requires twice the filament current of the latter, but offers the feature of an extended operating range at the higher frequencies. This feature is of particular value in the design of multi-range receivers, since the oscillator section of the 1C6 has sufficient mutual conductance to function at frequencies as high as 25 megacycles. In order to cover this same range of operation, the 1A6 requires the use of a triode connected in parallel with the oscillator section for frequencies above 10 megacycles.

The maximum conversion transconductance is obtained with an oscillator-grid current of slightly less than 0.2 milliampere. The size, inductance, and coupling of the oscillator-grid and plate coils will determine this value. The coupling of these coils should be adjusted to make the oscillator-grid current the proper value (approximately 0.2 milliampere) when a grid condenser of 250 $\mu\mu$f and a grid leak of 50000 ohms are used. For details of oscillator-coil assemblies, refer to type 2A7.





from JETEC release #1823, Jan. 14, 1957

1EP1, 1EP2, 1EP11

OSCILLOGRAPH TUBES

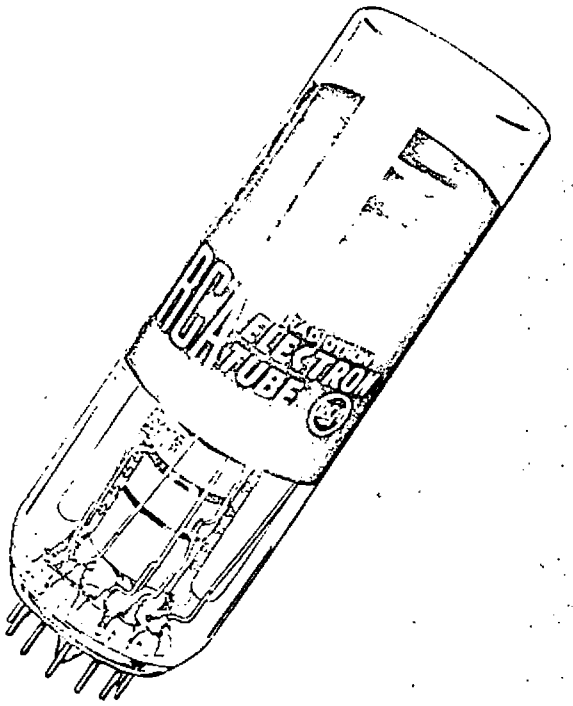
Electrostatic Focus
Electrostatic Deflection

Tubular Glass Envelope
Flat Face

1-5/16" Max. Diameter
4-1/16" Max. Length

TENTATIVE DATA

The 1E-series of "1-inch" cathode-ray tubes consists of three types--1EP1, 1EP2, and 1EP11--utilizing electrostatic focus and electrostatic deflection. They differ one from the other only in the spectral-energy emission and persistence characteristics of their respective phosphors P1, P2, and P11.



Actual Size

Design features of the 1E-types include a flat-face bulb, a minimum useful screen diameter of 1-1/16 inches, separate base-pin terminal for each deflecting electrode to permit use of balanced deflection, and a very sturdy structure.

RCA-1EP1

Medium-Persistence Type

The 1EP1 is designed especially for use in small, lightweight equipment, such as portable test equipment or aircraft equipment. It is also useful in larger equipment, such as computers or transmitters, where continuous monitoring of a waveform is desired. The 1EP1 provides a trace having high brightness at relatively low ultor voltage on a screen which has green fluorescence and medium persistence.

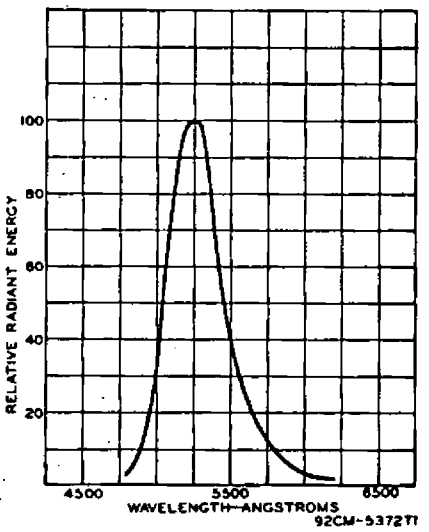


Fig. 1 - Spectral-Energy Emission Characteristic of Phosphor P1.

The spectral distribution of the energy emitted by the P1 phosphor is shown in Fig. 1; and the persistence of the P1 phosphor is given in Fig. 2. Because of its medium persistence, the 1EP1 is particularly useful where either medium-speed non-recurring phenomena or medium- and high-speed recurring phenomena are to be observed. The persistence is such that the 1EP1 can be operated with scanning frequencies as low as 20 cycles per second without excessive flicker.

The recommended minimum ultor voltage for the 1EP1 in general service is 500 volts, but a value as low as 300 volts may be used under conditions of low-velocity deflection and low ambient-light levels.

The curves in Fig. 3 show how line width of the 1EP1 varies with brightness for two values of ultor voltage.

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

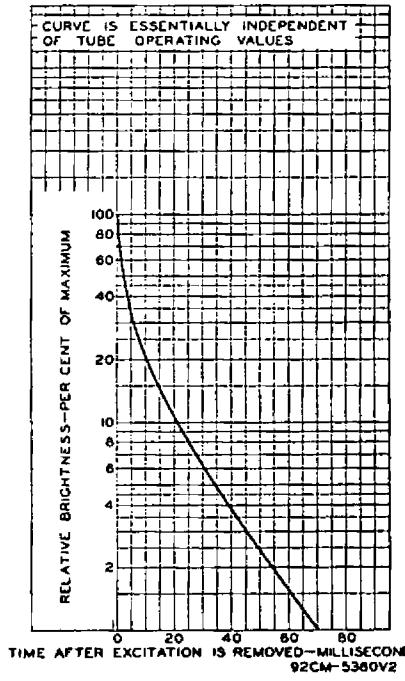


Fig. 2 - Persistence Characteristic of Phosphor P1.

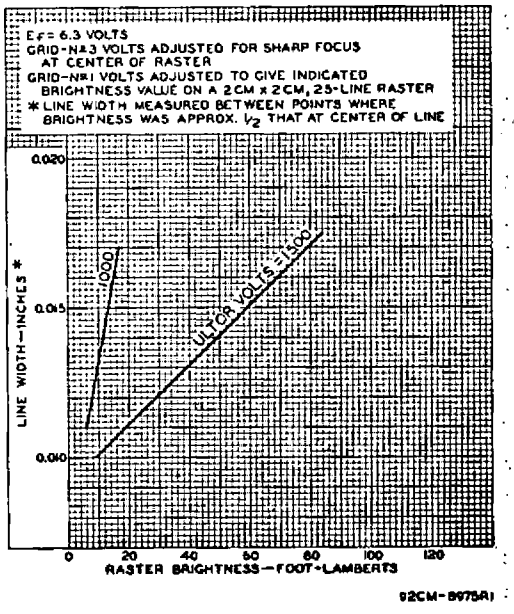


Fig. 3 - Average Characteristics of Type 1EP1.

RCA-1EP2

Long-Persistence Type

The 1EP2 is intended for use in lightweight portable equipment, or in continuous monitoring service for large electronic equipment. It is especially useful in applications where a temporary record of electrical phenomena is desired. The 1EP2 utilizes a long-persistence screen which exhibits greenish-yellow fluorescence of short persistence and greenish-yellow phosphorescence which persists for over a minute under conditions of adequate excitation and low ambient light.

The spectral distribution of the energy emitted by the P2 phosphor is shown in Fig. 4; and the persistence of the P2 phosphor is given in Fig. 5.

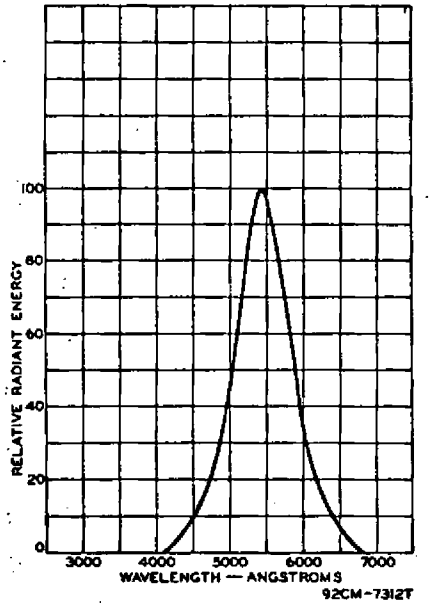


Fig. 4 - Spectral-Energy Emission Characteristic of Phosphor P2.

Because of its long persistence, the 1EP2 is particularly useful where either low-speed non-recurring or high-speed recurring phenomena are to be observed.

The persistent light of the 1EP2 permits the user to view a curve produced on the face of the tube by a single, high-speed sweep of the electron beam and, if desired, to make a tracing of the curve for record purposes.

In general, operation of the 1EP2 at an ultor voltage less than 750 volts is not recommended.

The curves in Fig. 6 show how line width of the 1EP2 varies with brightness for two values of ultor voltage.

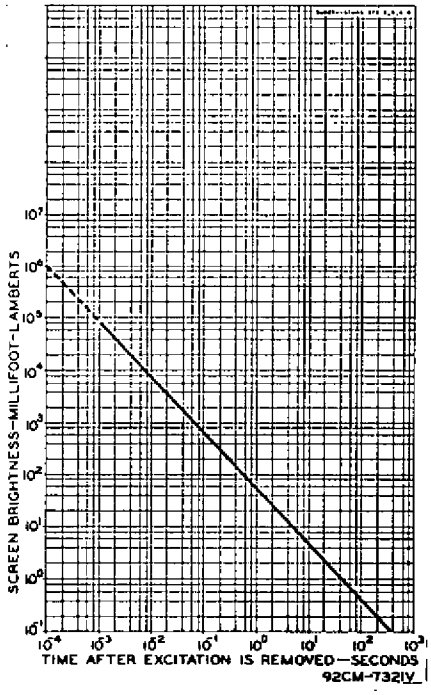


Fig. 5 – Persistence Characteristics of Phosphor P2.

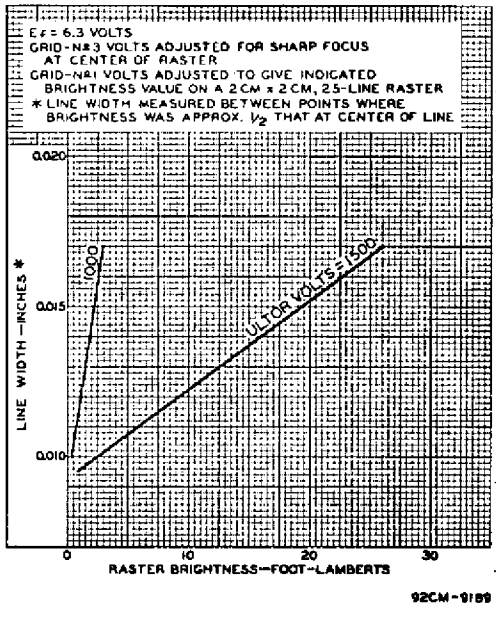


Fig. 6 – Average Characteristics of Type 1EP2.

RCA-1EP11

Short-Persistence Type

The 1EP11 is intended for use in lightweight portable equipment, or in continuous monitoring service for large electronic equipment. It is particularly useful in those applications involving photographic recording of electrical phenomena. The blue radiation of its fluorescent screen is highly actinic and has sufficiently short persistence to permit use of the 1EP11 in all photographic applications without blurring except in those where the film moves at high speed.

The 1EP11 is also quite satisfactory for visual observation of phenomena because it utilizes a phosphor having unusually high brightness for a blue screen.

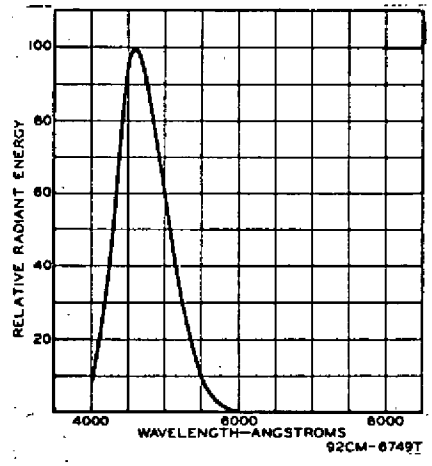


Fig. 7 – Spectral-Energy Emission Characteristics of Phosphor P11.

The spectral distribution of the energy emitted by the P11 phosphor is given in Fig. 7.

Persistence characteristics of the P11 phosphor for different screen-current densities are shown in Fig. 8. Because of its short persistence, the 1EP11 is especially useful where either high-speed non-recurring phenomena or medium- and high-speed recurring phenomena are to be observed.

In general, operation of the 1EP11 at an ultor voltage less than 750 volts is not recommended.

The curves in Fig. 9 show how line width of the 1EP11 varies with brightness for two values of ultor voltage.

In the case of moving photographic film, the use of high-contrast film and developer will minimize blurring caused by the image persistence. For maximum photographic-recording sensitivity with films generally available, the use of high-speed orthochromatic film is suitable.

In cases where a large amount of recording is to be done, the use of special, high-speed, blue-sensitive film may have an economic advantage.

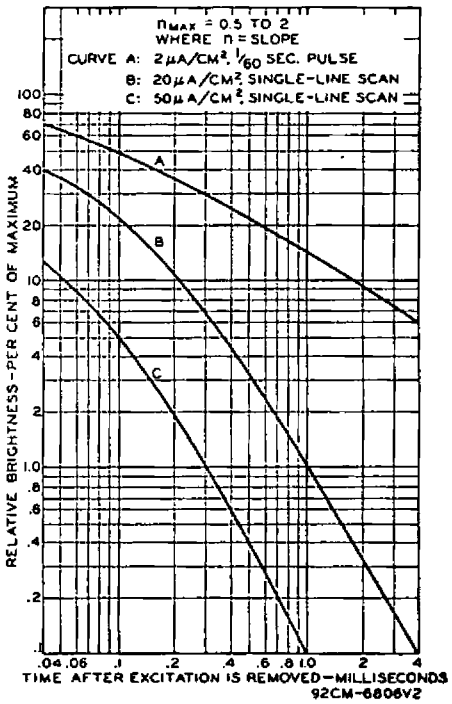


Fig. 8 - Persistence Characteristics of Phosphor P11.

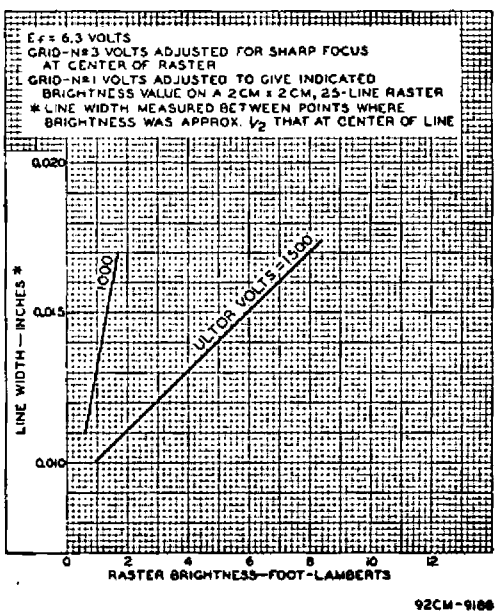


Fig. 9 - Average Characteristics of Type 1EP11.

DATA

For All 1E-Types

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6 ± 10%	amp
Direct Interelectrode Capacitances (Approx.):		
Grid No.1 to all other electrodes	6.5	μμf
Deflecting electrode DJ_1 to deflecting electrode DJ_2	1.7	μμf
Deflecting electrode DJ_3 to deflecting electrode DJ_4	0.6	μμf
DJ_1 to all other electrodes	5.0	μμf
DJ_2 to all other electrodes	5.0	μμf
DJ_3 to all other electrodes	3.8	μμf
DJ_4 to all other electrodes	3.8	μμf
Faceplate, Flat	Clear Glass	
Focusing Method	Electrostatic	
Deflection Method	Electrostatic	
Maximum Overall Length	4-1/16"	
Seated Length	3-9/16" ± 1/8"	
Diameter	1-1/4" ± 1/16"	
Minimum Useful Screen Diameter	1-1/16"	
Bulb	T10	
Base	Small-Button Unidekar 11-Pin (JETEC No.E11-22)	
Weight (Approx.)	2 oz	
Mounting Position	Any	

Maximum Ratings, *Design-Center Values:*

ULTOR● VOLTAGE	1500 max.	volts
GRID-No.3 VOLTAGE	1200 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	200 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK VOLTAGE BETWEEN ULTOR AND ANY DEFLECTING ELECTRODE	500 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	125 max.	volts

Equipment Design Ranges:

For any ultor voltage (E_{c_4}) between recommended minimum and 1500 volts*

Grid-No.3 Voltage for Focus	10% to 30% of E_{c_4}	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	-1.4% to -4.2% of E_{c_4}	volts
Grid-No.3 Current for Any Operating Condition	-15 to +10	μamp
Deflection Factors:		
DJ_1 & DJ_2	210 to 310 v dc/in./kv of E_{c_4}	
DJ_3 & DJ_4	240 to 350 v dc/in./kv of E_{c_4}	
Spot Position	##	

Examples of Use of Design Ranges:

For ultor voltage of	*500*	*1000*	*volts*
Grid-No.3 Voltage for Focus	50 to 150	100 to 300	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	-7 to -21	-14 to -42	volts
Deflection Factors:			
DJ_1 & DJ_2	105 to 155	210 to 310	volts dc/in.
DJ_3 & DJ_4	120 to 175	240 to 350	volts dc/in.

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms
Resistance in Any Deflecting-Electrode Circuit○○	2.0 max.	megohms

• The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 1E-types, the ultor function is performed by grid No.4. Since grid No.4, grid No.2, and collector are connected together within the 1E-types, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

* Brilliance and definition decrease with decreasing ultor voltage. Recommended minimum value of ultor voltage for the 1EP1 in general service is 500 volts, but a value as low as 300 volts may be used under conditions of low-velocity deflection and low ambient light levels. For operation between 300 and 500 volts, it is essential that the ultor voltage be applied before beam-current flow. Otherwise, a screen charge may develop to block off or distort the scanning pattern. Recommended minimum value for the 1EP2 and 1EP11 is 750 volts.

The center of the undeflected focused spot will fall within a circle having 2.5-mm radius concentric with the center of the tube face.

OO It is recommended that the deflecting-electrode-circuit resistances be approximately equal.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of the line-center value of 117 volts.

Support for the 1E-types may be provided by any convenient method required by the application. If the tube is supported by a clamp around the bulb, the clamp should be fastened only tight enough to provide mechanical support. Fastening the clamp too tight may cause glass strains with immediate or delayed cracking of the bulb.

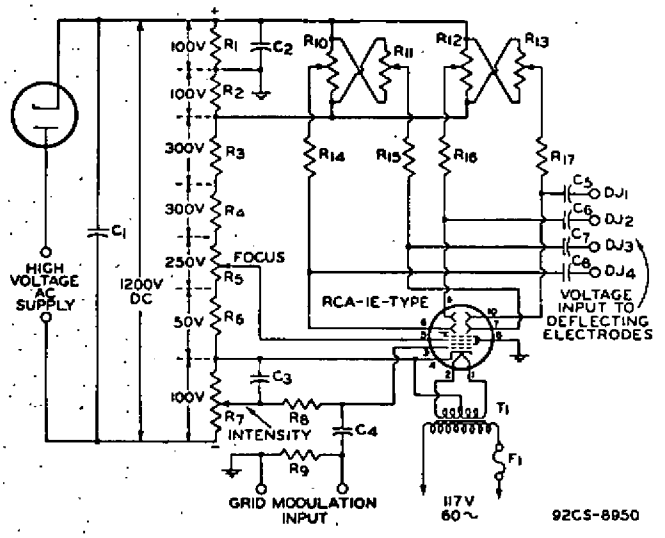
The *bulb*, except for the face, should be enclosed in a grounded shield if the tube is to be operated in the presence of magnetic fields. The shield should be made of high-permeability metal having low residual magnetism in order to minimize the effects of extraneous magnetic fields.

The *base pins* of the 1E-types fit the Unidekar 11-contact socket, such as Alden Nos.411 SBU (connector type) or 411 SBUP (with mounting plate for panel or chassis mounting), or equivalent. The design of the socket should be such that the circuit wiring cannot impress lateral strains through the socket contacts on the base pins. The point of bearing of the contacts on the base pins should not be closer than 1/8" from the bottom of the seated tube.

Two pairs of *electrostatic deflecting electrodes*, producing fields approximately at right angles to each other, provide for deflection of the electron beam in the directions of the respective fields.

Each pair of deflecting electrodes is normally operated at an *average potential* the same as that of grid No.4. Each electrode of each pair should be connected through a resistor of not more than 2 megohms to the grid-No.4 socket terminal. Under operating conditions involving high current to the screen or scanning beyond the limits of the screen, a small amount of current is collected by the deflecting electrodes. If the circuit resistance between each deflecting electrode and grid No.4 is high, the current collected by the deflecting electrodes produces negative potentials on the deflecting electrodes. Such potentials distort or shift the spot on the screen. These effects can be minimized by reducing equally the resistances of the deflecting-electrode circuits, by reducing the scanning width, by reducing the beam current, or by applying a small and equal dc compensating voltage to deflecting electrodes DJ_3 and DJ_4. This voltage should be positive with respect to grid No.4.

Operation with one pair of deflecting electrodes at an *average potential different from that of grid No.4* may be desired in certain applications. In such cases, the different potential should be applied to the pair of deflecting electrodes (DJ_1 and DJ_2) nearer the screen, and its average value should not differ from the operating grid-No.4 voltage by more than 15%. This type of operation causes spot-shape distortion which can be compensated by applying to deflecting electrodes DJ_3 and DJ_4 an average voltage of the same polarity as that applied to



C1: 0.5μf, 2000 volts
C2: 1μf, 200 volts
C3: 1μf, 200 volts
C4: 0.05μf, 1600 volts
C5 C6 C7 C8: 0.05μf, 600 volts
R1 R2: 510000 ohms, 1/2 watt
R3 R4: 300000 ohms, 1 watt
R5: 250000-ohm potentiometer, 2 watts
R6: 51000 ohms, 1/2 watt
R7: 100000-ohm potentiometer, 1/2 watt
R8: 510000 ohms, 1/2 watt
R9: 5 megohms, 1/2 watt
R10 R11: Dual 1-megohm potentiometer, 1/2 watt
R12 R13: Dual 1-megohm potentiometer, 1/2 watt
R14 R15 R16 R17: 1.5 megohms, 1/2 watt
T1: Transformer, with 6.3-volt/1-ampere secondary, insulated for at least 2000 volts, such as Thordarson T21F08
F1: 1-ampere fuse

Fig. 10 - Typical Oscillograph Circuit for 1E-Types.

DJ1 and DJ2 (positive or negative with respect to grid No.4).

The *dc voltages* for grid No.1, grid No.3, and grid No.4 may be obtained conveniently from a high-voltage vacuum-tube rectifier and filter. Since these cathode-ray tubes require very little current, the rectifier system can be of either the half-wave or the voltage-doubler type. Likewise, the filter requirements are simple. A 0.5 μf capacitor will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended. If the electrode voltages are obtained from a voltage-divider circuit, a current of 1.0 milliampere through the voltage divider is satisfactory. Considerably higher values may require more filtering than that provided by a single capacitor shunted across the dc supply. A typical circuit for the 1E-types is shown in Fig.10.

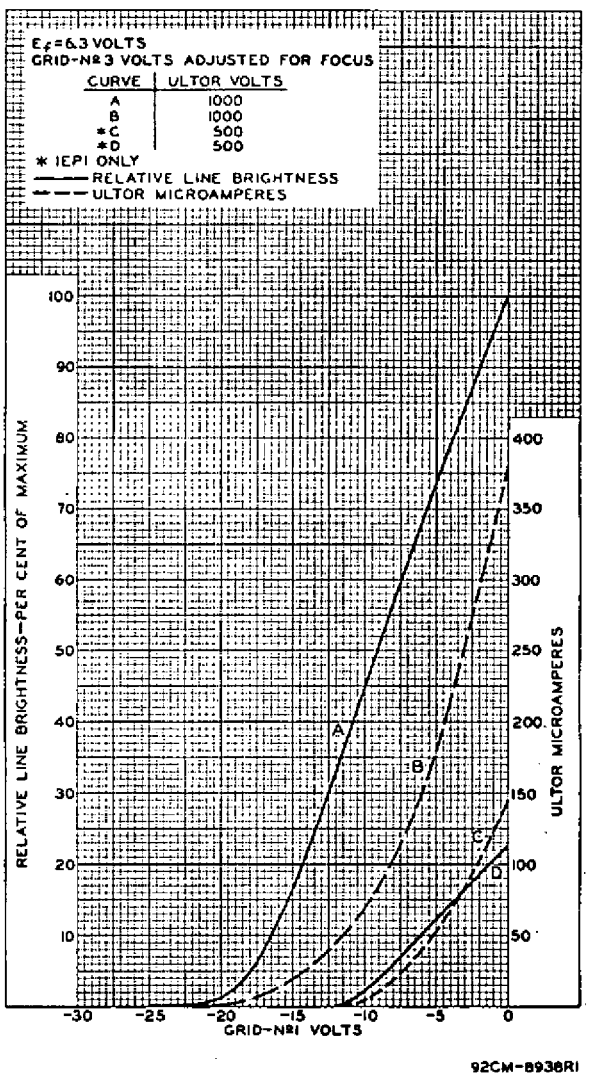


Fig. 11 – Average Characteristics for 1E-Types.

In most applications, it is recommended that the ultor (grid No.2, grid No.4, and collector) be grounded in order that the deflecting electrodes may be operated at ground potential. With this method, the cathode and heater are at high negative potential with respect to ground.

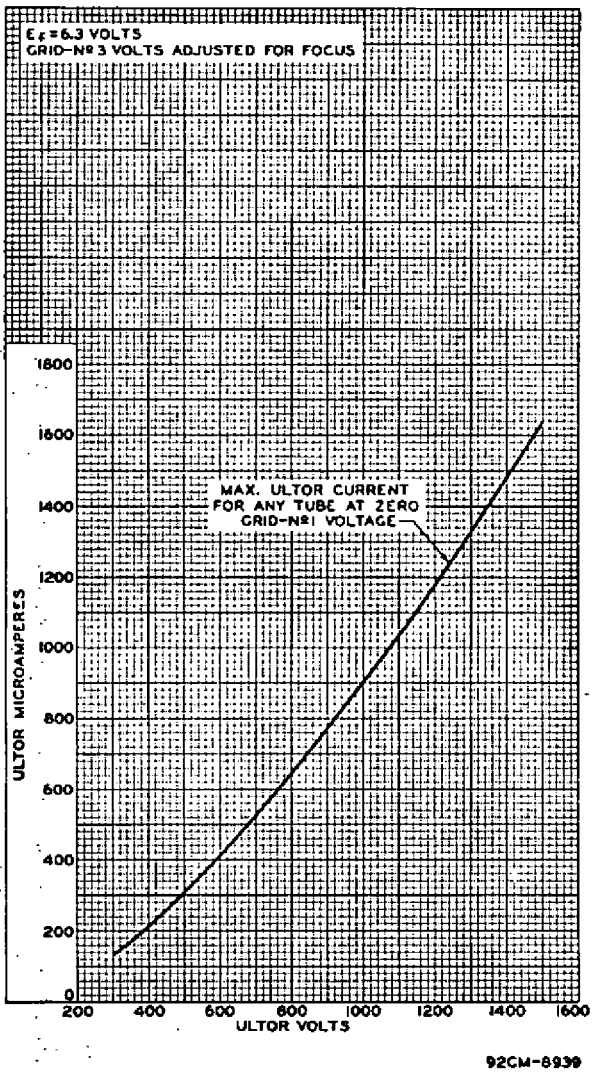


Fig. 12 – Maximum Ultor-Current Requirements from Power Supply for 1E-Types.

The high voltages at which these types are operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Safety precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuits of the power supply when access to the equipment is

required. In most applications, it is recommended that the ultor terminal be grounded rather than the cathode terminal. With this method, which places the heater and cathode at high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

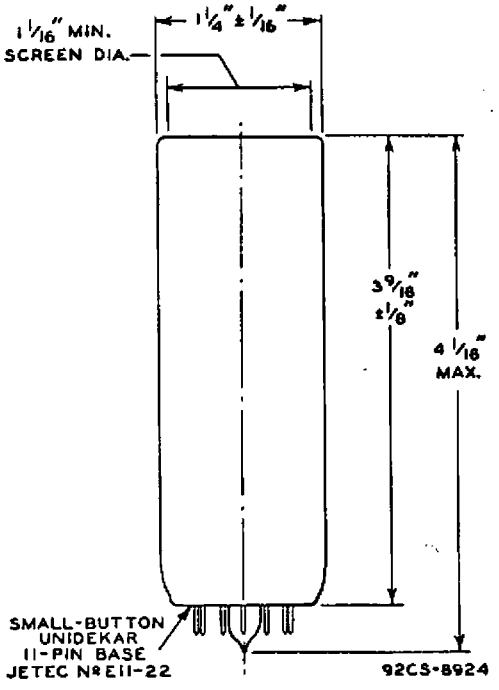
In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit as a result of capacitor breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off, and both terminals of any capacitors grounded.

The *undeflected focused spot* is normally close to the geometric center of the tube face. However, to compensate for stray magnetic fields, such as that of the earth, and for variation from tube to tube, designers should provide an adjustable and reversible supply of at least 35 volts dc per kilovolt of ultor voltage (balanced to ultor) for application between the two deflecting electrodes of each pair. By adjustment of this dc voltage on each pair of the deflecting electrodes, the spot may be centered.

A *high intensity spot* will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, the beam should always be kept in motion over a reasonably large area, or the beam current should be reduced. Such burning is especially noticeable when the IE-types are operated with ultor voltages less than 1000 volts.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE

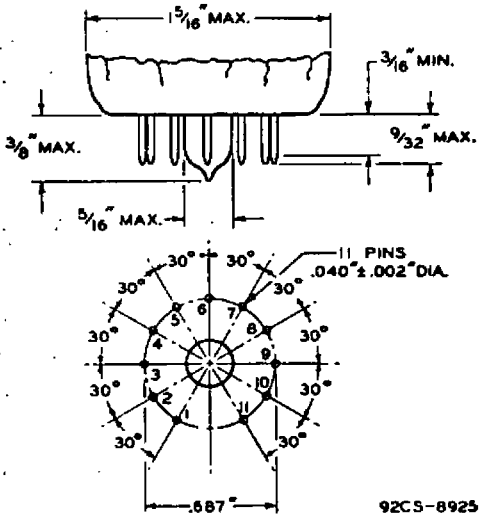


DJ_1 AND DJ_2 ARE NEARER THE SCREEN: DJ_3 AND DJ_4 ARE NEARER THE BASE. WITH DJ_2 POSITIVE WITH RESPECT TO DJ_1, THE SPOT IS DEFLECTED TOWARD THE MIDPOINT BETWEEN PINS 6 AND 7. WITH DJ_3 POSITIVE WITH RESPECT TO DJ_4, THE SPOT IS DEFLECTED TOWARD THE MIDPOINT BETWEEN PINS 9 AND 10.

THE ANGLE BETWEEN THE TRACE PRODUCED BY DJ_3 AND DJ_4 AND ITS INTERSECTION WITH THE PLANE THROUGH THE TUBE AXIS AND THE MIDPOINT BETWEEN PINS 9 AND 10 DOES NOT EXCEED ± 10°. THE ANGLE BETWEEN THE TRACE PRODUCED BY DJ_3 AND DJ_4 AND THE TRACE PRODUCED BY DJ_1 AND DJ_2 IS 90° ± 3°.

BASE DRAWING

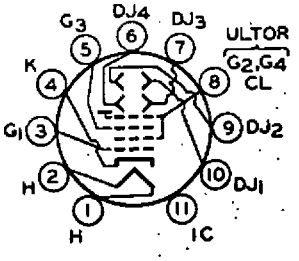
SMALL-BUTTON UNIDEKAR
11-PIN BASE
JETEC Nº E11-22



BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT THE PINS WILL FIT A FLAT-PLATE GAUGE HAVING THICKNESS OF 1/4" AND TWELVE HOLES 0.0520" ± 0.0005" SO LOCATED ON A 0.6870" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.1778" ± 0.0005" THE GAUGE IS ALSO PROVIDED WITH A HOLE 0.3750" ± 0.0100" CONCENTRIC WITH THE PIN-CIRCLE DIAMETER. PIN FIT IN GAUGE SHALL BE SUCH THAT THE ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, ENTER INTO AND DISENGAGE FROM THE GAUGE.

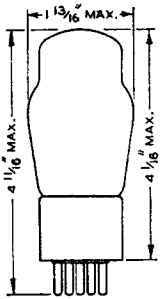
SOCKET CONNECTIONS

Bottom View



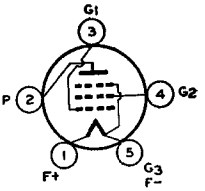
PIN 1: HEATER
PIN 2: HEATER
PIN 3: GRID No.1
PIN 4: CATHODE
PIN 5: GRID No.3
PIN 6: DEFLECTING ELECTRODE DJ_4
PIN 7: DEFLECTING ELECTRODE DJ_3
PIN 8: ULTOR (GRID No.2, GRID No.4, COLLECTOR)
PIN 9: DEFLECTING ELECTRODE DJ_2
PIN 10: DEFLECTING ELECTRODE DJ_1
PIN 11: INTERNAL CONNECTION— DO NOT USE

11V



RCA-1F4

POWER AMPLIFIER PENTODE



The 1F4 is a power-amplifier pentode for use in the output stage of battery-operated receivers. This tube has low filament- and plate-current requirements, high power sensitivity, and will deliver a considerable amount of audio output with low distortion.

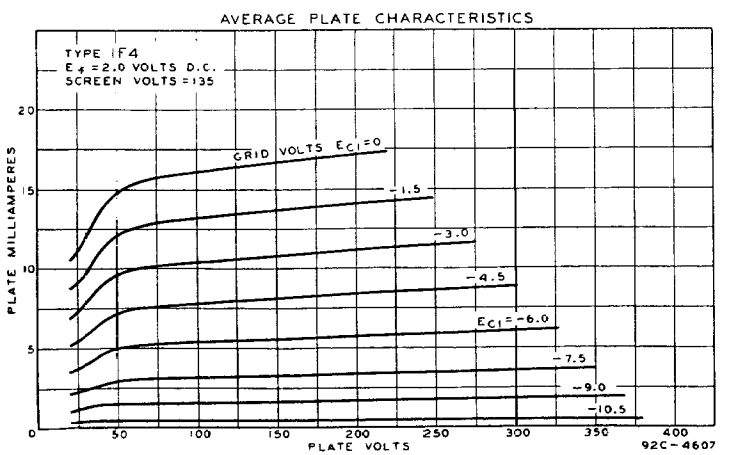
CHARACTERISTICS

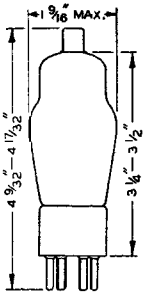
Filament Voltage (D. C.)		2.0	Volts
Filament Current		0.12	Ampere
Plate Voltage	90	135 *max.*	Volts
Screen Voltage (Grid No. 2)	90	135 *max.*	Volts
Grid Voltage (Grid No. 1)	−3	−4.5	Volts
Plate Current	4	8	Milliamperes
Screen Current	1.3	2.6	Milliamperes
Plate Resistance	240000	200000	Ohms
Amplification Factor	340	340	
Transconductance	1400	1700	Micromhos
Load Resistance	20000	16000	Ohms
Self-Bias Resistor	566	425	Ohms
Power Output*	120	340	Milliwatts
Bulb			ST-14
Base			Medium 5-Pin

* 5% total harmonic distortion.

INSTALLATION AND APPLICATION

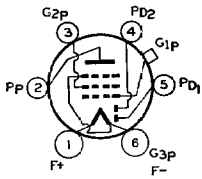
For INSTALLATION and APPLICATION, refer to type 33.





RCA-1F6

DUPLEX-DIODE PENTODE



The 1F6 is a duplex-diode pentode consisting of two diodes and a pentode in a single bulb. It is recommended for service as a combined detector, amplifier (radio-frequency, intermediate-frequency or audio-frequency), and automatic-volume-control tube in battery-operated receivers. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

Filament Voltage (D. C.)	2.0	Volts
Filament Current	0.06	Ampere
Grid-Pentode Plate Capacitance (With shield-can)	0.007 *max.*	μμf
Input Capacitance	4	μμf
Output Capacitance	9	μμf
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

Pentode Unit—As Class A R-F or I-F Amplifier

Plate Voltage	180 *max.*	Volts
Screen Voltage (Grid No. 2)	67.5 *max.*	Volts
Grid Voltage (Grid No. 1)	−1.5	Volts
Plate Current	2.0	Milliamperes
Screen Current	0.6	Milliampere
Plate Resistance (Approx.)	1	Megohm
Amplification Factor (Approx.)	650	
Transconductance	650	Micromhos
Transconductance (At —12 volts bias)*	15	Micromhos

Pentode Unit—As Resistance-Coupled A-F Amplifier

Plate-Supply Voltage	135		135		Volts
Screen-Supply Voltage	135		135		Volts
D-C Grid Voltage	−1.0		−2.0		Volts
Peak A-F Grid Voltage	0.64		0.62		Volt
Zero-Signal D-C Plate Current	0.42		0.42		Milliampere
Max.-Signal D-C Plate Current	0.34		0.34		Milliampere
Plate Resistor	0.25		0.25		Megohm
Screen Resistor	1		0.8		Megohm
Load Resistance	**		**		
Grid Resistor†	1.0	0.5	1.0	0.5	Megohm
Voltage Amplification	48	43	46	41	
Total Harmonic Distortion	5	5	5	5	Per cent
Peak Voltage Output	30.8	28	28	25.2	Volts

** The load resistance across which the output voltage is developed, consists of the plate resistor, coupling condenser, and grid resistor of the following tube.

† For the following tube.

* For cathode current cut-off.

Diode Units

The two diodes and the pentode are independent of each other except for the common filament. The two diode units are placed at the negative end of the filament. Operation curves for diode units are given under type 6B7.

INSTALLATION AND APPLICATION

Refer to INSTALLATION of type 1A6. The 1F6 is similar in application to type 6B8. The maximum value of resistance in the grid circuit of this tube should not exceed 1.0 megohm for any condition of operation. A family of plate characteristic curves is given on page 61.

RMA Release # 390
Nov. 3, 1944

U.S. CONFIDENTIAL

IP25
VIEWING TUBE

Spectral Response S-1 | **Red — Infra-Red Sensitive** | **Phosphor No.1**

(TENTATIVE DATA)

The RCA-IP25 is a new form of tube which, in combination with suitable optical systems, permits the viewing of a scene by radiant energy of low visual efficiency. It consists of a photocathode at the large end of the tube on which the scene to be viewed is imaged by means of an optical objective. The image on the photocathode is focused on the screen at the small end of the tube by electron-optical methods to form a reduced fluorescent image which can be viewed by the use of an optical magnifier. The objective may consist of a Schmidt optical system or a conventional objective lens. At the small end of the tube, a lens is built in as a part of the tube. This lens forms the front element of the optical magnifier.

Features of the IP25 are its good spectral response to infra-red radiation, a face plate having high optical quality, an integral screen lens, and small size.

GENERAL

SPECTRAL RESPONSE	S-1
FOCUS	Electrostatic
PHOSPHOR	No.1
FLUORESCENCE	Green
PERSISTENCE	Medium
OVERALL LENGTH	4-7/16" ± 1/8"
DIAMETER OF LARGE CYLINDER	1-5/8" $^{+1/16"}_{-3/32"}$
DIAMETER OF SMALL CYLINDER	7/8" $^{+1/32"}_{-3/32"}$
MINIMUM USEFUL PHOTOCATHODE DIAMETER	1-1/8"
MINIMUM USEFUL SCREEN DIAMETER	1/2"
BASE	Medium Annular 7-Pin
MOUNTING POSITION	Any

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS for Observations at Eye Threshold

GRID No.4 (High-Voltage Collector-Grid Electrode) VOLTAGE	4500 max.	Volts
GRID No.3 (Accelerating Electrode) VOLTAGE	800 max.	Volts
GRID No.2 (Focusing Electrode) VOLTAGE.	250 max.	Volts
GRID No.1 (Accelerating Electrode) VOLTAGE	15 max.	Volts
PHOTOCATHODE ILLUMINATION	50 max.	Foot-Candles
AMBIENT TEMPERATURE	50 max.	°C
TYPICAL OPERATION:		
Grid No.4 Voltage	4100	Volts
Grid No.3 Voltage	575	Volts
Grid No.2 Voltage*	100 □	Volts
Grid No.1 Voltage	10	Volts

* Supply should be adjustable to ±55% of value shown.
□ This value is for a photocathode illumination of approximately 10 foot-candles. For extremely low light levels, this voltage should be reduced by about 20%.

INSTALLATION

The *terminal pins* of the IP25 require the use of a special 7-pin socket which may be mounted to hold the tube in any position. The socket should have floating contacts which will prevent strains on the metal-to-glass seals. It should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The *bulb* of the IP25, except for the photocathode and screen ends, should be enclosed in a grounded metal case. If an iron or steel case is used to minimize the effects of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized.

The shielding case may be so designed, if desired, to include an annular end piece to position the tube properly in the optical system. For this purpose, the circle of the end piece bearing against the face plate should lie inside a circle of 5/8-inch radius, concentric with the axis of the large cylinder, to insure contact with the uniform surface of the face.

The *fluorescent screen* employs phosphor No.1 which fluoresces to produce a green luminescence. It has good visual and photographic qualities as well as high luminous efficiency. The spectral energy characteristic of phosphor No.1 is given in Fig.1.

The *photocathode* has good response to radiant energy in the infra-red region up to about 12000 angstroms. The spectral response of the IP25 is identified as S-1, and is shown in the curve of Fig.2.

The *maximum ambient temperature* rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface to evaporate with consequent decrease in life and sensitivity of the surface.

Exposure to intense light, such as direct sunlight, may temporarily decrease the tube's sensitivity even though there is no voltage applied. The magnitude and duration of this decrease depend on the length of exposure. Permanent damage to the tube may result if it is exposed to radiant energy so intense as to cause excessive heating of the cathode.

RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

1P25-7-44
Photolithographed in U.S.A.

The *d-c supply voltages* for the electrodes may be obtained conveniently from a vacuum-tube rectifier. Since the tube requires very little current, the rectifier system can be of either the half-wave or the voltage-doubler type. A 0.5 to 2 μf condenser will ordinarily provide sufficient filtering. It is recommended that the tube be operated with grid No.4 at ground potential.

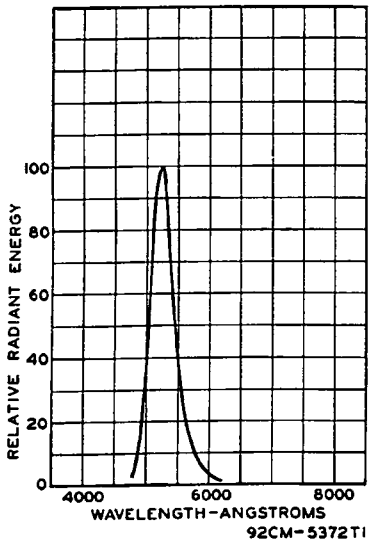


Fig. 1 - Spectral energy characteristic of phosphor No. 1.

The high voltages at which the 1P25 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions must include safeguards which eliminate all hazards to personnel. All circuit parts which may be at high potential should always be enclosed and interlock switches should be used to break the input circuit of the high-voltage power supply when access to the equipment is required.

In the use of high-voltage tubes, such as the 1P25, it should always be remembered that high voltages may appear at normally low-potential points in the circuit because of condenser breakdown or incorrect circuit connections. Before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

When the 1P25 is operated under conditions of eye-threshold phosphor brightness, the maximum ratings given in the tabulated data should not be exceeded.

Under conditions where higher than eye-threshold phosphor brightness exists and where operation at low brightness levels is not contemplated during the life of the tube, it may be operated under the following absolute maximum ratings: Grid No.4, 5500 volts; grid No.3, 900 volts; grid No.2, 300 volts; grid No.1, 15 volts; photocathode illumination, 50 foot-candles; and ambient temperature, 50°C. Suggested typical operating conditions are: Grid No.4, 5000 volts; grid No.3, 700 volts; grid No.2, 115 volts (supply should be adjustable to 50% of this value); grid No.1, 10 volts. When the 1P25 is operated at these higher voltages, the image brightness and the resolution of the tube are increased. Although the background level of fluorescence is also increased, it does not interfere with observations at high levels of phosphor brightness. Under such high-voltage operating conditions, the tube may show an occasional discharge, but such discharges do not prevent continued operation of the tube.

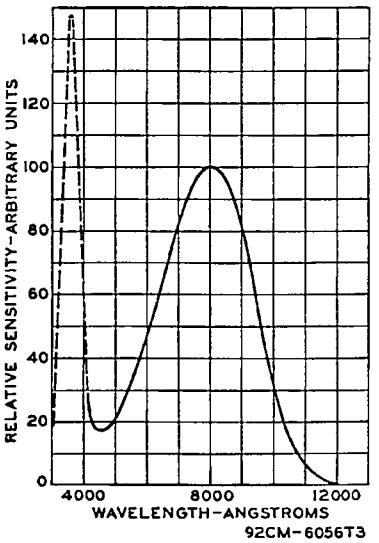
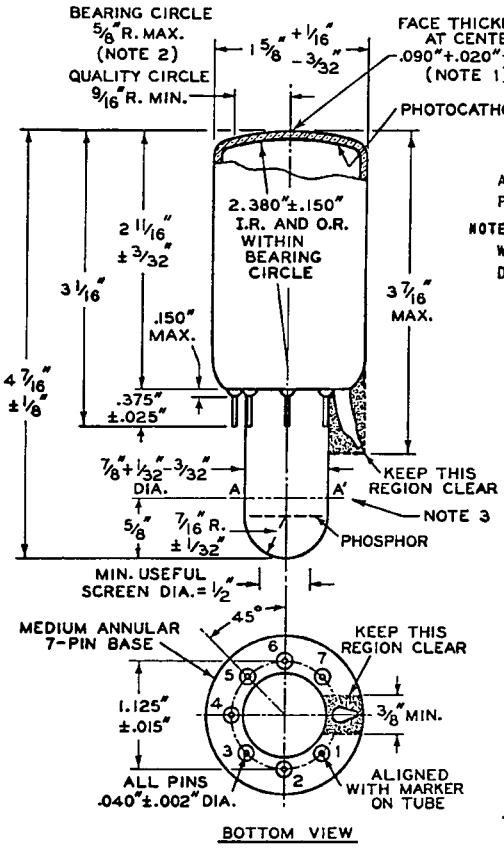


Fig. 2 - Spectral sensitivity characteristic of Type 1P25 having S-1 spectral response for equal values of radiant flux at all wavelengths.

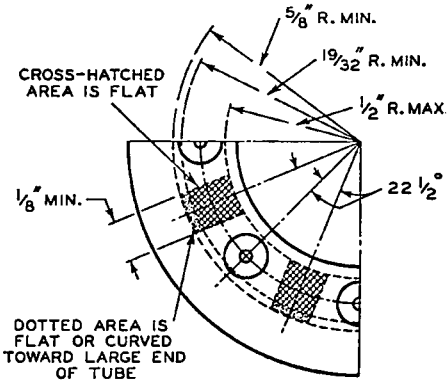


NOTE 1 – ON ANY TUBE, FACE THICKNESS AT PERIPHERY OF MAXIMUM BEARING CIRCLE DOES NOT VARY MORE THAN 0.030" DUE TO PRISM.

NOTE 2 – VARIATION OF THE DISTANCE FROM ANY OUTSIDE PERIPHERAL POINT ON THE MAXIMUM BEARING CIRCLE TO A PLANE OUTSIDE THE TUBE AND NORMAL TO AXIS OF PHOTOCATHODE CYLINDER DOES NOT EXCEED 0.025".

NOTE 3 – ECCENTRICITY OF PHOSPHOR CYLINDER AT AA' WITH RESPECT TO AXIS OF PHOTOCATHODE CYLINDER DOES NOT EXCEED 0.040".

DETAIL OF BOTTOM VIEW OF BASE



ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF PHOSPHOR CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND PHOSPHOR CYLINDER WILL FIT GAUGE WITH:

a. SEVEN PIN HOLES HAVING DIAMETER OF 0.0650" – 0.0655" ENLARGED TO DIAMETER OF 0.093" FOR A DEPTH OF 0.093" AND SPACED AT ANGLES OF 45°±5' ON CIRCLE DIAMETER OF 1.125"±0.0005".

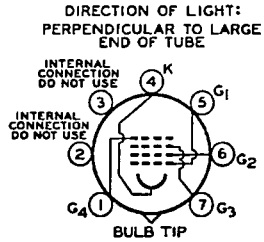
b. SIX STOPS HAVING HEIGHT OF 0.156"±0.001", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

c. PHOSPHOR-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 0.925"±0.001".

THE SOCKET DESIGN SHOULD BE SUCH THAT CIRCUIT WIRING CAN NOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. THE POINT OF BEARING OF THE SOCKET CONTACTS ON THE BASE PINS SHOULD NOT BE CLOSER THAN 0.050" FROM ENDS OF BASE-PIN BOSSES.

92CM-6453RI

Bottom View of Socket Connections



G_1 – Grid No.1 G_3 – Grid No.3
G_2 – Grid No.2 G_4 – Grid No.4
K – Photocathode

from RTMA release #378D, Aug. 31, 1950

1P28

MULTIPLIER PHOTOTUBE

9-Stage Type with S-5 Response

RCA-1P28 is a high-vacuum, multiplier phototube constructed with a special glass bulb which transmits radiant energy in the ultraviolet region down to about 2000 angstroms. It is especially suited for scientific research and specialized applications involving very low ultraviolet radiation levels because it features a combination of high photosensitivity, high secondary-emission amplification, very small dc dark current, and an ultraviolet equivalent noise input of 6×10^{-15} watt at 25°C.

The spectral response of the 1P28 covers the range from about 2000 to 6000 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 3400 angstroms.

The 1P28 is capable of multiplying feeble photoelectric current produced at the cathode by an average value of 1,000,000 times when operated at 100 volts per stage. The output current of the 1P28 is a linear function of the exciting energy under normal operating conditions.

The frequency response of the 1P28 is flat up to a frequency of about 100 megacycles per second above which the variation in electron transit time becomes the limiting factor.

Having small size, rugged construction, high sensitivity, extremely low equivalent noise input, and freedom from distortion, the 1P28 is recommended for use in spectrophotemetry, in scintillation counters, in scientific research, and in other specialized applications.

DATA

General:

Spectral Response	S-5
Wavelength of Maximum Response	3400 ± 500 angstroms
Cathode:	
Minimum Projected Length*	15/16"
Minimum Projected Width*	5/16"
Direct Interelectrode Capacitances (Approx.):	
Anode to Dynode No.9	4 μμf
Anode to All Other Electrodes	6.5 μμf
Maximum Overall Length	3-11/16"
Maximum Seated Length	3-1/8"
Length from Base Seat to Center of Useful Cathode Area	1-15/16" ± 3/32"
Maximum Diameter	1-5/16"
Bulb	T-9
Base	Small-Shell Submagnal 11-Pin, Non-hygroscopic
Mounting Position	Any

Maximum Ratings, *Absolute Values*:

ANODE-SUPPLY VOLTAGE (DC or Peak AC)□	1250 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.9 AND ANODE (DC or Peak AC)	250 max.	volts
PEAK ANODE CURRENT	5 max.	ma
AVERAGE ANODE CURRENTO	0.5 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics:

With 100 volts per dynode stage and 100 volts between dynode No.9 and anode

	Min.	Av.	Max.	
DC Anode Dark Current#●	–	–	0.1	μamp
Sensitivity:				
At 3400 angstroms	–	22600	–	μamp/μwatt
Luminous:§				
Cathode§	–	20	–	μamp/lumen
Anode▲:				
At 0 cps	4.5	20	300	amp/lumen
At 100 Mc	–	19	–	amp/lumen
Current Amplification■	–	1000000	–	
Luminous Equivalent Noise Input★	–	7×10^{-12}	–	lumen
Ultraviolet Equivalent Noise Input†	–	6×10^{-15}	–	watt

With 75 volts per dynode stage and 50 volts between dynode No.9 and anode

	Av.	
Sensitivity:		
At 3400 angstroms	3400	μamp/μwatt
Luminous:§		
Cathode§	20	μamp/lumen
Anode▲, at 0 cps	3	amp/lumen
Current Amplification■	150000	

* On plane perpendicular to the indicated direction of incident radiation.

□ Referred to cathode.

O Averaged over any interval of 30 seconds maximum.

\# Dark current due to thermionic emission and ion feedback may be reduced by the use of refrigerants.

● For maximum signal-to-noise ratio, operation below 1000 volts is recommended.

§ For conditions the same as shown under Anode Luminous Sensitivity except that the value of light flux is 0.01 lumen and that 100 volts are applied between cathode and all other electrodes connected together as an anode.

▲ For conditions where a tungsten lamp operated at a filament color temperature of 2870°K is used as a light source. A light flux of 10 microlumens from a rectangular aperture approximately 0.8" long and 0.2" wide is projected normal to the center of the cathode. The load resistor has a value of 0.01 megohm. The applied voltages are as indicated.

■ Ratio of anode sensitivity to cathode sensitivity.

★ Defined as the value where the rms output current is equal to the rms noise current determined under the following conditions: 100 volts per dynode stage, 25°C

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Radio Corporation of America

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

1P28-6-50
Photolithographed in U.S.A.

tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source of 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

† Defined the same as Luminous Equivalent Noise Input except that use is made of a monochromatic source having radiation at 2537 angstroms.

GENERAL CONSIDERATIONS

An *electron multiplier* is a vacuum tube which utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the IP28 multiplier phototube, represented in Fig. 2, the electrons emitted from the illuminated cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter).

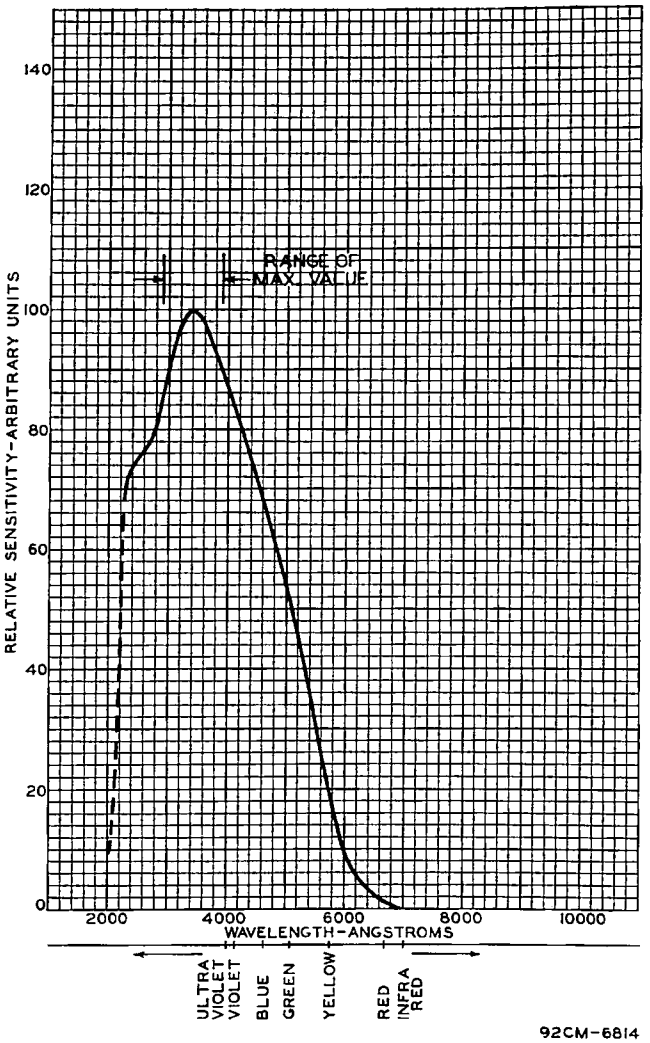


Fig. 1 – Spectral Sensitivity Characteristic of Type 1P28 which has S-5 Response. Curve is taken for Equal Values of Radiant Flux at all Wavelengths.

The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.9) are collected by the anode and constitute the current utilized in the output circuit.

Dynode No.9 is so shaped as to enclose partially the anode and to serve as a shield for it in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grid which allows the electrons from dynode No.8 to pass through it to dynode No.9. Spacing between dynode No.9 and anode creates a collecting field such that all the electrons it emits are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the IP28 can be coupled to any practical load impedance.

The shield which extends between the photocathode and the anode shields the photocathode from the anode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the photocathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration.

The grill through which the incident radiation reaches the photocathode, is connected to the photocathode and serves as an electrostatic shield for the open side of the electrode structure.

The successive stages of the IP28 are operated at voltages increasing in equal steps from the photocathode to the 9th dynode, and are generally chosen as 75 to 90 volts per stage. The voltage between dynode No.9 and the anode should be kept as low as will permit of operation at a point just giving anode-current saturation. This point on the anode characteristic curves corresponds to a voltage of about 50 volts. Low operating voltage between dynode No.9 and anode reduces the dark current due to leakage paths and also reduces the ion bombardment of the dynodes. As a result, the operating stability of the IP28 is improved without sacrifice in sensitivity. It is to be noted that the supply voltage required to give an operating voltage of 50 volts between dynode No.9 and anode will, of course, be contingent on the load impedance used and the signal output voltage desired.

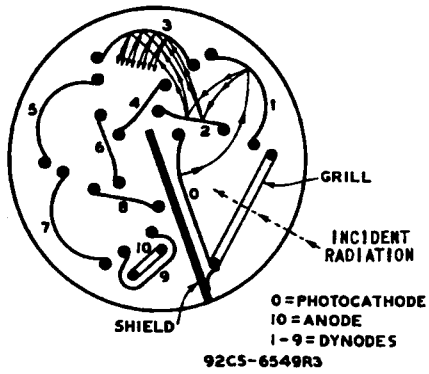


Fig. 2 - Schematic Arrangement of Type 1P28 Structure.

INSTALLATION and APPLICATION

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 1P28 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface and dynode surfaces to evaporate with consequent decrease in the life and sensitivity of the tube.

The *operating stability* of the 1P28 is dependent on the magnitude of the anode current and its duration. When the 1P28 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 1P28 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 0.5 milliampere is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 10 microamperes.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence, large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the nth power, where n is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for designers to provide adequate adjustment of the supply voltage per stage so as to be able to adjust the amplification of individual tubes to the desired design value. It is suggested that an overall voltage-adjustment range of 2 to 1 be provided. When the output current can be controlled by change in the radiant energy incident on the photocathode of the multiplier phototube, the required range of adjustment in the voltage per stage can be reduced.

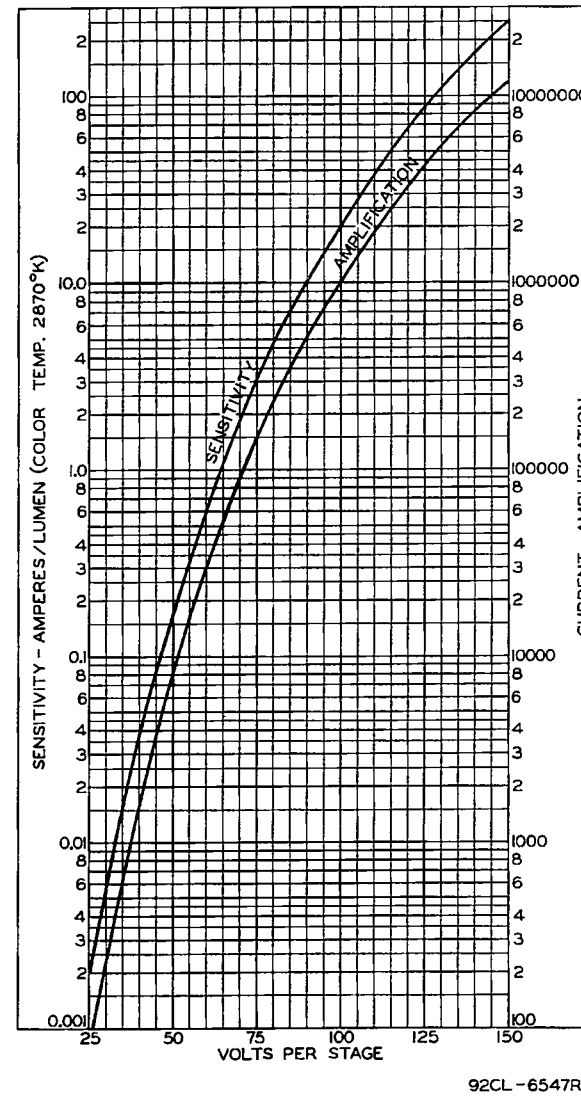


Fig. 3 - Average Characteristics of Type 1P28.

Fig. 3 shows sensitivity and current amplification versus the dc voltage per stage.

The *base pins* of the 1P28 fit the submagnal 11-contact socket designed for a pin-circle diame-

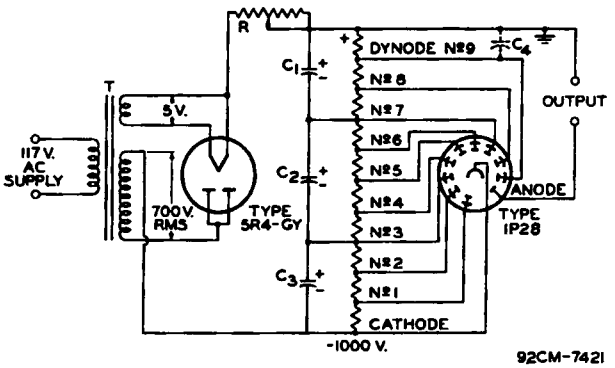
ter of 0.75 inch. The socket should be made of high-grade, low-leakage material, and should be installed so that the base key of the tube faces the incident radiation.

Magnetic shielding of the 1P28 is necessary if it is operated in the presence of strong magnetic fields.

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 1P28.

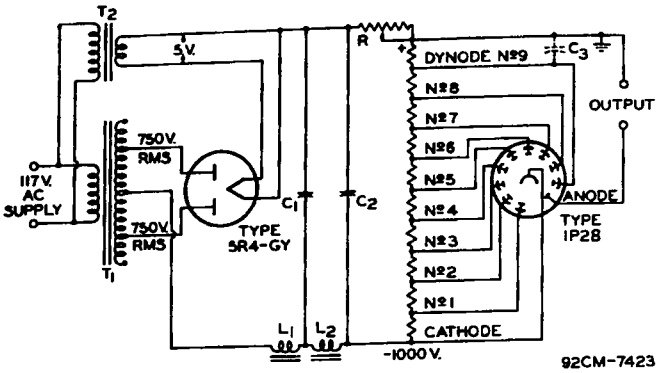
Whenever frequency response is important, the leads from the 1P28 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each dynode and for the anode can be supplied by equally spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation required by the application. In general, the current in the divider should be several times the value of the total average dynode current flowing through the divider. The value should be adequate to prevent variations of the dynode potentials by the signal currents. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will ordinarily be provided by a well-designed, two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Inasmuch as the gain of the 1P28 is critically dependent on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow



C1 C2 C3: 16 μf, 450 volts (dc working), electrolytic
C4: 8 μf, 150 volts (dc working), electrolytic.
Required only if high peak currents are drawn.
R: 100000 ohms, 1 watt, variable (Centralab A122, or equivalent)
T: United Transformer Corp. No.R-2, or equivalent
VOLTAGE DIVIDER: 10 Resistors, each 50000 ohms, 1/2 watt

Fig. 4 - Simple Half-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 1P28.



C1 C2: 2 μf, 1000 volts (dc working)
C3: 8 μf, 150 volts (dc working), electrolytic
Required only if high peak currents are drawn.
L1 L2: United Transformer Corp. No.R-17, or equivalent
R: 200000 ohms, 12 watts, variable (General Radio Type 471-A, or equivalent)
T1: United Transformer Corp. NO.S-45, or equivalent
T2: United Transformer Corp. No.FT-6, or equivalent
VOLTAGE DIVIDER: 10 Resistors, each 20000 ohms, 1 watt

Fig. 5 - Full-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 1P28 in Applications Critical as to Hum Modulation.

shifts in the line voltage produced by poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum-tube regulator circuit of the mu-bridge type.

In most applications, it is recommended that the positive high-voltage terminal be grounded rather than the negative terminal. With this method, which places the cathode at a high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

The high voltages at which the 1P28 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 1P28, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power supply switch should be turned off, the plug removed from the outlet, and both terminals of any capacitors grounded. Also, the use of a protective resistor having a minimum value of 10,000 ohms in the output circuit is recommended as a desirable procedure to prevent possible damage to component parts during adjustment.

Typical power-supply circuits for the IP28 are shown in Figs. 4 and 5. The circuit in Fig. 4 utilizes a half-wave rectifier to provide the dc power for the IP28. In applications where excellent regulation particularly for wide variation in the output current of the IP28 is required and where minimum hum modulation is essential, the circuit in Fig. 5 may be used.

The *anode family* for the IP28 is shown in Fig. 6.

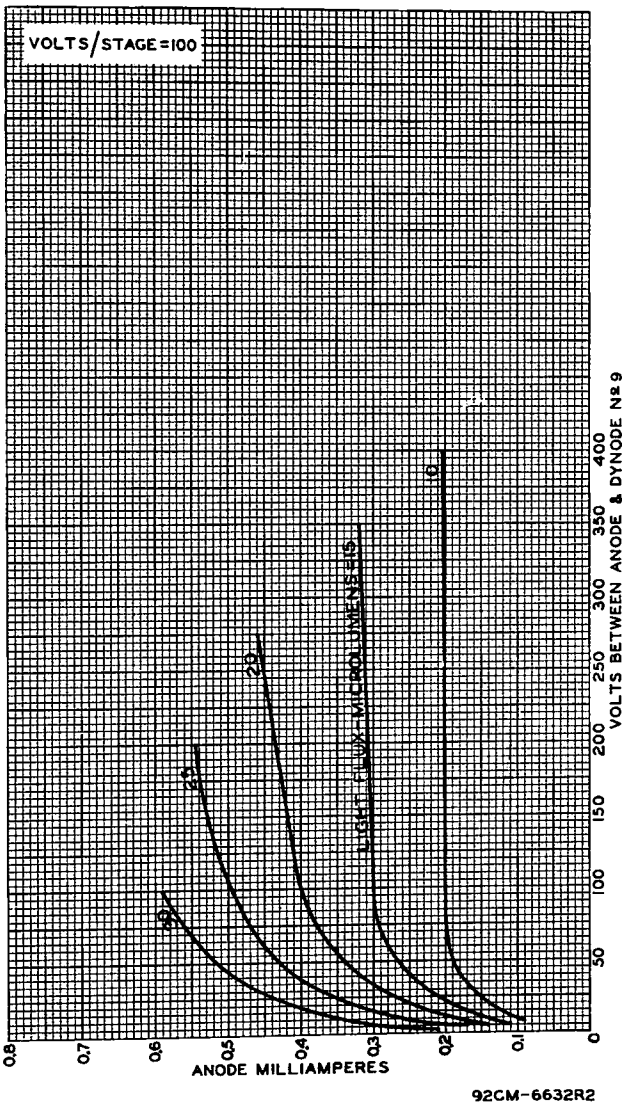


Fig. 6 - Average Anode Characteristics of Type 1P28.

The *use of a refrigerant*, such as dry ice or liquid air, to cool the IP28 is recommended in those applications where maximum gain with unusually low dark current is required.

An *external electrostatic shield* in contact with the sides of the glass envelope and connected to a negative dc potential essentially the same as that of the photocathode, should be employed in those applications where it is desired to reduce the luminous equivalent noise input of the IP28 to a minimum. Since the shield is at a dangerous potential, extreme care should be exercised to provide adequate protection for the operator, as described under *high voltages*.

The *luminous equivalent noise input as a function of the temperature* of the IP28 is shown in Fig. 7.

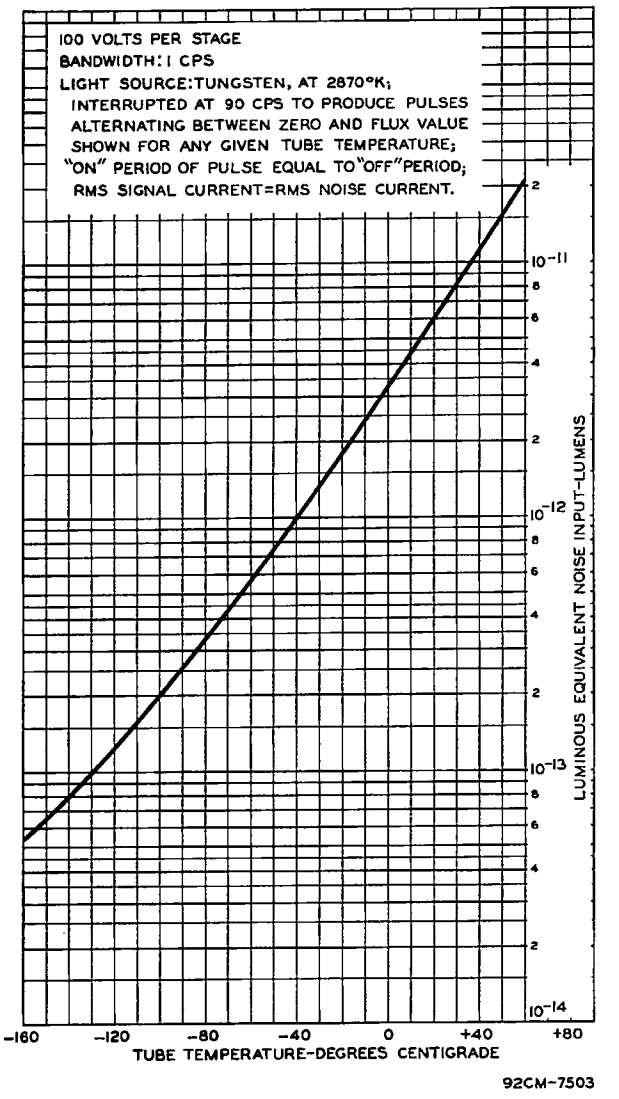


Fig. 7 - Equivalent Noise Input Characteristic of Type 1P28.

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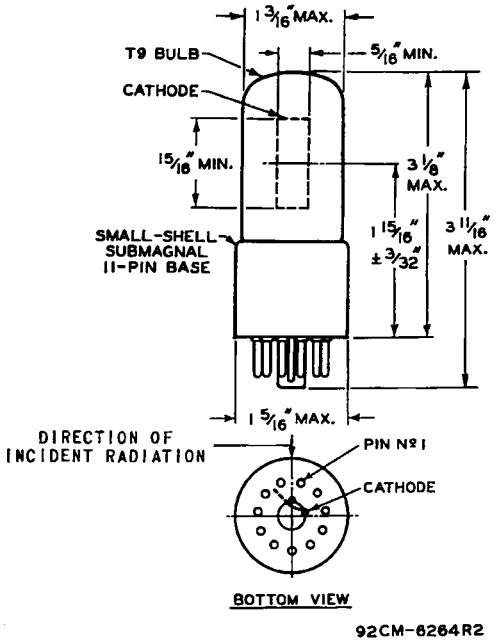
DIMENSIONAL OUTLINE

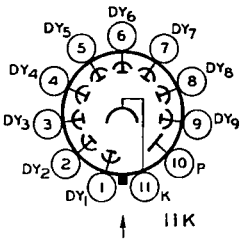


92CM-6264R2

℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

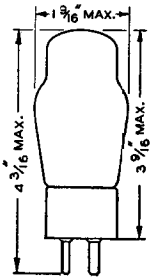
SOCKET CONNECTIONS

Bottom View



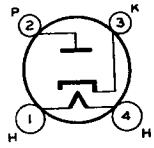
DIRECTION OF INCIDENT RADIATION

PIN 1: DYNODE NO.1
PIN 2: DYNODE NO.2
PIN 3: DYNODE NO.3
PIN 4: DYNODE NO.4
PIN 5: DYNODE NO.5
PIN 6: DYNODE NO.6
PIN 7: DYNODE NO.7
PIN 8: DYNODE NO.8
PIN 9: DYNODE NO.9
PIN 10: ANODE
PIN 11: CATHODE



RCA-1-v

HALF-WAVE RECTIFIER



The 1-v is a half-wave, high-vacuum rectifier tube employing a heater cathode. It is intended for use in radio equipment of either the "universal" or the automobile type designed for its characteristics. The low voltage drop of this tube makes it uniquely adapted to such service. The 1-v is interchangeable with type 1.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
A-C PLATE VOLTAGE (RMS)	350 *max.*	Volts
PEAK INVERSE VOLTAGE	1000 *max.*	Volts
D-C OUTPUT CURRENT	50 *max.*	Milliamperes
BULB		ST-12
BASE		Small 4-Pin

INSTALLATION

The base pins of the 1-v fit the standard four-contact socket which may be installed to hold the tube in any position.

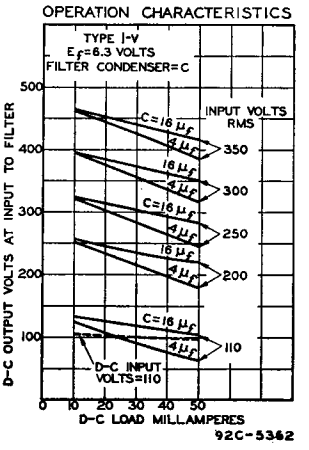
For heater operation, refer to type 6A8. The d-c potential between heater and cathode should never exceed 500 volts.

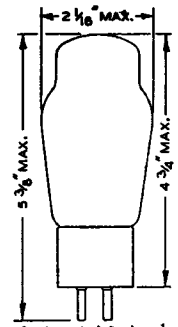
APPLICATION

The filter may be either of the condenser-input or the choke-input type provided the recommended maximum plate voltage and output current ratings given under CHARACTERISTICS are not exceeded.

If the condenser-input type of filter is used, consideration must be given to the instantaneous peak value of the a-c input voltage which, for a sinusoidal wave, is about 1.4 times the RMS value as measured with an a-c voltmeter. It is important, therefore, that the filter condensers (especially the input condenser) have a sufficiently high breakdown rating to withstand this instantaneous peak value. Particular attention must be given to this point when the waveshape input to the plates of the rectifier tube is non-sinusoidal.

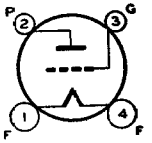
When the input-choke method is used, the available d-c output voltage will be somewhat lower than with the input-condenser method for a given a-c plate voltage. However, improved regulation, together with lower peak current, will be obtained.





RCA-2A3

POWER AMPLIFIER TRIODE



The 2A3 is a three-electrode, high-vacuum type of power amplifier tube for use in the power-output stage of a-c operated receivers. The exceptionally large power-handling ability of the 2A3 is the result of its design features. Among these are its extremely high transconductance and its large effective cathode area.

CHARACTERISTICS

Filament Voltage (A. C. or D. C.)	2.5	Volts
Filament Current	2.5	Amperes
Grid-Plate Capacitance	16.5	μμf
Grid-Filament Capacitance	7.5	μμf
Plate-Filament Capacitance	5.5	μμf
Bulb		ST-16
Base		Medium 4-Pin

As Single-Tube Class A_1 Amplifier

Filament Voltage (A. C.)	2.5	Volts
Plate Voltage	250 *max.*	Volts
Grid Voltage*	−45	Volts
Plate Current	60	Milliamperes
Plate Resistance	800	Ohms
Amplification Factor	4.2	
Transconductance	5250	Micromhos
Load Resistance	2500	Ohms
Self-Bias Resistor	750	Ohms
Undistorted Power Output	3.5	Watts

As Push-Pull Class AB_1 Amplifier (Two Tubes)

	Fixed Bias	*Self-Bias*	
Filament Voltage (A. C.)	2.5	2.5	Volts
Plate Voltage (Maximum)	300	300	Volts
Grid Voltage*	−62	—	Volts
Self-Bias Resistor	—	780	Ohms
Zero-Signal Plate Current (Per tube)	40	40	Milliamperes
Effective Load Resistance (Plate-to-plate)	3000	5000	Ohms
Total Harmonic Distortion	2.5	5	Per cent
Power Output	15	10	Watts

* Grid volts measured from mid-point of a-c operated filament.

INSTALLATION

The base pins of the 2A3 fit the standard four-contact socket which may be installed to hold the tube either in a vertical or in a horizontal position. For horizontal operation, the socket should be positioned with the filament-pin openings one vertically above the other. Sufficient ventilation should be provided to prevent overheating.

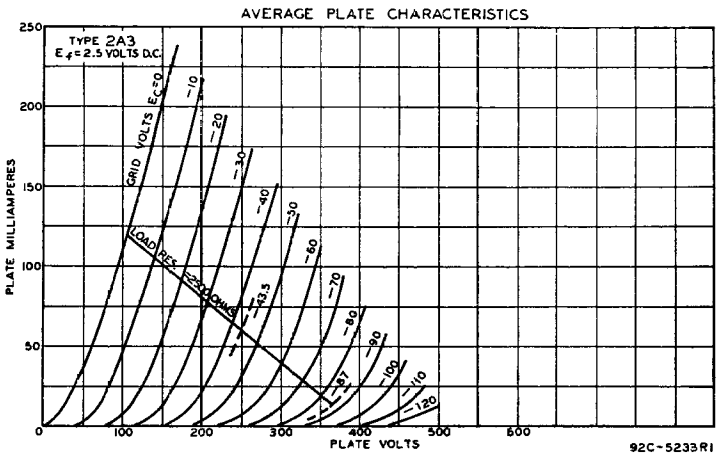
APPLICATION

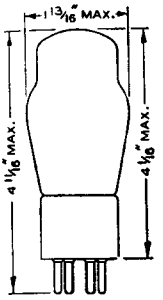
As a **power amplifier (Class A_1)**, the 2A3 is usable either singly or in **push-pull** combination in the power-output stage of a-c receivers. Recommended **operating** conditions are given under CHARACTERISTICS.

The values recommended for push-pull operation are different than the **conventional** ones usually given on the basis of characteristics for a single tube. **The** values shown for Push-Pull Class AB_1 operation cover operation with fixed **bias** and with self-bias, and have been determined on the basis of no grid current **flow** during the most positive swing of the input signal and of cancellation of **second**-harmonic distortion by virtue of the push-pull circuit. The self-bias resistor **should** preferably be shunted by a suitable filter network to minimize grid-bias **variations** produced by current surges in the self-bias resistor.

When 2A3's are operated in push-pull, it is desirable to provide means for **adjusting** independently the bias on each tube. This requirement is a result of the very high transconductance of these tubes—5250 micromhos. This very high **value** makes the 2A3 somewhat critical as to grid-bias voltage, since a very small **bias**-voltage change produces a very large change in plate current. It is obvious, **therefore**, that the difference in plate current between two tubes may be sufficient **to** unbalance the system seriously. To avoid this possibility, simple methods of **independent** self-bias adjustment may be used, such as (1) input transformer with **two** independent secondary windings, or (2) filament transformer with two **independent** filament windings. With either of these methods, each tube can be **biased** separately so as to obtain circuit balance.

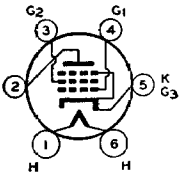
Any conventional type of **input coupling** may be used provided the resistance **added** to the grid circuit by this device is not too high. *Transformers or impedances are recommended.* When self-bias is used, the d-c resistance in the **grid** circuit should not exceed 0.5 megohm. With fixed-bias, however, the d-c **resistance** should not exceed 50000 ohms.





RCA-2A5

POWER AMPLIFIER PENTODE



The 2A5 is a heater-cathode type of power-amplifier pentode for use in the audio-output stage of a-c receivers. It is capable of giving large power output with a relatively small input-signal voltage. Because of the heater-cathode construction, a uniformly low hum-level is attainable in power-amplifier design.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	1.75	Amperes
BULB		ST-14
BASE		Medium 6-Pin

Other characteristics of this type are the same as for type 42.

INSTALLATION

The **base pins** of the 2A5 fit the standard six-contact socket which may be installed to hold the tube in any position.

The **bulb** of this tube will become very hot under certain conditions of operation. Sufficient ventilation should be provided to prevent overheating.

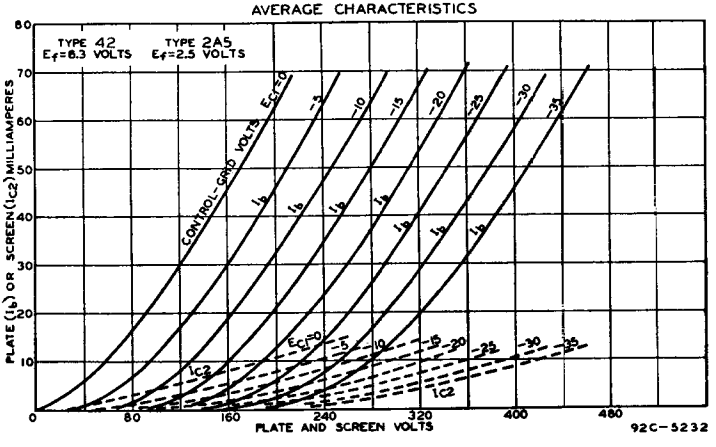
The **heater** is designed to operate at 2.5 volts. The transformer winding supplying the heater circuit should be designed to operate the heater at this recommended value for full-load operating conditions at average line voltage.

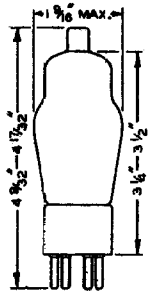
The **cathode** should preferably be connected directly to a mid-tap on the heater winding or to a center-tapped resistor across the heater winding. If this practice is not followed, the potential difference between heater and cathode should be kept as low as possible.

APPLICATION

Refer to APPLICATION on type 6F6. Additional curve information is given under type 42.

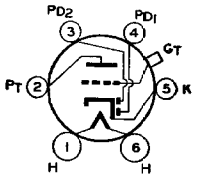
AVERAGE CHARACTERISTICS





RCA-2A6

DUPLEX-DIODE HIGH-MU TRIODE



The 2A6 is a heater type of tube consisting of *two diodes* and a *high-mu triode* in a single bulb. It is for use as a combined detector, amplifier, and automatic-volume-control tube in radio receivers designed for its characteristics. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	0.8	Ampere
BULB		ST-12
CAP		Small Metal
BASE		Small 6-Pin

Other characteristics of this type are the same as for the type 75.

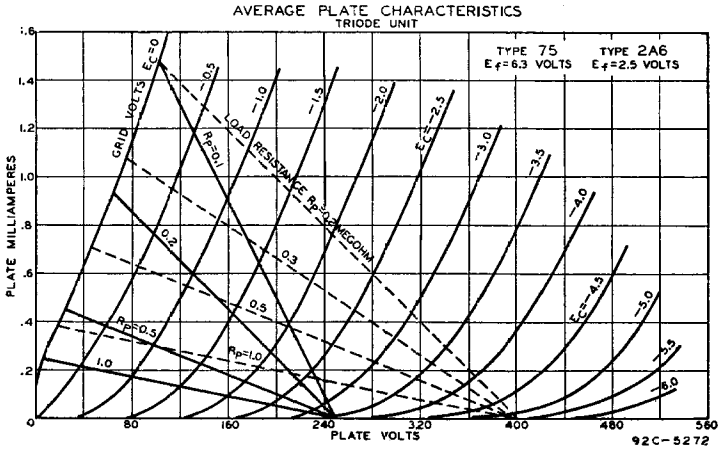
INSTALLATION

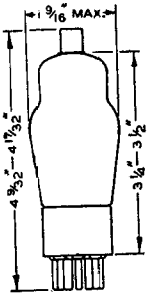
The base pins of the 2A6 fit the standard six-contact socket which may be installed to hold the tube in any position.

Heater operation and cathode connection are the same as for the 2A5.

APPLICATION

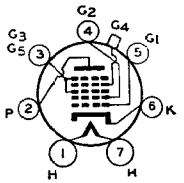
Refer to APPLICATION on the type 75.





RCA-2A7

PENTAGRID CONVERTER



The 2A7 is a multi-electrode type of vacuum tube designed to perform simultaneously the functions of a mixer (first detector) tube and of an oscillator tube in superheterodyne circuits. Through the use of this type, the independent control of each function is made possible within a single tube. The 2A7 is intended especially for use in a-c receivers having a 2.5-volt heater supply. For general discussion of pentagrid types, see FREQUENCY CONVERSION, page 31.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	0.8	Ampere

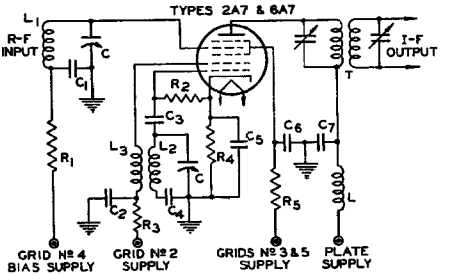
Other characteristics of this type are the same as for type 6A7.

INSTALLATION AND APPLICATION

The **base pins** of the 2A7 fit the seven-contact (0.75-inch pin-circle diameter) socket which may be installed to hold the tube in any position. For **heater** operation and **cathode** connection, refer to the type 2A5. Complete **shielding** of the 2A7 is generally necessary to prevent intercoupling between its circuit and the circuits of other stages. Refer to APPLICATION on type 6A8.

Since the capacity between grid No. 4 and plate is in a parallel path with the capacity and inductance of the plate load, it is important to use a load capacity of sufficient size to limit the magnitude of the r-f voltage built up across the load. If this is not done, r-f voltage feed-back will occur between plate and grid No. 4 to produce degenerative effects. For this reason, the size of the load condenser in the plate circuit should be not less than 50 $\mu\mu f$.

TYPICAL PENTAGRID CONVERTER CIRCUIT

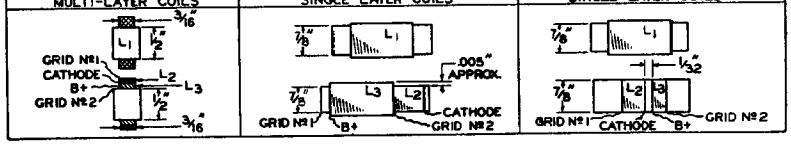


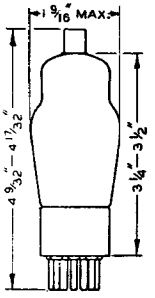
C = GANGED TUNING CONDENSER (40 TO 350 $\mu\mu f$)
C_1, C_2, C_5, C_6, C_7 = 0.1 μf
C_3 = 0.00025 μf
C_4 = SEE TABLE BELOW
R_1 = 250 000 OHMS, 0.1 WATT
R_2 = 10 000 - 50 000 OHMS, 0.1 WATT
R_3 = OSCILLATOR-ANODE (GRID Nº 2) VOLTAGE-DROPPING RESISTOR
R_4 = 150 - 300 OHMS, 0.1 WATT
R_5 = SCREEN (GRIDS Nº 3 & 5) FILTER RESISTOR
L = 60-MILLIHENRY R-F CHOKE
T = 465-KC I-F TRANSFORMER

COIL-DESIGN DETAILS

FREQUENCY BAND MEGACYCLES	0.15 TO 0.40		0.55 TO 1.5				1.5 TO 4.0		4.0 TO 10		10 TO 25	
ASSEMBLY Nº	1		1		2		2		3		3	
	TURNS	WIRE *	TURNS	WIRE *	TURNS	WIRE *	TURNS	WIRE *	TURNS	WIRE *	TURNS	WIRE *
R-F COIL (L_1)	422	36 SSE	116	30 SSE	146	32 ENAM	36.2	30 ENAM	10.1	30 ENAM	4.4	20 ENAM
OSC. GRID COIL (L_2)	198	36 SSE	80	30 SSE	92	32 ENAM	30.9	30 ENAM	9.7	30 ENAM	4.3	20 ENAM
OSC. PLATE COIL (L_3)	60	36 SSE	30	30 SSE	20	32 ENAM	12	30 ENAM	12	36 ENAM	6	36 ENAM
OSC. TRACKING COND. (C_4)	117 $\mu\mu f$		400 $\mu\mu f$				1070 $\mu\mu f$		2900 $\mu\mu f$		7300 $\mu\mu f$	

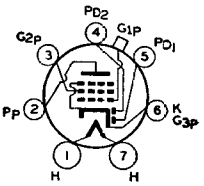
Nº 1	Nº 2	Nº 3
MULTI-LAYER COILS	SINGLE-LAYER COILS	SINGLE-LAYER COILS





RCA-2B7

DUPLEX-DIODE PENTODE



The 2B7 is a heater type of tube consisting of two diodes and a pentode in a single bulb. It is recommended for service as a combined detector, amplifier (radio-frequency, intermediate-frequency or audio-frequency), and automatic-volume-control tube in radio receivers. The 2B7 is intended especially for use in a-c receivers having 2.5-volt heater supply. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	0.8	Ampere
BULB		ST-12
CAP		Small Metal
BASE		Small 7-Pin

Other characteristics of this type are the same as for type 6B7.

Diode Units

Two diode plates are placed around a cathode, the sleeve of which is common to the pentode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

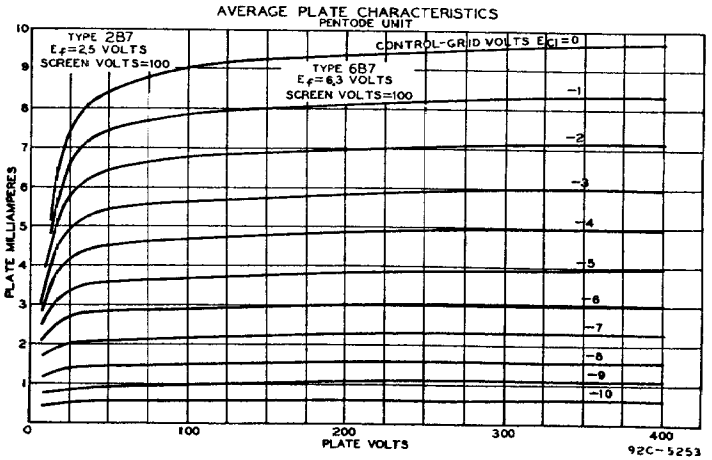
INSTALLATION AND APPLICATION

The base pins of the 2B7 fit the seven-contact (0.75-inch pin-circle diameter) socket which may be installed to hold the tube in any position.

For heater operation and cathode connection, refer to type 2A5.

Complete shielding of detector circuits employing the 2B7 is generally necessary to prevent r-f or i-f coupling between the diode circuits and the circuits of other stages.

Refer to APPLICATION on type 6B8. Typical duplex-diode pentode circuits are shown under type 6B7.



RMA Release # 324

Feb. 12, 1943

2J35
MAGNETRON

TRANSIT-TIME, SPLIT-PLATE TYPE WITH STABILIZING ELECTRODES AND INTERNAL CIRCUIT

Wavelength of 10 cm approx.

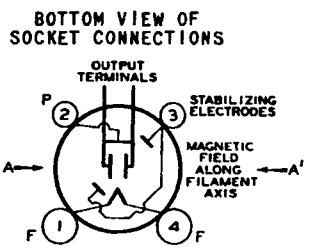
Filament	Tungsten	
Voltage	1.8	a-c or d-c volts
Current	2.0	amp.
Overall Length		6-5/16" ± 1/4"
Seated Height		5-11/16" ± 1/4"
Maximum Diameter		1-7/16"
Bulb		T-10
Base		Medium 4-Pin
Mounting Position		Any

Maximum Ratings Are Absolute Values

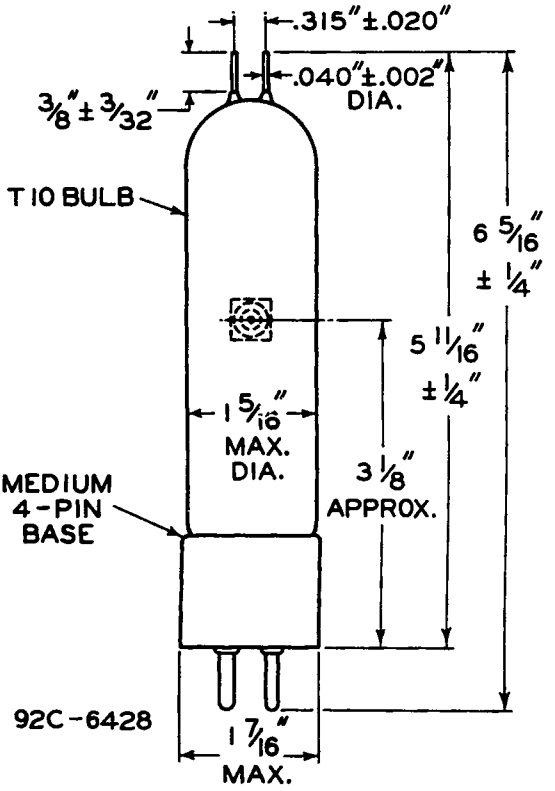
MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

D-C Plate Voltage		1000 max.	volts
D-C Stabilizing-Electrode Voltage		750 max.	volts
D-C Plate Current		5 max.	ma.
D-C Stabilizing-Electrode Current		13 max.	ma.
Typical Operation at 10 cm approx.:			
Filament Voltage *	1.8	1.8	volts
D-C Plate Voltage	900	1000	volts
D-C Stabilizing-Electrode Voltage	550	650	volts
D-C Plate Current	4	4	ma.
D-C Stabilizing-Electrode Current	6	10	ma.
Magnetic Field Intensity *	1300	1300	gauses
Power Output (approx.)	0.9	1	watt

* Adjusted for optimum performance.



Pin 1 - Filament
Pin 2 - Plate
Pin 3 - Stabilizing Electrodes
Pin 4 - Filament



2K56
KLYSTRON

SINGLE-RESONATOR, REFLEX TYPE

Frequency: 3840 to 4460 Mc.

GENERAL DATA

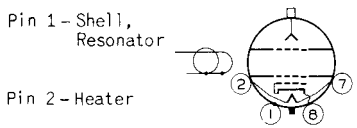
Electrical:

Heater, for Unipotential Cathode:		
Voltage	6.3 ± 0.5	ac or dc volts
Current	0.44	amp
Frequency Range	3840 to 4460	Mc

Mechanical:

Mounting Position	Any
Dimensions, Terminal Connections, and Mechanical Tuning Mechanism	See Outline Drawing
Resonant Cavity	Integral Part of Tube
Envelope	Metal
Cap	Miniature with Wafer
Base	Small-Wafer Octal 4-Pin with Pin No.4 replaced by Coaxial Output Line

BOTTOM VIEW



NOTE: COAXIAL OUTPUT LINE PASSES THROUGH VACANT PIN POSITION NO.4

CW OSCILLATOR - Class C

Maximum Ratings, ***Absolute Values*****:**

DC RESONATOR VOLTAGE	330 max.	volts
DC REFLECTOR VOLTAGE:		
Positive Value	0 max.	volts
Negative Value	400 max.	volts
DC RESONATOR CURRENT	37 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode.	50 max.	volts
Heater positive with respect to cathode.	50 max.	volts
AMBIENT TEMPERATURE OF SHELL	110 max.	°C
TEMPERATURE OF COAXIAL OUTPUT LINE	90 max.	°C

Typical Operation □ at 4150 Mc in Mode "A" with 1" x 2" Wave Guide

DC Resonator Voltage	300	volts
DC Reflector Voltage Range▲	-85 to -150	volts
DC Resonator Current	25	ma
DC Reflector Current	less than 7	μa

(continued on next page)

□, ▲: See next page.

2K56
KLYSTRON

Half-Power Electronic-Tuning		
Frequency Change■	35	Mc
Power Output	90	mw

▲ Adjusted for maximum power output at the given operating frequency.

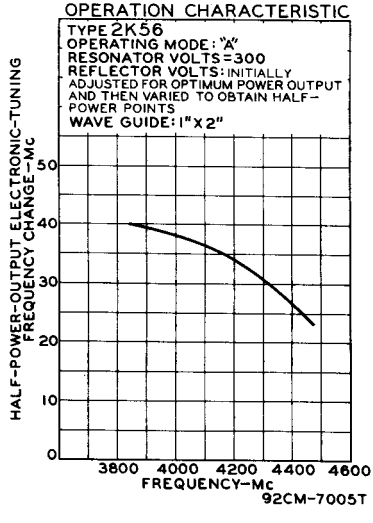
■ Change in frequency between the two half-power points when the reflector voltage is varied above and below the point of maximum power output corresponding to the given frequency.

□ The coaxial output line is coupled to the specified wave guide through the wide-band coaxial coupling unit shown on the following pages.

INSTALLATION and OPERATING NOTES for the 2K56 are the same as those shown for the 2K26, except that consideration should be given to the different coupling unit and wave guide required for the 2K56.

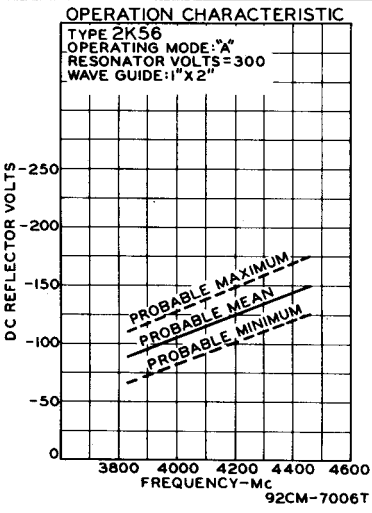
OUTLINE DIMENSIONS for Type 2K56 are the same as those for Type 2K26

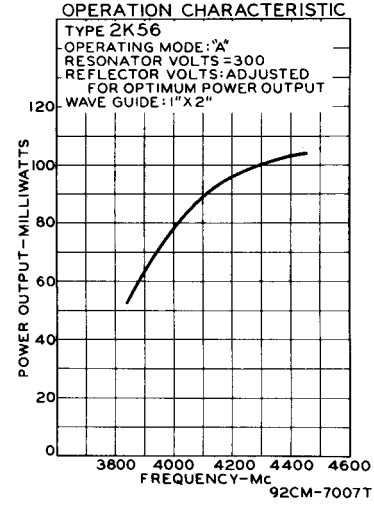
OPERATION CHARACTERISTIC



TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

2K56
KLYSTRON

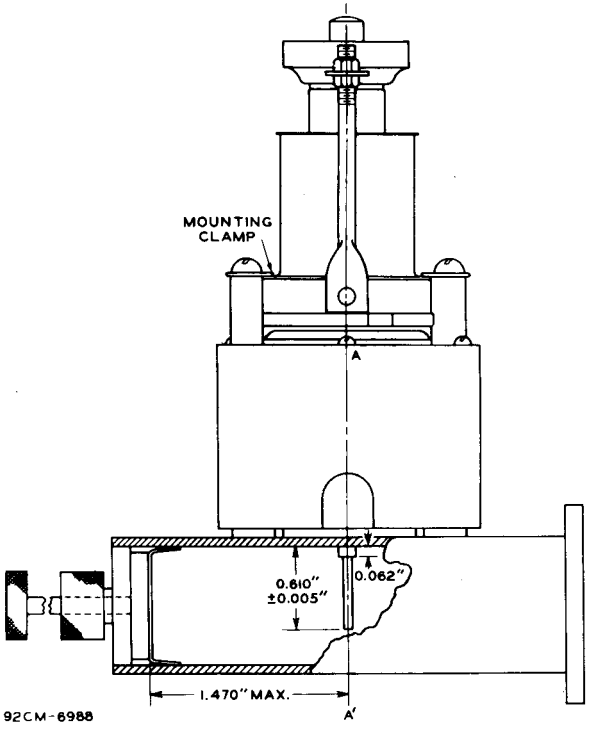




2K56
KLYSTRON

COUPLING ARRANGEMENT

RCA-2K56 Coupled to a 1" x 2" Wave Guide Through a Coaxial Transducer Coupling Circuit

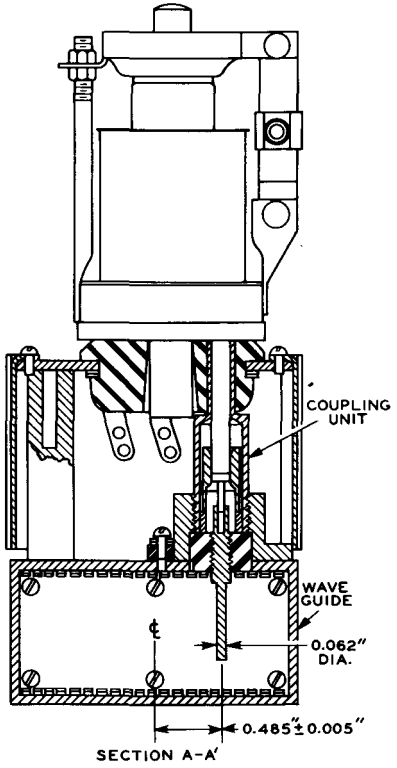


RCA

2K56

KLYSTRON

COUPLING ARRANGEMENT (Cont'd)



from RMA #825
Feb. 1, 1950

2P21

IMAGE ORTHICON

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Anode to All Other Electrodes	20	μμf
Photocathode, Semi-transparent:		
Response	See Fig. 1	
Useful Size of Rectangular Image (4 x 3 aspect ratio)	1.6" Diagonal	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	15-1/4" ± 1/2"	
Greatest Diameter of Bulb	3" ± 1/16"	
Shoulder Base	Jumbo Annular 7-Pin	
End Base	Small-Shell Diheptal 14-Pin	
Deflecting-Coil Length	5"	
Focusing-Coil Length	10"	
Alignment-Coil Length	15/16"	
Photocathode Distance Inside End of Focusing Coil	1/2"	

Maximum Ratings, *Absolute Values*:

PHOTOCATHODE VOLTAGE	450 max.	volts
PHOTOCATHODE ILLUMINATION	50 max.	ft-c
GRID-No.6 (ACCELERATOR) VOLTAGE	450 max.	volts
OVERALL MULTIPLIER VOLTAGE*	1650 max.	volts
MULTIPLIER VOLTAGE PER STAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	-100 max.	volts
Positive bias value	0 max.	volts
AMBIENT TEMPERATURE	50 max.	°C

Typical Operation:

Photocathode Voltage (Image Focus)**	-300	volts
Grid-No.6 Voltage (Accelerator)-- 80% of photocathode voltage°	-240	volts
Target Voltage°°	0	volts

NOTE: The 2P21 is a discontinued type; data are furnished for JETEC registration purposes only.

Typical Operation (Cont'd):

Grid-No.5 Voltage (Decelerator)#	25	volts
Grid-No.4 Voltage (Beam Focus)##	125	volts
Grid-No.3 Voltage□	210	volts
Grid-No.2 & Dynode-No.1 Voltage	210	volts
Grid-No.1 Voltage (For Picture Cutoff)□□	-45	volts
Dynode-No.2 Voltage	525	volts
Dynode-No.3 Voltage	850	volts
Dynode-No.4 Voltage	1150	volts
Dynode-No.5 Voltage	1450	volts
Anode Voltage	1500	volts
Target Operating Temperature	35 to 45	°C
Field Strength at Center of Focusing Coil	60	gausses

* Ratio of dynode voltages is shown under Typical Operation.

** Adjustable within ± 25% of indicated value.

○ For best operation, this voltage should be adjustable within ± 25% of indicated value. For simplified equipment, this voltage can be fixed.

○○ Adjustable within ± 3 volts of indicated value, with blanking voltage off.

\# For best operation, this voltage should be adjustable within ± 100% of indicated value. For simplified equipment, this voltage can be fixed.

Adjustable within ± 20% of indicated value.

□ Adjustable within ± 33% of indicated value. Adjust to give the most uniformly shaded picture near maximum signal.

□□ Adjustable over range from -5 to -70 volts.

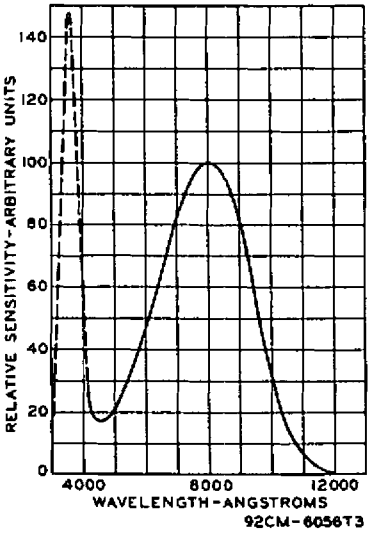


Fig. 1 - Approximate Spectral Sensitivity Characteristic of Type 2P21.

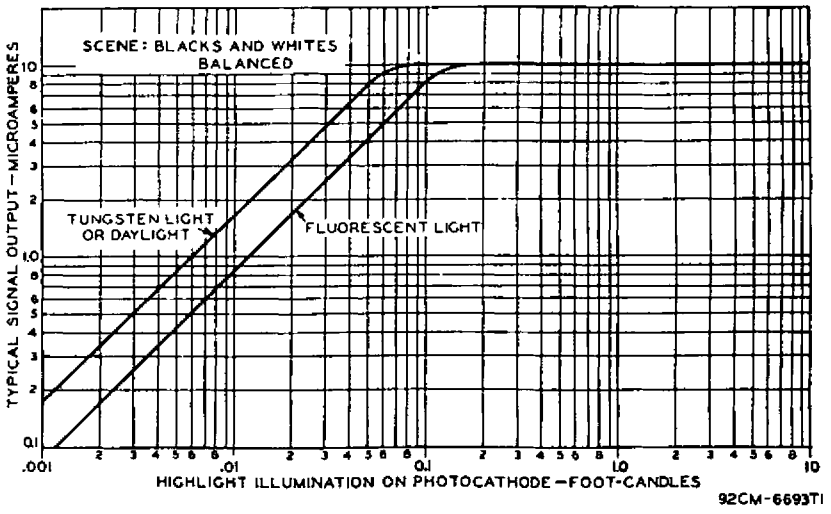
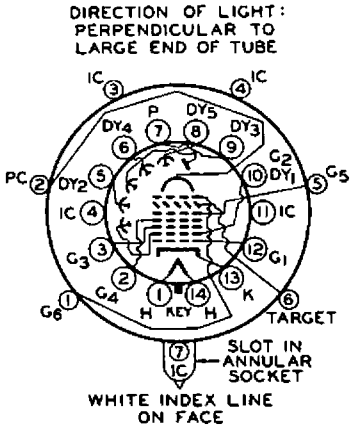


Fig. 2 - Typical Signal Output of Type 2P21.

SOCKET CONNECTIONS
Bottom View



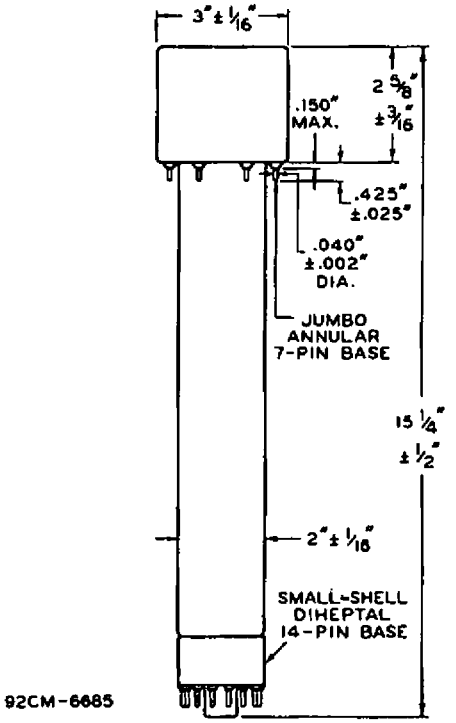
SMALL-SHELL DIHEPTAL 14-PIN BASE

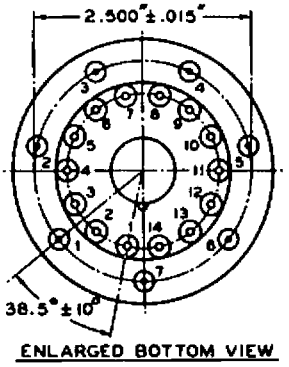
PIN 1: HEATER
PIN 2: GRID No. 4
PIN 3: GRID No. 3
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: DYNODE No. 2
PIN 6: DYNODE No. 4
PIN 7: ANODE
PIN 8: DYNODE No. 5
PIN 9: DYNODE No. 3
PIN 10: DYNODE No. 1, GRID No. 2
PIN 11: INTERNAL CONNECTION - DO NOT USE
PIN 12: GRID No. 1
PIN 13: CATHODE
PIN 14: HEATER

JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID No. 6
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNECTION - DO NOT USE
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: GRID No. 5
PIN 6: TARGET
PIN 7: INTERNAL CONNECTION - DO NOT USE

DIMENSIONAL OUTLINE





ENLARGED BOTTOM VIEW

RCA
2P22
IMAGE ORTHICON

Obsolete type--data are presented for JETEC Registration Records only

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DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	Ampere
Direct Interelectrode Capacitance:		
Anode to All Other Electrodes	9.5	μμf
Photocathode, Semitransparent:		
Response	See Accompanying Curve	
Useful Image Size (1 x 1 aspect ratio)	1-1/32" Max. Diagonal	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	8-13/16" ± 1/4"	
Maximum Bulb Radius	1-3/32"	
Base	Small-Button Trihexal 18-Pin	
Mounting Position	Any	
Focusing Coil Length	6"	
Deflecting-Coil Length	3-3/16"	
Alignment-Coil Length†	29/32"	
Photocathode Distance Inside End of Focus Coil	0.6"	
Deflection Coil Distance Inside End of Focus Coil	3"	

Maximum Ratings, *Absolute Values:*

PHOTOCATHODE:		
Voltage	-400 max.	volts
Illumination	10 max.	ft-c
AMBIENT TEMPERATURE	60 max.	°C
TARGET & GRID-NO.6 VOLTAGE:		
Positive Value	50 max.	volts
Negative Value	50 max.	volts
GRIDS No.4 & No.5 VOLTAGE	200 max.	volts
GRIDS No.2 & No.3 & DYNODE-No.1 VOLTAGE	300 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	50 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
ANODE-SUPPLY VOLTAGE●	1650 max.	volts
VOLTAGE PER MULTIPLER STAGE	350 max.	volts

Typical Operation:

Photocathode Voltage (Image Focus)*	-250	volts
Target & Grid No.6 Voltage○	0	volts
Grids-No.5 (Decelerator) & No.4 (Beam Focus) Voltage#	90	volts
Grids-No.3 & No.2 & Dynode-No.1 Voltage	210	volts
Grid-No.1 Voltage for Picture Cutoff⊕	-15	volts
Dynode-No.2 Voltage	520	volts
Dynode-No.3 Voltage	830	volts
Dynode-No.4 Voltage	1140	volts
Dynode-No.5 Voltage	1450	volts
Anode Voltage	1500	volts
Anode Current (DC)	15	μamp
Target Temperature Range	35 to 45	°C
Ratio of Peak-to-Peak Highlight Video Signal to RMS Noise Current (Approx.)	15	
Minimum Peak-to-Peak Blanking Voltage	10	volts
Field Strength at Center of Focusing Coil	75	gausses

from JETEC release #1336, July, 30, 1954

† Coil is provided with two opposite sets of windings, and should permit adjustment from 0 to 45 ampere turns. Adjust current and rotation for brightest picture.

● Ratio of dynode voltages is shown under Typical Operation.

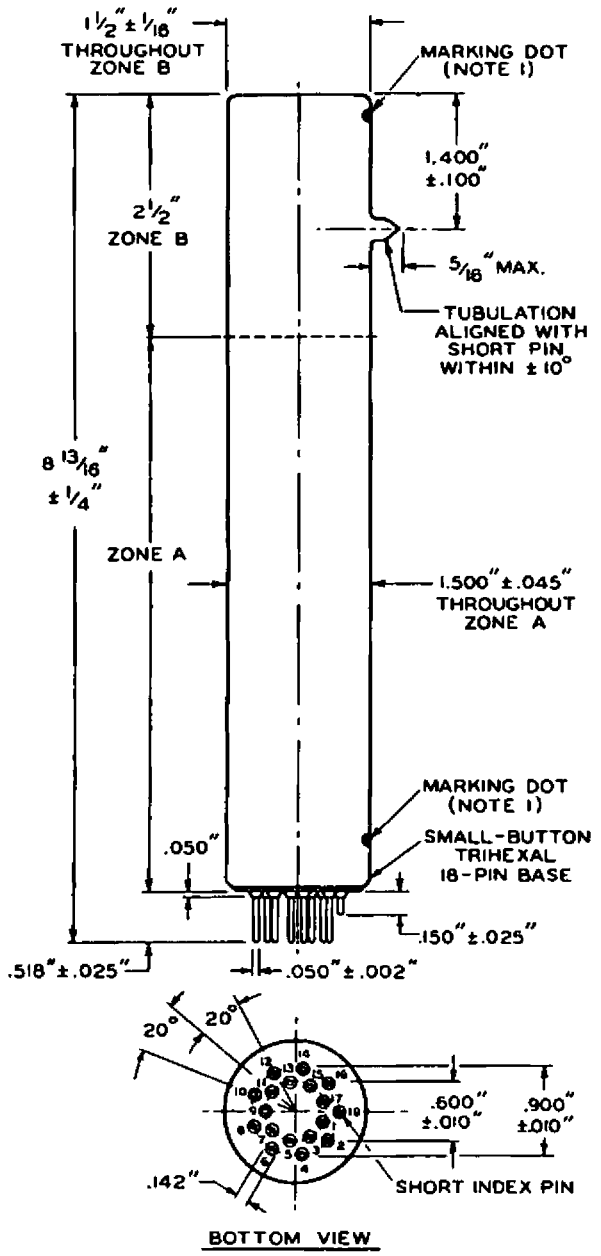
* Adjustable within +40% and -30% of this value.

° Adjustable within ±3 volts of indicated value, with blanking voltage off.

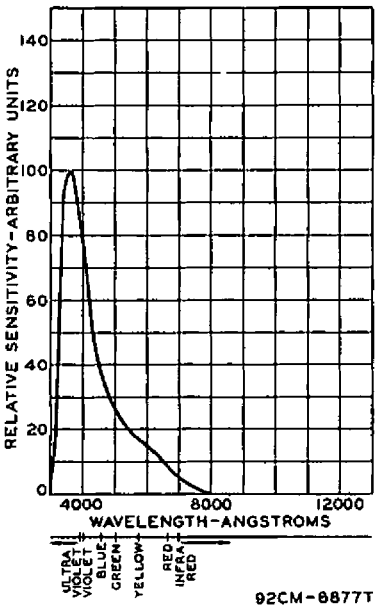
Adjustable within ±22.5% of indicated value.

⊕ Adjustable within ±67% of indicated value.

DIMENSIONAL OUTLINE

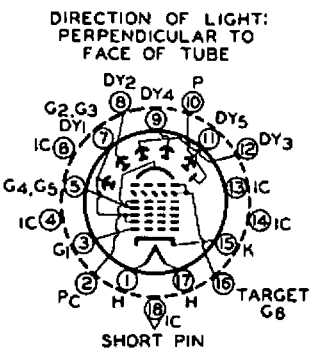


NOTE 1: MARKING DOTS ARE ALIGNED WITH SHORT PIN (No 18) AND INDICATE PROPER DIRECTION OF INSERTION IN FOCUS COIL.



Spectral Sensitivity Characteristic of Type 2P22 for Equal Values of Radiant Flux at all Wavelengths

SOCKET CONNECTIONS
Bottom View



PIN 1: HEATER

PIN 2: PHOTOCATHODE

PIN 3: GRID NO.1

PIN 4: INTERNAL CONNECTION—DO NOT USE

PIN 5: GRID NO.4, GRID NO.5

PIN 6: INTERNAL CONNECTION—DO NOT USE

PIN 7: GRID NO.2, GRID NO.3, DYNODE NO.1

PIN 8: DYNODE NO.2

PIN 9: DYNODE NO.4

PIN 10: ANODE

PIN 11: DYNODE NO.5

PIN 12: DYNODE NO.3

PIN 13: INTERNAL CONNECTION--DO NOT USE

PIN 14: INTERNAL CONNECTION—DO NOT USE

PIN 15: CATHODE

PIN 16: TARGET, GRID NO.6

PIN 17: HEATER

PIN 18: INTERNAL CONNECTION—DO NOT USE

from RMA release # 495, May 10, 1946

2P23

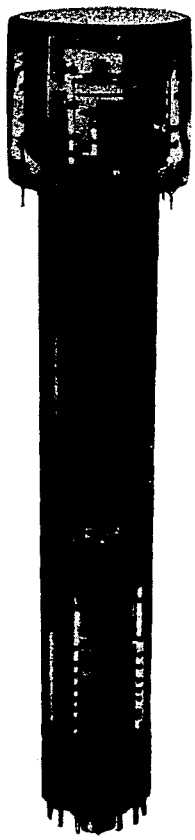
IMAGE ORTHICON

Magnetic Focus
Magnetic Deflection

For Outdoor Pickup
Exceptional Sensitivity

3"-Diameter Bulb
15-1/4" Length

RCA-2P23 is a television camera tube recommended for outdoor pickup use especially under conditions where the incident illumination is unusually low or is supplied by low-temperature incandescent sources. It is very stable in performance at all incident light levels on the object ranging from bright sunlight (several thousand foot-candles) to a deep shadow (one foot-candle or less). Commercially acceptable pictures can be obtained at light levels greater than about 25 foot-candles.



The photocathode utilized in the 2P23 is characterized by appreciable infrared response. Because of this response, the 2P23 has exceptional sensitivity to very low levels of daylight and incandescent illumination. The presence of infrared, however, causes some color-masking with the result that portrayal of colors in their true gradation is somewhat impaired. Therefore, except when exceptional sensitivity is essential, it is recommended that RCA-5769 with its spectral response which permits portrayal of colors in more nearly their true gradation be used in place of the 2P23. Both types have the same signal-to-noise ratio which is appreciably lower than that for less sensitive camera tubes.

The relatively small size of the 2P23 lends itself to use in comparatively light-weight, portable television cameras, and facilitates the use of a telephoto lens with such cameras.

PRINCIPLES OF OPERATION

The 2P23 has three sections--an image section, a scanning section, and a multiplier section, as shown in Fig. 1.

Image Section

The image section contains a semi-transparent photocathode on the inside of the face plate, a grid to provide an electrostatic accelerating field, and a target which consists of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

Light from the scene being televised is picked up by an optical lens system and focused on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focused on the target by the magnetic and accelerating fields.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite potential of about 2 volts with respect to target-voltage cutoff. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive charges which corresponds with the pattern of light from the scene being televised. Because of the thinness of the glass, the charges set up a similar potential pattern on the opposite or scanned side of the glass.

Scanning Section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No. 1), and an accelerating grid (grid No. 2). The beam is focused at the target by the magnetic field of an external focusing coil and the electrostatic field of grid No. 4.

Grid No. 5 serves to adjust the shape of the decelerating field between grid No. 4 and the target in order to obtain uniform landing of electrons over the entire target area. The electrons stop their forward motion at the surface of the glass and are turned back and focused into a five-stage signal multiplier, except when they approach the positively charged portions of the pattern on the glass. When this condition occurs, they are deposited from the scanning beam in quantities sufficient to neutralize the potential pattern on the glass. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode

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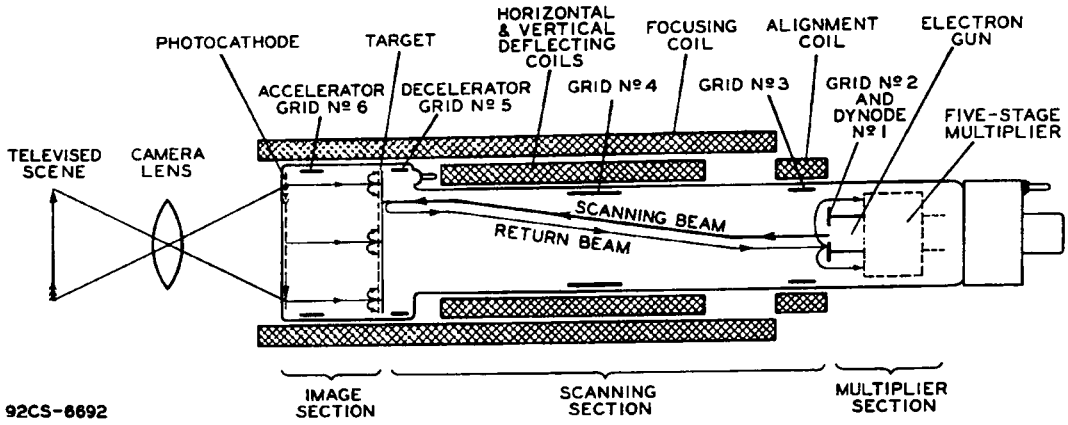


Fig. 1 – Schematic Arrangement of Type 2P23.

side. These charges will neutralize each other by conductivity through the glass in less than the time of one frame.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by an external coil located at the gun end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

Multiplier Section

The return beam is directed to the first dynode of a five-stage electrostatically focused multiplier. This utilizes the phenomenon of secondary emission to amplify signals composed of electron beams. The electrons in the beam impinging on the first dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No.5 are collected by the anode and constitute the current utilized in the output circuit.

The multiplier section amplifies the modulated beam about 500 times. The multiplication so obtained increases the signal-to-noise ratio of the tube and also permits the use of an amplifier with fewer stages. The gain of the multiplier is sufficiently high so that the limiting noise in the use of the tube is the random noise of the electron beam multiplied by the multiplier stages. This noise is larger than the input noise of the video amplifier.

It can be seen that when the beam moves from a less positive portion on the target to a more positive portion, the signal output voltage across the load resistor (R_{30} in Fig.2) changes in the positive direction. Hence, for highlights in the scene, the grid of the first video-amplifier stage swings in the positive direction.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Anode to All Other Electrodes	20	μμf
Photocathode Spectral Response	See Fig.6	
Image Size (3 x 4 aspect ratio)	1.6" Diagonal	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	15-1/4" ± 1/4"	
Greatest Diameter of Bulb	3" ± 1/16"	
Shoulder Base	Keyed Jumbo Annular 7-Pin	
End Base	Small-Shell Diheptal 14-Pin	
Mounting Position	See Text	
Minimum Deflecting-Coil Inside Diameter	2-1/8"	
Deflecting-Coil Length	5"	
Focusing-Coil Length	10"	
Alignment-Coil Length	15/16"	
Photocathode Distance Inside End of Focusing Coil	1/2"	

Maximum Ratings, *Absolute Values*:

PHOTOCATHODE VOLTAGE	−550 max.	volts
PHOTOCATHODE ILLUMINATION	50 max.	ft-c
OPERATING TEMPERATURE OF ANY PART OF BULB	65 max.	°C
OPERATING TEMPERATURE OF BULB AT LARGE END OF TUBE (TARGET SECTION)	35 min.	°C
TEMPERATURE DIFFERENCE: Between target section and any part of bulb hotter than target section	5 max.	°C
GRID-No.6 VOLTAGE	−550 max.	volts
TARGET VOLTAGE:		
Positive value	50 max.	volts
Negative value	50 max.	volts
GRID-No.5 VOLTAGE	150 max.	volts
GRID-No.4 VOLTAGE	300 max.	volts
GRID-No.3 VOLTAGE	400 max.	volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts

ANODE-SUPPLY VOLTAGE*.	1650 max.	volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	volts

Typical Operation and Characteristics:

Photocathode Voltage (Image Focus)	-300 to -500	volts
Grid-No.6 Voltage (Accelerator)--80% of photocathode voltage. . .	-240 to -400	volts
Target Voltage°.	0	volts
Grid-No.5 Voltage (Decelerator)°°	0 to 100	volts
Grid-No.4 Voltage (Beam Focus) . .	160 to 240	volts
Grid-No.3 Voltage#	225 to 330	volts
Grid-No.2 & Dynode-No.1 Voltage. .	300	volts
Grid-No.1 Voltage (For picture cutoff). . .	-45 to -115	volts
Dynode-No.2 Voltage.	600	volts
Dynode-No.3 Voltage.	880	volts
Dynode-No.4 Voltage.	1160	volts
Dynode-No.5 Voltage.	1450	volts
Anode Voltage.	1500	volts
Anode Current.	50	μa
Target Temperature Range (See text)	35 to 60	°C
Highlight Illumination on Photo-Cathode for Maximum Signal Output:		
With 2870°K Tungsten Illumination or Daylight. .	0.07	ft-c
With White Fluorescent Illumination. .	0.15	ft-c
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current (Approx.). .	35	
Minimum Peak-to-Peak Blanking Voltage. . .	10	volts
Field Strength at Center of Focusing Coil . . .	75	gausses
Focusing-Coil Current (Approx., for coil listed below). . .	75	ma
Deflecting-Coil Current (Approx., for assembly listed below):		
Horizontal (Peak to peak). . . .	625	ma
Vertical (Peak to peak).	290	ma
Alignment-Coil Current (Approx., for coil listed below). . .	0 to 30	ma

Components:

Deflecting-Coil Assembly (Includes Keyed Jumbo Annular 7-Pin Socket).	RCA Type No. 201D75
Focusing-Coil Assembly	RCA Type No. 202D75
Alignment-Coil Assembly.	RCA Type No. 204D75
Hor. Deflection Output Transformer	RCA Type No. 204T1
Ver. Deflection Output Transformer	RCA Type No. 204T2

* Ratio of dynode voltages is shown under Typical Operation.

° Adjustable from -3 to +5 volts with blanking voltage off.

°° Taps at 0, 30, 60, and 90 volts are recommended. Set at voltage giving most uniform resolution and signal output over entire picture area.

\# Adjust to give the most uniformly shaded picture near maximum signal.

INSTALLATION

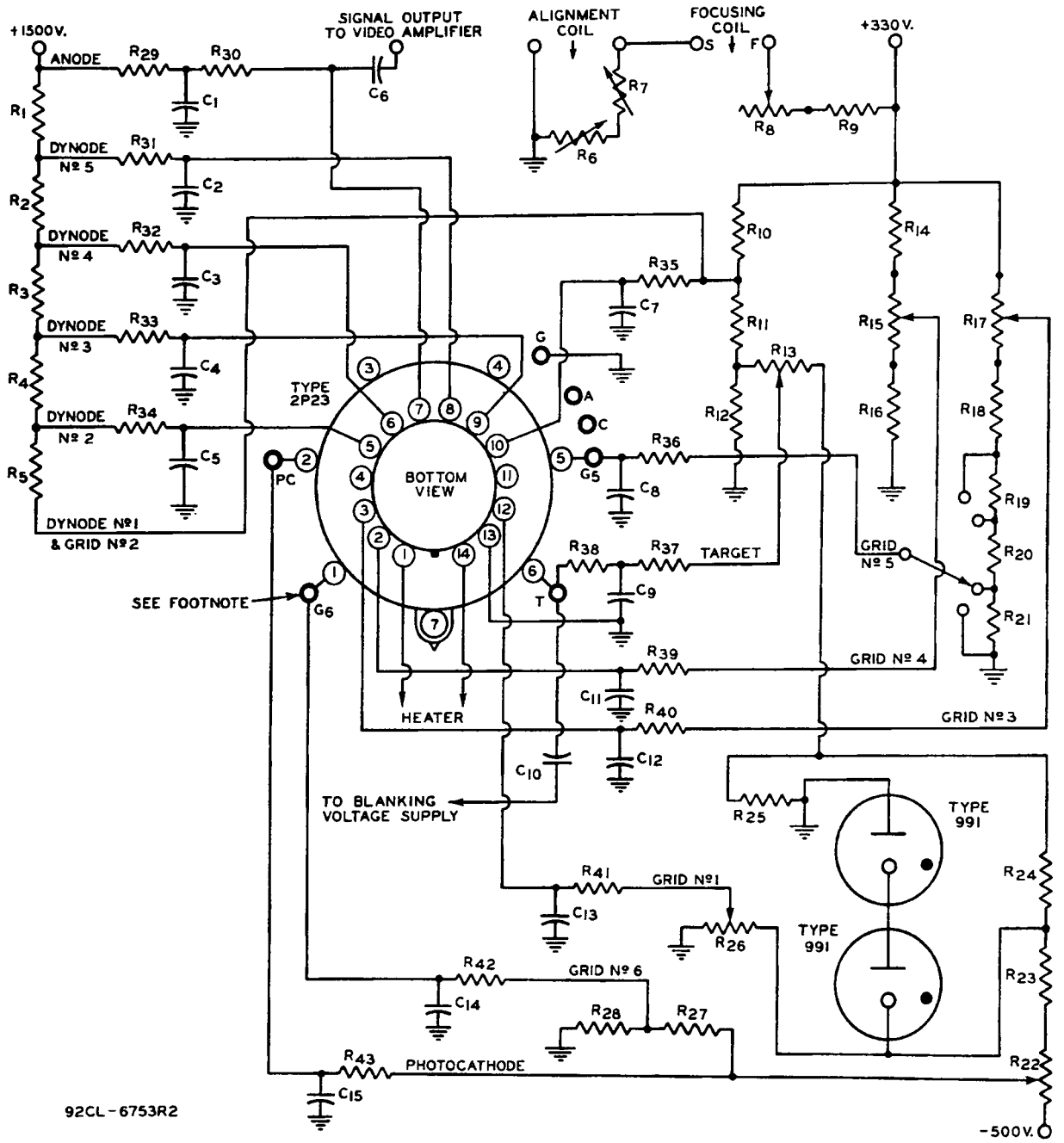
The *end-base* pins of the 2P23 fit the diheptal 14-pin socket; the *annular-base* pins fit the keyed jumbo annular 7-pin socket which is part of the deflecting-coil assembly having RCA Type No. 201D75.

The 2P23 has three complementary guides for inserting the tube correctly in the annular socket, i.e., the large pin (No.7) on the annular base, the white radial line on face of bulb, and a white longitudinal line on neck. Designers of equipment should position the annular socket so that pin No.7 of the annular base, and the white radial line when viewed from the face end of the tube, will be at the bottom of the face after the tube has been correctly inserted in the annular socket. The 2P23 is installed by inserting the diheptal-base end of the tube through the coil assembly and then turning the tube until the annular-base pins, keyed by pin No.7, can be inserted in the annular socket. Proper insertion aligns the white radial line on the face with center of the slot in the annular socket, and makes the longitudinal line on the neck visible through the sight hole in the deflecting-coil assembly. The annular-base pins are then pushed into their socket, and the diheptal socket is put on the 14-pin base.

The *operating position* of the 2P23 should preferably be such that any loose particles in the neck of the tube will not fall down and strike or become lodged on the target. Therefore, it is recommended that the tube never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical through the center of the base.

The *operating temperature* of any part of the glass bulb should never exceed 65°C, and no part of the bulb at the large end of the tube (target section) should ever fall below 35°C during operation. The temperature of the target is essentially the same as that of the adjacent glass bulb and can, therefore, be determined by measuring the temperature of the glass bulb adjacent to the target. It is recommended that the temperature of the entire bulb be held between 35° and 60°C. Operation at too low a temperature will be characterized by the appearance of a rapidly disappearing "sticking picture" of opposite polarity from the original when the picture is moved. Operation at too high a temperature will cause loss of resolution and possibly permanent damage to the tube. Resolution is regained by waiting for the temperature to drop below 65°C. No part of the bulb should run more than 5° hotter than the target section to prevent cesium migration to the target. Such migration will result in loss of resolution and in probable permanent damage to the tube. Like other photosensitive devices employing cesium, the 2P23 may show fluctuations in performance from time to time. Strict observance of the above recommendations with respect to operating temperature will not completely eliminate these variations but will greatly improve the stability of the characteristics during the life of the tube.

When the equipment design or operating conditions are such that the maximum temperature rating or maximum temperature difference as given under Maximum Ratings will be exceeded, provision should be made to direct a blast of cooling air from the diheptal-base end of the tube along the entire length of the bulb surface, i.e., through the space between the bulb surface and the surrounding deflecting coil and its extension. Any attempt to effect cooling of the tube by circulating even a large amount of air around the focusing coil will do little good, but a small



O = Terminals on Deflecting-Coil Assembly, RCA Type No.201D75. These terminals are connected to annular socket within the Assembly as shown, except for those marked G, A, and C. G is connected to yoke shielding. A and C are connected to heater terminals on face of annular socket. Other terminals on the Assembly not shown above are indicated in Figs.3 and 4.

Fig.2 - Voltage Dividers for Type 2P23 with Connections for: Alignment Coil, RCA Type No.204D75, and Focusing Coil, RCA Type No.202D75.

amount of air directly in contact with the bulb surface will effectively drop the bulb temperature. For this purpose, a small blower is satisfactory, but it should be run at low speed to prevent vibration of the 2P23 and the associated amplifier equipment. Unless vibration is prevented, distortion of the picture may occur.

Ordinarily, the temperature in a camera equipped with a blower will not exceed 65°C, except in very hot weather or unless the target heater is left on accidentally for a long period. In very hot weather, the direct rays of the sun should be prevented from striking the camera.

To keep the operating temperature of the large end of the tube from falling below 35°C, some form of controlled heating should be employed. Ordinarily, adequate heat will be supplied by the focusing coil, deflecting coils, and associated amplifier tubes so that the temperature can be controlled by the amount of cooling air directed along the bulb surface. If, in special cases, a target heater is required, it should fit snugly between the focusing coil and the bulb near the shoulder of the tube. Such a target heater is included in the RCA Deflecting-Coil Assembly.

The *lens system* used with the 2P23 should be designed according to basic optical principles and should incorporate an iris to control the amount of light entering the television camera lens. Because of the relatively small face diameter of the 2P23, the use of a telephoto lens is facilitated. The lens holder should have all inside surfaces finished in matte black to prevent internal reflections from reaching the photocathode. Under almost all conditions, the use of a lens shade is beneficial.

A *mask* having a diagonal or diameter of 1.6 inches should always be used on the photocathode to set limits for the maximum size of scan, and to reduce the amount of light reaching unused parts of the photocathode.

For the *high dc voltages* required by the 2P23, the use of two pulse supplies for which the plate voltage is provided by a well-regulated, 330-volt, B-supply may be used. Each of these supplies should be actuated by the horizontal driving pulse which is obtained from the synchronizing generator. One of the pulse supplies should be capable of furnishing 1500 volts with an output current of 1 milliampere for the multiplier section; the other pulse supply should be capable of furnishing -500 volts with an output current of 1 milliampere for the image section. In addition to supplying the plate voltage and current for the pulse supplies, the 330-volt B-supply should also provide an output current of 90 milliamperes for the focusing and alignment coils and for the voltage divider which is used to supply the voltages for the electrodes in the scanning section of the 2P23.

Voltage dividers to provide the required operating voltages for the various electrodes of the 2P23 are shown in Fig.2. It is to be noted that the blocking capacitor C_6 should be of the mineral-oil impregnated type to minimize capacitor leakage which will introduce disturbing effects into the picture.

In designing a voltage divider for the multiplier stages of the 2P23, engineers should recognize that the dc output of individual 2P23's may have a range of 10 to 1. This range, therefore, must be considered in the choice of bleeder-resistor values. If the values are too high, the distribution of voltages applied to the dynodes will be upset by a 2P23 with a dc output at the upper end of the range. As a result, there will be an abrupt drop in the ac output of the tube as the beam current is increased. When this drop occurs before the beam is at its optimum value, the ratio of signal to noise will be lessened.

A *horizontal deflection circuit* for use with the 2P23 is shown in Fig.3; and a *vertical deflection circuit* in Fig.4.

LEGEND FOR FIG.2

C1 C2: 0.05 μf, 1600 v working voltage
C3: 0.01 μf mica, 1600 v working voltage
C4: 0.001 μf mica, 1000 v working voltage
C5: 0.001 μf mica, 600 v working voltage
C6: 0.03 μf mineral-oil impregnated, 1600 v working voltage
C7 C8 C9 C11 C12 C13 C14: 0.001 μf mica, 400 v working voltage
C10: 1 μf, 400 v working voltage
R1: 47000 ohms, 1/2 watt
R2 R3: 270000 ohms, 1/2 watt
R4 R5: 300000 ohms, 1/2 watt
R6: 100 ohms, 1/2 watt, wire wound
R7: 20 ohms, 1 watt, wire wound
R8: 2500 ohms, 25 watts
R9: 750 ohms, 10 watts
R10: 5100 ohms, 1/2 watt
R11: 51000 ohms, 2 watts
R12: 510 ohms, 1/2 watt
R13: 150000-ohm potentiometer, 1/2 watt
R14: 820000 ohms, 1/2 watt
R15: 100000-ohm potentiometer, 1 watt
R16: 150000 ohms, 1/2 watt
R17: 100000-ohm potentiometer, 1 watt
R18: 56000 ohms, 1/2 watt
R19 R20 R21: 20000 ohms, 1/2 watt
R22: 250000-ohm potentiometer, 1 watt
R23: 180000 ohms, 1/2 watt
R24: 390000 ohms, 1/2 watt
R25: 11000 ohms, 1/2 watt
R26: 500000-ohm potentiometer, 1 watt
R27: 110000 ohms, 1/2 watt
R28: 560000 ohms, 1/2 watt
R29: 47000 ohms, 1/2 watt
R30: 20000 ohms, 1/2 watt
R31 R32: 100000 ohms, 1/2 watt
R33 R34 R36 R37 R39 R40 R41 R42 R43: 200000 ohms, 1/2 watt
R35: 50000 ohms, 1/2 watt
R38: 100000 ohms, 1/2 watt

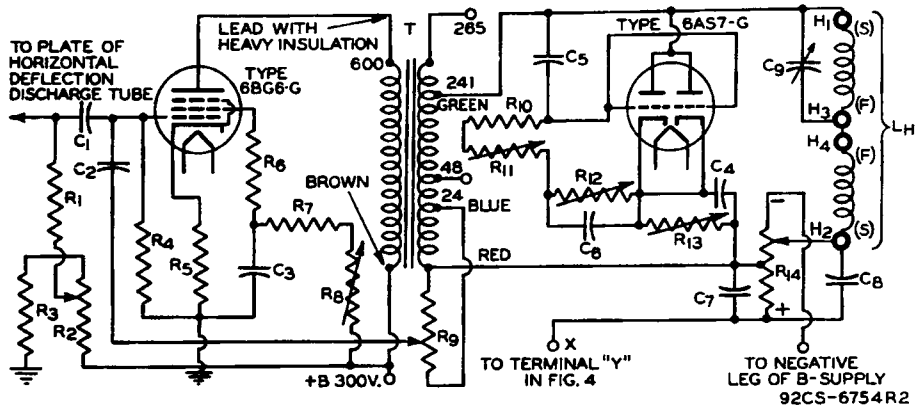
The *video amplifier* should be designed to cover a range of ac signal voltages corresponding to signal-output currents of 3 to 30 microamperes in the load resistor (R_{30} in Fig.2).

APPLICATION

Resolution of better than 400 lines at the center of the picture can be produced by the 2P23 when the photocathode highlight illumination from an RMA Standard Test Chart is above the knee of each of the curves in Fig.5. This value of resolution is that obtained after optimum adjustments have been made to minimize the prominence of beat patterns and dynode spots.

To utilize the resolution capability of the 2P23 in the horizontal direction with the standard scanning rate of 525 lines, it is necessary to use a video amplifier having a bandwidth of at least 5 megacycles. The maximum resolution obtainable is limited by the mesh-screen portion of the target.

Even with a wide-band amplifier, the resolution may be limited by "cross talk" caused by the scanning fields. Unless prevented by proper shielding from extending into the image section, these fields will cause the electron image on the target to move at scanning frequency. As a result, the picture will lack definition.



C1: 0.01 μf
C2: 150 μμf
C3 C4: 4 μf
C5: 30 μμf
C6: 0.02 μf
C7 C8: 100 μf
C9: Balancing Capacitor, 10 to 40 μμf
LH: Horizontal Deflecting Coils: Terminals H1, H2, H3, and H4 on Deflecting-Coil Assembly, RCA Type No.201D75. LH has inductance of 5.5 mh and dc resistance of 19 ohms.
R1: 1 Megohm
R2: Sawtooth Amplitude and Linearity Control, 250000 ohms
R3 R4: 250000 ohms
R5: 100 ohms, 2 watts
R6: 100 ohms
R7: 3000 ohms, 2 watts
R8: 10000 ohms, 2 watts. Value should be such that screen input of the 6BG6-G will not be exceeded.
R9: Peaking Amplitude and Linearity Control, 5000 ohms
R10: 50000 ohms, 1 watt
R11: Linearity Control, 250000 ohms
R12: Linearity Control, 100000 ohms
R13: Linearity Control, 500 ohms, 5 watts
R14: Centering Control, 10 ohms tapped at 5 ohms
T: Horizontal Deflection Output Transformer, RCA Type No.204T1. DC resistance of used portion of secondary is 3.4 ohms.

Fig.3 - Horizontal Deflection Circuit for Type 2P23.

A beat pattern is caused by the beating of the scanning lines against the lines of the target mesh. As a result, a moiré pattern, sometimes called a "swirl", appears in large-area highlights of the picture. Besides defocusing of the beam by adjustment of the beam-focus control (grid No.4), a slight change in the vertical or horizontal size controls of the camera may be helpful in reducing the beat-pattern effect.

A dynode spot is caused by a slight blemish on a dynode surface and appears as a white spot chiefly in the dark areas of the picture. Little defocusing of the beam is required to minimize the effect of dynode spots when the scene is brightly illuminated, but in dark scenes, the effect of dynode spots is a limiting item on resolution.

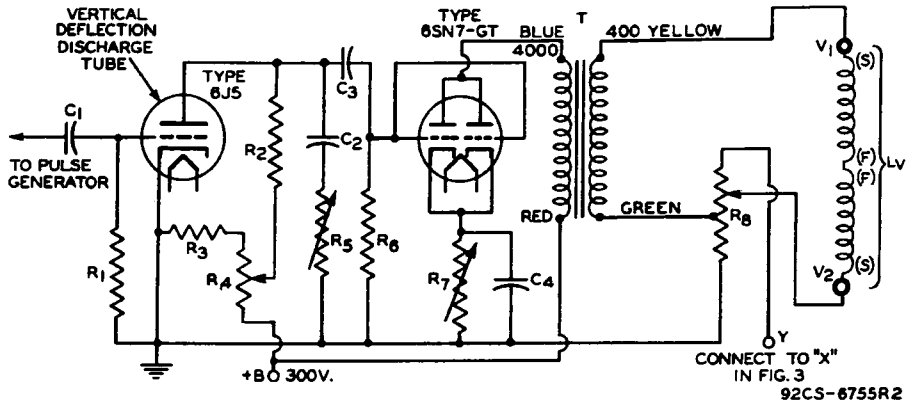
Proper shielding will be provided by a shield which employs seven separate layers of silicon-steel strips (0.007" thick and 1/2" wide) applied to the outside of the focusing coil as follows: First, wrap a single insulating layer of 0.005" thick motor paper around the focusing coil; then, wrap two turns, one above the other of the silicon-steel strip repeating the operation to fill the entire focusing-coil length but allowing 1/64" between each successive 2-turn section, to insure electrical insulation. Second, wrap a second insulating layer of motor paper and repeat the silicon-steel strip operation but space the 2-turn sections so that each is directly over a 1/64" insulating space of the previous layer. Operations 1 and 2 are repeated to provide 7 layers of shielding. The entire assembly is

completed with a final wrap of motor paper. A convenient method for handling the 2-turn strip sections is to cut the strips just long enough to take care of two turns. Each 2-turn section is, of course, completely independent of any other section.

If equipment space will not accommodate the full seven layers of shielding as described above, fewer layers can be used, but will be less effective in minimizing "cross talk".

The *sequence of adjustments* in operating the 2P23 is as follows: After the tube has been inserted in its sockets and the voltages applied as indicated under Typical Operation, allow it to warm up for 1/2 to 1 hour with the camera lens iris closed. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the target. Adjust the deflection circuits so that the beam will "overscan" the target, i.e., so that the area of the target scanned is greater than its sensitive area. This procedure during the warming-up period is recommended to prevent burning on the target a raster smaller than that used for on-the-air operation. Note that overscanning the target results in a smaller-than-normal picture on the monitor. Then open the iris partially and focus the scene to be televised on the photocathode. Next, adjust the grid-No. 1 voltage until a picture or noise appears on the monitor screen. If there is no picture, rotate the alignment coil and adjust the current through it until the maximum picture response is obtained. An occasional tube may require very little or no current through the alignment coil. Correct alignment is obtained when the picture does not rotate as the beam-focus control (grid No.4) is varied. Proper alignment may also be checked even more critically than by the above procedure by observing on the monitor any "dynode spots" resulting from small imperfections in the dynode surfaces. The spots appear as small white areas of various shapes, and can best be observed with no light on the photocathode. With proper alignment, the dynode spots do not rotate when the beam-focus control (grid No.4) is varied, but simply go in and out of focus. During alignment of the beam, and during operation of the tube, always keep the beam current as low as possible to give the best picture quality. Adjust the beam-current control to give only enough beam current to hold down the highlights. Next, adjust grid-No. 1 voltage and the target voltage for the best picture. Then, bring the picture into focus by varying the voltage on grid No.4 and on the photocathode. Next, vary the voltage on grid No.3 to give the most uniformly shaded picture at approximately maximum signal. Final adjustment is made by varying the voltages on grids No.5 and No.6. In general, these need little adjustment and are varied only after completing the other adjustments. When camera is used for rehearsal, the scanning may be restored nearly to normal size. Complete restoration should be made just prior to air-time.

Full-size scanning of the target should always be used during on-the-air operation. Full-size scanning can be assured by first adjusting the deflection circuits to overscan the target sufficiently to cause the corners of the target to be visible in the picture, and then reducing



C1: 0.1 μf
C2: 0.05 μf
C3: 1 μf
C4: 1000 μf
LV: Vertical Deflecting Coils: Terminals V1 and V2 on Deflecting Coil Assembly, RCA Type No.201D75. LV has inductance of 28.3 mh and dc resistance of 34 ohms.
R1: 1 megohm
R2: 5 megohms
R3: 100000 ohms
R4: Sawtooth Amplitude Control, 250000 ohms
R5: Peaking Amplitude Control, 25000 ohms
R6: 500000 ohms
R7: Linearity Control, 5000 ohms
R8: Centering Control, 10 ohms tapped at 5 ohms
T: Vertical Deflection Output Transformer, RCA Type No.204T2. DC resistance of secondary is 6.9 ohms.

Fig.4 - Vertical Deflection Circuit for Type 2P23.

the scanning until the corners just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. Full-size scanning will also reduce the prominence of a beat pattern (see *resolution*). As indicated previously, overscanning the target produces a smaller-than-normal picture on the monitor.

be constant to prevent fluctuation of the target voltage. During the blanking periods, the full beam current without video-signal modulation is returned to the multiplier and its multiplied output flows through the load resistance.

Shading may be required even with optimum adjustment of voltage on grid No.3 in order to

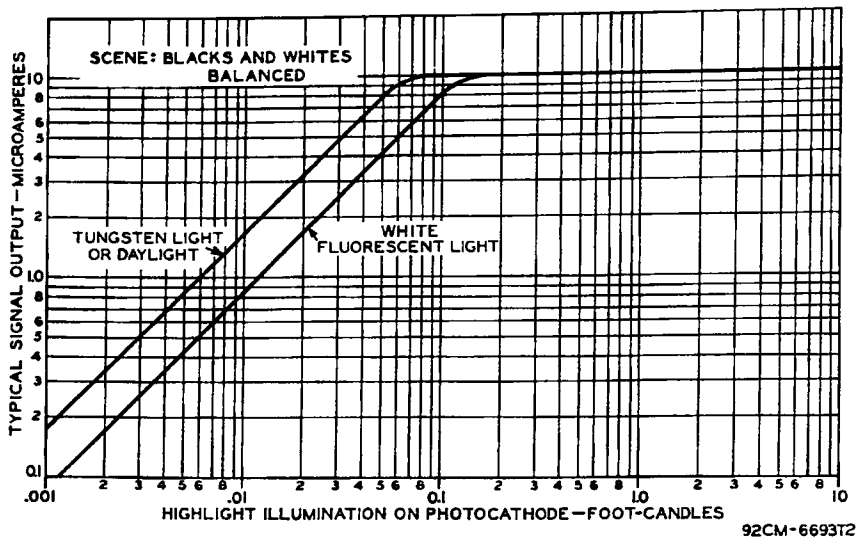


Fig.5 - Typical Signal Output of Type 2P23.

Underscanning the target, i.e., scanning an area of the target less than its sensitive area, should never be permitted. Underscanning produces a larger-than-normal picture on the monitor. If the target is underscanned for any length of time, a permanent change of target cutoff voltage of the underscanned area takes place with the result that the underscanned area thenceforth is visible in the picture when full-size scanning is restored.

The *target voltage* will depend on the type of scene to be televised and should be adjusted simultaneously with the beam-current control to obtain the best signal-to-noise ratio and gray-scale reproduction. If the scene has a large range of illumination (such as that for a baseball game on a sunny day), the target should be operated at about 1.5 to 2 volts above cutoff so that highlights will not bloom. For scenes with a lower range of illumination (such as that for a boxing match under artificial lighting), the target can be operated at about 2 to 3 volts above cutoff with resultant gain in signal-to-noise ratio, and improved detail in the shadows.

A *blanking signal* should be supplied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must

obtain a uniformly shaded picture. A shading signal having a sawtooth shape, a frequency equal to the horizontal scanning frequency, and an amplitude about twice that of the useful video signal, is recommended. Provision should be made for controlling the amplitude of the shading signal and for reversing its polarity. The signal may be introduced into the video channel after the pre-amplifier in the camera but ahead of the master gain control. With this arrangement, changing the gain-control setting does not change the ratio of the shading-signal amplitude to the video-signal amplitude.

The *illumination* on the photocathode is related to the scene illumination by the formula

$$I_s = \frac{4f^2 I_{pc} (m+1)^2}{TR}$$

where

I_s = scene illumination in foot-candles
f = f-number of lens
I_{pc} = photocathode illumination in foot-candles
m = linear magnification from scene to target
T = total transmission of lens
R = reflectance of principal subject in scene.

Except for very close shots, the linear magnification (m) from scene to target may be neglected.

For example, assume that the lens is f:3.5 having a transmission (T) of 75%, that the photocathode illumination from a tungsten source or from daylight is 0.1 foot-candle, and that the

scene to be televised is composed largely of whites and blacks (such as a test chart) where the reflectance (R) may be in the order of 50%. Then,

$$I_s = \frac{4 \times 3.5^2 \times 0.1}{0.75 \times 0.50} = 13 \text{ foot-candles}$$

In practice, and under the assumed conditions of the preceding example, it will be found that the required minimum illumination on the scene will be in the range from 7 to 20 foot-candles.

For average scenes where the principal subject has a reflectance of 5 to 10%, the incident tungsten or daylight illumination should have a value of 40 to 60 foot-candles.

It is good practice before attempting to transmit a particular scene to check its incident illumination with an illuminating-measuring device, such as an exposure meter. It is recommended that the average incident light level with tungsten or daylight illumination be greater than approximately 30 foot-candles for a good picture. If white fluorescent illumination is used, the incident light level should be greater than approximately 50 foot-candles.

Typical signal output of the 2P23 as a function of the highlight illumination on the photocathode under conditions where the televised scene has balanced blacks and whites for each of three types of illumination, is shown by the curves in Fig.5. It will be noted that when the scene has white fluorescent illumination, the signal-output curve for tungsten or daylight illumination is modified to the extent that the sloping part shifts to the right by an amount corresponding to an increase of photocathode illumination of two to three times.

For the most natural appearance of televised subjects or scenes, it is recommended that the 2P23 be operated so that the highlights on the photocathode bring the signal output slightly over the knee of the signal-output curve for the particular type of illumination utilized. Operation further along on the horizontal part of the curve will give pictures in which the subject has an over-emphasized outline. The position of the knee will shift for individual tubes. With tungsten light or daylight, the knee may occur at values of highlight illumination on the photocathode ranging from about 0.05 to 0.15 foot-candle; with fluorescent light, the range may occur from about 0.12 to 0.36 foot-candle.

The *spectral response* of the 2P23 is subject to considerable variation from tube to tube because of the nature of the photocathode surface employed. A representative approximation of the spectral response is shown by the curve in Fig.6.

Retention of a scene by the 2P23, sometimes called a "sticking picture", may be experienced if the 2P23 is allowed to remain focused on a stationary bright scene for several minutes, or if it is focused on a bright scene before reaching operating temperature in the range from 35° to 60°C. Often the retained image will disappear in a few seconds, but sometimes it may persist for long periods before it completely disappears. A retained image can generally be removed by focusing the 2P23 on a clear white screen, and allowing the 2P23 to operate for several hours with an illumination of about 1 foot-candle on the photocathode. This value is equivalent to 50 to 100 foot-candles on the screen with an f:2.8 lens.

To avoid retention of a scene, it is recommended that the 2P23 always be allowed to warm up in the camera for 1/2 to 1 hour with the lens iris closed, and that the 2P23 never be allowed to remain focused on a stationary bright scene for more than a few minutes. Never use more illumination than is necessary. If a target heater is used, the warm-up time can be reduced to approximately 10 or 15 minutes.

Failure of scanning even for a few minutes when light is incident on the photocathode may permanently damage the surface of the target. The damaged area shows up as a spot or line in the picture during subsequent operation.

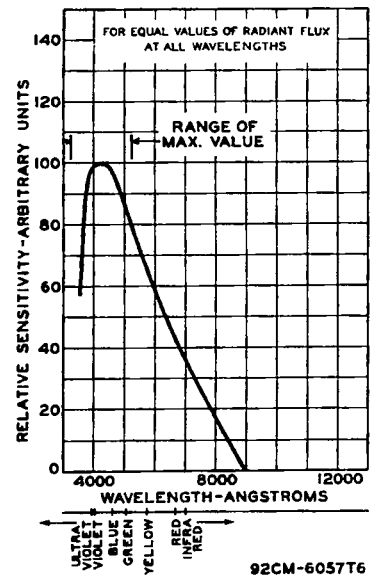


Fig.6 - Approximate Spectral Sensitivity Characteristic of Type 2P23.

To avoid damaging the 2P23 during scanning failure, provision should be made to prevent automatically the scanning beam from reaching the target. The scanning beam can be prevented from reaching the target by (1) cutting off the scanning beam, or (2) making the target sufficiently negative. The scanning beam can be cut off by a relay which applies -115 to -125 volts bias to grid No.1. The target can be made sufficiently negative by a relay which applies a bias

of at least -10 volts to it. Either relay is actuated by a tube which is controlled by a portion of the scanning pulse voltage developed across either the horizontal or the vertical deflecting coils, or both. It is important to insure that the horizontal scanning pulse and the vertical scanning pulse should each independently actuate the relay in case either one fails.

Rotation in the use of 2P23's is recommended. After a 2P23 is operated for 200 to 300 hours, it should be given an idle period of three or four weeks during which it generally will recover much of its original resolution and sensitivity.

New 2P23's should be placed in service immediately upon receipt. They should be operated for several hours before being set aside as spares.

Spare tubes should be placed in service for several hours at least once a month in order to keep them free from traces of gas which may be liberated within the tube during prolonged storage.

Occasionally, a *white spot* which does not change in size when the beam focus voltage is varied, may be observed in the center of the picture. Such a spot, especially if it is visible on the monitor with the camera lens capped, is probably an ion spot. If the spot begins to grow in size with continuous operation of the 2P23, the 2P23 should be removed from service at once, and returned for re-processing. Continued operation of an image orthicon with an ion spot will eventually damage the target permanently.

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Otto H. Schade, *"Electro-Optical Characteristics of Television Systems; Introduction and Part 1 - Characteristics of Vision and Visual Systems,"* RCA Review, March, 1948; *"Part 11 - Electro-Optical Specifications for Television Systems,"* RCA Review, June, 1948; *"Part 111 - Electro-Optical Characteristics of Camera Systems,* RCA Review, Sept., 1948; *"Part 1V - Correlation and Evaluation of Electro-Optical Characteristics of Imaging Systems,"* RCA Review, December, 1948.

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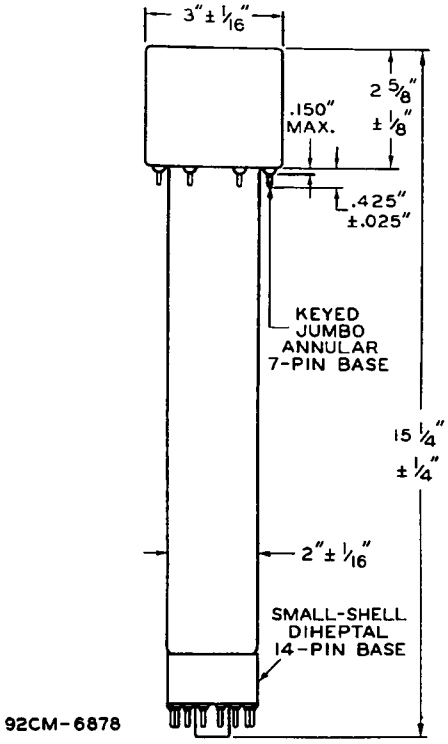
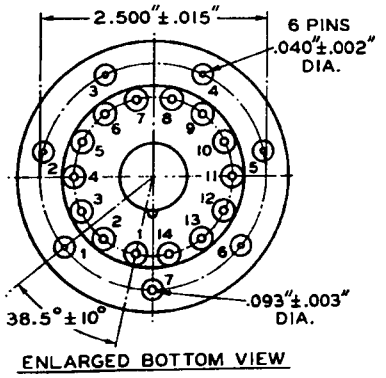
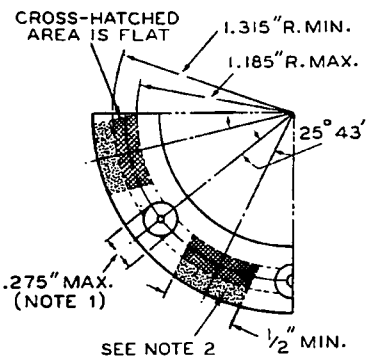
DIMENSIONAL OUTLINE





ENLARGED BOTTOM VIEW

DETAIL OF BOTTOM VIEW OF KEYED JUMBO ANNULAR BASE



NOTE 1: MEASURED AT DISTANCE OF 1/32" BELOW BOTTOM OF ANNULAR BASE.

NOTE 2: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.

KEYED ANNULAR BASE GAUGE

ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GAUGE WITH:

a. SIX HOLES HAVING DIAMETER OF 0.065" ±0.001" AND ONE HOLE HAVING DIAMETER OF 0.150" ±0.001". ALL HOLES HAVE DEPTH OF 0.265" ± 0.001". THE SIX 0.065" HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047". ALL HOLES ARE SPACED AT ANGLES OF 51°26' ± 5' ON CIRCLE DIAMETER OF 2.500" ± 0.001".

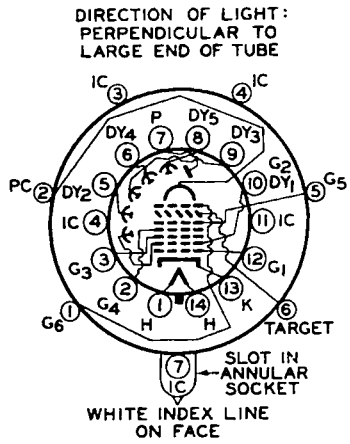
b. SIX STOPS HAVING HEIGHT OF 0.187" ± 0.001", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

c. RIM EXTENDING OUT A MINIMUM OF 1/8" FROM 2-13/16" DIAMETER AND HAVING HEIGHT OF 0.126" ± 0.001".

d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200" ± 0.001".

SOCKET CONNECTIONS

Bottom View



SMALL-SHELL DIHEPTAL 14-PIN BASE

PIN 1: HEATER
PIN 2: GRID No.4
PIN 3: GRID No.3
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: DYNODE No.2
PIN 6: DYNODE No.4
PIN 7: ANODE
PIN 8: DYNODE No.5
PIN 9: DYNODE No.3
PIN 10: DYNODE No.1, GRID No.2
PIN 11: INTERNAL CONNECTION - DO NOT USE
PIN 12: GRID No.1
PIN 13: CATHODE
PIN 14: HEATER

KEYED JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID No.6
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNECTION - DO NOT USE
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: GRID No.5
PIN 6: TARGET
PIN 7: INTERNAL CONNECTION - DO NOT USE

February 2, 1939

corrected copy

RCA Radiotron No. 1575

2V3-G

High-Voltage Half-Wave Rectifier

RCA-2V3-G is a tungsten-filament type of high-vacuum, half-wave rectifier for use in suitable rectifying devices to supply the high d-c voltages required by Kinescopes and cathode-ray tubes.

TENTATIVE RATINGS

FILAMENT VOLTAGE (A.C.)	2.5	Volts
FILAMENT CURRENT	5	Amperes
PEAK INVERSE VOLTAGE	16500 *max.*	Volts
PEAK PLATE CURRENT	12 *max.*	Milliamperes
AVERAGE PLATE CURRENT	2 *max.*	Milliamperes
BULB	ST-12	
CAP	Skirted Miniature - Style A	
BASE	Small Shell Octal 6-Pin	

INSTALLATION

The *base* of the 2V3-G fits the standard octal socket. The socket should be mounted to hold the tube in a vertical position with the base either up or down. Only a socket capable of carrying 5 amperes should be used. The plate connection is made to the cap at the top of the bulb.

The *bulb* becomes hot during operation of the tube. Sufficient ventilation should be provided to prevent overheating.

The *filament* of the 2V3-G is of the tungsten type and is designed for operation at 2.5 volts. The transformer supplying the filament voltage should be designed to give rated filament voltage under average line-voltage conditions. Experience indicates that a good average line voltage for design purposes is 117 volts. The design of the 2V3-G filament will permit the use of line voltages up to 125 volts without seriously affecting tube life. Also, a drop of line voltage to 105 volts can be tolerated without serious effect to tube performance and tube life (see voltage-regulation curve). However, when the line voltage drops below 105 volts, the tube dissipation increases and tube life and performance are seriously affected. If greater voltage variations are encountered than those discussed above, it is recommended that some method be provided for automatically reducing the variation in filament voltage. The filament transformer must have sufficient insulation to withstand the maximum peak inverse voltage encountered in the installation.

Caution should be observed when the filament voltage is measured because the filament circuit is at high d-c potential.

APPLICATION

As a *rectifier* for supplying the high-voltage d-c requirements of Kinescopes and cathode-ray tubes, RCA-2V3-G may be operated in conventional rectifier circuits under conditions not to exceed those given under RATINGS. In single-phase circuits, full-wave rectification is accomplished by using two 2V3-G's.

In *voltage doubler* service, two 2V3-G's may be connected to deliver approximately twice the voltage obtainable from the half-wave or the full-wave method for the same a-c input voltage. In this service a separate filament-supply winding suitably insulated is required for each tube.

Filter requirements, due to small d-c output current, are usually met by the use of a small condenser of approximately 0.1 μf shunted across the bleeder circuit. The shunt condenser should have a rating sufficient to withstand the instantaneous peak value of the a-c input voltage. If this filtering is inadequate for a particular application, a two-section filter is recommended.

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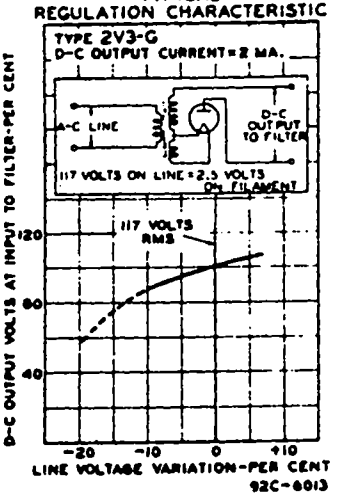
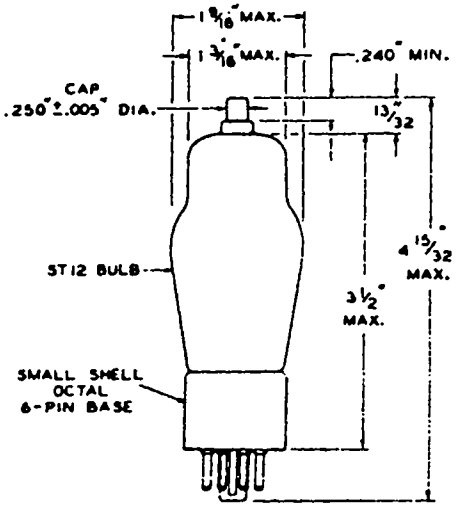
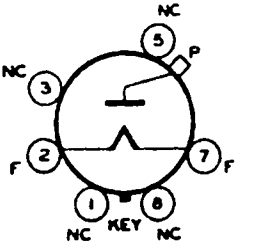
TYPICAL
REGULATION CHARACTERISTIC





Bottom View
of Socket Connections



92C-6005 R1

3DP1-A
CATHODE-RAY TUBE

Radial Deflection Type
Medium-Persistence Screen

3-Inch Bulb
Electrostatic Deflection and Focus

RCA-3DP1-A is a high-vacuum cathode-ray tube having a radial-deflecting electrode in addition to the usual two pairs of electrostatic deflecting electrodes. This arrangement provides for the observation and photography of recurrent and transient phenomena in polar coordinates. The use of polar coordinates is especially valuable where high accuracy of measurement of one coordinate is required since the trace length can be made several times that obtainable with the usual cathode-ray tube having the same screen diameter. The 3DP1-A has a medium-persistence fluorescent screen two and three quarters inches in diameter, and produces a brilliant luminous spot having a greenish hue.

The 3DP1-A employs an improved electron gun for projecting the electron beam onto the fluorescent screen. The improved gun provides sharper focus of the beam and is designed so that its anode No. 1 takes essentially no current. This feature permits the use of a bleeder system requiring very little current and, consequently, a smaller filter capacitance. As a result of the extremely small anode-No.1 current, variation in focus which may otherwise take place with change of beam current is minimized.

Two pairs of electrostatic deflecting electrodes located within the bulb neck produce fields at right angles to each other and, consequently, provide vertical and horizontal deflections of the beam. These pairs of electrodes may be used to produce a circular trace on the screen. This trace may then be modulated by applying to the radial-deflecting electrode, located at the center of the screen, a voltage representing the phenomena under observation.

RCA-3DP1-A supersedes RCA-3DP1.

DATA

General:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3	±10%	Volts
Current	0.6		Ampere
Direct Interelectrode Capacitances (Approx.):			
Grid No.1 to All Other Electrodes	8.5		μμf
Cathode to All Other Electrodes	8.0		μμf
DJ1 to DJ2	2.0		μμf
DJ3 to DJ4	2.0		μμf
DJ1 to All Other Electrodes	8.0		μμf
DJ3 to All Other Electrodes	6.0		μμf
DJ1 to All Other Electrodes except DJ2	6.0		μμf
DJ2 to All Other Electrodes except DJ1	5.0		μμf
DJ3 to All Other Electrodes except DJ4	4.0		μμf
DJ4 to All Other Electrodes except DJ3	6.0		μμf
DJ5 to Anode No.2	2.2		μμf
Phosphor			No.1
Fluorescence			Green
Persistence			Medium
Focusing Method			Electrostatic
Deflection Method			Electrostatic
Deflecting-Electrode Arrangement	See *Outline Drawing*		
Overall Length	10-7/16" + 5/16" - 3/8"		
Greatest Diameter of Bulb	3" ± 1/16"		
Minimum Useful Screen Diameter	2-3/4"		
Bulb Terminal	Small Ball Cap		
Base	Medium Shell Diheptal 12-Pin		
Mounting Position	Any		

Maximum Ratings, *Absolute Values*:

ANODE-No.2 & GRID-No.2 VOLTAGE	2200 max.	Volts
ANODE-No.1 VOLTAGE	1100 max.	Volts
GRID-No.1 (CONTROL ELECTRODE) VOLTAGE:		
Negative Value	125 max.	Volts
Positive Value	0 max.	Volts
PEAK VOLTAGE BETWEEN ANODE No.2 and ANY DEFLECTING ELECTRODE	550 max.	Volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	Volts
Heater positive with respect to cathode	10 max.	Volts

Typical Operation:

Anode-No.2 & Grid-No.2 Voltage*	1500	2000	Volts
Anode-No.1 Voltage for Focus at 75% of Grid-No.1 Voltage for Cutoff#	430	575	Volts
Grid-No.1 Voltage for Visual Cutoff##	-45	-60	Volts
Max. Anode-No.1 Current Range▲	Between -50 and +10 μamp.		
Deflection Sensitivity:			
DJ1 and DJ2	0.169	0.127	mm/volt dc
DJ3 and DJ4	0.229	0.172	mm/volt dc
Deflection Factor:			
DJ1 and DJ2**	150	220	volts dc/in.
DJ3 and DJ4**	111	148	volts dc/in.
DJ5 and Anode No.2### ■	245	327	volts dc/in.
Ratio of DJ1-DJ2 Factor to DJ3-DJ4 Factor□	1.35	1.35	

* Brilliance and definition decrease with decreasing anode No.2 voltage. In general, anode-No.2 voltage should not be less than 1500 volts.
** Individual tubes may vary from these values by ±20%.
# Individual tubes may require between +20% and -35% of the values shown with grid-No.1 voltage between zero and cutoff.
Visual extinction of stationary focused spot. Supply should be adjustable to +50% of these values.
For one-inch diameter circle. Deflection factor for any desired circle diameter is the value for a circle of one-inch diameter, given above, multiplied by the desired circle diameter in inches.
▲ See curve for average value.
□ Individual tubes may vary from this value by +15.5%.
■ Individual tubes may vary from these values by +25%.

Spot Position:
The undeflected focused spot will fall within a 15-mm square centered at the geometric center of the tube face and having one side parallel to the trace produced by DJ1 and DJ2. Suitable test conditions are: anode-No.2 volts, 1500; anode-No.1 volts, adjusted for focus; deflecting-electrode resistors, 1 megohm each, connected to anode No.2; the tube shielded from all extraneous fields. To avoid damage to the tube, grid-No.1 voltage should be near cutoff before application of any anode voltages.

Maximum Circuit Values:

Grid-No.1 Circuit Resistance	1.5 max.	Megohms
Impedance of Any Deflecting-Electrode Circuit at Heater-Supply Frequency	1.0 max.	Megohm
Resistance in Any Deflecting-Electrode Circuit▲	5.0 max.	Megohms

▲ It is recommended that the deflecting-electrode circuit resistances be approximately equal.

INSTALLATION and APPLICATION

The *base* pins of the 3DP1-A fit the diheptal (12-contact) socket which may be installed in any position. The socket alone should not be re-

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3DP1-A-6-45
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quired to support the tube; additional support in the form of a yoke or saddle arrangement should be used at or near the screen end of the tube. The socket should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The *bulb* should be enclosed in a grounded shield made of high permeability metal having low residual magnetism in order to minimize the effects of extraneous magnetic fields. When a grounded metal shield is used around the tube, it may be necessary to insulate the tube from the shield to avoid the effects of corona or leakage currents.

The *heater* is designed to be operated at 6.3 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage between heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage. The mid-tap or one side of the heater should preferably be connected to cathode. If necessary, the heater may be operated with a bias of not more than -200 volts or +10 volts with respect to cathode.

The *fluorescent screen* employs phosphor No.1 which fluoresces to produce a medium-persistence green luminescence.

The *dc voltages* for the grid and the two anodes may be obtained conveniently from a high-voltage vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage-doubler type. A capacitor of about 0.1 μf will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended. If the electrode voltages are obtained from a bleeder circuit, a bleeder current of about 0.2 milliampere usually is satisfactory. Considerably higher values may require the use of more filtering than that provided by a single capacitor shunted across the dc supply. In most applications, it is recommended that anode No.2 be grounded in order that the deflecting electrodes may be operated at or near ground potential. With this method, the cathode and heater are at high negative potential with respect to ground.

The high voltages at which the tube is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is required. In most applications, it is recommended that the anode-No.2 terminal be grounded rather than the cathode terminal. With this method, which places the cathode and heater at high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit due to capacitor breakdown or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged capacitors grounded.

Focusing of the fluorescent spot produced by the electron beam is controlled by adjustment of the ratio of anode-No.1 voltage to anode-No.2 voltage. Ordinarily, the ratio is adjusted by variation of anode-No.1 voltage. For this purpose, a potentiometer is required in the bleeder circuit; the necessary range of adjustment is indicated under TYPICAL OPERATION.

Regulation of spot brilliance can be accomplished by varying the current to anode No.2. This current can be increased by decreasing the bias voltage applied to grid No.1. An increase in the current increases the spot size and the quantity of light. To obtain the smallest spot, a slight readjustment of focus may be necessary. An increase in the anode-No.2 voltage increases the beam current and the sharpness of focus and, therefore, the spot brilliance.

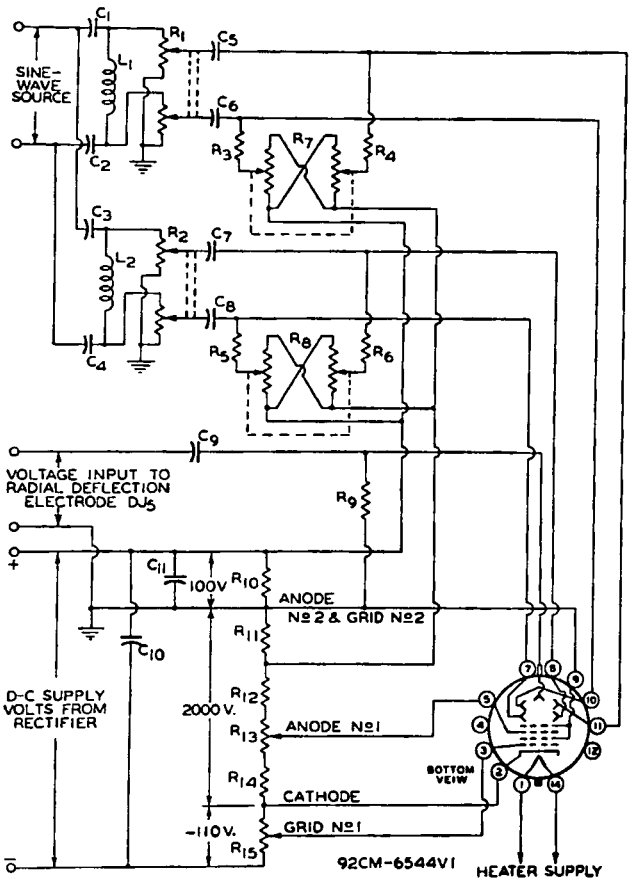
In applications involving extremely accurate measurements, the anode-No.2 current should be reduced to the minimum consistent with the desired brilliance of the pattern. In cases where high brilliance is an important consideration, the anode-No.2 voltage may be increased to the maximum rated value with due consideration to line-voltage variations. This procedure, however, is not always desirable since it results in reduced deflection sensitivity.

It is important to note that a high-intensity spot will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the spot be kept in motion over a reasonably large area or that the beam current should be reduced.

Two pairs of *electrostatic deflecting electrodes*, producing fields at right angles, are located within the bulb neck to provide for deflection of the electron beam. The electrostatic field of each pair of deflecting electrodes causes deflection of the beam in the direction of the gradient lines of the field and perpendicular to the plane of the deflecting electrodes; therefore, the deflections caused by the two fields are at right angles. Each set of deflecting electrodes should be maintained essentially at the dc potential of anode No.2. To do this, each electrode of each set should be connected through a resistor of not more than 5 megohms to the anode-No.2 terminal (ordinarily at ground potential). These resistors should have approximately equal resistances. This arrangement permits a choice of resistor values

such that the electron beam is not distorted by dc potentials built up on the deflecting electrodes. If, during operation, the zero axes should shift, it usually is because the beam current is too high for the resistor value used. When it is necessary to use a high value of beam current, as when photographs are taken, the value of the deflecting-electrode resistors should be reduced to minimize the shift of the zero axes and distortion of the focused spot.

The *radial-deflecting electrode* is used to produce a trace in polar coordinates. In accomplishing this, the signal to be observed is used to modulate a circular trace.



L1 L2: Inductors, see text
C1 C2 C3 C4: Tuning Capacitors, see text
C5 C6 C7 C8 C9: Isolating Capacitors, 0.05 μf*
C10: 0.1 μf
C11: 1.0 μf
R1 R2: Dual Potentiometers, 1 Megohm Each Section
R3 R4 R5 R6: 2 Megohms
R7 R8: Dual Potentiometers, 5 Megohms Each Section
R9 R10 R11: 2 Megohms
R12: 5.5 Megohms
R13: 2-Megohm Potentiometer
R14: 1.5 Megohms
R15: 0.5-Megohm Potentiometer
*When cathode is grounded, capacitors should have high voltage rating; when anode No.2 is grounded, they may have low voltage rating.

Typical Oscillograph Circuit

The *circular trace* is produced by supplying voltages in suitable phase to the coordinate-deflecting electrodes; a phase-splitting circuit for the purpose is included in the circuit diagram. In the circuit, a sine-wave voltage is split by means of a balanced branch circuit into two phases, separated by 90°. The design values of the phase-splitting circuit depend on the frequency of the sine-wave supply voltage. Inductors L1 and L2 are tuned to resonance by adjusting their respective pairs of capacitors C1 and C2, and C3 and C4. The capacitance of capacitors C1 and C2 is *reduced* to the point where the voltage developed across L1 is 0.707 times that at resonance. Similarly, the capacitance of C3 and C4 is *increased* to the point where the voltage developed across L2 is 0.707 times that at resonance. The voltages across the two inductors are then 90° out of phase. The magn tude of the voltage of each phase is adjustable by means of dual potentiometers R1 and R2, and R3 and R4. The use of dual potentiometers for controlling the voltage for each phase provides voltage balance to ground of the associated pairs of deflecting electrodes. The capacitors in each branch (C1 and C2, and C3 and C4) permit the use of low-voltage capacitors.

This method of obtaining phased voltages effectively eliminates harmonics from the circular trace. Any harmonics in the trace will cause irregularities which can be confused with the deflection caused by the radial-deflecting electrode.

The deflection sensitivities and the deflection factors for each pair of deflecting electrodes for typical anode-No.2 voltages are given under TYPICAL OPERATION. The deflection factor for the radial-deflecting electrode is given under TYPICAL OPERATION for a one-inch diameter circle. The deflection factor varies with the size of the basic circle and for any given circle size is found by multiplying the deflection factor by the circle diameter in inches.

Photographs of the phenomena appearing on the viewing screen can be made with an ordinary camera. The photographing is done preferably in complete darkness in order to obtain as much contrast as possible between the fluorescent pattern and the screen. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, and the brightness of the pattern. Where transients are to be photographed, maximum brightness may be required because of the short duration of the phenomena; where recurrent wave forms are to be photographed, patterns having low brightness can be compensated for by longer exposure. The use of emulsions having high green sensitivity is recommended; orthochromatic types of film and high-speed films have been found to give excellent results.

For high-speed photographic work involving non-recurrent phenomena, it is permissible to

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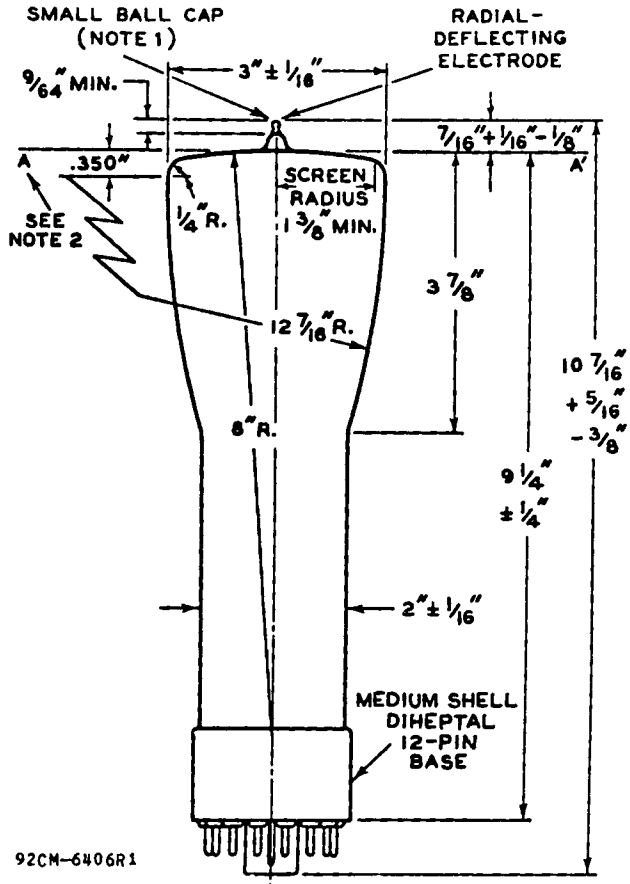
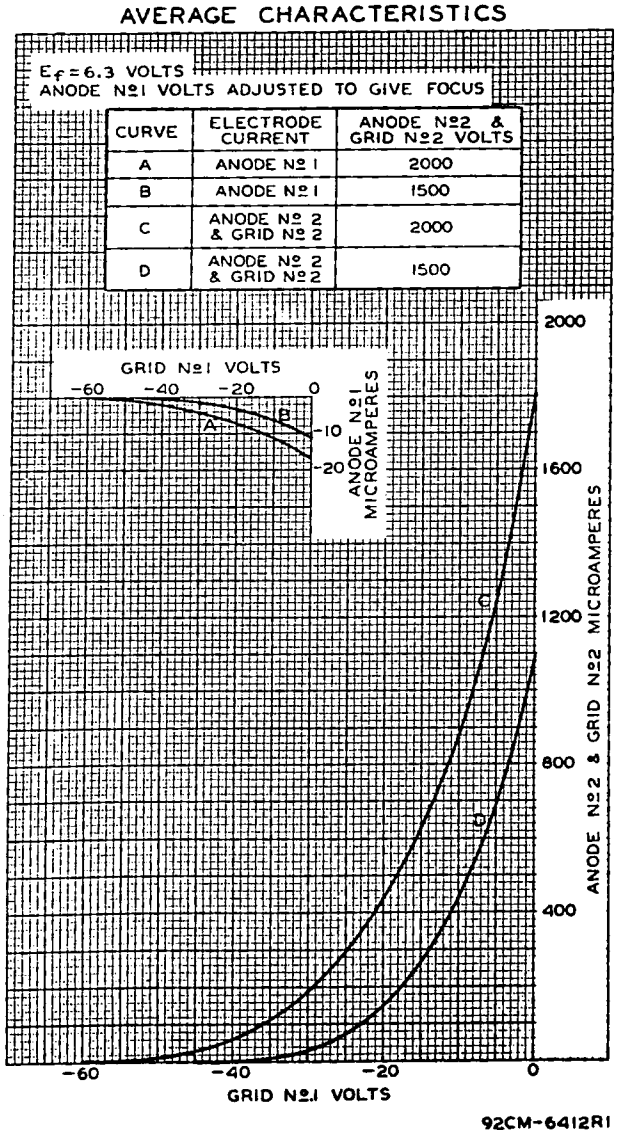
increase the trace brightness, for the short interval required to make the exposure, above that required for visual observation. The extent to which the anode current may be increased without harming the screen is proportional to the velocity of beam travel and pattern size, and an inverse function of the duration of the phenomena. Short-interval operation at increased current can be obtained by means of a temporary decrease in the grid-No.1 voltage. A switching arrangement should be provided to switch the grid-No.1 voltage rapidly between a negative and a less negative value. The exposure is made while the grid-No.1 voltage is at the less negative value.



AVERAGE CHARACTERISTICS



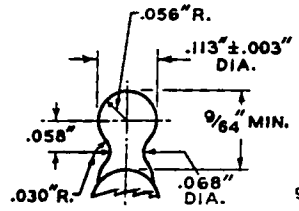
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

THE PLANE THROUGH THE TUBE AXIS AND PIN 5 MAY VARY FROM THE TRACE PRODUCED BY DJ1 AND DJ2 BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF 10°. ANGLE BETWEEN DJ1-DJ2 TRACE AND DJ3-DJ4 TRACE IS 90° ± 3°.

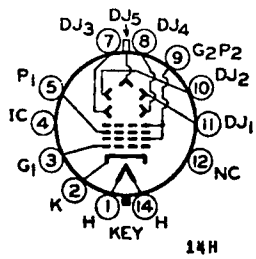
WITH DJ1 POSITIVE WITH RESPECT TO DJ2, THE SPOT IS DEFLECTED TOWARD PIN 5; WITH DJ3 POSITIVE WITH RESPECT TO DJ4, THE SPOT IS DEFLECTED TOWARD PIN 2.

NOTE 1: CAP MAY BE ECCENTRIC WITH RESPECT TO TUBE AXIS BY 1/16" MAX.
NOTE 2: LINE AA' IS PERPENDICULAR TO THE AXIS OF THE TUBE AND INTERSECTS THE FACE CONTOUR 5/16" FROM CENTER OF FACE.

Small Ball Cap



Bottom View of Socket Connections

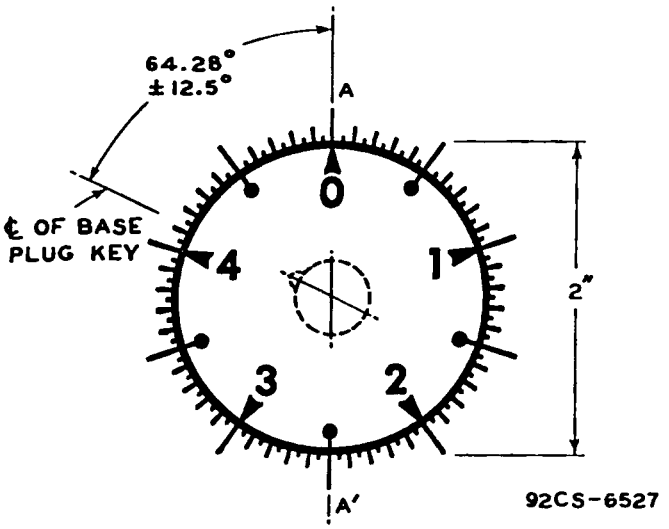


PIN 1: HEATER
PIN 2: CATHODE
PIN 3: GRID NO.1
PIN 4: INTERNAL CONNECTION; DO NOT USE
PIN 5: ANODE NO.1
PIN 7: DEFLECTING ELECTRODE DJ3
PIN 8: DEFLECTING ELECTRODE DJ4
PIN 9: ANODE NO.2 & GRID NO.2
PIN 10: DEFLECTING ELECTRODE DJ2
PIN 11: DEFLECTING ELECTRODE DJ1
PIN 12: NO CONNECTION
PIN 14: HEATER
CAP: DEFLECTING ELECTRODE DJ5

3DP1S2-A
CATHODE-RAY TUBE

RCA-3DP1S2-A is identical with RCA-3DP1-A except for the addition of an external scale to the screen end of the tube. This scale identified as S2 is illustrated below.

S2 SCALE



Trace produced by deflecting electrodes DJ1 and DJ2 is along line A-A'.

Scale may be eccentric with respect to the tube axis by 3/64".

The line through the zero and the center of the scale may vary from the line A-A' by 2.5° (measured about the tube axis).

from RMA release # 423, Aug. 15, 1945

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RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

3DP1S2-A-5-45
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3FP7-A

CATHODE-RAY TUBE

Electrostatic Focus
Electrostatic Deflection

Combination Long- and Short-Persistence Screen

10 Inches Long
3-Inch Bulb

RCA-3FP7-A is a cathode-ray tube of the electrostatic deflection and electrostatic focus type having a fluorescent screen two and one-half inches in diameter. The tube has a supplementary high-voltage anode which permits increasing the brightness of the fluorescent spot. The trace produced fluoresces a blue-white color which subsides immediately leaving a yellow long-persistence phosphorescence. Its brightness, while much lower than that of the fluorescence, is considerably higher than that of screens previously available. The difference in the colors of the fluorescence and the phosphorescence permits the use, by means of color filters, of the tube in applications requiring either a short or a long persistence characteristic.

The 3FP7-A employs an improved electron gun for projecting the electron beam onto the fluorescent screen. The improved gun provides sharper focus of the beam and is designed so that its anode No.1 takes essentially no current. This feature permits the use of a bleeder system requiring very little current and, consequently, a smaller filter capacitance. As a result of the extremely small anode-No.1 current, variation in focus which may otherwise take place with change in beam current is minimized.

The 3FP7-A is recommended for use in oscillographic applications where the features of the P7 screen are advantageous, and where the inertialess character of the electron beam, electrostatic deflection, and a brilliant image of the phenomena under observation are of importance.

RCA-3FP7-A supersedes RCA-3FP7.

DATA

General:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3	±10%	Volts
Current	0.6		Ampere
Direct Interelectrode Capacitances (Approx.):			
Grid No.1 to All Other Electrodes	8.5		μμf
Cathode to All Other Electrodes	8.0		μμf
DJ1 to DJ2	2.0		μμf
DJ3 to DJ4	2.0		μμf
DJ1 to All Other Electrodes	8.0		μμf
DJ3 to All Other Electrodes	6.0		μμf
DJ1 to All Other Electrodes except DJ2	6.0		μμf
DJ2 to All Other Electrodes except DJ1	5.0		μμf
DJ3 to All Other Electrodes except DJ4	4.0		μμf
DJ4 to All Other Electrodes except DJ3	6.0		μμf
Phosphor			No.7
Fluorescence			Blue-white
Phosphorescence			Yellow
Persistence			Combination Long and Short
Focusing Method			Electrostatic
Deflection Method			Electrostatic
Deflecting-Electrode Arrangement			See *Outline Drawing*
Overall Length			10" ± 1/4"
Greatest Diameter of Bulb			3" ± 1/16"
Minimum Useful Screen Diameter			2-1/2"
Cap			Recessed Small Ball
Base			Medium Shell Diheptal 12-Pin
Mounting Position			Any

Maximum Ratings, *Absolute Values*:

ANODE-No.3 VOLTAGE	4400 max.	Volts
ANODE-No.2 & GRID-No.2 VOLTAGE	2200 max.	Volts
RATIO of ANODE-No.3 VOLTAGE to ANODE-No.2 VOLTAGE	2.3:1 max.	
GRID-No.1 (CONTROL ELECTRODE) VOLTAGE:		
Negative Value	200 max.	Volts
Positive Value	0 max.	Volts
PEAK VOLTAGE BETWEEN ANODE-No.2 and ANY DEFLECTING ELECTRODE	550 max.	Volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	Volts
Heater positive with respect to cathode	10 max.	Volts

Typical Operation:

Anode-No.3 Voltage**	2000	3000	4000	Volts
Anode-No.2 & Grid No.2 Voltage***	2000	1500	2000	Volts
Anode-No.1 Voltage for Focus at 75% of Grid-No.1 Volt. for Cutoff#	575	430	575	Volts
Grid-No.1 Voltage for Visual Cutoff##	-60	-45	-60	Volts
Max. Anode-No.1 Current Range▲	Between -50 and +10			μamp.
Deflection Sensitivity:				
DJ1 and DJ2	0.127	0.135	0.102	mm/volt dc
DJ3 and DJ4	0.172	0.188	0.141	mm/volt dc
Deflection Factor:###				
DJ1 and DJ2	200	188	250	volts dc/in.
DJ3 and DJ4	148	135	180	volts dc/in.

** It is recommended that for high-speed scanning, anode-No.3 voltage should not be less than 3000 volts.

*** Brilliance and definition decrease with decreasing anode-No.2 voltage. In general, anode-No.2 voltage should not be less than 1500 volts.

Individual tubes may require between -20% and +35% of values shown with grid-No.1 voltage between zero and cutoff.

Visual extinction of stationary focused spot. Supply should be adjustable to ±50% of these values.

Individual tubes may vary from these values by ±20%.

▲ See curve for average values.

Spot Position:

The undeflected focused spot will fall within a 12-mm square centered at the geometric center of the tube face and having one side parallel to the trace produced by DJ1 and DJ2. Suitable test conditions are: anode-No.3 volts, 4000; anode-No.2 volts, 1500; anode-No.1 volts, adjusted for focus; deflecting-electrode resistors, 1 megohm each, connected to anode No.2; the tube shielded from all extraneous fields. To avoid damage to the tube, grid-No.1 voltage should be near cutoff before application of any anode voltages.

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	Megohms
Impedance of Any Deflecting-Electrode Circuit at Heater-Supply Frequency	1.0 max.	Megohm
Resistance in Any Deflecting-Electrode Circuit□	5.0 max.	Megohms

□ It is recommended that the deflecting-electrode circuit resistances be approximately equal.

INSTALLATION and APPLICATION

The *base* pins of the 3FP7-A fit the 12-pin diheptal socket which may be installed to hold the tube in any position. The socket alone, however,

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should not be used to support the tube. Other support, such as a yoke or saddle arrangement, should be used near the screen end of the tube. The socket should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The *bulb* should be enclosed in a grounded shield made of high permeability metal having low residual magnetism in order to minimize the effects of extraneous magnetic fields. When a grounded metal shield is used around the tube, it may be necessary to insulate the tube from the shield to avoid the effects of corona or leakage currents.

The *heater* is designed to be operated at 6.3 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage between heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage. The mid-tap or one side of the heater winding should preferably be connected to the cathode. If necessary, the heater may be operated with a bias of not more than -125 volts or +10 volts with respect to the cathode.

The *cathode* is connected to base pin 2 to which the grid and anode circuit returns should be made.

The *fluorescent screen* employs phosphor No.7 which fluoresces blue-white and phosphoresces light yellow. After excitation, the fluorescence drops rapidly to a small fraction of its initial value; after this initial period, the rate of decay of the phosphorescence is relatively low and, therefore, the yellow pattern remains visible for several minutes. In the case of recurrent phenomena of short duration, a yellow filter such as Wratten No. 15 can be used to greatly reduce the fluorescent flashes. The P7 phosphor may also be used with a blue filter such as Wratten No.47A to suppress the yellow phosphorescence and, thereby, to obtain a relatively short-persistence pattern.

The *dc voltages* for the grid and the three anodes may be obtained conveniently from a high-voltage vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage-doubler type. The Typical Oscillograph Circuit shown indicates a voltage doubler as the recommended type of circuit. Likewise, the filter requirements are simple. A 0.1 μf capacitor will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended. If the electrode voltages are obtained from a bleeder circuit, a bleeder current of about 0.2 milliampere usually is satisfactory. Considerably higher values may require more filtering than that provided by a single capacitor shunted across the dc supply.

In most applications, it is recommended that anode No.2 be grounded in order that the deflecting electrodes may be operated at ground potential. With this method, the cathode and heater are at high negative potential with respect to ground; when anode No.3 is operated at a higher positive potential than that of anode No.2, anode No.3 is at high positive potential with respect to ground. This is a desirable arrangement because, for a given anode-No.3 potential, the voltage to ground is reduced about one-half as compared with operation where the cathode is at ground potential.

Anode No.3 should be operated at or above the potential of anode No.2. Operation with a lower potential or without an applied potential is not recommended; operation with anode-No.3 potential below that of anode No.2 should never be permitted for even a short time as the screen will be darkened permanently. Application of anode-No.3 potential above that of anode No.2 provides acceleration of the electron beam after deflection and a more brilliant fluorescent spot than is obtained with anode No.3 at the potential of anode No.2. Under these conditions, also, there is a reduction of deflection sensitivity as may be seen by comparison of the first and third columns under TYPICAL OPERATION.

The high voltages at which the tube is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is required. In most applications, it is recommended that the anode No.2 terminal be grounded rather than the cathode terminal. With this method, which places the cathode and heater at high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit due to capacitor breakdown or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged capacitors grounded.

Focusing of the fluorescent spot produced by the electron beam is controlled by adjustment of the ratio of anode-No.2 voltage to anode-No.1 voltage. Ordinarily, the ratio is adjusted by variation of anode-No.1 voltage. For this purpose, a potentiometer is required in the bleeder circuit; the necessary range of adjustment is indicated under TYPICAL OPERATION.

Regulation of spot brilliance can be accomplished by varying the current to anode No.3. This current can be increased by decreasing the bias voltage applied to the control electrode. An increase in this current increases the spot.

size and the quantity of light. To obtain the smallest spot, a slight readjustment of focus may be necessary. An increase in the voltage applied to anode No.2 increases the beam current and the sharpness of focus and, therefore, the spot brilliance. Likewise, as discussed in an earlier paragraph, an increase in the voltage applied to anode No.3 increases the brilliance of the spot.

In applications involving extremely accurate measurements, the anode-No.2 and anode-No.3 currents should be reduced to the minimum consistent with the desired brilliance of the pattern. In cases where high brilliance is an important consideration, the voltage applied to the high-voltage anodes may be increased to the maximum rated values with due consideration to line-voltage variations. This procedure, however, is not always desirable since it results in reduced deflection sensitivity.

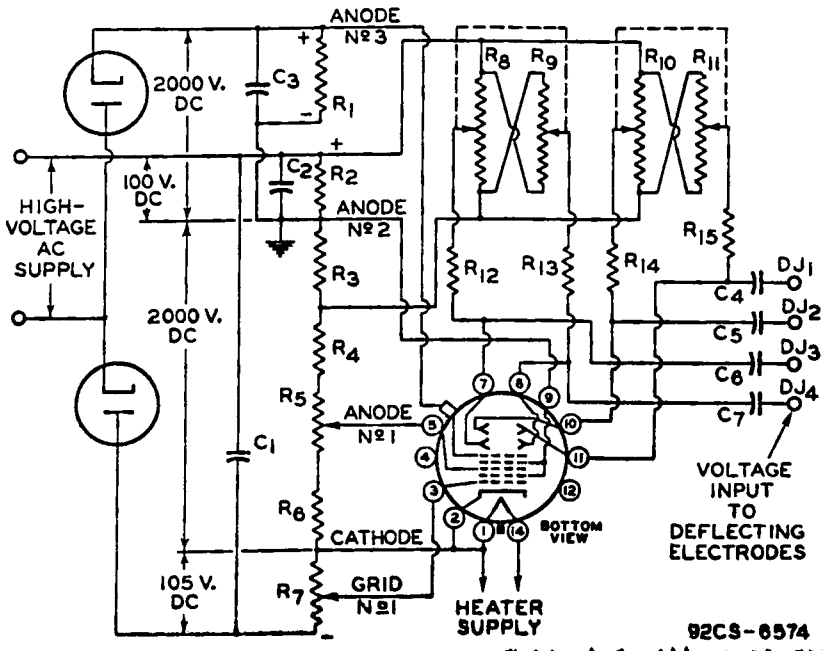
It is important to note that a high-intensity spot will burn the screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the spot be kept in motion over a reasonably large area or the beam current should be reduced.

Two pairs of *electrostatic electrodes*, producing fields at right angles, are located within the bulb neck to provide for deflection of the electron beam. The electrostatic field of each pair of deflecting electrodes causes deflection of the beam in the direction of the gradient lines of the field and perpendicular to the plane of the deflecting electrodes; therefore, the deflections caused by the two fields are at right angles. Each set of deflecting electrodes should be maintained essentially at the dc potential of anode No.2. To do this, each electrode of each set should be connected through a resistor of not more than 5 megohms to the anode-No.2 socket terminal (ordinarily at ground potential). This arrangement permits a choice of resistor values such that the electron beam is not distorted by dc potentials built up on the deflecting electrodes. If, during operation, the zero axes should shift, it usually is because the beam current is too high for the resistor value used. When it is necessary to use a high value of beam current, as when photographs are taken, the value of the deflecting-electrode resistors should be reduced to minimize the shift of the zero axes.

The deflection sensitivities and the deflection factors for each pair of deflecting electrodes for typical anode-No.2 voltages are given under TYPICAL OPERATION.

Photographs of the phenomena appearing on the viewing screen can be made with an ordinary camera. The photographing is done preferably in complete darkness in order to obtain as much contrast as possible between the fluorescent pattern and the screen. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, and the brightness of the pattern. Where transients are to be photographed, maximum brightness may be required because of the short duration of the phenomena; where recurrent wave forms are to be photographed, patterns having low brightness can be compensated for by longer exposure. The use of emulsions having high green sensitivity is recommended; orthochromatic types of film and high-speed films have been found to give excellent results.

For high-speed photographic work involving non-recurrent phenomena, it is permissible to



Typical Oscillograph Circuit

C1: 0.1 μf
C2: 1.0 μf
C3: 0.1 μf
C4 C5 C6 C7: 0.05-μf Blocking Capacitors*
R1: 50 Megohms
R2 R3: 2 Megohms
R4: 5.5 Megohms
R5: 2-Megohm Potentiometer
R6: 1.5 Megohms
R7: 0.5-Megohm Potentiometer
R8 R9: Dual 5-Megohm Potentiometer
R10 R11: Dual 5-Megohm Potentiometer
R12 R13 R14 R15: 2 Megohms

* When cathode is grounded, capacitors should have high voltage rating; when anode No.2 is grounded, they may have low voltage rating. For dc amplifier service, deflecting electrodes should be connected direct to amplifier output. It is preferable usually to remove deflecting-electrode resistors to minimize loading effect on amplifier. In order to minimize spot defocusing, it is essential that anode No.2 be returned to a point in the amplifier system which will give the lowest possible potential difference between anode No.2 and the deflecting electrodes.

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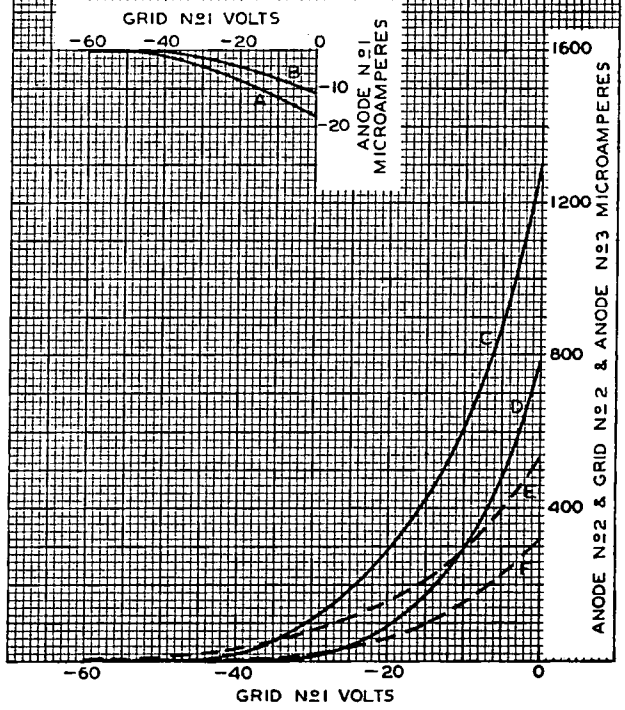
increase the trace brightness, for the short interval required to make the exposure, above that required for visual observation. The extent to which the anode current may be increased without harming the screen is proportional to the velocity of beam travel and pattern size, and an inverse function of the duration of the phenomena. Short-interval operation at increased current can be obtained by means of a temporary decrease in the grid-No.1 voltage. A switching arrangement should be provided to switch the grid-No.1 voltage rapidly between a negative and a less negative value. The exposure is made while the grid-No.1 voltage is at the less negative value.

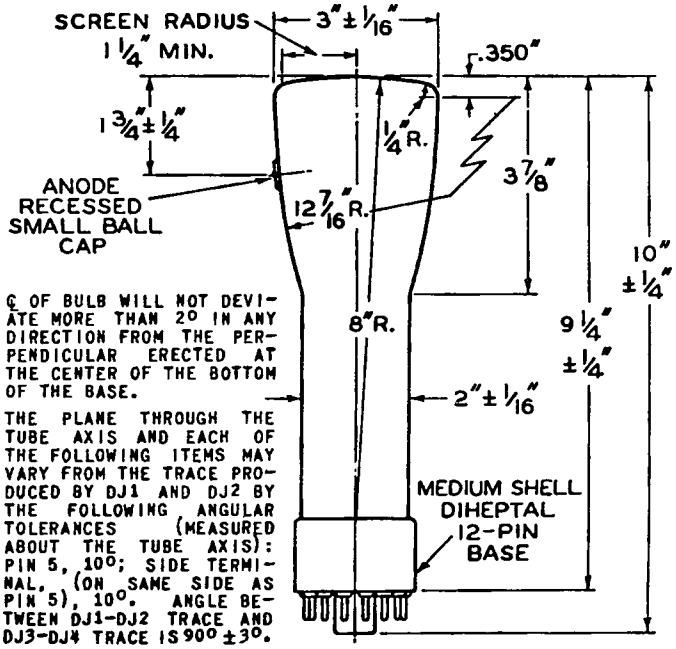
AVERAGE CHARACTERISTICS

E_f = 6.3 VOLTS
ANODE N°1 VOLTS ADJUSTED TO GIVE FOCUS

CURVE	ELECTRODE CURRENT	ANODE N°2 & GRID N°2 VOLTS	ANODE N°3 VOLTS
A	ANODE N° 1	2000	4000
B	ANODE N°1	1500	3000
C	ANODE N° 2 & GRID N° 2	2000	4000
D	ANODE N° 2 & GRID N° 2	1500	3000
E	ANODE N° 3	2000	4000
F	ANODE N° 3	1500	3000



92CM-6421R1



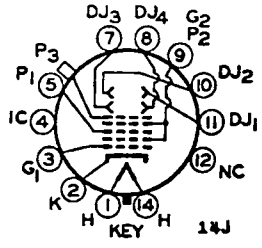
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF THE BOTTOM OF THE BASE.

THE PLANE THROUGH THE TUBE AXIS AND EACH OF THE FOLLOWING ITEMS MAY VARY FROM THE TRACE PRODUCED BY DJ1 AND DJ2 BY THE FOLLOWING ANGULAR TOLERANCES (MEASURED ABOUT THE TUBE AXIS): PIN 5, 10°; SIDE TERMINAL, (ON SAME SIDE AS PIN 5), 10°. ANGLE BETWEEN DJ1-DJ2 TRACE AND DJ3-DJ4 TRACE IS 90° ± 3°.

WITH DJ1 POSITIVE WITH RESPECT TO DJ2, THE SPOT IS DEFLECTED TOWARD PIN 5; WITH DJ3 POSITIVE WITH RESPECT TO DJ4, THE SPOT IS DEFLECTED TOWARD PIN 2.

92CM-6405R2

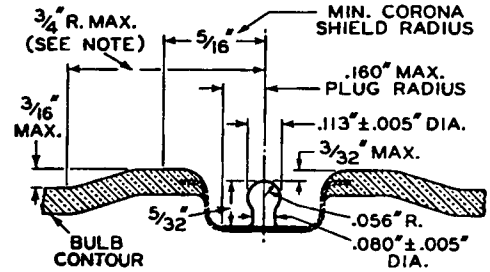
Bottom View of Socket Connections



PIN 1: HEATER
PIN 2: CATHODE
PIN 3: GRID NO.1
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: ANODE NO.1
PIN 7: DEFLECTING ELECTRODE DJ3
PIN 8: DEFLECTING ELECTRODE DJ4
PIN 9: ANODE NO.2 and GRID NO.2
PIN 10: DEFLECTING ELECTRODE DJ2
PIN 11: DEFLECTING ELECTRODE DJ1
PIN 12: NO CONNECTION
PIN 14: HEATER
CAP: ANODE NO.3

DETAILS OF RECESSED SMALL BALL CAP & BULB ASSEMBLY

ESSENTIAL DIMENSIONS FOR CONNECTOR DESIGN



NOTE: PROTRUSION OF GLASS AROUND CAP ABOVE BULB CONTOUR IS LIMITED TO AREA BOUNDED BY CIRCLE CONCENTRIC WITH CAP AXIS AND HAVING RADIUS OF 3/4" MAX.

92CS-6535R2

U.S. RESTRICTED

3HP7

HIGH-VACUUM CATHODE-RAY TUBE

Heater	Coated Unipotential Cathode	
Voltage	6.3	a-c or d-c volts
Current	0.6	amp.
Focusing Method		Magnetic
Deflection Method		Magnetic
Maximum Solid Deflection Angle		55 Degrees
Phosphor		No.7
Direct Interelectrode Capacitances (Approx.):		
Grid No.1 to All Other Electrodes		8.0 μμf
Cathode to All Other Electrodes		6.5 μμf
Overall Length		9-13/16" ± 1/4"
Bulb Diameter at Screen End		3" ± 1/16"
Minimum Useful Screen Diameter		2-1/2"
Bulb Side Terminal		Snap Terminal
Base		Long Medium-Shell Octal 8-Pin
Deflection Yoke:		
Position		Flush with Bulb-Neck Reference Line (See *OUTLINE DRAWING*)
Working Length for 55° Angle Deflection		2 max. inches

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

Anode (High-Voltage Electrode) Voltage		5500 max.	volts
Grid No.2 (Accelerating Electrode) Voltage		220 max.	volts
Grid No.1 (Control Electrode) Voltage		Never positive	
D-C Heater-Cathode Potential*		125 max.	volts
Grid No.1 Circuit Resistance		1.5 max.	megohms
Typical Operation:			
Anode Voltage #	4000	5000	volts
Grid No.2 Voltage	150	150	volts
Grid No.1 Voltage for Visual Cut-Off ##	-30	-30	volts
Values subject to variation of	±50	±50	per cent

* with heater negative. If the cathode is not directly connected to the heater, the heater-cathode potential should be kept as low as possible.

\# Brilliance and definition decrease with decreasing anode voltage. In general, anode voltage should not be less than 4000 volts.

\## Visual extinction of stationary focused spot.

SPOT POSITION

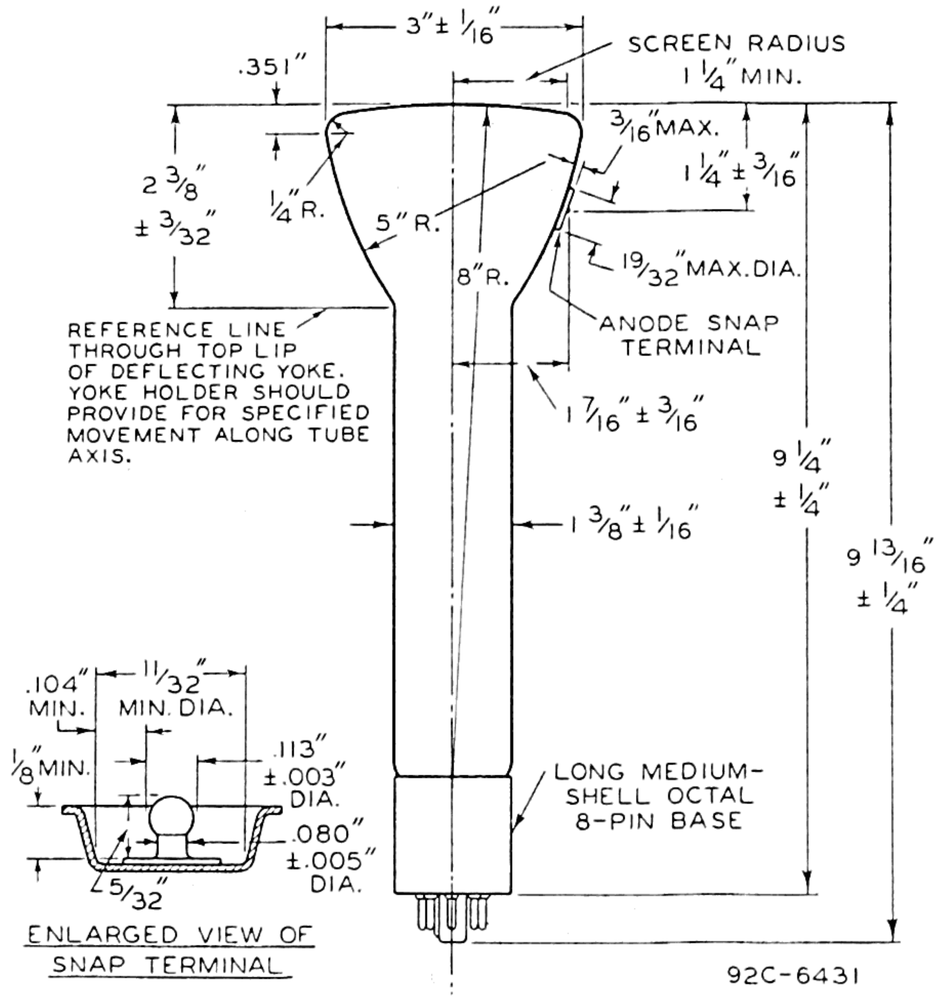
The undeflected focused spot will fall within a circle of 12-mm radius concentric with the tube face.

Suitable test conditions are: anode voltage, 4000 volts; spot unfocused; the tube shielded from all extraneous fields. To avoid damage to the tube, make the test with grid No.1 voltage near cut-off.

RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

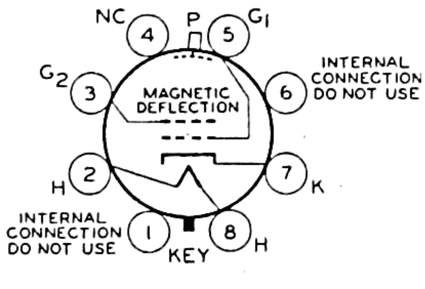
3HP7

HIGH-VACUUM CATHODE-RAY TUBE



THE PLANE THROUGH THE TUBE AXIS AND PIN 5 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND THE ANODE TERMINAL BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF 10°. ANODE TERMINAL IS ON THE SAME SIDE AS PIN 5.

TUBE MOUNTING POSITION: Any



5AN2

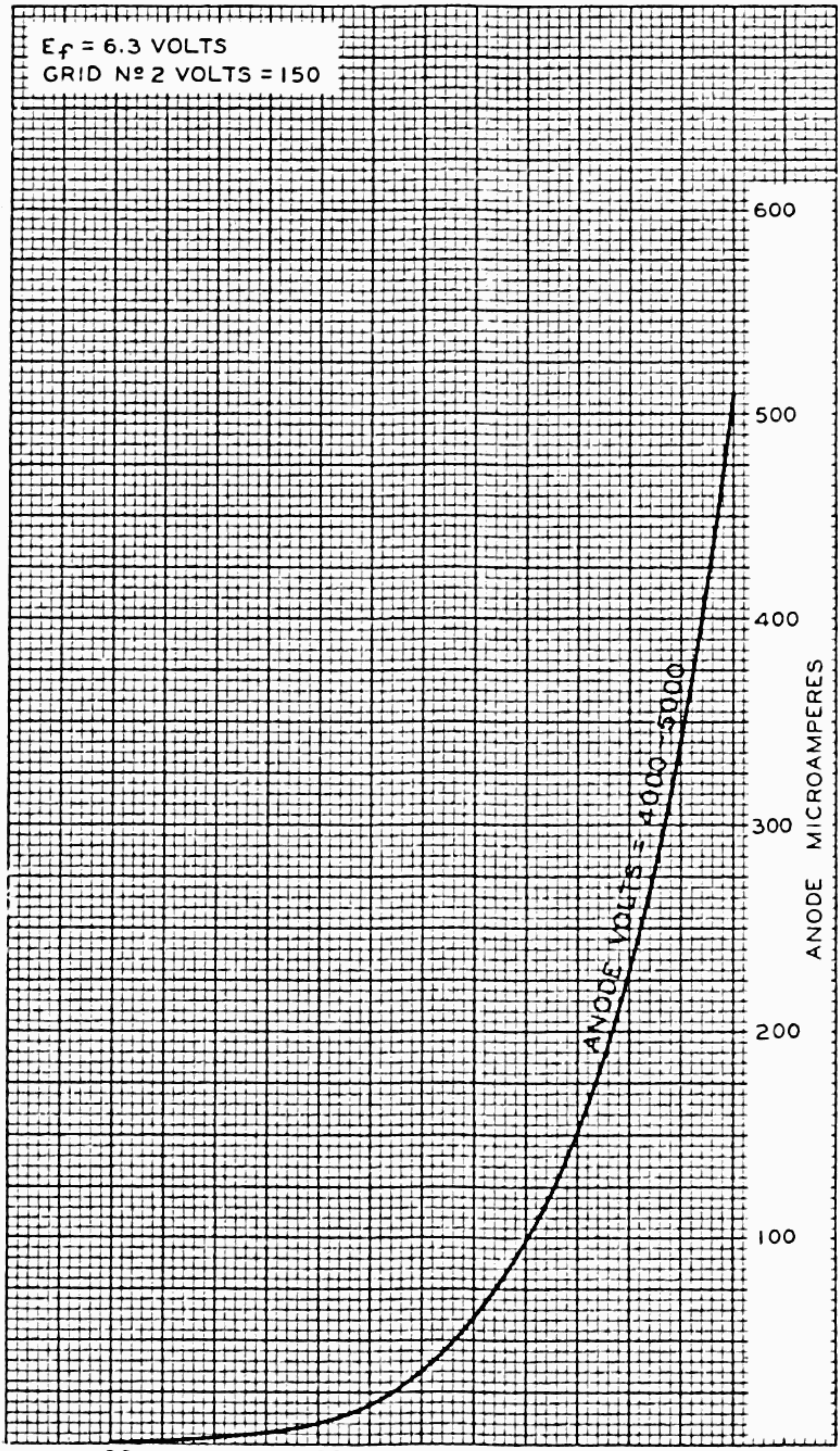
BOTTOM VIEW OF SOCKET CONNECTIONS

P = Anode
G_2 = Grid No.2
G_1 = Grid No.1
H = Heater
K = Cathode
NC = No Connection

RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

3HP7

AVERAGE CHARACTERISTIC



JAN. 11, 1943

RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

92C-6432

Nov. 3, 1944

RMA Release # 390

U.S. CONFIDENTIAL

4AP10
SKIATRON

Magnetic Deflection | **4-Inch Bulb** | **Magnetic Focus**

The RCA-4AP10 is a special form of cathode-ray tube having a screen that absorbs light. When the screen is brightly illuminated, the trace caused by the electron beam absorbs light in the middle range of the visible spectrum, and thus produces a dark image on a white background. This image may then be projected onto a viewing screen by means of a reflection-optics system involving the Schmidt principle. The system must be designed for use with the tube. For use in this system, the 4AP10 has a high-quality polished face plate having accurate radii of curvature and four dots in the screen surface to facilitate accurate positioning of the screen in the optical system. The electron gun of the 4AP10 is so designed that the tube is capable of producing an unusually fine spot on the screen.

GENERAL

HEATER VOLTAGE (A.C. or D.C.)	6.3 ±10%	Volts
HEATER CURRENT	0.6	Ampere
FOCUSING METHOD	Magnetic	
DEFLECTION METHOD	Magnetic	
MAXIMUM SOLID DEFLECTION ANGLE	40	Degrees
PHOSPHOR	No.10	
Contrast	30	Per cent
Decay Ratio (Approx.) at 10 seconds	5	
DIRECT INTERELECTRODE CAPACITANCES:		
Grid No.1 to All Other Electrodes	8	μμf
Grid No.2 to All Other Electrodes	6	μμf
Cathode to All Other Electrodes	6	μμf
OVERALL LENGTH	14-3/4" ± 3/8"	
GREATEST DIAMETER of BULB	4-1/8"	
MINIMUM USEFUL SCREEN DIAMETER	3-5/8"	
FACE-PLATE RADIUS of CURVATURE	5.8" ± 0.2"	
CAP	Medium	
BASE	Long Medium-Shell Octal 8-Pin	
DEFLECTION YOKE:		
Location on Tube Neck	End flush with Reference Line (See *Outline Drawing*)	
Length of Field	3 *max.*	Inches
FOCUSING COIL:		
Location on Tube Neck	See *Outline Drawing*	

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

ANODE (High-Voltage Electrode) VOLTAGE	9900 *max.*	Volts
GRID No.2 (Accelerating Electrode) VOLTAGE	500 *max.*	Volts
GRID No.1 (Control Electrode) VOLTAGE RANGE	0 (never +) to -125 *max.*	Volts
D-C HEATER-CATHODE POTENTIAL*	125 *max.*	Volts
GRID No.1 CIRCUIT RESISTANCE	1.5 *max.*	Megohms
FACE-PLATE TEMPERATURE	90 *max.*	°C
TYPICAL OPERATION:		
Anode Voltage #	9000	Volts
Grid No.2 Voltage ##	300	Volts
Grid No.1 Voltage for Cut-off **	-45	Volts
Focusing-Coil Current (Approx.)***	100	Ma.

* With heater negative. Cathode should be connected to one side or mid-tap of heater-transformer winding.

** For anode current of 2 microamperes. Grid voltage should be adjustable between -30 and -60 volts.

*** For coil described in text and for anode and grid voltages as shown: electron-beam microamperes, 100; center of air-gap in focusing coil from reference line, 2-3/4". Value of coil current should be adjustable to ±15% of this value.

\# In general, anode voltage should not be less than 8000 volts.

\## The maximum beam current and grid No.1 voltage for cut-off decrease with decreasing grid No.2 voltage. In general, grid No.2 voltage should not be less than 250 volts.

SPOT POSITION

The center of the undeflected focused spot will fall on the screen within a circle of 4-mm radius concentric with the rotational axis. Suitable test conditions are: anode volts, 9000; grid No.2 volts, 300; the spot focused; the tube shielded from all extraneous fields. To avoid damage to the tube, grid No.1 voltage should be near cut-off before application of anode voltage.

INSTALLATION and APPLICATION

The *base* pins of the 4AP10 fit sockets whose contacts have the standard octal arrangement. The socket may be installed to hold the tube in any position. The socket alone, however, should not be used to support the tube; other support such as a yoke or saddle arrangement should be used at or near the screen end of the tube. Since this tube is part of a precision optical system, it is necessary to position the tube accurately and to hold it firmly in place.

Pins 1 and 6 are connected together to serve as a convenient means for operating an electrical interlock circuit to prevent application of tube voltages when the tube is not in the socket. The connection between pins 1 and 6 is insulated to withstand 250 volts rms from the other electrode leads and has a maximum current-handling capacity of one ampere.

The *bulb*, except for the screen face, should be enclosed in a shield made of high-permeability metal having low residual magnetism, if appreciable extraneous magnetic fields are present.

The *heater* is designed to be operated at 6.3 volts ±10 per cent. The transformer winding supplying the heater should be designed to operate the heater at the rated voltage under average line-voltage conditions. The mid-tap or one side of the heater should be connected to the cathode. If the circuit design is such as to cause a high voltage between heater and cathode, the voltage value should be limited to 125 volts (with heater negative).

The *cathode* is connected to base pin 7 to which the circuit returns should be made.

The *screen* of the 4AP10 employs phosphor No.10 which, when excited by electron bombardment, has

the characteristic of absorbing radiant energy in the middle range of the visible spectrum. With normal room illumination, phosphor No. 10 fluoresces with a faint blue light during bombardment by the electron beam. When the screen is brightly

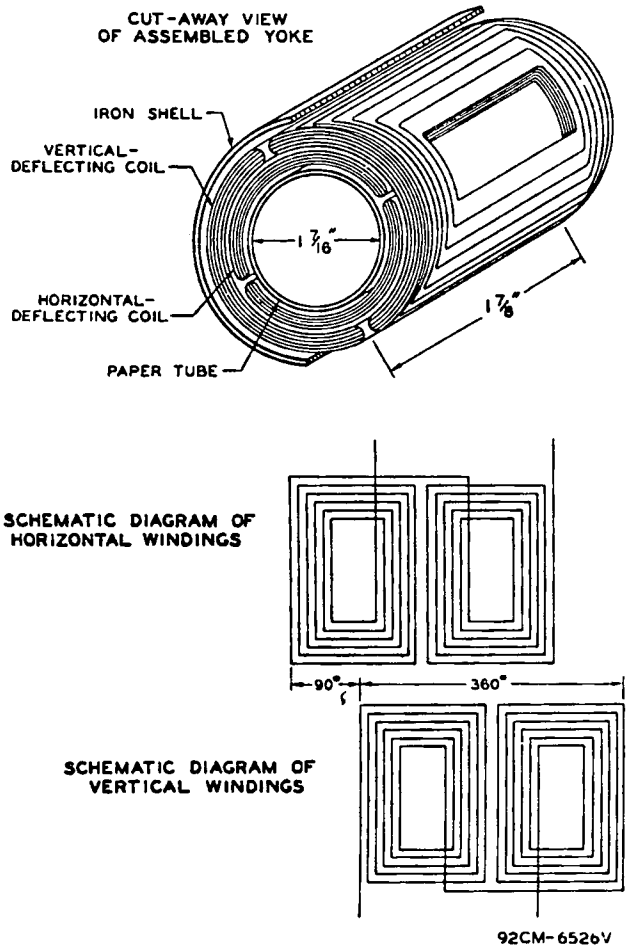


Fig. 1 - Wide-Angle Deflecting Yoke Assembly and Winding Scheme.

illuminated, the screen reflects light except in the path of the electron beam, and the resulting dark trace can be projected onto a viewing screen by means of an optical system. The tube is designed for use with a Schmidt-type optical system. A conventional lens system does not produce satisfactory results.

The degree and duration of darkening of the screen are dependent on several factors: screen temperature, amount of screen illumination, and duration and electron energy density of bombardment. The darkening under bombardment is approximately proportional to the electron energy density to the point where reflection is reduced to 30 per cent of the normal value obtained without bombardment. Electron energy density, in turn, is proportional to electron beam current and sharpness of focus. Bombardment will cause darkening which persists indefinitely unless intense illumination, elevated temperature, low-intensity electron bombardment, or a combination of these factors is utilized to make the darkening disappear. For normal operation, 8000 foot-candles at the screen from tungsten-filament sources and a face temperature of 60° ±10°C are suitable conditions. A supply of cooling air is required to maintain the temperature at this level. Heat filters between the light sources and the face of the tube may also be used.

The time required for the trace to disappear depends on the degree of darkening. Since under given conditions of illumination and temperature, darkening depends on the density and duration of electron bombardment, it follows that when rapid removal of the trace is needed the lowest beam

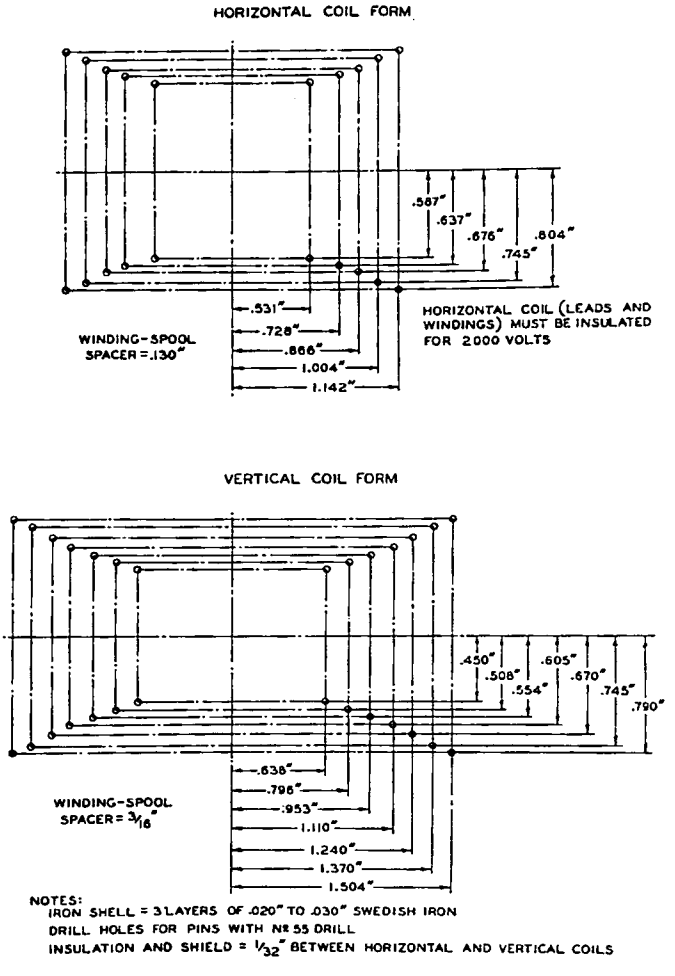


Fig. 2 - Coil Form Details of Wide-Angle Deflecting Yoke.

current should be used. With continued use, even under the conditions described, those sections of the screen subjected to repeated bombardment may show darkening which does not disappear during normal operation. This semi-permanent dark-

ening may be removed by either of two methods, or preferably a third method combining the two. First, the face temperature may be raised to about 125°C (never higher than 150°C) for about twenty minutes. This heating may be accomplished by reducing the flow of cooling air. Second, the darkening may be removed by scanning the screen with a slightly defocused spot. With this method, the beam current should be slightly less than that used in regular operation and, during the process, the beam current should be gradually reduced as the darkening disappears. Third, the two preceding methods may be combined for increased speed of removal. It is important to note that operation at high temperature reduces the sensitivity of the screen to darkening. For this reason, the total time of such high-temperature operation should be limited to about one and one-half hours during the useful life of the tube.

The degree of darkening of the screen in the path of the electron beam is termed the "contrast" and is given as a percentage. The contrast is defined as the ratio of the difference between the light reflected from the unexcited areas and that reflected from the excited areas to the light reflected from the unexcited areas.

Contrast as measured immediately following scanning of the screen is called "initial contrast." With intense illumination and elevated screen temperature, contrast fails after excitation. The ratio of the initial contrast to that measured at a later time is the decay ratio. In practice, the decay ratio after ten seconds is in the order of five. The decay ratio is increased, in general, by high temperature; however, care should be taken when the temperature is increased for the purpose of increasing the decay ratio because, as previously explained, operation at high temperature causes decreased sensitivity to darkening in normal operation. The decay ratio may also be controlled in operation by adjustment of the beam current since the increased darkening depends on electron beam density.

The bulb cone is coated externally with a dull black material to avoid the reflection of stray light which would reduce the contrast in the projected image. Care should be taken to avoid rubbing this coating since the material tends to polish and, therefore, to reflect light.

The *d-c voltages for the electrodes* may be obtained from a high-voltage, high-vacuum rectifier. Since the 4AP10 requires very small current, the rectifier system can be of either the half-wave or the voltage-doubler type. For the same reason, the filter requirements are simple. A 0.1 to 1 μf capacitor will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended. A small amount of voltage regulation in the anode supply acts to maintain sharp focus as the beam current is increased, since slightly more focusing-coil current is required with higher beam current. A regulation corresponding to that provided by an equivalent internal resistance of the rectifier system of one megohm gives good compensation. Such compensation is effective, in general, only for slow changes in current such as those determined by the time constant of the filter circuit. It should be noted, however, that variations in anode voltage cause changes in deflection sensitivity; therefore, better regulation may be required than that which produces the best focus compensation with changes in beam current.

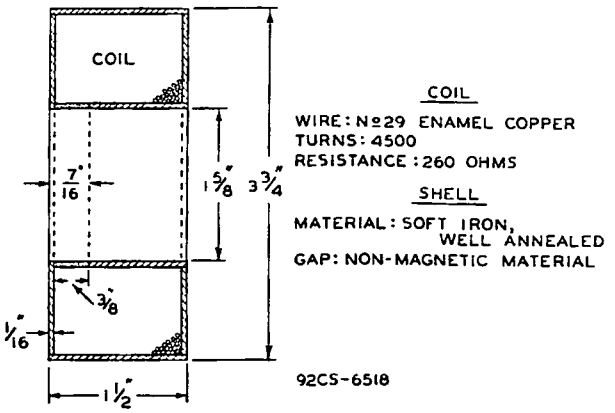


Fig. 3 - Focusing-Coil Details.

The current to grid No.2 is practically zero and, consequently, voltage for this electrode may be supplied from a high-resistance bleeder connected across the high-voltage power supply rather than from a separate low-voltage source.

If the electrode voltages are obtained from a bleeder circuit, a bleeder current of less than 0.5 milliampere usually is satisfactory. Considerably higher values may require the use of more filtering than that provided by a single capacitor shunted across the d-c supply. A variable d-c voltage for the control electrode (grid No.1) can be obtained from a potentiometer in the bleeder circuit. It may be more desirable in some cases to operate the control electrode at ground potential and to bias the cathode positive with respect to ground by means of the amplifier power supply.

A *d-c voltage from a well-regulated source* is required for the focusing coil. With the coil positioned as shown in the Outline Drawing, the coil current required for focus will be as shown under TYPICAL OPERATION. For other anode voltages than the one shown, the coil current will be proportional to the square root of the anode voltage. Provision should be made for adjusting the coil current over the specified range.

A *deflecting yoke* consisting of four electromagnetic coils may be employed for deflecting the electron beam. These coils are used in pairs; the coils of each pair, located diametrically opposite each other, produce fields of uniform

flux density. The axes of the two fields ordinarily intersect at right angles to each other and to the tube axis. The deflection of the electron beam is at right angles to the magnetic fields. By the use of two pairs of coils at right angles the beam may be deflected to any part of the screen. A deflecting yoke designed for wide-angle deflection is shown in Figs. 1 and 2. The yoke should be placed as close as possible to the junction of the bulb neck and the bulb flare (reference line). This yoke is designed so that deflection of the beam is accomplished in the axial space of not more than two inches. If desired, a yoke designed for a narrower deflection angle (maximum solid angle of 40°) may be used. A yoke of this kind with construction similar to that described will have a maximum length of three inches. A long yoke will have greater deflection sensitivity but the focusing coil will be closer to the electron gun, and thus the spot size will be slightly larger.

A *focusing coil* is required to concentrate the electron stream into a focused spot at the screen. Design data for a coil which may be used with the 4AP10 are shown in Fig. 3. This coil is cylindrical and has an air gap of short axial length. The coil should be spaced from the deflecting yoke to reduce interaction between the focusing and deflecting fields. A space of approximately one-half inch should be left between the yoke and the coil. The recommended position of the focusing coil on the tube is indicated in the Outline Drawing. This location is shown in terms of the axial distance from the reference line to the center of the focusing-coil gap. Further information on the focusing coil is given in the paragraph on *focusing*.

The coil described has been used to provide a standard focus current test; other designs may be required for specific equipments. In general, it will be desirable to keep the overall diameter within four inches to avoid cutting off part of the light in the optical system.

The coil shell should be made of soft iron. The face pieces of the shell should be well annealed. When the material is rolled in manufacture, a non-uniform magnetic characteristic may be introduced. If, in assembly of the coil shell, the two face pieces are oriented so that their directions of rolling are aligned, distortion of the pattern may result from lack of symmetry of the magnetic field. It is desirable, therefore, to cut the face pieces from a single sheet of material and to rotate one piece 90° with respect to the other when they are assembled.

The high voltages at which the 4AP10 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions must include safeguards which definitely eliminate all hazards to personnel. All circuit parts which may be at high potential should always be enclosed and interlock switches should be used to break the primary circuit of the high-voltage power transformer when access to the equipment is required.

In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit because of capacitor breakdown or incorrect circuit connections. Before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged capacitors grounded.

Focusing of the spot produced by the electron beam is controlled by adjustment of the strength of the focusing-coil magnetic field. This adjustment is accomplished by control of the current through the coil. The value of this current depends on the position of the coil with respect to the electron gun and the screen, the construction of the coil itself, and the operating conditions of the tube. In general, the focusing coil should be as far as practical above the electron gun in order to obtain a small-sized spot. On the other hand, if the focusing coil is too close to the deflecting fields, interaction may cause distortion of the pattern. A space of approximately one-half inch between the focusing coil and the deflecting yoke is recommended.

Four dots are located in the screen surface of the 4AP10 to assist in accurately positioning the surface in the reflection-optics system. The position of the tube is adjusted, by tilting or decentering the tube, in order to make the spherical screen surface concentric with that of the lens mirror. The correct position is indicated by equally sharp focus for all four dots. During this adjustment, the screen surface should be illuminated as for normal operation but it is not necessary to apply voltages to the tube. This feature permits adjustment without danger of accidental contact with the high voltage. When the four dots have been brought into focus, a slight axial adjustment of the tube may be necessary to obtain the best average focus over the whole screen face.

It is convenient in aligning the tube to provide for movement of the tube in the directions of the two pairs of opposite dots; a three-point or universal-joint support is less desirable in this respect. Provision should also be made for tilting the tube about its face as a center or for decentering the tube axis with respect to the mirror.

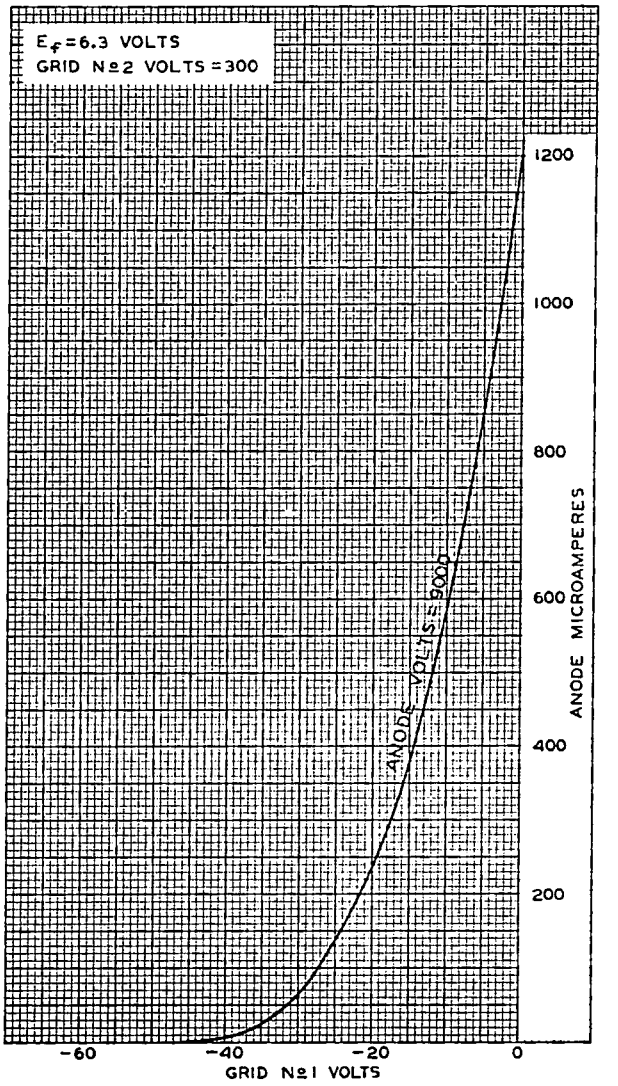
Centering of the spot on the screen should preferably be done by passing a d-c current through each pair of deflecting coils. Separate coils may also be used; the location of such centering coils is subject to the same considerations as those applying to the deflecting coils. The movement of the spot is at right angles to the axis of each pair of coils. An alternate method of centering the spot over small distances

is to skew the focusing coil on the tube neck, but this method is likely to introduce distortion.

Regulation of spot size and intensity can be accomplished by varying the focus and anode current, respectively. The current to the anode may be increased by decreasing the bias applied to grid No.1. Over the grid No.1 voltage range between zero and cut-off, the beam current increases with grid No.2 voltage. Grid No.2 can be used as a control electrode, if desired. An increase in the voltage applied to grid No.2 increases the maximum obtainable beam current and increases the grid No.1 voltage for cut-off. The grid No.1 voltage for cut-off is increased in direct proportion to the increase in grid No.2 voltage. The tube may be operated at lower anode and grid No.2 voltages than the recommended values but contrast and definition decrease with decreasing voltages. Minimum recommended anode and grid No.2 voltages are shown under TYPICAL OPERATION. When any of these voltages are adjusted, consideration should be given to the absolute MAXIMUM RATINGS.

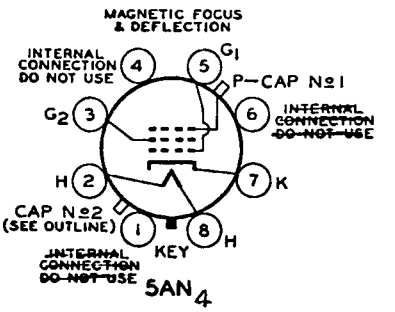
It is important to note that a high-intensity spot will burn the screen if the spot is allowed to remain stationary or if the beam travels slowly over the screen. To prevent this possibility, the spot should be kept in motion constantly or the beam current should be reduced. It is possible in some cases to recondition the screen by methods described in the paragraph under *screen*. Such treatment requires great care because of the possibility of permanent damage to the screen material.

AVERAGE CHARACTERISTIC



92CM-6517RI

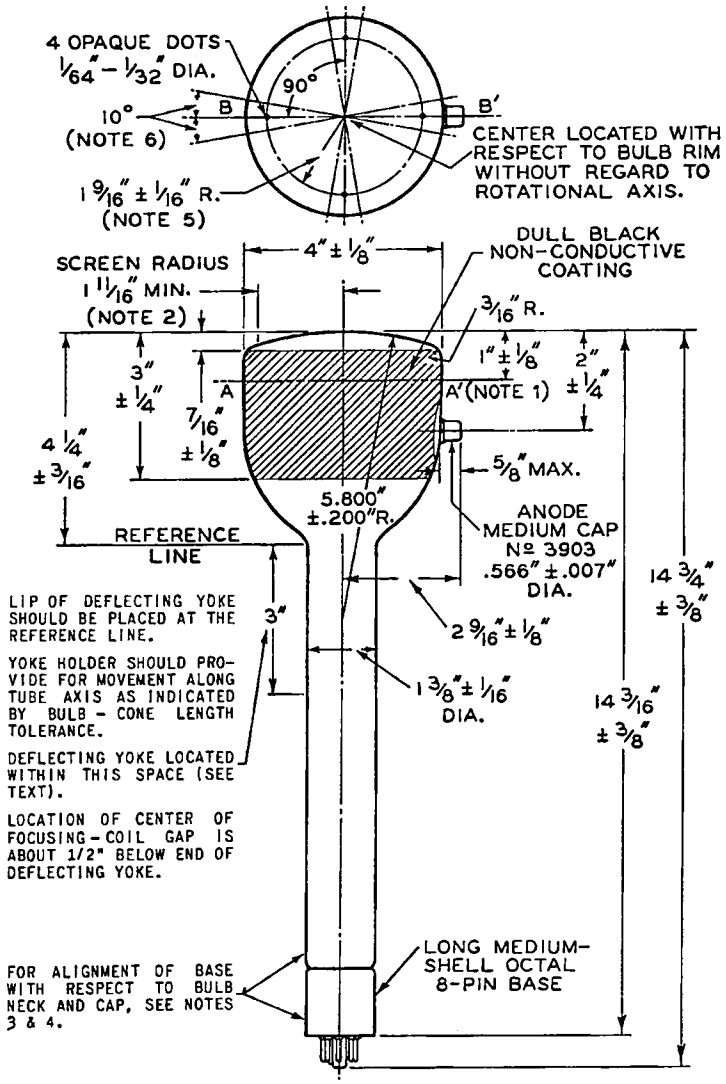
Bottom View of Socket Connections



5AN4

P – ANODE
G_2 – GRID NO.2
G_1 – GRID NO.1
K – CATHODE
H – HEATER
~~J – JUMPER~~

JUMPER CONNECTED WITHIN BASE BETWEEN PINS 1 & 6



92CM-6455RI

AS USED BELOW, "REFERENCE LINE," "ROTATIONAL AXIS," AND "FACE TILT" HAVE THE FOLLOWING DEFINITIONS:

a. REFERENCE LINE IS DETERMINED BY POSITION WHERE GAUGE 1.430" ± 0.003" I.D. AND 2" LONG WILL REST ON BULB CONE.

b. ROTATIONAL AXIS IS DETERMINED BY ROTATING BULB NECK IN TWO SETS OF "VEE WHEELS," ONE SET OF WHICH IS POSITIONED ON NECK 1/2" ± 1/4" FROM THE REFERENCE LINE, AND THE OTHER IS SPACED ALONG NECK 7" FROM THE FIRST.

c. FACE TILT IS VARIATION OF THE DISTANCE FROM ANY OUTSIDE PERIPHERAL POINT OF THE 1-11/16" RADIUS CIRCLE ON THE FACE PLATE TO A PLANE OUTSIDE THE TUBE AND NORMAL TO THE ROTATIONAL AXIS.

NOTE 1 – ECCENTRICITY OF BULB AT LINE AA' WITH RESPECT TO ROTATIONAL AXIS DOES NOT EXCEED ± 1/8".

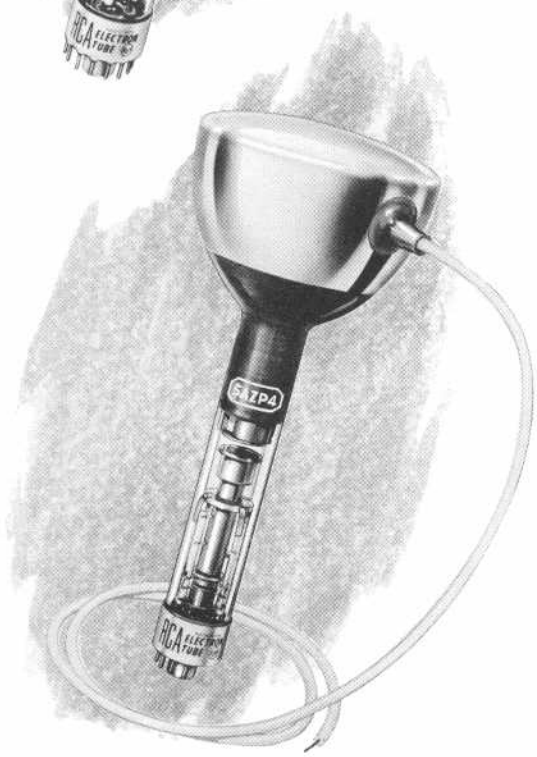
NOTE 2 – FACE TILT DOES NOT EXCEED 0.050".

NOTE 3 – BASE AND BULB NECK WILL PASS THROUGH GAUGE 7" LONG AND 1.469" ± 0.003" I.D.

NOTE 4 – PLANE THROUGH ROTATIONAL AXIS AND PIN 5 MAY VARY FROM THE PLANE THROUGH ROTATIONAL AXIS AND ANODE CAP BY 10°. PIN 5 IS ON SAME SIDE OF TUBE AS ANODE CAP.

NOTE 5 – RADIAL POSITIONS OF THE 4 DOTS ARE GIVEN WITH RESPECT TO CENTER OF BULB RIM AND WITHOUT REGARD TO CENTER ESTABLISHED BY ROTATIONAL AXIS.

NOTE 6 – ANGULAR VARIATIONS OF DOTS ARE MEASURED FROM QUADRANT LINES INTERSECTING AT BULB-RIM CENTER AND WITH QUADRANT LINE BB' LOCATED AT ANODE-CAP POSITION.



RCA Type	Description△
PROJECTION KINESCOPES ⊕	
5AZP4	5″ electrostatic-focus, magnetic-deflection type. Provides an 8′ by 6′ picture. Integral flexible ultor lead. Small-shell duodecal 7-pin base.††
7NP4	Similar to 7WP4 except provides a 20′ by 15′ picture at a projection-throw distance of about 60′.@
7WP4	7″ electrostatic-focus, magnetic-deflection type. Intended for theater-television use. Provides a 20′ by 15′ picture at a projection-throw distance of about 80′. Medium cap. Small-shell diheptal 14-pin base.@
MONOSCOPES	
2F21	5″ electrostatic-focus, magnetic-deflection type with Indian Head Pattern. For supplying signal to test video performance of television transmitters and receivers. Two recessed small ball caps. Long medium-shell small 6-pin base.
1699	Custom-built type like the 2F21 except that its pattern is individually styled to customer requirements.

△ Unless otherwise specified, all of these types have electrostatic focus and deflection and a heater rating of 6.3 volts and 0.6 amp.

†† Heater rating: 6.3 volts, 0.6 amp.

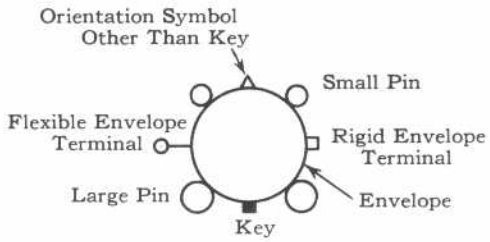
⊕ For information on picture tubes used in television broadcast receivers, see RCA booklet 1275-H (RCA Receiving Tubes and Picture Tubes).

@ Heater rating: 6.6 volts, 0.62 amp.

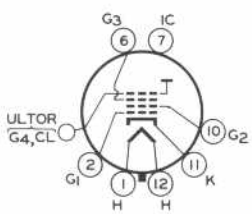
KEY TO BASE AND ENVELOPE CONNECTION DIAGRAMS

Diagrams show terminals viewed from the base end of the type

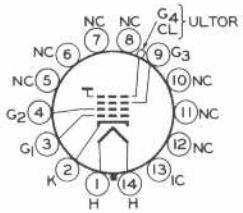
BE = Backing Electrode
C = External Conductive Coating
C_b = Balancing Capacitance
CL = Collector
DJ = Deflecting Electrode
DY = Dynode
G = Grid
H = Heater
IC = Internal Connection —Do Not Use
K = Cathode
NC = No Connection
P = Anode
PC = Photocathode
PJ = Pattern Electrode
SHJ = Shading Electrode
SJ = Signal Electrode
SS = Storage Surface
U = Unit
• = Gas-Type Tube



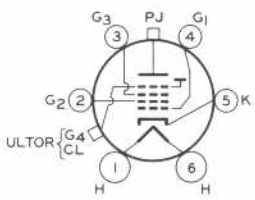
Lambda (λ) indicates that the primary characteristic of the element is designed to vary under the influence of light.



5AZP4



7NP4 7WP4



2F21 1699

Maximum Dimensions		Min. Useful Screen Diam.	Maximum Ratings♦♦					Operating Conditions					RCA Type
Overall Length inches	Envelope Diam. inches	inches	Final High-Voltage Electrode: Post-Ultor Volts	Final High-Voltage Electrode: Ultor■ Volts	Grid-No. 3 Volts	Grid-No. 2 Volts	Grid-No. 1 Bias Volts†	Final High-Voltage Electrode♦ Volts	Grid-No. 3 Voltage for Focus Approx.	Grid-No. 2 Volts	Maximum Grid-No. 1 Volts for Visual Cutoff¢	Deflection Factor volts dc/in.: DJ1 & DJ2	Deflection Factor volts dc/in.: DJ3 & DJ4	
PROJECTION KINESCOPES⊕														
12 9/16	5 1/8	4 1/2	—	40000	9000	400	−150	36000	6650 to 8100	140 to 350	−93	Deflection Angle, 50° approx.		5AZP4
20 1/8	7 3/16▲	5 x 3 3/4Ø	—	80000‡	20000‡	600‡	−250‡	75000	15000 to 17000	400 to 600✢	−155§	Deflection Angle, 35° approx.		7NP4
20 1/16	7 3/16▲	5 x 3 3/4Ø	—	80000‡	20000‡	600‡	−250‡	75000	15000 to 17000	400 to 600✢	−155§	Deflection Angle, 35° approx.		7WP4
MONOSCOPES														
12 11/16	5 1/16	2 5/16 x 3 1/16*	—	1500	Resolution Capability (with full scanning), 500 TV lines. Pattern-Electrode Signal Current (peak-to-peak), 0.3 to 0.7 μamp.									2F21
For additional data, refer to type 2F21.														1699

♦♦ Design-center values.

■ The "ultor" is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection.

† Positive bias value = 0 volts, positive peak value = 2 volts.

♦ Ultor volts.

¢ For visual cutoff of undeflected focused spot except as noted.

▲ Excluding side cap.

Ø Quality rectangle. Max. faceplate temperature = 100° C. Tube requires 40 cfm air flow to faceplate.

* Pattern size, approximate.

‡ Absolute value.

✢ Vary to cut off raster.

§ Recommended operating value.

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RMA Release # 297A

5HP1, 5HP4

HIGH-VACUUM CATHODE-RAY TUBE

Primarily for applications involving altitudes up to 25000 feet

Heater	Coated Unipotential Cathode	
Voltage	6.3	a-c or d-c volts
Current	0.6	amp.
Focusing Method		Electrostatic
Deflection Method		Electrostatic

Electrodes DJ_1 and DJ_2 (upper): nearest to screen
DJ_1 is on same side of tube as pin No.4
Electrodes DJ_3 and DJ_4 (lower): nearest to base
DJ_3 is on same side of tube as pin No.1

	5HP1	5HP4
Phosphor	No.1	No.4
Fluorescence	Green	White
Persistence	Medium	Medium

Direct Interelectrode Capacitances:

Control Electrode (Grid) to All Other Electrodes	9.5 μμf
DJ_1 to DJ_2	1.2 μμf
DJ_3 to DJ_4	0.65 μμf
DJ_1 to All Other Electrodes	9.0 μμf
DJ_3 to All Other Electrodes	12.0 μμf
DJ_1 to All Other Electrodes Except DJ_2	8.0 μμf
DJ_2 to All Other Electrodes Except DJ_1	6.5 μμf
DJ_3 to All Other Electrodes Except DJ_4	11.0 μμf
DJ_4 to All Other Electrodes Except DJ_3	8.0 μμf

Overall Length	16-3/4" ± 3/8"
Bulb Diameter at Screen End	5-1/4" $^{+1/16"}_{-3/32"}$
Base	Large Micanol-Wafer Medium Magnal 11-Pin, Sleeve

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

Maximum Ratings Are Absolute Values

Anode No.2 (High-Voltage Electrode) Voltage		2200 max.	volts
Anode No.1 (Focusing Electrode) Voltage		1100 max.	volts
Grid (Control Electrode) Voltage		Never positive	
Peak Voltage Between Anode No.2 and Any Deflecting Electrode		550 max.	volts
Grid-Circuit Resistance		1.5 max.	megohms
Impedance of Any Deflecting-Electrode Circuit at the Heater-Supply Frequency		1.0 max.	megohm
Typical Operation:			
Anode No.2 Voltage *	1500	2000	volts
Anode No.1 Voltage for Focus at 75% of Grid Voltage for Cut-Off (Approx.)**	310	425	volts
Grid Voltage for Cut-Off°	-30	-40	volts
Deflection Sensitivity:			
DJ_1 and DJ_2	0.400	0.300	mm/volt d.c.
DJ_3 and DJ_4	0.440	0.330	mm/volt d.c.
Deflection Factor:□			
DJ_1 and DJ_2	63.5	84.8	volts d.c./in.
DJ_3 and DJ_4	57.8	77.0	volts d.c./in.
□Subject to variation of	±17	±17	per cent

*, **, °: See next page.

HIGH-VACUUM CATHODE-RAY TUBE

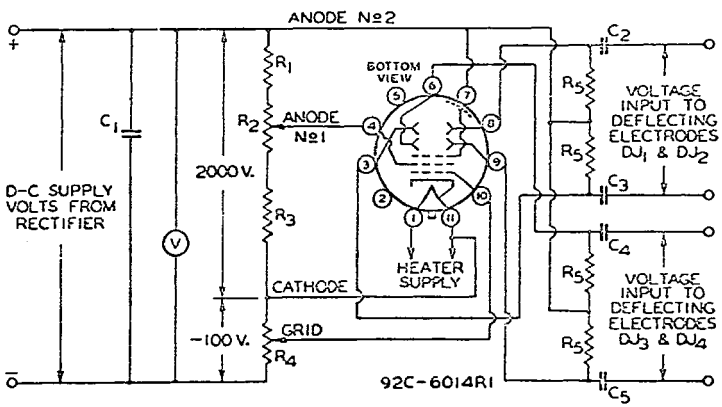
(continued from preceding page)

* Brilliance and definition decrease with decreasing anode No.2 voltages. In general, the anode No.2 voltage should not be less than 1500 volts.

** Supply should be adjustable to ±20% of this value.

o Visual extinction of a stationary focused spot. For cut-off supply should be adjustable to ±50% of this value.

TYPICAL OSCILLOGRAPH CIRCUIT



C_1 = FILTER CONDENSER 0.5 TO 2.0 μf
C_2, C_3, C_4, C_5 = SEE NOTE 2
R_1 = 0.65 MEGOHM
R_2^1 = 0.20 MEGOHM
R_3 = 0.175 MEGOHM
R_3^1 = 0.05 MEGOHM
R_4^1 = SEE NOTES 1 & 2
V = VOLTMETER

NOTE 1: The d-c potential of each deflecting electrode is maintained essentially equivalent to that of anode No.2 by connecting resistors having values not greater than 10 megohms between each deflecting electrode and anode No.2. This arrangement by suitable choice of resistor values minimizes pattern distortion and pattern drift resulting from unbalanced potentials on the deflecting electrodes. The smaller the resistor values, the less the distortion for a given beam current.

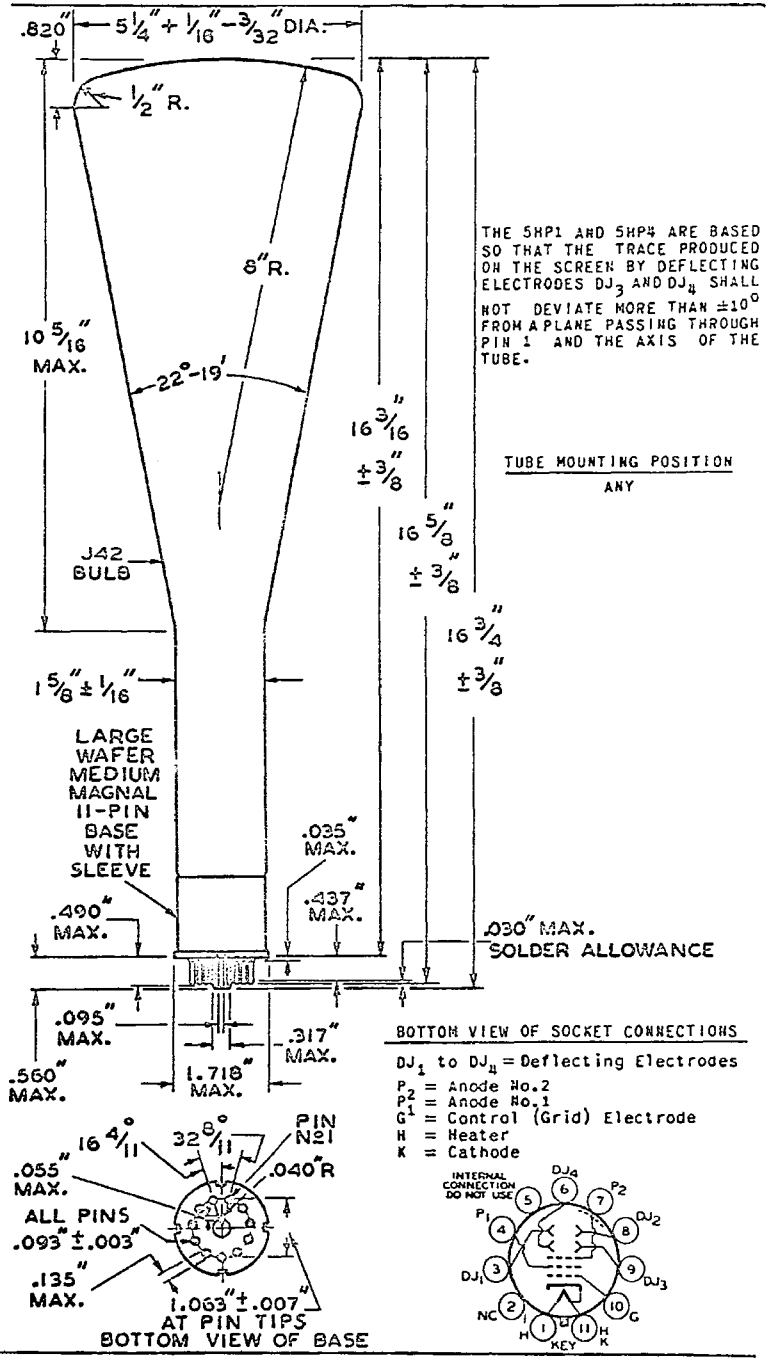
NOTE 2: When the cathode or the negative end of the cathode-ray high-voltage supply is grounded, blocking condensers C_2, C_3, C_4, and C_5 should have a high voltage rating. When anode No.2 is grounded, condensers C_2, C_3, C_4, and C_5 may be low-voltage condensers.

For d-c amplifier service, the deflecting electrodes should be coupled direct to the output of the amplifier by omitting the blocking condensers. In addition, it will usually be preferable to remove the associated deflecting electrode resistor in order to minimize the loading effect of the resistor on the d-c amplifier. With the resistor removed, it is essential, in order to minimize spot defocusing, that anode No.2 be returned to some point in the d-c amplifier circuit such that the potential difference between anode No.2 and the average voltage across the deflecting electrodes will be as low as possible.

The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

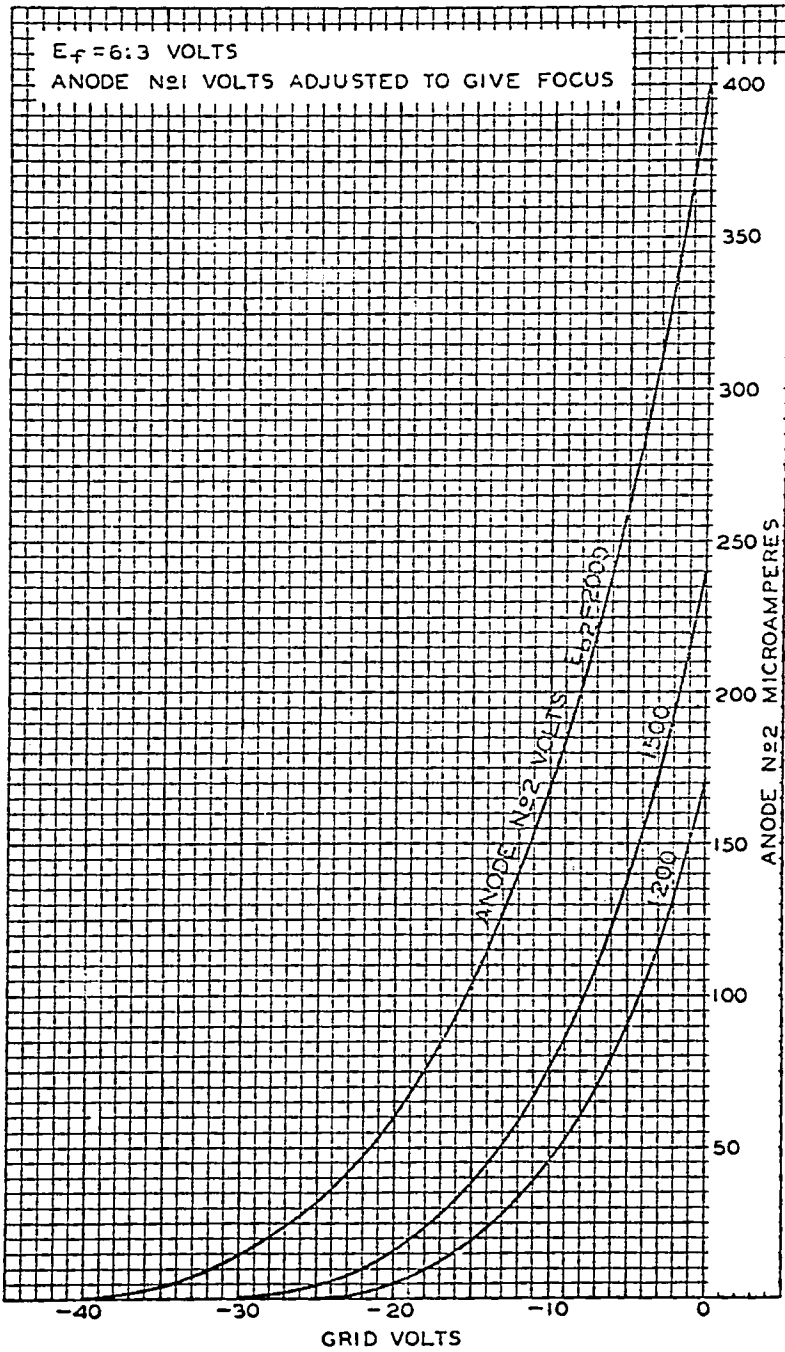
5HP1, 5HP4

HIGH-VACUUM CATHODE-RAY TUBE



5HP1, 5HP4

AVERAGE CHARACTERISTICS



MAY 19, 1942

RCA RADIOTRON DIVISION
RCA MANUFACTURING COMPANY, INC.

92C−4984R2

5HP1-A

CATHODE-RAY TUBE

Electrostatic Focus
Electrostatic Deflection

Medium-Persistence Screen

16-3/4 Inches Long
5-1/4-Inch Bulb

RCA-5HP1-A is a cathode-ray tube of the electrostatic deflection and electrostatic focus type. It has a medium-persistence screen, four and one-half inches in diameter, which produces a brilliant luminous spot suitable for the observation and photography of transient and recurrent phenomena. The 5HP1-A is like the 5BP1-A except that the 5HP1-A is equipped with a Micanol base and, therefore, is less easily damaged by repeated base-pin flashovers which may occur when the tube is used at low atmospheric pressure.

The 5HP1-A employs an improved electron gun for projecting the electron beam onto the fluorescent screen. The improved gun provides sharper focus of the beam and is designed so that its anode No.1 takes essentially no current. This feature permits the use of a bleeder system requiring very little current and, consequently, a smaller filter capacitance. As a result of the extremely small anode No.1 current, variation in focus which may otherwise take place with change in beam current is minimized.

RCA-5HP1-A supersedes RCA-5HP1.

DATA

General:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3	±10%	Volts
Current	0.6		Ampere
Direct Interelectrode Capacitances (Approx.):			
Grid No.1 to All Other Electrodes	8.0		μμf
DJ1 to DJ2	1.3		μμf
DJ3 to DJ4	1.2		μμf
DJ1 to All Other Electrodes	9.5		μμf
DJ3 to All Other Electrodes	12.0		μμf
DJ1 to All Other Electrodes except DJ2	8.0		μμf
DJ2 to All Other Electrodes except DJ1	7.5		μμf
DJ3 to All Other Electrodes except DJ4	10.0		μμf
DJ4 to All Other Electrodes except DJ3	7.5		μμf
Phosphor			No.1
Fluorescence			Green
Persistence			Medium
Focusing Method			Electrostatic
Deflection Method			Electrostatic
Deflecting-Electrode Arrangement			See *Outline Drawing*
Overall Length			16-3/4" ± 3/8"
Greatest Diameter of Bulb	5-1/4"	+1/16" -3/32"	
Minimum Useful Screen Diameter			4-1/2"
Base	Medium Shell Magnal 11-Pin, Micanol		
Mounting Position			Any

Maximum Ratings, *Absolute Values*:

ANODE-NO.2 & GRID-NO.2 VOLTAGE	2200 max.	Volts
ANODE-NO.1 VOLTAGE	1100 max.	Volts
GRID-NO.1 (CONTROL ELECTRODE) VOLTAGE:		
Negative Value	125 max.	Volts
Positive Value	0 max.	Volts
PEAK VOLTAGE BETWEEN ANODE NO.2 and ANY DEFLECTING ELECTRODE	550 max.	Volts

Typical Operation:

Anode-No.2 & Grid-No.2 voltage*	1500	2000	Volts
Anode No.1 Voltage for Focus at 75% of Grid-No.1 Voltage for Cutoff**	337	450	Volts
Grid-No.1 Voltage for Visual Cutoff#	-30	-40	Volts
Max. Anode-No.1 Current Range▲	Between -50 and +10 μamp.		
Deflection Sensitivity:			
DJ1 and DJ2	0.404	0.303	mm/volt dc
DJ3 and DJ4	0.446	0.334	mm/volt dc
Deflection Factor:##			
DJ1 and DJ2	63	84	volts dc/in.
DJ3 and DJ4	57	76	volts dc/in.

* Brilliance and definition decrease with decreasing anode-No.2 voltage. In general, anode-No.2 voltage should not be less than 1500 volts.

** Individual tubes may require between +25% and -30% of the values shown with grid-No.1 voltages between zero and cutoff.

\# Visual extinction of stationary focused spot. Supply should be adjustable to ±50% of these values

\#\# Individual tubes may vary from these values by ±17%.

▲ See curve for average values.

Spot Position:

The undeflected focused spot will fall within a 15-mm square centered at the geometric center of the tube face and having one side parallel to the trace produced by DJ1 and DJ2. Suitable test conditions are: anode-No.2 volts, 1500; anode-No.1 volts, adjusted for focus; deflecting-electrode resistors, one megohm each, connected to anode No.2; the tube shielded from all extraneous fields. To avoid damage to the tube, grid-No.1 voltage should be near cutoff before application of anode voltages.

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max. Megohms
Impedance of Any Deflecting-Electrode Circuit at Heater-Supply Frequency	1.0 max. Megohm
Resistance in Any Deflecting-Electrode Circuit□	5.0 max. Megohms

□ It is recommended that the deflecting-electrode circuit resistances be approximately equal.

INSTALLATION and APPLICATION

The *base* pins of the 5HP1-A fit the magnal 11-pin socket which may be installed to hold the tube in any position. The socket alone, however, should not be used to support the tube. Other support, such as a yoke or saddle arrangement should be used near the screen end of the tube. The socket should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The *bulb* should be enclosed in a grounded shield made of high permeability metal having low residual magnetism in order to minimize the effects of extraneous magnetic fields. When a grounded metal shield is used around the tube, it may be necessary to insulate the tube from the shield to avoid the effects of corona or leakage currents.

The *heater* is designed to be operated at 6.3 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions.

The *cathode* is connected to base pin 11 to which the grid and anode circuit returns should be made. Heater and cathode are connected internally.

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Radio Corporation of America

RCA VICTOR DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5HP1-A-5-45
Photolithographed in U.S.A.

The *fluorescent screen* employs phosphor No.1 which fluoresces to produce a medium-persistence green luminescence.

The *dc voltages* for the grid and the two anodes may be obtained conveniently from a high-voltage vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage-doubler type. Likewise, the filter requirements are simple. A capacitor of about 0.1 μf will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended. If the electrode voltages are obtained from a bleeder circuit, a bleeder current of about 0.2 milliampere usually is satisfactory. Considerably higher values may require the use of more filtering than that provided by a single capacitor shunted across the dc supply. In most applications, it is recommended that anode No.2 be grounded in order that the deflecting electrodes may be operated at or near ground potential. With this method, the cathode and heater are at high negative potential with respect to ground.

The high voltages at which the tube is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is required. In most applications, it is recommended that the anode No.2 terminal be grounded rather than the cathode terminal. With this method, which places the cathode and heater at high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit due to capacitor breakdown or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged capacitors grounded.

Focusing of the fluorescent spot produced by the electron beam is controlled by adjustment of the ratio of anode No.2 voltage to anode No.1 voltage. Ordinarily, the ratio is adjusted by variation of anode No.1 voltage. For this purpose, a potentiometer is required in the bleeder circuit; the necessary range of adjustment is indicated under TYPICAL OPERATION.

Regulation of spot brilliance can be accomplished by varying the current to anode No.2. This current can be increased by decreasing the bias voltage applied to the control electrode. An increase in the current increases the spot size and the quantity of light. To obtain the smallest spot, a slight readjustment of focus may be necessary. An increase in the voltage applied to anode No.2 increases the beam current and the sharpness of focus and, therefore, the spot brilliance.

In applications involving extremely accurate measurements, the anode No.2 current should be reduced to the minimum consistent with the desired brilliance of the pattern. In cases where high brilliance is an important consideration, the voltage applied to the high-voltage electrode may be increased to the maximum rated value with due consideration to the line-voltage variations. This procedure, however, is not always desirable since it results in reduced deflection sensitivity.

It is important to note that a high-intensity spot will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the spot be kept in motion over a reasonably large area or the beam current should be reduced.

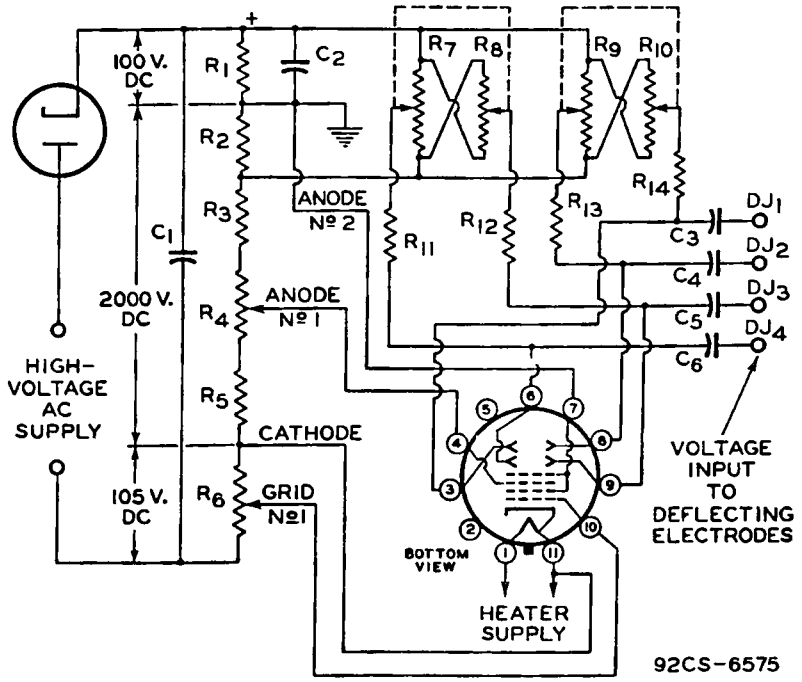
Two pairs of *electrostatic electrodes*, producing fields at right angles, are located within the bulb neck to provide for deflection of the electron beam. The electrostatic field of each pair of deflecting electrodes causes deflection of the beam in the direction of the gradient lines of the field and perpendicular to the plane of the deflecting electrodes; therefore, the deflections caused by the two fields are at right angles. Each set of deflecting electrodes should be maintained essentially at the dc potential of anode No.2. To do this, each electrode of each set should be connected through a resistor of not more than 5 megohms to the anode No.2 tube terminal (ordinarily at ground potential). This arrangement permits a choice of resistor values such that the electron beam is not distorted by dc potentials built up on the deflecting electrodes. If, during operation, the zero axes should shift, it usually is because the beam current is too high for the resistor value used. When it is necessary to use a high value of beam current, as when photographs are taken, the value of the deflecting-electrode resistors should be reduced to minimize the shift of the zero axes.

The deflection sensitivities and the deflection factors for each pair of deflecting electrodes for typical anode-No.2 voltages are given under TYPICAL OPERATION.

Photographs of the phenomena appearing on the viewing screen can be made with an ordinary camera. The photographing is done preferably in complete darkness in order to obtain as much contrast as possible between the fluorescent pattern and the screen. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, and the brightness of the pattern. Where transients are to be photographed, maximum brightness may be required because of the short duration of the

phenomena; where recurrent wave forms are to be photographed, patterns having low brightness can be compensated for by longer exposure. The use of emulsions having high green sensitivity is recommended; orthochromatic types of film and high-speed films have been found to give excellent results.

For high-speed photographic work involving non-recurrent phenomena, it is permissible to increase the trace brightness, for the short interval required to make the exposure, above that required for visual observation. The extent to which the anode current may be increased without harming the screen is proportional to the velocity of beam travel and pattern size, and an inverse function of the duration of the phenomena. Short-interval operation at increased current can be obtained by means of a temporary decrease in the grid-No.1 voltage. A switching arrangement should be provided to switch the grid-No.1 voltage rapidly between a negative and a less negative value. The exposure is made while the grid-No.1 voltage is at the less negative value.



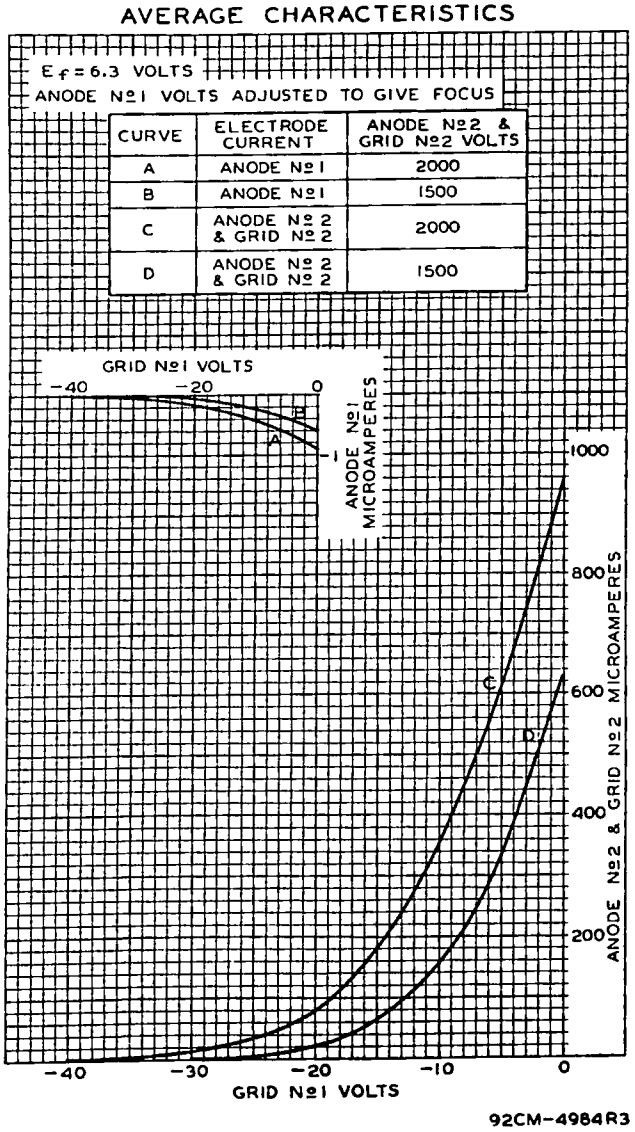
C1: 0.1 μf
C2: 1.0 μf
C3 C4 C5 C6: 0.05-μf Blocking Capacitors*
R1 R2: 2 Megohms
R3: 6 Megohms
R4: 2-Megohm Potentiometer
R5: 1.0 Megohm
R6: 0.5-Megohm Potentiometer
R7 R8: Dual 5-Megohm Potentiometer
R9 R10: Dual 5-Megohm Potentiometer
R11 R12 R13 R14: 2 Megohms

* When cathode is grounded, capacitors should have high voltage rating; when anode No.2 is grounded, they may have low voltage rating. For dc amplifier service, deflecting electrodes should be connected direct to amplifier output. In this service, it is preferable usually to remove deflecting-electrode resistors to minimize loading effect on amplifier. In order to minimize spot defocusing, it is essential that anode No.2 be returned to a point in the amplifier system which will give the lowest possible potential difference between anode No.2 and the deflecting electrodes.

Typical Oscillograph Circuit

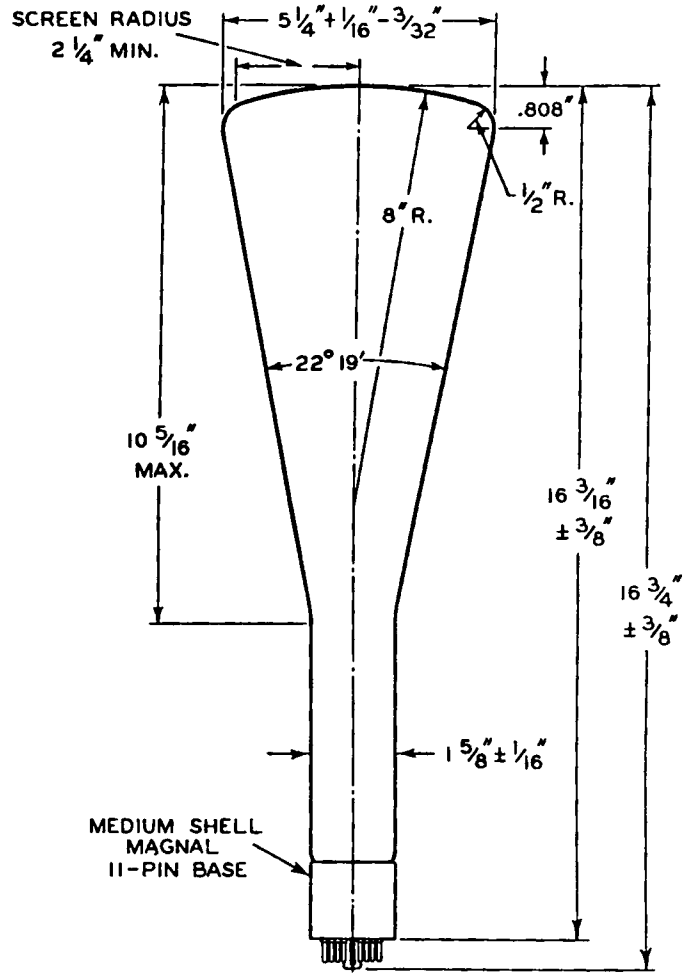
The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

AVERAGE CHARACTERISTICS



CURVE	ELECTRODE CURRENT	ANODE No2 & GRID No2 VOLTS
A	ANODE No1	2000
B	ANODE No1	1500
C	ANODE No 2 & GRID No 2	2000
D	ANODE No 2 & GRID No 2	1500

92CM-4984R3



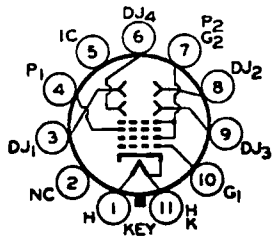
92CM-4976R2

℄ of bulb will not deviate more than 2° in any direction from perpendicular erected at center of bottom of base.

The plane through the tube axis and pin 1 may vary from the trace produced by DJ3 and DJ4 by an angular tolerance (measured about the tube axis) of 10°. Angle between DJ1-DJ2 trace and DJ3-DJ4 trace is 90° ± 3°.

With DJ1 positive with respect to DJ2, the spot will be deflected toward pin 4; likewise, with DJ3 positive with respect to DJ4, the spot will be deflected toward pin 1.

Bottom View of Socket Connections



11N

PIN 1: HEATER
PIN 2: NO CONNECTION
PIN 3: DEFLECTING ELECTRODE DJ1
PIN 4: ANODE NO.1
PIN 5: INTERNAL CONNECTION - DO NOT USE
PIN 6: DEFLECTING ELECTRODE DJ4
PIN 7: ANODE NO.2 and GRID NO.2
PIN 8: DEFLECTING ELECTRODE DJ2
PIN 9: DEFLECTING ELECTRODE DJ3
PIN 10: GRID NO.1
PIN 11: HEATER and CATHODE

from JEDEC release #4106, Jan. 28, 1963

5KE8, 6KE8

MEDIUM-MU TRIODE—SHARP-CUTOFF PENTODES

9-Pin Miniature Types
For Combined Oscillator-Mixer Applications in TV Receivers

RCA Dark Heater
High Pentode Transconductance (12000 μmhos)

Frame-Grid Pentode
High Mixer Gain

RCA-5KE8 and 6KE8 are multiunit tubes of the 9-pin miniature type each containing a medium-mu triode and a sharp-cutoff pentode in one envelope. The 5KE8 and 6KE8 are designed primarily for use as combined oscillator-mixer (converter) tubes in television receivers utilizing an intermediate frequency in the order of 40 Mc.

The pentode units of these tubes feature frame-grid construction, high transconductance (12,000 micromhos), and an excellent "knee" characteristic which contributes to high mixer gain.

Each unit of the 5KE8 and 6KE8 has its own cathode to permit flexibility of circuit design. An internal shield is provided to reduce interaction between the units.

The 6KE8 has a 6.3-volt/0.400-ampere heater. The 5KE8 is identical to the 6KE8 except that the 5KE8 has a 0.450-ampere/5.6-volt heater having a controlled 11-second warm-up time.

In addition, the 5KE8 and 6KE8 utilize the RCA Dark Heater which assures long and dependable performance.

GENERAL DATA

Electrical:

Heater Characteristics and Ratings:

	5KE8	*6KE8*	
Voltage (AC or DC)	5.6[a]	6.3 ± 0.6	volts
Current	0.450 ± 0.030	0.400[b]	amp
Warm-up time (Average)	11	–	sec
Peak heater-cathode voltage (Each unit):			
Heater negative with respect to cathode	200 max		volts
Heater positive with respect to cathode	200[c] max		volts

Direct Interelectrode Capacitances:[d]

Triode Unit:		
Grid to plate	1.3	pf
Grid to cathode, pentode cathode & pentode grid No.3 & internal shield, and heater	2.4	pf
Plate to cathode, pentode cathode & pentode grid No.3 & internal shield, and heater	2.0	pf
Pentode Unit:		
Grid No.1 to plate	0.015 max	pf
Grid No.1 to cathode & grid No.3 & internal shield, grid No.2, and heater	5.0	pf
Plate to cathode & grid No.3 & internal shield, grid No.2, and heater	3.4	pf
Heater to triode cathode and pentode cathode	5.5[e]	pf

Characteristics, Class A$_1$ Amplifier:

	Triode Unit	*Pentode Unit*	
Plate Supply Voltage	125	125	volts
Grid-No.2 Supply Voltage	–	125	volts
Grid-No.1 Supply Voltage	0	0	volts
Cathode Resistor	68	33	ohms
Amplification Factor	40	–	
Plate Resistance (Approx.)	5000	125000	ohms
Transconductance	8000	12000	μmhos
Plate Current	13	10	ma
Grid-No.2 Current	–	2.8	ma
Grid-No.1 Voltage (Approx.) for plate μa =			
100	-5	–	volts
50	–	-3	volts

Mechanical:

Operating Position	Any
Maximum Overall Length	2-3/16"
Maximum Seated Length	1-15/16"
Length, Base Seat to Bulb Top (Excluding tip)	1-9/16" ± 3/32"
Diameter	0.750" to 0.875"
Dimensional Outline	JEDEC No.6-2
Bulb	T6-1/2
Base	Small-Button Noval 9-Pin (JEDEC No.E9-1)

AMPLIFIER — Class A$_1$

Maximum Ratings, *Design-Maximum Values:*

	Triode Unit	*Pentode Unit*	
PLATE VOLTAGE	280 max	280 max	volts
GRID-No.2 SUPPLY VOLTAGE	–	280 max	volts
GRID-No.2 VOLTAGE	–	See *Fig.1*	
GRID-No.1 VOLTAGE:			
Positive-bias value	0 max	0 max	volts

Trademark(s) ® Registered
Marca(s) Registrada(s)

CATHODE CURRENT	20 max	20 max	ma
GRID-No.2 INPUT:			
For grid-No.2 voltages up to 140 volts	-	0.5 max	watt
For grid-No.2 voltages between 140 and 280 volts	-	See *Fig.1*	
PLATE DISSIPATION	2 max	2 max	watts

Maximum Circuit Values:

	Triode Unit	*Pentode Unit*	
Grid-No.1-Circuit Resistance:			
For fixed-bias operation. .	0.5 max	0.25 max	megohm
For cathode-bias operation.	1 max	0.5 max	megohm

[a] At heater amperes = 0.450.
[b] At heater volts = 6.3.
[c] The dc component must not exceed 100 volts.
[d] With external shield JEDEC No.315 connected to cathode of unit under test except as noted.
[e] With external shield JEDEC No.315 connected to ground.

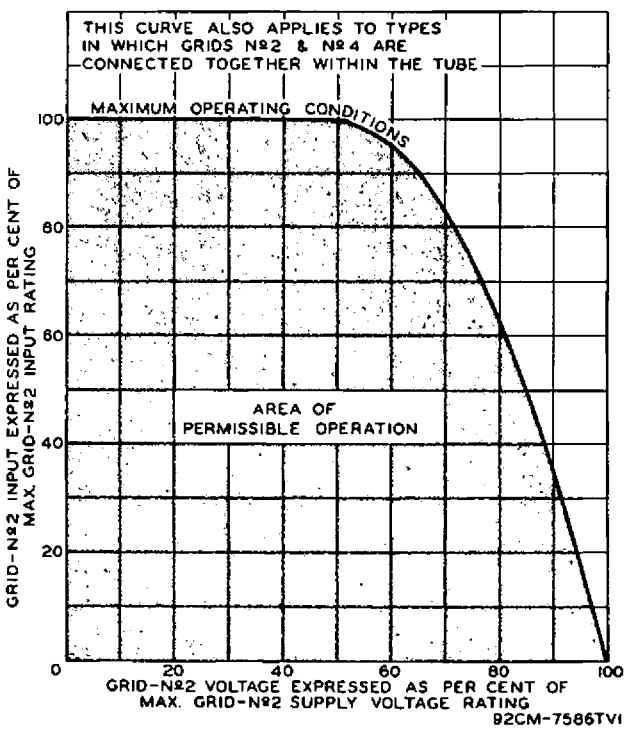


Fig. 1 — Grid-No. 2-Input Rating Chart for the Pentode Unit of Types 5KE8 and 6KE8.

OPERATING CONSIDERATIONS

When the 5KE8 is used in television receivers employing series heater strings, a resistor in series with the string of heaters will minimize voltage surges across any individual heater during starting. The resistor should preferably have a negative temperature characteristic.

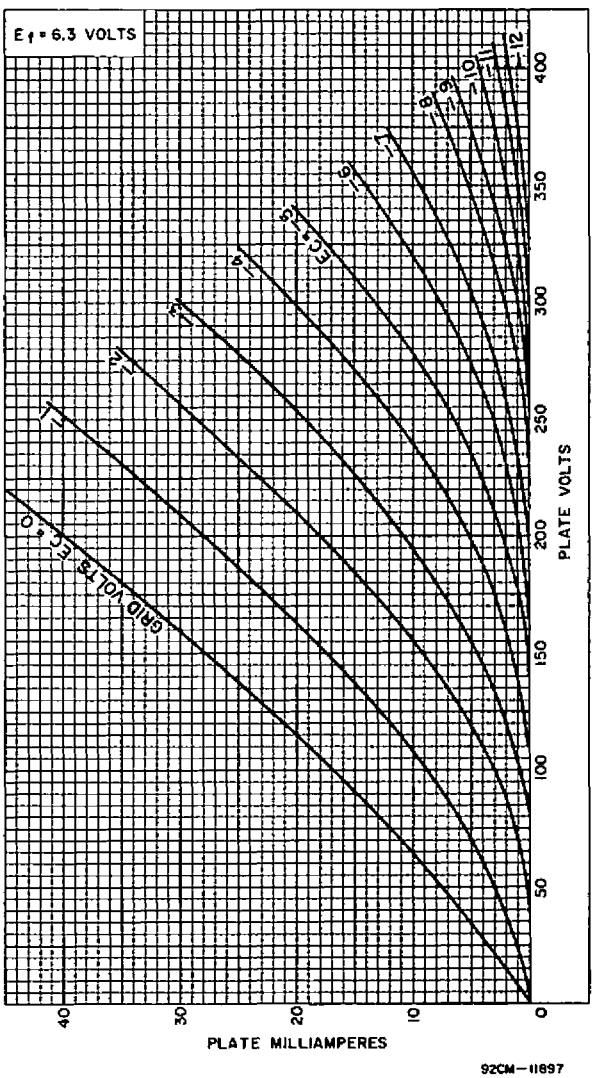


Fig. 2 — Average Plate Characteristics for the Triode Unit of Type 6KE8 and for the Triode Unit of Type 5KE8 except for E_f = 5.6 volts.

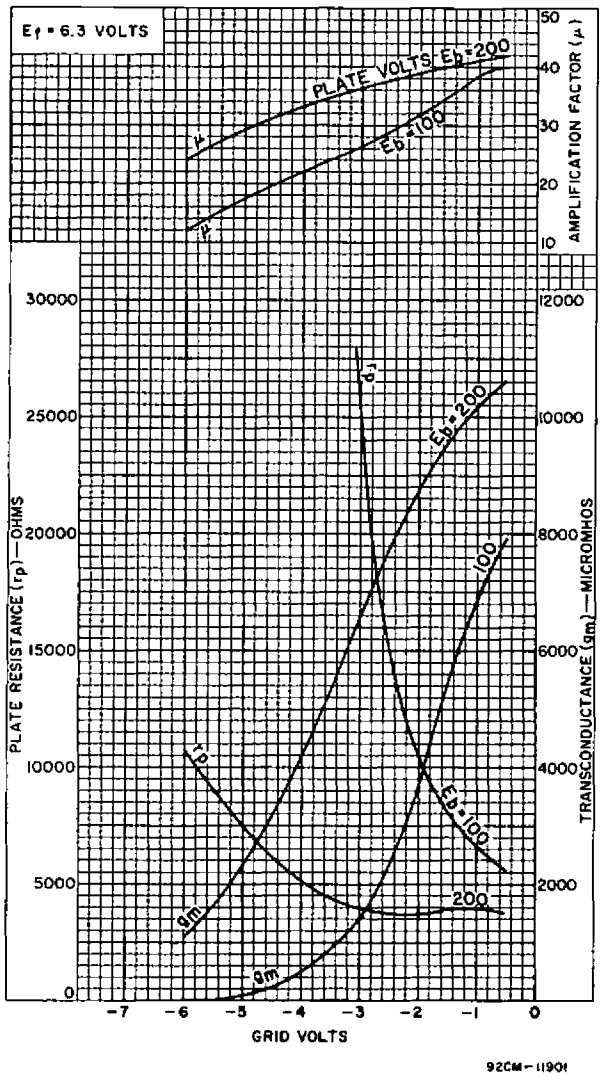


Fig. 3 — Average Characteristics for the Triode Unit of Type 6KE8 and for the Triode Unit of Type 5KE8 except for E_f = 5.6 volts.

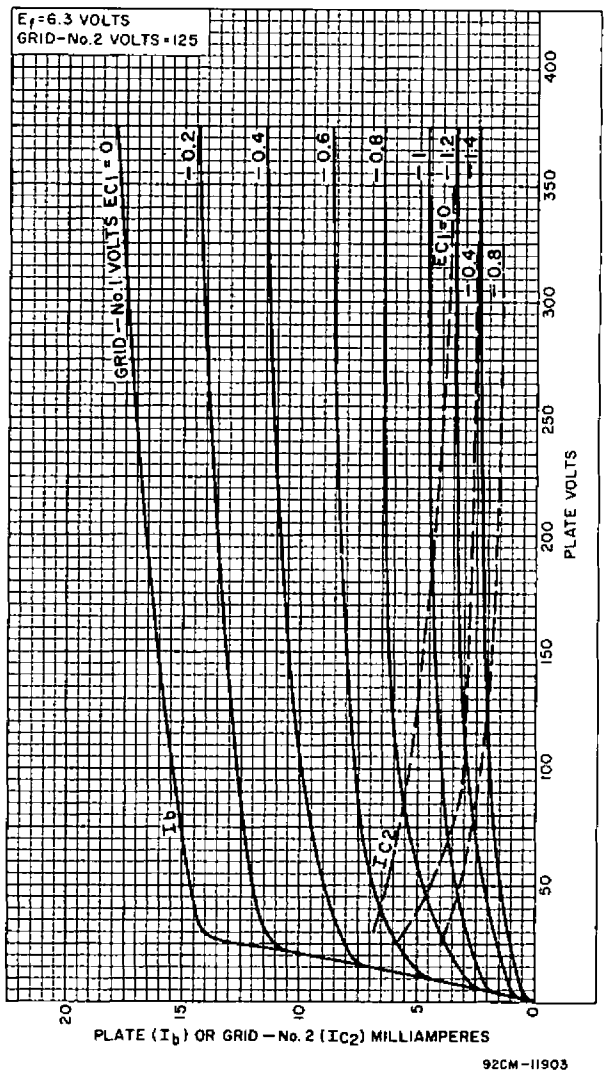


Fig. 4 — Average Characteristics for the Pentode Unit of Type 6KE8 and for the Pentode Unit of Type 5KE8 except for E_f = 5.6 volts.

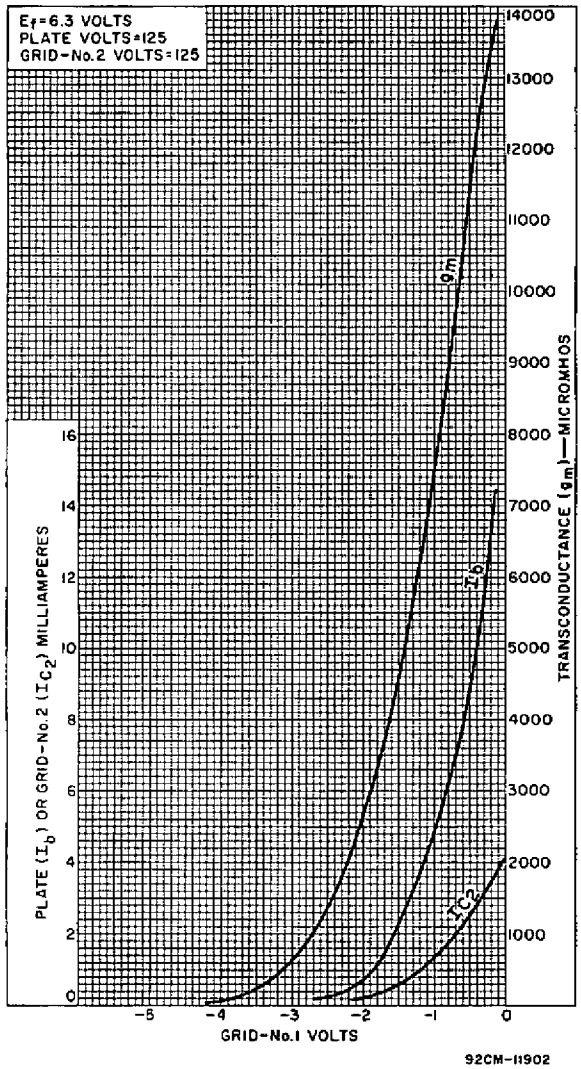
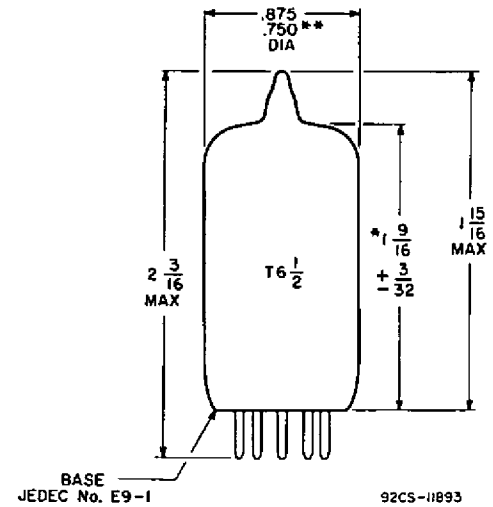


Fig. 5—Average Characteristics for the Pentode Unit of Type 6KE8 and for the Pentode Unit of Type 5KE8 except for Ef = 5.6 volts.

DIMENSIONAL OUTLINE JEDEC No.6-2
All Dimensions in Inches

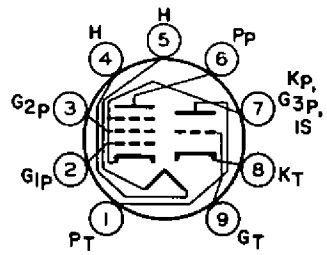


* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" INSIDE DIAMETER.

** APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

TERMINAL DIAGRAM
Bottom View

Pin 1 – Triode Plate
Pin 2 – Pentode Grid No.1
Pin 3 – Pentode Grid No.2
Pin 4 – Heater
Pin 5 – Heater
Pin 6 – Pentode Plate



Pin 7 – Pentode Cathode, Pentode Grid No.3, Internal Shield
Pin 8 – Triode Cathode
Pin 9 – Triode Grid

JEDEC 9DC

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RCA Cunningham Radiotron RADIO TUBES

RCA-5T4

FULL-WAVE HIGH-VACUUM RECTIFIER

(TENTATIVE DATA)

Filament Voltage (A.C.)	5.0 Volts
Filament Current	2.0 Amperes
Maximum Overall Length	4-1/4"
Maximum Diameter	1-23/32"
Base	Large Wafer Octal 5-Pin

As Full-Wave Rectifier

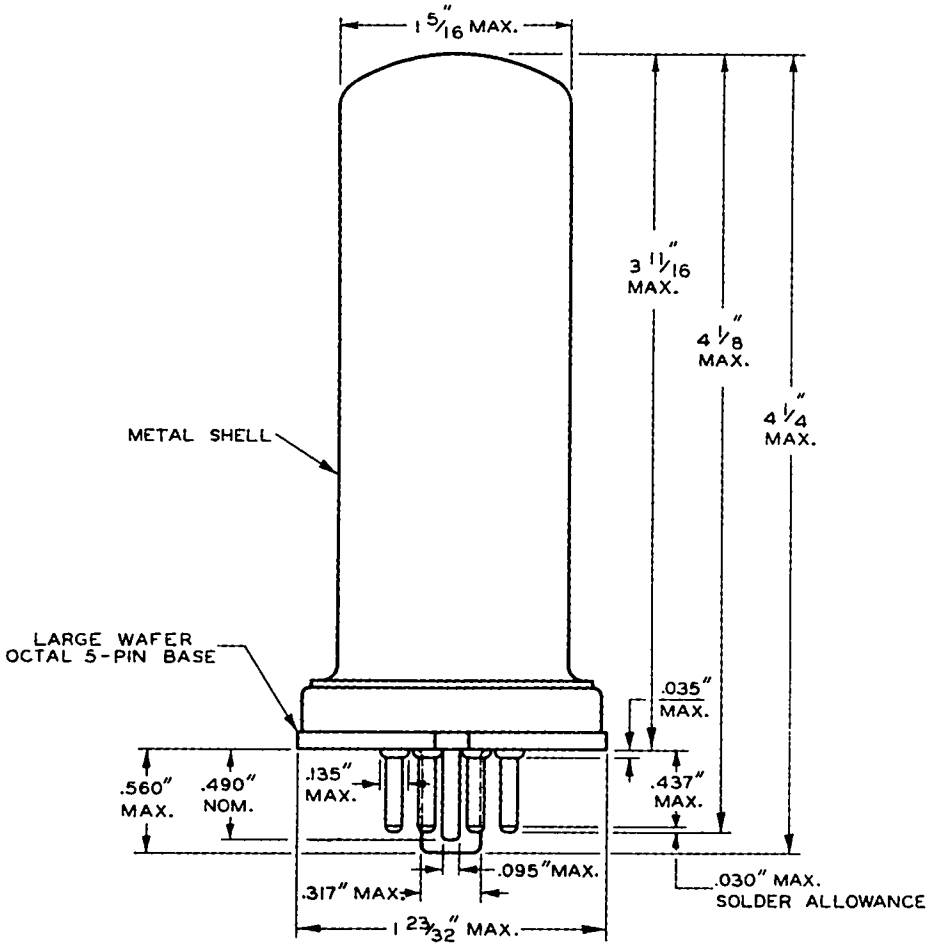
Condenser-Input to Filter

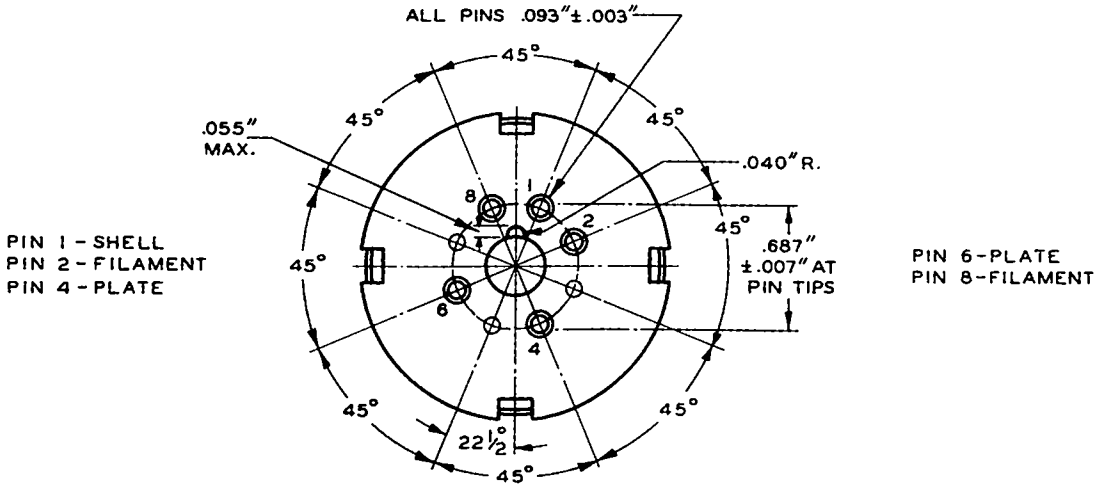
A-C Plate Voltage Per Plate (RMS)	450 max. Volts
Peak Inverse Voltage	1250 max. Volts
D-C Output Current	250 max. Milliamperes

from RMA release #106, Feb. 4, 1937

5T4

OUTLINE DRAWING





BOTTOM VIEW OF BASE

DEC. 10, 1936

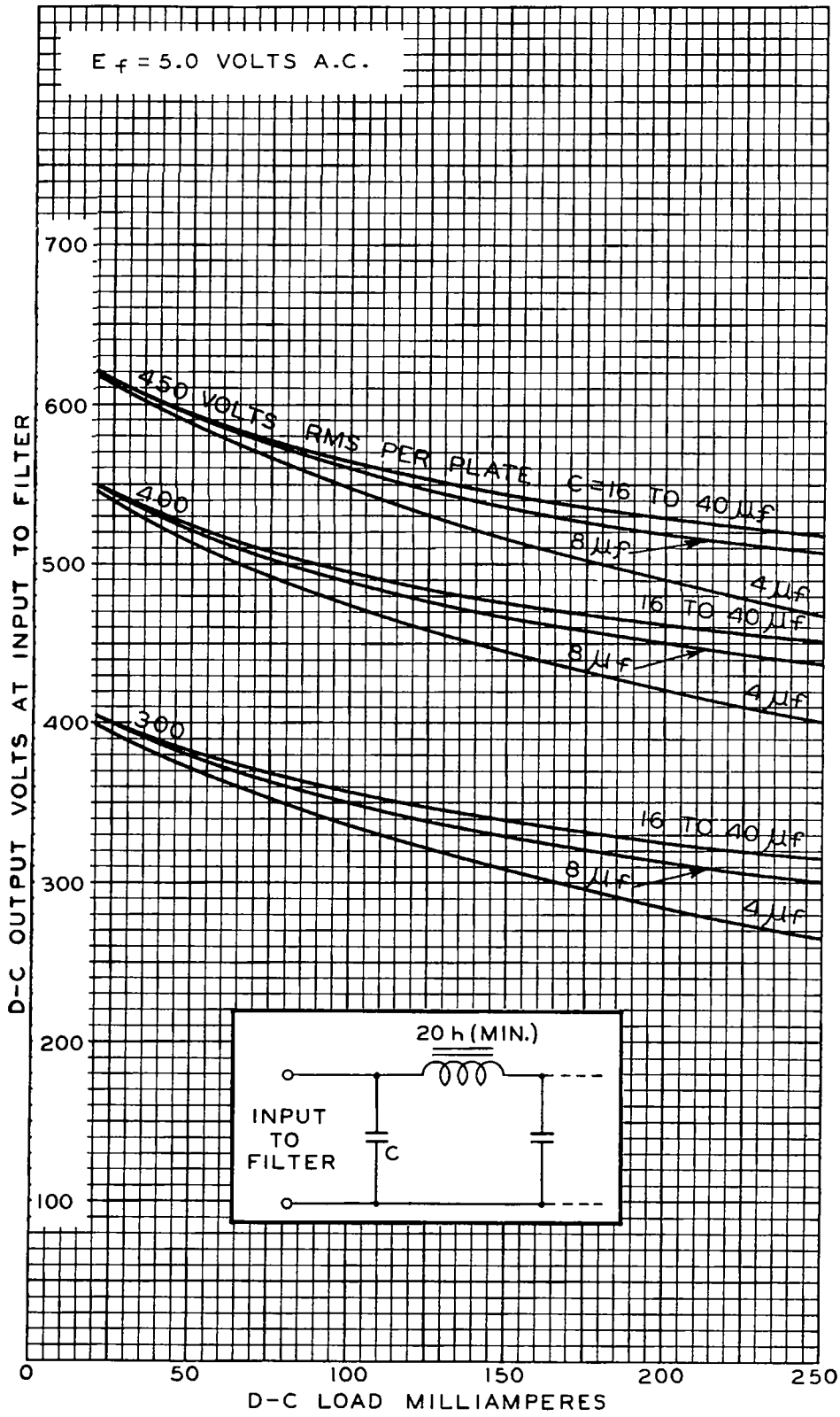
RCA RADIOTRON DIVISION
RCA MANUFACTURING COMPANY, INC.

92C-4699

RCA Cunningham Radiotron RADIO TUBES

RCA-5T4

OPERATION CHARACTERISTICS



RADIO MANUFACTURERS ASSOCIATION

SUITE 701-4 AMERICAN BUILDING
1317 F STREET, N.W.
WASHINGTON, D. C.

R.M.A. DATA BUREAU
90 West Street
New York, N. Y.

Release No. 106A

April 22, 1943

(5T4)

To
Tube Engineers:

On February 4th, 1937, in RMA Tube Standardization Release No 106, was announced registration for the Radiotron Division of the RCA Manufacturing Co., Inc. of tube type designation

5T4

in accordance with the accompanying defining data.

By the distribution of the Electron Tube Characteristic sheet with respect to the 5T4 on about August 5, 1941, was announced the modification of the registration to provide a tube flange diameter of 1-5/8".

The RCA Victor Division of the Radio Corporation of America now proposes to re-register the diameter of the flange of the base as

1-9/16" ± 1/16"

Accordingly, your attention is called to this proposal. Unless valid objection thereto is lodged with the RMA Data Bureau prior to May 6, 1943, the re-registration will be so made and no further announcement thereof will be distributed.

Respectfully yours,

RMA DATA BUREAU

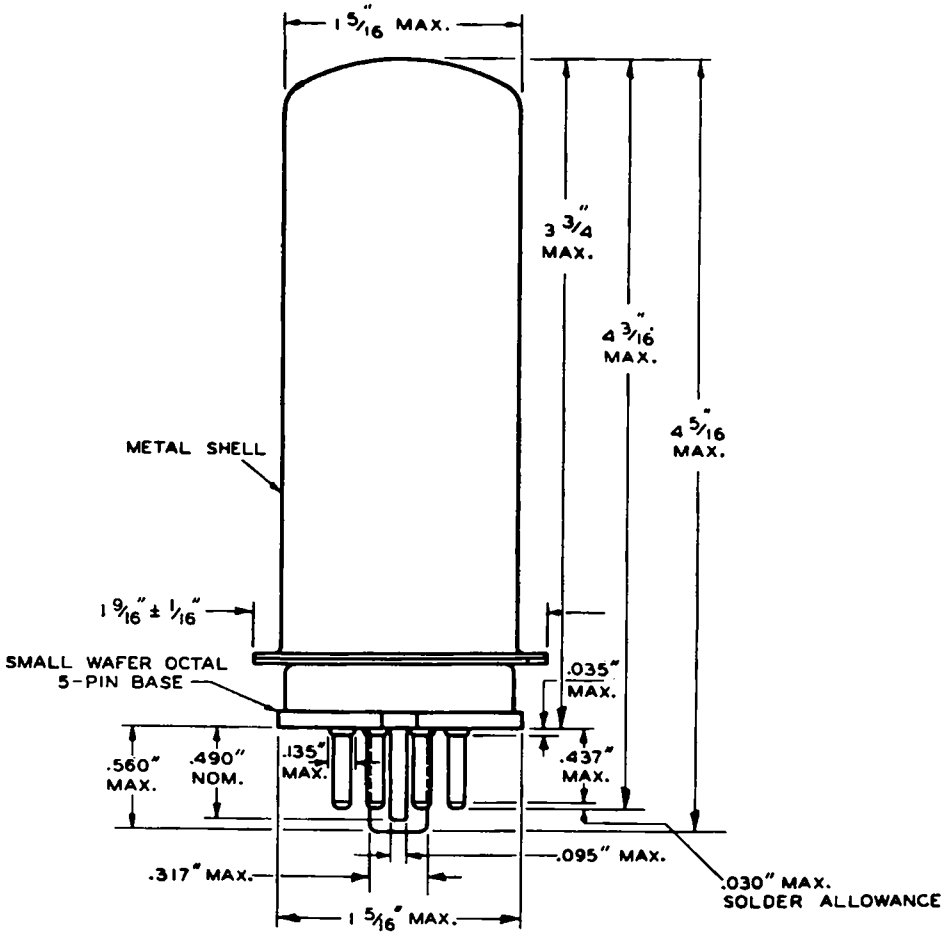
By L. C. F. Horle

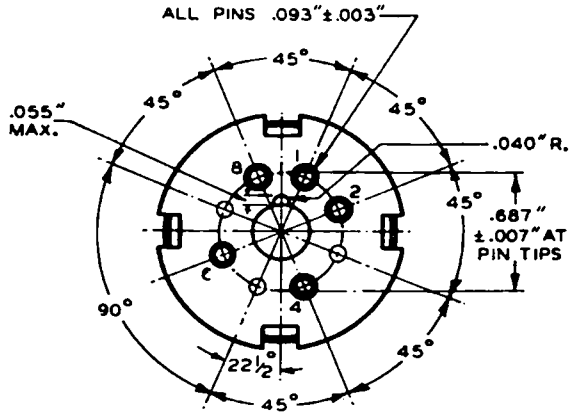
LCFHorle/CP

RMA Release # 106A

5T4

OUTLINE DRAWING

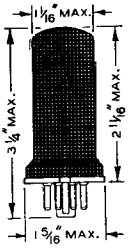




PIN 1 - SHELL
PIN 2 - FILAMENT
PIN 4 - PLATE №2

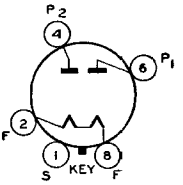
PIN 6 - PLATE №1
PIN 8 - FILAMENT

BOTTOM VIEW OF BASE



RCA-5W4

FULL-WAVE RECTIFIER



The 5W4 is a full-wave high-vacuum rectifying tube of the All-Metal type for use in a-c receivers of low current requirements.

CHARACTERISTICS

FILAMENT VOLTAGE (A. C.)	5.0	Volts
FILAMENT CURRENT	1.5	Amperes
A-C PLATE VOLTAGE PER PLATE (RMS)	350 *max.*	Volts
PEAK INVERSE VOLTAGE	1000 *max.*	Volts
D-C OUTPUT CURRENT	110 *max.*	Milliamperes
BASE	Small Wafer Octal 5-Pin	

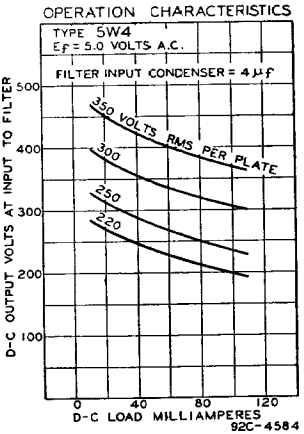
INSTALLATION

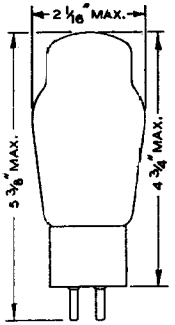
The base pins of the 5W4 fit the standard octal socket which should be installed to hold the tube in a vertical position with the base down. Provision should be made for adequate ventilation to prevent overheating.

The coated filament of the 5W4 is designed to operate from the a-c line through a step-down transformer. The voltage applied to the filament terminals should be the rated value of 5.0 volts under operating conditions and average line voltage.

APPLICATION

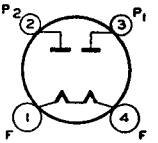
As a full-wave rectifier, the 5W4 may be operated as shown under CHARACTERISTICS. The recommended maximum values of plate voltage and d-c output current must not be exceeded. For a given value of a-c input voltage, the choke-input type filter will give somewhat less d-c output voltage than that obtained with a condenser-input filter, but has the advantage of reducing the peak plate current and improving the voltage regulation. Filter circuits are discussed on page 37.





RCA-5Z3

FULL-WAVE RECTIFIER



The 5Z3 is a high-vacuum rectifier of the full-wave type intended for supplying rectified power to radio equipment having very large direct-current requirements.

CHARACTERISTICS

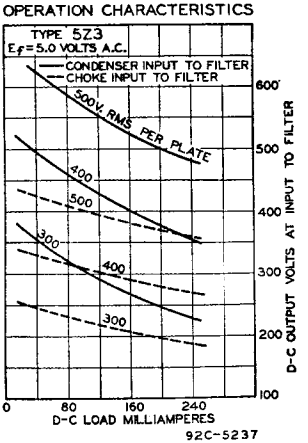
Filament Voltage (A. C.)	5.0	Volts
Filament Current	3.0	Amperes
A-C Plate Voltage Per Plate (RMS)	500 *max.*	Volts
Peak Inverse Voltage	1400 *max.*	Volts
D-C Output Current	250 *max.*	Milliamperes
Bulb		ST-16
Base		Medium 4-Pin

INSTALLATION

The base pins of the 5Z3 fit the standard four-contact socket which should be mounted preferably to hold the tube in a vertical position with the base down. If it is necessary to place the tube in a horizontal position the socket should be mounted with the filament-pin openings either at the top or at the bottom so that the plane of each filament is vertical. Only a socket making very good filament contact and capable of carrying three amperes continuously should be used with the 5Z3. Provision should be made for adequate ventilation to prevent overheating.

The coated filament of the 5Z3 is intended to operate from the a-c line through a step-down transformer. The voltage applied to the filament terminals should be the rated value of 5.0 volts under operating conditions and average line voltage. The high current taken by the filament makes it imperative that all connections in the filament circuit be of low resistance and of adequate current-carrying capacity.

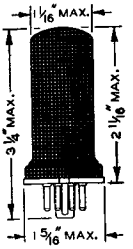
OPERATION CHARACTERISTICS



APPLICATION

As a **full-wave rectifier**, the 5Z3 may be operated with condenser-input or choke-input filter under conditions not to exceed the rating given under CHARACTERISTICS. Filter circuits are discussed on page 37.

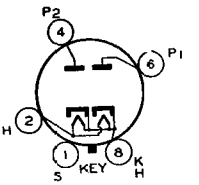
As a **half-wave rectifier**, one or more 5Z3's may be operated with plates connected in parallel. For example, two 5Z3's so arranged in a full-wave circuit can supply twice the output current of a single tube. In this service, the plates of each 5Z3 are tied together at the socket. The allowable voltage and load conditions per tube are the same as for full-wave service.



RCA-5Z4

FULL-WAVE RECTIFIER

The 5Z4 is a full-wave high-vacuum rectifying tube of the All-Metal type intended for use in d-c power-supply devices which operate from the a-c supply line.



CHARACTERISTICS

HEATER VOLTAGE (A. C.)	5.0	Volts
HEATER CURRENT	2.0	Amperes
A-C PLATE VOLTAGE PER PLATE	400 *max.*	Volts
PEAK INVERSE VOLTAGE	1100 *max.*	Volts
D-C OUTPUT CURRENT	125 *max.*	Milliamperes
BASE	Small Wafer Octal 5-Pin	

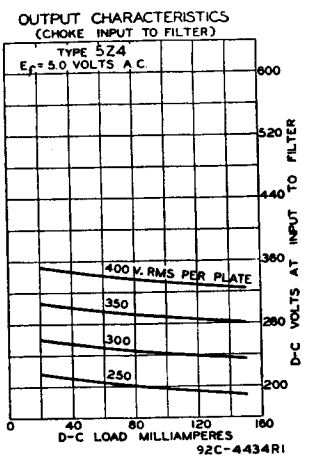
INSTALLATION AND APPLICATION

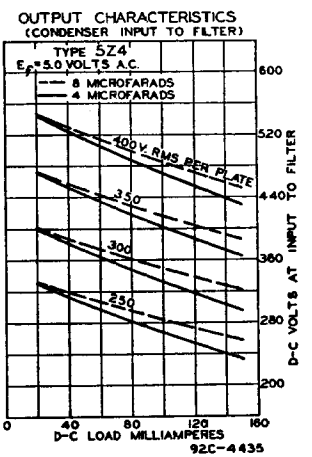
The **base** pins of the 5Z4 fit the standard octal socket which should be installed to hold the tube in any position. Provision should be made for adequate ventilation to prevent overheating.

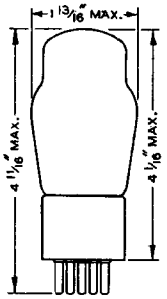
The **heater** of the 5Z4 is designed to operate from the a-c line through a step-down transformer. The voltage applied to the heater should be the rated value of 5.0 volts under operating conditions and average line voltage.

As a **full-wave rectifier,** the 5Z4 may be operated with condenser-input or choke-input filter under conditions not to exceed the ratings given under CHARACTERISTICS.

As a **half-wave rectifier,** two 5Z4's may be operated in a full-wave circuit with reasonable serviceability to deliver more d-c output current than can be obtained from one tube. For this use, the plates of each 5Z4 are tied together at the socket. The allowable voltage and load conditions per tube are the same as for full-wave service.

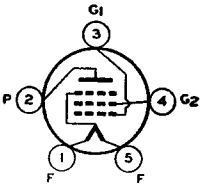






RCA-6A4

POWER-AMPLIFIER PENTODE



The 6A4 is a power-amplifier pentode of the 6.3-volt filament type for use in receivers employing a six-volt storage-battery filament supply. The 6A4 is interchangeable with type LA.

CHARACTERISTICS

Filament Voltage (A. C. or D. C.)				6.3	Volts
Filament Current				0.3	Ampere
Plate Voltage	100	135	165	180 *max.*	Volts
Screen Voltage (Grid No. 2)	100	135	165	180 *max.*	Volts
Grid Voltage* (Grid No. 1)	−6.5	−9	−11	−12	Volts
Plate Current	9	14	20	22	Milliamperes
Screen Current	1.6	2.5	3.5	3.9	Milliamperes
Plate Resistance (Approx.)	83250	52600	48000	45500	Ohms
Amplification Factor (App.)	100	100	100	100	
Transconductance	1200	1900	2100	2200	Micromhos
Load Resistance	11000	9500	8000	8000	Ohms
Self-Bias Resistor	615	545	470	465	Ohms
Power Output†	0.31	0.7	1.2	1.4	Watts
Bulb					ST-14
Base					Medium 5-Pin

* Grid volts measured from negative end of d-c operated filament. If the filament is a-c operated, the tabulated values of grid bias should each be increased by 4.0 volts and be referred to the mid-point of filament.

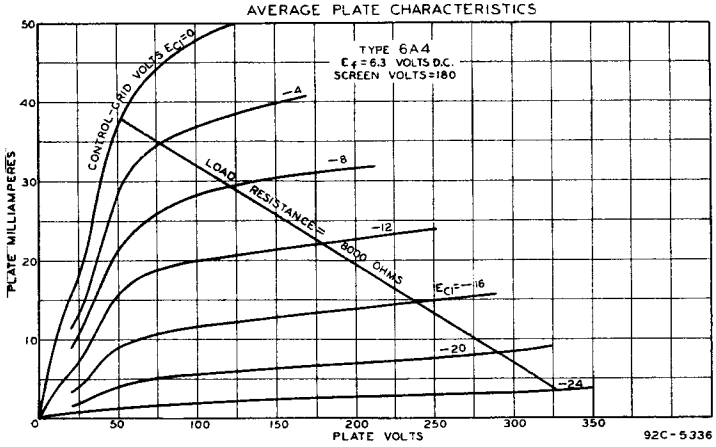
† 9 per cent total harmonic distortion.

INSTALLATION AND APPLICATION

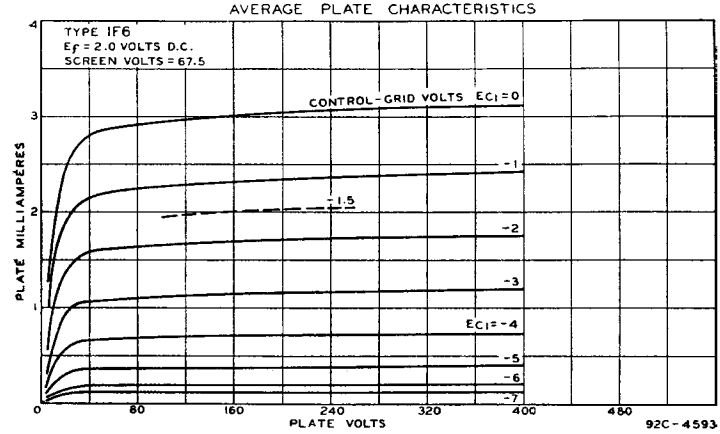
The base pins of the 6A4 fit the standard five-contact socket which should be mounted preferably to hold the tube in a vertical position. If it is necessary to place the tube in a horizontal position, the socket should be mounted with its filament-pin openings one vertically above the other. The coated filament of the 6A4 is primarily intended for operation from a six-volt storage battery. Socket terminal No. 1 should be connected to the positive battery terminal.

For the power amplifier stage, the 6A4 is recommended either singly or in push-pull combination. Transformer or impedance input-coupling devices are recommended. If, however, resistance coupling is employed, the grid resistor should not exceed 0.5 megohm. A family of plate characteristics for the 6A4 is shown on the following page.

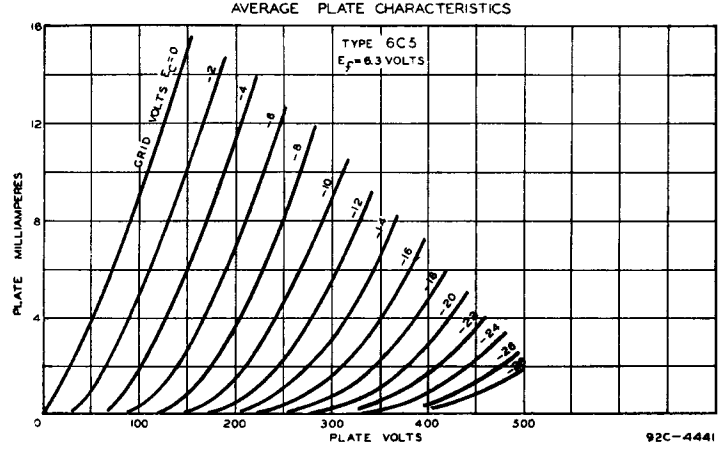
AVERAGE PLATE CHARACTERISTICS

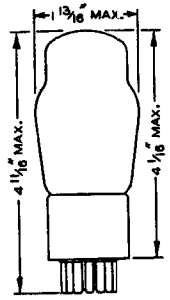


AVERAGE PLATE CHARACTERISTICS



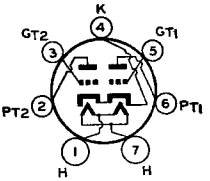
AVERAGE PLATE CHARACTERISTICS





RCA-6A6

CLASS B TWIN AMPLIFIER



The 6A6 is a heater-cathode type of tube combining in one bulb two high-mu triodes designed for Class B operation. The triode units have separate external terminals for all electrodes except the cathodes and heaters, so that circuit design is similar to that of Class B amplifiers utilizing two tubes in the output stage. The 6A6 may also be used as a Class A_1 amplifier (with triode units connected in parallel) to drive a 6A6 as a Class B amplifier in the output stage.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	6.3	Volts
HEATER CURRENT	0.8	Ampere
BULB		ST-14
BASE		Medium 7-Pin

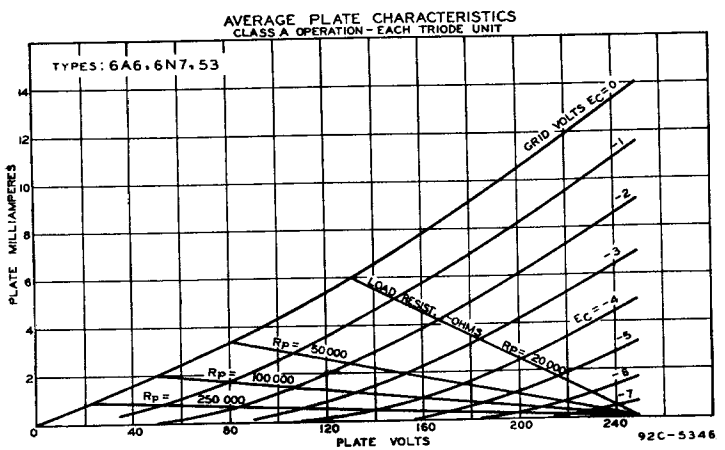
Other characteristics of this type are the same as for type 6N7.

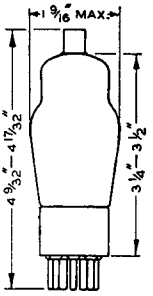
INSTALLATION AND APPLICATION

The base pins of the 6A6 fit the seven-contact (0.855-inch pin-circle diameter) socket which may be installed to hold the tube in any position. Sufficient ventilation should be provided to prevent overheating.

The heater is designed to operate at 6.3 volts. In a series-heater circuit employing several 6.3-volt types and one or more 6A6's, the heaters of the 6A6's should be placed on the positive side. Furthermore, since most 6.3-volt types have 0.3-ampere heaters, a bleeder circuit across these heaters is required to take care of the additional 0.5-ampere heater current of the 6A6's. Each 6.3-volt tube of the 0.3-ampere type in the series circuit should, therefore, be shunted by a bleeder resistance of 13 ohms.

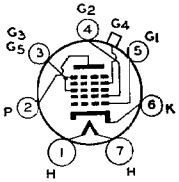
Refer to APPLICATION on type 6N7, and additional curve under type 53.





RCA-6A7

PENTAGRID CONVERTER



The 6A7 is a multi-electrode type of vacuum tube designed to perform simultaneously the functions of a mixer tube and of an oscillator tube in superheterodyne circuits.

For discussion of pentagrid types, see FREQUENCY CONVERSION, page 31.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances (Approx.):		
Grid No. 4 to Plate (With shield-can)	0.3	μμf
Grid No. 4 to Grid No. 2 (With shield-can)	0.15	μμf
Grid No. 4 to Grid No. 1 (With shield-can)	0.15	μμf
Grid No. 1 to Grid No. 2	1.0	μμf
Grid No. 4 to All Other Electrodes (R-F Input)	8.5	μμf
Grid No. 2 to All Other Electrodes (Osc. Output)	5.5	μμf
Grid No. 1 to All Other Electrodes (Osc. Input)	7.0	μμf
Plate to All Other Electrodes (Mixer Output)	9.0	μμf
Bulb		ST-12
Cap		Small Metal
Base		Small 7-Pin

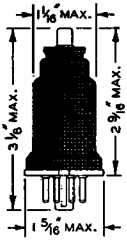
As Frequency Converter

Plate Voltage		250 *max.*	Volts
Screen Voltage (Grids No. 3 and 5)		100 *max.*	Volts
Anode-Grid Voltage (Grid No. 2)		200 *max.*	Volts
Anode-Grid Voltage Supply (Grid No. 2)*		250 *max.*	Volts
Control-Grid Voltage (Grid No. 4)		−3 *min.*	Volts
Total Cathode Current		14 *max.*	Milliamperes
Typical Operation			
Plate Voltage	100	250	Volts
Screen Voltage	50	100	Volts
Anode-Grid Voltage	100	200	Volts
Control-Grid Voltage (Minimum)	−1.5	−3	Volts
Oscillator-Grid Resistor (Grid No. 1)	10000	50000	Ohms
Plate Current	1.3	3.5	Milliamperes
Screen Current	2.5	2.2	Milliamperes
Anode-Grid Current	3.3	4.0	Milliamperes
Oscillator-Grid Current	1.2	0.7	Milliamperes
Total Cathode Current	8.3	10.4	Milliamperes
Cathode Resistor	150	300	Ohms
Plate Resistance	0.6	0.36	Megohm
Conversion Conductance	350	520	Micromhos
Control-Grid Voltage, Approximate (Conversion Conductance—2 μmhos)	−20	−45	Volts

* Voltages in excess of 200 volts require use of 20000-ohm voltage-dropping resistor by-passed by 0.1 μf condenser.

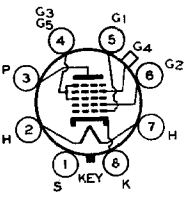
INSTALLATION AND APPLICATION

The base pins of the 6A7 fit the seven-contact (0.75-inch pin-circle diameter) socket which may be installed to hold the tube in any position. For heater and cathode operation, refer to type 6A8. Complete shielding of the 6A7 is generally necessary to prevent intercoupling between its circuit and the circuits of other stages. Refer to APPLICATION of types 6A8 and 2A7. A typical circuit is shown under type 2A7.



RCA-6A8

PENTAGRID CONVERTER



The 6A8 is a multi-electrode vacuum tube of the metal type designed to perform simultaneously the functions of a mixer (first detector) tube and of an oscillator tube in superheterodyne circuits. Through the use of this type, the independent control of each function is made possible within a single tube. For general discussion of pentagrid types, refer to FREQUENCY CONVERSION, page 31.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES (Approx.):*		
Grid No. 4 to Plate	0.03	μμf
Grid No. 4 to Grid No. 2	0.1	μμf
Grid No. 4 to Grid No. 1	0.09	μμf
Grid No. 1 to Grid No. 2	0.8	μμf
Grid No. 4 to All Other Electrodes (R-F Input)	12.5	μμf
Grid No. 2 to All Other Electrodes (Osc. Output)	5	μμf
Grid No. 1 to All Other Electrodes (Osc. Input)	6.5	μμf
Plate to All Other Electrodes (Mixer Output)	12.5	μμf
CAP		Miniature
BASE		Small Wafer Octal 8-Pin

* With shell connected to cathode.

As Frequency Converter

PLATE VOLTAGE	250 *max.*		Volts
SCREEN VOLTAGE (Grids No. 3 and 5)	100 *max.*		Volts
ANODE-GRID VOLTAGE (Grid No. 2)	200 *max.*		Volts
ANODE-GRID SUPPLY VOLTAGE (Grid No. 2)†	250 *max.*		Volts
CONTROL-GRID VOLTAGE (Grid No. 4)	−3 *min.*		Volts
TOTAL CATHODE CURRENT	14 *max.*		Milliamperes
TYPICAL OPERATION			
Plate Voltage	100	250	Volts
Screen Voltage	50	100	Volts
Anode-Grid Voltage	100	250†	Volts
Control-Grid Voltage (Minimum)	−1.5	−3	Volts
Oscillator-Grid Resistor (Grid No. 1)	50000	50000	Ohms
Plate Current	1.2	3.3	Milliamperes
Screen Current	1.5	3.2	Milliamperes
Anode-Grid Current	1.6	4.0	Milliamperes
Oscillator-Grid Current	0.25	0.5	Milliampere
Plate Resistance	0.6	0.36	Megohm
Conversion Conductance	350	500	Micromhos
Control-Grid Voltage, Approximate (Conversion Conductance = 2 μmhos)	−20	−45	Volts

† Anode-grid supply voltages in excess of 200 volts require the use of 20000-ohm voltage-dropping resistor by-passed by 0.1 μf condenser.

INSTALLATION

The base pins of the 6A8 fit the standard octal socket, which may be installed to hold the tube in any position.

The heater of the 6A8 is designed to operate on either d-c or a-c. For operation on a-c with a transformer, the winding which supplies the heater circuit

should operate the heater at its recommended value for full-load operating conditions at average line voltage. For service in automobile receivers, the heater terminals of the 6A8 should be connected directly across a 6-volt battery. In receivers that employ a series-heater connection, the heater of the 6A8 may be operated in series with the heater of other types having a 0.3-ampere rating. The current in the heater circuit should be adjusted to 0.3 ampere for the normal supply-line voltage.

The **cathode** of the 6A8, when operated from a transformer, should preferably be connected directly to the electrical mid-point of the heater circuit. When it is operated in receivers employing a 6-volt storage battery for the heater supply, the cathode circuit is tied in either directly or through bias resistors to the negative side of the d-c plate supply which is furnished either by the d-c power line or the a-c line through a rectifier. In circuits where the cathode is not directly connected to the heater, the potential difference between them should be kept as low as possible. If the use of a large resistor is necessary between the heater and cathode of the 6A8 in some circuit designs, it should be by-passed by a suitable filter network or objectionable hum may develop.

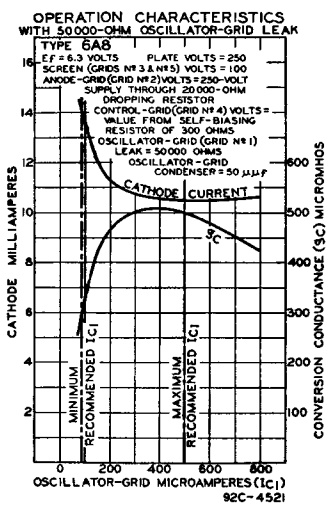
APPLICATION

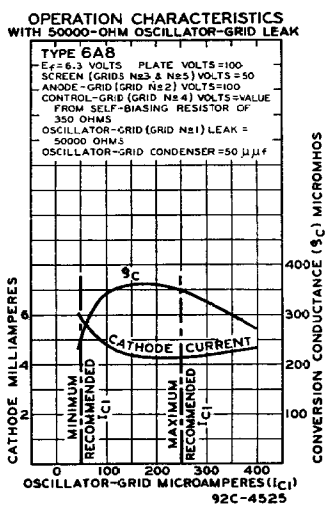
As a **frequency converter** in superheterodyne circuits, the 6A8 can supply the local oscillator frequency and at the same time mix it with radio-input frequency to provide the desired intermediate frequency. For this service, design information is given under CHARACTERISTICS.

For the **oscillator** circuit, the coils may be constructed according to conventional design, since the tube is not particularly critical. The supply voltage applied to the anode-grid No. 2 should not exceed the maximum value of 250 volts. In fact, from a performance standpoint, a lower value is to be preferred, because it will be adequate to provide for optimum translation gain. Under no condition of adjustment should the cathode current exceed a recommended maximum value of 14 milliamperes.

The bias voltage applied to grid No. 4 can be varied from −3 volts to cut-off to control the translation gain of the tube. With lower screen voltages, the cut-off point is less remote. The extended cut-off feature of this tube in combination with the similar characteristic of super-control tubes can be utilized advantageously to adjust receiver sensitivity.

Refer to type 2A7 for typical circuit and coils. When the 6A8 is used in this circuit, its shell should be connected to ground.





6AF6-G

ELECTRON-RAY TUBE

Twin Indicator Type

The 6AF6-G is a high-vacuum, heater-cathode type of tube designed to respond visually, by means of two shadows on a fluorescent target, to changes in the voltages applied to the control electrodes. It performs, therefore, as a voltage indicator and as such is particularly useful as a convenient and non-mechanical means to indicate accurate tuning of a receiver to the desired station.

Structurally, the 6AF6-G has a heater, a cathode, two ray-control electrodes, and a fluorescent target. Electrically, however, the 6AF6-G may be considered as two separate electron-ray tubes in one bulb, the cathode and target being common to both. Each control electrode can perform independently of the other to produce a separate shadow.

The control electrodes may be connected in parallel to give twin shadows or connected separately to give two independently controlled shadows. The voltage or voltages required for control are supplied to the 6AF6-G through one or more voltage amplifier tubes.

In addition to its two shadows, the 6AF6-G features small size which facilitates its use in compact receiver design.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.15	Ampere
OVERALL LENGTH	2" to 2-5/16"	
MAXIMUM DIAMETER	1-3/16"	
BULB	T-9	
BASE	Small Shell Octal 7-Pin	

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

TARGET VOLTAGE		135 *max.*	Volts
		90 *min.*	Volts
RAY-CONTROL-ELECTRODE SUPPLY VOLTAGE		135 *max.*	Volts
TYPICAL OPERATION:			
Heater Voltage	6.3	6.3	Volts
Target Voltage	100	135	Volts
Target Current *	0.9	1.5	Milliamperes
Ray-Control Electrode Voltage (Approx.)°	60	81	Volts
Ray-Control Electrode Voltage (Approx.)°°	0	0	Volts

For the control tube, a typical value of series-load resistor is

*, °, °°: See next page.

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0.5 megohm, when the ray-control electrodes of the 6AF6-G are connected in parallel.

* With 0 volts on ray-control electrodes. Subject to wide variation.
° For shadow angle of 0° produced by either ray-control electrode.
°° For shadow angle of 100° produced by either ray-control electrode.

INSTALLATION

The *base* pins of the 6AF6-G fit the standard octal socket which may be installed to hold the tube in any position. For convenience, the tube is usually mounted horizontally so that the fluorescent target is readily visible when the receiver circuit is tuned.

The *heater* is designed to operate on either a.c. or d.c. For operation on a.c. with a transformer, the winding which supplies the heater circuit should operate the heater at its recommended value for full-load operating conditions at average line voltage. In a-c/d-c receivers, the heater can be operated in series with the heaters of other types having a 0.15-ampere rating. The current in the heater circuit should be adjusted to 0.15 ampere for the normal supply-line voltage.

The *cathode*, when the 6AF6-G is operated from a transformer, should preferably be connected directly to the heater circuit. In a-c circuits where the cathode is not connected directly to the heater, the potential difference between them should be kept as low as possible. When a series-heater arrangement is used, the cathode should be connected directly to the negative side of the d-c plate supply.

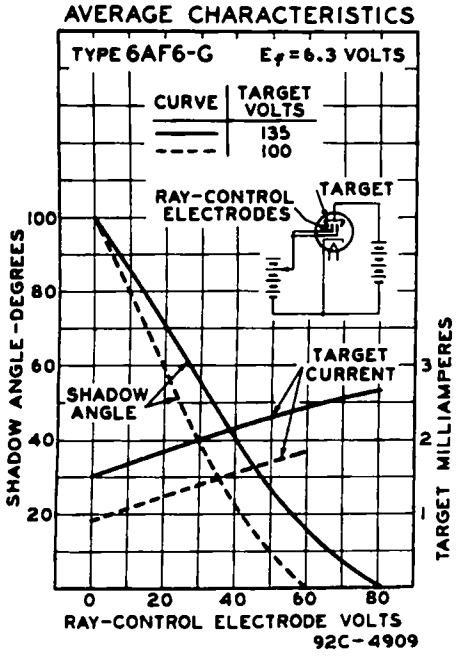
APPLICATION

As a *visual indicator*, the 6AF6-G provides a convenient and non-mechanical means of tuning a receiver to the desired station.

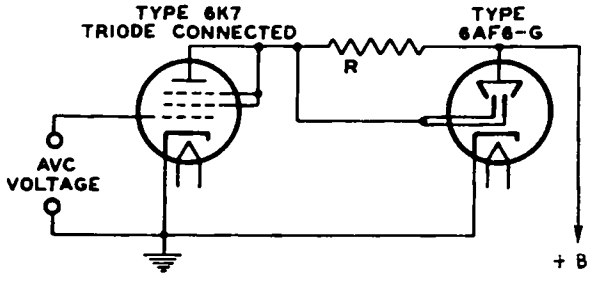
A typical circuit showing the use of the 6AF6-G with ray-control electrodes connected in parallel is shown on the next page. In this circuit, a triode-connected type 6K7 (or other triode-connected super-control amplifier tube with remote cut-off characteristic) is used to provide controlling voltage.

With this arrangement, the twin patterns vary from shaded angles of 100° with no controlling voltage (off tune) to shaded angles of approximately 0° at resonance with a strong carrier. Exact tuning is indicated by the narrowest shaded angles that can be obtained; the stronger the carrier, the narrower the angle.

The 6AF6-G is also suitable for use in other applications. For example, it may be used in circuits where each control electrode is supplied with a separate controlling voltage.

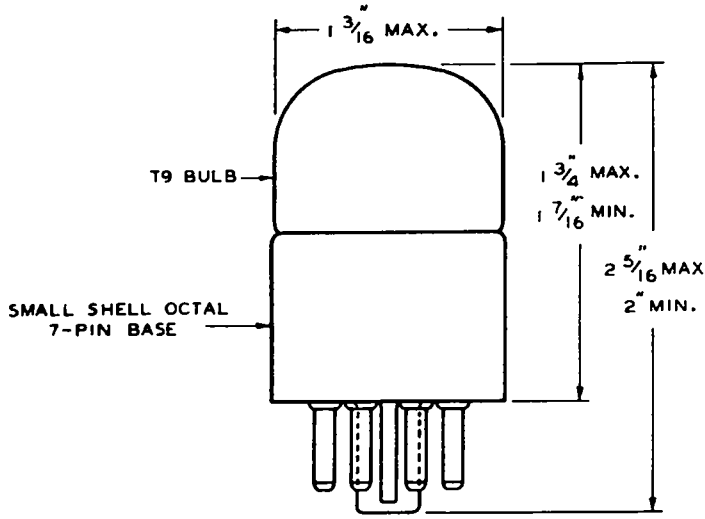


TYPICAL CIRCUIT USING TYPE 6AF6-G
WITH RAY-CONTROL ELECTRODES IN PARALLEL



R – TYPICAL VALUE IS 0.5 MEGOHM

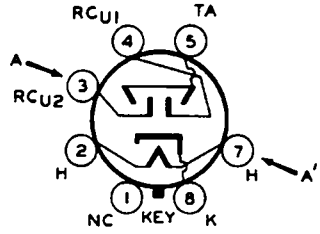
The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.



92C-4902

BOTTOM VIEW
OF SOCKET CONNECTIONS

AA' = PLANE OF RAY-CONTROL ELECTRODES



7AG

H = HEATER
K = CATHODE
NC = NO CONNECTION
RC_{U1} = RAY-CONTROL ELECTRODE OF UNIT No.1
RC_{U2} = RAY-CONTROL ELECTRODE OF UNIT No.2
TA = TARGET

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

JETEC TYPE 6AF6G

DOUBLE INDICATOR

MECHANICAL DATA

Coated unipotential cathode

Outline drawing. . . . . 9-1 or 9-36 Bulb T-9
Base . . . . . B6-81 or B7-7 intermediate shell octal
or B6-84 or B7-59 short intermediate shell octal
Maximum diameter . . . . . 1-5/16"
Maximum overall length . . . . . 2-5/16"
Maximum seated height. . . . . 1-3/4 "
Pin connections. . . . . Basing 7AG

*Pin 1 - No connection
Pin 2 - Heater
Pin 3 - Ray-control electrode, unit #2
Pin 4 - Ray-control electrode, unit #1
Pin 5 - Target
Pin 7 - Heater
Pin 8 - Cathode

*Pin #1 omitted on Base Nos. B6-81 and B6-84

Mounting position . . . . . Any**

**The plane of the ray-control electrodes passes through pins #3 and #7.

ELECTRICAL DATA

Ratings:

Heater voltage (ac or dc)	6.3	volts
Heater current	150	ma
Maximum ray-control electrode supply voltage	250	volts
Maximum target voltage	250	volts
Minimum target voltage	125	volts

Typical operating Conditions and Characteristics

Heater voltage***	6.3	6.3	volts
Target voltage	135	250	volts
Target current#	1.5	3.75	ma
Ray-control electrode voltage (approx.)##	81	155	volts
Ray-control electrode voltage###	0	0	volts

***In circuits where the cathode is not directly connected to the heater, the potential differences between heater and cathode should be kept as low as possible.

#With zero volts on rey-control electrodes. Subject to wide variation.
##For shadow angle of 0° produced by either ray-control electrode.
###For shadow angle of 100° produced by either ray-control electrode.

Refer to "Interpretation of Receiving Tube Ratings"

from RMA release #187
May 24, 1939

#187
5/24

6AG7

Video Beam Power Amplifier

RCA-6AG7 is a heater-cathode type of metal tube intended for use primarily in the output stage of the video amplifier of television receivers. It may also be used advantageously in television transmitters as a coupling device between video-frequency stages and transmission lines.

The design of the 6AG7 features not only an exceedingly high value of transconductance but also high plate-current capability. As a result, a large voltage for modulating a Kinescope can be built up across the relatively low load resistance required for coupling the 6AG7 to the Kinescope.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.65	Ampere
DIRECT INTERELECTRODE CAPACITANCES: °		
Grid to Plate	0.060 *max.*	μμf
Input	12	μμf
Output	12	μμf
Grid to Screen	5 *approx.*	μμf
Grid to Cathode and Heater	7 *approx.*	μμf
Heater to Cathode	11 *approx.*	μμf
MAXIMUM OVERALL LENGTH	3-1/4"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

CHARACTERISTICS

PLATE VOLTAGE	300	Volts
SCREEN VOLTAGE	300	Volts
GRID VOLTAGE	-10.5	Volts
INTERLEAD SHIELD	Connected to ground	
AMPLIFICATION FACTOR	770	
PLATE RESISTANCE	0.1	Megohm
TRANSCONDUCTANCE	7700	Micromhos
PLATE CURRENT	25	Milliamperes
SCREEN CURRENT	6.5	Milliamperes

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

VIDEO VOLTAGE AMPLIFIER - Class A

PLATE VOLTAGE	300 *max.**	Volts
SCREEN VOLTAGE	300 *max.**	Volts
PLATE DISSIPATION	8.7 *max.**	Watts
SCREEN INPUT	2 *max.**	Watts

° With shell connected to cathode.
* Design maximum for 117-volt line.

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TYPICAL OPERATION IN 4 Mc BANDWIDTH AMPLIFIER:

Heater Voltage #	6.3	Volts
Plate-Supply Voltage	250	Volts
Screen Voltage	140	Volts
Grid Voltage ##	-2	Volts
Grid Signal-Swing Voltage (Peak to peak)	4	Volts
Plate Current	33	Milliamperes
Screen Current	8.5	Milliamperes
Load Resistance	1700	Ohms
Voltage Output (Peak to peak)	70 *approx.*	Volts

In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.
The d-c resistance in the grid circuit should not exceed 0.25 megohm.

INSTALLATION

The *base* pins of the 6AG7 fit the standard octal socket which should be installed to hold the tube preferably in a vertical position with the base either up or down. Horizontal operation is permissible if the socket is positioned so that pins No.2 and No.7 are in a vertical plane.

The *heater* of the 6AG7 is designed to operate on either a.c. or d.c. When a.c. is used, the winding which supplies the heater circuit should operate the heater at its recommended value for full-load operating conditions at average line voltage. When d.c. is used on the heater, the heater terminals should be connected directly across a 6-volt battery. Under any condition of operation, the heater voltage should not deviate more than plus or minus 10% from the normal value of 6.3 volts.

The *cathode*, when the 6AG7 is operated from a transformer, should be connected through a bias source either to one side or to the electrical mid-point of the heater circuit. In the case of d-c operation from a 6-volt storage battery, the cathode circuit should be tied through a bias source to the negative battery terminal. The potential difference between heater and cathode should be kept as low as possible.

Control-grid bias may be obtained from a fixed supply, from a cathode resistor, or from a variable voltage supplied for automatic control purposes. In video use, the latter method provides for control of the picture background. With the cathode-resistor bias method, the resistor should not be by-passed if it is desired to have degeneration and freedom from distortion. When, however, no degeneration and maximum signal amplitude are desired, compensation can be provided by utilizing filters with equal time constants in the cathode circuit and in the plate circuit.

The *screen* voltage for the 6AG7 operated with fixed bias or cathode-resistor bias, should preferably be obtained through the use of a resistor in series with the high-voltage B-supply. The use of a series screen resistor requires the use of a large by-pass con-

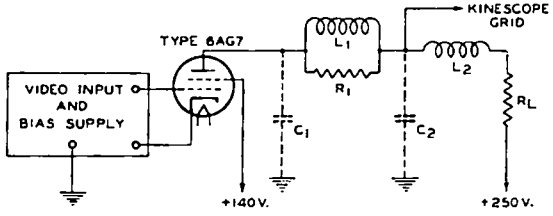
denser in the screen circuit. The size of the by-pass condenser can be reduced if a suitable compensating filter is used in the plate circuit. When the bias for the 6AG7 is obtained by the automatic background-control method, it is recommended that the screen voltage be obtained from a source of good regulation.

The *interlead shield* is connected within the tube to pin No.3. This pin should be grounded at the socket to provide a shield between the grid and heater (pin No.2).

APPLICATION

As a *video amplifier*, the 6AG7 is especially designed for use in the final video stage to modulate the Kinescope in a television receiver. In such service, the 6AG7 will provide adequate modulating voltage without frequency discrimination over the wide bandwidth required for high-definition television reception. The extremely high transconductance and the large plate current of this tube make possible relatively high voltage gain with the low load resistance needed to give uniform output over the wide frequency range. A typical circuit showing suitable constants for a video amplifier is shown below.

TYPICAL VIDEO VOLTAGE AMPLIFIER
HAVING BANDWIDTH OF 4 MEGACYCLES



C_1 = 16 μμf = TUBE OUTPUT CAPACITANCE + SOCKET CAPACITANCE + WIRING CAPACITANCE + COIL CAPACITANCE

C_2 = 16 μμf = KINESCOPE INPUT CAPACITANCE + SOCKET CAPACITANCE + WIRING CAPACITANCE + COIL CAPACITANCE

L_1 = 94 μh FILTER INDUCTOR

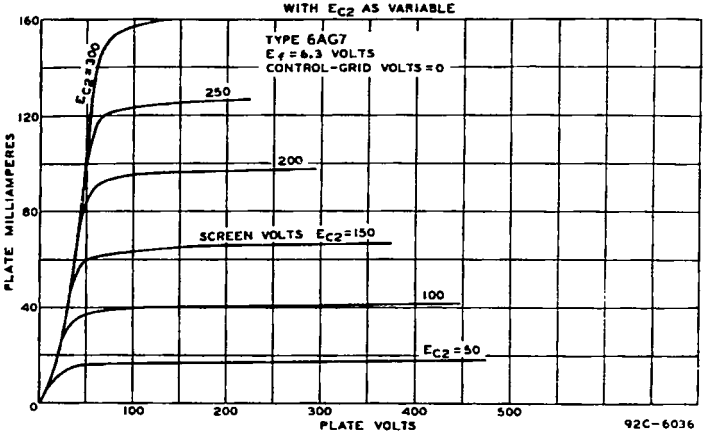
L_2 = 47 μh FILTER INDUCTOR

R_1 = 30000-OHM, NON-REACTIVE RESISTOR

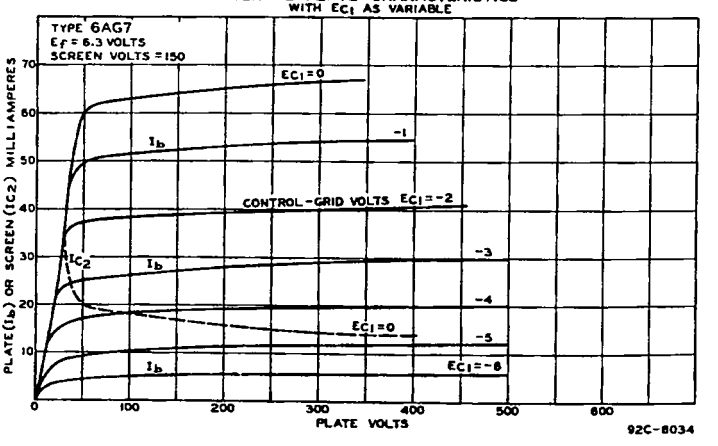
R_L = 1700-OHM, 10-WATT, NON-REACTIVE RESISTOR

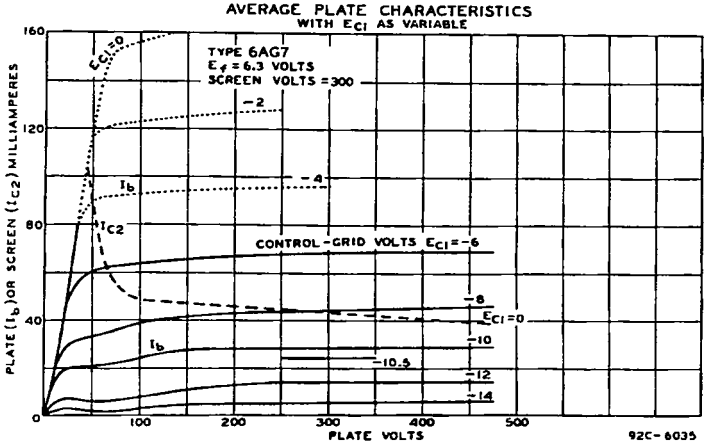
The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

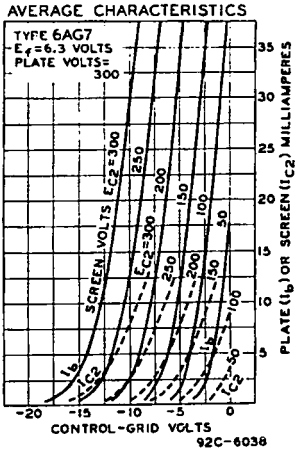
AVERAGE PLATE CHARACTERISTICS
WITH E_{C2} AS VARIABLE

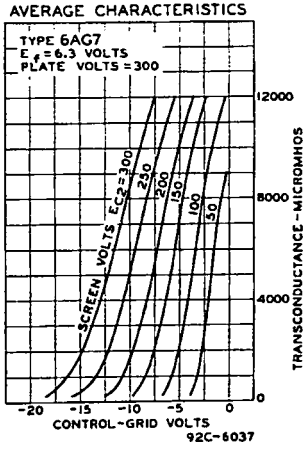


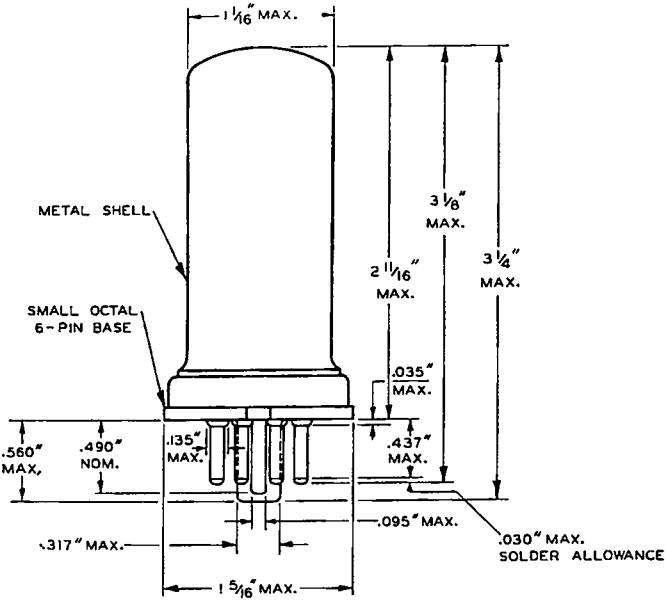
AVERAGE PLATE CHARACTERISTICS
WITH E_{C1} AS VARIABLE

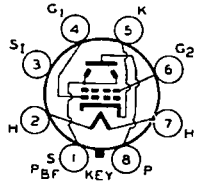



AVERAGE PLATE CHARACTERISTICS
WITH E_{C1} AS VARIABLE
TYPE 6AG7
E_f = 6.3 VOLTS
SCREEN VOLTS = 300
PLATE (I_b) OR SCREEN (I_{C2}) MILLIAMPERES
PLATE VOLTS
CONTROL-GRID VOLTS E_{C1} = -6
E_{C1} = 0
-2
-4
-8
-10
-10.5
-12
-14
I_b
I_{C2}
92C-6035


AVERAGE CHARACTERISTICS
TYPE 6AG7
E_f = 6.3 VOLTS
PLATE VOLTS = 300
SCREEN VOLTS E_{C2} = 300
250
200
150
100
50
PLATE (I_b) OR SCREEN (I_{C2}) MILLIAMPERES
CONTROL-GRID VOLTS
92C-6038


AVERAGE CHARACTERISTICS
TYPE 6AG7
E_f = 6.3 VOLTS
PLATE VOLTS = 300
SCREEN VOLTS E_{C2} = 300
250
200
150
100
50
TRANSCONDUCTANCE - MICROMHOS
CONTROL-GRID VOLTS
92C-6037





8Y

G_1 = GRID
G_2 = SCREEN
H = HEATER
K = CATHODE
P_{BF} = BEAM-FORMING PLATES
S_I = INTERLEAD SHIELD

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

JETEC TYPE 6AG7

PENTODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-6
Bulb	MT-8
Base	B8-21 small wafer octal 8-pin
Maximum diameter	1-5/16"
Maximum overall length	3-1/4"
Maximum seated height	2-11/16"
Pin connections	Basing 8Y

Pin 1 - Shell, grid #3	Pin 5 - Cathode
Pin 2 - Heater	Pin 6 - Grid #2
Pin 3 - Interlead shield	Pin 7 - Heater
Pin 4 - Grid #1	Pin 8 - Plate

Mounting position . . . . . Vertical*

*Horizontal operation permitted if pins #2 and #7 are in vertical plane.

ELECTRICAL DATA

Direct Interelectrode Capacitances**

Grid to plate: (g1 to p) max.	0.06	µµf
Input: g to (h+k+g2+g3+s+i.s.)	13	µµf
Output: p to (h+k+g2+g3+s+i.s.)	7.5	µµf
Grid #1 to grid #2: (g1 to g2) approx.	5.8	µµf
Grid #1 to cathode: (g1 to k) approx.	5.2	µµf
Heater to cathode: (h to k) approx.	10.7	µµf

**Pins #1 and #3 connected to pin #5.

Ratings

Heater voltage (ac or dc)	6.3	volts
Maximum heater-cathode voltage	90	volts
Maximum plate voltage	300	volts
Maximum grid #2 voltage	300	volts
Maximum plate dissipation	9	watts
Maximum grid #2 dissipation	1.5	watts
Maximum positive dc grid #1 voltage	0	volts
Maximum grid #1 circuit resistance (fixed bias)	0.25	megohm
Maximum grid #1 circuit resistance (self bias)	1.0	megohm

Continued on Page 2

ELECTRICAL DATA (Continued)

Typical Operating Conditions and Characteristics, Class A1 Amplifier

Heater voltage	6.3	volts
Heater current	0.65	ampere
Plate voltage	300	volts
Grid #2 voltage	150	volts
Grid #1 voltage	-3	volts
Peak a-f grid #1 voltage	3	volts
Zero-signal plate current	30	ma
Maximum-signal plate current	30.5	ma
Zero-signal grid #2 current	7	ma
Maximum-signal grid #2 current	9	ma
Plate resistance (approx.)	0.13	megohm
Transconductance	11,000	μmhos
Load resistance	10,000	ohms
Maximum-signal power output	3	watts
Total harmonic distortion	7	%

Typical Operating Conditions and Characteristics, Class A1 Video Voltage Amplifier 4MC bandwidth	Grid-leak Bias #	Cathode Bias	
Heater voltage	6.3	6.3	volts
Heater current	0.65	0.65	ampere
Plate supply voltage	300	300	volts
Grid #2 voltage	115##	125###	volts
Grid #1 voltage	0§	-2	volts
Minimum grid #1 resistor	0.25	-	megohm
Maximum grid #1 resistor	0.5	-	megohm
Cathode resistor (by-passed by 250 μf approx.)	-	57	ohms
Interlead shield	Connected to ground		
Grid signal swing (peak to peak)	4	4	volts
Zero-signal plate current	45	28	ma
Zero-signal grid #2 current	13	7	ma
Load resistance	3500	3500	ohms
Voltage output (peak to peak)	135	140	volts

#Intended for use where dc restoration is accomplished in the grid circuit of the 6AG7.
##Obtained with regulated power supply
###From plate supply through 25,000 ohm resistor
§Zero-signal value

JOINT ELECTRON DEVICE ENGINEERING COUNCIL

2260 Salmon Tower
11 West Forty-Second Street
New York 36, N. Y.
Telephone: LOngacre 5-0717

Announcement
of
Electron Device Type Reregistration

Release No. 187C (Tentative)*

March 29, 1960

The Joint Electron Device Engineering Council announced the registration of the following electron device designation

6AG7

on May 24, 1939, Release No. 187, under the sponsorship of Radio Corporation of America, Harrison, New Jersey.

The sponsor now proposes reregistration based on the following data:

ITEM	AS REGISTERED	AS PROPOSED
Under MECHANICAL DATA		
Pin Connections:		
Pin 3	Interlead Shield	No connection
Mounting Position	Vertical*	Any
* Horizontal operation permitted if pins #2 and #7 are in vertical plane.		
Under ELECTRICAL DATA		
Direct Interelectrode Capacitances:		
Input:	g to (h+k+g2+g3+s+i.s.)	gl to (h+k+g2+g3&s)
Output:	p to (h+k+g2+g3+s+i.s.)	p to (h+k+g2+g3&s)
Footnote **	Pins #1 and #3 connected to pin #5	Delete

*Unless valid objection to this reregistration is lodged with the EIA Standards Laboratory prior to April 29, 1960, this reregistration will be made and this information will be considered "FINAL" WITHOUT FURTHER NOTICE!

from JEDEC release #3320,
June 26, 1961

NOVAR

6AY3, 12AY3, 17AY3

HALF-WAVE VACUUM RECTIFIERS

Novar Types
For Television Damper Service

RCA-6AY3, 12AY3, and 17AY3 are half-wave vacuum rectifier tubes designed specifically for use as damper diodes in horizontal-deflection circuits of black-and-white television receivers. These tubes feature the new small-button novar 9-pin base. The short, large-diameter internal leads to the bases of these tubes assure an exceptionally firm support for the mount structure. These short heavy leads also facilitate electrode cooling by providing very good heat conduction. Two base-pin connections to the plate, in addition to the low heater power, contribute to cool operation. The relatively large pin-circle diameter (0.687 inch) and long pins of the novar base insure firm seating of the tube in its socket.

Rated to withstand a maximum peak-inverse plate voltage of 5000 volts, the 6AY3, 12AY3, and 17AY3 can supply a maximum peak plate current of 1100 milliamperes and a maximum dc plate current of 175 milliamperes. Designed with insulation between heater and cathode to withstand negative peak pulses between heater and cathode of as much as 5000 volts with a dc component up to 900 volts, these tubes provide flexibility in choice of deflection circuits.

In addition, these tubes utilize a cathode with a special low-impedance coating to withstand high-voltage pulses encountered in TV damper service. This coating not only minimizes sputtering, but also assures uniform emission over the cathode surface. In addition, specially designed micas together with a plate structure having rounded contours to reduce voltage gradients, insure against high-voltage breakdown.

Slots in the plate surface surrounding the cathode permit the escape of gas which may be released under abnormal operating conditions and thereby minimize the danger of sustained arcs.

The 12AY3 and 17AY3 are like the 6AY3 except that they are designed, respectively, with 600- and 450-milliampere heaters having a controlled warmup time for use in series-heater-string arrangements.

GENERAL DATA

Electrical:

	6AY3	*12AY3*	*17AY3*	
Heater, for Unipotential Cathode:				
Voltage (AC or DC)	6.3 ± 10%	12.6	16.8	volts
Current	1.2	0.6 ± 6%	0.45 ± 6%	amp
Warmup time (Average)	-	11	11	sec

Direct Interelectrode Capacitances (Approx. without external shield):

Plate to cathode and heater	6.5	μμf
Cathode to plate and heater	9.0	μμf
Heater to cathode	2.8	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	3.84"
Maximum Seated Length	3.46"
Length, Base Seat to Bulb Top (Excluding tip)	2.90" ± 0.09"
Diameter:	
Maximum	1.188"
Minimum	1.062"
Bulb	T9
Base	Small-Button Novar 9-Pin (JEDEC No. E9-75)

DAMPER SERVICE

Maximum Ratings, *Design-Maximum Values:*[a]

For operation in a 525-line, 30-frame system[b]

PEAK INVERSE PLATE VOLTAGE	5000[c] max.		volts
PEAK PLATE CURRENT	1100 max.		ma
DC PLATE CURRENT	175 max.		ma
PLATE DISSIPATION	6.5 max.		watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	5000[d] max.		volts
Heater positive with respect to cathode	300[e] max.		volts

[a] See RCA Application Note AN-174, "Design-Maximum System for Rating Electron Tubes", available on request from Commercial Engineering, Radio Corporation of America, Harrison, New Jersey.

[b] As described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations", Federal Communications Commission.

[c] This rating is applicable where the duty cycle of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

[d] The dc component must not exceed 900 volts.

[e] The dc component must not exceed 100 volts.

OPERATING CONSIDERATIONS

The *base pins* of the 6AY3, 12AY3, and 17AY3 fit the Cinch Mfg. Co. socket No. 149-19-00-024 or equivalent. The socket may be mounted to hold the tube in any position. Socket terminals for pins 1, 3, 6, and 8 should not be used for tie points. It is also recommended that socket clips for these pins be removed to minimize the possibility of arc-over and to minimize leakage.

In television receivers employing series-heater strings, a resistor in series with the string of tubes will minimize voltage surges across any individual tube during starting. The resistor should preferably have a negative temperature characteristic.

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Marca(s) Registrada(s)

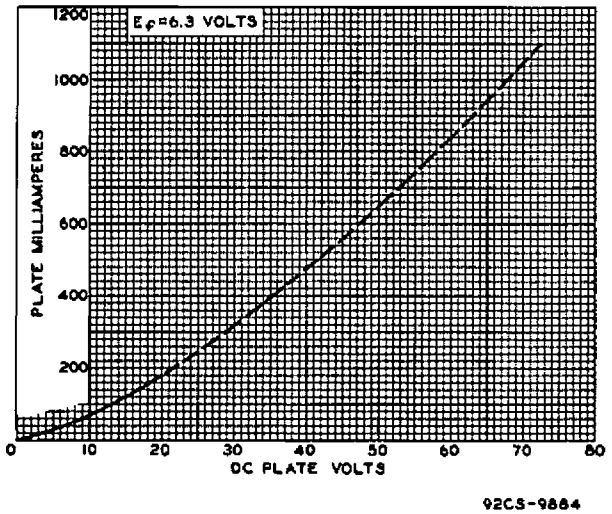
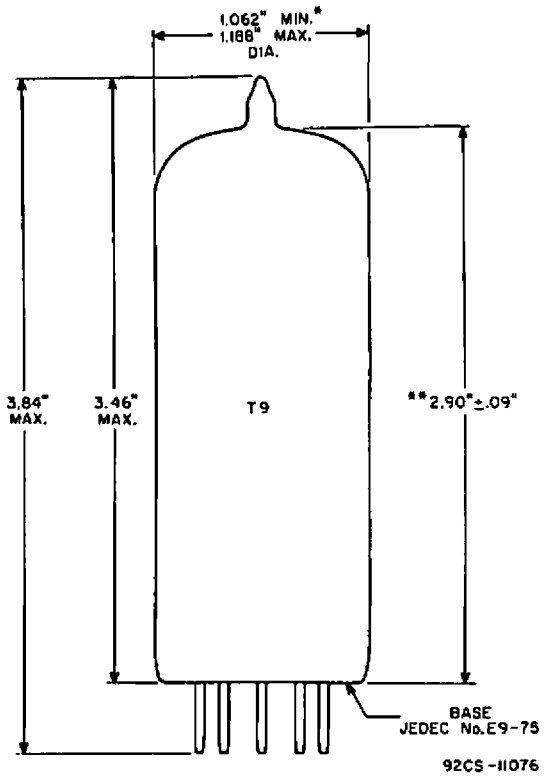


Fig. 1 – Average Plate Characteristic for Type 6AY3 and for Types 12AY3 and 17AY3 Except for Heater Voltage.

DIMENSIONAL OUTLINE

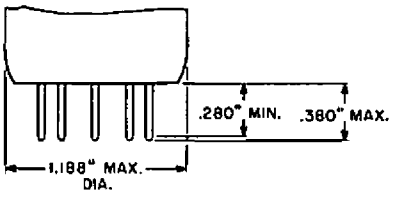


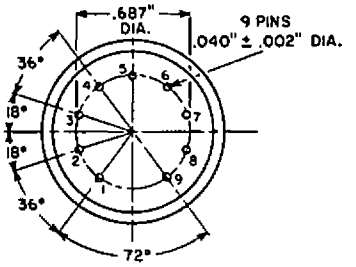
* Applies in zone starting 0.375" from base seat.

**Measured from base seat to bulb-top line as determined by a ring gauge of 0.600" I.D.

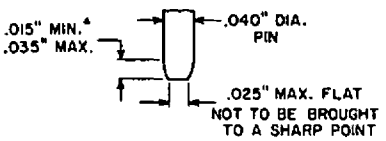
SMALL-BUTTON NOVAR 9-PIN

E9-75





PIN CONTOUR



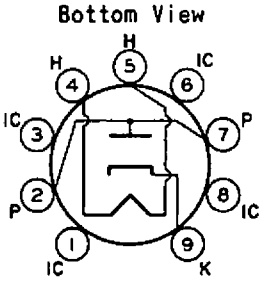
▲This dimension may vary within the limits shown around the periphery of any individual pin. The surface of the pin shall be convex or conical in shape and not brought to a sharp point.

PIN ALIGNMENT GAUGE

Base pin positions shall be held to tolerances such that the base will fit a flat-plate gauge having a thickness of 0.350" and ten equally spaced holes of 0.0520" ±0.0005" diameter located on a 0.6870" ± 0.0005" diameter circle that the distance along the chord between any two adjacent hole centers is 0.2123" ± 0.0005". Pin fit in the gauge shall be such that the entire length of pins will, without undue force, enter into and disengage from the gauge.

BASING DIAGRAM

Bottom View



9HP

PIN 1 – INTERNAL CONNECTION— DO NOT USE
PIN 2 – PLATE
PIN 3 – SAME AS PIN 1
PIN 4 – HEATER
PIN 5 – HEATER
PIN 6 – SAME AS PIN 1
PIN 7 – PLATE
PIN 8 – SAME AS PIN 1
PIN 9 – CATHODE

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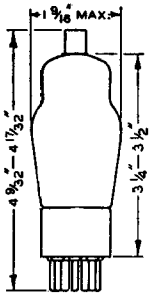
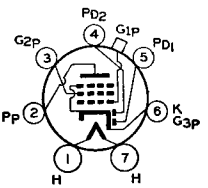


RCA-6B7

DUPLEX-DIODE PENTODE



The 6B7 is a heater type of tube consisting of two diodes and a pentode in a single bulb. It is recommended for service as combined detector, amplifier (radio-frequency, intermediate-frequency or audio-frequency), and automatic-volume-control tube in radio receivers. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Grid-Plate Capacitance (With shield-can)	0.007 *max.*	μμf
Input Capacitance	3.5	μμf
Output Capacitance	9.5	μμf
Bulb		ST-12
Cap		Small Metal
Base		Small 7-Pin

Pentode Unit—As Class A_1 Amplifier

Plate Voltage	100	180	250	250 *max.*	Volts
Screen Voltage (Grid No. 2)	100	75	100	125 *max.*	Volts
Grid Voltage† (Grid No. 1)	—3	—3	—3	—3	Volts
Plate Current	7.8	3.4	6.0	9.0	Milliamperes
Screen Current	1.7	0.9	1.5	2.3	Milliamperes
Plate Resistance	0.3	1.0	0.8	0.65	Megohm
Amplification Factor	285	840	800	730	
Transconductance	950	840	1000	1125	Micromhos
Grid Bias Volt. (Approx.)*	—17	—13	—17	—21	Volts

* For cathode current cut-off.

† The total resistance in the grid circuit of the 6B7 should be limited to 1.0 megohm.

Diode Units

Two diode plates are placed around a cathode, the sleeve of which is common to the pentode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

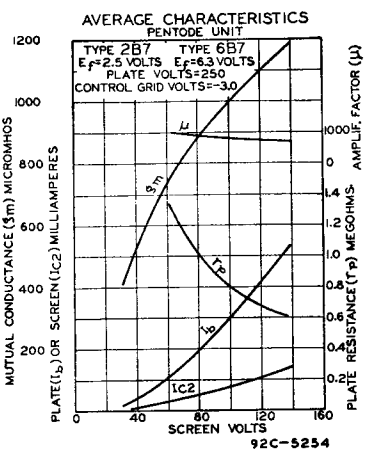
INSTALLATION AND APPLICATION

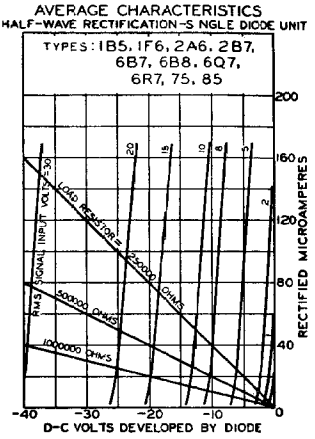
The base pins of the 6B7 fit the standard seven-pin (0.75-inch pin-circle diameter) socket which may be installed to hold the tube in any position.

For heater and cathode operation, refer to type 6A8.

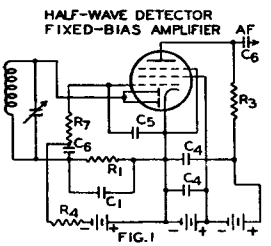
Complete shielding of detector circuits employing the 6B7 is generally necessary to prevent r-f or i-f coupling between the diode circuits and the circuits of other stages.

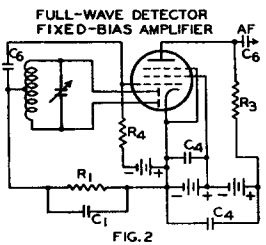
Refer to APPLICATION on the type 6B8. Plate characteristics of pentode unit are shown under type 2B7.

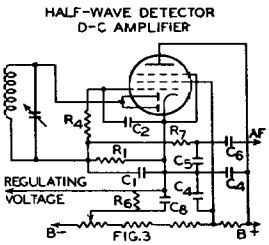


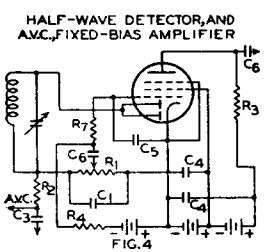


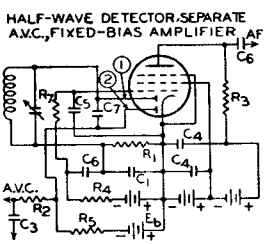
TYPICAL DUPLEX-DIODE PENTODE CIRCUITS
USING TYPES 2B7 OR 6B7

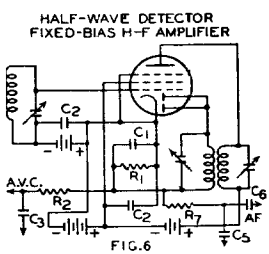










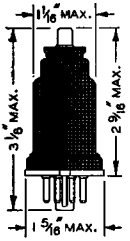


APPROXIMATE VALUES

R_1=0.5-1.0 MEGOHM
R_2=1.0-1.5 MEGOHMS
R_3=0.1-0.2 MEGOHM
R_4=0.5-1.0 MEGOHM
R_5=1.0 MEGOHM
R_6=30000-100000 OHMS
R_7=0.1-0.2 MEGOHM
E_b=VOLTAGE FOR SENSITIVITY CONTROL

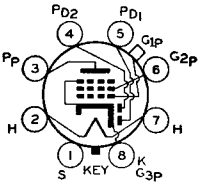
C_1= 150 μμf FOR 500-1500 KC.
C_1= 450 μμf FOR 175 KC.
C_2=0.1 μf
C_3=0.1 μf
C_4=0.5 μf OR LARGER
C_5=0.0001 μf OR SMALLER
C_6=0.01-0.1 μf
C_7=0.0005-0.001 μf
C_8=0.1 μf OR LARGER

NOTE: Suppressor connected to cathode within bulb.



RCA-6B8

DUPLEX-DIODE PENTODE



The 6B8 is an All-Metal type of tube consisting of *two diodes* and a *pentode* in a single envelope. It is recommended for service as combined detector, amplifier (radio-frequency, intermediate-frequency or audio-frequency), and automatic-volume-control tube in radio receivers. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
GRID-PLATE CAPACITANCE*	0.005 *max.*	μμf
INPUT CAPACITANCE*	6	μμf
OUTPUT CAPACITANCE*	9	μμf
CAP		Miniature
BASE		Small Wafer Octal 8-Pin

* With shell connected to cathode.

Pentode Unit—As Class A_1 Amplifier

PLATE VOLTAGE	250 *max.*	Volts
SCREEN VOLTAGE (Grid No. 2)	125 *max.*	Volts
GRID VOLTAGE (Grid No. 1)**	−3	Volts
PLATE CURRENT	10.0	Milliamperes
SCREEN CURRENT	2.3	Milliamperes
PLATE RESISTANCE	0.6	Megohm
AMPLIFICATION FACTOR	800	
TRANSCONDUCTANCE	1325	Micromhos
GRID BIAS VOLTAGE (Approx.)†	−21	Volts

† For cathode current cut-off.
** The value of the resistance in the grid circuit should not exceed a maximum of 1.0 megohm.

Diode Units

Two diode plates are placed around a cathode, the sleeve of which is common to the pentode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

INSTALLATION

Refer to INSTALLATION on the type 6A8.

APPLICATION

The 6B8 is recommended for performing the simultaneous functions of automatic-volume-control, detection, and amplification.

For detection, the diodes of this tube may be utilized in a full-wave circuit or in a half-wave circuit. In the latter case, one plate only or the two plates in parallel may be employed. The use of the half-wave arrangement will provide approximately twice the rectified voltage as compared with the full-wave arrangement.

For **automatic-volume-control,** a rectified voltage which is dependent on the r-f or i-f carrier is usually employed. This voltage may be utilized to regulate the gain of the r-f and/or i-f amplifier stages so as to maintain essentially constant-carrier input to the audio detector. Refer to discussion of automatic-volume-control methods on page 28.

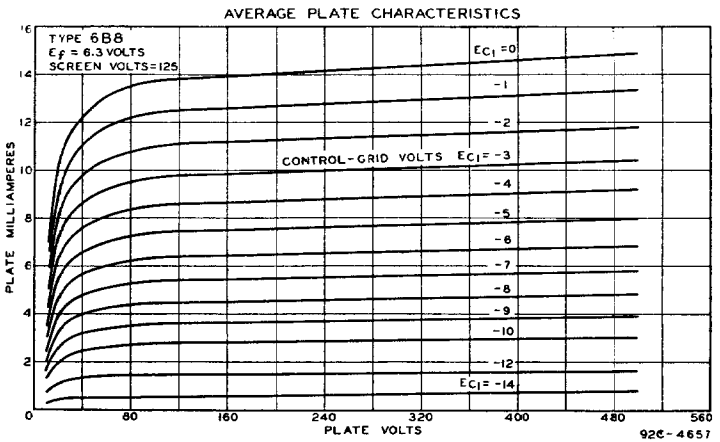
The complex structure of the 6B8 permits of obtaining automatic-volume-control voltage in a number of ways. In one case, the required voltage is obtained from the detector circuit by utilizing the voltage drop caused by the rectified current flowing through a resistor in the detector circuit. In another case, the required voltage is obtained by utilizing one diode for the sole purpose of automatic-volume-control. This latter method is of particular interest since it confines the sensitivity and time-delay function to the avc circuit. Time-delay action is determined by the use of a resistance and condenser combination having the desired time constant. The avc action may be postponed by applying a negative voltage to the avc diode plate. Another avc arrangement capable of various adaptations is to use the pentode as a d-c amplifier to supply the regulating voltage.

For **r-f or i-f amplification,** the pentode unit of the 6B8 may be employed in conventional circuit arrangements. It is designed so that its cut-off is somewhat extended to permit of moderate gain control by grid-bias variation without introducing cross-modulation effects. The cut-off point and the ability to handle the larger signals may be altered by choice of screen voltage to suit the requirements of the circuit. To assist in making this choice, different operating conditions for representative screen voltages are given under CHARACTERISTICS.

For many types of circuits a convenient and practical method of obtaining the desired benefit of the extended cut-off is to supply the screen voltage from a high-voltage tap through a series resistor. This arrangement provides automatically an increase in the voltage applied to the screen as the grid-bias is made more negative, with the result that the maximum signal-handling ability is obtained. When this method is used, the voltage applied to the screen should be limited to 125 volts for −3 volts grid-bias and to 200 volts for more negative values of grid-bias.

For **a-f amplification,** the pentode unit of the 6B8 may be used in a resistance-coupled circuit arrangement to provide high gain under operating conditions given in the Resistance-Coupled A-F Amplifier Section.

Typical duplex-diode pentode circuits are shown under type 6B7. When the 6B8 is used in these circuits, its shell should be connected to ground.



from JEDEC release #3320,
June 26, 1961

NOVAR

6BH3, 17BH3, 22BH3

HALF-WAVE VACUUM RECTIFIERS

T9 Bulb — **Novar Tubes For Television Damper Service** — **RCA "Dark Heater"**

RCA-6BH3, 17BH3, and 22BH3 are half-wave vacuum rectifier tubes designed specifically for use as damper diodes in horizontal-deflection circuits of black-and-white television receivers. These novar tubes have integral, all-glass 9-pin bases. The short, large-diameter internal leads to the bases of these tubes assure an exceptionally firm support for the mount structure. These short heavy leads also facilitate electrode cooling by providing very good heat conduction. Two base-pin connections to the plate, in addition to the low heater power, contribute to cool operation. The relatively large pin-circle diameter (0.687 inch) and long pins of the novar base insure firm retention of the tube in its socket.

Rated to withstand a maximum peak inverse plate voltage of 5500 volts, the 6BH3, 17BH3, and 22BH3 can supply a maximum peak plate current of 1100 milliamperes and a maximum dc plate current of 180 milliamperes. Designed with insulation between heater and cathode to withstand negative peak pulses between heater and cathode of as much as 5500 volts with a dc component up to 900 volts, these tubes provide flexibility in choice of deflection circuits.

Also featured in the design of the 6BH3, 17BH3, and 22BH3 is the new RCA "Dark Heater", which functions efficiently at operating temperatures 350° K below those of the heaters in conventional tube types. The dark surface of the new heater radiates heat more efficiently and improves the transfer of heat to the cathode so that optimum cathode temperature may be attained with the heater operating at approximately 1350° K.

The low operating temperature of the "Dark Heater" results in (1) lower internal stresses in the heater wire and smaller thermal change during heater warmup, (2) cooler operation of the heater which minimizes changes in heater shape and reduces the possibility of heater damage and heater shorts, (3) extremely stable current characteristics throughout life, and (4) significant reduction in effects of ac heater leakage.

In addition, these tubes utilize a cathode with a special low-impedance coating to withstand high-voltage pulses encountered in TV damper service. This coating not only minimizes sputtering, but also assures uniform emission over the cathode surface. Furthermore, specially designed micas together with a plate structure having rounded contours to reduce voltage gradients, insure against high-voltage breakdown. Slots in the plate surface surrounding the cathode permit the escape of gas which may be released under abnormal operating conditions and thereby minimize the danger of sustained arcs.

The 17BH3 and 22BH3 are like the 6BH3 except that they are designed respectively, with 600- and 450-milliampere heaters having a controlled warmup time for use in series-heater-string arrangements.

GENERAL DATA

Electrical:

	6BH3	17BH3	22BH3	
Heater, for Unipotential Cathode:				
Voltage (AC or DC)	6.3 ± 10%	17.0	22.4	volts
Current	1.6	0.6 ± 6%	0.45 ± 6%	amp
Warmup time (Average)	-	11	11	sec
Direct Interelectrode Capacitances (Approx. without external shield):				
Plate to cathode and heater			6.5	μμf
Cathode to plate and heater			9.0	μμf
Heater to cathode			2.8	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	3.84"
Maximum Seated Length	3.46"
Length, Base Seat to Bulb Top (Excluding tip)	2.90" ± .09"
Diameter:	
Maximum	1.188"
Minimum	1.062"
Bulb	T9
Base[a]	Small-Button Novar 9-Pin (JEDEC No.E9-75)

DAMPER SERVICE

Maximum Ratings, *Design-Maximum Values:*[b]

For operation in a 525-line, 30-frame system[c]

PEAK INVERSE PLATE VOLTAGE	5500[d]	max.	volts
PEAK PLATE CURRENT	1100	max.	ma
DC PLATE CURRENT	180	max.	ma
PLATE DISSIPATION	6.5	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	5500[e]	max.	volts
Heater positive with respect to cathode	300[f]	max.	volts

[a] The *base pins* of the 6BH3, 17BH3, and 22BH3 fit the Cinch Mfg. Co. socket No.149-19-00-024 or equivalent. The socket may be mounted to hold the tube in any position. Socket terminals for pins 1, 3, 6, and 8 should not be used for tie points. It is also recommended that socket clips for these pins be removed to reduce the possibility of arc-over and to minimize leakage.

[b] For further information, see RCA Application Note AN-174, "Design-Maximum System for Rating Electron Tubes", available on request from Commercial Engineering, Radio Corporation of America, Harrison, New Jersey.

[c] As described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations", Federal Communications Commission.

[d] This rating is applicable where the duty cycle of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

[e] The dc component must not exceed 900 volts.

[f] The dc component must not exceed 100 volts.

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Marca(s) Registrada(s)

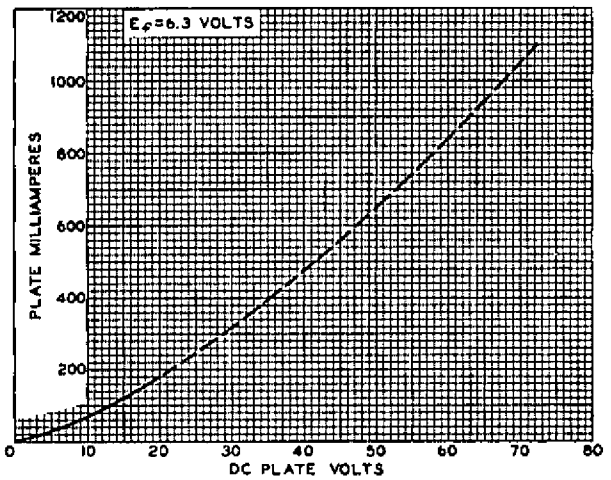
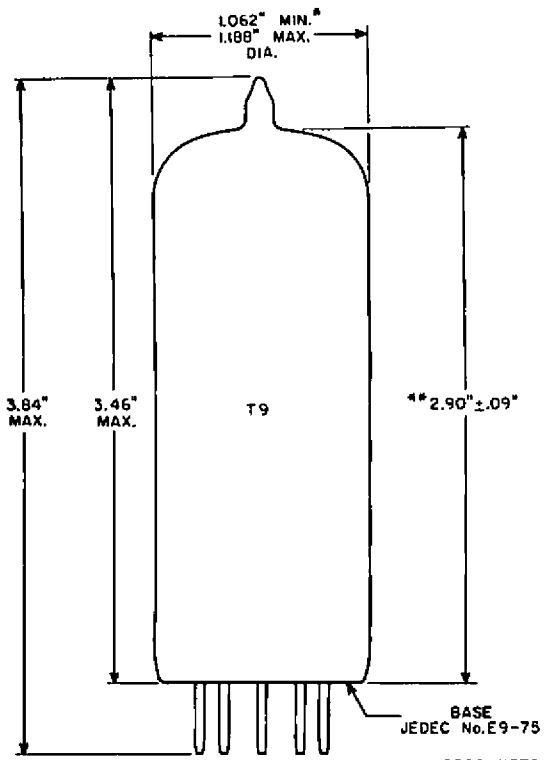


Fig. 1 - Average Plate Characteristic for Type 6BH3 and for Types 17BH3 and 22BH3 except for Heater Voltage.

DIMENSIONAL OUTLINE

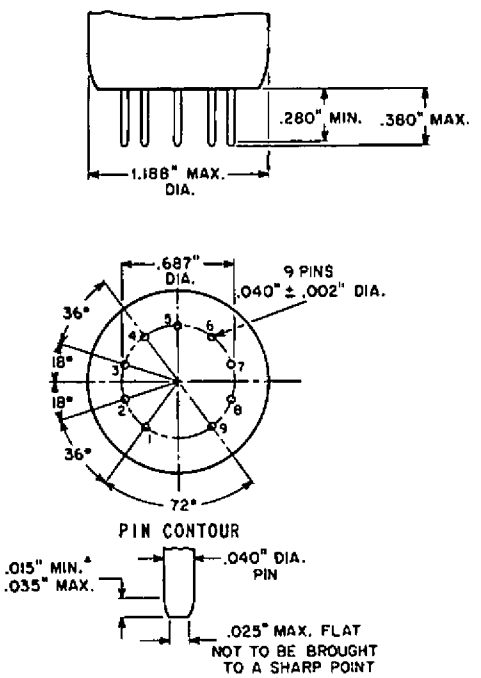


* APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

** MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY A RING GAUGE OF 0.600" I.D.

MALL-BUTTON NOVAR 9-PIN BASE

E9-75



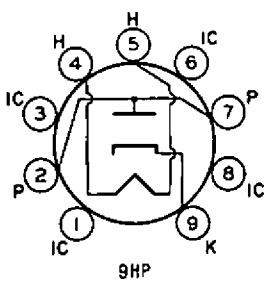
▲ THIS DIMENSION MAY VARY WITHIN THE LIMITS SHOWN AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN. THIS SURFACE OF THE PIN SHALL BE CONVEX OR CONICAL IN SHAPE AND NOT BROUGHT TO A SHARP POINT.

PIN ALIGNMENT GAUGE

BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT ENTIRE LENGTH OF PINS WILL WITHOUT UNDUE FORCE PASS INTO AND DISENGAGE FROM GAUGE JEDEC No.GE9-5. THIS GAUGE CONTAINS A FLAT-PLATE SECTION HAVING THICKNESS OF 0.350" AND TEN EQUALLY SPACED HOLES OF 0.0520" ± 0.0005" DIAMETER SO LOCATED ON A 0.6870" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.2123" ± 0.0005".

BASING DIAGRAM

Bottom View



9HP

PIN 1 - INTERNAL CONNECTION—DO NOT USE
PIN 2 - PLATE
PIN 3 - SAME AS PIN 1
PIN 4 - HEATER
PIN 5 - HEATER
PIN 6 - SAME AS PIN 1
PIN 7 - PLATE
PIN 8 - SAME AS PIN 1
PIN 9 - CATHODE

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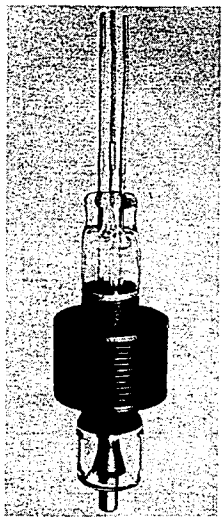
from RMA release # 454, Nov. 20, 1945

6C24
POWER TRIODE

Radiator Type
Forced-Air Cooling

Full Ratings up to 160 Megacycles
Plate Dissipation up to 600 Watts

RCA-6C24 is a compact power triode capable of delivering one kilowatt in class C amplifier and oscillator service at frequencies as high as 160 megacycles. Its small size, center-tapped filament, low interelectrode capacitances, and efficient radiator for forced-air cooling all contribute to the exceptionally good high-frequency performance.



For the usual transmitter applications, the maximum plate dissipation is 400 watts, but this rating can be increased to 600 watts by the use of increased air-flow through the radiator. For applications such as are encountered in electronic heating equipment where it is desirable to hold tube and circuit efficiencies to moderately low values, this higher dissipation rating provides reserve capability for conservative operation of the 6C24.

GENERAL DATA

Filament	Thoriated Tungsten	
Voltage (AC or DC)	11.0	Volts
Current	12.1	Amperes
Starting Current: The filament current must never exceed, even momentarily, 24 amperes.		
Resistance (Cold)	0.13	Ohms
Amplification Factor	30	
Direct Interelectrode Capacitances (Approx.):		
Grid to Plate	4.4	μμf
Grid to Filament	4.6	μμf
Plate to Filament	3.2	μμf
Terminal Connections	See *Outline Drawing*	
Radiator	Integral Part of Tube	
Mounting Position	Vertical, Filament or Grid End Up	
Mounting	See Drawing, page 7	

Cooling: See page 3 for cooling methods. Under any circumstances, sufficient air must be supplied to the radiator so that the rated maximum radiator temperature of 180°C will not be exceeded. In addition, a small amount of air is required on the filament and grid seals to limit their temperature at the hottest part to 150°C. Air flow must start before the application of any voltages.

AF POWER AMPLIFIER & MODULATOR – Class B

	Cooling Method I	*Cooling Method II*	
Maximum CCS* Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	3000 max.	3000 max.	Volts
MAX.-SIG. DC PLATE CUR.**	400 max.	400 max.	Ma.
MAX.-SIG. PLATE INPUT**	1200 max.	1200 max.	Watts
PLATE DISSIPATION**	400 max.	600 max.	Watts
Typical Operation:			
Unless otherwise specified, values are for two tubes			
DC Plate Voltage	3000		Volts
DC Grid Voltage#	-95		Volts
Peak AF Grid-to-Grid Voltage	470		Volts
Zero-Signal DC Plate Current	75		Ma.
Max.-Signal DC Plate Current	800		Ma.
Effective Load Resistance (plate-to-plate)	8600		Ohms
Max.-Signal Driving Power (Approx.)	30		Watts
Max.-Signal Power Output (Approx.)	1640		Watts

RF POWER AMPLIFIER – Class B Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

	Cooling Method I	*Cooling Method II*	
Maximum CCS*Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	3000 max.	3000 max.	Volts
DC PLATE CURRENT	250 max.	250 max.	Ma.
PLATE INPUT	600 max.	600 max.	Watts
PLATE DISSIPATION	400 max.	600 max.	Watts
Typical Operation:			
DC Plate Voltage	3000		Volts
DC Grid Voltage#	-95		Volts
Peak RF Grid Voltage	130		Volts
DC Plate Current	200		Ma.
DC Grid Current (Approx.)##	5		Ma.
Driving Power (Approx.)##	16		Watts
Power Output (Approx.)	210		Watts

PLATE-MODULATED RF POWER AMPLIFIER – Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

	Cooling Method I	*Cooling Method II*	
Maximum CCS* Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	2500 max.	2500 max.	Volts
DC GRID VOLTAGE	-500 max.	-500 max.	Volts
DC PLATE CURRENT	400 max.	400 max.	Ma.
DC GRID CURRENT	150 max.	150 max.	Ma.
PLATE INPUT	1000 max.	1000 max.	Watts
PLATE DISSIPATION	265 max.	400 max.	Watts
Typical Operation:			
DC Plate Voltage	2500		Volts
DC Grid Voltage:			
from a fixed supply of	-350		Volts
from grid resistor of	2600		Ohms
Peak RF Grid Voltage	620		Volts
DC Plate Current	400		Ma.
DC Grid Current (Approx.)##	135		Ma.
Driving Power (Approx.)##	75		Watts
Power Output (Approx.)	810		Watts

RF POWER AMPLIFIER & OSCILLATOR – Class C Telegraphy

Key-down conditions per tube without modulation ¢

	Cooling Method I	*Cooling Method II*	
Maximum CCS* Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	3000 max.	3000 max.	Volts
DC GRID VOLTAGE	-500 max.	-500 max.	Volts
DC PLATE CURRENT	500 max.	500 max.	Ma.
DC GRID CURRENT	150 max.	150 max.	Ma.
PLATE INPUT	1500 max.	1500 max.	Watts
PLATE DISSIPATION	400 max.	600 max.	Watts
Typical Operation:			
DC Plate Voltage	3000		Volts
DC Grid Voltage			
from fixed supply of	-250		Volts
from grid resistor of	1700		Ohms
from cathode resistor of	400		Ohms

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Peak RF Grid Voltage	520	Volts
DC Plate Current	500	Ma.
DC Grid Current (Approx.)##	150	Ma.
Driving Power (Approx.)##	75	Watts
Power Output (Approx.)	1100	Watts

* CCS = Continuous Commercial Service.

** Averaged over any af cycle of sine-wave form.

\# Grid voltages are given with respect to mid-point of filament operated on ac or dc.

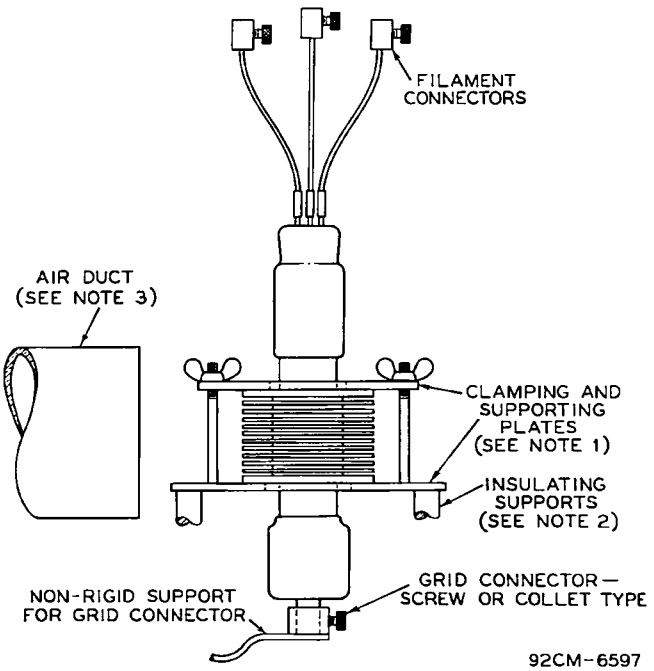
Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of delivering considerably more than the required driving power.

o At crest of af cycle with modulation factor of 1.0.

¢ Modulation essentially negative may be used if the positive peak of the af envelope does not exceed 115% of the carrier conditions.

INSTALLATION

In *transportation and storage* of the 6C24, care should be taken to protect the tube from rough handling that would damage the metal-to-glass seals or other parts. Each tube is suspended within its shipping carton so that it will not come in contact with the sides of the carton during shipment. The tube should preferably be stored in a vertical position in the carton and should be protected from moisture and extreme temperature changes. The weight of the tube is 13 ounces.



NOTE 1: SUPPORTING PLATE AND CLAMPING PLATE HAVE HOLES LARGE ENOUGH TO PERMIT PASSAGE OF THE GLASS BULBS OF THE TUBE.

NOTE 2: TWO OR MORE INSULATORS MAY BE USED. INSULATORS MUST BE PLACED SO AS TO NOT INTERFERE WITH AIR FLOW ONTO GRID TERMINAL.

NOTE 3: AIR DUCT MUST BE HORIZONTAL AND MUST BE DIRECTED AT CENTER OF RADIATOR.

Fig. 1 - Suggested Mounting for Cooling Method I.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, any foreign material clinging to the tube should be removed.

The *mounting* for the 6C24 requires a clamp support for the radiator (plate connection), a connector for the grid terminal, and three connectors for the filament leads. Because mounting and cooling arrangements are closely associated, refer also to *Cooling*.

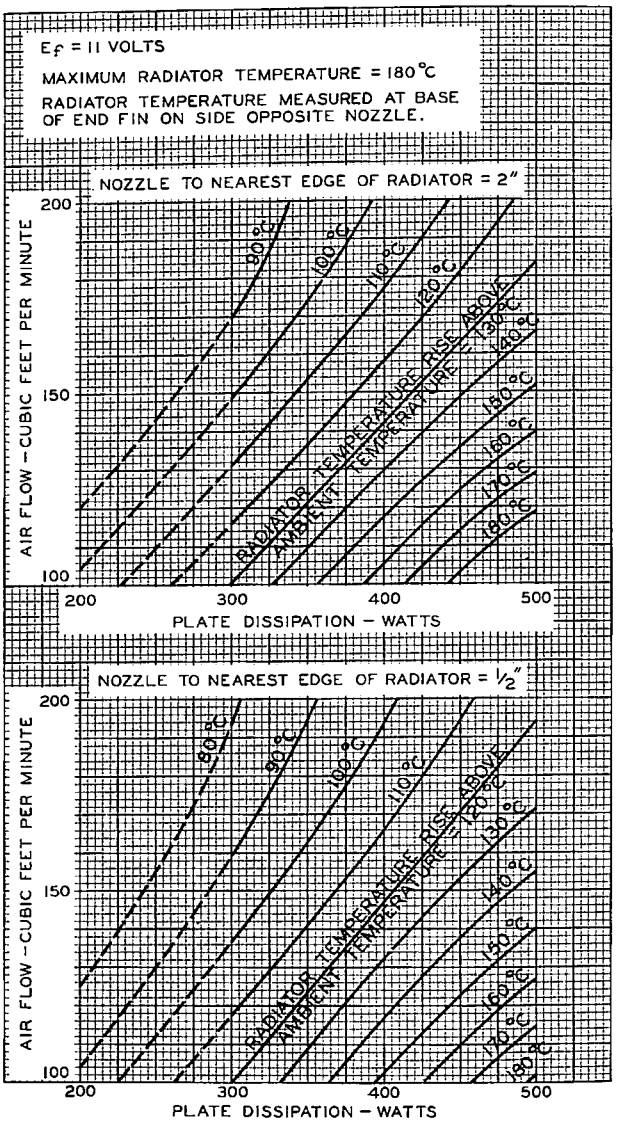


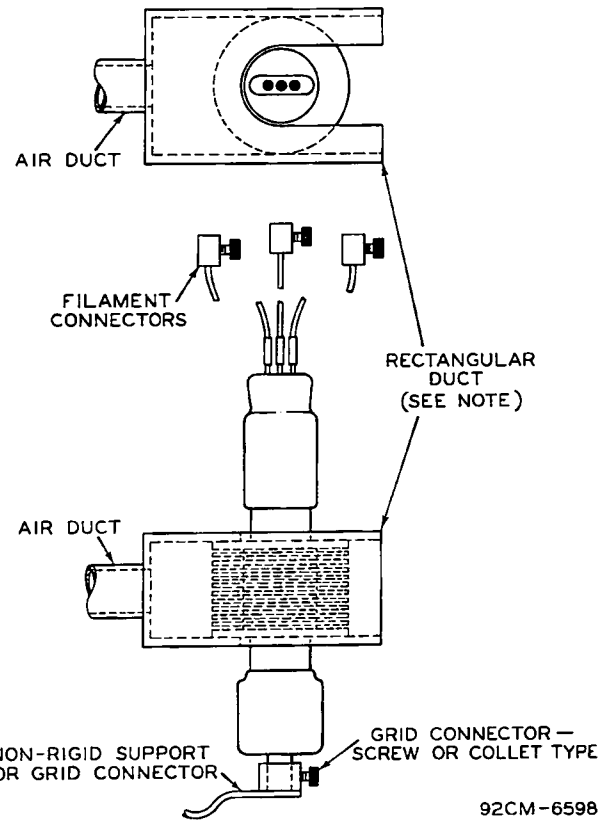
Fig. 2 - Cooling Requirements for Method I.

The tube should be supported in a vertical position with either the filament or the grid end up. If the tube is subjected to considerable vibration or shock in service, it is advisable to support the mounting by means of a spring suspension. The installation of all wires and connections must be made so that they will not be

close to or touch the glass parts. This precaution is necessary to prevent almost certain puncture of the glass from corona discharge. Suggested mounting devices are shown in Figs. 1 and 3.

Connections to the grid and filament terminals must be kept flexible in order not to put strain on the glass-to-metal seals. None of the terminals should be used to support circuit parts.

Cooling of the 6C24 is accomplished by passing a blast of air through the radiator. The tabulated data indicate two cooling methods which are illustrated in Figs. 1 and 3. The drawing of Fig. 1, showing a suggested way of mounting the tube for *Cooling Method I*, indicates a two-and-one-half inch duct directed horizontally at the center of the radiator. The air flow for two spacings of duct to radiator plotted against plate dissipation for several values of radiator temperature rise are shown in the curves of Fig. 2. *Cooling Method II* applies to those applications where, because low overall circuit efficiency is



NOTE: AIR DUCT MAY BE PART OF HIGH-FREQUENCY TRANSMISSION LINE. UPPER AND LOWER FACES OF RECTANGULAR DUCT HAVE SLOTS TO PERMIT PASSAGE OF TUBE. MEANS SHOULD BE PROVIDED TO LOCK TUBE IN POSITION.

Fig. 3 - Suggested Mounting for Cooling Method II.

desired, the plate dissipation is high. In this method, the tube is placed in the end of a rectangular duct so that all the air supply must pass through the radiator. Fig. 3 is a drawing illustrative of this method, and Fig. 4 shows the relations between rate of air flow vs plate dissipation, for various values of temperature rise of the radiator. This figure also indicates the air pressure drop through the radiator vs the rate of air flow.

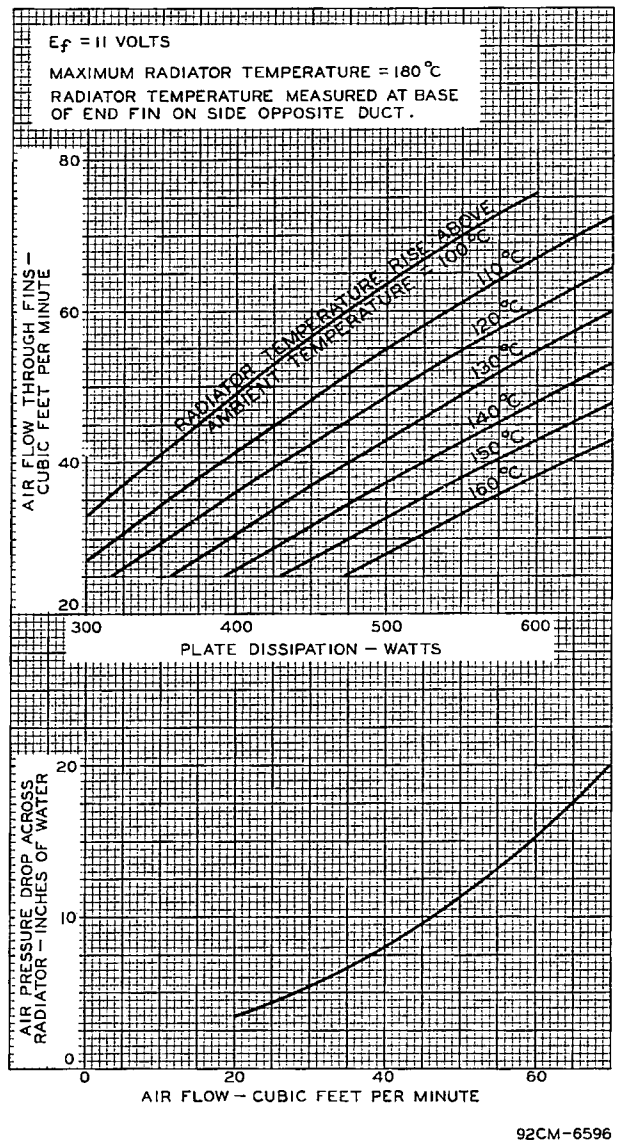


Fig. 4 - Cooling Requirements for Method II.

The cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the filament and plate power supplies. This arrangement is necessary to make sure that the tube is supplied with air before any voltages are applied. Air pressure interlocks which open the power transformer primaries are desirable for protecting the tube when the air flow is insufficient or ceases.

A small amount of cooling air is required on the grid and filament seals, and should be so

directed that the glass is cooled. Special attention to glass cooling may be required at the higher frequencies. The temperature of the glass should not exceed 150°C. This air supply should be interconnected with the power supplies as in the case of radiator cooling.

The maximum radiator temperature of 180°C is a tube rating and is to be observed in the same manner as other ratings. The temperature of the radiator should be measured at the base of an end fin on the side away from the air supply. The temperature may be measured either with a thermocouple or with temperature-sensitive paint such as Tempilac. The latter is made by the Tempil Corporation, 132 W.22 Street, New York in the form of liquid and stick and has an accuracy of 1%.

The *filament* of the 6C24 is of the thoriated tungsten type. Under normal full-load conditions the filament should be maintained at the rated voltage within ±5%; with light loads, reduction of the filament voltage by as much as 5% is permissible. In the latter case, care must be taken that the reduction of the filament voltage and, therefore, of emission is not so great that the peak current requirements cannot be met. It is recommended that, in intermittent service where the standby periods are no longer than 15 minutes, the filament voltage should be reduced to 80% of normal during standbys; for longer periods, the filament voltage should be shut off. The filament should be operated at constant voltage rather than at constant current. The filament must be allowed to reach normal operating temperature before other voltages are applied to the tube.

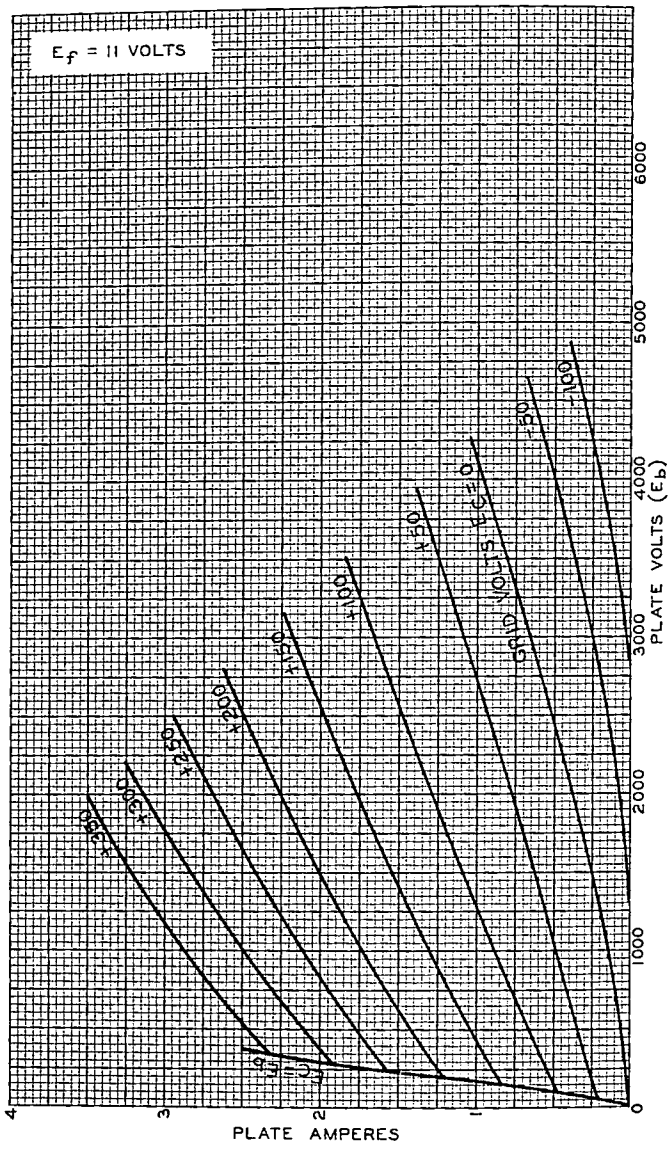
The filament is center tapped in order to minimize the effect of filament-lead inductance. At the higher frequencies, the grid- and plate-circuit returns should be by-passed for rf to the center lead of the filament. The returns should be made to this common connection in order to avoid rf coupling through common return circuits. It may be advisable to connect rf chokes in these returns to form a filter network. All three filament leads should be connected in parallel through rf by-pass capacitors. The center lead of this parallel connection should be by-passed to the filament transformer or to ground. It should not be returned to these points directly.

A filament starter should be used to raise the filament voltage gradually and to limit the high initial rush of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the filament current never exceed, even momentarily, a value of 24 amperes.

The *plate circuit* should be provided with a time-delay relay which will prevent the application of plate voltage before the filament has reached normal operating temperature.

A *protective device*, such as a high-voltage fuse, should be used to protect the plate against overloads. It should remove the high voltage when the average value of plate current reaches a value 50% above normal.

Overheating of the 6C24 by severe overload may decrease the filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 13 volts (not higher) for a few minutes.



92CM-6593

Fig. 5 - Average Plate Characteristics.

In order that the maximum ratings will not be exceeded, changes in electrode voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated appar-

atus must be determined. Average values of plate voltage should then be determined so that under the usual variations the maximum ratings of the tube will not be exceeded.

The rated plate voltage of this tube is high enough to be dangerous to the user. Great care should be taken during the adjustment of circuits, especially when exposed circuit parts are at high dc potential.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced. The reduction should be in order of 25% to 50% of normal plate voltage.

APPLICATION

In *class B af modulator service*, the 6C24 should be operated with grid bias obtained from a battery or other source of dc voltage of good regulation. It should not be obtained from a high-resistance source such as a grid resistor, nor from a rectifier unless the rectifier has exceptionally good voltage regulation. Each grid circuit should be provided with a separate bias adjustment to balance the grid and plate currents.

In *class B rf power amplifier telephony service*, the 6C24 is supplied with unmodulated dc plate voltage. The grid is excited with rf voltage modulated at audio frequency in one of the preceding stages, and power output is proportional to the square of the grid-excitation voltage. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. Grid bias is obtained from a battery or other source of dc voltage of good regulation.

In *plate-modulated class C rf amplifier service*, the tube should be supplied with bias from a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor. The cathode resistor should be by-passed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation. Grid-bias voltage is not particularly critical so that correct adjustment may be obtained with values differing widely from the calculated values.

In *class C rf telegraph service*, the 6C24 may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current and, therefore, the plate dissipation at a safe value. If the 6C24 is operated at the maximum rated plate voltage of 3000 volts, a fixed bias of at least -90 volts should be used.

The grid circuit should be designed and adjusted so that no appreciable voltage can occur between grid and filament at any frequency except the fundamental. This procedure will minimize the occurrence of parasitic oscillations and be simplified if the generation of unwanted harmonic frequencies is avoided. The use of a tank circuit having the proper Q and the avoidance of over-excitation are helpful. Link coupling between the driving stage and the power amplifier is useful especially if the Q of the grid tank circuit is high enough to provide good voltage regulation.

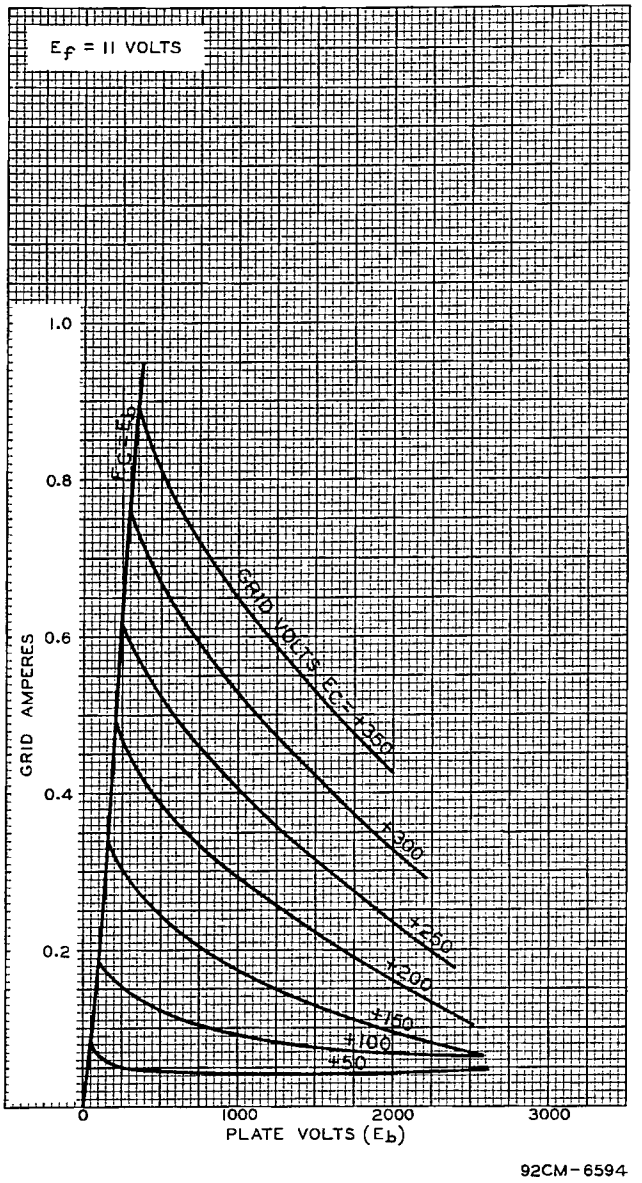


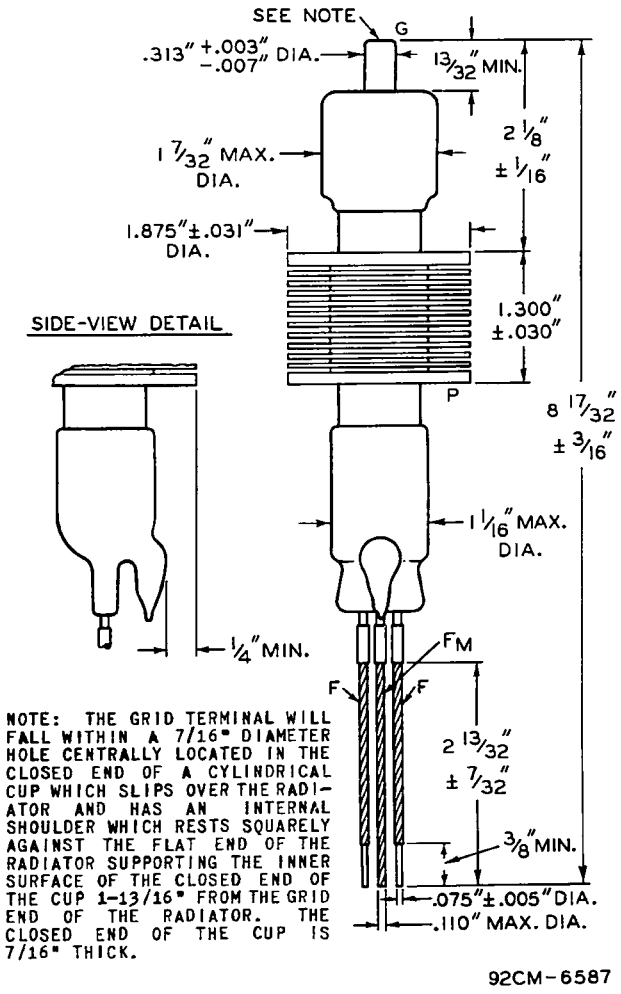
Fig. 6 - Typical Grid Characteristics.

Because of the high current carried by the grid lead and its circuit, heavy conductors should be used for these parts. When two or more tubes are used in the circuit, controls should be provided so that adjustment can be made to balance the plate current taken by each tube.

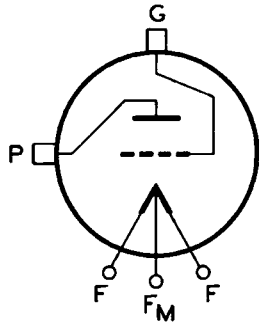
The 6C24 may be operated at maximum ratings

in all classes of service at frequencies as high as 160 megacycles.

When more radio-frequency power is required than can be obtained from a single tube, push-pull or parallel circuit arrangements may be used. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. If parasitic oscillations occur in the parallel or push-pull circuits, non-inductive resistors of about 10 to 100 ohms connected in series with each grid lead as close to the tube terminals as possible will often prevent the oscillations.



Terminal Connections



F: FILAMENT
FM: FILAMENT MID-TAP
G: GRID
P: PLATE

RCA Cunningham Radiotron RADIO TUBES

RCA-6C5

Detector Amplifier Triode

The 6C5 is a three-electrode tube of the metal type recommended for use as a detector, amplifier, or oscillator. This tube has a high mutual conductance together with a comparatively high amplification factor.

TENTATIVE CHARACTERISTICS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
PLATE VOLTAGE	250 *max.*	Volts
GRID VOLTAGE °	-8	Volts
PLATE CURRENT	8	Milliamperes
PLATE RESISTANCE	10000	Ohms
AMPLIFICATION FACTOR	20	
MUTUAL CONDUCTANCE	2000	Micromhos
GRID-PLATE CAPACITANCE *	1.8	μμf
GRID-CATHODE CAPACITANCE *	4	μμf
PLATE-CATHODE CAPACITANCE *	13	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Octal 6-Pin	

° If a grid-coupling resistor is used, its maximum value should not exceed 1.0 megohm.

* With shell connected to cathode.

INSTALLATION

The *base* pins of the 6C5 fit the six-contact octal-base socket (or the universal eight-contact socket) which may be installed to hold the tube in any position.

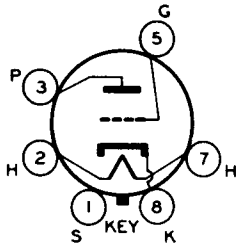
For *heater* operation and *cathode* connection, refer to INSTALLATION for type 6A8.

APPLICATION

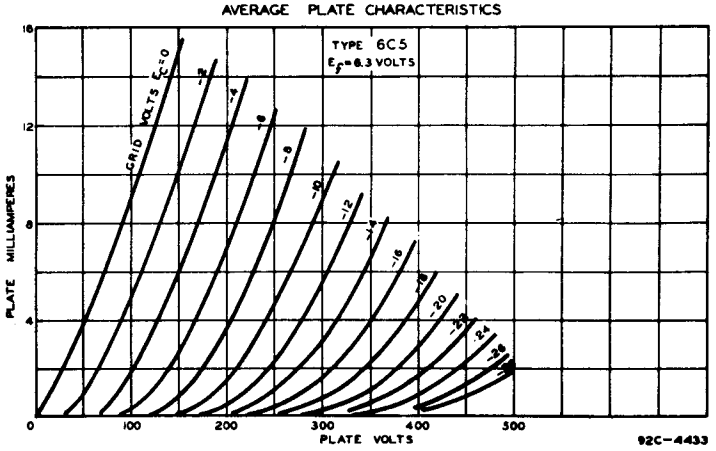
As an *amplifier*, the 6C5 is applicable to radio-frequency or audio-frequency circuits. Recommended operating conditions for service using transformer coupling are given under CHARACTERISTICS. For circuits utilizing resistance coupling, typical operating conditions are as follows:

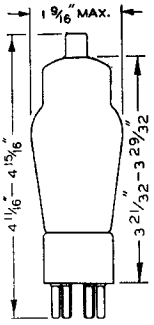
PLATE-SUPPLY VOLTAGE	250	Volts
GRID-BIAS VOLTAGE (Approx.)	-5	Volts
PLATE LOAD RESISTOR	50000 to 100000	Ohms
PLATE CURRENT	1 to 2	Milliamperes
VOLTAGE AMPLIFICATION	14	
VOLTAGE OUTPUT (5% second harmonic)	42	Volts (RMS)

As a detector, the 6C5 may be of the grid-leak and condenser or grid-bias type. The plate voltage for the grid leak and condenser method should be 45 to 100 volts. A grid leak from 0.1 to 1.0 megohm with a grid condenser of 0.00005 to 0.0005 μf is satisfactory. For the grid-bias method of detection, a plate-supply voltage of 250 volts may be used together with a negative grid-bias voltage of approximately 17 volts. The plate current should be adjusted to 0.2 milliampere with no input signal voltage. The grid-bias voltage may be supplied from the voltage drop in a resistor between cathode and ground.



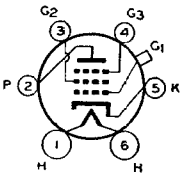
BOTTOM VIEW





RCA-6C6

TRIPLE-GRID DETECTOR AMPLIFIER



The 6C6 is a triple-grid tube of the heater-cathode type recommended for service as a biased detector in radio receivers designed for its characteristics. This tube is capable of delivering a large audio-frequency output voltage with relatively small input voltage. Significant among its electrical features are its sharp plate current "cut-off" with respect to grid voltage. The 6C6 is constructed with an internal shield connected to the cathode within the tube.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
GRID-PLATE CAPACITANCE (With shield-can)	0.007 *max.*	$\mu\mu$f
INPUT CAPACITANCE	5.0	$\mu\mu$f
OUTPUT CAPACITANCE	6.5	$\mu\mu$f
BULB		ST-12
CAP		Small Metal
BASE		Small 6-Pin

Other characteristics of this type are the same as for type 6J7.

INSTALLATION AND APPLICATION

The base pins of the 6C6 fit the standard six-contact socket which may be installed to hold the tube in any position.

For heater operation and cathode connection, refer to INSTALLATION for type 6A8.

The screen voltage may be obtained from a potentiometer or bleeder circuit across the B-supply source. Due to the screen-current characteristics of the 6C6, the use of a resistor in series with the high-voltage supply may be employed for obtaining the screen voltage provided the cathode-resistor method of bias control is used. This method, however, is not recommended if the high-voltage B-supply exceeds 250 volts.

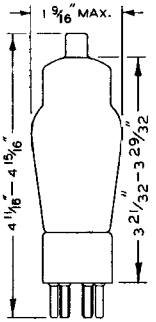
Complete shielding of detector circuits employing the 6C6 is generally necessary, since considerable voltage at carrier frequency is usually present in the plate circuit even though the latter is by-passed with a low impedance condenser. Two-section filters in the plate circuit are frequently necessary to prevent radio-frequency feed-back to the input of the detector.

In receivers employing a built-in loudspeaker, acoustic shielding may be necessary to prevent microphonic feed-back when a strong radio-frequency carrier voltage is present on the tube electrodes. It should be noted also that condenser plates may cause an audio howl due to mechanical feed-back from the speaker.

The application of this type is similar to that of type 6J7.

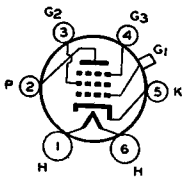
As an audio-frequency amplifier triode, the 6C6 should have its screen and suppressor connected to the plate. Operating conditions for triode service in transformer- or impedance-coupled circuits are: Plate voltage, 250 volts; grid voltage, −8 volts; and plate current, 7 milliamperes, approximate. Operating conditions as a resistance-coupled A-F amplifier are given in the Resistance-Coupled A-F Amplifier Section.

A plate family of curves is given under type 6J7.



RCA-6D6

TRIPLE-GRID SUPER-CONTROL AMPLIFIER



The 6D6 is a triple-grid super-control amplifier tube recommended for service in the radio-frequency and intermediate-frequency stages of radio receivers designed for its characteristics. The ability of this tube to handle the usual signal voltages without cross-modulation and modulation-distortion makes it adaptable to the r-f and i-f stages of receivers employing automatic volume control. The 6D6 is constructed with an internal shield connected to the cathode within the tube.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3		Volts
Heater Current	0.3		Ampere
Plate Voltage	100	250 *max.*	Volts
Screen Voltage	100	100 *max.*	Volts
Grid Voltage (Minimum)	−3	−3	Volts
Suppressor	Connected to cathode at socket		
Plate Current	8	8.2	Milliamperes
Screen Current	2.2	2.0	Milliamperes
Plate Resistance	0.25	0.8	Megohm
Amplification Factor	375	1280	
Transconductance	1500	1600	Micromhos
Transconductance (At −50 volts bias)	2	2	Micromhos
Grid-Plate Capacitance (With shield-can)		0.007 *max.*	$\mu\mu$f
Input Capacitance		4.7	$\mu\mu$f
Output Capacitance		6.5	$\mu\mu$f
Bulb			ST-12
Cap			Small Metal
Base			Small 6-Pin

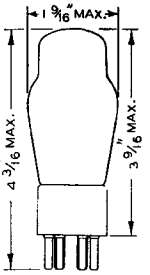
INSTALLATION AND APPLICATION

The **base** pins of the 6D6 fit the standard six-contact socket which may be installed to hold the tube in any position.

For **heater** operation and **cathode** connection, refer to INSTALLATION for type 6A8.

For **control-grid bias, screen** voltage, and **suppressor** connection, refer to INSTALLATION on type 6K7. **Shielding** requirements are similar to those for type 6C6.

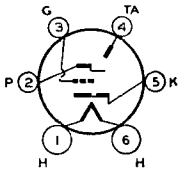
Refer to APPLICATION on type 6K7. A plate family of curves is given under type 58.



RCA-6E5

ELECTRON-RAY TUBE

(Indicator Type)



The 6E5 is a high-vacuum, heater-cathode type of tube designed to indicate visually, by means of a fluorescent target, the effects of a change in the controlling voltage. The tube, therefore, is essentially a voltage indicator and as such is particularly useful as a convenient and non-mechanical means to indicate accurate tuning of a receiver to the desired station. The 6E5 is similar to the 6G5 except that the 6G5 triode unit is designed with a remote plate-current cut-off characteristic. For discussion of Electron-Ray Tube considerations, refer to page 30.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)			6.3	Volts
Heater Current			0.3	Ampere
Plate-Supply Voltage			250 *max.*	Volts
Target Voltage*			250 *max.*	Volts
Typical Operation				
Plate- and Target-Supply Voltage	100	200	250	Volts
Series Triode-Plate Resistor	0.5	1	1	Megohm
Target Current (Approx.)	4.5	4.5	4.5	Milliamperes
Triode-Plate Current (For zero triode-grid voltage)	0.19	0.19	0.24	Milliampere
Triode-Grid Voltage (For shadow angle of 0°) (Approx.)	−3.3	−6.5	−8.0	Volts
Triode-Grid Voltage (For shadow angle of 90°) (Approx.)	0	0	0	Volts
Bulb				ST-12
Base				Small 6-Pin

* Minimum target voltage should not be less than 90 volts.

INSTALLATION

The base pins of the 6E5 fit the standard six-contact socket which may be installed to hold the tube in any position. For convenience, the tube is usually mounted horizontally so that the fluorescent screen is readily visible when the receiver circuit is tuned. A small hood, placed over the dome and fluorescent target, will help to eliminate external light reflections.

For heater operation and cathode connection, refer to type 6A8. The bulb of this tube becomes hot under certain conditions of operation. Sufficient ventilation should be provided to prevent overheating.

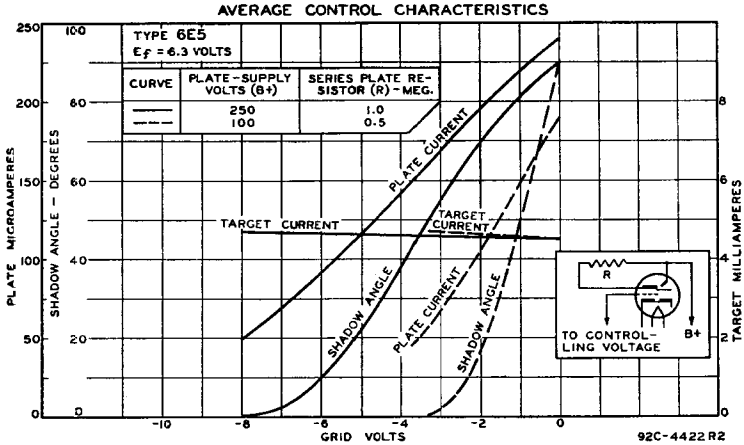
APPLICATION

The visible effect is observed on the fluorescent target located in the dome of the bulb. The pattern on the target varies from a shaded angle of 90° with zero bias (off tune) to a shaded angle of approximately 0° at resonance with a strong carrier. Exact tuning is indicated by the narrowest shaded angle that can be obtained. The stronger the carrier, the narrower is the shadow.

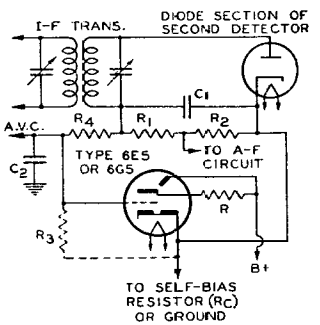
The diagrams on the next page show typical tuning-indicator circuits employing the 6E5. If the strongest carrier received produces sufficient avc voltage to exceed the cut-off bias value of −8 volts, the shadow area of the fluorescent target will overlap. To overcome this effect, resistor R_g should be connected, as shown, between the triode-unit grid and cathode in order to reduce the control voltage.

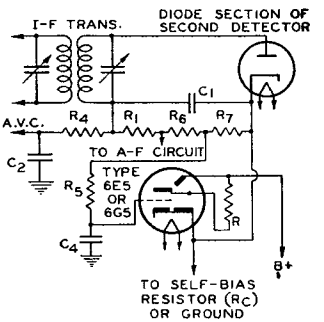
The value of R_S may easily be determined by applying a strong signal and adjusting R_S until the shadow-angle is nearly zero. If the resultant value of R_S is so low as to reduce the avc voltage appreciably, the d-c controlling voltage for the 6E5 should be obtained from a tap on the diode load resistor as shown in the diagram at the right.

AVERAGE CONTROL CHARACTERISTICS



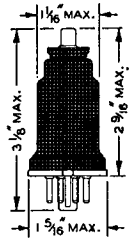
TYPICAL ELECTRON-RAY TUBE CIRCUITS





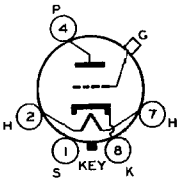
$R = \begin{cases} 1.0 \text{ MEGOHM FOR } B+ = 250 \text{ VOLTS} \\ 0.5 \text{ MEGOHM FOR } B+ = 100 \text{ VOLTS} \end{cases}$
$R_1 = 0.05$ MEGOHM (R-F FILTER)
$R_2 = 0.2$ MEGOHM
$R_3 =$ DETERMINED BY TEST. SEE TEXT.
$R_4 =$ AVC FILTER RESISTOR

$R_5 = R_4$
$R_6 + R_7 = 0.2$ MEGOHM
$C_1 = 100$ TO 200 $\mu\mu f$
$C_2 =$ AVC FILTER CONDENSER
$C_3 = 0.05$ TO 1.0 μf
$C_4 = C_2$



RCA-6F5

HIGH-MU TRIODE



The 6F5 is a high-mu triode of the All-Metal type. It is particularly suitable for use in resistance-coupled amplifier circuits.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Plate Voltage	250 *max.*	Volts
Grid Voltage	—2	Volts
Plate Current	0.9	Milliampere
Plate Resistance	66000	Ohms
Amplification Factor	100	
Transconductance	1500	Micromhos
Grid-Plate Capacitance*	2	μμf
Grid-Cathode Capacitance*	6	μμf
Plate-Cathode Capacitance*	12	μμf
Cap		Miniature
Base		Small Wafer Octal 5-Pin

* With shell connected to cathode.

INSTALLATION AND APPLICATION

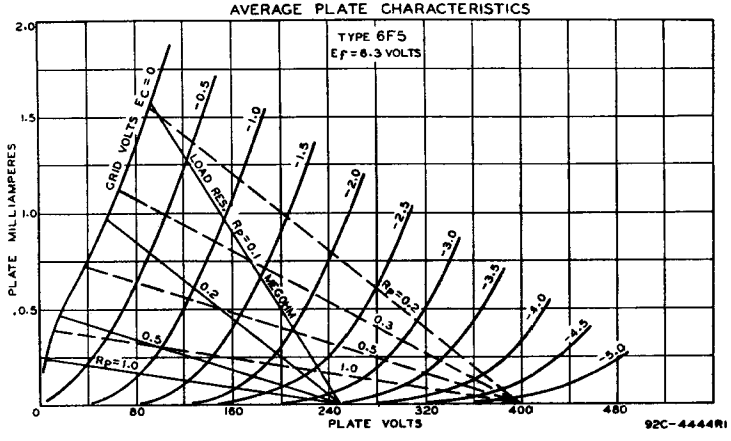
The base pins of the 6F5 fit the standard octal socket which may be mounted to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION for type 6A8.

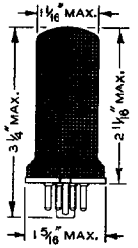
As an amplifier in resistance-coupled a-f circuits, the 6F5 may be operated under conditions given in the Resistance-Coupled A-F Amplifier Section.

In resistance-coupled circuits, the d-c resistance in the grid circuit of the 6F5 should not exceed 1.0 megohm.

When a 6F5 is used to amplify the output of the 6H6 diode, it is recommended that fixed grid bias be employed. Diode-biasing of the 6F5 is not suitable because of the probability of plate-current cut-off, even with relatively small signal voltages applied to the diode circuit.

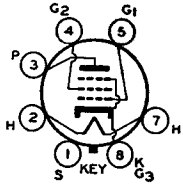
AVERAGE PLATE CHARACTERISTICS





RCA-6F6

POWER-AMPLIFIER PENTODE



The 6F6 is a heater-cathode power-amplifier pentode of the All-Metal type for use in the audio-output stage of a-c receivers. It is capable of giving large power output with a relatively small input voltage. Because of the heater-cathode construction, uniformly low hum-level is attainable in power-amplifier design.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.7	Ampere
Base	Small Wafer Octal 7-Pin	

As Single-Tube Class A_1 Amplifier—Pentode Connection

Plate Voltage	250	315* *max.*	Volts
Screen Voltage (Grid No. 2)	250	315* *max.*	Volts
Grid Voltage (Grid No. 1)	−16.5	−22	Volts
Plate Current	34	42	Milliamperes
Screen Current	6.5	8	Milliamperes
Plate Resistance (Approximate)	80000	75000	Ohms
Amplification Factor (Approx.)	200	200	
Transconductance	2500	2650	Micromhos
Load Resistance	7000	7000	Ohms
Total Harmonic Distortion	7	7	Per cent
Power Output	3	5	Watts

As Single-Tube Class A_1 Amplifier—Triode Connection
(Screen tied to plate)

Plate Voltage†	250	Volts
Grid Voltage	−20	Volts
Plate Current	31	Milliamperes
Plate Resistance	2600	Ohms
Amplification Factor	7	
Transconductance	2700	Micromhos
Load Resistance	4000	Ohms
Total Harmonic Distortion	5	Per cent
Power Output	0.85	Watt

Under the above maximum voltage conditions, transformer or impedance input-coupling devices are recommended. If resistance-coupling is used, refer to last paragraph of APPLICATION.

* Not recommended for automobile service or other similar services where heater voltage can rise more than 10% above rated value.

† Maximum plate voltage=315 volts.

As Push-Pull Class AB_2 Amplifier—Pentode Connection

Unless otherwise specified, values are for two tubes.

	Fixed Bias	*Self-Bias*	
Plate Voltage	375 *max.*	375 *max.*	Volts
Screen Voltage	250 *max.*	250 *max.*	Volts
Grid Voltage	−26 *min.*	—	Volts
Self-Bias Resistor	—	340 *min.*	Ohms
Peak A-F Grid-to-Grid Voltage	82	94	Volts

ZERO-SIGNAL PLATE CURRENT	34	54	Milliamperes
ZERO-SIGNAL SCREEN CURRENT	5	8	Milliamperes
LOAD RESISTANCE (Per Tube)	2500	2500	Ohms
EFFECTIVE LOAD RESISTANCE (Plate-to-plate)	10000	10000	Ohms
TOTAL HARMONIC DISTORTION	5	5	Per cent
POWER OUTPUT (Approx.)	19*	19†	Watts

Under the above maximum voltage conditions, transformer or impedance input-coupling devices must be used.

* With one triode-connected 6F6 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 3.32. The plate, screen and grid supply have negligible resistance.

† With one triode-connected 6F6 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 2.5. The plate and screen supply have negligible resistance. The value given for the self-bias resistor is determined for a minimum grid bias of −21 volts.

As Push-Pull Class AB_2 Amplifier—Triode Connection

(Screen tied to plate)

Unless otherwise specified, values are for two tubes.

	Fixed Bias	*Self-Bias*	
PLATE VOLTAGE	350 *max.*	350 *max.*	Volts
GRID VOLTAGE	−38	—	Volts
SELF-BIAS RESISTOR	—	730 *min.*	Ohms
PEAK A-F GRID-TO-GRID VOLTAGE	123	132	Volts
ZERO-SIGNAL PLATE CURRENT	45	50	Milliamperes
LOAD RESISTANCE (Per Tube)	1500	2500	Ohms
EFFECTIVE LOAD RESISTANCE (Plate-to-plate)	6000	10000	Ohms
TOTAL HARMONIC DISTORTION	7	7	Per cent
POWER OUTPUT (Approx.)	18°	14‡	Watts

Under the above maximum voltage conditions, transformer or impedance input-coupling devices must be used.

° With one triode-connected 6F6 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 1.67. The plate and grid supply have negligible resistance.

‡ With one triode-connected 6F6 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 1.29. The plate supply has negligible resistance. The value given for the self-bias resistor is determined for a minimum grid bias of −36.5 volts.

INSTALLATION

The **base** pins of the 6F6 fit the standard octal socket which may be installed to hold the tube in any position.

For **heater** operation and **cathode** connection, refer to type 42.

APPLICATION

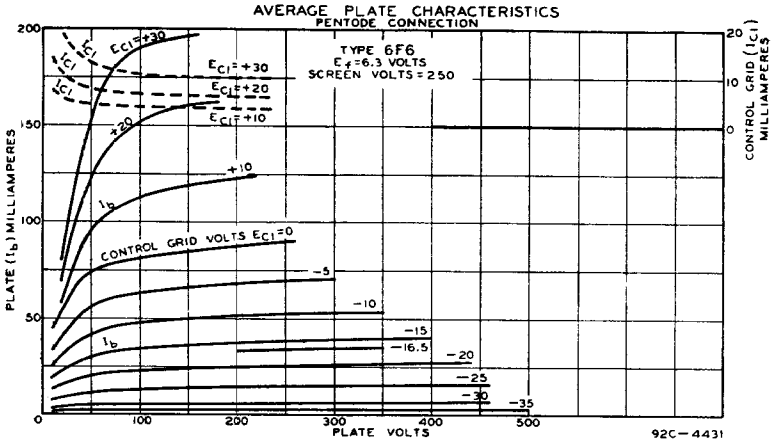
As a **Class A power-amplifier pentode,** the 6F6 may be used either singly or in push-pull. Recommended operating conditions are given under CHARACTERISTICS. If a single 6F6 is operated at a plate voltage of 250 volts, the self-bias resistor should have a value of approximately 410 ohms; at 315 volts, 440 ohms. For two tubes in the same stage, the value of the self-bias resistor should be approximately one-half that for a single tube.

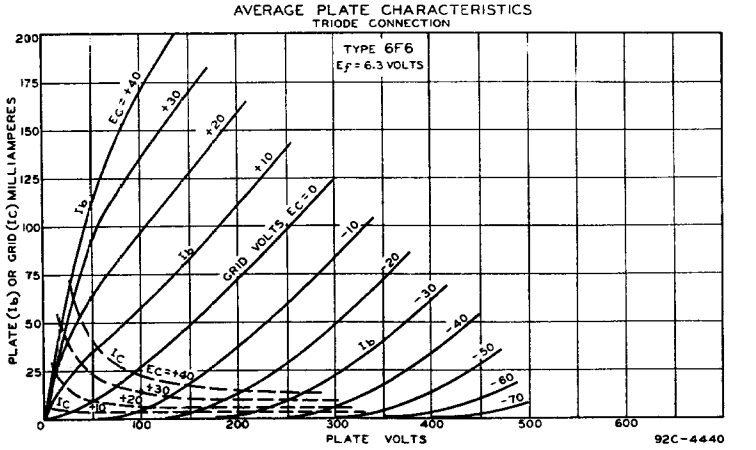
As a **Class A power-amplifier triode,** the 6F6 may be used either singly or in push-pull. For this service the screen is connected to the plate. Recommended operating conditions are given under CHARACTERISTICS. When a single 6F6 is operated as a Class A triode at a plate voltage of 250 volts, the self-bias resistor should have a value of approximately 650 ohms. For two tubes in the same stage, the value of the self-bias resistor should be approximately one-half that for a single tube.

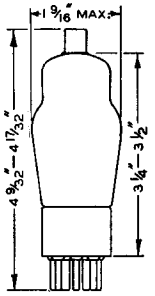
As a **Class AB power-amplifier triode or pentode,** the 6F6 should be operated as shown under the CHARACTERISTICS. The values shown cover operation with fixed-bias and with self-bias, and have been determined on the basis of some

grid-current flow during the most positive swing of the input signal and of cancellation of second-harmonic distortion by virtue of the push-pull circuit.

The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-coupling devices are recommended. When the grid circuit has a resistance not higher than 0.05 megohm, fixed bias may be used; for higher values, self-bias is required. With self-bias, the grid circuit may have a resistance as high as, but not greater than, 0.5 megohm provided the heater voltage is not allowed to rise more than 10% above rated value under any condition of operation.

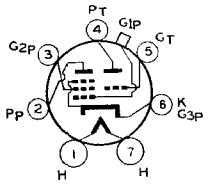






RCA-6F7

TRIODE-PENTODE



The 6F7 is a heater type of tube combining in one bulb a triode and an r-f pentode of the remote cut-off type. Since these two units are independent of each other except for the common cathode, the 6F7 may be adapted to circuit design in several ways.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances		
Triode Unit—Grid to Plate	2.0	μμf
Grid to Cathode	2.5	μμf
Plate to Cathode	3.0	μμf
Pentode Unit—Grid to Plate (With shield-can)	0.008 *max.*	μμf
Input	3.2	μμf
Output	12.5	μμf
Bulb		ST-12
Cap		Small Metal
Base		Small 7-Pin

As Amplifier

	Triode Unit	*Pentode Unit*		
Plate Voltage	100 *max.*	100	250 *max.*	Volts
Screen Voltage (Grid No. 2)	—	100	100 *max.*	Volts
Grid Voltage (Grid No. 1)	−3 *min.*	−3 *min.*	−3 *min.*	Volts
Plate Current	3.5	6.3	6.5	Milliamperes
Screen Current	—	1.6	1.5	Milliamperes
Amplification Factor	8	300	900	
Plate Resistance	16000	290000	850000	Ohms
Transconductance	500	1050	1100	Micromhos
Transconductance (At −35 volts bias)	—	9	10	Micromhos

As Frequency Converter

Typical Operation	*Triode Unit*	*Pentode Unit*	
Plate Voltage (Maximum)	100°	250	Volts
Screen Voltage	—	100	Volts
Grid Voltage	†	−10*	Volts
Oscillator Peak Voltage Input	—	7	Volts
D-C Grid Current	0.15	0	Milliampere
D-C Plate Current	2.4††	2.8	Milliamperes
Screen Current	—	0.6	Milliampere
Plate Resistance	—	2.0	Megohms
Conversion Transconductance	—	300	Micromhos

* May be obtained from 250-volt source through 60000-ohm dropping resistor.

° Obtained by means of 1700-ohm self-biasing (cathode) resistor.

† Obtained by 100000-ohm grid-leak resistor returned directly to cathode.

†† Oscillator conditions should be adjusted so that plate current does not exceed maximum of 4 milliamperes.

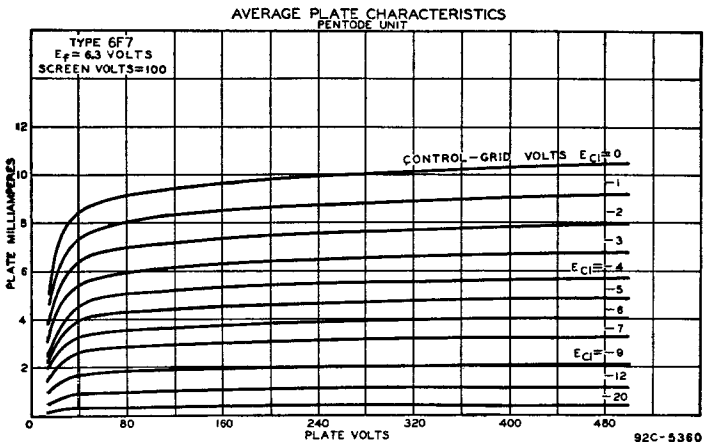
INSTALLATION

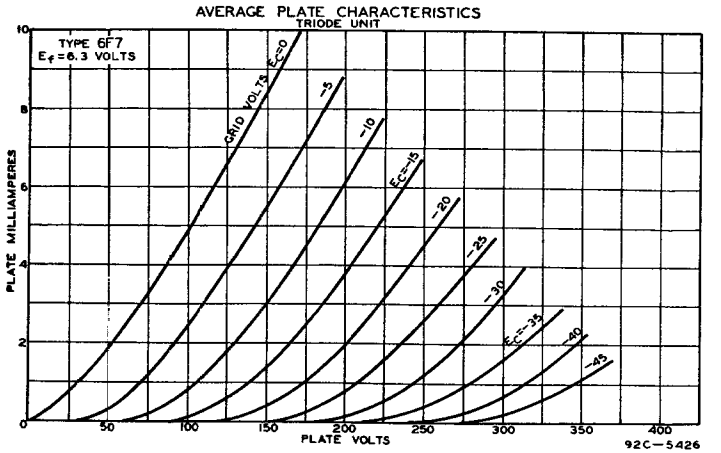
Refer to INSTALLATION on type 6A8.

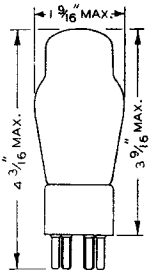
APPLICATION

Being of the multi-unit type, the 6F7 is suitable for diversified applications. The triode unit and the pentode unit can be utilized independently of each other for performing any of the functions expected of single-unit types with similar characteristics. Circuit design for the 6F7, therefore, will follow conventional practice.

As a **frequency converter,** the 6F7 is used by employing the triode unit as oscillator and the pentode unit as mixer (first detector). The circuit should be adjusted so that the grid-bias voltage is approximately 3 volts greater than the peak oscillator voltage. *In operation, the plate current of the oscillator should not exceed 4 milliamperes.*



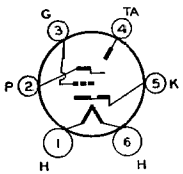




RCA-6G5

ELECTRON-RAY TUBE

(Indicator Type)



The 6G5 is a high-vacuum, heater-cathode type of tube designed to indicate visually, by means of a fluorescent target, the effects of change in the controlling voltage. The tube, therefore, is essentially a voltage indicator and as such is particularly useful as a convenient and non-mechanical means to indicate accurate tuning of a receiver to the desired station. For a discussion of Electron-Ray Tube considerations, refer to page 30.

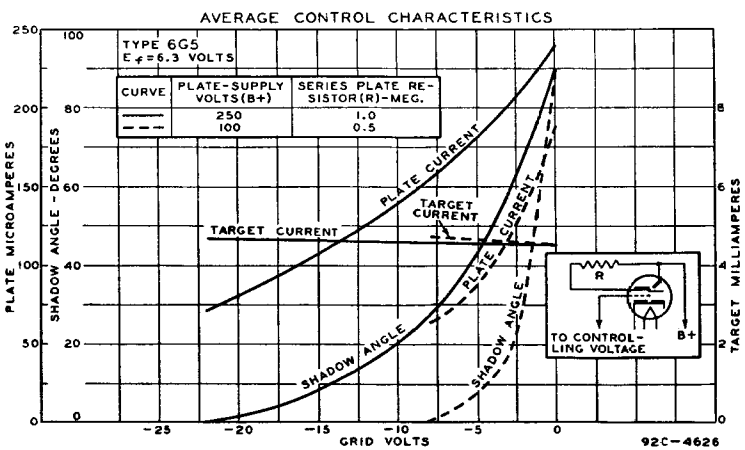
CHARACTERISTICS

Heater Voltage (A. C. or D. C.)			6.3	Volts
Heater Current			0.3	Ampere
Plate-Supply Voltage			250 *max.*	Volts
Target Voltage*			250 *max.*	Volts
Typical Operation				
Plate- and Target-Supply Voltage	100	200	250	Volts
Series Triode-Plate Resistor	0.5	1	1	Megohm
Target Current (Approx.)	4.5	4.5	4.5	Milliamperes
Triode-Plate Current (For zero triode-grid voltage)	0.19	0.19	0.24	Milliampere
Triode-Grid Voltage (For shadow angle of 0°) (Approx.)	−8	−18.5	−22	Volts
Triode-Grid Voltage (For shadow angle of 90°) (Approx.)	0	0	0	Volts
Bulb				ST-12
Base				Small 6-Pin

* Minimum target voltage should not be less than 90 volts.

INSTALLATION AND APPLICATION

For INSTALLATION, refer to type 6E5. The APPLICATION of the 6G5 is similar to that of the 6E5. Typical circuits are shown under the latter type. The essential difference between type 6E5 and type 6G5 is that the 6G5 has a remote plate-current cut-off characteristic.



6G8G

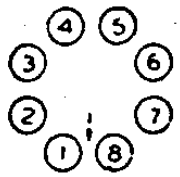
DUO-DIODE SUPER-CONTROL PENTODE

Heater	Coated Uni-potential Cathode	
Voltage	6.3	a-c or d-c volts
Current	0.3	amp.

Direct Interelectrode Capacitances - Pentode Unit:

Grid to Plate (with shield-can)	0.007 max.	µµf
Input	3.5	µµf
Output	9.5	µµf

Overall Length	4-7/32" to 4-15/32"
Maximum Diameter	1-9/16"
Bulb	ST-12
Cap	Skirted Miniature
Base	Small Shell Octal 8-Pin



Pin 1-No Connection
Pin 2-Heater
Pin 3-Plate
Pin 4-Diode Plate #2
Pin 5-Diode Plate #1
Pin 6-Screen
Pin 7-Heater
Pin 8-Cathode
Cap -Grid
BOTTOM VIEW

PENTODE UNIT : R-F or I-F Amplifier

Operating Conditions and Characteristics:

Heater*	6.3	6.3	volts
Plate	250	250	volts
Screen	100	125	volts
Grid	-3	-3	volts
Amp. Fact.	900	600	
Plate Res.	085	0.51	megohm
Mut. Cond.	1100	1210	µmhos
Plate Cur.	6.5	9.5	ma.
Grid Bias**	-35	-43	approx. volts
Screen Cur.	1.5	2.2	ma.

**For Mut. Cond. 10 µmhos

PENTODE UNIT : A-F Amplifier

Operating Conditions:

Heater*	6.3	volts
Plate Supply	250	volts
Screen Supply	250	volts
Load Resistance	0.25	megohm
Cathode Bias Resistor	2000	ohms

Screen voltage may be obtained from voltage divider (1 megohm and 0.25 megohm)

DIODE UNITS - Two

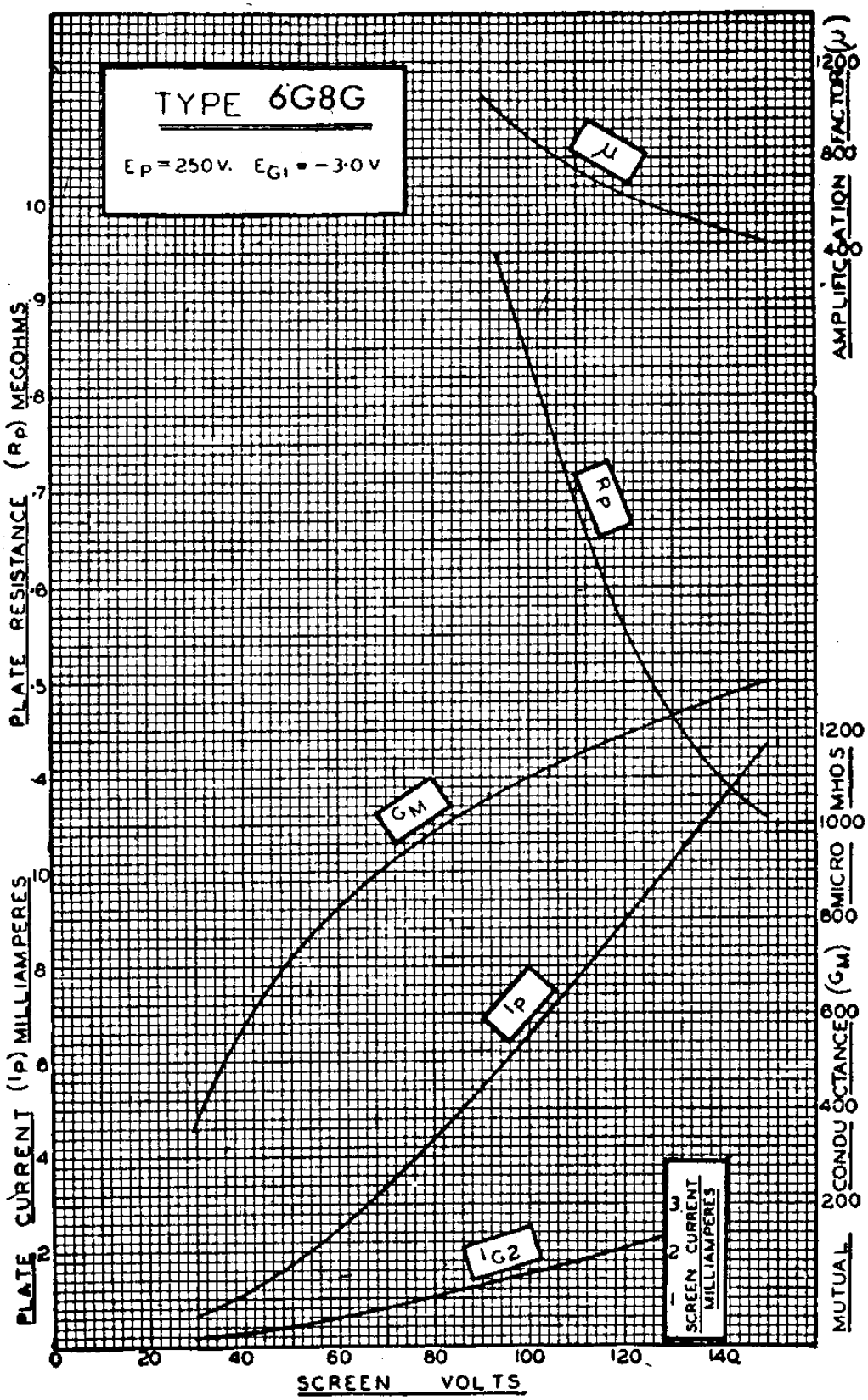
These units are independent of each other and from the pentode unit except for the common cathode sleeve. Their rectifying or detecting action may be used in half- or full-wave arrangement to supply signal voltage to the pentode unit and/or voltage to regulate the gain of the r-f or i-f amplifier stages so as to maintain essentially constant-carrier input to the audio detector. The half-wave circuit will provide approximately twice the rectified voltage obtainable from the full-wave circuit.

Regulation of amplifier gain by means of a rectified voltage may be accomplished by a number of methods. The regulating voltage may be applied to the control grids of the amplifier valves, or it may be applied in the case of r-f pentodes to their suppressors, plates and/or screens.

* The cathode should preferably be connected directly to the mid-tap of the heater winding. If this practice is not followed, the potential difference between heater and cathode should be kept as low as possible.

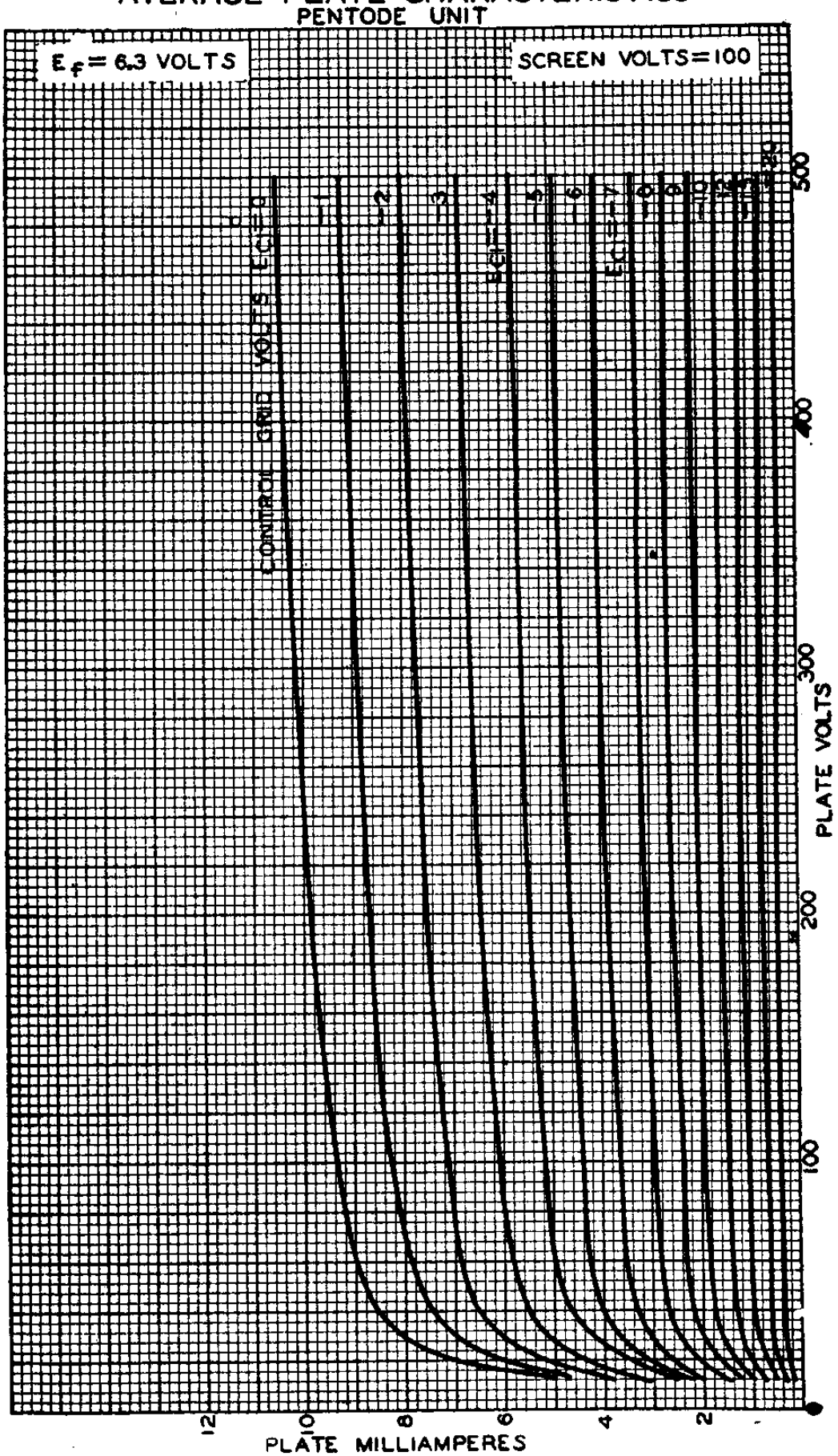
6G8G

DUO-DIODE SUPER-CONTROL PENTODE

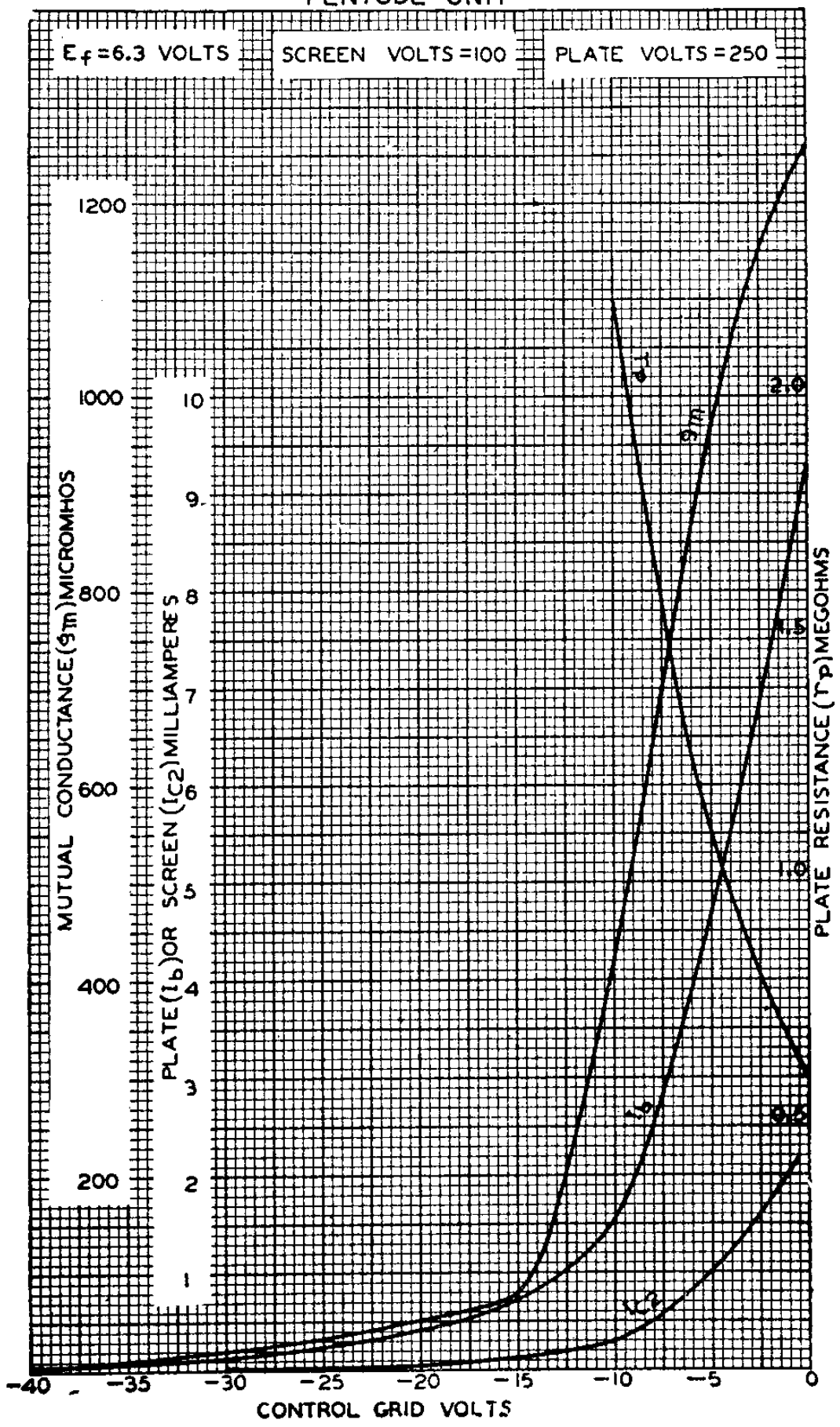


DUO-DIODE PENTODE

AVERAGE PLATE CHARACTERISTICS



6G8G
DUO-DIODE PENTODE
AVERAGE CHARACTERISTICS
PENTODE UNIT



6GF7, 10GF7, 13GF7

DUAL TRIODES

With Dissimilar Units

Novar Types

RCA-6GF7, 10GF7 and 13GF7 are multiunit tubes of the novar type containing a high-mu triode and a high-perveance low-mu triode in one envelope. They are intended especially for use in combined vertical-deflection-amplifier and vertical-deflection-oscillator applications in television receivers using picture tubes having deflection angles up to 110 degrees and operating at high ultor voltages.

Unit No.2, the low-mu unit, is designed for use in vertical-deflection-amplifier applications. This unit has a high value of plate current at low plate voltage under zero-bias conditions. This feature enables the designer to utilize for scanning purposes a relatively large proportion of the total input power to the deflection-amplifier circuit. In addition, unit No.2 has a maximum-plate-dissipation rating of 11 watts, which permits the tube to be used in circuits requiring large amounts of vertical-deflection power.

Unit No.1, the high-mu unit, is designed for use in vertical-deflection-oscillator applications.

The 6GF7, 10GF7, 13GF7 utilize a T9 bulb and a small-button novar 9-pin base. Novar construction assures an exceptionally strong mount support, firm retention of the tube in the socket, and relatively cool operation.

Also featured in the design of these tubes is the RCA "Dark Heater", which functions efficiently at operating temperatures 350° K below those of the heaters in conventional tube types. This feature insures long and dependable performance. In addition, the heaters of the 10GF7 and 13GF7 have a controlled warm-up time to insure dependable performance in television receivers using series-heater string arrangements.

GENERAL DATA

Electrical:

	6GF7	*10GF7*	*13GF7*	
Heater, for Unipotential Cathodes:				
Voltage (AC or DC)	6.3 ± 10%	9.7	13	volts
Current	0.985	0.6 ± 6%	0.45 ± 6%	amp
Warm-up Time (Average)	-	11	11	sec

Direct Interelectrode Capacitances (Approx. without external shield):

	Unit No.1	*Unit No.2*	
Grid to Plate	4.6	9.0	pf
Grid to Cathode and Heater	2.4	6.5	pf
Plate to Cathode and Heater	0.26	1.4	pf

Characteristics Class A_1 Amplifier:

	Unit No.1	*Unit No.2*	
Plate Voltage	250	150	volts
Grid Voltage	-3	-20	volts
Amplification Factor	64	5.4	
Plate Resistance (Approx.)	40000	750	ohms
Transconductance	1600	7200	μmhos
Plate Current	1.4	50	ma
Plate Current for plate volts = 60 and grid volts = 0	-	95	ma
Plate Current for grid volts = -28	-	10	ma
Grid Voltage (Approx.) for plate μa = 10	-5.5	-	volts
Grid Voltage (Approx.) for plate μa = 100	-	-45	volts

Mechanical:

Operating Position	Any
Maximum Overall Length	3.00"
Maximum Seated Length	2.62"
Length, Base Seat to Bulb Top (Excluding Tip)	2.10" to 2.28"
Diameter	1.062" to 1.188"
Bulb	T9
Base	Small-Button Novar 9-Pin (JEDEC No.E9-75)

VERTICAL-DEFLECTION OSCILLATOR

Values are for Unit No.1

Maximum Ratings, *Design-Maximum Values:*

For operation in a 525-line, 30-frame system[a]

DC PLATE VOLTAGE	330	max.	volts
PEAK NEGATIVE PULSE-GRID VOLTAGE	400	max.	volts
CATHODE CURRENT:			
Peak	77	max.	ma
Average	22	max.	ma
PLATE DISSIPATION	1.5	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	200	max.	volts
Heater positive with respect to cathode	200[b]	max.	volts

Maximum Circuit Values:

Grid-Circuit Resistance:			
For grid-resistor-bias or cathode-bias operation	2.2	max.	megohms

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

from JEDEC release #3816, July 16, 1962

VERTICAL-DEFLECTION AMPLIFIER

Values are for Unit No.2

Maximum Ratings, *Design-Maximum Values:*

For operation in a 525-line, 30-frame system[a]

DC PLATE VOLTAGE	330	max.	volts
PEAK POSITIVE-PULSE PLATE VOLTAGE[c]	1500	max.	volts
PEAK NEGATIVE-PULSE GRID VOLTAGE	250	max.	volts
CATHODE CURRENT:			
Peak	175	max.	ma
Average	50	max.	ma
PLATE DISSIPATION	11	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	200	max.	volts
Heater positive with respect to cathode	200[b]	max.	volts

Maximum Circuit Values:

Grid-Circuit Resistance:

For grid-resistor-bias operation	2.2	max.	megohms
For cathode-bias operation	2.2	max.	megohms

[a] As described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations" Federal Communications Commission.

[b] The dc component must not exceed 100 volts.

[c] Absolute value. This rating is applicable where the duration of the voltage pulse does not exceed 15 per cent of one vertical scanning cycle. In a 525-line, 30-frame system, 15 per cent of one vertical scanning cycle is 2.5 milliseconds.

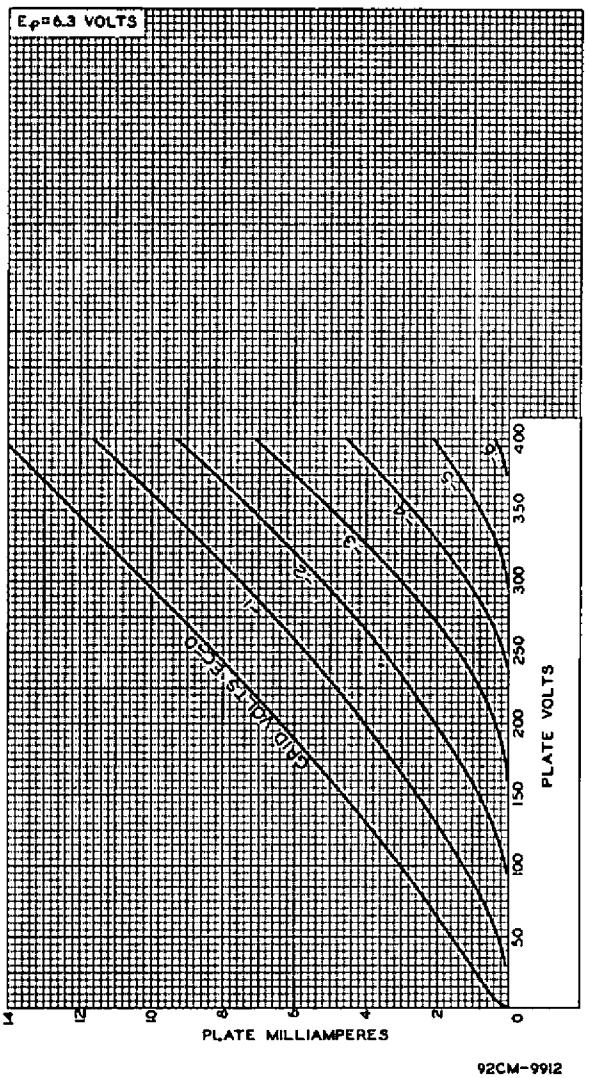


Fig. 1 - Average Plate Characteristics for Unit No. 1 of Type 6GF7, and for Unit No. 1 of Types 10GF7 and 13GF7 Except for Heater Voltage.

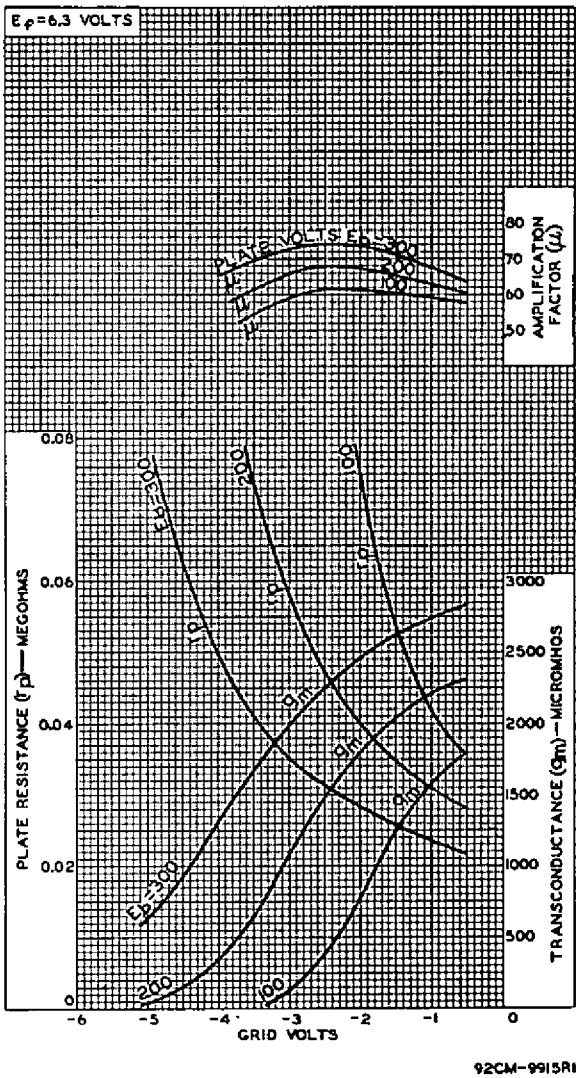


Fig. 2 - Average Characteristics for Unit No. 1 of Type 6GF7, and for Unit No. 1 of Types 10GF7 and 13GF7 Except for Heater Voltage.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data, except the rating for peak positive-pulse plate voltage, are established in accordance with the following definition of the *Design-Maximum Rating System* for rating electron tubes.

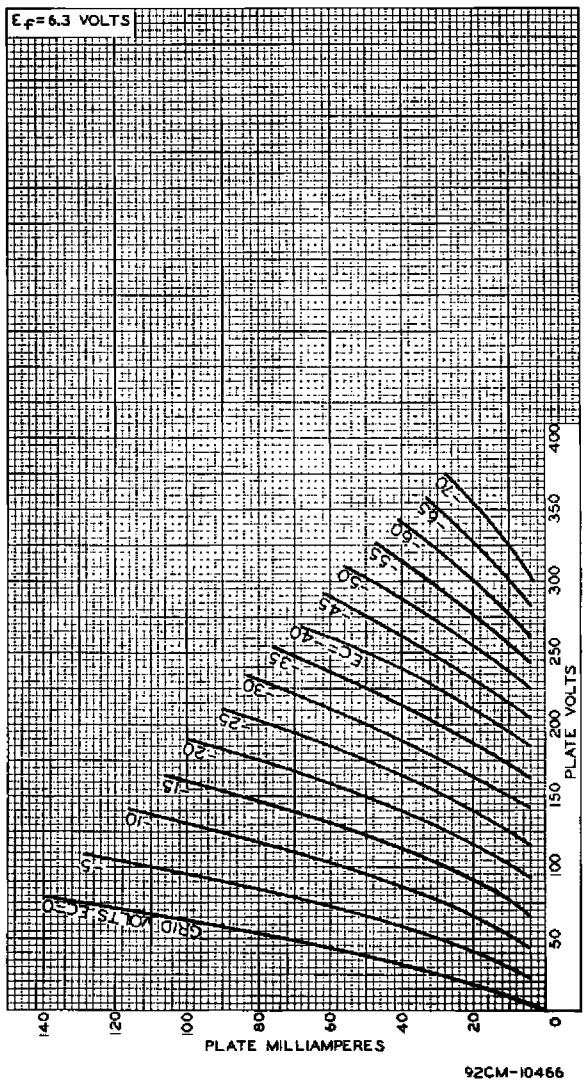


Fig. 3 - Average Plate Characteristics for Unit No. 2 of Type 6GF7, and for Unit No. 2 of Types 10GF7 and 13GF7 Except for Heater Voltage.

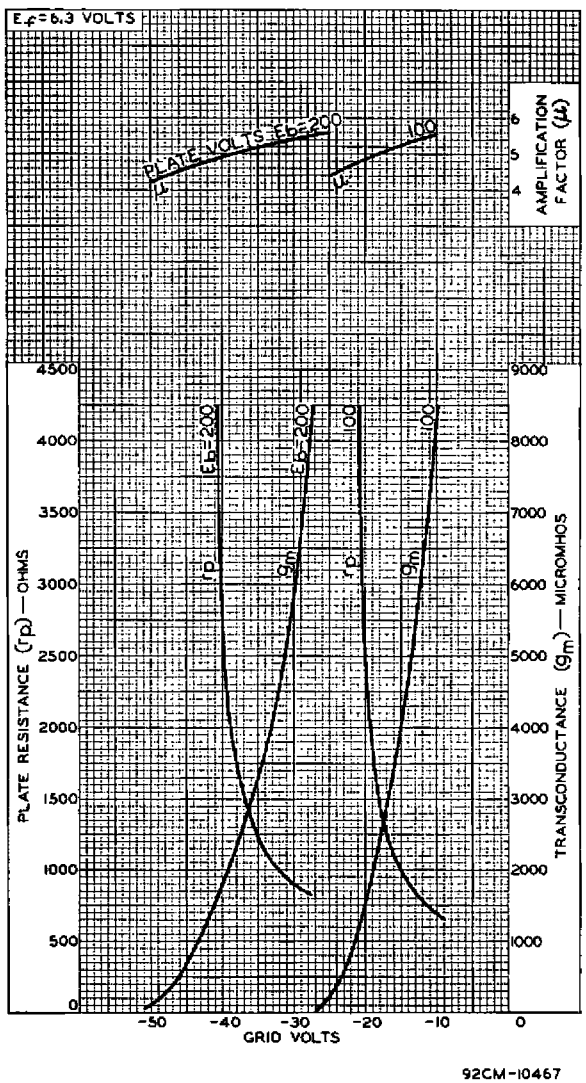


Fig. 4 - Average Characteristics for Unit No. 2 of Type 6GF7, and for Unit No. 2 of Types 10GF7 and 13GF7 Except for Heater Voltage.

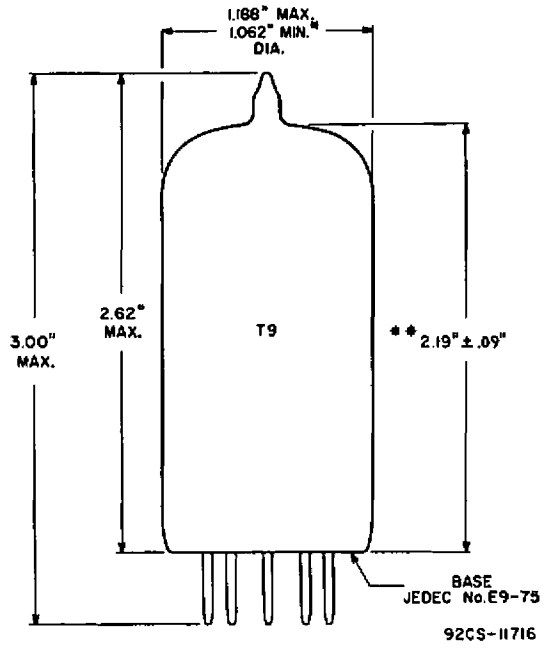
Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no design-maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

The bulb becomes hot during operation. To insure adequate cooling, therefore, it is essential that free circulation of air be provided around the 6GF7, 10GF7, and 13GF7.

DIMENSIONAL OUTLINE



* APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

** MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY A RING GAUGE OF 0.600" I.D.

BASING DIAGRAM

Bottom View

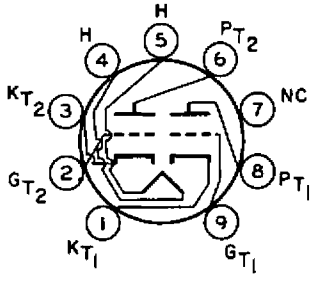
PIN 1 – CATHODE OF TRIODE UNIT NO.1

PIN 2 – GRID OF TRIODE UNIT NO.2

PIN 3 – CATHODE OF TRIODE UNIT NO.2

PIN 4 – HEATER

PIN 5 – HEATER



9QD

PIN 6 – PLATE OF TRIODE UNIT NO.2

PIN 7 – NO CONNECTION

PIN 8 – PLATE OF TRIODE UNIT NO.1

PIN 9 – GRID OF TRIODE UNIT NO.1

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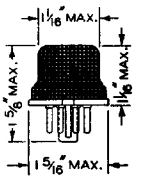
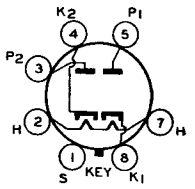


RCA-6H6

TWIN DIODE



The 6H6 is a heater-cathode type of All-Metal tube combining two diodes in one shell. Each diode has its own separate cathode and corresponding base pin. This arrangement offers flexibility in the design of circuits employing the 6H6 for detection, for low-voltage low-current rectification, or for automatic volume control. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Plate No. 1 to Plate No. 2 Capacitance*	0.02 *max.*	*μμf*
A-C Plate Voltage Per Plate (RMS)	100 *max.*	Volts
D-C Output Current	4 *max.*	Milliamperes
Base	Small Wafer Octal 7-Pin	

* With shell connected to cathode.

INSTALLATION

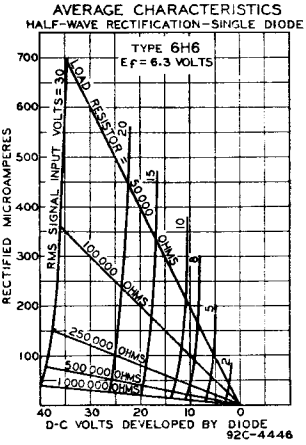
The base pins of the 6H6 fit the standard octal socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION for type 6A8.

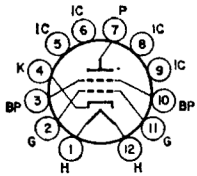
APPLICATION

For detection, the diodes may be utilized in a full-wave circuit or in a half-wave circuit. In the latter case, one plate only, or the two plates in parallel, may be employed. The use of the half-wave arrangement will provide approximately twice the rectified voltage as compared with the full-wave arrangement.

For automatic-volume control, the 6H6 may be used in circuits similar to those employed for any of the duplex-diode types of tubes. The only difference is that the 6H6 is more adaptable due to the fact that each diode has its own separate cathode.

Since the diodes by themselves do not provide any amplification, it is usually necessary to provide gain by means of a supplementary tube. Types such as the 6C5, 6F5, 6J7, and 6K7 are very suitable for this purpose. Their use in combination with the 6H6 is similar to that of the amplifier sections of duplex-diode triode or pentode types, such as the 6R7, 6Q7 and 6B8. The amplifier sections of these types have somewhat the same characteristics as the 6C5, 6F5 and 6J7, respectively.





12GY

BEAM TRIODE 6HZ5/6JD5

Duodecar type used as a pulse-type regulator in the high-voltage power supply of color televison receivers. Outlines section, 15F; requires duodecar 12-contact socket.

Heater Voltage (ac/dc)	6.3	volts
Heater Current	2.4	amperes
Direct Interelectrode Capacitances (Approx.):		
Grid to Plate	1.7	pF
Grid to Cathode, Heater, and Beam Plate	23	pF
Plate to Cathode, Heater, and Beam Plate	12	pF

Class A_1 Amplifier

CHARACTERISTICS

Pulse Plate Voltage*		3500	volts
Grid No.2 (Beam Plate)	Connected	to cathode at	socket
Grid-Voltage, Negative-bias value		4.4	volts
Peak Plate Current		300	mA
Amplification Factor		300	
Transconductance		55000	μmhos
Plate Resistance (Approx.)		4600	ohms
Grid Voltage (Approx.) for plate current of 1 mA and plate voltage of 3500 volts		—16	volts

* Duty cycle of the pulse must be less than 2.5%.

High-Voltage Regulator Service

For operation in a 525-line, 30-frame system

MAXIMUM RATINGS (Design-Maximum Values)

Peak Plate Voltage#		5500	volts
Plate Dissipation		35	watts
Peak Plate Current		325	mA
Heater-Cathode Voltage:			
Peak value	+200	—450	volts
Average value		100	volts
Bulb Temperature (At hottest point)		240	°C

MAXIMUM CIRCUIT VALUE

Grid-Circuit Resistance▲	0.1	megohm

Pulse duration must not exceed 15% of a horizontal scanning cycle (10 microseconds).

▲ Larger values of grid-circuit resistance may be used if provisons are made to protect the tube.

RCA Cunningham Radiotron RADIO TUBES

RCA-6J5

DETECTOR AMPLIFIER TRIODE

(TENTATIVE DATA)

Heater Voltage (A.C. or D.C.)	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances (Approx.): #		
Grid to Plate	3.4	μμf
Grid to Cathode	3.4	μμf
Plate to Cathode	3.6	μμf
Maximum Overall Length	2-5/8"	
Maximum Diameter	1-5/16"	
Base	Small Wafer Octal 6-Pin	

As Class A_1 Amplifier

Operating Conditions and Characteristics:

Plate Voltage	250 max.	Volts
Grid Voltage	-8	Volts
Plate Current	9	Milliamperes
Plate Resistance	7700	Ohms
Amplification Factor	20	
Transconductance	2600	Micromhos

With shell connected to cathode.

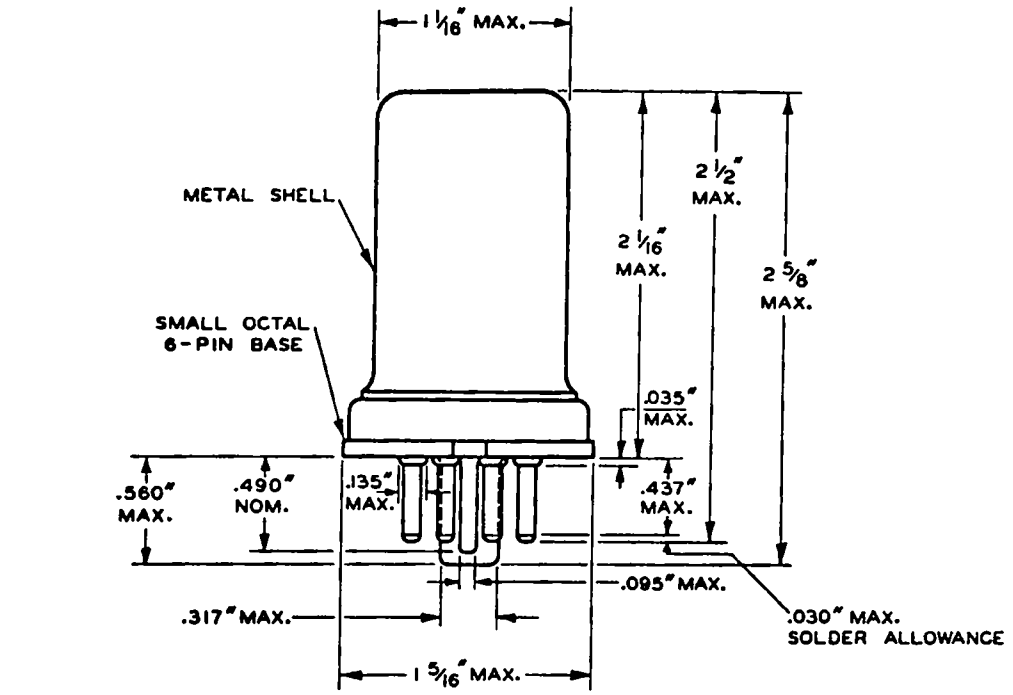
from RMA release #118, June 22, 1937

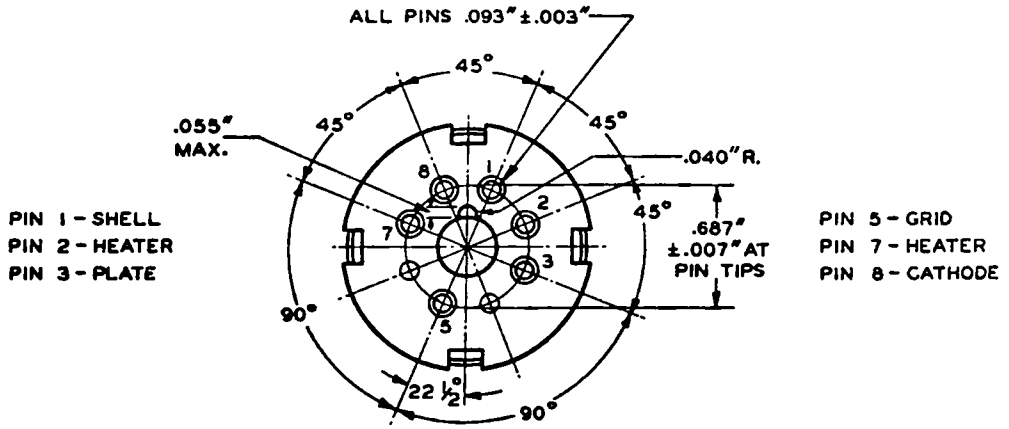
June 11, 1937

RCA Cunningham Radiotron

RCA-6J5

OUTLINE DRAWING



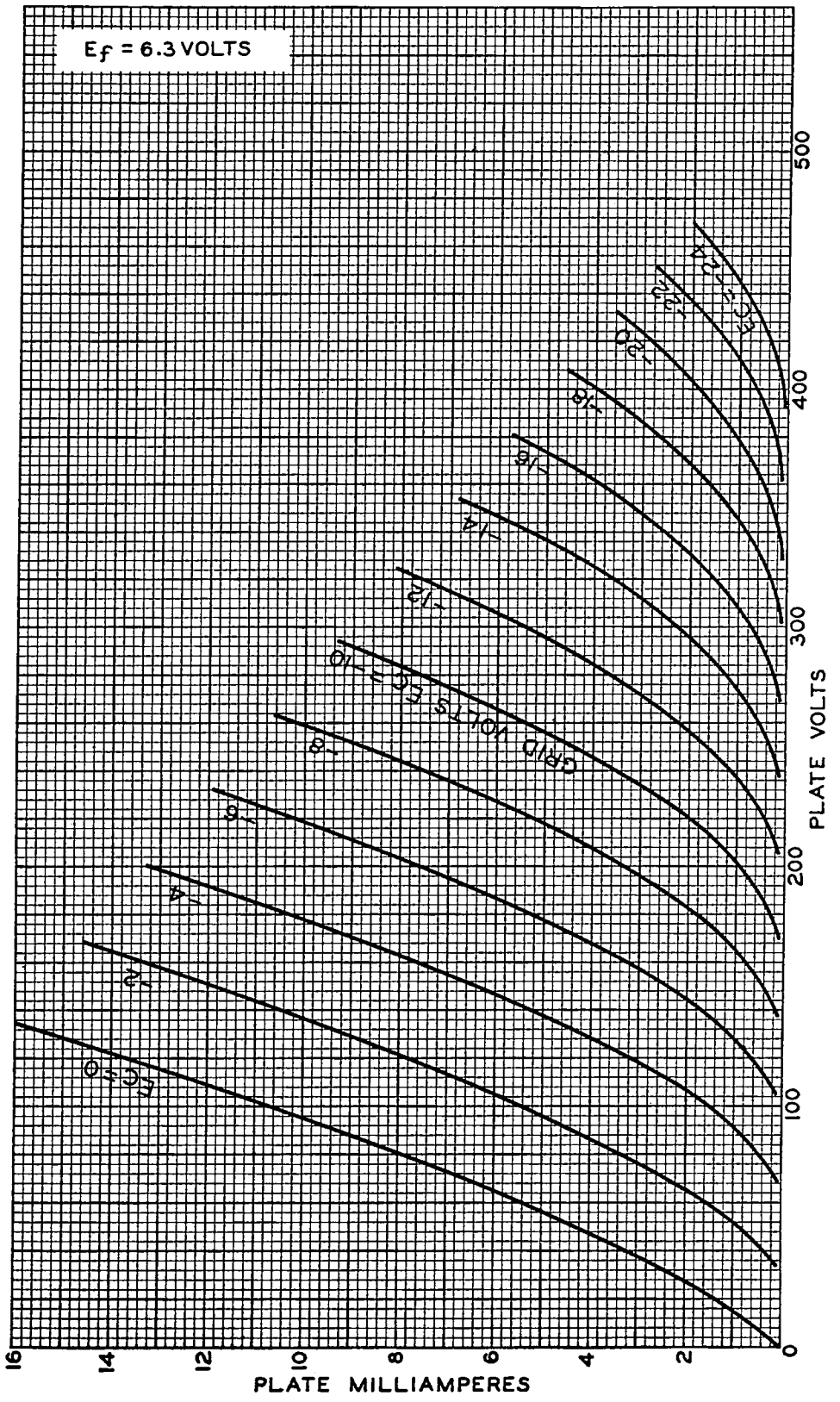


BOTTOM VIEW OF BASE

RCA Cunningham Radiotron RADIO TUBES

RCA-6J5

AVERAGE PLATE CHARACTERISTICS



JETEC TYPE 6J5

TRIODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-1	Bulb	MT-8
Base	B6-23 Small wafer octal 6-pin		
Maximum diameter	1-5/16"		
Maximum overall length	2-5/8"		
Maximum seated height	2-1/16"		
Pin connections	Basing 6Q		

Pin 1 - Shell
Pin 2 - Heater
Pin 3 - Plate
Pin 5 - Grid
Pin 7 - Heater
Pin 8 - Cathode

Mounting position . . . . . Any

ELECTRICAL DATA

Direct interelectrode capacitances*

Grid to plate (g to p)	3.4	μμf
Input: g to (h+k+s)	3.4	μμf
Output: p to (h+k+s)	3.6	μμf

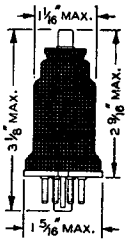
*Pin #1 connected to pin #8.

Ratings

Heater voltage (ac or dc)	6.3	volts
Maximum heater-cathode voltage	90	volts
Maximum plate voltage	300	volts
Maximum positive DC grid voltage	0	volts
Maximum grid circuit resistance	1.0	megohm
Maximum plate dissipation	2.5	watts
Maximum cathode current	20	ma

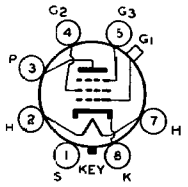
Typical operating conditions and characteristics, class A_1 amplifier

Heater voltage	6.3	6.3	volts
Heater current	300	300	ma
Plate voltage	90	250	volts
Grid voltage	0	-8	volts
Plate resistance (approx.)	6700	7700	ohms
Transconductance	3000	2600	μmhos
Plate current	10	9.0	ma
Amplification factor	20	20	
Grid #1 voltage (approx.) for Ib= 10 μa	-7.0	-18	volts



RCA-6J7

TRIPLE-GRID DETECTOR AMPLIFIER



The 6J7 is a triple-grid type of All-Metal tube recommended especially for service as a biased detector in radio receivers designed for its characteristics. In such service, this tube is capable of delivering a large audio-frequency output voltage with relatively small input voltage. Other applications of the 6J7 include its use as a high-gain amplifier tube.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)		6.3	Volts
Heater Current		0.3	Ampere
Plate Voltage	100	250 *max.*	Volts
Screen Voltage	100	100**	Volts
Grid Voltage*	−3	−3	Volts
Suppressor	Connected to cathode at socket		
Plate Current	2	2	Milliamperes
Screen Current	0.5	0.5	Milliampere
Plate Resistance	1.0	Greater than 1.5	Megohm
Amplification Factor	1185	Greater than 1500	
Transconductance	1185	1225	Micromhos
Grid Voltage (Approximate)†	−7	−7	Volts
Grid-Plate Capacitance°		0.005 *max.*	μμf
Input Capacitance°		7	μμf
Output Capacitance°		12	μμf
Cap			Miniature
Base			Small Wafer Octal 7-Pin

* The d-c resistance in the grid circuit should not exceed 1.0 megohm.

** Maximum Screen Volts = 125. † For cathode current cut-off. ° With shell connected to cathode.

INSTALLATION

The base pins of the 6J7 fit the standard octal socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION for type 6A8.

The screen voltage may be obtained from a potentiometer or bleeder circuit across the B-supply source. Due to the screen-current characteristics of the 6J7, a resistor in series with the high-voltage supply may be employed for obtaining the screen voltage, provided the cathode-resistor method of bias control is used. This method, however, is not recommended if the high-voltage B-supply exceeds 250 volts.

APPLICATION

As a biased detector, the 6J7 can deliver a large audio-frequency output voltage of good quality with a fairly small radio-frequency signal input. Typical recommended conditions for the 6J7 as a biased detector are as follows:

Plate Supply*	100	100	250	250	Volts
Screen Voltage	12	30	50	100	Volts
Grid Voltage	−1.16	−1.83	−2	−4.3	Volts
Cathode Resistor	18000	10000	3000	10000	Ohms
Suppressor	Connected to cathode at socket				
Cathode Cur. (Zero Signal)	0.63	0.183	0.65	0.43	Milliampere

Plate Resistor	1.0	0.25	0.25	0.50	Megohm
Blocking Condenser	0.01	0.01	0.03	0.03	μf
Grid Resistor†	1.0	0.5	0.25	0.25	Megohm
R-F Signal (RMS)**	1.05	1.6	1.18	1.37	Volts

* Voltage at plate will be PLATE-SUPPLY voltage less voltage drop in plate resistor caused by plate current.

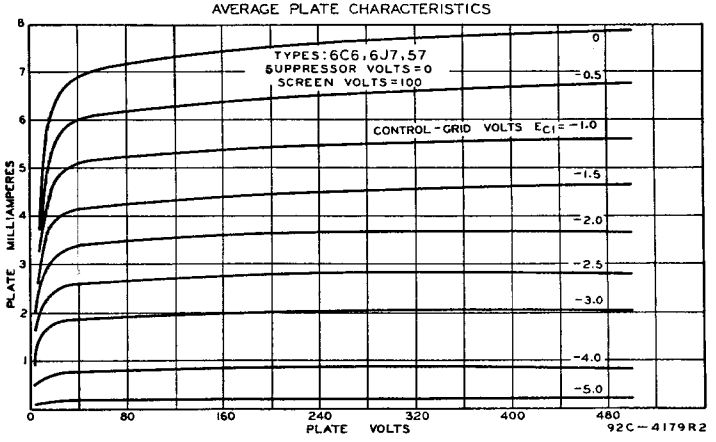
† For the following amplifier tube.

** With these signal voltages modulated 20%, the voltage output under each set of operating conditions is 17 peak volts at the grid of the following amplifier, a value sufficient to insure full audio output from a type 6F6 at 250 volts on plate.

Detector bias may be obtained from a bleeder circuit, from a resistor in the cathode circuit, or from a partial self-biasing circuit. The cathode-resistor method permits of higher output at low percentage modulation, since the input signal may be increased almost in inverse proportion to the modulation without resulting in objectionable distortion.

As an **audio-frequency amplifier pentode** in resistance-coupled circuits, the 6J7 may be operated as shown in the tables given in the Resistance-Coupled A-F Amplifier Section.

As a **radio-frequency amplifier pentode**, the 6J7 may be used particularly in applications where the r-f signal applied to the grid is relatively low, that is, of the order of a few volts. In such cases either screen or control-grid voltage (or both) may be varied to control the receiver volume. When larger signals are involved, a super-control amplifier tube should be employed to prevent the occurrence of excessive cross-modulation and modulation-distortion. Recommended operating conditions for amplifier services are given under CHARACTERISTICS.



6J8-GA

TRIODE HEPTODE CONVERTER

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage	6.3	a.c. or d.c. volts
Current	0.45	amp.
Direct Interelectrode Capacitances (With Standard Shield)		
Heptode Grid No. 1 to Heptode Plate	0.01 max.	uuF
Heptode Grid No. 1 to Triode Grid & Heptode Grid No. 3	0.13	uuF
Heptode Grid No. 1 to Triode Plate	0.015	uuF
Triode Grid & Heptode Grid No. 3 to Triode Plate	2.2	uuF
R.F. Input (Heptode Grid No. 1 to All Other Electrodes)	4.4	uuF
Osc. Output (Triode Plate to All Other Electrodes)	5.5	uuF
Osc. Input (Triode Grid & Heptode Grid No. 3 to All Other Electrodes)	11.7	uuF
Mixer Output (Heptode Plate to All Other Electrodes)	8.8	uuF

Mechanical:

Mounting Position	Any
Maximum Overall Length	4-15/32"
Maximum Seated Height	3-29/32"
Maximum Diameter	1- 9/16"
Bulb	ST-12
Cap	Skirted Miniature
Base	Small Shell Octal 8-Pin
Basing Designation for BOTTOM VIEW	G8H

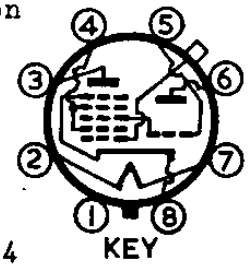
Pin 1 - No Connection

Pin 2 - Heater

Pin 3 - Heptode Plate

Pin 4 - Heptode Grids No. 2 & No. 4

Pin 5 - Heptode Grid No. 3 & Triode Grid



KEY

Pin 6 - Triode Plate

Pin 7 - Heater

Pin 8 - Cathode

Cap - Heptode Grid No. 1

CONVERTER

Maximum Ratings, Design-Centre Values:

Heptode Plate Voltage	300 max.	volts
Heptode Screen (Grids No. 2 & No. 4) Voltage	100 max.	volts
Heptode Screen Supply Voltage	300 max.	volts
Heptode Control-Grid (Grid No. 1) Voltage	0 min.	volts
Triode Plate Supply Voltage	250 max.	volts
Heptode Plate Dissipation	0.9 max.	watt
Heptode Screen Dissipation	0.4 max.	watt
Triode Plate Dissipation	0.8 max.	watt
Cathode Current	14.0	mA

6J8-GA

TRIODE HEPTODE CONVERTER

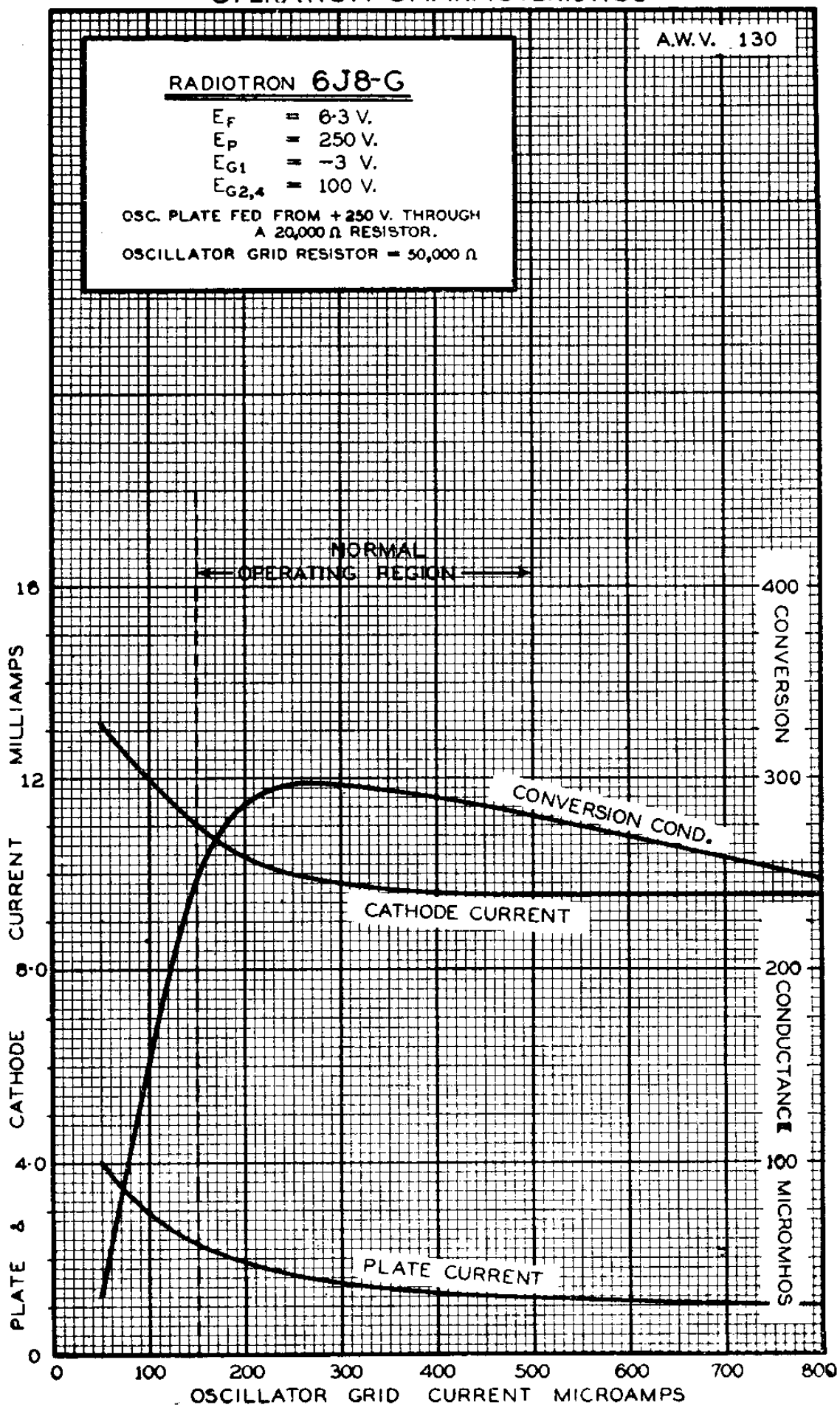
Typical Operation:				
Heptode Plate Voltage	100	250		volts
Heptode Screen Voltage	100	100		volts
Heptode Control-Grid Voltage	-3	-3	Δ	volts
Triode Plate Voltage	100	250	Δ	volts
Triode Grid Resistor	50000	50000		ohms
Heptode Plate Resistance	0.9	4.0		megohms
Conversion Transconductance	250	290		umhos
Heptode Control Grid Bias for Conver. Transcond. = 2 umhos	-20	-20		volts
Heptode Plate Current	1.4	1.3		mA
Heptode Screen Current	3.0	2.9		mA
Triode Plate Current	3.0	5.0		mA
Triode Grid & Heptode Grid No. 3 Current	0.3	0.4		mA

TRIODE SECTION

Plate Voltage	100	volts
Grid Voltage	0	volts
Amplification Factor	17	
Plate Resistance	10600	ohms
Transconductance	1600	umhos
Plate Current	7	mA

Δ Applied through a 20000 ohm dropping resistor.

6J8-G
OPERATION CHARACTERISTICS

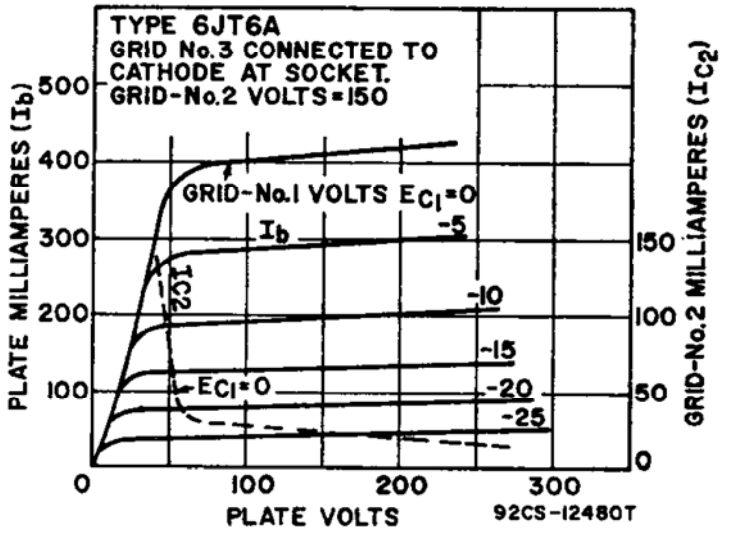


Average Cathode Current	175	mA
Plate Dissipation†	17.5	watts
Grid-No.2 Input	3.5	watts
Bulb Temperature (At hottest point)	240	°C
MAXIMUM CIRCUIT VALUE		
Grid-No.1-Circuit Resistance, for grid-resistor-bias operation	1	megohm

Pulse duration must not exceed 15% of a horizontal scanning cycle (10 microseconds).

▲ A positive voltage may be applied to grid No.3 to reduce interference from "snivets" which may occur in television receivers. A typical value for this voltage is 30 volts.

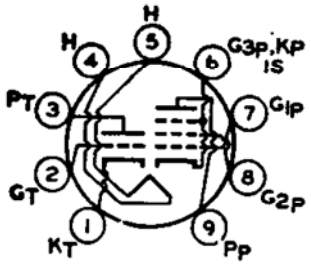
† A bias resistor or other means is required to protect the tube in absence of excitation.



HIGH-MU TRIODE— SHARP-CUTOFF PENTODE

6JT8

10JT8



9DX

Neonoval type with frame-grid pentode unit used in color and black-and-white television receivers. The triode unit is used as a voltage-amplifier or sync-separator tube, and the pentode unit is used as a video-amplified tube. **Outlines section,** 10A, except base is small-button miniature 9-pin; requires miniature 9-contact socket. Type 10JT8 is identical with type 6JT8 except for heater ratings.

	6JT8	10JT8	
Heater Voltage (ac/dc)	6.3	10.2	volts
Heater Current	0.725	0.45	ampere
Heater Warm-up Time (Average	—	11	seconds
Heater-Cathode Voltage:	±200 max	±200 max	volts
Peak value	100 max	100 max	volts
Average value			

Class A_1 Amplifier

MAXIMUM RATINGS (Design-Maximum Values)	Triode Unit	Pentode Unit	
Plate Voltage	330	330	volts
Grid-No.2 (Screen-Grid) Supply Voltage	—	330	volts
Grid-No.2 Voltage	—	See curve page 98	
Grid-No.1 (Control-Grid) Voltage, Positive-bias value	0	0	volts
Plate Dissipation	1	4	watts
Grid-No.2 Input:			
For grid-No.2 voltages up to 165 volts	—	1.1	watts
For grid-No.2 voltages between 165 and 330 volts	—	See curve page 98	

CHARACTERISTICS				
Plate Supply Voltage	250	50	200	volts
Grid-No.2 Supply Voltage	—	100	100	volts
Grid-No.1 Voltage	−2	0	—	volts
Cathode-Bias Resistor	—	—	82	ohms
Amplification Factor	100	—	—	
Plate Resistance (Approx.)	37000	—	50000	ohms

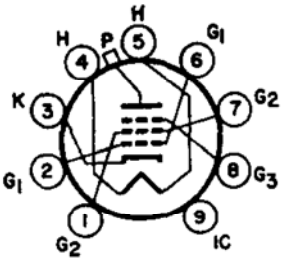
	Triode Unit	Pentode Unit		
Transconductance	2700	—	20000	μmhos
Plate Current	1.5	55•	17	mA
Grid-No.2 Current	—	18•	3.5	mA
Grid-No.1 Voltage (Approx.) for plate current of 100 μA	—	—	—5	volts
Grid-No.1 Voltage (Approx.) for plate current of 20 μA	—5.3	—	—	volts
MAXIMUM CIRCUIT VALUES				
Grid-No.1-Circuit Resistance:				
For fixed-bias operation	0.5	0.25		megohm
For cathode-bias operation	1	1		megohm

• This value can be measured by a method involving a recurrent waveform such that the maximum ratings of the tube will not be exceeded.

6JU6

22JU6

BEAM POWER TUBE



9QL

Novar type used as horizontal-deflection amplifier in color television receivers. **Outlines section, 18A; requires novar 9-contact socket. Type 22JU6 is identical with type 6JU6 except for heater ratings.**

	6JU6	22JU6	
Heater Voltage (ac/dc)	6.3	20	volts
Heater Current	1.6	0.45	amperes
Heater Warm-up Time	—	11	seconds
Heater-Cathode Voltage:			
Peak value	±200 max	±200 max	volts
Average value	100 max	100 max	volts
Direct Interelectrode Capacitances:			
Grid No.1 to Plate		1.2	pF
Grid No.1 to Cathode, Heater, Grid No.2, and Grid No.3		22	pF
Plate to Cathode, Heater, Grid No.2, and Grid No.3		9	pF

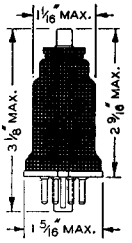
Class A_1 Amplifier

CHARACTERISTICS	Triode† Connection	Pentode Connection			
Plate Voltage	125	—	50	130	volts
Peak Positive-Pulse Plate Voltage#	—	6500	—	—	volts
Grid No.3 (Suppressor Grid)		Connected to cathode at socket			
Grid-No.2 (Screen-Grid) Voltage	125	125	125	125	volts
Grid-No.1 (Control-Grid) Voltage	—20	—	0	—20	volts
Amplification Factor	4.7	—	—	—	
Plate Resistance (Approx.)	—	—	—	18000	ohms
Transconductance	—	—	—	7000	μmhos
Plate Current	—	—	470††	45	mA
Grid-No.2 Current	—	—	32††	1.5	mA
Grid-No.1 Voltage for plate current of 1 mA	—	—75	—	—32	volts

Horizontal-Deflection Amplifier

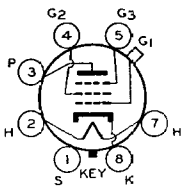
For operation in a 525-line, 30-frame system

MAXIMUM RATINGS (Design-Maximum Values)		
DC Plate Supply Voltage	770	volts
Peak Positive-Pulse Plate Voltage#	6500	volts
Peak Negative-Pulse Plate Voltage	1500	volts
DC Grid-No.3 Voltage•	75	volts
DC Grid-No.2 Voltage	220	volts
DC Grid-No.1 Voltage, Negative-bias value	55	volts
Peak Negative-Pulse Grid-No.1 Voltage	330	volts
Peak Cathode Current	950	mA
Average Cathode Current	275	mA
Grid-No.2 Input	3.5	watts
Plate Dissipation••	17	watts
Bulb Temperature (At hottest point)	240	°C
MAXIMUM CIRCUIT VALUES		
Grid-No.1-Circuit Resistance:		
For grid-resistor-bias operation	0.47	megohm
For plate-pulsed operation	10	megohms



RCA-6K7

TRIPLE-GRID SUPER-CONTROL AMPLIFIER



The 6K7 is a triple-grid super-control amplifier tube of the All-Metal type recommended for service in the radio-frequency and intermediate-frequency stages of radio receivers designed for its characteristics. The ability of this tube to handle unusual signal voltages without cross-modulation and modulation-distortion makes it adaptable to the r-f and i-f stages of receivers employing automatic volume control.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)				6.3	Volts
Heater Current				0.3	Ampere
Plate Voltage	90	180	250	250 *max.*	Volts
Screen Voltage	90	75	100	125 *max.*	Volts
Grid Voltage (Minimum)	−3	−3	−3	−3	Volts
Suppressor	Connected to cathode at socket				
Plate Current	5.4	4.0	7.0	10.5	Milliamperes
Screen Current	1.3	1.0	1.7	2.6	Milliamperes
Plate Resistance	0.315	1.0	0.8	0.6	Megohm
Amplification Factor	400	1100	1160	990	
Transconductance	1275	1100	1450	1650	Micromhos
Grid Voltage*	−38.5	−32.5	−42.5	−52.5	Volts
Grid-Plate Capacitance°				0.005 *max.*	μμf
Input Capacitance°				7	μμf
Output Capacitance°				12	μμf
Cap					Miniature
Base					Small Wafer Octal 7-Pin

* For transconductance = 2 micromhos.

° With shell connected to cathode.

INSTALLATION

The **base** pins of the 6K7 fit the standard octal socket which may be installed to hold the tube in any position.

For **heater** operation and **cathode** connection, refer to INSTALLATION for type 6A8.

Control-grid bias variation will be found effective in changing the volume of the receiver. In order to obtain adequate volume control, an available grid-bias voltage of approximately 50 volts will be required. The exact value will depend upon the circuit design and operating conditions. This voltage may be obtained, depending on the receiver requirements, from a potentiometer across a fixed supply voltage or by the use of a variable self-bias resistor in the cathode circuit.

The **screen** voltage may be obtained from a potentiometer or bleeder circuit across the B-supply source. Due to the screen current characteristics of the 6K7, a resistor in series with the high-voltage supply may be employed for obtaining the screen voltage provided the cathode-resistor method of bias control is used. This method, however, is not recommended if the high-voltage B-supply exceeds 250 volts. Furthermore, it should be noted that the use of a resistor in the screen circuit will have an effect on the change in plate resistance with variation in suppressor voltage in case the suppressor is utilized for control purposes.

The **suppressor** may be connected directly to the cathode or it may be made negative with respect to the cathode. For the latter condition, the suppressor voltage may be obtained from a potentiometer or bleeder circuit for manual volume- and selectivity-control, or from the drop in a resistor in the plate circuit of the automatic volume-control tube.

APPLICATION

As a **radio-frequency amplifier,** the 6K7 is especially applicable to radio receiver design because of its ability to reduce cross-modulation effects, its remote "cut-off" feature, and its flexible adaptability to circuit combinations and to receiver design. Recommended conditions for the 6K7 as an amplifier are given under CHARACTERISTICS.

To realize the maximum benefit of the long "cut-off" feature of this tube, it is necessary to apply a variable grid bias and to maintain the screen at a constant potential with respect to the cathode. Good results, however, may be obtained by using a variable cathode resistance. Such a resistance, of course, reduces the screen potential by the amount that the bias is increased and thus hastens the "cut-off." Therefore, the ability of the tube to handle large signals is somewhat impaired. This effect may be nullified by means of a series resistor in the screen circuit.

The use of series resistors for obtaining satisfactory control of screen voltage in the case of four-electrode tubes is usually impossible because of secondary emission phenomena. In the 6K7, however, the suppressor practically removes these effects and it is therefore possible to obtain satisfactorily the screen voltage from the plate supply or from some high intermediate voltage providing these sources do not exceed 250 volts. With this method, the screen-to-cathode voltage will fall off very little from minimum to maximum value of cathode-control resistor. In some cases, it may actually rise. This rise of screen-to-cathode voltage above the normal maximum value is allowable because the screen and the plate current are reduced simultaneously by a sufficient amount to prevent damage to the tube. It should be recognized in general that the series-resistor method of obtaining screen voltage from a higher voltage supply necessitates the use of the variable cathode-resistor method of controlling volume in order to prevent too high a voltage on the screen. When screen and control-grid voltage are obtained in this manner, the remote "cut-off" advantage of the 6K7 may be fully realized.

As a **mixer** in superheterodyne circuits, the 6K7 may be used although a pentagrid mixer or pentagrid converter type is generally preferable. The 6K7 as a mixer is capable of producing, under the proper conditions of grid and local oscillator voltage, a gain of about one-third that which can be obtained in an intermediate-frequency amplifier stage. This gain can be controlled by varying the grid bias either from a separate supply or from a variable resistor in the cathode circuit. This is a desirable feature in receivers employing automatic volume-control, because it enables a much lower threshold input to be received without loss of amplification and permits the reception of high input voltages without loss of control. Recommended conditions for the 6K7 as a superheterodyne mixer follow: Plate voltage, 250 volts; screen voltage, 100 volts; suppressor connected to cathode at socket; and grid-bias voltage, −10 volts approximate (with 7-volt oscillator peak swing).

A plate family of curves is given under type 78.

#128

RCA Cunningham Radiotron

RCA-6K8

TRIODE-HEXODE CONVERTER

The 6K8 is a multi-unit type of all-metal vacuum tube intended primarily for use as a converter in superheterodyne receivers, especially those of the all-wave type. In such receivers, performance of the 6K8 is characterized by improved frequency stability in the high-frequency band.

The design of the 6K8 incorporates a triode unit and a hexode unit in one metal shell.

The action of the 6K8 in converting a radio frequency to an intermediate frequency depends on (1) the generation of a local frequency by the triode unit, (2) the transferring of this frequency to the hexode grid No. 1, and (3) the mixing in the hexode unit of this frequency with that of the r-f signal frequency applied to the hexode grid No. 3.

Because of its design, the 6K8 offers distinctive features of practical interest to the set engineer as follows: (1) In a-c/d-c receivers, the same voltage can be used for the screen and plate of the hexode unit. Such operation is made possible because shield plates serve as a suppressor to raise the plate resistance of the hexode unit at low plate voltages. (2) The triode plate voltage can be the same as the hexode screen voltage and provide adequate oscillation, because the latter is substantially independent of the hexode screen voltage. (3) For adequate conversion transconductance and high plate resistance (hexode unit), only a low triode grid current is required. (4) There is small variation in transconductance of the triode unit with changes in bias on hexode control-grid No.3. As a result, the oscillator frequency is not appreciably influenced by avc voltage.

from RMA registration #128, Jan. 31, 1938

Cunningham Radiotron

RCA-6K8

TRIODE-HEXODE CONVERTER

(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	6.3 Volts
HEATER CURRENT	0.3 Ampere
DIRECT INTERELECTRODE CAPACITANCES (Approx.): *	
Hexode Grid No.3 to Hexode Plate	0.03 μμf
Hexode Grid No.3 to Triode Plate	0.01 μμf
Hexode Grid No.3 to Triode Grid	0.1 μμf
Triode Grid to Triode Plate	1.1 μμf
Triode Grid and Hexode Grid No.1 to Hexode Plate	0.05 μμf
Hexode Grid No.3 to All Other Electrodes = R-F Input	6.6 μμf
Triode Plate to All Other Electrodes (except Triode Grid and Hexode Grid No.1) = Osc. Output	3.2 μμf
Triode Grid and Hexode Grid No.1 to All Other Electrodes (except Triode Plate) = Osc. Input	6.0 μμf
Hexode Plate to All Other Electrodes = Mixer Output	3.5 μμf
MAXIMUM OVERALL LENGTH	3-1/8"
MAXIMUM DIAMETER	1-5/16"
CAP	Skirted Miniature - Style B
BASE	Small Wafer Octal 8-Pin

Converter Service

HEXODE PLATE VOLTAGE		250 max.	Volts
HEXODE SCREEN (Grids No.2 & 4) VOLTAGE		100 max.	Volts
HEXODE CONTROL-GRID (Grid No.3) VOLTAGE		-3 min.	Volts
TRIODE PLATE VOLTAGE		200 max.	Volts
TOTAL CATHODE CURRENT		16 max.	Milliamperes
TYPICAL OPERATION:			
Heater Voltage **	6.3	6.3	Volts
Hexode Plate Voltage	100	250	Volts
Hexode Screen Voltage	100	100	Volts
Hexode Control-Grid Voltage	-3	-3	Volts
Triode Plate Voltage	100	100	Volts
Triode Grid Resistor	50000	50000	Ohms
Hexode Plate Resistance (Approx.)	0.3	0.6	Megohms
Conversion Transconductance	360	400	Micromhos
Hexode Control-Grid Bias (Approx.) for Conversion Transconductance = 2 micromhos	-30	-30	Volts
Hexode Plate Current	2.3	2.7	Milliamperes
Hexode Screen Current	6.9	6.5	Milliamperes
Triode Plate Current	3.5	3.5	Milliamperes
Triode Grid Current	0.15	0.15	Milliamperes

The transconductance of the oscillator portion (not oscillating) of the 6K8 is approximately 2400 micromhos when the Triode Plate Voltage is 100 volts, and the Triode Grid Voltage is 0 volts.

* With shell connected to cathode.

** In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Pin Connections

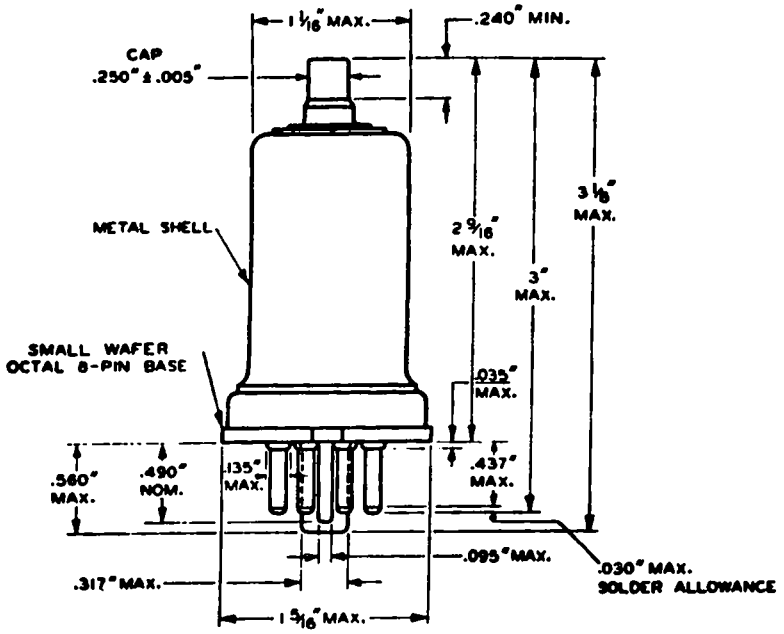
Pin 1 - Shell
Pin 2 - Heater
Pin 3 - Hexode Plate
Pin 4 - Hexode Grids No.2 & 4
Pin 5 - Hexode Grid No.1 & Triode Grid
Pin 6 - Triode Plate
Pin 7 - Heater
Pin 8 - Cathode
Cap - Hexode Grid No.3

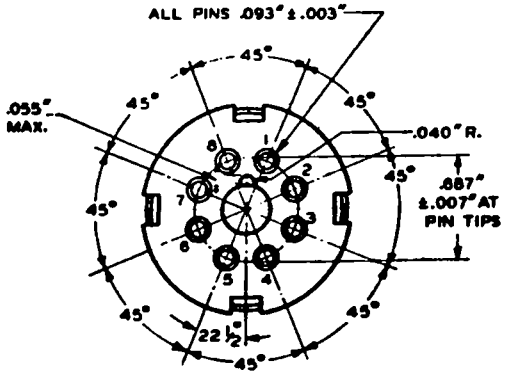
(Pin numbers are according to RMA system)

Cunningham Radiotron

RCA-6K8

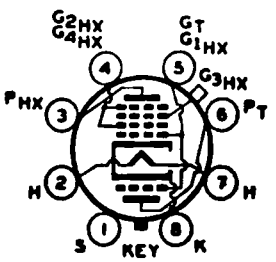
Outline Drawing





BOTTOM VIEW OF BASE

Tube Symbol & Bottom View of Socket Connections



8K

January 31, 1938

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

JETEC TYPE 6K8

TRIODE HEXODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-2
Bulb	MT-8
Base	B8-21, small wafer octal 8-pin
Top cap	C1-4, miniature
Maximum diameter	1-5/16"
Maximum overall length	3-1/8 "
Maximum seated height	2-9/16"
Pin connections	Basing 8K

Pin 1 - Shell
Pin 2 - Heater
Pin 3 - Plate
Pin 4 - Hexode grids #2 and #4
Pin 5 - Hexode grid #1, triode grid
Pin 6 - Triode plate
Pin 7 - Heater
Pin 8 - Cathode
Top cap-Hexode grid #3

Mounting position . . . . . Any

ELECTRICAL DATA

Direct interelectrode capacitances*

Signal grid to mixer plate: (g3h to ph) max.	0.03	µµf
Signal grid to oscillator plate: (g3h to pt) max.	0.02	µµf
Signal grid to oscillator grid: (g3h to gt&g1h) max.	0.2	µµf
Oscillator grid to oscillator plate: (gt&g1h to pt)	1.1	µµf
Oscillator grid to mixer plate: (gt&g1h to ph) max.	0.1	µµf
Signal input: g3h to (h+k+gt&g1h+g4h&g2h+pt+ph)	6.6	µµf
Oscillator input: gt&g1h to (h+k+g3h+g4h&g2h-ph)	6.0	µµf
Oscillator output: pt to (h+k+g3h+g4h&g2h+ph)	3.2	µµf
Mixer output: ph to (h+k+gt&g1h+g3h+g4h&g2h+pt)	3.5	µµf

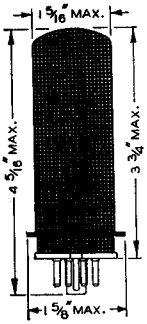
*Pin #1 connected to pin #8.

Ratings

Heater voltage	6.3	volts
Maximum hexode plate voltage	300	volts
Maximum hexode grids #2 and #4 supply voltage	300	volts
Maximum hexode grids #2 and #4 voltage	150	volts
Maximum hexode plate dissipation	.75	watts
Maximum hexode grids #2 and #4 dissipation	.70	watts
Maximum oscillator anode voltage	125	volts
Maximum oscillator anode dissipation	.75	watts
Maximum total cathode current	16	ma
Minimum external signal grid bias voltage	0	volts
Maximum heater-cathode voltage	90	volts

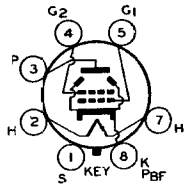
Note: page 2 of release #128A missing from RMA database.

Continued on Page 2



RCA-6L6

BEAM POWER AMPLIFIER



The 6L6 is a power-amplifier tube of the All-Metal type for use in the output stage of radio receivers, especially those designed to have ample reserve of power-delivering ability. The 6L6 provides high power output sensitivity and high efficiency. The power output at all levels has low third and negligible higher-order harmonic distortion. When operated at maximum ratings, this tube will give over 11 watts output in single-ended operation and as much as 60 watts in push-pull. When the push-pull connection is used with a 6600-ohm load, the 6L6 will give 34 watts of audio power without the need of grid-driving power. For discussion of beam power amplifier considerations, refer to page 10.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.9	Ampere
Average Characteristics		
Plate Voltage	250	Volts
Screen Voltage	250	Volts
Grid Voltage	−14	Volts
Plate Current	72	Milliamperes
Screen Current	5	Milliamperes
Plate Resistance	22500	Ohms
Amplification Factor	135	
Transconductance	6000	Micromhos
Base	Small Wafer Octal 7-Pin	

As Single-Tube Class A_1 Amplifier—With Self-bias

Plate Voltage			375 *max.*	Volts
Screen Voltage			250 *max.*	Volts
Screen Dissipation			3.5 *max.*	Watts
Plate and Screen Dissipation			24 *max.*	Watts
Typical Operation				
Plate Voltage	375	250	300	Volts
Screen Voltage	125	250	200	Volts
Self-Bias Resistor	365	170	220	Ohms
Peak A-F Grid Voltage	8.5	14	12.5	Volts
Zero-Signal Plate Current	24	75	51	Milliamperes
Max.-Signal Plate Current	24.3	78	54.5	Milliamperes
Zero-Signal Screen Current	0.7	5.4	3	Milliamperes
Max.-Signal Screen Current	1.8	7.2	4.6	Milliamperes
Load Resistance	14000	2500	4500	Ohms
Total Harmonic Distortion	9	10	11	Per cent
Second Harmonic Distortion	8	9.7	10.7	Per cent
Third Harmonic Distortion	4	2.5	2.5	Per cent
Max.-Signal Power Output	4	6.5	6.5	Watts

As Single-Tube Class A_1 Amplifier—Fixed Bias

Plate Voltage	375 *max.*	Volts
Screen Voltage	250 *max.*	Volts
Screen Dissipation	3.5 *max.*	Watts
Plate and Screen Dissipation (Total)	24 *max.*	Volts

TYPICAL OPERATION					
Plate Voltage	375	250	300	375	Volts
Screen Voltage	125	250	200	250	Volts
D-C Grid Voltage	−9	−14	−12.5	−17.5	Volts
Peak A-F Grid Voltage	8	14	12.5	17.5	Volts
Zero-Signal Plate Current	24	72	48	57	Milliamperes
Max.-Signal Plate Current	26	79	55	67	Milliamperes
Zero-Signal Screen Current	0.7	5	2.5	2.5	Milliamperes
Max.-Signal Screen Current	2	7.3	4.7	6	Milliamperes
Load Resistance	14000	2500	4500	4000	Ohms
Total Harmonic Distortion	9	10	11	14.5	Per cent
Second Harmonic Distortion	8	9.7	10.7	11.5	Per cent
Third Harmonic Distortion	4	2.5	2.5	4.2	Per cent
Max.-Signal Power Output	4.2	6.5	6.5	11.5	Watts

As Push-Pull Class A_1 Amplifier

PLATE VOLTAGE	375 *max.*	Volts
SCREEN VOLTAGE	250 *max.*	Volts
SCREEN DISSIPATION	3.5 *max.*	Watts
PLATE AND SCREEN DISSIPATION (Total)	24 *max.*	Watts

TYPICAL OPERATION *Values are for two tubes.*

	Fixed Bias	*Self-Bias*	
Plate Voltage	250	250	Volts
Screen Voltage	250	250	Volts
D-C Grid Voltage	−16	—	Volts
Self-Bias Resistor	—	125	Ohms
Peak A-F Grid-to-Grid Voltage	32	35.6	Volts
Zero-Signal Plate Current	120	120	Milliamperes
Max.-Signal Plate Current	140	130	Milliamperes
Zero-Signal Screen Current	10	10	Milliamperes
Max.-Signal Screen Current	16	15	Milliamperes
Load Resistance (Plate-to-plate)	5000	5000	Ohms
Total Harmonic Distortion	2	2	Per cent
Third Harmonic Distortion	2	2	Per cent
Max.-Signal Power Output	14.5	13.8	Watts

As Push-Pull Class AB_1 Amplifier

PLATE VOLTAGE	400 *max.*	Volts
SCREEN VOLTAGE	300 *max.*	Volts
SCREEN DISSIPATION	3.5 *max.*	Watts
PLATE AND SCREEN DISSIPATION (Total)	24 *max.*	Watts

TYPICAL OPERATION *Values are for two tubes.*

	Self-Bias		*Fixed Bias*		
Plate Voltage	400	400	400	400	Volts
Screen Voltage	250	300	250	300	Volts
D-C Grid Voltage	—	—	−20	−25	Volts
Self-Bias Resistor	190	200	—	—	Ohms
Peak A-F Grid-to-Grid Volt.	43.8	57	40	50	Volts
Zero-Signal Plate Current	96	112	88	102	Milliamperes
Max.-Signal Plate Current	110	128	124	152	Milliamperes
Zero-Signal Screen Current.	4.6	7	4	6	Milliamperes
Max.-Signal Screen Current.	10.8	16	12	17	Milliamperes
Load Resist. (Plate-to-plate).	8500	6600	8500	6600	Ohms
Total Harmonic Distortion	2	2	2	2	Per cent
Third Harmonic Distortion	2	2	2	2	Per cent
Max.-Signal Power Output	24	32	26.5	34	Watts

As Push-Pull Class AB_2 Amplifier—Fixed Bias

PLATE VOLTAGE	400 *max.*	Volts

SCREEN VOLTAGE		300 *max.*	Volts
SCREEN DISSIPATION		3.5 *max.*	Watts
PLATE AND SCREEN DISSIPATION (Total)		24 *max.*	Watts
TYPICAL OPERATION *Values are for two tubes.*			
Plate Voltage	400	400	Volts
Screen Voltage	250	300	Volts
D-C Grid Voltage	−20	−25	Volts
Peak A-F Grid-to-Grid Voltage	57	80	Volts
Zero-Signal Plate Current	88	102	Milliamperes
Max.-Signal Plate Current	168	230	Milliamperes
Zero-Signal Screen Current	4	6	Milliamperes
Max.-Signal Screen Current	13	20	Milliamperes
Load Resistance (Plate-to-plate)	6000	3800	Ohms
Peak Grid-Input Power†	0.18	0.35	Watt
Max.-Signal Power Output*	40	60	Watts

* With zero-impedance driver and perfect regulation, plate-circuit distortion does not exceed 2%. In practice, plate-voltage regulation, screen-voltage regulation, and grid-bias regulation, should not be greater than 5%, 5%, and 3%, respectively.

† Driver stage should be capable of supplying the grids of the Class AB stage with the specified peak values at low distortion. The effective resistance per grid circuit of the Class AB stage should be kept below 500 ohms and the effective impedance at the highest desired response frequency should not exceed 700 ohms.

INSTALLATION

The **base** pins of the 6L6 fit the standard octal socket which may be installed to hold the tube in any position.

The **heater** is designed to operate at 6.3 volts. The transformer supplying this voltage should be designed to operate the heater at this recommended value for full-load operating conditions at average line voltage. Under the maximum screen and plate dissipation conditions, the heater voltage should never fluctuate so that it exceeds 7.0 volts. For **cathode** connection, refer to type 6A8.

In all services precautions should be taken to insure that the dissipation rating is not exceeded with expected line-voltage variations, especially in the cases of fixed-bias operation. When the push-pull connection is used, fixed-bias values up to 10% of each typical screen voltage can be used without increasing distortion.

APPLICATION

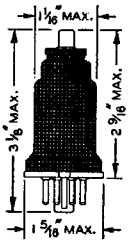
As a **Class A_1 power amplifier,** the 6L6 should be operated as shown under CHARACTERISTICS. The values cover self- and fixed-bias operation and have been determined on the basis that no grid current flows during any part of the input signal swing. The second harmonics can easily be eliminated by the use of push-pull circuits. In single-tube, resistance-coupled circuits, the second-harmonics can be minimized by generating out-of-phase second harmonics in the pre-amplifier.

As a **push-pull Class AB_1 power amplifier,** the 6L6 may be operated as shown under CHARACTERISTICS. The values shown cover self- and fixed-bias operation and have been determined on the basis that no grid current flows during any part of the input signal swing.

The type of **input coupling** used in Class A_1 and Class AB_1 service should not introduce too much resistance in the grid-circuit. Transformer- or impedance-coupling devices are recommended. When the grid circuit has a resistance not higher than 0.1 megohm fixed-bias may be used; for higher values, self-bias is required. With self-bias, the grid circuit may have a resistance as high as, but not greater than, 0.5 megohm provided the heater voltage is not allowed to rise more than 10% above the rated value under any condition of operation.

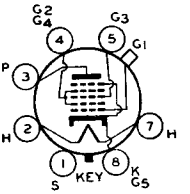
As a **push-pull Class AB_2 power amplifier,** the 6L6 may be operated as shown under CHARACTERISTICS. The values cover operation with fixed-bias and have been determined on the basis that some grid current flows during the most positive swing of the input signal.

Refer to Circuit Section for circuits employing the 6L6, and to page 21 for discussion of inverse-feedback arrangements. A family of plate characteristics curves is given on page 96.



RCA-6L7

PENTAGRID MIXER AMPLIFIER



The 6L7 is a multi-electrode vacuum tube of the All-Metal type designed with two separate control grids shielded from each other. This design permits each control grid to act independently on the electron stream. This tube, therefore, is especially useful as a mixer in superheterodyne circuits having a separate oscillator stage, as well as in other applications where dual control is desirable in a single stage. The design of the tube is such that coupling effects between oscillator and signal circuits are made very small. This feature enables the 6L7 to give high gain in high-frequency circuits. For general discussion of pentagrid types, see Frequency Conversion on page 31.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Direct Interelectrode Capacitances:*		
Grid No. 1 to Grid No. 3	0.12	μμf
Grid No. 1 to Plate	0.0005 *max.*	μμf
Grid No. 3 to Plate	0.025	μμf
Grid No. 1 to All Other Electrodes	8.5	μμf
Grid No. 3 to All Other Electrodes	11.5	μμf
Plate to All Other Electrodes	12.5	μμf
Cap	Miniature	
Base	Small Wafer Octal 7-Pin	

As Mixer

Plate Voltage		250 *max.*	Volts
Screen (Grids No. 2 and No. 4) Voltage		150 *max.*	Volts
Typical Operation:			
Plate Voltage	250	250†	Volts
Screen Voltage	100	150†	Volts
Signal-Grid (Grid No. 1) Voltage	−3 *min.*	−6 *min.*†	Volts
Oscillator-Grid (Grid No. 3) Voltage**	−10	−15	Volts
Peak Oscillator Voltage Applied to Grid No. 3 (Minimum)	12	18	Volts
Plate Current	2.4	3.3	Milliamperes
Screen Current	7.2	9.2	Milliamperes
Plate Resistance	Greater than 1		Megohm
Conversion Conductance	350	350	Micromhos
Signal-Grid (Grid No. 1) Voltage for Conver. Cond. of 5 Micromhos	−30	−45	Volts

** The d-c resistance in oscillator-grid-No. 3 circuit should be limited to 50000 ohms.

† Recommended values for all-wave receivers. * With shell connected to cathode.

As Amplifier

Plate Voltage	250 *max.*	Volts
Screen (Grids No. 2 and No. 4) Voltage	100 *max.*	Volts
Control-Grid (Grid No. 1) Voltage	−3 *min.*	Volts
Control-Grid (Grid No. 3) Voltage	−3	Volts
Plate Current	5.3	Milliamperes
Screen Current	6.5	Milliamperes
Amplification Factor	880	

PLATE RESISTANCE	0.8	Megohm
TRANSCONDUCTANCE	1100	Micromhos
TRANSCONDUCTANCE (−15 volts bias on Grid No. 1; −15 volts bias on Grid No. 3)	5	Micromhos

INSTALLATION

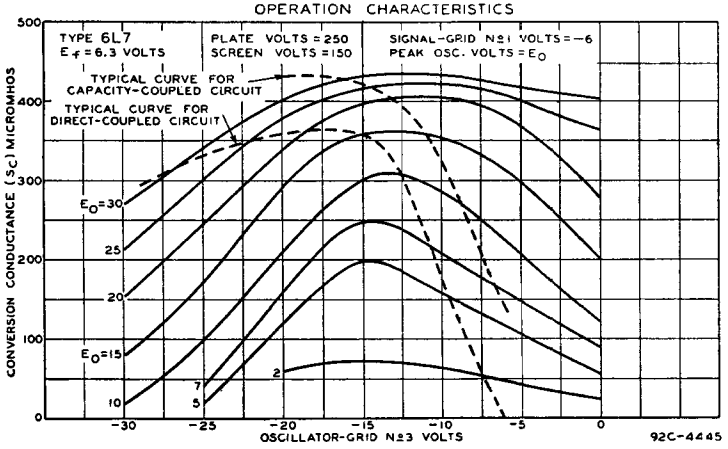
The **base** pins of the 6L7 fit the standard octal socket which may be installed to hold the tube in any position. For **heater** operation and **cathode** connection, refer to INSTALLATION for type 6A8.

APPLICATION

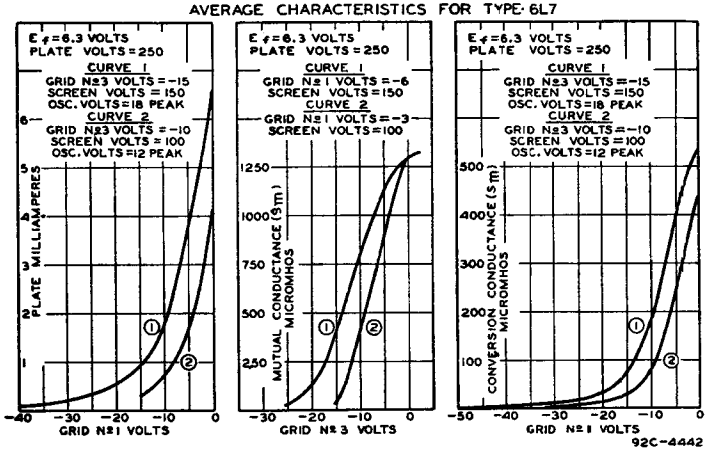
As a **mixer** in superheterodyne circuits, the 6L7 can mix the input from an external oscillator with the radio-input frequency to provide the desired intermediate frequency. For this service, design information is given under CHARACTERISTICS.

As a **radio-frequency** or **intermediate-frequency amplifier,** the 6L7 should be operated as shown under CHARACTERISTICS. In this application, the 6L7 has the advantage that avc bias can be applied to both the No. 1 grid and the No. 3 grid. With avc bias applied to the two grids, a small change in avc voltage produces a large change in the gain provided by the tube. For this reason the 6L7 as an r-f or i-f amplifier provides a flatter avc characteristic than a conventional pentode.

OPERATION CHARACTERISTICS



AVERAGE CHARACTERISTICS FOR TYPE 6L7



from JEDEC release #4320, July 1, 1963

RCA-6LC8, 8LC8

HIGH-MU TRIODE—SHARP-CUTOFF PENTODES

9-Pin Miniature Types

Triode Mu = 70

For Sync-Separator and Noise-Immune Gated-AGC-Amplifier Applications in Color and Black-and-White TV Receivers

RCA Dark Heater

RCA-6LC8 and 8LC8 are multiunit tubes of the 9-pin miniature type containing a high-mu triode and a sharp-cutoff pentode in the same envelope. These types are useful in both color and black-and-white television receivers.

The triode unit is useful in sync-separator circuits. The pentode unit is useful in noise-immune gated-agc-amplifier circuits. In such circuits, the pentode unit can provide high inverted-noise output at grid No.2 for use in the cancellation of positive-going noise pulses at the signal grid of the triode unit.

The 6LC8 and 8LC8 are like the 6KA8 and 8KA8, but differ in that they have a separate cathode for each unit and internal connections between pentode grid No.3, the triode cathode, and the internal shield.

The 6LC8 has a 6.3-volt/0.600-ampere heater having a controlled 11-second warm-up time. The 8LC8 is identical to the 6LC8 except that the 8LC8 has a 0.450-ampere/8.4-volt heater.

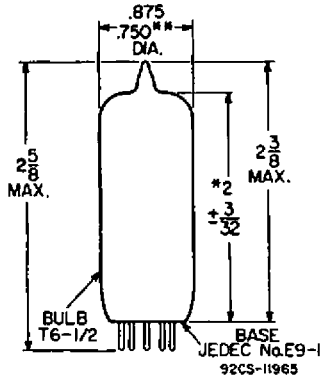
The RCA Dark Heater is utilized in both of these types for long life and dependable performance.

GENERAL DATA

Electrical:

Heater Characteristics and Ratings:

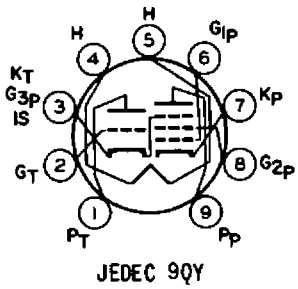
	6LC8		8LC8	
Voltage (AC or DC).	6.3[a]	6.3±0.6	8.4[c]	volts
Current. .	0.600 ± 0.040	0.600[b]	0.450 ± 0.030	amp
Warm-up time (Av.).	11	-	11	sec
Peak heater-cathode voltage (Each unit):				
Heater negative with respect to cathode	200	max.		volts
Heater positive with respect to cathode	200[d]	max.		volts
Direct Interelectrode Capacitances:[e]				
Triode Unit:				
Grid to plate.	2.2			pf
Grid to cathode & pentode grid No.3 & internal shield, and heater	2.8			pf
Plate to cathode & pentode grid No.3 & internal shield, and heater	2.2			pf
Pentode Unit:				
Grid No.1 to plate	0.10	max.		pf
Grid No.1 to cathode, triode cathode & grid No.3 & internal shield, grid No.2, and heater	10			pf
Grid No.3 & triode cathode & internal shield to plate.	3.4			pf
Grid No.1 to grid No.3 & triode cathode & internal shield	0.36			pf
Grid No.3 & triode cathode & internal shield to plate, cathode, grid No.2, grid No.1, and heater. . .	12.5			pf



*Measured from base seat to bulb-top line as determined by ring gauge of 7/16 inside diameter.

**Applies in zone starting 0.375 from base seat.

All Dimensions in Inches



JEDEC 9QY

Pin 1 – Triode Plate
Pin 2 – Triode Grid
Pin 3 – Triode Cathode, Pentode Grid No.3, Internal Shield
Pin 4 – Heater
Pin 5 – Heater
Pin 6 – Pentode Grid No.1
Pin 7 – Pentode Cathode
Pin 8 – Pentode Grid No.2
Pin 9 – Pentode Plate

RADIO CORPORATION OF AMERICA
Electron Tube Division Harrison, N. J.

Trademark(s) ® Registered
Marca(s) Registrada(s)

Characteristics, Class A_1 Amplifier:

	Triode Unit	*Pentode Unit*	
Plate Supply Voltage	200	150	volts
Grid No. 3	-	Connected to negative end of cathode resistor	
Grid-No. 2 Supply Voltage	-	100	volts
Grid-No. 1 Voltage	-2	-	volts
Grid No. 1	-	Connected to negative end of cathode resistor	
Cathode Resistor	-	180	ohms
Amplification Factor	70	-	
Plate Resistance (Approx.)	17500	100000	ohms
Transconductance, Grid No. 1 to Plate	4000	4400	μmhos
Transconductance, Grid No. 3 to Plate[f]	-	600	μmhos
Plate Current	4	4	ma
Grid-No. 2 Current	-	2.8	ma
Grid-No. 1 Supply Voltage (Approx.) for plate μa =			
10	-5	-	volts
20	-	-4	volts
Grid-No. 3 Supply Voltage (Approx.) for plate μa = 20[f]	-	-7	volts

Mechanical:

Operating Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length, Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Diameter	0.750" to 0.875"
Dimensional Outline	JEDEC No. 6-3
Bulb	T6-1/2
Base	Small-Button Noval 9-Pin (JEDEC No. E9-1)

GATED AGC AMPLIFIER & NOISE INVERTER

Pentode Unit

For operation in a 525-line, 30-frame system[g]

Maximum Ratings, *Design-Maximum Values:*

DC Plate Voltage	300 max.	volts
Peak Positive-Pulse Plate Voltage[h]	600 max.	volts
Grid-No. 3 (Control-Grid) Voltage:		
Negative-bias value	100 max.	volts
Positive-bias value	0 max.	volts
Grid-No. 2 (Screen-Grid) Supply Voltage	300 max.	volts
Grid-No. 2 Voltage	See *GRID-No.2-INPUT RATING CHART*	
Grid-No. 1 (Control-Grid) Voltage:		
Negative-bias value	50 max.	volts
Positive-bias value	0 max.	volts
Grid-No. 2 Input:		
For grid-No. 2 voltages up to 150 volts	1.1 max.	watts
For grid-No. 2 voltages between 150 and 300 volts	See *GRID-No.2-INPUT RATING CHART*	
Plate Dissipation	2 max.	watts

Maximum Circuit Values:

Grid-No. 1-Circuit Resistance:		
For fixed-bias operation	0.5 max.	megohm
For cathode-bias operation	1 max.	megohm

AMPLIFIER—Class A_1

Triode Unit

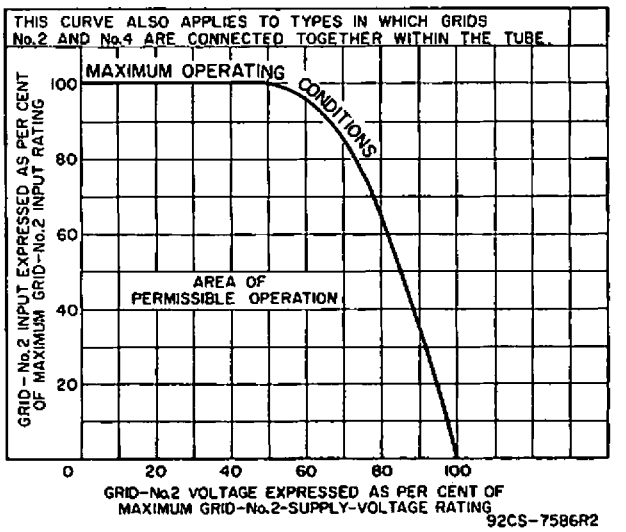
Maximum Ratings, *Design-Maximum Values:*

Plate Voltage	300 max.	volts
Grid Voltage:		
Negative-bias value	50 max.	volts
Positive-bias value	0 max.	volts
Plate Dissipation	1.1 max.	watts

Maximum Circuit Values:

Grid-Circuit Resistance:		
For fixed-bias operation	0.25 max.	megohm
For cathode-bias operation	1 max.	megohm

GRID-No.2-INPUT RATING CHART



[a] At heater amperes = 0.600.

[b] At heater volts = 6.3.

[c] At heater amperes = 0.450.

[d] The dc component must not exceed 100 volts.

[e] Without external shield.

[f] With no external connection to triode plate and triode grid.

[g] As described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations," Federal Communications Commission.

[h] This rating is applicable when the duration of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

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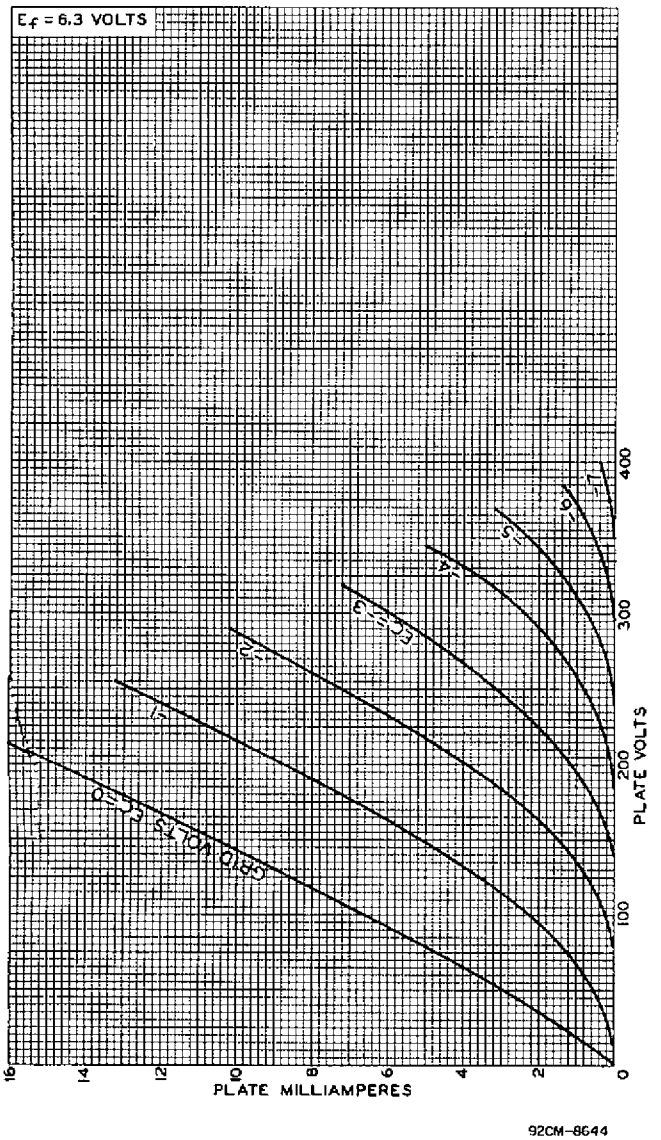
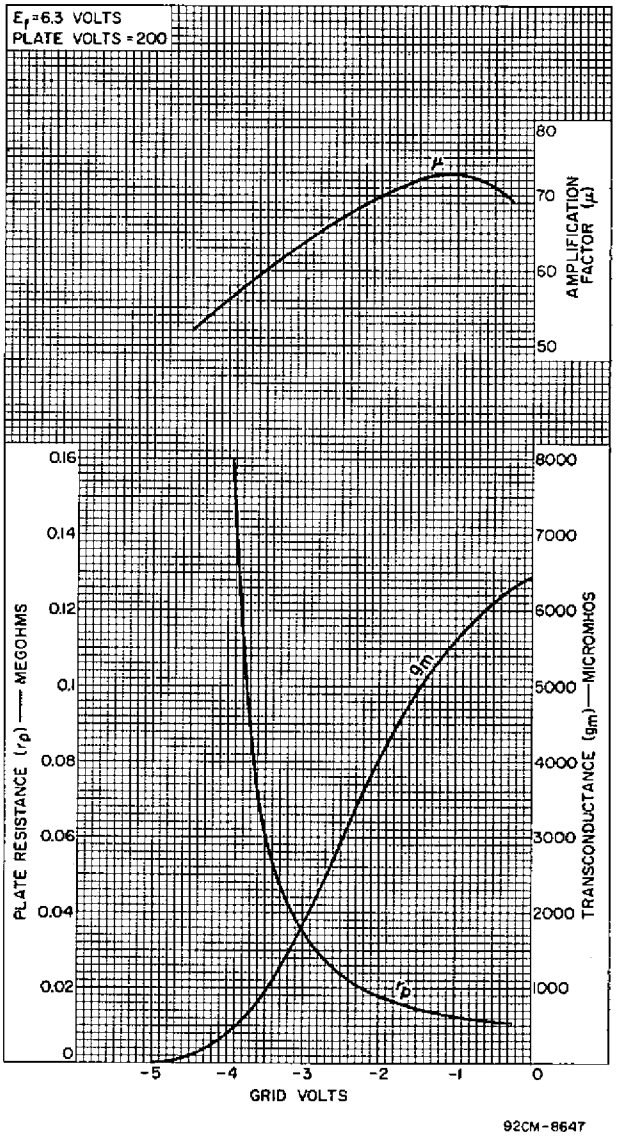
AVERAGE PLATE CHARACTERISTICS
Triode Unit

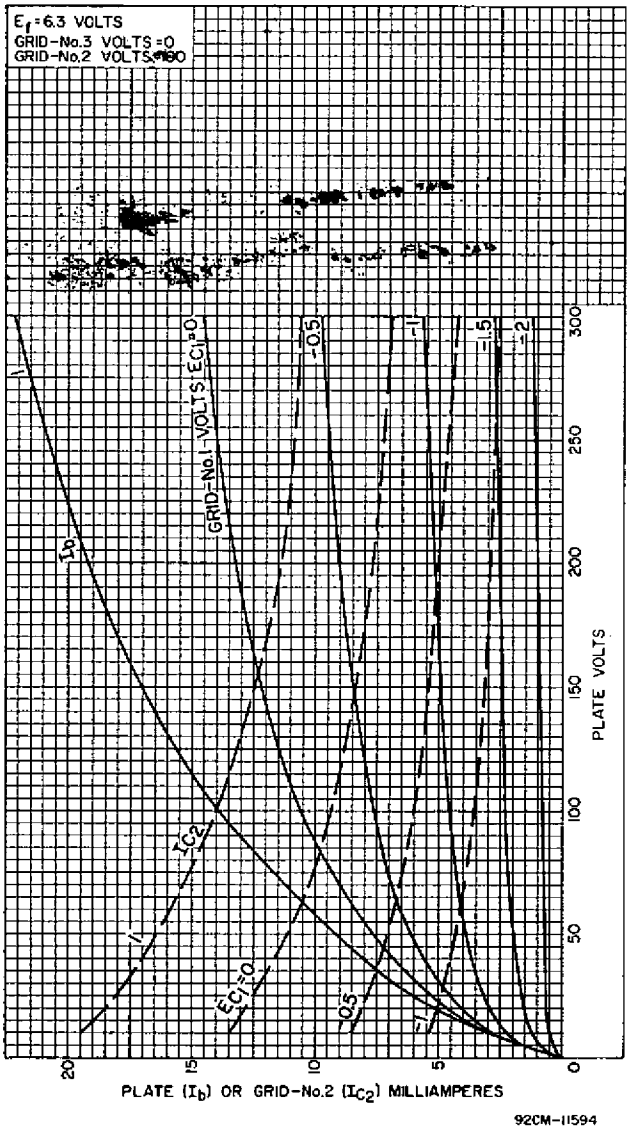


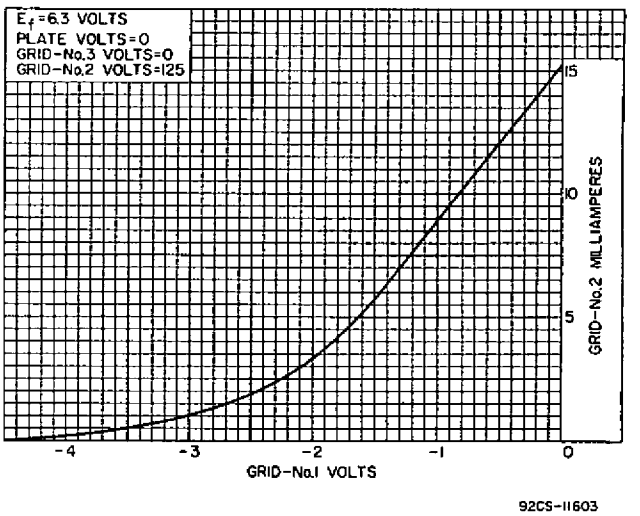
AVERAGE CHARACTERISTICS
Triode Unit



For Type 6LC8, and for Type 8LC8 (E_f = 8.4 V).

AVERAGE CHARACTERISTICS
Pentode Unit





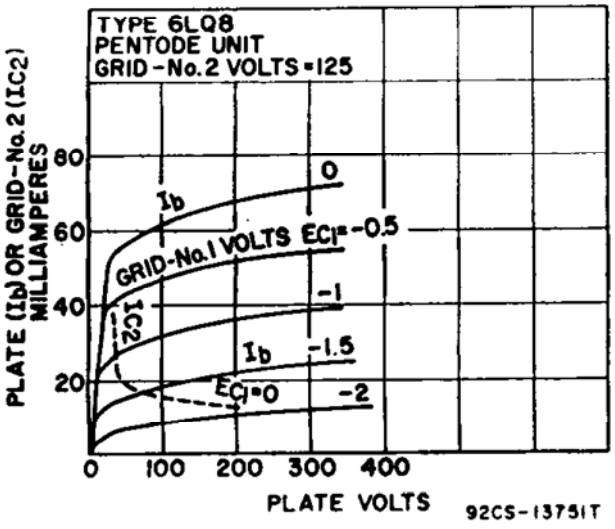
For Type 6LC8, and for Type 8LC8 (E_f = 8.4 V).

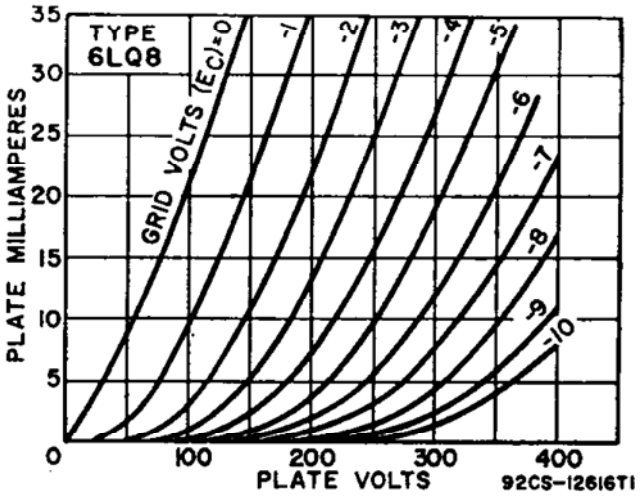
Class A_1 Amplifier

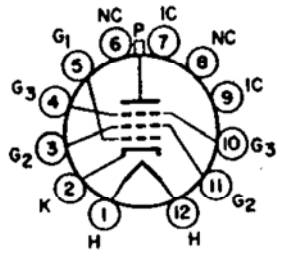
MAXIMUM RATINGS (Design-Maximum Values)	Triode Unit	Pentode Unit	
Plate Voltage	300	300	volts
Grid-No.2 (Screen-Grid) Supply Voltage	—	300	volts
Grid-No.2 Voltage	—	See curve page 300	
Grid-No.1 (Control-Grid) Voltage, Positive-bias value	0	0	volts
Plate Dissipation	2	5	watts
Grid-No.2 Input:			
For grid-No.2 voltages up to 150 volts	—	1	watts
For grid-No.2 voltages between 150 and 300 volts	—	See curve page 300	

CHARACTERISTICS	Triode Unit	Pentode Unit		
Plate Supply Voltage	125	125	200	volts
Grid-No.2 Supply Voltage	—	125	125	volts
Cathode-Bias Resistor	68	82	68	ohms
Amplification Factor	46	—	—	
Plate Resistance (Approx.)	4400	55000	75000	ohms
Transconductance	10400	21000	23000	μmhos
Plate Current	15	16.5	20	mA
Grid-No.2 Current	—	3.1	3.5	mA
Grid-No.1 Voltage(Approx.) for plate current of 100 μA	—6	—4.2	—4.2	volts

MAXIMUM CIRCUIT VALUES	Triode Unit	Pentode Unit	
Grid-No.1-Circuit Resistance:			
For fixed-bias operation	0.5	0.1	megohm
For cathode-bias operation	1	0.25	megohm







12FY

BEAM POWER TUBE

6LR6

35LR6

Duodecar type used as horizontal-deflection amplifier in color and black-and-white television receivers. An integral radiator-fin design dissipates heat uniformly. **Outlines section,** 16E; requires duodecar 12-contact socket. Type 35LR6 is identical with type 6LR6 except for heater ratings.

	6LR6	35LR6	
Heater Arrangement	Parallel	Series	
Heater Voltage (ac/dc)	6.3	35	volts
Heater Current	2.5	0.45±0.03	amperes
Heater Warm-up Time (Average)	—	11	seconds
Heater-Cathode Voltage:			
Peak value	±200 max	±200 max	volts
Average value	100 max	100 max	volts

Class A_1 Amplifier

CHARACTERISTICS	Triode†† Connection		Pentode Connection		
Plate Voltage	125	60	175	60	volts
Grid-No.3 (Suppressor Grid) Voltage	—		Connected to cathode at socket		
Grid-No.2 (Screen-Grid) Voltage	125	115	110	110	volts
Grid-No.1 (Control-Grid) Voltage	—20	0	—20	0	volts
Plate Resistance (Approx.)	--	—	5300	—	ohms

Transconductance (Grid No.1 to Plate)	—	—	16000	—	μmhos
Plate Current	—	740†	140	700	mA
Grid-No.2 Current	—	38†	2.4	35	mA
Grid-No.1 Voltage (Approx.) for plate current of 1 mA	—	—	−42	—	volts
Ratio (Plate Current/Grid No.2 Current)	—	19.5:1	—	20:1	
Triode Amplification Factor	3.5	—	—	—	

† This value can be measured by a method involving a recurrent waveform such that the maximum ratings of the tube will not be exceeded.
†† Grid No. 2 connected to plate.

Horizontal-Deflection Amplifier

For operation in a 525-line, 30-frame system

MAXIMUM RATINGS (Design-Maximum Values)

DC Plate Supply Voltage	990	volts
Peak Positive-Plate Pulse Voltage (Absolute Maximum)	7500	volts
Peak Negative-Pulse Plate Voltage	1100	volts
Positive Grid-No.3 Voltage	75	volts
DC Grid-No.2 Voltage	220	volts
Peak Negative-Pulse Grid-No.1 Voltage	330	volts
Average Cathode Current	375	mA
Peak Cathode Current	1300	mA
Plate Dissipation	30	watts
Grid-No.2 Input	5	watts
Bulb Temperature (At hottest point)	250	°C

MAXIMUM CIRCUIT VALUES

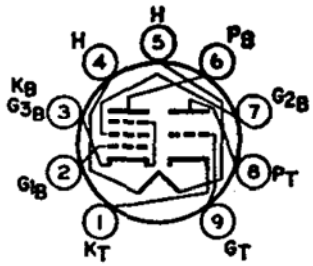
Grid-No.1-Circuit Resistance:		
Bias feedback high-voltage regulation	0.47	megohm
DC or pulse shunt high-voltage regulation	10	megohm

6LR8

21LR8, 31LR8

HIGH-MU TRIODE—BEAM POWER TUBE

Novar type used in combined vertical-deflection-oscillator and vertical-deflection-amplifier applications in color and black-and-white television receivers. Outlines section, 17E; requires novar 9-contact socket. Types 21LR8 and 31LR8 are identical with type 6LR8 except for heater ratings.



9QT

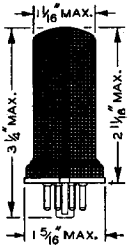
	6LR8	21LR8	31LR8	
Heater Voltage	6.3	21	31.5	volts
Heater Current	1.5	0.45	0.3	ampere
Heater Warm-up Time	—	11	11	seconds
Heater-Cathode Voltage:				
Peak value	±200 max	±200 max	±200 max	volts
Average value	100 max	100 max	100 max	volts

Class A_1 Amplifier

CHARACTERISTICS	Triode Unit	Beam Power Unit			
Plate Voltage	250	45	135	120	volts
Grid-No.2 (Screen-Grid) Voltage	—	125	120	120•	volts
Grid-No.1 (Control-Grid) Voltage	−4	0	−10	−10	volts
Amplification Factor	58	—	—	6.5	
Plate Resistance Approx.)	14000	—	14000	—	ohms
Transconductance	4100	—	9200	—	μmhos
Plate Current	2.6	200▪	51	—	mA
Grid-No.2 Current	—	200▪	3	—	mA
Grid-No.1 Voltage:					
For plate current of 10 μA	−6.6	—	—	—	volts
For plate current of 100 μA	—	—	−28	—	volts
For plate current of 1 mA	—	—	−24	—	volts

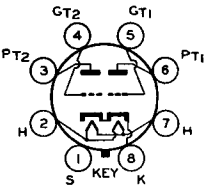
• Triode connection, Grid No.2 connected to plate at socket.

▪ This value can be measured by a method involving a recurrent waveform such that the maximum ratings of the tube will not be exceeded.



RCA-6N7

CLASS B TWIN TRIODE



The 6N7 is an All-Metal tube containing in one envelope two high-mu triodes designed for Class B operation. The triode units have separate external terminals for all electrodes except the cathodes and heaters. The 6N7 may also be used as a Class A_1 amplifier (with triode units connected in parallel) to drive a single 6N7 as a Class B amplier in the output stage.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.8	Ampere
Base	Small Wafer Octal 8-Pin	

As Class B Power Amplifier

Plate Voltage		300 *max.*	Volts
Peak Plate Current (Per Plate)		125 *max.*	Milliamperes
Average Plate Dissipation		10 *max.*	Watts
Typical Operation			
Plate Voltage	250	300	Volts
Grid Voltage	0	0	Volts
Zero-Signal Plate Current (Per Plate)	14	17.5	Milliamperes
Effective Load Resistance (Plate-to-plate)	8000	10000	Ohms
Power Output (Approximate)*	8	10	Watts

As Driver—Class A_1 Amplifier

(Both grids connected together at socket: likewise both plates.)

Plate Voltage†	250	294	Volts
Grid Voltage	−5	−6	Volts
Amplification Factor	35	35	
Plate Resistance	11300	11000	Ohms
Transconductance	3100	3200	Micromhos
Plate Current	6	7	Milliamperes

* With average input of 350 milliwatts applied between grids.

† Maximum plate voltage = 300 volts.

INSTALLATION

Refer to INSTALLATION on the type 6A6.

APPLICATION

As a Class B power amplifier, the 6N7 is used in circuits similar in design to those utilizing individual tubes in the output stage. It requires no grid-bias, since the high-mu feature of the triode units reduces the steady plate current at zero bias to a relatively low value. Refer to page 20 for general Class B amplifier design considerations.

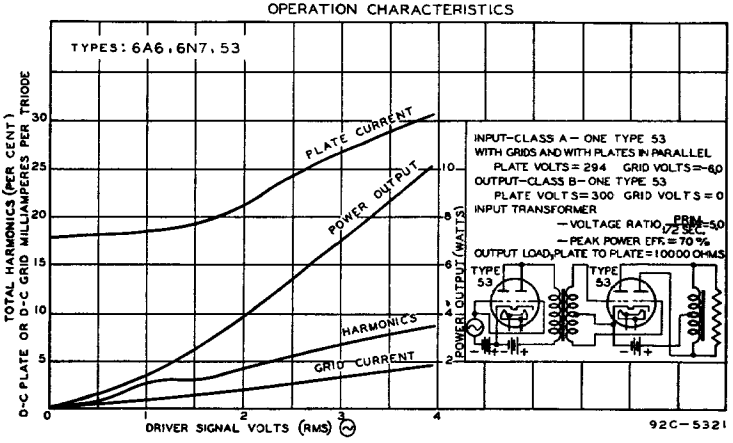
Two 6N7's can be operated in a Class B output stage with the two triode units of each 6N7 connected in parallel to give a power output of 20 watts, approximate, under conditions of 300 volts on the plates and of a 5000-ohm plate-to-plate load.

As a **Class A_1 amplifier triode**, the 6N7 may be employed in the driver stage of Class B amplifier circuits, and thus reduce the number of tube types necessary in a receiver. When operated in this way with a plate supply of 300 volts and corresponding grid-bias, the 6N7 is capable of supplying a power output upwards of 400 milliwatts. The load into which the driver works will depend largely on the design factors of the Class B amplifier. In general, however, the load will be between 20000 and 40000 ohms. The d-c resistance in the grid circuit of the 6N7, when operated as a Class A amplifier, may be as high as 0.5 megohm with self bias. With fixed bias, however, the resistance should not exceed 0.1 megohm. Typical operating values as a resistance-coupled amplifier are given in the Resistance-Coupled Amplifier Section.

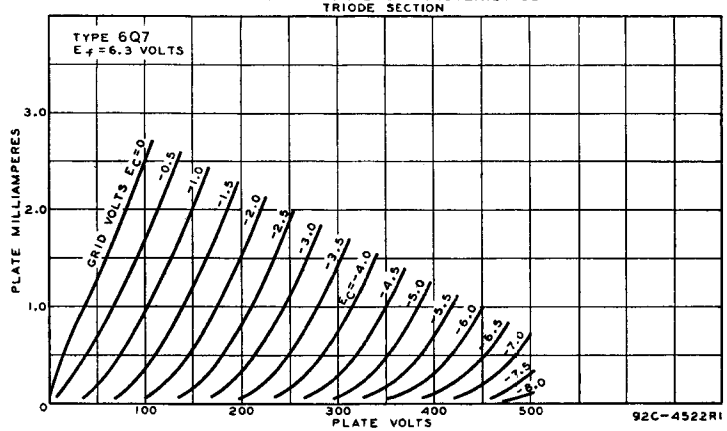
Among other and less conventional applications of the 6N7 are its use as (1) biased detector and one-stage a-f amplifier, (2) two-stage a-f amplifier, (3) amplifier and phase-inverter to supply resistance-coupled, push-pull output tubes, (4) two-tube oscillator, and (5) oscillator and amplifier.

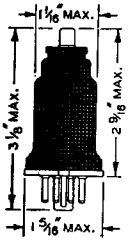
Additional curves are given under types 6A6 and 53.

OPERATION CHARACTERISTICS



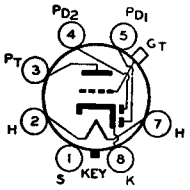
AVERAGE PLATE CHARACTERISTICS
TRIODE SECTION





RCA-6Q7

HIGH-MU TRIODE DUPLEX-DIODE



The 6Q7 is an All-Metal tube consisting of two diodes and a high-mu triode in one envelope. It is for use as a combined detector, amplifier, and automatic-volume-control tube in radio receivers designed for its characteristics. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Grid-Plate Capacitance*	1.5	μμf
Grid-Cathode Capacitance*	5.5	μμf
Plate-Cathode Capacitance*	5	μμf
Cap		Miniature
Base		Small Wafer Octal 7-Pin

Triode Unit—As Class A Amplifier

Plate Voltage	100	250 *max.*	Volts
Grid Voltage	−1.5	−3	Volts
Amplification Factor	70	70	
Plate Resistance	87500	58000	Ohms
Transconductance	800	1200	Micromhos
Plate Current	0.35	1.1	Milliamperes

* With shell connected to cathode.

Diode Units

The two diode plates are placed around a cathode, the sleeve of which is common to the triode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

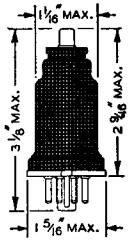
INSTALLATION AND APPLICATION

The base pins of the 6Q7 fit the standard octal socket which may be installed to hold the tube in any position. Heater and cathode considerations are the same as for the 6A8.

The 6Q7 is, in many respects, similar to the 75 except that it has a lower amplification factor which permits of handling somewhat larger input driving voltage without overloading. The triode unit is recommended for use only in resistance-coupled circuits. Typical recommended operating conditions are given in the Resistance-Coupled Amplifier Section.

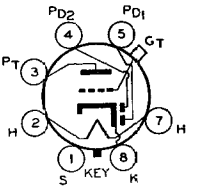
Grid bias for the triode unit of the 6Q7 may be obtained from a fixed source, such as a fixed-voltage tap on the d-c power supply or from a cathode-bias resistor. It should not be obtained by the diode-biasing method because of the probability of plate-current cut-off, even with relatively small signal voltages applied to the diode circuit.

A family of plate characteristic curves is given on the preceding page.



RCA-6R7

DUPLEX-DIODE TRIODE



The 6R7 is an All-Metal tube consisting of two diodes and a triode in a single envelope. It is for use as a combined detector, amplifier, and automatic-volume-control tube in radio receivers designed for its characteristics. For diode-detector considerations refer to page 26.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Grid-Plate Capacitance	2.5	$\mu\mu f$
Grid-Cathode Capacitance	5.5	$\mu\mu f$
Plate-Cathode Capacitance	4.0	$\mu\mu f$
Cap		Miniature
Base		Small Wafer Octal 7-Pin

Triode Unit—As Class A Amplifier

Plate Voltage	250 *max.*	Volts
Grid Voltage	−9	Volts
Amplification Factor	16	
Plate Resistance	8500	Ohms
Transconductance	1900	Micromhos
Plate Current	9.5	Milliamperes
Load Resistance	10000	Ohms
Undistorted Power Output	280	Milliwatts

Diode Units

The two diode plates are placed around a cathode, the sleeve of which is common to the triode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

INSTALLATION AND APPLICATION

The base pins of the 6R7 fit the standard octal socket which may be installed to hold the tube in any position. Heater and cathode considerations are the same as those for type 6A8.

As a **transformer-coupled amplifier,** the triode unit of the 6R7 may be employed in conventional circuit arrangements. Operating conditions are shown under CHARACTERISTICS.

As a **resistance-coupled amplifier,** the triode unit may be used under conditions given in the Resistance-Coupled Amplifier Section.

Grid bias for the triode unit of the 6R7 may be obtained from a fixed source, such as a fixed-voltage tap on the d-c power supply or from a cathode-bias resistor. It should not be obtained by the diode-biasing method because of the probability of plate-current cut-off, even with relatively small signal voltages applied to the diode circuit.

A family of plate characteristic curves is given on page 98.

Cunningham Radiotron

RCA-6S7

#129

TRIPLE-GRID SUPER-CONTROL AMPLIFIER

(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.15	Ampere
DIRECT INTERELECTRODE CAPACITANCES: °		
Grid to Plate	0.005 max.	μμf
Input	6.5	μμf
Output	10.5	μμf
MAXIMUM OVERALL LENGTH	3-1/8"	
MAXIMUM DIAMETER	1-5/16"	
CAP	Skirted Miniature - Style B	
BASE	Small Wafer Octal 7-Pin	

Amplifier - Class A

OPERATING CONDITIONS and CHARACTERISTICS:			
Heater Voltage *	6.3	6.3	Volts
Plate Voltage	135	250 max.	Volts
Screen Voltage	67.5	100 max.	Volts
Grid Voltage (Minimum)	-3	-3	Volts
Suppressor	Connected to cathode at socket		
Plate Current	3.7	8.5	Milliamperes
Screen Current	0.9	2.0	Milliamperes
Amplification Factor (Approx.)	-	1750	
Plate Resistance (Approx.)	-	1.0	Megohm
Transconductance	1250	1750	Micromhos
Grid Voltage for transconductance = 10 micromhos	-25	-38.5	Volts

° With shell connected to cathode.

* In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Pin Connections

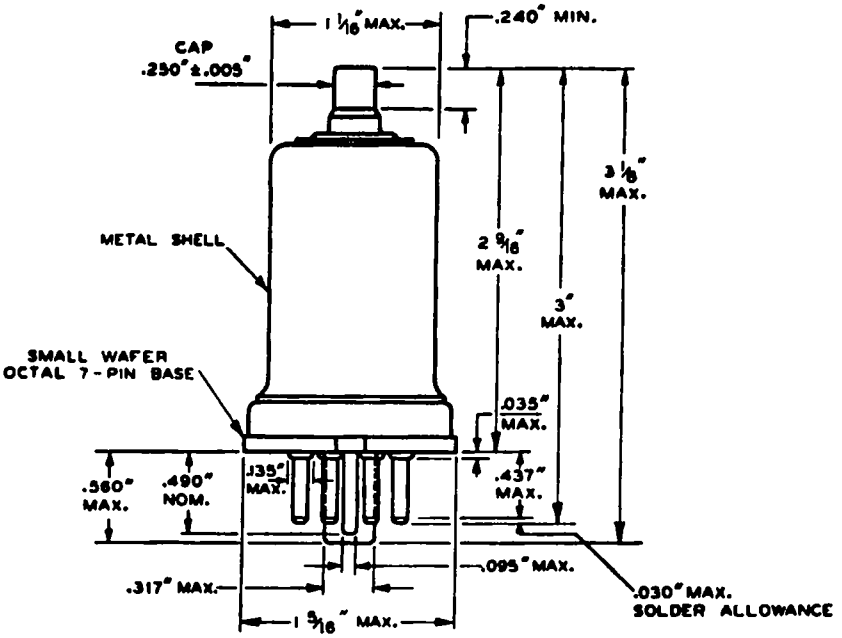
Pin 1 - Shell
Pin 2 - Heater
Pin 3 - Plate
Pin 4 - Screen
Pin 5 - Suppressor
Pin 7 - Heater
Pin 8 - Cathode
Cap - Grid

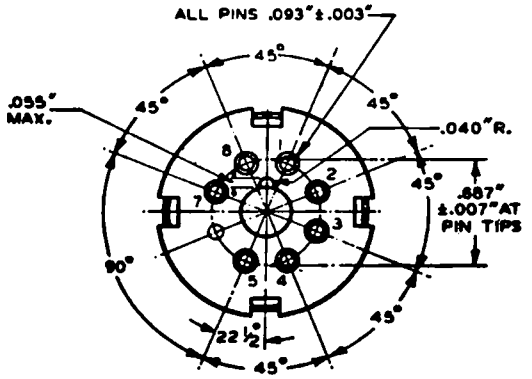
from RMA release #129, Feb. 23, 1938

Cunningham Radiotron

RCA-6S7

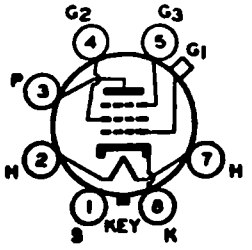
Outline Drawing





BOTTOM VIEW OF BASE

Tube Symbol & Bottom View of Socket Connections

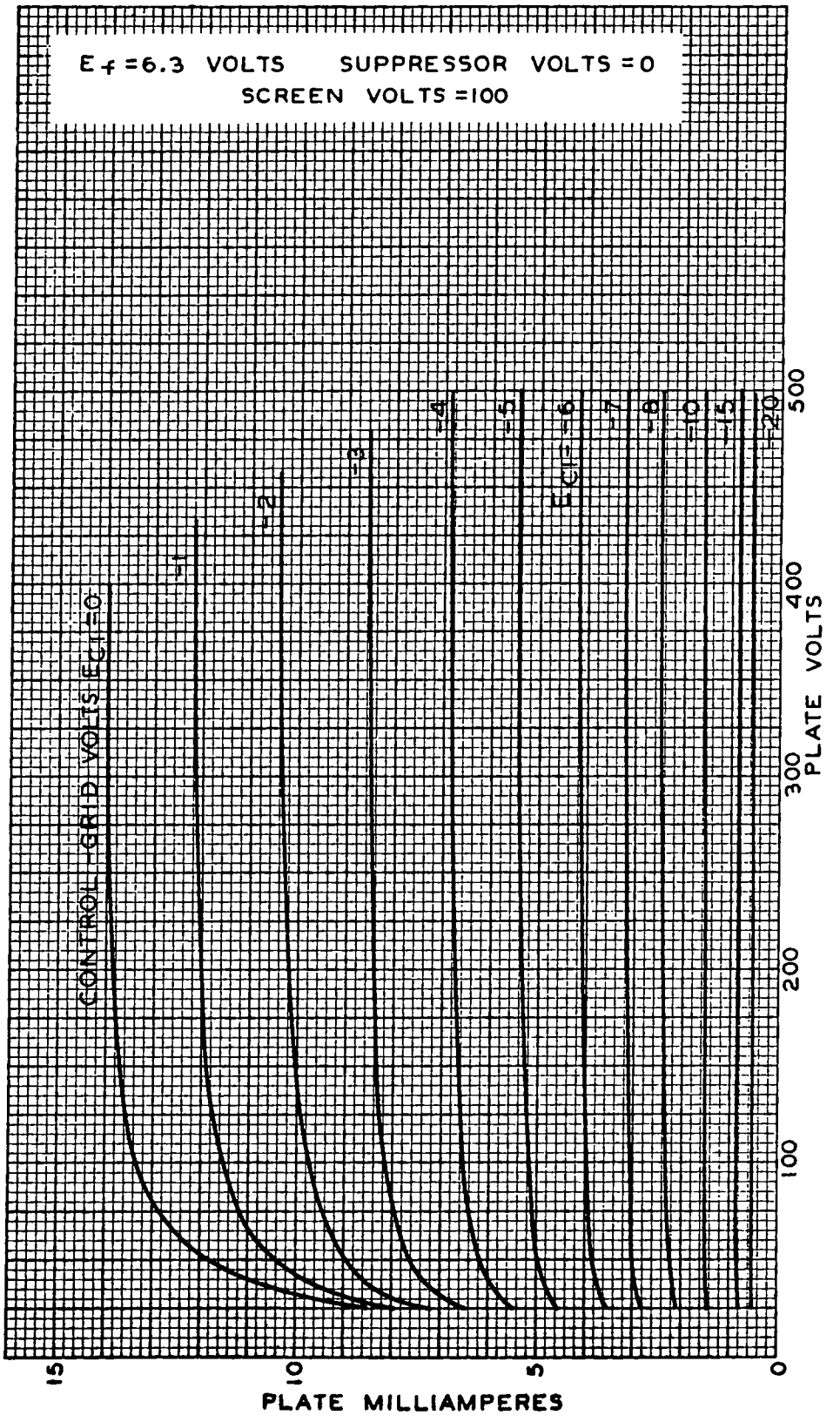


7R

RCA Cunningham Radiotron RADIO TUBES

RCA-6S7

AVERAGE PLATE CHARACTERISTICS



JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

129A
J5-6S7
APR 8 1958
FILE:

August 30, 1951

JETEC TYPE 6S7

PENTODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-2	Bulb	MT-8
Base	B7-22 small wafer octal 7-pin		
Top cap	C1-4 miniature		
Maximum diameter	1-5/16"		
Maximum overall length	3-1/8"		
Maximum seated height	2-9/16"		
Pin connections	Basing 7R		
Pin 1 - Shell, internal shield		Pin 5 - Grid #3	
Pin 2 - Heater		Pin 7 - Heater	
Pin 3 - Plate		Pin 8 - Cathode	
Pin 4 - Grid #2		Top cap - Grid #1	
Mounting position	any		

ELECTRICAL DATA

Direct Interelectrode Capacitances*

Grid to plate (g1 to p) max.	0.005	µµf
Input: g1 to (h+k+g2+g3+S)	6.5	µµf
Output: p to (h+k+g2+g3+S)	10.5	µµf

*Pin 1 connected to pin 8.

Ratings

Heater voltage	6.3	volts
Maximum plate voltage	300	volts
Maximum grid #2 voltage	See J5-C4	
Maximum grid #2 supply voltage	300	volts
Maximum positive dc grid #1 voltage	0	volts
Maximum plate dissipation	2.25	watts
Maximum grid #2 dissipation	0.25	watt
Maximum heater-cathode voltage	90	volts

Typical Operating Conditions and Characteristics, Class A1 Amplifier

Heater voltage	6.3	6.3	volts
Heater current	150	150	ma
Plate voltage	135	250	volts
Grid #2 voltage	67.5	100	volts
Grid #1 voltage	-3	-3	volts
Grid #3 voltage	Pin 5 connected to pin 8 at socket		
Plate resistance (approx.)	1.0	1.0	megohm
Transconductance	1250	1750	µmhos
Plate current	3.7	8.5	ma
Grid #2 current	0.9	2.0	ma
Grid #1 voltage (approx.) for Gm = 10 µmhos	-25	-38	volts

Refer to "Interpretation of Receiving Tube Ratings"

from RMA release #150
Nov. 18, 1938

RCA-6SA7

PENTAGRID CONVERTER
Single-Ended Metal Type

The 6SA7 is a new, single-ended, metal, pentagrid converter designed to perform simultaneously the functions of a mixer tube and of an oscillator tube in superheterodyne circuits, especially those of the all-wave type. It may also be used as a separately excited mixer.

Utilizing a special structure, the 6SA7 has excellent oscillator frequency stability. The magnitude of the input capacitance of the oscillator grid is not appreciably affected by signal-grid bias; changes in cathode current and in oscillator transconductance with avc voltage are small.

The 6SA7 offers several advantages from a circuit standpoint over other converter types: (1) elimination of loose or broken grid wires, (2) wiring can be completed below the set panel, (3) neater appearance of the chassis, (4) use of simplified oscillator coil and switching arrangements, (5) higher conversion gain, (6) small frequency shift at high frequencies, (7) lowered cost, and (8) simplification of tube renewal.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES:		
Grid #3 to All Other Electrodes (R-F Input) °	9.5	μμf
Plate to All Other Electrodes (Mixer Output) °	12	μμf
Grid #1 to All Other Electrodes °	7	μμf
Grid #3 to Plate °	0.13 max.	μμf
Grid #1 to Grid #3 °	0.15 max.	μμf
Grid #1 to Plate °	0.06 max.	μμf
Grid #1 to All Other Electrodes except Cathode	4.4	μμf
Grid #1 to Cathode	2.6	μμf
Cathode to All Other Electrodes except Grid #1	5	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

CONVERTER SERVICE

PLATE VOLTAGE				250 max.	Volts
GRIDS #2 & #4 VOLTAGE				100 max.	Volts
TOTAL CATHODE CURRENT				14 max.	Milliamperes
TYPICAL OPERATION:	*Self-Excitation**		*Separate Excitation*		
Heater Voltage □	6.3	6.3	6.3	6.3	Volts
Plate Voltage	100	250	100	250	Volts
Grids #2 & #4 Voltage	100	100	100	100	Volts
Grid #3 (Control Grid) Voltage	0	0	-2	-2	Volts
Shell & Grid #5 Voltage	0	0	0	0	Volts
Grid #1 Resistor	20000	20000	20000	20000	Ohms
Plate Resistance (Approx.)	0.5	0.8	0.5	0.8	Megohm
Conversion Transcond.	425	450	425	450	Micromhos
Grid #3 Bias (Approx.) for Conversion Transconductance = 5 micromhos	-35	-35	-35	-35	Volts
Plate Current	3.2	3.4	3.2	3.4	Milliamperes
Grids #2 & #4 Current	8	8	8	8	Milliamperes
Grid #1 Current	0.5	0.5	0.5	0.5	Milliampere

NOTE: The transconductance between Grid #1 and Grids #2 & #4 tied to plate (not oscillating) is approximately 4500 micromhos under the following conditions:

Grid #1, Grid #3, Grid #5 & Shell } at 0 volts

Grid #2 & #4, Plate } at 100 volts

°, *, □ : See next page.

o With shell connected to cathode.

* Characteristics values are approximate only and are shown for a Hartley circuit with a feedback of approximately 2 volts peak in the cathode circuit.

□ In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Pin Connections

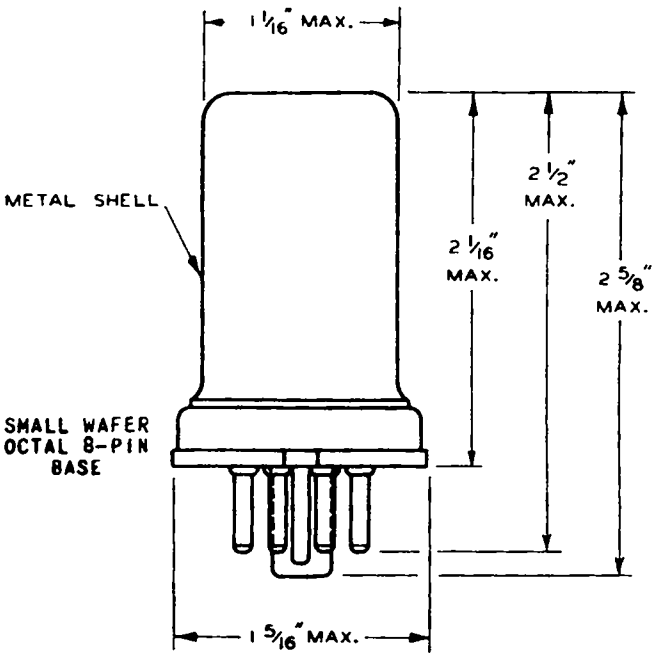
Pin 1 - Shell & Grid #5	Pin 5 - Grid #1
Pin 2 - Heater	Pin 6 - Cathode
Pin 3 - Plate	Pin 7 - Heater
Pin 4 - Grids #2 & #4	Pin 8 - Grid #3

(Pin numbers are according to RMA system)

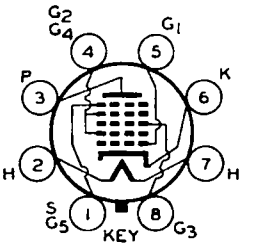
Mounting Position

Vertical or Horizontal - No restrictions

OUTLINE DRAWING FOR 6SA7



BOTTOM VIEW OF SOCKET CONNECTIONS FOR 6SA7



8R

RCA Laboratories Div.
Newark Industry Serv. Lab.
150A
APR 8 1958
Page 1
FILE Feb. 20, 1950

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

JETEC TYPE 6SA7

HEPTODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-1	Bulb	MT-8
Base	B8-21 small wafer octal 8-pin		
Maximum diameter	1-5/16"		
Maximum overall length	2-5/8"		
Maximum seated height	2-1/16"		
Pin connections	Basing 8R		

Pin 1 - Shell, grid #5
Pin 2 - Heater
Pin 3 - Plate
Pin 4 - Grids #2 and #4
Pin 5 - Grid #1
Pin 6 - Cathode
Pin 7 - Heater
Pin 8 - Grid #3

Mounting position . . . . . any

ELECTRICAL DATA

Direct Interelectrode Capacitances

Mixer grid to plate: (g3 to p) max.	0.25	μμf
Mixer grid to oscillator grid: (g3 to g1) max.	0.15	μμf
Mixer output: p to (h+k+S+g1+g2+4+g3+g5)	9.5	μμf
Oscillator input: g1 to (h+k+S+g2+4+g3+g5+p)	7	μμf
Oscillator grid to plate: (g1 to p) max.	0.06	μμf
Oscillator output: k to (h+S+g2+4+g3+g5+p)	5	μμf
Oscillator grid to cathode: (g1 to k)	2.6	μμf
Oscillator grid to all except cathode: g1 to (h+S+g2+4+g3+g5+p)	4.4	μμf
R.F. input: g3 to (h+k+S+g1+g2+4+g5+p)	9.5	μμf

Ratings

Heater voltage (ac or dc)	6.3	volts
Maximum heater-cathode voltage	90	volts
Maximum plate voltage	300	volts
Maximum grids #2 and #4 voltage	100	volts
Maximum grids #2 and #4 supply voltage	300	volts
Minimum negative dc grid #3 voltage	-50	volts
Maximum positive dc grid #3 voltage	0	volts
Maximum plate dissipation	1.0	watts
Maximum grids #2 and #4 dissipation	1.0	watts
Maximum cathode current	14	ma.

Continued on Page 2

ELECTRICAL DATA (Continued)

Typical Operating Conditions and Characteristics*

Heater voltage	6.3	6.3	volts
Heater current	300	300	ma
Plate voltage	100	250	volts
Grid #3 voltage	-2	-2	volts
Grids #2 and #4 voltage	100	100	volts
Oscillator grid (grid #1) voltage r.m.s.	10	10	volts
Oscillator grid (grid #1) resistance	20,000	20,000	ohms
Plate resistance (approx.)	0.5	1.0	megohm
Oscillator grid (grid #1) current	0.5	0.5	ma
Conversion transconductance	425	450	μmhos
Plate current	3.3	3.5	ma
Grids #2 and #4 current	8.5	8.5	ma
Cathode current	12.3	12.5	ma
Grid #3 voltage (approx.) for Gc = 10 μmhos	-25	-25	volts
Grid #3 voltage (approx.) for Gc = 100 μmhos	-9	-9	volts

*Characteristics shown are obtained in the standard R.M.A. Conversion Conductance Test Set which uses separate excitation. The characteristics under these conditions correspond very closely with those obtained in a self-excited oscillatory circuit operating with zero bias.

Oscillator Characteristics (not oscillating)

Grid #3 voltage	0	volts
Oscillator (grid #1) voltage	0	volts
Grids #2 and #4 connected to plate	100	volts
Transconductance between grid #1 and grids #2 and #4 connected to plate	4500	μmhos
Cathode current	25	ma
Amplification factor	14	
Grid #1 voltage (approx.) for Ib = 10 μa	14.0	volts

from RMA release #150,
Nov. 18, 1938

RCA-6SC7

TWIN TRIODE AMPLIFIER
Single-Ended Metal Type

The 6SC7 is a new, single-ended, metal, twin triode amplifier intended primarily for phase-inverter service. Each triode unit is designed with a high mu-factor to give high gain. Interlead shielding between grid and heater within the base reduces hum voltage picked up by the grid lead from the heater leads and permits operation with a satisfactory hum level.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

Characteristics - Each Triode Unit

HEATER VOLTAGE *		6.3	Volts
PLATE VOLTAGE		250 max.	Volts
GRID VOLTAGE		-2	Volts
AMPLIFICATION FACTOR		70	
PLATE RESISTANCE		53000 approx.	Ohms
TRANSCONDUCTANCE		1325 approx.	Micromhos
PLATE CURRENT		2	Milliamperes
TYPICAL OPERATION AS PHASE INVERTER:			
Plate-Voltage Supply [1]	90	300	Volts
Plate Load (R_L)	250000	250000	Ohms
Grid Resistor (R_g) for following stage	0.5	0.5	Megohm
Cathode Resistor (R_c) **	3750	1675	Ohms
Blocking Condenser	0.006	0.006	µf
Voltage Output [2]	9	55	Peak Volts
Voltage Gain [3]	30	42	

[1] Voltage at plate equals Plate-Supply Voltage minus voltage drop in R_L and R_c. For other supply voltages differing by as much as 50% from those listed, the values of resistors, condensers, and gain are approximately correct. The value of output voltage, however, for any of these other supply voltages equals the listed voltage output multiplied by the new plate-supply voltage divided by the plate-supply voltage corresponding to the listed voltage output.

[2] Voltage across R_g at grid-current point.

[3] Voltage gain at 5 volts (RMS) output.

** The value of R_c is specified on the basis that both units are operating simultaneously at the same values of plate load and plate voltage. For phase-inverter service, the cathode resistor should not by by-passed by a condenser. Omission of the condenser in this service assists in balancing the output voltages.

* In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Pin Connections

Pin 1 - Shell	Pin 5 - Plate (Triode T_1)
Pin 2 - Plate (Triode T_2)	Pin 6 - Cathode
Pin 3 - Grid (Triode T_2)	Pin 7 - Heater
Pin 4 - Grid (Triode T_1)	Pin 8 - Heater

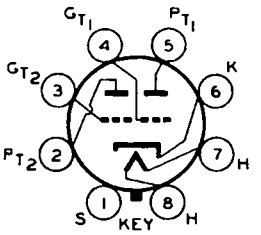
Mounting Position

Vertical or Horizontal - No restrictions

OUTLINE DRAWING FOR 6SC7

Same as for 6SA7

BOTTOM VIEW OF SOCKET CONNECTIONS FOR 6SC7



JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

E. I. A.
REGISTRATION
FILE

JETEC TYPE 6SC7

DOUBLE TRIODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-1	Bulb	MT-8
Base	B8-21 small wafer octal 8-pin		
Maximum diameter	.1-5/16"		
Maximum overall length	2-5/8"		
Maximum seated height	.2-1/16"		
Pin connections	Basing 8S		
Pin 1 - Shell		Pin 5 - #1 Plate	
Pin 2 - #2 Plate		Pin 6 - Cathode	
Pin 3 - #2 Grid		Pin 7 - Heater	
Pin 4 - #1 Grid		Pin 8 - Heater	

Mounting position . . . . . any

ELECTRICAL DATA

Direct Interelectrode Capacitances* (approx.)

Grid to plate: (g1 to p)	2.0	μμf
Input: g1 to (h+k+g2+g3+S)	2.0	μμf
Output: p to (h+k+g2+g3+S)	3.0	μμf

*Pin 1 connected to pin 6

Ratings

Heater voltage (ac or dc)	6.3	volts
Maximum heater-cathode voltage	90	volts
Maximum plate voltage	250	volts

Typical Operating Conditions and Characteristics, Class A1 Amplifier (each unit)

Heater voltage	6.3	volts
Heater current	300	ma
Plate voltage	250	volts
Grid voltage	-2	volts
Amplification factor	70	
Plate resistance	53,000	ohms
Transconductance	1325	μmhos
Plate current	2	ma

Refer to "Interpretation of Receiving Tube Ratings"

JOINT ELECTRON DEVICE ENGINEERING COUNCIL

650 Sallmon Tower
11 West Forty-Second Street
New York 36, N.Y.
Telephone: LOngacre 5-3450

Announcement

of

Electron Device Type Reregistration

Release No. 150B (Tentative)*

March 14, 1960

The Joint Electron Device Engineering Council announced the registration of the following electron device designation

6SC7

on November 2, 1938, Release No. 150, under the sponsorship of Radio Corporation of America, Harrison, New Jersey

The sponsor now proposes reregistration based on the following data:

ITEM	AS REGISTERED	AS PROPOSED
Under ELECTRICAL DATA		
Direct Interelectrode Capacitances* (Approx.)	See Release 150A (1/29/52)	Direct Interelectrode Capacitances* (Each Unit, Approx.)
Input:	g_1 to (h+k+g_2+g_3+S)	g_1 to (h+k+S)
Output:	p to (h+k+g_2+g_3+S)	p to (h+k+S)

*Pin 1 connected to pin 6.

*Unless valid objection to this reregistration is lodged with the EIA Standards Laboratory prior to April 14, 1960, this reregistration will be made and this information will be considered "FINAL" WITHOUT FURTHER NOTICE!

RCA-6SF5

HIGH-MU TRIODE
Single-Ended Metal Type

The 6SF5 is a new metal high-mu triode featuring single-ended construction with interlead shielding between grid and heater within the base. The shielding reduces the hum voltage picked up by the grid lead from the heater leads, and permits operation with a satisfactory hum level. The electrical characteristics of the 6SF5 are similar to those of type 6F5.

From a circuit standpoint, the single-ended construction offers distinct advantages in comparison with corresponding types previously available, as follows: (1) elimination of loose or broken grid leads, (2) wiring can be completed below the set panel, (3) neater appearance of the chassis, (4) lowered cost, and (5) simplification of tube renewal.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES: [o]		
Grid to Plate	2.6	μμf
Grid to Cathode	4.2	μμf
Plate to Cathode	3.8	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 6-Pin	

[o] With shell connected to cathode.

Amplifier - Class A

OPERATING CONDITIONS and CHARACTERISTICS:		
Heater Voltage*	6.3	Volts
Plate Voltage	250 max.	Volts
Grid Voltage	-2	Volts
Amplification Factor	100	
Plate Resistance	66000	Ohms
Transconductance	1500	Micromhos
Plate Current	0.9	Milliampere

* In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

INSTALLATION and APPLICATION

The 6SF5 is recommended for use in resistance-coupled circuits. Operating conditions are the same as those for type 6F5.

Outline Drawing

Same as for 6SJ7

Pin Connections

Pin 1 - Shell	Pin 5 - Plate
Pin 2 - Cathode	Pin 7 - Heater
Pin 3 - Grid	Pin 8 - Heater

(Pin numbers are according to RMA system)

Mounting Position

Vertical or Horizontal - No restrictions

September 19, 1938

from RMA release #144, Oct. 7, 1938

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

JETEC TYPE 6SF5

TRIODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-1
Bulb	MT-8
Base	B6-23, small wafer octal 6-pin
Maximum diameter	1-5/16"
Maximum overall length	2-5/8"
Maximum seated height	2-1/16"
Pin connections	Basing 6AB

Pin 1 - Shell
Pin 2 - Cathode
Pin 3 - Grid
Pin 5 - Plate
Pin 7 - Heater
Pin 8 - Heater

Mounting position . . . . . any

ELECTRICAL DATA

Ratings

Heater voltage	6.3	volts
Maximum plate voltage	300	volts
Maximum heater-cathode voltage	90	volts

Typical Operating Conditions and Characteristics, Class A1 Amplifier

Heater voltage	6.3	6.3	volts
Heater current	300	300	ma
Plate voltage	100	250	volts
Grid voltage	-1	-2	volts
Amplification factor	100	100	
Plate resistance	85,000	66,000	ohms
Transconductance	1150	1500	μmhos
Plate current	0.4	0.9	ma

Typical Operating Conditions and Characteristics, Resistance Coupled Amplifier

Heater voltage	6.3	6.3	6.3	6.3	volts
Plate supply voltage	100	100	300	300	volts
Control grid voltage	0	0	0	0	volts
Plate load resistor	0.25	0.25	0.25	0.25	megohm
Control grid resistor	10	10	10	10	megohm
Input condenser	.01	.005	.01	.005	μμf
Output condenser	.01	.005	.01	.005	μμf
Grid resistor of following stage	0.5	1.0	0.5	1.0	megohm
Signal source impedance	0	0	0	0	ohms
Distortion	5	5	5	5	%
Output voltage (r.m.s.)	7	8.5	44	50	volts
Voltage gain	48	52	66	71	

Refer to "Interpretation of Receiving Tube Ratings"

from RMA release #144,
Oct. 7, 1938

RCA-6SJ7, 6SK7

R-F AMPLIFIER PENTODES
Single-Ended Metal Type

The 6SJ7 and the 6SK7 are two new metal r-f amplifier pentodes featuring single-ended construction with interlead shielding. As a result of modern methods of tube manufacture, these new types not only have the same grid-plate capacitance as similar capped types, but also have lower values of input and output capacitance, and higher transconductance.

From a circuit standpoint, the single-ended construction offers distinct advantages in comparison with types previously available, as follows: (1) elimination of loose or broken grid leads, (2) wiring can be completed below the set panel, (3) neater appearance of the chassis, (4) more stable amplifier operation, (5) greater uniformity of gain in amplifiers, (6) higher gain per stage, (7) lowered cost, and (8) simplification of tube renewal.

The 6SJ7 has a sharp cut-off characteristic: the 6SK7 has a remote cut-off characteristic. Each type has a small wafer octal 8-pin base which fits the standard octal socket.

RCA-6SJ7

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES: °		
Grid to Plate	0.005 max.	μμf
Input	6.0	μμf
Output	7.0	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

Amplifier - Class A

OPERATING CONDITIONS and CHARACTERISTICS:			
Heater Voltage *	6.3	6.3	Volts
Plate Voltage	100	250 max.	Volts
Screen Voltage	100 max.	100 max.	Volts
Grid Voltage	-3	-3	Volts
Suppressor	Connected to cathode at socket		
Plate Current	2.9	3.0	Milliamperes
Screen Current	0.9	0.8	Milliamperes
Amplification Factor (Approx.)	1100	2500	
Plate Resistance (Approx.)	0.7	1.5	Megohms
Transconductance	1575	1650	Micromhos

Pin Connections

Pin 1 - Shell	Pin 5 - Cathode
Pin 2 - Heater	Pin 6 - Screen
Pin 3 - Suppressor	Pin 7 - Heater
Pin 4 - Grid	Pin 8 - Plate

(Pin numbers are according to RMA system)

Mounting Position

Vertical or Horizontal - No restrictions

RCA-6SK7

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES: °		
Grid to Plate	0.005 max.	μμf
Input	6.0	μμf
Output	7.0	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

°, *: See next page.

Amplifier - Class A

OPERATING CONDITIONS and CHARACTERISTICS:				
Heater Voltage *	6.3	6.3		Volts
Plate Voltage	100	250	max.	Volts
Screen Voltage	100	100	max.	Volts
Grid Voltage	-3	-3	min.	Volts
Suppressor	Connected to cathode at socket			
Plate Current	8.9	9.2		Milliamperes
Screen Current	2.6	2.4		Milliamperes
Amplification Factor (Approx.)	475	1600		
Plate Resistance (Approx.)	0.25	0.8		Megohm
Transconductance	1900	2000		Micromhos
Grid Voltage for Transconductance = 10 micromhos	-	-35		Volts

Pin Connections

Pin 1 - Shell	Pin 5 - Cathode
Pin 2 - Heater	Pin 6 - Screen
Pin 3 - Suppressor	Pin 7 - Heater
Pin 4 - Grid	Pin 8 - Plate

(Pin numbers are according to RMA system)

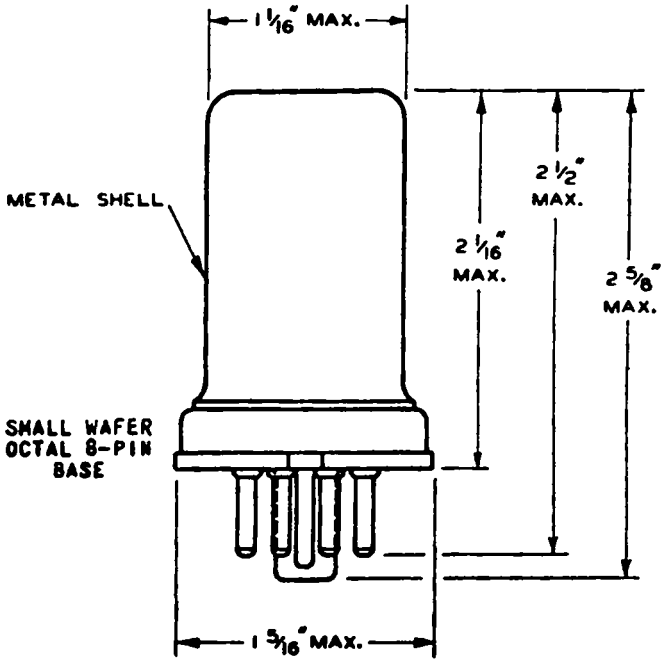
Mounting Position

Vertical or Horizontal - No restrictions

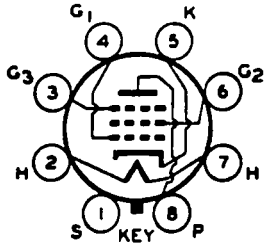
° With shell connected to cathode.

* In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

OUTLINE DRAWING FOR 6SJ7 and 6SK7



BOTTOM VIEW OF SOCKET CONNECTIONS FOR 6SJ7 and 6SK7

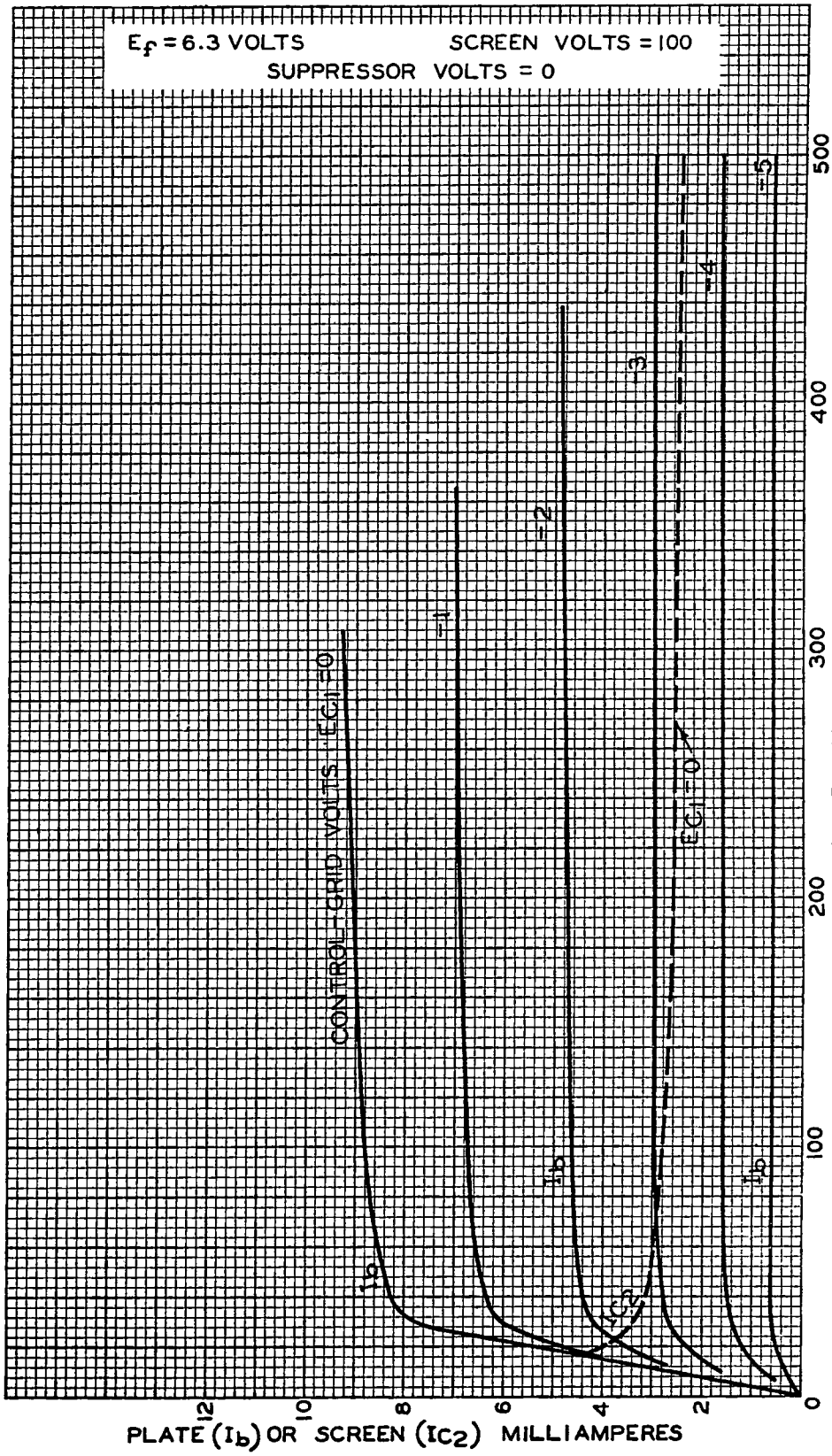


8N

G_1 = GRID
G_2 = SCREEN
G_3 = SUPPRESSOR
H = HEATER
K = CATHODE
P = PLATE
S = SHELL

6SJ7

AVERAGE PLATE CHARACTERISTICS



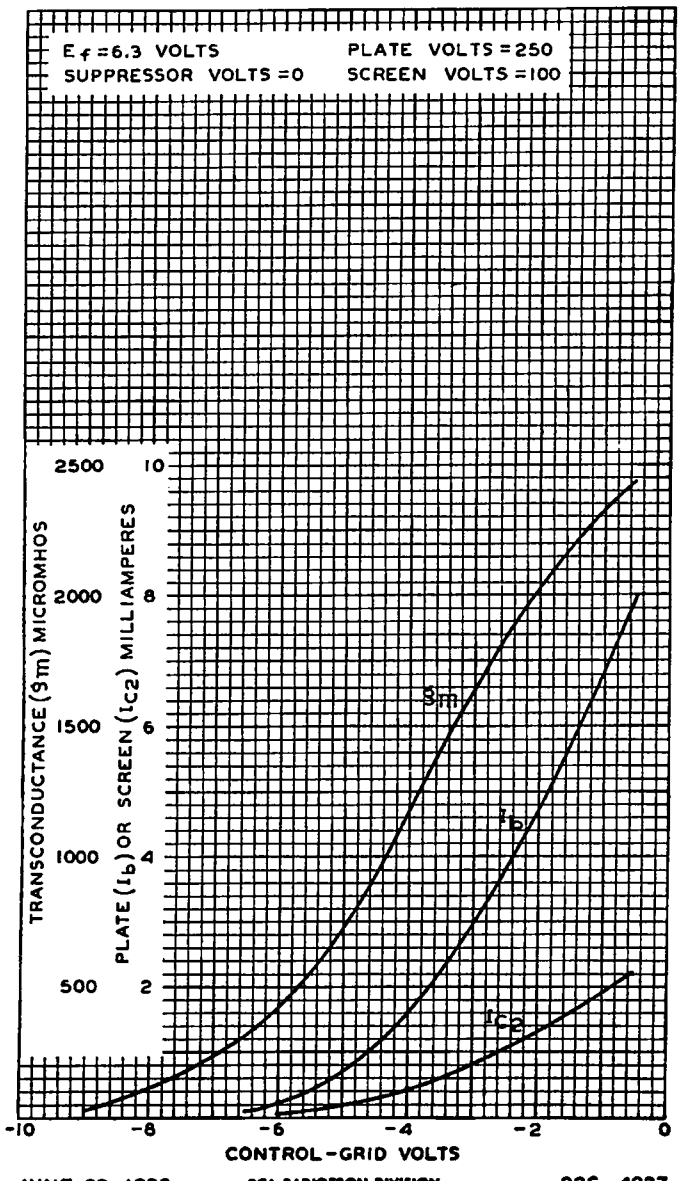
JUNE 23, 1938

RCA RADIOTRON DIVISION
RCA MANUFACTURING COMPANY, INC.

92C-4939

6SJ7

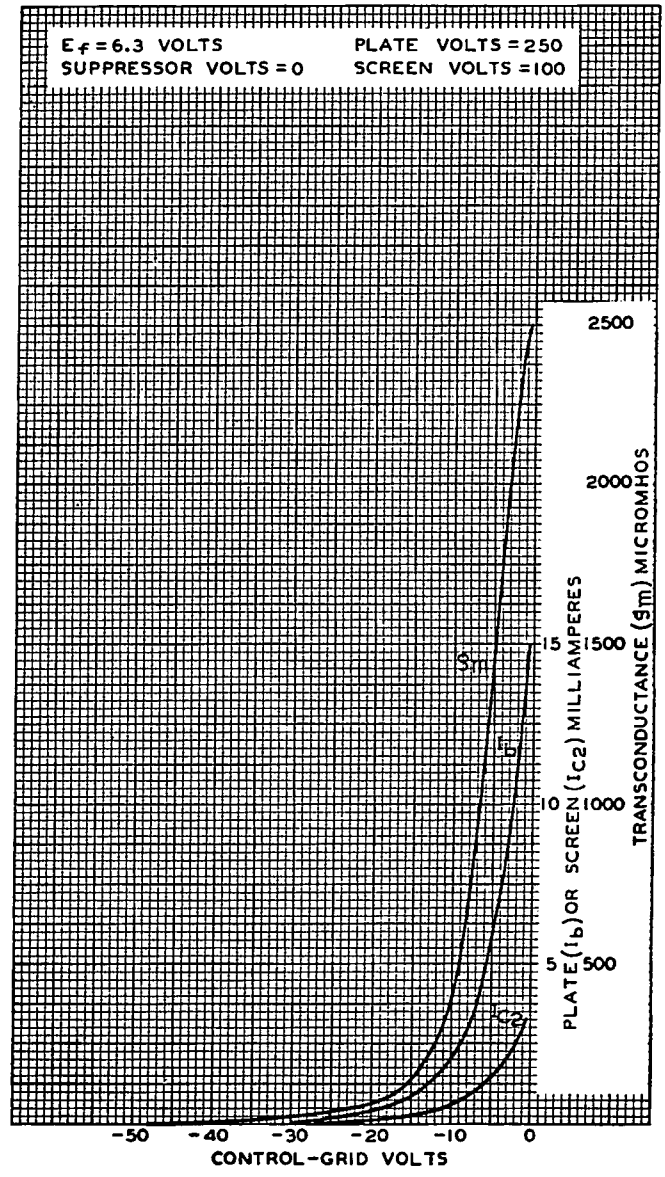
AVERAGE CHARACTERISTICS



JUNE 23, 1938 RCA RADIOTRON DIVISION RCA MANUFACTURING COMPANY, INC. 92C-4937

6SK7

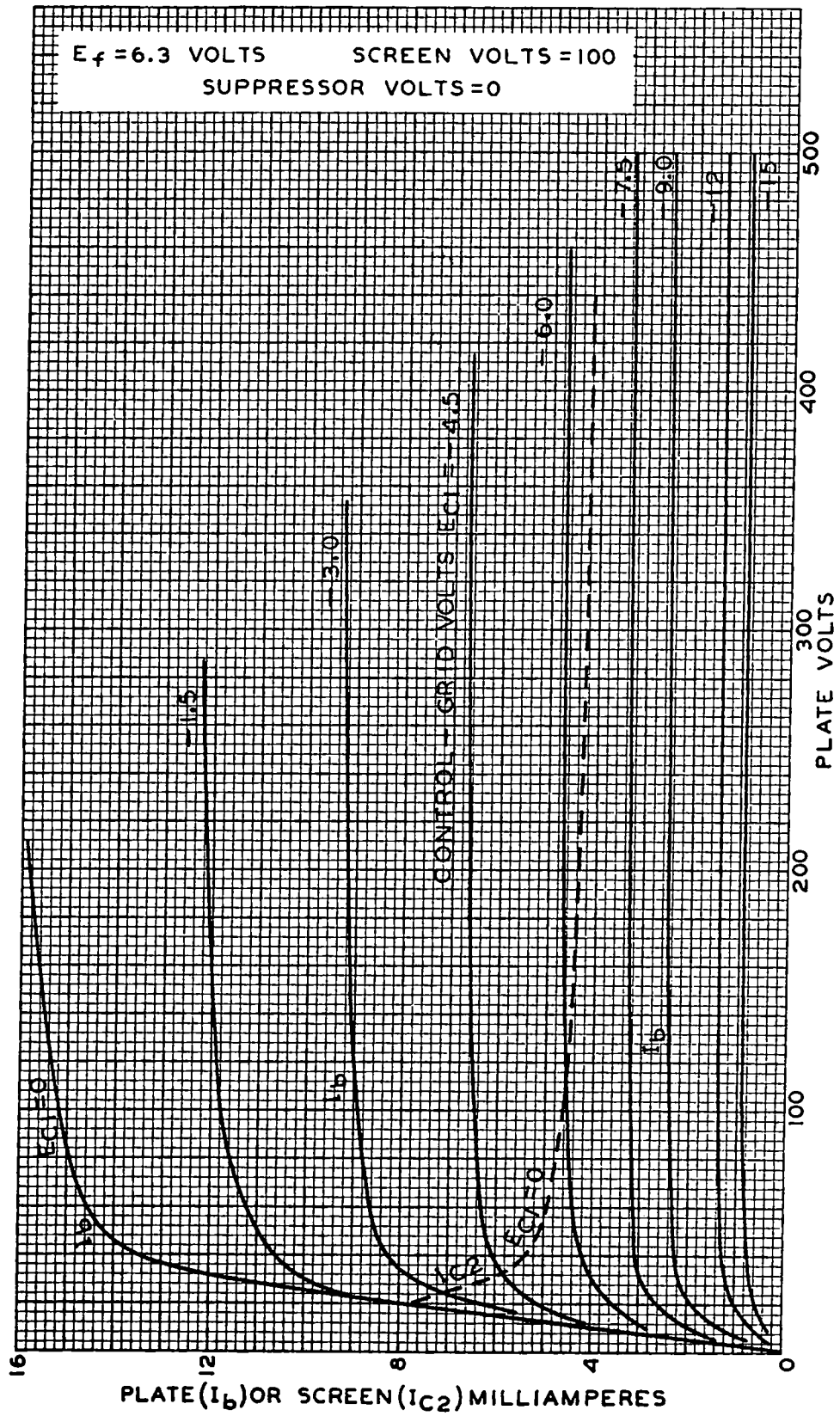
AVERAGE CHARACTERISTICS



JUNE 23, 1938 RCA RADIOTRON DIVISION RCA MANUFACTURING COMPANY, INC. 92C-4938

6SK7

AVERAGE PLATE CHARACTERISTICS



JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

E. I. A.
REGISTRATION
FILE

JETEC TYPE 6SJ7

PENTODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-1	Bulb	MT-8
Base			B8-21 small wafer octal 8-pin
Maximum diameter			1-5/16"
Maximum overall length			2-5/8"
Maximum seated height			2-1/16"
Pin connections			Basing 8N

Pin 1 - Shell, internal shield	Pin 5 - Cathode
Pin 2 - Heater	Pin 6 - Grid #2
Pin 3 - Grid #3	Pin 7 - Heater
Pin 4 - Grid #1	Pin 8 - Plate

Mounting position . . . . . any

ELECTRICAL DATA

Direct Interelectrode Capacitances*

Pentode connection:

Grid to plate: (g1 to p) max.	0.005	μμf
Input: g1 to (h+k+g2+g3+S)	6.0	μμf
Output: p to (h+k+g2+g3+S)	7.0	μμf

Triode connection: (g2 and g3 tied to plate)

Grid to plate: g1 to (p+g2+g3)	2.8	μμf
Input: g1 to (h+k+S)	3.4	μμf
Output: (p+g2+g3) to (h+k+S)	11	μμf

*Pin #1 connected to pin #5

Ratings	Triode**	Pentode	
Heater voltage (ac or dc)	6.3	6.3	volts
Maximum heater-cathode voltage	90	90	volts
Maximum plate voltage	250	300	volts
Maximum grid #2 supply voltage	Plate	300	volts
Maximum grid #2 voltage	Plate	See J5-C4	
Maximum grid #3 voltage. Pin #3 connected to:	Plate	Cathode	
Maximum plate dissipation	2.5	2.5	watts
Maximum grid #2 dissipation	-	0.4	watts
Maximum positive dc grid #1 voltage	0	0	volts
Maximum grid circuit resistance	1.0	1.0	megohm

**Grid #2, grid #3 connected to plate

Continued on Page 2

E L A
TECHNICAL
FILE

ELECTRICAL DATA (Continued)

Typical Operating Conditions and Characteristics, Class A1 Amplifier

	Triode**		Pentode		
Heater voltage	6.3	6.3	6.3	6.3	volts
Heater current	300	300	300	300	ma
Plate voltage	180	250	100	250	volts
Grid #2 voltage	Plate	Plate	100	100	volts
Grid #1 voltage	-6	-8.5	-3	-3	volts
Grid #3 voltage	Plate	Plate	Pin #3 connected to pin #5 at socket		
Transconductance	2300	2500	1575	1650	μmhos
Plate resistance	.0082	.0076	0.7	>1.0	megohm
Amplification factor	19	19	-	-	
Plate current	6	9.2	2.9	3	ma
Grid #2 current	-	-	0.9	0.8	ma
Grid #1 voltage (approx.) for Ib = 10μa			-8	-8	volts

**Grid #2, grid #3 connected to plate

Refer to "Interpretation of Receiving Tube Ratings"

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

J5-6SK7
December 15, 1950

JETEC TYPE 6SK7

PENTODE

E.I.A.
REGISTRATION
FILE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-1	Bulb	MT-8
Base	B8-21 small wafer octal 8-pin		
Maximum diameter	1-5/16"		
Maximum overall length	2-5/8"		
Maximum seated height	2-1/16"		
Pin connections	Basing 8N		

Pin 1 - Shell, internal shield	Pin 5 - Cathode
Pin 2 - Heater	Pin 6 - Grid #2
Pin 3 - Grid #3	Pin 7 - Heater
Pin 4 - Grid #1	Pin 8 - Plate

Mounting position . . . . . any

ELECTRICAL DATA

Direct Interelectrode Capacitances*

Grid to plate: (g1 to p) max.	0.003	μμf
Input: g1 to (h+k+g2+g3+s)	6.0	μμf
Output: p to (h+k+g2+g3+s)	7.0	μμf

*Pin #1 connected to pin #5

Ratings

Heater voltage (ac or dc)	6.3	volts
Maximum heater-cathode voltage	90	volts
Maximum plate voltage	300	volts
Maximum grid #2 supply voltage	300	volts
Maximum grid #2 voltage	See J5-C4	
Maximum grid #2 dissipation	0.4	watts
Maximum positive dc grid #1 voltage	0	volts
Maximum plate dissipation	4.0	watts

Typical Operating Conditions and Characteristics, Class A1 Amplifier

Heater voltage	6.3	6.3	volts
Heater current	300	300	ma.
Plate voltage	100	250	volts
Grid #2 voltage	100	100	volts
Grid #1 voltage	-1	-3	volts
Grid #3 voltage	Pin 3 connected to pin 5 at socket		
Plate current	13	9.2	ma
Grid #2 current	4.0	2.6	ma
Plate resistance (approx.)	0.12	0.8	megohm
Transconductance	2350	2000	μmhos
Grid #1 voltage (approx.) for Gm = 10 μmhos	-35	-35	volts

Refer to "Interpretation of Receiving Tube Ratings"

JOINT ELECTRON DEVICE ENGINEERING COUNCIL

2260 Salmon Tower
11 West Forty-Second Street
New York 36, N. Y.
Telephone: LOngacre 5-0717

Announcement
of
Electron Device Type Reregistration

Release No. 144B (Tentative)*

March 21, 1960

The Joint Electron Device Engineering Council announced the registration of the following electron device designation

6SJ7

on October 7, 1938, Release No. 144, under the sponsorship of Radio Corporation of America, Harrison, New Jersey.

The sponsor now proposes reregistration based on the following data:

ITEM	AS REGISTERED		AS PROPOSED	
Under ELECTRICAL DATA				
Ratings	Triode**	Pentode	Triode**	Pentode
Maximum grid # 2 dissipation	-	0.4	-	delete watt
Maximum grid # 2 dissipation:				
For grid # 2 voltages up to 150 volts	-	none	-	0.7 watt
For grid # 2 voltages between 150 and 300 volts	-	none	-	See J5-C4
Typical Operating Conditions and Characteristics, Class A_1 Amplifier				
	Triode**	Pentode	Triode**	Pentode
Plate Resistance	.0082	.0076	.00825	.0076 megohm

*Unless valid objection to this reregistration is lodged with the EIA Standards Laboratory prior to April 21, 1960, this reregistration will be made and this information will be considered "FINAL" WITHOUT FURTHER NOTICE!

RCA-6SQ7

DUPLEX-DIODE HIGH-MU TRIODE
Single-Ended Metal Type

The 6SQ7 is a new metal duplex-diode high-mu triode featuring single-ended construction with interlead shielding between grid and heater within the base. The shielding reduces the hum voltage picked up by the grid lead from the heater leads, and permits operation with a satisfactory hum level. The electrical characteristics of the 6SQ7 are similar to those of type 75.

From a circuit standpoint, the single-ended construction offers distinct advantages in comparison with corresponding types previously available, as follows: (1) elimination of loose or broken grid leads, (2) wiring can be completed below the set panel, (3) neater appearance of the chassis, (4) lowered cost, and (5) simplification of tube renewal.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES - Triode Unit: [o]		
Grid to Plate	1.8	μμf
Grid to Cathode	4.2	μμf
Plate to Cathode	3.4	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

[o] With shell connected to cathode.

Triode Unit - Class A Amplifier

OPERATING CONDITIONS and CHARACTERISTICS:		
Heater Voltage*	6.3	Volts
Plate Voltage	250 max.	Volts
Grid Voltage	-2	Volts
Amplification Factor	100	
Plate Resistance	91000	Ohms
Transconductance	1100	Micromhos
Plate Current	0.8	Milliampere

* In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Diode Units - Two

The two diode units are placed around a cathode, the sleeve of which is common to the triode unit. Each diode has its own base pin. Diode biasing of the triode unit is not suitable.

INSTALLATION and APPLICATION

The application and operating conditions for the 6SQ7 are the same as those for the type 75.

Outline Drawing

Same as for 6SJ7

Pin Connections

Pin 1 - Shell	Pin 5 - Diode Plate #1
Pin 2 - Triode Grid	Pin 6 - Triode Plate
Pin 3 - Cathode	Pin 7 - Heater
Pin 4 - Diode Plate #2	Pin 8 - Heater

(Pin numbers are according to RMA system)

Mounting Position

Vertical or Horizontal - No restrictions

from RMA release #144, Oct. 7, 1938

RCA Laboratories Div.
Navy Industry Serv. Lab.
J5-6SQ7
Page 1 8 1958
Nov. 6, 1950
FILE:

JETEC DATA
JOINT ELECTRON TUBE ENGINEERING COUNCIL
COMMITTEE ON RECEIVING TUBES

JETEC TYPE 6SQ7

DOUBLE DIODE TRIODE

MECHANICAL DATA

Coated unipotential cathode

Outline drawing	8-1	Bulb	MT-8
Base	B8-21 small wafer octal 8-pin		
Maximum diameter	1-5/16"		
Maximum overall length	2-5/8"		
Maximum seated height	2-1/16"		
Pin connections	Basing 8Q		
Pin 1 - Shell		Pin 5 - #1 diode plate	
Pin 2 - Triode grid		Pin 6 - Triode plate	
Pin 3 - Cathode		Pin 7 - Heater	
Pin 4 - #2 diode plate		Pin 8 - Heater	
Mounting position	any		

ELECTRICAL DATA

Direct Interelectrode Capacitances*

Diode input (each unit): (1P or 2P to H+K)	2.6	μμf
Triode grid to #1 diode plate: (G to 1P) max.	0.03	μμf

*Pin 1 connected to pin 3

Ratings

Heater voltage (ac or dc)	6.3	volts
Maximum heater-cathode voltage	90	volts
Maximum plate voltage	300	volts
Maximum positive dc grid voltage	0	volts
Maximum plate dissipation	0.5	watt
Maximum diode current each plate for continuous operation	1.0	ma

Typical Operating Conditions and Characteristics, Class A1 Amplifier

Heater voltage	6.3	6.3	volts
Heater current	300	300	ma
Plate voltage	100	250	volts
Grid voltage	-1	-2	volts
Plate resistance (approx.)	110,000	85,000	ohms
Transconductance	925	1,175	μmhos
Plate current	0.5	1.1	ma
Amplification factor	100	100	
Average diode current each plate with 10 volts dc applied	2.0	2.0	ma

Continued on Page 2

JOINT ELECTRON DEVICE ENGINEERING COUNCIL

2260 Salmon Tower
11 West Forty-Second Street
New York 36, N. Y.
Telephone: LOngacre 5-0717

Announcement
of
Electron Device Type Reregistration

Release No. 144C (Tentative)*

May 2, 1960

The Joint Electron Device Engineering Council announced the registration of the following electron device designation

6SQ7

on October 7, 1938, Release No. 1938, under the sponsorship of Radio Corporation of America, Harrison, New Jersey.

The sponsor now proposes reregistration based on the following data:

ITEM	AS REGISTERED	AS PROPOSED
Under ELECTRICAL DATA		
Direct Interelectrode Capacitances**		
Diode input (each unit): (1P or 2P to H+K)	2.6	3.3 max. uuf
Triode grid to triode plate	none	1.6 uuf
Triode grid to cathode and heater	none	3.2 uuf
Triode plate to cathode and heater	none	3.0 uuf
Triode grid to #2 diode plate	none	0.04 max. uuf

**Pin 1 connected to pin 3

*Unless valid objection to this reregistration is lodged with the EIA Standards Laboratory prior to June 2, 1960, this reregistration will be made and this information will be considered "FINAL" WITHOUT FURTHER NOTICE!

RMA Release # 288

6ST7

DUPLEX-DIODE TRIODE
Single-Ended Metal Type
(TENTATIVE DATA)

Ratings are to be interpreted according to RMA Standard M8-210 (Jan. 8, 1940 Rev. 11-40)

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.15	Ampere
DIRECT INTERELECTRODE CAPACITANCES - Triode Unit (Approx.): [o]		
Grid to Plate [C_{gp}]	1.5	μμf
Grid to Cathode [$C_{g(h+k+shell)}$]	2.8	μμf
Plate to Cathode [$C_{p(h+k+shell)}$]	3.0	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM SEATED HEIGHT	2-1/16"	
MAXIMUM DIAMETER	1-5/16"	
BULB	Metal Shell, MT-8	
BASE	Small Wafer Octal 8-Pin	
MOUNTING POSITION	Any	

[o] With shell connected to cathode.

Triode Unit

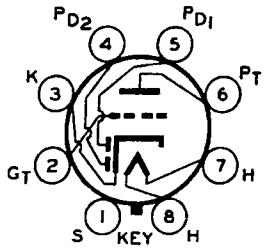
PLATE VOLTAGE	250 max.	Volts
PLATE DISSIPATION	2.5 max.	Watts
CHARACTERISTICS - Class A_1 Amplifier:		
Plate Voltage	250	Volts
Grid Voltage	-9	Volts
Amplification Factor	16	
Plate Resistance	8500	Ohms
Transconductance	1900	Micromhos
Plate Current	9.5	Milliamperes

Diode Units - Two

The two diode plates are placed at one end of a cathode, the sleeve of which is common to the triode unit. Diode biasing of the triode unit of the 6ST7 is not suitable.

Bottom View of Socket Connections

Pin 1 - Shell
Pin 2 - Triode Grid
Pin 3 - Cathode
Pin 4 - Diode Plate #2
Pin 5 - Diode Plate #1
Pin 6 - Triode Plate
Pin 7 - Heater
Pin 8 - Heater



8Q

E. I. A.
REGISTRATION
FILE

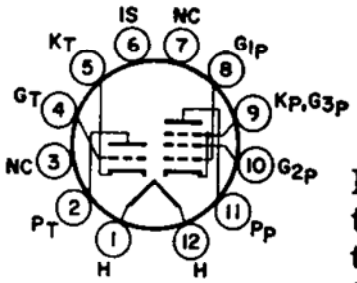
December 1, 1941

Plate Resistance (Approx.)	54000	58000	ohms
Transconductance	1300	1200	μmhos
Plate Current	0.8	1	mA

Diode Units

MAXIMUM RATINGS (Design-Maximum Values)

Plate Current (Each Unit)	5.5	mA



12FM

HIGH-MU TRIODE—POWER PENTODE 6T9

Duodecar type used in audio-frequency circuits. The triode unit is used as a voltage amplifier; the pentode unit is used as a power amplifier. Outlines section, 8B; requires duodecar 12-contact socket.

Heater Voltage (ac/dc)	6.3	volts
Heater Current	0.93	ampere
Heater-Cathode Voltage:		
Peak value	±200 max	volts
Average value	100 max	volts
Direct Interelectrode Capacitances:		
Pentode Section:		
Grid No.1 to Plate	0.2	pF
Grid No.1 to Cathode, Heater, Grid No.2, Grid No.3, and Internal Shield	11	pF
Plate to Cathode, Heater, Grid No.2, Grid No.3, and Internal Shield	11	pF
Triode Unit:		
Grid to Plate	2.6	pF
Grid to Cathode, Heater, and Internal Shield	3.4	pF
Plate to Cathode, Heater, and Internal Shield	1.1	pF

Class A_1 Amplifier

MAXIMUM RATINGS (Design-Maximum Values)	Triode Unit	Pentode Unit	
Plate Voltage	300	275	volts
Grid-No.2 (Screen-Grid) Voltage	—	275	volts
Grid-No.1 (Control-Grid) Voltage, Positive-bias value	0	0	volts
Plate Dissipation	1.5	12	watts
Grid-No.2 Input	—	2	watts
CHARACTERISTICS (Triode Unit)			
Plate Voltage		250	volts
Grid Voltage		—2	volts
Amplification Factor		95	
Plate Resistance (Approx.)		45000	ohms
Transconductance		2100	μmhos
Plate Current		1.5	mA
TYPICAL OPERATION (Pentode Unit)			
Plate Voltage		250	volts
Grid-No.2 Voltage		250	volts
Grid-No.1 Voltage		—8	volts
Peak AF Grid-No.1 Voltage		8	volts
Zero-Signal Plate Current		35	mA
Maximum-Signal Plate Current		39	mA
Zero-Signal Grid-No.2 Current		2.5	mA
Maximum-Signal Grid-No.2 Current		7	mA
Plate Resistance (Approx.)		0.1	megohm
Transconductance		6500	μmhos
Load Resistance		5000	ohms
Total Harmonic Distortion (Approx.)		10	per cent
Maximum-Signal Power Output		4.2	watts
MAXIMUM CIRCUIT VALUES			
Grid-No.1-Circuit Resistance:	Triode Unit	Pentode Unit	
For fixed-bias operation	0.5	0.25	megohm
For cathode-bias operation	1*	0.5	megohm

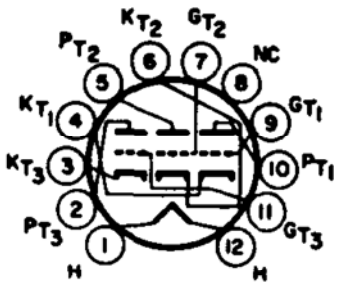
* For cathode-bias operation of the triode unit, a maximum resistance of 10 megohms can be used provided the plate dissipation never exceeds 0.25 watt.

	Triode Unit	Pentode Unit	
Cathode Current	18	18	mA
Plate Dissipation	1.5	2.1	watts
Grid-No.2 Input	—	0.7	watt
CHARACTERISTICS			
Plate Voltage	100	160	volts
Grid-No.3 (Suppressor-Grid) Voltage	—	0	volts
Grid-No.2 Voltage	—	110	volts
Grid-No.1 (Control-Grid) Voltage	−2	−1.4	volts
Mu Factor, Grid No.1 to Grid No.2	—	45	
Amplification Factor	17	—	
Transconductance	5000	12000	μmhos
Plate Current	14	13	mA
Grid-No.2 Current	—	5	mA
MAXIMUM CIRCUIT VALUES			
Grid-No.1-Circuit Resistance	1	1	megohm

• With a maximum duty cycle of 0.10 and maximum pulse duration of 10 microseconds.

6U10 THREE-UNIT TRIODE

Duodecar type used in amplifier applications. Units No.1 and No.3 are medium-mu triode units, and unit No.2 is a high-mu triode unit. **Outlines section,** 8A; requires duodecar 12-contact socket. **Heater:** volts (ac/dc), 6.3; amperes, 0.6; warm-up time (average), 11 seconds); maximum heater-cathode volts, ±275 (peak) for units 1 and 3; ±200 (peak) for unit 2; 100 (average) for each unit.



12FE

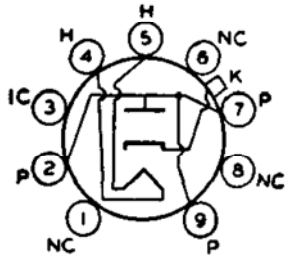
Class A_1 Amplifier

MAXIMUM RATINGS (Design-Maximum Values)	Units Nos. 1 and 3	Unit No.2	
Plate Voltage	330	330	volts
DC Grid Voltage:			
Positive-bias value	0	0	volts
Negative-bias value	50	50	volts
Average Cathode Current	20	—	mA
Plate Dissipation	2	1	watts
CHARACTERISTICS			
Plate Voltage	200	200	volts
Grid Voltage	−6	−1.5	volts
Amplification Factor	17.5	90	
Plate Resistance (Approx.)	7700	61000	ohms
Transconductance	2300	1600	μmhos
Plate Current	9.6	1.2	mA
Grid Voltage (Approx.):			
For plate current of 100 μA	−15	—	volts
For plate current of 35 μA	—	−3	volts
MAXIMUM CIRCUIT VALUES			
Grid-Circuit Resistance:			
For fixed-bias operation	1	0.5	megohm
For cathode-bias operation	2.2	1*	megohms

* This value may reach 10 megohms provided the plate-supply voltage and load resistance are such that the plate dissipation can never exceed 0.5 watt.

6V3A HALF-WAVE VACUUM RECTIFIER

Miniature type used as a damper tube in horizontal-deflection circuits of television receivers. **Outlines section,** 7B; requires miniature 9-contact socket. This tube, like other power-handling tubes, should be adequately ventilated. **Heater:** volts (ac/dc), 6.3; amperes, 1.75.



9BD

from RMA release #125,
Jan. 3, 1938

RCA Cunningham Radiotron

RCA-6V6

BEAM POWER AMPLIFIER

(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)##	6.3 Volts
HEATER CURRENT	0.45 Ampere
MAXIMUM OVERALL LENGTH	3-1/4"
MAXIMUM DIAMETER	1-5/16"
BASE	Small Wafer Octal 7-Pin

Static and Dynamic Characteristics

HEATER VOLTAGE	6.3	Volts
PLATE VOLTAGE	250	Volts
SCREEN VOLTAGE	250	Volts
GRID VOLTAGE	-12.5	Volts
AMPLIFICATION FACTOR	218	
PLATE RESISTANCE	52000	Ohms
TRANSCONDUCTANCE	4100	Micromhos
PLATE CURRENT	45	Milliamperes
SCREEN CURRENT	4.5	Milliamperes

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

As Single-Tube Amplifier - Class A_1*

PLATE VOLTAGE		250 max.	Volts
SCREEN VOLTAGE		250 max.	Volts
PLATE & SCREEN DISSIPATION (Total) #		12.5 max.	Watts
TYPICAL OPERATION:			
Plate Voltage	180	250	Volts
Screen Voltage	180	250	Volts
Grid Voltage°	-8.5	-12.5	Volts
Peak A-F Grid Voltage (Approx.)	8.5	12.5	Volts
Zero-Signal Plate Current	29	45	Milliamperes
Max.-Signal Plate Current	30	47	Milliamperes
Zero-Signal Screen Current	3	4.5	Milliamperes
Max.-Signal Screen Current	4	6.5	Milliamperes
Load Resistance	5500	5000	Ohms
Harmonic Distortion:			
Total	6	6	Per cent
Second	5.5	4.5	Per cent
Third	2.5	3.5	Per cent
Max.-Signal Power Output	2	4.25	Watts

As Push-Pull Amplifier - Class AB_1*

PLATE VOLTAGE		300 max.	Volts
SCREEN VOLTAGE		300 max.	Volts
PLATE & SCREEN DISSIPATION (Total) #		12.5 max.	Watts
TYPICAL OPERATION:			
Values are for 2 tubes			
Plate Voltage	250	300	Volts
Screen Voltage	250	300	Volts
Grid Voltage°	-15	-20	Volts
Peak A-F Grid-to-Grid Voltage	30	40	Volts
Zero-Signal Plate Current	70	78	Milliamperes
Max.-Signal Plate Current	79	90	Milliamperes
Zero-Signal Screen Current	5	5	Milliamperes
Max.-Signal Screen Current	12	13.5	Milliamperes
Load Resistance	10000	8000	Ohms
Harmonic Distortion:			
Total	4	4	Per cent
Third	3.5	3.5	Per cent
Max.-Signal Power Output	8.5	13	Watts

* Subscript 1 indicates that grid current does not flow during any part of the input cycle.

\# Precautions should be taken to insure that dissipation rating is not exceeded with expected line-voltage fluctuation, especially in case of fixed-bias operation.

\#\# The heater should be operated at 6.3 volts. Under maximum dissipation conditions, the heater voltage should never fluctuate so that it exceeds 7.0 volts. The potential difference between heater and cathode should be kept as low as possible.

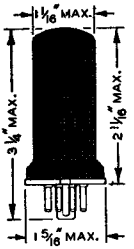
° The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-coupling devices are recommended. When the grid circuit has a resistance not higher than 0.05 megohm, fixed bias may be used; for higher values, self-bias is required. With self-bias, the grid circuit may have a resistance not to exceed 0.5 megohm, provided the heater voltage is not allowed to rise more than 10% above the rated value under any condition of operation.

Pin Connections

Pin 1-Shell	Pin 3-Plate	Pin 5-Grid	Pin 8-Cathode
Pin 2-Heater	Pin 4-Screen	Pin 7-Heater	

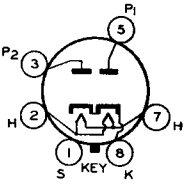
(Pin numbers are according to RMA system)

January 3, 1938



RCA-6X5

FULL-WAVE RECTIFIER



The 6X5 is a full-wave, high-vacuum rectifier of the All-Metal type. It is intended for use in automobile-radio receivers or in a-c operated receivers designed for its characteristics.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	6.3	Volts
HEATER CURRENT	0.6	Ampere
A-C PLATE VOLTAGE PER PLATE (RMS)	350 *max.*	Volts
PEAK INVERSE VOLTAGE	1250 *max.*	Volts
D-C OUTPUT CURRENT	75 *max.*	Milliamperes
BASE	Small Wafer Octal 6-Pin	

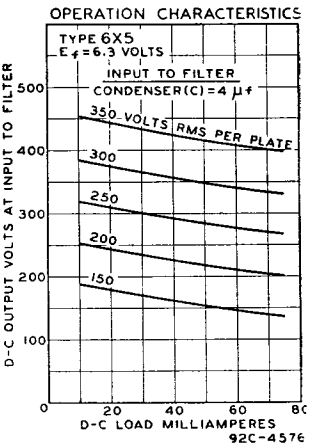
INSTALLATION

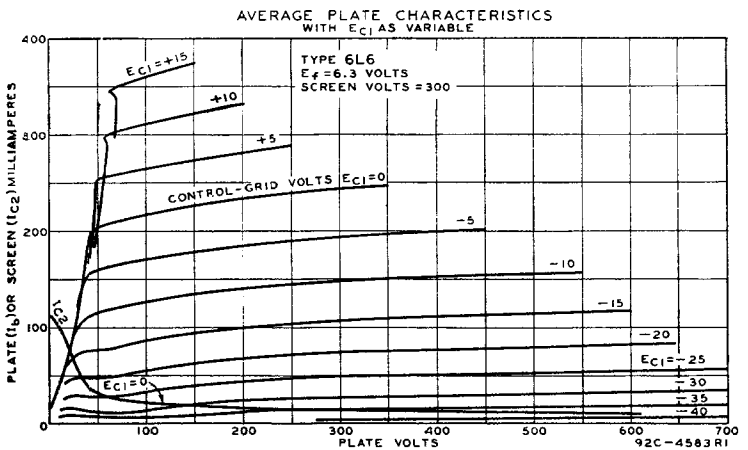
The **base** pins of the **6X5** fit the standard **octal** socket which may be installed to hold the **tube** in any position.

The **heater** should be operated at 6.3 volts. Under no condition should the heater voltage ever **fluctuate** so that it exceeds 7.5 volts. The d-c **potential** between heater and cathode should be **limited** to 400 volts.

APPLICATION

As a **full-wave rectifier,** the 6X5 may be **operated** with condenser-input or choke-input filter under conditions not to exceed the ratings given under CHARACTERISTICS. For discussion of **rectifiers** and filter circuits, refer to page 24 and **37,** respectively.





from RMA release #216, Sept. 21, 1939

#216
9/21/39
Rexm #198

7A7-LM

TRIPLE-GRID SUPER-CONTROL AMPLIFIER
Single-Ended Metal Type
(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	6.3□	Volts
HEATER CURRENT	0.3□□	Ampere
DIRECT INTERELECTRODE CAPACITANCES:°		
Grid to Plate	0.005 max.	μμf
Input	6	μμf
Output	7	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-1/4"	
BULB	Metal Shell, MT-8	
BASE	Intermediate Wafer Octalox 8-Pin	

□ Nominal value is 7 volts.
□□ Nominal value is 0.32 ampere.

Amplifier - Class A_1

OPERATING CONDITIONS and CHARACTERISTICS:		
Heater Voltage #	6.3	Volts
Plate Voltage	250 max.*	Volts
Screen Voltage	100 max.*	Volts
Grid Voltage	-3 min.**	Volts
Suppressor	Connected to cathode at socket	
Plate Resistance	0.8	Megohm
Transconductance	2000	Micromhos
Grid Bias for trans-conductance of 10 micromhos	-35	Volts
Plate Current	8.6	Milliamperes
Screen Current	2	Milliamperes

° With shell connected to cathode.
* Design maximum for 117-volt line.
** Design minimum for 117-volt line.
\# In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Pin Connections

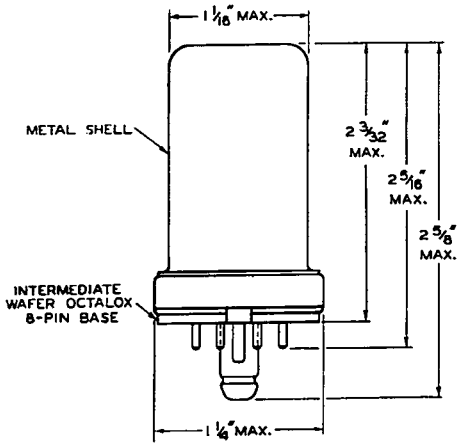
Pin 1 - Heater
Pin 2 - Plate
Pin 3 - Screen
Pin 4 - Suppressor
Pin 5 - Shell
Pin 6 - Grid
Pin 7 - Cathode
Pin 8 - Heater
Plug - Shell

(Pin numbers are according to RMA system)

Operating Position

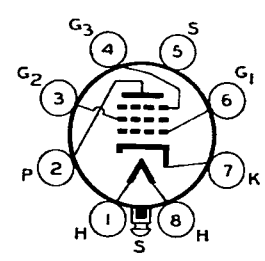
Vertical or Horizontal - No restrictions

Outline Drawing



92C-6060

Bottom View of Socket Connections



8V

September 21, 1939

RMA Release # 221 Oct. 18, 1939

7AP4

KINESCOPE

Seven-Inch Magnetic-Deflection Type with White Phosphor and Short Bulb

Kinescope RCA-7AP4, a high-vacuum cathode-ray tube designed for black-and-white reproduction of television pictures, employs magnetic deflection of the electron beam. Its screen accommodates a picture 4-1/2 inches by 6 inches in size, or slightly larger. A special feature of this tube is its relatively short overall length of approximately 13-1/2 inches. Because of this feature, a compact cabinet design can be used for television receivers in which the Kinescope is mounted in a horizontal position.

The electron gun in the 7AP4 provides an electron beam which impinges on the picture screen and produces a white spot of fluorescent light. The brilliance of this spot can be controlled by a modulating voltage, such as a video voltage, applied to the grid. The position of the spot on the picture screen can be controlled by means of a deflecting yoke consisting of two sets of electromagnetic deflecting coils. One set of these coils controls the horizontal motion of the spot; the other set, the vertical motion.

In the use of the RCA-7AP4 for television reception, currents of sawtooth waveform, synchronized with the transmitted signal, are supplied to the vertical-deflecting coils and to the horizontal-deflecting coils. The resultant deflections cause the spot to scan the picture area on the screen, thus forming the rectangular pattern of luminescence called the "raster". At the same time, the television picture signal is applied to the grid in order to modulate the brilliance of the spot. As a result of the modulation and motion of the spot, it traces on the screen of the Kinescope a reproduction of the scene being transmitted.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	2.5	Volts
HEATER CURRENT	2.1	Amperes
FLUORESCENT SCREEN:		
Material	Phosphor No.4	
Color of Fluorescence	White	
DIRECT INTERELECTRODE CAPACITANCE:		
Grid to all other electrodes	12 *max.* μμf	
OVERALL LENGTH	13-1/2" ± 3/8"	
MAXIMUM DIAMETER	7-1/8"	
BULB	J-56	
BASE	Medium 5-Pin	

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

HIGH-VOLTAGE ELECTRODE (Anode No.2) VOLTAGE	3500 *max.*△ Volts

△: See next page.

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RCA Manufacturing Co., Inc.

FOCUSING ELECTRODE (Anode No.1) VOLTAGE	1000 max.△	Volts
CONTROL ELECTRODE (Grid) VOLTAGE	Never Positive	
FLUORESCENT-SCREEN INPUT POWER PER SQ CM †	2.5 max.△	Milliwatts
TYPICAL OPERATION:		
Heater Voltage	2.5	Volts
Anode No.2 Voltage	3500	Volts
Anode No.1 Voltage (Approx.) *	675	Volts
Grid Voltage #° Adjusted to give suitable luminous spot		
Grid Signal-Swing Voltage □	15	Volts

* Adjustable to ± 20%.
\# Approximately 10% of Anode No.1 voltage is required for current cut-off if the maximum permissible resistance is used in the grid circuit.
□ Peak-to-peak value for good brilliance with good resolution. For greater brilliance, up to twice this value should be available.
° Maximum resistance in the grid circuit should be limited to 2 megohms.
† This value applies to the brightest portion of a stationary pattern. Approximately double this value is permissible with a moving pattern.
△ Design maximum for 117-volt line.

INSTALLATION

Handling of the 7AP4 requires care, because the tube may be broken or permanently damaged if subjected to sudden jars or excessive strains. When the Kinescope is placed on a hard surface, such as that of a table or work-bench, padding should be placed under the tube so as to prevent it from being scratched. Because the 7AP4 is highly evacuated and has a large surface area, its glass bulb is under considerable stress due to normal atmospheric pressure. Scratches may weaken the bulb so that it will not withstand this pressure. The 7AP4 should be inserted into its socket carefully. If the tube sticks, or fails to slip into its socket smoothly, the cause of the trouble should be investigated and removed; the tube should never be struck or forced. In order that strains will not be set up in the glass, the 7AP4 should not be subjected to rapid, extreme temperature changes.

The *base* pins of the 7AP4 fit a standard, five-contact socket, which may be installed for the operation of the tube in any position. The socket mounting should preferably be adjustable. The socket should be made of good insulating material; insulating baffles between contacts provide an additional factor of safety.

A metal *shielding case* for the Kinescope may be desirable if the tube is operated near electrical apparatus whose fields may cause distortion of the spot. If an iron or steel case is employed to minimize the effect of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized. The shield should be grounded and the Kinescope bulb supported within the shield on insulating supports. Otherwise, leakage currents through and along the glass envelope may cause pattern distortion.

The *heater* is designed to operate at 2.5 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. *If the circuit design is such as to cause a high voltage between the*

heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

The *cathode* is connected within the tube to one side of the heater. The terminal for this common connection is base pin No.5, to which grid and anode returns should be made. In television circuits, the cathode is usually operated near ground potential.

The *fluorescent screen* of the 7AP4 employs phosphor No.4, which fluoresces to produce a white spot and is particularly suited for the reproduction of television pictures. In equipment using the 7AP4, it is recommended that the screen of the tube be covered with a plate of clear, shatter-proof glass. This glass plate serves to protect the bulb from being struck accidentally and to protect the user in case the bulb should collapse due to some abnormal condition.

A *deflecting yoke* consisting of four electromagnetic coils is employed for deflecting the electron beam. These coils are used in pairs; the coils of each pair, located diametrically opposite each other, should produce a field of uniform flux density for deflection of the beam. The axes of the two fields ordinarily intersect at right angles in the axis of the electron beam and should be perpendicular to the beam axis. The deflection of the electron beam is at *right angles* to the direction of the magnetic fields. The yoke, placed around the bulb neck close to the bulb flare, should be properly oriented so as to produce the desired vertical and horizontal deflections.

Because of the short-bulb construction of the 7AP4, the electron beam must be deflected through a relatively wide angle (approximately 55 degrees) in order to scan the desired picture area. A deflecting yoke especially designed for wide-angle deflection should be used with this Kinescope (see Figs.3 and 4). The center of the magnetic deflecting fields should be located not more than one inch from the point where the bulb neck joins the bulb flare, measured toward the base end of the tube.

The *d-c supply voltages* for the electrodes may be obtained conveniently from a high-voltage, vacuum-tube rectifier. Because the 7AP4 requires very little current, the rectifier system can be of either the half-wave or the voltage-doubler type. For the same reason, the filter requirements are simple. A circuit of a suitable power supply is shown in Fig.1.

The high voltages at which the 7AP4 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions include the enclosing of high-potential terminals and the use of "interlock" switches to break the primary circuit of the high-voltage supply when access to the apparatus is required.

In the use of a Kinescope, it should always be remembered that high voltages may appear at points in the circuit normally at a low potential, due to condenser breakdown or to incorrect circuit connec-

tions. Therefore, before any part of a Kinescope circuit or its associated circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded. Whenever any adjustments or measurements are to be made within any chassis, both leads to the primary of the high-voltage transformer should be disconnected and taped.

APPLICATION

Kinescope 7AP4 is designed for the black-and-white reproduction of television pictures. Typical circuits for the application of the tube in a television receiver are shown in Figs.1 and 2.

A typical operating circuit for the 7AP4 in a television receiver, with voltage supply, is shown in Fig.1. Electrode voltages are obtained from a bleeder circuit connected across the high-voltage supply. A bleeder current of about one milliampere is usually satisfactory. Higher values of bleeder current will require the use of additional filtering. A variable d-c voltage for anode No.1 is obtained from a potentiometer in the bleeder circuit. In a television receiver, the video signal and the background-control bias supplied by the receiver are introduced in the grid-cathode circuit of the 7AP4.

The *fluorescent-screen input power* should never exceed 2.5 milliwatts per square centimeter in the brightest portion of a stationary pattern. Approximately twice this value is permissible with a moving pattern. The use of excessive screen-input power may cause temporary loss of sensitivity or permanent destruction of the active screen material. It is recommended that the spot always be kept in motion over a large area of the screen by the application of deflecting current to both sets of deflecting coils. When it is desired to make observations of a stationary spot, or when the spot is to scan only a small area of the screen, the brightness of the spot should be reduced to a low value by adjustment of the grid bias.

Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No.2 voltage to anode No.1 voltage. Ordinarily, focusing is accomplished by adjustment of anode No.1 voltage.

Spot size and *intensity* can be regulated by varying anode No.2 current or voltage. The current to anode No.2 may be increased by decreasing the bias voltage applied to the grid. An increase in anode No.2 current increases the size and intensity of the spot. An increase in the voltage applied to anode No.2 increases the speed of the electrons with the result that spot intensity is increased and spot size is decreased. When any of these adjustments are made, consideration should be given to the limiting voltage and power ratings shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

In television circuits, the currents supplied to both pairs of deflecting coils should have a sawtooth waveform and a frequency controlled by the synchronizing components of the incoming television

signal. Suitable circuits for supplying these deflecting currents are shown in Fig.2.

A typical *vertical-deflecting circuit* for television is shown in the upper section of Fig.2. This circuit generates a sawtooth deflecting voltage in the following manner: In the second 6N7 tube, triode unit "A" operates as a blocking oscillator. Oscillations are started in the circuit by the feedback action of transformer T_1. The flow of grid current which accompanies the first cycle of these oscillations causes a negative bias to build up across condenser C_4 and the grid leak, R_{10} and R_{11}. The bias voltage is sufficiently large to cause the plate current of triode "A" to cut off and thus stop the oscillations. When this occurs, the charge on C_4 leaks off gradually through R_{10} and R_{11} to a value such that the circuit will again start to oscillate. The tube blocks again, and the cycle is repeated.

Because the grid of triode unit "B" is connected to the grid of triode unit "A", the d-c plate current of "B" rises suddenly to a large value during the period of oscillation. When the oscillation stops, the d-c plate current becomes zero until a new cycle starts. With the sudden increase in d-c plate current, the plate voltage of "B" drops abruptly. During the period that the d-c plate current is zero, the plate voltage increases at a relatively slow rate, the rate being controlled chiefly by the time constant of C_{10} and R_{14}. Because the plate voltage of "B" thus goes through an abrupt decrease followed by a relatively slow increase, its variation has a sawtooth form. This voltage, applied to the grid of the 6L6, produces a sawtooth current in the plate circuit of the 6L6 and in the vertical-deflecting coils.

In television circuits, it is essential that this sawtooth wave be synchronized with that generated in the vertical scanning circuit of the Iconoscope at the studio. Synchronization of the vertical oscillator is accomplished by a synchronizing signal which is transmitted with the picture signal and which consists of a series of voltage pulses. In practice, the circuit of triode unit "A" is adjusted to function at a rate slightly slower than the rate of the incoming vertical synchronizing pulses. Hence, when the pulses are applied, the action of the blocking oscillator is speeded up to the proper rate for synchronization. The synchronizing signal should be strong enough so that it has positive control of the blocking oscillator.

Controls are provided so that the circuit can be adjusted for optimum operation. The *hold* controls, R_{10} and R_{11}, provide means for adjusting the frequency of blocking so that the oscillator can be synchronized by the incoming signal. The *picture-height* control, R_{13}, limits the voltage to which C_{10} can charge during the time that plate current is cut off in triode unit "B". The setting of R_{13}, therefore, fixes the amplitude of the sawtooth voltage generated by the 6N7, and thus controls the height of the picture. Controls R_{16} and R_{19} provide adjustments which help to improve the waveform of the vertical deflecting current. The *vertical centering control*,

R_{20}, utilizes the cathode current of both 6L6 amplifier tubes to supply a d-c deflecting current of variable polarity and magnitude to the vertical-deflecting coils. By adjustment of this control, the picture can be shifted up or down on the viewing screen.

A typical *horizontal-deflecting circuit* is shown in the lower section of Fig.2. In this circuit, a 6N7 and an output stage generate a synchronized, sawtooth current in a manner similar to that described for the vertical-deflecting circuit. However, the horizontal-deflecting circuit must operate at a much higher frequency than the vertical-deflecting circuit. Because the horizontal scanning frequency is high, the deflecting current decreases very rapidly on the return portion of the sawtooth cycle. This rapid decrease in current causes shock-excited oscillations in the plate circuit of the output stage. To damp out these oscillations, a type 83-v tube is connected across the plate circuit of the 6L6 horizontal amplifier. When oscillation starts, the effective inductance in the plate circuit of the 6L6 first swings the cathode of the 83-v to a high positive voltage, and then swings it negative. As soon as the cathode of the diode swings negative with respect to the diode plate, the diode conducts current and damps out further oscillations.

At the start of the oscillation, the upper end of the plate circuit may rise to a very large positive voltage — as high as 3000 volts. This voltage is impressed on the cathode of the 83-v. Because this voltage is much higher than the maximum value for which the 83-v is rated, some tubes may have a short life in this circuit. The high voltage is also applied to the plate of the 6L6. It is recommended that only 6L6's of recent production be used in this special application.

The heater transformer supplying the 83-v should be of special design having a secondary winding of low capacitance to ground. An air space of about 1/8 inch should be employed between the heater winding and the primary, and between the heater winding and the core. A low plate-to-ground capacitance in the output stage permits the use of a fast return time for the horizontal sweep. Adjustment of the value of capacitor C_{20} provides some control of the horizontal return time, as well as of the amplitude of the horizontal sweep.

The damping control, R_{34}, together with C_{23}, sets the point in the sawtooth cycle at which the 83-v begins to operate. Proper adjustment of this control helps to improve the waveform of the current in the horizontal-deflecting coils.

The hold control and the picture-width control in this circuit are similar to the corresponding controls in the vertical-deflecting circuit. The horizontal-centering control, R_{35}, supplies a d-c deflecting current of variable magnitude and polarity to the horizontal-deflecting coils.

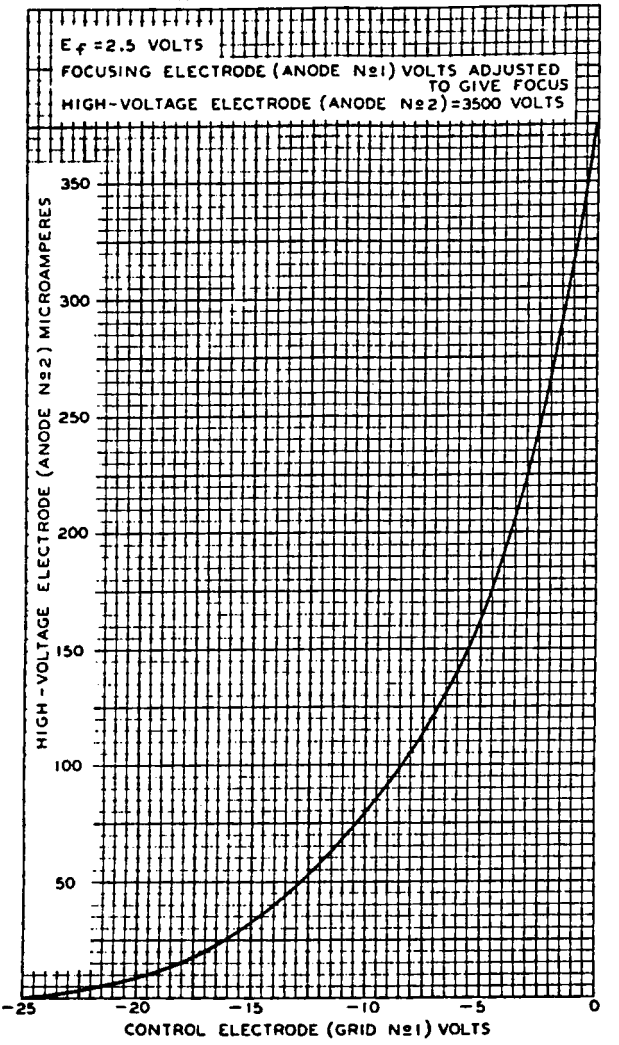
In the standard RMA type of television transmission, horizontal and vertical synchronizing signals are sent at the end of each

scanning line and field, respectively. These synchronizing signals are separated from the video signal in the sync-separator stage of the receiver. They can then be applied, with negative polarity, to the 6N7 frequency separator stage, shown in the upper section of Fig.2. In this stage, the horizontal and vertical synchronizing signals are separated from each other by means of suitable RC networks in the input and output circuits of the 6N7, and then applied to their respective blocking oscillators.

Many of the controls shown in Fig.2 can be adjusted once for optimum operation, and then left alone. For this reason, provision for adjusting them can be made on the chassis, rather than on the front panel of the receiver (see CIRCUIT CONTROLS, under the legend of Fig.2).

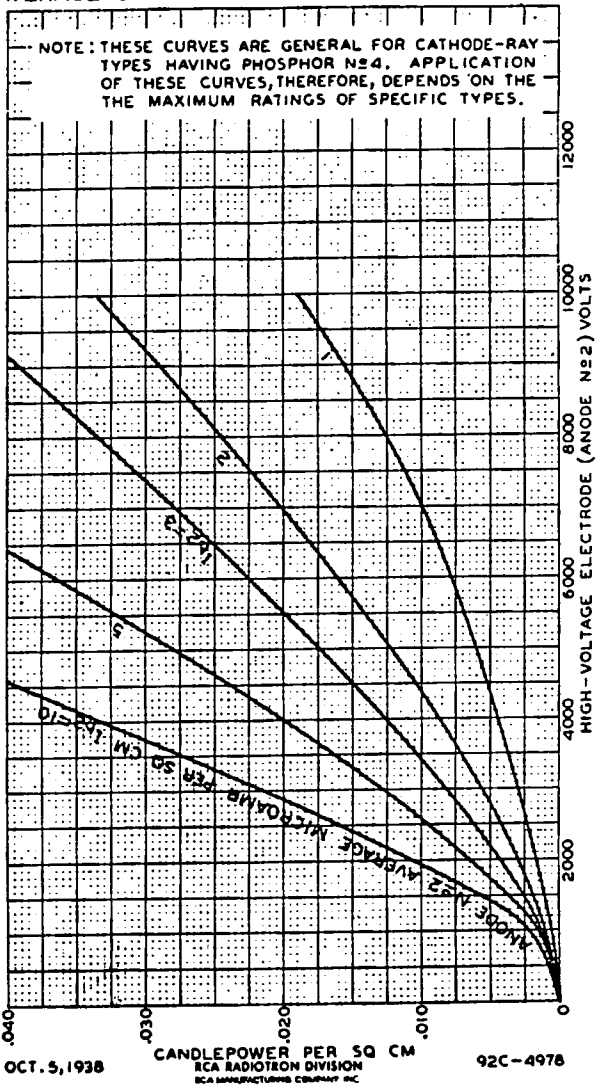
7AP4

AVERAGE CHARACTERISTIC

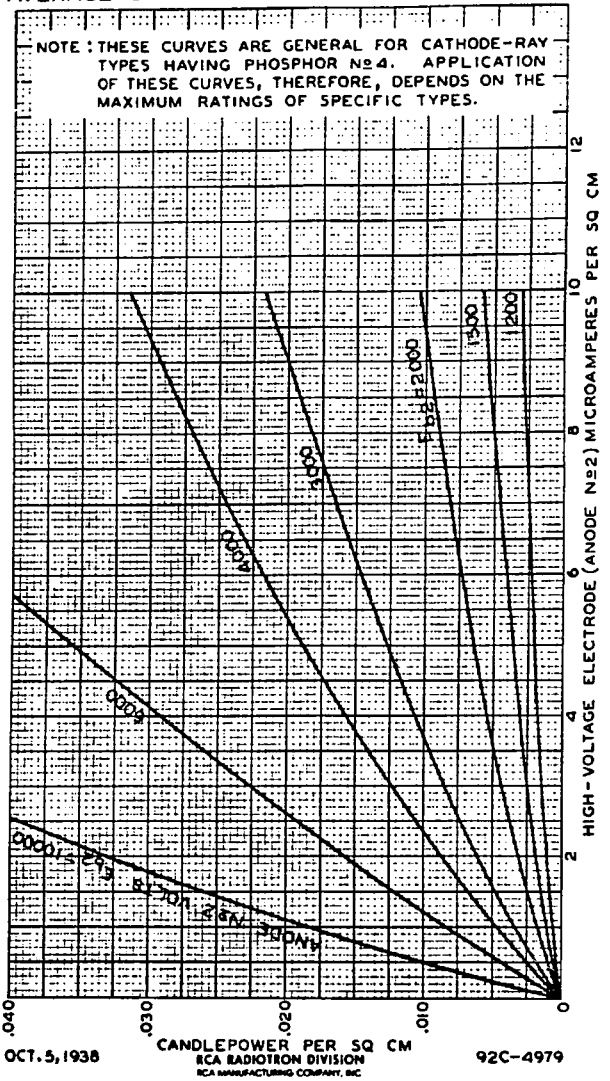


JULY 25, 1939 RCA RADIOTRON DIVISION 92C-6072

AVERAGE CHARACTERISTICS OF PHOSPHOR №4



AVERAGE CHARACTERISTICS OF PHOSPHOR №4



VOLTAGE-SUPPLY CIRCUIT FOR RCA-7AP4

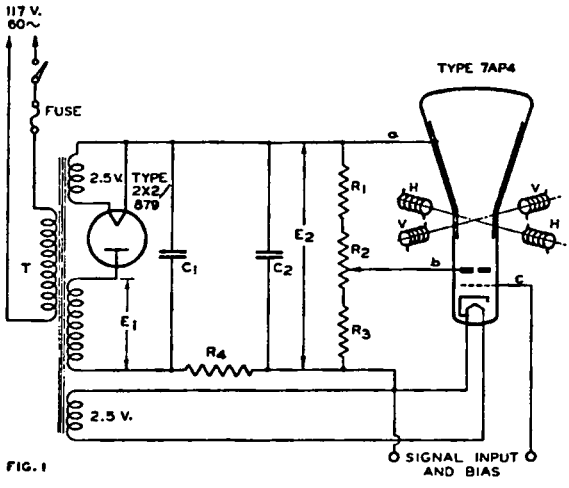


FIG. 1

CIRCUIT ELEMENT	SPECIFICATIONS
E_2	3500 VOLTS D.C.
E_1	3100 VOLTS RMS
C_1	0.05 μf, 4500 VOLTS
C_2	0.05 μf, 4000 VOLTS
R_1	2.25 MEGS., 4 WATTS #
R_2 *	0.25 MEG., 1 WATT
R_3	0.55 MEG., 1 WATT
R_4	0.5 MEG., 1 WATT

H = Horizontal Deflecting Coils
V = Vertical Deflecting Coils
T = Power Transformer

a = Anode No.2
b = Anode No.1
c = Grid

* Potentiometer R_2 should be adjusted by means of an insulated coupling shaft. If the range of voltage supplied by R_2 does not include the value for focus, the resistance of R_3 should be changed.

\# R_1 may conveniently consist of a series of four 0.5-megohm and one 0.25-megohm 1-watt resistors.

DIRECT-DRIVE MAGNETIC SCANNING CIRCUIT FOR KINESCOPE RCA-7AP4

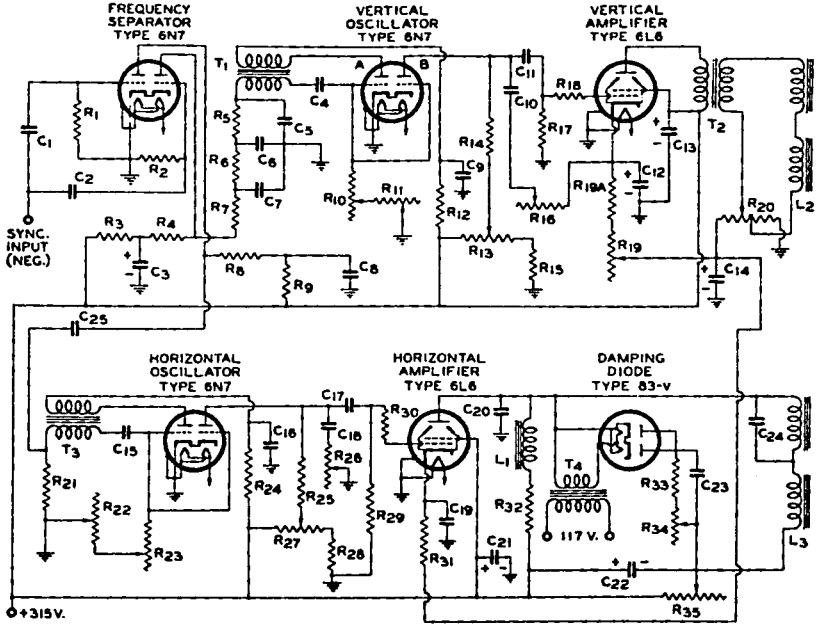


FIG.2

The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

LEGEND FOR FIG.2

R_1 R_2 R_{12} R_{24} = 100000 ohms, 0.5 watt
R_3 R_9 = 10000 ohms, 0.5 watt
R_4 R_{15} R_{28} = 5000 ohms, 0.5 watt
R_5 R_6 R_7 = 8000 ohms, 0.5 watt
R_8 = 3000 ohms, 0.5 watt
R_{10} = 200000-ohm potentiometer
R_{11} R_{16} = 50000-ohm potentiometer
R_{13} R_{23} R_{27} = 100000-ohm potentiometer
R_{14} = 1 megohm, 0.5 watt
R_{17} R_{25} R_{29} = 500000 ohms, 0.5 watt
R_{18} R_{30} = 100 ohms, 0.5 watt
R_{19} = 2000-ohm wire-wound potentiometer, 4 watts
R_{19A} = 200 ohms, 2 watts
R_{20} = 50-ohm wire-wound potentiometer with fixed center tap
R_{21} = 500 ohms, 0.5 watt
R_{22} = 10000-ohm potentiometer
R_{26} = 5000-ohm potentiometer, 4 watts †
R_{31} = 200 ohms, 2 watts
R_{32} = See footnote □
R_{33} = 2000 ohms, 5 watts
R_{34} R_{35} = 2000-ohm wire-wound potentiometer, 4 watts
C_1 = 0.0008 μf, mica
C_2 C_4 C_{10} = 0.1 μf, 400-v. paper
C_3 = 10 μf, 150-v. electrolytic
C_5 C_6 C_7 = 0.005 μf, mica
C_8 C_9 C_{11} = 0.25 μf, 400-v. paper
C_{12} C_{14} = 40 μf, 50-v. electrolytic
C_{13} C_{21} C_{22} = 8 μf, 450-v. electrolytic
C_{15} = 0.001 μf, mica
C_{16} C_{23} = 0.05 μf, 400-v. paper
C_{17} = 0.002 μf, mica
C_{18} = 0.00025 μf, mica
C_{19} = 1 μf, paper
C_{20} = 25 to 75 μμf, mica, 3000-v. peak *
C_{24} = 50 to 125 μμf, mica
C_{25} = 150 μμf, mica
T_1 = RCA vertical oscillator transformer, No.32898
T_2 = Vertical output transformer #
T_3 = RCA horizontal oscillation transformer, No.32899
T_4 = Special 5-volt heater transformer **
L_1 = Horizontal output reactor, 5 (approx.) henries, 100 ma. ## □
L_2 = Vertical coils of deflecting yoke
L_3 = Horizontal coils of deflecting yoke

* Value determined by desired return time and amplitude of horizontal sweep.
\# Turns ratio between 8:1 and 5:1, step-down; primary inductance approximately 50 henries.
** Secondary winding must have low capacitance to primary and to core, and must be insulated for 3000 volts peak.
Reactor should have low capacitance to ground.
† Minimum resistance setting of R_{26} should be sufficient to maintain plate-current cut-off in 6L6 during horizontal return time. Otherwise, plate dissipation of 6L6 may be exceeded.
□ Total resistance of R_{32} and L_1 should be approximately 250 ohms.

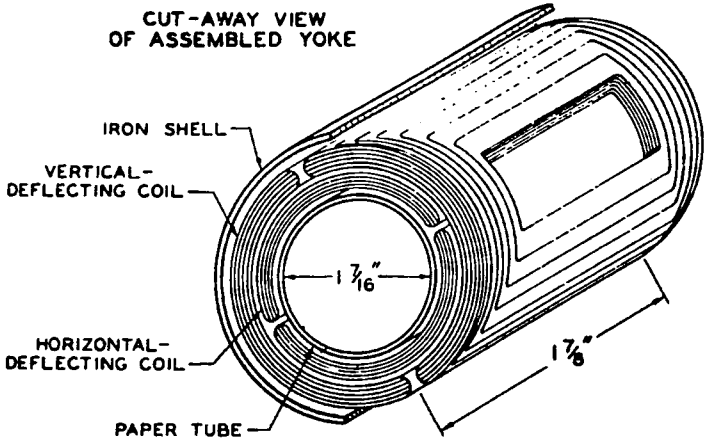
NOTE: All circuit leads associated with the 6L6 horizontal amplifier plate circuit should have low capacitance to ground. The 6L6 horizontal amplifier tube and the 83-v damping tube should have ceramic sockets.

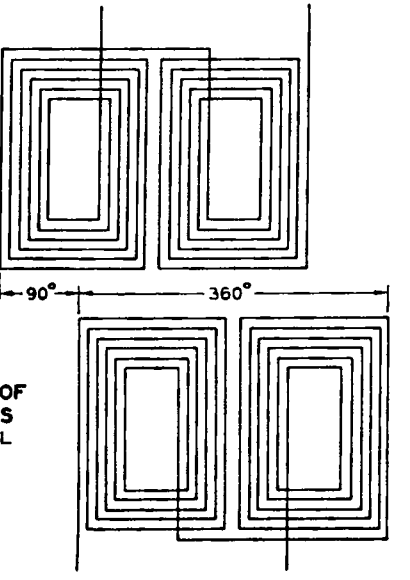
CIRCUIT CONTROLS

R_{10} = Vertical hold (coarse)
R_{11} = Vertical hold (fine) ★
R_{13} = Picture height
R_{16} R_{19} = Vertical linearity
R_{20} = Vertical centering
R_{22} = Horizontal hold (fine) ★
R_{23} = Horizontal hold (coarse)
R_{27} = Picture width
R_{26} R_{34} C_{20} C_{24} = Horizontal linearity
R_{35} = Horizontal centering

★ These controls should be adjustable from the front panel of the receiver. The other controls require infrequent adjustments which can generally be made on the chassis.

DEFLECTING YOKE
FOR WIDE-ANGLE DEFLECTION



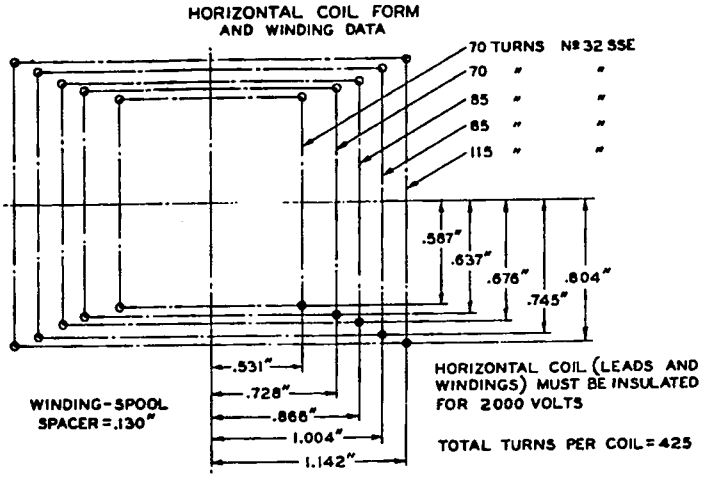


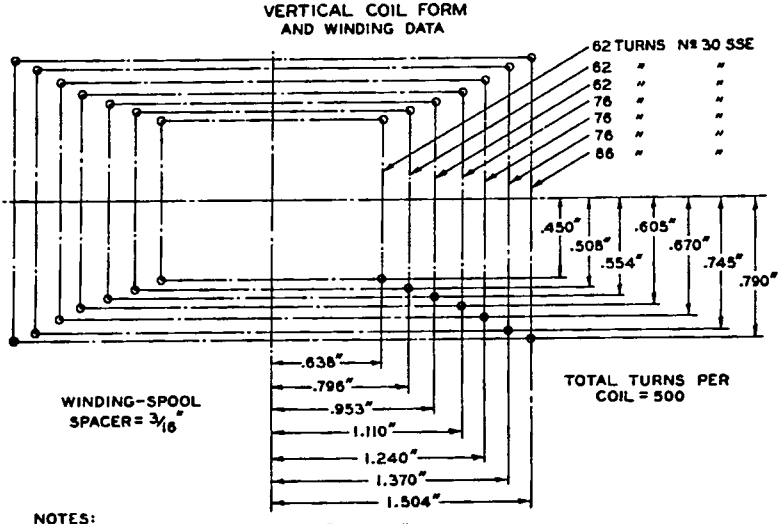
SCHEMATIC DIAGRAM OF
HORIZONTAL WINDINGS
425 TURNS EACH COIL

SCHEMATIC DIAGRAM OF
VERTICAL WINDINGS
500 TURNS EACH COIL

FIG.3

WIDE-ANGLE YOKE DATA
FOR RCA-7AP4



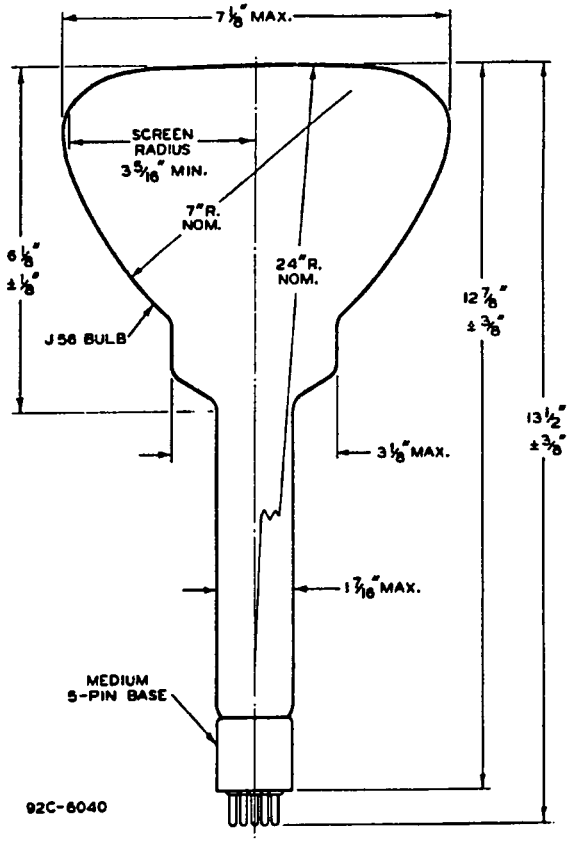


NOTES:
IRON SHELL = 3 LAYERS OF .020" TO .030" SWEDISH IRON
DRILL HOLES FOR PINS WITH Nº 55 DRILL
INSULATION AND SHIELD = 1/32" BETWEEN HORIZONTAL AND VERTICAL COILS

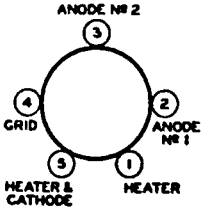
FIG. 8

7AP4

KINESCOPE



Top View of Socket Connections



RMA Release # 234

7B5-LT

POWER AMPLIFIER PENTODE

(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	6.3□ Volts
HEATER CURRENT	0.4□□ Ampere
MAXIMUM OVERALL LENGTH	3-5/32"
MAXIMUM SEATED HEIGHT	2-5/8"
MAXIMUM DIAMETER	1-1/4"
BULB	T-9
BASE	Small Wafer Octalox 8-Pin with Sleeve
BASING DESIGNATION	6AE

□ Nominal value is 7 volts.
□□ Nominal value is 0.43 ampere.

Amplifier - Class A_1

PLATE VOLTAGE			315 max.*	Volts
SCREEN VOLTAGE			250 max.*	Volts
PLATE DISSIPATION			8.5 max.*	Watts
SCREEN DISSIPATION			2.8 max.*	Watts
TYPICAL OPERATION and CHARACTERISTICS:				
Heater Voltage #	6.3	6.3	6.3	Volts
Plate Voltage	100	250	315	Volts
Screen Voltage	100	250	250	Volts
Grid Voltage ##	-7	-18	-21	Volts
Peak A-F Grid Voltage	7	18	21	Volts
Zero-Signal Plate Current	9	32	25.5	Milliamperes
Max.-Signal Plate Current	9.5	33	28	Milliamperes
Zero-Signal Screen Current	1.6	5.5	4	Milliamperes
Max.-Signal Screen Current	3	10	9	Milliamperes
Plate Resistance	104000	68000	75000	Ohms
Transconductance	1500	2300	2100	Micromhos
Load Resistance	12000	7600	9000	Ohms
Total Harmonic Distortion	11	11	15	Per Cent
Max.-Signal Power Output	0.35	3.4	4.5	Watts

* Design maximum for 117-volt line.

\# In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

\#\# The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-input coupling devices are recommended. When the grid circuit has a resistance not higher than 0.1 megohm, fixed bias may be used; for higher values, cathode bias is required. With cathode bias, the grid circuit may have a resistance not to exceed 1.0 megohm.

Pin Connections

Pin 1 - Heater	Pin 6 - Grid
Pin 2 - Plate	Pin 7 - Cathode
Pin 3 - Screen	Pin 8 - Heater
Pin 4 - No Connection	Plug - No Connection
Pin 5 - No Connection	

(Pin numbers are according to RMA system)

Operating Position

Vertical or Horizontal - No restrictions

from RMA release #234, March 13, 1940

7B6-LM

DUPLEX-DIODE HIGH-MU TRIODE
Single-Ended Metal Type
(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	6.3□ Volts
HEATER CURRENT	0.3□□ Ampere
MAXIMUM OVERALL LENGTH	2-5/8"
MAXIMUM SEATED HEIGHT	2-3/32"
MAXIMUM DIAMETER	1-1/4"
BULB	Metal Shell, MT-8
BASE	Small Wafer octalox 8-Pin
BASING DESIGNATION	8W

□ Nominal value is 7 volts.
□□ Nominal value is 0.32 ampere.

Triode Unit - Class A_1 Amplifier

PLATE VOLTAGE	250 max.*	Volts
CHARACTERISTICS:		
Heater Voltage #	6.3	Volts
Plate Voltage	250	Volts
Grid Voltage	-2	Volts
Amplification Factor	100	
Plate Resistance	91000	Ohms
Transconductance	1100	Micromhos
Plate Current	0.9	Milliampere

Diode Units - Two

The two diode units are placed around a cathode, the sleeve of which is common to the triode unit. Each diode has its own base pin. Diode biasing of the triode unit of the 7B6-LM is not suitable.

* Design maximum for 117-Volt line.
\# In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Pin Connections

Pin 1 - Heater	Pin 6 - Diode Plate #1
Pin 2 - Triode Plate	Pin 7 - Cathode
Pin 3 - Triode Grid	Pin 8 - Heater
Pin 4 - Cathode	Plug - Shell
Pin 5 - Diode Plate #2	

(Pin numbers are according to RMA system)

Operating Position

Vertical or Horizontal - No restrictions

from RMA release #234, March 13, 1940

7B8-LM

PENTAGRID CONVERTER
Single-Ended Metal Type
(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	6.3□ Volts
HEATER CURRENT	0.3□□ Ampere
DIRECT INTERELECTRODE CAPACITANCES:o	
Grid #4 to Plate	0.3 max. μμf
Grid #4 to Grid #2	0.2 μμf
Grid #4 to Grid #1	0.15 μμf
Grid #1 to Grid #2	0.8 μμf
Grid #4 to All Other Electrodes = R-F Input	10 μμf
Grid #2 to All Other Electrodes except Grid #1 = Osc. Output	3 μμf
Grid #1 to All Other Electrodes except Grid #2 = Osc. Input	4.8 μμf
Plate to All Other Electrodes = Mixer Output	12 μμf
MAXIMUM OVERALL LENGTH	2-5/8"
MAXIMUM DIAMETER	1-1/4"
BULB	Metal Shell, MT-8
BASE	Small Wafer Octalox 8-Pin
BASING DESIGNATION	8X

□ Nominal value is 7 volts.
□□ Nominal value is 0.32 ampere.
o With shell connected to cathode.

Converter Service

PLATE VOLTAGE		250 max.*	Volts
SCREEN (Grids #3 & #5) VOLTAGE		100 max.*	Volts
ANODE-GRID (Grid #2) VOLTAGE		200 max.*	Volts
ANODE-GRID (Grid #2) VOLTAGE SUPPLY oo		250 max.*	Volts
TOTAL CATHODE CURRENT		14 max.*	Milliamperes
TYPICAL OPERATION:			
Heater Voltage #	6.3	6.3	Volts
Plate Voltage	100	250	Volts
Screen Voltage	50	100	Volts
Anode-Grid Voltage	100	250●	Volts
Control-Grid Voltage	-1.5 min.*	-3 min.*	Volts
Oscillator-Grid (Grid #1) Resistor	50000	50000	Ohms
Plate Resistance (Approx.)	0.6	0.36	Megohm
Conversion Transconductance	360	550	Micromhos
Grid Bias (Grid #4) for Conversion Transconductance = 3 micromhos	-20	-	Volts
Grid Bias (Grid #4) for Conversion Transconductance = 6 micromhos	-	-35	Volts
Plate Current	1.1	3.5	Milliamperes
Screen Current	1.3	2.7	Milliamperes
Anode-Grid Current	2	4	Milliamperes
Oscillator-Grid Current	0.25	0.4	Milliampere

* Design value for 117-volt line.

oo Anode-grid supply voltages in excess of 200 volts require the use of a 20000-ohm voltage-dropping resistor by-passed by 0.1 μf condenser.

● This is an Anode-Grid Supply voltage applied through 20000-ohm voltage-dropping resistor.

\# In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

Pin Connections

Pin 1 - Heater	Pin 6 - Grid #4
Pin 2 - Plate	Pin 7 - Cathode
Pin 3 - Grid #2	Pin 8 - Heater
Pin 4 - Grid #1	Plug - Shell
Pin 5 - Grids #3 & #5	

(Pin numbers are according to RMA system)

Operating Position

Any

March 8, 1940

from RMA release #234, March 13, 1940

7C5-LT

BEAM POWER AMPLIFIER

(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	6.3□ Volts
HEATER CURRENT	0.45□□ Ampere
MAXIMUM OVERALL LENGTH	3-3/8"
MAXIMUM SEATED HEIGHT	2-27/32"
MAXIMUM DIAMETER	1-1/4"
BULB	T-9
BASE	Small Wafer Octalox 8-Pin with Sleeve
BASING DESIGNATION	6AA

□ Nominal value is 7 volts.
□□ Nominal value is 0.48 ampere.

Single-Tube Amplifier - Class A_1

PLATE VOLTAGE			315 max.*	Volts
SCREEN VOLTAGE			250 max.*	Volts
PLATE DISSIPATION			12 max.*	Watts
SCREEN DISSIPATION			2 max.*	Watts
TYPICAL OPERATION:				
Heater Voltage #	6.3	6.3	6.3	Volts
Plate Voltage	180	250	315	Volts
Screen Voltage	180	250	225	Volts
Grid Voltage ##	-8.5	-12.5	-13	Volts
Peak A-F Grid Voltage	8.5	12.5	13	Volts
Zero-Signal Plate Current	29	45	34	Milliamperes
Max.-Signal Plate Current	30	47	35	Milliamperes
Zero-Signal Screen Current	3	4.5	2.2	Milliamperes
Max.-Signal Screen Current	4	7	6	Milliamperes
Plate Resistance	58000	52000	77000	Ohms
Transconductance	3700	4100	3750	Micromhos
Load Resistance	5500	5000	8500	Ohms
Total Harmonic Distortion	8	8	12	Per Cent
Max.-Signal Power Output	2	4.5	5.5	Watts

Push-Pull Amplifier - Class AB_1

PLATE VOLTAGE	315 max.*		Volts
SCREEN VOLTAGE	250 max.*		Volts
PLATE DISSIPATION	12 max.*		Watts
SCREEN DISSIPATION	2 max.*		Watts
TYPICAL OPERATION:			
Values are for 2 tubes			
Heater Voltage #	6.3		Volts
Plate Voltage	250		Volts
Screen Voltage	250		Volts
Grid Voltage ##	-15		Volts
Peak A-F Grid-to-Grid Voltage	30		Volts
Zero-Signal Plate Current	70		Milliamperes
Max.-Signal Plate Current	79		Milliamperes
Zero-Signal Screen Current	5		Milliamperes
Max.-Signal Screen Current	13		Milliamperes
Effective Load Resistance (Plate to plate)	10000		Ohms
Total Harmonic Distortion	5		Per Cent
Max.-Signal Power Output	10		Watts

* Design maximum for 117-volt line.

\# In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

\#\# The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-input coupling devices are recommended. When the grid circuit has a resistance not higher than 0.05 megohm, fixed bias may be used; for higher values, cathode bias is required. With cathode bias, the grid circuit may have a resistance not to exceed 0.5 megohm.

Operating Position

Any

Pin Connections

Pin 1 - Heater	Pin 6 - Grid
Pin 2 - Plate	Pin 7 - Cathode
Pin 3 - Screen	Pin 8 - Heater
Pin 4 - No Connection	Plug - No Connection
Pin 5 - No Connection	

(Pin numbers are according to RMA system)

March 8, 1940

from RMA release #234, March 13, 1940

7CP4

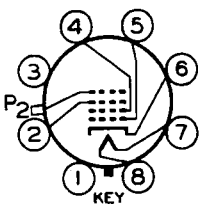
KINESCOPE

ELECTROSTATIC FOCUS, MAGNETIC DEFLECTION

General:

Heater, for Unipotential Cathode:		
Voltage	6.3 ± 10%	ac or dc volts
Current	0.6	amp
Direct Interelectrode Capacitances (Approx.):		
Grid No.1 to All Other Electrodes	8.0	μμf
Cathode to All Other Electrodes	6.5	μμf
Phosphor		No.4
Fluorescence		White
Persistence		Medium
Focusing Method		Electrostatic
Deflection Method		Magnetic
Solid Deflection Angle (Approx.)		57°
Overall Length		13-7/16" ± 3/8"
Greatest Diameter of Bulb		7" ± 1/8"
Minimum Useful Screen Diameter		6-1/2"
Raster Size (Approx.)		4" x 5-1/2"
Cap		Recessed Small Ball
Mounting Position		Any
Base		Long Medium-Shell Octal 8-Pin
Basing Designation for BOTTOM VIEW		6AZ

Pin 1 – No Connection
Pin 2 – Anode No.1
Pin 3 – No Connection
Pin 4 – Grid No.2
Pin 5 – Grid No.1



Pin 6 – Cathode
Pin 7 – Heater
Pin 8 – Heater
Cap – Anode No.2

Maximum Ratings, *Design-Center Values*:

ANODE-No.2 VOLTAGE	8000 max. volts
ANODE-No.1 VOLTAGE	2400 max. volts
GRID-No.2 VOLTAGE	300 max. volts
GRID-No.1 VOLTAGE:	
Negative bias value	125 max. volts
Positive bias value	2 max. volts
PEAK HEATER-CATHODE VOLTAGE:	
Heater negative with respect to cathode	125 max. volts
Heater positive with respect to cathode	125 max. volts

Typical Operation:

Anode-No.2 Voltage*	6000	volts
Anode-No.1 Voltage for Focus°	1140	volts
Grid-No.2 Voltage	250	volts
Grid-No.1 Voltage**	-45	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max. megohms

*, °, **, See next page.

TENTATIVE DATA

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY
from RMA release # 507, June 25, 1946

7CP4

KINESCOPE

* Brilliance and definition decrease with decreasing anode-No.2 voltage. In general, the anode No.2 voltage should not be less than 4000 volts.

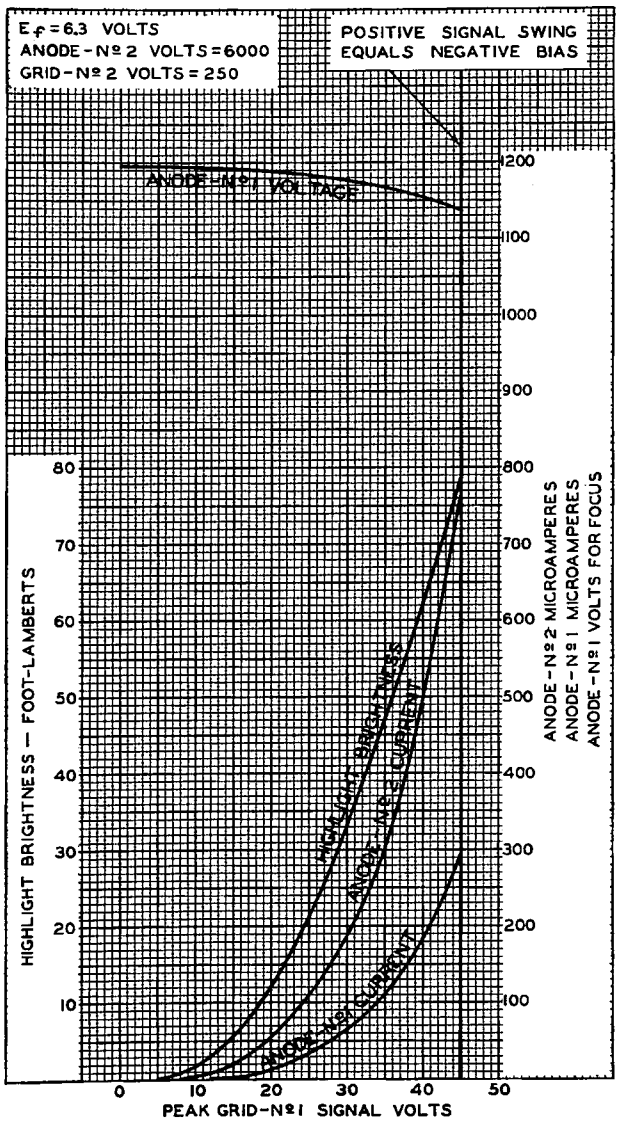
° With the combined grid-No.1-bias voltage and video-signal voltage adjusted to produce a highlight brightness of 10 foot-lamberts on a 4" x 5-1/2" picture area. The anode No.1 voltage supply should be adjustable to ±20% of indicated value.

** Visual extinction of undeflected focused spot. Supply should be adjustable to ±50% of indicated value.

7CP4

KINESCOPE

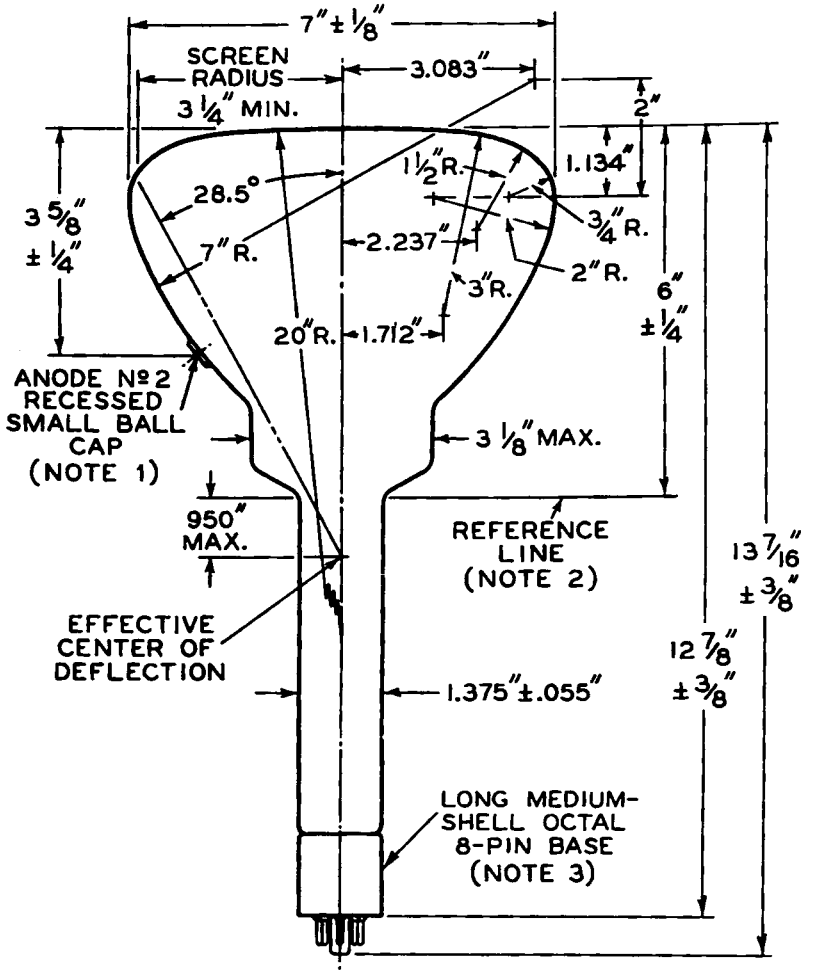
AVERAGE CHARACTERISTICS



92CM-6684

7CP4

KINESCOPE



NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.2 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE No.2 TERMINAL BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF 10°. ANODE No.2 TERMINAL IS ON SAME SIDE OF TUBE AS PIN No.2.

NOTE 2: REFERENCE LINE IS DETERMINED BY POSITION WHERE GAUGE 1.430" + .003" -.000" I.D. AND 2" LONG WILL REST ON BULB CONE.

NOTE 3: ℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF THE BOTTOM OF THE BASE.

92CM-6364R2

8NP4

MONITOR KINESCOPE

Low-Voltage Electrostatic Focus
90° Magnetic Deflection

Small, Compact, Rectangular Glass Type

7-3/16" x 5-3/8" Screen
8-1/2" Max. Bulb Diagonal
9-15/16" Max. Overall Length

RCA-8NP4 is a small, compact, rectangular, glass monitor kinescope having an aluminized screen with slightly curved sides and rounded corners, and a minimum projected screen area of 36 square inches.

Features include:

- 9-15/16" maximum overall length
- 5-13/16" neck length
- 90° magnetic deflection
- Electron gun requiring no ion-trap magnet
- Aluminized screen
- Spherical Filterglass faceplate

GENERAL DATA

Electrical:

Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angles (Approx.):	
Diagonal	90°
Horizontal	85°
Vertical	68°
Direct Interelectrode Capacitances:	
Cathode to all other electrodes	5 μμf
Grid No.1 to all other electrodes	6 μμf
Heater Current at 6.3 volts	600 ± 30 ma
Heater Warm-up Time (Average)	11 seconds

Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 5 volts.

Electron Gun	Type Requiring No Ion-Trap Magnet

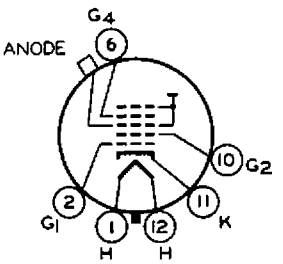
Optical:

Phosphor	P4—Sulfide Type, Aluminized
Faceplate	Filterglass
Light transmission at center (Approx.)	80%

Mechanical:

Weight (Approx.)	2-1/2 lbs
Tube Dimensions:	
Overall length	9-3/4" ± 3/16"
Neck length	5-13/16" ± 1/8"
Diagonal	8-7/16" + 1/16" - 1/32"
Greatest width	7-7/8" + 1/16" - 1/32"
Greatest height	6-1/16" + 1/16" - 1/32"
Minimum Screen Dimensions (Projected):	
Diagonal	7-3/4"
Greatest width	7-3/16"
Greatest height	5-3/8"
Area	36 sq. in.
Bulb Designation	J67-1/2 A1
Cap Designation	Recessed Small Cavity (JEDEC No.J1-21)
Base Designation	Small-Shell Duodecal 6-Pin (JEDEC Group 4, No.B6-63)
Basing Designation	12M

Pin 1: Heater
Pin 2: Grid No.1
Pin 6: Grid No.4
Pin 10: Grid No.2
Pin 11: Cathode
Pin 12: Heater
Cap: Anode (Grid No.3, Grid No.5, Screen, Collector)



BOTTOM VIEW

Maximum and Minimum Ratings, *Design-Maximum Values:*[a]

Unless otherwise specified, voltage values are positive with respect to cathode

ANODE VOLTAGE	18000 max.	volts
GRID-No.4 VOLTAGE:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
GRID-No.2 VOLTAGE	550 max. 200 min.	volts volts
GRID-No.1 VOLTAGE:		
Negative peak value	220 max.	volts
Negative bias value	155 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
HEATER VOLTAGE[b]	6.9 max. 5.7 min.	volts volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	200 max.	volts
Heater positive with respect to cathode:		
Combined AC & DC Voltage	200 max.	volts
DC Component	100 max.	volts

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Typical Operating Conditions for Grid-Drive[c] Service:

Unless otherwise specified, voltage values are positive with respect to cathode

Anode Voltage	16000	volts
Grid-No.4 Voltage[d]	200	volts
Grid-No.2 Voltage	300	volts
Grid-No.1 Voltage for Visual extinction of focused raster (See Fig.2)	-28 to -72	volts
Field strength of required adjustable Centering Magnet[e]	0 to 10	gausses
Maximum Circuit Value:		
Grid-No.1 Circuit Resistance	1.5 max.	megohms

[a] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Maximum Rating System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

[b] Measured between the heater terminals.

[c] Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

[d] The grid-No.4 voltage required for optimum focus of any individual tube will have a value anywhere between 0 and +400 volts.

[e] Distance from Reference Line for suitable PM centering magnet should not exceed 2-1/4 inches. The specified centering magnet compensates only for the effect which mechanical tube tolerances may have on the location of the undeflected, focused spot with respect to the center of the tube face. Maximum field strength of adjustable centering magnet equals

$$\sqrt{\frac{\text{Anode volts}}{16000 \text{ volts}}} \times 10 \text{ gausses.}$$

The equipment manufacturer must determine and supply additional compensation for the effects of the earth's magnetic field and extraneous fields due to choice of circuitry and components. The additional compensation should preferably be applied as part of the magnetic field of the deflecting yoke.

OPERATING CONSIDERATIONS

X-Radiation Warning. When operated at anode voltages up to 16 kilovolts, this monitor kinescope does not produce any harmful X-radiation. However, because the rating of this type permits operation at voltages as high as 18 kilovolts (design-maximum value), shielding of the tube for X-radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

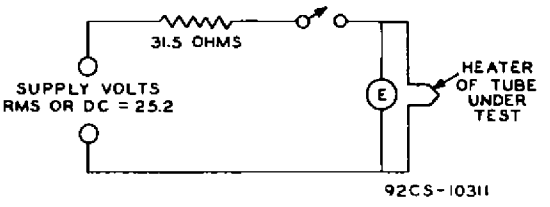

Fig.1 - Test Circuit for Determining Heater Warm-Up Time.

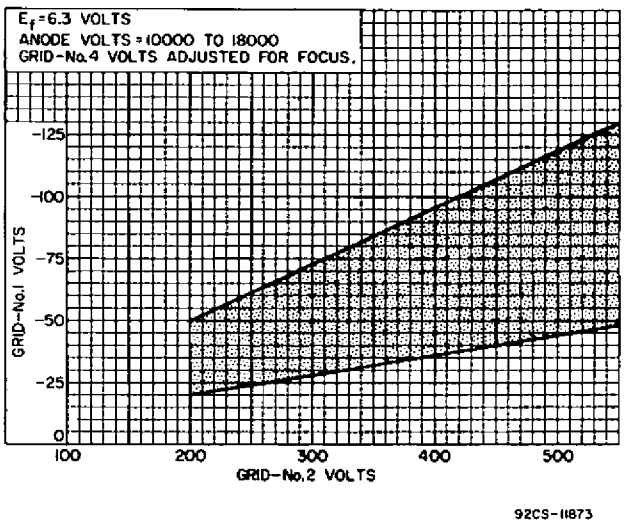

Fig.2 - Raster-Cutoff Range Chart for Type 8NP4.

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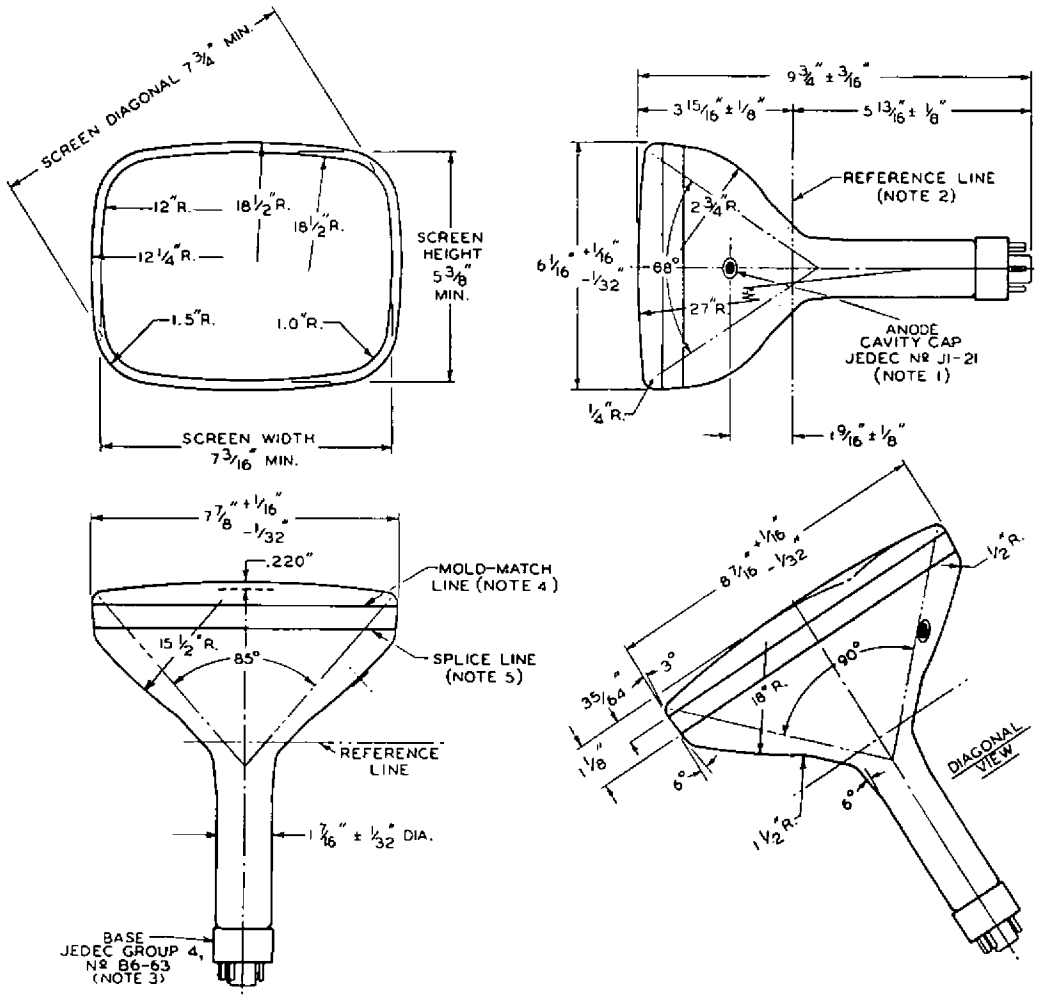
DIMENSIONAL OUTLINE



92CL-11874

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN NO.6 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ANODE TERMINAL IS ON SAME SIDE AS PIN NO.6.

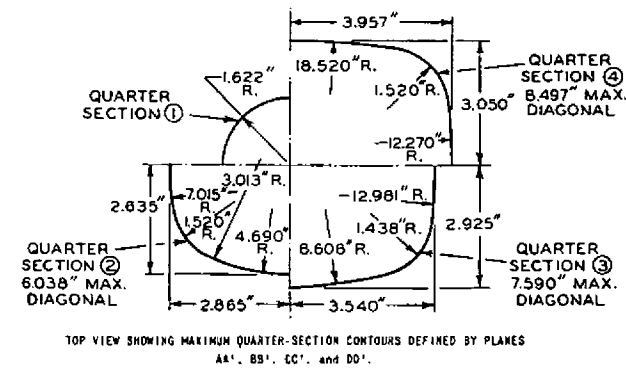
NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JEDEC No.G116) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AT THE REFERENCE LINE AND HAVING A DIAMETER OF 1-5/8 INCHES.

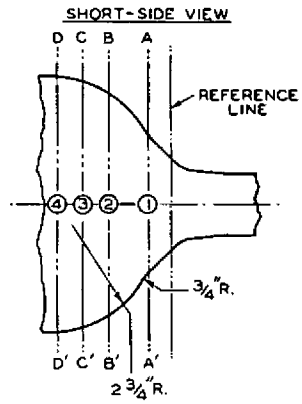
NOTE 4: THE MAXIMUM RADIAL DISPLACEMENT OF THE PERIPHERY OF THE FACE PANEL (JUST ABOVE THE MOLD-MATCH LINE) FROM ITS EXACT CENTERED POSITION ON THE NECK AXIS IS 0.040".

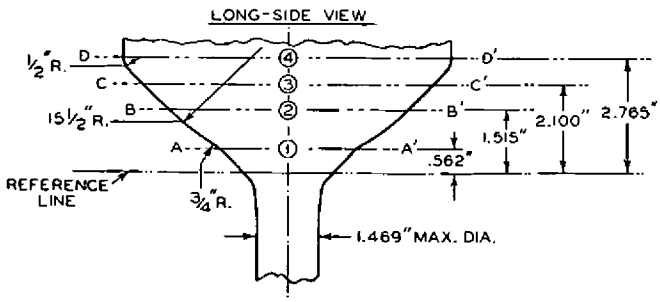
NOTE 5: BULGE AT SPLICE-LINE SEAL WILL NOT PROTRUDE BEYOND THE MAXIMUM ENVELOPE DIMENSIONS AT THE MOLD-MATCH LINE.

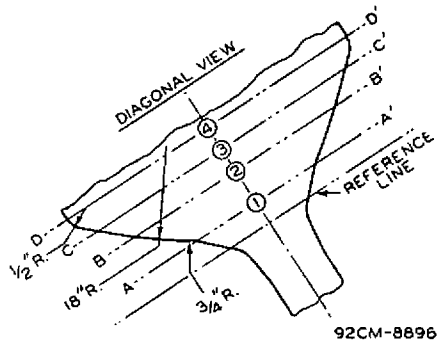
BULB-CONTOUR DIMENSIONS FOR MAXIMUM SPACE REQUIREMENTS



TOP VIEW SHOWING MAXIMUM QUARTER-SECTION CONTOURS DEFINED BY PLANES AA', BB', CC', and DD'.







CONTOURS (1), (2), (3), AND (4) DEFINE MAXIMUM BULB DIMENSIONS IN THE PLANES AA', BB', CC', AND DD'. THE PLANES ARE NORMAL TO THE TUBE AXIS AND AT FIXED LOCATIONS FROM THE REFERENCE LINE. WHEN DIMENSIONED FROM THE FACEPLATE, THE AXIAL POSITIONS OF PLANES AA', BB', CC', AND DD' WILL VARY BY ± 0.125".

9C25

POWER TRIODE

Forced-Air-Cooled, Grounded-Grid Type

TENTATIVE DATA

RCA-9C25 is a forced-air-cooled power triode designed for communication and industrial service. It has a maximum rated plate dissipation of 17.5 kilowatts, and can be operated with full plate voltage, plate input, and grid current at frequencies as high as 30 megacycles. Operation at frequencies up to 100 megacycles is permissible with reduced ratings.

The flanged-header grid terminal is a design feature of particular value when the 9C25 is used in grounded-grid circuits. In such circuits, this terminal when used with a large circular connector effectively isolates the filament from the plate circuit, and provides a direct, low-inductance path to the grid. As a result, neutralization is generally unnecessary in grounded-grid service. In grounded-filament circuits, the 9C25 can be used in the conventional manner.

The design of the 9C25 also includes an effective external radiator for cooling the plate by forced air; a single-phase, multistrand, thoriated tungsten filament; and a strong, conical grid support which provides a maximum of shielding between plate and filament to give extremely low plate-filament capacitance, and also serves to reduce effectively the grid-lead inductance.

GENERAL DATA

Filament, Multistrand Thoriated Tungsten:		
Excitation	Single-Phase AC or DC	
Voltage (AC or DC)	6	Volts
Current	285	Amperes
Starting Current: The filament current must never exceed, even momentarily, a value of 425 amperes.		
Cold Resistance	0.0025	Ohms
Amplification Factor	32	
Direct Interelectrode Capacitances (Approx.):		
Grid to Plate	40	μμf
Grid to Filament	58	μμf
Plate to Filament	0.9	μμf
Maximum Overall Length		17-3/8"
Maximum Diameter		14-1/4"
Mounting Position	Vertical, filament end up	
Radiator	Integral part of tube	
Mounting		Special
Air Flow:		
Through Radiator	1000 min.	cfm

The specified air flow at a pressure of 2 inches of water should be delivered by a blower vertically upward through the radiator before and during the application of any voltages, and be maintained for 2 minutes after removal of all voltages.

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

9C25-7-46
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from RMA release # 511, July 20, 1946

Air Flow (Cont'd):		
To Filament Seals	10	cfm
The specified air flow must be directed into the filament header before and during the application of any voltages in order to limit the temperature of the filament seals to the maximum value.		
Output Air Temperature (From radiator)	70 max.	°C
Radiator Temperature (Measured in thermometer well)	180 max.	°C
Bulb Temperature	180 max.	°C
Seal Temperature (Filament, grid, and plate)	165 max.	°C

AF POWER AMPLIFIER & MODULATOR--Class B

Maximum CCS® Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
MAX.-SIGNAL DC PLATE CURRENT*	4 max.	Amperes
MAX.-SIGNAL PLATE INPUT*	40 max.	Kw
PLATE DISSIPATION*	17.5 max.	Kw

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	10500	Volts
DC Grid Voltage	-250	Volts
Peak AF Grid-to-Grid Voltage	1310	Volts
Zero-Signal DC Plate Current	1.7	Amperes
Max.-Signal DC Plate Current	7	Amperes
Effective Load Resistance (Plate to plate)	3300	Ohms
Max.-Signal Driving Power (Approx.)	1500	Watts
Max.-Signal Power Output (Approx.)	50	Kw

RF POWER AMPLIFIER--Class B Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS® Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
DC PLATE CURRENT	3.2 max.	Amperes
PLATE INPUT	26 max.	Kw
PLATE DISSIPATION	17.5 max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	10000	Volts
DC Grid Voltage	-230	Volts
Peak RF Grid Voltage	400	Volts
DC Plate Current	2.5	Amperes
DC Grid Current (Approx.)**	0.016	Ampere
Driving Power (Approx.)** °	800	Watts
Power Output (Approx.)	9.2	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.):		
Carrier	800	Watts
Crest°	4	Kw
Power Output (Approx.)	10	Kw

PLATE-MODULATED RF POWER AMPLIFIER--Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	9000 max.	Volts
DC GRID VOLTAGE	-2000 max.	Volts
DC PLATE CURRENT	3.2 max.	Amperes
DC GRID CURRENT	0.65 max.	Ampere
PLATE INPUT	26 max.	Kw
PLATE DISSIPATION	11.5 max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	8000	Volts
DC Grid Voltage:		
From a fixed supply of	-650	Volts
From a grid resistor of	1280	Ohms
Peak RF Grid Voltage	1100	Volts
DC Plate Current	2.5	Amperes
DC Grid Current (Approx.)**	0.51	Ampere
Driving Power (Approx.)**	510	Watts
Power Output (Approx.)	15.8	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.)†	3000	Watts
Power Output (Approx.)	18	Kw

RF POWER AMPLIFIER & OSCILLATOR--Class C Telegraphy

Key-down conditions per tube without amplitude modulation□

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
DC GRID VOLTAGE	-2000 max.	Volts
DC PLATE CURRENT	4 max.	Amperes
DC GRID CURRENT	0.65 max.	Ampere
PLATE INPUT	40 max.	Kw
PLATE DISSIPATION	17.5 max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	10000	11000	Volts
DC Grid Voltage:			
From a fixed supply of	-500	-540	Volts
From a grid resistor of	860	900	Ohms
From a cathode resistor of	125	130	Ohms
Peak RF Grid Voltage	1000	1050	Volts
DC Plate Current	3.5	3.6	Amperes
DC Grid Current (Approx.)**	0.58	0.61	Ampere
Driving Power (Approx.)**	515	575	Watts
Power Output (Approx.)	25	29.5	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.)	3400	3750	Watts
Power Output (Approx.)	28	32.5	Kw

• CCS = Continuous Commercial Service.

* Averaged over any audio-frequency cycle of sine-wave form.

** Subject to wide variations depending on the impedance of the plate circuit. High-impedance plate circuits require more grid current and driving power to obtain the desired output. Low-impedance plate circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of supplying considerably more than the required driving power.

° At crest of audio-frequency cycle with modulation factor of 1.0.

🌡 Carrier power of driver modulated 100%.

□ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

INSTALLATION

In transportation and storage of the 9C25, care should be taken to protect the tube from rough handling that would damage the metal-to-glass seals or other parts. The 9C25 is suspended within its shipping crate so that it will not come in contact with the sides of the crate during shipment. It should be stored in the crate with the filament end up and should be protected from moisture and extreme temperature changes. Under no circumstances should crated tubes be piled one on top of another. Furthermore, while the tube is being handled, it should be kept in a vertical position with the filament end up. The weight of the 9C25 crated for shipment is approximately 295 pounds; uncrated, approximately 120 pounds.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, any foreign material clinging to the tube should be removed. An air blast is recommended for removing any such material from the entrant metal header.

Mounting of the 9C25 requires the use of an insulating sleeve support

which is usually part of the equipment. Information concerning the sleeve support can be obtained from us on request. The sleeve should support the tube in a vertical position with the filament end up. If the 9C25 is to be subjected to appreciable vibration in service, it is advisable to support the sleeve by springs. When concrete basework is provided for the equipment and when machines or other sources of vibration are not present, it is unnecessary to use a spring suspension. The installation of all wires and connections must be made so that they will not be close to or touch the bulb. This precaution is necessary to prevent almost certain puncture of the glass from corona discharge.

The 9C25 should be placed in the sleeve carefully and the radiator must be seated properly. The need for clamping the radiator is obviated by the weight of the tube, but correct seating is necessary for good electrical connection to the plate.

When the 9C25 is removed from its sleeve, first be sure that the temperature of the grid and filament is below red heat. Next remove the filament and grid connections. Then carefully remove the tube from the sleeve.

An air-cooling system, interlocked with the power supplies, is required to cool the radiator and also the entrant metal header. The air-cooling system consists of a blower capable of delivering a minimum air flow of 1000 cubic feet per minute at a pressure of 2 inches of water upward through the radiator, and an air duct of suitable cross-sectional area to convey a flow of approximately 10 cubic feet per minute downward into the header. The cooling air must not contain any water or foreign matter.

The radiator temperature measured in the thermometer well should not exceed 180°C; the temperature of the cooling air after passing through radiator should not exceed 70°C; the temperature of the bulb should not exceed 180°C at the hottest point; and the temperature of the seals (filament, grid, and plate) should be limited to 165°C.

The temperature of the bulb and seals may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilac. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York, N.Y., in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of 1 per cent.

The air-cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the filament and plate supplies to prevent the application of voltages to the tube without cooling. Air-pressure interlocks which open the circuit breakers of the filament- and plate-power transformers are necessary for protecting the tube when the air flow is insufficient or ceases. Precautions should be taken to insulate the air-cooling system from the tube or circuit parts which may be at high potential.

The thoriated-tungsten filament of the 9C25 may be operated from direct current or from single-phase alternating current. The filament consists of twelve strands which are brought out to two terminals sealed into the entrant

metal header. The filament connectors should make firm, large-surface contact with the filament terminals in order to prevent heating by the high filament current. The filament leads should not be taut, but should allow for some movement without placing a strain on the glass bulb.

Under normal full-load conditions, the filament voltage should be maintained at the rated value within ± 5 per cent; with light loads, reduction of the filament voltage by as much as 5 per cent is permissible. In the latter case, care must be taken that the reduction of the filament voltage and, therefore, of emission is not so great that the peak-current requirements can not be met. It is recommended that in intermittent service where the standby periods are no longer than 15 minutes, the filament voltage be reduced to 80 per cent of normal during standbys; for longer periods, the filament voltage should be turned off. The filament should be operated at constant voltage rather than at constant current, and must be allowed to reach normal operating temperature before other voltages are applied to the tube. A suitable voltmeter should be permanently connected directly across the filament terminals so that the filament voltage will always be known.

When direct current is used, the polarity of the leads should be reversed every 500 hours of operation.

A filament starter should be used to raise the filament voltage gradually and to limit the high initial rush of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the total filament current never exceed, even momentarily, a value of 425 amperes.

The grid terminal of the 9C25 is in the form of a flange on the entrant metal header. It is suggested that the connector for the grid lead be in the form of a flat yoke extending around perhaps half the circumference of the flange. At the higher frequencies, it is recommended that the flat-yoke connector extend completely around the circumference of the flange and that adequate connections be made to it to provide uniform rf current distribution over the flange. This yoke must be provided with holes so that it can be bolted to the flange for good electrical contact. The screws attaching the corona shield to the flange should be removed when the yoke is being bolted to the flange; they are then replaced. The yoke and grid lead should not place any strain on the header because of the possibility of damage to the glass-to-metal seal. Similarly, connections should not be soldered to the flange; and the flange should not be used to support circuit parts.

The plate connection for the 9C25 is provided automatically through the radiator which is connected electrically to the high-voltage supply. The rated plate voltage is extremely dangerous to the user. Great care should be taken during adjustment of the circuit. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should

function to break the primary circuit of the plate supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

The plate circuit should be provided with a time-delay relay to delay the application of plate voltage until the filament has reached normal operating temperature. The plate circuit must also be provided with protective devices to prevent the tube from drawing a heavy overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The time required for the operation of the relay and circuit breakers should be about 1/10 second and not more than 1/6 second. A voltage-dropping resistor should be permanently connected in series with the plate lead of each tube for protection of the tube during the time required for the relay and the circuit breaker to act. The minimum value of this resistor which will give adequate protection with minimum power loss is as follows:

SERIES RESISTOR	25	50	75	100	Ohms
MAXIMUM POWER OUTPUT OF RECTIFIER	40	100	250	640	Kw

A capacitor of high value should never be connected directly across the tube in such a manner that a disturbance within the tube will discharge appreciable energy from the capacitor.

The grid return and the plate return should be connected to the center point of the filament voltage supply when ac is used. When dc is used, the grid and the plate return should be connected to the negative filament terminal and should still be connected to the negative filament terminal whenever the filament polarity is reversed.

When a 9C25 is first placed in service, care should be taken to see that the air-cooling system is functioning properly. The tube should then be operated without plate voltage for 5 minutes at rated filament voltage. After this initial preheating schedule, the tube should be operated at approximately one-half the usual plate voltage for 15 minutes. Full plate voltage may then be applied and the tube operated under normal load conditions for a period of 1 hour or more. It is recommended that spare tubes be given the preheating and initial-operating treatment every 3 months. This procedure will insure that only good tubes are carried in stock.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube and associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the radiator or the glass bulb, the plate voltage may be raised in steps to the desired value. Adjustments should be made at each step for optimum operation.

Overheating of the 9C25 by severe overload may impair its vacuum. When the quantity of released gas is not too great, it is often possible to degassify the tube by operating it at reduced plate voltage. The first step in the process should be a short period of operation at a plate voltage of one-half the rated value. The plate voltage may then be increased to the normal value and the tube allowed to operate for an hour or more. In severe cases, it may be necessary to degassify the tube by increasing the plate voltage in small steps until the normal voltage is reached. At each new voltage, the tube should be allowed to operate long enough to insure the attainment of stabilized conditions. The voltage may be varied by means of a series resistor connected in the plate-supply lead.

If the release of gas has caused deactivation of the filament, the activity of the filament can often be restored by operating the filament at its normal voltage for 10 minutes or longer without plate or grid voltage. The reactivation process may be accelerated by raising the filament voltage to not higher than 120 per cent of normal value for a few minutes.

APPLICATION

The maximum ratings in the tabulated data for the 9C25 are limiting values above which the serviceability of the 9C25 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 9C25 may be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. It may be operated at higher frequencies provided the maximum values of plate voltage, plate input, and grid current are reduced as the frequency is raised. Other maximum ratings remain the same. When the 9C25 is used in grounded-grid circuits at the highest frequencies, care must be exercised to shield completely the filament-grid circuit from the grid-plate circuit.

The following table shows the highest percentage of maximum plate voltage, plate input, and grid current that can be safely used up to 100 megacycles. Special attention should be given to adequate cooling at the higher frequencies.

FREQUENCY	30	50	75	100	Mc
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE, PLATE INPUT & GRID CURRENT:					
Class B Telephony	100	93	87	80	per cent
Class C Telephony	100	87	74	61	per cent
Class C Telegraphy	100	87	74	61	per cent

in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

Circuit-design considerations affecting operation of the 9C25 are given in the following paragraphs.

The grid circuit of the 9C25 when used with its filament grounded should be designed and adjusted so that no appreciable voltage can occur between grid and filament at any frequency except the fundamental. This procedure will minimize the occurrence of parasitic oscillations and be simplified if the generation of unwanted harmonic frequencies is avoided. The use of a plate tank circuit having the proper Q and the avoidance of over-excitation are helpful. Link coupling between the driving stage and the power amplifier is useful especially if the Q of the grid tank circuit is high enough to provide good voltage regulation.

Because of the relatively large high-frequency currents carried by the grid and plate terminals, heavy conductors should be used to make the circuit connections.

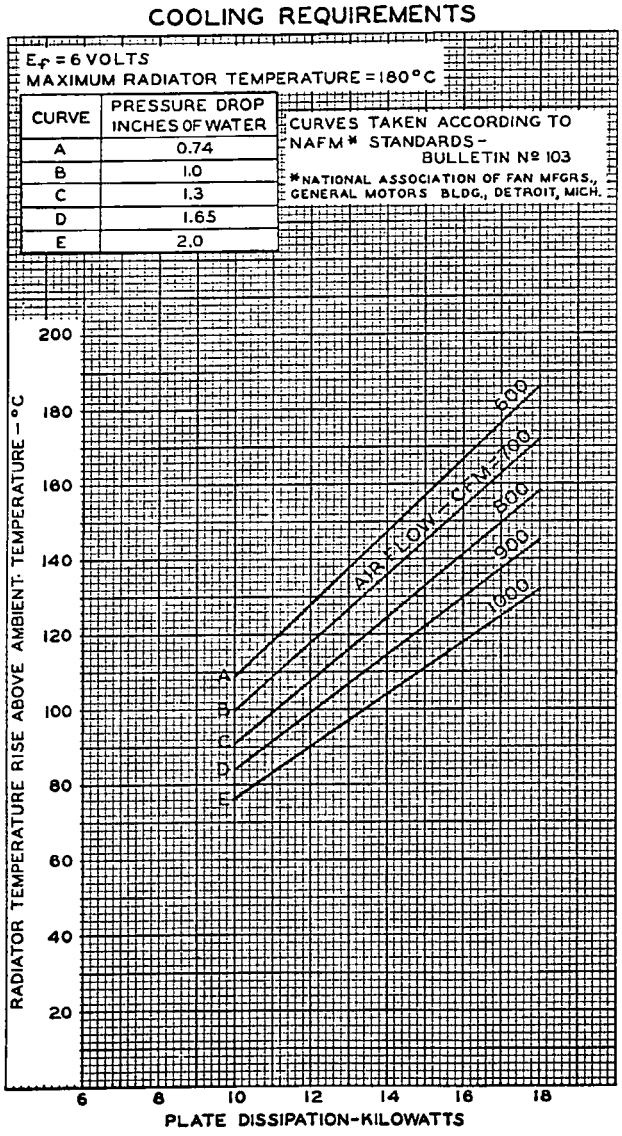
When more radio-frequency power is required than can be obtained from a single tube, push-pull or parallel circuit arrangements may be used. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive the tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits.

When two or more tubes are used in the circuit, precautions should be taken so that the plate current drawn by each tube is the same.

REFERENCE

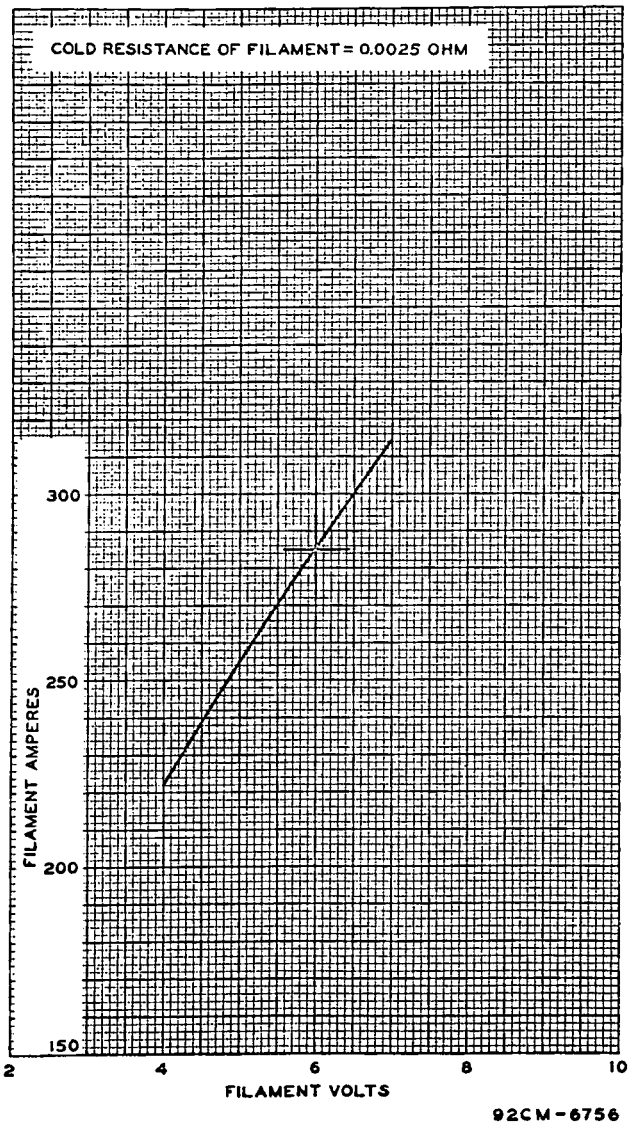
E. E. Spitzer, "Grounded-Grid Power Amplifiers," Electronics, Vol. 19, No.4, pp. 138 - 141 (April, 1946).

COOLING REQUIREMENTS

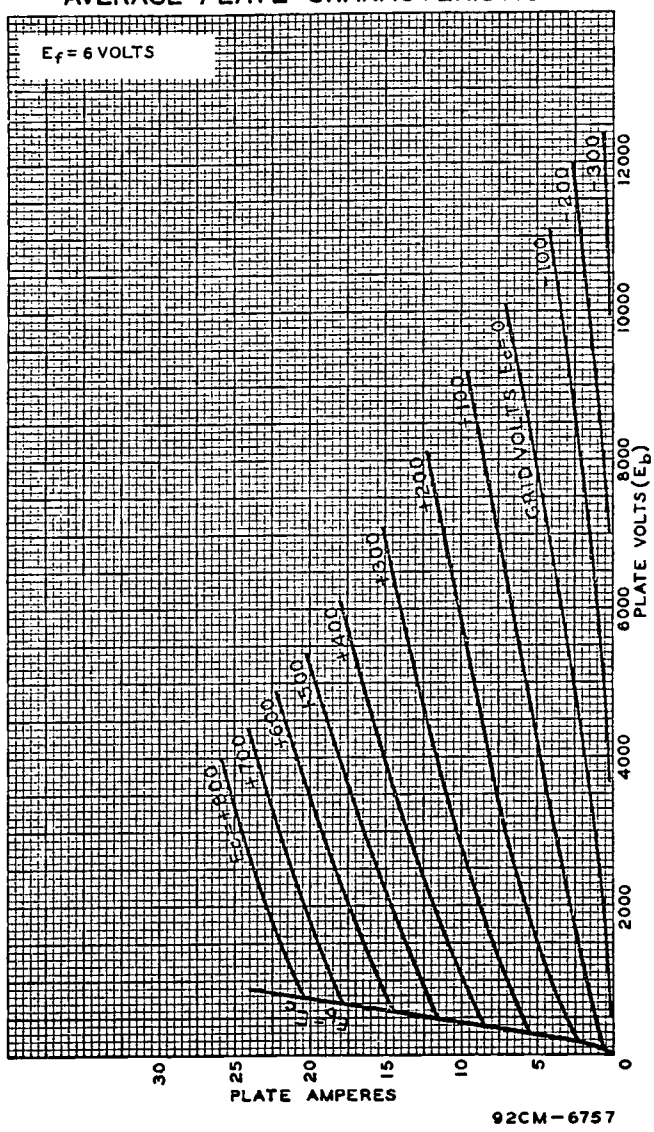


92CM-6761

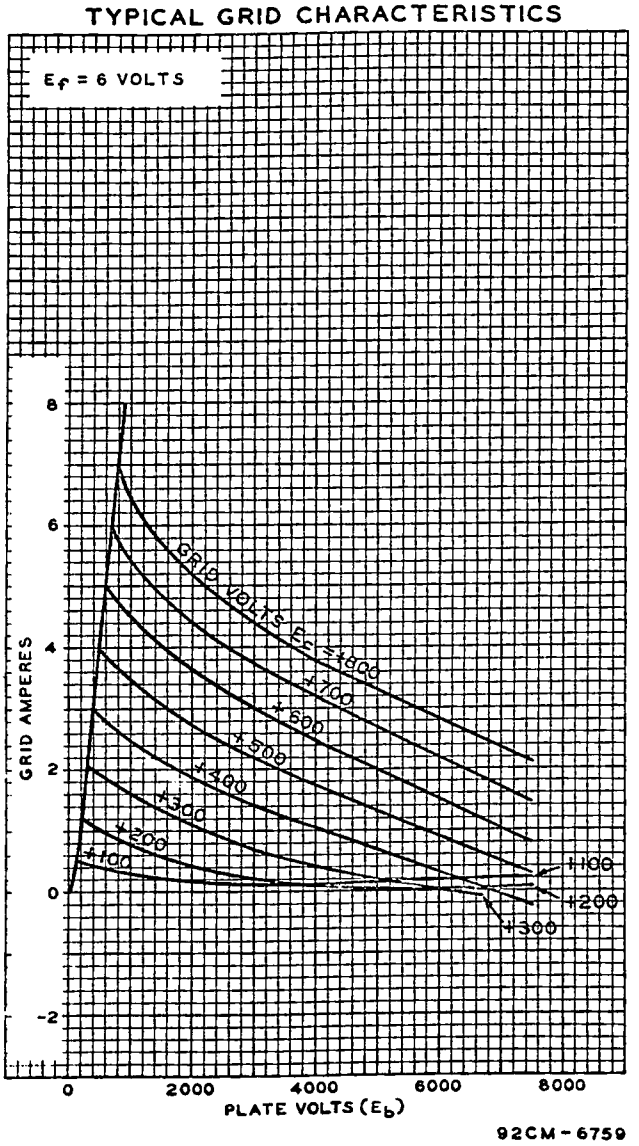
AVERAGE FILAMENT CHARACTERISTIC



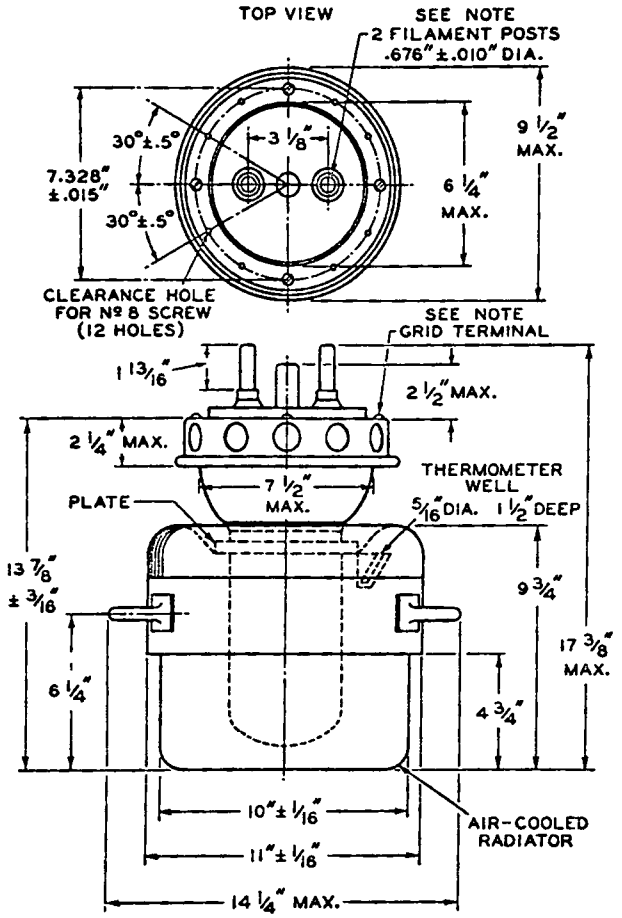
AVERAGE PLATE CHARACTERISTICS



TYPICAL GRID CHARACTERISTICS



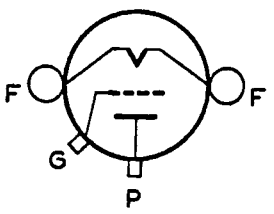
DIMENSIONAL OUTLINE



NOTE: FLEXIBLE CONNECTIONS ARE REQUIRED.

92CM-6750

TUBE SYMBOL



F: FILAMENT
G: GRID
P: PLATE

9C27

POWER TRIODE

Water- & Forced-Air-Cooled, Grounded-Grid Type

TENTATIVE DATA

RCA-9C27 is a water- and forced-air-cooled power triode designed for communication and industrial service. It has a maximum rated plate dissipation of 25 kilowatts, and can be operated with full plate voltage, plate input, and grid current at frequencies as high as 30 megacycles. Operation at frequencies up to 100 megacycles is permissible with reduced ratings.

The flanged-header grid terminal is a design feature of particular value when the 9C27 is used in grounded-grid circuits. In such circuits, this terminal when used with a large circular connector effectively isolates the filament from the plate circuit, and provides a direct, low-inductance path to the grid. As a result, neutralization is generally unnecessary in grounded-grid service. In grounded-filament circuits, the 9C27 can be used in the conventional manner.

The internal structure of the 9C27 utilizes a single-phase, multistrand, thoriated-tungsten filament, and a strong, conical grid support which provides a maximum of shielding between plate and filament to give extremely low plate-filament capacitance, and also serves to reduce effectively the grid-lead inductance.

GENERAL DATA

Filament, Multistrand Thoriated Tungsten:		
Excitation	Single-Phase AC or DC	
Voltage (AC or DC)	6	Volts
Current	285	Amperes
Starting Current: The filament current must never exceed, even momentarily, a value of 425 amperes.		
Cold Resistance	0.0025	Ohms
Amplification Factor	32	
Direct Interelectrode Capacitances (Approx.):		
Grid to Plate	36	μμf
Grid to Filament	58	μμf
Plate to Filament	0.8	μμf
Maximum Overall Length		16-3/8"
Maximum Diameter		9-1/2"
Mounting Position	Vertical, filament end up	
Water Jacket		Special
Gasket	RCA Stock No.43244	
Water Flow	12 to 15	gpm
The water flow must start before the application of any voltages and continue for at least 2 minutes after the removal of all voltages.		
Air Flow:		
To Filament Seals	10	cfm
The specified air flow directed into the filament header before and		

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

9C27-7-46
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during the application of any voltages is required to limit the temperature of the filament seals to the maximum value.

To Plate Seal and Bulb	250	cfm

The specified air flow must be directed at and distributed uniformly around the plate seal and bulb to limit the temperature of each to its maximum value at the hottest point.

Outlet Water Temperature	70 max.	°C
Bulb Temperature	180 max.	°C
Seal Temperature (Filament, Grid, and Plate)	165 max.	°C

AF POWER AMPLIFIER & MODULATOR--Class B

Maximum CCS® Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
MAX.-SIGNAL DC PLATE CURRENT *	4 max.	Amperes
MAX.-SIGNAL PLATE INPUT *	40 max.	Kw
PLATE DISSIPATION *	25 max.	Kw

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	10500	Volts
DC Grid Voltage	-250	Volts
Peak AF Grid-to-Grid Voltage	1310	Volts
Zero-Signal DC Plate Current	1.7	Amperes
Max.-Signal DC Plate Current	7	Amperes
Effective Load Resistance (Plate to plate)	3300	Ohms
Max.-Signal Driving Power (Approx.)	1500	Watts
Max.-Signal Power Output (Approx.)	50	Kw

RF POWER AMPLIFIER--Class B Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS® Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
DC PLATE CURRENT	3.5 max.	Amperes
PLATE INPUT	36 max.	Kw
PLATE DISSIPATION	25 max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	10000	Volts
DC Grid Voltage	-230	Volts
Peak RF Grid Voltage	400	Volts
DC Plate Current	2.5	Amperes
DC Grid Current (Approx.)**	0.016	Ampere
Driving Power (Approx.)** °	800	Watts
Power Output (Approx.)	9.2	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.):			
Carrier	800	. . .	Watts
Crest°	4	. . .	Kw
Power Output (Approx.)	10	. . .	Kw

PLATE-MODULATED RF POWER AMPLIFIER--Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	9000 max.	Volts
DC GRID VOLTAGE	-2000 max.	Volts
DC PLATE CURRENT	3.2 max.	Amperes
DC GRID CURRENT	0.65 max.	Ampere
PLATE INPUT	26 max.	Kw
PLATE DISSIPATION	15 max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	8000	. . .	Volts
DC Grid Voltage:			
From a fixed supply of	-650	. . .	Volts
From a grid resistor of	1280	. . .	Ohms
Peak RF Grid Voltage	1100	. . .	Volts
DC Plate Current	2.5	. .	Amperes
DC Grid Current (Approx.)**	0.51	. .	Ampere
Driving Power (Approx.)**	510	. . .	Watts
Power Output (Approx.)	15.8	. . .	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.)♦	3000	. . .	Watts
Power Output (Approx.)	18	. . .	Kw

RF POWER AMPLIFIER & OSCILLATOR--Class C Telegraphy

Key-down conditions per tube without amplitude modulation□

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
DC GRID VOLTAGE	-2000 max.	Volts
DC PLATE CURRENT	4 max.	Amperes
DC GRID CURRENT	0.65 max.	Ampere
PLATE INPUT	40 max.	Kw
PLATE DISSIPATION	25 max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	10000	11000	. . .	Volts
DC Grid Voltage:				
From a fixed supply of	-500	-540	. . .	Volts
From a grid resistor of	860	900	. . .	Ohms
From a cathode resistor of	125	130	. . .	Ohms

Peak RF Grid Voltage.	1000	1050	. . . Volts
DC Plate Current.	3.5	3.6	. . Amperes
DC Grid Current (Approx.)**	0.58	0.61	. . Ampere
Driving Power (Approx.)**	515	575	. . . Watts
Power Output (Approx.).	25	29.5	. . . Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.)	3400	3750	. . . Watts
Power Output (Approx.).	28	32.5	. . . Kw

• CCS = Continuous Commercial Service.

* Averaged over any audio-frequency cycle of sine-wave form.

** Subject to wide variations depending on the impedance of the plate circuit. High-impedance plate circuits require more grid current and driving power to obtain the desired output. Low-impedance plate circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of supplying considerably more than the required driving power.

o At crest of audio-frequency cycle with modulation factor of 1.0.

♦ Carrier power of driver modulated 100%.

□ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

INSTALLATION

In transportation and storage of the 9C27, care should be taken to protect the tube from rough handling that would damage the metal-to-glass seals or other parts. The 9C27 is suspended within its shipping crate so that it will not come in contact with the sides of the crate during shipment. It should be stored in the crate with the filament end up and should be protected from moisture and extreme temperature changes. Under no circumstances should crated tubes be piled one on top of another. Furthermore, while the tube is being removed from its crate or from its water jacket, it should be held with both hands on the bulb below the corona shield and be kept in a vertical position with the filament end up. Hands should be protected by heavy leather gloves as a safety precaution in case of bulb breakage. After such removal, the tube should be grasped by the plate below the plate flange, still keeping the filament end up. The weight of the 9C27 crated for shipment is approximately 69 pounds; uncrated, approximately 18 pounds.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, any foreign material clinging to the tube should be removed. An air blast is recommended for removing any such material from the entrant metal header.

Mounting of the 9C27 requires the use of a water jacket, and the standard gasket, RCA Stock No. 43244. Information concerning the water jacket can be

obtained from us on request. The jacket should support the tube in a vertical position with the filament end up. If the 9C27 is to be subjected to appreciable vibration in service, it is advisable to support the water jacket by springs. When concrete basework is provided for the equipment and when machines or other sources of vibration are not present, it is unnecessary to use a spring suspension. The installation of all wires and connections must be made so that they will not be close to or touch the bulb. This precaution is necessary to avoid almost certain puncture of the glass from corona discharge.

The 9C27 should be placed in its water jacket very carefully and then firmly fastened. It is advisable to fasten the tube in its jacket securely before making the electrical connections. Before the jacket clamping device is tightened, care must be taken to see that the contacts seat properly on top of the flange. This procedure prevents possible strain at the plate seal caused by improper seating of the flange on the jacket. When this preliminary adjustment indicates that the tube is properly seated, the jacket ring can be tightened gently. Do not tighten it more than is required to seat the flange properly on the gasket. The standard gasket is supplied with each tube. A new gasket should be used whenever a tube is placed in the jacket. It is recommended that the gasket be coated with a thin film of Pro-dag* to prevent sticking. If these precautions are not taken, the tube may be ruined by a glass crack caused by uneven pressure on the flange. The moving parts of the jacket should be kept free from rusting and sticking by coating them with a thin film of oil or Oil-dag*. Do not use adhesive to seal the jacket against leaks because any sticking of the plate in the jacket may cause damage to the tube during its removal. Before readjustment of either the tube or the jacket is made, the leads should be disconnected.

When the 9C27 is removed from its jacket, first be sure that the temperature of the grid and filament is below red heat. Next remove the filament and grid connections. Then completely release the locking device and carefully remove the tube from the jacket. Should sticking occur, twist the tube gently back and forth and, at the same time, gently raise. Never use force to remove the tube.

The water-cooling system consists, in general, of a source of cooling water, a water jacket, a feed-pipe system which carries the water to and from the jacket, and provision for interlocking the water flow with the power supplies. When the plate is at high potential above ground, the feed-pipe system should have good insulation qualities and proper design to reduce the leakage current to a negligible value.

The piping system must be arranged to avoid air traps in the water jacket. A water flow of 12 to 15 gallons per minute, depending on the type of service, is usually sufficient. Under abnormal conditions, an increased rate of flow may be necessary to prevent overheating. The use of an outlet water thermometer and a water flow meter is recommended. The water must not be allowed to boil and the flow must be great enough to prevent the formation of steam

* Made by Acheson Colloids Corporation, Port Huron, Michigan.

bubbles on the plate. The temperature of the water at the outlet must not exceed 70°C.

An approximate value of the plate dissipation, which should not exceed the value given under MAXIMUM RATINGS for each class of service, may be calculated from the following equation:

$$P_{kilowatts} = \frac{n(t_o - t_i)}{4}$$

in which t_i is the known initial temperature of the cooling water in centigrade degrees, t_o is the temperature of the water at the water-jacket outlet in centigrade degrees, and n is the number of gallons per minute of flow.

The formation of steam may be detected by the use of an improvised stethoscope which may consist of 6 feet of high-grade insulating tubing. This stethoscope is pressed against the jacket at various points while listening tests are made. Because of the danger involved in this test, care should be taken to ground the testing device at some point between the observer and the jacket. The test for boiling water should be made each time the tube is adjusted.

Distilled water is recommended for cooling because it greatly reduces the probability of scale formation. Scale is usually very hard and appears as a light-colored deposit on the plate during life. Scale prevents adequate cooling of the tube because it hinders proper transfer of heat from the plate to the water. Because undistilled water varies in mineral content, and because of variation in amount of heat to be dissipated, temperature of the water, and rate of flow, no specific recommendations can be given to prevent scale when undistilled water is used. In any case, a sample of the cooling water should be analyzed before plans are made for the water system. In general, water which shows a hardness greater than 10 grains per gallon should not be used. Regardless of the kind of water used, the system should be kept free of an accumulation of foreign matter. A 10 per cent solution of hydrochloric acid will dissolve scale in emergency cases. After such treatment, the plate should be carefully rinsed. Since the tube must be removed from its jacket for this treatment and since frequent removals are objectionable because of danger of accidental breakage, the best insurance against tube failure due to scale is the complete elimination of the cause of scale.

Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water will damage the tube. In fact, without cooling water, the heat of the filament alone is sufficient to cause serious harm. It is, therefore, necessary to provide a method of preventing operation of the tube in case the water supply should fail. This may be done by the use of water-flow circuit breakers or interlocks which open the filament and plate supplies when the flow is insufficient or ceases.

Water cooling of the 9C27 must continue for at least 2 minutes after the removal of all voltages.

An air-cooling system, interlocked with the power supplies, is required

to cool the entrant metal header of the 9C27. This system consists of a blower and an air duct of suitable cross-sectional area directed downward into the header. The air flow from the duct should be approximately 10 cubic feet per minute in order to limit the temperature of the filament seals to 165°C. The cooling air must not contain any water or foreign matter. A suitable duct should also be used to conduct air to the plate seal and bulb sufficient to limit the bulb temperature to 180°C at the hottest point, and the plate-seal temperature to 165°C. The temperature of the filament and plate seals and of the bulb may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilac. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York, N.Y., in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of 1 per cent.

The air-cooling system should be electrically interconnected with the filament and plate power supplies to prevent the application of voltages to the tube without cooling. Precautions should be taken to insulate the air-cooling system from the tube or circuit parts which may be at high potential.

The thoriated-tungsten filament of the 9C27 may be operated from direct current or from single-phase alternating current. The filament consists of twelve strands which are brought out to two terminals sealed into the entrant metal header. The filament connectors should make firm, large-surface contact with the filament terminals in order to prevent heating by the high filament current. The filament leads should not be taut, but should allow for some movement without placing a strain on the glass bulb.

Under normal full-load conditions, the filament voltage should be maintained at the rated value within ± 5 per cent; with light loads, reduction of the filament voltage by as much as 5 per cent is permissible. In the latter case, care must be taken that the reduction of the filament voltage, and therefore, of emission is not so great that the peak-current requirements can not be met. It is recommended that in intermittent service where the standby periods are no longer than 15 minutes, the filament voltage be reduced to 80 per cent of normal during standbys; for longer periods, the filament voltage should be turned off. The filament should be operated at constant voltage rather than at constant current, and must be allowed to reach normal operating temperature before other voltages are applied to the tube. A suitable voltmeter should be permanently connected directly across the filament terminals so that the filament voltage will always be known.

When direct current is used, the polarity of the leads should be reversed every 500 hours of operation.

A filament starter should be used to raise the filament voltage gradually and to limit the high initial rush of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the total filament current never exceed, even momentarily, a value of 425 amperes.

The grid terminal of the 9C27 is in the form of a flange on the entrant

metal header. It is suggested that the connector for the grid lead be in the form of a flat yoke extending around perhaps half the circumference of the flange. At the higher frequencies, it is recommended that the flat-yoke connector extend completely around the circumference of the flange and that adequate connections be made to it to provide uniform rf current distribution over the flange. This yoke must be provided with holes so that it can be bolted to the flange for good electrical contact. The screws attaching the corona shield to the flange should be removed when the yoke is being bolted to the flange; they are then replaced. The yoke and grid lead should not place any strain on the header because of the possibility of damage to the glass-to-metal seal. Similarly, connections should not be soldered to the flange; and the flange should not be used to support circuit parts.

The plate connection for the 9C27 is provided automatically through the clamping mechanism of the water jacket which is connected electrically to the high-voltage supply. The rated plate voltage is extremely dangerous to the user. Great care should be taken during adjustment of the circuit. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the plate supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

The plate circuit should be provided with a time-delay relay to delay the application of plate voltage until the filament has reached normal operating temperature. The plate circuit must also be provided with protective devices to prevent the tube from drawing a heavy overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The time required for the operation of the relay and circuit breakers should be about 1/10 second and not more than 1/6 second. A voltage-dropping resistor should be permanently connected in series with the plate lead of each tube for protection of the tube during the time required for the relay and circuit breaker to act. The minimum value of this resistor which will give adequate protection with minimum power loss is as follows:

SERIES RESISTOR	25	50	75	100	Ohms
MAXIMUM POWER OUTPUT OF RECTIFIER	40	100	250	640	Kw

A capacitor of high value should never be connected directly across the tube in such a manner that a disturbance within the tube will discharge appreciable energy from the capacitor.

The grid return and the plate return should be connected to the center

point of the filament voltage supply when ac is used. When dc is used, the grid and the plate return should be connected to the negative filament terminal and should still be connected to the negative filament terminal whenever the filament polarity is reversed.

When a 9C27 is first placed in service, care should be taken to see that the water- and air-cooling systems are functioning properly. The tube should then be operated without plate voltage for 5 minutes at rated filament voltage. After this initial preheating schedule, the tube should be operated at approximately one-half the usual plate voltage for 15 minutes. Full plate voltage may then be applied and the tube operated under normal load conditions for a period of 1 hour or more. It is recommended that spare tubes be given the preheating and initial-operation treatment every 3 months. This procedure will insure that only good tubes are carried in stock.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube and associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooling water or the glass bulb, the plate voltage may be raised in steps to the desired value. Adjustments should be made at each step for optimum operation.

Overheating of the 9C27 by severe overload may impair its vacuum. When the quantity of released gas is not too great, it is often possible to degassify the tube by operating it at reduced plate voltage. The first step in the process should be a short period of operation at a plate voltage of one-half the rated value. The plate voltage may then be increased to the normal value and the tube allowed to operate for an hour or more. In severe cases, it may be necessary to degassify the tube by increasing the plate voltage in small steps until the normal voltage is reached. At each new voltage, the tube should be allowed to operate long enough to insure the attainment of stabilized conditions. The voltage may be varied by means of a series resistor connected in the plate-supply lead.

If the release of gas has caused deactivation of the filament, the activity of the filament can often be restored by operating the filament at its normal voltage for 10 minutes or longer without plate or grid voltage. The reactivation process may be accelerated by raising the filament voltage to not higher than 120 per cent of normal value for a few minutes.

APPLICATION

The maximum ratings in the tabulated data for the 9C27 are limiting values above which the serviceability of the 9C27 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 9C27 may be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. It may be operated at higher frequencies provided the maximum values of plate voltage, plate input, and grid current are reduced as the frequency is raised. Other maximum ratings remain the same. When the 9C27 is used in grounded-grid circuits at the highest frequencies, care must be exercised to shield completely the filament-grid circuit from the grid-plate circuit.

The following table shows the highest percentage of maximum plate voltage, plate input, and grid current that can be safely used up to 100 megacycles. Special attention should be given to adequate cooling at the higher frequencies.

FREQUENCY	30	50	75	100	Mc
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE, PLATE INPUT & GRID CURRENT:					
Class B Telephony	100	93	87	80	per cent
Class C Telephony	100	87	74	61	per cent
Class C Telegraphy	100	87	74	61	per cent

In class B af power amplifier and modulator service, the 9C27 should be operated with grid bias obtained from a battery or other source of dc voltage of good regulation. It should not be obtained from a high-resistance source such as a grid resistor, nor from a rectifier unless the latter has exceptionally good voltage regulation. Each grid circuit should be provided with a separate bias adjustment to balance the grid and plate currents.

In class B rf power amplifier telephony service, the 9C27 is supplied with unmodulated dc plate voltage. The grid is excited with rf voltage modulated at audio frequency in one of the preceding stages, and power output is proportional to the square of the grid-excitation voltage. Under these conditions, the plate dissipation is greatest when the carrier is unmodulated. Grid bias is obtained from a battery or other source of dc voltage of good regulation.

When used in grounded-grid class B rf amplifier telephony service, the 9C27 can be modulated 100 per cent in the conventional manner except that increased driving power, resulting in increased power output, will be required as shown in the tabulated data. Grounded-grid operation has the advantage of greatly reducing or entirely eliminating the power dissipated in "swamping" resistors required in conventional grounded-filament operation.

In plate-modulated class C rf power amplifier service, the 9C27 should be supplied with bias from a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor. The cathode resistor should be by-passed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation. Grid-bias voltage

is not particularly critical so that correct adjustment may be obtained with values differing widely from the calculated values. For operation with a modulation factor of 1.0, sufficient cooling must be provided to dissipate 50 per cent more plate power than under carrier conditions.

In grounded-grid plate-modulated class C rf power amplifier service, the 9C27 can be modulated 100 per cent if the rf driver stage is also modulated 100 per cent simultaneously. Care should be taken to insure that the driver-modulation and the amplifier-modulation voltages are exactly in phase. In such service, the 9C27 requires increased driving power, but increased power output is obtained as shown in the tabulated data.

In class C rf telegraph service of either the grounded-filament or the grounded-grid type, the 9C27 may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value. If the 9C27 is operated at the maximum rated plate voltage of 11500 volts, a fixed bias of at least -250 volts should be used.

In tuning a grounded-grid rf amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

Circuit-design considerations affecting operation of the 9C27 are given in the following paragraphs.

The grid circuit of the 9C27 when used with its filament grounded should be designed and adjusted so that no appreciable voltage can occur between grid and filament at any frequency except the fundamental. This procedure will minimize the occurrence of parasitic oscillations and be simplified if the generation of unwanted harmonic frequencies is avoided. The use of a plate tank circuit having the proper Q and the avoidance of over-excitation are helpful. Link coupling between the driving stage and the power amplifier is useful especially if the Q of the grid tank circuit is high enough to provide good voltage regulation.

Because of the relatively large high-frequency currents carried by the grid and plate terminals, heavy conductors should be used to make the circuit connections.

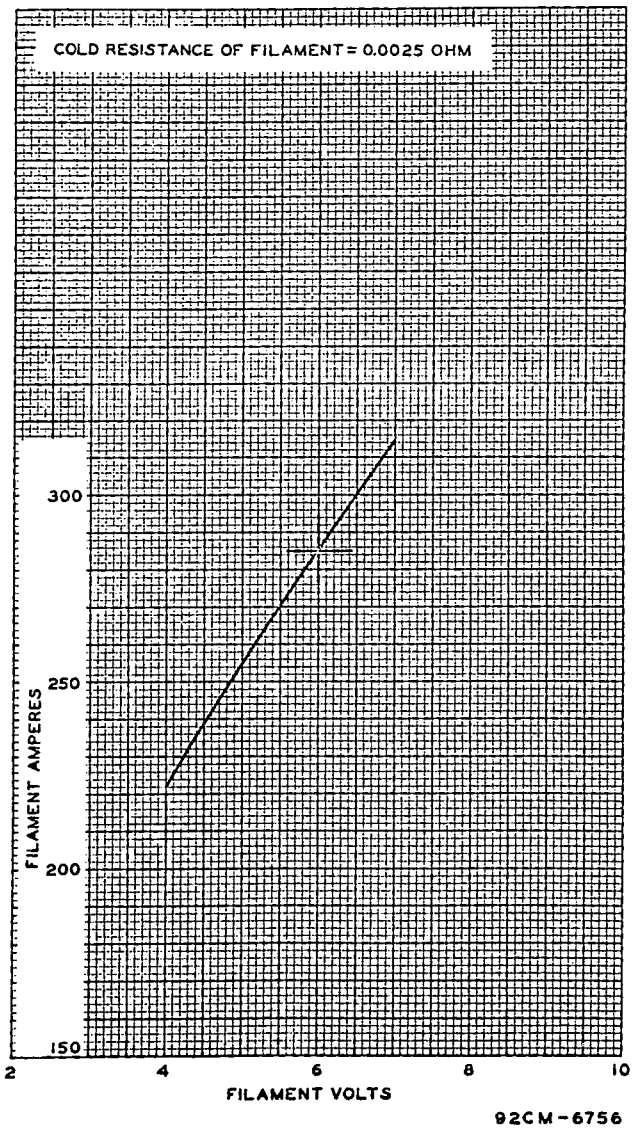
When more radio-frequency power is required than can be obtained from a single tube, push-pull or parallel circuit arrangements may be used. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive the tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. When two or more tubes are used in the circuit, precautions should be taken so that the plate

current drawn by each tube is the same.

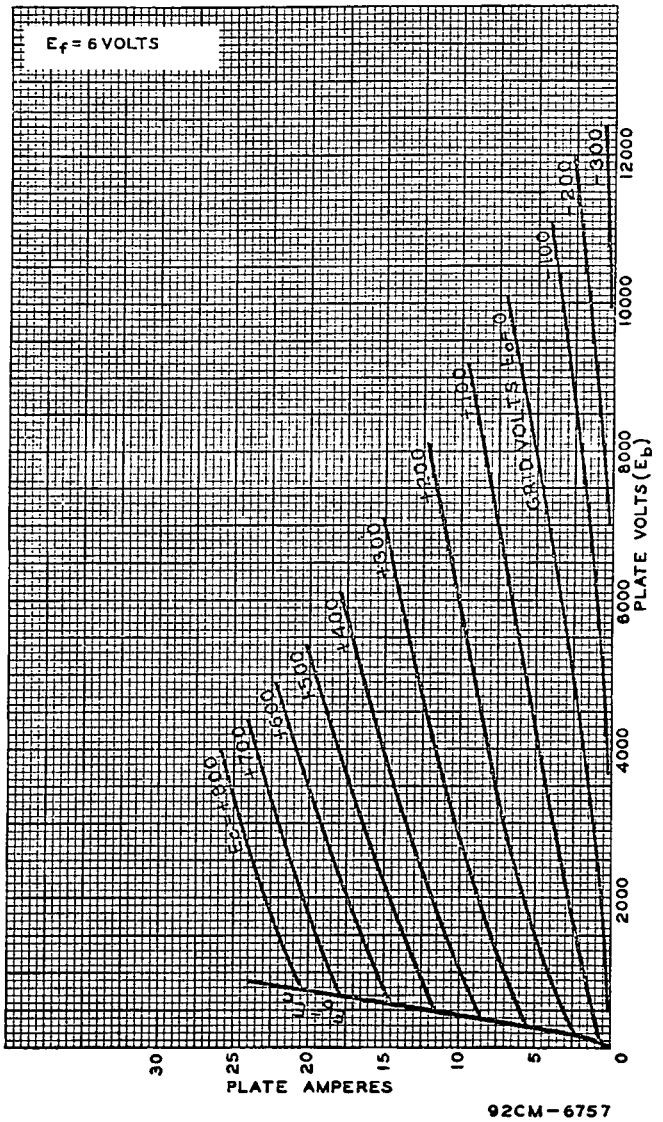
REFERENCE

E. E. Spitzer, "Grounded-Grid Power Amplifiers," Electronics, Vol. 19, No. 4, pp. 138 - 141 (April, 1946).

AVERAGE FILAMENT CHARACTERISTIC

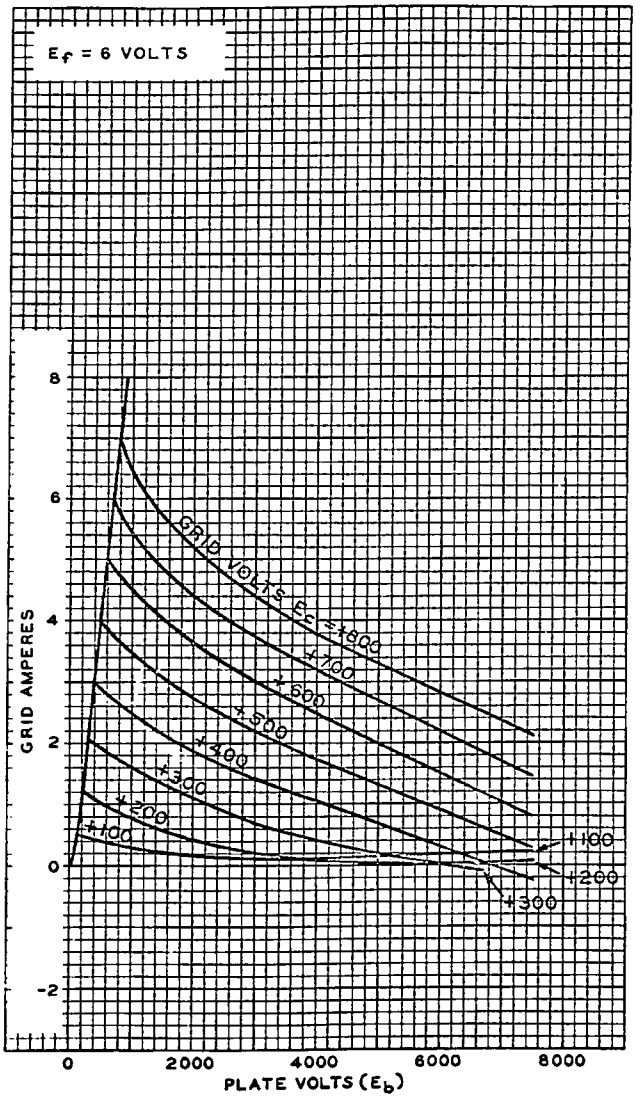


AVERAGE PLATE CHARACTERISTICS



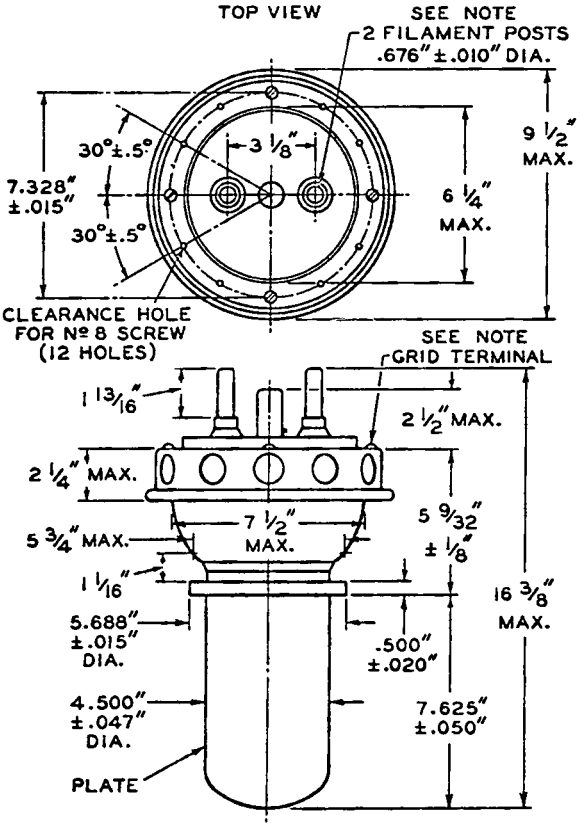
92CM-6757

TYPICAL GRID CHARACTERISTICS



92CM-6759

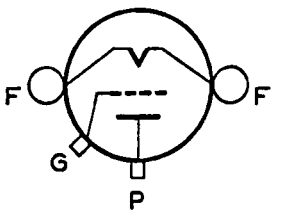
DIMENSIONAL OUTLINE



NOTE: FLEXIBLE CONNECTIONS ARE REQUIRED.

92CM-6709

TUBE SYMBOL



F: FILAMENT
G: GRID
P: PLATE

RMA Release # 295

File Release 295

May 9, 1942

CATHODE-RAY TUBE

Electrostatic-Magnetic Deflection
Electrostatic Focus
Medium Persistence Screen
16-Inch Overall Length
9-Inch Bulb

9JP1/1809-P1

RCA-9JP1/1809-P1 is a high-vacuum cathode-ray tube having a viewing screen nine inches in diameter. The tube uses a combination of magnetic and electrostatic fields for deflection of the electron beam. It features short overall length and close-spaced electrostatic electrodes to provide good deflection sensitivity. With this close spacing, the maximum spot travel caused by these electrodes is approximately two inches. The 9JP1/1809-P1 produces a luminous spot having a greenish hue, and is suitable for the observation and photography of transient and recurrent phenomena.

The indirectly-heated cathode, the control electrode (grid), the first anode, and the second anode constitute an electron gun for projecting a beam of electrons upon the fluorescent screen. The resultant luminous spot can be regulated as to spot size and intensity by suitable choice of electrode voltages.

Deflection of the electron beam is ordinarily accomplished by the use of an electromagnetic field and an electrostatic field. The electromagnetic field is usually placed so that its axis coincides with that of the electrostatic field in order that the deflection produced by one field will be at right angles to that produced by the other field. One field is controlled by the voltage under observation; the other is used for the time sweep.

The 9JP1/1809-P1 is recommended for use in oscillographic applications where the inertialess characteristic of the electron beam, the provision for two methods of beam control, the brilliant image, and the short overall length all contribute to the general utility of this type.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	2.5	Volts
HEATER CURRENT	2.1	Amperes
FOCUSING METHOD		Electrostatic
DEFLECTION METHOD		Electrostatic and Magnetic
Electrode DJ_1 is on same side of tube as base pin 2		
Electrode DJ_2 is on same side of tube as base pin 6		
PHOSPHOR		No.1
FLUORESCENCE		Green
PERSISTENCE		Medium
DIRECT INTERELECTRODE CAPACITANCES:		
Control Electrode to All Other Electrodes	8	μμf
Deflecting Electrode DJ_1 to Deflecting Electrode DJ_2	1	μμf
Either Deflecting Electrode DJ_1 or DJ_2 to All Other Electrodes	3.6	μμf
Cathode to All Other Electrodes	8	μμf
OVERALL LENGTH	15-11/16" ± 3/8"	
GREATEST DIAMETER of BULB	9" ± 1/8"	
MINIMUM DIAMETER of SCREEN		8"
BULB SIDE TERMINALS		Snap Connectors
BASE		Small Wafer Octal 8-Pin, Sleeve
DEFLECTION YOKE: Position on Tube Neck		{Lip Flush with Bulb Reference Line (see OUTLINE DRAWING)
Working Length for 55° Angle Deflection		2" *max.*

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

Maximum Ratings Are Based on a Line-Voltage Design Center of 117 Volts

ANODE NO.2 (High-Voltage Electrode) VOLTAGE		5000 *max.*	Volts
ANODE NO.1 (Focusing Electrode) VOLTAGE		2000 *max.*	Volts
GRID (Control Electrode) VOLTAGE		Never Positive	
PEAK VOLTAGE BETWEEN ANODE NO.2 and EITHER DEFLECTING ELECTRODE		3000 *max.*	Volts
D-C HEATER-to-CATHODE POTENTIAL		125 *max.*	Volts
GRID-CIRCUIT RESISTANCE		1.5 *max.*	Megohms
TYPICAL OPERATION:			
Anode No.2 Voltage#	2500	5000	Volts
Anode No.1 Voltage for Focus at 75% of Grid Voltage for Cut-Off (Approx.)*	785	1570	Volts
Grid Voltage for Cut-Off** ##	-45	-90	Volts
Deflection Sensitivity Electrodes DJ_1 and DJ_2	0.272	0.136	mm/volt D.C.
Deflection Factor Electrodes DJ_1 and DJ_2	93.8	187	volts D.C./in.

\# Brilliance and definition decrease with decreasing anode No.2 voltage. In general, anode No.2 voltage should not be less than 2500 volts.
* Supply should be adjustable to ± 20% of this value.
\## Supply should be adjustable to ± 50% of this value.
** Visual extinction of a stationary focused spot.

INSTALLATION

The *base* pins of the 9JP1 fit the standard octal socket which may be installed to hold the tube in any position. The socket should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The *bulb* of this type, except for the screen surface, should be enclosed in a grounded metal case. If an iron or steel case is used to minimize the effect of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized.

The *heater* is designed to operate at 2.5 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage between the heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

The *cathode* is connected to base pin No.6, to which the grid and anode returns should be made.

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The *fluorescent screen* employed in the 9JP1 is of the phosphor No.1 (medium persistence) type. It has good visual and photographic properties as well as high luminous efficiency.

The *d-c supply voltages* for the electrodes may be obtained conveniently from a high-voltage, vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage doubler type. For the same reason, the filter requirements are simple. A 0.5 to 2 μf condenser will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended.

Two *electrodes*, located in the bulb neck, provide for electrostatic deflection of the electron beam. These two electrodes are capable of producing a deflection of approximately two inches. The deflection so produced is parallel to the lines of the electrostatic field. The d-c potential of each deflecting electrode must be maintained essentially equivalent to that of anode No.2 in order to avoid building a charge on the deflecting electrodes. A charge on the deflecting electrodes causes a permanent deflection of the beam. The d-c potential of the deflecting electrodes may be kept essentially the same as that of anode No.2 by connecting resistors having values not greater than 10 megohms between each deflecting electrode and anode No.2. This arrangement by suitable choice of resistor values minimizes pattern distortion and pattern drift resulting from unbalanced potentials on the deflecting electrodes. The smaller the resistor values, the less distortion for a given beam current. The beam current should ordinarily be kept low. At times when it is necessary to use a high value of beam current, as when photographs are to be taken, the value of the resistor should be reduced so that the zero-axis shift will be minimized. The resistor of one or both deflecting electrodes may be connected to a d-c bias voltage to obtain centering of the beam.

The *deflection sensitivity* and the *deflection factors* of the deflecting electrodes for typical anode No.2 voltages are given under TYPICAL OPERATING CONDITIONS.

A second method for deflecting the beam is provided by an electromagnetic system which consists of one or more pairs of coils. Each coil of a pair is arranged diametrically opposite its mate in such a manner that the magnetic field is at right angles to the axis of the tube. The deflection of the beam is at right angles to the direction of the magnetic field. The yoke, placed around the bulb neck close to the bulb flare, should be designed so that the deflection of the beam is accomplished within the space of not more than two inches, parallel to the tube axis, measured from the reference line shown on the OUTLINE DRAWING.

Because of the short bulb of the 9JP1, the beam must be deflected through the relatively wide angle of 55° to cover the entire screen width. A deflection yoke suitable for this tube is shown in the accompanying drawings. Although this tube requires but one pair of coils, the drawings show two pairs: one pair may be used in conjunction with the electrostatic electrodes of the tube, or both pairs of coils may be used to obtain full magnetic deflection. In the latter case, the electrostatic electrodes may also be used to introduce an additional voltage for deflection of the beam. The yoke should be placed as close as possible to the junction of the bulb cone and the cylindrical neck. This arrangement is necessary to prevent the beam striking the neck when the deflection is sufficient to reach the edge of the screen.

The high voltages at which the 9JP1 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these voltages. Precautions must include safeguards which definitely eliminate all hazards to personnel. All circuit parts which may be at high potential should always be enclosed and "interlock" switches should be used to break the primary circuit when access to the equipment is required.

In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit because of condenser breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

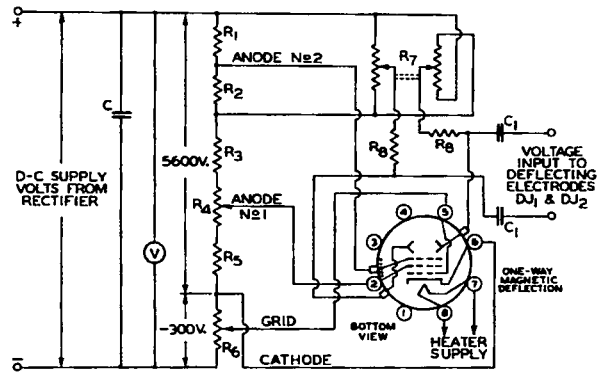
The cathode-ray oscillograph is an instrument adaptable to a wide variety of applications. A few of the more important are: the study of wave shapes and transients, measurement of modulation and peak voltages, adjustment of radio receivers, comparison of frequencies, and the indication of balance in bridge circuits.

A diagram illustrating the essential circuit for the use of the 9JP1 in an oscillograph is shown. The electrode voltages are obtained from a bleeder circuit connected across the high-voltage supply. A bleeder current of one or two milliamperes is usually satisfactory; considerably larger values may require the use of more filtering than can be provided conveniently by a single condenser shunted across the d-c supply. With small bleeder currents, a single condenser filter usually is adequate. A variable d-c voltage for the control electrode and one for anode No.1 can be obtained from potentiometers in the bleeder circuit.

Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No.1 voltage to anode No.2 voltage. Ordinarily, the ratio is varied by adjustment of anode No.1 voltage.

Regulation of spot size and intensity can be accomplished by varying anode No.2 current and/or voltage. The current to anode No.2 may be increased by decreasing the bias applied to the control electrode (grid). An increase in anode No.2 current increases the size and the intensity of the spot. An increase in the voltage applied to anode No.2 increases the speed of the electrons and, therefore, increases intensity and decreases spot size. The maximum anode No.2 voltage shown under MAXIMUM RATINGS is based on a line-voltage design center of 117 volts. The 9JP1 will operate satisfactorily at lower anode No.2 voltages, but brilliance and definition decreases with decreasing anode No.2 voltages. In general, anode No.2 voltage should not be less than 2500 volts. When any of these adjustments are made, consideration should be given to the limiting voltage ratings shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

TYPICAL OSCILLOGRAPH CIRCUIT



C = FILTER CONDENSER, 0.5 to 2 μf
C_1 = ISOLATING CONDENSERS, SEE NOTE BELOW
R_1,R_2 = 0.4 MEGOHM
R_3 = 1.2 MEGOHMS
R_4 = 0.5 MEGOHM POTENTIOMETER
R_5 = 0.5 MEGOHM
R_6 = 0.15 MEGOHM POTENTIOMETER
R_7 = 1.5 MEGOHM (EACH SECTION) DUAL POTENTIOMETER FOR BEAM CENTERING
R_8 = POTENTIAL EQUALIZING RESISTORS, SEE NOTE BELOW AND TEXT

NOTE: When the cathode or the negative end of the cathode-ray high-voltage supply is grounded, blocking condensers C_1 should have a high voltage rating. When anode No.2 is grounded, condensers C_1 may be low-voltage condensers.

For d-c amplifier service, the deflecting electrodes should be coupled direct to the output of the amplifier by omitting the blocking condensers. In addition, it will usually be preferable to remove the associated deflecting electrode resistor in order to minimize the loading effect of the resistor on the d-c amplifier. With the resistor removed, it is essential, in order to minimize the spot defocusing, that anode No.2 be returned to some point in the d-c amplifier circuit such that the potential difference between anode No.2 and the average voltage across the deflecting electrodes will be as low as possible.

In applications involving extremely accurate measurements, the anode No.2 current should be reduced to the minimum consistent with the desired brilliance of pattern. Where high brightness is an important consideration, the voltage applied to anode No.2 may be increased to the maximum value. This procedure, however, is not always desirable since the greater speed of the electrons in the beam causes reduced deflection sensitivity.

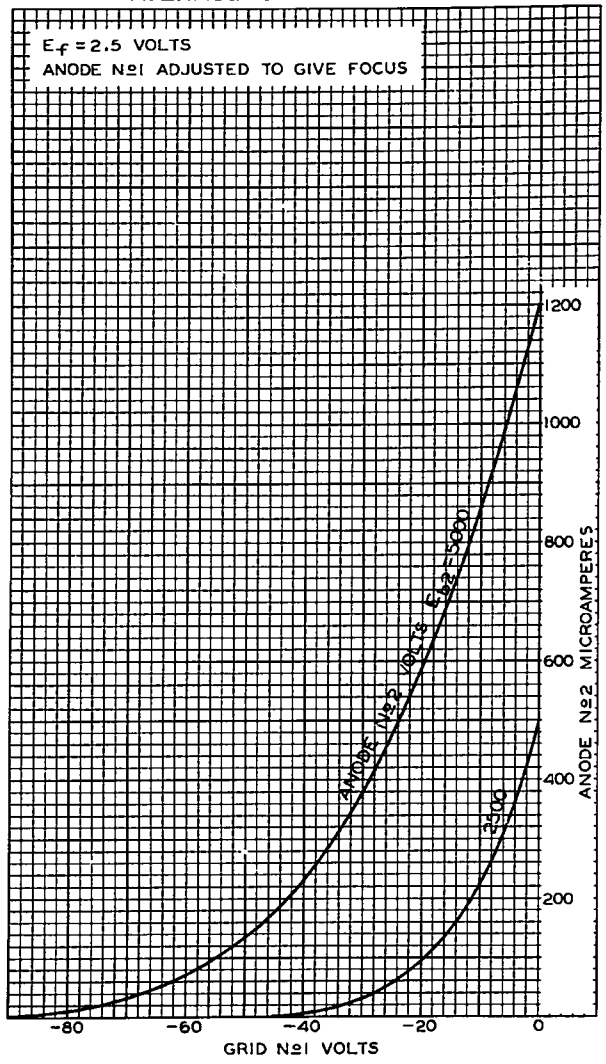
It is important to note that a beam producing a high-intensity spot will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the beam be kept in motion over a reasonably large area by the application of voltage to the deflecting systems or that the brilliance be reduced to a low value by adjustment of the control-electrode voltage.

Photographs of the phenomena appearing on the screen of the 9JP1 can be made with an ordinary camera. Photographing is done preferably in a subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the screen. The time of exposure will depend on the type of film or plate emulsion used, the magnification of the pattern and the brightness of the pattern. When transients are to be photographed, patterns having low brightness can easily be compensated for by longer exposure. The use of film having high green sensitivity is recommended. Verichrome-type film has been found to give excellent results.

For *high-speed photographic work* involving non-recurrent phenomena, it is permissible to increase the screen input power per sq cm, for the short time interval required to make the exposure, above that required for visual observation. The extent to which the anode No.2 current may be increased without harming the fluorescent screen is a function of the rate of beam travel and pattern size, and an inverse function of duration. Short-interval operation at increased input can be obtained by means of a temporary decrease in the control-electrode voltage. A switching arrangement should be provided to switch the control-electrode voltage rapidly between a negative and a less negative value. The exposure is made while the control-electrode voltage is at the decreased (less negative) value.

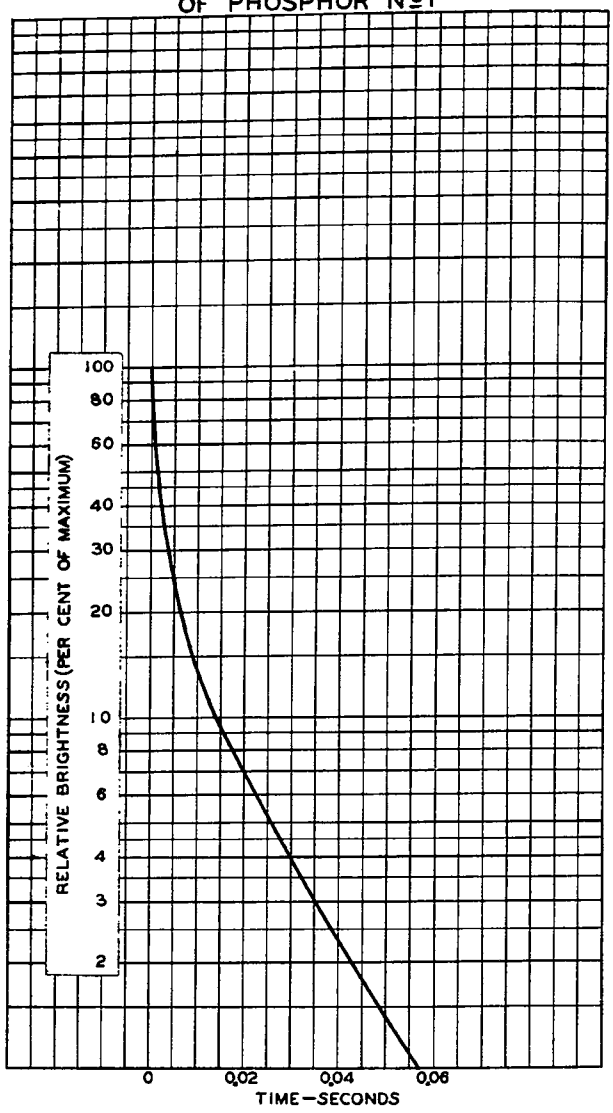
The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

AVERAGE CHARACTERISTICS



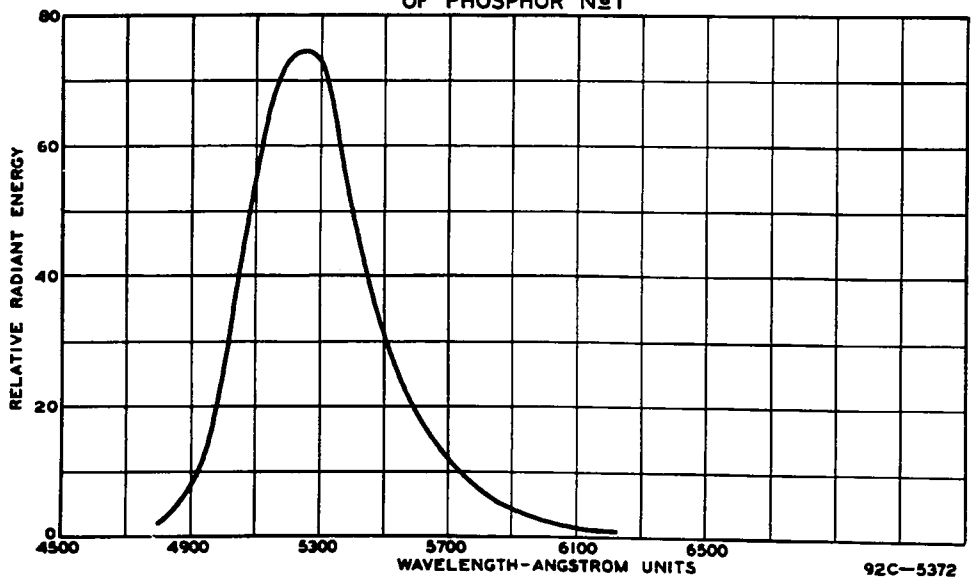
APRIL 20, 1942 92C-6390

PERSISTENCE CHARACTERISTIC OF PHOSPHOR N°1



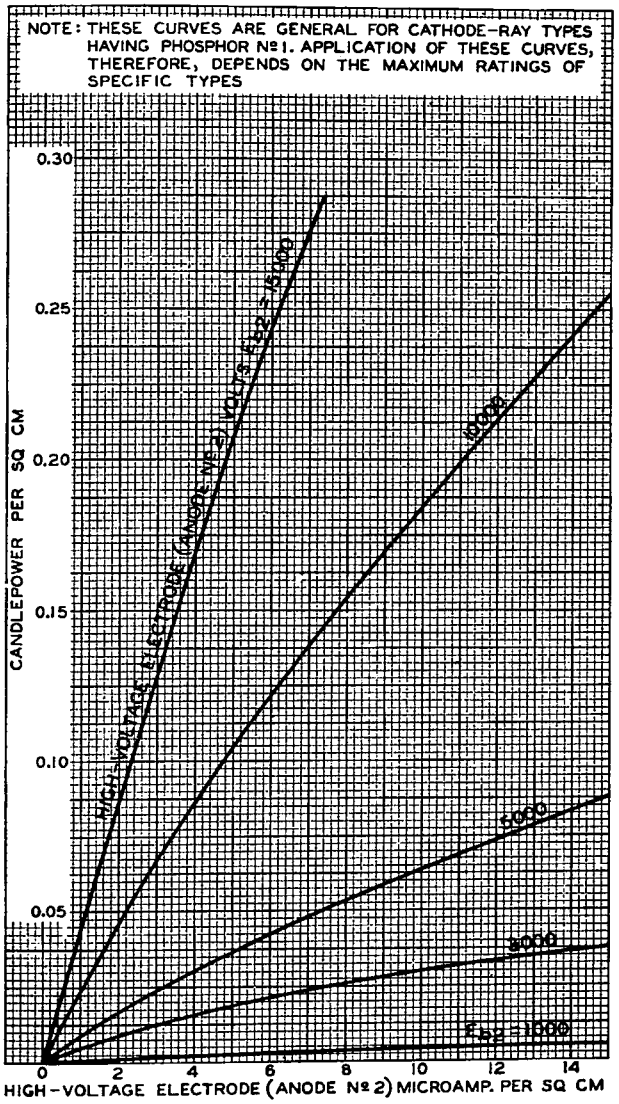
FEB. 28, 1936 92C-5380

SPECTRAL ENERGY CHARACTERISTIC OF PHOSPHOR N°1



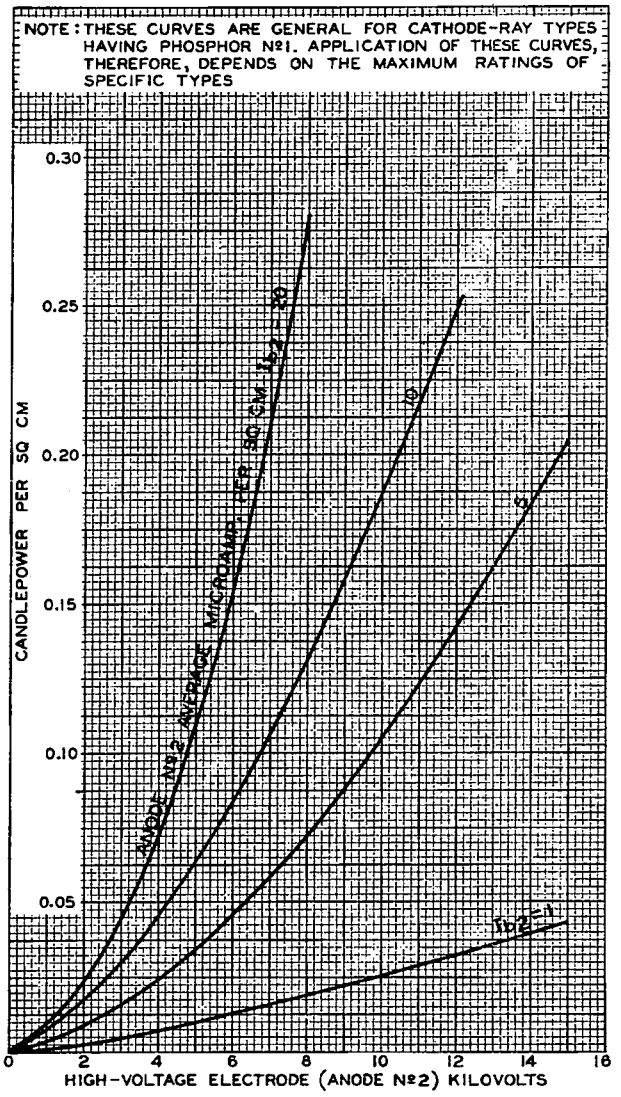
92C-5372

AVERAGE CHARACTERISTICS OF PHOSPHOR Nº 1



NOV. 23, 1938 92C-6010

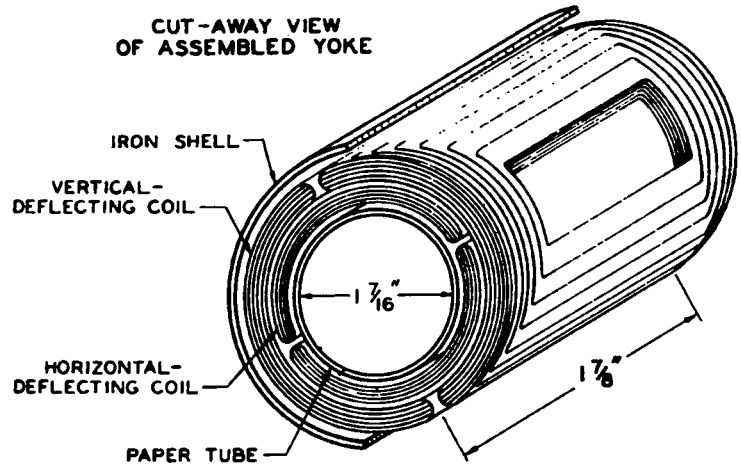
AVERAGE CHARACTERISTICS OF PHOSPHOR Nº 1



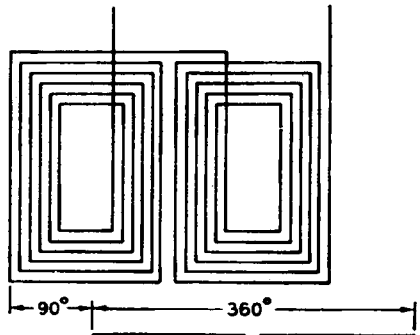
NOV. 23, 1938 92C-6009

DEFLECTING YOKE
FOR WIDE-ANGLE DEFLECTION

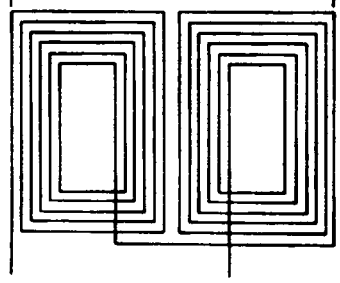
CUT-AWAY VIEW
OF ASSEMBLED YOKE



SCHEMATIC DIAGRAM OF
HORIZONTAL WINDINGS
425 TURNS EACH COIL

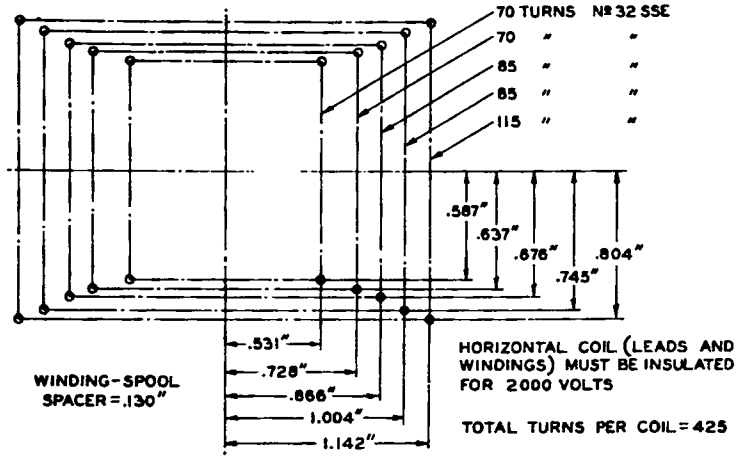


SCHEMATIC DIAGRAM OF
VERTICAL WINDINGS
500 TURNS EACH COIL

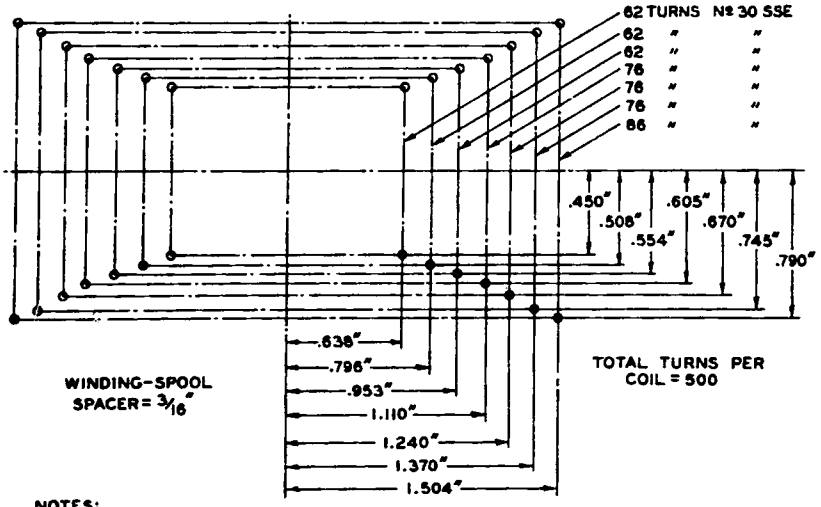


WIDE-ANGLE YOKE DATA

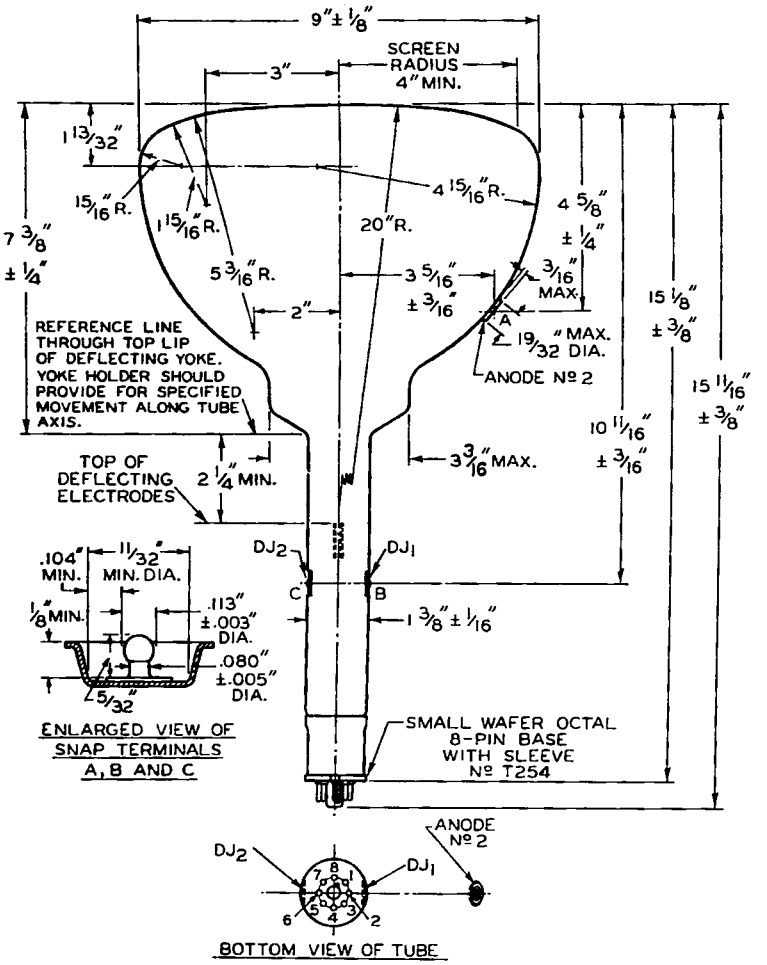
HORIZONTAL COIL FORM
AND WINDING DATA



VERTICAL COIL FORM
AND WINDING DATA



NOTES:
IRON SHELL = 3 LAYERS OF .020" TO .030" SWEDISH IRON
DRILL HOLES FOR PINS WITH Nº 55 DRILL
INSULATION AND SHIELD = 1/32" BETWEEN HORIZONTAL AND VERTICAL COILS

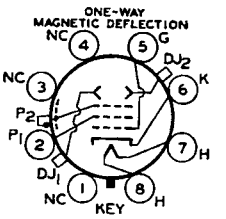


THE PLANE THROUGH THE TUBE AXIS AND EACH OF THE FOLLOWING ITEMS MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE NO.2 TERMINAL BY THE ANGULAR TOLERANCES (MEASURED ABOUT THE TUBE AXIS) AS SHOWN:

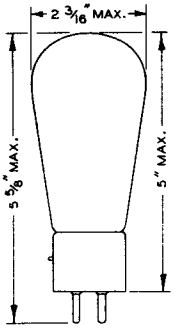
ITEM	TOLERANCE
PIN NO.2	± 9°
DJ_1	± 5°
DJ_2	±13°
TRACE PRODUCED BY DJ_1 & DJ_2	± 7°

92C-6331

Bottom View of Socket Connections

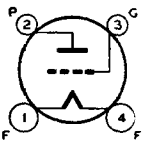


DJ_1, DJ_2 = DEFLECTING ELECTRODE
P_2 = ANODE NO.2
P^2 = ANODE NO.1
G^1 = GRID (CONTROL ELECTRODE)
H = HEATER
K = CATHODE
NC = NO CONNECTION



RCA-10

POWER AMPLIFIER OSCILLATOR



The 10 is a three-electrode, high-vacuum tube suitable for use as an audio-frequency amplifier in equipment designed for its characteristics.

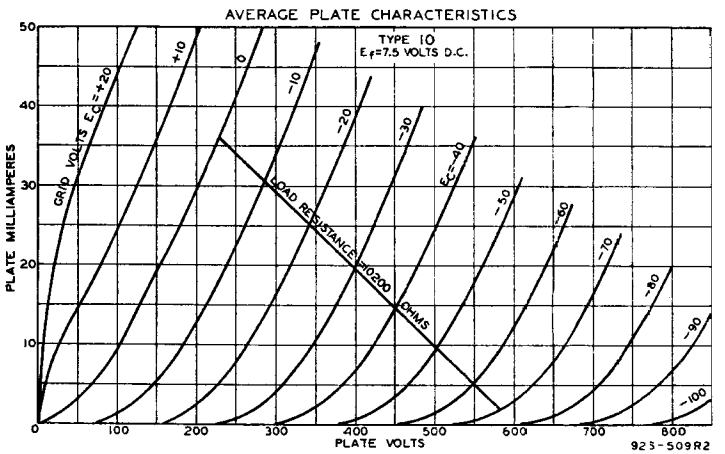
CHARACTERISTICS

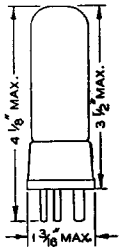
Filament Voltage (A. C. or D. C.)			7.5	Volts
Filament Current			1.25	Amperes
Plate Voltage	250	350	425 *max.*	Volts
Grid Voltage*	−23.5	−32	−40	Volts
Plate Current	10	16	18	Milliamperes
Plate Resistance	6000	5150	5000	Ohms
Amplification Factor	8	8	8	
Transconductance	1330	1550	1600	Micromhos
Load Resistance	13000	11000	10200	Ohms
Self-Bias Resistor	2350	2000	2220	Ohms
Undistorted Power Output	0.4	0.9	1.6	Watts
Grid-Plate Capacitance			7	μμf
Grid-Filament Capacitance			4	μμf
Plate-Filament Capacitance			3	μμf
Bulb				S-17
Base				Medium 4-Pin Bayonet

* Grid voltages are given with respect to the mid-point of filament operated on a. c. If d. c. is used, each stated value of grid voltage should be decreased by 5.0 volts and should be referred to the negative end of the filament.

INSTALLATION AND APPLICATION

The **base** pins of the 10 fit the standard four-contact socket which should be installed to hold the tube in a vertical position with the base down. The **filament** of this type is usually operated on a-c, see page 33. As an **audio power amplifier**, the 10 should be operated under conditions as given under CHARACTERISTICS.

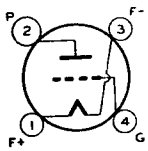




RCA-11

RCA-11, RCA-12

DETECTOR, AMPLIFIER

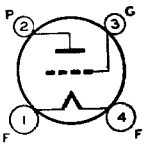


RCA-11

The 11 and 12 are three-electrode tubes for use as detector and amplifier in dry-cell operated receivers designed for their characteristics. Their electrical characteristics are identical.

CHARACTERISTICS

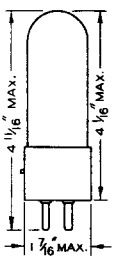
Filament Voltage (D. C.)		1.1	Volts
Filament Current		0.25	Ampere
Plate Voltage	90	135 *max.*	Volts
Grid Voltage	−4.5	−10.5	Volts
Plate Current	2.5	3	Milliamperes
Plate Resistance	15500	15000	Ohms
Amplification Factor	6.6	6.6	
Transconductance	425	440	Micromhos
Grid-Plate Capacitance		3.3	μμf
Grid-Filament Capacitance		2.5	μμf
Plate-Filament Capacitance		2.5	μμf



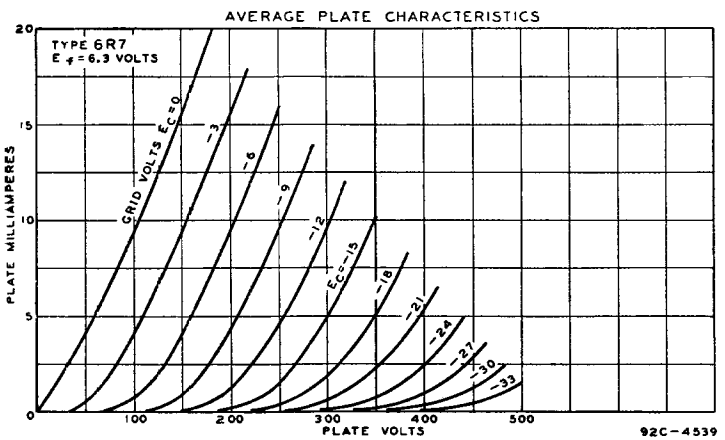
RCA-12

	RCA-11	RCA-12
Bulb	T-8	T-10
Base	WD-4-Pin Med.	4-Pin Bayonet

These two types are used principally for renewal purposes.



RCA-12



12AB5

BEAM POWER TUBE

For Use in Automobile Radio Receivers Operating From 12-Volt Storage Batteries

9-Pin Miniature Type

TENTATIVE DATA

RCA-12AB5 is a beam power tube of the 9-pin miniature type designed for use as the output amplifier in automobile radio receivers operating from a 12-volt storage battery.

The 12AB5 can provide high power output because of its high power sensitivity and high efficiency. For example, in class A_1 amplifier service, a single 12AB5 operated with a plate voltage of 250 volts, and a grid-No.2 voltage of 250 volts, can deliver a maximum-signal power output of 4.5 watts with a peak driving voltage of only about 12.5 volts. This performance, together with relatively low plate-current drain, make the 12AB5 especially suitable for use in the output stage of automobile receivers.

Design features of the 12AB5 include a large plate structure to allow for greater heat dissipation, a heater specially processed to withstand the severe operating conditions encountered during battery charging and discharging, and double base-pin connections for grid No.1 and grid No.2 to provide for cooler grid operation and greater flexibility of circuit connection.

GENERAL DATA

Electrical:

Heater for Unipotential Cathode:●		
Voltage Range	10.0 to 15.9	volts
This voltage range is on an absolute basis. For longest life, it is recommended that the heater be operated within the voltage range of 11 to 14 volts.		
Current (Approx.), at 12.6 volts	0.2	amp
Direct Interelectrode Capacitances (Without external shield):		
Grid No.1 to plate	0.7 max.	μμf
Grid No.1 to heater, cathode & grid No.3, and grid No.2	8	μμf
Plate to heater, cathode & grid No.3 and grid No.2	8.5	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin (JETEC No.E9-1)

SINGLE-TUBE CLASS A_1 AMPLIFIER

Maximum Ratings, *Design-Center Values:*

For application of these design-center ratings to storage-battery operation, see Operating Considerations.

PLATE VOLTAGE	315 max.	volts
GRID-No.2 (SCREEN) VOLTAGE	285 max.	volts
PLATE DISSIPATION	12 max.	watts
GRID-No.2 INPUT	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	°C

Characteristics with 12.6 volts on heater:

Plate Voltage	250	250	volts
Grid-No.2 Voltage	200	250	volts
Grid-No.1 Voltage	–	-12.5	volts
Cathode-Bias Resistor	270	–	ohms
Peak AF Grid-No.1 Voltage	10.5	12.5	volts
Zero-Signal Plate Current	33.5	45	ma
Max.-Signal Plate Current	36	47	ma
Zero-Signal Grid-No.2 Current (Approx.)	1.6	4.5	ma
Max.-Signal Grid-No.2 Current (Approx.)	3.2	7.0	ma
Plate Resistance (Approx.)	75000	50000	ohms
Transconductance	4000	4100	μmhos
Load Resistance	6000	5000	ohms
Total Harmonic Distortion	8	8	%
Max.-Signal Power Output	3.3	4.5	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.1 max.	megohm
For cathode-bias operation	0.5 max.	megohm

PUSH-PULL CLASS AB_1 AMPLIFIER

Values are for two tubes

Maximum Ratings, *Design-Center Values:*

For application of these design-center ratings to storage-battery operation, see Operating Considerations.

PLATE VOLTAGE	315 max.	volts
GRID-NO.2 (SCREEN) VOLTAGE	285 max.	volts
PLATE DISSIPATION	12 max.	watts
GRID-NO.2 INPUT	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface	250 max.	°C

Characteristics with 12.6 volts on heater:

Plate Voltage	250	volts
Grid-No.2 Voltage	250	volts
Grid-No.1 Voltage	-15	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	30	volts
Zero-Signal Plate Current	70	ma
Max.-Signal Plate Current	79	ma
Zero-Signal Grid-No.2 Current (Approx.)	5	ma
Max.-Signal Grid-No.2 Current (Approx.)	13	ma
Plate Resistance (Approx.)	60000	ohms

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

12AB5-6-55
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PUSH-PULL CLASS AB_1 AMPLIFIER (Cont'd)

Characteristics with 12.6 volts on heater:

Transconductance	3750	μmhos
Effective Load Resistance (Plate-to-plate)	10000	ohms
Total Harmonic Distortion	5	%
Max.-Signal Power Output	10	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.1 max.	megohm
For cathode-bias operation	0.5 max.	megohm

● Operation of heater in series with other heaters is not recommended.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 12AB5 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in storage-battery-operated equipment provided the following stipulations are observed:

In the case of storage-battery-with charger supply or similar supplies, the normal battery-voltage fluctuation may be as much as 35 per cent or more. This fluctuation imposes severe operating conditions on tubes. Under these conditions, the equipment should be designed so that 90% of the design-center maximum values of plate voltage, grid-No.2 voltage, plate dissipation and grid-No.2 input is never exceeded for a battery terminal potential of 13.2 volts. Although the operating voltages of the 12AB5 in this service will, at times, exceed the design-center maximum values, satisfactory performance with probable sacrifice in life will be obtained.

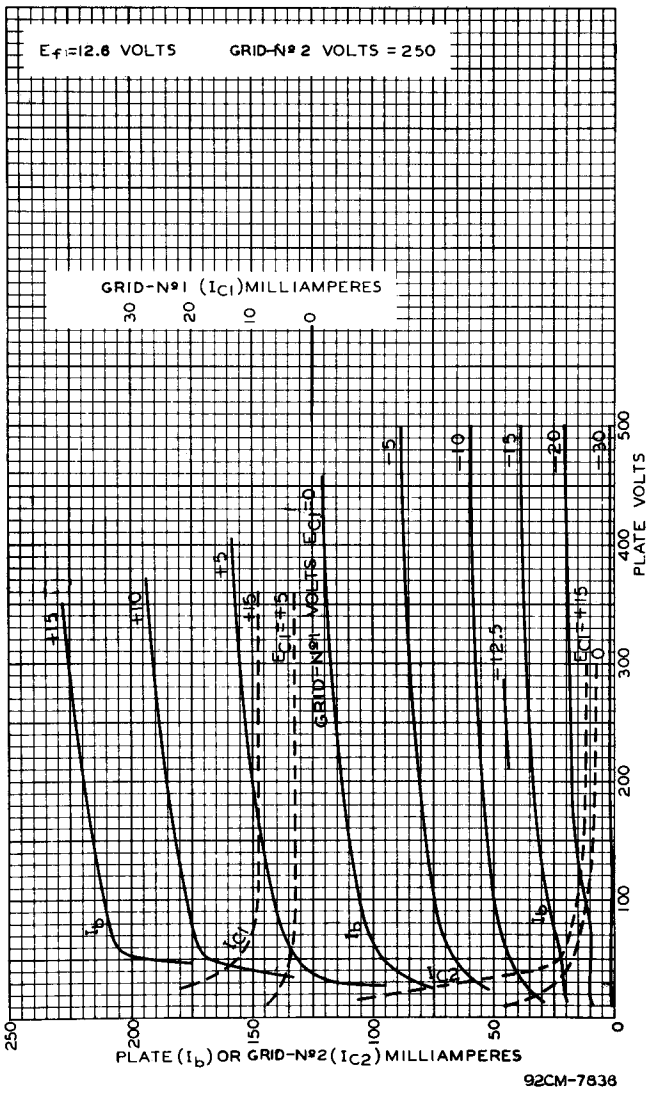


Fig. 1 - Average Plate Characteristics of Type 12AB5.

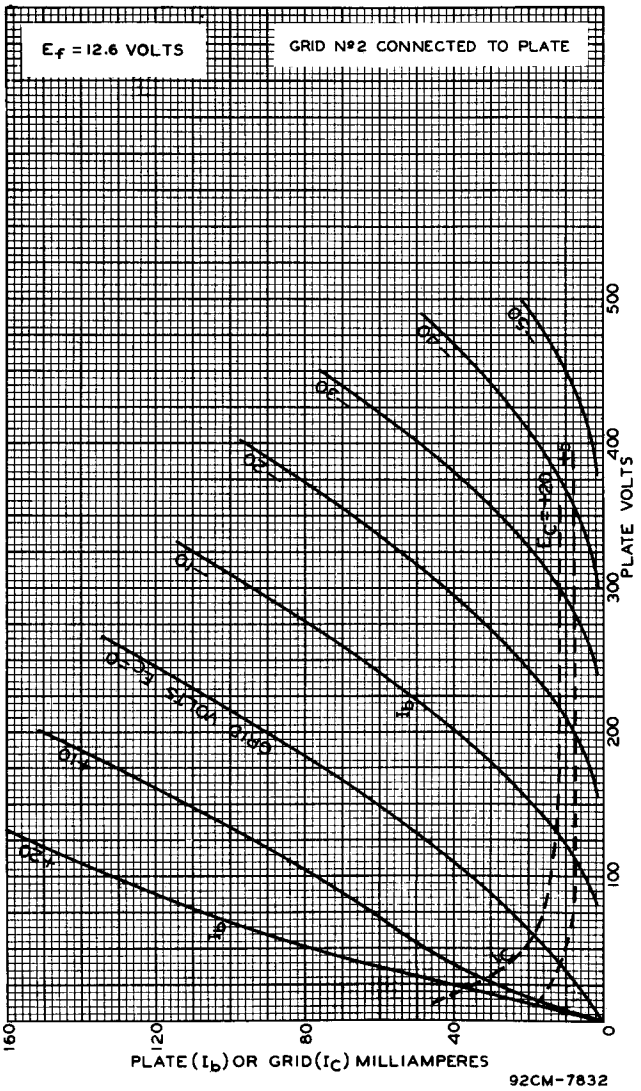


Fig-2 - Average Plate Characteristics of Type 12AB5 Connected as Triode.

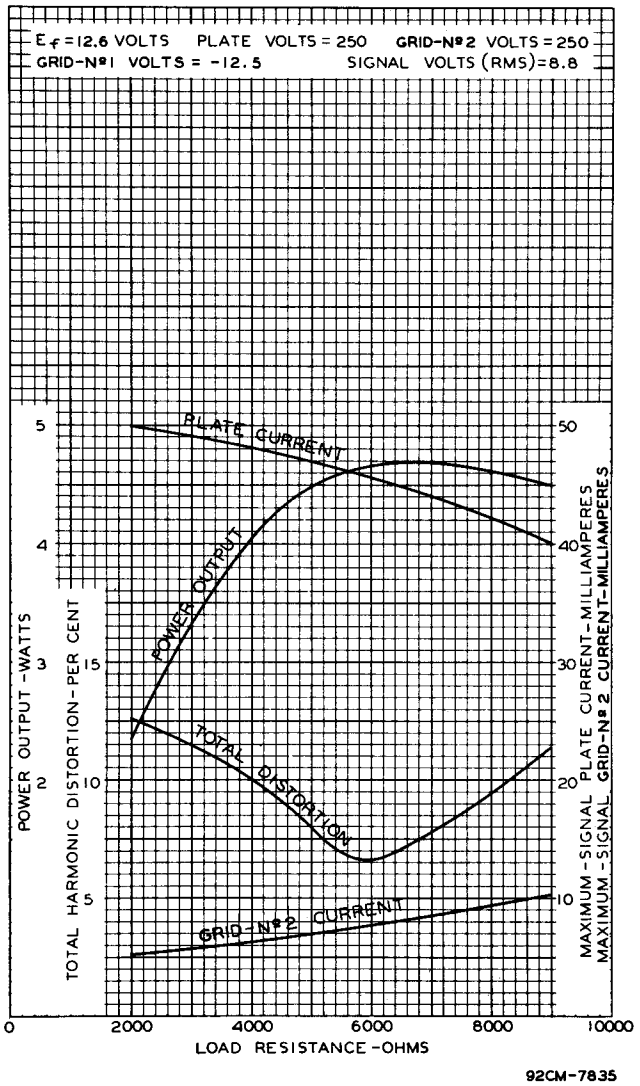
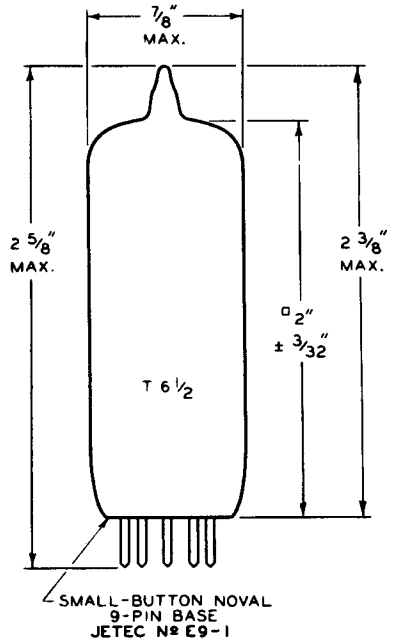


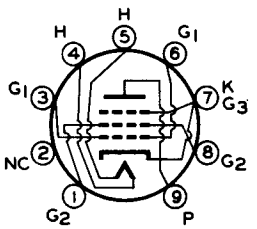
Fig. 3 - Operation Characteristics of Type 12AB5.

DIMENSIONAL OUTLINE



□ MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



PIN 1: GRID No.2
PIN 2: NO CONNECTION
PIN 3: GRID No.1
PIN 4: HEATER
PIN 5: HEATER
PIN 6: GRID No.1
PIN 7: CATHODE, GRID No.3
PIN 8: GRID No.2
PIN 9: PLATE

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

12AQ5

BEAM POWER AMPLIFIER

7-Pin Miniature Type

TENTATIVE DATA

RCA-12AQ5 is a beam power amplifier of the 7-pin miniature type intended primarily for use as the output amplifier of automobile radio receivers operating from a 12-volt storage battery. It may also be used in the output stage of ac-operated radio receivers.

The 12AQ5 can provide high power output because of its high power sensitivity and high efficiency. For example, in class A_1 amplifier service, a single 12AQ5 operated with a plate and grid-No.2 voltage of 250 volts, can deliver a maximum-signal power output of 4.5 watts with a peak driving voltage of only about 12 volts. These features together with relatively low plate-current drain make the 12AQ5 especially suitable for use in the output stage of automobile receivers.

Within its maximum ratings, the 12AQ5 is the performance equivalent of the larger glass type 12V6-GT.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	12.6	volts
Current	0.225	amp
Direct Interelectrode Capacitances (Approx., without external shield):		
Grid No.1 to Plate	0.35	μμf
Input	8.3	μμf
Output	8.2	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (Excluding Tip)	2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

AF POWER AMPLIFIER - Class A_1

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	250 max.	volts
GRID-No.2 (SCREEN) VOLTAGE	250 max.	volts
PLATE DISSIPATION	12 max.	watts
GRID-No.2 INPUT	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)●	250 max.	°C

Typical Operation and Characteristics:

Plate Voltage	180	250	volts
Grid-No.2 Voltage	180	250	volts
Grid-No.1 (Control-Grid) Voltage	-8.5	-12.5	volts
Peak AF Grid-No.1 Voltage	8.5	12.5	volts
Zero-Signal Plate Current	29	45	ma
Max.-Signal Plate Current	30	47	ma
Zero-Signal Grid-No.2 Current (Approx.)	3	4.5	ma
Max.-Signal Grid-No.2 Current (Approx.)	4	7	ma
Plate Resistance (Approx.)	58000	52000	ohms
Transconductance	3700	4100	μmhos
Load Resistance	5500	5000	ohms
Total Harmonic Distortion	8	8	per cent
Max.-Signal Power Output	2.0	4.5	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed bias	0.1 max.	megohm
For cathode bias	0.5 max.	megohm

AF POWER AMPLIFIER - Class AB_1

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	250 max.	volts
GRID-No.2 (SCREEN) VOLTAGE	250 max.	volts
PLATE DISSIPATION	12 max.	watts
GRID-No.2 INPUT	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)●	250 max.	°C

Typical Operation:

Unless otherwise indicated, values are for 2 tubes

Plate Voltage	250	volts
Grid-No.2 Voltage	250	volts
Grid-No.1 (Control-Grid) Voltage#	-15	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	30	volts
Zero-Signal Plate Current	70	ma
Max.-Signal Plate Current	79	ma
Zero-Signal Grid-No.2 Current (Approx.)	5	ma
Max.-Signal Grid-No.2 Current (Approx.)	13	ma
Plate Resistance (Approx. per tube)	60000	ohms
Transconductance (Per tube)	3750	μmhos
Effective Load Resistance (Plate to plate)	10000	ohms
Total Harmonic Distortion	5	per cent
Max.-Signal Power Output	10	watts

Maximum Circuit Values Per Tube:▲

Grid-No.1-Circuit Resistance:#		
For fixed bias	0.1 max.	megohm
For cathode bias	0.5 max.	megohm

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• High ambient temperature and shielding may necessitate a reduction in operating dissipation. When tube shields are used, it is advisable to paint the inside and outside surfaces of the tube shield a dull black and to provide ventilation slots to reduce operating temperature.

♯ The type of input coupling used should not introduce too much resistance in the grid-No.1 circuit. Transformer- or impedance-coupling devices are recommended.

▲ If the grid-No.1-circuit resistance is common to two tubes, the indicated maximum values per tube should be halved.

OPERATING CONSIDERATIONS

The maximum ratings in the tabulated data for the 12AQ5 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in storage-battery-operated equipment provided the following stipulations are observed:

When storage-battery equipment is operated without a charger, it should be designed so that the published maximum values of plate voltage, grid-No.2 voltage, and dissipations, are never exceeded for a terminal potential at the battery source of 2.0 volts per cell. When storage-battery equipment is operated with a charger, it should be designed so that 90 per cent of the same maximum values is never exceeded for a terminal potential at the battery source of 2.2 volts.

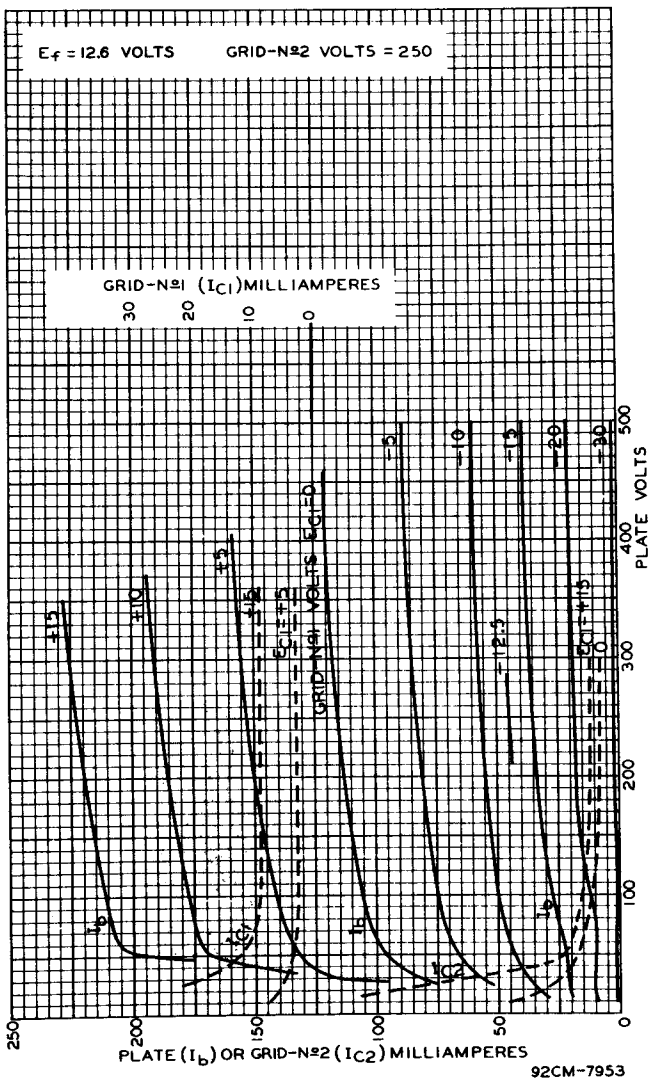


Fig. 1 - Average Plate Characteristics of Type 12AQ5

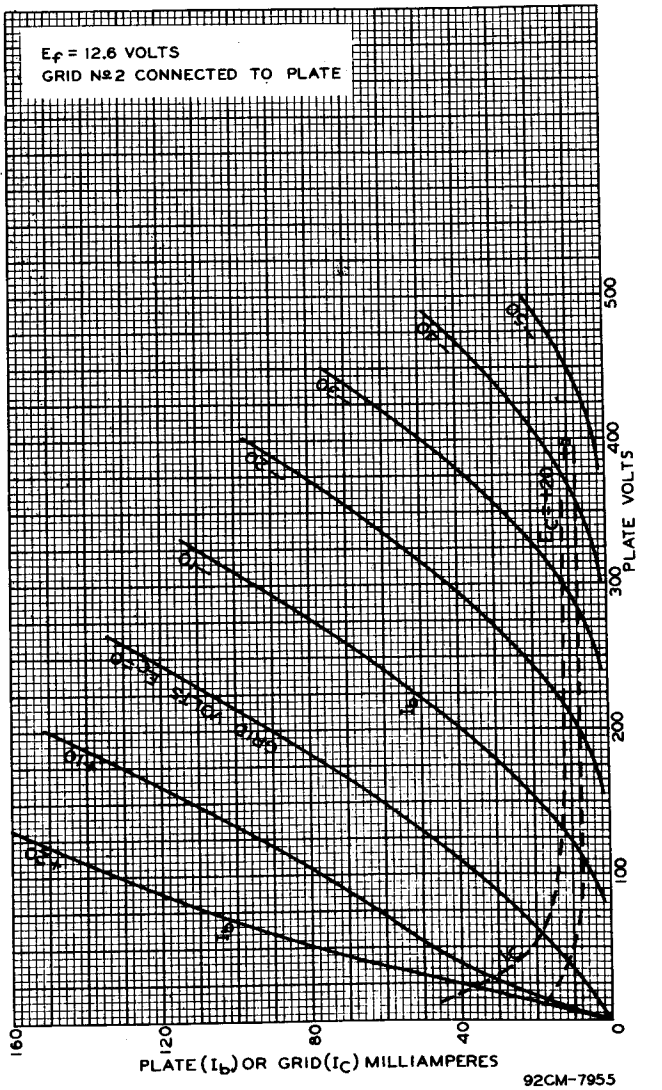


Fig. 2 - Average Plate Characteristics of Type 12AQ5 connected as Triode

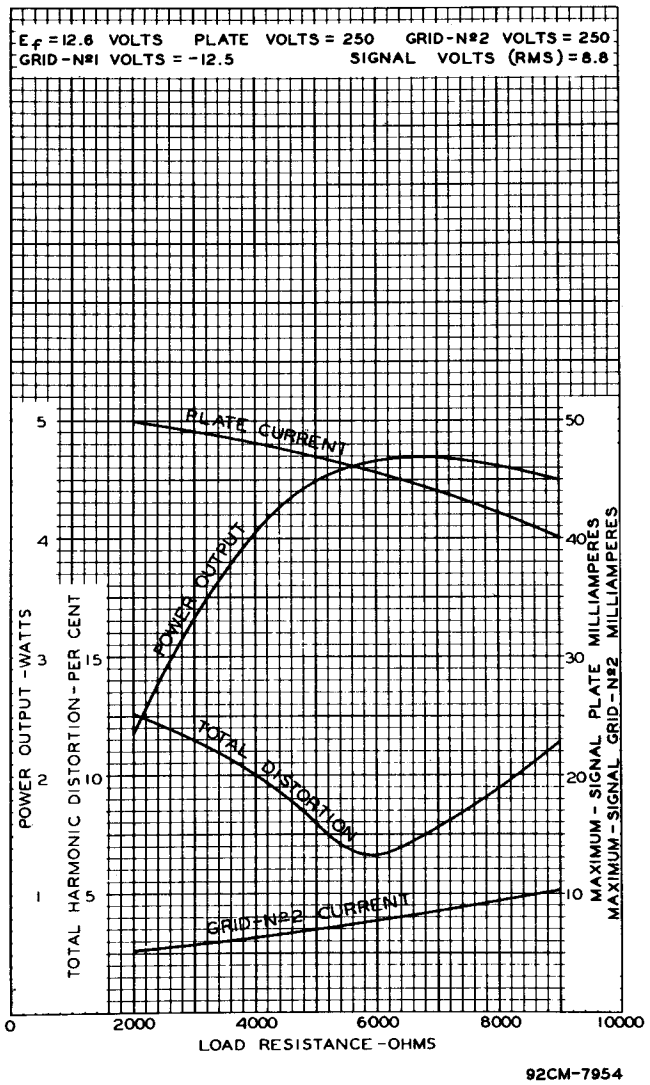
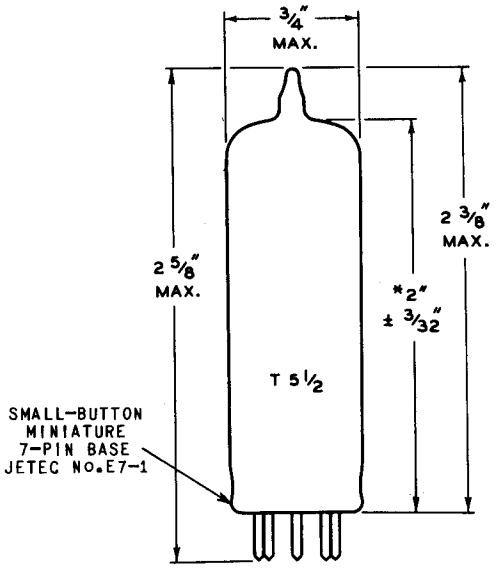


Fig. 3 - Operation Characteristics of Type 12AQ5

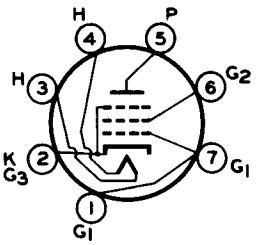
DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



PIN 1 - GRID NO.1
PIN 2 - GRID NO.3, CATHODE
PIN 3 - HEATER
PIN 4 - HEATER
PIN 5 - PLATE
PIN 6 - GRID NO.2
PIN 7 - GRID NO.1

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12AX4-GT

HALF-WAVE VACUUM RECTIFIER

For Television Damper Service

TENTATIVE DATA

RCA-12AX4-GT is a half-wave vacuum rectifier of the heater-cathode type designed primarily for use as a damper tube in horizontal deflection circuits of television receivers utilizing series-heater strings.

Designed with insulation between heater and cathode to withstand negative peak pulses between heater and cathode of as much as 4000 volts with a dc component up to 900 volts, the 12AX4-GT provides flexibility in choice of deflection circuits.

GENERAL DATA

Electrical

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	12.6	volts
Current	0.6	amp
Direct Interelectrode Capacitances (With no external shield):		
Heater to Cathode	7.5	μμf

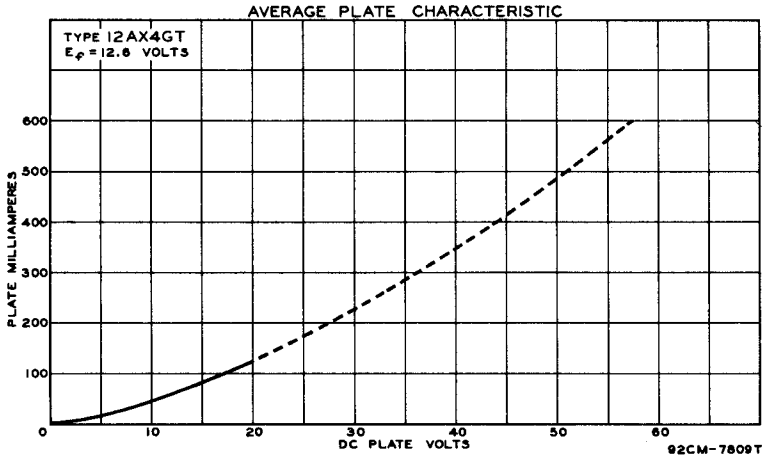
Mechanical:

Mounting Position	Any
Maximum Overall Length	3-5/16"
Maximum Seated Length	2-3/4"
Maximum Diameter	1-9/32"
Bulb	T-9
Base	Short Intermediate-Shell Octal 5-Pin

DAMPER SERVICE

Maximum Ratings, *Design-Center Values:*

PEAK INVERSE PLATE VOLTAGE	4000*	max.	volts
PEAK PLATE CURRENT	600	max.	ma
HOT-SWITCHING TRANSIENT PLATE CURRENT For duration of 0.2 second maximum.	3.0	max.	amp
DC PLATE CURRENT	125	max.	ma
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	4000▲	max.	volts
Heater positive with respect to cathode	100	max.	volts

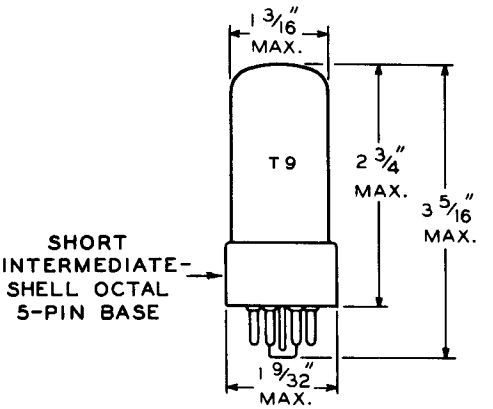


Average Plate Characteristic of Type 12AX4-GT.

OPERATING CONSIDERATIONS

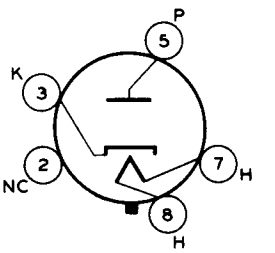
The *maximum ratings* in the tabulated data for the 12AX4-GT are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line center voltage value of 117 volts.

DIMENSIONAL OUTLINE



SOCKET CONNECTIONS

Bottom View



PIN 2: NO CONNECTION
PIN 3: CATHODE
PIN 5: PLATE
PIN 7: HEATER
PIN 8: HEATER

* This rating is applicable when the duty cycle of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

▲ The dc component must not exceed 900 volts.

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12AZ7

HIGH-MU TWIN TRIODE

9-Pin Miniature Type

TENTATIVE DATA

RCA-12AZ7 is a general-purpose high-mu twin triode of the 9-pin miniature type intended for a wide variety of applications in vhf television receivers including its use as a cathode-drive amplifier and frequency converter.

This tube has separate pin terminals for each cathode to provide flexibility of circuit arrangement, and a mid-tapped heater to permit operation from a 12.6-volt/0.225-ampere or 6.3-volt/0.45-ampere supply.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathodes:			
Heater arrangement	*Series*	*Parallel*	
Voltage (AC or DC)	12.6	6.3	volts
Current	0.225	0.450	amp

Direct Interelectrode Capacitances (Approx.):

	Without External Shield	*With External Shield°*	
Grid-Drive Operation:			
Grid to plate (Each unit)	1.9	1.9	μμf
Grid to heater and cathode (Each unit)	3.1	3.2	μμf
Plate to heater and cathode (Unit No.1)	0.5	1.3	μμf
Plate to heater and cathode (Unit No.2)	0.4	1.6	μμf
Heater to cathode (Each unit)	3.8	4	μμf
Cathode-Drive Operation:			
Plate to cathode (Each unit)	0.24	0.23	μμf
Cathode to grid and heater (Each unit)	6.9	7	μμf
Plate to grid and heater (Unit No.1)	2	2.8	μμf
Plate to grid and heater (Unit No.2)	2	3.2	μμf

Characteristics, Class A_1 Amplifier (Each Unit):

Plate-Supply Voltage	100	250	volts
Cathode-Bias Resistor	270	200	ohms
Amplification Factor	60	60	
Plate Resistance (Approx.)	15000	10900	ohms
Transconductance	4000	5500	μmhos
Plate Current	3.7	10	ma
Grid Voltage (Approx.) for plate current of 10 μa	-5	-12	volts

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-3/16"
Maximum Seated Length	1-15/16"
Length, Base Seat to Bulb Top (Excluding tip)	1-9/16" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin (JETEC No.E9-1)

AMPLIFIER - Class A_1

Values are for Each Unit

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	300 max.	volts
GRID VOLTAGE:		
Negative bias value	50 max.	volts
PLATE DISSIPATION	2.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200● max.	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.25 max.	megohm
For cathode-bias operation	1 max.	megohm

° With external shield JETEC No.315 connected to cathode of unit under test.

● DC component must not exceed 100 volts.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 12AZ7 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage, including normal variations, falls within ± 10 per cent of line-center voltage value of 117 volts.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

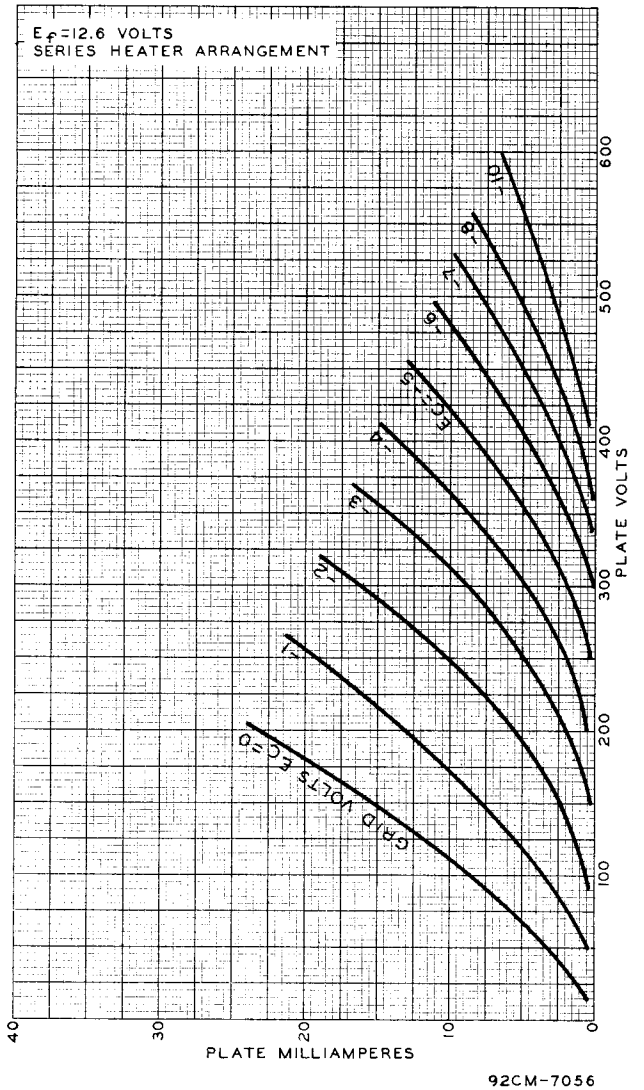


Fig. 1 – Average Plate Characteristics of Type 12AZ7.

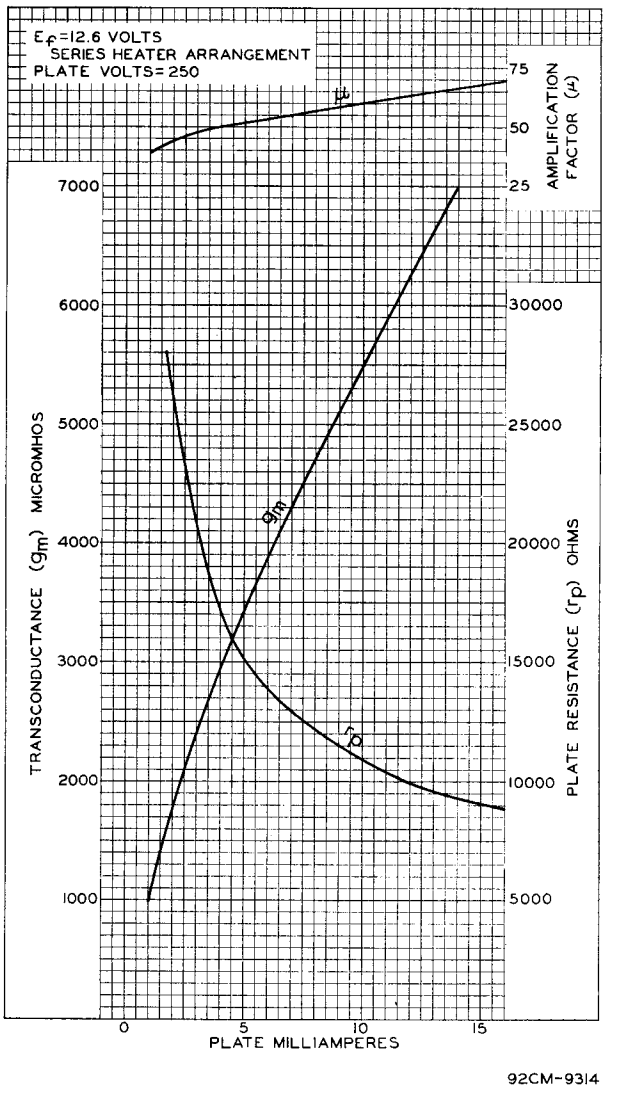
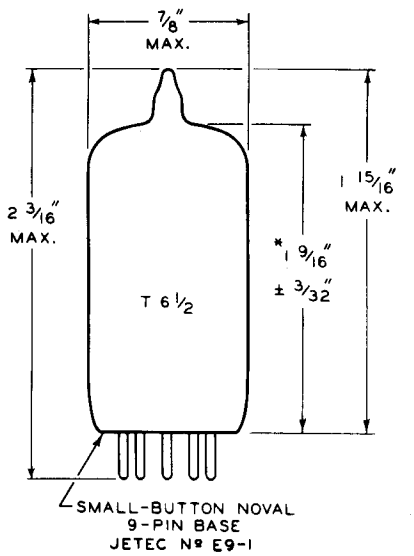


Fig. 2 – Average Characteristics of Type 12AZ7.

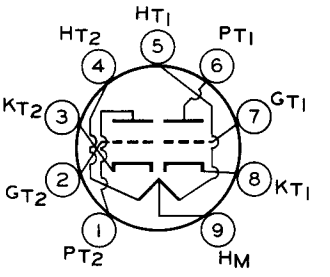
DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



9A

PIN 1: PLATE OF TRIODE UNIT No.2
PIN 2: GRID OF TRIODE UNIT No.2
PIN 3: CATHODE OF TRIODE UNIT No.2
PINS 4 & 9: HEATER OF TRIODE UNIT No.2
PINS 5 & 9: HEATER OF TRIODE UNIT No.1
PIN 6: PLATE OF TRIODE UNIT No.1
PIN 7: GRID OF TRIODE UNIT No.1
PIN 8: CATHODE OF TRIODE UNIT No.1
PIN 9: HEATER MID-TAP

12BF6

TWIN DIODE--MEDIUM-MU TRIODE

Miniature Type

TENTATIVE DATA

RCA-12BF6 is a multi-unit miniature tube of the heater-cathode type containing two diodes and a medium-mu triode in one envelope. It is intended primarily for use as a combined detector, amplifier, and avc tube in automobile radio receivers operating from a 12-volt storage battery.

Characteristics of the 12BF6 are such that it can be impedance-coupled or transformer-coupled to the output stage. In either case, the triode unit can supply more than ample output with low distortion to drive a pair of 12V6-GT's operating at maximum plate voltage in the output stage of automobile receivers. In performance, the 12BF6 is the equivalent of the larger metal type 12SR7.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	12.6	volts
Current	0.150	ampere

Direct Interelectrode Capacitances (Approx.):

	With External Shield▲	*Without External Shield*	
Triode Unit:			
Grid to Plate	2.0	2.0	μμf
Grid to Cathode	1.8	1.8	μμf
Plate to Cathode	1.1	0.8	μμf
Plate of Diode Unit No.1 to Cathode	1.4	0.7	μμf
Plate of Diode Unit No.2 to Cathode	1.5	0.1	μμf
Plate of Diode Unit No.1 to Triode Grid	0.06 max.	0.07 max.	μμf
Plate of Diode Unit No.2 to Triode Grid	0.05 max.	0.06 max.	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-1/8"
Maximum Seated Length	1-7/8"
Length from Base to Bulb Top (Excluding tip)	1-1/2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

TRIODE UNIT AS CLASS A_1 AMPLIFIER

Maximum Ratings, *Design-Center Values*:

PLATE VOLTAGE	300 max.	volts
PLATE DISSIPATION	2.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Typical Operation with Transformer Coupling:

Plate Voltage	250	volts
Grid Voltage	-9	volts
Amplification Factor	16	
Plate Resistance (Approx.)	8500	ohms
Transconductance	1900	umhos
Plate Current	9.5	ma
Load Resistance	10000	ohms
Total Harmonic Distortion	6.5	per cent
Power Output	300	milliwatts

Typical Operation as Resistance-Coupled Amplifier:

See Chart Below

DIODE UNITS

Maximum Ratings, *Design-Center Values*:

PLATE CURRENT (For each diode)	1.0 max.	ma

Diode Considerations:

Diode units No.1 and No.2 and the triode unit have a common cathode.

Diode biasing of the triode unit of the 12BF6 is not recommended.

▲ According to RTMA Standard ET-109A with External Shield No.315 tied to cathode.

Operating Conditions as Resistance-Coupled Amplifier

Plate-Supply Voltage	90			180			300			
Plate Load Resistor	0.047	0.1	0.22	0.047	0.1	0.22	0.047	0.1	0.22	Megohm
Grid Resistor (of following stage)	0.1	0.22	0.47	0.1	0.22	0.47	0.1	0.22	0.47	Megohm
Cathode Resistor	2800	5400	12000	2500	5100	11000	2400	5000	11000	Ohms
Cathode Bypass Capacitor●	2.0	1.0	0.5	2.2	1.1	0.5	2.4	1.2	0.5	μf
Blocking Capacitor●	0.033	0.013	0.0065	0.033	0.015	0.007	0.033	0.015	0.007	μf
Peak Output Voltage□	18	20	23	42	47	54	74	85	95	Volts
Voltage Gain▲	10	11	11	10	11	12	11	12	12	

● The cathode bypass capacitors and blocking capacitors have been chosen to give output voltages at 100 cps (f_1) which are equal to 0.8 of the mid-frequency value. For any other value of (f_1), multiply the values of cathode bypass and blocking capacitors by $100/f_1$.

▲ At an output voltage of 5 volts rms.

□ This peak output voltage is obtained across the grid resistor of the following stage at any frequency within the flat region of the output vs frequency curve, and is for the condition where the signal level is adequate to swing the grid of the resistance-coupled amplifier tube itself to the point where its grid starts to draw current.

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

12BF6-7-52
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OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 12BF6 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in storage-battery-operated equipment provided the following stipulations are observed: When storage-battery equipment is operated without a charger, it should be designed so that the published maximum values of plate voltages, grid-No.2 supply voltages, dissipations, and rectified output currents are never exceeded for a terminal potential at the battery source of 2.0 volts per cell. When storage-battery equipment is operated with a charger, it should be designed so that 90 per cent of the same maximum values is never exceeded for a terminal potential at the battery source of 2.2 volts.

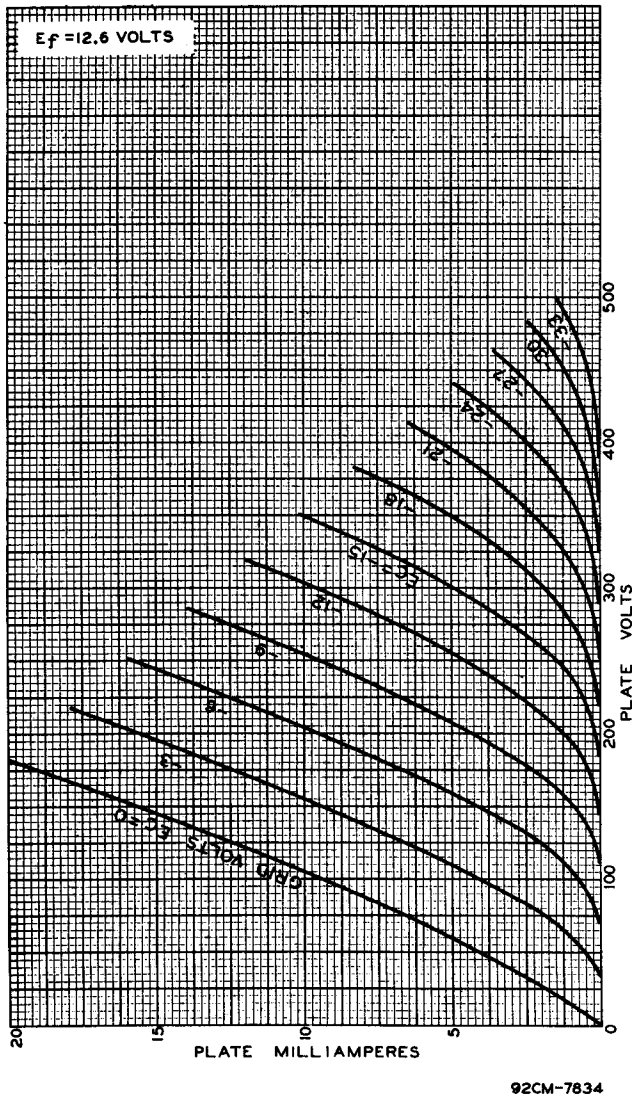


Fig. 1 - Average Plate Characteristics for Triode Unit of Type 12BF6.

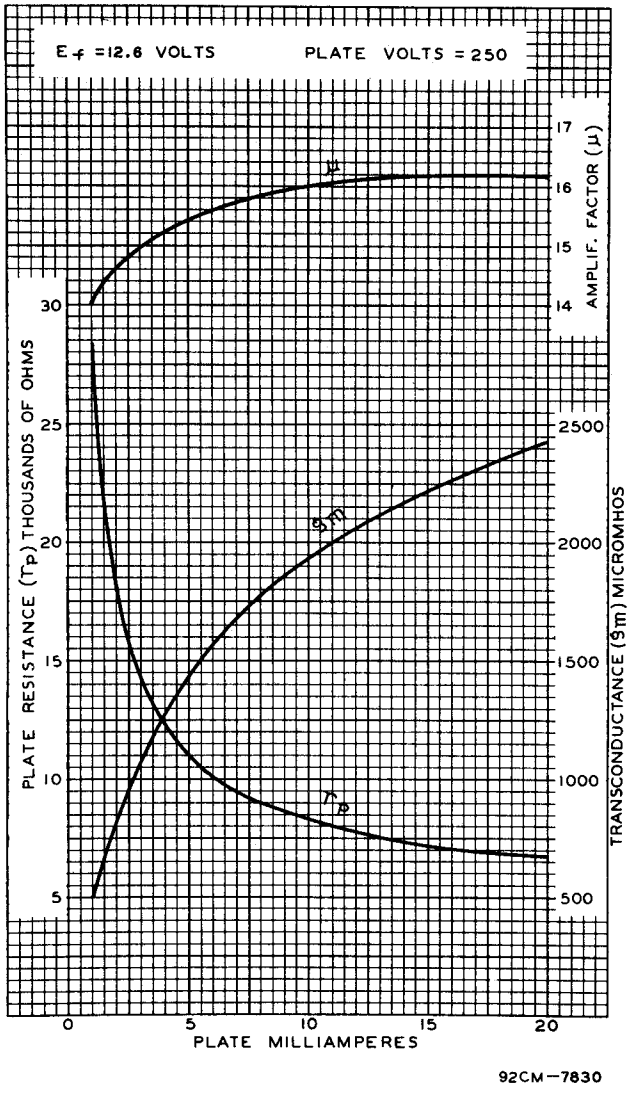


Fig. 2 - Average Characteristics for Triode Unit of Type 12BF6.

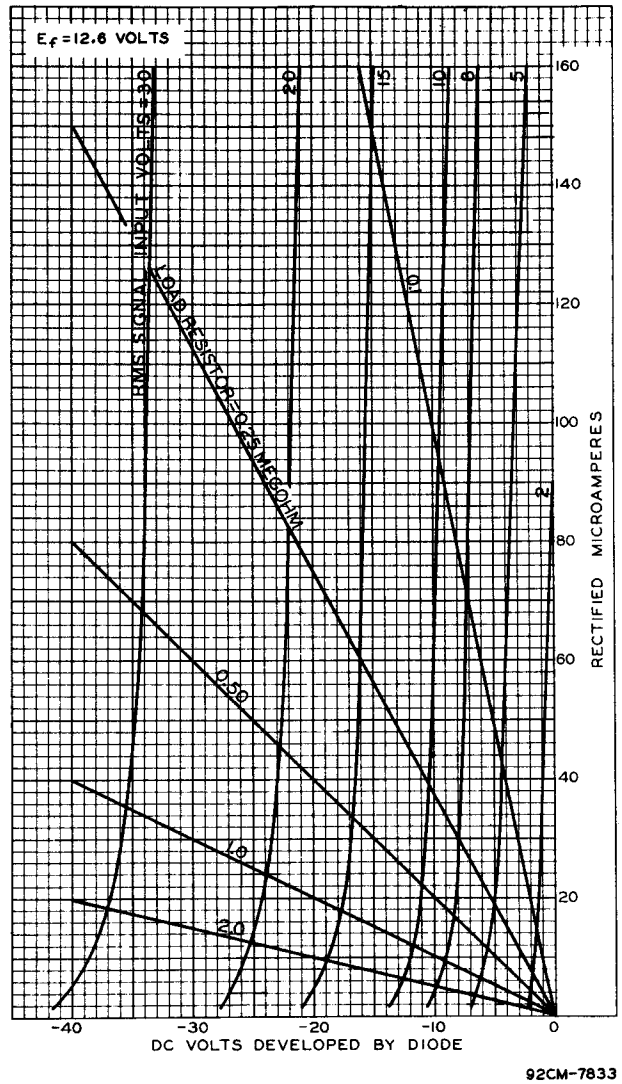
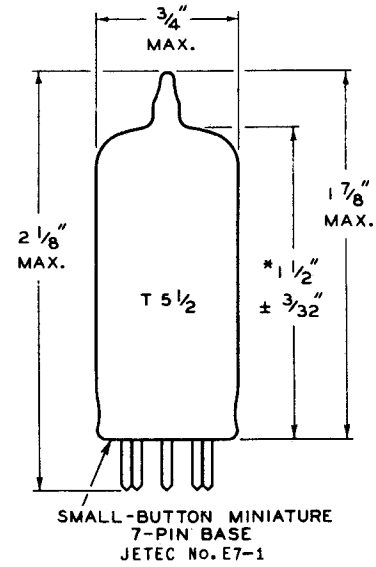
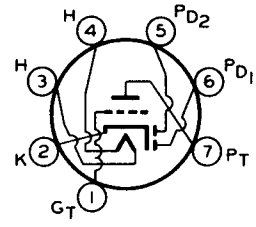


Fig. 3 - Half-Wave Rectification Characteristics for Single Diode of Type 12BF6.

DIMENSIONAL OUTLINE



SOCKET CONNECTIONS
Bottom View



7BT

PIN 1: TRIODE GRID
PIN 2: CATHODE
PIN 3: HEATER
PIN 4: HEATER
PIN 5: DIODE PLATE No. 2
PIN 6: DIODE PLATE No. 1
PIN 7: TRIODE PLATE

12DS7

TWIN DIODE--POWER TETRODE

9-Pin Miniature Type

For Use in "Hybrid" Automobile Receivers Operating Directly From 12-Volt Storage Batteries

TENTATIVE DATA

RCA-12DS7 is a multiunit tube of the 9-pin miniature type containing two diodes and a high-perveance power tetrode of the space-charge-grid type in one envelope. It is intended for use in "hybrid" automobile receivers in which tube and transistor electrode voltages are obtained directly from a 12-volt storage battery. In such receivers, the diode units are used for am signal detection and automatic volume control, while the tetrode unit serves as the driver for the transistorized af power output stage.

Because of its high perveance, the tetrode unit can supply high space-charge grid current and high plate current with only 12.6 volts on the plate. These features, in addition to a high value of grid-No.2-to-plate transconductance (15000 micromhos) and a low value of plate resistance of only 480 ohms, enable this tube to supply high input power at low distortion to the transistor in the power output stage of automobile receivers.

Space-charge-grid operation of the tetrode unit is accomplished by operating grid No.1 at a positive potential and utilizing grid No.2 as the control electrode.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage range (AC or DC)	10.0 to 15.9	volts
This voltage range is on an absolute basis. For longest life, it is recommended that the heater be operated within the voltage range of 11 to 14 volts.		
Current (Approx.) at 12.6 volts	0.4	amp
Direct Interelectrode Capacitances (Without external shield):		
Tetrode Unit:		
Grid No.2 to plate	12.5	μμf
Grid No.2 to grid No.1, heater, and cathode	13	μμf
Plate to grid No.1, heater, and cathode	2	μμf
Diode Units:		
Diode plate No.1 to diode cathode and heater	0.5	μμf
Diode plate No.2 to diode cathode and heater	0.5	μμf
Diode plate No.1 to diode plate No.2	0.1	μμf
Tetrode grid No.2 to diode plate No.1	0.15 max.	μμf
Tetrode grid No.2 to diode plate No.2	0.15 max.	μμf

Characteristics, Class A_1 Amplifier with 12.6 Volts on Heater:

Plate Voltage	12.6	volts
Grid-No.2 (Control-Grid) Voltage:		
Developed across a 2.2-megohm resistor	-0.5	volt
Grid-No.1 (Space-Charge-Grid) Voltage	12.6	volts
Plate Resistance (Approx.)	480	ohms
Amplification Factor, grid No.2 to plate	7.2	
Transconductance, grid No.2 to plate	15000	μmhos
Plate Current	40	ma
Grid-No.1 Current	75	ma

Mechanical:

Operating Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length, Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Diameter:	
Minimum	0.750"
Maximum	0.875"
Bulb	T-6-1/2
Base	Small-Button Noval 9-pin (JETEC No.E9-1)

TETRODE UNIT — AUDIO DRIVER SERVICE

Maximum Ratings, *Design-Center Values Except as Noted:*

PLATE VOLTAGE	16 max.	volts
GRID-No.2 (CONTROL-GRID) VOLTAGE:		
Negative bias value	-16 max.	volts
GRID-No.1 (SPACE-CHARGE-GRID) VOLTAGE (Absolute Maximum)	16 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	16 max.	volts
Heater positive with respect to cathode	16 max.	volts

Typical Operation:

With 12.6 volts on heater and grid-No.2 voltage obtained by a cathode resistor

Plate Supply Voltage	12.6	volts
Plate Voltage	Obtained from indicated plate supply through series 100-henry choke having dc resistance of 150 ohms	
Grid-No.1 Supply Voltage	12.6	volts
Grid-No.2 Supply Voltage	0	volts
Grid-No.2 Resistor	1.8	megohms
Cathode Resistor	18	ohms
Peak AF Grid-No.2 Supply Voltage (Approx.):		
From 3.3-megohm signal source	2.85	volts
Plate Current:		
Zero Signal (Approx.)	23	ma
Maximum Signal	13	ma
Grid-No.1 Current	77	ma
Load Resistance	1250	ohms
Total Harmonic Distortion	8	per cent
Max.-Signal Power Output	10	mw

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

12DS7 7-58
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Typical Operation:

With 12.6 volts on heater and grid-No.2 voltage obtained by a grid-No.2 resistor

Plate Voltage	12.6	volts
Grid-No.1 Voltage	12.6	volts
Grid-No.2 Voltage:		
Obtained by rectification through a 2.2-megohm resistor	-2	volts
Peak AF Grid-No.2 Voltage (Approx.):		
From 0.1-megohm signal source	2.5	volts
Plate Current:		
Zero Signal (Approx.)	40	ma
Maximum Signal	8	ma
Grid-No.1 Current	75	ma
Load Resistance	800	ohms
Total Harmonic Distortion	10	per cent
Max.-Signal Power Output	40	mw

Maximum Circuit Values:

Grid-No.2 Circuit Resistance	10 max.	megohms

DIODE UNITS -- Two

Values are for Each Unit

Maximum Ratings, *Design-Center Values:*

PLATE CURRENT	5 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	16 max.	volts
Heater positive with respect to cathode	16 max.	volts

Characteristics with 12.6 Volts on Heater:

Plate Current for plate volts = 10	3	ma

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data, except the rating for grid-No.1 voltage, are established in accordance with the following definition of the *Design-Center Rating System* for rating electron devices.

Design-Center ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

The device manufacturer chooses those values to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation*, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The equipment manufacturer should design so that initially no design-center value for the intended service is exceeded with a bogey device in equipment operating at the stated normal supply voltage.*

The *maximum rating* shown in the tabulated data for grid-No.1 voltage is established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron tubes.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

* For automotive equipment utilizing a 12-volt system, battery voltage range of 10.0 volts to 15.9 volts is accepted U.S.A. practice.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

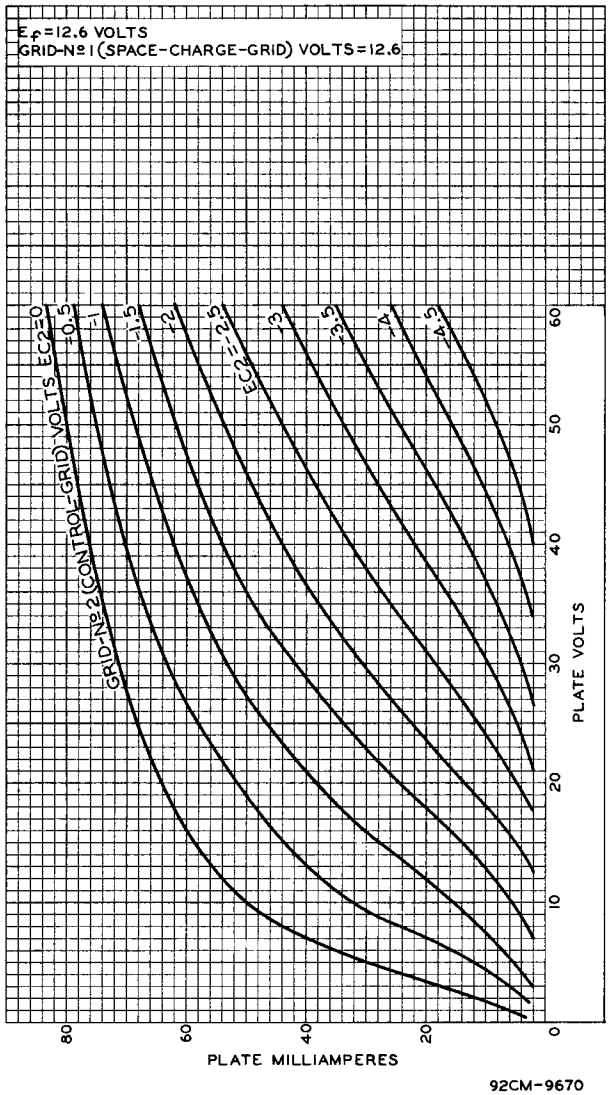


Fig. 1 - Average Plate Characteristics for Tetrode Unit of Type 12DS7.

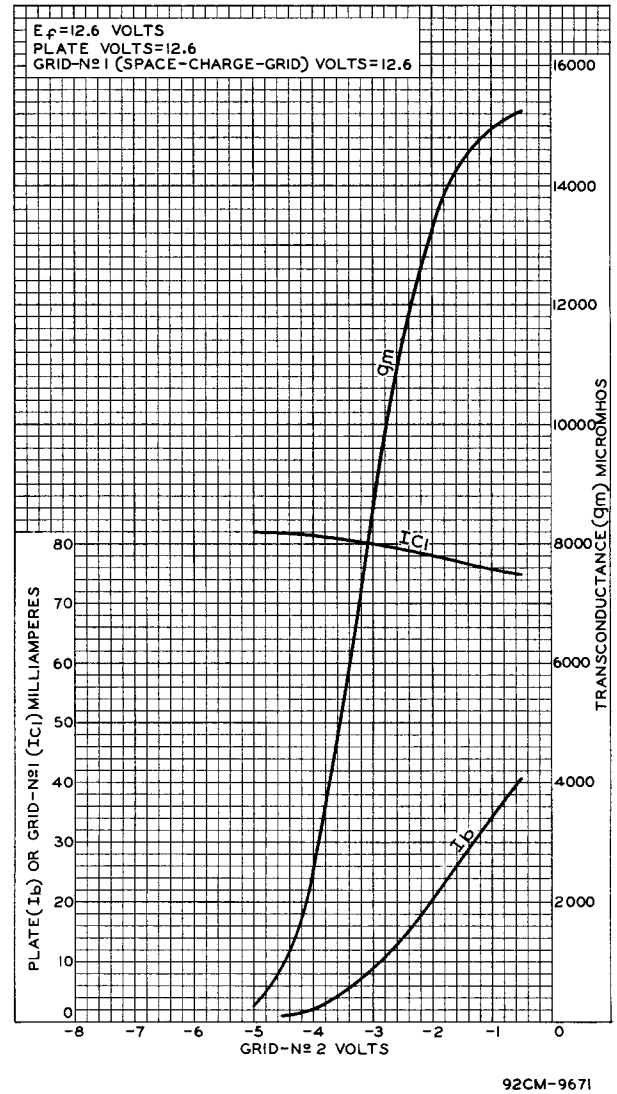
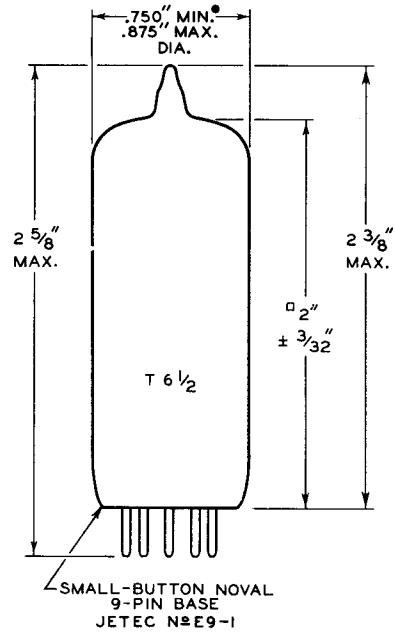


Fig. 2 - Average Characteristics for Tetrode Unit of Type 12DS7.

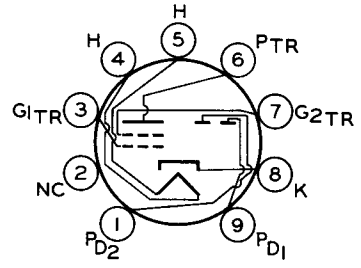
DIMENSIONAL OUTLINE



● APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

□ MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



9JU

PIN 1 – PLATE OF DIODE UNIT No.2
PIN 2 – NO CONNECTION
PIN 3 – GRID No.1 OF TETRODE UNIT
PIN 4 – HEATER
PIN 5 – HEATER
PIN 6 – PLATE OF TETRODE UNIT
PIN 7 – GRID No.2 OF TETRODE UNIT
PIN 8 – CATHODE
PIN 9 – PLATE OF DIODE UNIT No.1

This bulletin also applies to the 6DT8. Except for its 6.3-volt/0.3-ampere heater, the 6DT8 is like the 12DT8.

6DT8

12DT8

HIGH-MU TWIN TRIODE

9-Pin Miniature Type

TENTATIVE DATA

RCA-12DT8 is a general-purpose high-mu twin triode of the 9-pin miniature type intended for use as an rf amplifier and as a combined oscillator-mixer in fm tuners. This tube is also useful in a wide variety of applications in radio and television receivers.

In the 12DT8, the two units are effectively isolated from each other by an internal shield having a separate base-pin terminal. As a result each unit will give stable performance when used in high-frequency applications. In addition, separate pin terminals for each cathode provide the equipment designer with greater flexibility of circuit connections.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathodes:			
Voltage (AC or DC)	12.6		volts
Current	0.15		amp
Direct Interelectrode Capacitances (Approx., with external shield):	*Unit No.1*	*Unit No.2*	
Grid-Drive Operation○:			
Grid to plate	1.6	1.6	μμf
Grid to cathode, heater, and internal shield	2.7	2.7	μμf
Plate to cathode, heater, and internal shield	1.6	1.6	μμf
Heater to cathode	3.0	3.0	μμf
Cathode-Drive Operation:□			
Cathode to grid, heater, and internal shield	–	5.3	μμf
Plate to grid, heater, and internal shield	–	2.8	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2-3/16"
Maximum Seated Length	1-15/16"
Length, Base Seat to Bulb Top (Excluding tip)	1-9/16" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin (JETEC No.E9-1)

AMPLIFIER - Class A_1

Values are for Each Unit

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	300	max.	volts
GRID VOLTAGE:			
Negative bias value	50	max.	volts
PLATE DISSIPATION	2.5	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	200	max.	volts
Heater positive with respect to cathode	200●	max.	volts

Characteristics:

Plate-Supply Voltage	100	250	volts
Cathode-Bias Resistor	270	200	ohms
Amplification Factor	60	60	
Plate Resistance (Approx.)	15000	10900	ohms
Transconductance	4000	5500	μmhos
Plate Current	3.7	10	ma
Grid Voltage (Approx.) for plate Current of 10 μa	−5	−12	volts

Maximum Circuit Values:

Grid-Circuit Resistance:			
For fixed-bias operation	0.25	max.	megohm
For cathode-bias operation	1	max.	megohm

○ With external shield, JETEC No.315, connected to cathode of unit under test.

□ With external shield, JETEC No.315, connected to grid of unit under test.

● DC component must not exceed 100 volts.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 12DT8 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage, including normal variations, falls within ± 10 per cent of line-center voltage value of 117 volts.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

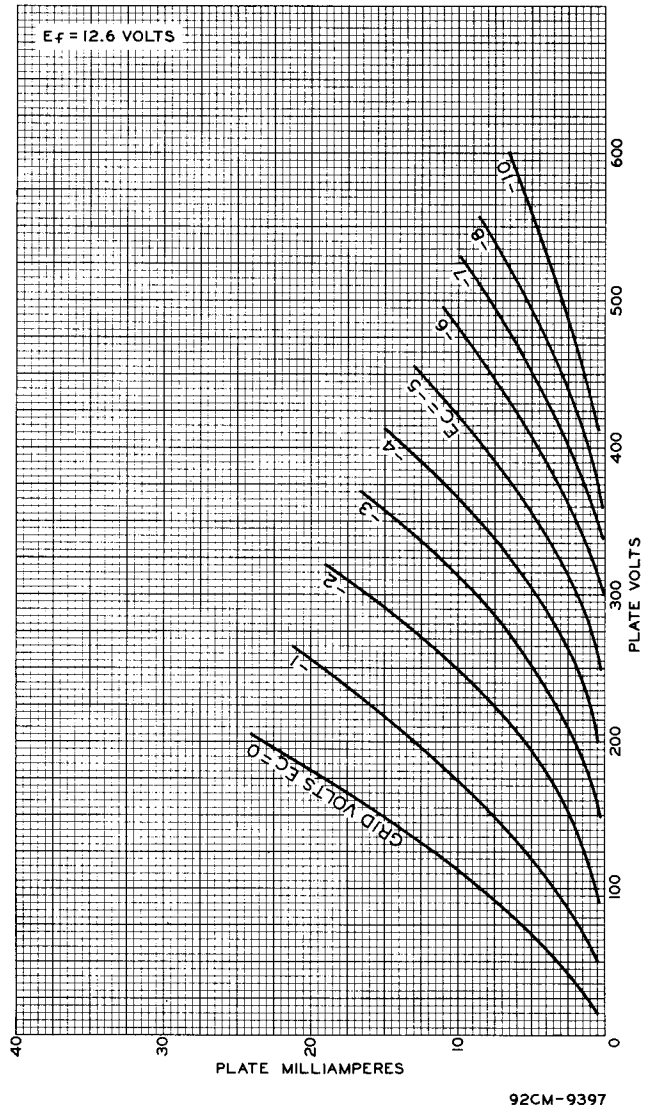


Fig. 1 – Average Plate Characteristics of Type 12DT8.

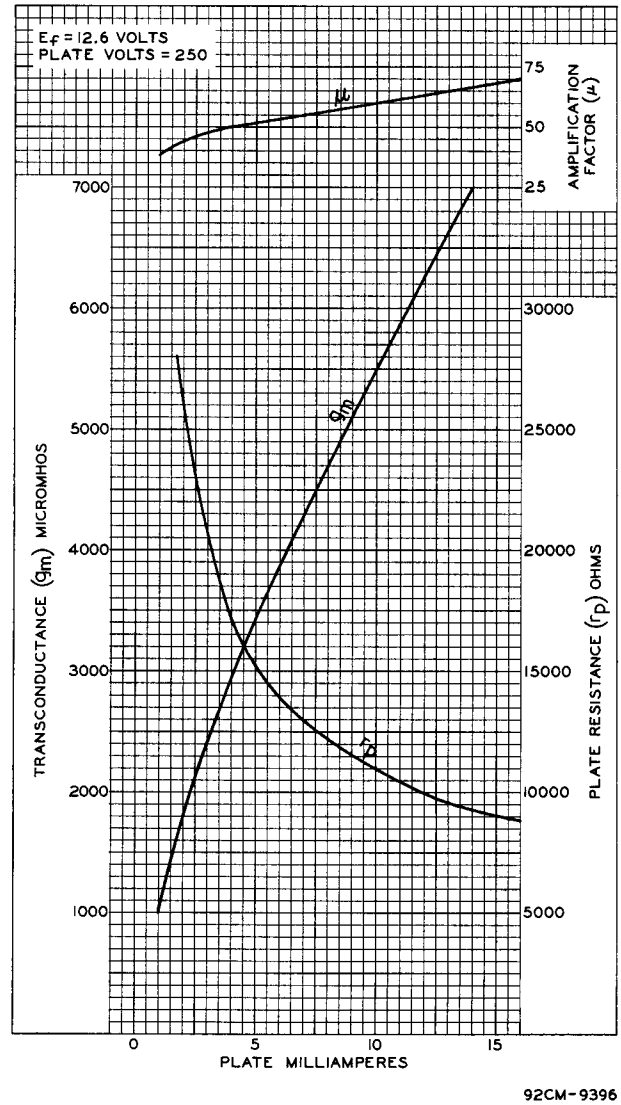
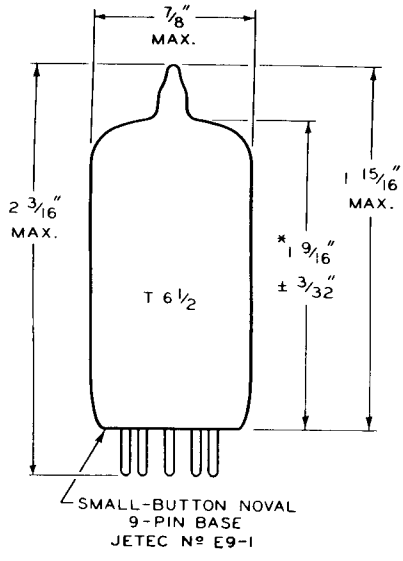


Fig. 2 – Average Characteristics of Type 12DT8.

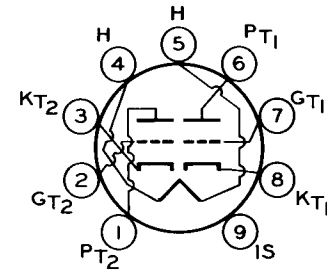
DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



9DE

PIN 1: PLATE OF TRIODE UNIT No.2
PIN 2: GRID OF TRIODE UNIT No.2
PIN 3: CATHODE OF TRIODE UNIT No.2
PIN 4: HEATER
PIN 5: HEATER
PIN 6: PLATE OF TRIODE UNIT No.1
PIN 7: GRID OF TRIODE UNIT No.1
PIN 8: CATHODE OF TRIODE UNIT No.1
PIN 9: INTERNAL SHIELD

12EG6

PENTAGRID AMPLIFIER

7-Pin Miniature Type With Two Independent Control Grids

For Use in "Hybrid" Automobile Receivers Operating Directly From 12-Volt Storage Batteries

TENTATIVE DATA

RCA-12EG6 is a pentagrid amplifier of the 7-pin miniature type intended for use as a radio-frequency amplifier tube in "hybrid" automobile receivers in which the tube and transistor electrode voltages are obtained directly from a 12-volt storage battery.

The design of this tube permits use of both grid No.1 and grid No.3 as independent control electrodes. This feature provides for improved automatic volume control under large-signal conditions when both grids are biased by the avc voltage.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage range (AC or DC)	10.0 to 15.9	volts
This voltage range is on an absolute basis. For longest life, it is recommended that the heater be operated within the voltage range of 11 to 14 volts.		
Current (Approx.) at 12.6 volts	0.15	amp
Direct Interelectrode Capacitances:•		
Grid No.3 to plate	0.25 max.	μμf
Grid No.3 to grid No.1	0.15 max.	μμf
Grid No.3 to heater, cathode, grid No.1, grids No.2 & 4, grid No.3, and grid No.5	6.5	μμf
Grid No.1 to heater, cathode, grids No.2 & 4, grid No.3, and grid No.5	5.7	μμf
Plate to heater, cathode, grid No.1, grids No.2 & 4, grid No.3, and grid No.5	12	μμf
Grid No.1 to cathode and grid No.5	3.2	μμf
Cathode to heater, grids No.2 & 4, grid No.3, and plate	23	μμf
Grid No.1 to plate	0.04 max.	μμf

Characteristics, Class A_1 Amplifier:

With 12.6 volts on heater and grid No.3 connected to grid No.1 through 100000-ohm resistor

Plate Voltage	12.6	volts
Grids No.2 & 4 (Screen-Grid) Voltage	12.6	volts
Grid-No.1 (Control-Grid) Voltage:		
Developed across 2.2-megohm resistor	-0.6	volt
Plate Current	0.55	ma
Grids-No.2 & 4 Current	2.8	ma
Transconductance, Grid No.3 to Plate	800	μmhos
Plate Resistance (Approx.)	0.15	megohm
Grid-No.1 Voltage (Approx.) for grid-No.3-to-plate transconductance of 20 μmhos	-3	volts

Mechanical:

Operating Position	Any
Maximum Overall Length	2-1/8"
Maximum Seated Length	1-7/8"
Length from Base Seat to Bulb Top (Excluding tip)	1-1/2" ± 3/32"
Diameter:	
Minimum	0.650"
Maximum	0.750"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

AMPLIFIER — Class A_1

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	16 max.	volts
GRID-No.3 VOLTAGE:		
Positive value	0 max.	volts
Negative value	-16 max.	volts
GRIDS-No.2 & 4 VOLTAGE	16 max.	volts
GRIDS-No.2 & 4 SUPPLY VOLTAGE	16 max.	volts
CATHODE CURRENT	20 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	16 max.	volts
Heater positive with respect to cathode	16 max.	volts

Maximum Circuit Values:

Grid-No.3-Circuit Resistance	10 max.	megohms

• With external shield, JETEC No.316, connected to pin No.2.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are estimated in accordance with the following definition of the *Design-Center Rating System* for rating electron devices:

Design-Center ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation*, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The equipment manufacturer should design so that initially no design-center value for the intended service is exceeded with a bogey device in equipment operating at the stated normal supply voltage.*

* For automotive equipment utilizing a 12-volt system, battery-voltage range of 10.0 volts to 15.9 volts is accepted U.S.A. practice.

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RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

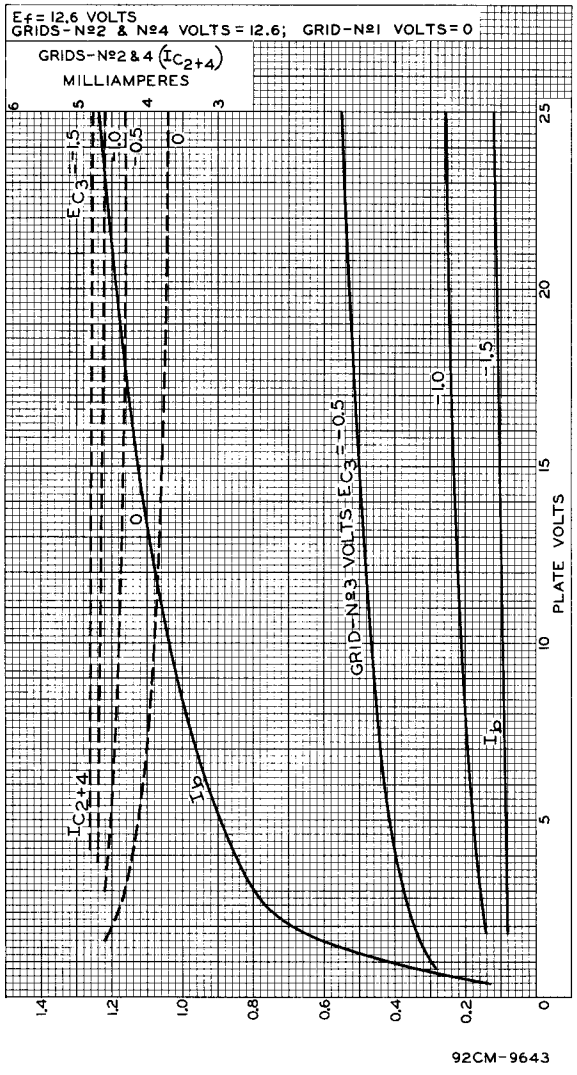


Fig. 1 - Average Characteristics of Type 12EG6.

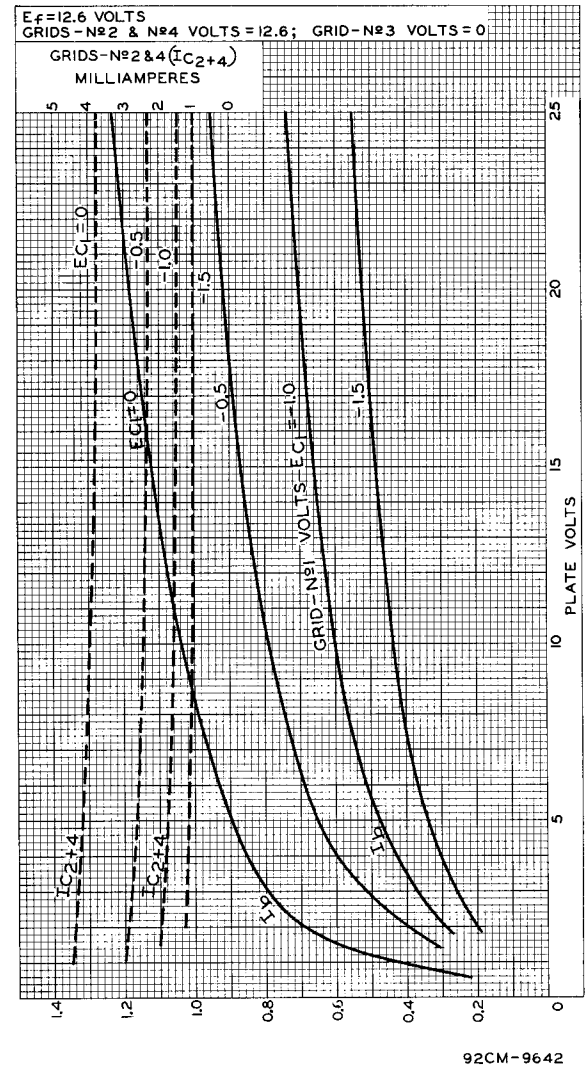


Fig. 2 - Average Characteristics of Type 12EG6.

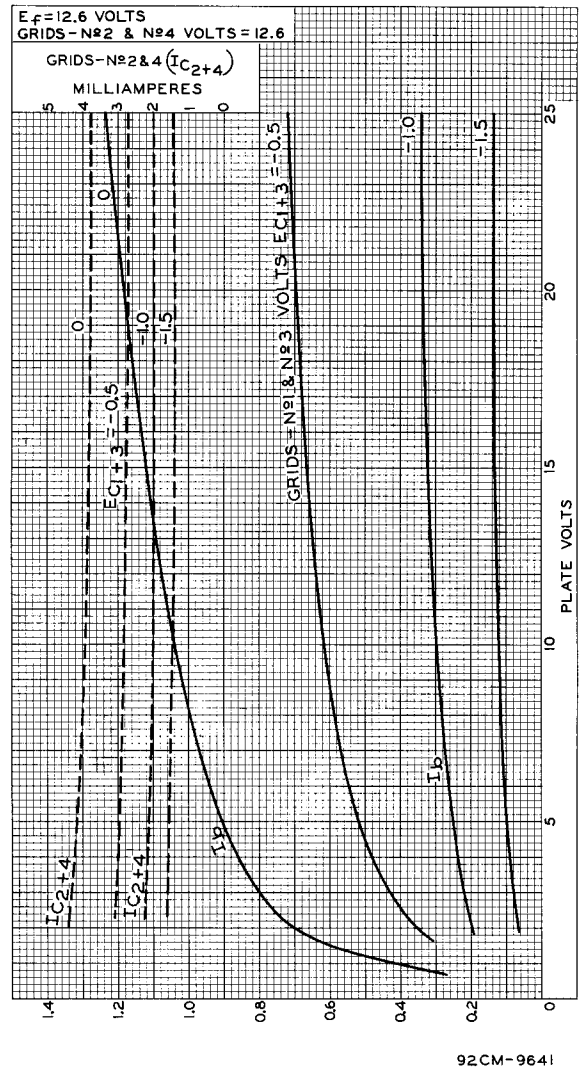
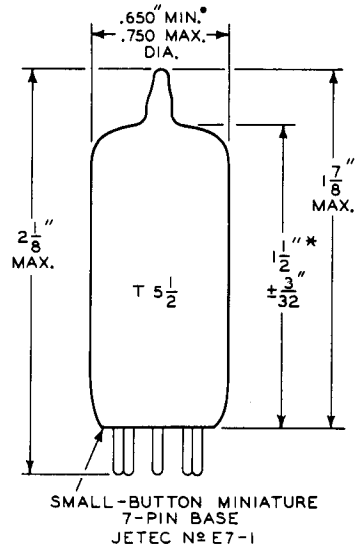


Fig. 3 - Average Characteristics of Type 12EG6.

DIMENSIONAL OUTLINE

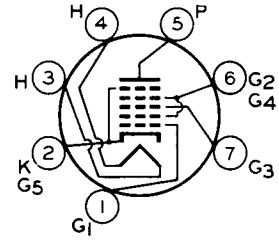


• APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



7CH

PIN 1 - GRID No.1
PIN 2 - CATHODE, GRID No.5
PIN 3 - HEATER
PIN 4 - HEATER
PIN 5 - PLATE
PIN 6 - GRIDS No.2 & 4
PIN 7 - GRID No.3

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12EK6

SHARP-CUTOFF PENTODE

For Use in "Hybrid" Automobile Receivers Operating Directly From 12-Volt Storage Batteries

7-Pin Miniature Type

TENTATIVE DATA

RCA-12EK6 is a sharp-cutoff pentode of the 7-pin miniature type. It is intended for use as an intermediate-frequency amplifier tube in "hybrid" automobile receivers in which the tube and transistor electrode voltages are obtained directly from a 12-volt storage battery. The 12EK6 may also be used as a radio-frequency amplifier tube at frequencies up into the vhf range.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage Range (AC or DC)	10.0 to 15.9	volts
This voltage range is on an absolute basis. For longest life, it is recommended that the heater be operated within the voltage range of 11 to 14 volts.		
Current (Approx.) at 12.6 volts	0.19	amp
Direct Interelectrode Capacitances (Without external shield):		
Grid No.1 to plate	0.032 max.	μμf
Grid No.1 to cathode, grid No.2, grid No.3 and internal shield, and heater	10	μμf
Plate to cathode, grid No.2, grid No.3 and internal shield, and heater	5.5	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2-1/8"
Maximum Seated Length	1-7/8"
Length from Base Seat to Bulb Top (Excluding tip)	1-1/2" ± 3/32"
Diameter:	
Minimum	0.650"
Maximum	0.750"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

AMPLIFIER — Class A_1

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	16 max.	volts
GRID-No.3 (SUPPRESSOR-GRID) VOLTAGE	0 max.	volts
GRID-No.2 (SCREEN-GRID) VOLTAGE	16 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	16 max.	volts
Heater positive with respect to cathode	16 max.	volts

Characteristics with 12.6 Volts on Heater:

Plate Voltage	12.6	volts
Grid-No.3	Connected to cathode at socket	
Grid-No.2 Voltage	12.6	volts
Grid-No.1 Supply Voltage	0	volts
Grid-No.1 Resistor (Bypassed)	2.2	megohms
Plate Resistance (Approx.)	40000	ohms
Transconductance	4200	μmhos
Grid-No.1 Voltage (Approx.) for plate current = 10 μa	−4	volts
Plate Current	4.4	ma
Grid-No.2 Current	2	ma

Maximum Circuit Values:

Grid-No.1 Circuit Resistance	10 max.	megohms

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Center Rating System* for rating electron devices:

Design-Center ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

The device manufacturer chooses those values to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation*, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The equipment manufacturer should design so that initially no design-center value for the intended service is exceeded with a bogey device in equipment operating at the stated normal supply voltage.*

* For automotive equipment utilizing a 12-volt system, battery voltage range of 10.0 volts to 15.9 volts is accepted U.S.A. practice.

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12EK6 6-58
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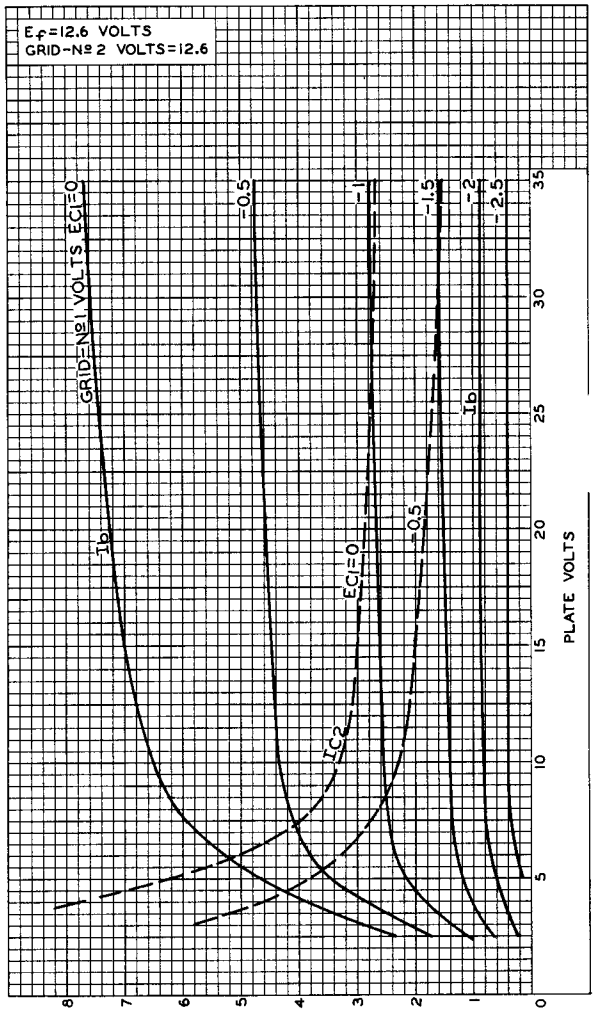


Fig. 1 - Average Characteristics for Type 12EK6.

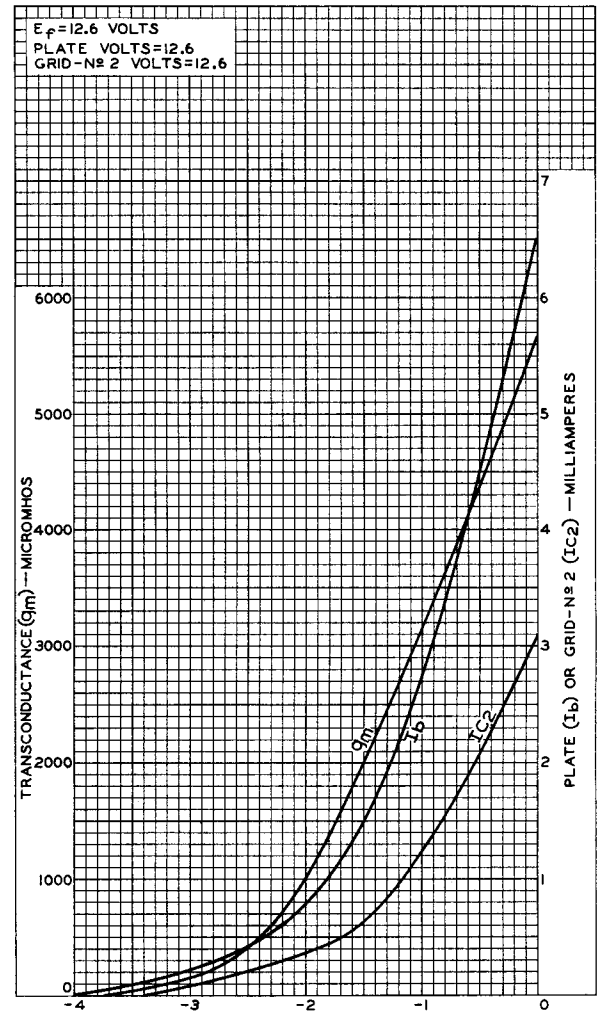
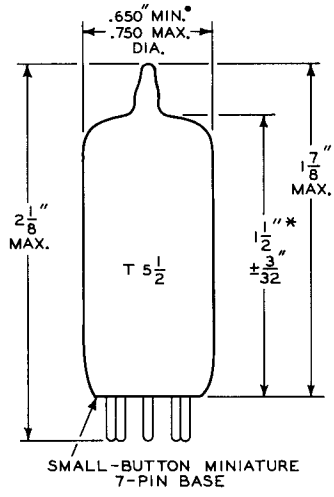


Fig. 2 - Average Characteristics for Type 12EK6.

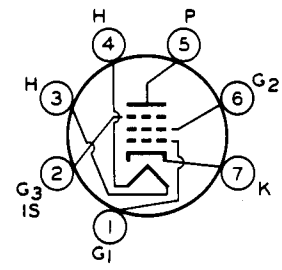
DIMENSIONAL OUTLINE



• APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



7BK

PIN 1 - GRID No.1
PIN 2 - GRID No.3
INTERNAL SHIELD
PIN 3 - HEATER
PIN 4 - HEATER
PIN 5 - PLATE
PIN 6 - GRID No.2
PIN 7 - CATHODE

12SP7

OSCILLOGRAPH TUBE

Magnetic Focus
Magnetic Deflection

Long-Persistence Screen
54° Deflection Angle

12-9/16" Max. Diameter
19-1/8" Max. Length

RCA-12SP7 is a 12-inch, directly viewed cathode-ray tube of the magnetic-focus and magnetic-deflection type intended primarily for use in radar indicator service, but it is also useful in general oscillographic applications where a temporary record of electrical phenomena is desired. It utilizes a long-persistence, cascade (two-layer) phosphor which exhibits bluish fluorescence of short persistence and greenish-yellow phosphorescence which persists for several minutes.

The face plate of the 12SP7 is made of Filterglass to provide increased trace contrast and has so slight a curvature that it is almost a flat surface. Therefore, it provides a large useful screen surface in relation to bulb diameter. This large, essentially flat surface facilitates the use of an external, transparent, calibrated scale.

The Filterglass face plate incorporates a neutral light-absorbing material which reduces ambient-light reflections from the phosphor and reflections within the face plate itself in a very much higher ratio than it reduces the directly viewed light of the trace. As a result, improved contrast is obtained.

The electron gun employed in the 12SP7 features a limiting aperture at the end of the electron gun to produce a sharper, rounder spot on the screen, especially when the tube is operated at high beam current, and hence provides greater effective resolution. Because of this feature, the 12SP7 is especially useful in those applications where pulse-modulated operation requires high grid-No.1 drive and resultant high beam current.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	ampere
Direct Interelectrode Capacitances:		
Grid No.1 to All Other Electrodes	6	μμf
Cathode to All Other Electrodes	5	μμf
Face Plate (With about 66% light transmission)	Filterglass	
Phosphor	No.7	
Fluorescence	Blue	
Phosphorescence	Greenish-Yellow	
Persistence	Long	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Deflection Angle (Approx.)	54°	
Overall Length	18-3/4" ± 3/8"	
Greatest Diameter of Bulb	12-7/16" ± 1/8"	
Minimum Useful Screen Diameter	11"	
Cap.	Recessed Small Cavity (JETEC No.J1-21)	
Base — Small-Shell Duodecal 5-Pin (JETEC No.B5-57)		

Maximum Ratings, *Design-Center Values*:

ANODE VOLTAGE	10000 max.	volts
GRID-No.2 VOLTAGE:		
Positive value (DC or Peak AC)	410 max.	volts
Negative value (DC or Peak AC)	180 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	180 max.	volts
Positive bias value#	0 max.	volts
Positive peak value	2 max.	volts
PEAK GRID-No.1 DRIVE FROM CUTOFF	65 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	125 max.	volts

Typical Operation:

Anode Voltage*	9000	volts
Grid-No.2 Voltage	250	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	-27 to -63	volts
Grid-No.2 Current	-15 to +15	μamp
Focusing-Coil Current (DC)**	107 ± 10%	ma
Spot Position	##	

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

\# At or near this rating, the effective resistance of the anode supply should be adequate to limit the anode input power to 6 watts.

* Brilliance and definition decrease with decreasing anode voltage. In general, the anode voltage should not be less than 8000 volts.

** For specimen focusing coil similar to JETEC No.106 with air gap toward tube face, center line of air gap 3-1/4" from Reference Line (see *Outline Drawing*), and total anode current of 200 microamperes.

\#\# The center of the undeflected, unfocused spot will fall within a circle having 18-mm radius concentric with the center of the tube face.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 12SP7 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

When operated at or below the maximum ratings shown in the tabulated data, *the 12SP7 does not produce any harmful x-ray radiation.* All types of cathode-ray tubes may be operated at voltages (if ratings permit) up to 16 kilovolts (absolute value) without personal injury on prolonged exposure at close range. Above 16 kilovolts, special shielding precautions for x-ray radiation may be necessary.

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

12SP7-5-51
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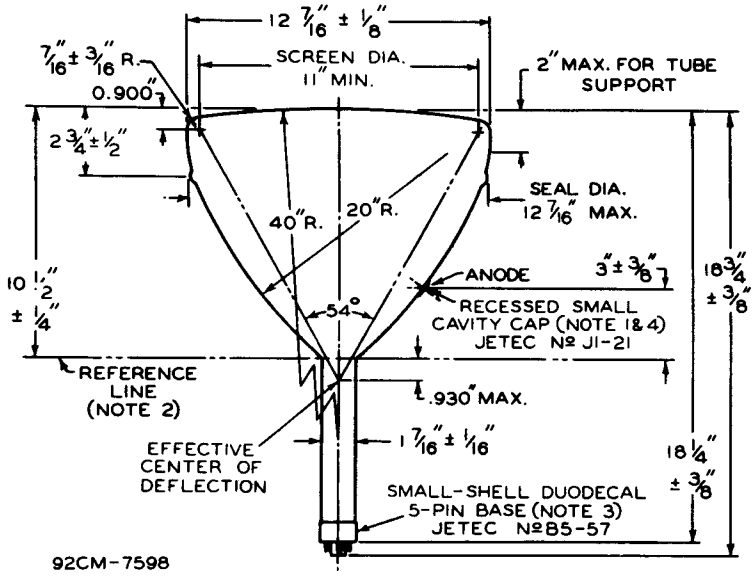
Location of the deflecting yoke and focusing coil or magnet on neck of the tube must be within a distance of 4-1/4 inches from the Reference Line (see *Outline Drawing*).

DIMENSIONAL OUTLINE

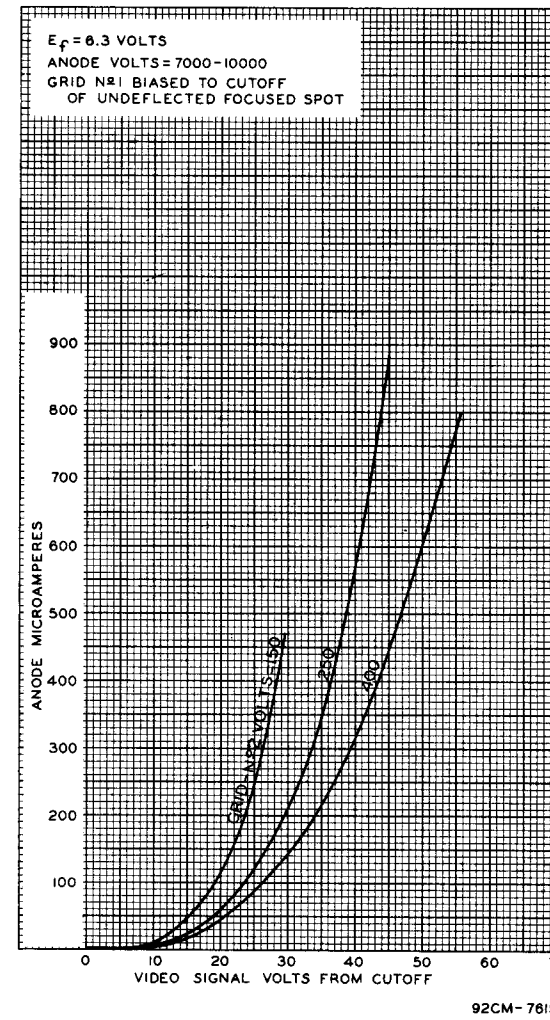


NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND VACANT PIN POSITION No.3 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE TERMINAL BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ±10°. ANODE TERMINAL IS ON SAME SIDE AS VACANT PIN POSITION No.3.

NOTE 2: REFERENCE LINE IS DETERMINED BY POSITION WHERE REFERENCE-LINE GAUGE (JETEC No.112) 1.500" + .003" -.000" I.D. AND 2" LONG WILL REST ON BULB CONE.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL FALL WITHIN CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING DIAMETER OF 1-7/8".

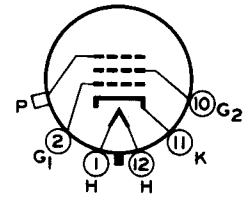
NOTE 4: TUBE SUPPORT MUST BE KEPT AT LEAST 2" AWAY FROM ANODE CAP.



Average Grid-Drive Characteristics of Type 12SP7.

SOCKET CONNECTIONS
Bottom View

PIN 1: HEATER
PIN 2: GRID No.1
PIN 10: GRID No.2



PIN 11: CATHODE
PIN 12: HEATER
CAP: ANODE

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12V6-GT

BEAM POWER AMPLIFIER

TENTATIVE DATA

RCA-12V6-GT is a beam power tube of the heater-cathode type intended primarily for use in the output amplifier of automobile radio receivers operating from a 12-volt storage battery.

The application of directed electron beam principles in the design of this tube makes it capable of producing relatively high power output with high power sensitivity. For example, a single 12V6-GT operated with a plate and grid-No.2 voltage of 250 volts can deliver a maximum-signal power output of 4.5 watts with a driving voltage of only about 12 volts. These features together with relatively low plate-current drain make the 12V6-GT especially suitable for use in the output stage of automobile receivers.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	12.6	volts
Current	0.225	ampere
Direct Interelectrode Capacitances (Approx. without external shield):		
Grid No.1 to Plate	0.7	μμf
Input	9.0	μμf
Output	7.5	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	3-5/16"
Maximum Seated Length	2-3/4"
Maximum Diameter	1-9/32"
Bulb	T-9
Base . . Intermediate-Shell Octal 7-Pin (JETEC No.B7-7)	

SINGLE-TUBE CLASS A_1 AMPLIFIER

Maximum Ratings, *Design-Center Values*:

PLATE VOLTAGE	315 max.	volts
GRID-No.2 (SCREEN) SUPPLY VOLTAGE	315 max.	volts
GRID-No.2 VOLTAGE	See Rating Chart	
PLATE DISSIPATION	12 max.	watts
GRID-No.2 INPUT	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Typical Operation:

Plate Voltage	180	250	315	volts
Grid-No.2 Voltage	180	250	225	volts
Grid-No.1 Voltage	-8.5	-12.5	-13	volts
Peak AF Grid-No.1 Voltage	8.5	12.5	13	volts
Zero-Signal Plate Current	29	45	34	ma
Max-Signal Plate Current	30	47	35	ma
Zero-Signal Grid-No.2 Current (Approx.)	3	4.5	2.2	ma
Max.-Signal Grid-No.2 Current (Approx.)	4	7	6	ma
Plate Resistance (Approx.)	50000	50000	80000	ohms
Transconductance	3700	4100	3750	μmhos
Load Resistance	5500	5000	8500	ohms
Total Harmonic Distortion	8	8	12	per cent
Max.-Signal Power Output	2	4.5	5.5	watts

PUSH-PULL CLASS AB_1 AMPLIFIER

Values are for two tubes

Maximum Ratings, *Design-Center Values*:

PLATE VOLTAGE	315 max.	volts
GRID-No.2 (SCREEN) SUPPLY VOLTAGE	315 max.	volts
GRID-No.2 VOLTAGE	See Rating Chart	
PLATE DISSIPATION	12 max.	watts
GRID-No.2 INPUT	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Typical Operation:

Plate Voltage	250	285	volts
Grid-No.2 Voltage▲	250	285	volts
Grid-No.1 Voltage▲	-15	-19	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	30	38	volts
Zero-Signal Plate Current	70	70	ma
Max.-Signal Plate Current	79	92	ma
Zero-Signal Grid-No.2 Current (Approx.)	5	4	ma
Max.-Signal Grid-No.2 Current (Approx.)	13	13.5	ma
Plate Resistance (Approx.)	60000	70000	ohms
Transconductance	3750	3600	μmhos
Effective Load Resistance	10000	8000	ohms
Total Harmonic Distortion	5	3.5	per cent
Max.-Signal Power Output	10	14	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.1 max.	megohm
For cathode-bias operation	0.5 max.	megohm

▲ The type of input coupling used should not introduce too much resistance in the grid-No.1 circuit. Transformer- or impedance-coupling devices are recommended.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 12V6-GT are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in storage-battery-operated equipment provided the following stipulations are observed:

When storage-battery equipment is operated without a charger, it should be designed so that the published maximum values of plate voltages, grid-No.2 supply voltages, dissipations, and rectified output currents are never exceeded for a terminal potential at the battery source of 2.0 volts per cell. When storage-battery equipment is operated with a charger, it should be designed so that 90 per cent of the same maximum values is never exceeded for a terminal potential at the battery source of 2.2 volts.

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

12V6-GT-10-52
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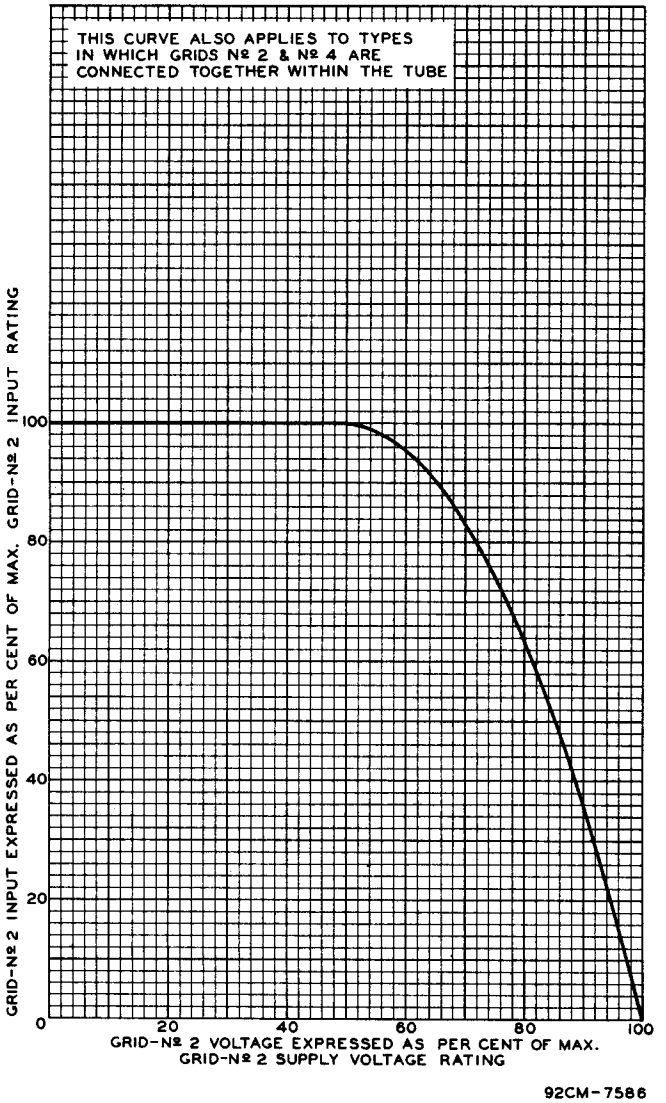


Fig. 1 - Grid-No. 2 Input Rating Curve

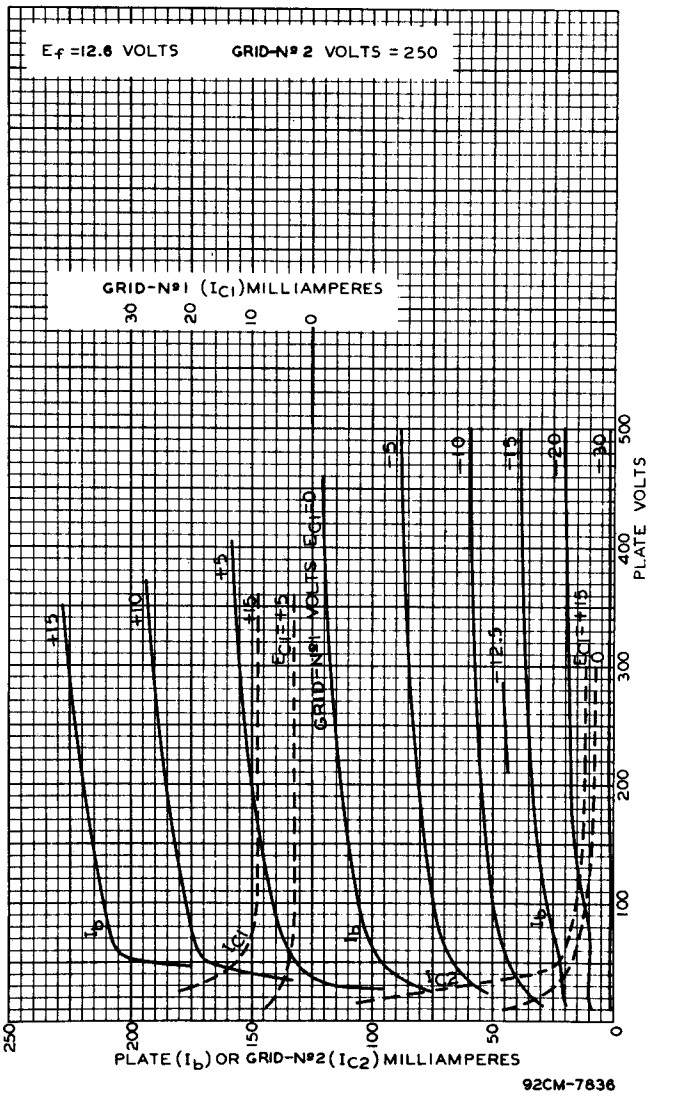


Fig. 2 - Average Plate Characteristics of Type 12V6-GT

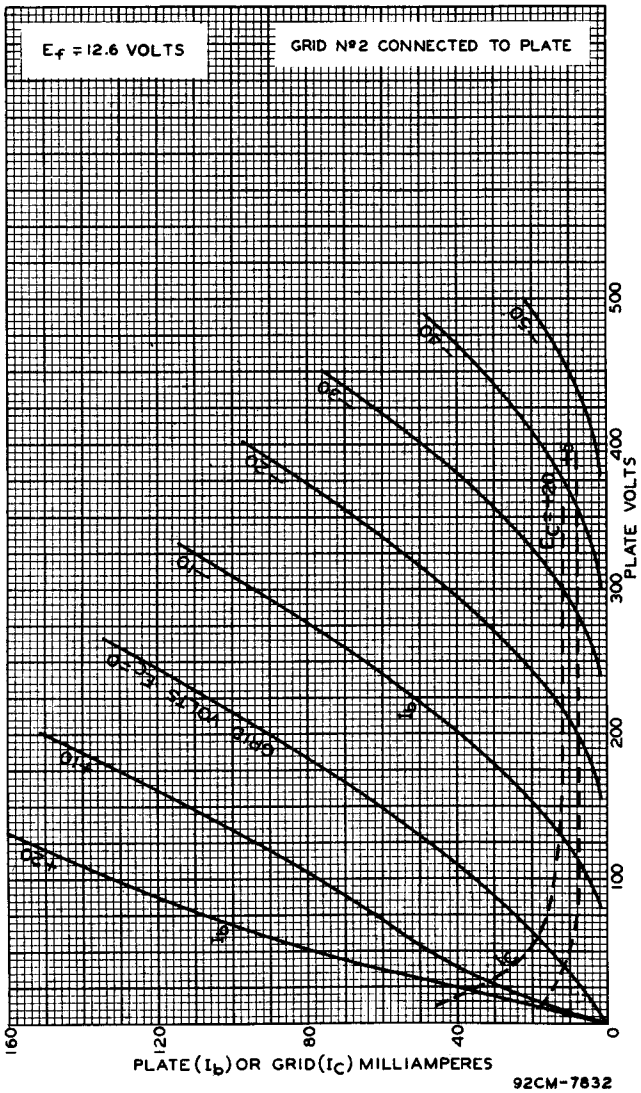


Fig. 3 - Average Plate Characteristics of Type 12V6-GT connected as Triode

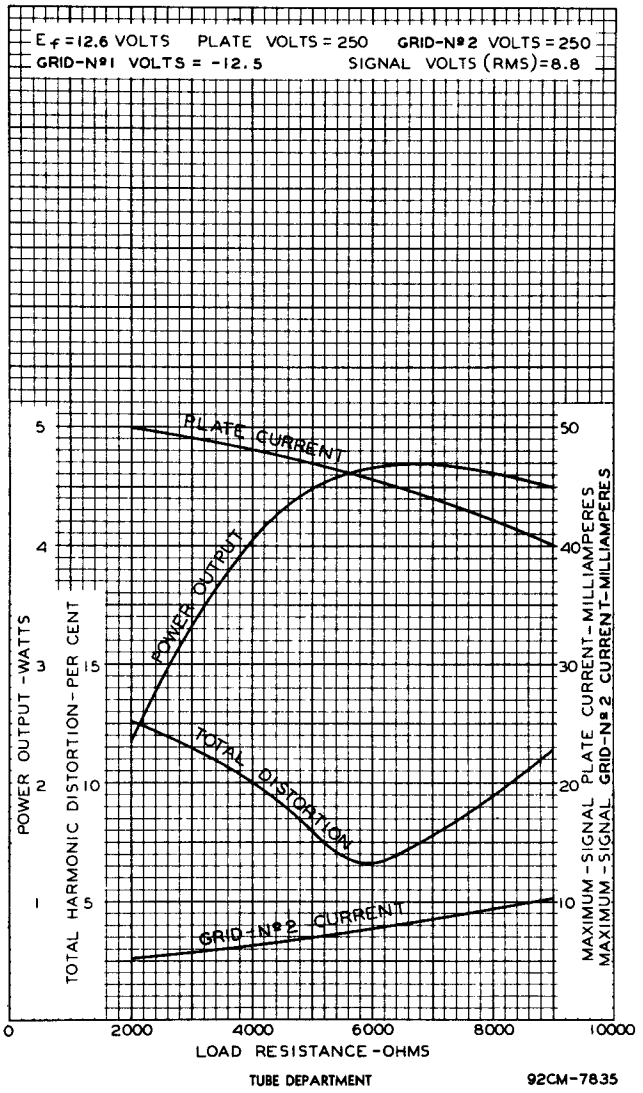
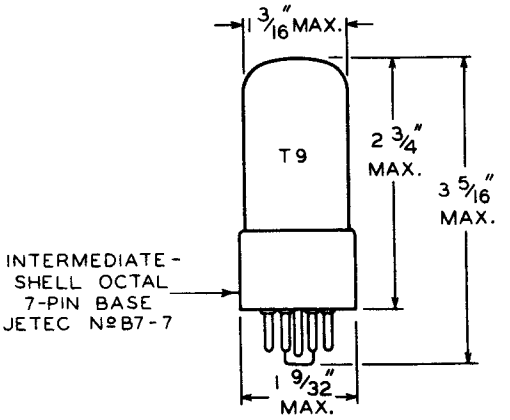
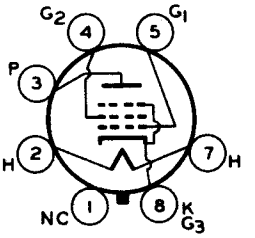


Fig. 4 - Operation Characteristics of Type 12V6-GT

DIMENSIONAL OUTLINE

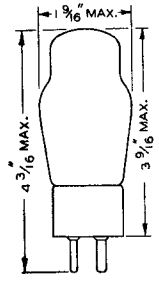


SOCKET CONNECTIONS
Bottom View



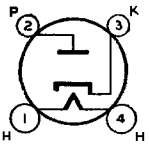
7AC

PIN 1: NO CONNECTION
PIN 2: HEATER
PIN 3: PLATE
PIN 4: GRID No.2
PIN 5: GRID No.1
PIN 7: HEATER
PIN 8: CATHODE, GRID No.3



RCA-12Z3

HALF-WAVE RECTIFIER



The 12Z3 is a half-wave, high-vacuum rectifier of the heater-cathode type for use in suitable circuits designed to supply d-c power from an a-c power line. It is intended for use in "transformerless" receivers of the "universal" (a.c.-d.c.) type. The adaptability of the 12Z3 to such receivers is facilitated by the heater design which permits of convenient series operation with other tube types.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	12.6	Volts
HEATER CURRENT	0.3	Ampere
A-C PLATE VOLTAGE (RMS)	250 *max.*	Volts
PEAK INVERSE VOLTAGE	700 *max.*	Volts
D-C OUTPUT CURRENT	60 *max.*	Milliamperes
BULB		ST-12
BASE		Small 4-Pin

INSTALLATION

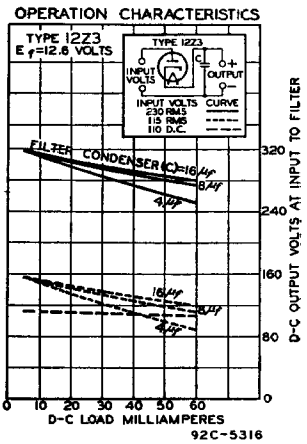
The base pins of the 12Z3 fit the standard four-contact socket which may be installed to hold the tube in any position. Sufficient ventilation should be provided to circulate air freely around the tube to prevent overheating.

The 12.6-volt heater of the 12Z3 is designed to operate under the normal conditions of line-voltage variation without materially affecting the performance or serviceability of this tube. For operation of the 12Z3 in series with the heaters of other types having 0.3 ampere rating, the current in the heater circuit should be adjusted to 0.3 ampere for the normal supply voltage. The d-c potential difference between heater and cathode should be limited to 350 volts.

APPLICATION

As a half-wave rectifier, the 12Z3 is particularly useful in "transformerless" receivers of the "universal" type. Conditions for this service are given under CHARACTERISTICS.

A filter of the condenser-input type is recommended for use with this tube in order to obtain a d-c output voltage as high as possible. A large input capacitance in the order of 16 μf is desirable. Typical output curves for several values of input condensers are shown in the accompanying diagram. As a supplement to the curves with an a-c input voltage, a dashed curve is included to show the output when the receiver is operated from a d-c power line.



14ATP4

KINESCOPE

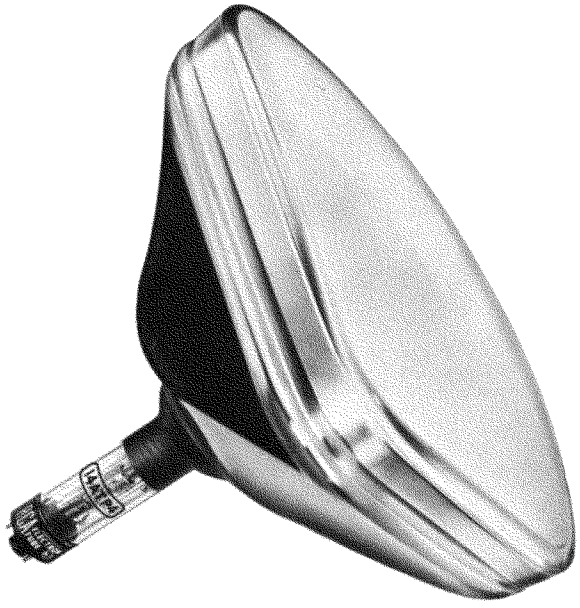
Low-Voltage Electrostatic Focus
Magnetic Deflection

Aluminized Screen
Short-Neck 90°-Deflection Type
Requires No Ion-Trap Magnet

12-1/16" x 9-1/2" Screen
14-1/8" Max. Bulb Diagonal
13-1/2" Max. Length

TENTATIVE DATA

RCA-14ATP4 is a very short, directly viewed rectangular, glass picture tube of the low-voltage electrostatic-focus and magnetic-deflection type. It has a spherical Filterglass faceplate, an aluminized screen 12-1/16" x 9-1/2" with slightly curved sides and rounded corners and a minimum projected screen area of 104 square inches.



The 14ATP4 utilizes an 8.4-volt, 450-milliampere heater having a controlled warm-up time to insure dependable performance in television receivers employing a series heater-string arrangement.

Employing wide-angle (90°) deflection, the 14ATP4 has a very short length—a length approximately 3 inches shorter than a type having the same size faceplate and 70° deflection.

The 14ATP4 utilizes an electron gun of the "straight" type designed to minimize deflection distortion. This gun permits a short neck—only 5-1/2" long, and eliminates the need for an ion-trap magnet.

Another design feature of the 14ATP4 is an external conductive bulb coating which with the internal conductive coating forms a supplementary filter capacitor.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	8.4	volts
Current	0.45	amp
Warm-Up Time (Average)	11	seconds
Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 6.7 volts.		
Direct Interelectrode Capacitances:		
Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor●	1000 max. 500 min.	μμf μμf
Faceplate, Spherical	Filterglass	
Light transmission (Approx.)	78%	
Phosphor	P4—Sulfide Type	
Fluorescence	White	
Phosphorescence	White	
Persistence	Short	
Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	90°	
Horizontal	85°	
Vertical	68°	
Tube Dimensions:		
Overall length	13-3/16" ± 5/16"	
Greatest width	13-1/16" ± 1/8"	
Greatest height	10-9/16" ± 1/8"	
Diagonal	14" ± 1/8"	
Neck length	5-1/2" ± 3/16"	
Screen Dimensions (Minimum):		
Greatest width	12-1/16"	
Greatest height	9-1/2"	
Diagonal	13"	
Projected area	104 sq. in.	
Cap	Recessed Small Cavity (JETEC No.J1-21)	
Bulb	J112 (90°)	
Base	Small-Shell Duodecal 6-Pin (JETEC No.B6-63)	
Weight (Approx.)	8.5 lbs	
Mounting Position	Any	

GRID-DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum Ratings, *Design-Center Values:*

ULTOR● VOLTAGE	14000 max. 8000 min.	volts volts
GRID-No.4 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts

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GRID-No.2 VOLTAGE.	500 max.	volts
GRID-No.1 VOLTAGE:		
Negative peak value.	200 max.	volts
Negative bias value.	140 max.	volts
Positive bias value.	0 max.	volts
Positive peak value.	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With ultor voltage (E_{c_5k}) between 8000 and 14000 volts and grid-No.2 voltage (E_{c_2k}) between 200 and 500 volts

Grid-No.4 Voltage for Focus§	0 to +400	volts
Grid-No.1 Voltage (E_{c_1k}) for Visual Extinction of Focused Raster. . .	See *Raster-Cutoff-Range Chart* for Grid-Drive Service	
Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak positive). . . .	Same value as determined for E_{c_1k} except video drive is a positive voltage	
Grid-No.4 Current.	−25 to +25	μamp
Grid-No.2 Current.	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*. . . .	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*10000*	*14000*	*volts*
and grid-No.2 voltage of	*300*	*400*	*volts*
Grid-No.4 Voltage for Focus.	0 to +400	0 to +400	volts
Grid-No.1 Voltage for Visual Extinction of Focused Raster. . .	−25 to −69	−31 to −90	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value. . . .	25 to 69	31 to 90	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum Ratings, *Design-Center Values:*

ULTOR●-TO-GRID-No.1 VOLTAGE.	14000 max. 8000 min.	volts volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE . . .	640 max.	volts
GRID-No.2-TO-CATHODE VOLTAGE	500 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value.	200 max.	volts
Positive bias value.	140 max.	volts
Negative bias value.	0 max.	volts
Negative peak value.	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 8000 and 14000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 640 volts

Grid-No.4-to-Grid-No.1 Voltage for Focus§. . .	0 to +400	volts
Cathode-to-Grid-No.1 Voltage (E_{kg_1}) for Visual Extinction of Focused Raster . . .	See *Raster-Cutoff-Range Chart* for Cathode-Drive Service	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value . . .	Same value as determined for E_{kg_1} except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*10000*	*14000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*300*	*400*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for Focus	0 to +400	0 to +400	volts
Cathode-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster. . . .	25 to 58	31 to 75	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value . . .	−25 to −58	−31 to −75	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 14ATP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 14ATP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

§ The grid-No.4 voltage or grid-No.4-to-grid-No.1 voltage required for focus of any individual tube is independent of ultor current and will remain essentially constant for values of ultor voltage (or ultor-to-grid-No.1 voltage) or grid-No.2 voltage (or grid-No.2-to-grid-No.1 voltage) within design ranges shown for these items.

* Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having 1/4-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 7/16-inch deflection of the spot from the center of the tube face.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

In television receivers employing series-heater strings, a resistor in series with the

string of tubes will minimize voltage surges across any individual tube during starting. The resistor should preferably have a negative temperature characteristic.

When operated at or below the maximum ratings shown in the tabulated data, the 14ATP4 does not produce any harmful X-ray radiation. All types of picture tubes may be operated at voltages (if ratings permit) up to 16 kilovolts (absolute value) without personal injury on prolonged exposure at close range. Above 16 kilovolts, special shielding precautions for X-ray radiation may be necessary.

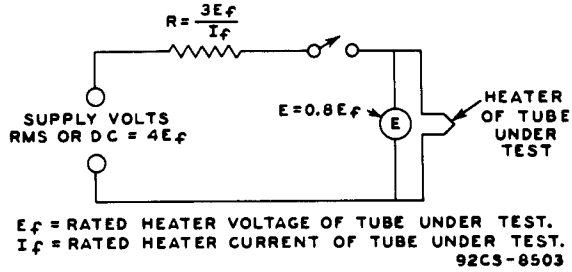


Fig. 1 - Test Circuit for Determining Heater Warm-Up Time.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

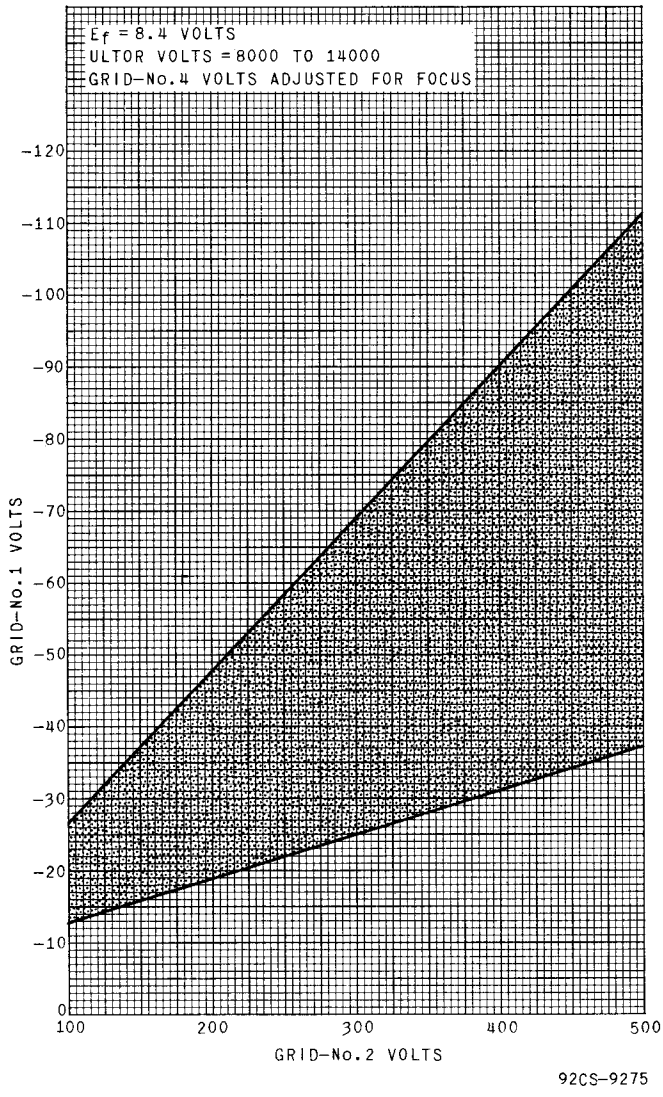


Fig. 2 - Raster-Cutoff Range for Type 14ATP4 in Grid-Drive Service.

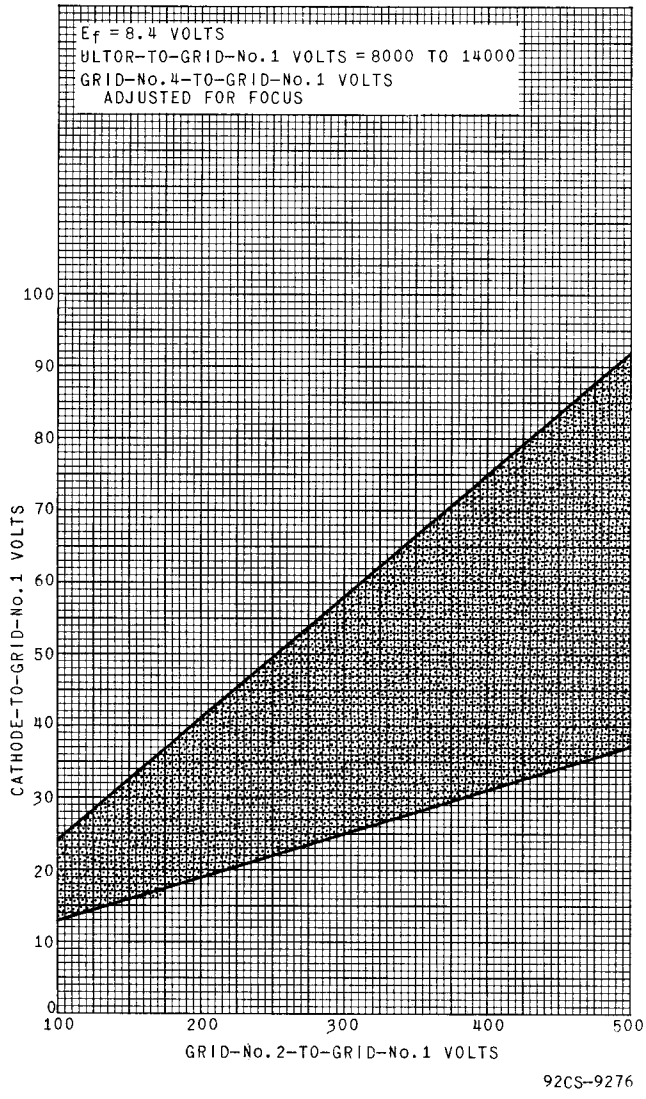


Fig. 3 - Raster-Cutoff Range for Type 14ATP4 in Cathode-Drive Service.

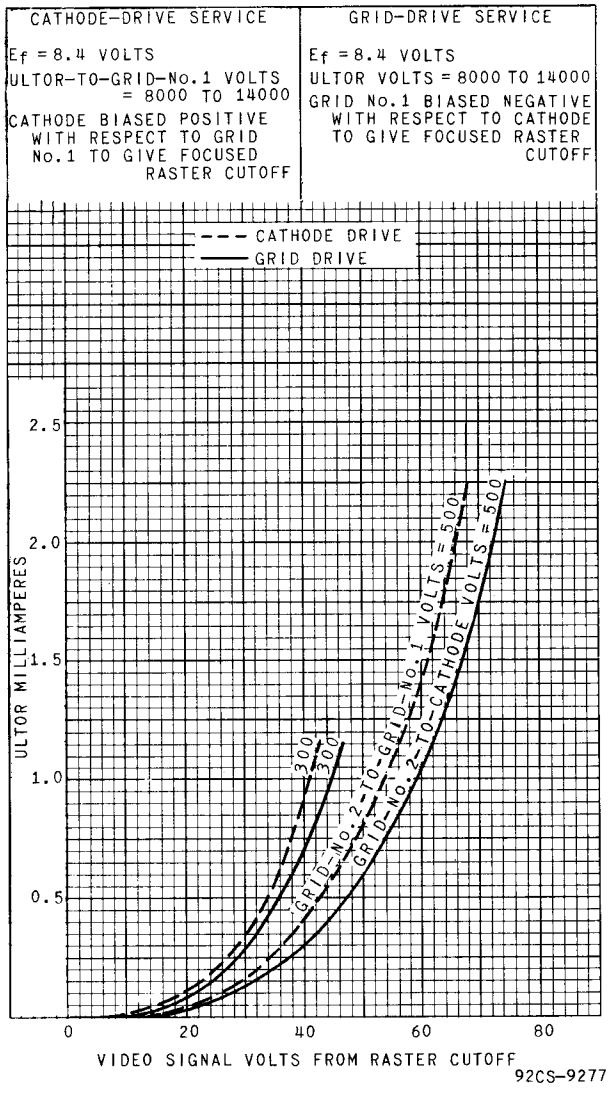


Fig. 4 – Average Drive Characteristics of Type 14ATP4.

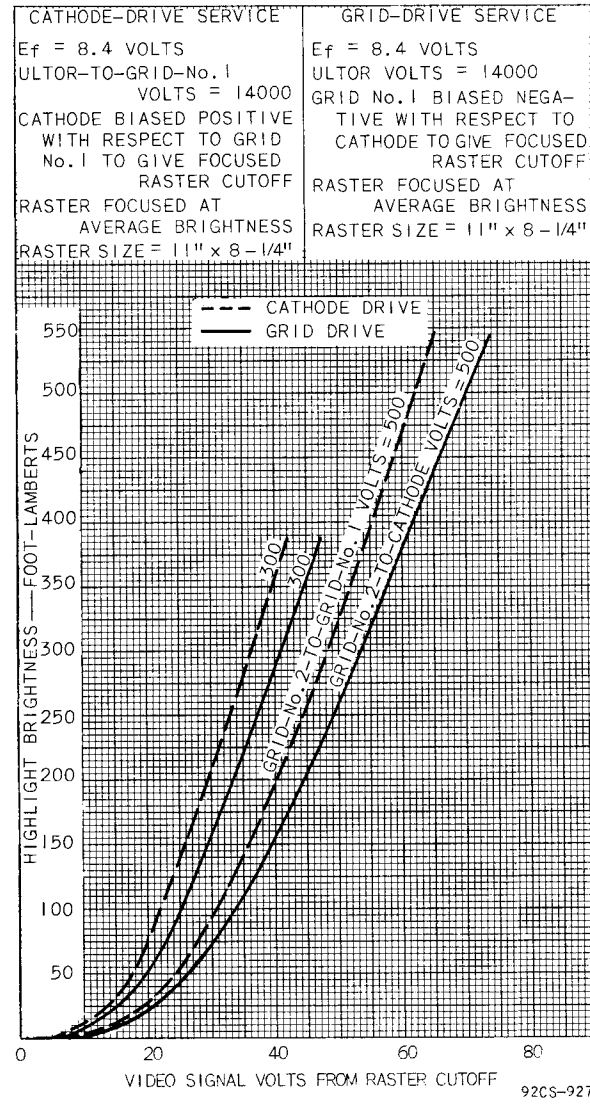
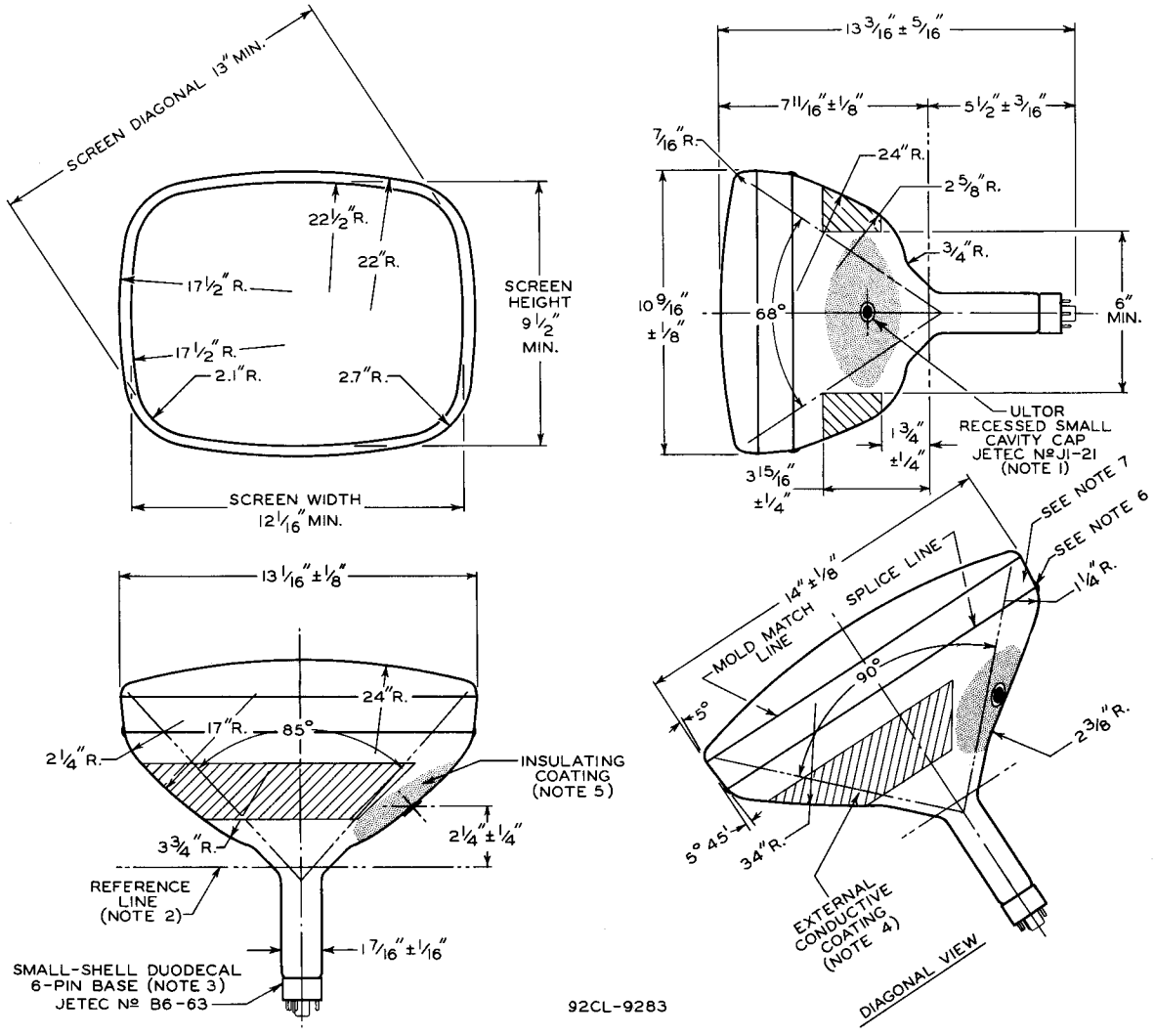


Fig. 5 – Average Drive Characteristics of Type 14ATP4.

DIMENSIONAL OUTLINE



NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.6 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND BULB TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ±30°. BULB TERMINAL IS ON SAME SIDE AS PIN No.6.

NOTE 2: WITH THE TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JETEC No.116) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 2-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

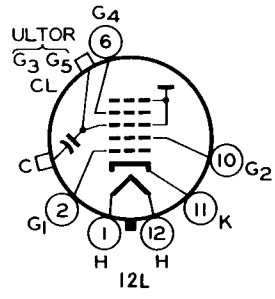
NOTE 6: BULGE AT SPLICE-LINE SEAL WILL NOT PROTRUDE BEYOND THE MAXIMUM INDICATED VALUE FOR ENVELOPE WIDTH, DIAGONAL, OR HEIGHT.

NOTE 7: UNDISTURBED AREA BETWEEN MOLD-MATCH LINE AND SPLICE LINE IS 3/4" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND.

SOCKET CONNECTIONS

Bottom View

PIN 1: HEATER
PIN 2: GRID No.1
PIN 6: GRID No.4
PIN 10: GRID No.2
PIN 11: CATHODE



PIN 12: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

14EP4

KINESCOPE

Magnetic Focus
Magnetic Deflection
Ion-Trap Gun

Rectangular Type
Filterglass Face Plate

11-3/8" x 8-1/2" Picture Area
13-13/16" Max. Bulb Diagonal
16-7/8" Max. Length

TENTATIVE DATA

RCA-14EP4 is a short, directly viewed, rectangular picture tube for use in television receivers. It has a picture area 11-3/8" x 8-1/2". The rectangular shape, which allows reproduction of the transmitted picture without waste of screen area, permits use of a cabinet having about 20 per cent less height than is required for a round-face tube having the same picture width. Consequently, the volume as well as cost of the cabinet can be substantially decreased and its

styling can be executed to give a more pleasing frontal area. In addition, the chassis need not be depressed or cut out under the face of the tube and controls can be located as desired beneath the tube.

The 14EP4 provides pictures having high brightness and good uniformity of focus over the whole picture area. It has a high-efficiency, white fluorescent screen on a face made of Filterglass to provide increased picture contrast. The Filterglass face plate incorporates a neutral light-absorbing material which reduces ambient-light reflections from the phosphor and reflections within the face plate itself in a very much higher ratio than it reduces the directly viewed light of the picture. As a result, improved contrast is obtained.

Employing magnetic focus and magnetic deflection, the 14EP4 features an improved design of funnel-to-neck section which facilitates centering of the yoke on the neck and, in combination with better centering of the beam inside the neck, contributes to the good uniformity of focus over the entire picture area. The diagonal deflection angle is 70° and the horizontal deflection angle is 65°.

Other features incorporated in the 14EP4 are short overall length; neck length of 7-3/16 inches recently adopted for use on picture tubes having deflection angle of 70° (diagonal or diameter); an external conductive coating which, with the internal conductive coating, forms a filter capacitor; and an ion-trap gun which requires only a single-field, external magnet.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	ampere
Direct Interelectrode Capacitances:		
Grid No.1 to All Other Electrodes	6	μμf
Cathode to All Other Electrodes	5	μμf
External Conductive Coating to Anode	2000 max.	μμf
	750 min.	μμf
Face Plate▲	Filterglass	
Phosphor	No.4—Sulfide Type	
Fluorescence	White	
Phosphorescence	White	
Persistence	Medium	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	70°	
Horizontal	65°	
Vertical	50°	
Ion-Trap Gun	Requires External, Single-Field Magnet	
Overall Length	16-1/2" ± 3/8"	
Greatest Diagonal of Tube at Face	13-11/16" ± 1/8"	
Greatest Width of Tube at Face	12-17/32" ± 1/8"	
Greatest Height of Tube at Face	9-23/32" ± 1/8"	
Screen Size	11-3/8" x 8-1/2"	

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Radio Corporation of America

Cap.	Recessed Small Cavity (JETEC No.J1-21)
Base	Small-Shell Duodecal 5-Pin (JETEC No.B5-57)
Mounting Position.	Any

Maximum Ratings, *Design-Center Values*:

ANODE VOLTAGE*	14000 max.	volts
GRID-NO.2 VOLTAGE.	410 max.	volts
GRID-NO.1 VOLTAGE:		
Negative bias value.	125 max.	volts
Positive bias value.	0 max.	volts
Positive peak value.	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds. .	410 max.	volts
After equipment warm-up period .	180 max.	volts
Heater positive with respect to cathode.	180 max.	volts

Typical Operation:

Anode Voltage**.	12000 . . .	volts
Grid-No.2 Voltage.	300 . . .	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	-33 to -77	volts
Focusing-Coil Current (DC)▲▲	96 ±6%	ma
Field Strength of Single-Field Ion-Trap Magnet# . .	45 . .	gausses
Ion-Trap Magnet Current (DC,approx.)●	70 . . .	ma

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

Minimum Circuit Values:

The power supply should be of the limited-energy type with inherent regulation to limit the continuous short-circuit current to 5 milliamperes. If the supply permits the instantaneous short-circuit current to exceed 1 ampere, or is capable of storing more than 250 microcoulombs, the effective resistance in circuit between indicated electrode and the output capacitor should be as follows:

Grid-No.1-Circuit Resistance . . .	150 min.	ohms
Grid-No.2-Circuit Resistance . . .	470 min.	ohms
Anode-Circuit Resistance	16000 min.	ohms

The resistors used should be capable of withstanding the applied voltage.

▲ Has transmission of about 65%.

* The product of anode voltage and average anode current should be limited to 6 watts.

** Brilliance and definition decrease with decreasing anode voltage. In general, the anode voltage should not be less than 10000 volts.

▲▲ For specimen focusing coil similar to JETEC Focusing Coil No.109 positioned with air gap toward kinescope screen, and center line of air gap 3 inches from Reference Line (see *Outline Drawing*). The indicated current is for condition with combined grid-No.1 bias voltage and video-signal voltage adjusted to produce a high-light brightness of 30 foot-lamberts on a 11-1/8" x 8-5/16" picture area sharply focused at center of screen. The indicated tolerance on focusing-coil current is on basis that distance from Reference Line to grid No.1 is controlled as shown in *Detail of Grid No.1 Position* on Outline Drawing.

\# Measured at center of field with General Electric Gauss Meter, Cat. No.409X51.

● For specimen ion-trap magnet similar to JETEC Ion-Trap Magnet No.111, located in optimum position and rotatec to give maximum brightness.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data for the 14EP4 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

When operated at or below the maximum ratings shown in the tabulated data, *the 14EP4 does not produce any harmful x-ray radiation.* All types of picture tubes may be operated at voltages (if ratings permit) up to 16 kilovolts (absolute value) without personal injury on prolonged exposure at close range. Above 16 kilovolts, special shielding precautions for x-ray radiation may be necessary.

Like other high-voltage devices, the 14EP4 requires that certain precautions be observed to minimize the possibility of failure due to humidity, dust, and corona.

Humidity Considerations. When humidity is high, a continuous film of moisture may form on the glass bulb immediately surrounding the anode cavity cap. This film may permit sparking to take place over the glass surface to the external conductive coating. Such sparking may introduce noise into the receiver. To prevent such a possibility, the uncoated bulb surface around the cap should be kept clean and dry.

Dust Considerations. The accumulation of dust on the uncoated area of the bulb around the anode cap will decrease the insulating qualities of the bulb surface. The dust usually consists of fibrous materials and may contain soluble salts. The fibers absorb and retain moisture; the soluble salts provide electrical leakage paths that increase in conductivity as the humidity increases. The resulting high leakage currents may overload the high-voltage power supply. It is recommended, therefore, that the uncoated bulb surface be kept clean and free from dust or other contamination such as finger prints.

Corona Considerations. A high-voltage system may be subject to corona, especially when the humidity is high, unless suitable precautions are taken. Corona, which is an electrical discharge appearing on the surface of a conductor when the voltage gradient exceeds the breakdown value of air, causes deterioration of organic insulating materials through formation of ozone, and induces arc-over at points and sharp edges. Sharp points or other irregularities on any part of the high-voltage system increase the possibility of corona and should be avoided. Instead, rounded corners and surfaces should be used.

As a further precaution to prevent corona, the deflecting-yoke surface on the end adjacent to the funnel should present a smooth electrical surface with respect to the anode terminal. The end of the yoke windings should not touch the funnel above the Reference Line (see *Outline Drawing*), but can follow the funnel contour departing gradually from it.

Tube Handling. A caution notice incorporating the information shown below is included in each 14EP4 carton. It is recommended that a similar

CAUTION--HANDLE WITH CARE

Breakage of this tube, which contains a high vacuum, may result in injury from flying glass. Do not strike or scratch the tube. Never subject it to more than moderate pressure when installing in or removing from equipment.

notice be prominently displayed on equipment using the 14EP4 and be included in the equipment service bulletin.

Shatter-Proof Cover Over Tube Face. It is recommended that receivers be designed with a shatter-proof, clear glass or plastic cover over the face of the 14EP4 to provide protection against flying glass in case of tube implosion caused by some abnormal condition.

The *conductive coating* on the exterior of the bulb *must be grounded.* Connection to the coating may be made by using a soft brush contact attached to the deflecting yoke or by means of a suitable strap around the tube at the face end of the coating. The latter arrangement minimizes radiation caused by the horizontal-scanning pulses. A contact area of at least 1/4 square inch should be used in making connection to the external coating. This coating must not be scratched and must never be washed with liquids likely to soften or dissolve lacquers.

The external bulb coating is designed to be used as one plate of a filter capacitor for the high-voltage power supply. The other plate of the capacitor is provided by the internal conductive coating on the bulb wall.

The *base pins* of the 14EP4 fit either the duodecal 12-contact socket or the duodecal 5-contact segment socket. The socket should be made of high-grade, low-leakage, insulating material. The socket should not be rigidly mounted; it should have flexible leads and be allowed to move freely.

Support for the tube, which may be operated in any position, should be provided by a cushioned arrangement near the screen end of the tube, and by the deflecting-yoke mounting on the neck.

The deflecting-yoke mounting, sometimes called the mounting hood, should provide adjustment for alignment of the yoke on the neck and should also provide sufficient pressure to hold the yoke firmly against the funnel. Some good insulating material, such as Neoprene, is required between the hood and the funnel not only to provide a cushion between them but also to prevent arcing from the anode terminal to the hood. The hood should be designed so that it can be placed as close as possible to the Reference Line (see *Outline Drawing*) without interfering with the yoke in order to reduce the amount of insulation required between hood and funnel. Furthermore, the hood should not exert undue pressure on the deflecting yoke.

The yoke should be held firmly against the funnel (see proper location under *Deflecting Yoke*), but any thrust should be absorbed by the insulating cushion. The hood, which also usually serves as the mounting for the focusing coil, should be specially braced to prevent lateral and longitudinal motion caused by buckling of the chassis which may occur during transportation of the receiver. A simple brace from the edge of the chassis usually provides the extra stiffness required; or a small foot placed directly under the yoke will be sufficient. Unless the precaution against thrust on the yoke is observed, the tube or yoke may be damaged during transportation of the receiver.

The *anode connection* is made by a flexible lead to the recessed small cavity cap on the side of the bulb.

The *heater* is designed to be operated at 6.3 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage between the heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

Although maximum values of peak heater-cathode voltage are specified in the tabulated data, it is recommended that the mid-tap or one side of the heater winding be connected directly to the cathode to minimize the possibility of damage to the tube produced by arcing between heater and cathode when a possible momentary internal arc causes the voltage between heater and cathode to exceed the maximum heater-cathode ratings. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

The *cathode* is connected to base pin No. 11 to which the grid-No. 1, grid-No. 2, and anode circuit returns should be made.

Grid No. 2 is incorporated in the design of the 14EP4 to prevent interaction between the fields produced by grid No. 1 and anode. Grid No. 2 may also be used to compensate for the normal variation to be expected in the grid-No. 1 voltage for cutoff in individual tubes. By adjusting the voltage applied to grid No. 2, with due consideration to its maximum rated value, it is possible to fix the grid-No. 1 bias at a desired value, and obtain approximately the same maximum anode current for individual tubes having different cutoff voltages. Adjusting grid-No. 1

voltage for beam cutoff in this way not only makes grid-No.1 drive more uniform, but also reduces variations in the anode current. Since grid No.2 draws at most only negligible leakage current, its voltage may be obtained from any convenient source.

The *fluorescent screen*, utilizing phosphor No.4--Sulfide Type, is highly efficient. Its white fluorescence has a color temperature of approximately 7000°K. The spectral distribution of the energy emitted by the P4 phosphor is shown in Fig. 1. The persistence of the phosphorescence is such that its brightness does not exceed 7 per cent of the peak value in 33 milliseconds after excitation is removed.

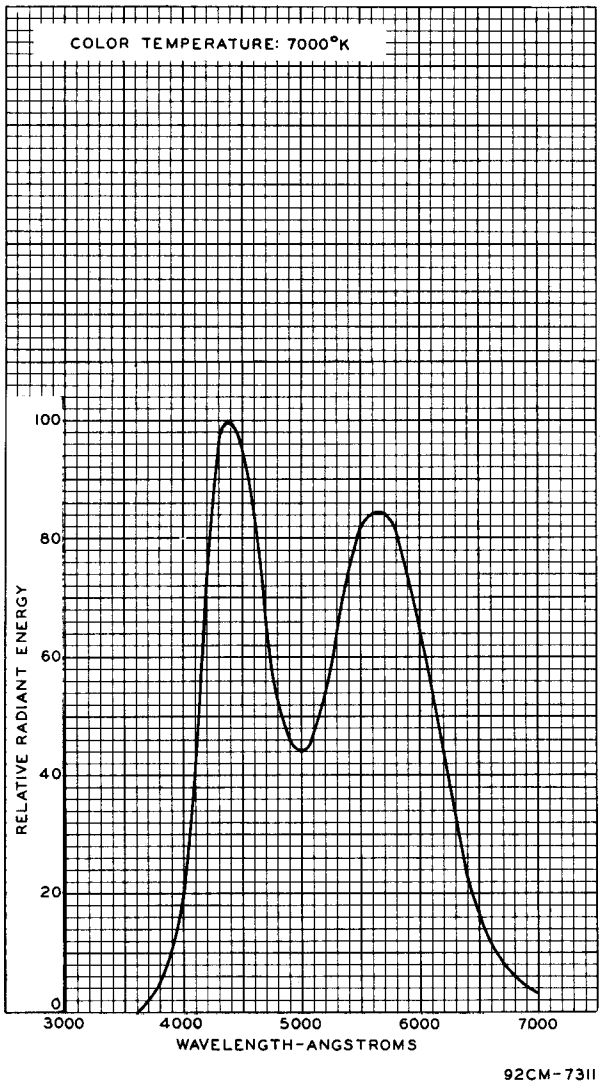


Fig. 1 - Spectral-Energy Emission Characteristic of Phosphor No.4--Sulfide Type.

The *dc voltages* for the 14EP4 may be obtained from low-energy power supplies. The supply for the anode may be of the pulse-operated or radio-frequency type; the voltage for grid No.2 may be obtained from any convenient source, such as the amplifier voltage supply; and a variable dc voltage for grid No.1 may be obtained from a potentiometer in the voltage divider across the amplifier voltage supply. It may be more convenient in some cases to operate grid No.1 at ground potential in a signal circuit and to bias the cathode positive with respect to ground by means of the amplifier voltage supply.

A small amount of voltage regulation in the anode supply acts to maintain sharp focus as the average beam current is changed. At high beam current, a relatively higher focusing-field strength is required to maintain sharp focus, but provision for such an increase is usually impractical in commercial receivers. Therefore, the same effect as would be produced by increased focusing-field strength is achieved automatically by reduction of anode voltage due to regulation. A regulation corresponding to that provided by an equivalent internal resistance of the rectifier system of 1 megohm gives good compensation. Such compensation is effective, in general, only for slow changes in current as determined by the time constant of the filter circuit.

It is recommended that the inherent regulation of the limited-energy power supply limit the continuous short-circuit current to 5 milliamperes. If the regulation of the supply permits the instantaneous short-circuit current to exceed 1 ampere, or if the power-supply output capacitor is capable of storing more than 250 microcoulombs, provision must be made to protect the tube electrodes connected to that supply. For this purpose, the use of resistors connected between the electrodes and the output capacitor of the power supply as specified in the tabulated data is recommended. The 14EP4 is designed so that an occasional internal arc will not damage the tube if the current is limited as recommended.

The high voltages at which the 14EP4 is operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is required.

In the case of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit because of capacitor breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors should be grounded.

A *deflecting yoke*, consisting of four electromagnetic coils, is required for deflecting the electron beam. These coils are used in pairs; the coils of each pair, located diametrically

opposite each other, produce a field of essentially uniform flux density. The axes of the two fields ordinarily intersect at right angles to each other and to the tube axis. The deflection of the electron beam is at right angles to the magnetic field of each pair of coils. By the use of two pairs of coils at right angles, the beam may be deflected to any part of the screen.

so that the effective center of deflection of the beam is about 1.15 inches from the Reference line (see *Outline Drawing*). This requirement is necessary to prevent the beam from striking the neck when deflection is sufficient to reach the edge of the screen.

The deflecting yoke should have an inside contour which conforms in general to the dimen-

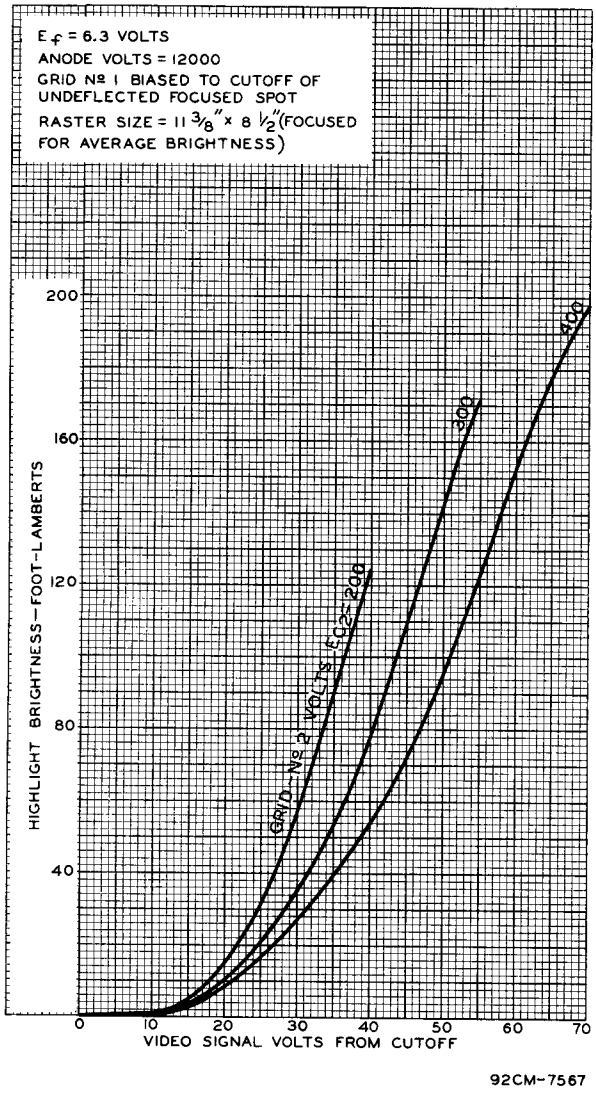


Fig. 2 – Average Grid-Drive Characteristics of Type 14EP4.

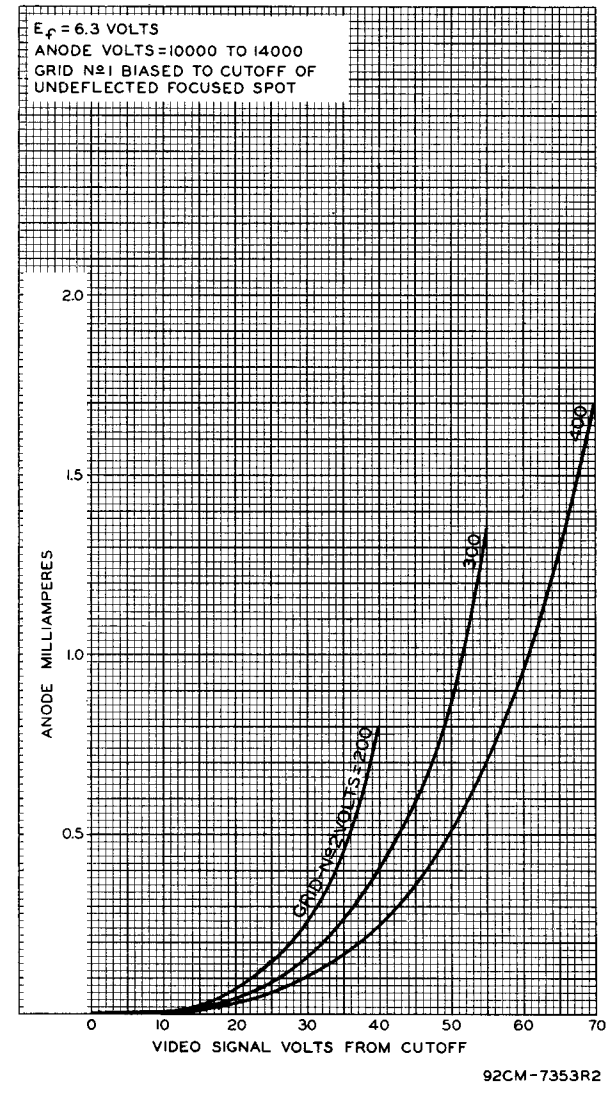


Fig. 3 – Average Grid-Drive Characteristics of Type 14EP4.

Because of the short length of the 14EP4, the electron beam must be deflected through a wide angle. To scan the screen area, it is necessary to deflect the beam through a diagonal deflection angle of 70°, a horizontal deflection angle of 65°, and a vertical deflection angle of 50°.

The deflecting yoke should have an effective length of not more than 1-11/16" and be designed

sions and shape shown in Fig.4. It is to be noted that the inner surface of the end of the yoke adjacent to the funnel should not come closer to the funnel than indicated by the 35° line in Fig.4 if adequate insulation is to be maintained across the funnel between the point of yoke contact and the anode terminal.

With a yoke designed as indicated above, it is possible to take full advantage of features

included in the 14EP4 to provide good uniformity of focus over the entire picture area. The good uniformity is obtained partly by an electron gun which centers the beam in the neck at the entrance to the deflecting fields when the ion-trap magnet is adjusted for maximum brightness, and partly by the shape of the neck-funnel section which permits good centering of the deflecting fields on the neck. The quality of edge focus will depend to a considerable extent on good deflecting-yoke design. The neck-funnel section centers the one end of the yoke when the yoke is pushed firmly against the funnel, and the other end can be centered by inserting a small cylindrical wedge of insulating material between the yoke and the neck.

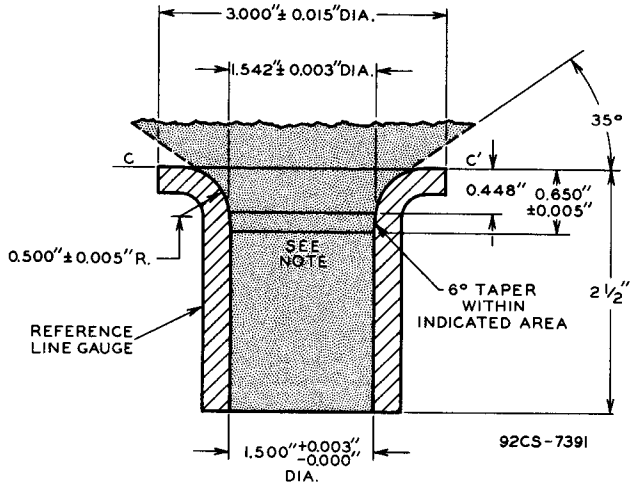


Fig. 4 - Reference-Line Gauge (JETEC No. 110) with Supplementary Information on Recommended Inside Contour of Yoke to Provide Proper Location of Yoke on Neck-Funnel Section.

A *focusing field,* supplied by an electromagnetic coil, permanent magnet, or a combination of the two, is required to concentrate the electron beam into a focused spot at the screen. The field should have excellent radial symmetry. When a coil is used, it should be supplied with direct current from a well-filtered source. The field strength to produce a focused spot is indicated in the tabulated data. For other anode voltages than that shown, the coil current will be approximately proportional to the square root of the anode voltage. Regardless of the kind of focusing device used, provision should be made for adjusting the field strength to cover the anode-voltage operating range and the normal variation between individual tubes.

The focusing field should be spaced at least 1/2 inch from the end of the deflecting-coil windings to reduce interaction between the focusing and deflecting fields. If the focusing field is placed too close to the deflecting fields, interaction between them may reduce deflection sensitivity and corner resolution, as well as cause objectionable rotation of the fluorescent pattern as the focus is varied. On the other hand, if the focusing field is too close to the electron gun, resolution will be reduced and pattern distortion may occur as a result of interaction with the ion-trap-magnet field.

As the air gap of the focusing device is moved away from the deflecting yoke, the corner resolution will be improved at the expense of slight loss in center resolution. The strength of the focusing field required increases appreciably as the distance between the deflecting-yoke windings and the air gap of the focusing device is increased.

The *ion-trap magnet,* required to recenter the electron beam in the gun structure, should be of the single-field type. It may be either a permanent magnet or an electromagnet, but should be capable of providing a field strength at its center of 45 gausses for operation in the range from 12000 to 14000 volts. If an electromagnet is used, it should be operated with direct current from a well-filtered source. Direction of the field of the ion-trap magnet should be such that the north pole is adjacent to vacant pin position No.8 and the south pole to pin No.2.

To operate properly with the electron gun in the 14EP4, the ion-trap magnet should be positioned in the region of grid No.2 (see Fig.5) with choice of position preferably toward the base rather than toward the funnel. This position should result in a properly centered pattern having full brightness and a minimum of shadowing at the edges. If full brightness is accompanied by an unsymmetrical raster shape and poor focus, it is an indication that the ion-trap magnet has incorrect rotational positioning and that the focusing field has been displaced to counteract incorrect positioning of the ion-trap magnet.

Centering of the pattern is preferably accomplished by passing direct current of the required value through each pair of deflecting coils. When this method of centering is not used, the yoke circuits should filter out the dc component of the deflecting currents. Then, the small amount of centering needed to position the pattern in the mask and to correct for small alignment errors can be provided by displacing the focusing field from its optimum position. Both decentering and tilting of the focusing field change the raster position but the former is generally preferred because it produces less distortion.

Adjustment of spot size and intensity is made by varying the focus and anode current. The current to the anode may be increased by decreasing the bias applied to grid No.1. Also, an increase in the voltage applied to grid No.2 increases the anode current as well as the sharpness of focus and, therefore, the spot intensity.

In applications where high definition is the principal requirement, the 14EP4 may be operated with the maximum anode and grid-No.2 voltages, and the lowest value of anode current consistent with the desired brightness. Higher anode voltages are not always desirable because they reduce deflection sensitivity. Higher grid-No.2 voltages require higher values of grid-No.1 voltage for beam cutoff and higher grid-No.1 drive to provide a given brightness as shown by the curves in Fig.2.

A *high-intensity spot* will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, the beam should always be kept in motion over a reasonably large area, or the beam current should be reduced.

The *maximum value of peak anode current* and the *maximum value of the average anode current* that will be required from the high-voltage power supply for the 14EP4 are 1 milliampere and 0.250 milliampere, respectively.

Grid drive, or the extent to which grid No.1 is driven in the positive direction from cutoff, should be limited on the maximum excursions above zero grid bias to + 2 volts. The positive grid-No.1 excursions may be limited to the rated maximum value by utilizing a diode limiter, a series grid-No.1 resistor, or some other suitable arrangement. The curves in Fig.3 show anode current versus video signal voltage from cutoff for the 14EP4 with an anode voltage of 10000 to 14000 volts and grid-No.2 voltages of 200, 300, and 400 volts.

The *characteristics curves* in Figs.2 and 3 are for the condition with grid No.1 biased to give visual extinction of the undeflected, focused spot. In viewing television pictures, it will be found that the actual cutoff voltage corresponding to black in the picture is approximately 5 volts less negative than shown on the curves; similarly, the grid-No.1 drive to obtain a given anode current or light output is also about 5 volts less negative.

The *recommended sequence of adjustments* in lining up the 14EP4 with its associated components is as follows:

1. Place the deflecting yoke on the tube neck and press it firmly against the funnel. Then insert a cylindrical liner with a tapered end between the base end of the yoke windings and the tube neck. Space the focusing device about 1/2 inch back of the deflecting-coil windings and position it coaxially with the tube neck. Next, position the ion-trap magnet on the neck so that its poles are roughly aligned with grid No.2 (see Fig.5).

2. Apply operating voltages with scanning to the tube and adjust the grid-No.1 voltage to a value about midway between zero and cutoff.

3. Then, promptly rotate the ion-trap magnet and move it slightly forward and backward until the maximum raster brightness is obtained. Readjust grid-No.1 bias to give average picture brightness. Move the ion-trap magnet backward and forward noting both positions at which brightness is diminished, and then locate it halfway between these positions.

It is important that this adjustment be made with low anode current and without delay after the operating voltages are applied. Operation of the tube with the ion-trap magnet improperly positioned may damage the tube. If the anode voltage supply is not of the limited-energy type, damage may occur very quickly.

4. Focus the pattern by adjusting the focusing-field strength. Then, rotate the deflecting yoke to align the raster with the tube mask and adjust the raster size to fit the mask. Center the raster by adjusting the dc current through the deflecting yoke. If such adjustment is not provided, centering may be obtained by moving the focusing field slightly off center or by tilting the focusing field. The latter method generally produces the most distortion. If a corner of the raster is shadowed, it may be due to excess dc current in the yoke or to incorrect alignment of the components on the tube neck. It may be possible to obtain minor correction by readjustment of the ion-trap magnet. If not, rotate both the tube and the ion-trap magnet 180° and repeat Steps 3 and 4.

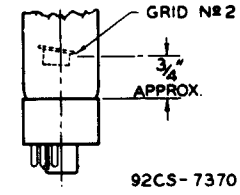
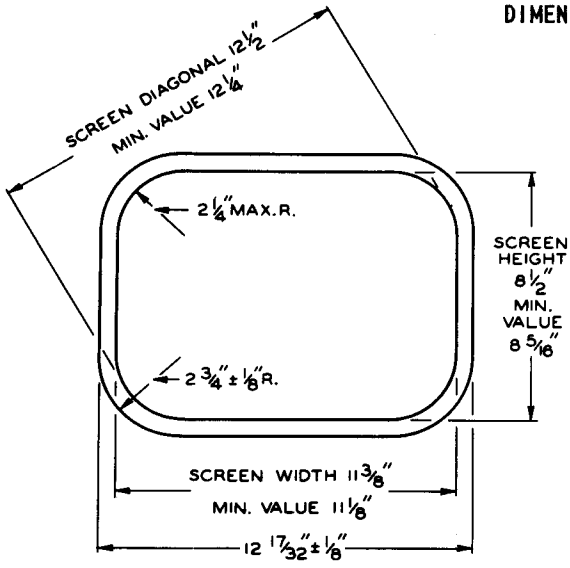


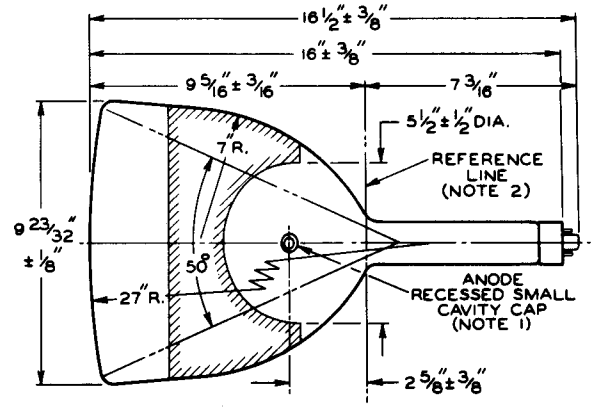
Fig.5 - Location of Grid No.2 in Tube Neck.

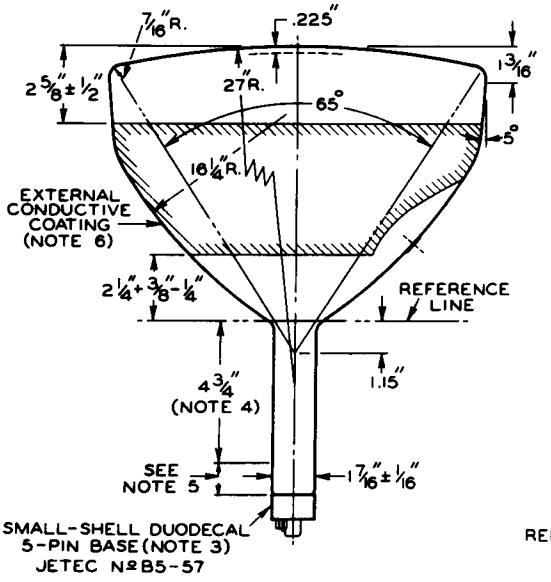
5. Vary grid-No.1 drive and grid-No.1 bias through the expected operating range to observe whether shadowing occurs. If a shadow appears near the edges of the raster, first check to be sure that the deflecting yoke bears firmly against the funnel; and then eliminate any remaining shadow as explained in Step 4.

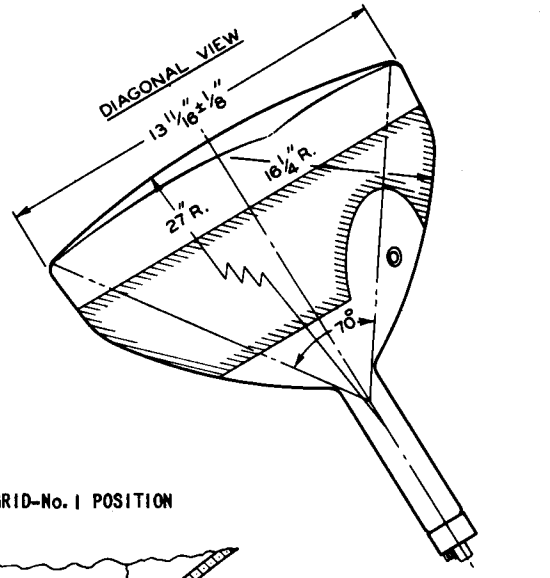
Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE









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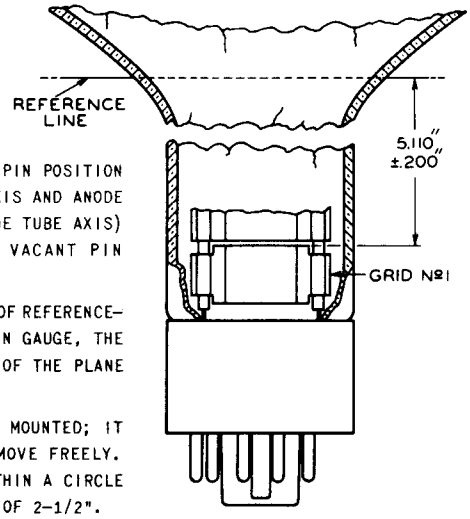
DETAIL OF GRID-No. 1 POSITION



92CS-7560

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND VACANT PIN POSITION No. 6 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF 30°. ANODE TERMINAL IS ON SAME SIDE AS VACANT PIN POSITION No. 6.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JETEC No. 110) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

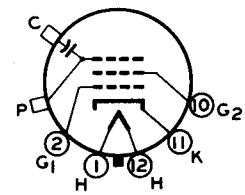
NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 2-1/2".

NOTE 4: LOCATION OF DEFLECTING YOKE AND FOCUSING DEVICE MUST BE WITHIN THIS SPACE.

NOTE 5: KEEP THIS SPACE CLEAR FOR SINGLE-FIELD, ION-TRAP MAGNET.

NOTE 6: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

SOCKET CONNECTIONS
Bottom View



PIN 1: HEATER
PIN 2: GRID No. 1
PIN 10: GRID No. 2
PIN 11: CATHODE
PIN 12: HEATER
CAP: ANODE
C: EXTERNAL CONDUCTIVE COATING

from RTMA release #967, April 23, 1951

Rel. 967

14GP4

KINESCOPE

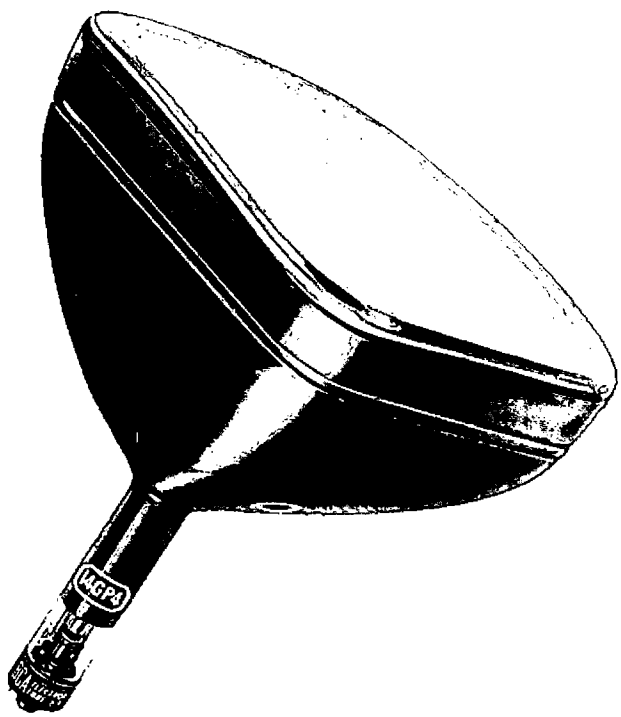
Electrostatic Focus
Magnetic Deflection
Ion-Trap Gun

Rectangular Glass Type
Filterglass Face Plate
External Conductive Coating

11-3/8" x 8-1/2" Picture Size
13-13/16" Max. Bulb Diagonal
17-3/16" Max. Length

TENTATIVE DATA

RCA-14GP4 is a short, directly viewed, rectangular, glass picture tube for use in television receivers. It has a picture size of 11-3/8" x 8-1/2". Utilizing electrostatic focusing, the 14GP4 features an electron gun of improved design



to provide good uniformity of focus over the entire picture area. Furthermore, focus is maintained automatically with variation in line voltage and with adjustment of picture brightness. Need for alignment of a focusing coil or focusing magnet is eliminated and therefore tube installation and adjustment for optimum performance are simplified. Because the electron gun is designed so that the focusing electrode (grid No.4) takes very little current, the voltage for the focusing electrode can be provided easily and economically.

The rectangular shape, which allows reproduction of the transmitted picture without waste of screen area, permits use of a cabinet having about 20 per cent less height than is required for a round-face tube having the same picture width. In addition, the chassis need not be depressed or cut out under the face of the tube and controls can be located as desired beneath the tube.

Providing pictures having high brightness, the 14GP4 has a high-efficiency, white fluorescent screen on a face made of Filterglass to provide increased picture contrast. The Filterglass face plate incorporates a neutral light-absorbing material which reduces ambient-light reflections from the phosphor and reflections within the face plate itself in a very much higher ratio than it reduces the directly viewed light of the picture. As a result, improved picture contrast is obtained.

Employing magnetic deflection, the 14GP4 is designed with a funnel-to-neck section which facilitates centering of the yoke on the neck and, in combination with a well-centered beam inside the neck, contributes to the good uniformity of focus over the entire picture area. The diagonal deflection angle is 70° and the horizontal deflection angle is 65°.

Other design features of the 14GP4 are short overall length; an external conductive coating which with the internal conductive coating forms a supplementary filter capacitor for the high-voltage supply; and an ion-trap gun requiring only a single-field, external magnet.

DATA

General:

Heater, for unipotential cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	ampere
Direct interelectrode Capacitances:		
Grid No.1 to All Other Electrodes	6	μμf
Cathode to All Other Electrodes	5	μμf
External Conductive Coating to Ultor	2000 max. / 750 min.	μμf
Face Plate (with about 66% light transmission)	Filterglass	

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Phosphor	No.4—Sulfide Type
Fluorescence	White
Phosphorescence	White
Persistence	Short
Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angles (Approx.):	
Diagonal	70°
Horizontal	65°
Vertical	50°
Ion-Trap Gun	Requires External, Single-Field Magnet
Overall Length	16-13/16" ± 3/8"
Greatest Diagonal of Tube at Face	13-11/16" ± 1/8"
Greatest Width of Tube at Face	12-17/32" ± 1/8"
Greatest Height of Tube at Face	9-23/32" ± 1/8"
Screen Size	11-3/8" x 8-1/2"
Cap	Recessed Small Cavity (JETEC No.J1-21)
Base	Small-Shell Duodecal 6-Pin (JETEC No.B6-63)
Mounting Position	Any

Maximum Ratings, *Design-Center Values*:

ULTOR● VOLTAGE	14000 max.	volts
GRID-NO.4 VOLTAGE	5000 max.	volts
GRID-NO.2 VOLTAGE	500 max.	volts
GRID-NO.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	410 max.	volts
After equipment warm-up period	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Typical Operation:

Ultor● voltage*	12000	volts
Grid-No.4 voltage for ultor current of 100 μamp (18.1% to 24.5% of applied ultor voltage)	2170 to 2940	volts
Grid-No.2 voltage	300	volts
Grid-No.1 voltage for visual extinction of undeflected focused spot	-33 to -77	volts
Grid-No.4 current	-15 to +25	μamp
Grid-No.2 current	-15 to +15	μamp
Field Strength of Single-Field Ion-Trap Magnet (Approx.)#	35	gausses
Ion-Trap-Magnet Current (DC, approx.)□	70	ma
Field Strength of Adjustable Centering Magnet	0 to 8	gausses

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● Grid No.3, grid No.5, and collector are connected together within the tube and are collectively identified by the new word "ultor" to facilitate reference to them. The "ultor" in a cathode-ray tube is the electrode, or the electrode in combination with one or more additional electrodes connected within the tube to it, to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection.

* Brilliance and definition decrease with decreasing ultor voltage. In general, the ultor voltage should not be less than 10000 volts.

\# Measured at center of field with General Electric Gauss Meter, Cat. No. 409X51.

□ For specimen ion-trap magnet similar to JETEC Ion-Trap Magnet No.111 located in optimum position and rotated to give maximum brightness.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 14GP4 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

When operated at or below the maximum ratings shown in the tabulated data, *the 14GP4 does not produce any harmful x-ray radiation.* All types of picture tubes may be operated at voltages (if ratings permit) up to 16 kilovolts (absolute value) without personal injury on prolonged exposure at close range. Above 16 kilovolts, special shielding precautions for x-ray radiation may be necessary.

Tube Handling. A caution notice incorporating the information shown below is included in each 14GP4 carton. It is recommended that a similar notice be prominently displayed on equipment using the 14GP4 and be included in the equipment service bulletin.

CAUTION--HANDLE WITH CARE

Breakage of this tube, which contains a high vacuum, may result in injury from flying glass. Do not strike or scratch the tube. Never subject it to more than moderate pressure when installing in or removing from equipment.

Shatter-Proof Cover Over The Tube Face. It is recommended that receivers be designed with a shatter-proof, clear glass or plastic cover over the face of the 14GP4 to provide protection against flying glass in case of tube implosion caused by some abnormal condition.

The *conductive coating* on the exterior of the bulb *must be grounded.* Connection to the coating may be made by using a soft brush contact attached to the deflecting yoke or by means of a suitable strap around the tube at the face end of the coating. The latter arrangement minimizes radiation caused by the horizontal-scanning pulses. A contact area of at least 1/4 square inch should be used in making connection to the external coating. This coating must not be scratched and must never be washed with liquids likely to soften or dissolve lacquers.

The external bulb coating is designed to be used as one plate of a supplementary filter capacitor for the high-voltage power supply. The other plate of the capacitor is provided by the internal conductive coating on the bulb wall.

Support for the tube, which may be operated in any position, should be provided by a cushioned arrangement near the screen end of the tube, and by the deflecting-yoke mounting on the neck of the tube.

The deflecting-yoke mounting, sometimes called the mounting hood, should provide adjustment for alignment of the yoke on the neck and should also provide sufficient pressure to hold the yoke

firmly against the funnel. Some good insulating material, such as Neoprene, is required between the hood and the funnel not only to provide a cushion between them but also to prevent arcing from the recessed small cavity cap to the hood. The hood should be designed so that it can be placed as close as possible to the Reference Line (see *Outline Drawing*) without interfering with the yoke in order to reduce the amount of insulation required between hood and funnel. Furthermore, the hood should not exert undue pressure on the deflecting yoke.

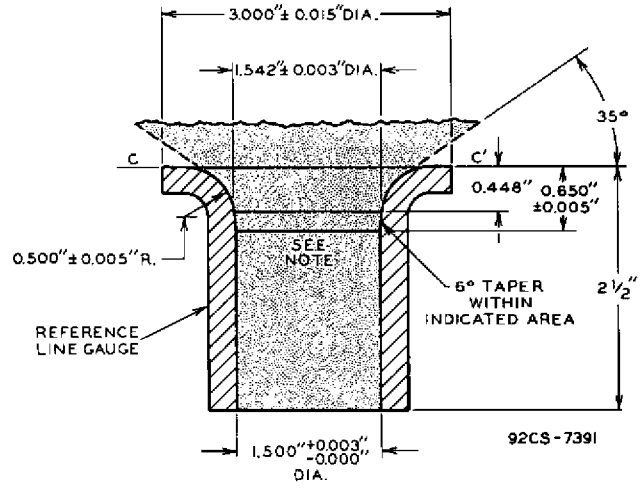

Fig. 1 - Reference-Line Gauge (JETEC No. 110) with Supplementary Information on Recommended Inside Contour of Yoke to Provide Proper Location of Yoke on Neck-Funnel Section.

The yoke should be held firmly against the funnel (see proper location under *Deflecting Yoke*), but any thrust should be absorbed by the insulating cushion. The hood should be specially braced to prevent lateral and longitudinal motion caused by buckling of the chassis which may occur during transportation of the receiver. A simple brace from the edge of the chassis usually provides the extra stiffness required; or a small foot placed directly under the yoke may be sufficient. Unless the precaution against thrust on the yoke is observed, the tube or yoke may be damaged during transportation of the receiver.

The *deflecting yoke* should have an effective length of not more than 1-11/16 inches and be designed so that the effective center of deflection of the beam is about 1.15 inches from the Reference Line (see *Outline Drawing*). This requirement is necessary to prevent the beam from striking the neck when deflection is sufficient to reach the edge of the screen.

The deflecting yoke should have an inside contour which conforms in general to the dimensions and shape shown in Fig. 1. It is to be noted that the inner surface of the end of the yoke adjacent to the funnel should not come closer to the funnel than indicated by the 35° line in Fig. 1 if adequate insulation is to be maintained across the funnel between the point of yoke contact and the recessed cap terminal.

Focusing of the beam in the 14GP4 is accomplished by adjustment of the voltage applied to grid No. 4. Because this electrode takes very low current, the focusing voltage can be easily provided. Any method used must take into account the grid-No. 4 leakage current as shown in the tabulated data. When the high voltage supply is of the pulse-operated, limited-energy type commonly used, the focusing voltage can be obtained by means of a simple rectifier system connected to a suitable tap on the horizontal-deflection-output and high-voltage transformer. Such an arrangement produces negligible drop in the output voltage of the high-voltage supply.

The *ion-trap magnet*, required to recenter the electron beam in the gun structure, should be of the single-field type. Direction of the field of the ion-trap magnet should be such that the north pole is adjacent to vacant pin position No. 8 and the south pole to pin No. 2.

To operate properly with the electron gun in the 14GP4, the ion-trap magnet should have a field strength such that the optimum position of the magnet is in the region of grid No. 2 (see Fig. 2), with any departure being in the direction of the base rather than toward the funnel. The optimum position should result in a properly centered pattern having full brightness and no shadowing at the edges.

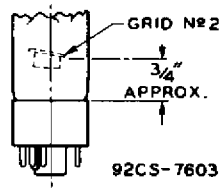

Fig. 2 - Location of Grid No. 2 in Tube Neck.

The use of an ion-trap magnet much stronger than indicated in the tabulated data tends to raise the focusing voltage beyond the indicated maximum value. Because of this fact and the absence of any shunting effect of the field by a focusing coil or magnet, it will be found that the optimum strength of the ion-trap magnetic field will be somewhat less than is required for a comparable magnetic-focus tube.

The strength of the ion-trap magnet required for other ultor voltages than that indicated will be proportional to the square root of the ultor voltage.

Centering of the pattern may be accomplished by the use of a small, adjustable centering magnet located near the base end of the deflecting yoke. The position of the centering magnet on the tube neck must be within a distance of 3-1/4 inches from the Reference Line (see *Outline*

Drawing). When the magnet is positioned at the limiting distance, the ac field of the deflecting yoke is relatively weak and will have little demagnetizing effect. When placed closer to the deflecting yoke, the magnet must be made of material capable of withstanding a stronger ac field without demagnetization. If the magnet is placed too far from the deflecting yoke, appreciable deflection defocusing or neck shadow will result.

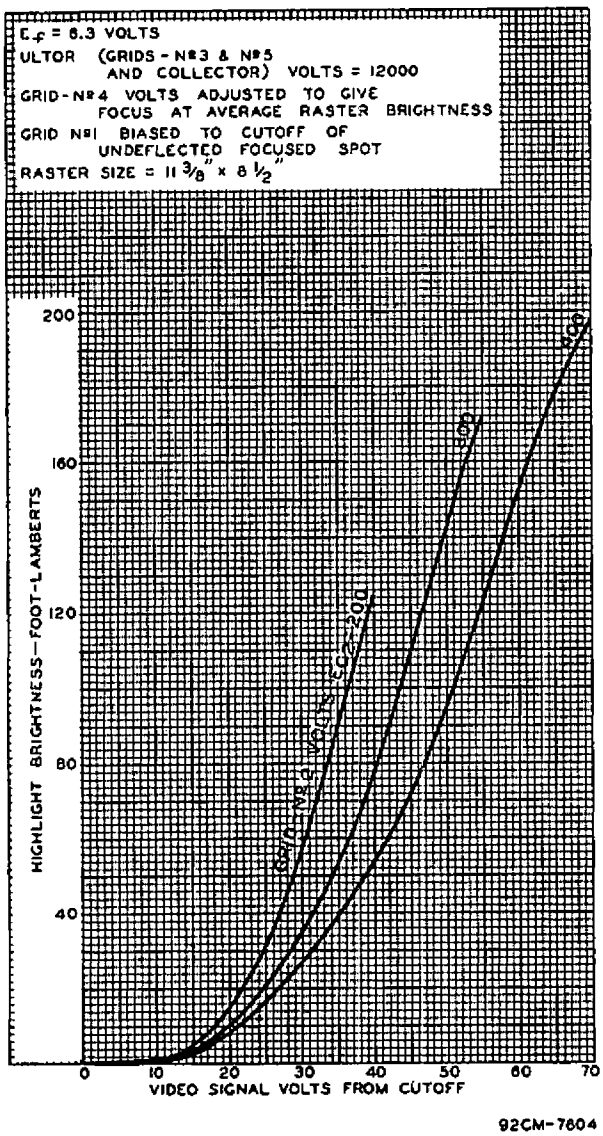

Fig. 3 - Average Grid-Drive Characteristics of Type 14GP4.

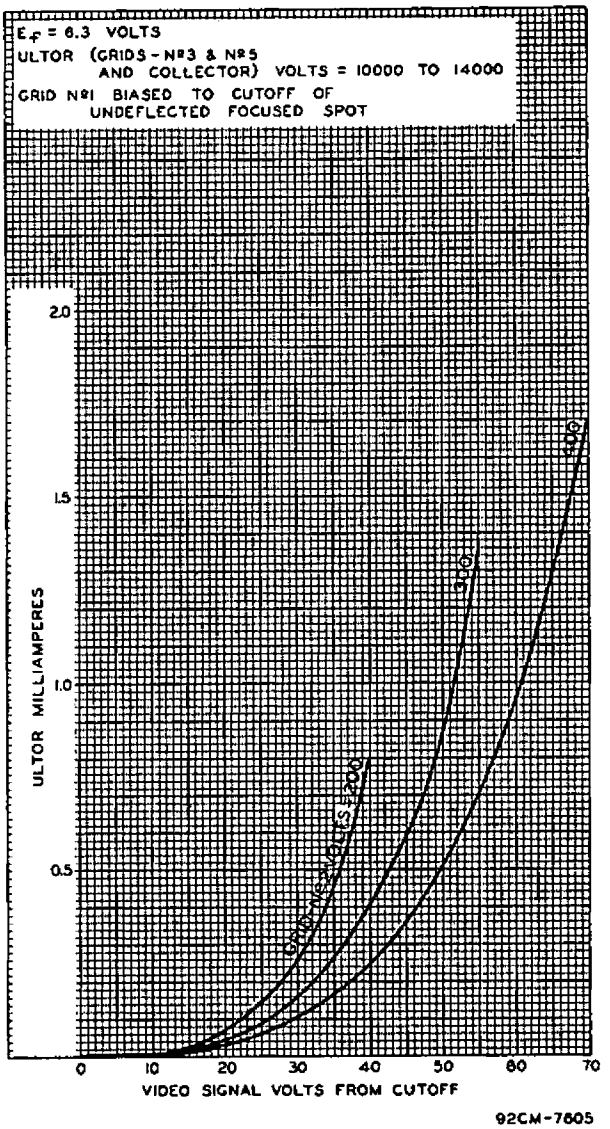

Fig. 4 - Average Grid-Drive Characteristics of Type 14GP4.

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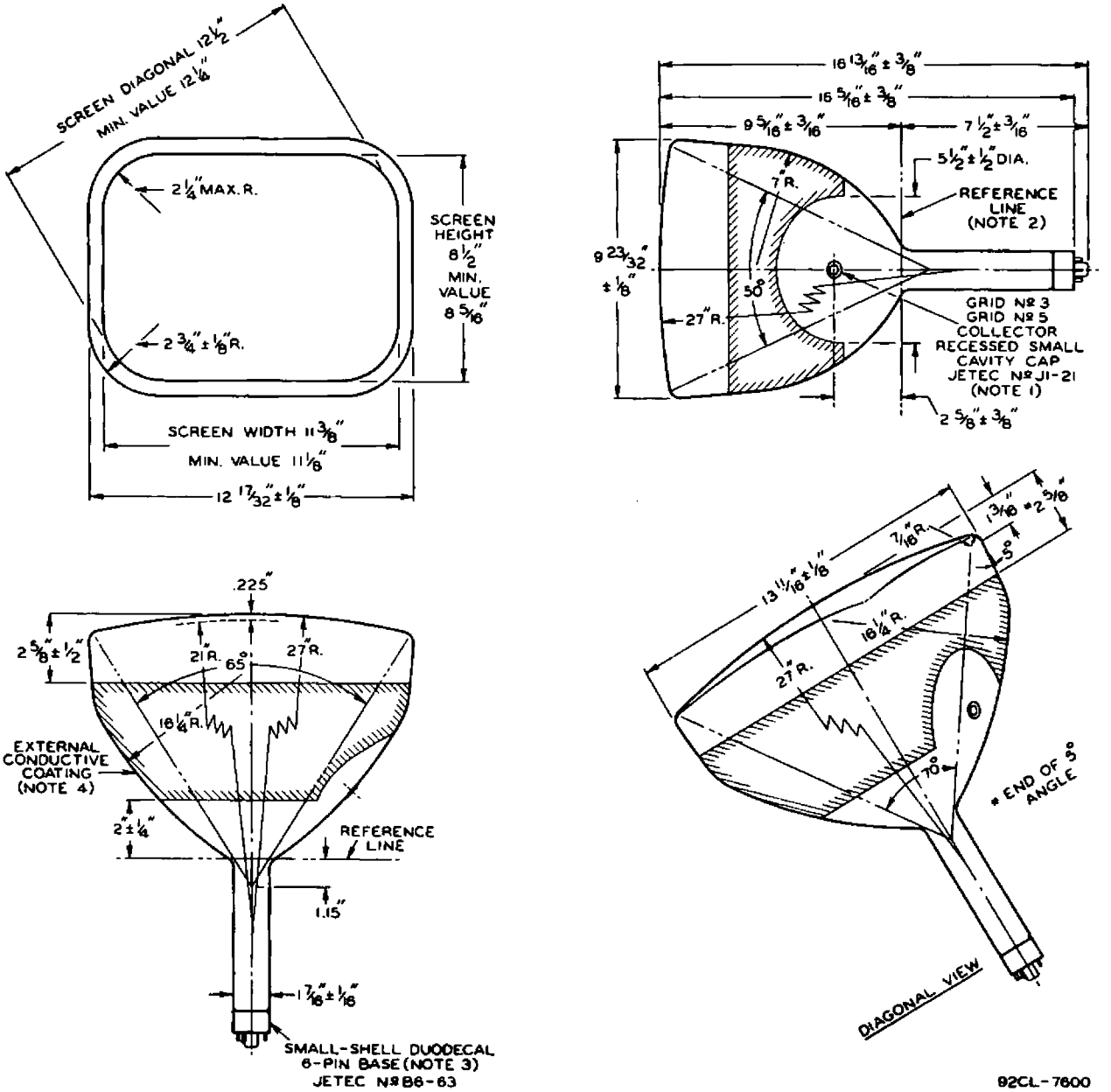
DIMENSIONAL OUTLINE



92CL-7600

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN NO.6 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND CAP BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. CAP IS ON SAME SIDE AS PIN NO.6.

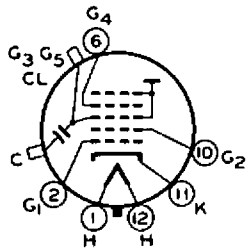
NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JETEC NO.110) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 2-1/2".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER
PIN 2: GRID NO. 1
PIN 6: GRID NO. 4
PIN 10: GRID NO. 2
PIN 11: CATHODE
PIN 12: HEATER
CAP: GRID NO. 3, GRID NO. 5, COLLECTOR
C: EXTERNAL CONDUCTIVE COATING

14RP4

KINESCOPE

Low-Voltage Electrostatic Focus Magnetic Deflection

Short Rectangular Glass Type Spherical Filterglass Faceplate

TENTATIVE DATA

12-1/8" x 9-5/8" Screen 14-1/8" Max. Bulb Diagonal 14-7/8" Max. Length

RCA-14RP4 is a short, lightweight, directly viewed, rectangular, glass picture tube of the low-voltage electrostatic-focus and magnetic-deflection type. Designed primarily for low-cost, lightweight, transportable instruments, the 14RP4 has a spherical Filterglass faceplate, a screen 12-1/8" x 9-5/8" with slightly curved sides and rounded corners, and a typical projected screen area of 108 square inches.

Employing wide-angle (90°) deflection, the 14RP4 has a very short length--a length approximately 2 inches shorter than a type having the same size faceplate and 70° deflection. Other design features of the 14RP4 include an external conductive bulb coating which with the internal conductive coating forms a supplementary filter capacitor; and an ion-trap gun requiring an external, single-field magnet.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6 ± 10%	amp
Direct Interelectrode Capacitances:		
Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor●	750 max. / 500 min.	μμf
Faceplate, Spherical	Filterglass	
Light transmission (Approx.)	78%	
Phosphor	P4--Sulfide Type	
Fluorescence	White	
Phosphorescence	White	
Persistence	Short	
Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	90°	
Horizontal	85°	
Vertical	68°	
Ion-Trap Gun	Requires External Single-Field Magnet	
Tube Dimensions:		
Overall length	14-9/16" ± 5/16"	
Greatest width	13-1/16" ± 1/8"	
Greatest height	10-9/16" ± 1/8"	
Diagonal	14" ± 1/8"	
Neck length	6-7/8" ± 3/16"	
Screen Dimensions (Minimum):		
Greatest width	12-1/8"	
Greatest height	9-5/8"	
Diagonal	13-1/16"	
Projected area	106 sq. in.	
Cap	Recessed Small Cavity (JETEC No.J1-21)	
Bulb	J112	
Base	Small-Shell Duodecal 6-Pin (JETEC No.B6-63)	
Weight (Approx.)	8.5 lbs	
Mounting Position	Any	

GRID-DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum Ratings, *Design-Center Values:*

ULTOR● VOLTAGE	14000 max.	volts
GRID-No.4 VOLTAGE:		
Positive value	500 max.	volts
Negative value	500 max.	volts
GRID-No.2 VOLTAGE	400 max.	volts
GRID-No.1 VOLTAGE:		
Negative peak value	160 max.	volts
Negative bias value	110 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Equipment Design Ranges:

With any ultor voltage (E_{c_5k}) between 8000 and 14000 volts and grid-No.2 voltage (E_{c_2k}) between 200 and 400 volts*

Grid-No.4 Voltage Required for Focus:

Changes directly with E_{c_5k} at the rate of approximately 30 volts for each 1000-volt change in E_{c_5k}.

Changes inversely with E_{c_5k} at the rate of approximately 10 volts for each 100-volt change in E_{c_2k}.

Changes inversely with ultor current at the rate of approximately 25 volts for each 50-μamp change in ultor current.

For typical values, see *Examples of Use of Design Ranges.*

Grid-No.1 Voltage (E_{c_1k}) for Visual Extinction of Focused Raster . . . . . See *Cutoff Design Chart* for Grid-Drive Service

Grid-No.1 Video Drive from Raster Cutoff (Black Level):

White-level value (Peak positive). . Same value as determined for E_{c_1k} except video drive is positive voltage.

Grid-No.4 Current. . .	−25 to +25	μamp
Grid-No.2 Current. . .	−15 to +15	μamp
Ion-Trap Magnet Current (Average)**.	$\sqrt{E_{c_5k}/14000} \times 38$	ma
Minimum Field Strength of PM Ion-Trap Magnet§.	$\sqrt{E_{c_5k}/14000} \times 43$	gausses
Field Strength of Adjustable Centering Magnet. . . .	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*10000*	*14000*	*volts*
and grid-No.2 voltage of	*300*	*300*	*volts*
Grid-No.4 Voltage for Focus with Ultor Current of 100 μamp. . .	−50 to +350	+70 to +470	volts
Grid-No.1 Voltage for Visual Extinction of Focused Raster	−26 to −70	−26 to −70	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value (Peak positive). . . .	26 to 70	26 to 70	volts
Min. Field Strength of PM Ion-Trap Magnet . . .	36	43	gausses

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE-DRIVE▪ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum Ratings, *Design-Center Values:*

ULTOR•-TO-GRID-No.1 VOLTAGE.	14000 max.	volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	500 max.	volts
Negative value	500 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE . . .	510 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value.	160 max.	volts
Positive bias value.	110 max.	volts
Negative bias value.	0 max.	volts
Negative peak value.	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode.	180 max.	volts
Heater positive with respect to cathode.	180 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 8000 and 14000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 510 volts*

Grid-No.4-to-Grid-No.1 Voltage Required for Focus:

Changes directly with $E_{c_5g_1}$ at the rate of approximately 30 volts for each 1000-volt change in $E_{c_5g_1}$.

Changes inversely with $E_{c_2g_1}$ at the rate of approximately 10 volts for each 100-volt change in $E_{c_2g_1}$.

Changes inversely with ultor current at the rate of approximately 25 volts for each 50-μamp change in ultor current.

For typical values, see *Examples of Use of Design Ranges.*

Cathode-to-Grid-No.1 Voltage (E_{kg_1}) for Visual Extinction of Focused Raster . . . . . See *Cutoff Design Chart* for Cathode-Drive Service

Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):

White-level value (Peak negative). . Same value as determined for E_{kg_1}

Grid-No.4 Current. . . .	−25 to +25	μamp
Grid-No.2 Current. . . .	−15 to +15	μamp
Ion-Trap Magnet Current (Average)**.	$\sqrt{E_{c_5g_1}/14000} \times 38$	ma
Minimum Field Strength of PM Ion-Trap Magnet§.	$\sqrt{E_{c_5g_1}/14000} \times 43$	gausses
Field Strength of Adjustable Centering Magnet.	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*10000*	*14000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*300*	*300*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for Focus with Ultor Current of 100 μamp	−50 to +350	+70 to +470	volts
Cathode-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster	26 to 59	26 to 59	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value (Peak negative). . .	26 to 59	26 to 59	volts
Min. Field Strength of PM Ion-Trap Magnet . .	36	43	gausses

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

• The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 14RP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 14RP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid No.1 potential with respect to cathode.

\# Brilliance and definition decrease with decreasing ultor voltage or ultor-to-grid-No.1 voltage. In general, the ultor voltage or ultor-to-grid-No.1 voltage should not be less than 8000 volts.

** For JETEC Ion-Trap Magnet No.117, or equivalent, located with the trailing edge of the pole pieces located over the gap between grid No.1 and grid No.2 and rotated to give maximum brightness.

§ For specimen PM ion-trap magnet, such as Heppner Model No.E437 or equivalent, located in optimum position and rotated to give maximum brightness. For a given equipment application, the tolerance range for the strength of the PM ion-trap magnet should be added to the minimum value. The maximum strength of this magnet should not exceed the specified minimum value by more than 6 gausses. This procedure will insure use of a PM ion-trap magnet allowing adequate adjustment to permit satisfactory performance without loss of highlight brightness.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid-No.1 and the other electrodes.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

When operated at or below the maximum ratings shown in the tabulated data, the 14RP4 does not produce any harmful x-ray radiation. All types of picture tubes may be operated at voltages (if ratings permit) up to 16 kilovolts (absolute value) without personal injury on prolonged exposure at close range. Above 16 kilovolts, special shielding precautions for x-ray radiation may be necessary.

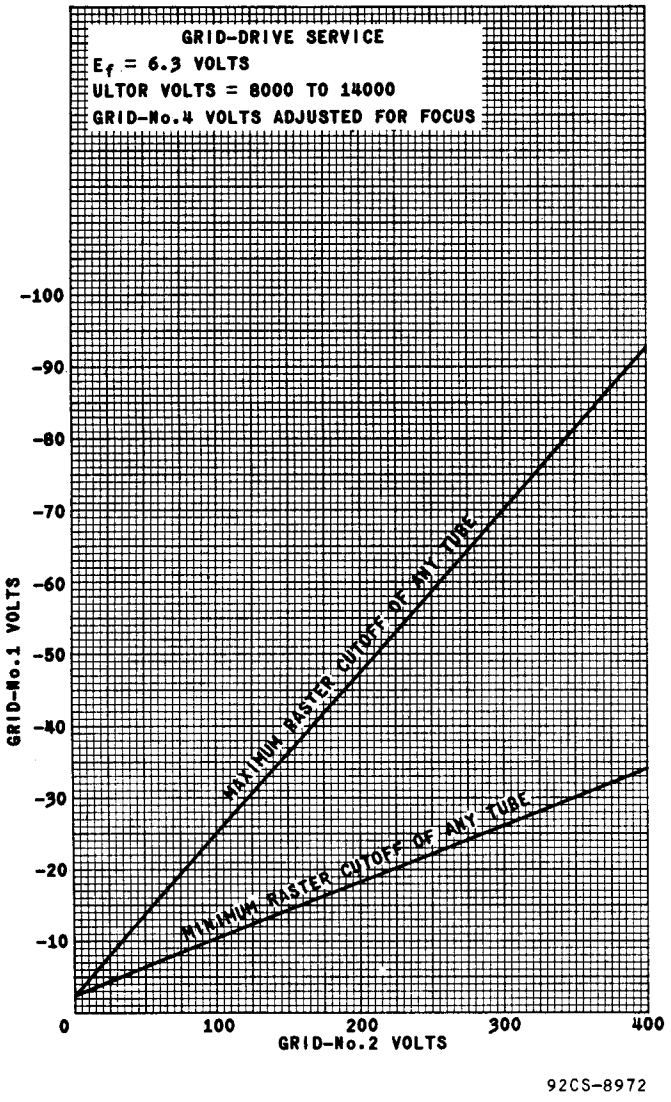


Fig.1 - Cutoff Design Chart for Type 14RP4 in Grid-Drive Service.

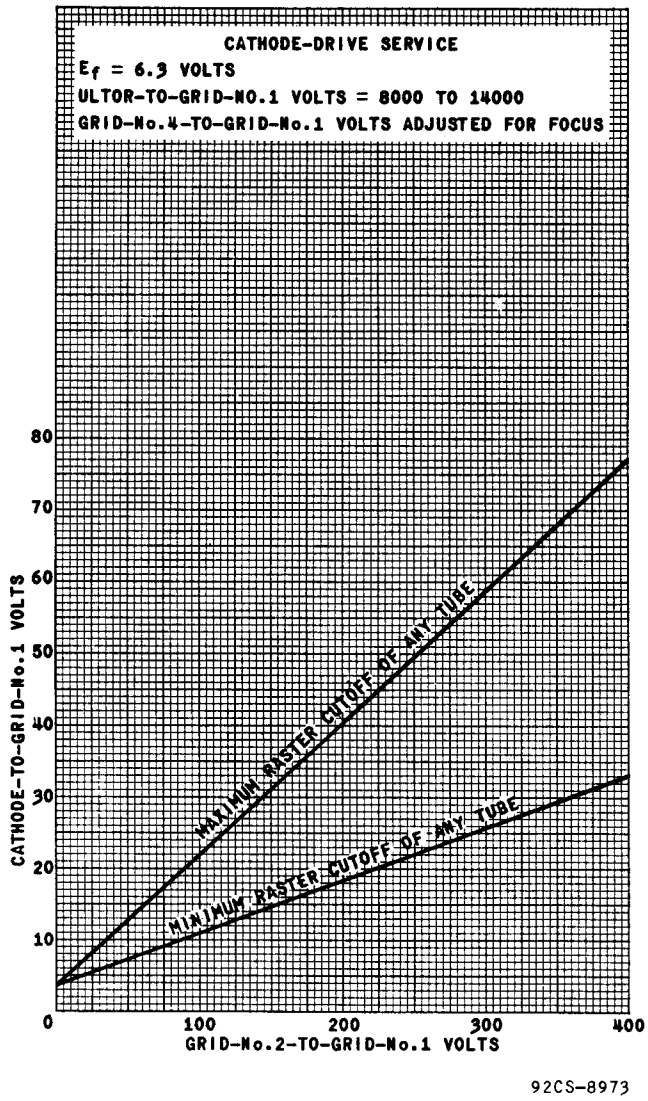


Fig.2 - Cutoff Design Chart for Type 14RP4 in Cathode-Drive Service.

The *Equipment Design Ranges for the 14RP4* include a new method of showing the focusing-voltage adjustment range needed for equipment design under different design conditions of

ultor voltage, ultor current, and grid-No.2 voltage. This new method offers equipment designers flexibility in determining the approximate focusing-voltage range to meet their particular requirements.

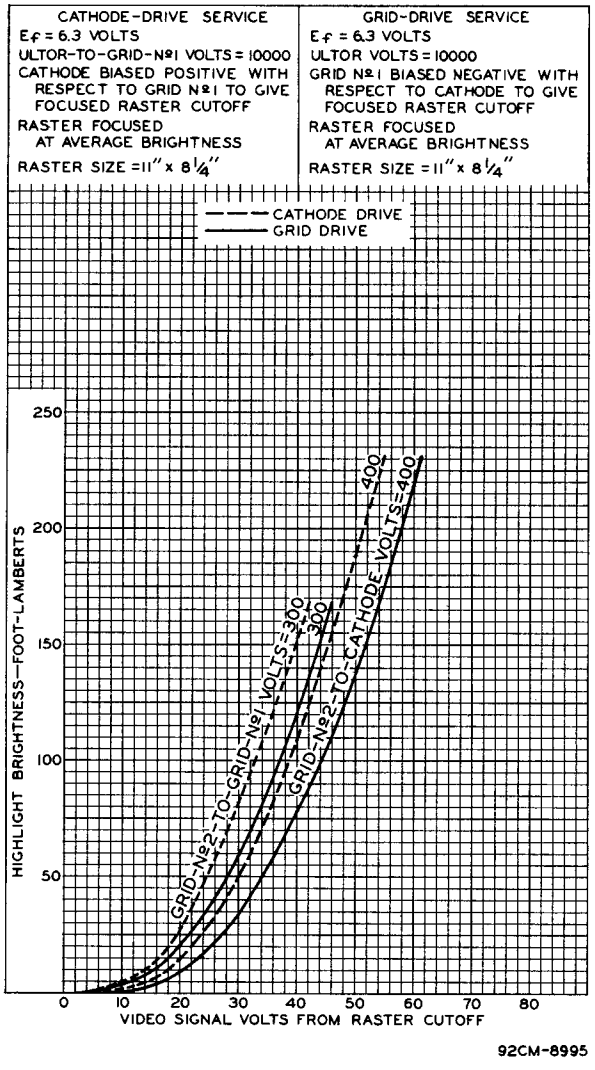


Fig.3 - Average Drive Characteristics of Type 14RP4.

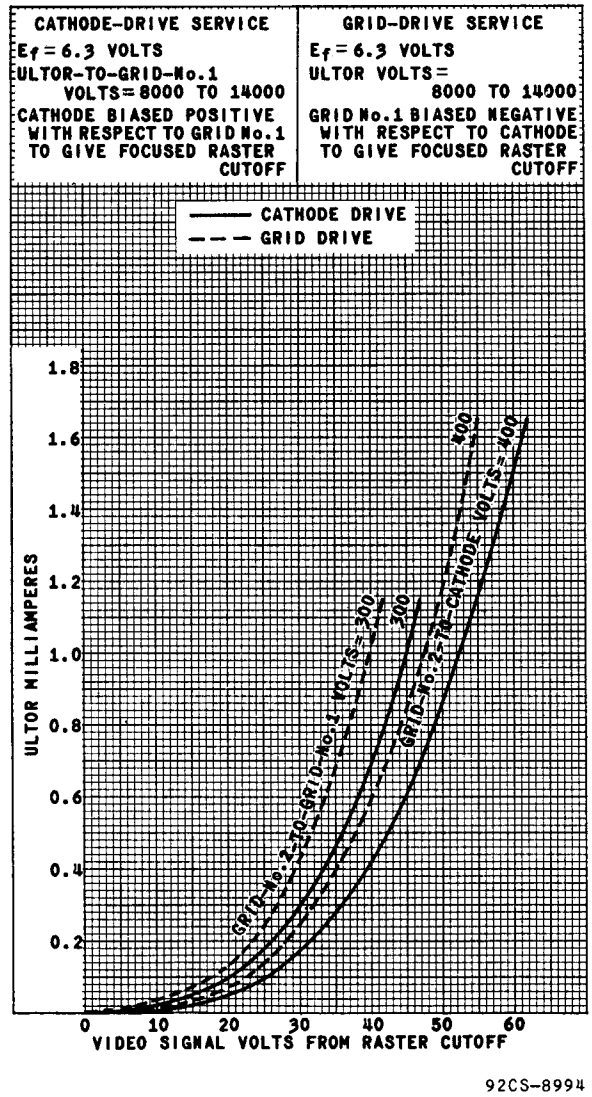


Fig.4 - Average Drive Characteristics of Type 14RP4.

For example, assume the desired operating conditions are as follows: ultor voltage, 12000; grid-No.2 voltage, 250; and ultor current, 150 microamperes.

To determine the focusing-voltage range, first refer to the focusing-voltage-range values shown for the 10000-volt and 300-volt conditions given under *Examples of Use of Design Ranges for Grid-Drive Service*. Starting with these focusing-voltage-range values of -50 to +350 volts at 100 microamperes, then proceed to determine the new values to fit the assumed conditions as follows:

1. Calculate the maximum focusing-voltage range value for the increase in ultor voltage from 10000 to 12000 volts by applying the rule that the focusing voltage changes directly at the rate of approximately 30 volts for each 1000-volt change in ultor voltage. Since the assumed ultor voltage represents an increase of 2000 volts, the 350-volt value for the maximum focusing voltage will be increased by 2 times 30 or 60 volts. This first calculation of the maximum range value, therefore, gives 350 + 60 or 410 volts. Correspondingly, the minimum value increases to +10 volts.

2. Calculate the maximum focusing-voltage-range value for the decrease in grid-No.2 voltage from 300 to 250 volts by applying the rule that the focusing voltage changes inversely at

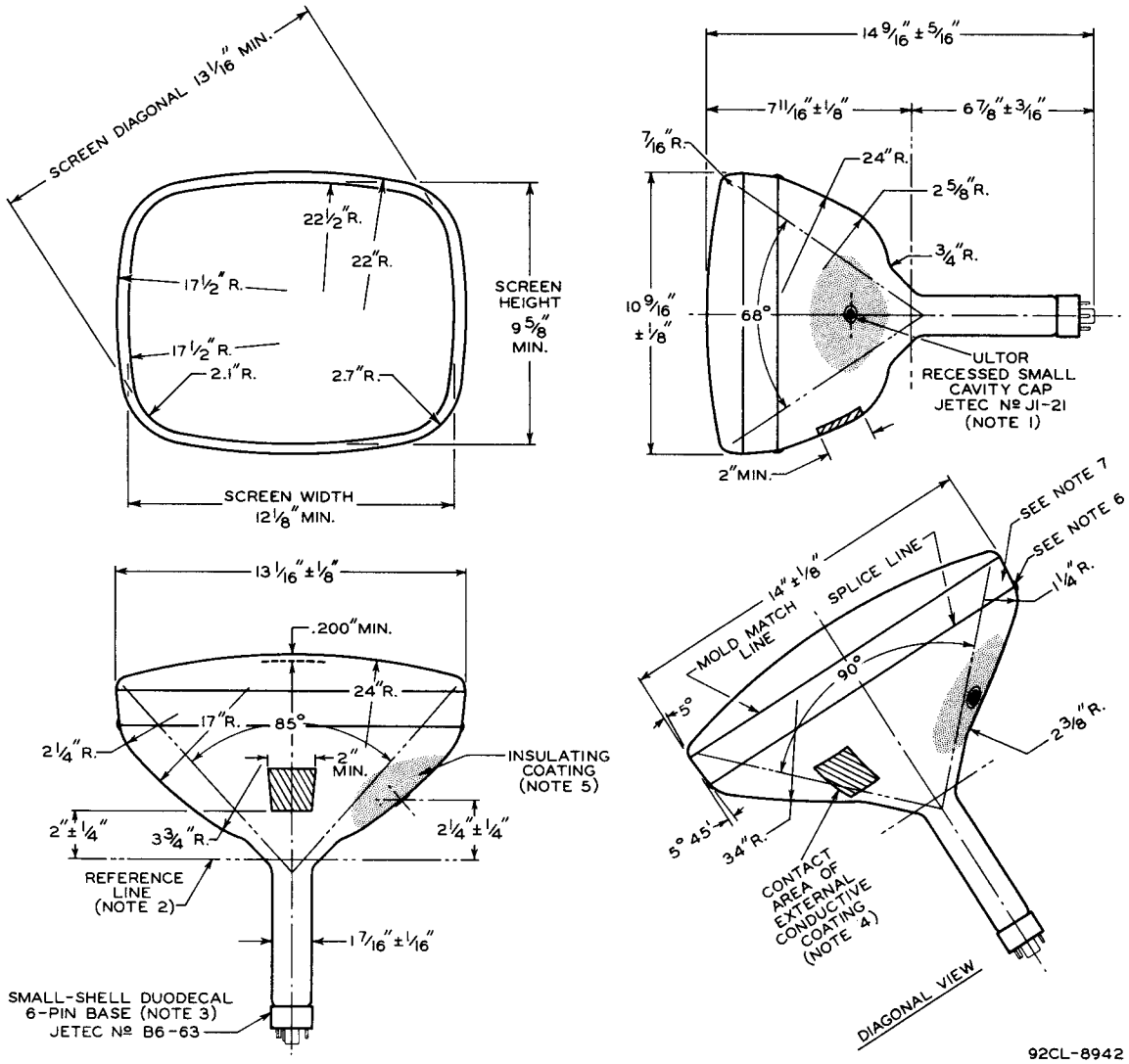
the rate of approximately 10 volts for each 100-volt change in grid-No.2 voltage. Since the assumed grid-No.2 voltage represents a decrease of 50 volts, the maximum focusing-voltage-range value calculated above will be increased by 1/2 of 10 volts or 5 volts. Adding this value will give 410 + 5 or 415 volts. Correspondingly, the minimum value increases to 15 volts.

3. Calculate the maximum focusing-voltage-range value for the increase in ultor current from 100 to 150 microamperes by applying the rule that the focusing voltage changes inversely at the rate of approximately 25 volts for each 50-microamperes change in ultor current. Since the assumed ultor current represents an increase of 50 microamperes, the maximum focusing-voltage-range value calculated above will be decreased by 25 volts. The maximum range value, therefore, is 415 - 25 or 390 volts. Correspondingly, the minimum value decreases to -10 volts.

The focusing-voltage-range for the assumed conditions is, therefore, -10 to 390 volts.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.6 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND BULB TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ±30°. BULB TERMINAL IS ON SAME SIDE AS PIN No.6

NOTE 2: WITH THE TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JETEC No.116) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 2-3/4".

NOTE 4: THE DRAWING SHOWS THE MINIMUM SIZE AND LOCATION OF THE CONTACT AREA OF THE EXTERNAL CONDUCTIVE COATING. THE ACTUAL AREA OF THIS COATING WILL BE GREATER THAN THE CONTACT AREA SO AS TO PROVIDE THE REQUIRED CAPACITANCE. EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

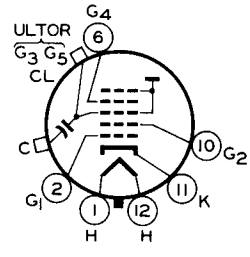
NOTE 6: BULGE AT SPLICE-LINE SEAL WILL NOT PROTRUDE BEYOND THE MAXIMUM INDICATED VALUE FOR ENVELOPE WIDTH, DIAGONAL OR HEIGHT.

NOTE 7: UNDISTURBED AREA BETWEEN MOLD-MATCH LINE AND SPLICE LINE IS 3/4" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND.

SOCKET CONNECTIONS

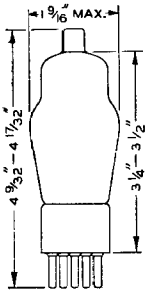
Bottom View

PIN 1: HEATER
PIN 2: GRID No.1
PIN 6: GRID No.4
PIN 10: GRID No.2
PIN 11: CATHODE



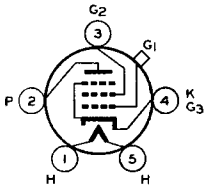
PIN 12: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

12L



RCA-15

R-F AMPLIFIER PENTODE



The 15 is a heater-cathode pentode of the 2.0-volt type for use in battery-operated receivers that require a separate cathode connection.

CHARACTERISTICS

Heater Voltage (D. C.)		2.0	Volts
Heater Current		0.22	Ampere
Plate Voltage	67.5	135 *max.*	Volts
Screen Voltage (Grid No. 2)	67.5	67.5 *max.*	Volts
Grid Voltage (Grid No. 1)	−1.5	−1.5	Volts
Plate Current	1.85	1.85	Milliamperes
Screen Current	0.3	0.3	Milliampere
Plate Resistance	0.63	0.8	Megohm
Amplification Factor	450	600	
Transconductance	710	750	Micromhos
Grid-Plate Capacitance (With shield-can)		0.01	μμf
Input Capacitance		2.35	μμf
Output Capacitance		7.80	μμf
Bulb			ST-12
Cap			Small Metal
Base			Small 5-Pin

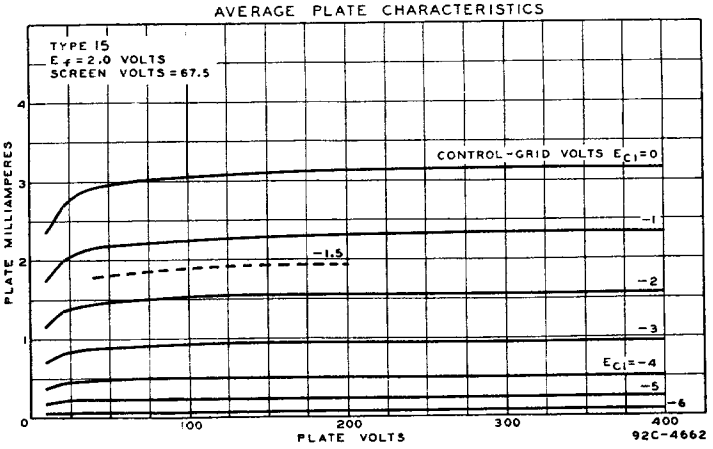
INSTALLATION AND APPLICATION

The base pins of the 15 fit the standard five-pin socket which may be installed to hold the tube in any position.

The potential difference between heater and cathode should be kept as low as possible. In no event should it exceed 22.5 volts.

The APPLICATION of the 15 is similar to that of type 32. The heater-cathode construction permits operation where a separate cathode connection is required.

AVERAGE PLATE CHARACTERISTICS



16ADP7

OSCILLOGRAPH TUBE

Magnetic Focus
Magnetic Deflection
53° Deflection Angle

Metal-Shell Envelope
Long-Persistence Screen
Filterglass Face

14-3/8" Min. Screen Dia.
16" Max. Diameter
22" Max. Length

TENTATIVE DATA

RCA-16ADP7 is a 16-inch oscillograph tube of the metal-shell type utilizing magnetic focus and magnetic deflection. It is intended particularly for those applications, such as radar indicator service, where grid No. 1 is pulse-modulated at low frequency to provide a temporary record of electrical phenomena, but it is also useful in general oscillographic applications where a temporary record of electrical phenomena is desired. The long-persistence, cascade (two-layer) screen used in the 16ADP7 exhibits bluish fluorescence of short persistence and greenish-yellow phosphorescence which persists for several minutes under conditions of adequate excitation and low ambient light.

Featured in the 16ADP7 is a limiting aperture at the end of the electron gun to produce a sharper, rounder spot on the screen, and hence greater effective resolution, especially at high values of beam current. This feature makes the 16ADP7 particularly useful in those applications where pulse-modulated operation causes high grid-No. 1 drive and resultant high beam current.

The high-quality faceplate of the 16ADP7 is made of Filterglass to provide increased contrast between the trace and the background. The Filterglass faceplate incorporates a neutral light-absorbing material which reduces ambient-light reflections from the phosphor and reflections within the faceplate itself in a much higher ratio than it reduces the directly viewed light of the trace. As a result, improved trace contrast is obtained. Also, having a relatively flat surface, the faceplate facilitates the use of an external, transparent, calibrated scale.

Because of its long persistence, the 16ADP7 is particularly useful where either low-speed non-recurring phenomena or high-speed recurring phenomena are to be observed. Furthermore, two or more phenomena can be observed simultaneously on the screen by means of a suitable switching arrangement. The persistence is such that the 16ADP7 without filter can be operated with scanning frequencies as low as 30 cycles per second without excessive flicker. When used with yellow filter, such as Wratten No. 15 (G), the 16ADP7 can be operated with much lower scanning frequencies.

The persistent light of the 16ADP7 permits the user to view a curve produced on the face of the tube by a single, high-speed sweep of the electron beam and, if desired, to make a tracing of the curve for record purposes.

Use of a yellow filter, such as Wratten No. 15 (G), over the tube face reduces the effect of the fluorescence in the observation of the phosphorescence. Use of a blue filter, such as Wratten No. 47A, reduces the observed phosphorescence and thus makes the screen appear to have only fluorescence.

Operation of the 16ADP7 as a short-persistence tube is suggested only when a short-persistence tube with P11 phosphor is not available. Because the persistence of the 16ADP7 used in this way is somewhat longer than the persistence of the P11 phosphor, any contemplated application should be limited either to visual observation or to photographic recording where the film does not move at more than moderate speed.

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Radio Corporation of America

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

16ADP7-10-51
Photolithographed in U.S.A.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	ampere
Direct Interelectrode Capacitances (Approx.):		
Grid No.1 to All Other Electrodes	6	μμf
Cathode to All Other Electrodes	5	μμf
Faceplate (With about 66% light transmission)	Filterglass	
Phosphor	P7	
Fluorescence	Blue	
Persistence	Short	
Phosphorescence	Greenish-Yellow	
Persistence	Long	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Deflection Angle (Approx.)	53°	
Maximum Overall Length	22"	
Greatest Diameter at Lip	15-7/8" ± 1/8"	
Minimum Useful Screen Diameter	14-3/8"	
Ultor● Terminal	Metal-Shell Lip	
Base	Small-Shell Duodecal 7-Pin (JETEC No. B7-51)	
Mounting Position	Any	

Maximum Ratings, *Design-Center Values*:

ULTOR● VOLTAGE	14000 max.	volts
GRID-No.2 VOLTAGE:		
Positive value (DC or Peak AC)	410 max.	volts
Negative value (DC or Peak AC)	180 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	180 max.	volts
Positive bias value▲	0 max.	volts
Positive peak value	2 max.	volts
PEAK GRID-No.1 DRIVE FROM CUTOFF	65 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	125 max.	volts

Typical Operation:

Ultor Voltage*	12000	volts
Grid-No.2 Voltage	250	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	-27 to -63	volts
Grid-No.2 Current	-15 to +15	μamp
Focusing-Coil Current (DC)○○	95 ± 15%	ma
Spot Position	##	

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

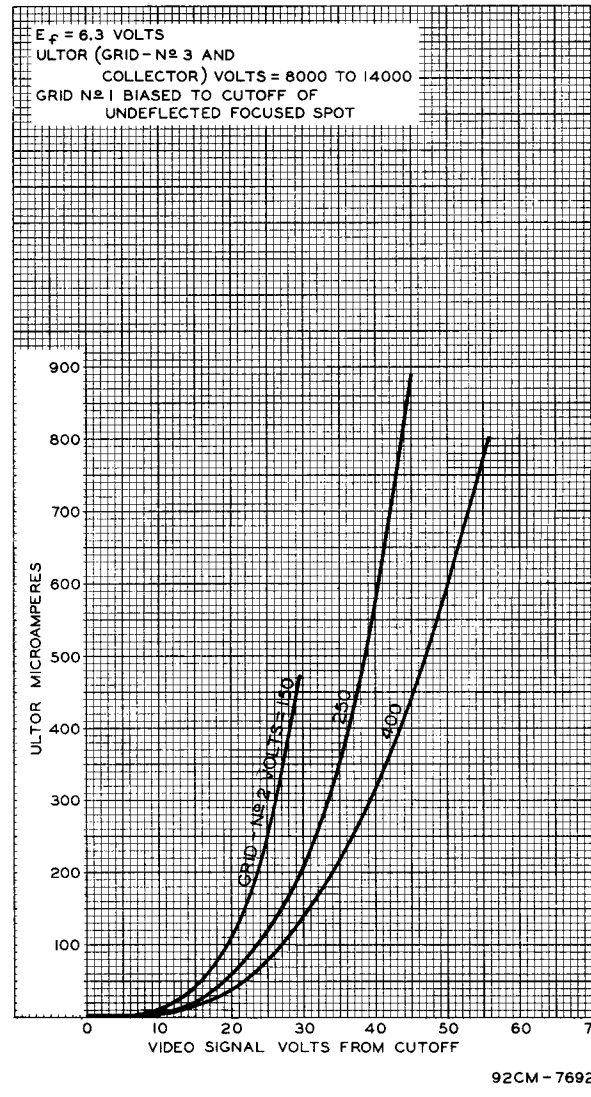
● In the 16ADP7, grid No.3 which has the ultor function, and collector are connected together within the tube and are conveniently referred to collectively as "ultor". The "ultor" in a cathode-ray tube is the electrode, or the electrode in combination with one or more additional electrodes connected within the tube to it, to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection.

▲ At or near this rating, the effective resistance of the ultor supply should be adequate to limit the ultor input power to 6 watts.

* Brilliance and definition decrease with decreasing ultor voltage. In general, the ultor voltage should not be less than 8000 volts.

OO For specimen focusing coil similar to JETEC Focusing Coil No.109 positioned with air gap toward faceplate and center line of air gap 3-1/4" from Reference Line (see *Outline Drawing*) and ultor current of 200 microamperes. The indicated tolerance on focusing-coil current is on basis that distance from Reference Line to grid No.1 is controlled as shown in Detail of Grid-No.1 Position on page 4.

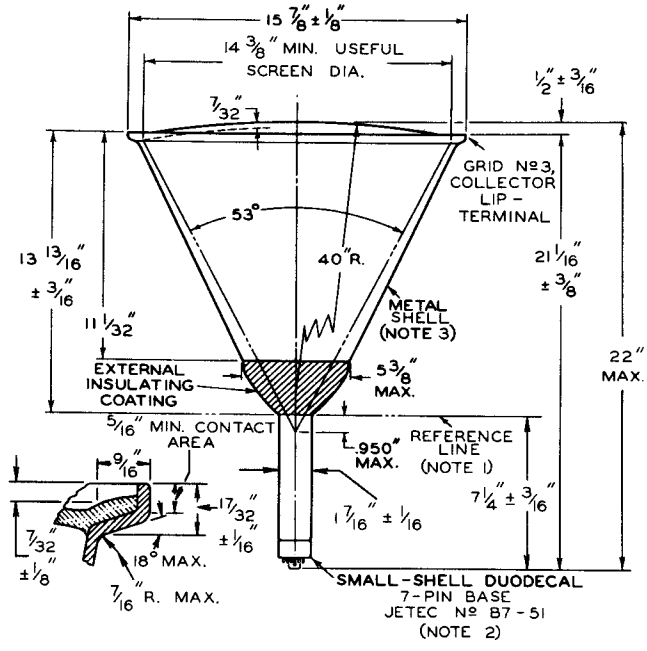
The center of the undeflected, unfocused spot will fall within a circle having 25-mm radius concentric with the center of the tube face.



Average Grid-Drive Characteristics of Type 16ADP7.

16ADP7

DIMENSIONAL OUTLINE



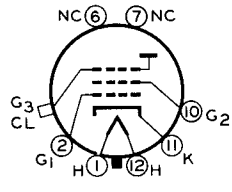
NOTE 1: REFERENCE LINE IS DETERMINED BY POSITION WHERE REFERENCE-LINE GAUGE (JETEC NO. 112) 1.500" + 0.003" - 0.000" I.D. AND 2" LONG WILL REST ON FUNNEL.

NOTE 2: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN CIRCLE CONCENTRIC WITH METAL-SHELL AXIS AND HAVING DIAMETER OF 3".

NOTE 3: METAL SHELL AND GLASS FACE OPERATE AT HIGH VOLTAGE. ANY MATERIAL IN CONTACT WITH THE SHELL OR THE FACE MUST BE INSULATED TO WITHSTAND THE MAXIMUM APPLIED ULTOR VOLTAGE.

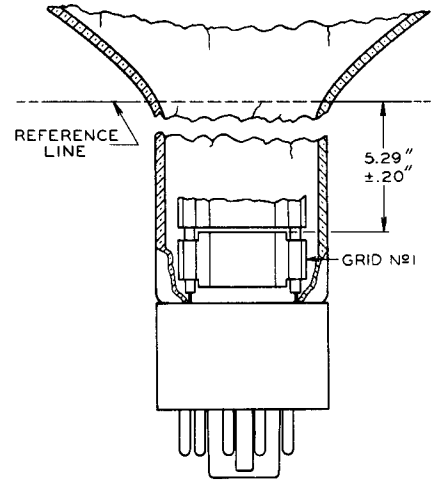
SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER
PIN 2: GRID NO. 1
PIN 6: NO CONNECTION
PIN 7: NO CONNECTION
PIN 10: GRID NO. 2
PIN 11: CATHODE
PIN 12: HEATER
CAP: GRID NO. 3, COLLECTOR

DETAIL OF GRID-No. 1 POSITION



92CS-7689

This bulletin also applies to RCA-16BDP4 which is identical with RCA-16AYP4 except for its heater current rating of 600 ± 30 ma.

16BDP4

from JEDEC release #4221, April 15, 1963

16AYP4
16BDP4

16AYP4

PICTURE TUBE

Low-Voltage Electrostatic Focus
114° Magnetic Deflection

Aluminized Screen
Initial Data

12.938" x 10.250" Screen
15.74" Max. Bulb Diagonal
10.50" Max. Overall Length

RCA-16AYP4 is a rectangular glass picture tube having an aluminized screen with nearly straight sides and slightly rounded corners.

Features include:

- 114° magnetic deflection
- Aluminized screen
- Very short electron gun which minimizes deflection distortion
- Electron gun requiring no ion-trap magnet
- 1-1/8-inch diameter neck
- Projected screen area of 125 square inches minimum
- External conductive coating

GENERAL DATA

Electrical:

Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	114°	
Horizontal	102°	
Vertical	85°	
Direct Interelectrode Capacitances:		
Cathode to all other electrodes	5	pf
Grid No.1 to all other electrodes	6	pf
External conductive coating to anode	1300 max.	pf
	800 min.	pf
Heater Current at 6.3 volts	450 ± 20	ma
Heater Warm-Up Time (Average)	11	seconds

Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 5 volts.

Electron Gun. . . . Type Requiring No Ion-Trap Magnet

Optical:

Phosphor. . . . . P4-Sulfide Type, Aluminized
Faceplate . . . . . Filterglass
Light Transmission at Center (Approx.). 78%

Mechanical:

Weight (Approx.). . . . . 8-1/2 lbs
Tube Dimensions:

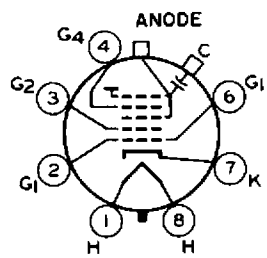
Overall length	10.25" ± 0.25"
Neck length	4.12" ± 0.12"
Diagonal	15.62" ± 0.12"
Greatest width	13.70" ± 0.12"
Greatest height	11.10" ± 0.12"

Minimum Screen Dimensions (Projected):

Diagonal	14.875"
Greatest width	12.938"
Greatest height	10.250"
Area	125 sq. in.

Bulb Designation. . . . . Not Assigned
Cap Designation . . . . . Recessed Small Cavity (JEDEC No.J1-21)
Base Designation. . . . Small-Button Neoeigntar 7-Pin, Arrangement 1, (JEDEC No.B7-208)
Basing Designation. 8HR

Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Grid No.2
Pin 4: Grid No.4
Pin 6: Grid No.1
Pin 7: Cathode
Pin 8: Heater
Cap: Anode (Grid No.3, Grid No.5, Screen, Collector)
C: External Conductive Coating



BOTTOM VIEW

Maximum and Minimum Ratings, *Design-Maximum Values:*[a]

Unless otherwise specified, voltage values are positive with respect to grid No.1

ANODE VOLTAGE	20000 max.	volts
	12000 min.	volts
GRID-No.4 VOLTAGE:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
GRID-No.2 VOLTAGE	550 max.	volts
	200 min.	volts
CATHODE VOLTAGE:		
Negative peak value	2 max.	volts
Negative bias value	0 max.	volts
Positive bias value	155 max.	volts
Positive peak value	220 max.	volts
HEATER VOLTAGE[b]	6.9 max.	volts
	5.7 min.	volts

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Marca(s) Registrada(s)

PEAK HEATER-CATHODE VOLTAGE:

Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	300 max.	volts
Heater positive with respect to cathode:		
Combined AC & DC voltage	200 max.	volts
DC Component	100 max.	volts

Typical Operating Conditions for Cathode-Drive[c] Service:

Unless otherwise specified, voltage values are positive with respect to grid No.1

Anode Voltage	16000	volts
Grid-No.4 Voltage[d]	100	volts
Grid-No.2 Voltage	300	volts
Grid No.1 Voltage for visual extinction of focused raster (See Fig.2)	28 to 60	volts
Field Strength of required adjustable Centering Magnet[e]	0 to 8	gausses

Maximum Circuit Value:

Grid-No.1 Circuit Resistance	1.5 max.	megohms

[a] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Maximum Rating System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

[b] Measured between the heater terminals.

[c] Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

[d] The grid-No.4 voltage required for optimum focus of any individual tube will have a value anywhere between -100 and +300 volts.

[e] Distance from Reference Line for suitable PM centering magnet should not exceed 2-1/4 inches. The specified centering magnet compensates only for the effect which mechanical tube tolerances may have on the location of the undeflected, focused spot with respect to the center of the tube face. Maximum field strength of adjustable centering magnet equals

$$\sqrt{\frac{\text{Anode volts}}{16000 \text{ volts}}} \times 8 \text{ gausses.}$$

The equipment manufacturer must determine and supply additional compensation for the effects of the earth's magnetic field and extraneous fields due to choice of circuitry and components. The additional compensation should preferably be applied as part of the magnetic field of the deflecting yoke.

OPERATING CONSIDERATIONS

X-Radiation Warning. When operated at anode voltages up to 16 kilovolts, this picture tube does not produce any harmful X-radiation. However, because the rating of this type permits operation at voltages as high as 20 kilovolts (design-maximum value), shielding of the tube for X-radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

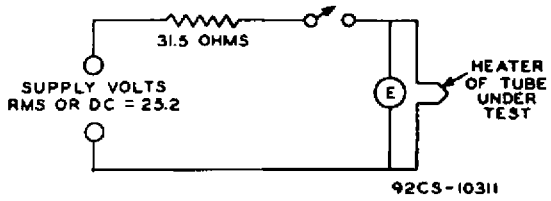

Fig. 1 - Test Circuit for Determining Heater Warm-up Time.

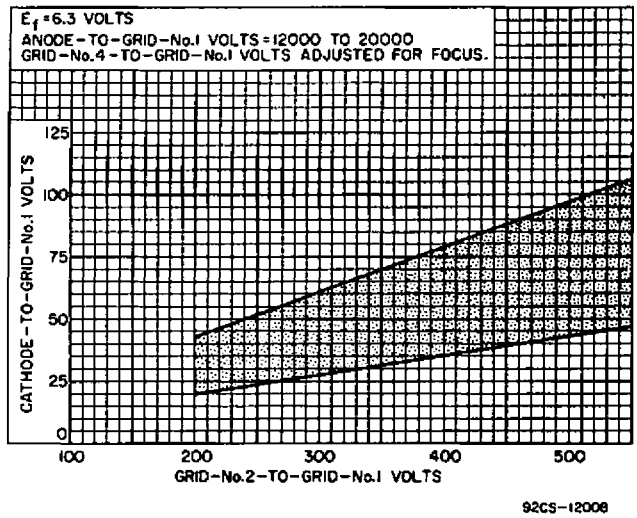

Fig. 2 - Raster-Cutoff-Range Chart for Type 16AYP4 in Cathode-Drive Service.

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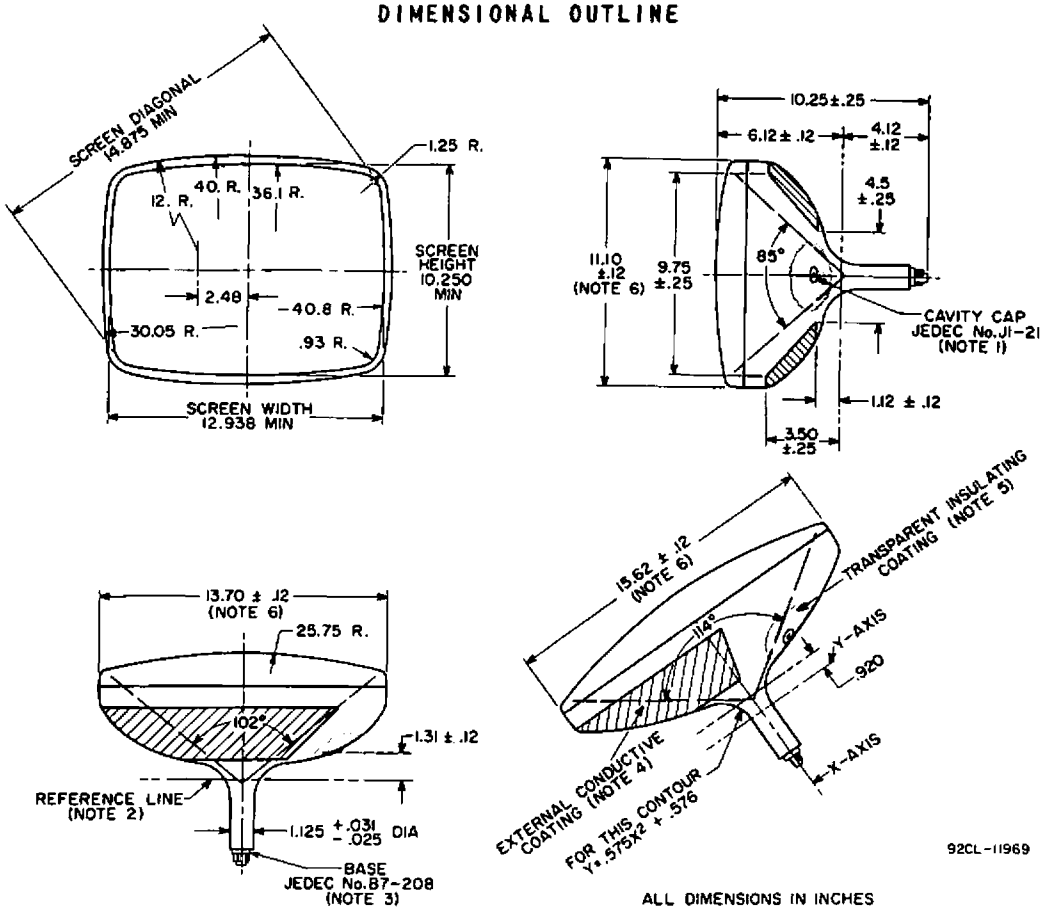
DIMENSIONAL OUTLINE



ALL DIMENSIONS IN INCHES

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN NO.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF $\pm 30^{\circ}$. ANODE TERMINAL IS ON SAME SIDE AS PIN NO.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC No.G-126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

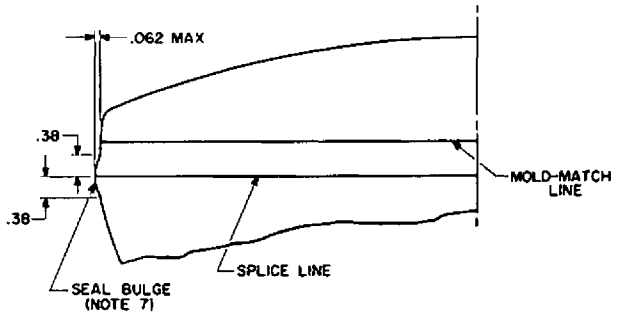
NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

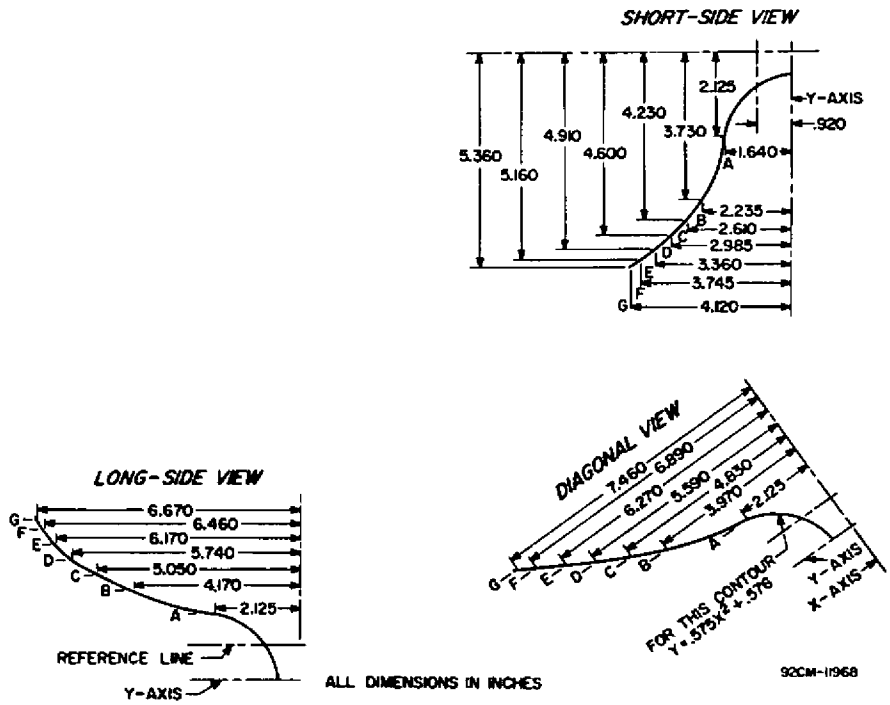
NOTE 6: MEASURED AT THE MOLD-MATCH LINE.

NOTE 7: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE LOCATION SPECIFIED FOR DIMENSIONING THE ENVELOPE WIDTH, DIAGONAL, AND HEIGHT.

Detail of Panel



BULB-CONTOUR DIMENSIONS



ALL DIMENSIONS IN INCHES

NOTE: PLANES A THRU G ARE NORMAL TO THE TUBE AXIS AND AT FIXED LOCATIONS FROM THE Y AXIS. THESE COORDINATES DESCRIBE THE BULB EXTERNAL CONTOUR IN PLANES THROUGH THE TUBE AXIS AND THE RESPECTIVE FACEPLATE AXES.

17CDP4

KINESCOPE

Low-Voltage Electrostatic Focus
110° Magnetic Deflection

Aluminized Screen
Very Short Rectangular Glass Type
for Series Heater-String Operation

14-3/4" x 11-11/16" Screen
16-11/16" Bulb Diagonal
12-13/16" Max. Length

TENTATIVE DATA

RCA-17CDP4 is a very short, directly viewed rectangular, glass picture tube of the low-voltage electrostatic-focus and magnetic-deflection type. It has a spherical Filterglass faceplate, an aluminized screen 14-3/4" x 11-11/16" with slightly curved sides and rounded corners and a minimum projected screen area of 155 square inches.

The 17CDP4 utilizes an 8.4-volt, 450 milliampere heater having a controlled warm-up time to insure dependable performance in television receivers employing a series heater-string arrangement.

Designed with a 110°-diagonal deflection angle, the 17CDP4 has a very short length--a length approximately 3" shorter than types having the same size faceplate and 90° deflection. As a result, this tube establishes new concepts for cabinet styling and for the design of more compact TV receivers utilizing 17"-type picture tubes.

The 17CDP4 has a neck diameter of only 1-1/8" which not only makes possible the use of a deflecting yoke having high deflection sensitivity but also permits deflection of the beam through the wide deflection angle with only slightly more power than is required to scan a tube with 90° deflection angle.

The 17CDP4 utilizes a new electron gun of the "straight" type having improved focus and a unique pre-focus lens system to maintain image sharpness over the entire screen area. This new electron gun eliminates the need for an ion-trap magnet.

Another design feature of the 17CDP4 is an integral glass-button base having straight-through leads fitted with an indexing plug. This basing arrangement eliminates any possibility of loose base-pin connections. In addition, the 17CDP4 has an external conductive bulb coating which with the internal conductive coating forms a supplementary filter capacitor.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	8.4	volts
Current	0.45	amp
Warm-Up Time (Average)	11	seconds
Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 6.9 volts.		
Direct Interelectrode Capacitances:		
Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor●	1500 max. 800 min.	μμf μμf
Faceplate, Spherical		Filterglass
Light transmission (approx.)		78%
Phosphor		P4--Sulfide Type
Fluorescence		White
Phosphorescence		White
Persistence		Short
Focusing Method		Electrostatic
Deflection Method		Magnetic
Deflection Angles (Approx.):		
Diagonal		110°
Horizontal		105°
Vertical		87°
Tube Dimensions:		
Overall length	12-9/16" ± 1/4"	
Greatest width	15-5/8" ± 1/8"	
Greatest height	12-3/4" ± 1/8"	
Diagonal	16-9/16" ± 1/8"	
Neck length	5-7/16" ± 1/8"	
Screen Dimensions (Minimum):		
Greatest width	14-3/4"	
Greatest height	11-11/16"	

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Printed in U.S.A.

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Diagonal	15-3/4"
Projected area	155 sq. in.
Cap.	Recessed Small Cavity (JETEC No.J1-21)
Bulb	J132-1/2 (110°)
Base	Small-Button Eightar 7-Pin Style B (JETEC No.B7-183)
Weight (Approx.)	10 lbs
Mounting Position	Any

GRID-DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum and Minimum Ratings, *Design-Center Values:*

ULTOR● VOLTAGE	16000 max. 12000 min.	volts volts
GRID-No.4 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2 VOLTAGE	500 max.	volts
GRID-No.1 VOLTAGE:		
Negative peak value	200 max.	volts
Negative bias value	140 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor voltage (E_{c_5k}) between 12000 and 16000 volts and grid-No.2 voltage (E_{c_2k}) between 200 and 500 volts

Grid-No.4-Voltage for Focus§	0 to 400	volts
Grid-No.1 Voltage (E_{c_1k}) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Grid-Drive Service	
Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak positive)	Same value as determined for E_{c_1k} except video drive is a positive voltage	
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*14000*	*16000*	*volts*
and grid-No.2 voltage of	*300*	*400*	*volts*
Grid-No.4 Voltage for Focus	0 to 400	0 to 400	volts
Grid-No.1 Voltage for Visual Extinction of Focused Raster	−28 to −72	−36 to −94	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	28 to 72	36 to 94	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum and Minimum Ratings, *Design-Center Values:*

ULTOR●-TO-GRID-No.1 VOLTAGE	16000 max. 12000 min.	volts volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	640 max.	volts
GRID-No.2-TO-CATHODE VOLTAGE	500 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	200 max.	volts
Positive bias value	140 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 12000 and 16000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 640 volts

Grid-No.4-to-Grid-No.1 Voltage for Focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage (E_{kg_1}) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Cathode-Drive Service	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value	Same value as determined for E_{kg_1} except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*14000*	*16000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*300*	*400*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for Focus	0 to 400	0 to 400	volts
Cathode-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster	28 to 60	36 to 78	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	−28 to −60	−36 to −78	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 17CDP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 17CDP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

§ The grid-No.4 voltage or grid-No.4-to-grid-No.1 voltage required for focus of any individual tube is independent of ultor current and will remain essentially constant for values of ultor voltage (or ultor-to-grid-No.1 voltage) or grid-No.2 voltage (or grid-No.2-to-grid-No.1 voltage) within design ranges shown for these items.

* Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having 5/16-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 1/2-inch deflection of the spot from the center of the tube face.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

In television receivers employing series-heater strings, a resistor in series with the string of tubes will minimize voltage surges across any individual tube during starting. The resistor should preferably have a negative temperature characteristic.

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 17CDP4 does not produce any harmful x-ray radiation. However, because the rating of this type permits operation at voltages as high as 17.6 kilovolts (absolute maximum value), shielding of the 17CDP4 for x-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

The *base pins* of the 17CDP4 fit the Eightar 8-contact socket, such as Ucinite Part No. 115446, or equivalent. The design of the socket should be such that the circuit wiring cannot impress lateral strains through the socket contacts on the base pins.

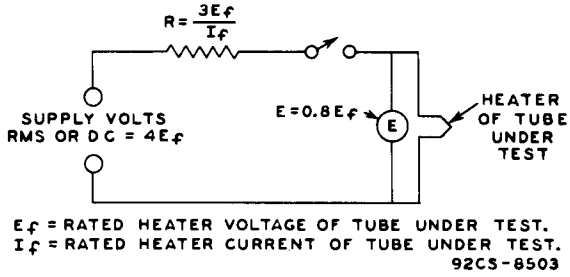


Fig. 1 - Test Circuit for Determining Heater Warm-Up Time.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

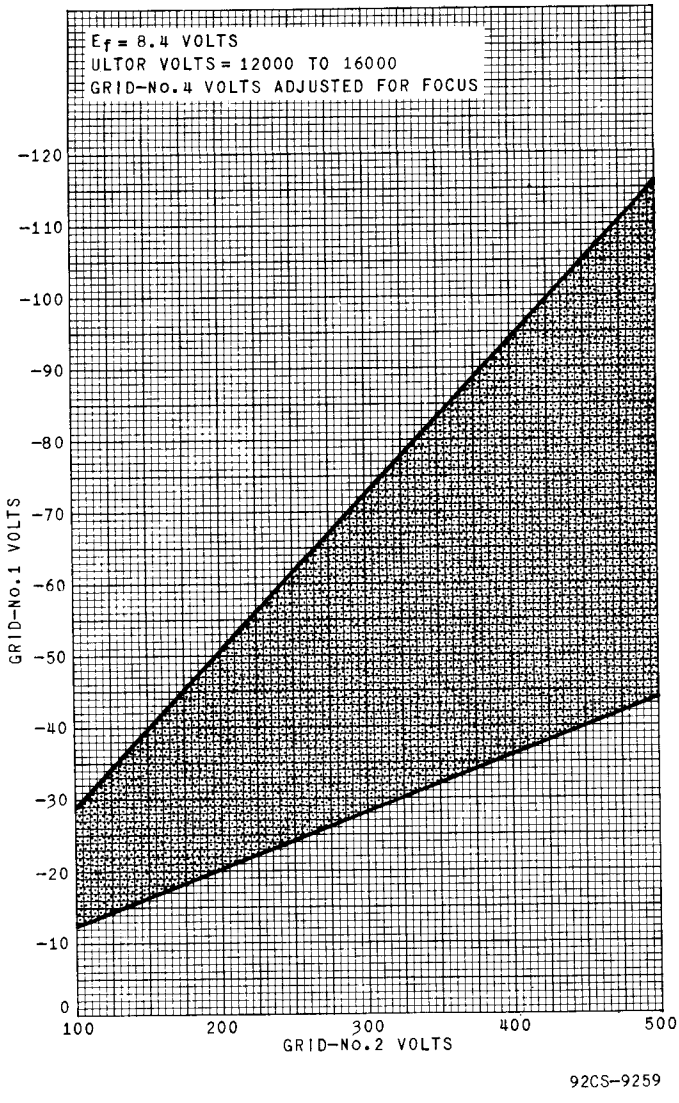


Fig. 2 - Raster-Cutoff Range for Type 17CDP4 in Grid-Drive Service.

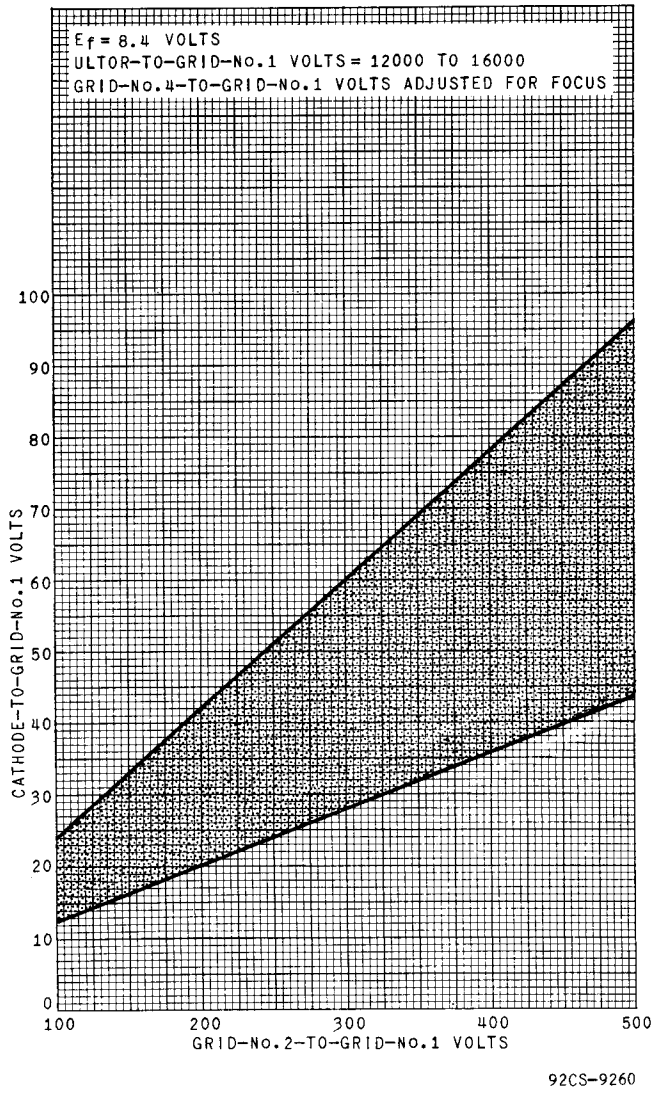


Fig. 3 - Raster-Cutoff Range for Type 17CDP4 in Cathode-Drive Service.

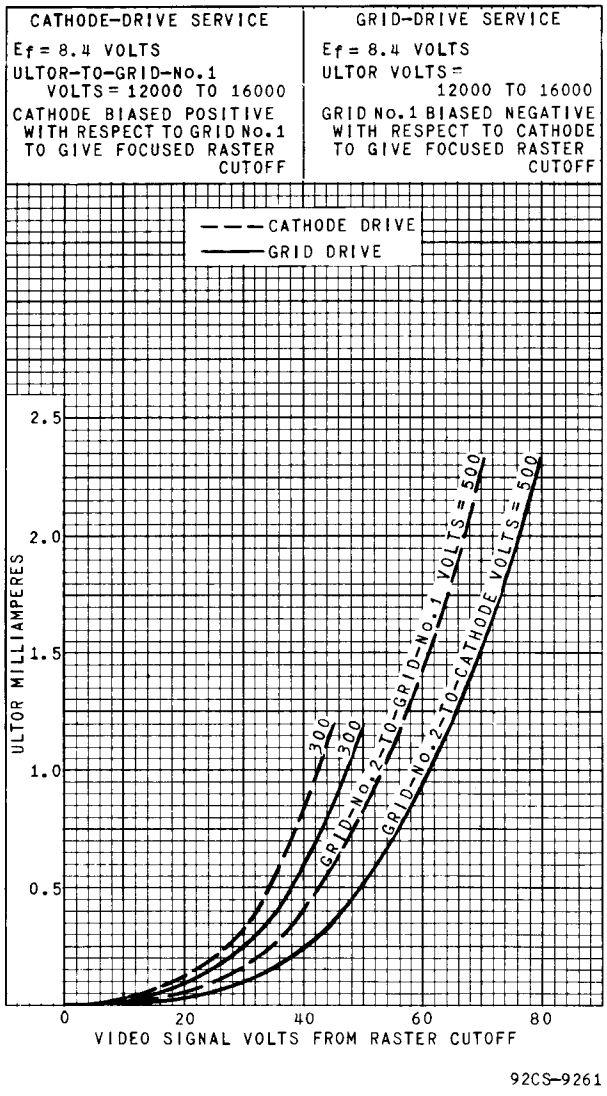


Fig. 4 - Average Drive Characteristics of Type 17CDP4.

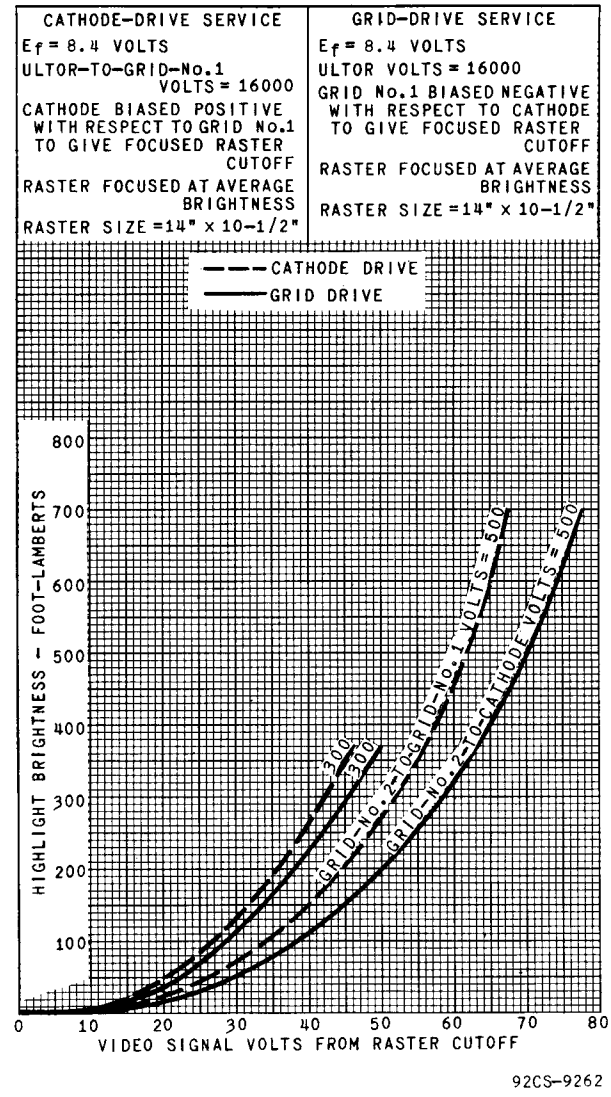
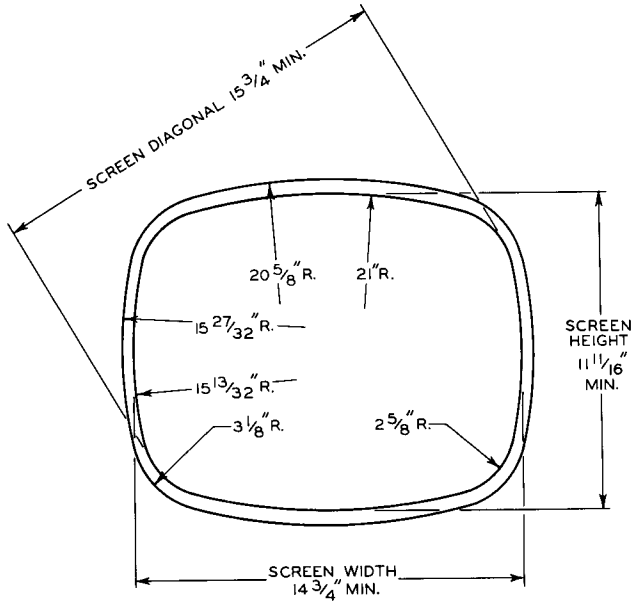
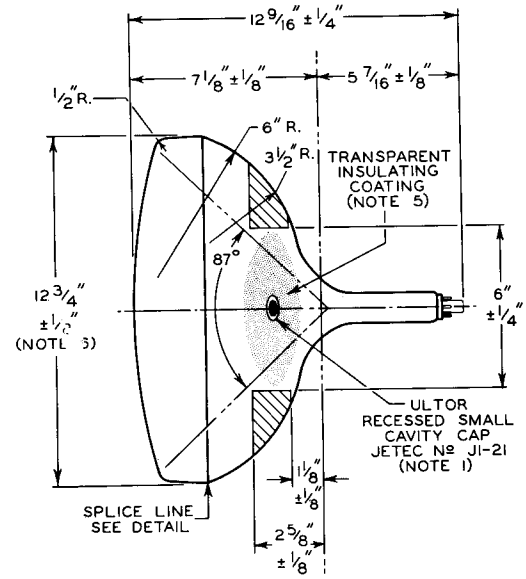
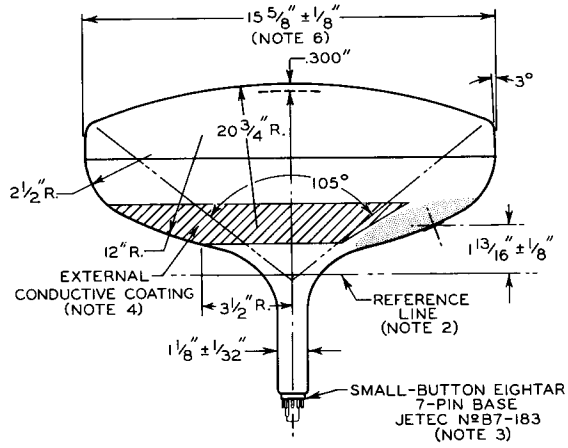


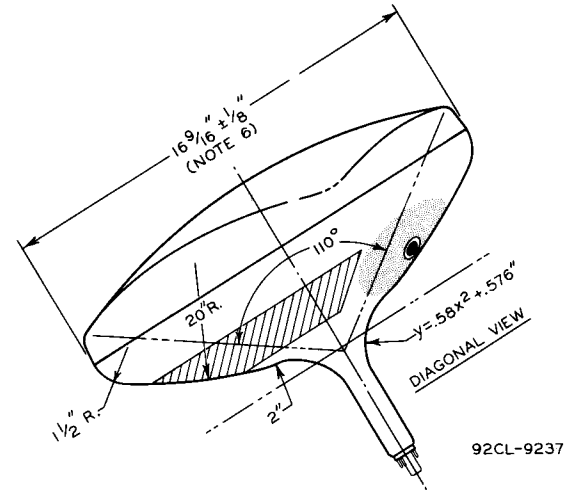
Fig. 5 - Average Drive Characteristics of Type 17CDP4.

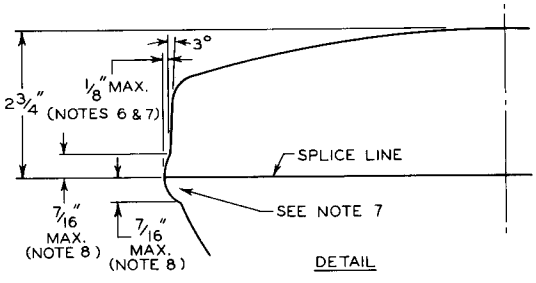
DIMENSIONAL OUTLINE











NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN No.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JETEC No.126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT THE CIRCUITRY CANNOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

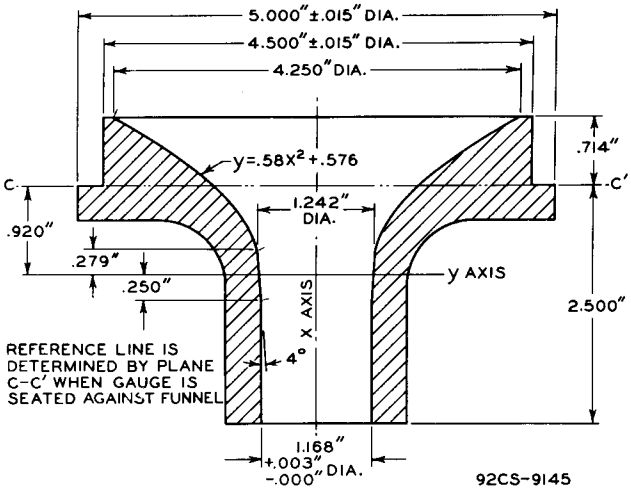
NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

NOTE 6: MEASURED 2-9/32" ± 1/32" FROM THE PLANE TANGENT TO THE SURFACE OF THE FACEPLATE AT THE TUBE AXIS.

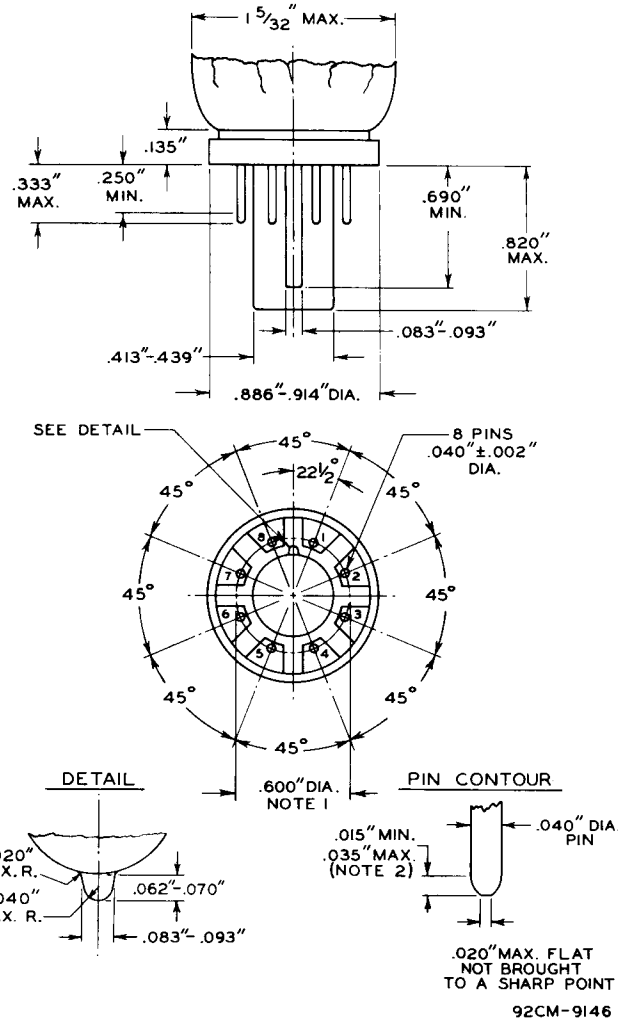
NOTE 7: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/4", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/8" BEYOND THE ENVELOPE SURFACE AT THE LOCATION SPECIFIED FOR DIMENSIONING THE ENVELOPE WIDTH, DIAGONAL, AND HEIGHT.

NOTE 8: THE TUBE SHOULD BE SUPPORTED ON BOTH SIDES OF THE BULGE. THE MECHANISM USED SHOULD PROVIDE CLEARANCE FOR THE MAXIMUM DIMENSIONS OF THE BULGE.

REFERENCE-LINE AND NECK-FUNNEL-CONTOUR GAUGE JETEC Nº 126

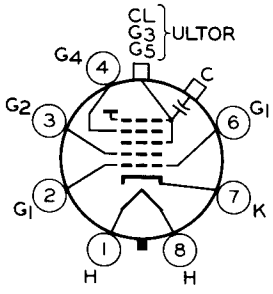


SMALL-BUTTON EIGHTAR BASE



SOCKET CONNECTIONS

Bottom View



8HR

PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.2
PIN 4: GRID No.4
PIN 6: GRID No.1
PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

NOTE 1: BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT THE BASE WILL FIT A FLAT-PLATE GAUGE HAVING A THICKNESS OF 3/8" AND EIGHT EQUALLY SPACED HOLES OF 0.0550" ± 0.0005" DIAMETER LOCATED ON A 0.6000" ± 0.0005" DIAMETER CIRCLE. THE GAUGE IS ALSO PROVIDED WITH A CENTER HOLE TO PROVIDE 0.010" DIAMETRIC CLEARANCE FOR THE LUG AND KEY. PIN FIT IN THE GAUGE SHALL BE SUCH THAT THE ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, ENTER INTO AND DISENGAGE FROM THE GAUGE.

NOTE 2: THIS DIMENSION AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN MAY VARY WITHIN THE LIMITS SHOWN.

JETEC No.	No. OF PINS	PINS
B8-181	8-Pin	1,2,3,4,5,6,7,8
B7-182	7-Pin STYLE A	2,3,4,5,6,7,8
B7-183	7-Pin STYLE B	1,2,3,4, 6,7,8

17TP4

KINESCOPE

Low-Voltage Electrostatic Focus Magnetic Deflection | **Rectangular Metal-Shell Type Frosted Filterglass Faceplate Ion-Trap Gun** | **14-5/8" x 11" Picture Size 17" Max. Shell Diagonal 19-5/16" Max. Length**

TENTATIVE DATA

RCA-17TP4 is a short, directly viewed, rectangular picture tube of the metal-shell type utilizing low-voltage, electrostatic focus and magnetic deflection. It has a frosted Filterglass faceplate; employs an ion-trap gun requiring an external, single-field magnet; and provides a picture 14-5/8" x 11" with slightly curved sides and rounded corners.

The focusing electrode in the 17TP4 has its own base-pin terminal to permit designers choice of focusing voltage for best results. Because the focusing electrode (grid No.4) operates at low voltage (only 0 to 2.5% of the ultor voltage) and takes very low current, the focusing voltage can conveniently be obtained from a fixed tap on the low-voltage dc supply for the receiver, or from a potentiometer between the boost voltage and -B supply. With either method, focus is maintained automatically with variation in line voltage and with adjustment of picture brightness.

When fixed focus is used, the designer can set the focusing voltage at a value which will give good results for his particular operating voltages. If somewhat better performance is desired, he can provide for adjustment of the focusing voltage.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	ampere
Direct Interelectrode Capacitances:		
Grid No.1 to All Other Electrodes	6	$\mu\mu$f
Cathode to All Other Electrodes	5	$\mu\mu$f
Faceplate (With about 66% light transmission)	Frosted Filterglass	
Phosphor	P4--Sulfide Type	
Fluorescence	White	
Phosphorescence	White	
Persistence	Short	
Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	70^0	
Horizontal	66^0	
Vertical	50^0	
Ion-Trap Gun	Requires External, Single-Field Magnet	
Maximum Overall Length	19-5/16"	
Greatest Diagonal of Tube at Lip	16-13/16" ± 3/16"	
Greatest Width of Tube at Lip	15-15/16" ± 1/8"	
Greatest Height of Tube at Lip	12-1/4" ± 1/8"	
Screen Size	14-5/8" x 11"	

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Radio Corporation of America

General (Cont'd):

Ultor● Terminal	Metal-Shell Lip
Base	Small-Shell Duodecal 6-Pin (JETEC No. B6-63)
Mounting Position	Any

Maximum Ratings, *Design-Center Values*:

ULTOR● VOLTAGE*	16000 max.	volts
GRID-No.4 VOLTAGE	500 max.	volts
GRID-No.2 VOLTAGE	500 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	410 max.	volts
After equipment warm-up period	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

	For any ultor voltage (E_u) between 12000 and 16000 volts and grid-No.2 voltage (E_{c_2}) between 150 and 500 volts	
Grid-No.4 Voltage for Ultor Current of 100 μamp.	0% to 2.5% of Eu	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	11% to 25.7% of E_{c_2}	volts
Grid-No.4 Current	-25 to +25	μamp
Grid-No.2 Current	-15 to +15	μamp
Field Strength of Single-Field Ion-Trap Magnet (Approx.)**	$\sqrt{\frac{Eu}{12000}} \times 33$	gausses
Field Strength of Adjustable Centering Magnet	0 to 8	gausses

Examples of Use of Design Ranges:

For ultor voltage of / *and grid-No.2 voltage of*	*14000* / *300*	*16000* / *300*	*volts* / *volts*
Grid-No.4 Voltage for Ultor Current of 100 μamp.	0 to 350	0 to 400	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	-33 to -77	-33 to -77	volts
Ion-Trap Magnet (Rated Strength)	35	40	gausses

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

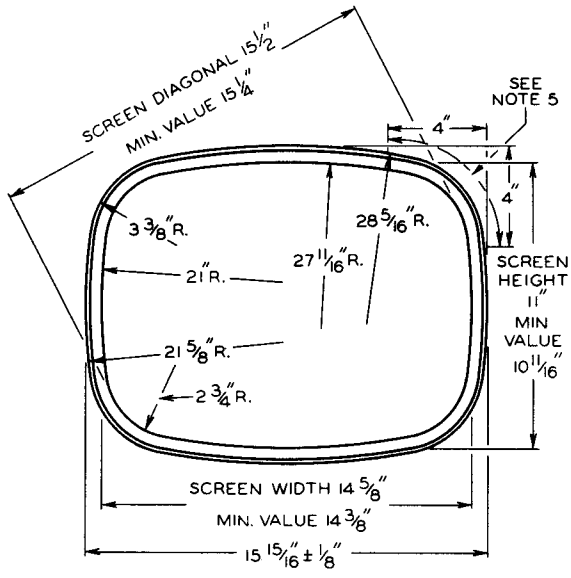
In the 17TP4, grid No.5 which has the ultor function, grid No.3, and collector are connected together within the tube and are conveniently referred to collectively as "ultor". The "ultor" in a cathode-ray tube is the electrode, or the electrode in combination with one or more additional electrodes connected within the tube to it, to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection.

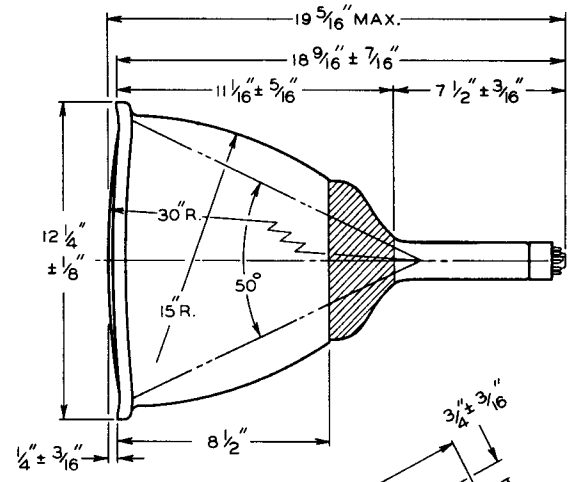
* Brilliance and definition decrease with decreasing ultor voltage. In general, the ultor voltage should not be less than 12000 volts.

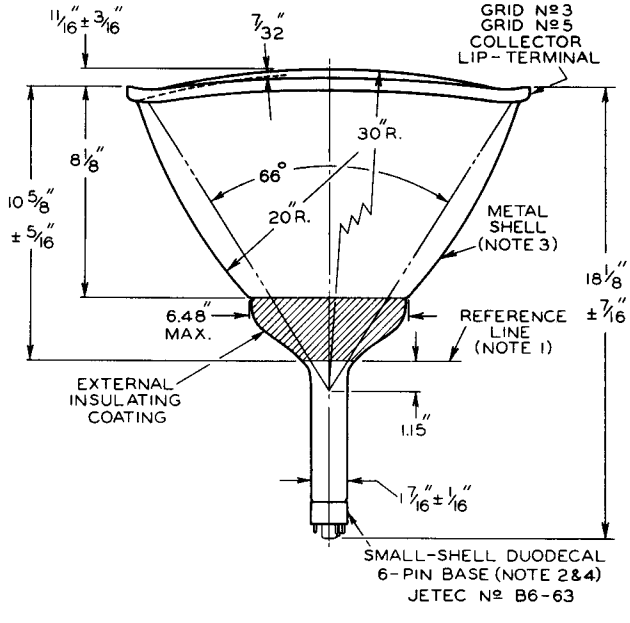
** With a specimen ion-trap magnet similar to JETEC Ion-Trap Magnet No.111 located in optimum position and rotated to give maximum brightness, the ion-trap magnet current is 70 milliamperes dc when the ultor voltage is 14000 volts.

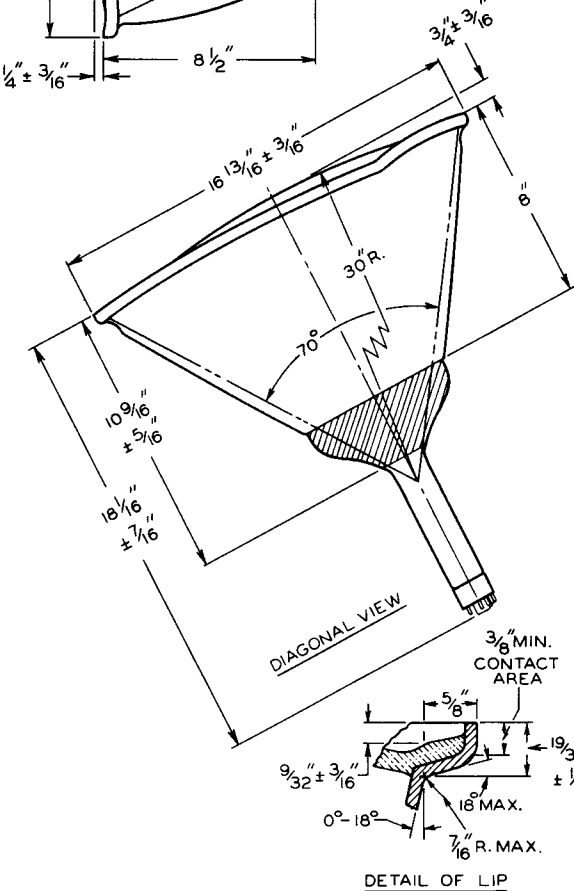
Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE









92CL-7601R1

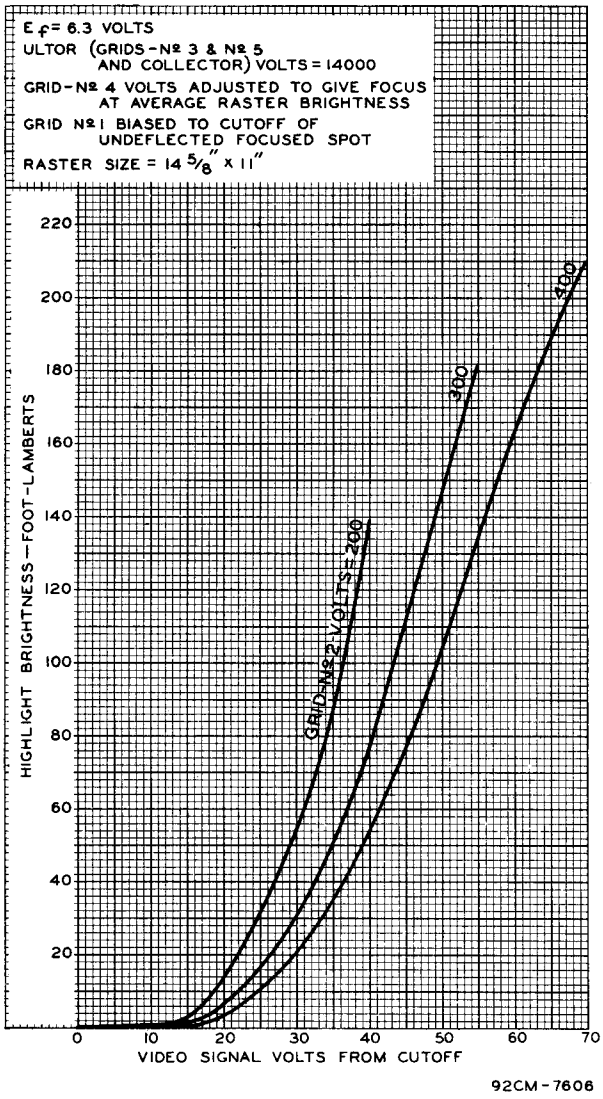
NOTE 1: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JETEC No. 110) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 2: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH METAL-SHELL AXIS AND HAVING A DIAMETER OF 2-3/4".

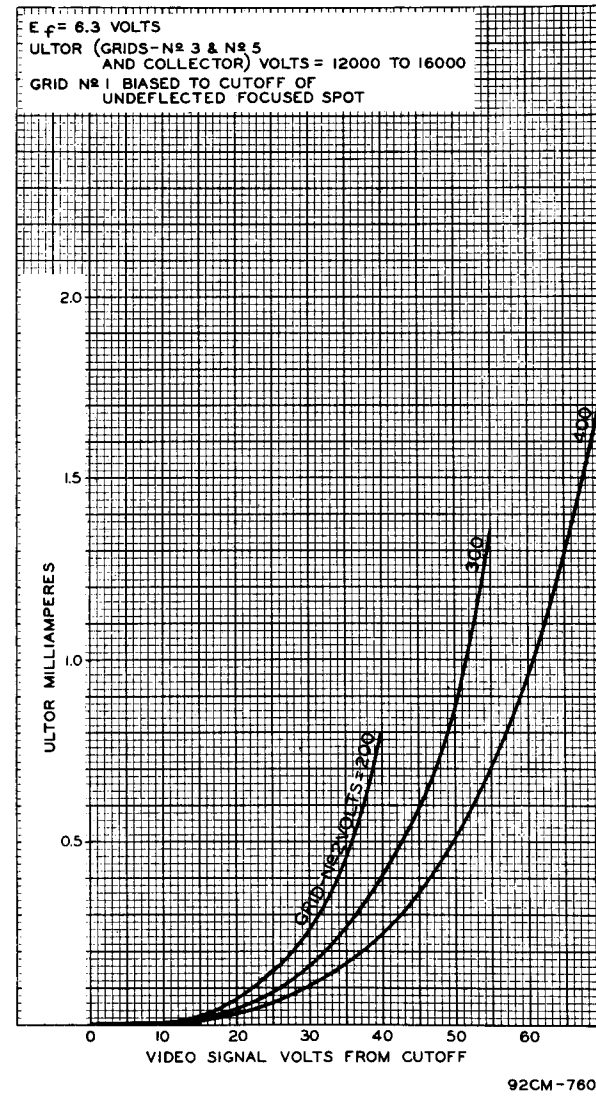
NOTE 3: METAL SHELL AND GLASS FACE OPERATE AT HIGH VOLTAGE. ANY MATERIAL IN CONTACT WITH THE SHELL OR THE FACE MUST BE INSULATED TO WITHSTAND THE MAXIMUM APPLIED ULTOR VOLTAGE.

NOTE 4: THE PLANE THROUGH THE TUBE AXIS AND PIN No. 6 MAY VARY FROM THE HORIZONTAL AXIS OF THE GLASS FACE BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 10°.

NOTE 5: SUPPORT TUBE BY LIP ONLY AT CORNERS WITHIN THIS SPACE.



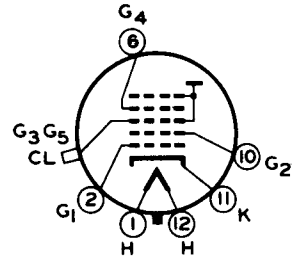
Average Grid-Drive Characteristics of Type 17TP4.



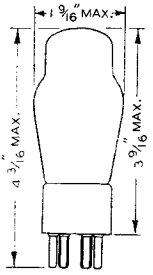
Average Grid-Drive Characteristics of Type 17TP4.

SOCKET CONNECTIONS

Bottom View

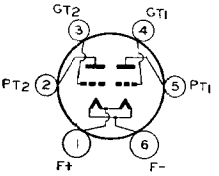


PIN 1: HEATER
PIN 2: GRID NO. 1
PIN 6: GRID NO. 4
PIN 10: GRID NO. 2
PIN 11: CATHODE
PIN 12: HEATER
METAL-SHELL LIP: GRID NO. 3, GRID NO. 5, COLLECTOR



RCA-19

CLASS B TWIN AMPLIFIER



The 19 combines in one bulb two high-mu triodes designed for Class B operation. It is intended for use in the output stage of battery-operated receivers and is capable of supplying approximately 2 watts of audio power. The triode units have separate external terminals for all electrodes except the filaments, so that circuit design is similar to that of Class B amplifiers utilizing individual tubes in the output stage.

CHARACTERISTICS

Filament Voltage (D. C.)	2.0	Volts
Filament Current	0.26	Ampere
Bulb		ST-12
Base		Small 6-Pin

As Class B Power Amplifier

Plate Voltage			135 *max.*	Volts
Maximum Signal Plate Current (Per plate)			50 *max.*	Milliamperes
Typical Operation				
Plate Voltage	135	135	135	Volts
Grid Voltage	−6	−3	0	Volts
Zero-Signal Plate Current (Per plate)	0.5	2	5	Milliamperes
Effective Load Resistance (Plate-to-plate)	10000	10000	10000	Ohms
Average Power Input (Approx.)*	95	130	170	Milliwatts
Power Output (Approximate)	1.6	1.9	2.1	Watts

* Applied between grids to give indicated values of power output.

INSTALLATION

The base pins of the 19 fit the standard six-contact socket. The socket should be installed to hold the tube in a vertical position. In same cases, cushioning of the socket may be found desirable.

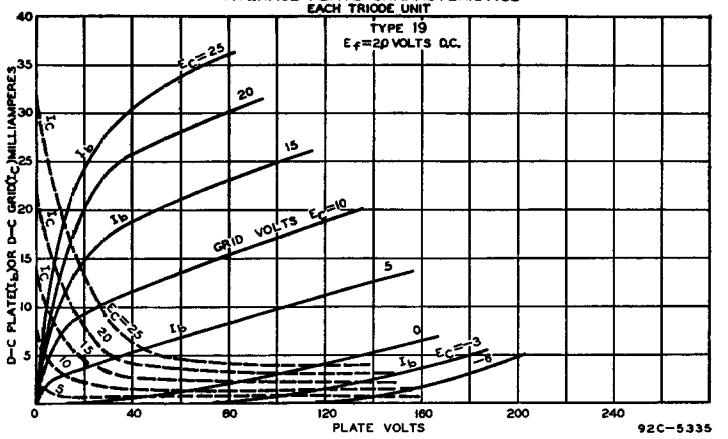
For filament operation, refer to INSTALLATION for type 1A6.

APPLICATION

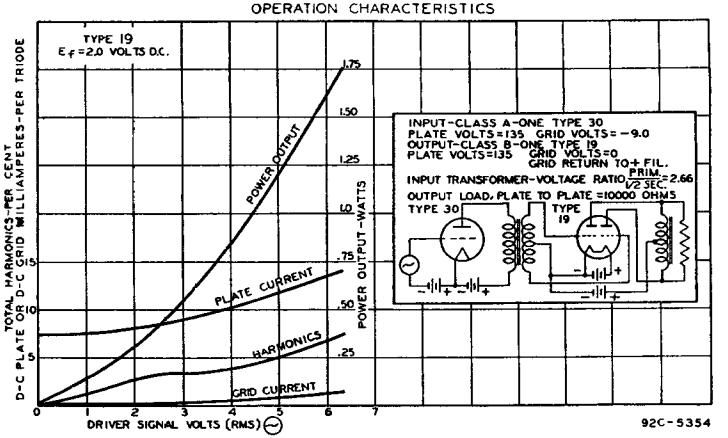
As a **Class B power amplifier** in the output stage of battery-operated receivers, the 19 should be operated as shown under CHARACTERISTICS. In such service, it may be operated either with zero grid bias or with negative grid bias. The latter method may be of advantage in cases where plate-battery drain must be conserved, even at some sacrifice in power output.

The type of driver tube chosen to precede the 19 should be capable of handling enough power to operate the Class B amplifier stage. Allowance should be made for transformer efficiency. It is most important, if low distortion is desired, that the driver tube be worked well below its Class A undistorted output rating, since distortion produced by the driver stage and the power stage will be present in the output. A discussion of Class B amplifier features is given on page 20.

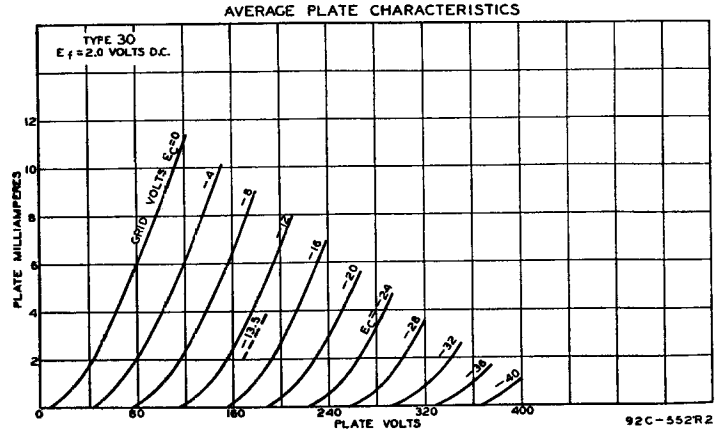
AVERAGE PLATE CHARACTERISTICS
EACH TRIODE UNIT



OPERATION CHARACTERISTICS



AVERAGE PLATE CHARACTERISTICS



19AU4

HALF-WAVE VACUUM RECTIFIER

For Television Damper Service

TENTATIVE DATA

RCA-19AU4 is a half-wave vacuum rectifier tube of the glass-octal type. It is particularly suited for use as a damper diode in horizontal-deflection circuits of black-and-white television receivers utilizing series-heater strings.

Rated to withstand a maximum peak inverse plate voltage of 4500 volts (absolute), the 19AU4 can supply a maximum peak plate current of 1050 milliamperes and a maximum dc plate current of 175 milliamperes. Designed with insulation between heater and cathode to withstand negative peak pulses between heater and cathode of as much as 4500 volts (absolute) with a dc component up to 900 volts, the 19AU4 provides flexibility in choice of deflection circuits.

This type is designed with a 600-milliampere heater having a controlled heating time to insure dependable performance in television receivers employing a series-heater string arrangement.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	18.9	volts
Current	0.6	amp
Warm-Up Time (Average)	11	seconds

Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 15.1 volts.

Direct Interelectrode Capacitances (Approx. without external shield):		
Plate to heater and cathode	8.5	μμf
Cathode to heater and plate	11.5	μμf
Heater to cathode	4.0	μμf

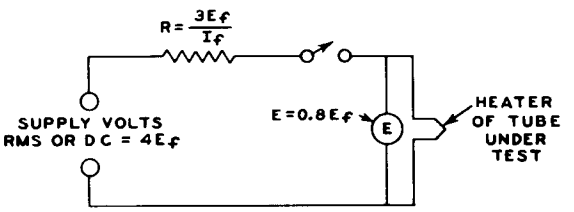


Fig. 1 - Test Circuit for Determining Heater Warm-Up Time.

Mechanical:

Mounting Position	Any
Maximum Overall Length	3-13/16"
Maximum Seated Length	3-1/4"
Maximum Diameter	1-9/32"
Bulb	T-9
Base	Short Intermediate-Shell Octal 5-or 6-Pin with External Barriers (JETEC Nos.B5-85 or B6-60)

DAMPER SERVICE

Maximum Ratings, *Design-Center Values Except as Noted:*

For operation in a 525-line, 30-frame system#

PEAK INVERSE PLATE VOLTAGE (ABSOLUTE MAXIMUM)◘	4500●	max.	volts
PEAK PLATE CURRENT	1050	max.	ma
DC PLATE CURRENT	175	max.	ma
PLATE DISSIPATION	6	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode (Absolute Maximum)	4500●*	max.	volts
Heater positive with respect to cathode	300†	max.	volts

\# As described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations," Federal Communications Commission.

◘ This rating is applicable where the duty cycle of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

● Under no circumstances should this absolute value be exceeded.

* The dc component must not exceed 900 volts.

† The dc component must not exceed 100 volts.

OPERATING CONSIDERATIONS

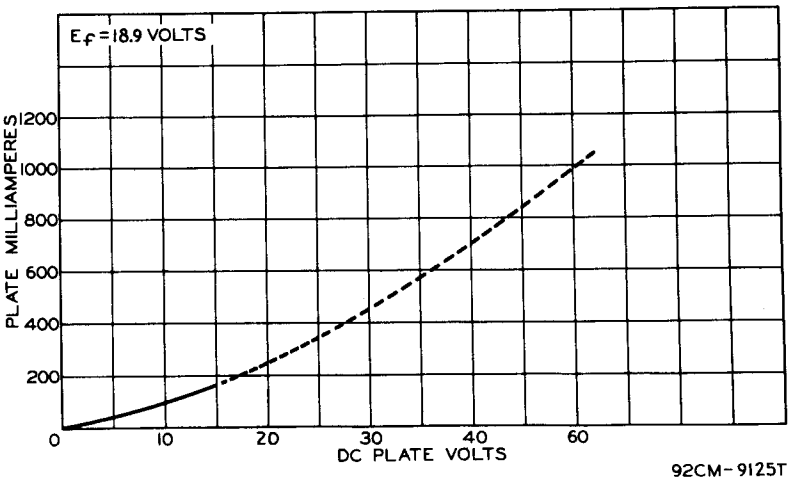
The *maximum ratings* shown in the tabulated data for peak plate current, dc plate current, plate dissipation, and peak heater-cathode voltage with the heater positive with respect to cathode are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage, including normal variations, falls within ± 10 per cent of line-center voltage value of 117 volts.

The *maximum ratings* shown in the tabulated data for peak inverse plate voltage and peak heater-cathode voltage with the heater negative with respect to cathode are limiting values above which the serviceability of the 19AU4 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order

not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute value will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

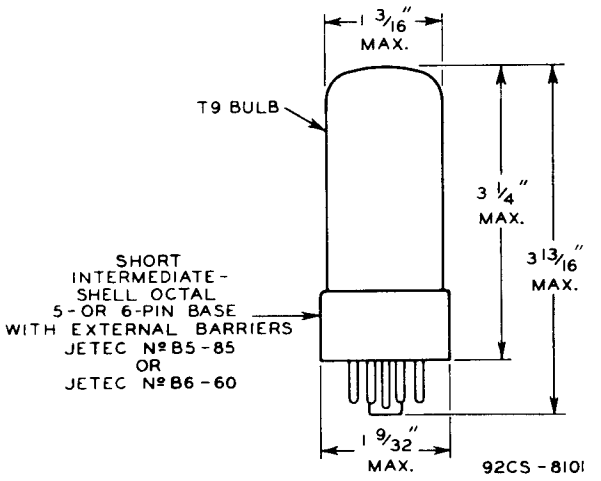
The *base pins* of the 19AU4 fit the standard octal socket. Socket terminals for pins 1, 2, 4, and 6 should not be used for tie points. It is also recommended that socket clips for these pins be removed to reduce the possibility of arc-over and to minimize leakage.

In television receivers employing series-heater strings, a resistor in series with the string of tubes will minimize voltage surges across any individual tube during starting. The resistor should preferably have a negative temperature characteristic.



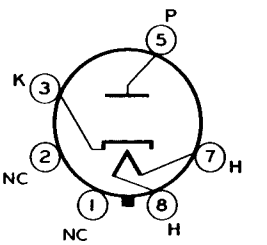
Average Plate Characteristics of Type 19AU4.

DIMENSIONAL OUTLINE



SOCKET CONNECTIONS

Bottom View



4CG

PIN 1: NO CONNECTION—DO NOT USE; OR OMITTED
PIN 2: NO CONNECTION—DO NOT USE
PIN 3: CATHODE
PIN 5: PLATE
PIN 7: HEATER
PIN 8: HEATER

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from JEDEC release #4549, Dec. 30, 1963

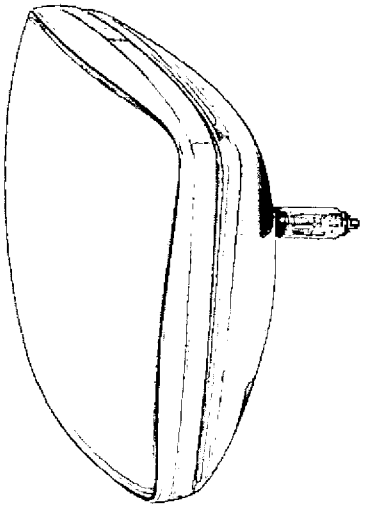
RCA-19DQP4

PAN-O-PLY
PICTURE TUBE

RCA-19DQP4 is a black-and-white pan-o-ply picture tube which eliminates the need for either an integral protective window or a separate safety-glass window and its companion dust seal in the receiver. Thereby internal reflections are reduced; consequently, picture contrast is improved. Integral implosion protection in the pan-o-ply picture tube is provided by means of a formed rim band and a welded tension band around the periphery of the tube panel. The 19DQP4 is a rectangular glass picture tube having an aluminized screen with nearly straight sides and slightly rounded corners.

Features of the 19DQP4 include:

- Pan-O-Ply—Integral Implosion Protection
- 114° Magnetic Deflection
- Low-Voltage Electrostatic Focus
- Aluminized Screen
- Electron Gun Requiring No Ion-Trap Magnet
- 11.625" Max. Overall Length
- 4.125" Neck Length
- 12.000" x 15.187" Screen
- 6.3 Volt/450 Ma Heater
- 23 kv Max. Anode Voltage



GENERAL DATA

Electrical:

Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	114°	
Horizontal	102°	
Vertical	85°	
Direct Interelectrode Capacitances:		
Cathode to all other electrodes	5	pf
Grid No.1 to all other electrodes	6	pf
External conductive coating to anode[a]	1500 max. 1000 min.	pf pf
Heater Current at 6.3 volts	450 ± 20	ma
Heater Warm-Up Time (Average)	11	seconds

Heater warm-up time is defined as the time required in the test circuit shown in *Fig. 1* for the voltage (E) across the heater terminals to increase from zero to 0.8 of rated heater voltage.

Electron Gun . . . . Type Requiring No Ion-Trap Magnet

Optical:

Phosphor . . . . . P4—Sulfide Type, Aluminized
Faceplate . . . . . Filterglass
Light Transmission at Center (Approx.) 49%

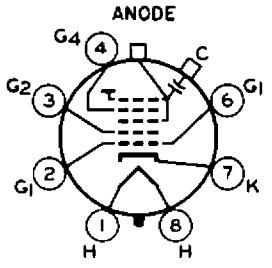
Mechanical:

Weight (Approx.) . . . . . 15 lbs

Tube Dimensions:

Overall length	11.375" ± .250"
Neck length	4.125" ± .125"
Diagonal	18.732" ± .100"
Greatest width	16.514" ± .100"
Greatest height	13.473" ± .100"
Minimum Screen Dimensions (Projected):	
Diagonal	17.562"
Greatest width	15.187"
Greatest height	12.000"
Area	172 sq.in.
Bulb Designation	J149 F1
Cap Designation	Recessed Small Cavity (JEDEC No.J1-21)
Base Designation	Small-Button Neoeightar 7-Pin, Arrangement 1, (JEDEC No.B7-208)
Basing Designation	8HR

Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Grid No.2
Pin 4: Grid No.4
Pin 6: Grid No.1
Pin 7: Cathode
Pin 8: Heater
Cap: Anode (Grid No.3, Grid No.5, Screen, Collector)
C: External Conductive Coating



BOTTOM VIEW

Maximum and Minimum Ratings, *Design-Maximum Values:*[b]

Unless otherwise specified, voltage values are positive with respect to cathode

Anode Voltage	23,000 max.	volts
	11,000 min.	volts
Grid-No.4 Voltage:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
Grid-No.2 Voltage	550 max.	volts
	200 min.	volts
Grid-No.1 Voltage:		
Negative peak value	220 max.	volts
Negative bias value	155 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
Heater Voltage[c]	6.9 max.	volts
	5.7 min.	volts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	300 max.	volts
Heater positive with respect to cathode:		
Combined AC & DC Voltage	200 max.	volts
DC Component	100 max.	volts

Typical Operating Conditions for Cathode-Drive[d] Service:

Unless otherwise specified, voltage values are positive with respect to grid No.1

Anode Voltage	16,000	volts
Grid-No.4 Voltage[e]	200	volts
Grid-No.2 Voltage	300	volts
Cathode Voltage for visual extinction of focused raster (See *Fig.2*)	28 to 62	volts
Field Strength of required adjustable Centering Magnet[f]	0 to 8	gauss
Maximum Circuit Value:		
Grid-No.1 Circuit Resistance	1.5 max.	megohms

[a] Includes implosion-protection hardware.

[b] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Maximum Rating System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

[c] Measured between the heater terminals.

[d] Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

[e] The grid-No.4 voltage required for optimum focus of any individual tube will have a value anywhere between 0 and +400 volts with the combined grid-No.1 voltage and video-signal voltage adjusted to give an anode current of 200 microamperes on a 13-1/2-inch by 18-inch pattern from an RCA-2F21 monoscope, or equivalent.

[f] Distance from Reference Line for suitable PM centering magnet should not exceed 2-1/4 inches. The specified centering magnet compensates only for the effect which mechanical tube tolerances may have on the location of the undeflected, focused spot with respect to the center of the tube face. Maximum field strength of adjustable centering magnet equals

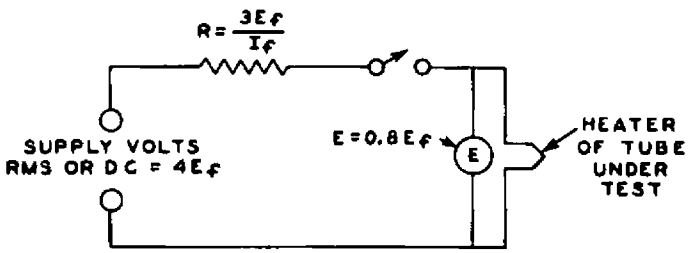
$$\sqrt{\frac{\text{Anode volts}}{16000 \text{ volts}}} \times 8 \text{ gauss}$$

The equipment manufacturer must determine and supply additional compensation for the effects of the earth's magnetic field and extraneous fields due to choice of circuitry and components. The additional compensation should preferably be applied as part of the magnetic field of the deflecting yoke.

OPERATING CONSIDERATIONS

X-Radiation Warning. When operated at anode voltages up to 16 kilovolts, this picture tube does not produce any harmful X-radiation. However, because the rating of this type permits operation at voltages as high as 23 kilovolts (design-maximum value), shielding of the tube for X-radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

TEST CIRCUIT FOR DETERMINING HEATER WARM-UP TIME



Ef = RATED HEATER VOLTAGE OF TUBE UNDER TEST.
If = RATED HEATER CURRENT OF TUBE UNDER TEST.
92CS-8503

Fig.1

Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

RASTER CUTOFF CHART

For Cathode-Drive Service

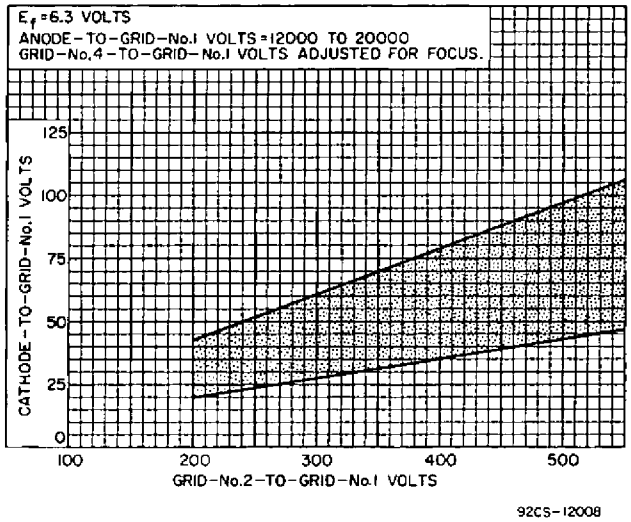
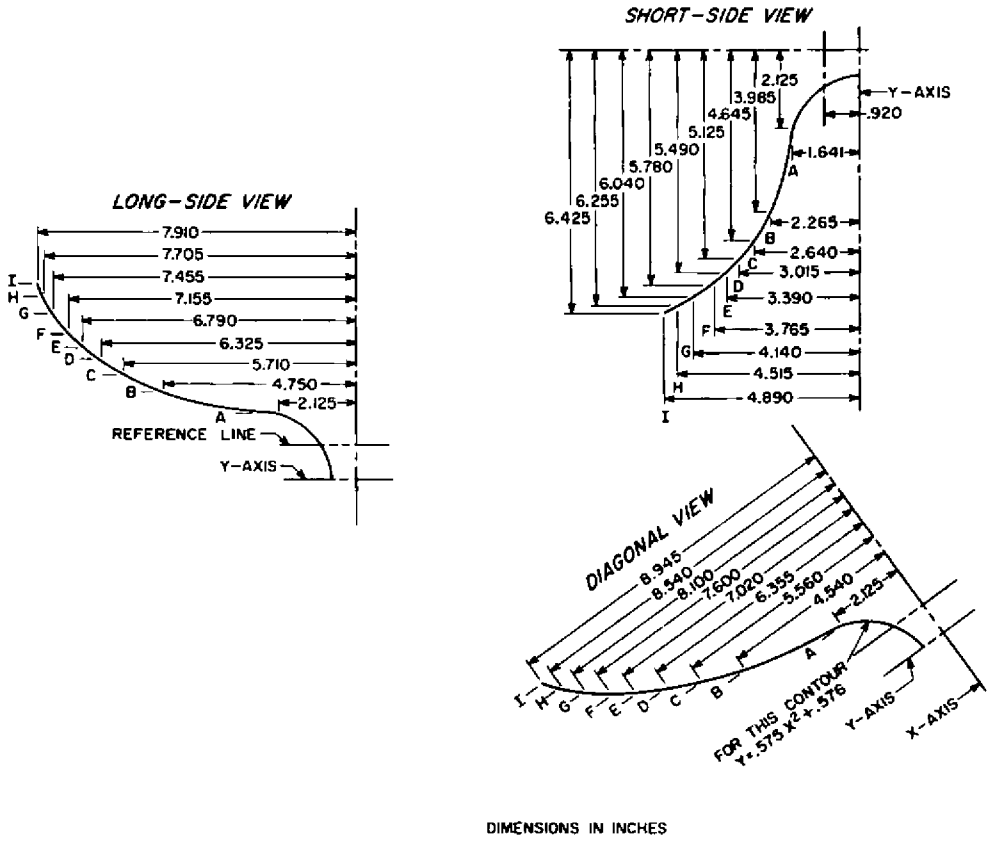


Fig.2

BULB-CONTOUR DIMENSIONS

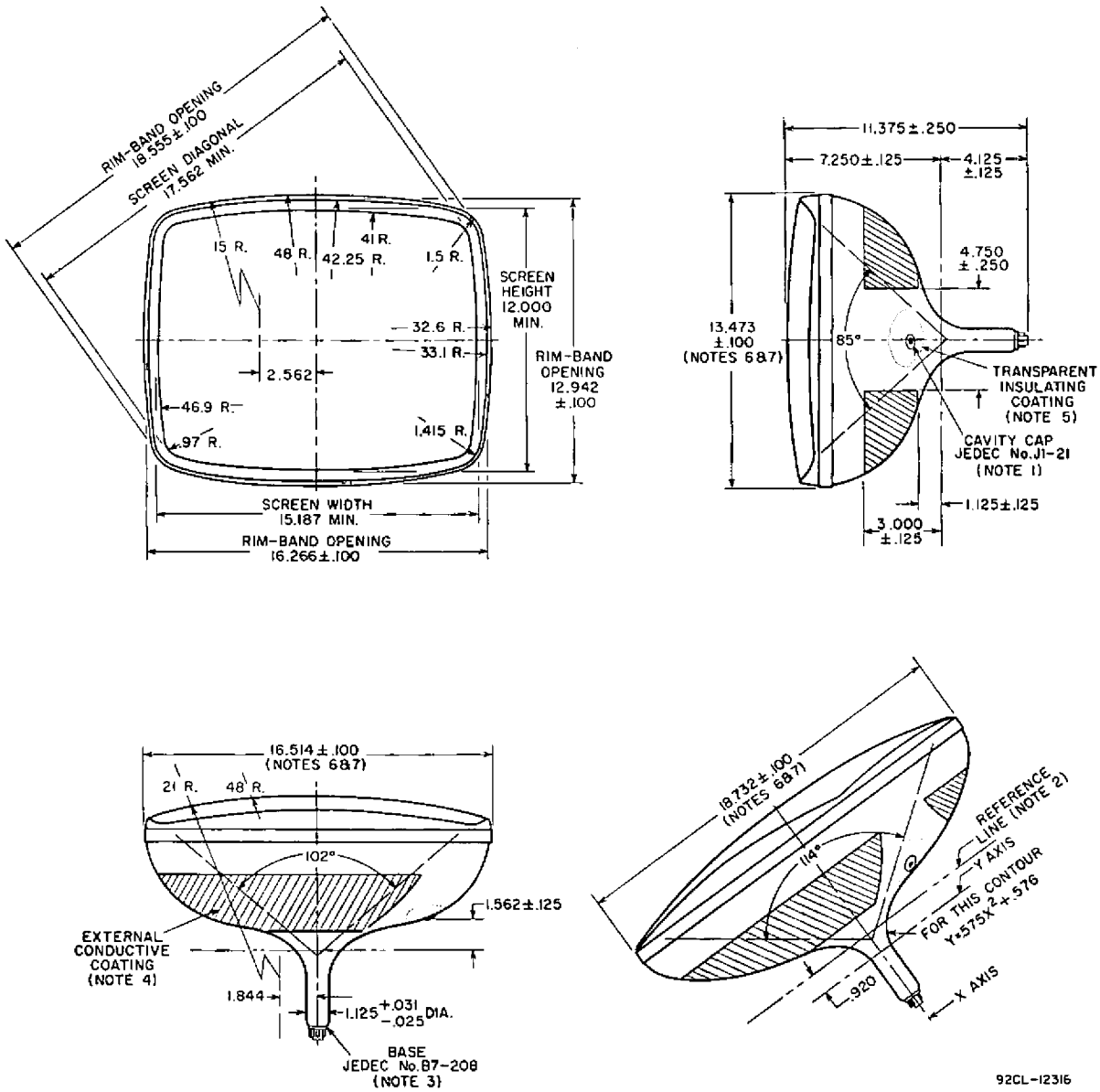


DIMENSIONS IN INCHES

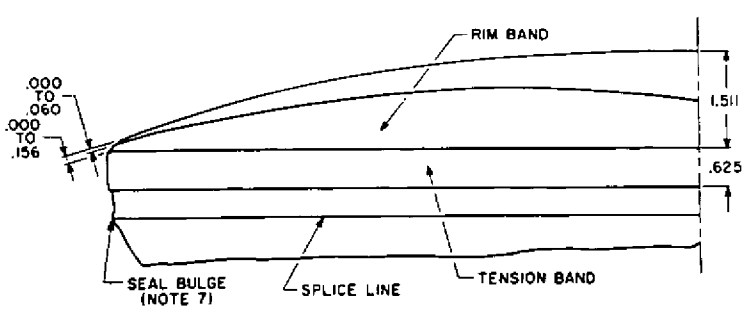
92CM-12294

PLANES A THROUGH G ARE NORMAL TO THE TUBE AXIS AND AT FIXED LOCATIONS FROM THE Y AXIS. THESE COORDINATES DESCRIBE THE BOGIE BULB EXTERNAL CONTOUR IN PLANES THROUGH THE TUBE AXIS AND THE RESPECTIVE FACEPLATE AXES.

DIMENSIONAL OUTLINE



DETAIL OF PANEL
(Diagonal View)



DIMENSIONS IN INCHES

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN NO.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ±30°. ANODE TERMINAL IS ON SAME SIDE AS PIN NO.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC No. G-126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING AND IMPLOSION PROTECTION HARDWARE MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

NOTE 6: MEASURED FROM THE TENSION BAND.

NOTE 7: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/16".

from JEDEC release #4549, Dec. 30, 1963

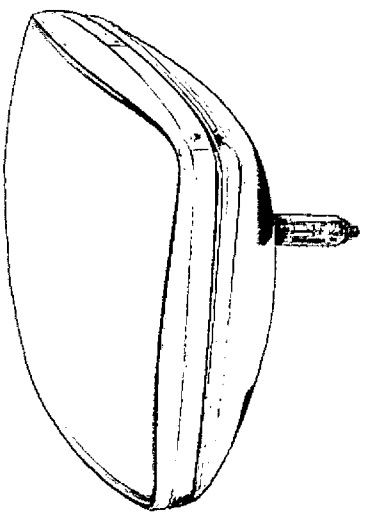
RCA-19DSP4

PAN-O-PLY
PICTURE TUBE

RCA-19DSP4 is a black-and-white pan-o-ply picture tube which eliminates the need for either an integral protective window or a separate safety-glass window and its companion dust seal in the receiver. Thereby internal reflections are reduced; consequently, picture contrast is improved. Integral implosion protection in the pan-o-ply picture tube is provided by means of a formed rim band and a welded tension band around the periphery of the tube panel. The 19DSP4 is a rectangular glass picture tube having an aluminized screen with nearly straight sides and slightly rounded corners.

Features of the 19DSP4 include:

- Pan-O-Ply—Integral Implosion Protection
- 114° Magnetic Deflection
- Low-Voltage Electrostatic Focus
- Aluminized Screen
- Electron Gun Requiring No Ion-Trap Magnet
- 11.875" Max. Overall Length
- 4.375" Neck Length
- 12.000" x 15.187" Screen
- 6.3 Volt/600 Ma Heater
- Low Grid-No.2 Voltage—
  For Cathode-Drive Service
- 20 kv Max. Anode Voltage



GENERAL DATA

Electrical:

Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	114°	
Horizontal	102°	
Vertical	85°	
Direct Interelectrode Capacitances:		
Cathode to all other electrodes	5	pf
Grid No.1 to all other electrodes	6	pf
External conductive coating to anode[a]	1500 max.	pf
	1000 min.	pf
Heater Current at 6.3 volts	600 ± 30	ma
Heater Warm-Up Time (Average)	11	seconds

Heater warm-up time is defined as the time required in the test circuit shown in *Fig.1* for the voltage (E) across the heater terminals to increase from zero to 0.8 of rated heater voltage.

Electron Gun . . . . Type Requiring No Ion-Trap Magnet

Optical:

Phosphor . . . . . P4—Sulfide Type, Aluminized
Faceplate . . . . . Filterglass
Light transmission at center (Approx.) 49%

Mechanical:

Weight (Approx.) . . . . . 15 lbs

Tube Dimensions:

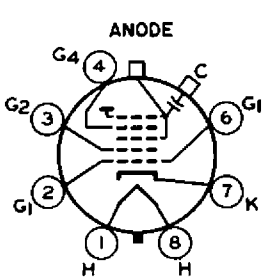
Overall length	11.625" ± .250"
Neck length	4.375" ± .125"
Diagonal	18.732" ± .100"
Greatest width	16.514" ± .100"
Greatest height	13.473" ± .100"

Minimum Screen Dimensions (Projected):

Diagonal	17.562"
Greatest width	15.187"
Greatest height	12.000"
Area	172 sq.in.

Bulb Designation J149 F1
Cap Designation . . . . . Recessed Small Cavity (JEDEC No.J1-21)
Base Designation . . . . . Small-Button Neoeightar 7-Pin, Arrangement 1, (JEDEC No.B7-208)
Basing Designation 8HR

Pin 1: Heater
Pin 2: Grid No.1
Pin 3: Grid No.2
Pin 4: Grid No.4
Pin 6: Grid No.1
Pin 7: Cathode
Pin 8: Heater
Cap: Anode (Grid No.3, Grid No.5, Screen, Collector)
C: External conductive Coating



BOTTOM VIEW

Maximum and Minimum Ratings, *Design-Maximum Values:*[b]

Unless otherwise specified, voltage values are positive with respect to grid No.1

Anode Voltage	20,000 max.	volts
	10,000 min.	volts
Grid-No.4 Voltage:		
Positive value	1250 max.	volts
Negative value	400 max.	volts
Grid-No.2 Voltage	70 max.	volts
	40 min.	volts
Cathode Voltage:		
Negative peak value	2 max.	volts
Negative bias value	0 max.	volts
Positive bias value	100 max.	volts
Positive peak value	150 max.	volts
Heater Voltage[c]	6.9 max.	volts
	5.7 min.	volts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	300 max.	volts
Heater positive with respect to cathode:		
Combined AC & DC voltage	200 max.	volts
DC Component	100 max.	volts

Typical Operating Conditions for Cathode-Drive[d] Service:

Unless otherwise specified, voltage values are positive with respect to grid No.1

Anode Voltage	16,000	volts
Grid-No.4 Voltage[e]	100	volts
Grid-No.2 Voltage	50	volts
Cathode Voltage for visual extinction of focused raster (See *Fig.2*)	32 to 50	volts
Field Strength of required adjustable Centering Magnet[f]	0 to 8	gauss

Maximum Circuit Value:

Grid-No.1 Circuit Resistance	1.5 max.	megohms

---

[a] Includes implosion protection hardware.

[b] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Maximum Rating System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

[c] Measured between the heater terminals.

[d] Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

[e] The grid-No.4 voltage required for optimum focus of any individual tube will have a value anywhere between -100 and +300 volts with the combined grid-No.1 voltage and video-signal voltage adjusted to give an anode current of 200 microamperes on a 13-1/2-inch by 18-inch pattern from an RCA-2F21 monoscope, or equivalent.

[f] Distance from Reference Line for suitable PM centering magnet should not exceed 2-1/4 inches. The specified centering magnet compensates only for the effect which mechanical tube tolerances may have on the location of the undeflected, focused spot with respect to the center of the tube face. Maximum field strength of adjustable centering magnet equals

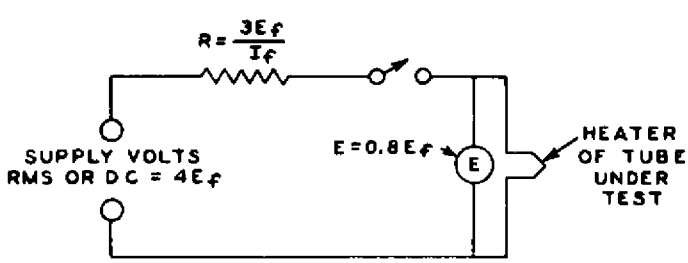
$$\sqrt{\frac{\text{Anode volts}}{16000 \text{ volts}}} \times 8 \text{ gauss}$$

The equipment manufacturer must determine and supply additional compensation for the effects of the earth's magnetic field and extraneous fields due to choice of circuitry and components. The additional compensation should preferably be applied as part of the magnetic field of the deflecting yoke.

OPERATING CONSIDERATIONS

X-Radiation Warning. When operated at anode voltages up to 16 kilovolts, this picture tube does not produce any harmful X-radiation. However, because the rating of this type permits operation at voltages as high as 20 kilovolts (design-maximum value), shielding of the tube for X-radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

TEST CIRCUIT FOR DETERMINING HEATER WARM-UP TIME



Ef = RATED HEATER VOLTAGE OF TUBE UNDER TEST.
If = RATED HEATER CURRENT OF TUBE UNDER TEST.
92CS-8503

Fig.1

Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

RASTER CUTOFF CHART

For Cathode-Drive Service

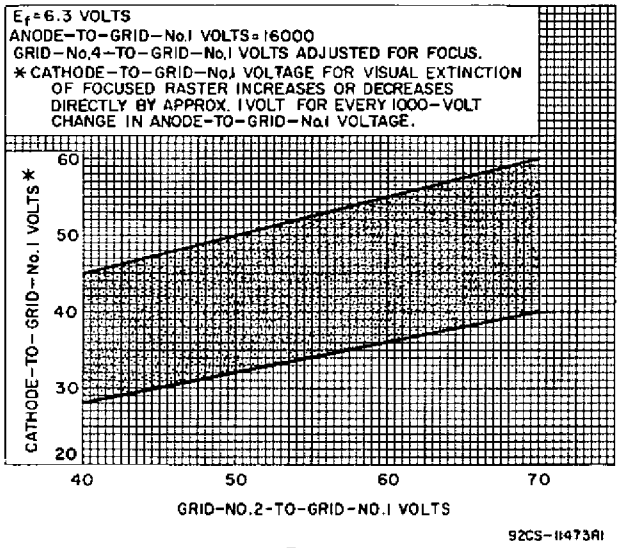
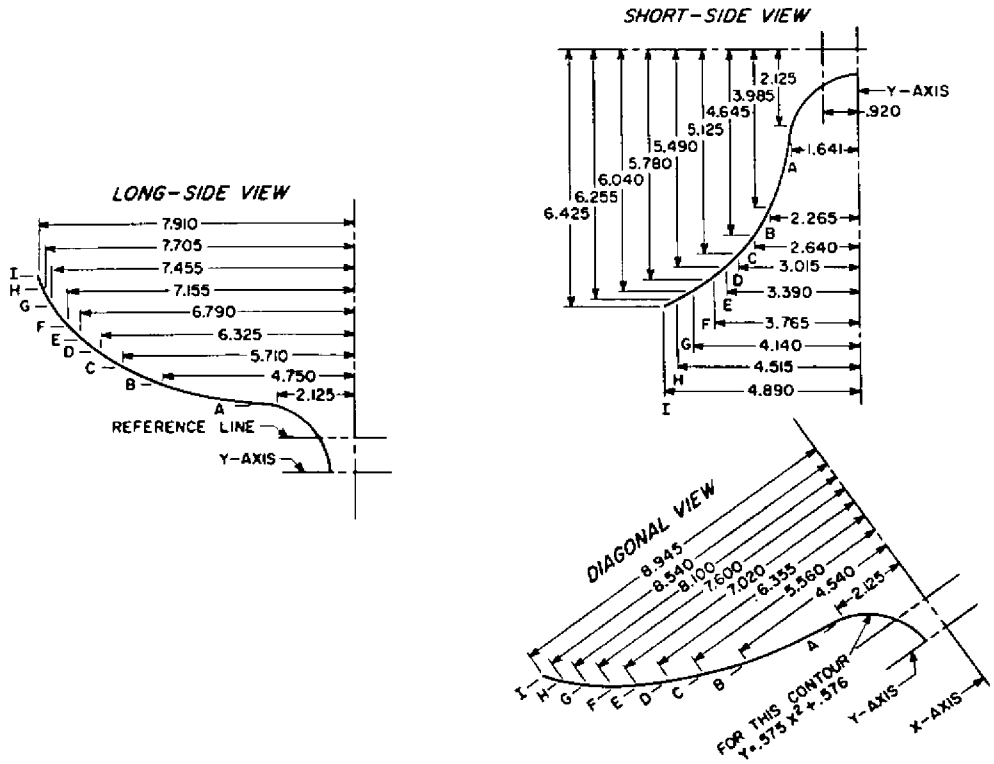


Fig.2

BULB-CONTOUR DIMENSIONS

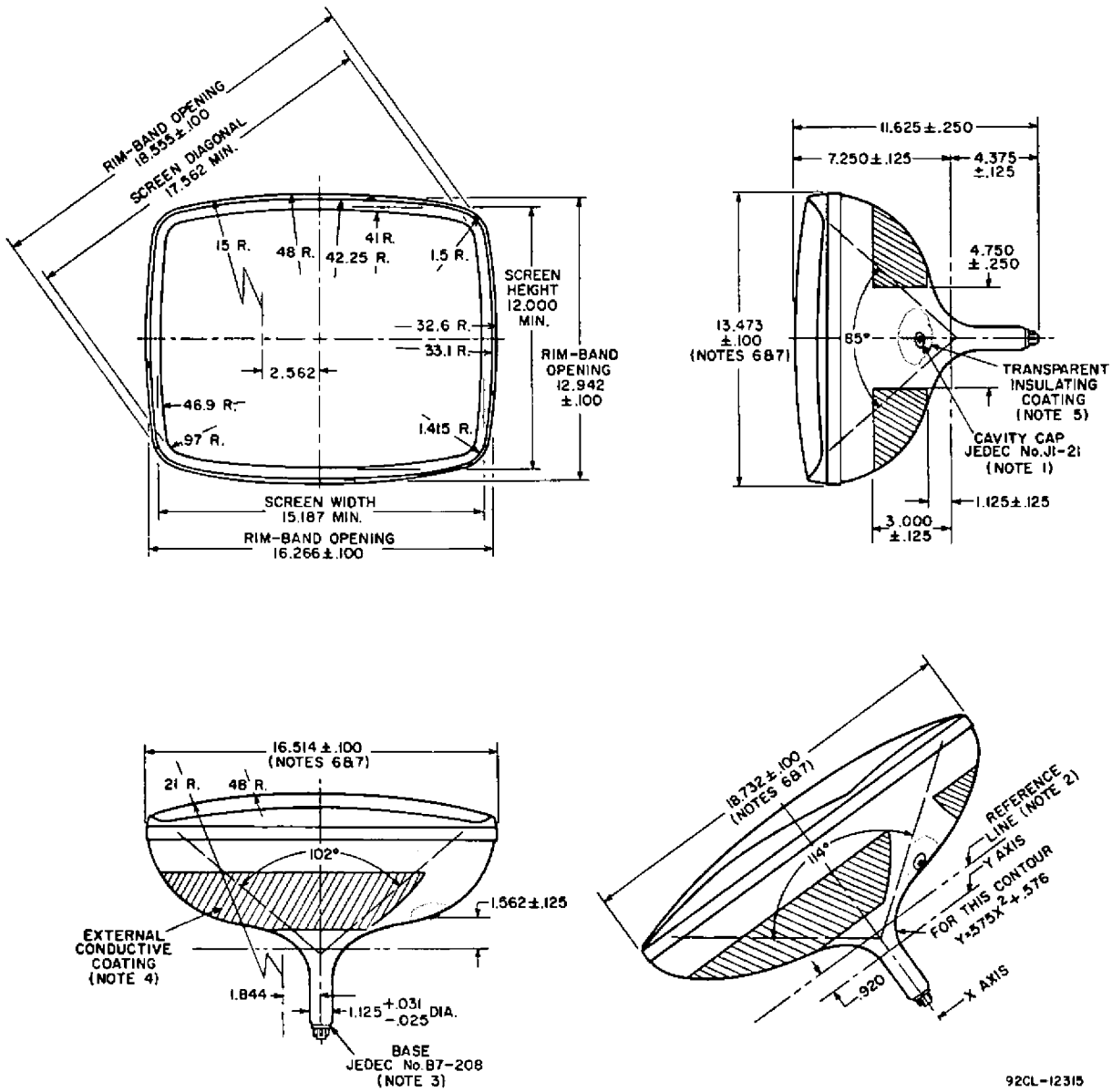


DIMENSIONS IN INCHES

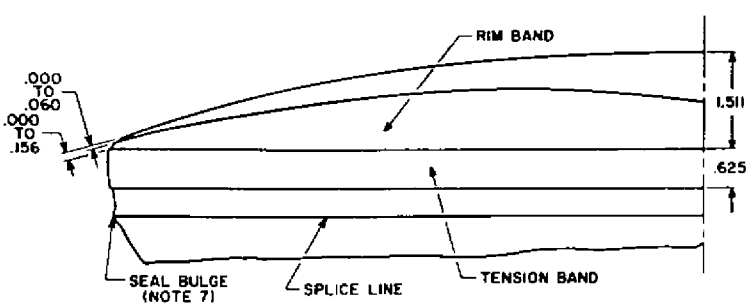
92CM-12294

PLANES A THROUGH G ARE NORMAL TO THE TUBE AXIS AND AT FIXED LOCATIONS FROM THE Y AXIS. THESE COORDINATES DESCRIBE THE BOGIE BULB EXTERNAL CONTOUR IN PLANES THROUGH THE TUBE AXIS AND THE RESPECTIVE FACEPLATE AXES.

DIMENSIONAL OUTLINE



DETAIL OF PANEL
(Diagonal View)



DIMENSIONS IN INCHES

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN NO.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ANODE TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ±30°. ANODE TERMINAL IS ON SAME SIDE AS PIN NO.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC No. G-126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING AND IMPLOSION PROTECTION HARDWARE MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

NOTE 6: MEASURED FROM THE TENSION BAND.

NOTE 7: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/16".

JOINT ELECTRON DEVICE ENGINEERING COUNCILS

JEDEC Electron Tube Council **JEDEC Solid State Products Council**

2001 Eye Street, NW
Washington, DC 20006

E. I. A.
REGISTRATION
FILE

Announcement

of

Electron Device Type Registration

Release No. 4549F

April 22, 1975

The Joint Electron Device Engineering Council announces the registration of the following electron device designations

19FAP4
19FQP4

according to the attached sheet on the application of

RCA Corp
Lancaster PA

Type 19FAP4 is similar to type 19DQP4 as registered in Release No. 4549E, dated January 28, 1975, except that the 19FAP4 incorporates integral mounting lugs. Dimensional differences are as follows:

Rectangle Containing Bulb Including Mounting System, Max.	17.032 x 12.510 in.
Mounting Hole, Center-to-Center	
Horizontal	16.156 in.
Vertical	11.469 in.
Z Reference Point to Lug	1.333 ± .062 in.
Lug Hole Diameter	.562 in.

Type 19FQP4 is similar to type 19DSP4 as registered in Release No. 4549E, dated January 28, 1975, except that the 19FQP4 incorporates integral mounting lugs and a different heater current. Differences are:

Heater Current at 6.3V	.450A
Rectangle Containing Bulb Including Mounting System, Max.	17.032 x 12.510 in.
Mounting Hole, Center-to-Center	
Horizontal	16.156 in.
Vertical	11.469 in.
Z Reference Point to Lug	1.333 ± .062 in.
Lug Hole Diameter	.562 in.

19J6

MEDIUM-MU TWIN TRIODE

Miniature Type

TENTATIVE DATA

RCA-19J6 is a miniature type of medium-mu twin triode intended especially for converter service in ac/dc FM and AM receivers. In such service, one triode unit may be used as a mixer, and the other as an oscillator. The 19J6 may also be used for oscillator, amplifier, or mixer service in television receivers of the "transformerless" type.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	18.9	volts
Current	0.15	ampere
Direct Interelectrode Capacitances (Each unit approx.)o:		
Grid to Plate	1.5	μμf
Grid to Cathode	2.0	μμf
Plate to Cathode	0.4	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-1/8"
Maximum Seated Height	1-7/8"
Length from Base Seat to Bulb Top (excluding tip)	1-1/2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin

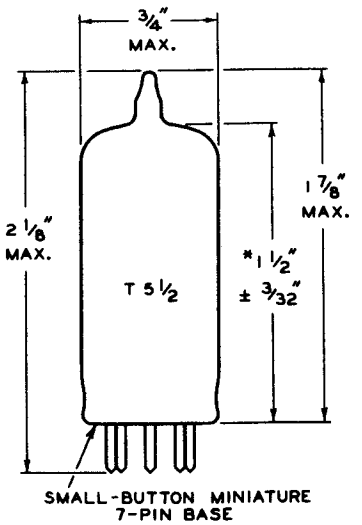
CLASS A_1 AMPLIFIER

Values are for each unit

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	300 max.	volts
PLATE DISSIPATION	1.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

CLASS A_1 AMPLIFIER (Cont'd)

Characteristics:

Plate Voltage	100	volts
Cathode-Bias Resistor**	50♦	ohms
Amplification Factor	38	
Plate Resistance	7100	ohms
Transconductance	5300	micromhos
Plate Current	8.5	ma

MIXER SERVICE

Values are for each unit

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	300 max.	volts
PLATE DISSIPATION	1.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Typical Operation:

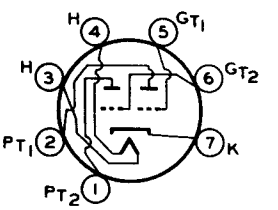
Plate Voltage	150	volts
Cathode-Bias Resistor**	810	ohms
Oscillator Peak Voltage	3	volts
Plate Resistance	10200	ohms
Conversion Transconductance	1900	micromhos
Short-Circuit Input Conductance at 100 Mc.	96	micromhos
Plate Current	4.8	ma

o With no external shield.

** Under maximum rated conditions, the resistance in the grid circuit should not exceed 0.5 megohm with cathode bias. Operation with fixed bias is not recommended.

♦ Value is for both units operating at the specified conditions.

SOCKET CONNECTIONS
Bottom View



7BF

PIN 1 - PLATE OF TRIODE No. 2
PIN 2 - PLATE OF TRIODE No. 1
PIN 3 - HEATER
PIN 4 - HEATER
PIN 5 - GRID OF TRIODE No. 1
PIN 6 - GRID OF TRIODE No. 2
PIN 7 - CATHODE

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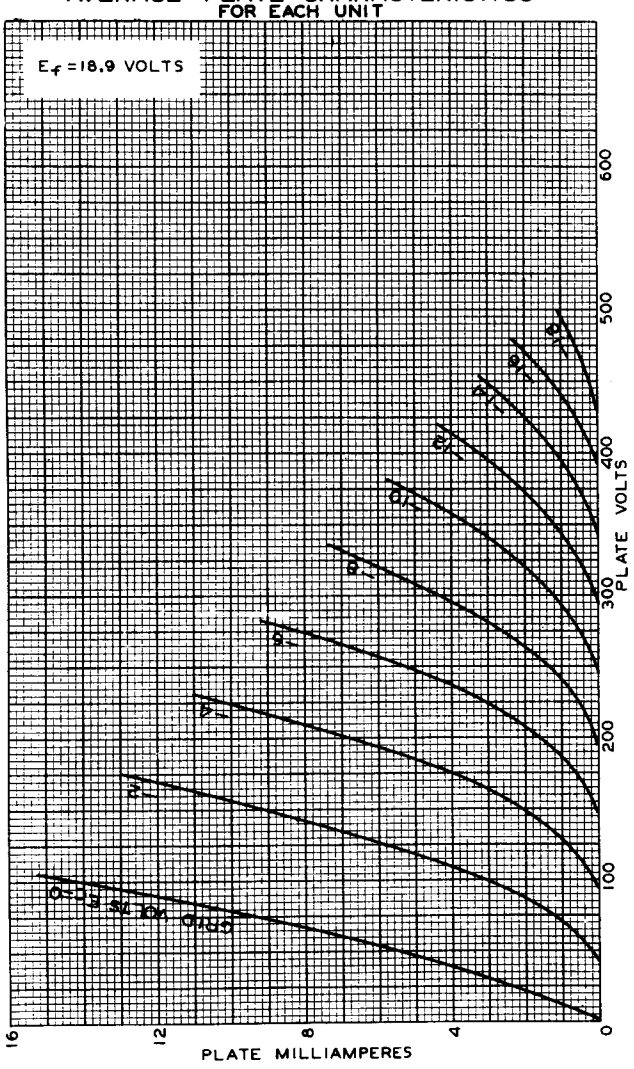
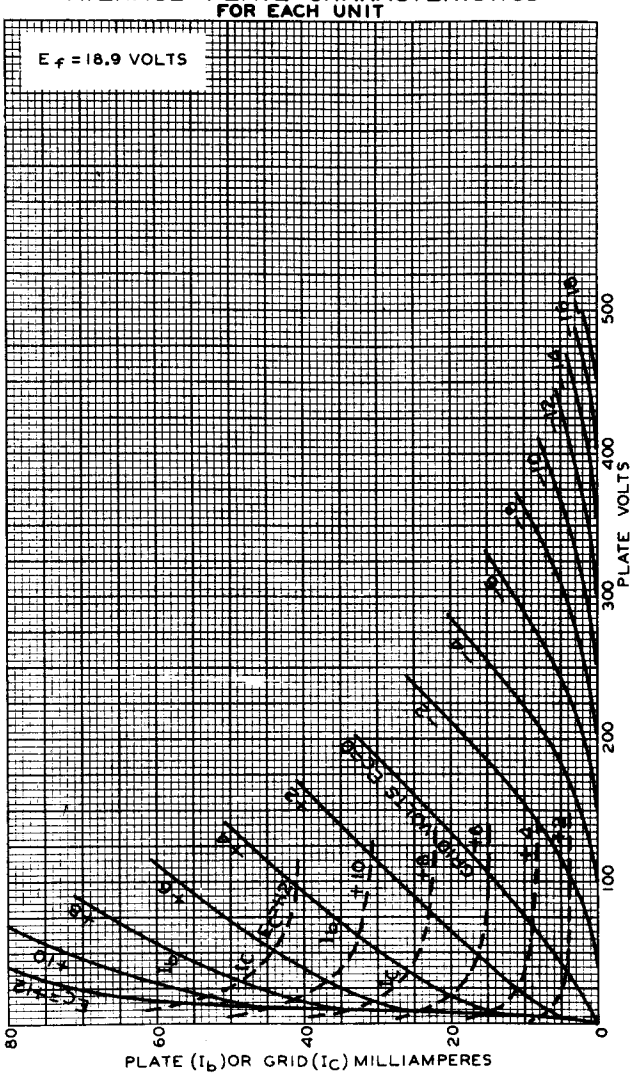
Radio Corporation of America

AVERAGE PLATE CHARACTERISTICS
FOR EACH UNIT



92CM-7060

AVERAGE PLATE CHARACTERISTICS
FOR EACH UNIT



92CM-7061

19X8

TRIODE-PENTODE CONVERTER

9-Pin Miniature Type

TENTATIVE DATA

RCA-19X8 is a multi-unit tube of the 9-pin miniature type containing a medium-mu triode and a sharp-cutoff pentode in one envelope. It is designed primarily for use as a combined oscillator and mixer tube in "transformerless" AM/FM receivers. The 19X8 has a 150-milliampere heater which permits series-string heater operation with other tubes having 150-milliamperes heaters.

The pentode mixer unit of the 19X8 provides low grid-No.1-to-plate capacitance as compared with a triode mixer and also has low output capacitance. The low value of capacitance between grid No.1 and plate minimizes feedback problems often encountered in mixer circuits operating into high-impedance plate loads. The low value of output capacitance enables the tube to work into a high-impedance plate circuit with resultant increase in mixer gain.

The 19X8 offers versatility to designers of AM/FM receivers. In the AM section, the pentode unit may be used as a pentode mixer to provide high gain; in the FM section, the pentode unit may be used either as a pentode mixer or as a triode-connected mixer depending on signal-to-noise considerations. Because triode mixers have relatively low equivalent noise resistance, they are preferred for receiver designs which do not include an rf stage. For receiver designs with an rf stage, a pentode mixer not only provides higher gain but better performance because in such designs the noise introduced by the mixer is negligible. For both the AM and the FM sections, the triode unit of the 19X8 makes a satisfactory oscillator.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)		18.9	volts
Current		0.15	ampere
Direct Interelectrode Capacitances:	Without External Shield	With External Shield#	
Triode Unit:			
Grid to Plate	1.4	1.4	μμf
Input	2.0	2.6	μμf
Output	0.5	1.0	μμf
Pentode Unit:			
Grid No.1 to Plate	0.09 max.	0.06 max.	μμf
Input	4.3	4.5	μμf
Output	0.7	1.4	μμf
Pentode Grid No.1 to Triode Plate	0.045 max.	0.035 max.	μμf
Pentode Plate to Triode Plate	0.040 max.	0.008 max.	μμf
Heater to Cathode	5.2	5.2	μμf

Direct Interelectrode Capacitances (Cont'd):	Without External Shield	With External Shield#	
Pentode Unit Connected as Triode:▲			
Grid No.1 to Plate	1.4	1.3	μμf
Input	3.0	3.2	μμf
Output	1.6	2.0	μμf

Characteristics:

Triode Unit:		
Plate Voltage	100	volts
Cathode-Bias Resistor	100	ohms
Amplification Factor	40	
Plate Resistance (Approx.)	6900	ohms
Transconductance	5800	μmhos
Grid-No.1 Bias (Approx.) for Plate Current of 10 μamp	-10	volts
Plate Current	8.5	ma
Pentode Unit:		
Plate Voltage	250	volts
Grid No.3 (Suppressor)	Connected to Cathode at Socket	
Grid-No.2 Voltage	150	volts
Cathode-Bias Resistor	200	ohms
Plate Resistance (Approx.)	750000	ohms
Transconductance	4600	μmhos
Grid-No.1 Bias (Approx.) for Plate Current of 10 μamp	-10	volts
Plate Current	7.7	ma
Grid-No.2 Current	1.6	ma
Pentode Unit Connected as Triode:		
Plate Voltage	150	volts
Grid No.3	Connected to Cathode at Socket	
Grid No.2	Tied to Plate	
Cathode-Bias Resistor	250	ohms
Amplification Factor	42	
Plate Resistance (Approx.)	7900	ohms
Transconductance	4000	μmhos
Grid-No.1 Bias (Approx.) for Plate Current of 10 μamp	-10	volts
Plate Current	7.8	ma

CONVERTER SERVICE

Maximum Ratings, ***Design-Center Values:***

Triode Unit as Oscillator

PLATE VOLTAGE	250 max.	volts
GRID VOLTAGE: Negative bias value	40 max.	volts
GRID VOLTAGE: Positive bias value	0 max.	volts
PLATE DISSIPATION	1.5 max.	watts
GRID INPUT	0.5 max.	watt
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts

Pentode Unit as Mixer

PLATE VOLTAGE	250 max.	volts
GRID-No.3 (SUPPRESSOR) VOLTAGE	0 max.	volts
GRID-No.2 SUPPLY VOLTAGE	250 max.	volts
GRID-No.2 (SCREEN) VOLTAGE	See Fig.1	
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Negative bias value	40 max.	volts
Positive bias value	0 max.	volts
PLATE DISSIPATION	2.0 max.	watts
GRID-No.2 INPUT	0.4 max.	watt
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts

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Pentode Unit as Triode-Connected Mixer▲

PLATE VOLTAGE	250 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Negative bias value	40 max.	volts
Positive bias value	0 max.	volts
PLATE DISSIPATION	2.4 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts

Typical Operation:

Triode Unit as 250-Mc Oscillator:●		
Plate Voltage	150	volts
Grid Resistor	2700	ohms
Plate Current	13	ma
Grid Current	3.6	ma
Power Output (Approx.)	0.5	watt
*Pentode Unit as Mixer:**		
Plate Voltage	150	volts
Grid No.3 (Suppressor)	Connected to Cathode at Socket	
Grid-No.2 Voltage	150	volts
Mixer Grid-No.1 Supply Voltage	-3.5	volts
Oscillator Voltage at Mixer Grid No.1	2.6 rms	volts
Mixer Grid-No.1-Circuit Resistance	120000	ohms
Conversion Transconductance	2100	μmhos
Plate Current	6.2	ma
Grid-No.2 Current	1.8	ma
Grid-No.1 Current	2.0	μamp
Pentode Unit as Triode-Connected Mixer:▲		
Plate Voltage	150	volts
Grid-No.1 Supply Voltage	-3.5	volts
Oscillator Voltage at Grid No.1	2.6 rms	volts
Grid-No.1-Circuit Resistance	120000	ohms
Conversion Transconductance	2800	μmhos
Plate Current	7.8	ma
Grid-No.1 Current	2.0	μamp

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.1 max.	megohm
For cathode-bias operation	0.5 max.	megohm

According to RTMA Standard ET-109A with external shield No.315 tied to cathode.

▲ Grid No.3 connected to cathode; grid No.2 connected to plate.

* With separate excitation and triode unit grounded.

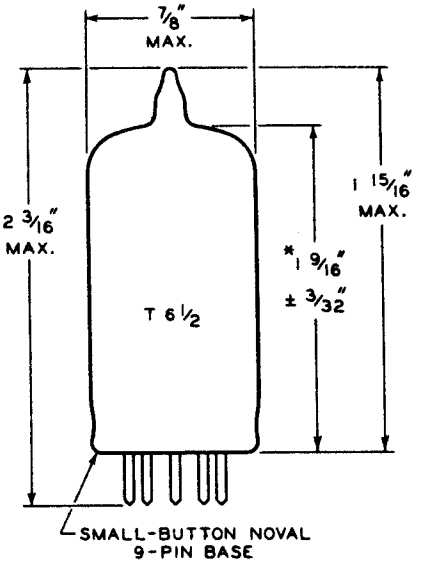
● In FM receivers, it is generally desirable to operate the oscillator with less power input than shown in the tabulated data in order to avoid over excitation and excessive oscillator radiation.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 19X8 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations fall within ± 10 per cent of line-center voltage value of 117 volts.

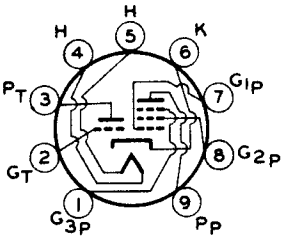
When the 19X8 is used as the converter in AM broadcast receivers, it is important that the tuned plate-load impedance of the first if coil does not exceed 75000 ohms. Any higher value will cause excessive degeneration due to the feedback in the pentode mixer unit.

DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



PIN 1: PENTODE GRID No.3
PIN 2: TRIODE GRID
PIN 3: TRIODE PLATE
PIN 4: HEATER
PIN 5: HEATER
PIN 6: CATHODE
PIN 7: PENTODE GRID No.1
PIN 8: PENTODE GRID No.2
PIN 9: PENTODE PLATE

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

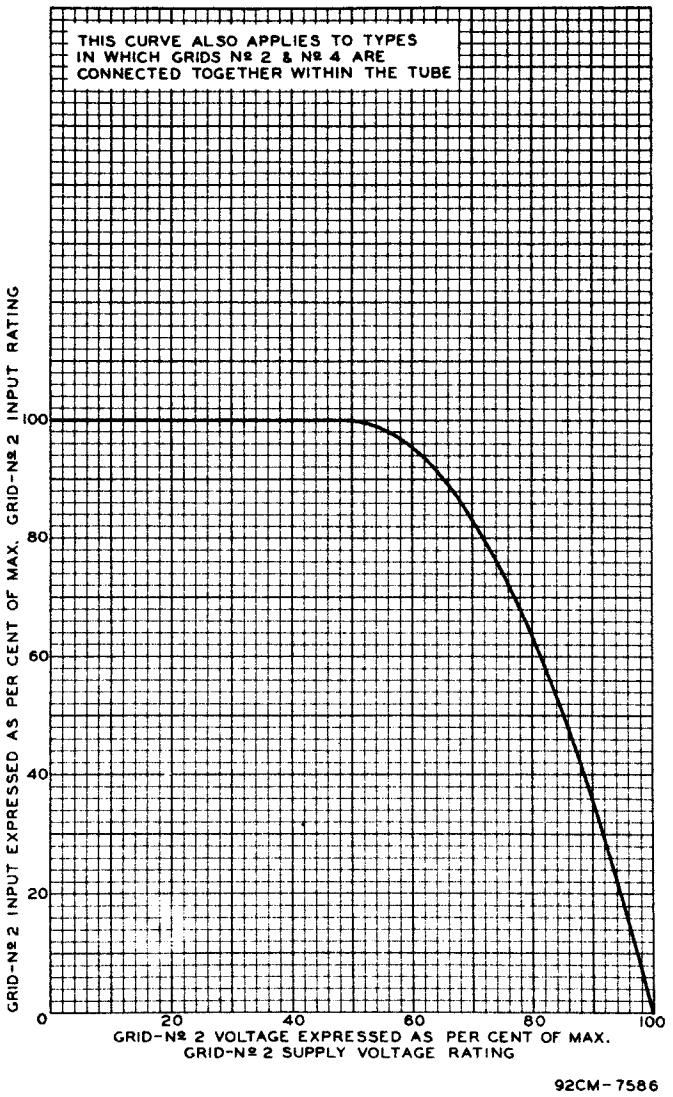


Fig. 1 - Grid-No. 2 Input Rating Curve of Type 19X8.

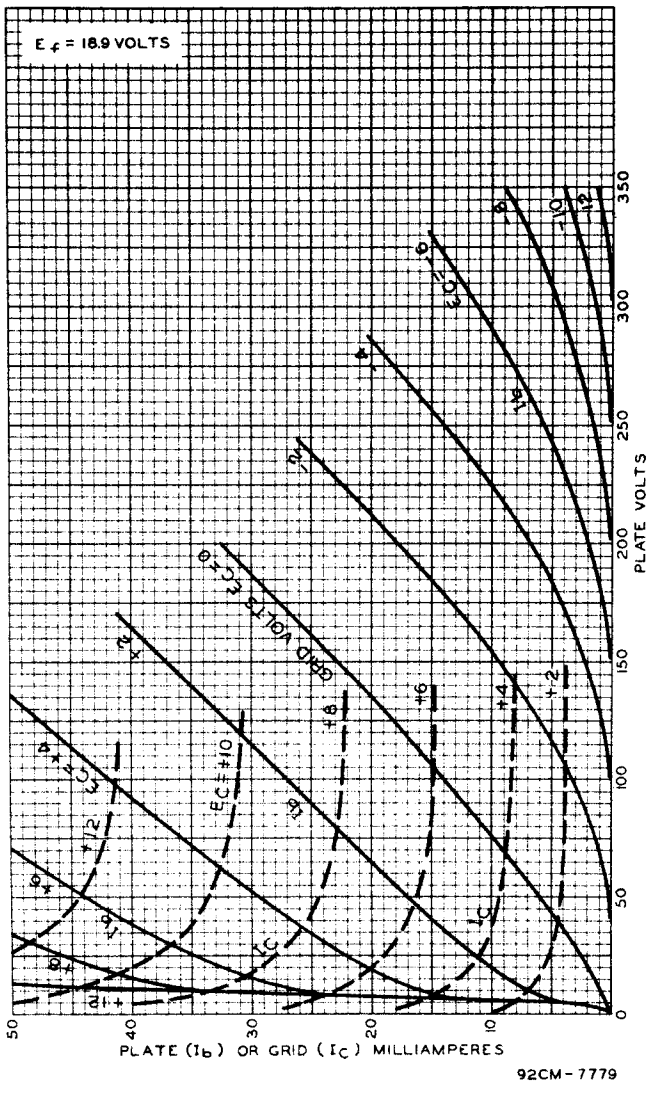


Fig. 2 - Average Plate Characteristics of 19X8 Triode Unit.

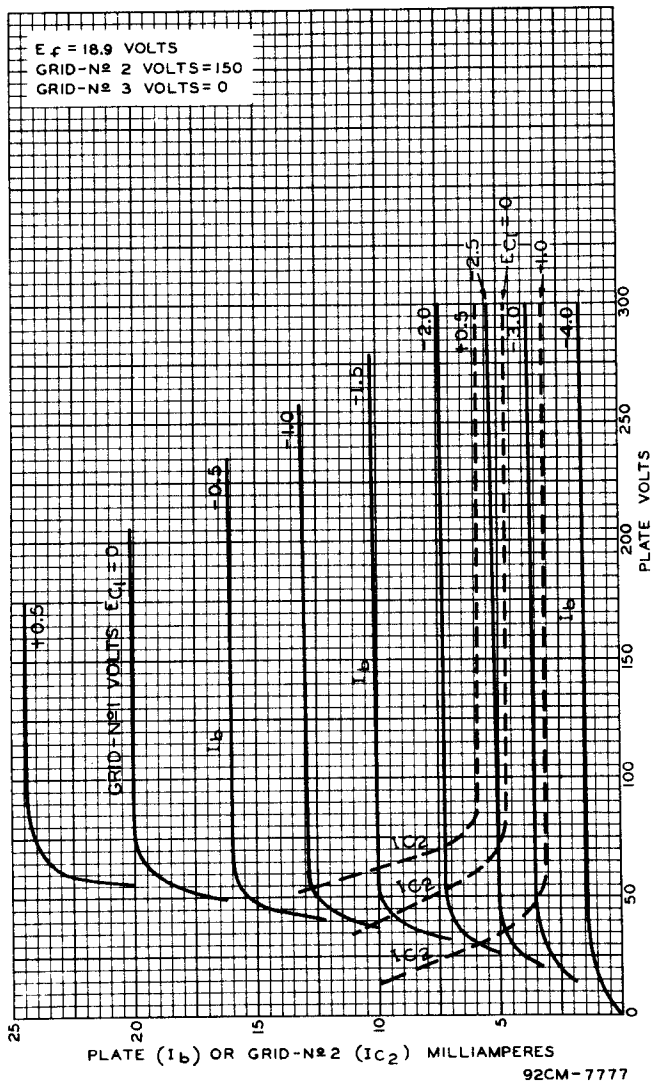


Fig. 3 - Average Plate Characteristics of 19X8 Pentode Unit.

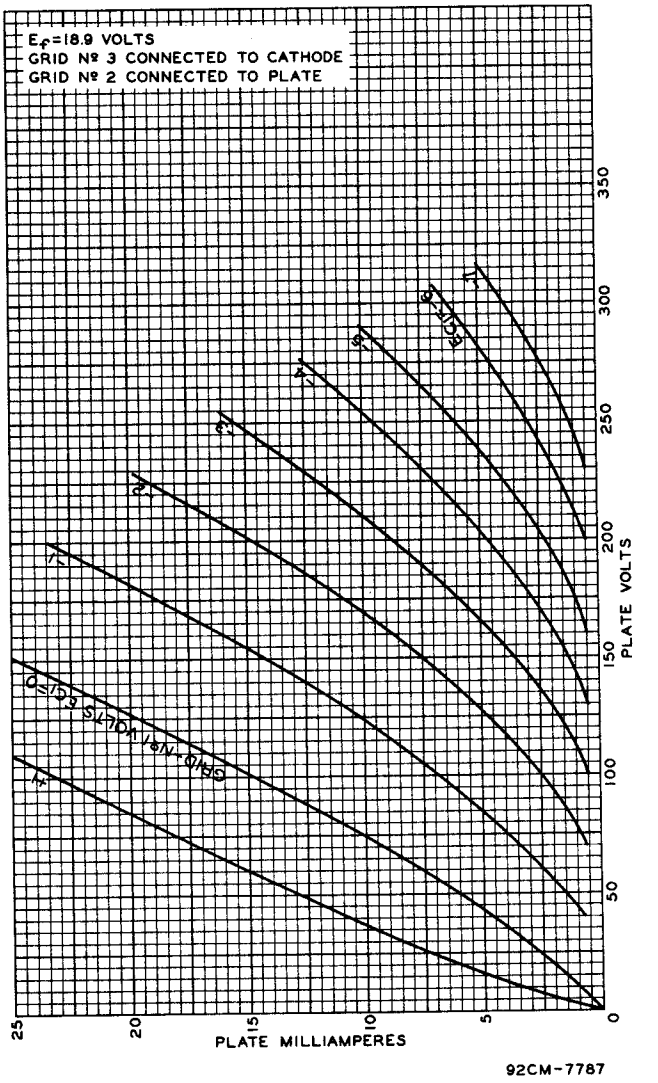


Fig. 4 - Average Plate Characteristics of 19X8 Pentode Unit Connected as Triode.

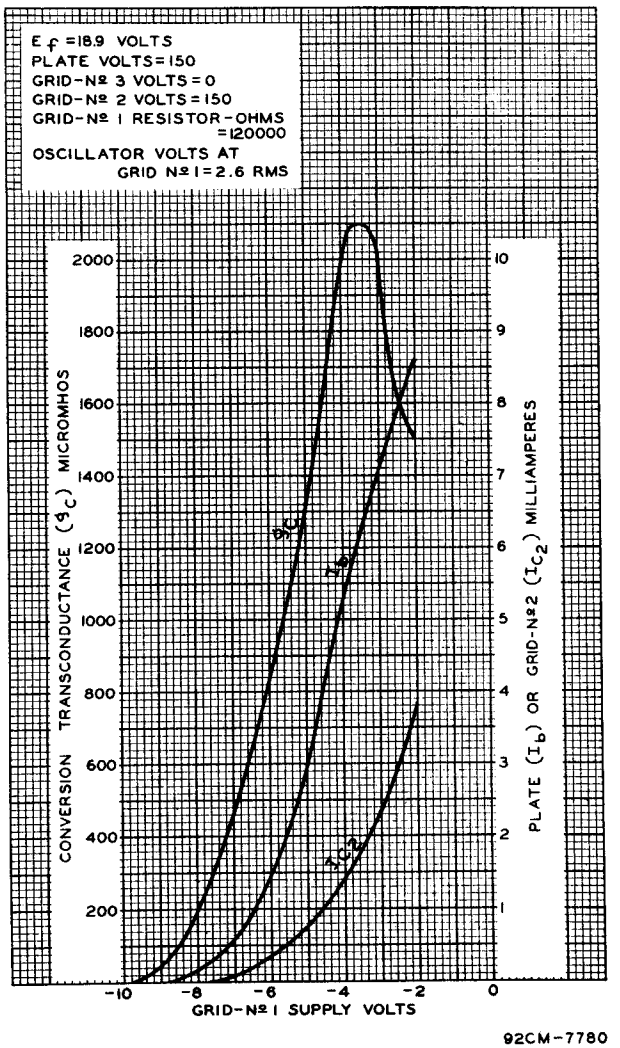


Fig. 5 - Operation Characteristic with Separate Oscillator Excitation of 19X8 Pentode Unit.

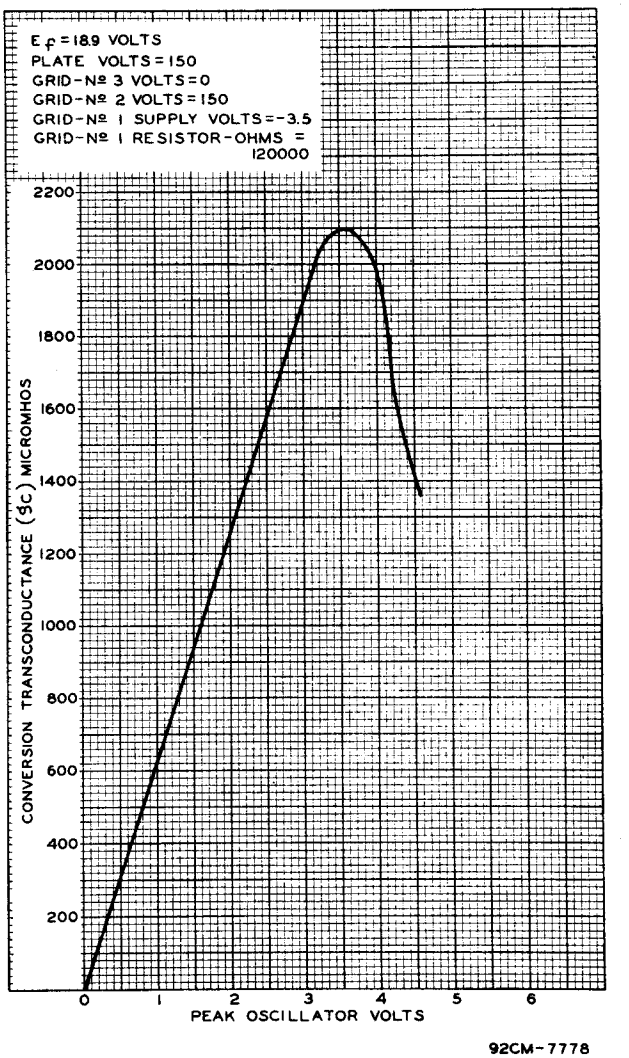


Fig. 6 - Operation Characteristic with Separate Oscillator Excitation of 19X8 Pentode Unit.

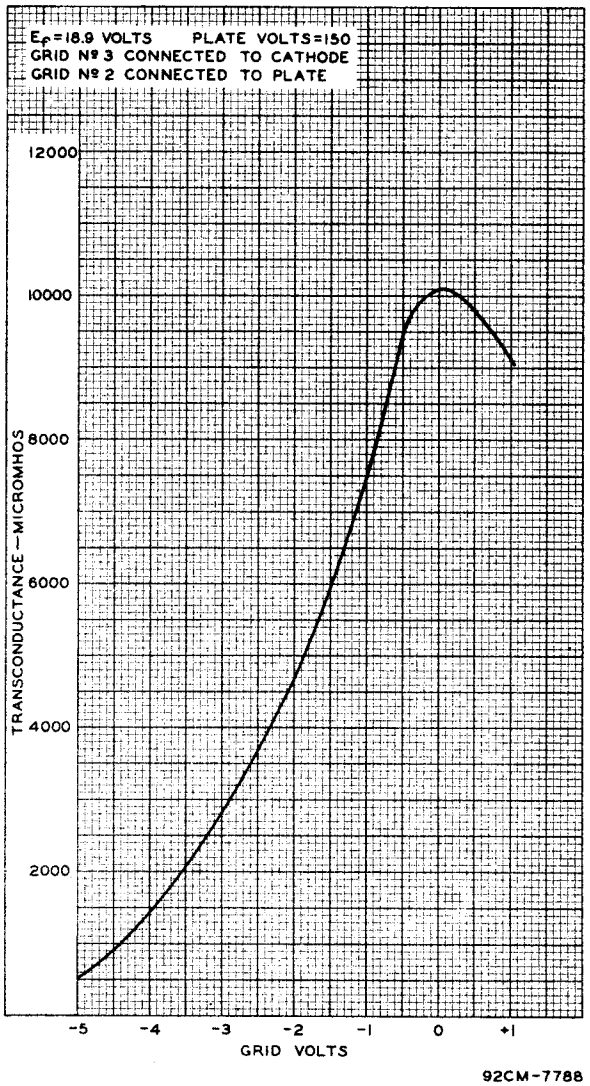


Fig. 7 - Average Characteristic of 19X8 Pentode Unit Connected as Triode.

from JEDEC release #2874, July 4, 1960

Attention is called to the use of Design-Maximum Ratings for this type.

19XP4

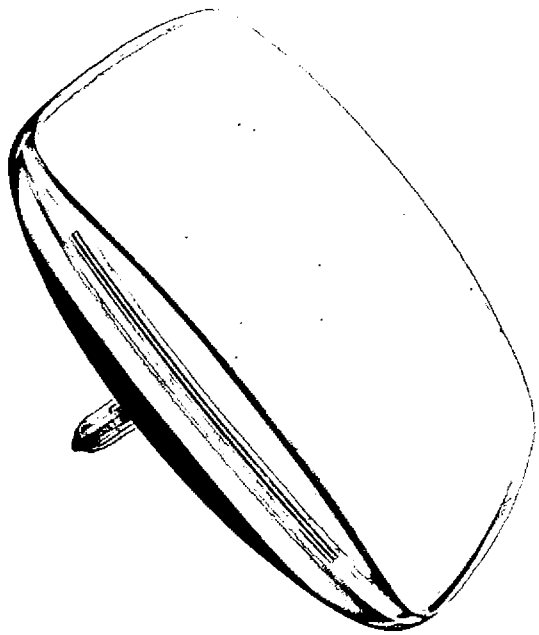
PICTURE TUBE

Low-Voltage Electrostatic Focus
114° Magnetic Deflection

Aluminized Screen
Rectangular Glass Type
Requires No Ion-Trap Magnet

15-1/8" x 12" Screen
18-3/4" Max. Bulb Diagonal
11-5/8" Max. Overall Length

RCA-19XP4 is a directly viewed, rectangular glass picture tube having an aluminized screen 15-1/8" x 12" with nearly straight sides and slightly rounded corners, and a minimum projected screen area of 172 square inches. Maximum overall length is 11-5/8".



The 19XP4 features an envelope having relatively flat, compound radius faceplate and special internal contouring in the deflecting yoke region to obtain 114° deflection with 110° deflecting components.

Other design features of the 19XP4 include a very short electron gun that minimizes deflection distortion and requires no ion-trap magnet; a neck diameter of 1-1/8"; an external conductive bulb coating; and a "neoeightar" 7-pin base of the integral glass-button type having straight through leads fitted with an indexing plug.

GENERAL DATA

Electrical:

Heater Current at 6.3 volts	600 ± 30	ma
Heater Warm-up Time (Average)	11	seconds

Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 5 volts.

Direct Interelectrode Capacitances:

Cathode to all other electrodes	5	μμf
Grid No.1 to all other electrodes	6	μμf
External conductive coating to ultor●	1500 max.	μμf
	1000 min.	μμf

Focusing Method	Electrostatic
Deflection Method	Magnetic
Diagonal	114°
Horizontal	102°
Vertical	85°
Electron Gun	Type Requiring No Ion-Trap Magnet

Optical:

Faceplate	Filterglass
Light transmission at center (Approx.)	78%
Phosphor	P4-Sulfide Type, Aluminized
Fluorescence	White
Phosphorescence	White
Persistence	Medium Short

Mechanical:

Tube Dimensions:

Overall length	11-3/8" ± 1/4"
Greatest width	16-13/32" ± 1/8"
Greatest height	13-11/32" ± 1/8"
Diagonal	18-5/8" ± 1/8"
Neck length	4-1/8" ± 1/8"

Radius of curvature of faceplate:

	Radius at center	*Radius at edge*
External surface	48"	21"
Internal surface:		
In plane of diagonal deflection	30"	20"
In plane of horizontal deflection	30"	20"
In plane of vertical deflection	30"	14"

Screen Dimensions (Minimum):

Greatest width	15-1/8"
Greatest height	12"
Diagonal	17-9/16"
Projected area	172 sq. in.
Bulb	J149A1
Cap	Recessed Small Cavity (JEDEC No.J1-21)
Base	Small-Button Neoeightar 7-Pin, Arrangement 1, (JEDEC No.B7-208)
Basing	8HR
Weight (Approx.)	14 lbs
Operating Position	Any

Trademark(s) ® Registered
Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

19XP4 6-60
Printed in U.S.A.

GRID-DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum and Minimum Ratings, *Design-Maximum Values:*♦

ULTOR● VOLTAGE	20000 max. / 11000 min.	volts
GRID-No.4 VOLTAGE:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
GRID-No.2 VOLTAGE	550 max. / 200 min.	volts
GRID-No.1 VOLTAGE:		
Negative peak value	220 max.	volts
Negative bias value	154 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
HEATER VOLTAGE	6.9 max. / 5.7 min.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	200 max.	volts
Heater positive with respect to cathode	200 max.	volts

Equipment Design Ranges:

With any ultor voltage (E_{c_5k}) between 11000 and 20000 volts and grid-No.2 voltage (E_{c_2k}) between 220 and 550 volts

Grid-No.4 Voltage for focus§	0 to 400	volts
Grid-No.1 Voltage (E_{c_1k}) for visual extinction of focused raster	*See Raster-Cutoff-Range Chart for Grid-Drive Service*	
Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value (Peak positive)	Same value as determined for E_{c_1k} except video drive is a positive voltage	
Grid-No.4 Current	−25 to +25	μa
Grid-No.2 Current	−15 to +15	μa
Field Strength of Adjustable Centering Magnet♦	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*16000*	*volts*
and grid-No.2 voltage of	*400*	*volts*
Grid-No.4 Voltage for focus§	0 to 400	volts
Grid-No.1 voltage for visual extinction of focused raster	−36 to −94	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value	36 to 94	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum and Minimum Ratings, *Design-Maximum Values:*

ULTOR●-TO-GRID-No.1 VOLTAGE	20000 max. / 11000 min.	volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	700 max. / 200 min.	volts
GRID-No.2-TO-CATHODE VOLTAGE	550 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	220 max.	volts
Positive bias value	154 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
HEATER VOLTAGE	6.9 max. / 5.7 min.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	200 max.	volts
Heater positive with respect to cathode	200 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 11000 and 20000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 700 volts

Grid-No.4-to-Grid-No.1 Voltage for focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage (E_{kg_1}) for visual extinction of focused raster	*See Raster-Cutoff-Range Chart for Cathode-Drive Service*	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value (Peak negative)	Same value as determined for E_{kg_1} except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μa
Grid-No.2 Current	−15 to +15	μa
Field Strength of Adjustable Centering Magnet♦	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*16000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*400*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage for visual extinction of focused raster	36 to 78	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value	−36 to −78	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

♦ The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Maximum Ratings System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, signal variation, and environmental conditions.

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 19XP4, the ultor function is performed by grid No.5. Since grid No.5, grid-No.3, and collector are connected together within the 19XP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

§ Individual tubes will have satisfactory focus at same value of grid-No.4 (or grid-No.4-to-grid-No.1) voltage between 0 and 400 volts with the combined bias voltage and video-signal voltage adjusted to produce an ultor current of 100 microamperes.

♦ Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having a 5/16-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 3/16-inch deflection of the spot from the center of the tube face.

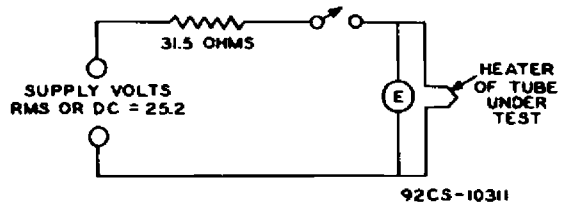


Fig. 1 – Test Circuit for Determining Heater Warm-Up Time.

OPERATING CONSIDERATIONS

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 19XP4 does not produce any harmful X-ray radiation. However, because the rating of this type permits operation at voltages as high as 20 kilovolts (design maximum value), shielding of the 19XP4 for X-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Shatter-Proof Cover Over the Tube Face. Following conventional picture-tube practice, it is recommended that the cabinet be provided with a shatter-proof, glass cover over the face of the 19XP4 to protect it from being struck accidentally and to protect against possible damage resulting from tube implosion under some abnormal condition. This safety cover can also provide X-ray protection when required.

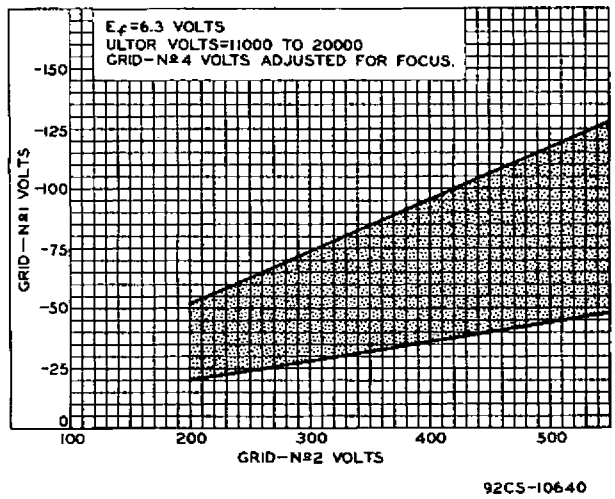


Fig. 2 – Raster-Cutoff-Range Chart for Type 19XP4 in Grid-Drive Service.

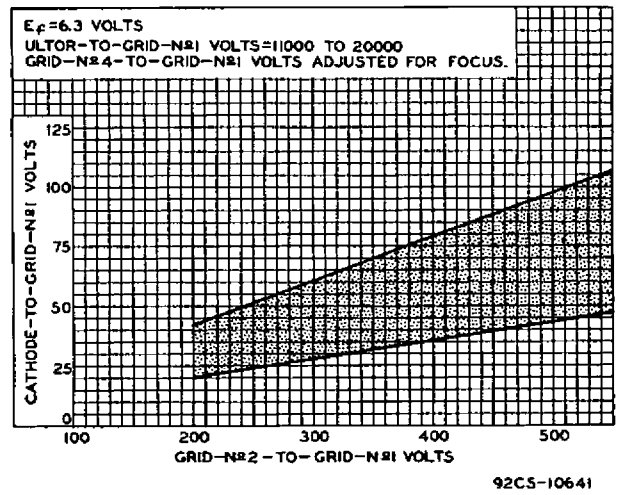


Fig. 3 – Raster-Cutoff-Range Chart for Type 19XP4 in Cathode-Drive Service.

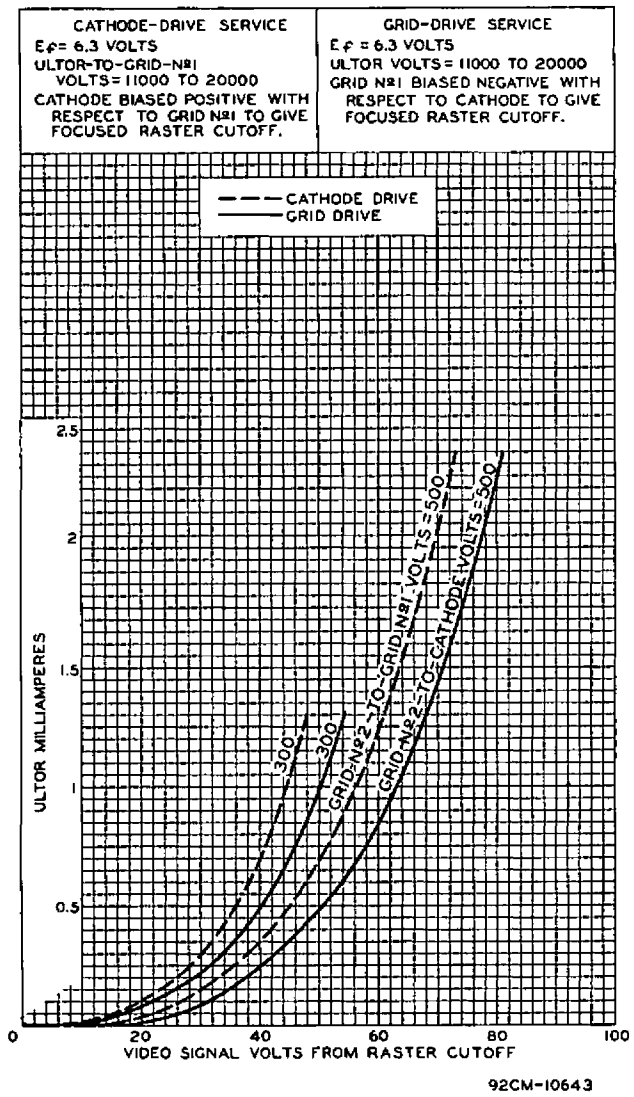


Fig. 4 – Average Drive Characteristics of Type 19XP4.

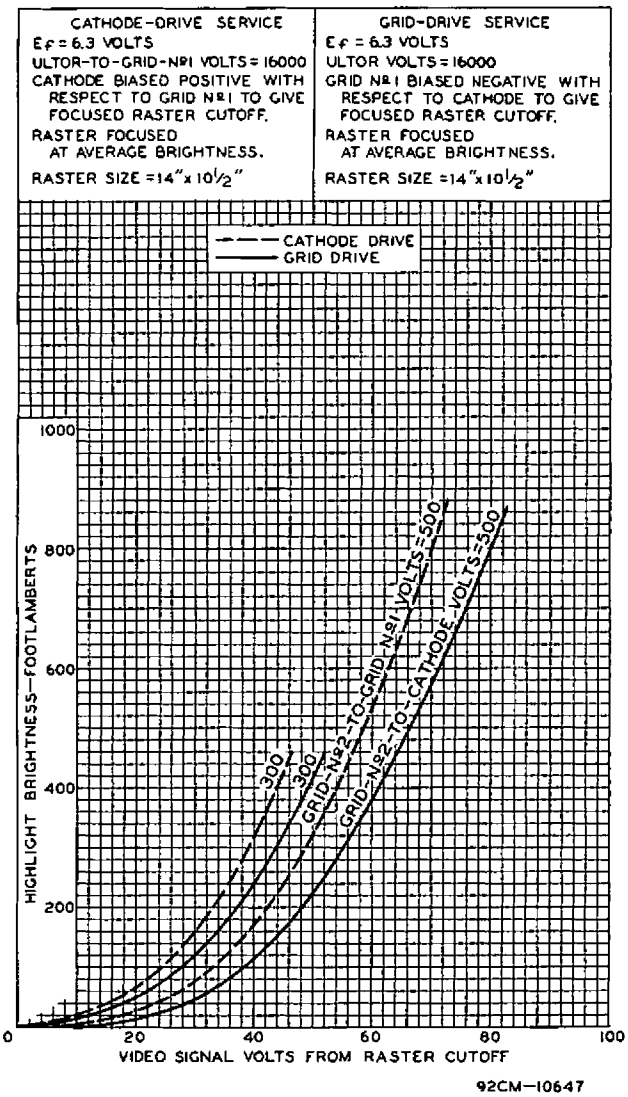
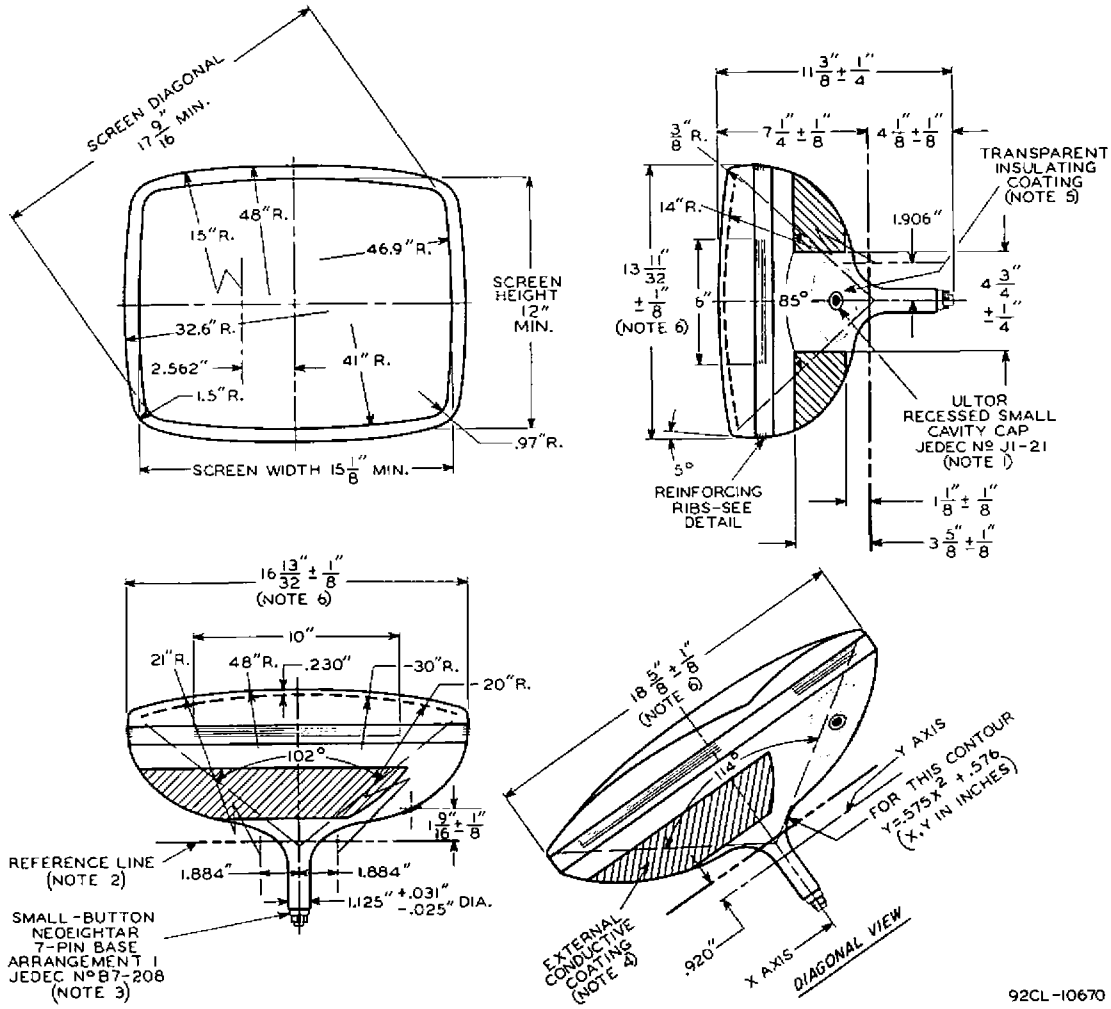
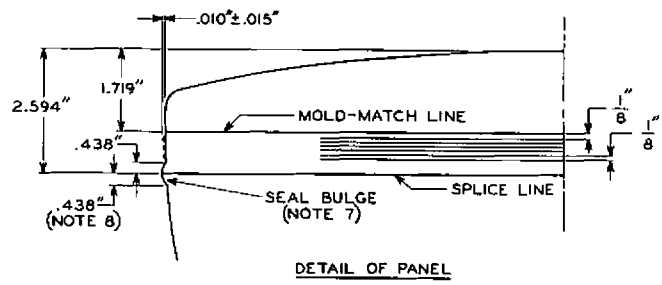


Fig. 5 – Average Drive Characteristics of Type 19XP4.

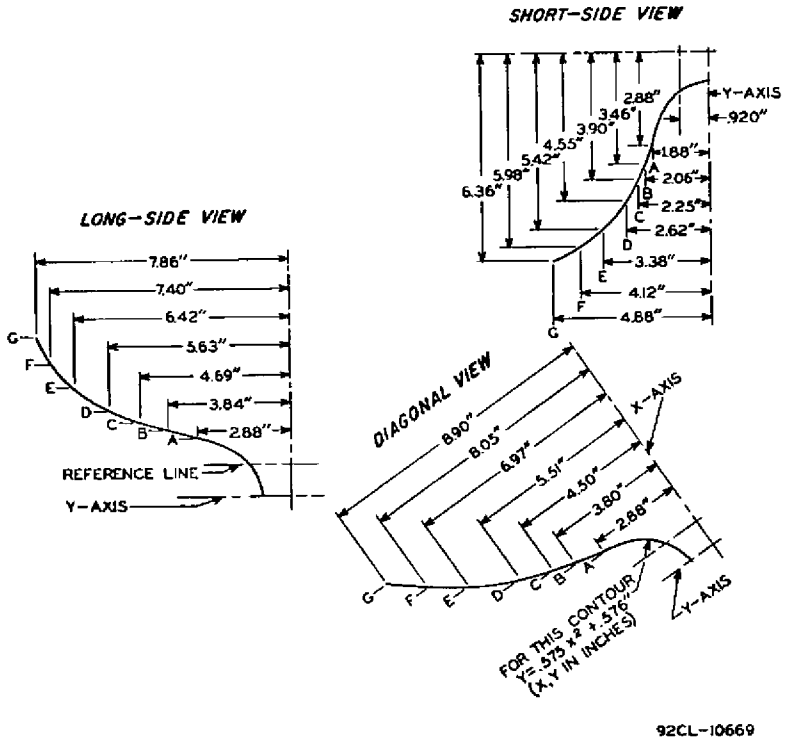
DIMENSIONAL OUTLINE





DETAIL OF PANEL

BULB-CONTOUR DIMENSIONS



PLANES A THROUGH G ARE NORMAL TO THE TUBE AXIS AND AT FIXED LOCATIONS FROM THE Y AXIS. THESE COORDINATES DESCRIBE THE BOGIE BULB EXTERNAL CONTOUR IN PLANES THROUGH THE TUBE AXIS AND THE RESPECTIVE FACEPLATE AXES.

NOTES FOR DIMENSIONAL OUTLINE

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN No.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC No.G-126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT THE CIRCUIT WIRING CANNOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINT-LESS CLOTH.

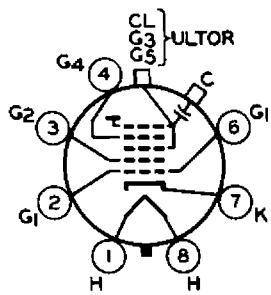
NOTE 6: MEASURED AT THE MOLD-MATCH LINE.

NOTE 7: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE MOLD-MATCH LINE.

NOTE 8: UNDISTURBED AREA BETWEEN MOLD-MATCH LINE AND SPLICE LINE IS 7/16" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF THE TUBE SUPPORT BAND. TUBE MOUNTING AND YOKE SUPPORT CLAMPS MUST BE SPACED FROM THE TUBE BY USE OF CUSHIONING PADS MADE OF MATERIAL SUCH AS ASPHALT-IMPREGNATED FELT, OR EQUIVALENT.

BASING DIAGRAM

Bottom View



8HR

PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.2
PIN 4: GRID No.4
PIN 6: GRID No.1

PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

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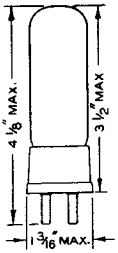
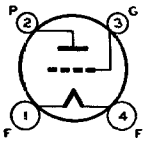


RCA-20

POWER AMPLIFIER



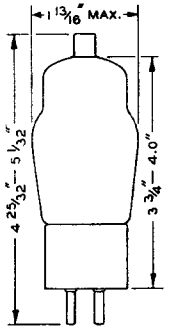
The 20 is a power amplifier triode for use in dry-battery operated receivers employing 3.3-volt filament tubes.

CHARACTERISTICS

Filament Voltage (D.C.)		3.0- 3.3	Volts
Filament Current		0.125-0.132	Ampere
Plate Voltage	90	135 *max.*	Volts
Grid Voltage	−16.5	−22.5	Volts
Plate Current	3	6.5	Milliamperes
Plate Resistance	8000	6300	Ohms
Amplification Factor	3.3	3.3	
Transconductance	415	525	Micromhos
Load Resistance	9600	6500	Ohms
Undistorted Power Output	45	110	Milliwatts
Grid-Plate Capacitance		4.1	μμf
Grid-Filament Capacitance		2.0	μμf
Plate-Filament Capacitance		2.3	μμf
Bulb			T-8
Base			Small 4-Pin

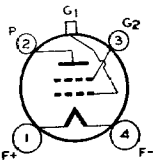
This type is used principally for renewal purposes.

———o0O0o———



RCA-22

SCREEN-GRID RADIO-FREQUENCY AMPLIFIER



The 22 is a screen grid tube designed particularly for radio-frequency amplification in dry-battery-operated receivers employing 3.3-volt filament tubes.

CHARACTERISTICS

Filament Voltage (D. C.)		3.3	Volts
Filament Current		0.132	Ampere
Plate Voltage	135	135 *max.*	Volts
Screen Voltage (Grid No. 2)	45*	67.5† *max.*	Volts
Grid Voltage (Grid No. 1)	−1.5	−1.5	Volts
Plate Current	1.7	3.7	Milliamperes
Screen Current (Maximum)	0.6	1.3	Milliamperes
Plate Resistance	725000	325000	Ohms
Amplification Factor	270	160	
Transconductance	375	500	Micromhos
Grid-Plate Capacitance (With shield-can)		0.02 *max.*	μμf
Input Capacitance		4.0	μμf
Output Capacitance		10	μμf
Bulb			ST-14
Cap			Small Metal
Base			Medium 4-Pin

* Maximum value of grid resistor is 5.0 megohms. † Maximum value of grid resistor is 1.0 megohm.

This type is used principally for renewal purposes.

21AP4

KINESCOPE

Magnetic Focus
Magnetic Deflection
Ion-Trap Gun

Rectangular Type
Metal-Shell Envelope
Frosted Filterglass Faceplate

18-3/8" x 13-15/16" Picture Size
21" Max. Shell Diagonal
22-5/16" Max. Length

TENTATIVE DATA

RCA-21AP4 is a short, directly viewed, rectangular picture tube of the metal-shell type for use in television receivers. It has a picture size of 18-3/8" x 13-15/16" with slightly curved sides and rounded corners--a shape that provides a very pleasing frame for the picture.

The rectangular shape, which allows reproduction of the transmitted picture without waste of screen area, permits use of a cabinet having about 20 per cent less height than is required for a round-face tube having the same picture width. In addition, the chassis need not be depressed or cut out under the face of the tube and controls can be located as desired beneath the tube.

The 21AP4 provides pictures having high brightness and good uniformity of focus over the whole picture area. It has a high-efficiency, white fluorescent screen on a relatively flat, high-quality face made of frosted Filterglass to prevent specular reflection and to provide increased picture contrast. The frosted Filterglass faceplate incorporates a neutral light-absorbing material which reduces ambient-light reflections from the phosphor and reflections within the faceplate itself in a much higher ratio than it reduces the directly viewed light of the picture. As a result, improved picture contrast is obtained. In addition, frosting of the face diffuses reflections of bright objects in the room which might otherwise be objectionable.

Employing magnetic focus and magnetic deflection, the 21AP4 is designed with a funnel-to-neck section which facilitates centering of the yoke on the neck and, in combination with better centering of the beam inside the neck, contributes to the good uniformity of focus over the entire picture area. The diagonal deflection angle is 70° and the horizontal deflection angle is 66°.

Other features incorporated in the 21AP4 are short overall length; metal-shell construction which weighs substantially less than a similar all-glass tube; a higher-quality faceplate than is commonly used in all-glass tubes; and an ion-trap gun requiring only a single-field, external magnet.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	ampere
Direct Interelectrode Capacitances:		
Grid No.1 to All Other Electrodes	6	μμf
Cathode to All Other Electrodes	5	μμf
Faceplate (With about 66% light transmission)	Frosted Filterglass	
Phosphor	No.4--Sulfide Type	
Fluorescence	White	
Phosphorescence	White	
Persistence	Short	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	70°	
Horizontal	66°	
Vertical	50°	

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Ion-Trap Gun	Requires External, Single-Field Magnet
Maximum Overall Length	22-5/16"
Greatest Diagonal of Tube at Lip	20-3/4" ± 1/4"
Greatest Width of Tube at Lip	19-23/32" ± 1/8"
Greatest Height of Tube at Lip	15-5/16" ± 1/8"
Screen Size	18-3/8" x 13-15/16"
Ultor● Terminal	Metal-Shell Lip
Base	Small-Shell Duodecal 5-Pin (JETEC No.B5-57)
Mounting Position	Any

Maximum Ratings, *Design-Center Values*:

ULTOR● VOLTAGE	18000 max.	volts
GRID-NO.2 VOLTAGE	500 max.	volts
GRID-NO.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	410 max.	volts
After equipment warm-up period	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Typical Operation:

Ultor Voltage*	14000	16000	volts
Grid-No.2 Voltage	300	300	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot	-33 to -77	-33 to -77	volts
Focusing-Coil Current (DC)OO	104 ±6%	110 ±6%	ma
Field Strength of Single-Field Ion-Trap Magnet	45	50	gausses
Ion-Trap Magnet Current (DC, approx.)#	90	-	ma
Field Strength of Adjustable Centering Magnet	0 to 8	0 to 8	gausses

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● In the 21AP4, grid No.3, which has the ultor function, and collector are connected together within the tube and are conveniently referred to collectively as "ultor". The "ultor" in a cathode-ray tube is the electrode, or the electrode in combination with one or more additional electrodes connected within the tube to it, to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection.

* Brilliance and definition decrease with decreasing ultor voltage. In general, the ultor voltage should not be less than 14000 volts.

OO For specimen focusing coil similar to JETEC Focusing Coil No.109 positioned with air gap toward kinescope screen and center line of air gap 3 inches from Reference Line (see *Outline Drawing*). The indicated current is for condition with combined grid-No.1 bias voltage and video-signal voltage adjusted to produce a highlight brightness of 30 foot-lamberts on a 18-3/8" x 13-15/16" picture area sharply focused at center of screen. The indicated tolerance on focusing-coil current is on basis that distance from Reference Line to grid No.1 is controlled as shown in Detail of Grid-No.1 position on page 7.

\# For specimen ion-trap magnet similar to JETEC Ion-Trap Magnet No.111 located in optimum position and rotated to give maximum brightness.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 21AP4 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 21AP4 does not produce any harmful x-ray radiation. However, because the rating of the tube permits operation at voltages as high as 19.8 kilovolts (absolute value), shielding of the 21AP4 for x-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Corona Considerations. Adequate spacing between the lip of the 21AP4 and any grounded element in the receiver, or between the metal shell and any grounded element, should be provided to preclude the possibility of corona. Such spacing should be not less than 1-1/2 inches of air.

Insulating Material for Mask. The glass of the faceplate does not have especially high electrical resistance. It is essential, therefore, that any mask material bearing on the faceplate be adequately insulated to withstand the maximum applied ultor voltage. Unless this precaution is observed, picture distortion may be experienced.

Tube Handling. Care should be taken to prevent bumping or striking the lip of the 21AP4. Rough treatment may damage the faceplate seal. This seal is most vulnerable along the sides of the metal shell, particularly to a blow on the inside of the lip.

A caution notice incorporating the information shown on page 3 is affixed to the metal shell of each 21AP4. It is recommended that a similar notice be prominently displayed on equipment using the 21AP4 and be included in the equipment service bulletin.

Do not allow the metal shell of the 21AP4 to come in contact with a magnet and thus become permanently magnetized. A magnetized shell produces localized distortion of the picture edges.

Care of Tube Face. The frosted Filterglass face of the 21AP4 is more easily scratched and abraded than an unfrosted face and must, therefore, be handled more carefully. Finger marks may be removed from the face with a detergent, such as Dreft, or with a grease solvent, such as carbon tetrachloride.

Shatter-Proof Cover Over The Tube Face. It is recommended that receivers be designed with a shatter-proof, clear glass or plastic cover over the face of the 21AP4 to protect it from being struck accidentally and to protect against possible damage resulting from tube implosion under some abnormal condition.

Support for the 21AP4, which may be operated in any position, should be provided at the large end by suitable supporting insulators at the corners of the tube, and by the deflecting-yoke mounting on the neck. Support areas on the lip are indicated on the *Outline Drawing*. Other

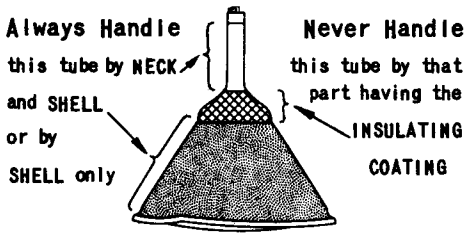
portions of the lip periphery should be left free to avoid the possibility of fracturing the face-plate-to-lip seal (see *Tube Handling*).

CAUTION-HIGH VOLTAGE

This METAL SHELL operates at HIGH VOLTAGE. DO NOT TOUCH while in operation. GROUND SHELL before touching after power is off.

X-RAY WARNING

Shielding of cathode-ray tubes for x-ray radiation may be needed to protect against possible danger of personal injury from prolonged exposure at close range when they are operated above 16 kilovolts.



Finger prints or dust on the insulating coating may cause electrical breakdown during humid weather.

HANDLE WITH CARE

Breakage of this tube, which contains a high vacuum, may result in injury from flying glass. Do not strike or scratch the tube. Never subject it to more than moderate pressure when installing in or removing from equipment.

The deflecting-yoke mounting, sometimes called the mounting hood, should provide adjustment for alignment of the yoke on the neck and should also provide sufficient pressure to hold the yoke firmly against the glass funnel. Some good insulating material, such as Neoprene, is required between the hood and the glass funnel not only to provide a cushion between them but also to prevent abrasion of the insulating coating on the funnel and resultant arcing from the metal shell to the hood. The hood should be designed so that it can be placed as close as possible to the Reference Line (see *Outline Drawing*) without interfering with the yoke in order to reduce the amount of insulation required between hood and funnel. It is also essential that no electrical contact be made from the hood to the funnel because any such contact will decrease the length of the leakage path across the insulating coating on the glass funnel. Furthermore, the hood should not exert undue pressure on the deflecting yoke.

The yoke should be held firmly against the glass funnel (see proper location under *Deflecting Yoke*), but any thrust should be absorbed by the insulating cushion. The hood, which also usually serves as the mounting for the focusing coil, should be specially braced to prevent lateral and longitudinal motion caused by buckling of the chassis which may occur during transportation of the receiver. A simple brace from the edge of the chassis usually provides the extra stiffness required; or a small foot placed directly under the yoke may be sufficient. Unless the precaution against thrust on the yoke is observed, the tube or yoke may be damaged during transportation of the receiver.

The *deflecting yoke* should have an effective length of not more than 1-11/16 inches and be designed so that the effective center of deflection of the beam is about 1.15 inches from the Reference Line (see *Outline Drawing*). This position takes into account centering by means of the focusing device or by the use of a centering magnet, and provides some leeway for their effect on the beam without causing the beam to strike the neck when deflection is sufficient to reach the edge of the screen.

The yoke should have an inside contour which conforms in general to the dimensions and shape shown in Fig. 1. It is to be noted that the inner

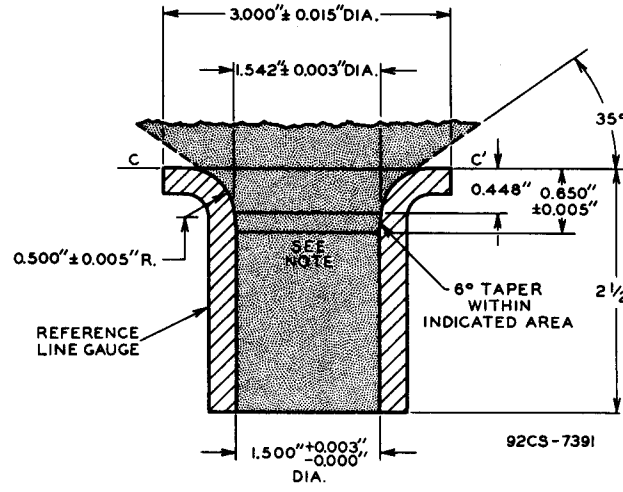


Fig. 1 - Reference-Line Gauge (JETEC No. 110) with Supplementary Information on Recommended Inside Contour of Yoke to Provide Proper Location of Yoke on Neck-Funnel Section.

surface of the end of the yoke adjacent to the glass funnel should not come closer to the funnel than indicated by the 35° line in Fig. 1 if adequate insulation is to be maintained across the glass funnel between the point of yoke contact and the metal shell.

A *focusing field*, supplied by an electromagnetic coil, permanent magnet, or a combination of the two, is required to concentrate the electron beam into a focused spot at the screen. The field should have excellent radial symmetry. When a coil is used, it should be supplied with direct current from a well-filtered source. The field strength to produce a focused spot is indicated in the tabulated data. For other voltages than those shown, the coil current will be approximately proportional to the square root of the ultor voltage. Regardless of the kind of focusing device used, provision should be made for adjusting the field strength to cover the ultor-operating range and the normal variation between individual tubes.

The focusing field should be spaced at least 1/2 inch from the end of the deflecting-coil windings to reduce interaction between the focusing and deflecting fields. If the focusing field is placed too close to the deflecting fields, interaction between them may reduce deflection sensitivity and corner resolution, as well as cause objectionable rotation of the fluorescent pattern as the focus is varied. On the other hand, if the focusing field is too close to the electron gun, resolution will be reduced and pattern distortion may occur as a result of interaction with the ion-trap-magnet field.

As the air gap of the focusing device is moved away from the deflecting yoke, the corner resolution will be improved at the expense of slight loss in center resolution. The strength of the focusing field required increases appreciably as the distance between the deflecting-yoke windings and the air gap of the focusing device is increased.

The *ion-trap magnet*, required to recenter the electron beam in the gun structure, should be of the single-field type. It should provide a uniform field across the transverse section of the tube neck to produce a round, focused spot. Direction of the field of the ion-trap magnet should be such that the north pole is adjacent to vacant pin position No.8 and the south pole to pin No.2.

To operate properly with the electron gun in the 21AP4, the ion-trap magnet should have a field strength such that the optimum position of the magnet is in the region of grid No.2 (see Fig.2), with any departure being in the direction of the base rather than toward the metal shell. The optimum position should result in a properly centered pattern having full brightness and no shadowing at the edges. If full brightness is accompanied by an unsymmetrical raster shape and poor focus, it is an indication that the ion-trap magnet has incorrect rotational positioning and that the focusing field has been displaced to counteract incorrect positioning of the ion-trap magnet.

The strength of the ion-trap magnet for other ultor voltages than those indicated will be proportional to the square root of the ultor voltage.

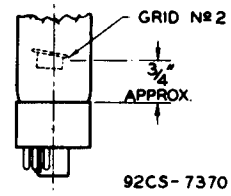


Fig.2 - Location of Grid No.2 in Tube Neck.

Centering of the pattern may be accomplished by decentering or tilting the focusing device, or by the use of a small, adjustable centering magnet located near the base end of the deflecting yoke. The dc component of the deflecting currents should be filtered out of the deflecting yoke in order to minimize the amount of centering adjustment needed.

REFERENCES

1. *"Medical X-ray Protection Up To Two Million Volts"*, National Bureau of Standards Handbook H41.
2. *"Safety Code for Industrial Use of X-rays"*, American Standards Association. ASA Code Z54.1-1946.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

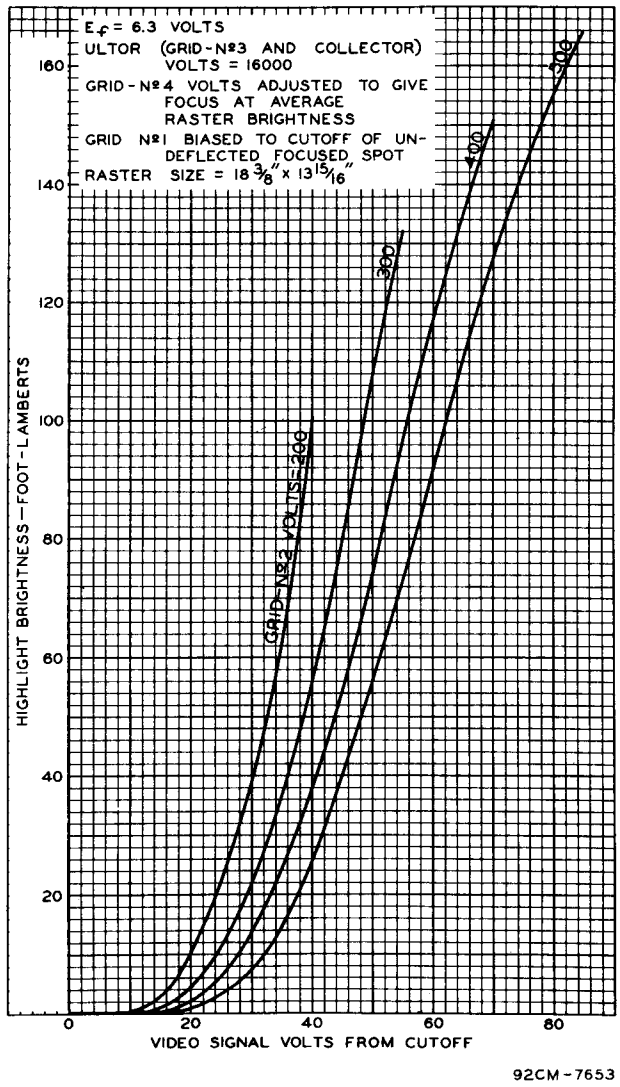


Fig. 3 - Average Grid-Drive Characteristics of Type 21AP4.

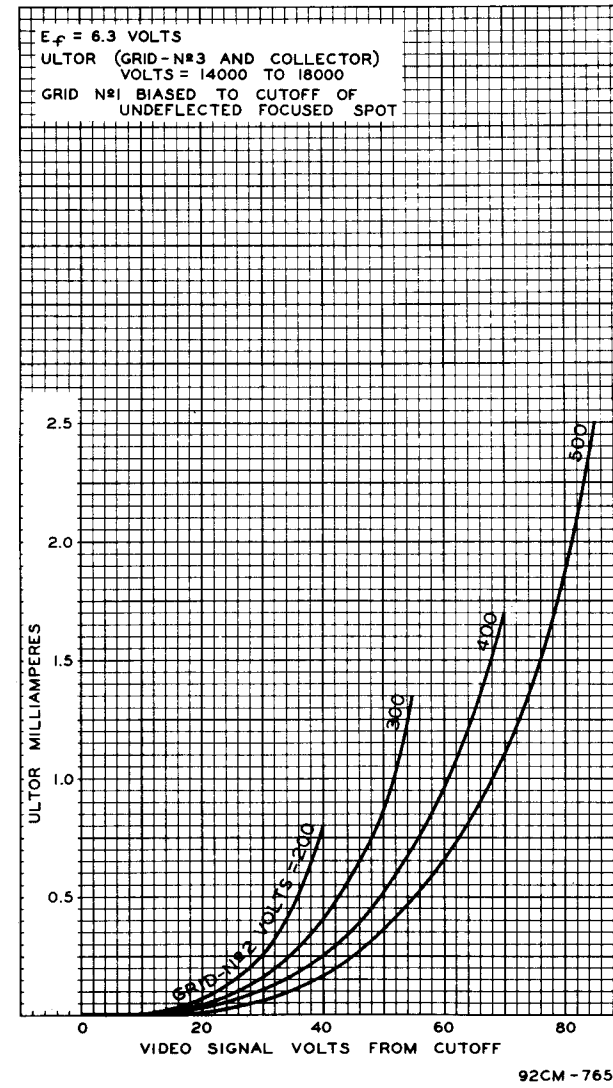
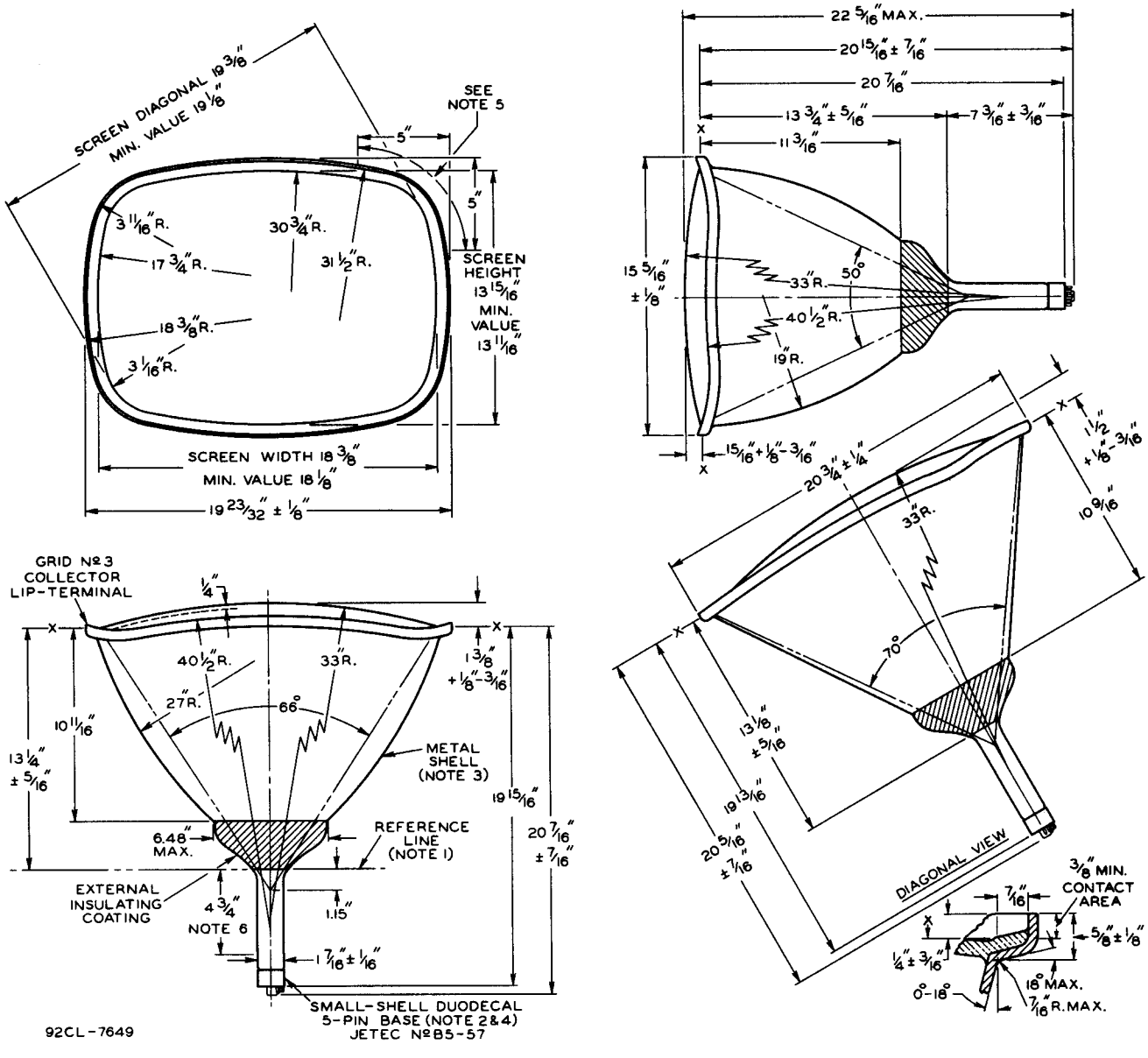


Fig. 4 - Average Grid-Drive Characteristics of Type 21AP4.

DIMENSIONAL OUTLINE



NOTE 1: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JETEC No.110) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 2: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH METAL-SHELL AXIS AND HAVING A DIAMETER OF 3-1/4".

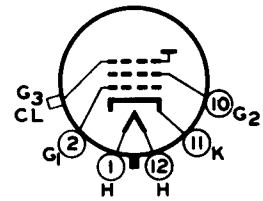
NOTE 3: METAL SHELL AND GLASS FACE OPERATE AT HIGH VOLTAGE. ANY MATERIAL IN CONTACT WITH THE SHELL OR THE FACE MUST BE INSULATED TO WITHSTAND THE MAXIMUM APPLIED ULTOR VOLTAGE.

NOTE 4: THE PLANE THROUGH THE TUBE AXIS AND VACANT PIN POSITION NO.6 MAY VARY FROM THE HORIZONTAL AXIS OF THE GLASS FACE BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 10°.

NOTE 5: SUPPORT TUBE IN LIP REGION ONLY AT CORNERS WITHIN THIS SPACE.

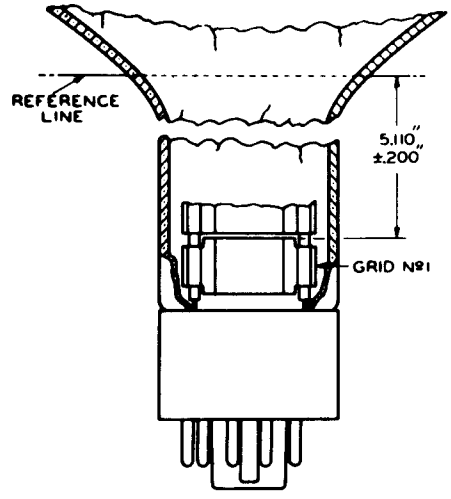
NOTE 6: LOCATION OF DEFLECTING YOKE AND FOCUSING DEVICE MUST BE WITHIN THIS SPACE.

SOCKET CONNECTIONS
Bottom View



PIN 1: HEATER
PIN 2: GRID No.1
PIN 10: GRID No.2
PIN 11: CATHODE
PIN 12: HEATER
METAL-SHELL LIP:
GRID No.3,
COLLECTOR

DETAIL OF GRID-No.1 POSITION



92CS-7560

21CEP4

KINESCOPE

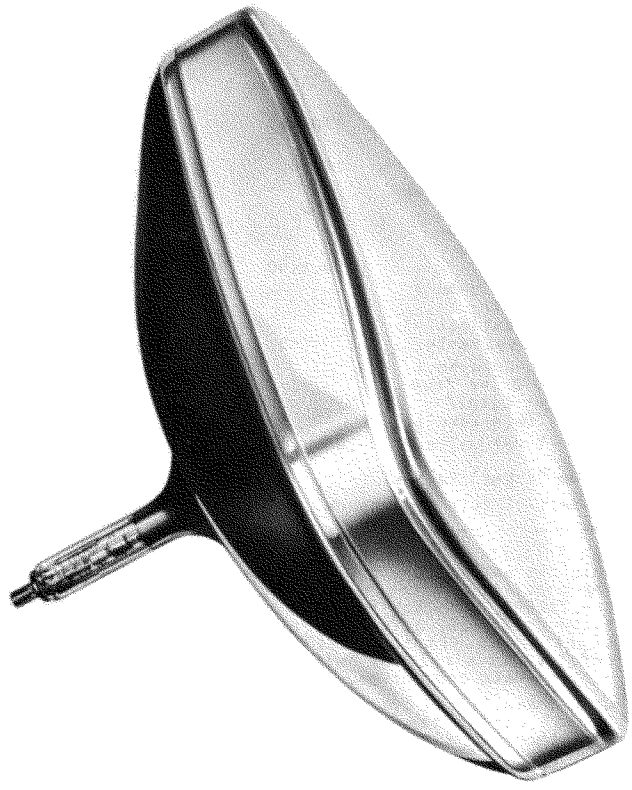
Low-Voltage Electrostatic Focus
Magnetic Deflection

Aluminized Screen
Very Short Rectangular Glass Type
Wide-Angle (110°) Deflection

19-1/16" x 15-1/16" Screen
21-1/2" Max. Bulb Diagonal
14-3/4" Max. Length

TENTATIVE DATA

RCA-21CEP4 is a very short, directly viewed, rectangular, glass picture tube of the low-voltage electrostatic-focus and magnetic-deflection type. It has a spherical Filterglass faceplate, an aluminized screen 19-1/16" x 15-1/16" with slightly curved sides and rounded corners and a minimum projected screen area of 262 square inches.



Designed with a 110° -diagonal deflection angle, the 21CEP4 has very short length--a length approximately 5-1/2" shorter than types having the same size faceplate and 90° deflection. As a result, this tube establishes new concepts for cabinet styling and for the design of more compact TV receivers.

The 21CEP4 has a neck diameter of only 1-1/8" which not only makes possible the use of a deflecting yoke having high deflection sensitivity but also permits deflection of the beam through the wide deflection angle with only slightly more power than is required to scan a tube with 90° deflection angle.

The 21CEP4 utilizes a new electron gun of the "straight" type with an improved focusing-lens system and a unique pre-focus lens system to maintain image sharpness over the entire screen area. This new electron gun eliminates the need for an ion-trap magnet.

Another design feature of the 21CEP4 is an integral glass-button base having straight-through leads fitted with an indexing plug. This basing arrangement eliminates any possibility of loose base-pin connections. In addition, the 21CEP4 has an external conductive bulb coating which with the internal conductive coating forms a supplementary filter capacitor.

DATA

General:

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 volts
Current	0.6 amp
Direct Interelectrode Capacitances:	
Grid No.1 to all other electrodes	6 μμf
Cathode to all other electrodes	5 μμf
External conductive coating to ultor	2500 max. μμf 2000 min. μμf
Faceplate, Spherical	Filterglass
Light transmission (Approx.)	73%
Phosphor	P4--Sulfide Type
Fluorescence	White
Phosphorescence	White
Persistence	Short
Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angles (Approx.):	
Diagonal	110°
Horizontal	106°
Vertical	85°
Tube Dimensions:	
Overall length	14-7/16" ± 5/16"
Greatest width	20-1/4" ± 1/8"
Greatest height	16-3/8" ± 1/8"
Diagonal	21-3/8" ± 1/8"
Neck length	5-7/16" ± 1/8"
Screen Dimensions (Minimum):	
Greatest width	19-1/16"
Greatest height	15-1/16"

TMK ®, Marca Registrada
Printed in U.S.A.

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Diagonal	20-1/4"
Projected area	262 sq. in.
Cap.	Recessed Small Cavity (JETEC No.J1-21)
Bulb	J171 (110°)
Base	Small-Button Eightar 7-Pin (JETEC No.B7-183)
Weight (Approx.)	23 lbs
Mounting Position	Any

GRID DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum Ratings, *Design-Center Values:*

ULTOR● VOLTAGE	18000 max.	volts
GRID-No.4 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2 VOLTAGE	500 max.	volts
GRID-No.1 VOLTAGE:		
Negative peak value	200 max.	volts
Negative bias value	140 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor voltage (E_{c_5k}) between 12000# and 18000 volts and grid-No.2 voltage (E_{c_2k}) between 200 and 500 volts

Grid-No.4-Voltage for Focus§	0 to 400	volts
Grid-No.1 Voltage (E_{c_1k}) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Grid-Drive Service	
Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak positive)	Same value as determined for E_{c_1k} except video drive is a positive voltage	
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*.	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*14000*	*16000*	*volts*
and grid-No.2 voltage of	*300*	*400*	*volts*
Grid-No.4 Voltage for Focus	0 to +400	0 to +400	volts
Grid-No.1 Voltage for Visual Extinction of Focused Raster	−28 to −72	−36 to −94	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	28 to 72	36 to 94	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum Ratings, *Design-Center Values:*

ULTOR●-TO-GRID-No.1 VOLTAGE	18000 max.	volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	640 max.	volts
GRID-No.2-TO-CATHODE VOLTAGE	500 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	200 max.	volts
Positive bias value	140 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 12000# and 18000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 640 volts

Grid-No.4-to-Grid-No.1 Voltage for Focus§	0 to +400	volts
Cathode-to-Grid-No.1 Voltage (E_{kg1}) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Cathode-Drive Service	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value	Same value as determined for E_{kg1} except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*.	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*14000*	*16000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*300*	*400*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for Focus	0 to +400	0 to +400	volts
Cathode-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster	28 to 60	36 to 78	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	−28 to −60	−36 to −78	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 21CEP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 21CEP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

Operation below this value is not recommended.

§ The grid-No.4 voltage or grid-No.4-to-grid-No.1 voltage required for focus of any individual tube is independent of ultor current and will remain essentially constant for values of ultor voltage (or ultor-to-grid-No.1 voltage) or grid-No.2 voltage (or grid-No.2-to-grid-No.1 voltage) within design ranges shown for these items.

* Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having a 3/8-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 1/2-inch deflection of the spot from the center of the tube face.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 21CEP4 does not produce any harmful x-ray radiation. However, because the rating of this type permits operation at voltages as high as 19.8 kilovolts (absolute maximum value), shielding of the 21CEP4 for x-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

The *base pins* of the 21CEP4 fit the Eightar 8-contact socket, such as Ucinite Part No. 115446, or equivalent. The design of the socket should be such that the circuit wiring cannot impress lateral strains through the socket contacts on the base pins.

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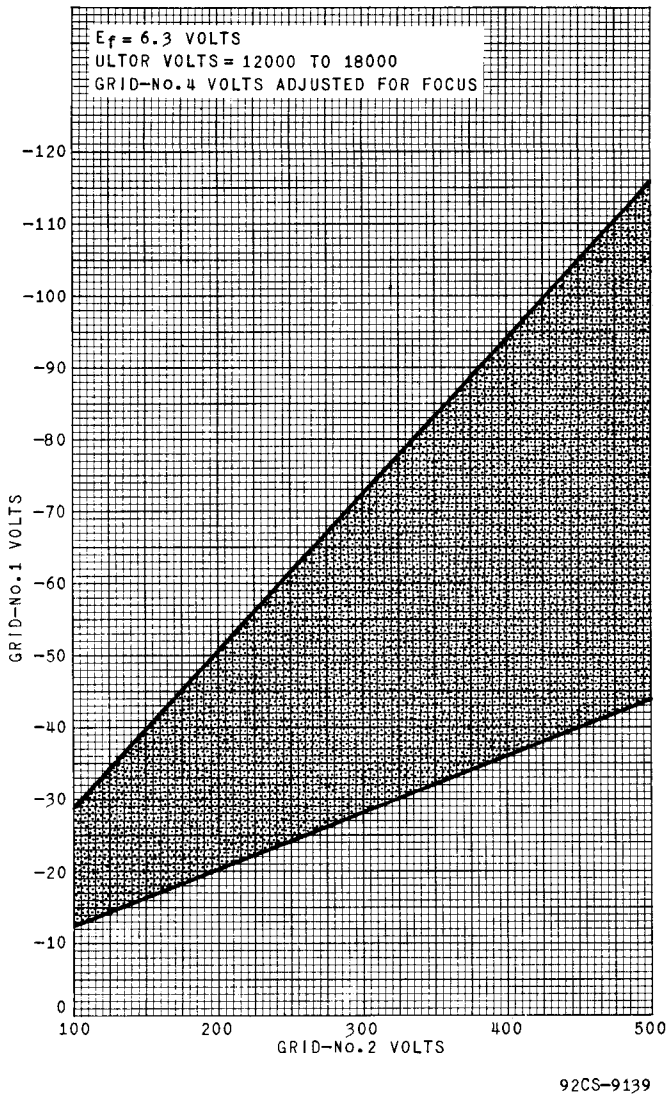


Fig. 1 - Raster Cutoff Range for Type 21CEP4 in Grid-Drive Service.

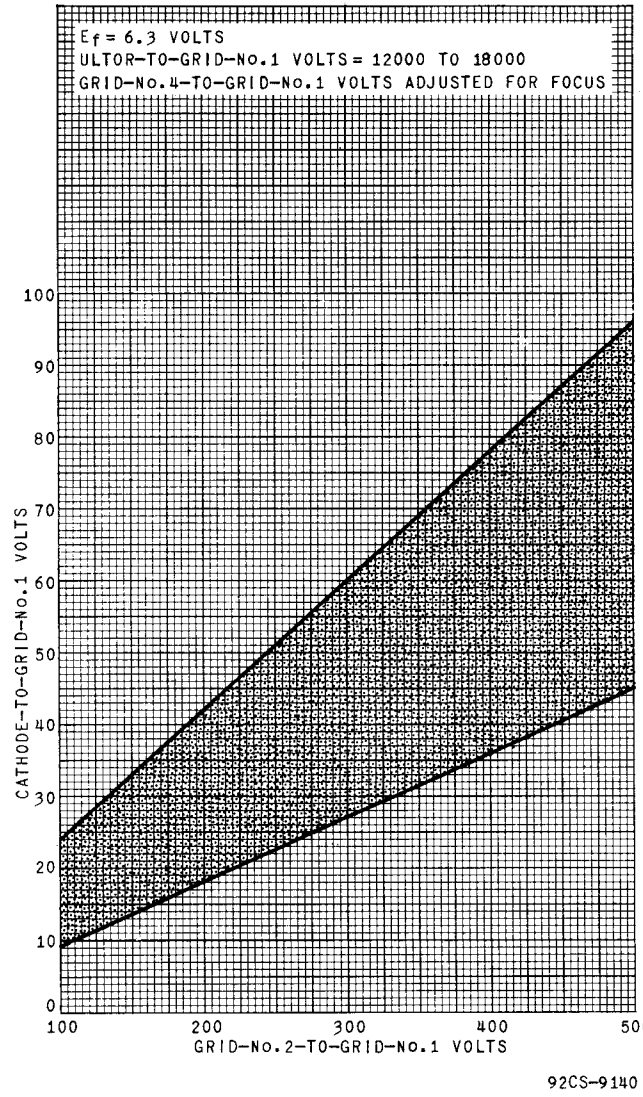


Fig. 2 - Raster Cutoff Range for Type 21CEP4 in Cathode-Drive Service.

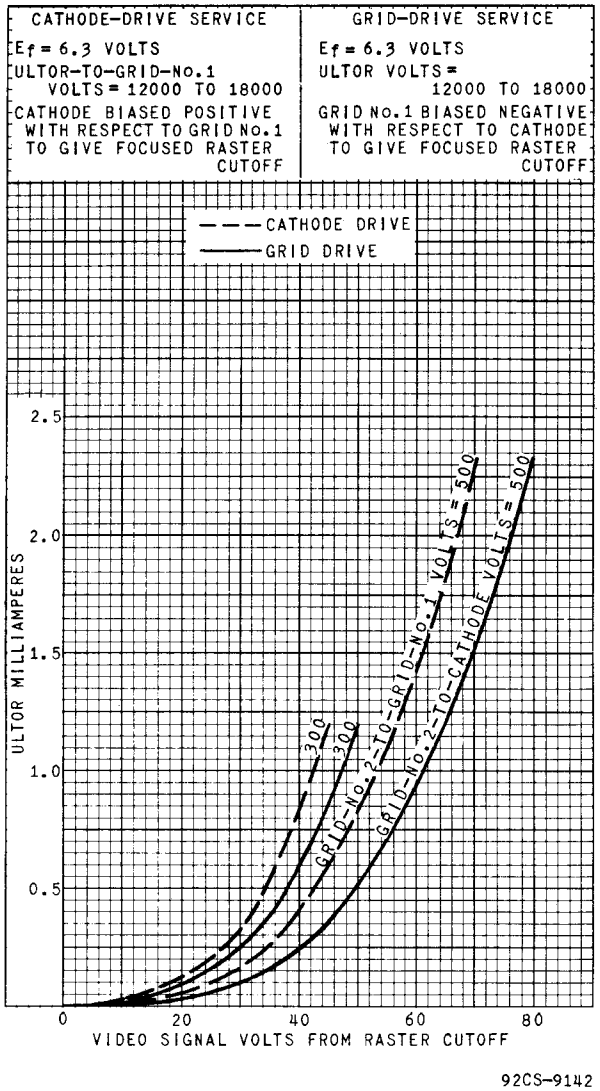


Fig. 3 – Average Drive Characteristics of Type 21CEP4.

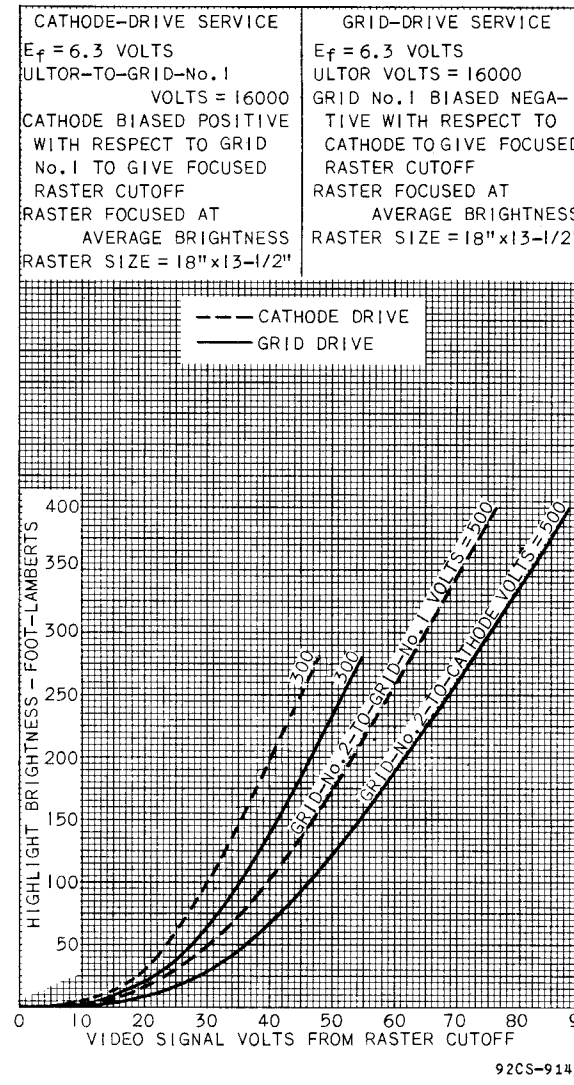
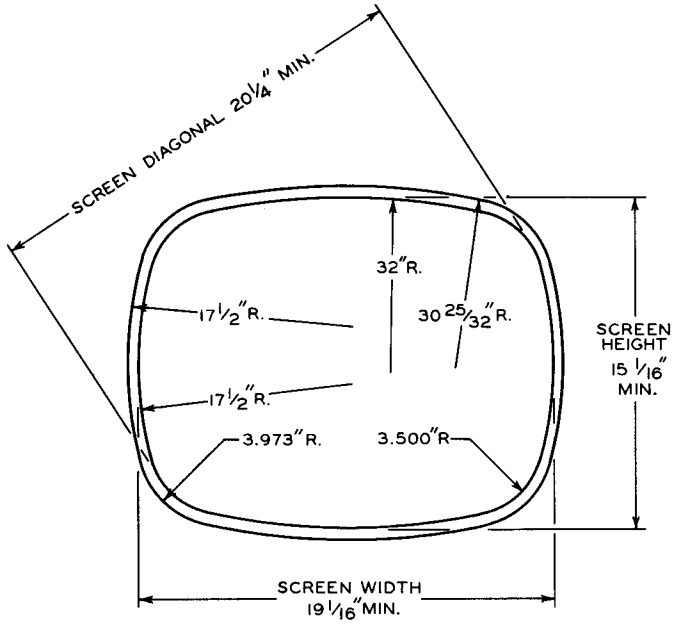
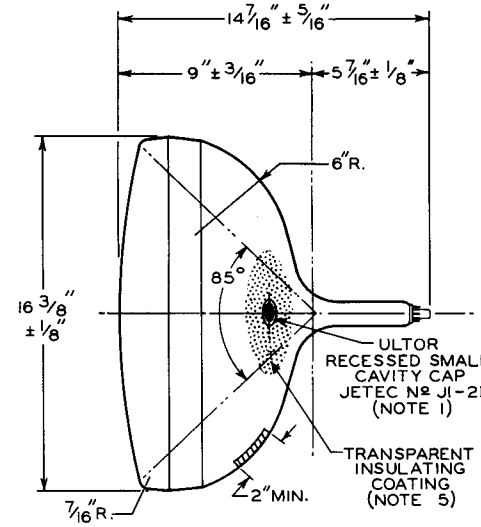
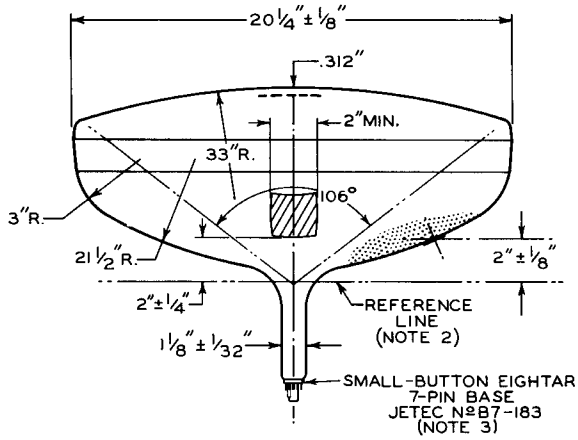


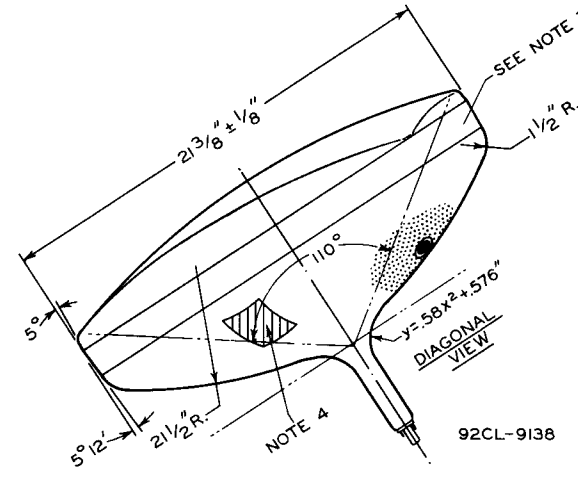
Fig. 4 – Average Drive Characteristics of Type 21CEP4.

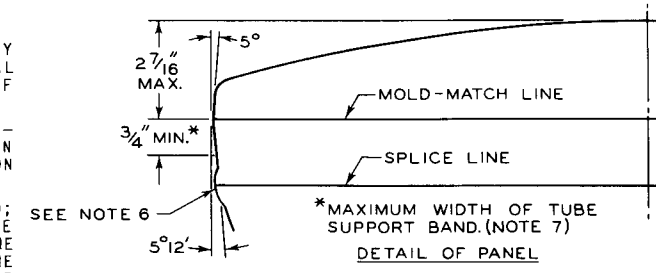
DIMENSIONAL OUTLINE











NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN No.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JETEC No.126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT THE CIRCUIT WIRING CANNOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: THE DRAWING SHOWS THE MINIMUM SIZE AND LOCATION OF THE CONTACT AREA OF THE EXTERNAL CONDUCTIVE COATING. THE ACTUAL AREA OF THIS COATING WILL BE GREATER THAN THE CONTACT AREA SO AS TO PROVIDE THE REQUIRED CAPACITANCE. EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

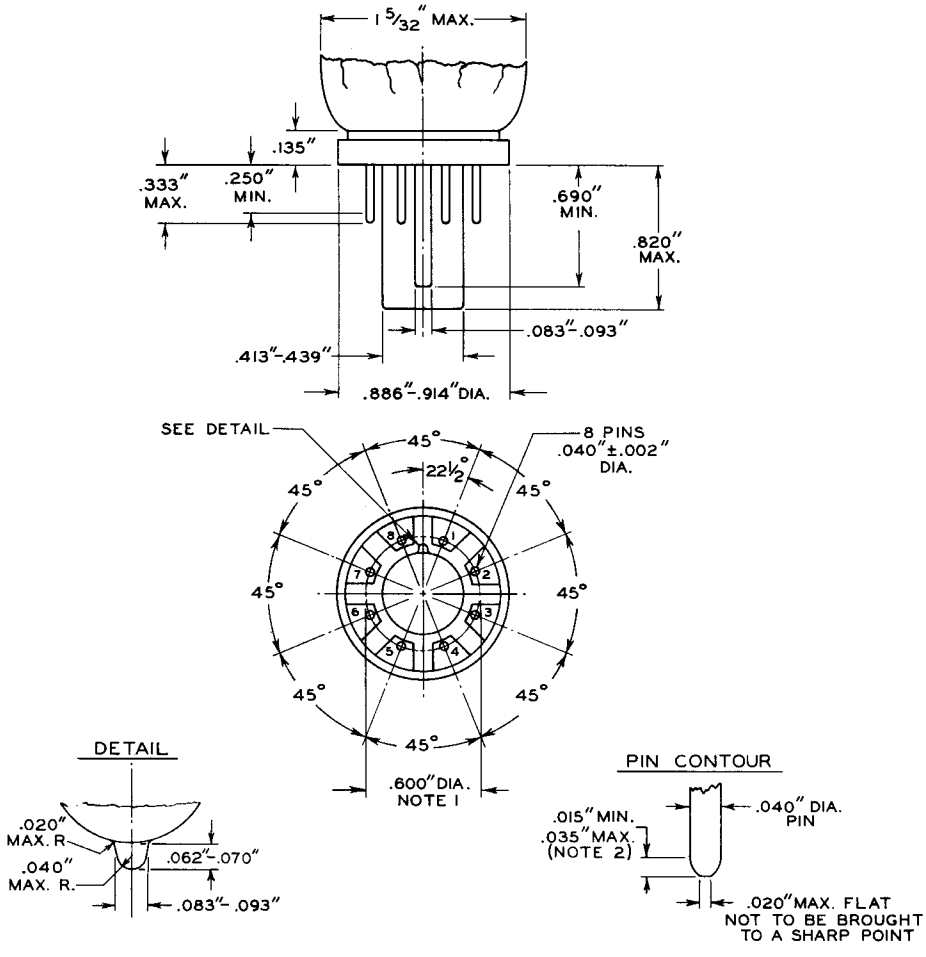
NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINT-LESS CLOTH.

NOTE 6: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE MOLD-MATCH LINE.

NOTE 7: UNDISTURBED AREA BETWEEN MOLD-MATCH LINE AND SPLICE LINE IS 3/4" MINIMUM. THIS SHOOLD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND.

BASE DRAWING

SMALL-BUTTON EIGHTAR BASE



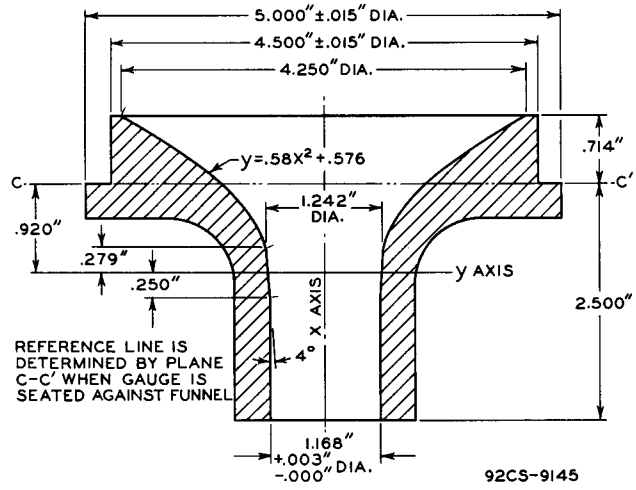
92CM-9146

NOTE 1: BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT THE BASE WILL FIT A FLAT-PLATE GAUGE HAVING A THICKNESS OF 3/8" AND EIGHT EQUALLY SPACED HOLES OF 0.0550" ± 0.0550" DIAMETER LOCATED ON A 0.6000" ± 0.0005" DIAMETER CIRCLE. THE GAUGE IS ALSO PROVIDED WITH A CENTER HOLE TO PROVIDE 0.010" DIAMETRIC CLEARANCE FOR THE LUG AND KEY. PIN FIT IN THE GAUGE SHALL BE SUCH THAT THE ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, ENTER INTO AND DISENGAGE FROM THE GAUGE.

NOTE 2: THIS DIMENSION AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN MAY VARY WITHIN THE LIMITS SHOWN.

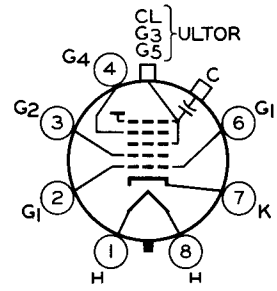
JETEC No.	No. OF PINS	PINS
B8-181	8-Pin	1,2,3,4,5,6,7,8
B7-182	7-Pin STYLE A	2,3,4,5,6,7,8
B7-183	7-Pin STYLE B	1,2,3,4, 6,7,8

REFERENCE-LINE AND NECK-FUNNEL-CONTOUR GAUGE JETEC Nº 126



SOCKET CONNECTIONS

Bottom View



8HR

PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.2
PIN 4: GRID No.4
PIN 6: GRID No.1
PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

from JETEC release
#2015, Sept. 23, 1957

21DFP4

PICTURE TUBE

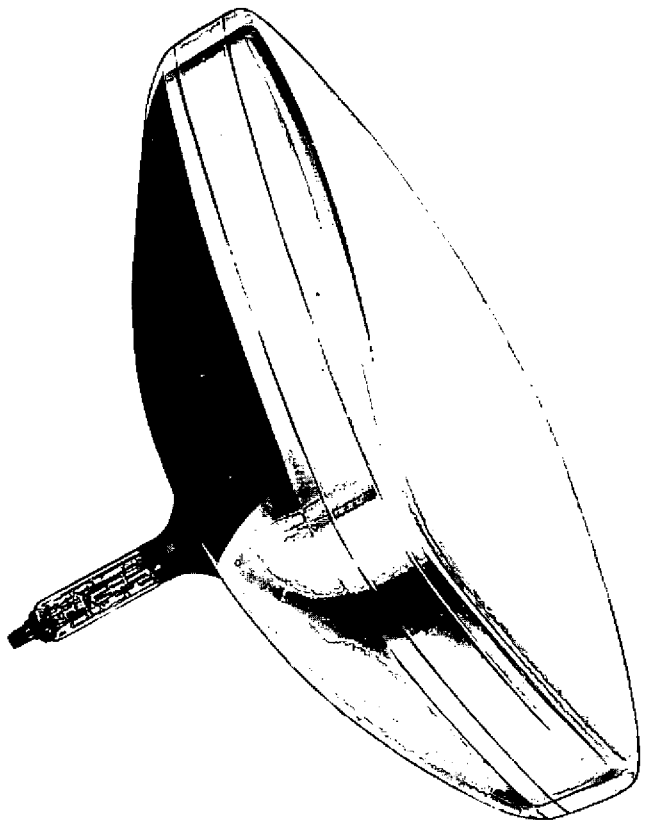
Low-Voltage Electrostatic Focus
110° Magnetic Deflection

Aluminized Screen
Very Short Rectangular Glass Type
Requires No Ion-Trap Magnet

19-1/16" x 15-1/16" Screen
21-1/2" Max. Bulb Diagonal
14-3/4" Max. Length

TENTATIVE DATA

RCA-21DFP4 is a very short, directly viewed, rectangular, glass picture tube of the low-voltage electrostatic-focus and magnetic-deflection type. It has a spherical Filterglass faceplate, an aluminized screen 19-1/16" x 15-1/16" with slightly curved sides and rounded corners and a minimum projected screen area of 262 square inches.



Designed with a 110°-diagonal deflection angle, the 21DFP4 has very short length--a length approximately 5-1/2" shorter than types having the same size faceplate and 90° deflection. As a result, this tube establishes new concepts for cabinet styling and for the design of more compact TV receivers utilizing 21"-type picture tubes.

The 21DFP4 has a neck diameter of only 1-1/8" which not only makes possible the use of a deflecting yoke having high deflection sensitivity but also permits deflection of the beam through the wide deflection angle with only slightly more power than is required to scan a tube with 90° deflection angle.

The 21DFP4 utilizes an electron gun of the "straight" type designed to minimize deflection distortion. This electron gun eliminates the need for an ion-trap magnet.

Another design feature of the 21DFP4 is an integral glass-button base having straight-through leads fitted with an indexing plug. This basing arrangement eliminates any possibility of loose base-pin connections. In addition, the 21DFP4 has an external conductive bulb coating which with the internal conductive coating forms a supplementary filter capacitor.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	amp
Direct Interelectrode Capacitances:		
Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to anode●	2200 max. 1500 min.	μμf μμf
Faceplate, Spherical	Filterglass	
Light transmission (Approx.)	73%	
Phosphor	P4--Sulfide Type, Aluminized	
Fluorescence	White	
Phosphorescence	White	
Persistence	Short	
Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	110°	
Horizontal	105°	
Vertical	87°	
Electron Gun	Type Requiring No Ion-Trap Magnet	
Tube Dimensions:		
Overall length	14-7/16" ± 5/16"	
Greatest width	20-1/4" ± 1/8"	
Greatest height	16-3/8" ± 1/8"	

TMK ®, Marca Registrada
Printed in U.S.A.

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Diagonal	21-3/8" ± 1/8"
Neck length	5-7/16" ± 1/8"
Screen Dimensions (Minimum):	
Greatest width	19-1/16"
Greatest height	15-1/16"
Diagonal	20-1/4"
Projected area	.262 sq. in.
Cap	Recessed Small Cavity (JETEC No.J1-21)
Bulb	J171 (110°)
Base	Small-Button Eightar 7-Pin, Arrangement 2, (JETEC No.B7-183)
Socket	Ucinite Part No.115446, or equivalent
Weight (Approx.)	23 lbs
Mounting Position	Any

GRID-DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum Ratings, *Design-Center Values:*

ULTOR● VOLTAGE	18000 max. volts 12000⊕ min. volts	
GRID-No.4 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2 VOLTAGE	500 max.	volts
GRID-No.1 VOLTAGE:		
Negative peak value	200 max.	volts
Negative bias value	140 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor voltage (E_{c_5k}) between 12000 and 18000 volts and grid-No.2 voltage (E_{c_2k}) between 200 and 500 volts

Grid-No.4 Voltage for Focus§	0 to 400	volts
Grid-No.1 Voltage (E_{c_1k}) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Grid-Drive Service	
Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak positive)	Same value as determined for E_{c_1k} except video drive is a positive voltage	
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*14000*	*16000*	*volts*
and grid-No.2 voltage of	*300*	*400*	*volts*
Grid-No.4 Voltage for Focus	0 to 400	0 to 400	volts
Grid-No.1 Voltage for Visual Extinction of Focused Raster	−28 to −72	−36 to −98	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	28 to 72	36 to 98	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum Ratings, *Design-Center Values:*

ULTOR●-TO-GRID-No.1 VOLTAGE	18000 max. volts 12000⊕ min. volts	
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	640 max.	volts
GRID-No.2-TO-CATHODE VOLTAGE	500 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	200 max.	volts
Positive bias value	140 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 12000 and 18000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 640 volts

Grid-No.4-to-Grid-No.1 Voltage for Focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage (E_{kg_1}) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Cathode-Drive Service	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak negative)	Same value as determined for E_{kg_1} except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*14000*	*16000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*300*	*400*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for Focus	0 to 400	0 to 400	volts
Cathode-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster	28 to 60	36 to 78	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	−28 to −60	−36 to −78	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 21DFP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 21DFP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

⊖ This value is a working design-center minimum. The equivalent *absolute minimum* ultor, or ultor-to-grid-No.1 voltage is 11000 volts, below which the serviceability of the 21DFP4 will be impaired. The equipment designer has the responsibility of determining a minimum design value such that under the worst probable operating conditions involving supply-voltage variation and equipment variation the absolute minimum ultor, or ultor-to-grid-No.1 voltage is never less than 11000 volts.

§ The grid-No.4 voltage or grid-No.4-to-grid-No.1 voltage required for focus of any individual tube is independent of ultor current and will remain essentially constant for values of ultor voltage (or ultor-to-grid-No.1 voltage) or grid-No.2 voltage (or grid-No.2-to-grid-No.1 voltage) within design ranges shown for these items.

* Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having a 3/8-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 1/2-inch deflection of the spot from the center of the tube face.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 21DFP4 does not produce any harmful X-ray radiation. However, because the rating of this type permits operation at voltages as high as 19.8 kilovolts (absolute maximum value), shielding of the 21DFP4 for X-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Shatter-Proof Cover Over the Tube Face. Following conventional picture-tube practice, it is recommended that the cabinet be provided with a shatter-proof, glass cover over the face of the 21DFP4 to protect it from being struck accidentally and to protect against possible damage resulting from tube implosion under some abnormal condition. This safety cover can also provide X-ray protection when required.

The *base pins* of the 21DFP4 fit the Eightar 8-contact socket, such as Ucinite Part No. 115446 or equivalent. The design of the socket should be such that the circuit wiring cannot impress lateral strains through the socket contacts on the base pins.

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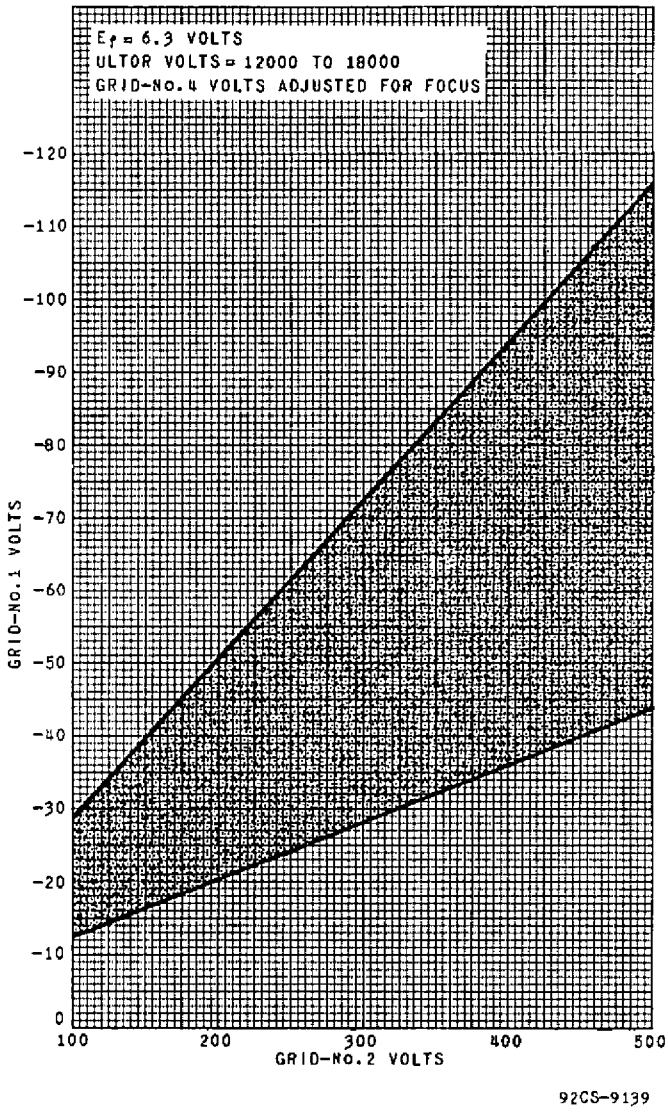

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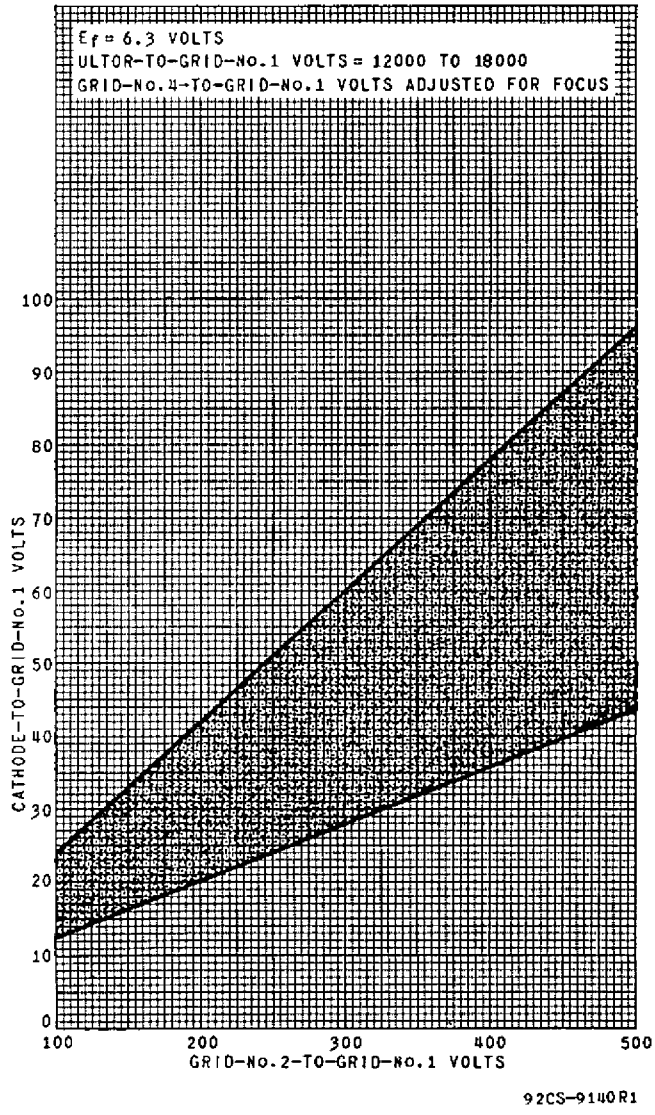
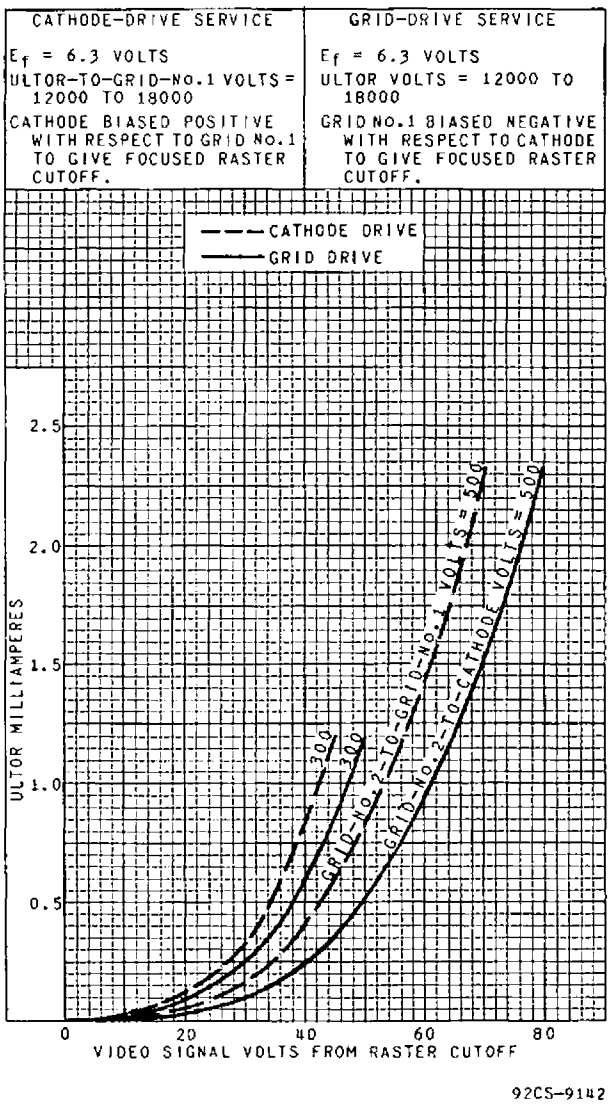


Fig. 2 - Raster Cutoff Range for Type 21DFP4 in Cathode-Drive Service.



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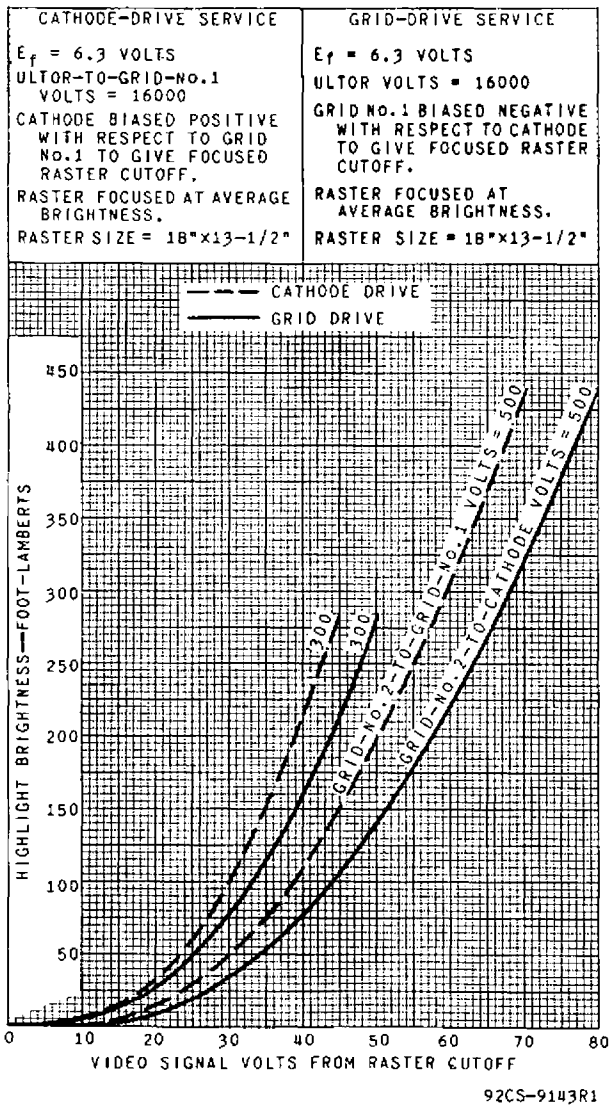
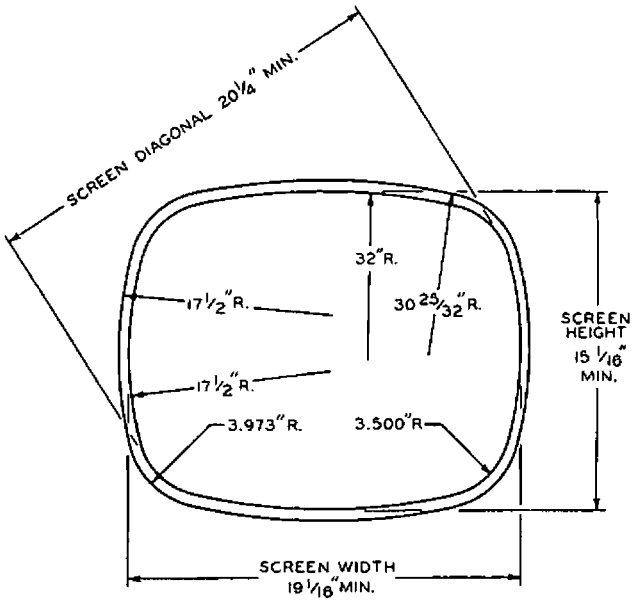
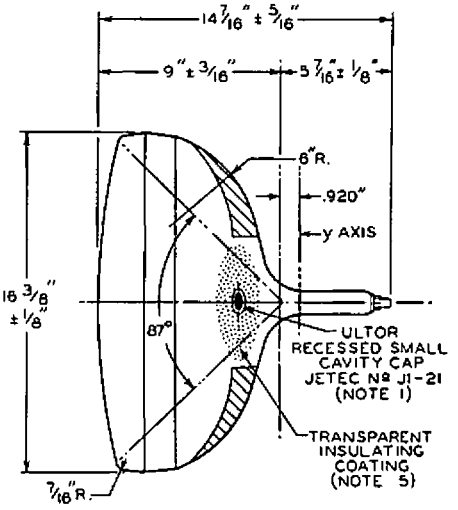
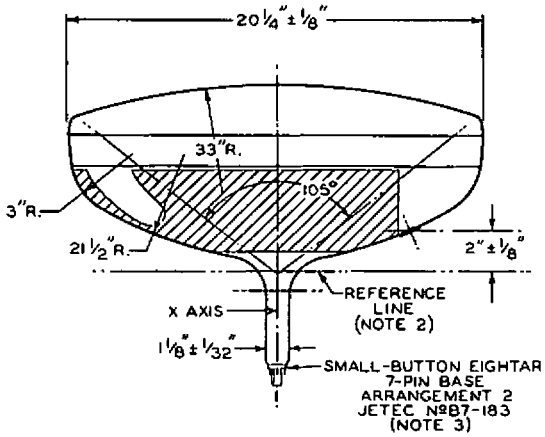


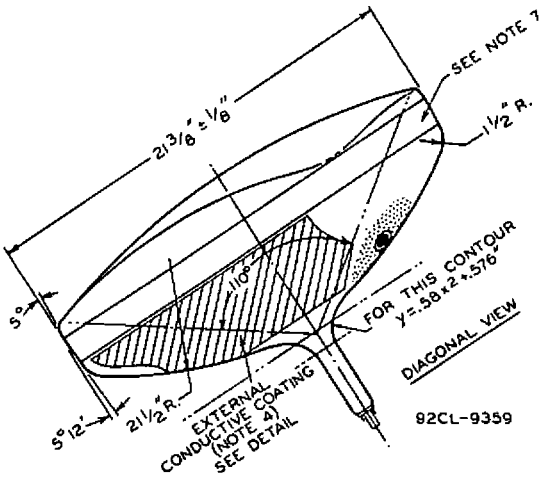
Fig.4 - Average Drive Characteristics of Type 21DFP4.

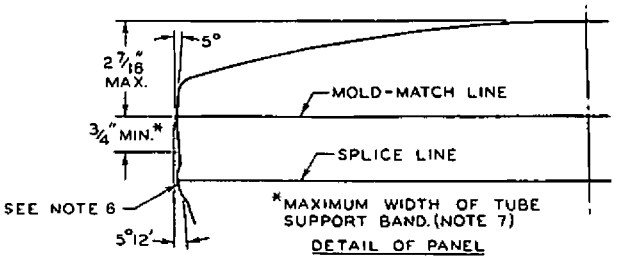
DIMENSIONAL OUTLINE











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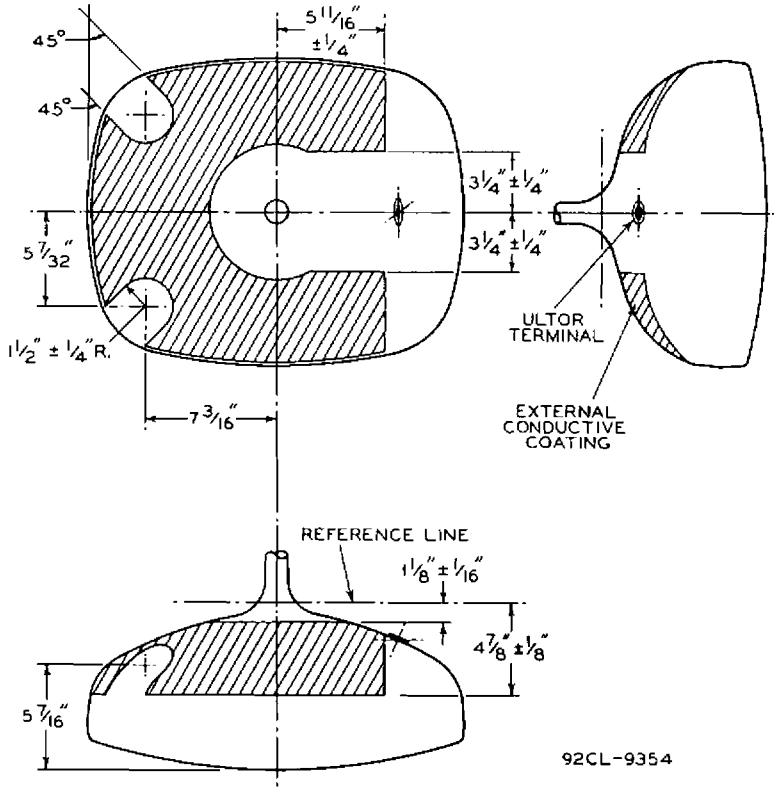
NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

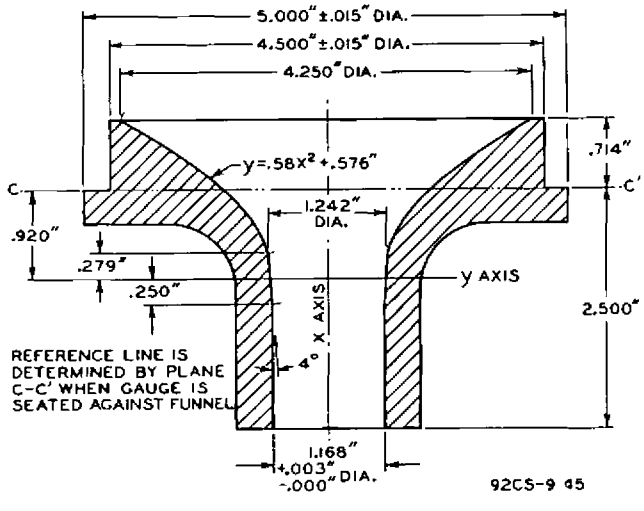
NOTE 6: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE MOLD-MATCH LINE.

NOTE 7: UNDISTURBED AREA BETWEEN MOLD-MATCH LINE AND SPLICE LINE IS 3/4" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND.

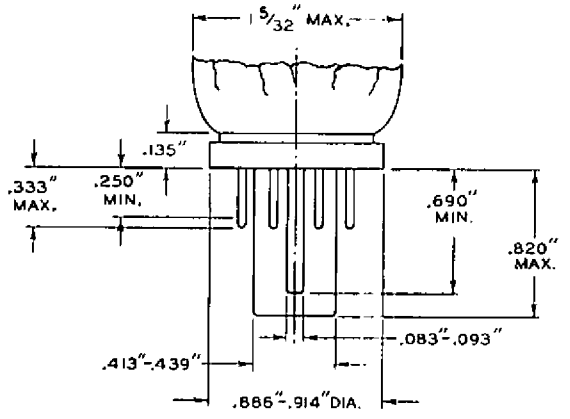
DETAIL SHOWING EXTERNAL CONDUCTIVE COATING

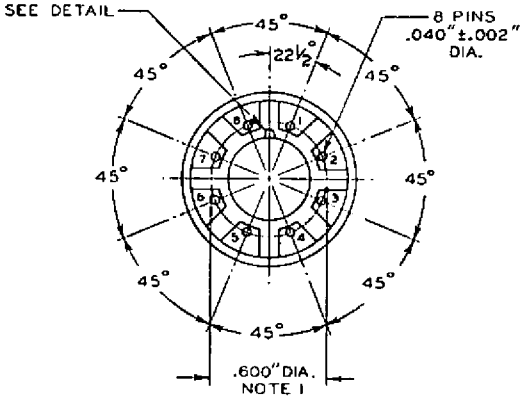


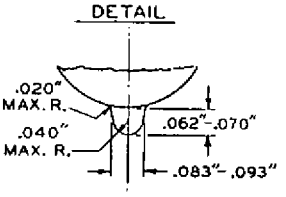
REFERENCE-LINE AND
NECK-FUNNEL-CONTOUR GAUGE
JETEC No. 126

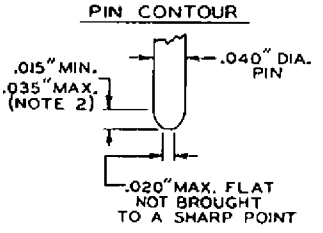


SMALL-BUTTON EIGHTAR BASE









92CM-9146

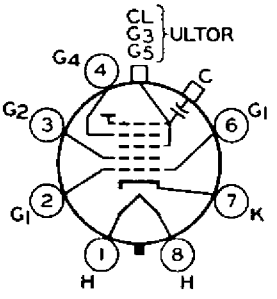
NOTE 1: BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT THE BASE WILL FIT A FLAT-PLATE GAUGE HAVING A THICKNESS OF 3/8" AND EIGHT EQUALLY SPACED HOLES OF 0.0550" ± 0.0005" DIAMETER LOCATED ON A 0.6000" ± 0.0005" DIAMETER CIRCLE. THE GAUGE IS ALSO PROVIDED WITH A CENTER HOLE TO PROVIDE 0.010" DIAMETRIC CLEARANCE FOR THE LUG AND KEY. PIN FIT IN THE GAUGE WILL BE SUCH THAT THE ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, ENTER INTO AND DISENGAGE FROM THE GAUGE.

NOTE 2: THIS DIMENSION AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN MAY VARY WITHIN THE LIMITS SHOWN.

JETEC No.	No. of PINS	PINS
B8-181	8-Pin	1,2,3,4,5,6,7,8
B7-182	7-Pin ARRANGEMENT 1	2,3,4,5,6,7,8
B7-183	7-Pin ARRANGEMENT 2	1,2,3,4, 6,7,8

SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.2
PIN 4: GRID No.4
PIN 6: GRID No.1

PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

8HR

21DP4

KINESCOPE

Electrostatic Focus
Magnetic Deflection
Ion-Trap Gun

Rectangular Type
Metal-Shell Envelope
Frosted Filterglass Face Plate

18-3/8" x 13-15/16" Picture Size
21" Max. Shell Diagonal
22-5/8" Max. Length

TENTATIVE DATA

RCA-21DP4 is a short, directly viewed, rectangular picture tube of the metal-shell type for use in television receivers. It has a picture size of 18-3/8" x 13-15/16" with slightly curved sides and rounded corners.

Utilizing electrostatic focusing, the 21DP4 features an electron gun of improved design to provide good uniformity of focus over the entire picture area. Furthermore, focus can be maintained automatically with variation in line voltage and with adjustment of picture brightness. Need for alignment of a focusing coil or focusing magnet is eliminated and therefore tube installation and adjustment for optimum performance are simplified. Because the electron gun is designed so that the focusing electrode (grid No.4) takes very little current, the voltage for the focusing electrode can be provided easily and economically.

The rectangular shape, which allows reproduction of the transmitted picture without waste of screen area, permits use of a cabinet having about 20 per cent less height than is required for a round-face tube having the same picture width. In addition, the chassis need not be depressed or cut out under the face of the tube and controls can be located as desired beneath the tube.

Providing pictures having high brightness, the 21DP4 has a high-efficiency, white fluorescent screen on a relatively flat, high-quality face made of frosted Filterglass to prevent specular reflection and to provide increased picture contrast. The frosted Filterglass face plate incorporates a neutral light-absorbing material which reduces ambient-light reflections from the phosphor and reflections within the face plate itself in a much higher ratio than it reduces the directly viewed light of the picture. As a result, improved picture contrast is obtained. In addition, frosting of the face diffuses reflections of bright objects in the room which might otherwise be objectionable.

Employing magnetic deflection, the 21DP4 is designed with a funnel-to-neck section which facilitates centering of the yoke on the neck and, in combination with a well-centered beam inside the neck, contributes to the good uniformity of focus over the entire picture area. The diagonal deflection angle is 70° and the horizontal deflection angle is 66°.

Other design features of the 21DP4 are its short overall length, its lesser weight than that of a similar all-glass type, and its ion-trap gun requiring only a single-field, external magnet.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current.	0.6	ampere

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Radio Corporation of America

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

21DP4-5-51
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Direct Interelectrode Capacitances:		
Grid No.1 to All Other Electrodes.	6	μμf
Cathode to All Other Electrodes. .	5	μμf
Face Plate (With about 66% light transmission). .	Frosted Filterglass	
Phosphor	No.4--Sulfide Type	
Fluorescence	White	
Phosphorescence.	White	
Persistence.	Short	
Focusing Method.	Electrostatic	
Deflection Method.	Magnetic	
Deflection Angles (Approx.):		
Diagonal	70°	
Horizontal	66°	
Vertical	50°	
Ion-Trap Gun . . . Requires External, Single-Field Magnet		
Maximum Overall Length	22-5/8"	
Greatest Diagonal of Tube at Lip	20-3/4" ± 1/4"	
Greatest Width of Tube at Lip.	19-23/32" ± 1/8"	
Greatest Height of Tube at Lip	15-5/16" ± 1/8"	
Screen Size.	18-3/8" x 13-15/16"	
Ultor● Terminal.	Metal-Shell Lip	
Base . . . . Small-Shell Duodecal 6-Pin (JETEC No.B6-63)		
Mounting Position.	Any	

Maximum Ratings, ***Design-Center Values:***

ULTOR● VOLTAGE	18000 max.	volts
GRID-No.4 VOLTAGE.	5000 max.	volts
GRID-No.2 VOLTAGE.	500 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value.	125 max.	volts
Positive bias value.	0 max.	volts
Positive peak value.	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds. .	410 max.	volts
After equipment warm-up period .	180 max.	volts
Heater positive with respect to cathode.	180 max.	volts

Equipment Design Ranges:

For any ultor voltage (E_u) between 14000* and 18000 volts and grid-No.2 voltage (E_{c_2}) between 150 and 500 volts

Grid-No.4 Voltage for Ultor Current of 100 μamp.	19.7% to 26.7% of Eu	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot.	11% to 25.7% of E_{c_2}	volts
Grid-No.4 Current.	-15 to +25	μamp
Grid-No.2 Current.	-15 to +15	μamp
Field Strength of Single-Field Ion-Trap Magnet (Approx.)□	$\sqrt{\frac{Eu}{14000}} \times 38$	gausses
Field Strength of Adjustable Centering Magnet . .	0 to 8	gausses

Examples of Use of Design Ranges:

For ultor voltage of	***14000***	***16000***	***volts***
and grid-No.2 voltage of	***300***	***300***	***volts***
Grid-No.4 Voltage for Ultor Current of 100 μamp	2750 to 3740	3150 to 4270	volts
Grid-No.1 Voltage for Visual Extinction of Undeflected Focused Spot.	-33 to -77	-33 to -77	volts
Ion-Trap Magnet (Rated Strength). .	40	40	gausses

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● In the 21DP4, grid No.5, which has the ultor function, grid No.3, and collector are connected together within the tube and are conveniently referred to collectively as "ultor". The "ultor" in a cathode-ray tube is the electrode, or the electrode in combination with one or more additional electrodes connected within the tube to it, to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection.

* Brilliance and definition decrease with decreasing ultor voltage. In general, the ultor voltage should not be less than 14000 volts.

□ With a specimen ion-trap magnet similar to JETEC Ion-Trap Magnet No.111 located in optimum position and rotated to give maximum brightness, the ion-trap magnet current is approximately 75 milliamperes dc when the ultor voltage is 14000 volts.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 21DP4 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 21DP4 does not produce any harmful x-ray radiation. However, because the rating of the tube permits operation at voltages as high as 19.8 kilovolts (absolute value), shielding of the 21DP4 for x-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Corona Considerations. Adequate spacing between the lip of the 21DP4 and any grounded element in the receiver, or between the metal shell and any grounded element, should be provided to preclude the possibility of corona. Such spacing should be not less than 1-1/2 inches of air.

Insulating Material for Mask. The glass of the face plate does not have especially high electrical resistance. It is essential, therefore, that any mask material bearing on the face plate be adequately insulated to withstand the maximum applied ultor voltage. Unless this precaution is observed, picture distortion may be experienced.

Tube Handling. Care should be taken to prevent bumping or striking the lip of the 21DP4. Rough treatment may damage the face-plate seal. This seal is most vulnerable along the sides of the metal shell, particularly to a blow on the inside of the lip.

A caution notice incorporating the information shown on page 3 is affixed to the metal shell of each 21DP4. It is recommended that a similar notice be prominently displayed on equipment using the 21DP4 and be included in the equipment service bulletin.

Do not allow the metal shell of the 21DP4 to come in contact with a magnet and thus become permanently magnetized. A magnetized shell produces localized distortion of the picture edges.

Care of Tube Face. The frosted Filterglass face of the 21DP4 is more easily scratched and abraded than an unfrosted face and must, therefore, be handled more carefully. Finger marks may be removed from the face with a detergent, such as Dreft, or with a grease solvent, such as carbon tetrachloride.

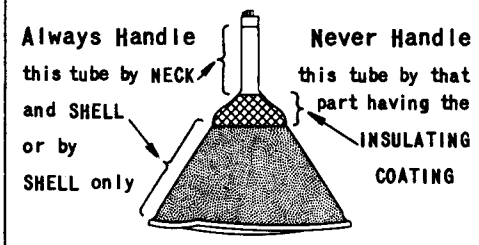
Shatter-Proof Cover Over The Tube Face. It is recommended that receivers be designed with a shatter-proof, clear glass or plastic cover over the face of the 21DP4 to protect it from being

CAUTION-HIGH VOLTAGE

This METAL SHELL operates at HIGH VOLTAGE. DO NOT TOUCH while in operation. GROUND SHELL before touching after power is off.

X-RAY WARNING

Shielding of cathode-ray tubes for x-ray radiation may be needed to protect against possible danger of personal injury from prolonged exposure at close range when they are operated above 16 kilovolts.



Finger prints or dust on the insulating coating may cause electrical breakdown during humid weather.

HANDLE WITH CARE

Breakage of this tube, which contains a high vacuum, may result in injury from flying glass. Do not strike or scratch the tube. Never subject it to more than moderate pressure when installing in or removing from equipment.

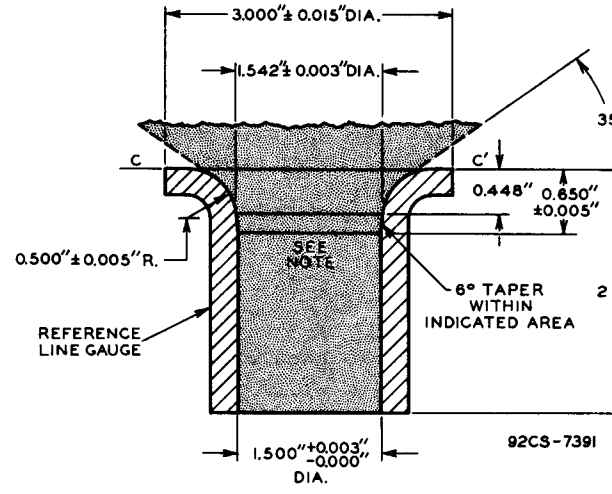
struck accidentally and to protect against possible damage resulting from tube implosion under some abnormal condition.

Support for the 21DP4, which may be operated in any position, should be provided at the large end by suitable supporting insulators at the corners of the tube, and by the deflecting-yoke mounting on the neck. Support areas on the lip are indicated on the *Outline Drawing*. Other portions of the lip periphery should be left free to avoid the possibility of fracturing the face plate-to-lip seal (see *Tube Handling*).

The deflecting-yoke mounting, sometimes called the mounting hood, should provide adjustment for alignment of the yoke on the neck and should also provide sufficient pressure to hold the yoke firmly against the glass funnel. Some good insulating material, such as Neoprene, is required between the hood and the glass funnel not only to provide a cushion between them but also to prevent abrasion of the insulating coating on the funnel and resultant arcing from the metal shell to the hood. The hood should be designed so that it can be placed as close as possible to the Reference Line (see *Outline Drawing*) without interfering with the yoke in order to reduce the amount of insulation required between hood and funnel. It is also essential that no electrical contact be made from the hood to the funnel because any such contact will decrease the length of the leakage path across the insulating coating on the glass funnel. Furthermore, the hood should not exert undue pressure on the deflecting yoke.

The yoke should be held firmly against the glass funnel (see proper location under *Deflecting Yoke*), but any thrust should be absorbed by the insulating cushion. The hood should be specially braced to prevent lateral and longitudinal motion caused by buckling of the chassis which may occur during transportation of the receiver. A simple brace from the edge of the chassis usually provides the extra stiffness required; or a small foot placed directly under the yoke may be sufficient. Unless the precaution against thrust on the yoke is observed, the tube or yoke may be damaged during transportation of the receiver.

The *deflecting yoke* should have an effective length of not more than 1-11/16 inches and be designed so that the effective center of deflec-



NOTE: INNER SURFACE OF YOKE MUST NOT EXTEND INTO SHADED REGION

Fig. 1 - Reference-Line Gauge (JETEC No. 110) with Supplementary Information on Recommended Inside Contour of Yoke to Provide Proper Location of Yoke on Neck-Funnel Section.

tion of the beam is about 1.15 inches from the Reference Line (see *Outline Drawing*). This position takes into account the use of a center-

ing magnet and provides some leeway for its effect on the beam without causing the beam to strike the neck when deflection is sufficient to reach the edge of the screen.

The yoke should have an inside contour which conforms in general to the dimensions and shape shown in Fig.1. It is to be noted that the inner surface of the end of the yoke adjacent to the glass funnel should not come closer to the funnel than indicated by the 35° line in Fig.1 if adequate insulation is to be maintained across the glass funnel between the point of yoke contact and the metal shell.

Focusing of the beam in the 21DP4 is accomplished by adjustment of the voltage applied to grid No.4. Because this electrode takes very low current, the focusing voltage can be easily provided. Any method used must take into account the grid-No.4 leakage current as shown in the tabulated data. When the high-voltage supply is of the pulse-operated, limited-energy type commonly used, the focusing voltage can be obtained by means of a simple rectifier system connected to a suitable tap on the horizontal-deflection-output and high-voltage transformer. Such an arrangement produces negligible drop in the output voltage of the high-voltage supply.

The *ion-trap magnet*, required to recenter the electron beam in the gun structure, should be of the single-field type. It should provide a uniform field across the transverse section of the tube neck to produce a round, focused spot. Direction of the field of the ion-trap magnet should be such that the north pole is adjacent to vacant pin position No.8 and the south pole to pin No.2.

To operate properly with the electron gun in the 21DP4, the ion-trap magnet should have a field strength such that the optimum position of the magnet is in the region of grid No.2 (see Fig.2), with any departure being in the direction of the base rather than toward the metal shell. The optimum position should result in a properly centered pattern having full brightness and no shadowing at the edges.

The use of an ion-trap magnet much stronger than indicated in the tabulated data tends to raise the focusing voltage beyond the indicated maximum value. Because of this fact and the absence of any shunting effect of the field by a focusing coil or magnet, it will be found that the optimum strength of the ion-trap magnetic field will be somewhat less than is required for a comparable magnetic-focus tube.

The strength of the ion-trap magnet for other ultor voltages than those indicated will be proportional to the square root of the ultor voltage.

Centering of the pattern may be accomplished by the use of a small, adjustable centering magnet located near the base end of the deflecting yoke. This magnet should provide a uniform field over the transverse section of the electron beam in order to prevent the formation of an elliptically shaped spot with consequent defocusing on the screen. The field is considered to be uniform when its field lines are straight instead of curved. The position of the centering magnet on the tube neck must be within a distance of 3-1/4 inches from the Reference Line (see *Outline Drawing*). When the magnet is positioned at the limiting distance, the ac field of the deflecting yoke is relatively weak and will have little demagnetizing effect. When placed closer to the deflecting yoke, the magnet must be made of material capable of withstanding a stronger ac field without demagnetization. If the magnet is placed too far from the deflecting yoke, appreciable deflection defocusing or neck shadow will result. The dc component of the deflecting currents should be filtered out of the deflecting yoke in order to minimize the amount of centering adjustment needed.

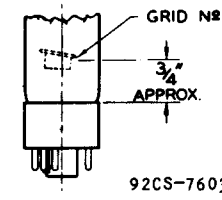


Fig.2 - Location of Grid No.2 in Tube Neck.

REFERENCES

1. *"Medical X-ray Protection Up To Two Million Volts"*, National Bureau of Standards Handbook H41.
2. *"Safety Code for Industrial Use of X-rays"*, American Standards Association, ASA Code Z54.1-1946.

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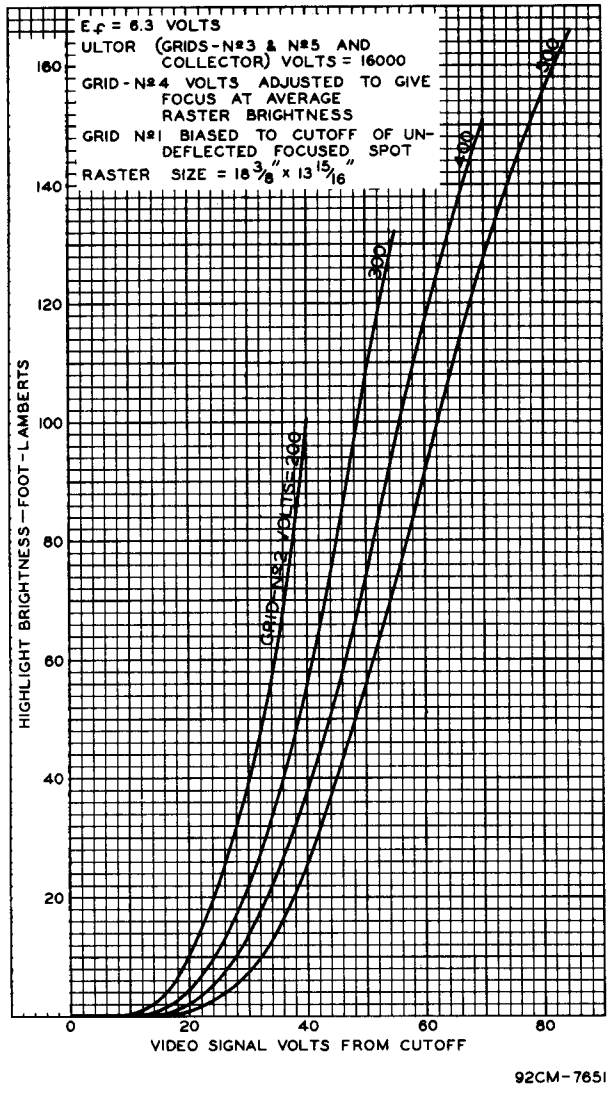


Fig. 3 - Average Grid-Drive Characteristics of Type 21DP4.

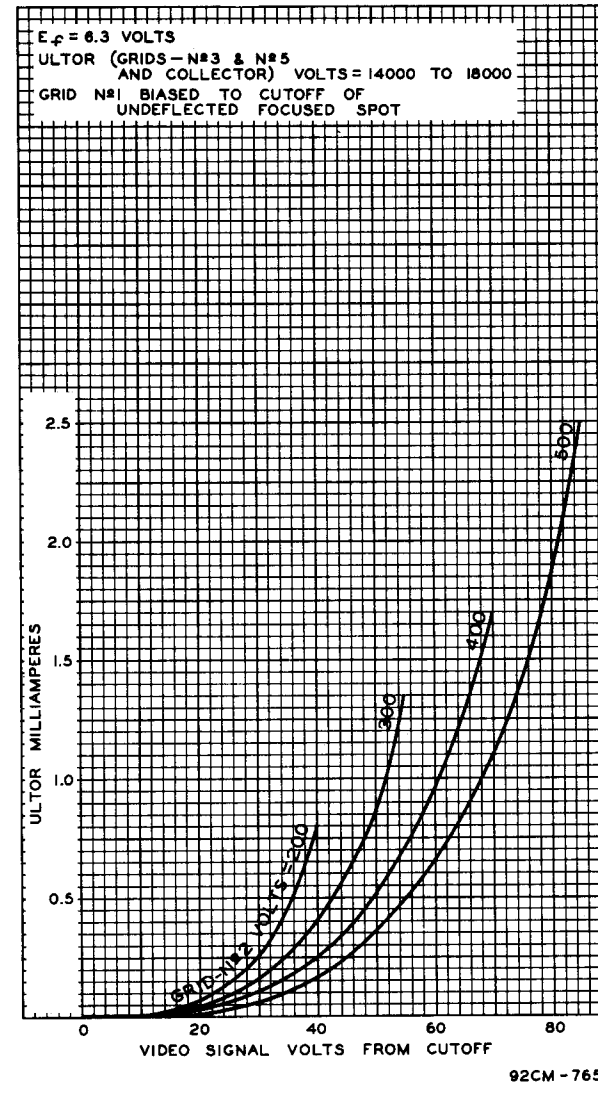
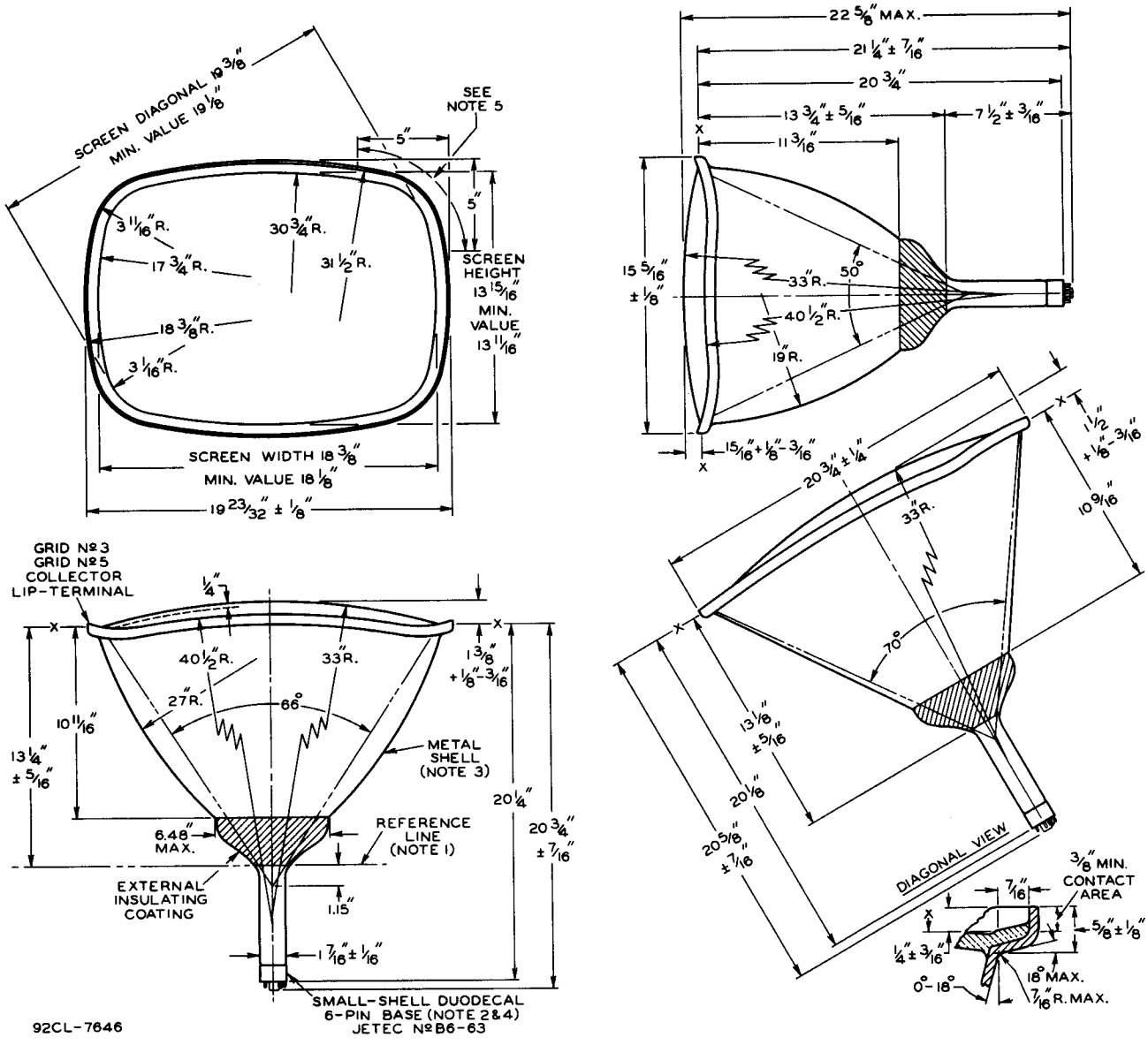


Fig. 4 - Average Grid-Drive Characteristics of Type 21DP4.

DIMENSIONAL OUTLINE



NOTE 1: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE (JETEC NO.110) AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 2: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE SHELL WILL FALL WITHIN A CIRCLE CONCENTRIC WITH METAL-SHELL AXIS AND HAVING A DIAMETER OF 3-1/4".

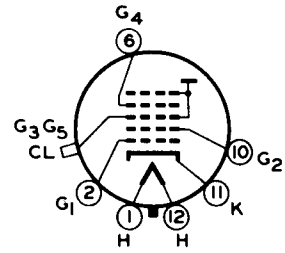
NOTE 3: METAL SHELL AND GLASS FACE OPERATE AT HIGH VOLTAGE. ANY MATERIAL IN CONTACT WITH THE SHELL OR THE FACE MUST BE INSULATED TO WITHSTAND THE MAXIMUM APPLIED ULTOR VOLTAGE.

NOTE 4: THE PLANE THROUGH THE TUBE AXIS AND PIN NO.6 MAY VARY FROM THE HORIZONTAL AXIS OF THE GLASS FACE BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 10°.

NOTE 5: SUPPORT TUBE IN LIP REGION ONLY AT CORNERS WITHIN THIS SPACE.

SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER
PIN 2: GRID NO.1
PIN 6: GRID NO.4
PIN 10: GRID NO.2
PIN 11: CATHODE
PIN 12: HEATER
METAL-SHELL LIP: GRID NO.3,
GRID NO.5, COLLECTOR

23BKP4

BI-PANEL PICTURE TUBE

Low-Voltage Electrostatic Focus
92° Magnetic Deflection

Aluminized Screen
Low-Grid-No.2-Voltage Type
for Cathode-Drive Operation

19-5/16" x 15-1/4" Screen
24-51/64" Max. Bulb Diagonal
18-7/8" Max. Overall Length

RCA-23BKP4 is a directly viewed, bi-panel, rectangular, glass picture tube having an aluminized screen 19-5/16" x 15-1/4" with nearly straight sides and slightly rounded corners, and a minimum projected screen area of 282 square inches. Employing 92°-angle magnetic deflection and low-voltage electrostatic focus, it is intended for use in cathode-drive circuits.

The bi-panel construction used in the 23BKP4 provides an integral Filterglass protective panel which is sealed to the faceplate of the tube. This construction eliminates the need for a separate safety-glass window and its companion dust seal in the receiver. It also eliminates the air separation between faceplate and protective window and thereby reduces reflections; consequently, picture contrast is improved.

The 23BKP4 has an electron gun that has improved cathode-drive sensitivity; that requires no ion-trap magnet; and that minimizes deflection distortion.

GENERAL DATA

Electrical:

Heater Current at 6.3 volts	600 ± 30	ma
Heater Warm-up Time (Average)	11	seconds
Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 5 volts.		
Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	92°	
Horizontal	81°	
Vertical	66°	
Direct Interelectrode Capacitances:		
Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor[a]	2500 max. / 1700 min.	μμf
Electron Gun	Type Requiring No Ion-Trap Magnet	

Optical:

Faceplate	Filterglass
Light Transmission at Center (Approx.)	40%
Phosphor	P4-Sulfide Type, Aluminized
Fluorescence	White
Phosphorescence	White
Persistence	Medium Short

Mechanical:

Tube Dimensions:	
Overall length	18-7/16" ± 7/16"
Greatest width	21-5/16" ± 1/8"
Greatest height	17-13/32" + 3/32" - 1/8"
Diagonal	24-45/64" + 3/32" - 1/16"
Neck length	5-5/8" ± 3/16"
Curvature of Faceplate (External)	See *Dimensional Outline*
Screen Dimensions (Minimum):	
Greatest width	19-5/16"
Greatest height	15-1/4"
Diagonal	22-5/16"
Projected area	282 sq. in.
Bulb Designation	J18701/02 fitted with Protective Panel FP198A1
Cap Designation	Recessed Small-Cavity (JEDEC No.J1-21)
Base Designation	Short Small-Shell Duodecal 6-pin (JEDEC Group 4, No.B6-203)
Basing Designation	12L
Weight (Approx.)	35 lbs
Operating Position	Any

CATHODE-DRIVE[b] SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum and Minimum Ratings, *Design-Maximum Values:*[c]

ULTOR[a]-TO-GRID-No.1 VOLTAGE	25000 max. / 15000 min.	volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1250 max.	volts
Negative value	400 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	225 max. / 40 min.	volts
GRID-No.2-TO-CATHODE VOLTAGE	70 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	220 max.	volts
Positive bias value	154 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
HEATER VOLTAGE	6.9 max. / 5.7 min.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	200 max.	volts
Heater positive with respect to cathode	200 max.	volts

Typical Operating Conditions:

With ultor-to-grid-No.1 voltage (E_{c5g1}) of	*20000*	*volts*
and grid-No.2-to-grid-No.1 voltage (E_{c2g1}) of	*50*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for focus[d]	200	volts
Cathode-to-Grid-No.1 Voltage for visual extinction of focused raster (See *Fig.2*)	36 to 54	volts
Field Strength of Adjustable Centering Magnet[e]	0 to 12	gauss

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

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[a] The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In this tube type, the ultor function is performed by grid No.5. Since grid No.3, grid No.5, and collector are connected together within the tube, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

[b] Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

[c] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Maximum Ratings System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

[d] The grid-No.4-to-grid-No.1 voltage required for optimum focus of any individual tube will have a value anywhere between 0 and 400 volts, is independent of ultor current and will remain essentially constant for values of ultor-to-grid-No.1 voltage or grid-No.2-to-grid-No.1 voltage within the design-maximum ratings shown for these items.

[e] Distance from Reference Line for suitable PM centering magnet should not exceed 2-1/4 inches. The specified centering magnet compensates only for the effect which mechanical tube tolerances may have on the location of the undeflected, focused spot with respect to the center of the tube face. Maximum field strength of adjustable centering magnet equals

$$\sqrt{\frac{Ec_5g_1\ (volts)}{16000\ (volts)}} \times 10 \text{ gausses}$$

The equipment manufacturer must determine and supply additional compensation for the effects of the earth's magnetic field and extraneous fields due to choice of circuitry and components. The additional compensation should preferably be applied as part of the magnetic field of the deflecting yoke.

OPERATING CONSIDERATIONS

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 23BKP4 does not roduce any harmful X-ray radiation. However, ecause the rating of this type permits operation at voltages as high as 25 kilovolts (design-maximum value), shielding of the 23BKP4 for X-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

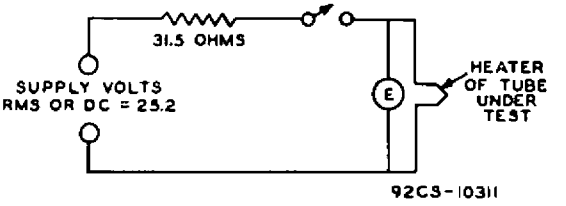


Fig.1 - Test Circuit for Determining Heater Warm-Up Time.

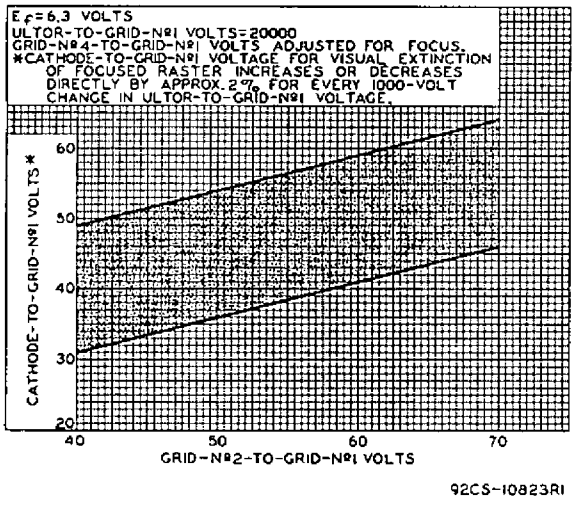
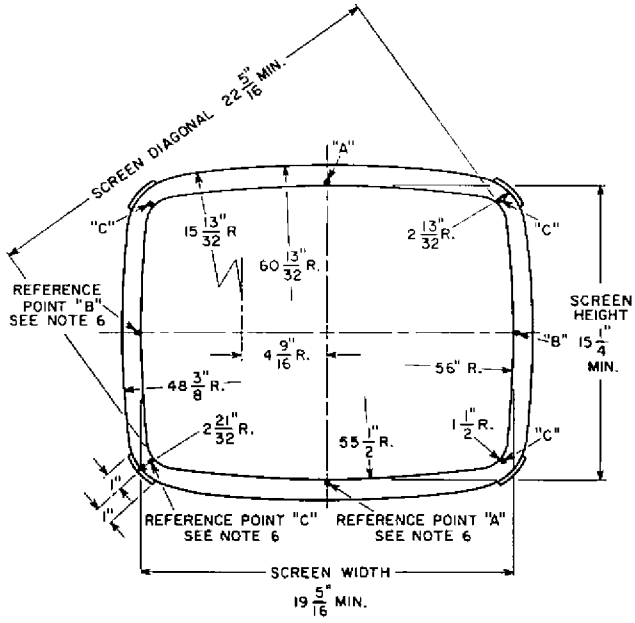
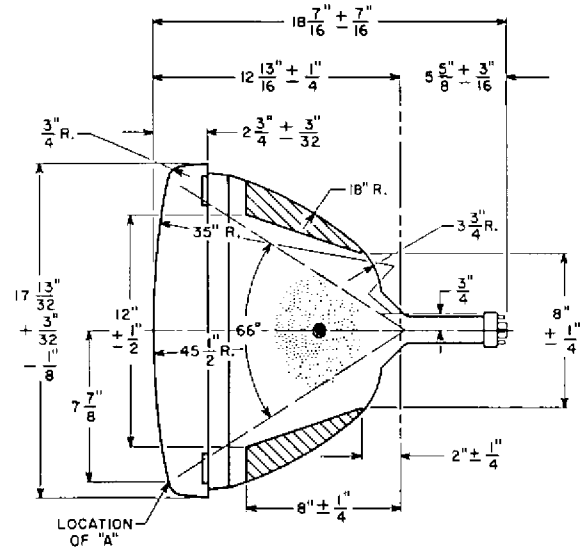


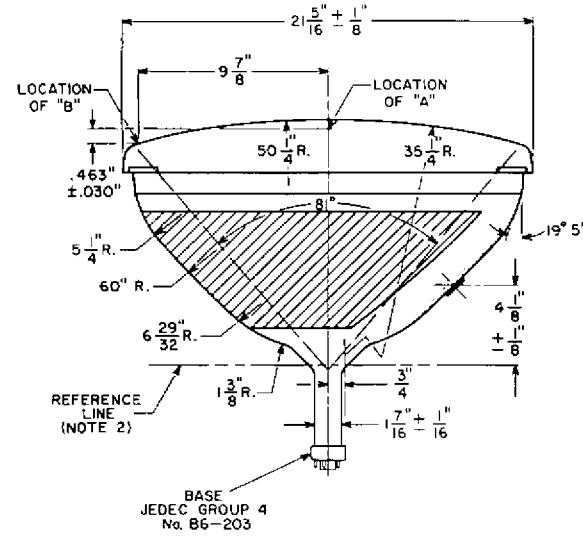
Fig.2 - Raster-Cutoff-Range Chart for Type 23BKP4.

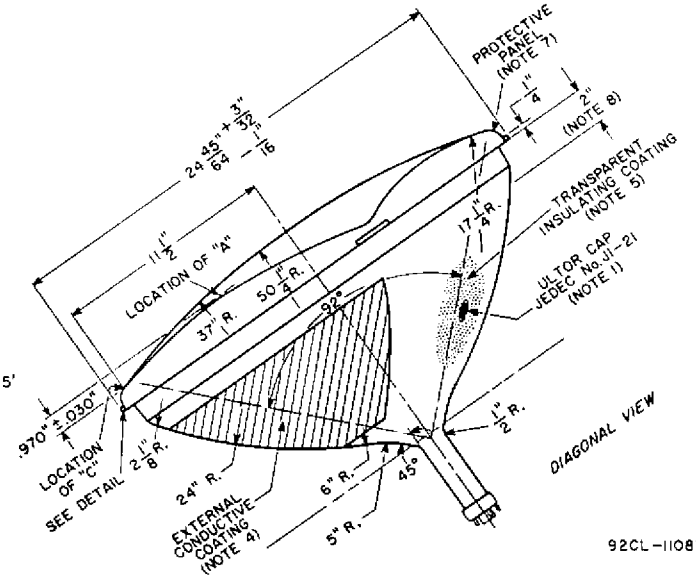
Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

DIMENSIONAL OUTLINE



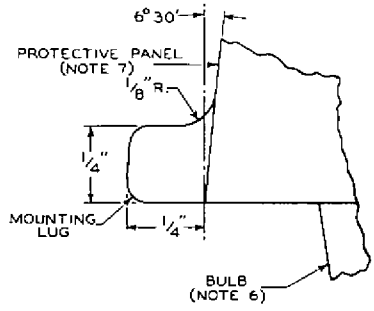






92CL-11087

DETAIL OF MOUNTING LUG



NOTES FOR DIMENSIONAL OUTLINE

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.6 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN No.6.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC No.G-116 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE-LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 2-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINT-LESS CLOTH.

NOTE 6: REFERENCE POINTS A,B, AND C ARE PROVIDED FOR USE IN DESIGN OF A MASK CONTOURED FOR CLOSE FIT TO THE PROTECTIVE PANEL.

NOTE 7: THE CENTER OF THE PROTECTIVE PANEL MAY BE ECCENTRIC WITH RESPECT TO THE AXIS OF THE TUBE ENVELOPE. ASSOCIATED SHIFT OF THE PROTECTIVE PANEL ALONG ITS MINOR AND/OR MAJOR AXIS WILL NOT EXCEED 1/16".

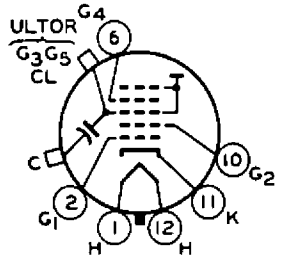
NOTE 8: KEEP THIS CIRCUMFERENTIAL AREA FREE OF MOUNTING HARDWARE.

NOTE 9: ADEQUATE TUBE SUPPORT IS OBTAINED BY CLAMPING TO THE MOUNTING LUGS PROVIDED AT EACH CORNER OF THE PROTECTIVE PANEL. TUBE MOUNTING AND YOKE SUPPORT CLAMPS MUST BE SPACED FROM THE TUBE BY USE OF CUSHIONING PADS MADE OF MATERIAL SUCH AS ASPHALT-IMPREGNATED FELT, OR EQUIVALENT.

BASING DIAGRAM

Bottom View

PIN 1: HEATER
PIN 2: GRID No.1
PIN 6: GRID No.4
PIN 10: GRID No.2
PIN 11: CATHODE



PIN 12: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

12L

from JEDEC release #2874, July 4, 1960

Attention is called to the use of Design-Maximum Ratings for this type.

23MP4

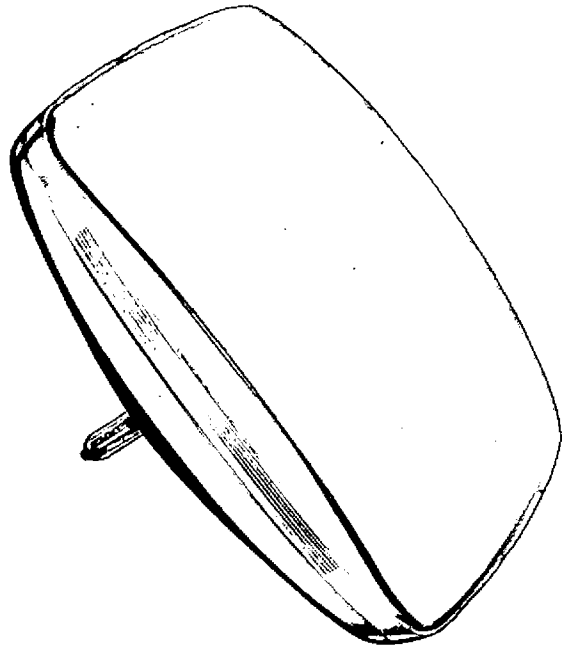
PICTURE TUBE

Low-Voltage Electrostatic Focus
114° Magnetic Deflection

Aluminized Screen
Rectangular Glass Type
Requires No Ion-Trap Magnet

19-1/4" x 15-1/8" Screen
23-31/64" Max. Bulb Diagonal
14-11/16" Max. Overall Length

RCA-23MP4 is a directly viewed, rectangular glass picture tube having an aluminized screen 19-1/4" x 15-1/8" with nearly straight sides and slightly rounded corners, and a minimum projected screen area of 282 square inches. Maximum overall length is 14-11/16".



The 23MP4 features an envelope having a relatively flat, compound radius faceplate and special internal contouring in the deflecting-yoke region to obtain 114° deflection with 110° deflecting components.

Other design features of the 23MP4 include an electron gun that minimizes deflection distortion and requires no ion-trap magnet; a neck diameter of 1-1/8"; an external conductive bulb coating; and a "neoeightar" 7-pin base of the integral glass-button type having straight through leads fitted with an indexing plug.

GENERAL DATA

Electrical:

Heater Current at 6.3 volts	600 ± 30	ma
Heater Warm-up Time (Average)	11	seconds

Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 5 volts.

Direct Interelectrode Capacitances:

Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor*	2500 max.	μμf
	1700 min.	μμf

Focusing Method	Electrostatic
Deflection Method	Magnetic
Deflection Angles (Approx.):	
Diagonal	114°
Horizontal	102°
Vertical	84°
Electron Gun	Type Requiring No Ion-Trap Magnet

Optical:

Faceplate	Filterglass
Light transmission at center (Approx.)	78%
Phosphor	P4-Sulfide Type, Aluminized
Fluorescence	White
Phosphorescence	White
Persistence	Medium Short

Mechanical:

Tube Dimensions:	
Overall length	14-3/8" ± 5/16"
Greatest width	20-1/2" + 1/16" - 1/8"
Greatest height	16-1/2" ± 1/8"
Diagonal	23-25/64" + 3/32" - 1/8"
Neck length	5-1/8" ± 1/8"
Curvature of faceplate:	
External surface—	
Center radius	50"
Edge radius	36-3/4"
Internal surface—	
Center radius	30"
Intermediate radius	48"
Edge radius	24"
Screen Dimensions (Minimum):	
Greatest width	19-1/4"
Greatest height	15-1/8"
Diagonal	22-5/16"
Projected area	282 sq. in.
Bulb	J187 (114°)
Cap	Recessed Small Cavity (JEDEC No.J1-21)
Base	Small-Button Neoeightar 7-Pin, Arrangement 1, (JEDEC No.B7-208)
Basing	BHR
Weight (Approx.)	24 lbs.
Operating Position	Any

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Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

23MP4 6-60
Printed in U.S.A.

GRID-DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum and Minimum Ratings, *Design-Maximum Values:*♦

ULTOR● VOLTAGE	22000 max. 11000 min.	volts volts
GRID-No.4 VOLTAGE:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
GRID-No.2 VOLTAGE	550 max. 200 min.	volts volts
GRID-No.1 VOLTAGE:		
Negative peak value	220 max.	volts
Negative bias value	154 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
HEATER VOLTAGE	6.9 max. 5.7 min.	volts volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	200 max.	volts
Heater positive with respect to cathode	200 max.	volts

Equipment Design Ranges:

With any ultor voltage (E_{c_5k}) between 11000 and 22000 and grid-No.2 voltage (E_{c_2k}) between 220 and 550 volts

Grid-No.4 Voltage for focus§	0 to 400	volts
Grid-No.1 Voltage (E_{c_1k}) for visual extinction of focused raster	*See Raster-Cutoff-Range Chart for Grid-Drive Service*	
Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value (Peak positive)	Same value as determined for E_{c_1k} except video drive is a positive voltage	
Grid-No.4 Current	−25 to +25	μa
Grid-No.2 Current	−15 to +15	μa
Field Strength of Adjustable Centering Magnet♦	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*18000*	*volts*
and grid-No.2 voltage of	*400*	*volts*
Grid-No.4 Voltage for focus§	0 to 400	volts
Grid-No.1 Voltage for visual extinction of focused raster	−36 to −94	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value	36 to 94	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum and Minimum Ratings, *Design-Maximum Values:*♦

ULTOR●-TO-GRID-No.1 VOLTAGE	22000 max. 11000 min.	volts volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	700 max. 200 min.	volts volts
GRID-No.2-TO-CATHODE VOLTAGE	550 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	220 max.	volts
Positive bias value	154 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
HEATER VOLTAGE	6.9 max. 5.7 max.	volts volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	200 max.	volts
Heater positive with respect to cathode	200 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 11000 and 22000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 700 volts

Grid-No.4-to-Grid-No.1 Voltage for focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage (Ekg_1) for visual extinction of focused raster	*See Raster-Cutoff-Range Chart for Cathode-Drive Service*	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value (Peak negative)	Same value as determined for Ekg_1 except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μa
Grid-No.2 Current	−15 to +15	μa
Field Strength of Adjustable Centering Magnet♦	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*18000*	*volts*
and grid-No.2-to grid-No.1 voltage of	*400*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage for visual extinction of focused raster	36 to 78	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value	−36 to −78	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

♦ The **maximum ratings** in the tabulated data are established in accordance with the following definition of the *Design-Maximum Rating System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 23MP4, the ultor function is performed by grid No.5. Since grid No.5, grid-No.3, and collector are connected together within the 23MP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

§ Individual tubes will have satisfactory focus at some value of grid-No.4 (or grid-No.4-to-grid-No.1) voltage between 0 and 400 volts under conditions with the combined bias voltage and video-signal voltage adjusted to produce an ultor current of 200 microamperes.

♦ Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having a 3/8-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 1/2-inch deflection of the spot from the center of the tube face.

OPERATING CONSIDERATIONS

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 23MP4 does not produce any harmful X-ray radiation. However, because the rating of this type permits operation at voltages as high as 22 kilovolts (design-maximum value), shielding of the 23MP4 for X-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Shatter-Proof Cover Over the Tube Face. Following conventional picture-tube practice, it is recommended that the cabinet be provided with a shatter-proof, glass cover over the face of the 23MP4 to protect it from being struck accidentally and to protect against possible damage resulting from tube implosion under some abnormal condition. This safety cover can also provide X-ray protection when required.

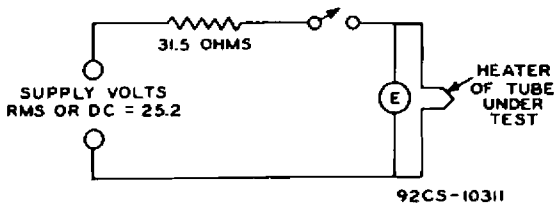


Fig. 1 - Test Circuit for Determining Heater Warm-Up Time.

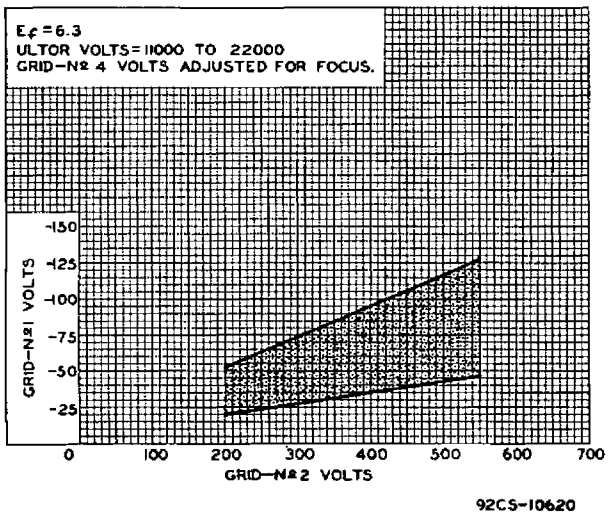


Fig. 2 - Raster-Cutoff-Range Chart for Type 23MP4 in Grid-Drive Service.

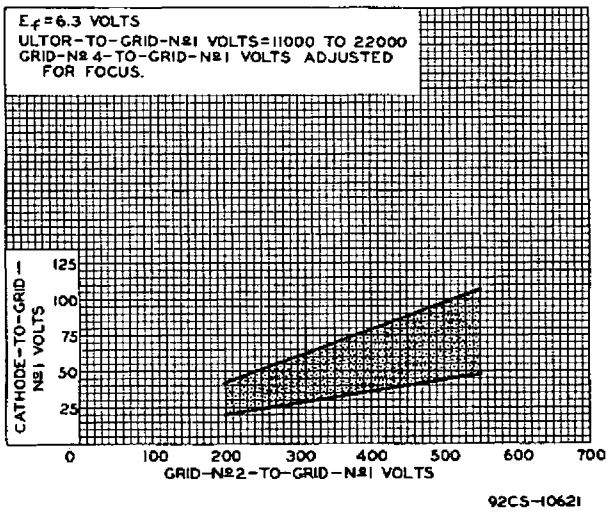


Fig. 3 - Raster-Cutoff-Range Chart for Type 23MP4 in Cathode-Drive Service.

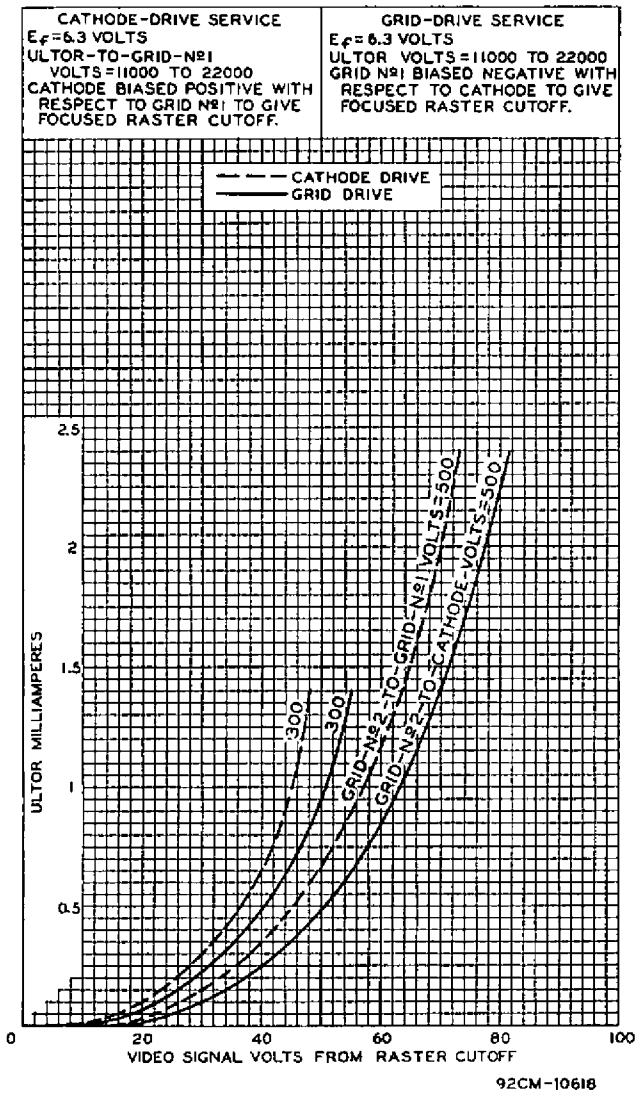


Fig. 4 – Average Drive Characteristics of Type 23MP4.

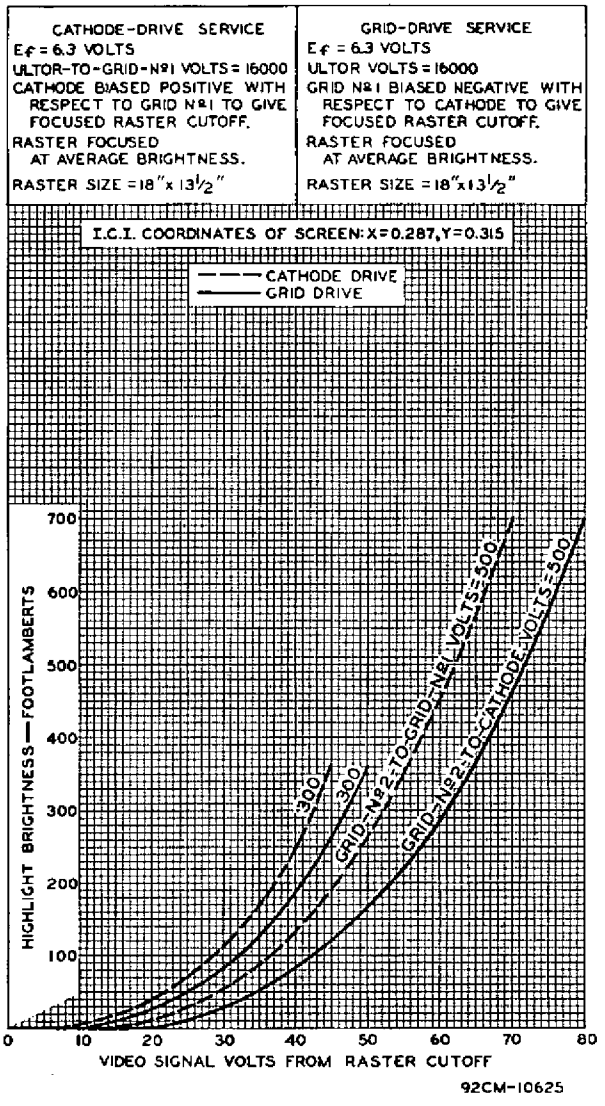
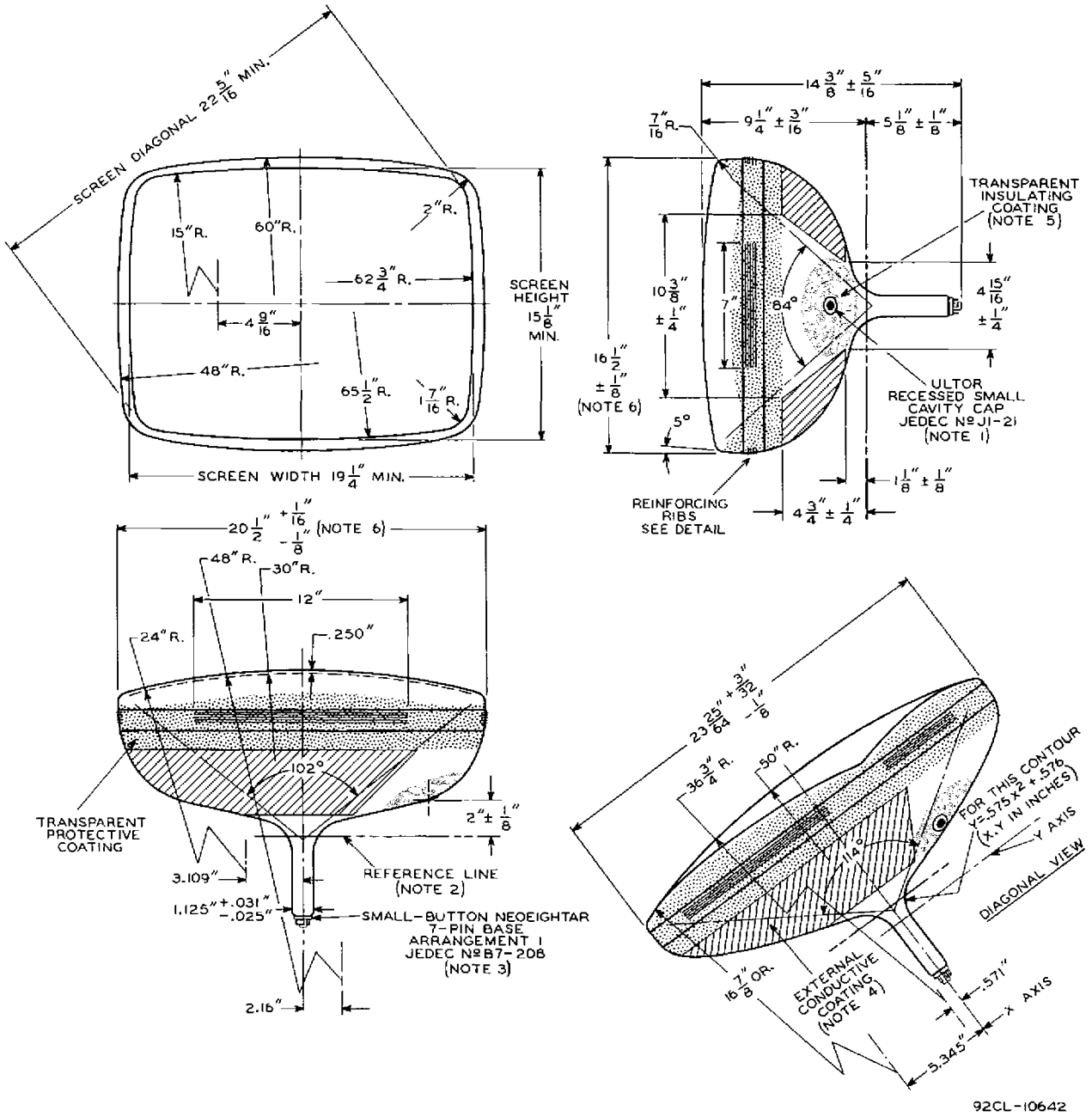
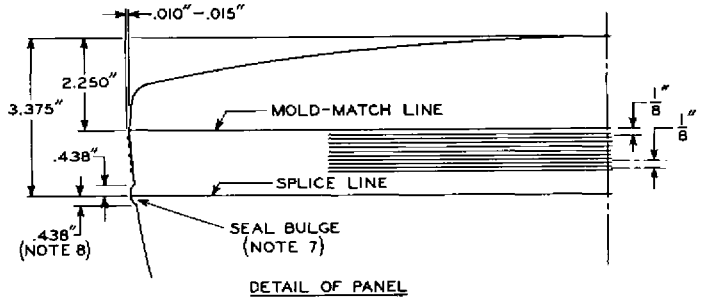


Fig. 5 – Average Drive Characteristics of Type 23MP4.

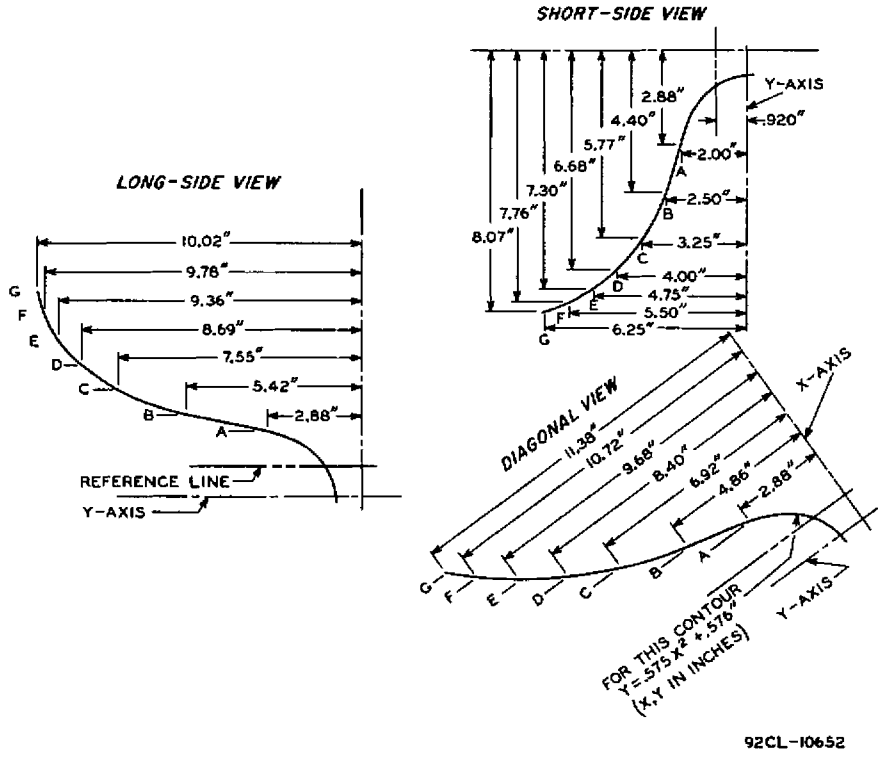
DIMENSIONAL OUTLINE





DETAIL OF PANEL

BULB-CONTOUR DIMENSIONS



NOTE: PLANES A THRU G ARE NORMAL TO THE TUBE AXIS AND AT FIXED LOCATIONS FROM THE Y AXIS. THESE COORDINATES DESCRIBE THE BULB EXTERNAL CONTOUR IN PLANES THROUGH THE TUBE AXIS AND THE RESPECTIVE FACEPLATE AXES.

NOTES FOR DIMENSIONAL OUTLINE

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN NO.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ±30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN NO.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC NO.G-126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT THE CIRCUITRY CANNOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

NOTE 6: MEASURED AT THE MOLD-MATCH LINE.

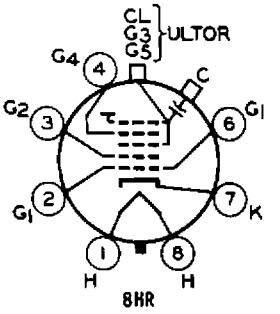
NOTE 7: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE LOCATION SPECIFIED FOR DIMENSIONING THE ENVELOPE WIDTH, DIAGONAL, AND HEIGHT.

NOTE 8: AREA BETWEEN MOLD-MATCH LINE AND SEAL BULGE IS 1/2" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND. SUPPORTS MUST BE SPACED FROM THE TUBE BY THE USE OF CUSHIONING PADS MADE OF ASPHALT, IMPREGNATED FELT OR EQUIVALENT.

SOCKET CONNECTIONS

Bottom View

PIN 1: HEATER
PIN 2: GRID NO.1
PIN 3: GRID NO.2
PIN 4: GRID NO.4
PIN 6: GRID NO.1



PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

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from JEDEC release #2874, July 4, 1960

Attention is called to the use of Design-Maximum Ratings for this type.

23NP4

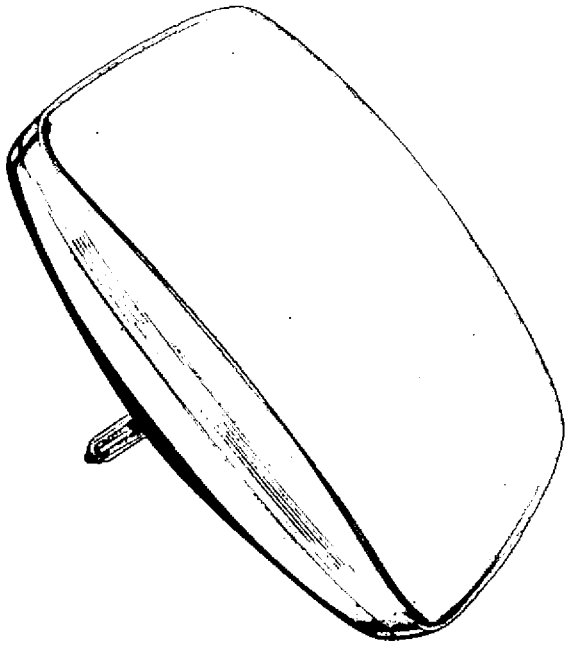
PICTURE TUBE

Low-Voltage Electrostatic Focus
114° Magnetic Deflection

Aluminized Screen
Low-Grid-No.2-Voltage Type
for Cathode-Drive Operation

19-1/4" x 15-1/8" Screen
23-31/64" Max. Bulb Diagonal
14-11/16" Max. Overall Length

RCA-23NP4 is a directly viewed, rectangular glass picture tube having an aluminized screen 19-1/4" x 15-1/8" with nearly straight sides and slightly rounded corners, and a minimum projected screen area of 282 square inches. Maximum overall length is 14-11/16".



The 23NP4 features an envelope having a relatively flat, compound radius faceplate and special internal contouring in the deflecting yoke region to obtain 114° deflection with 110° deflecting components.

The 23NP4 has an electron gun that has improved cathode-drive sensitivity; that requires no ion-trap magnet; and that minimizes deflection distortion.

Other design features of the 23NP4 include a neck diameter of 1-1/8"; an external conductive bulb coating; and a "neoeightar" 7-pin base of the integral glass-button type having straight through leads fitted with an indexing plug.

GENERAL DATA

Electrical:

Heater Current at 6.3 volts	600 ± 30	ma
Heater Warm-Up Time (Average)	11	seconds

Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 5 volts.

Direct Interelectrode Capacitances:

Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor●	2500 max.	μμf
	1700 min.	μμf

Focusing Method	Electrostatic
Deflection Method	Magnetic

Deflection Angles (Approx.):

Diagonal	114°
Horizontal	102°
Vertical	84°

Electron Gun. . . . . Type Requiring No Ion-Trap Magnet

Optical:

Faceplate	Filterglass
Light transmission at center (Approx.)	78%
Phosphor	P4-Sulfide Type, Aluminized
Fluorescence	White
Phosphorescence	White
Persistence	Medium Short

Mechanical:

Tube Dimensions:

Overall length	14-3/8" ± 5/16"
Greatest width	20-1/2" + 1/16"-1/8"
Greatest height	16-1/2" ± 1/8"
Diagonal	23-25/64" + 3/32"-1/8"
Neck length	5-1/8" ± 1/8"
Curvature of faceplate:	
External surface—	
Center radius	50"
Edge radius	36-3/4"
Internal surface—	
Center radius	30"
Intermediate radius	48"
Edge radius	24"

Screen Dimensions (Minimum):

Greatest width	19-1/4"
Greatest height	15-1/8"
Diagonal	22-5/16"
Projected area	282 sq. in.
Bulb	J167 (114°)
Cap	Recessed Small Cavity (JEDEC No.J1-21)
Base	Small-Button Neoeightar 7-Pin, Arrangement 1, (JEDEC No.B7-208)
Basing	8HR
Weight (Approx.)	24 lbs.
Operating Position	Any

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

23NP4 6-60
Printed in U.S.A.

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum and Minimum Ratings, *Design-Maximum Values:*♦

ULTOR●-TO-GRID-No.1 VOLTAGE	22000 max.	volts
	11000 min.	volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1100 max.	volts
Negative value	550 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	70 max.	volts
	40 min.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	220 max.	volts
Positive bias value	154 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
HEATER VOLTAGE	6.9 max.	volts
	5.7 min.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	200 max.	volts
Heater positive with respect to cathode	200 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage (E_{c5g_1}) between 11000 and 22000 volts and grid-No.2-to-grid-No.1 voltage (E_{c2g_1}) between 44 and 70 volts

Grid-No.4-to-Grid-No.1 Voltage for focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage (E_{kg_1}) for visual extinction of focused raster	*See Raster-Cutoff-Range Chart*	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black level):		
White-level value (Peak negative)	Same value as determined for E_{kg_1} except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μa
Grid-No.2 Current	−15 to +15	μa
Field Strength of Adjustable Centering Magnet♦	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*18000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*50*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage for visual extinction of focused raster	34 to 49	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black level):		
White-level value	−34 to −49	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

♦ The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Maximum Rating System* for rating electron tubes.

Design-Maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Design-Maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, and environmental conditions.

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 23NP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 23NP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

§ Individual tubes will have satisfactory focus at some value of grid-No.4-to-grid-No.1 voltage between 0 and 400 volts with the combined bias voltage and video-signal voltage adjusted to give an ultor current of 200 microamperes.

♦ Distance from Reference Line for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having a 7/16-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 1/2-inch deflection of the spot from the center of the tube face.

OPERATING CONSIDERATIONS

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 23NP4 does not produce any harmful X-ray radiation. However, because the rating of this type permits operation at voltages as high as 22 kilovolts (design-maximum value), shielding of the 23NP4 for X-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Shatter-Proof Cover Over the Tube Face. Following conventional picture-tube practice, it is recommended that the cabinet be provided with a shatter-proof, glass cover over the face of the 23NP4 to protect it from being struck accidentally and to protect it against possible damage resulting from tube implosion under some abnormal condition. This safety cover can also provide X-ray protection when required.

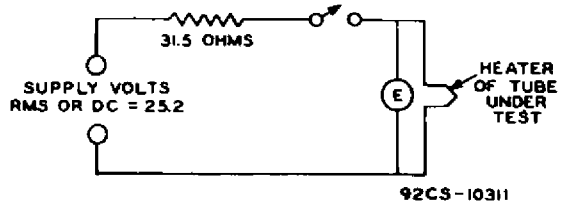


Fig. 1 – Test Circuit for Determining Heater Warm-Up Time.

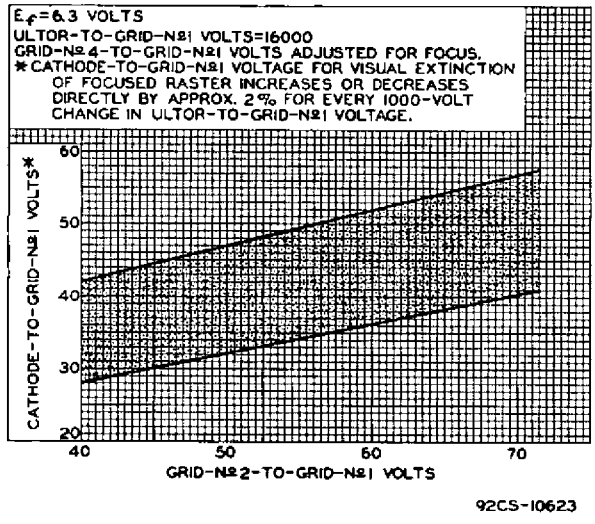


Fig. 2 – Raster-Cutoff-Range Chart for Type 23NP4.

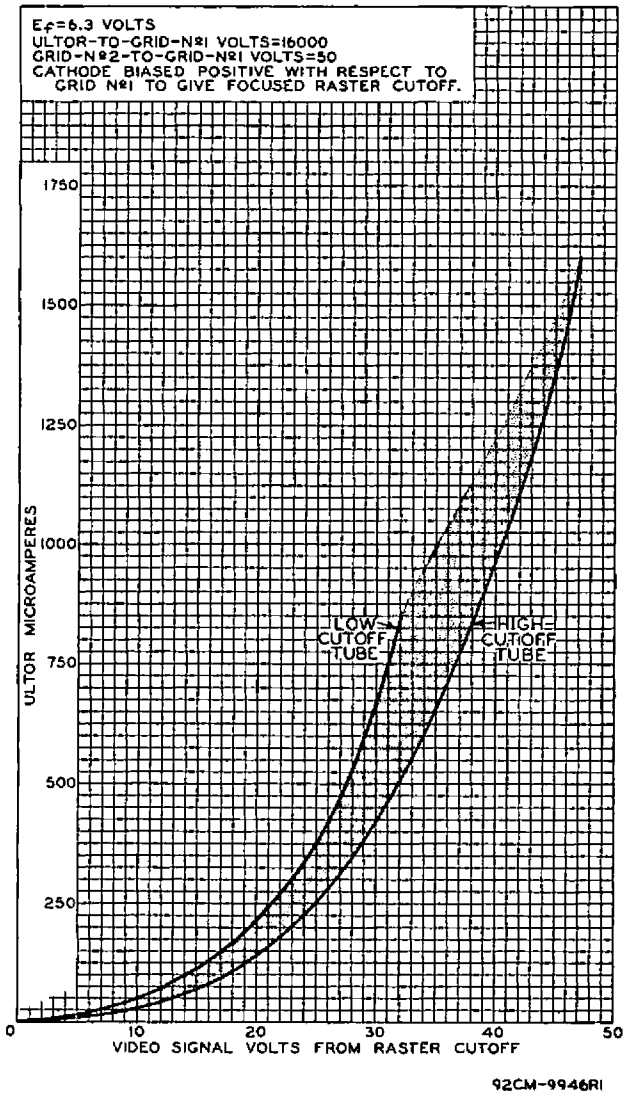


Fig. 3 – Cathode-Drive Characteristics of Type 23NP4.

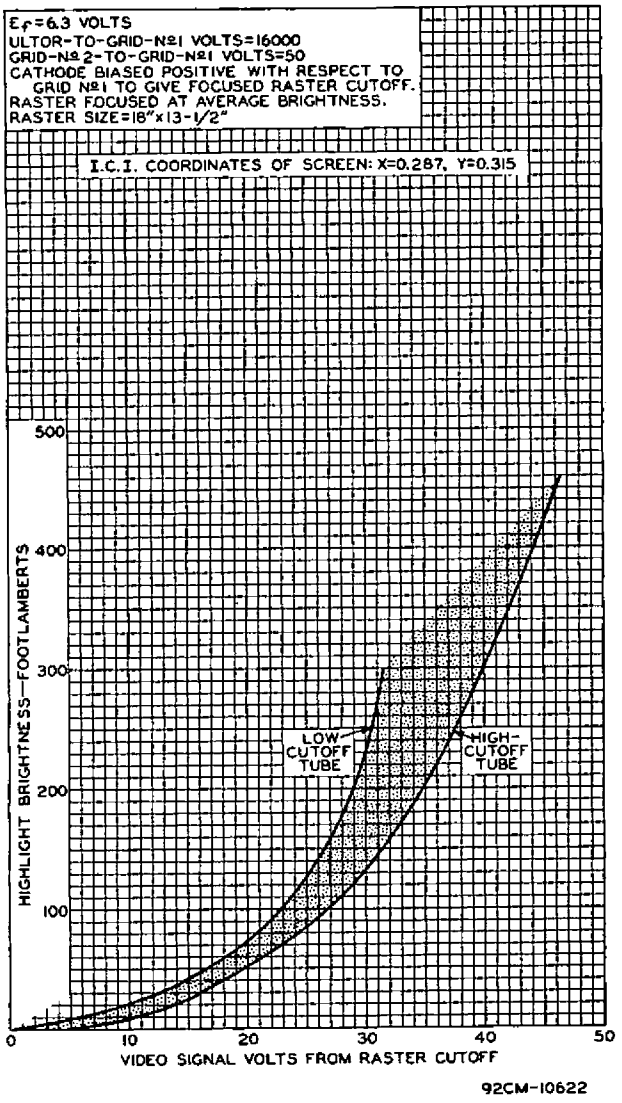
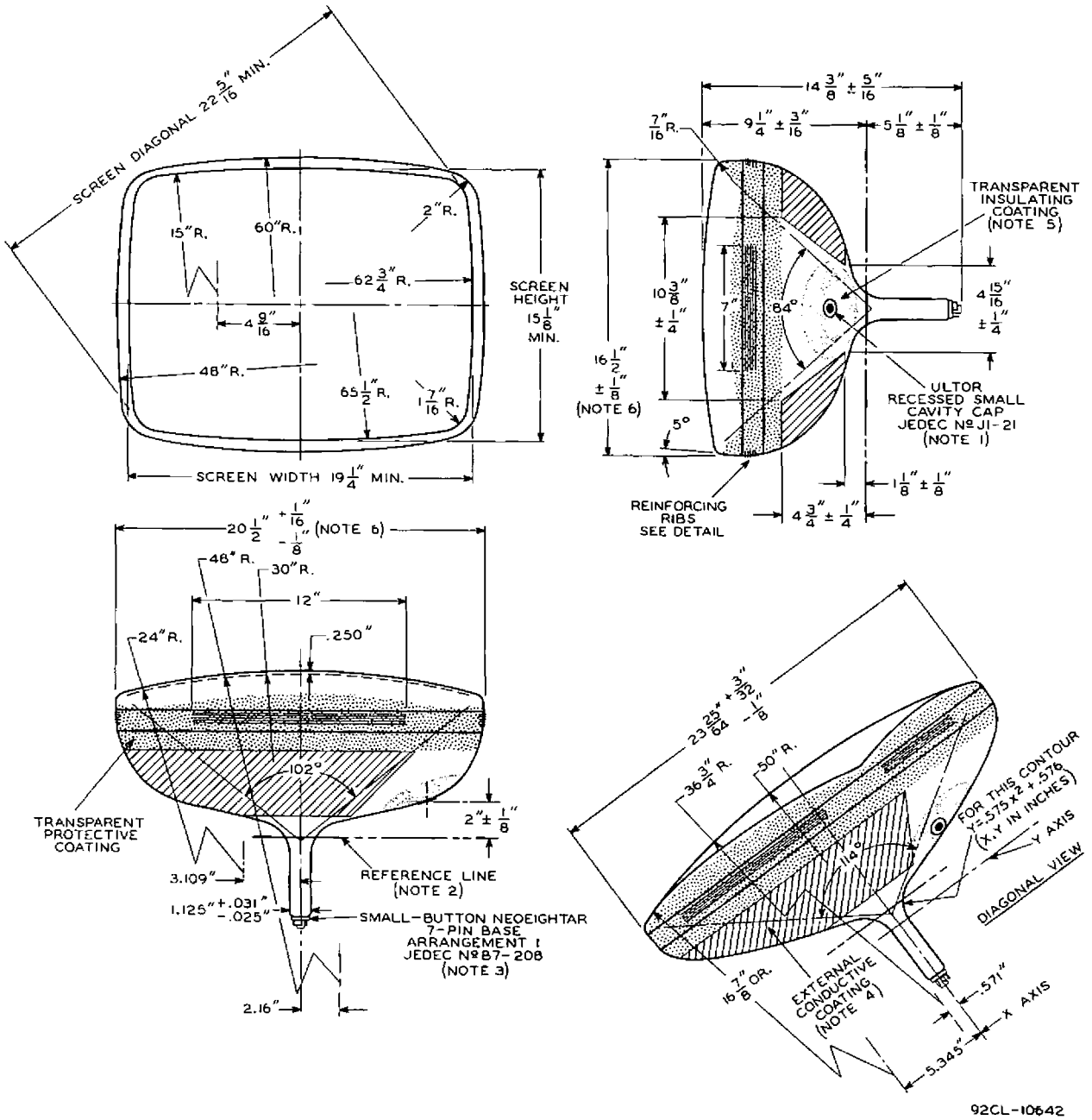


Fig. 4 – Cathode Drive Characteristics of Type 23NP4.

DIMENSIONAL OUTLINE



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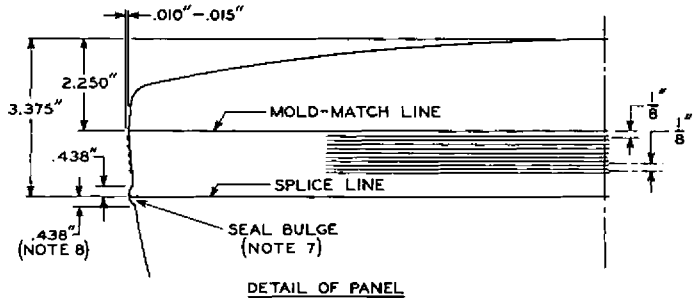
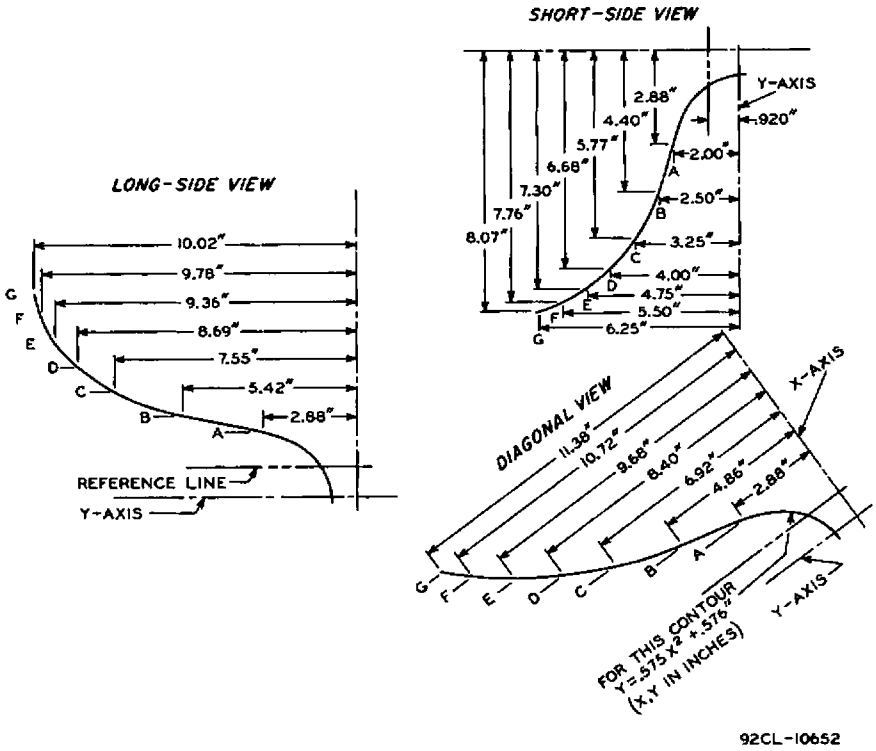


DETAIL OF PANEL

BULB-CONTOUR DIMENSIONS



NOTE: PLANES A THRU G ARE NORMAL TO THE TUBE AXIS AND AT FIXED LOCATIONS FROM THE Y AXIS. THESE COORDINATES DESCRIBE THE BULB EXTERNAL CONTOUR IN PLANES THROUGH THE THE TUBE AXIS AND THE RESPECTIVE FACEPLATE AXES.

NOTES FOR DIMENSIONAL OUTLINE

NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN No.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC No.G-126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT THE CIRCUITRY CANNOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

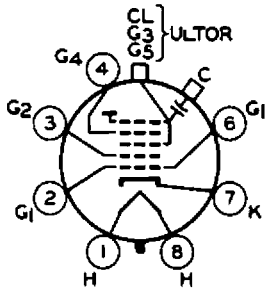
NOTE 6: MEASURED AT THE MOLD-MATCH LINE.

NOTE 7: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE LOCATION SPECIFIED FOR DIMENSIONING THE ENVELOPE WIDTH, DIAGONAL, AND HEIGHT.

NOTE 8: AREA BETWEEN MOLD-MATCH LINE AND SEAL BULGE IS 1/2" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND. SUPPORTS MUST BE SPACED FROM THE TUBE BY THE USE OF CUSHIONING PADS MADE OF ASPHALT, IMPREGNATED FELT OR EQUIVALENT.

SOCKET CONNECTIONS
Bottom View

PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.2
PIN 4: GRID No.4
PIN 6: GRID No.1



8HR

PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

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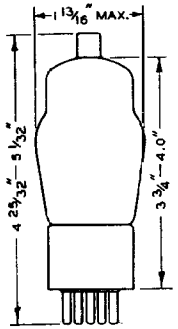
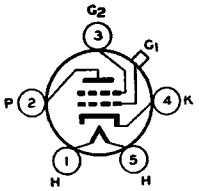


RCA-24-A

SCREEN-GRID RADIO-FREQUENCY AMPLIFIER



The 24-A is a screen-grid amplifier tube of the heater-cathode type for use primarily as a radio-frequency amplifier in a-c receivers. The 24-A may also be used as a screen-grid detector or audio amplifier.

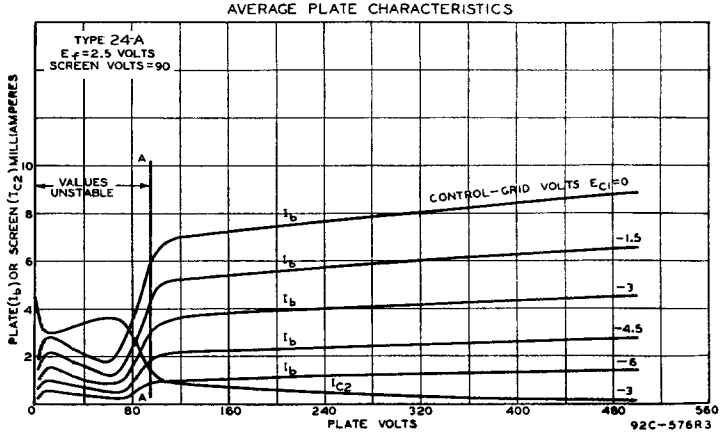
CHARACTERISTICS

Heater Voltage (A. C. or D. C.)		2.5	Volts
Heater Current		1.75	Amperes
Plate Voltage*	180	250	Volts
Screen Voltage (Grid No. 2)	90 *max.*	90 *max.*	Volts
Grid Voltage (Grid No. 1)	−3	−3	Volts
Plate Current	4	4	Milliamperes
Screen Current (Maximum)	1.7	1.7	Milliamperes
Plate Resistance	0.4	0.6	Megohm
Amplification Factor	400	630	
Transconductance	1000	1050	Micromhos
Grid-Plate Capacitance (With shield-can)		0.007 *max.*	$\mu\mu$f
Input Capacitance		5.3	$\mu\mu$f
Output Capacitance		10.5	$\mu\mu$f
Bulb			ST-14
Cap			Small Metal
Base			Medium 5-Pin

* Maximum plate voltage = 275 volts.

INSTALLATION AND APPLICATION

The **base** pins of the 24-A fit the standard five-contact socket. The socket may be installed to hold the tube in any position. For **heater** operation and **cathode** connection, refer to type 2A5. The **screen voltage** for the 24-A may be obtained from a fixed or variable tap on a voltage divider across the high-voltage supply, or across a portion of the supply. Complete **shielding** in all stages of the circuit is necessary if maximum gain per stage is to be obtained.



24AHP4

PICTURE TUBE

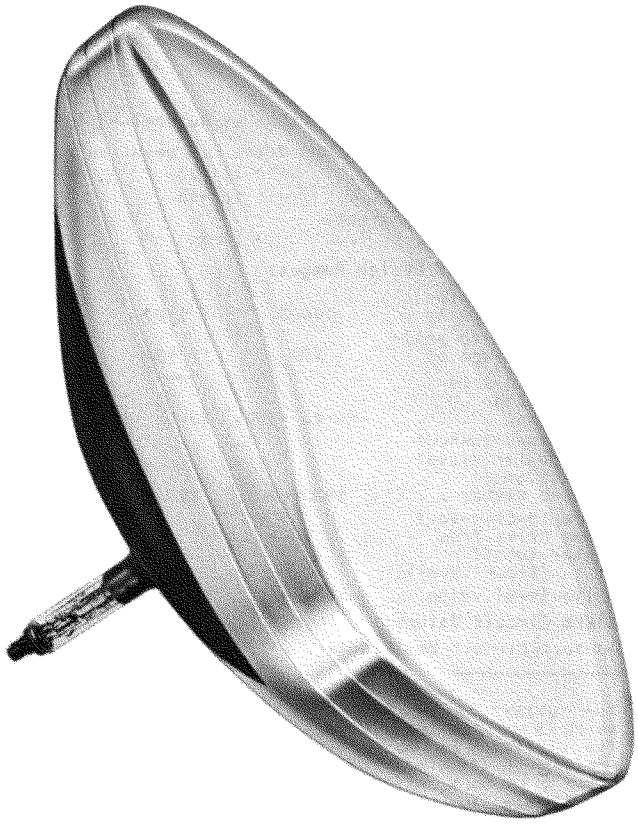
Low-Voltage Electrostatic Focus
110° Magnetic Deflection

Aluminized Screen
Very Short Rectangular Glass Type
Requires No Ion-Trap Magnet

21-7/16" x 16-7/8" Screen
24-1/8" Max. Bulb Diagonal
16-3/16" Max. Length

TENTATIVE DATA

RCA-24AHP4 is a very short, directly viewed, rectangular, glass picture tube of the low-voltage electrostatic-focus and magnetic-deflection type. It has a spherical Filterglass faceplate, an aluminized screen 21-7/16" x 16-7/8" with slightly curved sides and rounded corners and a minimum projected screen area of 332 square inches.



Designed with a 110°-diagonal deflection angle, the 24AHP4 has very short length--a length approximately 5-1/4" shorter than types having the same size faceplate and 90° deflection. As a result, this tube establishes new concepts for cabinet styling and for the design of more compact TV receivers utilizing 24"-type picture tubes.

The 24AHP4 has a neck diameter of only 1-1/8" which not only makes possible the use of a deflecting yoke having high deflection sensitivity but also permits deflection of the beam through the wide deflection angle with only slightly more power than is required to scan a tube with 90° deflection angle.

The 24AHP4 utilizes a new electron gun of the "straight" type designed to minimize deflection distortion. This new electron gun eliminates the need for an ion-trap magnet.

Another design feature of the 24AHP4 is an integral glass-button base having straight-through leads fitted with an indexing plug. This basing arrangement eliminates any possibility of loose base-pin connections. In addition, the 24AHP4 has an external conductive bulb coating which with the internal conductive coating forms a supplementary filter capacitor.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6 ± 10%	amp
Direct Interelectrode Capacitances:		
Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor●	2500 max. 2000 min.	μμf μμf
Faceplate, Spherical	Filterglass	
Light transmission (Approx.)	76%	
Phosphor	P4--Sulfide Type, Aluminized	
Fluorescence	White	
Phosphorescence	White	
Persistence	Short	
Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angles (Approx.):		
Diagonal	110°	
Horizontal	105°	
Vertical	87°	
Electron Gun	Type Requiring No Iron-Trap Magnet	
Tube Dimensions:		
Overall length	15-7/8" ± 5/16"	
Greatest width	22-11/16" ± 1/8"	
Greatest height	18-1/2" ± 1/8"	
Diagonal	24" ± 1/8"	
Neck length	5-7/16" ± 1/8"	

TMK ®, Marca Registrada
Printed in U.S.A.

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Screen Dimensions (Minimum):	
Greatest width	21-7/16"
Greatest height	16-7/8"
Diagonal	22-13/16"
Projected area	332 sq. in.
Cap.	Recessed Small Cavity (JETEC No.J1-21)
Bulb	J192 (110°)
Base	Small-Button Eightar 7-Pin, Arrangement 2, (JETEC No.B7-183)
Weight (Approx.)	28 lbs
Mounting Position	Any

GRID-DRIVE▲ SERVICE

Unless otherwise specified, voltage values are positive with respect to cathode

Maximum Ratings, *Design-Center Values:*

ULTOR● VOLTAGE	20000✠ max.	volts
	12000✠ min.	volts
GRID-No.4 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2 VOLTAGE	500 max.	volts
GRID-No.1 VOLTAGE:		
Negative peak value	200 max.	volts
Negative bias value	140 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	410 max.	volts
After equipment warm-up period	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor voltage (E_{c_5k}) between 12000 and 20000 volts and grid-No.2 voltage (E_{c_2k}) between 200 and 500 volts

Grid-No.4-Voltage for Focus§	−50 to +350	volts
Grid-No.1 Voltage (E_{c_1k}) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Grid-Drive Service	
Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak positive). . .Same value as determined for E_{c_1k} except video drive is a positive voltage		
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor voltage of	*14000*	*16000*	*volts*
and grid-No.2 voltage of	*300*	*400*	*volts*
Grid-No.4 Voltage for Focus	−50 to +350	−50 to +350	volts
Grid-No.1 Voltage for Visual Extinction of Focused Raster	−28 to −72	−36 to −94	volts
Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	28 to 72	36 to 94	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum Ratings, *Design-Center Values:*

ULTOR●-TO-GRID-No.1 VOLTAGE	20000✠ max.	volts
	12000✠ min.	volts
GRID-No.4-TO-GRID-No.1 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-No.2-TO-GRID-No.1 VOLTAGE	640 max.	volts
GRID-No.2-TO-CATHODE VOLTAGE	500 max.	volts
CATHODE-TO-GRID-No.1 VOLTAGE:		
Positive peak value	200 max.	volts
Positive bias value	140 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	410 max.	volts
After equipment warm-up period	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 12000 and 20000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 225 and 640 volts

Grid-No.4-to-Grid-No.1 Voltage for Focus§	−50 to +350	volts
Cathode-to-Grid-No.1 Voltage (Ekg_1) for Visual Extinction of Focused Raster	See *Raster-Cutoff-Range Chart* for Cathode-Drive Service	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak negative). . .Same value as determined for Ekg_1 except video drive is a negative voltage		
Grid-No.4 Current	−25 to +25	μamp
Grid-No.2 Current	−15 to +15	μamp
Field Strength of Adjustable Centering Magnet*	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*14000*	*16000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*300*	*400*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for Focus	−50 to +350	−50 to +350	volts
Cathode-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster	28 to 60	36 to 78	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):			
White-level value	−28 to −60	−36 to −78	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 24AHP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 24AHP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

▲ Grid drive is the operating condition in which the video signal varies the grid-No.1 potential with respect to cathode.

✠ This value is a working design-center minimum. The equivalent *absolute minimum* ultor, or ultor-to-grid-No.1, voltage is 11000 volts, below which the serviceability of the 24AHP4 will be impaired. The equipment designer has the responsibility of determining a minimum design value such that under the worst probable operating conditions involving supply-voltage variation and equipment variation the absolute minimum ultor, or ultor-to-grid-No.1, voltage is never less than 11000 volts.

§ The grid-No.4 voltage or grid-No.4-to-grid-No.1 voltage required for focus of any individual tube is independent of ultor current and will remain essentially constant for values of ultor voltage (or ultor-to-grid-No.1 voltage) or grid-No.2 voltage (or grid-No.2-to-grid-No.1 voltage) within design ranges shown for these items.

* Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having a 7/16-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 1/2-inch deflection of the spot from the center of the tube face.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ± 10 per cent of line-center voltage value of 117 volts.

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 24AHP4 does not produce any harmful X-ray radiation. However, because the rating of this type permits operation at voltages as high as 22 kilovolts (absolute maximum value), shielding of the 24AHP4 for X-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Shatter-Proof Cover Over the Tube Face. Following conventional picture-tube practice, it is recommended that the cabinet be provided with a shatter-proof, glass cover over the face of the 24AHP4 to protect it from being struck accidentally and to protect against possible damage resulting from tube implosion under some abnormal condition. This safety cover can also provide X-ray protection when required.

The *base pins* of the 24AHP4 fit the Eightar 8-contact socket, such as Ucinite Part No. 115446, or equivalent. The design of the socket should be such that the circuit wiring cannot impress lateral strains through the socket contacts on the base pins.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

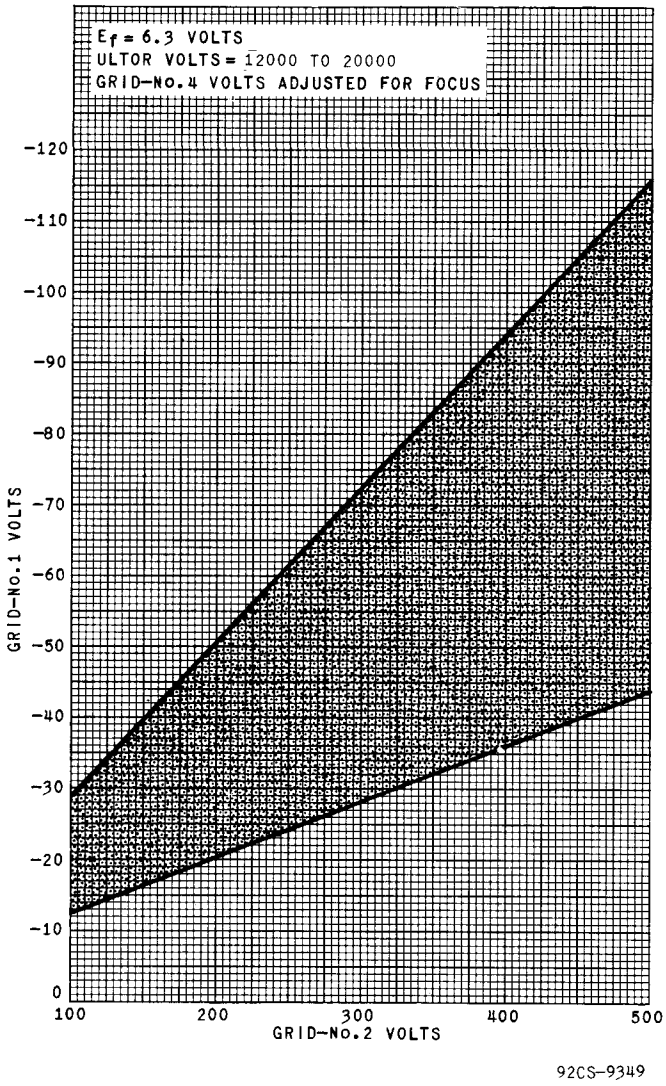


Fig. 1 - Raster-Cutoff Range for Type 24AHP4 in Grid-Drive Service.

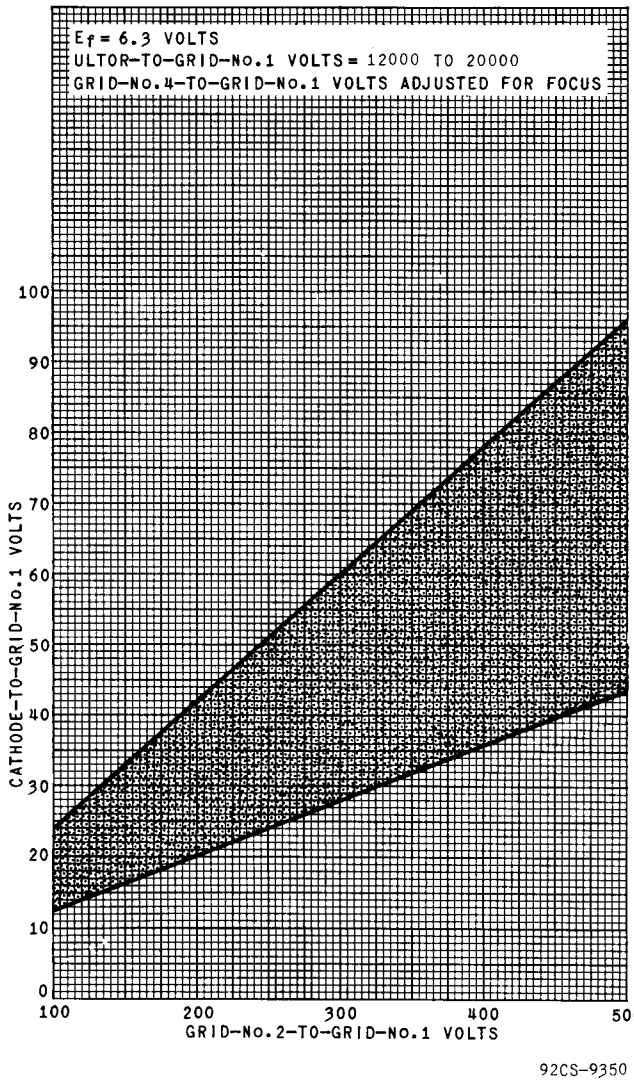


Fig. 2 - Raster-Cutoff Range for Type 24AHP4 in Cathode-Drive Service.

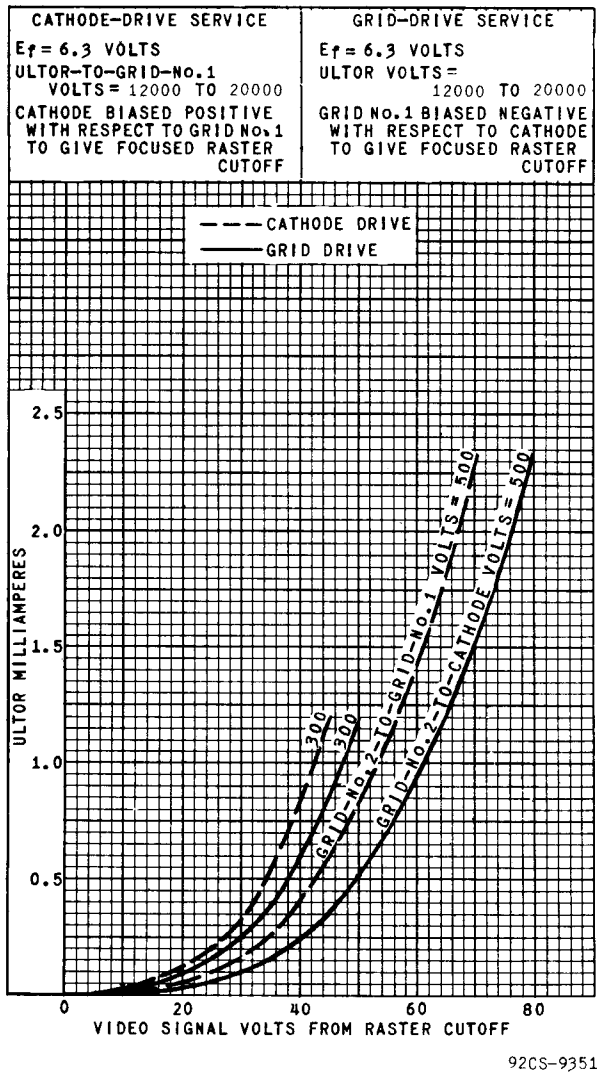


Fig. 3 - Average Drive Characteristics of Type 24AHP4.

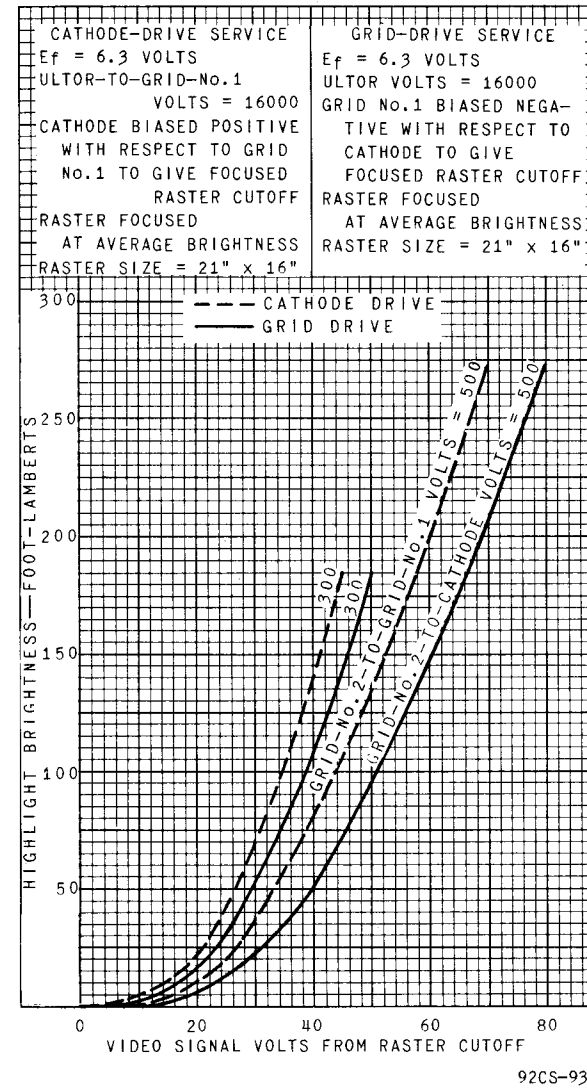
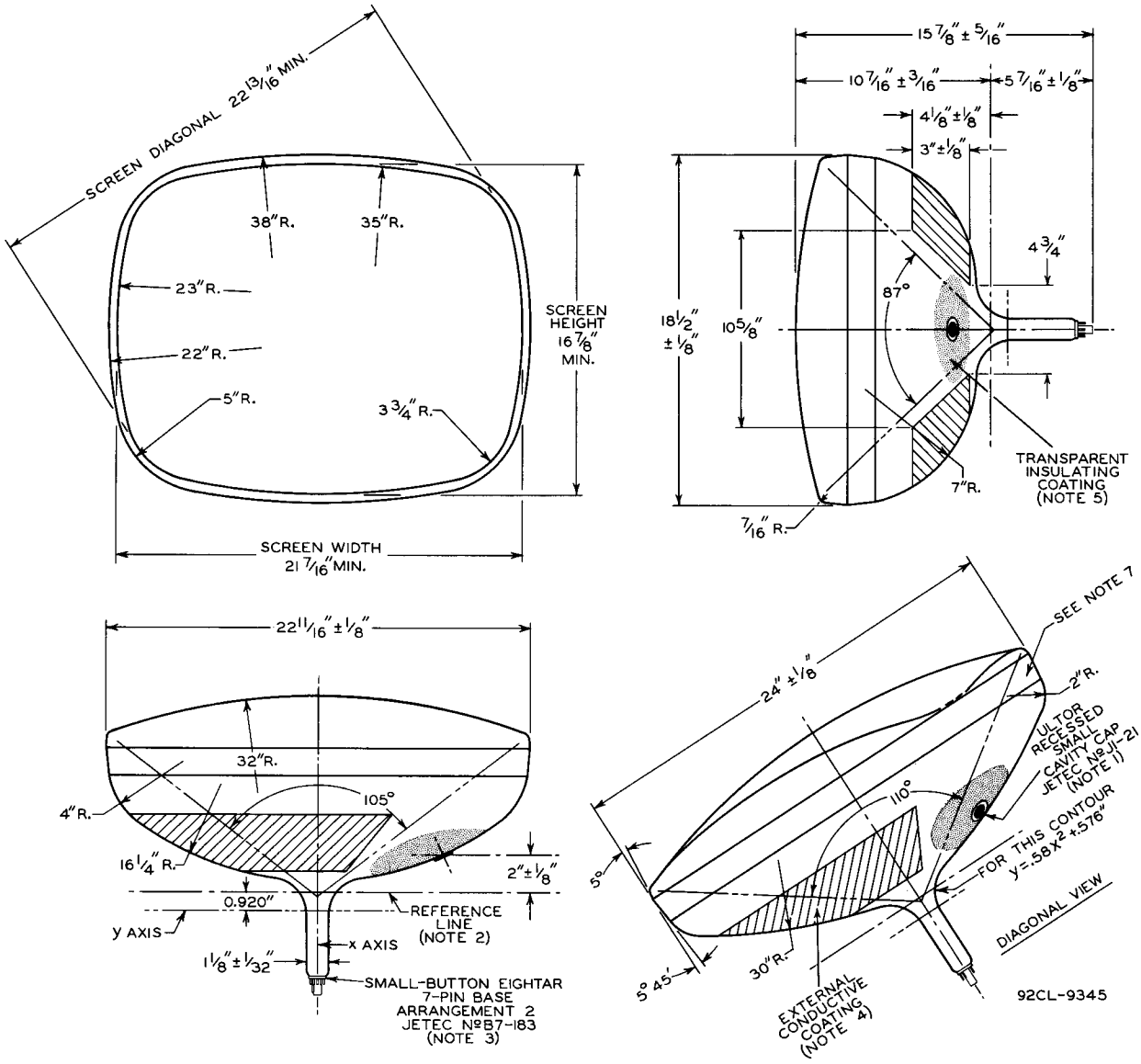


Fig. 4 - Average Drive Characteristics of Type 24AHP4.

DIMENSIONAL OUTLINE



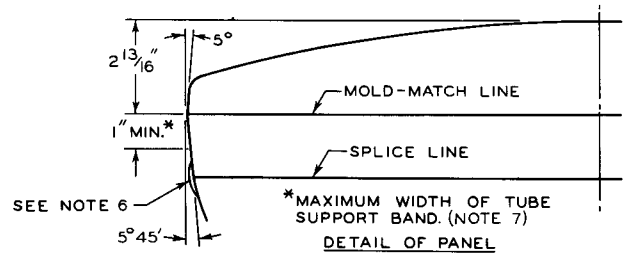
NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN No.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JETEC No.126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT THE CIRCUIT WIRING CANNOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

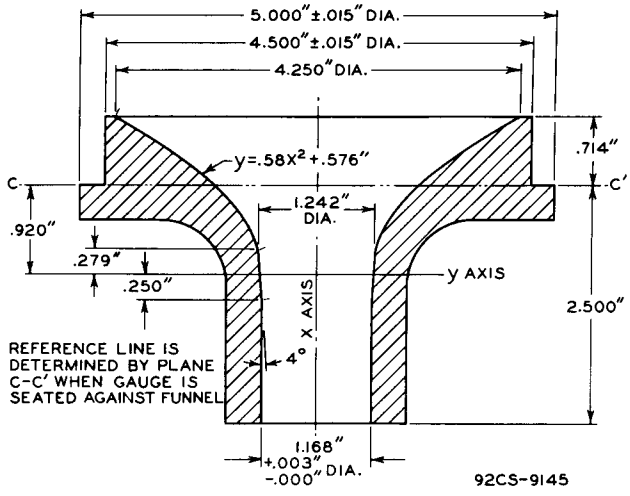
NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINT-LESS CLOTH.



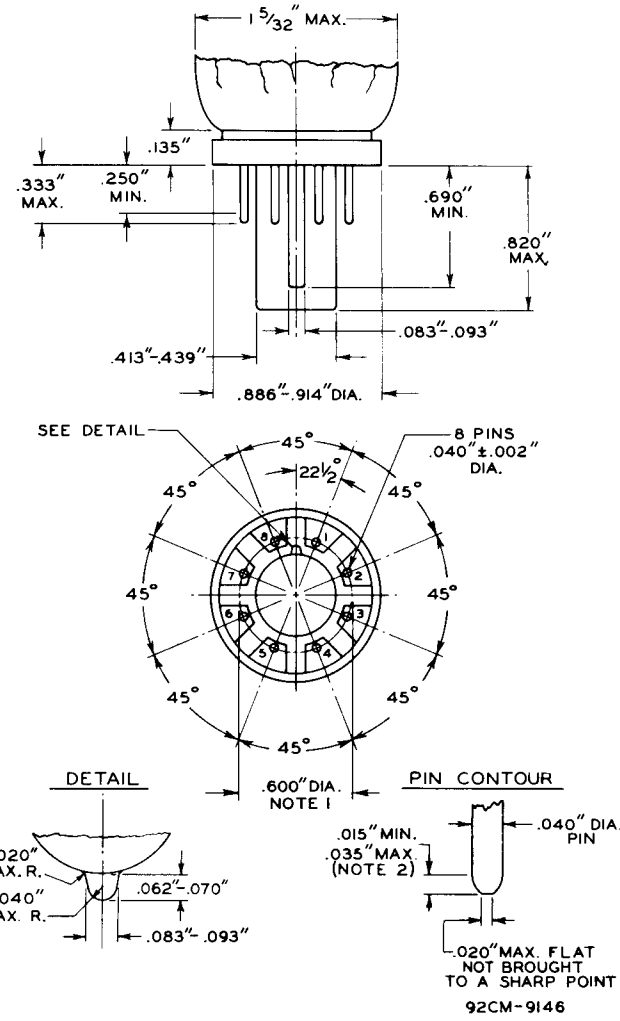
NOTE 6: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE MOLD-MATCH LINE.

NOTE 7: UNDISTURBED AREA BETWEEN MOLD-MATCH LINE AND SPLICE LINE IS 1" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND.

REFERENCE-LINE AND NECK-FUNNEL-CONTOUR GAUGE JETEC Nº 126

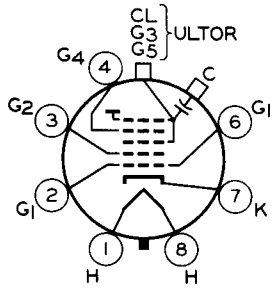


SMALL-BUTTON EIGHTAR BASE



SOCKET CONNECTIONS

Bottom View



8HR

PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.2
PIN 4: GRID No.4
PIN 6: GRID No.1
PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

NOTE 1: BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT THE BASE WILL FIT A FLAT-PLATE GAUGE HAVING A THICKNESS OF 3/8" AND EIGHT EQUALLY SPACED HOLES OF 0.0550" ± 0.0005" DIAMETER LOCATED ON A 0.6000" ± 0.0005" DIAMETER CIRCLE. THE GAUGE IS ALSO PROVIDED WITH A CENTER HOLE TO PROVIDE 0.010" DIAMETRIC CLEARANCE FOR THE LUG AND KEY. PIN FIT IN THE GAUGE SHALL BE SUCH THAT THE ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, ENTER INTO AND DISENGAGE FROM THE GAUGE.

NOTE 2: THIS DIMENSION AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN MAY VARY WITHIN THE LIMITS SHOWN.

JETEC No.	No. OF PINS	PINS
B8-181	8-Pin	1,2,3,4,5,6,7,8
B7-182	7-Pin Arrangement 1	2,3,4,5,6,7,8
B7-183	7-Pin Arrangement 2	1,2,3,4, 6,7,8

from JEDEC release #2442, April 13, 1959

24BAP4

PICTURE TUBE

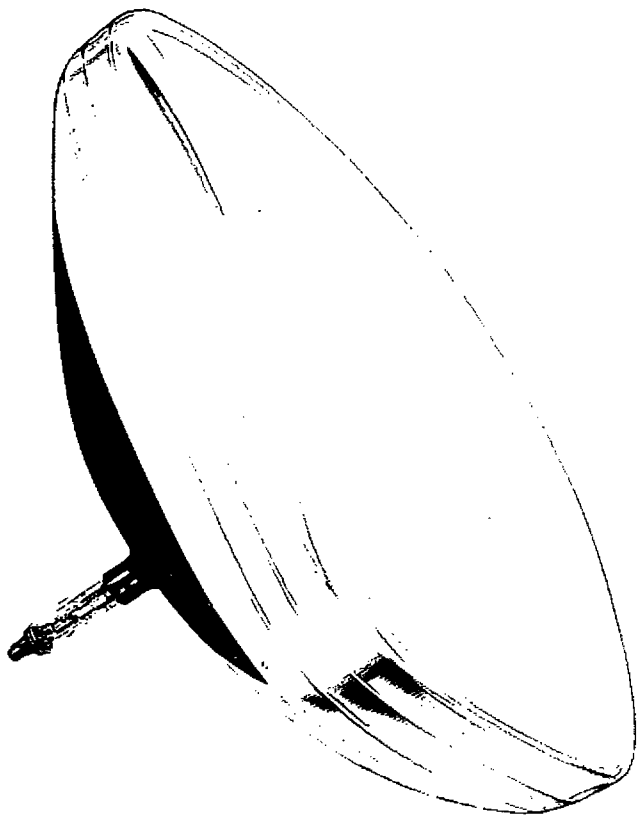
Low-Voltage Electrostatic Focus
110° Magnetic Deflection

Aluminized Screen
Low-Grid-No.2-Voltage Type
for Cathode-Drive Operation

21-7/16" x 16-7/8" Screen
24-1/8" Max. Bulb Diagonal
16-3/16" Max. Length

TENTATIVE DATA

RCA-24BAP4 is a directly viewed, rectangular glass picture tube having a 24-inch diagonal envelope. Employing a 110°-diagonal deflection angle and low-voltage electrostatic focus, it is intended primarily for use in cathode-drive applications.



Featured in the 24BAP4 is an electron gun that has improved cathode-drive sensitivity; that requires no ion-trap magnet; and that minimizes deflection distortion.

The neck of the 24BAP4 has a diameter of only 1-1/8 inches which makes possible the use of a deflecting yoke having high deflection sensitivity and permits deflection of the beam through the wide deflection angle with only slightly more power than is required to scan a tube with 90° deflection angle.

The 24BAP4 has a spherical Filterglass faceplate; an aluminized screen 21-7/16" x 16-7/8" with slightly curved sides and rounded corners; a minimum projected screen area of 332 square inches; a maximum overall length of 16-3/16"; an external conductive bulb coating; and an integral glass-button base having straight-through leads fitted with an indexing plug.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	amp
Direct Interelectrode Capacitances:		
Grid No.1 to all other electrodes	6	μμf
Cathode to all other electrodes	5	μμf
External conductive coating to ultor●	2500 max. / 2000 min.	μμf
Faceplate, Spherical		Filterglass
Light transmission (Approx.)		76%
Phosphor		P4--Sulfide Type Aluminized
Fluorescence		White
Phosphorescence		White
Persistence		Short
Focusing Method		Electrostatic
Deflection Method		Magnetic
Deflection Angles (Approx.):		
Diagonal		110°
Horizontal		105°
Vertical		87°
Electron Gun		Type Requiring No Ion-Trap Magnet
Tube Dimensions:		
Overall length		15-7/8" ± 5/16"
Greatest width		22-11/16" ± 1/8"
Greatest height		18-1/2" ± 1/8"
Diagonal		24" ± 1/8"
Neck length		5-7/16" ± 1/8"
Screen Dimensions (Minimum):		
Greatest width		21-7/16"
Greatest height		16-7/8"
Diagonal		22-13/16"
Projected area		332 sq. in.
Cap		Recessed Small Cavity (JEDEC No.J1-21)
Bulb		J192 C_1/D_1

Trademark(s) ® Registered
Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

24BAP4 4-59
Printed in U.S.A.

Socket	Ucinite Part No.115446, or equivalent
Base	Small-Button Eightar 7-Pin, Arrangement 2, (JEDEC NO.B7-183)
Weight (Approx.)	28 lbs
Operating Position	Any

CATHODE-DRIVE■ SERVICE

Unless otherwise specified, voltage values are positive with respect to grid No.1

Maximum Ratings, *Design-Center Values:*

ULTOR●-TO-GRID-NO.1 VOLTAGE	20000 max. / 12000⊕ min.	volts
GRID-NO.4-TO-GRID-NO.1 VOLTAGE:		
Positive value	1000 max.	volts
Negative value	500 max.	volts
GRID-NO.2-TO-GRID-NO.1 VOLTAGE	64 max.	volts
CATHODE-TO-GRID-NO.1 VOLTAGE:		
Positive peak value	200 max.	volts
Positive bias value	140 max.	volts
Negative bias value	0 max.	volts
Negative peak value	2 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	180 max.	volts
Heater positive with respect to cathode	180 max.	volts

Equipment Design Ranges:

With any ultor-to-grid-No.1 voltage ($E_{c_5g_1}$) between 12000 and 20000 volts and grid-No.2-to-grid-No.1 voltage ($E_{c_2g_1}$) between 50 and 64 volts

Grid-No.4-to-Grid-No.1 Voltage for Focus§	0 to 400	volts
Cathode-to-Grid-No.1 Voltage (E_{kg_1}) for Visual Extinction of Focused Raster	*See Raster-Cutoff-Range Chart*	
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level):		
White-level value (Peak negative)	Same value as determined for E_{kg_1} except video drive is a negative voltage	
Grid-No.4 Current	−25 to +25	μa
Grid-No.2 Current	−15 to +15	μa
Field Strength of Adjustable Centering Magnet▲	0 to 8	gausses

Examples of Use of Design Ranges:

With ultor-to-grid-No.1 voltage of	*16000*	*20000*	*volts*
and grid-No.2-to-grid-No.1 voltage of	*50*	*64*	*volts*
Grid-No.4-to-Grid-No.1 Voltage for Focus	0 to 400	0 to 400	volts
Cathode-to-Grid-No.1 Voltage for Visual Extinction of Focused Raster	32 to 47	42 to 58	volts
Cathode-to-Grid-No.1 Video Drive from Raster Cutoff (Black Level): White-level value	−32 to −47	−42 to −58	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms

● The "ultor" in a cathode-ray tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 24BAP4, the ultor function is performed by grid No.5. Since grid No.5, grid No.3, and collector are connected together within the 24BAP4, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

■ Cathode drive is the operating condition in which the video signal varies the cathode potential with respect to grid No.1 and the other electrodes.

⊕ This value is a working design-center minimum. The equivalent *absolute minimum* ultor-to-grid-No.1 voltage is 11000 volts below which the serviceability of the 24BAP4 will be impaired. The equipment designer has the responsibility of determining a minimum design value such that under the worst probable operating conditions involving supply-voltage variation and equipment variation the absolute minimum ultor-to-grid-No.1 voltage is never less than 11000 volts.

§ The grid-No.4-to-grid-No.1 voltage required for optimum focus of any individual tube may have a value anywhere between 0 and 400 volts; is independent of ultor current; and will remain essentially constant for values of ultor-to-grid-No.1 voltage, or grid-No.2-to-grid-No.1 voltage, within design ranges shown for these items.

▲ Distance from *Reference Line* for suitable PM centering magnet should not exceed 2-1/4". Excluding extraneous fields, the center of the undeflected focused spot will fall within a circle having a 3/8-inch radius concentric with the center of the tube face. It is to be noted that the earth's magnetic field can cause as much as 1/2-inch deflection of the spot from the center of the tube face.

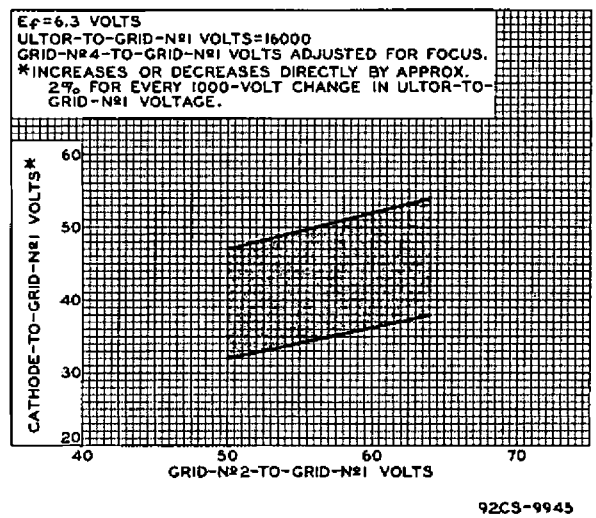


Fig. 1 - Raster-Cutoff-Range Chart for Type 24BAP4.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Design-Center Rating System* for rating electron devices.

Design-Center ratings are limiting values of operating and environmental conditions applicable to a bogey electron device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation*, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The equipment manufacturer should design so that initially no design-center value for the intended service is exceeded with a bogey device in equipment operating at the stated normal supply voltage.*

X-Ray Warning. When operated at ultor voltages up to 16 kilovolts, the 24BAP4 does not produce any harmful X-ray radiation. However, because the rating of this type permits operation at voltages as high as 22 kilovolts (absolute maximum value), shielding of the 24BAP4 for

* For an AC power source, 117 volts ± 10% is accepted U.S.A. practice.

X-ray radiation may be needed to protect against possible injury from prolonged exposure at close range whenever the operating conditions involve voltages in excess of 16 kilovolts.

Shatter-Proof Cover Over the Tube Face. Following conventional picture-tube practice, it is recommended that the cabinet be provided with a shatter-proof, glass cover over the face of the 24BAP4 to protect it from being struck accidentally and to protect against possible damage resulting from tube implosion under some abnormal condition. This safety cover can also provide X-ray protection when required.

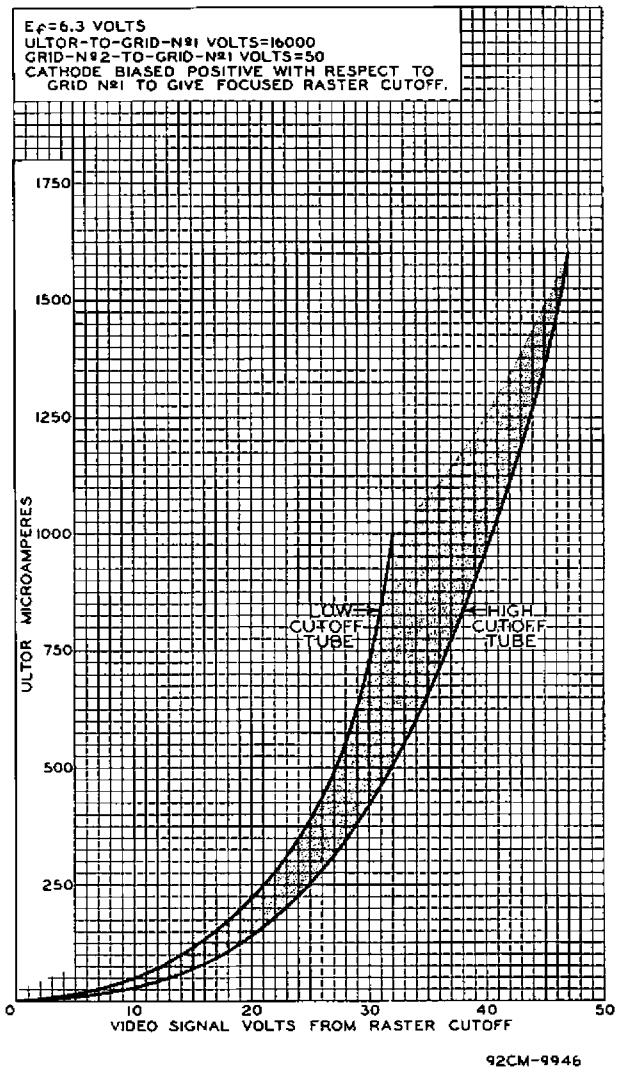


Fig. 2 – Cathode-Drive Characteristics of Type 24BAP4.

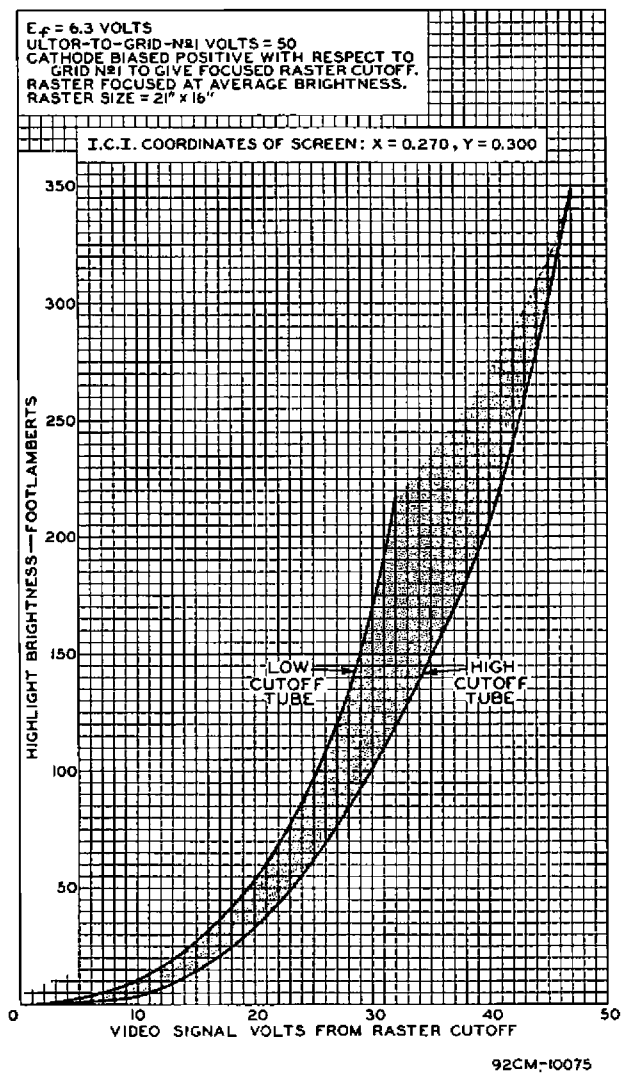
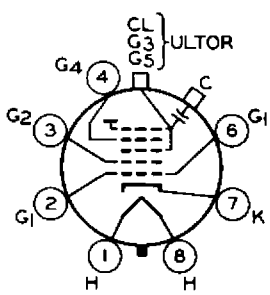


Fig. 3 – Cathode-Drive Characteristics of Type 24BAP4.

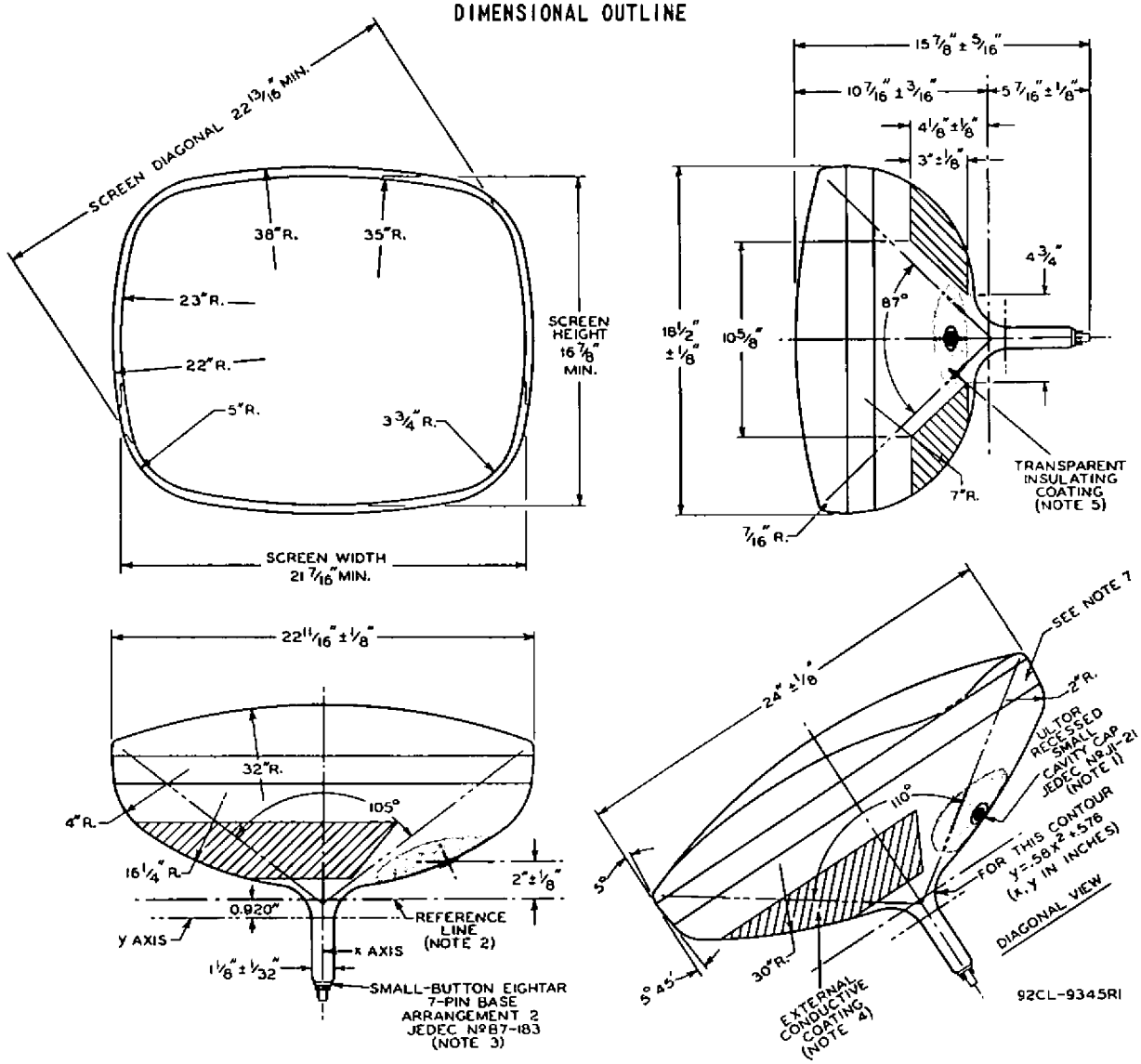
SOCKET CONNECTIONS
Bottom View

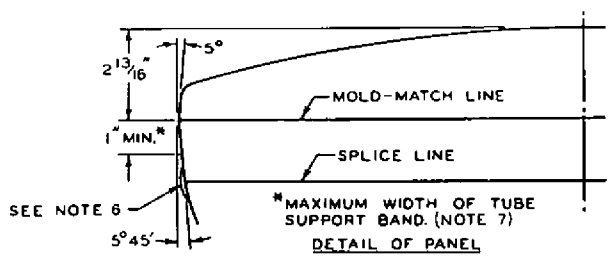


PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.2
PIN 4: GRID No.4
PIN 6: GRID No.1
PIN 7: CATHODE
PIN 8: HEATER
CAP: ULTOR (Grid No.3, Grid No.5, Collector)
C: EXTERNAL CONDUCTIVE COATING

8HR

DIMENSIONAL OUTLINE





NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND PIN No.4 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ULTOR TERMINAL BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF ± 30°. ULTOR TERMINAL IS ON SAME SIDE AS PIN No.4.

NOTE 2: WITH TUBE NECK INSERTED THROUGH FLARED END OF REFERENCE-LINE GAUGE JEDEC No.G126 AND WITH TUBE SEATED IN GAUGE, THE REFERENCE LINE IS DETERMINED BY THE INTERSECTION OF THE PLANE CC' OF THE GAUGE WITH THE GLASS FUNNEL.

NOTE 3: SOCKET FOR THIS BASE SHOULD NOT BE RIGIDLY MOUNTED; IT SHOULD HAVE FLEXIBLE LEADS AND BE ALLOWED TO MOVE FREELY. THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT THE CIRCUIT WIRING CANNOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. BOTTOM CIRCUMFERENCE OF BASE WAFER WILL FALL WITHIN A CIRCLE CONCENTRIC WITH BULB AXIS AND HAVING A DIAMETER OF 1-3/4".

NOTE 4: EXTERNAL CONDUCTIVE COATING MUST BE GROUNDED.

NOTE 5: TO CLEAN THIS AREA, WIPE ONLY WITH SOFT DRY LINTLESS CLOTH.

NOTE 6: BULGE AT SPLICE-LINE SEAL MAY INCREASE THE INDICATED MAXIMUM VALUE FOR ENVELOPE WIDTH, DIAGONAL, AND HEIGHT BY NOT MORE THAN 1/8", BUT AT ANY POINT AROUND THE SEAL, THE BULGE WILL NOT PROTRUDE MORE THAN 1/16" BEYOND THE ENVELOPE SURFACE AT THE MOLD-MATCH LINE.

NOTE 7: WIDTH OF UNDISTURBED REGION BETWEEN MOLD-MATCH LINE AND SPLICE LINE IS 1" MINIMUM. THIS SHOULD BE THE MAXIMUM WIDTH OF TUBE SUPPORT BAND.

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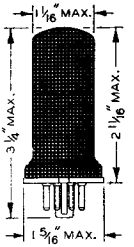
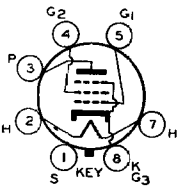


RCA-25A6

POWER-AMPLIFIER PENTODE



The 25A6 is a power-amplifier pentode of the All-Metal type for use in the output stage of radio receivers, especially those of the "d-c power line" or "universal" type. In such applications, the 25A6 is capable of handling relatively large audio power.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)			25	Volts
Heater Current			0.3	Ampere
Plate Voltage	95	135	180 *max.*	Volts
Screen Voltage (Grid No. 2)	95	135	135 *max.*	Volts
Grid Voltage (Grid No. 1)	−15	−20	−20	Volts
Plate Current	20	37	38	Milliamperes
Screen Current	4	8	7.5	Milliamperes
Plate Resistance (Approximate)	45000	35000	40000	Ohms
Amplification Factor (Approx.)	90	85	100	
Transconductance	2000	2450	2500	Micromhos
Load Resistance	4500	4000	5000	Ohms
Self-Bias Resistor	625	440	440	Ohms
Power Output	0.9*	2†	2.75‡	Watts
Base				Small Wafer Octal 7-Pin

* 11% total harmonic distortion.
† 9% total harmonic distortion.
‡ 10% total harmonic distortion.

INSTALLATION

The **base** pins of the 25A6 fit the standard octal socket which may be installed to hold the tube in any position.

The 25-volt **heater** of the 25A6 is designed to operate under the normal conditions of line-voltage variation without materially affecting the performance or serviceability of this tube. For operation of the 25A6 in series with the heaters of other types having 0.3-ampere rating, the current in the heater circuit should be adjusted to 0.3 ampere for the normal supply voltage.

In a series-heater circuit of the "d-c power line" type employing several 0.3-ampere (6.3-volt) types and one or two 25A6's, the heaters of the 25A6's should be placed on the positive side of the line. Under these conditions, heater-cathode voltage of the 25A6 must not exceed the value given under **cathode.** In a series-heater circuit of the "universal" type employing rectifier tube 25Z6, one or two 25A6's, and several 0.3-ampere (6.3-volt) types, it is recommended that the heater(s) of the 25A6('s) be placed in the circuit so that the higher values of heater-cathode bias will be impressed on the 25A6('s) rather than on the 6.3-volt types. This is accomplished by arranging the 25A6('s) on the side of the supply line which is connected to the cathode of the rectifier, i.e., the positive terminal of the rectified voltage supply. Between this side of the line and the 25A6('s), any necessary auxiliary resistance and the heater of the 25Z6 are connected in series.

The **cathode** circuit in "d-c power line" or "universal" receivers is tied in either directly or through biasing resistors to the negative side of the d-c plate supply which is furnished either by the d-c power line or by the a-c line by means of a rectifier. The potential difference thus introduced between heater and cathode of the 25A6 should not exceed 90 volts d.c., as measured between the negative heater terminal and the cathode.

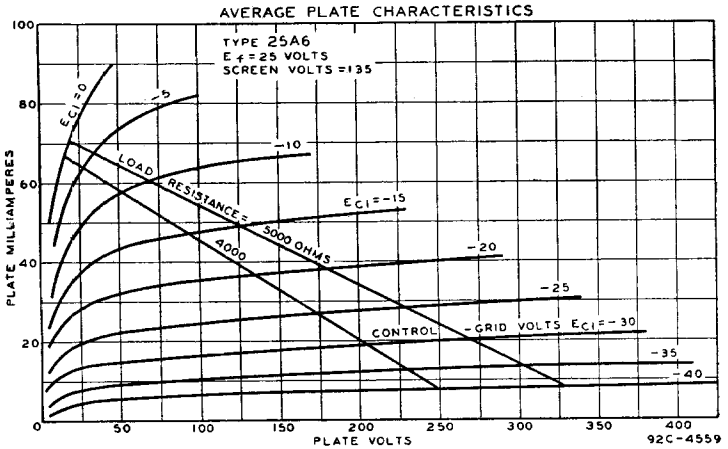
APPLICATION

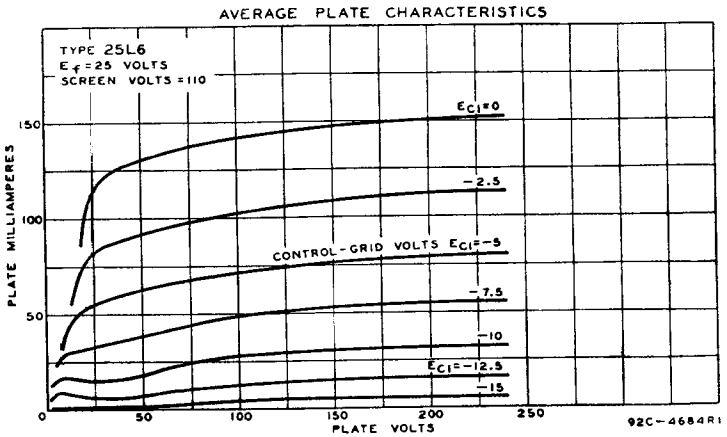
As a power amplifier (Class A), the 25A6 is recommended for use either singly or in push-pull combination in the power output stages of "d-c power line" and "universal" receivers. Recommended operating conditions are given under CHARACTERISTICS.

The self-bias resistor should be shunted by a suitable filter network to avoid degenerative effects at low audio frequencies. The use of two 25A6's in push-pull eliminates the necessity for shunting the resistor. The self-bias resistor for two 25A6's in the same stage is approximately one-half the value given for single-tube operation.

The total d-c resistance in the grid circuit should not exceed 0.5 megohm with self-bias; or 0.5 megohm for the 95-volt condition and 50000 ohms for the 135-volt and 180-volt conditions with fixed bias.

An additional plate family for this type is shown under type 43.





25C5

BEAM POWER TUBE

7-Pin Miniature Type

TENTATIVE DATA

RCA-25C5 is a beam power tube of the 7-pin miniature type intended for use particularly in the audio output stage of radio receivers.

Because of its high power sensitivity and high efficiency at low plate and screen voltages, the 25C5 is capable of providing a relatively high power output. For example, in class A_1 amplifier service, a single 25C5 operated with a plate voltage of 120 volts, and a grid-No.2 voltage of 110 volts, can deliver a maximum signal power output of 2.3 watts.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	25	volts
Current	0.3	amp
Direct Interelectrode Capacitances (Approx. without external shield):		
Grid No.1 to plate	0.6	μμf
Grid No.1 to cathode & grid No.3, heater, and grid No.2	13	μμf
Plate to cathode & grid No.3, heater, and grid No.2	8.5	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

AMPLIFIER - Class A_1

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	135	max.	volts
GRID-No.2 (SCREEN-GRID) VOLTAGE	117	max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:			
Positive bias value	0	max.	volt
PLATE DISSIPATION	6	max.	watts
GRID-No.2 INPUT	1.25	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	200	max.	volts
Heater positive with respect to cathode	200*	max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	220	max.	°C

Typical Operation and Characteristics:

Plate Voltage	120	volts
Grid-No.2 Voltage	110	volts
Grid-No.1 Voltage	-8	volts
Peak AF Grid-No.1 Voltage	8	volts
Zero-Signal Plate Current	49	ma
Max.-Signal Plate Current	50	ma
Zero-Signal Grid-No.2 Current	4	ma
Max.-Signal Grid-No.2 Current	8.5	ma
Plate Resistance (Approx.)	10000	ohms
Transconductance	7500	μmhos
Load Resistance	2500	ohms
Total Harmonic Distortion	10	per cent
Max.-Signal Power Output	2.3	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.1 max.	megohm
For cathode-bias operation	0.5 max.	megohm

* The dc component must not exceed 100 volts.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 25C5 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage, including normal variations, falls within ± 10 per cent of line-center voltage value of 117 volts.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

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RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

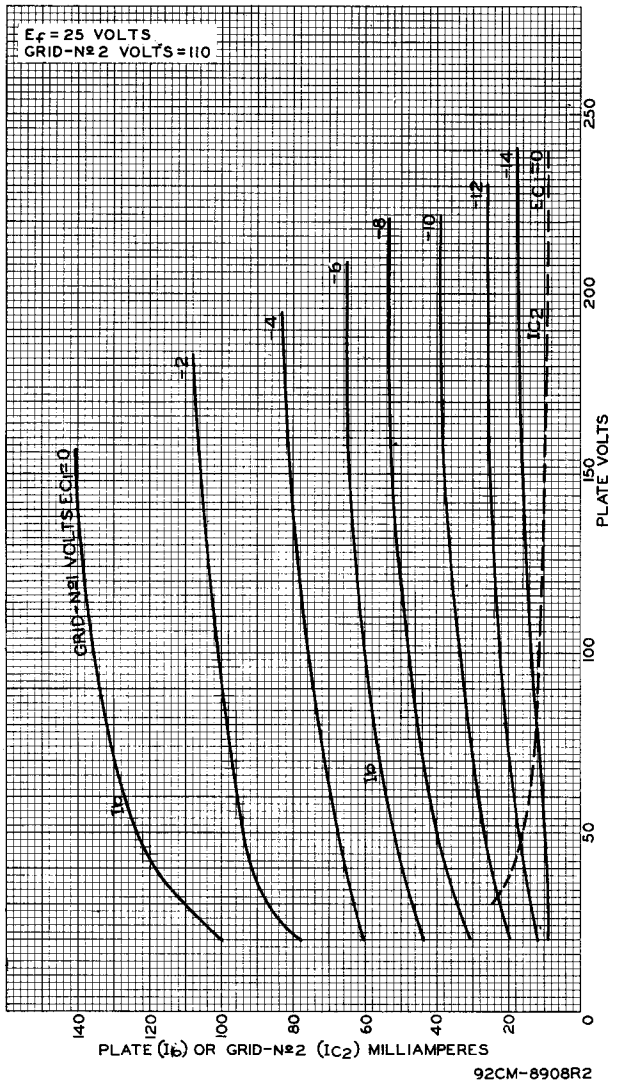


Fig. 1 – Average Characteristics for Type 25C5.

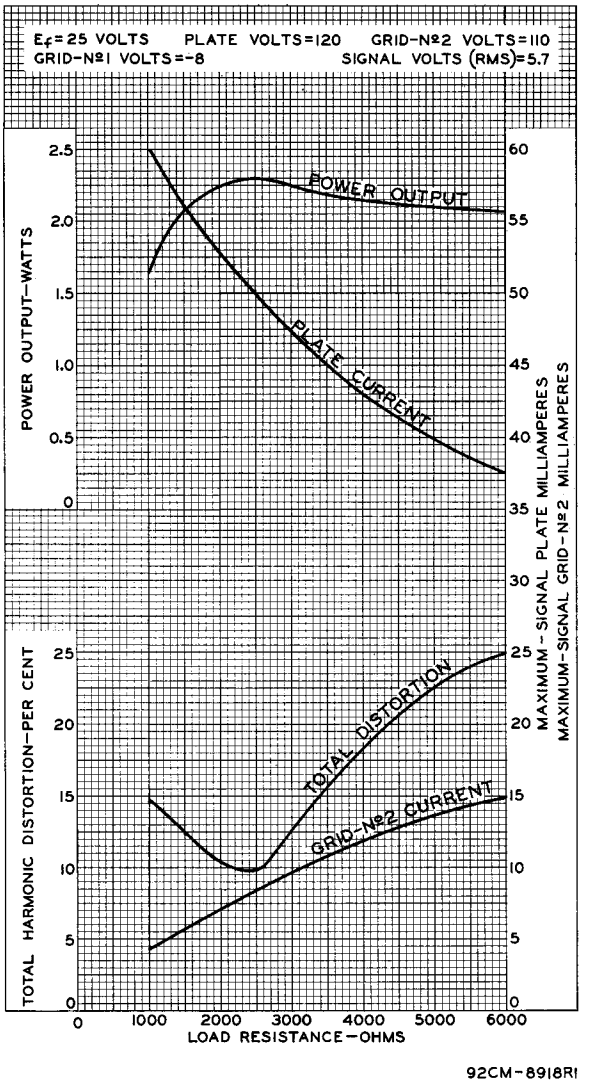
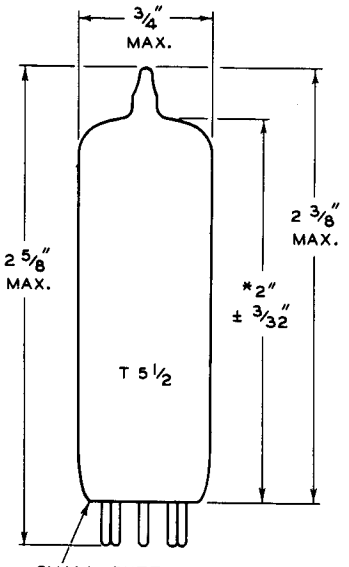


Fig. 2 – Operation Characteristics for Type 25C5.

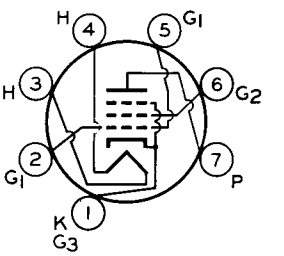
DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



7CV

PIN 1: CATHODE, GRID No.3
PIN 2: GRID No.1
PIN 3: HEATER
PIN 4: HEATER
PIN 5: GRID No.1
PIN 6: GRID No.2
PIN 7: PLATE

25CD6-GB

BEAM POWER TUBE

TENTATIVE DATA

RCA-25CD6-GB is a high-perveance beam power tube of the glass-octal type designed especially for use as a horizontal-deflection amplifier tube in television receivers of the "transformerless" type.

The 25CD6-GB is like the 25CD6-G and 25CD6-GA, but utilizes a button-stem construction and a T-12 envelope, and features a mount design to provide high perveance and to permit operation at higher ratings.

The 25CD6-GB has a maximum peak positive-pulse plate voltage of 7000 volts, a maximum plate dissipation of 20 watts, and a maximum bulb temperature of 225°C. These features, in addition to low mu-factor, high plate current at low plate voltage, and a high operating ratio of plate current to grid-No.2 current enable a single 25CD6-GB, in suitable circuits, to deflect fully picture tubes having a deflection angle of 90 degrees.

Design features include a mount structure utilizing stem leads which provide high heat conductivity. This feature permits cool operation of grid No.1 and grid No.2 thereby minimizing grid emission. In addition, the structure provides for maximum distribution of heat to prevent hot spots on the plate.

The 25CD6-GB is designed with a 600-milliampere heater having a controlled warm-up time to insure dependable performance in television receivers employing a series-string heater arrangement.

The 25CD6-GB is a direct replacement for the 25CD6-G and 25CD6-GA.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:			
Voltage		25	volts
Current		0.6	ampere
Warm-Up Time (Average)		11	seconds
Heater warm-up time is defined as the time required in the test circuit shown in Fig.1 for the voltage (E) across the heater terminals to increase from zero to 20 volts.			
Direct Interelectrode Capacitances (Approx., with no external shield):			
Grid No.1 to plate		1.1	μμf
Grid-No.1 to cathode & grid No.3, heater and grid No.2		22	μμf
Plate to cathode & grid No.3, heater and grid No.2		8.5	μμf

Characteristics, Class A_1 Amplifier:

Plate Voltage	60	175	volts
Grid-No.2 (Screen) Voltage	100	175	volts
Grid-No.1 (Control-Grid) Voltage	0	-30	volts
Mu-Factor, Grid No.2 to Grid No.1	-	3.9	
Plate Resistance (Approx.)	-	7200	ohms
Transconductance	-	7700	μmhos
Grid-No.1 Voltage (Approx.) for plate current of 1 milliampere	-	-55	volts
Plate Current	230*	75	ma
Grid-No.2 Current	21*	5.5	ma

Mechanical:

Mounting Position	Vertical, or Horizontal with pins 2 & 7 in vertical plane
Maximum Overall Length	5"
Seated Length	4-1/4" ± 3/16"
Maximum Diameter	1-9/16"
Bulb	T-12
Cap	Small (JETEC No.C1-1)
Base	Short Medium-Shell Octal 8-Pin with External Barriers (JETEC No.B8-110, Style A) or Short Medium-Shell Octal 8-Pin with External Barriers (JETEC No.B8-118, Style B)

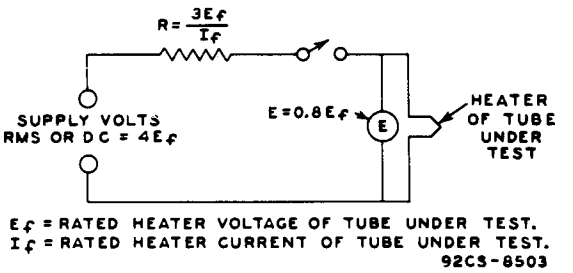


Fig.1 - Test Circuit for Determining Heater Warm-Up Time.

HORIZONTAL DEFLECTION AMPLIFIER

Maximum Ratings, *Design-Center Values Except as Noted: For operation in a 525-line, 30-frame system*●

PLATE VOLTAGE:			
DC (Including boost)	700	max.	volts
Peak positive-pulse⊕ (Absolute max.)	7000□	max.	volts
Peak negative-pulse⊕	1500	max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	175	max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:			
DC	-50	max.	volts
Peak negative-pulse	200	max.	volts
CATHODE CURRENT:			
DC	200	max.	ma
Peak	700	max.	ma
GRID-No.2 INPUT	3	max.	watts
PLATE DISSIPATION†	20	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	200	max.	volts
Heater positive with respect to cathode	200#	max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	225	max.	°C

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:			
For grid-resistor-bias operation†	0.47	max.	megohm

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

25CD6-GB-11-56

* These values can be measured by a method involving a recurrent waveform such that the plate dissipation and grid-No.2 input will be kept within ratings in order to prevent damage to the tube.

● As described in "Standards of Good Engineering Practice Concerning Television Broadcast Stations", Federal Communications Commission.

⊕ This rating is applicable where the duration of the voltage pulse does not exceed 15 per cent of one horizontal scanning cycle. In a 525-line, 30-frame system, 15 per cent of one horizontal scanning cycle is 10 microseconds.

□ Under no circumstances should this absolute value be exceeded.

† It is essential that the plate dissipation be limited in the event of loss of grid signal. For this purpose, some protective means such as a cathode resistor of suitable value should be employed.

The dc component must not exceed 100 volts.

OPERATING CONSIDERATIONS

The *maximum ratings* shown in the tabulated data for the 25CD6-GB, except the rating for peak positive-pulse plate voltage, are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage, including normal variations, falls within ± 10 per cent of line-center voltage value of 117 volts.

The *maximum rating* shown in the tabulated data for peak positive-pulse plate voltage is a limiting value above which the serviceability of the 25CD6-GB may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed this absolute rating, the equipment designer has the responsibility of determining an average design value for this rating below the absolute value of this rating by an amount such that the absolute value will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

In television receivers employing series-heater strings the use of a resistor in series with the string of tubes will minimize voltage surges across any individual tube during starting. The resistor should preferably have a negative temperature characteristic.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

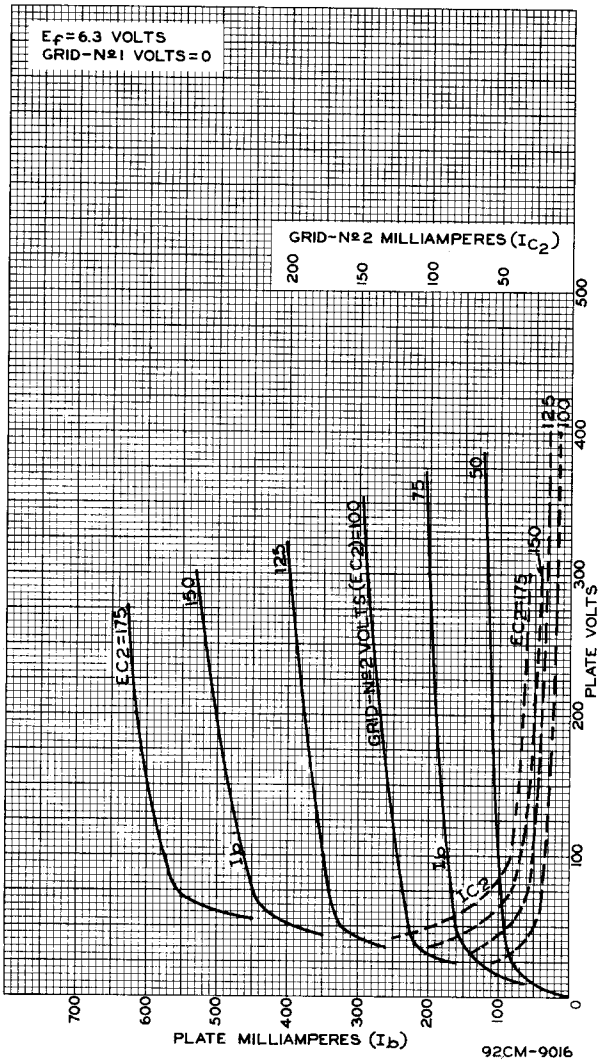


Fig. 2 - Average Characteristics for Type 25CD6-GB.

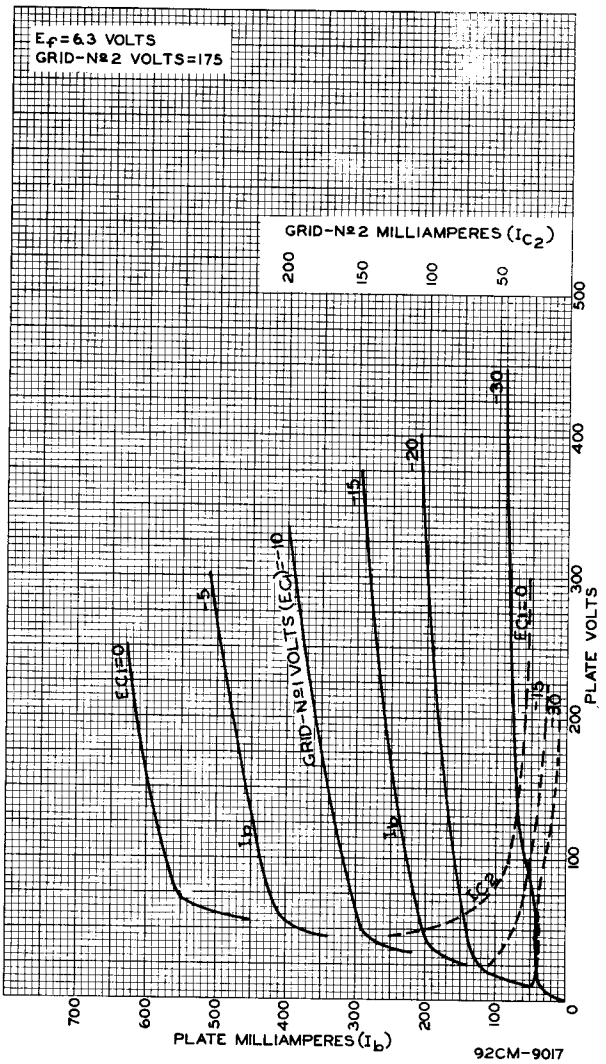
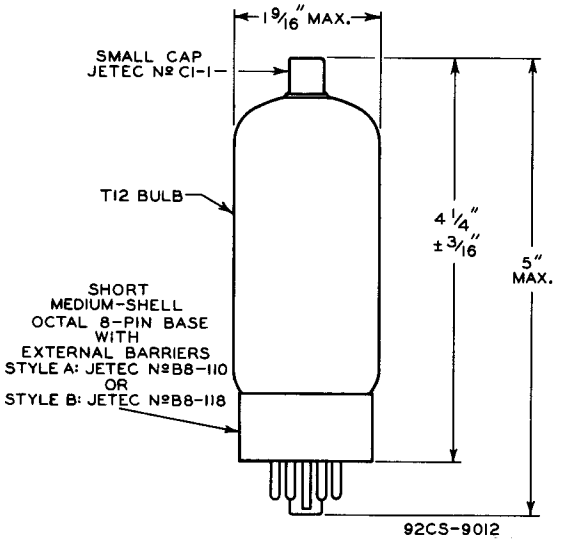
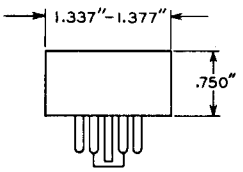


Fig. 3 - Average Characteristics for Type 25CD6-GB.

DIMENSIONAL OUTLINE



SHORT
MEDIUM-SHELL
OCTAL 8-PIN BASE
WITH
EXTERNAL BARRIERS
STYLE A: JETEC Nº B8-110



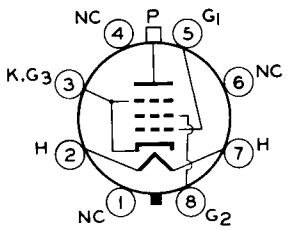
SHORT
MEDIUM-SHELL
OCTAL 8-PIN BASE
WITH
EXTERNAL BARRIERS
STYLE B: JETEC Nº B8-118

Style B is same as Style A
except shell height is 0.700".

92CS-9013

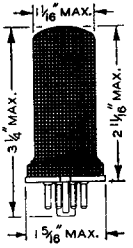
SOCKET CONNECTIONS

Bottom View



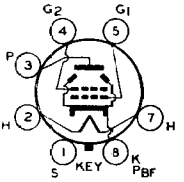
5BT

PIN 1: NO CONNECTION
PIN 2: HEATER
PIN 3: CATHODE, GRID No.3
PIN 4: NO CONNECTION
PIN 5: GRID No.1
PIN 6: NO CONNECTION
PIN 7: HEATER
PIN 8: GRID No.2
CAP: PLATE



RCA-25L6

BEAM POWER AMPLIFIER



The 25L6 is a power-amplifier tube of the All-Metal type for use in the output stage of "transformerless" (a.c.-d.c.) radio receivers, especially those designed to have ample reserve of power-delivering ability. The new tube provides high power output at the relatively low plate and screen voltages available for transformerless receivers. The high power output is obtained with high power sensitivity and high efficiency.

These distinctive features have been made possible by the application of directed-electron-beam principles in the design of the 25L6. The design is similar to that of the RCA-6L6 with the difference that the 25L6 is intended for operation in a.c.-d.c. receivers.

TENTATIVE CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	25.0	Volts
Heater Current	0.3	Ampere
Base	Small Wafer Octal 7-Pin	

As Single-Tube Class A_1 Amplifier

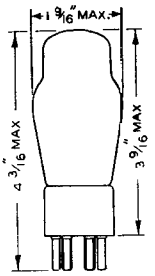
Plate Voltage	110	110	Volts
Screen Voltage (Grid No. 2)	110	110	Volts
Grid Voltage (Grid No. 1)	−7.5	−7.5	Volts
Peak A-F Grid Voltage	7.5	7.5	Volts
Zero-Signal Plate Current	49	49	Milliamperes
Max.-Signal Plate Current	54	50	Milliamperes
Zero-Signal Screen Current	4	4	Milliamperes
Max.-Signal Screen Current	9	11	Milliamperes
Plate Resistance (Approx.)	10000	10000	Ohms
Transconductance	8200	8200	Micromhos
Load Resistance	1500	2000	Ohms
Distortion:			
Total Harmonic	11	10	Per cent
Second Harmonic	10	3.5	Per Cent
Third Harmonic	4	8.5	Per cent
Power Output	2.1	2.2	Watts

INSTALLATION

The base pins of the 25L6 fit the standard octal-base socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to type 25A6.

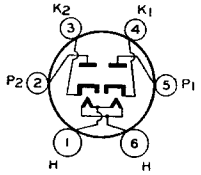
APPLICATION

The 25L6 should be operated as shown under CHARACTERISTICS. The values have been determined on the basis that grid current does not flow during any part of the input cycle. The type of input coupling used should not introduce too much resistance in the grid circuit. Transformer- or impedance-coupling devices are recommended. When the grid circuit has a d-c resistance not higher than 0.1 megohm, fixed bias may be used; for higher values, self-bias is required. With self-bias, the grid circuit may have a d-c resistance as high as, but not greater than 0.5 megohm. A family of plate characteristic curves is given on the preceding page.



RCA-25Z5

RECTIFIER-DOUBLER



The 25Z5 is a full-wave, high-vacuum rectifier of the heater-cathode type for use in suitable circuits designed to supply d-c power from an a-c power line. This tube is well suited for "transformerless" receivers of either the "universal (a.c.-d.c.)" type or the "a-c operated" type. In "universal" receivers, the 25Z5 may be used as a half-wave rectifier, while in the "a-c operated" type, it may be used as a voltage doubler to provide about twice the d-c output voltage obtainable from the half-wave arrangement. This two-fold application is made possible by the use of a separate base pin for each of the two cathodes. For voltage-doubler considerations, see page 25.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	25	Volts
HEATER CURRENT	0.3	Ampere
BULB		ST-12
BASE		Small 6-Pin

As Voltage Doubler

A-C PLATE VOLTAGE PER PLATE (RMS)	125 *max.*	Volts
PEAK PLATE CURRENT	500 *max.*	Milliamperes
D-C OUTPUT CURRENT	100 *max.*	Milliamperes

As Half-Wave Rectifier

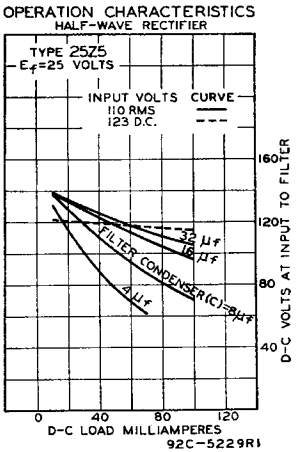
A-C PLATE VOLTAGE PER PLATE (RMS)	125 *max.*	250* *max.*	Volts
PEAK PLATE CURRENT (per plate)	500 *max.*	500 *max.*	Milliamperes
D-C OUTPUT CURRENT (per plate)	85	85 *max.*	Milliamperes

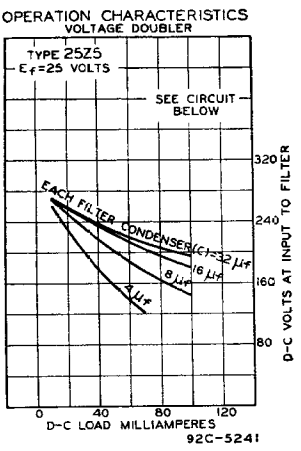
* On a-c input voltage above 125 volts, it is necessary to connect a 100 ohm resistor in series with each plate lead, or a 100 ohm resistor common to both plates (giving somewhat poorer regulation) may be used.

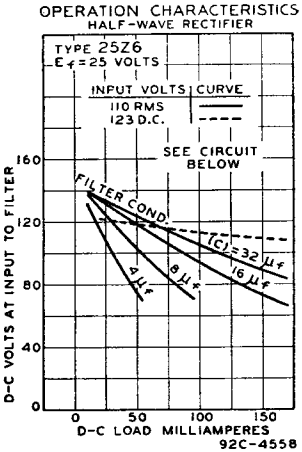
INSTALLATION AND APPLICATION

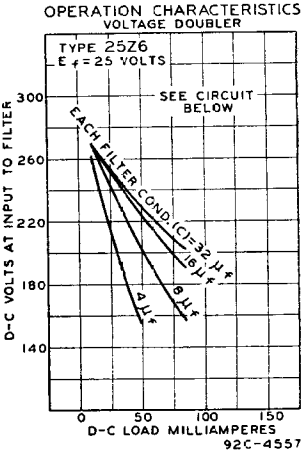
The base pins of the 25Z5 fit the standard six-contact socket which may be installed to hold the tube in any position. The bulb of this tube will become quite hot under certain conditions of operation. Sufficient ventilation should be provided to circulate air freely around the tube to prevent overheating. For heater operation, filter considerations, and APPLICATION, refer to type 25Z6.

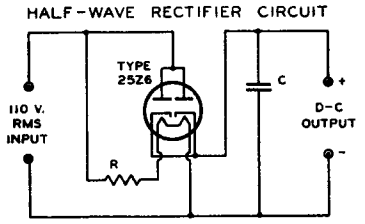
Operation curves and circuits are given on the following page.



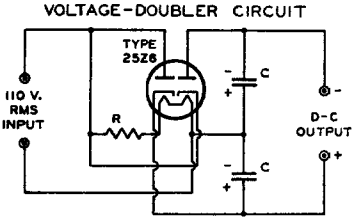




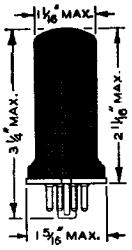




R=HEATER VOLTAGE-DROPPING RESISTOR
C=FILTER CONDENSER

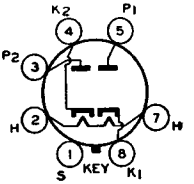


R=HEATER VOLTAGE-REDUCING RESISTOR
C=FILTER CONDENSER



RCA-25Z6

RECTIFIER-DOUBLER



The **25Z6** is a full-wave, high-vacuum rectifier of the heater-cathode type for use in suitable circuits designed to supply d-c power from an a-c power line. This tube is well suited for "transformerless" receivers of either the "universal (a.c.-d.c.)" type or the "a-c operated" type. In "universal" receivers, the 25Z6 may be used as a half-wave rectifier, while in the "a-c operated" type, it may be used as a voltage doubler to provide about twice the d-c output voltage obtainable from the half-wave arrangement. For voltage-doubler considerations, see page 25.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	25	Volts
HEATER CURRENT	0.3	Ampere
BASE	Small Wafer Octal 7-Pin	

As Voltage Doubler

A-C PLATE VOLTAGE PER PLATE (RMS)	125 *max.*	Volts
PEAK PLATE CURRENT	500 *max.*	Milliamperes
D-C OUTPUT CURRENT	85 *max.*	Milliamperes

As Half-Wave Rectifier

A-C PLATE VOLTAGE PER PLATE (RMS)	125 *max.*	250* *max.*	Volts
PEAK PLATE CURRENT PER PLATE	500 *max.*	500 *max.*	Milliamperes
D-C OUTPUT CURRENT PER PLATE	85 *max.*	85 *max.*	Milliamperes

* An a-c input voltage greater than 125 volts requires the use of a series resistor or resistors. A 100-ohm resistor in each plate lead or a 100-ohm resistor common to both plates (giving somewhat poorer regulation) may be used.

INSTALLATION

The base pins of the 25Z6 fit the standard octal socket which may be installed to hold the tube in any position.

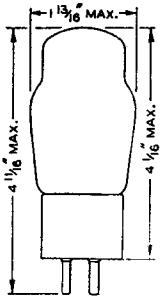
The heater is designed to operate under the normal conditions of line voltage variation without materially affecting the performance or serviceability of this tube. The current in the heater circuit should be adjusted to 0.3 ampere for the normal supply voltage.

A filter of the condenser-input type is recommended for use with this tube in order to obtain a d-c output voltage as high as possible. A large input capacitance in the order of 16 μf is desirable for half-wave rectifier service, while a higher value is advantageous for voltage-doubler circuits.

APPLICATION

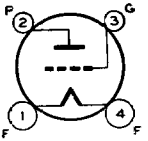
As a **half-wave rectifier**, the 25Z6 is designed for service in "transformerless" receivers of the "universal" type. In such service, the two plates are connected together at the socket in order to act as a single plate; likewise, the cathodes are connected as a unit. Conditions for this method of operation are given under CHARACTERISTICS. Typical output curves for several values of input condensers are shown on page 109. As a supplement to the curves with a-c input voltage, a dotted curve is included to show the output when the receiver is operated from a d-c power line.

As a **voltage doubler**, the 25Z6 is useful in "transformerless" receivers of the "a-c operated" type and is capable of supplying approximately twice the d-c output voltage of the half-wave circuit. In voltage-doubling service, the two diode units of the tube are arranged as shown in the voltage-doubler circuit, below. Circuits are given on the preceding page.



RCA-26

AMPLIFIER



The 26 is an amplifier tube containing a filament designed for operation on alternating current. This tube is for use as an r-f or a-f amplifier in equipment designed for its characteristics. The 26 is not ordinarily suitable for use as a detector or power output tube.

CHARACTERISTICS

Filament Voltage (A. C. or D. C.)			1.5	Volts
Filament Current			1.05	Amperes
Plate Voltage	90	135	180 *max.*	Volts
Grid Voltage*	−7	−10	−14.5	Volts
Plate Current	2.9	5.5	6.2	Milliamperes
Plate Resistance	8900	7600	7300	Ohms
Amplification Factor	8.3	8.3	8.3	
Transconductance	935	1100	1150	Micromhos
Grid-Plate Capacitance			8.1	μμf
Grid-Filament Capacitance			2.8	μμf
Plate-Filament Capacitance			2.5	μμf
Bulb				ST-14
Base				Medium 4-Pin

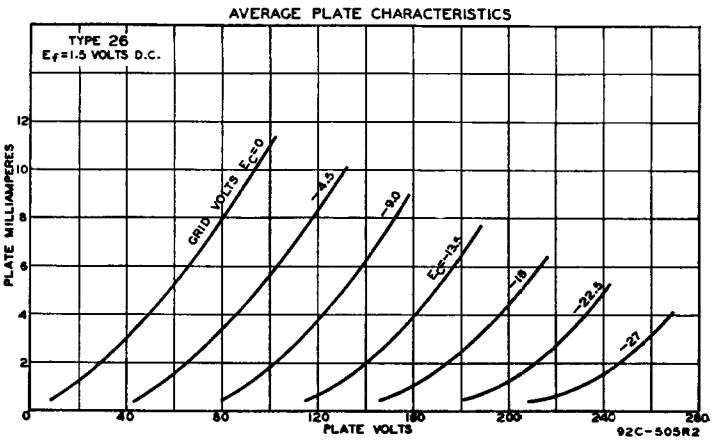
* Grid voltage measured from mid-point of a-c operated filament.

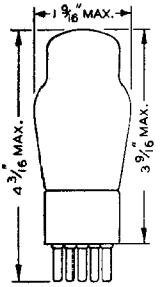
INSTALLATION AND APPLICATION

The **base** pins of the 26 fit the standard four-contact socket, which should be installed to hold the tube in a vertical position.

The coated **filament** of the 26 should be operated at the rated voltage of 1.5 volts from the a-c line through a step-down transformer.

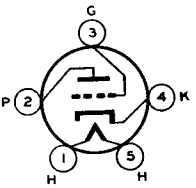
As an **amplifier**, the 26 should be operated as shown under CHARACTERISTICS.





RCA-27

DETECTOR, AMPLIFIER



The 27 is a three-electrode general purpose tube of the heater-cathode type for use as an amplifier and detector in a-c receivers.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)				2.5	Volts
HEATER CURRENT				1.75	Amperes
PLATE VOLTAGE*	90	135	180	250	Volts
GRID VOLTAGE†	−6	−9	−13.5	−21	Volts
PLATE CURRENT	2.7	4.5	5.0	5.2	Milliamperes
PLATE RESISTANCE	11000	9000	9000	9250	Ohms
AMPLIFICATION FACTOR	9	9	9	9	
TRANSCONDUCTANCE	820	1000	1000	975	Micromhos
GRID-PLATE CAPACITANCE				3.3	$\mu\mu$f
GRID-CATHODE CAPACITANCE				3.1	$\mu\mu$f
PLATE-CATHODE CAPACITANCE				2.3	$\mu\mu$f
BULB					ST-12
BASE					Small 5-Pin

* Maximum plate voltage = 275 volts.
† Maximum value of d-c resistance in grid circuit is 1.0 megohm.

INSTALLATION AND APPLICATION

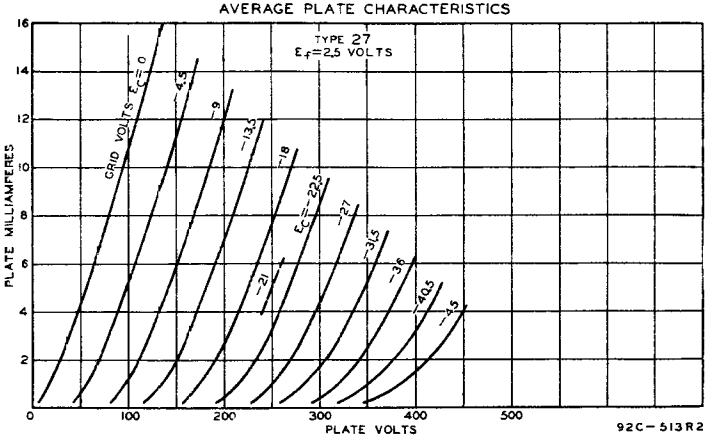
The **base** pins of the 27 fit the standard five-contact socket. The socket may be installed to hold the tube in any position.

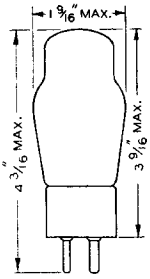
For **heater** operation and **cathode** connection, refer to type 2A5.

As an **amplifier,** the 27 is applicable to the audio- or the radio-frequency **stages** of a receiver. Recommended plate and grid voltages are shown under CHARACTERISTICS.

As a **detector,** the 27 may be operated either with grid leak and condenser or with grid bias. The plate voltage for grid leak and condenser detection is 45 volts. A grid leak of from 1 to 5 megohms used with a grid condenser of 0.00025 μf is suitable. For grid-bias detection, a plate voltage of 275 volts or less may be used. The corresponding grid bias should be adjusted so that the plate current, when no signal is being received, is approximately 0.2 milliampere. For the condition of 250 volts on plate and transformer coupling, the grid bias will be approximately −30 volts.

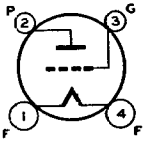
AVERAGE PLATE CHARACTERISTICS





RCA-30

DETECTOR, AMPLIFIER



The 30 is a detector and amplifier tube of the three-electrode type for battery-operated radio receivers where economy of filament-current drain is important.

CHARACTERISTICS

Filament Voltage (D. C.)	2.0	Volts
Filament Current	0.060	Ampere
Grid-Plate Capacitance	6.0	$\mu\mu$f
Grid-Filament Capacitance	3.0	$\mu\mu$f
Plate-Filament Capacitance	2.1	$\mu\mu$f
Bulb		ST-12
Base		Small 4-Pin

As Class A_1 Amplifier

Plate Voltage	90	135	180 *max.*	Volts
Grid Voltage	−4.5	−9	−13.5	Volts
Plate Current	2.5	3.0	3.1	Milliamperes
Plate Resistance	11000	10300	10300	Ohms
Amplification Factor	9.3	9.3	9.3	
Transconductance	850	900	900	Micromhos

As Class B Amplifier

Plate Voltage	180 *max.*	Volts
Maximum-Signal Plate Current	50 *max.*	Milliamperes
Zero-Signal Plate Current (Per tube)	1.5 *max.*	Milliamperes

Typical Operation (2 tubes)

Values are for two tubes.

Plate Voltage	157.5	Volts
Grid Voltage	−15	Volts
Zero-Signal Plate Current (Per tube)	1.0	Milliampere
Effective Load Resistance (Plate-to-plate)	8000	Ohms
Maximum-Signal Driving Power	260	Milliwatts
Power Output, Approximate*	2.1	Watts

* With one type 30 as driver operated under the following conditions: Plate voltage, 157.5 volts, negative grid bias voltage, 11.3 volts; plate load of approximately 18000 ohms; and input transformer ratio (primary to one-half secondary), 1.165: Total distortion is 6 to 7%.

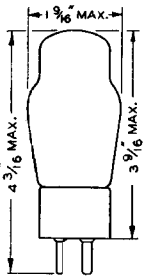
INSTALLATION AND APPLICATION

The base pins of the 30 fit the standard four-contact socket which should be installed to hold the tube in a vertical position. Cushioning of the socket in the detector stage may be desirable if microphonic disturbances are encountered. For filament operation, refer to INSTALLATION on type 1A6.

As a detector, the 30 may be operated either with grid leak and condenser or with grid-bias. The plate voltage for the former method should not be more than 45 volts. A grid leak of from 1 to 5 megohms used with a grid condenser of 0.00025 μf is satisfactory. The grid return should be connected to the positive filament socket terminal. For grid-bias detection, plate voltages up to the maximum value of 180 volts may be used. The corresponding grid-bias should be adjusted so that the plate current is about 0.2 milliampere when no signal is being received.

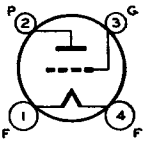
In resistance-coupled service, the maximum d-c resistance in the grid circuit should not exceed 2 megohms.

A family of plate characteristic curves is given on page 102.



RCA-31

POWER AMPLIFIER



The 31 is a power-amplifier tube of the three-electrode type for battery-operated radio receivers where economy of filament-current drain is important.

CHARACTERISTICS

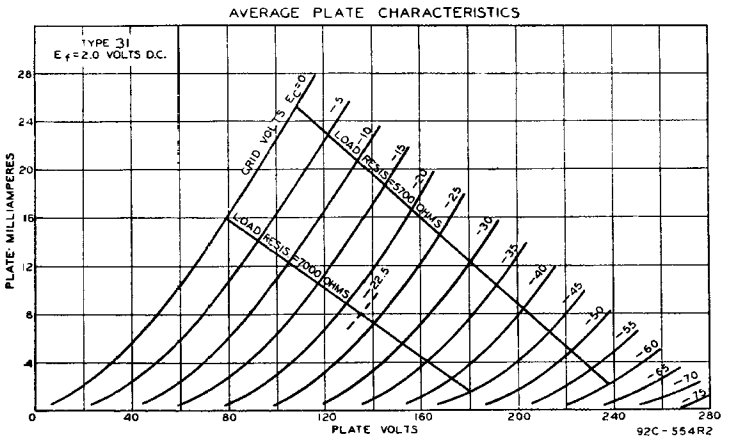
Filament Voltage (D. C.)		2.0	Volts
Filament Current		0.130	Ampere
Plate Voltage	135	180 *max.*	Volts
Grid Voltage	−22.5	−30	Volts
Plate Current	8.0	12.3	Milliamperes
Plate Resistance	4100	3600	Ohms
Amplification Factor	3.8	3.8	
Transconductance	925	1050	Micromhos
Load Resistor	7000	5700	Ohms
Self-Bias Resistor	2815	2440	Ohms
Undistorted Power Output	0.185	0.375	Watt
Grid-Plate Capacitance		5.7	μμf
Grid-Filament Capacitance		3.5	μμf
Plate-Filament Capacitance		2.7	μμf
Bulb			ST-12
Base			Small 4-Pin

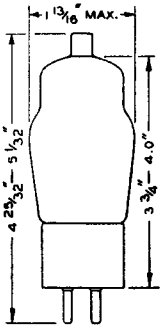
INSTALLATION

Refer to INSTALLATION on type 30.

APPLICATION

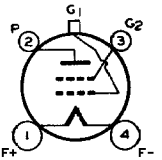
As a **power amplifier,** the 31 should be operated as shown under CHARACTERISTICS. Grid voltage may be obtained from a C-battery, or by means of a self-bias resistor connected in the negative plate-return lead. The latter method is required where a grid resistor (maximum value 1 megohm) is used. If more output is desired than can be obtained from a single 31, two 31's may be operated either in parallel or **push-pull connection.**





RCA-32

RADIO-FREQUENCY AMPLIFIER



The 32 is a screen-grid tube recommended primarily for use as a radio-frequency amplifier in battery-operated radio receivers where economy of filament-current drain is important.

CHARACTERISTICS

Filament Voltage (D. C.)		2.0	Volts
Filament Current		0.060	Ampere
Plate Voltage	135	180 *max.*	Volts
Screen Voltage (Grid No. 2)	67.5 *max.*	67.5 *max.*	Volts
Grid Voltage (Grid No. 1)	−3	−3	Volts
Plate Current	1.7	1.7	Milliamperes
Screen Current (Maximum)	0.4	0.4	Milliampere
Plate Resistance	0.95	1.2	Megohms
Amplification Factor	610	780	
Transconductance	640	650	Micromhos
Grid-Plate Capacitance (With shield-can)		0.015 *max.*	$\mu\mu$f
Input Capacitance		5.3	$\mu\mu$f
Output Capacitance		10.5	$\mu\mu$f
Bulb			ST-14
Cap			Small Metal
Base			Medium 4-Pin

INSTALLATION AND APPLICATION

For **socket** mounting and **filament** operation, refer to INSTALLATION for type 30.

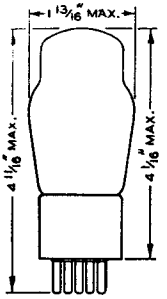
The **screen voltage** may be obtained from a tap on the plate battery or a bleeder circuit across the supply battery in whole or in part. Never attempt to obtain the screen voltage for the 32 by connecting the screen through a series resistor to a high-voltage source. The results will not be satisfactory because of voltage-drop variation produced by the different screen currents of individual tubes. **Volume control** may be effected by variation of the screen voltage between 0 and 67.5 volts. The variation must, however, be made by a potentiometer shunted across the screen-voltage supply and not by a high-resistance rheostat.

Complete **shielding** of all stages is recommended if maximum gain per stage is to be obtained.

As a **detector,** the 32 may be operated either with grid leak and condenser or with grid bias. For grid bias detection, suitable operating conditions are: Plate-supply voltage, 180 volts applied through a plate-coupling resistance of 0.1 megohm or an equivalent impedance; screen voltage, 67.5 volts; and a negative grid bias (approximately 6 volts) adjusted so that a plate current of 0.2 milliampere is obtained with no input signal. In designing circuits to use the 32 as a detector, it is desirable to work from the detector stage directly into the power-output stage.

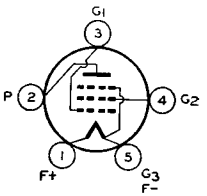
The d-c resistance in the grid circuit of the 32 should not exceed 2 megohms.

A family of plate characteristic curves is given on page 118.



RCA-33

POWER-AMPLIFIER PENTODE



The 33 is a power-amplifier pentode for use in the output stage of battery-operated receivers where economy of battery consumption is important.

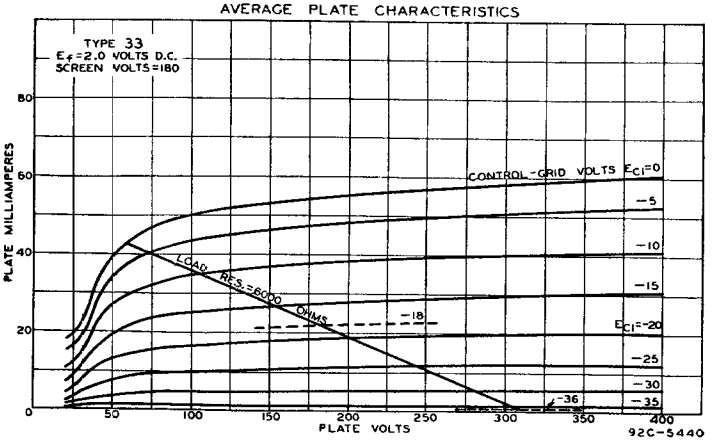
CHARACTERISTICS

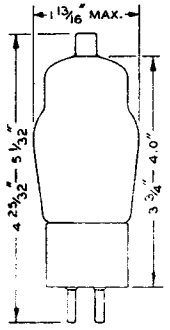
Filament Voltage (D. C.)		2.0	Volts
Filament Current		0.260	Ampere
Plate Voltage	135	180 *max.*	Volts
Screen Voltage (Grid No. 2)	135	180 *max.*	Volts
Grid Voltage (Grid No. 1)	−13.5	−18	Volts
Plate Current	14.5	22	Milliamperes
Screen Current	3	5	Milliamperes
Plate Resistance	50000	55000	Ohms
Amplification Factor (Approx.)	70	90	
Transconductance	1450	1700	Micromhos
Load Resistance	7000	6000	Ohms
Self-Bias Resistor	770	670	Ohms
Power Output (7% total harmonic distort.)	0.7	1.4	Watts
Bulb			ST-14
Base			Medium 5-Pin

INSTALLATION AND APPLICATION

The **base** pins of the 33 fit the standard five-contact socket. The **socket** should be installed to hold the tube in a vertical position. In some cases, cushioning of the socket may be found desirable. For **filament** operation, refer to INSTALLATION for type 1A6.

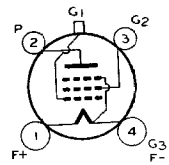
For the **power amplifier** stage of radio receivers, the 33 is recommended either **singly** or in push-pull combination. More than one audio stage preceding the 33 is **undesirable** because of the possibility of microphonic disturbances resulting from the **high** level of amplification. Transformer or impedance coupling devices are **preferable**. If resistance coupling is employed, the d-c resistance in the grid circuit **should** not exceed 1.0 megohm under self-bias conditions; without self-bias, the **maximum** value is 0.5 megohm.





RCA-34

SUPER-CONTROL R-F AMPLIFIER PENTODE



The 34 is a super-control pentode recommended for use primarily as a radio-frequency amplifier and intermediate-frequency amplifier in battery-operated receivers where economy of filament-current drain is important. The 34 is very effective in reducing cross-modulation and modulation-distortion over the usual range of signal voltages without the use of antenna potentiometers or auxiliary volume-control switches. (See Super-Control amplifier, page 16.) This super-control characteristic makes the tube uniquely adaptable to the r-f and i-f stages of receivers employing automatic volume control.

CHARACTERISTICS

Filament Voltage (D. C.)			2.0	Volts
Filament Current			0.060	Ampere
Plate Voltage	67.5†	135	180 *max.*	Volts
Screen Voltage (Grid No. 2)*	67.5 *max.*	67.5 *max.*	67.5 *max.*	Volts
Grid Voltage, Variable (Grid No. 1)	−3 *min.*	−3 *min.*	−3 *min.*	Volts
Plate Current	2.7	2.8	2.8	Milliamperes
Screen Current	1.1	1.0	1.0	Milliamperes
Plate Resistance	0.4	0.6	1.0	Megohm
Amplification Factor	224	360	620	
Transconductance	560	600	620	Micromhos
Transconductance (At −22.5 volts bias)	15	15	15	Micromhos
Grid-Plate Capacitance (With shield-can)			0.015 *max.*	*μμf*
Input Capacitance			6.0	*μμf*
Output Capacitance			11.5	*μμf*
Bulb				S1-14
Cap				Small Metal
Base				Medium 4-Pin

* Under conditions of maximum plate current.
† Recommended values for use in portable receivers.

INSTALLATION

The **base** pins of the 34 fit the standard four-contact socket which should be installed to hold the tube in a vertical position. Although this tube is quite free from microphonic disturbances, cushioning of its socket may sometimes be desirable.

For **filament** operation, refer to INSTALLATION for type 1A6.

The **screen voltage** may be obtained from a tap on the B-supply battery or from a bleeder circuit across the battery, as a whole or in part. Due to the screen current characteristics of the 34, a resistor in series with the B-supply may be employed, if desired, for obtaining the screen voltage, provided the maximum voltage between screen and filament does not exceed 100 volts under conditions of reduced plate current.

Stage **shielding** enclosing all the components of each stage is, in general, necessary for multi-stage amplifier circuits.

APPLICATION

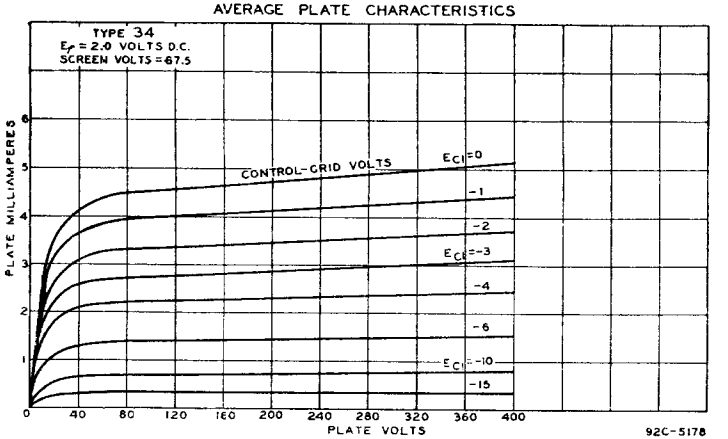
As an **r-f** or **i-f amplifier,** the 34 is applicable in receivers designed for it. Plate, screen, and minimum grid voltages are given under CHARACTERISTICS for a number of operating conditions.

Volume control of the receiver is accomplished effectively by variation of the negative voltage applied to the grid. In order to obtain adequate volume control, an available grid-bias voltage of approximately −22.5 volts will be required. The exact value will depend upon the circuit design and operating conditions. This voltage may be obtained from a potentiometer, a bleeder circuit, or a separate source, depending on receiver requirements.

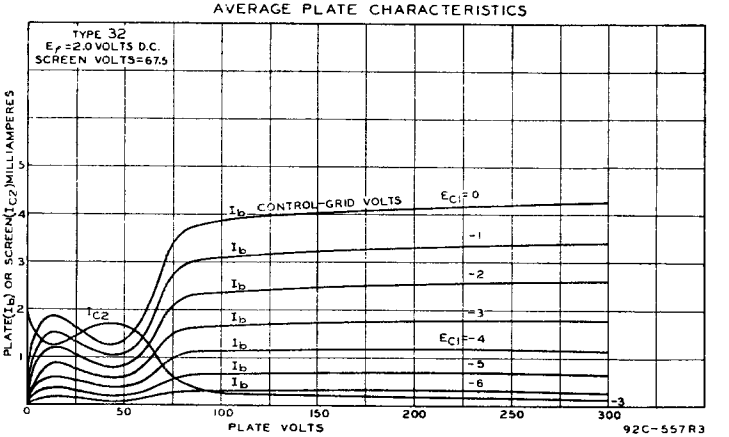
Owing to the fact that the super-control feature of the 34 requires a comparatively large grid-bias change, the screen and plate voltage may vary considerably for various volume settings, depending on receiver design. It is recommended, therefore, that design features be incorporated in the receiver so that the screen voltage will not exceed 67.5 volts under conditions of minimum grid bias and maximum plate current. With a design arrangement of this kind, the screen voltage at decreased values of plate current may reach a value higher than 67.5 volts but should not exceed 100 volts. It should be recognized that under the condition of screen voltage above 67.5 volts at low plate current, an increase in the grid-bias voltage supply must be provided for adequate volume control.

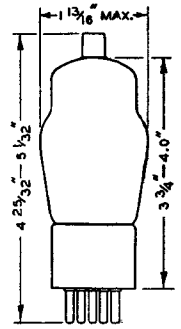
As the **mixer** in superheterodyne circuits, the 34 may be utilized to advantage. It should be noted that by varying the grid bias on the mixer in conjunction with that on the radio-frequency and/or the intermediate-frequency stages, additional control of volume may be accomplished. Recommended conditions are: Plate voltage, 67.5 to 180 volts; screen voltage, 67.5 volts; grid-bias voltage, −5 volts approximately (with 4-volt oscillator peak swing).

AVERAGE PLATE CHARACTERISTICS



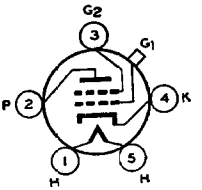
AVERAGE PLATE CHARACTERISTICS





RCA-35

SUPER-CONTROL R-F AMPLIFIER



The 35 is a super-control screen grid amplifier tube of the heater-cathode type recommended as an r-f amplifier and an i-f amplifier in a-c receivers. The 35 is very effective in reducing cross-modulation and modulation-distortion over the entire range of received signals. Its design is such as to permit easy control of a large range of signal voltages without the use of local-distance switches or antenna potentiometers. This super-control feature makes the tube adaptable to circuits incorporating automatic volume control. See page 16 for Super-Control feature. The 35 is interchangeable with type 51.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)		2.5	Volts
Heater Current		1.75	Amperes
Plate Voltage*	180	250	Volts
Screen Voltage (Maximum)	90	90	Volts
Grid Voltage, Variable (Minimum)	−3	−3	Volts
Plate Current	6.3	6.5	Milliamperes
Screen Current (Maximum)	2.5	2.5	Milliamperes
Plate Resistance	0.3	0.4	Megohm
Amplification Factor	305	420	
Transconductance	1020	1050	Micromhos
Transconductance (At −40 volts bias)	15	15	Micromhos
Grid-Plate Capacitance (With shield-can)		0.007 *max.*	*μμf*
Input Capacitance		5.3	*μμf*
Output Capacitance		10.5	*μμf*
Bulb			ST-14
Cap			Small Metal
Base			Medium 5-Pin

* Maximum plate voltage = 275 volts.

INSTALLATION

The **base** pins of the 35 fit the standard five-contact socket which may be installed to hold the tube in any position.

For **heater** operation and **cathode** connection, refer to type 2A5.

The **screen voltage** for the 35 may be obtained from a fixed or variable tap on a voltage divider across the supply voltage or from a portion of the supply.

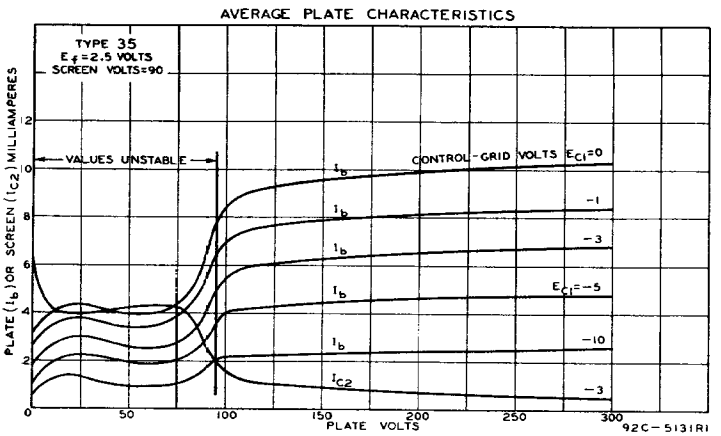
Complete **shielding** for all stages of the circuit is necessary if maximum gain and the volume-control-range capabilities of this tube are to be realized.

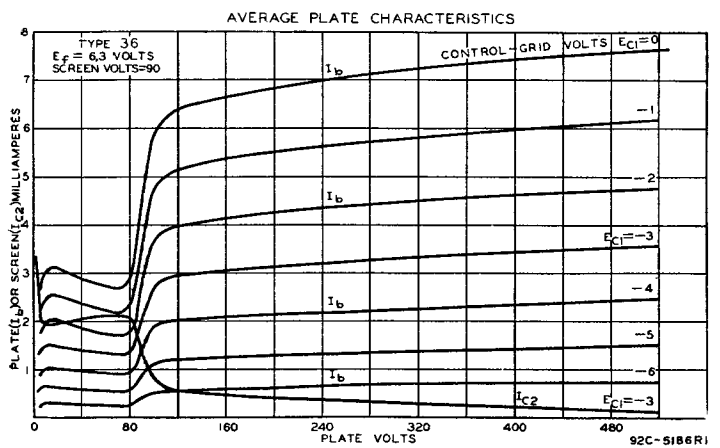
APPLICATION

As a **radio-frequency** and **intermediate-frequency amplifier**, the 35 should be operated as shown under CHARACTERISTICS. In general, properly designed radio-frequency transformers are preferable to interstage coupling impedances, especially in cases where a high-impedance B-supply may cause oscillation below radio frequencies.

Volume control of receivers designed for the 35 may be accomplished by variation of the negative grid bias of this tube. In order to utilize the full volume-control range of the 35, an available grid-bias voltage of approximately 50 volts will be required, depending on the circuit design and operating conditions. This voltage may be obtained from a potentiometer, a bleeder circuit, or from an adjustable cathode resistor.

As a mixer in superheterodyne receivers, the 35 may be used under the following conditions: Plate voltage, 250 volts; screen voltage, 90 volts; and grid bias, −7 volts with a 6-volt peak swing from the oscillator. By varying the grid bias on the mixer in conjunction with that on the radio-frequency and/or the intermediate-frequency stages, additional control of volume may be accomplished.





35A5-LT

BEAM POWER AMPLIFIER
(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	35	Volts
HEATER CURRENT	0.15	Ampere
MAXIMUM OVERALL LENGTH	3-3/8"	
MAXIMUM DIAMETER	1-1/4"	
BULB	T-9	
BASE	Intermediate Wafer Octalox 8-Pin with Sleeve	

Single-Tube Amplifier - Class A_1

OPERATING CONDITIONS and CHARACTERISTICS:

Heater Voltage #	35		Volts
Plate Voltage	110	max.*	Volts
Screen Voltage	110	max.*	Volts
Grid Voltage ##	-7.5		Volts
Peak A-F Grid Voltage	7.5		Volts
Plate Resistance	14000		Ohms
Transconductance	5800		Micromhos
Zero-Signal Plate Current	40		Milliamperes
Max.-Signal Plate Current	41		Milliamperes
Zero-Signal Screen Current	3		Milliamperes
Max.-Signal Screen Current	7		Milliamperes
Load Resistance	2500		Ohms
Total Harmonic Distortion	6.5		Per cent
Power Output	1.5		Watts

* Design maximum for 117-volt line.

\# Heater to cathode bias should not exceed 90 volts d.c. as measured between the negative heater terminal and cathode.

\#\# The type of input coupling should not introduce too much resistance in the grid circuit. Transformer- or impedance-coupling devices are recommended. When the grid circuit has a resistance not higher than 0.1 megohm, fixed bias may be used; for higher values, self-bias is required. With self-bias, the grid circuit may have a resistance not to exceed 0.5 megohm, provided the heater voltage is not allowed to rise more than 10% above the rated value under any condition of operation.

Pin Connections

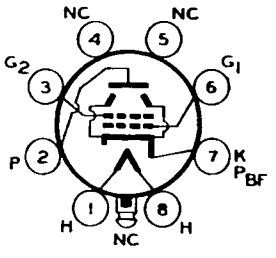
Pin 1 - Heater	Pin 6 - Grid
Pin 2 - Plate	Pin 7 - Cathode
Pin 3 - Screen	Pin 8 - Heater
Pin 4 - No Connection	Plug - No Connection
Pin 5 - No Connection	

(Pin numbers are according to RMA system)

Operating Position

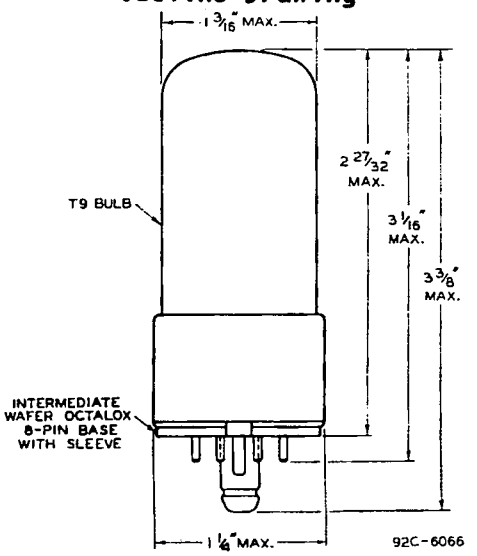
Vertical or Horizontal - No restrictions

Bottom View of Socket Connections



6AT

Outline Drawing



September 21, 1939

from EIA Registration # 216, Sept. 21, 1939

#216
9/21/39
A237

35Z3-LT

HALF-WAVE HIGH-VACUUM RECTIFIER

(TENTATIVE DATA)

HEATER VOLTAGE (A.C. or D.C.)	35	Volts
HEATER CURRENT	0.15	Ampere
MAXIMUM OVERALL LENGTH	3-5/32"	
MAXIMUM DIAMETER	1-1/4"	
BULB	T-9	
BASE	Intermediate Wafer Octalox 8-Pin with Sleeve	

Maximum Ratings *

	Without Series Resistor	*With Series Resistor***	
A-C PLATE VOLTAGE (RMS)	117 max.	250 max.	Volts
PEAK INVERSE VOLTAGE	700 max.	700 max.	Volts
PEAK PLATE CURRENT	600 max.	600 max.	Milliamperes
D-C OUTPUT CURRENT	100 max.	100 max.	Milliamperes

* Design maximum for 117-volt line.

** An a-c input voltage greater than a design value of 117 volts requires the use of a 100-ohm (min.) resistor in series with the plate lead.

Pin Connections

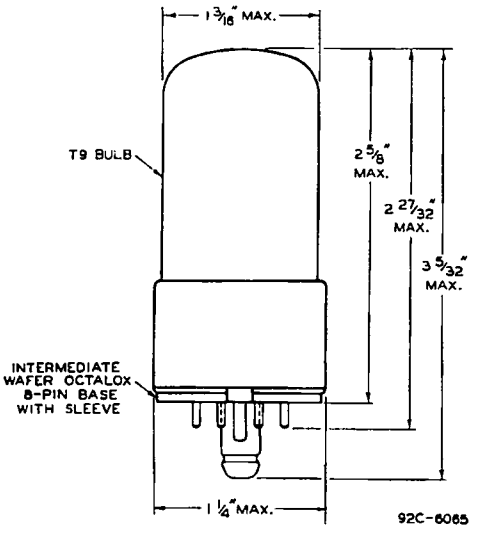
Pin 1 - Heater	Pin 6 - No Connection
Pin 2 - Plate	Pin 7 - Cathode
Pin 3 - No Connection	Pin 8 - Heater
Pin 4 - No Connection	Plug - No Connection
Pin 5 - No Connection	

(Pin numbers are according to RMA system)

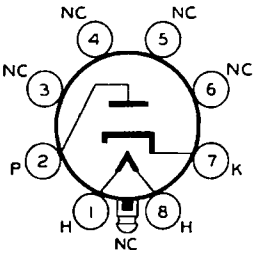
Operating Position

Vertical or Horizontal - No restrictions

Outline Drawing

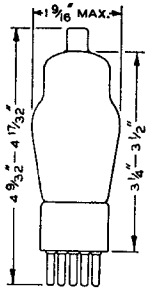


Bottom View of Socket Connections



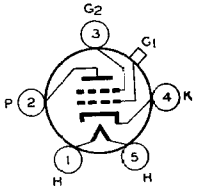
4Z

from RMA release #216, Sept. 21, 1939



RCA-36

RADIO-FREQUENCY AMPLIFIER



The 36 is a heater-cathode type of screen grid tube intended for use as a radio-frequency amplifier, intermediate-frequency amplifier, and detector.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)				6.3	Volts
Heater Current				0.3	Ampere
Plate Voltage	100	135	180	250 *max.*	Volts
Screen Voltage	55	67.5	90 *max.*	90 *max.*	Volts
Grid Voltage	−1.5	−1.5	−3	−3	Volts
Plate Current	1.8	2.8	3.1	3.2	Milliamperes
Screen Current	—	—	—	1.7 *max.*	Milliamperes
Plate Resistance	0.55	0.475	0.5	0.55	Megohm
Amplification Factor	470	475	525	595	
Transconductance	850	1000	1050	1080	Micromhos
Grid-Plate Capacitance (With shield-can)				0.007 *max.*	μμf
Input Capacitance				3.7	μμf
Output Capacitance				9.2	μμf
Bulb					ST-12
Cap					Small Metal
Base					Small 5-Pin

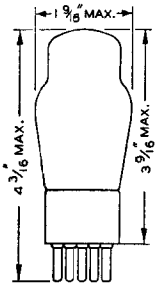
INSTALLATION AND APPLICATION

The base pins of the 36 fit the standard five-contact socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION for type 6A8. For screen voltage and shielding, refer to INSTALLATION for type 35.

As a radio-frequency amplifier, the 36 should be operated as shown under CHARACTERISTICS.

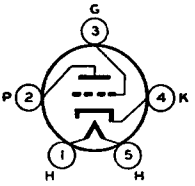
As a detector, the 36 may be operated either with grid leak and condenser or with grid bias. For grid-bias detection, suitable operating conditions are: Plate-supply voltage, 180 volts applied through a plate-coupling resistor of 0.25 megohm or an equivalent impedance; screen voltage, 67.5 volts; and negative grid bias, 6 volts (approx.) so adjusted that a plate current of 0.1 milliampere is obtained with no input signal.

A plate family of characteristics is given on the preceding page.



RCA-37

DETECTOR, AMPLIFIER



The 37 is a three-electrode general-purpose tube of the heater-cathode type for use as amplifier and detector.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)				6.3	Volts
HEATER CURRENT				0.3	Ampere
PLATE VOLTAGE	90	135	180	250 *max.*	Volts
GRID VOLTAGE*	−6	−9	−13.5	−18	Volts
PLATE CURRENT	2.5	4.1	4.3	7.5	Milliamperes
PLATE RESISTANCE	11500	10000	10200	8400	Ohms
AMPLIFICATION FACTOR	9.2	9.2	9.2	9.2	
TRANSCONDUCTANCE	800	925	900	1100	Micromhos
GRID-PLATE CAPACITANCE				2.0	μμf
GRID-CATHODE CAPACITANCE				3.5	μμf
PLATE-CATHODE CAPACITANCE				2.9	μμf
BULB					ST-12
BASE					Small 5-Pin

* The d-c resistance in the grid circuit should not exceed 1.0 megohm.

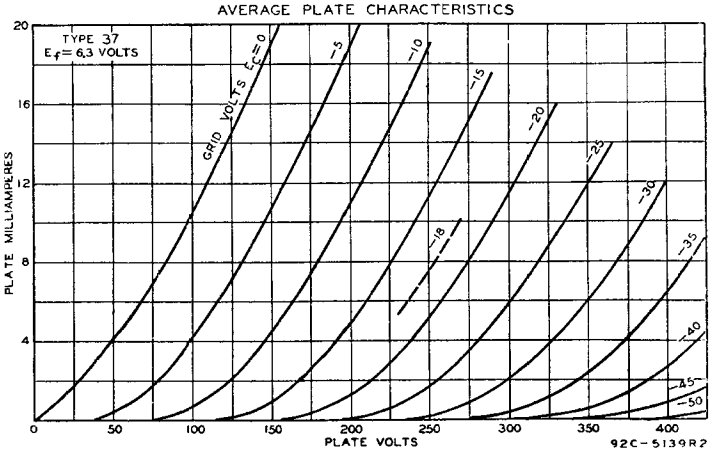
INSTALLATION AND APPLICATION

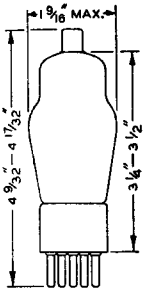
The **base** pins of the 37 fit the standard five-contact socket which may be installed to hold the tube in any position. For **heater** operation and **cathode** connection, refer to INSTALLATION for type 6A8.

As an **amplifier**, the 37 is applicable to the audio- or the radio-frequency stages of a receiver. Recommended plate and grid voltages are shown under CHARACTERISTICS.

As a **detector**, the 37 may be operated with either grid leak and condenser or with grid bias. The plate voltage for the grid leak and condenser method is 45 volts. A grid leak of from 1 to 5 megohms used with a grid condenser of 0.00025 μf is suitable. For grid-bias detection a plate voltage of 250 volts, together with a negative grid bias of approximately 28 volts, may be used. The plate current should be adjusted to 0.2 milliampere with no input signal.

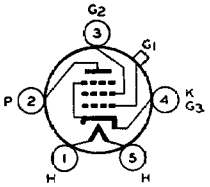
AVERAGE PLATE CHARACTERISTICS





RCA-38

POWER-AMPLIFIER PENTODE



The 38 is a power-amplifier pentode of the heater-cathode type. The relatively low heater current of this type makes it suitable for automobile receivers and for power-line-operated sets, particularly those with a series-heater arrangement.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)				6.3	Volts
Heater Current				0.3	Ampere
Plate Voltage	100	135	180	250 *max.*	Volts
Screen Voltage	100	135	180	250 *max.*	Volts
Grid Voltage	−9	−13.5	−18	−25	Volts
Plate Current	7	9	14	22	Milliamperes
Screen Current	1.2	1.5	2.4	3.8	Milliamperes
Plate Resistance	0.14	0.13	0.115	0.10	Megohm
Amplification Factor	120	120	120	120	
Transconductance	875	925	1050	1200	Micromhos
Load Resistance	15000	13500	11600	10000	Ohms
Self-Bias Resistor	1100	1100	1100	970	Ohms
Power Output	0.27*	0.55†	1.0*	2.5*	Watts
Grid-Plate Capacitance				0.30	μμf
Input Capacitance				3.5	μμf
Output Capacitance				7.5	μμf
Bulb					ST-12
Cap					Small Metal
Base					Small 5-Pin

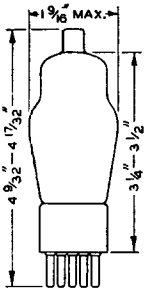
* 8% total harmonic distortion.
† 10% total harmonic distortion.

INSTALLATION AND APPLICATION

The base pins of the 38 fit the standard five-contact socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION for type 6A8.

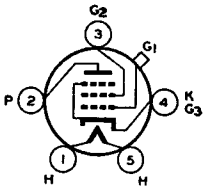
For the power amplifier stage of radio receivers, the 38 is recommended either singly or in push-pull combination. Transformer or impedance-coupling devices are preferable. If, however, resistance coupling is used, the d-c resistance in the grid circuit should be limited to 1.0 megohm with plate voltages up to 250 volts, provided the heater voltage does not rise more than 10% above the rated value under any condition of operation.

A plate family of characteristics is given on page 125.



RCA-39/44

SUPER-CONTROL R-F AMPLIFIER PENTODE



The 39/44 is a heater-cathode tube of the remote cut-off type suitable for use primarily as a radio-frequency amplifier, intermediate-frequency amplifier, and mixer in receivers designed for its characteristics. The 39/44 is effective in reducing cross-modulation and modulation-distortion over the usual range of signal voltages without the use of antenna potentiometers or auxiliary volume-control switches. An explanation of the Super-Control feature is given on page 16.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)			6.3	Volts
Heater Current			0.3	Ampere
Plate Voltage	90	180	250 *max.*	Volts
Screen Voltage	90	90	90 *max.*	Volts
Grid Voltage (Minimum)	−3	−3	−3	Volts
Plate Current	5.6	5.8	5.8	Milliamperes
Screen Current	1.6	1.4	1.4	Milliamperes
Plate Resistance	0.375	0.75	1.0	Megohm
Amplification Factor	360	750	1050	
Transconductance	960	1000	1050	Micromhos
Transconductance (At −42.5 volts bias)	2	2	2	Micromhos
Grid-Plate Capacitance (With shield-can)			0.007 *max.*	*μμf*
Input Capacitance			3.5	*μμf*
Output Capacitance			10	*μμf*
Bulb				ST-12
Cap				Small Metal
Base				Small 5-Pin

INSTALLATION

The **base** pins of the 39/44 fit the standard five-contact socket. The **socket** may be installed to hold the tube in any position.

For **heater** operation and **cathode** connection, refer to INSTALLATION for type 6A8.

The **screen voltage** for the 39/44 may be obtained from a section of the B-battery, from a fixed or variable tap on a voltage divider across the supply voltage, or from a portion of the supply. Care should be taken to keep the impedance between the screen and cathode as low as possible.

When the 39/44 is self-biased, a resistor in series with the high-voltage supply may be used for obtaining the screen voltage. This is possible because of the stable screen-current characteristic of the 39/44 pentode. The resistor method of securing the screen voltage is limited to circuits where the screen-voltage supply does not exceed 180 volts as a maximum. The value of this resistance should be such that under the conditions of minimum grid bias and maximum plate current the screen voltage will not exceed 90 volts. A resistance of approximately 80000 ohms will be suitable.

Complete **shielding** of all stages is necessary if maximum gain per stage is to be obtained.

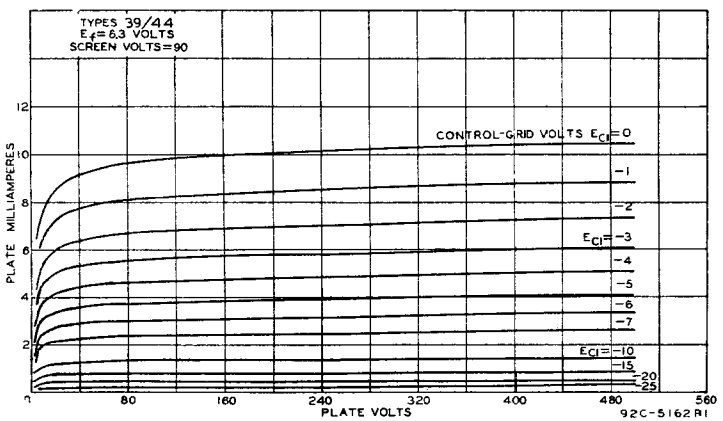
APPLICATION

As a **radio-frequency** and **intermediate-frequency amplifier**, the 39/44 should be operated as shown under CHARACTERISTICS. In general, properly designed radio-frequency transformers are preferable to interstage coupling impedances, especially in cases where a high impedance B-supply may cause oscillation below radio frequencies.

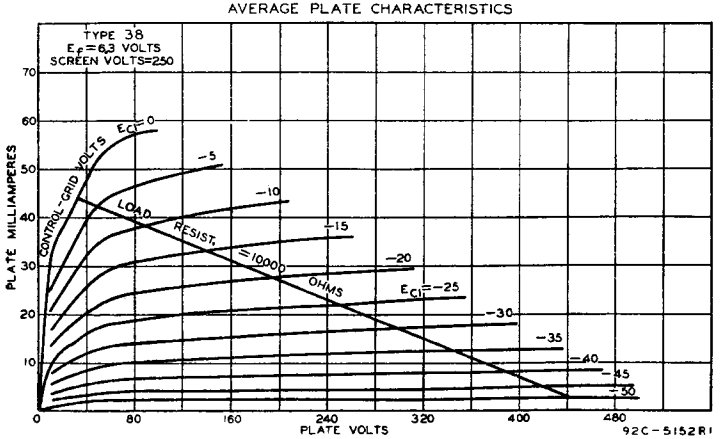
Volume control of receivers designed for the 39/44 may be accomplished by variation of the negative grid bias of this tube. In order to obtain adequate volume control, an available grid-bias voltage of approximately 45 volts will be required. The exact value will depend upon the circuit design and operating conditions. This voltage may be obtained from a potentiometer, a bleeder circuit, a variable resistor in the cathode circuit, or from a separate source.

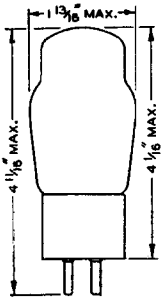
As a **detector mixer** in superheterodyne receivers, the 39/44 may be utilized. Suitable operating voltages for such service are: Plate voltage, 90 to 250 volts; screen voltage, 90 volts; grid voltage, −7 volts (approx.), with a 6-volt peak swing from the oscillator. By varying the grid bias on the mixer in conjunction with that on the r-f and/or the i-f stages, additional control of volume may be accomplished.

AVERAGE PLATE CHARACTERISTICS



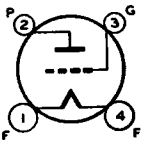
AVERAGE PLATE CHARACTERISTICS





RCA-40

VOLTAGE AMPLIFIER



The 40 is a high-mu triode of the storage-battery type for use in resistance-coupled or impedance-coupled amplifier or detector circuits.

CHARACTERISTICS

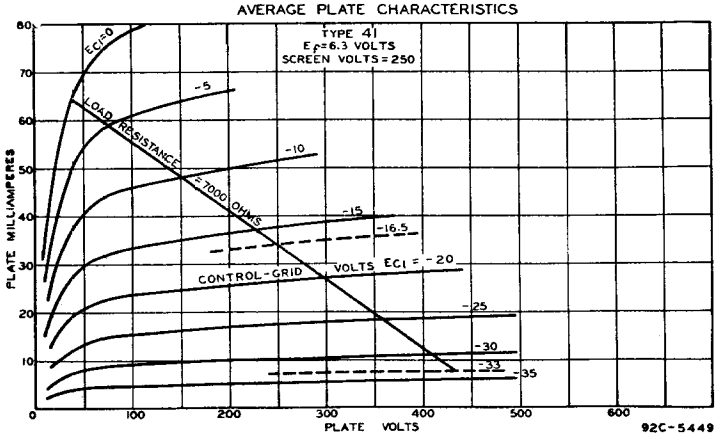
Filament Voltage (D. C.)		5.0	Volts
Filament Current		0.25	Ampere
Plate Voltage*	135	180	Volts
Grid Voltage	−1.5	−3	Volts
Plate Current	0.2	0.2	Milliampere
Plate Resistance	150000	150000	Ohms
Amplification Factor	30	30	
Transconductance	200	200	Micromhos
Bulb			ST-14
Base			Medium 4-Pin Bayonet

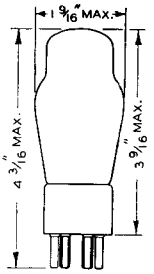
* Effective voltage at plate will be plate supply voltage minus voltage drop in load of 0.25 megohm caused by plate current; the effective value should not exceed 180 volts.

This type is used principally for renewal purposes.

———o0O0o———

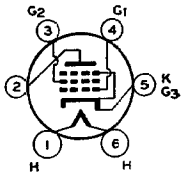
AVERAGE PLATE CHARACTERISTICS





RCA-41

POWER-AMPLIFIER PENTODE



The 41 is a power-amplifier pentode of the heater-cathode type for use in the audio-output stage of radio receivers with 6.3-volt heater supply. The tube is capable of giving a large power output with a relatively small input-signal voltage.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)				6.3	Volts
HEATER CURRENT				0.4	Ampere
PLATE VOLTAGE	100	135	180	250 *max.*	Volts
SCREEN VOLTAGE	100	135	180	250 *max.*	Volts
GRID VOLTAGE	−7	−10	−13.5	−18	Volts
PLATE CURRENT	9.0	12.5	18.5	32	Milliamperes
SCREEN CURRENT	1.6	2.2	3.0	5.5	Milliamperes
PLATE RESISTANCE (Approx.)	103500	94000	81000	68000	Ohms
AMPLIF. FACTOR (Approx.)	150	150	150	150	
TRANSCONDUCTANCE	1450	1600	1850	2200	Micromhos
LOAD RESISTANCE	12000	10400	9000	7600	Ohms
SELF-BIAS RESISTOR	660	680	630	480	Ohms
POWER OUTPUT*	0.33	0.75	1.5	3.4	Watts
BULB					ST-12
BASE					Medium 6-Pin

* 10% total harmonic distortion.

INSTALLATION AND APPLICATION

The **base** pins of the 41 fit the standard six-contact socket which may be installed to hold the tube in any position. For **heater** operation and **cathode** connection, refer to INSTALLATION on type 6A8.

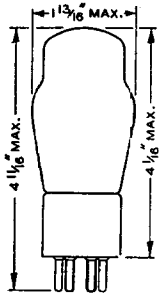
For the **power amplifier** stage of receivers, the 41 may be used either singly or in push-pull combination. More than one audio stage preceding the 41 is undesirable because of the possibility of microphonic disturbances resulting from the high level of amplification.

If a single 41 is operated self-biased, the self-bias resistor should be shunted by a suitable filter network to avoid degenerative effects at low audio frequencies. The use of two 41's in push-pull eliminates the necessity for shunting the resistor. The self-bias resistor required for two 41's in the same stage is one-half that for a single stage.

Any conventional type of **input coupling** may be used provided the resistance added to the grid circuit by this device is not too high. Transformer or impedance coupling devices are recommended. If, however, resistance coupling is employed, the grid resistor should not exceed one megohm with self-bias, provided the heater voltage does not rise more than 10% above the rated value under any condition of operation. When self-bias is not used, the value should be limited to 100000 ohms.

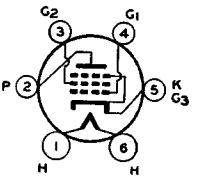
An **output transformer** should be used to supply power to the winding of the reproducing unit. The optimum value of load resistance for a single tube is given under CHARACTERISTICS. For push-pull operation, the plate-to-plate load resistance should be twice that for a single tube. For best results, the impedance in the plate circuit of the 41 should be as uniform as possible over the entire audio-frequency range.

A family of plate characteristic curves is given on the preceding page.



RCA-42

POWER-AMPLIFIER PENTODE



The 42 is a heater-cathode type of power-amplifier pentode for use in the audio-output stage of receivers. It is capable of giving large power output with a relatively small input-signal voltage. Because of the heater-cathode construction, a uniformly low hum-level is attainable in power amplifier design.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.7	Ampere
Bulb		ST-14
Base		Medium 6-Pin

As Single-Tube Class A_1 Amplifier

	Pentode Connection		*Triode Connection Screen tied to plate*	
Plate Voltage	250	315 *max.*	250°	Volts
Screen Voltage (Grid No. 2)	250	315 *max.*	—	Volts
Grid Voltage (Grid No. 1)	−16.5	−22	−20	Volts
Plate Current	34	42	31	Milliamperes
Screen Current	6.5	8	—	Milliamperes
Plate Resistance (Approx.)	80000	100000	2700	Ohms
Amplification Factor (Approx.)	190	260	6.2	
Transconductance	2350	2600	2300	Micromhos
Load Resistance	7000	7000	3000	Ohms
Total Harmonic Distortion	7	7	5	Per cent
Power Output	3	5	0.65	Watts

Under the above maximum voltage conditions, transformer or impedance input-coupling devices are recommended. If resistance coupling is used, refer to last paragraph of APPLICATION under type 6F6.

° Maximum plate volts = 315.

As Push-Pull Class AB_2 Amplifier—Pentode Connection

Values are for two tubes.

	Fixed Bias	*Self-Bias*	
Plate Voltage	375 *max.*	375 *max.*	Volts
Screen Voltage (Grid No. 2)	250 *max.*	250 *max.*	Volts
Grid Voltage (Grid No. 1)	−26 *min.*	—	Volts
Self-Bias Resistor	—	340 *min.*	Ohms
Zero-Signal Plate Current	34	54	Milliamperes
Zero-Signal Screen Current	5	8	Milliamperes
Load Resistance (Plate-to-plate)	10000	10000	Ohms
Total Harmonic Distortion	5	5	Per Cent
Power Output	19*	19‡	Watts

* With one triode-connected 42 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 3.32. The plate, screen and grid supply have negligible resistance.

‡ With one triode-connected 42 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 2.5. The plate and screen supply have negligible resistance. The value given for the self-bias resistor is determined for a minimum grid bias of −21 volts.

Under the above maximum voltage conditions, transformer or impedance input-coupling devices must be used.

As Push-Pull Class AB_2 Amplifier—Triode Connection
Screen Tied to Plate

Values are for two tubes.

	Fixed Bias	*Self-Bias*	
PLATE VOLTAGE	350 *max.*	350 *max.*	Volts
GRID VOLTAGE	−38 *min.*	—	Volts
SELF-BIAS RESISTOR	—	730 *min.*	Ohms
ZERO-SIGNAL PLATE CURRENT	45	50	Milliamperes
LOAD RESISTANCE (Plate-to-plate)	6000	10000	Ohms
TOTAL HARMONIC DISTORTION	7	7	Per cent
POWER OUTPUT	18†	14**	Watts

† With one triode-connected 42 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 1.67. The plate and grid supply have negligible resistance.

** With one triode-connected 42 as driver operated at plate volts of 250, grid volts of −20, and with a minimum plate load of approximately 10000 ohms: input transformer ratio, primary to one-half secondary, is 1.29. The plate supply has negligible resistance. The value given for the self-bias resistor is determined for a minimum grid bias of −36.5 volts.

Under the above maximum voltage conditions, transformer or impedance input-coupling devices must be used

INSTALLATION AND APPLICATION

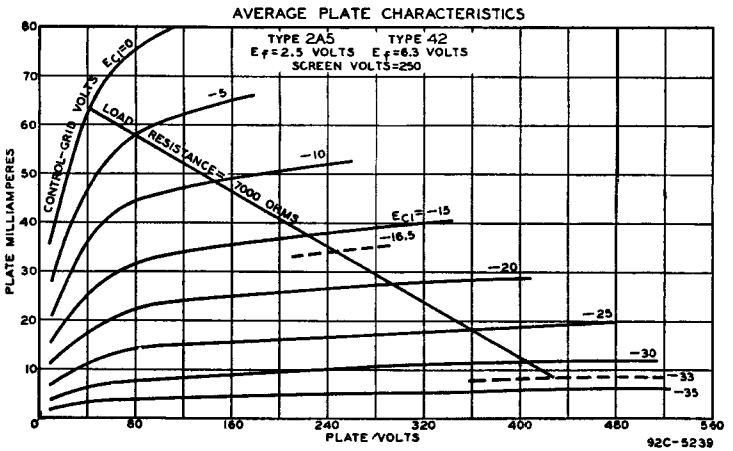
The **base** pins of the 42 fit the standard six-contact socket which may be installed to hold the tube in any position. Sufficient ventilation should be provided to prevent overheating.

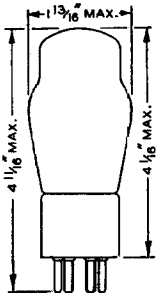
The **heater** is designed to operate at 6.3 volts. In a series-heater circuit employing several 6.3-volt types and one or more 42's, the heaters of the 42's should be placed on the positive side. Furthermore, since most 6.3-volt types have 0.3-ampere heaters, a bleeder circuit across these heaters is required to take care of the additional 0.4-ampere heater current of the 42. Each 6.3-volt tube of the 0.3-ampere type in the series circuit should, therefore, be shunted by a bleeder resistance of 16 ohms.

The **cathode** should preferably be connected directly to a mid-tap on the heater winding or to a center-tapped resistor across the heater winding. If this practice is not followed, the potential difference between heater and cathode should be kept as low as possible.

For **application,** refer to type 6F6.

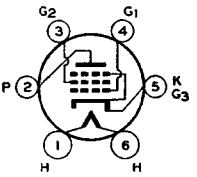
Additional curve data is given under type 2A5.





RCA-43

POWER-AMPLIFIER PENTODE



The 43 is a power-amplifier pentode of the heater-cathode type for use in the output stage of radio receivers, especially those of the "d-c power line" type and the "universal (a.c.-d.c.)" type. In such applications, the 43 is capable of handling relatively large audio power at the low plate and screen voltage available. A single 43 in the output stage operating with 100 volts on plate and screen can deliver nearly one watt of audio power, while two 43's in push-pull arrangement with the same voltages can supply approximately two watts.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	25	Volts
HEATER CURRENT	0.3	Ampere
BULB		ST-14
BASE		Medium 6-Pin

Other characteristics of this type are the same as for the type 25A6.

INSTALLATION AND APPLICATION

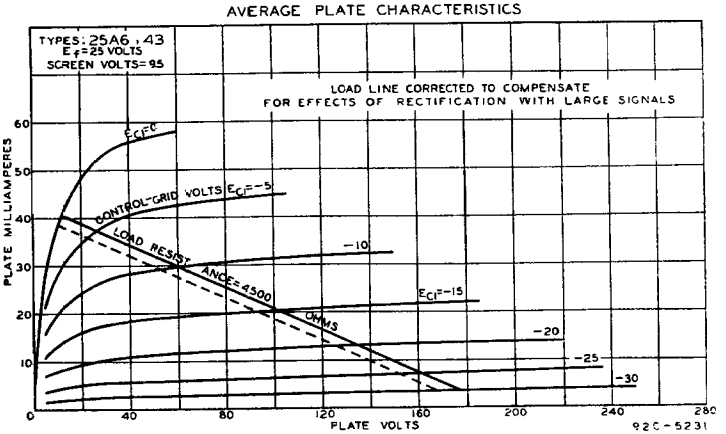
The base pins of the 43 fit the standard six-contact socket which may be installed to hold the tube either in a vertical or in a horizontal position. Sufficient ventilation should be provided to circulate air freely around the tube to prevent overheating.

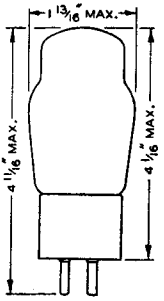
For heater operation and cathode connection, refer to type 25A6.

For APPLICATION, refer to type 25A6.

An additional family of plate characteristic curves which applies to type 43 is given under type 25A6.

AVERAGE PLATE CHARACTERISTICS

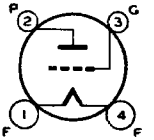




RCA-45

POWER AMPLIFIER

The 45 is a power-amplifier triode of the filament type capable of supplying large undistorted output in a-c operated receivers.



CHARACTERISTICS

Filament Voltage (A. C. or D. C.)	2.5	Volts
Filament Current	1.5	Amperes
Grid-Plate Capacitance	7	$\mu\mu f$
Grid-Filament Capacitance	4	$\mu\mu f$
Plate-Filament Capacitance	3	$\mu\mu f$
Bulb		ST-14
Base		Medium 4-Pin

As Single-Tube Class A_1 Amplifier

Filament Voltage (A. C.)			2.5	Volts
Plate Voltage	180	250	275 *max.*	Volts
Grid Voltage*	−31.5	−50	−56	Volts
Plate Current	31	34	36	Milliamperes
Plate Resistance	1650	1610	1700	Ohms
Amplification Factor	3.5	3.5	3.5	
Transconductance	2125	2175	2050	Micromhos
Load Resistance	2700	3900	4600	Ohms
Self-Bias Resistor	1020	1470	1550	Ohms
Undistorted Power Output	0.825	1.6	2.0	Watts

* Grid volts measured from mid-point of a-c operated filament. Self-bias is advisable in all cases, required if grid d-c resistance (max. value of 1.0 megohm) is used in grid circuit.

As Push-Pull Class AB_2 Amplifier (Two Tubes)

Values are for two tubes.

	Fixed Bias	*Self-Bias*	
Filament Voltage (A. C.)	2.5	2.5	Volts
Plate Voltage (Maximum)	275	275	Volts
Grid Voltage	−68	—	Volts
Self-Bias Resistor	—	775	Ohms
Zero-Signal Plate Current	28	72	Milliamperes
Maximum-Signal Plate Current	138	90	Milliamperes
Load Resistance (Plate-to-plate)	3200	5060	Ohms
Total Harmonic Distortion	5	5	Per cent
Power Output	18	12	Watts

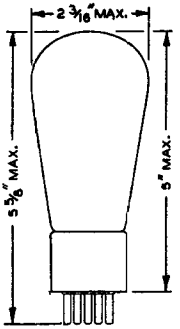
INSTALLATION AND APPLICATION

For installation refer to INSTALLATION on type 2A3.

As a **power amplifier** (Class A_1), the 45 may be used either singly or in push-pull. Typical operating conditions are given under CHARACTERISTICS.

In a **push-pull** Class AB_2 stage, the 45 is operated under conditions such that a small amount of grid current flows during the most positive swing of the input signal and the second harmonic distortion is cancelled by virtue of the push-pull circuit. A driver stage, consisting of one 56 operated at 250 volts on the plate, will drive two 45's in push-pull (fixed-bias or self-bias) to the stated output values. A step-down interstage transformer of suitable design is required.

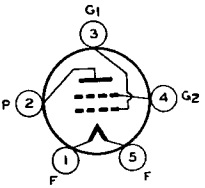
A family of plate characteristic curves is given on page 143.



RCA-46

DUAL-GRID POWER AMPLIFIER

The 46 is a double-grid power-amplifier tube recommended especially for service in Class B amplifier circuits of suitable design.



CHARACTERISTICS

Filament Voltage (A. C. or D. C.)	2.5	Volts
Filament Current	1.75	Amperes
Bulb		S-17
Base		Medium 5-Pin

As Class B Amplifier

(Grid No. 1 and No. 2 connected together at socket)

Plate Voltage	400 *max.*	Volts
Peak Plate Current	200 *max.*	Milliamperes
Average Plate Dissipation	10 *max.*	Watts

Typical Operation (2 tubes)

Values are for two tubes.

Plate Voltage	300	400	Volts
Grid Voltage	0	0	Volts
Zero-Signal Plate Current	8	12	Milliamperes
Effective Load Resistance (Plate-to-plate)	5200	5800	Ohms
Power Output (Approximate)	16*	20†	Watts

* With average power input of 950 milliwatts applied between grids.
† With average power input of 650 milliwatts applied between grids.

As Class A_1 Amplifier

(Grid No. 2 connected to plate at socket)

Plate Voltage	250 *max.*	Volts
Grid Voltage	−33	Volts
Plate Current	22	Milliamperes
Plate Resistance	2380	Ohms
Amplification Factor	5.6	
Transconductance	2350	Micromhos
Load Resistance (For max. undistorted power)††	6400	Ohms
Undistorted Power Output	1.25	Watts

†† Approximately twice this value is recommended for load of this tube as driver for Class B stage.

INSTALLATION

The base pins of the 46 fit the standard five-contact socket which may be installed to hold the tube either in a vertical or in a horizontal position. For horizontal operation, the socket should be positioned with the filament-pin openings one vertically above the other. Sufficient ventilation should be provided around the tube to prevent overheating.

The filament is designed to operate at 2.5 volts. The transformer winding supplying the filament circuit should operate the filament at this recommended value for full-load operating conditions at average line voltage. The filament wiring should, insofar as possible, be isolated from the input circuit of the driver stage in order to avoid the possibility of hum caused by electrostatic induction from this wiring.

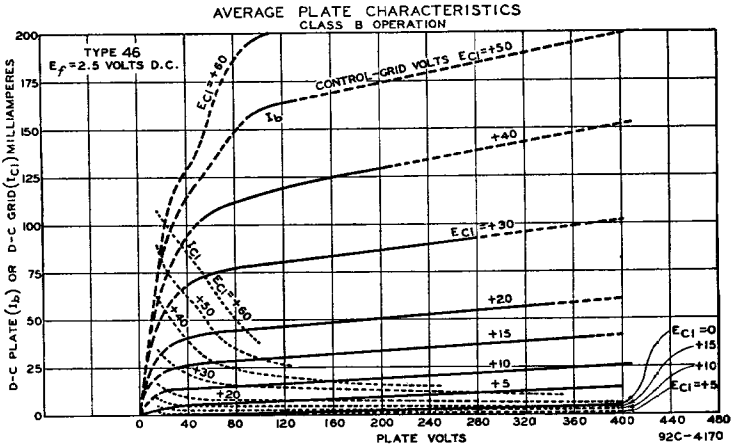
The grid- and the plate-return lead for the Class B stage should be connected to the mid-tap of the filament winding or to the center-tap of a 20-ohm resistor across the winding. The grid- and plate-return for the driver stage should be made

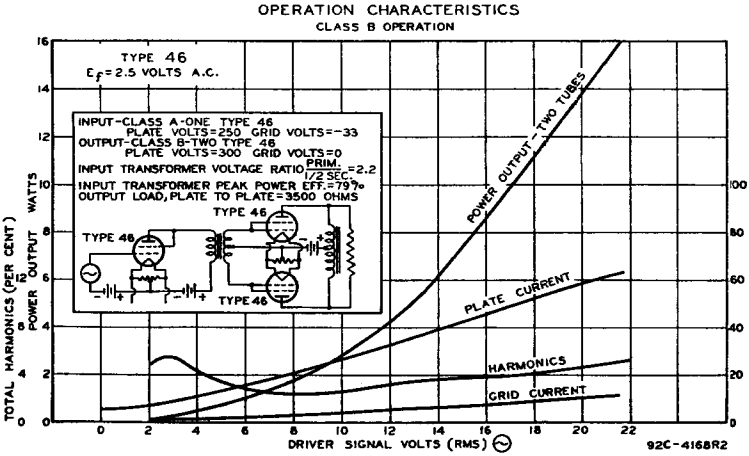
to a variable center-tapped resistor across the filament supply for minimum hum adjustment. The use of a push-pull driver stage with either equi-potential or filament-type tubes will reduce hum resulting from the filament supply, but is required only in special applications.

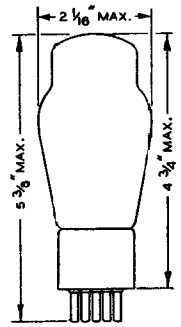
APPLICATION

In **Class B audio power-amplifier service,** the 46 is recommended because the two grids in the tube are connected together and, thus, the signal voltage is applied to both simultaneously. Consideration of general Class B amplifier design features is given on page 20.

For **Class A_1 operation** of the 46, the grid adjacent to the plate is connected to the plate. The intended application of the 46 as a Class A amplifier is for driving two 46's in a Class B amplifier circuit. The tube has been constructed for this dual service in order to reduce the number of tube types necessary in a receiver. The tabulated values for Class A operation of this type, as given under CHARACTERISTICS, are for its operation as a power output tube.

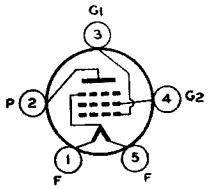






RCA-47

POWER-AMPLIFIER PENTODE



The 47 is a power-amplifier pentode for use in the audio output stage of a-c receivers. In comparison with three-electrode Class A power amplifiers of the same plate dissipation, the 47 is capable of greater output with the additional feature of higher amplification.

CHARACTERISTICS

Filament Voltage (A. C. or D. C.)	2.5	Volts
Filament Current	1.75	Amperes
Plate Voltage	250 *max.*	Volts
Screen Voltage	250 *max.*	Volts
Grid Voltage*	−16.5	Volts
Plate Current	31	Milliamperes
Screen Current	6	Milliamperes
Plate Resistance	60000	Ohms
Amplification Factor	150	
Transconductance	2500	Micromhos
Load Resistance	7000	Ohms
Self-Bias Resistor	450	Ohms
Power Output (6% total harmonic distortion)	2.7	Watts
Grid-Plate Capacitance	1.2	μμf
Input Capacitance	8.6	μμf
Output Capacitance	13.0	μμf
Bulb		ST-16
Base		Medium 5-Pin

* If filament is operated on d-c, grid bias should be −15.3 volts.

INSTALLATION AND APPLICATION

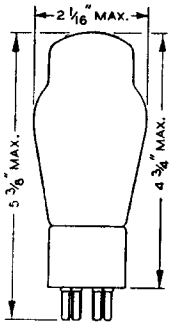
The base pins of the 47 fit the standard five-contact socket which should be installed preferably to hold the tube in a vertical position. If it is necessary to place the tube in a horizontal position, the socket should be mounted with its filament-pin openings one vertically above the other. Sufficient ventilation should be provided around the tube to prevent overheating.

For the **power amplifier** stage of radio receivers, the 47 is recommended either singly or in push-pull combination. More than one audio stage preceding the 47 is undesirable because of the possibility of microphonic disturbances resulting from the high level of amplification.

Any conventional type of **input coupling** may be used, provided the resistance added to the grid circuit by this device is not too high. Transformer or impedance-coupling devices are preferable. If resistance coupling is used, the d-c resistance in the grid circuit should not exceed 0.5 megohm with self-bias, or 50000 ohms with fixed bias.

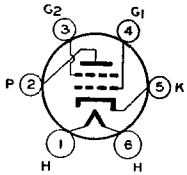
The **blue glow** which frequently appears on the inner surface of the 47 bulb is due to fluorescence caused by stray electrons from the filament which strike the interior of the getter-coated bulb. *This fluorescence is a natural effect and is in no manner an indication of the performance of the tube.*

A family of plate characteristic curves is given at the bottom of page 138.



RCA-48

POWER-AMPLIFIER TETRODE



The 48 is a power-amplifier tetrode which has pentode characteristics when operated at the recommended screen and plate voltage. It is for use in the audio-output stage of receivers designed to operate from 115-volt d-c power lines. The 48 is exceptional in its ability to deliver power at the low plate and screen voltage obtainable in such service.

The large power-delivering ability of the 48 is made practical by the unique features of its electrical and structural design. Among these are the big cathode with its large emitting surface, the control-grid structure with its heat radiator, and the plate with a rib structure fastened to its inner surface. The rib structure serves to suppress the effects of secondary emission which limit the power output of four-electrode screen grid types.

CHARACTERISTICS

Heater Voltage (D. C.)	30	Volts
Heater Current	0.4	Ampere
Bulb		ST-16
Base		Medium 6-Pin

As Single-Tube Class A Amplifier

	Tetrode Connection		*Triode Connection Screen tied to plate*		
Plate Voltage	96	125 *max.*	80	125 *max.*	Volts
Screen Voltage (Grid No. 2)	96	100 *max.*	—	—	Volts
Grid Voltage (Grid No. 1)	−19	−20	−20	−32.5	Volts
Plate Current	52	56	31	52	Milliamperes
Screen Current	9	9.5	—	—	Milliamperes
Plate Resistance	Subject to consid-		760	675	Ohms
Amplification Factor	erable variation.		2.5	2.5	
Transconductance	3800	3900	3300	3700	Micromhos
Load Resistance	1500	1500	—	—	Ohms
Self-Bias Resistor	310	310	—	—	Ohms
Power Output*	2	2.5	—	—	Watts

* 9% total harmonic distortion.

As Push-Pull Class A Amplifier

Values are for two tubes

	Tetrode Connection	*Triode Connection Screen tied to plate*	
Plate Voltage	125 *max.*	125 *max.*	Volts
Screen Voltage (Grid No. 2)	100 *max.*	—	Volts
Grid Voltage (Grid No. 1)	−20	−32.5	Volts
Zero-Signal Plate Current	100	100	Milliamperes
Load Resistance (Plate-to-Plate)	3000	1250	Ohms
Total Harmonic Distortion	9	2	Per cent
Power Output	5	3	Watts

INSTALLATION AND APPLICATION

The **base pins** of the 48 fit the standard six-contact socket which may be installed to hold the tube either in a vertical or in a horizontal position. For horizontal operation, the socket should be positioned with the plate-pin opening at the top and the cathode-pin opening at the bottom, or vice versa. Sufficient ventilation should be provided around the tube to prevent overheating.

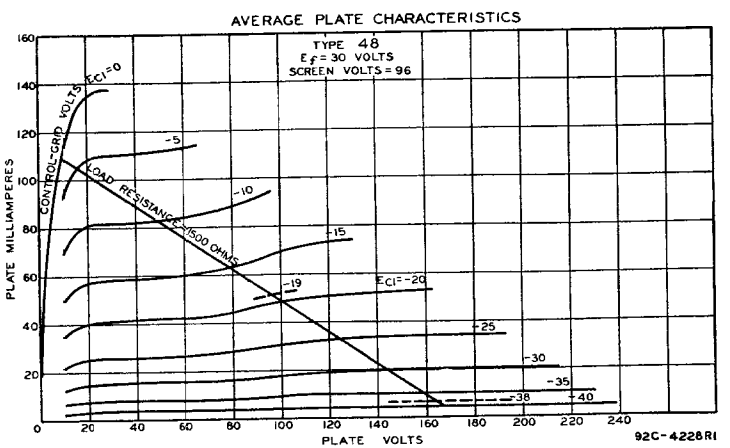
The **heater** of the 48 is designed to operate at approximately 30 volts d. c. Due to the heater-cathode design, the heater voltage may range between 26 and 34 volts during line-voltage fluctuations without greatly affecting the performance or serviceability of the tube.

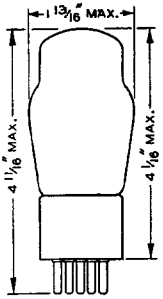
In a series-heater circuit employing several 6.3-volt types and one or more 48's, the heaters of the 48's should be placed on the positive side of the line. Furthermore, since the 6.3-volt types have 0.3-ampere heaters, a bleeder circuit across these heaters is required to take care of the additional 0.1-ampere heater current of the 48. Each 6.3-volt tube in the series circuit should, therefore, be shunted by a bleeder resistance of 63 ohms.

The **cathode** circuit in d-c receivers is tied in either directly or through biasing resistors to the negative side of the heater circuit. The potential difference thus introduced between heater and cathode of the 48 should not exceed 90 volts, as measured between the negative heater terminal and the cathode.

As a **Single Class A power-amplifier** tetrode the 48 should be operated as shown under CHARACTERISTICS.

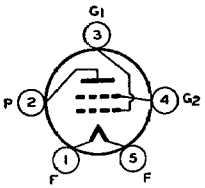
Any conventional type of **input coupling** may be used, provided the resistance added to the grid circuit by this device is not too high. Transformer or impedance-coupling devices are preferable. In any case, the d-c resistance in the grid circuit should not exceed 10000 ohms.





RCA-49

DUAL-GRID POWER AMPLIFIER



The 49 is a double-grid power-amplifier tube designed for use in battery-operated receivers employing 2-volt tubes. In such service, it may be used either as a Class B output tube or, by a change in socket connections, as a Class A driver tube.

CHARACTERISTICS

Filament Voltage (D. C.)	2.0	Volts
Filament Current	0.12	Ampere
Bulb		ST-14
Base		Medium 5-Pin

As Class B Power Amplifier

(Grids No. 1 and No. 2 connected together at socket)

Plate Voltage	180 *max.*	Volts
Peak Plate Current	50 *max.*	Milliamperes

Typical Operation (2 tubes)

Values are for two tubes.

Plate Voltage	135	180	Volts
Grid Voltage	0	0	Volts
Zero-Signal Plate Current	2.6	4	Milliamperes
Effective Load Resistance (Plate-to-plate)	8000	12000	Ohms
Power Output Approximate	2.3	3.5	Watts

As Driver—Class A_1 Amplifier

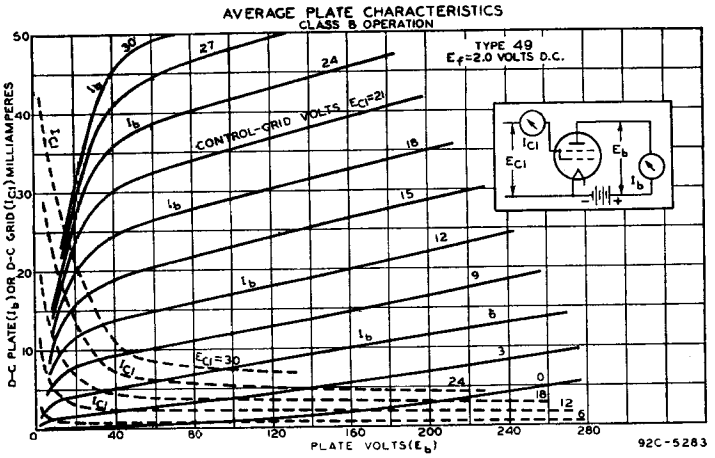
(Grid No. 2 connected to plate at socket)

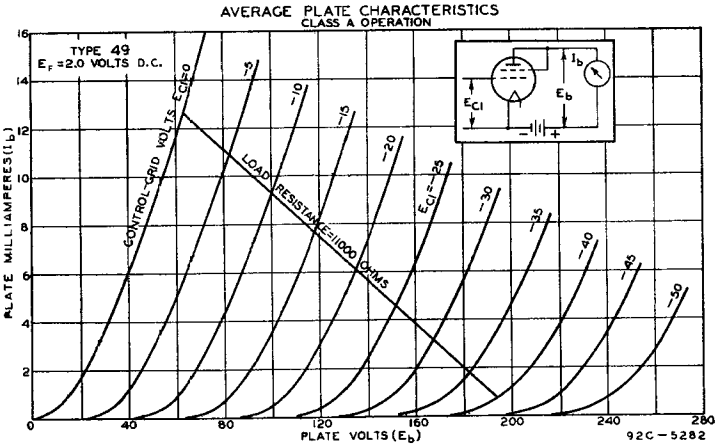
Plate Voltage	135 *max.*	Volts
Grid Voltage	−20	Volts
Plate Current	6.0	Milliamperes
Plate Resistance	4175	Ohms
Amplification Factor	4.7	
Transconductance	1125	Micromhos
Load Resistance	11000*	Ohms
Power Output (Approximate)	0.170	Watt

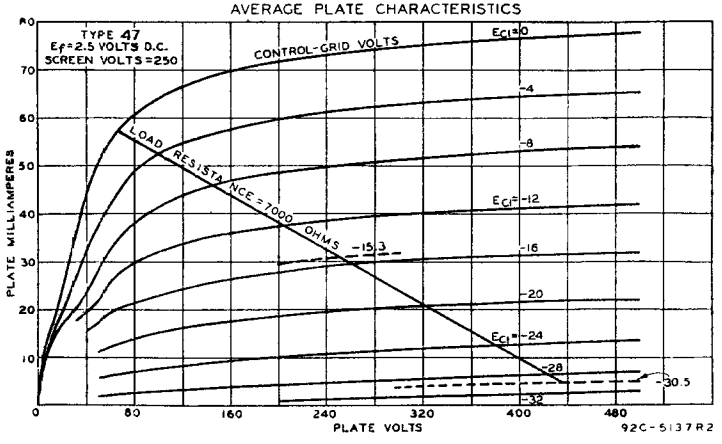
* Approximately twice this value is recommended for load of this tube as driver for Class B stage.

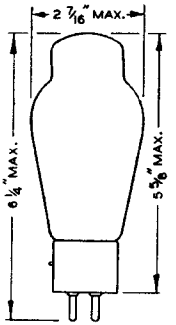
INSTALLATION AND APPLICATION

The base pins of the 49 fit the standard five-contact socket which should be installed to hold the tube in a vertical position. In some cases, cushioning of the socket may be found desirable. For filament operation, refer to INSTALLATION on type 1A6. Refer to APPLICATION for type 46. Plate characteristics curves are given on the following page.


AVERAGE PLATE CHARACTERISTICS
CLASS B OPERATION
TYPE 49
Ef=2.0 VOLTS D.C.
D-C PLATE(Ib) OR D-C GRID(ICI) MILLIAMPERES
PLATE VOLTS(Eb)
CONTROL-GRID VOLTS ECI=21
ECI=30
92C-5283

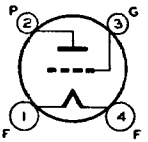

AVERAGE PLATE CHARACTERISTICS
CLASS A OPERATION
TYPE 49
Ef=2.0 VOLTS D.C.
PLATE MILLIAMPERES(Ib)
PLATE VOLTS(Eb)
CONTROL-GRID VOLTS ECI=0
LOAD RESISTANCE=11000 OHMS
92C-5282


AVERAGE PLATE CHARACTERISTICS
TYPE 47
Ef=2.5 VOLTS D.C.
SCREEN VOLTS=250
PLATE MILLIAMPERES
PLATE VOLTS
CONTROL-GRID VOLTS
LOAD RESISTANCE=7000 OHMS
92C-5137R2



RCA-50

POWER AMPLIFIER



The 50 is a power-amplifier tube designed for use primarily in the output stage of an audio-frequency amplifier employing transformer coupling. It is capable of delivering large undistorted power.

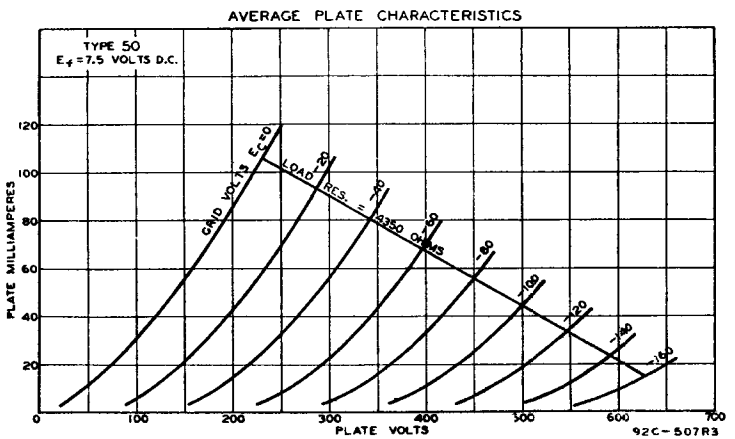
CHARACTERISTICS

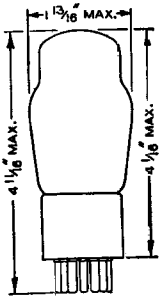
Filament Voltage (A. C. or D. C.)			7.5	Volts
Filament Current			1.25	Amperes
Plate Voltage	350	400	450 *max.*	Volts
Grid Voltage*	−63	−70	−84	Volts
Plate Current	45	55	55	Milliamperes
Plate Resistance	1900	1800	1800	Ohms
Amplification Factor	3.8	3.8	3.8	
Transconductance	2000	2100	2100	Micromhos
Load Resistance	4100	3670	4350	Ohms
Self-Bias Resistor	1400	1275	1530	Ohms
Undistorted Power Output	2.4	3.4	4.6	Watts
Bulb				ST-19
Base				Medium 4-Pin Bayonet

* Measured from mid-point of a-c operated filament.

INSTALLATION AND APPLICATION

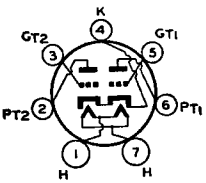
Refer to INSTALLATION and APPLICATION on type 10. Any conventional type of input coupling may be used provided the resistance added to the grid circuit by this device does not exceed 10000 ohms.





RCA-53

CLASS B TWIN AMPLIFIER



The 53 is a heater-cathode type of tube combining in one bulb two high-mu triodes designed for Class B operation. It is intended primarily for use in the output stage of a-c operated radio receivers. The triode units have separate external terminals for all electrodes except the cathodes and heaters, so that circuit design is similar to that of Class B amplifiers utilizing individual tubes in the output stage. The 53 may be used as a Class A_1 amplifier (with triode units connected in parallel) to drive a 53 as a Class B amplifier in the output stage.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	2.0	Amperes
BULB		ST-14
BASE		Medium 7-Pin

Other characteristics of this type are the same as for type 6N7.

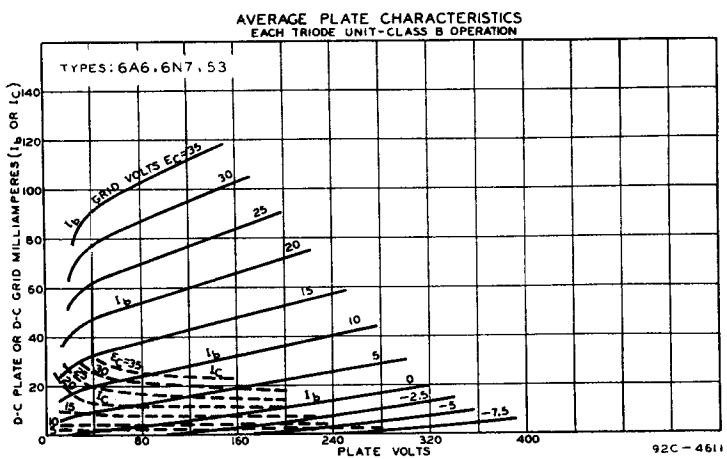
INSTALLATION

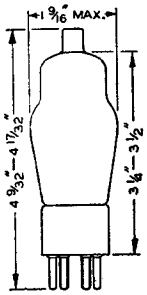
The base pins of the 53 fit the seven-contact (0.855 inch pin-circle diameter) socket which may be installed to hold the tube in any position. Sufficient ventilation should be provided to circulate air freely around the tube to prevent overheating.

For heater operation and cathode connection, refer to type 2A5.

APPLICATION

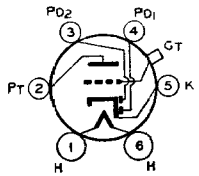
For APPLICATION refer to type 6N7. Additional curves are shown under types 6A6 and 6N7.





RCA-55

DUPLEX-DIODE TRIODE



The 55 is an a-c heater type of tube consisting of *two diodes* and a *triode* in a single bulb. It is recommended for service as a combined detector, amplifier and automatic-volume-control tube.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	1.0	Ampere
BULB		ST-12
CAP		Small Metal
BASE		Small 6-Pin

Other characteristics of this type are the same as for type 85.

Diode Units

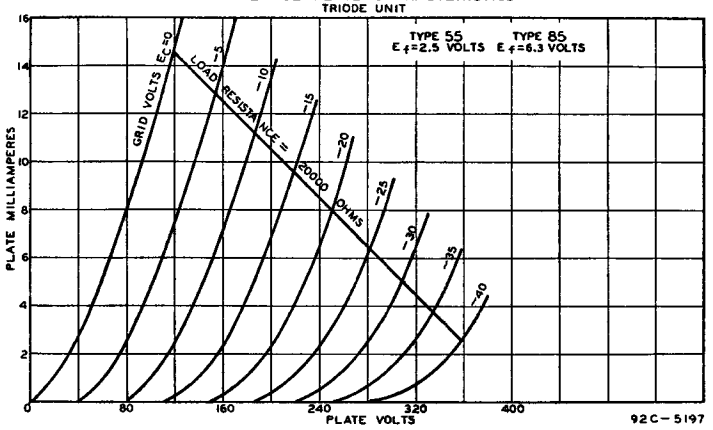
Two diode plates are placed around a cathode, the sleeve of which is common to the triode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

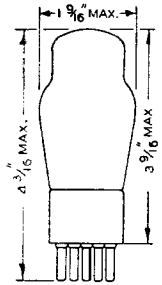
INSTALLATION AND APPLICATION

The **base** pins of the 55 fit the standard six-contact socket, which may be installed to hold the tube in any position. For **heater** operation and **cathode** connection, refer to INSTALLATION under type 2A5. Complete **shielding** of detector circuits employing the 55 is generally necessary to prevent r-f or i-f coupling between the diode circuits and the circuits of other stages.

For APPLICATION, refer to type 85, and to the chart of the Resistance-Coupled Amplifier Section. Circuits using the 55 are given under type 85.

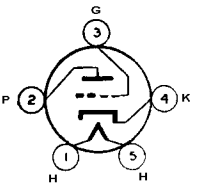
AVERAGE PLATE CHARACTERISTICS
TRIODE UNIT





RCA-56

SUPER-TRIODE AMPLIFIER DETECTOR



The 56 is a three-electrode tube of the heater-cathode type recommended for use as detector, amplifier, or oscillator in a-c receivers designed for it. This tube is characterized by its high mutual conductance, and its comparatively high amplification factor. The 56 is useful in resistance-coupled audio-frequency amplifiers.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)		2.5	Volts
Heater Current		1.0	Ampere
Plate Voltage	100	250 *max.*	Volts
Grid Voltage*	−5	−13.5	Volts
Plate Current	2.5	5	Milliamperes
Plate Resistance	12000	9500	Ohms
Amplification Factor	13.8	13.8	
Transconductance	1150	1450	Micromhos
Grid-Plate Capacitance		3.2	μμf
Grid-Cathode Capacitance		3.2	μμf
Plate-Cathode Capacitance		2.2	μμf
Bulb			ST-12
Base			Small 5-Pin

* If a grid-coupling resistor is used, its maximum value should not exceed 1.0 megohm.

INSTALLATION

The base pins of the 56 fit the standard five-contact socket which may be installed to hold the tube in any position.

The **bulb** of this tube will become very hot under certain conditions of operation. Sufficient ventilation should be provided to prevent overheating.

The **heater** is designed to operate at 2.5 volts. The transformer winding supplying the heater circuit should be designed to operate the heater at this recommended value for full-load operating conditions at average line voltage.

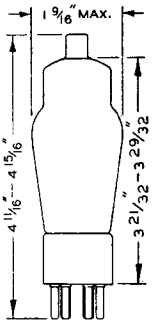
The **cathode** should preferably be connected directly to a mid-tap on the heater winding or to a center-tapped resistor across the heater winding. If this practice is not followed, the potential difference should be kept as low as possible.

APPLICATION

As an **amplifier,** the 56 is applicable either to radio-frequency or audio-frequency circuits. Recommended operating conditions for service using transformer coupling are given under CHARACTERISTICS. For operation as a resistance-coupled amplifier, refer to the Resistance-Coupled Amplifier Section.

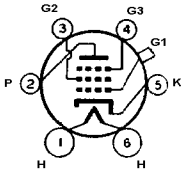
As a **detector,** the 56 may be of the grid leak and condenser or grid-bias type. The plate voltage for the grid leak and condenser method should be about 45 volts. A grid leak of from 1 to 5 megohms with a grid condenser of 0.00025 μf is satisfactory. For the grid-bias method of detection, a plate-supply voltage of 250 volts may be used together with a negative grid-bias voltage of approximately 20 volts. The plate current should be adjusted to 0.2 milliampere, with no input signal voltage. The grid-bias voltage may be supplied from the voltage drop in a resistor between cathode and ground. The value of this self-bias resistor is not critical, 30000 to 150000 ohms being suitable. The higher value will permit the application of a larger input signal.

A plate family for this type is given under type 76.



RCA-57

TRIPLE-GRID DETECTOR AMPLIFIER



The 57 is a triple-grid tube recommended especially for service as a biased detector in a-c receivers designed for its characteristics. The 57 is constructed with an internal shield connected to the cathode within the tube.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	2.5	Volts
Heater Current	1.0	Ampere
Grid-Plate Capacitance (With shield-can)	0.007 *max.*	$\mu\mu$f
Input Capacitance	5.0	$\mu\mu$f
Output Capacitance	6.5	$\mu\mu$f
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

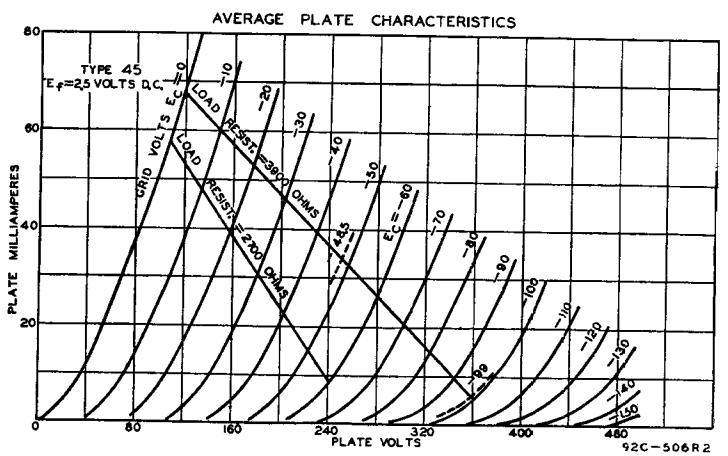
Other characteristics of this type are the same as for type 6J7.

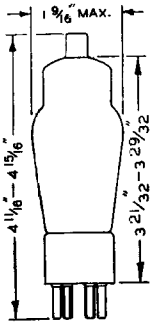
INSTALLATION AND APPLICATION

The **base** pins of the 57 fit the standard six-contact socket which may be installed to hold the tube in any position. For **heater** operation and **cathode** connection, refer to INSTALLATION for type 2A5.

For **screen** voltage and **shielding** requirements, see INSTALLATION on type 6C6.

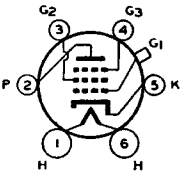
Refer to APPLICATION on type 6J7. The curve shown under 6J7 also applies to the 57.





RCA-58

TRIPLE-GRID SUPER-CONTROL AMPLIFIER



The 58 is a triple-grid super-control amplifier tube recommended especially for service in the radio-frequency and intermediate-frequency stages of a-c receivers designed for its characteristics. The 58 is constructed with an internal shield connected to the cathode within the tube.

CHARACTERISTICS

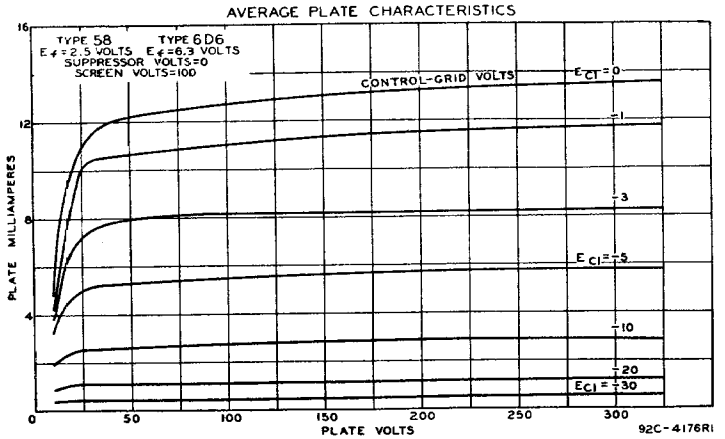
Heater Voltage (A. C. or D. C.)	2.5	Volts
Heater Current	1.0	Ampere
Grid-Plate Capacitance	0.007 *max.*	$\mu\mu$f
Input Capacitance	4.7	$\mu\mu$f
Output Capacitance	6.3	$\mu\mu$f
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

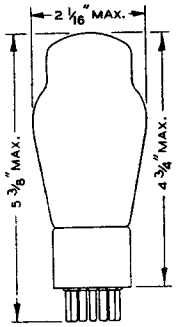
Other characteristics of this type are the same as for type 6D6. The curve shown under the 6D6 also applies to the 58.

INSTALLATION AND APPLICATION

The base pins of the 58 fit the standard six-contact socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION for type 2A5.

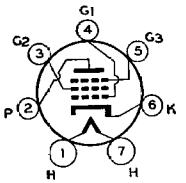
For control-grid bias variation, screen voltage, and suppressor connection, refer to INSTALLATION on type 6K7. Shielding requirements are similar to those for type 6C6. Refer to APPLICATION on type 6K7.





RCA-59

TRIPLE-GRID POWER AMPLIFIER



The 59 is a triple-grid power-amplifier tube of the heater-cathode type for use in the output stage of a-c operated receivers. The triple-grid construction of this tube, with external connections for each grid, makes possible its application as (1) a Class A Power-Amplifier Triode, (2) a Class A Power-Output Pentode, and (3) a Class B Power-Output Triode.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	2.5	Volts
Heater Current	2.0	Amperes
Bulb		ST-16
Base		Medium 7-Pin

As Class A_1 Power Amplifier

	Triode°	*Pentode*°°	
Plate Voltage	250 *max.*	250 *max.*	Volts
Screen Voltage (Grid No. 2)	—	250 *max.*	Volts
Grid Voltage (Grid No. 1)	−28	−18	Volts
Plate Current	26	35	Milliamperes
Screen Current	—	9	Milliamperes
Amplification Factor	6	100	
Plate Resistance	2300	40000	Ohms
Transconductance	2600	2500	Micromhos
Load Resistance	5000*	6000	Ohms
Self-Bias Resistor	1080	410	Ohms
Power Output	1.25	3†	Watts

As Class B Power Amplifier—Triode Connection

(Grids No. 1 and No. 2 tied together; grid No. 3 tied to plate)

Plate Voltage	400 *max.*	Volts
Peak Plate Current	200 *max.*	Milliamperes
Average Plate Dissipation	10 *max.*	Watts
Average Grid Dissipation (Grids No. 1 and No. 2)	1.5 *max.*	Watts

Typical Operation (2 tubes)

Values are for two tubes.

Plate Voltage	300	400	Volts
Grid Voltage	0	0	Volts
Zero-Signal Plate Current	20	26	Milliamperes
Effective Load Resistance (Plate-to-plate)	4600	6000	Ohms
Power Output, Approximate	15	20	Watts

° Grids No. 2 and No. 3 tied to plate; grid No. 1 is control grid.

°° Grid No. 3 tied to cathode; grid No. 1 is control grid; grid No. 2 is screen.

* Optimum for maximum undistorted power output of 1.25 watts. Approximately twice this value is recommended for load of this type as driver for Class B stage.

† 7% total harmonic distortion.

INSTALLATION

The **base** pins of the 59 fit the seven-contact (0.855-inch pin-circle diameter) socket which may be installed to hold the tube in any position.

The **bulb** of this tube may become very hot under certain conditions of operation. Sufficient ventilation, therefore, should be provided to prevent overheating.

For **heater** operation and **cathode** connection, refer to INSTALLATION for type 2A5.

APPLICATION

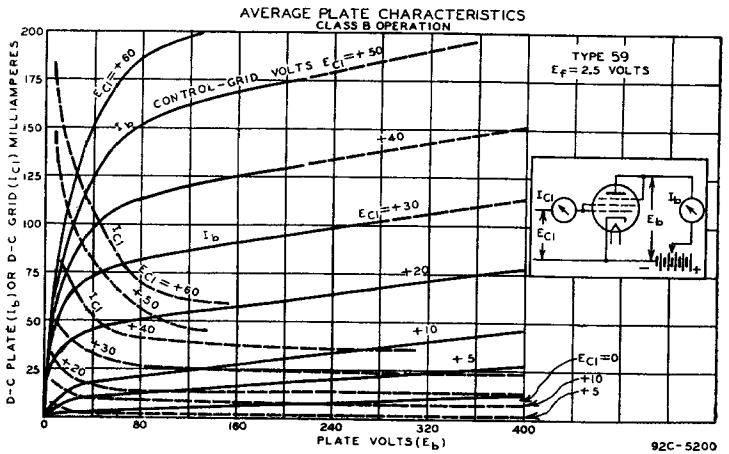
For **Class A_1 Triode Operation** of the 59, the two grids (No. 2 and No. 3) immediately adjacent to the plate are connected to the plate, while the third (No. 1) is employed for control purposes. Operation of the tube is then similar to any Class A power-amplifier triode. The tabulated values for Class A operation of this type as given under CHARACTERISTICS, are for its operation as a power-output tube. When it is used as the driver for a Class B stage, the load requirements are changed, as indicated in the note under CHARACTERISTICS. This change is recommended in order to minimize distortion due to the driver stage.

The d-c resistance in the grid circuit of the 59, operating as a Class A amplifier (either with triode or pentode connection) should not exceed 0.5 megohm if self-bias is used. Without self-bias, the resistance should not exceed 10000 ohms. The use of resistances higher than these may cause the tube to lose bias due to grid current, with the result that the plate current will rise to a value sufficiently high to damage the tube.

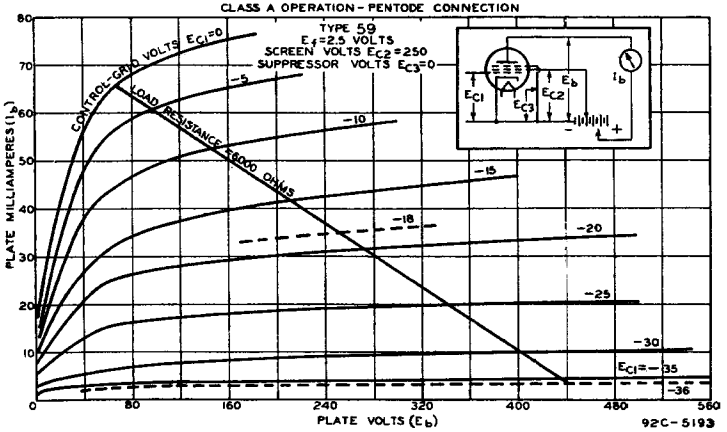
For **Class A_1 Pentode Operation** of the 59, the grid (No. 3) adjacent to the plate is tied to the cathode and thus serves as the suppressor, while the other two grids (No. 2 and No. 1) serve as the screen grid and control grid respectively. Operation of the tube is then similar to any Class A power-output pentode.

For either method of Class A operation, the self-bias resistor should be shunted by a suitable filter network to avoid degenerative effects at low audio frequencies. The use of the two 59's in push-pull eliminates the necessity for shunting the resistor. The value of the self-bias resistor required for two tubes in the same stage is approximately one-half that for a single tube.

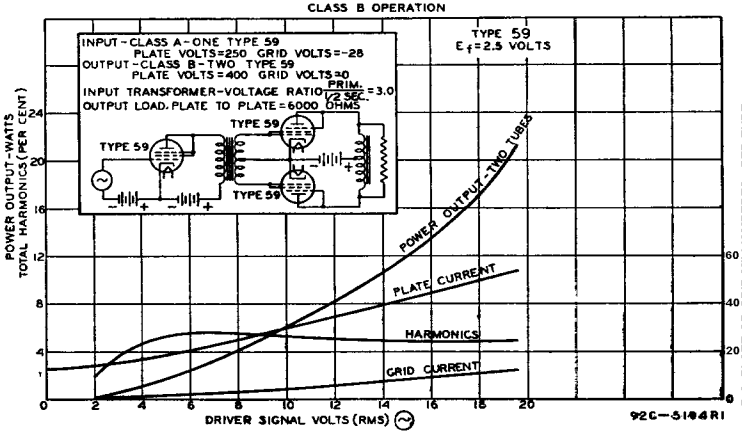
For **Class B Triode Operation** of the 59, the grid (No. 3) adjacent to the plate is tied to the plate, while the other grids (No. 1 and No. 2) are connected together to serve as a single control-grid. No grid bias is necessary with this connection. This feature is particularly important because it prevents the variation of bias with applied signal which would otherwise exist if any self-bias arrangement were employed. A discussion of Class B design features is given on page 20.



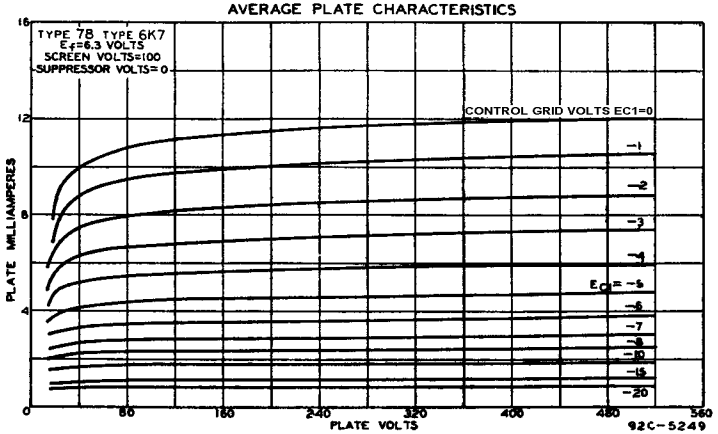
AVERAGE PLATE CHARACTERISTICS
CLASS A OPERATION - PENTODE CONNECTION

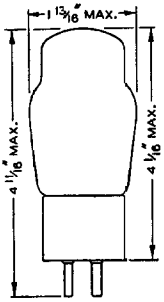


OPERATION CHARACTERISTICS
CLASS B OPERATION



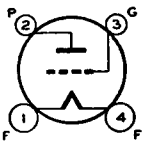
AVERAGE PLATE CHARACTERISTICS





RCA-71-A

POWER AMPLIFIER



The 71-A is a power-amplifier tube of low-output impedance for use in the output stage of audio-frequency amplifiers.

CHARACTERISTICS

Filament Voltage (A. C. or D. C.)			5.0	Volts
Filament Current			0.25	Ampere
Plate Voltage	90	135	180 *max.*	Volts
Grid Voltage*	−16.5	−27	−40.5	Volts
Plate Current	10	17.3	20	Milliamperes
Plate Resistance	2170	1820	1750	Ohms
Amplification Factor	3	3	3	
Transconductance	1400	1650	1700	Micromhos
Load Resistance	3000	3000	4800	Ohms
Self-Bias Resistor	1600	1700	2150	Ohms
Undistorted Power Output	0.125	0.4	0.79	Watt
Grid-Plate Capacitance			7.5	$\mu\mu$f
Grid-Filament Capacitance			3.2	$\mu\mu$f
Plate-Filament Capacitance			2.9	$\mu\mu$f
Bulb				ST-14
Base				Medium 4-Pin Bayonet

* For operation on a-c filament supply, increase grid-bias voltage 2.5 volts. The d-c resistance in the grid circuit should not exceed 0.5 megohm.

INSTALLATION AND APPLICATION

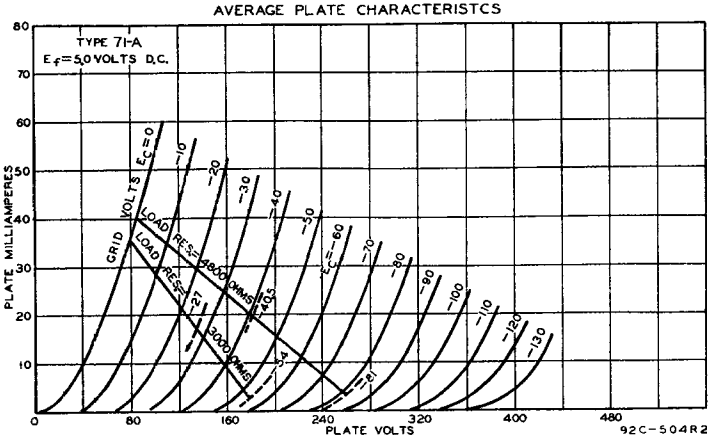
The base pins of this tube fit the standard four-contact socket which should be installed to hold the tube in a vertical position.

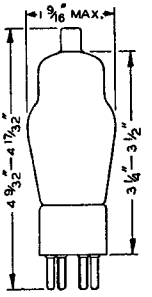
The coated filament of the 71-A may be operated from a storage battery or from the a-c line through a step-down transformer. For operation of this tube from a storage battery, a fixed or variable resistor of suitable value is required to reduce the battery voltage to 5.0 volts across the filament terminals at the socket.

Operating conditions are given under CHARACTERISTICS for the use of this tube in the power output stage.

An output device should be used to transfer power to the winding of the reproducing unit.

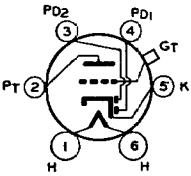
AVERAGE PLATE CHARACTERISTCS





RCA-75

DUPLEX-DIODE HIGH-MU TRIODE



The 75 is a heater type of tube consisting of two diodes and a high-mu triode in a single bulb. It is for use as a combined detector, amplifier, and automatic-volume-control tube in a-c receivers designed for its characteristics. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Grid-Triode-Plate Capacitance	1.7	$\mu\mu$f
Grid-Cathode Capacitance	1.7	$\mu\mu$f
Triode Plate-Cathode Capacitance	3.8	$\mu\mu$f
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

Triode Unit—As Class A_1 Amplifier

Plate Voltage	250 *max.*	Volts
Grid Voltage	−2	Volts
Amplification Factor	100	
Plate Resistance	91000	Ohms
Transconductance	1100	Micromhos
Plate Current	0.8	Milliampere

Diode Units

The two diode plates are placed around a cathode, the sleeve of which is common to the triode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

INSTALLATION

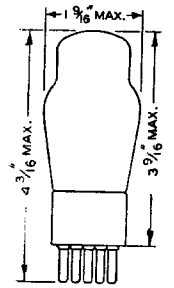
The **base pins** of the 75 fit the standard six-contact socket which may be installed to hold the tube in any position.

Heater operation and **cathode** connection are the same as for the type 6A8.

APPLICATION

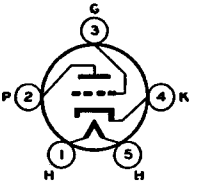
The 75 in many respects is similar in application to the 6Q7. The outstanding difference, however, is that the 75 has a high-mu triode. For this reason, the tube is recommended for use only in resistance-coupled circuits. Furthermore, diode-biasing of the triode unit is not suitable because of the probability of triode plate-current cut-off, even with relatively small signal voltages applied to the diode circuit.

As an **amplifier** in resistance-coupled a-f circuits, the 75 may be operated under the conditions given in the Resistance-Coupled Amplifier Section. A family of average plate characteristic curves applicable to this type will be found under type 2A6.



RCA-76

SUPER-TRIODE AMPLIFIER DETECTOR



The 76 is a three-electrode tube of the heater-cathode type recommended for use as detector, amplifier, or oscillator with either a-c or d-c heater supply. This tube is characterized by its high mutual conductance and its comparatively high amplication factor. The 76 is useful in resistance-coupled audio-frequency amplifiers.

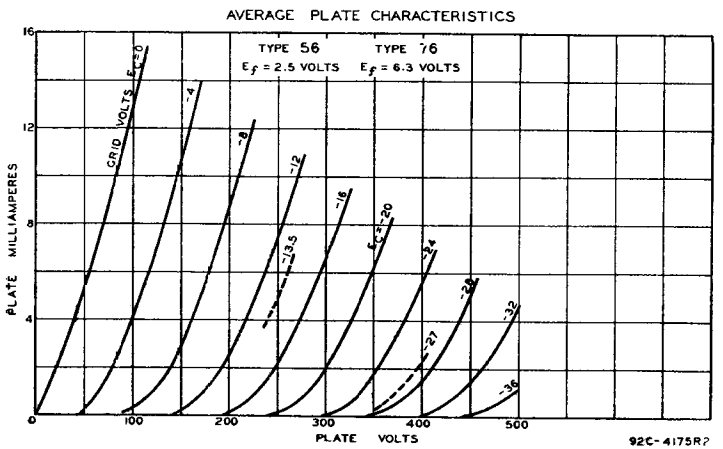
CHARACTERISTICS

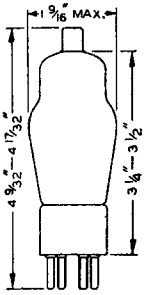
Heater Voltage (A. C. or D. C.)		6.3	Volts
Heater Current		0.3	Ampere
Plate Voltage	100	250 *max.*	Volts
Grid Voltage*	−5	−13.5	Volts
Plate Current	2.5	5	Milliamperes
Plate Resistance	12000	9500	Ohms
Amplification Factor	13.8	13.8	
Transconductance	1150	1450	Micromhos
Grid-Plate Capacitance		2.8	μμf
Grid-Cathode Capacitance		3.5	μμf
Plate-Cathode Capacitance		2.5	μμf
Bulb			ST-12
Base			Small 5-Pin

* If a grid-coupling resistor is used, its maximum value should not exceed 1.0 megohm.

INSTALLATION AND APPLICATION

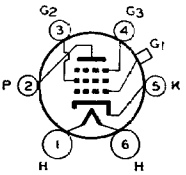
The base pins of the 76 fit the standard five-contact socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION for type 6A8. Refer to APPLICATION for the type 56.





RCA-77

TRIPLE-GRID DETECTOR AMPLIFIER



The 77 is a triple-grid tube recommended especially for service as a biased detector in radio receivers designed for its characteristics. In such service, this tube is capable of delivering a large audio-frequency output voltage with relatively small input voltage. Other applications of the 77 include its use as a low-signal-input screen-grid amplifier tube and as an automatic-volume-control tube.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)		6.3	Volts
Heater Current		0.3	Ampere
Plate Voltage	100	250 *max.*	Volts
Screen Voltage (Grid No. 2)	60	100 *max.*	Volts
Grid Voltage* (Grid No. 1)	−1.5	−3	Volts
Suppressor (Grid No. 3)	Connected to cathode at socket		
Plate Current	1.7	2.3	Milliamperes
Screen Current	0.4	0.5	Milliampere
Plate Resistance (Approximate)	0.65	1.5	Megohms
Amplification Factor	715	1500	
Transconductance	1100	1250	Micromhos
Grid Voltage (Approximate)†	−5.5	−7.5	Volts
Grid-Plate Capacitance (With shield-can)		0.007 *max.*	μμf
Input Capacitance		4.7	μμf
Output Capacitance		11.0	μμf
Bulb			ST-12
Cap			Small Metal
Base			Small 6-Pin

* The d-c resistance in the grid circuit should not exceed 1.0 megohm.

† For cathode current cut-off.

INSTALLATION

The base pins of the 77 fit the standard six-contact socket which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION under type 6A7. Shielding and screen voltage requirements are similar to those for the type 6C6.

APPLICATION

As a radio-frequency amplifier pentode, the 77 may be used particularly in applications where the r-f signal applied to the grid is relatively low, that is, of the order of a few volts. In such cases either screen or control grid voltage (or both) may be varied to control the receiver volume. When larger signals are involved, a super-control amplifier tube should be employed to prevent the occurrence of excessive cross-modulation and modulation-distortion. Recommended operating conditions for amplifier service are given under CHARACTERISTICS.

As a biased **detector**, the 77 is particularly recommended because of its ability to deliver a large audio-frequency output voltage of good quality with a fairly small radio-frequency signal input. Recommended conditions for the 77 as a biased detector are as follows:

PLATE SUPPLY*	100	250	250	Volts
SCREEN VOLTAGE	36	50	100max.	Volts
GRID VOLTAGE	−2	−2	−4.3	Volts
CATHODE RESISTOR	12500	3000	10000	Ohms
SUPPRESSOR	Connected to cathode at socket			
CATHODE CURRENT (No signal)	0.16	0.65	0.43	Milliampere
PLATE RESISTOR	0.25	0.25	0.50	Megohm
BLOCKING CONDENSER	0.01	0.03	0.03	μf
GRID RESISTOR†	0.25	0.25	0.25	Megohm
R-F SIGNAL (RMS)**	1.88	1.18	1.37	Volts

* Voltage at plate will be PLATE SUPPLY voltage minus voltage drop in plate resistor caused by plate current.

† For the following amplifier tube.

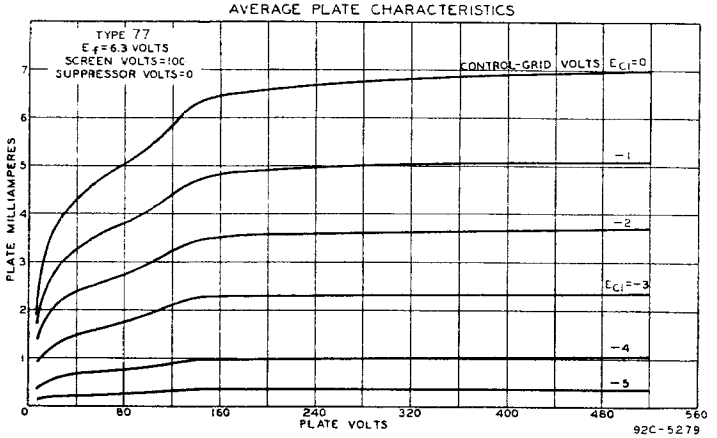
** With these signal voltages modulated 20%, the voltage output for the 100-volt plate supply is 14 peak volts at the grid of the following amplifier, a value sufficient to insure full audio output from a type 43; likewise for the 250-volt conditions, 17 peak volts, a value sufficient to insure full audio ouput from a type 2A5.

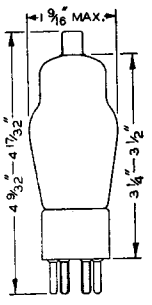
Detector bias may be obtained from a bleeder circuit, from a resistor in the cathode circuit, or from a partial self-bias circuit. The cathode-resistor method permits of higher output at lower percentage modulation since the input signal may be increased almost in inverse proportion to the modulation without resulting in objectionable distortion.

As an **audio-frequency amplifier pentode** in resistance-coupled circuits, the 77 may be operated as shown in the Resistance-Coupled Amplifier Section.

As an **audio-frequency amplifier triode**, the 77 should have its screen and suppressor connected to the plate. Operating conditions for triode service in transformer- or impedance-coupled circuits are: Plate voltage, 250 volts; grid voltage, −8 volts; and plate current, 8 milliamperes, approximate. If resistance coupling is used, a plate-supply voltage of 250 volts may be applied through a plate-coupling resistor of 0.1 to 0.25 megohm.

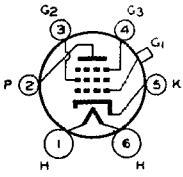
As a **mixer** in superheterodyne circuits, the 77 can be employed, but a tube having super-control characteristics is to be preferred, especially if signals of large magnitude are to be received, and if supplementary volume control is to be obtained in this stage.





RCA-78

TRIPLE-GRID SUPER-CONTROL AMPLIFIER



The 78 is a triple-grid super-control amplifier tube recommended for service in the radio-frequency and intermediate-frequency stages of radio receivers designed for its characteristics. The ability of this tube to handle usual signal voltages without cross-modulation and modulation-distortion makes it adaptable to the r-f and i-f stages of receivers employing automatic volume-control. The internal shield around the plate of the 78 is connected to the cathode within the tube.

CHARACTERISTICS

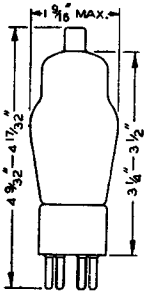
Heater Voltage (A. C. or D. C.)				6.3	Volts
Heater Current				0.3	Ampere
Plate Voltage	90	180	250 *max.*	250 *max.*	Volts
Screen Voltage	90	75	100	125 *max.*	Volts
Grid Voltage (Minimum)	−3	−3	−3	−3	Volts
Suppressor	Connected to cathode at socket				
Plate Current	5.4	4.0	7.0	10.5	Milliamperes
Screen Current	1.3	1.0	1.7	2.6	Milliamperes
Plate Resistance	0.315	1.0	0.8	0.6	Megohm
Amplification Factor	400	1100	1160	990	
Transconductance	1275	1100	1450	1650	Micromhos
Grid Voltage*	−38.5	−32.5	−42.5	−52.5	Volts
Grid-Plate Capacitance (With shield-can)				0.007 *max.*	$\mu\mu$f
Input Capacitance				4.5	$\mu\mu$f
Output Capacitance				11.0	$\mu\mu$f
Bulb					ST-12
Cap					Small Metal
Base					Small 6-Pin

* For transconductance = 2 micromhos.

INSTALLATION AND APPLICATION

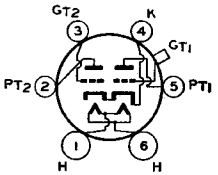
The **base** pins of the 78 fit the standard six-contact socket which may be installed to hold the tube in any position. **Heater** operation and **cathode** connection are the same as for the type 6A8. **Control-grid bias** variation, **screen** voltage supply, and **suppressor** connection follow the methods given under INSTALLATION for the type 6D6. **Shielding** requirements are similar to those of the type 6C6. Refer to APPLICATION on the type 6K7.

A plate family of characteristic curves is given at the bottom of page 147.



RCA-79

CLASS B TWIN AMPLIFIER



The 79 is a heater-cathode type of tube combining in one bulb two high-mu triodes designed for Class B operation. It is intended for use in the audio-output stage of radio receivers with 6.3-volt heater supply. The triode units have separate external terminals for all electrodes except the cathode and heater so that circuits employing the 79 are similar to those of Class B amplifiers utilizing individual tubes in the output stage.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.6	Ampere
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

As Class B Power Amplifier

Plate Voltage		250 *max.*	Volts
Peak Plate Current (Per Plate)		90 *max.*	Milliamperes
Average Plate Dissipation		11.5 *max.*	Watts
Typical Operation			
Plate Voltage	180	250	Volts
Grid Voltage	0	0	Volts
Zero-Signal Plate Current (Per plate)	3.8	5.3	Milliamperes
Effective Load Resistance (Plate-to-plate)	7000	14000	Ohms
Power Output (Approximate)*	5.5	8.0	Watts

* With average power input of 380 milliwatts applied between grids.

INSTALLATION AND APPLICATION

The **base** pins of the 79 fit the standard six-contact socket which may be installed to operate the tube either in a vertical or in a horizontal position. Sufficient ventilation should be provided to circulate air freely around the tube to prevent overheating.

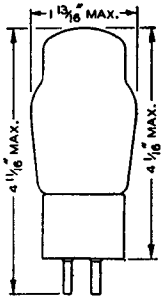
For **heater** operation and **cathode** connection, refer to INSTALLATION on type 6A8.

As a **Class B power amplifier,** the 79 is used in circuits similar in design to those utilizing individual tubes in the output stage. It requires no grid-bias, since the high-mu feature of the triode units reduces the steady plate current at zero bias to only a few milliamperes. Refer to page 20 for general Class B amplifier design considerations.

As a **Class A amplifier,** the 79 may be used with grid-bias voltage for small input signals. Such applications include circuits employing the two triode units either in parallel or in push-pull connection.

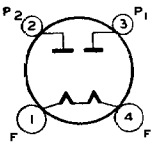
In other applications, the two triode units of the 79 may be used in various circuits to combine the functions of oscillation, detection and/or amplification.

A family of plate characteristic curves is given on page 156.



RCA-80

FULL-WAVE RECTIFIER



The 80 is a full-wave rectifying tube intended for use in d-c power-supply devices which operate from the a-c supply line.

CHARACTERISTICS

Filament Voltage (A. C.)	5.0	Volts
Filament Current	2.0	Amperes
1 A-C Plate Voltage Per Plate (RMS)	350	Volts
1 D-C Output Current	125 *max.*	Milliamperes
2 A-C Plate Voltage Per Plate (RMS)	400 *max.*	Volts
2 D-C Output Current	110 *max.*	Milliamperes
3* A-C Plate Voltage Per Plate (RMS)	550 *max.*	Volts
3* D-C Output Current	135 *max.*	Milliamperes
Bulb		ST-14
Base		Medium 4-Pin

* This rating is permissible only with filter circuits having an input choke of at least 20 henries

INSTALLATION

The **base** pins of the 80 fit the standard four-contact socket which should be mounted preferably to hold the tube in a vertical position. If it is necessary to place the tube in a horizontal position, the socket should be mounted with both of the filament-pin openings, either at the top or at the bottom. This precaution locates the filament-plane vertical for most satisfactory performance. Provision should be made for free circulation of air around the bulb since it becomes quite hot during operation.

The coated **filament** of the 80 is designed to operate from the a-c line through a step-down transformer. The voltage applied to the filament terminals should be the rated value of 5.0 volts under operating conditions and average line voltage.

The approximate **d-c output voltage** of the 80 for various values of a-c input voltage may be obtained from the curves, page 156. For the d-c voltage available at the radio set, it is necessary to subtract the voltage drop across the filter from the value read from the curves.

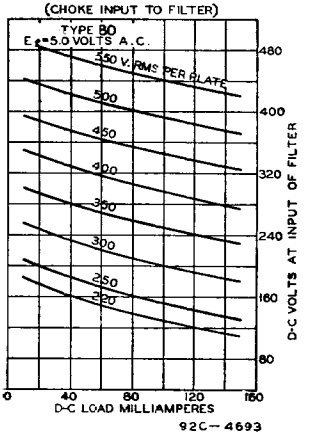
APPLICATION

As a **full-wave rectifier,** the 80 may be operated with condenser-input or choke-input filter under conditions not to exceed the ratings given under CHARACTERISTICS.

As a **half-wave rectifier,** two 80's may be operated in a full-wave circuit with reasonable serviceability to deliver more d-c output current than can be obtained from one tube. For this use, the plates of each 80 are tied together at the socket. The allowable voltage and load conditions per tube are the same as for full-wave service.

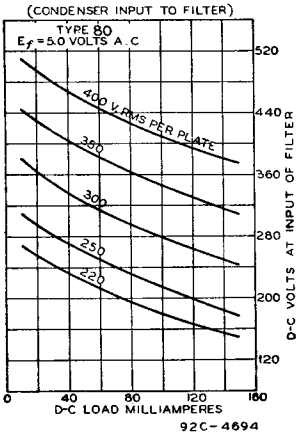
The **filter** may be of either the condenser-input or choke-input type. If an input condenser is used, consideration must be given to the instantaneous peak value of the a-c input voltage. The peak voltage is about 1.4 times the RMS value as measured by most a-c voltmeters. Filter condensers, therefore, especially the input condenser, should have a rating high enough to withstand the instantaneous peak value, if breakdown is to be avoided. When the input-choke method is used, the available d-c output voltage will be somewhat lower than with the input condenser method for a given a-c plate voltage. However, improved regulation, together with lower peak current, will be obtained.

OUTPUT CHARACTERISTICS
(CHOKE INPUT TO FILTER)



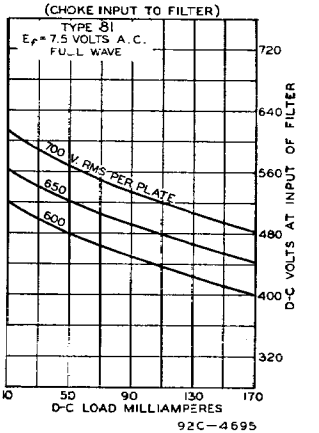
92C-4693

OUTPUT CHARACTERISTICS
(CONDENSER INPUT TO FILTER)



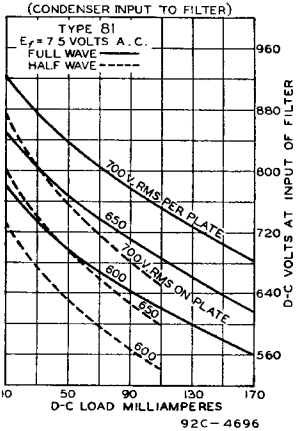
92C-4694

OUTPUT CHARACTERISTICS
(CHOKE INPUT TO FILTER)



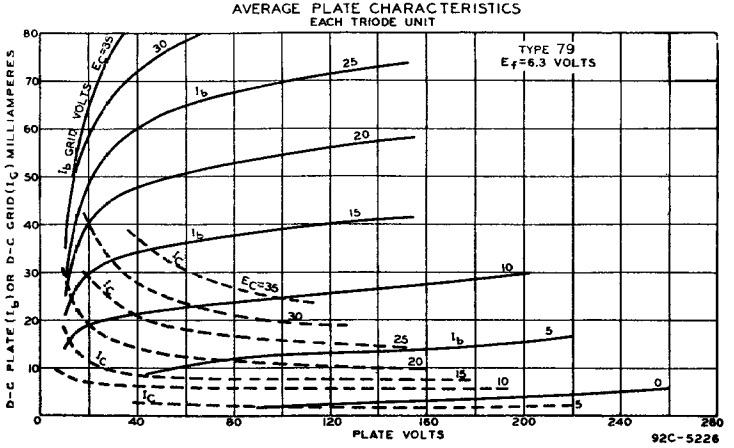
92C-4695

OUTPUT CHARACTERISTICS
(CONDENSER INPUT TO FILTER)

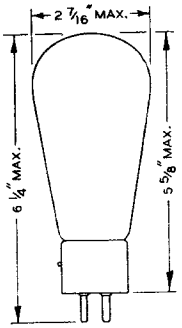


92C-4696

AVERAGE PLATE CHARACTERISTICS
EACH TRIODE UNIT

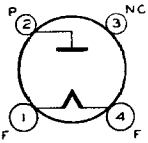


92C-5226



RCA-81

HALF-WAVE RECTIFIER



The 81 is a half-wave rectifier tube of the high-vacuum type for use in d-c power-supply devices operating from the alternating-current supply line. Full-wave rectification may be accomplished by two 81's.

CHARACTERISTICS

Filament Voltage (A. C.)	7.5	Volts
Filament Current	1.25	Amperes
A-C Plate Voltage (RMS)	700 *max.*	Volts
D-C Output Current	85 *max.*	Milliamperes
Bulb		S-19
Base	Medium	4-Pin Bayonet

INSTALLATION

The **base** pins of the 81 fit the standard four-contact socket which should be mounted to hold the tube in a vertical position. Provision should be made for free circulation of air around the bulb since it becomes quite hot during operation.

The coated **filament** of the 81 is designed to operate from the a-c line through a step-down transformer. The voltage applied to the filament terminals should be the rated value of 7.5 volts under operating conditions and average line voltage.

The approximate **d-c output voltage** of the 81 in half-wave and full-wave connection, for various values of a-c input voltage, may be obtained from the curves on the preceding page. For the d-c voltage available at the radio set, it is necessary to subtract the voltage drop across the filter from the value read from the curves.

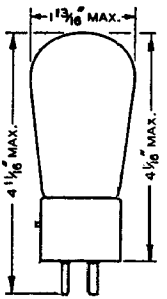
APPLICATION

As a **half-wave rectifier,** the 81 may be operated under conditions not to exceed those given under CHARACTERISTICS.

In **full-wave** circuits, two 81's are required to rectify both halves of the a-c voltage. Operating voltages per tube are the same as for the half-wave circuit, but twice the d-c output current may be obtained.

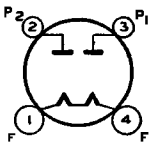
The **filter** may be of either the condenser-input or choke-input type. If an input condenser is used, consideration must be given to the instantaneous peak value of the a-c input voltage. The peak value is about 1.4 times the RMS value as measured by most a-c voltmeters. For this reason, filter condensers, especially the input condenser, should have a rating high enough to withstand the instantaneous peak value, if breakdown is to be avoided. When the input-choke method is used, the available d-c output voltage will be somewhat lower than with the input-condenser method for a given a-c plate voltage. However, improved regulation, together with lower peak current, will be obtained.

For **special applications,** it is possible to obtain a d-c output voltage approximately double that to be expected from conventional rectifier circuits, without exceeding the recommended maximum a-c input-voltage per tube. This is accomplished by means of a voltage-doubling system designed for each particular application. See page 25.



RCA-82

FULL-WAVE MERCURY-VAPOR RECTIFIER



The 82 is a full-wave mercury-vapor rectifier tube of the hot-cathode type for use in suitable rectifying devices designed to supply d-c power of uniform voltage to receivers in which the direct-current requirements are subject to considerable variation. The excellent voltage-regulation characteristic of the 82 is due to its low and practically constant tube voltage drop (only about 15 volts) for any current drain up to the full emission of the filament (see page 8).

CHARACTERISTICS

Filament Voltage (A. C.)	2.5	Volts
Filament Current	3.0	Amperes
A-C Voltage Per Plate (RMS)	500 *max.*	Volts
Peak Inverse Voltage	1400 *max.*	Volts
D-C Output Current (Continuous)	125 *max.*	Milliamperes
Peak Plate Current	400 *max.*	Milliamperes
Tube Voltage Drop (Approximate)	15	Volts
Bulb		S-14
Base		Medium 4-Pin

MERCURY-VAPOR RECTIFIER CONSIDERATIONS

The 82 has very low internal resistance, so that the current it delivers depends on the resistance of the load and the regulation of the power transformer. Sufficient protective resistance or reactance must always be used with this tube to limit its current to the recommended maximum value. If this value is exceeded, the tube voltage drop will increase rapidly and may permanently damage the filaments.

It is characteristic of mercury-vapor rectifiers that no appreciable plate current will flow until the plate voltage reaches a certain critical positive value. At this point the plate current rises steeply to a high value in a small fraction of a second This surge of current re-occurring each time either plate becomes positive may excite circuits in the vicinity of the tube to damped oscillation and thus cause noisy radio receiver operation. It is usually necessary, therefore, to provide small radio-frequency chokes in series with each plate lead so that the slope of the current wave front to the filter is reduced sufficiently to eliminate impact excitation.

INSTALLATION

The **base** pins of the 82 fit the standard four-contact socket, which should be installed to hold the tube in a vertical position with the base down. Only a socket making very good filament contact and capable of carrying 3 amperes continuously should be used. Poor contact at the filament pins will cause overheating at the pins and socket, lowered filament voltage, and high internal tube drop with consequent injury to the tube.

The **bulb** becomes hot during continuous operation. Provision should be made for adequate natural ventilation to prevent overheating, especially if shielding is employed.

The coated **filament** is intended for a-c operation from one of the secondary windings of a power transformer. This winding, provided with a center-tap or center-tap resistor, should supply at the filament terminals the rated operating voltage of 2.5 volts when average rated voltage is applied to the primary. The high current taken by the filament and the possibility of damage caused by applying plate voltage to the tube with its filament insufficiently heated make it imperative that all connections in the filament circuit be of low resistance and of adequate current-carrying capacity.

The **plate supply** is obtained from a center-tapped high-voltage winding designed so that the maximum a-c input voltage per plate will not exceed 500 volts RMS under varying conditions of supply-line voltage. The resistance of the transformer windings should, of course, be low if full advantage of the excellent regulation capabilities of this mercury-vapor rectifier is to be obtained. Since the drop through the tube is practically constant, any reduction in rectified voltage when the load is increased is due to the drop in the transformer and/or the filter windings. The return-lead from the plates, i.e., the positive bus of the filter and load circuit, should be connected to the center-tap of the filament winding.

Shielding of this tube, particularly in sensitive receivers, may be necessary to eliminate objectionable noise. Radio-frequency choke coils, connected in series with each plate lead and placed within the shielding if used, are usually necessary in receivers having high sensitivity. The inductance of the chokes should be one millihenry or more.

A **fuse** having a rating approximately 50% in excess of normal load requirements should be inserted in the primary of the power transformer to prevent damage in case of excessive current which may flow under abnormal conditions.

It is recommended that the entire equipment be disconnected from the a-c power supply whenever the 82 is removed from or installed in its socket.

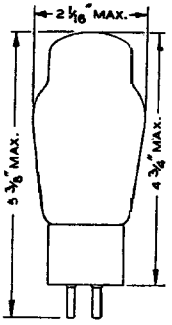
APPLICATION

As a **full-wave rectifier,** the 82 is recommended for supplying d-c power to receivers, particularly those in which the direct-current requirements cause considerable variation in the load impressed on the rectifier tube.

As a **half-wave rectifier,** the 82 may be operated with plates connected in parallel. For example, two 82's so arranged in a full-wave circuit can supply twice the output current of a single tube. When the 82's plates are operated in parallel, a resistor of not less than 100 ohms should be connected in series with each plate in order that each plate will carry its proper share of the total load.

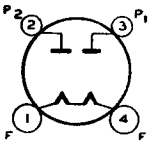
Filter circuits (page 37) of either the condenser-input or the choke-input type may be employed provided the maximum voltages and currents tabulated under CHARACTERISTICS are not exceeded. The choke-input type of circuit is to be preferred from the standpoint of obtaining the maximum continuous d-c output current from the 82 under the most favorable conditions.

Under operating conditions, the 82 has a bluish-white glow filling the space within the plates and extending to some degree into the surrounding space outside the plates. This glow, caused by the mercury vapor, is an inherent operating characteristic of the 82.



RCA-83

FULL-WAVE MERCURY-VAPOR RECTIFIER



The 83 is a heavy-duty, full-wave, mercury-vapor rectifier tube of the hot-cathode type. It is intended for use in suitable rectifying devices designed to supply d-c power of uniform voltage to receivers. The excellent voltage regulation characteristic of the 83 is due to its low and practically constant tube voltage drop (only about 15 volts) for any current drain up to the full emission of its filaments. For mercury-vapor rectifier considerations, refer to page 8 and to type 82.

CHARACTERISTICS

FILAMENT VOLTAGE (A. C.)	5.0	Volts
FILAMENT CURRENT	3.0	Amperes
A-C PLATE VOLTAGE PER PLATE (RMS)	500 *max.*	Volts
PEAK INVERSE VOLTAGE	1400 *max.*	Volts
D-C OUTPUT CURRENT (Continuous)	250 *max.*	Milliamperes
PEAK PLATE CURRENT	800 *max.*	Milliamperes
TUBE VOLTAGE DROP (Approximate)	15	Volts
BULB		ST-16
BASE		Medium 4-Pin

INSTALLATION

Installation of the 83 is similar to that of the type 82.

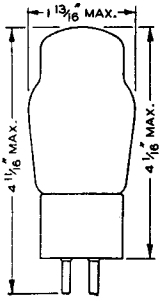
APPLICATION

As a **full-wave rectifier,** the 83 is intended for supplying large amounts of d-c power to receivers whose requirements are in excess of the rating of the 82. The 83 is recommended for heavy-drain receivers in which the direct-current requirements cause considerable variation in the load impressed on the rectifier tube.

As a **half-wave rectifier,** the 83 may be operated with plates connected in parallel. For example, two 83's so arranged in a full-wave circuit can supply twice the output current of a single tube. When the 83's plates are operated in parallel, a resistor of not less than 50 ohms should be connected in series with each plate in order that each plate will carry its proper share of the total load. If the load is less than 75% of the total maximum current rating of the tube(s), the series plate resistors should be increased to 100 ohms each.

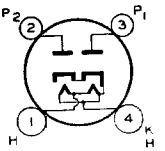
Filter circuits (page 37) of either the condenser-input or the choke-input type may be employed, provided the maximum voltages and currents tabulated under CHARACTERISTICS are not exceeded. The choke-input type of circuit is to be preferred from the standpoint of obtaining the maximum continuous d-c output current from the 83 under the most favorable conditions.

Under operating conditions, the 83 has a bluish-white glow filling the space within the plates and extending to some degree into the surrounding space outside the plates. This glow, caused by the mercury-vapor, is an inherent operating characteristic of the tube.



RCA-83-v

FULL-WAVE RECTIFIER



The 83-v is a high-vacuum, full-wave rectifier tube of the heater-cathode type. It is intended for use in suitable rectifying devices designed to supply d-c power to receivers having large d-c requirements. The excellent voltage regulation characteristic of the 83-v is due to the close spacing of the cathode and plate.

CHARACTERISTICS

HEATER VOLTAGE (A. C.)	5.0	Volts
HEATER CURRENT	2.0	Amperes
A-C PLATE VOLTAGE PER PLATE (RMS)	400 *max.*	Volts
PEAK INVERSE VOLTAGE	1100 *max.*	Volts
D-C OUTPUT CURRENT	200 *max.*	Milliamperes
BULB		ST-14
BASE		Medium 4-Pin

INSTALLATION

The **base** pins of the 83-v fit the standard four-contact socket which may be mounted to hold the tube in any position.

The **bulb** becomes hot during continuous operation. Provision should be made for adequate natural ventilation to prevent overheating.

The **heater** is designed to operate from the a-c line through a step-down transformer. The voltage applied to the heater should be the rated value of 5.0 volts under operating conditions and average line voltage. The heater leads should have as low resistance as practical.

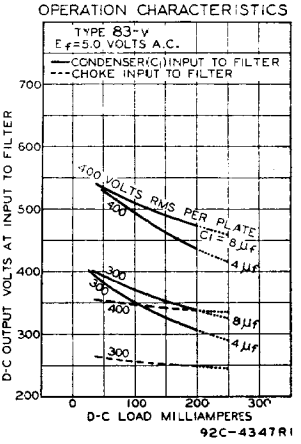
The **cathode** of the 83-v is connected to the heater within the tube.

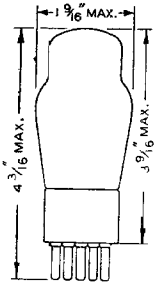
APPLICATION

As a **full-wave rectifier,** the 83-v is useful for supplying large amounts of d-c power to receivers, particularly those in which the d-c requirements cause considerable variation in the load impressed on the rectifier tube.

Filter circuits of either the choke-input or the condenser-input type may be employed, provided the maximum voltages and currents tabulated under CHARACTERISTICS are not exceeded. The choke-input type of circuit is to be preferred from the standpoint of obtaining the maximum continuous d-c output current from the 83-v under the most favorable conditions.

For discussion of rectifiers and filter circuits, refer to pages 24 and 37, respectively.

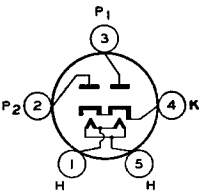




RCA-84

FULL-WAVE RECTIFIER

The 84 is a high-vacuum rectifier of the heater-cathode type, intended for supplying rectified power to automobile-radio equipment designed for its characteristics. This type is interchangeable with the 6Z4.



CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.5	Ampere
A-C Plate Voltage Per Plate (RMS)	350 *max.*	Volts
Peak Inverse Voltage	1000 *max.*	Volts
D-C Output Current	50 *max.*	Milliamperes
Bulb		ST-12
Base		Small 5-Pin

INSTALLATION

The **base** pins of the 84 fit the standard five-contact socket which may be mounted to hold the tube in any position.

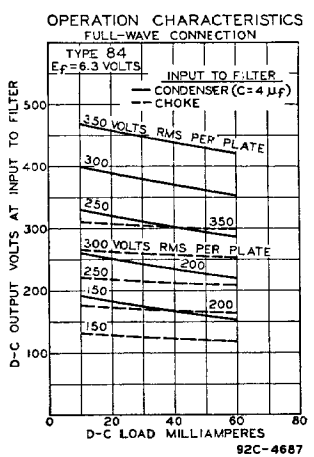
The **bulb** of this tube will become very hot under certain conditions of operation. Adequate ventilation should be provided for cooling the tube by the use of chassis enclosures designed to radiate heat efficiently.

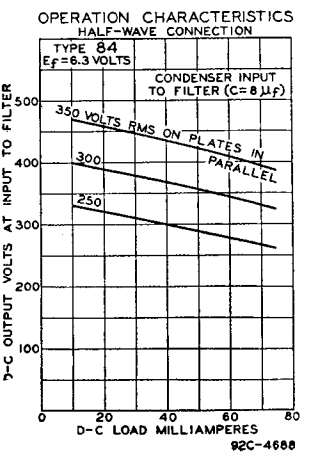
The **heater** is designed so that the normal voltage variation of 6-volt automobile batteries during charge and discharge will not materially affect the performance or serviceability of this tube. Under no condition of operation should the normal operating heater voltage of this tube fluctuate to exceed a maximum of 7.5 volts. The d-c potential difference heater and cathode should be limited to 500 volts.

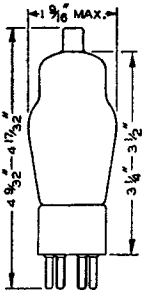
APPLICATION

As a **full-wave rectifier,** the 84 may be operated with condenser-input or choke-input filter under conditions not to exceed the ratings given under CHARACTERISTICS.

As a **half-wave rectifier,** the 84 may be used by connecting the two plate terminals together at the socket. With this arrangement, the maximum d-c output current is 75 milliamperes, while other values are the same as for full-wave service.

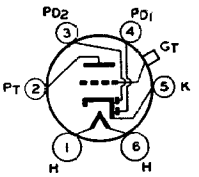






RCA-85

DUPLEX-DIODE TRIODE



The 85 is a heater type of tube consisting of two diodes and a triode in a single bulb. It is for use as a combined detector, amplifier, and automatic-volume-control tube in radio receivers designed for its characteristics. The two diodes and the triode are independent of each other except for a common cathode sleeve, which has one emitting surface for the diodes and another for the triode. The separate tube units permit of unusual flexibility in circuit arrangement and design. For example, the diodes of this tube can perform the functions of detection and of automatic volume-control; while, at the same time, the triode may be used as an amplifier under its own optimum conditions. For diode-detector considerations, refer to page 26.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.3	Ampere
Grid-Plate Capacitance	1.5	$\mu\mu$f
Grid-Cathode Capacitance	1.5	$\mu\mu$f
Plate-Cathode Capacitance	4.3	$\mu\mu$f
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

Triode Unit—As Class A Amplifier

Plate Voltage	135	180	250 *max.*	Volts
Grid Voltage	−10.5	−13.5	−20	Volts
Amplification Factor	8.3	8.3	8.3	
Plate Resistance	11000	8500	7500	Ohms
Transconductance	750	975	1100	Micromhos
Plate Current	3.7	6.0	8.0	Milliamperes
Load Resistance	25000	20000	20000	Ohms
Power Output	0.075	0.16	0.35	Watt

Diode Units

The two diode plates are placed around a cathode, the sleeve of which is common to the triode unit. Each diode plate has its own base pin. Operation curves for the diode units are given under type 6B7.

INSTALLATION

The base pins of the 85 fit the standard six-contact socket, which may be installed to hold the tube in any position. For heater operation and cathode connection, refer to INSTALLATION under type 6A8. Complete shielding of detector circuits employing the 85 is generally necessary to prevent r-f or i-f coupling between the diode circuits and the circuits of other stages.

APPLICATION

The 85 is recommended for performing the simultaneous functions of automatic volume-control, detection, and amplification.

For **detection**, the diodes may be utilized in a full-wave circuit or in a half-wave circuit. In the latter case, one plate only, or the two plates in parallel, may be employed. The use of the half-wave arrangement will provide approximately twice the rectified voltage as compared with the full-wave arrangement.

For **automatic volume-control**, a rectified voltage which is dependent on the r-f or i-f carrier, is usually employed. This voltage is utilized to regulate the gain of the r-f and/or i-f amplifier stages so as to maintain essentially constant-carrier input to the audio detector. The regulation of amplifier gain by means of the rectified voltage may be accomplished by a number of methods, differing chiefly in

the means of applying the voltage to the various electrodes of the amplifier tubes. As is well known, the regulating voltage may be applied to the control grids of the amplifier tubes. On the other hand, by less familiar methods, the voltage may, depending on the requirements of the designer, be applied to other electrodes. For example, the voltage may be applied to suppressor, plate and/or screen of an r-f pentode.

The complex structure of the 85 permits of obtaining automatic-volume-control voltage in a number of ways. In one case, the required voltage is obtained from the detector circuit by utilizing the voltage drop caused by the rectified current flowing through a resistor in the detector circuit. In another case, the required voltage is obtained by utilizing one diode for the sole purpose of automatic volume-control (a.v.c.). This latter method is of particular interest since it confines the sensitivity and time-delay function to the a.v.c. circuit. Time-delay action is, of course, determined by the use of a resistance and condenser combination having the desired time constant. The a.v.c. action may be postponed by applying a negative voltage to the a.v.c. diode plate. Another a.v.c. arrangement capable of various adaptations is to use the triode as a d-c amplifier to supply the regulating voltage. Additional information on automatic volume-control is given on page 28.

For **amplification,** the triode may be employed in conventional circuit arrangements. Representative conditions for resistance-coupled amplifier applications are given in the Resistance-Coupled Amplifier Section. Grid bias for the triode, depending upon circuit design, may be obtained from a fixed-voltage tap on the d-c power supply or may be obtained by utilizing the variable voltage drop caused by the rectified current flowing through a resistor in the detector circuit. In this connection, it should be noted that the circuits shown below designate this latter arrangement as "Diode-Biased Amplifier." Diode biasing of the triode unit may be employed only when at least 20000 ohms resistance is used in the triode plate circuit.

A plate family of characteristics for the triode unit is given under type 55.

TYPICAL DUPLEX-DIODE TRIODE CIRCUITS

HALF-WAVE DETECTOR
DIODE BIASED AMPLIFIER

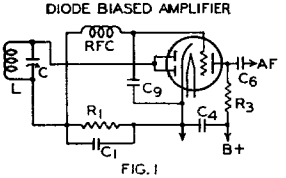


FIG. 1

FULL-WAVE DETECTOR
DIODE BIASED AMPLIFIER

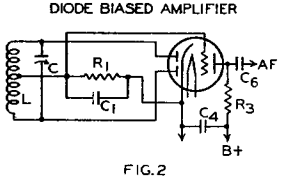
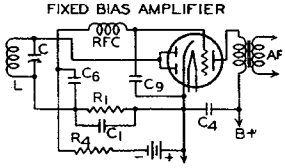


FIG. 2

HALF-WAVE DETECTOR
FIXED BIAS AMPLIFIER



HALF-WAVE DETECTOR
DIODE BIASED D-C AMPLIFIER

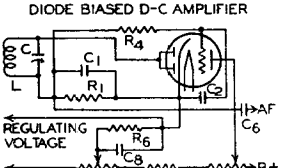


FIG. 4

HALF-WAVE DETECTOR
FIXED BIAS AMPLIFIER

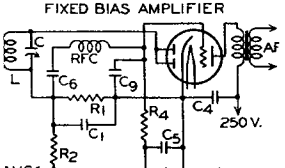


FIG. 5

HALF-WAVE DETECTOR, SEPARATE
A.V.C., FIXED BIAS AMPLIFIER

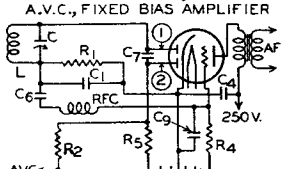
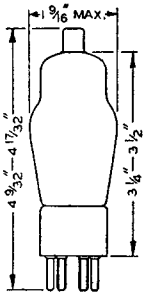


FIG. 6

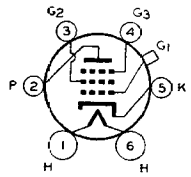
APPROXIMATE VALUES

C_1 = 150 μμf FOR 500–1500 KC.; 450 μμf FOR 175 KC.
C_2 = 0.1 μf
C_3 = 0.1 μf
C_4 = 0.5 μf OR LARGER
C_5 = 0.5 μf OR LARGER
C_6 = 0.01–0.1 μf
C_7 = 0.00005–0.001 μf
C_8 = 0.1 μf OR LARGER
C_9 = 0.00001 μf OR SMALLER
R_1 = 0.5–1.0 MEGOHM
R_2 = 1.0–1.5 MEGOHMS
R_3 = 0.1 MEGOHM
R_4 = 0.5–1.0 MEGOHM
R_5 = 1.0 MEGOHM
R_6 = 25000–75000 OHMS
E_b = VOLTAGE FOR SENSITIVITY CONTROL



RCA-89

TRIPLE-GRID POWER AMPLIFIER



The 89 is a triple-grid power-amplifier tube of the heater-cathode type recommended for use in receivers with 6.3-volt heater supply. The triple-grid construction of this tube, with external connections for each grid, makes possible its application as (1) a Class A Power-Amplifier Triode, (2) a Class A Power-Output Pentode, and (3) a Class B Power-Output Triode.

CHARACTERISTICS

Heater Voltage (A. C. or D. C.)	6.3	Volts
Heater Current	0.4	Ampere
Bulb		ST-12
Cap		Small Metal
Base		Small 6-Pin

Class A_1 Power Amplifier—Triode Connection

(Grids No. 2 and No. 3 tied to plate)

Plate Voltage	160	180	250 *max.*	Volts
Grid Voltage (Grid No. 1)	−20	−22.5	−31	Volts
Plate Current	17	20	32	Milliamperes
Amplification Factor	4.7	4.7	4.7	
Plate Resistance	3300	3000	2600	Ohms
Transconductance	1425	1550	1800	Micromhos
Load Resistance*	7000	6500	5500	Ohms
Self-Bias Resistor	1180	1125	970	Ohms
Undistorted Power Output	0.3	0.4	0.9	Watt

* Optimum for maximum undistorted power output. Approximately twice the value or any given set of conditions is recommended for load of this tube when used as driver for Class B stage.

Class A_1 Power Amplifier—Pentode Connection

(Grid No. 3 tied to cathode)

Plate Voltage	100	135	180	250 *max.*	Volts
Screen Voltage (Grid No. 2)	100	135	180	250 *max.*	Volts
Grid Voltage (Grid No. 1)	−10	−13.5	−18	−25	Volts
Plate Current	9.5	14	20	32	Milliamperes
Screen Current	1.6	2.2	3.0	5.5	Milliamperes
Amplification Factor	125	125	125	125	
Plate Resistance	104000	92500	80000	70000	Ohms
Transconductance	1200	1350	1550	1800	Micromhos
Load Resistance	10700	9200	8000	6750	Ohms
Self-Bias Resistor	900	830	785	670	Ohms
Power Output*	0.33	0.75	1.5	3.4	Watts

* 9% total harmonic distortion.

Class B Power Amplifier—Triode Connection

(Grids No. 1 and No. 2 tied together, grid No. 3 tied to plate)

Plate Voltage	250 *max.*	Volts
Peak Plate Current	90 *max.*	Milliamperes
Average Grid Dissipation (Grids No. 1 and No. 2)	0.35 *max.*	Watt
Typical Operation *Values are for two tubes.*		
Plate Voltage	180	Volts
Grid Voltage	0	Volts

Zero-Signal Plate Current.....	6	Milliamperes
Effective Load Resistance (Plate-to-plate).....	9400	Ohms
Power Output (Approximate).....	3.5	Watts

INSTALLATION AND APPLICATION

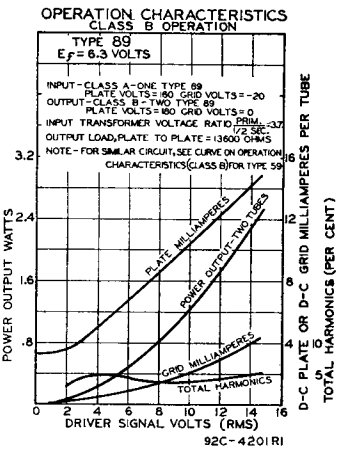
The **base** pins of the 89 fit the standard six-contact socket which may be installed to hold the tube in any position. Sufficient ventilation should be provided to circulate air freely around the tube to prevent overheating.

For **heater** operation and **cathode** connection, refer to type 6A8.

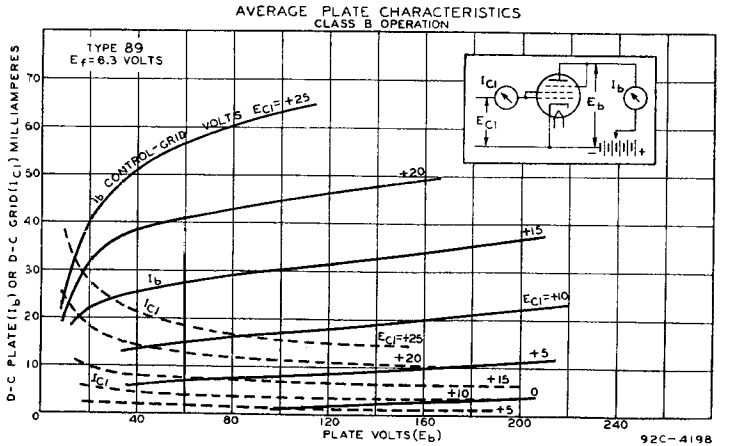
For **Class A_1 Triode Operation** of the 89, the two grids (No. 2 and No. 3), immediately adjacent to the plate, are connected to the plate, while the third (No. 1) is employed for control purposes. Operation of the tube is then similar to any Class A Power-Amplifier Triode. When it is used as the driver for a Class B stage, the load requirements are changed as indicated in the note under CHARACTERISTICS. This change is recommended in order to minimize distortion due to the driver stage.

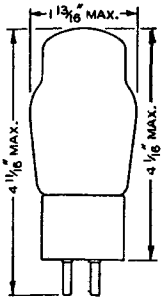
For **Class A_1 Pentode Operation** of the 89, the grid (No. 3) adjacent to the plate is tied to the cathode and thus serves as the suppressor, while the other two grids (No. 1 and No. 2) serve as the screen-grid and control-grid respectively. Operation of the tube is then similar to any Class A power-output pentode.

When the 89 is operated as a Class A Amplifier (triode or pentode), input transformer- or impedance-coupling devices are recommended. If, however, resistance coupling is used, a resistance of 1.0 megohm may be employed, provided the heater voltage does not rise more than 10 per cent above rated value under any condition of operation.



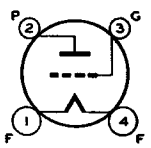
For **Class B Triode Operation** of the 89, the grid (No. 3) adjacent to the plate is tied to the plate, while the other two grids (No. 1 and No. 2) are connected together to serve as a single control grid. A discussion of Class B design features is given on page 20.





RCA-112-A

DETECTOR, AMPLIFIER



The 112-A is a three-electrode storage-battery tube for use as a detector and as an amplifier.

CHARACTERISTICS

Filament Voltage (D. C.)			5.0	Volts
Filament Current			0.25	Ampere
Plate Voltage	90	135	180 *max.*	Volts
Grid Voltage*	−4.5	−9	−13.5	Volts
Plate Current	5.0	6.2	7.7	Milliamperes
Plate Resistance	5400	5100	4700	Ohms
Amplification Factor	8.5	8.5	8.5	
Transconductance	1575	1650	1800	Micromhos
Load Resistance	5000	9000	10650	Ohms
Undistorted Power Output	0.035	0.13	0.285	Watt
Grid-Plate Capacitance			8.5	μμf
Grid-Filament Capacitance			4.0	μμf
Plate-Filament Capacitance			2.0	μμf
Bulb				ST-14
Base				Medium 4-Pin Bayonet

* The d-c resistance in the grid circuit should not exceed one megohm.

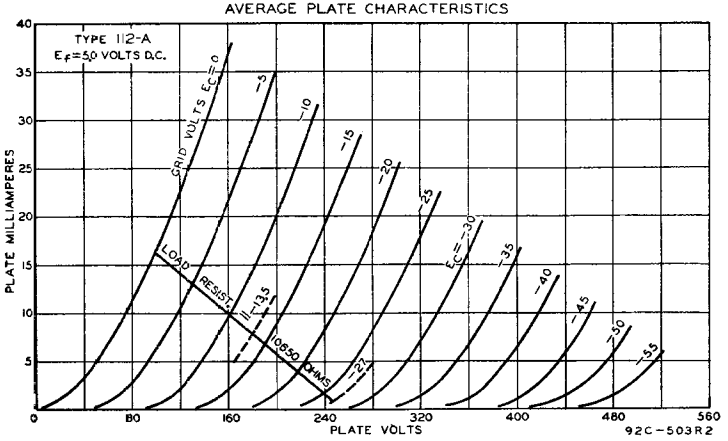
INSTALLATION AND APPLICATION

The **base** pins of the 112-A fit the standard four-contact socket which **should** be installed to hold the tube in a vertical position.

As a **detector,** the 112-A may be operated either with grid leak and **condenser** or with grid bias. For grid-bias detection, plate voltages up to the maximum **value** of 180 volts may be used with the corresponding negative grid-bias voltage (21 **volts** approximately, at 180 volts).

As an **amplifier,** the 112-A should be operated as shown under CHARACTERISTICS.

AVERAGE PLATE CHARACTERISTICS



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BEAM POWER TUBE

Useful at Frequencies up to 125 Mc

GENERAL DATA

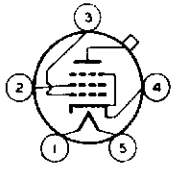
Electrical:

Heater, for Unipotential Cathode:		
Voltage	6.3 ± 0.6	ac or dc volts
Current	0.9	amp
Transconductance (Approx.) for plate volts = 250, grid-No.2 volts = 250, grid-No.1 volts = −14	6000	μmhos
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 250, grid-No.2 volts = 250, and grid-No.1 volts = −20	8	
Direct Interelectrode Capacitances:		
Grid No.1 to plate[○]	0.2 max.	μμf
Grid No.1 to cathode & grid No.3, grid No.2, and heater	12	μμf
Plate to cathode & grid No.3, grid No.2, and heater	7	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	5-3/4"
Seated Length	4-31/32" ± 5/32"
Maximum Diameter	2-1/16"
Weight (Approx.)	3 oz
Bulb	ST-16
Cap.	Small (JETEC No.C1-1)
Base . . . Medium-Micanol-Shell Small 5-Pin (JETEC No.A5-11)	
Basing Designation for BOTTOM VIEW	5AW

Pin 1 – Heater
Pin 2 – Grid No.2
Pin 3 – Grid No.1



Pin 4 – Cathode, Grid No.3
Pin 5 – Heater
Cap – Plate

AF POWER AMPLIFIER & MODULATOR – Class AB$_1$♦

Triode Connection--Grid No.2 Connected to Plate

Maximum Ratings, *Absolute Values*:

	CCS●	*ICAS*●●	
DC PLATE VOLTAGE	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	125 max.	125 max.	ma
MAX.-SIGNAL DC PLATE PLUS GRID-No.2 INPUT*	50 max.	50 max.	watts
PLATE DISSIPATION PLUS GRID-No.2 INPUT*	25 max.	30 max.	watts

○ With external shield JETEC No.312.

♦, ●, ●●, *: See next page. —indicates a change.

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BEAM POWER TUBE

	CCS●	ICAS●●	
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation:●	CCS●	ICAS●●	
Values are for 2 tubes			
DC Plate Voltage	400	400	volts
DC Grid-No.1 (Control-Grid) Voltage	−45	−45	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage●●	90	90	volts
→ Zero-Signal DC Plate Current	64	64	ma
Max.-Signal DC Plate Current	140	140	ma
Effective Load Resistance (Plate to Plate)	3000	3000	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	15	15	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:○○		
With fixed bias	0.1 max.	megohm
With cathode bias	0.5 max.	megohm

AF POWER AMPLIFIER & MODULATOR - Class AB_1♦

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	300 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	120 max.	120 max.	ma
MAX.-SIGNAL DC PLATE INPUT*	60 max.	90 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT*	3.5 max.	3.5 max.	watts
PLATE DISSIPATION*	25 max.	30 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

♦ Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● In class AB_1 service, the normal design limitation is the requirement that grid-No.1 current should not flow. For this reason, the typical operating values shown for both CCS and ICAS conditions are the same.

●● The driver stage should be capable of supplying the No.1 grids of the class AB_1 stage with the specified driving voltage at low distortion.

●, ●●, *, ○○: See next page.

→ indicates a change.

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BEAM POWER TUBE

Typical Operation:	CCS●			ICAS●●	
Values are for 2 tubes					
DC Plate Voltage	400	500	600	750	volts
DC Grid-No.2 Voltage**	300	300	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage:					
From fixed-bias source	-30	-32	-34	-35	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	60	64	68	70	volts
Zero-Signal DC Plate Current	56	44	36	30	ma
Max.-Signal DC Plate Current	143	141	139	139	ma
Zero-Signal DC Grid-No.2 Current	2	1	0.6	0.5	ma
Max.-Signal DC Grid-No.2 Current	16	15	15	16	ma
Effective Load Resistance (Plate to plate)	6800	8200	10000	12000	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	0●	watts
Max.-Signal Power Output (Approx.)	36	46	56	72	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:○○
- With fixed bias . . . . . 0.1 max. megohm
- With cathode bias . . . . . Not recommended

AF POWER AMPLIFIER & MODULATOR - Class AB_2#

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	300 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	120 max.	120 max.	ma
MAX.-SIGNAL PLATE INPUT*	60 max.	90 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT*	3.5 max.	3.5 max.	watts
PLATE DISSIPATION*	25 max.	30 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Subscript 2 indicates that the grid-No.1 current flows during some part of the input cycle.

* Averaged over any audio-frequency cycle of sine-wave form.

●, ●●, **, ○○: See next page.

←Indicates a change.

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BEAM POWER TUBE

Typical Operation:	CCS●			ICAS●●	
Values are for 2 tubes					
DC Plate Voltage	400	500	600	750	volts
DC Grid-No.2 Voltage**	300	300	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage:					
From fixed-bias source	-28	-30	-32	-35	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	80	86	90	96	volts
Zero-Signal DC Plate Current	72	60	48	30	ma
Max.-Signal DC Plate Current	240	240	200	240	ma
Zero-Signal DC Grid-No.2 Current	2	0.9	0.7	0.5	ma
Max.-Signal DC Grid-No.2 Current	20	20	18	20	ma
Effective Load Resistance (Plate to plate)	3700	4600	6900	7300	ohms
Max.-Signal Driving Power (Approx.)◆◆	0.2	0.2	0.1	0.2	watt
Max.-Signal Power Output (Approx.)▲	55	75	80	120	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:∞

With fixed bias	30000 max.	ohms
With cathode bias	Not recommended	

RF POWER AMPLIFIER-Class B Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	300 max.	volts
DC PLATE CURRENT	80 max.	90 max.	ma
PLATE INPUT	37.5 max.	45 max.	watts
GRID-No.2 INPUT	2.5 max.	2.5 max.	watts

** Preferably obtained from a separate source, or from the plate-voltage supply with a voltage divider.

◆◆ Driver stage should be capable of supplying the specified driving power at low distortion to the No.1 grids of the class AB_2 stage. The effective resistance per grid-No.1 circuit of the class AB_2 stage should be kept below 500 ohms and the effective impedance should not exceed 700 ohms at the highest response frequency.

▲ With zero-impedance driver and perfect regulation, plate-circuit distortion does not exceed 2%. In practice, the regulation of the plate-voltage, grid-No.2 voltage, and grid-No.1 voltage should not be greater than 5%, 5%, and 3%, respectively.

●, ●●, ∞: See next page.

→ Indicates a change.

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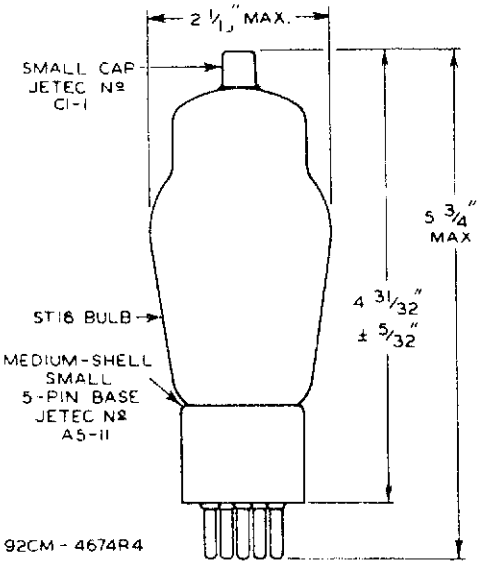
BEAM POWER TUBE



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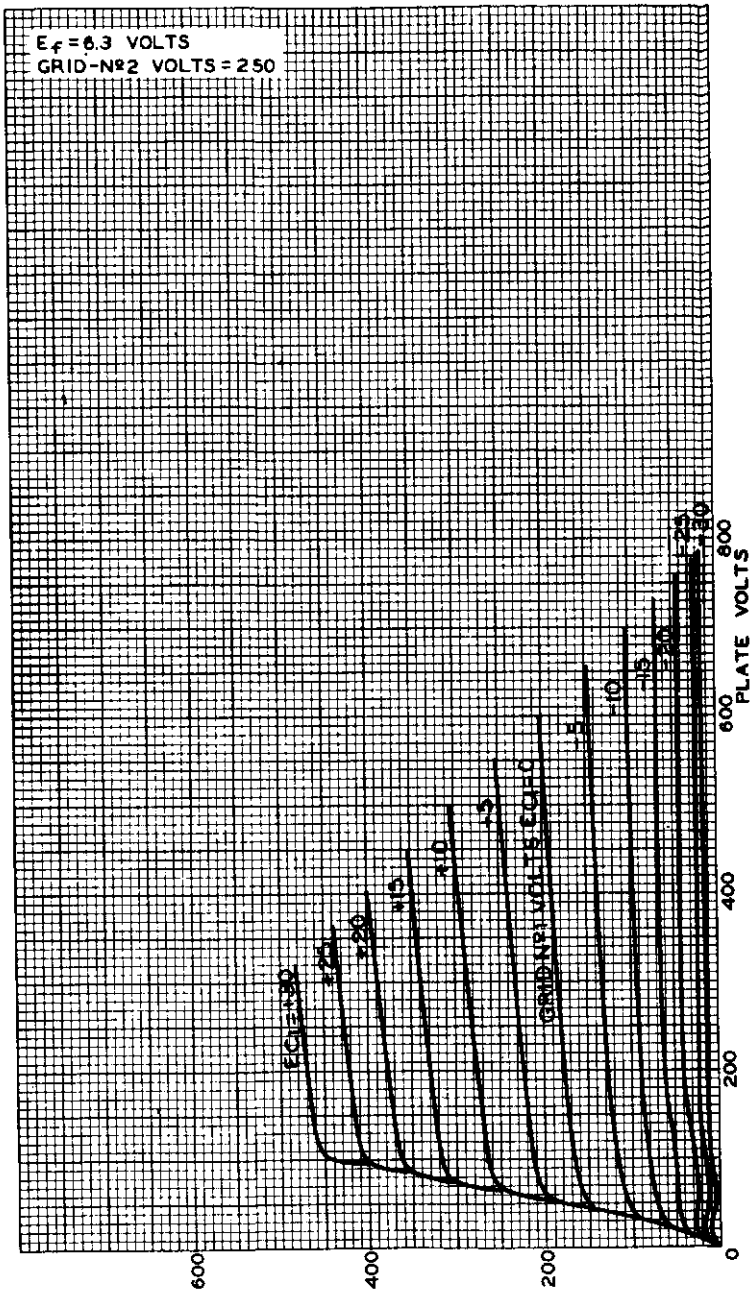
AVERAGE PLATE CHARACTERISTICS



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RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

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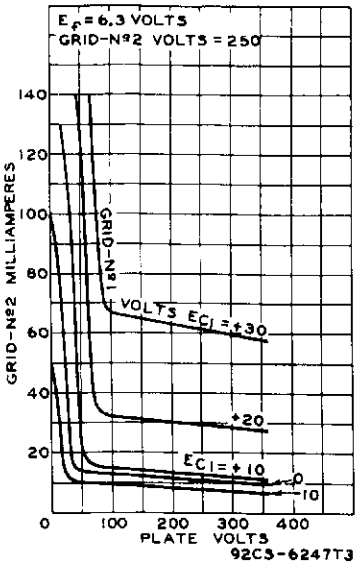
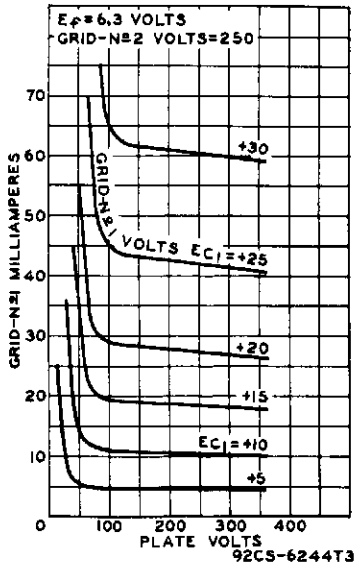
AVERAGE CHARACTERISTICS





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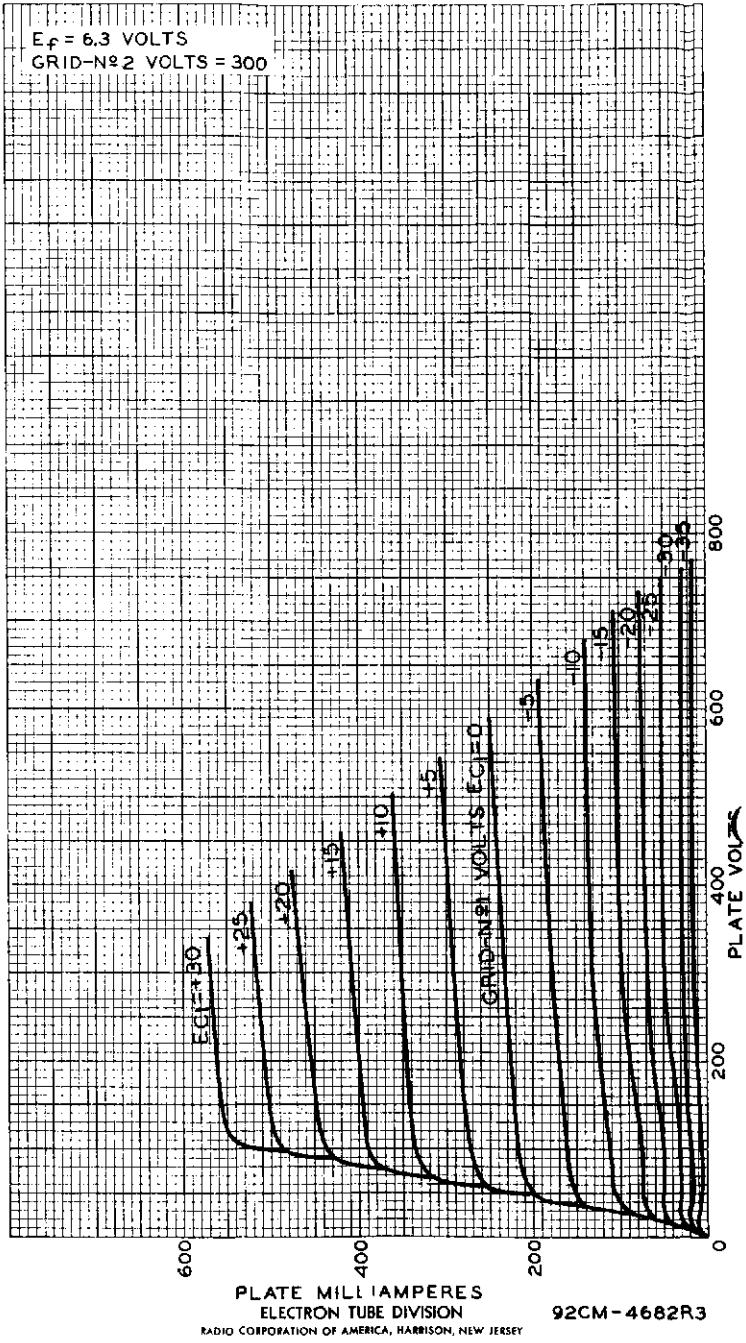
AVERAGE PLATE CHARACTERISTICS



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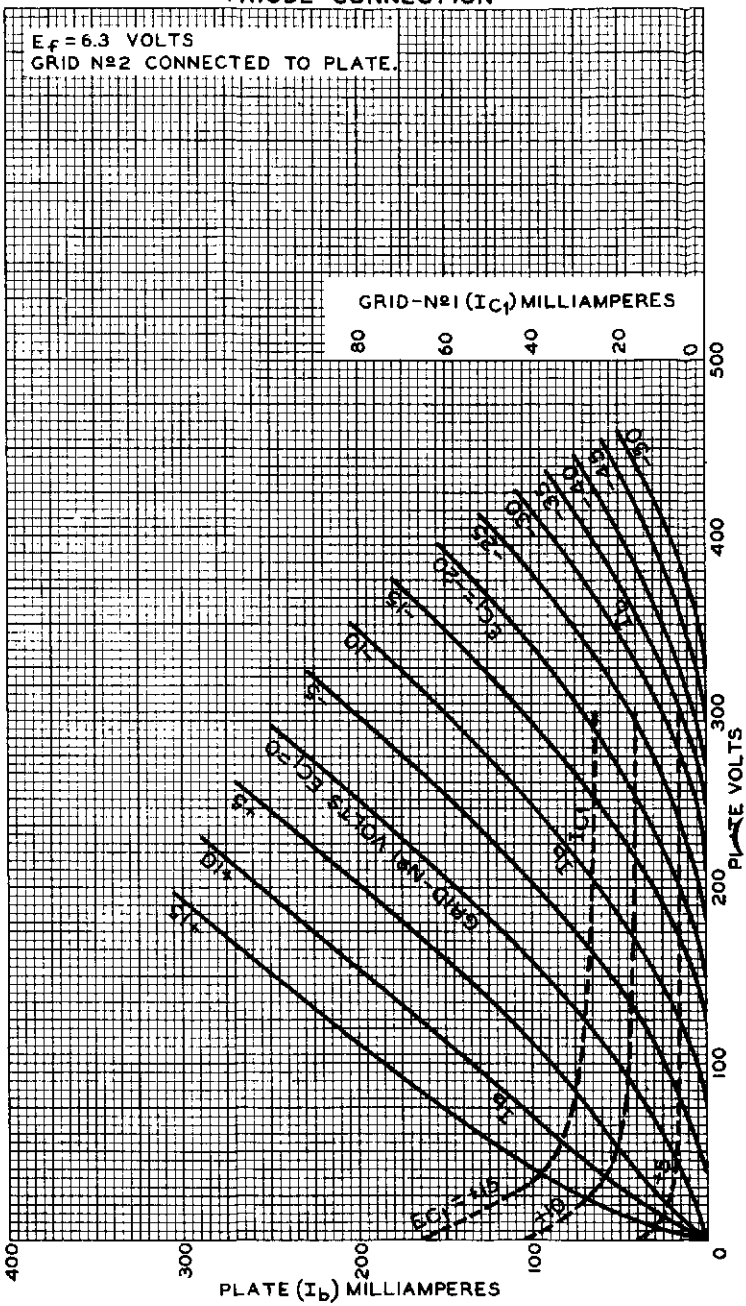
AVERAGE CHARACTERISTICS

TRIODE CONNECTION



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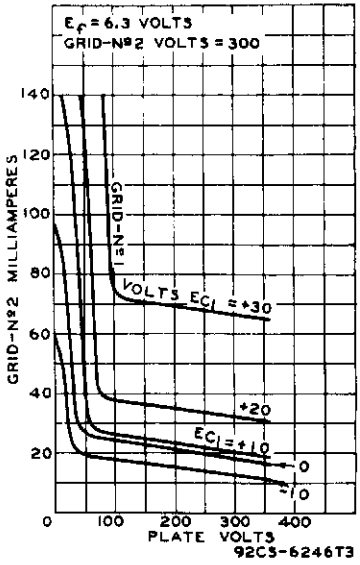
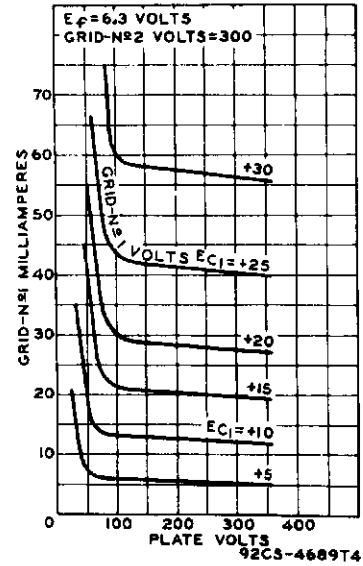
AVERAGE CHARACTERISTICS





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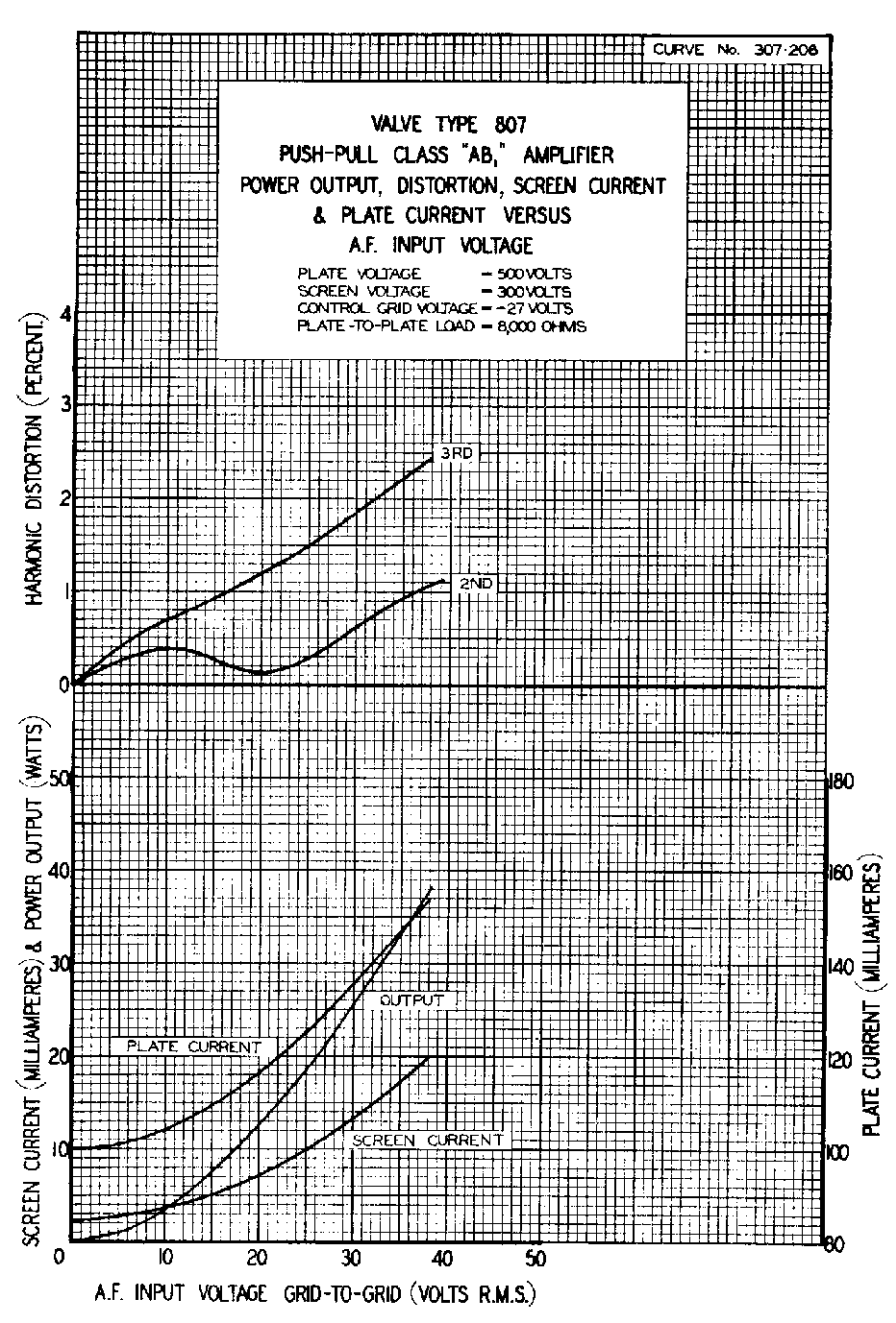
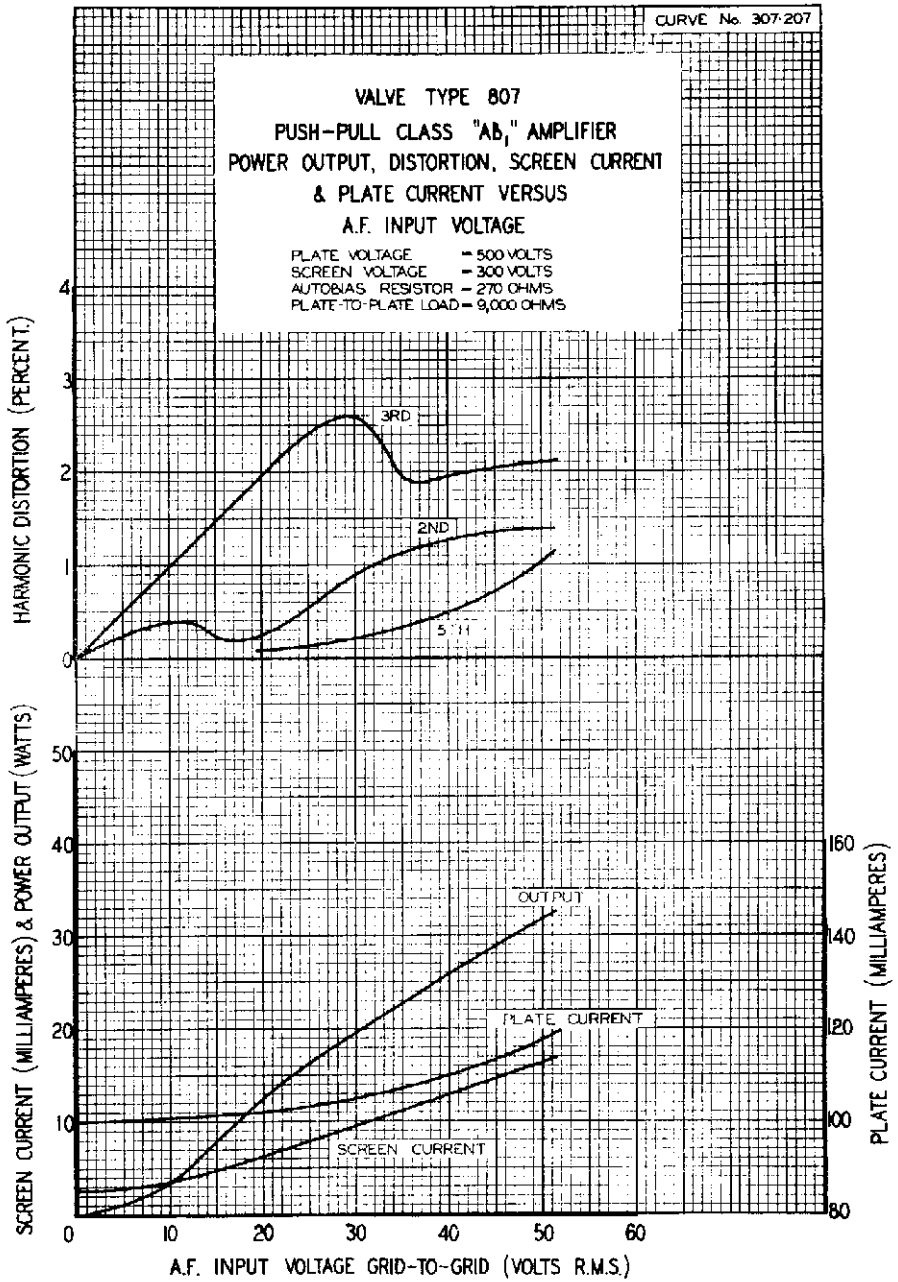
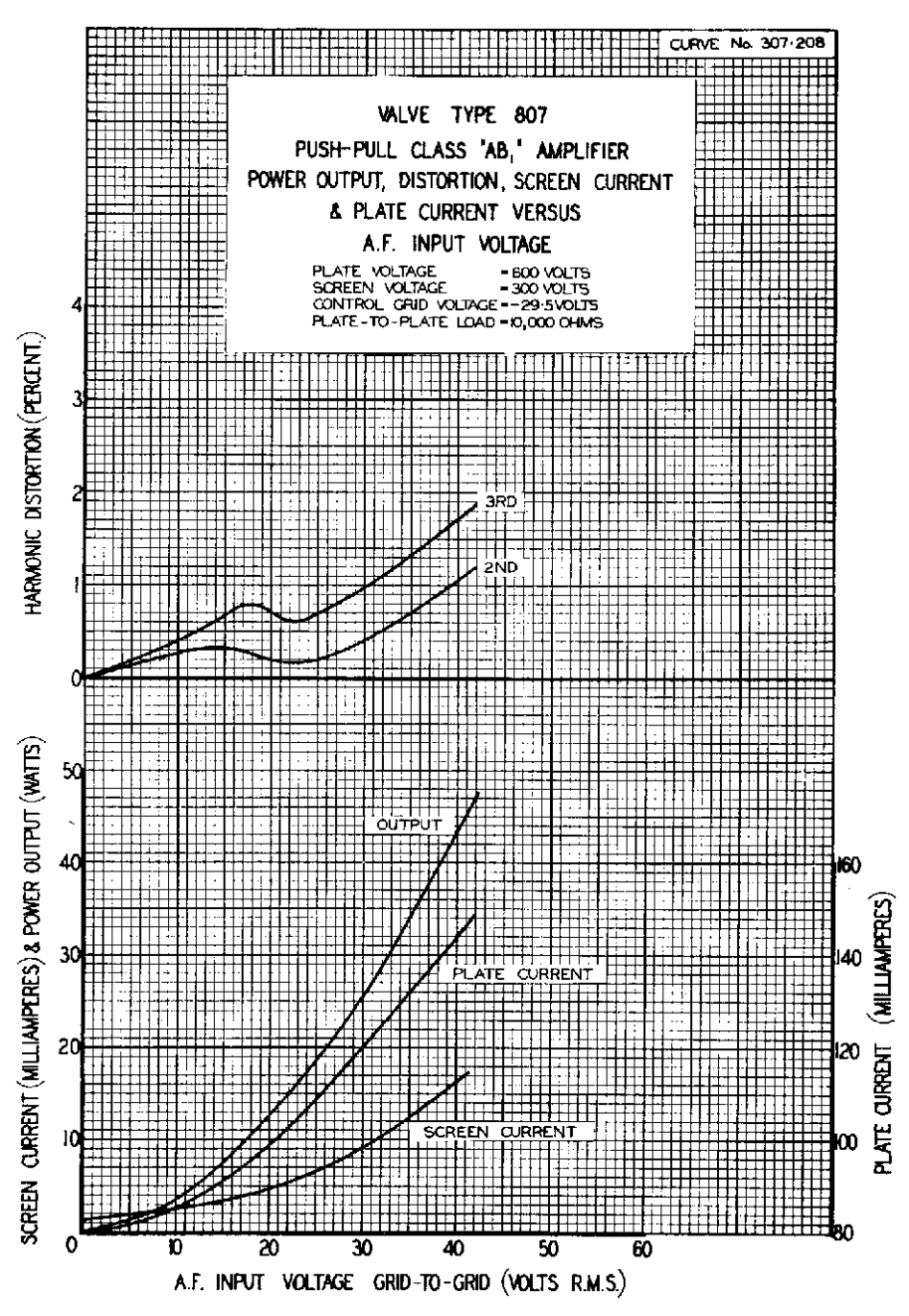
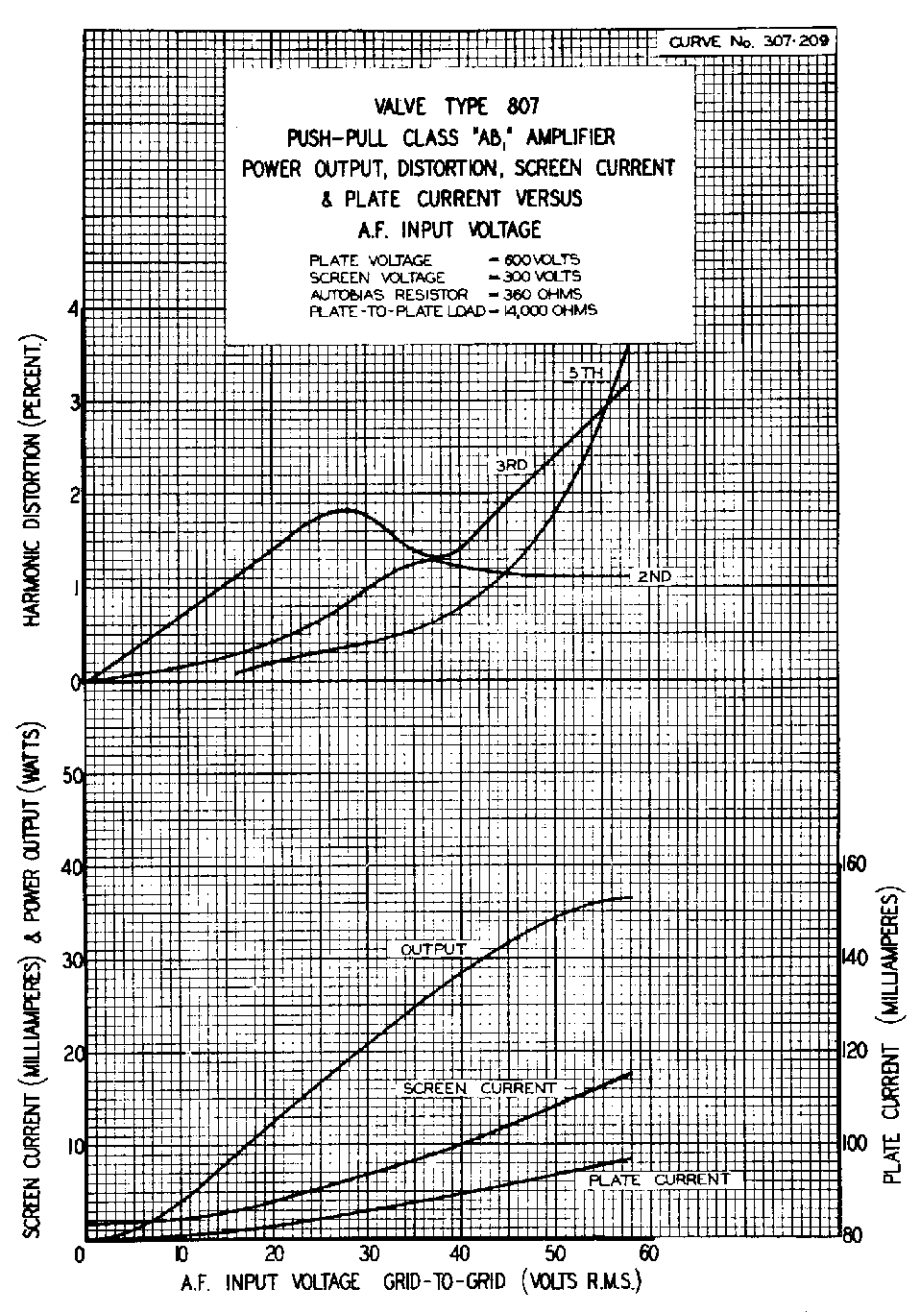
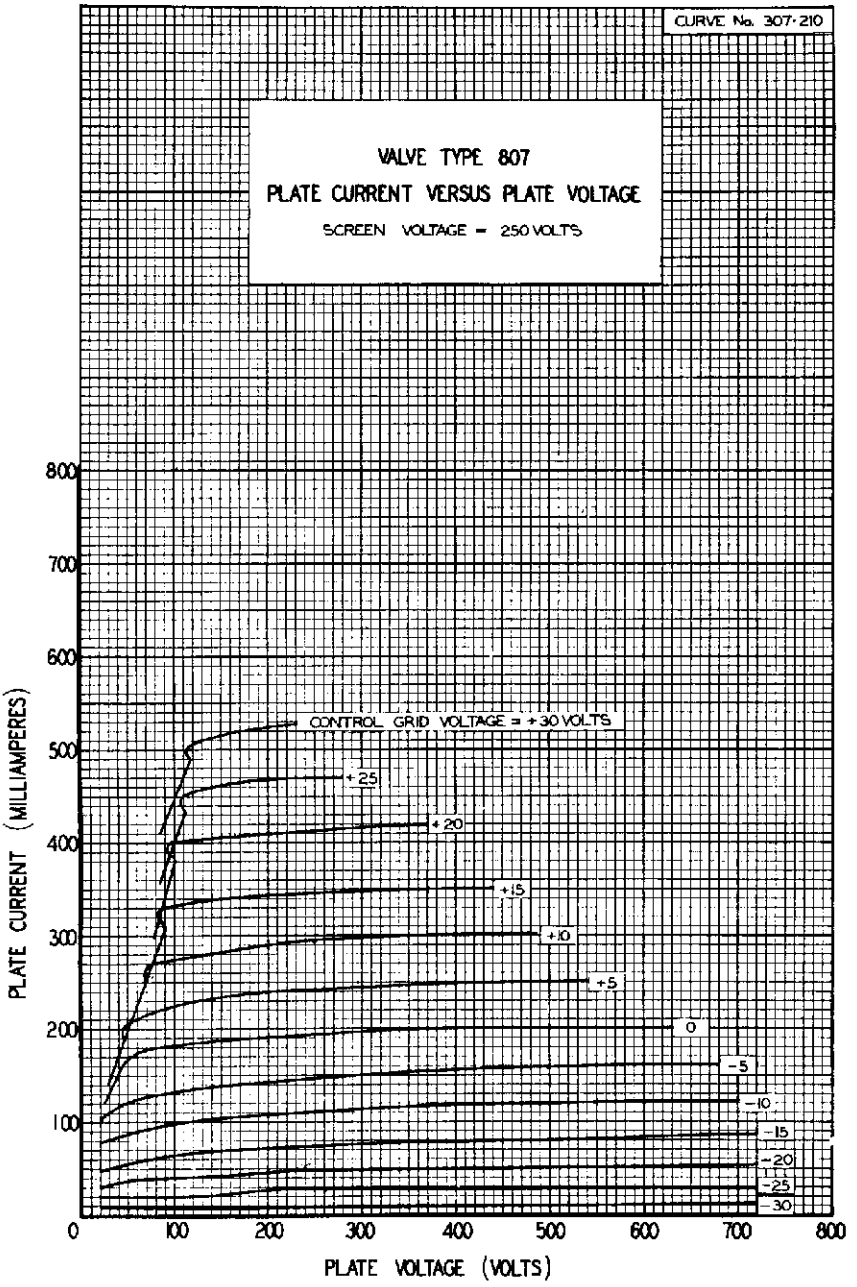
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

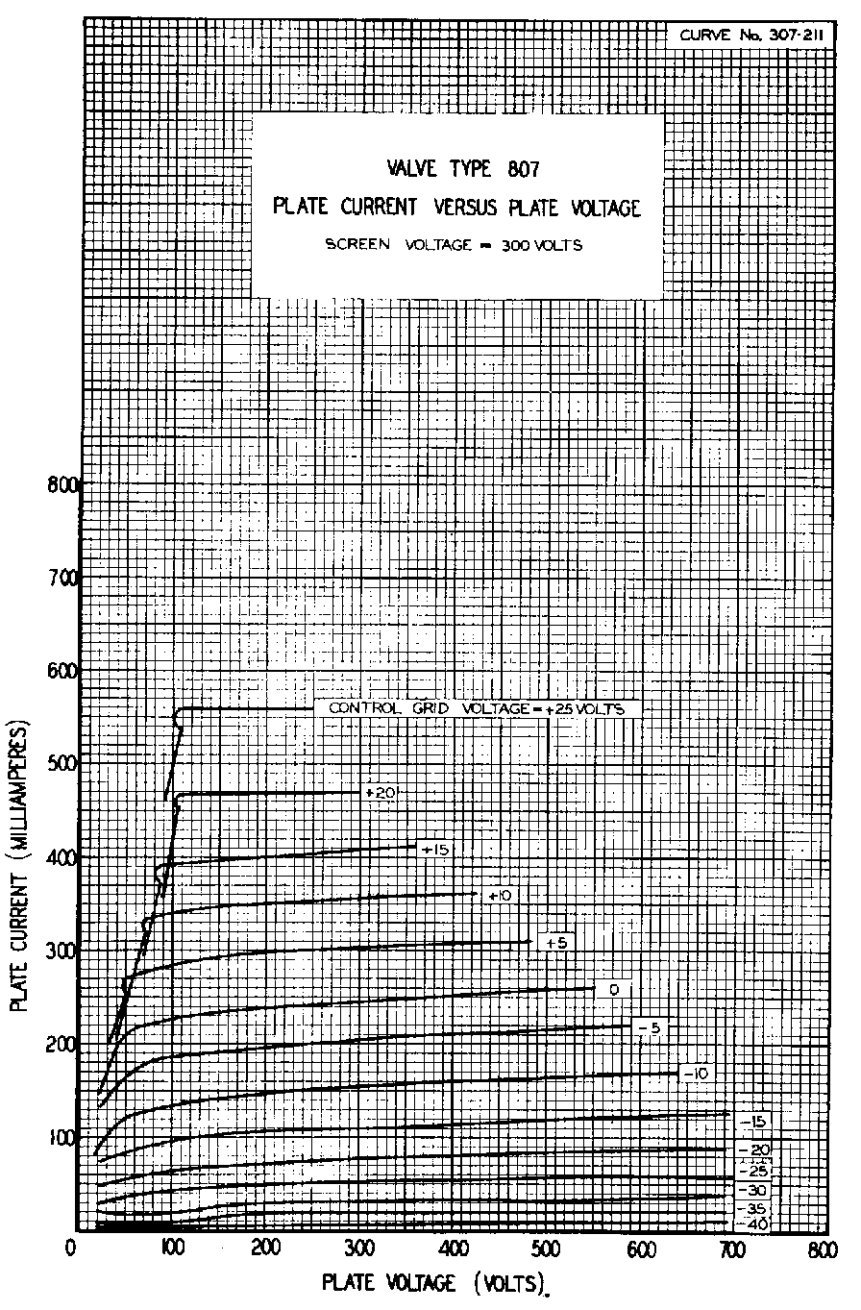

CURVE No. 307-206
VALVE TYPE 807
PUSH-PULL CLASS "AB," AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 500 VOLTS
SCREEN VOLTAGE = 300 VOLTS
CONTROL GRID VOLTAGE = -27 VOLTS
PLATE-TO-PLATE LOAD = 8,000 OHMS
HARMONIC DISTORTION (PERCENT)
3RD
2ND
SCREEN CURRENT (MILLIAMPERES) & POWER OUTPUT (WATTS)
PLATE CURRENT (MILLIAMPERES)
OUTPUT
PLATE CURRENT
SCREEN CURRENT
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)

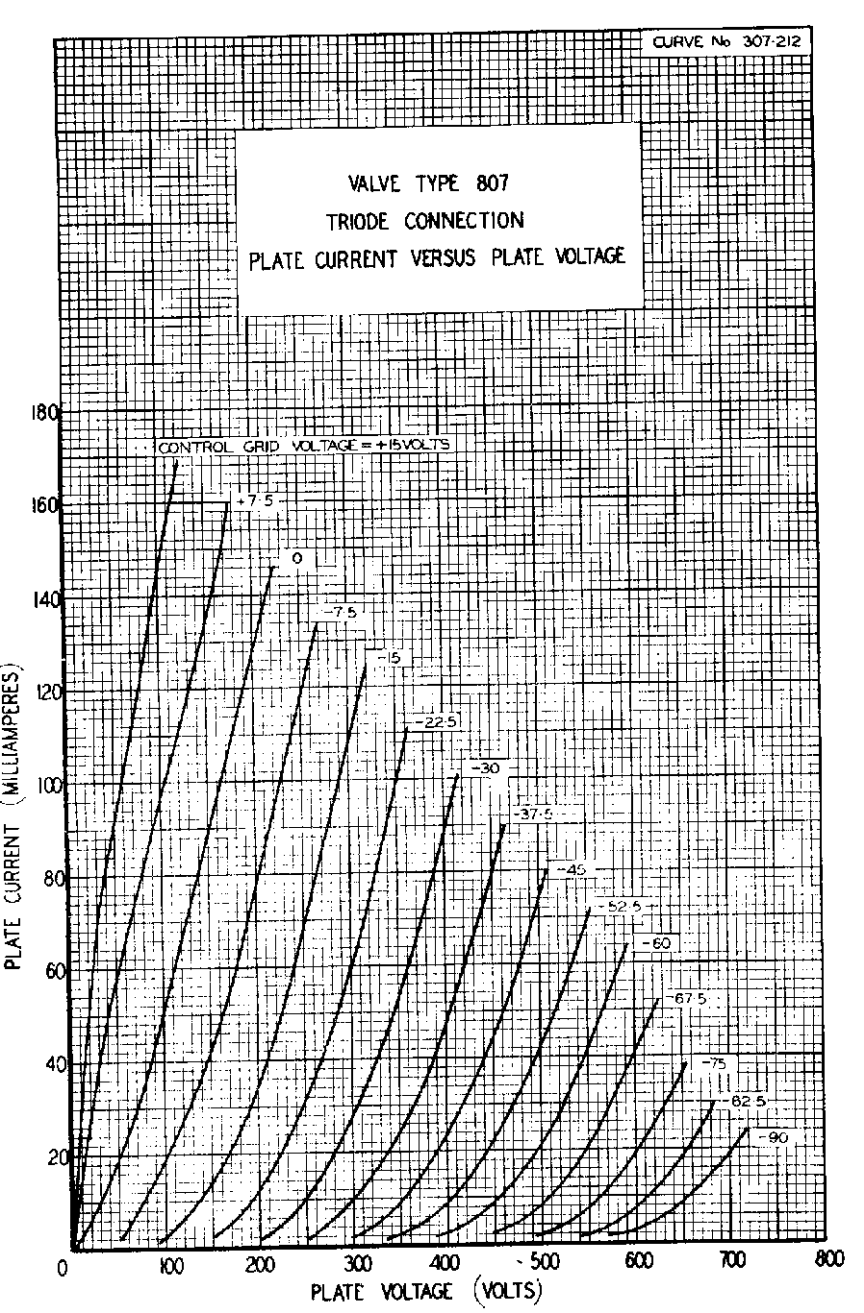

CURVE No. 307-207
VALVE TYPE 807
PUSH-PULL CLASS "AB1" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 500 VOLTS
SCREEN VOLTAGE = 300 VOLTS
AUTOBIAS RESISTOR = 270 OHMS
PLATE-TO-PLATE LOAD = 9,000 OHMS
3RD
2ND
5TH
OUTPUT
PLATE CURRENT
SCREEN CURRENT
HARMONIC DISTORTION (PERCENT.)
SCREEN CURRENT (MILLIAMPERES) & POWER OUTPUT (WATTS)
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
1
2
3
4
10
20
30
40
50
60
80
100
120
140
160


CURVE No. 307-208
VALVE TYPE 807
PUSH-PULL CLASS 'AB,' AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 600 VOLTS
SCREEN VOLTAGE = 300 VOLTS
CONTROL GRID VOLTAGE = -29·5 VOLTS
PLATE-TO-PLATE LOAD = 10,000 OHMS
HARMONIC DISTORTION (PERCENT.)
3RD
2ND
SCREEN CURRENT (MILLIAMPERES) & POWER OUTPUT (WATTS)
OUTPUT
PLATE CURRENT
SCREEN CURRENT
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)


CURVE No. 307-209
VALVE TYPE 807
PUSH-PULL CLASS "AB1" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 600 VOLTS
SCREEN VOLTAGE = 300 VOLTS
AUTOBIAS RESISTOR = 360 OHMS
PLATE-TO-PLATE LOAD = 14,000 OHMS
5TH
3RD
2ND
OUTPUT
SCREEN CURRENT
PLATE CURRENT
HARMONIC DISTORTION (PERCENT.)
SCREEN CURRENT (MILLIAMPERES) & POWER OUTPUT (WATTS)
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
1
2
3
4
10
20
30
40
50
60
80
100
120
140
160


CURVE No. 307-210
VALVE TYPE 807
PLATE CURRENT VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 250 VOLTS
CONTROL GRID VOLTAGE = +30 VOLTS
+25
+20
+15
+10
+5
0
-5
-10
-15
-20
-25
-30
PLATE CURRENT (MILLIAMPERES)
800
700
600
500
400
300
200
100
0
100
200
300
400
500
600
700
800
PLATE VOLTAGE (VOLTS)


CURVE No. 307-211
VALVE TYPE 807
PLATE CURRENT VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 300 VOLTS
CONTROL GRID VOLTAGE = +25 VOLTS
+20
+15
+10
+5
0
-5
-10
-15
-20
-25
-30
-35
-40
PLATE CURRENT (MILLIAMPERES)
800
700
600
500
400
300
200
100
0
100
200
300
400
500
600
700
800
PLATE VOLTAGE (VOLTS)

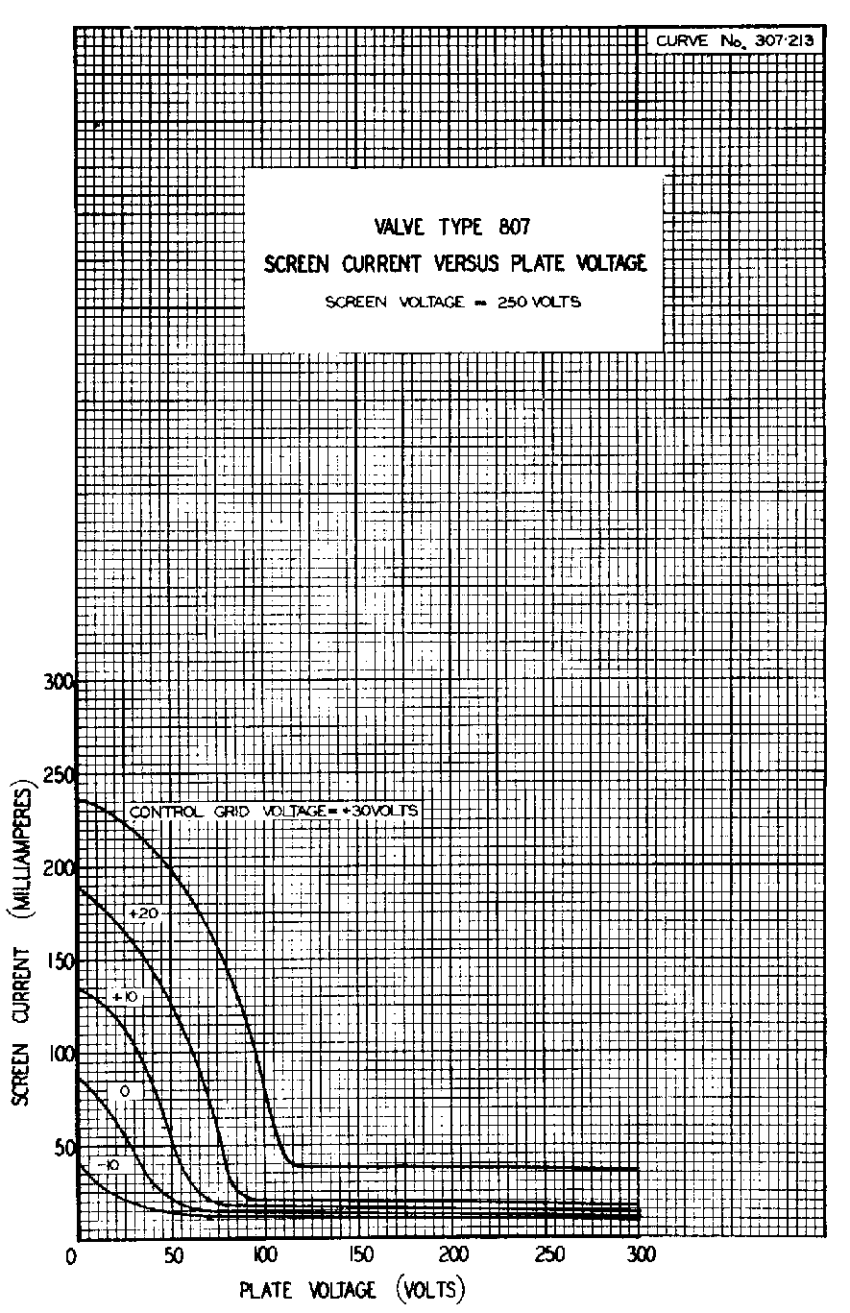

CURVE No 307-212
VALVE TYPE 807
TRIODE CONNECTION
PLATE CURRENT VERSUS PLATE VOLTAGE
CONTROL GRID VOLTAGE = +15 VOLTS
+7.5
0
-7.5
-15
-22.5
-30
-37.5
-45
-52.5
-60
-67.5
-75
-82.5
-90
PLATE CURRENT (MILLIAMPERES)
PLATE VOLTAGE (VOLTS)
0
20
40
60
80
100
120
140
160
180
100
200
300
400
500
600
700
800

CURVE No. 307-213

VALVE TYPE 807

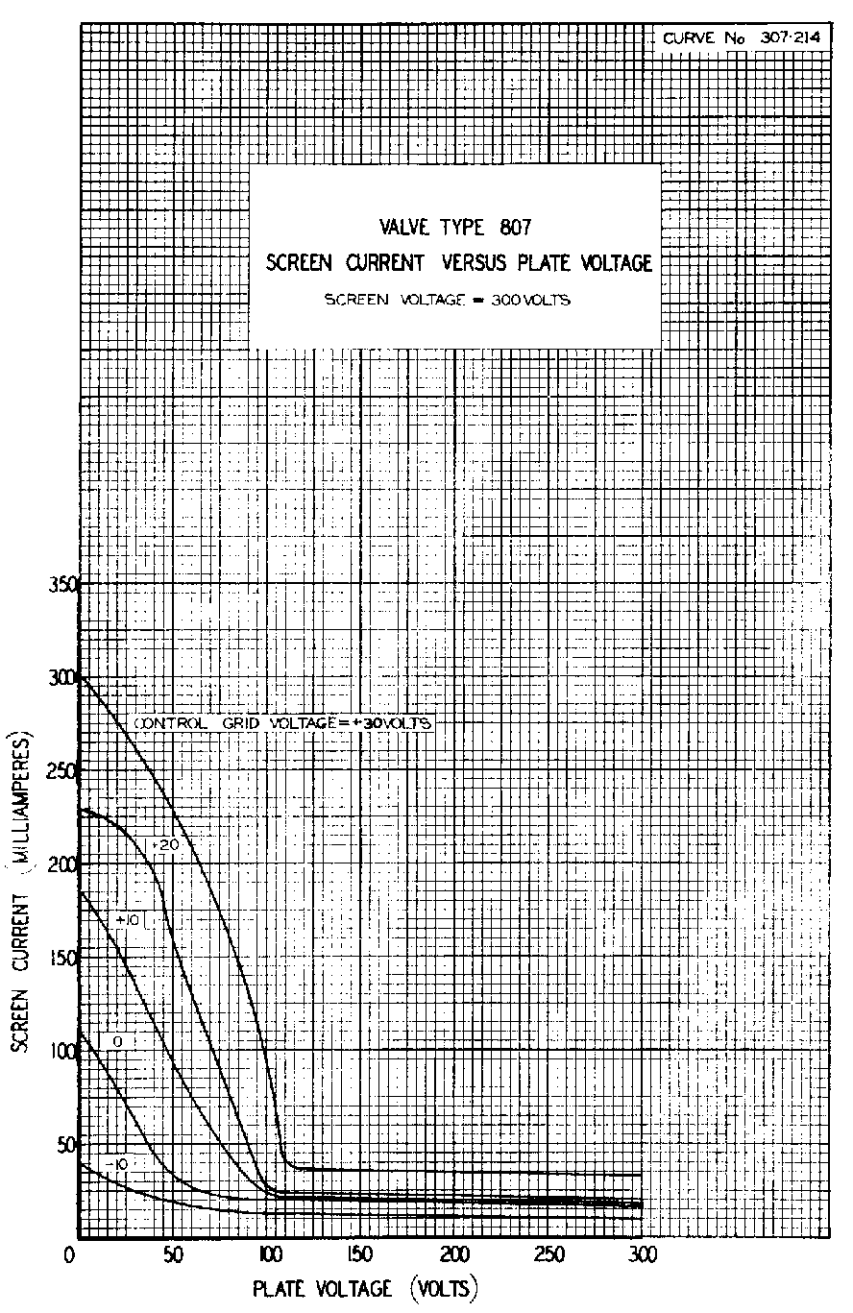
SCREEN CURRENT VERSUS PLATE VOLTAGE

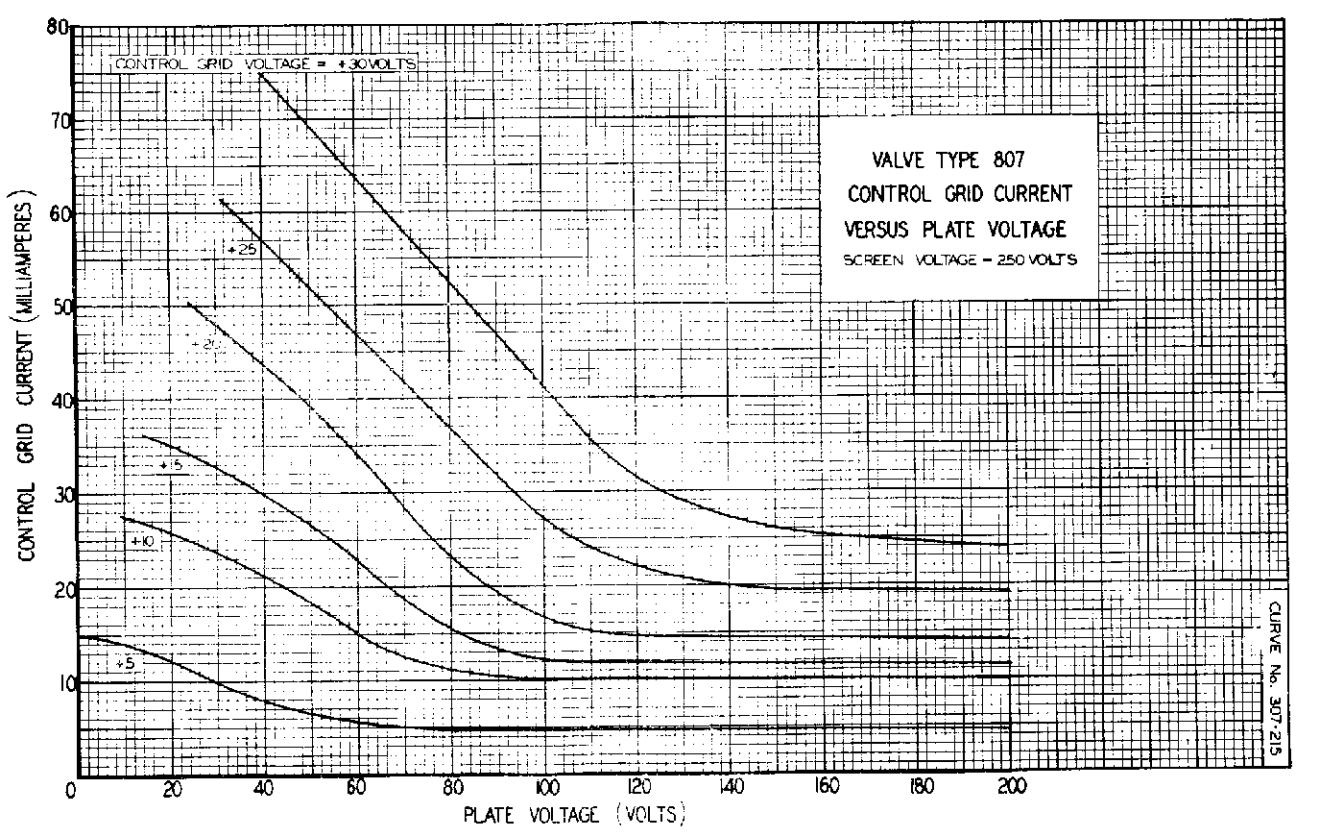
SCREEN VOLTAGE = 250 VOLTS

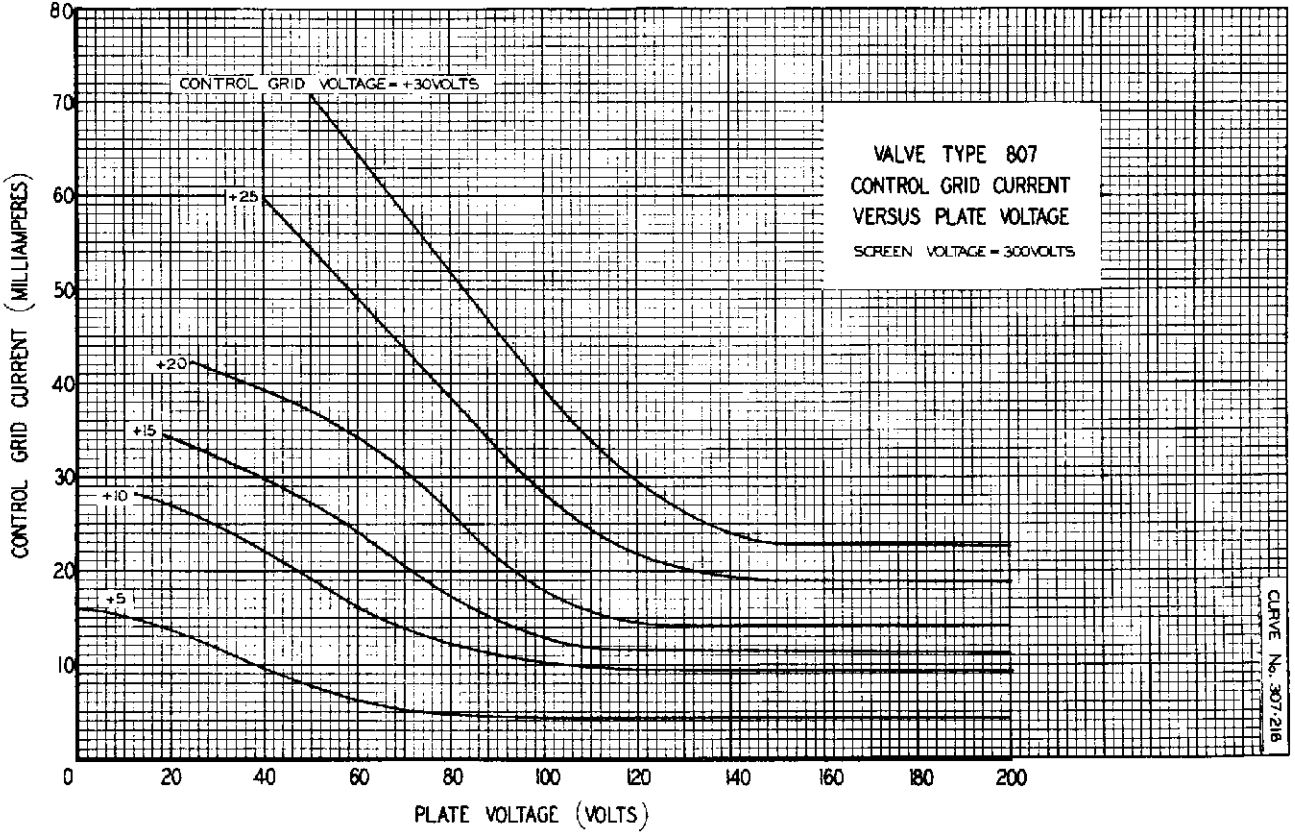


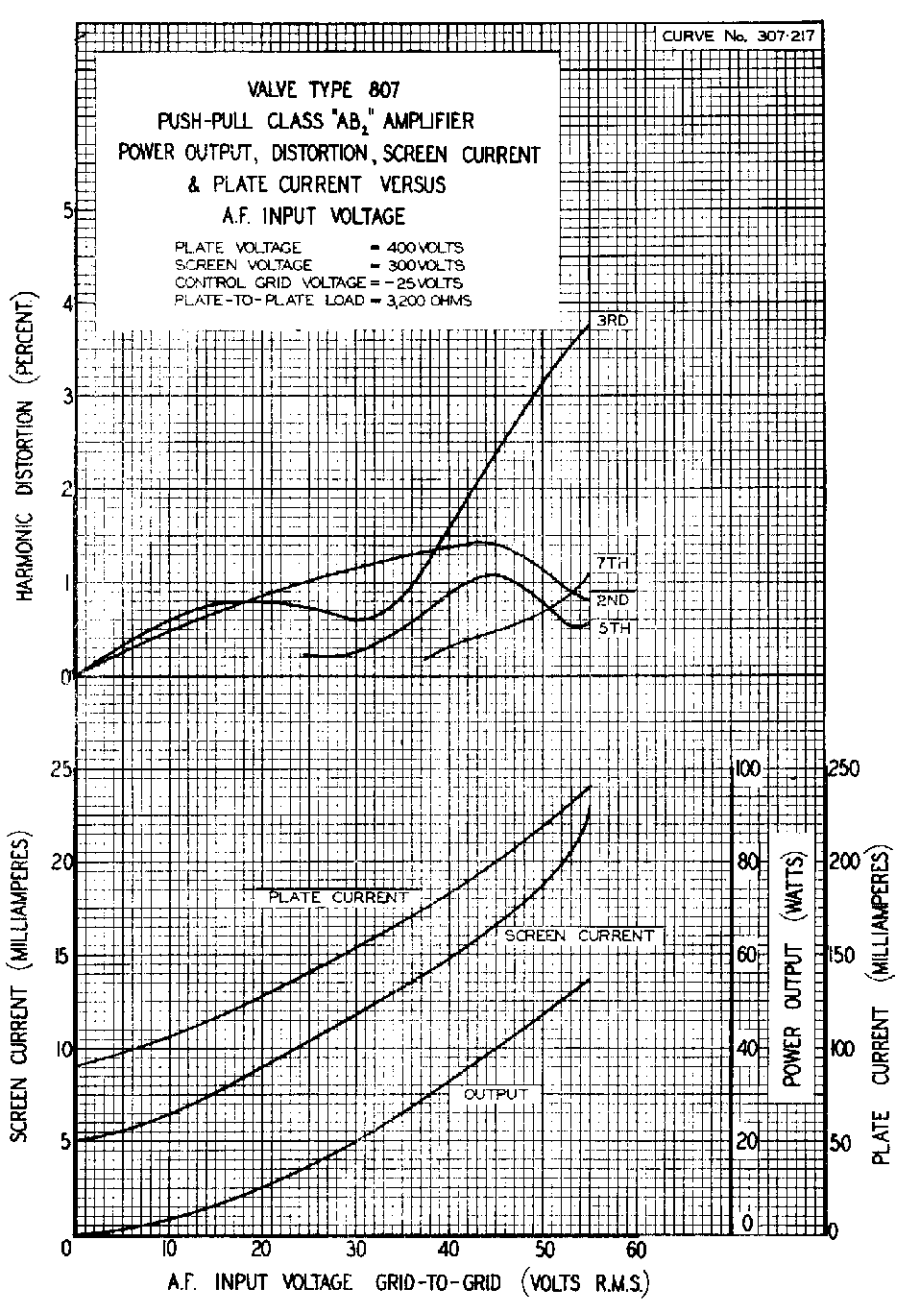
CURVE No 307-214

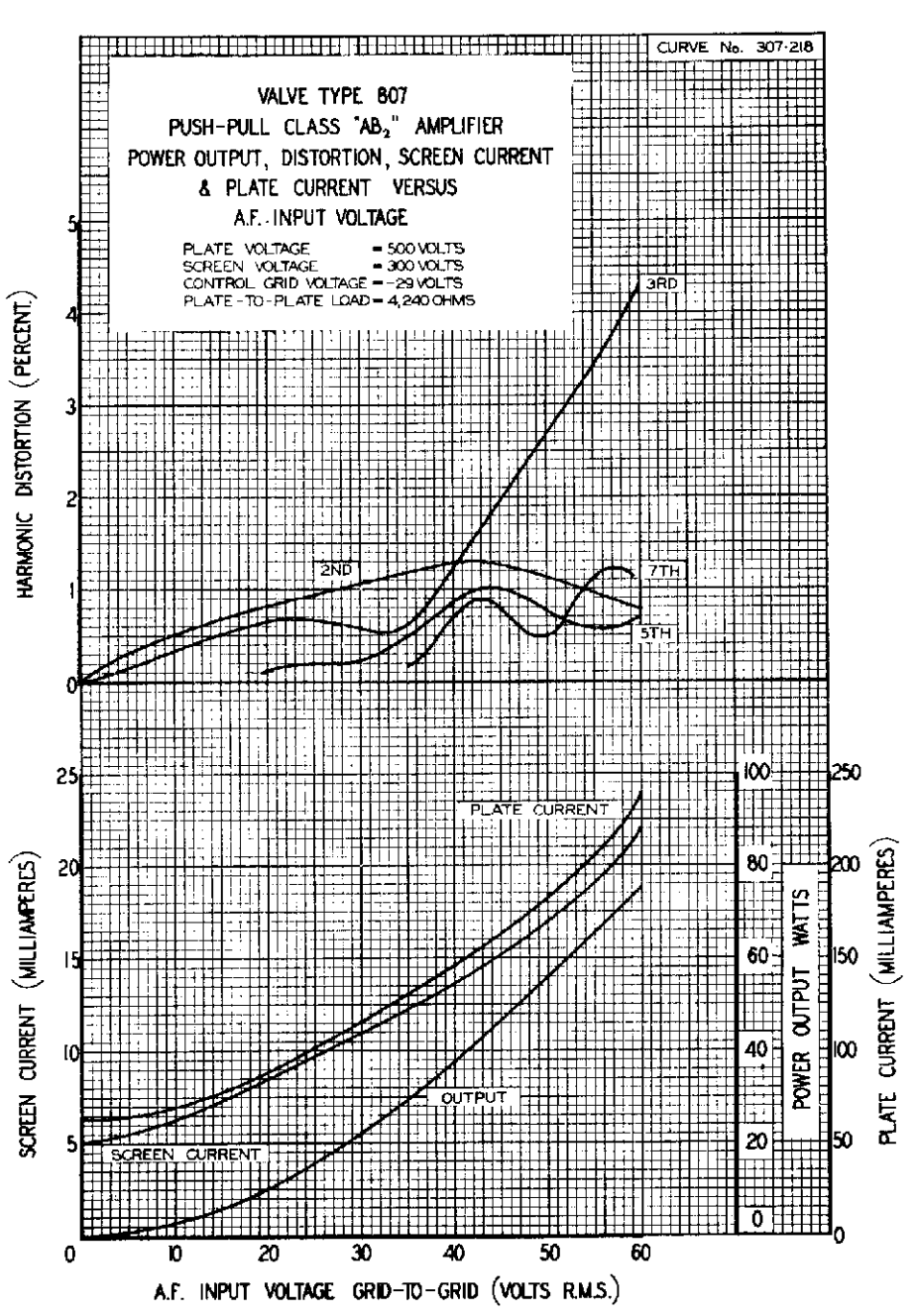
VALVE TYPE 807
SCREEN CURRENT VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 300 VOLTS

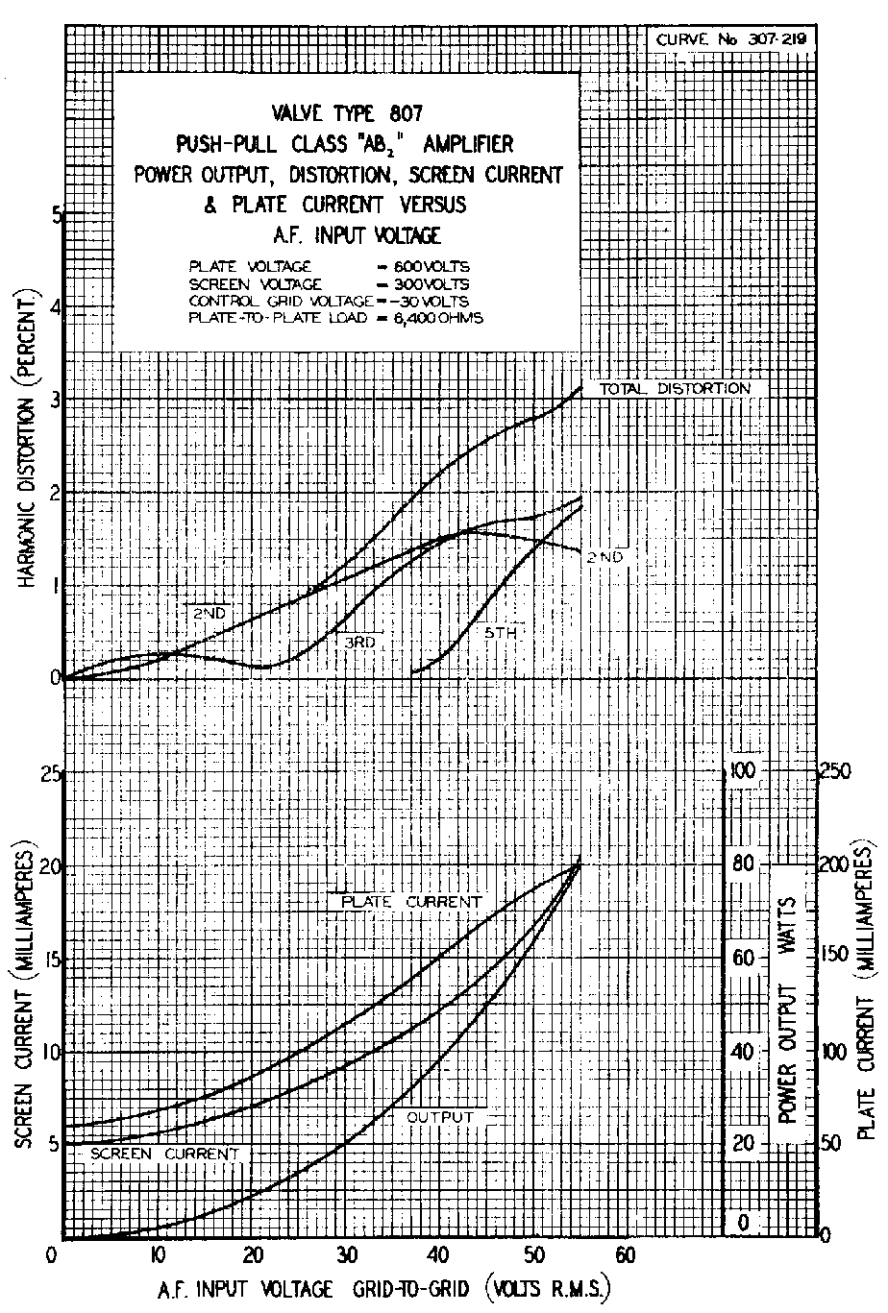


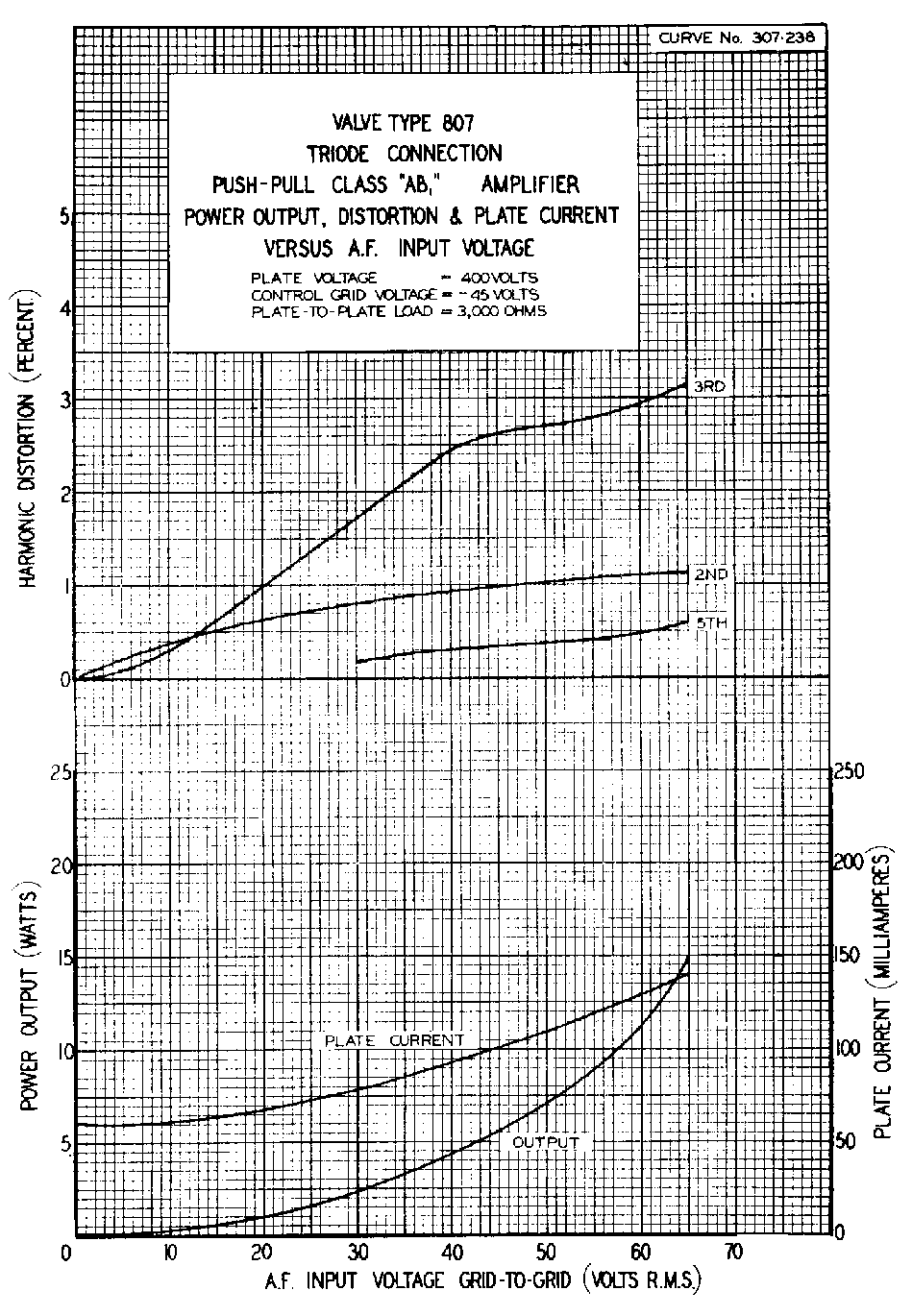

CONTROL GRID VOLTAGE = +30 VOLTS
+25
+20
+15
+10
+5
VALVE TYPE 807
CONTROL GRID CURRENT
VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 250 VOLTS
CONTROL GRID CURRENT (MILLIAMPERES)
PLATE VOLTAGE (VOLTS)
0
20
40
60
80
100
120
140
160
180
200
10
20
30
40
50
60
70
80
CURVE No. 307-215


VALVE TYPE 807
CONTROL GRID CURRENT
VERSUS PLATE VOLTAGE
SCREEN VOLTAGE = 300VOLTS
CONTROL GRID VOLTAGE = +30VOLTS
+25
+20
+15
+10
+5
CONTROL GRID CURRENT (MILLIAMPERES)
PLATE VOLTAGE (VOLTS)
0
10
20
30
40
50
60
70
80
20
40
60
80
100
120
140
160
180
200
CURVE No. 307-218


CURVE No. 307-217
VALVE TYPE 807
PUSH-PULL CLASS "AB2" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 400 VOLTS
SCREEN VOLTAGE = 300 VOLTS
CONTROL GRID VOLTAGE = -25 VOLTS
PLATE-TO-PLATE LOAD = 3,200 OHMS
HARMONIC DISTORTION (PERCENT)
3RD
7TH
2ND
5TH
SCREEN CURRENT (MILLIAMPERES)
PLATE CURRENT
SCREEN CURRENT
OUTPUT
POWER OUTPUT (WATTS)
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)


CURVE No. 307-218
VALVE TYPE 807
PUSH-PULL CLASS "AB2" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 500 VOLTS
SCREEN VOLTAGE = 300 VOLTS
CONTROL GRID VOLTAGE = -29 VOLTS
PLATE-TO-PLATE LOAD = 4,240 OHMS
HARMONIC DISTORTION (PERCENT.)
3RD
2ND
7TH
5TH
PLATE CURRENT
OUTPUT
SCREEN CURRENT
SCREEN CURRENT (MILLIAMPERES)
POWER OUTPUT WATTS
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)

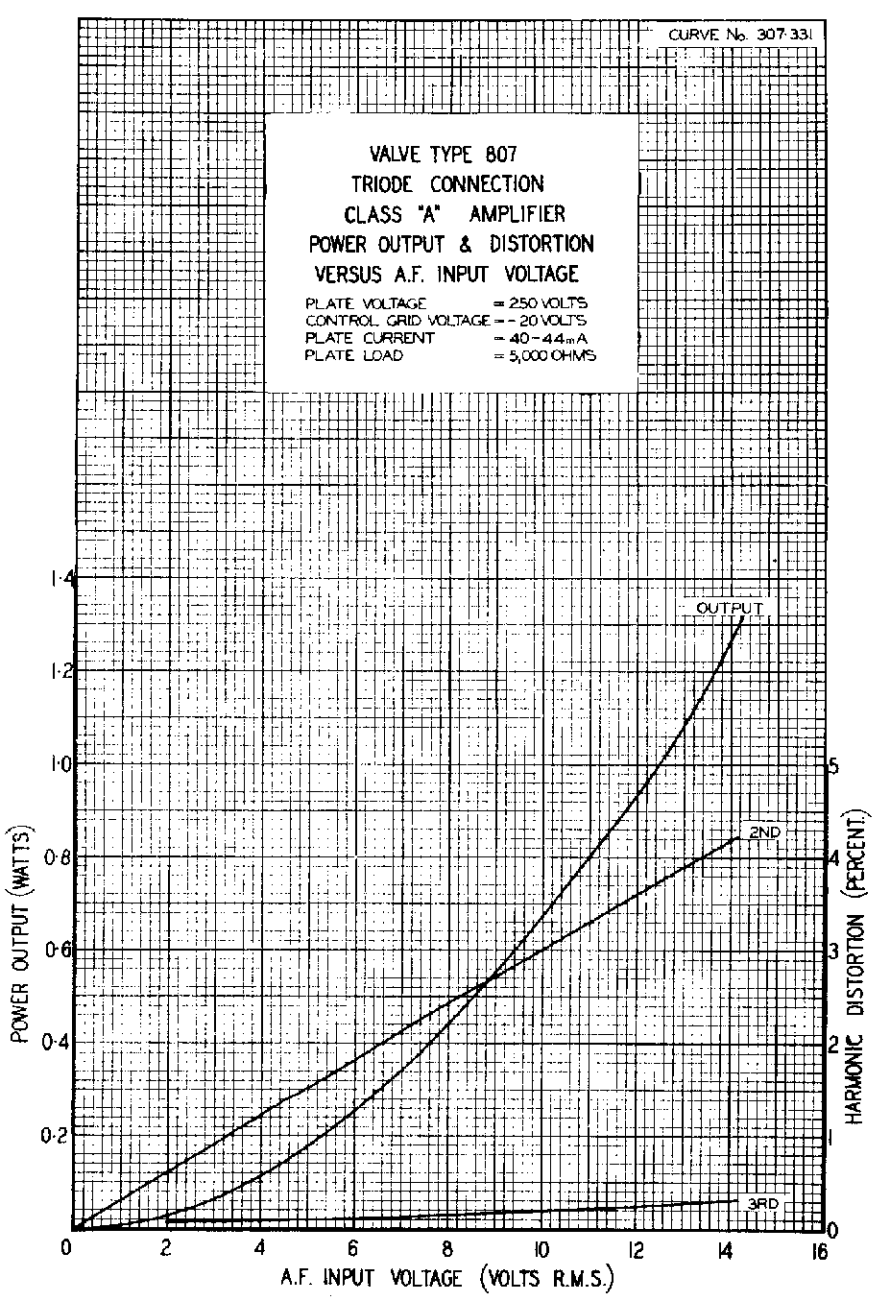

CURVE No 307-219
VALVE TYPE 807
PUSH-PULL CLASS "AB2" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 600 VOLTS
SCREEN VOLTAGE = 300 VOLTS
CONTROL GRID VOLTAGE = -30 VOLTS
PLATE-TO-PLATE LOAD = 6,400 OHMS
HARMONIC DISTORTION (PERCENT)
TOTAL DISTORTION
2ND
3RD
5TH
2ND
SCREEN CURRENT (MILLIAMPERES)
PLATE CURRENT
OUTPUT
SCREEN CURRENT
POWER OUTPUT WATTS
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)

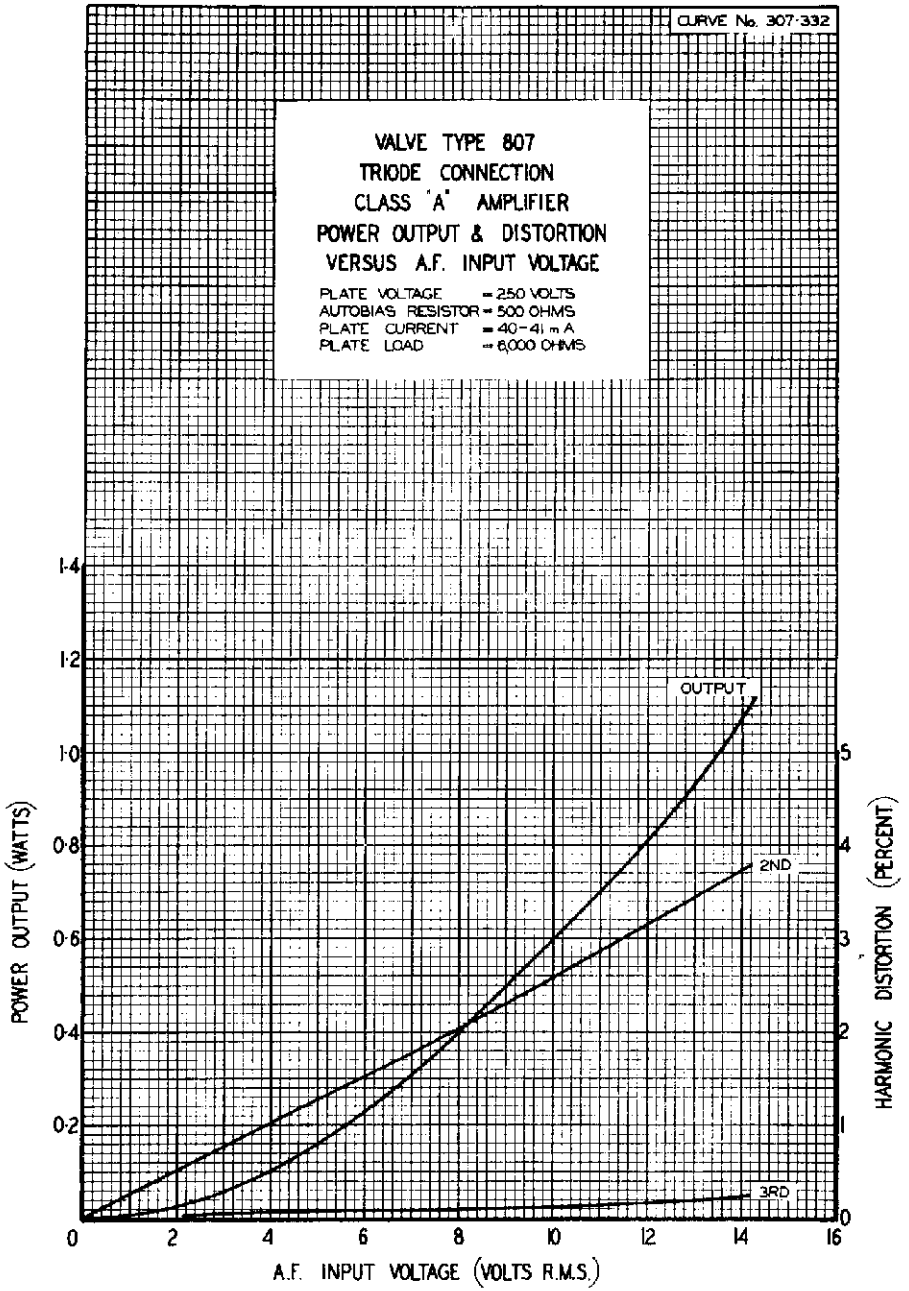

CURVE No. 307-238
VALVE TYPE 807
TRIODE CONNECTION
PUSH-PULL CLASS "AB," AMPLIFIER
POWER OUTPUT, DISTORTION & PLATE CURRENT
VERSUS A.F. INPUT VOLTAGE
PLATE VOLTAGE = 400 VOLTS
CONTROL GRID VOLTAGE = -45 VOLTS
PLATE-TO-PLATE LOAD = 3,000 OHMS
HARMONIC DISTORTION (PERCENT)
3RD
2ND
5TH
POWER OUTPUT (WATTS)
PLATE CURRENT (MILLIAMPERES)
PLATE CURRENT
OUTPUT
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)

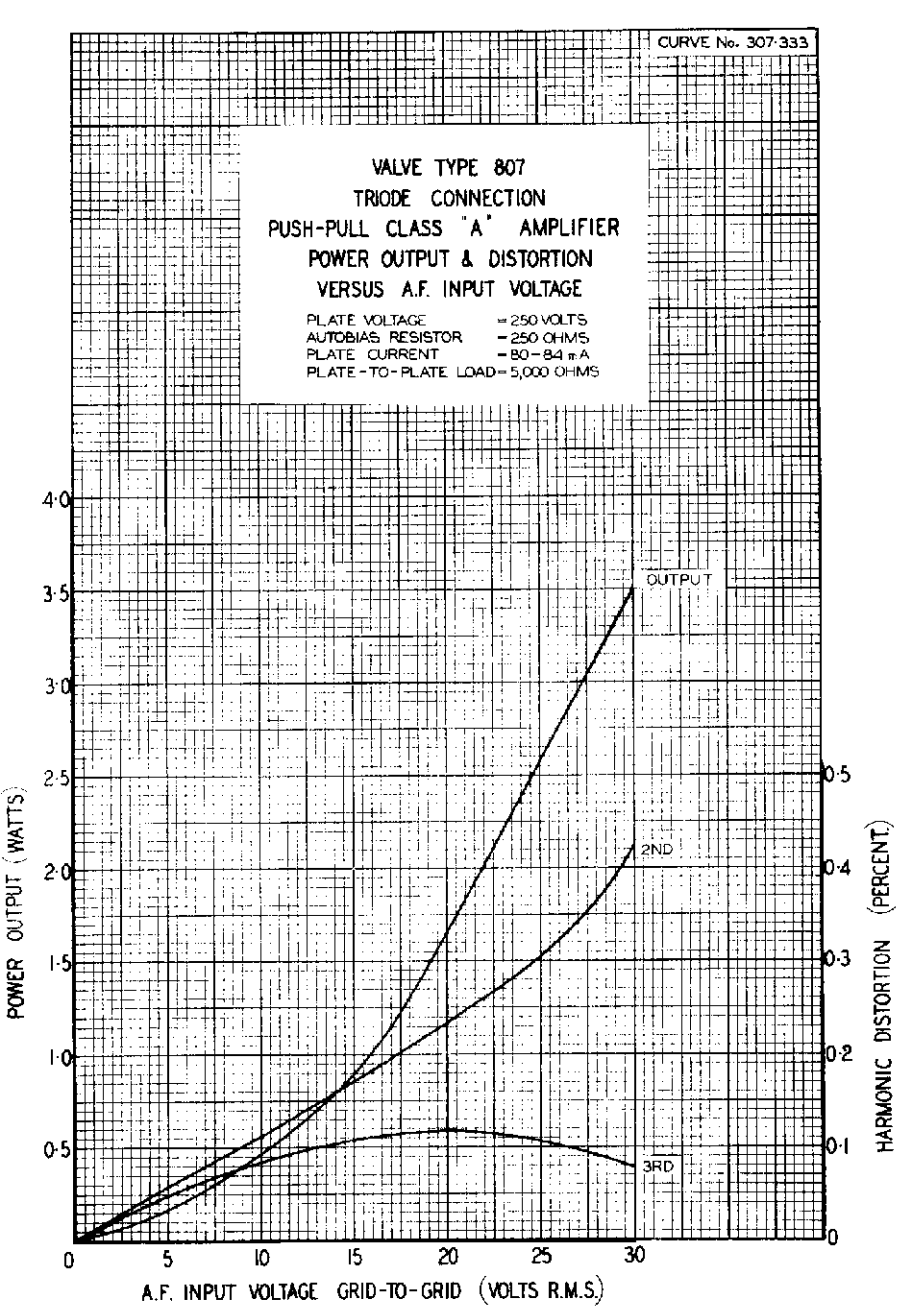
CURVE No. 307-331

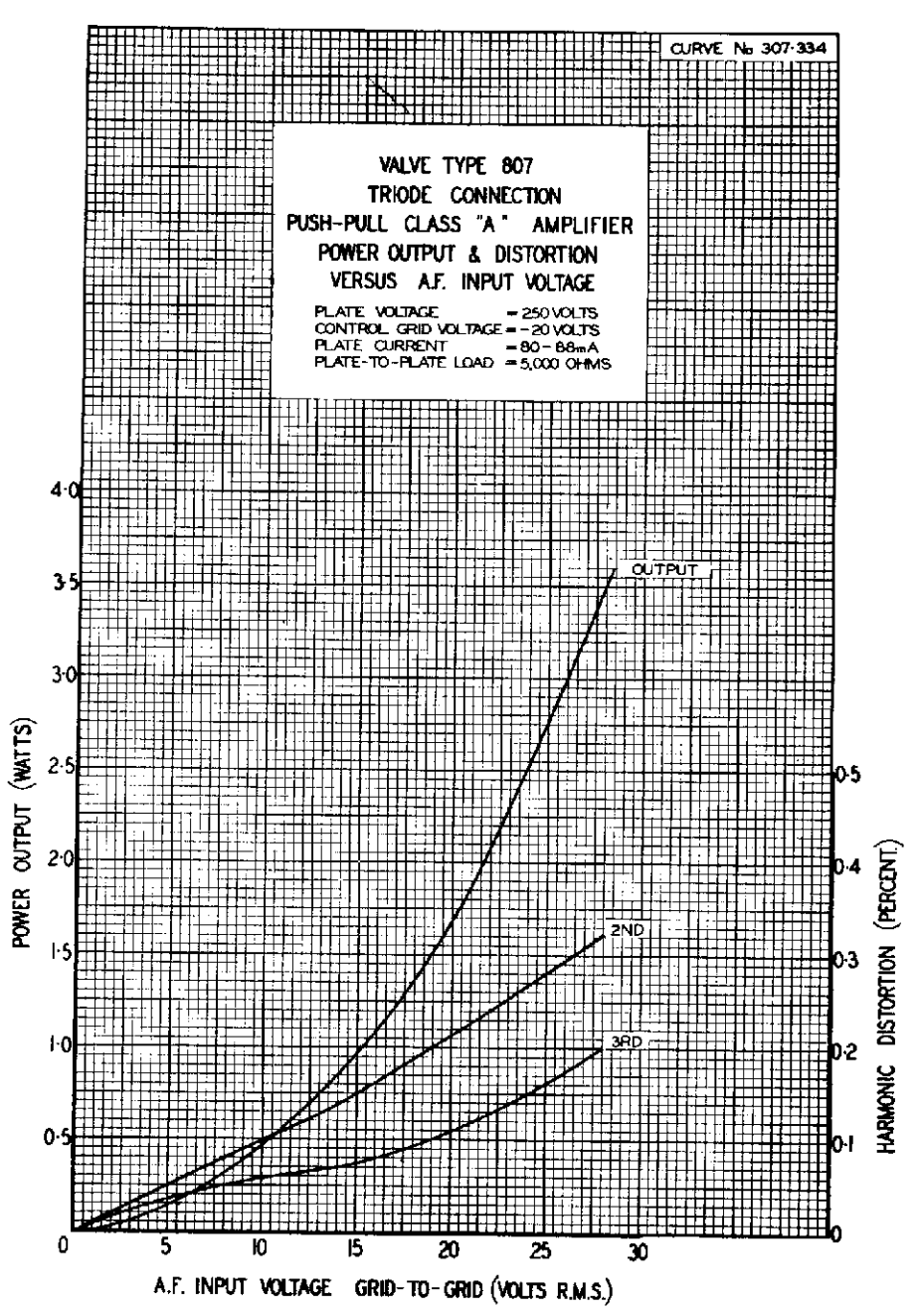
VALVE TYPE 807
TRIODE CONNECTION
CLASS "A" AMPLIFIER
POWER OUTPUT & DISTORTION
VERSUS A.F. INPUT VOLTAGE

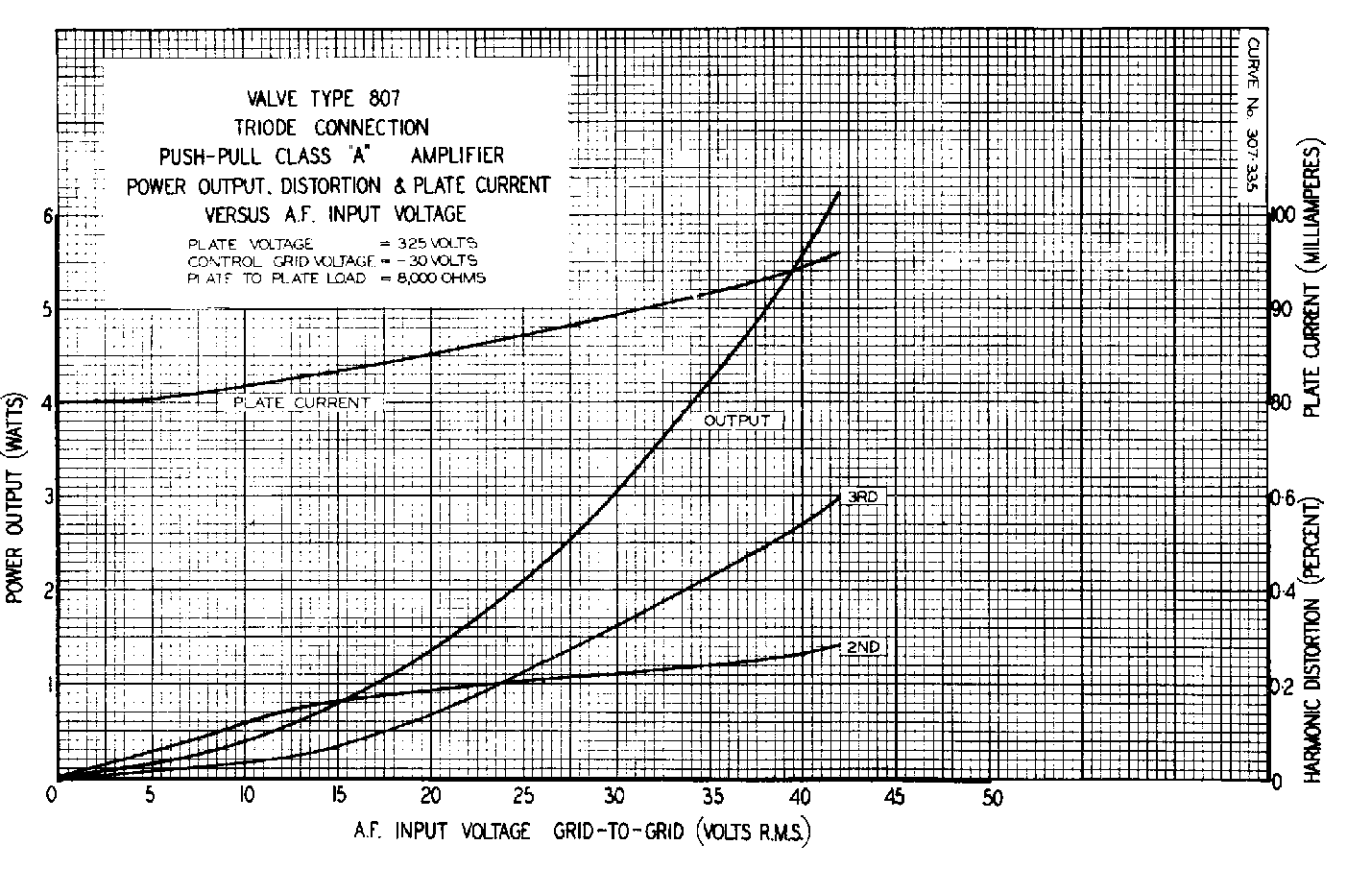
PLATE VOLTAGE = 250 VOLTS
CONTROL GRID VOLTAGE = - 20 VOLTS
PLATE CURRENT = 40 - 44 m A
PLATE LOAD = 5,000 OHMS

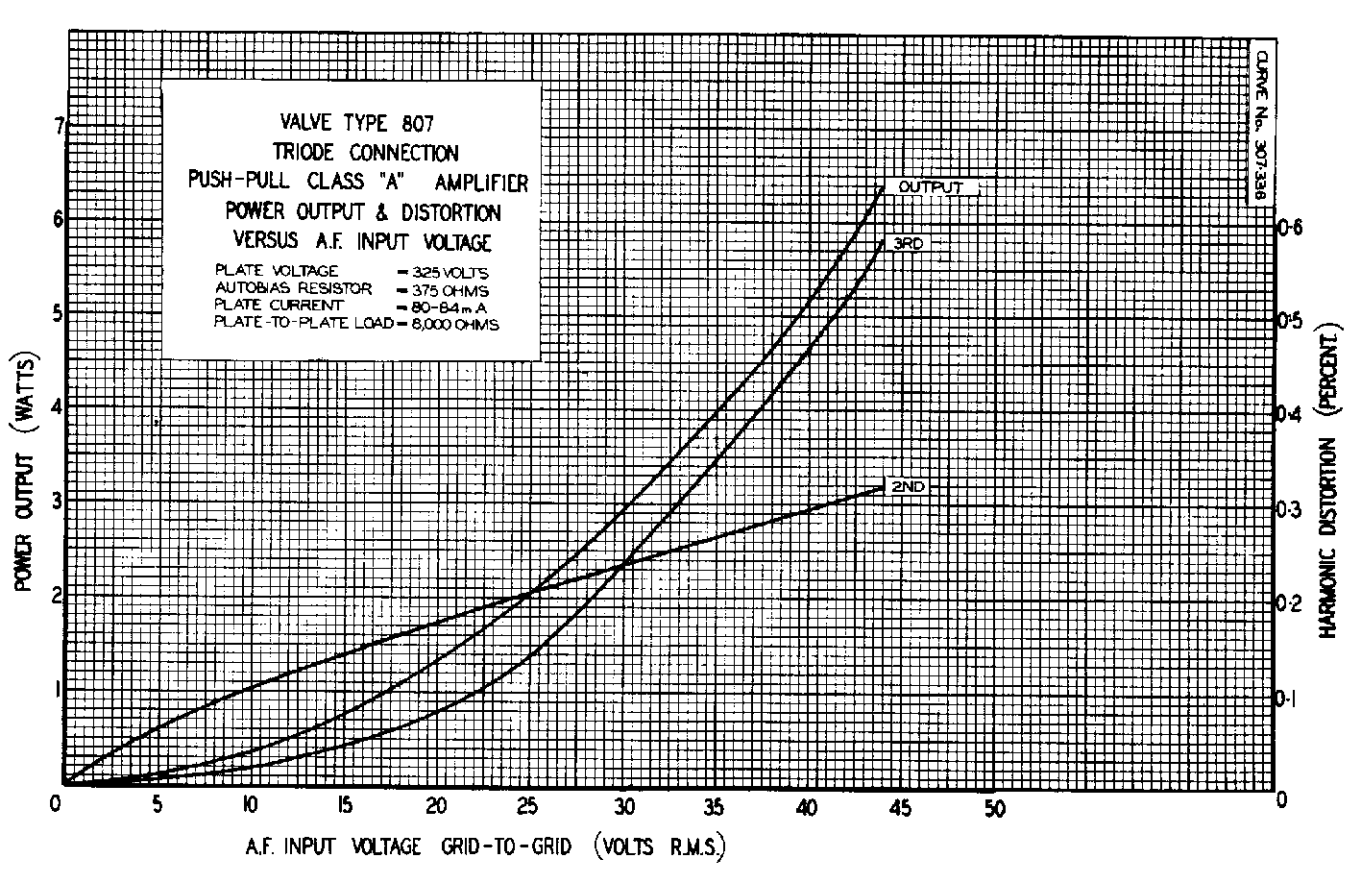


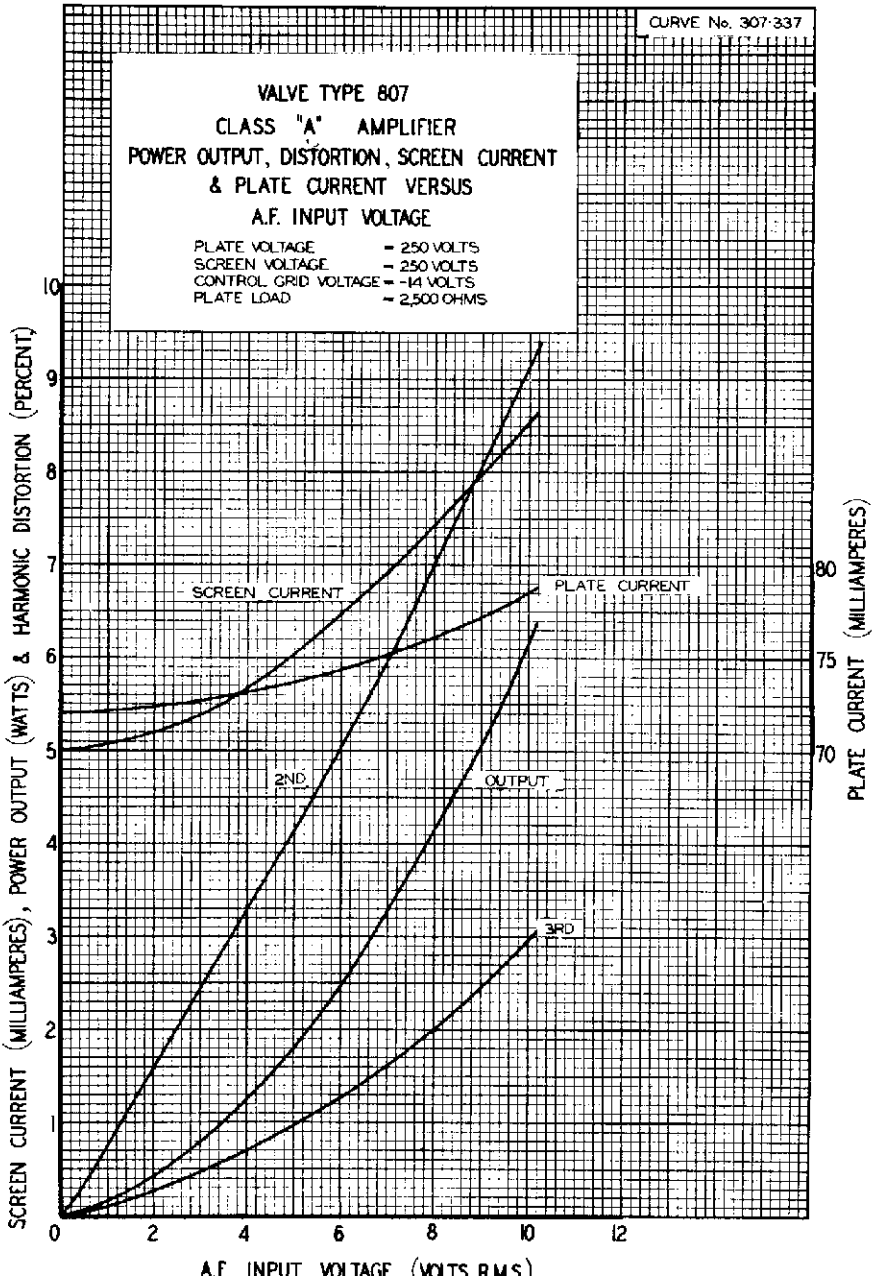

CURVE No. 307-332
VALVE TYPE 807
TRIODE CONNECTION
CLASS "A" AMPLIFIER
POWER OUTPUT & DISTORTION
VERSUS A.F. INPUT VOLTAGE
PLATE VOLTAGE = 250 VOLTS
AUTOBIAS RESISTOR = 500 OHMS
PLATE CURRENT = 40-41 m A
PLATE LOAD = 6,000 OHMS
OUTPUT
2ND
3RD
POWER OUTPUT (WATTS)
HARMONIC DISTORTION (PERCENT)
A.F. INPUT VOLTAGE (VOLTS R.M.S.)
0
0·2
0·4
0·6
0·8
1·0
1·2
1·4
1
2
3
4
5
2
4
6
8
10
12
14
16

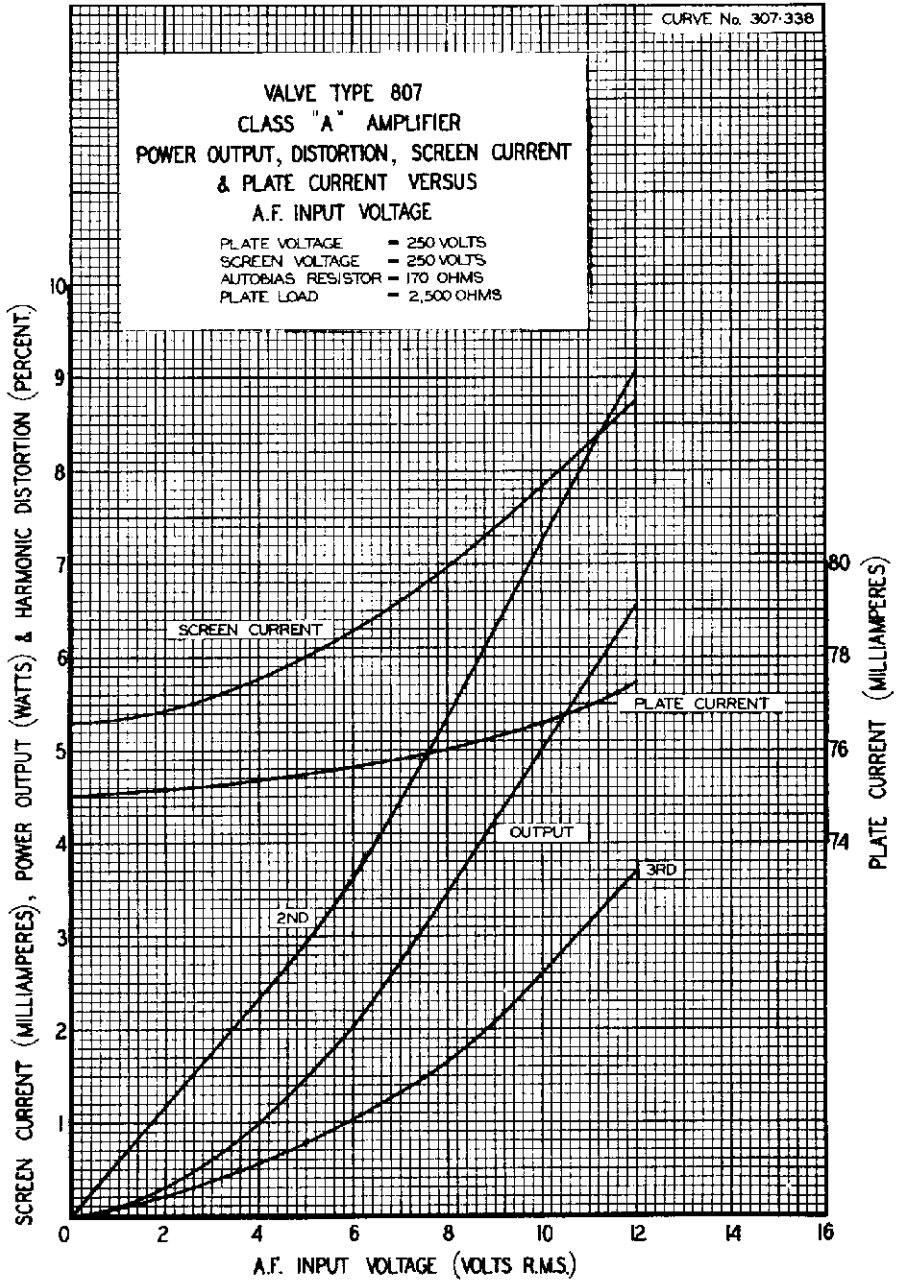

CURVE No. 307-333
VALVE TYPE 807
TRIODE CONNECTION
PUSH-PULL CLASS "A" AMPLIFIER
POWER OUTPUT & DISTORTION
VERSUS A.F. INPUT VOLTAGE
PLATE VOLTAGE = 250 VOLTS
AUTOBIAS RESISTOR = 250 OHMS
PLATE CURRENT = 80-84 m A
PLATE-TO-PLATE LOAD = 5,000 OHMS
OUTPUT
2ND
3RD
POWER OUTPUT (WATTS)
HARMONIC DISTORTION (PERCENT)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
0·5
1·0
1·5
2·0
2·5
3·0
3·5
4·0
0·1
0·2
0·3
0·4
0·5
5
10
15
20
25
30

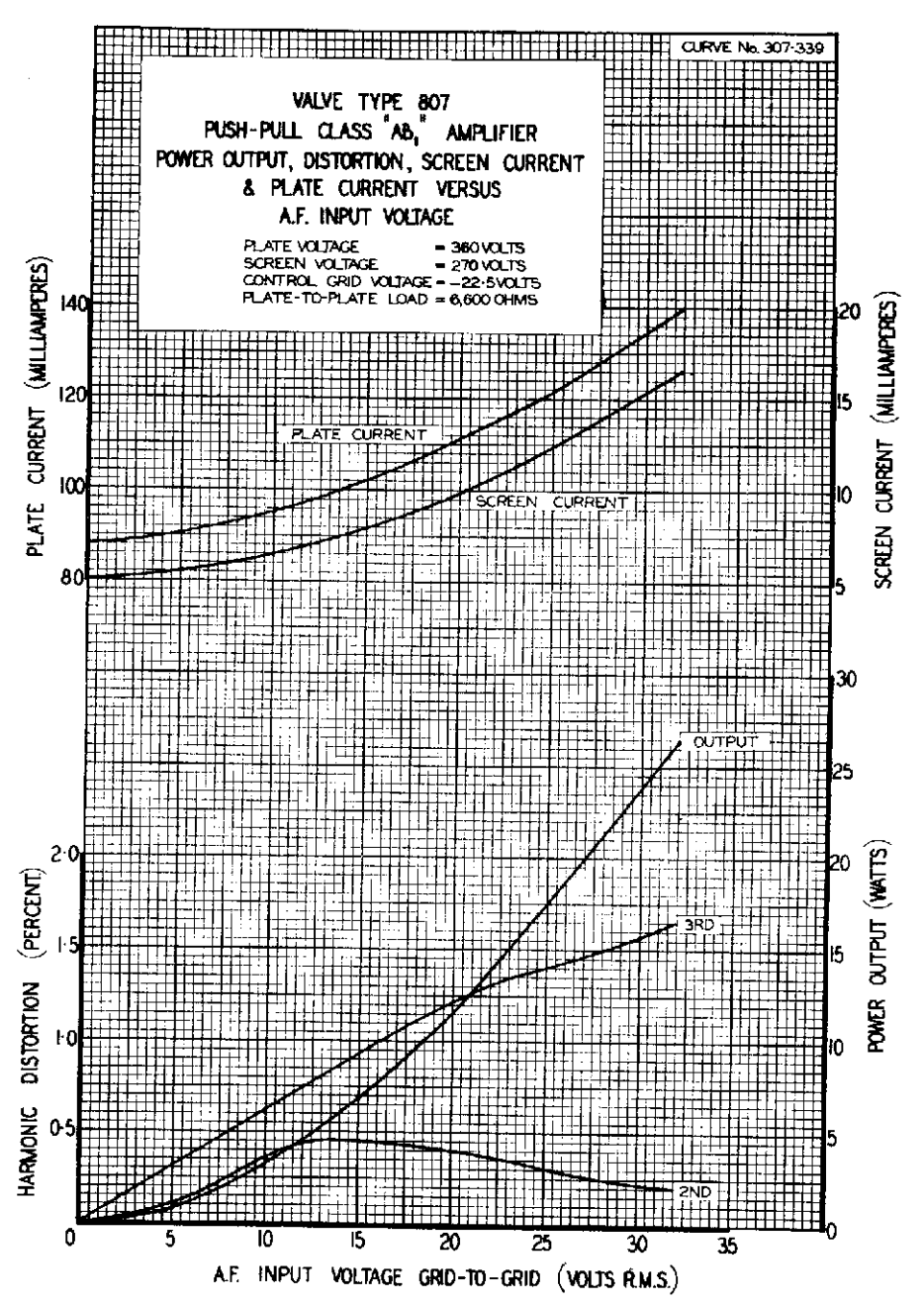

CURVE No 307-334
VALVE TYPE 807
TRIODE CONNECTION
PUSH-PULL CLASS "A" AMPLIFIER
POWER OUTPUT & DISTORTION
VERSUS A.F. INPUT VOLTAGE
PLATE VOLTAGE = 250 VOLTS
CONTROL GRID VOLTAGE = -20 VOLTS
PLATE CURRENT = 80 - 88mA
PLATE-TO-PLATE LOAD = 5,000 OHMS
OUTPUT
2ND
3RD
POWER OUTPUT (WATTS)
HARMONIC DISTORTION (PERCENT)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
0·5
1·0
1·5
2·0
2·5
3·0
3·5
4·0
0·1
0·2
0·3
0·4
0·5
5
10
15
20
25
30

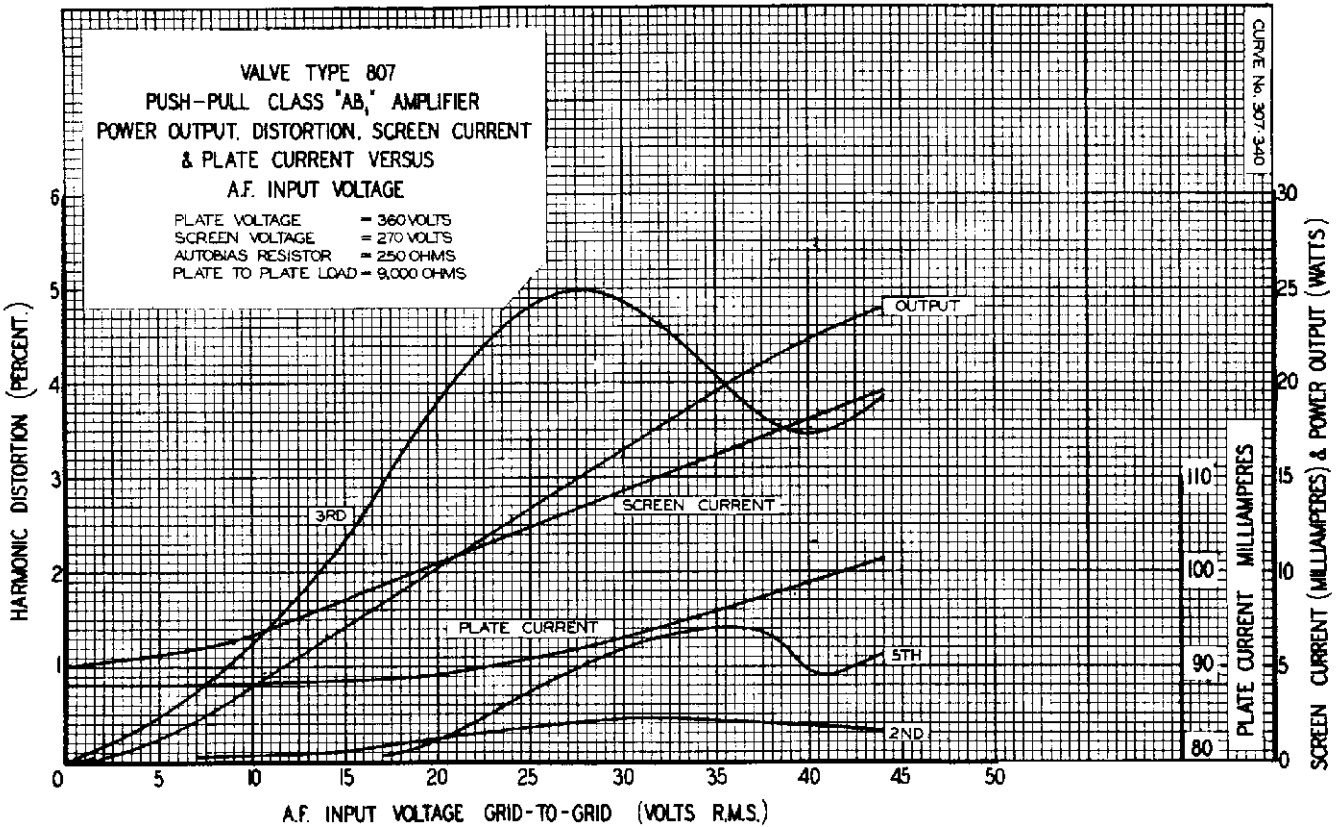

VALVE TYPE 807
TRIODE CONNECTION
PUSH-PULL CLASS "A" AMPLIFIER
POWER OUTPUT, DISTORTION & PLATE CURRENT
VERSUS A.F. INPUT VOLTAGE
PLATE VOLTAGE = 325 VOLTS
CONTROL GRID VOLTAGE = -30 VOLTS
PLATE TO PLATE LOAD = 8,000 OHMS
CURVE No. 307-335
PLATE CURRENT
OUTPUT
3RD
2ND
POWER OUTPUT (WATTS)
PLATE CURRENT (MILLIAMPERES)
HARMONIC DISTORTION (PERCENT)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
1
2
3
4
5
6
0·2
0·4
0·6
80
90
100
5
10
15
20
25
30
35
40
45
50

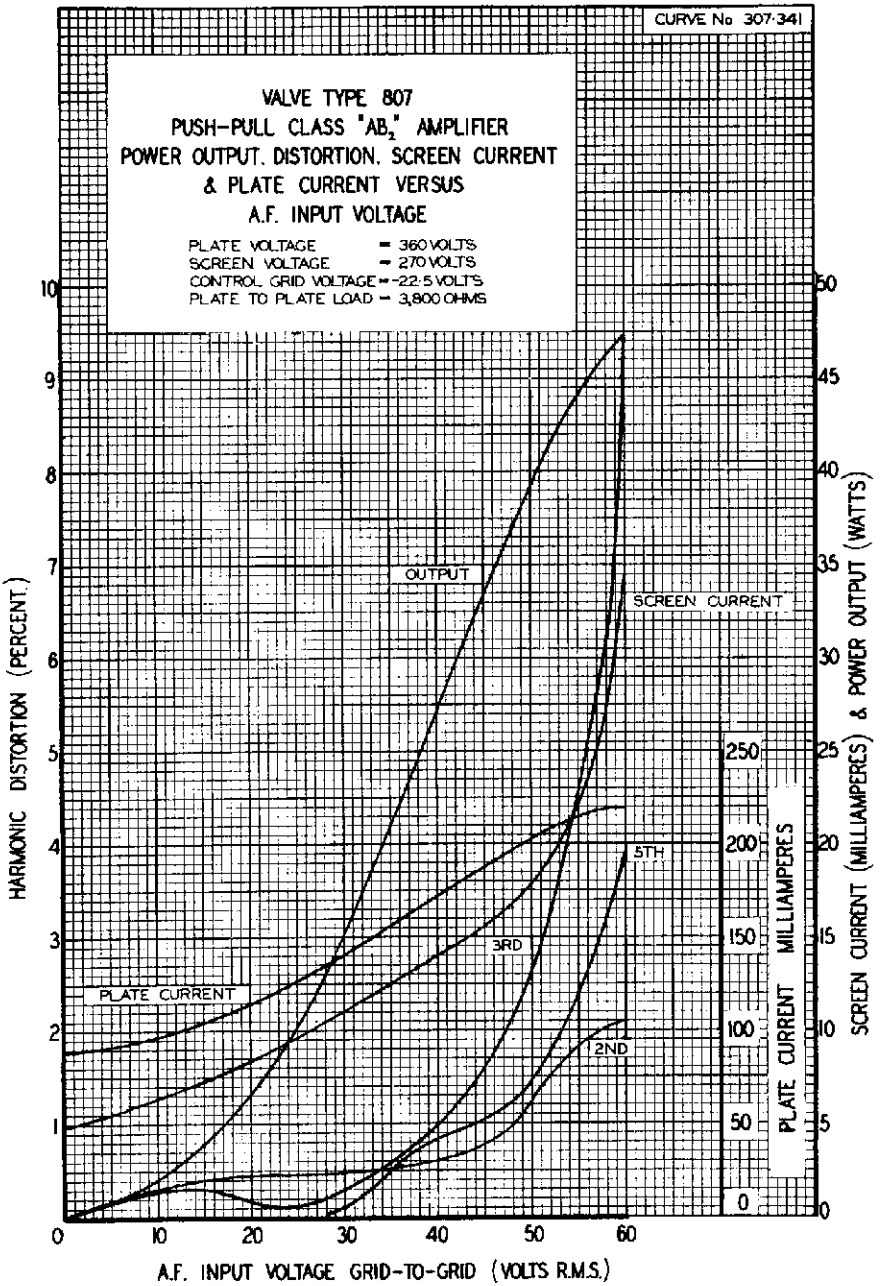

VALVE TYPE 807
TRIODE CONNECTION
PUSH-PULL CLASS "A" AMPLIFIER
POWER OUTPUT & DISTORTION
VERSUS A.F. INPUT VOLTAGE
PLATE VOLTAGE = 325 VOLTS
AUTOBIAS RESISTOR = 375 OHMS
PLATE CURRENT = 80-84 m.A
PLATE-TO-PLATE LOAD = 8,000 OHMS
OUTPUT
3RD
2ND
POWER OUTPUT (WATTS)
HARMONIC DISTORTION (PERCENT)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
5
10
15
20
25
30
35
40
45
50
1
2
3
4
5
6
7
0·1
0·2
0·3
0·4
0·5
0·6


CURVE No. 307-337
VALVE TYPE 807
CLASS "A" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 250 VOLTS
SCREEN VOLTAGE = 250 VOLTS
CONTROL GRID VOLTAGE = -14 VOLTS
PLATE LOAD = 2,500 OHMS
SCREEN CURRENT
PLATE CURRENT
2ND
OUTPUT
3RD
SCREEN CURRENT (MILLIAMPERES), POWER OUTPUT (WATTS) & HARMONIC DISTORTION (PERCENT)
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE (VOLTS R.M.S.)
0
1
2
3
4
5
6
7
8
9
10
70
75
80
2
4
6
8
10
12


CURVE No. 307-338
VALVE TYPE 807
CLASS "A" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 250 VOLTS
SCREEN VOLTAGE = 250 VOLTS
AUTOBIAS RESISTOR = 170 OHMS
PLATE LOAD = 2,500 OHMS
SCREEN CURRENT
PLATE CURRENT
OUTPUT
2ND
3RD
SCREEN CURRENT (MILLIAMPERES), POWER OUTPUT (WATTS) & HARMONIC DISTORTION (PERCENT)
PLATE CURRENT (MILLIAMPERES)
A.F. INPUT VOLTAGE (VOLTS R.M.S.)
0
2
4
6
8
10
12
14
16
1
3
5
7
9
74
76
78
80


CURVE No. 307-339
VALVE TYPE 807
PUSH-PULL CLASS "AB1" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 360 VOLTS
SCREEN VOLTAGE = 270 VOLTS
CONTROL GRID VOLTAGE = -22·5 VOLTS
PLATE-TO-PLATE LOAD = 6,600 OHMS
PLATE CURRENT
SCREEN CURRENT
OUTPUT
3RD
2ND
PLATE CURRENT (MILLIAMPERES)
SCREEN CURRENT (MILLIAMPERES)
HARMONIC DISTORTION (PERCENT)
POWER OUTPUT (WATTS)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
140
120
100
80
20
15
10
5
2·0
1·5
1·0
0·5
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35


VALVE TYPE 807
PUSH-PULL CLASS "AB1" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 360 VOLTS
SCREEN VOLTAGE = 270 VOLTS
AUTOBIAS RESISTOR = 250 OHMS
PLATE TO PLATE LOAD = 9,000 OHMS
CURVE No. 3074/40
OUTPUT
3RD
SCREEN CURRENT
PLATE CURRENT
5TH
2ND
HARMONIC DISTORTION (PERCENT.)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
PLATE CURRENT MILLIAMPERES
SCREEN CURRENT (MILLIAMPERES) & POWER OUTPUT (WATTS)
0
1
2
3
4
5
6
5
10
15
20
25
30
35
40
45
50
80
90
100
110
0
5
10
15
20
25
30


CURVE No 307-341
VALVE TYPE 807
PUSH-PULL CLASS "AB2" AMPLIFIER
POWER OUTPUT, DISTORTION, SCREEN CURRENT
& PLATE CURRENT VERSUS
A.F. INPUT VOLTAGE
PLATE VOLTAGE = 360 VOLTS
SCREEN VOLTAGE = 270 VOLTS
CONTROL GRID VOLTAGE = -22.5 VOLTS
PLATE TO PLATE LOAD = 3,800 OHMS
OUTPUT
SCREEN CURRENT
5TH
3RD
2ND
PLATE CURRENT
HARMONIC DISTORTION (PERCENT.)
PLATE CURRENT MILLIAMPERES
SCREEN CURRENT (MILLIAMPERES) & POWER OUTPUT (WATTS)
A.F. INPUT VOLTAGE GRID-TO-GRID (VOLTS R.M.S.)
0
10
20
30
40
50
60
1
2
3
4
5
6
7
8
9
10
0
50
100
150
200
250
0
5
10
15
20
25
30
35
40
45
50

MILITARY SPECIFICATION SHEET

ELECTRON TUBES, TRANSMITTING

TYPES 807 AND 1625 1/

The complete requirements for procuring the electron tubes described herein shall consist of this document and the latest issue of MIL-E-1.

This specification is mandatory for use by all Departments and Agencies of the Department of Defense.

DESCRIPTION: Amplifier, beam power. F1 = 60 MHz. F2 = 125 MHz

Outline --- 16-2 (EIA)

Base
807 --- A5-11 (low-loss phenolic)
1625 --- A7-13 (low-loss phenolic)

Cap --- C1-1

Envelope --- ST16

Cathode --- Coated unipotential

Base connections:

Pin No.	---	1	2	3	4	5	6	7	Cap
Element									
807	---	h	g2	g1	k, g3 (Note 2)	h	---	---	a
1625	---	h	nc	g2	g1	nc	k, g3 (Note 2)	h	a

ABSOLUTE-MAXIMUM RATINGS:

Parameter: / Unit:	Ef V	Eb Vdc	Ec1 Vdc	Ec2 Vdc	Ib mAdc	Ic1 mAdc	Pg2 W	Pp W	Pi W	© Ehk V	Modulation ---	Alt ft
Type 807												
Class B AF:	6.3 ±10%	600	---	300	120	---	3.5	25	60	135	---	10,000
Class B RF:	6.3 ±10%	600	---	300	80	---	2.5	25	37.5	135	---	10,000
Class C Telep:	6.3 ±10%	475	-200	300	83	5	2.5	16.5	40	135	Anode	10,000
Class C Teleg:	6.3 ±10%	600	-200	300	100	5	3.5	25	60	135	---	10,000
TEST CONDITIONS:	6.3	600	-29	300	---	---	---	---	---	---	---	---
Type 1625												
Class B AF:	12.6 ±10%	600	---	300	120	---	3.5	25	60	135	---	10,000
Class B RF:	12.6 ±10%	600	---	300	80	---	2.5	25	37.5	135	---	10,000
Class C Telep:	12.6 ±10%	475	-200	300	83	5	2.5	16.5	40	135	Anode	10,000
Class C Teleg:	12.6 ±10%	600	-200	300	100	5	3.5	25	60	135	---	10,000
TEST CONDITIONS:	12.6 Vdc	600	-29	300	---	---	---	---	---	---	---	---

GENERAL:

Qualification - Required

1/ See note 1

© denotes changes

METHOD	REQUIREMENT OR TEST	CONDITIONS	AQL (PERCENT DEFECTIVE)	INSPECTION LEVEL OR CODE	SYMBOL	LIMITS MIN	LIMITS MAX	UNIT
	Qualification inspection							
1236	Power oscillation (2)	Power oscillation (1): F = 60 MHz	---	---	Po	28	---	W
	Quality conformance inspection, part 1		Ⓒ					
1231	Emission	Eb = Ec1 = Ec2 = 50 Vdc (see note 3)	0.65	II	Is	300	---	mAdc
1236	Power oscillation (1)	Ec2 = 200 Vdc: Rg = 10,000 ohms: Ic1 = 6 mAdc: Ib = 100 mAdc: F = 15 MHz	0.65	II	Po	33	---	W
1256	Electrode current (1) (anode)		0.65	II	Ib	24	48	mAdc
1266	Total grid current	See note 3	0.65	II	Ic	---	-4.0	µAdc
Ⓒ 1201	Short and discontinuity detection		0.4	II	---	---	---	---
	Quality conformance inspection, part 2							
1031	Low frequency vibration	Eb = 250 Vdc: Ec2 = 100 Vdc: Ec1 = -10 Vdc: Rp = 2,000 ohms	---	---	Fp	---	500	mVac
1036	Bump	Hammer angle = 20°	---	---	---	---	---	---
1301	Heater current							
	Type 807		---	---	If	810	990	mA
	Type 1625		---	---	If	405	495	mA
Ⓒ 1336	Heater-cathode leakage		---	---	Ihk	---	100	µAdc
Ⓒ 1256	Electrode current (2) (anode)	Ec1 = -100 Vdc	---	---	Ib	---	0.5	mAdc
Ⓒ 1256	Electrode current (screen)		---	---	Ic2	0	4.0	mAdc
1266	Primary grid emission Type 807	Ec2 = 175 Vac (approx): Eb = Ec2 = 0: Ec1 = 0 to 6 Vdc: Pg2 = 5 W (see note 4)	---	---	Ic2	---	-750	µAdc
1306	Transconductance Type 1625	Eb = Ec2 = 250 Vdc: Ec1 = -14 Vdc	---	---	Sm	5,100	6,900	µmhos
1236	Internal insulation		---	---	---	---	---	---
1331	Direct-interelectrode capacitance	Shield No. 312	---	---	Cgp	---	0.2	pF
		Without shield			Cin	10.0	14.0	pF
		Without shield			Cout	5.3	8.7	pF
Ⓒ 1216	Base material insulating quality		---	---	---	---	---	---

METHOD	REQUIREMENT OR TEST	CONDITIONS	AQL (PERCENT DEFECTIVE)	INSPECTION LEVEL OR CLASS	SYMBOL	LIMITS MIN	LIMITS MAX	UNIT
	Quality conformance inspection, part 2 -Continued							
Ⓒ 1101	Secureness of base, cap, or insert		---	---	---	---	---	---
Ⓒ 1105	Permanence of marking		---	---	---	---	---	---
	Quality conformance inspection, part 3							
---	Life-test provisions	Group B: Ehk - 135 V	---	---	---	---	---	---
---	Life-test end points (500 hours)	Total grid current and Power oscillation (1)	--- ---	--- ---	Ic1 Po	0 27	-4.0 ---	μAdc W

NOTES:

1. Tube type 5933 has been deleted from this tube specification sheet. For replacement purposes use tube type 5933WA, MIL-E-1/652.
2. The beam forming plate lead and the cathode lead shall be individually passed through the glass stem of the tube and shall be electrically connected together only at the base pin.
3. This test to be performed at the conclusion of the holding period.
4. A protective resistor of 15,000 ohms shall be placed in series with the primary emission current meter. Grid No. 2 input power shall be calculated as 2.40 times the product of the rectified current and rectified voltage. Test duration shall be sufficient to obtain a stabilized negative Ic2 value.

Custodians:
Army - EL
Navy - EC
Air Force - 80

Review activities:
Army - EL
Navy -
Air Force - 11, 80
DSA - ES

User activities:
Army - MU, WC
Navy - AS, OS, MC, CG, SH
Air Force - 19

Preparing activity: Navy - EC

Agent: DSA - ES

(Project 5960-2425-52)

813

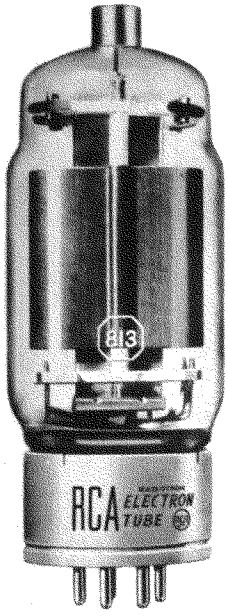
BEAM POWER TUBE

Thoriated-Tungsten Filament
High Power Sensitivity

400 Watts Input on Phone (ICAS) up to 30 Mc
500 Watts Input on CW (ICAS) up to 30 Mc

7-1/2" Max. Length
2-9-16" Max. Diameter

RCA-813 is a general-purpose transmitting beam power tube of the thoriated-tungsten filament type designed for use as an rf power amplifier and oscillator as well as an af power amplifier and modulator. The 813 has a maximum plate dissipation of 125 watts under ICAS conditions in modulator service and cw service. In the latter service it can be operated with full input to 30 Mc and with reduced input to 120 Mc.



Because of its high power sensitivity, the 813 requires very little driving power to give full power output. For example, in class C telegraph service under ICAS conditions, a single 813 is capable of giving a power output of approximately 375 watts with a driving power of only about 4 watts.

DATA

Electrical:

Filament, Thoriated Tungsten:		
Voltage (AC or DC)	10.0 ± 5%	volts
Current at 10.0 volts	5.0	amp
Transconductance (Approx.) for plate volts = 2000, grid-No.2 volts = 400, and plate current = 50 ma	3750	μmhos
Mu-Factor, grid No.2 to grid No.1 for plate volts = 2000, grid-No.2 volts = 400, and plate current = 50 ma	8.5	
Direct Interelectrode Capacitances:[o]		
Grid No.1 to plate	0.25 max.	μμf
Grid No.1 to filament, grid No.2, and grid No.3	16.3	μμf
Plate to filament, grid No.2, and grid No.3	14	μμf

Mechanical:

Mounting Position	Vertical, Base up or down; Horizontal, with pins 2 & 6 in vertical plane
Maximum Overall Length	7-1/2"
Seated Length	6-5/8" ± 1/4"
Maximum Diameter	2-9/16"
Bulb	T-20
Cap	Medium (JETEC No.C1-5)
Base	Medium-Metal-Shell Giant 7-Pin with Bayonet (JETEC No.A7-17)
Weight (Approx.)	8 oz.

AF POWER AMPLIFIER & MODULATOR - Class AB_1[#]

Maximum Ratings, *Absolute Values:*

	CCS[●]	ICAS[●●]	
DC PLATE VOLTAGE	2250 max.	2500 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	1100 max.	1100 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	180 max.	225 max.	ma
MAX.-SIGNAL PLATE INPUT*	360 max.	450 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT*	22 max.	22 max.	watts
PLATE DISSIPATION*	100 max.	125 max.	watts

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	1500	2000	2250	2500	volts
DC Grid-No.3 (Suppressor) Voltage[†]	0	0	0	0	volts
DC Grid-No.2 Voltage**	750	750	750	750	volts
DC Grid-No.1 (Control-Grid) Voltage:[⊕]					
From fixed-bias source	-85	-90	-95	-95	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage[◆]	160	160	170	180	volts
Zero-Signal DC Plate Current	50	50	50	50	ma
Max.-Signal DC Plate Current	305	265	255	290	ma
Zero-Signal DC Grid-No.2 Current	2	2	2	2	ma
Max.-Signal DC Grid-No.2 Current	45	43	53	54	ma
Effective Load Resistance (Plate to plate)	9300	16000	20000	19000	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	0	watts
Max.-Signal Power Output (Approx.)	260	335	380	490	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:[##]

With fixed bias	30000 max.	ohms
With cathode bias	Not recommended	

RF POWER AMPLIFIER - Class B Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum Ratings, *Absolute Values:*

	CCS[●]	ICAS[●●]	
DC PLATE VOLTAGE	2000 max.	2250 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
DC PLATE CURRENT	100 max.	125 max.	ma
PLATE INPUT	150 max.	200 max.	watts
GRID-No.2 INPUT	15 max.	20 max.	watts
PLATE DISSIPATION	100 max.	125 max.	watts

Typical Operation:

DC Plate Voltage	1500	2000	2250	volts
DC Grid-No.3 (Suppressor) Voltage[†]	0	0	0	volts
DC Grid-No.2 Voltage	400	400	400	volts

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

813-4-55
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DC Grid-No.1 (Control-Grid) Voltage⊕♦	−60	−75	−60	volts
Peak RF Grid-No.1 Voltage	70	80	70	volts
DC Plate Current	100	75	85	ma
DC Grid-No.2 Current	4	3	3	ma
DC Grid-No.1 Current	★	★	★	ma
Driving Power□##	▲	▲	▲	watts
Power Output (Approx.)	50	50	70	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1 Circuit Resistance	30000 max.	ohms

GRID-MODULATED RF POWER AMPLIFIER - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum Ratings, *Absolute Values:*

	CCS●	ICAS●●	
DC PLATE VOLTAGE	2000 max.	2250 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	−200 max.	−200 max.	volts
DC PLATE CURRENT	100 max.	125 max.	ma
PLATE INPUT	150 max.	200 max.	watts
GRID-No.2 INPUT	15 max.	20 max.	watts
PLATE DISSIPATION	100 max.	125 max.	watts

Typical Operation:

DC Plate Voltage	1500	2000	2250	volts
DC Grid-No.3 (Suppressor) Voltage†	0	0	0	volts
DC Grid-No.2 Voltage	400	400	400	volts
DC Grid-No.1 Voltage♦♦	−140	−120	−110	volts
Peak RF Grid-No.1 Voltage	145	120	135	volts
Peak AF Grid-No.1 Voltage	60	60	55	volts
DC Plate Current	70	75	85	ma
DC Grid-No.2 Current	3	3	2.5	ma
DC Grid-No.1 Current	★	★	★	ma
Driving Power##	□□	□□	□□	watts
Power Output (Approx.)	40	50	75	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:		
With fixed bias	30000 max.	ohms
With cathode bias	Not recommended	

PLATE-MODULATED RF POWER AMPLIFIER - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum Ratings, *Absolute Values:*

	CCS●	ICAS●●	
DC PLATE VOLTAGE	1600 max.	2000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	−300 max.	−300 max.	volts
DC PLATE CURRENT	150 max.	200 max.	ma
DC GRID-No.1 CURRENT	25 max.	30 max.	ma
PLATE INPUT	240 max.	400 max.	watts
GRID-No.2 INPUT	15 max.	20 max.	watts
PLATE DISSIPATION	67 max.	100 max.	watts

Typical Operation:

DC Plate Voltage	1250	1600	2000	volts
DC Grid-No.3 (Suppressor) Voltage†	0	0	0	volts
DC Grid-No.2 Voltage▲▲	300	300	350	volts
From a series resistor of	27000	43000	41000	ohms
DC Grid-No.1 Voltage††	−160	−160	−175	volts
From a grid resistor of	12500	13500	11000	ohms
Peak RF Grid-No.1 Voltage	250	250	300	volts
DC Plate Current	150	150	200	ma
DC Grid-No.2 Current	35	30	40	ma
DC Grid-No.1 Current (Approx.)	13	12	16	ma
Driving Power (Approx.)##	2.9	2.7	4.3	watts
Power Output (Approx.)	140	180	300	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance	30000 max.	ohms

RF POWER AMPLIFIER & OSCILLATOR - Class C Telegraphy

Key-down conditions per tube without amplitude modulation■

Maximum Ratings, *Absolute Values:*

	CCS●	ICAS●●	
DC PLATE VOLTAGE	2000 max.	2250 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	−300 max.	−300 max.	volts
DC PLATE CURRENT	180 max.	225 max.	ma
DC GRID-No.1 CURRENT	25 max.	30 max.	ma
PLATE INPUT	360 max.	500 max.	watts
GRID-No.2 INPUT	22 max.	22 max.	watts
PLATE DISSIPATION	100 max.	125 max.	watts

Typical Operation:

DC Plate Voltage	1250	1500	2000	2250	volts
DC Grid-No.3 (Suppressor) Voltage†	0	0	0	0	volts
DC Grid-No.2 Voltage■■	300	300	400	400	volts
From a series resistor of	27000	40000	36000	46000	ohms
DC Grid-No.1 Voltage⊕††##	−75	−90	−120	−155	volts
From a grid resistor of	6000	7500	12000	10000	ohms
From a cathode resistor of	330	400	520	565	ohms
Peak RF Grid-No.1 Voltage	160	175	205	275	volts
DC Plate Current	180	180	180	220	ma
DC Grid-No.2 Current	35	30	45	40	ma
DC Grid-No.1 Current (Approx.)	12	12	10	15	ma
Driving Power (Approx.)##	1.7	1.9	1.9	4.0	watts
Power Output (Approx.)	170	210	275	375	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance	30000 max.	ohms

SELF-RECTIFYING OSCILLATOR or AMPLIFIER - Class C

Maximum CCS● Ratings, *Absolute Values:*

AC PLATE VOLTAGE (RMS)	2800 max.	volts
AC GRID-No.2 (SCREEN) VOLTAGE (RMS)	550 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	−100 max.	volts
DC PLATE CURRENT	95 max.	ma
DC GRID-No.1 CURRENT	10 max.	ma
PLATE INPUT★★	295 max.	watts
GRID-No.2 INPUT★★	22 max.	watts
PLATE DISSIPATION	100 max.	watts

Typical Operation:

AC Plate Voltage (RMS)	2800		volts
DC Grid-No.3 (Suppressor) Voltage†	0		volts
AC Grid-No.2 Voltage (RMS)○○	530		volts
DC Grid-No.1 Voltage♦♦	−37		volts
From a grid resistor of	37000		ohms
DC Plate Current	95		ma
DC Grid-No.2 Current	12		ma
DC Grid-No.1 Current (Approx.)	1		ma
Driving Power (Approx.)##‡	1		watt
Output-Circuit Efficiency (Approx.)	75		per cent
Useful Power Output (Approx.)	170Ø		watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	30000 max.	ohms

AMPLIFIER or OSCILLATOR - Class C

With Separate, Rectified, Unfiltered, Single-Phase, Full-Wave Plate and Grid-No.2 Supply

Maximum CCS● Ratings, *Absolute Values:*

DC PLATE VOLTAGE	1800 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	360 max.	volts

DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-200 max.	volts
DC PLATE CURRENT	190 max.	ma
DC GRID-No.1 CURRENT	22 max.	ma
PLATE INPUT‡‡	360 max.	watts
GRID-No.2 INPUT‡‡	22 max.	watts
PLATE DISSIPATION	100 max.	watts
Typical Operation:		
DC Plate Voltage	1800	volts
DC Grid-No.3 (Suppressor) Voltage†	0	volts
DC Grid-No.2 Voltage♣	250	volts
DC Grid-No.1 Voltage◆◆	-120	volts
From a grid resistor of	10000	ohms
DC Plate Current	160	ma
DC Grid-No.2 Current	37	ma
DC Grid-No.1 Current (Approx.)	12	ma
Driving Power (Approx.)♣♣ ●●	2	watts
Output-Circuit Efficiency (Approx.)	75	per cent
Useful Power Output (Approx.)	210ø	watts
Maximum Circuit Values:		
Grid-No.1-Circuit Resistance	30000 max.	ohms

MAXIMUM RATINGS vs OPERATING FREQUENCY

FREQUENCY	30	45	60	120	Mc
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE AND PLATE INPUT:					
Class B Telephony	100	93	88	76	%
Class C Telephony:					
Grid Modulated	100	93	88	76	%
Plate Modulated	100	87	75	50	%
Class C Telegraphy	100	87	75	50	%
Class C Self-Rectifying Oscillator, Amplifier	100	87	75	50	%
Class C Separately Rectified Oscillator, Amplifier	100	87	75	50	%

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Filament Current	1	4.7	5.3	amp
Direct Interelectrode Capacitances:				
Grid No.1 to plate	2	-	0.25	μμf
Grid No.1 to filament, grid No.2, and grid No.3	2	13	19.6	μμf
Plate to filament, grid No.2, and grid No.3	2	10.5	17.5	μμf
Plate Current (1)	1,3	35	65	ma
Plate Current (2)	1,4	-	2	ma
Grid-No.2 Current	1,3	-	4	ma
Useful Power Output	1,5	198	-	watts

Note 1: With 10 volts dc on filament.

Note 2: With no external shield and with base shell floating.

Note 3: With dc plate voltage of 2000 volts, grid No.3 connected to negative filament terminal, dc grid-No.2 voltage of 400 volts, and dc grid-No.1 voltage of -35 volts.

Note 4: With dc plate voltage of 2000 volts, grid No.3 connected to negative filament terminal, dc grid-No.2 voltage of 400 volts, and dc grid No.1 voltage of -80 volts.

Note 5: In a self-excited oscillator with dc plate voltage of 2000 volts, grid No.3 connected to negative filament terminal, dc grid-No.2 voltage of 400 volts, dc grid-No.1 current of 9.6 to 14.4 ma, grid-No.1 resistor of 10000 ± 10% ohms, dc plate current of 180 ma, and frequency of 15 Mc.

---

o With no external shield and with base shell floating.

Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

●● Intermittent Commercial and Amateur Service.

* Averaged over any audio-frequency cycle of sine-wave form.

† Grid No.3 should be connected to mid-tap on filament-transformer secondary winding or to negative end of filament operated on dc.

** Preferably obtained from a separate source or from the plate-voltage supply with a voltage divider.

⊕ For ac filament supply.

◆ The driver stage should be capable of supplying the No.1 grids of the class AB_1 stage with the specified driving voltage at low distortion.

The type of input coupling network used should not introduce too much resistance in the grid-No.1 circuit. Transformer or impedance coupling devices are recommended. When the 813 is operated in class AB_1 service, only fixed bias should be used.

♦ Fixed supply or bypassed cathode-resistor bias is recommended.

★ Usually negligible.

▲ Never more than 2 watts.

□ At crest of audio-frequency cycle with a modulation factor of 1.0.

♣♣ Value shown for each operating condition is power required by grid No.1 and biasing device when the 813 is operated at frequency sufficiently low to avoid high-frequency losses. At moderate frequencies, the driver stage should be capable of providing about twice the tabulated value; at higher frequencies, the driver stage may have to supply 3 to 10 times the value shown.

♦♦ Obtained from fixed supply, or cathode resistor unbypassed for audio frequencies.

□□ RF driving power is never more than 2 watts. AF power is usually not more than 1 watt.

▲▲ Obtained from a separate source modulated along with the plate supply, or from the modulated plate supply through a series resistor of the value shown for each operating condition.

†† Obtained from a grid-No.1 resistor, from cathode resistor, or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

■ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

■■ Obtained from a separate source, from the plate-voltage supply with a voltage divider, or through a series resistor of the value shown for each operating condition. A series grid-No.2 resistor should be used only when the 813 is used in a circuit which is not keyed. Grid-No.2 voltage must not exceed 800 volts under key-up conditions.

♣ If preceding stage is keyed, the grid-No.1 bias must be obtained partially from a fixed supply in order to limit the plate current and, therefore, the plate dissipation to a safe value.

‡ From a self-rectified driver.

ø This value of useful power is measured at load of output circuit having indicated efficiency.

‡‡ Power input is 1.23 times the product of dc voltage and dc current.

●● From a driver with a rectified, unfiltered, single-phase, full-wave plate supply.

oo Obtained from a separate ac supply in phase with the plate supply or from a low-voltage tap on the plate transformer. Use of a grid-No.2 series voltage-dropping resistor is not recommended.

◆◆ Obtained from a grid-No.1 resistor of the value shown or from a combination of grid-No.1 resistor and cathode resistor. Fixed-bias operation is not recommended. The bias resistors should not be bypassed for the plate and grid-No.2 voltage supply frequency.

★★ Power input is 1.11 times the product of the ac voltage (rms) and the dc current.

♣ Obtained from a separate, rectified, unfiltered, single-phase, full-wave supply in phase with the plate supply, or from the rectified, unfiltered, single-phase, full-wave supply by means of taps on the plate transformer.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 813 are limiting values above which the serviceability of the 813 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The rated plate voltage and grid-No.2 voltage of this tube are high enough to be dangerous to the user. Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

Heavy leads and conductors together with suitable insulation should be used in all parts of the rf plate tank circuit so that losses due to rf voltages and currents may be kept at a minimum. At the higher frequencies, it is essential that short, heavy leads be used for circuit connections in order to minimize lead inductance and losses.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage and grid-No.2 voltage. If the 813 is operated at maximum ratings and grid-No.2 voltage is obtained through a series dropping

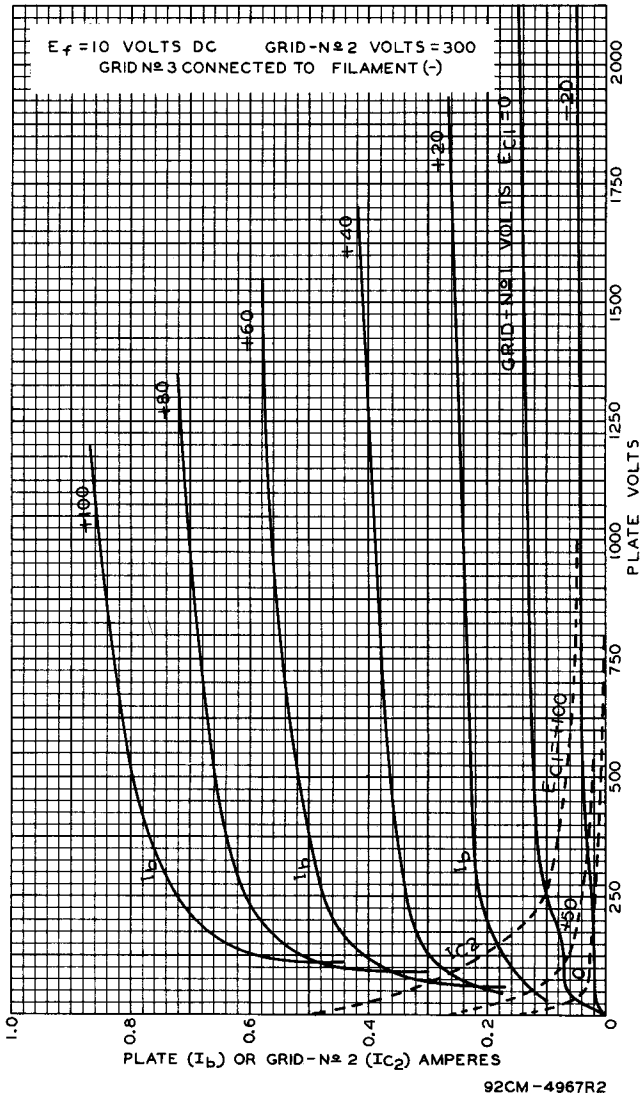


Fig. 1 - Average Plate Characteristics of Type 813.

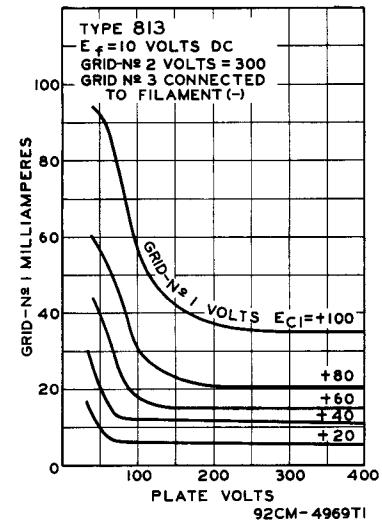


Fig. 2 - Average Characteristics of Type 813.

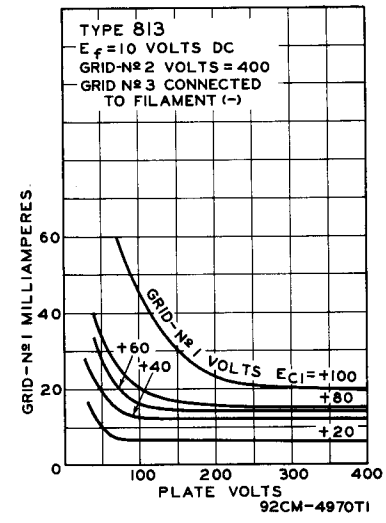


Fig. 3 - Average Characteristics of Type 813.

resistor, the use of a 5000-ohm protective resistor in the high-voltage supply lead is recommended. When a separate grid-No.2 voltage supply is used, a 4000-ohm protective resistor should be connected in the grid-No.2 supply lead.

A protective device, such as a fuse, should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the plate circuit should be fused. Similarly, a fuse in the lead to grid-No.2 should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

Shielding and isolation of the input and output circuits are necessary for stable operation. In some cases where the 813 is used as an rf amplifier, neutralization may be necessary to prevent feedback. It is not necessary, however, to provide an external shield for the 813.

The *rf impedance between grid No.2 and the cathode* must be kept low, usually by means of a suitable bypass capacitor. In telephony service when grid No.2 is modulated, a smaller bypass capacitor than is used for telegraphy service may be required in order to avoid excessive af bypassing. However, if the capacitance value is too small, rf feedback may occur between plate and grid No.1, depending on the circuit layout, operating frequency, and power gain of the stage. AF bypassing difficulties can usually be eliminated if the grid-No.2 bypass capacitor is replaced by a series-resonant circuit which is tuned to resonate at the operating frequency.

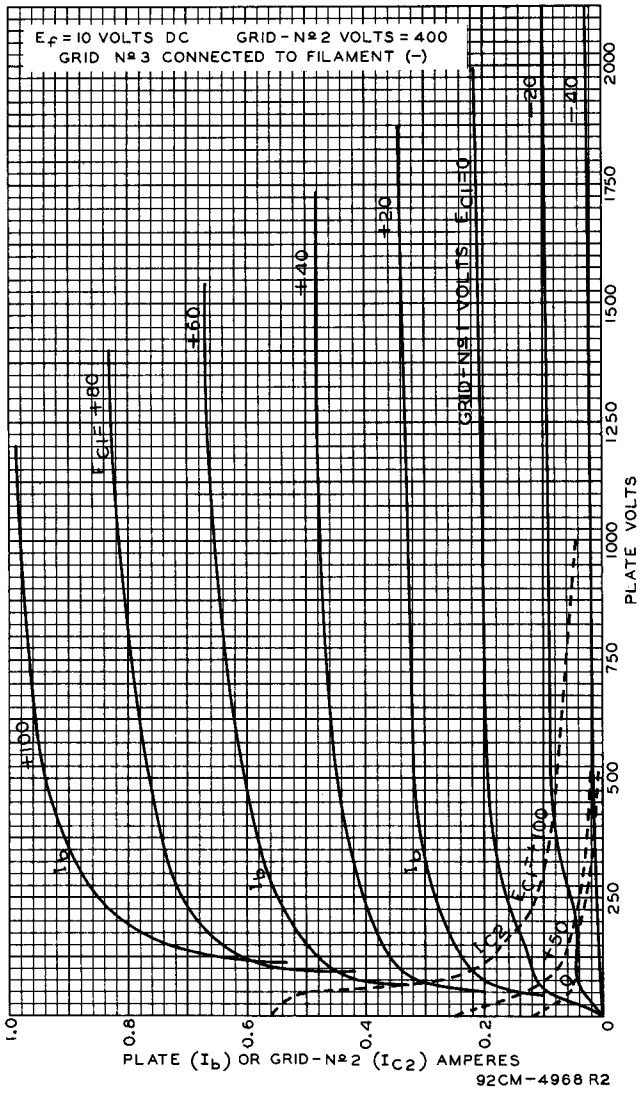


Fig.4 - Average Plate Characteristics of Type 813.

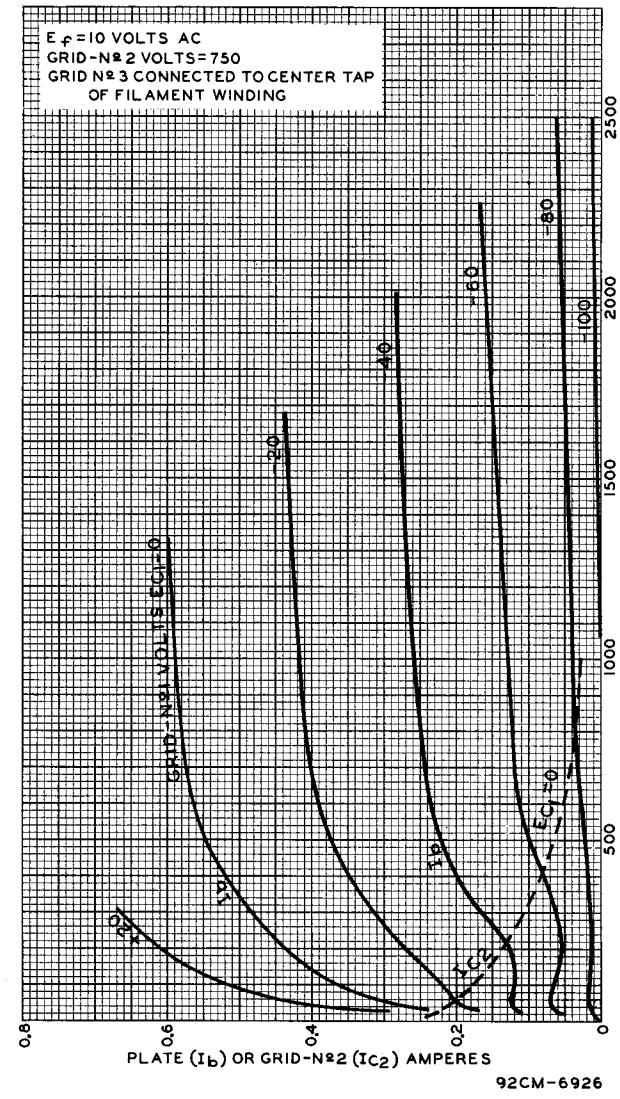


Fig.5 - Average Plate Characteristics of Type 813.

This circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.

The *base pins* of the 813 fit the giant 7-contact socket which should be mounted to hold the tube in a vertical position with base up or down. If

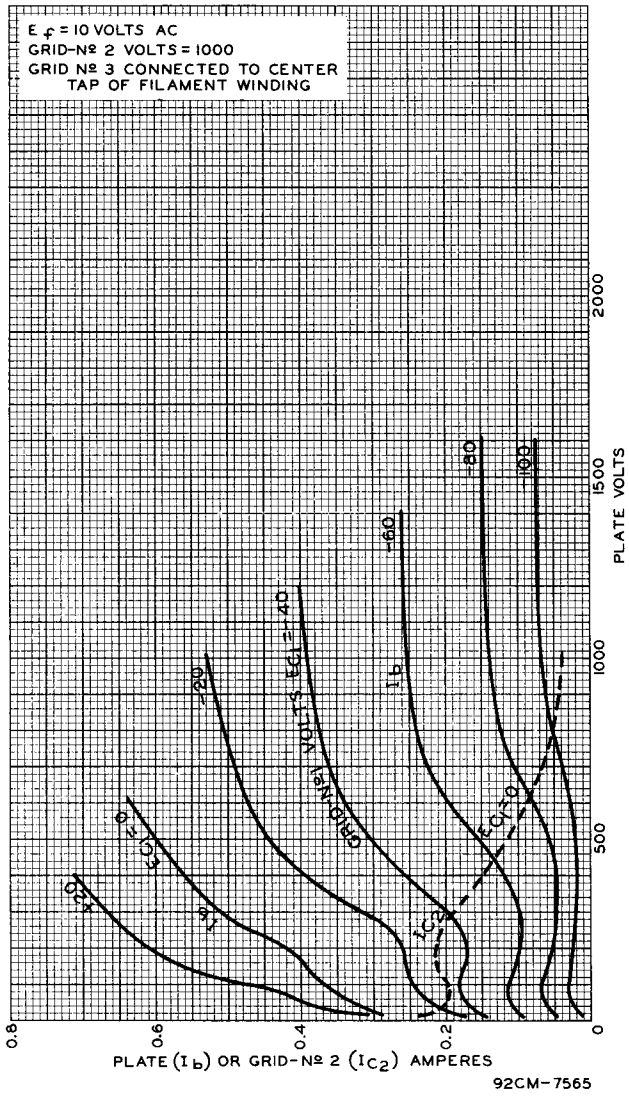


Fig. 6 - Average Plate Characteristics of Type 813.

it is necessary to operate the tube in a horizontal position, the base pins No.2 and No.6 should be positioned vertically one above the other.

The *filament* of the 813 is of the thoriated-tungsten type. It should be operated at the rated value of 10 volts ± 5%. During standby periods in intermittent operation, it is recommended that the filament voltage be reduced to 80% of normal when the period is less than 15 minutes. For longer periods, the filament should be turned off.

Overheating of the 813 by severe overload may decrease the filament emission. Filament activity may sometimes be restored by operating the filament at rated voltage for ten minutes or more without voltages on the other electrodes. This process may be accelerated by raising the filament voltage to 12 volts (not higher) for a few minutes.

The *bulb* becomes very hot during operation. To insure adequate cooling, therefore, it is essential that free circulation of air be provided around the 813. The installation of all wires and connections should be made so they will not be close to or touch the bulb, in order to avoid puncture of the glass.

The *plate* shows no color when the 813 is operated at full ratings under either CCS or ICAS conditions in any class of service. Connections to the plate should be made with a flexible lead to prevent any strain on the seal at the cap.

Grid-No.2 voltage should be obtained from a source of good regulation. The plate voltage should be applied before or simultaneously with the grid-No.2 voltage; otherwise, with voltage on grid-No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the dc power input determined.

The grid-No.2 current is a very sensitive indication of plate-circuit loading and grid-No.2 current rises excessively (often to the point of damaging the tube) when the amplifier is operated without load. Therefore, care should be taken when tuning a circuit employing an 813 under no-load conditions in order to prevent exceeding the grid-No.2 input rating of the tube.

In *plate-modulated class C amplifier service*, the 813 can be modulated 100 per cent. The grid-No.2 voltage must be modulated simultaneously along with the plate voltage so that the ratio of grid-No.2 voltage to plate voltage remains constant. Modulation of the grid-No.2 voltage can be accomplished either by connecting grid-No.2 through a separate winding on the modulation transformer to the fixed grid-No.2 voltage supply, or by connecting grid No.2 through an audio-frequency choke of suitable impedance for low audio frequencies to the fixed grid-No.2 supply voltage. The supply end of the choke should be well-bypassed to ground.

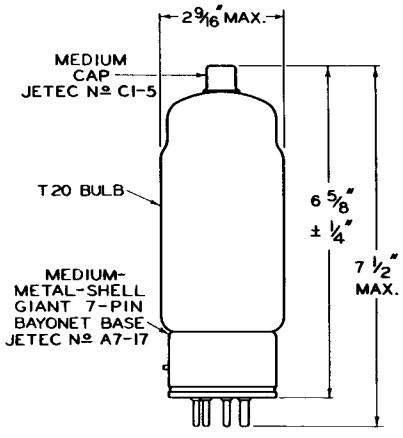
When operated as a *self-rectifying class C amplifier*, or as a *class C amplifier with a separate, rectified, unfiltered, single-phase, full-wave plate and grid-No.2 supply*, the 813 can be biased by means of a grid-No.1 resistor, a cathode resistor, or a combination of the two methods. The use of grid-No.1 resistor bias is preferred, however, because the bias is automatically adjusted as the load on the circuit

varies. In those applications, such as are encountered in therapeutic equipment, where grid-No.1 current and grid-No.1 voltage may vary widely because of fluctuating loads, it is important to design equipment so that the maximum grid-No.1 current and grid-No.1 voltage ratings are never exceeded for any load.

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 813 is operated under load conditions such that maximum rated plate current flows at the plate voltage which will give maximum rated input.

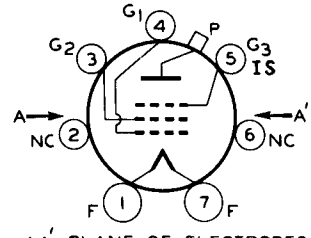
Push-pull or parallel circuit arrangements can be used when more radio-frequency power is required than can be obtained from a single 813. Two 813's in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage from that required for a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits.

DIMENSIONAL OUTLINE



92CM-4963R3

SOCKET CONNECTIONS
Bottom View



AA'=PLANE OF ELECTRODES

5BA

PIN 1: FILAMENT
PIN 2: NO CONNECTION
PIN 3: GRID No.2
PIN 4: GRID No.1
PIN 5: GRID No.3, INTERNAL SHIELD
PIN 6: NO CONNECTION
PIN 7: FILAMENT
CAP: PLATE

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

829

PUSH-PULL R-F BEAM POWER AMPLIFIER

RCA-829 is a push-pull, beam-power transmitting tube of the heater-cathode type. It contains two beam power units within one envelope. Total maximum plate dissipation is 40 watts. The exceptional efficiency and high power sensitivity of the 829 permit full power output with very low driving power. *For example, a single tube operated in push-pull class C telegraph service is capable of handling a power input of 120 watts with less than a watt of driving power--at frequencies as high as 200 Mc (1-1/2 meters).* The 829 may be operated at reduced ratings at frequencies as high as 250 Mc.

The exceptional efficiency of the 829 at the ultra-high frequencies is made possible by the balanced and compact structure of the beam power units, excellent internal shielding, and close electrode spacing. The internal leads are short and heavy in order to minimize internal lead inductance. The terminal arrangement provides excellent insulation and is designed to facilitate symmetry of circuit layout. Neutralization of the tube is unnecessary in adequately shielded circuits.

The heaters are arranged to allow operation from either a 12.6- or a 6.3-volt supply.

CHARACTERISTICS and RATINGS

Unless otherwise specified, values are for both units

HEATER:		
Voltage (A.C. or D.C.) per unit	6.3	Volts
Current per Unit	1.125	Amperes
TRANSCONDUCTANCE, for plate current of 60 ma.	8500 *approx.*	Micromhos
GRID-SCREEN MU-FACTOR	7	
DIRECT INTERELECTRODE CAPACITANCES (Each Unit):		
Grid-Plate (with external shielding)	0.1 *max.*	μμf
Input	14.5	μμf
Output	7.0	μμf
SCREEN-CATHODE CAPACITANCE (Including internal screen by-pass condenser)	65 *approx.*	μμf
BULB	T-16	
TERMINAL MOUNTING	See INSTALLATION	
TYPE OF COOLING	See INSTALLATION (under *Bulb*)	

MAXIMUM CCS RATINGS and TYPICAL OPERATING CONDITIONS

CCS = Continuous Commercial Service

Maximum Ratings Are Absolute Values

As Grid-Modulated Push-Pull R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

D-C PLATE VOLTAGE	500 *max.*	Volts
D-C SCREEN VOLTAGE (Grid No.2)	225 *max.*	Volts
D-C GRID VOLTAGE (Grid No.1)	-175 *max.*	Volts
D-C PLATE CURRENT	120 *max.*	Ma.
PLATE INPUT	60 *max.*	Watts
SCREEN INPUT	6 *max.*	Watts
PLATE DISSIPATION	40 *max.*	Watts
TYPICAL OPERATION: *With modulation factor of 0.7*		
D-C Plate Voltage	500	Volts
D-C Screen Voltage	200	Volts
D-C Grid Voltage	-38	Volts
Peak R-F Grid-to-Grid Voltage	82	Volts
Peak A-F Grid Voltage	17	Volts
D-C Plate Current	120	Ma.
D-C Screen Current	10	Ma.
D-C Grid Current (Approx.)	2	Ma.
Driving Power (Approx.)*	0.5	Watt
Power Output (Approx.)	23	Watts

As Plate-Modulated Push-Pull R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

D-C PLATE VOLTAGE	425 *max.*	Volts
D-C SCREEN VOLTAGE (Grid No.2)	225 *max.*	Volts
D-C GRID VOLTAGE (Grid No.1)	-175 *max.*	Volts
D-C PLATE CURRENT	212 *max.*	Ma.
D-C GRID CURRENT	15 *max.*	Ma.
PLATE INPUT	90 *max.*	Watts
SCREEN INPUT	7 *max.*	Watts
PLATE DISSIPATION	28 *max.*	Watts
TYPICAL OPERATION:		
D-C Plate Voltage	425	Volts
D-C Screen Voltage of *from a series resistor of* *	200 6400	Volts Ohms
D-C Grid Voltage of *from a grid resistor of***	-60 5500	Volts Ohms
Peak R-F Grid-to-Grid Voltage	154	Volts
D-C Plate Current	212	Ma.
D-C Screen Current	35	Ma.
D-C Grid Current (Approx.)	11	Ma.
Driving Power (Approx.)	0.8	Watt
Power Output (Approx.)	63	Watts

As Push-Pull R-F Power Amplifier and Oscillator - Class C Telegraphy

Key-down conditions per tube without modulation##

D-C PLATE VOLTAGE	500 *max.*	Volts
D-C SCREEN VOLTAGE (Grid No.2)	225 *max.*	Volts
D-C GRID VOLTAGE (Grid No.1)	-175 *max.*	Volts
D-C PLATE CURRENT	240 *max.*	Ma.
D-C GRID CURRENT	15 *max.*	Ma.
PLATE INPUT	120 *max.*	Watts
SCREEN INPUT	7 *max.*	Watts
PLATE DISSIPATION	40 *max.*	Watts
TYPICAL OPERATION:		
D-C Plate Voltage	500	Volts
D-C Screen Voltage:		
from a fixed supply of	200	Volts
from a series resistor of	9300	Ohms
D-C Grid Voltage:		
from a fixed supply of	-45	Volts
from a cathode resistor of	160	Ohms
*from a grid resistor of***	3750	Ohms
Peak R-F Grid-to-Grid Voltage	124	Volts
D-C Plate Current	240	Ma.
D-C Screen Current	32	Ma.
D-C Grid Current (Approx.)	12	Ma.
Driving Power (Approx.)	0.7	Watt
Power Output (Approx.)	83	Watts

* At crest of audio-frequency cycle with modulation factor of 0.7

** The grid-circuit resistance should never exceed 15000 ohms (total) per tube, or 30000 ohms per unit. If additional bias is necessary, use a cathode resistor or a fixed supply.

‡ Connected to *modulated* plate-voltage supply.

‡‡ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

INSTALLATION

The 829 may be mounted by means of a special socket

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having floating contacts, such as the RCA stock Nos. 9934 or 9935.. No. 9934 (UT-106) is made for use at frequencies below 60 Mc; No. 9935 (UT-107) has built-in by-pass condensers for the heater and the screen and is designed for use at frequencies above 60 Mc. The plate terminals take clips with flexible leads. Flexible leads are necessary so that normal expansion will not place a strain on the glass at the seals. Each lead should be connected to its clip before the clip is placed on the plate terminal. Connections should never be soldered directly to the tube terminals because the heat of the soldering operation may crack the lead seals. The 829 may be mounted in a vertical position with the plate terminals either up or down. It may also be mounted in a horizontal position provided the plane of each plate is vertical (on edge).

The *bulb* becomes very hot during continuous operation of the tube so that forced-air cooling is recommended. Forced-air cooling is not required for the 829 in intermittent service where the "on" period of plate-power application is ordinarily not more than five minutes, and where the "off" period is not less than the "on" period.

The *heaters* of the 829 are connected in series within the tube. The center connection is brought out of the bulb to a separate pin terminal to permit either series operation from a 12.6-volt supply or parallel operation from a 6.3-volt supply. Either an a-c or a d-c supply may be used. Under any condition of operation, the heater-voltage should not deviate more than ±10% from the rated value.

The *cathodes* of the 829 are connected together within the tube. The cathode circuit should be connected to the electrical mid-point of the heater circuit when the heaters are operated from an a-c supply, or to the negative heater-supply lead when the heaters are operated from a d-c source. In circuits where the cathode is not directly connected to the heater, the potential difference between them should not exceed 100 volts. If the use of a large resistor is necessary between heater and cathode in some circuits, it should be by-passed to avoid the possibility of hum.

The *plates* of the 829 show no color when the tube is operated at its maximum plate-dissipation rating.

The *screens* of the 829 are connected together within the tube, and they are by-passed by means of a 65 μμf condenser connected inside the tube between the screens and cathodes. Screen voltage may be obtained from a separate source, from the plate supply through a series resistor or by means of a voltage divider. The choice of method depends on the service in which the tube is used (see APPLICATION). When the screen voltage is obtained from a separate source, or from a voltage divider, plate voltage should be applied before or with the screen voltage. Otherwise, with voltage on the screens only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series-resistance method for obtaining screen voltage is desirable because of its simplicity and because it limits the d-c power input to the screen. A d-c milliammeter should be used in the screen circuit so that the screen current can be measured and the d-c power input to the screen determined. *The screens should not be allowed to attain a temperature corresponding to more than a barely perceptible red color.* This temperature corresponds to the screen-input values shown under CHARACTERISTICS.

The screen current is a very sensitive indication of plate-circuit loading and the screen current rises excessively (often to the point of damaging the tube) when the amplifier is operated without a load. Therefore, care should be taken when tuning an 829 under no-load conditions in order to prevent exceeding the screen-input rating of the tube.

A *protective device*, such as a high-voltage fuse, should be used to protect both the screens and plates against overloads. When a bleeder resistor of poor regulation or a series resistor is used for obtaining the screen voltage, this device should be placed in the common positive high-voltage supply lead. It should remove the high-voltage supply when the d-c plate current reaches a value 50% greater than normal. When the screen voltage is obtained from a separate source or from a voltage divider of good regulation, a protective device should also be placed in the screen-supply lead. It should remove the screen voltage when the d-c screen current reaches a value of 50% greater than normal.

Shielding of the r-f amplifier stage employing the 829 is required for stable operation. A convenient method of shielding is to insert the plate end of the tube through a hole in a metal plate so that the edge of the opening is in close proximity to the internal shield of the tube. An alternative shielding and mounting arrangement is to insert the grid end of the tube through a hole in the shield and then clamp a ring or cup to the chassis so as to complete the shielding and lock the tube in the mounting.

R-F by-passing of the 829 at its terminals is necessary in order to realize the full capabilities of the tube at the ultra-high frequencies. Conventional by-passing methods and grounding are not adequate. One convenient method of by-passing is to use ribbon heater and screen leads to the tube terminals and to insulate the leads from the external shield plate by means of mica spacers to form by-pass condensers right at the tube terminals. It is important that the grid-, plate-, and screen-circuit returns are made to the common cathode connection in order to avoid r-f interaction through common return circuits. It may also be advisable in some applications to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the voltage supply leads.

In order that the maximum ratings given under CHARACTERISTICS are not exceeded, changes in electrode voltages due to battery- or line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of voltage for each electrode should then be determined. An average value of voltage for each electrode should then be chosen so that under the usual voltage variations the maximum rated volt-

ages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltage. This may be done conveniently by means of a protective resistance of about 2000 ohms (total) in series with the screen lead and a protective resistance of about 2000 ohms in series with the high-voltage supply lead.

APPLICATION

In *grid-modulated class C telephone service*, the 829 is supplied with unmodulated r-f grid excitation voltage and with a d-c grid bias which is modulated at audio frequencies. Grid bias should preferably be obtained from a fixed supply. The plates are supplied with unmodulated d-c voltage. The audio power required in this service is very small and need be sufficient only to meet the peak power requirement of the grids of the class C amplifier on the positive crest of the input signal. The actual peak value is generally never more than 0.15 watt. The screen voltage should be obtained from a separate source or from a voltage divider connected across the plate supply.

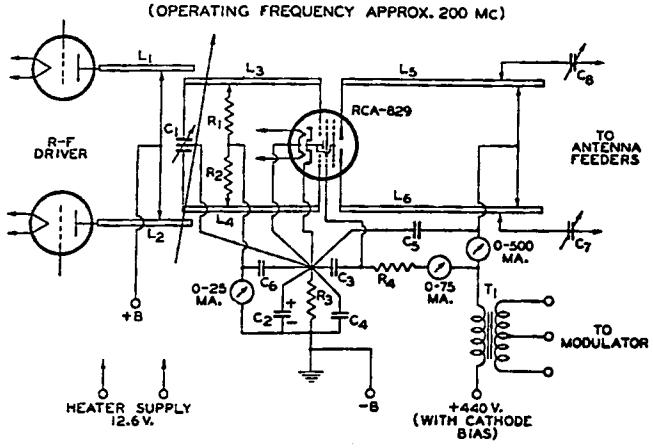
In *plate-modulated class C r-f amplifier service*, RCA-829 can be modulated 100%. The screen voltage may be obtained from a separate source; a voltage-dropping resistor in series with the *modulated* plate supply may also be used. In any case, the screen voltage must be modulated simultaneously with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen lead to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance for low audio frequencies should be connected in series with the screen-supply lead. Control-grid bias should be obtained from a grid resistor or from a combination of either grid resistor and fixed supply, or grid resistor and cathode bias resistor. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion effects by bias-supply compensation.

In *class C r-f telegraph service*, the 829 may be supplied with screen voltage by any of the methods shown under INSTALLATION. When a series screen resistor is used, the regulation of the plate supply should be good enough so that the screen voltage will not exceed 600 volts under key-up conditions. Grid bias may be obtained by any convenient method.

RCA-829 may be operated at maximum ratings in all classes of service at frequencies as high as 200 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under CHARACTERISTICS). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 250 Mc for any class of service. Special attention should be given to shielding, cooling and r-f by-passing at these frequencies.

FREQUENCY	200	250	Mc
MAX. PERMISSIBLE PERCENTAGE of MAX. RATED PLATE VOLTAGE and PLATE INPUT:			
Class C (grid-modulation	100	94	Per Cent
Class C (plate-modulation	100	89	Per Cent
Class C (telegraphy	100	89	Per Cent

ULTRA-HIGH-FREQUENCY PLATE-MODULATED PUSH-PULL R-F POWER AMPLIFIER
(OPERATING FREQUENCY APPROX. 200 Mc)



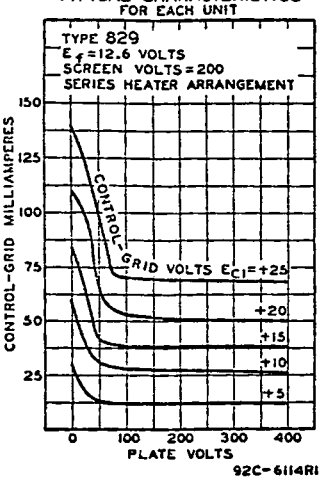
C_1 = 1.2 TO 10 μμf PER SECTION
C_2 = 25 μf, 200 VOLTS
C_3 C_4 C_5 C_6 = 500 μμf, MICA
C_7 C_8 = 3 to 35 μμf
R_1 R_2 = 7500 TO 15000 OHMS, 1 WATT
R_3 = 60 OHMS, 10 WATTS
R_4 = 6400 OHMS, 15 WATTS
T_1 = MODULATION TRANSFORMER
L_1 L_2 = DIMENSIONS DEPENDENT ON TYPE OF DRIVER TUBE: APPROX. SAME AS L_5 L_6
L_3 L_4 = 1/4" DIA. COPPER TUBING, APPROX. 10" LONG AND SPACED APPROX. 7/8" BETWEEN CENTERS
L_5 L_6 = 3/8" DIA. COPPER TUBING, APPROX. 7" LONG AND SPACED APPROX. 7/8" BETWEEN CENTERS

NOTE 1: ADJUST COUPLING OF L_1L_2 AND L_3L_4 FOR OPTIMUM GRID EXCITATION.

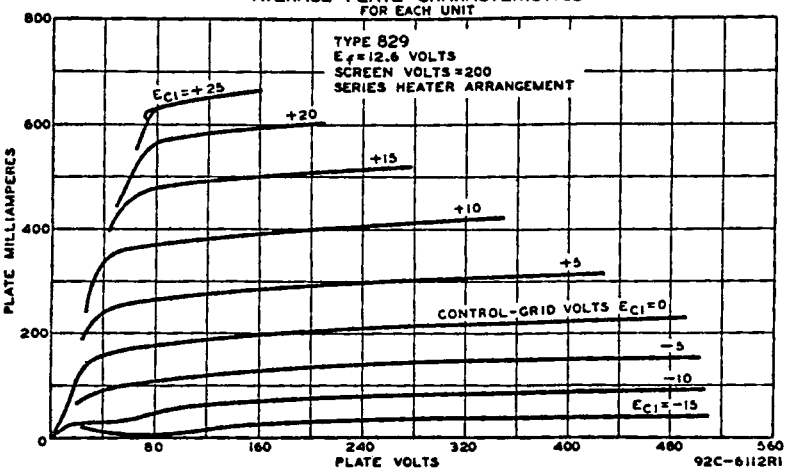
NOTE 2: GRID RESISTORS SHOULD BE ADJUSTED ON L_3L_4 AT VOLTAGE NODE.

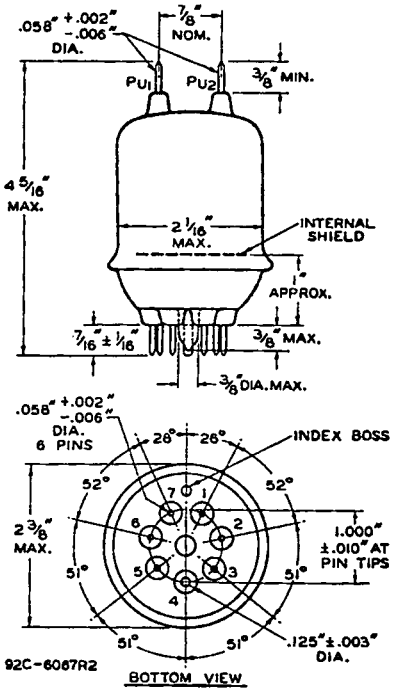
The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

TYPICAL CHARACTERISTICS
FOR EACH UNIT



AVERAGE PLATE CHARACTERISTICS
FOR EACH UNIT

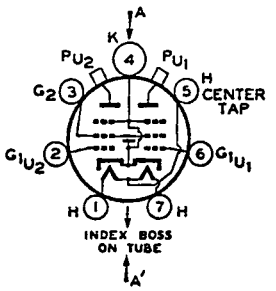




ANGULAR VARIATIONS BETWEEN PINS ARE HELD TO TOLERANCES SUCH THAT PINS WILL FIT GAUGE HAVING SIX 0.080" HOLES AND ONE 0.145" HOLE ARRANGED AT EXACT ANGLES ON 1.000" CIRCLE.

THE PLANE THROUGH THE TUBE AXIS AND EITHER PLATE TERMINAL WILL NOT VARY FROM THE PLANE THROUGH THE TUBE AXIS AT RIGHT ANGLES TO THE PLANE THROUGH PIN 4 AND THE TUBE AXIS BY MORE THAN ±5°.

Bottom View of Socket Connections



PLANE OF ELECTRODES OF EACH UNIT IS PARALLEL TO PLANE THROUGH AXIS OF TUBE AND AA'

Pin 1 – Heater
Pin 2 – Grid No.1 of Unit No.2
Pin 3 – Screen
Pin 4 – Cathode
Pin 5 – Heater Center Tap
Pin 6 – Grid No.1 of Unit No.1
Pin 7 – Heater
P_{U1} & P_{U2} – Plate Terminals of Units No.1 and No.2, respectively

RCA-831

R-F Power Amplifier, Oscillator

RCA-831 is a high-power, air-cooled transmitting tube of the three-electrode type containing a thoriated-tungsten filament. Each electrode is supported on a separate stem and each electrode lead is brought out of the bulb through a separate seal. The 831 can be operated at maximum ratings at frequencies as high as 20 megacycles. The plate dissipation for class C telegraph and class B services is 400 watts.

CHARACTERISTICS

Filament Volts (a-c or d-c)	11.0	Grid-Plate Capacitance	4 μμf
Filament Amperes	10	Grid-Filament Capacitance	3.8 μμf
Amplification Factor	14.5	Plate-Filament Capacitance	1.4 μμf

MAXIMUM RATINGS

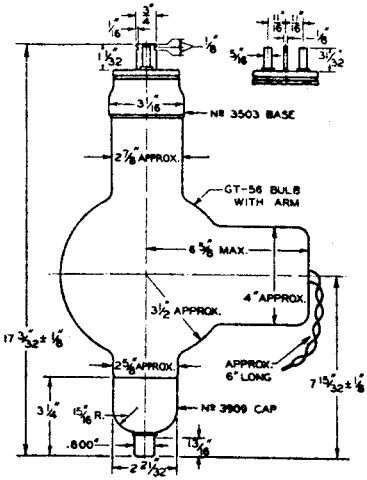
	*Class B Telephony**	*Class C Telephony**	*Class C Telegraphy***	
D-C Plate Voltage	3500	3000	3500	Volts
D-C Grid Voltage	—	−1000	−1000	Volts
D-C Plate Current	250	300	350	Milliamperes
D-C Grid Current	—	75	75	Milliamperes
Plate Input	600	650	1200	Watts
Plate Dissipation	400	270	400	Watts

* Carrier conditions per tube with a max. modulation factor of 1.0.

** Key-down conditions per tube without modulation. Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

INSTALLATION AND APPLICATION

The **filament base** and **grid cap** of the 831 fit the standard RCA end mountings UT-1085 and UT-1086, respectively. The tube must be mounted in a vertical position with the grid cap down.

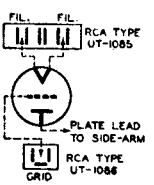


The **plate** of the 831 shows an orange-red color at the maximum plate-dissipation rating for each class of service.

For **high-frequency operation** above 20 megacycles, see page 144.

For additional information, see chapters on INSTALLATION and APPLICATION.

Connections to End-Mountings



832

PUSH-PULL R-F BEAM POWER AMPLIFIER

RCA-832 is a heater-cathode type of transmitting tube containing in one envelope two beam power units. The tube is designed primarily for use as a push-pull r-f power amplifier with maximum ratings at frequencies as high as 200 megacycles and with reduced ratings at frequencies as high as 250 Mc. Its total plate dissipation is 15 watts for class C telegraph service. Neutralization of the tube is unnecessary in adequately shielded circuits.

The exceptional efficiency of the 832 at the ultra-high frequencies is made possible by the balanced and compact structure of the beam power units, excellent internal shielding, and close electrode spacing. The internal leads are short and heavy in order to minimize internal lead inductance. The terminal arrangement provides excellent insulation and is designed to facilitate symmetry of circuit layout.

The heaters are arranged to allow operation from either a 12.6- or a 6.3-volt supply.

CHARACTERISTICS and RATINGS

Unless otherwise specified, values are for both units

HEATER (A.C. or D.C.):			
Voltage per Unit	6.3		Volts
Current per Unit	0.8		Ampere
TRANSCONDUCTANCE, For plate cur. of 30 ma.	3500	*approx.*	Micromhos
GRID-SCREEN MU-FACTOR	7		
DIRECT INTERELECTRODE CAPACITANCES (Each Unit):			
Grid-Plate (With external shielding)	0.05	*max.*	μμf
Input	7.5		μμf
Output	3.8		μμf
SCREEN-CATHODE CAPACITANCE (Including internal screen by-pass condenser)	65	*approx.*	μμf
BULB	T-16		
RCA SOCKET	See INSTALLATION		

MAXIMUM CCS RATINGS and TYPICAL OPERATING CONDITIONS

CCS = Continuous Commercial Service

Maximum Ratings Are Absolute Values

As Grid-Modulated Push-Pull R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

D-C PLATE VOLTAGE		500 *max.*	Volts
D-C SCREEN VOLTAGE (Grid No. 2)		250 *max.*	Volts
D-C GRID VOLTAGE (Grid No. 1)		-100 *max.*	Volts
D-C PLATE CURRENT		55 *max.*	Ma.
PLATE INPUT		22 *max.*	Watts
SCREEN INPUT		3.4 *max.*	Watts
PLATE DISSIPATION		15 *max.*	Watts
TYPICAL OPERATION:			
With modulation factor of	*0.7*	*0.8*	
D-C Plate Voltage	400	500	Volts
D-C Screen Voltage	250	200	Volts
D-C Grid Voltage	-60	-55	Volts
Peak R-F Grid-to-Grid Voltage	110	100	Volts
Peak A-F Grid Voltage	14	14	Volts
D-C Plate Current	55	44	Ma.
D-C Screen Current	6	3	Ma.
D-C Grid Current (Approx.)	0	0	Ma.
Driving Power (Approx.)	0.1	0.1	Watt
Power Output (Approx.)	7.6	8	Watts

As Plate-Modulated Push-Pull R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

D-C PLATE VOLTAGE		425 *max.*	Volts
D-C SCREEN VOLTAGE (Grid No. 2)		250 *max.*	Volts
D-C GRID VOLTAGE (Grid No. 1)		-100 *max.*	Volts
D-C PLATE CURRENT		68 *max.*	Ma.
D-C GRID CURRENT		6 *max.*	Ma.
PLATE INPUT		22 *max.*	Watts
SCREEN INPUT		3.4 *max.*	Watts
PLATE DISSIPATION		10 *max.*	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	325	425	Volts
D-C Screen Voltage:			
from a fixed supply of	210	200	Volts
*from a series resistor of***	7700	14000	Ohms
D-C Grid Voltage*:			
from a fixed supply of	-50	-60	Volts
from a grid resistor of	21000	25000	Ohms
Peak R-F Grid-to-Grid Voltage	100	140	Volts
D-C Plate Current	68	52	Ma.
D-C Screen Current	15	16	Ma.
D-C Grid Current (Approx.)	2.4	2.4	Ma.
Driving Power (Approx.)	0.11	0.15	Watt
Power Output (Approx.)	12	16	Watts

As Push-Pull R-F Power Amplifier and Oscillator - Class C Telegraphy

Key-down conditions per tube without modulation ##

D-C PLATE VOLTAGE		500 *max.*	Volts
D-C SCREEN VOLTAGE (Grid No. 2)		250 *max.*	Volts
D-C GRID VOLTAGE (Grid No. 1)		-100 *max.*	Volts
D-C PLATE CURRENT		90 *max.*	Ma.
D-C GRID CURRENT		6 *max.*	Ma.
PLATE INPUT		36 *max.*	Watts
SCREEN INPUT		5 *max.*	Watts
PLATE DISSIPATION		15 *max.*	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	400	500	Volts
D-C Screen Voltage:			
from a fixed supply	250	200	Volts
from a series resistor of	8300	21000	Ohms
D-C Grid Voltage*:			
from a fixed supply of	-60	-65	Volts
from a grid resistor of	20000	25000	Ohms
from a cathode resistor of	540	730	Ohms
Peak R-F Grid-to-Grid Voltage	124	150	Volts
D-C Plate Current	90	72	Ma.
D-C Screen Current	18	14	Ma.
D-C Grid Current (Approx.)	3	2.6	Ma.
Driving Power (Approx.)	0.18	0.18	Watt
Power Output (Approx.)	22	26	Watts

* The grid-circuit resistance should never exceed 25000 ohms (total) per tube, or 50000 ohms per unit. If additional bias is necessary, use a cathode resistor or a fixed supply.
At crest of audio-frequency cycle with modulation factor indicated.

** Connected to *modulated* plate-voltage supply.

Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

INSTALLATION

The 832 may be mounted by means of a special socket having floating contacts, such as the RCA stock Nos. 9934 or 9935. No. 9934 (UT-106) is made for use at frequencies below 60 Mc; No. 9935 (UT-107) has built-in by-pass condensers for the heater and the screen and is designed for use at frequencies above 60 Mc. The plate terminals take clips with flexible leads.

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Flexible leads are necessary so that strains will not be placed on the glass at the seals. Connections should never be soldered directly to the plate terminals as the heat of soldering may crack the lead seals. The 832 may be mounted in any position.

The *heaters* of the 832 are connected together within the tube. The center connection is brought out of the bulb to a separate pin terminal to permit either series operation from a 12.6-volt supply or parallel operation from a 6.3-volt supply. Under any condition of operation, the heater voltage should not deviate more than ± 10% from the rated value.

The *cathodes* of the 832 are connected together within the tube. The cathode circuit should be connected to the electrical mid-point of the heater circuit when the heaters are operated from an a-c supply or to the negative heater-supply lead when the heaters are operated from a d-c source. In circuits where the cathode is not directly connected to the heater, the potential difference between them should not exceed 100 volts. If the use of a large resistor is necessary between the heater and cathode in some circuits, it should be by-passed by a suitable filter network to avoid the possibility of hum.

The *plates* of the 832 show no color when the tube is operated at its maximum plate-dissipation rating.

The *screens* of the 832 are connected together within the tube and by-passed by means of a 65-μμf condenser connected inside the tube between the screens and the cathodes. Screen voltage can be obtained from a separate source or from the plate-supply through a series resistor or by means of a voltage divider. The choice of method depends on the service in which the tube is used (see APPLICATION). When the screen voltage is obtained from a separate source, or from a voltage divider, plate voltage should be applied before or simultaneously with the screen voltage. Otherwise, with voltage on the screens only, the screen current may rise high enough to cause excessive screen dissipation. When screen-voltage regulation is not an important factor, the series-resistance method for obtaining screen voltage is desirable because of its simplicity and because it limits the d-c input power to the screen. A d-c milliammeter should be used in the screen circuit so that the screen current can be measured and the d-c power input to the screen determined. The screens should not be allowed to attain a temperature corresponding to more than a barely perceptible red color. This temperature corresponds to the screen-input values shown under MAXIMUM RATINGS.

The screen current is a very sensitive indication of the plate-circuit loading and rises excessively (often to the point of damaging the tube) when the amplifier is operated without load. Therefore, care should be taken when tuning an 832 under no-load conditions in order to prevent exceeding the screen-input rating of the tube.

A *protective device*, such as a high-voltage fuse, should be used to protect both the plate and screen against overloads. When a voltage divider or a resistor in series with the plate-voltage supply is used for obtaining the screen voltage, the protective device should be placed in the common positive high-voltage supply lead. It should remove the high voltage when the plate current reaches a value 50% greater than normal. When the screen voltage is obtained from a separate source or from a voltage divider of good regulation, a protective device should be placed in the screen-supply lead. It should remove the screen voltage when the screen current reaches a value of 50% greater than normal.

Shielding of the r-f amplifier stage employing the 832 is required for stable operation. A convenient method of shielding is to insert the plate end of the tube through a hole in a metal plate so that the edge of the opening is in close proximity to the internal shield of the tube. An alternative shielding and mounting arrangement is to insert the grid end of the tube through a hole in the shield and then clamp a ring or cup to the chassis so as to complete the shielding and lock the tube in the mounting.

R-f by-passing of the 832 at the tube terminals is necessary in order to realize the full capabilities of the tube at the ultra-high frequencies. Conventional by-passing methods and grounding are not adequate. One convenient method of by-passing is to use ribbon leads to the tube terminals and to insulate the leads from the external shield plate by means of mica spacers to form by-pass condensers right at the tube terminals. It is important that the grid-, plate-, and screen-circuit returns are made to the common cathode connection in order to avoid r-f interaction through common return circuits. It may also be advisable in some applications to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the voltage-supply leads.

In order that the maximum ratings given under CHARACTERISTICS are not exceeded, changes in electrode voltages due to battery- or line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of voltage for each electrode should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate and screen voltages. This may be done conveniently by means of a protective resistance of about 10000 ohms (total) in series with the screen lead and a protective resistance of about 2000 ohms in series with the high-voltage supply lead.

APPLICATION

In *grid-modulated class C telephone service*, the 832 is supplied with unmodulated r-f grid excitation voltage and with d-c grid bias which is modulated at audio frequencies. Grid bias should preferably be obtained from a fixed supply. The plates are supplied with unmodulated d-c voltage. The audio power required in this service is very small. It must be sufficient to meet the peak power requirement of the grids of the class C amplifier on the positive crest of the input signal. The screen voltage should be obtained from a separate source or from a voltage divider connected across the high-voltage supply.

In *plate-modulated class C amplifier service,* RCA-832 can be modulated 100%. The screen voltage may be obtained from a separate source or from a voltage-dropping resistor connected in series with the *modulated* plate supply. The screen voltage must be modulated simultaneously with the plate voltage so that the ratio of screen voltage to plate voltage remains constant. Modulation of a fixed screen-voltage supply can be accomplished either by connecting the screen lead to a separate winding on the modulation transformer or by connecting it through a blocking condenser to a tap on the modulation transformer or choke. With the latter method, an a-f choke of suitable impedance for low frequencies should be connected in series with the screen-supply lead. Control-grid bias may be obtained from a grid resistor or from a combination of either grid resistor and fixed supply or grid resistor and cathode resistor. The combination method has the advantage not only of protecting the tube from damage through loss of excitation but also of minimizing distortion through bias-supply compensation.

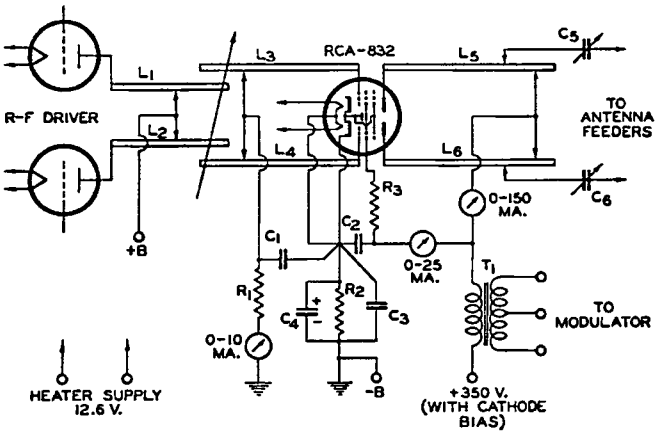
In *class C r-f telegraph service,* the 832 may be supplied with screen voltage from a fixed supply such as a voltage divider or from a separate source. The screen voltage may also be obtained from the plate-voltage supply through a series resistor, provided the regulation of the plate supply is good enough so that the screen voltage will not exceed 600 volts under key-up conditions. Grid bias may be obtained by any convenient method.

RCA-832 may be operated at maximum ratings in all classes of service at frequencies as high as 200 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used at frequencies up to 250 Mc.

FREQUENCY	200	250	Mc
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE and PLATE INPUT:			
grid-mod. class C r-f amplifier	100	94	Per Cent
plate-mod. class C r-f amplifier	100	89	Per Cent
class C telegraphy	100	89	Per Cent

ULTRA-HIGH-FREQUENCY PLATE-MODULATED PUSH-PULL R-F POWER AMPLIFIER

POWER OUTPUT 12 WATTS (APPROX.) AT 2 METERS



C_1, C_2, C_3 = 500 μμf
C_4 = 25 μf, 200 VOLTS
C_5, C_6 = 3 TO 35 μμf
R_1 = 10000 TO 20000 OHMS, 1 WATT
R_2 = 300 OHMS, 5 WATTS
R_3 = 7500 OHMS, 5 WATTS
L_1, L_2 = DIMENSIONS DEPENDENT ON TYPE OF DRIVER TUBE; APPROX. SAME AS L_5 L_6.

L_3, L_4 = ¼" DIA. COPPER TUBING, APPROX. 10" LONG AND SPACED 1" BETWEEN CENTERS.
L_5, L_6 = ¼" DIA. COPPER TUBING, APPROX. 12" LONG AND SPACED 1" BETWEEN CENTERS.
T_1 = MODULATION TRANSFORMER

NOTE: ADJUST COUPLING OF L_1 L_2 AND L_3 L_4 FOR OPTIMUM GRID EXCITATION.

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838

Class B Modulator, R-F Power Amplifier

RCA-838 is a high-mu, three-electrode transmitting tube for use as a zero-bias class B audio-frequency power amplifier. The grid is designed so that the amplification factor of the tube varies with the amplitude of the input signal. This feature facilitates the design of class B amplifiers to give high output with low distortion. In class B audio service, two tubes of this type are capable of giving an output of 260 watts with less than 5% distortion. The 838 may also be used as a radio-frequency power amplifier or oscillator at maximum ratings for frequencies as high as 30 Mc. The maximum plate dissipation for class B and class C telegraph services is 100 watts.

CHARACTERISTICS and RATINGS

FILAMENT VOLTAGE (A.C. or D.C.)	10.0	Volts
FILAMENT CURRENT	3.25	Amperes
DIRECT INTERELECTRODE CAPACITANCES:		
Grid-Plate	8	μμf
Grid-Filament	6.5	μμf
Plate-Filament	5	μμf
BULB (For dimensions, see page 4)	T-18	
BASE (For socket connections, see page 4)	Jumbo 4-Large Pin	

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

As A-F Power Amplifier and Modulator - Class B

D-C PLATE VOLTAGE	1250 max.	Volts
MAX.-SIGNAL D-C PLATE CURRENT *	175 max.	Milliamperes
MAX.-SIGNAL PLATE INPUT *	220 max.	Watts
PLATE DISSIPATION *	100 max.	Watts

TYPICAL OPERATION:

Unless otherwise specified, values are for 2 tubes

D-C Plate Voltage	1000	1250	Volts
D-C Grid Voltage oo	0	0	Volts
Peak A-F Grid-to-Grid Voltage	200	200	Volts
Zero-Sig. D-C Plate Current	106	148	Milliamperes
Max.-Sig. D-C Plate Current	320	320	Milliamperes
Load Resistance (Per tube)	1725	2250	Ohms
Effective Load Resistance (Plate-to-plate)	6900	9000	Ohms
Max.-Sig. Driving Power (Approx.)	7	7.5	Watts
Max.-Sig. Power Output (Approx.) #	200	260	Watts

As R-F Power Amplifier - Class B Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

D-C PLATE VOLTAGE	1250 max.	Volts
D-C PLATE CURRENT	150 max.	Milliamperes
PLATE INPUT	150 max.	Watts
PLATE DISSIPATION	100 max.	Watts

TYPICAL OPERATION:

D-C Plate Voltage	1000	1250	Volts
D-C Grid Voltage oo	0	0	Volts
Peak R-F Grid Voltage	70	60	Volts
D-C Plate Current	130	106	Milliamperes
D-C Grid Current (Approx.) **	15	15	Milliamperes
Driving Power (Approx.) ** o	8	6	Watts
Power Output (Approx.)	40	42.5	Watts

As Plate-Modulated R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

D-C PLATE VOLTAGE	1000 max.	Volts
D-C GRID VOLTAGE	-400 max.	Volts
D-C PLATE CURRENT	175 max.	Milliamperes
D-C GRID CURRENT	70 max.	Milliamperes
PLATE INPUT	175 max.	Watts
PLATE DISSIPATION	67 max.	Watts

TYPICAL OPERATION:

D-C Plate Voltage	750	1000	Volts
D-C Grid Voltage:			

*, **, #, o, oo: See end of tabulation.

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From fixed supply of	-100	-135		Volts
From grid resistor of	1700	2300		Ohms
Peak R-F Grid Voltage	220	255		Volts
D-C Plate Current	150	150		Milliamperes
D-C Grid Current (Approx.) **	60	60		Milliamperes
Driving Power (Approx.) **	14	16		Watts
Power Output (Approx.)	65	100		Watts

As R-F Power Amplifier and Oscillator - Class C Telegraphy

Key-down conditions per tube without modulation **

D-C PLATE VOLTAGE			1250 max.	Volts
D-C GRID VOLTAGE			-400 max.	Volts
D-C PLATE CURRENT			175 max.	Milliamperes
D-C GRID CURRENT			70 max.	Milliamperes
PLATE INPUT			220 max.	Watts
PLATE DISSIPATION			100 max.	Watts
TYPICAL OPERATION:				
D-C Plate Voltage	750	1000	1250	Volts
D-C Grid Voltage:				
From fixed supply of	-80	-85	-90	Volts
From cathode resistor of	445	470	500	Ohms
From grid resistor of	2700	2800	3000	Ohms
Peak R-F Grid Voltage	190	195	200	Volts
D-C Plate Current	150	150	150	Milliamperes
D-C Grid Current (Approx.) **	30	30	30	Milliamperes
Driving Power (Approx.) **	6	6	6	Watts
Power Output (Approx.)	65	100	130	Watts

* Averaged over any audio-frequency cycle of sine-wave form. Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.

Approximately 4% harmonic distortion.

Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

o At crest of audio-frequency cycle with modulation factor of 1.0.

oo Grid voltages are given for either a-c or d-c filament operation. When a.c. is used, the circuit returns are made to the mid-point of the filament circuit. When d.c. is used, the returns are made to the negative filament terminal.

INSTALLATION

The *base* of the 838 fits the standard transmitting 4-contact socket such as the RCA type UT-541A which should be installed to hold the tube in a vertical position, base down. If it is necessary to mount the tube in a horizontal position, the tube should be mounted with the plate in a vertical plane (on edge).

The *bulb* becomes very hot during continuous operation so that free circulation of air around the tube should be provided. The installation of all wires and connections should be made so that they will not be close to or touch the bulb in order to avoid puncture of the glass due to peak voltage effects.

The *filament* is of the thoriated-tungsten type. The filament voltage should not vary more than plus or minus 5% from the rated value; otherwise, a loss of filament emission may result. When the apparatus in which the tube is used is idle for periods not exceeding two hours, the filament should be maintained at its rated voltage during the "standbys".

The *plate* of the 838 shows a barely perceptible red color at the maximum plate-dissipation rating for each service.

Overheating of the 838 by severe overload may decrease filament emission. The activity of the filament can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 12 volts (not higher) for a few minutes. The positive high-voltage supply lead of the 838 should be provided with a protective device such as a high-voltage fuse to prevent the tube from drawing excessive plate current. This device should instantly remove the plate voltage when the d-c plate current reaches a value 50% greater than normal.

In order that the maximum ratings given under CHARACTERISTICS will not be exceeded, changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus, must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltage will not be exceeded.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage. This may be done conveniently by connecting a resistance of about 3000 ohms in series with the high-voltage plate lead during the adjustments.

The rated plate voltage of this tube is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at the high d-c plate potential.

APPLICATION

In *class B modulator or audio-frequency service,* two 838's are used in a balanced circuit, each tube amplifying half the time. The output transformer should be designed so that the resistance load presented by the modulated class C amplifier is reflected as the recommended plate-to-plate load. The input transformer can be designed for operation under approximately uniform loading conditions to give excellent frequency response. Due to the low grid-bias characteristic of the 838, grid current is drawn on any input signal. Grid bias should be obtained from a battery or other d-c source of good regulation. It should not be obtained from a high-resistance supply such as a grid leak or cathode resistor.

In special cases where it is desirable to keep the audio-frequency distortion of the class B a-f amplifier or modulator to a value lower than 4%, the use of a small amount of grid-bias voltage is advantageous. Typical operating conditions are approximately the same as those for zero-bias operation. With a plate-supply voltage of 1250 volts, the exceptions are: grid-bias voltage, -15 volts; peak a-f grid-to-grid voltage, 210 volts; and zero-signal d-c plate current, 50 milliamperes (2 tubes).

In *class B r-f service,* the 838 is supplied with unmodulated d-c voltage. The grid is excited by r-f voltage modulated at audio frequency in one of the preceding stages. The plate dissipation is greatest when the carrier is unmodulated. Grid bias may be obtained from a battery or from a cathode resistor, suitably bypassed for audio and radio frequencies.

In *plate-modulated class C r-f service,* the 838 may be supplied with grid bias from a grid leak, or from a suitable combination of either grid leak and fixed supply, or grid leak and cathode resistor. The cathode resistor should be suitably by-passed for audio and radio frequencies. The combination-bias method of grid leak and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also minimizes distortion effects by means of bias-supply compensation. Grid-bias voltage is not critical so that correct adjustment may be obtained with values differing widely from those indicated for this service.

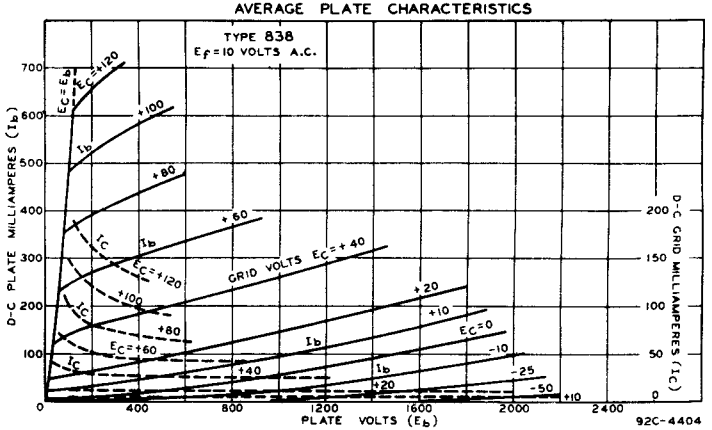
In *class C r-f telegraph service,* RCA-838 may be supplied with grid bias by any convenient method. The grid-leak method is particularly useful, for even when the grid excitation is accidentally removed, the probability of tube damage is small because of low zero-bias plate current.

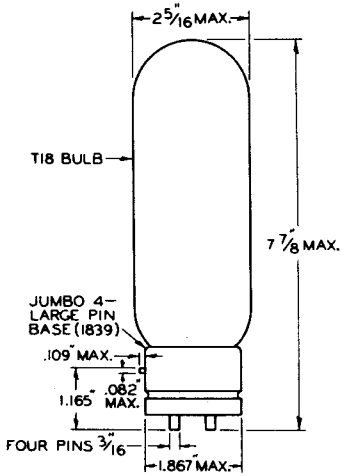
RCA-838 may be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced as the frequency is raised (other maximum ratings are the same as shown under CHARACTERISTICS). The tabulation below shows the highest percentage of maximum plate voltage and power input that can be used up to 120 Mc. Special attention should be given to adequate ventilation at these frequencies.

FREQUENCY	30	50	120	Megacycles
PERCENTAGE of MAX. RATED PLATE VOLTAGE and PLATE INPUT	100 *max.*	75 *max.*	50 *max.*	Per Cent

If more radio-frequency power output is required than can be obtained from a single 838, the push-pull or the parallel connection may be used. For example, two tubes connected in push-pull or in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage; the push-pull connection requires twice the r-f excitation necessary to drive a single tube. With either connection the driving power required is approximately twice that for single-tube operation while the grid bias is the same as that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits to ground and of cancelling the even-order harmonics from the output. Parasitic suppressors connected in series with each grid lead as close to the tube socket as possible will often prevent parasitic oscillations in push-pull and in parallel circuits. The suppressor consists of a non-inductive resistor of 10 to 100 ohms connected in parallel across a suitable r-f choke. It is preferable to provide for separate grid-bias or grid-excitation adjustment in order to balance the grid and plate current.

AVERAGE PLATE CHARACTERISTICS

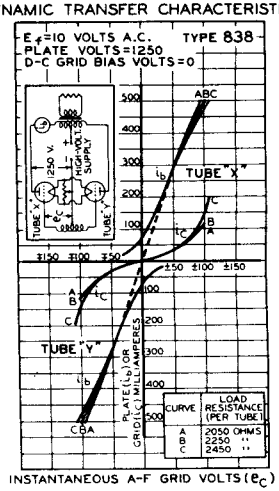




BOTTOM VIEW OF BASE

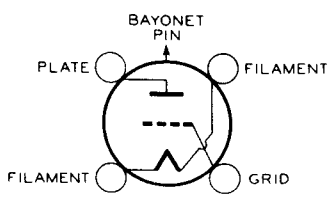
92S-4313

DYNAMIC TRANSFER CHARACTERISTICS

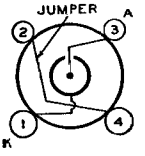


92C-4407RI

Top View of Socket Connections



RCA-874



VOLTAGE REGULATOR

The 874 is a voltage regulator tube designed to maintain constant d-c output from rectifier devices for varying values of d-c load current.

CHARACTERISTICS

Starting Supply Voltage (D. C.)	125 *min.*	Volts
Operating Voltage (D. C.)	90	Volts
Operating Current (D. C.)	10 to 50	Milliamperes
Continuous Current (D. C.)	50 *max.*	Milliamperes
Maximum Overall Length	5⅝	Inches
Maximum Diameter	2 1/16	Inches
Bulb		S-17
Base		Medium 4-Pin Bayonet

INSTALLATION AND APPLICATION

The base pins of the 874 fit the standard four-contact socket. Pins No. 2 and No. 4 are connected together within the base; the connection is used as a link in the primary circuit of the power transformer to prevent the application of voltage when the 874 is removed from its socket.

Sufficient resistance must always be used in series with the 874 to limit the current to 50 milliamperes when no load current is being drawn from the rectifier.

This type is used principally for renewal purposes.

RCA-876, RCA-886

CURRENT REGULATORS

The 876 and 886 are, within their ranges of operation, constant-current regulating devices.

CHARACTERISTICS

	Type 876	*Type 886*	
Voltage Range	40 to 60	40 to 60	Volts
Operating Current	1.7	2.05	Amperes
Ambient Temperature (Fahrenheit)	150	150	Degrees
Maximum Overall Length	8	8	Inches
Maximum Diameter	2 1/16	2 1/16	Inches
Bulb	T-16	T-16	
Base	Mogul Screw	Mogul Screw	

INSTALLATION AND APPLICATION

The bases of these types fit the standard mogul screw socket which may be installed to hold the tubes in any position. These tubes operate at a high bulb temperature and must be surrounded by a metal ventilating stack.

Either type may be used in series with the primary of a suitably designed transformer (or with a resistive load) to maintain essentially constant input voltage to the primary (or load) over a range of line voltage variation of 20 volts. The primary of the transformer should be designed for a voltage input equal to the average line voltage minus 50 volts. The primary current of the transformer should be 1.7 amperes for the 876 and 2.05 amperes for the 886. If less than this current is drawn, adjustment to the rated value must be made either by a shunt resistor or increased load on the secondary. Two or more of these tubes are required if the current drawn is more than the rated values.

These two types are used principally for renewal purposes.

RMA release # 399,
Feb. 21, 1945

902

CATHODE-RAY TUBE

Electrostatic Deflection
Electrostatic Focus

2-Inch Diameter

Medium-Persistence Screen
7-1/2" Overall Length

RCA-902 is a high-vacuum cathode-ray tube having a fluorescent viewing screen two inches in diameter. This tube is provided with two sets of electrostatic electrodes for deflection of the electron beam. The 902 will operate with anode voltages as low as 400 volts, and it can replace electrically the RCA-913 provided the anode No.2 voltage is not less than 400 volts. The 902 produces a brilliant luminous spot having a greenish hue and is suitable for use in compact, portable oscillographic equipment for the observation and photography of transient and recurrent phenomena.

General

HEATER VOLTAGE (A.C. or D.C.)	6.3 ±10% Volts
HEATER CURRENT	0.6 Ampere
FOCUSING METHOD	Electrostatic
DEFLECTION METHOD	Electrostatic
Electrodes DJ_1 and DJ_2: nearest to screen	
DJ_1 is on same side of tube as base pin 3	
Electrodes DJ_3 and DJ_4: nearest to base	
DJ_3 is on same side of tube as base pin 1	
PHOSPHOR	No.1
FLUORESCENCE	Green
PERSISTENCE	Medium
DIRECT INTERELECTRODE CAPACITANCES (Approx.):	
Grid No.1 to All Other Electrodes	7 μμf
DJ_1 to All Other Electrodes	9.5 μμf
DJ_4 to All Other Electrodes	5.5 μμf
OVERALL LENGTH	7-7/16" ±3/16"
GREATEST DIAMETER of BULB	2" ±1/16"
MINIMUM USEFUL SCREEN DIAMETER	1-3/4"
BASE	Medium Shell Octal 8-pin

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

ANODE No.2 (High-Voltage Electrode) VOLTAGE		660 max.	Volts
ANODE No.1 (Focusing Electrode) VOLTAGE		330 max.	Volts
GRID No.1 (control Electrode) VOLTAGE RANGE	0 (never +)	to −125 max.	Volts
PEAK VOLTAGE BETWEEN ANODE No.2 and ANY DEFLECTING ELECTRODE		385 max.	Volts
IMPEDANCE of ANY DEFLECTING-ELECTRODE CIRCUIT at HEATER-SUPPLY FREQUENCY		1 max.	Megohm
GRID-CIRCUIT RESISTANCE		5 max.	Megohms
TYPICAL OPERATION:			
Anode No.2 Voltage*	400	600	Volts
Anode No.1 Voltage for Focus at 75% of Grid Voltage for Cut-Off (Approx.)**	100	150	Volts
Grid Voltage for Cut-Off‡	−40	−60	Volts
Deflection Sensitivity:			
DJ_1 and DJ_2	0.273	0.182 mm/volt	D.C.
DJ_3 and DJ_4	0.321	0.214 mm/volt	D.C.
Deflection Factor:‡‡			
DJ_1 and DJ_2	93	139 volts	D.C./in.
DJ_3 and DJ_4	78	117 volts	D.C./in.

* Brilliance and definition decrease with decreasing anode No.2 voltages. In general, anode No.2 voltage should not be less than 400 volts.

** Individual tubes may require between +20% and −35% of values shown for focus when grid No.1 voltage is varied between zero and cut-off.

‡ Visual extinction of a stationary focused spot. Supply should be adjustable to ±50% of the values shown.

‡‡ Individual tubes may vary ±20% of the values shown.

SPOT POSITION

The undeflected focused spot will fall within a 10-mm square centered at the geometric center of the tube face and having one side parallel to the trace produced by DJ_3 and DJ_4. Suitable test conditions are: anode No.2 volts, 600; anode No.1 volts, adjusted for focus; deflecting-electrode resistors, 1 megohm each, connected to anode No.2; the tube shielded from extraneous fields. To avoid damage to the tube, grid No.1 voltage should be near cut-off before anode voltage is applied.

BASING and DEFLECTING-ELECTRODE ARRANGEMENT

The angle between the trace produced by DJ_3 and DJ_4 and its intersection with the plane through the tube axis and pin 1 will not exceed 10°.

The angle between the trace produced by DJ_1 and DJ_2 and the trace produced by DJ_3 and DJ_4 will be 90° ±4°.

When DJ_1 (pin 4) is positive with respect to DJ_2 (pin 1), the spot will be deflected toward pin 3; likewise, when DJ_3 (pin 1) is positive with respect to DJ_4 (pin 6), the spot will be deflected toward pin 1.

INSTALLATION

The *base* pins of the 902 fit the standard octal socket which may be installed to hold the tube in any position. The socket should preferably be mounted so that it may be rotated through a small angle. It should be made of good insulating material; a type of socket having insulating baffles between contacts provides an additional factor of safety.

The *bulb* of this type, except for the screen surface, should be enclosed in a grounded metal case. If an iron or steel case is employed to minimize the effects of extraneous fields on tube operation, care should be taken in its construction to insure that the case is completely demagnetized.

The *heater* is designed to operate at 6.3 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage to appear between the heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

The *cathode* is connected within the tube to one side of the heater. The terminal for this common connection is base pin No.2.

The *fluorescent screen* of the 902 employs phosphor No.1 which fluoresces to produce a green spot. It has good visual and photographic qualities as well as high luminous efficiency.

The *d-c supply voltages* for the electrodes may be obtained conveniently from a vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be

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of either the half-wave or the voltage-doubler type. For the same reason, the filter requirements are simple. A 0.5 to 2 μf condenser will ordinarily provide sufficient filtering. If this is inadequate, a two-section filter is recommended.

Two pairs of *electrostatic electrodes*, at right angles to each other, are located within the bulb neck to provide for deflection of the beam. The electrostatic field of each pair of electrodes causes deflection of the beam parallel to the lines of the field; therefore, the deflections caused by each pair are at right angles. The d-c potential of each electrode must be maintained essentially equivalent to that of anode No.2 in order to avoid building up a charge on the deflecting electrode. A charge on the deflecting electrodes causes a permanent deflection of the beam. The d-c potential of the deflecting electrodes may be kept essentially the same as that of anode No.2 by connecting resistors having values not greater than 10 megohms between each deflecting electrode and anode No.2. This arrangement by suitable choice of resistor values minimizes pattern distortion and pattern drift resulting from unbalanced potentials on the deflecting electrodes. The smaller the resistor values, the less the distortion for a given beam current. The beam current should ordinarily be kept low. At times when it is necessary to use a high value of beam current, as when photographs are taken, the value of the resistor should be reduced so that the zero-axis shift will be minimized. The resistor of one or both free deflecting electrodes may be connected to a d-c bias voltage to obtain centering of the beam.

The *deflection sensitivity* and the *deflection factors* of the deflecting electrodes for typical anode No.2 voltages are given under TYPICAL OPERATING CONDITIONS.

The high voltages at which the 902 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions must include safeguards which definitely eliminate all hazards to personnel. All circuit parts which may be at high potentials should always be enclosed and "interlock" switches should be used to break the primary circuit of the high-voltage power supply when access to the equipment is required.

In the use of cathode-ray tubes it should always be remembered that high voltages may appear at normally low-potential points in the circuit because of condenser breakdown or incorrect circuit connections. Before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

The cathode-ray oscillograph is an instrument adaptable to a wide variety of applications. A few of the more important are: the study of wave shapes and the comparison of frequencies, measurements of modulation and peak voltages, location and adjustment of faults in radio receivers and a-f amplifiers, and the indication of balance in bridge circuits. The low cost of the 902 and its associated apparatus, the low voltages at which it can be operated, and the small size and portability of equipment using the tube are factors contributing to the utility of the 902 by engineers, radio servicemen, radio amateurs, and school laboratories.

An oscillograph, in its simplest form, can be designed to use only the cathode-ray tube and a bleeder circuit with provision for connection to external anode and heater supplies. Means of coupling to the deflecting electrodes usually consist of condensers in the lead to the common connection to anode No.2 and two of the deflecting electrodes, and in each of the leads to the "free" deflecting electrodes. When the cathode or the negative end of the cathode-ray high-voltage supply is grounded, these coupling condensers should have a high voltage rating since the deflecting electrodes and anode No.2 are then at high potential with respect to ground. When anode No.2 is grounded, the condenser in the lead to the anode may be omitted and the condensers in the leads to the "free" deflecting electrodes may be low-voltage condensers. For d-c amplifier service, the deflecting electrodes should be coupled direct to the output of the amplifier by omitting the condensers. In addition, it will usually be preferable to remove the associated deflecting-electrode resistors in order to minimize the loading effect of the resistors on the d-c amplifier. With the resistor removed, it is essential, in order to minimize spot defocusing, that anode No.2 be returned to some point in the d-c amplifier circuit such that the potential difference between anode No.2 and the average voltage across the deflecting electrodes will be as low as possible.

The simple basic circuit arrangement can be improved greatly by the inclusion of a sweep oscillator and amplifier, and an amplifier for the phenomena under observation. Such a circuit is shown in the accompanying diagram. The electrode voltages are obtained from a bleeder circuit connected across a separate high-voltage supply. A bleeder current of one or two milliamperes is satisfactory usually; considerably higher values may require the use of more filtering than that provided by a single condenser shunted across the high-voltage supply. With small bleeder currents, a single filter condenser usually is adequate. A variable d-c voltage for the control electrode and one for anode No.1 are obtained from potentiometers in the bleeder circuit. One set of deflecting electrodes is used for the phenomenon under observation; the other set for the time sweep which spreads the trace across the fluorescent screen. Two a-f voltage amplifiers are shown— one for the vertical and one for the horizontal deflecting electrodes. Many applications, however, do not require the signal-volt-

age amplifier, and others can dispense with the linear time-sweep oscillator and amplifier.

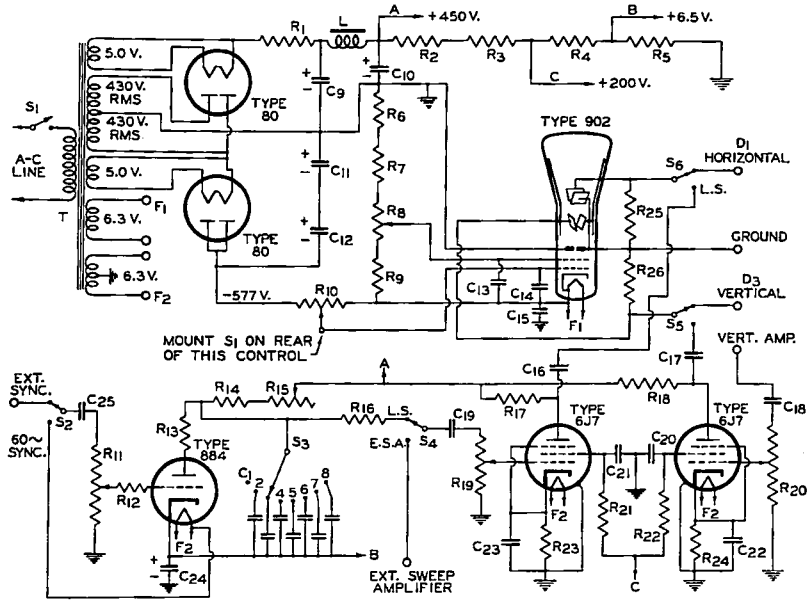
Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No. 1 voltage to anode No. 2 voltage. Ordinarily, the ratio is varied by adjustment of anode No. 1 voltage.

Spot intensity, for a given anode No. 2 voltage, can be varied by changing the control-electrode (grid) voltage.

Anode No. 2 voltage may be chosen from a range of values. As anode No. 2 voltage is increased, the spot intensity increases and the spot size decreases. The 902 will operate satisfactorily at lower anode voltages than the highest typical values shown but brilliance and definition decrease with decreasing anode No. 2 voltage. In general, anode No. 2 voltage should not be less than 400 volts. The maximum value shown under MAXIMUM RATINGS is an absolute value beyond which the usefulness of the tube may be impaired.

The anode No. 2 current should be reduced to the minimum consistent with the desired brilliance of the pattern. Where high brightness is an important consideration, the voltage applied to anode No. 2 may be increased to the maximum value. This procedure, however, is not always desirable since the greater speed of the electrons causes reduced deflection sensitivity while

OSCILLOGRAPH CIRCUIT WITH LINEAR SWEEP AND AMPLIFIERS



C_1 – STRAY CIRCUIT CAPACITANCE*
C_2 – 0.0008 μf, 500 V.
C_3 – 0.002 μf, 500 V.
C_4 – 0.005 μf, 500 V.
C_5 – 0.015 μf, 500 V.
C_6 – 0.05 μf, 500 V.
C_7 – 0.15 μf, 500 V.
C_8 – 0.25 μf, 500 V.
C_9 C_{10} C_{11} C_{12} – 8 μf, 475 V. (Working)
C_{13} C_{14} – 0.1 μf, 250 V.
C_{15} – 0.1 μf, 600 V.
C_{16} C_{17} – 0.25 μf, 500 V.
C_{18} C_{19} – 0.5 μf, 500 V.
$C_{20}C_{21}C_{25}$ – 0.25 μf, 250 V.
C_{22} C_{23} – 0.003 μf
C_{24} – 25 μf, 15 V.
R_1 – SEE NOTE 1
R_2 – 10000 OHMS, 2 WATTS
R_3 – 15000 OHMS, 2 WATTS
R_4 – 20000 OHMS, 5 WATTS
R_5 – 650 OHMS, 0.5 WATT
R6 R7 – 50000 OHMS, 1 WATT
R8 – 25000-OHM POTENTIOMETER
R9 – 15000 OHMS, 0.5 WATT
R10 – 25000-OHM POTENTIOMETER
R11 – 250000-OHM POTENTIOMETER
R12 – 25000 OHMS, 0.5 WATT
R13 – 500 OHMS, 0.5 WATT
R14 – 300000 OHMS, 0.5 WATT
R15 – 2-MEGOHM POTENTIOMETER
R16 – 1 MEGOHM, 0.5 WATT
R17 – 70000 OHMS, 1 WATT
R18 – 100000 OHMS, 1 WATT
R19 R20 – 0.5-MEGOHM POTENTIOMETER
R21 R22 – 200000 OHMS, 0.5 WATT
R23 R24 – 1000 OHMS, 0.5 WATT
R25 R26 – 2 MEGOHMS, 0.5 WATT
L – 30 HENRYS, 15 MA.
T – POWER TRANSFORMER
S_1 – A-C LINE SWITCH
S_2 S_4 – S.P.D.T. SWITCH
S_3 – S.P. 8-POINT SWITCH
S5 S6 – S.P.D.T. LOW-CAPACITY SWITCH

NOTE 1: Choose values of R_1 to give 450 volts at point A. Start with 10000 ohms and decrease value until desired voltage is obtained. This method protects condensers C_9 and C_{10} from excessive voltage.

* The 884 will not oscillate when S_3 is set at C_1. This point may be used to stop the saw-tooth oscillator when the linear sweep is not being used.

The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

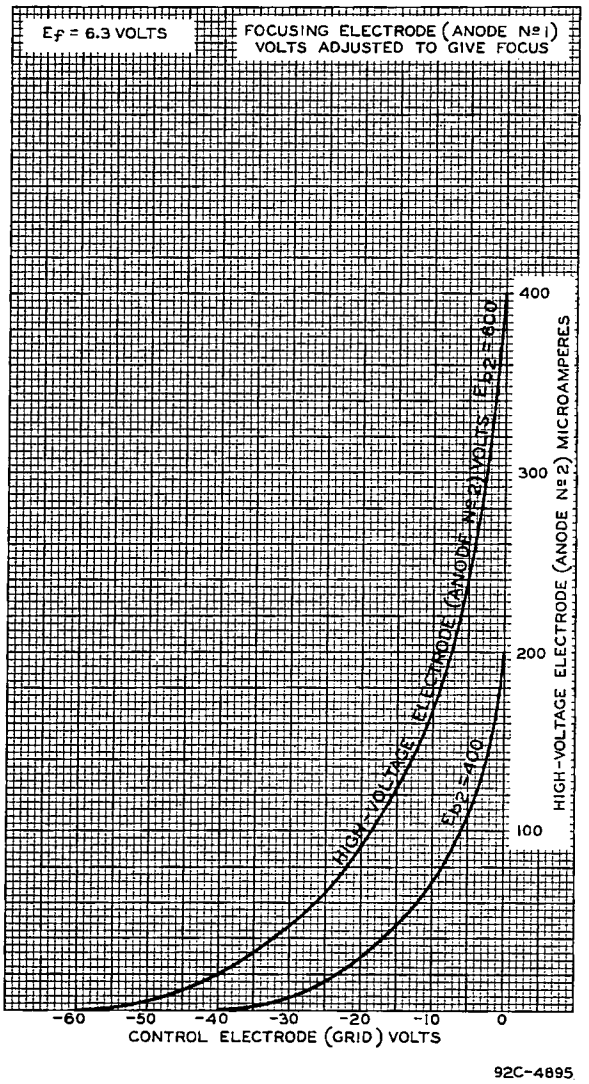
reduced electron speed results in improved spot size and prevents burning of the screen.

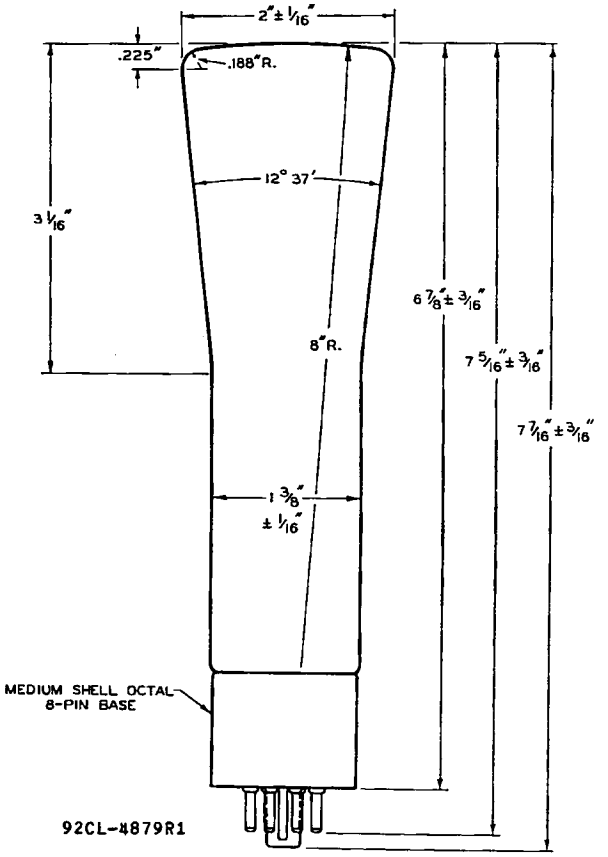
It is important to note that a high-intensity spot will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the beam be kept in motion over a reasonably large area by the application of voltage to the deflecting electrodes or that the brilliance be reduced to a low value by adjustment of the grid voltage.

Photographs of the phenomena under observation can be made with an ordinary camera. The photographing is done preferably in a subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the screen. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, the magnification of the pattern and the brightness of the pattern. Where transients are to be photographed, maximum brightness and a short exposure are required; where recurrent wave forms are to be photographed, patterns having low brightness can be compensated for by longer exposure. The use of film having high green sensitivity is recommended; orthochromatic types of emulsion have been found to give excellent results.

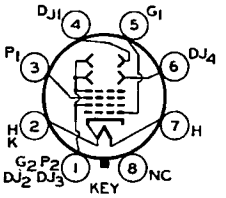
For high-speed photographic work involving non-recurrent phenomena, it is permissible to increase the trace brightness for the short interval required to make the exposure, above that required for visual observation. The extent to which the anode No.2 current may be increased without harming the screen is proportional to the velocity of beam travel and pattern size, and an inverse function of the duration of the phenomenon. Short-interval operation at increased current can be obtained by means of a temporary decrease in the control-electrode voltage. A switching arrangement should be provided to switch the control-electrode voltage rapidly between a negative and a less negative value. The exposure is made while the control-electrode voltage is at the less-negative value.

AVERAGE CHARACTERISTICS





BOTTOM VIEW of SOCKET CONNECTIONS



DJ_1 to DJ_4 – Deflecting Electrodes
P_2 – Anode No.2
P_1 – Anode No.1
G_2 – Grid No.2
G_1 – Grid No.1
H – Heater
K – Cathode
NC – No connection

RMA release # 399,
Feb. 21, 1945

905

CATHODE-RAY TUBE

Five-Inch Electrostatic-Deflection Type

RCA-905 is a high-vacuum cathode-ray tube with a fluorescent viewing screen five inches in diameter. This tube, designed for oscillographic applications, is provided with two sets of electrostatic electrodes for deflection of the electron beam. The 905 produces a brilliant luminous spot having a greenish hue, and is suitable for the observation and photography of recurrent and transient phenomena.

The electron source of the 905 is a substantial cathode, indirectly heated. The cathode, grid, and two anodes constitute an electron gun which projects an electron beam upon the fluorescent screen. The resulting luminous spot, easily visible in a normally lighted room, can be regulated as to size and intensity by a suitable choice of electrode voltages.

The two sets of electrostatic electrodes in the bulb neck produce fields at right angles to each other and, consequently, deflections at right angles. By their use, the luminous spot can be deflected to any part of the screen.

The 905 is recommended for use in oscillographic applications where the inertialess character of the electron beam, electrostatic deflection, and a brilliant image of the phenomena under observation are of importance.

GENERAL

HEATER VOLTAGE (A.C or D.C.)	2.5 Volts
HEATER CURRENT	2.1 Amperes
FOCUSING METHOD	Electrostatic
DEFLECTION METHOD	Electrostatic
Electrodes DJ_1 and DJ_2 (upper): nearest to screen	
Electrodes DJ_3 and DJ_4 (lower): nearest to base	
DJ_1 is on same side of tube as pin 3	
DJ_3 is on same side of tube as pin 2	
PHOSPHOR	No.1
FLUORESCENCE	Green
PERSISTENCE	Medium
DIRECT INTERELECTRODE CAPACITANCES (Approx.):	
Control Electrode to All Other Electrodes	9.0 μμf
Deflecting Electrode DJ_1 to Deflecting Electrode DJ_2	2.0 μμf
Deflecting Electrode DJ_3 to Deflecting Electrode DJ_4	1.0 μμf
OVERALL LENGTH	16-1/2" ± 3/8"
BULB DIAMETER AT SCREEN END	5-1/4" + 1/16" - 3/32"
MINIMUM USEFUL SCREEN DIAMETER	4-1/2"
CAPS (four)	Small
BASE	Long Shell Medium 5-Pin MICANOL

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

ANODE NO.2 (High-Voltage Electrode) VOLTAGE	2200 max. Volts
ANODE NO.1 (Focusing Electrode) VOLTAGE	660 max. Volts
GRID (Control Electrode) VOLTAGE RANGE	0 (never positive) to -125 max. Volts
PEAK VOLTAGE BETWEEN ANODE NO.2 and ANY DEFLECTING ELECTRODE	1100 max. Volts
GRID-CIRCUIT RESISTANCE	1.5 max. Megohms

TYPICAL OPERATION:			
Anode No.2 Voltage *	1500	2000	Volts
Anode No.1 Voltage for Focus at 75% of Grid Voltage for Cut-Off #	338	450	Volts
Grid Voltage for Visual Cut-Off ##	-26	-35	Volts
Deflection Sensitivity:			
DJ_1 and DJ_2	0.295	0.221	mm/volt d.c.
DJ_3 and DJ_4	0.349	0.262	mm/volt d.c.
Deflection Factor:			
DJ_1 and DJ_2	86.2	115	volts d.c./in.
DJ_3 and DJ_4	72.7	97	volts d.c./in.
Subject to variation of	±20	±20	per cent

* Brilliance and definition decrease with decreasing anode voltage. In general, anode voltage should not be less than 1500 volts.

\# Individual tubes may require between +25% and -30% of these values with grid voltage between zero and cut-off.

\## Visual extinction of stationary focused spot. Supply should be adjustable to ±50% of these values.

INSTALLATION

The *base* pins of the 905 fit a standard, five-contact socket which may be mounted to hold the tube in any position. The socket alone, however, should not be used to support the tube. Other support, such as a yoke or saddle arrangement should be used near the screen end of the tube. The socket should be made of good insulating material; a type having insulating baffles between contacts provides an additional factor of safety.

The *bulb* of this type, except for the screen surface, should be enclosed in a grounded metal case. If an iron or steel case is employed to minimize the effect of extraneous fields on tube operation, care should be taken to insure that the case is completely demagnetized.

The *heater* is designed to operate at 2.5 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage between the heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

The *cathode* is connected within the tube to one side of the heater and to base pin 5 to which grid and anode returns should be made.

The *fluorescent screen* employed in the 905 is of the phosphor No.1 (medium persistence) type. It has good visual and photographic qualities as well as high luminous efficiency.

The *d-c supply voltages* for the electrodes may be conveniently obtained from a high-voltage, vacuum-tube rectifier. Since a cathode-ray tube requires very little current, the rectifier system can be of either the half-wave or the voltage doubler type. Likewise, the filter requirements are simple. A 0.5 to 2 μf condenser will ordinarily provide sufficient filtering. If this

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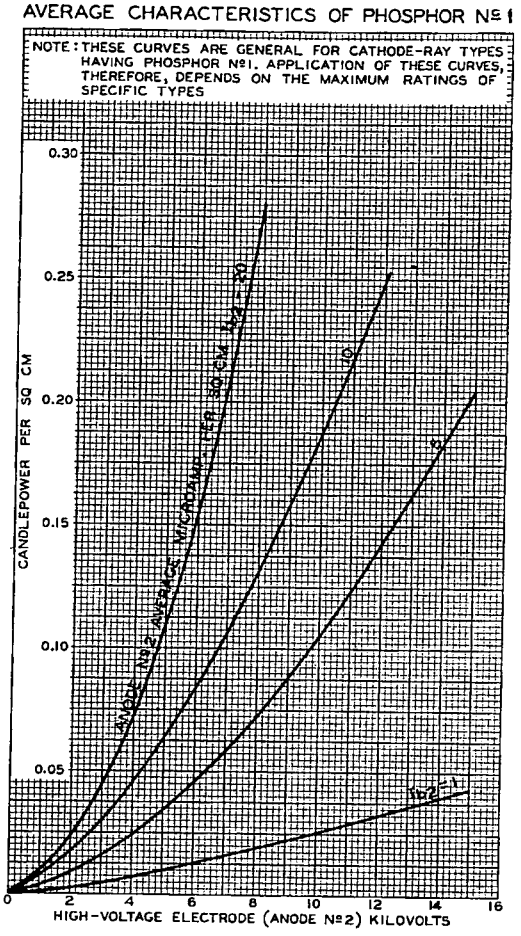
905-12-43
Photolithographed in U.S.A.

is inadequate for a particular application, a two-section filter is recommended.

AVERAGE CHARACTERISTICS OF PHOSPHOR Nº 1

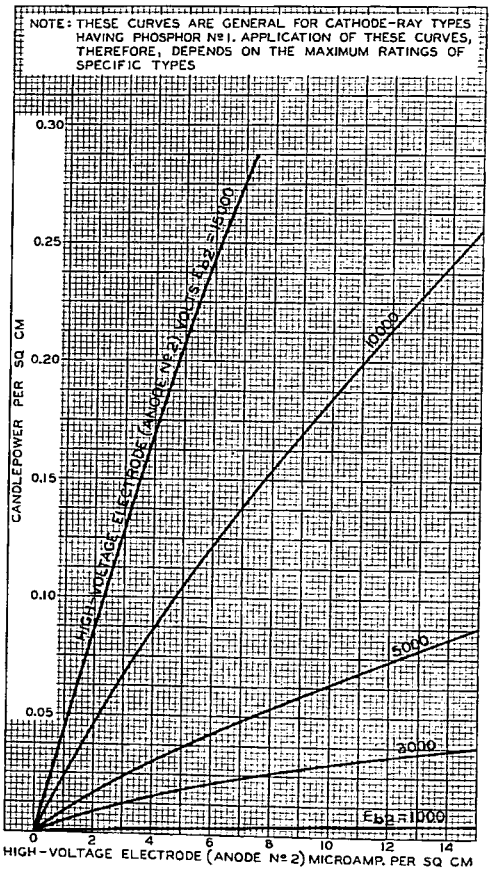


Two sets of *electrostatic electrodes*, producing fields at right angles, are located within the bulb neck to provide for deflection of the electron beam. The electrostatic field of each pair of deflecting electrodes deflects the beam parallel to the lines of the field; therefore, the deflections produced by the two fields are at right angles. In order to maintain each set of electrodes at essentially the d-c potential of anode No.2, each electrode of each set should be connected through a resistor of up to ten megohms to the anode No.2 socket terminal (ordinarily grounded). This arrangement permits a choice of resistor value such that the electron beam is not distorted by d-c potentials built up on the deflecting electrodes. If, during operation, the zero axis should be permanently deflected, it is usually because the beam current is too high for the resistors used. The beam current should ordinarily be kept low. At times when it is necessary to use a high value, such as when photographs are taken, the value of the deflecting-electrode resistors should be reduced so that the zero-axis shift will not carry the spot off the viewing screen. Where only a small shift in the spot is required, one resistor of each pair of the deflecting-electrode resistors can be connected to a d-c bias voltage to compensate for the shift.

The deflection sensitivity of each set of electrodes for typical anode No.2 voltages is given under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

The high voltages at which the 905 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions include the enclosing of high-potential terminals and the use of "interlock" switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required. In most installations it is recommended that the positive high-voltage terminal be grounded, rather than the cathode terminal. With this method, which places the cathode and heater at a high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

AVERAGE CHARACTERISTICS OF PHOSPHOR Nº 1



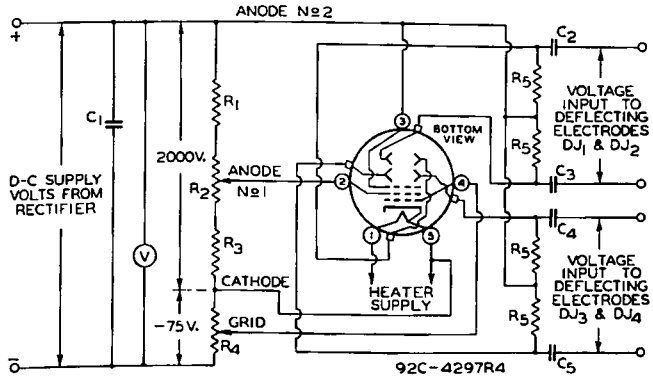
In the use of cathode-ray tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit, due to condenser breakdown or to incorrect circuit connections. Therefore, before any part of a cathode-ray tube circuit or its associated circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded.

APPLICATION

The cathode-ray oscillograph is an instrument adaptable to a wide variety of applications. A few of the more important are: the study of wave shapes and transients, measurement of modulation and peak voltages, adjustment of radio receivers, comparison of frequencies, and the indication of balance in bridge circuits.

A diagram illustrating the *essential circuit* for the use of the 905 in an oscillograph is shown below. The electrode voltages are obtained from a bleeder circuit connected across the high-voltage supply. A bleeder current of one or two milliamperes is usually satisfactory; considerably larger values may require the use of

TYPICAL OSCILLOGRAPH CIRCUIT



C_1 – FILTER CONDENSER 0.5 TO 2 μf
C_2 C_3 C_4 C_5 – SEE NOTE BELOW
R_1 – 0.45 MEGOHM
R_2 – 0.10 MEGOHM
R_3 – 0.125 MEGOHM
R_4 – 0.025 MEGOHM
R_5 – SEE TEXT, PAGE 2
V – VOLTMETER

NOTE: When the cathode or the negative end of the cathode-ray high-voltage supply is grounded, blocking condensers $C_2C_3C_4C_5$ should have a high voltage rating. When anode No.2 is grounded, condensers $C_2C_3C_4C_5$ may be low-voltage condensers.

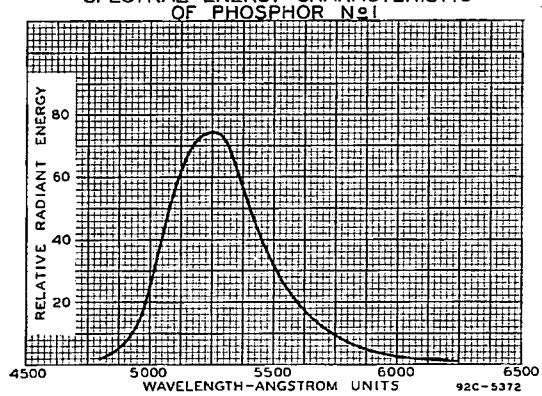
more filtering than that provided by a single condenser shunted across the d-c supply. With small bleeder currents, a single condenser filter is usually adequate. A variable d-c voltage for the control electrode and for anode No.1 can be obtained from potentiometers in the bleeder circuit. One set of electrostatic deflecting electrodes is used for the phenomena under observation; the other set, for the sweep, which serves to spread the tracing across the fluorescent screen.

Focusing of the fluorescent spot produced by the beam is controlled by adjustment of the ratio of anode No.2 voltage to anode No.1 voltage. Ordinarily, the ratio is varied by adjustment of anode No.1 voltage.

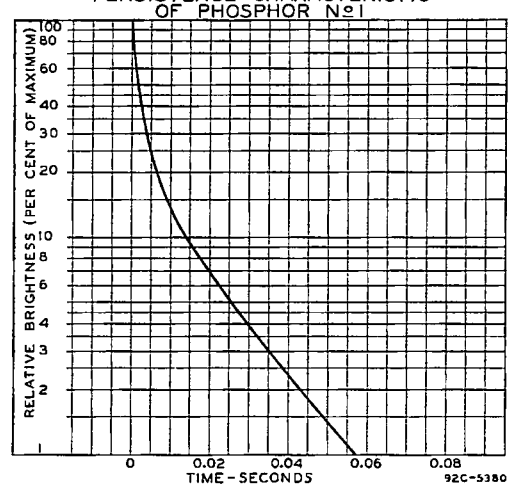
Regulation of *spot size* and *intensity* can be accomplished by varying anode No.2 current and/or voltage. The current to anode No.2 may be increased by decreasing the bias voltage applied to the control electrode (grid). An increase in anode No.2 current increases the size and intensity of the spot. An increase in the voltage applied to anode No.2 increases the beam current and the sharpness of focus and, therefore, the spot intensity. When any of these adjustments are made, consideration should be given to the absolute maximum voltage ratings shown under MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS.

In applications involving *extremely accurate measurements*, the anode No.2 current should be reduced to the minimum value consistent with the desired brilliance of pattern. Where high brightness is an important consideration, the voltage applied to anode No.2 may be increased to the maximum rated value. This procedure, however, is not always desirable since the greater speed of the electrons in the beam causes reduced deflection sensitivity.

SPECTRAL ENERGY CHARACTERISTIC OF PHOSPHOR N°1



PERSISTENCE CHARACTERISTIC OF PHOSPHOR N°1



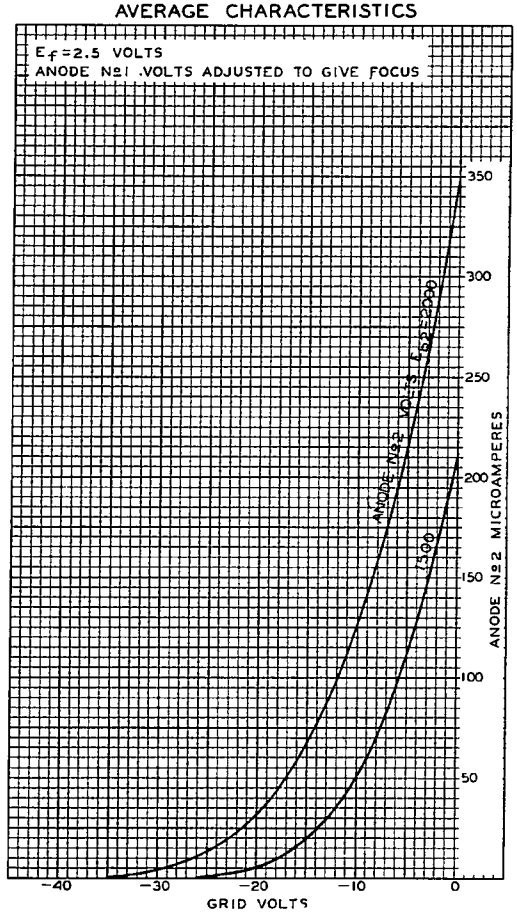
92C-4578

It is important to note that a beam producing a high-intensity spot will burn the fluorescent screen if the spot is allowed to remain stationary. To prevent this possibility, it is recommended that the *beam be kept in motion* by the application of voltage to the deflecting plates or that the brilliancy be reduced to a low value by adjustment of the control-electrode voltage. The spot may also be prevented from burning the screen by removal of the voltage from anode No.2.

Photographs of the phenomena appearing on the

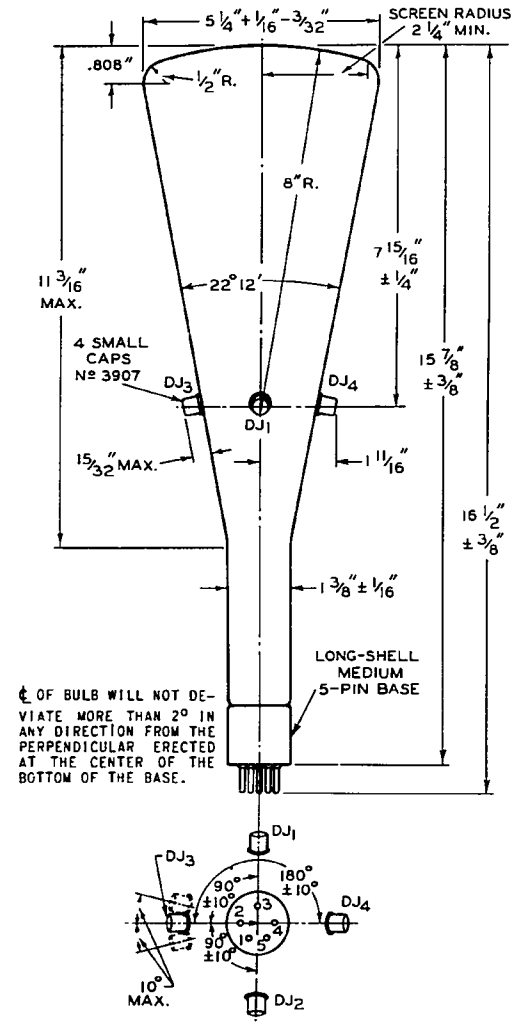
viewing screen of the 905 can be made with an ordinary camera. The photographing is done preferably in subdued light in order to obtain as much contrast as possible between the fluorescent pattern and the background. The time of exposure will depend on the speed of the camera lens, the kind of film or plate emulsion used, the magnification of the pattern, and the brightness of the pattern. Where transients are to be photographed, maximum brightness and a short exposure are required; where recurrent wave forms are to be photographed, patterns having low brightness can easily be compensated for by longer exposure. The use of panchromatic film may be preferable due to its greater sensitivity at the longer wavelengths of the light spectrum, although verichrome film gives excellent results.

AVERAGE CHARACTERISTICS



92C-5409R3

For *high-speed photographic work* involving non-recurring phenomena, it is permissible to increase the screen input power per sq cm, for the short interval required to make the exposure, above that required for visual observation. The extent to which the anode No.2 current may be increased without harming the screen is a direct function of the rate of beam travel and pattern size, and an inverse function of duration. Short-interval operation at increased input can be obtained by means of a temporary decrease in the control-electrode voltage. A switching arrangement should be provided to switch the control-electrode voltage rapidly between a negative and a less negative value. The exposure is made while the control-electrode voltage is at the decreased (less negative) value.

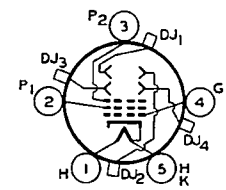


BOTTOM VIEW OF TUBE

THE PLANE THROUGH THE TUBE AXIS AND PIN 3 MAY VARY FROM THE TRACE PRODUCED BY DJ_1 AND DJ_2 BY AN ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF 10°; ANGLE BETWEEN DJ_1-DJ_2 TRACE AND DJ_3-DJ_4 TRACE IS 90° ± 6°.

92C-4283R8

Bottom View of Socket Connections



DJ_1 to DJ_4 – DEFLECTING ELECTRODES
P_2 – ANODE No.2
P_1 – ANODE No.1
G – GRID
K – CATHODE
H – HEATER

The license extended to the purchaser of tubes appears in the License Notice accompanying them. Information contained herein is furnished without assuming any obligations.

RMA Release # 400

March 21, 1945

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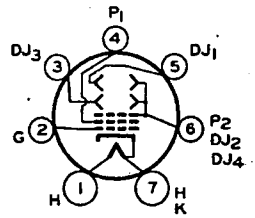
HIGH-VACUUM CATHODE-RAY TUBE

General:

Heater, for Unipotential Cathode:		
Voltage	2.5 ± 10%	ac or dc volts
Current	2.1	amp.
Direct Interelectrode Capacitances:		
Grid to All Other Electrodes	9.0	μμf
DJ_1 to All Other Electrodes	8.5	μμf
DJ_3 to All Other Electrodes	6.5	μμf
Phosphor		No. 5
Fluorescence		Bluish
Persistence	Brightness negligible in less than 30 microseconds	
Focusing Method		Electrostatic
Deflection Method		Electrostatic
Overall Length		11-1/2" ± 3/8"
Greatest Diameter of Bulb		3" ± 1/16"
Minimum Useful Screen Diameter		2-3/4"
Mounting Position		Any
Base		Medium 7-Pin
Basing Designation for BOTTOM VIEW		7AN

Pin 1 – Heater
Pin 2 – Grid
Pin 3 – Deflecting Electrode DJ_3
Pin 4 – Anode No.1
Pin 5 – Deflecting Electrode DJ_1
Pin 6 – Anode No.2, Deflecting Electrodes DJ_2 & DJ_4
Pin 7 – Heater, Cathode



DJ_1 and DJ_2 are nearer the screen
DJ_3 and DJ_4 are nearer the base

With DJ_4 (pin 6) positive with respect to DJ_3 (pin 3), the spot is deflected approximately toward pin 6. With DJ_2 (pin 6) positive with respect to DJ_1 (pin 5), the spot is deflected approximately toward pin 1.

The angle between the trace produced by DJ_3 and DJ_4 and its intersection with the plane through the tube axis and pin 6 does not exceed 10°.

The angle between the trace produced by DJ_3 and DJ_4 and the trace produced by DJ_1 and DJ_2 is 90° ± 3°.

Maximum Ratings, *Absolute Values*:

ANODE No.2 VOLTAGE	1650 *max.*	volts
ANODE No.1 VOLTAGE	1100 *max.*	volts
GRID (CONTROL ELECTRODE) VOLTAGE RANGE	0 *(never +)* to −125 *max.*	volts
PEAK VOLTAGE BETWEEN ANODE No.2 and ANY DEFLECTING ELECTRODE	660 *max.*	volts

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RCA

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HIGH-VACUUM CATHODE-RAY TUBE

(continued from preceding page)

Typical Operation and Characteristics:

Anode No.2 Voltage *	1000	1500	. . . volts
Anode No.1 Voltage for Focus at 75% of Grid Voltage for Cutoff •	285	430	approx. volts
Grid Voltage for Visual Cutoff # . .	-33	-50	. . . volts
Max. Anode No.1 Current **	—	1330	microamp.
Deflection Sensitivity:			
DJ_1 and DJ_2	0.33	0.22	. . mm/v dc
DJ_3 and DJ_4	0.35	0.23	. . mm/v dc
Deflection Factor: ▲			
DJ_1 and DJ_2	76	114	. v dc/in.
DJ_3 and DJ_4	73	109	. v dc/in.

* Brilliance and definition decrease with decreasing anode No.2 voltage. In general, anode No.2 voltage should not be less than 1000 volts.

• Individual tubes may require between +25% and -30% of the values shown with grid voltages between zero and cutoff.

Visual extinction of stationary focused spot. For cutoff, supply should be adjustable to ±50% of these values.

▲ Individual tubes may vary from these values by ±20%.

** Under conditions with anode No.2 volts = 1500, anode No.1 volts adjusted for focus, and grid volts = 0.

Spot Position:

The undeflected focused spot will fall within a 15-mm square centered at the geometric center of the tube face and having one side parallel to the trace produced by DJ_1 and DJ_2. Suitable test conditions are: anode No.2 voltage, 1500 volts; anode No.1 voltage, adjusted for focus; deflecting electrode resistors, 1 megohm each, connected to anode No.2; the tube shielded from all extraneous fields. To avoid damage to the tube, make the test with the grid voltage near cutoff.

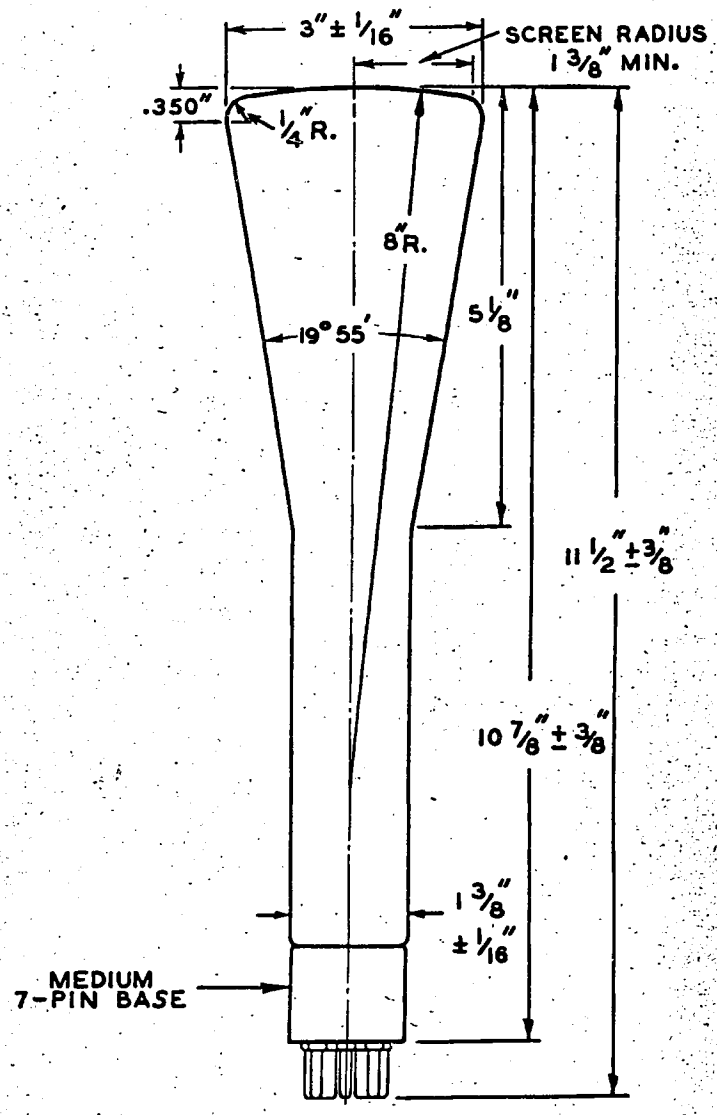
Maximum Circuit Values:

Grid-Circuit Impedance.	1.5 *max.* megohms
Impedance of Any Deflecting-Electrode Circuit at Heater-Supply Frequency	1.0 *max.* megohm
Resistance in Any Deflecting-Electrode Circuit	5.0 *max.* megohms

RCA

908

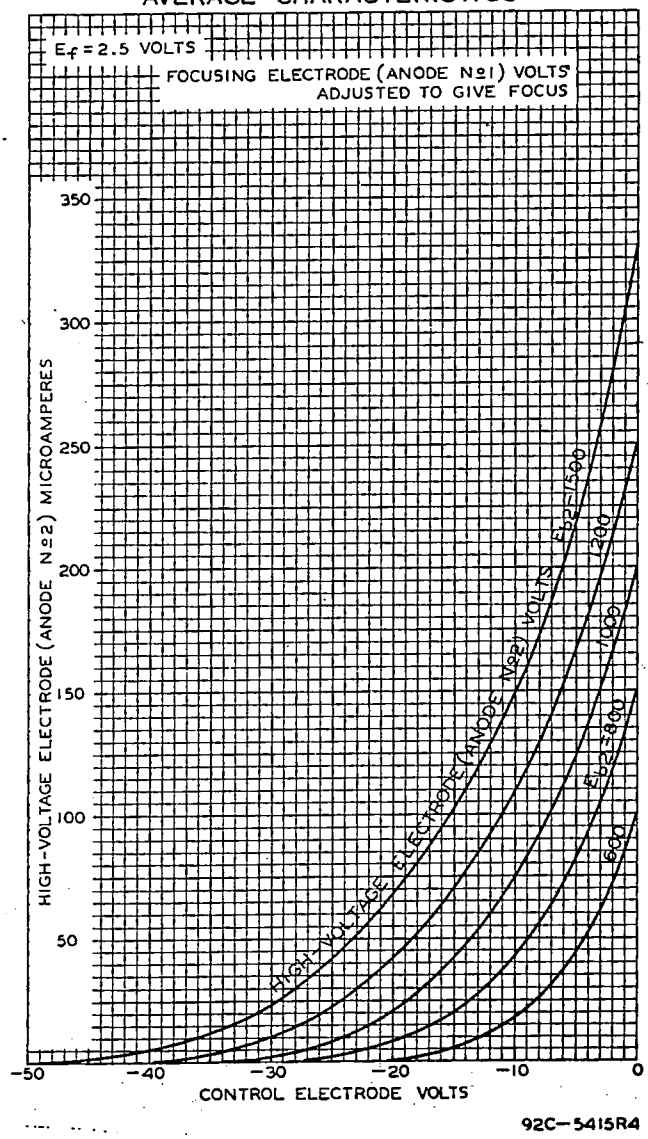
HIGH-VACUUM CATHODE-RAY TUBE



℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM PERPENDICULAR ERECTED AT CENTER OF THE BOTTOM OF THE BASE.

92CM-4284R7

AVERAGE CHARACTERISTICS



92C-5415R4

ORC 959

957 • 958 • 959

(Acorn* Types)

RCA-957, 958, and 959 are a new series of Acorn tubes having low-current filaments of the coated type. These tubes are designed for use by amateurs and experimenters working at the ultra-high frequencies. Their economy of filament and plate power and small sizes make them particularly useful in compact portable and other battery-operated equipment where minimum size and weight are important features. *The filament of each of these three types can be operated without series resistance directly from a single flashlight dry cell.*

The 957 is a triode having a moderately high amplification factor. It may be used as a detector, amplifier, and oscillator. The 958 is a triode especially designed for transmitting service as an oscillator and radio-frequency amplifier. It may also be used as an audio power output tube. Useful audio output for headphone operation may be obtained with plate voltage down to 45 volts, or lower. The 959 is a sharp cut-off pentode intended for use as an r-f amplifier and detector. It may also be used as a resistance-coupled a-f amplifier having moderate gain.

The excellent performance of these tubes at the ultra-high frequencies is due to an unconventional structure having small size, close electrode spacing, and short terminal connections.

TENTATIVE RATINGS and CHARACTERISTICS

	957	958	959	
FILAMENT VOLT. (D.C.)	1.25	1.25	1.25	Volts
FILAMENT CURRENT	0.05	0.10	0.05	Ampere
PLATE VOLT. (Max.)	135	135	135	Volts
SUPPRESSOR	-	-	**	
SCREEN VOLT. (Max.)	-	-	67.5	Volts
GRID VOLT. ##	-5	-7.5	-3	Volts
PLATE CURRENT	2	3	1.7	Milliamperes

*, **, ##: See end of tabulation.

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SCREEN CURRENT	–	–	0.4	Milliampere
PLATE RES.(Approx.)	24600	10000	800000	Ohms
AMPLIFICATION FACTOR	16	12	480	
TRANSCONDUCTANCE	650	1200	600	Micromhos
DIRECT INTERELECTRODE CAPACITANCES:				
Grid–Plate	1.8	2.6	0.015#	μμf
Grid–Filament	0.5	0.7	–	μμf
Plate–Filament	1.2	1.1	–	μμf
Input	–	–	1.8	μμf
Output	–	–	3	μμf
BULB	T–4½	T–4½	T–4½	
TERMINAL MOUNTING	Special	Special	Special	

* Registered trademark.
\# Connected to minus filament at mounting.
\# Maximum, with shield baffle.
Maximum resistance in grid circuit should not exceed 0.5 meg.

INSTALLATION and APPLICATION

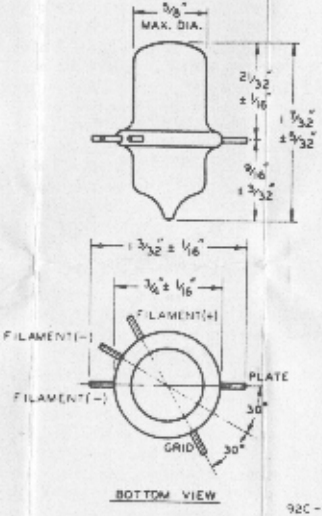
The *terminals* of these tubes fit the standard Acorn-tube mounting. A plate clip and a grid clip are supplied with the 959. Terminal connections are shown on pages 3 and 4. Since the tube terminals are located symmetrically, the socket should have a stop of insulating material opposite the center filament clip. This stop prevents insertion of the filament terminals in the wrong clips. The center filament terminal of each tube type is connected within the tube to the negative side of the filament. The terminal mounting of these tubes may be mounted to hold the tubes in either a vertical or a horizontal position. When the tubes are mounted in a horizontal position, the plate should be in a vertical plane (on edge). *Do not solder connections to the terminals.*

The *filament* of each of these types is designed for operation at 1.25 volts and can be operated without a series resistance directly from a dry cell. The negative filament terminal should be connected to the negative battery terminal. Parallel operation is recommended. Series operation is permissible if the current of each tube filament circuit is adjusted to its rated value by the use of a shunt resistor. For example, when the 958 is operated in series with the 957 and 959, shunt resistors of 25 ohms each should be connected across the filament terminals of the latter tubes. Series-parallel operation of these tubes is not recom-

mended because failure of one tube may cause excessive voltage across the other tubes.

R-F by-passing of the tubes at the socket terminals by means of high-quality condensers is essential in order to provide the shortest possible circuit returns and to realize the full capabilities of the tubes at the ultra-high frequencies. Conventional by-passing methods are not adequate. One convenient method of by-passing is to use ribbon leads to the clips and to insulate these by mica spacers to form by-pass condensers right at the tube terminals. It is important that the grid, plate, and screen circuits are by-passed to the negative filament terminal in order to avoid r-f interaction through common return circuits. It may also be advisable in some applications to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the returns or in the electrode supply leads.

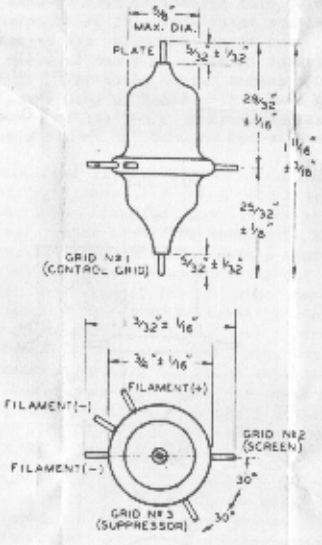
957, 958



92C-4998

RCA

959



BOTTOM VIEW

92C-5000

Note: This data sheet. does not actually exist. This data is the result of investigating RCA-1630 owned by itself. and data of literature are gathered in the format similar to RCA Receiving Tube Manual RC-13 (1937). However. all content is correct.
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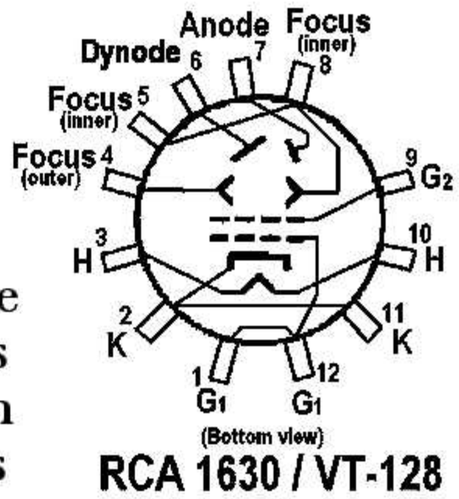
RCA-1630

U-H-F ORBITAL-BEAM HEXODE



RCA 1630 / VT-128

The RCA-1630(A-5588) is a Acorn type orbital-beam hexode well suited for use as a detector or r-f amplifier in ultra high frequencies receivers. The RCA-1630 is 6.3-volt heater-cathode types, designed for use by engineers and experimenters particularly at the u-h-f RADAR.

CHARACTERISTICS

(NOTE:Typical operating conditions for Developmental Multiplier Tube)

Heater voltage	6.3	volts
Heater current	0.3	ampere
Plate (output anode) voltage	370	volts
Secondary-emitter voltage	240	volts
Outer focusing-electrode voltage	0	volts
Inner focusing-electrode voltage	300	volts
Grgd No. 2 voltage	45	volts
Gnd No. 1 voltage	−1	volt
Plate current	12	milliamperes
Secondary-emitter current	9.5	milliamperes
Cathode current	3.5	milliamperes
Grid N o. 1-plate transconductance	15, 000	micromhos
Input capacitance	6.5	μμf
Output capacitance	3.5	μμf
Figure of merit	3100	micromhos per μμf

INSTALLATION AND APPLICATION

For INSTALLATION, reference to type 955; for APPLICATION, refer to VT-128.

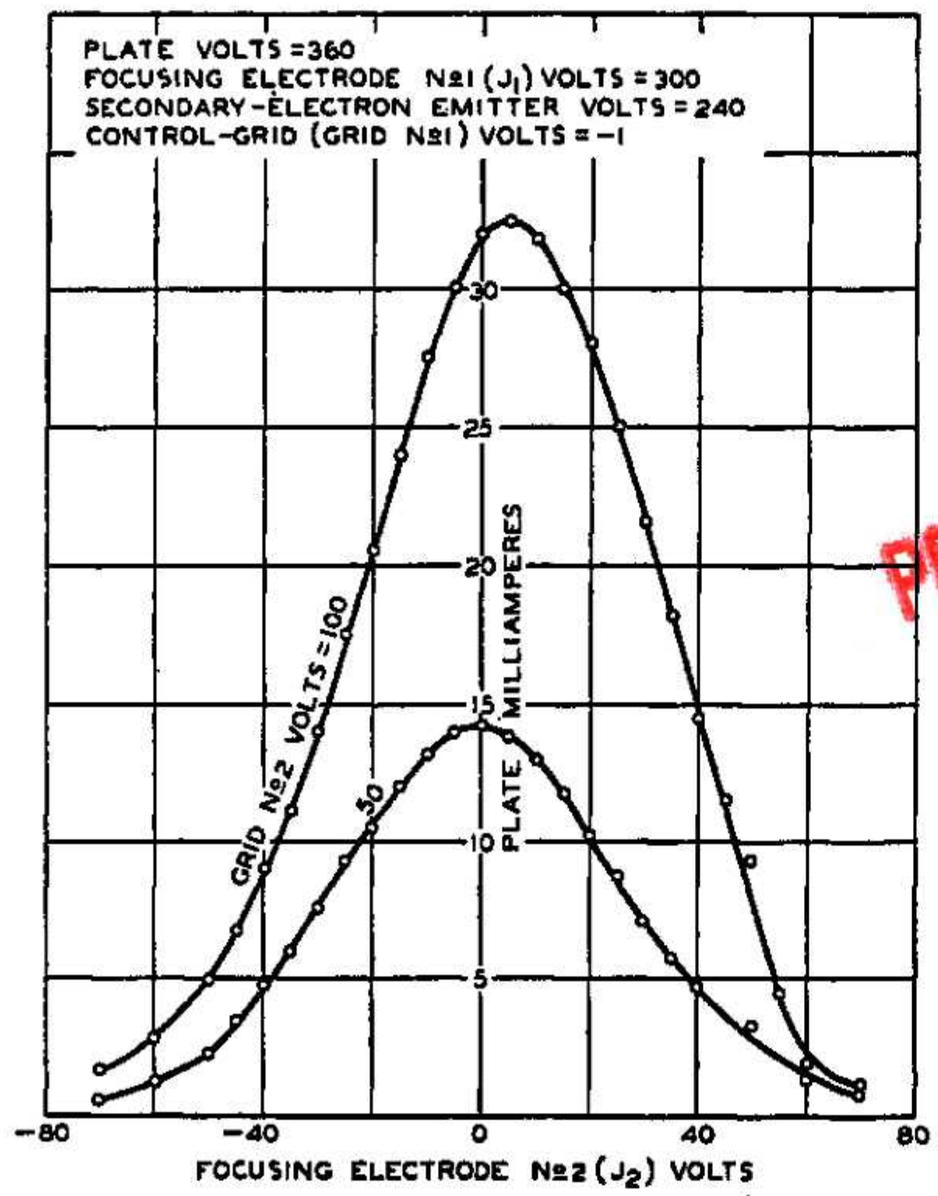


Fig. 3—Volume-control characteristic provided by deflection of the electron beam.

PRELIMINARY

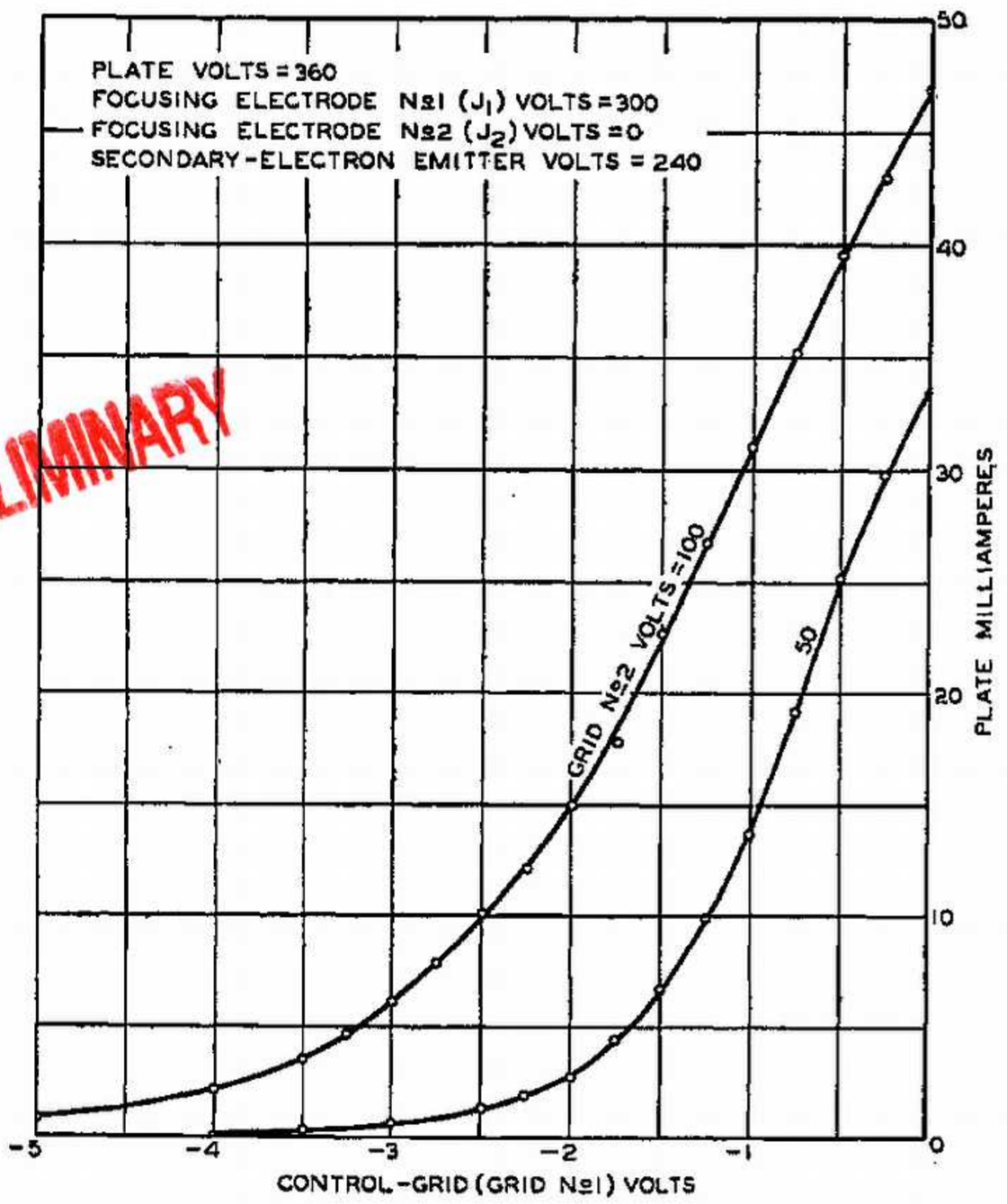


Fig. 4—Transfer characteristics of orbital-beam multiplier.

Note: This data sheet, does not actually exist. This data is the result of investigating RCA-1630 owned by itself, and data of literature are gathered in the format similar to RCA Receiving Tube Manual RC-13 (1937). However, all content is correct.

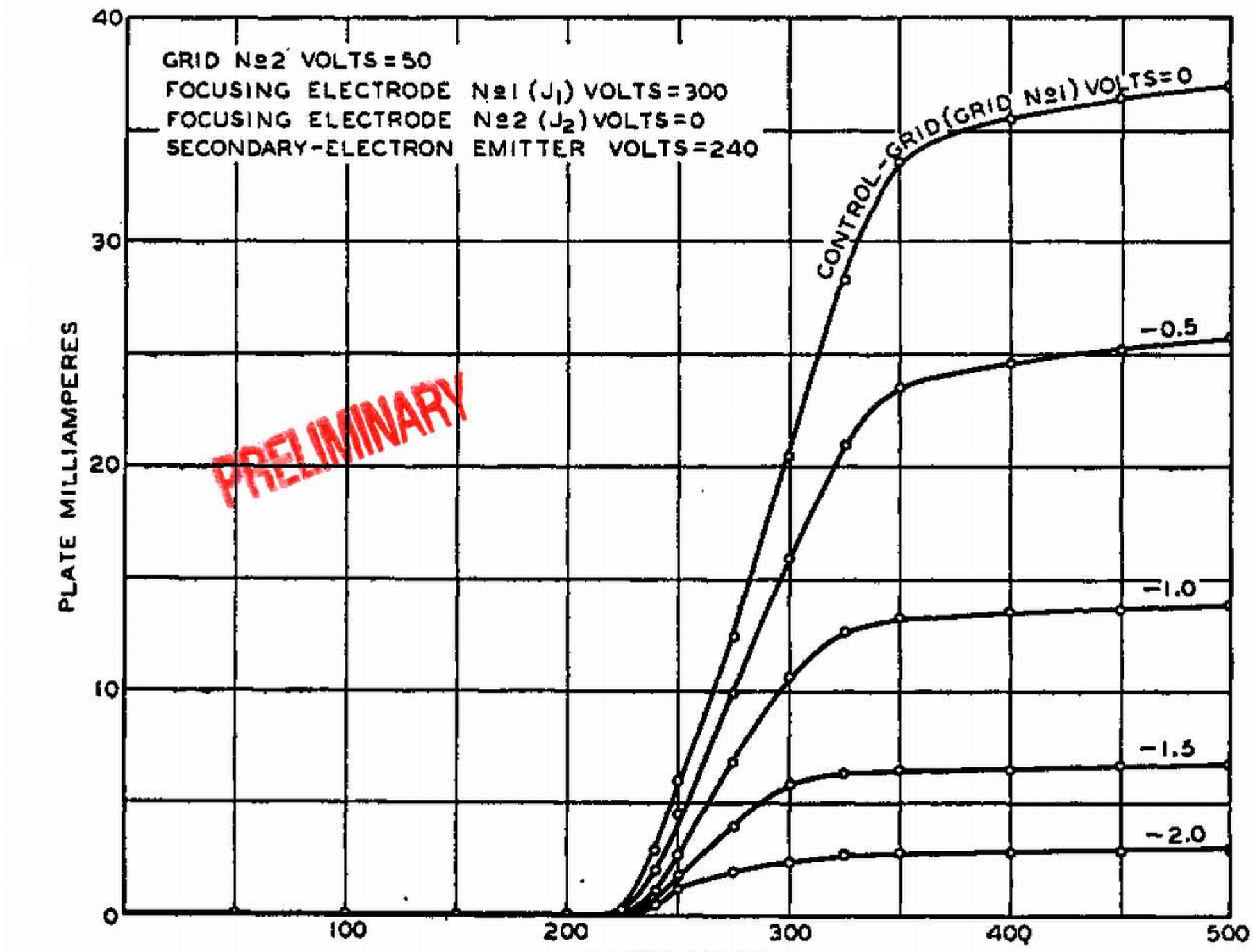


Fig. 5—Plate characteristics of orbital-beam multiplier.

Source: 1) 『The Orbital-Beam Secondary-Electron Multiplier for Ultra-High-Frequency Amplification』
Wagner, H.M.; Ferris, W.R.; (http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1694186)
Proceeding of Institute of Radio Engineers, Volume: 29 , Issue: 11 (1941), Page(s): 598-602
2) 『1630 /VT128 orbital-beam hexode』 Virtual Valve Museum, (http://www.tubecollector.org/1630.htm)
3) 『VT-128』 Radio Museum, (http://www.radiomuseum.org/tubes/tube_vt128.html)
4) 『真空管[エーコン管]物語』 JA2OP,JA1KGW/書山憲太郎さんのhp 真空管顛末記
(http://homepage2.nifty.com/kawoyama/tubestoryacorn.html)

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RMA Release # 389 Nov. 3, 1944

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U-H-F BEAM-DEFLECTION MIXER

1636

RCA-1636 is a mixer tube designed primarily for operation at the ultra-high frequencies from 400 to 600 megacycles. It employs a new principle in that the operation of the tube depends on the movement of an electron beam, by a pair of deflecting electrodes, across narrow apertures. The deflecting electrodes, because they are not in the electron stream, require very little power and, therefore, the input-circuit loading is low at the ultra-high frequencies. By this method of control, also, coupling between the input and the output circuits is reduced to a very low value. A well-defined electron beam and narrow apertures are used to obtain a high ratio of transconductance to effective beam current. In addition, the 1636 includes a single stage of secondary-emission multiplication to increase the overall transconductance. As compared with conventional tubes at the ultra-high frequencies, the 1636 is capable of providing a several-fold improvement in gain and a signal-to-noise ratio which is several db better.

Additional features of the 1636 are its low input capacitance together with short deflecting-electrode leads which permit the use of a relatively large external circuit, and the low power required from the local oscillator.

TENTATIVE DATA

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES:		
Each Deflecting Electrode to Grid-Anode	1	μμf
Deflecting Electrode DJ_1 to Deflecting Electrode DJ_2	1 max.	μμf
Dynode to Grid-Anode	1.4	μμf
OVERALL LENGTH	4-11/16" ± 1/8"	
MAXIMUM SEATED HEIGHT	4-1/4"	
RADIUS	1-1/8" ± 1/16"	
BULB	T-10-1/2	
CAPS (Three)	Terminals	
BASE	Medium Shell Octal 8-Pin	

Maximum Ratings Are Design-Center Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

GRID-ANODE (Grids No.2,3,4) VOLTAGE	300 max.	Volts
DYNODE VOLTAGE	250 max.	Volts
DEFLECTING ELECTRODE VOLTAGE (Focusing)	150 max.	Volts
GRID-ANODE DISSIPATION	3 max.	Watts
TYPICAL OPERATION:		
Grid-Anode Voltage	300	Volts
Dynode Voltage	240	Volts
Deflecting Electrode Focusing Voltage ##	140	Volts
Deflecting Electrode Centering Voltage *	-5 to+5	Volts
Cathode Shield (Grid No.1)	0	Volts
Cathode Bias	**	
Deflecting Electrode Voltage for Operation on Oscillator Fundamental Frequency	1 max.	Volt#

* Centering voltage is given with respect to deflecting-electrode focusing voltage.
\# Peak-to-peak volt.
** 1000-ohm cathode resistor is recommended.
\## Must be adjustable to ±15 volts in order to focus the electron beam.

BEAM-DEFLECTION MIXER CONSIDERATIONS

A beam-deflection mixer is a vacuum tube whose basis of operation is deflection control of an electron beam. In the 1636, a well-defined rectangular beam of electrons, focused on a barrier, is deflected across two narrow apertures by a signal voltage and a local oscillator voltage impressed on the deflecting electrodes.

The operation of the 1636 is most readily discussed with reference to Fig. 1 in which the essential parts are identified. The cathode, the cathode shield (Grid No.1), and the first and second apertures (Grids No.2 and 3) serve to produce, form and accelerate the electron beam. The deflecting electrodes move the beam across two parts of the third aperture (Grid No.4). In addition, the deflecting electrodes are used to focus and center the beam on the barrier in Grid No.4. Grids No.2, 3, and 4 are operated at a common positive voltage with respect to the cathode, and they are constructed in a single assembly in the tube. This assembly, called the grid-anode, takes its name from the combined functions of the three parts.

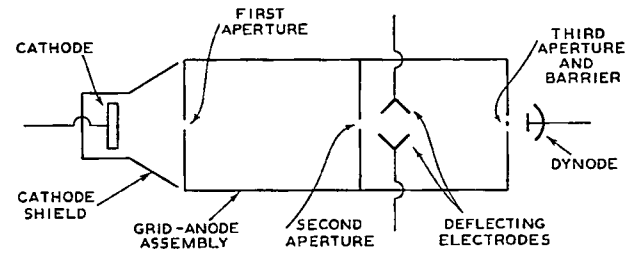


Fig. 1 - Schematic arrangement of type 1636 structure.

A dynode, or secondary-emission multiplier, is located just past the Grid No.4 so that it intercepts the electron beam when the beam is deflected to either side of the barrier in Grid No.4. Since the dynode is operated at a lower voltage with respect to the cathode than the grid-anode, secondary electrons from the dynode are attracted to the grid-anode. The output of the 1636 appears in the dynode, grid-anode circuit.

The apertures in Grid No.4 are formed by a barrier which divides a rectangular opening in the

center lengthwise. The barrier is lined up with the apertures in Grids No.2 and 3 so that it effectively blocks the electron beam, for the no-signal operating condition, from the dynode when the beam is centered and focused.

Emission from the dynode depends on the bombardment of the dynode by the electron beam. When the beam is deflected to either side of the barrier in Grid No.4, electrons will flow from the dynode to the grid-anode. As the beam is deflected further to either side, it is cut off from the dynode by the limits of the two apertures of Grid No.4. The output current characteristic for a properly centered and focused beam is then as shown in Fig. 2.

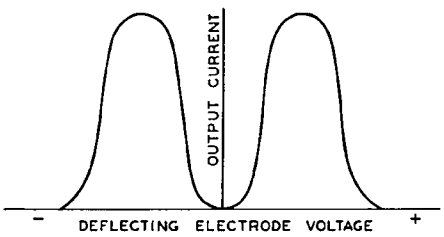


Fig. 2 - Proper output current characteristic.

Efficient operation of the 1636 depends on the ability of Grid No.4 to block or to pass all the electrons passing through the series of apertures. If the beam is not accurately focused on the barrier in Grid No.4, the quiescent output current will be high. External magnetic fields may so distort the beam that the apertures of Grid No.4 are scanned diagonally. Such operation will deform the output current characteristic as illustrated in Fig. 3.

The best operation of the tube is obtained by adjustment of the deflecting-electrode focusing and centering voltages to give the lowest minimum current between the two maximums. The two maximums should be about equal and the minimum should be but a small fraction of the maximum.

INSTALLATION

The *base* of the 1636 fits the standard octal socket which may be installed to hold the tube in any position. Connection to the dynode is made to the terminal at the top of the bulb, while connections to the deflecting electrodes are made to the two terminals at the side of the bulb. Leads to all of the terminals must be sufficiently flexible so that normal expansion will not place a strain on the glass at the seals. The lead wires whould be connected to the terminals by means of clamps attached to the leads before connections to the tube are made. The clamps should be sprung slightly so that they can be slipped on the terminals easily. Connections should never be soldered to the terminals as the heat of soldering may result in cracking of the seals. The terminals should never be used to support circuit parts.

The *heater* voltage, under any conditions of operation, should not be allowed to vary more than ± 10% from the rated value. Conventional heater-cathode circuits may be used.

The *cathode shield*, Grid No.1, may be operated either with a bias or connected directly to the cathode. A self-biasing resistor of 1000 ohms connected between shield and cathode is recommended. The cathode shield is then placed at ground potential.

The *deflecting electrodes*, in addition to the adjustable positive voltage (for focusing), should be supplied with an adjustable voltage for centering the beam on the barrier in Grid No.4. A range of plus or minus five volts is sufficient. The beam should not be allowed to remain stationary on the dynode longer than is necessary to make circuit adjustments.

The dynode is supplied with a positive voltage somewhat lower than that of grid-anode.

APPLICATION

As a mixer, the 1636 may be operated on the fundamental of the local oscillator, or on the second or third harmonic of the local-oscillator frequency. This flexibility is made possible by the nature of the output-current, deflecting-electrode-voltage characteristic. Operation on the fundamental frequency of the local oscillator is recommended because of the better signal-to-noise ratio.

A typical mixer circuit is shown in Fig. 4. The signal voltage and the local oscillator voltage are both impressed across the deflecting electrodes. The input circuit may consist of a

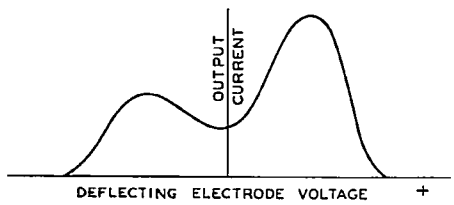


Fig. 3 - Deformed output current characteristic.

balanced line arranged to that d-c voltages may be fed to the deflecting electrodes. The line should be well shielded to minimize radiation loss. Adjustment of the circuit for best operation should begin with the deflecting-electrode voltages. With voltages of approximately the values shown under TYPICAL OPERATING CONDITIONS applied to the tube, the deflecting-electrode focusing and centering voltages should be adjusted simultaneously for the lowest current at the minimum-current point of the characteristic curve (see Fig. 2). This operation focuses and centers the beam on the barrier in Grid No.4.

Apply a signal voltage and tune the input circuit for the maximum step-up from the input line as indicated by an increase in output current.

This may be done easily with a signal in the order of 20 millivolts and without the local oscillator in operation. The local oscillator is then coupled to the input circuit and its frequency and amplitude are adjusted so that the dynode current is from 10 to 20 per cent of the maximum

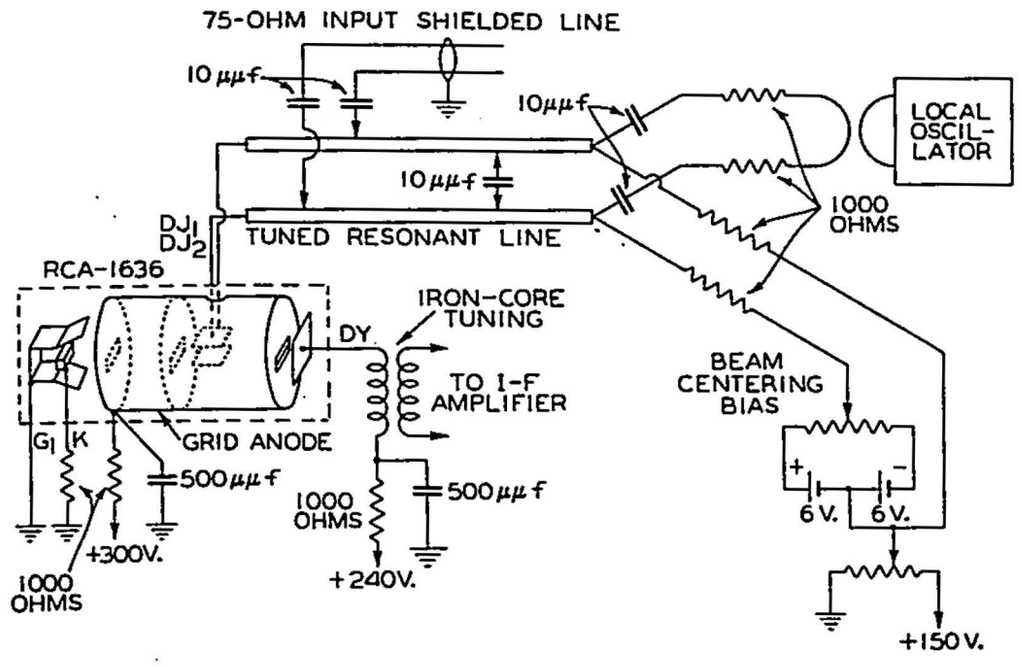


Fig. 4 - Typical mixer circuit for RCA-1636.

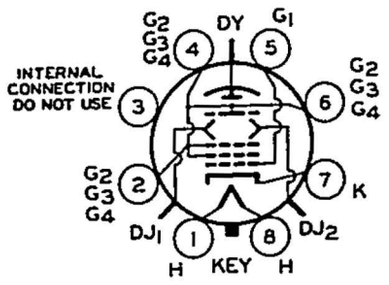
instantaneous dynode current (current at the maximum-current point of the characteristic curve Fig. 2). A final adjustment of the deflecting-electrode focusing and centering voltages for the condition producing the best gain should be made.

The *signal-to-noise ratio* can be improved by increasing the signal input coupling slightly higher than for the condition producing the maximum gain. The local oscillator output should be slightly lower than for maximum gain.

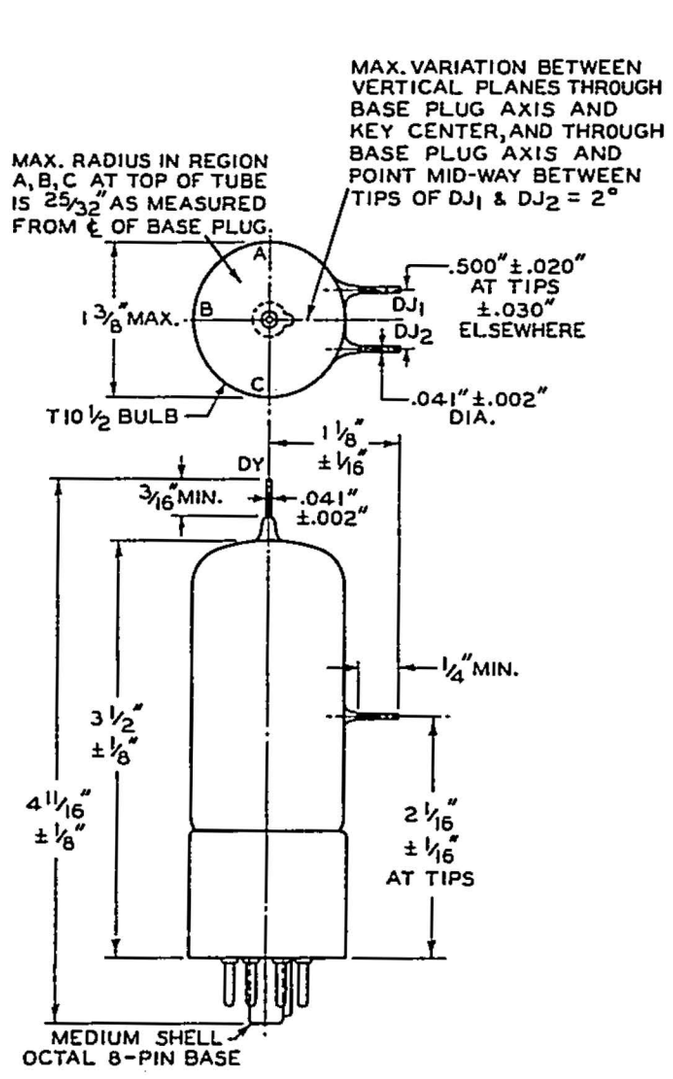
Second-harmonic operation requires that the beam centering voltage on the deflecting electrodes be adjusted to a point of maximum slope on the characteristic curve. Local oscillator excitation must be increased over that needed for operation on the fundamental. Third harmonic operation is obtained with the same centering adjustment as for fundamental operation but twice the oscillator excitation is required. Operation on either the second or third harmonic results in slightly less gain than with fundamental operation and a signal-to-noise ratio which is considerably poorer.

The equivalent noise voltage of a receiver using this tube in the first stage is in the order of 13 db above the thermal noise of a dummy antenna when the tube is used at oscillator fundamental in the frequency range for which it was designed (400 to 600 mc). This is about 3 db better than the capability of any commercial type previously available for use at the ultra-high frequencies.

Bottom View of Socket Connections



DY = DYNODE
DJ_1, DJ_2 = DEFLECTING ELECTRODES
G_1 = CATHODE SHIELD
G_2, G_3, G_4 = GRID-ANODE
H = HEATER
K = CATHODE



92C-6335

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from RTMA release #944, Feb. 15, 1951

1850-A

ICONOSCOPE

RCA-1850-A is a television camera tube recommended particularly for pickup from motion-picture film or slides. It requires a steady highlight illumination of 4 to 6 foot-candles on the mosaic for slides and an average value of pulsed highlight illumination of 10 to 20 foot-candles for motion-picture film.

The photosensitive mosaic of the 1850-A is characterized by a spectral response having good sensitivity over the entire visible spectrum. Maximum sensitivity occurs in the blue region as shown by the spectral-response curve in Fig. 1.

The 1850-A has a very high ratio of signal to noise but relatively low sensitivity. In applications where higher sensitivity is desired, as in outdoor and studio live pickups, the use of an image orthicon is recommended.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitances (Approx.):		
Grid No.1 to All Other Electrodes	6.5	μμf
Signal Electrode to Grid No.4 (With external shield)	10	μμf
Mosaic, Photosensitive:		
Response	See Fig.1	
Useful Size of Rectangular Image (4 x 3 Aspect Ratio)	5.75" max. diagonal	
Focusing Method	Electrostatic	
Deflection Method	Magnetic	
Deflection Angle (Approx.)	55°	
Max. Width of Mounted Tube	8-1/8"	
Height of Mounted Tube	10-3/16" ± 3/4"	
Depth of Mounted Tube	12-13/16" ± 3/4"	
Caps (Two)	Medium (JETEC No.C1-5)	
Base	Long Medium-Shell Small 6-Pin	
Mounting Position	Mosaic in vertical plane	
Minimum Deflecting-Coil Inside Diameter	1-1/2"	
Maximum Deflecting-Coil Length	2-1/4"	

Maximum Ratings, *Absolute Values*:

AVERAGE MOSAIC ILLUMINATION●	50 max.	ft-c
OPERATING TEMPERATURE OF BULB AT LARGE END OF TUBE	40 max.	°C
SIGNAL-ELECTRODE VOLTAGE	1200 max.	volts
GRID-No.4 (COLLECTOR) VOLTAGE	1200 max.	volts
GRID-No.3 VOLTAGE	450 max.	volts
GRID-No.2 VOLTAGE	1200 max.	volts

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Radio Corporation of America

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

1850-A-1-51
Photolithographed in U.S.A.

Maximum Ratings, *Absolute Values (Cont'd):*

GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
GRID-No.4 CURRENT	0.5 max.	μamp

Typical Operation and Characteristics:

Signal-Electrode Voltage	1000	volts
Grid-No.4 Voltage	1000	volts
Grid-No.3 Voltage (Beam Focus)—		
24% to 36% of Grid-No.4 Voltage	240 to 360	volts
Grid-No.2 Voltage	1000	volts
Max. Grid-No.1 Voltage for Pattern Cutoff—		
7% of Grid-No.4 Voltage	-70	volts
Grid-No.4 Current (With no illumination on mosaic)*	0.1 to 0.2	μamp
External Load Resistance	0.1	megohm
Illumination on Mosaic:		
Steady Highlight Value for Slides	4 to 6	ft-c
Average Pulsed Highlight Value for Motion-Picture Film	10 to 20	ft-c
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current (Approx.)	100	
Minimum Peak-to-Peak Blanking Voltage	20	volts
Deflecting-Coil Current (Approx.):**		
Horizontal (Peak to peak)	600	ma
Vertical (Peak to peak)	140	ma

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.0 max.	megohm

• Averaged over any interval of 1 sec. max.

* Allowance should be made for leakage currents.

** For RCA Deflecting Yoke Type No.201D76.

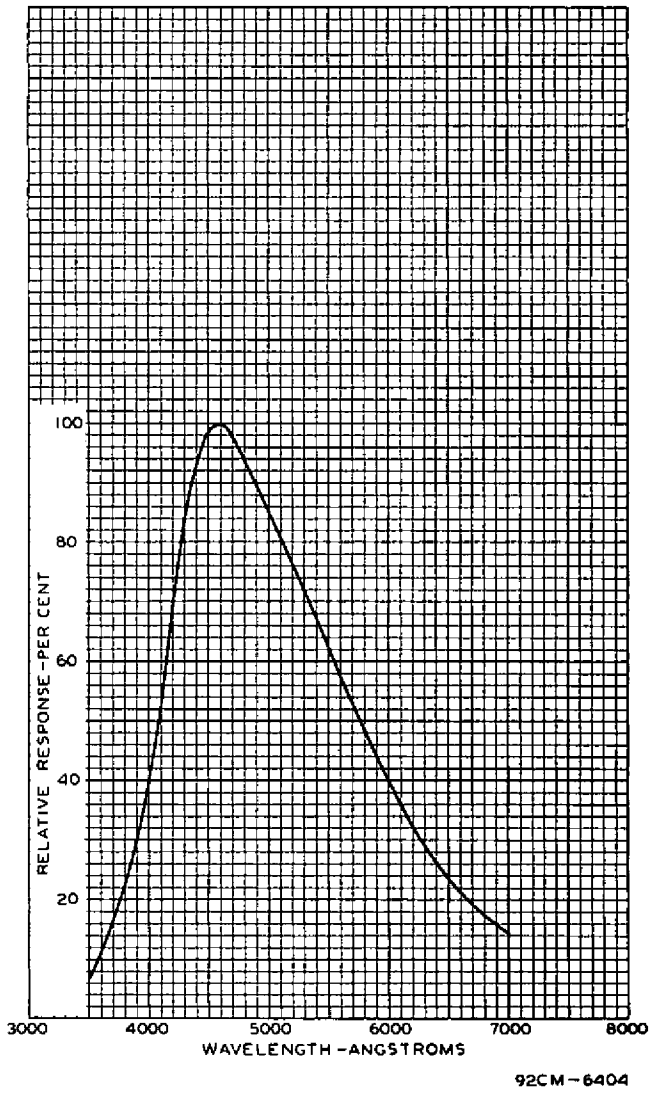


Fig. 1 - Spectral Sensitivity Characteristic of Type 1850-A Mosaic. Curve is taken for Equal Values of Radiant Flux at All Wavelengths.

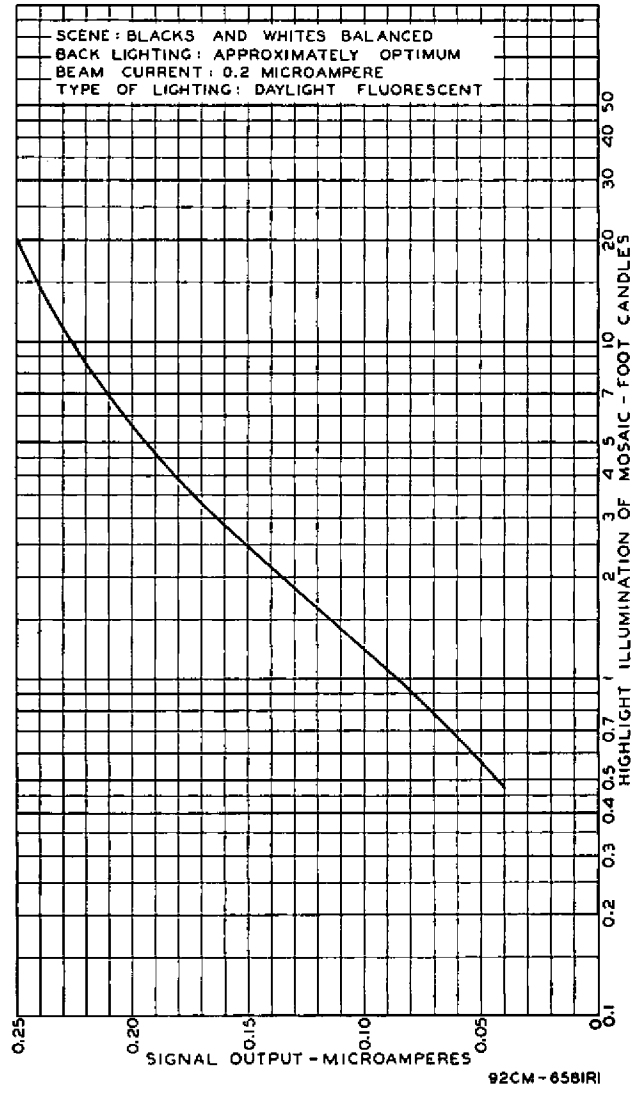
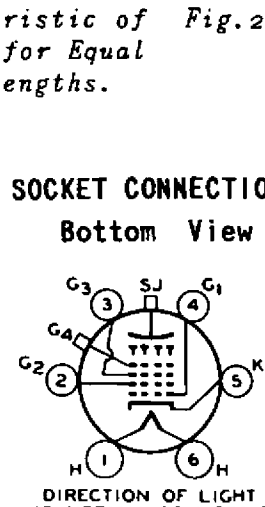


Fig. 2 - Typical Signal-Output Characteristic of Type 1850-A Under Continuous Illumination.

SOCKET CONNECTIONS

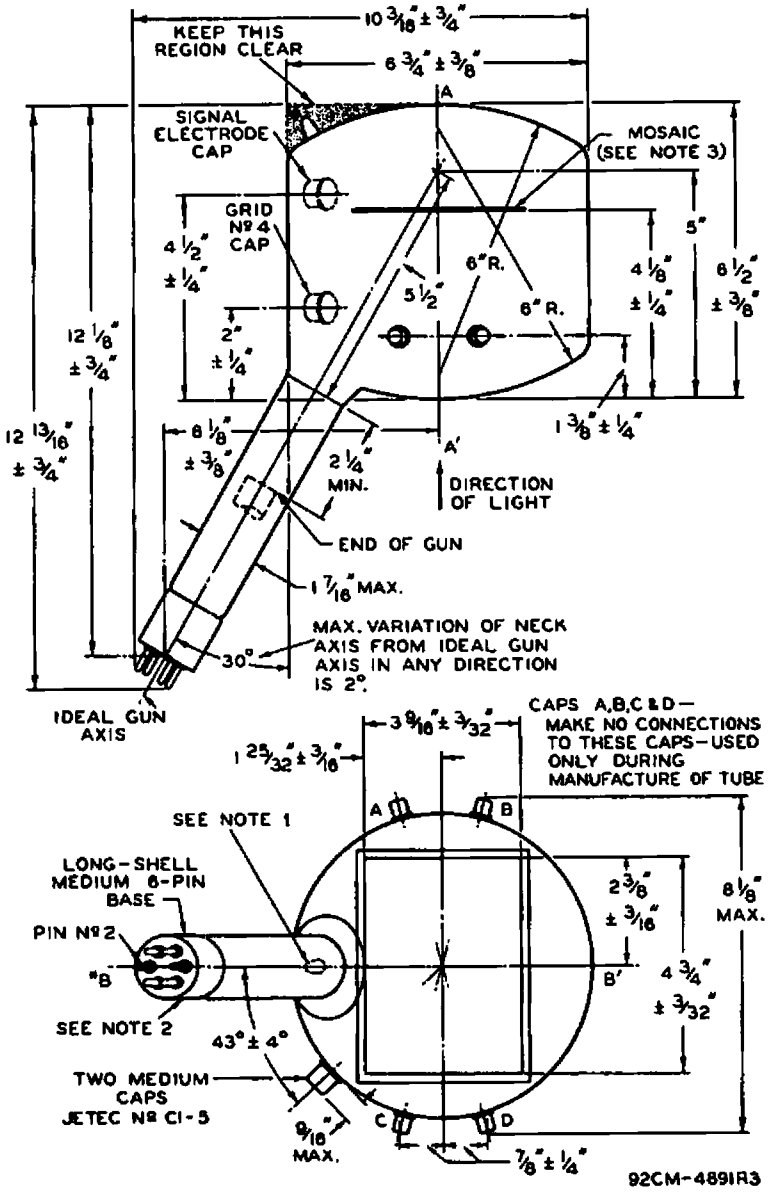
Bottom View

PIN 1 - HEATER
PIN 2 - GRID No. 2
PIN 3 - GRID No. 3
PIN 4 - GRID No. 1
PIN 5 - CATHODE



PIN 6 - HEATER
CAPS { SEE OUTLINE DRAWING
S_J - SIGNAL ELECTRODE
G_4 - GRID No. 4 (COLLECTOR)

DIMENSIONAL OUTLINE



* BB' IS THE PLANE THROUGH THE BULB AXIS AA' AND THE IDEAL GUN AXIS.

NOTE 1: VARIATION OF TIP CENTER FROM PLANE BB' IS 1/2".

NOTE 2: MAXIMUM ROTATION OF LINE THROUGH PINS 2 AND 5 ABOUT IDEAL GUN AXIS IS ± 10°, MEASURED FROM PLANE BB'.

NOTE 3: DEVIATION OF PLANE OF MOSAIC FROM PLANE PERPENDICULAR TO THE BULB AXIS AA' IS 2.5° MAX. ROTATION OF MOSAIC ABOUT THE BULB AXIS AA' WITH RESPECT TO A LINE OF INTERSECTION FORMED BY MOSAIC PLANE AND PLANE BB' IS 2.5° MAX.

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from RMA release #166
March 18, 1939

#166

1852

Television Amplifier Pentode

RCA-1852 is a heater-cathode type of metal tube intended for use by the amateur and experimenter in experimental television receivers. It is recommended for use in the r-f and i-f stages of the picture amplifier of such receivers as well as in the first stages of the video amplifier when several video stages are employed. The 1852 can also be used as a mixer and makes a good oscillator in low-voltage applications.

The electrode assembly of the 1852 is the same as that in the 1851, but a special shielded lead construction has been employed in the 1852 to permit bringing out the control-grid lead to a base pin rather than to a pin cap. With this construction, it has been possible to keep the grid-plate capacitance as low as that of this tube with capped construction. From a circuit standpoint, the proximity of grid pin to cathode pin simplifies wiring and decreases the size of the inductance loop connecting the input circuit to the tube. These are features important at high frequencies because they provide decreased feedback and improved circuit stability.

TENTATIVE CHARACTERISTICS AND RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.45	Ampere
DIRECT INTERELECTRODE CAPACITANCES: °		
Grid to Plate	0.015 *max.*	μμf
Input	11	μμf
Output	5	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

PLATE VOLTAGE		300 *max.*	Volts
SCREEN VOLTAGE		150 *max.*	Volts
SCREEN-SUPPLY VOLTAGE		300 *max.*	Volts
PLATE & SCREEN DISSIPATION (Total)		3.4 *max.*	Watts
SCREEN DISSIPATION		0.38 *max.*	Watts
TYPICAL OPERATION and CHARACTERISTICS:	*Condition I* *	*Condition II* **	
Plate Voltage	300	300	Volts

° With shell connected cathode.

* Condition I with fixed screen supply gives a sharp cut-off characteristic.

** Condition II with series screen resistor gives an extended cut-off characteristic for applications where gain is controlled by variation of grid bias.

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Suppressor Voltage	0		0	Volts
Screen-Supply Voltage #	150		300	Volts
Screen Series Resistor	-		60000	Ohms
Cathode-Bias Resistor ##	160	*min.*	160	*min.* Ohms
Amplification Factor (Approx.)	6750		6750	
Plate Resistance (Approx.)	0.75		0.75	Megohm
Transconductance	9000		9000	Micromhos
Plate Current	10		10	Milliamperes
Screen Current	2.5		2.5	Milliamperes

The d-c resistance of the grid circuit should not exceed 0.25 megohm when the screen voltage is obtained from a fixed source. When a series screen resistor is used with full cathode bias, the d-c resistance in the grid circuit may be made as high as 0.5 megohm.

Screen-supply voltages in excess of 150 volts require use of a series dropping resistor to limit the voltage at the screen to 150 volts when the plate current is at its normal value of 10 milliamperes.

INSTALLATION

The *base* pins of the 1852 fit the standard octal socket which should be installed to hold the tube preferably in a vertical position with the base either up or down. Horizontal operation is permissible if the socket is positioned so that Pins No.2 and No.7 are in a vertical plane.

The *heater* of the 1852 is designed to operate on either a.c. or d.c. When a.c. is used, the winding which supplies the heater circuit should operate the heater at its recommended value for full-load operating conditions at average line voltage. When d.c. is used on the heater, the heater terminals should be connected directly across a 6-volt battery. Under any condition of operation, the heater voltage should not deviate more than plus or minus 10% from the normal value of 6.3 volts.

The *cathode,* when the 1852 is operated from a transformer, should be connected through a bias resistor either to one side or to the electrical mid-point of the heater circuit. In the case of d-c operation from a 6-volt storage battery, the cathode circuit should be tied through a bias resistor to the negative battery terminal. The potential difference between heater and cathode should be kept as low as possible.

In some installations having automatic bias control which provides a fixed minimum bias adequate to limit the plate current to 10 milliamperes, and also using a 60000-ohm series screen resistor, the cathode may be connected directly to ground, or it may be connected through an unby-passed resistor to ground. This resistor may conveniently form a portion of the fixed minimum bias. Such an arrangement serves to minimize changes of input capacitance and input conductance, as explained under Control-Grid Bias.

Control-grid bias for the 1852 may be obtained by means of a cathode-bias (self-bias) resistor adjusted to give a plate current of 10 milliamperes.

In tubes such as the 1852, with an exceedingly high value of transconductance, there are pronounced changes of input capacitance and input conductance with plate current. In order to minimize these changes when the 1852 is used as an r-f or i-f amplifier, a portion of the cathode-bias resistor may be left unby-passed. Reducing the changes of input capacitance and input conductance in this manner, however, is accomplished with some sacrifice in effective transconductance and with some increase in effective grid-plate capacitance. To prevent excessive effective grid-plate capacitance, precautions should be observed to keep the external capacitances between plate and cathode leads at a minimum. It should be observed that with this method of minimization, the cathode is not at a-c ground potential. Because of this fact, the most favorable connection of the tube electrodes will be obtained when screen and suppressor are at a-c ground potential, as shown in the circuit R-F or I-F AMPLIFIER on page 5.

In video stages, the cathode-bias resistor should not be by-passed if it is desired to have degeneration and freedom from distortion. When, however, no degeneration and maximum amplitude are desired, the cathode-bias resistor should be by-passed with a large condenser (350 μf).

The *screen* voltage in Condition I may be obtained from a potentiometer or bleeder circuit across the B-supply source. This operating condition is suitable when the gain is fixed and the signals are not too large. For applications where bias adjustment is used to vary the gain, either manually or automatically, an extended cut-off characteristic may be obtained, as shown in Condition II where the screen voltage is obtained from the B-supply through a series screen resistor. This arrangement permits the handling of somewhat larger signals.

The *suppressor* should be connected in r-f and i-f stages directly to ground, in order to minimize feedback.

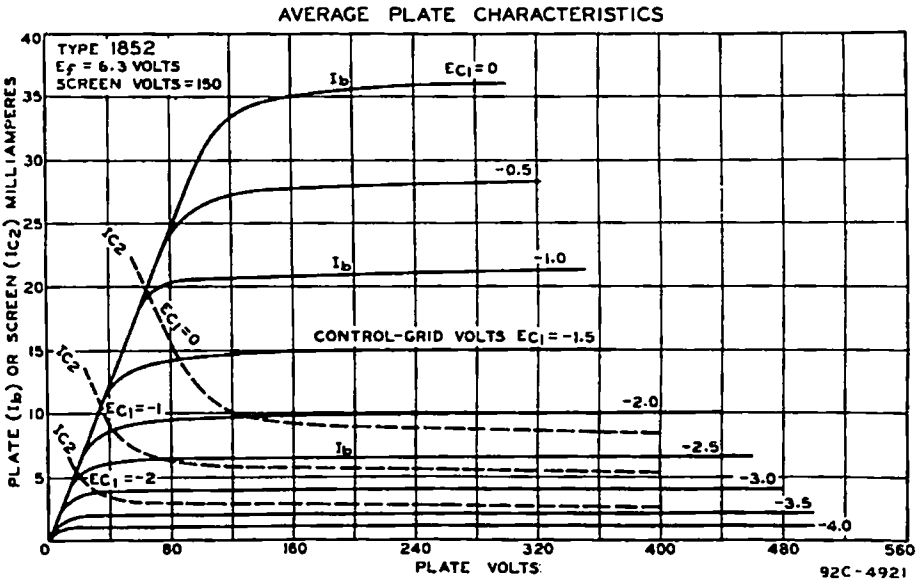
APPLICATION

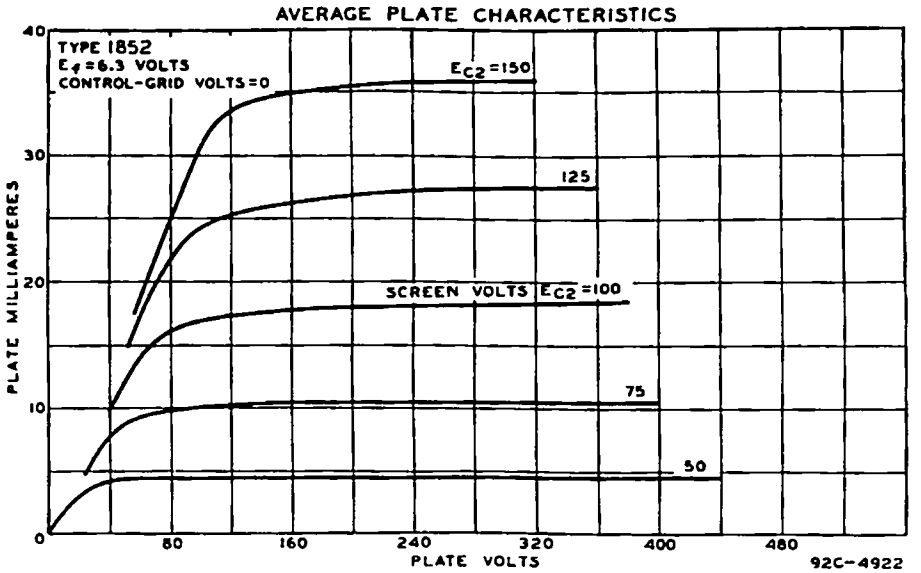
As an *amplifier*, the 1852 is especially suited for use in the r-f and i-f stages of the picture amplifier of experimental television receivers, and may also be used in the first stages of the video amplifier when several video stages are used in such receivers. The use of the 1852 as a high-gain audio amplifier is not recommended unless the heater is operated from a battery source.

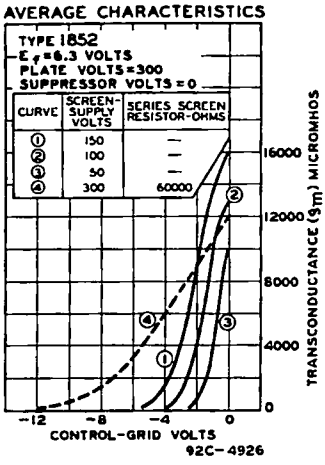
When minimization of changes in input capacitance and input conductance is not accomplished by leaving a portion of the cathode-bias resistor unby-passed, it will be found advisable to operate the 1852 with circuits heavily loaded by resistance and capacitance. Although such circuits minimize the effect of the relatively small variations in tube capacitance and conductance, they also cause some sacrifice in gain.

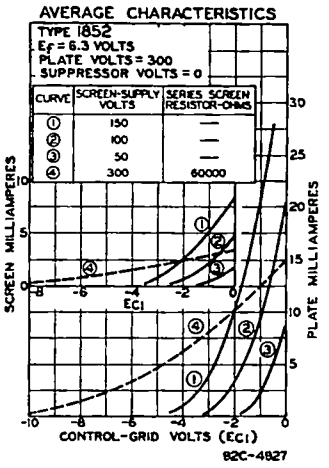
When the gain of the r-f and i-f stages as well as that of the video stages is controlled automatically, it is recommended that the series-screen-resistor method be employed for obtaining screen voltage. This method of obtaining screen voltage from the plate supply is satisfactory for the 1852 because its suppressor practically removes the effects of secondary emission phenomena. With this method, the screen-to-cathode voltage will rise as the control-grid voltage is varied from minimum to maximum. This rise of screen-to-cathode voltage above the normal maximum value is allowable because the screen and the plate current are reduced simultaneously by a sufficient amount to prevent damage to the tube.

Several schematic circuits illustrating the use of the 1852 are shown on pages 5 and 6.

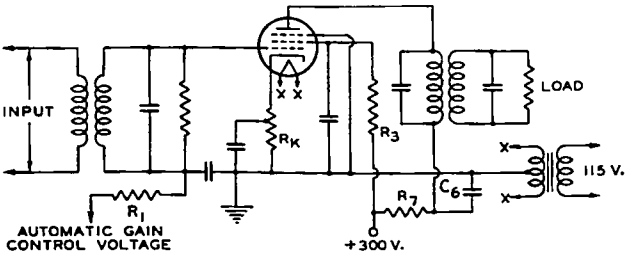




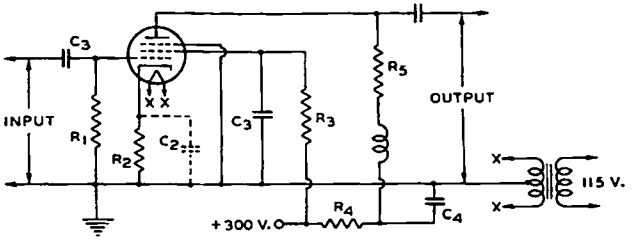




R-F OR I-F AMPLIFIER



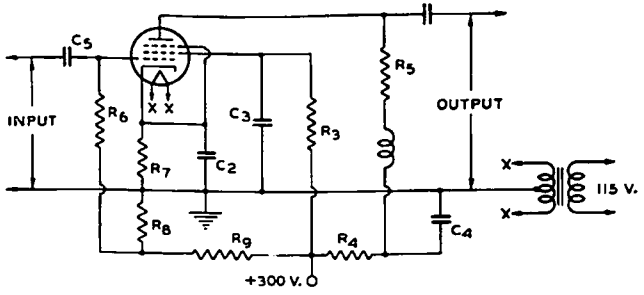
VIDEO AMPLIFIER



NOTE: THE CATHODE BY-PASS CONDENSER C_2 IS USED WHEN MAXIMUM SIGNAL AMPLITUDE AND NO DEGENERATION ARE DESIRED. OMISSION OF C_2 PROVIDES DEGENERATION AND GIVES LESS DISTORTION.

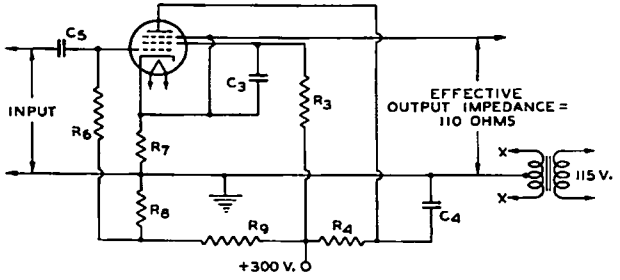
FOR VALUES OF CIRCUIT PARTS, SEE NEXT PAGE.

VIDEO AMPLIFIER
WITH HIGH-RESISTANCE INPUT COUPLING



NOTE: THE USE OF R_6 = 1.0 MEGOHM IS PERMISSIBLE IN THIS CIRCUIT BECAUSE OF THE REGULATING EFFECT PRODUCED BY R_7. THE BIAS VOLTAGE APPLIED TO THE GRID BY MEANS OF THE CATHODE RESISTOR R_7, AND THE BLEEDER RESISTORS R_8 AND R_9 SHOULD BE ADJUSTED TO GIVE A PLATE CURRENT OF 10 MA. NOTE THAT THE VOLTAGE ACROSS R_8 BUCKS A PORTION OF THAT ACROSS R_7.

IMPEDANCE TRANSFORMER
FOR USE BETWEEN HIGH-IMPEDANCE CIRCUIT AND LOW-IMPEDANCE CIRCUIT



C_1 = 0.1 μf
C_2 = 350 μf
C_3 = 1.0 μf
C_4 = 12 μf
C_5 = 0.25 μf
C_6 = 0.05 μf

R_K = 160 OHMS, WITH TAP AT APPROXIMATELY 35 OHMS FROM CATHODE END
R_1 = 0.25 MEGOHM
R_2 = 160 OHMS
R_3 = 60000 OHMS

R_4 = 5000 OHMS
R_5 = 2000 OHMS
R_6 = 1.0 MEGOHM
R_7 = 1000 OHMS
R_8 = 9000 OHMS
R_9 = 250000 OHMS

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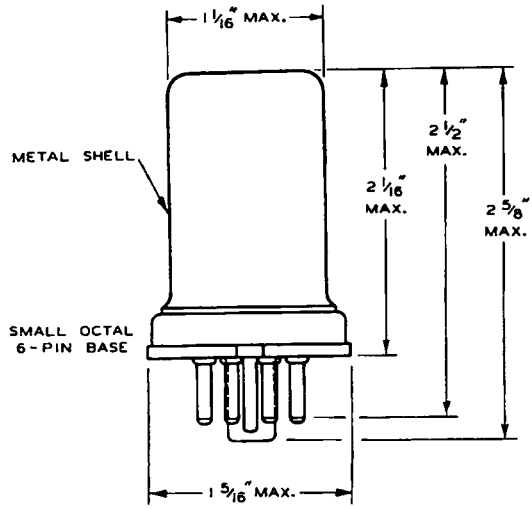
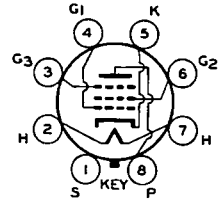


BOTTOM VIEW OF SOCKET CONNECTIONS



G_1 = CONTROL GRID
G_2 = SCREEN
G_3 = SUPPRESSOR
H = HEATER
K = CATHODE
S = SHELL

from RMA release #166
March 18, 1939

Reserved
RMA # 6AB7

1853

Television Amplifier Pentode

RCA-1853 is a heater-cathode type of metal tube indended for use by the amateur and experimenter in experimental television receivers. Because of its extended cut-off characteristic, it is recommended for use in the r-f and i-f stages of the picture amplifier of such receivers, particularly those employing automatic gain control. The 1853 can also be used as a mixer and makes a good oscillator in low-voltage amplifications.

A special shielded lead construction has been employed in the 1853 to permit bringing out the control-grid lead to a base pin rather than to a pin cap. With this construction, it has been possible to keep the grid-plate capacitance as low as that of this tube with capped construction. From a circuit standpoint, the proximity of grid pin to cathode pin simplifies wiring and decreases the size of the inductance loop connecting the input circuit to the tube. These are features important at high frequencies because they provide de-decreased feedback and improved circuit stability.

TENTATIVE CHARACTERISTICS and RATINGS

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.45	Ampere
DIRECT INTERELECTRODE CAPACITANCES: °		
Grid to Plate	0.015 *max.*	μμf
Input	8	μμf
Output	5	μμf
MAXIMUM OVERALL LENGTH	2-5/8"	
MAXIMUM DIAMETER	1-5/16"	
BASE	Small Wafer Octal 8-Pin	

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

PLATE VOLTAGE	300 *max.*	Volts
SCREEN VOLTAGE	200 *max.*	Volts
SCREEN-SUPPLY VOLTAGE	300 *max.*	Volts
PLATE & SCREEN DISSIPATION (total)⊕	4.4 *max.*	Watts
SCREEN DISSIPATION	0.65 *max.*	Watts

TYPICAL OPERATION and CHARACTERISTICS:

	*Condition I**	*Condition II***	
Plate Voltage	300	300	Volts
Suppressor Voltage	0	0	Volts
Screen-Supply Voltage #	200	300	Volts
Screen Series Resistor	-	30000	Ohms
Grid Voltage ## ●	-3 *min.*	-3 *min.*	Volts
Amplification Factor (Approx.)	3500	3500	

°, ⊕, *, **, #, ##, ●: See next page.

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Plate Resistance (Approx.)	0.7	0.7	Megohm
Transconductance	5000	5000	Micromhos
Grid Bias for Transconductance = 50 micromhos	-15	-22.5	Volts
Plate Current	12.5	12.5	Milliamperes
Screen Current	3.2	3.2	Milliamperes

° With shell connected to cathode.

* Condition I is with fixed screen supply.

** Condition II is with series screen resistor.

Screen-supply voltages in excess of 200 volts require use of a series dropping resistor to limit the voltage at the screen to 200 volts when the plate current is at its normal value of 12.5 milliamperes.

• May be obtained with cathode-bias resistor having a minimum value of 190 ohms.

The d-c resistance of the grid circuit should not exceed 0.25 megohm with fixed bias. When full cathode bias and a series screen resistor are used, the d-c resistance of the grid circuit may be as high as 0.5 megohm.

● Precautions should be taken to insure that dissipation rating is not exceeded with expected line-voltage fluctuations, especially in the case of fixed-bias operation.

INSTALLATION

The *base* pins of the 1853 fit the standard octal socket which should be installed to hold the tube preferably in a vertical position, with the base either up or down. Horizontal operation is permissible if the socket is positioned so that pins No.2 and No.7 are in a vertical plane.

The *heater* of the 1853 is designed to operate on either a.c. or d.c. When a.c. is used, the winding which supplies the heater circuit should operate the heater at its recommended value for full-load operating conditions at average line voltage. When d.c. is used on the heater, the heater terminals should be connected directly across a 6-volt battery. Under any condition of operation, the heater voltage should not deviate more than plus or minus 10% from the normal value of 6.3 volts.

The *cathode*, when the 1853 is operated from a transformer, should be connected through a bias source either to one side or to the electrical mid-point of the heater circuit. In the case of d-c operation from a 6-volt storage battery, the cathode circuit should be tied through a bias source to the negative battery terminal. The potential difference between heater and cathode should be kept as low as possible.

In some installations having automatic bias control which provides a fixed minimum bias adequate to limit the plate current to 12.5 milliamperes, and also using a 30000-ohm series screen resistor, the cathode may be connected through an unby-passed resistor to ground. This resistor may conveniently form a portion of the fixed minimum bias. Such an arrangement serves to minimize changes of input capacitance and input conductance, as explained under Control-Grid Bias.

Control-grid bias for the 1853 may be obtained by means of a cathode-bias (self-bias) resistor adjusted to give a plate current

of 12.5 milliamperes, or from a fixed source, depending on the application.

In tubes such as the 1853, with a very high value of transconductance, there are appreciable changes of input capacitance and input conductance with plate current. In order to minimize these changes when the 1853 is used as an r-f or i-f amplifier, a portion of the cathode-bias resistor may be left unby-passed. Reducing the changes of input capacitance and input conductance in this manner, however, is accomplished with some sacrifice in effective transconductance and with some increase in effective grid-plate capacitance. To prevent excessive effective grid-plate capacitance, precautions should be observed to keep the external capacitances between plate and cathode leads at a minimum. It should be observed that with this method of minimization, the cathode is not at a-c ground potential. Because of this fact, the most favorable connection of the tube electrodes will be obtained when screen and suppressor are at a-c ground potential, as shown in the circuit R-F or I-F AMPLIFIER on page 5.

The *screen* voltage for the 1853 may be obtained from a potentiometer, a bleeder circuit across the B-supply source, or through a series screen resistor. Use of the series screen resistor (Condition II) provides a somewhat more extended cut-off characteristic than is obtained with fixed screen voltage (Condition I).

The *suppressor* should be connected in r-f and i-f stages directly to ground, in order to minimize feedback.

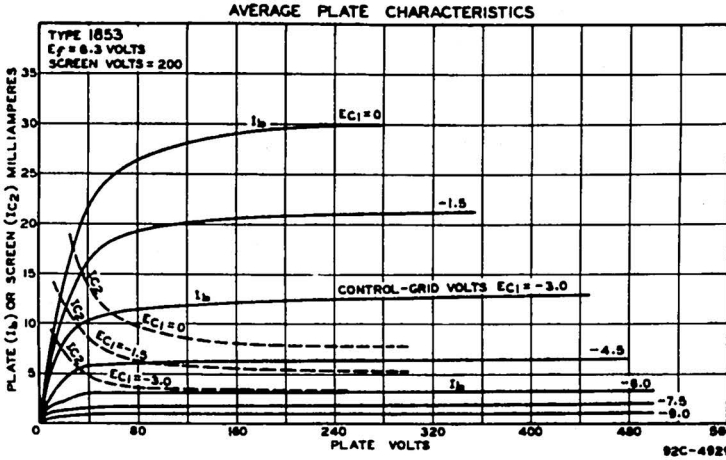
APPLICATION

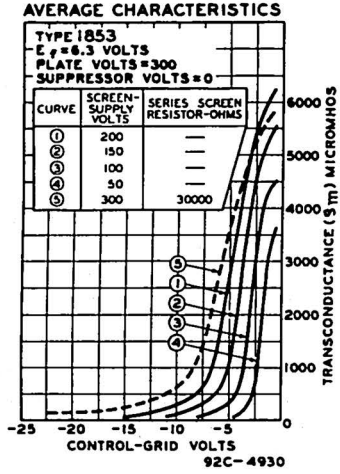
As an *amplifier*, the 1853 is especially suited for use in the r-f and i-f stages of the picture amplifier of experimental television receivers employing automatic gain control.

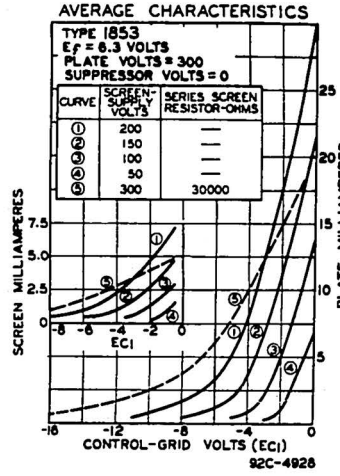
When minimization of changes in input capacitance and input conductance is not accomplished by leaving a portion of the cathode-bias resistor unby-passed, it will be found advisable to operate the 1853 with circuits heavily loaded by resistance and capacitance. Although such circuits minimize the effect of the relatively small variations in tube capacitance and conductance, they also cause some sacrifice in gain.

The series-screen-resistor method of obtaining screen voltage from the plate supply is satisfactory for the 1853 because its suppressor practically removes the effects of secondary emission phenomena. With this method, the screen-to-cathode voltage will rise as the control-grid voltage is varied from minimum to maximum. This rise of screen-to-cathode voltage above the normal maximum value is allowable because the screen and the plate current are reduced simultaneously by a sufficient amount to prevent damage to the tube.

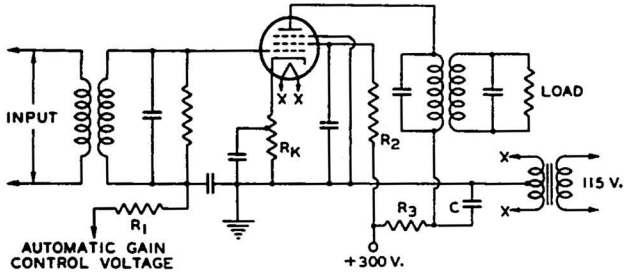
A schematic circuit illustrating the use of the 1853 is shown on page 5.


AVERAGE PLATE CHARACTERISTICS
TYPE 1853
Ef = 6.3 VOLTS
SCREEN VOLTS = 200
PLATE (Ib) OR SCREEN (Ic2) MILLIAMPERES
PLATE VOLTS
CONTROL-GRID VOLTS EC1 = -3.0
Ec1=0
-1.5
-3.0
-4.5
-6.0
-7.5
-9.0
92C-4929

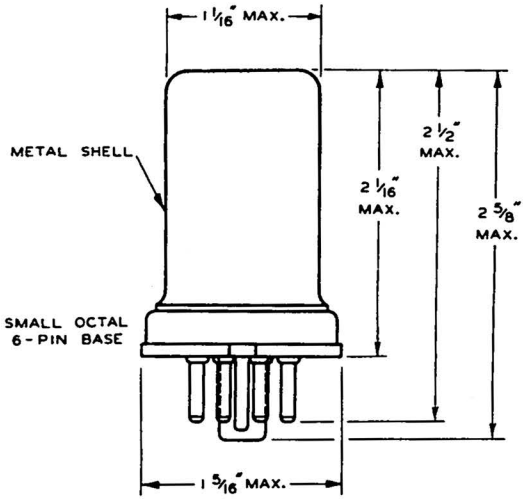

AVERAGE CHARACTERISTICS
TYPE 1853
Ef = 6.3 VOLTS
PLATE VOLTS = 300
SUPPRESSOR VOLTS = 0
CURVE
SCREEN-SUPPLY VOLTS
SERIES SCREEN RESISTOR-OHMS
① 200 —
② 150 —
③ 100 —
④ 50 —
⑤ 300 30000
TRANSCONDUCTANCE (Sm) MICROMHOS
CONTROL-GRID VOLTS
92C-4930


AVERAGE CHARACTERISTICS
TYPE 1853
Ef = 6.3 VOLTS
PLATE VOLTS = 300
SUPPRESSOR VOLTS = 0
CURVE
SCREEN-SUPPLY VOLTS
SERIES SCREEN RESISTOR-OHMS
①②③④⑤ 200 —
①②③④⑤ 150 —
①②③④⑤ 100 —
①②③④⑤ 50 —
⑤ 300 30000
SCREEN MILLIAMPERES
PLATE MILLIAMPERES
EC1
CONTROL-GRID VOLTS (EC1)
92C-4928

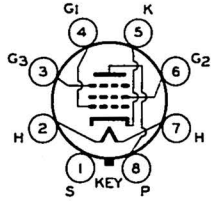
R-F OR I-F AMPLIFIER



C = 0.05 μf
R_1 = 0.25 MEGOHM
R_2 = 30000 OHMS
R_3 = 1000 OHMS
R_K = 190 OHMS, WITH TAP AT APPROXIMATELY 70 OHMS FROM CATHODE END



BOTTOM VIEW OF SOCKET CONNECTIONS



G_1 = CONTROL GRID
G_2 = SCREEN
G_3 = SUPPRESSOR
H = HEATER
K = CATHODE
S = SHELL

8 N

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RCA-1960

PROTECTIVE TUBE

The RCA-1960 is designed for use as a protective tube. The voltage characteristics shown under TENTATIVE DATA apply only for 60-cycle sine-wave operation. Normal variations in ambient temperature have negligible effect on the tube's performance.

TENTATIVE DATA

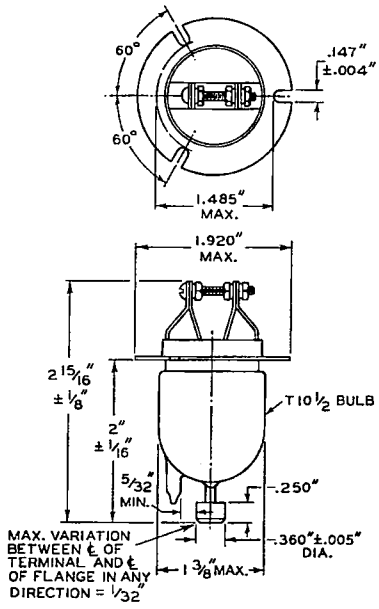
INTERELECTRODE CAPACITANCE	1.35 μμf
DIMENSIONS	See *OUTLINE DRAWING*
MOUNTING	Special
MOUNTING POSITION	Any
TERMINALS	Cap and flange

Characteristics Measured on 60-Cycle Sine-Wave Supply

PEAK SUPPLY VOLTAGE	425 min. Volts
PEAK INITIAL BREAKDOWN VOLTAGE (Tube cold)	425 max. Volts
PEAK RECURRENT BREAKDOWN VOLTAGE*	285 max. Volts
TUBE VOLTAGE DROP*	175 Volts

* With tube current of 30 ma.

NOTE: The energy dissipated in the tube should not be sufficient to establish a sustained arc.



92C-6332

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HARRISON, NEW JERSEY

1960-1-43
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RCA-1961

PROTECTIVE TUBE

The RCA-1961 is designed for use as a protective tube. The voltage characteristics shown under TENTATIVE DATA apply only for 60-cycle sine-wave operation. Normal variations in ambient temperature have negligible effect on the tube's performance.

TENTATIVE DATA

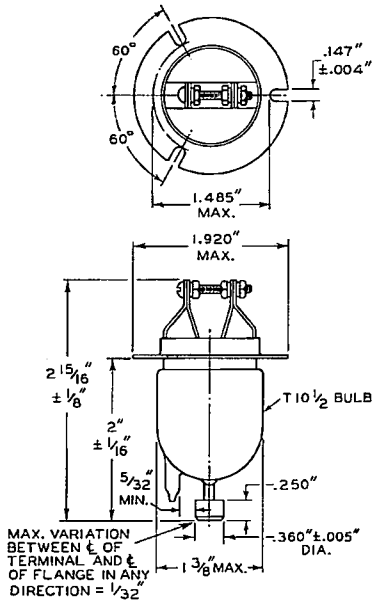
INTERELECTRODE CAPACITANCE	1.35 μμf
DIMENSIONS	See *OUTLINE DRAWING*
MOUNTING	Supplied with Tube
MOUNTING POSITION	Any
TERMINALS	Cap and Flange

Characteristics Measured on 60-Cycle Sine-Wave Supply

PEAK SUPPLY VOLTAGE	770 min. Volts
PEAK INITIAL BREAKDOWN VOLTAGE (Tube cold)	770 max. Volts
PEAK RECURRENT BREAKDOWN VOLTAGE*	670 max. Volts
TUBE VOLTAGE DROP*	220 Volts

* With tube current of 30 ma.

NOTE: The energy dissipated in the tube should not be sufficient to establish a sustained arc.



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1961-1-43
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4009

TRAVELING-WAVE TUBE

38 db Low-Level Gain

Integral Periodic-Permanent-Magnet Type
2000 - 4000 Mc

25 mw Saturated Power Output

TENTATIVE DATA

RCA-4009 is a low-power traveling-wave amplifier tube of the helix-transmission-line type designed to operate in the frequency range from 2000 to 4000 Mc. It is intended primarily for use as a driver for an intermediate-power traveling-wave tube such as the RCA-4010, but may be used in the first stage of wide-band microwave receivers and repeaters where a low noise figure is not essential, as well as in grid-No.1 pulsed applications involving negligible driving power.

When operated in cw applications at 3000 Mc, the 4009 can provide a typical small-signal gain of 38 db and a typical saturated power output of 28 milliwatts.

Design features of the 4009 include built-in periodic permanent magnets to focus the electron beam, operating capability over an ambient temperature range of 0° to 75° C without significant effect on performance, and a light-weight structure capable of withstanding shocks up to 30g for 11 milliseconds and vibrational acceleration of 5g at frequencies up to 500 cps. These features together with the ability of the 4009 to operate with full ratings at altitudes up to 50000 feet under high-humidity conditions without pressurization, commend this type for use in the design of airborne electronic equipment.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 5%	volts
Current at 6.3 volts	1.3	amp
Starting Current	Must never exceed 4.0 amperes, even momentarily	
Minimum Cathode Heating Time	2.5	minutes
Frequency Range	2000 to 4000	Mc
Cold Insertion Loss	60	db
Direct Interelectrode Capacitance:		
Grid No.1 to all other electrodes (Approx.)	12	μμf

Mechanical:

Operating Position	Any
Cooling	Natural
Maximum Overall Length (Excluding flexible leads)	15-3/8"
Maximum Height	2-5/8"
Maximum Width	2-1/32"
Terminal Leads (Seven)	See *Dimensional Outline*
RF Connectors:	
Input	Type TNC Jack
Output	Type TNC Jack
Weight (Approx.)	2-1/2 pounds

Maximum Ratings, *Absolute-Maximum Values for Altitudes up to 50000 feet:*

For CW operation, and pulsed-grid-No.1 operation with duty cycle up to 1

DC COLLECTOR VOLTAGE	1000 max.	volts
DC HELIX VOLTAGE	1000 max.	volts
DC GRID-No.2 VOLTAGE	300 max.	volts
GRID-No.1 VOLTAGE:		
Negative-bias value	150 max.	volts
Positive-peak value	0 max.	volts
DC COLLECTOR CURRENT	5 max.	ma
DC HELIX CURRENT	2 max.	ma
DC GRID-No.2 CURRENT	1.5 max.	ma
DC GRID-No.1 CURRENT	2 max.	ma
CATHODE CURRENT:		
DC or peak	6 max.	ma
RF POWER INPUT	1 max.	watt
TEMPERATURE OF METAL SHELL:		
During operation	100 max.	°C
	0 min.	°C
During storage	-62 min.	°C
LOAD VOLTAGE STANDING WAVE RATIO	4 max.	

Typical CW Operation at 3000 Mc:

DC Collector Voltage	700	volts
DC Helix Voltage	600	volts
DC Grid-No.2 Voltage	225	volts
DC Grid-No.1 Voltage	0	volts
DC Collector Current	3	ma
DC Helix Current	0.75	ma
DC Grid-No.2 Current	0.5	ma
DC Grid-No.1 Current	0.2	ma
Gain for output up to 1 mw	38	db
Gain at 10 mw output	35	db
Power Output (Saturated, approx.)	28	mw

Characteristics Range Values for Equipment Design:

	Note	*Min.*	*Max.*	
Heater Current	1	1.0	1.6	amp
DC Helix Voltage	1,2	550	700	volts
DC Grid-No.2 Voltage	1,3	150	300	volts
Insertion Loss	1,4	30	-	db
Gain, for output up to 1 milliwatt	1,3,5	33	-	db
Gain, for output of 10 milliwatts	1,3,5	30	-	db
Saturated Power Output	1,3,6	10	-	mw
Modulation (AM) due to vibration	1,3,7	-	1	db

Note 1: With heater voltage of 6.3 volts.

Note 2: With collector volts = 700; helix voltage adjusted to value for operation over the frequency range of 2000 to 4000 Mc; grid-No.2 voltage adjusted to produce collector-current value specified on

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

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tube label, and grid-No.1 volts = 0. It is to be noted that the optimum helix voltage determined in this test is indicated for each tube on the tube label, and that the indicated voltage range is given to show the expected range for tubes of this type.

Note 3: With collector volts = 700; helix voltage adjusted to value specified on label for operation over the frequency range 2000 to 4000 Mc.; grid-No.2 voltage adjusted to produce collector-current value specified on label; and grid-No.1 volts = 0.

Note 4: Same as Note 3 except grid-No.1 volts = −50.

Note 5: With rf signal input adjusted to produce specified output.

Note 6: With rf signal input adjusted to give maximum power output at any frequency in the range from 2000 to 4000 Mc.

Note 7: With the tube assembly vibrated (1) with a fixed amplitude of 0.005" (travel of 0.010") over a frequency range of 5 to 55 cps, and (2) at an acceleration of 2g over a frequency range of 55 to 500 cps. Tube is vibrated in each of 3 mutually perpendicular planes (specified in MIL-E-1C, par 4.9.20.3).

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

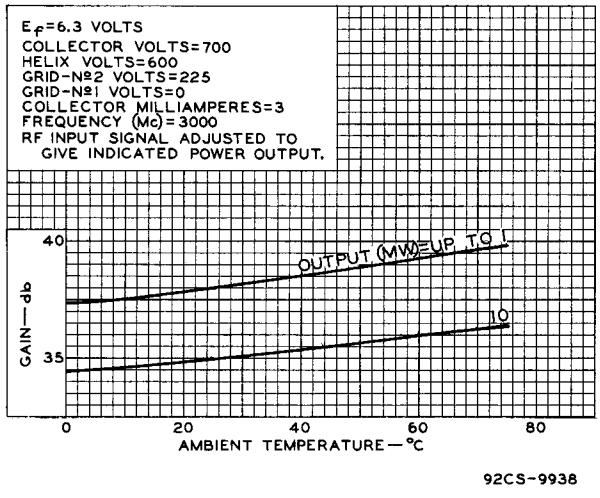

Fig. 1 – Typical Gain Characteristics of Type 4009.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

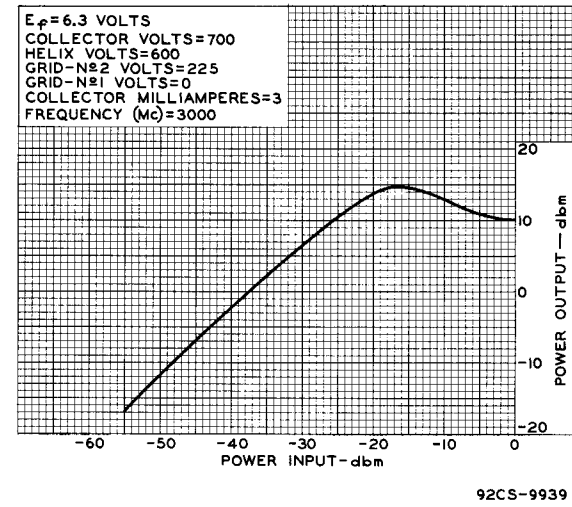

Fig. 2 – Typical Power-Output Characteristic of Type 4009.

The *rated values for collector voltage, helix voltage, and grid-No.2 voltage are high enough to be dangerous to the user.* Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

The *power supply* for the 4009 should be capable of holding ripple voltage sufficiently low to prevent excessive phase or amplitude modulation of the output, and should have adequate regulation to prevent a change in operating conditions which might decrease the gain or power output. Typical values of ripple voltage on different electrodes which will produce amplitude modulation amounting to ± 0.1 db in the tube output are shown below.

Tube Electrode	Typical Operating Volts DC	Typical Ripple Volts* Peak to Peak
Grid No.2	225	0.9
Helix	600	0.6
Collector	700	70

* For ± 0.1 db amplitude modulation.

The power supply should incorporate a helix-current overload protective device to prevent damage to the tube in the event of loss of collector voltage. Such a condition would cause the entire electron beam current to flow to the helix and thereby overheat the electrode. If it is desired to remove all voltages by a single con-

trol, the time-constant values of the power supply should be so chosen that the helix voltage decays faster than the collector voltage.

The *magnetic field* required to focus the electron beam in the 4009 is supplied by integral periodic permanent magnets. Although the periodic magnet structure is difficult to demagnetize, and has small stray field, care should be taken to prevent the presence of any appreciable external transverse magnetic field which might cause defocusing of the electron beam within the tube.

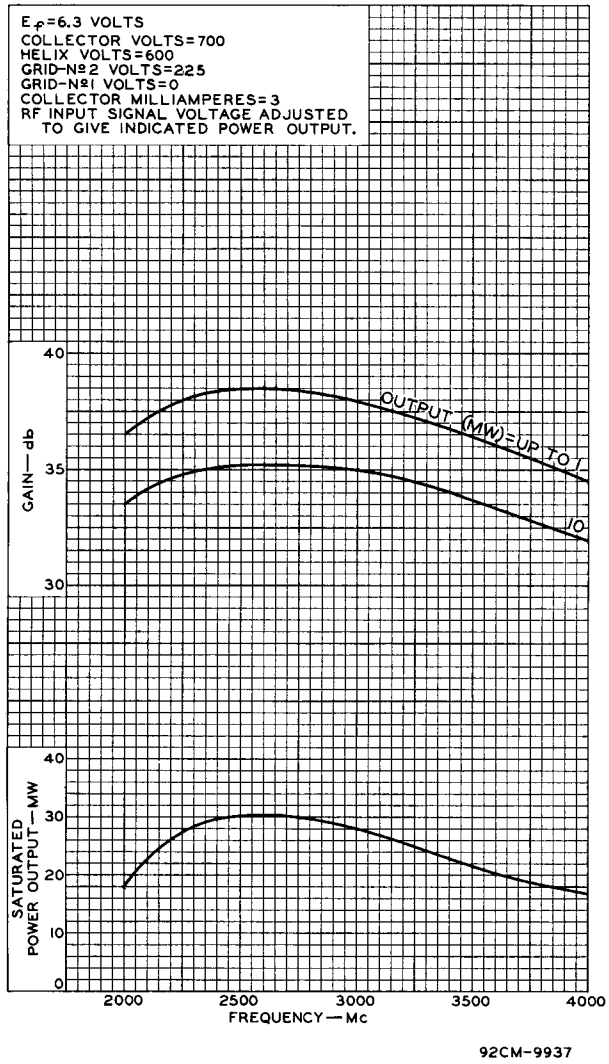

Fig. 3 - Typical Characteristics of Type 4009.

Tubes can be operated as close together as 3" center-to-center without magnetic interaction.

Mounting. The 4009 may be mounted in any position by means of bolts through the holes in the two mounting brackets.

Electrical connections are made to the 4009 by means of the seven, color-coded, flexible, insulated leads identified on the *Dimensional Outline*. RF input and output connections require the use of coaxial plugs† which can be connected to 50-ohm coaxial cable and which fit the type TNC jacks on the tube (see *Dimensional Outline*).

Starting Procedure

For pulsed operation. Apply the rated heater voltage to the 4009 for 2.5 minutes to allow the cathode to reach normal operating temperature. Then apply a collector voltage of 700 volts, helix voltage as specified on the tube label, and grid-No.1 bias voltage of -50 volts. Next, apply the value of dc grid-No.2 voltage specified on the tube label, and then the pulsed signal to grid No.1. Increase the amplitude of the signal until the peak collector-current value specified on the tube label is obtained. This current value corresponds to that obtained with an effective grid-No.1 voltage of 0 volts.

For cw operation. Apply the rated heater voltage to the 4009 for 2.5 minutes to allow the cathode to reach normal operating temperature. Then apply collector voltage of 700 volts and helix voltage as shown on the tube label, in the order indicated. Next, with zero volts on grid No.1, apply a low value of grid-No.2 voltage. Then increase grid-No.2 voltage gradually until the value of collector current specified on the tube label is reached.

The value of helix voltage specified on the tube label is that necessary to provide broadband operation from 2000 to 4000 Mc. If it is desired to operate at a single frequency or on a narrow band, increased gain may sometimes be obtained by readjustment of the helix voltage.

Turn-Off Procedure

First reduce the collector current by removing the pulsed grid-No.1 signal (when pulsed operation is employed), and then remove grid-No.2 voltage, grid-No.1 bias voltage (when used), helix voltage, and collector voltage in the order indicated.

† Such as Catalog No.166A, General RF Fittings, Inc., 702 Beacon Street, Boston 15, Massachusetts, or equivalent.

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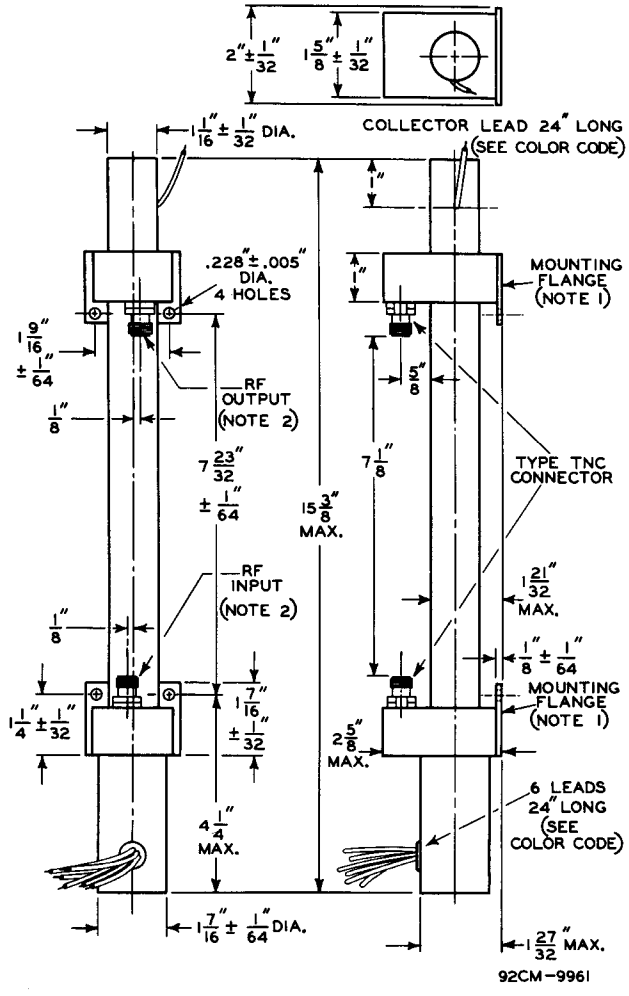
DIMENSIONAL OUTLINE



COLOR CODE

HEATER (2)	BROWN
COLLECTOR	RED
HELIX	ORANGE
GRID No. 2	BLUE
GRID No. 1	GREEN
CATHODE	YELLOW

NOTE 1: WITH TUBE MOUNTING FLANGES RESTING ON A SMOOTH, PLANE SURFACE, A 0.015" THICKNESS GAUGE 1/8" WIDE WILL NOT ENTER BETWEEN ANY POINT ON THE MOUNTING FLANGE AND THE PLANE SURFACE.

NOTE 2: THIS JACK REQUIRES COAXIAL PLUG SUCH AS CATALOG No. 166A, GENERAL RF FITTINGS, INC., 702 BEACON STREET, BOSTON 15, MASS., OR EQUIVALENT.

4010

TRAVELING-WAVE TUBE

35 db Low-Level Gain | **Integral Periodic-Permanent-Magnet Type, 2000 - 4000 Mc, Forced-Air Cooled** | **1.5 watts Saturated Power Output**

TENTATIVE DATA

RCA-4010 is an intermediate-power traveling-wave amplifier tube of the helix-transmission-line type designed to operate in the frequency range from 2000 to 4000 Mc. It is intended primarily for use as a driver for a high-power traveling-wave tube. The 4010 may also be used as the output tube when power output requirements are less than about 1.5 watts, as well as in grid-No.1-pulsed applications involving negligible driving power.

When operated in cw applications at 3000 Mc, the 4010 can provide a typical small-signal gain of more than 35 db and a typical saturated power output of 1.8 watts.

Design features of the 4010 include built-in periodic-permanent-magnets to focus the electron beam, operating capability over an ambient temperature range of 0° to 75° C without significant effect on performance, a light-weight sturdy structure capable of withstanding shocks of 30 g for 11 milliseconds, and vibrational acceleration of 5g at frequencies up to 500 cps. These features, together with the ability of the 4010 to operate with full ratings at altitudes up to 50000 feet under high humidity conditions without pressurization commend this type for use in the design of airborne electronic equipment.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 5%	volts
Current at 6.3 volts	1.3	amp
Starting Current	Must never exceed 4.0 amperes, even momentarily	
Minimum Cathode Heating Time	2.5	minutes
Frequency Range	2000 to 4000	Mc
Cold Insertion Loss	60	db
Direct Interelectrode Capacitance:		
Grid No.1 to all other electrodes (Approx.)	12	μμf

Mechanical:

Operating Position	Any
Air Flow	An air stream should be directed into the radiator port at the small-diameter end of the 4010. Adequate flow should be provided so that the temperature of the radiator on the collector does not exceed 150° C under any condition of operation. Typical air-flow requirements are shown in Fig.1.
Maximum Overall Length.(Excluding flexible leads)	15-3/8"
Maximum Height	2-5/8"
Maximum Width	2-1/32"
Terminal Leads (Seven)	See *Dimensional Outline*
RF Connectors:	
Input	Type TNC Jack
Output	Type TNC Jack
Weight (Approx.)	2-1/2 pounds

Maximum Ratings, *Absolute Maximum Values for Altitudes up to 50000 feet:*

For CW operation, and pulsed-grid-No.1 operation with duty cycle up to 1

DC COLLECTOR VOLTAGE	1300 max.	volts
DC HELIX VOLTAGE	1200 max.	volts
DC GRID-No.2 VOLTAGE	700 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	150 max.	volts
Positive peak value	0 max.	volts
DC COLLECTOR CURRENT	25 max.	ma
DC HELIX CURRENT	5 max.	ma
DC GRID-No.2 CURRENT	4 max.	ma
DC GRID-No.1 CURRENT	2 max.	ma
CATHODE CURRENT:		
DC or Peak	25 max.	ma
RF POWER INPUT	1 max.	watt
TEMPERATURE OF METAL SHELL:		
During operation	100 max. 0 min.	°C °C
During storage	-62 min.	°C
LOAD VOLTAGE STANDING WAVE RATIO	4 max.	

Typical CW Operation at 3000 Mc:

DC Collector Voltage	1150	volts
DC Helix Voltage	1075	volts
DC Grid-No.2 Voltage	575	volts
DC Grid-No.1 Voltage	0	volts
DC Collector Current	18	ma
DC Helix Current	2.0	ma
DC Grid-No.2 Current	0.5	ma
DC Grid-No.1 Current	0.25	ma
Gain for output up to 0.1 watt	35	db
Gain at 1 watt output	32	db
Power Output (Saturated, approx.)	1.8	watts

Characteristics Range Values for Equipment Design:

	Note	*Min.*	*Max.*	
Heater Current	1	1.0	1.6	amp
DC Helix Voltage	1,2	1000	1150	volts
DC Grid-No.2 Voltage	1,3	475	675	volts
Insertion Loss	1,4	30	-	db
Gain for output up to 0.1 watt	1,3,5	33	-	db
Gain for output of 1 watt	1,3,5	30	-	db
Saturated Power Output	1,3,6	1	-	watt
Modulation (AM) due to Vibration	1,3,7	-	1	db

Note 1: With heater voltage of 6.3 volts.

Note 2: With collector volts = 1150; helix voltage adjusted to value for operation over the frequency range of 2000 to 4000 Mc; grid-No.2 voltage adjusted to

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RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

4010 3-59
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produce collector-current value specified on tube label; and grid-No.1 volts = 0. It is to be noted that the optimum helix voltage determined in this test is indicated for each tube on the tube label, and that the indicated range is given to show the expected range for tubes of this type.

Note 3: With collector volts = 1150; helix voltage adjusted to value specified on label for operation over the frequency range 2000 to 4000 Mc.; grid-No.2 voltage adjusted to produce collector-current value specified on label; and grid-No.1 volts = 0.

Note 4: Same as Note 3 except grid-No.1 volts = -75.

Note 5: With rf signal input adjusted to produce specified output.

Note 6: With rf signal input adjusted to give maximum power output over the frequency range 2000 to 4000 Mc.

Note 7: With the tube assembly vibrated (1) with a fixed amplitude of 0.005" (travel of 0.010") over a frequency range of 5 to 55 cps, and (2), at an acceleration of 2g over a frequency range of 55 to 500 cps. Tube is vibrated in each of 3 mutually perpendicular planes (specified in MIL-E-1C, par.4.9.20.3).

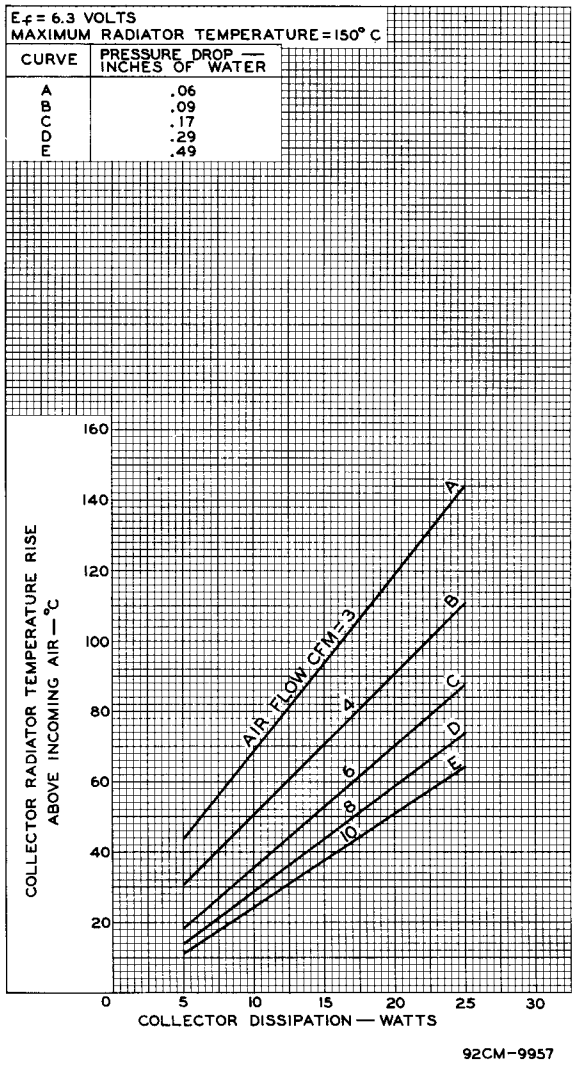


Fig. 1 - Cooling Requirements of Type 4010.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

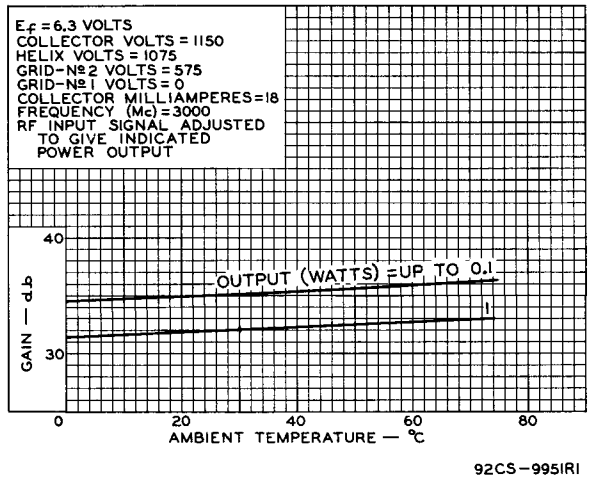


Fig. 2 - Typical Gain Characteristics of Type 4010.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

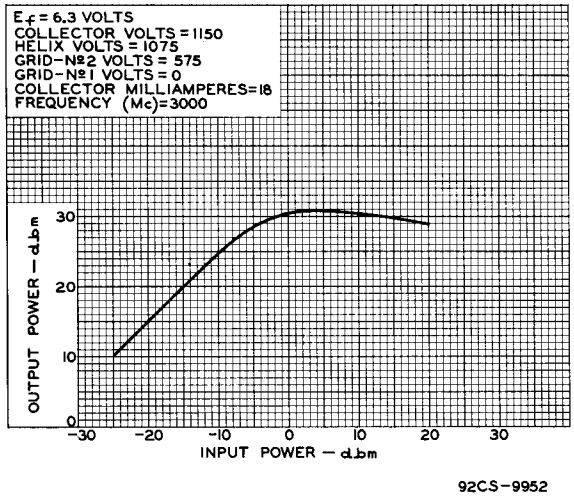


Fig. 3 - Typical Power Output Characteristic of Type 4010.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment-component variation, equipment-control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The *rated values for collector voltage, helix voltage, and grid-No.2 voltage are high enough to be dangerous to the user.* Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

The *power supply* for the 4010 should be capable of holding ripple voltage sufficiently low to prevent excessive phase or amplitude modulation of the output, and should have adequate regulation to prevent a change in operating conditions which might decrease the gain or power output. Typical values of ripple voltage on different elements which will produce amplitude modulation amounting to ±0.1 db in the tube output are shown below.

Tube Electrode	Typical Operating Volts DC	Typical Ripple Volts* Peak to Peak
Grid No.2	575	2.5
Helix	1075	1
Collector	1100	100

* For ±0.1 db amplitude modulation.

The power supply should incorporate a helix-current overload protective device to prevent damage to the tube in the event of loss of collector voltage. Such a condition would cause the entire electron beam current to flow to the helix and thereby overheat the electrode. If it is desired to remove all voltages by a single control, the time-constant values of the power supply should be so chosen that the helix voltage decays faster than the collector voltage.

The *magnetic field* required to focus the electron beam in the 4010 is supplied by integral periodic permanent magnets. Although the periodic magnet structure is difficult to demagnetize, and has small stray field, care should be taken to prevent the presence of any appreciable external transverse magnetic field which might cause defocusing of the electron beam within the tube. Tubes can be operated as close together as 3" center-to-center without magnetic interaction.

Mounting. The 4010 may be mounted in any position by means of bolts through the holes in the two mounting brackets.

Electrical connections are made to the 4010 by means of the seven color-coded flexible, insulated leads identified on the *Dimensional Outline.* RF Input and output connections require the use of coaxial plugs† which can be connected to 50-ohm coaxial cable and which fit the type TNC jacks on the tube (see *Dimensional Outline).*

Starting Procedure

For pulsed operation. Apply the rated heater voltage to the 4010 for 2.5 minutes to allow the cathode to reach normal operating temperature. Then apply a collector voltage of 1150 volts, helix voltage as specified on the tube label, and grid-No.1 bias voltage of -75 volts.

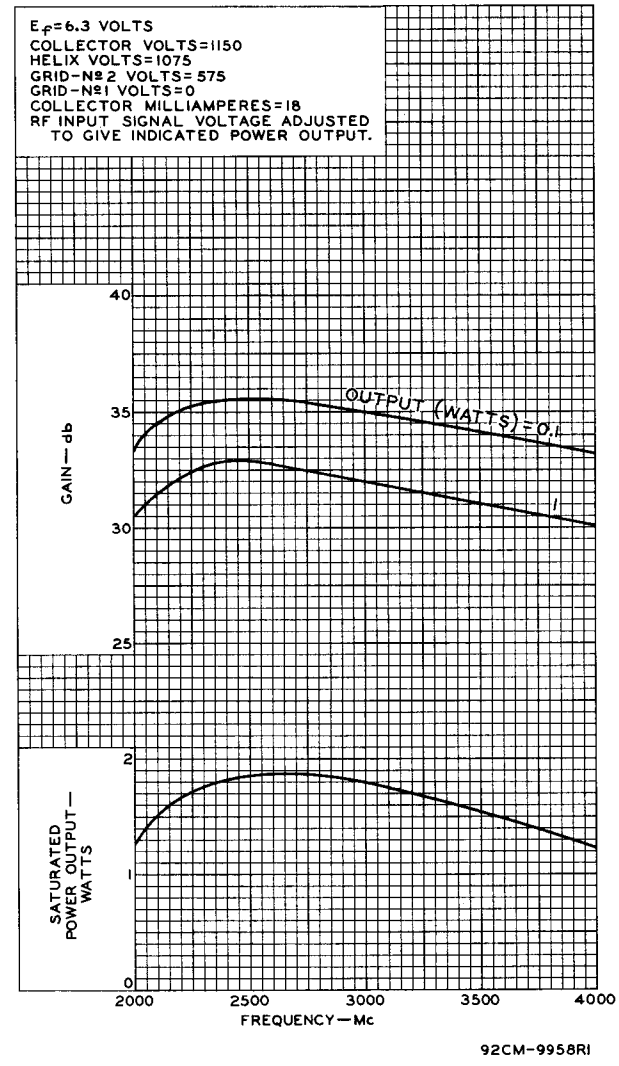


Fig.4 - Typical Characteristics of Type 4010.

Next, apply the value of dc grid-No.2 voltage specified on the tube label, and then the pulsed signal to grid No.1. Increase the amplitude of the signal until the peak collector-current value specified on the tube label is obtained. This current value corresponds to that obtained with an effective grid-No.1 voltage of 0 volts.

† Such as Catalog No. 166A, General RF Fittings, Inc., 702 Beacon St., Boston 15, Mass., or equivalent.

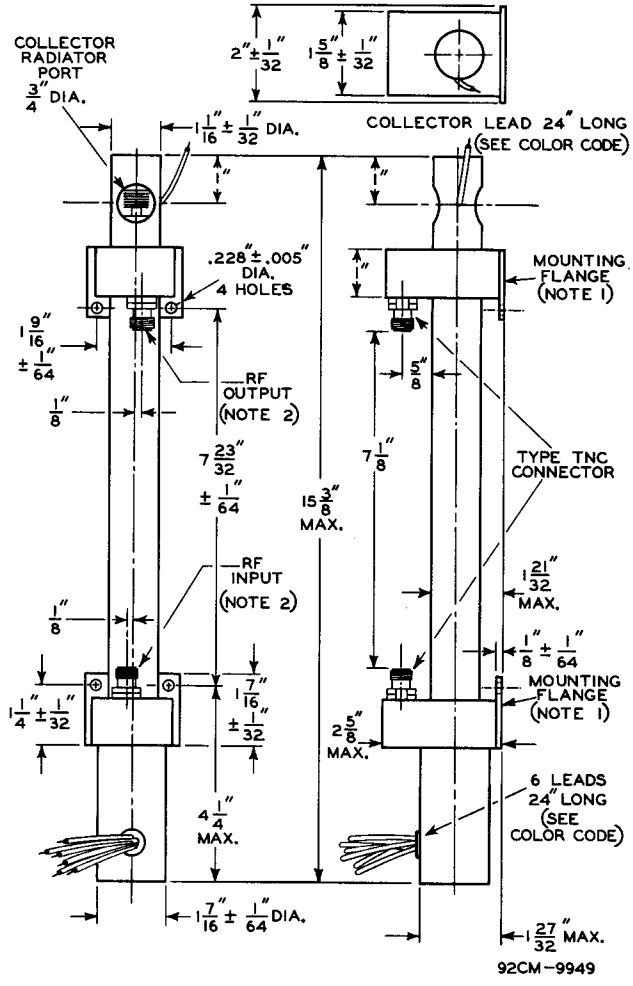
For cw operation. Apply the rated heater voltage to the 4010 for 2.5 minutes to allow the cathode to reach normal operating temperature. Then apply collector voltage of 1150 volts and helix voltage as shown on the tube label, in the order indicated. Next, with zero volts on grid No.1 apply a low value of grid-No.2 voltage. Then increase grid-No.2 voltage gradually until the value of collector current specified on the tube label is reached.

The value of helix voltage specified on the tube label is that necessary to provide broadband operation from 2000 to 4000 Mc. If it is desired to operate at a single frequency or on a narrow band, increased gain may sometimes be obtained by readjustment of the helix voltage.

Turn-Off Procedure

First reduce the collector current by removing the pulsed grid-No.1 signal (when pulsed operation is employed), and then remove grid-No.2 voltage, grid-No.1 bias voltage (when used), helix voltage, and collector voltage in the order indicated.

DIMENSIONAL OUTLINE



COLOR CODE

HEATER (2)	BROWN
COLLECTOR	RED
HELIX	ORANGE
GRID No.2	BLUE
GRID No.1	GREEN
CATHODE	YELLOW

NOTE 1: WITH TUBE MOUNTING FLANGES RESTING ON A SMOOTH, PLANE SURFACE, A 0.015" THICKNESS GAUGE 1/8" WIDE WILL NOT ENTER BETWEEN ANY POINT ON THE MOUNTING FLANGE AND THE PLANE SURFACE.

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4604

BEAM POWER TUBE

Quick-Heating Filament
Small Size
Sturdy Structure

High Power Sensitivity
90 Watts CW Input (ICAS) up to 60 Mc
60 Watts CW Input (ICAS) at 175 Mc

3-13/16" Max. Length
1-21/32" Max. Diameter
Octal 8-Pin Base

RCA-4604 is a quick-heating beam power tube having high efficiency and high power sensitivity. It is designed as an rf power amplifier in push-to-talk use in mobile and emergency-communications equipment. The 4604 has a maximum plate dissipation of 25 watts under ICAS conditions in cw and fm telephony service. At this service, it can be operated with full input to 60 Mc and with reduced input to 175 Mc.

The 4604 employs a quick-heating, oxide-coated filament which reaches operating temperature less than one second after filament voltage is applied. In addition to its quick-heating characteristic the filament is both sturdy and efficient.

Small in size for its power-output capability, the 4604 has a rugged button-stem construction with short internal leads, a T-12 bulb, triple base-pin connections for grid No.3 and filament tap (both joined to internal shield inside the tube) to permit effective rf grounding, and an octal base with short metal sleeve having its own base-pin terminal. The sleeve shields the input to the tube and isolates it from the output circuit so completely that no other external shielding is required. Separation of input and output circuits is accomplished by bringing the plate lead out of the bulb to a cap opposite the base.

GENERAL DATA

Electrical:

Filament, Coated:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	0.65	ampere
Heating time	1	second
Transconductance, for plate volts = 200, grid-No.2 volts = 200, and plate ma = 100	6000	μmhos
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 200, grid-No.2 volts = 200, and plate ma = 100	4	
Direct Interelectrode Capacitances:		
Grid No.1 to plate	0.24 max.	μμf
Grid No.1 to filament & grid No.3 & internal shield, base sleeve and grid No.2	11	μμf
Plate to filament & grid No.3 & internal shield, base sleeve and grid No.2	8.5	μμf

Mechanical:

Operating Position	Vertical, or horizontal with plane of pins 3 and 7 vertical
Maximum Overall Length	3-13/16"
Seated Length	3-1/8" ± 1/8"
Maximum Diameter	1-21/32"
Bulb	T-12
Cap	Small (JEDEC No.C1-1)
Base	Small Wafer Octal 8-Pin with Sleeve (JEDEC Group 1, No.B8-150)
Bulb Temperature (At hottest point)	220 max. °C

RF POWER AMPLIFIER & OSC. — Class C Telegraphy♦ and RF POWER AMPLIFIER — Class C FM Telephony

Maximum ICAS★ Ratings, *Absolute-Maximum Values:*♦

	Up to 60 Mc	
DC PLATE VOLTAGE	750 max.	volts
DC GRID-No.2 VOLTAGE	250 max.	volts
DC GRID-No.1 VOLTAGE	-150 max.	volts
DC PLATE CURRENT	150 max.	ma
DC GRID-No.1 CURRENT	4 max.	ma
PLATE INPUT	90 max.	watts
GRID-No.2 INPUT	3 max.	watts
PLATE DISSIPATION	25 max.	watts

Typical Operation as Amplifier at 175 Mc:

DC Plate Voltage	400	volts
DC Grid-No.2 Voltage♦	190	volts
From a series resistor of	18000	ohms
DC Grid-No.1 Voltage♦	-60	volts
From a grid resistor of	30000	ohms

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DC Plate Current	150	ma
DC Grid-No.2 Current	11	ma
DC Grid-No.1 Current (Approx.)	2	ma
Driving Power (Approx.)	4.5	watts
Power Output (Approx.)	30	watts

Maximum Circuit Values:

Grid-No.1 Circuit Resistance♣	30000 max.	ohms

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	*Max.*	
Filament Current at 6.3 volts ac.	0.59	0.71	ampere
Direct Interelectrode Capacitances:			
Grid No.1 to plate	–	0.24	μμf
Grid No.1 to filament & grid No.3 & internal shield, base sleeve and grid No.2	9.5	12.5	μμf
Plate to filament & grid No.3 & internal shield, base sleeve and grid No.2	7.3	9.5	μμf
Plate Current⊕	46	94	ma
Grid-No.2 Current⊕	–	5.5	ma
Useful Power Output*	47	–	watts

● Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

★ Intermittent Commercial and Amateur Service.

♦ The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment-component variation, equipment-control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

♦ Obtained preferably from a separate source, or from the plate-supply voltage with a voltage divider, or through a series resistor. A series grid-No.2 resistor should be used only when the 4604 is used in a circuit which is not keyed. Grid-No.2 voltage must not exceed 400 volts under key-up conditions.

♠ Obtained from fixed supply, by grid-No.1 resistor, or by combination methods.

♣ When grid No.1 is driven positive and the 4604 is operated at maximum ratings, the total dc grid-No.1-circuit resistance should not exceed the specified value of 30000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a fixed supply.

⊕ With 6.3 volts ac on filament, dc plate voltage of 300 volts, dc grid-No.2 voltage of 200 volts, and dc grid-No.1 voltage of −26 volts.

* In a single-tube self-excited oscillator circuit, and with 6.3 volts ac on filament, dc plate voltage of 600 volts, dc grid-No.2 voltage of 200 volts, grid-No.1 resistor of 30000 ± 10% ohms, dc plate current of 100 to 112 ma., dc grid-No.1 current of 2 to 2.5 ma., and frequency of 15 Mc.

MECHANICAL CONSIDERATIONS

The *bulb* becomes hot during operation. To insure adequate cooling, therefore, it is essential that free circulation of air be provided around the 4604.

The *plate* shows no color when the 4604 is operated at full ratings under ICAS conditions. Connections to the plate should be made with a flexible lead to prevent any strain on the seal at the cap.

ELECTRICAL CONSIDERATIONS

The rated plate voltage and grid-No.2 voltage of this tube are high enough to be dangerous. Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

Heavy leads and conductors together with suitable insulation should be used in all parts of the rf plate tank circuit so that losses due to rf voltages and currents may be kept at a minimum. At the higher frequencies, it is essential that short, heavy leads be used for circuit connections in order to minimize lead inductance and losses.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage and grid-No.2 voltage. If the 4604 is operated at maximum ratings and grid-No.2 voltage is obtained through a series dropping resistor, the use of a 2500-ohm protective resistor in the high-voltage supply lead is recommended. When a separate grid-No.2 voltage supply is used, a 10000-ohm protective resistor should be connected in the grid-No.2 supply lead.

Grid-No.2 voltage should be obtained from a source of good regulation. The plate voltage should be applied before or simultaneously with the grid-No.2 voltage; otherwise, with voltage on grid-No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the dc power output determined.

The *grid-No.2 current* is a very sensitive indication of plate-circuit loading and grid-No.2 current rises excessively (often to the point of damaging the tube) when the amplifier is operated without load. Therefore, care should be taken when tuning a 4604 under no-load conditions in order to prevent exceeding the grid-No.2 input rating of the tube.

The *driver stage* for the 4604 in either class C telephony or telegraphy service should have considerably more output capability than the typical driving power shown in the tabulated data in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuit and the coupling circuits. This recommendation is particularly important near the maximum-rated frequency where there are other losses of driving power, such as circuit losses, radiation losses, and transit-time losses.

Highest operating efficiency in high frequency service, and therefore maximum power output, will be obtained when the 4604 is operated under load conditions such that the maximum rated plate current flows at the plate voltage which will give maximum rated input.

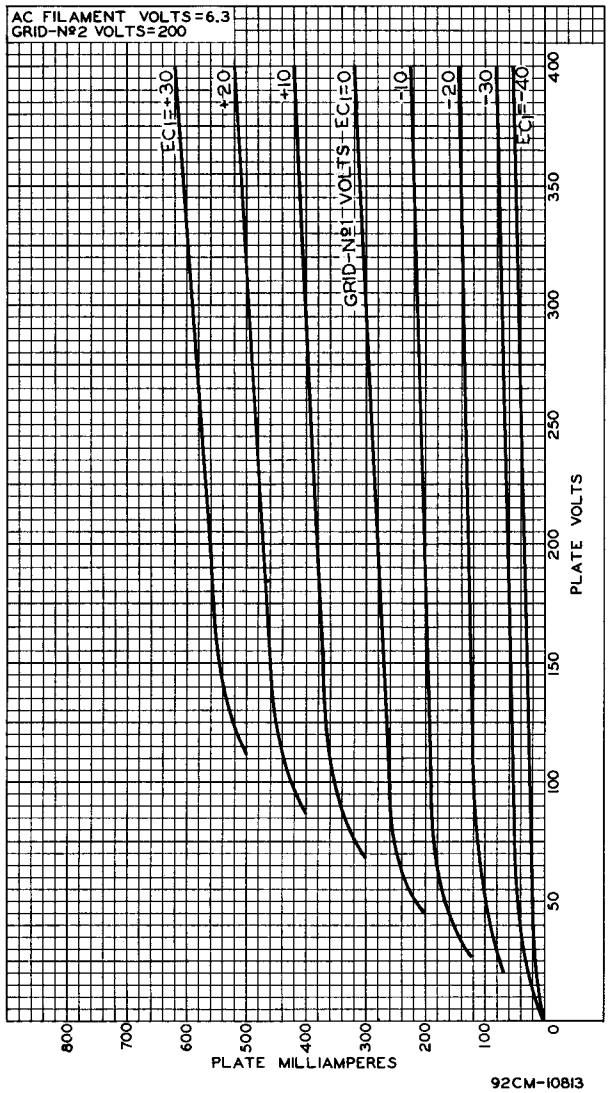


Fig. 1 - Typical Plate Characteristics of Type 4604.

Push-pull or parallel circuit arrangements can be used when more radio-frequency power is required than can be obtained from a single 4604. Two 4604's in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits.

When two or more tubes are used in the circuit, precautions should be taken to insure that each tube draws the same plate current.

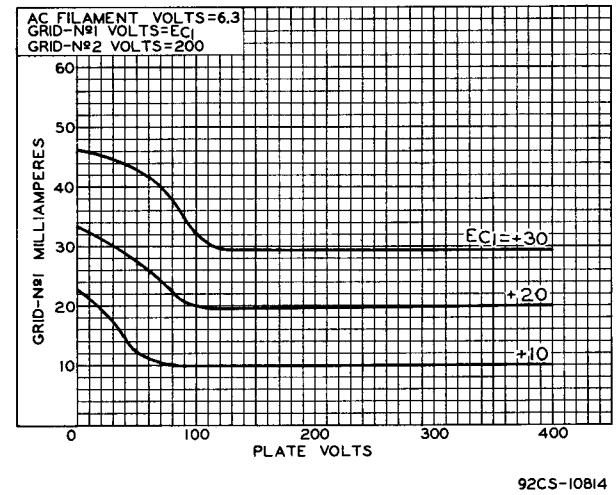


Fig. 2 - Typical Characteristics of Type 4604.

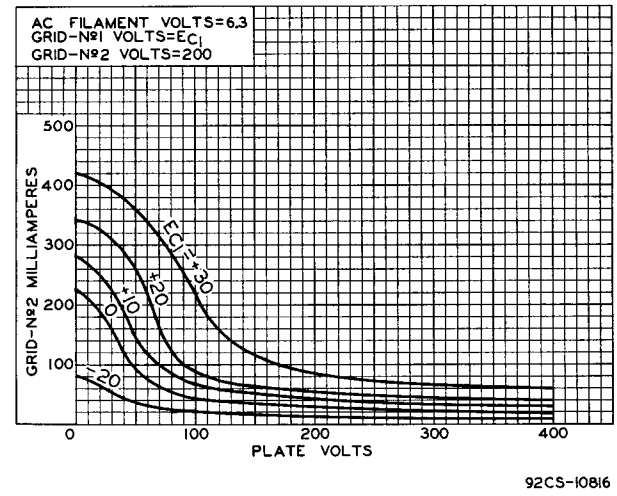


Fig. 3 - Typical Characteristics of Type 4604.

When two 4604's are used in push-pull or parallel circuit arrangements with their filaments connected in series across a 12.6-volt supply, a different bias voltage is required for each tube. Furthermore, the relative polarity of the filament terminals must be maintained when switching between negative-ground and positive-ground supplies.

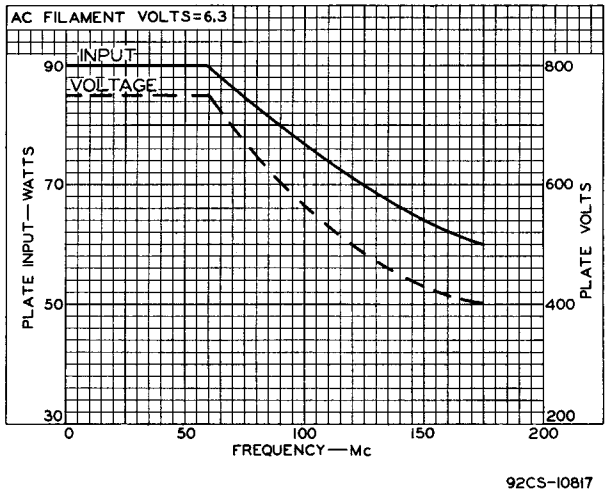
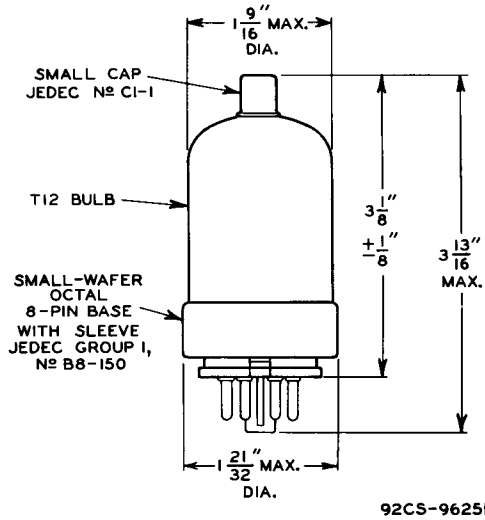
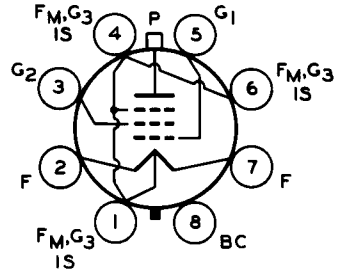


Fig. 4 - Maximum Ratings vs. Operating Frequency for Type 4604 in ICAS Class C Telegraphy or Telephony Service.

DIMENSIONAL OUTLINE



BASING DIAGRAM
Bottom View

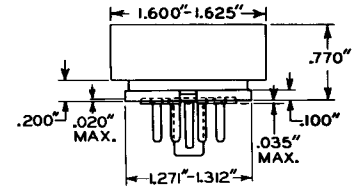


7CL

PIN 1: FILAMENT TAP, GRID NO.3, INTERNAL SHIELD
PIN 2: FILAMENT
PIN 3: GRID NO.2
PIN 4: SAME AS PIN NO.1
PIN 5: GRID NO.1
PIN 6: SAME AS PIN NO.1
PIN 7: FILAMENT
PIN 8: BASE SLEEVE
CAP: PLATE

BASE DRAWING

SMALL-WAFER OCTAL WITH SLEEVE
JEDEC GROUP 1, No. B8-150



BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT ENTIRE LENGTH OF PINS WILL ENTER FLAT-PLATE GAUGE (JEDEC No.GB8-1) HAVING THICKNESS OF 1/4" AND EIGHT HOLES WITH DIAMETERS OF 0.1030" ± 0.0005" SO LOCATED ON A 0.6870" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.2629" ± 0.0005".

PIN FIT IN GAUGE IS SUCH THAT GAUGE TOGETHER WITH SUPPLEMENTARY WEIGHT TOTALING 2 POUNDS WILL NOT BE LIFTED WHEN PINS ARE WITHDRAWN.

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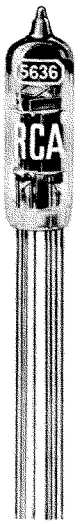
5636

SHARP-CUTOFF PENTODE

Two Independent Control Grids | **"Premium" Subminiature Type** | **For Operation At Altitudes Up to 60000 Feet**

TENTATIVE DATA

RCA-5636 is a subminiature sharp-cutoff pentode of the heater-cathode type having flexible leads. It is intended particularly for use in military and critical industrial applications including gated amplifier circuits, delay circuits, mixer circuits at frequencies up to 400 megacycles per second, and gain-controlled amplifier circuits. The 5636 is rated for service at altitudes up to 60000 feet without the use of pressurized chambers.



Actual Size

The design of the 5636 incorporates a compact structure in which special attention has been given to features which enable it to resist shock and vibration. These features include: (1) tube parts precisely made and accurately fitted to minimize mechanical movement, (2) special connections between tube electrodes and stem leads to reduce stresses on tube elements and to insure good welds and, (3) a pure-tungsten heater having high mechanical strength.

As a result of its structural design, this tube is characterized by small spread in electrical characteristics, reduced microphonic effects, and long life under conditions of frequent on-off switching.

The 5636 utilizes a separate terminal for grid No.3 as well as for grid No.1. Because both grids have a sharp-cutoff characteristic, either grid may be used independently as a control electrode. Furthermore, the cathode is provided with two lead terminals. This arrangement permits separation of the input and output circuit returns and facilitates isolation of the input and output circuits.

Manufactured under rigid controls, the 5636 undergoes rigorous tests during manufacture to insure its "premium" quality as follows: (1) factory controls and design tests under typical plate-current cutoff conditions in gated-amplifier circuits, (2) test readings at the end of 1 hour, 100 hours, and 500 hours to insure that tubes fall within the established tight characteristics limits and that early failures are held to a low percentage.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)		6.3	volts
Current		0.150	ampere
Direct Interelectrode Capacitances:	*With External Shield**	*Without External Shield*	
Grid No.1 to plate	0.02 max.	0.034 max.	μμf
Grid No.1 to all other electrodes	4	4	μμf
Grid No.1 to grid No.3	0.15 max.	0.17 max.	μμf
Grid No.3 to all other electrodes	4	3.8	μμf
Grid No.3 to plate	1.1 max.	1.1 max.	μμf
Plate to all other electrodes	3.4	1.9	μμf

Mechanical:

Operating Position	Any
Maximum Bulb Length	1-3/8"
Length from Button Seal to Bulb top (Excluding Tip)	1.075" ± 0.060"
Diameter	0.366" - 0.400"
Bulb	T-3
Leads, Flexible	8
Length	1-1/2" to 1-3/4"
Orientation and Diameter	See Dimensional Outline

CLASS A_1 AMPLIFIER

Maximum Ratings, *Absolute Values:*

For Operation At Altitudes Up To 60000 Feet

PLATE VOLTAGE	165 max.	volts
GRID-No.3 (SUPPRESSOR-GRID) VOLTAGE:		
Positive bias value	30 max.	volts
GRID-No.2 (SCREEN-GRID) VOLTAGE	155 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Positive bias value	0 max.	volts
Negative bias value	55 max.	volts
PLATE CURRENT	11 max.	ma
GRID-No.2 CURRENT	7 max.	ma
PLATE DISSIPATION	1.1 max.	watts
GRID-No.2 INPUT	0.7 max.	watt
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	°C

Characteristics and Typical Operation as Class A_1 Amplifier:

Plate Supply Voltage	100	100	volts
Grid No.3	Connected to Cathode	-	
Grid-No.3 Supply Voltage	-	-1	volt

TMK ®, Marca Registrada
Printed in U.S.A.

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Grid-No.2 Supply Voltage . .	100	100	volts
Cathode Resistor	150	150	ohms
Plate Resistance (Approx.) .	0.11	0.05	megohm
Transconductance:			
Grid No.1 to plate	3200	1950	μmhos
Grid No.3 to plate	500	950	μmhos
Plate Current.	5.6	4	ma
Grid-No.2 Current.	4	5.8	ma
Grid-No.1 Voltage (Approx.) for plate current of 10 μa	-7.5	-	volts
Grid-No.3 Voltage (Approx.) for plate current of 10 μa	-	-8	volts

Characteristics and Typical Operation as Mixer:[o]

Plate Supply Voltage	100	volts
Grid-No.3 Supply Voltage (RMS)	15	volts
Grid-No.2 Supply Voltage	100	volts
Cathode Resistor	150	ohms
Plate Resistance (Approx.)	0.32	megohm
Conversion Transconductance.	1280	μmhos
Plate Current.	3.5	ma
Grid-No.2 Current.	5.7	ma

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For cathode-bias operation	1.1 max.	megohm

* With 0.405" internal diameter shield connected to lead terminal No.8.

o With local oscillator injection to grid No.3. DC grid-No.3-circuit resistance should be kept at as low as possible at the high frequencies.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN*

Values Are Initial, Unless Otherwise Specified

	Note	*Min.*	*Max.*	
Heater Current	1	0.140	0.160	amp
Direct Interelectrode Capacitances:				
Grid No.1 to all other electrodes	2	3.5	4.5	μμf
Grid No.3 to all other electrodes	2	3.5	4.5	μμf
Plate to all other electrodes	2	2.9	3.9	μμf
Plate Current (1).	1,3	3.7	6.9	ma
Plate Current (2).	1,4	-	100	μa
Plate Current (3).	1,5	-	100	μa
Grid-No.2 Current.	1,3	2.8	5.4	ma
Transconductance, Grid No.1 to Plate:				
Range with heater volts = 6.3.	3	2700	4000	μmhos
Change with heater volts = 5.7.	3	-	15	per cent
Change at end of 500 hours with heater volts = 6.3.	3	-	20	per cent
Change at end of 500 hours with heater volts = 5.7.	3	-	15	per cent
Difference between average transconductance initially, and average after 500 hours, expressed as a percentage of the initial average. . . .	1,3	-	15	per cent
Transconductance, Grid No.3 to plate.	1,6	500	1800	μmhos
Reverse Grid Current . . .	1,7	-	0.3	μa
Reverse Grid Current at 500 hours.	1,7	-	0.9	μa
Grid-Emission Current. . .	8	-	0.5	μa
Heater-Cathode Leakage Current:				
Heater 100 volts negative with respect to cathode	1,3	-	5	μa
Heater 100 volts positive with respect to cathode	1,3	-	5	μa
Heater-Cathode Leakage Current at 500 hours:				
Heater 100 volts negative with respect to cathode	1,3	-	10	μa
Heater 100 volts positive with respect to cathode	1,3	-	10	μa
Leakage Resistance:				
Grid No.1 to all other electrodes	1,9	100	-	megohms
Plate to all other electrodes	1,10	100	-	megohms
Leakage Resistance at 500 hours:				
Grid No.1 to all other electrodes	1,9	50	-	megohms
Plate to all other electrodes	1,10	50	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With shield having internal diameter of 0.405" connected to cathode.

Note 3: With plate supply voltage of 100 volts, grid No.3 tied to cathode, grid-No.2 supply voltage of 100 volts, and cathode resistor of 150 ohms.

Note 4: With plate voltage of 100 volts, grid No.3 connected to cathode, grid-No.2 voltage of 100 volts, and grid-No.1 voltage of -7.5 volts.

Note 5: With plate supply voltage of 100 volts, grid-No.3 supply voltage of -8 volts, grid-No.2 supply voltage of 100 volts, and cathode resistor of 150 ohms.

Note 6: With plate supply voltage of 100 volts, grid-No.3 supply voltage of -1 volt, grid-No.2 supply voltage of 100 volts, and cathode resistor of 150 ohms.

Note 7: With plate supply voltage of 100 volts, grid No.3 tied to cathode, grid-No.2 supply voltage of 100 volts, cathode resistor of 150 ohms, and grid-No.1 resistor of 1 megohm.

Note 8: With heater voltage of 7.5 volts ac or dc, plate voltage of 100 volts, grid-No.3 voltage of 0 volts, grid-No.2 voltage of 100 volts, grid-No.1 voltage of -7.5 volts, and grid-No.1 resistor of 1 megohm.

Note 9: With grid-No.1 voltage of -100 volts with respect to all other electrodes.

Note 10: With plate voltage of -300 volts with respect to all other electrodes.

* Each tube is stablized before characteristics testing by continuous operation for at least 45 hours at room temperature and with dissipation values equivalent to life test conditions.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration. . . . . 450 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are held rigid and are tested in four different positions. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, and transconductance change.

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected in each of three positions to 2.5 g vibrational acceleration at 60 cycles per second for 32 hours. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, and transconductance change.

Low-Frequency Vibration Performance:

RMS Output Voltage . . . . . 60 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, grid No.3 tied to cathode, grid-No.2 supply voltage of 100 volts, cathode resistor of 150 ohms, cathode-bypass capacitor of 1000 μf, plate load resistor of 10000 ohms and vibrational acceleration of 15 g at 40 cps.

Heater-Cycling Life Performance:

Cycles of Intermittent Operation . . 2000 min. cycles

Under the following conditions: Heater voltage of 7.0 volts cycled one minute on one minute off, heater 140 volts rms with respect to cathode, and all other elements grounded.

Audio-Frequency Noise and Microphonic Performance:

Output Voltage . . . . . 70 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, grid No.3 connected to cathode, grid-No.2 supply voltage of 19 volts, cathode resistor of 150 ohms, grid-No.1 resistor of 0.1 megohm, grid-No.2 resistor of 1000 ohms, plate load resistor of 0.2 megohm, and cathode-bypass capacitor of 1000 μf. The output voltage of a tube, when tapped, will not cause a reading on a vu meter greater than that produced when a calibrating signal of 70 millivolts rms is applied to the plate of the tube.

Shorts and Continuity Test:

This test is performed on a sample lot of tubes from each production run. In this test a tube is considered inoperative if it shows a permanent or temporary short or open circuit, or a value of reverse grid current in excess of 1.0 microampere under the conditions specified in the CHARACTERISTICS RANGE VALUES for reverse grid current.

1-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that the tubes have been properly stabilized. Tubes are checked for transconductance under conditions specified under 500-Hour Intermittent Life Performance. At the end of 1 hour, the value of transconductance is read. The variation in transconductance from the 0-hour reading will not exceed 15 per cent.

100-Hour Survival Life Performance:

This test is performed on a sample lot of tubes from each production run under conditions specified under 500-Hour Intermittent Life Performance to insure a low percentage of early inoperatives. At the end of 100 hours, a tube is considered inoperative if it shows a permanent or temporary short or open circuit or a grid-No.1-to-plate transconductance of less than 2350 micromhos under the conditions specified in Characteristics Range Values.

500-Hour Intermittent Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures of any of the characteristics indicated below. Life testing is conducted under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, grid No.3 tied to cathode, grid-No.2 supply voltage of 100 volts, heater-cathode voltage of 200 volts (heater positive with respect to cathode), cathode resistor of 150 ohms, grid-No.1 resistor of 1 megohm and bulb temperature of 220°C. At the end of 500 hours, tube will not show permanent shorts or open circuits and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to pass established initial limits of heater current, grid-No.1-to-plate transconductance change, grid-No.3-to-plate transconductance, and 500 hour limits for reverse grid current, heater-cathode leakage current, leakage resistance, and the difference in grid-No.1-to-plate transconductance between the initial value and average value shown under Characteristics Range Values.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 5636 are limiting values above which the serviceability of the 5636 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *heater supply* should be well regulated because life and reliability of the 5636 are adversely affected by departures from the 6.3-volt value. The extent to which life is affected is a function of the amount of these departures and their durations.

The *flexible leads* of the 5636 are usually soldered to the circuit elements. Soldering of the connections should be made as far as possible from the glass button. If this precaution is not followed, the heat of the soldering may crack the glass seals of the leads and damage the tube.

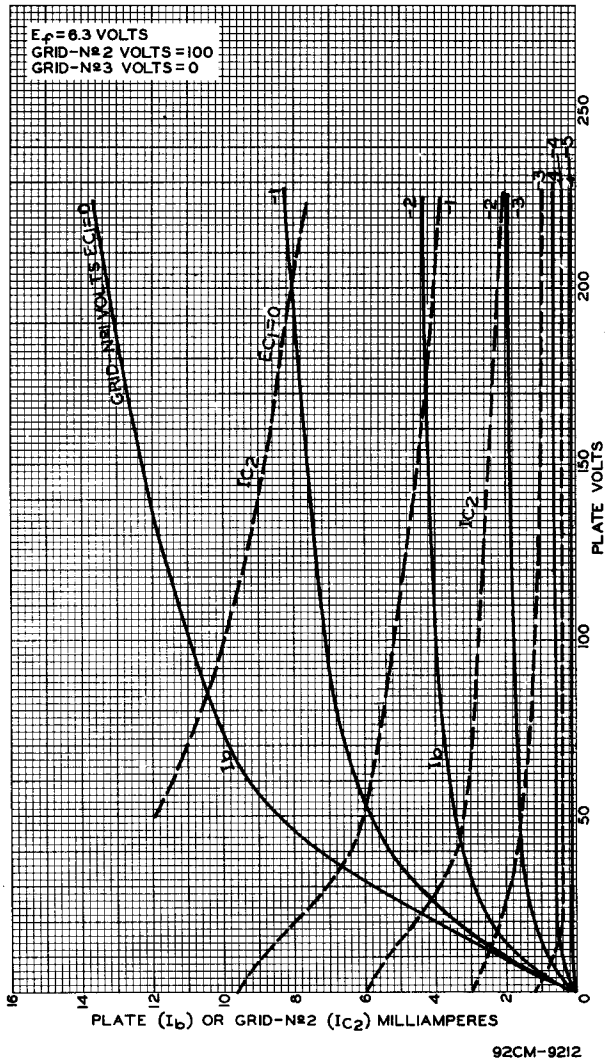


Fig. 1 - Average Characteristics of Type 5636.

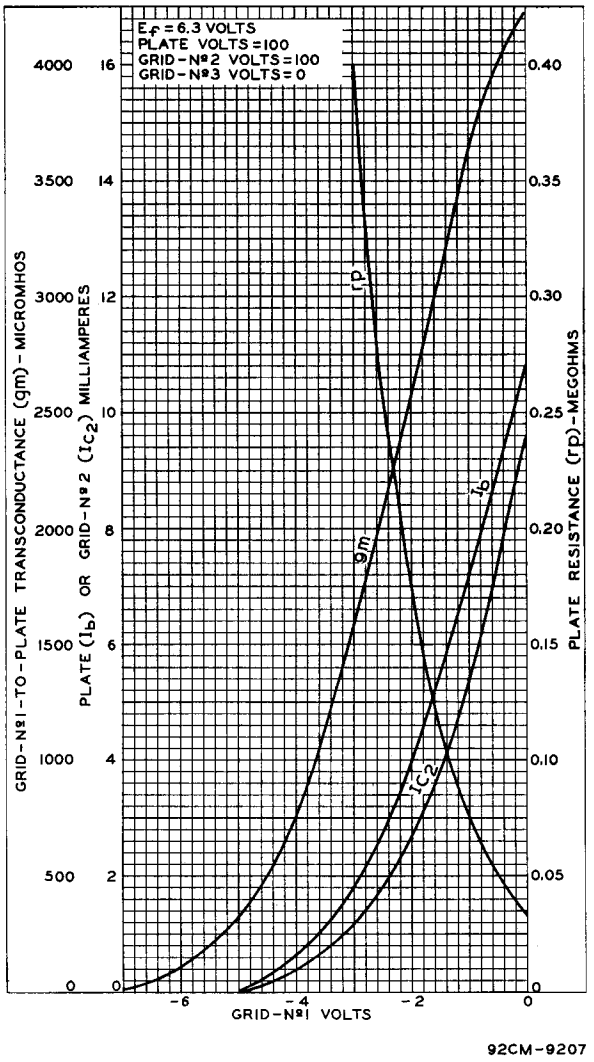


Fig. 2 - Average Characteristics of Type 5636.

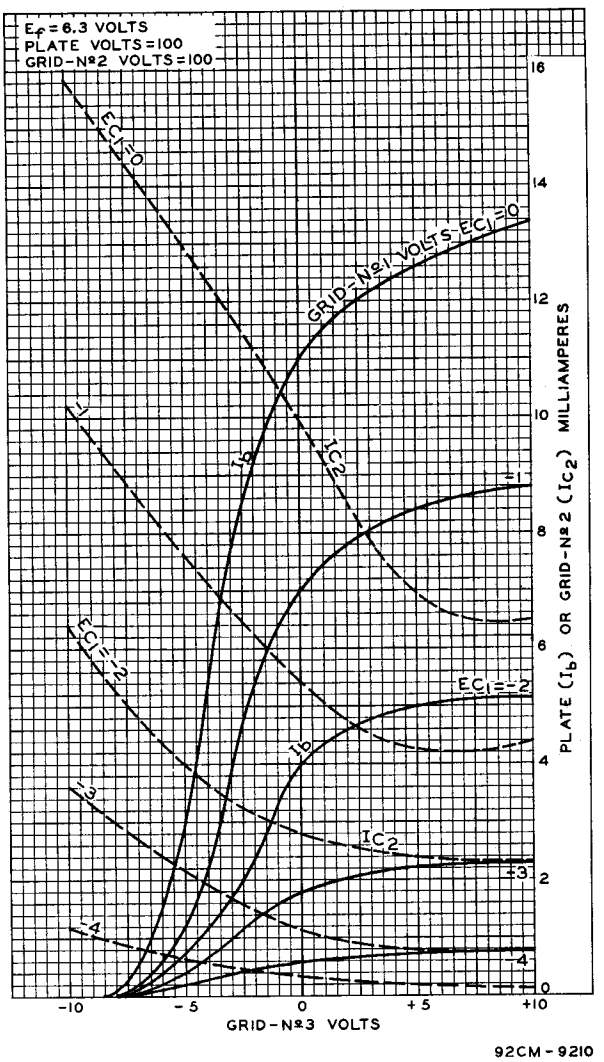


Fig.3 - Average Characteristics of Type 5636.

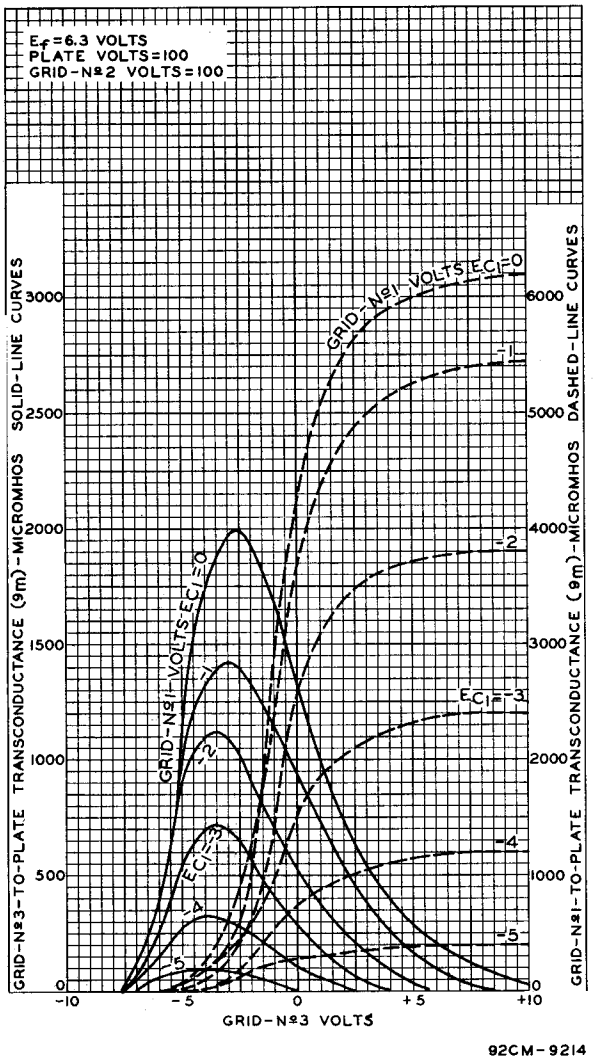
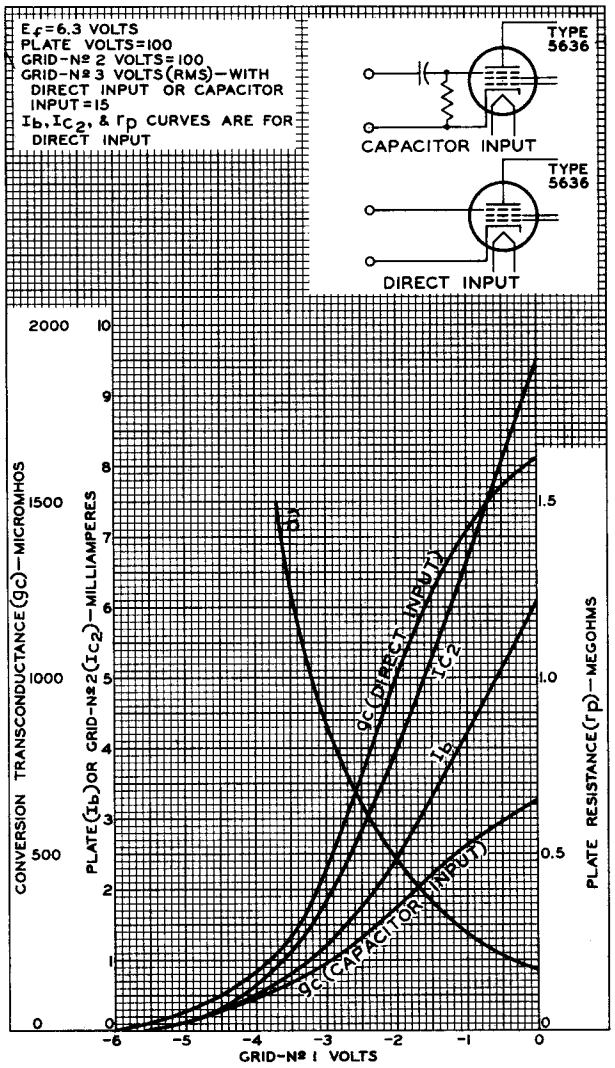


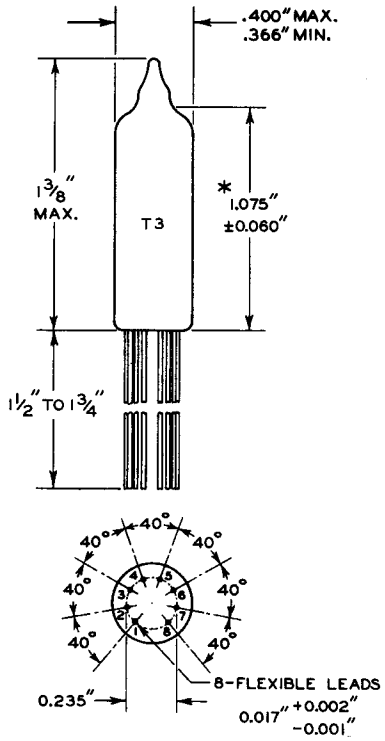
Fig.4 - Average Characteristics of Type 5636.



92CM-9215

Fig.5 - Average Characteristics of Type 5636.

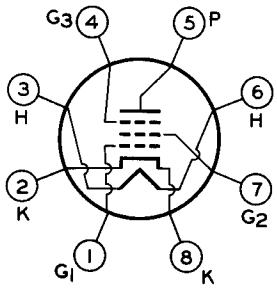
DIMENSIONAL OUTLINE



* MEASURED FROM BULB SEAT TO BULB-TOP LINE AS DETERMINED BY A RING GAUGE OF 0.210" ± 0.001" I.D.

TERMINAL CONNECTIONS

Bottom View



8DC

LEAD No.1: GRID No.1
LEAD No.2: CATHODE
LEAD No.3: HEATER
LEAD No.4: GRID No.3
LEAD No.5: PLATE
LEAD No.6: HEATER
LEAD No.7: GRID No.2
LEAD No.8: CATHODE

5654

SHARP-CUTOFF PENTODE

"PREMIUM" TUBE

For RF and IF Broad-Band Applications

TENTATIVE DATA

RCA-5654 is a "premium" version of the sharp-cutoff pentode 6AK5. It is designed for use as an rf or if amplifier in high-frequency broad-band circuits of mobile and aircraft communications receivers and is especially constructed to give dependable performance under shock and vibration.

This tube features a grid-No.1 electrode treated to minimize grid emission, a pure-tungsten heater to give longer life under conditions of on-off switching, and a compact design in which special attention has been given to structural details which provide increased mount strength against shock and against vibration. In addition each tube is subjected to rigid controls and rigorous tests during manufacture to insure "premium" quality.

Like the 6AK5, the 5654 has high transconductance, low interelectrode capacitances, high input resistance, and high signal-to-noise ratio --features contributing to the suitability of this tube for rf and if applications.

GENERAL DATA

Electrical:

Heater, Pure Tungsten, for Unipotential Cathode:		
Voltage	6.3 ± 10%	volts
Current	0.175	ampere
Direct Interelectrode Capacitances:▲		
Grid No.1 to Plate	0.020 max.	μμf
Input	4.0	μμf
Output	2.85	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	1-3/4"
Maximum Seated Length	1-1/2"
Length from Base Seat to Bulb Top (Excluding tip)	1-1/8" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

AMPLIFIER - CLASS A_1

Maximum Ratings, *Absolute Values*:

PLATE VOLTAGE	200 max.	volts
GRID-No.2 (SCREEN) VOLTAGE	155 max.	volts
PLATE DISSIPATION	1.85 max.	watts
GRID-No.2 INPUT	0.55 max.	watt
CATHODE CURRENT	20 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater positive with respect to cathode	100 max.	volts
Heater negative with respect to cathode	100 max.	volts

Typical Operation and Characteristics:

Plate Voltage	120	180	volts
Grid-No.2 Voltage	120	120	volts
Cathode-bias Resistor	180	180	ohms
Plate Resistance (Approx.)	0.30	0.50	megohm
Transconductance	5000	5100	μmhos
Plate Current	7.5	7.7	ma
Grid-No.2 Current	2.5	2.4	ma
Grid-No.1 Voltage (Approx.) for plate current of 10 μamp	-8.5	-8.5	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	0.5 max.	megohm

Shock and Fatigue Tests:

Shock Test:		
Impact Acceleration	500 max.	g

Tubes are held rigid in three different positions in a Navy Type, High Impact (flyweight) Shock Machine and are subjected to the specified impact acceleration.

Fatigue Test:

Vibrational Acceleration	2.5 max.	g

Tubes are rigidly mounted and subjected to the specified maximum vibrational acceleration at 60 cycles per second for 32 hours in each of three positions.

Heater Cycling Life Test:

Cycles of Intermittent Operation at heater volts = 7.5	2000 min.	cycles

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.160	0.190	amp
Grid-No.1-to-Plate Capacitance	-	-	0.020	μμf
Input Capacitance	-	3.4	4.6	μμf
Output Capacitance	-	2.45	3.25	μμf
Plate Current	1,2	3.0	12.0	ma
Transconductance	1,2	3500	6500	μmhos
Reverse Grid Current	1,3	-	0.1	μamp

Note 1: With 6.3 volts ac on heater.

Note 2: With plate voltage of 120 volts, grid-No.2 voltage of 120 volts, and grid-No.1 voltage of -2 volts.

Note 3: With plate voltage of 120 volts, grid-No.2 voltage of 120 volts, grid-No.1 voltage of -2 volts, and grid-No.1 resistor of 0.1 megohm.

▲ According to RTMA Standard ET-109A with external shield No.316.

OPERATING NOTES

The *maximum ratings* in the tabulated data for the 5654 are limiting values above which the serviceability of the 5654 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5654-10-52
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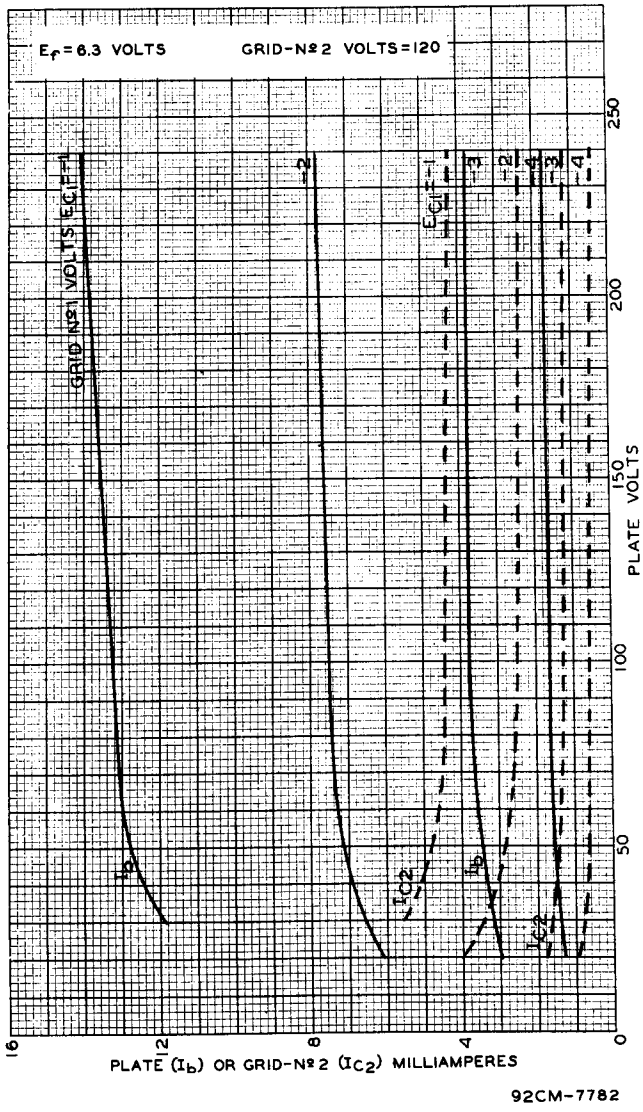


Fig. 1 – Average Plate Characteristics of 5654.

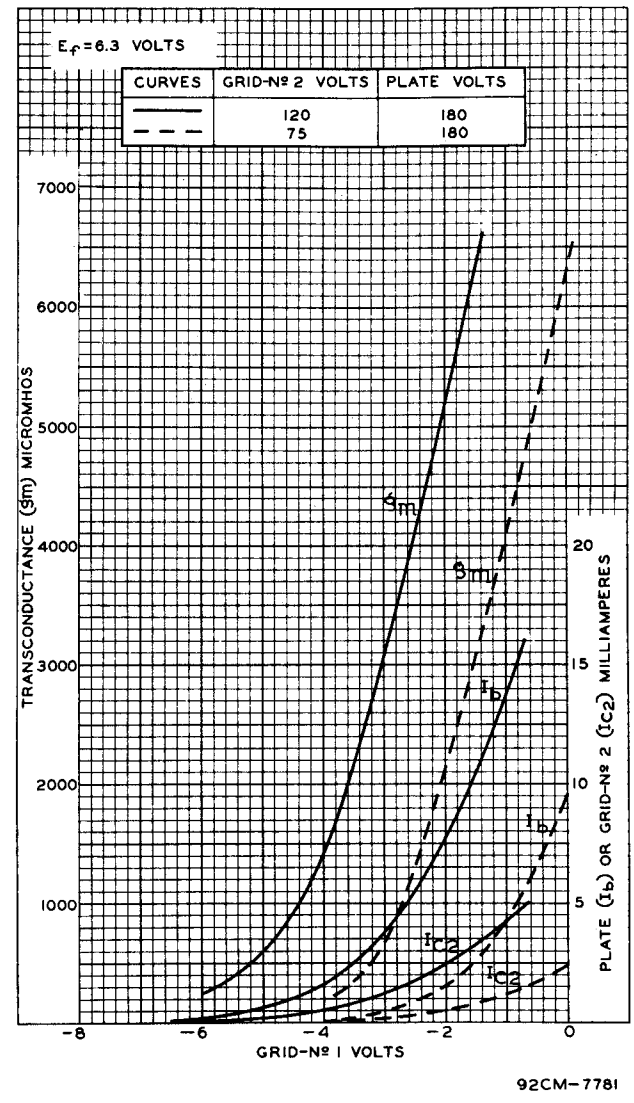
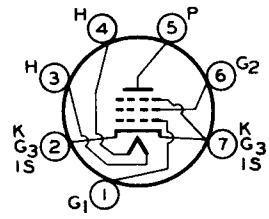
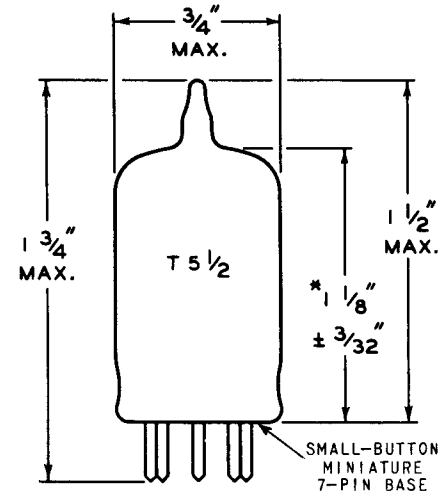


Fig. 2 – Average Characteristics of 5654.

SOCKET CONNECTIONS
Bottom View



PIN 1: GRID No.1
PIN 2: CATHODE, GRID No.3, INTERNAL SHIELD
PIN 3: HEATER
PIN 4: HEATER
PIN 5: PLATE
PIN 6: GRID No.2
PIN 7: CATHODE, GRID No.3, INTERNAL SHIELD



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

from RMA release # 598,
Aug. 22, 1947

SEP 2 1947

5655

IMAGE ORTHICON

Tentative Data

The 5655 is a television camera tube recommended for studio use. It is similar to type 2P23 but differs in that its photocathode has practically no infrared response, its resolution is somewhat better, its signal-to-noise ratio has been improved about twice, and its response to half tones is more natural. It does not, however, cover as wide a light range as the 2P23.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3±10%	Volts
Current	0.6	Ampere
Direct Interelectrode Capacitance:		
Anode to All Other Electrodes	20	μμf
Photocathode Response	See accompanying curve	
Image Size (4 x 3 aspect ratio)	1.6" Diagonal	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	15-1/4" ± 1/4"	
Greatest Diameter of Bulb	3" ± 1/16"	
Shoulder Base	Keyed Jumbo Annular 7-Pin	
End Base	Small-Shell Diheptal 14-Pin	

Mounting Position: Never in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical through the center of the base.

Minimum Deflecting-Coil Inside Diameter	2-1/8"
Deflecting-Coil Length	5"
Focusing-Coil Length	10"
Alignment-Coil Length	15/16"
Photocathode Distance Inside End of Focusing Coil	1/2"

Maximum Ratings, Absolute Values:

PHOTOCATHODE VOLTAGE	-550 max.	Volts
PHOTOCATHODE ILLUMINATION	50 max.	Foot-Candles
AMBIENT TEMPERATURE	50 max.	°C
GRID-No.6 VOLTAGE	-550 max.	Volts
TARGET VOLTAGE:		
Positive Value	50 max.	Volts
Negative Value	50 max.	Volts
GRID-No.5 VOLTAGE	150 max.	Volts
GRID-No.4 VOLTAGE	300 max.	Volts
GRID-No.3 VOLTAGE	400 max.	Volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	Volts

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GRID-No.1 VOLTAGE:		
Negative Bias Value	125 max.	Volts
Positive Bias Value	0 max.	Volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	Volts
Heater positive with respect to cathode	10 max.	Volts
ANODE-SUPPLY VOLTAGE #	1500 max.	Volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	Volts
ANODE CURRENT	100 max.	Microamp.

Typical Operation:

Photocathode Voltage (Image Focus)	-300 to -500	Volts
Grid-No.6 Voltage (Accelerator)— 80% of photocathode voltage	-240 to -400	Volts
Target Voltage °	0	Volts
Grid-No.5 Voltage (Decelerator)°°	0 to 100	Volts
Grid-No.4 Voltage (Beam Focus)	160 to 240	Volts
Grid-No.3 Voltage ##	225 to 330	Volts
Grid-No.2 & Dynode-No.1 Voltage	300	Volts
Grid-No.1 Voltage (For Picture Cutoff)	-35 to -90	Volts
Dynode-No.2 Voltage	600	Volts
Dynode-No.3 Voltage	800	Volts
Dynode-No.4 Voltage	1000	Volts
Dynode-No.5 Voltage	1200	Volts
Anode Voltage	1250	Volts
Target Temperature Range	35 to 45	°C
Ratio of Peak-to-Peak Highlight Video Signal Current to RMS Noise Current (Approx.)	70	
Minimum Peak-to-Peak Blanking Voltage	10	Volts
Field Strength at Center of Focusing Coil	75	Gausses
Focusing-Coil Current (Approx., for coil listed below)	75	Ma
Deflecting-Coil Current (Approx., for assembly listed below):		
Horizontal (Peak to Peak)	625	Ma
Vertical (Peak to Peak)	290	Ma
Alignment-Coil Current (Approx., for coil listed below)	0 to 30	Ma

Components:

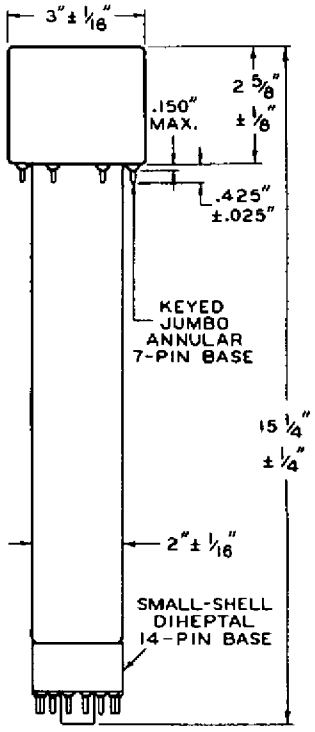
Deflecting-Coil Assembly	RCA Type No.201D75
Focusing-Coil Assembly	RCA Type No.202D75
Alignment-Coil Assembly	RCA Type No.204D75

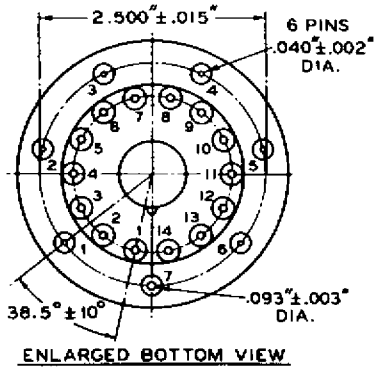
\# Ratio of dynode voltages is shown under Typical Operation.

° Adjustable within ±3 volts of indicated value with blanking voltage off.

°° Taps at 0, 30, 60, and 90 volts are recommended. Set at voltage giving most uniform resolution over entire picture area.

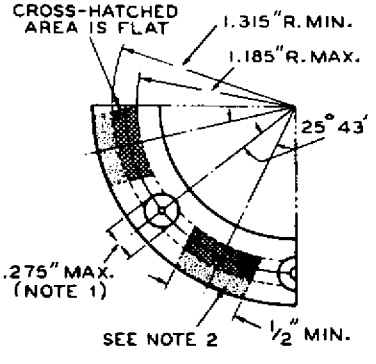
Adjust to give the most uniformly shaded picture near maximum signal.





ENLARGED BOTTOM VIEW

DETAIL OF BOTTOM VIEW OF KEYED JUMBO ANNULAR BASE

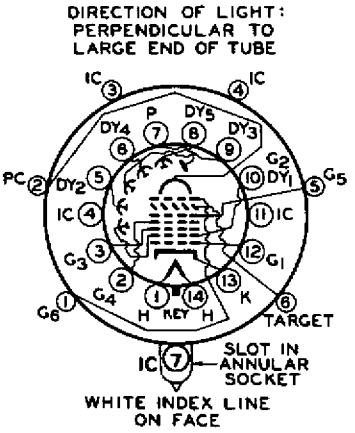


NOTE 1: Measured at distance of 1/32" below bottom of annular base.

NOTE 2: Dotted area is flat or extends toward diheptal-base end of tube by 0.060" max.

SOCKET CONNECTIONS

Bottom View

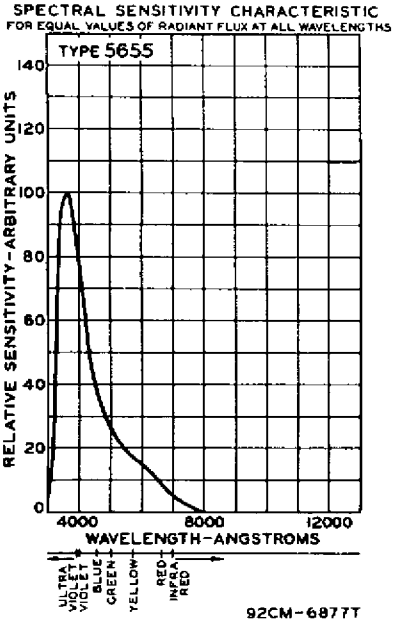


SMALL-SHELL DIHEPTAL 14-PIN BASE

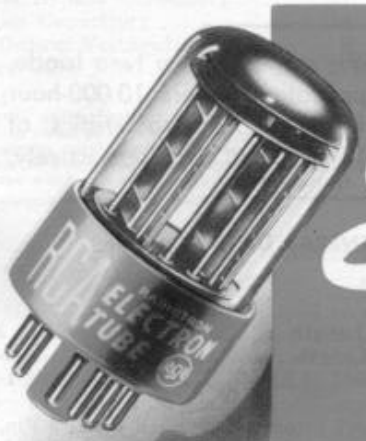
Pin 1:	Heater	Pin 9:	Dynode No. 3
Pin 2:	Grid No. 4	Pin 10:	Dynode No. 1, Grid No. 2
Pin 3:	Grid No. 3		
Pin 4:	Internal Connection – Do Not Use	Pin 11:	Internal Connection – Do Not Use
Pin 5:	Dynode No. 2		
Pin 6:	Dynode No. 4	Pin 12:	Grid No. 1
Pin 7:	Anode	Pin 13:	Cathode
Pin 8:	Dynode No. 5	Pin 14:	Heater

KEYED JUMBO ANNULAR 7-PIN BASE

Pin 1:	Grid No. 6	Pin 5:	Grid No. 5
Pin 2:	Photocathode		
Pin 3:	Internal Connection – Do Not Use	Pin 6:	Target
Pin 4:	Internal Connection – Do Not Use	Pin 7:	Internal Connection – Do Not Use



RCA



Special Red TUBES

FOR APPLICATIONS WHERE EXTREME DEPENDABILITY AND UNIFORMITY ARE PARAMOUNT.

5691

5692

5693

TUBE DIVISION

RADIO CORPORATION of AMERICA

HARRISON, N. J.

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5691, 5692, 5693

SPECIAL RED TUBES

The present "Special Red Tubes" include a high-mu twin triode, 5691; a medium-mu twin triode, 5692; and a sharp-cutoff pentode, 5693. They are for industrial applications where 10 000-hour life, rigid construction, uniformity, and stability are paramount. The electrical characteristics, of the 5691, 5692, and 5693 are very similiar to those of the 6SL7-GT, 6SN7-GT, and 6SJ7, respectively.

• RCA-5691 •

HIGH-MU TWIN TRIODE

RCA-5691 is a high-mu twin triode designed and manufactured for critical industrial applications. In such service, it is particularly useful as a voltage amplifier.

In addition to the features illustrated on page 8 this type has its heaters for the two triode units connected in series so that failure of either heater in bridge circuits makes both units inoperative.

The 5691 is similar to the 6SL7-GT except that it has twice the heater current (0.6 ampere). It is recommended as a replacement for the 6SL7-GT only where provision for the increased heater current can be made, only where the operating conditions are within the ratings of 5691, and only where long life, rigid construction, extreme uniformity, and exceptional stability are needed. If the 5691 is operated at the higher maximum ratings of the 6SL7-GT, the full advantages of the 5691 will not be obtained.

GENERAL DATA

Electrical:

Heater, Pure Tungsten, for Unipotential Cathodes:

Voltage (AC or DC)	6.3 ± 5%*	Volts
Current	0.6	Amp

Direct Interelectrode Capacitances:°

	Min.	Av.	Max.	
Triode Unit No. 1—				
Grid to Plate	3.1	3.6	4.1	μμf
Grid to Cathode	1.9	2.4	2.9	μμf
Plate to Cathode	1.8	2.3	2.8	μμf
Triode Unit No. 2—				
Grid to Plate	3.1	3.6	4.1	μμf
Grid to Cathode	2.2	2.7	3.2	μμf
Plate to Cathode	2.1	2.6	3.1	μμf
Plate of Triode Unit No. 1 to Plate of Triode Unit No. 2	0.31	0.35	0.39	μμf

*May deviate ±10% from rated value provided such deviation occurs for less than 2% of the operating time.
°With no external shield.

GENERAL DATA (Cont'd)

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-7/8"
Maximum Seated Length	2-5/16"
Maximum Diameter	1-9/32"
Bulb	T-9
Base	Short Intermediate-Shell Octal 8-Pin, with External Barriers, Non-Hygroscopic

INDUSTRIAL SERVICE

Includes applications such as dc and audio amplifiers

Values are for Each Unit

Maximum Ratings, *Absolute Values:*

DC Plate Voltage	275 max.	Volts
DC Plate Supply Voltage	330 max.	Volts
Grid Voltage:		
Negative bias range	—1• min. to —100 max.	Volts
Negative peak value	—200 max.	Volts
DC Grid Current	2 max.	Ma
DC Cathode Current	10 max.	Ma
Plate Dissipation	1 max.	Watt
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	100 max.	Volts
Heater positive with respect to cathode	100 max.	Volts
Ambient Temperature Range	— 55 to +90	°C

Maximum Circuit Value *(for any operating condition):*

Grid-Circuit Resistance	2 max.	Meg

Characteristics and Range Values:

Heater Volts, 6.3; Plate Volts, 250; Grid Volts, —2

	Min.	Av.	Max.	
Heater Current	0.58	0.6	0.62	Amp
Heater-Cathode Current with heater-cathode voltage of ±100 volts	—	—	5	μa
Plate Current	1.7	2.3	2.9	Ma
Plate Current for grid voltage of —5.5 volts	—	—	15	μa
Difference in Plate Current between triode units	—	—	0.6	Ma
Reverse Grid Current	—	—	0.2	μa
Amplification Factor	60	70	80	
Plate Resistance	—	44000	—	Ohms
Transconductance	1300	1600	1900	μmhos

• For resistance-coupled amplifier applications, the negative bias may be as low as —0.5 volt.

5691

Typical Operation—Resistance-Coupled Amplifier (Each Triode Unit):

Plate-Supply Voltage	90			180			300			Volts
Plate Load Resistor	0.1	0.22	0.47	0.1	0.22	0.47	0.1	0.22	0.47	Megohm
Grid Resistor (of following stage)	0.22	0.47	1.0	0.22	0.47	1.0	0.22	0.47	1.0	Megohm
Cathode Resistor	4700	7400	14400	2600	4600	9000	2180	3970	7550	Ohms
Cathode Bypass Capacitor‡	2.1	1.3	0.7	2.8	1.6	0.9	3.1	1.8	1	μf
Blocking Capacitor‡	0.014	0.0065	0.0035	0.014	0.0065	0.0035	0.014	0.0065	0.0035	μf
Peak Output Voltage†	9	13	17	30	37	44	59	76	88	Volts
Voltage Gain	27‖	35§	40§	33¶	42¶	46¶	36¶	45¶	50¶	

†This peak output voltage is obtained across the grid resistor of the following stage at any frequency within the flat region of the output vs frequency curve, and is for the condition where the signal level is adequate to swing the grid of the resistance-coupled amplifier tube to the point where its grid starts to draw current.

§At an output voltage of 4 volts rms.

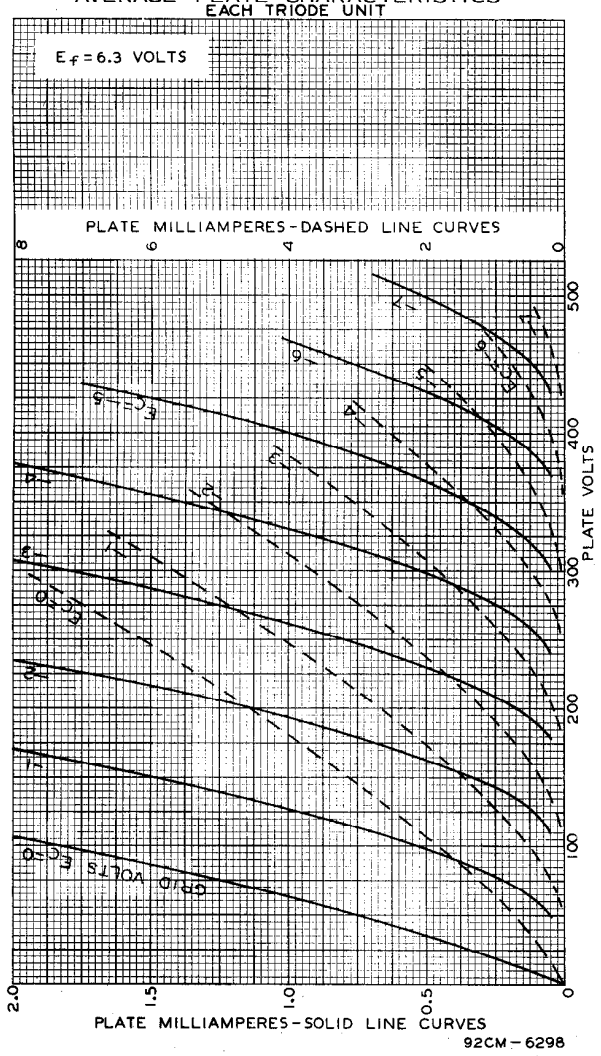
‡The cathode bypass capacitors and blocking capacitors have been chosen to give output voltages at 100 cps (f_1) which are equal to 0.8 of the mid-frequency value. For any other value of (f_1), multiply the values of cathode bypass and blocking capacitors by $100/f_1$.

‖At an output voltage of 3 volts rms.

¶At an output voltage of 5 volts rms.

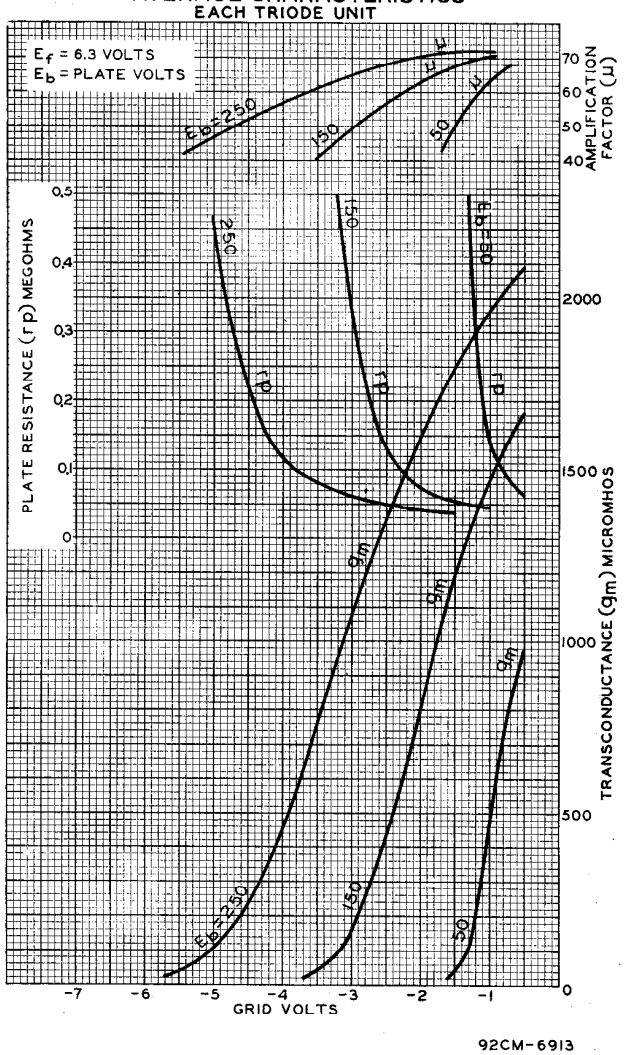
DIMENSIONAL OUTLINE and SOCKET CONNECTIONS
for the 5691 are the same as those shown
on page 5 for the 5692

AVERAGE PLATE CHARACTERISTICS
EACH TRIODE UNIT



92CM-6298

AVERAGE CHARACTERISTICS
EACH TRIODE UNIT

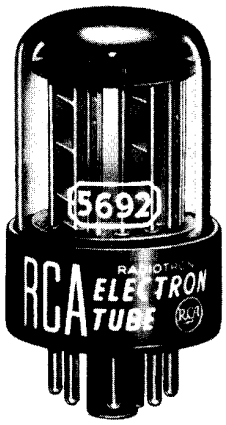


92CM-6913

• RCA-5692 •

MEDIUM-MU TWIN TRIODE

RCA-5692 is a medium-mu twin triode designed and manufactured for critical industrial applications. It is particularly useful as a balanced dc amplifier, multivibrator, blocking oscillator, and resistance-coupled amplifier.



In addition to the features illustrated on page 8, this type has its heaters for the two triode units connected in series so that failure of either heater in bridge circuits makes both units inoperative.

The electrical characteristics of the 5692 are similar to those of the 6SN7-GT. The 5692 is recommended as a replacement for the 6SN7-GT only where the operating conditions are within the ratings of the 5692 and only where long life, rigid construction, extreme uniformity, and exceptional stability are needed. If the 5692 is operated at the higher maximum ratings of the 6SN7-GT, the full advantages of the 5692 will not be obtained.

GENERAL DATA

Electrical:

Heater, Pure Tungsten, for Unipotential Cathodes:

Voltage (AC or DC)	6.3 ± 5%*	Volts
Current	0.6	Amp

Direct Interelectrode Capacitances:°

	Min.	Av.	Max.	
Triode Unit No. 1—				
Grid to Plate	3.0	3.5	4.0	μμf
Grid to Cathode	1.8	2.3	2.8	μμf
Plate to Cathode	2.0	2.5	3.0	μμf
Triode Unit No. 2—				
Grid to Plate	2.8	3.3	3.8	μμf
Grid to Cathode	2.1	2.6	3.1	μμf
Plate to Cathode	2.2	2.7	3.2	μμf
Plate of Triode Unit No. 1 to Plate of Triode Unit No. 2	0.31	0.35	0.39	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-7/8"
Maximum Seated Length	2-5/16"
Maximum Diameter	1-9/32"
Bulb	T-9
Base	Short Intermediate-Shell Octal 8-Pin, with External Barriers, Non-Hygroscopic

INDUSTRIAL SERVICE

Includes applications such as dc amplifiers, audio amplifiers and relaxation oscillators

Values are for Each Unit

Maximum Ratings, *Absolute Values:*

DC Plate Voltage	275 max.	Volts
DC Plate Supply Voltage	330 max.	Volts
Grid Voltage:		
Negative bias value	—1• min. to —100 max.	Volts
Negative peak value	—200 max.	Volts
DC Grid Current	2 max.	Ma
DC Cathode Current	15 max.	Ma
Plate Dissipation	1.75 max.	Watts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	100 max.	Volts
Heater positive with respect to cathode	100 max.	Volts
Ambient Temperature Range	— 55 to +90	°C

Maximum Circuit Value *(for any operating condition)*:

Grid-Circuit Resistance	2 max.	Meg

Characteristics and Range Values:

Heater Volts, 6.3; Plate Volts, 250; Grid Volts, —9

	Min.	Av.	Max.	
Heater Current	0.58	0.6	0.62	Amp
Heater-Cathode Current with heater-cathode voltage of ±100 volts	—	—	5	μa
Plate Current	4.8	6.5	8.2	Ma
Plate Current for grid voltage of —24 volts	—	—	15	μa
Difference in Plate Current between triode units	—	—	1.6	Ma
Reverse Grid Current	—	—	0.2	μa
Amplification Factor	18	20	22	
Plate Resistance	—	9100	—	Ohms
Transconductance	1825	2200	2575	μmhos

Typical Operation—Resistance-Coupled Amplifier (Each Triode Unit):

Plate-Supply Voltage	90			180			300			Volts
Plate Load Resistor	0.05	0.1	0.25	0.05	0.1	0.25	0.05	0.1	0.25	Megohm
Grid Resistor (of following stage)	0.1	0.25	0.5	0.1	0.25	0.5	0.1	0.25	0.5	Megohm
Cathode Resistor	2070	3940	9760	1490	2830	7000	1270	2440	5770	Ohms
Cathode Bypass Capacitor‡	2.66	1.29	0.55	2.86	1.35	0.62	2.96	1.42	0.64	μf
Blocking Capacitor‡	0.029	0.012	0.007	0.032	0.012	0.007	0.034	0.0125	0.0075	μf
Peak Output Voltage†	14	17	18	30	34	36	51	56	57	Volts
Voltage Gain¶	12	13	13	13	14	14	14	14	14	

• For resistance-coupled amplifier applications, the negative bias may be as low as —0.5 volt.

†This peak output voltage is obtained across the grid resistor of the following stage at any frequency within the flat region of the output vs frequency curve, and is for the condition where the signal level is adequate to swing the grid of the resistance-coupled amplifier tube to the point where its grid starts to draw current.

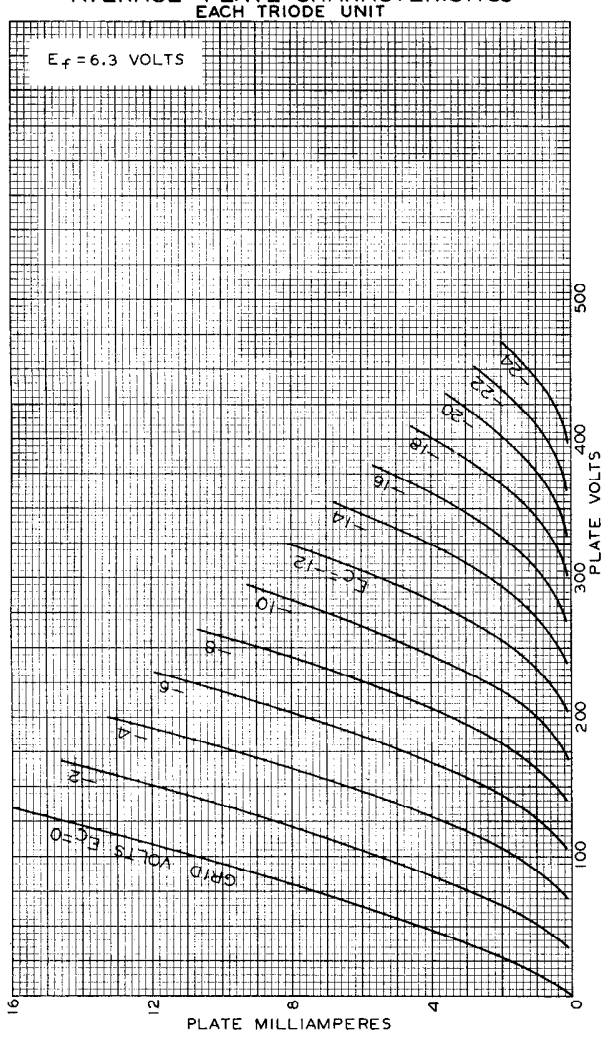
*May deviate ±10% from rated value provided such deviation occurs for less than 2% of the operating time.

°With no external shield. ¶At an output voltage of 5 volts rms.

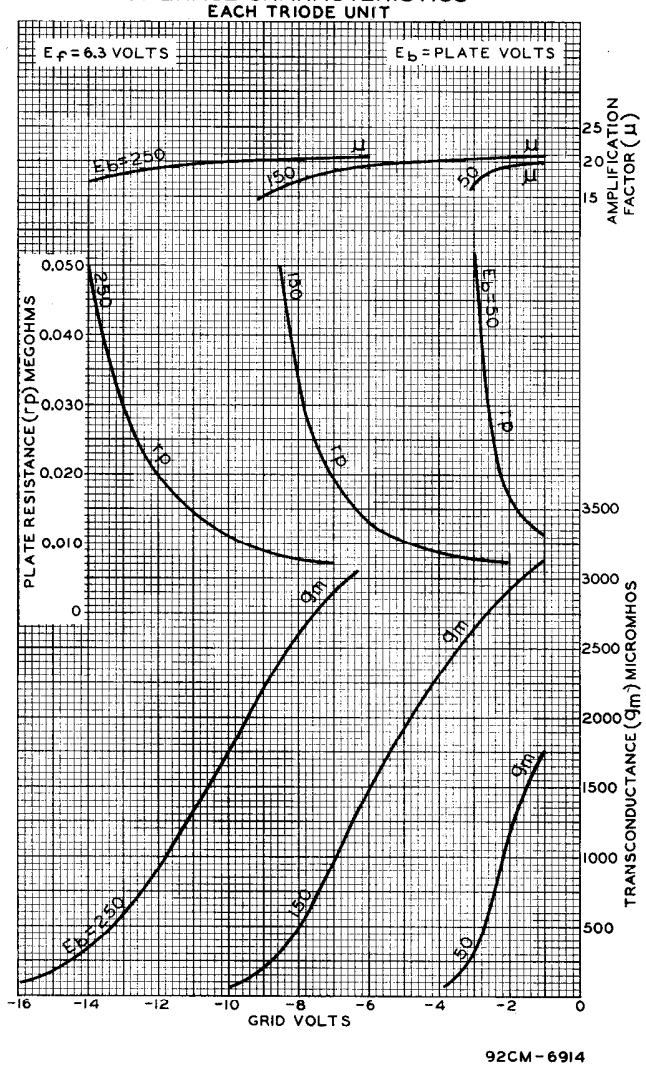
‡The cathode bypass capacitors and blocking capacitors have been chosen to give output voltages at 100 cps (f_1) which are equal to 0.8 of the mid-frequency value. For any other value of (f_1), multiply the values of cathode bypass and blocking capacitors by $100/f_1$.

5692

AVERAGE PLATE CHARACTERISTICS
EACH TRIODE UNIT

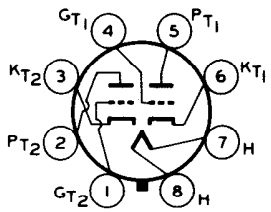


AVERAGE CHARACTERISTICS
EACH TRIODE UNIT



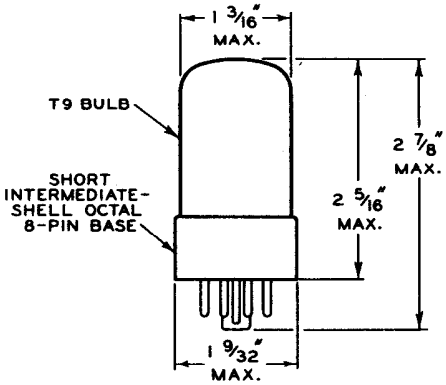
SOCKET CONNECTIONS

Bottom View



Pin 1: Grid of Triode Unit No. 2
Pin 2: Plate of Triode Unit No. 2
Pin 3: Cathode of Triode Unit No. 2
Pin 4: Grid of Triode Unit No. 1
Pin 5: Plate of Triode Unit No. 1
Pin 6: Cathode of Triode Unit No. 1
Pin 7: Heater
Pin 8: Heater

DIMENSIONAL OUTLINE



• RCA-5693 •

SHARP-CUTOFF PENTODE

RCA-5693 is a sharp-cutoff pentode designed and manufactured for critical industrial applications. In such service, it is particularly useful as a high-gain resistance-coupled amplifier.

This tube can be operated with a grid-No.1 resistor having a value as high as 40 megohms depending on the operating conditions as given on page 7.

The electrical characteristics of the 5693 are similar to those of the 6SJ7. The 5693 is recommended as a replacement for the 6SJ7 only where the operating conditions are within the ratings of the 5693, and only where long life, rigid construction, extreme uniformity and exceptional stability are needed. If the 5693 is operated at the higher maximum ratings of the 6SJ7, the full advantages of the 5693 will not be obtained.

GENERAL DATA

Electrical:

Heater, Pure Tungsten, for Unipotential Cathodes:				
Voltage (AC or DC)			6.3 ± 5%*	Volts
Current			0.3	Amp
Direct Interelectrode Capacitances:°	*Min.*	*Av.*	*Max.*	
Grid to Plate	—	—	0.005	μμf
Input	4.8	5.3	5.8	μμf
Output	5.6	6.2	6.8	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-5/8"
Seated Length	1-31/32" ± 3/32"
Maximum Diameter	1-5/16"
Bulb	Metal Shell MT-8
Base	Small-Wafer Octal 8-Pin, with External Barriers, Non-Hygroscopic

INDUSTRIAL SERVICE

Includes applications such as dc and resistance-coupled amplifiers

Maximum Ratings, *Absolute Values:*

DC Plate Voltage	300 max.	Volts
DC Plate Supply Voltage	330 max.	Volts
DC Grid-No. 3 (Suppressor) Voltage:		
Negative bias value	0 min.	Volts
	—100 max.	Volts
DC Grid-No. 2 (Screen) Voltage	125** max.	Volts
DC Grid-No. 2 Supply Voltage	330 max.	Volts
Grid-No. 1 (Control-Grid) Voltage:		
Negative bias range	—1■ min. to —50 max.	Volts
Negative peak value	—50 max.	Volts
DC Cathode Current	10 max.	Ma
Plate Dissipation	2 max.	Watts
Grid-No. 2 Dissipation	0.3 max.	Watt
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	100 max.	Volts
Heater positive with respect to cathode	100 max.	Volts
Ambient Temperature Range	—55 to +90	°C

Maximum Circuit Value:

See curve on page 7 for max. values of grid-No.1 resistor.

Characteristics and Range Values:

Heater Volts, 6.3; Plate Volts, 250; Grid-No. 3 Volts, 0; Grid-No. 2 Volts, 100; Grid-No. 1 Volts, —3

	Min.	*Av.*	*Max.*	
Heater Current	0.290	0.3	0.310	Amp
Heater-Cathode Current with heater-cathode voltage ±100 volts	—	—	5	μa
Plate Current	2.3	3.0	3.7	Ma
Plate Cur. for grid-No.1 voltage of —7.5 volts	2	30	80	μa
Plate Cur. for grid-No.3 voltage of —70 volts	50	275	500	μa
Grid-No. 2 Current	0.60	0.85	1.10	Ma
Reverse Grid No.1 Cur.	—	—	0.1	μa
Plate Resistance	1.0	—	—	Meg
Transconductance	1400	1650	1900	μmhos

Typical Operation—Resistance-Coupled Amplifier:

Plate & Grid-No. 2 Supply Voltage	90			180			300			Volts
Plate Load Resistor	0.1	0.25	0.5	0.1	0.25	0.5	0.1	0.25	0.5	Megohm
Grid-No. 1 Resistor	0.25	0.5	1	0.25	0.5	1	0.25	0.5	1	Megohm
Grid-No. 2 Resistor	0.29	0.92	1.7	0.31	0.94	2.2	0.37	1.10	2.2	Megohms
Cathode Resistor	880	1700	3800	800	1060	2180	530	860	1410	Ohms
Grid-No. 2 Bypass Capacitor•	0.085	0.045	0.03	0.09	0.06	0.04	0.09	0.06	0.05	μf
Cathode Bypass Capacitor•	7.4	4.5	2.4	8	6.6	3.8	10.9	7.4	5.8	μf
Blocking Capacitor•	0.016	0.005	0.002	0.015	0.004	0.002	0.016	0.004	0.002	μf
Peak Output Voltage†	23	18	22	60	47	44	96	88	79	Volts
Voltage Gain¶	68	93	119	82	131	192	98	167	238	

¶At an output voltage of 5 volts rms.

*May deviate ±10% from rated value provided such deviation occurs for less than 2% of the operating time.

°With shell connected to cathode.

**The 5693 may be operated at a grid-No.2 voltage as high as the maximum rated grid-No.2 supply voltage (330 volts) when the grid-No.2 dissipation is not exceeded for any signal conditions and when a resistor is used in series with the grid No.2 and its supply voltage.

■For resistance-coupled amplifier applications, the negative grid-No.1 bias may be as low as —0.5 volt.

• The cathode and grid-No.2 bypass capacitors and blocking capacitors have been chosen to give output voltages at 100 cps (f_1) which are equal to 0.7 of the mid-frequency value. For any other value of (f_1), multiply the values of cathode bypass, grid-No.2 bypass, and blocking capacitors by $100/f_1$.

†This peak output voltage is obtained across the grid resistor of the following stage at any frequency within the flat region of the output vs frequency curve, and is for the condition where the signal level is adequate to swing the grid of the resistance-coupled amplifier tube to the point where its grid starts to draw current.

5693

OPERATION CHARACTERISTICS

E_f = 6.3 VOLTS PLATE VOLTS = 300 GRID-№3 VOLTS = 0

CURVE	GRID-№2 RESISTOR	GRID-№2 SUPPLY VOLTS
1	0 MEG.	100
2	0.25 MEG.	300
3	0.5 MEG.	300
4	0.75 MEG.	300

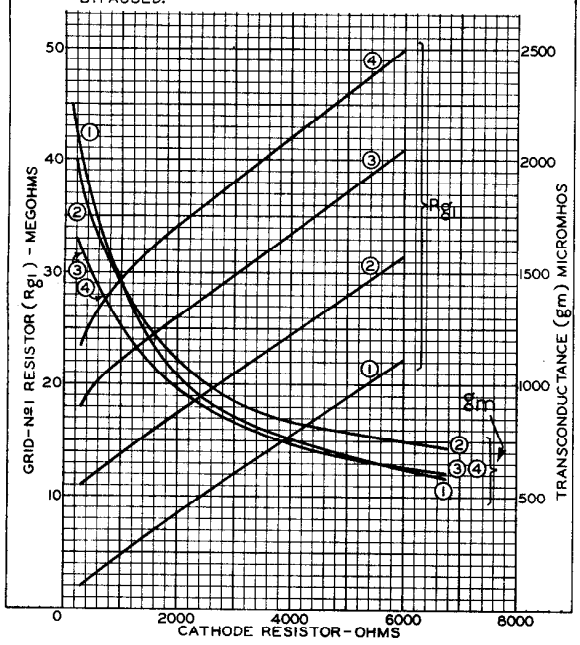
THESE CURVES ARE BASED ON THE FOLLOWING VALUES: ΔI_K=300μAMP, ΔI_{g_1}=0.1μAMP

EXPRESSING THESE VALUES AS A RATIO, WE HAVE:

$$\frac{\Delta I_K}{\Delta I_{g_1}} = \frac{300}{0.1} \text{ OR } 3000$$

FOR THOSE APPLICATIONS PERMITTING OTHER VALUES OF ΔI_K, A NEW RATIO OF $\Delta I_K/\Delta I_{g_1}$ CAN BE CALCULATED. THE VALUES OF R_{g_1} AS READ FROM THE CURVE MUST BE MULTIPLIED BY A FACTOR WHICH IS THE QUOTIENT OF THE NEW RATIO DIVIDED BY THE OLD RATIO. FOR EXAMPLE, IF THE NEW RATIO IS 6000 THE MULTIPLYING FACTOR IS 6000/3000, OR 2, AND VALUES OF R_{g_1} AS READ FROM THE CURVE ARE THEREFORE MULTIPLIED BY 2.

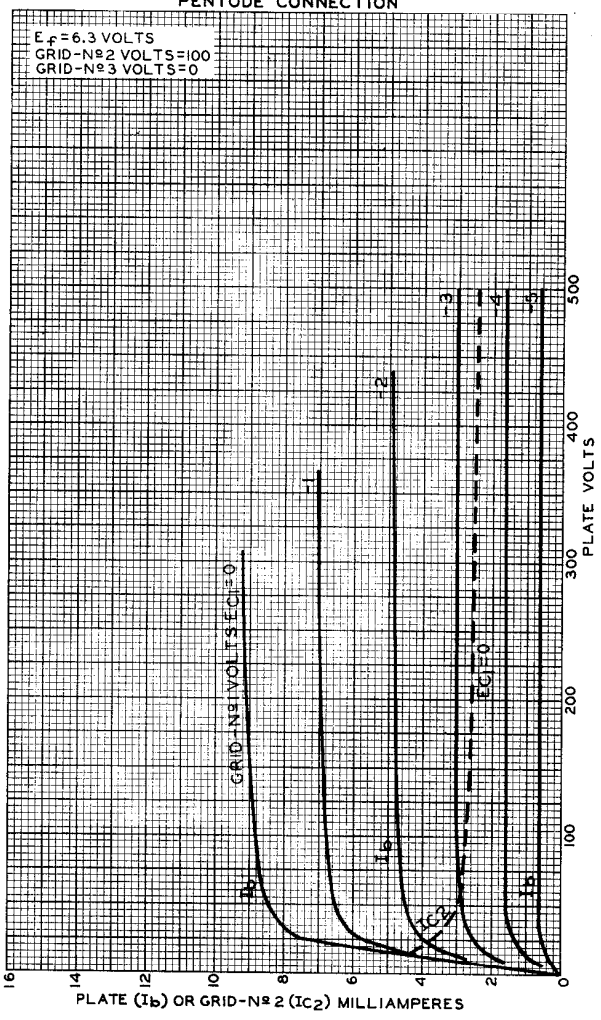
NOTE: TRANSCONDUCTANCE CURVES WERE OBTAINED WITH GRID-№2 RESISTOR AND CATHODE RESISTOR SUITABLY BYPASSED.



92CM-6920RI

AVERAGE PLATE CHARACTERISTICS

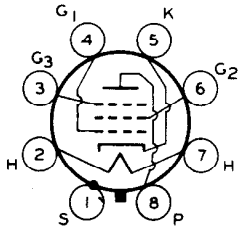
PENTODE CONNECTION



92CM-4939RI

SOCKET CONNECTIONS

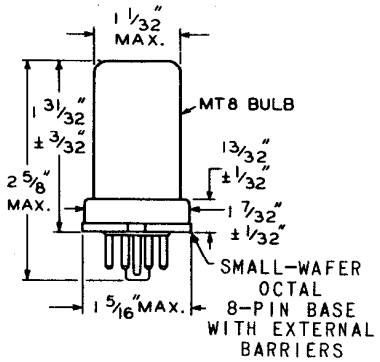
Bottom View



8N

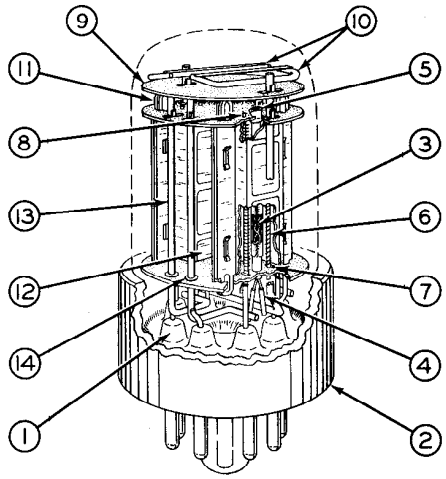
Pin 1: Shell
Pin 2: Heater
Pin 3: Grid No. 3
Pin 4: Grid No. 1
Pin 5: Cathode
Pin 6: Grid No. 2
Pin 7: Heater
Pin 8: Plate

DIMENSIONAL OUTLINE



RCA *Special Red* TUBES

for 10,000 Hours of Dependable Service



1—Low-leakage button stem.
2—Non-hygroscopic base.
3—Pure-tungsten heater for high mechanical strength.
4—Sleeves on heater legs insure good mechanical and electrical bond between heater and heater leads.
5—Cathode sleeves locked to mica insulator.
6—Grid plated to minimize variation in contact potential.
7—"Stops" prevent vertical movement of grid rods.
8—Grid rods fit tightly into mica insulators.
9—Extra mica insulator provides getter shield.
10—Two getters for long life.
11—Plates held rigid by plate ears wedged into mica insulators.
12—Plates are designed to minimize electron coupling between units.
13—Mount secured by five supporting rods.
14—Twelve reinforcing eyelets provide a firm bond between mica insulators and five supporting rods.

Structure of RCA-5691 and RCA-5692

- **when the proper operation of vital manufacturing, communications, laboratory, and other industrial equipment depends on tube uniformity and stability.**
- **when tube failure means factory shutdown or hazardous operation.**
- **when initial tube cost is secondary to cost of maintenance.**

- **WHENEVER the accent is on quality—and quality alone—**

USE RCA "Special Red" Tubes : RCA-5691, RCA-5692, or RCA-5693. They are skillfully engineered, ruggedly designed, precisely manufactured, exactingly processed, and rigorously tested, and will withstand impact shocks of 500g for short periods, and 2.5g of continuous vibration for hundreds of hours.

5696

THYRATRON

Gas-Tetrode, Miniature Type

TENTATIVE DATA

RCA-5696 is a sensitive, four-electrode thyratron of the indirectly heated cathode type. It features low-heater current drain and short deionization time, and is designed for use in relay applications particularly those involving counter circuits.

The 5696 has a steep control characteristic which is essentially independent of ambient temperature over a wide range. It also has extremely low pre-conduction or gas-leakage currents, low control-grid-to-anode capacitance, and low control-grid current.

Because of the low control-grid-to-anode capacitance, the 5696 is practically insensitive to line voltage surges; and because of its low control-grid current, a high value of resistance can be used in the grid circuit to give high circuit sensitivity. In a high sensitivity circuit, the 5696 can be operated directly from a high-vacuum phototube.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.150	ampere

Cathode:

Minimum Heating Time prior to tube conduction	10	seconds
Direct Interelectrode Capacitances (With no external shield):		
Grid No.1 to Anode	0.03	μμf
Input	1.8	μμf
Output	0.54	μμf
Ionization Time (Approx.): For conditions: dc anode volts = 100, grid-No.1 square-pulse volts = + 50, peak cathode amperes during conduction = 0.150	0.5	μsec
Deionization Time (Approx.): For conditions: dc anode volts = 500, dc grid-No.1 volts = -100, grid-No.1 resistor (ohms) = 1000, dc cathode amperes = 0.025	25	μsec
For conditions: dc anode volts = 500, dc grid-No.1 volts = -13, grid-No.1 resistor (ohms) = 1000, dc cathode amperes = 0.025	40	μsec
Maximum Critical Grid-No.1 Current: For conditions: ac anode-supply volts = 350 (RMS), average cathode amperes = 0.025	0.5	μamp
Anode Voltage Drop (Approx.)	10	volts
Grid-No.1 Control Ratio (Approx.): For conditions: grid-No.1 resistor (ohms) = 0, grid-No.2 volts = 0	250	
Grid-No.2 Control Ratio (Approx.): For conditions: grid-No.1 volts = 0, grid-No.2 resistor (ohms) = 0	15	

Mechanical:

Mounting Position	Any
Maximum Overall Length	1-3/4"
Maximum Seated Length	1-1/2"
Length from Base Seat to Bulb Top (Excluding Tip)	1-1/8" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin

Maximum Ratings, *Absolute Values*:

PEAK ANODE VOLTAGE:		
Forward	500 max.	volts
Inverse	500 max.	volts
GRID-No.2 VOLTAGE:		
Peak, before anode conduction	-50 max.	volts
Average, during anode conduction	-10 max.	volts
GRID-No.1 VOLTAGE:		
Peak, before anode conduction	-100 max.	volts
Average, during anode conduction	-10 max.	volts
CATHODE CURRENT:		
Peak	0.100 max.	ampere
Average▲	0.025 max.	ampere
Surge, for duration of 0.1 second maximum	2 max.	amperes
AVERAGE GRID-No.2 CURRENT▲	0.005 max.	ampere
AVERAGE GRID-No.1 CURRENT▲	0.005 max.	ampere
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	25 max.	volts
AMBIENT TEMPERATURE RANGE	-55 to +90	°C

Typical Operation in Relay Service:

AC Anode Voltage (RMS)	117	volts
Grid No.2	Connected to cathode at socket	
Grid-No.1 Bias Voltage (RMS)♯	5	volts
Grid-No.1 Signal Voltage (Peak)	5	volts
Grid-No.1-Circuit Resistance	0.1	megohm
Anode-Circuit Resistance◇	5000	ohms

Maximum Circuit Value:

Grid-No.1-Circuit Resistance	10	megohms

▲ Averaged over a period not exceeding 30 seconds.

♯ Approximately 180° out of phase with the anode voltage.

◇ Sufficient resistance including the tube load must be used under any conditions of operation to prevent exceeding the current ratings.

INSTALLATION

The *base* pins of the 5696 fit the miniature 7-pin socket which may be installed to hold the tube in any position. The socket should be made of any insulating material having low leakage.

The *heater* is designed to operate on either ac or dc at 6.3 volts. When it is operated on ac with a transformer, the heater winding should operate the heater at its recommended voltage value for full-load operating conditions at average line voltage. When it is operated from a battery with charger attached, provision must be made through the use of regulation-control devices to hold the voltage across the heater to

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the recommended value. Regardless of the heater-voltage supply used, ***the heater voltage must never be allowed to deviate more than 10% from its rated value.*** Heater operation outside of this voltage range will impair tube performance and may cause tube failure. Series heater operation is not recommended. Low heater voltage causes low cathode temperature with resultant cathode sputtering and consequent destruction of the cathode; high heater voltage causes high cathode temperature with resultant heating of grid No.1 and consequent grid emission which produces unpredictable shifts in the critical grid voltage for conduction.

The *cathode* should be allowed to reach normal operating temperature before tube conduction is permitted to start. The delay period should be not less than 10 seconds after application of the heater voltage. Unless this recommendation is followed, the cathode will be damaged.

When the heater of the 5696 is operated from a transformer, the cathode should preferably be connected directly to the mid-point or to one side of the heater circuit. When the 5696 is used in equipment employing a storage battery for the heater supply, the cathode circuit is usually tied directly to the negative side of the heater supply. In circuits where the cathode is not connected directly to the heater, the potential difference between them should never exceed the recommended peak potentials shown in the tabulated data.

A *grid-No.1 resistor* having a value of 0.1 megohm is recommended for the usual application. If, however, the source of the control-grid signal has high internal impedance, it may be desirable to use a higher value of grid-No.1 resistor in order to apply as large a signal as possible to the control grid. A value as high as 10 megohms may be used with the 5696 because its control-grid current is low. Howeyer, when a grid-No.1-circuit resistor having a value of 10 megohms is used, the tube base and socket should be kept clean and dry in order to make the effect of leakage currents between the control-grid base pin and the anode base pin small.

When the 5696 is operated with a high value of grid-No.1 resistor and ac voltage on the anode, the circuit capacitance between grid No.1 and anode should be kept low by placing the grid-No.1 resistor directly at the socket grid terminal, by connecting both grid-No.2 terminals (pins 5 and 7) to the cathode (pin 2) at the socket, and by using a close-fitting shield connected to the cathode terminal.

Sufficient anode-circuit resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings of the tube.

APPLICATION

The 5696 has a *critical control-grid voltage* which will initiate tube conduction for any specific grid-No.2 voltage and positive anode voltage. If the control grid is maintained more negative than this critical voltage, the tube does not conduct and the anode current remains zero. If the control grid is made less negative than this critical voltage, the tube will conduct

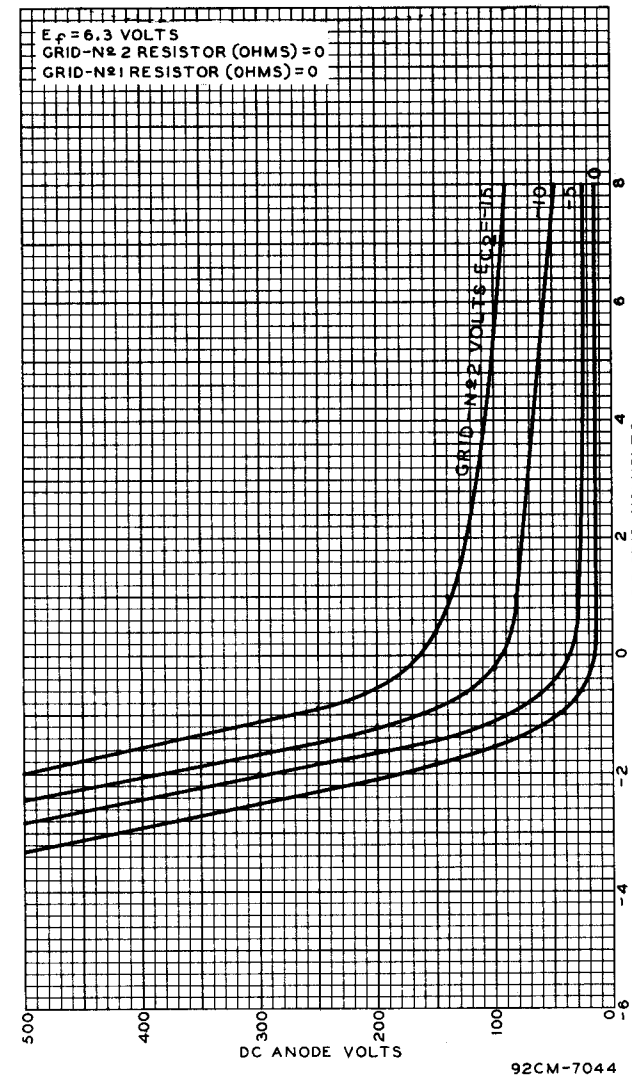


Fig. 1 - Average Control Characteristics.

and the anode current assumes a value determined by the applied anode voltage and the impedance in the anode circuit. In the conducting condition, the 5696 has a voltage drop which is relatively low, substantially constant over the rated anode-current range, and independent of grid-No.1 bias. Conduction may be stopped and grid No.1 allowed to regain control by reducing

the anode voltage to zero or making it negative. A family of curves showing the relation between grid-No.1 (control) volts, grid-No.2 (shield) volts, and anode voltage is shown in Fig. 1.

The value of critical grid voltage is affected by several factors including: the operating anode voltage, grid-No.2 voltage, variations of heater-supply voltage, value of grid-No.1 resistor, and individual tube variation both initially and during life. Fig. 2 shows the range of critical control-grid voltage. The range takes into account the combined effect of individual tube variation and variation throughout tube life for a grid-No.1 resistor value of 0.1 megohm and also for a value of 10 megohms. About 10% of the total variation range for any particular operating condition is attributable to a heater-voltage variation of ± 10% from the rated value.

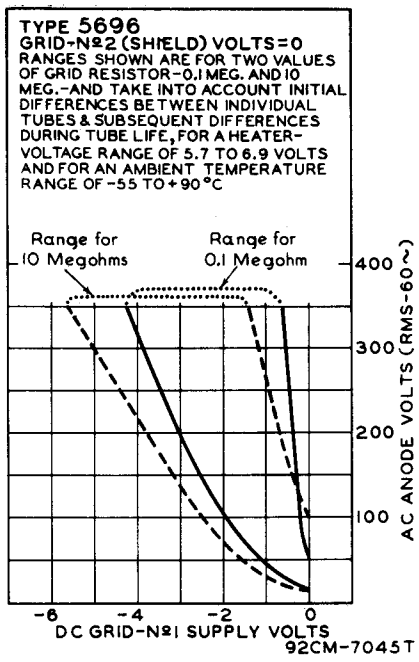


Fig. 2 - Operational Range of Critical Grid Voltage.

The equipment designer should give careful consideration to the range values shown in Fig. 2. From them he can determine for specified operating conditions not only the proper value of control-grid bias necessary to prevent conduction until it is desired, but also the magnitude of the signal (triggering) voltage necessary to initiate conduction. Ample triggering voltage should always be provided to insure anode conduction even under the worst operating conditions to which the equipment will usually be subjected.

The effective control-grid bias obtained when a high value of grid-No.1 circuit resistor is used is influenced by the grid currents flowing before and during conduction. These currents consist of leakage currents, gas currents, grid-emission currents, and capacitive currents. Except for capacitive currents, the magnitude of all these currents before conduction is shown in microamperes in Fig. 3, and during conduction in milliamperes in Fig. 4. The capacitive current appears only when the anode is supplied with ac voltage, and,

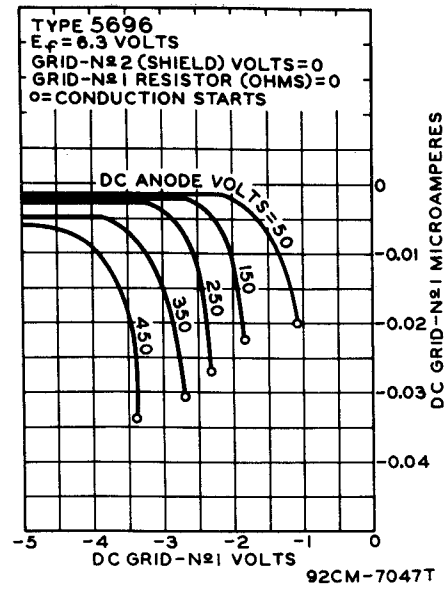


Fig. 3 - Average Characteristics Before Anode Conduction.

since the shield-grid construction of the 5696 provides low grid-anode capacitance, these capacitive currents are consequently low. A further advantage in having low grid-anode capacitance is to make the tube relatively insensitive to line-voltage surges.

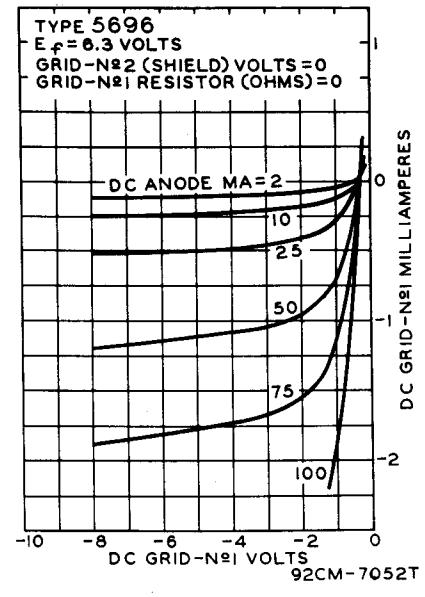
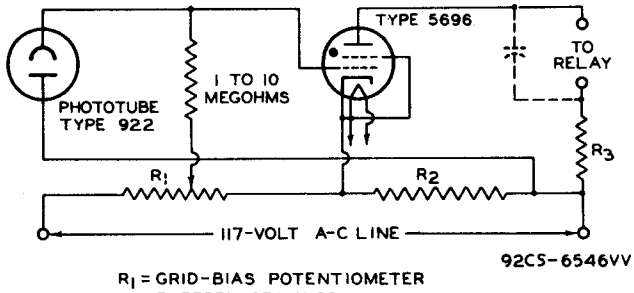


Fig. 4 - Average Characteristics During Anode Conduction.

The advantage in having a low value of control-grid current is that the control characteristic will remain relatively fixed as the grid resistor is increased in value.

The ***anode voltage*** for the 5696 may be obtained from either an ac or dc source and should never be less than 100 volts in order to insure stable tube operation. When a dc supply is used, the circuit has a lock-in feature because the grid loses control when conduction starts. In order for the grid to regain control and restore the tube to the non-conducting condition, it is necessary to remove the anode voltage momentarily. When an ac supply is used, the circuit has no lock-in feature because the anode becomes negative during the negative half of the ac cycle and thus allows the grid to resume control before the next positive half-cycle.

With an ac supply, control of the firing of the 5696 may be accomplished by varying the amplitude of the ac control-grid voltage, by varying a dc bias applied to the control grid, by phasing a sinusoidal control-grid voltage with respect to the anode voltage, by phasing a peaked grid voltage with respect to the anode voltage, or by a combination of these methods. A typical light-operated relay circuit is shown in Fig. 5.



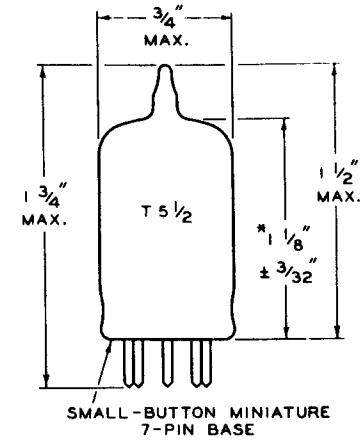
R_1 = GRID-BIAS POTENTIOMETER
R_2 = BLEEDER RESISTOR
R_3 = ANODE-CURRENT-LIMITING RESISTOR

Fig. 5 - Typical Light-Operated Relay Circuit.

In addition to the factors contributing to the range values shown in Fig. 2, the effect of high ambient temperature may become important. Ambient temperature changes between -55° to +90°C have negligible effect on critical grid voltage when the 5696 is operated with a low value of grid-No.1 resistor. However, when the grid resistor has a high value, temperature changes within the operating range of -55°C to +90°C may cause a change of 20% in the critical grid voltage. Most of this change occurs at the higher temperatures and is caused by leakage outside the tube. Therefore, under operating conditions involving a high value of grid resistor and high ambient temperature, it is essential that precautions be taken to minimize leakage.

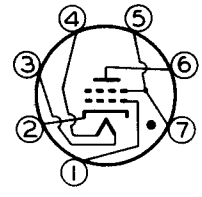
The ***maximum average cathode current*** is the highest current which can be drawn continuously through the tube. The average current should be determined on the basis of 30-second operation of the tube. If the cycle of operation during the 30-second period is rapid, the average current can be read on a dc meter. If the cycle is long, it is necessary to calculate the average current from readings taken during the 30-second period.

DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



PIN 1 - GRID No. 1
PIN 2 - CATHODE
PIN 3 - HEATER
PIN 4 - HEATER
PIN 5 - GRID No. 2
PIN 6 - ANODE
PIN 7 - GRID No. 2

7BN

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

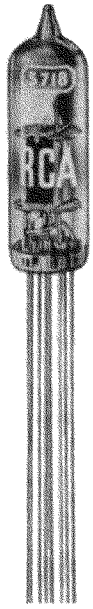
5718

MEDIUM-MU TRIODE

"Premium" Subminiature Type

TENTATIVE DATA

RCA-5718 is a medium-mu subminiature triode of the heater-cathode type designed primarily for use as an rf power amplifier and oscillator in uhf applications where dependable performance under shock and vibration is a major consideration. It is capable of giving a useful power output of nearly one watt at a frequency of 500 megacycles per second. Operation with full input is permissible up to 1000 megacycles per second.



Actual Size

The 5718 features high transconductance, a pure-tungsten heater to give long life under conditions of frequent on-off switching, and a compact design in which special attention has been given to structural details which provide increased mount strength against shock and vibration. In addition, each tube is manufactured under rigid controls and undergoes rigorous tests to insure long and dependable performance.

Because of its high transconductance, the 5718 is suitable for use in cathode follower, multivibrator, and blocking oscillator circuits. It is also useful as a resistance-coupled amplifier.

The 5718 has been combined with and supersedes the 5897.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)		6.3 ± 5%	volts
Current		0.150	ampere
Direct Interelectrode Capacitances:	*With External Shield*[o]	*Without External Shield*	
Grid to Plate	1.3	1.4	μμf
Input	2.4	2.2	μμf
Output	2.4	0.7	μμf

[o] Having inside diameter of 0.405" and connected to lead No. 5.

Characteristics, Class A$_1$ Amplifier:

Plate Voltage	100	150	volts
Cathode Resistor	150	180	ohms
Amplification Factor	27	27	
Plate Resistance	4650	4150	ohms
Transconductance	5800	6500	μmhos
Plate Current	8.5	13.0	ma
Grid Volts (Approx.) for plate current of 10 μamp	-7	-11	volts

Mechanical:

Operating Position	Any
Maximum Bulb Length	1-3/8"
Length from Button Seal to Bulb Top (Excluding tip)	1.075" ± 0.060"
Diameter	0.383" ± 0.017"
Bulb	T-3
Leads, Flexible	8
Length	1-1/2" to 1-3/4"
Orientation and Diameter	See Dimensional Outline

AMPLIFIER - Class A$_1$

Maximum Ratings, *Absolute Values*:

DC PLATE VOLTAGE	165 max.	volts
PLATE DISSIPATION	3.3 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	°C

Typical Operation as Resistance-Coupled Amplifier:

See Chart on Page 2

Maximum Circuit Values:

Grid-Circuit Resistance:		
For cathode-bias operation	1.2 max.	megohms
For fixed-bias operation	Not recommended	

Cathode-Bias Resistance - An adequate value of cathode-bias resistor should be used to protect the tube in event of temporary failure of excitation and resultant loss in developed bias.

RF AMPLIFIER and OSCILLATOR - CLASS C

Maximum Ratings, *Absolute Values*:

DC PLATE VOLTAGE	165 max.	volts
DC GRID VOLTAGE	-55 max.	volts
DC PLATE CURRENT	22 max.	ma
DC GRID CURRENT	5.5 max.	ma
PLATE DISSIPATION	3.3 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	°C

Maximum Circuit Values:

Grid-Circuit Resistance:		
For cathode-bias operation	1.2 max.	megohms
For fixed-bias operation	Not recommended	

Cathode-Bias Resistance - An adequate value of cathode-bias resistor should be used to protect the tube in event of temporary failure of excitation and resultant loss in developed bias.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN*

	Note	*Min.*	*Max.*	
Heater Current	1	0.138	0.162	amp
Grid-to-Plate Capacitance	2	1.1	1.8	μμf
Input Capacitance	2	1.6	2.8	μμf
Output Capacitance	2	0.5	0.9	μμf
Amplification Factor	1,3	23	31	
Plate Current	1,3	6.0	11.0	ma
Plate Current	1,4	-	100	μamp
Transconductance	1,3	4800	6800	μmhos
Transconductance	5,3	4500	-	μmhos
Grid Current	1,6	-	±0.4	μamp

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CHARACTERISTICS RANGE VALUES (Cont'd)

	Note	Min.	Max.	
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode. . .	1,7	-	7.0	μamp
Heater positive with respect to cathode. . .	1,8	-	7.0	μamp
Leakage Resistance:				
Between Grid and All Other Electrodes Tied .	1,9	100	-	megohms
Between Plate and All Other Electrodes Tied .	1,10	100	-	megohms
Useful Power Output. . . .	1,11	600	-	mw

* Each tube is stabilized before characteristics testing by continuous operation for at least 45 hours at room temperature and with dissipation values equivalent to life test conditions.

Note 1: With 6.3 volts ac or dc on heater.

Note 2: Without external shield.

Note 3: With dc plate voltage of 100 volts, cathode resistor of 150 ohms, and cathode bypass capacitor of 1000 microfarads.

Note 4: With dc plate voltage of 100 volts, and dc grid voltage of -7 volts.

Note 5: With 5.5 volts ac or dc on heater.

Note 6: With dc plate voltage of 100 volts, cathode resistor of 150 ohms, and grid resistor of 0.5 megohm.

Note 7: With -100 volts dc between heater and cathode.

Note 8: With +100 volts dc between heater and cathode.

Note 9: With grid 100 volts negative with respect to all other electrodes tied together.

Note 10: With plate 300 volts negative with respect to all other electrodes tied together.

Note 11: In self-excited oscillator with dc plate voltage of 150 volts, grid resistor and feedback optimized to give useful power output at a plate current of 20 ma. and frequency of 500 Mc.

SPECIAL TESTS

Shock Test:

Impact Acceleration. . . . . 450 max. g

Tubes are held rigid in three different positions in a Navy Type, High Impact (flyweight) Shock Machine and are subjected to the specified impact acceleration.

Fatigue Test:

Vibrational Acceleration . . . . . 2.5 max. g

Tubes are rigidly mounted and subjected to the specified maximum vibrational acceleration at 60 cycles per second for 32 hours in each of three positions.

Uniform Acceleration Test. . . . . . 1000 max. g

Tubes are subjected to a gradually applied uniform acceleration in each of three positions.

High-Frequency Vibration Test:

RMS Output Voltage . . . . . 25 max. mv

Under the following conditions: A 150-volt plate voltage supply having an impedance not exceeding that of a 40 μf capacitor, plate load resistance of 10000 ohms, cathode bypass capacitor of 1000 μf, and vibrational acceleration of 15 g at 40 cps.

Heater-Cycling Life Test:

Cycles of Intermittent Operation . . 2500 min. cycles

Under the following conditions: With heater voltage of 7.0 volts cycled 1 minute on and 4 minutes off, heater-cathode voltage of 140 volts (rms), and plate and grid voltage = 0 volts.

Average Life Test Performance:

The average life test performance based on a 500-hour test at 175°C ambient temperature is not less than 450 hours. This life test is made on sample lot of tubes with heater voltage of 6.3 volts; plate voltage of 100 volts; dc heater-cathode voltage (heater positive with respect to cathode) of 200 volts; cathode resistor of 150-ohms; and grid resistor of 1 megohm.

The 500-hour end-point limits for the 5718 with heater voltage of 6.3 volts, plate voltage of 100 volts, cathode resistor of 150 ohms bypassed by capacitor having a maximum reactance of 3 ohms, and dc heater-cathode voltage of 100 volts with heater either positive or negative with respect to cathode are: transconductance, 3500 micromhos minimum; heater-cathode leakage current, 20 microamperes maximum; and grid current not to exceed +1.0 microampere maximum or -1.0 microampere maximum.

OPERATING NOTES

The *maximum ratings* in the tabulated data for the 5718 are limiting values above which the serviceability of the 5718 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *heater supply* should be well regulated because life and reliability of the 5718 are adversely affected by departures from the 6.3-volt value. The extent to which life is affected is a function of the amounts of these departures and their durations.

The *flexible leads* of the 5718 are usually soldered to the circuit elements. Soldering of the connections should be made as far as possible from the glass button. If this precaution is not followed, the heat of the soldering may crack the glass seals of the leads and damage the tube.

OPERATING CONDITIONS AS RESISTANCE-COUPLED AMPLIFIER

Plate-Supply Voltage	100						200						volts
Plate Load Resistor	0.047		0.10		0.27		0.047		0.10		0.27		megohm
Grid Resistor (of following stage)	0.10	0.27	0.27	0.47	0.27	0.47	0.10	0.27	0.27	0.47	0.27	0.47	megohm
Cathode Resistor	1000	1200	2200	2700	6800	8200	820	1000	1800	2200	4700	5600	ohms
Peak Output Voltage	8.2	8.5	8.2	8.2	7.3	7.4	19	19.5	18.6	18.1	16.2	16.2	volts
Voltage Gain	16.4	17	16.4	16.4	14.6	14.8	19	19.5	18.6	18.1	16.2	16.2	

Note 1: RMS output voltage is based on 5 per cent total harmonic distortion.

Note 2: Coupling capacitors should be selected to give desired frequency response. Cathode resistor should be adequately bypassed.

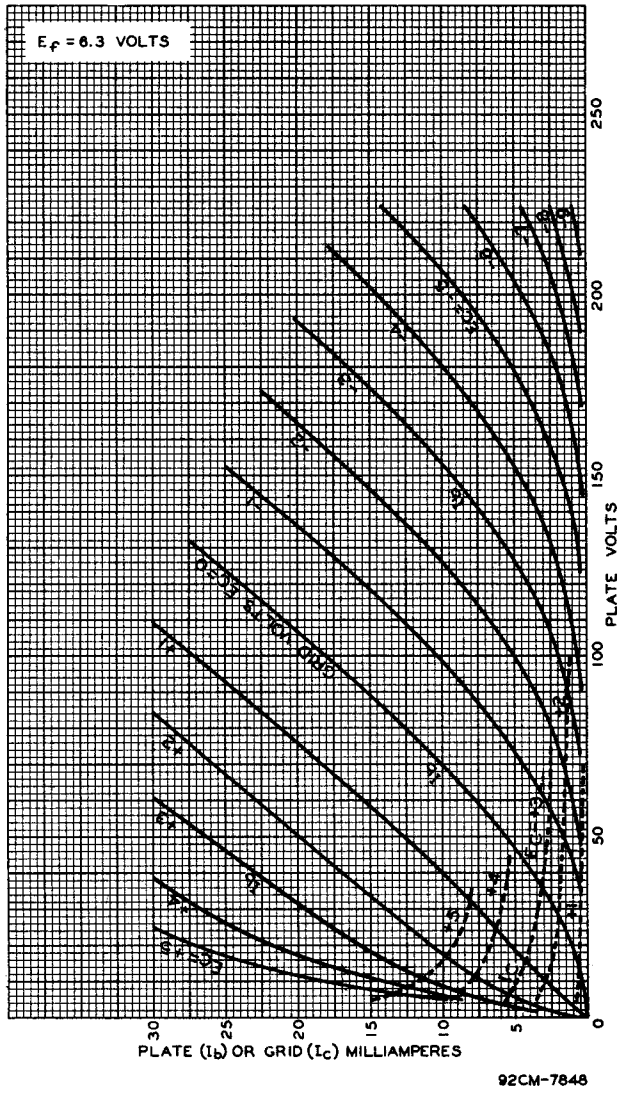


Fig. 1 – Average Plate Characteristics of Type 5718.

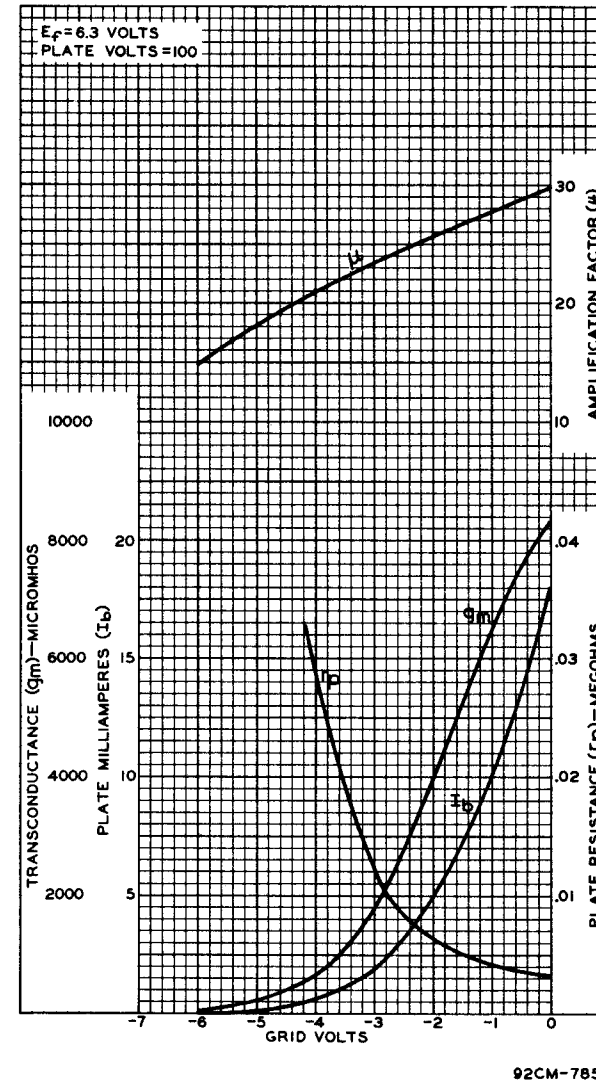


Fig. 2 – Average Characteristics of Type 5718.

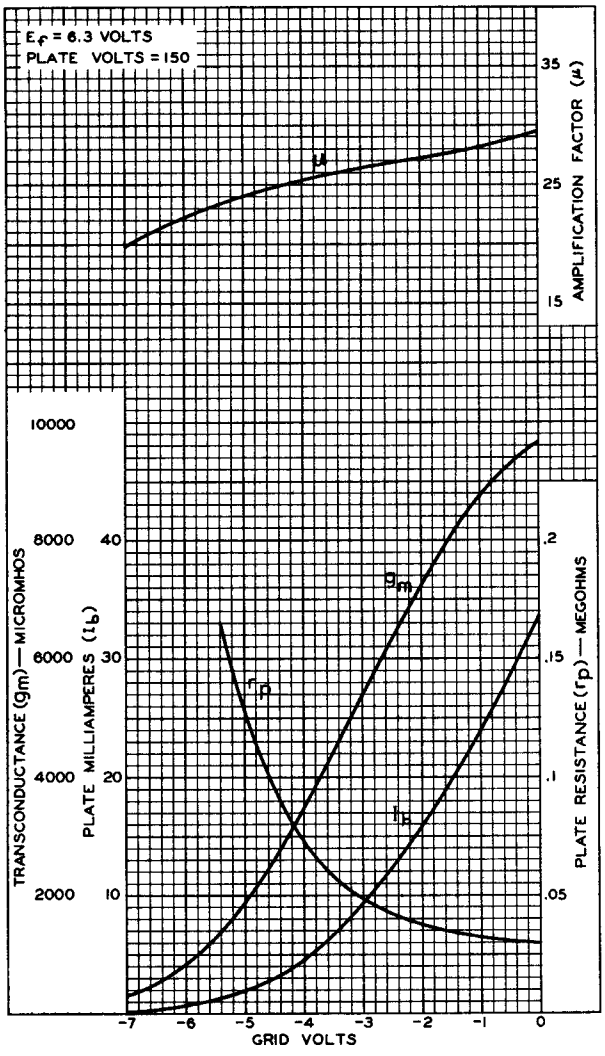
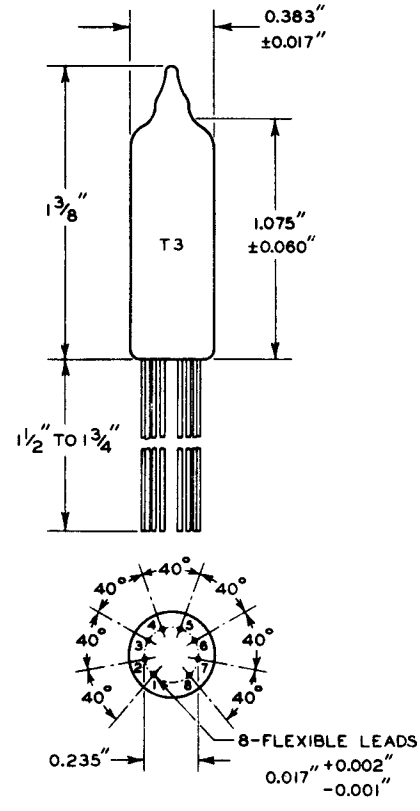


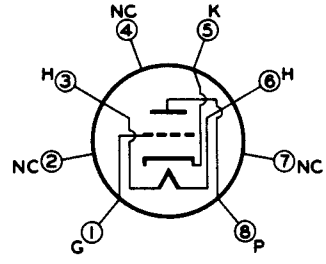
Fig. 3 – Average Characteristics of Type 5718.

DIMENSIONAL OUTLINE



FLEXIBLE LEAD CONNECTIONS

LEAD No. 1: GRID
LEAD No. 2: NO CONNECTION
LEAD No. 3: HEATER
LEAD No. 4: NO CONNECTION



LEAD No. 5: CATHODE
LEAD No. 6: HEATER
LEAD No. 7: NO CONNECTION
LEAD No. 8: ANODE

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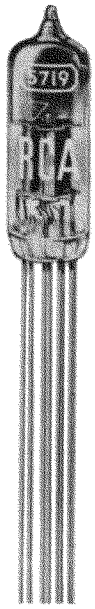
5719

HIGH-MU TRIODE

"Premium" Subminiature Type

TENTATIVE DATA

RCA-5719 is a high-mu subminiature triode of the heater-cathode type designed primarily for use as an audio amplifier in mobile and aircraft receivers where dependable performance under shock and vibration is a prime consideration. In audio service as a resistance-coupled amplifier, it is capable of providing high voltage gain.



Actual Size

The 5719 features a pure-tungsten heater to give long life under conditions of frequent on-off switching, and a compact design in which special attention has been given to structural details which provide increased mount strength against shock and vibration and reduced microphonic output. In addition, each tube is manufactured under rigid controls and undergoes rigorous tests to insure long and dependable performance.

The 5719 supersedes the 5898.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ±5%	volts
Current	0.150	ampere
Direct Interelectrode Capacitances:		

	With External Shield[o]	*Without External Shield*	
Grid to Plate	0.8	0.8	μμf
Input	1.9	1.7	μμf
Output	2.2	0.6	μμf

[o] Having inside diameter of 0.405" and connected to cathode.

Characteristics, Class A_1 Amplifier:

Plate Supply Voltage	100	150	volts
Cathode Resistor	1500	680	ohms
Amplification Factor	70	70	
Plate Resistance	41000	30500	ohms
Transconductance	1700	2300	μmhos
Plate Current	0.73	1.85	ma
Grid Volts (Approx.) for plate current of 10 μamp	-2.5	-3.8	volts

Mechanical:

Operating Position	Any
Maximum Bulb Length	1-3/8"
Length from Button Seal to Bulb Top (Excluding tip)	1.075" ± 0.060"
Diameter	0.383" ± 0.017"
Bulb	T-3
Leads, Flexible	8
Length	1-1/2" to 1-3/4"
Orientation and Diameter	See Dimensional Outline

AMPLIFIER - Class A_1

Maximum Ratings, *Absolute Values*:

PLATE VOLTAGE	165 max.	volts
GRID VOLTAGE	-55 max.	volts
PLATE CURRENT	3.3 max.	ma
PLATE DISSIPATION	0.55 max.	watt
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	°C

Typical Operation as Resistance-Coupled Amplifier:

See Chart on Page 2

Maximum Circuit Values:

Grid-Circuit Resistance:		
For cathode-bias operation	1.2 max.	megohms
For fixed-bias operation	Not recommended	

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN*

	Note	*Min.*	*Max.*	
Heater Current	1	0.138	0.162	amp
Grid-to-Plate Capacitance	2	0.6	1.0	μμf
Input Capacitance	2	1.2	2.2	μμf
Output Capacitance	2	0.4	0.8	μμf
Amplification Factor	1,3	60	80	
Plate Current	1,3	0.5	0.9	ma
Plate Current	1,4	-	50	μamp
Transconductance	1,3	1400	2000	μmhos
Transconductance	5,3	1300	-	μmhos
Grid Current	1,6	-	±0.3	μamp
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,7	-	7.0	μamp
Heater positive with respect to cathode	1,7	-	7.0	μamp
Leakage Resistance:				
Between Grid and All Other Electrodes Tied Together	1,8	100	-	megohms
Between Plate and All Other Electrodes Tied Together	1,9	100	-	megohms

* Each tube is stabilized before characteristics testing by continuous operation for at least 45 hours at room temperature and with dissipation values equivalent to life test conditions.

Note 1: With 6.3 volts ac or dc on heater.

Note 2: Without external shield.

Note 3: With plate supply voltage of 100 volts, cathode resistor of 150 ohms, and cathode bypass capacitor of 1000 microfarads.

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Note 4: With dc plate voltage of 100 volts, and dc grid voltage of −2.5 volts.

Note 5: With 5.7 volts ac or dc on heater.

Note 6: With plate supply voltage of 100 volts, cathode resistor of 1500 ohms, cathode bypass capacitor of 1000 microfarads and grid resistor of 0.1 megohm.

Note 7: With 100 volts dc between heater and cathode.

Note 8: With grid 100 volts negative with respect to all other electrodes tied together.

Note 9: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS & PERFORMANCE DATA

Shock Rating:

Impact Acceleration. . . . . 450 max. g
Tubes are held rigid in three different positions in a Navy Type, High Impact (flyweight) Shock Machine and are subjected to 450 g impact acceleration.

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g
Tubes are rigidly mounted and subjected in each of three positions to 2.5 g vibrational acceleration at 25 cycles per second for 32 hours.

Uniform Acceleration Rating: . . . . . 1000 max. g
Tubes are subjected in each of three positions to a gradually applied uniform acceleration up to 1000 g.

Low-Frequency Vibration Performance:

RMS Output Voltage . . . . . 25 max. mv
Under the following conditions: A 150-volt plate voltage supply having an impedance not exceeding that of a 40 μf capacitor, plate load resistance of 10000 ohms, grid resistor of 0.1 megohm, cathode resistor of 1500 ohms, cathode bypass capacitor of 1000 μf, and vibrational acceleration of 15 g at 40 cps.

Heater-Cycling Life Performance:

Cycles of Intermittent Operation . . 2500 min. cycles
Under the following conditions: With heater voltage of 7.0 volts cycled 1 minute on and 4 minutes off, heater-cathode voltage of 140 volts (rms), and plate and grid voltage = 0 volts.

Average Life Performance:

The average life performance based on a 500-hour test at 175°C ambient temperature is not less than 450 hours. This life test is made on sample lot of tubes with heater voltage of 6.3 volts; plate supply voltage of 100 volts; dc heater-cathode voltage (heater positive with respect to cathode) of 200 volts; cathode resistor of 1500 ohms; and grid resistor of 1 megohm.

The 500-hour end-point limits for the 5719 with heater voltage of 6.3 volts, plate supply voltage of 100 volts, cathode resistor of 680 ohms bypassed by capacitor having a maximum reactance of 3 ohms, and dc heater-cathode voltage of 100 volts with heater either positive or negative with respect to cathode are: transconductance, 1000 micromhos minimum; heater-cathode leakage current, 20 microamperes maximum; and grid current, +0.9 microampere maximum or −0.9 microampere maximum.

OPERATING CONDITIONS AS RESISTANCE-COUPLED AMPLIFIER

Cathode-Bias Operation

Plate Supply Voltage	100						200						volts
Plate Load Resistor	0.1	0.1	0.27	0.27	0.47	0.47	0.1	0.1	0.27	0.27	0.47	0.47	megohm
Grid Resistor (of following stage)	0.27	0.47	0.47	1.0	0.47	1.0	0.27	0.47	0.47	1.0	0.47	1.0	megohm
Cathode Resistor	2700	2700	5600	6800	10000	10000	1500	1800	3300	3900	5600	6800	ohms
Signal Input Volts (rms)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	volt
Output Volts (rms)	3.7	3.9	4.1	4.2	3.95	4.3	4.4	4.6	4.9	5.0	4.8	5.0	volts
Gain▲	37	39	41	42	39.5	43	44	46	49	50	48	50	
Distortion	2.4	2.1	2.1	1.8	2.4	1.7	0.7	0.7	0.9	0.7	0.9	0.7	per cent
Signal Input Volts (rms)*	0.20	0.20	0.20	0.26	0.20	0.25	0.51	0.61	0.50	0.59	0.49	0.64	volt
Output Volts (rms)	7.3	7.7	8.1	10.7	7.8	10.7	22	27	24.2	29	23.2	31.6	volts
Gain▲	36.5	38.5	40.5	41.2	39	42.8	43.1	44.3	48.4	49.2	47.3	49.4	
Distortion	5.0	4.5	4.3	4.9	5.0	4.5	3.9	5.0	4.5	4.5	5.0	5.0	per cent

Zero-Bias Operation

Plate-Supply Voltage	100						200						volts
Plate Load Resistor	0.1	0.1	0.27	0.27	0.47	0.47	0.1	0.1	0.27	0.27	0.47	0.47	megohm
Grid Resistor (of following stage)	0.27	0.47	0.47	1.0	0.47	1.0	0.27	0.47	0.47	1.0	0.47	1.0	megohm
Signal Input Volts (rms)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	volt
Output Volts (rms)	3.8	4.0	4.3	4.55	4.2	4.55	4.7	4.9	5.35	5.4	5.2	5.4	volts
Gain▲	38	40	43	45.5	42	45.5	47	49	53.5	54	52	54	
Distortion	2.2	2.0	1.9	1.6	2.1	1.6	0.4	0.4	0.8	0.7	0.9	0.7	per cent
Signal Input Volts (rms)*	0.2	0.21	0.22	0.26	0.2	0.27	0.59	0.63	0.54	0.65	0.5	0.63	volt
Output Volts (rms)	7.25	7.9	8.95	11	7.9	11.3	25	27.7	25.8	31.5	23.5	30.5	volts
Gain▲	36.2	37.6	40.6	42.4	39.5	41.8	42.4	43.9	47.7	48.5	47	48.4	
Distortion	5.0	4.8	4.9	4.8	4.8	5.0	4.9	5.0	4.9	5.0	5.0	4.8	per cent

Note 1: Coupling capacitors should be selected to give desired frequency response. Cathode resistor should be adequately bypassed.

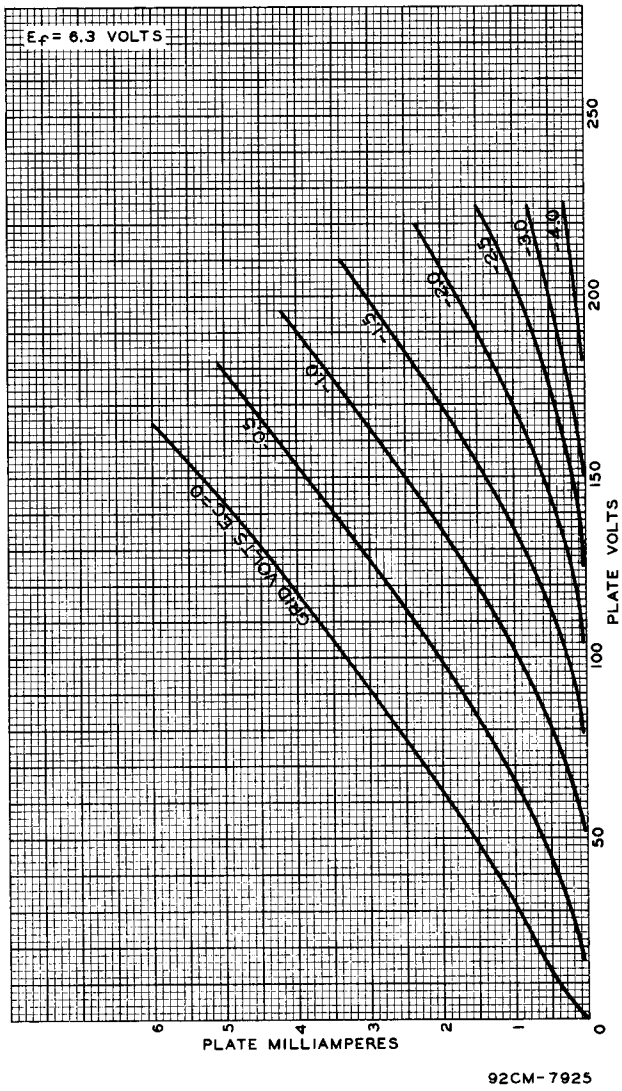
* Maximum value to swing the grid of resistance-coupled amplifier tube to the point where its grid starts to draw current.

▲ Ratio of signal output to signal input.

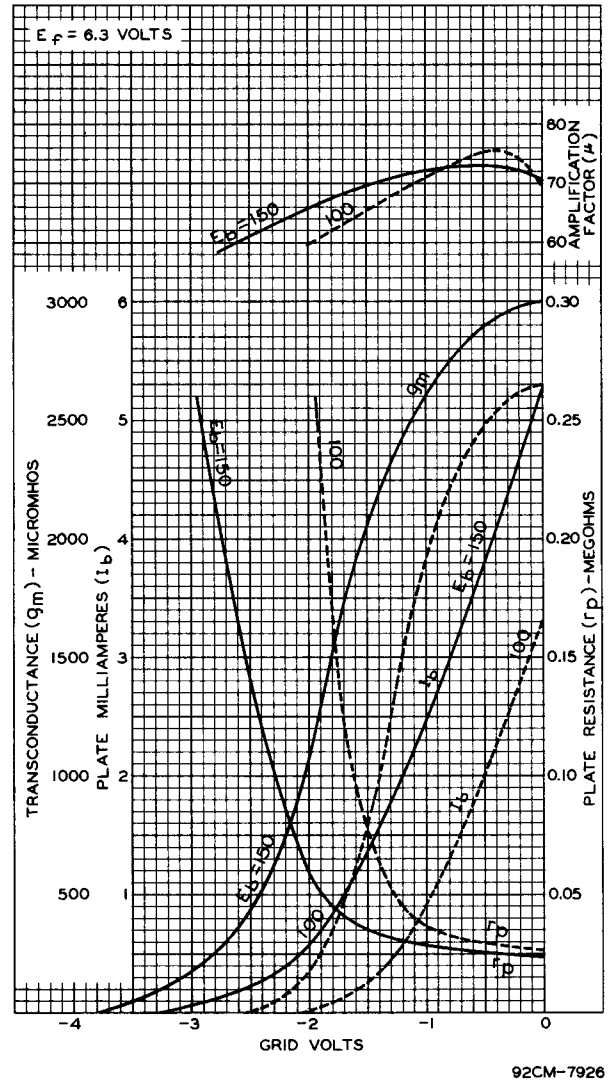
OPERATING NOTES

The *maximum ratings* in the tabulated data for the 5719 are limiting values above which the serviceability of the 5719 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *heater supply* should be well regulated because life and reliability of the 5719 are adversely affected by departures from the 6.3-volt value. The extent to which life is affected is a function of the amounts of these departures and their durations.



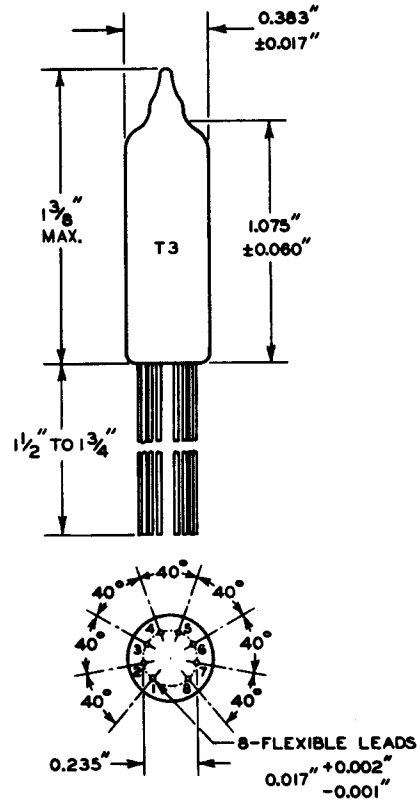
Average Plate Characteristics of Type 5719.



Average Characteristics of Type 5719.

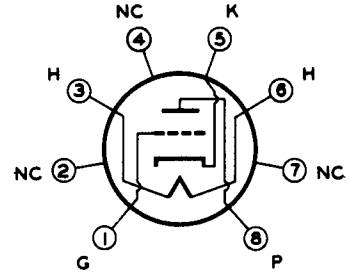
The *flexible leads* of the 5719 are usually soldered to the circuit elements. Soldering of the connections should be made as far as possible from the glass button. If this precaution is not followed, the heat of the soldering may crack the glass seals of the leads and damage the tube.

DIMENSIONAL OUTLINE



FLEXIBLE LEAD CONNECTIONS

LEAD NO. 1: GRID
LEAD NO. 2: NO CONNECTION
LEAD NO. 3: HEATER
LEAD NO. 4: NO CONNECTION



LEAD NO. 5: CATHODE
LEAD NO. 6: HEATER
LEAD NO. 7: NO CONNECTION
LEAD NO. 8: PLATE

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

5726

TWIN DIODE

"Premium" Miniature Type

TENTATIVE DATA

RCA-5726 is a high-perveance, miniature twin diode especially useful as a detector in circuits utilizing wide-band amplifiers. Constructed to give dependable performance under shock and vibration, this "premium" version of the 6AL5W is, therefore, well suited for use in mobile and aircraft equipment.

The two, sturdy, coiled heaters used in the 5726 are internally connected in series to provide fail-safe operation in applications which require that burn-out of either heater will make the heaters of both units simultaneously inoperative. These heaters employ pure tungsten to provide long life under conditions of frequent on-off switching.

Each 5726 is manufactured under rigid controls and undergoes rigorous tests to insure "premium" quality.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathodes:		
Voltage (AC or DC)	6.3 ±10%	volts
Current	0.3	ampere
Resonant Frequency (Each unit, approx.)	700	Mc
Direct Interelectrode Capacitances (With external shield JETEC No.316):		
Unit No.1:		
Plate to Cathode + External Shield, Heater, and Internal Shield	3.2	μμf
Cathode to Plate + External Shield, Heater, and Internal Shield	3.9	μμf
Unit No.2:		
Plate to Cathode + External Shield, Heater, and Internal Shield	3.2	μμf
Cathode to Plate + External Shield, Heater, and Internal Shield	3.9	μμf
Plate of Unit No.1 to Plate of Unit No.2●	0.026 max.	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	1-3/4"
Maximum Seated Length	1-1/2"
Length, Base Seat to Bulb Top (Excluding tip)	1-1/8" ±3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

HALF-WAVE RECTIFIER

Maximum Ratings, *Absolute Values*:

PEAK INVERSE PLATE VOLTAGE	360 max.	volts
PEAK PLATE CURRENT PER PLATE	60 max.	ma
HOT-SWITCHING TRANSIENT PLATE CURRENT For duration of 0.2 second maximum	350 max.	ma
DC OUTPUT CURRENT PER PLATE	10 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	360 max.	volts
Heater positive with respect to cathode	360 max.	volts

Typical Operation:

The two units may be used separately or in parallel

AC Plate-Supply Voltage Per Plate (RMS)	117	volts
Minimum Total Effective Plate-Supply Impedance Per Plate	300	ohms
DC Output Current Per Plate	9	ma

Shock and Vibration Tests:

These tests are made as indicated in the JAN Specifications: JAN 1-A for Electron Tubes, May 1946 under the section as follows:

Section F6b (9e) Shock Test:		
Instantaneous Impact Acceleration	700 max.	g
Section F6b (9f) Vibration Test:		
Vibrational Acceleration	2.5 max.	g

Heater Cycling Life Test:

This test is made as indicated in the JAN Specifications JAN 1-A for Electron Tubes for type 5726/6AL5W.

Cycles of Intermittent Operation:		
At a heater voltage of 7.5 volts	2000 min.	cycles

Characteristics Range Values for Equipment Design:

	Note	*Min.*	*Max.*	
Heater Current	1	0.275	0.325	amp
Direct Interelectrode Capacitances (With external shield JETEC No.316):				
Unit No.1:				
Plate to Cathode + External Shield, Heater, and Internal Shield	–	2.4	4.0	μμf
Cathode to Plate + External Shield, Heater, and Internal Shield	–	2.8	4.4	μμf
Unit No.2:				
Plate to Cathode + External Shield, Heater, and Internal Shield	–	2.4	4.0	μμf
Cathode to Plate + External Shield, Heater, and Internal Shield	–	2.8	4.4	μμf
Plate of Unit No.1 to Plate of Unit No.2	2	–	0.026	μμf
Plate Current (Per Plate)	1,3	40	–	ma

Note 1: With 6.3 volts ac on heater.

Note 2: With external and internal shield connected to ground.

Note 3: With dc plate voltage = 10 volts. Each unit tested separately with electrodes of opposite unit grounded.

● With external and internal shield connected to ground.

OPERATING NOTES

The *maximum ratings* in the tabulated data for the 5726 are limiting values above which the serviceability of the 5726 may be impaired from viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

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Radio Corporation of America

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5726-6-52
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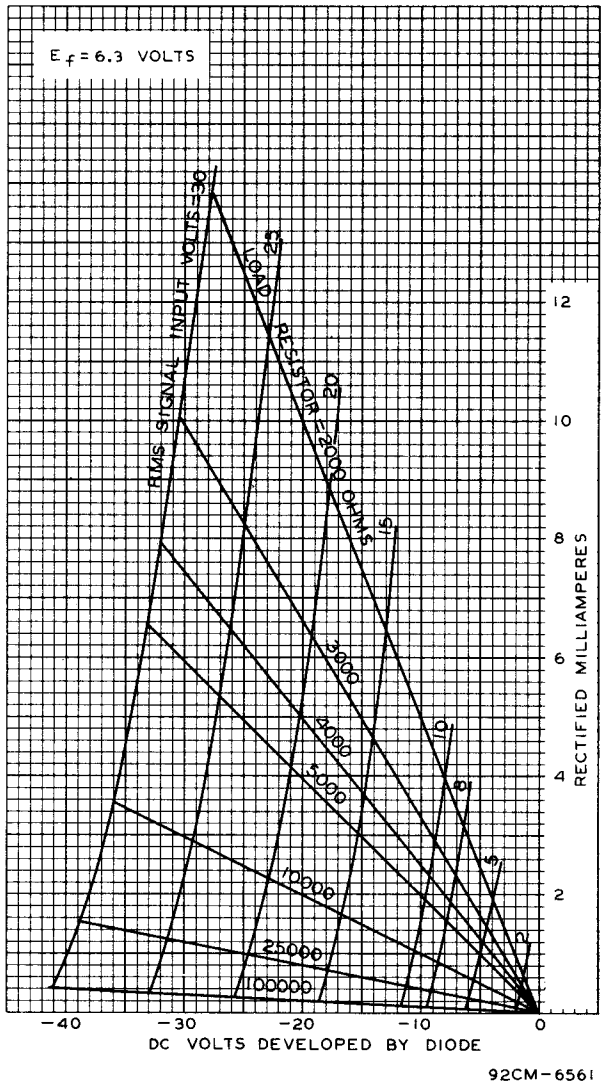
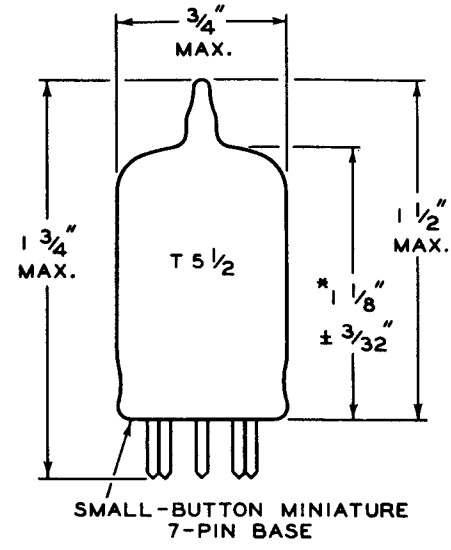


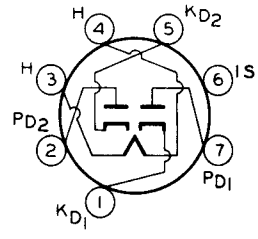
Half-Wave Rectification Characteristics for Single Diode of Type 5726.

DIMENSIONAL OUTLINE

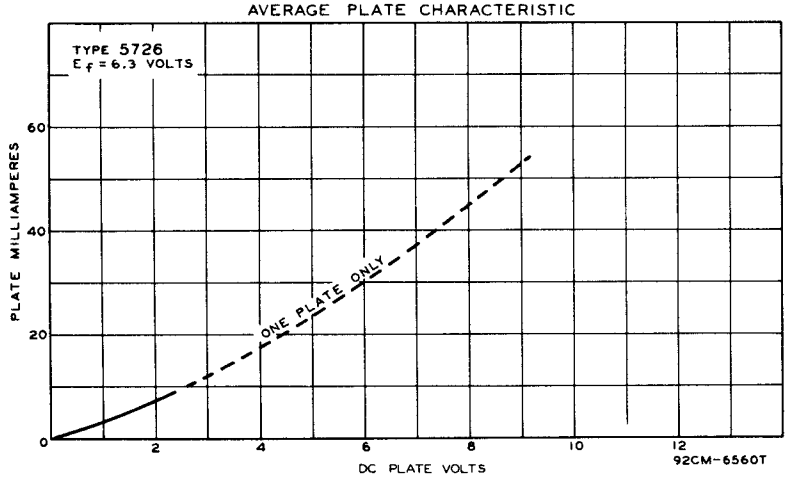


* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



PIN 1: CATHODE OF DIODE UNIT NO. 1
PIN 2: PLATE OF DIODE UNIT NO. 2
PIN 3: HEATER
PIN 4: HEATER
PIN 5: CATHODE OF DIODE UNIT NO. 2
PIN 6: INTERNAL SHIELD
PIN 7: PLATE OF DIODE UNIT NO. 1



Average Plate Characteristic for Either Unit of Type 5726.

5727

THYRATRON

"Premium" Gas-Tetrode, Miniature Type

TENTATIVE DATA

The 5727 is a sensitive, four-electrode thyratron of the indirectly heated cathode type designed for use in relay, grid-controlled rectifier, and pulse-modulator applications. Constructed to give dependable performance under conditions of shock and vibration, this "premium" tube, which is similar to the 2D21, is especially suited for use in critical industrial applications and in military equipment. It has a steep control characteristic (high control ratio) which is essentially independent of ambient temperature over a wide range, extremely small preconduction or gas-leakage currents right up to the beginning of conduction, very low grid-No.1-to-anode capacitance, and very low grid-No.1 current. Having very low grid-No.1-to-anode capacitance, the 5727 is not appreciably affected by line-voltage surges; and having very low grid-No.1 current, it can be used with a high value of resistance in the grid-No.1 circuit to give high circuit sensitivity. In a high sensitivity circuit, the 5727 can be operated directly from a high-vacuum phototube.

Featured in the design of the 5727 is a structure in which special attention has been given to features which improve its strength for both shock and vibration. Other design features include: (1) tube parts precisely made and accurately fitted to minimize variations in electrical characteristics due to mechanical movement, (2) ceramic insulator on anode support rod to prevent spurious breakdown, and (3) the use of special micas having slots to minimize leakage resistance between electrodes. In addition, the design of the 5727 incorporates a pure-tungsten heater having high mechanical strength to give long life under conditions of frequent "on-off" switching.

The 5727 is manufactured under rigid controls and undergoes rigorous tests to insure its "premium" quality as follows: (1) factory tests under typical grid-controlled rectifier and pulse-modulator conditions, and (2) test readings at the end of 1 hour, 100 hours, and 500 hours on sample lots to insure that tubes fall within the established tight characteristics limits and that early failures are held to a low percentage.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%*	volts
Current	0.6	amp
Cathode:		
Minimum heating time prior to tube conduction	20	sec
Direct Interelectrode Capacitances (Approx., without external shield):		
Grid No.1 to anode	0.026	μμf
Grid No.1 to cathode, grid No.2, and heater	2.4	μμf
Anode to cathode, grid No.2, and heater	1.6	μμf
Ionization Time (Approx.):		
For dc anode volts = 100; grid-No.1 volts (square-wave pulse = 50; peak anode current during conduction = 0.5 ampere	0.5	μsec
Deionization Time (Approx.):		
For dc anode volts = 125; dc anode current = 0.1 ampere; grid-No.1 resistor (ohms) = 1000; and grid-No.1 volts = -100	35	μsec
For dc anode volts = 125; dc anode current = 0.1 ampere; grid-No.1 resistor (ohms) = 1000; and grid-No.1 volts = -10	75	μsec
Maximum Critical Grid-No.1 Current:		
For anode-supply voltage (rms) = 460 volts, and average anode current = 0.1 ampere	0.5	μa
Anode Voltage Drop (Approx.)	8	volts
Grid-No.1 Control Ratio (Approx.) with grid-No.1 resistor (megohms) = 0; grid-No.2 volts = 0	250	
Grid-No.2 Control Ratio (Approx.) with grid-No.1 resistor (megohms) =0; grid-No.2 resistor (megohms) = 0; grid-No.1 volts = 0	1000	

Mechanical:

Operating Position	Any
Maximum Overall Length	2-1/8"
Maximum Seated Length	1-7/8"
Length, Base Seat to Bulb Top (excluding tip)	1-1/2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

TMK ®, Marca Registrada
Printed in U.S.A.

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

RELAY and GRID-CONTROLLED RECTIFIER SERVICE

For Anode Supply Frequency of 60 cps

Maximum Ratings, *Absolute Values:*

PEAK ANODE VOLTAGE:		
Forward	650 max.	volts
Inverse	1300 max.	volts
GRID-No.2 (SHIELD-GRID) VOLTAGE:		
Peak, before anode conduction	-100 max.	volts
Average[■], during anode conduction	-10 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Peak, before anode conduction	-100 max.	volts
Average, during anode conduction	-10 max.	volts
CATHODE CURRENT:		
Peak	0.5 max.	amp
Average[□]	0.1 max.	amp
Fault, for duration of 0.1 sec. max.	10 max.	amp
GRID-No.2 CURRENT:		
Average[■]	+0.01 max.	amp
GRID-No.1 CURRENT:		
Average[■]	+0.01 max.	amp
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	25 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	150 max.	°C
AMBIENT TEMPERATURE	-75 min.	°C

Typical Operating Conditions for Relay Service:

RMS Anode Voltage	117	400	volts
Grid-No.2 Voltage	0	0	volts
RMS Grid-No.1 Bias Voltage[□]	5	-	volts
DC Grid-No.1 Bias Voltage	-	-6	volts
Peak Grid-No.1 Signal Voltage	5	6	volts
Grid-No.1-Circuit Resistance	1.0	1.0	megohm
Anode-Circuit Resistance[#]	1200	2000	ohms

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	10 max.	megohms

PULSE-MODULATOR SERVICE

For Rectangular-Wave Shapes, Duty Cycle of 0.001 max., Pulse Duration of 5 μsec. max., and Pulse Repetition Rate of 500 pps max.

Maximum Ratings, *Absolute Values:*

PEAK ANODE VOLTAGE:		
Forward	500 max.	volts
Inverse	100 max.	volts
GRID-No.2 (SHIELD-GRID) VOLTAGE:		
Peak, before anode conduction	-50 max.	volts
Average, during anode conduction	-10 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Peak, before anode conduction	-100 max.	volts
Average, during anode conduction	-10 max.	volts
CATHODE CURRENT:		
Peak	10 max.	amp
Average	0.01 max.	amp
Rate of change	100 max.	amp/μsec
PEAK GRID-No.2 CURRENT	0.02 max.	amp
PEAK GRID-No.1 CURRENT	0.02 max.	amp
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	0 max.	volts
Heater positive with respect to cathode	0 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	150 max.	°C
AMBIENT TEMPERATURE	-75 min.	°C

Maximum and Minimum Circuit Values:

Grid-No.1-Circuit Resistance	0.5 max.	megohms
Grid-No.2-Circuit Resistance	25000 max.	ohms
	2000 min.	ohms

* For pulse-modulator service, tolerance is +10%, -5%.

■ Averaged over any interval of 30 seconds max.

□ Approximately 180° out of phase with the anode voltage.

\# Sufficient resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values are Initial, Unless Otherwise Specified

	Note	Min.	Max.	
Heater Current	1	540	660	ma
Grid-No.1 Supply Voltage for Anode Conduction (1)	1,2	-2.9	-4.5	volts
Grid-No.1 Supply Voltage for Anode Conduction (2)	1,3	-	5.2	volts
Grid-No.1 Supply Voltage for Anode Conduction (3)	4,3	-	-6.4	volts
Anode Supply Voltage for Anode Conduction (1)	1,5	-	38	volts
Anode Supply Voltage for Anode Conduction (1) at 500 hours.	1,5	-	50	volts
Anode Supply Voltage for Anode Conduction (2)	6,5	-	50	volts
Anode Supply Voltage for Anode Conduction (3)	7,8	650	-	volts
RMS Grid-No.2 Supply Voltage for Anode Conduction (this voltage is 180° out of phase with anode supply voltage)	1,9	1.9	3.3	volts
Heater-Cathode Leakage Current:				
Heater 25 volts positive with respect to cathode	1	-	15	μa
Heater 100 volts negative with respect to cathode	1	-	15	μa
Heater-Cathode Leakage Current at 500 Hours:				
Heater 25 volts positive with respect to cathode	1	-	20	μa
Heater 100 volts negative with respect to cathode	1	-	20	μa
Leakage Resistance:				
Grid-No.2 to anode	1,10	760	-	megohms
Leakage Resistance:				
Grid-No.2 to anode at 500 Hours	1,10	380	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With anode supply voltage of 460 volts (rms), grid-No.2 voltage of 0 volts, load resistor of 3000 ohms, and grid-No.1 resistor of 0.1 megohm.

Note 3: With plate supply voltage of 460 volts (rms), grid-No.2 voltage of 0 volts, load resistor of 3000 ohms, and grid-No.1 resistor of 10 megohms.

Note 4: With 7.0 volts ac or dc on heater.

Note 5: With grid-No.2 voltage of 0 volts, grid-No.1 voltage of 0 volts, load resistor of 1000 ohms, and grid-No.1 resistor of 0.1 megohm.

Note 6: With 5.7 volts ac or dc on heater.

Note 7: With 0 volts on heater.

Note 8: With grid-No.1 voltage of -100 volts, grid-No.2 voltage of 0 volts, and load resistor of 10000 ohms.

Note 9: With anode supply voltage of 150 volts (rms), grid-No.1 supply voltage of 16 volts (rms and in phase with anode supply voltage).

Note 10: With grid-No.2 voltage of ±380 volts with respect to anode and all other electrodes floating.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration. . . . . 750 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are held rigid and are tested in four different positions. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for heater-cathode leakage current, grid-No.1 supply voltage for anode conduction (1) and anode supply voltage for anode conduction (1).

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected in each of three positions to 2.5-g vibrational acceleration at 60 cycles per second for 32 hours. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for heater-cathode leakage current, grid-No.1 supply voltage for anode conduction (1) and anode supply voltage for anode conduction (1).

Heater-Cycling Life Performance:

Cycles of Intermittent Operation . . 2000 min. cycles

Under the following conditions: Heater voltage of 7.5 volts cycled one minute on and one minute off, heater 100 volts negative with respect to cathode, and all other elements grounded.

Shorts and Continuity Test:

This test is performed on a sample lot of tubes from each production run. In this test a tube is considered inoperative if it shows a permanent or temporary short or open circuit.

1-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that tubes have been properly stabilized. Conditions of life testing are specified under 500-Hour Intermittent Life Performance, except test run at room temperature. Tubes are initially read for Grid-No.1 Supply Voltage for Anode Conduction (1). At the end of 1 hour grid-No.1 supply voltage is read. The variation in the 0-hour and 1-hour readings will not exceed 15 per cent. Tubes must also meet established limits of grid-No.1 supply voltage.

100-Hour Survival Life Performance:

This test is performed on a sample lot of tubes from each production run to insure a low percentage of early inoperatives. Conditions of life testing are specified under 500-Hour Intermittent Life Performance, except test run at room temperature. At the end of 100 hours, a tube is considered inoperative if it shows a permanent or temporary short or open circuit or fails to meet established limits of grid-No.1 supply voltage for anode conduction (1).

500-Hour Intermittent Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures of any of the characteristics indicated below. Life testing is conducted under the following conditions: Heater voltage of 6.3 volts, anode supply voltage of 460 volts (rms), grid-No.2 supply voltage of 0 volts, average anode current of 80 milliamperes, peak anode current of 500 milliamperes, grid-No.1 resistor of 50000 ohms, and minimum bulb temperature of 150°C. At the end of 500 hours, tube will not show permanent shorts or open circuits and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to pass established initial limits of heater current, grid-No.1 supply voltage (1), and 500-hour limits for anode supply voltage (1), heater-cathode leakage current, and leakage resistance shown under Characteristics Range Values.

INSTALLATION AND APPLICATION

The *base pins* of the 5727 fit the miniature 7-contact socket which may be installed to hold the tube in any position. The socket should be

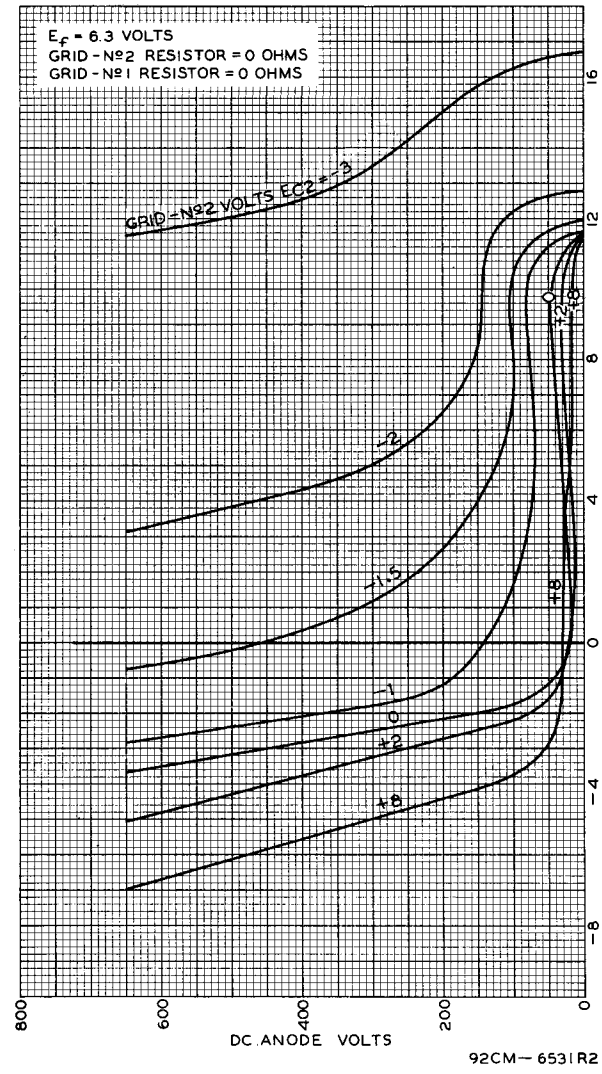


Fig. 1 - Average Control Characteristics of Type 5727.

made of an insulating material having leakage current low in comparison with the pre-conduction grid current of the 5727.

The *heater* is designed to operate on either ac or dc at 6.3 volts. Regardless of the heater-voltage supply used, *the heater voltage must never be allowed to deviate more than 10% from its rated value, except for pulse-modulator service where the tolerance is +10%, -5%.* Heater operation outside of this voltage range will impair tube performance and may cause tube failure. Low heater voltage causes low cathode temperature

with resultant cathode sputtering and consequent destruction of the cathode; high heater voltage causes high cathode temperature with resultant heating of the grid and consequent grid emission which produces unpredictable shifts in the critical grid-No.1 voltage for conduction.

The *cathode* should be allowed to reach normal operating temperature before anode current is drawn. *The delay period should not be less than 20 seconds after application of heater voltage.* Unless this recommendation is followed, the cathode will be damaged.

The *shield grid* (grid No.2) is normally connected to the cathode. It may, however, be used as a control electrode because the control characteristic of grid No.1 may be shifted by varying the potential of grid No.2. As grid No.2 is made negative, the grid-No.1 characteristic is shifted in the positive direction. With -2 volts on grid No.2, the grid-No.1 characteristic lies completely in the positive region. The use of grid No.2 as the control electrode (with grid No.1 tied to cathode) has the advantage of increased sensitivity but consideration must be given to the higher preconduction current, higher capacitance to anode, and less stability of operation.

A *grid-No.1 resistor* having a value as high as 10 megohms to give circuit sensitivity can be used with the 5727 because its control-grid current is very low. However, when a high value of grid resistor is used, care should be taken to keep the tube base and socket clean and dry in order to make the effect of leakage currents between the control-grid base pin and anode base pin very small.

When the 5727 is operated with a high value of grid-No.1 resistor and ac voltage on the anode, the circuit capacitance between grid No.1 and anode should be kept low by placing the grid resistor directly at the socket grid terminal, by connecting both grid-No.2 terminals (pins 5 and 7) to the cathode (pin 2) at the socket, and by using a close-fitting shield connected to the cathode terminal.

Sufficient anode-circuit resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings of the tube.

OPERATING CONSIDERATIONS

The 5727 operates by virtue of the fact that, for any specific grid-No.2 potential and positive anode potential, there is a critical value of grid-No.1 voltage. If grid No.1 is maintained more negative than this critical value, the tube does not conduct and the anode current remains zero. If grid No.1 is made less negative than the critical value, the tube will conduct and the anode current assumes a value determined by the applied anode potential and the impedance in the anode circuit. In the conducting condition, the 5727 has a voltage drop which is quite low and substantially independent of both anode current and grid-No.1 bias. Conduction may be stopped and grid No.1 allowed to regain control by reducing the anode voltage to zero or making it negative. A family of curves showing the relations between grid-No.1 voltage, grid-No.2 voltage, and anode voltage is given in Fig.1.

In the design of equipment to utilize the 5727, consideration should be given to its maximum ratings which are on an *absolute maximum* basis. In order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that

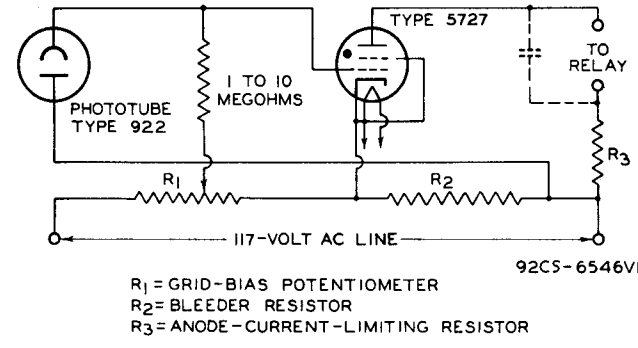


Fig.2 - Typical Light-Operated Relay Circuit Utilizing Type 5727.

the absolute values will never be exceeded under any usual conditions of supply-voltage variation, or manufacturing variation in the equipment itself.

The 5727 can be operated with an anode voltage obtained from either an ac or a dc source. When a dc supply is used, the circuit has a lock-in feature because grid No.1 loses control when conduction starts. In order for grid No.1 to regain control and to restore the tube to the non-conducting condition, the anode voltage must be removed momentarily. When an ac supply is used, the circuit has no lock-in feature because the anode becomes negative during the negative half of the ac cycle and allows grid No.1 to resume control. In ac operation, control of the average anode current may be accomplished by relative phasing of the grid-No.1, grid-No.2, and anode potentials. A typical light-operated relay circuit is shown in Fig.2.

The electrode structure of the 5727 provides very low grid-No.1-to-anode capacitance with the result that the tube is insensitive to line-voltage surges. This characteristic also insures that only very low values of capacitive current will flow through the grid-No.1 resistor. Such a characteristic is very desirable because the

grid-No.1 bias required to prevent conduction is increased by an amount equal to the peak IR drop across the grid resistor.

The effective grid-No.1 bias obtained when a high value of grid-circuit resistor is used is influenced by the grid-No.1 currents flowing before and during conduction. The magnitude of these currents before conduction is shown in microamperes in Fig.3 and during conduction in milliamperes in Fig.4.

The critical grid-No.1 voltage for any given anode voltage is that value of grid-No.1 voltage which will permit conduction to start. The value of critical grid-No.1 voltage is affected by several factors including: the operating anode voltage, grid-No.2 voltage, variation of

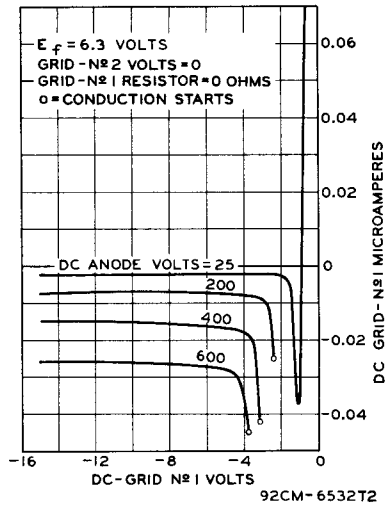


Fig.3 - Average Grid-No.1 Characteristics Before Anode Conduction.

heater-supply voltage, value of grid-No.1 resistor, and individual tube variations both initially and during life. In Fig.5 is shown the range of critical grid-No.1 voltage based on the combined effect of individual tube variation, and variation throughout tube life for a grid resistor value of 0.1 megohm and also for a value of 10 megohms. About 10% of the total variation range for any particular operating condition is attributable to a heater-voltage variation of ± 10% from the rated value.

The equipment designer should give careful consideration to the range values shown in Fig.5. From them he can determine for specified operating conditions not only the proper value of grid-No.1 bias to prevent conduction until it is desired but also the magnitude of the signal (triggering) voltage to cause conduction. Ample triggering voltage should always be provided to insure anode conduction even under the worst operating conditions to which the equipment will usually be subjected.

In addition to the factors contributing to the range values shown in Fig.5, the effect of high ambient temperature may become important. When the 5727 is used with a low value of grid-No.1 resistor, the effect on critical grid-No.1

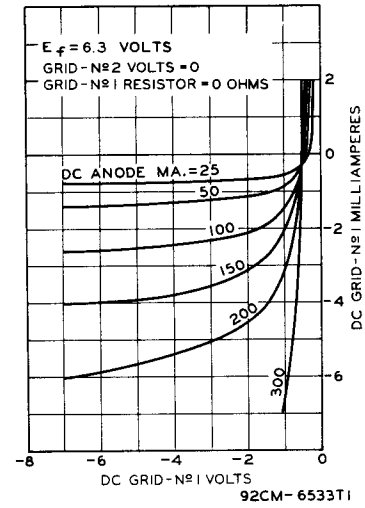


Fig.4 - Average Grid-No.1 Characteristics During Anode Conduction.

voltage of temperature changes between the minimum ambient temperature rating and the maximum bulb temperature rating is negligible. However, when the grid-No.1 resistor has a high value, tempera-

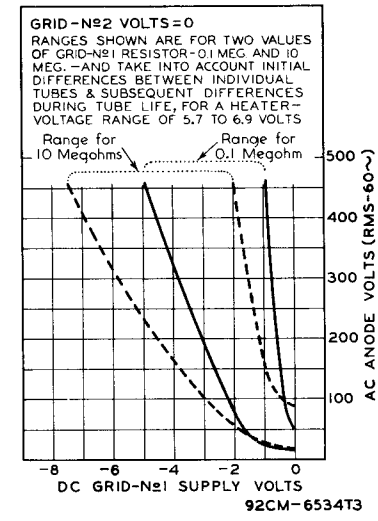


Fig.5 - Operational Range of Critical Grid-No.1 Voltage.

ture changes within the minimum ambient temperature and maximum bulb temperature range may cause a change of 20% in the critical grid-No.1 voltage. Most of this change occurs at the higher temperatures and is caused by leakage outside the tube.

Therefore, under operating conditions involving a high value of grid-No.1 resistor and high bulb temperature, it is essential that precautions be taken to minimize leakage.

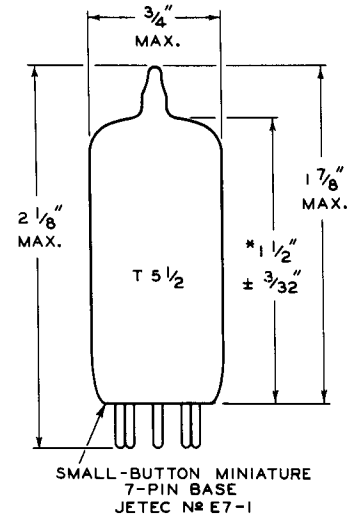
The *maximum average cathode current, shown under relay and grid-controlled rectifier service,* is the highest current which can be drawn continuously through the tube and is based on the allowable heating of the tube. The average current should be determined on the basis of 30-second operation of the tube. If the cycle of operation during the 30-second period is rapid, the average current can be read on a dc meter. If the cycle is long, it is necessary to calculate the average current from readings taken during the 30-second period.

REFERENCE

"Pulse-Firing Time and Recovery Time of the 2D21 Thyratron", by J. A. Olmstead and M. Roth, RCA REVIEW, June, 1957.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

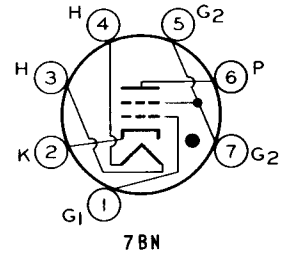
DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



7BN

PIN 1 – GRID No.1
PIN 2 – CATHODE
PIN 3 – HEATER
PIN 4 – HEATER
PIN 5 – GRID No.2
PIN 6 – ANODE
PIN 7 – GRID No.2

5731

UHF TRIODE

Acorn Type

The 5731 is an acorn triode of the heater-cathode type for use at frequencies up to 600 megacycles. It is intended particularly for radiosonde applications.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.15	ampere
Direct Interelectrode Capacitances:[o]		
Grid to Plate	1.3	μμf
Grid to Cathode	1.0	μμf
Plate to Cathode	0.4	μμf

Mechanical:

Mounting Position	Any
Overall Length	1-7/32" ± 5/32"
Overall Diameter	1-3/32" ± 1/16"
Bulb	T-4-1/2
Base	Small Radial 5-Pin
Outline	JETEC 4-1
Basing Designation	5BC

AF AMPLIFIER—Class A_1

Maximum Ratings, Design-Center Values:

DC PLATE VOLTAGE	250 max.	volts
PLATE DISSIPATION	1.6 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	80 max.	volts
Heater positive with respect to cathode	80 max.	volts

Characteristics:

DC Plate Voltage	90	135	180	250	volts
DC Grid Voltage	-2.5	-3.75	-5	-7	volts
Amplification Factor	25	25	25	25	
Plate Resistance	14700	13200	12500	11400	ohms
Transconductance	1700	1900	2000	2200	micromhos
DC Plate Current	2.5	3.5	4.5	6.3	ma
Load Resistance	-	-	20000	-	ohms

[o] With no external shield.

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Radio Corporation of America

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5731-7-48
Photolithographed in U. S. A.

from RMA release # 684, Aug. 31, 1948

Characteristics (Cont'd):

2nd Harmonic Distortion.	-	-	5	-	%
Power Output	-	-	135	-	mw

RF POWER AMPLIFIER & OSCILLATOR--Class C

Plate Modulated or CW

Maximum Ratings, Design-Center Values:

DC PLATE VOLTAGE	180 max.	volts
DC PLATE CURRENT	8 max.	ma
DC GRID CURRENT.	2 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode.	80 max.	volts
Heater positive with respect to cathode.	80 max.	volts

Typical Operation:

DC Plate Voltage	180	volts
DC Grid Voltage (Approx.)	-35	volts
DC Plate Current	7	ma
DC Grid Current (Approx.)	1.5	ma
Power Output (Approx.)*	0.5	watt

* At 5 meters. Only moderate reduction in this value will be found for wavelengths as low as 1 meter. Below 1 meter, the power output decreases as the wavelength is increased.

CHARACTERISTICS RANGE VALUES

	Note	Min.	
Emission	1	25	ma
Oscillator Grid Current.	2	250	~~ma~~ μa

Note 1: With 5.5 volts on heater, +15 volts on grid, and +15 volts on plate.

Note 2: With 5.5 volts on heater, 150 volts on plate, grid resistor of 10000 ohms, and oscillator frequency of 600 megacycles. Circuit has tuned line input to grid which is capacitively coupled to plate.

Outline, Basing Diagram, and Curves
are the same as for RCA-955

from RMA release #722, Dec. 17, 1948

5769

IMAGE ORTHICON

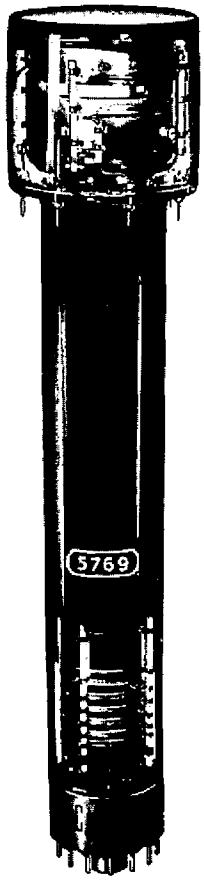
Magnetic Focus
Magnetic Deflection

For Outdoor and Studio Pickup
Excellent Sensitivity

3"-Diameter Bulb
15-1/4" Length

TENTATIVE DATA

RCA-5769 is a television camera tube recommended for outdoor pickup use but it is also suitable for studio use and other applications where the illumination is not excessively low.



The 5769 is very stable in performance at all incident light levels on the object ranging from bright sunlight (several thousand foot-candles) to a deep shadow (one foot-candle or less). Commercially acceptable pictures can be obtained at light levels greater than about 50 foot-candles.

The 5769, like the RCA-5655, utilizes a photocathode characterized by a spectral response having high blue sensitivity, good green sensitivity, useful red sensitivity, and practically no infrared sensitivity. This latter characteristic of the response prevents any color-masking by infrared, and thus permits portrayal of colors in more nearly their true gradation. For the most satisfactory portrayal of colors, it is recommended that the lighting be provided by 3500 or 4500 white fluorescent lamps supplemented by tungsten illumination to provide the red.

Because of its spectral characteristics, its wide light-range capability, and its high sensitivity, the 5769 can be substituted to advantage for the RCA-2P23 in any application where the intensity of the illumination is not excessively low. In the studio, the 5769 can be substituted for RCA-5655 to gain somewhat more freedom in set lighting by taking advantage of the greater light-range capability of the 5769, but with some sacrifice in performance because of the lower signal-to-noise ratio of the 5769.

In applications where the high sensitivity of the 5769 is not essential, as in the case of film pickup, the use of a less sensitive type of camera tube, such as RCA-1850-A Iconoscope, is suggested.

The relatively small size of the 5769 lends itself to use in comparatively light-weight, portable television cameras, and facilitates the use of a telephoto lens with such cameras.

PRINCIPLES OF OPERATION

The 5769 has three sections--an image section, a scanning section, and a multiplier section, as shown in Fig. 1.

Image Section

The image section contains a semi-transparent photocathode on the inside of the face plate, a grid to provide an electrostatic accelerating field, and a target which consists of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

Light from the scene being televised is picked up by an optical lens system and focused on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focused on the target by the magnetic and accelerating fields.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite potential of about two volts with respect to target voltage cutoff. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive charges which corresponds with the pattern of light from the scene being televised. Because of the thinness of the glass, the charges set up a similar potential pattern on the opposite or scanned side of the glass.

Scanning Section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No. 1), and an accelerating grid (grid No. 2). The beam is focused at the target by the magnetic field of an external focusing coil and the electrostatic field of grid No. 4.

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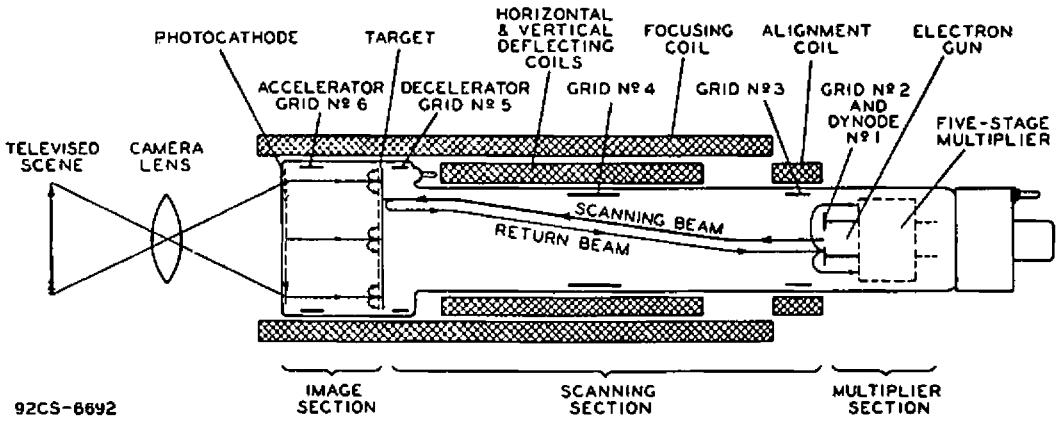


Fig. 1 - Schematic Arrangement of Type 5769.

Grid No.5 serves to adjust the shape of the decelerating field between grid No.4 and the target in order to obtain uniform landing of electrons over the entire target area. The electrons stop their forward motion at the surface of the glass and are turned back and focused into a five-stage signal multiplier, except when they approach the positively charged portions of the pattern on the glass. When this condition occurs, they are deposited from the scanning beam in quantities sufficient to neutralize the potential pattern on the glass. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode side. These charges will neutralize each other by conductivity through the glass in less than the time of one frame.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by an external coil located at the gun end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

Multiplier Section

The return beam is directed to the first dynode of a five-stage electrostatically focused multiplier. This utilizes the phenomenon of secondary emission to amplify signals composed of electron beams. The electrons in the beam impinging on the first dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No.5 are collected by the anode and constitute the current utilized in the output circuit.

The multiplier section amplifies the modulated beam about 500 times. The multiplication so obtained increases the signal-to-noise ratio of the tube and also permits the use of an amplifier with fewer stages. The gain of the multiplier is sufficiently high so that the limiting noise in the use of the tube is the random noise of the electron beam multiplied by the multiplier stages. This noise is larger than the input noise of the video amplifier.

It can be seen that when the beam moves from a less positive portion on the target to a more positive portion, the signal output voltage across the load resistor (R_{30} in Fig.2) changes in the positive direction. Hence, for highlights in the scene, the grid of the first video-amplifier stage swings in a positive direction.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ±10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Anode to All Other Electrodes	20	μμf
Photocathode Spectral Response	See Fig.6	
Image Size (3 x 4 aspect ratio)	1.6"	Diagonal
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	15-1/8" ± 1/8"	
Greatest Diameter of Bulb	3" ± 1/16"	
Shoulder Base	Keyed Jumbo Annular 7-Pin	
End Base	Small-Shell Diheptal 14-Pin	
Mounting Position	See Text	
Minimum Deflecting-Coil Inside Diameter	2-1/8"	
Deflecting-Coil Length	5"	
Focusing-Coil Length	10"	
Alignment-Coil Length	15/16"	
Photocathode Distance Inside End of Focusing Coil	1/2"	

Maximum Ratings, *Absolute Values*:

PHOTOCATHODE VOLTAGE	-550 max.	volts
PHOTOCATHODE ILLUMINATION	50 max.	ft-c
OPERATING TEMPERATURE OF ANY PART OF BULB	65 max.	°C
OPERATING TEMPERATURE OF BULB AT LARGE END OF TUBE (TARGET SECTION)	35 min.	°C

TEMPERATURE DIFFERENCE:		
Between target section and any part of bulb hotter than target section	-5 max.	°C
GRID-No.6 VOLTAGE	-550 max.	volts
TARGET VOLTAGE:		
Positive value	50 max.	volts
Negative value	50 max.	volts
GRID-No.5 VOLTAGE	150 max.	volts
GRID-No.4 VOLTAGE	300 max.	volts
GRID-No.3 VOLTAGE	400 max.	volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
ANODE-SUPPLY VOLTAGE[x]	1650 max.	volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	volts

Typical Operation and Characteristics:

Photocathode Voltage (Image Focus)	-300 to -500	volts
Grid-No.6 Voltage (Accelerator)-- 80% of photocathode voltage	-240 to -400	volts
Target Voltage[o]	0	volts
Grid-No.5 Voltage (Decelerator)[oo]	0 to 100	volts
Grid-No.4 Voltage (Beam Focus)	160 to 240	volts
Grid-No.3 Voltage[#]	225 to 330	volts
Grid-No.2 & Dynode-No.1 Voltage	300	volts
Grid-No.1 Voltage (For picture cutoff)	-85 to -115	volts
Dynode-No.2 Voltage	600	volts
Dynode-No.3 Voltage	880	volts
Dynode-No.4 Voltage	1160	volts
Dynode-No.5 Voltage	1450	volts
Anode Voltage	1500	volts
Anode Current	50	μa
Target Temperature Range (See text)	35 to 60	°C
Highlight Illumination on Photocathode for Maximum Signal Output:		
With 2870°K Tungsten Illumination	0.15	ft-c
With White Fluorescent Illumination or Daylight	0.07	ft-c
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current (Approx.)	35	
Minimum Peak-to-Peak Blanking Voltage	10	volts
Field Strength at Center of Focusing Coil	75	gausses
Focusing-Coil Current (Approx., for coil listed below)	75	ma
Deflecting-Coil Current (Approx., for assembly listed below):		
Horizontal (Peak to peak)	625	ma
Vertical (Peak to peak)	290	ma
Alignment-Coil Current (Approx., for coil listed below)	0 to 30	ma

Components:

Deflecting-Coil Assembly (Includes Keyed Jumbo Annular 7-Pin Socket)	RCA Type No. 201D75
Focusing-Coil Assembly	RCA Type No. 202D75
Alignment-Coil Assembly	RCA Type No. 204D75
Hor. Deflection Output Transformer	RCA Type No. 204T1
Ver. Deflection Output Transformer	RCA Type No. 204T2

[x] Ratio of dynode voltages is shown under Typical Operation.

[o] Adjustable from -3 to +5 volts with blanking voltage off.

[oo] Taps at 0, 30, 60, and 90 volts are recommended. Set at voltage giving most uniform resolution and signal output over entire picture area.

[#] Adjust to give the most uniformly shaded picture near maximum signal.

INSTALLATION

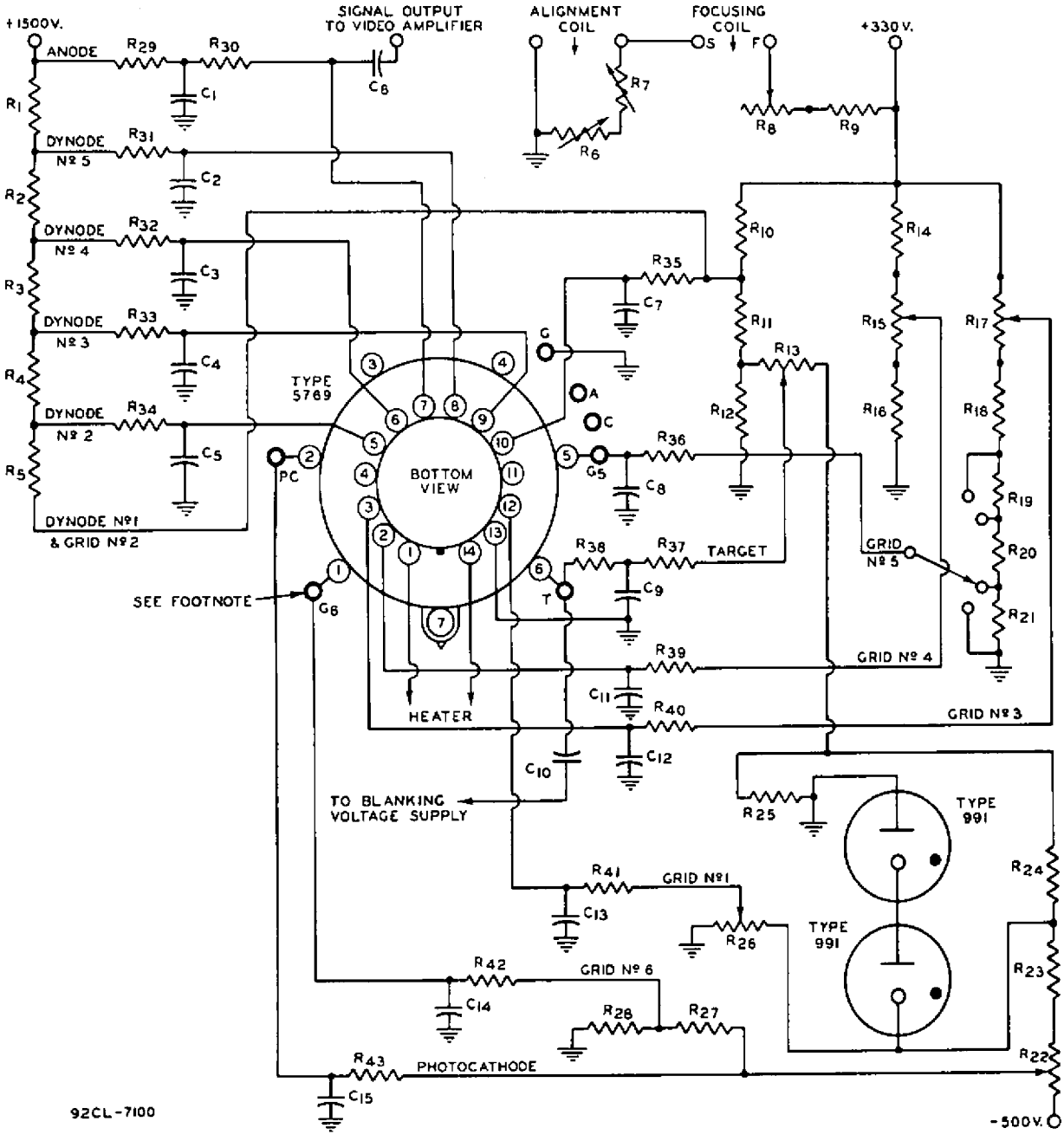
The *end-base* pins of the 5769 fit the diheptal 14-pin socket; the *annular-base* pins fit the keyed jumbo annular-7-pin socket which is part of the deflecting-coil assembly having RCA type No. 201D75.

The 5769 has three complementary guides for inserting the tube correctly in the annular socket, i.e., the large pin (No.7) on the annular base, the white radial line on face of bulb, and a white longitudinal line on neck. Designers of equipment should position the annular socket so that pin No.7 of the annular base, and the white radial line when viewed from the face end of the tube, will be at the bottom of the face after the tube has been correctly inserted in the annular socket. The 5769 is installed by inserting the diheptal-base end of the tube through the coil assembly and then turning the tube until the annular-base pins, keyed by pin No.7, can be inserted in the annular socket. Proper insertion aligns the white radial line on the face with center of the slot in the annular socket, and makes the longitudinal line on the neck visible through the sight hole in the deflecting-coil assembly. The annular-base pins are then pushed into their socket, and the diheptal socket is put on the 14-pin base.

The *operating position* of the 5769 should preferably be such that any loose particles in the neck of the tube will not fall down and strike or become lodged on the target. Therefore, it is recommended that the tube never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical through the center of the base.

The *operating temperature* of any part of the glass bulb should never exceed 65°C, and no part of the bulb at the large end of the tube (target section) should ever fall below 35°C during operation. It is recommended that the temperature of the entire bulb be held between 35° and 60°C. Operation at too low a temperature will be characterized by the appearance of a "sticking picture" of opposite polarity from the original when the picture is moved. Operation at too high a temperature will cause loss of resolution. No part of the bulb should run more than 5° hotter than the target section to prevent cesium migration to the target. Such migration will result in loss of resolution and in probable permanent damage to the tube. Like other photosensitive devices employing cesium, the 5769 may show fluctuations in performance from time to time. Strict observance of the above recommendations with respect to operating temperature will not completely eliminate these variations but will greatly improve the stability of the characteristics during the life of the tube.

When the equipment design or operating conditions are such that the maximum temperature rating or maximum temperature difference as given under Maximum Ratings will be exceeded, provision should be made to direct a stream of cooling air from the diheptal-base end of the tube along the entire length of the bulb surface, i.e., through the space between the bulb surface and the surrounding deflecting coil and its extension.



o = Terminals on Deflecting-Coil Assembly, RCA Type No.201D75. These terminals are connected to annular socket within the Assembly as shown, except for those marked G, A, and C. G is connected to yoke shielding. A and C are connected to heater terminals on face of annular socket. Other terminals on the Assembly not shown above are indicated in Figs. 3 and 4.

Fig. 2 – Voltage Dividers for Type 5769 with Connections for: Alignment Coil, RCA Type No.204D75, and Focusing Coil, RCA Type No.202D75.

Any attempt to effect cooling of the tube by circulating even a large amount of air around the focusing coil will do little good, but a small amount of air directly in contact with the bulb surface will effectively drop the bulb temperature. For this purpose, a small blower is satisfactory, but it should run at low speed to prevent vibration of the 5769 and the associated amplifier equipment. Unless vibration is prevented, distortion of the picture may occur.

To keep the operating temperature of the large end of the tube from falling below 35°C, some form of controlled heating should be employed. Ordinarily, adequate heat will be supplied by the focusing coil, deflecting coils, and associated amplifier tubes so that the temperature can be controlled by the amount of cooling air directed along the bulb surface. If, in special cases, a target heater is required, it should fit snugly between the focusing coil and the bulb near the shoulder of the tube. Such a target heater is included in the RCA Deflecting-Coil Assembly.

The *lens system* used with the 5769 should be designed according to basic optical principles and should incorporate an iris to control the amount of light entering the television camera lens. Because of the relatively small face diameter of the 5769, the use of a telephoto lens is facilitated. The lens holder should have all inside surfaces finished in matte black to prevent internal reflections from reaching the photocathode.

For the *high dc voltages* required by the 5769, the use of two pulse supplies for which the plate voltage is provided by a well-regulated, 330-volt, B-supply may be used. Each of these supplies should be actuated by the horizontal driving pulse which is obtained from the synchronizing generator. One of the pulse supplies should be capable of furnishing 1500 volts with an output current of 1 milliampere for the multiplier section; the other pulse supply should be capable of furnishing −500 volts with an output current of 1 milliampere for the image section. In addition to supplying the plate voltage and current for the pulse supplies, the 330-volt B-supply should also provide an output current of 90 milliamperes for the focusing and alignment coils and for the voltage divider which is used to supply the voltages for the electrodes in the scanning section of the 5769.

Voltage dividers to provide the required operating voltages for the various electrodes of the 5769 are shown in Fig. 2. It is to be noted that the blocking capacitor C_6 should be of the mineral-oil impregnated type to minimize capacitor leakage which will introduce disturbing effects into the picture.

In designing a voltage divider for the multiplier stages of the 5769, engineers should recognize that the dc output of individual 5769's may have a range of 10 to 1. This range, therefore, must be considered in the choice of bleeder-resistor values. If the values are too high, the distribution of voltages applied to the dynodes will be upset by a 5769 with a dc output at the upper end of the range. As a result, there will be an abrupt drop in the ac output of the tube as the beam current is increased. When this drop occurs before the beam is at its optimum value, the ratio of signal to noise will be lessened.

A *horizontal deflection circuit* for use with the 5769 is shown in Fig. 3; and a *vertical deflection circuit* in Fig. 4.

The *video amplifier* should be designed to cover a range of ac signal voltages corresponding to signal-output currents of 3 to 30 microamperes in the load resistor (R_{30} in Fig. 2).

APPLICATION

Resolution of better than 400 lines at the center of the picture can be produced by the 5769 when the photocathode highlight illumination from an RMA Standard Test Chart is above the knee of each of the curves in Fig. 5. To utilize such resolution capability in the horizontal direction with the standard scanning rate of 525 lines, it

LEGEND FOR FIG. 2

C1 C2: 0.05 μf, 1600 v working voltage
C3: 0.01 μf mica, 1600 v working voltage
C4: 0.001 μf mica, 1000 v working voltage
C5: 0.001 μf mica, 600 v working voltage
C6: 0.03 μf mineral-oil impregnated, 1600 v working voltage
C7 C8 C9 C11 C12 C13 C14: 0.001 μf mica, 400 v working voltage
C10: 1 μf, 400 v working voltage
R1: 47000 ohms, 1/2 watt
R2 R3: 270000 ohms, 1/2 watt
R4 R5: 300000 ohms, 1/2 watt
R6: 100 ohms, 1/2 watt, wire wound
R7: 20 ohms, 1 watt, wire wound
R8: 2500 ohms, 25 watts
R9: 750 ohms, 10 watts
R10: 5100 ohms, 1/2 watt
R11: 51000 ohms, 2 watts
R12: 510 ohms, 1/2 watt
R13: 150000-ohm potentiometer, 1/2 watt
R14: 820000 ohms, 1/2 watt
R15: 100000-ohm potentiometer, 1 watt
R16: 150000 ohms, 1/2 watt
R17: 100000-ohm potentiometer, 1 watt
R18: 56000 ohms, 1/2 watt
R19 R20 R21: 20000 ohms, 1/2 watt
R22: 250000-ohm potentiometer, 1 watt
R23: 180000 ohms, 1/2 watt
R24: 390000 ohms, 1/2 watt
R25: 11000 ohms, 1/2 watt
R26: 500000-ohm potentiometer, 1 watt
R27: 110000 ohms, 1/2 watt
R28: 560000 ohms, 1/2 watt
R29: 47000 ohms, 1/2 watt
R30: 20000 ohms, 1/2 watt
R31 R32: 100000 ohms, 1/2 watt
R33 R34 R36 R37 R39 R40 R41 R42 R43: 200000 ohms, 1/2 watt
R35: 50000 ohms, 1/2 watt
R38: 100000 ohms, 1/2 watt

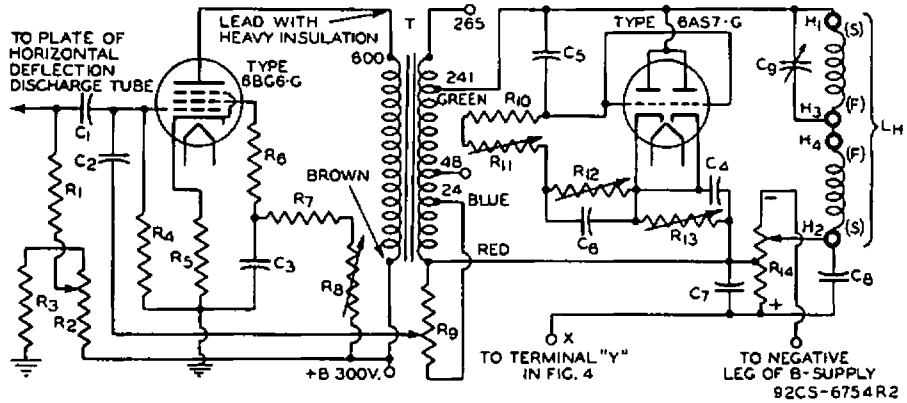
is necessary to use a video amplifier having a bandwidth of at least 5.5 megacycles. The maximum resolution obtainable is limited by the mesh-screen portion of the target.

Even with a wide-band amplifier, the resolution may be limited by "cross talk" caused by the scanning fields. Unless prevented by proper shielding from extending into the image section, these fields will cause the electron image on the target to move at scanning frequency. As a result, the picture will lack definition.

Proper shielding will be provided by a shield which employs seven separate layers of silicon-steel strips (0.007" thick and 1/2" wide) applied to the outside of the focusing coil as follows: First, wrap a single insulating layer of 0.005" thick motor paper around the focusing coil; then, wrap two turns one above the other of the silicon-steel strip repeating the operation to fill the entire focusing-coil length but allowing 1/64" between each successive 2-turn section, to insure electrical insulation. Second, wrap a second insulating layer of motor paper and repeat the silicon-steel strip operation but space the 2-turn sections so that each is directly over a 1/64" insulating space of the previous layer. Operations 1 and 2 are repeated to provide 7 layers of shielding. The entire assembly is completed with a final wrap of motor paper. A convenient method for handling the 2-turn strip sections is to cut the strips just long enough to take care of two turns. Each 2-turn section is, of course, completely independent of any other section.

If equipment space will not accommodate the full seven layers of shielding as described above, fewer layers can be used, but will be less effective in minimizing "cross talk".

The *sequence of adjustments* in operating the 5769 is as follows: After the tube has been inserted in its sockets and the voltages applied as indicated under Typical Operation, allow it to warm up for 1/2 to 1 hour with the camera lens iris closed. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the target. Adjust the deflection circuits so that the beam will "overscan" the target, i.e., so that the area of the target scanned is greater than its sensitive area. This procedure during the warming-up period is recommended to prevent burning on the target a raster smaller than that used for on-the-air operation. Note that overscanning the target results in a smaller than normal picture on the monitor. Then open the iris partially and focus the scene to be televised on the photocathode. Next, adjust the grid-No. 1 voltage until a picture or noise appears on the monitor screen. If there is no picture, rotate the alignment coil until the picture appears and then adjust the current through the alignment coil until the maximum picture response is obtained. Correct alignment is obtained when the picture does not rotate as the beam-focus control (grid No. 4) is varied. During alignment of the beam, and during operation of the tube, always keep the beam current as low as possible to give the best picture quality. Next, adjust grid-No. 1 voltage and the



C1: 0.01 μf
C2: 150 μμf
C3 C4: 4 μf
C5: 30 μμf
C6: 0.02 μf
C7 C8: 100 μf
C9: Balancing Capacitor, 10 to 40 μμf
LH: Horizontal Deflecting Coils: Terminals H1, H2, H3, and H4 on Deflecting-Coil Assembly, RCA Type No. 201075. LH has inductance of 5.5 mh and dc resistance of 19 ohms.

R1: 1 Megohm
R2: Sawtooth Amplitude and Linearity Control, 250000 ohms
R3 R4: 250000 ohms
R5: 100 ohms, 2 watts
R6: 100 ohms
R7: 3000 ohms, 2 watts
R8: 10000 ohms, 2 watts. Value should be such that screen input of the 6BG6-G will not be exceeded.
R9: Peaking Amplitude and Linearity Control, 5000 ohms
R10: 50000 ohms, 1 watt

R11: Linearity Control, 250000 ohms
R12: Linearity Control, 100000 ohms
R13: Linearity Control, 500 ohms, 5 watts
R14: Centering Control, 10 ohms tapped at 5 ohms
T: Horizontal Deflection Output Transformer, RCA Type No. 204T1, DC resistance of used portion of secondary is 3.4 ohms

Fig. 3 - Horizontal Deflection Circuit for Type 5769.

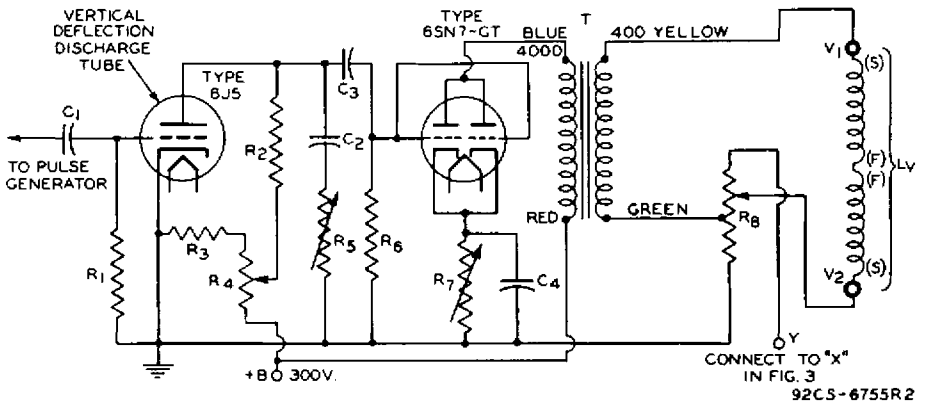
target voltage for the best picture. Then, bring the picture into focus by varying the voltage on grid No.4 and on the photocathode. Next, vary the voltage on grid No.3 to give the most uniformly shaded picture at approximately maximum signal. Final adjustment is made by varying the voltages on grids No.5 and No.6. In general, these need little adjustment and are varied only after completing the other adjustments. When camera is used for rehearsal, the scanning may be restored nearly to normal size. Complete restoration should be made just prior to air-time.

The *target voltage* will depend on the type of scene to be televised. If the scene has a large range of illumination (such as that for a baseball game on a sunny day), the target should be operated at about 1.5 to 2 volts above cutoff so that highlights will not bloom. For scenes with a lower range of illumination (such as that for a boxing match under artificial lighting), the target can be operated at about 2 to 3 volts above cutoff with resultant gain in signal-to-noise ratio, and improved detail in the shadows.

A *blanking signal* should be supplied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must be constant to prevent fluctuation of the target voltage. During the blanking periods, the full beam current without video-signal modulation is returned to the multiplier and its multiplied output flows through the load resistance.

Shading may be required even with optimum adjustment of voltage on grid No.3 in order to obtain a uniformly shaded picture. A shading signal having a sawtooth shape, a frequency equal to the horizontal scanning frequency, and an amplitude about twice that of the useful video signal, is recommended. Provision should be made for controlling the amplitude of the shading signal and for reversing its polarity. The signal may be introduced into the video channel after the preamplifier in the camera but ahead of the master gain control. With this arrangement, changing the gain-control setting does not change the ratio of the shading-signal amplitude to the video-signal amplitude.



C1: 0.1 μf
C2: 0.05 μf
C3: 1 μf
C4: 1000 μf
LV: Vertical Deflecting Coils: Terminals V1 and V2 on Deflecting Coil Assembly, RCA Type No. 201D75. LV has inductance of 28.3 mh, and dc resistance of 34 ohms.
R1: 1 megohm
R2: 5 megohms
R3: 100000 ohms
R4: Sawtooth Amplitude Control, 250000 ohms
R5: Peaking Amplitude Control, 250000 ohms
R6: 500000 ohms
R7: Linearity Control, 5000 ohms
R8: Centering Control, 10 ohms tapped at 5 ohms
T: Vertical Deflection Output Transformer, RCA Type No.204T2. DC resistance of secondary is 6.9 ohms.

Fig.4 - Vertical Deflection Circuit for Type 5769.

The *illumination* on the photocathode is related to the scene illumination by the formula

$$I_s = \frac{4f^2 I_{pc} (m+1)^2}{TR}$$

where

I_s = scene illumination in foot-candles
f = f-number of lens
I_{pc} = photocathode illumination in foot-candles
m = linear magnification from scene to target
T = total transmission of lens
R = reflectance of principal subject in scene.

Except for very close shots, the linear magnification (m) from scene to target may be neglected.

For example, assume that the lens is f:3.5 having a transmission (T) of 75%, that the photocathode illumination from a tungsten source is 0.15 foot-candle, and that the scene to be tele-

vised is composed largely of whites and blacks (such as a test chart) where the reflectance (R) may be in the order of 50%. Then,

$$I_s = \frac{4 \times 3.5^2 \times 0.15}{0.75 \times 0.50} = 20 \text{ ft-c approx.}$$

In practice, and under the assumed conditions of the preceding example, it will be found that the required minimum illumination on the scene will be in the range from 10 to 30 foot-candles.

light or daylight, the knee may occur at values of highlight illumination on the photocathode ranging from about 0.05 to 0.1 foot-candle; with tungsten light, the knee may occur in the range from about 0.1 to 0.2 foot-candle.

When colors are televised, the most satisfactory gradation in black and white will be obtained when white fluorescent illumination is augmented by tungsten floodlights. The exact

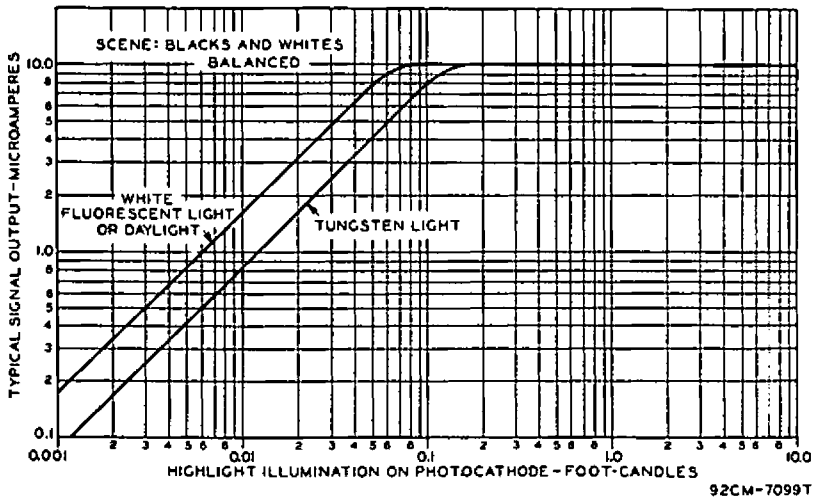


Fig. 5 - Typical Signal Output of Type 5769.

For average scenes where the principal subject has a reflectance of 5 to 10%, the incident illumination should have a value of 50 to 100 foot-candles.

It is good practice before attempting to transmit a particular scene to check its incident illumination with an illumination-measuring device, such as an exposure meter. It is recommended that the average incident light level be greater than approximately 50 foot-candles for a good picture. If white fluorescent or daylight illumination is used, the incident light level may be as low as 25 foot-candles.

Typical signal output of the 5769 as a function of the highlight illumination on the photocathode under conditions where the televised scene has balanced blacks and whites for each of three types of illumination is shown by the curves in Fig. 5.

For the most natural appearance of televised subjects, it is recommended that the 5769 be operated so that the highlights on the photocathode bring the signal output slightly over the knee of the curve for the particular type of illumination utilized. Operation further along on the straight part of the curve will give pictures in which the subject has an over-emphasized outline. The position of the knee will shift for individual tubes. With white fluorescent proportion of tungsten to fluorescent illumination will vary with desired results and can best be determined by trial.

The *spectral response* of the 5769 is not subject to appreciable variation from tube to tube. The spectral response is shown by the curve in Fig. 6.

Retention of a scene by the 5769, sometimes called a "sticking picture", may be experienced if the 5769 is allowed to remain focused on a bright scene for an hour or more, or if it is focused on a bright scene before reaching operating temperature in the range from 35° to 60°C. Often the retained image will disappear in a few seconds, but sometimes it may persist for long periods before it completely disappears. A retained image can generally be removed by focusing the 5769 on a clear white screen, and allowing the 5769 to operate for several hours with an illumination of about 1 foot-candle on the photocathode.

To avoid retention of a scene, it is recommended that the 5769 always be allowed to warm up in the camera for 1/2 to 1 hour with the lens iris closed, and that the 5769 never be allowed to remain focused on a stationary bright scene for an hour or more. If a target heater is used, the warm-up time can be reduced to approximately 10 or 15 minutes.

Failure of scanning even for only a few minutes when light is incident on the photocathode, may permanently damage the surface of the target. The damaged area shows up as a spot or line in the picture during subsequent operation.

To avoid damaging the 5769 during scanning failure, provision should be made to prevent automatically the scanning beam from reaching the target. The scanning beam can be prevented from reaching the target by (1) cutting off the scanning beam, or (2) making the target sufficiently negative. The scanning beam can be cut off by a relay which applies −115 to −125 volts bias to grid No. 1. The target can be made sufficiently negative by a relay which applies a bias of at least −10 volts to it. Either relay is actuated by a tube which is controlled by a portion of the scanning pulse voltage developed across either the horizontal or the vertical deflecting coils, or both. It is important to insure that the horizontal scanning pulse and the vertical scanning pulse should each independently actuate the relay in case either one fails.

Rotation in the use of 5769's is recommended. After a 5769 is operated for 200 to 300 hours, it should be given an idle period of 3 or 4 weeks during which it generally will recover much of its original resolution and sensitivity. Spare tubes should be placed in service for several hours at least once a month in order to keep them free from any traces of gas which may be liberated within them during prolonged storage.

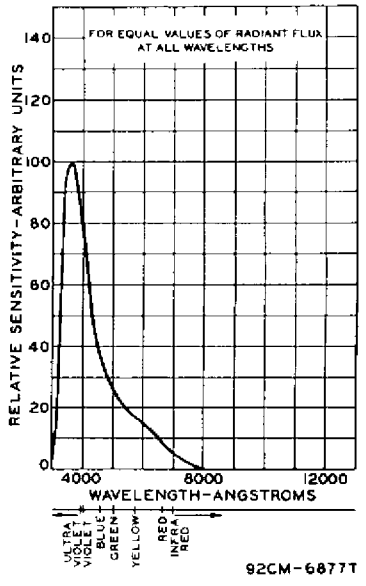


Fig. 6 - Spectral Sensitivity Characteristic of Type 5769.

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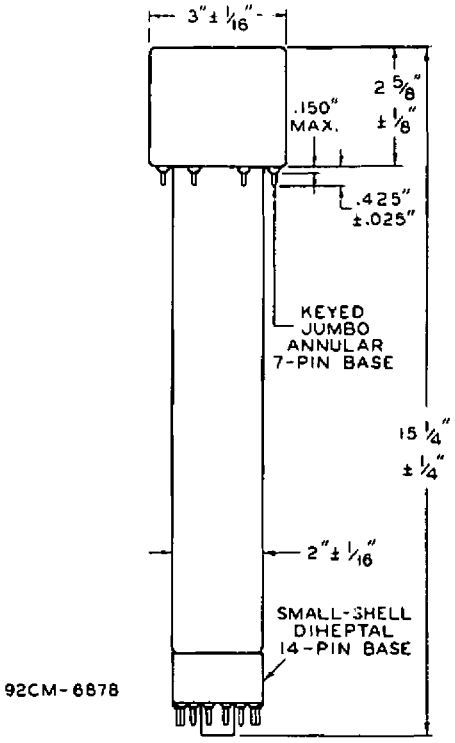
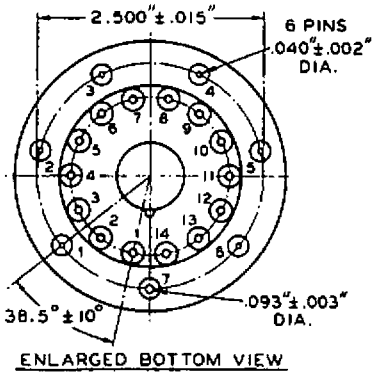
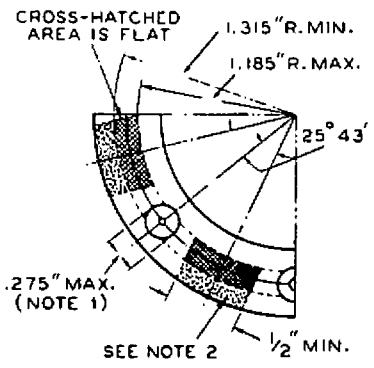
DIMENSIONAL OUTLINE





ENLARGED BOTTOM VIEW

DETAIL OF BOTTOM VIEW OF KEYED JUMBO ANNULAR BASE



NOTE 1: MEASURED AT DISTANCE OF 1/32" BELOW BOTTOM OF ANNULAR BASE.

NOTE 2: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.

KEYED ANNULAR BASE GAUGE

ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GUAGE WITH:

a. SIX HOLES HAVING DIAMETER OF 0.065" ± 0.001" AND ONE HOLE HAVING DIAMETER OF 0.150" ± 0.001". ALL HOLES HAVE DEPTH OF 0.265" ± 0.001". THE SIX 0.065" HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047". ALL HOLES ARE SPACED AT ANGLES OF 51°26' ± 5' ON CIRCLE DIAMETER OF 2.500" ± 0.001".

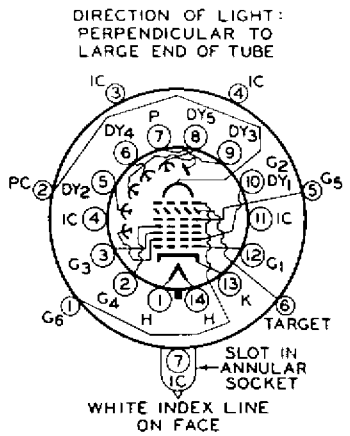
b. SIX STOPS HAVING HEIGHT OF 0.187" ± 0.001", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

c. RIM EXTENDING OUT A MINIMUM OF 1/8" FROM 2-13/16" DIAMETER AND HAVING HEIGHT OF 0.126" ± 0.001".

d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200" ± 0.001".

SOCKET CONNECTIONS

Bottom View



SMALL-SHELL DIHEPTAL 14-PIN BASE

PIN 1: HEATER
PIN 2: GRID No.4
PIN 3: GRID No.3
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: DYNODE No.2
PIN 6: DYNODE No.4
PIN 7: ANODE
PIN 8: DYNODE No.5
PIN 9: DYNODE No.3
PIN 10: DYNODE No.1, GRID No.2
PIN 11: INTERNAL CONNECTION - DO NOT USE
PIN 12: GRID No.1
PIN 13: CATHODE
PIN 14: HEATER

KEYED JUMBO ANNULAR 7-PIN BASE

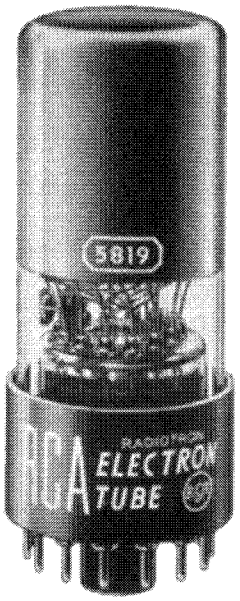
PIN 1: GRID No.6
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNECTION - DO NOT USE
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: GRID No.5
PIN 6: TARGET
PIN 7: INTERNAL CONNECTION - DO NOT USE

5819

MULTIPLIER PHOTOTUBE

10-Stage, Head-On Type
with 1-1/2" Semi-Transparent Cathode and S-9 Response

RCA-5819 is a head-on type of high-vacuum multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear particle radiation, and in other applications involving low-level, large-area light sources.



The spectral response of the 5819 covers the range from about 3000 to 6400 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 4800 angstroms. The 5819, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation. Because of its spectral response, the 5819 is well suited for use with organic phosphors such as anthracene as well as with inorganic materials such as silver-activated zinc sulfide.

Design features of the 5819 include a semi-transparent cathode having a diameter of 1-1/2 inches on the inner glass surface of the face end of the bulb, and ten electrostatically focused multiplying stages. The relatively large cathode area permits very efficient collection of light from excited phosphor crystals, such as are employed in scintillation counters.

The 5819 is capable of multiplying feeble photoelectric current produced at the cathode by an average value of 600,000 times when operated at 90 volts per stage. The output current of the 5819 is a linear function of the exciting illumination under normal operating conditions.

The frequency response of the 5819 is flat up to a frequency of about 50 megacycles per second above which the variation in electron transit time becomes the limiting factor.

In the scintillation type of nuclear radiation detector, the 5819 is particularly useful because of its large, essentially flat cathode area which permits good optical coupling between the phospnor and the cathode. As a result, the scintillation pulses are larger in amplitude than the majority of the dark-current pulses and thus discrimination against the dark-current pulses is facilitated. The 5819 permits the design of a scintillation counter with high efficiency and a resolving time of only a small fraction of a microsecond.

DATA

General:

Spectral Response		S-9
Wavelength of Maximum Response	4800 ± 500	angstroms
Cathode, Semi-transparent:		
Shape		Circular
Window Area	1.8	sq. in.
Minimum Diameter of Window	1.5	in.
Direct Interelectrode Capacitances:		
Anode to Dynode No.10	4.2	μμf
Anode to All Other Electrodes	6.5	μμf
Overall Length		5-5/8" ± 3/16"
Seated Length		4-7/8" ± 3/16"
Maximum Diameter		2-1/4"
Bulb		T-16
Base	Medium-Shell Diheptal 14-Pin,	Non-hygroscopic
Mounting Position		Any

Maximum Ratings, *Absolute Values:*

ANODE-SUPPLY VOLTAGE (DC or Peak AC)□	1250 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE NO.10 AND ANODE (DC or Peak AC)	150 max.	volts
PEAK ANODE CURRENT	7.5 max.	ma
AVERAGE ANODE CURRENT○	0.75 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics:

With 90 volts per dynode stage and 90 volts between dynode No.10 and anode

	Min.	Av.	Max.	
DC Anode Dark Current#●	–	–	0.05	μamp
Sensitivity:				
At 4800 angstroms	–	14900	–	μamp/μwatt
Luminous:▲				
Cathode	–	40	–	μamp/lumen
Anode:				
At 0 cps	10	24	–	amp/lumen
At 100 MC	–	21	–	amp/lumen
Current Amplification■	–	600000	–	
Equivalent Noise Input★	–	2×10^{-11}	–	lumen

With 75 volts per dynode stage and 50 volts between dynode No.10 and anode

	Av.	
Sensitivity:		
At 4800 angstroms	3720	μamp/μwatt
Luminous:▲		
Cathode	40	μamp/lumen
Anode, at 0 cps	6	amp/lumen
Current Amplification■	150000	

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5819-5-50
Photolithographed in U.S.A.

□ Referred to cathode.

o Averaged over any interval of 30 seconds maximum.

Dark current due to thermionic emission and ion feedback may be reduced by the use of refrigerants.

● For maximum signal-to-noise ratio, operation below 1000 volts is recommended.

▲ For conditions where a tungsten lamp operated at a filament color temperature of 2870°K is used as a light source. A light flux of 10 microlumens from a rectangular aperture approximately 0.8" long and 0.2" wide is projected normal to the center of the cathode. The load resistor has a value of 0.01 megohm. The applied voltages are as indicated.

■ Ratio of anode sensitivity to cathode sensitivity.

★ Defined as the value where the rms output current is equal to the rms noise current determined under the following conditions: 90 volts per stage, 25°C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

GENERAL CONSIDERATIONS

An *electron multiplier* is a vacuum tube which utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 5819 multiplier phototube, represented in Fig.2, the electrons emitted from the illuminated, semi-transparent cathode are accelerated to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from the last dynode (dynode No.10) are collected by the anode and constitute the current utilized in the output circuit.

Dynode No.10 is so shaped as to enclose partially the anode and to serve as a shield for it, in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grid which allows the electrons from dynode No.9 to pass through it to dynode No.10. Spacing between dynode No.10 and anode creates a collecting field such that all the electrons it emits are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 5819 can be coupled to any practical load impedance.

The shield which extends between dynode No.1 and the anode shields dynode No.1 and the cathode from the anode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the cathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration. The metallic coating on the inner side wall of the glass bulb is connected to the cathode, and serves not only to prevent extraneous light from reaching dynode No.1, but also to direct the electrons from the cathode toward dynode No.1.

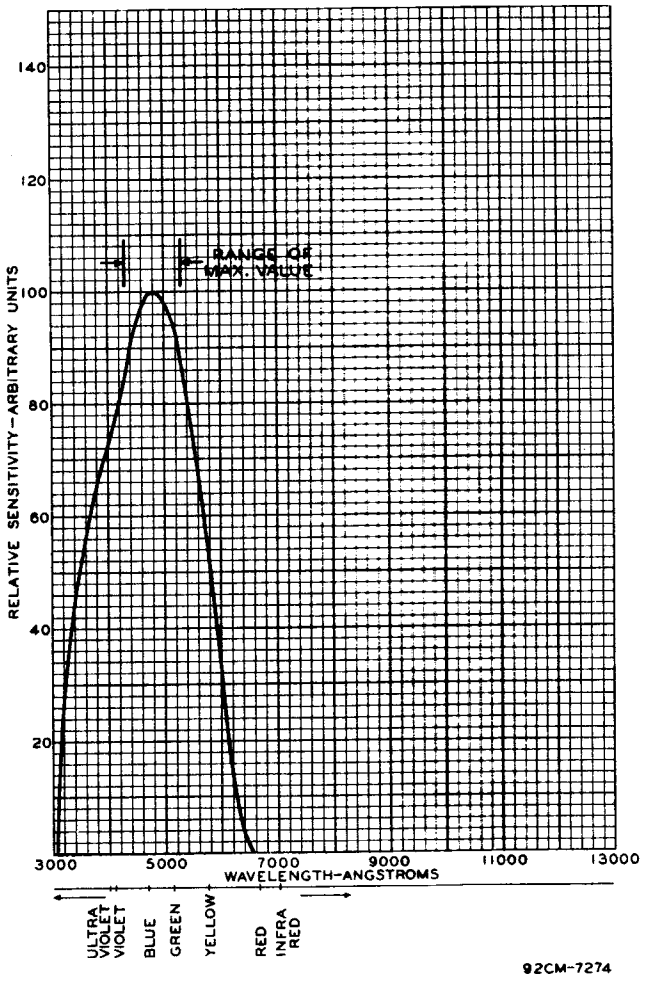


Fig.1 - Spectral Sensitivity Characteristic of Type 5819 which has S-9 Response. Curve is taken for Equal Values of Radiant Flux at all Wavelengths.

The grill through which the electrons reach dynode No.1, is connected to dynode No.1 and serves along with the accelerating electrode as an electrostatic shield for the open side of the electrode structure.

When the 5819 is operated with a very low cathode current, random variations occur in the rate of electron emission, and are observed as shot noise. Noise is also caused if the 5819 is operated with a voltage in excess of the maximum rating or if the voltage between dynode No.1 and the cathode is too low. When too high a voltage per stage is used, positive-ion feedback causes

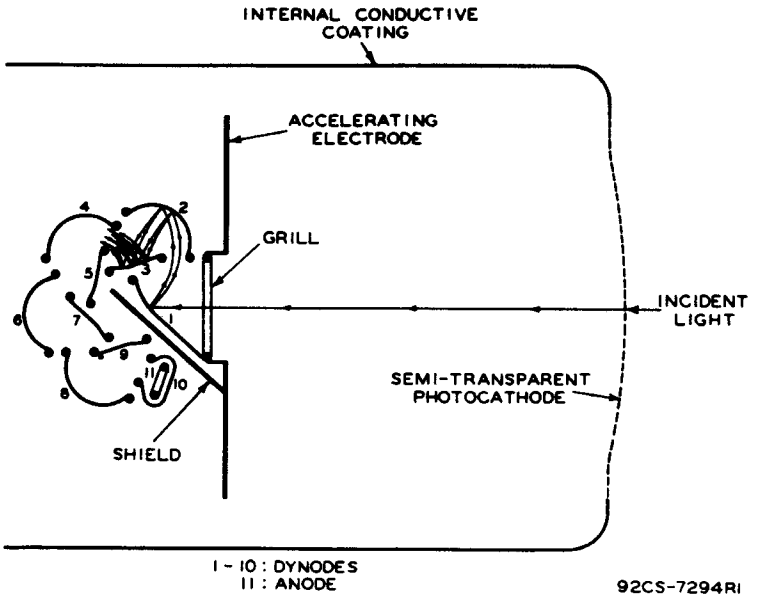


Fig. 2 – Schematic Arrangement of Type 5819 Structure.

regeneration, and when too low a voltage is applied between dynode No. 1 and cathode, the electrons from the cathode are not focused properly on dynode No. 1 with the result that many electrons are not channeled through the multiplier structure and gain is sacrificed. In order to minimize noise, it is recommended that the 5819 be operated with 150 volts between dynode No. 1 and cathode and with 75 volts between each of the succeeding dynode stages.

INSTALLATION and APPLICATION

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 5819 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface and dynode surfaces to evaporate with consequent decrease in the life and sensitivity of the tube.

The *operating stability* of the 5819 is dependent on the magnitude of the anode current and its duration. When the 5819 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 5819 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 0.75 milliampere is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 100 microamperes.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the nth power, where n is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for designers to provide adequate adjustment of the supply voltage per stage so as to be able to adjust the amplification of individual tubes to the desired design value. It is suggested that an overall voltage-adjustment range of at least 2 to 1 be provided. When the output current can be controlled by change in the illumination of the photocathode of the multiplier phototube, the required range of adjustment in the voltage per stage can be reduced.

Fig. 3 shows sensitivity and current amplification versus the dc voltage per stage.

The *base pins* of the 5819 fit the medium diheptal 14-contact socket. The socket should be made of high-grade, low-leakage material, and should be installed so that the incident light falls on the face end of the tube.

Magnetic shielding of the 5819 may be necessary. It will be observed with certain orientations of the 5819 that the earth's magnetic field is sufficient to cause a noticeable decrease in the response of the tube. Therefore, it may be desirable to provide magnetic shielding for the 5819, particularly when it is to be used in a strong magnetic field.

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 5819. Although the metallic coating on the inner side wall of the glass bulb serves to reduce the amount of extraneous light reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous light.

Whenever frequency response is important, the leads from the 5819 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

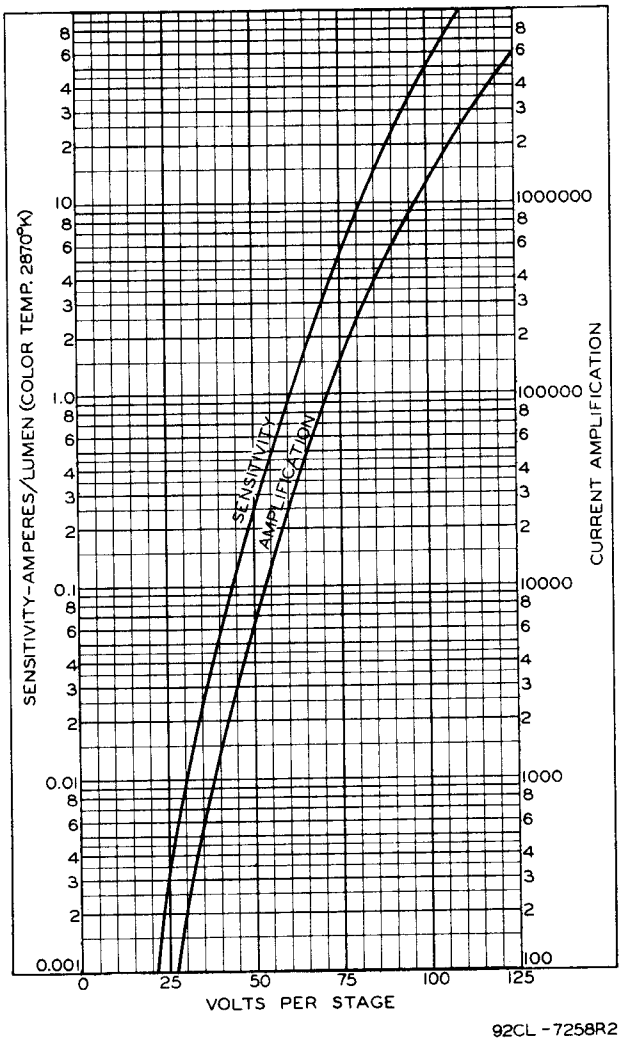


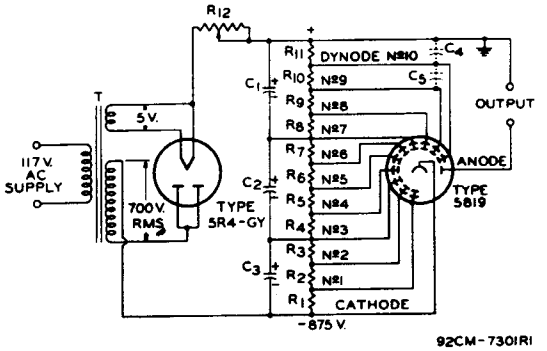
Fig. 3 - Average Characteristics of Type 5819.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each dynode and for the anode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation required by the application. In general, the current in the divider should be about 10 times the maximum value of total dynode current flowing through the divider. Such a value will prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will ordinarily be provided by a well-designed, two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Due to critical dependence of the gain of the 5819 on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum-tube regulator circuit of the mu-bridge type.

In most applications, it is recommended that the positive high-voltage terminal be grounded rather than the negative terminal. With this method, which places the cathode at a high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

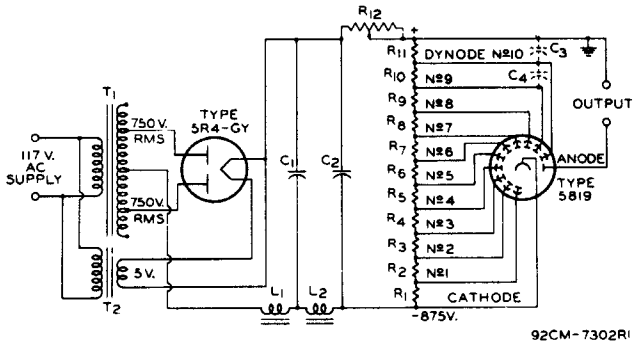
The high voltages at which the 5819 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 5819, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and



C1 C2 C3: 16 μf, electrolytic, 450 volts (dc working)
C4 C5: 8 μf, electrolytic, 150 volts (dc working)
Required only if high peak currents are drawn.
R1: 100000 ohms, 1/2 watt
R2 R3 R4 R5 R6 R7 R8 R9 R10: 50000 ohms, 1/2 watt
R11: 33000 ohms, 1/2 watt
R12: 100000 ohms, 1 watt, variable (Centralab A122, or equivalent)
T: United Transformer Corp. No. R-2, or equivalent

Fig. 4 - Simple Half-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 5819.



C1 C2: 2 μf, 1000 volts (dc working)
C3 C4: 8 μf, electrolytic, 150 volts (dc working)
Required only if high peak currents are drawn.
L1 L2: United Transformer Corp. No.R-17, or equivalent
R1: 39000 ohms, 2 watts
R2 R3 R4 R5 R6 R7 R8 R9 R10: 18000 ohms, 1 watt
R11: 12000 ohms, 1 watt
R12: 200000 ohms, 12 watts, variable (General Radio Type 471-A, or equivalent)
T1: United Transformer Corp. No.S-45, or equivalent
T2: United Transformer Corp. No.FT-6, or equivalent

Fig.5 - Full-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 5819 in Applications Critical as to Hum Modulation.

both terminals of any capacitors grounded. Also, the use of a protective resistor having a minimum value of 10,000 ohms in the output circuit is recommended as a desirable procedure to prevent possible damage to component parts during adjustment.

Typical power-supply circuits for the 5819 are shown in Figs.4 and 5. The circuit in Fig.4 utilizes a half-wave rectifier to provide the dc power for the 5819. In applications where excellent regulation particularly for wide variation in output current of the 5819 is required and where minimum hum modulation is essential, the circuit of Fig.5 may be used.

The *anode family* for the 5819 is shown in Fig.6.

The *use of a refrigerant*, such as dry ice or liquid air, to cool the bulb of the 5819 is recommended in those applications where maximum gain with unusually low dark current is required. The base of the tube should not be immersed in liquid air, because it is subject to stress on cooling to liquid-air temperature and may crack.

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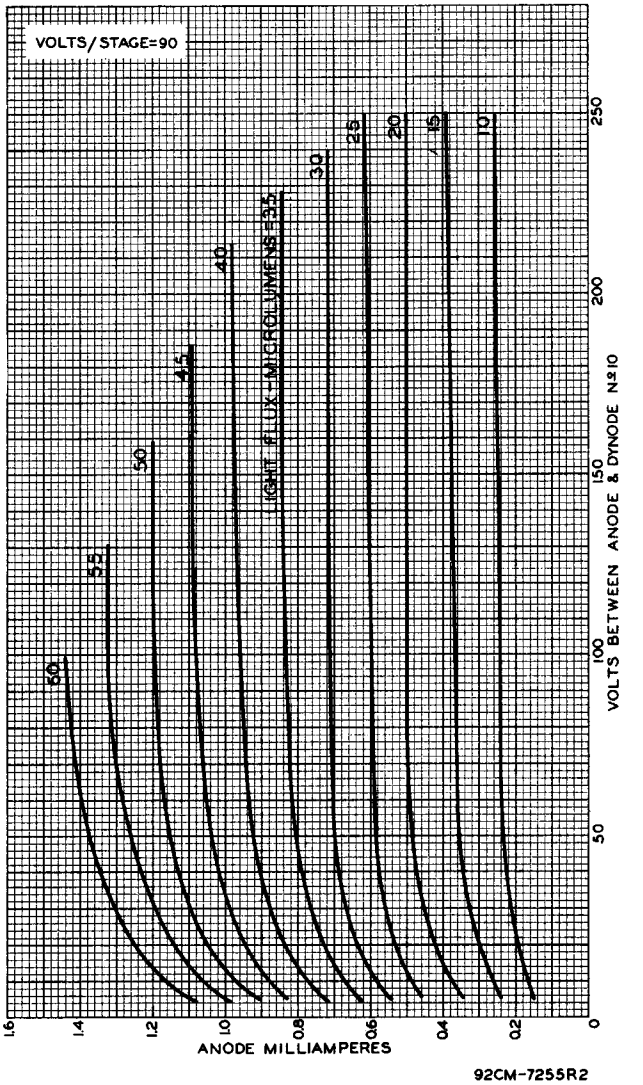
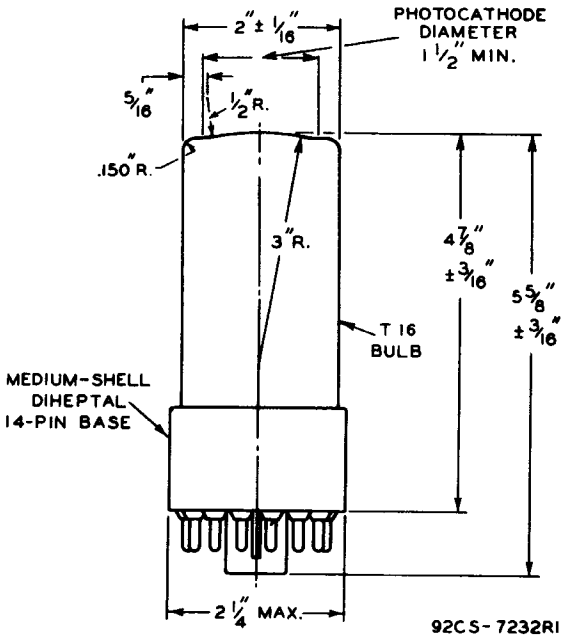


Fig.6 - Average Anode Characteristics of Type 5819.

DIMENSIONAL OUTLINE

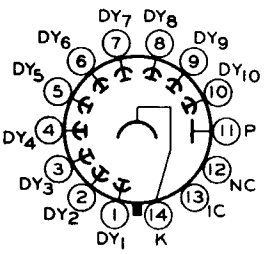


℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

SOCKET CONNECTIONS

Bottom View

PIN 1: DYNODE NO.1
PIN 2: DYNODE NO.2
PIN 3: DYNODE NO.3
PIN 4: DYNODE NO.4
PIN 5: DYNODE NO.5
PIN 6: DYNODE NO.6
PIN 7: DYNODE NO.7
PIN 8: DYNODE NO.8



DIRECTION OF LIGHT: INTO END OF BULB

14M1

PIN 9: DYNODE NO.9
PIN 10: DYNODE NO.10
PIN 11: ANODE
PIN 12: NO CONNECTION
PIN 13: INTERNAL CONNECTION—DO NOT USE
PIN 14: CATHODE

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

5820-A

IMAGE ORTHICON

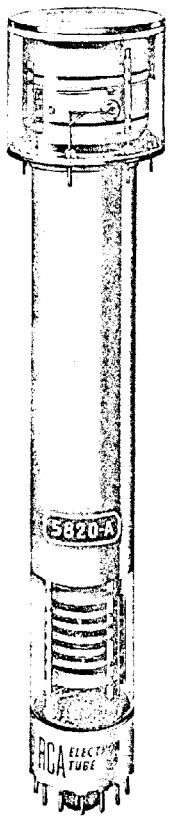
Magnetic Focus
Magnetic Deflection

For Outdoor and Studio Pickup
High Sensitivity

3"-Diameter Bulb
15.20" Length

The 5820-A is unilaterally interchangeable with the 5820.

RCA-5820-A is an image-orthicon type of television camera tube intended for both outdoor and studio pickup. It features extremely tight limits on such important performance characteristics as signal-to-noise ratio, resolution, sensitivity, and uniformity of sensitivity and background. The 5820-A is capable of providing pictures of very high quality and also of providing stable operation over a wide range of incident light levels on the object.



Stable performance is obtained with incident light levels on the object ranging from bright sunlight (several thousand footcandles) to a deep shadow (one footcandle or less). The sensitivity of the 5820-A is equivalent to photographic film having an ASA exposure index of 8000. Commercially acceptable pictures can be obtained at incident light levels greater than about 10 footcandles with appropriate setting of the camera lens stops. The 5820-A has an S-10 spectral response which approaches the response of the eye.

The photocathode utilized in the 5820-A is characterized by a spectral response having high blue sensitivity, high green sensitivity, good red sensitivity, and practically no infrared sensitivity. This latter characteristic of the response prevents any color-masking by infrared, and thus permits gray-scale rendition of colors in nearly their true tonal gradation.

Under proper operating conditions, the 5820-A has light transfer characteristics which do not require the use of gamma-correction circuits to provide normal tone rendition in black-and-white pictures on the picture-tube screen.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Anode to all other electrodes	12	pf ←
Spectral Response	S-10	
Wavelength of Maximum Response	4500 ± 300	angstroms
Photocathode, Semitransparent:		
Rectangular Image (4 x 3 aspect ratio):		
Useful size of	1.8" max. Diagonal	
Note: The size of the optical image focused on the photocathode should be adjusted so that its maximum diagonal does not exceed the specified value. The corresponding electron image on the target should have a size such that the corners of the rectangle just touch the target ring.		
Orientation of	Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through center of faceplate and pin No.7 of the shoulder base.	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	15.20" ± 0.25"	
Greatest Diameter of Bulb	3.00" ± 0.06"	
Shoulder Base	Keyed Jumbo Annular 7-Pin	
End Base	Small-Shell Diheptal 14-Pin (JEDEC No.B14-45)	
Operating Position	The tube should never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with the base up makes an angle of less than 20° with the vertical.	
Weight (Approx.)	1 lb 6 oz	
Minimum Deflecting-Coil Inside Diameter	2-3/8"	
Deflecting-Coil Length	5"	
Focusing-Coil Length	10"	
Alignment-Coil Length	15/16"	
Photocathode Distance Inside End of Focusing Coil	1/2"	

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← Indicates a change.

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RADIO CORPORATION OF AMERICA
Electronic Components and Devices Lancaster, Pa.

5820-A 11-63
Printed in U.S.A.

Maximum Ratings, *Absolute-Maximum Values:*[a]

PHOTOCATHODE:		
Voltage	-550 max.	volts
Illumination	50 max.	fc
OPERATING TEMPERATURE:		
Of any part of bulb	50 max.	°C
Of bulb at large end of tube (Target section)	35 min.	°C
TEMPERATURE DIFFERENCE:		
Between target section and any part of bulb hotter than target section	5 max.	°C
GRID-No.6 VOLTAGE	-550 max.	volts
TARGET VOLTAGE:		
Positive value	10 max.	volts
Negative value	10 max.	volts
GRID-No.5 VOLTAGE	150 max.	volts
GRID-No.4 VOLTAGE	300 max.	volts
GRID-No.3 VOLTAGE	400 max.	volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative-bias value	125 max.	volts
Positive-bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
ANODE-SUPPLY VOLTAGE[b]	1350 max.	volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	volts

Typical Operating Values:

Photocathode Voltage (Image Focus)	-400 to -540	volts
Grid-No.6 Voltage (Accelerator)—(Approx. 75% of photocathode voltage)	-300 to -405	volts
Target-Cutoff Voltage[c]	-3 to +1	volts
Grid-No.5 Voltage (Decelerator)	0 to 125	volts
Grid-No.4 Voltage (Beam Focus)	140 to 180	volts
Grid-No.3 Voltage[d]	225 to 330	volts
Grid-No.2 & Dynode-No.1 Voltage	300	volts
Grid-No.1 Voltage for Picture Cutoff	-45 to -115	volts
Dynode-No.2 Voltage	600	volts
Dynode-No.3 Voltage	800	volts
Dynode-No.4 Voltage	1000	volts
Dynode-No.5 Voltage	1200	volts
Anode Voltage	1250	volts
Minimum Peak-to-Peak Blanking Voltage	5	volts
Field Strength at Center of Focusing Coil[e]	75	gausses
Field Strenth of Alignment Coil	0 to 3	gausses

Performance Data:[f]

With conditions shown under Typical Operating Values and with camera lens set to bring the picture highlights one stop above the "knee" of the light transfer characteristic

	Min.	Average	Max.	
Cathode Radiant Sensitivity at 4500 angstroms	-	0.030	-	amp/watt
Luminous Sensitivity	30	60	-	μa/lumen
Anode Current (DC)	-	30	-	μa
Signal-Output Current (Peak to Peak)	3	8	24	μa
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current for Bandwidth of 4.5 MC	35:1	40:1	-	
Photocathode Illumination at 2870° K Required to bring Picture Highlights One Stop above "Knee" of Light Transfer Characteristic	-	0.02	0.04	fc
Peak-to-Peak Response to Square-Wave Test Pattern of 400 TV Lines per Picture Height (Per cent of large-area black to large-area white)[g]	35	60	-	%
Uniformity:				
Ratio of Shading (Background) Signal to Highlight Signal	-	0.12	0.15	
Variation of Highlight Signal (Per cent of maximum highlight signal)[h]	-	20	25	%

→ Indicates a change.

a The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

b Dynode voltage values are shown under *Typical Operating Values.*

c Normal setting of target voltage is +2 volts from target cutoff. The target supply voltage should be adjustable from -3 to +5 volts.

d Adjust to give the most uniformly shaded picture near maximum signal.

e Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil, with indicator located outside of and at the image end of the focusing coil.

f With 5820-A operated in properly adjusted RCA TK-31 camera.

g Measured with amplifier having flat frequency response.

h Variation of response over scanned area.

INTERCHANGEABILITY

The 5820-A is directly interchangeable with the 5820 in all existing cameras. The information shown on the following pages under *Set-Up Procedure, Operating Considerations, Camera-Design Considerations,* and *Principles of Operation* is identical with that recommended for the 5820.

SET-UP PROCEDURE

The *set-up procedure* for operating the 5820-A is as follows: After the tube has been inserted in its sockets and the voltages applied as indicated under *Typical Operation,* allow it to warm up for 1/4 to 1/2 hour with the camera lens capped. Uncap the lens momentarily while adjusting the grid-No.1 voltage to give a small amount of beam current. This procedure will prevent the mesh from being electrostatically pulled into contact with the glass disc. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the target.

Adjust the deflection circuits so that the beam will "overscan" the target, i.e., so that the area of the target scanned is greater than its sensitive area. This procedure during the warming-up period is recommended to prevent burning on the target a raster smaller than that used for on-the-air operation. Note that overscanning the target results in a smaller-than-normal picture on the monitor.

With the lens still capped and the target voltage set at approximately 2 volts negative, adjust the grid-No.1 voltage until noise or a rough-textured picture of dynode No.1 appears on the monitor. Then adjust the alignment-coil current so that the small white dynode spot does not move when the beam-focus control (grid No.4) is varied, but simply goes in and out of focus. During alignment of the beam, and also during operation of the tube, always keep the beam current as low as possible to give the best picture quality and to prevent excessive noise.

Next, uncap the lens and open the lens iris partially. Focus the camera on a test pattern. The target voltage is then advanced until a reproduction of the test pattern is just discernible on the monitor. This value of target voltage is known as the "target cutoff voltage". The target voltage should then be raised exactly 2 volts above the cutoff-voltage value, and the beam-current control adjusted to give just sufficient beam current to discharge the highlights.

Then adjust the lens to produce best optical focus, and the voltage on the photocathode as well as the voltage on grid No.4 to produce the sharpest picture.

At this point, attention should be given to the grid-No.5 and grid-No.3 voltage controls. Grid No.5 is used to control the landing of the beam on the target and consequently the uniformity of signal output. The grid-No.5 voltage control should be adjusted to produce a picture that has most uniform shading from center to edge with the lens iris opened sufficiently to permit operation with the highlights above the knee of the light transfer characteristic. The value of grid-No.5 voltage should be as high as possible consistent with uniform shading. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The grid-No.3 voltage control should be adjusted to produce the maximum signal output.

Now with a test pattern consisting of a straight line centered on the face of the 5820-A adjust the voltage on grid-No.6 along with the voltage on the photocathode to produce a sharply focused straight line on the monitor. Improper adjustment of the grid-No.6 voltage control will result in the straight-line pattern being reproduced with a slight S-shape.

The above adjustments constitute a rough set-up of the 5820-A. Final adjustments necessary for the 5820-A to produce the best possible picture are as follows: With the lens capped, realign the beam. Beam alignment is necessary after each change of the grid-No.5 voltage control and sometimes after each adjustment of the grid-No.3 voltage control.

The proper illumination level for camera operation should next be determined. Adjust the target voltage accurately to 2 volts above the target-cutoff value. Remove the lens cap and focus the camera on a test pattern. Open the lens iris just to the point where the highlights of the test pattern do not rise as fast as the low-lights when viewed on a video waveform oscilloscope.

Next, cap the lens and adjust the grid-No.3 voltage control so that the video signal when viewed on a video waveform oscilloscope has the flattest possible trace consistent with high signal output. This represents the black level of the picture.

The lens iris setting should then be noted, and the lens stop opened not more than one position beyond this point, unless extreme scene-contrast ranges necessitate opening the lens stop beyond this point.

The use of a higher value of target voltage than that recommended will shorten the life of the 5820-A. The target-voltage control should not be used as an operating control to match pictures from two different cameras. Matching of cameras should be accomplished by control of the lens iris openings.

Retention of a scene by the 5820-A sometimes called a "sticking picture", may be experienced if the 5820-A is allowed to remain focused on a stationary bright scene, or if it is focused on a bright scene before reaching operating temperature in the range from 35° to 45° C. Often the retained image will disappear in a few seconds, but sometimes it may persist for long periods before it completely disappears. A very persistent image can generally be removed by focusing the 5820-A on a clear white screen and allowing it to operate for a period of time with an illumination of about 1 footcandle on the photocathode.

To avoid retention of a scene, it is recommended that the 5820-A always be allowed to warm up in the camera for 1/4 to 1/2 hour with the lens iris closed and with a slight amount of beam current. Never allow the 5820-A to remain focused on a stationary bright scene, and never use more illumination than is necessary.

OPERATING CONSIDERATIONS

New 5820-A's should be placed in service immediately upon receipt. They should be operated for several hours before being set aside as spares.

Spare 5820-A's should be placed in service for several hours at least once a month in order

to keep them free from traces of gas which may be liberated within the tube during prolonged storage.

Occasionally, a *white spot* which does not change in size when the beam-focus voltage is varied, may be observed in the center of the picture. Such a spot, especially if it is visible on the monitor with the camera lens capped, is probably an ion spot. If the spot begins to grow in size with continuous operation, the 5820-A should be removed from service at once, and returned for re-processing. Continued operation of an image orthicon with an ion spot will eventually damage the target permanently.

The *spectral response* of the 5820-A is shown in Fig.1.

The *operating temperature* of any part of the glass bulb should never exceed 50° C, and no part of the bulb at the large end of the tube (target section) should ever fall below 35° C during operation. The temperature of the target is essentially the same as that of the adjacent glass bulb and can, therefore, be determined by measuring the temperature of the glass bulb adjacent to the target. For best results, it is recommended that the temperature of the entire bulb be held between 35° and 45° C. Operation of too low a temperature will be characterized by the appearance of a rapidly disappearing "sticking picture" of opposite polarity from the original when the picture is moved. Operation at too high a temperature will cause loss of resolution and possibly permanent damage to the tube. Resolution is regained by waiting for the temperature to drop below 45° C. *No part of the bulb should run more than 5° C hotter than the target section to prevent cesium migration to the target.* Such migration will result in loss of resolution and in probable permanent damage to the tube. Like other photosensitive devices employing cesium, the 5820-A may show fluctuations in performance from time to time. Strict observance of the above recommendations with respect to operating temperature will not completely eliminate these variations but will greatly improve the stability of the characteristics during the life of the tube.

Full-size scanning of the target should always be used during on-the-air operation. Full-size scanning can be assured by first adjusting the deflection circuits to overscan the target sufficiently to cause the corners of the target to be visible in the picture, and then reducing the scanning until the corners just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. Note that overscanning the target produces a smaller-than-normal picture on the monitor.

Underscanning the target, i.e., scanning an area of the target less than its sensitive area, should never be permitted. Underscanning produces a larger-than-normal picture on the monitor. If the target is underscanned for any length of time, a permanent change in target cutoff voltage of the underscanned area takes place with the result that the underscanned area thenceforth is visible in the picture when full-size scanning is restored.

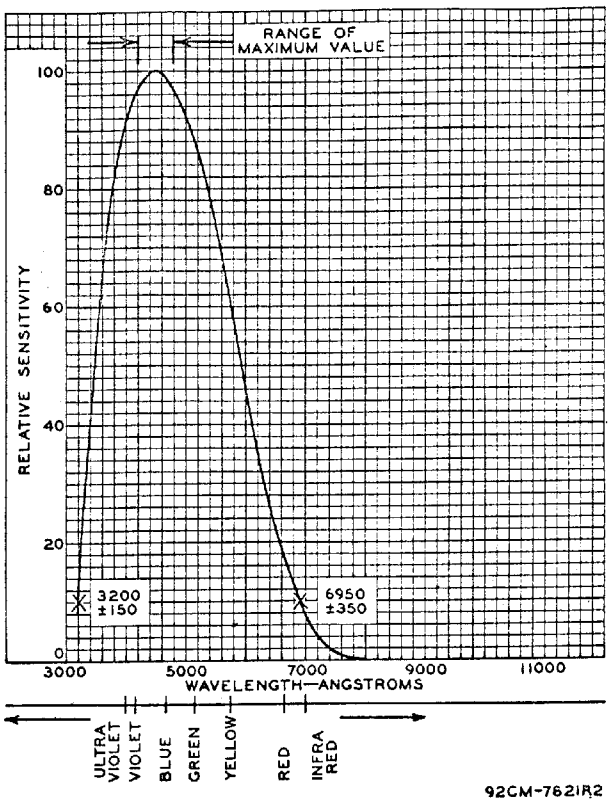


Fig. 1 - Spectral Sensitivity Characteristic of Type 5820-A which has S-10 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

To utilize the *resolution capability* of the 5820-A in the horizontal direction with the standard scanning rate of 525 lines, it is necessary to use a video amplifier having a bandwidth of at least 6 megacycles.

Even with a wide-band amplifier, the resolution may be limited in the image section by "cross talk" caused by the scanning fields. Unless prevented by proper shielding from extending into the image section (see *Proper Shielding* under *Camera-Design Considerations*), these fields will cause the electron image on the target to move at scanning frequency. As a result, the picture will lack definition.

The *dynode aperture* appears as a small white spot near the center of the image of the dynode surface. The white spot is most evident when it falls within dark areas of the scene. Little defocusing of the beam is required to minimize the effect of dynode aperture when the scene is brightly illuminated, but in dark scenes, the

effect of dynode aperture is a limiting item on resolution.

Dynamic focusing may be employed to give more uniform focus from center to edge of picture, and to eliminate dynode pattern or texture in low-light portions of a scene. Dynamic focusing is accomplished by applying to the beam-focus electrode (grid No.4) a voltage with parabolic waveform consisting of mixed horizontal and vertical scanning frequencies. The peaks of the parabolic waveform should be negative and coincident with those of the blanking signal. The dynamic-focusing voltage should have a peak-to-peak value of about 5 volts.

The *light transfer characteristics* of the 5820-A change for different illumination levels (see Reference 2). The basic light transfer characteristic of the 5820-A is shown in Fig.2. This curve is representative only for small-area highlights. For larger-area highlights, the bend or "knee" is not quite as abrupt as shown in Fig.2.

Sensitivity and Illumination: The image orthicon is an ultra-sensitive device exceeding in relative sensitivity most high-speed photographic film. When related to photographic film and compared at shutter speeds of 1/60 second which is the field rate of the television system, the 5820-A with proper illumination will have an equivalent ASA exposure index of 8000. This equivalent film-speed rating can be used in conjunction with a photographic exposure meter to determine the approximate light level or lens-stop setting necessary for operating the 5820-A.

The illumination on the photocathode of the 5820-A in relation to the scene illumination, can be determined by the following relationship:

$$I_s = \frac{4f^2 I_{pc} (m + 1)^2}{TR}$$

where

I_s = scene illumination in footcandles
f = f-number of lens
I_{pc} = photocathode illumination in footcandles
m = linear magnification from scene to target
T = total transmission of lens
R = reflectance of principal subject in scene

Except for very close shots, the linear magnification (m) from scene to target may be neglected.

For example, assume that the lens is f:11 having a transmission (T) of 80%, that the photocathode illumination is 0.020 footcandle, and that the scene to be televised has a highlight reflectance (R) of 75%.
Then,

$$I_s = \frac{4 \times 11^2 \times 0.020}{0.8 \times 0.75} = 16 \text{ footcandles}$$

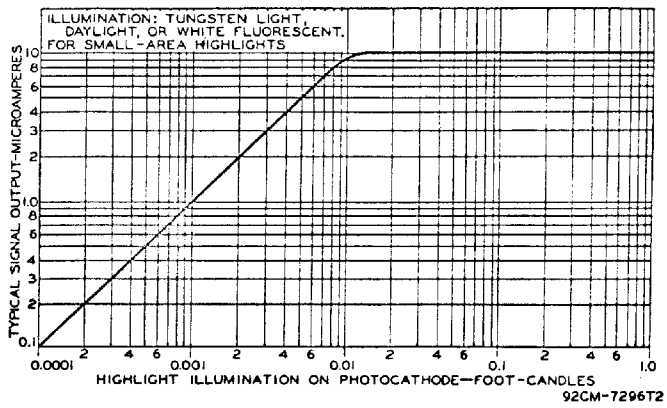


Fig.2 - Basic Light Transfer Characteristic of Type 5820-A.

The exact illumination for each 5820-A as finally set up on the scene should be determined by observing the video waveform on an oscilloscope. First adjust the lens setting of each camera to that level of light necessary to reach the knee of the light transfer characteristic. The camera lens is then normally set to bring picture highlights one stop above the knee of the transfer characteristic.

For very high illumination or for individual tubes with exceptionally high photocathode sensitivity, it may not be possible to stop the lens down far enough to reduce the highlight illumination on the photocathode to a value near the knee of the transfer characteristic. When such a condition is encountered, the use of a Wratten neutral filter selected to give the required reduction in illumination is recommended. Ordinarily, two filters—one having 10% transmission and the other 20%—will give sufficient choice. Such filters with lens-adapter rings can be obtained at photographic-supply stores.

The low illumination level needed on the photocathode of the 5820-A makes it necessary that no stray light from without or within the camera falls on the face of the tube.

CAMERA-DESIGN CONSIDERATIONS

The 5820-A has two complementary guides for inserting the tube correctly in the annular socket, i.e., the large pin (No.7) on the annular base, and the white radial line on the face of the bulb. The annular socket should be positioned so that the key pin (No.7) of the annular base is in a vertical plane through the common axis of the deflecting-coil assembly and the focusing coil assembly, and is at the bottom of the pin circle of the annular base.

The 5820-A is installed by inserting the diheptal-base end of the tube through the coil assembly and then turning the tube until the

annular-base pins, keyed by pin No.7, can be inserted in the annular socket. Proper insertion aligns the white radial line on the face with center of the key-pin hole in the annular socket. The diheptal socket is then put on the 14-pin base.

A *mask* having a diagonal or diameter of 1.8 inches should always be used on the photocathode to set limits for the maximum size of scan, and to reduce the amount of light reaching unused parts of the photocathode.

The *optical system* used with the 5820-A should be designed according to basic optical principles and should incorporate an iris to control the amount of light entering the television camera lens. The entire optical system should have all inside surfaces finished in mat black to prevent internal reflections from reaching the photocathode. Under almost all conditions, the use of a lens shade is beneficial.

Proper shielding of the image section can be provided by wrapping around the outside of the focusing coil directly over the center of the deflecting coils a triple layer of Mumetal strip 0.006" thick and 5" wide, or equivalent. Then, wrap another triple layer of Mumetal strip 0.006" thick and 3" wide around the focusing coil directly over the image section of the 5820-A. Additional shielding is provided by fitting the inside of the focusing coil directly over the image section with a copper cylinder having a length of approximately 2-1/4" and a wall thickness of 1/32". The Mumetal shielding effectively shunts the field-rate deflection field, while the copper cylinder shields the higher frequency line-scanning field from the electron path in the image section. Unless proper shielding is provided, "cross talk" from the deflecting yoke into the image section will result in loss of picture sharpness.

A *blanking signal* should be supplied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must be constant to prevent fluctuation of the target voltage. During the blanking periods, the full beam current without video-signal modulation is returned to the multiplier and its multiplied output flows through the load resistance. Excessive amounts of blanking voltage applied to the target will impair resolution, since during retrace the target is out of focus to the continuously flowing photocathode current. A desirable amount of target blanking is 6 volts peak to peak.

Shading may be required even with optimum adjustment of voltage on grid No.3 in order to obtain a uniformly shaded picture. Sawtooth and parabolic waveforms of adjustable amplitude and polarity at both the vertical- and horizontal-scanning frequency should be provided for insertion in the video amplifier to aid in obtaining a flat background. The shading signal should be introduced in the amplifier after clamping is performed, since clamping circuits will remove the vertical-frequency shading component if added previous to the clamp-circuit location.

Failure of scanning even for a few minutes when light is incident on the photocathode may permanently damage the surface of the target. The damaged area shows up as a spot or line in the picture during subsequent operation.

To avoid damaging the 5820-A during scanning failure, provision should be made to prevent automatically the scanning beam from reaching the target. The scanning beam can be prevented from reaching the target by (1) cutting off the scanning beam, or (2) making the target sufficiently negative. The scanning beam can be cut off by a relay which applies -115 to -125 volts bias to grid No.1. The target can be made sufficiently negative by a relay which applies a bias of -10 volts to it. Either relay is actuated by a tube which is controlled by a portion of the scanning pulse voltage developed across either the horizontal or the vertical deflecting coils, or both. It is important to insure that in the event of failure of either the horizontal scanning pulse or the vertical scanning pulse, the circuitry should be capable of actuating the protection relay.

PRINCIPLES OF OPERATION

The 5820-A has three sections—an image section, a scanning section, and a multiplier section.

Image Section

The image section contains a semitransparent photocathode on the inside of the faceplate, a grid to provide an electrostatic accelerating field, and a target which consists of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

Light from the scene being televised is picked up by an optical lens system and focused on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focused on the target by the magnetic and accelerating fields.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite potential of about 2 volts with respect to target-voltage cutoff. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive

charges which corresponds with the pattern of light from the scene being televised. Because of the thinness of the glass, the charges set up a similar potential pattern on the opposite or scanned side of the glass.

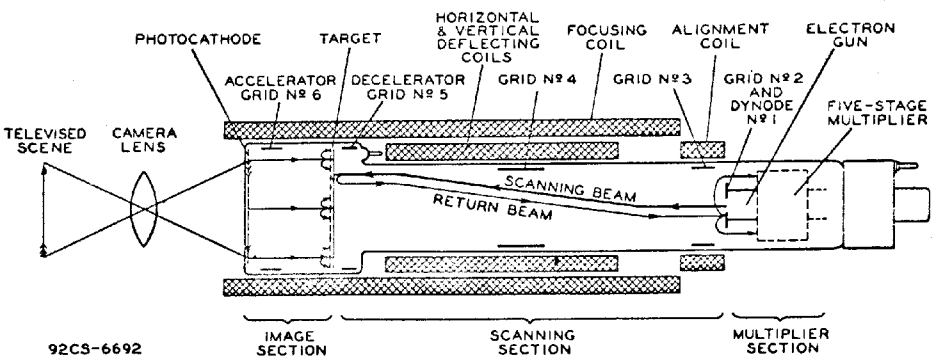


Fig. 3 - Schematic Arrangement of Type 5820-A.

Scanning Section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No.1), and an accelerating grid (grid No.2). The beam is focused at the target by the magnetic field of an external focusing coil and the electrostatic field of grid No.4.

Grid No.5 serves to adjust the shape of the decelerating field between grid No.4 and the target in order to obtain uniform landing of electrons over the entire target area. The electrons stop their forward motion at the surface of the glass and are turned back and focused into a five-stage signal multiplier, except when they approach the positively charged portions of the pattern on the glass. When this condition occurs, they are deposited from the scanning beam in quantities sufficient to neutralize the potential pattern on the glass. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode side. These charges will neutralize each other by conductivity through the glass in less than the time of one frame.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by an external coil located at the gun end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

Multiplier Section

The return beam is directed to the first dynode of a five-stage electrostatically focused multiplier. This utilizes the phenomenon of secondary emission to amplify the modulated beam current more than 500 times. The electrons in the beam impinging on the first-dynode surface produce many other electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No.5 are collected by the anode and constitute the current utilized in the output circuit.

The signal-to-noise ratio of the output signal from the 5820-A is high. The gain of the multiplier is such as to raise the output signal sufficiently above the noise level of the video-amplifier stages so that they contribute no noise to the final video signal. The signal-to-noise ratio of the video signal, therefore, is determined only by the random variations of the modulated electron beam.

DOS and DON'TS on Use of RCA-5820-A

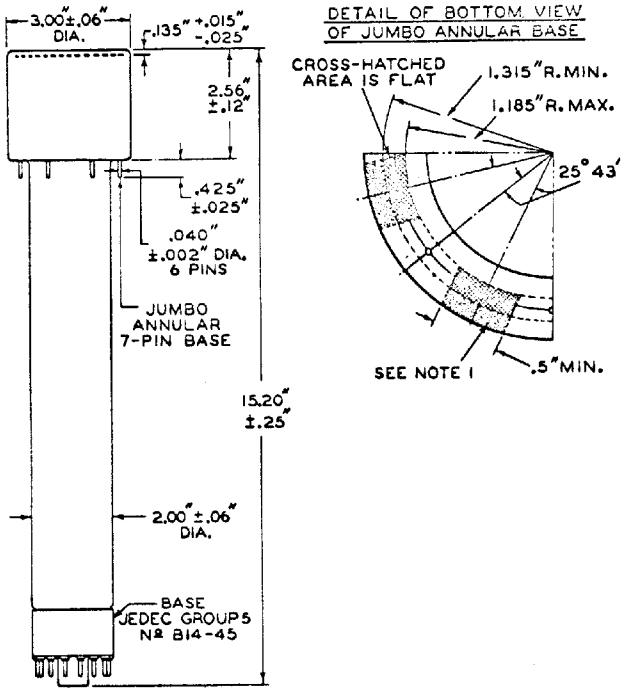
Here are the "dos"—

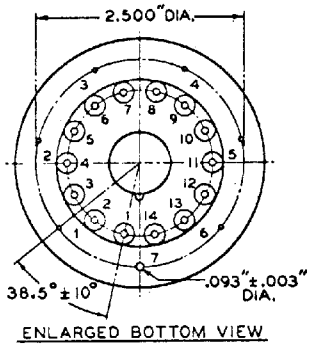
1. Allow the 5820-A to warm up prior to operation.
2. Hold temperature of the 5820-A within operating range.
3. Make sure alignment coil is properly adjusted.
4. Adjust beam-focus control for best usable resolution.
5. Condition spare 5820-A's by operating several hours once each month.
6. Determine proper operating point with target voltage adjusted to exactly 2 volts above target cutoff.
7. Keep beam current as low as possible for best picture quality and to prevent excessive noise.
8. Cap lens during standby operation.

Here are the "don'ts"—

1. Don't force the 5820-A into its shoulder socket.
2. Don't operate the 5820-A without scanning.
3. Don't underscan target.
4. Don't operate a 5820-A having an ion spot.
5. Don't focus the 5820-A on a stationary bright scene.
6. Don't turn off beam while voltages are applied to photocathode, grid-No.6, target, dynodes, and anode during warmup or standby operation.

DIMENSIONAL OUTLINE





ENLARGED BOTTOM VIEW

NOTE 1: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.

ANNULAR BASE GAUGE

ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GAUGE WITH:

a. SIX HOLES HAVING DIAMETER OF 0.065" ± 0.001" AND ONE HOLE HAVING DIAMETER OF 0.150" ± 0.001". ALL HOLES HAVE DEPTH OF 0.265" ± 0.001". THE SIX 0.065" HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047". ALL HOLES ARE SPACED AT ANGLES OF 51°26' ± 5' ON CIRCLE DIAMETER OF 2.500" ± 0.001".

b. SEVEN STOPS HAVING HEIGHT OF 0.187" ± 0.001", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

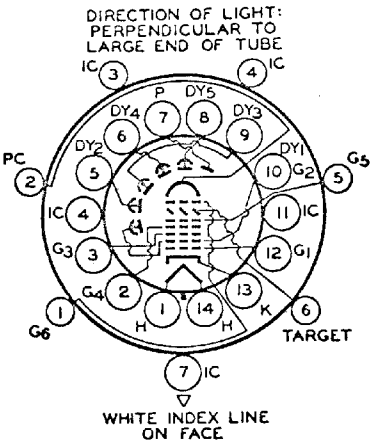
c. RIM EXTENDING OUT A MINIMUM OF 0.125" FROM 2.812" DIAMETER AND HAVING HEIGHT OF 0.126" ± 0.001".

d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200" ± 0.001".

92CM-8293R3

BASING DIAGRAM

Bottom View



SMALL-SHELL DIHEPTAL 14-PIN BASE

PIN 1: HEATER
PIN 2: GRID NO.4
PIN 3: GRID NO.3
PIN 4: INTERNAL CONNECTION—DO NOT USE
PIN 5: DYNODE NO.2
PIN 6: DYNODE NO.4
PIN 7: ANODE
PIN 8: DYNODE NO.5
PIN 9: DYNODE NO.3
PIN 10: DYNODE NO.1 GRID NO.2
PIN 11: INTERNAL CONNECTION—DO NOT USE
PIN 12: GRID NO.1
PIN 13: CATHODE
PIN 14: HEATER

KEYED JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID NO.6
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNECTION—DO NOT USE
PIN 4: INTERNAL CONNECTION—DO NOT USE
PIN 5: GRID NO.5
PIN 6: TARGET
PIN 7: INTERNAL CONNECTION—DO NOT USE

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from RMA release #761, June 25, 1949

5823

GLOW-DISCHARGE TRIODE

Cold-Cathode, Miniature Type

TENTATIVE DATA

RCA-5823 is a cold-cathode, glow-discharge triode of the miniature type designed for use primarily as a relay tube for the "on-off" control of low-current electrical circuits. The discharge of this tube can be initiated by a very small amount of electrical energy applied to the starter-electrode circuit.

The 5823 requires no warm-up and consumes no stand-by power.

AVERAGE LIFE-EXPECTANCY CONSIDERATIONS

The 5823 will give excellent life performance in intermittent relay service. The average life expectancy of a tube of this kind is a function of frequency of "on" cycles, total duration of "on" periods, and peak value of cathode current. Varying any of these factors affects the average life expectancy. If a 5823 is operated on 60-cycle ac and triggered every cycle, its life is determined primarily by the number of starts which it can withstand and the peak value of the cathode current. In such service, the average starts-number expectancy is approximately 45,000,000. For dc, the same factors apply but the total duration of the "on" periods becomes increasingly important with reduced frequency of starts. For increased tube life with either ac or dc operation, the cathode current should be kept as low as possible.

DATA

General:

Cathode	Cold
Maximum Overall Length	2-1/8"
Maximum Seated Length	1-7/8"
Length from Base Seat to Bulb Top (excluding tip)	1-1/2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin
Mounting Position	Any

Maximum Ratings▲, *Absolute Values*:

For First-Quadrant Operation Only

PEAK ANODE AND STARTER-ELECTRODE VOLTAGE:		
Inverse	200 max.	volts
Forward	200 max.	volts
CATHODE CURRENT:		
Peak	100 max.	ma
Average*	25 max.	ma
PEAK STARTER-ELECTRODE CURRENT:		
With starter-electrode voltage positive	100 max.	ma
AMBIENT TEMPERATURE	-60 to +75	°C

Typical Operating Conditions:

For Relay Service with 60-Cycle AC Supply

AC Anode Supply Voltage (RMS)	117	volts
AC Starter-Electrode Voltage:		
Max. Peak Positive Pre-Firing Voltage	70	volts
Min. Peak Positive Triggering Voltage	35	volts
Min. Firing Voltage (Sum of In-Phase Instantaneous Pre-Firing Voltage and Instantaneous Triggering Voltage)	105	volts

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

For First-Quadrant Operation Only

	Note	Min.	Av.	Max.	
Anode Breakdown Voltage	1	200	290	-	volts
Starter-Electrode Breakdown Voltage	2	73	80	105■	volts
Required Transfer Current (DC or Instantaneous AC) for transition of discharge to anode at 140 volts peak	3	-	50	400■	μamp
Anode Voltage Drop	4	-	62	85■	volts
Starter-Electrode Voltage Drop	5	-	61	75■	volts
Deionization Time (Approx.)	6	-	500	-	μsec
Ionization Time (Approx.)	6	-	20	-	μsec

Note 1: With a variable dc anode voltage, dc starter-electrode voltage of 0 volts, anode-circuit series resistance of 3000 ohms, and starter-electrode series resistance of 50000 ohms.

Note 2: With dc anode voltage of 0 volts, variable dc starter-electrode voltage, anode-circuit series resistance of 3000 ohms, and starter-electrode series resistance of 50000 ohms.

Note 3: With a variable dc starter-electrode voltage, anode-circuit series resistance of 3000 ohms, and starter-electrode series resistance of 2 megohms.

Note 4: With dc anode voltage of 230 volts, dc starter-electrode voltage of 91 volts, dc cathode current of 50 milliamperes, anode-circuit series resistance of 3000 ohms, and starter-electrode series resistance of 50000 ohms.

Note 5: With dc anode voltage of 0 volts, variable dc starter-electrode voltage, dc starter-electrode current of 10 milliamperes, and starter-electrode series resistance of 3000 ohms.

Note 6: With instantaneous anode voltage of 185 volts, peak positive starter-electrode pre-firing voltage of 70 volts, peak positive starter-electrode triggering voltage of 50 volts, anode-circuit series resistance of 820 ohms, and starter-electrode series resistance of 100000 ohms.

▲ These ratings apply to the 5823 when it is operated from a power supply having a frequency of 60 cycles per second. If a contemplated application involves higher supply frequencies, please write, stating the proposed operating frequency, to the attention of Commercial Engineering Section, Harrison, New Jersey for information as to required changes in maximum ratings and characteristics.

* Averaged over any interval of 15 seconds max.

■ Maximum individual tube values during life.

INSTALLATION AND APPLICATION

The *base* pins of the 5823 fit the miniature 7-pin socket. The socket may be mounted to hold the tube in any position. *Make no connections to*

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pins 2, 5, and 6. Any potentials applied to these pins may cause erratic tube performance.

The *breakdown characteristic* of the 5823 in all quadrants is shown in Fig. 1. These curves describe the voltage conditions necessary for breakdown between any two of the electrodes of the 5823. The area between the inner and outer curves indicates the typical operating region of the tube throughout useful life. The inner curve shows the minimum positive and negative electrode values; the outer curve shows the maximum positive and negative electrode values; dashed sections indicate approximate values only.

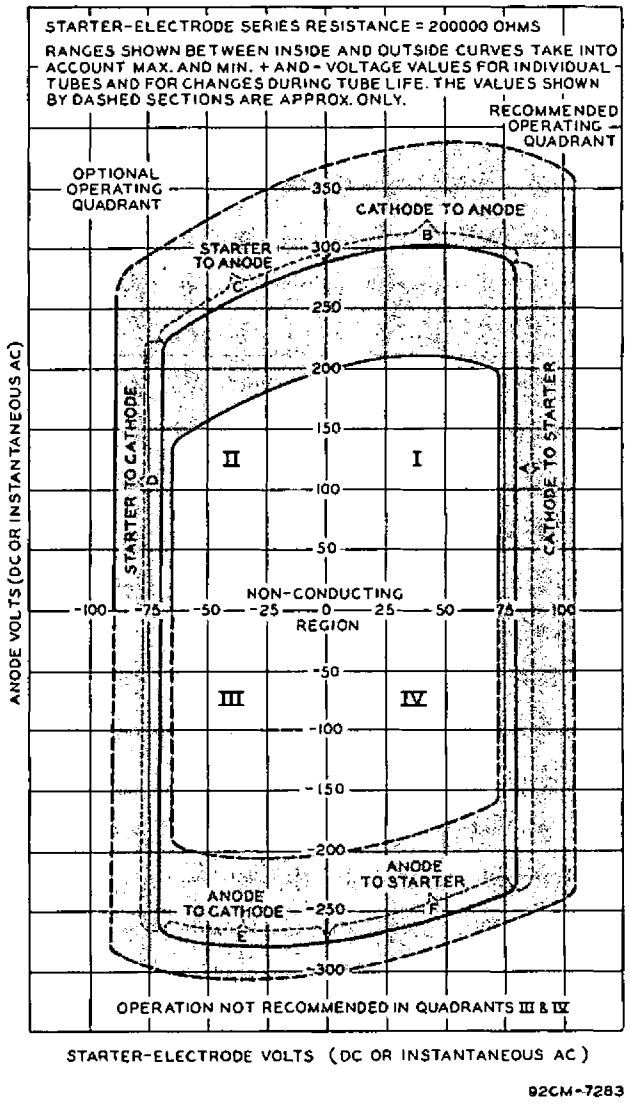


Fig. 1 - RCA-5823 Breakdown Characteristic For All Quadrants.

RCA-5823 is recommended for operation only in that part of the breakdown characteristic designated by Quadrant I. Operation in Quadrant II is satisfactory but changes in tube ratings are necessary. Operation in Quadrants III and IV is not recommended, because the anode and starter electrode are not designed for efficient cathode operation; their use in this manner will result in unstable operation and shorter tube life. The information given for quadrants III and IV is of value to the equipment designer in that it indicates the need for precautions to be taken in order that the peak inverse voltage rating is not exceeded.

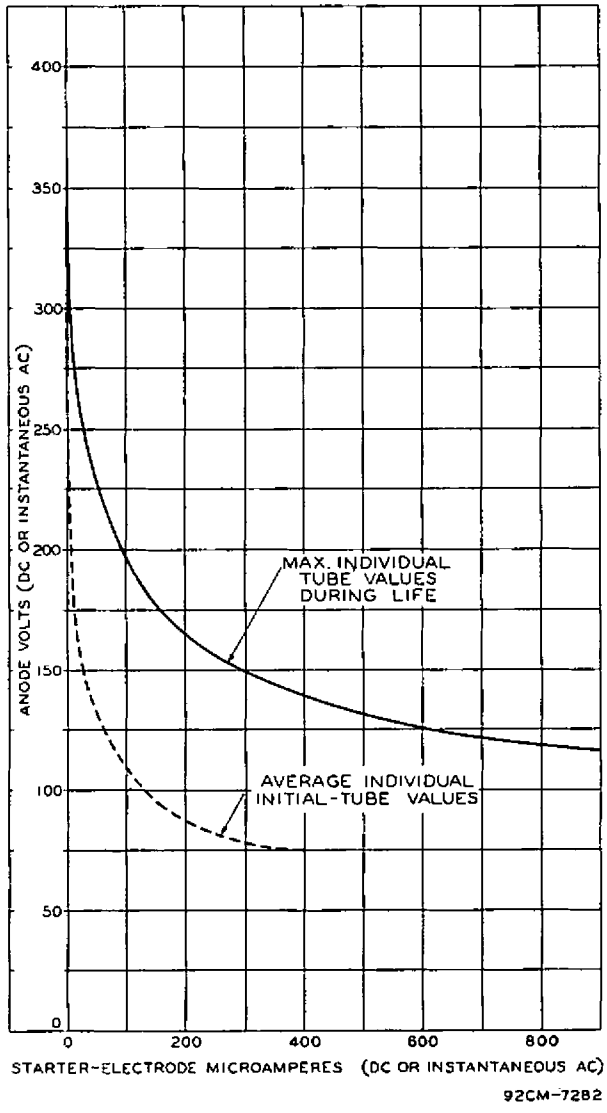


Fig. 2 - RCA-5823 Transition Characteristic.

To obtain most satisfactory performance from the 5823, it is necessary to understand the significance of the *breakdown characteristic.* In the *non-conducting region,* the relation between the starter-electrode voltage and the anode voltage is such that breakdown does not occur. As the starter-electrode voltage is increased to a value near the edge of this region, breakdown occurs depending on the value of the associated anode

voltage. The maximum or outside curves indicate what minimum triggering voltages should be used to insure operation of the 5823 at all times during useful life.

For operation of the 5823 in Quadrant I, the peak anode supply voltage and the peak positive starter-electrode pre-firing voltage must not exceed the minimum values indicated by the inner solid curve. A triggering voltage is applied to the starter electrode. This voltage must be in-phase with the pre-firing voltage and must be of sufficient magnitude to initiate a discharge between starter electrode and cathode. The minimum sum of these starter-electrode voltages is indicated by the outer solid curve. To transfer the discharge to the anode-cathode circuit, it is essential that adequate transfer current flow to the starter electrode, as shown in Fig.2. When the 5823 is operated with ac on both anode and starter electrode, the equipment designer should also refer to Quadrant III. The peak values of ac anode supply voltage and ac starter-electrode pre-firing voltage selected should not exceed the values given by the inside dotted curve of this quadrant. If it is desired to operate the 5823 with ac anode supply voltage and a positive dc starter-electrode pre-firing voltage, the equipment designer should be guided by the peak inverse rating as given by the minimum values of the inner dotted curve in Quadrant IV. For straight dc operation, the equipment designer should consider the same voltage limitations as given for ac operation but need not consider the peak inverse rating unless an inductive load is used. In this case the limitation on the peak inverse anode voltage rating is of importance because of the inductive kick-back voltage.

The *transfer characteristic* of the 5823, as given in Fig.2, indicates the minimum transfer-current requirements of the starter electrode for transition of the discharge from starter electrode to anode for any given anode supply voltage. From an equipment designer's standpoint, the maximum individual-tube values during life, as shown by the solid curve, are minimum starter-current requirements for satisfactory tube performance. The dashed curve gives the average individual-tube initial values. Fig. 2 shows that for each value of anode voltage there is a corresponding minimum value of starter-electrode current necessary to initiate the main discharge between cathode and anode. For example, with an ac anode supply voltage of 166 volts peak (117 volts rms), and an ac starter-electrode pre-firing voltage of 70 volts peak (50 volts rms), it follows from the curve in Fig.1 that the minimum required triggering voltage will be 35 volts peak. Under these conditions, Fig.2 shows that the minimum starter-electrode current required to transfer the discharge from the starter electrode to the anode will be 200 microamperes.

In Fig. 1, section C of Quadrant II shows the relation between anode voltage and starter voltage that is required for a discharge from starter to anode when there are no ions to assist the initiation of the discharge. In this section, the starter acts as a cathode with the result that the slope of section C is approximately 45 degrees. This discharge can occur with positive values of anode voltage, because the distance between the anode and the starter electrode is less than the distance between the anode and the cathode.

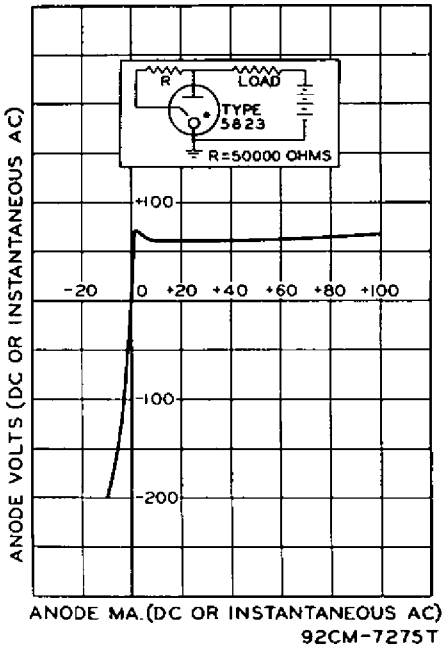


Fig. 3 - RCA-5823 Average Anode Characteristic.

Section D shows the relation between anode voltage and starter-electrode voltage necessary for a discharge from starter to cathode when there are no ions to assist the initiation of this discharge. It should be noted that this discharge takes place between the same two electrodes as in Section A. However, under the conditions indicated in Section D, the starter acts as a cathode because it is negative with respect to the cathode.

Sections E and F show relations between anode volts and starter volts necessary to initiate a discharge from anode to cathode and from anode to starter-electrode respectively, when there are no ions to assist the initiation of these discharges. Under the conditions indicated in sections E and F, the anode acts as cathode.

The *average anode characteristic* of the 5823 is given in Fig. 3. The curve shows that over the useful operating range, the anode voltage drop remains substantially constant at 62 volts. The curve also shows by its assymetrical shape, that the 5823 can be used as a rectifier. This feature is an advantage when the anode is supplied

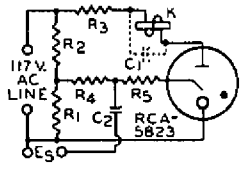
with ac power to operate a dc relay. When used as a rectifier, the 5823 has a maximum peak inverse anode voltage rating of 200 volts and a maximum peak cathode current as indicated in the tabulated data. Operation at values of dc cathode current less than 8 milliamperes is not recommended because of resulting instability.

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 5823 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed the absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

Fig.4 shows the 5823 in a typical ac-operated relay circuit. The pre-firing voltage supplied by the voltage divider (R1 and R2) is just below that required for tube conduction. A positive triggering voltage applied to the starter electrode develops a voltage across resistor R4 which, when added to the pre-firing voltage, causes the tube to breakdown. Resistors R3 and R5 are current-limiting resistors for the anode and the starter electrode.

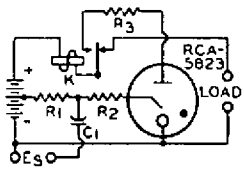
Fig.5 shows the 5823 in a dc-operated locking relay. The pre-firing voltage is provided by the battery supply. A positive triggering voltage applied to the starter electrode develops a voltage across resistor R1 which, when added to the pre-firing voltage causes the tube to breakdown. The anode current energizes the relay which switches the supply voltage to the load. The load current must be sufficient to keep the relay energized. R3 and R2 are current-limiting resistors for the anode and the starter electrode.

Fig.6 shows the 5823 in a dc-operated self-resetting relay circuit. The pre-firing voltage is provided by the battery supply. A positive triggering voltage applied to the starter electrode develops a voltage across resistor R1 which, when added to the pre-firing voltage, causes the tube to breakdown. Capacitor C2 which has been charged by the supply voltage through R2 will discharge through the tube and energize the relay winding until the voltage on the anode is insufficient to maintain tube conduction. Relay resets itself when capacitor C2 recharges through resistor R2.



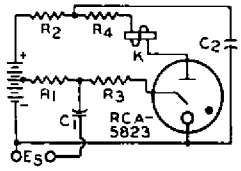
C1: 2 to 8 μf, 250 volts: used if needed to prevent relay chatter
C2: 0.1 μf, 250 volts
Es: Triggering Voltage
K: Winding for high-resistance sensitive relay
R1: 5000 ohms, 1 watt
R2: 8200 ohms, 1 watt
R4: 10 megohms
R3, R5: Peak current-limiting resistor—value depends on desired operating conditions.

Fig.4 - Typical AC-Operated Relay Circuit Using RCA-5823



C1: 0.1 μf, 250 volts
Es: Triggering Voltage
K: Winding for high-resistance sensitive relay
R1: 10 megohms
R2, R3: Peak current-limiting resistor—value depends on desired operating conditions

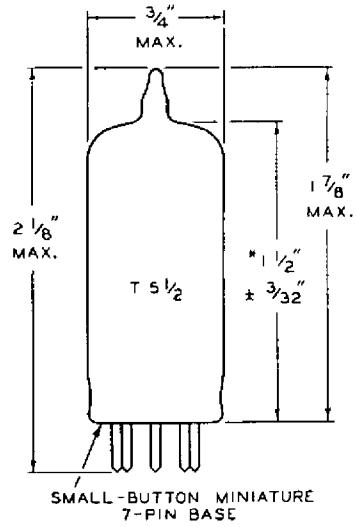
Fig.5 - Typical DC-Operated Locking Relay Circuit Using RCA-5823



C1: 0.1 μf, 250 volts
C2: 1.0 μf, 250 volts
Es: Triggering Voltage
K: Winding for high-resistance sensitive relay
R1: 10 megohms
R2: 1 megohm, 1 watt
R3, R4: Peak current-limiting resistor—value depends on desired operating conditions

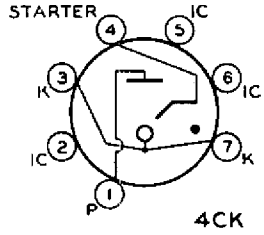
Fig.6 - Typical DC-Operated Self-Resetting Relay Circuit Using RCA-5823

DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



PIN 1: ANODE
PIN 2: INTERNAL CONNECTION—DO NOT USE
PIN 3: CATHODE
PIN 4: STARTER ELECTRODE
PIN 5: INTERNAL CONNECTION—DO NOT USE
PIN 6: INTERNAL CONNECTION—DO NOT USE
PIN 7: CATHODE

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5826

IMAGE ORTHICON

Magnetic Focus
Magnetic Deflection

For Studio Pickup
Exceptional Sensitivity

3"-Diameter Bulb
15-1/4" Length

TENTATIVE DATA

RCA-5826 is a television camera tube recommended for studio use and other applications where the lighting can be controlled. It has exceptional sensitivity combined with a spectral response approaching that of the eye, and good stability over the range of light levels usually encountered with artificial illumination. Commercially acceptable pictures can be obtained with incident light levels greater than about 35 foot-candles.

The photocathode utilized in the 5826 is characterized by a spectral response having high blue sensitivity, high green sensitivity, good red sensitivity, and practically no infrared sensitivity. This latter characteristic of the response prevents any color-masking by infrared, and thus permits portrayal of colors in nearly their true tonal gradation.

Because of its spectral characteristics and exceptional sensitivity, the 5826 can be substituted to advantage for the type 5655. Requiring a minimum light level only 0.15 of that required by the 5655, the 5826 makes it possible to reduce substantially the amount of illumination as well as air conditioning needed in the studio. Furthermore, the 5826 permits considerably improved gray-scale rendition of color while retaining the same good signal-to-noise ratio of the 5655.

The relatively small size of the 5826 lends itself to use in comparatively light-weight, portable television cameras, and facilitates the use of a telephoto lens with such cameras.

For general outdoor pickup use, RCA-5820 is recommended.

PRINCIPLES OF OPERATION

The 5826 has three sections--an image section, a scanning section, and a multiplier section, as shown in Fig. 1.

Image Section

The image section contains a semi-transparent photocathode on the inside of the face plate, a grid to provide an electrostatic accelerating field, and a target which consists of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

Light from the scene being televised is picked up by an optical lens system and focused on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focused on the target by the magnetic and accelerating fields.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite potential of about 2 volts with respect to target-voltage cutoff. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive charges which corresponds with the pattern of light from the scene being televised. Because of the thinness of the glass, the charges set up a similar potential pattern on the opposite or scanned side of the glass.

Scanning Section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No. 1), and an accelerating grid (grid No. 2). The beam is focused at the target by the magnetic field of an external focusing coil and the electrostatic field of grid No. 4.

Grid No. 5 serves to adjust the shape of the decelerating field between grid No. 4 and the target in order to obtain uniform landing of electrons over the entire target area. The electrons stop their forward motion at the surface of the glass and are turned back and focused into a five-stage signal multiplier, except when they approach the positively charged portions of the pattern on the glass. When this condition occurs,

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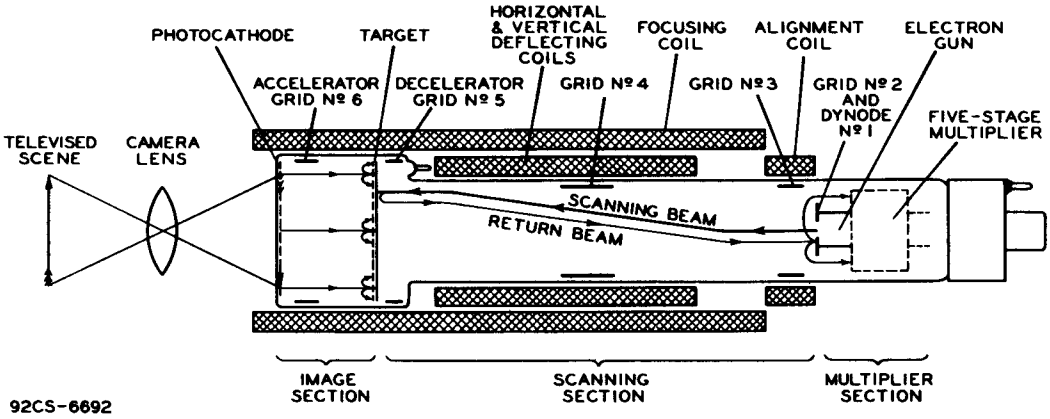


Fig. 1 - Schematic Arrangement of Type 5826.

they are deposited from the scanning beam in quantities sufficient to neutralize the potential pattern on the glass. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode side. These charges will neutralize each other by conductivity through the glass in less than the time of one frame.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by an external coil located at the gun end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

Multiplier Section

The return beam is directed to the first dynode of a five-stage electrostatically focused multiplier. This utilizes the phenomenon of secondary emission to amplify signals composed of electron beams. The electrons in the beam impinging on the first dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No.5 are collected by the anode and constitute the current utilized in the output circuit.

The multiplier section amplifies the modulated beam about 500 times. The multiplication so obtained increases the signal-to-noise ratio of the tube and also permits the use of an amplifier with fewer stages. The gain of the multiplier is sufficiently high so that the limiting noise in the use of the tube is the random noise of the electron beam multiplied by the multiplier stages. This noise is larger than the input noise of the video amplifier.

It can be seen that when the beam moves from a less positive portion on the target to a more positive portion, the signal output voltage across the load resistor (R_{30} in Fig.2) changes in the positive direction. Hence, for highlights in the scene, the grid of the first video-amplifier stage swings in the positive direction.

DATA

General:

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 ± 10% volts
Current	0.6 ampere
Direct Interelectrode Capacitance:	
Anode to All Other Electrodes	20 μμf
Photocathode, Semi-transparent:	
Response	See Fig.6
Useful Size of Rectangular Image (4 x 3 aspect ratio)	1.6" max. Diagonal
Orientation of Rectangular Image -- Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through center of face plate and pin No.7 of the shoulder base.	
Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	15-1/4" ± 1/4"
Greatest Diameter of Bulb	3" ± 1/16"
Shoulder Base	Keyed Jumbo Annular 7-Pin
End Base	Small-Shell Diheptal 14-Pin
Mounting Position	See Text
Minimum Deflecting-Coil Inside Diameter	2-1/8"
Deflecting-Coil Length	5"
Focusing-Coil Length	10"
Alignment-Coil Length	15/16"
Photocathode Distance Inside End of Focusing Coil	1/2"

Maximum Ratings, *Absolute Values*:

PHOTOCATHODE VOLTAGE	-550 max.	volts
PHOTOCATHODE ILLUMINATION	50 max.	ft-c
OPERATING TEMPERATURE OF ANY PART OF BULB	65 max.	°C
OPERATING TEMPERATURE OF BULB AT LARGE END OF TUBE (TARGET SECTION)	45 min.	°C
TEMPERATURE DIFFERENCE: Between target section and any part of bulb hotter than target section	5 max.	°C
GRID-No.6 VOLTAGE	-550 max.	volts

TARGET VOLTAGE:		
Positive value	50 max.	volts
Negative value	50 max.	volts
GRID-No.5 VOLTAGE	150 max.	volts
GRID-No.4 VOLTAGE	300 max.	volts
GRID-No.3 VOLTAGE	400 max.	volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
ANODE-SUPPLY VOLTAGE*	1500 max.	volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	volts

Typical Operation and Characteristics:

Photocathode Voltage (Image Focus)	-300 to -500	volts
Grid-No.6 Voltage (Accelerator)— 80% of photocathode voltage	-240 to -400	volts
Target Voltage°	0	volts
Grid-No.5 Voltage (Decelerator)°°	0 to 100	volts
Grid-No.4 Voltage (Beam Focus)	160 to 240	volts
Grid-No.3 Voltage#	225 to 330	volts
Grid-No.2 & Dynode-No.1 Voltage	300	volts
Grid-No.1 Voltage (For picture cutoff)	-45 to -115	volts
Dynode-No.2 Voltage	600	volts
Dynode-No.3 Voltage	800	volts
Dynode-No.4 Voltage	1000	volts
Dynode-No.5 Voltage	1200	volts
Anode Voltage	1250	volts
Anode Current	50	μa
Target Temperature Range (See text)	45 to 60	°C
Highlight Illumination on Photocathode for Maximum Signal Output: With 2870°K Tungsten Illumination, Daylight, or White Fluorescent Illumination	0.04	ft-c
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current (Approx.)	70	
Minimum Peak-to-Peak Blanking Voltage	10	volts
Field Strength at Center of Focusing Coil	75	gausses
Focusing-Coil Current (Approx., for Coil listed below)■	75	ma
Deflecting-Coil Current (Approx., for Assembly listed below):		
Horizontal (Peak to peak)	625	ma
Vertical (Peak to peak)	290	ma
Alignment-Coil Current (Approx., for Coil listed below)	0 to 30	ma

Components:

Deflecting-Coil Assembly (Includes Keyed Jumbo Annular 7-Pin Socket)	RCA Type No. 201D75
Focusing-Coil Assembly	RCA Type No. 202D75
Alignment-Coil Assembly	RCA Type No. 204D75
Hor. Deflection Output Transformer	RCA Type No. 204T1
Ver. Deflection Output Transformer	RCA Type No. 204T2

* Ratio of dynode voltages is shown under Typical Operation.

° Adjustable from -3 to +5 volts with blanking voltage off.

°° Taps at 0, 30, 60, and 90 volts are recommended. Set at voltage giving most uniform resolution and signal output over entire picture area.

\# Adjust to give the most uniformly shaded picture near maximum signal.

■ Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil.

INSTALLATION

The *end-base* pins of the 5826 fit the diheptal 14-pin socket; the *annular-base* pins fit the keyed jumbo annular 7-pin socket which is part of the deflecting-coil assembly having RCA Type No. 201D75.

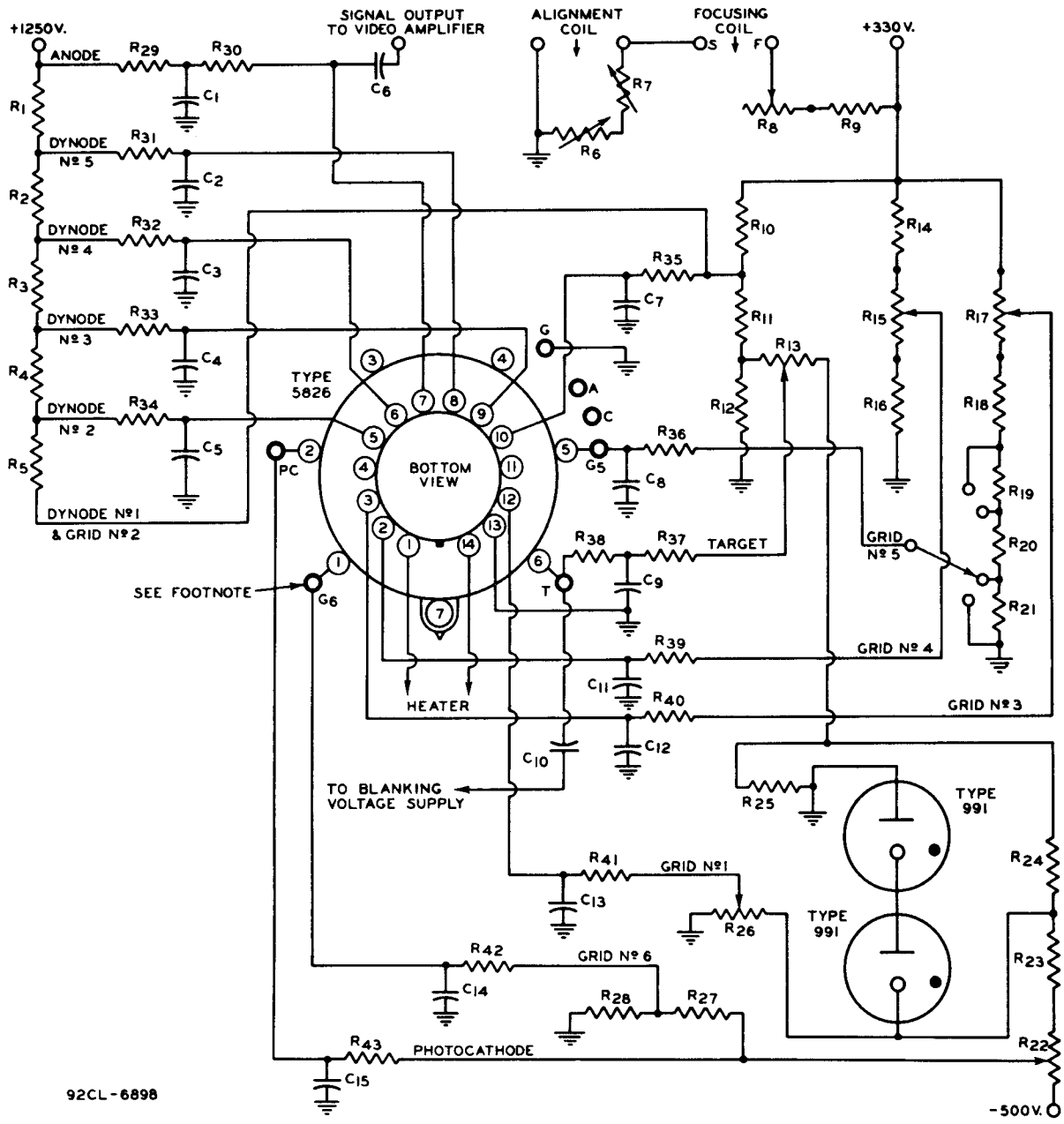
The 5826 has three complementary guides for inserting the tube correctly in the annular socket, i.e., the large pin (No.7) on the annular base, the white radial line on face of bulb, and a white longitudinal line on neck. Designers of equipment should position the annular socket so that pin No.7 of the annular base, and the white radial line when viewed from the face end of the tube, will be at the bottom of the face after the tube has been correctly inserted in the annular socket. The 5826 is installed by inserting the diheptal-base end of the tube through the coil assembly and then turning the tube until the annular-base pins, keyed by pin No.7, can be inserted in the annular socket. Proper insertion aligns the white radial line on the face with center of the slot in the annular socket, and makes the longitudinal line on the neck visible through the sight hole in the deflecting-coil assembly. The annular-base pins are then pushed into their socket, and the diheptal socket is put on the 14-pin base.

Proper orientation of the annular socket with respect to the horizontal-deflecting field is essential, and is obtained when the plane which is perpendicular to the plane of the annular socket and which passes through the center of the annular socket and the center line between pins 3 and 4 of the annular base is at right angles to the horizontal scanning field. This orientation prevents the damper bars in the target assembly from showing in the picture when the target is normally scanned, and also minimizes beat-pattern effects by placing the sides of the mesh holes at an angle of 45° with respect to the horizontal scanning lines.

The damper bars serve to minimize microphonics and consist of two metal strips between the mesh-screen portion and the glass-disc portion of the target. They are positioned so that, with the orientation described above, they appear parallel to the horizontal scanning lines when the target is over-scanned, but do not show in the picture with normal scanning of the target.

The *operating position* of the 5826 should preferably be such that any loose particles in the neck of the tube will not fall down and strike or become lodged on the target. Therefore, it is recommended that the tube never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical through the center of the base.

The *operating temperature* of any part of the glass bulb should never exceed 65°C, and no part of the bulb at the large end of the tube (target section) should ever fall below 45°C during operation. The temperature of the target is essentially the same as that of the adjacent glass bulb and can, therefore, be determined by measuring the temperature of the glass bulb adjacent to the target. It is recommended that the temperature of the entire bulb be held between



O = Terminals on Deflecting-Coil Assembly, RCA Type No.201D75. These terminals are connected to annular socket within the Assembly as shown, except for those marked G, A, and C. G is connected to yoke shielding. A and C are connected to heater terminals on face of annular socket. Other terminals on the Assembly not shown above are indicated in Figs.3 and 4.

Fig.2 - Voltage Dividers for Type 5826 with Connections for: Alignment Coil, RCA Type No.204D75, and Focusing Coil, RCA Type No.202D75.

45° and 60°C. Operation at too low a temperature will be characterized by the appearance of a rapidly disappearing "sticking picture" of opposite polarity from the original when the picture is moved. Operation at too high a temperature will cause loss of resolution and possibly permanent damage to the tube. Resolution is regained by waiting for the temperature to drop below 65°C. No part of the bulb should run more than 5° hotter than the target section to prevent cesium migration to the target. Such migration will result in loss of resolution and in probable permanent damage to the tube. Like other photosensitive devices employing cesium, the 5826 may show fluctuations in performance from time to time. Strict observance of the above recommendations with respect to operating temperature will not completely eliminate these variations but will greatly improve the stability of the characteristics during the life of the tube.

When the equipment design or operating conditions are such that the maximum temperature rating or maximum temperature difference as given under Maximum Ratings will be exceeded, provision should be made to direct a blast of cooling air from the diheptal-base end of the tube along the entire length of the bulb surface, i.e., through the space between the bulb surface and the surrounding deflecting coil and its extension. Any attempt to effect cooling of the tube by circulating even a large amount of air around the focusing coil will do little good, but a small amount of air directly in contact with the bulb surface will effectively drop the bulb temperature. For this purpose, a small blower is satisfactory, but it should be run at low speed to prevent vibration of the 5826 and the associated amplifier equipment. Unless vibration is prevented, distortion of the picture may occur.

Ordinarily, the temperature in a camera equipped with a blower will not exceed 65°C, except in very hot weather or unless the target heater is left on accidentally for a long period.

To keep the operating temperature of the large end of the tube from falling below 45°C, some form of controlled heating should be employed. Ordinarily, adequate heat will be supplied by the focusing coil, deflecting coils, and associated amplifier tubes so that the temperature can be controlled by the amount of cooling air directed along the bulb surface. If, in special cases, a target heater is required, it should fit snugly between the focusing coil and the bulb near the shoulder of the tube. Such a target heater is included in the RCA Deflecting-Coil Assembly.

The *lens system* used with the 5826 should be designed according to basic optical principles and should incorporate an iris to control the amount of light entering the television camera lens. Because of the relatively small face diameter of the 5826, the use of a telephoto lens is facilitated. The lens holder should have all inside surfaces finished in matte black to prevent internal reflections from reaching the photocathode. Under almost all conditions, the use of a lens shade is beneficial.

A *mask* having a diagonal or diameter of 1.6 inches should always be used on the photocathode to set limits for the maximum size of scan, and to reduce the amount of light reaching unused parts of the photocathode.

For the *high dc voltages* required by the 5826, the use of two pulse supplies for which the plate voltage is provided by a well-regulated, 330-volt, B-supply may be used. Each of these supplies should be actuated by the horizontal driving pulse which is obtained from the synchronizing generator. One of the pulse supplies should be capable of furnishing 1250 volts with an output current of 1 milliampere for the multiplier section; the other pulse supply should be capable of furnishing -500 volts with an output current of 1 milliampere for the image section. In addition to supplying the plate voltage and current for the pulse supplies, the 330-volt

LEGEND FOR FIG. 2

C1 C2: 0.05 μf, 1600 v working voltage
C3: 0.01 μf mica, 1600 v working voltage
C4: 0.001 μf mica, 1000 v working voltage
C5: 0.001 μf mica, 600 v working voltage
C6: 0.03 μf mineral-oil impregnated, 1600 v working voltage
C7 C8 C9 C11 C12 C13 C14: 0.001 μf mica, 400 v working voltage
C10: 1 μf, 400 v working voltage
R1: 47000 ohms, 1/2 watt
R2 R3 R4: 220000 ohms, 1/2 watt
R5: 270000 ohms, 1/2 watt
R6: 100 ohms, 1/2 watt, wire wound
R7: 20 ohms, 1 watt, wire wound
R8: 2500 ohms, 25 watts
R9: 750 ohms, 10 watts
R10: 5100 ohms, 1/2 watt
R11: 51000 ohms, 2 watts
R12: 510 ohms, 1/2 watt
R13: 150000-ohm potentiometer, 1/2 watt
R14: 820000 ohms, 1/2 watt
R15: 100000-ohm potentiometer, 1 watt
R16: 150000 ohms, 1/2 watt
R17: 100000-ohm potentiometer, 1 watt
R18: 56000 ohms, 1/2 watt
R19 R20 R21: 20000 ohms, 1/2 watt
R22: 250000-ohm potentiometer, 1 watt
R23: 180000 ohms, 1/2 watt
R24: 390000 ohms, 1/2 watt
R25: 11000 ohms, 1/2 watt
R26: 500000-ohm potentiometer, 1 watt
R27: 110000 ohms, 1/2 watt
R28: 560000 ohms, 1/2 watt
R29: 47000 ohms, 1/2 watt
R30: 20000 ohms, 1/2 watt
R31 R32: 100000 ohms, 1/2 watt
R33 R34 R36 R37 R39 R40 R41 R42 R43: 200000 ohms, 1/2 watt
R35: 50000 ohms, 1/2 watt
R38: 100000 ohms, 1/2 watt

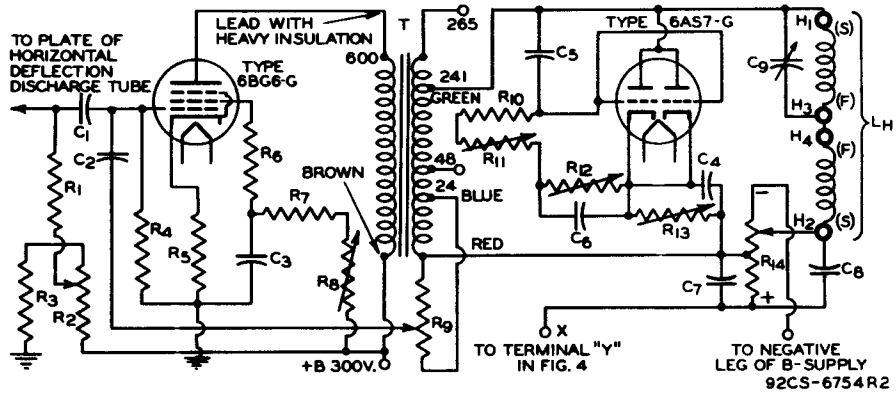
B-supply should also provide an output current of 90 milliamperes for the focusing and alignment coils and for the voltage divider which is used to supply the voltages for the electrodes in the scanning section of the 5826.

Voltage dividers to provide the required operating voltages for the various electrodes of the 5826 are shown in Fig.2. It is to be noted that the blocking capacitor C_6 should be of the mineral-oil impregnated type to minimize capacitor leakage which will introduce disturbing effects into the picture.

In designing a voltage divider for the multiplier stages of the 5826, engineers should recognize that the dc output of individual 5826's of the multiplier as the beam current is increased. This current reversal will also produce a sharp drop in the ac output of the tube. To prevent such current reversal, it is recommended that provision be made to reduce the overall multiplier voltage for tubes with dc outputs at the upper end of the range. A reduction to 1000 volts should be adequate.

A *horizontal deflection circuit* for use with the 5826 is shown in Fig.3; and a *vertical deflection circuit* in Fig.4.

The *video amplifier* should be designed to cover a range of ac signal voltages corresponding to signal-output current of 3 to 30 microamperes in the load resistor (R_{30} in Fig.2).



C1: 0.01 μf
C2: 150 μμf
C3 C4: 4 μf
C5: 30 μμf
C6: 0.02 μf
C7 C8: 100 μf
C9: Balancing Capacitor, 10 to 40 μμf
LH: Horizontal Deflecting Coils: Terminals H1, H2, H3, and H4 on Deflecting-Coil Assembly, RCA Type No.201D75. LH has inductance of 5.5 mh and dc resistance of 19 ohms.
R1: 1 megohm
R2: Sawtooth Amplitude and Linearity Control, 250000 ohms
R3 R4: 250000 ohms
R5: 100 ohms, 2 watts
R6: 100 ohms
R7: 3000 ohms, 2 watts
R8: 10000 ohms, 2 watts. Value should be such that screen input of the 6BG6-G will not be exceeded.
R9: Peaking Amplitude and Linearity Control, 5000 ohms
R10: 50000 ohms, 1 watt
R11: Linearity Control, 250000 ohms
R12: Linearity Control, 100000 ohms
R13: Linearity Control, 500 ohms, 5 watts
R14: Centering Control, 10 ohms tapped at 5 ohms
T: Horizontal Deflection Output Transformer, RCA Type No.204T1. DC resistance of used portion of secondary is 3.4 ohms.

Fig.3 - Horizontal Deflection Circuit for Type 5826.

may have a range of 10 to 1. This range, therefore, must be considered in the choice of bleeder-resistor values. If the values are too high, the distribution of voltages applied to the dynodes will be upset by a 5826 with a dc output at the upper end of the range. As a result, there will be an abrupt drop in the ac output of the tube as the beam current is increased. When this drop occurs before the beam is at its optimum value, the ratio of signal to noise will be lessened.

Even with satisfactory bleeder-resistor values, it is possible to overload the tube itself. For 5826's having high dc outputs, a current reversal can occur at the 5th dynode stage

APPLICATION

Resolution of better than 500 lines at the center of the picture can be produced by the 5826 when the photocathode highlight illumination from an RMA Standard Test Chart is above the knee of the curve in Fig.5. This value of resolution is that obtained after optimum adjustments have been made to minimize the prominence of beat patterns and dynode spots.

A beat pattern is caused by the beating of the scanning lines against the lines of the target mesh. As a result, a moiré pattern, sometimes called a "swirl", appears in large-area highlights of the picture. Besides defocusing of the beam

by adjustment of the beam-focus control (grid No.4), a slight change in the vertical or horizontal size controls of the camera may be helpful in reducing the beat-pattern effect.

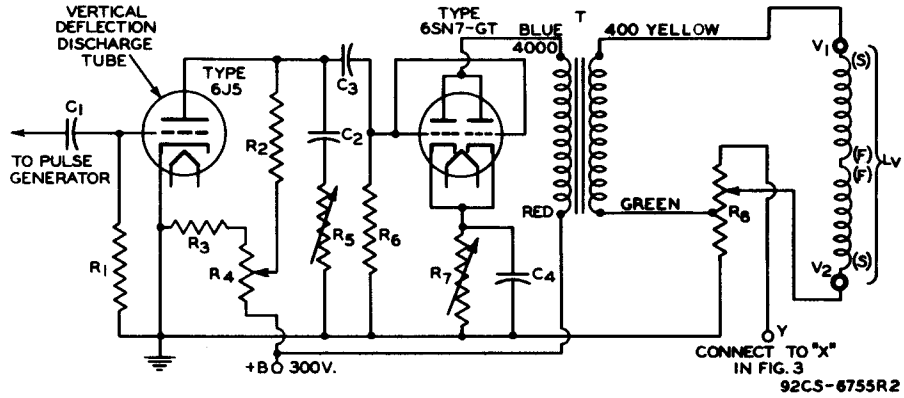
A dynode spot is caused by a slight blemish on a dynode surface and appears as a white spot chiefly in the dark areas of the picture. Little defocusing of the beam is required to minimize the effect of dynode spots when the scene is brightly illuminated, but in dark scenes, the effect of dynode spots is a limiting item on resolution.

To utilize the resolution capability of the 5826 in the horizontal direction with the standard scanning rate of 525 lines, it is necessary to use a video amplifier having a bandwidth of at least 6 megacycles. The maximum resolution obtainable is limited by the mesh-screen portion of the target.

Even with a wide-band amplifier, the resolution may be limited by "cross talk" caused by the scanning fields. Unless prevented by proper shielding from extending into the image section, these fields will cause the electron image on the target to move at scanning frequency. As a result, the picture will lack definition.

Proper shielding will be provided by a shield which employs seven separate layers of silicon-steel strips (0.007" thick and 1/2" wide) applied to the outside of the focusing coil as follows: First, wrap a single insulating layer of 0.005" thick motor paper around the focusing coil; then, wrap two turns, one above the other of the silicon-steel strip repeating the operation to fill the entire focusing-coil length but allowing 1/64" between each successive 2-turn section, to insure electrical insulation. Second, wrap a second insulating layer of motor paper and repeat the silicon-steel strip operation but space the 2-turn sections so that each is directly over a 1/64" insulating space of the previous layer. Operations 1 and 2 are repeated to provide 7 layers of shielding. The entire assembly is completed with a final wrap of motor paper. A convenient method for handling the 2-turn strip sections is to cut the strips just long enough to take care of two turns. Each 2-turn section is, of course, completely independent of any other section.

If equipment space will not accommodate the full seven layers of shielding as described above, fewer layers can be used, but will be less effective in minimizing "cross talk".



C1: 0.1 μf
C2: 0.05 μf
C3: 1 μf
C4: 1000 μf
LV: Vertical Deflecting Coils: Terminals V1 and V2 on Deflecting Coil Assembly, RCA Type No.201D75. LV has inductance of 28.3 mh and dc resistance of 34 ohms.
R1: 1 megohm
R2: 5 megohms
R3: 100000 ohms
R4: Sawtooth Amplitude Control, 250000 ohms
R5: Peaking Amplitude Control, 25000 ohms
R6: 500000 ohms
R7: Linearity Control, 5000 ohms
R8: Centering Control, 10 ohms tapped at 5 ohms
T: Vertical Deflection Output Transformer, RCA Type No.204T2. DC resistance of secondary is 6.9 ohms.

Fig.4 - Vertical Deflection Circuit for Type 5826.

The *sequence of adjustments* in operating the 5826 is as follows: After the tube has been inserted in its sockets and the voltages applied as indicated under Typical Operation, allow it to warm up for 1/2 to 1 hour with the camera lens iris closed. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the target. Adjust the deflection circuits so that the beam will "overscan" the target, i.e., so that the area of the target scanned is greater than its sensitive area. This procedure during the warming-up period is recommended to prevent burning on the target a raster smaller than that used for on-the-air operation. Note that overscanning the target results in a smaller-than-normal picture on the

monitor. Then open the iris partially and focus the scene to be televised on the photocathode. Next, adjust the grid-No.1 voltage until a picture or noise appears on the monitor screen. If there is no picture, rotate the alignment coil and adjust the current through it until the maximum picture response is obtained. An occasional tube may require very little or no current through the alignment coil. Correct alignment is obtained when the picture does not rotate as the beam-focus control (grid No.4) is varied. Proper alignment may also be checked even more critically than by the above procedure by observing on the monitor any "dynode spots" resulting from small imperfections in the dynode surfaces. The spots appear as small white areas of various shapes, and can best be observed with no light on the photocathode. With proper alignment, the dynode spots do not rotate when the beam-focus control (grid No.4) is varied, but simply go in and out of focus. During alignment of the beam, and during operation of the tube, always keep the beam current as low as possible to give the best picture quality. Adjust the beam-current control to give only enough beam current to hold down the highlights. Next, adjust grid-No.1 voltage and the target voltage for the best picture. Then, bring the picture into focus by varying the voltage on grid No.4 and on the photocathode. Next, vary the voltage on grid No.3 to give the most uniformly shaded picture at approximately maximum signal. Final adjustment is made by varying the voltages on grids No.5 and No.6. In general, these need little adjustment and are varied only after completing the other adjustments. When camera is used for rehearsal, the scanning may be restored nearly to normal size. Complete restoration should be made just prior to air-time.

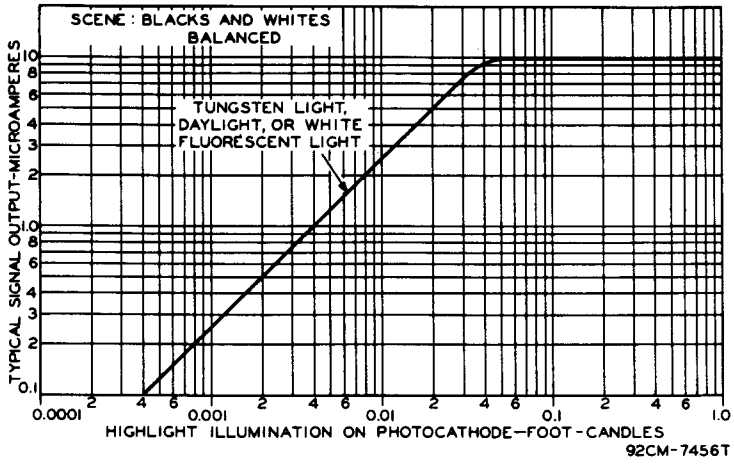


Fig.5 - Typical Signal Output of Type 5826.

Full-size scanning of the target should always be used during on-the-air operation. Full-size scanning can be assured by first adjusting the deflection circuits to overscan the target sufficiently to cause the corners of the target to be visible in the picture, and then reducing the scanning until the corners just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. Full-size scanning will also reduce the prominence of a beat pattern (see *Resolution*). As indicated previously, overscanning the target produces a smaller-than-normal picture on the monitor.

Underscanning the target, i.e., scanning an area of the target less than its sensitive area, should never be permitted. Underscanning produces a larger-than normal picture on the monitor. If the target is underscanned for any length of time, a permanent change of target cutoff voltage of the underscanned area takes place with the result that the underscanned area thenceforth is visible in the picture when full-size scanning is restored.

The *target voltage* will depend on the type of scene to be televised and should be adjusted simultaneously with the beam-current control to obtain the best signal-to-noise ratio and gray-scale reproduction. If the scene has a large range of illumination, the target should be operated at about 1.5 to 2 volts above cutoff so that highlights will not bloom. For scenes with a lower range of illumination, the target can be operated at or a little over 2 volts above cutoff with resultant gain in signal-to-noise ratio, and improved detail in the shadows.

A *blanking signal* should be supplied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must be constant to prevent fluctuation of the target voltage. During the blanking periods, the full beam current without video-signal modulation is returned to the multiplier and its multiplied output flows through the load resistance.

Shading may be required even with optimum adjustment of voltage on grid No.3 in order to obtain a uniformly shaded picture. A shading signal having a sawtooth shape, a frequency equal to the horizontal scanning frequency, and an amplitude about twice that of the useful video signal, is recommended. Provision should be made for controlling the amplitude of the shading signal and for reversing its polarity. The signal may be introduced into the video channel after the pre-amplifier in the camera but ahead

of the master gain control. With this arrangement, changing the gain-control setting does not change the ratio of the shading-signal amplitude to the video-signal amplitude.

The *illumination* on the photocathode is related to the scene illumination by the formula

$$I_s = \frac{4f^2\ I_{pc}\ (m+1)^2}{TR}$$

where

I_s = scene illumination in foot-candles

f = f-number of lens

I_{pc} = photocathode illumination in foot-candles

m = linear magnification from scene to target

T = total transmission of lens

R = reflectance of principal subject in scene.

Except for very close shots, the linear magnification (m) from scene to target may be neglected.

For example, assume that the lens is f:3.5 having a transmission (T) of 75%, that the photocathode illumination is 0.06 foot-candle, and that the scene to be televised is composed largely of whites and blacks (such as a test chart) where the reflectance (R) may be in the order of 50%. Then,

$$I_s = \frac{4 \times 3.5^2 \times 0.06}{0.75 \times 0.50} = 8 \text{ foot-candles}$$

For average scenes where the principal subject has a reflectance of 5 to 10%, the incident illumination should have a value of 30 to 40 foot-candles.

It is good practice before attempting to transmit a particular scene to check its incident illumination with an illuminating-measuring device, such as an exposure meter. It is recommended that the average incident light level be greater than approximately 30 foot-candles for a good picture.

Typical signal output of the 5826 as a function of the highlight illumination on the photocathode under conditions where the televised scene has balanced blacks and whites for each of three types of illumination, is shown by the curve in Fig.5.

For the most natural appearance of televised subjects or scenes, it is recommended that the 5826 be operated so that the highlights on the photocathode bring the signal output slightly over the knee of the signal-output curve for the particular type of illumination utilized. Operation further along on the horizontal part of the curve will give pictures in which the subject has an over-emphasized outline. The position of the knee will shift for individual tubes. The knee may occur at values of highlight illumination on the photocathode ranging from about 0.03 to 0.05 foot-candle.

The *spectral response* of the 5826 is not subject to appreciable variation from tube to tube. The spectral response of the 5826 without correcting filter is shown by curve A in Fig.6. Curve B in this same figure, shows the spectral response when a Wratten No.6 filter is used with the 5826. This curve very closely approaches that of the eye shown by the dotted curve C. Use of the filter, which can be obtained with lens-adapter ring at photographic-supply stores, results in a loss of sensitivity by about 2 to 1.

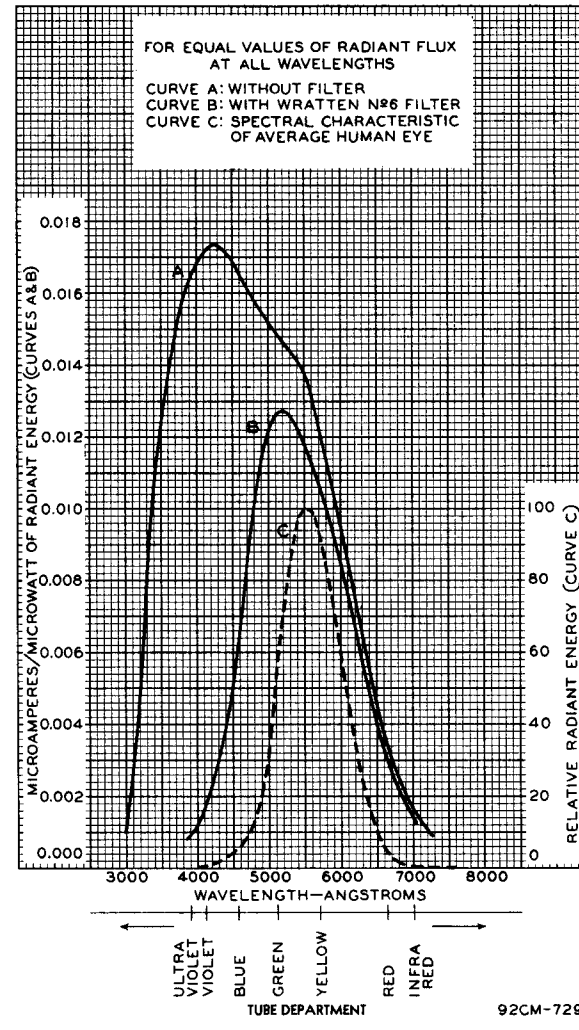


Fig.6 - Spectral Sensitivity Characteristic of Type 5826 With and Without Filter.

Retention of a scene by the 5826, sometimes called a "sticking picture", may be experienced if the 5826 is allowed to remain focused on a stationary bright scene for several minutes, or if it is focused on a bright scene before reaching operating temperature in the range from 45° to 60°C. Often the retained image will disappear in a few seconds, but sometimes it may persist for long periods before it completely disappears.

A retained image can generally be removed by focusing the 5826 on a clear white screen, and allowing the 5826 to operate for several hours with an illumination of about 1 foot-candle on the photocathode. This value is equivalent to 50 to 100 foot-candles on the screen with an f:2.8 lens.

To avoid retention of a scene, it is recommended that the 5826 always be allowed to warm up in the camera for 1/2 to 1 hour with the lens iris closed, and that the 5826 never be allowed to remain focused on a stationary bright scene for more than a few minutes. Never use more illumination than is necessary. If a target heater is used, the warm-up time can be reduced to approximately 10 or 15 minutes.

Failure of scanning even for a few minutes when light is incident on the photocathode may permanently damage the surface of the target. The damaged area shows up as a spot or line in the picture during subsequent operation.

To avoid damaging the 5826 during scanning failure, provision should be made to prevent automatically the scanning beam from reaching the target. The scanning beam can be prevented from reaching the target by (1) cutting off the scanning beam, or (2) making the target sufficiently negative. The scanning beam can be cut off by a relay which applies -115 to -125 volts bias to grid No.1. The target can be made sufficiently negative by a relay which applies a bias of at least -10 volts to it. Either relay is actuated by a tube which is controlled by a portion of the scanning pulse voltage developed across either the horizontal or the vertical deflecting coils, or both. It is important to insure that the horizontal scanning pulse and the vertical scanning pulse should each independently actuate the relay in case either one fails.

Rotation in the use of 5826's is recommended. After a 5826 is operated for 200 to 300 hours, it should be given an idle period of three or four weeks during which it generally will recover much of its original resolution and sensitivity.

New 5826's should be placed in service immediately upon receipt. They should be operated for several hours before being set aside as spares.

Spare tubes should be placed in service for several hours at least once a month in order to keep them free from traces of gas which may be liberated within the tube during prolonged storage.

Occasionally, a *white spot* which does not change in size when the beam focus voltage is varied, may be observed in the center of the picture. Such a spot, especially if it is visible on the monitor with the camera lens capped, is probably an ion spot. If the spot begins to grow in size with continuous operation of the 5826, the 5826 should be removed from service at once, and returned for re-processing. Continued operation of an image orthicon with an ion spot will eventually damage the target permanently.

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R.B. Janes, R.E. Johnson, and R.S. Moore, *"Design and Performance of Television Camera Tubes,"* RCA Review, June, 1949.

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DOS and DON'TS on Use of RCA-5826

Here are the "dos"--

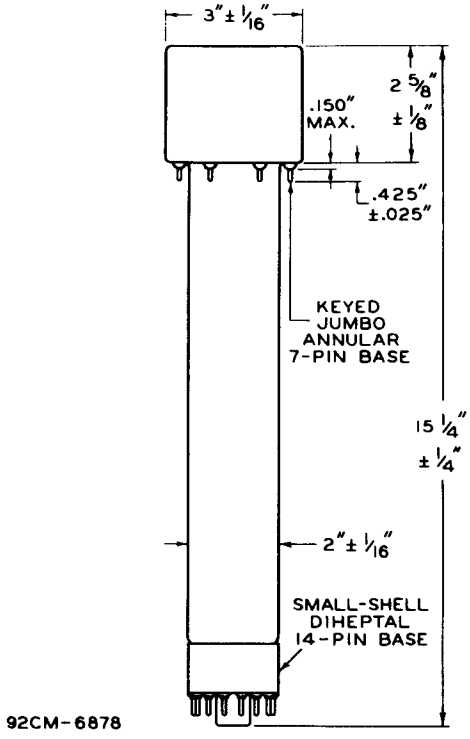
1. Allow the 5826 to warm up prior to operation.
2. Hold temperature of the 5826 within operating range.
3. Make sure alignment coil is properly aligned.
4. Check scene illumination before televising.
5. Select lens stop for best picture.
6. Use lowest beam current and highest target voltage for best signal-to-noise ratio and gray-scale reproduction.
7. Adjust beam-focus control for best usable resolution.
8. Give the 5826 an idle period every 200 hours.
9. Condition spare 5826's by operating several hours once each month.

Here are the "don'ts"--

1. Don't force the 5826 into its shoulder socket.
2. Don't operate the 5826 without scanning.
3. Don't underscan target.
4. Don't focus the 5826 on a stationary bright scene.
5. Don't operate a 5826 having an ion spot.

The significance of each of the above "dos" and "don'ts" in obtaining optimum performance from the 5826 is explained in the preceding pages of this bulletin.

DIMENSIONAL OUTLINE



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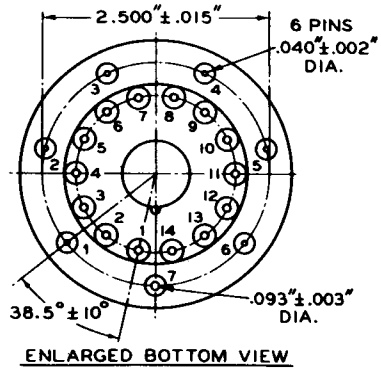
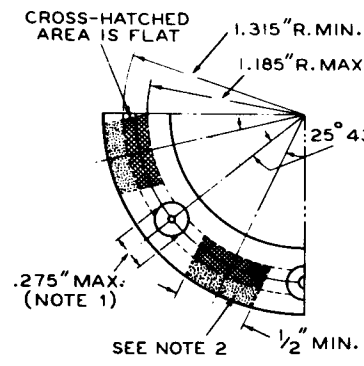


ENLARGED BOTTOM VIEW

DETAIL OF BOTTOM VIEW OF KEYED JUMBO ANNULAR BASE



NOTE 1: MEASURED AT DISTANCE OF 1/32" BELOW BOTTOM OF ANNULAR BASE.

NOTE 2: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.

KEYED ANNULAR BASE GAUGE

ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GAUGE WITH:

a. SIX HOLES HAVING DIAMETER OF 0.065" ± 0.001" AND ONE HOLE HAVING DIAMETER OF 0.150" ± 0.001". ALL HOLES HAVE DEPTH OF 0.265" ± 0.001". THE SIX 0.065" HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047". ALL HOLES ARE SPACED AT ANGLES OF 51°26' ± 5' ON CIRCLE DIAMETER OF 2.500" ± 0.001".

b. SIX STOPS HAVING HEIGHT OF 0.187" ± 0.001", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

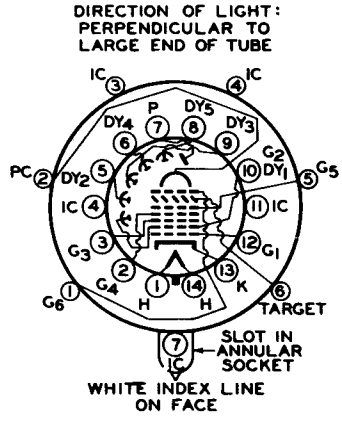
c. RIM EXTENDING OUT A MINIMUM OF 1/8" FROM 2-13/16" DIAMETER AND HAVING HEIGHT OF 0.126" ± 0.001".

d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200" ± 0.001".

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

SOCKET CONNECTIONS

Bottom View



SMALL-SHELL DIHEPTAL 14-PIN BASE

PIN 1: HEATER
PIN 2: GRID No.4
PIN 3: GRID No.3
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: DYNODE No.2
PIN 6: DYNODE No.4
PIN 7: ANODE
PIN 8: DYNODE No.5
PIN 9: DYNODE No.3
PIN 10: DYNODE No.1, GRID No.2
PIN 11: INTERNAL CONNECTION - DO NOT USE
PIN 12: GRID No.1
PIN 13: CATHODE
PIN 14: HEATER

KEYED JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID No.6
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNECTION - DO NOT USE
PIN 4: INTERNAL CONNECTION - DO NOT USE
PIN 5: GRID No.5
PIN 6: TARGET
PIN 7: INTERNAL CONNECTION - DO NOT USE

from RTMA release 841B, March 26, 1951

5831

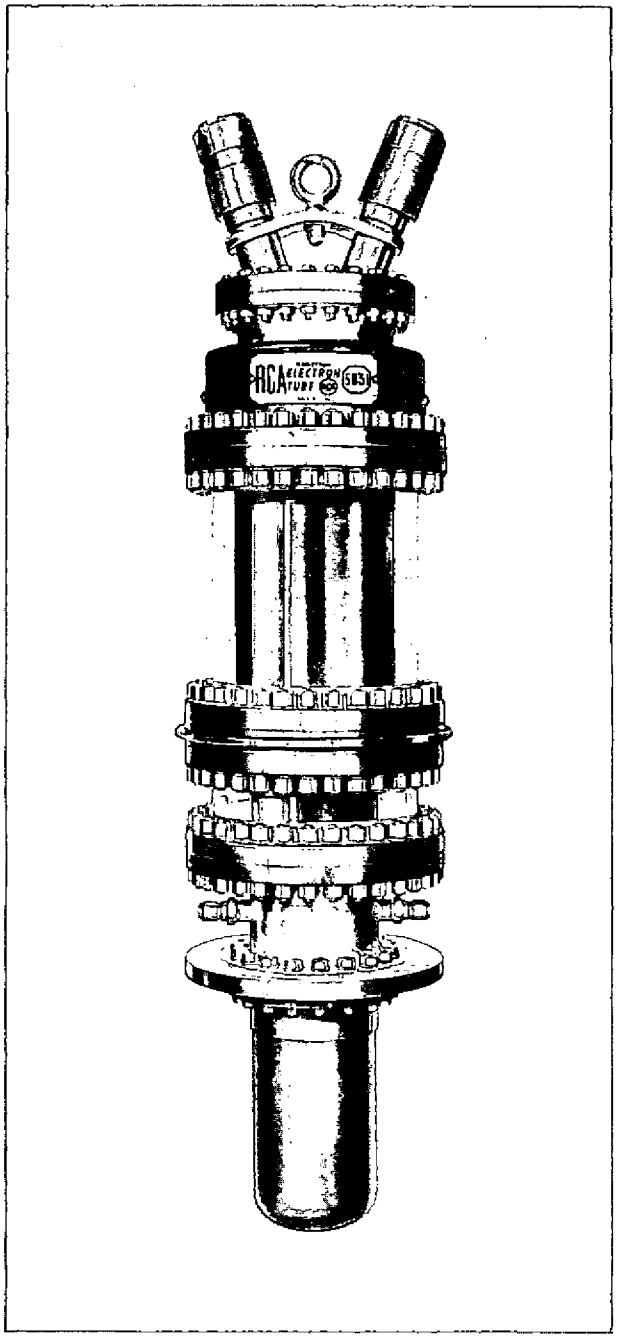
SUPER-POWER BEAM TRIODE

650-Kw Plate Input
Very High Power Sensitivity

Water Cooled

TENTATIVE DATA

150-Kw Plate Dissipation
Thoriated-Tungsten Filament



RCA-5831 is a water-cooled beam triode of unique design capable of generating several hundred kilowatts of power at high efficiency and with exceptionally low driving power. It is intended primarily for use as a class C rf power amplifier, either modulated or unmodulated, but is also useful as a class B af power amplifier and modulator. In unmodulated class C service, the 5831 has a maximum plate voltage rating of 16000 volts, a maximum plate input of 650 kilowatts, and a maximum plate dissipation of 150 kilowatts. It can be operated with maximum rated plate voltage and plate input at frequencies up through the "Standard Broadcast Band" and much higher. The limitations for operation at the higher frequencies and at higher power have not yet been determined but requests for information on specific applications will be welcomed.

The 5831 is unique in that it features a symmetrical array of unit electron-optical systems embodying a mechanical structure which permits close spacing and accurate alignment of the electrodes to a degree unusual in high-power tubes. Ducts for water cooling the plate and the beam-forming cylinder are built in and have simplified hose connections. The grid-terminal flange requires a water-cooled connector. Because of the electron-optical principles incorporated in its design, the 5831 has low grid current and hence requires less than 2 kilowatts of driving power.

Other features of the 5831 include a multi-strand, thoriated-tungsten filament for economical operation as well as high emission capability, low-inductance rf leads and flange terminals, and compactness—features contributing to the overall suitability of the 5831 in high-efficiency, high-power applications.

Copyright, 1950
Radio Corporation of America

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5831-1-51
Photolithographed in U.S.A.

GENERAL DATA

Electrical:

Filament, Multistrand Thoriated Tungsten:		
Voltage (Single-Phase AC)	6	volts
Current	2100	amperes
Starting Current . . Must never exceed 3550 amperes, even momentarily		
Cold Resistance	0.0005	ohm
Minimum Heating Time	60	seconds
Amplification Factor	30	
Direct Interelectrode Capacitances:		
Grid to Plate	125	μμf
Grid to Filament	620	μμf
Plate to Filament	7	μμf

Mechanical:

Mounting Position	Vertical, plate end up
Maximum Overall Length	38-3/4"
Maximum Diameter	9-17/32"
Terminal Connections	See Outline Drawing

Water Cooling:

Water cooling of the beam-forming cylinder, the grid-terminal flange, and the plate is required. The water flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages. Interlocking of the water flow for each of the cooled elements with all power supplies is recommended to prevent tube damage in case of failure of adequate water flow. The use of distilled or deionized water is essential (see text).

Water Flow:	*Min. gpm*	*Pressure Drop@ psi*	*Max. Gauge Pressure* psi*
To Plate:			
For plate dissipation less than 135 kw	40	10	100
For plate dissipation from 135 to 150 kw	60	20	100
To Grid Connector	1	–	–
To Beam-Forming Cylinder	6	20	50

Outlet Water Temperature (Any outlet)	70 max.	°C
Seal Temperature (Plate, grid, or filament)	165 max.	°C
Bulb Temperature (At hottest point)	180 max.	°C

Fittings:

Fittings for the plate and beam-forming-cylinder water connections may be obtained from B-R Engineering Company, 309 East Saratoga Street, Baltimore 2, Maryland, U.S.A.

AF POWER AMPLIFIER and MODULATOR—Class B

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	10500 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	30 max.	amp
MAX.-SIGNAL PLATE INPUT**	300 max.	kw
PLATE DISSIPATION**	135 max.	kw

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	10000	volts
DC Grid Voltage	-390	volts
Peak AF Grid-to-Grid Voltage	1800	volts
Zero-Signal DC Plate Current	6	amp
Max.-Signal DC Plate Current	57	amp
Effective Load Resistance (Plate to plate)	425	ohms
Max.-Signal Driving Power (Approx.)▲	800	watts
Max.-Signal Power Output (Approx.)	370	kw

PLATE-MODULATED RF POWER AMP.—Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	10500 max.	volts
DC GRID VOLTAGE	-2000 max.	volts
DC PLATE CURRENT	25 max.	amp
DC GRID CURRENT	1.5 max.	amp
PLATE INPUT	250 max.	kw
PLATE DISSIPATION	135 max.	kw

Typical Operation:

DC Plate Voltage	10000	volts
DC Grid Voltage#	-1000	volts
Peak RF Grid Voltage	2000	volts
DC Plate Current	21.9	amp
DC Grid Current (Approx.)	0.5	amp
Driving Power (Approx.)	900	watts
Power Output (Approx.)	175	kw

RF POWER AMPLIFIER and OSC.—Class C Telegraphy

Key-down conditions per tube without amplitude modulation■■

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	16000 max.	volts
DC GRID VOLTAGE	-2000 max.	volts
DC PLATE CURRENT	41 max.	amp
DC GRID CURRENT	1.5 max.	amp
PLATE INPUT	650 max.	kw
PLATE DISSIPATION	150 max.	kw

Typical Operation:

DC Plate Voltage	11500	16000	volts
DC Grid Voltage#	-825	-925	volts
Peak RF Grid Voltage	1650	2000	volts
DC Plate Current	33	39	amp
DC Grid Current (Approx.)	0.65	0.5	amp
Driving Power (Approx.)	1200	900	watts
Power Output (Approx.)	300	500	kw

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Filament Current	1	1950	2250	amp
Amplification Factor	1,2	26	34	
Grid-Plate Capacitance	–	100	150	μμf
Grid-Filament Capacitance	–	500	740	μμf
Plate-Filament Capacitance	–	5	9	μμf

Note 1: With 6.0 volts ac on filament.

Note 2: With dc grid voltage of -50 volts, and with plate voltage adjusted to give dc plate current of 10 amperes.

@ Approximate pressure drop directly across cooled element for the indicated minimum flow.

* At tube inlets.

● Continuous Commercial Service.

** Averaged over any audio-frequency cycle of sine-wave form.

▲ The driving stage should have good regulation and should be capable of supplying considerably more than the indicated value which is the power absorbed by the grid and grid-bias source and does not include circuit losses.

Obtained by grid resistor or by partial self-bias methods.

■■ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

♦ Obtained from fixed supply for amplifier service, or from adjustable grid resistor for oscillator service.

GENERAL CONSIDERATIONS

Each 5831 is thoroughly tested before shipment. However, to insure that the tube has not been damaged in transit, it should be tested (see "Break-In" Treatment) upon receipt in the equipment in which it is to be used. Should there be any evidence of damage in transit, a "bad order" report should immediately be filed with the transportation company.

The *serial number* which identifies each individual 5831 and which should be used in any correspondence concerning the tube, is stamped on the plate structure inside the glass envelope, as indicated on the Outline Drawing.

In *handling* the 5831, care should be taken to prevent damage to the metal-to-glass seals and other parts. *Never allow the tube to rest on the exhaust-tube cover (see Outline Drawing).* A hoisting ring at the plate end of the tube is provided to facilitate lifting the tube with the aid of a suitable hoist, either when the tube is being installed in its equipment or being removed therefrom. The weight of the 5831 crated for shipment is approximately 300 pounds; uncrated, approximately 135 pounds.

During *storage*, the 5831 should be kept in its container with the plate end up and should be protected from moisture and extreme temperature changes. Before a 5831 is placed in storage or shipped, it should be tipped so that the water can be poured out of its cooling ducts and then should be blown free of any remaining water. Removing all water prevents the possibility of freezing during cold weather and of voltaic action in the ducts with resultant corrosion. Care should be taken to prevent any foreign matter from entering the water-cooling connections. As a safeguard, it is recommended that during storage each of the four water-cooling connections be covered with Pliofilm, or equivalent, and then sealed.

As in the case of all large power tubes, no 5831 should remain in storage for more than 3 months. It should be operated in rotation with other 5831's in order to keep it free from traces of gas which may be liberated during prolonged storage. This procedure of rotating 5831's in service will insure that only good tubes are carried in stock.

Tube cleanliness is an important consideration. As with other high-voltage equipment, it is essential that the glass bulb and other external parts of the 5831 be kept free from accumulated dirt to minimize surface leakage and the possibility of arc-over. Make it a regular practice to wipe dirt from the glass bulb and other external parts of the tube about twice a month or more frequently if necessary to keep the tube clean.

INSTALLATION

Mounting of the 5831 requires the use of a suitable socket at the filament end of the tube. The socket should support the tube in a vertical position with the plate end up. Because of the low-voltage, high-current filament, it is recommended that the socket be an integral part of the filament transformer so that the filament connectors can be kept short and the voltage drop in them minimized. The connector for the cylindrical terminal of the filament should be of the spring-pressure-contact type, while the connector for the flange terminal of the filament may be of the clamp type.

Provision should be made to prevent subjecting the 5831 to appreciable vibration.

Connection to the grid-terminal flange should be made by a water-cooled connector, as shown in Fig. 1, in intimate thermal contact with the grid-terminal flange. Each bolt should be adequately tightened so that its copper finger makes intimate contact with the grid-terminal flange.

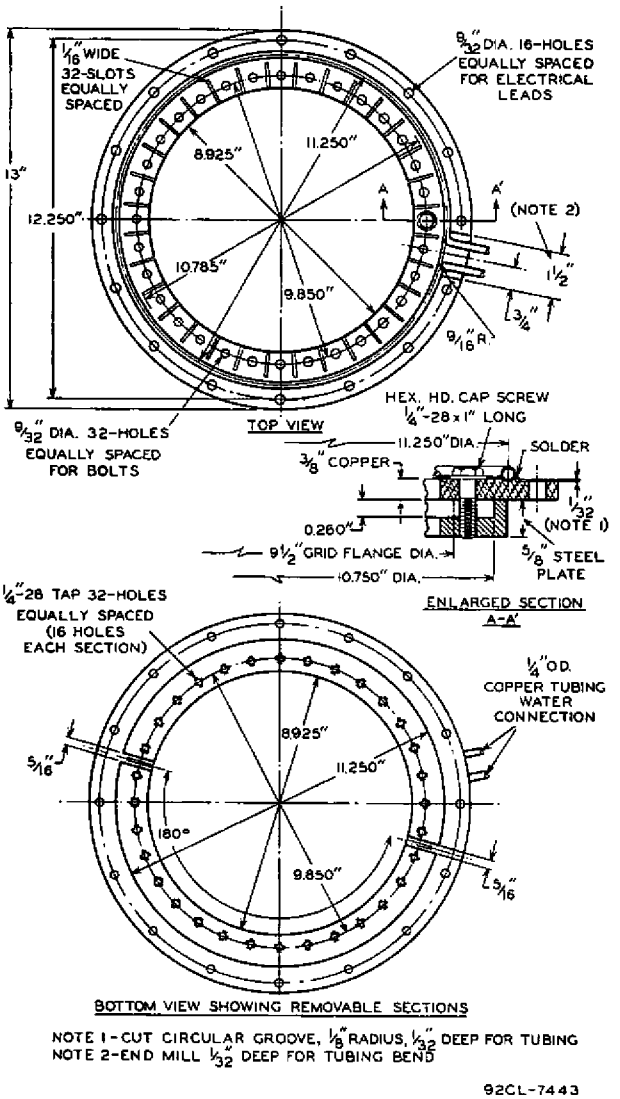


Fig. 1 - Details of Water-Cooled Grid-Flange Connector.

Connection to the plate-terminal flange should be made by a band-type clamp or a system of fingers bearing on the cylindrical surface of the flange (see Outline Drawing).

When connecting or disconnecting the water hoses and the electrical connections to the 5831, it is essential that no strain be placed on the seals. The installation of all con-

nections must be made so that they are flexible and will not be close to or touch the bulb. This precaution is necessary to avoid almost certain puncture of the glass from corona discharge.

The *water-cooling system* consists, in general, of a source of cooling water, a feed-pipe system which carries water through flexible hoses to the beam-forming cylinder, the grid-flange connector, and the plate, and provision for interlocking the water flow through each of these cooled elements with the power supplies. It is essential in making water connections that the direction of water flow through the tube be in the direction indicated by markings at the water connections. When the plate is at high potential above ground, the feed-pipe system should have good insulating qualities and proper design to reduce leakage current to a negligible value.

It is recommended that the water-cooling system be of the closed type utilizing distilled or deionized water to prevent the possibility of scale formation and corrosion, both of which can be expected with tap water. Scale not only restricts water flow but prevents proper transfer of heat from the cooled elements to the cooling water, while corrosion may damage the elements and ducts. The rate of scale formation and corrosion depends on the electrical conductivity of the cooling water. To prevent the possibility of scale formation and corrosion, the use of water having an initial resistance of at least 100,000 ohms per cubic centimeter is recommended. Since a very small amount of contamination can change appreciably the conductivity of distilled water, frequent measurement of its resistance is desirable. The water should be changed when its resistance falls below 20,000 ohms per cubic centimeter.

Lack of corrosion at the positive end of a hose and no deposit at the negative end are good indications of a clean water system.

The use of a filter in the water-supply line to the tube is essential in order to trap any foreign particles likely to impair the water flow through the ducts. It is suggested that a filter with an 100-mesh screen (0.005" openings) be used. The filter should be taken care of according to the manufacturer's instructions. Clean the filter as often as conditions require so that the water flow will always be adequate.

Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water flow will damage the 5831. In fact, without cooling water, the heat of the filament alone is sufficient to cause serious harm. It is essential, therefore, to keep the water-flow interlocks in proper adjustment as prescribed by the equipment manufacturer. They should never be set to operate below the recommended level.

The water flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages. Specific flow data are given in the tabulated data. Under no circumstances should the temperature of the water from any outlet ever exceed 70°C.

An approximate value of the plate dissipation, which should not exceed the value shown under Maximum Ratings for each type of service in the tabulated data, may be calculated from the water-flow conditions by the use of the following equation:

$$P_{kw} = n\,(t_o - t_i) \,/\, 4$$

in which t_i is the temperature of the cooling water at the inlet in degrees Centigrade, t_o is the temperature of the water at the outlet in degrees Centigrade, and n is the number of gallons per minute of flow.

The *thoriated-tungsten filament* in the 5831 is of the multistrand type and is designed for single-phase ac operation. Each individual strand is recessed in a slot in a beam-forming cylinder through which water is circulated. The filament connectors, as described under *Mounting*, should make firm, large-surface contact. If the filament terminals of the tube become discolored, they should be cleaned with fine emery cloth and then wiped clean.

The filament of the 5831 should be operated at rated voltage within ± 0.3 volt and must be allowed to reach normal operating temperature before plate voltage is applied. The filament heating time is about 60 seconds depending on the type of filament starter employed. A suitable voltmeter should be permanently connected across the filament terminals directly at the tube so that the filament voltage will always be known.

A *filament starter* should be used to raise the filament voltage gradually in order to limit the high initial surge of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance or reactance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the filament current never exceed, even momentarily, a value of 3550 amperes.

Overheating of the 5831 by severe overload may decrease the filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for 30 minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 7.2 volts (not higher) for a few minutes.

Circuit returns from the plate and from the grid should be made to the cathode terminal flange which is connected within the tube to one side of the filament as shown in the *tube symbol*. *Connection to the cathode-terminal flange* should

be made by a band-type clamp or a system of fingers bearing on the cylindrical surface of the flange (see Outline Drawing).

A *time-delay relay* should be provided in the plate-supply circuit to delay application of plate voltage until the filament has reached normal operating temperature.

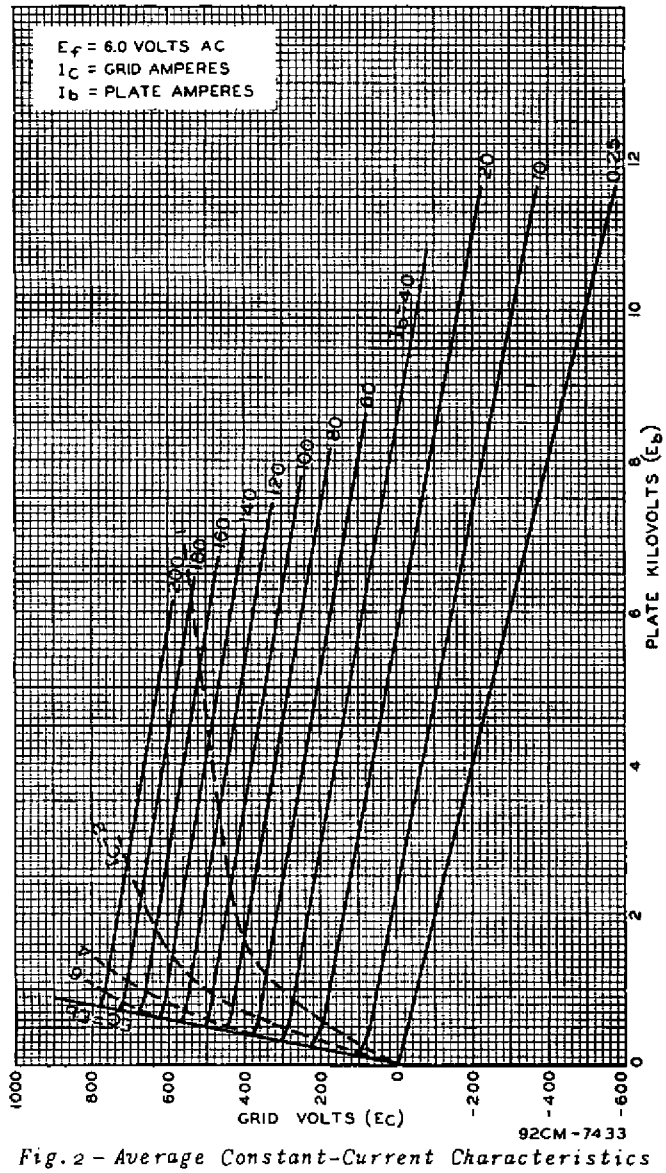


Fig. 2 – Average Constant-Current Characteristics of Type 5831.

A *high-speed, electronic protective device* must be used to remove the plate voltage in the event of abnormal operation such as internal arcing. In addition, the grid circuit should be provided with overload relays which will act to remove within a period of 0.1 second all grid power in the event of excessive grid-current flow. The protective device employed to remove the plate voltage in any installation must be approved by the RCA Tube Department. Details concerning a high-speed, electronic protective device for removal of plate voltage may be obtained on request to Commercial Engineering, RCA, Harrison, N.J.

The *temperature of the seals and of the bulb* should not exceed 165°C and 180°C, respectively, at the hottest point. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York 11, N.Y. in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of 1 per cent. Glass heating caused by thermal radiation from the electrodes is negligible.

The following *"break-in" treatment* should be given to a new 5831 before it is placed in service or set aside as a spare, or to a 5831 after it has been in prolonged storage. The treatment should preferably be given in the rf power amplifier.

Step 1: Make sure that the water-cooling system and protective devices are functioning properly.

Step 2: With no other voltages on tube, apply voltage to the filament in the normal manner and operate at 6 volts for 30 minutes.

Step 3: Apply normal grid bias and grid drive.

Step 4: Apply approximately 50 per cent of normal plate voltage and operate the tube for several minutes or until stable performance is obtained.

CAUTION: During this step, it is particularly important that the high-speed, electronic protective device be functioning properly to protect against any abnormal condition.

Step 5: Raise the plate voltage in steps if possible until the desired operating condition is achieved.

After giving the 5831 the above treatment and after it is operating normally to give the desired output, it is suggested that the readings of the meters and flow indicators as well as the control settings be logged, especially when the tube is to be set aside as a spare. Then, in the event of an emergency tube change, the tube can be put in service quickly.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube and associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooling water or the glass bulb, the plate voltage may be raised in steps to the desired value. Adjustments should be made at each step for optimum operation.

The rated plate voltage of the 5831 is extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The

tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the plate supply and the grid supply when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

APPLICATION

The *maximum ratings* in the tabulated data for the 5831 are limiting values above which the serviceability of the 5831 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute value will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 5831 may be operated with maximum rated plate voltage and plate input at frequencies up through the "Standard Broadcast Band" and much higher. The limitations for operation at the higher frequencies have not yet been determined. If operation of the 5831 is contemplated at a higher frequency, write for operating recommendations to Commercial Engineering, RCA, Harrison, N.J., giving complete details as to the proposed service.

In *class B modulator or af service*, the 5831 should be operated with grid bias obtained from a dc voltage source of good regulation. Each grid circuit should be provided with a separate bias adjustment to balance the grid and plate currents.

In *plate-modulated class C rf amplifier service*, the 5831 should be supplied with bias from a grid resistor, or from a suitable combination of grid resistor and fixed supply. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply voltage compensation.

In *class C rf telegraph service*, the 5831 should be supplied with bias obtained from a fixed supply for amplifier service, or from an adjustable grid resistor for oscillator service. Variation of dc grid current between individual tubes requires provision for adjustment of the grid resistor to obtain the desired total bias for each tube.

When the 5831 is used in either *class C telephony or telegraphy service*, the grid current and driving power required to obtain the desired power output will vary with the plate loading. If the plate circuit presents a relatively low resistance to the tube, the desired output can be obtained with relatively low grid current and driving power, but plate-circuit efficiency is sacrificed. Conversely, if the tube operates into a relatively high-load resistance, the plate-circuit efficiency will be high, but relatively high grid current and driving power are required to obtain the desired output. In practice, a compromise must be made between these extremes. The typical operating conditions given in the tabulated data represent conditions which will give good plate-circuit efficiency with reasonable driving power.

Because the 5831 requires unusually low grid drive, some care must be exercised to avoid excessive electronic drive power to the grid. Under no circumstances should the product of the dc grid current in amperes and the difference between peak rf voltage and grid bias in volts ever exceed a value of 450.

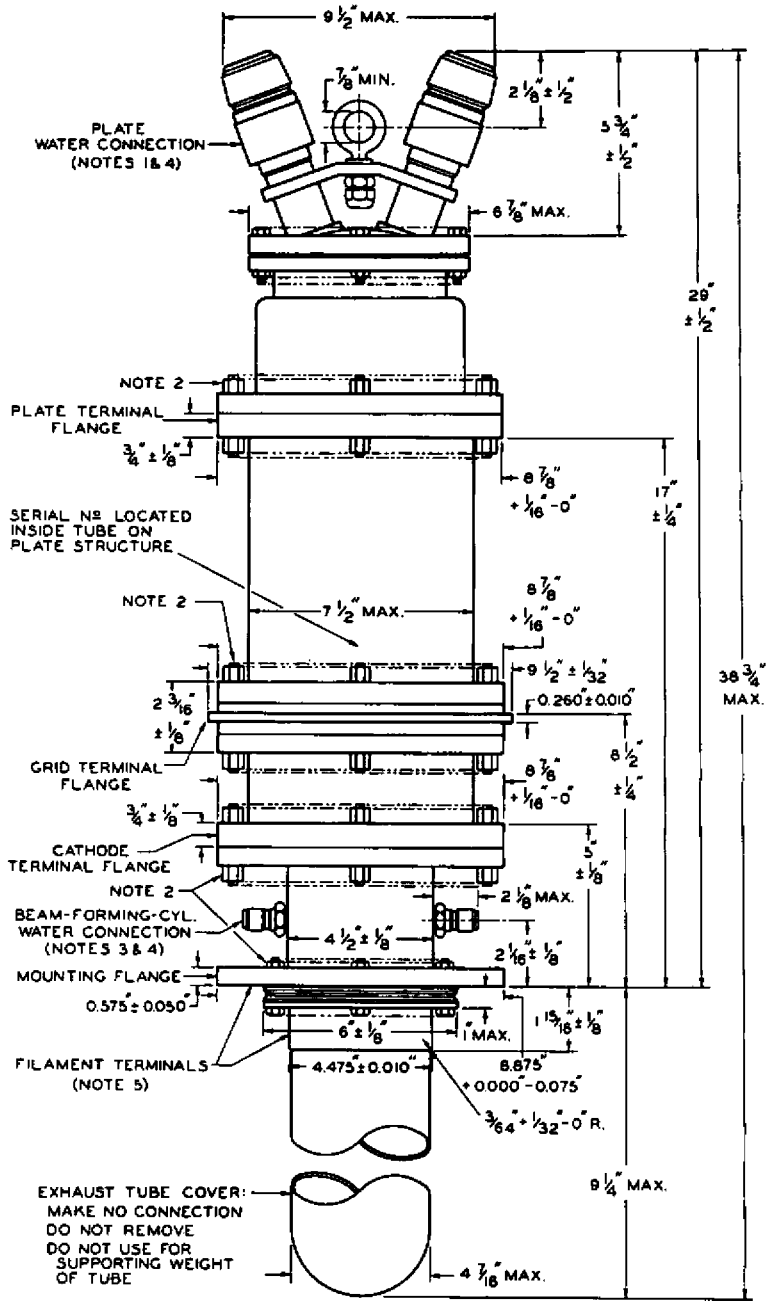
In order to permit considerable range of adjustment, and also to provide for losses in the grid circuit and the coupling circuits, the driver stage should have considerably more output capability than the typical driving power shown in the tabulated data.

It is to be noted that the 5831 is capable of power gain at frequencies in the ultra-high-frequency region. Therefore, the associated circuits and connecting leads must be unusually free from conditions contributing to the generation of parasitic oscillations. Circuit and instrument connections to the grid-terminal flange should be located so that they do not appreciably increase the coupling between the grid circuit and the plate structure.

At the higher frequencies, uneven heating of the seals may be encountered because of circuit arrangement. Such effects should be minimized through proper circuit design.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



NOTE 1 - PLUG Nº 32-BS, HANSEN MFG. CO. VARIOUS STYLES OF FITTINGS FOR THIS PLUG MAY BE OBTAINED FROM B-R ENGINEERING CO., 309 EAST SARATOGA ST., BALTIMORE 2, MD.

NOTE 2 - DO NOT TAMPER WITH BOLTS.

NOTE 3 - PLUG Nº 4T-25, HANSEN MFG. CO. (SEE NOTE 1).

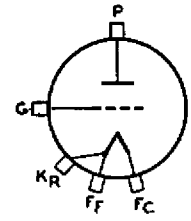
NOTE 4 - DIRECTION OF WATER FLOW THROUGH TUBE SHOULD BE IN DIRECTION INDICATED BY MARKINGS AT WATER CONNECTIONS.

NOTE 5 - USE FOR FILAMENT POWER ONLY. CIRCUIT RETURNS SHOULD BE MADE TO CATHODE-TERMINAL FLANGE.

92CL-7432R1

TUBE SYMBOL

For Terminal Connections, See Outline Drawing



F_C: FILAMENT CYLINDRICAL TERMINAL

F_F: FILAMENT FLANGE TERMINAL

K_R: CATHODE FLANGE TERMINAL FOR CIRCUIT RETURNS

G : GRID FLANGE TERMINAL

P : PLATE FLANGE TERMINAL

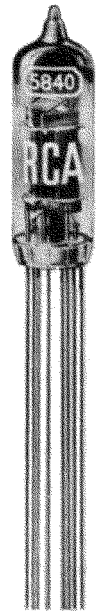
5840

SHARP-CUTOFF PENTODE

"Premium" Subminiature Type
For RF and IF Broad-Band Applications

TENTATIVE DATA

RCA-5840 is a sharp-cutoff subminiature pentode of the heater-cathode type designed primarily for use as an rf or if amplifier in high-frequency broad-band circuits of mobile and aircraft receivers where dependable performance under shock and vibration is a prime consideration. As an rf amplifier, the 5840 can be used at frequencies up to about 400 Mc.



Actual Size

The 5840 features a pure-tungsten heater to give long life under conditions of frequent "on-off" switching, three leads to the cathode to permit isolation of the input and output circuit returns, and a compact design in which special attention has been given to structural details that provide increased mount strength to resist shock and vibration. In addition, each 5840 is manufactured under rigid controls and undergoes rigorous tests to insure its "premium" quality.

The 5840 supersedes the 5901.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 5%	volts
Current	0.150	ampere

Direct Interelectrode Capacitances:

	With External Shield[o]	*Without External Shield*	
Grid No.1 to Plate	0.015 max.	0.03 max.	μμf
Input	4.2	4.0	μμf
Output	3.4	1.9	μμf

[o] Having inside diameter of 0.405" and connected to cathode.

Mechanical:

Operating Position	Any
Maximum Bulb Length	1-3/8"
Length from Button Seal to Bulb Top (Excluding tip)	1.075" ± 0.060"
Diameter	0.383" ± 0.017"
Bulb	T-3
Leads, Flexible	8
Length	1-1/2" to 1-3/4"
Orientation and Diameter	See Dimensional Outline

AMPLIFIER - Class A_1

Maximum Ratings, *Absolute Values*:

DC PLATE VOLTAGE	165 max.	volts
GRID-NO.2 (SCREEN) VOLTAGE	155 max.	volts
GRID-NO.1 (CONTROL-GRID) VOLTAGE:		
Negative bias value	55 max.	volts
PLATE DISSIPATION	1.1 max.	watts
GRID-NO.2 INPUT	0.55 max.	watt
DC CATHODE CURRENT	16.5 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	°C

Characteristics:

Plate Supply Voltage	100	volts
Grid-No.2 Supply Voltage	100	volts
Cathode Resistor	150	ohms
Plate Resistance	260000	ohms
Transconductance	5000	μmhos
Plate Current	7.5	ma
Grid-No.2 Current	2.4	ma
Grid-No.1 Volts (Approx.) for plate current of 10 μamp	-9	volts

Typical Operation as Resistance-Coupled Amplifier:

See Chart on Page 2

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For cathode-bias operation	1.2 max.	megohms
For fixed-bias operation	Not recommended	

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN*

	Note	*Min.*	*Max.*	
Heater Current	1	0.138	0.162	amp
Grid-No.1-to-Plate Capacitance	2	-	0.015	μμf
Input Capacitance	2	3.5	4.9	μμf
Output Capacitance	2	2.9	3.9	μμf
Plate Current	1,3	5.5	9.5	ma
Plate Current	1,4	-	50	μamp
Transconductance	1,3	4100	5900	μmhos
Transconductance	5,3	3750	-	μmhos
Grid-No.1 Current	1,6	-	±0.3	μamp
Grid-No.2 Current	1,3	0.5	3.5	ma
Plate Resistance	1,7	0.175	-	megohm
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,8	-	7.0	μamp
Heater positive with respect to cathode	1,8	-	7.0	μamp

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5840-2-53
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CHARACTERISTICS RANGE VALUES (Cont'd)

	Note	Min.	Max.	
Leakage Resistance:				
Between Grid No.1 and All Other Electrodes Tied Together	1,9	100	-	megohms
Between Plate and All Other Electrodes Tied Together	1,10	100	-	megohms

* Each tube is stabilized before characteristics testing by continuous operation for at least 45 hours at room temperature and with dissipation values equivalent to life test conditions.

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With external shield having inside diameter of 0.405" and connected to cathode.

Note 3: With plate supply voltage of 100 volts, grid-No.2 supply voltage of 100 volts, cathode resistor of 150 ohms, and cathode bypass capacitor of 1000 microfarads.

Note 4: With dc plate voltage of 100 volts, dc grid-No.2 voltage of 100 volts, and dc grid-No.1 voltage of -9 volts.

Note 5: With 5.7 volts ac or dc on heater.

Note 6: With plate supply voltage of 100 volts, grid-No.2 supply voltage of 100 volts, cathode resistor of 150 ohms, cathode bypass capacitor of 1000 microfarads, and grid-No.1 resistor of 0.1 megohm.

Note 7: With plate supply voltage of 100 volts, grid-No.2 supply voltage of 100 volts, cathode resistor of 150 ohms bypassed by capacitor having a maximum reactance of 3 ohms.

Note 8: With 100 volts dc between heater and cathode.

Note 9: With grid No.1 100 volts negative with respect to all other electrodes tied together.

Note 10: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS & PERFORMANCE DATA

Shock Rating:

Impact Acceleration . . . . . 450 max. g
Tubes are held rigid in three different positions in a Navy Type, High Impact (flyweight) Shock Machine and are subjected to 450 g impact acceleration.

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g
Tubes are rigidly mounted and subjected in each of three positions to 2.5 g vibrational acceleration at 60 cycles per second for 32 hours.

Uniform Acceleration Rating . . . . . 1000 max. g
Tubes are subjected in each of three positions to a gradually applied uniform acceleration up to 1000 g.

High-Frequency Vibration Performance:

RMS Output Voltage . . . . . 60 max. mv
Under the following conditions: A 100-volt plate and grid-No.2 voltage supply having an impedance not exceeding that of a 40-μf capacitor, plate load resistance of 10000 ohms, grid-No.1 resistor of 0.1 megohm, cathode resistor of 150 ohms, cathode bypass capacitor of 1000 μf, and vibrational acceleration of 15 g at 40 cps.

Heater-Cycling Life Performance:

Cycles of Intermittent Operation. . 2500 min. cycles
Under the following conditions: With heater voltage of 7.0 volts cycled 1 minute on and 4 minutes off, heater-cathode voltage of 140 volts (rms), and plate, grid-No.2, and grid-No.1 voltage = 0 volts.

Average Life Performance:

The average life performance based on a 500-hour test at 175°C ambient temperature is not less than 450 hours. This life test is made on sample lot of tubes with heater voltage of 6.3 volts; plate supply voltage of 100 volts; grid-No.2 supply voltage of 100 volts; dc heater-cathode voltage (heater positive with respect to cathode) of 200 volts; cathode resistor of 150 ohms; and grid-No.1 resistor of 1 megohm.

The 500-hour end-point limits for the 5840 with heater voltage of 6.3 volts, plate supply voltage of 100 volts, grid-No.2 supply voltage of 100 volts, cathode resistor of 150 ohms bypassed by capacitor having a maximum reactance of 3 ohms, and dc heater-cathode voltage of 100 volts with heater either positive or negative with respect to cathode are: transconductance, 3250 micromhos minimum; heater-cathode leakage current, 20 microamperes maximum; and grid-No.1 current, +0.9 microampere maximum or -0.9 microampere maximum.

OPERATING NOTES

The *maximum ratings* in the tabulated data for the 5840 are limiting values above which the serviceability of the 5840 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that

OPERATING CONDITIONS AS RESISTANCE-COUPLED AMPLIFIER

Plate-Supply Voltage	100						150						volts
Plate Load Resistor	0.10	0.10	0.27	0.27	0.47	0.47	0.10	0.10	0.27	0.27	0.47	0.47	megohm
Grid-No.2 Resistor	0.22	0.22	0.68	0.68	1.2	1.2	0.27	0.27	0.82	0.82	1.5	1.5	megohm
Grid-No.1 Resistor (of following stage)	0.27	0.47	0.47	1.0	0.47	1.0	0.27	0.47	0.47	1.0	0.47	1.0	megohm
Cathode Resistor	820	820	2200	2200	3300	3300	560	560	1500	1500	2200	2200	ohms
Signal Input Voltage (rms)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	volt
Output Voltage (rms)	8.2	9.0	9.5	11.8	9.2	11.7	11.5	12.5	13.2	15.5	13	16.7	volts
Voltage Gain▲	82	90	95	118	92	117	115	125	132	155	130	167	
Distortion	2.8	3.8	2.5	3.0	3.1	2.3	1.5	2.2	2.4	2.4	3.7	3.0	per cent
Signal Input Voltage (rms)*	0.23	0.22	0.15	0.16	0.12	0.14	0.20	0.18	0.16	0.16	0.11	0.14	volt
Output Voltage	17.7	18.6	13.6	17	11	16	21.7	21.7	20.5	24	14	22.2	volts
Voltage Gain▲	77	85	91	106	92	114	109	120	128	150	127	159	
Distortion	4.9	4.8	4.7	4.4	4.8	5.0	4.8	5.0	4.9	4.8	4.2	4.8	per cent

Note 1: Coupling capacitors should be selected to give desired frequency response. Cathode resistor should be adequately bypassed.

* Maximum value to swing the grid of resistance-coupled amplifier tube to the point where its grid No.1 starts to draw current.

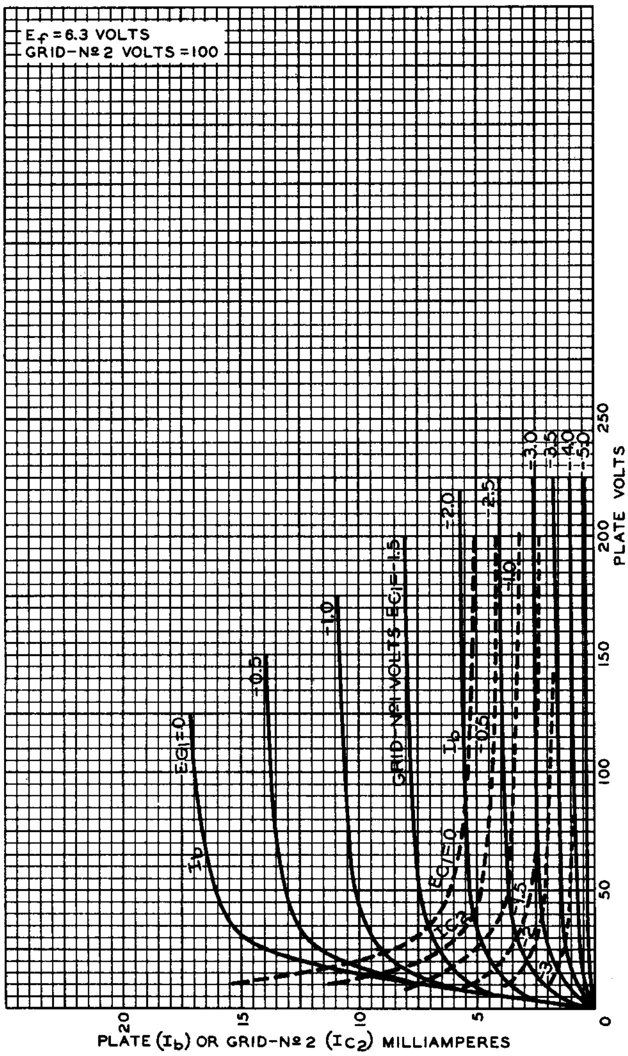
▲ Ratio of signal output to signal input.

rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *heater supply* should be well regulated because life and reliability of the 5840 are adversely affected by departures from the 6.3-volt value. The extent to which life is affected is a function of the amounts of these departures and their durations.

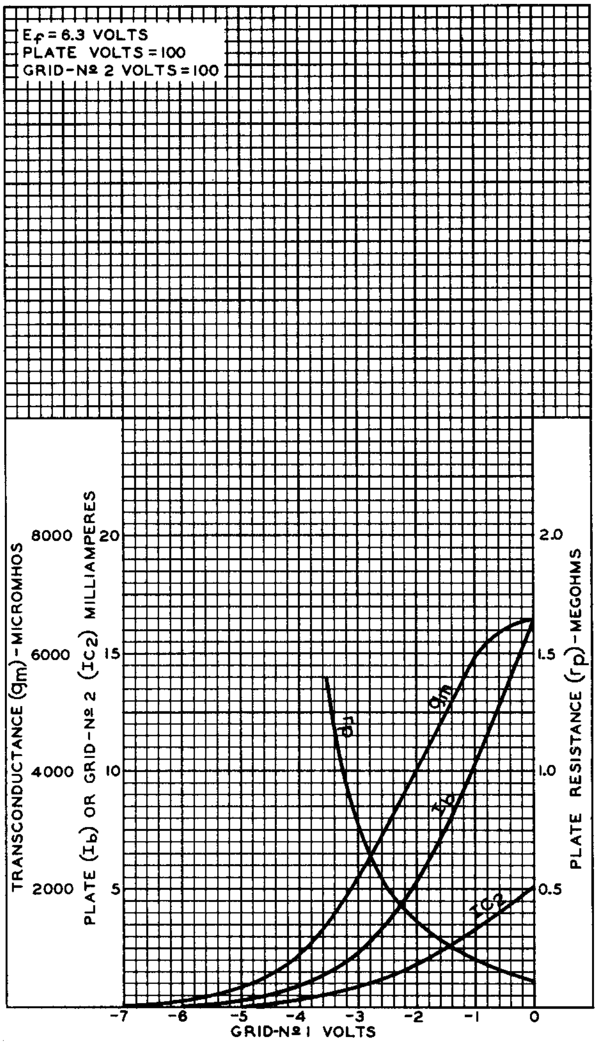
The *cathode* is provided with 3 leads. It is suggested that leads 2 and 8 be used for the input circuit return and that lead 4 be used for the output circuit return. This practice reduces the portion of input loading due to cathode lead inductance and reduces feedback effects.

The *flexible leads* of the 5840 are usually soldered to the circuit elements. Soldering of the connections should be made as far as possible from the glass button. If this precaution is not followed, the heat of the soldering operation may crack the glass seals of the leads and damage the tube.



92CM-7893

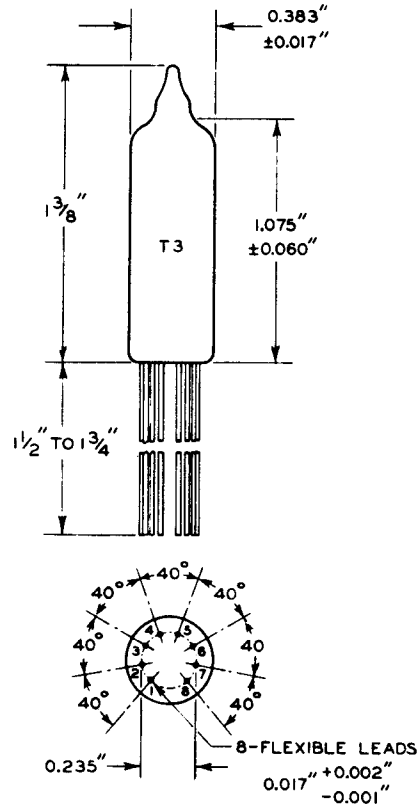
Average Plate Characteristics of Type 5840.



92CM-7892

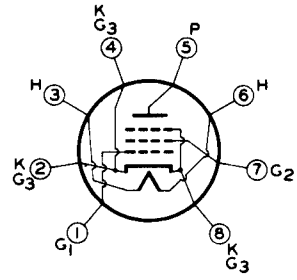
Average Characteristics of Type 5840.

DIMENSIONAL OUTLINE



FLEXIBLE LEAD CONNECTIONS

LEAD NO.1: GRID NO.1
LEAD NO.2: CATHODE, GRID NO.3
LEAD NO.3: HEATER
LEAD NO.4: CATHODE, GRID NO.3



8DL

LEAD NO.5: PLATE
LEAD NO.6: HEATER
LEAD NO.7: GRID NO.2
LEAD NO.8: CATHODE, GRID NO.3

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

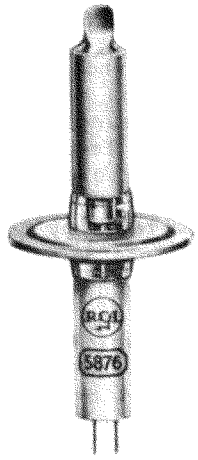
5876

UHF HIGH-MU TRIODE

"Pencil Type" for Grounded-Grid Service

TENTATIVE DATA

RCA-5876 is a general-purpose, high-mu triode intended particularly for use in grounded-grid service as an rf amplifier, if amplifier, or mixer tube in receivers operating at frequencies up to about 1000 megacycles per second; as a frequency multiplier up to about 1500 megacycles per second; and as an oscillator up to 1700 megacycles per second. The 5876 may also be used as a low power rf amplifier in mobile transmitters



Actual Size

As an unmodulated class C rf amplifier, the 5876 is capable of giving a useful power output of 5 watts at 500 megacycles per second. As an unmodulated class C oscillator, the 5876 can deliver a useful power output of 3 watts at 500 megacycles per second and 750 milliwatts at 1700 megacycles per second.

Featured in the 5876 is the "pencil-type" construction which not only meets requirements as to minimum transit time, low lead inductance, and low interelectrode capacitances, but also provides other desirable design features such as small size, light weight, low heater wattage, good thermal stability, and convenience of use in equipment design. The tube is less than 2-3/8 inches long and has a diameter of only 1/4 inch exclusive of the grid flange.

The coaxial-electrode structure employed is of the double-ended type in which the plate cylinder and cathode cylinder extend outward from each side of the grid flange. The latter is particularly effective in permitting isolation of the plate circuit from the cathode circuit in grounded-grid service. Although designed for use in circuits of the coaxial-cylinder type, the 5876 is also suitable for use in circuits of the line type and lumped-circuit type.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 5%	volts
Current	0.135	ampere
Direct Interelectrode Capacitances (Approx.):		
Grid To Plate	1.4	μμf
Grid to Cathode	2.5	μμf
Plate to Cathode	0.035 max.	μμf

Mechanical:

Mounting Position	Any
Dimensions and Terminal Connections	See Outline Drawing

CLASS A_1 AMPLIFIER

Maximum Ratings, *Absolute Values*:

DC PLATE VOLTAGE	300 max.	volts
DC GRID VOLTAGE	−100 max.	volts
DC PLATE CURRENT	25 max.	ma
PLATE DISSIPATION◇	6.25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
PLATE-SEAL TEMPERATURE	175 max.	°C

Characteristics:

Plate Voltage	250	volts
Cathode-Bias Resistor	75	ohms
Amplification Factor	56	
Plate Resistance	8625	ohms
Transconductance	6500	μmhos
Plate Current	18	ma

Maximum Circuit Values:

Grid-Circuit Resistance	0.5 max.	megohm

PLATE-MODULATED RF POWER AMP. - Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS° Ratings, *Absolute Values*:

DC PLATE VOLTAGE	275 max.	volts
DC GRID VOLTAGE	−100 max.	volts
DC PLATE CURRENT	22 max.	ma
DC GRID CURRENT	8 max.	ma
PLATE INPUT	6.0 max.	watts
PLATE DISSIPATION◇	4.25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
PLATE-SEAL TEMPERATURE	175 max.	°C

Maximum Circuit Values:

Grid-Circuit Resistance	0.1 max.	megohm

RF POWER AMPLIFIER & OSC. - Class C Telegraphy

Key-down conditions per tube without amplitude modulation•

Maximum CCS° Ratings, *Absolute Values*:

DC PLATE VOLTAGE	360 max.	volts
DC GRID VOLTAGE	−100 max.	volts
DC PLATE CURRENT	25 max.	ma
DC GRID CURRENT	8 max.	ma
PLATE INPUT	9 max.	watts
PLATE DISSIPATION◇	6.25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
PLATE-SEAL TEMPERATURE	175 max.	°C

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RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5876-4-50
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Typical Operation as Oscillator in Grounded-Grid Circuit:

	500 Mc	1700 Mc	
DC Plate Voltage	250	250	volts
DC Grid Voltage♦	-12	-2	volts
DC Plate Current	23	23	ma
DC Grid Current (Approx.)	6	3	ma
Useful Power Output (Approx.)	3	0.75	watts

Typical Operation as RF Power Amplifier in Grounded-Grid Circuit:

	500 Mc	
DC Plate Voltage	275	volts
DC Grid Voltage♦	-51	volts
DC Plate Current	23	ma
DC Grid Current (Approx.)	7	ma
Driver Power Output (Approx.)	2	watts
Useful Power Output (Approx.)	5	watts

Maximum Circuit Values:

Grid-Circuit Resistance . . . . . 0.1 max. megohm

FREQUENCY MULTIPLIER

Maximum CCS° Ratings, *Absolute Values*:

DC PLATE VOLTAGE	330 max.	volts
DC GRID VOLTAGE	-100 max.	volts
DC PLATE CURRENT	22 max.	ma
DC GRID CURRENT	8 max.	ma
PLATE INPUT	7.5 max.	watts
PLATE DISSIPATION◊	6.25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
PLATE-SEAL TEMPERATURE	175 max.	°C

Typical Operation:

	Tripler to 480 Mc	Doubler to 960 Mc	
DC Plate Voltage	300	300	volts
DC Grid Voltage♦	-90	-70	volts
DC Plate Current	18	17.3	ma
DC Grid Current (Approx.)	6	7	ma
Driver Power Output (Approx.)	2.1	2	watts
Useful Power Output (Approx.)	2.1	2	watts

Maximum Circuit Values:

Grid-Circuit Resistance . . . . . 0.1 max. megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Av.	Max.	
Heater Current	1	0.125	0.135	0.145	ampere
Grid-to Plate Capacitance	-	1.2	1.4	1.6	μμf
Grid-to Cathode Capacitance	-	2.2	2.5	2.8	μμf
Plate-to Cathode Capacitance	-	-	-	0.035	μμf

Note 1: With 6.3 volts ac or dc on heater.

◊ In applications where the plate dissipation exceeds 2.5 watts, it is important that a large area of contact be provided between the plate cylinder and the terminal to provide adequate heat conduction.

° Continuous Commercial Service.

● Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

♦ Obtained from grid resistor.

INSTALLATION and APPLICATION

The 5876 may be mounted in any position. Connections to the cathode cylinder, grid flange, and plate cylinder should be made by flexible spring contacts only. The connectors must make firm, large-surface contact, yet must be sufficiently flexible so that no part of the tube is subjected to strain. Unless this recommendation is observed, the glass-to-metal seals may be damaged.

The *heater* leads of the 5876 fit the Cinch socket No. 54A11953. They should not be soldered to circuit elements. The heat of the soldering operation may crack the glass seals of the heater leads and damage the tube.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

The *temperature* of the plate seal should not exceed 175 degrees centigrade (at the hottest point). The temperature may be measured with temperature sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York 11, N. Y. in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of one percent.

The *maximum ratings* are limiting values above which the serviceability of the 5876 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

In *class A_1 amplifier service*, grid-bias voltage should be obtained from a cathode resistor.

In *plate-modulated class C rf power amplifier service*, the 5876 should be supplied with bias from a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor. The cathode resistor should be bypassed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation. Grid-bias voltage is not particularly critical so that correct adjustment may be obtained with values differing widely from the calculated values.

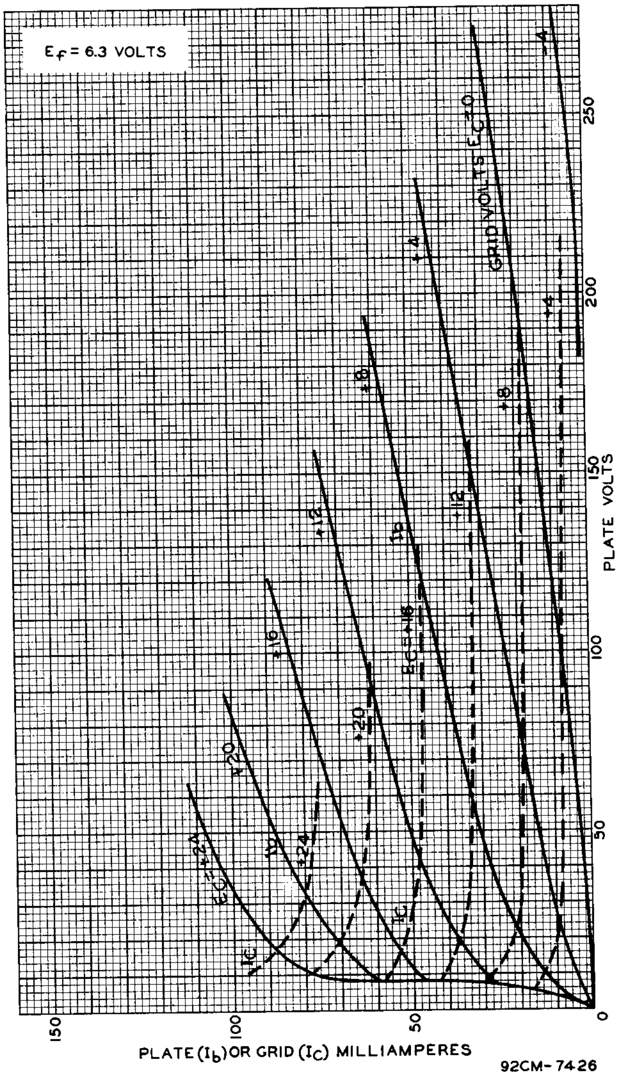
In *grounded-grid plate-modulated class C telephony service*, the 5876 can be modulated 100 percent if the rf driver stage is also modulated 100 percent simultaneously. Care should be taken to insure that the driver-modulation and the amplifier-modulation voltages are exactly in phase. In such service, the 5876 requires increased driving power, but increased power output is obtained as shown in the tabulated data.

In *class C rf telegraphy service,* the 5876 may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value. If the 5876 is operated at a plate voltage of 300 volts, a fixed bias of at least -2 volts should be used.

In *grounded-grid circuits* the grid-driving voltage and the developed rf plate voltage act in series to supply the load circuit. As a result, the required driving power is increased over that needed for grounded-cathode circuits. The increased driving power is not lost because it appears as output from the grounded-grid stage. If the driving voltage and grid current are increased, the output will always increase.

In tuning a grounded-grid rf amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

When more radio-frequency power is required than can be obtained from a single tube, push-pull or parallel circuit arrangements may be used. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. When two or more tubes are used in the circuit, precautions should be taken to balance the plate currents.



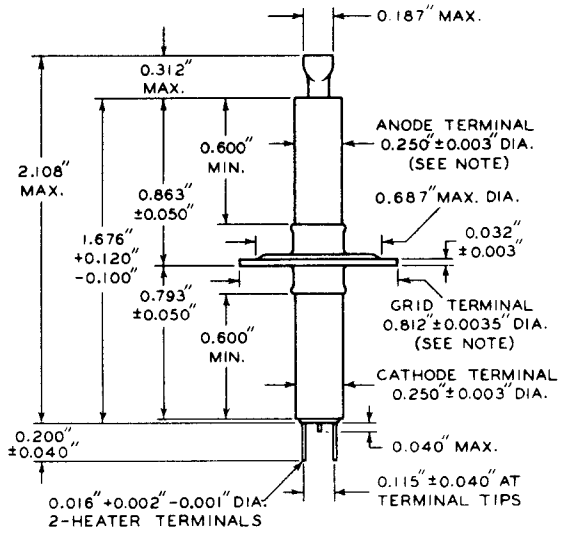
Average Plate Characteristics of Type 5876.

REFERENCES

G. M. Rose, D. W. Power and W. A. Harris, *"Pencil-Type UHF Triodes"*, RCA Review, Vol. 10, No.3, pp. 321-338 (September, 1949).

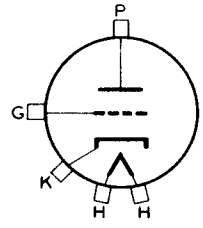
E. E. SPITZER, *"Grounded-Grid Power Amplifiers"*, Electronics, Vol. 19, No.4, pp. 138-141 (April, 1946).

DIMENSIONAL OUTLINE



NOTE: MAX. ECCENTRICITY OF ℄ (AXIS) OF ANODE TERMINAL OR GRID-TERMINAL FLANGE WITH RESPECT TO THE ℄ (AXIS) OF THE CATHODE TERMINAL IS 0.008".

TERMINAL CONNECTIONS



H: HEATER
K: CATHODE
G: GRID
P: PLATE

5879

SHARP-CUTOFF PENTODE

9-Pin Miniature Type

TENTATIVE DATA

RCA-5879 is a sharp-cutoff pentode of the 9-pin miniature type intended for use as an audio amplifier in applications requiring reduced microphonics, leakage noise, and hum. It is especially useful in the input stages of medium-gain public address systems, home sound recorders, and general-purpose audio systems.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.150	amp
Direct Interelectrode Capacitances (With no external shield):		
Pentode Connection:		
Grid No.1 to Plate	0.11 max.	μμf
Input	2.7	μμf
Output	2.4	μμf
Triode Connection:		
(Grids No.2 and No.3 Connected to Plate)		
Grid No.1 to Plate	1.4	μμf
Grid No.1 to Cathode	1.4	μμf
Plate to Cathode	0.85	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-3/16"
Maximum Seated Length	1-15/16"
Length from Base Seat to Bulb Top (excluding tip)	1-9/16" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin

Class A_1 AMPLIFIER

Pentode Connection

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	300 max.	volts
GRID-No.2 (SCREEN) VOLTAGE	150 max.	volts
GRID-No.2 SUPPLY VOLTAGE	300 max.	volts
GRID-No.2 INPUT	0.25 max.	watt
PLATE DISSIPATION	1.25 max.	watts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Negative Bias Value	50 max.	volts
Positive Bias Value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Characteristics:

Plate Voltage	250	volts
Grid No.3 (Suppressor)	Connected to cathode at socket	
Grid-No.2 Voltage	100	volts
Grid-No.1 Voltage	-3	volts
Plate Resistance (Approx.)	2	megohms
Transconductance	1000	μmhos
Grid-No.1 Bias (Approx.) for Plate Current of 10 μamp	-8	volts
Plate Current	1.8	ma
Grid-No.2 Current	0.4	ma

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	2.2 max.	megohms

Triode Connection

Grids No.2 and No.3 Connected to Plate

Maximum Ratings, *Design-Center Values:*

PLATE VOLTAGE	250 max.	volts
TOTAL PLATE DISSIPATION	1.5 max.	watts
GRID-No.1 VOLTAGE:		
Negative Bias Value	50 max.	volts
Positive Bias Value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts

Characteristics:

Plate Voltage	100	250	volts
Grid-No.1 Voltage	-3	-8	volts
Amplification Factor	21	21	
Plate Resistance (Approx.)	17000	13700	ohms
Transconductance	1240	1530	μmhos
Total Plate Current	2.2	5.5	ma

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	2.2 max.	megohms

INSTALLATION and APPLICATION

The *base pins* of the 5879 fit the noval 9-pin socket. The socket may be mounted to hold the tube in any position.

It is recommended that pins No.2 and 6 be grounded in all applications. Grounding of these pins will effectively shield grid No.1 and plate from heater and help to reduce hum level when an ac heater supply is used.

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Operating Conditions as Resistance-Coupled Amplifier for Maximum Voltage Output

		90			180			300		
Plate-Supply Voltage										volts
Plate Load Resistor	0.1	0.22	0.47	0.1	0.22	0.47	0.1	0.22	0.47	megohm
Grid-No.2 Resistor	0.15	0.40	1.0	0.20	0.53	1.1	0.2	0.52	1.2	megohms
Grid-No.1 Resistor (of following Stage)	0.22	0.47	1.0	0.22	0.47	1.0	0.22	0.47	1.0	megohm
Cathode Resistor	2200	3800	7400	1400	2300	3700	1100	1600	2500	ohms
Grid-No.2 Bypass Capacitor ●	0.08	0.065	0.04	0.08	0.07	0.07	0.1	0.1	0.1	μf
Cathode Bypass Capacitor ●	4.4	3.2	2.0	5.85	4.45	3.5	6.8	5.45	4.3	μf
Blocking Capacitor ●	0.013	0.006	0.003	0.013	0.006	0.003	0.013	0.006	0.004	μf
Peak Output Voltage □	28	30	30	59	62	59	110	113	110	volts
Voltage Gain †	32	44	57	46	62	66	53	64	76	

Operating Conditions as Resistance-Coupled Amplifier for Maximum Voltage Gain

		90			180			300		
Plate-Supply Voltage										volts
Plate Load Resistor	0.1	0.22	0.47	0.1	0.22	0.47	0.1	0.22	0.47	megohm
Grid-No.2 Resistor	0.35	0.80	1.9	0.35	0.80	1.9	0.35	0.80	1.9	megohms
Grid-No.1 Resistor (of following Stage)	0.22	0.47	1.0	0.22	0.47	1.0	0.22	0.47	1.0	megohm
Cathode Resistor	1700	3000	7000	700	1200	2500	300	600	1200	ohms
Peak Output Voltage □	17	21	25	28	31	32	32	37	42	volts
Voltage Gain *	39	59	75	56	87	122	68	109	152	

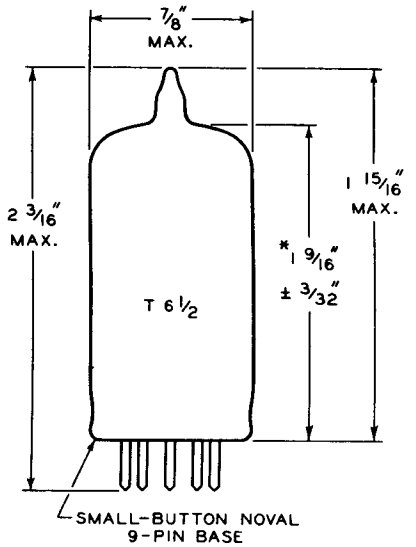
● The grid-No.2 and cathode bypass capacitors, and blocking capacitors have been chosen to give output voltages at 100 cps (f_1) which are equal to 0.8 of the mid-frequency value. For any other value of (f_1), multiply the value of cathode and bypass blocking capacitors by $100/f_1$.

* At an output voltage of 1 volt rms and grid-No.1 bias of 1 volt.

□ This peak output voltage is obtained across the grid resistor of the following stage at any frequency within the flat region of the output vs frequency curve, and is for the condition where the signal level is adequate to swing the grid of the resistance-coupled amplifier tube to the point where its grid starts to draw current.

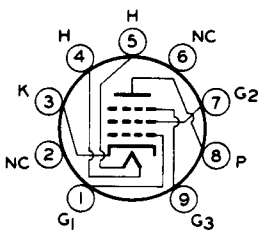
† At an output voltage of 5 volts rms.

DIMENSIONAL OUTLINE



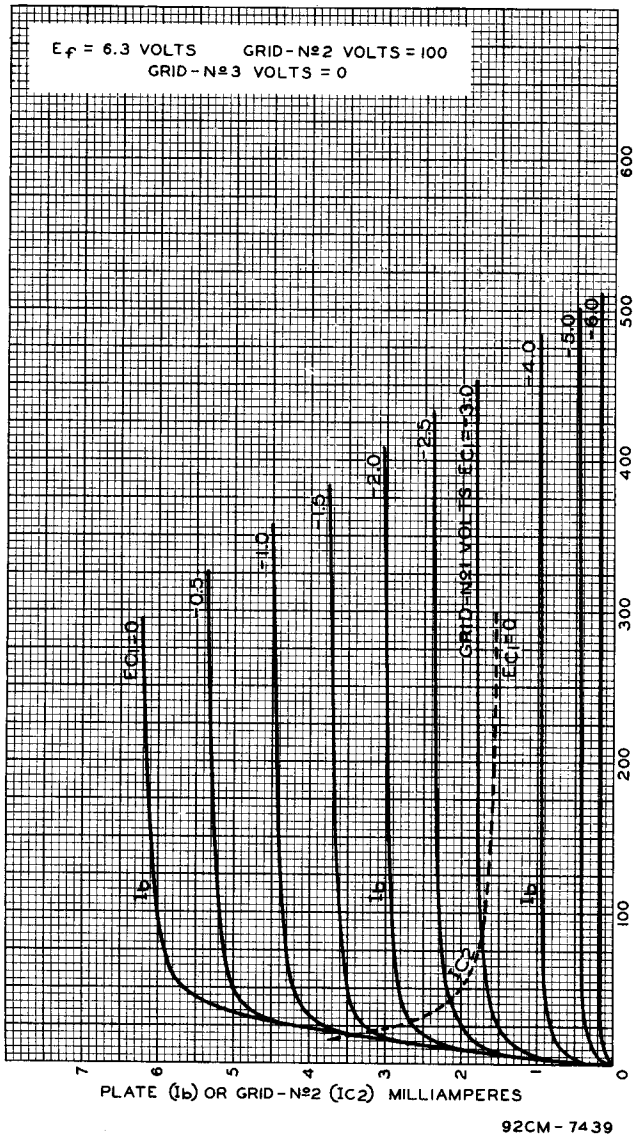
* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View

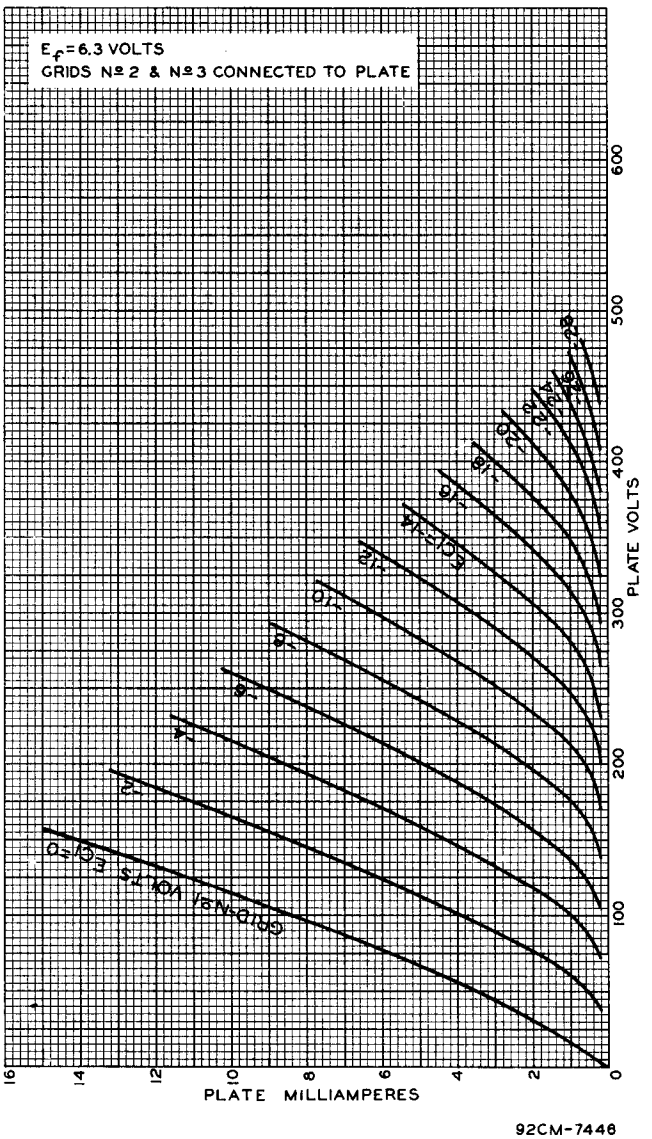


9AD

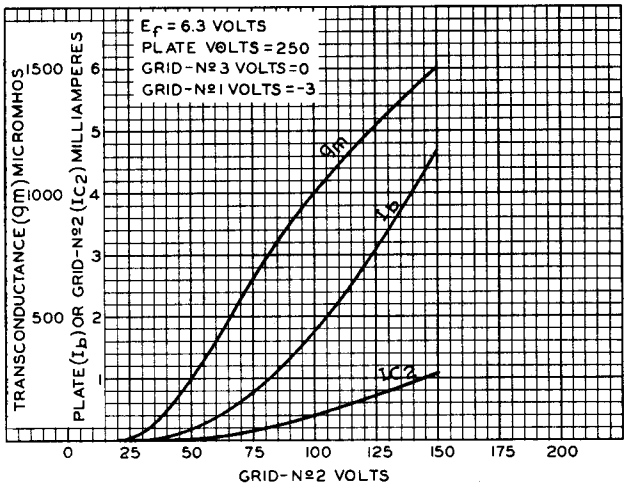
PIN 1: GRID No.1
PIN 2: NO CONNECTION
PIN 3: CATHODE
PIN 4: HEATER
PIN 5: HEATER
PIN 6: NO CONNECTION
PIN 7: GRID No.2
PIN 8: PLATE
PIN 9: GRID No.3

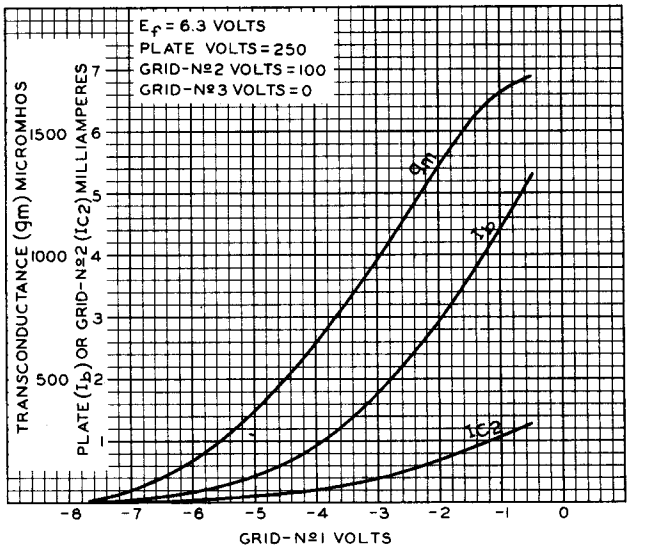


92CM-7439



92CM-7446


E_f = 6.3 VOLTS
PLATE VOLTS = 250
GRID-№3 VOLTS = 0
GRID-№1 VOLTS = -3
TRANSCONDUCTANCE (gm) MICROMHOS
PLATE (I_b) OR GRID-№2 (I_{C2}) MILLIAMPERES
gm
I_b
I_{C2}
GRID-№2 VOLTS


E_f = 6.3 VOLTS
PLATE VOLTS = 250
GRID-№2 VOLTS = 100
GRID-№3 VOLTS = 0
TRANSCONDUCTANCE (gm) MICROMHOS
PLATE (I_b) OR GRID-№2 (I_{C2}) MILLIAMPERES
gm
I_b
I_{C2}
GRID-№1 VOLTS

92CM-7440

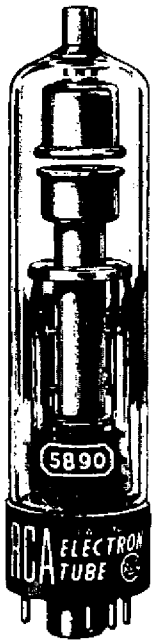
5890

REMOTE-CUTOFF BEAM PENTODE

High-Voltage, Low-Current, Regulator Type

TENTATIVE DATA

RCA-5890 is a low-current beam pentode of the remote-cutoff type intended particularly for the voltage regulation of high-voltage dc power supplies. It has a maximum dc plate-voltage rating of 30000 volts, a maximum dc plate-current rating of 500 microamperes, and a maximum plate-dissipation rating of 10 watts.



The high-voltage insulation required in the 5890 for its intended service is obtained by the use of a double-ended structure utilizing a suitably designed electron gun which consists of a thermionic cathode and three grids. The plate connection is made to a small cap at the end of the bulb.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	ampere
Mu-Factor, Grid No.2 to Grid No.1	5	
Direct Interelectrode Capacitances:		
Grid No.1 to Plate	0.018	μμf
Input	7.5	μμf
Output	1.6	μμf

Mechanical:

Mounting Position		Any
Overall Length	6-1/2"	± 1/4"
Seated Length	6"	± 1/4"
Maximum Diameter		1-1/2"
Cap		Small
Base	Small-Shell Duodecal	7-Pin
Bulb Temperature (At hottest point)	220 max.	°C

VOLTAGE-CONTROL SERVICE

Maximum CCS• Ratings, *Absolute Values*:

DC PLATE VOLTAGE	30000 max.	volts
DC GRID-No.3 VOLTAGE	6600 max.	volts
DC GRID-No.2 VOLTAGE	450 max.	volts
DC GRID-No.1 VOLTAGE:		
Negative bias value	200 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
MAX.-SIGNAL DC PLATE CURRENT	500 max.	μamp
MAX.-SIGNAL GRID-No.3 INPUT	1 max.	watt
MAX.-SIGNAL GRID-No.2 INPUT	0.1 max.	watt
PLATE DISSIPATION	10 max.	watts

• Continuous Commercial Service.

PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode:		
During equipment warm-up period not exceeding 15 seconds	450 max.	volts
After equipment warm-up period	165 max.	volts
Heater positive with respect to cathode	165 max.	volts

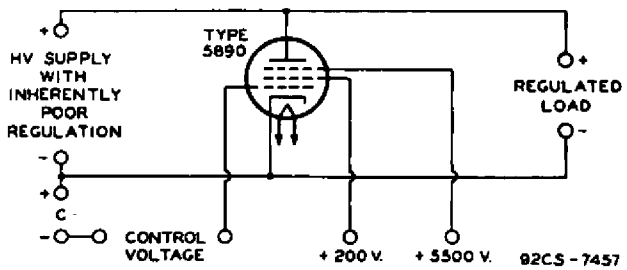
Typical Operation As Shunt Voltage-Regulator Tube in Accompanying Circuit:

DC Plate Voltage	20000	30000	volts
DC Grid-No.3 Voltage	5500	5500	volts
DC Grid-No.2 Voltage*	200	200	volts
DC Grid-No.1 Voltage**	-60	-60	volts
Peak Grid-No.1 Voltage	45	20	volts
Zero-Signal DC Plate Current	0	0	μamp
Max.-Signal DC Plate Current	500	60	μamp
Zero-Signal DC Grid-No.3 Current	0	0	μamp
Max.-Signal DC Grid-No.3 Current	0	0	μamp
Zero-Signal DC Grid-No.2 Current	0	0	μamp
Max.-Signal DC Grid-No.2 Current	0	0	μamp
Grid-No.1 Bias (Approx.) for plate current of 10 μamp	-52	-52	volts
Grid-No.1—Plate Transconductance	11	3	μmhos

* Subject to variation of ± 40% if grid-No.1 voltage is desired at indicated value.

** Subject to variation of ± 40% if grid-No.2 voltage is desired at indicated value.

SHUNT VOLTAGE-REGULATOR CIRCUIT



NOTE: THE CONTROL VOLTAGE MAY BE TAKEN FROM THE LOAD CIRCUIT OR FROM A CIRCUIT SUPPLYING SIGNAL TO THE LOAD CIRCUIT, DEPENDING ON THE TYPE OF LOAD INVOLVED.

OPERATING NOTES

The *maximum ratings* in the tabulated data for the 5890 are limiting values above which the serviceability of the 5890 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design

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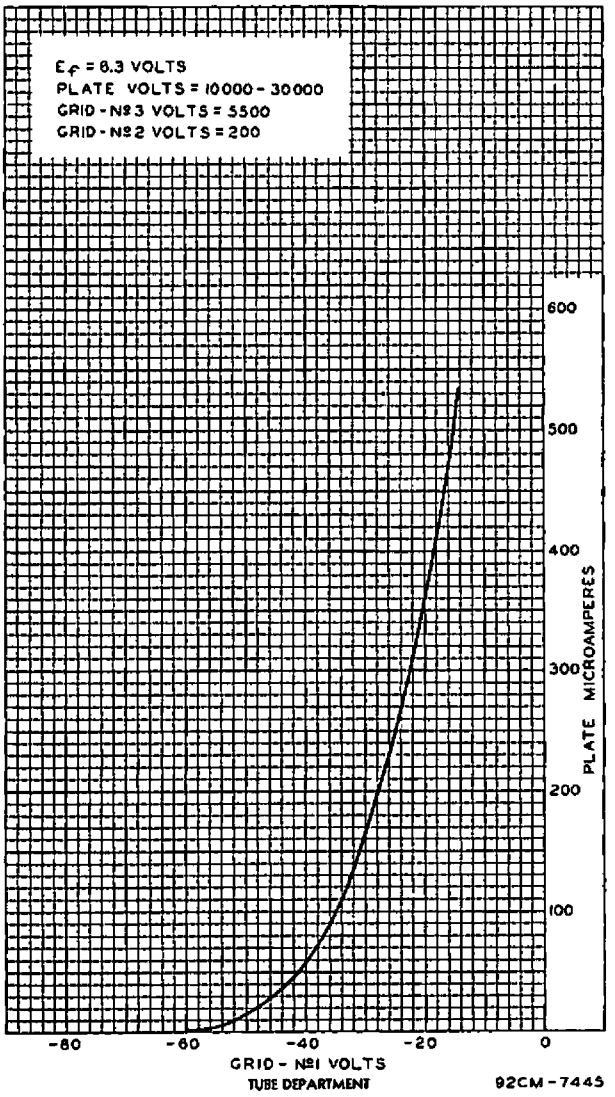
value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

AVERAGE CHARACTERISTIC



The high dc voltages at which the 5890 is operated may be extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

It should always be remembered that high voltages may appear at normally low-potential points in the circuit because of capacitor breakdown or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors should be grounded.

The *temperature of the bulb* may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York 11, N.Y., in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of 1 per cent.

Operation of the 5890 with a plate voltage above approximately 16000 volts results in the production of soft x-rays which can constitute a health hazard on prolonged exposure unless the tube is adequately shielded. Relatively simple shielding should prove adequate, but the need for this precaution should be considered in equipment design (see *References 1 and 2*).

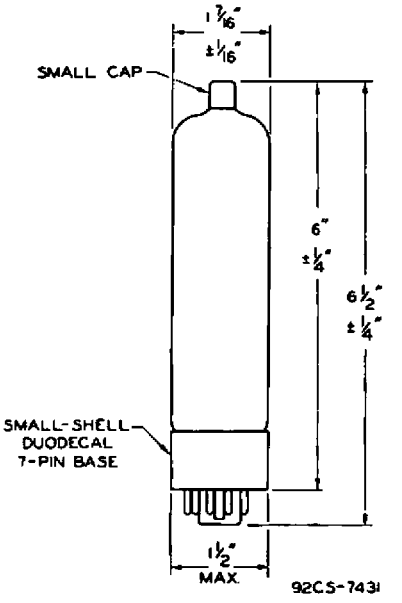
Under normal operating conditions, the 5890 may exhibit a *blue glow* on the upper half of the inner surface of the bulb wall and a *red or orange glow* on the plate. These effects are caused by fluorescence and are not to be mistaken for gas and overheating of the plate.

REFERENCES

1. *"Medical X-ray Protection Up To Two Million Volts,"* National Bureau of Standards Handbook H41.
2. *"Safety Code for Industrial Use of X-rays,"* American Standards Association, ASA Code Z54.1-1946.

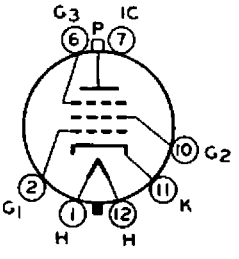
Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



SOCKET CONNECTIONS

Bottom View



12J

PIN 1: HEATER
PIN 2: GRID No.1
PIN 6: GRID No.3
PIN 7: INTERNAL CONNECTION—DO NOT USE
PIN 10: GRID No.2
PIN 11: CATHODE
PIN 12: HEATER
CAP: PLATE

RCA

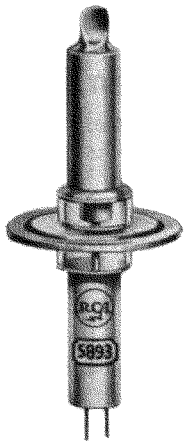
5893

UHF MEDIUM-MU TRIODE

"Pencil-Type" for Grounded-Grid Service

TENTATIVE DATA

RCA-5893 is a medium-mu triode of the "pencil-type" construction intended particularly for use in grounded-grid service as a plate-pulsed oscillator up to 3300 megacycles per second. In such service, it is capable of giving a useful peak power output of 1200 watts.



Actual Size

The 5893 may also be used as an rf power amplifier, cw oscillator, or frequency doubler up to 1000 megacycles per second particularly in low-power mobile transmitters. As an unmodulated class C rf power amplifier under ICAS conditions, this tube is capable of delivering a useful power output of approximately 6 watts at 1000 megacycles per second.

Featured in the 5893 is an improved "pencil-type" construction which not only meets requirements as to minimum transit time, low lead inductance, and low interelectrode capacitances, but also provides other desirable design features such as extreme sturdiness, small size, light weight, low heater wattage, good thermal stability, and convenience of use in equipment design. The tube has a length of only 2-5/16 inches and a diameter of only 1/4 inch exclusive of the grid flange.

The coaxial-electrode structure is of the double-ended metal-glass type in which the plate cylinder and cathode cylinder extend outward from each side of the grid flange. The latter is particularly effective in permitting isolation of the plate circuit from the cathode circuit in grounded-grid service. In addition, the disk-seal type of electrode termination, inherent in the design of "pencil-type" tubes, permits the utilization of closed-cavity resonators which minimize power loss through radiation, besides giving much lower inductance values and higher resonant frequencies than are obtainable with wire leads. Although designed for use in circuits of the coaxial-cylinder type, the 5893 is also suitable for use in circuits of the line type and lumped-circuit type.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC):		
Under Transmitting Conditions	6.0 ± 10%	volts
Under Standby Conditions	6.3 max.	volts
Current	0.330	ampere
Direct Interelectrode Capacitances (Approx.):		
Grid to Plate	1.75	μμf
Grid to Cathode	2.5	μμf
Plate to Cathode	0.07 max.	μμf

Characteristics, Class A_1 Amplifier:

Plate Voltage	200	volts
Cathode-Bias Resistor	100	ohms
Amplification Factor	27	
Plate Resistance	4500	ohms
Transconductance	6000	μmhos
Plate Current	25	ma

Mechanical:

Mounting Position		Any
Dimensions and Terminal Connections	See Outline Drawing	
Plate Seal Temperature	175 max.	°C

PLATE-PULSED OSCILLATOR[▲] - Class C

Maximum Ratings, *Absolute Values:*

For a maximum "on" time[♦] of 5 microseconds

PEAK POSITIVE-PULSE PLATE-SUPPLY VOLTAGE[♦]	1750 max.	volts
PEAK NEGATIVE-PULSE GRID-BIAS VOLTAGE	150 max.	volts
PEAK PLATE CURRENT FROM PULSE SUPPLY	.3 max.	amp
PEAK RECTIFIED GRID CURRENT	1.3 max.	amp
DC PLATE CURRENT	0.003 max.	amp
DC GRID CURRENT	0.0013 max.	amp
PLATE DISSIPATION[⊕]	6 max.	watts
PULSE DURATION	1.5 max.	μsec

Typical Operation with Rectangular Wave Shape in Grounded-Grid Circuit at 3300 Mc:

With duty factor[⊕] of 0.001

Peak Positive-Pulse Plate-Supply Voltage[♦]	1750	volts
Peak Negative-Pulse Grid-Bias Voltage. From Grid Resistor of	110 100	volts ohms
Peak Plate Current from Pulse Supply	3.0	amp
Peak Rectified Grid Current	1.1	amp
DC Plate Current	0.003	amp
DC Grid Current	0.0011	amp
Useful Power Output at Peak of Pulse[§] (Approx.)	1200	watts
Pulse Duration	1.0	μsec
Pulse Repetition Rate	1000	pps

PLATE-MODULATED RF POWER AMPLIFIER - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum Ratings, *Absolute Values:*

	CCS[●]	*ICAS*[●●]	
DC PLATE VOLTAGE	260 max.	320 max.	volts
DC GRID VOLTAGE	-100 max.	-100 max.	volts
DC PLATE CURRENT	33 max.	33 max.	ma

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

5893-7-51
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	CCS●	ICAS●●	
DC GRID CURRENT.	15 max.	15 max.	ma
PLATE INPUT.	8.5 max.	10.5 max.	watts
PLATE DISSIPATION⊕	5 max.	5.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode . .	90 max.	90 max.	volts
Heater positive with respect to cathode . .	90 max.	90 max.	volts

Typical Operation in Grounded-Grid Circuit at 500 Mc:

DC Plate Voltage	250	300	volts
DC Grid Voltage▲	-36	-45	volts
DC Plate Current	30	30	ma
DC Grid Current (Approx.).	11	12	ma
Driver Power Output (Approx.) . . .	1.8	2.0	watts
Useful Power Output (Approx.) . . .	5.5	6.5	watts

Maximum Circuit Value:

Grid-Circuit Resistance. .	0.1 max.	0.1 max.	megohm

RF POWER AMPLIFIER AND OSCILLATOR - Class C Telegraphy

Key down conditions per tube without amplitude modulation★

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	320 max.	400 max.	volts
DC GRID VOLTAGE.	-100 max.	-100 max.	volts
DC PLATE CURRENT	35 max.	40 max.	ma
DC GRID CURRENT.	15 max.	15 max.	ma
PLATE INPUT.	11 max.	16 max.	watts
PLATE DISSIPATION⊕	7 max.	8 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode . .	90 max.	90 max.	volts
Heater positive with respect to cathode . .	90 max.	90 max.	volts

Typical Operation as RF Power Amplifier in Grounded-Grid Circuit at 500 Mc:

DC Plate Voltage	300	350	volts
DC Grid Voltage†	-47	-51	volts
DC Plate Current	33	35	ma
DC Grid Current (Approx.).	13	13	ma
Driver Power Output (Approx.) . . .	2	2.5	watts
Useful Power Output (Approx.) . . .	7.5	8.5	watts

Typical Operation as RF Power Amplifier in Grounded-Grid Circuit at 1000 Mc:

DC Plate Voltage	300	350	volts
DC Grid Voltage†	-30	-33	volts
DC Plate Current	33	35	ma
DC Grid Current (Approx.).	12	13	ma
Driver Power Output (Approx.) . . .	1.9	2.4	watts
Useful Power Output (Approx.) . . .	5.5	6.5	watts

Typical Operation as Oscillator in Grounded-Grid Circuit at 500 Mc:

DC Plate Voltage	300	350	volts
DC Grid Voltage†	-47	-51	volts
DC Plate Current	33	35	ma
DC Grid Current (Approx.).	13	13	ma
Useful Power Output (Approx.) . . .	5	6	watts

Maximum Circuit Value:

Grid-Circuit Resistance. .	0.1 max.	0.1 max.	megohm

FREQUENCY DOUBLER

Maximum Ratings, *Absolute Values*:

	CCS●	ICAS●●	
DC PLATE VOLTAGE	260 max.	320 max.	volts
DC GRID VOLTAGE.	-100 max.	-100 max.	volts
DC PLATE CURRENT	33 max.	33 max.	ma
DC GRID CURRENT.	12 max.	12 max.	ma
PLATE INPUT.	8.5 max.	10.5 max.	watts
PLATE DISSIPATION⊕	6 max.	7.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode . .	90 max.	90 max.	volts
Heater positive with respect to cathode . .	90 max.	90 max.	volts

Typical Operation as Doubler to 1000 Mc in Grounded-Grid Circuit:

DC Plate Voltage	250	300	volts
DC Grid Voltage†	-40	-50	volts
DC Plate Current	33	33	ma
DC Grid Current (Approx.).	7	8	ma
Driver Power Output (Approx.) . . .	3.2	3.5	watts
Useful Power Output (Approx.) . . .	2.75	3.0	watts

Maximum Circuit Value:

Grid-Circuit Resistance. .	0.1 max.	0.1 max.	megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Max.	
Heater Current	1	0.3	0.36	amp
Grid-to-Plate Capacitance.	-	1.45	2.05	μμf
Grid-to-Cathode Capacitance	-	2.05	2.95	μμf
Plate-to-Cathode Capacitance	-	-	0.07	μμf
Plate Current.	1,2	16	34	ma
Useful Power Output at Peak of Pulse	1,3	750	-	watts

Note 1: With 6.0 volts ac or dc on heater.

Note 2: With dc plate voltage of 200 volts and cathode resistor of 100 ± 1% ohms.

Note 3: With peak positive-pulse plate-supply voltage of 1750 volts, grid resistor varied to give dc plate current of 3 ma, dc grid current of approximately 1.1 ma, duty factor of 0.001, and frequency of 3300 Mc.

● Continuous Commercial Service.

●● Intermittent Commercial and Amateur Service.

▲ In this class of service, the heater should be allowed to warm up for a minimum of 60 seconds before plate voltage is applied.

⊕ In applications where the plate dissipation exceeds 2.5 watts, it is important that a large area of contact be provided between the plate cylinder and the connector in order to provide adequate heat conduction.

♦ "On" time for this tube is the sum of the durations of all the individual pulses which occur during any 5000-microsecond interval. Pulse duration is defined as the time interval between the two points on the pulse at which the instantaneous value is 70% of the peak value. The peak value is defined as the maximum value of a smooth curve through the average of the fluctuations over the top portion of the pulse.

♦ The magnitude of any spike on the plate voltage pulse should not exceed a value of 2000 volts with respect to cathode and its duration should not exceed 0.01 microsecond measured at the peak-pulse-value level.

⊕ Duty factor is the product of pulse duration and repetition rate. For variable pulse durations and pulse repetition rates, the duty factor is defined as the ratio of time "on" to total elapsed time in any 5000-microsecond interval.

§ The power output at peak of pulse is obtained from the average power output using the duty factor of the peak pulse. This procedure is necessary since the power output pulse duty factor may be less than the applied voltage pulse duty factor because of a delay in the start of rf power output.

† Obtained from grid resistor.

★ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

OPERATING CONSIDERATIONS

The *maximum ratings* are limiting values above which the serviceability of the 5893 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to

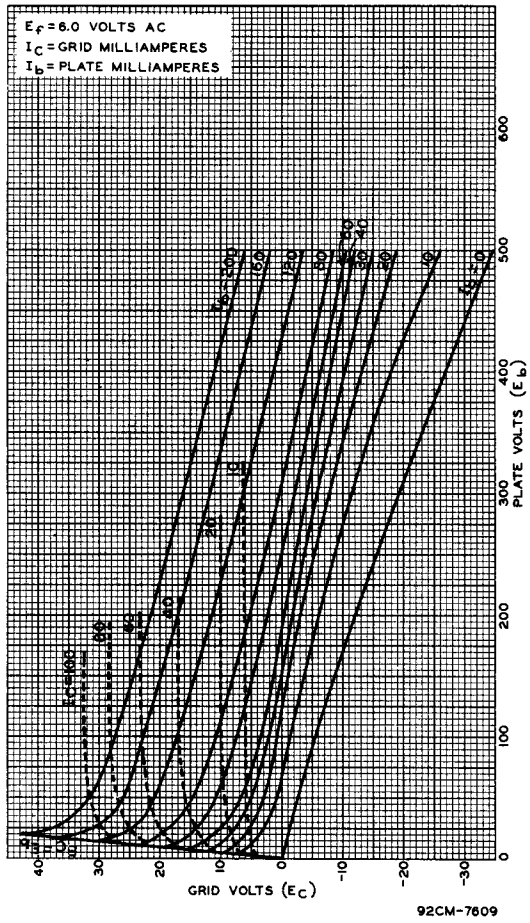


Fig. 1 - Average Constant-Current Characteristics of Type 5893.

exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of the rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *temperature* of the plate seal should not exceed 175 degrees centigrade (at the hottest point). The temperature may be measured with temperature sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York 11, N. Y. in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of one per cent.

Connections to the cathode cylinder, grid flange, and plate cylinder should be made by flexible spring contacts only. The connectors must make firm, large-surface contact, yet must be sufficiently flexible so that no part of the tube is subjected to strain. Unless this recommendation is observed, the glass-to-metal seals may be damaged.

The *heater* leads of the 5893 fit the Cinch socket No. 54A11953. They should not be soldered to circuit elements. The heat of the soldering operation may crack the glass seals of the heater leads and damage the tube.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

In *grounded-grid plate-pulsed oscillator service*, the 5893 should be supplied with bias from a grid resistor. In such service, if the pulse is applied to the plate through a pulse transformer, it is necessary that the contact-potential current in the plate and grid circuits (which can be measured while the modulator is off) be subtracted from the dc plate and grid currents measured during operation in order to obtain the value of plate current for measuring peak plate current and power input. For example, the average contact-potential currents are approximately 0.4 milliampere dc in the plate circuit and 1 milliampere dc in the grid circuit. The value in the grid circuit will vary to some extent with the grid-circuit impedance. A plate current reading of 3 milliamperes during the pulse would, therefore, be corrected to 2.6 milliamperes for use in determining the peak power input.

In *plate-modulated class C rf power amplifier service*, the 5893 should be supplied with bias from a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor. The cathode resistor should be bypassed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation. Grid-bias voltage is not particularly critical so that correct adjustment may be obtained with values differing widely from the calculated values.

In *grounded-grid plate-modulated class C telephony service*, the 5893 can be modulated 100 per cent if the rf driver stage is also modulated 100 per cent simultaneously. Care should be taken to insure that the driver-modulation and the amplifier-modulation voltages are exactly in phase. In such service, the 5893 requires increased driving power, but increased power output is obtained as shown in the tabulated data.

In *class C rf telegraphy service*, the 5893 may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value. If the 5893 is operated at a plate voltage of 300 volts, a fixed bias of at least -10 volts should be used.

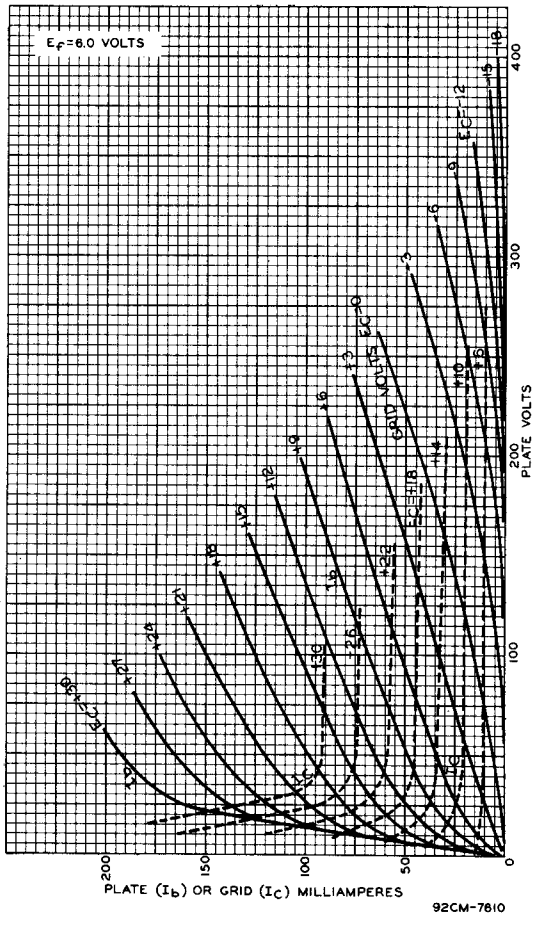


Fig. 2 - Average Plate Characteristics of Type 5893.

In *grounded-grid circuits*, the grid-driving voltage and the developed rf plate voltage act in series to supply the load circuit. As a result, the required driving power is increased over that needed for grounded-cathode circuits. The increased driving power is not lost because it appears as output from the grounded-grid stage. If the driving voltage and grid current are increased, the output will always increase.

In tuning a grounded-grid rf amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

Push-pull or parallel circuit arrangements may be used when more radio-frequency power is required than can be obtained from a single tube. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits. When two or more tubes are used in the circuit, precautions should be taken to balance the plate currents.

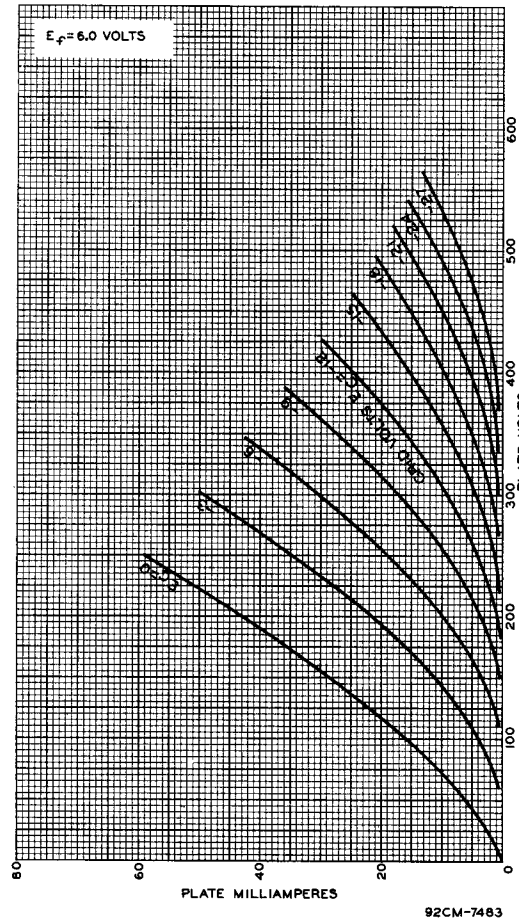


Fig. 3 - Average Plate Characteristics of Type 5893.

REFERENCES

G.M. Rose, D.W. Power, and W.A. Harris, *"Pencil-Type UHF Triodes"*, RCA Review, Vol. 10, No. 3, pp. 321-338 (September, 1949).

E.E. Spitzer, *"Grounded-Grid Power Amplifiers"*, Electronics, Vol. 19, No. 4, pp. 138-141 (April, 1946).

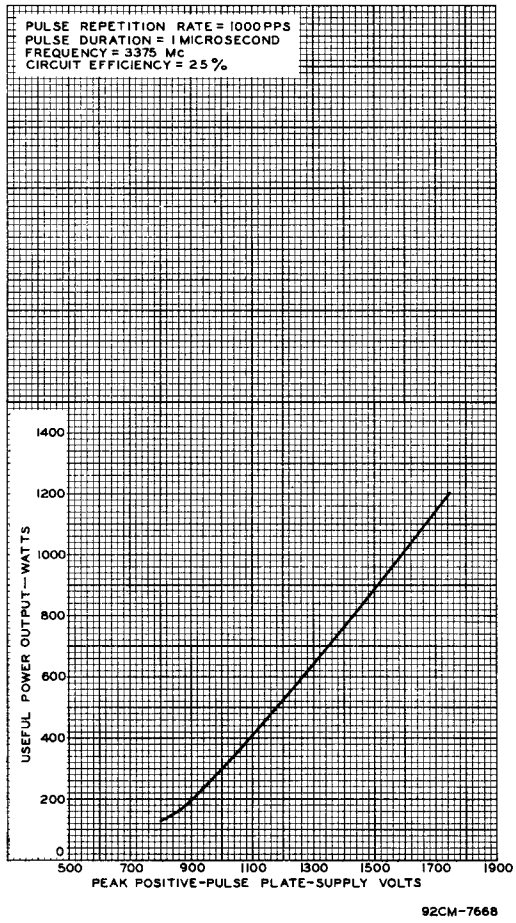
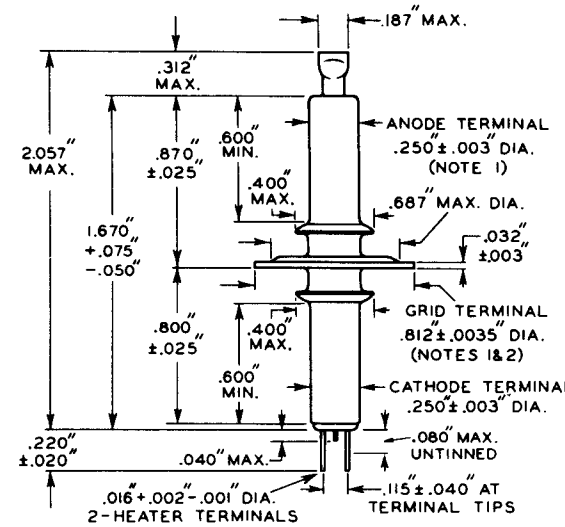


Fig. 4 - Average Performance Characteristic of Type 5893.

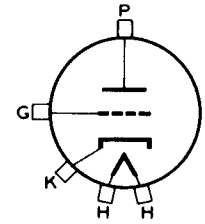
DIMENSIONAL OUTLINE



NOTE 1: MAX. ECCENTRICITY OF ℄ (AXIS) OF ANODE TERMINAL OR GRID-TERMINAL FLANGE WITH RESPECT TO THE ℄ (AXIS) OF THE CATHODE TERMINAL IS 0.008".

NOTE 2: TILT OF GRID-TERMINAL FLANGE WITH RESPECT TO ROTATIONAL AXIS OF CATHODE TERMINAL IS DETERMINED BY CHUCKING THE CATHODE TERMINAL, ROTATING THE TUBE, AND GAUGING THE TOTAL TRAVEL DISTANCE OF THE GRID-TERMINAL FLANGE PARALLEL TO THE AXIS AT A POINT APPROXIMATELY 0.020" INWARD FROM ITS EDGE FOR ONE COMPLETE ROTATION. THE TOTAL TRAVEL DISTANCE WILL NOT EXCEED 0.020".

TERMINAL CONNECTIONS



H: HEATER
K: CATHODE
G: GRID
P: PLATE

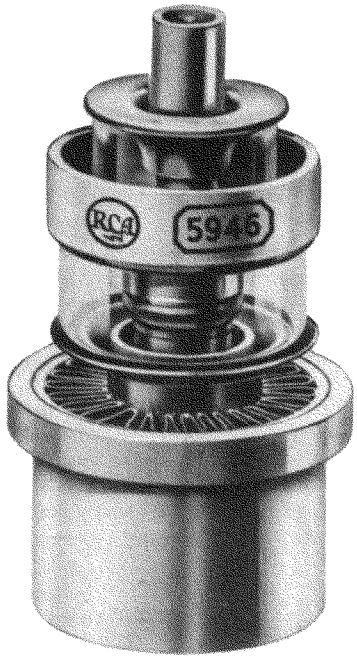
5946

POWER TRIODE

Forced-Air Cooled, Grounded-Grid Type

TENTATIVE DATA

RCA-5946 is a very compact, forced-air cooled power triode designed for uhf plate-pulsed oscillator and amplifier service. In such service, it has a maximum rated plate dissipation of 250



watts, and can be operated with full plate voltage at frequencies up to 1300 megacycles per second. Operation at higher frequencies is permissible with reduced ratings.

The 5946 features a coaxial-electrode structure designed especially for use with circuits of the coaxial-cylinder type. The design provides low-inductance, large-area, rf electrode terminals for insertion into the cylinders, and permits effective isolation of the plate from the cathode. The latter feature makes the 5946 particularly suitable for grounded-grid circuits.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	3.4	amperes
Minimum Heating Time	1	minute
Amplification Factor	27	
Direct Interelectrode Capacitances:		
Grid to Plate	6	μμf
Grid to Cathode	11	μμf
Plate to Cathode[o]	0.32 max.	μμf

Mechanical:

Mounting Position	Vertical, with radiator up or down
Overall Length	3-5/16" ± 3/32"
Greatest Diameter	1.750" ± 0.010"
Radiator	Integral part of tube
Mounting	Special

Air Flow:

The specified air flow for various plate dissipations, as indicated in the tabulation below, should be delivered by a blower onto the respective terminals and seals, and through the radiator before and during the application of any voltages. Heater power, plate power, and air may be removed simultaneously.

Plate Dissipation	150	200	250	watts
Min. Air Flow	5.7	10	16	cfm
Static Pressure	0.16	0.4	0.85	in. of water

The above flow and pressure values are for condition with radiator temperature held constant at 135°C rise above ambient temperature. The air flow must be adequate to limit the temperature of the radiator, grid terminal, cathode terminal, and seals to their respective maximum values.

Radiator Temperature (Measured on core at end adjacent to plate ring)	180 max.	°C
Grid-Terminal Temperature	150 max.	°C
Cathode-Terminal Temperature	150 max.	°C
Seal Temperature (Plate, grid, and cathode)	150 max.	°C

PLATE-PULSED OSCILLATOR & AMPLIFIER -Class C

Maximum Ratings, *Absolute Values*:

For a maximum pulse duration of 5 microseconds*

PEAK POSITIVE-PULSE PLATE-SUPPLY VOLTAGE	7500 max.	volts
PEAK NEGATIVE-PULSE GRID-BIAS VOLTAGE	600 max.	volts
PEAK PLATE CURRENT FROM PULSE SUPPLY	4.5 max.	amp
PEAK RECTIFIED GRID CURRENT	1.0 max.	amp
DC PLATE CURRENT	0.045 max.	amp
DC GRID CURRENT	0.010 max.	amp
PLATE DISSIPATION	250 max.	watts

Typical Operation with Rectangular Wave Shape in Oscillator Circuit at 1250 Mc:

*With duty factor** of 0.01*

Peak Positive-Pulse Plate-Supply Voltage	5500	7500	volts
Peak Negative-Pulse Grid-Bias Voltage	375	500	volts
Cathode Resistor▲	100	100	ohms
Peak RF Grid Voltage	625	850	volts
Peak Plate Current From Pulse Supply	3.5	4.5	amp
Peak Rectified Grid Current	0.25	0.5	amp
DC Plate Current	0.035	0.045	amp
DC Grid Current	0.0025	0.005	amp
Useful Power Output at Peak of Pulse■ (Approx.)	8000	14000	watts

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Characteristics Range Values For Equipment Design:

	Note	Min.	Max.	
Heater Current	1	3.05	3.75	amp
Amplification Factor . . .	1,2	20	34	
Grid-Plate Capacitance . .	-	5.5	6.5	μμf
Grid-Cathode Capacitance .	-	9.6	12.4	μμf
Plate-Cathode Capacitance.	3	-	0.32	μμf
Plate Voltage.	1,4	550	810	volts
Plate Voltage.	1,5	750	1150	volts
Grid Voltage	1,6	-	-125	volts
Peak Cathode Current . . .	1,7	12	-	amp
Useful Power Output at Peak of Pulse . . .	1,8	12	-	kw

Note 1: With 6.3 volts on heater.

Note 2: With dc grid voltage of -15 volts, and dc plate voltage adjusted to give dc plate current of 250 milliamperes.

Note 3: With external shield connected to grid terminal.

Note 4: With dc grid voltage of -10 volts, and dc plate voltage adjusted to give dc plate current of 250 milliamperes.

Note 5: With dc grid voltage of -20 volts, and dc plate voltage adjusted to give dc plate current of 250 milliamperes.

Note 6: With dc plate voltage of 1250 volts, and dc grid voltage adjusted to give dc plate current of 1.0 milliampere.

Note 7: Represents the maximum value of cathode current (plate current and grid current) for the tube under any condition of operation.

Note 8: With peak positive-pulse plate-supply voltage of 7500 volts, cathode-bias resistor of 100 ± 10% ohms, peak plate current from pulse supply of 4.5 amperes, peak rectified grid current of 0.5 ampere, duty factor of 0.01, and frequency of 1250 Mc.

Ratings vs Operating Frequency:

Operating Frequency Mc	Maximum Permissible Percentage of Maximum Rated Plate Voltage
1300	100
2000	75

---

o With external shield connected to grid terminal.

* Pulse duration is defined as the time interval between the two points on the pulse at which the instantaneous value is 70% of the peak value. The peak value is defined as the maximum value of a smooth curve through the average of the fluctuations over the top portion of the pulse. The magnitude of any spike on the plate voltage pulse should not exceed a value of 8500 volts with respect to cathode and its duration should not exceed 0.5 microsecond measured at the peak-pulse-value level.

** Duty factor is the product of pulse duration and repetition rate. For variable pulse durations and pulse repetition rates, the duty factor is defined as the ratio of time "on" to total elapsed time in any 500-microsecond interval.

▲ It is recommended that the entire bias be obtained from a cathode resistor. In certain applications, partial grid-resistor bias may be used.

■ The power output at peak of pulse is obtained from the average power output using the duty factor of the peak power output pulse. This procedure is necessary since the power output pulse duty factor may be less than the applied voltage pulse duty factor because of a delay in the start of rf power output.

INSTALLATION and APPLICATION

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 5946 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The maximum radiator temperature of 180°C as well as the maximum terminal and seal temperatures of 150°C are tube ratings and are to be observed in the same manner as other ratings. The temperature of the radiator should be measured on the core at the end adjacent to the plate ring (see *Outline Drawing*). The temperature may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N. Y., in the form of liquid and stick, and is stated by the maker to have an accuracy of 1 per cent.

In *transportation and storage* of the 5946, care should be taken to protect the tube from rough handling that would damage the glass-to-metal seals or dent or mar the rf contact surfaces. Particular care should be taken not to subject the tube to severe shock which might permanently deform the internal elements. It is recommended that the tube be tested upon receipt in the equipment in which it is to be used.

The *mounting* should support the 5946 in a vertical position with the radiator either up or down. The tube may be supported by the plate ring or by the radiator in any convenient way, but the mounting arrangement used must not subject the grid, cathode, and heater terminals to undue stress.

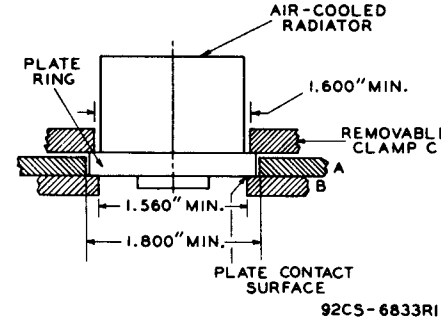


Fig. 1 - Mounting Arrangement for Use with Coaxial-Line or Cavity Circuits.

Because the terminals of the 5946 have progressively smaller diameters from plate to grid to cathode to heater as shown in the *Outline Drawing*, it is possible to insert the 5946 into coaxial and cavity circuits from one end without disassembly of the circuit. In such circuits, the 5946 is supported by the plate ring as shown in Fig. 1.

In the design of this mounting, it is to be noted that the hole in part A, which limits movement of the tube in directions parallel to the plate contact surface, is approximately 0.050" larger than the maximum diameter of the plate ring in order to allow the tube to seek its position freely when being inserted into the grid, cathode, and heater contacts, and to seat properly on the plate contact surface of part B. After the tube is in place, the removable clamp C is brought into position and closed to make the plate contact secure and to anchor the tube firmly in place.

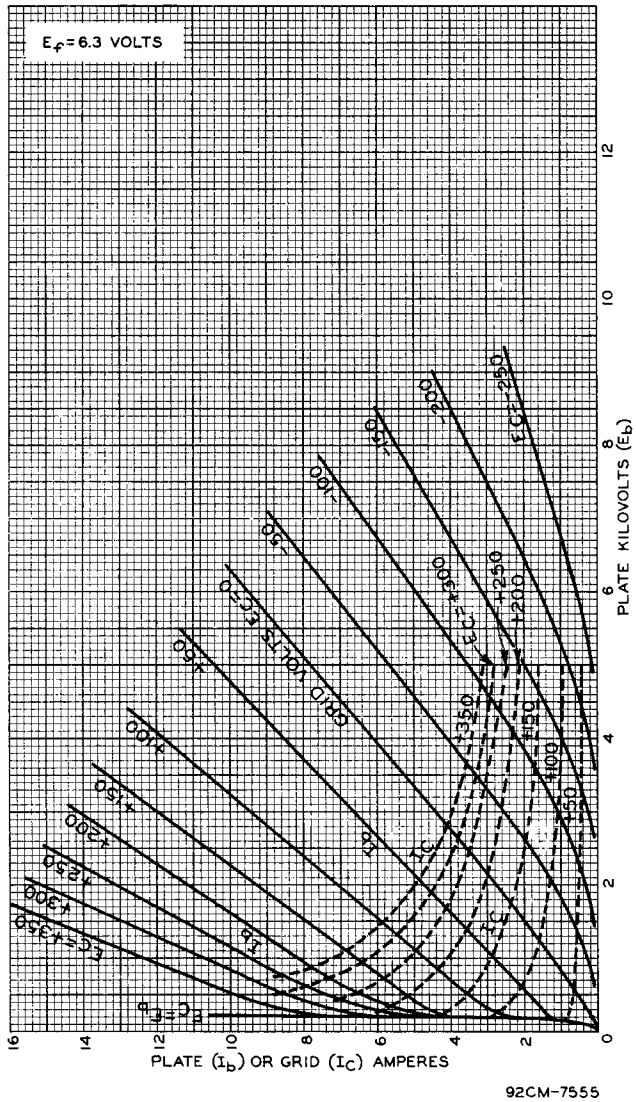
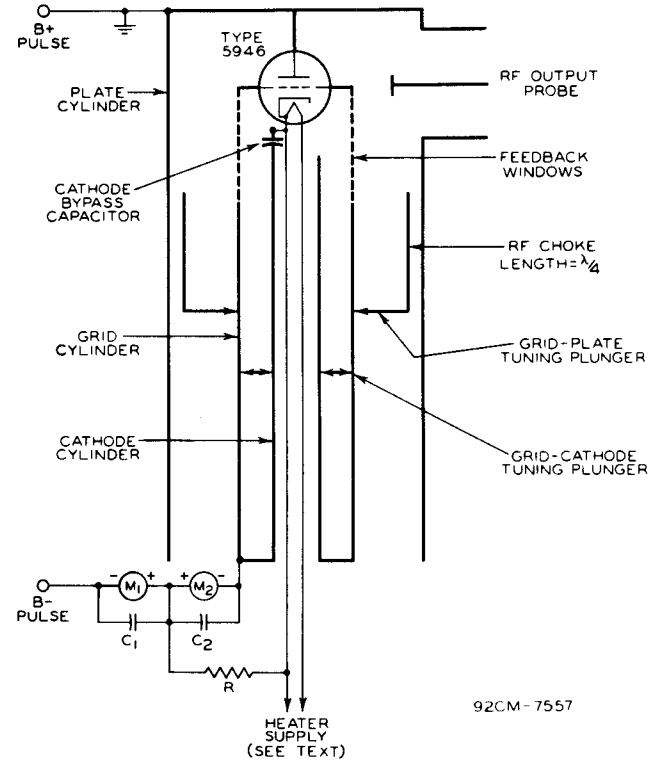


Fig. 2 - Average Characteristics of Type 5946.

In addition to the dimensions shown in Fig. 1, the equipment designer should also observe the diameter tolerances on the grid, cathode, and heater terminals and the limits on concentricity defined by the gauge (see *Outline Drawing*) in order to provide for variation from tube to tube.

Cooling of the 5946 is accomplished by delivering a stream of clean air from a blower onto the respective terminals and seals, and through the radiator before and during the application of any voltages. The air flow through the radiator may be in either direction. The minimum rate of air flow for various plate dissipations is shown in the tabulated data. A suitable air filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated



C_1 C_2 = PAPER CAPACITOR, 4 µf, 1000 VOLT (DC WORKING)
M_1 = DC MILLIAMMETER (PLATE CURRENT)
M_2 = DC MILLIAMMETER (GRID CURRENT)
R = RESISTOR, NON-INDUCTIVE, 100 OHMS (CATHODE BIAS)

Fig. 3 - Diagrammatic Sketch of Pulsed-Oscillator Circuit of the Folded-Back Coaxial Type Employing the 5946 at 1250 Mc.

dirt will not obstruct the required flow of air through the radiator. When the 5946 is operated at full ratings, a flow of 16 cubic feet per minute at a pressure of about 0.85 inch of water is recommended.

The cooling system should be properly installed to insure safe operation of the 5946 under all conditions and for this reason should be electrically interconnected with the heater and plate power supplies. This arrangement is necessary to make sure that the tube is supplied with air before any voltages are applied. Air pressure interlocks which open the power transformer primary of the heater supply and the pulse supply

are desirable for protecting the tube when the air flow is insufficient or ceases.

The *heater* is designed to be operated at 6.3 volts under average line-voltage conditions. Rated heater voltage should be applied for at least one minute to allow the cathode to reach normal operating temperature before voltages are applied to the other electrodes. In circuits where the plate is grounded and the negative pulse is applied to the cathode, the heater supply must be insulated to withstand the peak positive-pulse plate-supply voltage, and it should also present a minimum amount of capacitance loading to the pulse-supply source.

The *unipotential cathode* is indirectly heated by the heater, one terminal of which is common to the cathode.

The *grid* of the 5946 in uhf service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid current, but also by circulating rf currents. For these reasons, more than ordinary care must be taken during operation to prevent overloading the grid.

Average characteristics for the 5946 are shown by the curves in Fig.2.

A *typical pulsed oscillator circuit* of the folded-back, coaxial-cylinder type employing the 5946 at 1250 megacycles per second is illustrated diagrammatically in Fig.3. The structural arrangement of this circuit is shown in Fig.4a with details of the cathode cylinder given in Fig.4b. In this circuit, the plate is grounded, the negative pulse voltage is applied to the cathode and grid, and a minimum of capacitance loading is presented to the pulse-supply source. The heater supply must be insulated to withstand the pulse voltage and should also present minimum capacitance loading to the pulse-supply source.

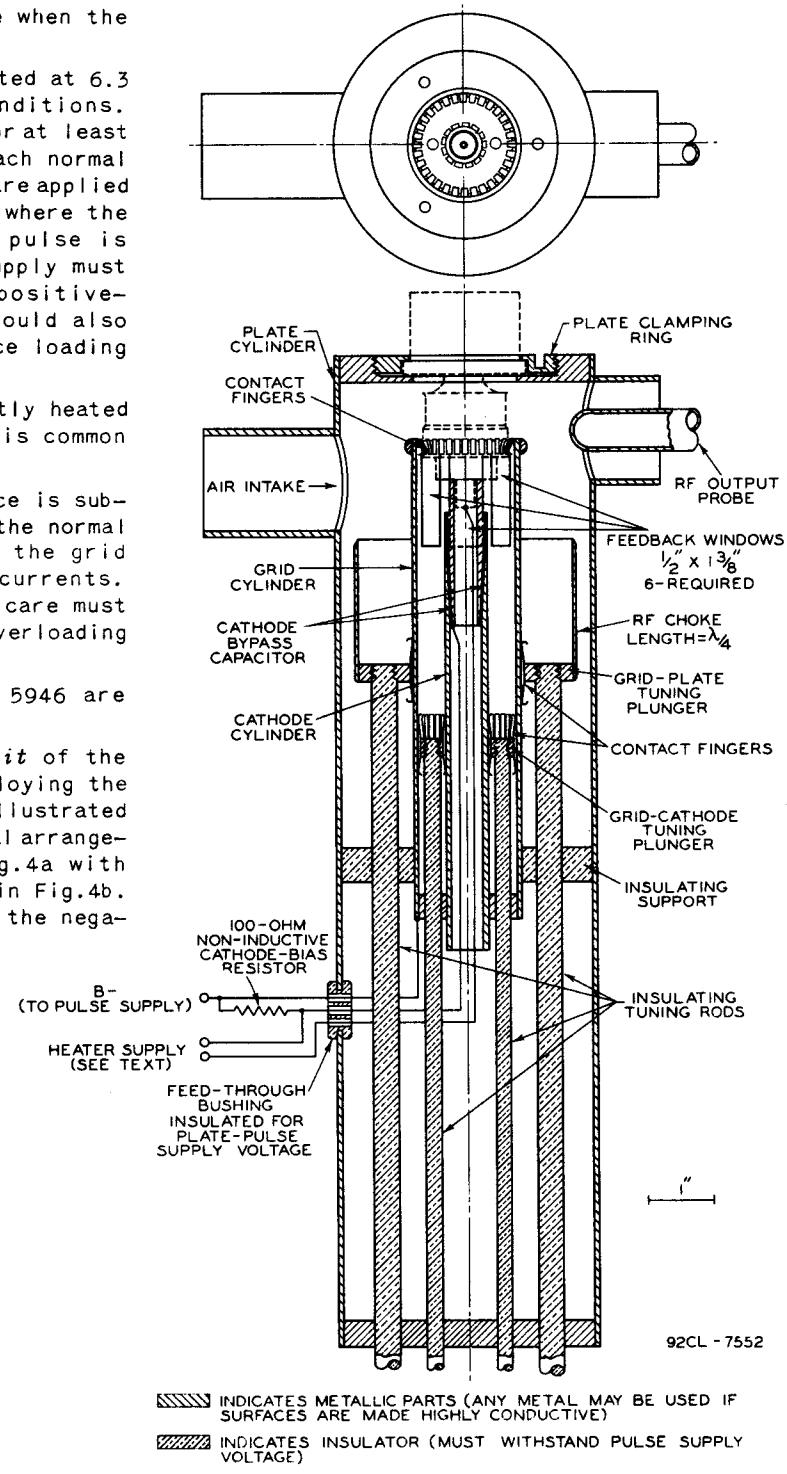


Fig.4a - Structural Arrangement of Pulsed-Oscillator Circuit Shown in Fig.3.

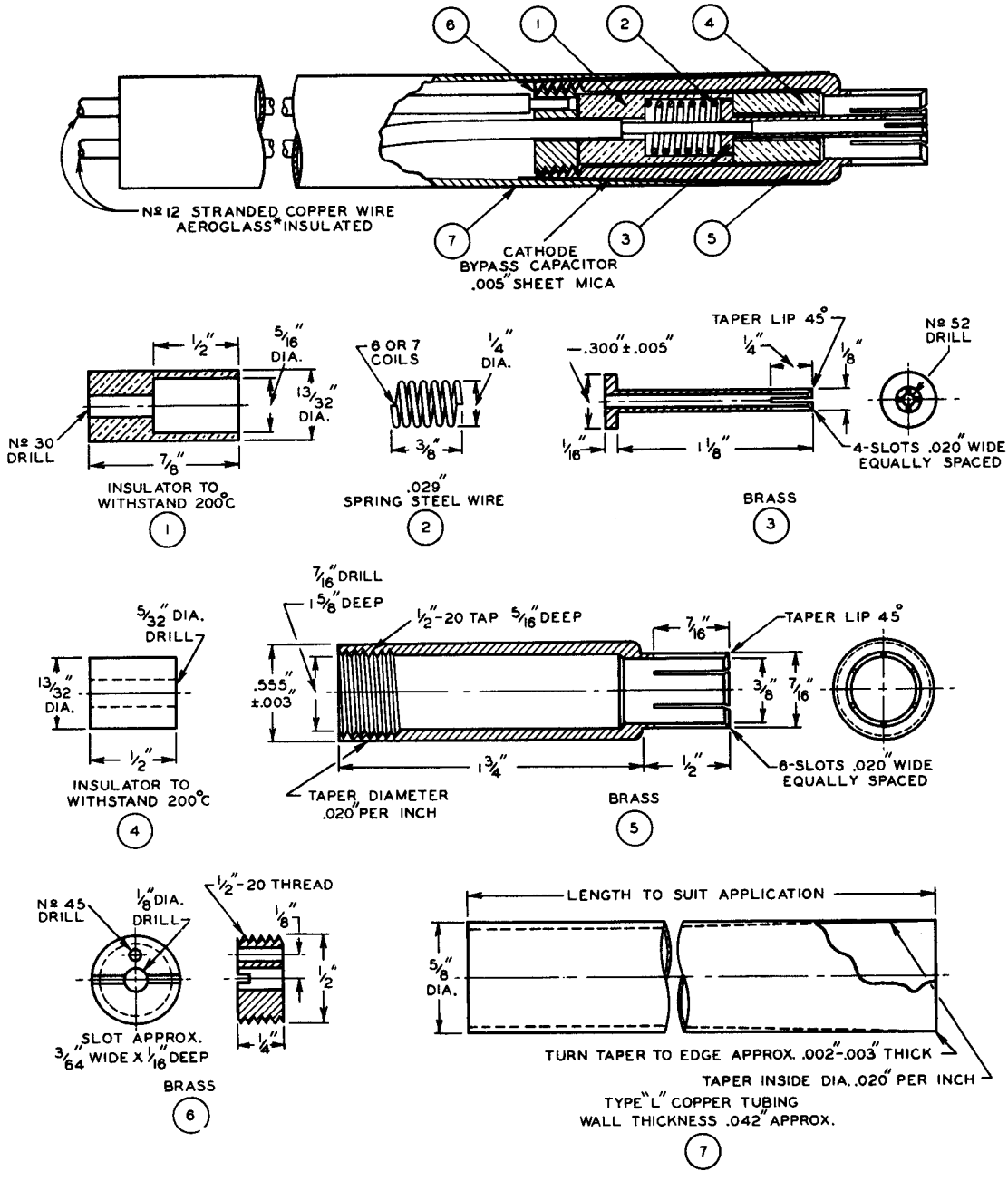
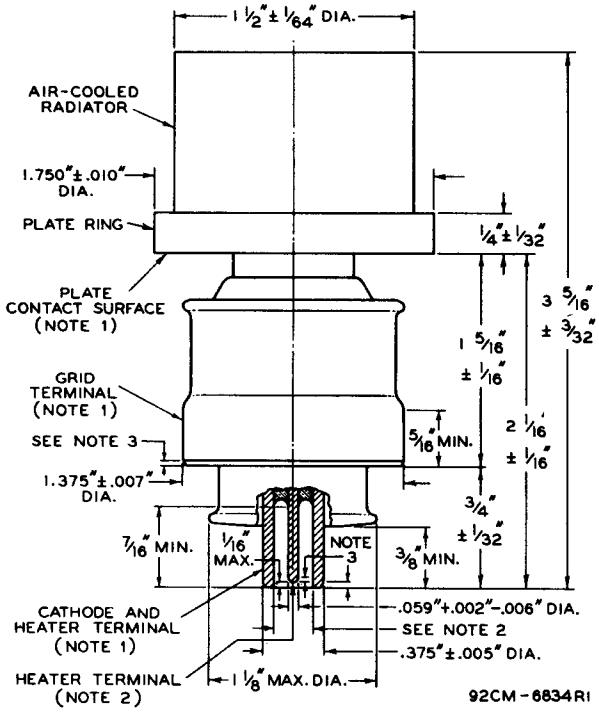


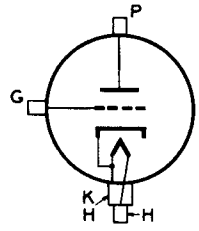
Fig. 4b - Details of The Cathode Cylinder Shown in Fig. 4a.

DIMENSIONAL OUTLINE



TERMINAL CONNECTIONS

P: PLATE
G: GRID



K: CATHODE
H: HEATER

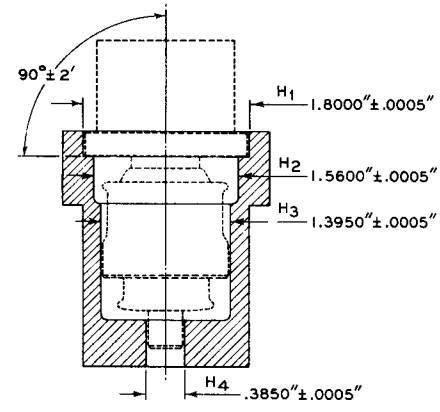
NOTE 1: WITH THE CYLINDRICAL SURFACES OF ITS GRID AND CATHODE TERMINALS CLEAN, SMOOTH, AND FREE OF BURRS, THE TUBE WILL ENTER A GAUGE AS SHOWN IN SKETCH G1. THE FOUR CYLINDRICAL HOLES H_1, H_2, H_3, AND H_4 HAVE AXES COINCIDENT WITHIN 0.0005", LENGTHS DETERMINED FROM THE OUTLINE DRAWING, AND SUCCESSIVELY SMALLER DIAMETERS AS SHOWN IN THE SKETCH.

THE PLATE RING WILL BE ENTIRELY ENGAGED BY HOLE H_1, AND THE CONTACT SURFACE OF THE PLATE RING WILL SEAT ON THE SHOULDER BETWEEN HOLES H_1 AND H_2. THE PLANE SURFACE OF THIS SHOULDER IS 90° ± 2' TO THE AXES OF THE HOLES. SEATING IS DETERMINED BY FAILURE OF A 0.005" THICKNESS GAUGE, 1/8" WIDE, TO ENTER MORE THAN 1/16" BETWEEN THE SHOULDER SURFACE AND THE PLATE CONTACT SURFACE. WITH THE TUBE PROPERLY SEATED AS DESCRIBED ABOVE, THE GRID TERMINAL WILL BE ENTIRELY ENGAGED BY HOLE H_3, AND THE CATHODE TERMINAL WILL BE ENGAGED BY HOLE H_4 TO A DEPTH OF AT LEAST 1/4".

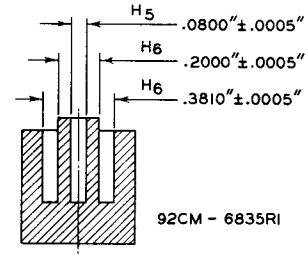
NOTE 2: CONCENTRICITY OF THE HEATER TERMINAL WITH RESPECT TO THE CATHODE TERMINAL IS DETERMINED BY A GAUGE AS SHOWN IN SKETCH G2. THE CYLINDRICAL HOLE H_5 AND THE ANNULAR HOLE H_6 HAVE AXES COINCIDENT WITHIN 0.0005", LENGTHS DETERMINED FROM THE OUTLINE DRAWING, AND DIAMETERS AS SHOWN IN THE SKETCH. THE CATHODE TERMINAL AND THE HEATER TERMINAL WILL ENTER THIS GAUGE TO A DEPTH OF 3/8".

NOTE 3: ROUNDED OR BEVELED NOT TO EXCEED 1/16".

Sketch G1



Sketch G2



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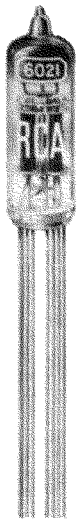
6021

MEDIUM-MU TWIN TRIODE

"Premium" Subminiature Type
For Operation At Altitudes Up To 60000 Feet

TENTATIVE DATA

RCA-6021 is a subminiature medium-mu twin triode of the heater-cathode type having flexible leads. It is intended for use in oscillator and amplifier applications at frequencies up to 400 Mc. Constructed to give dependable performance under conditions of shock and vibration, this "premium" tube is especially suited for use in mobile and aircraft equipment and is rated for service at altitudes up to 60000 feet without the use of pressurized chambers.



Actual Size

The design of the 6021 incorporates a compact structure in which special attention has been given to the following features: (1) "U" frame construction to keep the mount rigid and prevent distortion of plates, (2) precisely made and accurately fitted tube parts, including new mica design, to lock the parts firmly in place, (3) grid side rods having high heat conductivity to provide cool operation of the grids, (4) pure-tungsten heater having high mechanical strength, (5) getter shield to prevent deposit of getter flash on tube elements, and (6) pure nickel plate to minimize evolution of gas.

As a result of its structural design, this tube is characterized by: (1) small spread in electrical characteristics, (2) reduced microphonic effects, (3) reduced grid emission, (4) long life under frequent on-off switching, and (5) low leakage currents and high leakage resistance between the elements. In addition, this tube utilizes separate terminals for each cathode to permit flexibility of circuit arrangement.

Manufactured under rigid controls, the 6021 undergoes rigorous tests during manufacture to insure its "premium" quality as follows: test readings at the end of 1 hour, 100 hours, and 500 hours to insure that tubes fall within the established tight characteristics limits and that early failures are held to a low percentage.

GENERAL DATA

Electrical:

Heater for Unipotential Cathodes:			
Voltage (AC or DC)	6.3 ± 5%		volts
Current	0.3		amp
Direct Interelectrode Capacitances:	*With External Shield**	*Without External Shield*	
Grid to plate (Each unit)	1.4	1.5	μμf
Grid to cathode and heater (Each unit)	2.1	2.4	μμf
Plate to cathode and heater (Unit No.1)	1.3	0.28	μμf
Plate to cathode and heater (Unit No.2)	1.4	0.32	μμf
Grid to grid	0.011 max.	0.013 max.	μμf
Plate to plate	0.33 max.	0.52 max.	μμf

Mechanical:

Operating Position	Any
Maximum Bulb Length	1-3/8"
Length from Button Seal to Bulb Top (Excluding tip)	1.075" ± 0.060"
Diameter	0.366" - 0.400"
Bulb	T3
Leads, Flexible	8
Minimum Length	1.5"
Orientation and Diameter	See Dimensional Outline

AMPLIFIER -- Class A_1

Values are for Each Unit

Maximum Ratings, *Absolute Values:*

For Operation At Altitudes Up To 60000 Feet

PLATE VOLTAGE	165 max.	volts
GRID VOLTAGE:		
Positive bias value	0 max.	volts
Negative bias value	-55 max.	volts
PLATE CURRENT	22 max.	ma
GRID CURRENT	5.5 max.	ma
PLATE DISSIPATION	1.1 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	220 max.	°C

Characteristics:

Plate Supply Voltage	100	volts
Cathode Resistor	150	ohms
Plate Current	6.5	ma

TMK ®, Marca Registrada
Printed in U.S.A

Amplification Factor	35	
Plate Resistance (Approx.)	6500	ohms
Transconductance	5400	μmhos
Grid Voltage (Approx.) for plate current of 10 μa	-6.5	volts

Maximum Circuit Values:

Grid-Circuit Resistance:		
For cathode-bias operation	1.1 max.	megohm

* With 0.405" internal diameter shield connected to cathode of unit under test.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values Are For Each Unit (Other unit grounded) and are Initial, Unless Otherwise Indicated.

	Note	Min.	Max.	
Heater Current	1	0.280	0.320	amp
Heater Current at 500 Hours	1	0.276	0.328	amp
Direct Interelectrode Capacitances:				
Grid to plate	2	1.2	1.8	μμf
Grid to cathode and heater	2	1.8	3.0	μμf
Plate to cathode and heater (Unit No.1)	2	0.20	0.36	μμf
Plate to cathode and heater (Unit No.2)	2	0.22	0.42	μμf
Grid to grid	3	-	0.013	μμf
Plate to plate	3	-	0.52	μμf
Amplification Factor	1,4	30	40	
Plate Current (1)	1,4	4.5	8.5	ma
Plate-Current Difference Between Units	1,4	-	1.6	ma
Plate Current (2)	1,5	-	100	μa
Transconductance (1)	1,4	4450	6350	μmhos
Transconductance(1)Change: With heater voltage reduced to 5.7 volts	4	-	15	per cent
Individual at 500 Hours.	1,4	-	25	per cent
Average at 500 Hours	1,4	-	15	per cent
Average at 500 Hours: With heater voltage reduced to 5.7 volts.	4	-	15	per cent
Reverse Grid Current	1,6	-	0.3	μa
Reverse Grid Current at 500 Hours	1,6	-	0.9	μa
Grid Emission Current	7	-	-0.5	μa
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1	-	5	μa
Heater positive with respect to cathode	1	-	5	μa
Heater-Cathode Leakage Current at 500 Hours:				
Heater 100 volts negative with respect to cathode	1	-	10	μa
Heater 100 volts positive with respect to cathode	1	-	10	μa
Leakage Resistance:				
Between grid and all other electrodes tied together	1,3,8	100	-	megohms
Between plate and all other electrodes tied together	1,3,9	100	-	megohms
Leakage Resistance at 500 Hours:				
Between grid and all other electrodes tied together	1,3,8	50	-	megohms
Between plate and all other electrodes tied together	1,3,9	50	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: Without external shield.

Note 3: Other electrodes grounded.

Note 4: With dc plate supply voltage of 100 volts, cathode resistor of 150 ohms, and cathode-resistor bypass capacitor of 1000 μf.

Note 5: With dc plate voltage of 100 volts and grid voltage of -6.5 volts.

Note 6: With dc plate supply voltage of 150 volts, cathode resistor of 300 ohms, and grid resistor of 1 megohm.

Note 7: With ac or dc heater voltage of 7.5 volts, dc plate voltage of 150 volts, grid voltage of -7.5 volts, and grid resistor of 1 megohm.

Note 8: With grid voltage of -100 volts.

Note 9: With dc plate voltage of -300 volts.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration . . . . . 450 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are held rigid and are tested in four different positions. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, and transconductance change.

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected in each of three positions to 2.5 g vibrational acceleration at 60 cycles per second for 32 hours. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, and transconductance change.

Variable-Frequency Vibration Performance:

This test is performed on a sample lot from each production run. Tubes are vibrated over the frequency range of 5 to 50 cps at a total excursion of 0.08" for 3 minutes. At the end of this test, tubes are required to meet established limits for low-frequency vibration, heater-cathode leakage current, and transconductance change.

Low-Frequency Vibration Performance:

RMS Output Voltage . . . . . 50 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, cathode resistor of 150 ohms, plate load resistor of 10000 ohms and vibrational acceleration of 15 g at 40 cps.

Heater-Cycling Life Performance:

Cycles of Intermittent Operation . . 2000 min. cycles

Under the following conditions: Heater voltage of 7.0 volts cycled one minute on four minutes off, heater 140 volts rms with respect to both cathodes tied together.

Audio-Frequency Noise and Microphonic Performance:

Output Voltage . . . . . 65 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, cathode resistor of 75 ohms, grid-No.1 resistor of 0.1 megohm, plate load resistor of 0.01 megohm, and cathode-bypass capacitor of 1000 μf. Units are connected in parallel. The output voltage of a tube, when tapped, will not cause a reading on a vu meter greater than that produced when a calibrating signal of 65 millivolts rms is applied to the plates of the tube.

Shorts and Continuity Test:

This test is performed on a sample lot of tubes from each production run. In this test a tube is considered inoperative it it shows a permanent or temporary

short or open circuit, or a value of reverse grid current in excess of 1.0 microampere under the conditions specified in the Characteristics Range Values for reverse grid current.

1-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that the tubes have been properly stabilized. Conditions of life testing are specified under 500-Hour Intermittent Life Performance, except test run at room temperature. Tubes are initially read for Transconductance (1). At the end of 1 hour, the value of transconductance (1) is read. The variation in transconductance (1) from the 0-hour reading will not exceed 15 per cent under the conditions specified in Characteristics Range Values.

100-Hour Survival Life Performance:

This test is performed on a sample lot of tubes from each production run to insure a low percentage of early inoperatives. Conditions of life testing are specified under 500-Hour Intermittent Life Performance, except test run at room temperature. At the end of 100 hours, a tube is considered inoperative if it shows a permanent or temporary short or open circuit, reverse grid current in excess of 1.0 microampere, or a transconductance (1) of less than 4000 micromhos under the conditions specified in Characteristics Range Values.

500-Hour Intermittent Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures of any of the characteristics indicated below. Life testing is conducted under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, heater-cathode voltage of 200 volts (heater positive with respect to cathode), cathode resistor of 150 ohms, grid resistor of 1 megohm and bulb temperature of 220° C. At the end of 500 hours, tube will not show permanent shorts or open circuits and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to pass established initial limits of heater current, individual, average, and 5.7 heater voltage transconductance change, reverse grid current and heater-cathode leakage current shown under Characteristics Range Values.

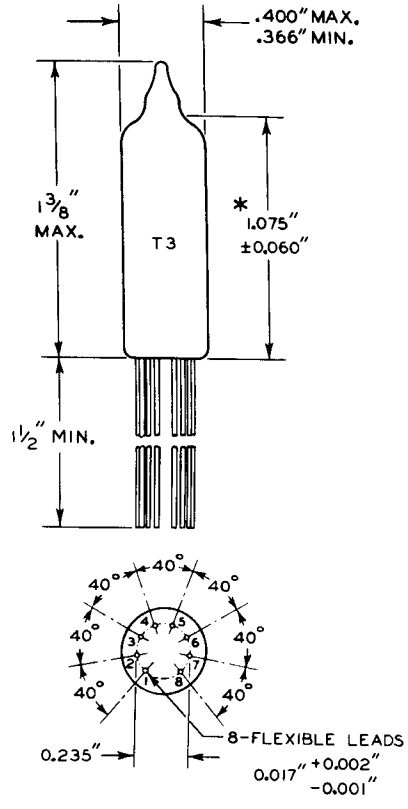
OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6021 are limiting values above which the serviceability of the 6021 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *heater supply* should be well regulated because life and reliability of the 6021 are adversely affected by departures from the 6.3-volt value. The extent to which life is affected is a function of the amount of these departures and their durations.

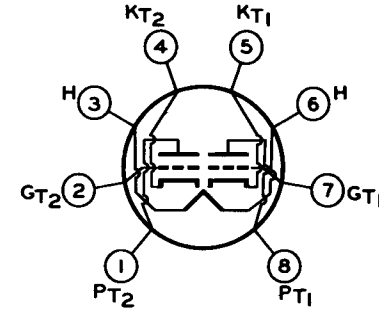
The *flexible leads* of the 6021 are usually soldered to the circuit elements. Soldering of the connections should be made as far as possible from the glass button. If this precaution is not followed, the heat of the soldering may crack the glass seals of the leads and damage the tube.

DIMENSIONAL OUTLINE



* MEASURED FROM BULB SEAT TO BULB-TOP LINE AS DETERMINED BY A RING GAUGE OF 0.210" ± 0.001" I.D.

LEAD CONNECTIONS
Bottom View



LEAD No.1: PLATE OF TRIODE No.2
LEAD No.2: GRID OF TRIODE No.2
LEAD No.3: HEATER
LEAD No.4: CATHODE OF TRIODE No.2
LEAD No.5: CATHODE OF TRIODE No.1
LEAD No.6: HEATER
LEAD No.7: GRID OF TRIODE No.1
LEAD No.8: PLATE OF TRIODE No.1

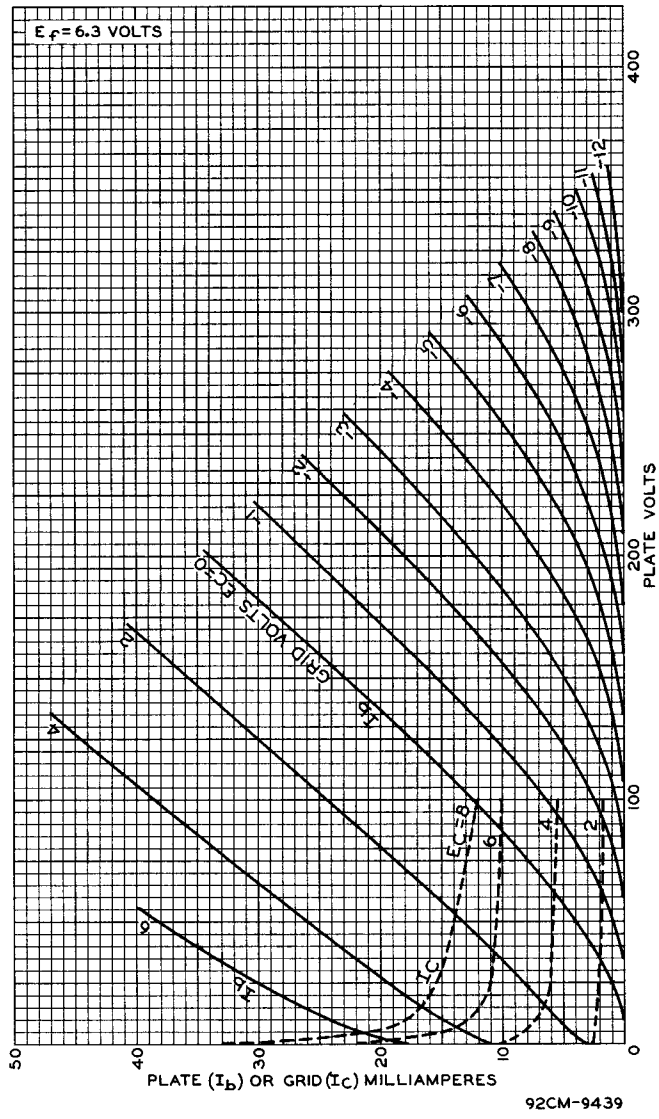


Fig. 1 - Average Characteristics for Each Unit of Type 6021.

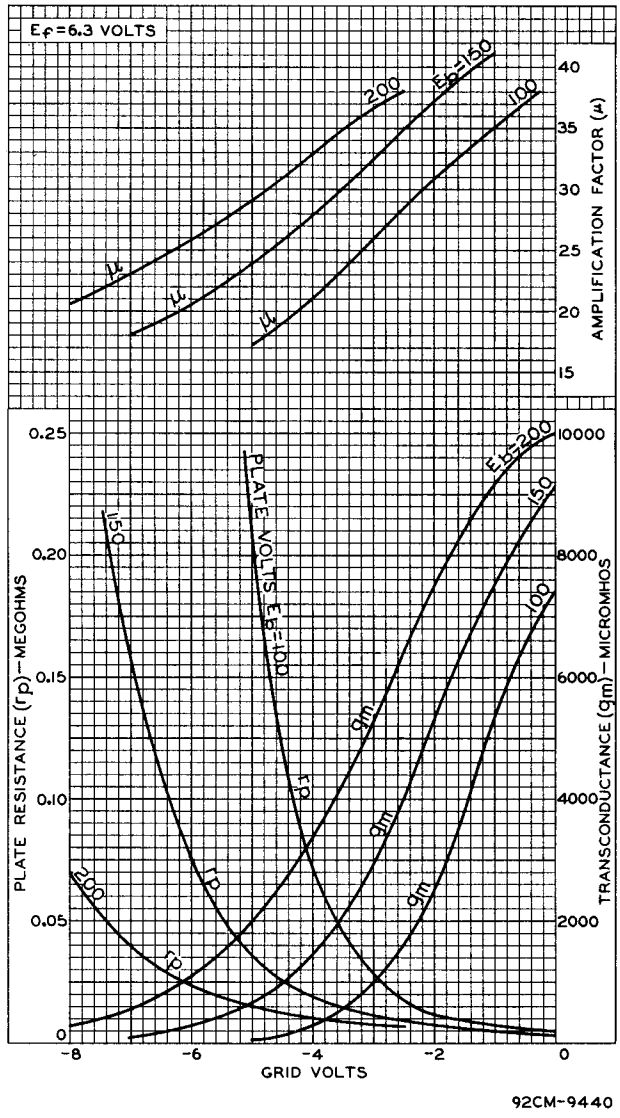


Fig. 2 - Average Characteristics for Each Unit of Type 6021.

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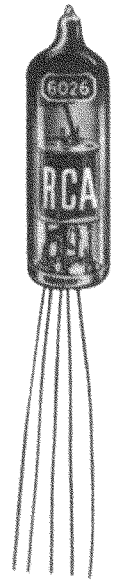
6026

OSCILLATOR TRIODE

Subminiature Type for Radiosonde Service at 400 Mc

TENTATIVE DATA

RCA-6026 is a high-efficiency oscillator triode of the subminiature type intended particularly for transmitting service in radiosonde and similar applications. As a class C oscillator in such service, the tube can deliver a useful power output of 1.25 watts.



Actual Size

Utilizing subminiature construction with flexible leads, the 6026 has very short transit time and low interelectrode capacitances. In addition, the very small size and light weight of this tube make it especially useful in equipment requiring extreme compactness.

Ratings for this tube have been established on the basis of its intended use in radiosonde and similar applications where power output, compactness, and light weight are the primary considerations, and where a tube life of only a few hours is required.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage Range* (AC or DC)	5.2 to 6.6	volts
Current, with 6.3 volts on heater	0.2	ampere
Direct Interelectrode Capacitances (With no external shield):		
Grid to Plate	1.3	μμf
Input	2.2	μμf
Output	0.38	μμf
Characteristics, Class A Amplifier:		
Plate Voltage	120	volts
Cathode Resistor	220	ohms
Amplification Factor	24	
Plate Resistance	4000	ohms
Transconductance	5900	micromhos
Plate Current	12	ma

Mechanical:

Mounting Position	Any
Maximum Envelope Length	1-1/2"
Maximum Length from Button Seal to Bulb Top (Excluding tip)	1.26"
Maximum Diameter	0.4"
Bulb	T-3
Leads, flexible	5
Length	1-1/2" to 1-3/4"
Orientation and Diameter	Same as Sub-Minar Base

OSCILLATOR - Class C Telegraphy

Maximum Ratings,* *Absolute Values*:

DC PLATE VOLTAGE	150 max.	volts
DC GRID VOLTAGE	-50 max.	volts
TOTAL CATHODE CURRENT	40 max.	ma
DC GRID CURRENT	10 max.	ma
PLATE INPUT	3.3 max.	watts
PLATE DISSIPATION	3.0 max.	watts
PEAK HEATER-CATHODE VOLTAGE	0 max.	volts

Typical Operation as Oscillator at 400 Mc:

DC Plate Voltage	135	volts
Grid Resistor	1300	ohms
DC Plate Current	20	ma
DC Grid Current (Approx.)	9.5	ma
Useful Power Output	1.25	watts

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current:				
With 5.2 volts ac on heater	-	0.176	-	amp
With 6.6 volts ac on heater	-	-	0.225	amp
Amplification Factor	1	17	31	
Grid-to-Plate Capacitance	-	1.05	1.55	μμf
Grid-to-Cathode Capacitance	-	1.75	2.65	μμf
Plate-to-Cathode Capacitance	-	0.305	0.455	μμf
Plate Current	2	8	16	ma
Plate Current	3	9.5	18.5	ma
Plate Current	4	-	300	μamp
Transconductance	2	4200	7600	μmhos
Transconductance	3	4600	8000	μmhos

Note 1: With 5.2 or 6.3 volts ac on heater, 120 volts dc on plate, and cathode resistor of 220 ohms.
Note 2: With 5.2 volts ac on heater, 120 volts dc on plate, and cathode resistor of 220 ohms.
Note 3: With 6.3 volts ac on heater, 120 volts dc on plate, and cathode resistor of 220 ohms.
Note 4: With 5.2 volts ac on heater, 120 volts dc on plate, -12 volts dc on grid, and cathode resistor of 220 ohms.

* Heater voltage range and maximum ratings are established on basis that tube heater will be supplied from batteries in radiosonde and similar applications utilizing equipment designed for extreme compactness and light weight and requiring tube life of only a few hours.

OPERATING NOTES

The *maximum ratings* in the tabulated data for the 6026 are limiting values above which the serviceability of the 6026 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

It is recommended that the cathode be connected directly to the heater.

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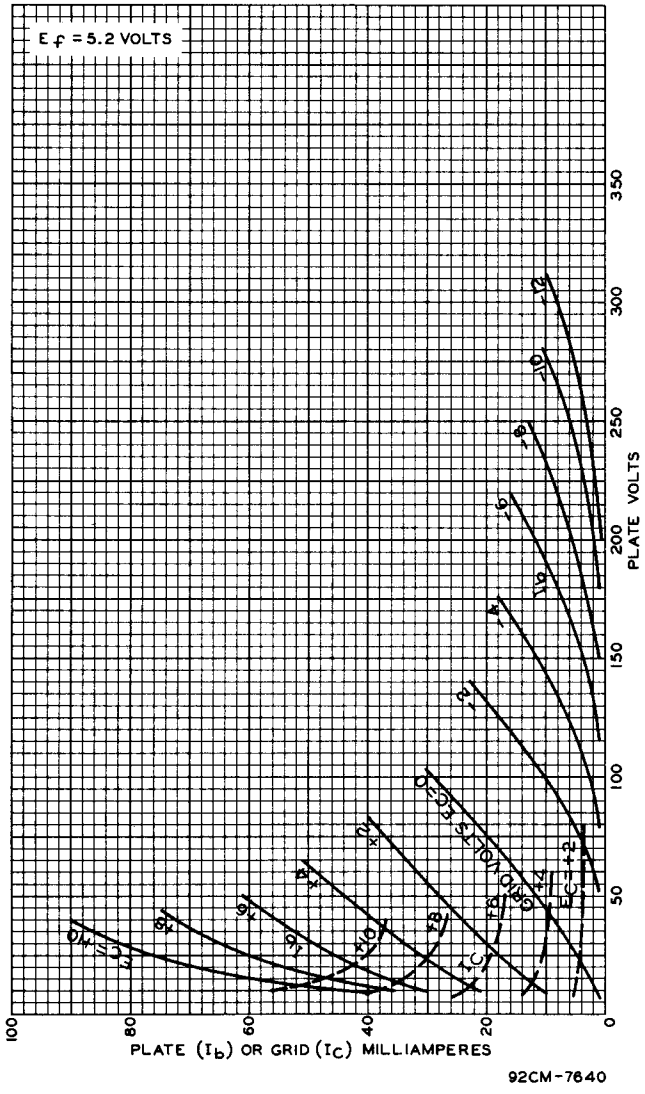
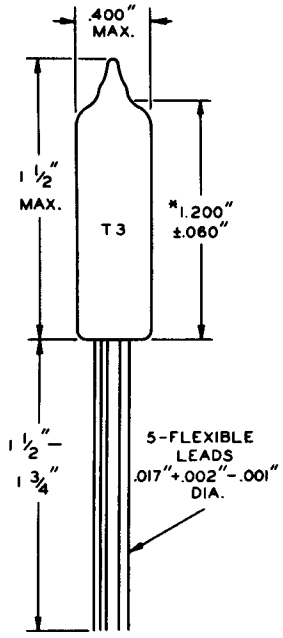
The *flexible leads* of the 6026 are usually soldered to the circuit elements. Soldering of the connections should be made as far as possible from the glass button. If this precaution is not followed, the heat of the soldering operation may crack the glass seals of the leads and damage the tube.



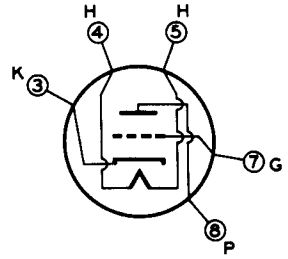
Average Plate Characteristics of Type 6026.

DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF .210" I.D.

TERMINAL CONNECTIONS



LEAD 3: CATHODE
LEAD 4: HEATER
LEAD 5: HEATER
LEAD 7: GRID
LEAD 8: PLATE

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6073

VOLTAGE REGULATOR

Miniature Glow-Discharge Type

TENTATIVE DATA

RCA-6073 is a cold-cathode, glow-discharge tube of the miniature type having very stable characteristics. It is intended for voltage-regulator applications critical as to excessive shock and vibration.

GENERAL DATA

Cathode	Cold
Maximum Instantaneous Impact Acceleration⊕	900g
Maximum Vibrational Acceleration for Extended Periods●	2.5g

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No. E7-1)

Maximum Ratings, *Absolute Values*:

AVERAGE STARTING CURRENT■	75 max.	ma
DC CATHODE CURRENT	30 max.	ma
	5 min.	ma
AMBIENT TEMPERATURE RANGE	-55 to +90	°C
FREQUENCY	0 max.	cps

Characteristics Range Values for Equipment Design:

	Min.	*Av.*	*Max.*	
DC Anode-Supply Voltage	185▲	-	-	volts
Anode Breakdown Voltage	-	156	185✠	volts
Anode Voltage Drop	140★	151	168✠	volts
Regulation (5 to 30 ma)	-	2	6✠	volts

Circuit Values:

Shunt Capacitor	-	-	0.1	μf
Series Resistor			See Note 1	

⊕ Forces in any direction as applied by the NRL Standard High-Impact Shock Machine for Electronic Devices or its equivalent.

● Vibrational forces in any direction at 25 cycles per second for a period not exceeding 96 hours.

■ Averaged over starting period not exceeding 10 seconds. When equipment utilizing the 6073 is "turned on", a starting current in excess of the average operating current is permissible as indicated under Maximum Ratings.

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6073-8-51
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When the tube is subjected to such high starting currents, the regulated voltage may require up to 20 minutes to drop to its normal operating value. This performance is characteristic of voltage-regulator tubes of the glow-discharge type. Similarly, the regulation is affected by changes in current within the operating current range. For example, the regulation of a tube operated for a protracted period at 5 milliamperes and then changed to 25 milliamperes, may be somewhat different from the value that will be obtained after a long period of operation at 25 milliamperes. Likewise, the regulation may change somewhat after a long idle period.

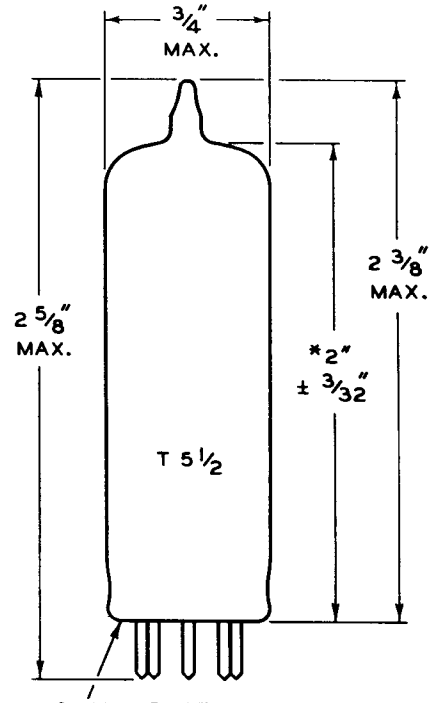
▲ Not less than indicated supply voltage should be provided to insure "starting" throughout tube life.

✠ Maximum individual tube value during life.

★ Minimum individual tube value during life.

Note 1: A series resistor must always be used with the 6073. The resistance value must be chosen so that the maximum current rating (30 ma) of the 6073 is not exceeded at the highest anode-supply voltage employed, and so that the minimum current rating (5 ma) is always exceeded at the lowest anode-supply voltage.

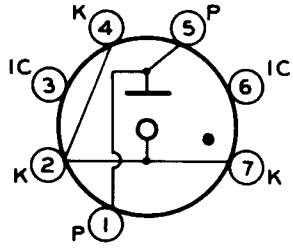
DIMENSIONAL OUTLINE



SMALL-BUTTON MINIATURE 7-PIN BASE

* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



5BO

PIN 1 – ANODE
PIN 2 – CATHODE
PIN 3 – INTERNAL CON. DO NOT USE
PIN 4 – CATHODE
PIN 5 – ANODE
PIN 6 – INTERNAL CON. DO NOT USE
PIN 7 – CATHODE

6074

VOLTAGE REGULATOR

Miniature Glow-Discharge Type

TENTATIVE DATA

RCA-6074 is a cold-cathode, glow-discharge tube of the miniature type having very stable characteristics. It is intended for voltage-regulator applications critical as to excessive shock and vibration.

GENERAL DATA

Cathode	Cold
Maximum Instantaneous Impact Acceleration⊕	900g
Maximum Vibrational Acceleration for Extended Periods●	2.5g

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T-5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No. E7-1)

Maximum Ratings, *Absolute Values*:

AVERAGE STARTING CURRENT■	75 max.	ma
DC CATHODE CURRENT	30 max. 5 min.	ma ma
AMBIENT TEMPERATURE RANGE	-55 to +90	°C
FREQUENCY	0 max.	cps

Characteristics Range Values for Equipment Design:

	Min.	*Av.*	*Max.*	
DC Anode-Supply Voltage	133▲	-	-	volts
Anode Breakdown Voltage	-	115	133✠	volts
Anode Voltage Drop	101★	108	114✠	volts
Regulation (5 to 30 ma)	-	1	4✠	volts

Circuit Values:

Shunt Capacitor	-	-	0.1	μf
Series Resistor			See Note 1	

⊕ Forces in any direction as applied by the NRL Standard High-Impact Shock Machine for Electronic Devices or its equivalent.

● Vibrational forces in any direction at 25 cycles per second for a period not exceeding 96 hours.

■ Averaged over starting period not exceeding 10 seconds. When equipment utilizing the 6074 is "turned on", a starting current in excess of the average operating current is permissible as indicated under Maximum Ratings. When the tube is subjected to such high starting currents, the regulated

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voltage may require up to 20 minutes to drop to its normal operating value. This performance is characteristic of voltage-regulator tubes of the glow-discharge type. Similarly, the regulation is affected by changes in current within the operating current range. For example, the regulation of a tube operated for a protracted period at 5 milliamperes and then changed to 25 milliamperes, may be somewhat different from the value that will be obtained after a long period of operation at 25 milliamperes. Likewise, the regulation may change somewhat after a long idle period.

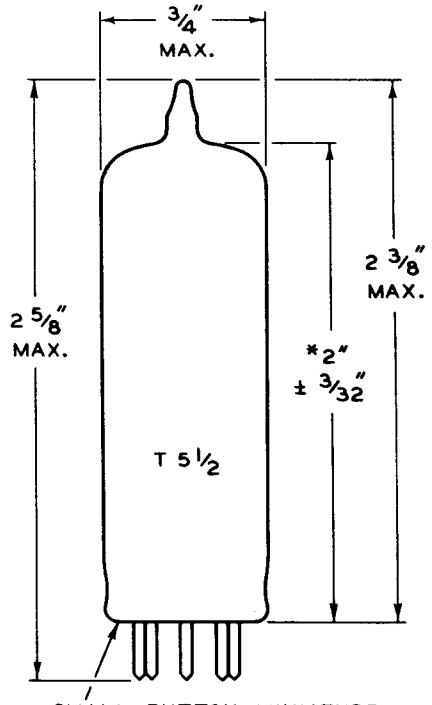
▲ Not less than indicated supply voltage should be provided to insure "starting" throughout tube life.

✠ Maximum individual tube value during life.

★ Minimum individual tube value during life.

Note 1: A series resistor must always be used with the 6074. The resistance value must be chosen so that the maximum current rating (30 ma) of the 6074 is not exceeded at the highest anode-supply voltage employed, and so that the minimum current rating (5 ma) is always exceeded at the lowest anode-supply voltage.

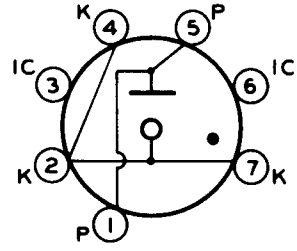
DIMENSIONAL OUTLINE



SMALL-BUTTON MINIATURE 7-PIN BASE

* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View



5BO

PIN 1 – ANODE
PIN 2 – CATHODE
PIN 3 – INTERNAL CON. DO NOT USE
PIN 4 – CATHODE
PIN 5 – ANODE
PIN 6 – INTERNAL CON. DO NOT USE
PIN 7 – CATHODE

6111

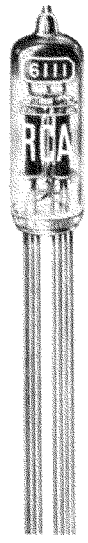
MEDIUM-MU TWIN TRIODE

"Premium" Subminiature Type

For Operation at Altitudes Up to 60000 Feet

TENTATIVE DATA

RCA-6111 is a subminiature medium-mu twin triode of the heater-cathode type having flexible leads. It is intended for use in oscillator and amplifier applications at frequencies up through the vhf region. Constructed to give dependable performance under conditions of shock and vibration, this "premium" tube is especially suited for use in critical industrial applications and in aircraft equipment. Full ratings may be used at altitudes up to 60000 feet without the use of pressurized chambers.



Actual Size

In the 6111, special attention has been given to structural features which improve its strength for resistance to both shock and vibration. These features include a special "U" frame construction to keep the mount rigid, and special tube parts which are precisely made and accurately fitted to lock the parts firmly in place and thus eliminate variations in electrical characteristics. Other features include grid rods having high heat conductivity to provide cool operation thereby minimizing grid emission, a pure-tungsten heater having high mechanical strength to give long life under conditions of frequent on-off switching, and a special getter shield to prevent deposit of getter flash on tube elements. These features in addition to rigid controls and rigorous tests to insure "premium" quality, make this tube especially useful in military and critical industrial applications.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathodes:		
Voltage (AC or DC)	6.3 ± 5%	volts
Current	0.3	ampere

Direct Interelectrode Capacitances:

	*With External Shield**	*Without External Shield*	
Grid to plate (Each unit)	1.4	1.5	μμf
Grid to cathode and heater (Each unit)	2.1	1.9	μμf
Plate to cathode and heater (Unit No.1)	1.3	0.28	μμf
Plate to cathode and heater (Unit No.2)	1.4	0.32	μμf
Grid to grid	0.010 max.	0.011 max.	μμf
Plate to plate	0.30 max.	0.50 max.	μμf

Mechanical:

Operating Position	Any
Maximum Bulb Length	1-3/8"
Length from Button Seal to Bulb Top (Excluding tip)	1.075" ± 0.060"
Diameter	0.400" max. - 0.366" min.
Bulb	T3
Leads, Flexible	8
Minimum Length	1.5"
Orientation and Diameter	See Dimensional Outline

AMPLIFIER -- Class A_1

Maximum Ratings, *Absolute Values:*

For Operation at Altitudes Up to 60000 Feet

Values are for Each Unit

PLATE VOLTAGE	165 max.	volts
GRID VOLTAGE:		
Positive bias value	0 max.	volts
Negative bias value	55 max.	volts
PLATE DISSIPATION	1.1 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	200 max.	volts
Heater positive with respect to cathode	200 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	°C

Characteristics:

Plate Supply Voltage	100	volts
Cathode Resistor	220	ohms
Amplification Factor	20	
Plate Resistance (Approx.)	4000	ohms
Transconductance	5000	μmhos
Plate Current	8.5	ma
Grid Voltage (Approx.) for plate current of 10 μa	-9	volts

Maximum Circuit Values:

Grid-Circuit Resistance:		
For cathode-bias operation	1.2 max.	megohms

* With 0.405" internal diameter shield connected to cathode of unit under test.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values are for Each Unit and are Initial, Unless Otherwise Specified

	Note	*Min.*	*Max.*	
Heater Current	1	280	320	ma
Direct Interelectrode Capacitances:				
Grid to plate	2	1.2	1.8	μμf

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

	Note	Min.	Max.	
Grid to cathode and heater	2	1.4	2.4	μμf
Plate to cathode and heater (Unit No.1) . .	2	0.20	0.36	μμf
Plate to cathode and heater (Unit No.2) . .	2	0.22	0.42	μμf
Grid to grid	2	–	0.011	μμf
Plate to plate	2	–	0.50	μμf
Amplification Factor . . .	1,3	17	23	
Plate Current (1).	1,3	6	11	ma
Plate-Current Difference Between Units.	1,3	–	2	ma
Plate Current (2).	1,4	–	100	μa
Transconductance:				
With heater volts = 6.3.	3	4100	5900	μmhos
Individual change from 0 to 500 hours	1,3	–	20	per cent
Individual change at end of 500-hour life test with heater voltage reduced to 5.7 volts .	3	–	15	per cent
Difference between average transconductance initially, and average after 500 hours, expressed as a percentage of the initial average.	1,3	–	15	per cent
Reverse Grid Current . . .	1,5	–	0.3	μa
Grid-Emission Current. . .	6,7	–	-0.5	μa
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode . . .	1,8	–	5	μa
Heater positive with respect to cathode . . .	1,8	–	5	μa
Heater-Cathode Leakage Current at 500 Hours:				
Heater negative with respect to cathode . . .	1,8	–	10	μa
Heater positive with respect to cathode . . .	1,8	–	10	μa
Leakage Resistance:				
Grid to all other electrodes tied together .	1,9	100	–	megohms
Plate to all other electrodes tied together .	1,10	100	–	megohms
Leakage Resistance at 500 Hours:				
Grid to all other electrodes tied together .	1,9	50	–	megohms
Plate to all other electrodes tied together .	1,10	50	–	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With no external shield.

Note 3: With supply voltage of 100 volts, cathode resistor of 220 ohms, and cathode bypass capacitor of 1000 μf. Each unit is tested separately. Elements of unit not under test are grounded.

Note 4: With plate voltage of 100 volts and grid voltage of -9 volts. Each unit is tested separately. Elements of unit not under test are grounded.

Note 5: With plate voltage of 100 volts, grid resistor of 1 megohm, and cathode resistor of 200 ohms. Each unit is tested separately. Unit not under test is grounded.

Note 6: With 7.5 volts dc on heater.

Note 7: With plate voltage of 100 volts, grid resistor of 1 megohm and grid voltage of -9 volts. Preheated prior to testing for 5 minutes at heater voltage of 7.5 volts ac or dc, plate voltage of 100 volts, grid resistor of 1 megohm, and cathode resistor of 220 ohms.

Note 8: With 100 volts between heater and cathode. Each unit is tested separately. Unit not under test is grounded.

Note 9: With grid 100 volts negative with respect to all other electrodes tied together.

Note 10: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Values are for Each Unit, Unless Otherwise Specified

Shock Rating:

Impact Acceleration. . . . . 450 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are held rigid and are tested in four different positions. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, and transconductance change.

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected in each of three positions to 2.5 g vibrational acceleration at 60 cycles per second for 32 hours. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, and transconductance change.

Low-Frequency Vibration Performance:

RMS Output Voltage . . . . . 100 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, cathode resistor of 220 ohms, cathode-bypass capacitor of 1000 μf, plate load resistor of 10000 ohms and vibrational acceleration of 15 g at 40 cps.

Heater-Cycling Life Performance:

Cycles of Intermittent Operation . . 2000 min. cycles

Under the following conditions: Heater voltage of 7.0 volts cycled one minute on four minutes off, heater 140 volts rms with respect to cathode, and all other elements grounded. At the end of this test, tubes will not show heater-cathode shorts or open circuits.

Audio-Frequency Noise and Microphonic Performance:

Output Voltage . . . . . 65 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Units connected in parallel, heater voltage of 6.3 volts, plate supply voltage of 100 volts, cathode resistor of 100 ohms, plate load resistor of 0.01 megohm, and cathode-bypass capacitor of 1000 μf. The output voltage of a tube, when tapped, will not cause a reading on a vu meter greater than that produced when a calibrating signal of 65 millivolts rms is applied to the plates of the tube.

Shorts and Continuity Test:

This test is performed on a sample lot of tubes from each production run. In this test a tube is considered inoperative if it shows a permanent or temporary short or open circuit, or a value of reverse grid current in excess of 1.0 microampere under the conditions specified in the Characteristics Range Values for reverse grid current.

1-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that the tubes have been properly stabilized. Life-test conditions are the same as those specified under 500-Hour Intermittent Life Performance, except that the test run at room temperature. At the end of 1 hour, the value of transconductance is read. The variation in transconductance from the 0-hour reading will not exceed 10 per cent.

100-Hour Survival Life Performance:

This test is performed on a sample lot of tubes from each production run to insure a low percentage of early inoperatives. Life test conditions are the same as those specified under 500-Hour Intermittent Life Performance, except that the test run at room temperature. At the end of 100 hours, a tube is considered inoperative if it shows a permanent or temporary short or open circuit or a value of reverse grid current in excess of 1.0 microampere under the conditions specified in Characteristics Range Values.

500-Hour Intermittent Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures of any of the characteristics indicated below. Life testing is conducted under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 100 volts, heater-cathode voltage of 200 volts (heater positive with respect to cathode), cathode resistor of 220 ohms, grid-No.1 resistor of 1 megohm and bulb temperature of 220° C. At the end of 500 hours, tube will not show permanent shorts or open circuits, and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to pass established initial limits of heater current, individual transconductance change, transconductance change with heater voltage of 5.7 volts, and 500 hour limits for reverse grid current, heater-cathode leakage current, leakage resistance, and the difference in transconductance between the initial value and average value shown under Characteristics Range Values.

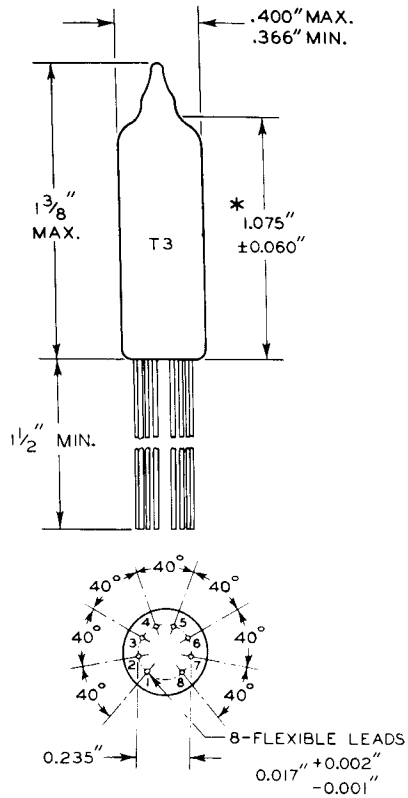
OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6111 are limiting values above which the serviceability of the 6111 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *heater supply* should be well regulated because life and reliability of the 6111 are adversely affected by departures from the 6.3 volt value. The extent to which life is affected is a function of the amount of these departures and their durations.

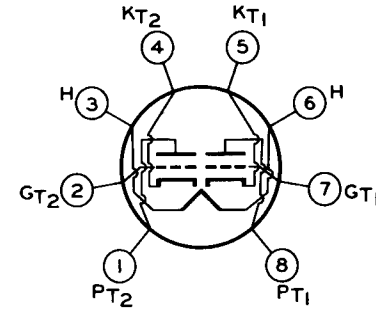
The *flexible leads* of the 6111 are usually soldered to the circuit elements. Soldering of the connections should be made as far as possible from the glass button. If this precaution is not followed, the heat of the soldering may crack the glass seals of the leads and damage the tube.

DIMENSIONAL OUTLINE



* MEASURED FROM BULB SEAT TO BULB-TOP LINE AS DETERMINED BY A RING GAUGE OF 0.210" ± 0.001" I.D.

TERMINAL CONNECTIONS



8DG

LEAD No.1: PLATE OF TRIODE UNIT No.2
LEAD No.2: GRID OF TRIODE UNIT No.2
LEAD No.3: HEATER
LEAD No.4: CATHODE OF TRIODE UNIT No.2
LEAD No.5: CATHODE OF TRIODE UNIT No.1
LEAD No.6: HEATER
LEAD No.7: GRID OF TRIODE UNIT No.1
LEAD No.8: PLATE OF TRIODE UNIT No.2

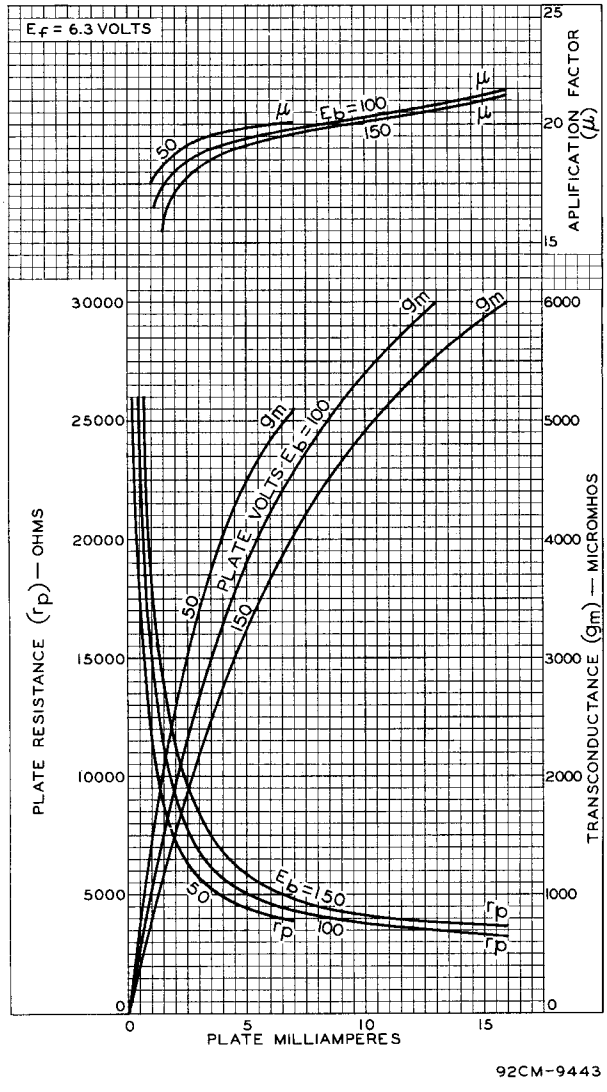


Fig. 1 - Average Characteristics for Each Unit of Type 6111.

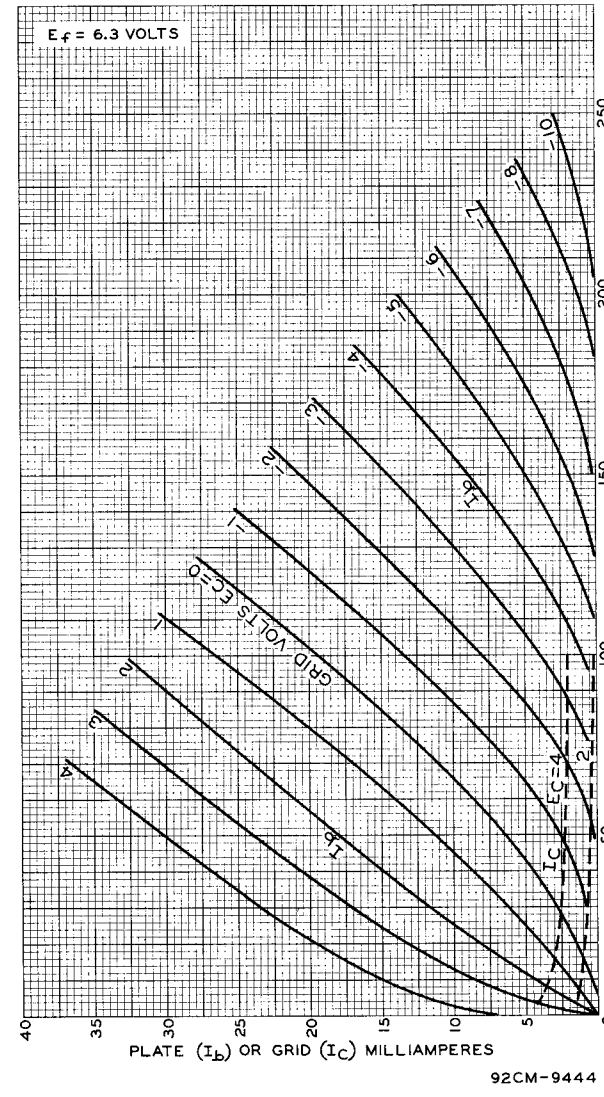


Fig. 2 - Average Characteristics for Each Unit of Type 6111.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

6136

SHARP-CUTOFF PENTODE

"Premium" 7-Pin Miniature Type

TENTATIVE DATA

RCA-6136 is a sharp-cutoff pentode of the 7-pin miniature type intended particularly for use as an intermediate-frequency or rf amplifier in high-gain, wide-band circuits of vhf communications receivers. Constructed to give dependable performance under conditions of shock and vibration, this "premium" tube, which is similar to the 6AU6, is especially suited for use in critical industrial and military applications.

Actual Size

Featured in the design of the 6136 is a structure utilizing tube parts which are precisely made and accurately fitted to minimize variations in electrical characteristics due to mechanical movement and to minimize microphonic effects. In addition, the design incorporates a pure-tungsten heater having high mechanical strength to give long life under conditions of frequent "on-off" switching.

The 6136 is manufactured under rigid control and undergoes rigorous tests to insure its "premium" quality as follows: test readings at the end of 1 hour, 100 hours, and 500 hours to insure that tubes fall within the established tight characteristics limits and that early failures are held to a low percentage.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathodes:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.3	amp
Direct Interelectrode Capacitances (Without external Shield):		
Grid No.1 to plate	0.0035 max.	μμf
Grid No.1 to cathode, heater, grid No.2 and grid No.3 & internal shield	6	μμf
Plate to cathode, heater, grid No.2 and grid No.3 & internal shield	5	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2-1/8"
Maximum Seated Length	1-7/8"
Length, Base Seat to Bulb Top (Excluding tip)	1-1/2" ± 3/32"
Maximum Diameter	3/4"
Bulb	T5-1/2
Base	Small-Button Miniature 7-Pin (JETEC No.E7-1)

AMPLIFIER -- Class A_1

Maximum Ratings, *Absolute Values:*

PLATE VOLTAGE	330 max.	volts
GRID-No.3 (SUPRESSOR-GRID) VOLTAGE	0 max.	volts
GRID-No.2 (SCREEN-GRID) VOLTAGE	165 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Positive bias value	0 max.	volts
GRID-No.2 INPUT	0.7 max.	watt
PLATE DISSIPATION	3.3 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	165 max.	°C

Characteristics:

Plate Supply Voltage	100	250	volts
Grid No.3	Connected to cathode at socket		
Grid-No.2 Supply Voltage	100	150	volts
Cathode Resistor	150	68	ohms
Plate Resistance (Approx.)	0.5	1	megohm
Transconductance	3900	5200	μmhos
Plate Current	5	10.6	ma
Grid-No.2 Current	2.1	4.3	ma
Grid-No.1 Voltage (Approx.) for plate current of 10 μa	-4.2	-6.5	volts

Typical Operation as Resistance-Coupled Amplifier:

See Chart on Page 3.

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For cathode-bias operation	0.5 max.	megohm
For fixed-bias operation	0.25 max.	megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values are Initial, Unless Otherwise Specified

	Note	Min.	Max.	
Heater Current	1	0.275	0.325	amp
Direct Interelectrode Capacitances: (Without external shield):				
Grid No.1 to plate	-	-	0.0035	μμf
Grid No.1 to cathode, heater, grid No.2, and grid No.3 & internal shield	-	4.8	7.2	μμf
Plate to cathode, heater grid No.2, and grid No.3 & internal shield	-	3.9	5.9	μμf
Plate Current (1)	1,2	8	13.5	ma
Plate Current (2)	1,3	-	35	μa
Grid-No.2 Current	1,2	2.6	6	ma
Transconductance Grid No.1 to Plate:				
With heater volts = 6.3	1,2	4150	6250	μmhos
With heater volts = 5.5	2	3900	-	μmhos
At end of 500 hours with heater volts = 6.3	1,2	3600	6250	μmhos

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

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Difference between average transconductance initially, and average after 500 hours, expressed as a percentage of the initial average.	1,2	-	17	per cent
Reverse Grid Current. . . .	1,4	-	1	μa
Reverse Grid Current at 500 hours	1,4	-	1	μa
Grid-Emission Current . . .	5	-	2	μa
Heater-Cathode Leakage Current:				
Heater 100 volts negative with respect to cathode.	1	-	10	μa
Heater 100 volts positive with respect to cathode.	1	-	10	μa
Heater-Cathode Leakage Current at 500 Hours:				
Heater 100 volts negative with respect to cathode.	1	-	10	μa
Heater 100 volts positive with respect to cathode.	1	-	10	μa
Leakage Resistance:				
Grid No.1 to all other electrodes.	1,6	100	-	megohms
Plate to all other electrodes.	1,7	100	-	megohms
Leakage Resistance at 500 Hours:				
Grid No.1 to all other electrodes.	1,6	50	-	megohms
Plate to all other electrodes.	1,7	50	-	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With plate supply voltage of 250 volts, grid-No.2 supply voltage of 150 volts, cathode resistor of 68 ohms, cathode-bypass capacitor of 1000 μf, and grid No.3 tied to cathode.

Note 3: With plate voltage of 250 volts, grid-No.2 voltage of 150 volts, grid-No.1 voltage of -9 volts, plate load resistor of 0.1 megohm, and grid No.3 tied to cathode.

Note 4: With plate voltage of 250 volts, grid-No.3 voltage, of 0 volts, grid-No.2 voltage of 150 volts, grid-No.1 voltage of -1 volt, and grid-No.1 resistor of 0.25 megohm

Note 5: With 7.5 volts ac or dc on heater, plate voltage of 250 volts, grid-No.3 voltage of 0 volts, grid-No.2 voltage of 150 volts, grid-No.1 voltage of -10 volts, and grid-No.1 resistor of 0.25 megohm.

Note 6: With grid No.1 100 volts negative with respect to all other electrodes tied together.

Note 7: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration. . . . . 450 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are held rigid and are tested in four different positions. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, reverse grid current and transconductance.

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected in each of three positions to 2.5 g vibrational acceleration at 60 cycles per second for 32 hours. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for low-frequency vibration, heater-cathode leakage current, reverse grid current, and transconductance.

Low-Frequency Vibration Performance:

RMS Output Voltage . . . . . 300 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 250 volts, grid No.3 tied to cathode, grid-No.2 supply voltage of 150 volts, cathode resistor of 68 ohms, cathode-bypass capacitor of 1000 μf, plate load resistor of 2000 ohms and vibrational acceleration of 2.5 g at 25 cps.

Heater-Cycling Life Performance:

Cycles of Intermittent Operation . . 2000 min. cycles

Under the following conditions: Heater voltage of 7.5 volts cycled one minute on and one minute off, heater 135 volts positive with respect to cathode, and all other elements grounded.

Shorts and Continuity Test:

This test is performed on a sample lot of tubes from each production run. In this test a tube is considered inoperative if it shows a permanent or temporary short or open circuit, or a value of reverse grid current in excess of 1.0 microampere under the conditions specified in the Characteristics Range Values for reverse grid current.

1-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that the tubes have been properly stabilized. Tubes are checked for transconductance under conditions specified under 500-Hour Intermittent Life Performance. At the end of 1 hour, the value of transconductance is read. The variation in transconductance from the 0-hour reading will not exceed 10 per cent.

100-Hour Survival Life Performance:

This test is performed on a sample lot of tubes from each production run under conditions specified under 500-Hour Intermittent Life Performance to insure a low percentage of early inoperatives. At the end of 100 hours, a tube is considered inoperative if it shows a permanent or temporary short or open circuit or a value of reverse grid current in excess of 1.0 microampere under the conditions specified in Characteristics Range Values.

500-Hour Intermittent Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures of any of the characteristics indicated below. Life testing is conducted under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 300 volts, grid No.3 tied to cathode, grid-No.2 supply voltage of 150 volts, heater-cathode voltage of 135 volts (heater positive with respect to cathode), cathode resistor of 80 ohms and grid-No.1 resistor of 0.5 megohm. At the end of 500 hours, tube will not show permanent shorts or open circuits and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to pass established initial limits of heater current, and 500 hour limits for reverse grid current, heater-cathode leakage current, leakage resistance, transconductance range, and the difference in transconductance between the initial value and average value shown under Characteristics Range Values.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6136 are limiting values above which the serviceability of the 6136 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply voltage variation, load variation, or manufacturing variation in the equipment itself.

Operating Conditions as Resistance-Coupled Amplifier (Each Unit)

Plate Supply Voltage	*90*			*180*			*300*			*volts*
Plate Load Resistor	0.1	0.22	0.47	0.1	0.22	0.47	0.1	0.22	0.47	megohm
Grid-No.2 Resistor	0.09	0.26	0.75	0.15	0.43	1	0.24	0.5	1.1	megohm
Grid-No.1 Resistor (of following stage)	0.22	0.47	1	0.22	0.47	1	0.22	0.47	1	megohm
Cathode Resistor	2100	3200	6500	900	1700	3400	600	1000	1900	ohms
Peak Output Voltage[O]	32	32	32	82	67	65	103	108	105	volts
Voltage Gain[□]	72	99	126	116	171	232	145	230	318	

[O] Obtained across grid-No.1 resistor of following stage and is for the condition where the signal level is adequate to swing the grid of the resistance-coupled amplifier tube to the point where its grid starts to draw current.

[□] At 5 volts (RMS) output.

Note: Coupling capacitors should be selected to give desired frequency response. Cathode and grid-No.2 resistors should be adequately bypassed.

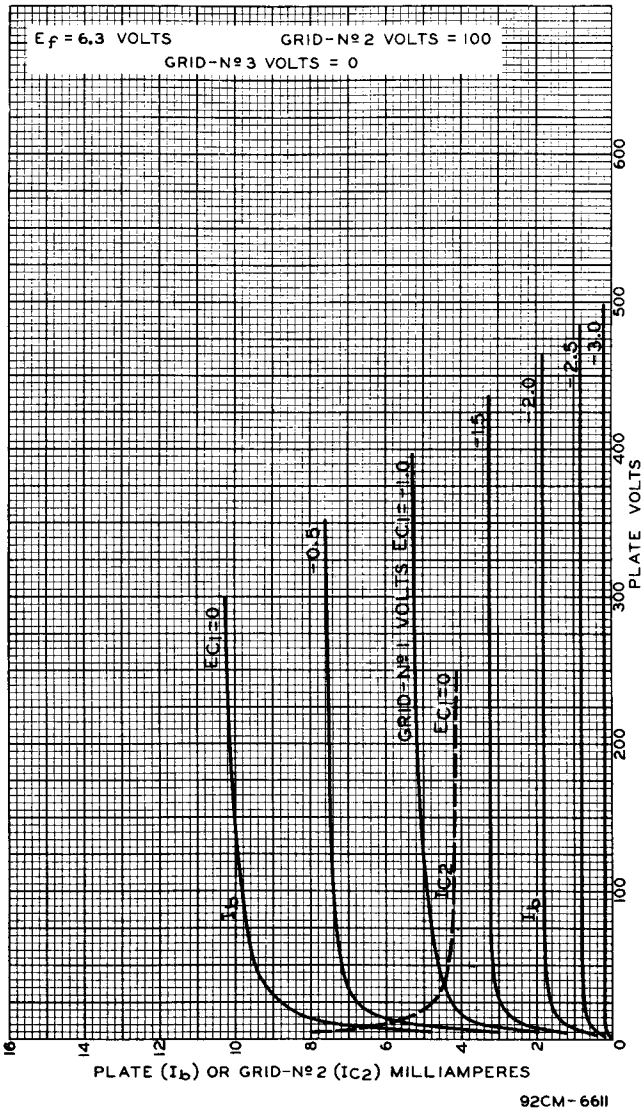


Fig. 1 - Average Characteristics for Each Unit of Type 6136.

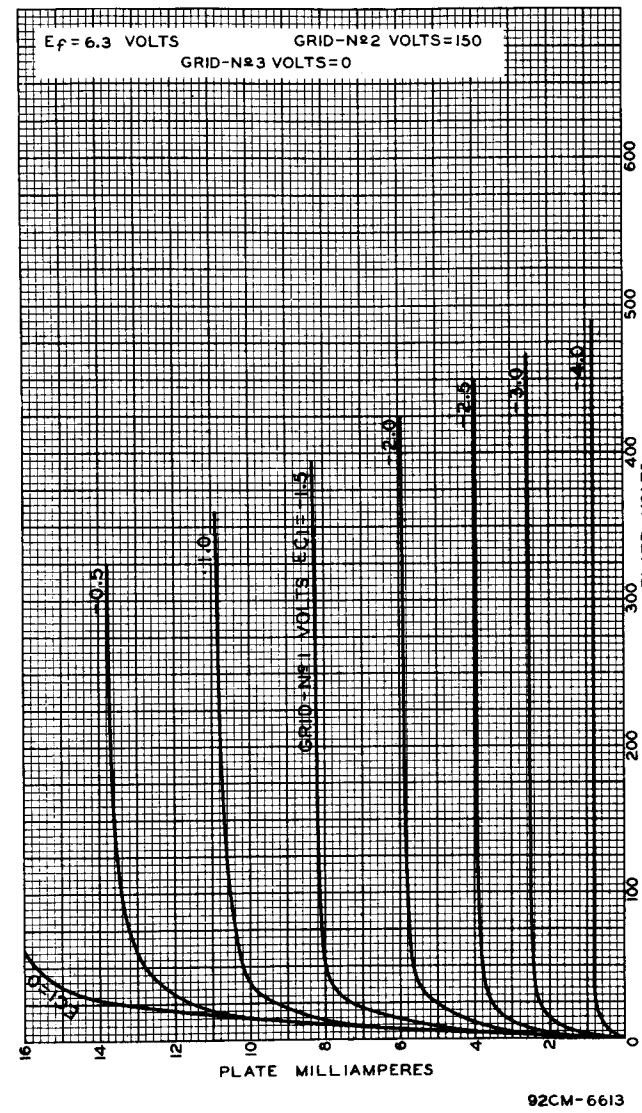


Fig. 2 - Average Characteristics for Each Unit of Type 6136.

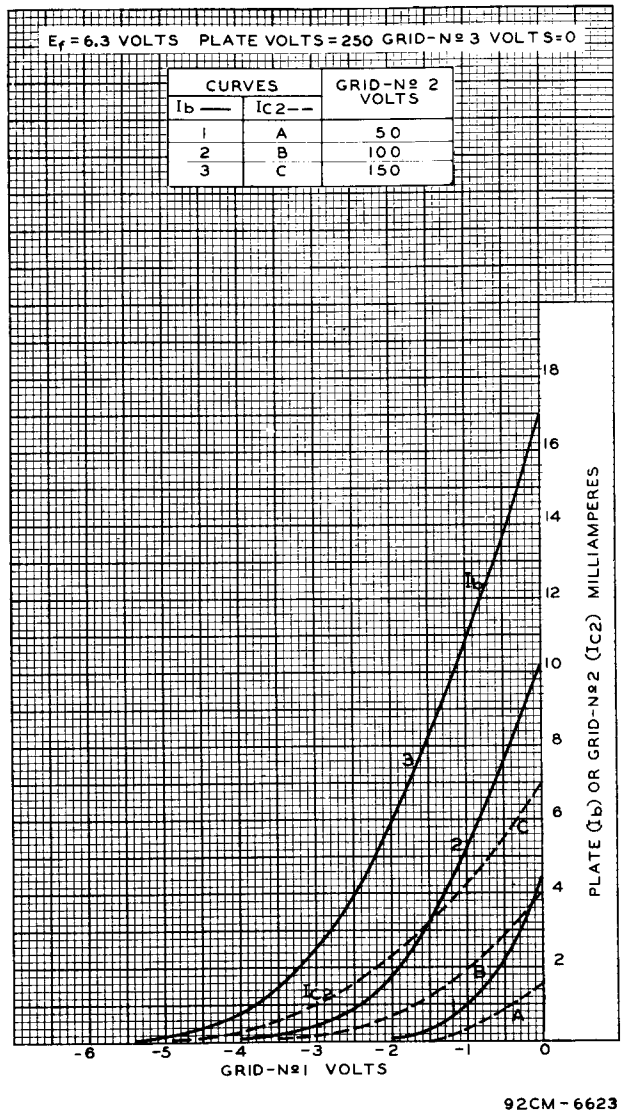


Fig. 3 - Average Characteristics for Each Unit of Type 6136.

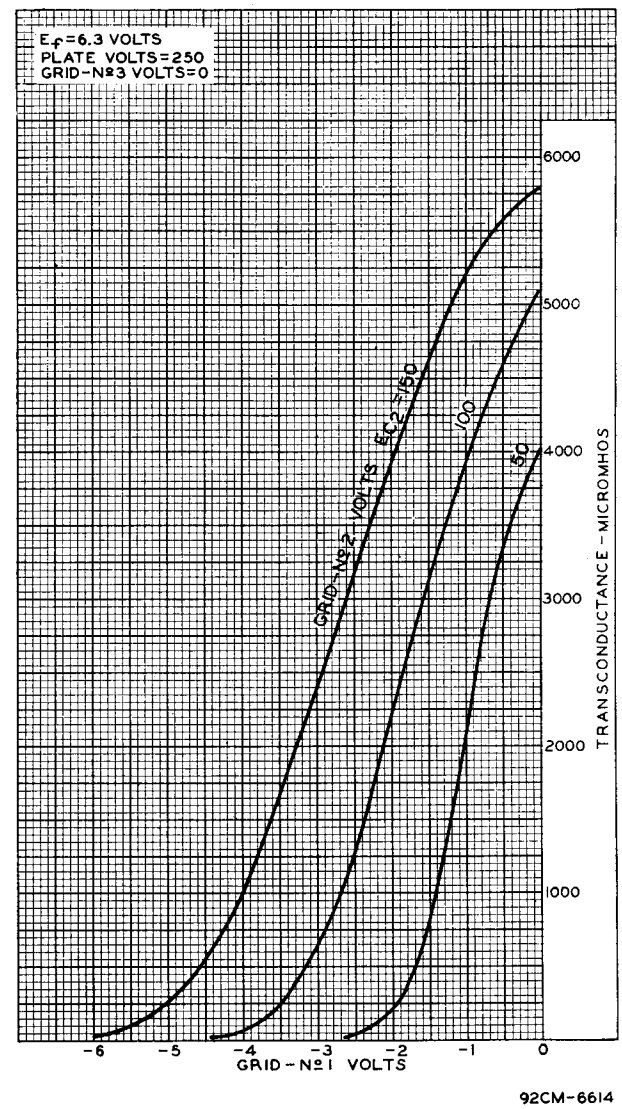
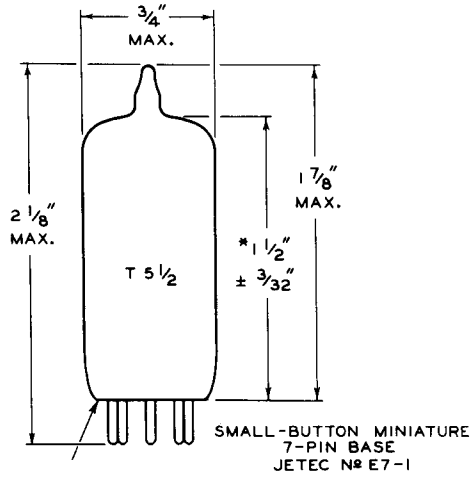


Fig. 4 - Average Characteristics for Each Unit of Type 6136.

DIMENSIONAL OUTLINE

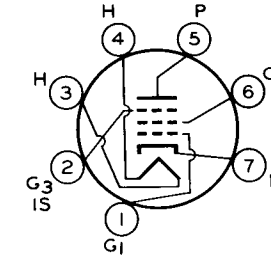


* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View

PIN 1: GRID NO.1
PIN 2: GRID NO.3, INTERNAL SHIELD
PIN 3: HEATER
PIN 4: HEATER
PIN 5: PLATE
PIN 6: GRID NO.2
PIN 7: CATHODE



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Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

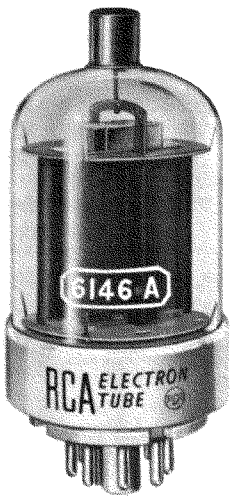
RCA-6146A
BEAM POWER TUBE

Controlled Zero-Bias Plate Current
Controlled Power Output at Reduced Heater Voltage

90 Watts CW Input (ICAS) up to 60 Mc
60 Watts CW Input (ICAS) at 175 Mc
Sturdy Structure
RCA "Dark Heater"

3-13/16" Max. Length
1-21/32" Max. Diameter
Octal 8-Pin Base
Small Size

RCA-6146A is a small, sturdy, beam power tube having high efficiency and high power sensitivity. It is designed for use as an rf power amplifier and oscillator as well as an af power amplifier and modulator in both mobile and fixed equipment. The 6146A has a maximum plate dissipation of 25 watts under ICAS conditions in modulator service and in cw service. In the latter service, it can be operated with full input to 60 Mc and with reduced input to 175 Mc.



Because of its high power sensitivity and high efficiency, the 6146A can be operated with relatively low plate voltage to give large power output with small driving power.

The 6146A features more dependable performance with battery power supplies because it is designed to deliver not less than 90% of useful power output when the heater voltage is reduced to 5 volts. See Test No. 8 of Characteristics Range Values.

Controlled zero-bias plate current is offered in the 6146A to insure more dependable performance as a Class AB_1 linear rf amplifier for single-sideband suppressed-carrier service. See Test No. 4 of Characteristics Range Values.

Also featured in the design of the 6146A is the new RCA "Dark Heater", which functions efficiently at operating temperatures 350° K below those of the heaters in conventional tube types. The dark surface of the new heater radiates heat more efficiently and improves the transfer of heat to the cathode so that optimum cathode temperature may be attained with the heater operating at approximately 1350° K.

The low operating temperature of the "Dark Heater" results in (1) lower internal stresses in the heater wire and smaller thermal change during heater warmup, (2) cooler operation of the heater which minimizes changes in heater shape and reduces the possibility of heater damage and heater shorts, (3) extremely stable heater current characteristics throughout life, and (4) significant reduction in effects of ac heater leakage.

Small in size for its power-output capability, the 6146A has a rugged button-stem construction with short internal leads, a T12 bulb, triple base-pin connections for grid No. 3 and cathode (both joined to internal shield inside the tube) to permit effective rf grounding, and an octal base with short metal sleeve having its own base-pin terminal. The sleeve shields the input to the tube and isolates it from the output circuit so completely that no other external shielding is required. Separation of input and output circuits is accomplished by bringing the plate lead out of the bulb to a cap opposite the base.

The 6146A is unilaterally interchangeable with the 6146.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)[a]	6.3	volts
Current at 6.3 volts	1.25	amp
Minimum heating time	60	sec
Transconductance, for plate volts = 200, grid-No. 2 volts = 200, and plate ma. = 100	7000	μmhos
Mu-Factor, Grid No. 2 to Grid No. 1 for plate volts = 200, grid-No. 2 volts = 200, and plate ma. = 100.	4.5	
Direct Interelectrode Capacitances (Approx.):[b]		
Grid No. 1 to plate	0.24 max.	pf
Grid No. 1 to cathode & grid No. 3 & internal shield, base sleeve, grid No. 2, and heater	13	pf
Plate to cathode & grid No. 3 & internal shield, base sleeve, grid No. 2, and heater	8.5	pf

Mechanical:

Operating Position	Any
Maximum Overall Length	3-13/16"

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Electron Tube Division Harrison, N. J.

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Seated Length	3-1/8" ± 1/8"
Maximum Diameter	1-21/32"
Bulb	T12
Cap	Small (JEDEC No. C1-1)
Base	Large-Wafer Octal 8-Pin with Sleeve (JEDEC Group 1, No. B8-86), Large-Wafer Octal 8-Pin with External Barriers and Sleeve (JEDEC Group 1, No. B8-98), Small-Wafer Octal 8-Pin with Sleeve (JEDEC Group 1, No. B8-150), or Small-Wafer Octal 8-Pin with External Barriers and Sleeve (JEDEC Group 1, No. B8-159)
Bulb Temperature (At hottest point)	220 max. °C
Weight (Approx.)	2.3 oz

AF POWER AMPLIFIER & MODULATOR—Class AB_1

Maximum Ratings, *Absolute-Maximum Values:*

	CCS	ICAS	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No. 2 VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT[c]	125 max.	135 max.	ma
MAX.-SIGNAL PLATE INPUT[c]	60 max.	85 max.	watts
MAX.-SIGNAL GRID-No. 2 INPUT[c]	3 max.	3 max.	watts
PLATE DISSIPATION[c]	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode.	135 max.	135 max.	volts
Heater positive with respect to cathode.	135 max.	135 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	400	500	600	volts
DC Grid-No. 2 Voltage[d]	190	185	180	volts
DC Grid-No. 1 Voltage:				
With fixed-bias source.	-40	-40	-45	volts
Peak AF Grid-No. 1-to-Grid-No. 1 Voltage[e]	80	80	90	volts
Zero-Signal DC Plate Current	63	57	26	ma
Max.-Signal DC Plate Current	228	215	200	ma
Zero-Signal DC Grid-No. 2 Current	2.5	2	1	ma
Max.-Signal DC Grid-No. 2 Current	25	25	23	ma
Effective Load Resistance (Plate to plate)	4000	5500	7000	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	watts
Max.-Signal Power Output (Approx.)	55	70	82	watts

Typical ICAS Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No. 2 Voltage[d]	200	195	volts
DC Grid-No. 1 Voltage:			
From fixed-bias source.	-50	-50	volts
Peak AF Grid-No. 1-to-Grid-No. 1 Voltage[e]	100	100	volts
Zero-Signal DC Plate Current	28	23	ma
Max.-Signal DC Plate Current	229	220	ma
Zero-Signal DC Grid-No. 2 Current	1	1	ma
Max.-Signal DC Grid-No. 2 Current	27	26	ma
Effective Load Resistance (Plate to plate)	6000	8000	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	95	120	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No. 1-Circuit Resistance under Any Condition:[f]	
With fixed bias	0.1 max. megohm
With cathode bias	Not recommended

AF POWER AMPLIFIER & MODULATOR—Class AB_2

Maximum Ratings, *Absolute-Maximum Values:*

	CCS	ICAS	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No. 2 VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT[c]	125 max.	135 max.	ma
MAX.-SIGNAL PLATE INPUT[c]	62.5 max.	90 max.	watts
MAX.-SIGNAL GRID-No. 2 INPUT[c]	3 max.	3 max.	watts
PLATE DISSIPATION[c]	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode.	135 max.	135 max.	volts
Heater positive with respect to cathode.	135 max.	135 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	400	500	600	volts
DC Grid-No. 2 Voltage[d]	175	175	165	volts
DC Grid-No. 1 Voltage:				
From fixed-bias source.	-41	-44	-44	volts
Peak AF Grid-No. 1-to-Grid-No. 1 Voltage	95	102	97	volts
Zero-Signal DC Plate Current	33	27	22	ma
Max.-Signal DC Plate Current	232	242	207	ma
Zero-Signal DC Grid-No. 2 Current	1.1	0.7	0.6	ma
Max.-Signal DC Grid-No. 2 Current	18	18	17	ma
Max.-Signal DC Grid-No. 1 Current	1.6	1.9	1.1	ma
Effective Load Resistance (Plate to plate)	3700	4600	6800	ohms
Max.-Signal Driving Power (Approx.)[g]	0.2	0.3	0.2	watt
Max.-Signal Power Output (Approx.)	62	83	90	watts

Typical ICAS Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No. 2 Voltage[d]	190	165	volts
DC Grid-No. 1 Voltage:			
From fixed-bias source.	-48	-46	volts
Peak AF Grid-No. 1-to-Grid-No. 1 Voltage	109	108	volts
Zero-Signal DC Plate Current	28	22	ma
Max.-Signal DC Plate Current	270	240	ma
Zero-Signal DC Grid-No. 2 Current	1.2	0.3	ma
Max.-Signal DC Grid-No. 2 Current	20	20	ma

Max.-Signal DC Grid-No.1 Current.	2	2.6	ma
Effective Load Resistance (Plate to plate).	5000	7400	ohms
Max.-Signal Driving Power (Approx.)[g].	0.3	0.4	watt
Max.-Signal Power Output (Approx.)	113	131	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No. 1-Circuit Resistance:[h]
With fixed bias . . . . . 30,000 max. ohms
With cathode bias . . . . . Not recommended

LINEAR RF POWER AMPLIFIER—Class AB$_1$
Single-Sideband Suppressed-Carrier Service

Maximum Ratings, *Absolute-Maximum Values up to 60 Mc:*

	CCS	ICAS	
DC PLATE VOLTAGE. . .	600 max.	750 max.	volts
DC GRID-No. 2 VOLTAGE. .	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT. . .	125 max.	135 max.	ma
MAX.-SIGNAL PLATE INPUT.	60 max.	85 max.	watts
MAX.-SIGNAL GRID-No. 2 INPUT . . .	3 max.	3 max.	watts
PLATE DISSIPATION . . .	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode.	135 max.	135 max.	volts
Heater positive with respect to cathode.	135 max.	135 max.	volts

Typical Operation:

At 60 Mc with "Single-Tone" Modulation

	CCS		ICAS		
DC Plate Voltage. . . .	400	600	600	750	volts
DC Grid-No. 2 Voltage[j] .	190	180	200	195	volts
DC Grid-No. 1 Voltage[k] .	-40	-45	-50	-50	volts
Zero-Signal DC Plate Current	32	13	14	12	ma
Effective RF Load Resistance.	2000	3500	3000	4000	ohms
Max.-Signal DC Plate Current	114	100	115	110	ma
Max.-Signal DC Grid-No. 2 Current . .	12	11	14	13	ma
Max.-Signal Peak RF Grid-No. 1 Voltage . .	40	45	50	50	volts
Max.-Signal Driving Power (Approx.)	0	0	0	0	watts
Max.-Signal Power Output (Approx.). . .	27	41	48	60	watts

Maximum Circuit Values:

Grid-No. 1-Circuit Resistance:[f]
With fixed bias . . . . . 30,000 max. ohms
With cathode bias . . . . . Not recommended

PLATE-MODULATED RF POWER AMPLIFIER—
Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0; at frequencies up to 60 Mc

	CCS	ICAS	
Maximum Ratings, *Absolute-Maximum Values:*			
DC PLATE VOLTAGE. .	480 max.	600 max.	volts
DC GRID-No.2 VOLTAGE .	250 max.	250 max.	volts
DC GRID-No.1 VOLTAGE .	-150 max.	-150 max.	volts
DC PLATE CURRENT. . .	117 max.	125 max.	ma
DC GRID-No.1 CURRENT .	3.5 max.	4.0 max.	ma
PLATE INPUT	45 max.	67.5 max.	watts
GRID-No. 2 INPUT . . .	2 max.	2 max.	watts
PLATE DISSIPATION . .	13.3 max.	16.7 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode. . . .	135 max.	135 max.	volts
Heater positive with respect to cathode. . . .	135 max.	135 max.	volts

Typical Operation:

DC Plate Voltage. .	400	475	600	volts
DC Grid-No. 2 Voltage[m].	150	135	150	volts
From a series resistor of . . .	33,000	51,000	56,000	ohms
DC Grid-No. 1 Voltage[n].	-87	-77	-87	volts
From a grid resistor of . . .	27,000	27,000	27,000	ohms
Peak RF Grid-No. 1 Voltage	107	95	107	volts
DC Plate Current. .	112	94	112	ma
DC Grid-No.2 Current	7.8	6.4	7.8	ma
DC Grid-No.1 Current (Approx.)	3.4	2.8	3.4	ma
Driving Power (Approx.)	0.4	0.3	0.4	watt
Power Output (Approx.)	32	34	52	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No. 1-Circuit Resistance[p] . . 30,000 max. ohms

RF POWER AMPLIFIER & OSC.—Class C Telegraphy
and
RF POWER AMPLIFIER—Class C FM Telephony

	CCS	ICAS	
Maximum Ratings, *Absolute-Maximum Values up to 60 Mc:*			
DC PLATE VOLTAGE. . .	600 max.	750 max.	volts
DC GRID-No. 2 VOLTAGE.	250 max.	250 max.	volts
DC GRID-No. 1 VOLTAGE.	-150 max.	-150 max.	volts
DC PLATE CURRENT. . .	140 max.	150 max.	ma
DC GRID-No. 1 CURRENT.	3.5 max.	4.0 max.	ma
PLATE INPUT	67.5 max.	90 max.	watts
GRID-No. 2 INPUT . . .	3 max.	3 max.	watts
PLATE DISSIPATION . .	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode. . . .	135 max.	135 max.	volts
Heater positive with respect to cathode. . . .	135 max.	135 max.	volts

Typical Operation as Amplifier up to 60 Mc:

DC Plate Voltage. . .	500	600	600	750	volts
DC Grid-No.2 Voltage[q].	170	150	180	160	volts
From a series resistor of	36,000	51,000	43,000	56,000	ohms
DC Grid-No.1 Voltage[r].	-66	-58	-71	-62	volts
From a grid-No. 1 resistor of . . .	27,000	20,000	24,000	20,000	ohms
From a cathode resistor of . . .	470	470	430	470	ohms

Peak RF Grid-No. 1 Voltage	84	73	91	79	volts
DC Plate Current	135	112	150	120	ma
DC Grid-No.2 Current	9	9	10	11	ma
DC Grid-No.1 Current (Approx.)	2.5	2.8	2.8	3.1	ma
Driving Power (Approx.)	0.2	0.2	0.3	0.2	watt
Power Output (Approx.)	48	52	66	70	watts

Typical Operation as Amplifier at 175 Mc:

DC Plate Voltage	320	400	volts
DC Grid-No.2 Voltage[q]	180	190	volts
From a series resistor of	13,000	20,000	ohms
DC Grid-No.1 Voltage[r]	-51	-54	volts
From a grid resistor of	27,000	24,000	ohms
From a cathode resistor of	330	330	ohms
Peak RF Grid-No. 1 Voltage	64	68	volts
DC Plate Current	140	150	ma
DC Grid-No. 2 Current	10	10.4	ma
DC Grid-No. 1 Current (Approx.)	2	2.2	ma
Driving Power (Approx.)	3	3	watts
Power Output (Approx.)	25	35	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No. 1-Circuit Resistance[p] . . 30,000 max. ohms

MAXIMUM RATINGS vs. OPERATING FREQUENCY

OPERATING FREQUENCY Megacycles per second	MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE & PLATE INPUT			
	TELEPHONY		TELEGRAPHY	
	Class C Plate-Modulated		Class C Unmodulated	
	Voltage	*Input*	*Voltage*	*Input*
60	100	100	100	100
80	84	92	84	92
125	65	78	65	78
150	58	72	58	72
160	56	70	56	70
175	53	67	53	67

CHARACTERISTICS RANGE VALUES

	Note	*Min.*	*Max.*	
1. Heater Current	1	1.175	1.325	amp
2. Direct Interelectrode Capacitances:				
Grid No. 1 to plate	2	-	0.24	pf
Grid No. 1 to cathode & grid No. 3 & internal shield, base sleeve, grid No. 2, and heater	2	12.0	15.0	pf
Plate to cathode & grid No. 3 & internal shield, base sleeve, grid No. 2, and heater	2	7.3	9.5	pf
3. Plate Current	1,3	46	94	ma
4. Zero-Bias Plate Current	1,4	330	-	ma
5. Grid-No. 2 Current	1,3	-	5.5	ma
6. Dynamic Grid-No. 2 Current	1,5	3	21	ma
7. Useful Power Output I	1,5	47	-	watts
8. Useful Power Output II	6		(See Note 6)	

Note 1: With 6.3 volts ac on heater.

Note 2: With no external shield.

Note 3: With dc plate voltage of 300 volts, dc grid-No. 2 voltage of 200 volts, and dc grid-No. 1 voltage of -33 volts.

Note 4: With dc plate voltage of 100 volts, dc grid-No. 2 voltage of 200 volts, and dc grid-No. 1 voltage of -100 volts. Grid No. 1 is square-wave pulsed at 1000 kc to zero volts. Limit value is peak-pulse current.

Note 5: In a single-tube, self-excited oscillator circuit, and with dc plate voltage of 600 volts, dc grid-No. 2 voltage of 180 volts, grid-No. 1 resistor of 30000 ± 10% ohms, dc plate current of 112 max. ma., dc grid-No. 1 current of 2 to 2.5 ma., and frequency of 15 Mc.

Note 6: With conditions in test No. 7, reduce heater voltage to 5 volts. Useful power output shall be at least 90% of that at heater voltage of 6.3 volts.

---

a Heater voltage fluctuations will cause variations in power output. See Test No. 8 of Characteristics Range Values.

b With no external shield.

c Averaged over any audio-frequency cycle or sine-wave form.

d Obtained preferably from a separate source or from the plate voltage supply with a voltage divider.

e The driver stage should be capable of supplying the No. 1 grids of the class AB_1 stage with the specified driving voltage at low distortion.

f The type of input coupling network used should not introduce too much resistance in the grid-No. 1 circuit. Transformer or impedance coupling devices are recommended.

g Driver stage should be capable of supplying the specified driving power at low distortion to the No. 1 grids of the AB_2 stage.

h To minimize distortion, the effective resistance per grid-No. 1 circuit of the AB_2 stage should be held at a low value. For this purpose the use of transformer coupling is recommended. In no case, however, should the total dc grid-No. 1-circuit resistance exceed 30,000 ohms when the 6146A is operated at maximum ratings. For operation at less than maximum ratings, the dc grid-No. 1-circuit resistance may be as high as 100,000 ohms.

j Obtained preferably from a separate, well regulated source.

k Obtained from a fixed supply.

m Obtained preferably from a separate source modulated with the plate supply, or from the modulated plate supply through a series resistor.

n Obtained from grid-No. 1 resistor or from a combination of grid-No. 1 resistor with either fixed supply or cathode resistor.

p When grid No. 1 is driven positive and the 6146A is operated at maximum ratings, the total dc grid-No. 1-circuit resistance should not exceed the specified value of 30,000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply. For operation at less than maximum ratings, the dc grid-No. 1-circuit resistance may be as high as 100,000 ohms.

[q] Obtained preferably from separate source, or from the plate-supply voltage with a voltage divider, or through a series resistor. A series grid-No.2 resistor should be used only when the 6146A is used in a circuit which is not keyed. Grid-No.2 voltage must not exceed 400 volts under key-up conditions.

[r] Obtained from fixed supply, by grid-No.1 resistor, by cathode resistor, or by combination methods.

DEFINITIONS

AB_1 - The subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

AB_2 - The subscript 2 indicates that grid-No.1 current flows during some part of the input cycle.

CCS - Continuous Commercial Service.

ICAS - Intermittent Commercial and Amateur Service.

Ratings System - The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

Single-Tone Modulation - Single-Tone Modulation operation refers to that class of amplifier service in which the input consists of a monofrequency rf signal having constant amplitude. This signal is produced in a single-sideband suppressed-carrier system when a single audio frequency of constant amplitude is applied to the input of the system.

GENERAL CONSIDERATIONS

Temperature

The maximum bulb temperature of 220° C is a tube rating and is to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y.

To insure adequate cooling it is essential that free circulation of air be provided around the tube. In most cases, no additional air is required.

Plate Color

The plate shows no color when the 6146A is operated at full ratings under either CCS or ICAS conditions.

MECHANICAL CONSIDERATIONS

Plate Circuit

Heavy leads and conductors together with suitable insulation should be used in all parts of the rf plate tank circuit so that losses due to rf voltages and currents may be kept at a minimum. At the higher frequencies, it is essential that short, heavy leads be used for circuit connections in order to minimize lead inductance and losses.

Connections to the plate should be made with a flexible lead to prevent any strain on the seal at the cap.

ELECTRICAL CONSIDERATIONS

Plate and Grid No.2

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage and grid-No.2 voltage. If the 6146A is operated at maximum ratings and grid-No.2 voltage is obtained through a series dropping resistor, the use of a 2500-ohm protective resistor in the high-voltage supply lead is recommended. When a separate grid-No.2 voltage supply is used, a 10,000-ohm protective resistor should be connected in the grid-No.2 supply lead.

The plate voltage should be applied before or simultaneously with the grid-No.2 voltage; otherwise, with voltage on grid No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the dc power input determined.

The grid-No.2 current is a very sensitive indication of plate-circuit loading and grid-No.2 current rises excessively (often to the point of damaging the tube) when the amplifier is operated without load. Therefore, care should be taken when tuning a 6146A under no-load conditions in order to prevent exceeding the grid-No.2 input rating of the tube.

Driver

The driver stage for the 6146A in either class C telephony or telegraphy service should have considerably more output capability than the typical driving power shown in the tabulated data in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuit and the coupling circuits. This recommendation is particularly important near the maximum-rated frequency where there are other losses of driving power, such as circuit losses, radiation losses, and transit-time losses.

Efficiency

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 6146A is operated under load conditions such that the maximum rated plate current flows at the plate voltage which will give maximum rated input.

Class C Telephony

In plate-modulated class C amplifier service, the 6146A can be modulated 100 per cent. The grid-No. 2 voltage must be modulated simultaneously with the plate voltage so that the ratio of grid-No. 2 voltage to plate voltage remains constant. Modulation of the grid-No. 2 voltage can be accomplished either by connecting grid No. 2 through a separate winding on the modulation transformer to the fixed grid-No. 2 voltage supply, or by connecting grid No. 2 through an audio-frequency choke of suitable impedance for low audio frequencies to the fixed grid-No. 2 supply voltage. The supply end of the choke should be well bypassed to ground.

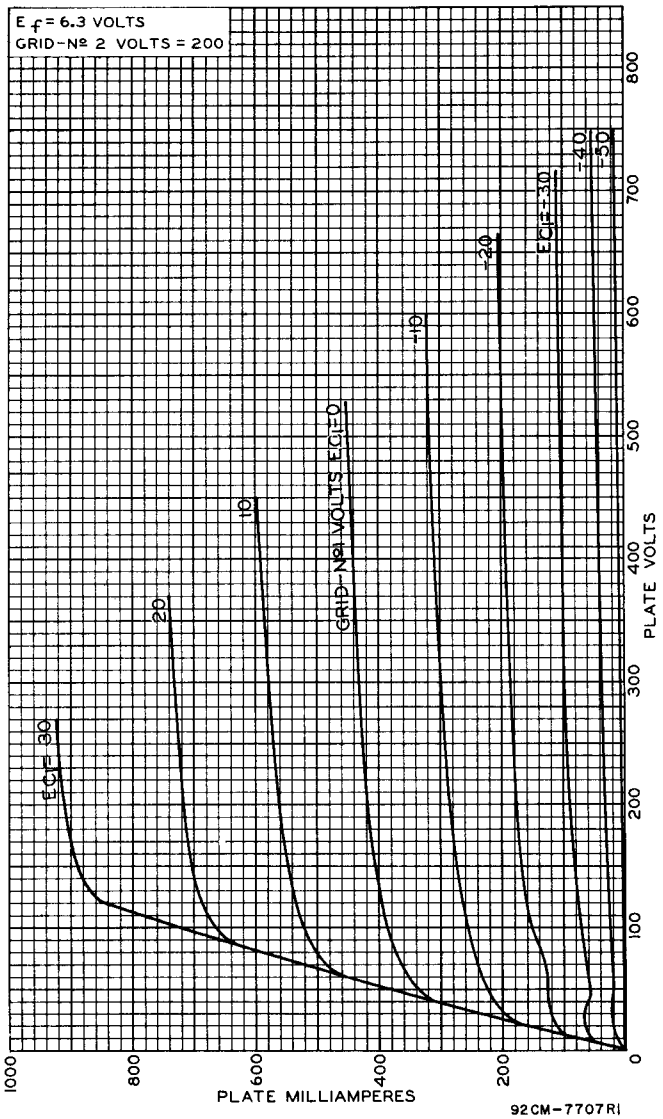


Fig. 1 - Typical Plate Characteristics of Type 6146A.

Circuit Arrangements

Push-pull or parallel circuit arrangements can be used when more radio-frequency power is required than can be obtained from a single 6146A. Two 6146A's in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube.

With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits.

When two or more tubes are used in the circuit, precautions should be taken to insure that each tube draws the same plate current.

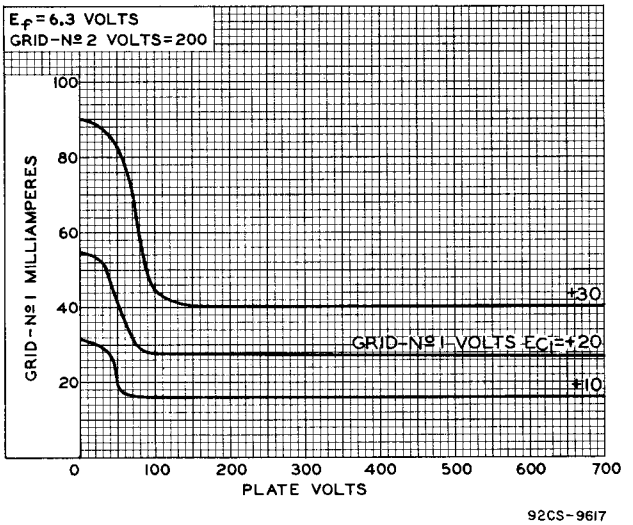


Fig. 2 - Typical Characteristics of Type 6146A.

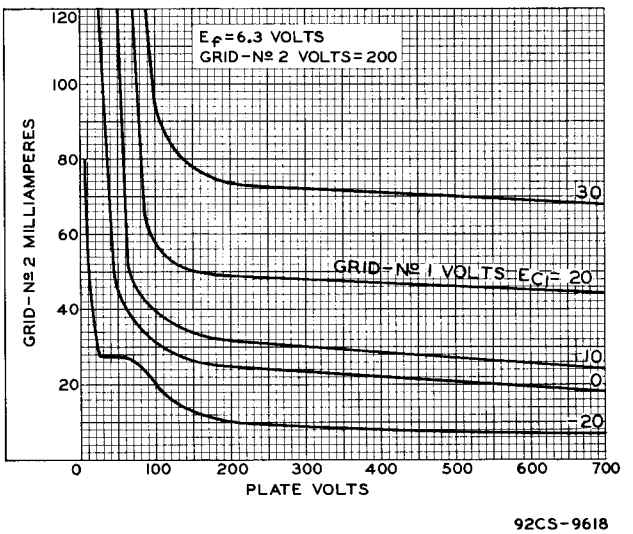


Fig. 3 - Typical Characteristics of Type 6146A.

Standby Operation

During standby periods in intermittent operation, the heater voltage may be maintained at normal operating value for most applications.

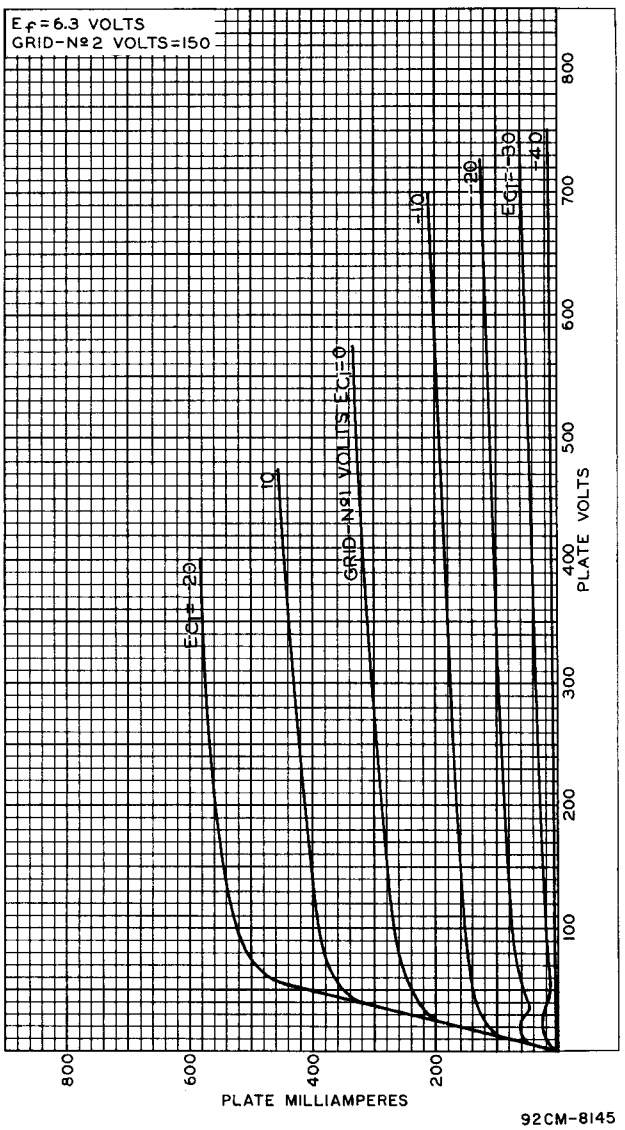


Fig.4 - Typical Plate Characteristics of Type 6146A.

In those applications which require maximum reliability, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; that it be reduced to 80 per cent of normal when the period is between 15 minutes and 2 hours; and that for longer periods, the heater voltage should be turned off.

Protective Devices

Protective devices should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the dc plate and grid-No.2 voltage when the average value of plate current reaches a value slightly higher than normal plate current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

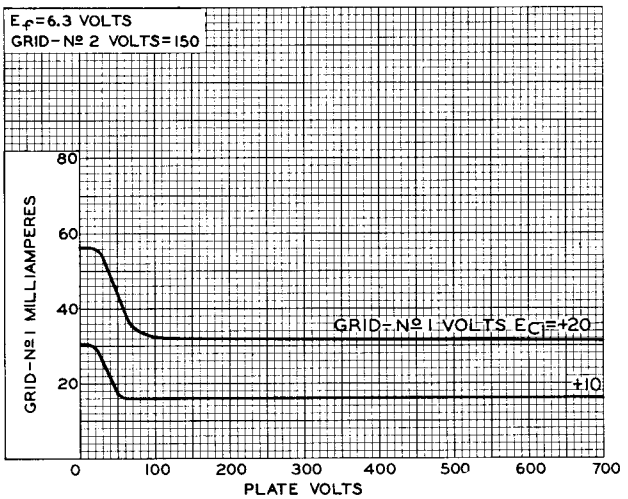


Fig.5 - Typical Characteristics of Type 6146A.

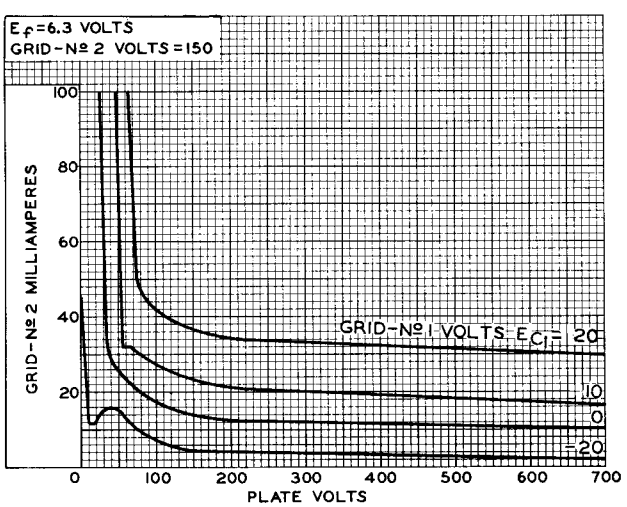


Fig.6 - Typical Characteristics of Type 6146A.

Precautions

The rated plate and grid-No.2 voltages of this tube are extremely dangerous. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a

protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

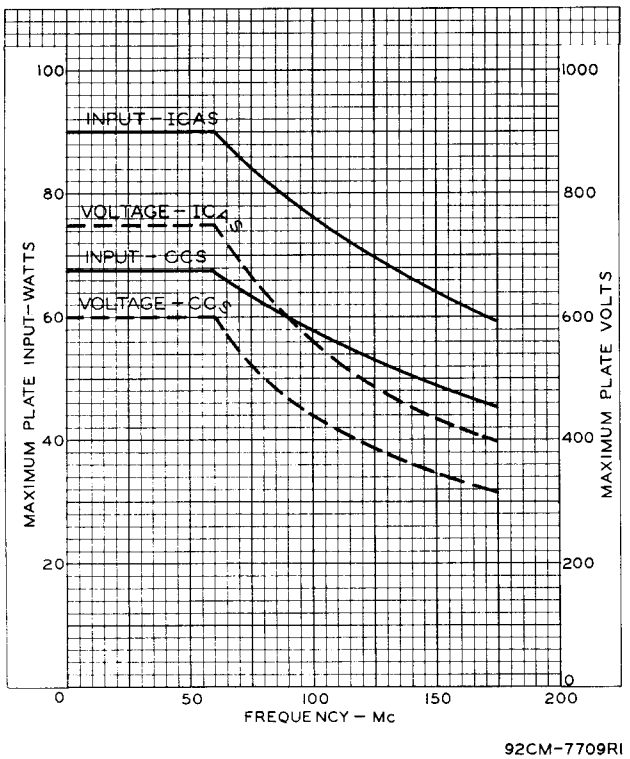


Fig. 7 - Curves Showing Plate Voltage and Plate Input vs Frequency for Type 6146A in Class C Telegraphy Service.

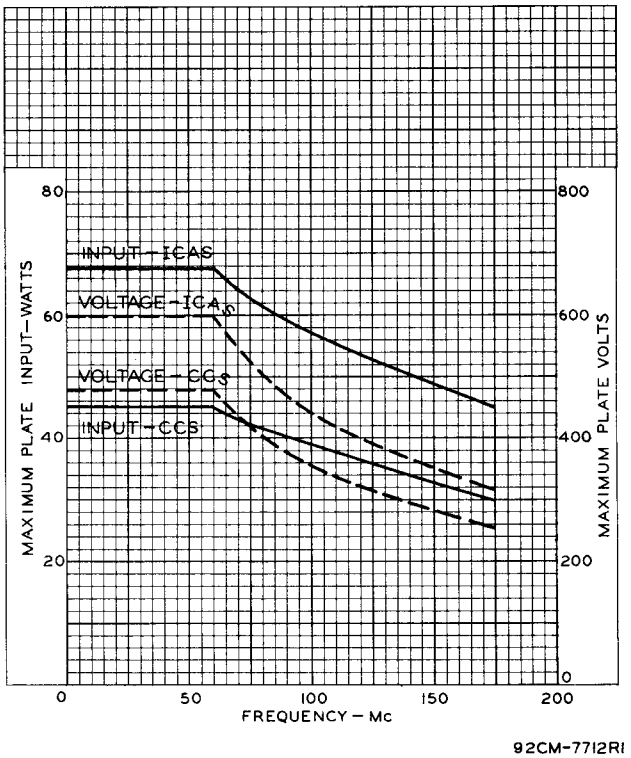
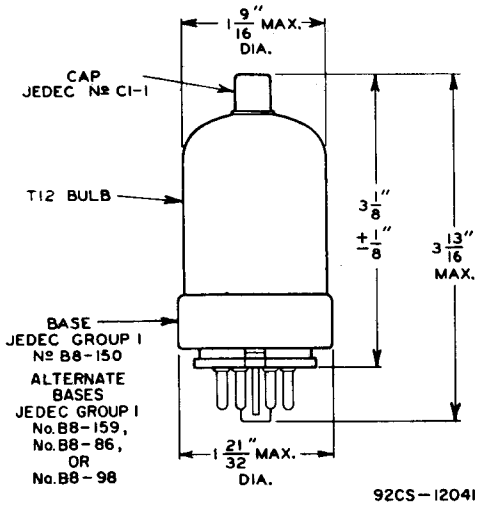


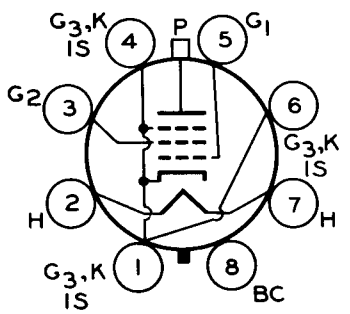
Fig. 8 - Curves Showing Plate Voltage and Plate Input vs Frequency for Type 6146A in Class C Telephony Service.

DIMENSIONAL OUTLINE



TERMINAL CONNECTIONS

Bottom View



7CK

PIN 1: CATHODE, GRID NO.3, INTERNAL SHIELD
PIN 2: HEATER
PIN 3: GRID NO.2
PIN 4: SAME AS PIN 1
PIN 5: GRID NO.1
PIN 6: SAME AS PIN 1
PIN 7: HEATER
PIN 8: BASE SLEEVE
CAP: PLATE

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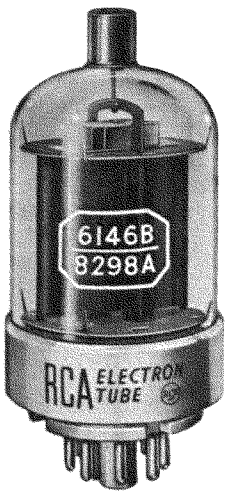
RCA-6146B/8298A
BEAM POWER TUBE

Controlled Zero-Bias Plate Current
Controlled Power Output at Reduced Heater Voltage

85 Watts CW Output (ICAS) at 60 Mc
50 Watts CW Output (ICAS) at 175 Mc
RCA "Dark Heater" with 5- to 8-volt Range

3-13/16" Max. Length
1-21/32" Max. Diameter
Octal 8-Pin Base
Small, Sturdy Structure



RCA-6146B/8298A is a small, sturdy, beam power tube having high efficiency and high power sensitivity for use in mobile and stationary equipment. It is rated as an af power amplifier and modulator, a linear rf power amplifier, and a Class C rf power amplifier and oscillator.

The 6146B features a heater designed to operate over a voltage range of 6.0 to 7.5 volts and which will take excursions from 5 to 8 volts in battery operation. The heater design insures dependable performance in mobile equipment under operating conditions during battery charging and discharging. See *Special Performance Data* on page 4 for information covering heater overvoltage and undervoltage operation.

Controlled zero-bias plate current is offered in the 6146B to insure more dependable performance as a Class AB_1 linear rf amplifier for single-sideband suppressed-carrier service. See *Test No.3* of *Characteristics Range Values*.

Also featured in the design of the 6146B is the new RCA "Dark Heater", which functions efficiently at operating temperatures 350° K below those of the heaters in conventional tube types. The dark surface of the new heater radiates heat more efficiently and improves the transfer of heat to the cathode so that optimum cathode temperature may be attained with the heater operating at approximately 1350° K.

The low operating temperature of the "Dark Heater" results in (1) lower internal stresses in the heater wire and smaller thermal change during heater warmup, (2) cooler operation of the heater which minimizes changes in heater shape and reduces the possibility of heater damage and heater shorts, (3) extremely stable heater current characteristics throughout life, and (4) significant reduction in effects of ac heater leakage.

Small in size for its power-output capability, the 6146B has a rugged button-stem construction with short internal leads, a T12 bulb, triple base-pin connections for grid No.3 and cathode (both joined to internal shield inside the tube) to permit effective rf grounding, and an octal base with short metal sleeve having its own base-pin terminal. The sleeve shields the input to the tube and isolates it from the output circuit so completely that no other external shielding is required. Separation of input and output circuits is accomplished by bringing the plate lead out of the bulb to a cap opposite the base.

The 6146B/8298A is unilaterally interchangeable with the 6146, 6146A, and 8298.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current at 6.3 volts	1.125	amp
Minimum heating time	60	sec

See Special Performance Data on page 4 for heater operation in stationary equipment and in mobile equipment.

Transconductance, for plate volts = 200, grid-No.2 volts = 200, and plate ma. = 100	7000	μmhos
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 200, grid-No.2 volts = 200, and plate ma. = 100	4.5	
Direct Interelectrode Capacitances (Approx.):[a]		
Grid No.1 to plate	0.22 max.	pf
Grid No.1 to cathode & grid No.3 & internal shield, base sleeve, grid No.2, and heater	13	pf
Plate to cathode & grid No.3 & internal shield, base sleeve, grid No.2, and heater	8.5	pf

Mechanical:

Operating Position	Any
Maximum Overall Length	3-13/16"
Seated Length	3-1/8" ± 1/8"
Maximum Diameter	1-21/32"
Bulb	T12
Cap	Small (JEDEC No.C1-1)
Base	Small-Wafer Octal 8-Pin with Sleeve (JEDEC Group 1, No.B8-150), or Small-Wafer Octal 8-Pin with External Barriers and Sleeve (JEDEC Group 1, No.B8-159)
Bulb Temperature (At hottest point)	260 max. °C
Weight (Approx.)	2.3 oz

AF POWER AMPLIFIER & MODULATOR – Class AB_1

Maximum Ratings, *Absolute-Maximum Values:*

	CCS	ICAS	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT[b]	175 max.	220 max.	ma
MAX.-SIGNAL PLATE INPUT[b]	90 max.	120 max.	watts

	CCS	ICAS	
MAX.-SIGNAL GRID-No.2 INPUT[b]	3 max.	3 max.	watts
PLATE DISSIPATION[b]	27 max.	35 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No.2 Voltage[c]	200	200	volts
DC Grid-No.1 Voltage:			
With fixed-bias source	-47	-48	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage[d]	94	96	volts
Zero-Signal DC Plate Current	48	50	ma
Max.-Signal DC Plate Current	250	250	ma
Max.-Signal DC Grid-No.2 Current	14.8	12.6	ma
Effective Load Resistance (Plate to plate)	5600	7200	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	96	124	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance under Any Condition:[e]

With fixed bias	0.1 max.	megohm
With cathode bias	.Not recommended	

AF POWER AMPLIFIER & MODULATOR – Class AB_2

Maximum Ratings, *Absolute-Maximum Values:*

	CCS	ICAS	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT[b]	175 max.	220 max.	ma
MAX.-SIGNAL PLATE INPUT[b]	90 max.	120 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT[b]	3 max.	3 max.	watts
PLATE DISSIPATION[b]	27 max.	35 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	500	600	volts
DC Grid-No.2 Voltage[c]	200	200	volts
DC Grid-No.1 Voltage:			
From fixed-bias source	-46	-48	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	108	106	volts
Zero-Signal DC Plate Current	50	40	ma
Max.-Signal DC Plate Current	308	270	ma
Max.-Signal DC Grid-No.2 Current	26	27	ma
Max.-Signal DC Grid-No.1 Current	2.7	1.3	ma
Effective Load Resistance (Plate to plate)	3620	5200	ohms
Max.-Signal Driving Power (Approx.)[f]	0.2	0.7	watt
Max.-Signal Power Output (Approx.)	100	110	watts

Typical ICAS Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No.2 Voltage[c]	200	150	volts
DC Grid-No.1 Voltage:			
From fixed-bias source	-47	-39	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	114	110	volts
Zero-Signal DC Plate Current	50	40	ma
Max.-Signal DC Plate Current	328	294	ma
Max.-Signal DC Grid-No.2 Current	26	28	ma
Max.-Signal DC Grid-No.1 Current	3.4	7.6	ma
Effective Load Resistance (Plate to plate)	4160	6050	ohms
Max.-Signal Driving Power (Approx.)[f]	0.2	0.5	watt
Max.-Signal Power Output (Approx.)	130	148	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:[g]

With fixed bias	30,000 max.	ohms
With cathode bias	.Not recommended	

LINEAR RF POWER AMPLIFIER, Class AB_1

Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

	CCS	ICAS	
Maximum CCS Ratings, *Absolute-Maximum Values:*			
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 VOLTAGE	250 max.	250 max.	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE	175 max.	220 max.	ma
PLATE DISSIPATION	27 max.	35 max.	watts
GRID-No.2 DISSIPATION	3 max.	3 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation with "Two-Tone Modulation":

	At 30 Mc		
DC Plate Voltage	600	750	volts
DC Grid-No.2 Voltage[h]	200	200	volts
DC Grid-No.1 Voltage[h]	-47	-48	volts
Zero-Signal DC Plate Current	24	25	ma
Effective RF Load Resistance	2800	3600	ohms
DC Plate Current at Peak of Envelope	125	125	ma
Average DC Plate Current	86	86	ma

	CCS	ICAS	
DC Grid-No. 2 Current at Peak of Envelope	7.4	6.3	ma
Average DC Grid-No. 2 Current	5.0	3.9	ma
Distortion Products Level:[i]			
Third order	24	26	db
Fifth order	30	31	db
Useful Power Output (Approx.):			
Average	24.5	30.5	watts
Peak envelope	49	61	watts

Maximum Circuit Values:

Grid-No. 1 Circuit Resistance under Any Condition:		
With fixed bias	30,000 max.	ohms

PLATE-MODULATED RF POWER AMPLIFIER — Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0; at frequencies up to 60 Mc

	CCS	ICAS	
Maximum Ratings, *Absolute-Maximum Values:*			
DC PLATE VOLTAGE	480 max.	600 max.	volts
DC GRID-No. 2 VOLTAGE	250 max.	250 max.	volts
DC GRID-No. 1 VOLTAGE	-150 max.	-150 max.	volts
DC PLATE CURRENT	145 max.	180 max.	ma
DC GRID-No. 1 CURRENT	3.5 max.	4.0 max.	ma
PLATE INPUT	60 max.	85 max.	watts
GRID-No. 2 INPUT	2 max.	2 max.	watts
PLATE DISSIPATION	18 max.	23 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical Operation:			
DC Plate Voltage	475	600	volts
DC Grid-No. 2 Voltage[j]	165	175	volts
DC Grid-No. 1 Voltage[k]	-86	-92	volts
From a grid resistor of	26,000	27,000	ohms
Peak RF Grid-No. 1 Voltage	106	114	volts
DC Plate Current	125	140	ma
DC Grid-No. 2 Current	8.5	9.5	ma
DC Grid-No. 1 Current (Approx.)	3.3	3.4	ma
Driving Power (Approx.)	0.4	0.5	watt
Power Output (Approx.)	42	62	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No. 1-Circuit Resistance[n]	30,000 max.	ohms

RF POWER AMPLIFIER & OSC. — Class C Telegraphy and RF POWER AMPLIFIER — Class C FM Telephony

	CCS	ICAS	
Maximum Ratings, *Absolute-Maximum Values up to 60 Mc:*			
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No. 2 VOLTAGE	250 max.	250 max.	volts
DC GRID-No. 1 VOLTAGE	-150 max.	-150 max.	volts
DC PLATE CURRENT	175 max.	220 max.	ma
DC GRID-No. 1 CURRENT	3.5 max.	4.0 max.	ma
PLATE INPUT	90 max.	120 max.	watts
GRID-No. 2 INPUT	3 max.	3 max.	watts
PLATE DISSIPATION	27 max.	35 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical Operation as Amplifier up to 60 Mc:			
DC Plate Voltage	600	750	volts
DC Grid-No. 2 Voltage[l]	200	200	volts
DC Grid-No. 1 Voltage[m]	-70	-77	volts
From a grid-No. 1 resistor of	24,000	28,000	ohms
Peak RF Grid-No. 1 Voltage	90	95	volts
DC Plate Current	150	160	ma
DC Grid-No. 2 Current	10	10	ma
DC Grid-No. 1 Current (Approx.)	2.8	2.7	ma
Driving Power (Approx.)	0.3	0.3	watt
Power Output (Approx.)	63	85	watts

Typical Operation as Amplifier at 175 Mc:

DC Plate Voltage	320	400	435	volts
DC Grid-No. 2 Voltage[l]	210	220	230	volts
DC Grid-No. 1 Voltage[m]	-52	-55	-56	volts
From a grid resistor of	26,000	30,000	24,000	ohms
Peak RF Grid-No. 1 Voltage	65	67	73	volts
DC Plate Current	170	180	210	ma
DC Grid-No. 2 Current	12	12	11	ma
DC Grid-No. 1 Current (Approx.)	2	1.9	2.3	ma
Driving Power (Approx.)	2	2	3	watts
Power Output (Approx.)	29	40	50	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No. 1-Circuit Resistance[n]	30,000 max.	ohms

CHARACTERISTICS RANGE VALUES

	Note	Min.	Max.	
1. Direct Interelectrode Capacitances:				
Grid No. 1 to plate	1	-	0.22	pf
Grid No. 1 to cathode & grid No. 3 & internal shield, base sleeve, grid No. 2, and heater	1	12.0	15.0	pf
Plate to cathode & grid No. 3 & internal shield, base sleeve, grid No. 2, and heater	1	7.3	9.5	pf
2. Plate Current	2	46	94	ma
3. Zero-Bias Plate Current	3	330	-	ma
4. Grid-No. 2 Current	2	-	5.5	ma

Note 1: With no external shield.

Note 2: With heater voltage of 6.75 volts, dc plate voltage of 400 volts, dc grid-No. 2 voltage of 200 volts, and dc grid-No. 1 voltage of -34 volts.

Note 3: With heater voltage of 6.75 volts, dc plate voltage of 100 volts, dc grid-No. 2 voltage of 200 volts, and dc grid-No. 1 voltage of -100 volts. Grid No. 1 is square-wave pulsed at 1000 kc to zero volts. Limit value is peak-pulse current.

SPECIAL PERFORMANCE DATA ON HEATER OPERATION

Stationary Equipment Operation:

Heater, for Unipotential Cathode:

	Min.	Design Center	Max.	
Voltage (AC or DC)[a] . .	-	6.3	-	volts
Current at 6.3 volts. .	1.050	-	1.200	amp
Dynamic Grid-No.2 Current[b]	-	-	15	ma
Useful Power Output[b]. . .	59	-	-	watts

[a] It is recommended that the design-center heater voltage be 6.3 volts; the heater power supply should not fluctuate more than 10% to insure long life.

[b] In a single-tube, self-excited oscillator circuit, and with ac heater voltage of 6.3 volts, dc plate voltage of 600 volts, dc grid-No.2 voltage of 200 volts, grid-No.1 resistor of 24,000 ± 10% ohms, dc plate current of 150 max. ma., dc grid-No.1 current of 2.5 to 3 ma., and frequency of 15 Mc.

Mobile Equipment Operation:

Heater, for Unipotential Cathode:

	Min.	Design Range	Max.	
Voltage (AC or DC)[a] . .	-	6.0-7.5	-	volts
Current at 6.75 volts .	1.100	-	1.230	amp
Dynamic Grid-No.2 Current[b]	-	-	15	ma
Useful Power Output I[b]. .	59			watts
Useful Power Output II. .	See *Note c*			

Overvoltage Heater Life Tests:

Continuous heater life tests are performed periodically on sample lots of tubes with 8 volts on the heater, all other electrodes "floating". Intermittent heater life tests are performed periodically on sample lots of tubes with 11 volts on the heater, a cycle of 1 minute "ON" and 4 minutes "OFF". After 1000 hours of the continuous heater life test and after 48 hours of the intermittent heater life test, the following tests are performed:

With heater voltage of 6.75 volts and ± 100 dc volts between cathode and heater, the heater-cathode leakage current will not exceed 100 microamperes.

With ac or dc heater voltage of 6.75 volts, grid-No.1 volts = -200 and cathode, grid No.2, and plate grounded, the minimum grid-No.1 leakage resistance will be 10 megohms.

With ac or dc heater voltage of 6.75 volts, plate volts = -200, and cathode grid No.1 and grid No.2 grounded, the minimum plate leakage resistance will be 10 megohms.

[a] It is recommended that the heater voltage operate within the range of 6.0 to 7.5 volts and within excursions from 5 to 8 volts in battery operation. See *Useful Power Output Test II* and *Overvoltage Tests*.

[b] In a single-tube, self-excited oscillator circuit, and with ac heater voltage of 6.3 volts, dc plate voltage of 600 volts, dc grid-No.2 voltage of 200 volts, grid-No.1 resistor of 24,000 ± 10% ohms, dc plate current of 150 max. ma., dc grid-No.1 current of 2.5 to 3 ma., and frequency of 15 Mc.

[c] With conditions in note b above, reduce heater voltage to 5 volts. Useful power output will be at least 90% of the power output at heater voltage of 6.3 volts.

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[a] With no external shield.

[b] Averaged over any audio-frequency cycle of sine-wave form.

[c] Obtained preferably from a separate source or from the plate voltage supply with a voltage divider.

[d] The driver stage should be capable of supplying the No. 1 grids of the class AB_1 stage with the specified driving voltage at low distortion.

[e] The type of input coupling network used should not introduce too much resistance in the grid-No. 1 circuit. Transformer or impedance coupling devices are recommended.

[f] Driver stage should be capable of supplying the specified driving power at low distortion to the No. 1 grids of the AB_2 stage.

[g] To minimize distortion, the effective resistance per grid-No. 1 circuit of the AB_2 stage should be held at a low value. For this purpose the use of transformer coupling is recommended. In no case, however, should the total dc grid-No. 1-circuit resistance exceed 30,000 ohms when the tube is operated at maximum ratings. For operation at less than maximum ratings, the dc grid-No. 1-circuit resistance may be as high as 100,000 ohms.

[h] Obtained preferably from a separate, well-regulated source.

[i] Referenced to either of the two tones and without the use of feedback to enhance linearity.

[j] Obtained preferably from a separate source modulated with the plate supply, or from the modulated plate supply through a series resistor.

[k] Obtained from grid-No. 1 resistor or from a combination of grid-No. 1 resistor with either fixed supply or cathode resistor.

[l] Obtained preferably from separate source, or from the plate-supply voltage with a voltage divider, or through a series resistor. A series grid-No. 2 resistor should be used only when the tube is used in a circuit which is not keyed. Grid-No. 2 voltage must not exceed 435 volts under key-up conditions.

[m] Obtained from fixed supply, by grid-No. 1 resistor, by cathode resistor, or by combination methods.

[n] When grid No. 1 is driven positive and the tube is operated at maximum ratings, the total dc grid-No. 1-circuit resistance should not exceed the specified value of 30,000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply. For operation at less than maximum ratings, the dc grid-No. 1-circuit resistance may be as high as 100,000 ohms.

DEFINITIONS

AB_1 - The subscript 1 indicates that grid-No. 1 current does not flow during any part of the input cycle.

AB_2 - The subscript 2 indicates that grid-No. 1 current flows during some part of the input cycle.

CCS - Continuous Commercial Service.

ICAS - Intermittent Commercial and Amateur Service.

Ratings System - The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

Two-Tone Modulation - Two-Tone Modulation operation refers to that class of amplifier service in which the input consists of two monofrequency rf signals having equal peak amplitude.

MAXIMUM RATINGS vs. OPERATING FREQUENCY
In Class C Telegraphy Service

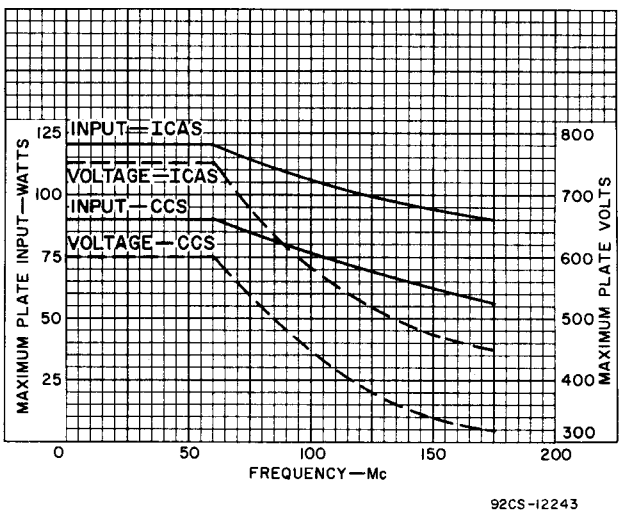


Fig. 1A

MAXIMUM RATINGS vs. OPERATING FREQUENCY
In Class C Telephony Service

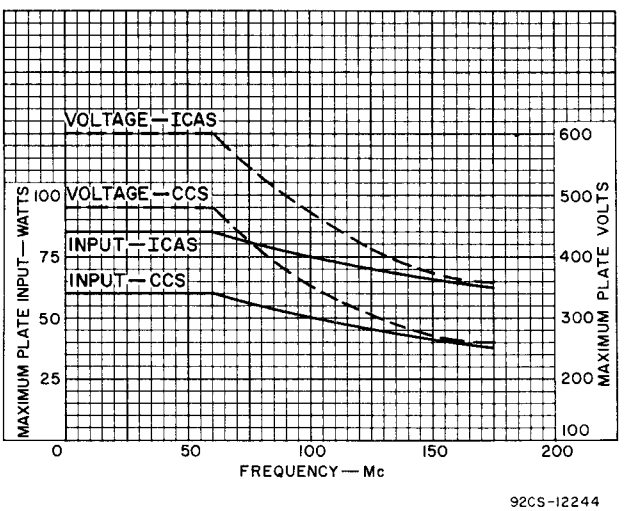


Fig. 1B

GENERAL CONSIDERATIONS

Temperature

The maximum bulb temperature of 260° C is a tube rating and is to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y.

TYPICAL PLATE CHARACTERISTICS

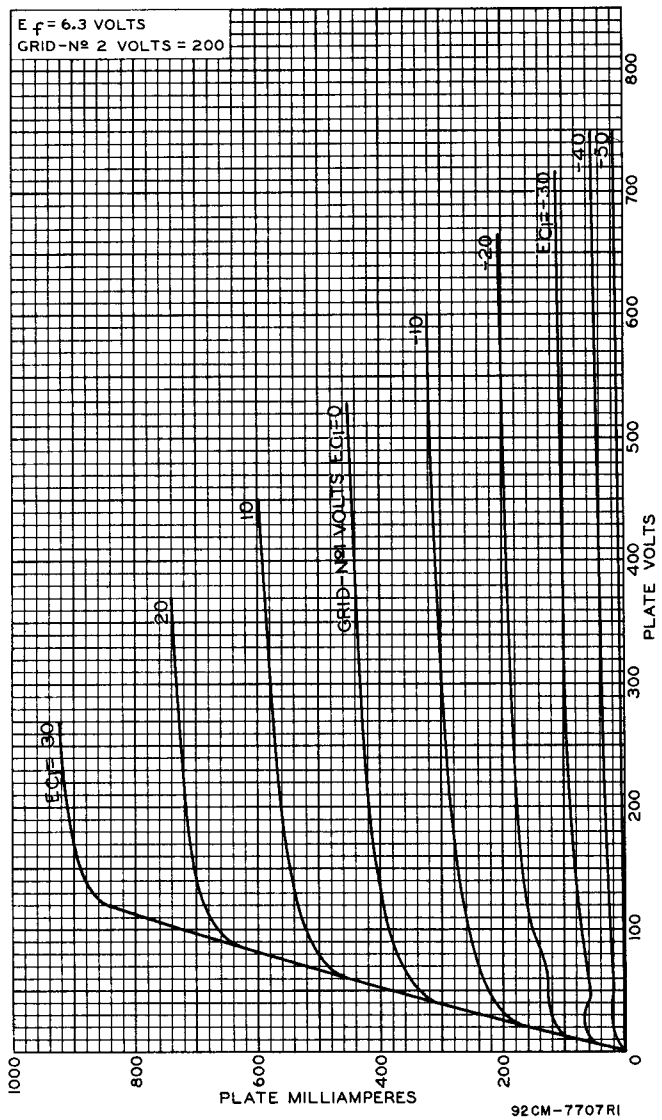


Fig.2

To insure adequate cooling it is essential that free circulation of air be provided around the tube. In most cases, no additional air is required.

Plate Color

The plate shows no color when the 6146B is operated at full ratings under either CCS or ICAS conditions.

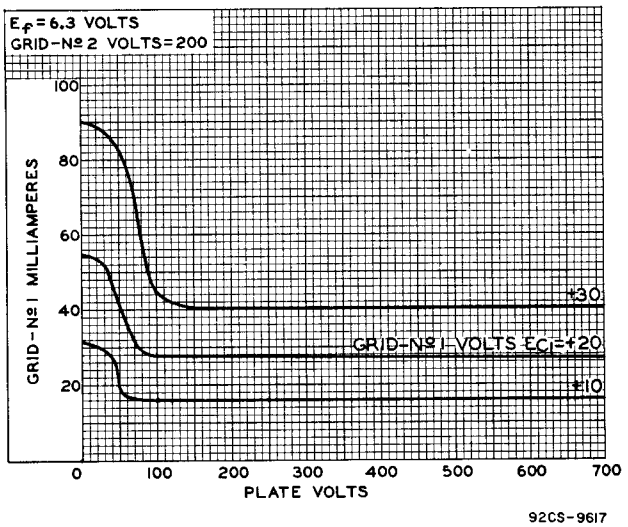
MECHANICAL CONSIDERATIONS

Plate Circuit

Heavy leads and conductors together with suitable insulation should be used in all parts of the rf plate tank circuit so that losses due to rf voltages and currents may be kept at a minimum. At the higher frequencies, it is essential that short, heavy leads be used for circuit connections in order to minimize lead inductance and losses.

Connections to the plate should be made with a flexible lead to prevent any strain on the seal at the cap.

TYPICAL CHARACTERISTICS



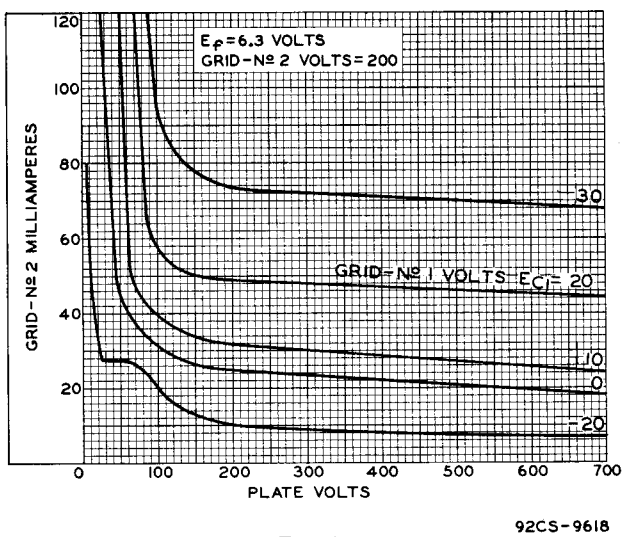


Fig.4

ELECTRICAL CONSIDERATIONS

Plate and Grid No. 2

When a new circuit is tried or when adjustments are made, it is advisable to reduce the

plate voltage and grid-No.2 voltage. If the 6146B is operated at maximum ratings and grid-No.2 voltage is obtained through a series dropping resistor, the use of a 2500-ohm protective resistor in the high-voltage supply lead is recommended. When a separate grid-No.2 voltage supply is used, a 10,000-ohm protective resistor should be connected in the grid-No.2 supply lead.

The grid-No.2 current is a very sensitive indication of plate-circuit loading and grid-No.2 current rises excessively (often to the point of damaging the tube) when the amplifier is operated without load. Therefore, care should be taken when tuning a 6146B under no-load conditions in order to prevent exceeding the grid-No.2 input rating of the tube.

TYPICAL PLATE CHARACTERISTICS

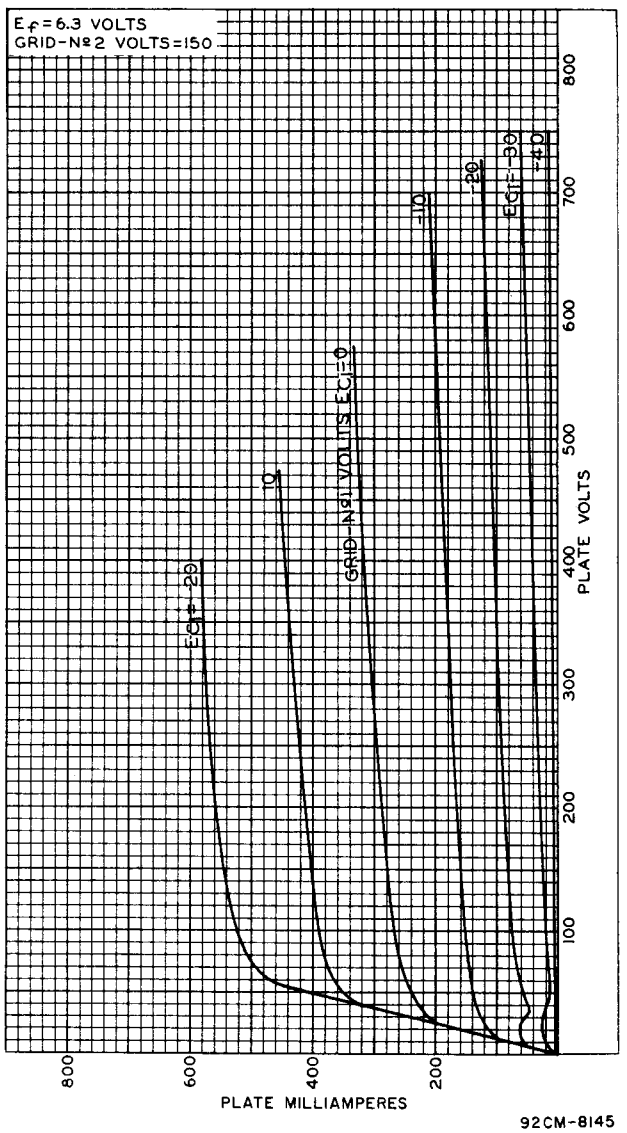
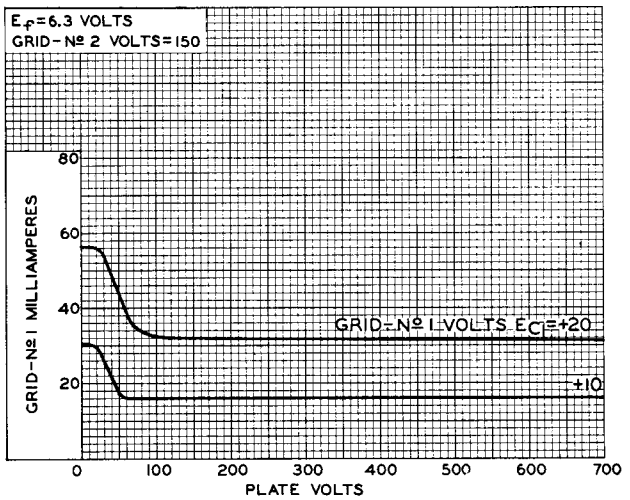


Fig.5

TYPICAL CHARACTERISTICS



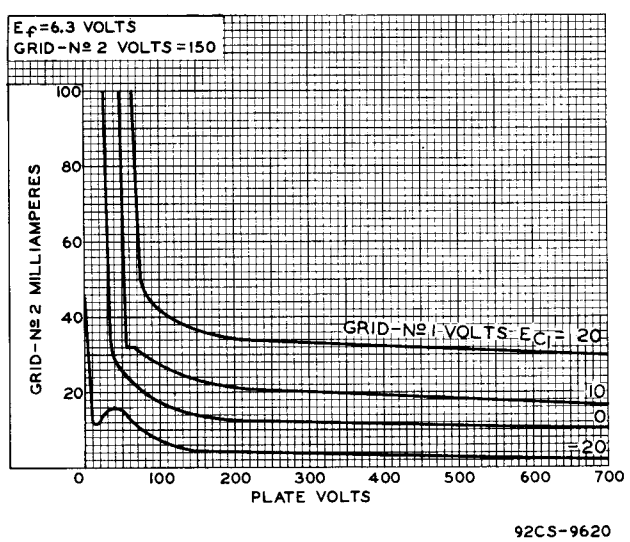


Fig.7

The plate voltage should be applied before or simultaneously with the grid-No.2 voltage; otherwise, with voltage on grid No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the dc power input determined.

Driver

The driver stage for the 6146B in either class C telephony or telegraphy service should have considerably more output capability than the typical driving power shown in the tabulated data in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuit and the coupling circuits.

This recommendation is particularly important near the maximum-rated frequency where there are other losses of driving power, such as circuit losses, radiation losses, and transit-time losses.

Efficiency

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 6146B is operated under load conditions such that the maximum rated plate current flows at the plate voltage which will give maximum rated input.

Class C Telephony

In plate-modulated class C amplifier service, the 6146B can be modulated 100 per cent. The grid-No.2 voltage must be modulated simultaneously with the plate voltage so that the ratio of grid-No.2 voltage to plate voltage remains constant. Modulation of the grid-No.2 voltage can be accomplished either by connecting grid No.2 through a separate winding on the modulation transformer to the fixed grid-No.2 voltage supply, or by connecting grid No.2 through an audio-frequency choke of suitable impedance for low audio frequencies to the fixed grid-No.2 supply voltage. The supply end of the choke should be well bypassed to ground.

Circuit Arrangements

Push-pull or parallel circuit arrangements can be used when more radio-frequency power is required than can be obtained from a single 6146B. Two 6146B's in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube.

With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits.

When two or more tubes are used in the circuit, precautions should be taken to insure that each tube draws the same plate current.

Standby Operation

During standby periods in intermittent operation, the heater voltage may be maintained at normal operating value for most applications.

In those applications which require maximum reliability, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; that it be reduced to 80 per cent of normal when the period is between 15 minutes and 2 hours; and that for longer periods, the heater voltage should be turned off.

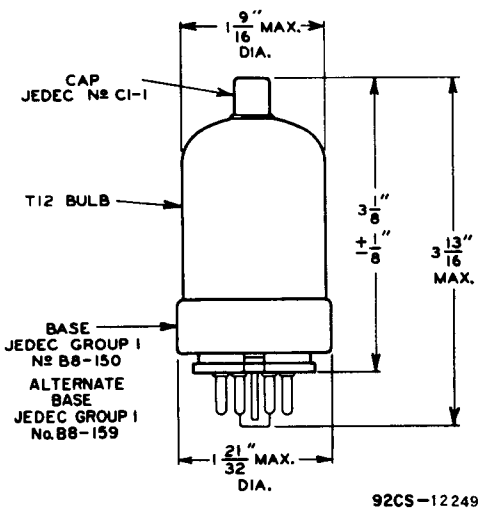
Protective Devices

Protective devices should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the dc plate and grid-No.2 voltage when the average value of plate current reaches a value slightly higher than normal plate current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

Precautions

The rated plate and grid-No.2 voltages of this tube are extremely dangerous. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

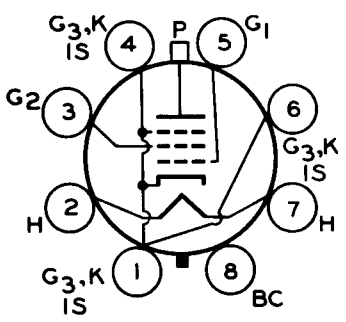
DIMENSIONAL OUTLINE



92CS-12249

TERMINAL CONNECTIONS

Bottom View



7CK

PIN 1: CATHODE, GRID NO.3, INTERNAL SHIELD
PIN 2: HEATER
PIN 3: GRID NO.2
PIN 4: SAME AS PIN 1
PIN 5: GRID NO.1
PIN 6: SAME AS PIN 1
PIN 7: HEATER
PIN 8: BASE SLEEVE
CAP: PLATE

6161

UHF POWER TRIODE

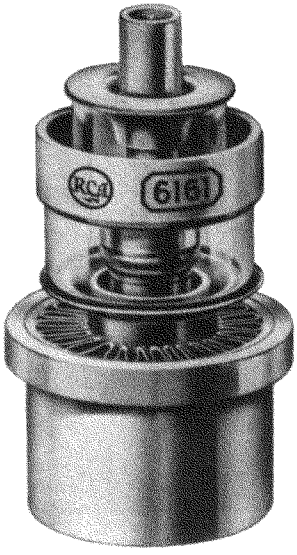
Small Size
Coaxial Electrode Structure

Forced-Air-Cooled, Grounded-Grid Type
400 Watts CW Input to 900 Mc
250 Watts CW Input at 2000 Mc

TENTATIVE DATA

3-13/32" Max. Length
1.760" Max. Diameter
Integral Radiator

RCA-6161 is a very compact, forced-air-cooled power triode of the grounded-grid type designed for uhf service in television and cw applications.



It has a maximum plate dissipation of 250 watts in cw and television service. The 6161 can be operated with full plate voltage and plate input at frequencies as high as 900 Mc, and with reduced ratings up to 2000 Mc.

Featured in the 6161 is a coaxial-electrode structure designed especially for use with circuits of the coaxial-cylinder type. The design provides low-inductance, large-area, rf electrode terminals for insertion into the cylinders, and permits effective isolation of the plate from the cathode. The latter feature makes the 6161 particularly suitable for grounded-grid circuits.

The 6161 supersedes the type 5588 for new equipment design.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)*.	6.3 av. / 6.9 max.	volts / volts
Current.	3.4	amperes
Minimum Heating Time	1	minute
Amplification Factor	27	
Direct Interelectrode Capacitances:		
Grid to Plate.	6	μμf
Grid to Cathode.	11	μμf
Plate to Cathode♦	0.32 max.	μμf

Mechanical:

Mounting Position.	Any
Overall Length	3-5/16" ± 3/32"
Greatest Diameter.	1.750" ± 0.010"
Radiator	Integral part of tube
Mounting	Special

Air Flow:

The specified air flow for various plate dissipations, as indicated in the tabulation below, should be delivered by a blower onto the respective terminals and seals, and through the radiator before and during the application of any voltages. Heater power, plate power, and air may be removed simultaneously.

Percentage of Max. Rated Plate Dissipation for Each Class of Service .	100	80	60	per cent
Minimum Air Flow. .	16	10	5.7	cfm
Static Pressure . .	0.85	0.4	0.16	in.of water

The above flow and pressure values are for condition with radiator temperature held constant at 135°C rise above incoming-air temperature. The air flow must be adequate to limit the temperature of the radiator, grid terminal, cathode terminal, and seals to their respective maximum values.

Incoming-Air Temperature	45 max.	°C
Radiator Temperature (Measured on core at end adjacent to plate ring)	180 max.	°C
Grid-Terminal Temperature.	150 max.	°C
Cathode-Terminal Temperature	150 max.	°C
Seal Temperature (Plate, grid, and cathode) . .	150 max.	°C
Weight (Approx.)	8	ounces

RF POWER AMPLIFIER--Class B Television Service

Synchronizing-level conditions unless otherwise specified

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	1600 max.	volts
DC PLATE CURRENT	0.350 max.	amp
DC GRID CURRENT.	0.100 max.	amp
PLATE INPUT.	560 max.	watts
PLATE DISSIPATION.	250 max.	watts

Typical Operation in Grounded-Grid Circuit at 600 Mc:

	Bandwidth♦ of 6 Mc	
DC Plate Voltage	1500	volts
DC Grid Voltage.	−100	volts
Peak RF Grid Voltage:		
Synchronizing Level.	130	volts
Pedestal Level	117	volts
DC Plate Current:		
Synchronizing Level.	0.350	amp
Pedestal Level	0.285	amp
DC Grid Current (Approx.):		
Synchronizing Level.	0.040	amp
Pedestal Level	0.013	amp
Driver Power Output (Approx.):♣		
Synchronizing Level.	65#	watts
Pedestal Level	40	watts
Output-Circuit Efficiency (Approx.).	89	per cent
Useful Power Output (Approx.):		
Synchronizing Level.	325●●	watts
Pedestal Level	195●●	watts

Typical Operation in Grounded-Grid Circuit at 900 Mc:

	Bandwidth♦ of 6 Mc	
DC Plate Voltage	1500	volts
DC Grid Voltage.	−100	volts
Peak RF Grid Voltage:		
Synchronizing Level.	135	volts
Pedestal Level	120	volts
DC Plate Current:		
Synchronizing Level.	0.350	amp
Pedestal Level	0.280	amp

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DC Grid Current (Approx.):		
Synchronizing Level	0.030	amp
Pedestal Level	0.010	amp
Driver Power Output (Approx.):♣		
Synchronizing Level	75⊕	watts
Pedestal Level	45	watts
Output-Circuit Efficiency (Approx.)	65	per cent
Useful Power Output (Approx.):		
Synchronizing Level	230●●	watts
Pedestal Level	135●●	watts

GRID-MODULATED RF POWER AMPLIFIER--Class C Television Service

Synchronizing-level conditions unless otherwise specified

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	1600 max.	volts
DC GRID VOLTAGE (White level)	-300 max.	volts
DC PLATE CURRENT	0.350 max.	amp
DC GRID CURRENT	0.100 max.	amp
PLATE INPUT	560 max.	watts
PLATE DISSIPATION	250 max.	watts

Typical Operation in Grounded-Grid Circuit at 600 Mc:

Bandwidth♦ of 6 Mc

DC Plate Voltage	1500	volts
DC Grid Voltage:		
Synchronizing Level	-100	volts
Pedestal Level	-150	volts
White Level	-230	volts
Peak RF Grid Voltage	130	volts
DC Plate Current:		
Synchronizing Level	0.350	amp
Pedestal Level	0.250	amp
DC Grid Current (Approx.):		
Synchronizing Level	0.040	amp
Pedestal Level	0.013	amp
Driver Power Output (Approx.):♣		
Synchronizing Level	65#	watts
Output-Circuit Efficiency (Approx.)	89	per cent
Useful Power Output (Approx.):		
Synchronizing Level	325●●	watts
Pedestal Level	195●●	watts

Typical Operation in Grounded-Grid Circuit at 900 Mc:

Bandwidth♦ of 6 Mc

DC Plate Voltage	1500	volts
DC Grid Voltage:		
Synchronizing Level	-100	volts
Pedestal Level	-150	volts
White Level	-230	volts
Peak RF Grid Voltage	135	volts
DC Plate Current:		
Synchronizing Level	0.350	amp
Pedestal Level	0.250	amp
DC Grid Current (Approx.):		
Synchronizing Level	0.030	amp
Pedestal Level	0.010	amp
Driver Power Output (Approx.):♣		
Synchronizing Level	75⊕	watts
Output-Circuit Efficiency (Approx.)	65	per cent
Useful Power Output (Approx.):		
Synchronizing Level	230●●	watts
Pedestal Level	135●●	watts

PLATE-MODULATED RF POWER AMPLIFIER--Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	1300 max.	volts
DC GRID VOLTAGE	-300 max.	volts
DC PLATE CURRENT	0.210 max.	amp
DC GRID CURRENT	0.075 max.	amp
PLATE INPUT	270 max.	watts
PLATE DISSIPATION	167 max.	watts

Typical Operation in Grounded-Grid Circuit at 600 Mc:

DC Plate Voltage	1250	volts
DC Grid Voltage	-150	volts
From grid resistor of	2150	ohms
Peak RF Grid Voltage	200	volts
DC Plate Current	0.210	amp
DC Grid Current (Approx.)	0.070	amp
Driver Power Output (Approx.)♣	70**	watts
Output-Circuit Efficiency (Approx.)	80	per cent
Useful Power Output (Approx.)	180●●	watts

Typical Operation in Grounded-Grid Circuit at 900 Mc:

DC Plate Voltage	1250	volts
DC Grid Voltage	-150	volts
From grid resistor of	2150	ohms
Peak RF Grid Voltage	200	volts
DC Plate Current	0.210	amp
DC Grid Current (Approx.)	0.070	amp
Driver Power Output (Approx.)♣	75#	watts
Output-Circuit Efficiency (Approx.)	60	per cent
Useful Power Output (Approx.)	120●●	watts

RF POWER AMPLIFIER & OSC.--Class C Telegraphy□ and RF POWER AMPLIFIER--Class C FM Telephony

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	1600 max.	volts
DC GRID VOLTAGE	-300 max.	volts
DC PLATE CURRENT	0.250 max.	amp
DC GRID CURRENT	0.075 max.	amp
PLATE INPUT	400 max.	watts
PLATE DISSIPATION	250 max.	watts

Typical Operation as Amplifier in Grounded-Grid Circuit at 600 Mc:

DC Plate Voltage	1500	volts
DC Grid Voltage:		
From fixed supply of	-150	volts
From grid resistor of	3000	ohms
From cathode resistor of	500	ohms
Peak RF Grid Voltage	200	volts
DC Plate Current	0.250	amp
DC Grid Current (Approx.)	0.050	amp
Driver Power Output (Approx.)♣	75▲	watts
Output-Circuit Efficiency (Approx.)	82	per cent
Useful Power Output (Approx.)	270●●	watts

Typical Operation as Amplifier in Grounded-Grid Circuit at 900 Mc:

DC Plate Voltage	1500	volts
DC Grid Voltage:		
From fixed supply of	-150	volts
From grid resistor of	15000	ohms
From cathode resistor of	575	ohms
Peak RF Grid Voltage	200	volts
DC Plate Current	0.250	amp
DC Grid Current (Approx.)	0.010	amp
Driver Power Output (Approx.)♣	80†	watts
Output-Circuit Efficiency (Approx.)	60	per cent
Useful Power Output (Approx.)	180●●	watts

FREQUENCY MULTIPLIER--Class C

Maximum CCS● Ratings, *Absolute Values*:

DC PLATE VOLTAGE	1600 max.	volts
DC GRID VOLTAGE	-300 max.	volts
DC PLATE CURRENT	0.250 max.	amp
DC GRID CURRENT	0.075 max.	amp
PLATE INPUT	400 max.	watts
PLATE DISSIPATION	250 max.	watts

Typical Operation in Grounded-Grid Circuit:

	Doubler to 600 Mc	*Doubler to 900 Mc*	
DC Plate Voltage	1500	1500	volts
DC Grid Voltage:			
From fixed supply of	-260	-175	volts
From grid resistor of	5200	8300	ohms
From cathode resistor of	860	645	ohms
Peak RF Grid Voltage	300	300	volts
DC Plate Current	0.250	0.250	amp
DC Grid Current (Approx.)	0.050	0.021	amp
Driver Power Output (Approx.)♣	125	100	watts
Output-Circuit Efficiency (Approx.)	90	80	per cent
Useful Power Output (Approx.)	180●●	140●●	watts

MAXIMUM RATINGS vs OPERATING FREQUENCY

FREQUENCY	900	1200	1400	1650	2000	Mc
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE AND PLATE INPUT:						
Class B Television	100	80	71	62.5	62.5	%
Class C Television, Grid-Modulated	100	80	71	62.5	62.5	%
Class C Telephony, Plate-Modulated	100	80	71	62.5	62.5	%
Class C Telegraphy	100	80	71	62.5	62.5	%
Class C FM Telephony	100	80	71	62.5	62.5	%

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Max.	
Heater Current	1	3.05	3.75	amp
Amplification Factor . . .	1,2	20	34	
Grid-Plate Capacitance . .	-	5.5	6.5	μμf
Grid-Cathode Capacitance .	-	9.6	12.4	μμf
Plate-Cathode Capacitance.	3	-	0.32	μμf
Plate Voltage.	1,4	550	810	volts
Plate Voltage.	1,5	750	1150	volts
Grid Voltage	1,6	-	-165	volts
Peak Cathode Current . . .	1,7	9	-	amp
Useful Power Output. . . .	1,8	225	-	watts

Note 1: With 6.3 volts ac on heater.
Note 2: With dc grid voltage of -15 volts, and dc plate voltage adjusted to give dc plate current of 250 ma.
Note 3: With external shield, as described under (♦) connected to grid terminal.
Note 4: With dc grid voltage of -10 volts, and dc plate voltage adjusted to give dc plate current of 250 ma.
Note 5: With dc grid voltage of -20 volts, and dc plate voltage adjusted to give dc plate current of 250 ma.
Note 6: With dc plate voltage of 1600 volts, and dc grid voltage adjusted to give dc plate current of 1.0 ma.
Note 7: Designers should limit the maximum useable cathode current (plate current and grid current) to this value under any condition of operation.
Note 8: In a self-excited oscillator circuit and with dc plate voltage of 1600 volts, dc plate current of 250 ma., dc grid current of 50 to 75 ma., grid resistor of 2000 ± 10% ohms, and frequency of 15 Mc.

---

* Because the cathode is subjected to considerable back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should be reduced depending on operating conditions and frequency to prevent overheating the cathode and resultant short life.

♦ With external flat shield 7-1/2" min. diameter located in plane of the grid terminal and perpendicular to axis of tube. Shield is connected to grid terminal.

● Continuous Commercial Service.

♦ Computed between half-power points and based on tube output capacitance only.

♣ The driver stage is required to supply tube losses, rf circuit losses, and rf power added to plate input. The driver stage should be designed to provide an excess of power above the indicated value to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

This value includes 24 watts of circuit loss and 36 watts added to plate input.

●● This value of useful power is measured at load of output circuit having indicated efficiency.

⊕ This value includes 28 watts of circuit loss and 40 watts added to plate input.

** This value includes 18 watts of circuit loss and 40 watts added to plate input. In grounded-grid, plate-modulated class C rf power amplifier service, the 6161 can be modulated 100% if the rf driver stage is also modulated 100% simultaneously. Care should be taken to insure that the driver-modulation and amplifier-modulation voltages are exactly in phase.

⊕ This value includes 23 watts of circuit loss and 40 watts added to plate input.

□ Key-down conditions per tube without amplitude modulation. Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

▲ This value includes 18 watts of circuit loss and 45 watts added to plate input.

† This value includes 23 watts of circuit loss and 45 watts added to plate input.

OPERATING CONSIDERATIONS

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6161 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The maximum radiator temperature of 180°C as well as the maximum terminal and seal temperatures of 150°C are tube ratings and are to be observed in the same manner as other ratings. The temperature of the radiator should be measured on the core at the end adjacent to the plate ring (see *Outline Drawing*). The temperature may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilaq The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y., in the form of liquid and stick, and is stated by the maker to have an accuracy of 1 per cent.

In *transportation and storage* of the 6161, care should be taken to protect the tube from rough handling that would damage the glass-to-metal seals or dent or mar the rf contact surfaces. Particular care should be taken not to subject the tube to severe shock which might permanently deform the internal elements. It is recommended that the tube be tested upon receipt in the equipment in which it is to be used.

The *mounting* may be arranged to support the 6161 in any position. The tube may be supported by the plate ring or by the radiator in any convenient way, but the mounting arrangement used must not subject the grid, cathode, and heater terminals to undue stress.

Because the terminals of the 6161 have progressively smaller diameters from plate to grid to cathode to heater as shown in the *Outline Drawing*, it is possible to insert the 6161 into coaxial and cavity circuits from one end without disassembly of the circuit. In such circuits, the 6161 is supported by the plate ring as shown in Fig. 1.

In the design of this mounting, it is to be noted that the hole in part A, which limits movement of the tube in directions parallel to the plate contact surface, is approximately 0.050"

larger than the maximum diameter of the plate ring in order to allow the tube to seek its position freely when being inserted into the grid, cathode, and heater contacts, and to seat properly on the plate contact surface of part B. After the tube is in place, the removable clamp C is brought into position and closed to make the plate contact secure and to anchor the tube firmly in place.

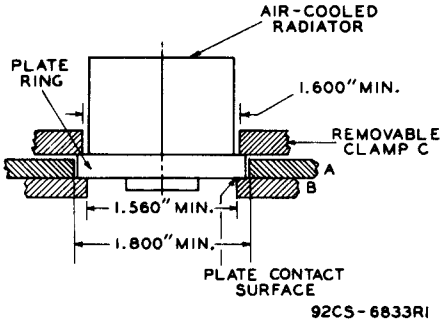


Fig. 1 - Mounting Arrangement for Use with Coaxial-Line or Cavity Circuits.

In addition to the dimensions shown in Fig. 1, the equipment designer should also observe the diameter tolerances on the grid, cathode, and heater terminals and the limits on concentricity defined by the gauge (see *Outline Drawing*) in order to provide for variation from tube to tube.

Cooling of the 6161 is accomplished by delivering a stream of clean air from a blower onto the respective terminals and seals, and through the radiator before and during the application of any voltages. The air flow through the radiator may be in either direction. The minimum rate of air flow for various plate dissipations is shown in the tabulated data. A suitable air filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air through the radiator. When the 6161 is operated at full ratings, a flow of at least 16 cubic feet per minute at a pressure of about 0.85 inch of water is recommended.

The cooling system should be properly installed to insure safe operation of the 6161 under all conditions and for this reason should be electrically interconnected with the heater and plate power supplies. This arrangement is necessary to make sure that the tube is supplied with air before any voltages are applied. Air pressure interlocks which open the power transformer primary of the heater supply and the plate supply are desirable for protecting the tube when the air flow is insufficient or ceases.

The *heater* of the 6161 should be operated at constant voltage rather than constant current. The rated heater voltage of 6.3 volts should be applied for at least 1 minute to allow the cathode to reach normal operating temperature before voltages are applied to the other electrodes.

The *unipotential cathode* is indirectly heated by the heater, one terminal of which is common to the cathode. The cathode of the 6161 in uhf service is subjected to considerable bombardment resulting from transit-time effects. This back bombardment raises the temperature of the cathode. The magnitude of the heating caused by back bombardment is a function of the operating conditions and frequency, and must be compensated by reduction of the heater input in order to prevent overheating of the cathode and resultant short life. When long life in continuous service

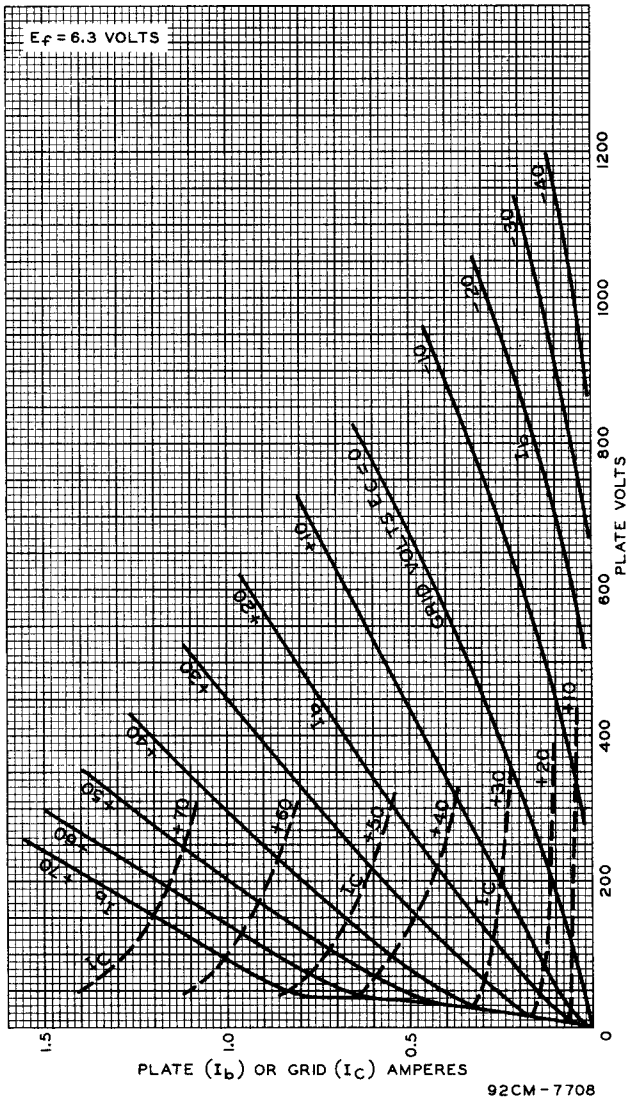


Fig. 2 - Average Characteristics of Type 6161.

is desired, the 6161 should always be put in operation with full rated heater voltage (6.3 volts) which should then be reduced to the lowest

value that will give the desired power output. Because the cathode of this tube when operated with a heater voltage of 6.3 volts provides emission usually in excess of any requirements within ratings, it is recommended that the heater voltage be reduced below 6.3 volts to a value that will give adequate but not excessive emission from the cathode for any particular application. The proper operating value may then be found by reducing the heater voltage, with normal modulation applied to the transmitter, until a reduction in output is observed. The heater voltage must then be increased by an amount equivalent to the maximum percentage regulation of the heater-voltage supply, and then further increased by about 0.1 volt to allow for other variations. After the heater voltage is reduced, circuit readjustment may be necessary. It is suggested that the adjustment procedure be carried out daily. However, if no significant changes in the operating voltage are found necessary, the adjustment procedure can be scheduled less frequently. Good regulation of the heater voltage is in general economically advantageous from the viewpoint of tube life.

The *grid* of the 6161 in uhf service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid current, but also by bombardment due to transit-time effects and by circulating rf currents. For these reasons, more than ordinary care must be taken during operation to prevent overloading the grid.

The *plate* should be protected against overload. The protective device, such as a fuse in the plate circuit, should remove the dc plate voltage when the average value of plate current reaches a value 50% above normal.

Average characteristics for the 6161 are shown by the curves in Fig.2.

In *tuning a grounded-grid rf amplifier*, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

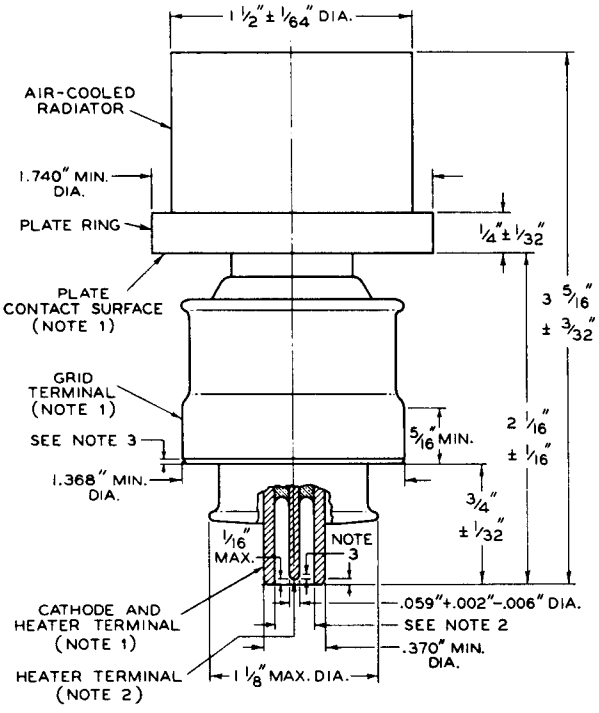
During *standby periods* of less than 15 minutes, it is recommended that the heater voltage be reduced to 80% of normal to conserve life; for longer standby periods, the heater power should be turned off.

REFERENCE

E. E. Spitzer, *"Grounded-Grid Power Amplifiers,"* Electronics, Vol.19, No.4, pp. 138-141 (April, 1946).

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



NOTE 1: WITH THE CYLINDRICAL SURFACES OF ITS GRID AND CATHODE TERMINALS CLEAN, SMOOTH, AND FREE OF BURRS, THE TUBE WILL ENTER A GAUGE AS SHOWN IN SKETCH G1. THE FOUR CYLINDRICAL HOLES H_1, H_2, H_3, AND H_4 HAVE AXES COINCIDENT WITHIN 0.0005", LENGTHS DETERMINED FROM THE OUTLINE DRAWING, AND SUCCESSIVELY SMALLER DIAMETERS AS SHOWN IN THE SKETCH.

THE PLATE RING WILL BE ENTIRELY ENGAGED BY HOLE H_1, AND THE CONTACT SURFACE OF THE PLATE RING WILL SEAT ON THE SHOULDER BETWEEN HOLES H_1 AND H_2. THE PLANE SURFACE OF THIS SHOULDER IS 90° ± 2′ TO THE AXES OF THE HOLES. SEATING IS DETERMINED BY FAILURE OF A 0.005" THICKNESS GAUGE, 1/8" WIDE, TO ENTER MORE THAN 1/16" BETWEEN THE SHOULDER SURFACE AND THE PLATE CONTACT SURFACE.

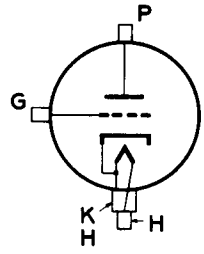
WITH THE TUBE PROPERLY SEATED AS DESCRIBED ABOVE, THE GRID TERMINAL WILL BE ENTIRELY ENGAGED BY HOLE H_3, AND THE CATHODE TERMINAL WILL BE ENGAGED BY HOLE H_4 TO A DEPTH OF AT LEAST 1/4".

NOTE 2: CONCENTRICITY OF THE HEATER TERMINAL WITH RESPECT TO THE CATHODE TERMINAL IS DETERMINED BY A GAUGE AS SHOWN IN SKETCH G2. THE CYLINDRICAL HOLE H_5 AND THE ANNULAR HOLE H_6 HAVE AXES COINCIDENT WITHIN 0.0005". THE CATHODE TERMINAL AND THE HEATER TERMINAL WILL ENTER THIS GAUGE TO A DEPTH OF 3/8".

NOTE 3: MAY BE ROUNDED OR BEVELED NOT TO EXCEED 1/16".

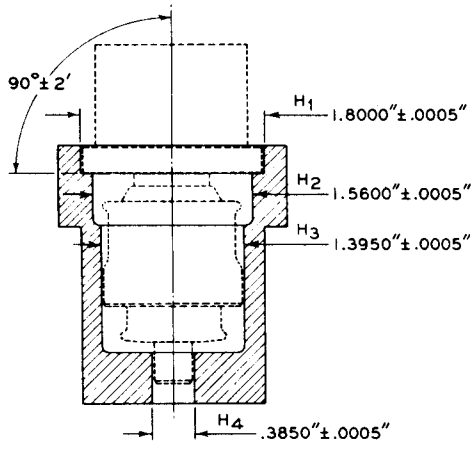
92CM-7704

TERMINAL CONNECTIONS

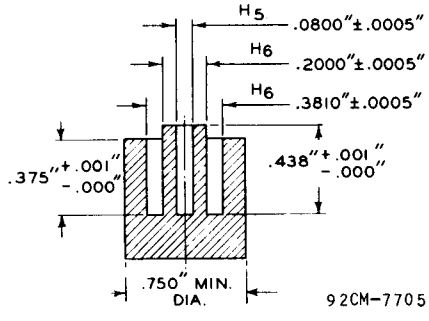


P: PLATE
G: GRID
K: CATHODE
H: HEATER

Sketch G1



Sketch G2



92CM-7705

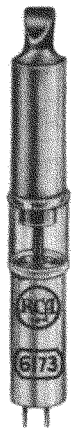
6173

UHF DIODE

"Pencil-Type" for Pulse-Detection Service

TENTATIVE DATA

RCA-6173 is a "pencil-type", high-perveance, uhf diode intended particularly for use in pulse-detection and pulse-power-measuring service. In such service, it may be operated at frequencies as high as 3300 megacycles per second. Because of its small size and frequency capability, the tube is especially useful in rf probes of electronic voltmeters.



Actual Size

The "pencil-type" design of the 6173 features a coaxial-electrode structure of the double-ended metal-glass type having minimum transit time, low lead inductance, and low interelectrode capacitance. Other desirable features include very low heater wattage (0.85 watt), and a weight of only 1/5 ounce.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	0.135	amp
Resonant Frequency (Approx.)	1600	Mc
Direct Interelectrode Capacitance (Approx.):		
Plate to Cathode	1.1	μμf

Mechanical:

Mounting Position	Any
Dimensions and Terminal Connections	See *Outline Drawing*

PULSE-DETECTION AND PULSE-POWER-MEASURING SERVICE▲

Maximum Ratings, *Absolute Values*:

PEAK INVERSE PLATE VOLTAGE	1000 max.	volts
PEAK PULSE PLATE VOLTAGE	150 max.	volts
PEAK PULSE PLATE CURRENT	1.0 max.	amp
AVERAGE PLATE CURRENT	1 max.	ma.
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
SEAL TEMPERATURE (Plate or Cathode)	175 max.	°C

HALF-WAVE RECTIFIER

Maximum Ratings, *Absolute Values*:

PEAK INVERSE PLATE VOLTAGE	375 max.	volts
PEAK PLATE CURRENT	50 max.	ma
HOT-SWITCHING TRANSIENT PLATE CURRENT For duration of 0.2 second maximum	250 max.	ma
DC OUTPUT CURRENT	5.5 max.	ma
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	90 max.	volts
Heater positive with respect to cathode	90 max.	volts
SEAL TEMPERATURE (Plate or Cathode)	175 max.	°C

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.125	0.145	amp
Plate-to-Cathode Capacitance	–	0.8	1.4	μμf
Tube Voltage Drop	1,2	–	15	volts

Note 1: With 6.3 volts ac or dc on heater.
Note 2: With peak plate current of 50 milliamperes provided by an applied dc voltage. Tube drop is measured by a voltmeter connected between plate and cathode.

▲ In this class of service, the heater should be allowed to warm up for a minimum of 60 seconds before plate voltage is applied in order to allow the cathode to reach normal operating temperature and to be able to supply the high peak plate currents encountered in this class of service.

OPERATING CONSIDERATIONS

The *maximum ratings* are limiting values above which the serviceability of the 6173 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *temperature* of the plate or cathode seal should not exceed 175°C. The temperature may be measured with temperature sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York 11, N. Y. in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of one per cent.

Connections to the cathode cylinder and plate cylinder should be made by flexible spring contacts only. The connectors must make firm, large-surface contact, yet must be sufficiently flexible so that no part of the tube is subjected to strain. Unless this recommendation is observed, the glass-to-metal seals may be damaged.

The *heater* leads of the 6173 fit the Cinch Socket No.54A16325. They should not be soldered to circuit elements. The heat of the soldering operation may crack the glass seals of the heater leads and damage the tube.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold

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the peak heater-cathode voltage to the maximum values shown in the tabulated data. RF chokes may be used in the heater leads to keep the rf potential between heater and cathode at a low value.

In *rectifier service*, the 6173 requires a minimum plate-load impedance (including the source impedance) of 300 ohms to limit the hot-switching transient plate current and thereby prevent damage to the tube when the plate voltage is applied.

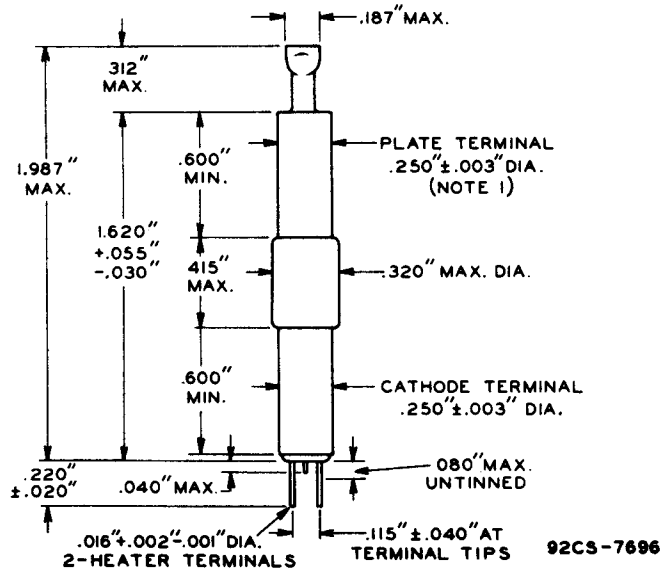
The *resonant frequency* shown in the tabulated data is an approximate value which will change from tube to tube and with mounting arrangement. When the tube is used in rf probes of electronic voltmeters at the resonant frequency or in its vicinity, the output voltage will increase unless suitable compensation is provided.

The *Pulse Rating Chart* given in Fig. 2 represents graphically the relationships between pulse duration, pulse repetition rate, and peak pulse plate current. This Chart gives the equipment designer a wide choice of operating parameters within the tube's ratings.

Dotted boundary line "ABC" is the locus of the maximum peak pulse plate current values for various pulse durations. In most applications, two of the three parameters shown in the Pulse Rating Chart are known. Knowing any two parameters, the equipment designer can select from the Chart the maximum allowable value of the third parameter. For example, if an application requires a 1.0-microsecond pulse and a pulse repetition rate of 1000 per second, the maximum allowable peak pulse plate current is 1.0 ampere. Since the pulse repetition rate of 1000 is a maximum value for a pulse duration of 1.0 microsecond, it follows that any pulse repetition rate up to 1000 may be used under these conditions. If a longer pulse duration is required, e.g., 1.5 microseconds, and the same pulse repetition rate of 1000 is required, the maximum allowable peak pulse plate current is 0.67 ampere.

In applications where groups of pulses are employed, the equipment designer can total the pulse duration of the individual pulses in any one group and then treat the pulse duration of the group as a single wide pulse.

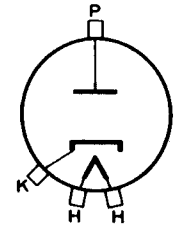
DIMENSIONAL OUTLINE



NOTE 1: MAX. ECCENTRICITY OF ℄ (AXIS) OF PLATE TERMINAL WITH RESPECT TO THE ℄ (AXIS) OF THE CATHODE TERMINAL IS 0.008".

TERMINAL CONNECTIONS

H: HEATER LEADS
P: PLATE CYLINDER
(Adjacent to Pinch-off)



K: CATHODE CYLINDER
(Adjacent to Heater Leads)

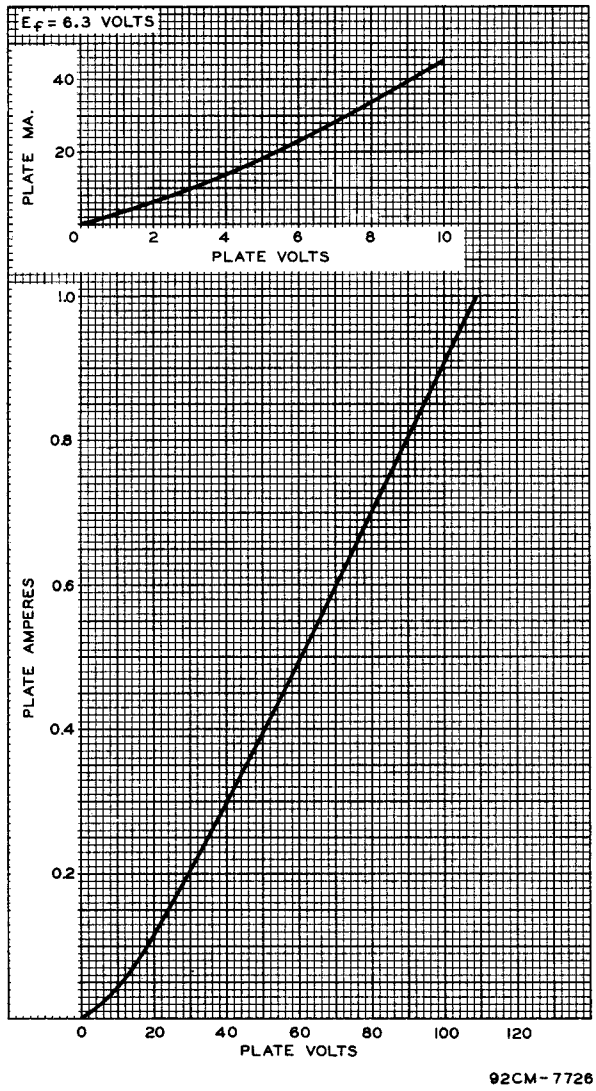


Fig. 1 - Average Plate Characteristics of Type 6173.

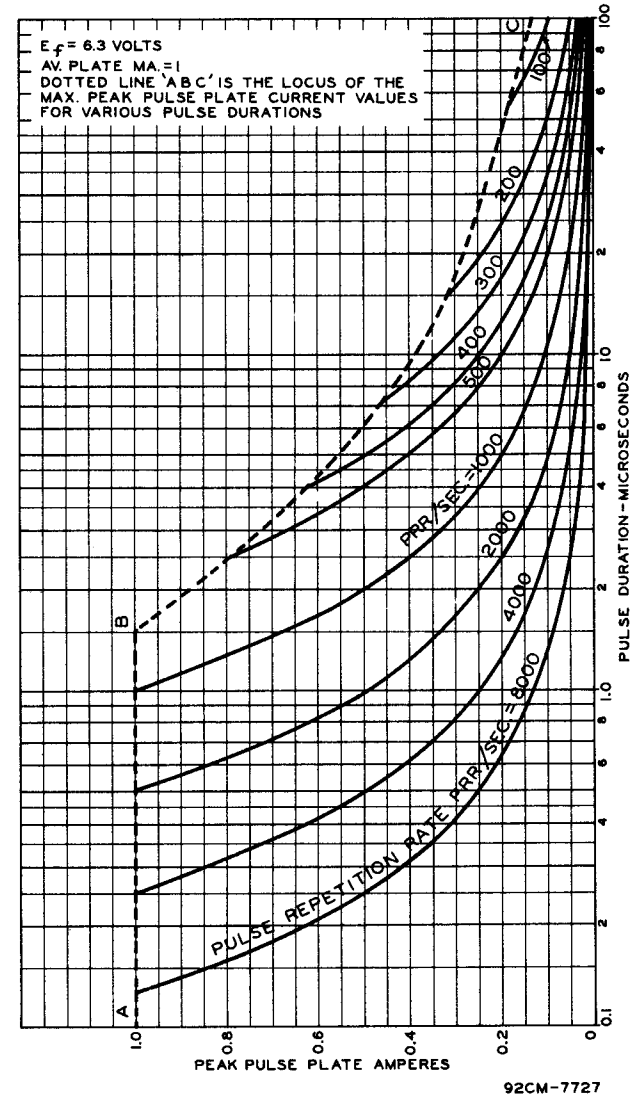


Fig. 2 - Pulse Rating Chart of Type 6173.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

NATIONAL UNION ELECTRON TUBE

NEW DATA

N.U. 6193

6193

RUGGEDIZED
SUBMINIATURE TWIN-TRIODE

APPLICATION:

The **NU-6193** is a T-3 subminiature twin-triode designed for reliable as well as rugged applications as encountered in the military service. It is primarily intended for use as a mixer, amplifier, multivibrator. This is the equivalent to a 7F8 except for dissipation limits.

RATINGS:

Heater Voltage (AC or DC) ±10%	6.3 volts
Maximum Plate Voltage	250 volts
Maximum Heater to Cathode Voltage	100 volts
Maximum Plate Dissipation (per section)	2.0 watts
Maximum Cathode Current (per section)	15 ma
Maximum impact	500 g
Maximum vibration output ●	30 mv
Maximum bulb temperature	200° C

INTERELECTRODE CAPACITANCES:

	SHIELDED	UNSHIELDED
Grid to Plate	1.46 μμf	1.52 μμf
Input	2.75 μμf	2.60 μμf
Output	2.20 μμf	1.07 μμf

TYPICAL CONDITION OF OPERATION: ■

Heater Voltage	6.3			volts
Heater Current	300			ma
Plate Voltage	180	120	90	volts
Grid Voltage	-1	-.75	-.50	volts
Plate Current	11.5	6.0	4.5	ma
Grid Voltage for 10 μamp. Plate Current (approx.)	-7	--	--	volts
Plate Resistance	8500	8300	9000	ohms
Transconductance	6500	6000	5800	μmhos
Amplification Factor	55	50	50	

NOTE: LEADS MAY BE CUT TO .200" FOR USE IN CINCH SOCKET 54A-13686

● Measured across a 10,000 ohms load resistor when vibrated at 25 cps at .080" excursion.

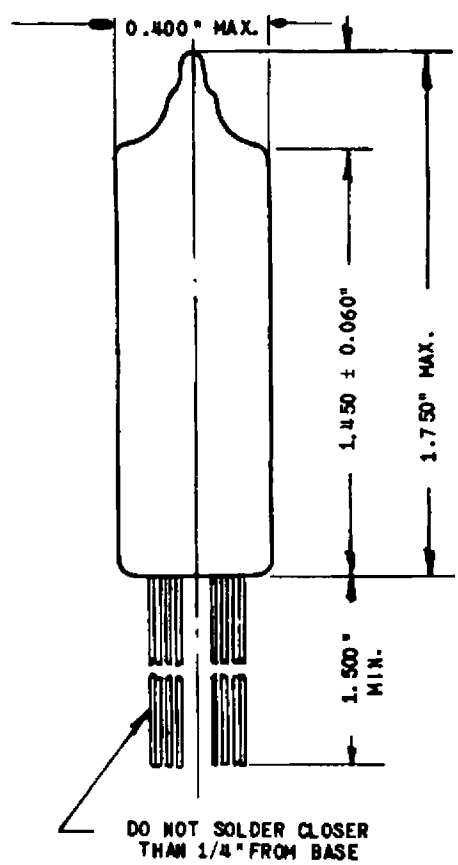
■ All values are for a single section except for Heater Ratings.

PHYSICAL SPECIFICATIONS

Style	Sub Miniature
Bulb	T-3-3
Mounting Position	Any
Leads	Flexible
Basing Diagram	8DG
Base	K8-1

BASE PIN CONNECTIONS

PIN 1 Plate
PIN 2 Grid
PIN 3 Heater
PIN 4 Cathode
PIN 5 Cathode
PIN 6 Heater
PIN 7 Plate
PIN 8 Grid



from RTMA release #1107, July 24, 1952

JUNE 1952

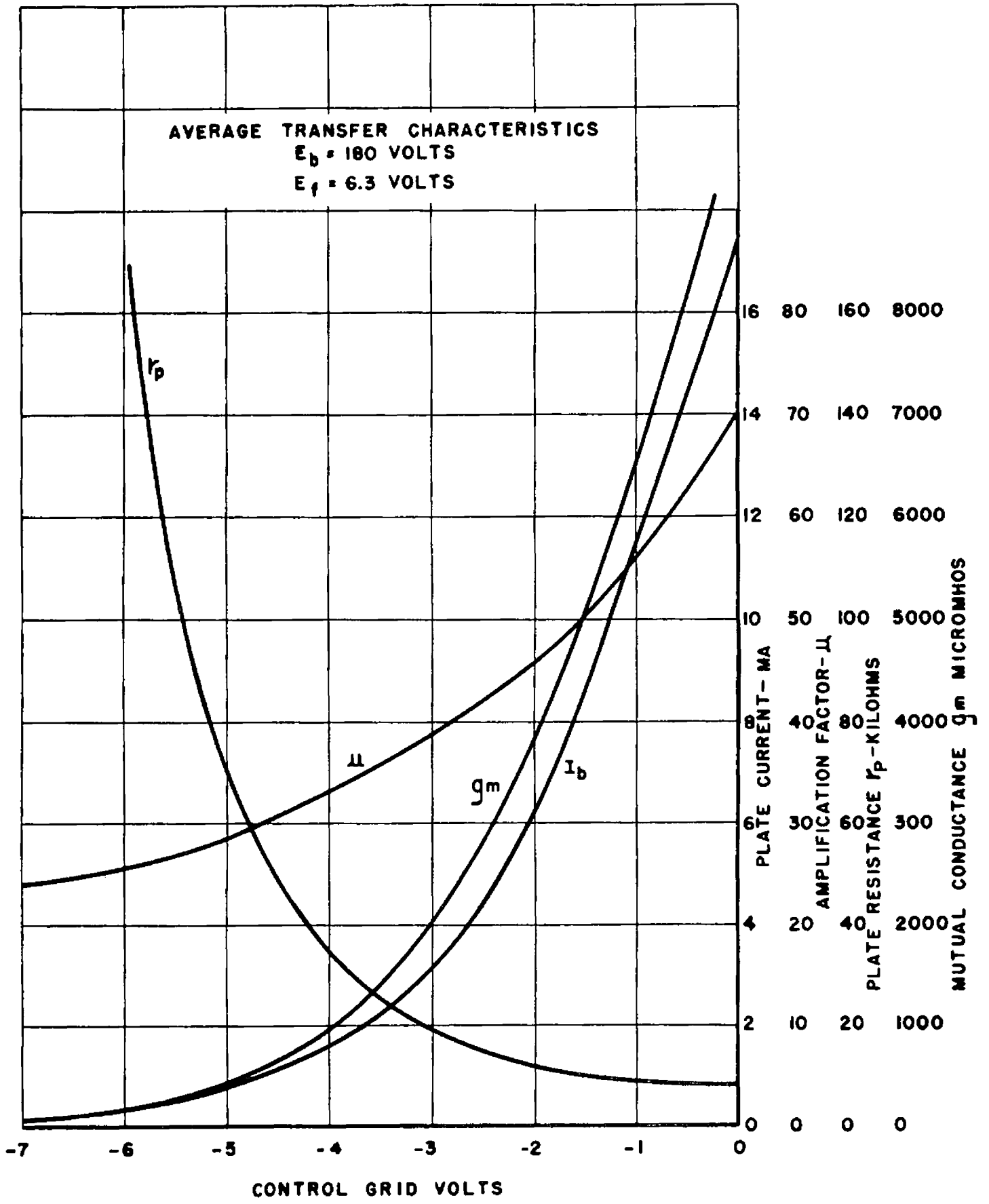
Research Division

ORANGE NATIONAL UNION RADIO CORPORATION NEW JERSEY

NATIONAL UNION RADIO CORPORATION

RESEARCH DIVISION

NU-6193 TWIN TRIODE



6198

VIDICON

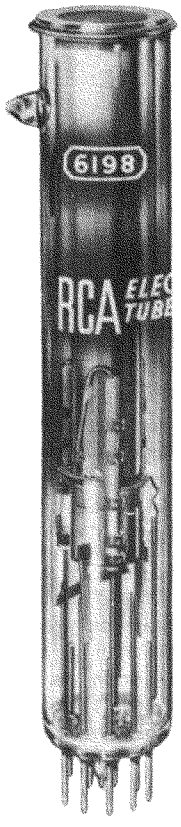
Magnetic Focus
Magnetic Deflection

High Sensitivity
400-Line Resolution

1"-Diameter Bulb
6-1/4" Length

TENTATIVE DATA

RCA-6198 is a small, television camera tube intended primarily for use in industrial applications. Its small size and simplicity facilitate the design of the camera and associated equipment in comparison with that needed for larger types of camera tubes. The resolution capability of the 6198 is about 400 lines.



Utilizing a photoconductive layer as its light-sensitive element, the 6198 has a sensitivity which permits televising scenes with 100 to 200 foot-candles of incident illumination on the scene. The photoconductive layer is characterized by a spectral response approaching that of the eye.

The small size of the 6198 lends itself to use in light-weight, compact television cameras. The size and location of the photoconductive layer permit a wide choice of commercially available lenses.

PRINCIPLES OF OPERATION

The structural arrangement of the 6198, shown in Fig. 1, consists of the signal electrode, a transparent conducting film on the inner surface of the faceplate; a light-sensitive element consisting of a thin layer of photoconductive material deposited on the signal electrode; a fine mesh screen (grid No.4) located adjacent to the photoconductive layer; a focusing electrode (grid No.3) connected to grid No.4; and an electron gun for producing a beam of electrons.

Each element of the photoconductive layer is an insulator in the dark but becomes slightly conductive when it is illuminated and acts like a leaky capacitor having one plate at the fixed positive potential of the signal electrode and the other floating. When light from the scene being televised is picked up by an optical lens system and focused on the photoconductive-layer surface next to the faceplate, each illuminated layer element conducts slightly depending on the amount of illumination on the element and thus causes the potential of its opposite surface (on the gun side) to rise in less than the time of one frame toward that of the signal-electrode potential. Hence, there appears on the gun side of the entire layer surface a positive potential pattern, composed of the various element potentials, corresponding to the pattern of light from the scene imaged on the opposite surface of the layer.

The gun side of the photoconductive layer is scanned by a low-velocity electron beam produced by the electron gun. This gun contains a thermionic cathode, a control grid (grid No.1), and an accelerating grid (grid No.2). The beam is focused at the surface of the photoconductive layer by the combined action of the uniform magnetic field of an external coil or permanent magnet and the electrostatic field of grid No.3. Grid No.4 serves to provide a uniform decelerating field between itself and the photoconductive layer so that the electron beam will approach the layer in a direction perpendicular to it—a condition necessary for driving the surface to cathode potential. The beam electrons approach the layer at low velocity because of the low operating potential of the signal electrode.

When the gun side of the photoconductive layer with its positive potential pattern is scanned by the electron beam, electrons are deposited from the beam in sufficient quantities until the surface potential is reduced to that of the cathode, and thereafter are turned back to form a return beam which is not utilized in this tube. Deposition of electrons on the scanned surface of any particular element of the layer causes a change in the difference of potential between the two surfaces of the element. When the two surfaces of the element, which in effect is a charged capacitor, are connected through the external signal-electrode circuit and the scanning beam, a capacitive current is produced and constitutes the video signal. The magnitude

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

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of the current is proportional to the surface potential of the element being scanned and to the rate of scan. The video-signal current is then used to develop a signal output voltage across a load resistor. The signal polarity is such that for highlights in the scene the grid of the first video-amplifier tube swings in a negative direction.

Alignment of the beam is accomplished by a transverse magnetic field produced by external coils located at the base end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

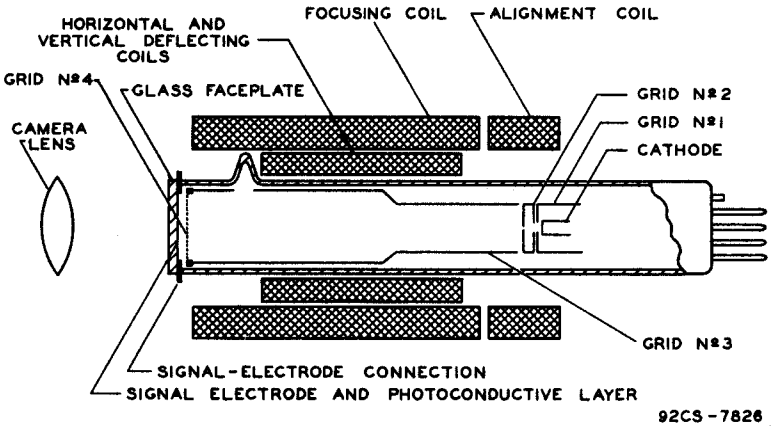


Fig. 1 - Schematic Arrangement of Type 6198.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Signal Electrode to All Other Electrodes	4.5	μμf
Spectral Response		See Curve
Photoconductive Layer:		
Maximum Useful Diagonal of Rectangular Image (4 x 3 Aspect Ratio)	0.62	inch
Orientation of Quality Rectangle—Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.		
Focusing Method		Magnetic
Deflection Method		Magnetic
Overall Length	6-1/4" ± 1/4"	
Greatest Diameter (Excluding Side Tip)	1.125" ± 0.010"	
Maximum Radius (Including Side Tip)	0.805"	
Bulb		T-8
Base	Small-Button Ditetrar 8-Pin (JETEC No. E8-11)	
Operating Position		Any

Maximum Ratings, *Absolute Values*:

SIGNAL-ELECTRODE VOLTAGE	125 max.	volts
GRID-No.4 & GRID-No.3 VOLTAGE	350 max.	volts
GRID-No.2 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
FACEPLATE TEMPERATURE	60 max.	°C

Typical Operation and Characteristics:

For scanned area of 1/2" x 3/8"

Signal-Electrode Voltage for Dark Current of 0.02 μamp	10 to 125	volts
Grid-No.4 (Decelerator) & Grid-No.3 (Beam Focus) Voltage	200 to 300	volts
Grid-No.2 (Accelerator) Voltage	300	volts
Grid-No.1 Voltage (For picture cutoff)	-45 to -100	volts
Signal-Output Current:*		
Normal Operating Range	0.1 to 0.2	μamp
Minimum, with 0.6 foot-candle of uniform 2870°K tungsten illumination on tube face	0.02	μamp
Uniform 2870°K Tungsten Illumination on Tube Face to Produce Signal-Output Current of 0.1 to 0.2 μamp	3 to 10	ft-c
Ratio (Approx.) of Tube-Face Illumination Required to Produce Signal-Output Current of 0.2 μamp to That Required to Produce 0.02 μamp	30	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No.1	30	volts
When applied to cathode	10	volts
Field Strength at Center of Focusing Device	40	gausses
Field Strength of Adjustable Alignment Coil	0 to 4	gausses

* Defined as the component of the signal-electrode current after the dark-current component has been subtracted.

OPERATING CONSIDERATIONS

The *base pins* of the 6198 fit the ditetrar 8-pin connector, such as Cinch No.54A18088, or equivalent.

The *signal-electrode connection* is made by a suitable spring contact bearing against the edge of the metal flange at the face end of the tube. This spring contact may conveniently be provided as part of the focusing-coil design.

Support for the 6198 is provided by a suitable spring-finger suspension at the face end of the tube and by a clamping mechanism near the base end. Orientation of the 6198 in its support should be such that the horizontal scan is essentially parallel to the plane passing through the tube axis and the short index base pin.

The *lens* used with the 6198 may be chosen from a large variety of commercially available camera lenses. It should be a high-quality type incorporating an iris to control the amount of light passing through it. An f:2 lens of the type used for 16-mm movie cameras is satisfactory for many applications. The lens holder should have all inside surfaces finished in matte black to prevent internal reflections from reaching the photoconductive layer, and should provide suitable focusing means. Under almost all conditions, the use of a lens shade is beneficial.

Electrostatic shielding of the signal electrode from external fields is required to prevent interference effects in the picture. Effective shielding is ordinarily provided by grounding a shield on the inside of the faceplate end of the

focusing coil; by grounding a shield on the inside of the deflecting yoke; and by grounding the lens mount and its supporting assembly.

The *temperature* of the faceplate should not exceed 60°C (140°F), either during operation or storage of the 6198. Operation with a faceplate temperature in the range from about 25°C to 35°C (77° to 99°F) is recommended. The signal-output current and the dark current both increase with

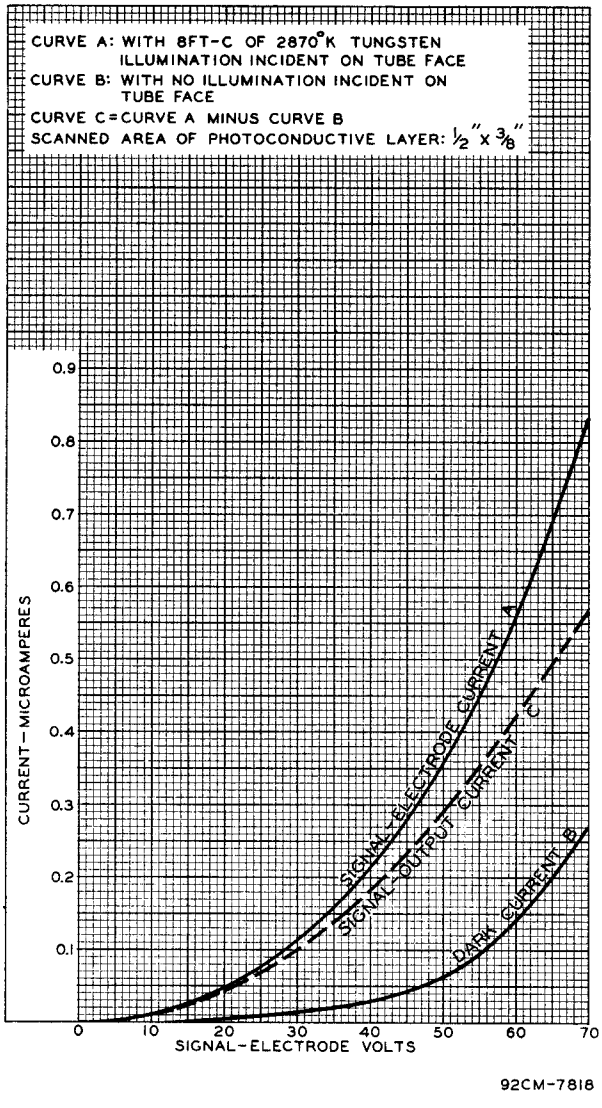


Fig. 2 - Typical Characteristics of Type 6198.

increasing faceplate temperature for a given signal-electrode voltage and illumination. Since the dark current increases the more rapidly of the two, it is necessary to reduce the signal-electrode voltage in an effort to restore the signal output-to-dark current ratio. Operation with the faceplate at a temperature of 50° to 60°C causes some sacrifice in performance because the sensitivity at a given signal output-to-dark current ratio or the signal output-to-dark current ratio at a given sensitivity is somewhat lower than at lower temperature. Operation at the higher temperature, however, does not adversely affect the performance of the tube when it is subsequently operated at lower temperature.

The *signal-electrode voltage* should be obtained from a dc source which can provide a voltage adjustable over a range of 10 to 125 volts. As the signal-electrode voltage is increased, the signal-output current (i.e., the component of the signal-electrode current after the dark-current component has been subtracted) and the dark current both increase, as shown in Fig. 2. However, a limiting value of signal-electrode voltage is reached beyond which the non-uniformity in the dark-current background of the transmitted picture is no longer tolerable.

For a given signal-electrode voltage, the sensitivity and dark current both tend to change gradually during the life of the tube. By making the signal-electrode voltage supply adjustable, the equipment designer can provide means to compensate for these changes.

The *focusing-electrode (grid No. 3) voltage* may be fixed at a value of about 250 volts when focusing control is obtained by adjusting the current through the focusing coil. The necessary range of current adjustment will depend on the design of the coil, but should be such as to provide a field-strength range of 36 to 44 gausses. When it is desired to use a fixed value of focusing-coil current, or to use a permanent-magnet type of focusing device, capable of providing a fixed strength of 40 gausses at the center of the focusing device, the grid-No. 3 voltage should be adjustable over a range from 200 to 300 volts.

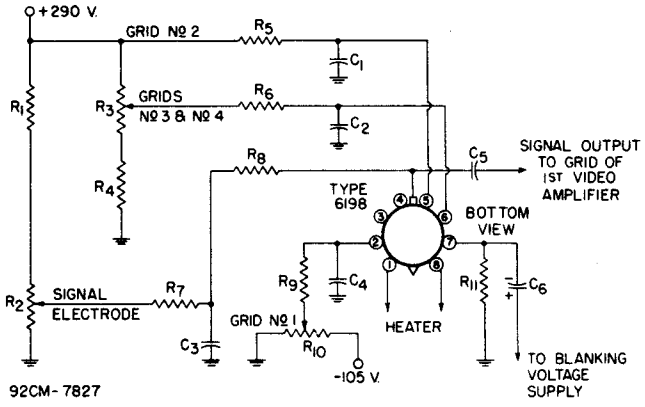
The *grid-No. 1 voltage* should be adjustable from 0 to -100 volts.

The *dc voltages* required by the 6198 can be provided by the circuit shown in Fig. 3.

A *blanking signal* should be supplied to grid No. 1 or to the cathode to prevent the electron beam from striking the photoconductive layer during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the reproduced picture. The blanking signal is a series of negative voltage pulses when the blanking signal is applied to grid No. 1, or a series of positive voltage pulses when the blanking signal is applied to the cathode.

Beam intensity is controlled by the amount of negative voltage on grid No. 1. The beam must have adequate intensity to drive the highlight elements of the photoconductive-layer surface to cathode potential on each scan. When the beam has an intensity sufficient only to drive the lowlight elements to cathode potential, the high-

light elements are not returned to cathode potential. As a result, the picture highlights all have the same brightness and show no detail. It is also to be noted with a beam of insufficient intensity that the photoconductive-layer surface, which normally rises in potential by only a small fraction of the signal-electrode potential during each scan, gradually rises in potential to a value approaching nearly the full signal-electrode potential in the highlights. Under this condition, many scans of a beam with inadequate intensity



C1 C4: 0.01 μf, 300 volts (working voltage)
C2: 0.1 μf, 300 volts (working voltage)
C3 C5: 0.1 μf, 200 volts (working voltage)
C6: 4 μf, electrolytic, 300 volts (working voltage)
R1: 120000 ohms, 1/2 watt
R2: 100000-ohm potentiometer, 2 watt
R3: 50000-ohm potentiometer, 2 watt
R4: 70000 ohms, 1/2 watt
R5: 5000 ohms, 1/2 watt
R6: 10000 ohms, 1/2 watt
R7: 200000 ohms, 1/2 watt
R8: 50000 ohms, non-inductive, 1/2 watt
R9: 100000 ohms, 1/2 watt
R10: 500000-ohm potentiometer, 2 watt
R11: 1000 ohms, non-inductive, 1/2 watt

Fig. 3 - Typical Voltage Dividers for Supplying DC Electrode Voltages to Type 6198.

are required to drive to cathode potential any element which has changed from a highlight to a lowlight because of movement of the subject. As a result, the highlights tend to "stick". The loss of detail in and sticking of the highlights is referred to as "bloom."

On the other hand, a beam with excessively high intensity should not generally be used because the size of the scanning spot increases with resultant decrease in resolution.

When the 6198 is operated under normal conditions with adequate but not excessive beam intensity, it will be noted that any sudden, large excess of illumination on the televised scene will cause bloom in the televised picture.

The *video amplifier* should be designed to cover a range of ac signal voltages corresponding to signal-output current of 0.02 to 0.2 microampere in the load resistor. A low-noise, video amplifier suitable for use with the 6198 is shown in Fig. 4. This amplifier has an 8-Mc bandwidth and incorporates a gain control as well as a frequency- and phase-compensation control.

Resolution of better than 350 lines at the center of the picture can be produced by the 6198. To utilize the resolution capability of the 6198 in the horizontal direction with the standard scanning rate of 525 lines, it is necessary to use a video amplifier having a bandwidth of at least 6 megacycles per second. The maximum resolution obtainable is limited by the size of the scanning-beam spot.

The *illumination* on the photoconductive layer is related to the scene illumination by the formula

$$I_s = \frac{4f^2 \, I_{pl} \, (m+1)^2}{TR}$$

where

I_s = scene illumination in foot-candles
f = f-number of lens
I_{pl} = photoconductive-layer illumination in foot-candles
m = linear magnification from scene to photoconductive layer
T = total transmission of lens
R = reflectance of part of scene under consideration.

Except for very close shots, the linear magnification (m) from scene to photoconductive layer may be neglected.

For example, assume that the lens is f:2 having a transmission (T) of 75%, that the photoconductive layer illumination (I_{pl}) is 3 foot-candles, and that the brightest part of the scene under consideration has a reflectance (R) of 50%. Then,

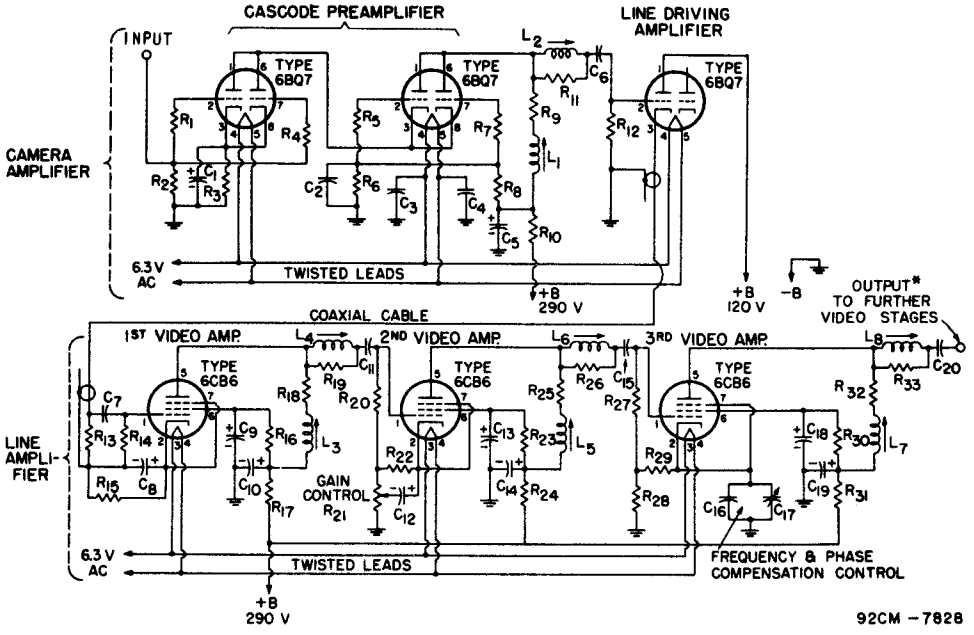
$$I_s = \frac{4 \times 2^2 \times 3}{0.75 \times 0.50} = 128 \text{ foot-candles}$$

It is good practice before attempting to transmit a particular scene to check its incident illumination with an illumination-measuring device, such as an exposure meter.

The *minimum illumination level* which can be used on the photoconductive layer to give a picture depends on a compromise between the ratio of signal-output current to amplifier noise and the ratio of signal-output current to vidicon dark current. Either of these ratios may be a limiting factor depending on the choice of signal-electrode voltage. When the signal-electrode voltage is kept low, the dark current is low. Under this condition, the minimum value of illumination is that which will give a signal-output current larger than the noise of the amplifier. With the usual compensated amplifier, the rms amplifier noise is a fixed amount equivalent to a signal-output current of about 0.002 microampere. The signal-output current can be

increased for a given illumination level by raising the signal-electrode voltage as indicated in Fig.2, but it will be noted that the dark current also increases and at a faster rate than the signal-output current. As the signal-electrode voltage is raised, the dark current reaches a

Typical signal output as a function of uniform 2870°K tungsten illumination on the photoconductive layer of the 6198 is shown in Fig.5. It will be noted that if an increase of 10 times in signal-output current is desired, the illumination must be increased by about 30 times.



Coaxial Cable: Amphenol No.21-025 (Army-Navy No.RG-59/U), or equivalent.
C1 C8: 50 μf, electrolytic, 3 volts (working voltage)
C2 C11 C15 C20: 0.1 μf, 300 volts (working voltage)
C3 C4 C7: 0.1 μf, 100 volts (working voltage)
C5 C9 C10 C13 C14 C18 C19: 10 μf, electrolytic, 300 volts (working voltage)
C6: 0.05 μf, 300 volts (working voltage)
C12: 100 μf, electrolytic, 50 volts (working voltage)
C16: 120 μμf, ceramic, 150 volts (working voltage)
C17: 50 - 150 μμf, ceramic, adjustable, 150 volts (working voltage)
L1: 19 μh peaking coil, adjustable core to cover range from 15 to 23 μh
L2 L3 L5 L7: 24 μh peaking coil, adjustable core to cover range from 20 to 30 μh
L4 L6 L8: 5 μh peaking coil, adjustable core to cover range from 4 to 6 μh

All of the following resistors are of the non-inductive type

R1 R4 R5 R7: 100 ohms, 1/2 watt
R2: 250000 ohms, 1/2 watt
R3: 51 ohms, 1/2 watt
R6: 82000 ohms, 1/2 watt
R8: 100000 ohms, 1/2 watt
R9: 2000 ohms, 1 watt
R10: 1000 ohms, 1 watt
R11: 10000 ohms, 1/2 watt
R12 R14 R20 R27: 510000 ohms, 1/2 watt
R13: 75 ohms, 1/2 watt
R15: 120 ohms, 1/2 watt
R16 R30: 3000 ohms 1/2 watt
R17 R24: 10000 ohms, 2 watt
R18 R25 R32: 1500 ohms, 1/2 watt
R19 R26 R33: 6800 ohms, 1/2 watt
R21: 1000-ohm potentiometer, 2 watts
R22: 200 ohms, 1/2 watt
R23: 15000 ohms, 1/2 watt
R28: 7500 ohms, 2 watts
R29: 150 ohms, 1/2 watt
R31: 3000 ohms, 1 watt

* This output circuit is designed to work into a 6CB6 as video amplifier. With gain control (R21) set at minimum and 0.2 microampere signal-current input to camera amplifier, the output voltage is 0.25 volt peak to peak; with gain control set at maximum and with 0.015 microampere signal-current input, the output voltage is 0.25 volt peak to peak.

Fig.4 - Low-noise Video Amplifier for use with Type 6198.

value beyond which the non-uniformity in the dark-current background of the picture becomes intolerable. When this condition occurs, nothing further can be gained by increasing the signal-electrode voltage. It is evident, therefore, that the optimum operating point is a compromise to give the best ratio of signal-output current to both noise and to dark current, and that a useful ratio can be realized only when the level of illumination is adequate to give a value of signal-output current several times larger than either the amplifier noise current or the dark current.

Persistence of the photoconductive layer in the 6198 is given by the curve in Fig.6. This curve shows the decay in signal-output current from an initial value of 0.2 microampere after the illumination is cut off. With adequate illumination on the photoconductive layer, the persistence is sufficiently short to prevent smearing except when the subject moves rapidly across the field of view. With low levels of illumination, the persistence increases somewhat with the result that there is a greater tendency for moving objects to produce smearing. To

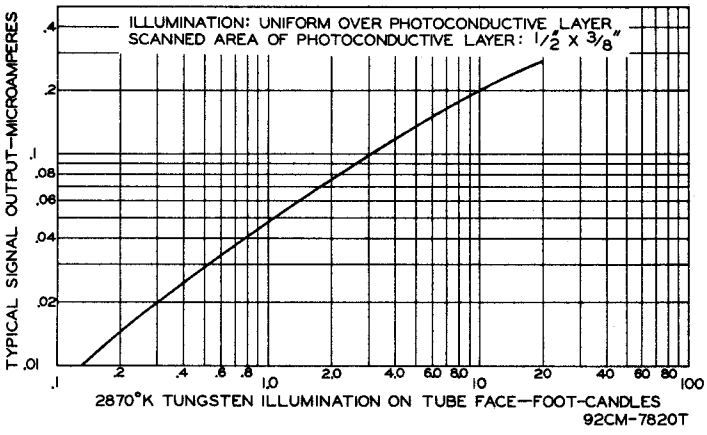


Fig. 5 - Typical Signal Output of Type 6198.

minimize smearing, the use of more illumination is recommended.

Signal-output-current buildup when light is applied to the photoconductive layer previously in the dark is as fast as or faster than the rate of decay indicated by the persistence curve in Fig. 6.

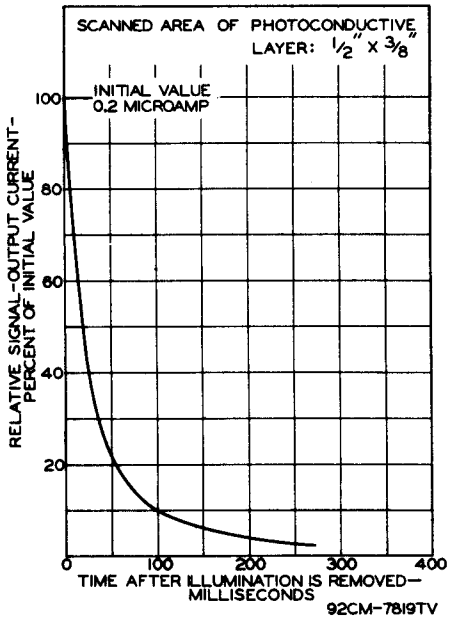


Fig. 6 - Persistence Characteristic of Type 6198.

The *spectral response* of the 6198 is shown by curves A and C in Fig. 7. Curve A is on the basis of equal values of signal-output current at all wavelengths, whereas curve C is on the basis of equal values of signal-output current with radiant flux from a tungsten source at 2870°K. For comparison purposes, the response of the eye is shown in curve B.

Full-size scanning of the photoconductive layer should always be used. Full size scanning can be assured by first adjusting the deflection circuits to overscan the photoconductive layer sufficiently to cause the edges of the sensitive area to be visible in the corners of the picture, and then reducing the scanning until the edges just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. It is to be noted that overscanning the photoconductive layer produces a smaller-than-normal picture on the monitor.

Underscanning the photoconductive layer, i.e., scanning an area of the layer less than the useful quality area, should never be permitted. Underscanning produces a larger-than-normal picture on the monitor. Because the scanned area may exhibit a permanent change in sensitivity and dark current during operation, an underscanned area showing such change will be visible in the picture when full-size scanning is restored.

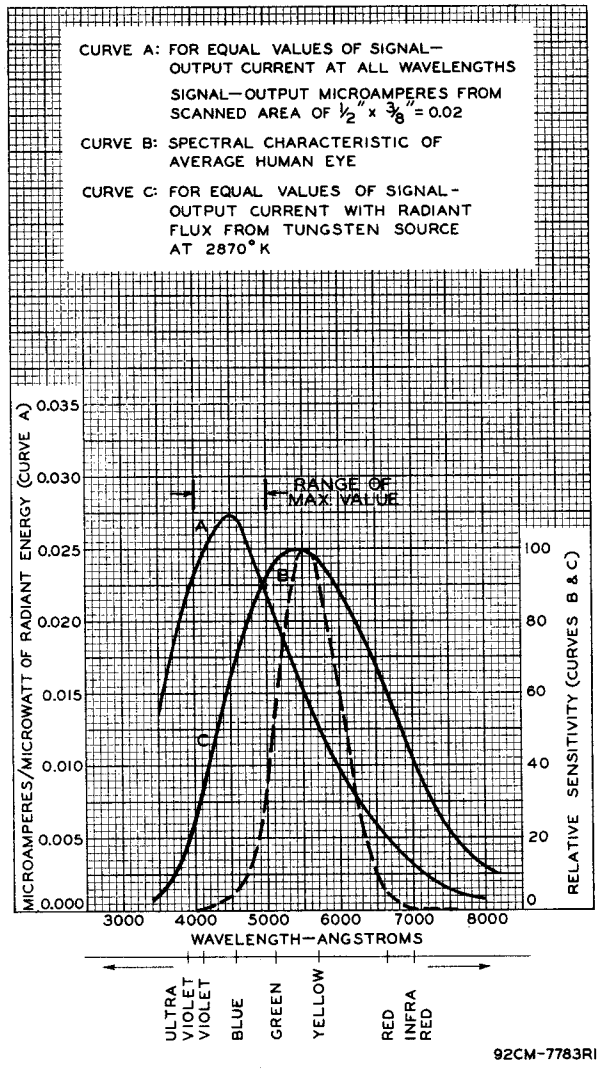


Fig. 7 - Spectral Sensitivity Characteristic of Type 6198.

Failure of scanning even for a few minutes may permanently damage the photoconductive layer. The damaged area shows up as a spot or line in the picture during subsequent operation. To avoid damaging the 6198 during scanning failure, it is necessary to prevent the scanning beam from reaching the layer. The scanning beam can conveniently be prevented from reaching the layer by increasing the grid-No.1 voltage to cutoff.

The *sequence of adjustments* in operating the 6198 is as follows: With the grid-No.1 voltage control set for maximum bias (beam cutoff) and with the camera lens iris closed, apply voltages to the tube as indicated under Typical Operation. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the photoconductive layer. Set the signal-electrode voltage at about 25 volts for a first trial. Then open the iris partially and image a scene of adequate intensity on the photoconductive layer. Next, decrease the grid-No.1 voltage until a picture appears on the monitor screen. The lowlights will appear first. Adjust grid-No.1 voltage to bring out a complete picture from the entire scanned area. Then adjust grid-No.3 voltage (or the magnetic-field strength of the focusing coil if fixed grid-No.3 voltage is used) and the optical focus alternately to obtain the best picture. Next, adjust the deflection amplitude and centering to scan the desired area on the photoconductive layer. If the picture is faint (corresponding to an average signal-electrode current of less than 0.05 microampere), even with adequate video amplifier gain, open the lens iris somewhat more and, if necessary, increase the signal-electrode voltage to give a brighter picture. The signal-electrode voltage, however, should not be increased to the extent that it produces an uneven background that is visible on the monitor with the lens capped. Dark current is excess of 0.1 microampere will cause excessive shading. Then, adjust the alignment field so that the center of the picture does not move as the grid-No.3 voltage is varied, and so that the picture has the best shading. Finally, readjust the grid-No.1 voltage for the best resolution in the picture. A signal-electrode current of more than 0.2 microampere is not desirable because resolution is sacrificed.

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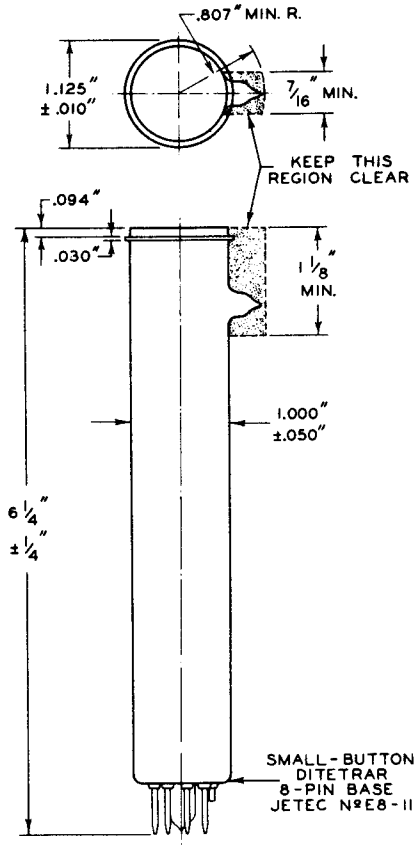
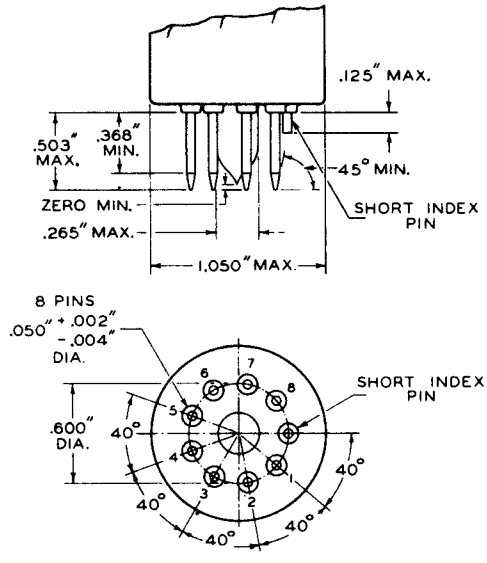
DIMENSIONAL OUTLINE



92CS-7772

BASE DRAWING

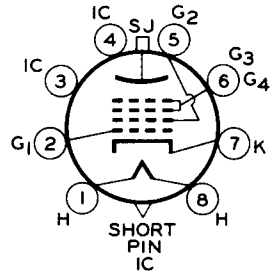
SMALL-BUTTON DITETRAR
8-PIN BASE
JETEC NºE8-11



92CS-7765

Base-pin positions are held to tolerances such that pins will fit a flat-plate gauge having thickness of 1/4" and 9 holes 0.0700" ± 0.0005" so located on a 0.6000" ± 0.0005" diameter circle that the distance along the chord between any two adjacent hole centers is 0.2052" ± 0.0005". Gauge is provided with center hole having diameter of 0.300" ± 0.001" and same center as the pin circle.

SOCKET CONNECTIONS
Bottom View



PIN 1: HEATER
PIN 2: GRID No. 1
PIN 3: INTERNAL CONNECTION—DO NOT USE
PIN 4: INTERNAL CONNECTION—DO NOT USE
PIN 5: GRID No. 2
PIN 6: GRIDS No. 3 and No. 4
PIN 7: CATHODE
PIN 8: HEATER
FLANGE: SIGNAL ELECTRODE (SJ)
SHORT INDEX PIN: INTERNAL CONNECTION—MAKE NO CONNECTION

DIRECTION OF LIGHT:
INTO FACE END OF TUBE

6201

HIGH-MU TWIN TRIODE

"Premium" 9-Pin Miniature Type

TENTATIVE DATA

RCA-6201 is a high-mu twin triode of the heater-cathode type. It is intended for use in a wide variety of applications including mixers, oscillators, and amplifiers at frequencies up to 300 megacycles, multivibrators, synchronizing amplifiers, and numerous critical industrial control devices. Constructed to give dependable performance under conditions of shock and vibration, this "premium" version of the 12AT7 is especially suited for use in mobile and aircraft equipment.

In the 6201, special attention has been given to structural features which improve its strength for resistance to both shock and vibration. These features include a special "U"-frame construction to keep the mount rigid, and special tube parts which are precisely made and accurately fitted to lock the parts firmly in place and thus eliminate variations in electrical characteristics. Other features include grid rods having high heat conductivity to provide cool operation thereby minimizing grid emission, a pure-tungsten heater having high mechanical strength to give long life under conditions of frequent on-off switching, and a special getter shield to prevent deposit of getter flash on tube elements. Furthermore, the 6201 is controlled for cathode interface to insure dependable performance in "on-off" control applications involving long periods of operation under cutoff conditions. These features in addition to rigid controls and rigorous tests to insure "premium" quality, make this tube especially useful in critical industrial applications.

The 6201 utilizes separate terminals for each cathode to permit flexibility of circuit arrangement, and a mid-tapped heater to permit operation from either a 6.3- or a 12.6-volt supply.

GENERAL DATA

Electrical:

Heater for Unipotential Cathodes:

Heater Arrangement	*Series*	*Parallel*	
Voltage (AC or DC)	12.6	6.3	volts
Current	0.15	0.3	amp

Direct Interelectrode Capacitances:

Grid-Drive Service

	*With External Shield**	*Without External Shield*	
Grid to plate (Each unit)	1.6	1.6	μμf
Grid to cathode and heater (Each unit)	2.5	2.5	μμf
Plate to cathode and heater (Unit No.1)	1.2	0.45	μμf
Plate to cathode and heater (Unit No.2)	1.3	0.38	μμf
Heater to cathode (Each Unit)	2.8	2.8	μμf
Plate to plate	–	0.24	μμf

Cathode-Drive Service

	With External Shield°	*Without External Shield*	
Plate to cathode (Unit No.1)	0.18	0.2	μμf
Plate to cathode (Unit No.2)	0.2	0.24	μμf
Cathode to grid and heater (Each Unit)	5	5	μμf
Plate to grid and heater (Unit No.1)	2.7	1.9	μμf
Plate to grid and heater (Unit No.2)	2.7	1.8	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-3/16"
Maximum Seated Length	1-15/16"
Length from Base Seat to Bulb Top (Excluding tip)	1-9/16" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin (JETEC No.E9-1)

AMPLIFIER--Class A_1

Values are for Each Unit

Maximum Ratings, *Absolute Values:*

PLATE VOLTAGE	330 max.	volts
GRID VOLTAGE:		
Negative bias value	55 max.	volts
Positive bias value	0 max.	volts
PLATE DISSIPATION	2.75 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	180 max.	°C

Characteristics:

Plate Supply Voltage	100	250	volts
Cathode-Bias Resistor	270	200	ohms
Amplification Factor	57	60	
Plate Resistance (Approx.)	14300	10900	ohms

TMK ®, Marca Registrada
Printed in U.S.A.

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Transconductance	4000	5500	μmhos
Grid Voltage (Approx.) for plate current of 10 μamp	-5	-12	volts
Plate Current	3.3	10	ma

Maximum Circuit Values:

Grid-Circuit Resistance:		
For fixed bias operation	0.25 max.	megohm
For cathode-bias operation	1 max.	megohm

* With external shield, JETEC No.315, connected to cathode of unit under test.

○ With external shield, JETEC No.315, connected to grid of unit under test.

Operating Conditions as Resistance-Coupled Amplifier (Each Unit)

Plate Supply Voltage	*90*			*180*			*300*			*volts*
Plate Load Resistor	0.1	0.24	0.51	0.1	0.24	0.51	0.1	0.24	0.51	megohm
Grid Resistor (of following stage)	0.24	0.51	1	0.24	0.51	1	0.24	0.51	1	megohm
Cathode Resistor	2400	5300	11000	1400	3600	7100	1200	2900	6400	ohms
Peak Output Voltage	13	15	16	28	31	33	47	52	55	volts
Voltage Gain▲	27	28	28	33	33	32	33	34	34	

▲ At 2 volts (RMS) output

Note: Coupling capacitors should be selected to give desired frequency response. Cathode resistors should be adequately bypassed.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN●

Values Are For Each Unit and are Initial, Unless Otherwise Specified

	Note	*Min.*	*Max.*	
Heater Current	1	0.138	0.162	amp
Direct Interelectrode Capacitances:				
Grid to plate	2	1.3	1.9	μμf
Grid to cathode and heater	2	2	3	μμf
Plate to cathode and heater (Unit No.1)	2	0.2	0.7	μμf
Plate to cathode and heater (Unit No.2)	2	0.16	0.6	μμf
Heater to cathode	2	2.1	3.5	μμf
Plate to plate	3	0.15	0.33	μμf
Amplification Factor	1,4	50	70	
Plate Current (1)	1,4	7	14	ma
Plate-Current Difference Between Units	1,4	-	3.2	ma
Plate Current (2)	1,5	-	100	μamp
Transconductance (1)	1,4	4500	6500	μmhos
Transconductance (1) at 500 Hours	1,4	3800	6500	μmhos
Transconductance (2)	3,6	4100	-	μmhos
Transconductance Change: Difference between average transconductance (1) initially, and average after 500 hours, expressed as a percentage of the initial average	1,4	-	15	per cent
Reverse Grid Current	1,7	-	0.7	μamp
Grid Emission Current	7,9	-	1.5	μamp
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,10	-	10	μamp
Heater positive with respect to cathode	1,10	-	10	μamp
Leakage Resistance:				
Between grid and all other electrodes tied together	1,11	100	-	megohms
Between plate and all other electrodes tied together	1,12	100	-	megohms
Leakage Resistance at 500 Hours:				
Between grid and all other electrodes tied together	1,11	50	-	megohms
Between plate and all other electrodes tied together	1,12	50	-	megohms

Note 1: With 12.6 volts ac or dc on heater (series connection).

Note 2: With no external shield and electrodes of unit not under test grounded.

Note 3: With no external shield.

Note 4: With dc plate-supply voltage of 250 volts, cathode resistor od 200 ohms, and cathode bypass capacitor of 1000 μf. Each unit is tested separately. Electrodes of units not under test are grounded.

Note 5: With dc plate-supply voltage of 250 volts, plate load resistance of 0.1 megohm, and dc grid voltage of -20 volts. Each unit is tested separately. Electrodes of unit not under test are grounded.

Note 6: With 11.0 volts ac or dc on heater (series connection).

Note 7: With dc plate-supply voltage of 250 volts, grid resistor of 0.5 megohm, cathode resistor of 200 ohms, and cathode bypass capacitor of 1000 μf. Each unit is tested separately. Electrodes of unit not under test are grounded.

Note 8: With 15.0 volts ac or dc on heater (series connection).

Note 9: With dc plate voltage of 250 volts, grid resistor of 0.5 megohm, and dc grid voltage of -20 volts. Each unit is tested separately.

Note 10: With 100 volts dc between heater and cathode and units connected in parallel.

Note 11: With grid 100 volts negative with respect to all other electrodes tied together.

Note 12: With plate 300 volts negative with respect to all other electrodes tied together.

● Each tube is stabilized before characteristics testing by continuous operation for at least 45 hours at room temperature and with dissipation values equivalent to life test conditions.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

Impact Acceleration. . . . . 600 max. g

This test is performed on a sample lot of tubes from each production run in a Navy Type, High-Impact (fly-weight) Shock Machine. Tubes are held rigid in four different positions and are subjected to 20 blows at the specified maximum impact acceleration. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for vibrational acceleration, heater-cathode leakage current, and transconductance.

Fatigue Rating:

Vibrational Acceleration . . . . . 2.5 max. g

This test is performed on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected in each of three positions to 2.5 g vibrational acceleration at 25 cycles per second for 32 hours. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet established limits for impact acceleration, heater-cathode leakage current, and transconductance.

Low-Frequency Vibration Performance:

RMS Output Voltage . . . . . 100 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Plate of unit No.1 tied to plate of unit No.2 and grid of unit No.1 tied to grid of unit No.2; heater voltage of 12.6 volts, dc plate voltage of 250 volts, dc grid voltage of -3 volts, plate load resistance of 2000 ohms, and vibrational acceleration of 2.5 g at 25 cps.

Heater-Cycling Life Performance:

Cycles of Intermittent Operation . . . 2000 min. cycles

Under the following conditions and with heaters of unit No.1 and unit No.2 connected in parallel: Heater voltage of 7.5 volts cycled one minute on and one minute off, heater 135 volts positive with respect to cathode, and plate and grid voltage = 0 volts.

Audio-Frequency Noise and Microphonic Performance:

RMS Output Voltage . . . . . 100 max. mv

This test is performed on a sample lot of tubes from each production run under the following conditions: Plate of unit No.1 tied to plate of unit No.2, grid of unit No.1 tied to grid of unit No.2; heater voltage of 12.6 volts dc, plate-supply voltage of 300 volts, cathode-bias resistor of 200 ohms common to both units, and plate load resistance of 10000 ohms.

Shorts and Continuity Test:

This test is performed on a sample lot of tubes from each production run. In this test a tube is considered inoperative if it shows a permanent or temporary short or open circuit, or a value of reverse grid current in excess of 1.4 microamperes under the conditions specified in the CHARACTERISTICS RANGE VALUES for reverse grid current.

1-Hour Stability Life Performance:

This test is performed on a sample lot of tubes from each production run to insure that the tubes have been properly stabilized. With both units operating, each unit is checked for variation in transconductance under conditions of maximum rated plate dissipation. At the end of 1 hour, the value of transconductance of each unit is read. The variation in transconductance from the 0-hour reading will not exceed 10 per cent.

100-Hour Life Performance:

This test is performed on a sample lot of tubes from each production run under conditions of maximum rated plate dissipation to insure a low percentage of early inoperatives. At the end of 100 hours, a tube is considered inoperative if it shows a permanent or temporary short or open circuit, or a value of reverse grid current in excess of 1.4 microamperes under the conditions specified in CHARACTERISTICS RANGE VALUES for reverse grid current.

500-Hour Average Life Performance:

This 500-hour test is made on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures of any of the characteristics indicated below. With both units operating, each unit is life tested separately at room temperature under the following conditions: heater voltage of 12.6 volts ac or dc (series Connection), plate-supply voltage of 250 volts, cathode resistor of 200 ohms, grid-No.1 resistor of 0.5 megohm and dc heater-cathode voltage of 135 volts (heater positive with respect to cathode), and bulb temperature of 180°C. At the end of 500 hours, tube will not show permanent shorts or open circuits and will be criticized for the total number of defects in the sample lot and for the number of tubes failing to pass the established initial limits of heater current, reverse grid current, heater-cathode leakage current, and 500-hour limits for Transconductance (1), Transconductance Change, and Leakage Resistance as shown under CHARACTERISTICS RANGE VALUES.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6201 are limiting values above which the serviceability of the 6201 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

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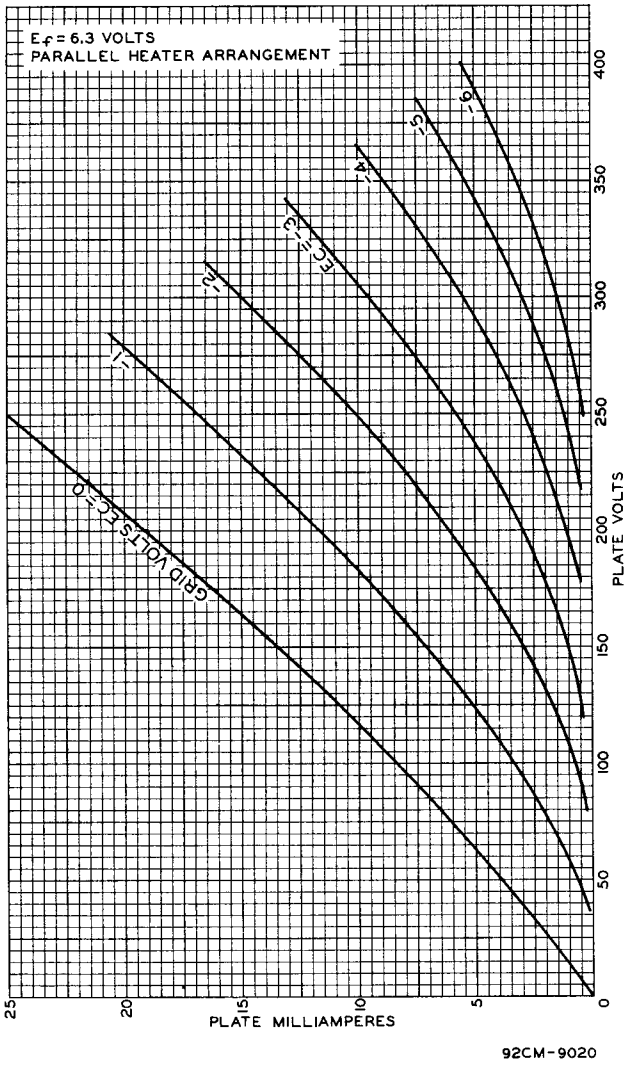


Fig. 1 - Average Plate Characteristics for Each Unit of Type 6201.

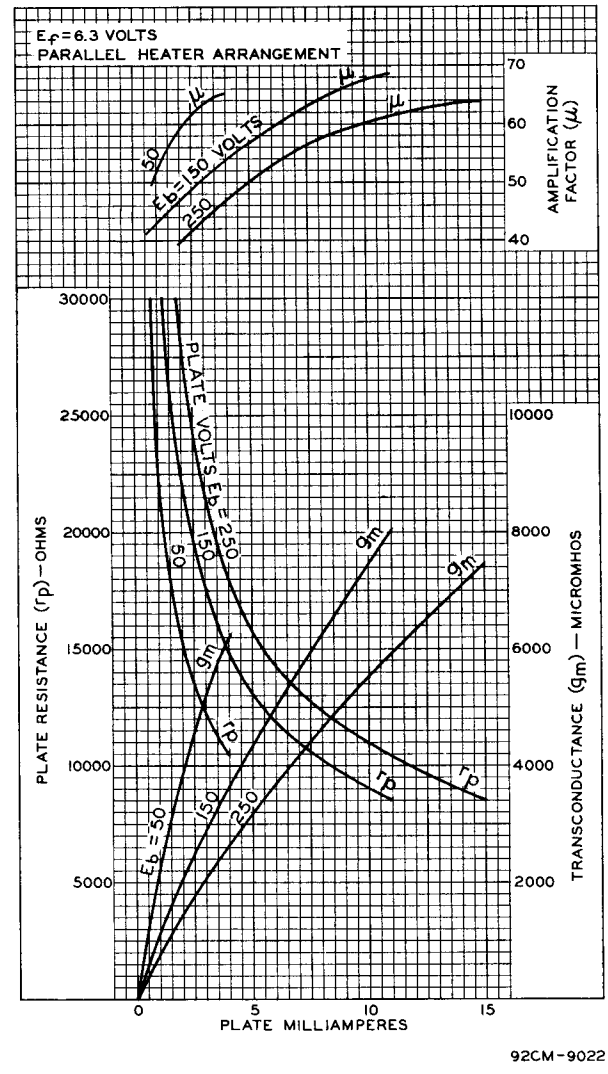


Fig. 2 - Average Characteristics for Each Unit of Type 6201.

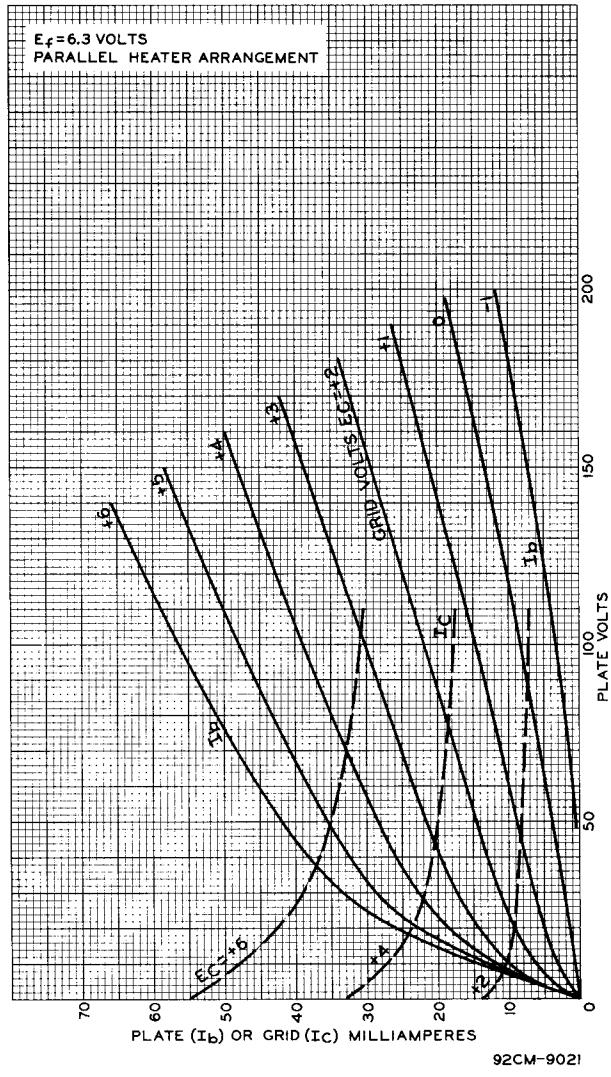


Fig. 3 - Average Plate Characteristics for Each Unit of Type 6201.

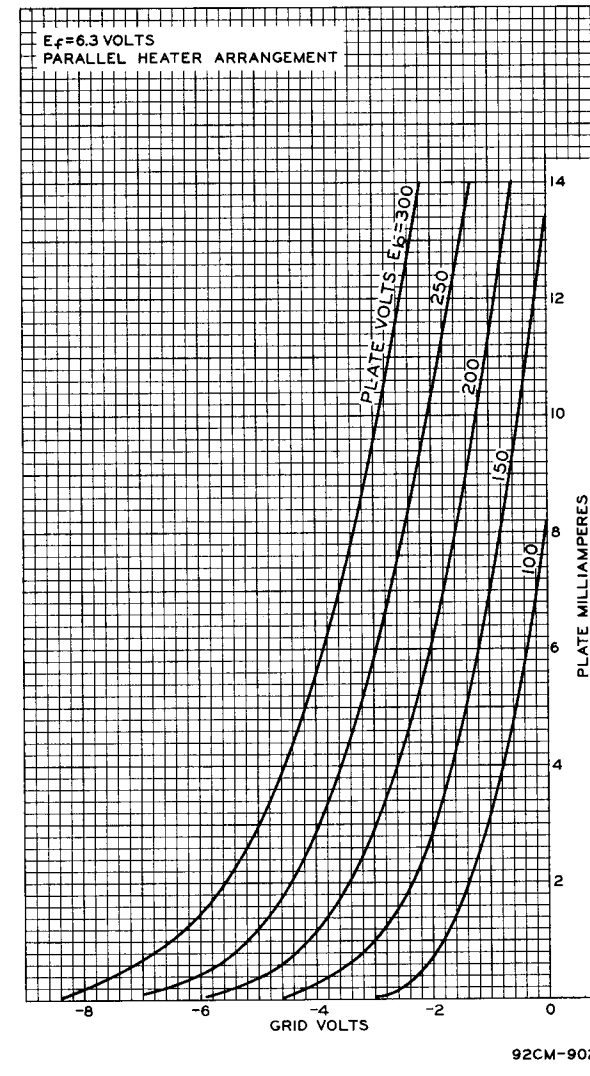
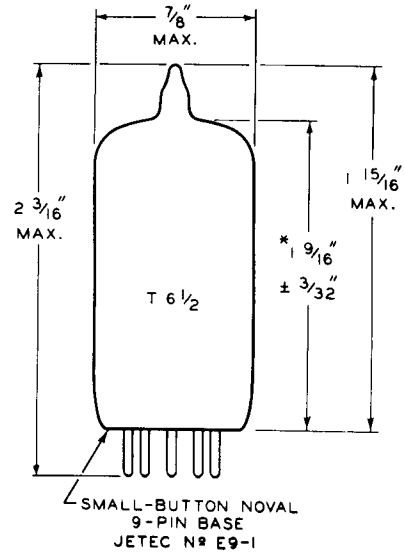


Fig. 4 - Average Characteristics for Each Unit of Type 6201.

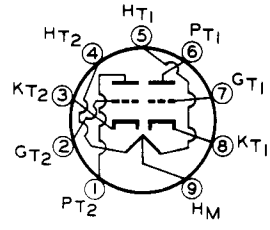
DIMENSIONAL OUTLINE



* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



9A

PIN 1: PLATE OF TRIODE UNIT No.2
PIN 2: GRID OF TRIODE UNIT No.2
PIN 3: CATHODE OF TRIODE UNIT No.2
PIN 4: HEATER OF TRIODE UNIT No.2
PIN 5: HEATER OF TRIODE UNIT No.1
PIN 6: PLATE OF TRIODE UNIT No.1
PIN 7: GRID OF TRIODE UNIT No.1
PIN 8: CATHODE OF TRIODE UNIT No.1
PIN 9: HEATER MID-TAP

6217

MULTIPLIER PHOTOTUBE

10-Stage, Head-On Type
with 1-1/2" Semi-Transparent Cathode and S-10 Response

TENTATIVE DATA

RCA-6217 is a head-on type of vacuum multiplier phototube intended for use in color densitometers, spectrometers, color comparators, flying-spot signal generators, and other applications where good red sensitivity is desired.

The spectral response of the 6217 covers the range from about 3000 to 8000 angstroms, as shown by the curve in Fig. 1. This curve also shows that the 6217 has a maximum response which is essentially flat over the wide spectral range from about 3700 (violet) to 5600 (yellow) angstroms and good response through 6700 (red) angstroms.

Design features of the 6217 include a semi-transparent cathode having a diameter of 1-1/2 inches on the inner glass surface of the face end of the bulb, and ten electrostatically focused multiplying stages. The relatively large cathode area permits very efficient collection of light.

The 6217 is capable of multiplying feeble photoelectric current produced at the cathode by an average value of 600,000 times when operated with a supply voltage of 1000 volts. The output current of the 6217 is a linear function of the exciting illumination under normal operating conditions.

The frequency response of the 6217 is flat up to a frequency of about 50 megacycles per second above which the variation in electron transit time becomes the limiting factor.

DATA

General:

Spectral Response	S-10
Wavelength Range of Highest-Response Region	3700 to 5600 angstroms
Cathode, Semi-transparent:	
Shape	Circular
Window:	
Area	1.8 sq. in.
Minimum Diameter	1.5 in.
Index of Refraction	1.51
Direct Interelectrode Capacitances:	
Anode to Dynode No. 10	4.2 μμf
Anode to All Other Electrodes	6.5 μμf
Overall Length	5-5/8" ± 3/16"
Seated Length	4-7/8" ± 3/16"
Maximum Diameter	2-1/4"
Bulb	T-16
Base	Medium-Shell Diheptal 14-Pin, Non-hygroscopic (JETEC No. B14-38)
Mounting Position	Any

Maximum Ratings, *Absolute Values*:

ANODE-SUPPLY VOLTAGE (DC or Peak AC)□	1250 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No. 10 AND ANODE (DC or Peak AC)	150 max.	volts
ANODE CURRENT:		
Peak	7.5 max.	ma
Average○	0.75 max.	ma
Average for Minimum Fatigue○	0.1 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across voltage divider providing 1/6 of E between cathode and dynode No. 1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No. 10 and anode.

With E = 1000 volts (except as noted)

	Min.	*Av.*	*Max.*	
Sensitivity:				
Anode, at 5400 angstroms	–	8500	–	μamp/μwatt
Luminous:				
Anode:*				
At 0 cps	10	24	–	amp/lumen
At 100 Mc	–	21	–	amp/lumen
Cathode:				
With Tungsten Light Source●	20	40	–	μamp/lumen
With Red-Infrared Light Source (See Fig. 2)#	0.05	–	–	μamp
Current Amplification■	–	600000	–	
Equivalent Anode-Dark Current Input**	–	1×10^{-8}	2.5×10^{-8}	lumen
Equivalent Noise Input##	–	4×10^{-11}	–	lumen

□ Referred to cathode.

○ Averaged over any interval of 30 seconds maximum.

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Radio Corporation of America
TMK ® Marca Registrada

TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6217-9-52
Photolithographed
in U.S.A.

With E = 750 volts (except as noted)

	Min.	Av.	Max.	
Sensitivity:				
Anode, at 5400 angstroms	–	850	–	μamp/μwatt
Luminous:				
Anode:*				
At 0 cps	–	2.4	–	amp/lumen
Cathode:				
With Tungsten Light Source●	20	40	–	μamp/lumen
With Red-Infrared Light Source (See Fig. 2)#	0.05	–	–	μamp
Current Amplification■	–	60000	–	

* For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light input of 10 microlumens is used. The load resistor has a value of 0.01 megohm.

● For conditions the same as shown under (*) except that the value of light flux is 0.01 lumen and that 150 volts are applied between cathode and all other electrodes connected together as anode.

\# Under the following conditions: Light incident on the cathode is transmitted through a red-infrared filter (combination of Corning, Glass Code Nos. 3482 and 5850 filters) from a tungsten-filament lamp operated at a color temperature of 2870°K. The value of light flux on the filter is 0.1 lumen. The load resistor has a value of 0.01 megohm, and 150 volts are applied between cathode and all other electrodes connected together as anode. This test evaluates the magnitude of the infra-red response in the tail of the response characteristic and provides a critical criterion for the response in the red band.

■ Ratio of anode sensitivity to cathode sensitivity under conditions of 2870°K tungsten light input.

** Defined as the quotient of the dc anode dark current by the anode luminous sensitivity. After tube has been in the dark for 30 minutes, the equivalent dark-current input is measured at a tube temperature of 25°C and with the supply voltage (E) adjusted to give an anode luminous sensitivity of 20 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

\## Defined as the value where the rms output current is equal to the rms noise current determined under the following conditions: Supply voltage (E) is 1000 volts, 25°C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source of 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

GENERAL CONSIDERATIONS

An *electron multiplier* is a vacuum tube which utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 6217 multiplier phototube, represented in Fig. 3, the electrons emitted from the illuminated, semi-transparent cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from the last dynode (dynode No. 10) are collected by the anode and constitute the current utilized in the output circuit.

Dynode No. 10 is so shaped as to enclose partially the anode and to serve as a shield for it, in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grid which allows the electrons from dynode No. 9 to pass through it to dynode No. 10. Spacing between dynode No. 10 and anode creates a collecting field such that all the electrons it emits are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 6217 can be coupled to any practical load impedance.

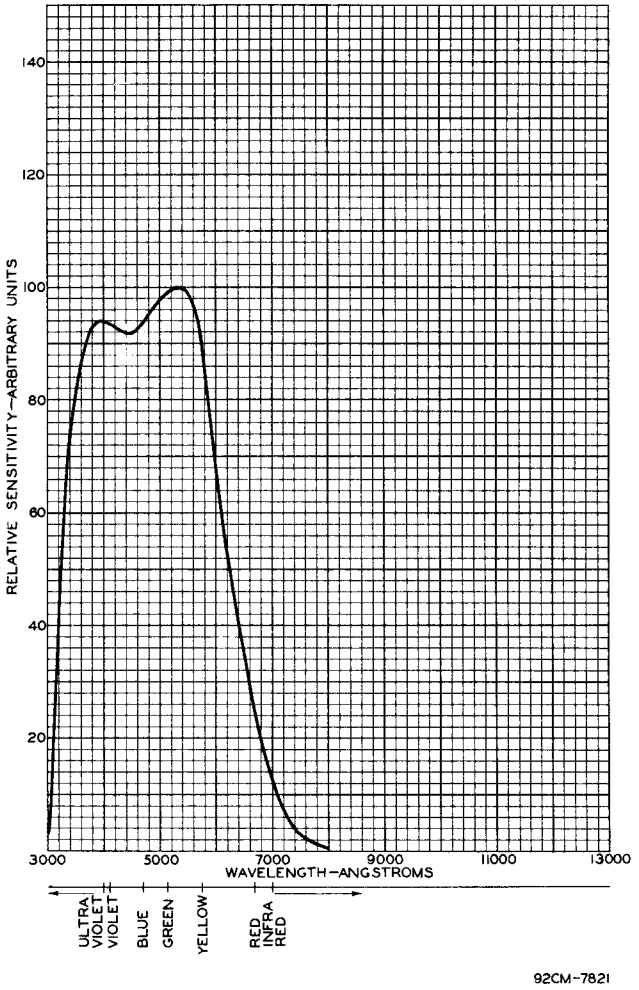


Fig. 1 - Spectral Sensitivity Characteristic of Type 6217 which has S-10 Response. Curve is taken for Equal Values of Radiant Flux at All Wavelengths.

The shield which extends between dynode No. 1 and the anode shields dynode No. 1 and the cathode from the anode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the cathode or the initial dynode stages, they would cause

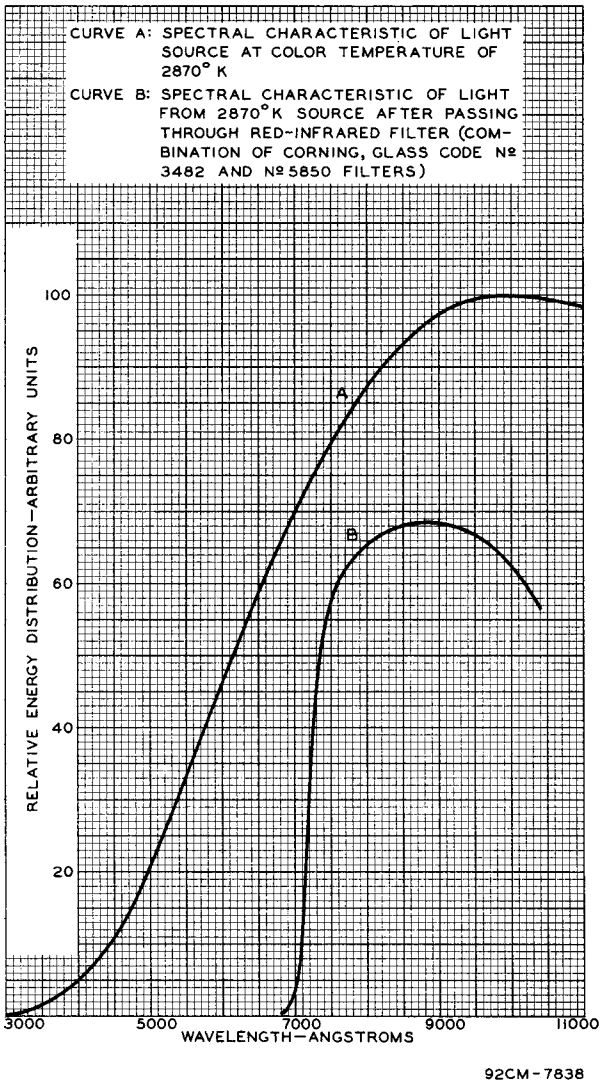


Fig. 2 - Spectral Characteristic of 2870°K Light Source, and Spectral Characteristic of Light from 2870°K Source After Passing Through Indicated Filter.

the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration. The metallic coating on the inner side wall of the glass bulb is connected to the cathode, and serves not only to prevent extraneous light from reaching dynode No. 1, but also to direct the electrons from the cathode toward dynode No. 1.

The grill through which the electrons reach dynode No. 1, is connected to dynode No. 1 and serves along with the accelerating electrode as an electrostatic shield for the open side of the electrode structure.

When the 6217 is operated with a very low cathode current, random variations occur in the rate of electron emission, and are observed as shot noise. Noise is also caused if the 6217 is operated with a voltage in excess of the maximum rating or if the voltage between dynode No. 1 and the cathode is too low. When too high a voltage per stage is used, positive-ion feedback causes regeneration, and when too low a voltage is applied between dynode No. 1 and cathode, the electrons from the cathode are not focused properly on dynode No. 1 with the result that many electrons are not channeled through the multiplier structure and gain is sacrificed. In order to minimize noise, it is recommended that the 6217 be operated

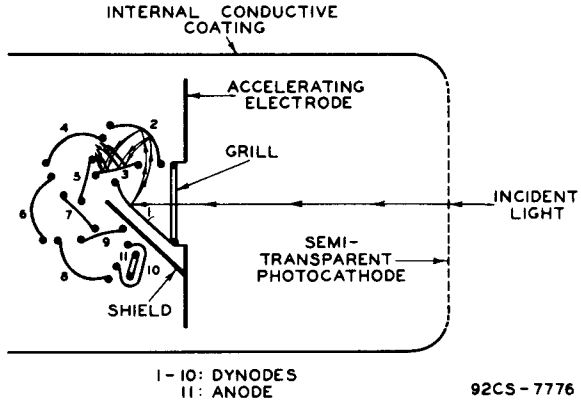


Fig. 3 - Schematic Arrangement of Type 6217 Structure.

with a voltage between dynode No. 1 and cathode which is twice that between each of the succeeding dynode stages, and that the supply voltage be limited to 750 volts.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 6217 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings.

This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface and dynode surfaces to evaporate with consequent decrease in the life and sensitivity of the tube.

The *operating stability* of the 6217 is dependent on the magnitude of the anode current and its duration. When the 6217 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 6217 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 0.75 milliampere is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 100 microamperes.

The *anode family* for the 6217 is shown in Fig. 4.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the nth power, where n is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for designers to provide adequate

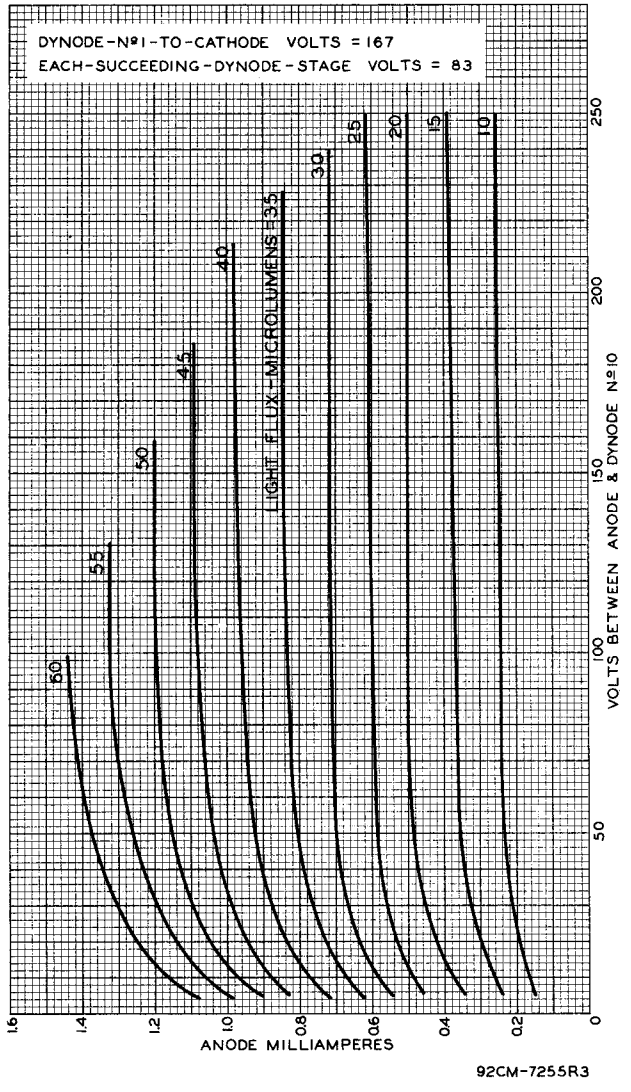


Fig. 4 - Average Anode Characteristics of Type 6217.

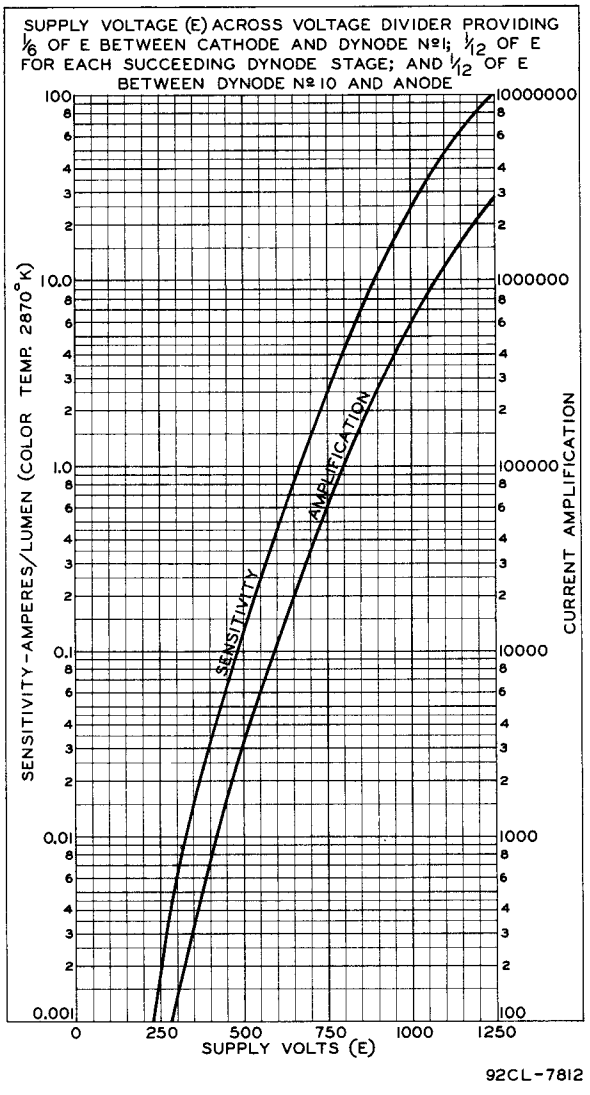


Fig. 5 - Average Characteristics of Type 6217.

adjustment of the supply voltage per stage so as to be able to adjust the amplification of individual tubes to the desired design value. It is suggested that an overall voltage-adjustment range of at least 2 to 1 be provided. When the output current can be controlled by change in the illumination of the photocathode of the multiplier phototube, the required range of adjustment in the voltage per stage can be reduced.

Fig.5 shows sensitivity and current amplification characteristics of the 6217.

Magnetic shielding of the 6217 may be necessary. It will be observed with certain orientations of the 6217 that the earth's magnetic field is sufficient to cause a noticeable decrease in the response of the tube. Therefore, it may be desirable to provide magnetic shielding for the 6217, particularly when it is to be used in a strong magnetic field. The curve in Fig.6 shows the effect on anode current of variation in magnetic-field strength under the conditions indicated. With increase in voltage above 100 volts between cathode and dynode No.1, the effect of the magnetic field will cause less decrease in anode current.

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 6217. Although the metallic coating on the inner side wall of the glass bulb serves to reduce the amount of extraneous light reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous light.

The *use of a refrigerant*, such as dry ice or liquid air, to cool the bulb of the 6217 is recommended in those applications where maximum gain with unusually low dark current is required.

Do not expose the 6217 to intense ultraviolet or visible radiation, even with no voltage applied to the tube. Such exposure may cause an increase in anode dark current of as much as 100 times. After cessation of such irradiation, the dark current drops rapidly but remains at an abnormal value for several hours.

Whenever frequency response is important, the leads from the 6217 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

The *base pins* of the 6217 fit the medium diheptal 14-contact socket. The socket should be made of high-grade, low-leakage material, and should be installed so that the incident light falls on the face end of the tube.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each dynode and for the anode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation required by the application. In general, the current in the divider should be about 10 times the maximum value of total dynode current flowing through the divider. Such a value will prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended.

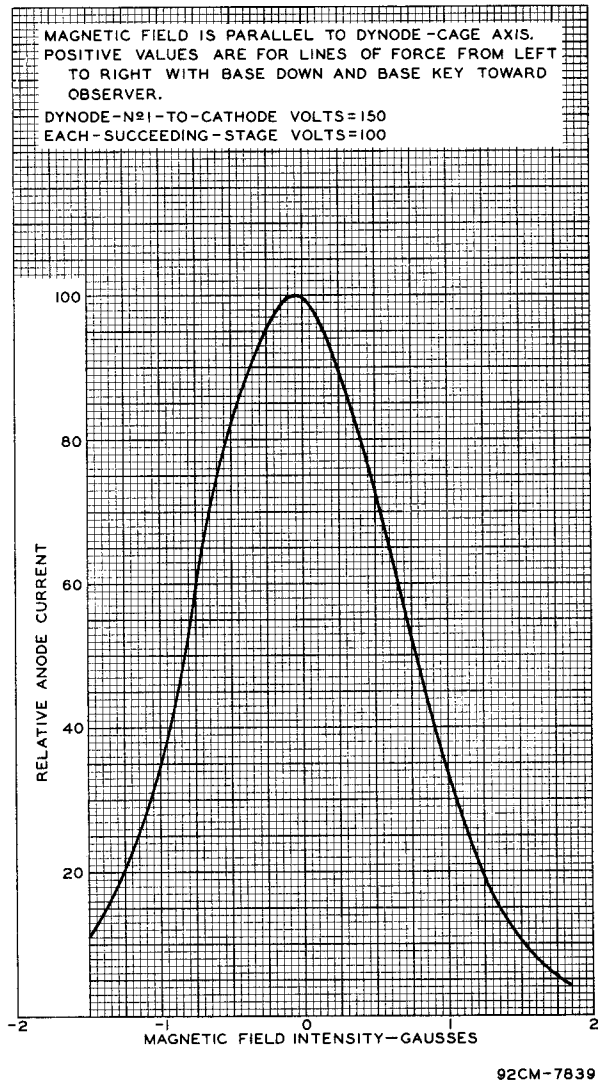


Fig.6 - Effect of Magnetic Field on Anode Current of Type 6217.

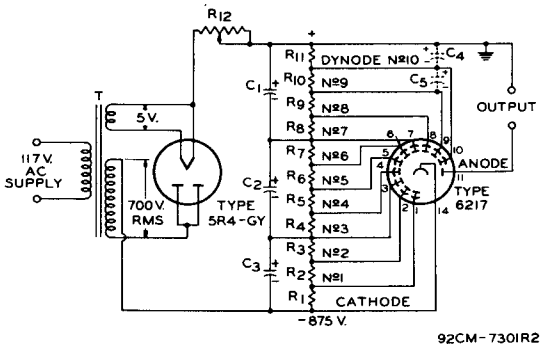
Sufficient filtering will ordinarily be provided by a well-designed, two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Due to critical dependence of the gain of the 6217 on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due

to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum-tube regulator circuit of the mu-bridge type.

In most applications, it is recommended that the positive high-voltage terminal be grounded rather than the negative terminal. With this method, which places the cathode at a high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

The high voltages at which the 6217 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 6217, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at

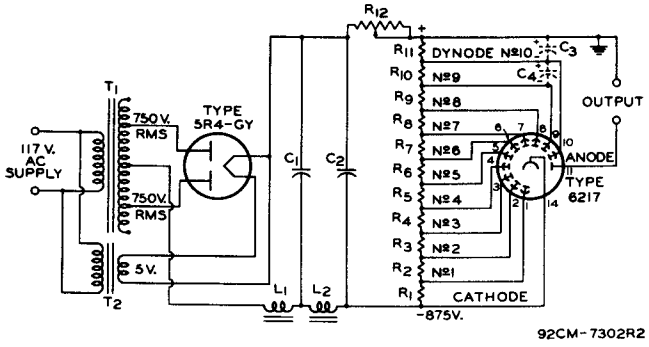


92CM-7301R2

C1 C2 C3: 16 μf, electrolytic, 450 volts (dc working)
C4 C5: 8 μf, electrolytic, 150 volts (dc working)
Required only if high peak currents are drawn.
R1: 100000 ohms, 1/2 watt
R2 R3 R4 R5 R6 R7 R8 R9 R10: 50000 ohms, 1/2 watt
R11: 33000 ohms, 1/2 watt
R12: 100000 ohms, 1 watt, adjustable (Centralab A122, or equivalent)
T: United Transformer Corp. No.R-2, or equivalent

Fig.7 - Simple Half-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 6217.

low potential, because of defective circuit parts or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded. Also, the use of a protective resistor having a minimum value



92CM-7302R2

C1 C2: 2 μf, 1000 volts (dc working)
C3 C4: 8 μf, electrolytic, 150 volts (dc working)
Required only if high peak currents are drawn.
L1 L2: United Transformer Corp. No.R-17, or equivalent
R1: 39000 ohms, 2 watts
R2 R3 R4 R5 R6 R7 R8 R9 R10: 18000 ohms, 1 watt
R11: 12000 ohms, 1 watt
R12: 200000 ohms, 12 watts, adjustable (General Radio Type 471-A, or equivalent)
T1: United Transformer Corp. No.S-45, or equivalent
T2: United Transformer Corp. No.FT-6, or equivalent

Fig.8 - Full-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 6217 in Applications Critical as to Hum Modulation.

of 10,000 ohms in the output circuit is recommended as a desirable procedure to prevent possible damage to component parts during adjustment.

Typical power-supply circuits for the 6217 are shown in Figs.7 and 8. The circuit in Fig.7 utilizes a half-wave rectifier to provide the dc power for the 6217. In applications where excellent regulation particularly for wide variation in output current of the 6217 is required and where minimum hum modulation is essential, the circuit of Fig.8 may be used.

REFERENCES

R. B. Janes and A. M. Glover, *"Recent Developments in Phototubes,"* RCA Review, Vol.6, No.1, pp.43-54, July, 1941.

Ralph W. Engstrom, *"Multiplier Phototube Characteristics; Application to Low Light Levels,"* Journal of the Optical Society of America, Vol.37, pp.420-431, June, 1947.

F. V. Hunt and R. W. Hickman, *"On Electronic Voltage Stabilizers,"* Review of Scientific Instruments, Vol.10, pp.6-21, January, 1939.

R. W. Engstrom, R. G. Stoudenheimer, and A. M. Glover, *"Production Testing of Multiplier Phototubes Designed for Scintillation Counter Applications,"* Nucleonics, Vol.10, No.4, pp.58-62, April, 1952.

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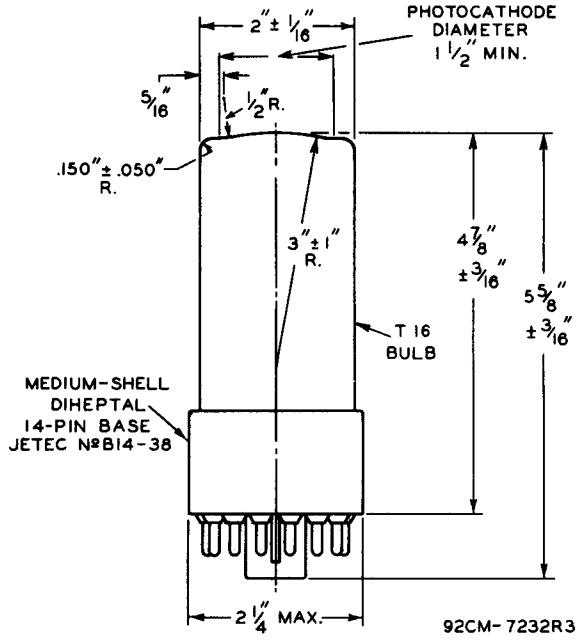
DIMENSIONAL OUTLINE

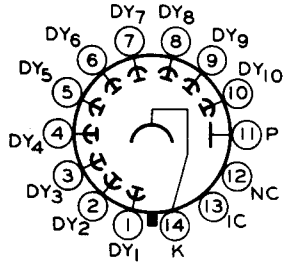


℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

SOCKET CONNECTIONS

Bottom View

PIN 1: DYNODE NO. 1
PIN 2: DYNODE No. 2
PIN 3: DYNODE No. 3
PIN 4: DYNODE No. 4
PIN 5: DYNODE No. 5
PIN 6: DYNODE No. 6
PIN 7: DYNODE No. 7
PIN 8: DYNODE No. 8



DIRECTION OF LIGHT: INTO END OF BULB

PIN 9: DYNODE No. 9
PIN 10: DYNODE No. 10
PIN 11: ANODE
PIN 12: NO CONNECTION
PIN 13: INTERNAL CONNECTION--DO NOT USE
PIN 14: CATHODE

6263

UHF MEDIUM-MU TRIODE

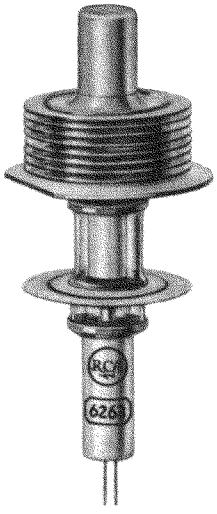
External Plate Radiator
High Transconductance

"Pencil-Type" Structure
13-Watt ICAS Plate Dissipation

High-Altitude Operation
Full Ratings to 500 Mc.

TENTATIVE DATA

RCA-6263 is a uhf triode utilizing the "pencil-type" structure with external plate radiator and having an amplification factor of 27. It is intended for use as an rf power amplifier and oscillator in mobile equipment and in aircraft transmitters operating at altitudes up to 60000 feet without pressurized chambers. Its structure makes it particularly suitable in cathode-drive applications. In such applications, the grid is employed to provide rf isolation within the tube between the load circuit and the input circuit. The 6263 can be operated with full ratings at frequencies up to 500 megacycles per second and with reduced ratings at frequencies as high as 1700 megacycles per second.



Actual Size

When operated under ICAS conditions at a frequency of 500 megacycles per second, the 6263 is capable of giving a useful power output of approximately 10 watts as an unmodulated class C rf power amplifier or 7 watts as an unmodulated class C oscillator with a plate input of only 14 watts.

Featured in the design of the 6263 is an efficient radiator for plate cooling by means of convection or forced air. The radiator consists of 9 disc-type cooling fins, one of which serves as the plate terminal and is wider and thicker than the others. This fin provides high thermal conductivity to the supporting cavity or circuit connections. In addition, this fin has a segment removed to provide a straight edge for locating the plane of the heater leads, and for orienting a pair of tubes so that their straight edges face each other to facilitate compact cavity design.

The 6263 also incorporates a newly designed, sturdy grid flange that permits the design of a clamp connector which will not subject the grid seal to appreciable strain, and a longer glass section between the plate cylinder and grid flange to prevent arc-over at very high altitudes.

The coaxial-electrode structure of the 6263 is of the double-ended metal-glass type in which the plate cylinder with attached radiator and cathode cylinder extend outward from each side of the grid flange. The latter is particularly effective in permitting rf isolation of the load circuit from the input circuit. In addition, the disc-seal type of electrode termination, inherent in the design of "pencil-type" tubes, permits the utilization of closed-cavity resonators which minimize power loss through radiation. As compared with more conventional terminals, this type of termination gives much lower inductance values and higher resonant frequencies. Although designed for use in circuits of the coaxial-cylinder type, the 6263 is also suitable for use in circuits of the line type and lumped-circuit type.

The "pencil-type" construction not only meets requirements as to minimum transit time, low lead inductance, and low interelectrode capacitances, but also provides other desirable design features such as extreme sturdiness, small size, light weight, low heater voltage, good thermal stability, and convenience of use in equipment design.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC):		
Under Transmitting Conditions. . .	6.0 ± 10%	volts
Under Standby Conditions	6.3 max.	volts
Current at 6.0 Volts	0.280	amp
Amplification Factor	27	
Transconductance, for dc plate current of 27 milliamperes and dc plate voltage of 200 volts.	7000	μmhos

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6263-11-53
Photolithographed
in U.S.A.

Direct Interelectrode Capacitances:

	With External Shield▲	*Without External Shield*	
Grid to Plate. . . .	1.5	1.7	μμf
Grid to Cathode. . .	-	2.9	μμf
Plate to Cathode . .	-	0.08 max.	μμf

Mechanical:

Mounting Position. . . . . Any

Dimensions and Terminal Connections. . . . . See Dimensional Outline

Radiator . . . . . Integral part of tube

Cooling:

In many applications, the 6263 does not require forced-air cooling. The radiator in combination with a connector having adequate heat conduction capability will generally provide adequate cooling under conditions of free circulation of air. The cooling must be sufficient to limit the plate-seal temperature to 175°C. When conditions do not provide adequate circulation of air, provision should be made to direct a blast of cooling air from a small blower through the radiator fins. The quantity of air should be sufficient to limit the plate-seal temperature to 175°C. See curves in Fig.1.

Incoming Air Temperature	40 max.	°C
Plate-Seal Temperature (Measured on Plate Seal)	175 max.	°C
Weight (Approx.)	24 grams(0.85 oz)	

RF POWER AMPLIFIER & OSCILLATOR - Class C Telegraphy

*Key-down conditions per tube without amplitude modulation**

	CCS#	*ICAS*##	
Maximum Ratings, *Absolute Values:*			
*For Pressures down to 46 mm of Hg***			
DC PLATE VOLTAGE	330 max.	400 max.	volts
DC GRID VOLTAGE.	-100 max.	-100 max.	volts
DC PLATE CURRENT	40 max.	55 max.	ma
DC GRID CURRENT.	25 max.	25 max.	ma
DC CATHODE CURRENT	55 max.	70 max.	ma
PLATE INPUT.	13 max.	22 max.	watts
PLATE DISSIPATION.	8 max.	13 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode. . .	90 max.	90 max.	volts
Heater positive with respect to cathode. . .	90 max.	90 max.	volts
Typical Operation as Oscillator in Cathode-Drive Circuit at 500 Mc:			
DC Plate Voltage	300	350	volts
DC Grid Voltage□	-30	-35	volts
DC Plate Current	35	40	ma
DC Grid Current (Approx.). .	11	14	ma
Useful Power Output (Approx.)	5●	7●	watts
Typical Operation as RF Power Amplifier in Cathode-Drive Circuit at 500 Mc:			
DC Plate Voltage	300	350	volts
DC Grid Voltage□	-48	-58	volts
DC Plate Current	35	40	ma
DC Grid Current (Approx.). .	13	15	ma
Driver Power Output (Approx.)	2.2	3	watts
Useful Power Output (Approx.)	7●	10●	watts
Maximum Circuit Values (CCS or ICAS Conditions):			
Grid-Circuit Resistance.	0.1 max.		megohm

▲ A flat plate shield 1-1/4" diameter located parallel to the plane of the grid flange and midway between the grid flange and the radiator plate terminal. The shield is tied to the cathode.

* Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

** Corresponds to altitude of about 60000 feet.

PLATE-MODULATED RF POWER AMPLIFIER - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	CCS#	*ICAS*##	
Maximum Ratings, *Absolute Values:*			
*For Pressures down to 46 mm of Hg***			
DC PLATE VOLTAGE	275 max.	300 max.	volts
DC GRID VOLTAGE.	-100 max.	-100 max.	volts
DC PLATE CURRENT	33 max.	46 max.	ma
DC GRID CURRENT.	25 max.	25 max.	ma
DC CATHODE CURRENT	50 max.	60 max.	ma
PLATE INPUT.	9 max.	15 max.	watts
PLATE DISSIPATION.	5.5 max.	9 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode. . .	90 max.	90 max.	volts
Heater positive with respect to cathode. . .	90 max.	90 max.	volts
Tyical Operation in Cathode-Drive Circuit at 500 Mc:			
DC Plate Voltage	275	320	volts
DC Grid Voltage□	-42	-52	volts
DC Plate Current	35	35	ma
DC Grid Current (Approx.). .	13	12	ma
Driver Power Output (Approx.)	2	2.4	watts
Useful Power Output (Approx.)	6.7●	8●	watts
Maximum Circuit Values (CCS or ICAS Conditions):			
Grid-Circuit Resistance.	0.1 max.		megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.260	0.300	amp
Grid-to-Plate Capacitance. . . .	-	1.45	1.95	μμf
Grid-to-Cathode Capacitance. . . .	-	2.45	3.35	μμf
Plate-to-Cathode Capacitance. . . .	-	-	0.08	μμf
Plate Current.	1,2	18	36	ma
Transconductance . . .	1,2	5600	8400	μmhos
Useful Power Output . .	3,4	6.5	-	watts

Note 1: With 6.0 volts ac or dc on heater.

Note 2: With dc plate voltage of 200 volts, cathode resistor of 100 ± 1% ohms, and cathode bypass capacitor of 1000 μf.

Note 3: With 5.4 volts ac or dc on heater.

Note 4: With dc plate voltage of 350 volts, grid resistor adjusted to give a dc plate current of 50 milliamperes in a cavity-type oscillator operating at 500 megacycles per second and having an efficiency of about 75 per cent.

\# Continuous Commercial Service.

\#\# Intermittent Commercial and Amateur Service.

□ From a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor.

● This value of useful power is measured at load of output circuit having an efficiency of about 75 per cent.

OPERATING CONSIDERATIONS

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6263 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for

each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum seal temperature* of 175°C is a tube rating and is to be observed in the same manner as other ratings. The temperature of the plate seal should be measured on the plate seal. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 11 W. 25th Street, New York 10, N. Y., in the form of liquid and stick.

The *mounting* for the 6263 in coaxial-line, parallel-line, or lumped circuits may support the tube securely by one of the three terminals as described in RCA Application Note No. AN-156, "Electrode-Terminal Connections for Pencil-Type UHF Triodes". Connections to the other two terminals must be made by flexible contacts with leads.

The mounting for the 6263 in cavity-type circuits should preferably support the tube by the large fin of the radiator to provide maximum heat conductivity. This fin, which serves as the plate terminal, should make firm contact to the cavity surface.

The *heater* leads of the 6263 fit the Cinch socket No. 54A16325 or equivalent. They should not be soldered to circuit elements. The heat of the soldering operation may crack the glass seals of the heater leads and damage the tube.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

In *plate-modulated class C rf power amplifier service*, the 6263 should be supplied with bias from a grid resistor, from a suitable combination of grid resistor and fixed supply, or from a suitable combination of grid resistor and cathode resistor. The cathode resistor should be bypassed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

In *cathode-drive plate-modulated class C telephony service*, the 6263 can be modulated 100 per cent if the rf driver stage is also modulated 100 per cent simultaneously. Care should be taken to insure that the driver-modulation and the amplifier-modulation voltages are exactly in phase. In such service, the 6263 requires increased driving power, but increased power output is obtained as shown in the tabulated data.

In *class C rf telegraphy service*, the 6263 may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value. If the 6263 is operated at a plate voltage of 300 volts, a fixed bias of at least -10 volts should be used.

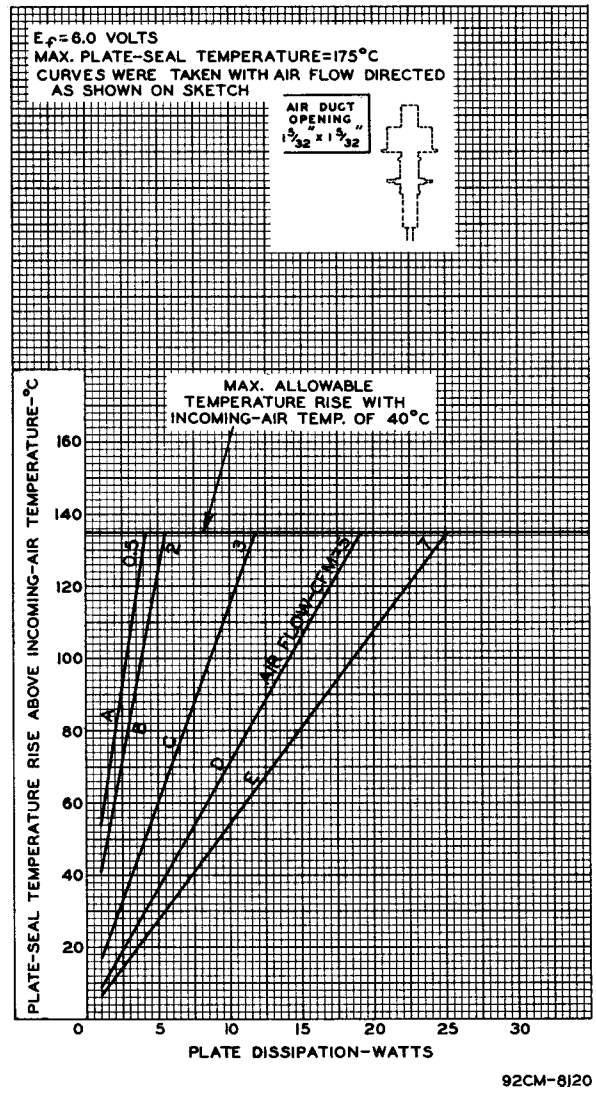

Fig. 1 - Cooling Requirements for Type 6263.

In *cathode-drive circuits*, the grid driving voltage and the developed rf plate voltage act in series to supply the load circuit. Furthermore, the power required to drive the grid is greatly increased over that needed for grid-drive circuits. However, this increase in power is not lost, because it is transferred to the plate circuit and appears there as tube output.

Another distinction between cathode-drive and grid-drive circuits is that in a grid-drive circuit where a surplus of grid driving power is always available, the power output is only moderately affected by variations in tube characteristics and operating conditions with the result that the power output is fairly independent of such variations. In a cathode-drive circuit, however, because part of the grid-driving power is transferred to the output circuit, the power output continues to increase with increased driving power to the point that the tube may be seriously overloaded. This difference in the operating nature of the two circuits is especially important when several tubes are operated in cascade.

In the grid-drive circuit, the output from the final stage is affected to only a minor degree by variations in tube characteristics and operating conditions, whereas in a cathode-drive circuit, the effects of either high or low efficiency are cumulative and can produce wide differences in power output. It is important, therefore, in the design of cathode-drive circuits that due allowances are made for the normal variations which can be expected from individual tubes.

For example, it is not good design practice to base the expected performance of cascaded cathode-drive stages on a few high performance tubes. If this practice were to be followed, a substantial percentage of tubes would either

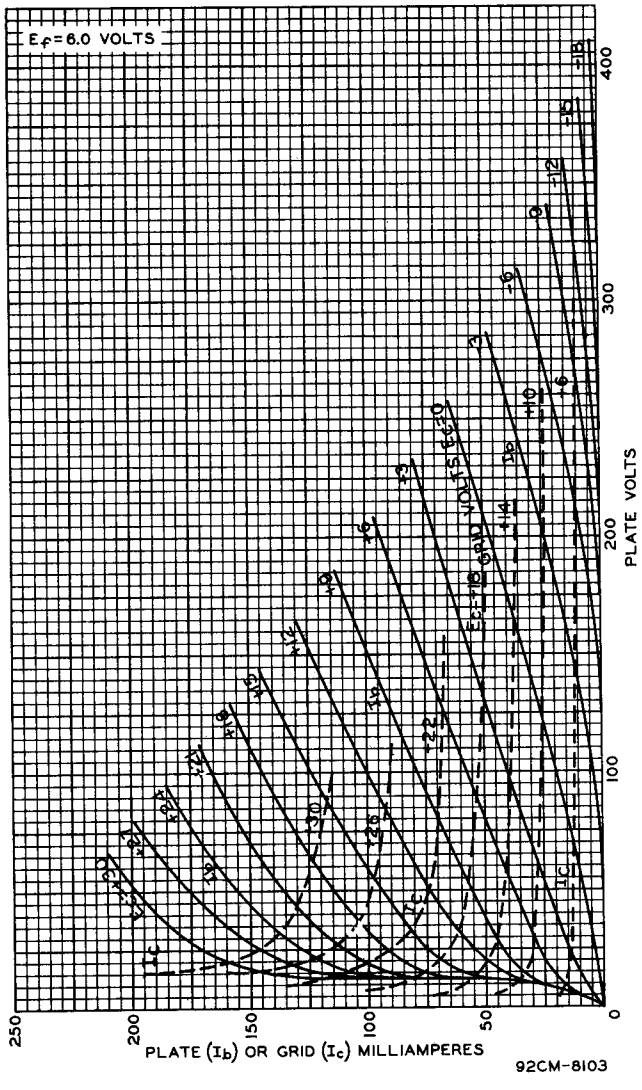

Fig. 2 - Average Plate Characteristics for Type 6263.

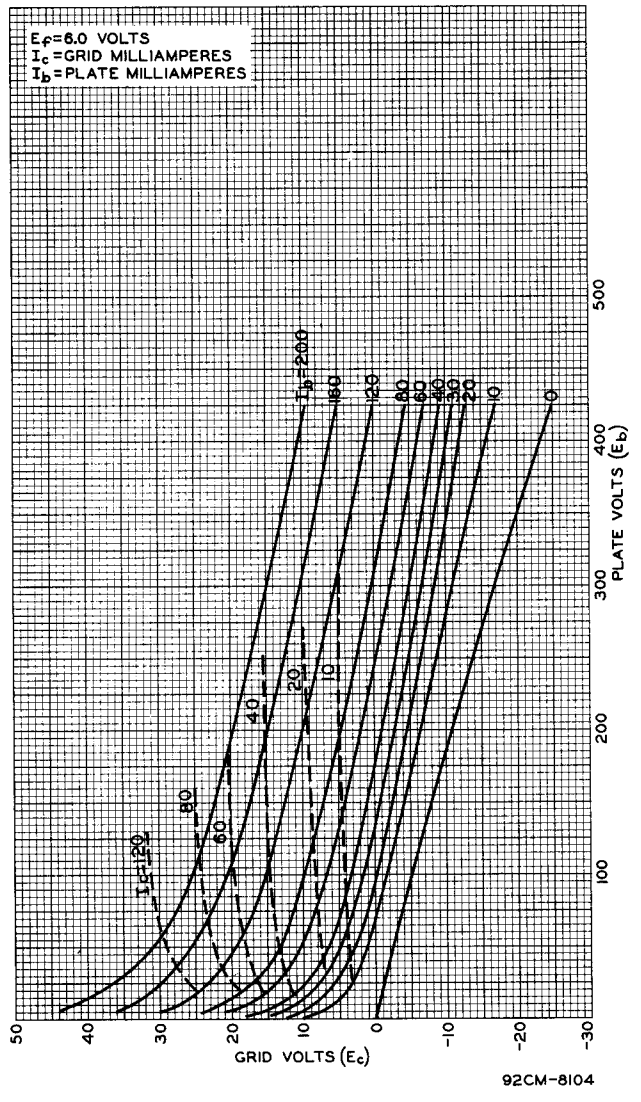

Fig. 3 - Average Constant-Current Characteristics for Type 6263.

not give the anticipated performance or would be disastrously overloaded.

In tuning an rf amplifier in a cathode-drive circuit, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

Parallel circuit arrangements may be used when more radio-frequency power is required than can be obtained from a single tube. Two tubes in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage over that required to drive a single tube, but the driving power required is approximately twice that for a single tube. When two or more tubes are used in the circuit, precautions should be taken to balance the plate currents.

REFERENCES

G. M. Rose, D. W. Power, and W. A. Harris, *"Pencil-Type UHF Triodes"*, RCA Review, Vol. 10, No.3, pp. 321-338 (September, 1949).

E. E. Spitzer, *"Grounded-Grid Power Amplifiers"*, Electronics, Vol. 19, No.4, pp. 138-141 (April, 1946).

RCA Application Note *"Electrode-Terminal Connections for Pencil-Type UHF Triodes"*, No. AN-156 (September, 1953).

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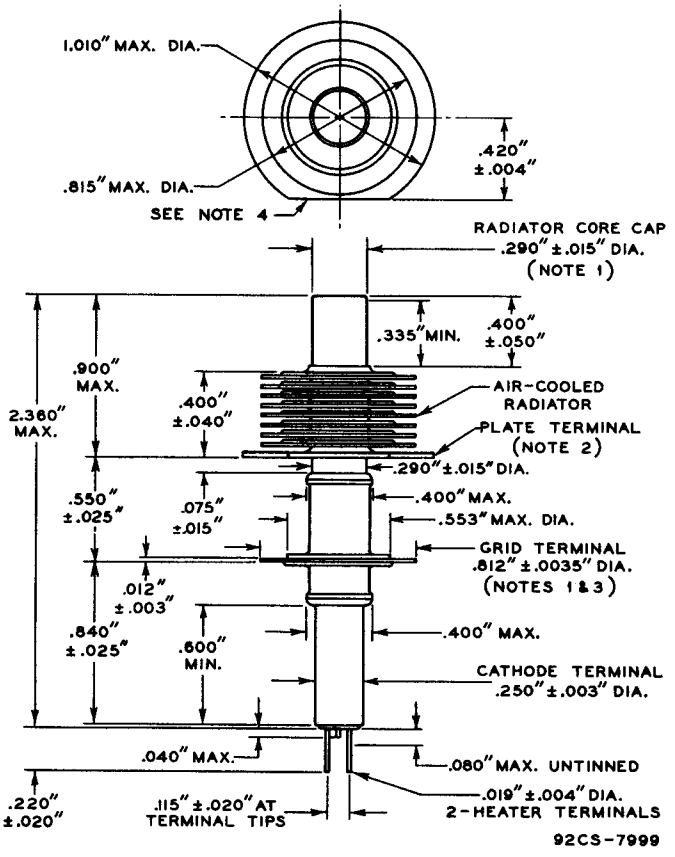
DIMENSIONAL OUTLINE



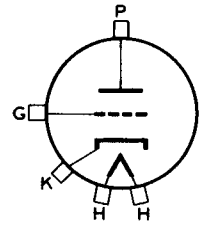
NOTE 1: MAX. ECCENTRICITY OF ℄ (AXIS) OF RADIATOR-CORE CAP OR GRID-TERMINAL FLANGE WITH RESPECT TO THE ℄ (AXIS) OF THE CATHODE TERMINAL IS 0.015".

NOTE 2: TILT OF PLATE-TERMINAL FIN OF RADIATOR WITH RESPECT TO ROTATIONAL AXIS OF CATHODE CYLINDER IS DETERMINED BY CHUCKING THE CATHODE TERMINAL, ROTATING THE TUBE, AND GAUGING THE TOTAL TRAVEL DISTANCE OF THE PLATE-TERMINAL FIN PARALLEL TO THE AXIS AT A POINT APPROXIMATELY 0.020" INWARD FROM THE STRAIGHT EDGE OF THE PLATE-TERMINAL FIN FOR ONE COMPLETE ROTATION. THE TOTAL TRAVEL DISTANCE WILL NOT EXCEED 0.035".

NOTE 3: TILT OF GRID-TERMINAL FLANGE WITH RESPECT TO ROTATIONAL AXIS OF CATHODE TERMINAL IS DETERMINED BY CHUCKING THE CATHODE TERMINAL, ROTATING THE TUBE, AND GAUGING THE TOTAL TRAVEL DISTANCE OF THE GRID-TERMINAL FLANGE PARALLEL TO THE AXIS AT A POINT APPROXIMATELY 0.020" INWARD FROM ITS EDGE FOR ONE COMPLETE ROTATION. THE TOTAL TRAVEL DISTANCE WILL NOT EXCEED 0.025".

NOTE 4: THE STRAIGHT EDGE ON THE PERIMETER OF THE LARGE FIN (PLATE TERMINAL) IS PARALLEL TO A PLANE THROUGH THE CENTERS OF THE HEATER LEADS AT THEIR SEALS WITHIN 15°.

TERMINAL CONNECTIONS



H: HEATER

K: CATHODE CYLINDER
(Adjacent to heater lead terminals)

G: GRID FLANGE
(Between glass sections)

P: PLATE CYLINDER
(With integral radiator)

6264

UHF MEDIUM-MU TRIODE

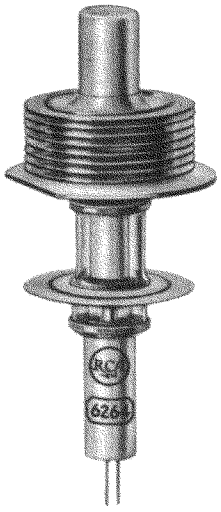
External Plate Radiator
High Transconductance

"Pencil-Type" Structure
13-Watt ICAS Plate Dissipation

High-Altitude Operation
Full Ratings to 500 Mc.

TENTATIVE DATA

RCA-6264 is a uhf triode utilizing the "pencil-type" structure with external plate radiator and having an amplification factor of 40. It is intended for use as a frequency multiplier, and as an rf power amplifier and oscillator in mobile equipment and in aircraft transmitters operating at altitudes up to 6000 feet without pressurized chambers. Its structure makes it particularly suitable in cathode-drive applications. In such applications, the grid is employed to provide rf isolation within the tube between the load circuit and the input circuit. The 6264 can be operated with full ratings at frequencies up to 500 megacycles per second and with reduced ratings at frequencies as high as 1700 megacycles per second.



Actual Size

When operated under ICAS conditions, the 6264 can deliver useful power outputs of approximately 3.4 watts as a frequency tripler to 510 megacycles per second, 10 watts as an unmodulated class C rf power amplifier at 500 megacycles per second, and 6 watts as an unmodulated class C oscillator at 500 megacycles per second. The oscillator output of 6 watts is obtained with a plate input of only 12 watts.

Featured in the design of the 6264 is an efficient radiator for plate cooling by means of convection or forced air. The radiator consists of 9 disc-type cooling fins, one of which serves as the plate terminal and is wider and thicker than the others. This fin provides high thermal conductivity to the supporting cavity or circuit connections. In addition, this fin has a segment removed to provide a straight edge for locating the plane of the heater leads, and for orienting a pair of tubes so that their straight edges face each other to facilitate compact cavity design.

The 6264 also incorporates a newly designed, sturdy grid flange that permits the design of a clamp connector which will not subject the grid seal to appreciable strain, and a longer glass section between the plate cylinder and grid flange to prevent arc-over at very high altitudes.

The coaxial-electrode structure of the 6264 is of the double-ended metal-glass type in which the plate cylinder with attached radiator and cathode cylinder extend outward from each side of the grid flange. The latter is particularly effective in permitting rf isolation of the load circuit from the input circuit. In addition, the disc-seal type of electrode termination, inherent in the design of "pencil-type" types, permits the utilization of closed-cavity resonators which minimize power loss through radiation. As compared with more conventional terminals, this type of termination gives much lower inductance values and higher resonant frequencies. Although designed for use in circuits of the coaxial-cylinder type, the 6264 is also suitable for use in circuits of the line type and lumped-circuit type.

The "pencil-type" construction not only meets requirements as to minimum transit time, low lead inductance, and low interelectrode capacitance, but also provides other desirable design features such as extreme sturdiness, small size, light weight, low heater wattage, good thermal stability, and convenience of use in equipment design.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC):		
Under Transmitting Conditions . .	6.0 ± 10%	volts
Under Standby Conditions	6.3 max.	volts
Current at 6.0 volts	0.280	amp

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6264-11-53
Photolithographed
in U.S.A.

Amplification Factor	40	
Transconductance, for dc plate current of 18.5 milliamperes and dc plate voltage of 200 volts	6800	μmhos

Direct Interelectrode Capacitances:

	With External Shield▲	*Without External Shield*	
Grid to Plate	1.5	1.75	μμf
Grid to Cathode	-	2.95	μμf
Plate to Cathode	-	0.07 max.	μμf

Mechanical:

Mounting Position . . . . . Any

Dimensions and Terminal Connections . . . . . See Dimensional Outline

Radiator . . . . . Integral part of tube

Cooling:

In many applications, the 6264 does not require forced-air cooling. The radiator in combination with a connector having adequate heat conduction capability will generally provide adequate cooling under conditions of free circulation of air. The cooling must be sufficient to limit the plate-seal temperature to 175°C. When conditions do not provide adequate circulation of air, provision should be made to direct a blast of cooling air from a small blower through the radiator fins. The quantity of air should be sufficient to limit the plate-seal temperature of 175°C. See curves in Fig.1.

Incoming Air Temperature	40 max.	°C
Plate-Seal Temperature (Measured on Plate Seal)	175 max.	°C
Weight (Approx.)	24 grams(0.85 oz)	

RF POWER AMPLIFIER AND OSCILLATOR-- Class C Telegraphy

*Key-down conditions per tube without amplitude modulation**

	CCS#	*ICAS##*	
Maximum Ratings, *Absolute Values:*			
*For Pressures Down to 46 mm of Hg***			
DC PLATE VOLTAGE	330 max.	400 max.	volts
DC GRID VOLTAGE	-100 max.	-100 max.	volts
DC PLATE CURRENT	40 max.	50 max.	ma
DC GRID CURRENT	25 max.	25 max.	ma
DC CATHODE CURRENT	55 max.	70 max.	ma
PLATE INPUT	13 max.	22 max.	watts
PLATE DISSIPATION	8 max.	13 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	90 max.	90 max.	volts
Heater positive with respect to cathode	90 max.	90 max.	volts

Typical Operation as Oscillator in Cathode-Drive Circuit at 500 Mc:

DC Plate Voltage	300	350	volts
DC Grid Voltage†	-25	-30	volts
DC Plate Current	35	35	ma
DC Grid Current (Approx.)	11	13	ma
Useful Power Output (Approx.)	5●	6●	watts

Typical Operation as RF Power Amplifier in Cathode-Drive Circuit at 500 Mc:

DC Plate Voltage	300	350	volts
DC Grid Voltage†	-42	-45	volts
DC Plate Current	35	40	ma
DC Grid Current (Approx.)	13	15	ma
Driver Power Output (Approx.)	2.4	3	watts
Useful Power Output (Approx.)	7.5●	10●	watts
Maximum Circuit Values:			
Grid-Circuit Resistance	0.1 max.	0.1 max.	megohm

FREQUENCY MULTIPLIER

	CCS#	*ICAS##*	
Maximum Ratings, *Absolute Values:*			
*For Pressures Down to 46 mm of Hg***			
DC PLATE VOLTAGE	300 max.	350 max.	volts
DC GRID VOLTAGE	-125 max.	-140 max.	volts
DC PLATE CURRENT	33 max.	45 max.	ma
DC GRID CURRENT	15 max.	15 max.	ma
DC CATHODE CURRENT	45 max.	55 max.	ma
PLATE INPUT	9.9 max.	15.8 max.	watts
PLATE DISSIPATION	6 max.	9.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	90 max.	90 max.	volts
Heater positive with respect to cathode	90 max.	90 max.	volts

Typical Operation as Tripler to 510 Mc in Cathode-Drive Circuit:

DC Plate Voltage	300	350	volts
DC Grid Voltage†	-110	-122	volts
DC Plate Current	26	36.5	ma
DC Grid Current (Approx.)	4.1	5.8	ma
Driver Power Output (Approx.)	2.75	4.5	watts
Useful Power Output (Approx.)	2.1●	3.4●	watts
Maximum Circuit Values:			
Grid-Circuit Resistance	0.1 max.	0.1 max.	megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.260	0.300	ma
Grid-to-Plate Capacitance	-	1.50	2.0	μμf
Grid-to-Cathode Capacitance	-	2.50	3.40	μμf
Plate-to-Cathode Capacitance	-	-	0.07	μμf
Plate Current	1,2	13	24	ma
Transconductance	1,2	5400	8200	μmhos
Useful Power Output	3,4	6.5	-	watts

Note 1: With 6.0 volts ac or dc on heater.

Note 2: With dc plate voltage of 200 volts, cathode resistor of 100 ± 1% ohms, and cathode bypass capacitor of 1000 uf.

Note 3: With 5.4 volts ac or dc on heater.

Note 4: With plate voltage of 350 volts, grid resistor adjusted to give a dc plate current of 50 milliamperes in a cavity-type oscillator operating at 500 megacycles per second and having an efficiency of about 75 per cent.

▲ A flat plate shield 1-1/4" diameter located parallel to the plane of the grid flange and midway between the grid flange and the radiator plate terminal. The shield is tied to the cathode.

* Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

** Corresponds to altitude of about 60000 feet.

Continuous Commercial Service.

Intermittent Commercial and Amateur Service.

● This value of useful power is measured at load of output circuit having an efficiency of about 75 per cent.

† From a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor.

OPERATING CONSIDERATIONS

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6264 may be impaired from the viewpoint of life and satisfactory performance.

Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum seal temperature* of 175°C is a tube rating and is to be observed in the same manner as other ratings. The temperature of the plate seal should be measured on the plate seal. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 11 W. 25th Street, New York 10, N. Y., in the form of a liquid and stick.

The *mounting* for the 6264 in coaxial-line, parallel-line, or lumped circuits may support the tube securely by any one of the three terminals as described in RCA Application Note No. AN-156, "Electrode-Terminal Connections for Pencil-Type UHF Triodes". Connections to the other two terminals must be made by contacts with flexible leads.

The mounting for the 6264 in cavity-type circuits should preferably support the tube by the large fin of the radiator to allow for maximum heat conductivity. This fin, which serves as the plate terminal, should make firm contact to the cavity surface.

The *heater* leads of the 6264 fit the Cinch socket No.54A16325 or equivalent. They should not be soldered to circuit elements. The heat of the soldering operation may crack the glass seals of the heater leads and damage the tube.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

In *class C rf telegraphy service*, the 6264 may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value. If the 6264 is operated at a plate voltage of 300 volts, a fixed bias of at least -5 volts should be used.

In *cathode-drive circuits*, the grid driving voltage and the developed rf plate voltage act in series to supply the load circuit. Furthermore, the power required to drive the grid is greatly increased over that needed for grid-drive circuits. However, this increase in power is not lost, because it is transferred to the plate circuit and appears there as tube output.

Another distinction between cathode-drive and grid-drive circuits is that in a grid-drive circuit where a surplus of grid driving power is always available, the power output is only moderately affected by variations in tube characteristics and operating conditions with the result that the power output is fairly independent of such variations. In a cathode-drive circuit, however, because part of the grid-driving power is transferred to the output circuit, the power output continues to increase with increased driving power to the point that the tube may be seriously overloaded. This difference in the operating nature of the two circuits is especially important when several tubes are operated in cascade.

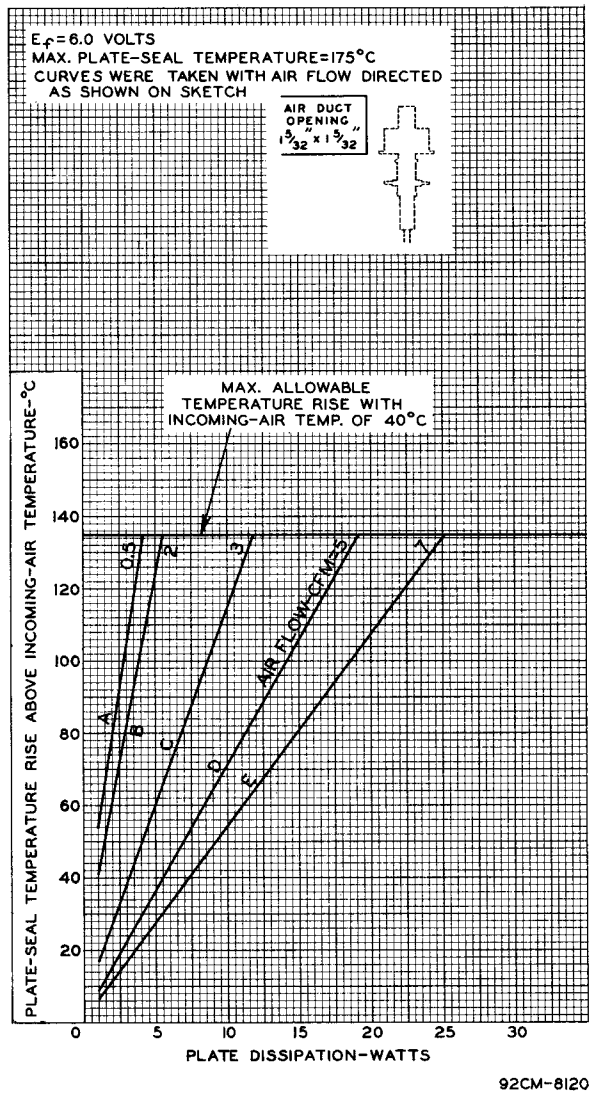

Fig. 1 - Cooling Requirements of Type 6264.

In the grid-drive circuit, the output from the final stage is affected to only a minor degree by variations in tube characteristics and

operating conditions, whereas in a cathode-drive circuit, the effects of either high or low efficiency are cumulative and can produce wide differences in power output. It is important, therefore, in the design of cathode-drive circuits that due allowances are made for the normal variations which can be expected from individual tubes.

on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

Parallel circuit arrangements may be used when more radio-frequency power is required than

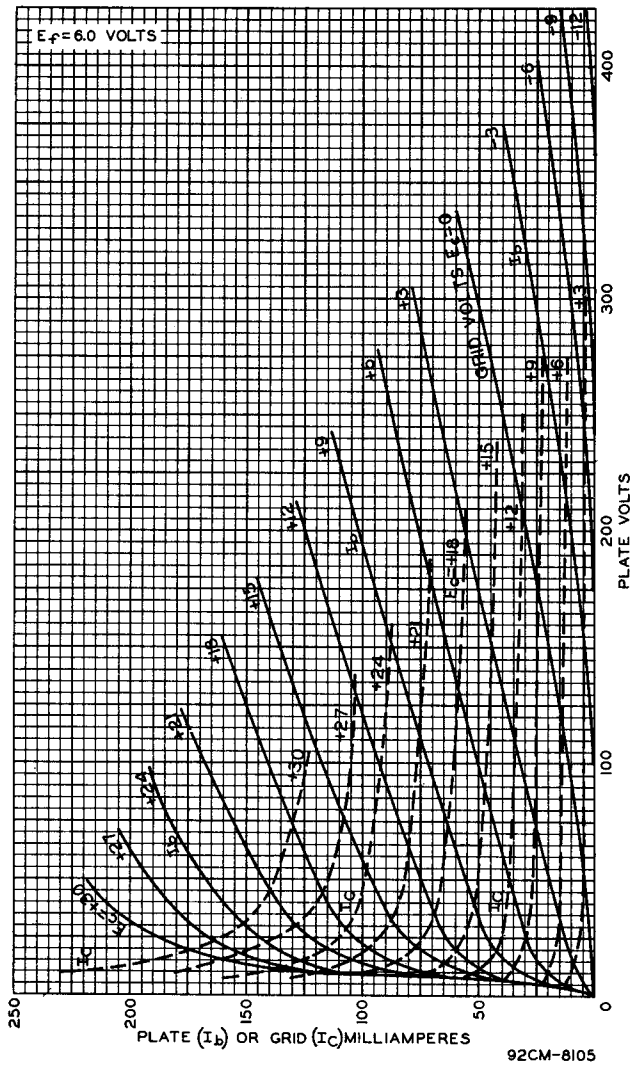

Fig. 2 - Average Plate Characteristics of Type 6264.

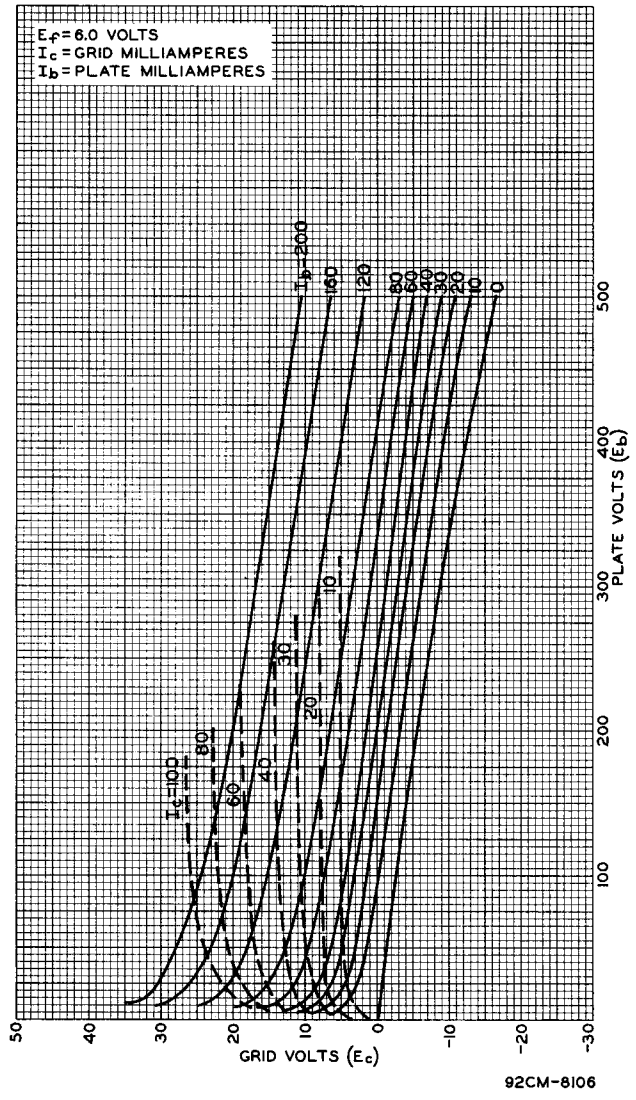

Fig. 3 - Average Constant-Current Characteristics of Type 6264.

For example, it is not good design practice to base the expected performance of cascaded cathode-drive stages on a few high-performance tubes. If this practice were to be followed, a substantial percentage of tubes would either not give the anticipated performance or would be disastrously overloaded.

In tuning a cathode-drive rf amplifier, it must be remembered that variations in the load can be obtained from a single tube. Two tubes in parallel will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage over that required to drive a single tube, but the driving power required is approximately twice that for a single tube. When two or more tubes are used in the circuit, precautions should be taken to balance the plate currents.

REFERENCES

G. M. Rose, D. W. Power, and W. A. Harris, *"Pencil-Type UHF Triodes"*, RCA Review, Vol.10, No.3, pp.321-338 (September, 1949).

E. E. Spitzer, *"Grounded-Grid Power Amplifiers"*, Electronics, Vol.19, No.4 pp.138-141 (April, 1946).

RCA Application Note *"Electrode-Terminal Connections for Pencil-Type UHF Triodes"*, No.AN-156 September, 1953.

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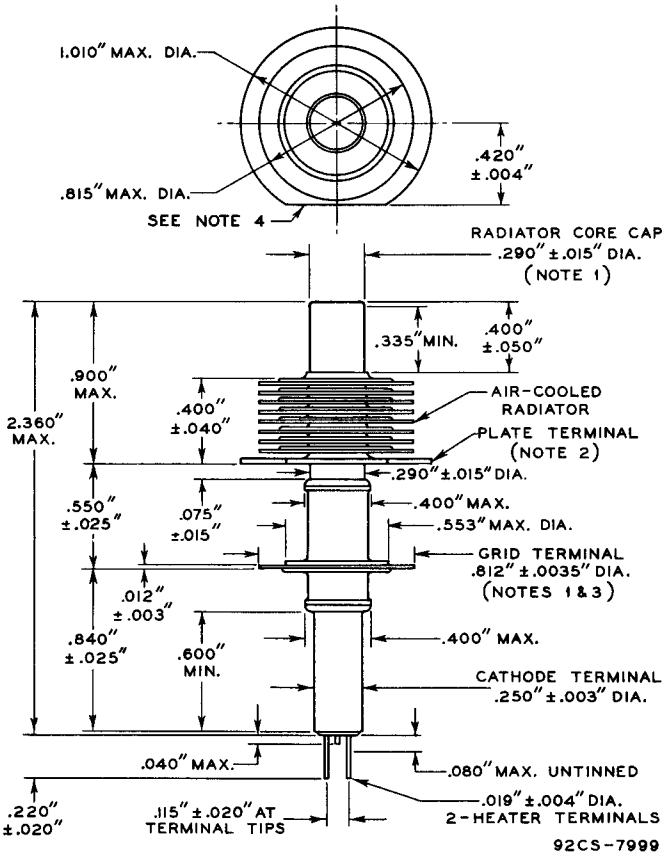
DIMENSIONAL OUTLINE



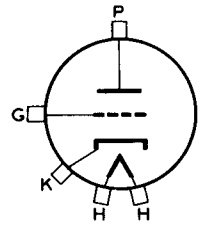
NOTE 1: MAX. ECCENTRICITY OF ℄ (AXIS) OF RADIATOR-CORE CAP OR GRID-TERMINAL FLANGE WITH RESPECT TO THE ℄ (AXIS) OF THE CATHODE TERMINAL IS 0.015".

NOTE 2: TILT OF PLATE-TERMINAL FIN OF RADIATOR WITH RESPECT TO ROTATIONAL AXIS OF CATHODE CYLINDER IS DETERMINED BY CHUCKING THE CATHODE TERMINAL, ROTATING THE TUBE, AND GAUGING THE TOTAL TRAVEL DISTANCE OF THE PLATE-TERMINAL FIN PARALLEL TO THE AXIS AT A POINT APPROXIMATELY 0.020" INWARD FROM THE STRAIGHT EDGE OF THE PLATE-TERMINAL FIN FOR ONE COMPLETE ROTATION. THE TOTAL TRAVEL DISTANCE WILL NOT EXCEED 0.035".

NOTE 3: TILT OF GRID-TERMINAL FLANGE WITH RESPECT TO ROTATIONAL AXIS OF CATHODE TERMINAL IS DETERMINED BY CHUCKING THE CATHODE TERMINAL, ROTATING THE TUBE, AND GAUGING THE TOTAL TRAVEL DISTANCE OF THE GRID-TERMINAL FLANGE PARALLEL TO THE AXIS AT A POINT APPROXIMATELY 0.020" INWARD FROM ITS EDGE FOR ONE COMPLETE ROTATION. THE TOTAL TRAVEL DISTANCE WILL NOT EXCEED 0.025".

NOTE 4: THE STRAIGHT EDGE ON THE PERIMETER OF THE LARGE FIN (PLATE TERMINAL) IS PARALLEL TO A PLANE THROUGH THE CENTERS OF THE HEATER LEADS AT THEIR SEALS WITHIN 15°.

TERMINAL CONNECTIONS



H: HEATER
K: CATHODE CYLINDER
(Adjacent to heater-lead terminals)
G: GRID FLANGE
(Between glass sections)
P: PLATE CYLINDER
(With integral radiator)

6293

BEAM POWER AMPLIFIER

For Pulse Modulator Service

TENTATIVE DATA

RCA-6293 is a small, sturdy, beam power amplifier tube intended for pulse modulator service in both fixed and mobile equipment. It can deliver a peak plate current of 3 amperes during a pulse length of 30 microseconds under conditions with duty factor of 0.003 and plate-supply voltage of 2000 volts; or a peak plate current of 1.4 amperes during a pulse length of 200 microseconds under conditions with duty factor of 0.02 and plate-supply voltage of 3500 volts.

Small in size for its power-output capability, the 6293 has a rugged button-stem construction with short internal leads, a T-12 bulb, triple base-pin connections for grid No.3 and cathode (both joined to internal shield inside the tube), and an octal base with short metal sleeve having its own base-pin terminal. The plate lead is brought out of the bulb to a cap opposite the base.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	1.25	amp
Transconductance, for plate volts = 200, grid-No.2 volts = 200, and plate ma. = 100	7300	μmhos
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 200, grid-No.2 volts = 200, and plate ma. = 100	4.5	
Direct Interelectrode Capacitances:*		
Grid No.1 to Plate	0.22 max.	μμf
Input	13.5	μμf
Output	8.5	μμf

Mechanical:

Mounting Position	Any
Overall Length	3-11/16" ± 1/8"
Seated Length	3-1/8" ± 1/8"
Maximum Diameter	1-23/32"
Bulb	T-12
Cap	Small (JETEC No.C1-1)
Base	Large-Wafer Octal 8-Pin with Sleeve (JETEC No.B8-86)
Bulb Temperature (At hottest point)	175 max. °C

MODULATOR - Rectangular-Wave Modulation

Maximum and Minimum CCS● Ratings, *Absolute Values:*

For Duty Factor◆ Between 0.001 and 1.0 and Maximum Averaging Time of 10000 μsec in Any Interval

DC PLATE SUPPLY VOLTAGE (E_{bb})▲	See Rating Chart I (Fig.1)	
INSTANTANEOUS PLATE VOLTAGE	115% of E_{bb}	
DC GRID-No.2 SUPPLY VOLTAGE▲	500 max.	volts
DC GRID-No.1 SUPPLY VOLTAGE▲	300 max. (Minimum--See Rating Chart I (Fig.1)	volts
GRID-No.1 VOLTAGE:		
Instantaneous Negative Value	400 max.	volts
Peak Positive Value	100 max.	volts
PEAK PLATE CURRENT	See Rating Chart II (Fig.2)	
PEAK GRID-No.2 CURRENT	0.75 max.	amp
PEAK GRID-No.1 CURRENT	0.5 max.	amp
PLATE INPUT	80 max.	watts
GRID-No.2 INPUT	1.75 max.	watts
GRID-No.1 INPUT	0.5 max.	watt
PLATE DISSIPATION#	See Rating Chart I (Fig.1)	
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	135 max.	volts
Heater positive with respect to cathode	135 max.	volts

Typical Operation with Rectangular-Wave Shapes in Test Circuit of Fig.3:

With Duty Factor◆ of 0.01

DC Plate Supply Voltage	3000	volts
DC Grid-No.2 Supply Voltage	300	volts
DC Grid-No.1 Supply Voltage	-175	volts
Peak Positive Grid-No.1 Voltage	65	volts
Plate Current:		
Peak	1.5	amp
DC	0.015	amp
DC Grid-No.2 Current	0.004	amp
DC Grid-No.1 Current	0.0025	amp
Load Resistance (R_L), 100 watts, non-inductive	1500 ± 5%	ohms

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	30000 max.	ohms

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Max.	
Heater Current	1	1.175	1.325	amp
Grid-No.1-to-Plate Capacitance	2	-	0.22	μμf
Input Capacitance	2	11.1	15.9	μμf
Output Capacitance	2	6.4	10.6	μμf

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6293-6-53
Photolithographed in U.S.A.

CHARACTERISTICS RANGE VALUES (Cont'd):

	Note	Min.	Max.	
Plate Current.	3	46	94	ma
Grid-No.2 Current. . .	3	0	5.5	ma
Peak Plate Current . .	1,4	2.4	-	amp

Note 1: With 6.3 volts ac on heater.

Note 2: With no external shield. Base sleeve (pin No.8) is grounded.

Note 3: With 6.3 volts ac on heater, dc plate voltage of 300 volts, dc grid-No.2 voltage of 200 volts, and dc grid-No.1 voltage of -33 volts.

Note 4: With the tube in the test circuit of Fig.3 under the following conditions: rectangular-wave modulation applied to grid No.1; pulse duration of 1 microsecond approx.; pulse repetition rate of 3000 cps approx.; dc plate supply voltage of 2000 volts; dc grid-No.2 supply voltage of 500 volts; dc grid-No.1 supply voltage of -300 volts; peak positive grid-No.1 swing of 100 volts; and load resistance (R_L) of 375 ± 5% ohms, 50 watts, non-inductive.

* With no external shielding and base sleeve connected to ground.

● Continuous Commercial Service.

♦ *Duty Factor* for the 6293 is defined as the "on" time in microseconds divided by 10000 microseconds.

"On" Time is defined as the sum of the durations of all the individual pulses which occur during any 10000-microsecond interval.

"Pulse Duration" is defined as the time interval between the two points on the pulse at which the instantaneous value is 70% of the peak value. The peak value is defined as the maximum value of a smooth curve through the average of the fluctuations over the top portion of the pulse.

▲ For tube protection, it is essential that sufficient resistance be used in the plate supply circuit, the grid-No.2 supply circuit, and the grid-No.1 supply circuit so that the short-circuit current is limited to 0.5 ampere in each circuit.

Averaged over any interval not exceeding 10000 microseconds. Care should be used in determining the plate dissipation. A calculated value based on rectangular pulses can be considerably in error when the actual pulses have a finite rise and fall time. Plate dissipation should preferably be determined by measuring the bulb temperature under actual operating conditions; then, with the tube in the same socket and under the same ambient-temperature conditions, apply to the tube sufficient dc input to obtain the same bulb temperature. This value of dc input is a measure of the plate dissipation.

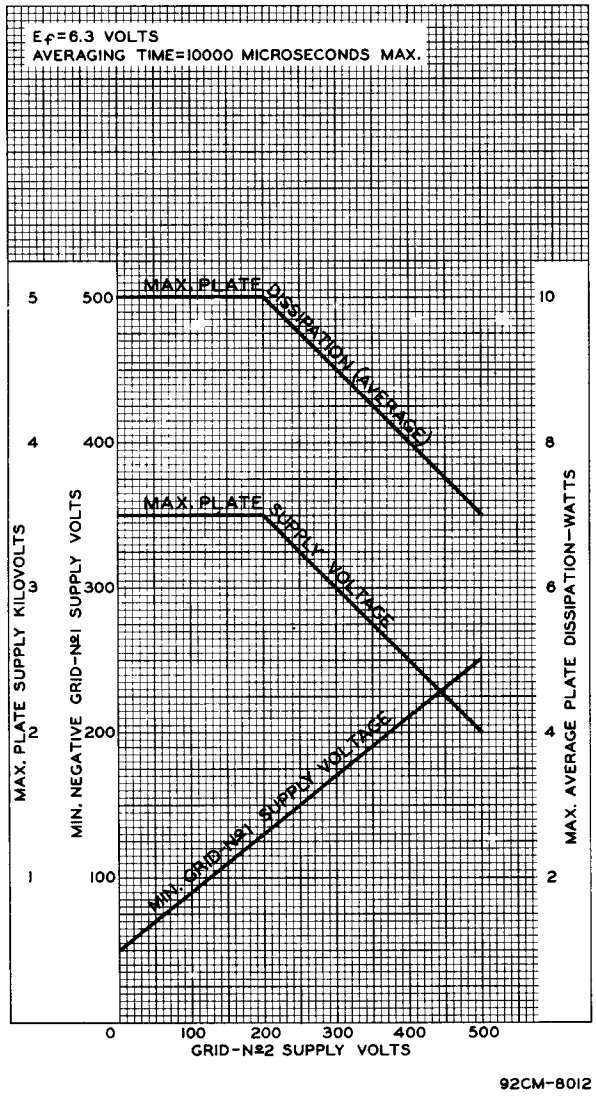


Fig. 1 - Rating Chart I for Type 6293.

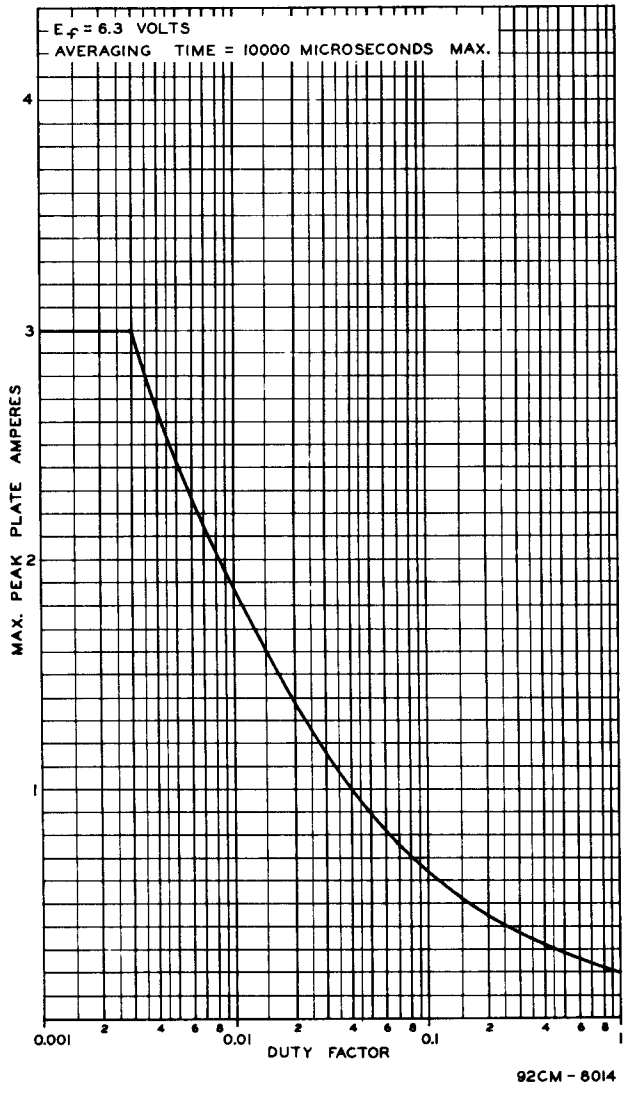
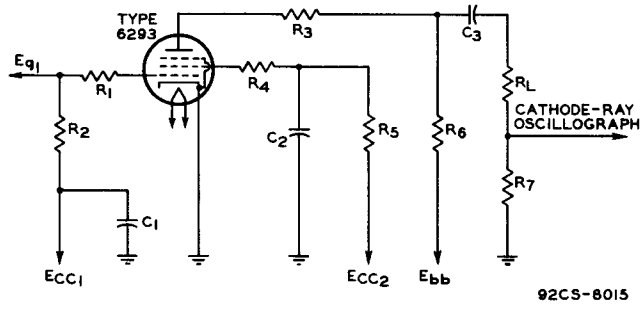


Fig. 2 - Rating Chart II for Type 6293.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6293 are limiting values above which the serviceability of the 6293 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.



C_1: 0.1 μf, 600 v dc
C_2: 2 μf, 600 v dc
C_3: 0.25 μf, 5000 v dc
E_{cc1}: Grid-No.1 Supply Volt.
E_{cc2}: Grid-No.2 Supply Volt.
E_{bb}: Plate Supply Voltage
E_{g1}: Rectangular-Wave Signal Voltage
R_1: 20 ohms, 1 watt, non inductive
R_2: 30000 ohms, 1 watt
R_3: 10 ohms, 5 watts, non-inductive
R_4: 25 ohms, 1 watt, non-inductive
R_5: 1000 ohms, 1 watt
R_6: 10000 ohms, 50 watts
R_7: 30 ± 1% ohms, non-inductive
R_L: For values, see Typical Operation and Characteristics Range Values (Note 4)

Fig.3 - Test Circuit for Type 6293.

The *bulb* becomes hot during operation. To insure adequate cooling, therefore, it is essential that free circulation of air be provided around the 6293.

The *plate* shows no color when operated with maximum rated dissipation. Connection to the plate cap should be made with a flexible lead to prevent any strain on the seal at the cap.

For *tube protection*, it is essential that sufficient resistance be used in the plate supply circuit, the grid-No.2 supply circuit, and the grid-No.1 supply circuit so that the short-circuit current is limited to 0.5 ampere in each circuit.

The *test circuit*, shown in Fig.3, requires the use of damping resistors to suppress oscillations which may be caused by the rectangular-wave signal. These resistors should be non-inductive and they should be placed as close as possible to the socket terminals.

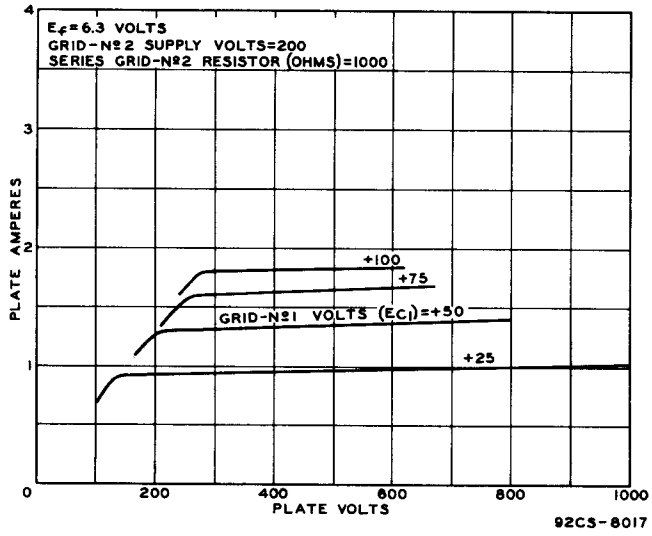


Fig.4 - Average Plate Characteristics of Type 6293.

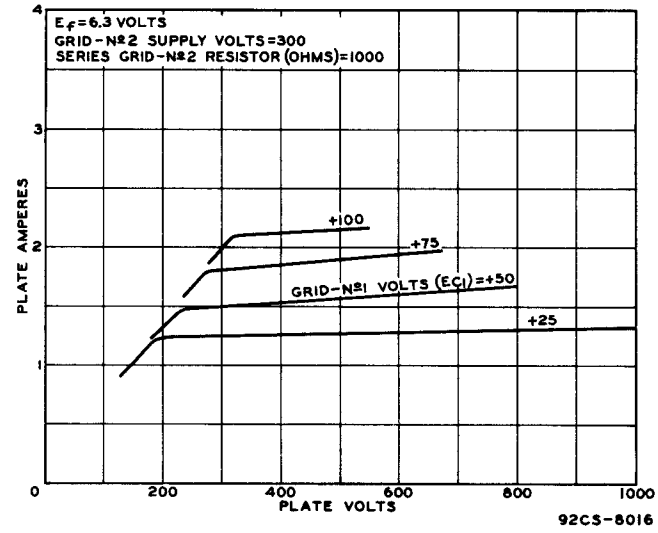


Fig.5 - Average Plate Characteristics of Type 6293.

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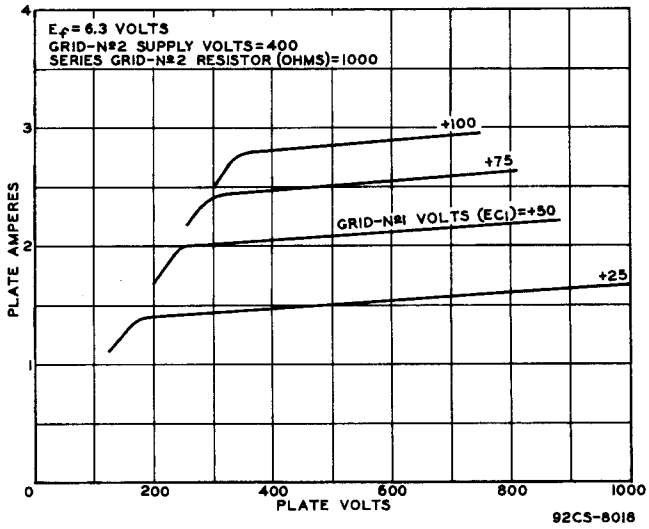


Fig. 6 - Average Plate Characteristics of Type 6293.

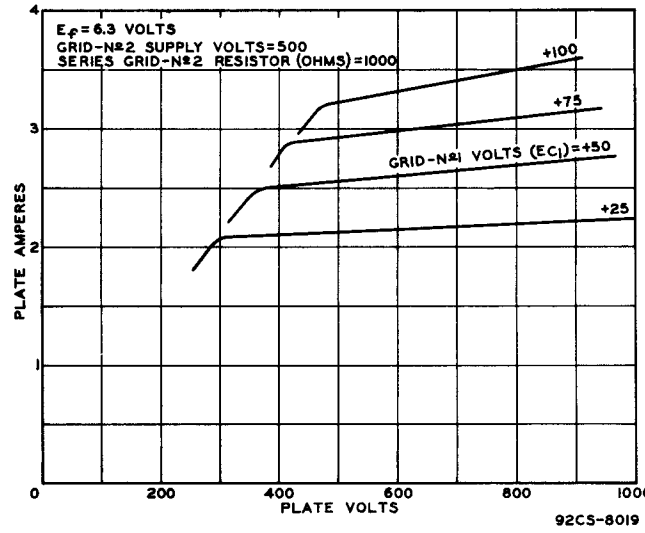
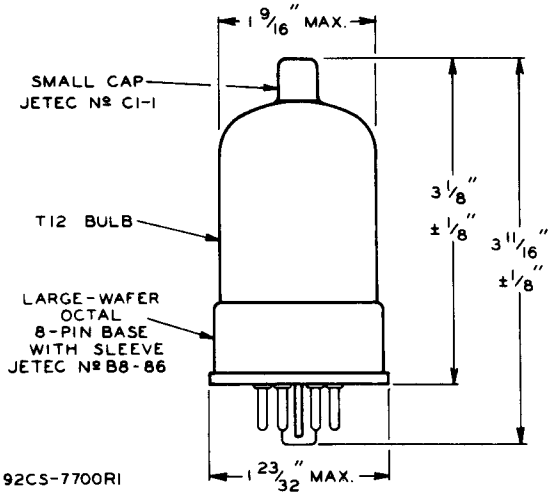


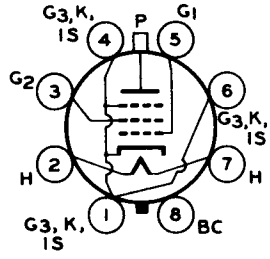
Fig. 7 - Average Plate Characteristics of Type 6293.

DIMENSIONAL OUTLINE



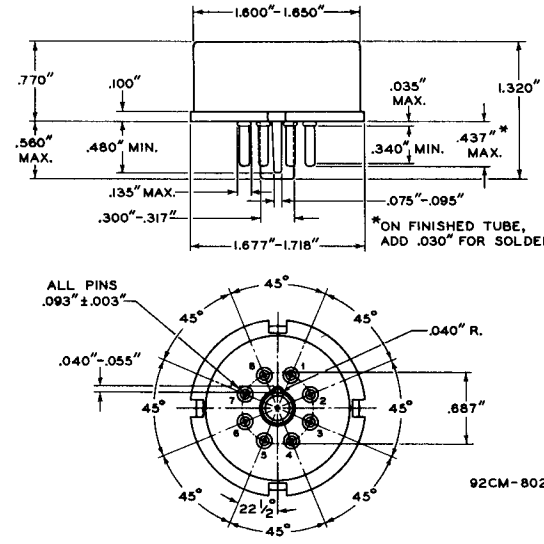
SOCKET CONNECTIONS

Bottom View



PIN 1: CATHODE, GRID No.3 INTERNAL SHIELD
PIN 2: HEATER
PIN 3: GRID No.2
PIN 4: SAME AS PIN 1
PIN 5: GRID No.1
PIN 6: SAME AS PIN 1
PIN 7: HEATER
PIN 8: BASE SLEEVE
CAP: PLATE

JETEC No. B8-86 BASE



Base-pin positions are held to tolerances such that entire length of pins will enter flat-plate gauge (JETEC No. GB8-1) having thickness of 1/4" and eight 0.1030" ± 0.0005" holes so located on a 0.6870" ± 0.0005" diameter circle that the distance along the chord between any two adjacent hole centers is 0.2630" ± 0.0005".

Pin fit in gauge shall be such that gauge together with supplementary weight totaling 2 lbs. will not be lifted when pins are withdrawn.

6323

MULTIPLIER PHOTOTUBE

9-Stage Type with S-4 Response
for Headlight-Control Service
TENTATIVE DATA

RCA-6323 is a 9-stage multiplier phototube intended especially for automobile headlight-dimming service. Small in size and ruggedly constructed, the 6323 features high luminous sensitivity which allows use of an amplifier with relatively low-impedance input and fewer stages, and provides instantaneous response to meet the critical timing requirements of headlight-control service. In addition, the 6323 has low electrode dark current which permits the use of high-resistance voltage-divider networks. When thus used, the 6323 is capable of providing stable performance over long periods in headlight-dimming service.

DATA

General:

Spectral Response	S-4
Wavelength of Maximum Response	4000 ± 500 angstroms
Cathode:	
Minimum Projected Length*	15/16"
Minimum Projected Width*	5/16"
Direct Interelectrode Capacitances (Approx.):	
Anode to Dynode No.9	4 μμf
Anode to All Other Electrodes	6.5 μμf
Maximum Overall Length	3-11/16"
Maximum Seated Length	3-1/8"
Length from Base Seat to Center of Useful Cathode Area	1-15/16" ± 3/32"
Maximum Diameter	1-5/16"
Bulb	T-9
Base	Small-Shell Submagnal 11-Pin, Non-hygroscopic (JETEC No.B11-88)
Mounting Position	Any

Maximum Ratings, *Absolute Values*:

ANODE SUPPLY VOLTAGE (DC or Peak AC)□	1250 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.9 AND ANODE (DC or Peak AC)	250 max.	volts
ANODE CURRENT:		
Peak	1 max.	ma
Average°	0.1 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

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TMK R , Marca Registrada

TUBE DEPARTMENT
Radio Corporation of America
Harrison, New Jersey

from RTMA release #1220, Aug. 7, 1953

Characteristics Range Values for Equipment Design:#

Under conditions with supply voltage (E) across voltage divider providing 1/10 of E between cathode and dynode No.1; 1/10 of E for each succeeding dynode stage; and 1/10 of E between dynode No.9 and anode

With E = 1000 volts

	Min.	Av.	Max.	
Sensitivity:				
Radiant●, at 4000 angstroms	–	32500	–	μamp/μwatt
Luminous▲	5	35	250	amp/lumen
Electrode Dark Current at 25°C:				
Anode	–	–	0.1	μamp
Any Other Electrode	–	–	0.75	μamp

---

* On plane perpendicular to indicated direction of incident light.

□ Referred to cathode.

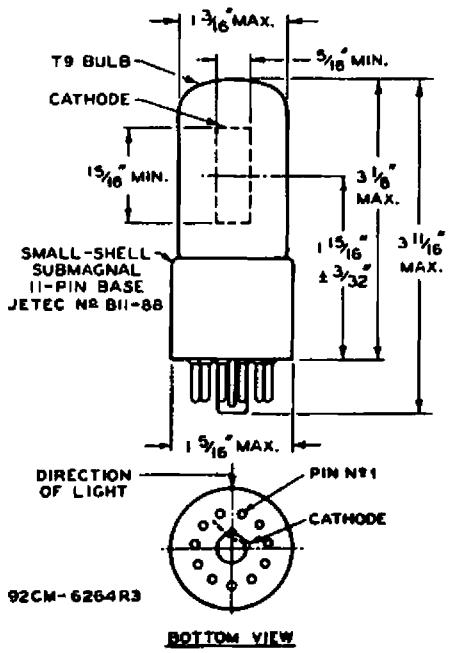
○ Averaged over any interval of 30 seconds maximum.

The 6323 is processed during manufacture and tested under simulated headlight-control operating conditions to provide the high stability needed in headlight-control service.

● The radiant sensitivity of a phototube is the quotient of output current by incident radiant energy of a given wavelength at constant electrode voltages.

▲ For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light input of 10 microlumens is used. The load resistor has a value of 0.01 megohm.

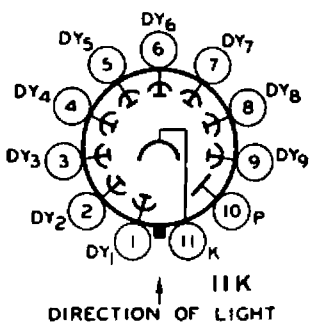
DIMENSIONAL OUTLINE



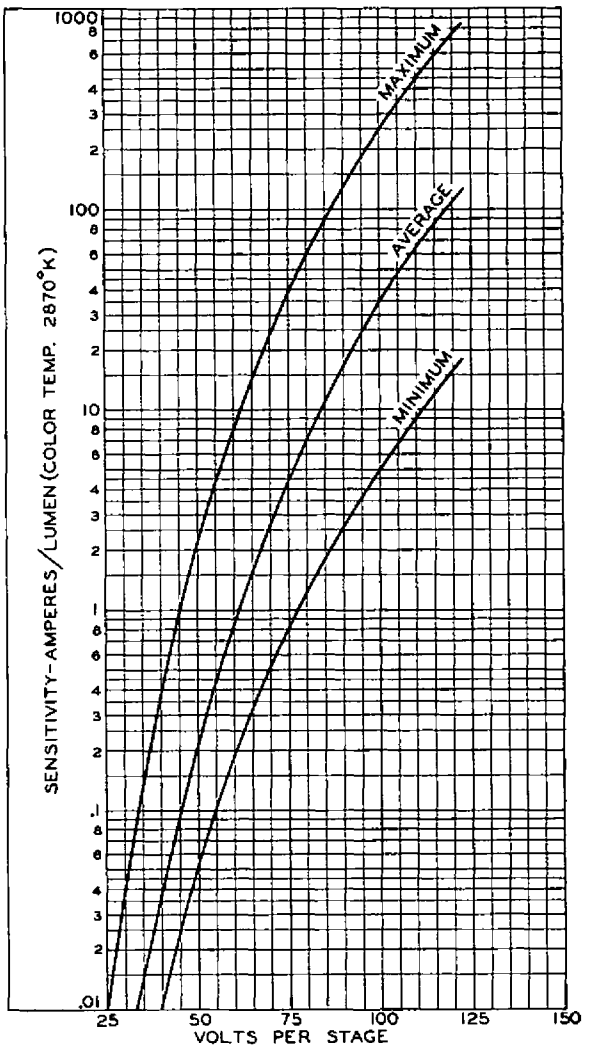
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

SOCKET CONNECTIONS

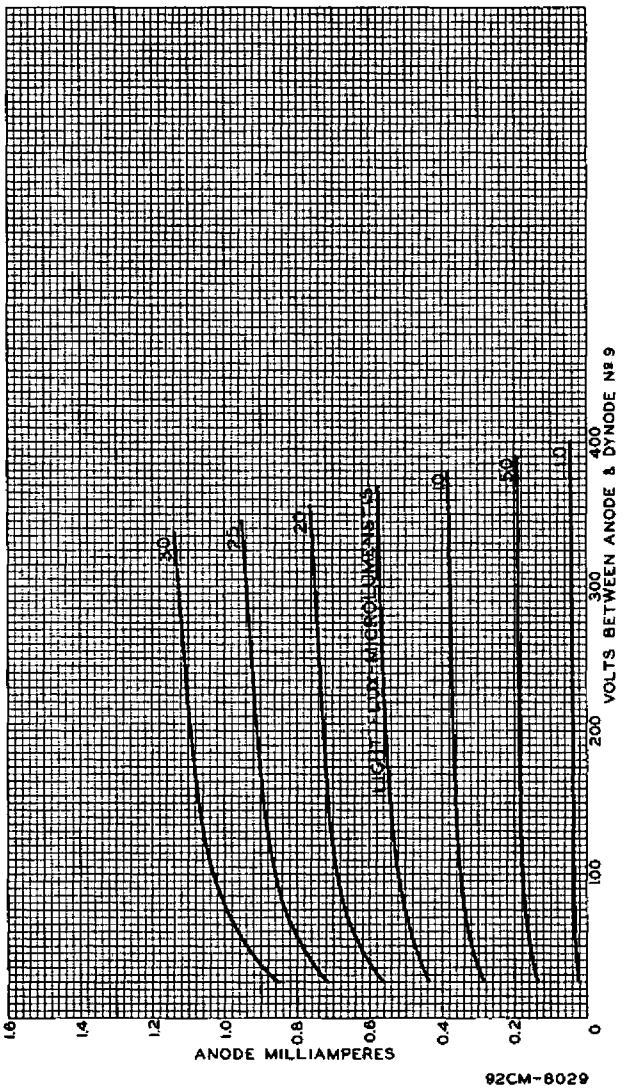
Bottom View



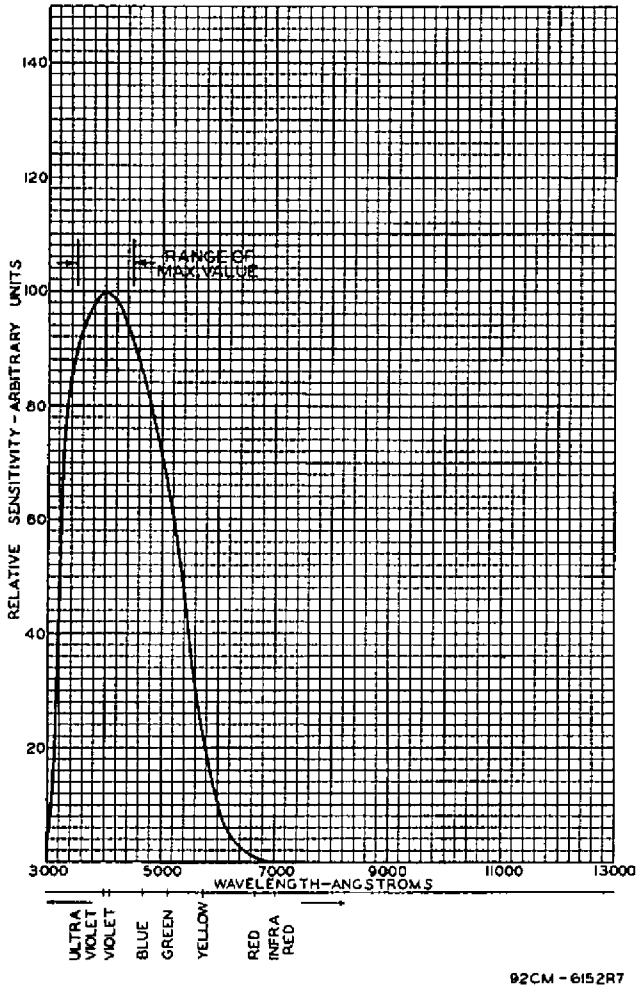
PIN 1: DYNODE No.1
PIN 2: DYNODE No.2
PIN 3: DYNODE No.3
PIN 4: DYNODE No.4
PIN 5: DYNODE No.5
PIN 6: DYNODE No.6
PIN 7: DYNODE No.7
PIN 8: DYNODE No.8
PIN 9: DYNODE No.9
PIN 10: ANODE
PIN 11: CATHODE



Range of Luminous Sensitivity of Type 6323.



Average Anode Characteristics of Type 6323.



Spectral Sensitivity Characteristic of Type 6323 which has S-4 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

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6326-A

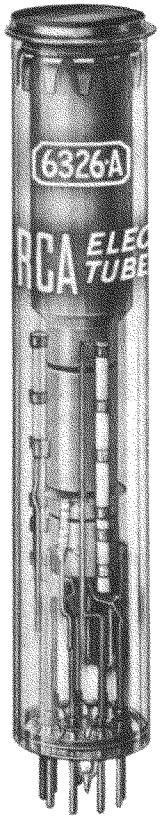
VIDICON

Magnetic Focus
Magnetic Deflection

For Film and Live Pickup
with Color or Black-and-White TV Cameras
600-Line Resolution
TENTATIVE DATA

1"-Diameter Bulb
6-1/4" Length

RCA-6326-A is a small camera tube intended primarily for use in compact color television cameras utilizing the method of simultaneous pickup of the film or live subjects to be televised. This method employs three 6326-A's--one for each channel--to produce the information necessary for the formation of a color-television image. The 6326-A is also suitable for use in black-and-white TV cameras for either film or live pickup. In either color or black-and-white service, the 6326-A can provide a picture of high quality for broadcasting or industrial television applications. Its resolution capability is about 600 television lines.



Utilizing a photoconductive layer as its light-sensitive element, the 6326-A has a sensitivity such that it requires illumination levels comparable to those required for motion-picture film cameras. The spectral response of the 6326-A covers the entire visible spectrum and enables the tube to translate color very accurately when operated in a color camera with appropriate color filters and optical arrangements.

Featured in the design of the 6326-A is a tipless structure which allows the use of a longer deflecting yoke than a side-tip structure. The longer yoke offers the advantages of less deflecting power, and a narrower deflecting angle which effectively reduces deflection distortion and improves the center-to-edge focus of the beam. In addition, the tipless structure simplifies the layout of optical arrangements for light splitting in a color system.

The 6326-A is an improved version of the 6326 and is unilaterally interchangeable with it.

PRINCIPLES OF OPERATION

The structural arrangement of the 6326-A, shown in Fig. 1, consists of the signal electrode which is a transparent conducting film on the inner surface of the faceplate; a light-sensitive element consisting of a thin layer of photoconductive material deposited on the signal electrode; a fine mesh screen (grid No.5) located adjacent to the photoconductive layer; a beam-focusing electrode (grid No.4) connected to grid No.5; a dynamic-focusing electrode (grid No.3); and an electron gun for producing a beam of electrons.

Each element of the photoconductive layer is an insulator in the dark but becomes slightly conductive when it is illuminated and acts like a leaky capacitor having one plate at the fixed positive potential of the signal electrode and the other floating. When light from the film or live subject being televised is focused on the photoconductive-layer surface next to the faceplate, each illuminated layer element conducts slightly depending on the amount of illumination on the element and thus causes the potential of its opposite surface (on the gun side) to rise in less than the time of one frame toward that of the signal-electrode potential. Hence, there appears on the gun side of the entire layer surface a positive potential pattern, composed of the various element potentials, corresponding to the pattern of light from the film projector, or live subject, imaged on the layer.

The gun side of the photoconductive layer is scanned by a low-velocity electron beam produced by the electron gun. This gun contains a thermionic cathode, a control grid (grid No.1), and an accelerating grid (grid No.2). The beam is focused at the surface of the photoconductive layer by the combined action of the uniform magnetic field of an external coil and the electrostatic fields of grids No.3 and No.4. If desired, grid No.3 may be operated separately to permit the use of circuitry to provide for the

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feature of dynamic focusing. Grid No.5 serves to provide a uniform decelerating field between itself and the photoconductive layer so that the electron beam will approach the layer in a direction perpendicular to it--a condition necessary for driving the surface to cathode potential. The beam electrons approach the layer at low velocity because of the lower operating potential of the signal electrode.

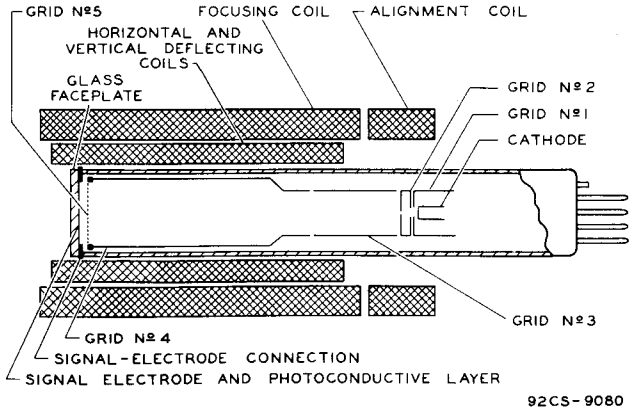


Fig. 1 - Schematic Arrangement of Type 6326-A.

When the gun side of the photoconductive layer with its positive potential pattern is scanned by the electron beam, electrons are deposited from the beam until the surface potential is reduced to that of the cathode, and thereafter are turned back to form a return beam which is not utilized. Deposition of electrons on the scanned surface of any particular element of the layer causes a change in the difference of potential between the two surfaces of the element. When the two surfaces of the element, which in effect is a charged capacitor, are connected through the external signal-electrode circuit and the scanning beam, a capacitive current is produced and constitutes the video signal. The magnitude of the current is proportional to the surface potential of the element being scanned and to the rate of scan. The video-signal current is then used to develop a signal output voltage across a load resistor. The signal polarity is such that for highlights in the film or live subject, the grid of the first video-amplifier tube swings in a negative direction.

Alignment of the beam is accomplished by a transverse magnetic field produced by external coils located at the base end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	amp
Direct Interelectrode Capacitance:♦		
Signal electrode to all other electrodes	4.5	μμf
Spectral Response	See Curves in Fig.10	
Photoconductive Layer:		
Maximum useful diagonal of rectangular image (4 x 3 aspect ratio)	0.62	inch
Orientation of quality rectangle--Proper orientation is obtained when the horizontal scan is essentially parallel to the straight sides of the masked portions of the faceplate. The straight sides are parallel to the plane passing through the tube axis and short index pin. The masking is for orientation only and does not define the proper scanned area of the photoconductive layer.		
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	6-1/4" ± 1/4"	
Greatest Diameter	1.125" ± 0.010"	
Bulb	T-8	
Base	Small-Button Ditetrar 8-Pin (JETEC No.E8-11)	
Operating Position	Approx. horizontal, or faceplate up	
Weight (Approx.)	2 oz	

Maximum Ratings, *Absolute Values*:

SIGNAL-ELECTRODE VOLTAGE	100 max.	volts
GRID-No.5 & GRID-No.4 VOLTAGE	350 max.	volts
GRID-No.3 VOLTAGE	350 max.	volts
GRID-No.2 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
FACEPLATE:		
Illumination	1000 max.	ft-c
Temperature	60 max.	°C

Typical Operation with Static Focusing:

Grid No.3 connected to grids No.4 and No.5; scanned area of 1/2" x 3/8"

Faceplate Illumination:		
Average highlight▲, for pickup from film	50 to 300	ft-c
Constant highlight, for pickup from limited-motion live scenes	20	ft-c
Signal-Electrode Voltage:		
For pickup from film	20 to 40	volts
For pickup from limited-motion live scenes	40 to 70	volts
Grid-No.5 (Decelerator) and Grids-No.4 & No.3 (Beam-Focus Electrodes*) Voltage	200 to 300	volts
Grid-No.2 (Accelerator) Voltage	300	volts
Grid-No.1 Voltage for Picture Cutoff●	-45 to -100	volts
Highlight Signal-Electrode Current	0.3 to 0.4	μamp
Average Signal-Output Current#	0.1 to 0.2	μamp
Peak Signal-Output Current	0.3 to 0.4	μamp
Maximum Dark Current:		
For pickup from film	0.004	μamp
For pickup from limited-motion live scenes	0.02	μamp
Average "Gamma" of Transfer Characteristic for signal-output current between 0.02 μamp and 0.2 μamp	0.65	
Visual Equivalent Signal-to-Noise Ratio (Approx.)○	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No.1	40	volts
When applied to cathode	10	volts
Field Strength of Adjustable Alignment Coil	0 to 4	gausses

Typical Operation with Dynamic Focusing:

Grid No.3 used separately as Dynamic Focusing Electrode; scanned area of 1/2" x 3/8"

Values are the same as shown above for *Typical Operation with Static Focusing* except as follows:

Grid-No.5 (Decelerator) and Grid-No.4 (Beam-Focus Electrode**) Voltage . . .	200 to 300	volts
Grid-No.3 (Dynamic-Focus Electrode**) Voltage:		
DC value	140 to 240	volts
Peak-to-peak value (Approx.)	60	volts

♦ This capacitance, which effectively is the output impedance of the 6326-A, is increased by about 3 μμf when the tube is mounted in the deflecting-yoke and focusing-coil assembly. The resistive component of the output impedance is in the order of 100 megohms.

▲ Averaged over the time of one TV frame.

* Beam focus is obtained by combined effect of grids-No.4 & No.3 voltage which should be adjustable over indicated range, and a focusing coil having an average field strength of 40 gausses.

● With no blanking voltage on grid No.1.

\# Defined as the component of the signal-electrode current after the dark-current component has been subtracted.

o For amplifier system shown in Fig.5 (b). Because the noise in such a system is predominately of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of highlight video-signal current to rms noise current, multiplied by a factor of 3.

** Static beam focus is obtained by combined effect of grid-No.4 voltage which should be adjustable over indicated range, and a focusing coil having an average field strength of 40 gausses. Dynamic beam focus to give improved edge focus is supplementary to static beam focus and is accomplished by adjusting the dc grid-No.3 voltage to a value about 60 volts lower than that of grid No.4 and by applying to grid No.3 an ac voltage having parabolic waveform. (For circuit, see Fig.3.)

OPERATING CONSIDERATIONS

The *maximum ratings* shown for the 6326-A are limiting values above which its serviceability may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these maximum ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

In the *handling* of the 6326-A, precautions should be taken to keep the tube in a vertical position with the faceplate up. This procedure will prevent any loose particles in the tube from causing possible damage to the photoconductive layer.

The *base pins* of the 6326-A fit the ditetrar 8-contact connector, such as Cinch No.54A18088, or equivalent.

The *signal-electrode connection* is made by a suitable spring contact bearing against the edge of the metal flange at the face end of the tube. This spring contact may conveniently be provided as part of the focusing-coil design.

Support for the 6326-A is provided by a suitable spring-finger suspension at the face end of the tube and by a clamping mechanism near the base end. Orientation of the 6326-A in its support should be such that the horizontal scan is essentially parallel to the straight sides of the masked portions of the faceplate. The straight sides are parallel to the plane passing through the tube axis and short index pin.

The *optical system* associated with the 6326-A should be of high quality and provide depth of focus sufficient to focus a sharp image on the photoconductive layer.

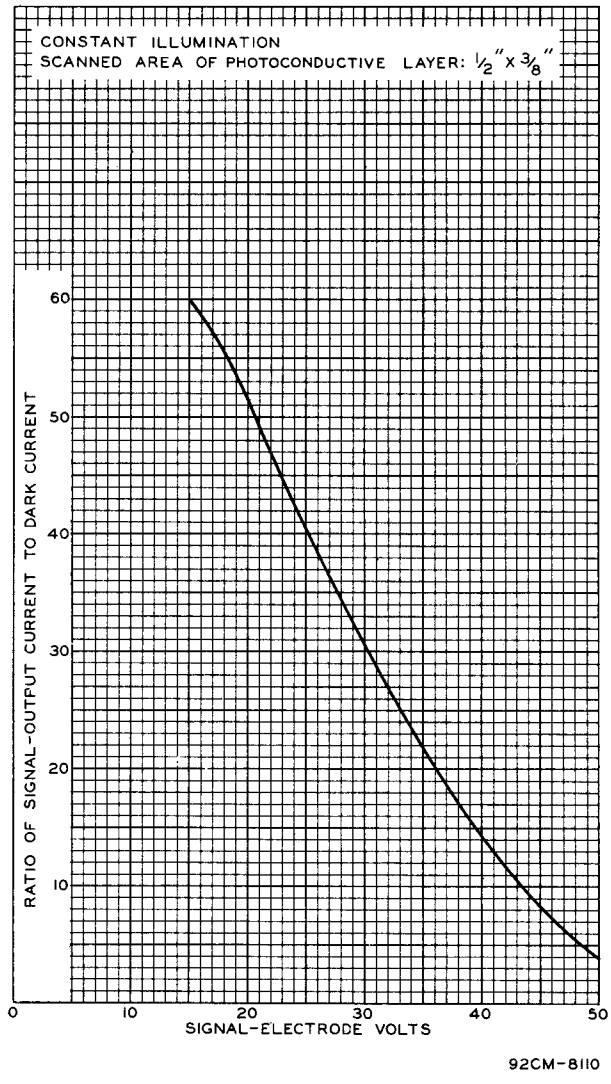


Fig. 2 - Typical Characteristic of Type 6326-A.

The *deflecting yoke* and *focusing coil*, designed to fit around the tipless structure of the 6326-A, should extend 1/4 to 1/2 inch beyond the faceplate of the tube, as shown in Fig.1. A long yoke, in comparison with a short yoke, not only requires less deflecting power but also deflects the beam through a narrower angle which effectively gives better center-to-edge focus and reduces geometric distortion of the image. Freedom

from such distortion is particularly important in color cameras utilizing the method of simultaneous pickup in which three images must be identical for proper registration of the three video signals.

The yoke should be positioned so that the end of the deflecting coils toward the base of the tube will not extend more than 3-1/2 inches from the faceplate.

Electrostatic shielding of the signal electrode from external fields is required to prevent interference effects in the picture. Effective shielding from the fields produced by the deflecting components is ordinarily provided by grounding a shield on the inside of the faceplate end of the focusing coil and by grounding a shield on the inside of the deflecting yoke.

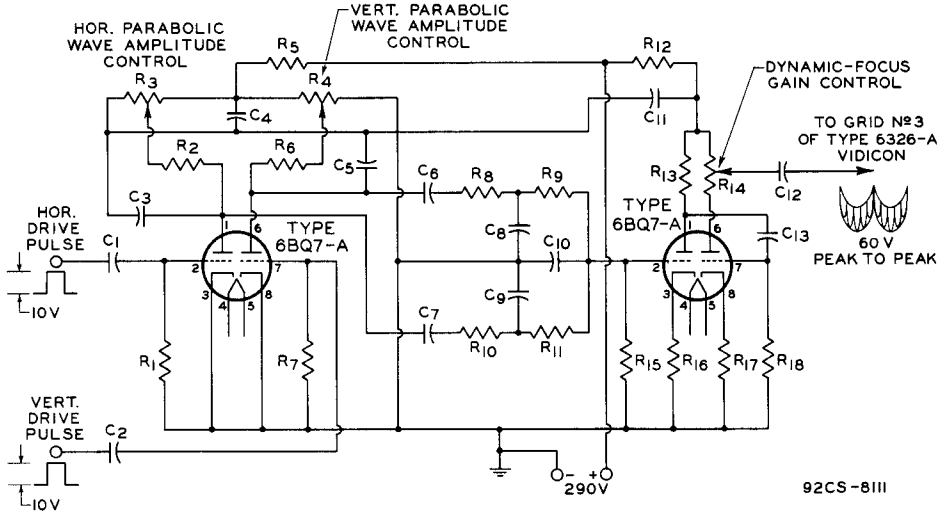
The *temperature of the faceplate* should not exceed 60°C (140°F), either during operation or storage of the 6326-A. Operation with a faceplate temperature in the range from about 25° to 35°C (77° to 99°F) is recommended. The temperature of the faceplate is determined by the combined heating effects of the incident illumination on the faceplate, the associated components, and the tube itself. To reduce these heating effects in film-pickup cameras and permit operation in the preferred temperature range with a high value of illumination, the use of an infrared filter between the projector and faceplate as well as a blast of cooling air directed across the faceplate from a blower is recommended.

Signal-output current and dark current both increase with increasing faceplate temperature for a given signal-electrode voltage and illumination. Since the dark current increases the more rapidly of the two, it is necessary to reduce the signal-electrode voltage in an effort to restore the ratio of signal-output current to dark current. Operation at higher faceplate temperatures causes some sacrifice in performance because the sensitivity at a given signal-output-to-dark-current ratio (or the signal-output-to-dark-current ratio at a given sensitivity) is somewhat reduced. Operation at the higher temperatures, however, does not adversely affect the performance of the tube when it is subsequently operated at a lower temperature.

The *signal-electrode voltage* should be obtained from an adjustable dc source. As the signal-electrode voltage is increased, the signal-output-to-dark-current ratio decreases, as shown in Fig. 2. When the 6326-A is used for pickup from film, the signal-electrode voltage should be set at a value where the dark-current background is absolutely flat or uniform. This same value is also suitable for pickup from limited-motion live scenes when sufficient light is available on the face of the tube. For proper adjustment of the signal-electrode voltage on each 6326-A, see *sequence of adjustments* on page 9.

The signal-electrode voltage required for a given sensitivity and dark current may change gradually during the life of the tube. By making the signal-electrode voltage supply adjustable, the equipment designer can provide means to compensate for these changes.

The *grid-No.4 and the grid-No.3 voltage* (dc) should be obtained from a common source. When the 6326-A is used without dynamic focusing, grid No.3 should be connected to grids No.4 and No.5, and the voltage source should be adjustable over a range from 200 to 300 volts. Static focusing is obtained by the combined effect of the adjustable grid-No.3-and-grid-No.4 voltage and the



All capacitor voltages are working values

C1: 0.002 μf, 200 volts
C2: 0.25 μf, 200 volts
C3 C9: 0.004 μf, 300 volts
C4 C11: 10 μf, 300 volts
C5: 0.1 μf, 300 volts
C6 C12 C13: 0.25 μf, 300 volts
C7: 0.01 μf, 300 volts
C8: 0.03 μf, 300 volts
C10: 0.005 μf, 300 volts

All resistors are of the carbon-composition type

R1 R7 R18: 500000 ohms, 1/2 watt
R2: 55000 ohms, 1/2 watt
R3 R4: 250000-ohm potentiometer, 2 watts
R5: 10000 ohms, 1 watt
R6: 240000 ohms, 1/2 watt
R8 R9: 750000 ohms, 1/2 watt
R10 R11: 6800 ohms, 1/2 watt
R12: 2500 ohms, 1/2 watt
R13: 4000 ohms, 1/2 watt
R14: 10000-ohm potentiometer, 2 watts
R15: 1 megohm, 1/2 watt
R16 R17: 300 ohms, 1/2 watt

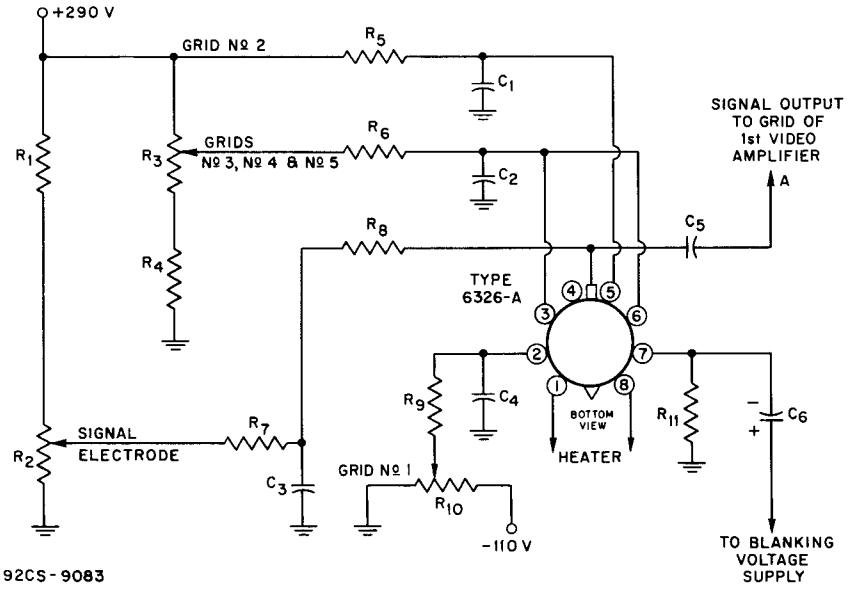
Fig. 3 - Typical Circuit for Supplying Dynamic Focusing Voltage to Type 6326-A.

magnetic field of a focusing coil capable of providing a fixed strength of 40 gausses at its center.

When advantage is taken of the feature of the 6326-A which permits the use of dynamic focusing to provide improved edge focus, grid No.3 is operated separately as the dynamic-focusing electrode. In this case, the voltage source for grid No.4 should be adjustable over a range from 200 to 300 volts, and grid No.3 is supplied with a dc voltage having a value about 60 volts lower than that applied to grid No.4. In addition, grid No.3 is supplied with an ac voltage obtained from a circuit as shown in Fig.3. In this circuit, the waveshape of the horizontal and vertical scanning voltages is modified so that a resultant voltage having parabolic waveform is applied to grid No.3.

The *grid-No.1 voltage* should be adjustable from 0 to -110 volts.

The *dc voltages* required by the 6326-A when operating with static focusing can be provided by the circuit shown in Fig.4(a); and when operated with dynamic focusing, by the circuit shown in Fig.4(b).



C1 C4: 0.01 μf, 300 volts (working voltage)
C2: 0.1 μf, 300 volts (working voltage)
C3 C5: 0.1 μf, 200 volts (working voltage)
C6: 4 μf, electrolytic, 300 volts (working voltage)
R1: 120000 ohms, 1/2 watt
R2: 100000-ohm potentiometer, 2 watts
R3: 50000-ohm potentiometer, 2 watts
R4: 70000 ohms, 1/2 watt
R5: 5000 ohms, 1/2 watt
R6: 10000 ohms, 1/2 watt
R7: 200000 ohms, 1/2 watt
R8: 50000 ohms, 1/2 watt, non-inductive
R9: 100000 ohms, 1/2 watt
R10: 500000-ohm potentiometer, 2 watts
R11: 1000 ohms, 1/2 watt, non-inductive

Fig.4(a) - Typical Voltage Dividers for Supplying DC Electrode Voltages to Type 6326-A when Operated with Grid No.3 Connected to Grids No.4 & No.5.

A *blanking signal* should be supplied to grid No.1 or to the cathode to prevent the electron beam from striking the photoconductive layer during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the reproduced picture. The blanking signal is a series of negative voltage pulses when it is applied to grid No.1, or a series of positive voltage pulses when it is applied to the cathode.

Beam intensity is controlled by the amount of negative voltage on grid No.1. The beam must have adequate intensity to drive the highlight elements of the photoconductive-layer surface to cathode potential on each scan. When the beam has an intensity sufficient only to drive the lowlight elements to cathode potential, the highlight elements are not returned to cathode potential. As a result, the picture highlights all have the same brightness and show no detail. Also, when the beam has insufficient intensity, the photoconductive-layer surface which normally rises in potential by only a small fraction of the signal-electrode potential during each scan, gradually rises in potential to a value approaching nearly the full signal-electrode potential in the highlights. Under this condition, many scans are required to drive to cathode potential any element which has changed from a highlight to a lowlight because of movement of the image on the film. As a result, the highlights tend to "stick". The loss of highlight detail and sticking of the highlights is referred to as "bloom".

On the other hand, a beam with excessively high intensity should not generally be used because the size of the scanning spot increases with resultant decrease in resolution.

The *video amplifier system* should be designed to handle peak ac voltages corresponding to a highlight signal-electrode current of 0.4 microampere through the signal-electrode load resistor. Such a system is shown by the block diagram in Fig.5 (a). This system employs a low-noise, cascode preamplifier having an 8-Mc bandwidth as shown in Fig.5 (b). This type of amplifier insures a signal-to-noise ratio which is adequate for use in the phase-and-aperture-correction circuit illustrated in Fig.5 (c).

Aperture correction compensates for the aperturing effect of the scanning beam in the 6326-A. This effect produces a horizontal amplitude response shown by the "uncompensated" curve in Fig.6. When this effect is compensated by the circuit in Fig.5 (c), the horizontal amplitude

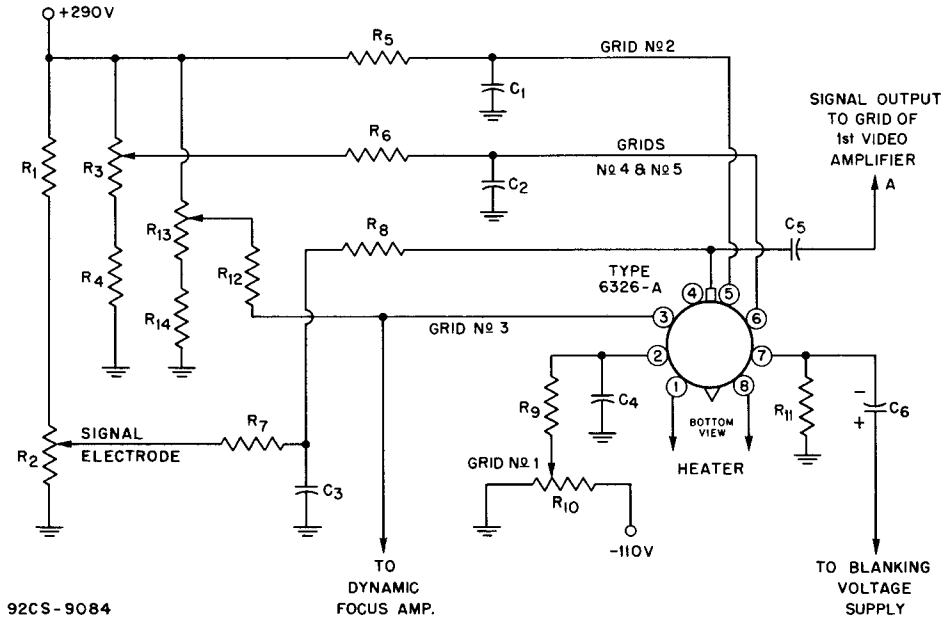
response of the video system is raised to approximately 100 per cent over the entire broadcast bandwidth of 4.5 Mc, and is shown by the "compensated" curve in Fig.6. This compensation, however, does not affect the vertical resolution. Combining the compensated horizontal resolution and the uncorrected vertical resolution yields the equivalent amplitude response which is shown in Fig.6 and is expressed by the equation

$$\text{Equiv. Amplitude Response} = \sqrt{R_V \times R_h}$$

where R_V and R_h are the vertical amplitude response and the horizontal amplitude response, respectively.

The *illumination* incident on the faceplate will range from relatively high values for film pickup to relatively low values for direct pickup. For satisfactory operation of the 6326-A at these extremely different light levels, it is essential that the signal-electrode voltage be properly adjusted with reference to the curves in Figs.2, 7, and 9. For proper adjustment of the signal-electrode voltage, see *sequence of adjustments* on page 9.

For film pickup, an average highlight illumination of 50 to 300 foot-candles is required on the faceplate of the 6326-A for minimum lag and best black-level uniformity. For this range of illumination, the signal-electrode voltage will range between 20 to 40 volts.



Circuit parts are the same as those shown in Fig.4(a) with the following additions:
R12: 100000 ohms, 1/2 watt, non-inductive R13: 600000-ohm potentiometer, 2 watts
R14: 50000 ohms, 1/2 watt

Fig.4(b) - Typical Voltage Dividers for Supplying DC Electrode Voltages to Type 6326-A when Operated with Grid No.3 Used as Dynamic Focusing Electrode.

For direct pickup, a good picture can be obtained with a constant highlight illumination of not less than 10 foot-candles, or its equivalent when color filters are used, on the faceplate of the 6326-A. At 10 foot-candles, the signal-electrode voltage will range between 40 and 70 volts. With the relatively low light levels encountered in direct pickup, the lag will be greater than and the black-level uniformity will be inferior to the lag and uniformity obtained under the higher light levels and lower signal-electrode voltages used in film pickup.

In all cases, the illumination level and/or signal-electrode voltage must be limited or adjusted so that the peak signal-output current does not exceed a value of 0.3 to 0.4 microampere. In order that the signal-output current will be known at all times, it is recommended that the camera be provided with a suitable microammeter in the signal-electrode circuit of each 6326-A to read average current, or that a calibration pulse of the proper magnitude be fed into the input of the video pre-amplifier to indicate peak signal current.

The maximum amount of illumination on the photoconductive layer is limited primarily by the temperature of the faceplate which should never exceed 60°C and should preferably be maintained within the operating range from 25°C to 35°C for most satisfactory performance.

Signal Output and Light Transfer Characteristics. Typical signal output as a function of uniform 2870°K tungsten illumination on the photoconductive layer for different signal-electrode voltages is shown in Fig.8. It is to be noted that these curves are for a typical 6326-A under the conditions indicated. Because the signal-electrode voltage needed to give maximum sensitivity at a maximum dark current of 0.02 microampere may range between 20 and 100 volts, it is essential that the best operating signal-electrode voltage be determined for each 6326-A. From these curves, it will also be noted that the illumination must be increased about 30 times to produce an increase of 10 times in signal-output current for any given signal-electrode voltage.

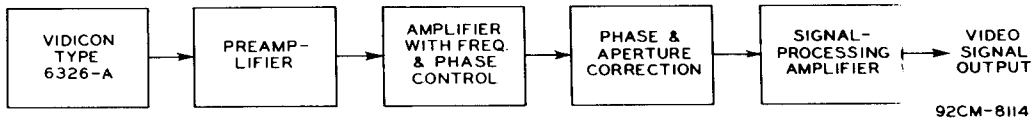
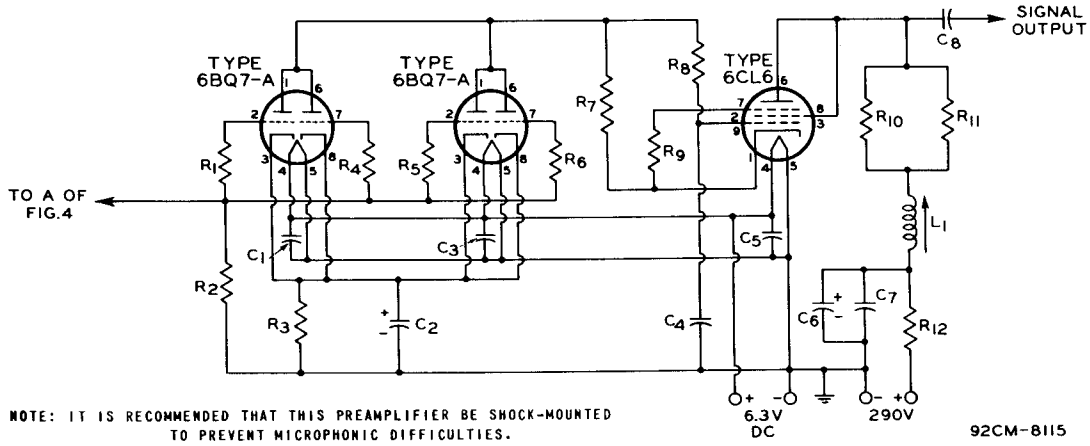


Fig. 5(a) - Block Diagram of Video System.



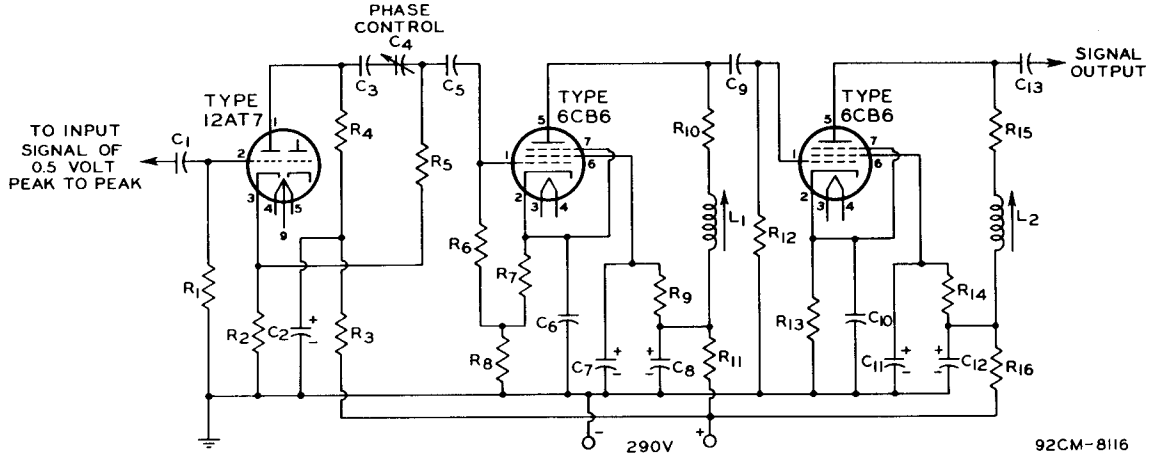
All capacitor voltages are working values

C1 C3 C5: 0.01 μf, 100 volts
C2: 2000 μf, electrolytic, 3 volts
C4: 0.01 μf, 350 volts
C6: 90 μf, electrolytic, 350 volts
C7: 0.1 μf, 350 volts
C8: 0.1 μf, 300 volts
L1: 12 μh peaking coil, adjustable core to cover range from 9 to 15 μh

All resistors are of the carbon-composition type

R1 R4 R5 R6: 100 ohms, 1/2 watt
R2: 500000 ohms, 1/2 watt
R3: 15 ohms, 1/2 watt
R7: 12 ohms, 1/2 watt
R8: 100000 ohms, 1/2 watt
R9: 1 megohm, 1/2 watt
R10 R11: 1800 ohms, 2 watts
R12: 470 ohms, 2 watts

Fig. 5(b) - Low-Noise Cascode Preamplifier Having 8-Mc Bandwidth.



All capacitor voltages are working values

C1: 0.25 μf, 300 volts
C2 C7 C8 C11 C12: 10 μf, electrolytic 350 volts
C3: 0.001 μf, 600 volts
C4: 0-100 μμf, adjustable, 600 volts
C5: 0.25 μf, 200 volts
C6: 200 μμf, 600 volts
C9 C13: 0.1 μf, 300 volts
C10: 75 μμf, 600 volts
L1 L2: 15 μh peaking coil, adjustable core to cover range from 10 to 25 μh

All resistors are of the carbon-composition type

R1 R6: 330000 ohms, 1/2 watt
R2 R4: 100 ohms, 1/2 watt
R3 R11 R16: 8200 ohms, 2 watts
R5: 680 ohms, 1/2 watt
R7: 120 ohms, 1/2 watt
R8: 300 ohms, 1/2 watt
R9 R14: 62000 ohms, 1/2 watt
R10 R15: 1500 ohms, 1/2 watt
R12: 250000 ohms, 1/2 watt
R13: 220 ohms, 1/2 watt

Fig. 5(c) - Phase- and Aperture-Correction Circuit.

The average "gamma", or slope, of the light transfer characteristic curves shown in Fig. 8 is approximately 0.65. This value is relatively constant over an adjustment range of 3 to 1 in signal-electrode voltage for a signal-output current range between 0.01 and 0.3 microampere.

Persistence or lag of the photoconductive layer as a function of signal-electrode voltage is given by the curve in Fig. 9. This curve shows decreasing lag with decreasing signal-electrode voltage, and a small value of lag for the low signal-electrode voltages recommended for film pickup.

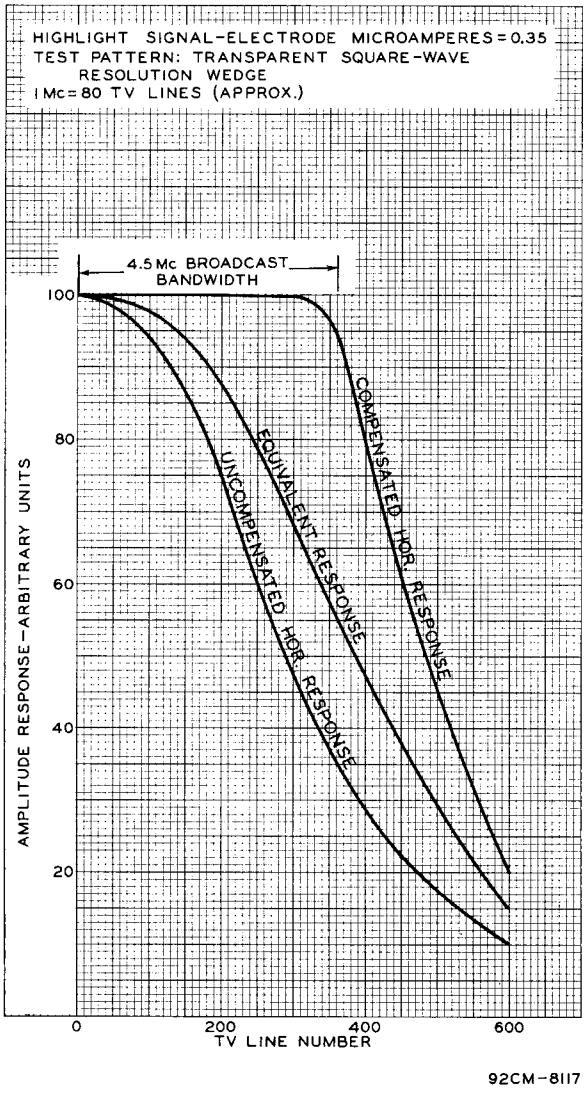


Fig. 6 - Characteristics of the Video System Showing Uncompensated Horizontal Amplitude Response, Compensated Horizontal Amplitude Response, and Equivalent Amplitude Response.

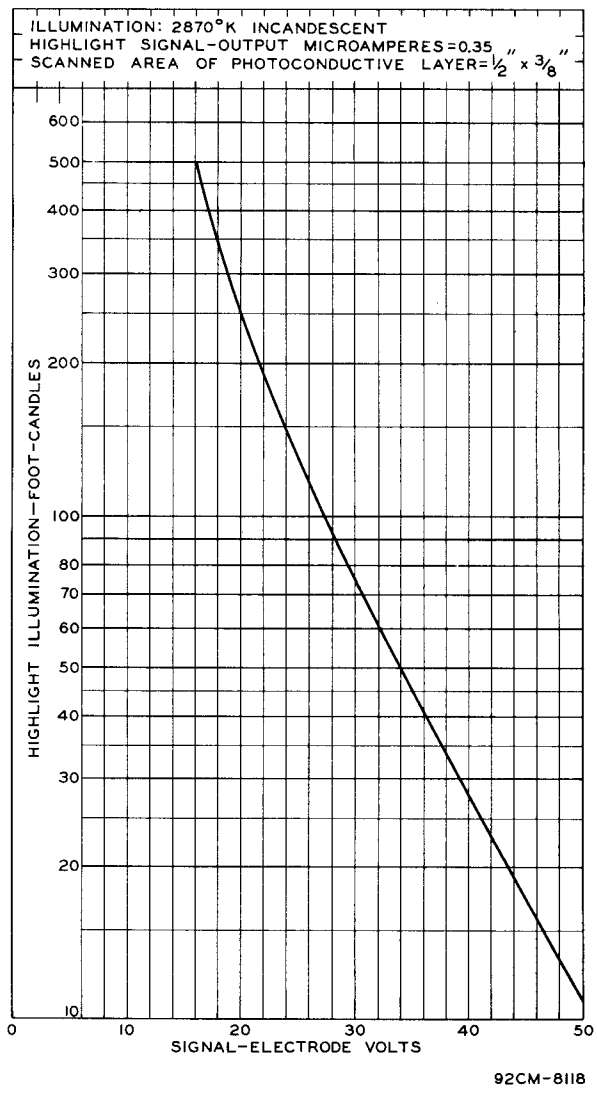


Fig. 7 - Typical Characteristic of Type 6326-A.

Close uniformity in the value of gamma between individual 6326-A's is maintained to insure satisfactory operation of color cameras in which the signal-output currents of the three 6326-A's must match closely over a wide range of scene illumination. Because its transfer characteristic is approximately the complement of the transfer characteristic of a kinescope, the 6326-A can produce a picture having proper tone rendition.

The *spectral response* of the 6326-A is shown by curves A and C in Fig. 10. Curve A is on the basis of equal values of signal-output current at all wavelengths, whereas curve C is on the basis of equal values of signal-output current with radiant flux from a tungsten source at 2870°K. For comparison purposes, the response of the eye is shown in curve B.

Full-size scanning of the 1/2" x 3/8" area of the photoconductive layer should always be used. This condition can be assured by first adjusting the deflection circuits to overscan the photoconductive layer sufficiently so that

the edges of the sensitive area can be seen on the monitor. Then, after centering the image on the tube face just inside the edges of the sensitive area (see Fig. 11), reduce scanning until

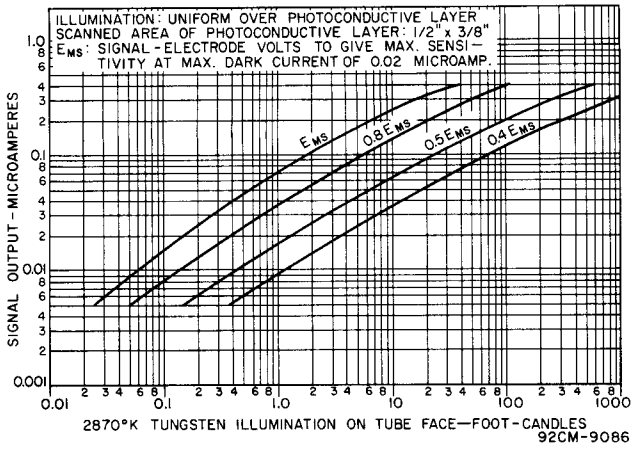


Fig. 8 - Light Transfer Characteristics of a Typical 6326-A Vidicon.

the edges just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. It should be noted that overscanning the photoconductive layer produces a smaller-than-normal picture on the monitor.

Underscanning of the photoconductive layer, i.e., scanning an area of the layer less than its useful quality area, should never be permitted. This condition which produces a larger-than-normal picture on the monitor, not only causes sacrifice in signal-to-noise ratio and resolution, but also may cause permanent change in sensitivity and dark current of the underscanned area. An underscanned area showing such a change will be visible in the picture when full-size scanning is restored.

Failure of scanning even for a few minutes may permanently damage the photoconductive layer. The damaged area shows up as a spot or line in the picture during subsequent operation. To avoid damaging the 6326-A during scanning failure, it is necessary to prevent the scanning beam from reaching the layer. The scanning beam can conveniently be prevented from reaching the layer by increasing the grid-No. 1 voltage to cutoff.

The *sequence of adjustments* in operating the 6326-A for film pickup is as follows: With the Grid-No. 1 Voltage Control set for minimum bias, Signal-Electrode Voltage Control set for minimum voltage, and Deflection Controls set for maximum overscan, apply other voltages to the 6326-A as indicated under *Typical Operation*.

Next, with the projector operating and with a suitable test strip of film in the gate, focus and center the image from the projector on the face of the tube as shown in Fig. 11. Increase grid-No. 1 bias to just bring out the highlight details of the picture on the monitor. Adjust Beam-Focus Voltage Control and the optical focus to obtain the best picture. Reduce horizontal and vertical scanning so that the edges of the image extend just outside the scanned area on the monitor.

With no illumination on the tube face, increase the signal-electrode voltage until a dark-current value of approximately 0.005 microampere is measured. If a microammeter is not available or if an available microammeter is not sufficiently sensitive, note the setting of the Signal-

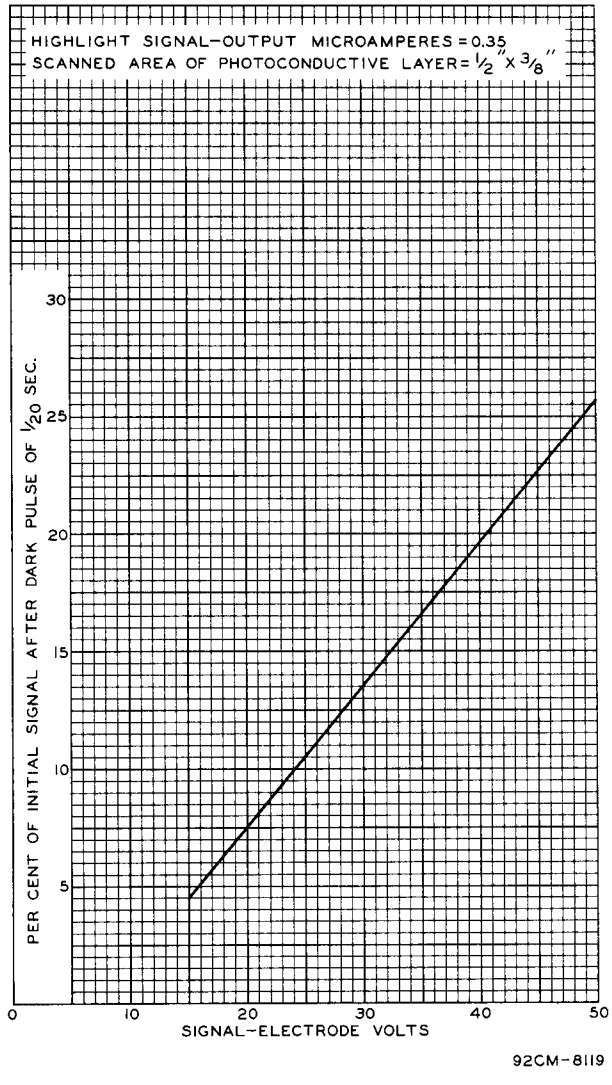


Fig. 9 - Persistence Characteristic of Type 6326-A.

Electrode Voltage Control at which flare becomes objectionable or the dark-current value reaches 0.02 microampere, and then adjust this control to give approximately one half of the voltage determined in this manner.

Next, adjust the alignment field so that the center of the picture does not move as the beam-focus voltage is varied. Some readjustment of horizontal and vertical centering may be necessary after alignment. Now, with the projector operating and no film in the gate, adjust the illumination on the faceplate of the 6326-A so as to obtain a dc signal-electrode current of 0.35 to 0.40 microampere. A value greater than this is not desirable because resolution is sacrificed. Readjust the grid-No.1 voltage to bring out the details in the highlights of the picture.

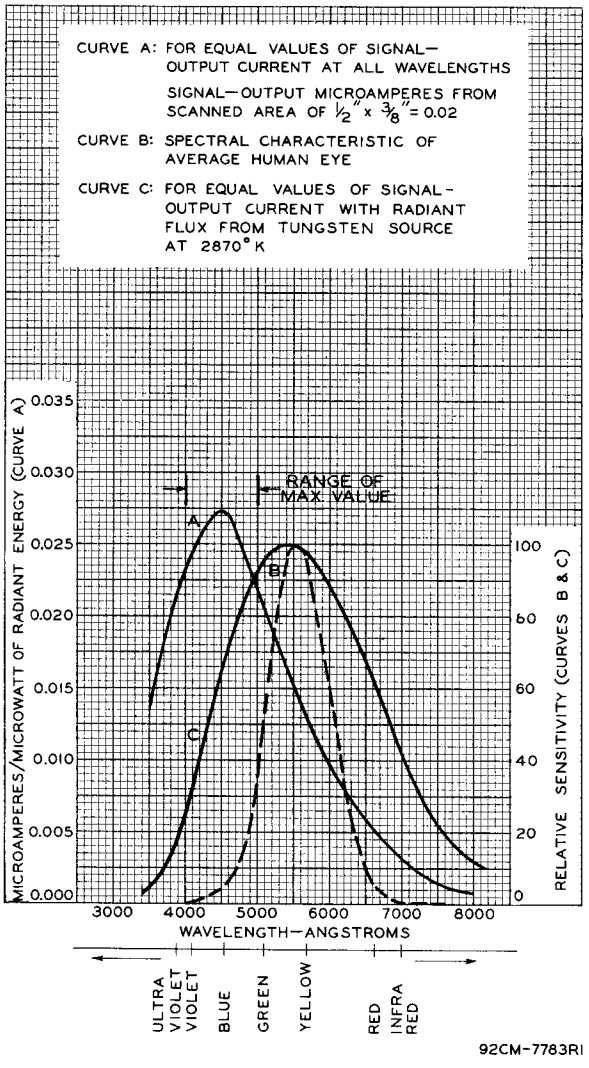


Fig. 10 - Spectral Sensitivity Characteristics of Type 6326-A.

When dynamic focusing is used, and after making the preceding adjustments, adjust the Dynamic-Focus Gain Control to provide the best overall focus.

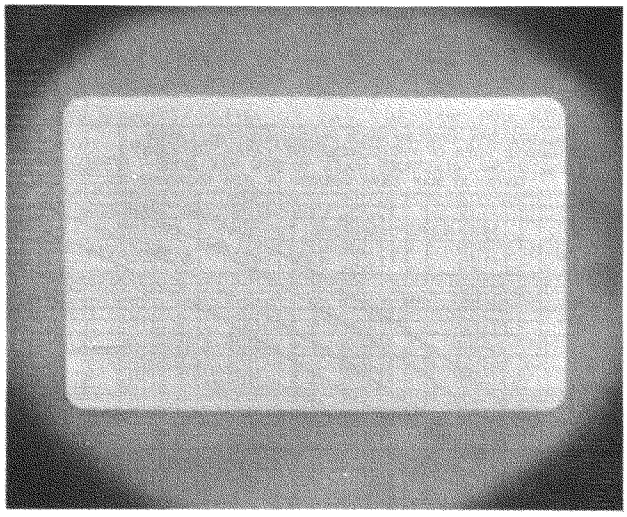


Fig. 11 - Photograph Showing Proper Positioning of Image from Projector on the Face of the Vidicon.

The adjustments in operating the 6326-A for pickup from limited-motion live scenes are similar to those for film pickup except that the signal-electrode voltage is adjusted, with no illumination on the tube face, to the highest value which will permit obtaining a uniform or flat dark-current output. With the signal-electrode voltage thus adjusted, maximum sensitivity for direct pickup is obtained but at a cost of increased lag. In setting up three 6326-A's in a color camera, particular attention must be given to proper alignment, best obtainable focus, and identical centering of scanning areas on the photoconductive layers. Observation of these operating conditions will assure good registration of the three separate video signals.

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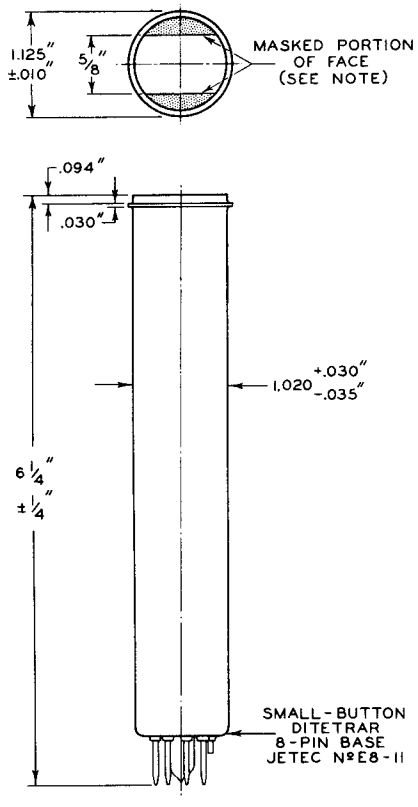
DIMENSIONAL OUTLINE

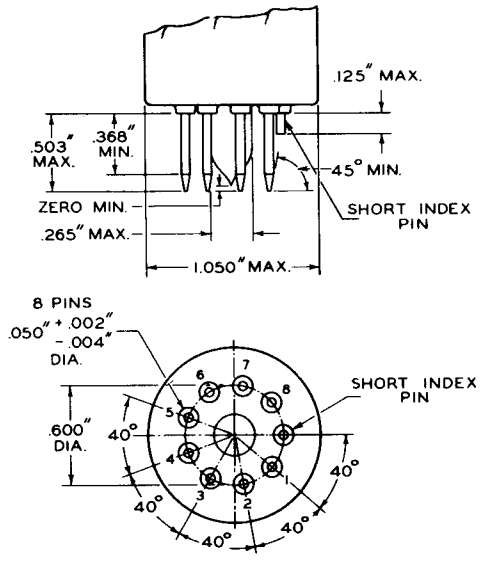


92CS-9081

NOTE: STRAIGHT SIDES OF MASKED PORTIONS ARE PARALLEL TO THE PLANE PASSING THROUGH TUBE AXIS AND SHORT INDEX PIN.

BASE DRAWING

SMALL-BUTTON DITETRAR
8-PIN BASE
JETEC NºE8-11

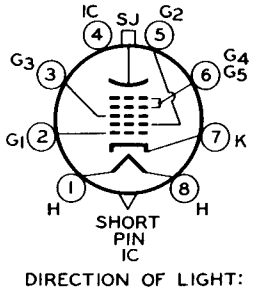


92CS-7765

Base-pin positions are held to tolerances such that pins will fit a flat-plate gauge having thickness of 1/4" and 9 holes 0.0700" ± 0.0005" so located on a 0.6000" ± 0.0005" diameter circle that the distance along the chord between any two adjacent hole centers is 0.2052" ± 0.0005". Gauge is provided with center hole having diameter of 0.300" ± 0.001" and same center as the pin circle.

SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: GRID No.3
PIN 4: INTERNAL CONNECTION--DO NOT USE
PIN 5: GRID No.2
PIN 6: GRIDS No.4 and No.5

PIN 7: CATHODE
PIN 8: HEATER
FLANGE: SIGNAL ELECTRODE (SJ)
SHORT INDEX PIN: INTERNAL CONNECTION--MAKE NO CONNECTION

DIRECTION OF LIGHT:
INTO FACE END OF TUBE

8HL

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6328

MULTIPLIER PHOTOTUBE

9-Stage Type with S-4 Response for Headlight-Control Service

TENTATIVE DATA

RCA-6328 is a short, rugged multiplier phototube of the 9-stage type intended especially for automobile headlight-dimming service.

Having instantaneous response to meet the critical timing requirements of headlight-control service, the 6328 is capable of providing stable performance over long periods. Its high luminous sensitivity allows use of an amplifier with relatively low-impedance input and fewer stages than required by a less-sensitive tube. Furthermore, the 6328 has low electrode dark current which makes feasible the use of high-resistance voltage-divider networks to minimize power requirements and to improve not only operating stability but also life.

DATA

General:

Spectral Response	S-4
Wavelength of Maximum Response	4000 ± 500 angstroms
Cathode:	
Minimum Projected Length*	15/16"
Minimum Projected Width*	5/16"
Direct Interelectrode Capacitances:	
Anode to Dynode No.9	4.2 μμf
Anode to All Other Electrodes	5.5 μμf
Maximum Overall Length	3-1/8"
Maximum Seated Length	2-11/16"
Length from Base Seat to Center of Useful Cathode Area	1-9/16" ± 3/32"
Maximum Diameter	1-5/16"
Bulb	T-9
Base	Small-Shell Neosubmagnal 11-Pin, Non-hygroscopic (JETEC No. B11-104)
Mounting Position	Any

Maximum Ratings, *Absolute Values*:

ANODE-SUPPLY VOLTAGE (DC or Peak AC)	1250 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.9 AND ANODE (DC or Peak AC)	250 max.	volts
AVERAGE ANODE CURRENT°	0.1 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

* On plane perpendicular to the indicated direction of light (see *Dimensional Outline*).

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across voltage divider providing 1/10 of E between cathode and dynode No.1; 1/10 of E for each succeeding dynode stage; and 1/10 of E between dynode No.9 and anode

With E = 1000 volts

	Min.	Av.	Max.	
Sensitivity:				
Radiant, at 4000 angstroms	–	32500	–	μamp/μwatt
Luminous:▲				
At 0 cps	5	35	250	amp/lumen
At 100 Mc	–	33	–	amp/lumen
Electrode Dark Current (At 25°C):				
Anode	–	–	0.1	μamp
Any other electrode	–	–	0.75	μamp

° Averaged over any interval of 30 seconds maximum.

▲ For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light input of 10 microlumens is used. The load resistor has a value of 0.01 megohm.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant energy of a given wavelength, at constant electrode voltages.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Electrode Dark Current. The electrode current which flows when there is no radiant flux incident on the photocathode.

GENERAL CONSIDERATIONS

An *electron multiplier* is a vacuum tube which utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 6328 multiplier phototube, represented in Fig.3, the electrons emitted from the illuminated cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.9) are collected by the anode and constitute the current utilized in the output circuit.

Dynode No.9 is so shaped as to enclose partially the anode and to serve as a shield for

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it in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grating which allows the electrons

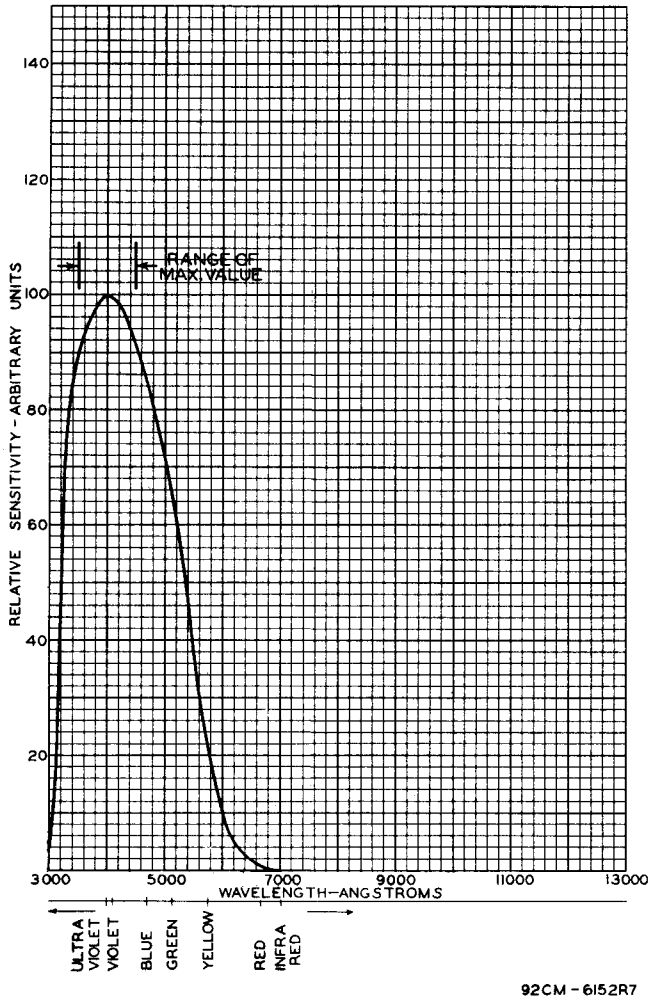


Fig. 1 - Spectral Sensitivity Characteristic of Type 6328 which has S-4 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

from dynode No.8 to pass through it to dynode No.9. Spacing between dynode No.9 and anode creates a collecting field such that all the electrons emitted by dynode No.9 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 6328 can be coupled to any practical load impedance.

The shield which extends between the photocathode and the anode shields the photocathode from the anode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the photocathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration.

The grill through which the incident radiation reaches the photocathode, is connected to the photocathode and serves as an electrostatic shield for the open side of the electrode structure.

INSTALLATION and APPLICATION

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6328 may be impaired from the

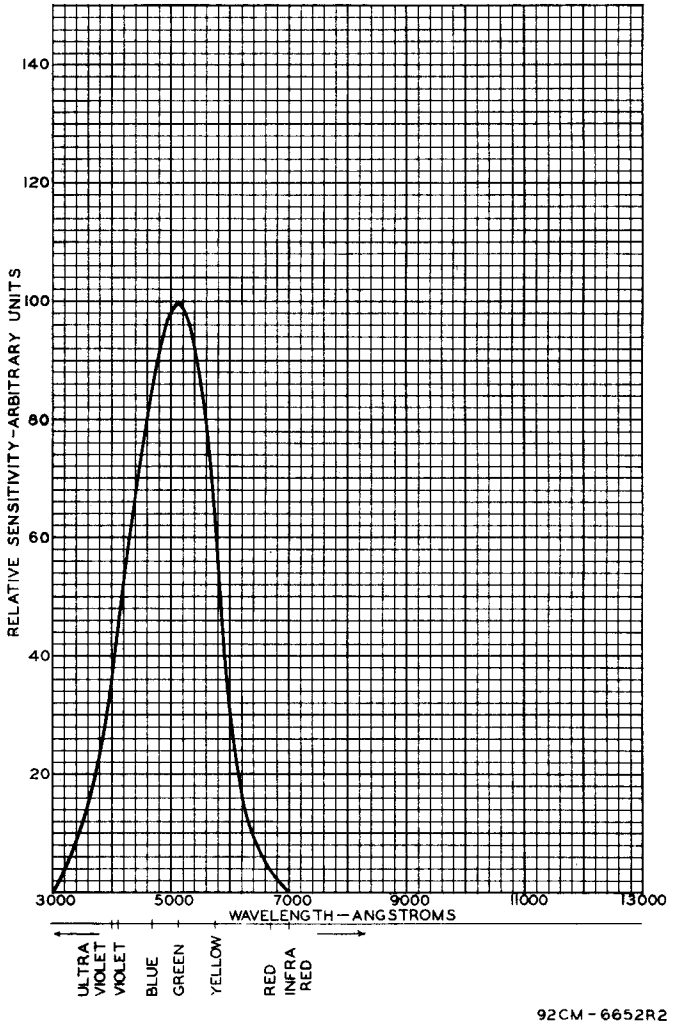


Fig. 2 - Sensitivity Characteristic of Type 6328 Obtained by Multiplying Its Spectral Sensitivity Characteristic in Fig. 1 by the Relative Energy Distribution Characteristic of a Tungsten Lamp at 2870°K.

viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value

for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

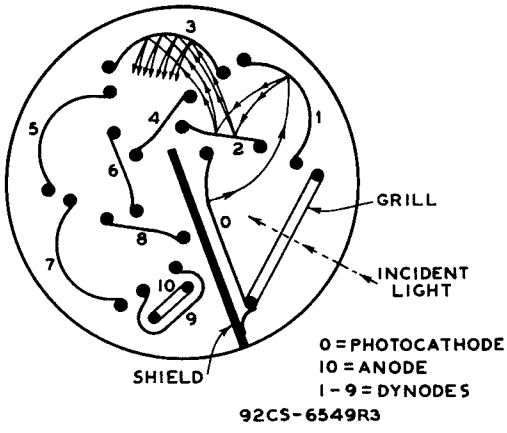


Fig.3 - Schematic Arrangement of Type 6328 Structure.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface and dynode surfaces to evaporate with consequent decrease in the life and sensitivity of the tube.

The *base pins* of the 6328 fit the neosubmagnal 11-contact socket. The socket should be made of high-grade, low-leakage material, and should be installed so that the base key of the tube faces the incident radiation.

In general, the *operating voltages* for the 6328 are as follows. The successive stages are operated at voltages increasing in equal steps from the photocathode to the 9th dynode. The steps are generally chosen as 50 to 100 volts per stage. The voltage between dynode No.9 and the anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristic curves, shown in Fig.4, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. Low operating voltage between dynode No.9 and anode reduces the dark current. As a result, the operating stability of the 6328 is improved without sacrifice in sensitivity. To obtain the indicated operating voltage between dynode No.9 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

The *operating stability* of the 6328 is dependent on the magnitude of the anode current and its duration. When the 6328 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 6328 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 0.1 milliampere is recommended when stability of operation is important. When maximum stability is required, the

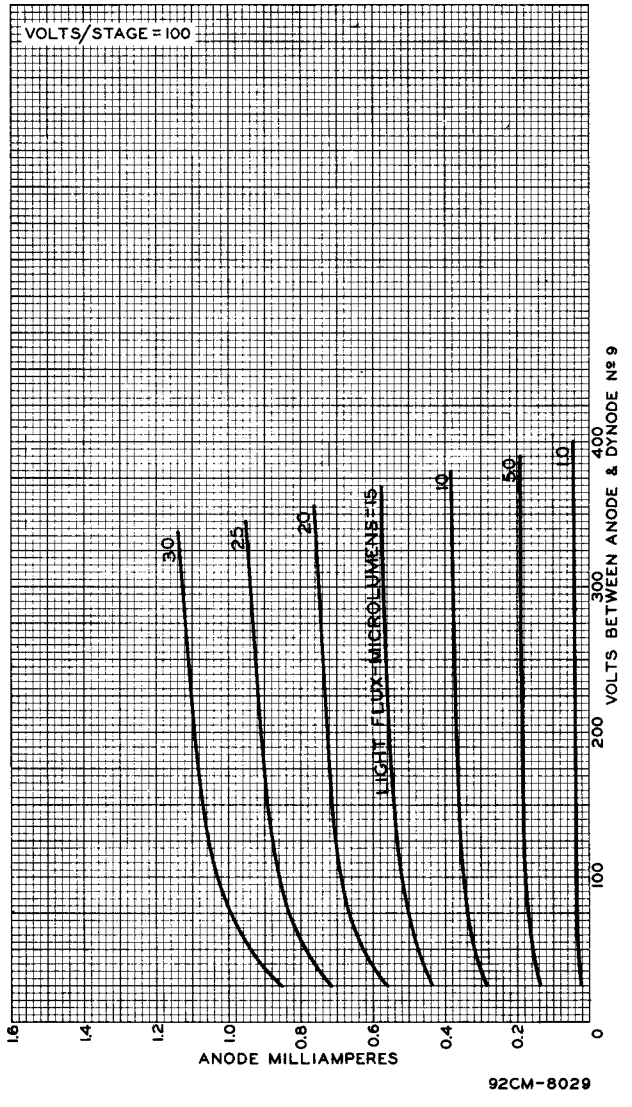


Fig.4 - Average Anode Characteristics of Type 6328.

The *sensitivity of the photocathode surface* varies with respect to the position of the light spot on the surface. Fig.5a shows the variation in sensitivity of the surface as the position of

a 1-mm light spot is moved from one end of the photocathode to the other. Similarly, the curve in Fig.5b shows how the sensitivity of the photocathode surface varies across its projected width in the plane of the grill. From these curves, the equipment designer can readily determine the optimum position of any light spot on the photocathode surface to give the highest sensitivity.

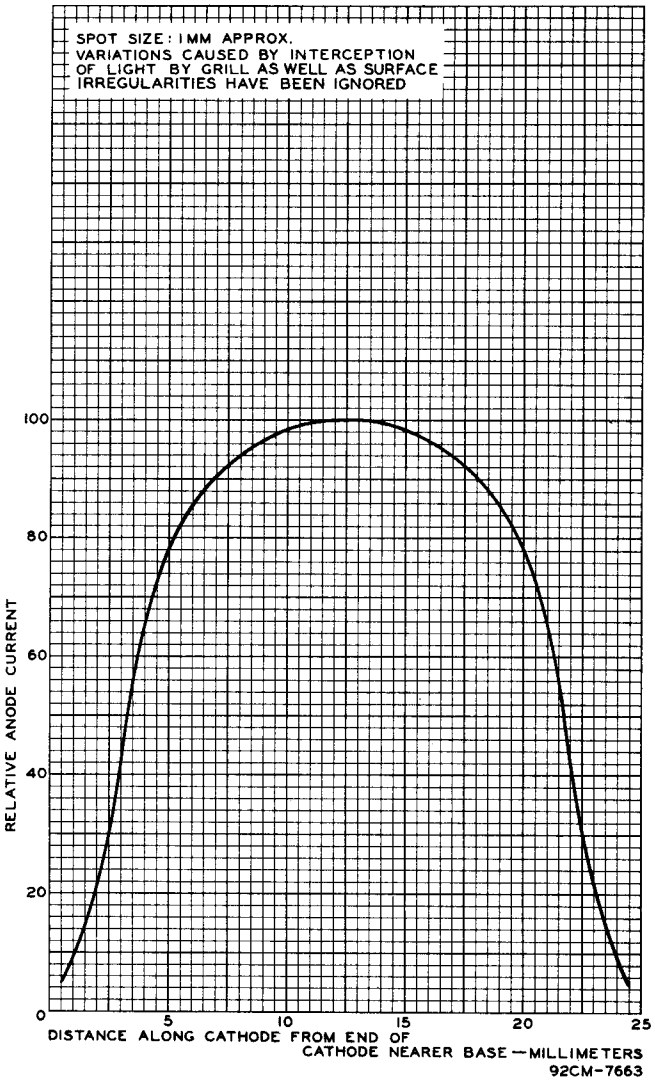


Fig.5a - Variation in Sensitivity of Photocathode Along Its Length.

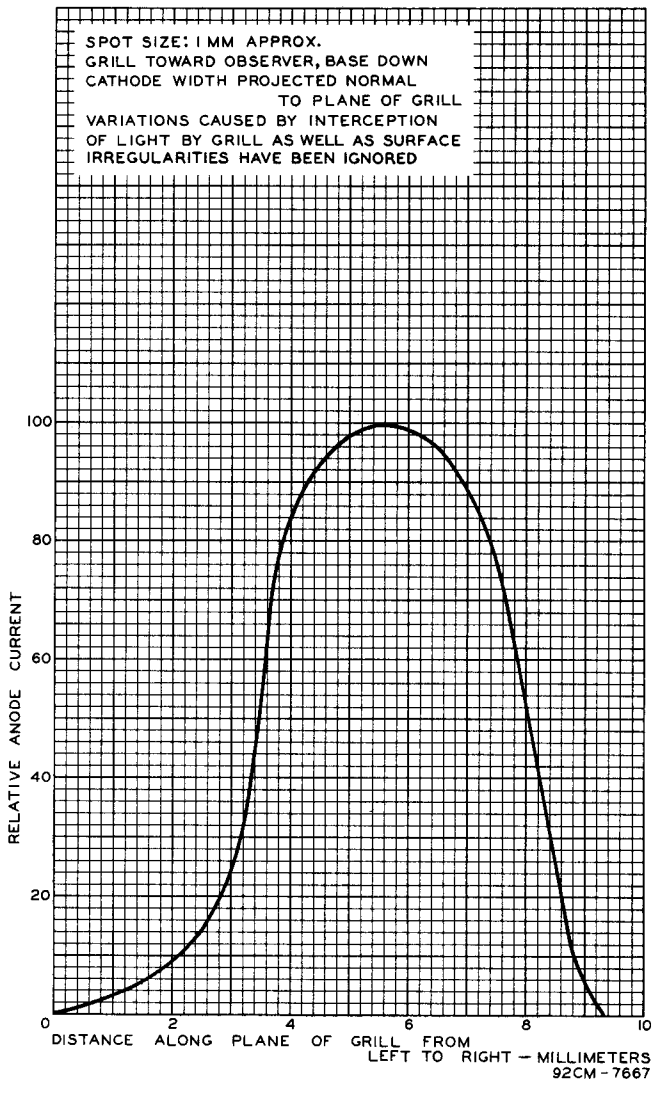


Fig.5b - Variation in Sensitivity of Photocathode Across Its Projected Width in Plane of Grill.

Fig.6 shows the range of luminous sensitivity versus the dc voltage per stage for the 6328.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence, large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the nth power, where n is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for the equipment designer to provide adequate adjustment of the supply voltage so that the amplification of individual tubes can be adjusted to the desired design value. It is suggested that an overall voltage-adjustment range of 2 to 1 be provided.

When the 6328 is operated with an ac supply, its effective sensitivity is reduced because appreciable anode current flows only near the peak of the positive cycle. The amount of the reduction is dependent on the ac waveshape. For

an ideal square wave, the sensitivity is reduced by a factor of 2.

The *electrode voltages* may be obtained from an adequately regulated ac or dc power supply. An *ac supply* may be conveniently obtained from a high-voltage transformer operated from a suitable vibrator. A *dc supply* may be obtained by employing a high-voltage, vacuum tube rectifier operated from a high-voltage transformer fed by a vibrator. The voltage for each dynode and for the anode can be supplied by fixed taps on a voltage divider across the power supply.

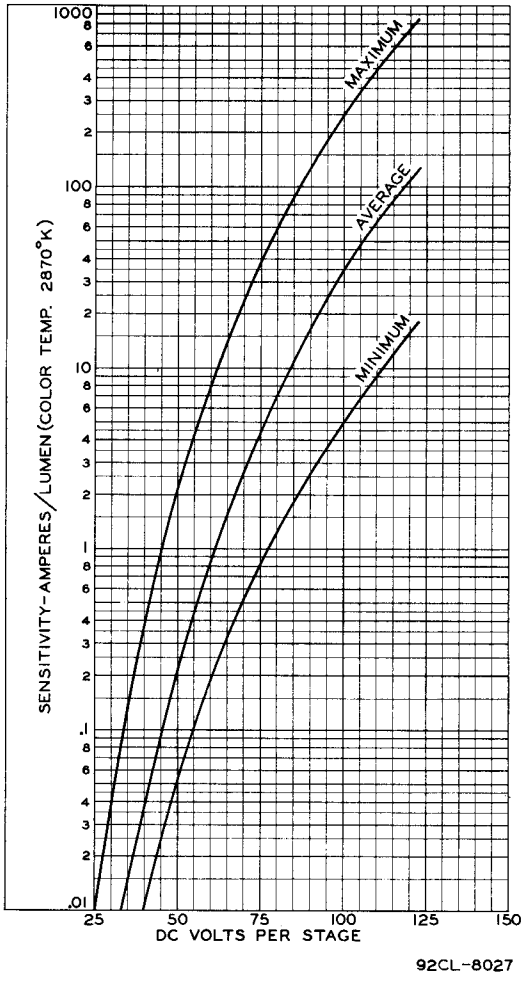
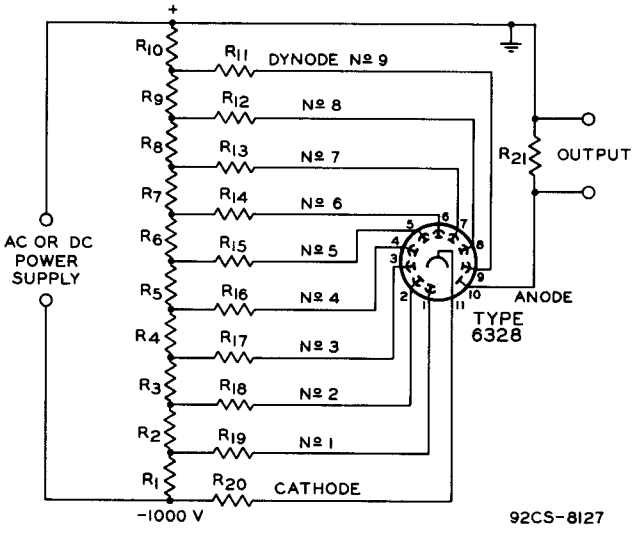


Fig. 6 - Range of Luminous Sensitivity of Type 6328.

A recommended design of voltage-divider network for use with the 6328 to provide stable operation and long tube life is shown in Fig. 7. This design provides linear operation within the range normally required for dimming. At higher light levels, the network design limits the tube output to a safe value. The indicated design values provide dimming operation for an anode current in the range between 5 and 10 microamperes.

It is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.



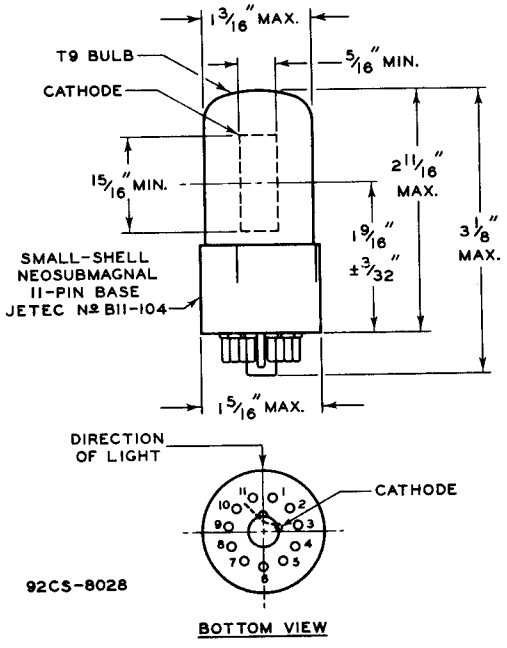
R1 R2 R3 R4 R5
R6 R7 R8 R9 R10: 1 megohm, 1/2 watt
R11: 2 megohms, 1/2 watt
R12: 5.1 megohms, 1/2 watt
R13 R14 R15 R16
R17 R18 R19 R20: 8.2 megohms, 1/2 watt
R21: 820,000 ohms, 1/2 watt

Fig. 7 - Recommended Voltage-Divider Network for Use with Type 6328 in Headlight Dimming Service.

The high voltages at which the 6328 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 6328, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power supply should be disconnected and both terminals of any capacitors grounded.

DIMENSIONAL OUTLINE

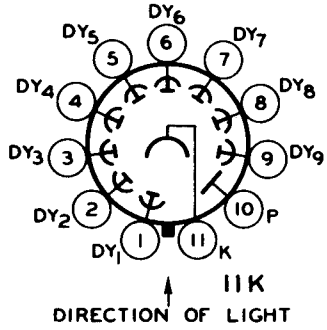


BOTTOM VIEW

℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: THE MAXIMUM ANGULAR VARIATION BETWEEN THE PLANE THROUGH PINS No. 1 AND No. 11 AND THE PLANE OF THE GRILL WILL NOT EXCEED 6°.

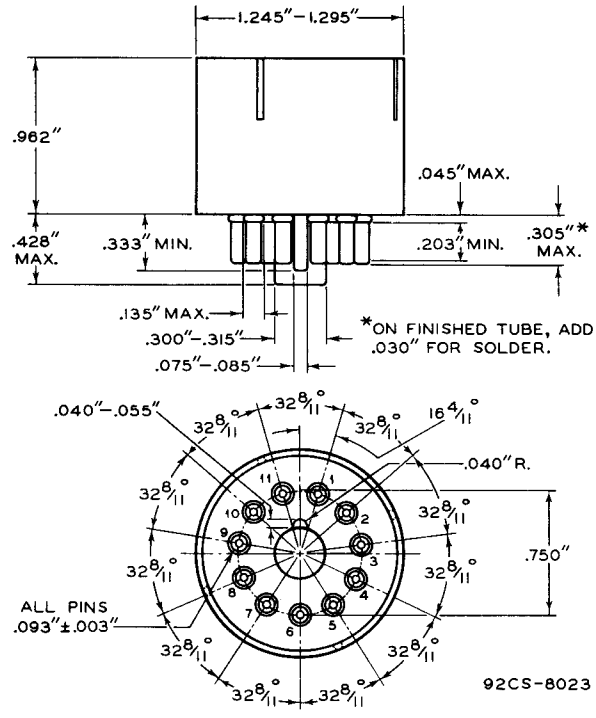
SOCKET CONNECTIONS
Bottom View



DIRECTION OF LIGHT

PIN 1: DYNODE No. 1
PIN 2: DYNODE No. 2
PIN 3: DYNODE No. 3
PIN 4: DYNODE No. 4
PIN 5: DYNODE No. 5
PIN 6: DYNODE No. 6
PIN 7: DYNODE No. 7
PIN 8: DYNODE No. 8
PIN 9: DYNODE No. 9
PIN 10: ANODE
PIN 11: CATHODE

SMALL-SHELL NEOSUBMAGNAL
11-PIN BASE
JETEC No. B11-104



Base-pin positions are held to tolerances such that pins will fit flat-plate gauge having thickness of 1/4 inch and eleven 0.1030"-0.1035" holes so located on a 0.7500" ± 0.0005" diameter circle that the distance along the chord between any two adjacent hole centers is 0.2125" ± 0.0005". Pin fit in gauge shall be such that entire length of pins will enter gauge, and on withdrawal, they will become disengaged without lifting gauge and supplementary weight totaling 3 pounds.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

6342-A

MULTIPLIER PHOTOTUBE

1.68" Dia. Curved Circular Semitransparent Photocathode

10-Stage, Head-On Type, Flat Faceplate
S-11 Response
High-Current Dynodes

2.31" Max. Diameter
5.81" Max. Length
Diheptal 14-Pin Base

TENTATIVE DATA

RCA-6342-A is a head-on type of multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear radiation, and in other applications involving low-level light sources.

Design features of the 6342-A include dynodes with stable high-current capability, a focusing electrode with external connection for shaping the field which directs photoelectrons from the photocathode onto the first dynode, and a semitransparent photocathode on the curved inner surface of the face end of the bulb.

The focusing electrode permits optimizing the magnitude, uniformity, or speed of the response in critical applications.

The curved photocathode surface of the 6342-A assures very good collection by dynode No.1 of electrons from all parts of the useful photocathode area to give a typical pulse-height resolution of about 8 per cent. The curved surface together with the electrode configuration employed in the 6342-A minimizes variation in electron-transit time between the photocathode and dynode No.1.

The spectral response of the 6342-A covers the range from about 3000 to 6500 angstroms, as shown in Fig.2. Maximum response occurs at approximately 4400 angstroms. The 6342-A, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation.

DATA

General:

Spectral Response	S-11
Wavelength of Maximum Response	4400 ± 500 angstroms
Cathode, Semitransparent:	
Shape	Curved Circular
Window:	
Area	2.2 sq. in.
Minimum diameter	1.68 in.
Index of refraction	1.51
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10	4.4 μμf
Anode to all other electrodes	7.0 μμf
Maximum Overall Length	5.81"
Seated Length	4.87" ± 0.19"
Maximum Diameter	2.31"
Bulb	T-16
Base	Medium-Shell Diheptal 14-Pin (JETEC Group 5, No.B14-38), Non-hygroscopic
Operating Position	Any
Weight (Approx.)	5.2 oz

Maximum Ratings, *Absolute Values:*

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE (DC or Peak AC)	1500 max.	volts
SUPPLY VOLTAGE BETWEEN ANODE AND DYNODE No.10 (DC or Peak AC)	250 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC or Peak AC)	400 max.	volts
FOCUSING-ELECTRODE SUPPLY VOLTAGE (DC or Peak AC)	400 max.	volts
AVERAGE ANODE CURRENT■	2 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between dynode No.1 and cathode; 1/12 of E for each succeeding dynode stage; and 1/12 of E between anode and dynode No.10.

With E = 1250 volts (except as noted) and Focusing-Electrode* Voltage Adjusted to Give Maximum Anode Current

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	–	11000	–	μa/μw
Cathode Radiant, at 4400 angstroms	–	0.064	–	μa/μw
Luminous:●				
At 0 cps	4	14	120	amp/lumen
With dynode No.10 as output electrode†	–	10	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲	50	80	–	μa/lumen
With blue light source⊕	0.05	–	–	μa

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6342-A 9-58
Printed in U.S.A.

	Min.	Median	Max.	
Current Amplification	-	175000	-	
Equivalent Anode-Dark-Current Input#●	-	5×10^{-10}	2×10^{-9}	lumen
Equivalent Noise Input**	-	7×10^{-12}	1.7×10^{-11}	lumen
Anode-Pulse Rise Time□	-	3	-	millimicrosec
Greatest Delay Between Anode Pulses:				
Due to position from which electrons are simultaneously released within a circle centered on tube face and having a diameter of—				
1-1/8"	-	1.3✠	-	millimicrosec
1-9/16"	-	4✠	-	millimicrosec

■ Averaged over any interval of 30 seconds maximum.

* The focusing electrode should be connected to the adjustable arm of a potentiometer between cathode and dynode No.1 in the voltage divider, and operated at an optimum potential within the range of 10 to 60 per cent of the dynode No.1 potential.

● For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K. A light input of 10 microlumens is used. The load resistor has a value of 0.01 megohm.

† An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.10 as the output electrode. With this arrangement, the load is connected in the dynode-No.10 circuit and the anode serves only as collector.

▲ For conditions the same as shown under (●) except that the value of light flux is 0.01 lumen and 200 volts are applied between the cathode and all other electrodes connected together as anode.

⊕ Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 200 volts are applied between cathode and all other electrodes connected together as anode.

\# Measured at a tube temperature of 25° C and with the supply voltage (E) adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

● For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1250 volts is recommended.

** Under the following conditions: Supply voltage (E) is 1250 volts, 25° C tube temperature, external shield potential -1250 volts with respect to anode, ac-amplifier bandwidth of 1 cycle per second, tungsten light source of 2870° K interrupted at low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

□ Measured between 10 per cent and 90 per cent of maximum anode-pulse height. This anode pulse rise time is determined by transit-time variations in the multiplier stages only with an incident light spot approximately 1 millimeter in diameter centered on the photocathode.

✠ These values also represent the difference in time of transit between the photocathode and dynode No.1 for electrons simultaneously released from the center and from the periphery of the specified areas.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Pulse Rise Time. The time required for the instantaneous amplitude of the pulse to go from 10 per cent to 90 per cent of the peak value.

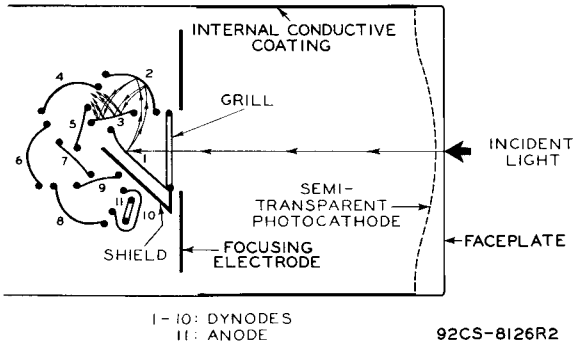

Fig. 1 - Schematic Arrangement of Type 6342-A Structure.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The use of an *average anode current* well below the maximum rated value of 2 milliamperes is recommended when stability of operation is important.

Electrostatic and/or magnetic shielding of the 6342-A may be necessary. When a shield is used it should be connected to a potential near that of the cathode.

The high voltages at which the 6342-A is operated are very dangerous. Before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

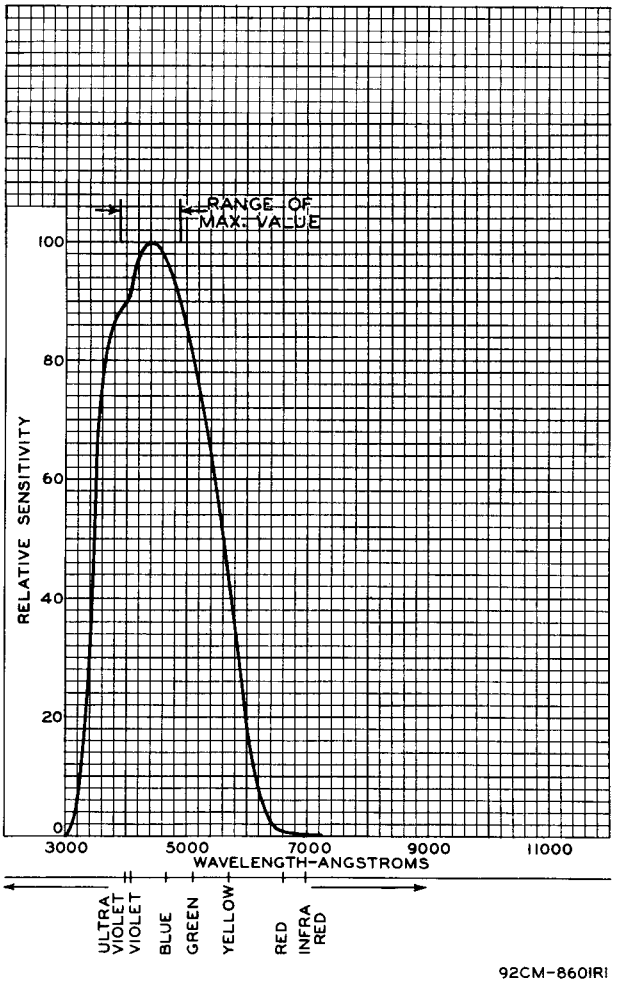

Fig. 2 - Spectral Sensitivity Characteristic of Type 6342-A which has S-11 Response. Curve is shown for Equal Values of Radiant Power at All Wavelengths.

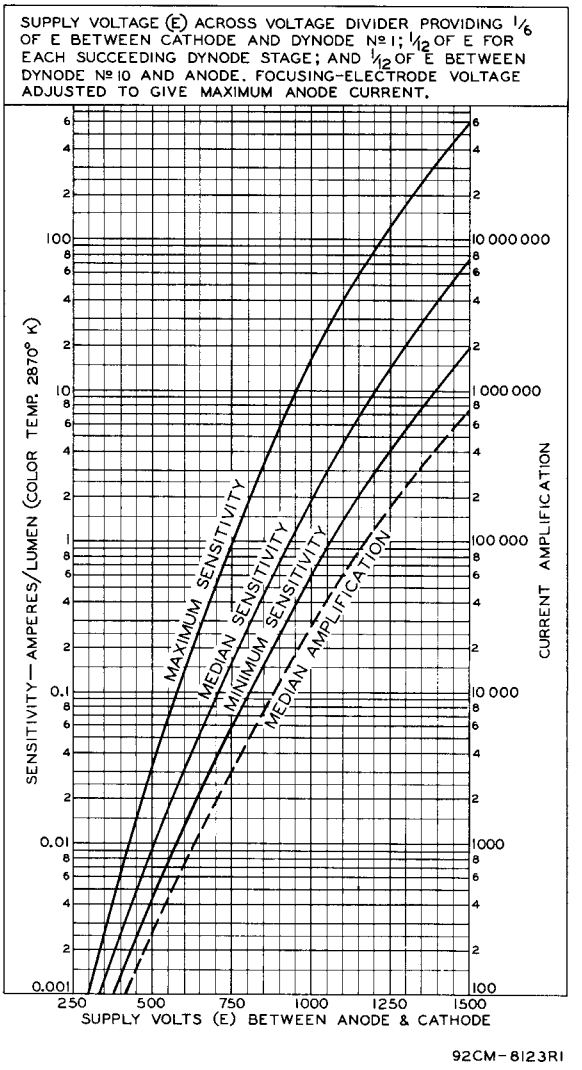

Fig. 3 - Characteristics of Type 6342-A.

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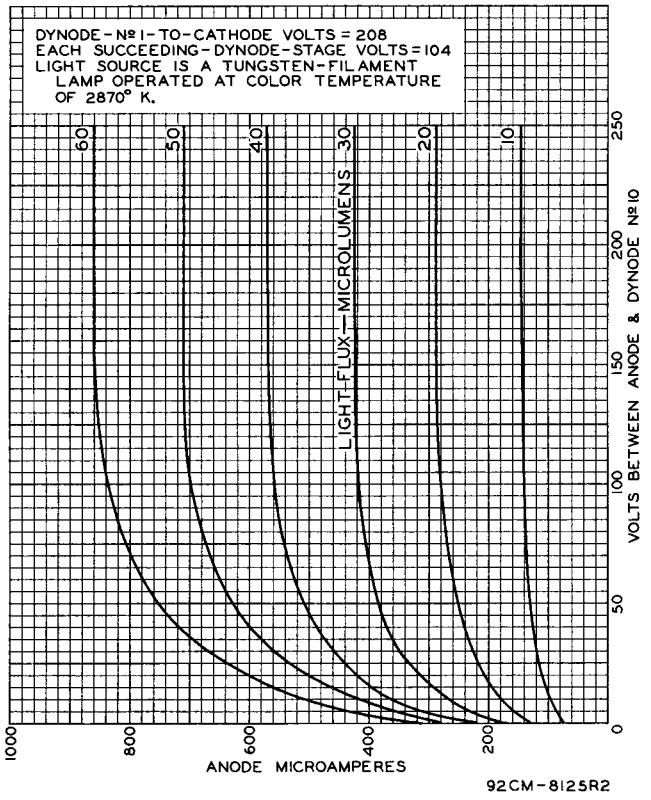


Fig. 4 - Average Anode Characteristics of Type 6342-A.

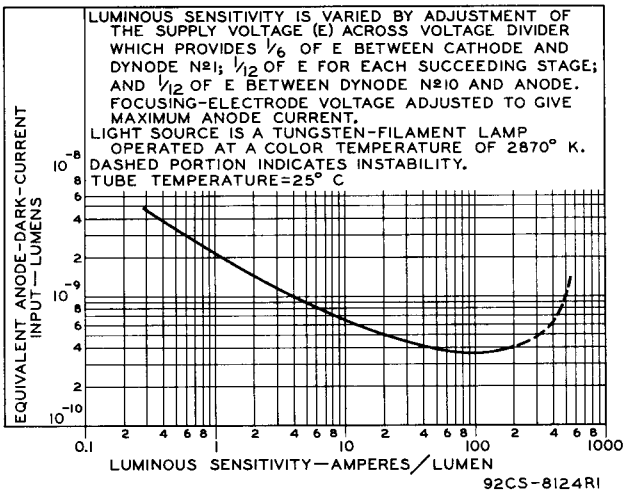
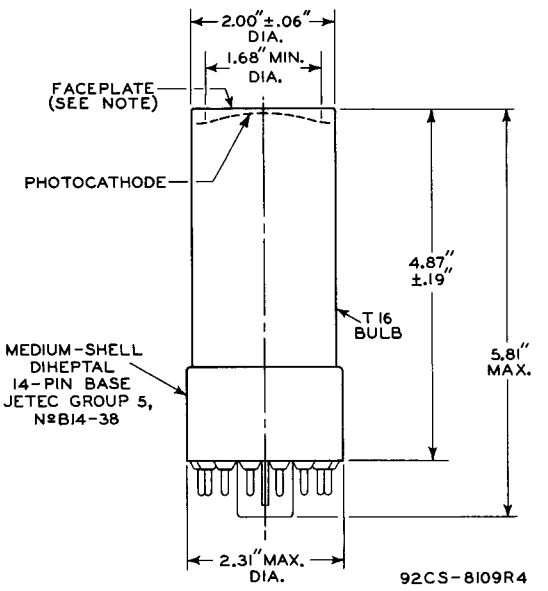


Fig. 5 - Typical Anode-Dark-Current Characteristic of Type 6342-A.

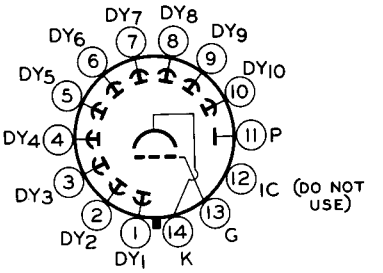
DIMENSIONAL OUTLINE



℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: WITHIN 1.68" DIAMETER, DEVIATION FROM FLATNESS OF EXTERNAL SURFACE OF FACEPLATE WILL NOT EXCEED 0.010" FROM PEAK TO VALLEY.

SOCKET CONNECTIONS
Bottom View



DIRECTION OF LIGHT:
INTO END OF BULB

14AA

PIN 1: DYNODE No.1
PIN 2: DYNODE No.2
PIN 3: DYNODE No.3
PIN 4: DYNODE No.4
PIN 5: DYNODE No.5
PIN 6: DYNODE No.6
PIN 7: DYNODE No.7
PIN 8: DYNODE No.8
PIN 9: DYNODE No.9
PIN 10: DYNODE No.10
PIN 11: ANODE
PIN 12: INTERNAL CONNECTION—DO NOT USE
PIN 13: FOCUSING ELECTRODE
PIN 14: CATHODE

6350

MEDIUM-MU TWIN TRIODE

For Computer Service and Other "On-Off" Control Applications

TENTATIVE DATA

RCA-6350 is a medium-mu twin triode of the 9-pin miniature type designed for use in electronic computers and other "on-off" control applications involving long periods of operation under cutoff conditions. It is particularly useful in pulse-amplifier, inverter, frequency-divider, cathode-follower, and multivibrator circuits of high-speed digital-type electronic computers.

Actual Size

In such service, the 6350 maintains its emission capabilities even after long standby periods and will supply a high minimum value of plate current during its "on" cycles. Furthermore, consistency of cutoff bias is maintained because of the stable cutoff characteristic of the 6350 and its freedom from grid emission.

The design of the 6350 includes a cathode made of special alloy material to minimize cathode interface, a protective shield to prevent deposition of getter material on micas and electrodes to minimize interelectrode leakage, radiating fins on the grids to increase the tubes dissipation capabilities, and a carbonized pure-nickel plate to minimize gas evolution. In addition, the 6350 utilizes a pure-tungsten, mid-tapped heater to permit operation from a 6.3-volt or 12.6-volt supply, and separate cathodes with individual base-pin connections to permit flexibility of circuit connections.

The 6350 is manufactured under rigid controls and undergoes rigorous tests as follows: (1) extreme care in the selection and inspection of materials, and close gauging of parts, (2) factory controls and design tests under typical computer operating conditions, (3) tests for cathode interface, interelectrode leakage, high resistance and intermittent shorts, and (4) conduction and standby life performance tests in addition to those for stability and survival rate. These tests and controls insure dependable performance for the 6350 both initially and throughout life.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathodes:

	Series	*Parallel*	
Heater Arrangement			
Voltage (AC or DC)	12.6 ± 5%	6.3 ± 5%	volts
Current	0.3	0.6	amp

Direct Interelectrode Capacitances (Approx., without external shield):

Grid to plate (Each Unit)	3.2	μμf
Grid to cathode and heater (Each Unit)	3.6	μμf
Plate to cathode and heater (Each Unit)	0.6	μμf
Grid to grid	0.042 max.	μμf
Plate to plate	1 max.	μμf
Heater to cathode (Each Unit)	4.6	μμf

Mechanical:

Mounting Position	Vertical preferred, or horizontal with pins 1 and 4 in vertical plane, but any permissible.
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin (JETEC No.E9-1)

Characteristics, Class A_1 Amplifier (Each Unit):

Plate Voltage	150	volts
Grid Voltage	-5	volts
Plate Current	11	ma
Transconductance	4600	μmhos
Amplification Factor	18	
Plate Resistance (Approx.)	3900	ohms
Grid Voltage (Approx.) for plate voltage of 150 volts and plate current of 100 microamperes	-11	volts
Grid Voltage (Approx.) for plate voltage of 200 volts and plate current of 1 milliampere	-12	volts

COMPUTER SERVICE AND "ON-OFF" CONTROL SERVICE

Values Are For Each Unit

Maximum Ratings, *Absolute Values:*

PLATE VOLTAGE:		
DC	330 max.	volts
Peak positive pulse*	1000 max.	volts
GRID VOLTAGE:		
DC negative	82 max.	volts
DC positive	3.8 max.	volts
Peak negative-pulse*	440 max.	volts
Peak positive-pulse*	14.3 max.	volts
GRID CURRENT:		
DC	5.5 max.	ma
Peak*	110 max.	ma
CATHODE CURRENT:		
DC	27.5 max.	ma
Peak*	333 max.	ma

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

PLATE DISSIPATION:		
For either plate alone	3.85 max.	watts
For both plates with both units operating	7.7 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	220 max.	volts
Heater positive with respect to cathode	220† max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	120 max.	°C

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For cathode-bias operation	0.5 max.	megohm
For fixed-bias operation	0.1 max.	megohm

* Under the following conditions: Rectangular pulse; pulse duration, 0.08 microsecond; pulse repetition rate, 1 x 10^6 pps; and duty factor, 0.08.

† The dc component must not exceed 110 volts.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Values Are For Each Unit, Unless Otherwise Specified Each unit is tested separately. Electrodes of unit not under test are grounded.

	Note	Min.	Max.	
Heater Current	1	0.275	0.325	amp
Plate Current (1)	1,3	6	16	ma
Plate Current (2)	1,4	-	1	ma
Plate Current (3)	1,5	-	100	μamp
Transconductance	1,3	3200	6000	μmhos
Amplification Factor	1,3	15	21	
Reverse Grid Current	1,6	-	2.5	μamp
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,7	-	15	μamp
Heater positive with respect to cathode	1,7	-	15	μamp
Grid-Voltage Difference Between Units For Plate Current of 1 milliampere	1,8	-	2.5	volts
Leakage Resistance:				
Between plate and all other electrodes tied together	1,9	100	-	megohms
Between grid and all other electrodes tied together	1,10	100	-	megohms

Note 1: With 12.6 volts ac or dc on heater (series connection).

Note 2: Without external shield.

Note 3: With plate voltage of 150 volts and grid voltage of -5 volts.

Note 4: With plate voltage of 200 volts and grid voltage of -15 volts.

Note 5: With plate voltage of 150 volts and grid voltage of -15 volts.

Note 6: With plate voltage of 180 volts, grid voltage of -5 volts, and grid resistor of 0.1 megohm. Both units connected in parallel.

Note 7: With 100 volts dc between heater and cathode.

Note 8: With plate voltage of 200 volts and grid voltage varied for plate current of 1 milliampere.

Note 9: With plate 300 volts negative with respect to all other electrodes tied together.

Note 10: With grid 100 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Heater-Cycling Life Performance:

Cycles of intermittent operation. 2000 min. cycles

Under the following conditions: Heater voltage of 7.5 volts cycled one minute on-four minutes off, heater 180 volts rms with respect to cathode, and all other elements grounded.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6350 are limiting values above which the serviceability of the 6350 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

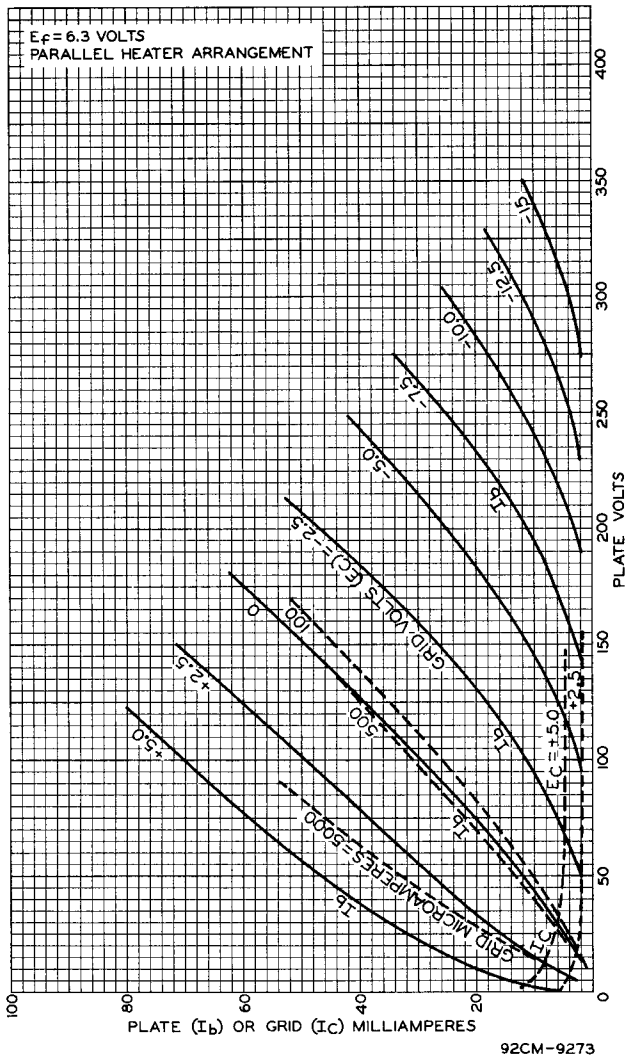


Fig. 1 - Average Characteristics for Each Unit of Type 6350.

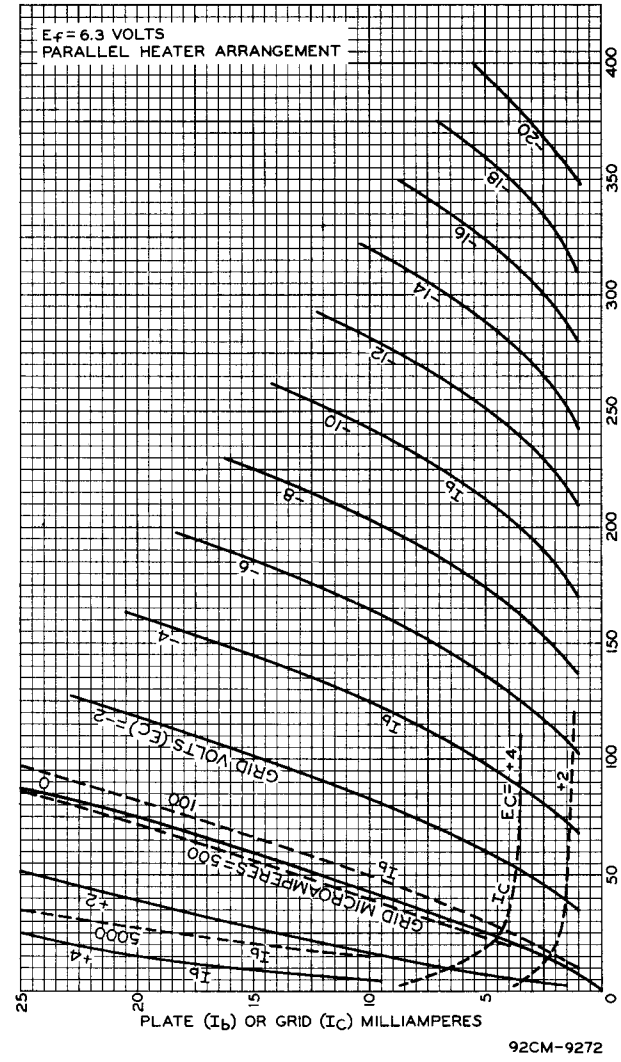


Fig. 2 - Average Characteristics for Each Unit of Type 6350.

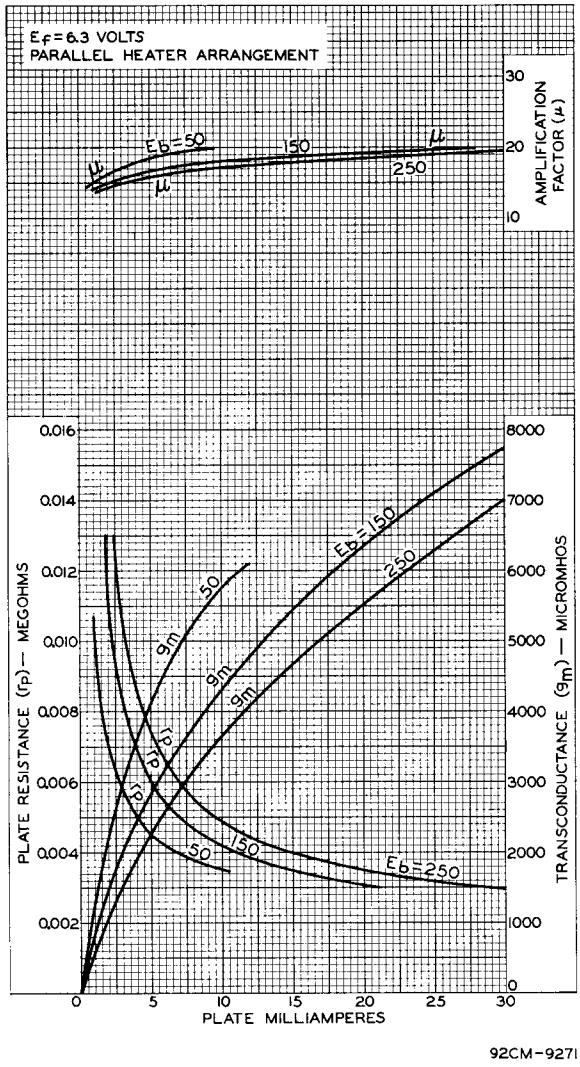
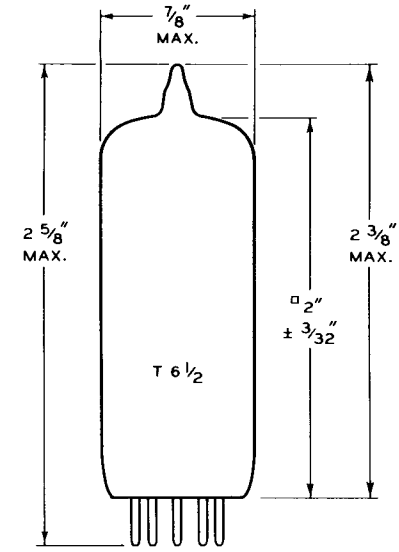


Fig. 3 - Average Characteristics for Each Unit of Type 6350.

DIMENSIONAL OUTLINE

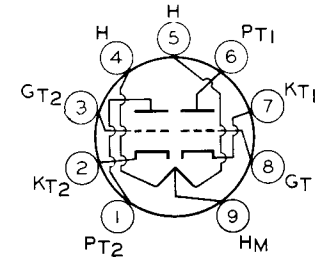


-SMALL-BUTTON NOVAL
9-PIN BASE
JETEC NºE9-1

□ MEASURED FROM BASE SEAT TO BULB TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



9CZ

PIN 1: PLATE OF TRIODE UNIT NO.2
PIN 2: CATHODE OF TRIODE UNIT NO.2
PIN 3: GRID OF TRIODE UNIT NO.2
PINS 4 & 9: HEATER OF UNIT NO.2
PINS 5 & 9: HEATER OF UNIT NO.1
PIN 6: PLATE OF TRIODE UNIT NO.1
PIN 7: CATHODE OF TRIODE UNIT NO.1
PIN 8: GRID OF TRIODE UNIT NO.1
PIN 9: HEATER MID-TAP

from JEDEC release #3858, AUg. 27, 1962

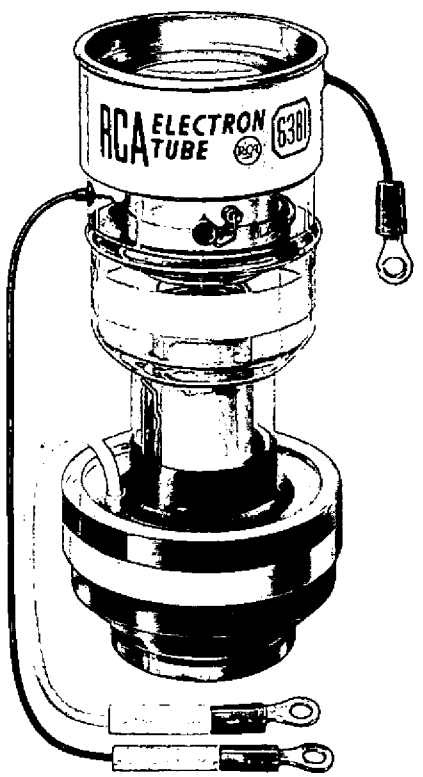
6381

IMAGE-CONVERTER TUBE

Electrostatic Focus
Good Resolution Capability

4-25/32" Max. Length
2.115" Max. Diameter

RCA-6381 is a three-electrode tube of the image-converter type which, in combination with suitable optical systems, permits the viewing of a scene with near infrared radiation.



The 6381 is supplied with semiflexible leads for making electrical connection to the tube electrodes and has an integral optical lens coupled to the phosphor screen.

DATA

General:

Spectral Response	S-1
Wavelength of Maximum Response	8000 ± 1000 angstroms
Photocathode, Semitransparent:	
Shape	Circular
Minimum Window Area (Approx.)	0.74 sq. in.
Minimum Window Diameter	0.970 in.
Phosphor	P20
Fluorescence	Yellow-Green
Phosphorescence	Yellow-Green
Persistence	Medium-Short
Fluorescent Screen:	
Shape	Circular
Minimum Diameter	0.73"
Focusing Method	Electrostatic
Overall Length	4-11/16" ± 3/32"
Maximum Diameter	2.115"
Terminals	See *Dimensional Outline*
Operating Position	Any
Weight (Approx.)	4 oz

Maximum Ratings, *Absolute-Maximum Values:*[a]

DC GRID-No.2 VOLTAGE[bc]	16000 max.	volts
GRID-No.1 VOLTAGE[c]	3000 max.	volts
PEAK PHOTOCATHODE CURRENT[d]	3.5 max.	μamp
AVERAGE PHOTOCATHODE CURRENT (Continuous Operation)	0.35 max.	μamp
AMBIENT TEMPERATURE RANGE	-54 to +68	°C

Characteristics:

Grid-No.2 Voltage[bc]	16000	volts
Grid-No.1 (Focusing Electrode) Voltage[c]— 13.25% to 16.25% of grid-No.2 voltage	2120 to 2600	volts
Max. Grid-No.2 Dark Current at 25° C	1.0	μamp
Paraxial Magnification Factor[e]	0.58	
Sensitivity:		
Radiant, at 8000 angstroms	0.0019	amp/watt
Infrared[f]	5	μamp/lumen
Minimum Conversion Index[fg]	10	
Minimum Resolution (In central area of photocathode)[h]	25	line-pairs/mm

[a] The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

[b] Grid No.2 serves the dual function of high-voltage electrode for accelerating the electron beam and of collector through which the electrons leave the tube after their energy has been transformed within the tube.

[c] Referred to photocathode.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6381 8-62
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[d] The 6381 should not be subjected to this peak photocathode current value more than 10 times during the useful life of the tube. No single time period during which this current is drawn should exceed 2 minutes.

[e] Defined as the ratio of the separation of two diametrically opposite image points on the screen to the separation of the corresponding image points on the photocathode.

[f] Under the following conditions: 2870° K tungsten light source; light flux of 0.1 lumen incident on Corning No.2540 Infrared Filter (Melt 1613, 2.61 mm thick), or equivalent; irradiated area of photocathode is 3/4 inch in diameter

[g] Ratio of light flux from fluorescent screen to the product of the light flux incident on the infrared filter multiplied by the filter factor.

[h] Under the conditions shown in (f) except the entire photocathode is irradiated. The resolution, both horizontally and vertically, in a 0.150 inch diameter circle centered on the photocathode is determined with a pattern consisting of alternate black and white lines of equal width. Any two adjacent lines are designated as a "line-pair".

OPERATING CONSIDERATIONS

The *high voltage at which the 6381 is operated may be very dangerous.* Great care should be taken in the design of apparatus to prevent the user from coming in contact with the high voltage. Precautions must include safeguards which eliminate all hazards to operating personnel. In the use of high-voltage tubes, such as the 6381, it should always be remembered that high voltage may appear at normally low-potential points in the circuit because of capacitor breakdown or incorrect circuit connections. Before any part of the circuit is touched, the voltage-supply switch should be turned off and both terminals of any capacitors grounded.

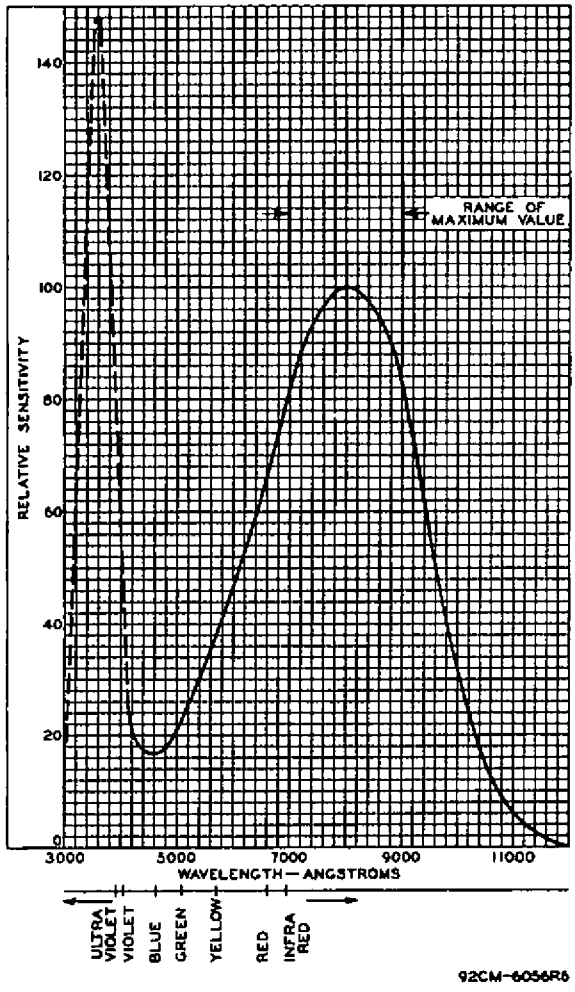


Fig. 1 - Spectral Sensitivity Characteristic of Type 6381 which has S-1 Response. Curve is shown for Equal Values of Radiant Power at All Wavelengths.

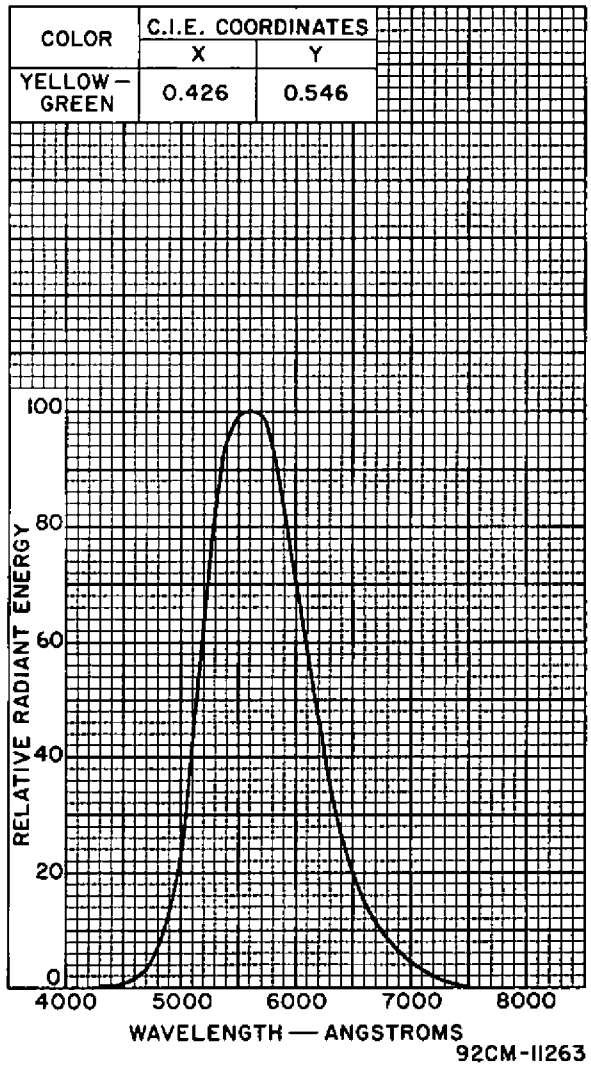
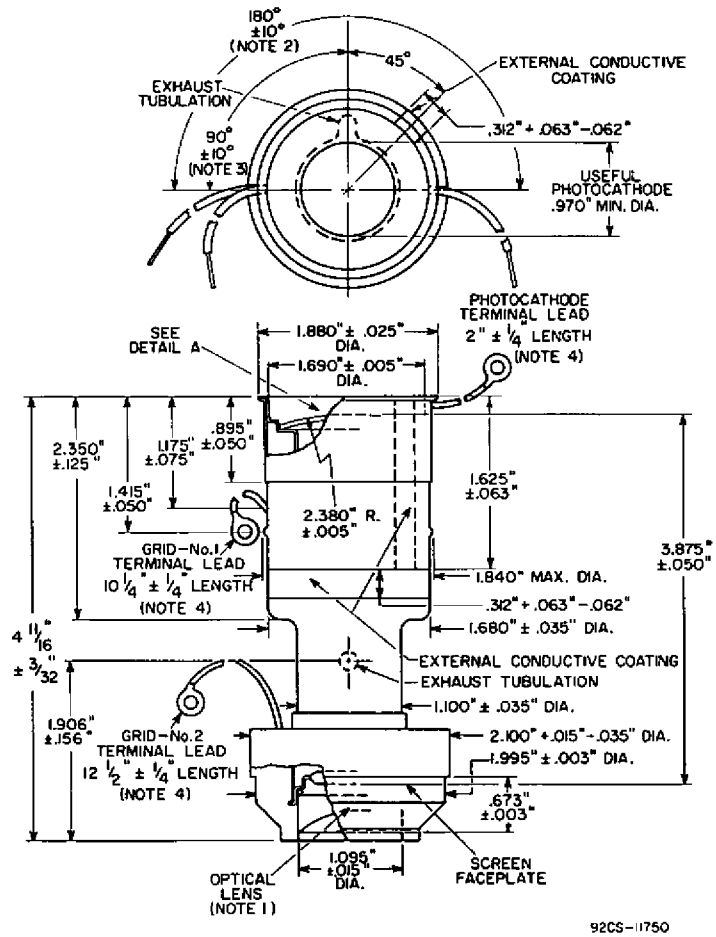


Fig. 2 - Spectral-Energy Emission Characteristic of Phosphor P20.

DIMENSIONAL OUTLINE



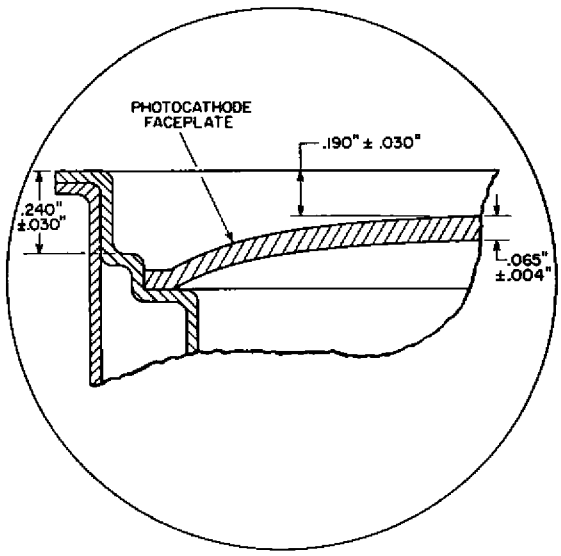
NOTE 1: AXIAL THICKNESS OF LENS IS 0.180" ± 0.030". BACK FOCAL LENGTH IS 1.354" ± 0.027".

NOTE 2: TERMINAL LEAD ORIENTATION.

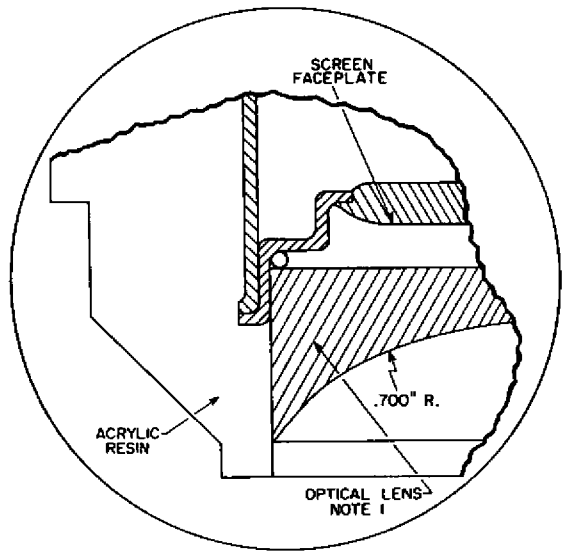
NOTE 3: EXHAUST TUBULATION ORIENTATION.

NOTE 4: TERMINAL LEAD HOLE-DIAMETER IS 0.145" ± 0.005".

DETAIL A



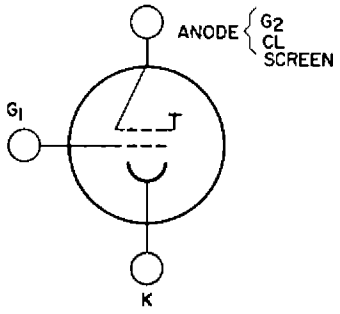
DETAIL B



TERMINAL CONNECTIONS

(See Dimensional Outline)

DIRECTION OF INCIDENT RADIATION:
PERPENDICULAR TO
PHOTOCATHODE END OF TUBE



G_1: GRID NO.1

K : PHOTOCATHODE—
At photocathode
end of tube

ANODE: (Grid No.2,
Collector,
Screen)—
At phosphor screen
end of tube

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6405/1640

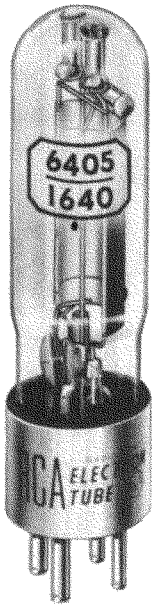
GAS PHOTOTUBE

High Sensitivity
Low Dark Current

S-1 Response
Low-Microphonic Type

4-7/16" Max. Length
1-1/8" Max. Diameter

RCA-6405/1640 is a gas phototube designed for use in industrial applications critical as to microphonics and sensitivity gradient. Among such applications are electronic beverage-inspection equipment and ampul-inspection equipment.



Having high sensitivity to red and near infrared radiant energy, the 6405 is especially suitable for use with an incandescent light source.

The 6405 is provided with a non-hygroscopic base which insures a value of resistance between anode and cathode pins about 10 times higher than conventional bases under adverse operating conditions of high humidity. As a result, more output for a given light input is obtainable under high-humidity conditions.

DATA

General:

Spectral Response	S-1
Wavelength of Maximum Response	8000 ± 1000 angstroms
Cathode:	
Shape	Semi-cylindrical
Minimum Projected Length*	1-1/4"
Minimum Projected Width*	5/8"
Direct Interelectrode Capacitance	3 μμf
Overall Length	4-5/16" ± 1/8"
Seated Length	3-11/16" ± 1/8"
Seated Length to Center of Cathode	2-1/8" ± 3/32"
Maximum Diameter	1-1/8"
Bulb	T-8
Base	Dwarf-Shell Small 4-Pin (JETEC No. A4-26), Non-hygroscopic
Mounting Position	Any
Weight (Approx.)	1.3 oz

Maximum Ratings, *Absolute Values*:

	Rating I	*Rating II*	
ANODE-SUPPLY VOLTAGE (DC or Peak AC)	70 max.	90 max.	volts
AVERAGE CATHODE-CURRENT DENSITY	50 max.	25 max.	μamp/sq.in.
AVERAGE CATHODE CURRENT°	10 max.	5 max.	μamp
AMBIENT TEMPERATURE	100 max.	100 max.	°C

Characteristics at 90 Volts on Anode:

	Min.	*Av.*	*Max.*	
Sensitivity:				
Radiant at 8000 angstroms	–	0.0135	–	μamp/μwatt
Luminous:▲				
At 0 cps	80	135	200	μamp/lumen
At 5000 cps	–	116	–	μamp/lumen
At 10000 cps	–	100	–	μamp/lumen
Sensitivity Difference Between Highest Value and Lowest Value Along Cathode Length🌡	–	–	25	μamp/lumen
Gas Amplification Factor	–	–	9	
Anode Dark Current:				
At 25°C	–	–	0.1	μamp

Minimum Circuit Values:

With anode-supply voltage of	*70 or less*	*90*	*volts*
DC-Load Resistance:			
For dc currents above 5 μamp	0.1 min.	–	megohm
For dc currents below 5 μamp	0 min.	–	megohm
For dc currents above 3 μamp	–	2.5 min.	megohms
For dc currents below 3 μamp	–	0.1 min.	megohm

* On plane perpendicular to indicated direction of incident light.

° Averaged over any interval of 30 seconds maximum.

▲ For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A dc anode supply of 90 volts and a 1-megohm load resistor are used. For the 0-cycle measurements, a light input of 0.1 lumen is used. For the 5000 and 10000-cycle measurements, the light input is varied sinusoidally about a mean value of 0.015 lumen from zero to a maximum of twice the mean.

🌡 Measured under the same conditions as indicated under (▲) with light input of 0.1 lumen and a light spot 1/2 inch in diameter.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant energy of a given wavelength, at constant electrode voltages.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Electrode Dark Current. The electrode current that flows when there is no radiant flux incident on the photocathode.

Gas Amplification Factor. The ratio of radiant sensitivities with and without ionization of the contained gas.

INSTALLATION and APPLICATION

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6405 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsi-

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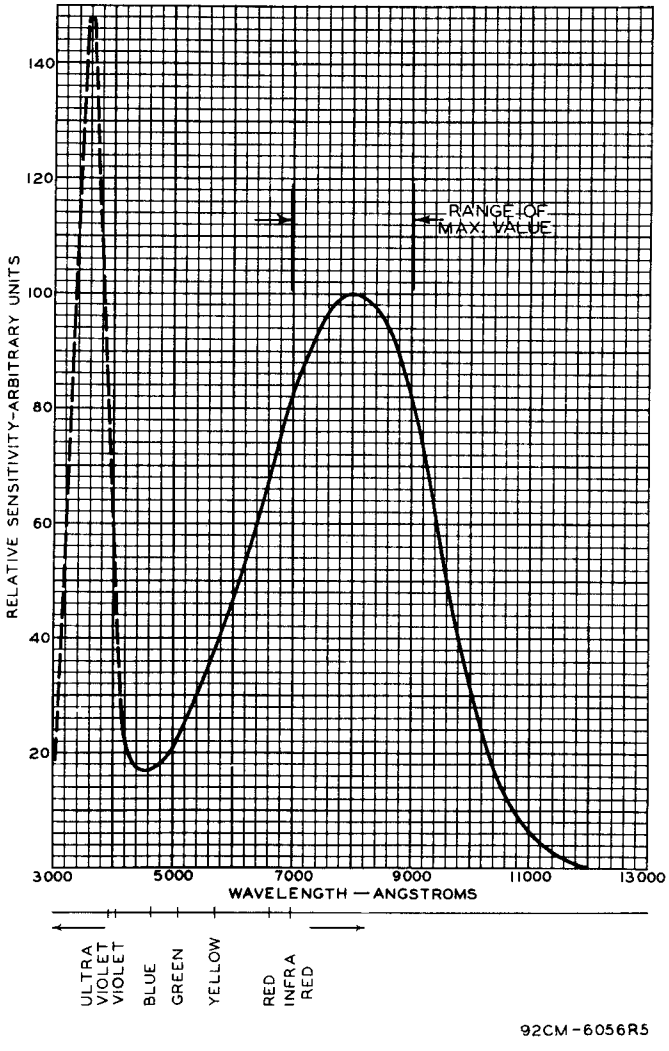
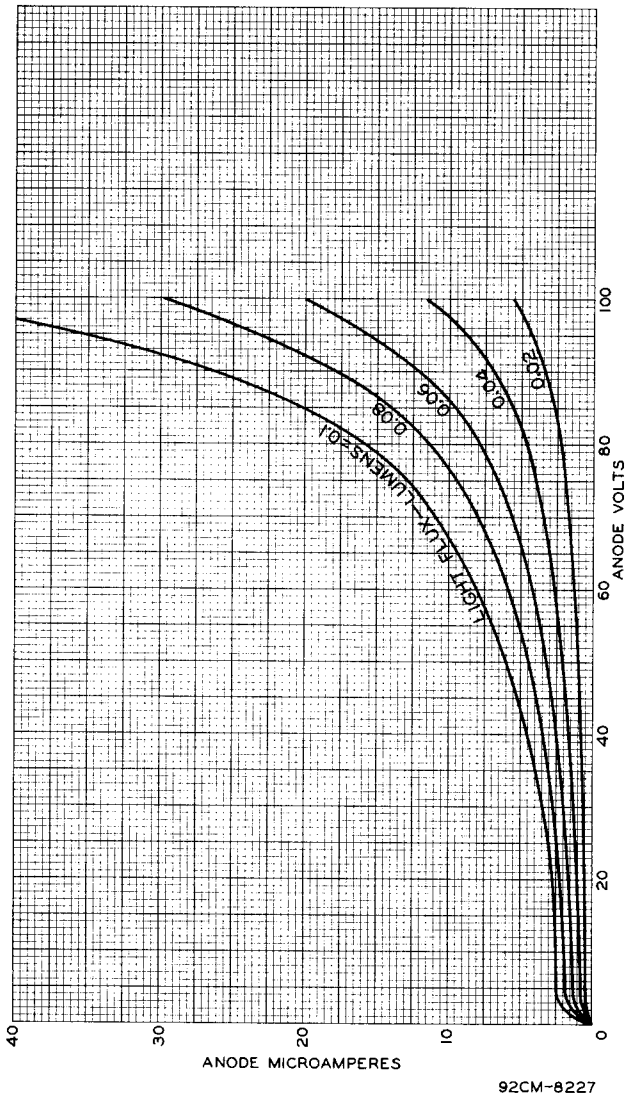
bility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface to evaporate with consequent decrease in the life and sensitivity of the tube.

The *minimum dc load resistance values* shown in the tabulated data are specified to prevent



Spectral Sensitivity Characteristic of Phototube Having S-1 Response. Curve is Shown for Equal Values of Radiant Flux at All Wavelengths.



Average Anode Characteristics of Type 6405.

If the voltage and current ratings of the 6405 are exceeded, a gas discharge may occur. This discharge is indicated by a faint blue glow within the tube. Once started, this discharge will continue independently of the illumination on the phototube. When a glow occurs, the anode-supply voltage should be disconnected immediately in order to prevent permanent damage to the tube.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings.

a blue glow discharge. With the indicated values of load resistance, supply voltage, and maximum cathode current, the dc voltage drop across the load is large enough to protect the 6405.

The *base pins* of the 6405 fit the small 4-contact socket which should be positioned so that the two large pin openings (pins No.1 and No.4) are toward the light source. This position places the cathode so that light is intercepted by its concave surface.

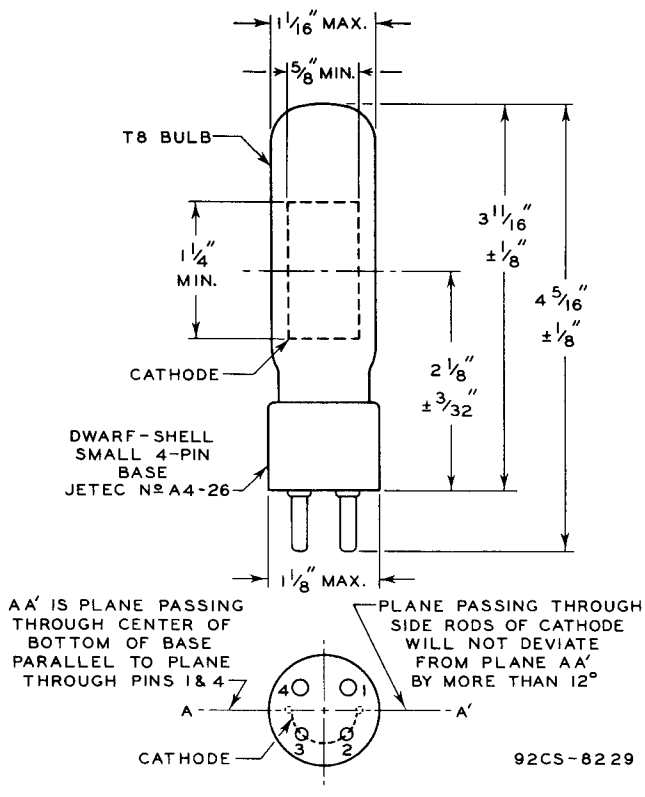
Shielding of the 6405 and its leads to the amplifier is recommended when amplifier gain is high or when the phototube load resistance is high. Whenever frequency response is important in a phototube circuit, the leads from the phototube to the amplifier should be made short so as to minimize capacitance shunting of the phototube load. Since a phototube is a high-resistance device, it is important that insulation of associated circuit parts and wiring be adequate.

The *operating stability* of the 6405 is dependent on the magnitude of the luminous-flux input and its duration. When the 6405 is operated continuously at high values of light input, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 6405 like other gas phototubes usually recovers a substantial percentage of such loss in sensitivity.

When maximum stability is required, the use of a light input not exceeding 0.02 lumen is recommended.

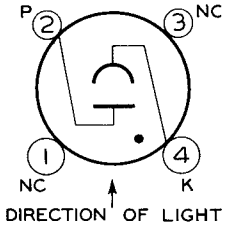
Exposure to intense illumination, such as direct sunlight, may decrease the sensitivity of the 6405 even though no voltage is applied to the tube. The magnitude and duration of the decrease depend on the length of the exposure. Permanent damage to the tube may result if it is exposed to light so intense as to cause excessive heating of the cathode.

DIMENSIONAL OUTLINE



SOCKET CONNECTIONS

Bottom View



PIN 1: NO CONNECTION
PIN 2: ANODE
PIN 3: NO CONNECTION
PIN 4: CATHODE

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

This bulletin also applies to RCA-5763 which is identical with RCA-6417 except for its heater rating of 6.0 ± 10% volts, 0.75 ampere.

6417

VHF BEAM POWER TUBE

High Transconductance
High Power Sensitivity

9-Pin Miniature Type
Full Input to 50 Mc
13.5-Watt ICAS Plate Dissipation

2-5/8" Max. Length
7/8" Max. Diameter

TENTATIVE DATA

RCA-6417 is a general-purpose transmitting beam power tube of the heater-cathode type intended for use in compact, low-power mobile and portable transmitters and in emergency communications equipment operating directly from 12-volt storage batteries. It can also be used in the low-power stages of larger fixed station transmitters. The 6417 can be operated with full input up to 50 megacycles per second and with reduced input up to 175 megacycles per second.

Because of its high transconductance, and a plate characteristic favorable to the generation of a high harmonic output, the 6417 is particularly useful in the doubler and tripler stages of transmitters. Because of its high perveance, this tube can supply high power output at relatively low supply voltages. These features in addition to its high power sensitivity make the 6417 especially useful as an rf power amplifier, frequency multiplier, oscillator (VFO or crystal), and as a vhf driver tube for larger tube types.

Featured in the design of the 6417 are heavy control-grid support rods and two control-grid base-pin connections which provide for cooler grid operation; a cathode with a large area to supply the high peak currents required for multiplier service; and a 12.6-volt heater which can be conveniently operated from a storage battery.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	12.6 ±10%	volts
Current	0.375	amp
Transconductance for dc plate current of 45 ma, dc plate voltage of 250 volts, and dc grid-No.2 voltage of 250 volts.	7000	μmhos
Mu-Factor, Grid No.2 to Grid No.1	16	
Direct Interelectrode Capacitances:*		
Grid No.1 to Plate	0.3 max.	μμf
Input	9.5	μμf
Output	4.5	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2"
Base	Small-Button Noval 9-Pin (JETEC No.E9-1)

PLATE-MODULATED RF POWER AMP. - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	CCS●	ICAS●●	
Maximum Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	250 max.	300 max.	volts
DC GRID-No.3 (SUPPRESSOR) VOLTAGE	0 max.	0 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-125 max.	-125 max.	volts
DC PLATE CURRENT	40 max.	50 max.	ma
DC GRID-No.2 CURRENT	15 max.	15 max.	ma
DC GRID-No.1 CURRENT	5 max.	5 max.	ma
PLATE INPUT	10 max.	15 max.	watts
GRID-No.2 INPUT	1.5 max.	1.5 max.	watts
PLATE DISSIPATION	8 max.	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	volts
Heater positive with respect to cathode	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	250 max.	°C
Typical Operation up to 30 Mc:			
DC Plate Voltage	250	300	volts
Grid No.3	Connected to cathode at socket		
DC Grid-No.2 Voltage##	250	250	volts
DC Grid-No.1 Voltage□	-39	-42.5	volts
From a grid resistor of	39000	18000	ohms
Peak RF Grid-No.1 Voltage	46.5	53.5	volts
DC Plate Current	40	50	ma
DC Grid-No.2 Current	5.6	6	ma
DC Grid-No.1 Current (Approx.)	1	2.4	ma
Driving Power (Approx.)	0.05	0.15	watt
Useful Power Output (Approx.)	6.4♦	10♦	watts
Maximum Circuit Values (For maximum rated conditions):			
Grid-No.1-Circuit Resistance	0.1 max.	0.1 max.	megohm

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TUBE DEPARTMENT
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6417-2-54
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RF POWER AMP. & OSC. - Class C Telegraphy▲ and RF POWER AMPLIFIER - Class C FM Telephony

	CCS●	ICAS●●	
Maximum Ratings, *Absolute Values*:			
DC PLATE VOLTAGE	300 max.	350 max.	volts
DC GRID-NO.3 (SUPPRESSOR) VOLTAGE	0 max.	0 max.	volts
DC GRID-NO.2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
DC GRID-NO.1 (CONTROL-GRID) VOLTAGE	-125 max.	-125 max.	volts
DC PLATE CURRENT	50 max.	50 max.	ma
DC GRID-NO.2 CURRENT	15 max.	15 max.	ma
DC GRID-NO.1 CURRENT	5 max.	5 max.	ma
PLATE INPUT	15 max.	17 max.	watts
GRID-NO.2 INPUT	2 max.	2 max.	watts
PLATE DISSIPATION	12 max.	13.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	volts
Heater positive with respect to cathode	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max.	250 max.	°C
Typical Operation up to 30 Mc:			
DC Plate Voltage	300	350	volts
Grid No.3	Connected to cathode at socket		
DC Grid-No.2 Voltage	250	250	volts
DC Grid-No.1 Voltage#	-28.5	-28.5	volts
From a grid resistor of	18000	18000	ohms
Peak RF Grid-No.1 Voltage	37.5	37	volts
DC Plate Current	50	48.5	ma
DC Grid-No.2 Current	6.6	6.2	ma
DC Grid-No.1 Current (Approx.)	1.6	1.6	ma
Driving Power (Approx.)	0.1	0.1	watt
Useful Power Output (Approx.)	10.3♦	12♦	watts
Typical Operation at 50 Mc:			
DC Plate Voltage	300	-	volts
Grid No.3	Connected to cathode at socket		
DC Grid-No.2 Voltage	250	-	volts
DC Grid-No.1 Voltage#	-60	-	volts
From a grid resistor of	22000	-	ohms
Peak RF Grid-No.1 Voltage	80	-	volts
DC Plate Current	50	-	ma
DC Grid-No.2 Current	5	-	ma
DC Grid-No.1 Current (Approx.)	3	-	ma
Driving Power (Approx.)	0.35	-	watt
Useful Power Output (Approx.)	7♦	-	watts
Maximum Circuit Values (For maximum rated conditions):			
Grid-No.1-Circuit Resistance	0.1 max.	-	megohm

FREQUENCY MULTIPLIER

Maximum CCS● Ratings, *Absolute Values*:	
DC PLATE VOLTAGE	300 max. volts
DC GRID-NO.3 (SUPPRESSOR) VOLTAGE	0 max. volts
DC GRID-NO.2 (SCREEN) VOLTAGE	250 max. volts
DC GRID-NO.1 (CONTROL-GRID) VOLTAGE	-125 max. volts
DC PLATE CURRENT	50 max. ma
DC GRID-NO.2 CURRENT	15 max. ma
DC GRID-NO.1 CURRENT	5 max. ma
PLATE INPUT	15 max. watts
GRID-NO.2 INPUT	2 max. watts
PLATE DISSIPATION	12 max. watts
PEAK HEATER-CATHODE VOLTAGE:	
Heater negative with respect to cathode	100 max. volts
Heater positive with respect to cathode	100 max. volts
BULB TEMPERATURE (At hottest point on bulb surface)	250 max. °C

Typical Operation:

	Doubler to 175 Mc	Tripler to 175 Mc	
DC Plate Voltage	300	300	volts
Grid No.3	Connected to cathode at socket		
DC Grid-No.2 Voltage	**	**	volts
DC Grid-No.1 Voltage#	-75	-100	volts
From a grid resistor of	75000	100000	ohms
Peak RF Grid-No.1 Voltage	95	120	volts
DC Plate Current	40	35	ma
DC Grid-No.2 Current	4	5	ma
DC Grid-No.1 Current (Approx.)	1	1	ma
Driving Power (Approx.)	0.6	0.6	watt
Useful Power Output (Approx.)	2.1♦	1.3♦	watts
Maximum Circuit Values (For maximum rated conditions):			
Grid-No.1-Circuit Resistance	0.1 max.	0.1 max.	megohm

MAXIMUM RATINGS vs OPERATING FREQUENCY

FREQUENCY	50	175		Mc
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE AND PLATE INPUT:		*Voltage*	*Input*	
Class C Telephony, Plate Modulated	100	100	80	per cent
Class C Telegraphy	100	100	80	per cent
Class C FM Telephony	100	100	80	per cent
Frequency Multiplier	100	100	80	per cent

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.345	0.405	amp
Grid No.1-to-Plate Capacitance	2	-	0.3	μμf
Input Capacitance	2	8	11	μμf
Output Capacitance	2	3.8	5.2	μμf
Transconductance	1,3	5100	8900	μmhos
Plate Current	1,3	33	57	ma
Grid-No.2 Current	1,3	-	10	ma
Reverse Grid-No.1 Current	1,4	-	2	μamp

NOTE 1: With 12.6 volts ac or dc on heater.

NOTE 2: With no external shield.

NOTE 3: With dc plate voltage of 250 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage of -7.5 volts.

NOTE 4: With dc plate voltage of 250 volts, dc grid-No.2 voltage of 250 volts, dc grid-No.1 voltage of -7.5 volts, and grid-No.1-circuit resistance of 0.1 megohm.

---

* With no external shield.

● Continuous Commercial Service.

●● Intermittent Commercial and Amateur Service.

Obtained preferably from a separate source modulated with the plate supply, or from the modulated plate supply through a series resistor.

▲ Key down conditions per tube without amplitude modulation. Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent of the carrier conditions.

□ Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

♦ This value of useful power is measured at load of output circuit.

\# Obtained from a fixed supply, or by a grid-No.1 resistor of value shown.

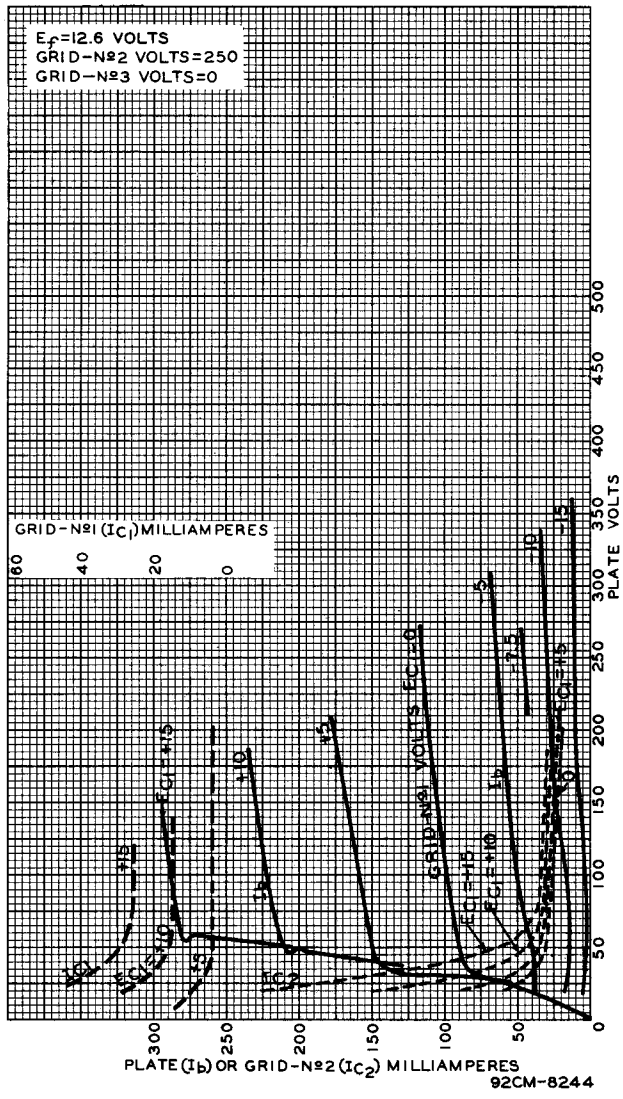
** Obtained from plate supply voltage of 300 volts through a series resistor of 12500 ohms.

INSTALLATION AND APPLICATION

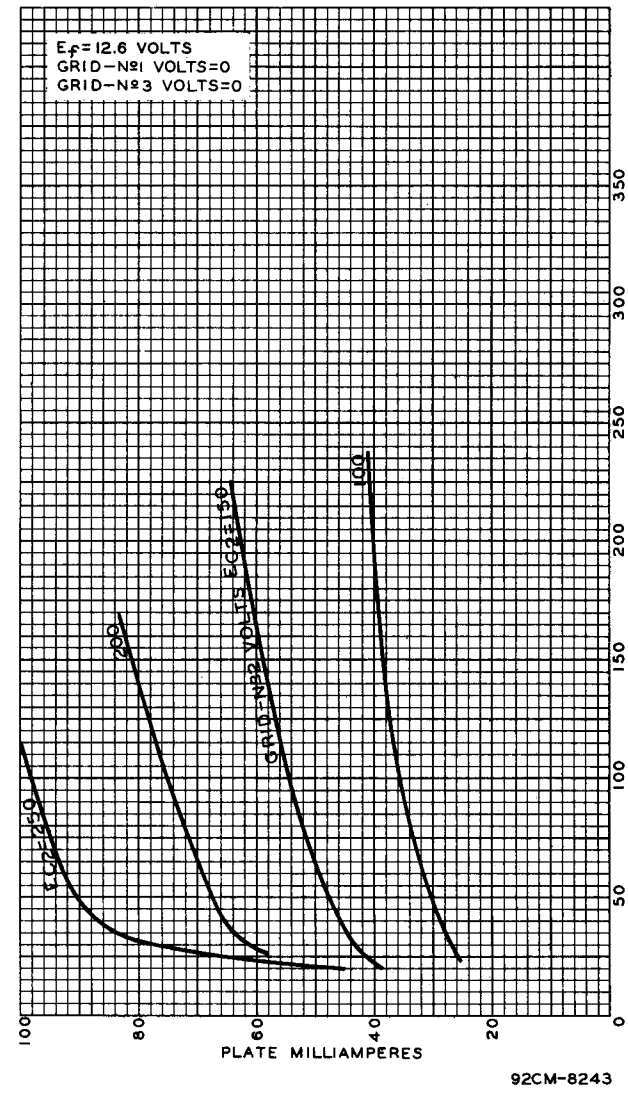
The *maximum ratings* are limiting values above which the serviceability of the 6417 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 6417 can be operated at full input up to 50 megacycles. It is recommended that it be used as a frequency multiplier rather than as a straight-through amplifier at frequencies above 135 megacycles, in order to avoid excessive driving power due to high-frequency input loading.

Heavy leads and conductors together with suitable insulation should be used in all parts of the rf plate tank circuit so that losses due to rf voltages and currents may be kept at a minimum. At the higher frequencies, it is essential that short, heavy leads be used for circuit connections in order to minimize lead inductance and losses.



Average Characteristics of Type 6417 with E_{c_1} as Variable.



Average Plate Characteristics of Type 6417 with E_{c_2} as Variable.

The *base pins* of the 6417 fit the noval socket. The socket may be mounted to hold the tube in any position.

If the 6417 is to be used in aircraft transmitters at high altitudes, it is recommended that the socket clip corresponding to pin No.2 be removed. Removal of this clip will help to insulate the plate (pin No.1) from grid No.3 (pin No.3) and thus prevent any flashover.

The *bulb* becomes hot during continuous operation and, therefore, free circulation of air around the

tube should be provided. If a tube shield is used, it is advisable to paint the inside and outside surface of the shield a mat black, and to provide ventilation slots in order to prevent the temperature at the hottest point of the bulb surface from exceeding 250° centigrade.

Grid No.1 of the 6417 is designed with heavy support rods, and has 2 pin connections (pins 8 and 9) to permit cooler grid operation. In operating the 6417, it is essential that both grid-No.1 pins be connected into the circuit.

In *plate-modulated class C rf power amplifier service*, the 6417 should be supplied with bias from a grid-No.1 resistor or from a suitable combination of grid-No.1 resistor and fixed supply or grid-No.1 resistor and cathode resistor. The cathode resistor should be bypassed for both audio and radio frequencies. The combination method of grid-resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

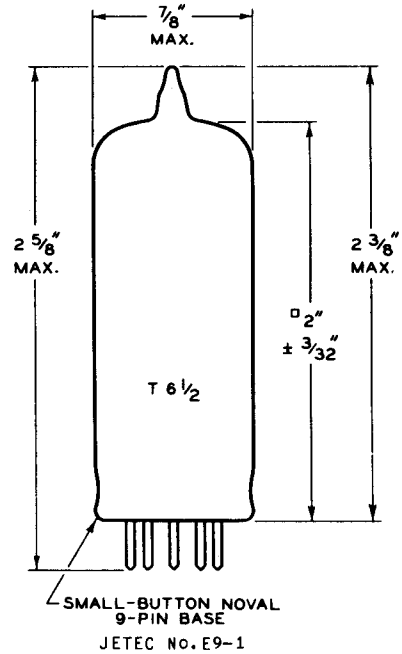
In *class C rf telegraphy and class C FM telephony service*, the 6417 should be operated with grid-No.1 bias obtained from a fixed supply or from a grid-No.1 bias resistor. The use of a grid-No.1 resistor is preferred because the bias is automatically adjusted as the load on the circuit varies. Because of the high amplification factor of the 6417, a small cathode resistor of 68 ohms can furnish sufficient voltage to protect the tube in the event of excitation failure and resultant loss in developed bias. The cathode bias of 3 volts required for protection is sufficiently small to make the dc plate power loss an unimportant factor.

The *driver stage* for the 6417 in either class C telephony or telegraphy service should have considerably more output capability than the typical tube driving power shown in the tabulated data in order to permit considerable range of adjustment and also to provide for losses in the grid-No.1 circuit and the coupling circuits. This recommendation is particularly important near the maximum rated frequency where there are other losses of driving power, such as circuit losses, radiation losses, and transit-time losses.

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 6417 is operated under load conditions such that the maximum rated plate current flows at the plate voltage which will give maximum rated input.

Push-pull or parallel circuit arrangements can be used when more radio-frequency power is required than can be obtained from a single 6417. Two 6417's in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits. When two or more tubes are used in the circuit, precautions should be taken to insure that each tube draws the same plate current.

DIMENSIONAL OUTLINE

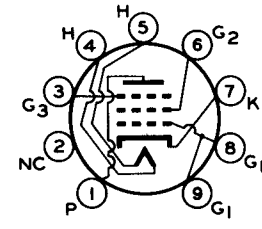


JETEC No. E9-1

□ MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS

Bottom View



9K

PIN 1: PLATE
PIN 2: NO CONNECTION
PIN 3: GRID No.3
PIN 4: HEATER
PIN 5: HEATER
PIN 6: GRID No.2
PIN 7: CATHODE
PIN 8: GRID No.1
PIN 9: GRID No.1

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6474/1854

IMAGE ORTHICON

Magnetic Focus
Magnetic Deflection

For Simultaneous Color Pickup
Exceptional Sensitivity

TENTATIVE DATA

3"-Diameter Bulb
15-1/4" Length

RCA-6474/1854 is a television camera tube intended for use in color cameras utilizing the method of simultaneous pickup of the studio or outdoor scene to be televised. This method employs three 6474's--one for each channel--to produce the information necessary for the formation of a color-television image.

The 6474 has exceptional sensitivity combined with a spectral response approaching that of the eye, and good resolution capability. With a color camera employing a suitably designed optical system and utilizing efficient color filters, commercially acceptable color pictures can be obtained with about 350 foot-candles of incident incandescent illumination on the scene and a lens stop of f:5.6.

The photocathode utilized in the 6474 is characterized by a relatively wide spectral response having high blue sensitivity, high green sensitivity, good red sensitivity, and practically no infrared sensitivity. This spectral characteristic enables the tube to translate colors very accurately when operated in a color camera with appropriate color filters and optical arrangements.

The 6474 is designed to operate on a substantially linear signal-output curve, and is thus capable of producing a picture having natural tone value and accurate detail. Furthermore, the 6474 features a signal-to-noise ratio and contrast range commensurate with the requirements of color reproduction.

The designation 6474/1854, or simply 6474, is the new type number for the image orthicon previously supplied under the type designation 1854.

PRINCIPLES OF OPERATION

The 6474 has three sections--an image section, a scanning section, and a multiplier section, as shown in Fig. 1.

Image Section

The image section contains a semitransparent photocathode on the inside of the faceplate, a grid (grid No.6) to provide an electrostatic accelerating field, and a target which consists of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

Light from the scene being televised is picked up by an optical system and focused on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focused on the target by the magnetic and accelerating fields.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite potential of several volts with respect to target-voltage cutoff. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive charges which corresponds with the pattern of light from the scene being televised. Because of the thinness of the glass, the charges set up a similar potential pattern on the opposite or scanned side of the glass.

Scanning Section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No.1), and an accelerating grid (grid No.2).

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TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6474/1854-4-54
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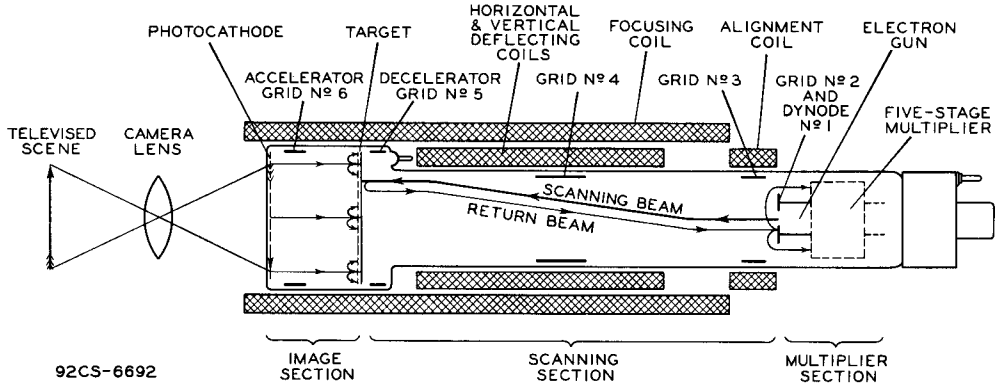


Fig. 1 - Schematic Arrangement of Type 6474.

The beam is focused at the target by the magnetic field of an external focusing coil and the electrostatic field of grid No.4.

Grid No.5 serves to adjust the shape of the decelerating field between grid No.4 and the target in order to obtain uniform landing of electrons over the entire target area. The electrons stop their forward motion at the surface of the glass and are turned back and focused into a five-stage signal multiplier, except when they approach the positively charged portions of the pattern on the glass. When this condition occurs, they are deposited from the scanning beam in quantities sufficient to neutralize the potential pattern on the glass. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode side. These charges neutralize each other by conductivity through the glass in less than the time of one frame.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by an external coil located at the gun end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

Multiplier Section

The return beam is directed to the first dynode of a five-stage electrostatically focused multiplier. This utilizes the phenomenon of secondary emission to amplify signals composed of electron beams. The electrons in the beam impinging on the first-dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No.5 are collected by the anode and constitute the current utilized in the output circuit. The multiplier section amplifies the modulated beam about 500 times. This multiplication permits the use of a video amplifier with fewer stages.

The signal-to-noise ratio of the output signal from the 6474 is high. The gain of the multiplier is such as to raise the output signal sufficiently above the noise level of the video amplifier stages so that they contribute no noise to the final video signal. The signal-to-noise ratio of the video signal, therefore, is determined only by the random variations of the modulated electron beam.

It can be seen that when the beam moves from a less-positive portion on the target to a more-positive portion, the signal-output voltage across the load resistor (R_{25} in Fig.2) changes in the positive direction. Hence, for highlights in the scene, the grid of the first video-amplifier stage swings in the positive direction.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Anode to all other electrodes	20	μμf
Photocathode, Semitransparent:		
Response	See Fig.3	
Rectangular Image (4 x 3 aspect ratio):		
Useful size of	1.6" max.	Diagonal
Orientation of	Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through center of faceplate and pin No.7 of the shoulder base.	

Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	15-3/16" ± 1/4"
Greatest Diameter of Bulb	3" ± 1/16"
Shoulder Base	Keyed Jumbo Annular 7-Pin
End Base	Small-Shell Diheptal 14-Pin Base (JETEC No. B14-45)
Operating Position	See Text
Weight (Approx.)	1 lb 6 oz
Minimum Deflecting-Coil Inside Diameter	2-3/8"
Deflecting-Coil Length	5"
Focusing-Coil Length	10"
Alignment-Coil Length	15/16"
Photocathode Distance Inside End of Focusing Coil	1/2"

Maximum Ratings, *Absolute Values*:

PHOTOCATHODE:		
Voltage	-550 max.	volts
Illumination	50 max.	ft-c
OPERATING TEMPERATURE:		
Of any part of bulb	50 max.	°C
Of bulb at large end of tube (Target section)	35 min.	°C
TEMPERATURE DIFFERENCE:		
Between target section and any part of bulb hotter than target section	5 max.	°C
GRID-No.6 VOLTAGE	-550 max.	volts
TARGET VOLTAGE:		
Positive value	10 max.	volts
Negative value	10 max.	volts
GRID-No.5 VOLTAGE	150 max.	volts
GRID-No.4 VOLTAGE	300 max.	volts
GRID-No.3 VOLTAGE	400 max.	volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
ANODE-SUPPLY VOLTAGE*	1350 max.	volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	volts

Typical Operation and Characteristics:

Photocathode Voltage (Image Focus)	-300 to -500	volts
Grid-No.6 Voltage (Accelerator)--75% of photocathode voltage	-225 to -375	volts
Target Voltage°	0 to 3	volts
Grid-No.5 Voltage (Decelerator)	0 to 125	volts
Grid-No.4 Voltage (Beam Focus)	160 to 220	volts
Grid-No.3 Voltage#	225 to 330	volts
Grid-No.2 & Dynode-No.1 Voltage	300	volts
Grid-No.1 Voltage for Picture Cutoff	-45 to -115	volts
Dynode-No.2 Voltage	600	volts
Dynode-No.3 Voltage	800	volts
Dynode-No.4 Voltage	1000	volts
Dynode-No.5 Voltage	1200	volts
Anode Voltage	1250	volts
Anode Current (DC)	30	μamp
Signal-Output Current (Peak to peak)	3 to 20	μamp
Target Temperature Range (See Text)	35 to 45	°C
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current (Approx.)	60	
Minimum Peak-to-Peak Blanking Voltage	5	volts
Field Strength at Center of Focusing Coil▲	75	gausses
Field Strength of Alignment Coil (Approx.)	0 to 3	gausses

* Ratio of dynode voltages is shown under *Typical Operation*.

° Adjustable from -3 to +5 volts with blanking voltage off.

Adjust to give the most uniformly shaded picture near maximum signal.

▲ Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

INSTALLATION

The *end-base pins* of the 6474 fit the small diheptal 14-contact socket. The *annular-base pins* fit the keyed jumbo annular 7-contact socket which should be rigidly fastened to the deflecting-coil assembly.

The 6474 has two complementary guides for inserting the tube correctly in the annular socket, i.e., the large pin (No.7) on the annular base, and the white radial line on the face of the bulb. The annular socket should be positioned so that the key pin (No.7) of the annular base is in a vertical plane through the common axis of the deflecting-coil assembly and the focusing-coil assembly.

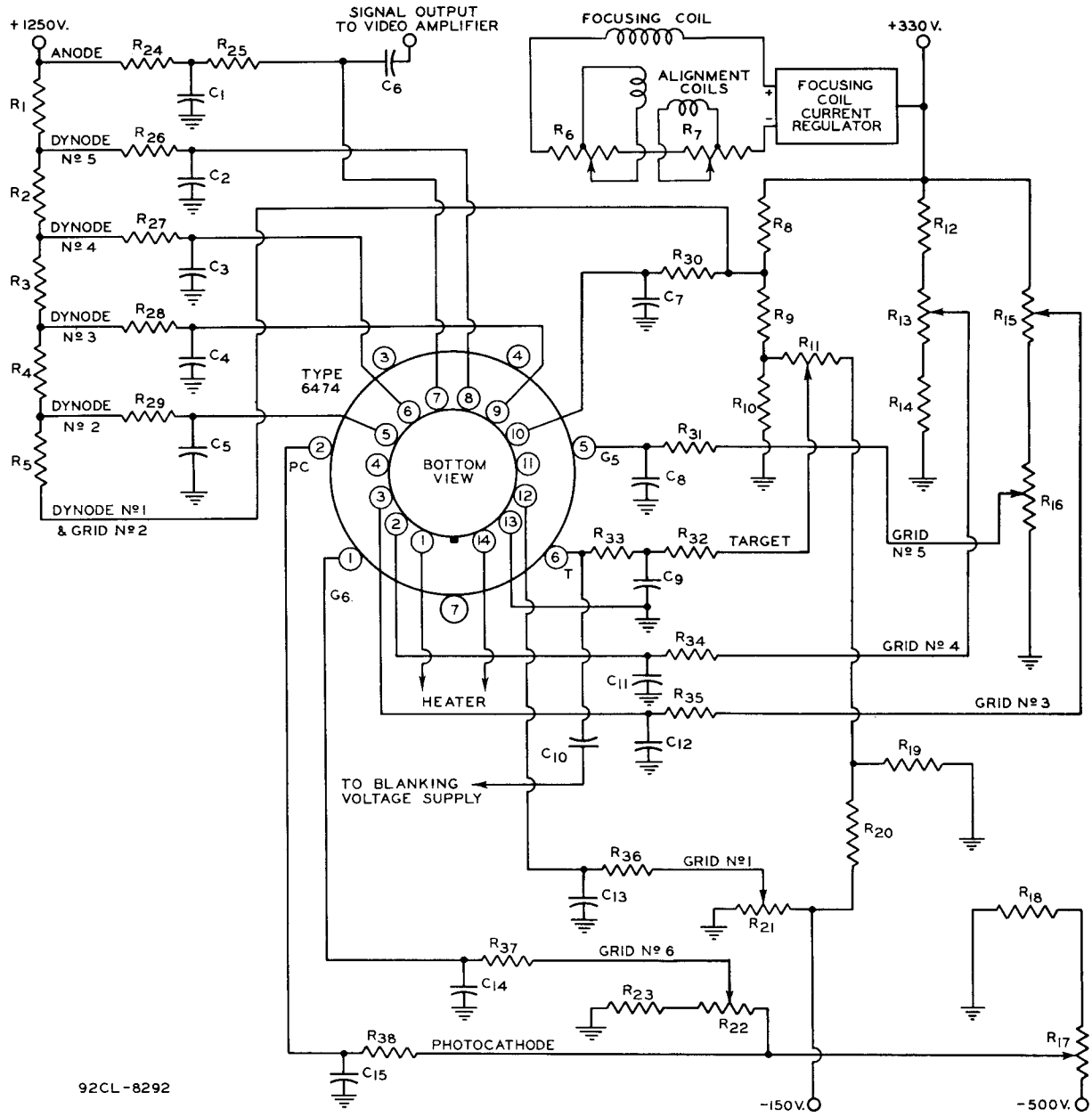
The 6474 is installed by inserting the diheptal-base end of the tube through the coil assembly and then turning the tube until the annular-base pins, keyed by pin No.7, can be inserted in the annular socket. Proper insertion aligns the white radial line on the face with center of the key-pin hole in the annular socket. The diheptal socket is then put on the 14-pin base.

Proper orientation of the annular socket with respect to the horizontal-deflecting field is essential, and is obtained when the plane which is perpendicular to the plane of the annular socket and which passes through the center of the annular socket and the center line between pins 3 and 4 of the annular base is at right angles to the horizontal scanning field. This orientation minimizes beat-pattern effects by placing the sides of the mesh holes at an angle of 45° with respect to the horizontal scanning lines.

The *operating position* of the 6474 should preferably be such that any loose particles in the neck of the tube will not fall down and strike or become lodged on the target. Therefore, it is recommended that the tube never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical.

A *mask* having a diagonal or diameter of 1.6 inches should always be used on the photocathode to set limits for the maximum size of scan, and to reduce the amount of light reaching unused parts of the photocathode.

The *optical system* used with the 6474 should be designed according to basic optical principles and should incorporate an iris to control the amount of light entering the television camera lens. The entire optical system should have all



C1 C2: 0.05 μf, 1600 v working voltage
C3: 0.01 μf mica, 1600 v working voltage
C4: 0.001 μf mica, 1000 v working voltage
C5: 0.001 μf mica, 600 v working voltage
C6: 0.03 μf mineral-oil impregnated, 1600 v working voltage
C7 C8 C9 C11 C12 C13 C14 C15: 0.001 μf mica, 400 v working voltage
C10: 1 μf, 400 v working voltage
R1: 47000 ohms, 1/2 watt
R2 R3 R4: 220000 ohms, 1/2 watt
R5: 270000 ohms, 1/2 watt
R6 R7: 200-ohm potentiometer, center-tapped, 2 watts
R8: 5100 ohms, 1/2 watt
R9: 51000 ohms, 2 watts
R10: 510 ohms, 1/2 watt
R11: 150000-ohm potentiometer, 1/2 watt
R12: 100000 ohms, 1/2 watt
R13: 75000-ohm potentiometer, 1 watt
R14: 150000 ohms, 1/2 watt
R15: 250000-ohm potentiometer, 1 watt
R16: 150000-ohm potentiometer, 1 watt
R17: 250000-ohm potentiometer, 1 watt
R18: 510000 ohms, 1 watt
R19: 11000 ohms, 1/2 watt
R20: 310000 ohms, 1/2 watt
R21: 500000-ohm potentiometer, 1 watt
R22: 250000 ohms, 1 watt
R23: 560000 ohms, 1/2 watt
R24: 47000 ohms, 1/2 watt
R25: 20000 ohms, 1/2 watt
R26 R27: 100000 ohms, 1/2 watt
R28 R29 R31 R32 R34 R35 R36 R37 R38: 200000 ohms, 1/2 watt
R30: 50000 ohms, 1/2 watt
R33: 100000 ohms, 1/2 watt

Fig. 2 - Voltage-Divider Circuit for Type 6474 with Recommended Arrangement for Connecting the Focusing Coil and Alignment Coils.

inside surfaces finished in mat black to prevent internal reflections from reaching the photocathode. Under almost all conditions, the use of a lens shade is beneficial.

Proper shielding of the image section can be provided by wrapping around the outside of the focusing coil directly over the center of the deflecting coils a triple layer of Mumetal strip 0.006" thick and 5" wide, or equivalent. Then, wrap another triple layer of Mumetal strip 0.006" thick and 3" wide around the focusing coil directly over the image section of the 6474. Additional shielding is provided by fitting the inside of the focusing coil directly over the image section with a copper cylinder having a length of approximately 2-1/4" and a wall thickness of 1/32". The Mumetal shielding effectively shunts the field-rate deflection field, while the copper cylinder shields the higher frequency line-scanning field from the electron path in the image section. Unless proper shielding is provided, "cross talk" from the deflecting yoke into the image section will result in loss of picture sharpness.

For the *high dc voltages* required by the 6474, the use of two pulse supplies for which the plate voltage is provided by a well-regulated, 330-volt, B-supply may be used. Each of these supplies should be actuated by the horizontal driving pulse which is obtained from the synchronizing generator. One of the pulse supplies should be capable of furnishing 1250 volts with an output current of 1 milliampere for the multiplier section; the other pulse supply should be capable of furnishing -500 volts with an output current of 1 milliampere for the image section. In addition to supplying the plate voltage and current for the pulse supplies, the 330-volt B-supply should also provide an output current of 90 milliamperes for the focusing and alignment coils and for the voltage divider which is used to supply the voltages for the electrodes in the scanning section of the 6474. Provision should be made for regulating the focusing-coil current.

A *voltage divider* to provide the required operating voltages for the various electrodes of the 6474 is shown in Fig.2. It is to be noted that the blocking capacitor C_6 should be of the mineral-oil impregnated type to minimize capacitor leakage which will introduce disturbing effects into the picture.

In designing a voltage divider for the multiplier stages of the 6474, engineers should recognize that the dc output of individual 6474's may have a range of 10 to 1. This range, therefore, must be considered in the choice of bleeder-resistor values. If the values are too high, the distribution of voltages applied to the dynodes will be upset by a 6474 with a dc output at the upper end of the range. As a result, there will be an abrupt drop in the ac output of the tube as the beam current is increased. When this drop occurs before the beam is at its optimum value, the ratio of signal to noise will be lessened, and compression of the signal information will result.

Even with satisfactory bleeder-resistor values, it is possible to overload the tube itself. For 6474's having high dc outputs, a current reversal can occur at the 5th dynode stage of the multiplier as the beam current is increased. This current reversal will also produce a sharp drop in the ac output of the tube. To prevent such current reversal, it is recommended that provision be made to reduce the overall multiplier voltage for tubes with dc outputs at the upper end of the range. A reduction to 1000 volts should be adequate.

A *blanking signal* should be supplied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must be constant to prevent fluctuation of the target voltage. During the blanking periods, the full beam current without video-signal modulation is returned to the multiplier and its multiplied output flows through the load resistance. Excessive amounts of blanking voltage applied to the target will impair resolution, since during retrace the target is out of focus to the continuously flowing photocathode current. A desirable amount of target blanking is 6 volts peak to peak.

Shading may be required even with optimum adjustment of voltage on grid No.3 in order to obtain a uniformly shaded picture. Sawtooth and parabolic waveforms of adjustable amplitude and polarity at both the vertical- and horizontal-scanning frequency should be provided for insertion in the video amplifier to aid in obtaining a flat background. The shading signal should be introduced in the amplifier after clamping is performed, since clamping circuits will remove the vertical-frequency shading component if added previous to the clamp-circuit location.

The *video amplifier* should be designed to cover a range of ac signal voltages corresponding to signal-output current of 3 to 20 microamperes peak to peak in the load resistor (R_{25} in Fig.2). For bandwidth, refer to *Resolution* under OPERATING CONSIDERATIONS.

Failure of scanning even for a few minutes when light is incident on the photocathode may permanently damage the surface of the target. The damaged area shows up as a spot or line in the picture during subsequent operation.

To avoid damaging the 6474 during scanning failure, provision should be made to prevent

automatically the scanning beam from reaching the target. The scanning beam can be prevented from reaching the target by (1) cutting off the scanning beam, or (2) making the target sufficiently negative. The scanning beam can be cut off by a relay which applies -115 to -125 volts bias to grid No. 1. The target can be made sufficiently negative by a relay which applies a bias of at least -10 volts to it. Either relay is actuated by a tube which is controlled by a portion of the scanning pulse voltage developed across either the horizontal or the vertical deflecting coils, or both. It is important to insure that the horizontal scanning pulse and the vertical scanning pulse should each independently actuate the relay in case either one fails.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6474 are limiting values above which the serviceability of the 6474 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

New 6474's should be placed in service immediately upon receipt. They should be operated for several hours before being set aside as spares.

Spare 6474's should be placed in service for several hours at least once a month in order to keep them free from traces of gas which may be liberated within the tube during prolonged storage.

Rotation in the use of 6474's is recommended. After a 6474 is operated for 200 to 300 hours, it should be given an idle period of three or four weeks during which it generally will recover much of its original resolution and sensitivity.

Occasionally, a *white spot* which does not change in size when the beam-focus voltage is varied, may be observed in the center of the picture. Such a spot, especially if it is visible on the monitor with the camera lens capped, is probably an ion spot. If the spot begins to grow in size with continuous operation, the 6474 should be removed from service at once, and returned for re-processing. Continued operation of an image orthicon with an ion spot will eventually damage the target permanently.

The *spectral response* of the 6474 is shown in Fig.3 and is not subject to appreciable variation from tube to tube.

The *operating temperature* of any part of the glass bulb should never exceed 50°C, and no part of the bulb at the large end of the tube (target section) should ever fall below 35°C during operation. The temperature of the target is essentially the same as that of the adjacent glass bulb and can, therefore, be determined by measuring the temperature of the glass bulb adjacent to the target. For best results, it is recommended that the temperature of the entire bulb be held between 35° and 45°C. Operation at too low a temperature will be characterized by the appearance of a rapidly disappearing "sticking picture" of opposite polarity from the original when the picture is moved. Operation at too high a temperature will cause loss of resolution and possibly permanent damage to the tube. Resolution is regained by waiting for the temperature to drop below 45°C. *No part of the bulb should run more than 5° hotter than the target section to prevent cesium migration to*

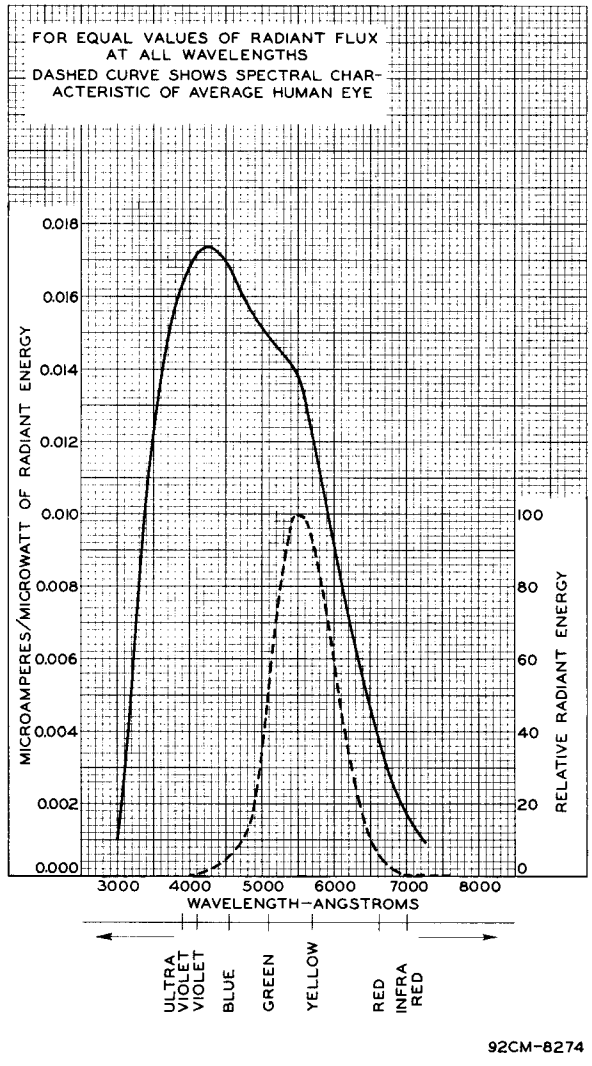


Fig.3 - Spectral Sensitivity Characteristic of Type 6474.

the target. Such migration will result in loss of resolution and in probable permanent damage to the tube. Like other photosensitive devices employing cesium, the 6474 may show fluctuations in performance from time to time. Strict observance of the above recommendations with respect to operating temperature will not completely eliminate these variations but will greatly improve the stability of the characteristics during the life of the tube.

When the equipment design or operating conditions are such that the maximum temperature rating or maximum temperature difference as given under *Maximum Ratings* will be exceeded, provision should be made to direct a blast of cooling air from the diheptal-base end of the tube along the entire length of the bulb surface, i.e., through the space between the bulb surface and the surrounding deflecting-coil assembly and its extension. Any attempt to effect cooling of the tube by circulating even a large amount of air around the focusing coil will do little good, but a small amount of air directly in contact with the bulb surface will effectively drop the bulb temperature. For this purpose, a small blower is satisfactory, but it should be run at low speed to prevent vibration of the 6474 and the associated amplifier equipment. Unless vibration is prevented, distortion of the picture may occur.

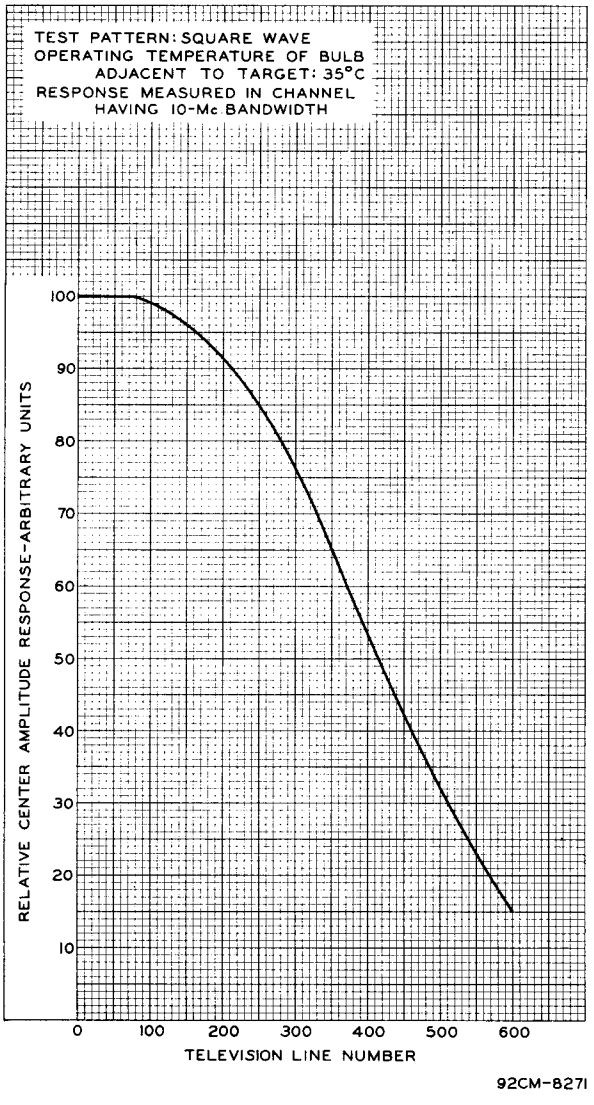


Fig. 4 - Amplitude Response Characteristic of Type 6474.

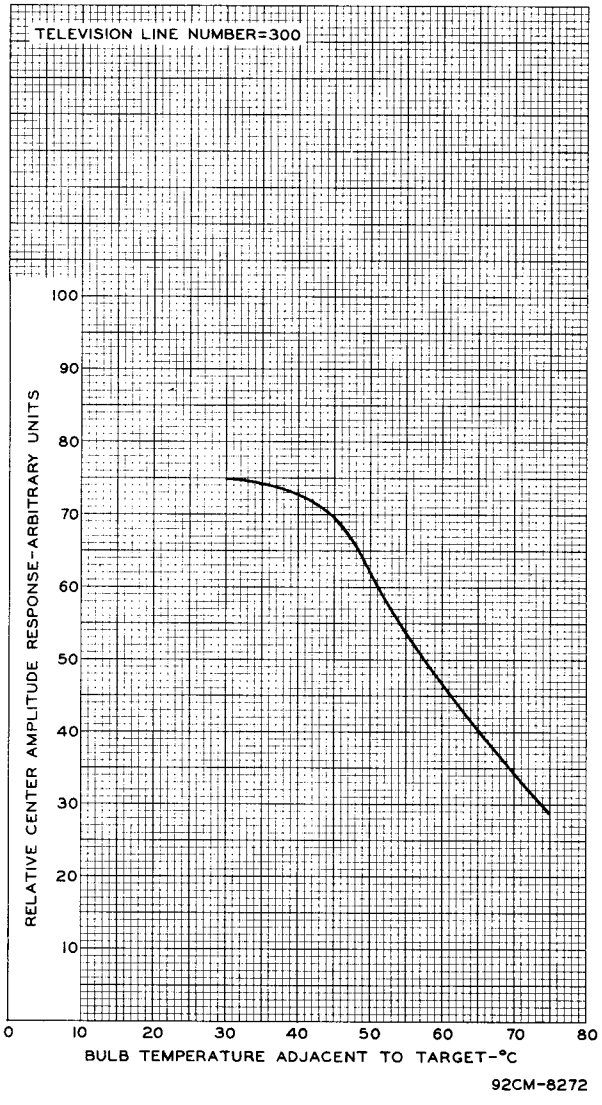


Fig. 5 - Temperature Effect on Amplitude Response of Type 6474.

Ordinarily, the temperature in a camera equipped with a blower will not exceed 45°C, except in very hot weather or unless the target heater is left on accidentally for a long period.

To keep the operating temperature of the large end of the tube from falling below 35°C, some form of controlled heating should be employed. Ordinarily, adequate heat will be supplied by the focusing coil, deflecting coils, and associated amplifier tubes so that the temperature can be controlled by the amount of cooling air directed along the bulb surface. If, in special cases, a target heater is required, it should fit between the focusing coil and the bulb near the shoulder of the tube, and be non-inductively wound.

Full-size scanning of the target should always be used during on-the-air operation. Full-size scanning can be assured by first adjusting the deflection circuits to overscan the target sufficiently to cause the corners of the target to be visible in the picture, and then reducing the scanning until the corners just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. Full-size scanning will also reduce the prominence of a beat pattern (see *Resolution*). Note that overscanning the target produces a smaller-than-normal picture on the monitor.

Underscanning the target, i.e., scanning an area of the target less than its sensitive area, should never be permitted. Underscanning produces a larger-than-normal picture on the monitor. If the target is underscanned for any length of time, a permanent change in target cutoff voltage of the underscanned area takes place with the result that the underscanned area thenceforth is visible in the picture when full-size scanning is restored.

Resolution in excess of 500 lines at the center of the picture can be produced by the 6474 when operated for color reproduction. The resolution curve in Fig.4 shows the relative center amplitude response versus television line number for the 6474 when it is operated with the highlights below the knee of the light transfer characteristic (see text below) and at a temperature of 35°C. The values of response plotted on the curve are those obtained after optimum adjustments are made to minimize the prominence of beat patterns and dynode spots.

A beat pattern is caused by the beating of the scanning lines against the lines of the target mesh. As a result, a moiré pattern, sometimes called a "swirl", appears in large-area highlights of the picture. Defocusing of the beam by adjustment of the beam-focus control (grid No.4) may be helpful in reducing the beat-pattern effect. For additional way to minimize beat-pattern effects, refer to *Proper orientation of the annular socket* under INSTALLATION.

A dynode spot is caused by a slight blemish on a dynode surface and appears as a white spot chiefly in the dark areas of the picture. Little defocusing of the beam is required to minimize the effect of dynode spots when the scene is brightly illuminated, but in dark scenes, the effect of dynode spots is a limiting item on resolution.

Loss of resolution with increased bulb temperature adjacent to the target is illustrated in Fig.5. The loss of resolution is caused by the decreasing resistivity of the target glass disc with increasing temperature. As a result, lateral leakage of the image charge occurs.

To utilize the resolution capability of the 6474 in the horizontal direction with the standard scanning rate of 525 lines, it is necessary to use a video amplifier having a bandwidth of at least 6 megacycles. The maximum resolution obtainable is limited by the mesh-screen portion of the target.

Even with a wide-band amplifier, the resolution may be limited in the image section by "cross talk" caused by the scanning fields. Unless prevented by proper shielding from extending into the image section (see *Proper shielding* under INSTALLATION), these fields will cause the electron image on the target to move at scanning frequency. As a result, the picture will lack definition.

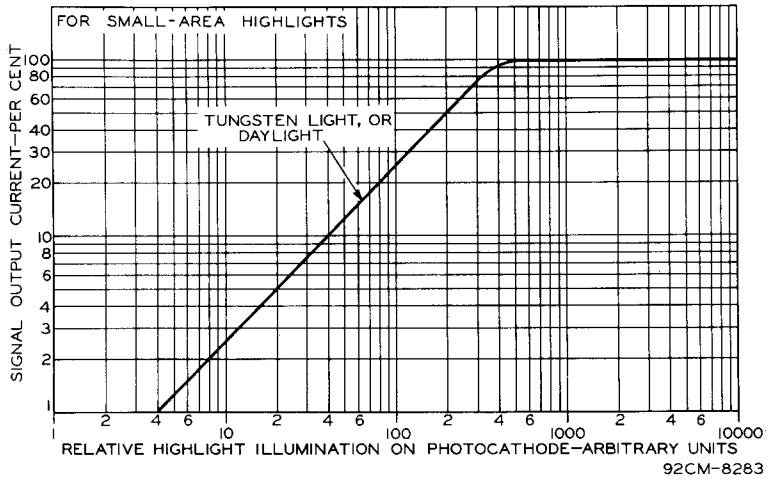


Fig.6 - Basic Light Transfer Characteristic of Type 6474.

The *light transfer characteristics* of the 6474 change for different illumination levels (see Reference 6). The basic light transfer characteristic of the 6474 is shown in Fig.6. This curve is representative only for small-area highlights. The bend or "knee" of the curve is explained by the fact that the charge accumulated

by the target can not exceed the charge which raises the voltage of the target to the collector-mesh potential. As a result, when the 6474 is operated with highlights above the knee, not all of the secondary electrons emitted by the target glass disc are collected by the adjacent mesh. Those not collected are randomly distributed over adjacent picture areas. For black-and-white picture transmission, this random distribution is not objectionable if the image orthicon is operated so that the highlights bring the signal output only slightly above the knee. However, for color picture transmission, *any* random distribution represents color dilution or contamination and, therefore, the image orthicon must be operated in such a manner that substantially all of the secondary electrons from the target are collected by the adjacent mesh. Instructions for obtaining this operating condition are given under *Setup Procedure*. Fig.7 shows the light transfer characteristics for the 6474 operated below the knee with two different target voltages. More complete collection and hence a more accurate color picture is reproduced when the target voltage is 4 volts and the signal output is limited to a maximum charge buildup corresponding to the 2-volt initial setup condition as discussed under *Setup Procedure*.

The *setup procedure* for operating the 6474 is as follows: After the tube has been inserted in its sockets and the voltages applied as indicated under *Typical Operation*, allow it to warm up for 1/2 to 1 hour with the camera lens capped. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the target. Adjust the deflection circuits so that the beam will "overscan" the target, i.e., so that the area of the target scanned is greater than its sensitive area. This procedure during the warming-up period is recommended to prevent burning on the target a raster smaller than that used for on-the-air operation. Note that overscanning the target results in a smaller-than normal picture on the monitor.

With the lens still capped and the target voltage set at approximately 2 volts negative, adjust the grid-No.1 voltage until noise or a rough-textured picture of dynode No.1 appears on the monitor. Then adjust the alignment-coil current so that the small white dynode spots do not move when the beam-focus control (grid No.4) is varied, but simply go in and out of focus. During alignment of the beam, and also during operation of the tube, always keep the beam current as low as possible to give the best picture quality and also to prevent excessive noise, and burn of the dynode-No.1 surface.

Next, uncap the lens and open the lens iris partially. Focus the camera on a test pattern. The target voltage is then advanced until a reproduction of the test pattern is just discernable on the monitor. This value of target voltage is known as the "target cutoff voltage". The target voltage should then be raised exactly two volts above the cutoff-voltage value, and the beam-current control adjusted to give just sufficient beam current to discharge the highlights.

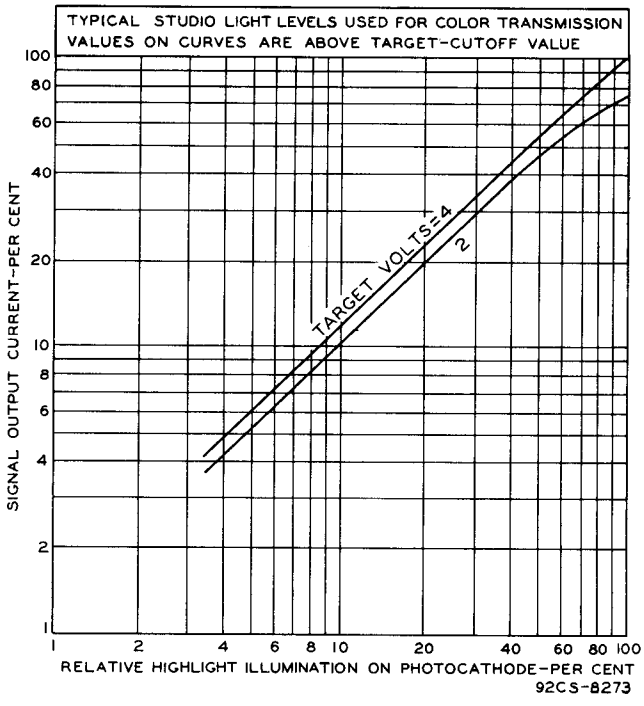


Fig.7 - Light Transfer Characteristics of Type 6474.

Then adjust the lens to produce best optical focus, and the voltage on the photocathode as well as the voltage on grid No.4 to produce the sharpest picture.

At this point, attention should be given to the grid-No.5 and grid-No.3 voltage controls. Grid No.5 is used to control the landing of the beam on the target and consequently the uniformity of signal output. The grid-No.5 voltage control should be adjusted to produce a picture that has most uniform shading from center to edge with the lens iris opened sufficiently to permit operation with the highlights above the knee of the light transfer characteristic. The value of grid-No.5 voltage should be as high as possible consistent with uniform shading. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The grid-No.3 voltage control should be adjusted to produce the maximum signal output.

Now with a test pattern consisting of a straight line centered on the face of the 6474, adjust the voltage on grid No.6 along with the voltage on the photocathode to produce a sharply focused straight line on the monitor. Improper

adjustment of the grid-No.6 voltage control will result in the straight-line pattern being reproduced with a slight S-shape.

The above adjustments constitute a rough setup of the 6474. Final adjustments necessary for the 6474 to produce the best possible picture for color or black-and-white transmission are as follows: With the lens capped, realign the beam. Beam alignment is necessary after each change of the grid-No.5 voltage control and sometimes after each adjustment of the grid-No.3 voltage control.

The proper illumination level for color-camera operation should next be determined. Adjust the target voltage accurately to 2 volts above the target-cutoff value. Remove the lens cap and focus the camera on a neutral (black and white) test pattern consisting of progressive tonal steps from black to white. Open the lens iris just to the point where the highest step of the test pattern does not rise as fast as the lower steps when viewed on a video waveform oscilloscope. This operating point assures that the highlights of the scene will not run above the knee of the light transfer characteristic. If the highlights run above the knee of the light transfer characteristic, color dilution or contamination will occur.

Then adjust the grid-No.1 voltage control to just discharge the brightest highlight of the pattern.

Cap the lens and adjust the grid-No.3 voltage control so that the video signal when viewed on a video waveform oscilloscope has the flattest possible trace. This represents the black level of the picture. Unwanted variations in the black level of a color picture are much more evident and objectionable than in a black-and-white picture.

From this point on, the waveform monitor for the camera should be used to determine the lens stop necessary to give the maximum desired highlight signal as determined with the neutral step pattern.

Improved linearity of signal output and color purity can be achieved by next raising the target voltage to approximately 4 volts above the target-cutoff value. This increase assures nearly complete collection of the secondary electrons by the target mesh. In no case should the highlight signal output be greater than the maximum previously determined with the neutral test pattern and controlled by the iris setting. If higher signal output is obtained by increased illumination and beam current, resolution will suffer due to random attraction of the low-velocity scanning beam by the adjacent image charge.

Retention of a scene by the 6474, sometimes called a "sticking picture", may be experienced if the 6474 is allowed to remain focused on a stationary bright scene for several minutes, or it it is focused on a bright scene before reaching operating temperature in the range from 35° to 45°C. Often the retained image will disappear in a few seconds, but sometimes it may persist for long periods before it completely disappears. A retained image can generally be removed by focusing the 6474 on a clear white screen and allowing it to operate for several hours with an illumination of about 1 foot-candle on the photocathode.

To avoid retention of a scene, it is recommended that the 6474 always be allowed to warm up in the camera for 1/2 to 1 hour with the lens iris closed and with a slight amount of beam current. Never allow the 6474 to remain focused on a stationary bright scene for more than a few minutes, and never use more illumination than is necessary.

Further detailed information on use of this image orthicon in a three-tube image orthicon color camera is given in Reference 7.

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3. Otto H. Schade, *"Electro-Optical Characteristics of Television Systems; Introduction and*
   Part I--Characteristics of Vision and Visual Systems", RCA Review, March, 1948;
   Part II--Electro-Optical Specifications for Television Systems", RCA Review, June, 1948;
   Part III--Electro-Optical Characteristics of Camera Systems", RCA Review, September, 1948;
   Part IV--Correlation and Evaluation of Electro-Optical Characteristics of Imaging Systems", RCA Review, December, 1948.
4. R. B. Janes, R. E. Johnson, and R. S. Moore, *"Design and Performance of Television Camera Tubes"*, RCA Review, June, 1949.
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6. R. B. Janes and A. A. Rotow, *"Light Transfer Characteristics of Image Orthicons"*, RCA Review, September, 1950.
7. R. G. Neuhauser, A. A. Rotow, and F. S. Veith, *"Image Orthicons for Color Cameras"*, Proc. of I.R.E., January, 1954.

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DOS and DON'TS
on Use of RCA-6474/1854

Here are the "dos"--

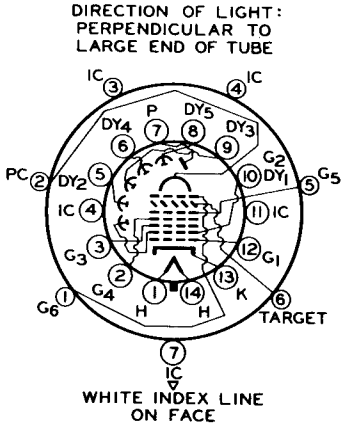
1. Allow the 6474 to warm up prior to operation.
2. Hold temperature of the 6474 within operating range.
3. Make sure alignment coil is properly aligned.
4. Adjust beam-focus control for best usable resolution.
5. Give the 6474 an idle period every 200 hours.
6. Condition spare 6474's by operating several hours once each month.
7. Determine proper operating point with target voltage adjusted to exactly 2 volts above target cutoff.
8. Cap lens during standby operation.

Here are the "don'ts"--

1. Don't force the 6474 into its shoulder socket.
2. Don't operate the 6474 without scanning.
3. Don't underscan target.
4. Don't focus the 6474 on a stationary bright scene.
5. Don't operate a 6474 having an ion spot.

The significance of each of the above "dos" and "don'ts" in obtaining optimum performance from the 6474 is explained in the preceding pages of this bulletin.

SOCKET CONNECTIONS
Bottom View



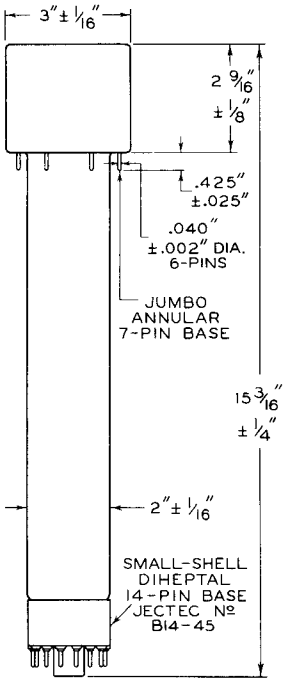
SMALL-SHELL DIHEPTAL 14-PIN BASE

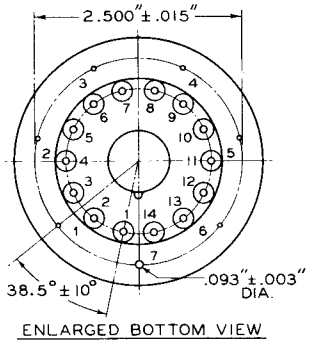
PIN 1: HEATER
PIN 2: GRID No.4
PIN 3: GRID No.3
PIN 4: INTERNAL CONNEC-TION--DO NOT USE
PIN 5: DYNODE No.2
PIN 6: DYNODE No.4
PIN 7: ANODE
PIN 8: DYNODE No.5
PIN 9: DYNODE No.3
PIN 10: DYNODE No.1, GRID No.2
PIN 11: INTERNAL CONNEC-TION--DO NOT USE
PIN 12: GRID No.1
PIN 13: CATHODE
PIN 14: HEATER

KEYED JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID No.6
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNEC-TION--DO NOT USE
PIN 4: INTERNAL CONNEC-TION--DO NOT USE
PIN 5: GRID No.5
PIN 6: TARGET
PIN 7: INTERNAL CONNEC-TION--DO NOT USE

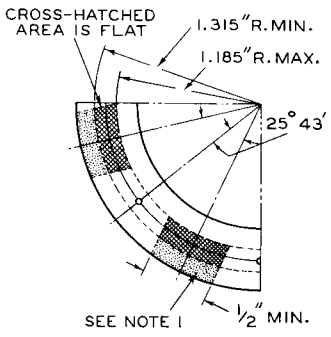
DIMENSIONAL OUTLINE





ENLARGED BOTTOM VIEW

DETAIL OF BOTTOM VIEW OF JUMBO ANNULAR BASE



NOTE 1: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.

ANNULAR BASE GAUGE

ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GAUGE WITH:

a. SIX HOLES HAVING DIAMETER OF 0.065" ± 0.001" AND ONE HOLE HAVING DIAMETER OF 0.150" ± 0.001". ALL HOLES HAVE DEPTH OF 0.265" ± 0.001". THE SIX 0.065" HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047". ALL HOLES ARE SPACED AT ANGLES OF 51°26' ±5' ON CIRCLE DIAMETER OF 2.500" ± 0.015".

b. SIX STOPS HAVING HEIGHT OF 0.187" ± 0.001", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

c. RIM EXTENDING OUT A MINIMUM OF 1/8" FROM 2-13/16" DIAMETER AND HAVING HEIGHT OF 0.126" ± 0.001".

d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200" ± 0.001".

92CM-8293

This bulletin also applies to RCA-6850 which is identical with RCA-6524 except for its heater rating of 12.6 ± 10% volts, 0.625 ampere. Heater-current range with 12.6 volts on heater is 0.588 to 0.663 ampere.

6524

TWIN BEAM POWER TUBE

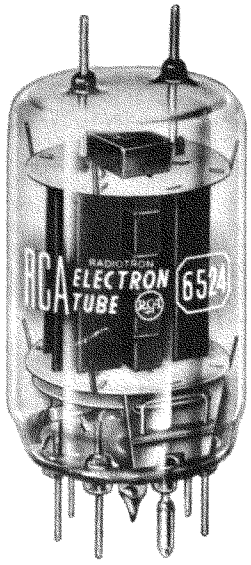
Small Size
Sturdy Structure

High Power Sensitivity
45 Watts Input (ICAS) at 470 Mc
85 Watts Input (ICAS) up to 100 Mc

TENTATIVE DATA

3-9/16" Max. Length
1-11/16" Max. Diameter

RCA-6524 is a small, sturdy, twin beam power tube intended primarily for use as a push-pull rf power amplifier or as a frequency tripler in fixed and mobile equipment operating in the uhf range between 450 and 470 megacycles per second. At lower frequencies in the vhf range, it can be operated with higher plate voltage and plate input to give increased power output. The 6524 is also useful as an af power amplifier and modulator.



The 6524 has a maximum plate dissipation rating of 25 watts under ICAS conditions in modulator service and in cw service. In the latter service, it can be operated with full input to 100 Mc and with reduced input to 470 Mc. In class C telegraphy and frequency-modulated service at 462 Mc under ICAS conditions, the 6524 can deliver a power output of approximately 20 watts; and as a tripler to 462 Mc, it can deliver about 8 watts.

Because of its high power sensitivity and high efficiency, the 6524 can be operated with relatively low plate voltage to give large power output with small driving power.

The excellent efficiency obtainable with the 6524 in push-pull service with circuits of the conventional line type, even at the maximum frequency of 470 Mc, is made possible by several design features. Included among these is the balanced, compact structure of the beam power units which have low interelectrode capacitances, close electrode spacing, and a cathode common to the two units. Rf losses are minimized by the use of short, heavy, internal leads and high-conductivity seals. Use of a single cathode common to the two units, instead of a cathode for each unit, reduces cathode inductance to a negligible value. Furthermore, input degeneration is prevented by the balanced arrangement of the units in push-pull service.

DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	1.25	amperes
Transconductance (Each Unit) for dc plate volts = 200, dc grid-No.2 volts = 200, and dc plate ma. = 50.	4500	μmhos
Mu-Factor, Grid No.2 to Grid No.1 (Each Unit) for dc plate volts = 200, dc grid-No.2 volts = 200, and dc plate ma. = 50.	8.5	
Direct Interelectrode Capacitances (Each Unit):*		
Grid No.1 to plate	0.11 max.	μμf
Grid No.1 to cathode & grid No.3 & internal shield, grid No.2 (pins 1 & 7), and heater	7	μμf
Plate to cathode & grid No.3 & internal shield, grid No.2 (pins 1 & 7), and heater	3.4	μμf

Mechanical:

Mounting Position	Any
Maximum Overall Length	3-9/16"
Seated Length	3" ± 1/8"
Maximum Diameter	1-11/16"
Bulb	See *Dimensional Outline*
Bulb Terminals (Two)	See *Dimensional Outline*
Base	Medium-Button Septar 7-Pin (JETEC No.E7-20)
Weight (Approx.)	3 oz
Bulb Temperature (At hottest point)	210 max. °C

Cooling: Free circulation of air around the tube is required. In addition, some forced-air cooling will generally be required to prevent exceeding the specified maximum bulb temperature.

AF POWER AMPLIFIER & MODULATOR--Class AB_2†

Values are on a per-tube basis

	CCS°	ICAS°°	
Maximum Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	500 max.	600 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	300 max.	volts
DC GRID-No.2 SUPPLY VOLTAGE	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	150 max.	150 max.	ma
MAX.-SIGNAL PLATE INPUT**	70 max.	85 max.	watts

TMK ®, Marca Registrada
Printed in U.S.A.

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

AF POWER AMPLIFIER & MODULATOR (Cont'd)

	CCS[O]	ICAS[OO]	
MAX.-SIGNAL GRID-No.2 INPUT**. .	3 max.	3 max.	watts
PLATE DISSIPATION**. . . .	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical CCS Operation:			
DC Plate Voltage	400	500	volts
DC Grid-No.2 Voltage▲. . .	200	200	volts
DC Grid-No.1 (Control-Grid) Voltage:			
From fixed-bias source .	-23	-26	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage. .	72	70	volts
DC Plate Current:			
Zero-signal value. . . .	25	20	ma
Max.-signal value. . . .	145	116	ma
DC Grid-No.2 Current:			
Zero-signal value. . . .	0.1	0.1	ma
Max.-signal value. . . .	10	10	ma
DC Grid-No.1 Current:			
Max.-signal value. . . .	2.4	2.6	ma
Effective Load Resistance (Plate to plate)	7100	11100	ohms
Max.-Signal Driving Power (Approx.)◆	0.1	0.1	watt
Max.-Signal Power Output (Approx.)	39	40	watts
Typical ICAS Operation:			
DC Plate Voltage	500	600	volts
DC Grid-No.2 Voltage▲. . .	200	200	volts
DC Grid-No.1 (Control-Grid) Voltage:			
From fixed-bias source .	-25	-26	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage. .	76	76	volts
DC Plate Current:			
Zero-signal value. . . .	25	21	ma
Max.-signal value. . . .	145	135	ma
DC Grid-No.2 Current:			
Zero-signal value. . . .	0.1	0.1	ma
Max.-signal value. . . .	10	13	ma
DC Grid-No.1 Current:			
Max.-signal value. . . .	2.9	3.3	ma
Effective Load Resistance (Plate to plate)	8900	11400	ohms
Max.-Signal Driving Power (Approx.)◆	0.1	0.1	watt
Max.-Signal Power Output (Approx.)	50	57	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:◆

With fixed bias.	30000 max. ohms
With cathode bias.	Not recommended

PLATE-MODULATED PUSH-PULL RF POWER AMPLIFIER--Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Values are on a per-tube basis

	CCS[O]	ICAS[OO]	
Maximum Ratings, *Absolute Values*:			
For max. plate voltage and max. plate input above 100 Mc, see Rating Chart I			
DC PLATE VOLTAGE	400 max.	500 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE. .	300 max.	300 max.	volts
DC GRID-No.2 SUPPLY VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE. .	-200 max.	-200 max.	volts
DC PLATE CURRENT	125 max.	125 max.	ma
DC GRID-No.1 CURRENT . . .	4 max.	4 max.	ma
PLATE INPUT.	45 max.	55 max.	watts
GRID-No.2 INPUT.	2 max.	2 max.	watts
PLATE DISSIPATION.	13.5 max.	16.7 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical Operation up to 100 Mc:			
DC Plate Voltage	400	500	volts
DC Grid-No.2 Voltage (Approx.)◆	200	200	volts
From an adjustable series resistor having max. value of	45000	45000◢	ohms
DC Grid-No.1 Voltage★. . .	-61	-61	volts
From combination employing grid resistor of . . .	6200	6200	ohms
with fixed bias of . .	-45	-45	volts
DC Plate Current	100	100	ma
DC Grid-No.2 Current (Approx.)	7	7	ma
DC Grid-No.1 Current (Approx.)	2.5	2.5	ma
Driving Power (Approx.). .	0.2	0.2	watt
Power Output (Approx.)#. .	31	40	watts
Typical Operation at 462 Mc:			
DC Plate Voltage	300	300	volts
DC Grid-No.2 Voltage (Approx.)◆	200	240	volts
From an adjustable series resistor having max. value of	45000	25000	ohms
DC Grid-No.1 Voltage★. . .	-60	-60	volts
From combination employing grid resistor of . . .	15000	15000	ohms
with fixed bias of . .	-45	-45	volts
DC Plate Current	75	95	ma
DC Grid-No.2 Current (Approx.)	4	5.5	ma
DC Grid-No.1 Current (Approx.)	1	1	ma
Driver Power Output (Approx.)	7	7	watts
Useful Power Output (Approx.)●●	9	12	watts
Maximum Circuit Values:			
Grid-No.1-Circuit Resistance‡	30000 max.	30000 max.	ohms

PUSH-PULL RF POWER AMPLIFIER & OSCILLATOR--Class C Telegraphy□ and PUSH-PULL RF POWER AMPLIFIER--Class C FM Telephony

Values are on a per-tube basis

	CCS[O]	ICAS[OO]	
Maximum Ratings, *Absolute Values*:			
For max. plate voltage and max. plate input above 100 Mc, see Rating Chart II			
DC PLATE VOLTAGE	500 max.	600 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE. .	300 max.	300 max.	volts
DC GRID-No.2 SUPPLY VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE. .	-200 max.	-200 max.	volts
DC PLATE CURRENT	150 max.	150 max.	ma
DC GRID-No.1 CURRENT . . .	4 max.	4 max.	ma
PLATE INPUT.	70 max.	85 max.	watts
GRID-No.2 INPUT.	3 max.	3 max.	watts

PLATE DISSIPATION.	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation up to 100 Mc:

DC Plate Voltage	500	600	volts
DC Grid-No.2 Voltage (Approx.)⊕. .	200	200	volts
From an adjustable series resistor having max. value of	40000◤	40000◤	ohms
DC Grid-No.1 Voltage■. . .	-44	-44	volts
From grid resistor of. .	12000	12000	ohms
From cathode resistor of	330	330	ohms
DC Plate Current	120	120	ma
DC Grid-No.2 Current (Approx.)	8	8	ma
DC Grid-No.1 Current (Approx.)	3.7	3.7	ma
Driving Power (Approx.). .	0.2	0.2	watt
Power Output (Approx.)⊕⊕ .	46	56	watts

Typical Operation as Amplifier at 462 Mc:◆

DC Plate Voltage	300	300	volts
DC Grid-No.2 Voltage (Approx.)⊕. .	200	250	volts
From an adjustable series resistor having max. value of	60000	20000	ohms
DC Grid-No.1 Voltage■. . .	-31	-38	volts
From grid resistor of. .	12000	12000	ohms
From cathode resistor of	240	240	ohms
DC Plate Current	120	150	ma
DC Grid-No.2 Current (Approx.)	3	6	ma
DC Grid-No.1 Current (Approx.)	2.6	3.2	ma
Driver Power Output (Approx.)	7	7	watts
Useful Power Output (Approx.)●●	16	20	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance‡	30000	30000 max.	ohms

FREQUENCY TRIPLER--Class C

Values are on a per-tube basis

	CCS[o]	*ICAS*[oo]	
Maximum Ratings, *Absolute Values*:			
For max. plate voltage and max. plate input above 100 Mc, see Rating Chart III			
DC PLATE VOLTAGE	400 max.	400 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE. .	300 max.	300 max.	volts
DC GRID-No.2 SUPPLY VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1(CONTROL-GRID) VOLTAGE. .	-200 max.	-200 max.	volts
DC PLATE CURRENT	100 max.	115 max.	ma
DC GRID-No.1 CURRENT . . .	4 max.	4 max.	ma
PLATE INPUT.	36 max.	45 max.	watts
GRID-No.2 INPUT.	3 max.	3 max.	watts
PLATE DISSIPATION.	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation as Tripler to 462 Mc:

DC Plate Voltage	300	300	volts
DC Grid-No.2 Voltage (Approx.)⊕	220	250	volts
From an adjustable series resistor having max. value of	30000	20000	ohms
DC Grid-No.1 Voltage■. . .	-148	-148	volts
From grid resistor of. .	51000	51000	ohms
DC Plate Current	90	110	ma
DC Grid-No.2 Current (Approx.)	5	6.5	ma
DC Grid-No.1 Current (Approx.)	2.9	2.9	ma
Driver Power Output (Approx.)	4	4	watts
Useful Power Output (Approx.)●●	7	8.5	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance‡‡	60000 max.	60000 max.	ohms

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	1.175	1.325	amp
Mu-Factor, Grid No.2 to Grid No.1 (Each Unit). .	1,2	7	10	
Direct Interelectrode Capacitances (Each Unit):				
Grid No.1 to plate . . .	3	-	0.11	μμf
Grid No.1 to cathode & grid No.3 & internal shield, grid No.2 (pins 1 & 7), and heater . .	3	5.8	8.2	μμf
Plate to cathode & grid No.3 & internal shield, grid No.2 (pins 1 & 7), and heater	3	2.6	4.2	μμf

Note 1: With 6.3 volts ac on heater.

Note 2: With dc plate voltage of 200 volts, dc grid-No.2 voltage of 200 volts, and dc plate current of 50 ma.

Note 3: With no external shield.

---

* With no external shield.

† Subscript 2 indicates that grid-No.1 current flows during some part of the input cycle.

o Continuous Commercial Service.

oo Intermittent Commercial and Amateur Service.

** Averaged over any audio-frequency cycle of sine-wave form.

▲ Preferably obtained from a separate source or from the plate-voltage supply with a voltage divider.

◆ Driver stage should be capable of supplying the specified driving power at low distortion to the No.1 grids of the AB_2 stage. To minimize distortion, the effective resistance per grid-No.1 circuit of the AB_2 stage should be held at a low value. For this purpose, the use of transformer coupling is recommended. In no case, however, should the total dc grid-No.1-circuit resistance exceed 30000 ohms.

● Obtained preferably from a separate source modulated with the plate supply, or from the modulated plate supply through a series resistor. It is recommended that this resistor be adjustable to permit obtaining the desired operating plate current after initial tuning adjustments are completed.

◤ Connected to a 400-volt tap or suitable voltage divider across the plate-supply voltage.

★ Obtained from a combination of grid-No.1 resistor with either fixed supply or cathode resistor. The combination of grid-No.1 resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

⊕ At 100 Mc, useful power output measured at load of output circuit is approximately 29 watts CCS and 36 watts ICAS.

●● This value of useful power is measured at load of output circuit.

‡ When grid No.1 is driven positive, the total dc grid-No.1-circuit resistance should not exceed the specified value of 30000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply.

□ Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

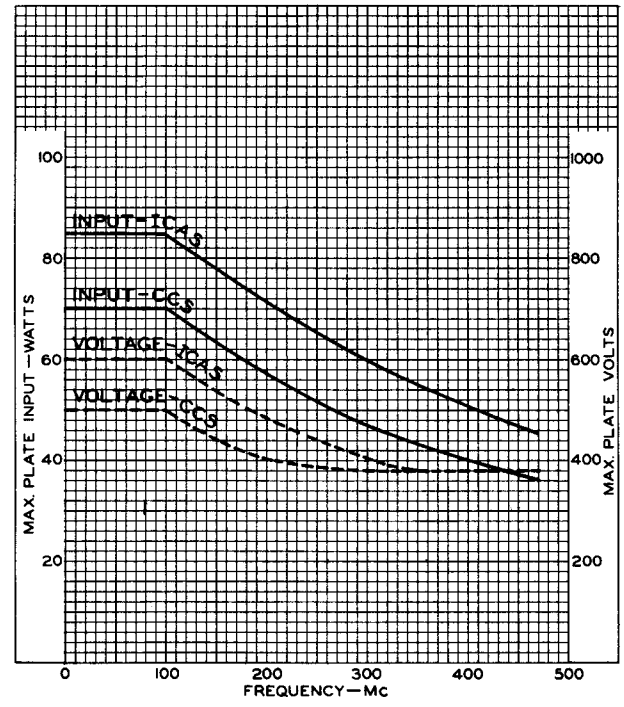
⊕ Obtained preferably from a separate source, or from the plate-supply voltage with a voltage divider, or through a series resistor. A series grid-No.2 resistor should be used only when the 6524 is used in a circuit which is not keyed. It is recommended that this resistor be adjustable to permit obtaining the desired operating plate current after initial tuning adjustments are completed. Grid-No.2 voltage must not exceed 400 volts under key-up conditions.

■ Obtained from fixed supply, by grid-No.1 resistor, by cathode resistor, or by combination methods.

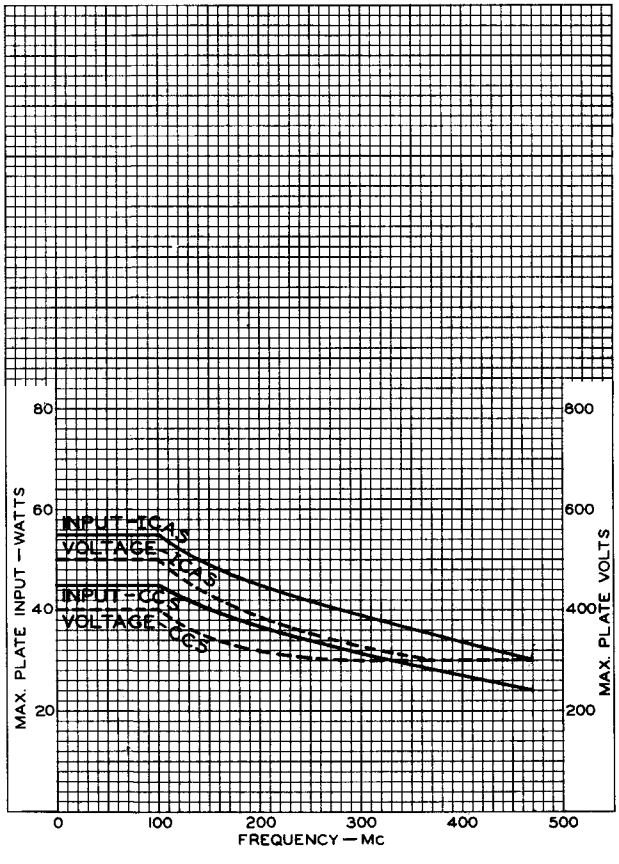
At 100 Mc, useful power output measured at load of output circuit is approximately 43 watts CCS and 52 watts ICAS.

Typical operation as an oscillator at 462 Mc is the same as that shown for amplifier service except that the useful power output measured at load of output circuit is approximately 9 watts CCS and 13 watts ICAS.

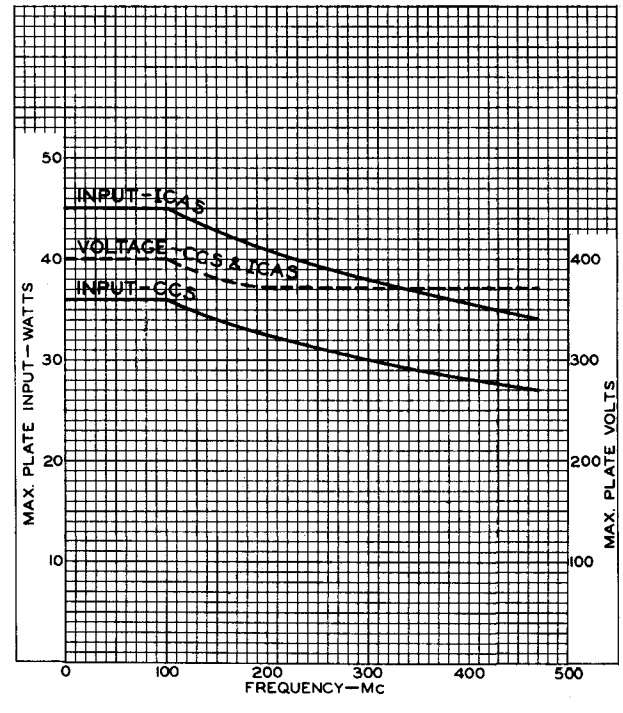
‡‡ When grid No.1 is driven positive, the total dc grid-No.1-circuit resistance should not exceed the specified value of 60000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply.



Rating Chart II for Type 6524 in Class C Telegraphy Service.



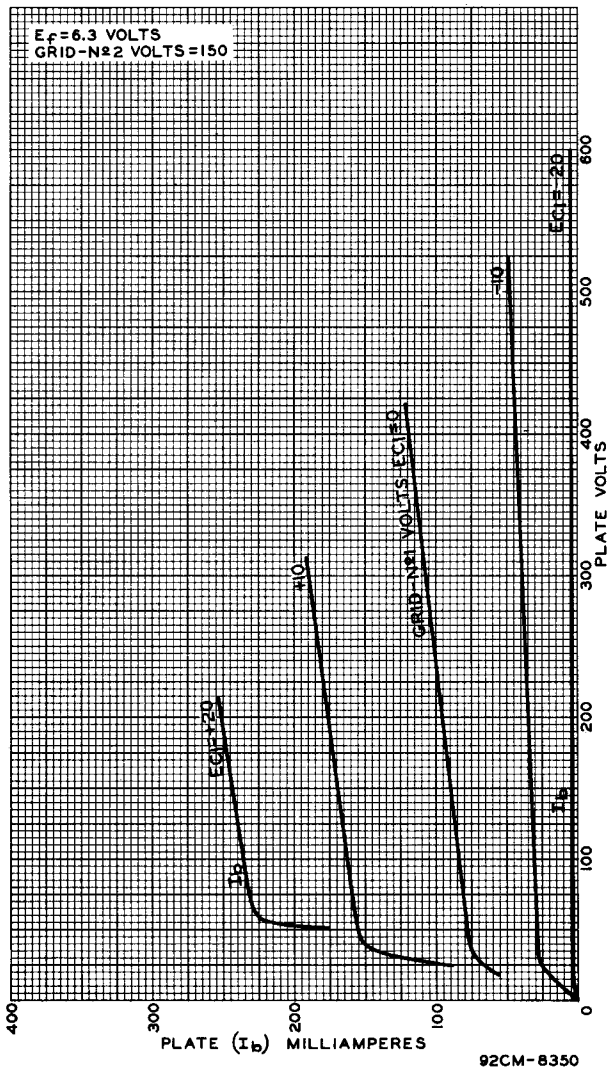
Rating Chart I for Type 6524 in Plate-Modulated Class C Telephony Service.



Rating Chart III for Type 6524 in Class C Tripler Service.

OPERATING CONSIDERATIONS

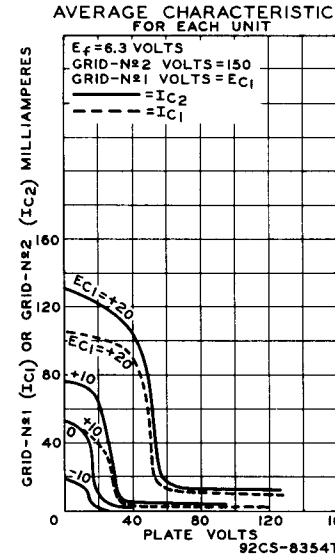
The *maximum ratings* in the tabulated data for the 6524 are limiting values above which the serviceability of the 6524 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value



Average Plate Characteristics for Each Unit of Type 6524.

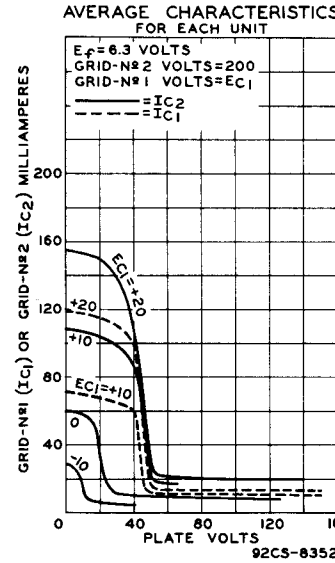
of that rating by an amount such that the absolute values will never be exceeded under any normal condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum bulb temperature* of 210°C is a tube rating and is to be observed in the same manner as other ratings. The temperature should be measured at the hottest point on the bulb with the tube operating in the completely assem-



Average Characteristics for Each Unit of Type 6524.

bled equipment with all covers in place, and delivering the maximum output under the highest ambient-temperature conditions and the most severe operating cycle for which the equipment



Average Characteristics for Each Unit of Type 6524.

is designed. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y., in the form of liquid and stick.

Operation of the 6524 at frequencies above 100 Mc requires reduction in the applied plate voltage and plate input as shown by the Rating Charts *I*, *II*, and *III*. In using these charts, it is to be noted that the maximum plate input that can be applied to the 6524 operating at any given frequency must be chosen, depending on circuit efficiency, so that the plate-dissipation rating of the 6524 will not be exceeded.

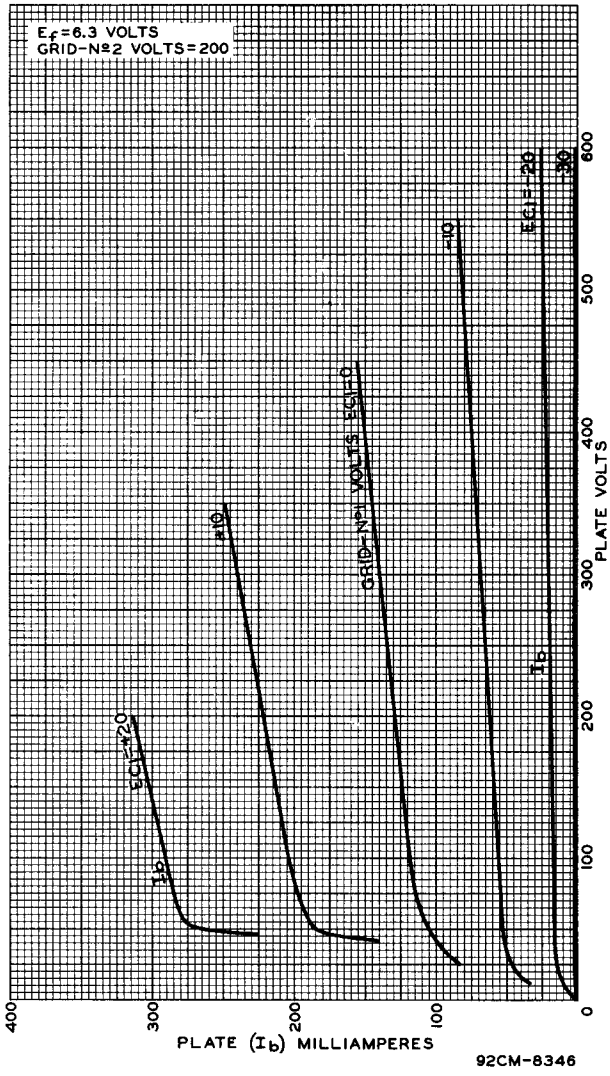
The *rated plate voltage and grid-No.2 voltage of the 6524 are high enough to be dangerous to the user.* Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage and grid-No.2 voltage.

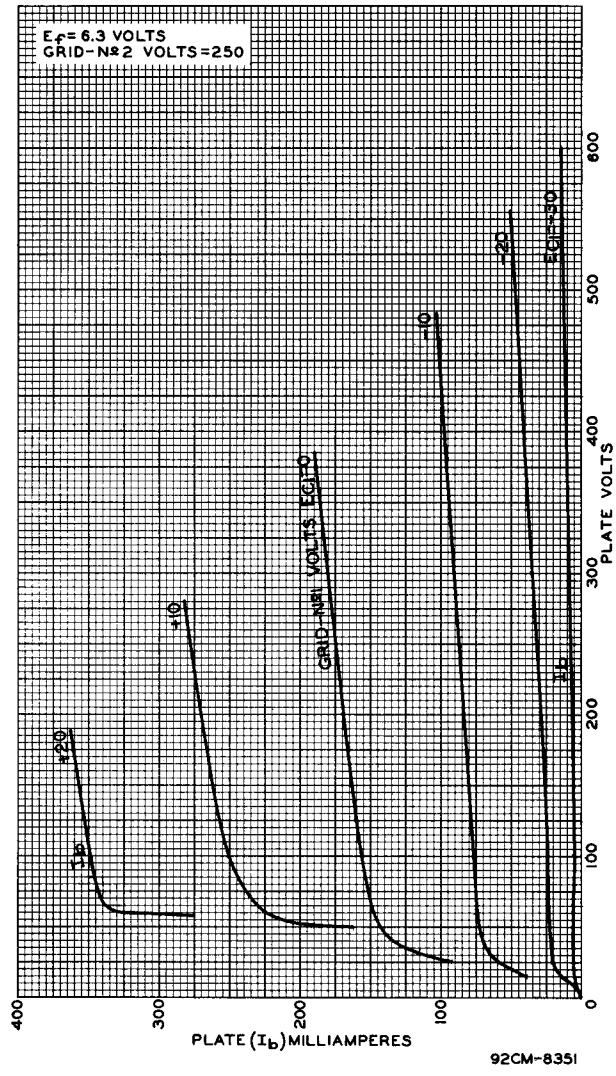
A *protective device*, such as a fuse, should be used to protect not only the plates but also the No.2 grid against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the plate circuits should be fused. Similarly, a fuse in the lead to the No.2 grid should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

The *base pins* of the 6524 fit the standard transmitting seven-contact socket designed for use with the septar 7-pin base, such as Johnson No.122-248.

Shielding of the 6524 in rf service is required for stable operation. A convenient method of shielding is to mount the socket approximately 5/8" beneath a hole in the chassis plate so that



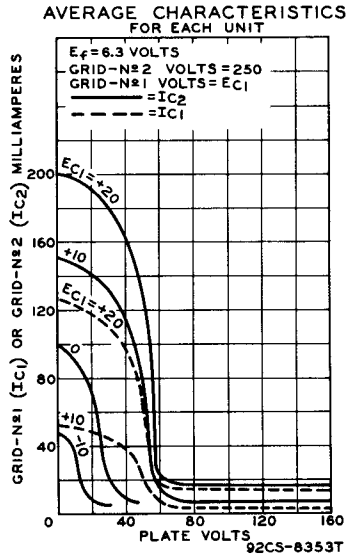
Average Plate Characteristics for Each Unit of Type 6524.



Average Plate Characteristics for Each Unit of Type 6524.

when the 6524 is inserted in the socket, the internal shield (see *Dimensional Outline*) of the tube will be close to the edge of the hole and in the same plane as the chassis plate. This arrangement provides an effective shield to isolate the grid-No.1 circuits from the plate circuits.

The *connections to the plate terminals* should have sufficient flexibility to allow for mechanical tolerances on the plate terminals (see *Dimensional Outline*) and also for thermal expansion and other movements of associated circuits to prevent subjecting the plate-terminal seals to any strain. Connectors should be designed to facilitate heat conduction and to avoid losses caused by poor contact. The connectors should never be soldered directly to the plate terminals.



Average Characteristics for Each Unit of Type 6524.

The *plates* show no color when the 6524 is operated at maximum plate-dissipation rating. During tuning adjustments, or when the load is removed from the tube, precautions should be taken to limit the plate dissipation to the rated maximum value.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

Grid No.2 is common to the two units of the 6524. When the grid-No.2 voltage is obtained from a separate source, the plate voltage should be applied before or simultaneously with the grid-No.2 voltage. Otherwise, with voltage on grid No.2 only, its current would be large enough to cause excessive grid-No.2 dissipation even though some protective bias is employed. When the grid-No.2 voltage is obtained from a voltage divider or through a series resistor from the plate supply, it is recommended that the resistor be adjustable so that the plate current of individual tubes can be adjusted to maintain the desired input. By thus compensating for the normal plate-current variation between tubes, the dc plate input can be held constant to provide more uniform power output and better performance. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the dc power input determined.

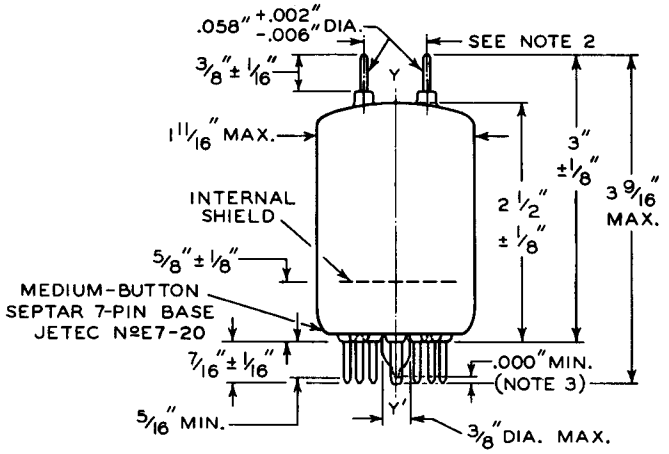
The *grid-No.2 current* is a very sensitive indication of plate-circuit loading. When the amplifier is operated without load, the grid-No.2 current rises excessively, often to a value which damages the tube. Therefore, care should be taken when tuning the 6524 under no-load or lightly loaded conditions to prevent exceeding the grid-No.2 input rating of the tube. In this connection, reduction of the grid-No.2 voltage will be helpful.

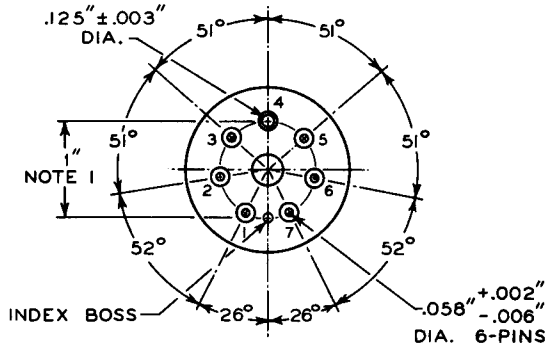
The *driver stage* for the 6524 in either class C telephony or telegraphy service should have considerably more output capability than the typical driving power shown in the tabulated data in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuits and the coupling circuits. This recommendation is particularly important near the rated maximum frequency where circuit losses, radiation losses, and transit-time losses increase. These losses have been taken into account in the values of driver power output shown under Typical Operation.

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 6524 is operated under load conditions such that the maximum rated plate current flows at the plate voltage which will give maximum rated input.

In *plate-modulated class C amplifier service*, the 6524 can be modulated 100 per cent. The grid-No.2 voltage must be modulated simultaneously with the plate voltage so that the ratio of grid-No.2 voltage to plate voltage remains constant. Modulation of the grid-No.2 voltage can be accomplished either by connecting grid No.2 through a separate winding on the modulation transformer to the fixed grid-No.2 voltage supply, or by connecting grid No.2 through an audio-frequency choke of suitable impedance for low audio frequencies to the fixed grid-No.2 supply voltage. The supply end of the choke should be well bypassed to ground.

DIMENSIONAL OUTLINE





92CM-8345RI

BOTTOM VIEW

THE REFERENCE AXIS YY' IS DEFINED AS THE AXIS OF THE BASE-PIN GAUGE DESCRIBED IN NOTE 1.

NOTE 1: ANGULAR VARIATIONS BETWEEN PINS AND VARIATION IN PIN-CIRCLE DIAMETER ARE HELD TO TOLERANCES SUCH THAT PINS WILL ENTER TO A DISTANCE OF 0.375" A FLAT-PLATE BASE-PIN GAUGE HAVING SIX HOLES 0.0800" ± 0.0005" AND ONE HOLE 0.1450" ± 0.0005" ARRANGED ON A 1.0000" ± 0.0005" CIRCLE AT SPECIFIED ANGLES WITH TOLERANCE OF ± 5' FOR EACH ANGLE. GAUGE IS ALSO PROVIDED WITH A HOLE 0.500" ± 0.010" CONCENTRIC WITH PIN CIRCLE WHOSE CENTER IS ON THE AXIS YY'.

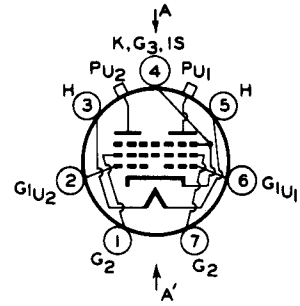
NOTE 2: THE PLATE LEADS WILL ENTER A FLAT-PLATE PLATE-LEAD GAUGE HAVING MINIMUM THICKNESS OF 0.375" AND HAVING TWO HOLES 0.1200" ± 0.0005" WHOSE CENTERS ARE LOCATED AT A DISTANCE OF 0.343" ± 0.001" FROM THE AXIS YY' AND WHOSE AXES ARE PARALLEL TO YY'. THE PLANE THROUGH THESE AXES WILL BE 90° ± 5' FROM THE PLANE THROUGH YY' AND PIN No.4.

NOTE 3: EXHAUST TIP WILL NOT EXTEND BEYOND THE PLANE WHICH PASSES THROUGH THE ENDS OF THE THREE LONGEST PINS.

SOCKET CONNECTIONS

Bottom View

PIN 1: GRID No.2
PIN 2: GRID No.1 OF UNIT No.2
PIN 3: HEATER
PIN 4: CATHODE, GRID No.3, INTERNAL SHIELD



PIN 5: HEATER
PIN 6: GRID No.1 OF UNIT No.1
PIN 7: GRID No.2
P_{U_1}: PLATE OF UNIT No.1
P_{U_2}: PLATE OF UNIT No.2

PLANE OF ELECTRODES OF EACH UNIT IS PARALLEL TO PLANE THROUGH AXIS OF TUBE AND AA'

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

6562

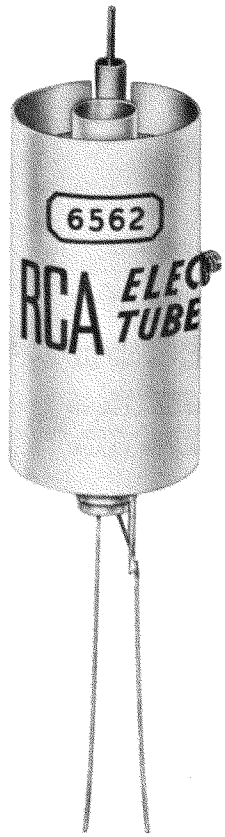
FIXED-TUNED OSCILLATOR TRIODE

"Pencil Type" With Integral Resonators

For Radiosonde Service at 1680 Mc

TENTATIVE DATA

RCA-6562 is a fixed-tuned, ultra-high frequency oscillator triode having a pencil-type construction and intended for transmitting service in radiosonde applications. It has two resonators which are integral with the tube. One of the resonators is fixed-tuned and connected between grid and cathode. The other, which is connected between grid and plate, is loop-coupled to a coaxial rf-output terminal and can be tuned to 1680 megacycles by means of a frequency-adjustment screw. The 6562 has a useful power output in the order of 600 milliwatts.



Actual Size

Features contributing to the usefulness of the 6562 in radiosonde oscillator applications are its high efficiency, small frequency drift, low battery drain, and small size. In addition, the 6562 has flexible heater leads which can be soldered or welded into the associated circuit. The cathode is externally connected to one of the heater leads to simplify circuit connections.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage range* (AC or DC)	5.2 to 6.6	volts
Current with 6.0 volts on heater	0.160	ampere
Frequency (Approx.)	1680	Mc
Frequency Adjustment Range	±12**	Mc
RF Coaxial Output Terminal:		
Characteristic impedance (Approx.)	50	ohms

Mechanical:

Mounting Position	Any
Dimensions	*See Dimensional Outline*
Resonators (Two)	Integral Part of Tube

FIXED-TUNED OSCILLATOR SERVICE

Maximum Ratings, ***Absolute Values:***

DC PLATE VOLTAGE	120 max.	volts
DC PLATE CURRENT	34 max.	ma
DC GRID CURRENT	8 max.	ma
PLATE INPUT	4 max.	watts
PLATE DISSIPATION	3.6 max.	watts
PEAK HEATER-CATHODE VOLTAGE	0 max.	volts
AMBIENT-TEMPERATURE RANGE	−55 to +75	°C

Operating Frequency Drift:

Maximum Frequency Drift:

For heater voltage range of 5.2 to 6.6 volts, plate voltage range of 95 to 117 volts, and ambient-temperature range of +22° to −40°C . . . +4 to −1 Mc

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Av.	Max.	
Heater Current	1	0.135	0.148	0.157	amp
Power Output	2,4	–	600	–	mw
Power Output	3,4	300	–	–	mw

Note 1: With 5.2 volts ac on heater.

Note 2: With ac heater voltage of 6.6 volts, dc plate voltage of 117 volts, frequency of 1680 megacycles per second and grid resistor chosen within the range of 1300 to 1800 ohms. The choice of grid resistor should be such that for any individual tube, the dc plate current must not exceed 34 milliamperes, and when this value of grid resistor is used in the test of Note 3, a minimum power output of 300 milliwatts is obtained.

Note 3: With ac heater voltage of 5.2 volts, dc plate voltage of 95 volts, frequency of 1680 megacycles per second, and grid resistor chosen within the range of 1300 to 1800 ohms. The choice of grid resistor to give a minimum power output of 300 milliwatts for any individual tube must be such that when this same resistor value is used in the test of Note 2 the dc plate current will not exceed 34 milliamperes.

Note 4: Measured with a coaxial-type load having an impedance of approximately 50 ohms and adjusted for a maximum voltage standing-wave ratio of 1.1.

* This range of heater voltage is for radiosonde applications in which the heater is supplied from batteries and in which the equipment design requirements of minimum size, light weight, and high efficiency are the primary considerations even though the average life expectancy of the 6562 in such service is only a few hours.

** As supplied, tubes are adjusted to 1680 ±4 megacycles.

INSTALLATION and APPLICATION

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6562 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsi-

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TMK ®, Marca Registrada

6562-8-55
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in U.S.A.

bility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *flexible heater leads* of the 6562 are usually soldered to the circuit elements. Soldering of these connections should not be made closer than 3/4" from the end of the tube (excluding cathode tab). If this precaution is not followed, the heat of the soldering operation may crack the glass seals of the leads and damage the tube. Under no circumstances should any of the electrodes be soldered to the circuit elements. Connections to the electrodes should be made by spring contact only.

The 6562 should be supported by a suitable clamp around the metal shell either above or below the frequency-adjustment screw. It is essential, however, that the pressure exerted on the shell by the clamp be held to a minimum because excessive pressure can distort the resonators and result in a change in frequency.

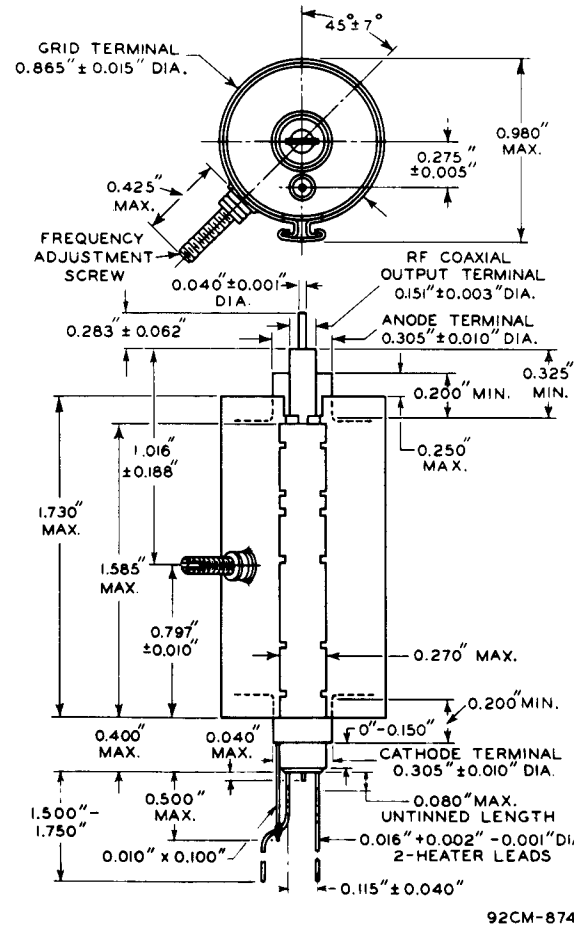
The *plate connection* should have a flexible lead which will accommodate variation in the relative positions of the plate terminals in individual tubes.

The 6562 may be mechanically tuned by adjustment of the frequency-adjustment screw located on the metal shell of the tube. A clockwise rotation of the frequency-adjustment screw will decrease the frequency, while a counter-clockwise rotation will increase the frequency. The range of adjustment provided by the screw is ± 12 megacycles.

REFERENCE

M.W. Bell, *"Production Testing of UHF Radiosonde Tube Type 5794,"* Electronics, November 1953, pp.254 to 266.

DIMENSIONAL OUTLINE



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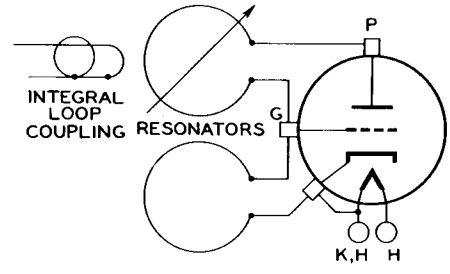
TERMINAL CONNECTIONS



H: HEATER
K: CATHODE
G: GRID
P: PLATE

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

from JETEC release
#1434, March 21, 1955

6571

COMPUTER STORAGE TUBE

Single Beam
Electrostatic Focus
Electrostatic Deflection

Primary-Current-Modulation Type
Redistribution Writing
Capacitance-Discharge Reading

3"-Diameter Bulb
11-1/2" Overall Length
Duodecal 10-Pin Base

TENTATIVE DATA

RCA-6571 is a storage tube designed primarily for use in binary-digital computer systems. It is of the single-beam type, utilizes electrostatic focus and deflection, has its storage surface on the inner surface of the faceplate, and requires an external signal-output electrode shaped to conform to and placed in contact with the entire area of the faceplate. Redistribution writing and capacitance-discharge reading are employed.

Design features which make the 6571 particularly suitable for computer service include (1) a storage-surface having relatively uniform secondary emission to prevent "bad spots" on which information can not be stored, (2) a focused beam having an exceptionally small effective area including the fringe of low-density beam current and a well-defined boundary which is especially significant whenever a single storage element is addressed several times before neighboring elements are regenerated, and (3) separate external connection for the collector to serve as an effective shield to prevent cross-coupling between the electron gun and the external signal-output electrode.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	volts
Current	0.6	amp
Direct Interelectrode Capacitances (Approx.):		
Grid No.1 to all other electrodes	6.5	μμf
Grid No.1 to deflecting electrode DJ_1	0.2	μμf
Grid No.1 to deflecting electrode DJ_2	0.2	μμf
Grid No.1 to deflecting electrode DJ_3	0.2	μμf
Grid No.1 to deflecting electrode DJ_4	0.2	μμf
Cathode to all other electrodes	5	μμf
DJ_1 to DJ_2	2.8	μμf
DJ_3 to DJ_4	2.6	μμf
DJ_1 to all other electrodes	9	μμf
DJ_2 to all other electrodes	9	μμf
DJ_3 to all other electrodes	8	μμf
DJ_4 to all other electrodes	7	μμf
Focusing Method	Electrostatic	
Deflection Method	Electrostatic	
Deflecting-Electrode Arrangement	See *Dimensional Outline*	
Storage Surface	On inner surface of faceplate	
Signal-Output Electrode	Metal plate or 50-line (minimum) mesh covering external surface of faceplate and capacitively coupled to the storage surface. (This electrode is not supplied with tube).	
Overall Length	11-1/2" ± 1/4"	
Greatest Diameter of Bulb	3" ± 1/16"	
Base	Small-Shell Duodecal 10-Pin Base (JETEC No. B10-75)	
Cap	Recessed Small Cavity (JETEC No. J1-21)	
Mounting Position	Center of tube face must be at same elevation as or at higher elevation than tube base	

Maximum Ratings, *Design-Center Values*:

COLLECTOR VOLTAGE:		
Difference between collector voltage and ultor voltage	150 max.	volts
ULTOR● VOLTAGE	2500 max.	volts
GRID-NO.3 VOLTAGE	1000 max.	volts
GRID-NO.1 VOLTAGE:		
Negative bias value	200 max.	volts
Positive bias value	0 max.	volts
Positive peak value	2 max.	volts
PEAK VOLTAGE BETWEEN ULTOR AND ANY DEFLECTING ELECTRODE	500 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	125 max.	volts

Equipment Design Ranges:

For any ultor voltage (E_{c_4}) between 1000 and 2500 volts

Collector Voltage	95% to 105% of E_{c_4}	volts
Grid-No.3 Voltage	20% to 28% of E_{c_4}	volts
Max. Grid-No.1 Voltage for Beam-Current Cutoff	2.4% of E_{c_4}	volts
Max. Grid-No.3 Current Range	-15 to +10	μamp
Deflection Factors:		
DJ_1 & DJ_2	39 to 53	v dc/in./kv of E_{c_4}
DJ_3 & DJ_4	35.5 to 48.5	v dc/in./kv of E_{c_4}
Focused-Beam Position	##	

Examples of Use of Design Ranges:

For ultor voltage of	*1000*	*2500*	*volts*
Collector Voltage	950 to 1050	2375 to 2625	volts
Grid-No.3 Voltage	200 to 280	500 to 700	volts
Max. Grid-No.1 Voltage for Beam-Current Cutoff	-24	-60	volts

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Examples of Use of Design Ranges (Cont'd):

For ultor voltage of	*1000*	*2500*	*volts*
Deflection Factors:			
DJ_1 & DJ_2	39 to 53	97.5 to 133	volts dc/in.
DJ_3 & DJ_4	35.5 to 48.5	89 to 122	volts dc/in.

Storage Characteristics for Ultor Voltage of 2500 Volts:

Storage-Surface Boundary (in terms of deflection voltage):		
In the $DJ_1 - DJ_2$ direction from position of undeflected focused beam	±109	volts
In the $DJ_3 - DJ_4$ direction from position of undeflected focused beam	±100	volts
Blemish Factor*, for storage surface within indicated boundary	0.5 max.	
Spill (Determined for Double-Dot Pattern):**		
Under conditions involving 255 references to "spill" element and 1 reference to "test" element		
Separation Between Storage Elements, in either the $DJ_1 - DJ_2$ or $DJ_3 - DJ_4$ direction in terms of deflection voltage:		
At center of storage surface	8 max.	volts
At midpoint on each side of storage-surface boundary	10 max.	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	1.5 max.	megohms
Resistance in Any Deflecting-Electrode Circuit■	1.0 max.	megohm

● The "ultor" in a storage tube is the electrode to which is applied the highest dc voltage for accelerating the electrons in the beam prior to its deflection. In the 6571, the ultor function is performed by grid No.4. Since grid No.4 and grid No.2 are connected together within the 6571, they are collectively referred to simply as "ultor" for convenience in presenting data and curves.

The center of the undeflected focused beam will fall within a circle having a 7.5-mm radius concentric with the center of the tube face.

* Blemish factor is defined as the factor by which the normal positive signal is reduced by the blemish.

** Spill is indicative of the amount of binary information that can be stored by the tube. The storage capability is determined by the separation between two storage elements at which the signal from one element is changed by no more than a specified amount after repeated references to the other element. For the 6571, the separation is measured, in terms of deflection voltage, when the amplitude of the negative signal of the "test" element has decreased to 50% of its maximum negative amplitude. The maximum negative amplitude is determined by separating the two elements far enough to eliminate the effects of secondary electron redistribution from the "spill" element.

■ It is recommended that the deflecting-electrode-circuit resistances be approximately equal.

OPERATING CONSIDERATIONS

Handling. The 6571 should always be handled and transported with the face up in order to prevent possible damage to the storage surface caused by any loose particles striking the storage surface and adhering to it.

The *maximum ratings* in the tabulated data for the 6571 are working design-center maximums established according to the standard design-center system of rating electron tubes. Tubes so rated will give satisfactory performance in equipment designed so that these maximum ratings will not be exceeded when the equipment is operated from ac or dc power-line supplies whose normal voltage including normal variations falls within ±10 per cent of line-center voltage value of 117 volts.

Support for the tube should be provided by a padded mechanism about the neck and by a cushioned ring or saddle arrangement near the large end of the tube. The tube should not be supported by the socket nor by a clamping arrangement on the base.

Shielding. In typical computer applications, the 6571 is mounted in a compartment having effective magnetic and electrostatic shielding. It is recommended that the bulb be provided with a tight-fitting electrostatic shield extending from the base to the collector coating (see *Dimensional Outline*). This external shield supplements the shielding action of the collector in preventing cross-coupling between the electron gun and the external signal electrode.

The *heater* is designed to be operated at 6.3 volts. The transformer winding supplying the heater power should be designed to operate the heater at the rated voltage under average line-voltage conditions. If the circuit design is such as to cause a high voltage between heater winding and ground, the heater transformer should be adequately insulated to withstand the high voltage.

Although maximum values of peak heater-cathode voltage are specified in the tabulated data, it is recommended that the mid-tap or one side of the heater winding be connected directly to the cathode to minimize the possibility of damage to the tube produced by arcing between heater and cathode when a possible momentary internal arc causes the voltage between heater and cathode to exceed the maximum heater-cathode ratings. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

Grid No.2, connected within the tube to grid No.4 and operated at grid-No.4 potential, is incorporated in the electron-gun design so that the beam current and grid-No.1 cutoff voltage will not be affected by focusing adjustment. Because of the effect of grid No.2, and the negligible current taken by grid No.3, the beam can be sharply focused on the storage surface and remains sharp when beam current is varied over a wide range.

Grid No.3, the focusing electrode, is so designed that it takes negligible current. This feature makes possible the use of a low-current voltage-divider system. Focusing of the beam is controlled by adjustment of the ratio of grid-No.3 voltage to grid-No.4 voltage. Ordinarily, the ratio is adjusted by variation of grid-No.3 voltage. For this purpose, a potentiometer adequately insulated is required in the voltage-divider circuit; the necessary range of adjustment is indicated under *Equipment Design Ranges* and *Examples* in the tabulated data.

The *collector* connection should be made by a flexible lead to the recessed small cavity cap on the side of the bulb. The separate connection to the collector permits operation of the collector at a voltage slightly different from that of the ultor and enables the collector to serve as an effective shield to prevent cross-coupling between the electron gun and the external signal electrode. Normally, the collector is connected to the common ground of the system.

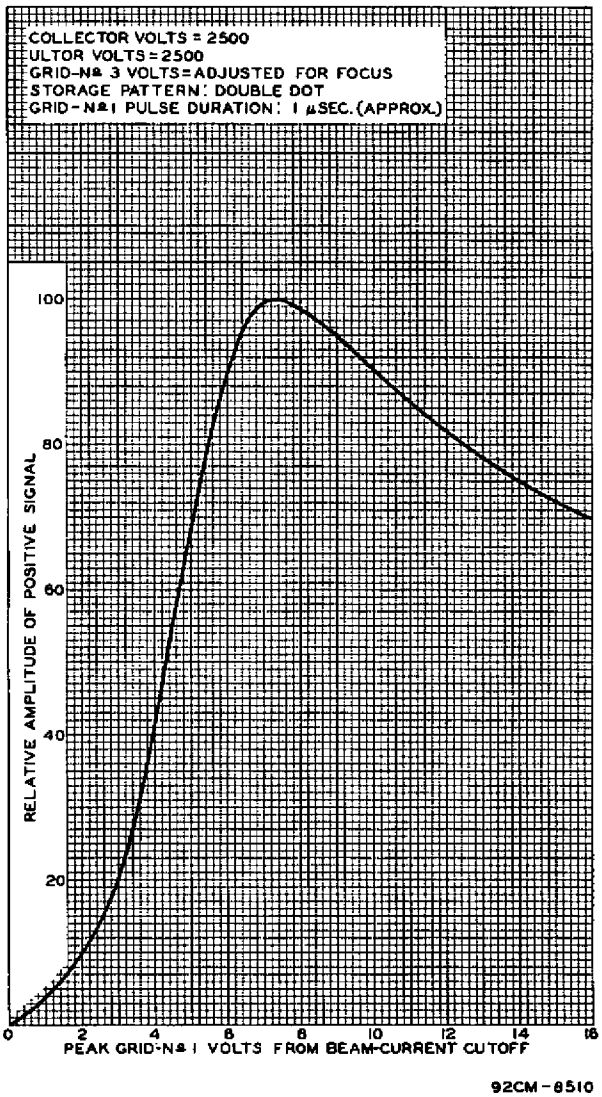

Fig. 1 – Average Characteristic of Type 6571.

Two pairs of *electrostatic deflecting electrodes*, producing fields approximately at right-angles to each other, are located within the bulb neck to provide for deflection of the electron beam in the directions of the respective fields.

Each pair of deflecting electrodes is normally operated at an average potential the same as that of grid No.4. The grid-No.4 voltage may be adjusted with respect to the average deflecting-electrode potential to provide control of astigmatism. Each electrode of each pair should be connected through a resistor of not more than 1 megohm to the grid-No.4 socket terminal.

A *signal-output electrode* shaped to conform with the external contour of the faceplate and placed in contact with the entire area of the faceplate, is required. The signal-output electrode is connected to a low-noise, video amplifier having sufficient gain to amplify signals from a fraction of a millivolt to the desired level.

The *dc voltages* for grid No.1, grid No.3, and ultor should be obtained from an extremely well-regulated power supply essentially free of ripple.

In most applications, it is recommended that the ultor (grids No.2 and No.4) be grounded in order that the deflecting electrodes may be operated at essentially ground potential. With this method, the cathode and heater are at high negative potential with respect to ground.

The high voltages at which this tube is operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Safety precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is desired. In most applications, it is recommended that the ultor terminal be grounded rather than the cathode terminal. With this method, which places the heater and cathode at high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

In the use of high-voltage tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit as a result of capacitor breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off, and both terminals of any capacitors grounded.

The *undeflected focused beam* is normally close to the geometric center of the tube face. However, to compensate for variation from tube to tube, designers should provide an adjustable and reversible supply of at least 12 volts dc per kilovolt of ultor voltage (balanced to ultor) for application between the two deflecting electrodes of each pair. By adjustment of this dc voltage on each pair of the deflecting electrodes, the beam may be centered.

The *amount of information that can be stored by the 6571* is dependent on the manner in which it is operated, and is affected by the stability of the deflecting system, freedom from noise in the associated output circuit, the number of regenerations compared with the number of ad-

dresses, and the effectiveness of the electrostatic and magnetic shielding.

In general, the number of storage elements is proportional to the operating ultor voltage. For the greatest number of storage elements, the 6571 should be operated at the rated maximum ultor voltage and so that the peak grid-No.1 drive is less than that required for the maximum positive amplitude but high enough to provide a satisfactory output signal.

It is recommended that the beam current be limited to the minimum value which provides satisfactory signal amplitude. As shown by the curve in Fig.1, an increase in beam current or grid-No.1 drive beyond the peak of the curve (i.e., saturation of the positive signal) does not increase the amplitude of the positive signal.

The *storage characteristics* in the tabulated data and the curve in Fig.1 are based on the use of a double-dot pattern. In this method of storage, the positive signal is produced by adjusting the beam current and the distance between two dot storage elements so that the optimum positive signal is produced when the "test" element is addressed. Other methods of storage such as superimposed focused and defocused spots or dots and dashes may be used equally well with the 6571.

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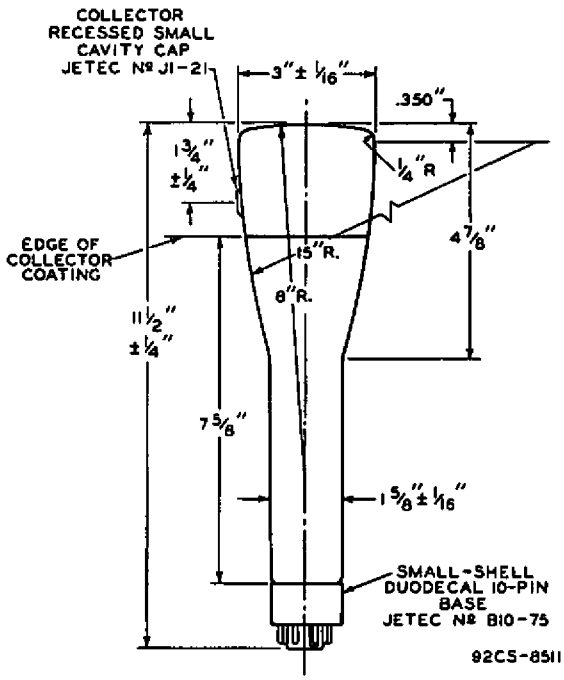
J. P. Eckert, Jr., H. Lukoff, and G. Smoliar, *"A Dynamically Regenerated Memory Tube,"* Proc. I.R.E., Vol. 38, pp.498-510, 1950.

R. Thorensen, *"An Improved Cathode-Ray Tube Storage System"*. National Bureau of Standards, Report No.2275, 1953.

M. Knoll and B. Kazan, *"Storage Tubes and Their Basic Principles"*. John Wiley & Sons, Inc., New York (1952).

DIMENSIONAL OUTLINE



CENTER LINE OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

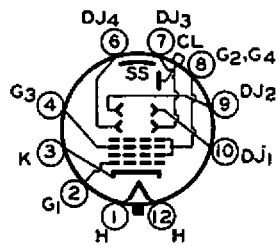
DJ_1 AND DJ_2 ARE NEARER THE STORAGE SURFACE: DJ_3 AND DJ_4 ARE NEARER THE BASE. WITH DJ_1 POSITIVE WITH RESPECT TO DJ_2, THE BEAM WILL BE DEFLECTED TOWARD PIN 2; LIKEWISE, WITH DJ_3 POSITIVE WITH RESPECT TO DJ_4, THE BEAM WILL BE DEFLECTED TOWARD VACANT PIN POSITION 11.

THE PLANE THROUGH TUBE AXIS AND EACH OF THE FOLLOWING ITEMS MAY VARY FROM THE DEFLECTION PATH PRODUCED BY DJ_1 AND DJ_2 BY THE FOLLOWING ANGULAR TOLERANCES (MEASURED ABOUT THE TUBE AXIS): PIN 2, 10°; SIDE TERMINAL (ON SAME SIDE AS PIN 8), 10°. ANGLE BETWEEN DJ_1-DJ_2 DEFLECTION PATH AND DJ_3-DJ_4 DEFLECTION PATH IS 90° ± 3°.

SOCKET CONNECTIONS

Bottom View

PIN 1: HEATER
PIN 2: GRID NO.1
PIN 3: CATHODE
PIN 4: GRID NO.3
PIN 6: DEFLECTING ELECTRODE DJ_4
PIN 7: DEFLECTING ELECTRODE DJ_3
PIN 8: ULTOR (GRIDS NO.2 & NO.4)



PIN 9: DEFLECTING ELECTRODE DJ_2
PIN 10: DEFLECTING ELECTRODE DJ_1
PIN 12: HEATER
CAP: COLLECTOR (CL)
SS: STORAGE SURFACE TO WHICH EXTERNAL SIGNAL-OUTPUT ELECTRODE IS CAPACITIVELY COUPLED (SEE DATA)

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from JETEC release #1461,
May 9, 1955

6694

PHOTOCONDUCTIVE CELL

Cadmium-Sulfide Type

TENTATIVE DATA

RCA-6694 is a very tiny, cadmium-sulfide photoconductive cell of the head-on type. It features high luminous sensitivity, very low dark current, extremely low background noise, and signal output which is directly proportional to the incident light intensity. Furthermore, the characteristics of the 6694 are not substantially affected by wide change in operating temperature.

Actual Size

Because of its tiny size and high sensitivity, the 6694 is especially useful in those light applications where a single tiny photosensitive device is desired, in light-controlled relay applications, in computer applications utilizing a modulated light input to the cell to provide a modulated output signal for use with an ac amplifier, and in light meters for measuring the brightness of small luminous spots. It also finds application in x-ray intensity measurements.

The spectral response of the 6694 covers the visible range from about 3500 to 5500 angstroms, as shown in Fig.1. Maximum response occurs at about 5000 angstroms. The 6694, therefore, has high sensitivity to blue-green light. The sensitivity is directly proportional to the applied voltage between terminals within the ratings of the cell.

The frequency response of the 6694 falls off with increase in frequency. Its upper limit is about 500 cycles per second. A somewhat more extended response is obtained with high light levels than with low light levels.

DATA

General:

Spectral Response	S-12
Wavelength of Maximum Response	5000 ± 500 angstroms
Sensitive Area:	
Shape	Rectangular
Dimensions (Minimum)	0.020" x 0.018"
Maximum Overall Length	0.387"
Maximum Seated Length	0.190"
Width	0.320" ± 0.020"
Depth	0.165" ± 0.020"
Base	Small-Oblong Linotetrar 3-Pin (JETEC No.E3-14)
Mounting Position	Any

Maximum Ratings, *Absolute Values*:

POLARIZING VOLTAGE	200 max.	volts
POWER DISSIPATION	30 max.	mw
AMBIENT TEMPERATURE	-40 to +70	°C

Characteristics:

Under conditions with polarizing voltage of 90 volts and at ambient temperature of 25°C

	Min.	Median	Max.	
Sensitivity:				
Radiant, at 5000 angstroms	-	250	-	μamp/μwatt
Luminous*, at 0 cps.	0.3	0.6	-	amp/lumen
Luminous Intensity▲, at 0 cps	1.6	3	-	μamp/ft-c
Dark Current	-	-	0.1	μamp
Frequency Response:				
At 30 cps, as arbitrary reference	-	100	-	per cent
At 300 cps	-	20	-	per cent
Dark Noise	Essentially lower than that of associated circuit			
Photocurrent Decay	See Fig.5			

* For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light flux of about 200 microlumens is used.

▲ For conditions the same as shown under (*) except that an incident light intensity of 73 foot-candles is used.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Luminous Intensity Sensitivity. The quotient of output current by the incident luminous intensity, at constant electrode voltages.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 6694 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *base pins* of the 6694 fit the linotetrar, 3-pin socket, such as Cinch Part No.46AZ20248,

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or equivalent. The socket should be made of high-grade, low-leakage material and should be installed so that the incident light falls on the face end of the cell.

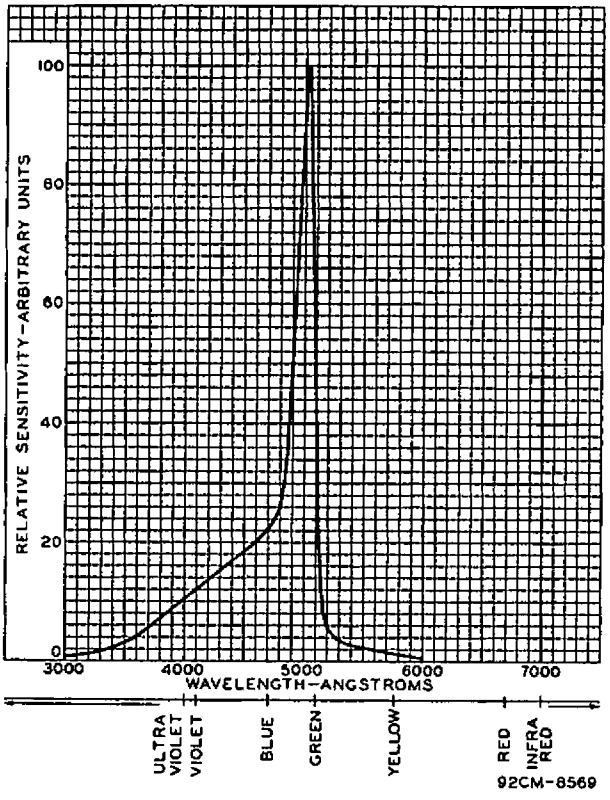


Fig. 1 - Spectral Sensitivity Characteristic of Photoconductive Cell Having S-12 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

The *polarizing voltage* for the 6694 may be applied without regard to polarity. Within the maximum voltage rating of the cell, the sensitivity is directly proportional to the applied voltage.

A *simple lens arrangement* for focusing the incident light onto the small area of the photosensitive surface is suggested, especially when the incident light level is low. It is to be noted, however, that the area of the focused light spot must not be less than the area of the photosensitive surface. Otherwise, a blocking action produced by the unilluminated area of the cell will occur and cause unsatisfactory operation. To obtain the full sensitivity of the cell, it is essential that its entire photosensitive area be illuminated.

The *frequency response* of the 6694 falls off rapidly with increase in frequency from zero to about 500 cycles per second. The decrease is somewhat more rapid with low light levels than with high light levels. The operating frequency range may be extended appreciably by simultaneously irradiating the photosensitive area with red or near-infrared radiation. The amount of such irradiation may be less than or equal to the amount of the controlling light input. The effect of such irradiation is a quenching action which shortens the decay time of the cell and thus permits more rapid response to incident modulated-light fluctuations.

Exposure of the 6694 to intense light, such as direct sunlight, may decrease the cell's sensitivity even though there is no voltage applied. The magnitude and duration of the decrease depend on the length of exposure. Permanent damage to the cell may result if it is exposed to radiant energy so intense as to cause excessive heating of the cell.

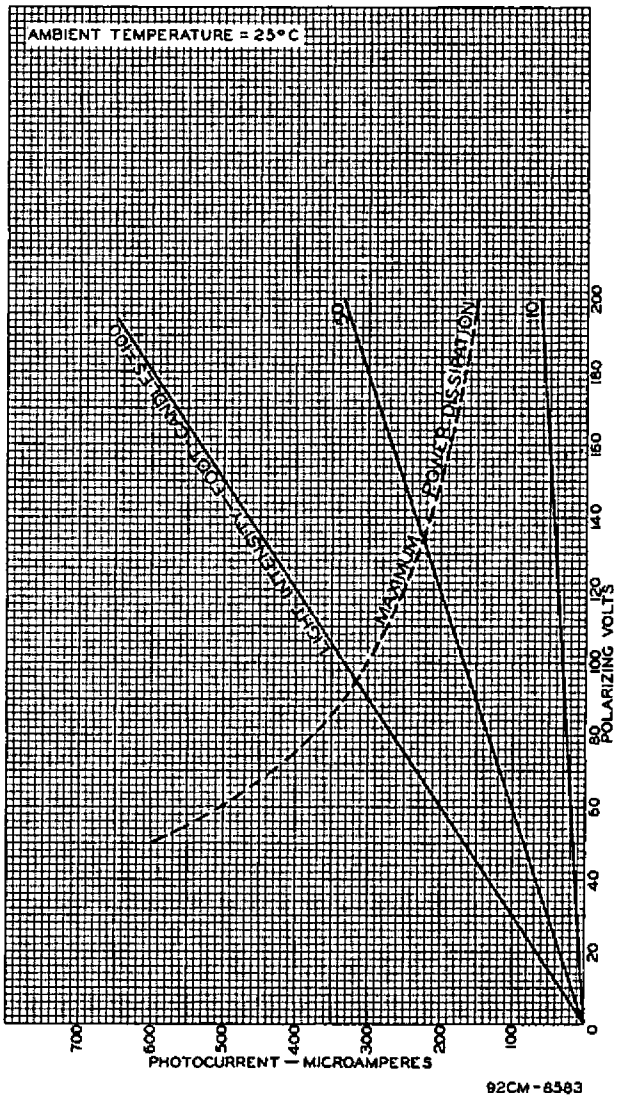


Fig. 2 - Average Characteristics of Type 6694.

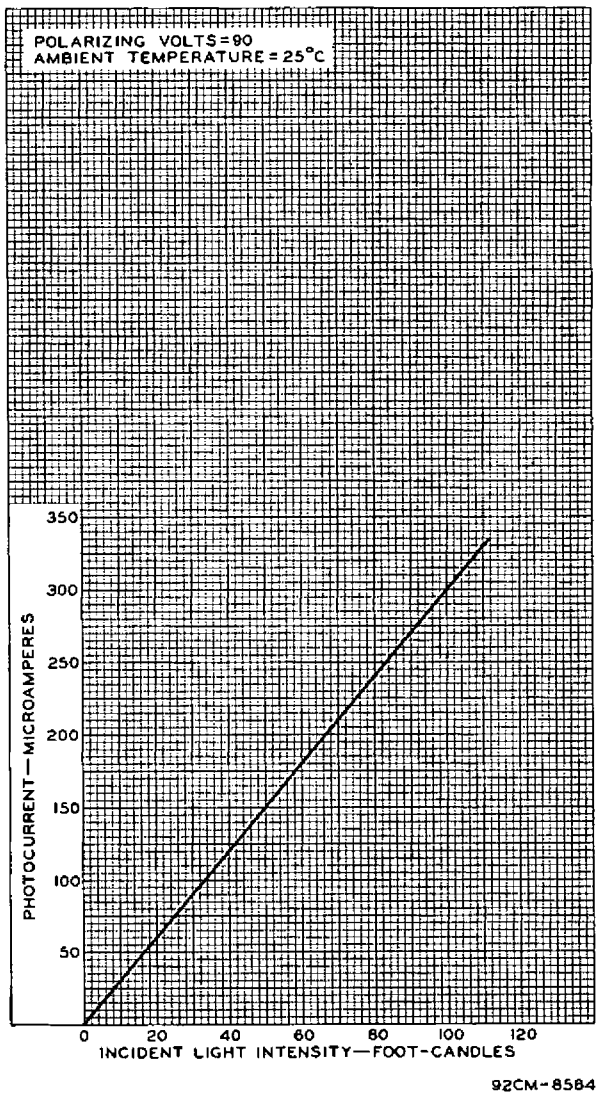


Fig. 3 - Typical Characteristic of Type 6694.

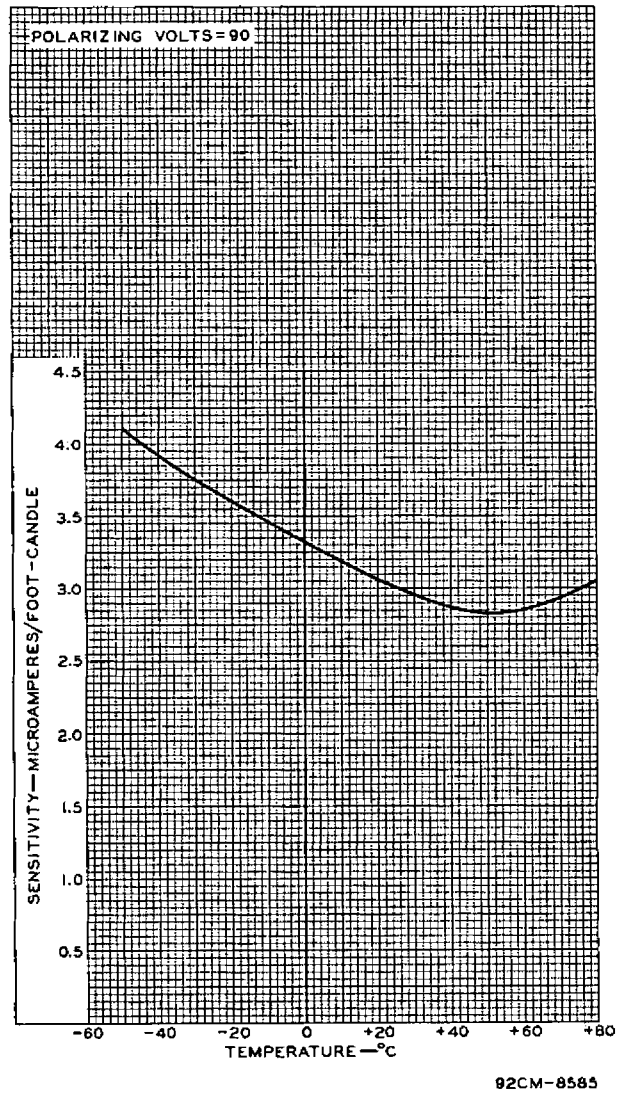


Fig. 4 - Typical Characteristic of Type 6694.

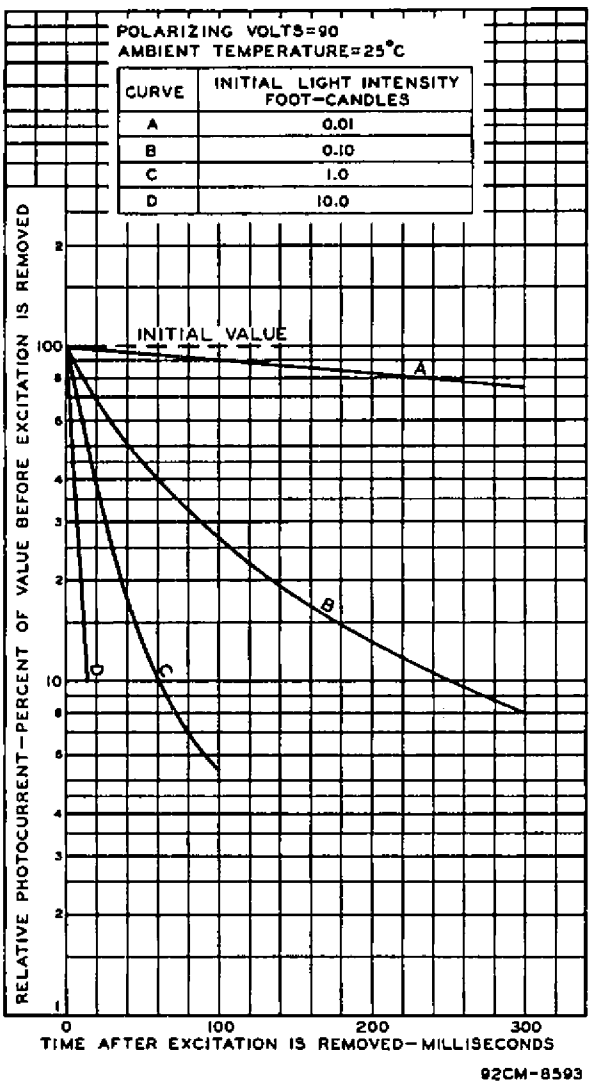
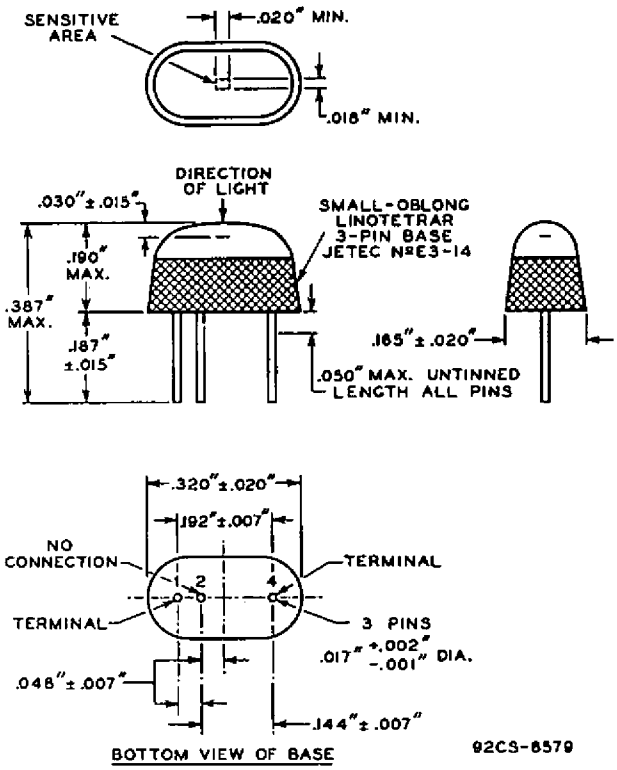
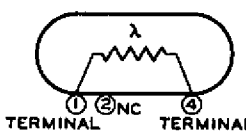


Fig. 5 – Typical Decay Characteristics of Type 6694.

DIMENSIONAL OUTLINE



SOCKET CONNECTIONS



DIRECTION OF LIGHT: INTO FACE OF CELL

PIN 1: TERMINAL
PIN 2: NO CONNECTION
PIN 4: TERMINAL

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6810-A

MULTIPLIER PHOTOTUBE

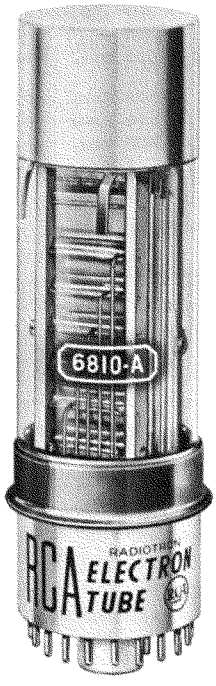
1-11/16" Dia. Curved Circular Semitransparent Photocathode

14-Stage, Head-On Type, Flat Faceplate
S-11 Response
Very Short Time-Resolution Capability

7-1/2" Max. Length
2-3/8" Max. Diameter
Bidecal 20-Pin Base

TENTATIVE DATA

RCA-6810-A is a head-on type of multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear radiation, and applications involving the measurement of low-level light sources. Its fast response, high current gain, high peak-current capability, relative freedom from after-pulses, and its very small spread in electron-transit time make it particularly useful for fast coincidence scintillation counting.



The 6810-A is capable of delivering pulse currents having magnitudes up to 0.5 ampere without space-charge effects causing appreciable deviation from linearity. Consequently, the need for an associated wide-band amplifier to amplify the output pulse is eliminated in many applications.

The spectral response of the 6810-A covers the range from about 3000 to 6500 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 4400 angstroms. The 6810-A, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation. Because of its spectral response, the 6810-A is well suited for use with organic phosphors such as anthracene as well as with inorganic materials such as thallium-activated sodium iodide.

Design features of the 6810-A include a semi-transparent cathode on the curved inner surface of the face end of the bulb; a minimum cathode diameter of 1-11/16 inches; a faceplate with a flat external surface to facilitate the mounting of flat phosphor crystals in direct contact with the surface; fourteen electrostatically focused multiplying (dynode) stages; a focusing electrode with external connection for shaping the field which directs photoelectrons from the cathode onto the first dynode; and an accelerating electrode with external connection for minimizing the space-charge effect in the region of dynode No. 12. The material of which the dynodes are made has stable, high-current-carrying capabilities and permits tube processing to minimize regenerative effects, such as after-pulses.

The internal leads from dynode No. 14 and anode to their respective base-pin terminals are short and direct. This arrangement makes possible the use of a load circuit having a short time constant--an essential feature in pulse service.

The curved cathode surface of the 6810-A assures very good collection by dynode No. 1 of electrons from all parts of the useful cathode area. The curved surface together with the electrode configuration employed in the 6810-A provides minimum spread in electron-transit time. As a result, the 6810-A has very short time-resolution capability, i.e., in the order of 1 millimicrosecond.

The 6810-A is capable of multiplying feeble photoelectric current produced at the cathode by a median value of 12,500,000 times when operated with a supply voltage of 2000 volts. The output current of the 6810-A is a linear function of the exciting illumination under normal operating conditions.

In the scintillation type of nuclear radiation detector, the 6810-A is particularly useful because its flat faceplate permits excellent optical coupling between the phosphor and the tube. As a result, a maximum number of photoelectrons are produced for each scintillation. This feature is important in nuclear

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radiation spectroscopy because it offers the advantage of minimum statistical spread in output-pulse heights. Furthermore, the focusing electrode permits optimizing the magnitude, uniformity, or speed of the response in critical applications; and the accelerating electrode permits obtaining higher peak output current in pulse service than would otherwise be possible.

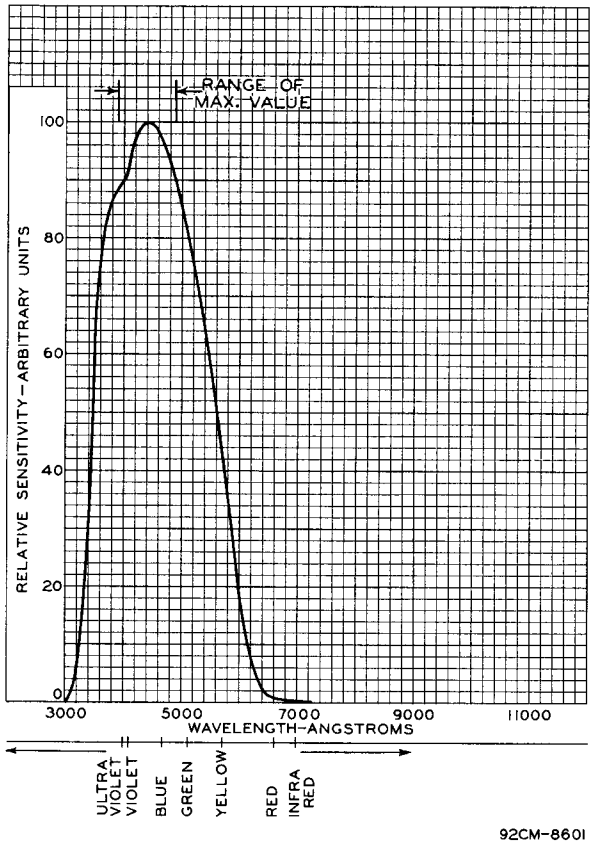


Fig. 1 - Spectral Sensitivity Characteristic of Type 6810-A which has S-11 Response. Curve is shown for Equal Values of Radiant Power at All Wavelengths.

The various outstanding features of the 6810-A commend its use in the design of a scintillation counter with high efficiency and a resolving time of approximately 1 millimicrosecond.

DATA

General:

Spectral Response	S-11	
Wavelength of Maximum Response	4400 ± 500	angstroms
Cathode, Semitransparent:		
Shape	Curved Circular	
Window:		
Area	2.2	sq.in.
Minimum diameter	1-11/16	in.
Index of refraction	1.51	
Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.14	2.4	μμf
Anode to all other electrodes	5.5	μμf
Dynode No.14 to all other electrodes	7.5	μμf
Maximum Overall Length	7-1/2"	
Seated Length	6-11/16" ± 3/16"	
Maximum Diameter	2-3/8"	
Bulb	T-16	
Base	Small-Shell Bidecal 20-Pin (JETEC No.B20-102)	
Mounting Position	Any	
Weight (Approx.)	8 oz.	

VERY-LOW-LIGHT-LEVEL, LOW-NOISE HIGH-GAIN SERVICE

With Supply Voltage (E) Across Voltage Divider Providing Electrode Voltages Shown in Table I--Column A.

Maximum Ratings, *Absolute Values:*

ANODE-SUPPLY VOLTAGE (DC)	2400 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.14 AND ANODE (DC)	400 max.	volts
SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES (DC)	500 max.	volts
SUPPLY VOLTAGE BETWEEN ACCELERATING-ELECTRODE AND DYNODE No.13 (DC)	±500 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC)	400 max.	volts
FOCUSING-ELECTRODE SUPPLY VOLTAGE (DC)	400 max.	volts
AVERAGE ANODE CURRENT●	2 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics Range Values for Equipment Design:

With E = 2000 volts (except as noted) and Accelerating-Electrode Voltage adjusted to give maximum gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	-	0.6	-	amp/μwatt
Cathode Radiant, at 4400 angstroms	-	0.048	-	μamp/μwatt
Luminous:#				
At 0 cps	120	750	4500	amp/lumen
With dynode No.14 as output electrode†	-	525	-	amp/lumen
Cathode Luminous:				
With tungsten light source▲	40	60	-	μamp/lumen
With blue light source (See Fig.2)**	0.04	-	-	μamp
Current Amplification	-	12.5×10^6	-	
Equivalent Anode-Dark-Current Input✙■	-	5×10^{-10}	2×10^{-9}	lumen
Equivalent Noise Input★	-	6×10^{-12}	-	lumen
Max. Transit Time Spread:				
Within a circle centered on tube face and having a diameter of—				
1-1/8"	-	1	-	milliμsec
1-9/16"	-	3	-	milliμsec

HIGH-OUTPUT-PULSE SERVICE

With Supply Voltage (E) Across Voltage Divider Providing Electrode Voltages Shown in Table I--Column B

Maximum Ratings, *Absolute Values:*

ANODE-SUPPLY VOLTAGE (DC)	2800 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.14 AND ANODE (DC)	400 max.	volts
SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES (DC)	500 max.	volts
SUPPLY VOLTAGE BETWEEN ACCELERATING-ELECTRODE AND DYNODE No.13 (DC)	±500 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC)	400 max.	volts
FOCUSING-ELECTRODE SUPPLY VOLTAGE (DC)	400 max.	volts
AVERAGE ANODE CURRENT●	2 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics Range Values for Equipment Design:

With E = 2400 volts (except as noted) and Accelerating-Electrode Voltage adjusted to give maximum gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms .	–	0.6	–	amp/μwatt
Cathode Radiant, at 4400 angstroms .	–	0.048	–	μamp/μwatt
Luminous:#				
At 0 cps	–	750	–	amp/lumen
With dynode No.14 as output electrode† . .	–	525	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲.	40	60	–	μamp/lumen
With blue light source (See Fig.2)**. . . .	0.04	–	–	μamp
Current Amplification	–	12.5×10^6	–	
Equivalent Anode-Dark-Current Input●⊕	–	1.1×10^{-9}	–	lumen
Equivalent Noise Input★★.	–	8×10^{-12}	–	lumen

TABLE I

VOLTAGE TO BE PROVIDED BY DIVIDER		
Between	**COLUMN A** 5.4% of Supply Voltage (E) multiplied by	**COLUMN B** 2.75% of Supply Voltage (E) multiplied by
Cathode and Focusing Electrode	1	1
Focusing Electrode and Dynode No.1	1	1
Dynode No.1 and Dynode No.2	1	1
Dynode No.2 and Dynode No.3	1	1
Dynode No.3 and Dynode No.4	1	1
Dynode No.4 and Dynode No.5	1	1
Dynode No.5 and Dynode No.6	1	1
Dynode No.6 and Dynode No.7	1	1.2
Dynode No.7 and Dynode No.8	1	1.5
Dynode No.8 and Dynode No.9	1	1.9
Dynode No.9 and Dynode No.10	1	2.4
Dynode No.10 and Dynode No.11	1	3.0
Dynode No.11 and Dynode No.12	1.25	3.8
Dynode No.12 and Dynode No.13	1.5	4.8
Dynode No.13 and Dynode No.14	1.75	6
Dynode No.14 and Anode	2	4.8
Anode and Cathode	18.5	36.4

● Averaged over any interval of 30 seconds maximum.

\# Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light input of 0.1 microlumen is used. The load resistor has a value of 0.01 megohm.

† An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.14 as the output electrode. With this arrangement, the load is connected in the dynode-No.14 circuit and the anode serves only as collector.

▲ Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870°K. The value of light flux is 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected together as anode. The load resistor has a value of 0.01 megohm.

** Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870°K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 200 volts are applied between cathode and all other electrodes connected together as anode.

⊕ Measured at a tube temperature of 25°C and with the supply voltage (E) adjusted to give a luminous sensitivity of 2000 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

■ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 2000 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 2000 volts, 25°C tube temperature, external shield potential of −2000 volts, ac-amplifier bandwidth of 1 cycle per second, tungsten light source of 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

● Measured at a tube temperature of 25°C and with the supply voltage (E) adjusted to give a luminous sensitivity of 2000 amperes per lumen. Dark current caused by thermionic emission may be reduced by the use of a refrigerant.

⊕ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 2300 volts is recommended.

★★ Same as (★) except the supply voltage (E) is 2400 volts, and the external shield potential is −2400 volts.

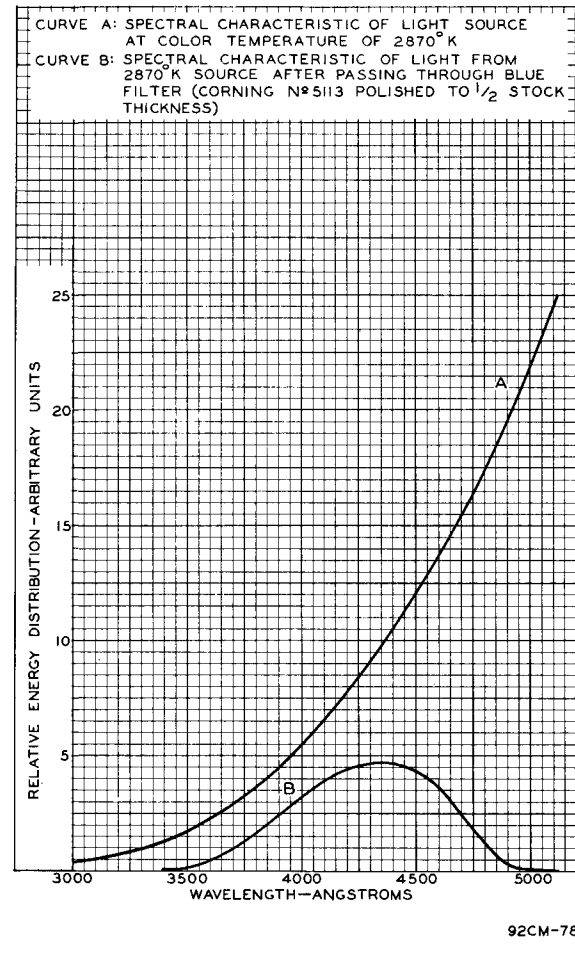


Fig.2 - Spectral Characteristic of 2870°K Light Source, and Spectral Characteristic of Light from 2870°K after Passing through Indicated Filter.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Transit-Time Spread. The increase in width of the anode pulse over that of the input pulse. Anode pulse width is measured at 50% of the pulse height.

GENERAL CONSIDERATIONS

The 6810-A is a phototube incorporating an electron multiplier. An electron multiplier utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 6810-A multiplier phototube, represented in Fig.3, the electrons emitted from the illuminated curved cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.14) are collected by the anode and constitute the current utilized in the output circuit.

The anode consists of a grating which allows the electrons from dynode No.13 to pass through it to dynode No.14. Spacing between dynode No.14 and anode creates a collecting field such that all the electrons emitted by dynode No.14 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 6810-A can be coupled to any practical load impedance.

The shield which is adjacent to dynode No.1 shields dynode No.1 and the cathode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the cathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration. The metallic coating on the inner side wall of the glass bulb is connected to the cathode, and serves to direct the electrons from the cathode toward dynode No.1.

The focusing electrode shapes the field which directs photoelectrons from the cathode onto dynode No.1. For consideration of the operating voltage applied to the focusing electrode, see INSTALLATION and APPLICATION.

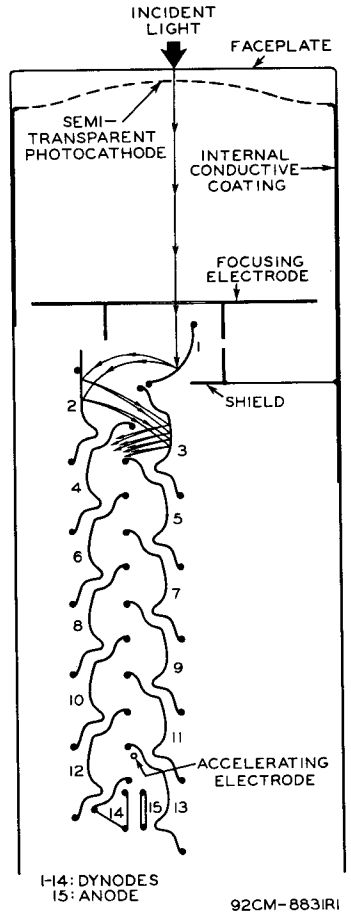


Fig.3 - Schematic Arrangement of Type 6810-A Structure.

The accelerating electrode serves to minimize the effect of space charge in the region of dynode No.12. For consideration of the operating potential of dynode No.12 with respect to dynode No.13, see INSTALLATION and APPLICATION.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 6810-A may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation,

load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface to evaporate with consequent decrease in the life and sensitivity of the tube.

The *base pins* of the 6810 fit the bidecal 20-contact socket, such as "Alden No.220FT with 20 contacts", or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that the incident light falls on the face end of the tube.

In general, *supply voltages* for the electrodes of the 6810-A should be provided as shown in Table I. For *applications involving very low light and requiring low noise and high gain*, supply voltages should be provided as shown in Table I--Column A. For *applications requiring high output pulses*, higher operating voltages may be used as shown in Table I--Column B.

The operating voltage between dynode No.14 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristics curves, shown in Fig.4, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. With low operating voltage between dynode No.14 and anode, the dark current is reduced. As a result, the operating stability of the 6810-A is improved without sacrifice in sensitivity. To obtain the indicated operating voltage between dynode No.14 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

The *focusing-electrode potential* may be adjusted between that of the photocathode and that of dynode No.1 to optimize the magnitude, uniformity, or speed of the response. When the focusing electrode is operated at dynode-No.1 potential, the smallest possible spread in transit time of the photoelectrons as well as good uniformity of response over the entire cathode area is obtained. As the potential of the focusing electrode is decreased toward that of the cathode, all other electrode potentials remaining constant, it will be noticed that the anode current generally passes through a maximum which occurs when the value of focusing-electrode potential is 40 to 80 per cent of that between cathode and dynode No.1. Operation with the focusing electrode at a potential near that of the cathode is characterized by optimum signal magnitude with some increase in transit-time spread and some decrease in uniformity of response over the cathode area. Such operation may offer an advantage in some applications where the increased number of collected photoelectrons is the primary consideration. The voltage for the focusing electrode can be obtained by connecting it to the arm of a potentiometer between cathode and dynode No.1 in the voltage divider.

The *accelerating electrode*, when operated at a suitable potential with respect to dynode No.13, serves to minimize the effect of space charge in the region of dynode No.12. Provision should be made to adjust the accelerating-electrode voltage over a range extending from the value at which dynode No.13 operates to that at which the anode operates. The adjustment may be accomplished by means of a high-resistance potentiometer connected between the voltage-divider tap for dynode No.13 and the anode end of the voltage divider. Since the accelerating electrode draws

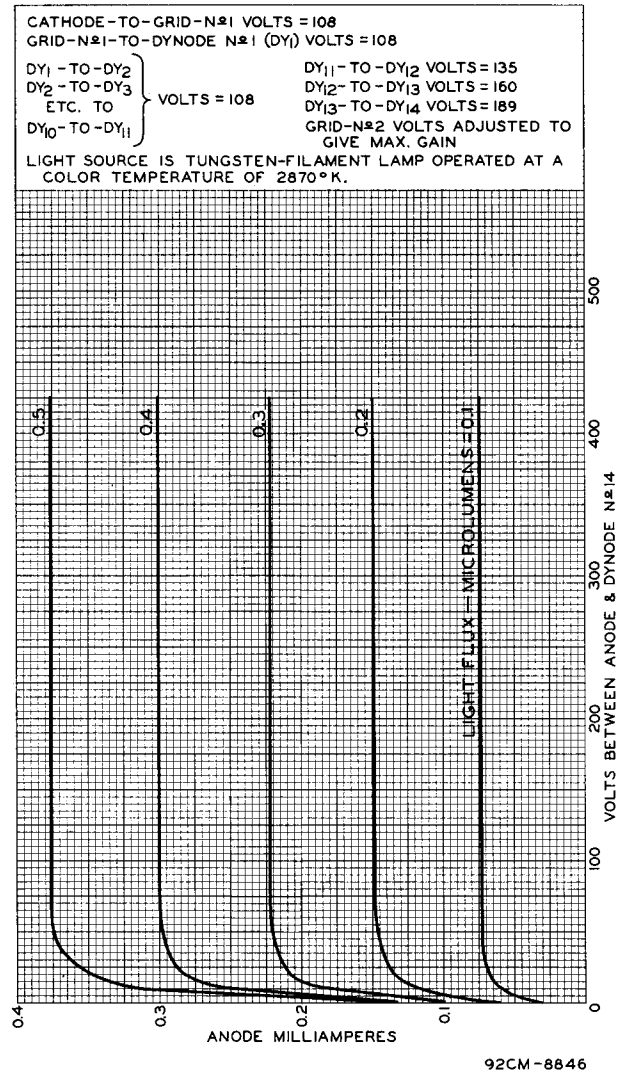


Fig.4 - Average Anode Characteristics of Type 6810-A Used in Low-Light, Low-Noise, High-Gain Service.

at most only negligible current, the potentiometer can have sufficiently high resistance so that it will not substantially affect the voltage distribution at the taps of the shunted section of

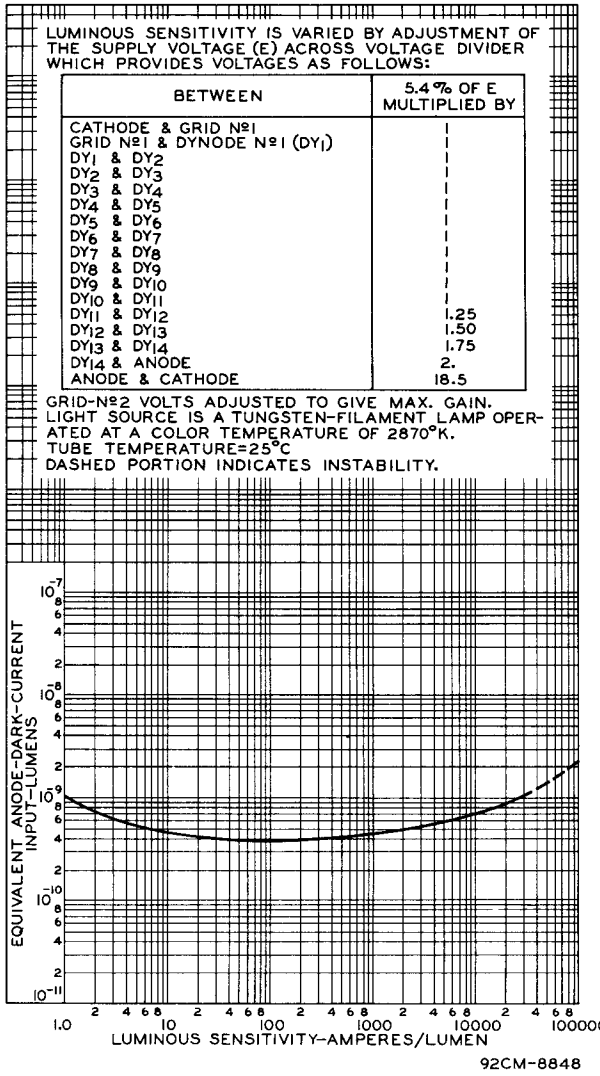


Fig.5 - Typical Anode-Dark-Current Characteristic of Type 6810-A Used in Low-Light, Low-Noise, High-Gain Service.

the divider. Within the specified adjustment range, it will be found that the accelerating-electrode voltage may be adjusted to obtain either maximum gain or maximum peak output current. In general, the adjustment to apply the highest voltage to the accelerating electrode will permit the highest peak current with some sacrifice in gain.

In applications where it is desired to keep the statistical fluctuations to a minimum, e.g., as in nuclear radiation spectroscopy, the potential between cathode and dynode No.1 may be increased to the rated maximum value of 400 volts.

A very small *dark current* is observed when voltage is applied to the electrodes of the 6810-A in complete darkness. This current has a component caused by leakage, and a component consisting of pulses produced by electrons thermionically released from the cathode, by secondary electrons released by ionic bombardment of the dynodes or cathode, or by cold emission from the electrodes. The magnitude of the dark current establishes a limit below which the exciting radiation on the cathode can not be detected.

When the application utilizes *continuous luminous excitation and dc anode current*, and it

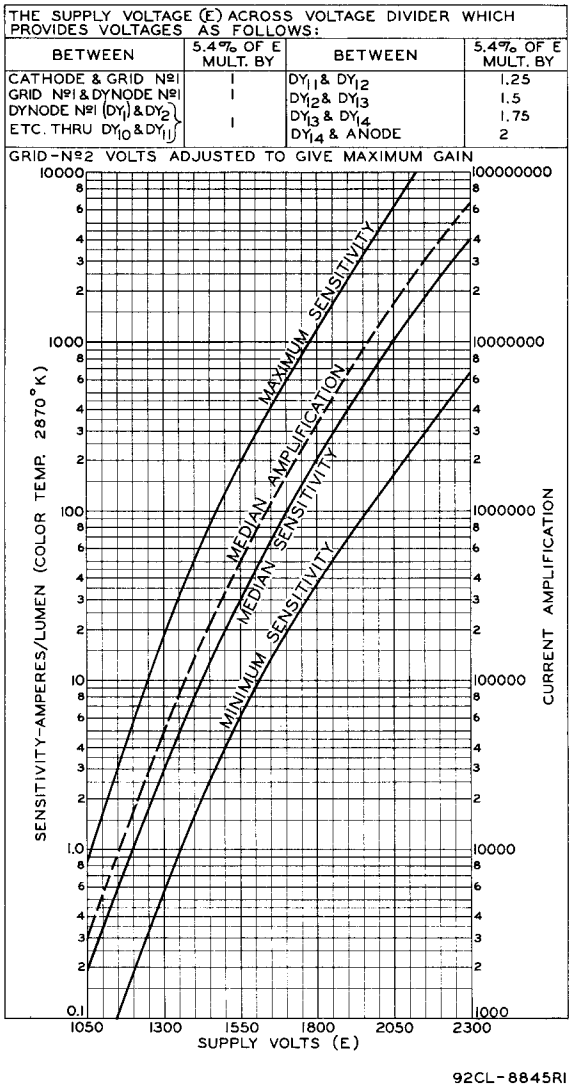


Fig.6 - Characteristics of Type 6810-A Used in Low-Light, Low-Noise, High-Gain Service.

is desired to have a high ratio of signal output to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig.5 or Fig.7 which shows the

equivalent anode-dark-current input as a function of luminous sensitivity for the 6810-A and the curve in Fig.6 or Fig.8 which shows luminous sensitivity as a function of the supply voltage. The voltage between dynode No.14 and the anode should be kept as low as will permit operation at a point just giving anode-current saturation.

In applications involving low-light level *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 1500 to 2000 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise

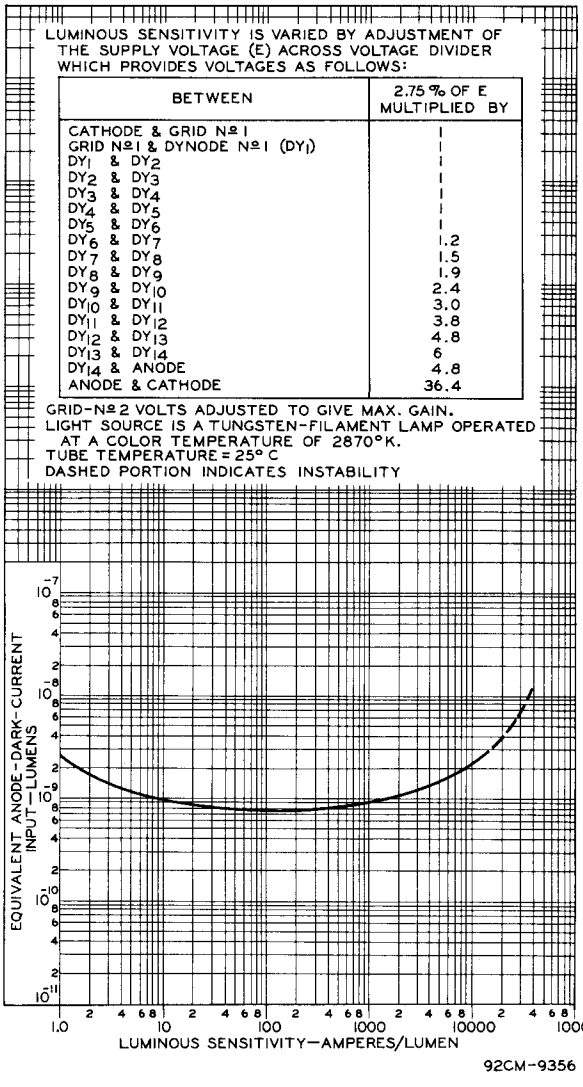


Fig.7 - Typical Anode-Dark-Current Characteristic of Type 6810-A Used in High-Output-Pulse Service.

power spectrum is essentially flat up to about 50 megacycles per second. At voltages above 2000 volts, regenerative phenomena usually contribute to the noise.

The noise spectrum of the 6810-A is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of

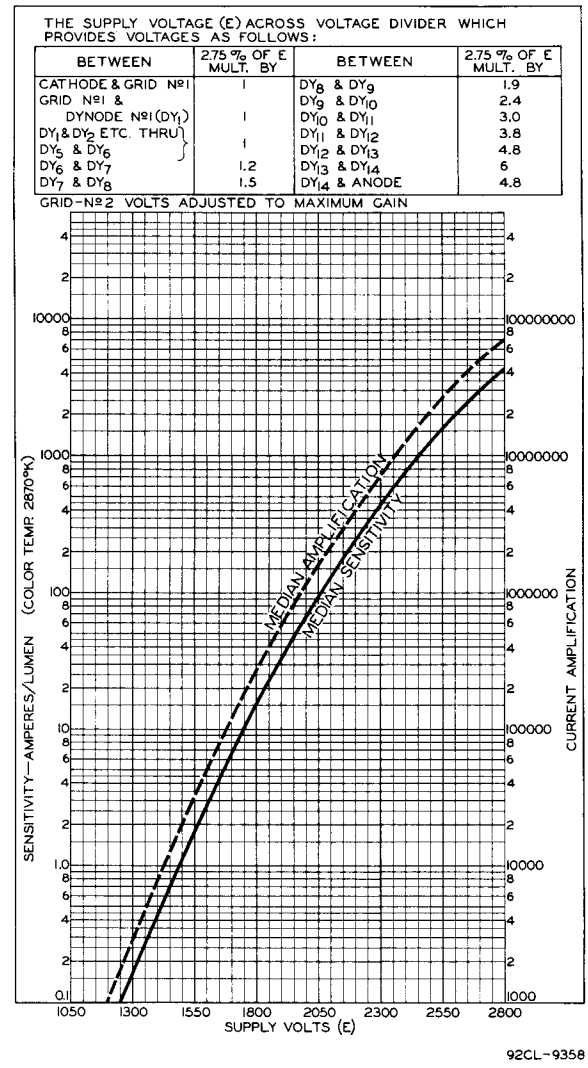


Fig.8 - Characteristics of Type 6810-A Used in High-Output-Pulse Service.

the exciting signal in order to eliminate as much noise as possible.

In either dc or ac applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice or liquid air, to cool the bulb of the 6810-A is recommended. The resulting reduction in thermionic emission from the cathode lowers the detection threshold to give improved operation. The curves in Figs.9 and 10 show the equivalent noise input as a function of the temperature of the 6810-A.

Exposing the 6810-A to strong ultraviolet radiation may cause an increase in anode dark current. After cessation of such irradiation, the dark current drops rapidly.

The *operating stability* of the 6810-A is dependent on the magnitude of the anode current and its duration. When the 6810-A is operated at high average values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 6810-A usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 2 milliamperes is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 250 microamperes.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the *nth* power, where *n* is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

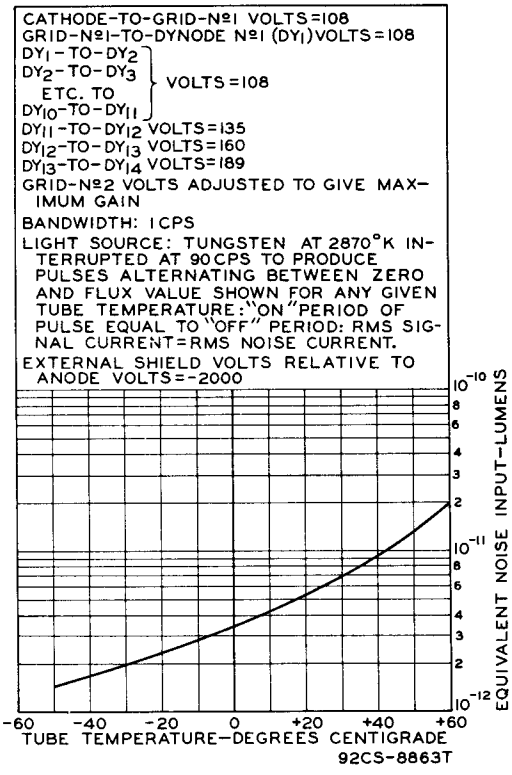


Fig. 9 - Equivalent-Noise-Input Characteristic of Type 6810-A Used in Low-Light, Low-Noise, High-Gain Service.

Because these overall changes are very large, it is advisable for the equipment designer to provide adequate adjustment of the supply voltage so that the amplification of individual tubes can be adjusted to the desired design value. The voltage-adjustment range required to take care of variations between individual tubes may be determined from Fig. 6 for low-light-level service. For example, if a sensitivity design value of 400 amperes per lumen is desired, it will be observed that this value on the "minimum" sensitivity curve corresponds to a supply voltage of about 2200 volts, and on the "maximum" sensitivity curve to a supply voltage of 1650 volts. Therefore, provision should be made to adjust the supply voltage over the range from 1650 to 2200 volts.

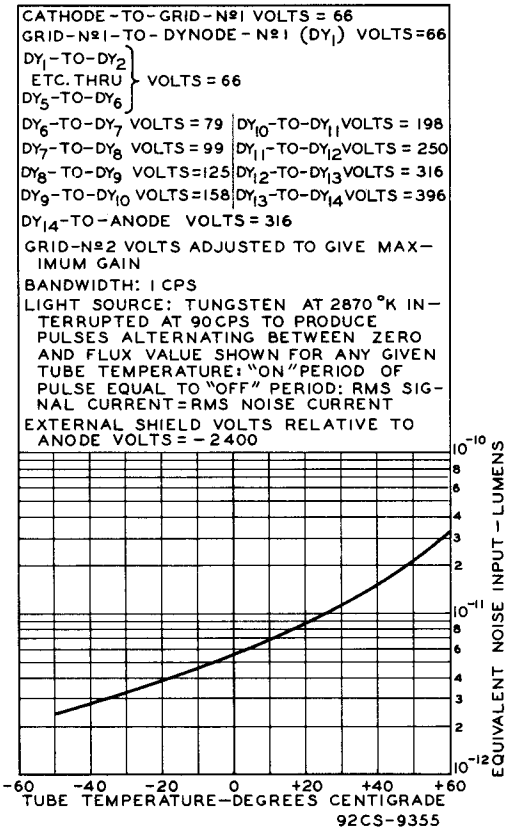


Fig. 10 - Equivalent-Noise-Input Characteristic of Type 6810-A Used in High-Output-Pulse Service.

Electrostatic and/or magnetic shielding of the 6810-A may be necessary. The metallic coating on the inner side wall of the glass bulb acts as an electrostatic shield to prevent the coated portion of the bulb wall from charging to a positive potential. However, the uncoated area of the bulb wall tends to charge to a potential near

that of the anode, especially when the 6810-A is operated at voltages near the maximum, with the result that an internal discharge phenomenon may occur and cause an increase in noise. To prevent this possibility, it is suggested that a shield

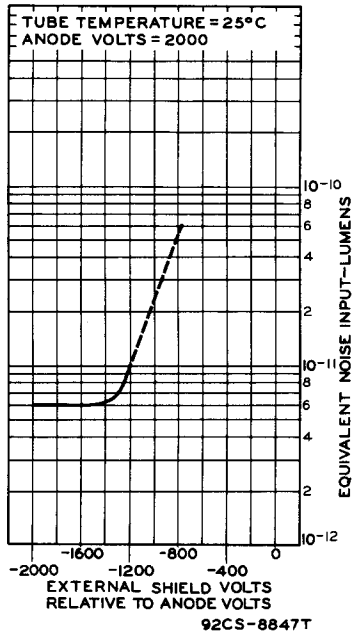


Fig. 11 - Effect of External-Shield Potential on Equivalent Noise Input of Type 6810-A Used in Low-Light, Low-Noise, High-Gain Service

be closely fitted over the uncoated area and be connected, as a safety precaution (see below), through a high impedance in the order of 10 megohms to a potential near that of the cathode. The shield may consist of a conductive coating painted on the clear portion of the bulb above the base, or metallic foil wrapped around the clear area. The curve in Fig. 11 illustrates the effect of shield potential on the equivalent noise input.

It is recommended that the *metal collar* (see Dimensional Outline) be operated at cathode potential.

With certain orientations of the 6810-A, it will be observed that the earth's magnetic field is sufficient to cause a noticeable decrease in the response of the tube. The curve in Fig. 12 shows the effect on anode current of variation in magnetic-field strength under the conditions indicated. With increase in voltage between cathode and dynode No. 1, the effect of the magnetic field will cause less decrease in anode current. When the focusing electrode is operated at a potential near that of the cathode, the effect of the magnetic field is less pronounced. When the magnetic field is parallel to the axis of the tube, the effect is least.

To prevent such decrease in response of the tube, magnetic shielding should be provided. In general it is recommended that the shield be connected to cathode potential. When so connected, the shielding may closely fit the bulb and serves the dual purpose of providing both magnetic and electrostatic shielding. When connected to anode potential, this shielding should be spaced

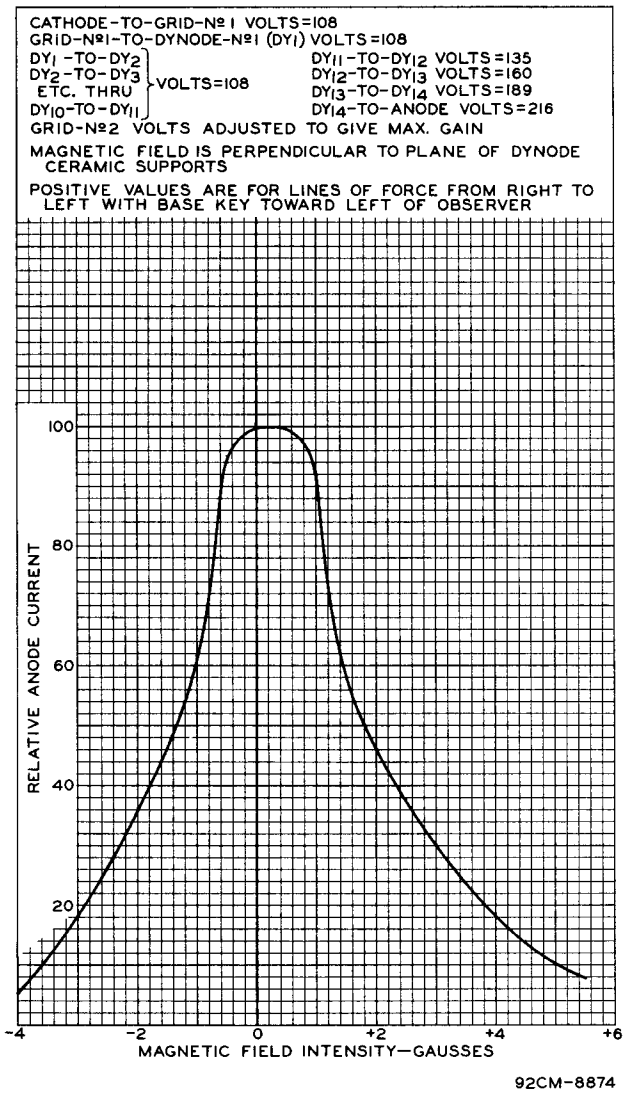


Fig. 12 - Effect of Magnetic Field on Anode Current of Type 6810-A Used in Low-Light, Low-Noise, High-Gain Service.

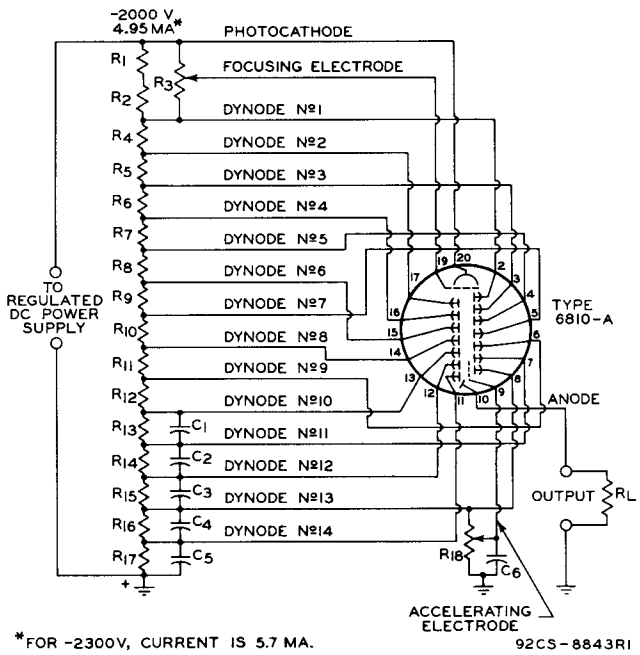
at least 1/2 inch from the bulb wall to prevent the internal discharge phenomenon described above.

It is to be noted that the use of an external magnetic and/or electrostatic shield at high

negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 6810-A. Although the metallic coating on the inner side wall of the glass bulb serves to reduce the amount of extraneous light reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous light.

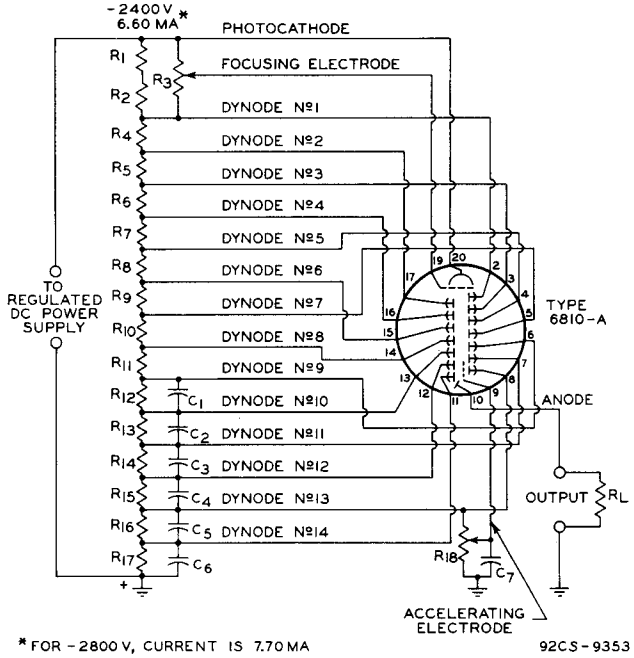
Whenever frequency response is important, the leads from the 6810-A to the amplifier should be short so as to minimize capacitance shunting of the phototube load.



C_1 = 25 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_2 = 50 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_3 = 100 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_4 = 250 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_5 = 500 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_6 = 100 $\mu\mu$f, disk ceramic, 1000 volts (dc working)
R_1 = 24000 ohms, 1 watt
R_2 = 22000 ohms, 1 watt
R_3 = 1 megohm, 2 watts, adjustable
R_4 through R_{13} = 22000 ohms, 1 watt
R_{14} = 27000 ohms, 2 watts
R_{15} = 33000 ohms, 2 watts
R_{16} = 39000 ohms, 2 watts
R_{17} = 43000 ohms, 2 watts
R_{18} = 10 megohms, 2 watts, adjustable
R_L = Value will depend on magnitude of peak pulse voltage desired. For a peak pulse amplitude of 100 volts, the value is approximately 300 ohms.

Note: Capacitors C_1 through C_6 should be connected at tube socket.

Fig. 13 - Voltage-Divider Arrangement for Type 6810-A Used in Low-Light, Low-Noise, High-Gain Service.



C_1 = 25 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_2 = 39 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_3 = 150 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_4 = 750 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_5 = 4000 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_6 = 40000 $\mu\mu$f, (4-10000 $\mu\mu$f disk ceramic, 600 volts (dc working) connected in parallel)
C_7 = 150 $\mu\mu$f, disk ceramic, 1000 volts (dc working)
R_1 = 10000 ohms, 1 watt
R_2 = 10000 ohms, 1 watt
R_3 = 1 megohm, 2 watts, adjustable
R_4 through R_8 = 10000 ohms, 1 watt
R_9 = 12000 ohms, 1 watt
R_{10} = 15000 ohms, 1 watt
R_{11} = 20000 ohms, 2 watts
R_{12} = 24000 ohms, 2 watts
R_{13} = 30000 ohms, 2 watts
R_{14} = 39000 ohms, 4 watts
R_{15} = 47000 ohms, 4 watts
R_{16} = 60000 ohms, 4 watts
R_{17} = 47000 ohms, 4 watts
R_{18} = 1 megohm, 2 watts, adjustable
R_L = Value will depend on magnitude of peak pulse voltage desired. For a peak pulse amplitude of 100 volts, the value is approximately 200 ohms.

Note: Capacitors C_1 through C_7 should be connected at tube socket.

Fig. 14 - Voltage-Divider Arrangement for Type 6810-A Used in High-Output-Pulse Service.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each dynode and for the anode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation and the linearity required by the application. In general, the current in the divider should be several times the maximum value of anode current. The value should also be adequate to prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will ordinarily be provided by a well-designed two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Inasmuch as the gain of the 6810-A is critically dependent on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum tube regulator circuit of the mu-bridge type.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.

Typical voltage-divider arrangements for use with the 6810-A are shown in Figs. 13 and 14.

The high voltages at which the 6810-A is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 6810-A, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

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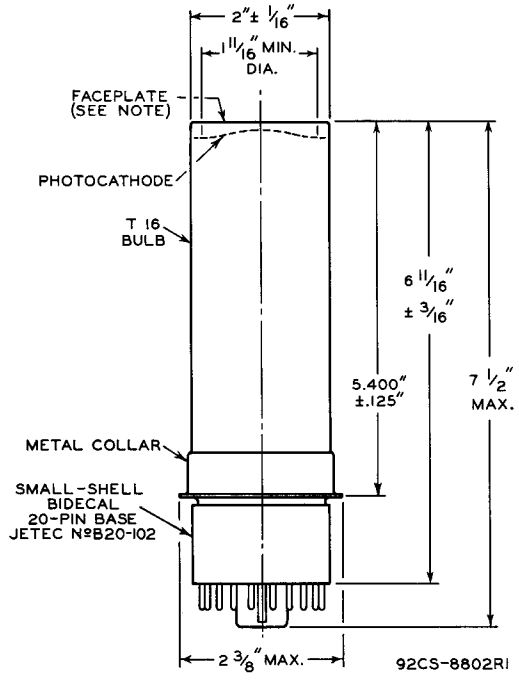
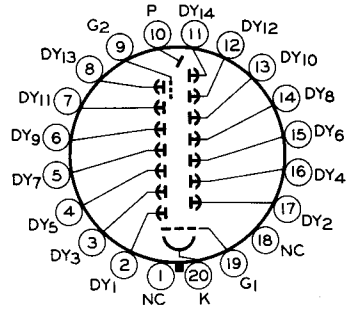
DIMENSIONAL OUTLINE



℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: WITHIN 1-11/16" DIAMETER, DEVIATION FROM FLATNESS OF EXTERNAL SURFACE OF FACEPLATE WILL NOT EXCEED 0.010" FROM PEAK TO VALLEY.

SOCKET CONNECTIONS
Bottom View



DIRECTION OF LIGHT: INTO END OF BULB

PIN 1: NO CONNECTION
PIN 2: DYNODE No.1
PIN 3: DYNODE No.3
PIN 4: DYNODE No.5
PIN 5: DYNODE No.7
PIN 6: DYNODE No.9
PIN 7: DYNODE No.11
PIN 8: DYNODE No.13
PIN 9: GRID No.2 (ACCELERATING ELECTRODE)
PIN 10: ANODE

PIN 11: DYNODE No.14
PIN 12: DYNODE No.12
PIN 13: DYNODE No.10
PIN 14: DYNODE No.8
PIN 15: DYNODE No.6
PIN 16: DYNODE No.4
PIN 17: DYNODE No.2
PIN 18: NO CONNECTION
PIN 19: GRID No.1 (FOCUSING ELECTRODE)
PIN 20: PHOTOCATHODE

This bulletin also applies to RCA-6884 which is identical with RCA-6816 except for its heater rating of 26.5 ± 10% volts, 0.52 ampere.

6884

6816

BEAM POWER TUBE

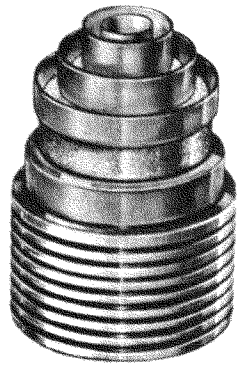
Coaxial-Electrode Structure
Ceramic-Metal Seals
Unipotential Cathode

For Use at Frequencies Up to 2000 Mc
Forced-Air Cooled
180 Watts CW Input Up to 1200 Mc

1.955" Max. Length
1.265" Max. Diameter
Integral Radiator

TENTATIVE DATA

RCA-6816 is a very small, forced-air-cooled beam power tube designed for use as a uhf power amplifier, oscillator, and frequency multiplier as well as an af power amplifier and modulator in compact mobile and fixed equipment. The 6816 has a maximum plate dissipation of 115 watts in modulator service and in cw service. In the latter service, it can be operated with full ratings up to 1200 Mc and is useful at frequencies up through 2000 Mc and above.



Actual Size

Because of its high power sensitivity and high efficiency, the 6816 can be operated with relatively low plate voltage to give large power output with small driving power.

Featured in the design of the 6816 is a coaxial-electrode structure in which "one-piece" construction combines each electrode, its support, and its gold-plated external contact surface, and in which the respective electrode contact surfaces are insulated from each other by low-loss ceramic bushings. This type of construction facilitates accurate assembly of the electrodes and provides low-inductive, high-conductivity paths to the electrodes themselves.

The coaxial-electrode structure with its ring-type ceramic-metal seals having graduated diameters makes the 6816 particularly useful in either coaxial-cylinder cavity or parallel-line circuits. Its very small size facilitates the construction of compact equipment utilizing grid-drive or cathode-drive circuits.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)♦	6.3 ±10%	volts
Current	2.1	amp
Minimum heating time	60	sec
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 1000, grid-No.2 volts = 300, and plate ma = 100	16	
Direct Interelectrode Capacitances:		
Grid No.1 to plate*	0.085 max.	μμf
Grid No.1 to cathode & heater	14	μμf
Plate to cathode & heater*,**	0.015 max.	μμf
Grid No.1 to grid No.2	17	μμf
Grid No.2 to plate	6	μμf
Grid No.2 to cathode & heater**	0.5 max.	μμf

Mechanical:

Mounting Position	Any
Overall Length	1.885" $^{+\ .070"}_{-\ .080"}$
Greatest Diameter	1.250" ± 0.015"
Terminal Connections	See *Dimensional Outline*
Radiator	Integral part of tube

Air Flow:

Through Radiator--Adequate air flow to limit the plate-seal temperature to 250°C should be delivered by a blower through the radiator before and during the application of plate, grid-No.2, and grid-No.1 voltages. Typical values of air flow directed through the radiator without cowling and with cowling versus plate dissipation are shown in the curves of Figs.1 and 2, respectively. Plate power, grid-No.2 power, and air flow may be removed simultaneously.

To Grid-No.2, Grid-No.1, Cathode, and Heater Seals--A sufficient quantity of air should be delivered to these seals to prevent their temperature from exceeding the specified maximum value of 250°C.

During Standby Operation--Cooling air is not normally required when only heater voltage is applied to the tube.

Seal Temperature (Plate, Grid No.2, Grid No.1, Cathode, and Heater)	250 max.	°C
Weight (Approx.)	2	oz

AF POWER AMPLIFIER & MODULATOR--Class AB_1†

Maximum CCS● Ratings, *Absolute Values:*

DC PLATE VOLTAGE	1000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	volts
MAX.-SIGNAL DC PLATE CURRENT★	180 max.	ma
MAX.-SIGNAL PLATE INPUT★	180 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT★	4.5 max.	watts
PLATE DISSIPATION★	115 max.	watts

Typical CCS Operation:

	Values are for 2 tubes		
DC Plate Voltage	650	850	volts
DC Grid-No.2 Voltage▲	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage:			
From fixed-bias source	-15	-15	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage○	30	30	volts
Zero-Signal DC Plate Current	80	80	ma
Max.-Signal DC Plate Current	200	200	ma
Zero-Signal DC Grid-No.2 Current	0	0	ma

TMK ®, Marca Registrada
Printed in U.S.A.

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Max.-Signal DC Grid-No.2 Current	20	20	ma
Effective Load Resistance (Plate to plate)	4330	7000	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	50	80	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under Any Condition:[OO]

With fixed bias	30000 max.	ohms
With cathode bias	Not recommended	

AF POWER AMPLIFIER & MODULATOR--Class AB_2#

Maximum CCS● Ratings, *Absolute Values:*

DC PLATE VOLTAGE	1000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	volts
MAX.-SIGNAL DC PLATE CURRENT★	180 max.	ma
MAX.-SIGNAL DC GRID-No.1 (CONTROL-GRID) CURRENT★	30 max.	ma
MAX.-SIGNAL PLATE INPUT★	180 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT★	4.5 max.	watts
PLATE DISSIPATION★	115 max.	watts

Typical CCS Operation:

	Values are for 2 tubes		
DC Plate Voltage	650	850	volts
DC Grid-No.2 Voltage▲	300	300	volts
DC Grid-No.1 Voltage: From fixed-bias source	-15	-15	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	46	46	volts
Zero-Signal DC Plate Current	80	80	ma
Max.-Signal DC Plate Current	355	355	ma
Zero-Signal DC Grid-No.2 Current	0	0	ma
Max.-Signal DC Grid-No.2 Current	25	25	ma
Max.-Signal DC Grid-No.1 Current	15	15	ma
Effective Load Resistance (Plate to plate)	2450	3960	ohms
Max.-Signal Driving Power (Approx.)◆	0.3	0.3	watt
Max.-Signal Power Output (Approx.)	85	140	watts

LINEAR RF POWER AMPLIFIER--Single-Sideband Suppressed-Carrier Service

Maximum CCS● Ratings, *Absolute Values:*

DC PLATE VOLTAGE	1000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	volts
MAX.-SIGNAL DC PLATE CURRENT	180 max.	ma
MAX.-SIGNAL DC GRID-No.1 (CONTROL-GRID) CURRENT	30 max.	ma
MAX.-SIGNAL PLATE INPUT	180 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT	4.5 max.	watts
PLATE DISSIPATION	115 max.	watts

Typical CCS Class AB_1 "Single-Tone" Operation:◆◆

	Up to 60 Mc		
DC Plate Voltage	650	850	volts
DC Grid-No.2 Voltage▲	300	300	volts
DC Grid-No.1 Voltage	-15	-15	volts
Zero-Signal DC Plate Current	40	40	ma
Zero-Signal DC Grid-No.2 Current	0	0	ma
Effective RF Load Resistance	2165	3500	ohms
Max.-Signal DC Plate Current	100	100	ma
Max.-Signal DC Grid-No.2 Current	10	10	ma
Max.-Signal DC Grid-No.1 Current	0	0	ma
Max.-Signal Peak RF Grid-No.1 Voltage	15	15	volts
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	25	40	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under Any Condition:

With fixed bias	30000	ohms
With cathode bias	Not recommended	

PLATE-MODULATED RF POWER AMPLIFIER--Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS● Ratings, *Absolute Values:*

DC PLATE VOLTAGE	800 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-100 max.	volts
DC PLATE CURRENT	150 max.	ma
DC GRID-No.1 CURRENT	30 max.	ma
PLATE INPUT	120 max.	watts
GRID-No.2 INPUT	3 max.	watts
PLATE DISSIPATION	75 max.	watts

Typical CCS Operation:

	At 400 Mc		
DC Plate Voltage	400	700	volts
DC Grid-No.2 Voltage●●	200	250	volts
DC Grid-No.1 Voltage★★	-20	-50	volts
DC Plate Current	100	130	ma
DC Grid-No.2 Current	5	10	ma
DC Grid-No.1 Current	5	10	ma
Driver Power Output (Approx.)■	2	3	watts
Useful Power Output (Approx.)	16	45	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under Any Condition	30000‡ max.		ohms

RF POWER AMPLIFIER & OSCILLATOR--Class C Telegraphy and RF POWER AMPLIFIER--Class C FM Telephony

Maximum CCS● Ratings, *Absolute Values:*

DC PLATE VOLTAGE	1000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-100 max.	volts
DC PLATE CURRENT	180 max.	ma
DC GRID-No.1 CURRENT	30 max.	ma
PLATE INPUT	180 max.	watts
GRID-No.2 INPUT	4.5 max.	watts
PLATE DISSIPATION	115 max.	watts

Typical CCS Operation:

	At 400 Mc		*At 1200 Mc*	
DC Plate Voltage	400	900	900	volts
DC Grid-No.2 Voltage⊕	200	300	300	volts
DC Grid-No.1 Voltage⊕⊕	-35	-30	-22	volts
DC Plate Current	150	170	170	ma
DC Grid-No.2 Current	5	1	1	ma
DC Grid-No.1 Current	3	10	4	ma
Driver Power Output (Approx.)■	3	3	5	watts
Useful Power Output (Approx.)	23	80	40	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under Any Condition	30000‡ max.		ohms

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● Because the cathode is subjected to considerable back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should be reduced depending on operating conditions and frequency to prevent overheating the cathode and resultant short life.

* With external flat metal shield having diameter of 6" and center hole 1" in diameter. Shield is located in plane of grid-No.2 terminal, perpendicular to the tube axis, and is connected to grid-No.2 terminal.

** With external flat metal shield having diameter of 6" and center hole 3/4" in diameter. Shield is located in plane of grid-No.1 terminal, perpendicular to the tube axis, and is connected to grid-No.1 terminal.

† Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

★ Averaged over any audio-frequency cycle of sine-wave form.

▲ Preferably obtained from a fixed supply.

o The driver stage should be capable of supplying the No.1 grids of the class AB_1 stage with the specified driving voltage at low distortion.

oo The resistance introduced into the grid-No.1 circuit by the input coupling should be held to a low value. In no case should it exceed the specified maximum value. Transformer or impedance coupling devices are recommended.

Subscript 2 indicates that grid-No.1 current flows during some part of the input cycle.

♦ Driver stage should be capable of supplying the specified driving power at low distortion to the No.1 grids of the AB_2 stage. To minimize distortion, the effective resistance per grid-No.1 circuit of the AB_2 stage should be held at a low value. For this purpose, the use of transformer coupling is recommended.

♦♦ "Single-Tone" operation refers to that class of amplifier service in which the grid-No.1 input consists of a monofrequency rf signal having constant amplitude. This signal is produced in a single-sideband suppressed-carrier system when a single audio frequency of constant amplitude is applied to the input of the system.

●● Obtained preferably from a separate source modulated along with the plate supply.

★★ Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

■ The driver stage is required to supply tube losses and rf circuit losses. It should be designed to provide an excess of power above the indicated values to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

‡ If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply.

□ Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

⊕ Obtained preferably from a fixed supply, or from the plate-supply voltage with a voltage divider.

⊕⊕ Obtained from fixed supply, by grid-No.1 resistor, by cathode resistor, or by combination methods.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 6816 are limiting values above which the serviceability of the 6816 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum seal temperature* of 250°C is a tube rating and is to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y. in the form of liquid and stick.

A suggested *mounting arrangement* for the 6816 is shown in Fig.4 along with a layout of the associated contacts. Flexible connectors are required for the plate, grid-No.2, grid-No.1, cathode, and heater contact surfaces.

Adequate *cooling* of the 6816 is provided in most applications by passing a stream of clean air through the radiator only. A guide to the

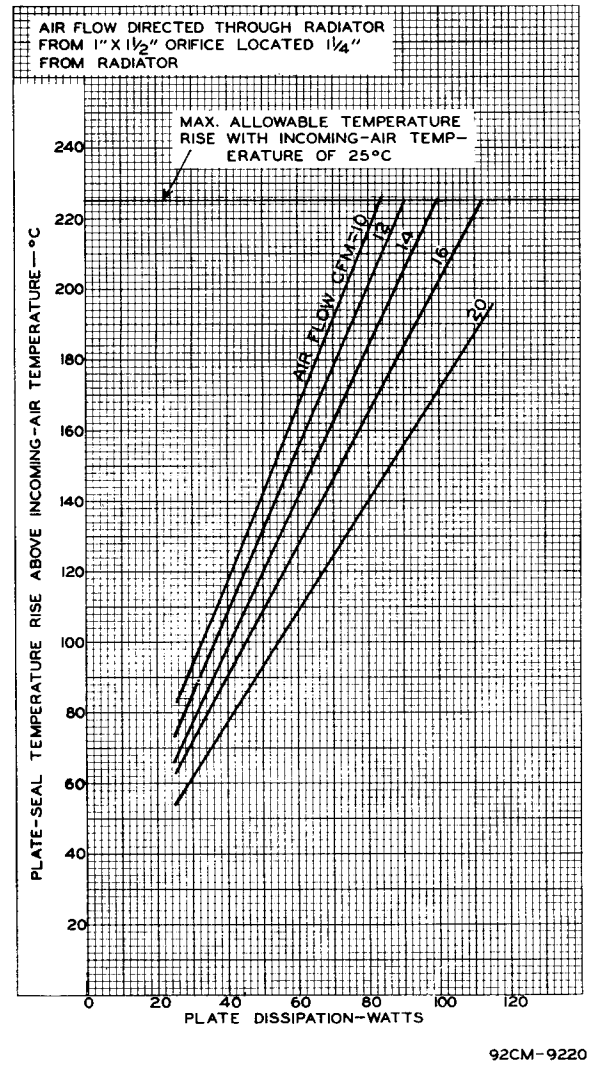


Fig. 1 - Typical Cooling Requirements for Type 6816 With Air Flow Directed Through Radiator Without Cowling.

required air flow through the radiator for various plate dissipations is given by the curves in Figs. 1 and 2. A recommended arrangement of cowling for the radiator is shown in Fig.3. Under operating conditions at the higher frequencies or at high ambient temperatures, it may be necessary to direct a stream of air onto the cathode and heater seals, the grid-No.1 seal, and the grid-No.2 seal. In all cases, adequate cooling

air must be provided to prevent exceeding the maximum temperature rating of 250°C for any seal.

The cooling system should be properly installed to insure safe operation of the 6816 under all conditions and for this reason should be electrically interconnected with the plate

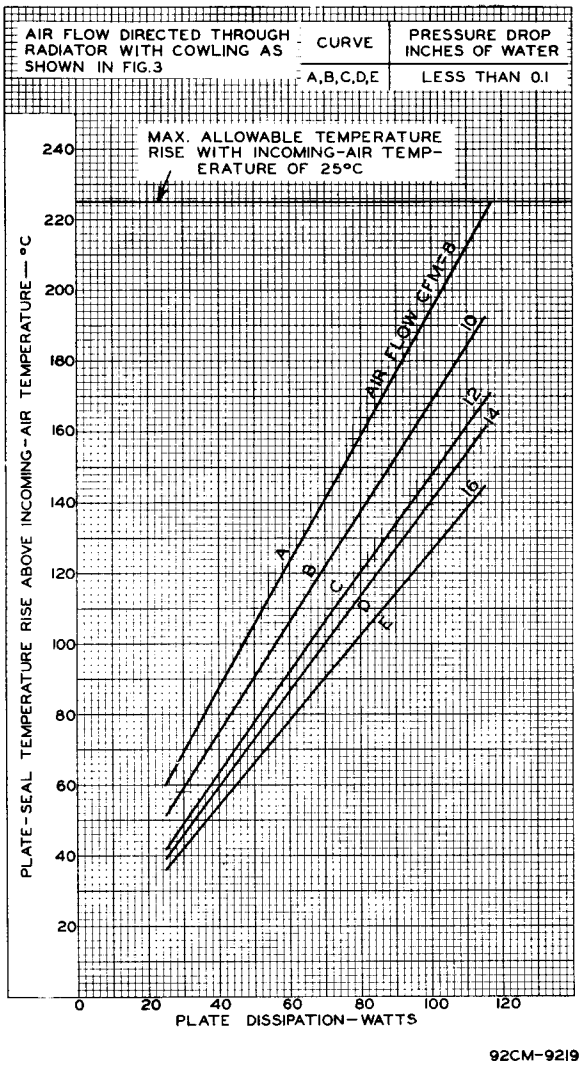


Fig. 2 - Typical Cooling Requirements for Type 6816 With Air Flow Directed Through Radiator With Cowling.

power supply. Air-flow interlocks which open the power transformer primaries are desirable for protecting the tube when the air flow is insufficient or ceases.

A suitable air filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air through the radiator or to the seals.

The *heater* of the 6816 should be operated at constant voltage rather than constant current. The rated heater voltage of 6.3 volts should be applied for 60 seconds to allow the cathode to reach normal operating temperature before voltages are applied to the other electrodes. After this warm-up period, the heater voltage should be adjusted as described in the next paragraph.

The unipotential cathode is indirectly heated by the heater, one terminal of which is common to the cathode. The cathode of the 6816 in uhf

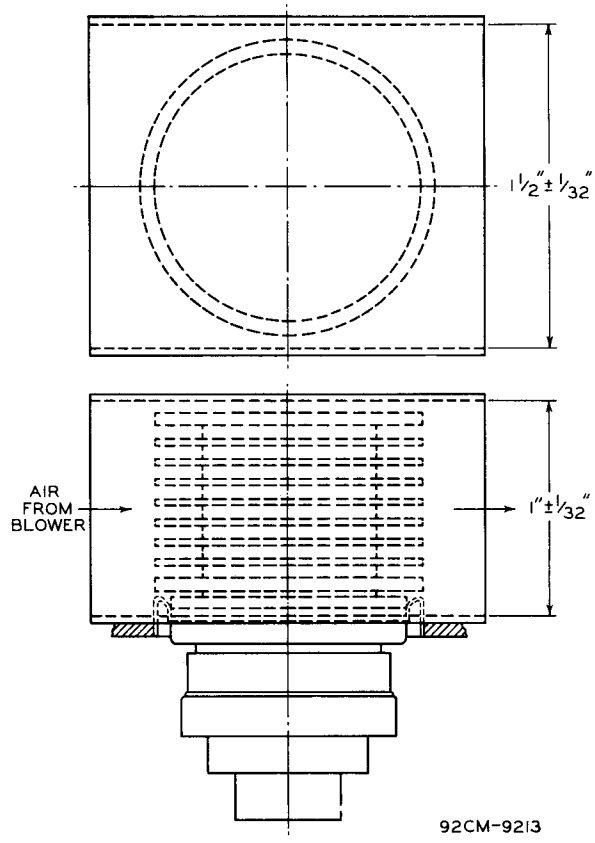


Fig. 3 - Recommended Cowling for Directing Air Flow Through Radiator of Type 6816.

service is subjected to considerable bombardment resulting from transit-time effects. This back bombardment is a function of the operating conditions and frequency, and must be compensated by reduction of the heater input in order to prevent overheating of the cathode and resultant short life. When long life in continuous service is desired, the 6816 should always be put in operation with full rated heater voltage (6.3 volts) which should then be reduced to the lowest value that will give the desired output.

Grid No. 1 of the 6816 in uhf service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid

current, but also by circulating rf currents. For these reasons, more than ordinary care must be taken during operation to prevent exceeding the grid-No.1 current rating and the maximum grid-No.1 seal temperature rating.

Grid No.2 of the 6816 draws very little current under normal operating conditions. The

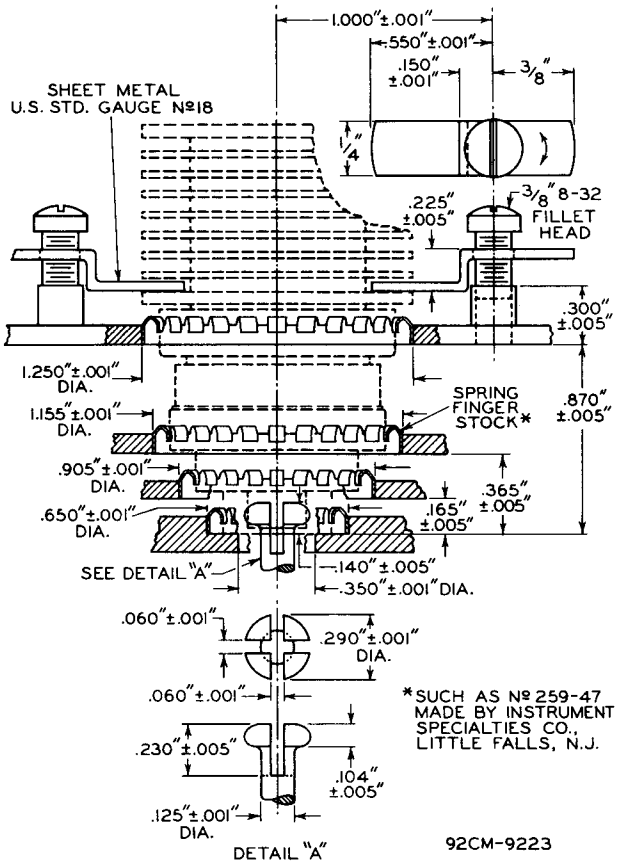


Fig.4 - Suggested Mounting Arrangement for Type 6816 and Layout of Associated Contacts.

voltage for grid No.2 should be obtained from a source of good regulation. The plate voltage should be applied before or simultaneously with grid-No.2 voltage; otherwise, with voltage on grid No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the screen dissipation determined.

The *grid-No.2 current* is a very sensitive indication of plate-circuit loading. When the 6816 is operated without load, the grid-No.2 current rises excessively, often to a value which damages the tube. Therefore, care should be taken when tuning the 6816 circuit under no-load or lightly loaded conditions to prevent exceeding the grid-No.2 input rating of the tube. In this connection, reduction of the grid-No.2 voltage will be helpful.

Protective devices should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the dc plate voltage when the average value of plate current reaches a value slightly higher than normal plate current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

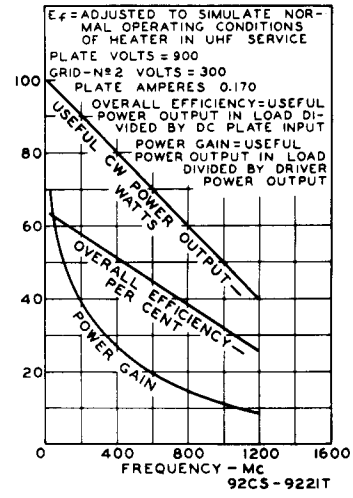


Fig.5 - Typical Performance Characteristics of Type 6816 in Class C Telegraphy or Class C FM Telephony Amplifier Service.

The rated plate and grid-No.2 voltages of this tube are extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

The *driver stage* for the 6816 in rf service should have considerably more output capability than the typical driving power shown in the tabulated data in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuits and the coupling circuits. This recommendation is particularly important near the rated maximum frequency where circuit losses, radiation losses, and transit-time losses

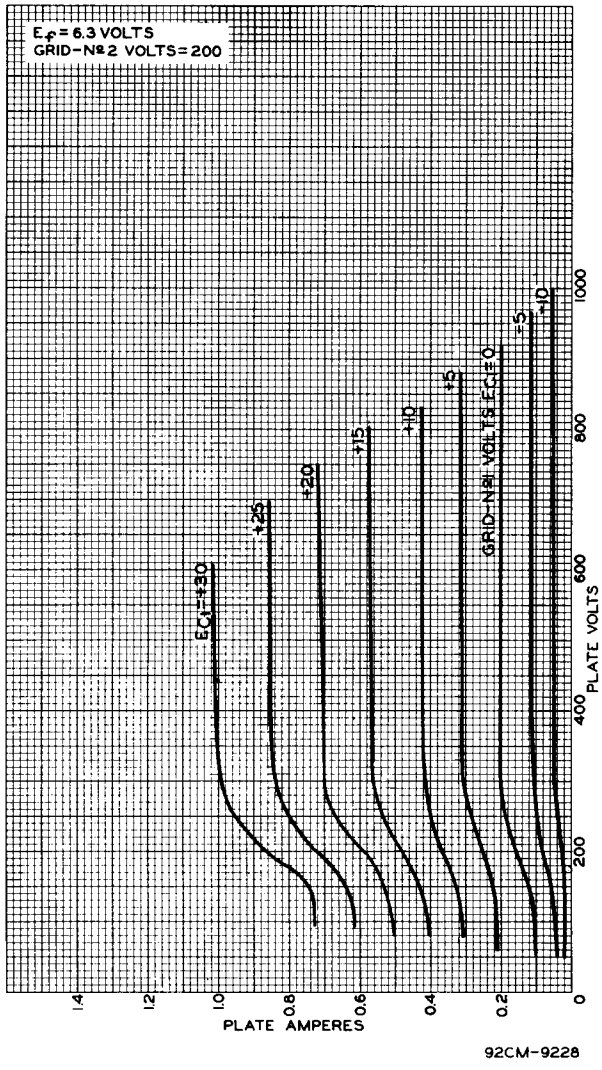


Fig. 6 - Typical Plate Characteristics of Type 6816

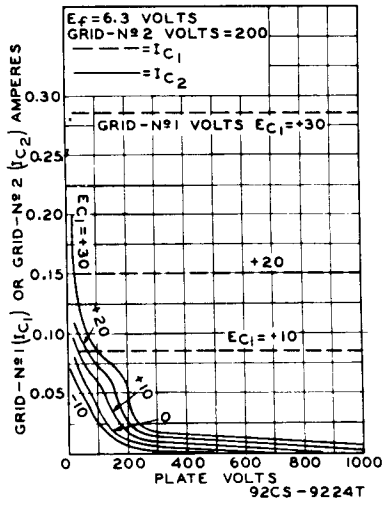


Fig. 7 - Typical Characteristics of Type 6816.

increase. Typical losses have been taken into account in the values of driver power output shown in the tabulated data.

In *cathode-drive circuits*, a further increase in driving power is required because the grid-No. 1 driving voltage and the developed rf plate

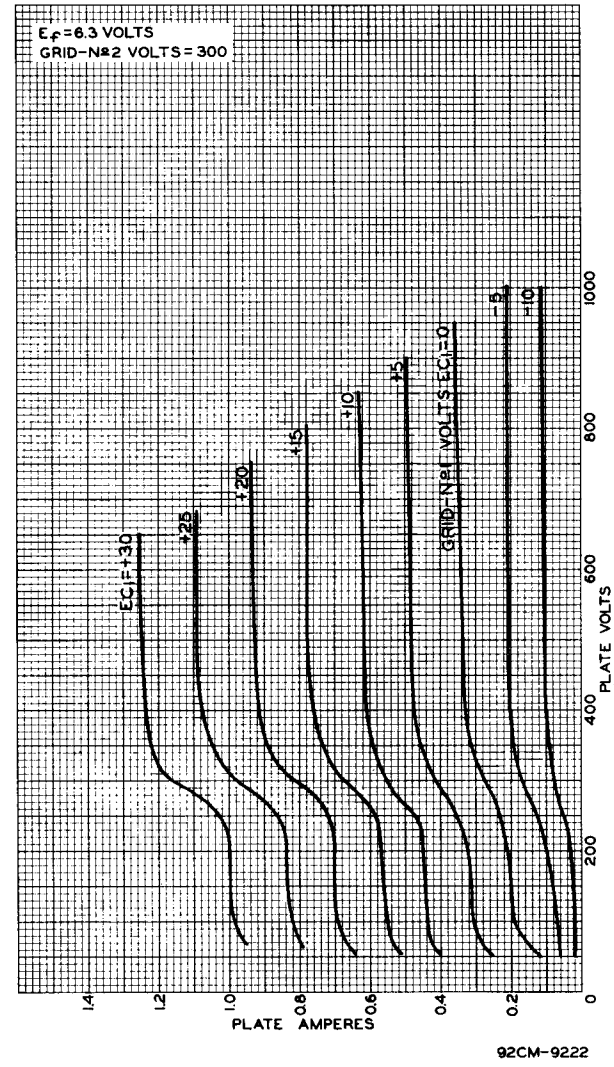


Fig. 8 - Typical Plate Characteristics of Type 6816.

voltage act in series to supply the load circuit. The increased driving power is not lost because it appears as output from the cathode-drive stage. If the driving voltage and grid-No. 1 current are increased, the output will always increase. Such is not the case in a grid-drive circuit where a saturation effect takes place, i.e., above a certain value of driving voltage and current, the output increases very slowly and may even decrease. It is important to recognize this difference and not try to saturate a cathode-drive stage because the maximum grid-No. 2 input may easily be exceeded.

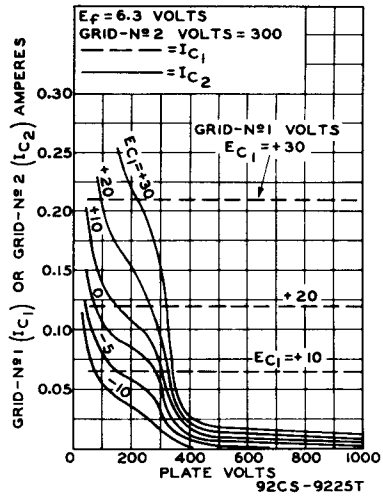


Fig. 9 - Typical Characteristics of Type 6816.

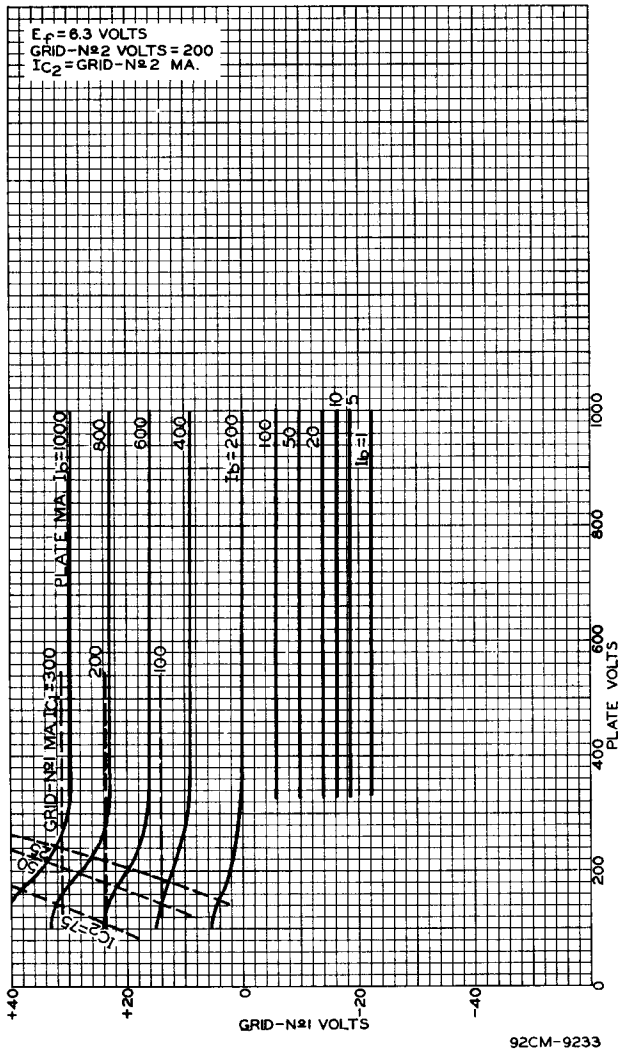


Fig. 10 - Typical Constant-Current Characteristics of Type 6816.

In tuning a cathode-drive rf amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

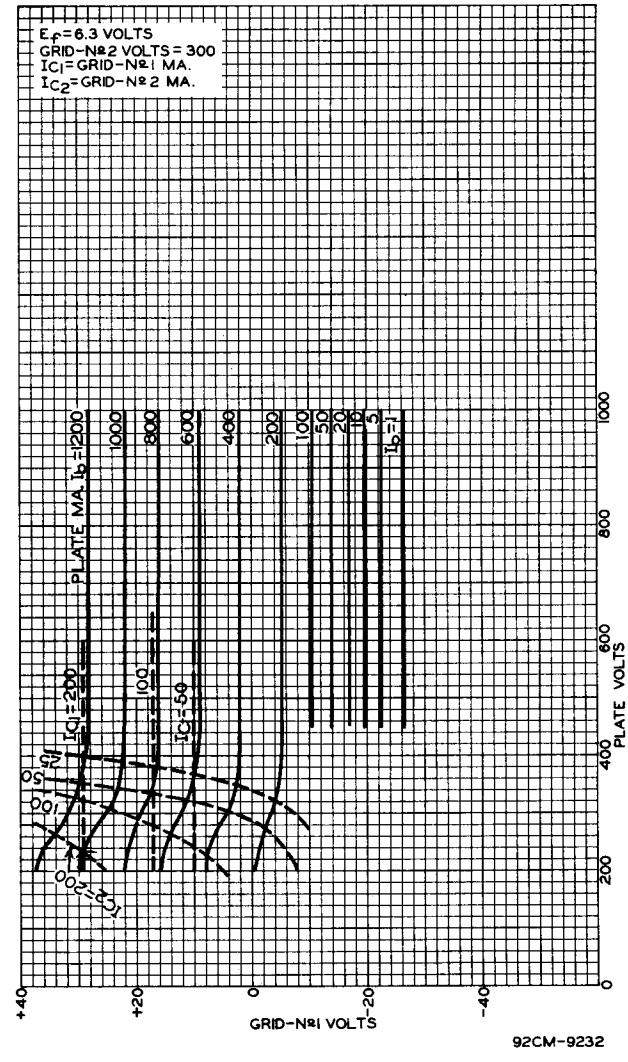


Fig. 11 - Typical Constant-Current Characteristics of Type 6816.

Typical performance curves for the 6816 are shown in Fig. 5.

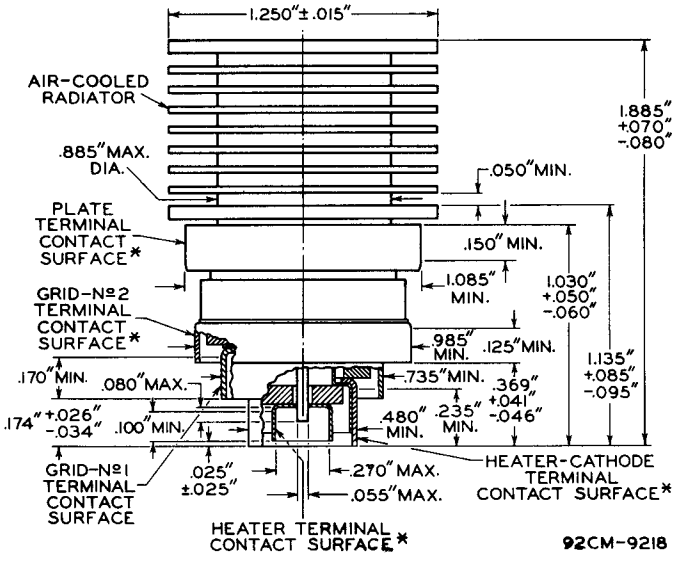
In *plate-modulated class C amplifier service*, the 6816 can be modulated 100 per cent. The grid-No. 2 voltage must be modulated simultaneously with the plate voltage so that the ratio of grid-No. 2 voltage to plate voltage remains constant. Modulation of the grid-No. 2 voltage can be accomplished either by connecting grid No. 2 through a separate winding on the modulation transformer to the fixed grid-No. 2 voltage supply, or by

connecting grid No.2 through an audio-frequency choke of suitable impedance for low audio frequencies to the fixed grid-No.2 supply voltage. The supply end of the choke should be well bypassed to ground.

In *class C rf telegraphy service*, the 6816 may be supplied with bias by any convenient method except when the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying. In this case, an amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value.

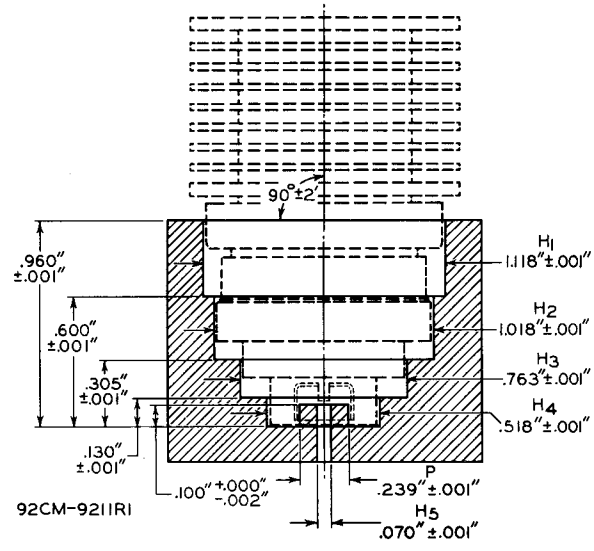
During standby periods in intermittent operation, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; and that it be reduced to 80 per cent of normal when the period is between 15 minutes and 2 hours. For longer periods, the heater voltage should be turned off.

DIMENSIONAL OUTLINE



* WITH THE CYLINDRICAL SURFACES OF THE PLATE TERMINAL, GRID-No.2 TERMINAL, GRID-No.1 TERMINAL, HEATER-CATHODE TERMINAL, AND HEATER TERMINAL CLEAN, SMOOTH, AND FREE OF BURRS, THE TUBE WILL ENTER A GAUGE AS SHOWN IN SKETCH G_1. THE TUBE IS PROPERLY SEATED IN THE GAUGE WHEN A 0.010 THICKNESS GAUGE 1/8" WIDE WILL NOT ENTER BETWEEN THE HEATER-CATHODE TERMINAL AND THE BOTTOM SURFACE OF H_4. THE GAUGE IS PROVIDED WITH A SLOT TO PERMIT MAKING MEASUREMENT OF SEATING OF HEATER-CATHODE TERMINAL ON BOTTOM OF HOLE H_4.

SKETCH G_1



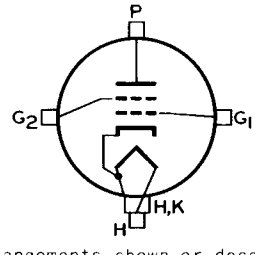
THE AXES OF THE CYLINDRICAL HOLES H_1 THROUGH H_5 AND THE AXIS OF POST P ARE COINCIDENT WITHIN 0.001".

TERMINAL CONNECTIONS

G_1 – Grid-No.1 Terminal Contact Surface (Adjacent to Cathode & Heater Terminal Contact Surface)

G_2 – Grid-No.2 Terminal Contact Surface (Adjacent to Grid-No.1 Terminal Contact Surface)

H – Heater Terminal Contact Surface (Within Cathode & Heater Terminal Contact Surface)



H,K – Cathode & Heater Terminal Contact Surface (End Opposite Air-Cooled Radiator)

P – Plate Terminal Contact Surface (Adjacent to Air-Cooled Radiator)

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

from JETEC release
#1607, March 19, 1956

6865

MAGNETRON

Tunable
8750 - 9600 Mc

Forced-Air Cooled
Integral Magnet
TENTATIVE DATA

200 Kw Peak
Power Output

RCA-6865 is a tunable magnetron intended for service as a pulsed oscillator at frequencies between 8750 and 9600 megacycles per second. It offers the advantage of providing in one tube an adjustable frequency for radar equipment without requiring appreciably more space than that occupied by a fixed-frequency magnetron having comparable power output.

The 6865 operates with high efficiency at pulse durations up to 2.5 microseconds, and has a maximum peak input power rating of 630 kilowatts, a maximum peak anode voltage of 23 kilovolts, and a maximum peak anode current of 27.5 amperes. When operated at a peak anode current of 27.5 amperes, corresponding to a peak anode voltage of about 22 kilovolts, the 6865 is capable of giving a peak power output of approximately 200 kilowatts. Similarly, when the 6865 is operated at a peak anode current of 21 amperes, the peak power output is approximately 155 kilowatts.

The 6865 design provides good spectrum shape, low pushing figure, good frequency stabilization, low thermal drift during warm-up and after tuning, and a relatively uniform power output over the frequency band. In addition, the 6865 features an axial cathode having good structural rigidity; a getter to maintain a high vacuum and minimize any tendency toward arcing after a period of storage; and an output waveguide which can be coupled to a standard JAN RG-51/U waveguide by means of a modified JAN UG-52A/U choke flange. A double-helical heater minimizes mechanical resonance of the heater and reduces hum modulation at the power-line frequency.

The design of the output waveguide flange and the mounting flange permits use of pressure seals. The heater-cathode stem of the 6865 will operate without electrical breakdown at atmospheric pressures of 600 mm of mercury or greater.

The 6865 is electrically similar to the fixed-frequency type 4J50 and has the same mounting arrangement.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	13.75 ± 10%	volts
Current at 13.75 volts	3.15	amperes
Starting Current . . The maximum instantaneous starting current must never exceed 12 amperes, even momentarily		
Minimum Cathode Heating Time	2.5	minutes
Frequency	8750-9600	Mc
Maximum Frequency Pulling at VSWR of 1.5	13	Mc

Mechanical:

Mounting Position . . . . . Any
Dimensions . . . . . See *Dimensional Outline*
Air Flow:

To Fins--An air stream should be directed along the cooling fins toward the body of the tube. Adequate flow should be provided so that the temperature of the anode block does not exceed 150°C.

To Heater-Cathode Terminal--Adequate flow should be provided to maintain the temperature of the heater-cathode terminal below 165°C.

Waveguide Output Flange . . . . . Mates with Modified JAN UG-52A/U Flange
Tuner . . . . . Calibrated, equipped with lock
Weight (Approx.) . . . . . 11-1/2 lbs

PULSED OSCILLATOR SERVICE

Maximum and Minimum Ratings, *Absolute Values:*

For Duty Cycle of 0.001 max.

PEAK ANODE VOLTAGE	23 max.	23 max.	kv
PEAK ANODE CURRENT	23 max.	27.5 max.	amp
PEAK POWER INPUT	530 max.	630 max.	kw
AVERAGE POWER INPUT	0.530 max.	0.630 max.	kw
PULSE DURATION	2.5 max.	1.1 max.	μsec
OPERATION TIME IN ANY 100-MICROSECOND INTERVAL	5.0 max.	5.0 max.	μsec
RATE OF RISE OF VOLTAGE PULSE	150 max.	150 max.	kv/μsec
	70 min.	70 min.	kv/μsec
ANODE-BLOCK TEMPERATURE	150 max.	150 max.	°C
HEATER-CATHODE TERMINAL TEMPERATURE	165 max.	165 max.	°C
LOAD VOLTAGE STANDING WAVE RATIO	1.5 max.	1.5 max.	

Typical Operation▲ with Load Voltage Standing Wave Ratio Equal to or Less than 1.05, except as noted:

With Duty Cycle of 0.001

Heater Voltage	-	-	See Text
Peak Anode Voltage	21.5	22.0	kv
Peak Anode Current	21.0	27.5	amp
Pulse Repetition Rate	1000	1000	cps
Pulse Duration	1	1	μsec
RF Bandwidth with worst phasing of 1.5 VSWR	2.0	2.0	Mc
Side Lobes with worst phasing of 1.5 VSWR	10	8	db
Pulling Figure at VSWR of 1.5	9	9	Mc
Pushing Figure	0.2	0.2	Mc/amp
Thermal Factor for any 30° range between 70° and 130°C	0.2	0.2	Mc/°C
Peak Power Output	165	210	kw

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	3.0	3.75	amp
Peak Anode Voltage	-	20	23	kv

TMK ®, Marca Registrada
Printed in U.S.A.

CHARACTERISTICS RANGE VALUES (Cont'd):

	Note	Min.	Max.	
Peak Power Output (1).	2	140	-	kw
Peak Power Output (2).	3	180	-	kw
Pulses Missing from Total (1). .	2,4	-	0.25	%
Pulses Missing from Total (2). .	3,4	-	0.50	%

Note 1: With 13.75 volts ac or dc on heater.

Note 2: With peak anode current of 21.0 amperes corresponding to a peak anode voltage in the order of 21.5 kv, anode-block temperature of 100°C approx., pulse duration of 1 microsecond, and maximum load voltage standing wave ratio equal to or less than 1.05. For heater voltage, see page 4.

Note 3: With peak anode current of 27.5 amperes corresponding to a peak anode voltage in the order of 22.0 kv, anode-block temperature of 100°C approx., pulse duration of 1 microsecond, and maximum load voltage standing wave ratio equal to or less than 1.05. For heater voltage, see page 4.

Note 4: Pulses are considered to be missing if the energy level at the operating frequency is less than 70 per cent of the normal value at a VSWR of 1.5, and with VSWR phase adjusted to produce maximum instability.

● For atmospheric pressures greater than 600 millimeters of mercury in the vicinity of the heater-cathode stem. Operation at pressures lower than 600 millimeters of mercury may result in arc-over across the stem with consequent damage to the tube. The waveguide should always be pressurized to a minimum of 30 psi absolute to prevent arcing, especially when there is a mismatched load. Arcing in the waveguide due to lack of pressure can damage the tube.

▲ It is essential that the input circuit be designed so that if arcing occurs the energy per pulse delivered to the tube cannot greatly exceed the normal energy per pulse. To satisfy this requirement, it is recommended that pulsers of the discharging-network type be used.

OPERATING CONSIDERATIONS

The *maximum ratings* shown in the tabulated data are limiting values above which the serviceability of the 6865 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *high voltage* at which the 6865 is operated is very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltage. Precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is required.

Magnetic-Field Precautions. In general, magnetrons with integral magnets, such as the 6865 should be stored so as to maintain a minimum distance of 6 inches between tubes. If this precaution is not followed, excessive interaction between the magnetic fields of adjacent magnets may occur with consequent decrease in the strength of the magnetic fields. In addition, it is important to maintain a minimum distance of 2 inches between the magnet and any magnetic materials and to use non-ferrous tools during installation. Failure to observe this latter precaution may subject the magnet to sharp mechanical shocks which may result in demagnetization of the magnet. Furthermore, precautions should be observed to insure that the magnetic field of the 6865 does not affect nearby instruments and tubes.

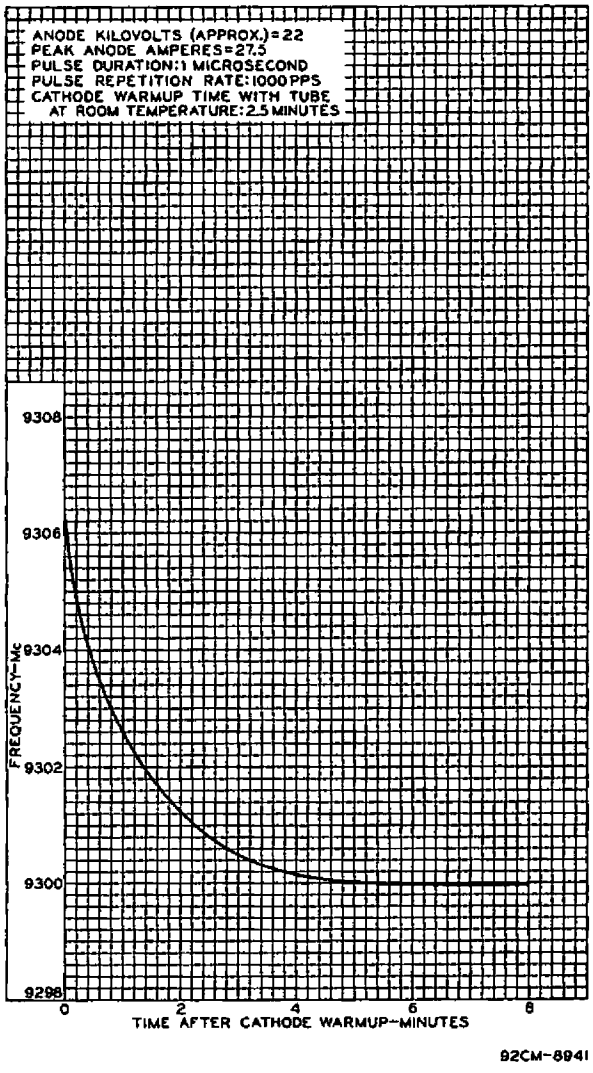


Fig. 1 - Typical Stabilization Characteristic of Type 6865.

In *handling* the 6865, exercise care to prevent rough treatment which might distort the metal structure and cooling fins. Any such distortion may result in loss of vacuum or impairment of the electrical characteristics. *The tube should never be held by the heater-cathode stem* because undue strain on the cathode assembly will weaken the structure and will result in permanent damage to the tube.

Care should be taken to prevent any foreign matter or corrosive substances from entering the recessed cathode terminal or from lodging in the opening in the waveguide output flange. As a safeguard, it is recommended that the protective dust cover over this flange be left on until the tube is ready to be mounted in the equipment.

surface having adequate flatness so as to avoid possible distortion of the mounting flange when it is bolted to the mounting surface.

Fastening the JAN RG-51/U waveguide to the waveguide output flange of the tube is accomplished in the following manner. A JAN UG-52A/U choke flange or equivalent should be modified by

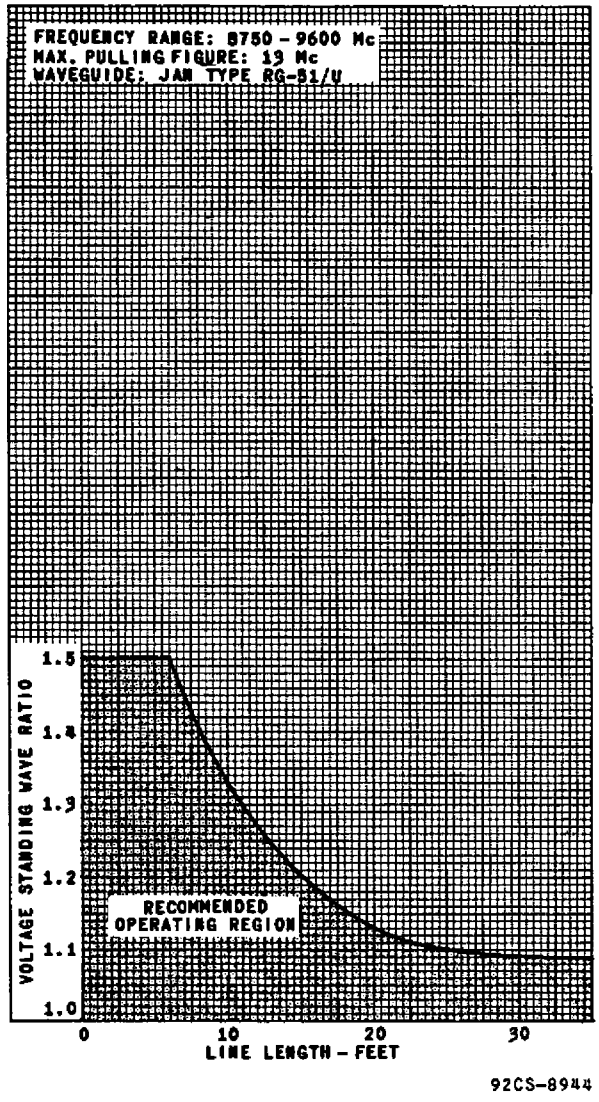


Fig. 2 - Operating Region of Type 6865.

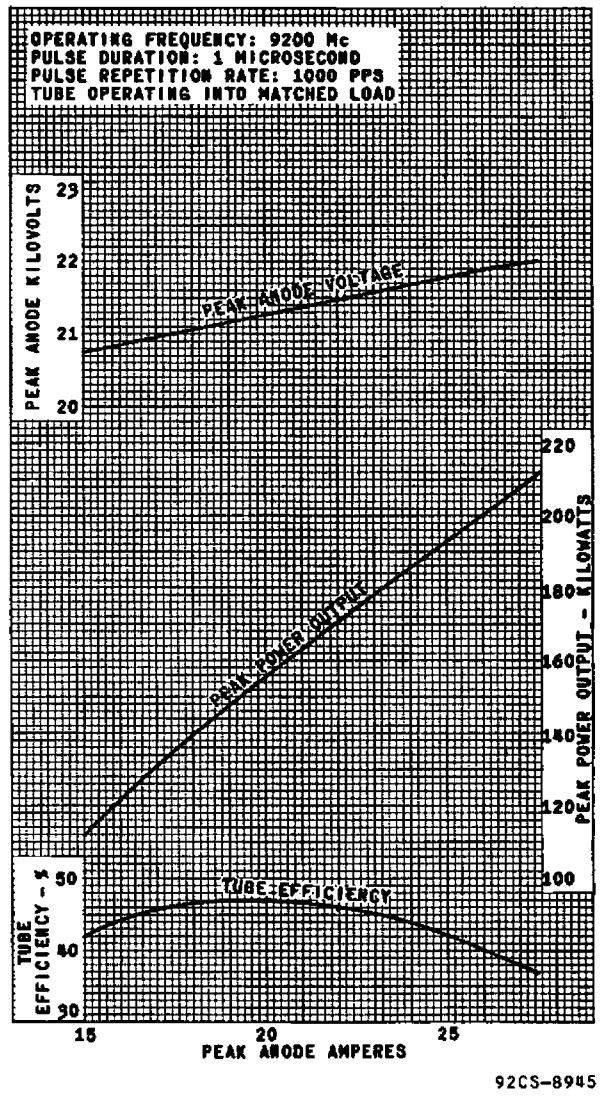


Fig. 3 - Performance Chart of Type 6865.

The approximate weight of the 6865 is: packed for shipment, 18 pounds; and unpacked, 11-1/2 pounds.

Mounting of the 6865 should be accomplished by means of the mounting flange which may be positioned to operate the tube in any orientation. The flange is made so as to permit use of the 6865 in applications requiring a pressure seal. Care should be taken by the equipment designer to insure that the tube is mounted on a

drilling out the screw threads from the four mounting holes in the choke flange using a No. 15 drill. This operation will permit four size 8-32 bolts inserted through the flange mounting holes, to engage the threaded waveguide output flange of the tube. It is recommended that the choke flange be sufficiently tight to avoid arcing and other contact effects. Before the choke flange is fastened to the waveguide output flange of the tube, the user should make certain that the wave-

guide window is entirely free of dust to prevent possible arcing with consequent damage to the tube.

Cooling of the 6865 is accomplished by directing a stream of clean air along the cooling fins toward the body of the tube. Adequate flow should be provided to maintain the temperature of the anode block below 150°C under any condition of operation. Failure to provide adequate cooling will impair tube life.

The *heater terminal* and the *heater cathode terminal require the use of a connector with flexible leads* such as the Ucinite* No. 115364 with built-in capacitor, or equivalent. Unless flexible leads are used, the heater-and-cathode seals may be damaged. Adequate air flow should be provided to maintain the temperature of the heater-cathode terminal below 165°C.

When a new tube is first placed in service, it is recommended that the pulse voltage be raised gradually to minimize possible arcing within the tube. If there is evidence of arcing, operate the tube with reduced input for a period of from 15 to 30 minutes after which arcing usually ceases.

A *heater starter* should be used to raise the voltage gradually and to limit the instantaneous starting current through the heater when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance heater transformer, or a simple rheostat. Regardless of the method of control, it is important that the maximum instantaneous starting current never exceed, even momentarily, a value of 12 amperes. Exceeding this value may damage the heater.

After the heater voltage is raised to its rated value of 13.75 volts, allow the cathode to warm up for at least 2-1/2 minutes to make sure that the cathode reaches operating temperature. When the cathode has reached full operating temperature, high-voltage pulses, negative with respect to anode (ground), can be applied to the heater-cathode terminal. As soon as the 6865 begins to oscillate, the heater voltage (E_f) should be reduced in accordance with the following formula, depending on the average power input (P_i) to the tube:

P_i up to 450 watts: $E_f = 13.75 \left(1 - \frac{P_i}{450}\right)$ volts

P_i greater than 450 watts: $E_f = 0$ volts

When the 6865 is oscillating, the cathode is subjected to considerable electron bombardment which raises the temperature of the cathode. The magnitude of such heating is a function of the total dissipation and must be compensated by reduction of heater voltage in order to prevent overheating of the cathode. Failure to start the tube at rated heater voltage and to reduce the heater voltage as soon as oscillation starts may adversely affect tube life.

The heater should be protected against input pulse power by placing a suitable capacitor in shunt with the heater leads as near the heater-cathode stem as possible in order to limit high transient voltages from developing across the heater.

Stabilization. After the high-voltage pulses are applied, the temperature of the tube rises until a condition of thermal equilibrium is reached. During this period the physical dimensions of the tube change, causing the resonant frequency of the anode structure to change. The time required for stabilization is shown in Fig.1.

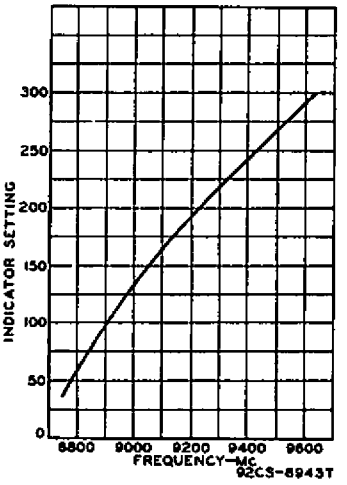


Fig.4 - Typical Tuning Characteristic of Type 6865.

For standby operation, during which the high-voltage pulses are not applied to the tube, the heater voltage should be restored to 13.75 volts.

The *anode-circuit return* should be made to the *heater-cathode* terminal. If the anode-circuit return is made to the heater terminal, all of the anode current will flow through the heater and may result in heater burnout.

The leads between the pulse generator and the magnetron should be kept as short as possible because the reactance of long leads may distort the pulse waveform.

The *shape of the voltage pulse* as supplied to the tube by the driving circuit should conform to the values indicated in the tabulated data. It is essential that the total voltage variation across the top of a single pulse be less than five per cent of the smooth peak value to insure good spectrum shape. Poor pulse shape can cause excessive frequency modulation and tube

* Manufactured by Ucinite Division of United-Carr Fastener Corporation, Newtonville 60, Mass.

instability. Modulation of the mean pulse voltage from pulse to pulse should be held to a minimum. The trailing edge of the voltage pulse should decrease rapidly to produce the best frequency spectrum. High positive peaks in the ripple, or backswing following the voltage pulse, if excessive, may cause instability or noise.

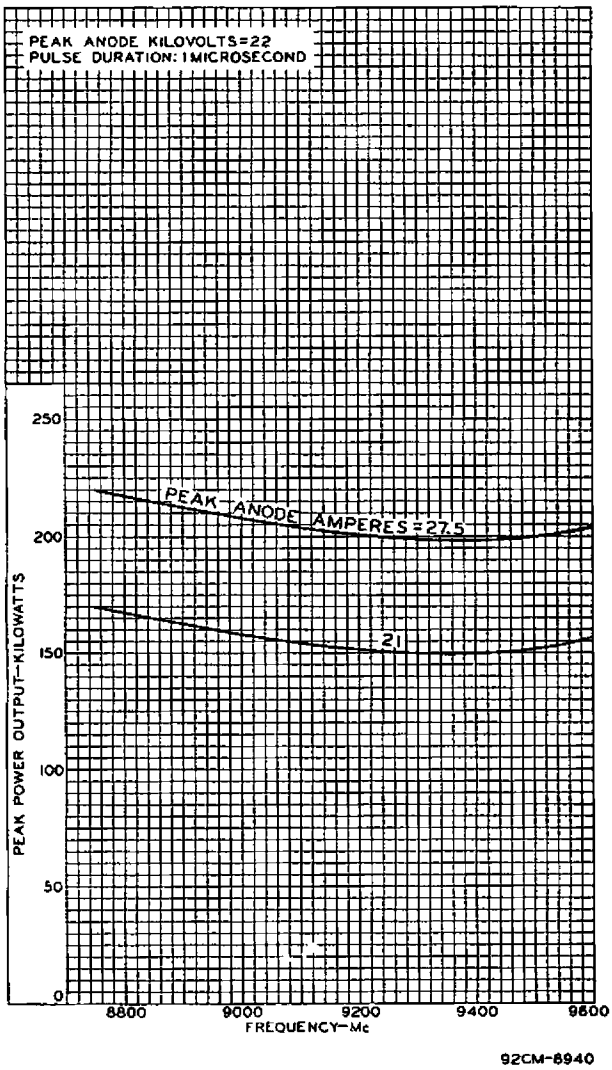


Fig.5 - Operation Characteristics of Type 6865.

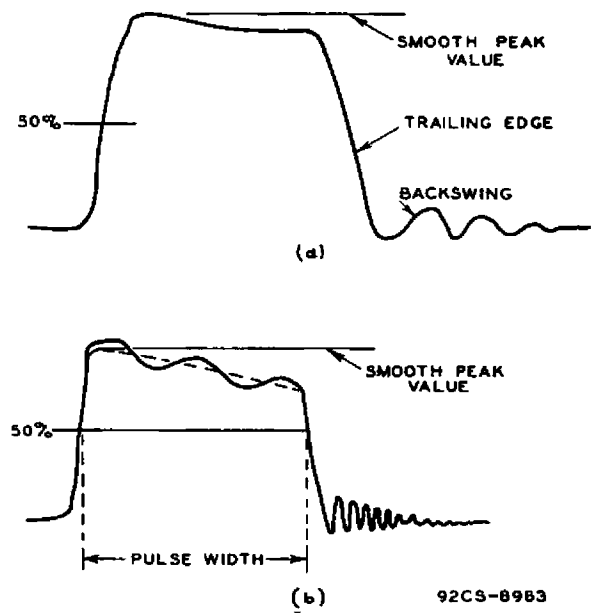
The 6865 should be operated with a *well-matched load*. Tube life and reliability will be increased if the VSWR of the load is kept near unity, either by the use of a suitably matched load or by using a ferrite load isolator. Under no circumstances should the tube be operated with a VSWR greater than 1.5.

The use of an electrically long *transmission line* between the output of a magnetron and its load can cause frequency instability with resulting deterioration of spectrum. Such unsatisfactory operation has been called "long-line effect". The extent to which "long-line effect" is exhibited depends on three factors: the pulling factor or degree of coupling of the load to the oscillator, the length of line between an impedance discontinuity and the tube, and the degree of impedance discontinuity. Fig.2 indicates the recommended operating region for the 6865 over its entire tuning range.

For optimum performance, the pulse-generating equipment, pulse line, pulse transformer, the magnetron, and the associated circuitry should all be considered as a unit and be designed to work together.

A typical performance chart for the 6865 is given in Fig.3. It shows the peak power output, tube efficiency, and peak anode voltage as functions of peak anode current with the tube operating into a matched load.

Tuning is accomplished by turning the tuning knob until the setting of the micrometer-type indicator is reached which corresponds to the desired frequency, as determined from the calibration on the tube. Then lock the tuning knob. A typical curve of indicator setting vs frequency is shown in Fig.4. For precise tuning adjustment, the final indicator setting should be approached



a - Voltage Pulse *b - Current Pulse*

Fig.6 - Waveforms Showing Smooth Peak Value, Trailing Edge, Backswing, and Pulse Width.

using the same direction of rotation of the tuning knob. There is little frequency drift after changing tuner setting. A typical curve of peak power output vs frequency is shown in Fig.5.

Our engineers are ready to assist you in circuit applications of the RCA-6865. For further information, write to Commercial Engineering, RCA, Harrison, New Jersey, giving complete details as to the proposed service.

DEFINITIONS

Smooth Peak Value. The maximum value of a smooth curve drawn through the average of the fluctuation over the top of a voltage or current pulse, as illustrated in Fig.6.

Pulse Width. The time interval between the two points of the current pulse at which the current is 50 per cent of the smooth peak value.

Rate of Rise of Voltage Pulse. The steepest slope of the voltage pulse leading edge above 50 per cent of the smooth peak value.

Measurement of the rate of rise of voltage should be made using a capacitance divider with an input capacitance not exceeding 6 $\mu\mu$f. An oscilloscope of sufficient bandpass, such as the Tektronix 517 or equivalent, should be used.

REFERENCES

J. B. Fisk, H. D. Hagstrom, and L. A. Hartman, *"The Magnetron as Generator of Centimeter Waves"*, The Bell System Technical Journal, Vol.XXV, No.2, pp.167-348, April, 1946.

George B. Collins (Editor) *"Microwave Magnetrons"*, McGraw-Hill Book Company, Inc., 1948.

Joseph F. Hull, Gabriel Novick, and Richard Cordray, *"How Long-Line Effect Impairs Tunable Radar"*, Electronics, Vol.27, No.2, p.168, February, 1954.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

NOTES FOR DIMENSIONAL OUTLINE

Reference plane A is defined as the plane through that portion of the mounting flange designated as annular surface D.

Reference plane B is defineo as the plane which is perpendicular to plane A and passes through the exact centers of mounting flange holes No.2 & No.3.

Reference plane C is defined as the plane which is perpendicular to plane A & plane B & passes through the exact center of mounting flange holes No.3 & No.4.

NOTE 1: Surface E of the waveguide output flange, and the entire mounting flange are made so that they may be used to provide a hermetic seal.

NOTE 2: The axis of the heater-cathode terminal will be within the confines of a cylinder whose radius is 3/64" and whose axis is perpendicular to reference plane A at the specified location.

NOTE 3: All points on mounting flange will lie within 0.025" above or below reference plane A.

NOTE 4: The limits include angular as well as lateral deviations.

NOTE 5: These dimensions define extremities of the 0.169" internal diameter of the cylindrical heater terminal.

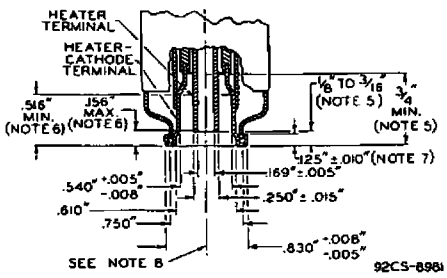
NOTE 6: These dimensions define extremities of the 0.540" internal diameter of the cylindrical heater-cathode terminal.

NOTE 7: No part of the connector device for the heater and heater-cathode terminals should bear against the underside of this lip.

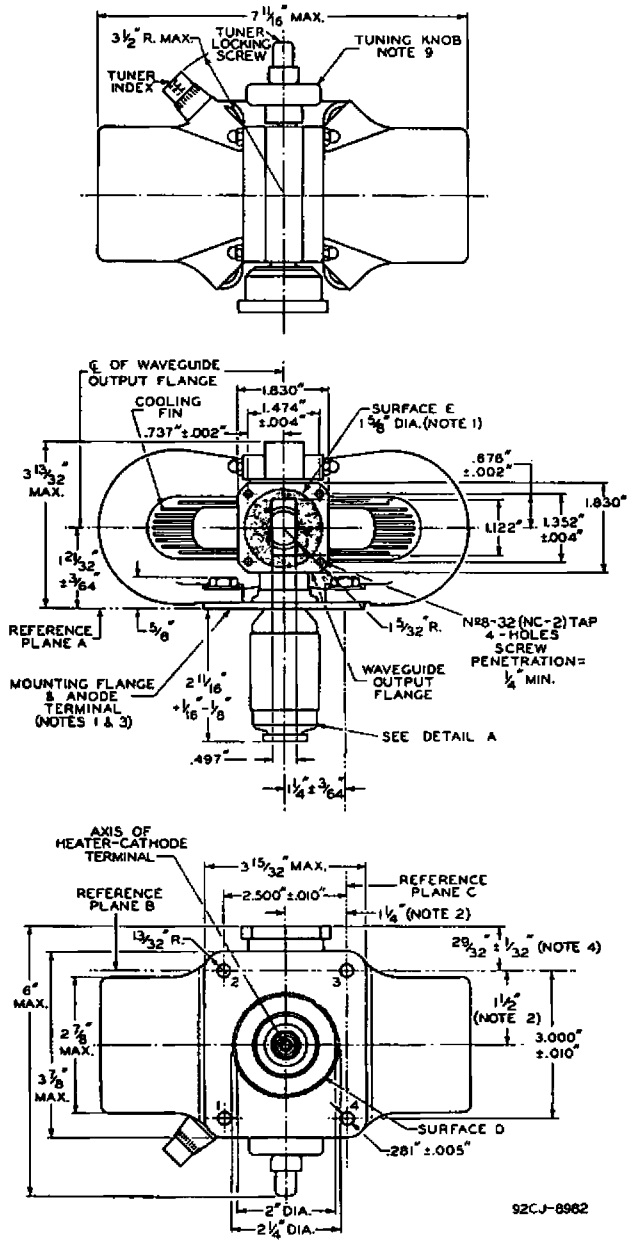
NOTE 8: The heater terminal and the heater-cathode terminal are concentric within 0.010".

NOTE 9: Clockwise rotation of tuner increases frequency.

DETAIL A



DIMENSIONAL OUTLINE



6903

MULTIPLIER PHOTOTUBE

1-5/8" Dia. Flat Face Semitransparent Cathode | **10-Stage Head-On Type S-13 Response** | **6-9/16" Max. Length 2-5/16" Max. Diameter**

TENTATIVE DATA

RCA-6903 is a head-on type of multiplier phototube intended especially for the detection and measurement of ultraviolet radiation, and in other applications involving low-level radiation sources. It is constructed with a fused-silica faceplate which transmits radiant energy in the ultraviolet region down to and below 2000 angstroms. The response below 2000 angstroms is limited only by the transmission of the faceplate. The 6903 may also be used in scintillation counters for the detection and measurement of nuclear radiation.

The spectral response of the 6903 covers the range from about 2000 to 6500 angstroms, as shown in Fig.1. Maximum response occurs at approximately 4400 angstroms. The 6903, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation.

Because of its spectral response, the 6903 is well suited for use with organic phosphors such as anthracene as well as with inorganic materials such as thallium-activated sodium iodide.

Design features of the 6903 include a semitransparent cathode having a minimum diameter of 1-5/8 inches on the inner surface of the face end of the bulb; ten electrostatically focused multiplying (dynode) stages; and a focusing electrode with external connection for shaping the field which directs photoelectrons from the cathode onto the first dynode.

The 6903 is capable of multiplying feeble photoelectric current produced at the cathode by a median value of 400,000 times when operated with a supply voltage of 1000 volts. The output current of the 6903 is a linear function of the exciting energy under normal operating conditions.

The electrode configuration of the 6903 is designed to provide minimum spread in electron transit time. As a result, the 6903 has very short time-resolution capability, i.e., in the order of 1 millimicrosecond. For an input pulse having a duration of 1 millimicrosecond or less, the time spread of the pulse at the anode is about 8 millimicroseconds measured at 50 per cent of the maximum pulse height.

The various features of the 6903 commend its use in applications involving measurement of ultraviolet radiation and also in the design of a scintillation counter with high efficiency and a resolving time of only a small fraction of a microsecond.

DATA

General:

Spectral Response	S-13	
Wavelength of Maximum Response	4400 ± 500	angstroms
Cathode, Semitransparent:		
Shape	Circular	
Window:		
Area	2.0	sq. in.
Minimum diameter	1-5/8	in.
Index of refraction at 2000 angstroms	1.50	
Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.10	4.4	μμf
Anode to all other electrodes	7.0	μμf
Maximum Overall Length	6-9/16"	
Seated Length	5-5/8" ± 3/16"	
Maximum Diameter	2-5/16"	
Bulb	T-16	
Faceplate	Fused Silica	
Maximum Thickness	0.150"	
Base . . . .Medium-Shell Diheptal 14-Pin, Non-hygroscopic (JETEC No.B14-38)		
Mounting Position	Any	
Weight (Approx.)	7	oz

Maximum Ratings, *Absolute Values:*

ANODE-SUPPLY VOLTAGE (DC or Peak AC)	1250 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.10 AND ANODE (DC or Peak AC)	250 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC or Peak AC)	300 max.	volts
FOCUSING-ELECTRODE VOLTAGE (DC or Peak AC)	300 max.	volts
AVERAGE ANODE CURRENT●	0.75 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

TMK ®, Marca Registrada
Printed in U.S.A.

TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across voltage divider providing 1/6 of E between cathode and dynode No.1: 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode.

With E = 1000 volts (except as noted) and Focusing Electrode* connected to Dynode No.1 at socket

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	–	19000	–	μamp/μwatt
Cathode radiant, at 4400 angstroms. . .	–	0.047	–	μamp/μwatt
Luminous:♦				
At 0 cps . . .	8	24	240	amp/lumen
With dynode No.10 as output electrode**. . .	–	14	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲	40	60	–	μamp/lumen
With blue light source (See Fig.2)⊕	0.04	–	–	μamp
Current Amplification. .	–	400000	–	
Equivalent Anode-Dark Current Input#□.	–	1×10^{-9}	3×10^{-9}	lumen
Equivalent Noise Input:				
Luminous★. . . .	–	6.7×10^{-12}	–	lumen
Ultraviolet† . .	–	1.6×10^{-14}	–	watt
Dark Current to Any Electrode Except Anode (At 25°C). . . .	–	–	0.75	μamp

With E = 750 volts (except as noted) and Focusing Electrode* connected to Dynode No.1 at socket

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	–	1650	–	μamp/μwatt
Cathode radiant, at 4400 angstroms. . .	–	0.047	–	μamp/μwatt
Luminous:♦				
At 0 cps . . .	–	2.1	–	amp/lumen
With dynode No.10 as output electrode**.	–	1.0	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲. . .	40	60	–	μamp/lumen
With blue light source (See Fig.2)⊕	0.04	–	–	μamp
Current Amplification.	–	35000	–	

● Averaged over any interval of 30 seconds maximum.

* In general, the focusing electrode is connected to dynode No.1 at the socket and operated at the same fixed potential as dynode No.1. However, in applications critical as to magnitude, uniformity, or speed of the response, the focusing electrode may be connected to the adjustable arm of a potentiometer between cathode and dynode No.1 in the voltage divider, and operated at an optimum potential within a range of 10 to 60 per cent of the dynode-No.1 potential.

♦ For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light input of 10 microlumens is used. The load resistor has a value of 0.01 megohm.

** An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.10 as the output electrode. With this arrangement, the load is connected in the dynode-No.10 circuit and the anode serves only as collector.

▲ For conditions the same as shown under (♦) except that the value of light flux is 0.01 lumen and 150 volts are applied between cathode and all other electrodes connected together as anode.

⊕ Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870°K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 150 volts are applied between cathode and all other electrodes connected together as anode.

Measured at a tube temperature of 25°C and with the supply voltage (E) adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

□ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1000 volts is recommended.

★ Under the following conditions: Supply voltage (E) 1000 volts, 25°C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at color temperature of 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

† Determined under the same conditions as shown under (★) except that use is made of monochromatic source having radiation of 2537 angstroms.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity, The quotient of output current by incident luminous flux, at constant electrode voltages.

Cathode Luminous Sensitivity. The quotient of current leaving the photocathode by the incident luminous flux.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux or incident radiant power which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

GENERAL CONSIDERATIONS

The 6903 is a phototube incorporating an electron multiplier. An electron multiplier utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 6903 multiplier phototube, represented in Fig.3, the electrons emitted from the irradiated cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.10) are collected by

the anode and constitute the current utilized in the output circuit.

Dynode No.10 is so shaped as to enclose partially the anode and to serve as a shield for it in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grating which allows the electrons from dynode No.9 to pass through it to dynode No.10. Spacing between dynode No.10 and anode creates a collecting field such that all the electrons emitted by dynode No.10 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 6903 can be coupled to any practical load impedance.

The shield which extends between dynode No.1 and the anode shields dynode No.1 and the cathode from the anode and prevents ion feedback. If positive ions produced in the high-current region

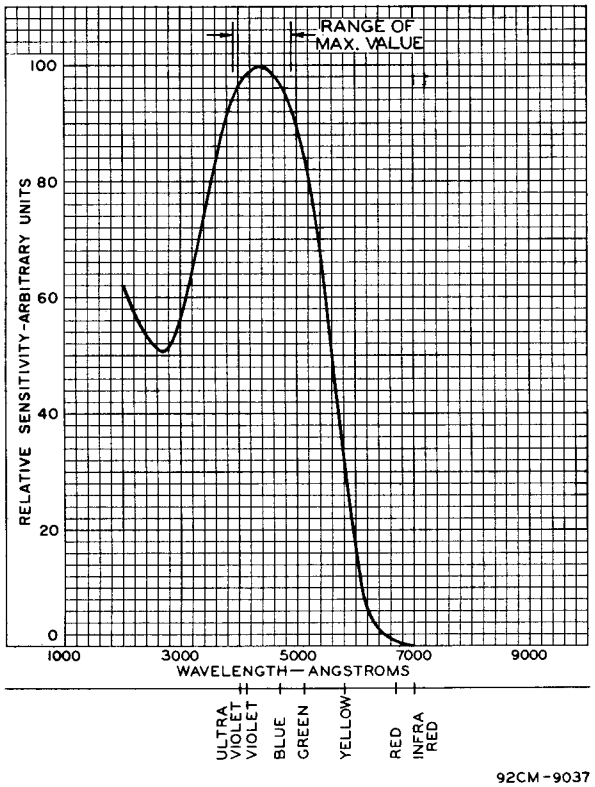


Fig.1 - Tentative Spectral Sensitivity Characteristic of Type 6903 which has S-13 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

near the anode were allowed to reach the cathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration. The metallic coating on the inner side wall of the glass bulb is connected to the cathode, and serves to direct the electrons from the cathode toward dynode No.1.

The grill through which the electrons reach dynode No.1, is connected to dynode No.1 and

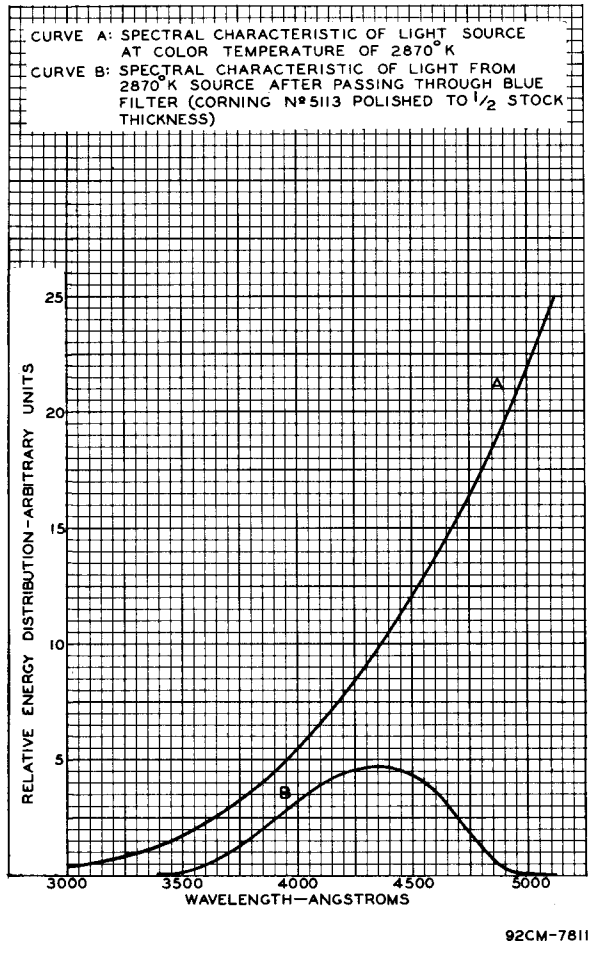


Fig.2 - Spectral Characteristic of 2870°K Light Source, and Spectral Characteristic of Light from 2870°K after Passing through Indicated Filter.

serves along with accelerating electrode as an electrostatic shield for the open side of the electrode structure.

The focusing electrode shapes the field which directs photoelectrons from the cathode onto dynode No.1.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 6903 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of

determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface and dynode surfaces to evaporate with consequent decrease in the life and sensitivity of the tube.

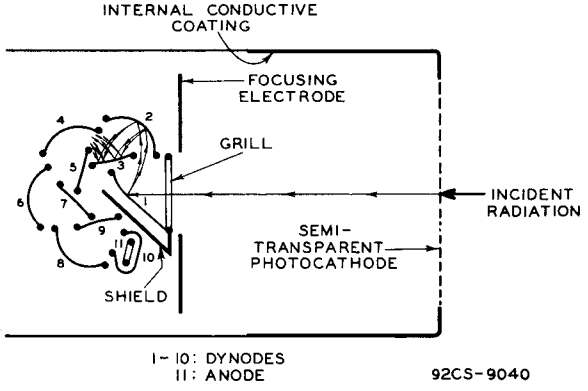


Fig.3 - Schematic Arrangement of Type 6903 Structure.

The *base pins* of the 6903 fit the medium diheptal 14-contact socket. The socket should be made of high-grade, low-leakage material, and should be installed so that the incident radiation falls on the face end of the tube.

In general, the *operating voltages* for the 6903 are as follows. The cathode-to-dynode-No.1 potential is about twice the potential applied between the successive dynodes. The steps for the successive stages are generally chosen as 75 to 125 volts. The voltage between dynode No.10 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristic curves, shown in Fig.4, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. Low operating voltage between dynode No.10 and anode reduces the dark current. To obtain the indicated operating voltage between dynode No.10 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

In applications where it is desired to keep the statistical fluctuations to a minimum, e.g., as in nuclear radiation spectroscopy, the potential between cathode and dynode No.1 may be increased to the rated maximum value of 300 volts.

The *focusing-electrode potential* may be adjusted between that of the photocathode and that of dynode No.1 to optimize the magnitude, uniformity, or speed of the response. When the focusing electrode is operated at dynode-No.1 potential, the smallest possible spread in transit time of the photoelectrons as well as good

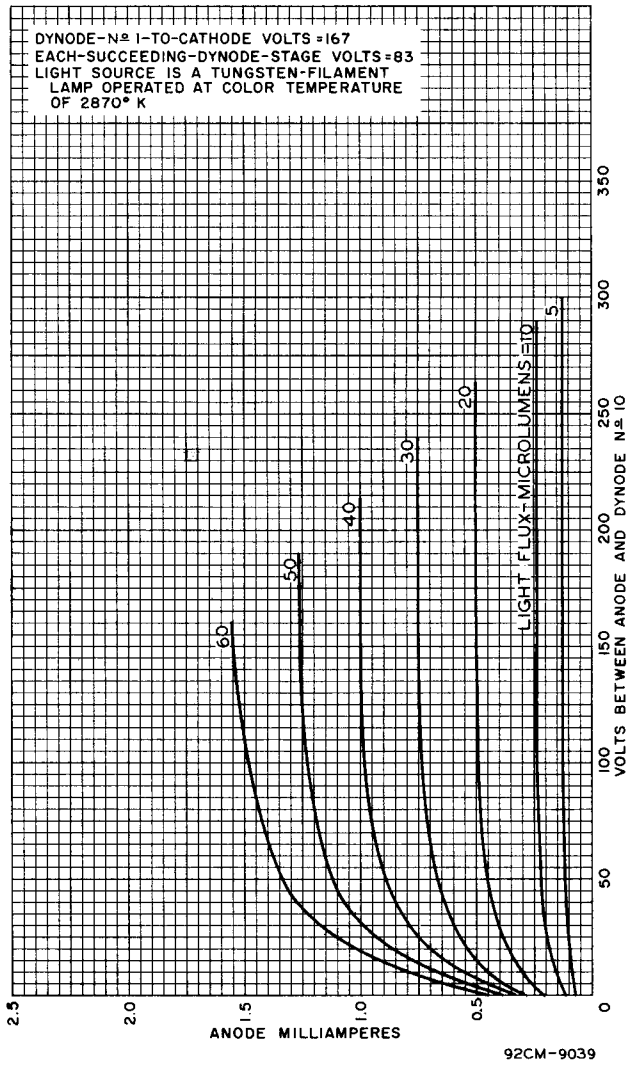


Fig.4 - Average Anode Characteristics of Type 6903.

uniformity of response over the entire cathode area is obtained. As the potential of the focusing electrode is decreased toward that of the cathode, all other electrode potentials remaining constant, it will be noticed that the anode current generally passes through a maximum which occurs when the value of focusing-electrode potential is 10 to 60 per cent of that between cathode and dynode No.1. Operation with the focusing electrode at a potential near that of

the cathode is characterized by optimum signal magnitude with some increase in transit-time spread and some decrease in uniformity of response over the cathode area. Such operation may offer an advantage in some applications where the increased number of collected photoelectrons is the primary consideration.

diation on the cathode can not be detected. Dark current may be kept at a minimum by storing tubes in light-proof containers.

When the application utilizes *continuous luminous excitation and dc anode current* and it is desired to have a high ratio of signal output to dark current, it is recommended that the oper-

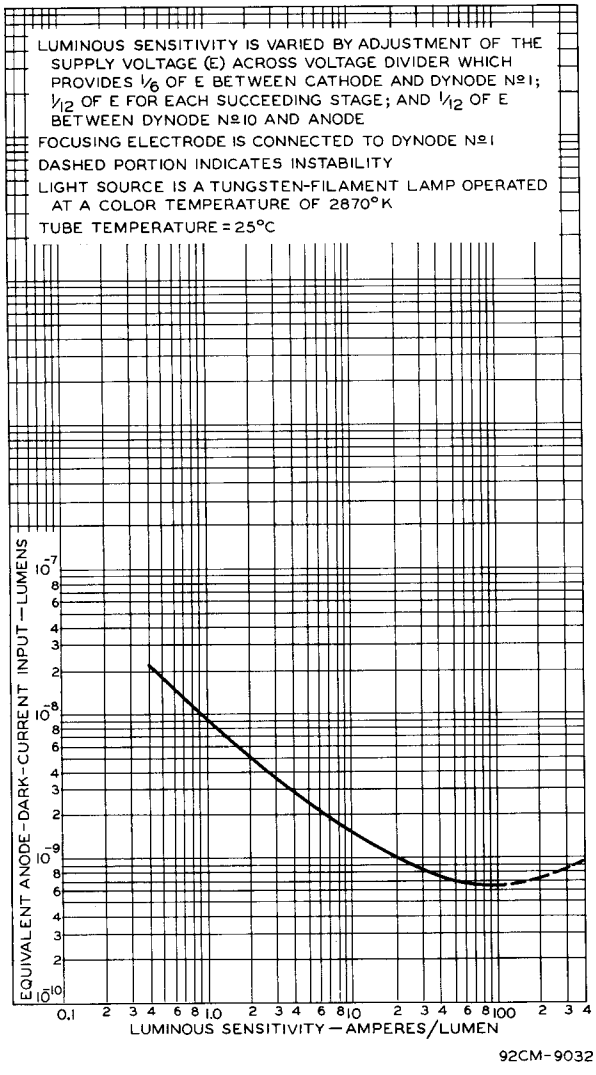


Fig.5 - Typical Anode-Dark-Current Characteristic for Type 6903.

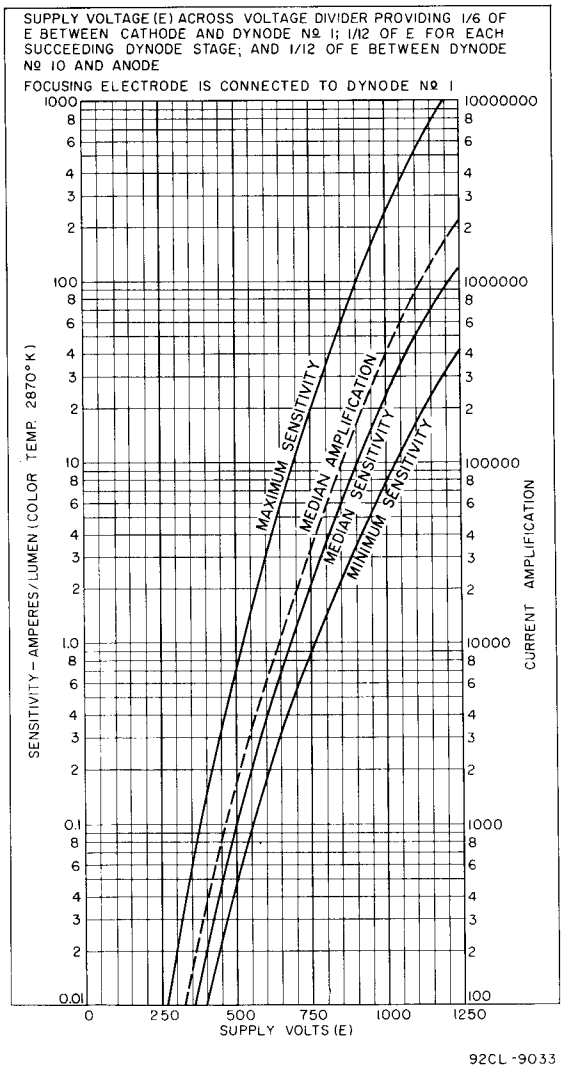


Fig.6 - Characteristics of Type 6903.

A very small *dark current* is observed when voltage is applied to the electrodes of the 6903 in complete darkness. This current has a component caused by leakage, and a component consisting of pulses produced by electrons thermionically released from the cathode, by secondary electrons released by ionic bombardment of the dynodes or cathode, or by cold emission from the electrodes. The magnitude of the dark current establishes a limit below which the exciting radiation on the cathode can not be detected. Dark current may be kept at a minimum by storing tubes in light-proof containers.

When the application utilizes *continuous luminous excitation and dc anode current* and it is desired to have a high ratio of signal output to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig.5 which shows the equivalent anode-dark-current input as a function of luminous sensitivity for the 6903, and the curves in Fig.6 which show luminous sensitivity as a function of the supply voltage. The voltage between dynode No.10 and the anode should be kept as low as will permit operation at a point just giving anode-current saturation. This point on the anode characteristic curves, shown

in Fig.4, occurs in the approximate range of 50 to 100 volts.

In applications involving *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 750 to 1000 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise power spectrum is essentially flat up to about 50 megacycles per second. At voltages above 1000 volts, regenerative phenomena usually contribute to the noise.

The noise spectrum of the 6903 is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of the exciting signal in order to eliminate as much noise as possible.

In either dc or ac applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice or liquid air, to cool the bulb of the 6903 is recommended. The refrigerant reduces the thermionic emission, and thereby lowers the detection threshold to give improved operation. The curve in

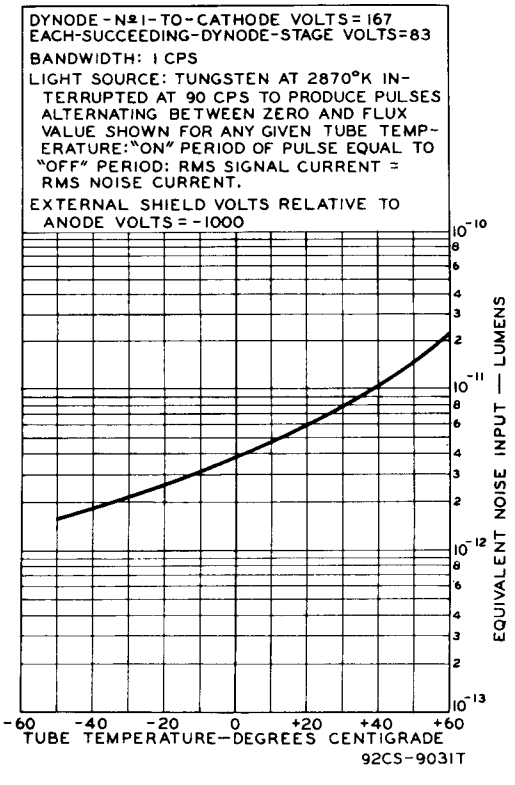


Fig.7 - Equivalent Noise-Input Characteristic of Type 6903.

Fig.7 shows the equivalent noise input as a function of the temperature of the 6903.

Exposing the 6903 to strong ultraviolet radiation may cause an increase in anode dark current. After cessation of such irradiation, dark current drops rapidly.

The *operating stability* of the 6903 is dependent on the magnitude of the anode current and its

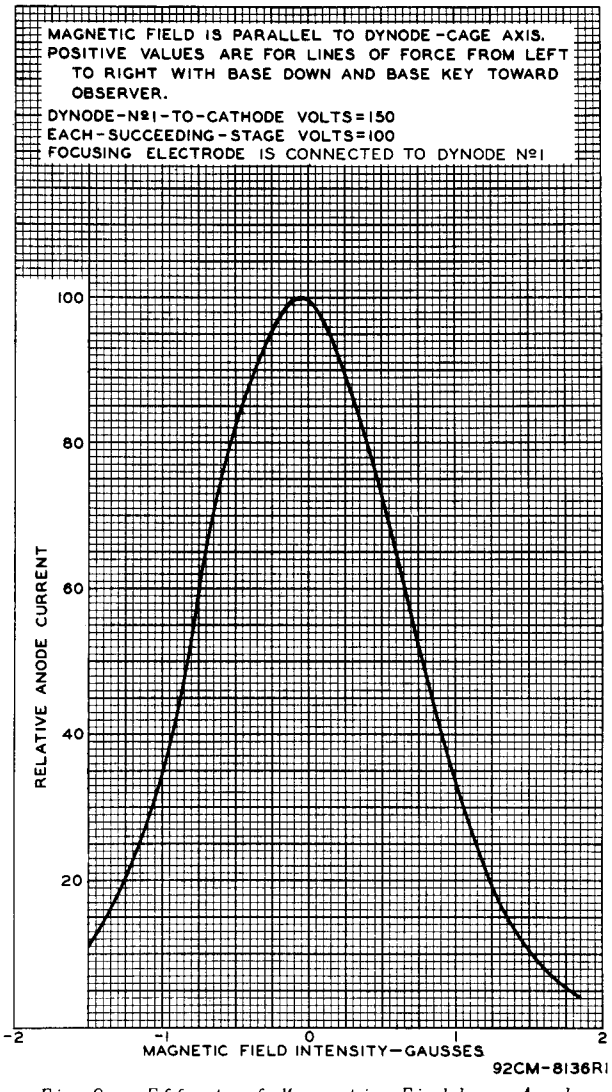


Fig.8 - Effect of Magnetic Field on Anode Current of Type 6903.

duration. When the 6903 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 6903 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 0.75 milliampere is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 100 microamperes.

The *range of sensitivity* values is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity

can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the *n*th power, where *n* is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for designers to provide adequate adjustment of the supply voltage per stage so as to be able to adjust the amplification of individual tubes to the desired design value. The voltage-adjustment range required to take care of variations between individual tubes may be determined from Fig.6. For example, if a sensitivity of 2 amperes per lumen is desired, it will be observed that this value on the "minimum" sensitivity curve corresponds to a supply voltage of about 840 volts, and on the "maximum" sensitivity curve to a supply voltage of 570 volts. Therefore, provision should be made to adjust the supply voltage over the range from 570 to 840 volts.

Electrostatic and/or magnetic shielding of the 6903 may be necessary. The metallic coating on the inner side wall of the glass bulb acts as an electrostatic shield to prevent the coated portion of the bulb wall from charging to a positive potential. However, the uncoated area of the bulb wall tends to charge to a potential near that of the anode, especially when the 6903 is operated at voltages near the maximum, with the result that an internal discharge phenomenon may occur and cause an increase in noise. To prevent this possibility, it is suggested that a shield be closely fitted over the uncoated area and be connected as a safety precaution (see below), through a high impedance in the order of 10 megohms to a potential near that of the cathode. The shield may consist of a conductive coating painted on the clear portion of the bulb above the base, or metallic foil wrapped around the clear area.

With certain orientations of the 6903, it will be observed that the earth's magnetic field is sufficient to cause a noticeable decrease in the response of the tube. The curve in Fig.8 shows the effect on anode current of variation in magnetic-field strength under the conditions indicated. With increase in voltage above 100 volts between cathode and dynode No.1, the effect of the magnetic field will cause less decrease in anode current.

To prevent such decrease in response of the tube, magnetic shielding should be provided. When connected to cathode potential, this shielding may closely fit the bulb and serves the dual purpose of providing both magnetic and electrostatic shielding. When connected to anode potential, this shielding should be spaced at least 1/2 inch from the bulb wall to prevent the internal discharge phenomenon described above.

It is to be noted that the use of an external magnetic and/or electrostatic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

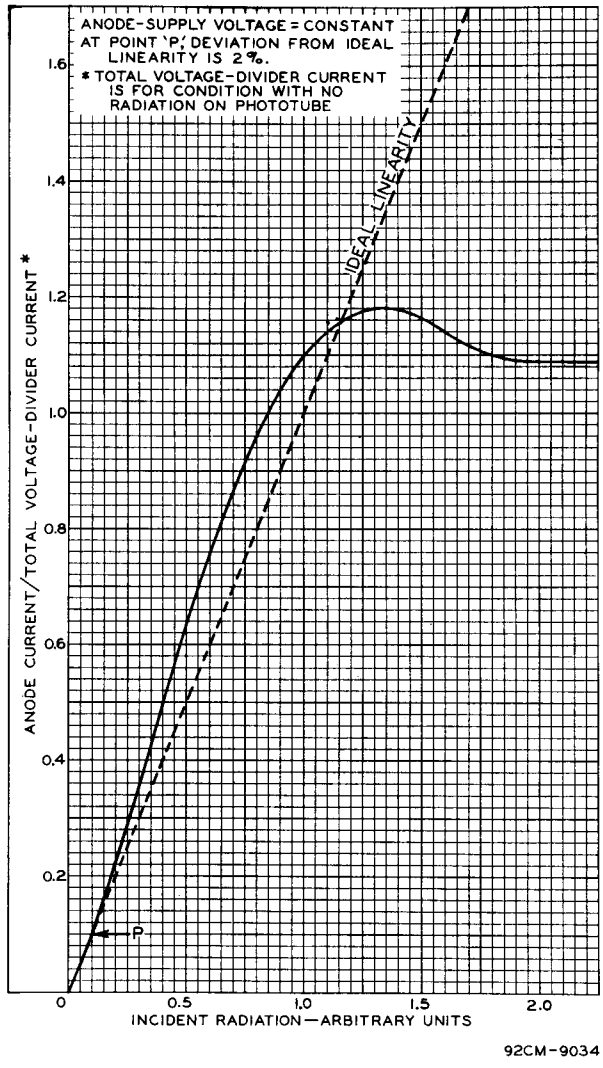
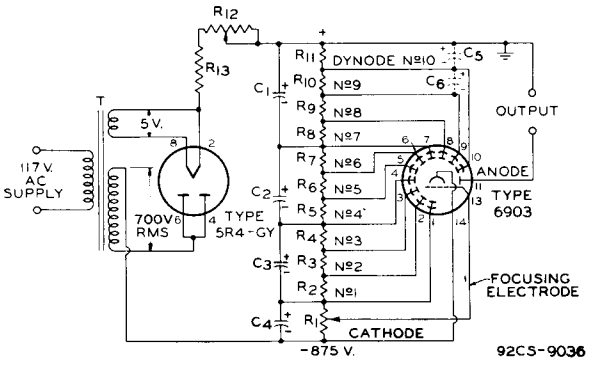


Fig.9 - Linearity Characteristic of Type 6903 as Affected by Ratio of Anode Current to Total Divider Current.

Adequate *light and ultraviolet-radiation shielding* should be provided to prevent extraneous radiation from reaching any part of the 6903. Although the metallic coating on the inner side wall of the glass bulb serves to reduce the amount of extraneous radiation reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous radiation.

Whenever frequency response is important, the leads from the 6903 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

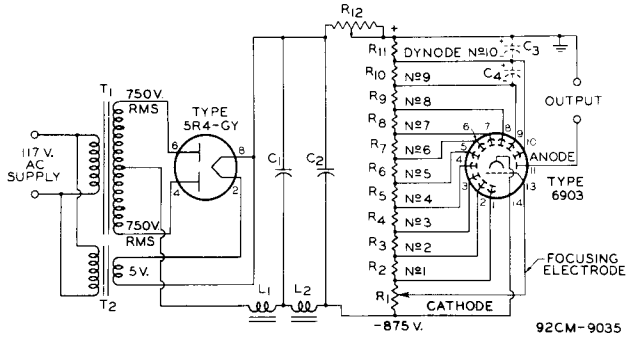
The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each dynode and for the anode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation required by the application. In general, the current in the divider should be about 10 times the maximum value of total dynode current flowing through the divider. Such a value will prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will ordinarily be provided by a well-designed, two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Due to critical dependence of the gain of the 6903 on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum-tube regulator circuit of the mu-bridge type.



C1 C2 C3 C4: 16 μf, electrolytic, 450 volts (dc working)
C5 C6: 8 μf, electrolytic, 150 volts (dc working)
Required only if high peak currents are drawn.
R1 R12: 100000 ohms, 2 watts, adjustable
R2 R3 R4 R5 R6 R7 R8 R9 R10: 50000 ohms, 1 watt
R11: 33000 ohms, 1 watt
R13: 100000 ohms, 2 watts
T: United Transformer Corp. No.R-2, or equivalent.

Fig. 10 - Simple Half-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 6903.

The relationship between the ratio of anode current-to-voltage-divider current and incident radiation is shown in Fig.9. For operation along the *ideal linearity* curve of Fig.9, the anode current-to-voltage-divider current ratio should be less than 0.1.



C1 C2: 2 μf, 1000 volts (dc working)
C3 C4: 8 μf, electrolytic, 150 volts (dc working)
Required only if high peak currents are drawn.
L1 L2: United Transformer Corp. No.R-17, or equivalent
R1: 50000 ohms, 5 watts, adjustable (General Radio Co. Type 314-A or equivalent)
R2 R3 R4 R5 R6 R7 R8 R9 R10: 18000 ohms, 2 watts
R11: 12000 ohms, 2 watts
R12: 100000 ohms, 10 watts, adjustable (General Radio Type 471-A, or equivalent)
T1: United Transformer Corp. No.S-45, or equivalent
T2: United Transformer Corp. No.FT-6, or equivalent

Fig. 11 - Full-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 6903 in Applications Critical as to Hum Modulation.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.

The high voltages at which the 6903 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 6903 as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

Typical power-supply circuits for the 6903 are shown in Figs.10 and 11. The circuit in Fig.10 utilizes a half-wave rectifier to provide the dc power for the 6903. In applications where excellent regulation particularly for wide variation in output current of the 6903 is required and where minimum hum modulation is essential, the circuit of Fig.11 may be used.

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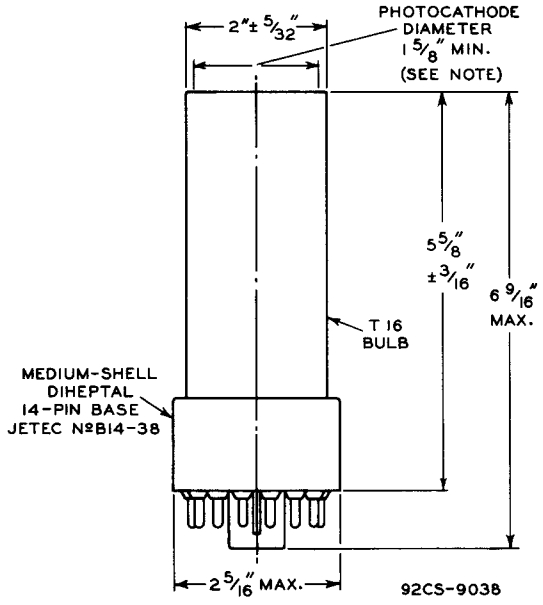
Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



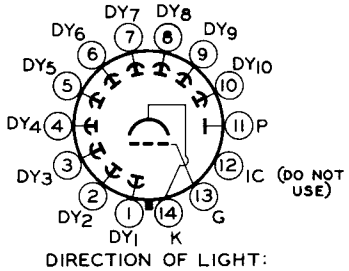
℄ OF BULB WILL NOT DEVIATE MORE THAT 3° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: WITHIN MINIMUM DIAMETER, DEVIATION FROM FLATNESS WILL NOT EXCEED 0.010" FROM PEAK TO VALLEY.

SOCKET CONNECTIONS

Bottom View

PIN 1: DYNODE No.1
PIN 2: DYNODE No.2
PIN 3: DYNODE No.3
PIN 4: DYNODE No.4
PIN 5: DYNODE No.5
PIN 6: DYNODE No.6
PIN 7: DYNODE No.7
PIN 8: DYNODE No.8



DIRECTION OF LIGHT: INTO END OF BULB

14AA

PIN 9: DYNODE No.9
PIN 10: DYNODE No.10
PIN 11: ANODE
PIN 12: INTERNAL CONNECTION—DO NOT USE
PIN 13: FOCUSING ELECTRODE
PIN 14: CATHODE

6939

TWIN POWER PENTODE

Internally Neutralized for Push-Pull Amplifier Service | **9-Pin Miniature Type** | **14 Watts CW Input (ICAS) up to 500 Mc**

RCA-6939 is a twin power pentode of the 9-pin miniature type intended for use as a push-pull rf-power-amplifier tube or as a frequency-multiplier tube in communications equipment operating at frequencies up to 500 Mc. At 500 Mc, the 6939 can deliver useful power output of 5 watts in Continuous Commercial Service (CCS) or 6 watts in Intermittent Commercial and Amateur Service (ICAS).

The 6939 uses frame-type control grids which contribute to its high power sensitivity. It also uses plate and grid-No.2 materials having high heat dissipation capabilities. This feature insures low plate and grid-No.2 emission and low gas evolution, and thus contributes to stable operation of the 6939 for long periods. In addition, the use of a single cathode and grid No.2, common to both units, minimizes the effects of internal-lead reactance in push-pull circuit applications.

Built-in capacitors, connected from each plate to the control grid of the other unit, neutralize grid-to-plate feedback of each unit, and contribute to stable operation up to 500 Mc. Base pins and internal connectors made of material having high rf conductivity minimize rf losses.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:			
Heater arrangement	*Series*	*Parallel*	
Voltage (AC or DC)	12.6 ± 10%	6.3 ± 10%	volts
Current	0.3	0.6	amp
Transconductance (each pentode) for dc plate volts = 150, dc grid-No.2 volts = 150 and dc plate ma. = 25	10500		μmhos
Mu-Factor, Grid No.2 to Grid No.1 (each pentode) for dc plate volts = 150, dc grid-No.2 volts = 150 and dc plate ma. = 25	31		
Direct Interelectrode Capacitances (Approx., without external shield):			
Grid No.1 to plate (each pentode)	0.15		μμf
Grid No.1 to cathode & grid No.3, grid No.2 and heater (each pentode)	6.4		μμf
Plate to cathode & grid No.3, grid No.2 and heater (each pentode)	1.6		μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length, Base Seat to Bulb Top	(Excluding tip) 2" ± 3/32"
Diameter:	
Maximum	0.875"
Minimum	0.750"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin (JEDEC No.E9-1)

PUSH-PULL RF POWER AMPLIFIER & OSCILLATOR — Class C Telegraphy▲ and PUSH-PULL RF POWER AMPLIFIER — Class C FM Telephony

Values are on a per-tube basis, unless otherwise specified

Maximum Ratings, *Absolute-Maximum Values:*

For Operation At Frequencies Up to 500 Mc

	CCS●	*ICAS***	
DC PLATE VOLTAGE	250 max.	250 max.	volts
DC GRID-No.2 (SCREEN-GRID) VOLTAGE	200 max.	200 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	−100 max.	−100 max.	volts
DC PLATE CURRENT	90 max.	100 max.	ma
DC GRID-No.1 CURRENT	6 max.	8 max.	ma
DC CATHODE CURRENT	100 max.	120 max.	ma
PLATE INPUT	12 max.	14 max.	watts
GRID-No.2 INPUT	3 max.	3.5 max.	watts
GRID-No.1 INPUT	0.2 max.	0.24 max.	watt
PLATE DISSIPATION	6 max.	7.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	volts
Heater positive with respect to cathode	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point)	225 max.	225 max.	°C

Typical Operation at 500 Mc:

DC Plate Voltage	180	200	volts
DC Grid-No.2 Voltage	180	200	volts
DC Grid-No.1 Voltage	−20	−20	volts
From grid resistor for each grid of	27000	27000	ohms
Peak-to-Peak RF Grid-No.1 Voltage	50	50	volts
DC Plate Current	55	60	ma
DC Grid-No.2 Current	12.5	14	ma
DC Grid-No.1 Current	1.5	1.5	ma
Driver Power Output (Approx.)	1.2	1.2	watts
Useful Power Output (Approx.)♦	5	6	watts

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Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6939 10-60
Printed in U.S.A.

PLATE-MODULATED PUSH-PULL RF POWER AMPLIFIER — Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Values are on a per-tube basis

Maximum Ratings, *Absolute-Maximum Values:*

For Operation At Frequencies Up to 500 Mc.

	CCS●	ICAS**	
DC PLATE VOLTAGE.	200 max.	200 max.	volts
DC GRID-No.2 (SCREEN-GRID) VOLTAGE	200 max.	200 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-100 max.	-100 max.	volts
DC PLATE CURRENT.	64 max.	80 max.	ma
DC GRID-No.1 CURRENT. . . .	6 max.	8 max.	ma
DC CATHODE CURRENT.	80 max.	96 max.	ma
PLATE INPUT	8 max.	10 max.	watts
GRID-No.2 INPUT	2 max.	2.3 max.	watts
GRID-No.1 INPUT	0.2 max.	0.24 max.	watt
PLATE DISSIPATION	4 max.	5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode. . .	100 max.	100 max.	volts
Heater positive with respect to cathode. . .	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point). . . .	225 max.	225 max.	°C

Typical Operation at 500 Mc:

DC Plate Voltage.	180	180	volts
DC Grid-No.2 Voltage. . . .	180	180	volts
DC Grid-No.1 Voltage. . . .	-20	-20	volts
From grid resistor for each grid of.	68000	27000	ohms
Peak-to-Peak RF Grid-No.1 Voltage	45	50	volts
DC Plate Current.	40	55	ma
DC Grid-No.2 Current. . . .	9.5	12.5	ma
DC Grid-No.1 Current. . . .	0.6	1.5	ma
Driver Power Output (Approx.)	1	1.2	watts
Useful Power Output (Approx.)♦.	3.5	5	watts

FREQUENCY TRIPLER — Class C

Values are on a per-tube basis

Maximum Ratings, *Absolute-Maximum Values:*

For Operation At Frequencies Up to 500 Mc.

	CCS●	ICAS**	
DC PLATE VOLTAGE.	250 max.	250 max.	volts
DC GRID-No.2 (SCREEN-GRID) VOLTAGE	200 max.	200 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-100 max.	-100 max.	volts
DC PLATE CURRENT.	60 max.	80 max.	ma
DC GRID-No.1 CURRENT. . . .	6 max.	8 max.	ma
DC CATHODE CURRENT.	70 max.	80 max.	ma
PLATE INPUT	8 max.	10 max.	watts
GRID-No.2 INPUT	3 max.	3.5 max.	watts
GRID-No.1 INPUT	0.2 max.	0.24 max.	watt
PLATE DISSIPATION	6 max.	7.5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode. . .	100 max.	100 max.	volts
Heater positive with respect to cathode. . .	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point). . . .	225 max.	225 max.	°C

Typical Operation as Tripler to 500 Mc:

DC Plate Voltage.	180	200	volts
DC Grid-No.2 Voltage (Approx.)	180	190	volts
Through resistor of . . .	1200	1200	ohms
DC Grid-No.1 Voltage. . . .	-74	-74	volts
From grid resistor for each grid of.	82000	82000	ohms
Peak-to-Peak RF Grid-No.1 Voltage	165	165	volts
DC Plate Current.	40	46	ma
DC Grid-No.2 Current. . . .	9.7	11	ma
DC Grid-No.1 Current. . . .	1.8	1.8	ma
Driver Power Output (Approx.)	1.1	1.1	watts
Useful Power Output (Approx.)♦.	1.8	2.2	watts

▲ Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

● Continuous Commercial Service.

** Intermittent Commercial and Amateur Service.

♦ This value of useful power is measured at load of output circuit.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The *maximum bulb temperature* of 225° C is a tube rating and is to be observed in the same manner as other ratings. The temperature should be measured at the hottest point on the bulb with the tube operating in the completely assembled equipment with all covers in place, and delivering the maximum output under the highest ambient-temperature conditions and the most severe operating cycle for which the equipment is designed. The temperature may be measured with temperature-sensitive paint, such as

Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y., in the form of liquid and stick.

Shielding of the 6939 in "straight-through" rf amplifier service may be required for stable operation. To minimize external feedback from the plate to grid No.1, a grounded shield crossing the terminal end of the tube socket through the space between pins 4 and 5 and the space between pins 1 and 9, is generally adeqate for this purpose.

The *heater may be effectively bypassed* by grounding one heater pin at the tube socket and bypassing the other heater pin to ground with a low inductance capacitor. If further isolation of the ungrounded heater pin is required a suitable rf choke followed by another low inductance bypass capacitor, is recommended.

The *cathode* of the 6939 should be grounded by means of the shortest possible connection to reduce the effect of cathode lead inductance.

The *rf impedance between grid No.2 and the cathode* must be kept low, usually by means of a suitable bypass capacitor. In telephony service when grid No.2 is modulated, a smaller bypass capacitor than is used for telegraphy service may be required in order to avoid excessive af bypassing. However, if the capacitance value is too small, rf feedback may occur between plate and grid No 1, depending on the circuit layout, operating frequency, and power gain of the stage. AF bypassing difficulties can usually be eliminated if the grid-No.2 bypass capacitor is replaced by a series-resonant circuit which is tuned to resonate at the operating frequency. This circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.

To *prevent generation of parasitic oscillations*, it is recommended that a 100-ohm resistor be connected in series with grid No.2 as close to the socket as possible.

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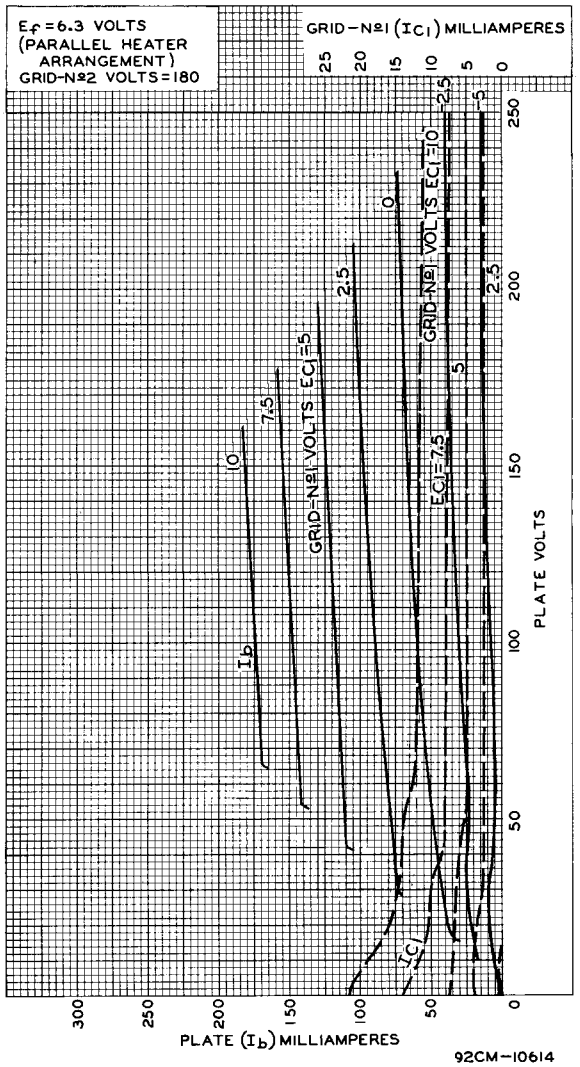


Fig. 1 - Average Characteristics for Each Pentode of Type 6939.

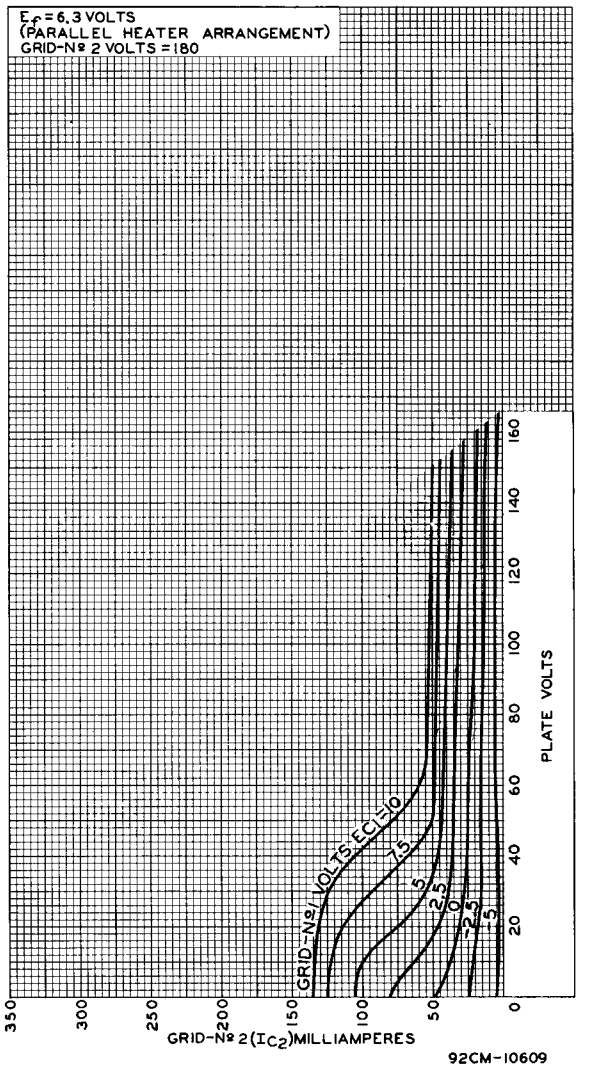


Fig. 2 - Average Grid-No. 2 Characteristics for Each Pentode of Type 6939.

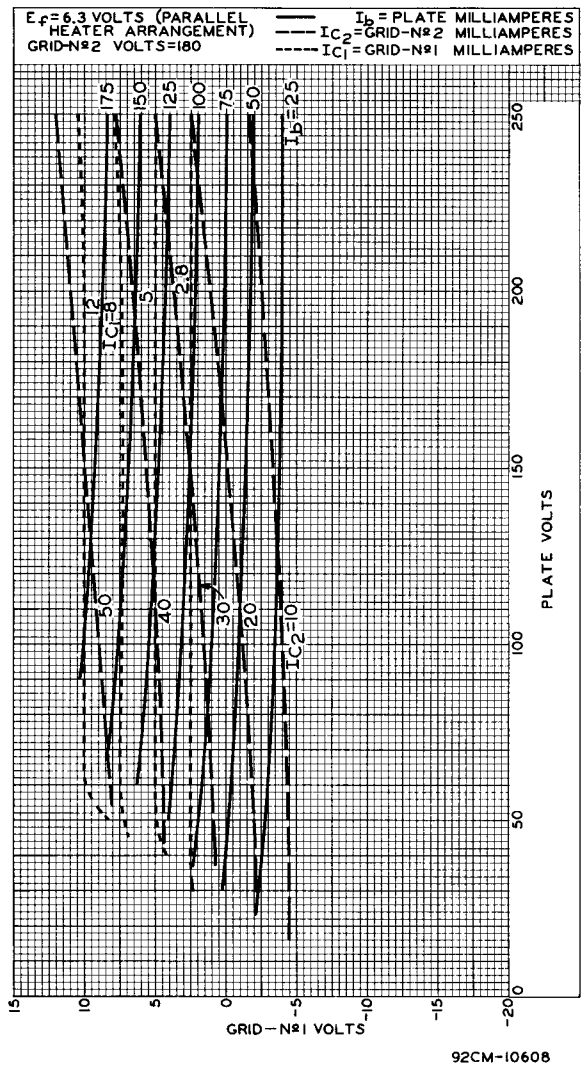


Fig. 3 - Average Constant-Current Characteristics for Each Pentode of Type 6939.

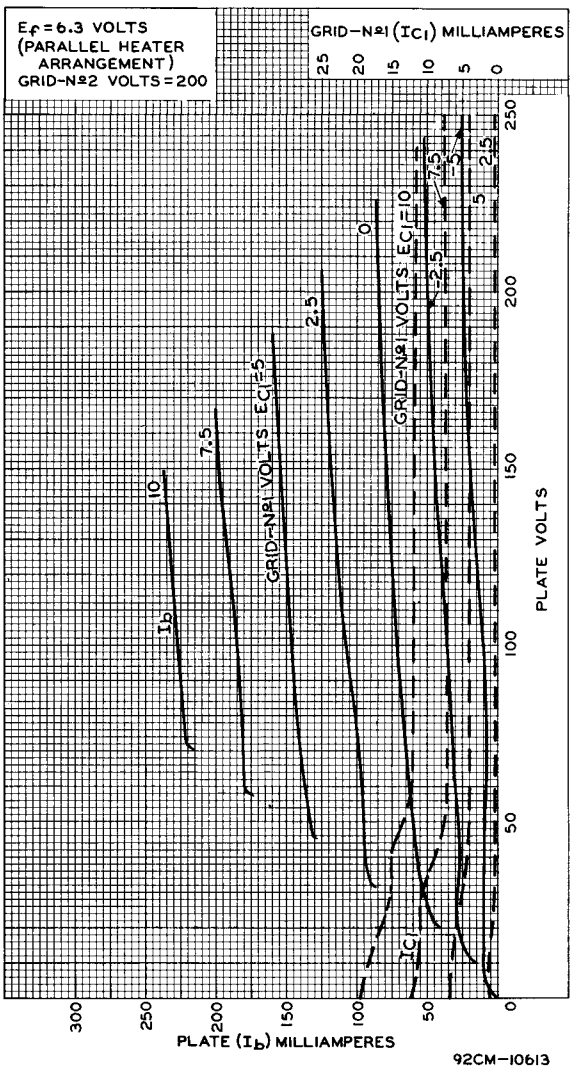


Fig. 4 - Average Characteristics for Each Pentode of Type 6939.

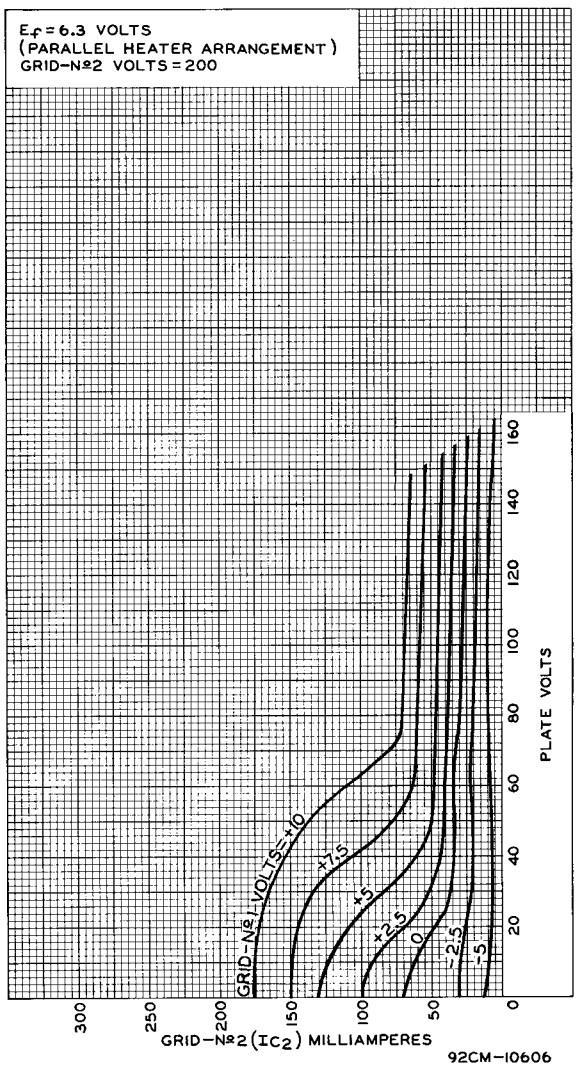


Fig. 5 – Average Grid-No. 2 Characteristics for Each Pentode of Type 6939.

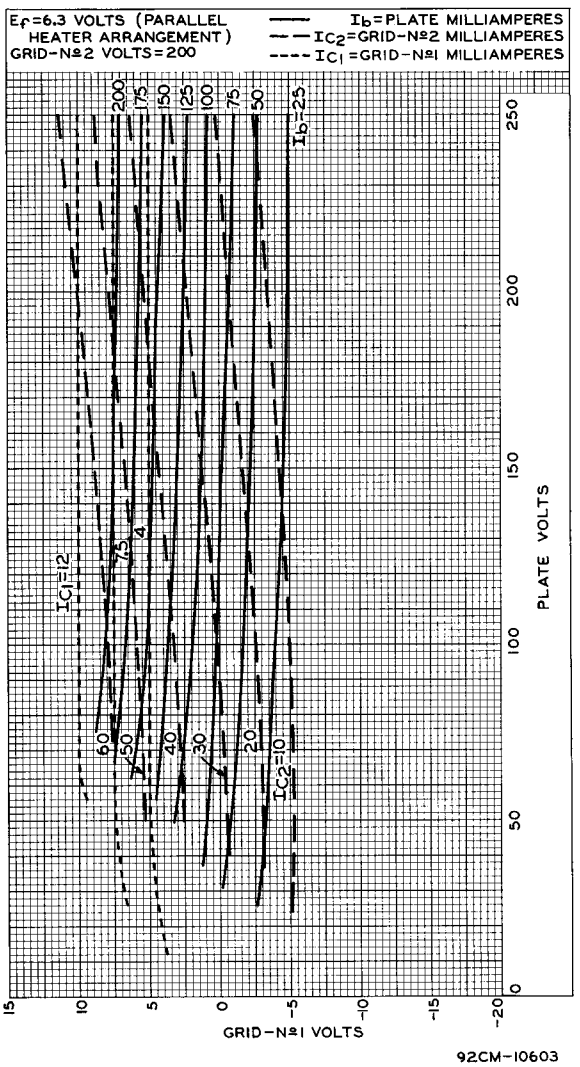
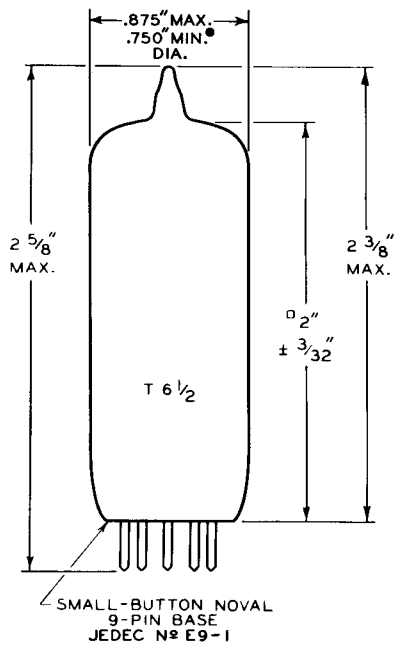


Fig. 6 – Average Constant-Current Characteristics for Each Pentode of Type 6939.

DIMENSIONAL OUTLINE

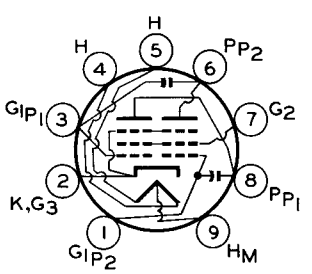


● APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

□ MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

BASING DIAGRAM
Bottom View

PIN 1: GRID NO.1 OF PENTODE No.2
PIN 2: CATHODE, GRID No.3
PIN 3: GRID NO.1 OF PENTODE No.1
PIN 4: HEATER



9HL

PIN 5: HEATER
PIN 6: PLATE OF PENTODE No.2
PIN 7: GRID NO.2
PIN 8: PLATE OF PENTODE No.1
PIN 9: HEATER MID-TAP

6950/2039*

SUPER-POWER SHIELDED-GRID BEAM TRIODE

Double-Ended Coaxial-Electrode Structure
Ceramic-Metal Seals

For Grid-Driven Plate-Pulsed RF Power Amplifier Service
1500 Kw Useful Peak Power Output at 200 Mc

Integral Water Ducts
37.24" Max. Length
20.50" Max. Diameter

RCA-6950 is a water-cooled, shielded-grid beam triode of unique design intended for use as a plate-pulsed rf power amplifier. It is especially suited for use in long-range search-radar and in particle-accelerator service. In such service, the 6950 can provide a useful peak power output of 1500 kilowatts at 200 Mc.

The 6950 can be operated with maximum ratings at frequencies up to 200 Mc and with reduced ratings to higher frequencies. The capabilities of the 6950 for operation at higher frequencies and at higher powers have not yet been completely determined, but requests for information on specific applications will be welcomed.

Design features of the 6950 include its double-ended configuration which makes possible an extended operating frequency range in comparison with that of an equivalent single-ended tube, as described in Reference 1; shielded-grid construction which permits separation of the rf input and rf output circuits and makes feasible grid-drive operation at very-high frequencies; rf electrode terminals insulated from each other by low-loss ceramic bushings which are extremely strong mechanically; large-area terminals with radial compression seals so that rf currents to the active portions of the tube flow exclusively on low-loss copper surfaces; internal ducts for water cooling the plate and beam-forming cylinder; hose couplings with simplified connections; a symmetrical array of unit electron-optical systems embodying a mechanical structure which permits close spacing and accurate alignment of the electrodes to a degree unusual in high-power tubes; and a multistrand thoriated-tungsten filament for economical operation, high emission capability, and long life.

The capabilities of the generic design of the 6950 for cw applications have not yet been completely determined, but a useful cw power output of about 500 kilowatts at 425 kc may be expected. Requests for information on a cw version of the 6950 are invited.

RCA-6950 is supplied in accordance with the RCA-6950 Acceptance Specification in effect at the time of purchase.

GENERAL DATA

Electrical:

Filament$^{\phi}$, Multistrand Thoriated Tungsten:

Voltage (Single-Phase AC or DC)$^{\phi\phi}$	7.3 min. 7.8 max.	volts volts
Current at 7.3 volts	1140	amp

* RCA Commercial Designation for Dev. Type A-2342.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

6950/2039 9-60
Printed in U.S.A.

from JEDEC release #2975, Sept. 26, 1960

Starting Current	Must never exceed 1700 amperes, even momentarily	
Cold Resistance	0.0007	ohm
Minimum time to reach normal operating voltage	30	seconds
Minimum heating time at normal operating filament voltage before plate voltage is applied	30	seconds
Amplification Factor, for dc grid voltage of -50 volts and dc plate voltage adjusted to give dc plate current of 10 amperes	57	
Direct Interelectrode Capacitances:		
Grid to plate	12	μμf
Grid to filament	1400	μμf
Plate to filament	160	μμf

Mechanical:

Operating Position	Vertical, with filament terminal down
Maximum Overall Length	37.24"
Maximum Diameter	20.50"
Terminal Connections	See *Dimensional Outline*

Air Cooling:

It is important that the temperature of any external part of the tube should not exceed 150° C. In general, forced-air cooling of the ceramic bushings will not be required unless the 6950 is used in cavity-type circuits or in a confined space without free circulation of air. Under such conditions, provision should be made for blowing an adequate quantity of air at the ceramic bushings to limit their temperature to 150° C. Forced-air cooling of the *upper* and *lower rf-output-return cathode terminals (K_U and K_L shown on Tube Symbol and Dimensional Outline)* may be necessary to prevent exceeding the maximum temperature rating of 150° C, particularly at vhf frequencies.

Water Cooling:

Water cooling of the beam-forming cylinder, each grid-terminal connector, and the plate is required. The water flow must start before application of any voltages and preferably should continue for several minutes after removal of all voltages. Interlocking of the water flow for each of the cooled elements with all power supplies is recommended to prevent tube damage in case of failure of adequate water flow. The use of high-quality water is essential (see text).

Water Flow:

	Absolute Min. Flow	*Typical Flow*	*Pressure Drop for Typical Flow*	*Max. Gauge Pressure*
	gpm	*gpm*	*psi*	*psi*
To plate (in direction shown on *Dimensional Outline*):				
For average plate dissipation of 150 kw	80	88	40	100
To beam-forming cylinder	7	8	12	50

Outlet Water Temperature (Any outlet)	70 max.	°C
Min. Plate-Water-Column Resistance at 25° C	1/2 megohm per kv of peak pulse plate voltage	
Ceramic-Bushing Temperature	150 max.	°C
Metal-Surface Temperature	100 max.	°C
Weight (Approx.)	204	lbs

Fittings:

Fittings for the plate and beam-forming-cylinder water connections may be obtained from suppliers indicated under *Dimensional Outline*.

PLATE-PULSED RF POWER AMPLIFIER

Maximum Ratings, *Absolute-Maximum Values for Altitudes up to 5000 feet:*

For a maximum "ON" time† of 2500 microseconds during any 40000-microsecond interval

PEAK POSITIVE-PULSE PLATE SUPPLY VOLTAGE$	40000 max.	volts
DC GRID VOLTAGE	-1000 max.	volts
PEAK PLATE CURRENT FROM PULSE SUPPLY	92 max.	amp
PEAK RECTIFIED GRID CURRENT	5 max.	amp
DC PLATE CURRENT	5.7 max.	amp
DC GRID CURRENT	0.3 max.	amp
PLATE INPUT (AVERAGE)	230000 max.	watts
PLATE DISSIPATION (AVERAGE)	150000 max.	watts

Typical Operation at 200 Mc with Rectangular-Waveshape Pulses:

With duty factor§ of 0.05

Peak Positive-Pulse Plate Supply Voltage	30000	volts
DC Grid Voltage	-250	volts
Peak RF Grid Voltage	2250	volts
Peak Plate Current from Pulse Supply	90	amp
Peak Rectified Grid Current	2	amp
DC Plate Current	4.5	amp
DC Grid Current	0.10	amp
Peak Driver Power Output (Approx.)	100000	watts
Useful Power Output at Peak of Pulse	1500000	watts

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Filament Current	1	1060	1220	amp
Amplification Factor	1,2	46	68	
Direct Interelectrode Capacitances:				
Grid to plate	-	-	'18	$\mu\mu$f
Grid to filament	-	1200	1680	$\mu\mu$f
Plate to filament	-	144	184	$\mu\mu$f

Note 1: With 7.3 volts ac on filament.

Note 2: For dc grid voltage of -50 volts and dc plate voltage adjusted to give dc plate current of 10 amperes.

ø Tube life can be conserved by operating the filament at the lowest power that will enable the tube to provide the desired power output. To determine filament power, it is necessary that both filament current and filament voltage be monitored. Meters should be adequately shielded from extraneous magnetic fields which may affect the reading. The maximum filament voltage specified in the tabulated data provides emission in excess of any requirements within tube ratings. Therefore, the filament power must be reduced to a value that will give adequate but not excessive emission for any particular application. It is recommended that the filament-voltage supply be continuously adjustable over the specified filament-voltage range. Good regulation of the filament power supply is economically advantageous from the viewpoint of tube life.

øø To avoid undue thermal stresses in the filament, it is recommended that the filament voltage be raised to operating value in not less than 30 seconds.

■ At tube inlets.

† *"ON" time* is defined as the sum of the durations of all the individual pulses which occur during a specified interval. *Pulse duration* is defined as the time interval between the two points on the pulse at which the instantaneous value is 70% of the peak value.

$ The magnitude of any spike on the plate-voltage pulse should not exceed its peak value by more than 4000 volts and the duration of any spike when measured at the peak-value level should not exceed 10% of the maximum "ON" time.

§ Duty factor is the product of pulse duration and repetition rate.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The *maximum ceramic-bushing temperature* of 150° C, the *maximum metal-surface temperature* of 100° C, the *maximum outlet-water temperature* of 70° C at any outlet, and the *maximum gauge pressures* for the water inlets are tube ratings and are to be observed in the same manner as other ratings. The temperature of the ceramic bushings and metal surfaces can conveniently be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y.

The *serial number* which identifies each individual 6950 and which should be used in any correspondence concerning the tube, is printed on the name plate as indicated on the *Dimensional Outline*. Other numbers stamped externally on the tube are for purposes of manufacturing records only.

In *transportation and handling* of the 6950, care should be taken to protect the tube from rough handling that would damage the bushings or other parts. *Never allow the tube to rest on the exhaust-tube cover* (see *Dimensional Outline)*. The safety cable on the 6950 is provided to protect personnel against possible injury while hoisting the tube into its operating position, or lifting the tube therefrom. After the tube has been seated in the equipment, remove the cable and lifting plate from the tube before operating it. Save the cable and lifting plate so that they can again be fitted on the tube when it is desired to remove the tube from the equipment. In fitting the cable to the tube, tighten the cable only enough to remove slack. Fastening the cable too tight may introduce stresses in the plate ceramic bushing with immediate or delayed damage to the bushing and/or seal.

The weight of the 6950 crated for shipment is approximately 375 pounds; uncrated, approximately 204 pounds.

It is recommended that the 6950 be tested upon receipt in the equipment in which it is to be used. For recommended *"break-in" treatment,* see page 9. Before the tube is placed in operation, remove any foreign material adhering to it.

During *storage,* the 6950 should be kept in its shipping container and should be protected from moisture and extreme temperature changes. Before a 6950 is placed in storage or shipped, it should be tipped so that the water can be poured out of its cooling ducts and then should be blown free of any remaining water. Removing all water prevents the possibility of voltaic action in the ducts with resultant corrosion and also avoids the possibility of water freezing in the ducts should the surrounding temperature drop below 0° C (32° F). Care should be taken to prevent any foreign matter from entering the water-cooling connections. As a safeguard, it is recommended that during storage each of the four water-cooling connections be covered with Pliofilm, or equivalent, and then sealed.

As in the case of all large power tubes, no 6950 should remain in storage for extended periods. It should be operated in rotation with other 6950's in order to keep it free from traces of gas which may be

liberated during prolonged storage. This procedure of rotating 6950's in service will insure that only good tubes are carried in stock.

Tube cleanliness is an important consideration. As with other high-voltage equipment, it is essential that external parts of the 6950 be kept free from accumulated dirt to minimize surface leakage and the possibility of arc-over. Make it a regular practice to wipe dirt from the external parts of the tube about twice a month or more frequently if necessary to keep the tube clean.

The *mounting* used for the 6950 should hold the tube vertically with the filament terminal down. The entire weight of the tube should be supported by the filament-terminal flange. Because of the low-voltage, high-current filament, it is recommended that the socket be an integral part of the filament transformer so that the filament connectors can be kept short and the voltage drop in them minimized. The use of coaxial filament connectors is recommended to minimize the effect of magnetic fields.

Provision should be made to prevent subjecting the 6950 to appreciable vibration.

The *connector for the cylindrical terminal of the filament* should be of the spring-pressure-contact type, while the *connector for the flange terminal of the filament* may be of the clamp type. The filament connectors should make firm, large-surface contact.

Connection to the upper and lower rf-output-return cathode terminals should be made by a band-type clamp or system of fingers.

Connection to the upper rf-input-return cathode terminal (outer) and to the lower rf-input-return cathode terminal (flange) will depend on the type of cavity employed.

Connection to the cylindrical lower rf-input-return cathode terminal should be made by a band-type clamp or a system of fingers. When a clamp is used, care must be taken in tightening the clamp not to exert too much stress which might deform the copper cylinder.

Connection to the upper and the lower grid terminal should be made by suitable water-cooled connector in intimate thermal contact with the grid-terminal surface. When the connector is fastened to the surface, *screws should be inserted carefully in the tapped holes in the copper grid terminal to avoid stripping the copper threads.*

Connection to the upper and the lower rf plate terminal should be made by a band-type clamp or a system of fingers.

The *terminal connections* should be designed so that they place no undue stress on the ceramic-metal seals. When power is applied to the tube, there may be a small movement of various parts of the tube and associated circuitry due to thermal expansion. It is necessary, therefore, that the connecting leads to the terminals be flexible. The connecting leads and water hoses should be installed so that the slack does not come close to or touch the body of the tube.

When connecting or disconnecting the water hoses and the electrical connections, it is essential that no undue stress be placed on the seals. The direction of water flow as indicated on the plate water connections, and on the beam-forming-cylinder water connections must be followed.

The *water-cooling system* consists, in general, of a source of cooling water; a feed-pipe system which carries water through flexible hoses to

the beam-forming cylinder, the plate, and water-cooled connectors, as required; and provision for interlocking the water flow through each of these cooled elements with the power supplies. When the plate is at high potential above ground, the feed-pipe system should have good insulating qualities and proper design to reduce leakage current to a negligible value.

It is recommended that the water-cooling system be of the closed type utilizing distilled water. When pure distilled water is introduced into the system, it becomes contaminated by the system components. For example, in a copper-plumbing system, the presence of oxygen and carbon dioxide enhances the dissolution of copper into the system water and its subsequent deposition as copper oxide on the hot plate structure of the tube. The rate of formation of this oxide is dependent on the operating plate dissipation of the tube and the amount of copper, oxygen, and carbon dioxide in the water system. Eventually the amount of precipitated oxide may reach a magnitude such that it will thermally insulate the plate from the water and cause the plate to crack because of insufficient cooling.

It is recommended (1) that high-quality water be used to fill the system initially, (2) that provision be made for continuous regeneration (purification) of the system water, and (3) that steps be taken to eliminate insofar as possible the sources of contamination. These recommendations will prevent scale formation, corrosion, and excessive electrolysis, and thereby permit obtaining longer tube life.

A suggested method of achieving high quality of the system water is as follows:

1. Use only distilled water to fill the system. The use of distilled water avoids the introduction of organic or colloidal matter that may exist in de-ionized water.

2. To maintain high quality, continuous regeneration (purification) of the water in the system is necessary. This regeneration can be achieved by passing a portion of the flow through suitable ion exchangers and filters. A recommended regeneration loop is shown in Fig.1. Operation of the regeneration loop should be in accord with the recommendations of the manufacturer of each component with regard to pressure, temperature, and maintenance of the individual components.

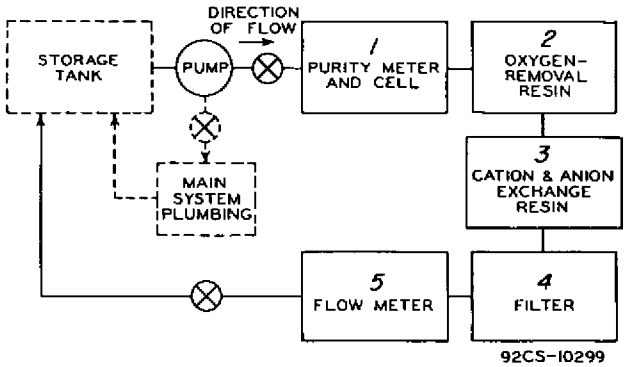
3. The efficiency and life of the regeneration loop may be improved by retarding the rate of recontamination of the water by foreign matter. Pipe lines should be connected to the water tank below the water level to minimize turbulence and thus to decrease absorption of gases by the water. It is also to be noted that any contaminating gases should be excluded from the storage tank in the closed water system.

4. In order to minimize electrolysis, the plate water-column (water path between plate and ground) resistance should have a value not less than that specified in the tabulated data.

Although an accurate chemical analysis is the absolute method of checking system-water quality, a measurement of the water resistivity may be used as a guide to determine whether or not ionized contaminants are excessive. Dissolved gases, metals, and other contaminants reduce the resistivity of the water in varying amounts. Some contaminants, such as oxygen, have no direct effect while others, such as carbon dioxide, greatly reduce the resistivity. However, if the specific resistivity of the water at 25° C falls below 1 megohm-cm, it can be assumed that the

contaminants are high. Also, if the pH of the water is outside of the range from 6.8 to 7.2, the water contains contaminants.

Proper functioning of the water-cooling system is of the utmost importance. Even a momentary failure of the water flow will damage the 6950. In fact, without cooling water, the heat of the filament alone is sufficient to destroy the tube. It is, therefore, necessary to provide a method of preventing operation of the tube in case the water supply should fail. This may be done by the use of water-flow circuit breakers or interlocks which open the power supplies when the the flow through any element is insufficient or ceases. It is essential to keep the water-flow interlocks in proper adjustment as prescribed by the equipment manufacturer. They should never be set to operate below the recommended level. The water flow must start before application of any voltages and normally should continue for several minutes after removal of all voltages. The absolute minimum water flow required through the plate for an average plate dissipation of 150 kw, and through the beam-forming cylinder, together with pressure drops is given in the tabulated data. Under no circumstances should the temperature of the water from any outlet exceed 70° C.



Block No.

1. Resistivity cell (0.01 cell constant) and meter, such as Barnstead PM-18 meter with B-18 cell. This cell and meter are optional test equipment.
2. Oxygen-removal resin, such as Barnstead No.0810 cartridge, in BD-2 Bantam Demineralizer.
3. Mixed bed demineralizer, such as Barnstead Type M Bantam Demineralizer.
4. Sub-micron filter, such as Barnstead MF-25.
5. Flow meter.

The above items may be purchased from the Barnstead Still & Sterilizer Co., 2 Lanesville Terrace, Boston 31, Mass.

Fig. 1 - Block Diagram of a Water-Regeneration Loop.

When the tube is used in equipment under conditions such that the ambient temperature is below 0° C (32° F), precaution should be taken to prevent freezing of the water in the tube ducts after the power has been turned off.

An approximate value of the plate dissipation which should not exceed the value shown under *Maximum Ratings* in the tabulated data, may be calculated from the following equation:

$$P_{watts} = n\ (t_o - t_i) \times 264$$

in which t_i is the temperature of the cooling water at the inlet to plate in degrees Centigrade, t_o is the temperature of the water at the outlet from plate in degrees Centigrade, and n is the number of gallons per minute of flow.

A *time-delay relay* should be provided in the plate-supply circuit to delay application of plate voltage until the filament has reached normal operating temperature.

A *high-speed, electronic protective device* must be used to remove the plate voltage within a few microseconds in the event of abnormal operation such as internal arcing. The protective device employed to remove

the plate voltage in any installation must be approved by the RCA Electron Tube Division. In addition, the grid circuit should be provided with overload relays which will act to remove within a period of 0.1 second all grid power in the event of excessive grid-current flow. Inquiries concerning a high-speed, electronic protective device for removal of plate voltage from the 6950 may be addressed to Commercial Engineering, RCA, Harrison, N.J.

The *rated plate voltage of this tube is extremely dangerous.* Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

The *thoriated-tungsten filament* in the 6950 is of the multistrand type and is designed for dc or single-phase ac operation. Each individual strand is recessed in a slot in a beam-forming cylinder through which water is circulated. If the filament terminals of the tube become discolored, they should be cleaned with fine emery cloth and then wiped clean.

The filament of the 6950 must be allowed to reach normal operating temperature before plate voltage is applied. A suitable voltmeter should be permanently connected across the filament terminals directly at the tube so that the filament voltage will always be known.

For applications extremely critical as to hum, it is recommended that dc filament excitation be used.

A *filament starter* should be used to raise the filament voltage gradually (in not less than 30 seconds) in order to limit the high initial surge of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance or reactance out of the circuit, a high-reactance filament transformer, or an adjustable autotransformer. Regardless of the method of control, it is important that the filament current never exceed, even momentarily, a value of 1700 amperes.

The filament requires a *minimum heating time* of 30 seconds at normal operating voltage before plate voltage is applied to the 6950.

The *life of the filament can be conserved by* operating it at the lowest voltage, within its rated operating range (see General Data), which will enable the 6950 to give the desired power output. Because the filament when operated near the maximum value of 7.8 volts provides emission in excess of any requirements within tube ratings, it is recommended that the filament voltage be reduced to a value (not less that 7.3 volts) that will give adequate but not excessive emission for any particular application. Good regulation of the filament voltage is in general economically advantageous from the viewpoint of tube life.

Overheating of the 6950 by severe overload may decrease the filament emission. The filament activity can sometimes be restored by operating the filament at 7.5 volts for 30 minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 7.8 volts (not higher) for a few minutes. During this reactivation process, it is essential that normal water flow to the tube be maintained.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube and associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the cooling water or the ceramic bushings, the plate voltage may be raised in steps to the desired value. Adjustments should be made at each step for optimum operation.

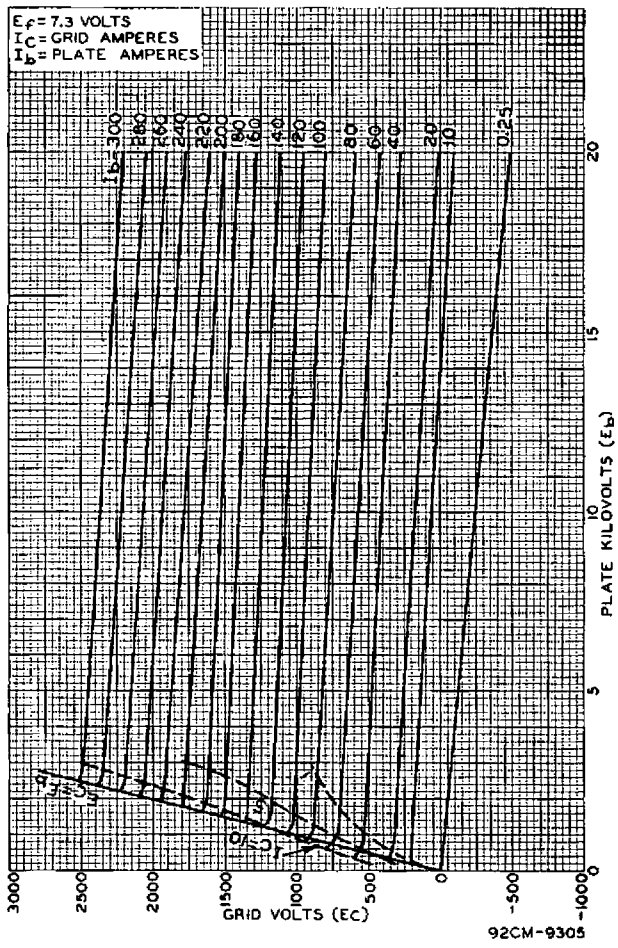


Fig. 2 - Typical Constant-Current Characteristics of Type 6950.

At the higher frequencies, uneven heating of the seals may be encountered because of circuit arrangement. Such effects should be minimized through proper circuit design.

The following *"break-in"* treatment should be given to a new 6950 before it is placed in service or set aside as a spare, or to a 6950 after it has been in prolonged storage.

Step 1: Make sure that the water-cooling system and protective devices are functioning properly.

Step 2: With no other voltages on tube, apply voltage to the filament in the normal manner and operate at 7.3 volts for 15 minutes.

Step 3: Apply normal grid bias and grid drive.

Step 4: Apply approximately 50 per cent of normal plate voltage and operate the tube for several minutes until stable performance is obtained.

Caution: During this step and step 5, it is particularly important that the high-speed electronic protective device be functioning properly to protect against any abnormal condition.

Step 5: Raise the plate voltage in steps if possible until the desired operating condition is achieved.

After giving the 6950 the above treatment and after it is operating normally to give the desired output, it is suggested that the readings of the meters and flow indicators as well as the control settings be logged, especially when the tube is to be set aside as a spare. Then, in the event of an emergency tube change, the tube can be put in service quickly.

REFERENCES

1. M. V. Hoover, *"Advances in the Techniques and Applications of Very-High-Power Grid-Controlled Tubes"*, Proceedings of International Convention on Microwave Valves, May, 1958, Proceedings Institution of Electrical Engineers (London), Vol. 105, Part B Suppl. No.10, 1958.
2. W. N. Parker and M. V. Hoover, *"Gas Tubes Protect High Power Transmitters"*, Electronics, January, 1956.

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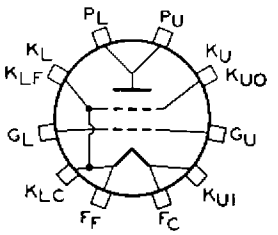
TUBE SYMBOL



F_C : FILAMENT TERMINAL (CYLINDER)
Do Not Use for Circuit Returns

F_F : FILAMENT TERMINAL (FLANGE)
Do Not Use for Circuit Returns

G_L : LOWER GRID TERMINAL

G_U : UPPER GRID TERMINAL

K_{LC}: LOWER RF-INPUT-RETURN CATHODE TERMINAL (CYLINDER)
For Input-Circuit Return

K_{LF}: LOWER RF-INPUT-RETURN CATHODE TERMINAL (FLANGE)
For Input-Circuit Return

K_{UI}: UPPER RF-INPUT-RETURN CATHODE TERMINAL (INNER)
For Input-Circuit Return

K_{UO}: UPPER RF-INPUT-RETURN CATHODE TERMINAL (OUTER)
For Input-Circuit Return

K_L : LOWER RF-OUTPUT-RETURN CATHODE TERMINAL
For Output-Circuit Return

K_U : UPPER RF-OUTPUT-RETURN CATHODE TERMINAL
For Output-Circuit Return

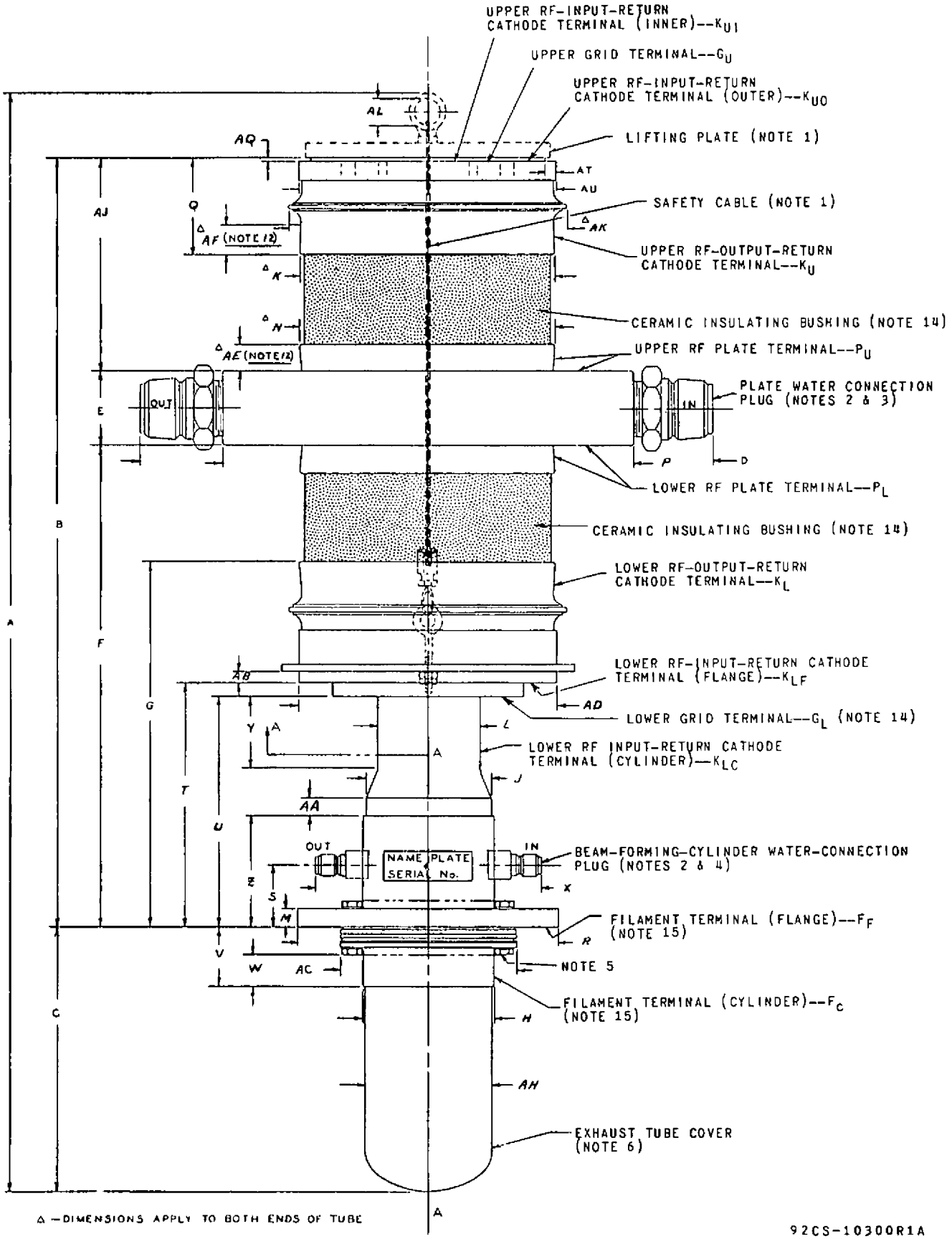
P_L : LOWER RF PLATE TERMINAL

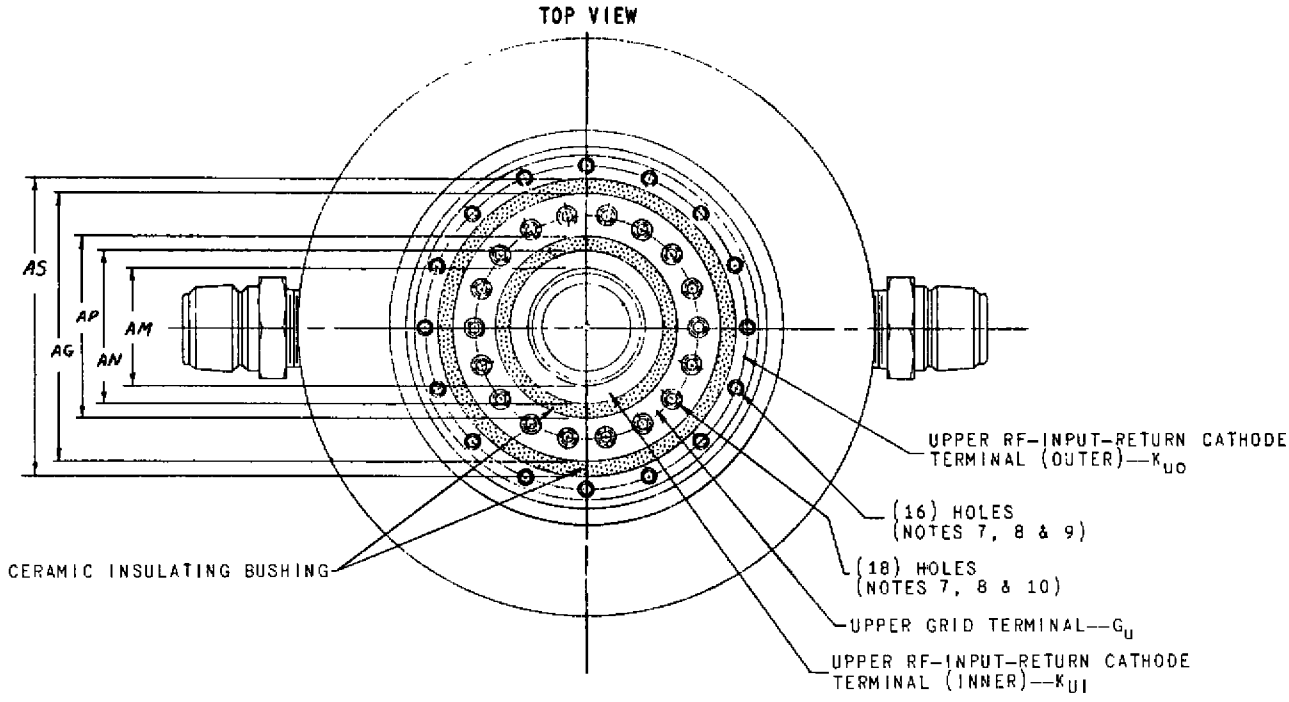
P_U : UPPER RF PLATE TERMINAL

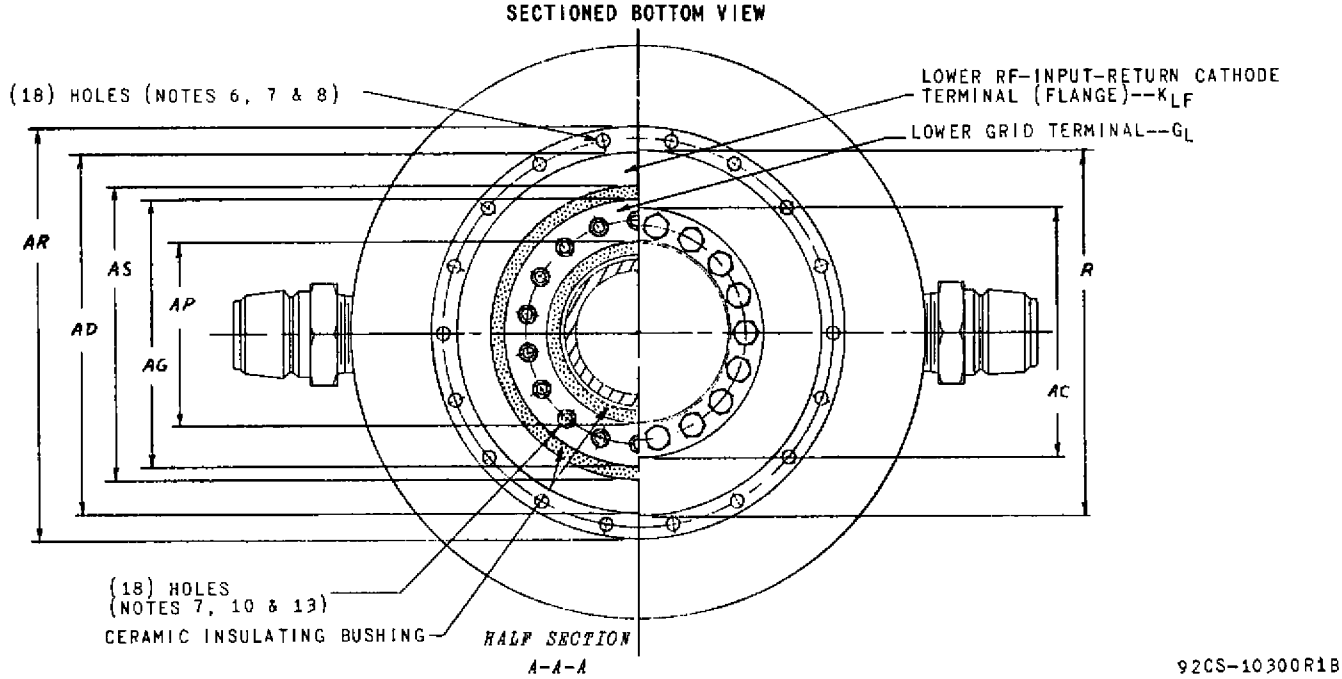
CAUTION: DO NOT MAKE ANY DC CONNECTION BETWEEN K_{UO} AND K_{UI}. SUCH A CONNECTION WILL SHORT THE FILAMENT SUPPLY.

For location of respective terminals, see Dimensional Outline

DIMENSIONAL OUTLINE







92CS-10300R1B

TABULATED DIMENSIONS FOR DIMENSIONAL OUTLINE
(All Dimensions in inches)

Dimension	Value	Dimension	Value
A	37.24 max.	AA	0.38 min.
B	25.34 ± 0.24	AB	0.38 ± 0.04
C	9.24 max.	AC	6.12 max. dia.
D	20.50 max.	AD	8.82 ± 0.06 dia.
E	2.50 ± 0.04	AE	0.88 min. (Note 12)
F	15.66 ± 0.08	AF	1 min. (Note 12)
G	11.68 ± 0.20	AG	6.56 ± 0.06 dia.
H	4.47 ± 0.03 dia.	AH	4.4 max.
J	$4.34^{+0.04}_{-0.06}$ dia.	AJ	7.18 ± 0.12
K	8.62 ± 0.10 dia.	AK	9.6 max. dia.
L	3.50 ± 0.05 dia.	AL	0.8 min.
M	0.56 ± 0.06	AM	2.82 ± 0.06 dia.
N	8.62 ± 0.10 dia.	AN	3.68 ± 0.06 dia.
P	14.12 max. dia.	AP	4.40 ± 0.10 dia.
Q	3.24 ± 0.08	AQ	0.10 ± 0.04
R	8.84 ± 0.06 dia.	AR	10.06 max. dia.
S	2.06 ± 0.12	AS	7.16 ± 0.06 dia.
T	8.38 ± 0.12	AT	0.22 min.
U	7.88 ± 0.12	AU	8.82 ± 0.06
V	1.94 ± 0.12		
W	0.8 min.		
X	8.4 max.		
Y	2 min.		
Z	3.70 ± 0.08		

NOTES FOR DIMENSIONAL OUTLINE

Note 1: Remove the lifting plate and safety cable before operating tube. Keep them for future tube handling.

Note 2: Inlet water connections (IN) are both on same side of tube and to the right when tube is viewed with name plate toward observer.

Note 3: This plug is removable and is Hansen No.12T45, 1-1/2". Hansen socket No.12-S46, 1-1/2" (with female pipe thread connection) fits this plug. For manufacturers's address, see Note 4.

Note 4: This plug is not removable and is Breco No.E4M4, 1/2". Any one of the following sockets fits this plug:
(a) Breco No.4EF4, 1/2" (with female pipe thread connection)
(b) Breco No.4EM4, 1/2" (with male pipe thread connection)
(c) Hansen No.4-S25, 1/2" (with male pipe thread connection)
(d) Hansen No.4-S26, 1/2" (with female pipe thread connection)
(e) Hansen No.4-S27, 1/2" (with hose stem)

Breco sockets are made by Breco Division, Perfecting Service Co., 332 Atando Ave., Charlotte 6, N.C.

Hansen sockets are made by Hansen Manufacturing Co., 4031 West 150th Street, Cleveland, Ohio.

Note 5: Do not tamper with these bolts.

Note 6: Do not use for supporting weight of tube. Do not remove. Make no connection.

Note 7: Holes on different bolt circles are not indexed with respect to any other point.

Note 8: The planes of the upper rf-input-return cathode terminals (inner and outer) and the upper grid terminal and parallel within 0.060" and coincident within 0.090". Runout between the bolt circles of the upper terminals will be within 0.12".

Note 9: Sixteen (16) holes, tapped 1/4-28 NF-1B 0.31" minimum depth, equally spaced within 0.025" on a bolt-circle diameter of 7.857" ± 0.100".

Note 10: Eighteen (18) holes, tapped 1/4-28 NF-1B 0.38" minimum depth, equally spaced within 0.025" on a bolt-circle diameter of 5.450" ± 0.025".

Note 11: Eighteen (18) holes equally spaced within 0.025" on a bolt-circle diameter of 9.50" ± 0.03" for 1/4"-diameter bolts.

Note 12: This area is subjected to a maximum taper of 0.060" to the inch. The maximum diameter along this taper will be on the end toward the ceramic.

Note 13: Runout between bolt circles of the lower terminals will be within 0.12".

Note 14: A potting compound (silicon rubber, or equivalent) has been applied in the space formed at the junction of each of the following metal terminals and its associated ceramic bushing:

A. the upper rf-output-return cathode terminal
B. the upper rf plate terminal
C. the lower rf-output-return cathode terminal
D. the lower rf plate terminal
E. the rf-input-return cathode terminal flange
F. the lower grid terminal
G. the lower rf-input-return cathode terminal -- cylinder
H. the lower grid terminal

Note 15: Use for filament power only. Input-circuit returns should be made to the rf-input-return cathode terminals. Output-circuit returns should be made to the rf-output-return cathode terminals.

7029

MULTIPLIER PHOTOTUBE

Semitransparent Cathode On Reflective Substrate | **10-Stage, Dormer-Window Type S-17 Response** | **3.75" Max. Length 1.56" Max. Diameter**

TENTATIVE DATA

RCA-7029 is a sturdy, dormer-window type of multiplier phototube intended for use in the detection of low-level light signals in the presence of relatively high background illumination. It is, therefore, especially suited for low-contrast applications.

Outstanding features of the 7029 are its median cathode sensitivity of 125 microamperes per lumen and its stabilized sensitivity. Other distinguishing features include a dormer window through which light is directed onto a semitransparent photocathode located on the inner spherical surface at the end of the bulb; and 10 electrostatically focused multiplying (dynode) stages having stabilized secondary-emission characteristics.

The spectral response of the 7029 covers the range from about 2900 to 6200 angstroms as shown in Fig. 1. Maximum response occurs at approximately 4900 angstroms.

The 7029 is capable of very short time-resolution. For an input pulse having a duration of 1 millimicrosecond or less, the time spread of the pulse at the anode is less than 5 millimicroseconds measured at 50 per cent of the maximum pulse height.

DATA

General:

Spectral Response	S-17	
Wavelength of Maximum Response	4900 ± 500	angstroms
Cathode, Semitransparent on Reflective Substrate:		
Shape	Rectangular on concave spherical surface	
Minimum projected length on plane of window	0.65	in.
Minimum projected width on plane of window	0.5	in.
Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.10	4	μμf
Anode to all other electrodes	7	μμf
Maximum Overall Length	3.75"	
Maximum Seated Length	3.25"	
Length From Base Seat to Center of Window Area	2.69" ± 0.19"	
Diameter	1.50" ± 0.06"	
Bulb	T-12 With Special End Contour	
Base	Ultrashort Small-Shell Duodecal 12-Pin (JETEC No.B12-186), Non-hygroscopic	
Socket	E8y No.160, or equivalent	
Operating Position	Any	

Maximum Ratings, *Absolute Values:*

For Altitudes up to 60,000 Feet

ANODE-SUPPLY VOLTAGE (DC or Peak AC)	1250 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.10 AND ANODE (DC or Peak AC)	250 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC or Peak AC)	300 max.	volts
AVERAGE ANODE CURRENT●	20 max.	μa
AMBIENT TEMPERATURE RANGE	-50 to +75	°C

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across voltage divider providing 1/11 of E per stage.

With E = 1000 volts (except as noted)

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4900 angstroms	–	27200	–	μa/μw
Cathode Radiant, at 4900 angstroms	–	0.085	–	μa/μw
Luminous◆	10	40	300	amp/lumen
Cathode Luminous:				
With tungsten light source▲	100	125	–	μa/lumen
With blue light source (See Fig.2)⊕	0.006	–	–	μa
Current Amplification	–	320000	–	
Equivalent Anode-Dark Current Input⊞□	–	4×10^{-10}	–	lumen
Equivalent Noise Input★	–	1.1×10^{-11}	–	lumen

● Averaged over any interval of 30 seconds maximum.

◆ For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K. A light input of 1 microlumen is used. The load resistor has a value of 0.01 megohm.

▲ For conditions the same as shown under (◆) except that the value of light flux is 0.001 lumen and 100 volts are applied between cathode and all other electrodes connected together as anode.

⊕ Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux on the filter is 0.001 lumen. The load resistor has a value of

TMK ®, Marca Registrada
Printed in U.S.A

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

0.01 megohm, and 100 volts are applied between cathode and all other electrodes connected together as anode.

⌖ Measured at a tube temperature of 25° C and with the supply voltage (E) adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

□ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1000 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 1000 volts, 25° C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at color temperature of 2870° K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

SPECIAL PERFORMANCE DATA

4-Hour Stability Life Performance:

This test is performed on each 7029. Before this test is made, the tube is kept in total darkness for 24 hours. Under conditions with supply voltage E of 1000 volts, tube temperature of 25° C, and light flux adjusted to give an anode current of 10 microamperes within 1 minute after turning on light source, the tube is operated for 4 hours. At the end of this period the anode current will not increase by more than 1 microampere nor decrease by more than 1.5 microamperes.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Cathode Luminous Sensitivity. The quotient of current leaving the photocathode by the incident luminous flux.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

GENERAL CONSIDERATIONS

The 7029 is a phototube incorporating an electron multiplier. An electron multiplier utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 7029 multiplier phototube, represented in Fig.3, the electrons emitted from the illuminated cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed-electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.10) are collected by the anode and constitute the current utilized in the output circuit.

Dynode No.10 is so shaped as to enclose partially the anode and to serve as a shield for it in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grating which allows the electrons from dynode No.9 to pass through it to dynode No.10. Spacing between dynode No.10 and

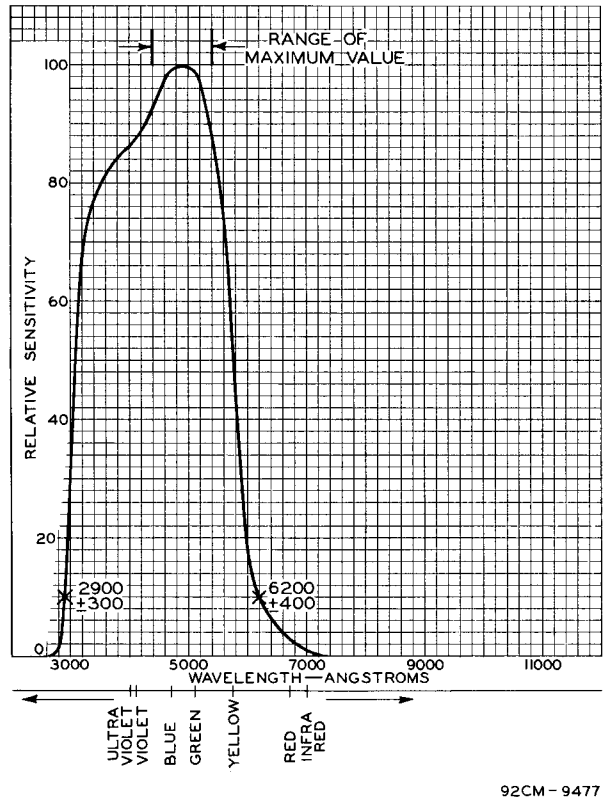


Fig. 1 - Tentative Spectral Sensitivity Characteristic of Type 7029 which has S-17 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

anode creates a collecting field such that all the electrons emitted by dynode No.10 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 7029 can be coupled to any practical load impedance. The metallic coating on the inner side wall of the glass bulb is connected to the cathode, and serves to direct the electrons from the cathode toward dynode No.1.

The grill through which the electrons reach dynode No.1, is connected to dynode No.1 and serves along with the accelerating electrode as an electrostatic shield for the open side of the electrode structure.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 7029 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute

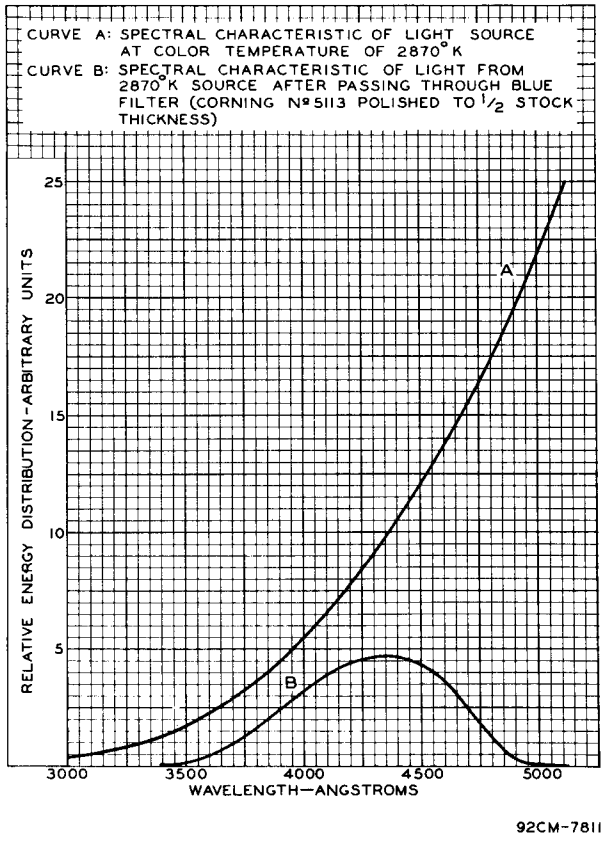


Fig. 2 - Spectral Characteristic of 2870° K Light Source, and Spectral Characteristic of Light from 2870° K Source after Passing through Indicated Filter.

values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself. Care should be taken not to exceed the maximum ambient temperature of 75° C

The *base pins* of the 7029 fit the duodecal 12-contact socket. The socket should be made of high-grade, low-leakage material, and should be installed so that the incident light falls on the dormer window of the tube. It is to be noted that the basing arrangement is such that the voltage between anode pin and adjacent pins is not more than twice the voltage per stage. As a result, external leakage between anode pin and adjacent pins is kept low.

In general, the *operating voltages* for the 7029 are as follows. The cathode-to-dynode-No. 1 potential is about the same as that applied between the successive dynodes. The steps for the successive stages are generally chosen as 75 to 125 volts. The voltage between dynode No. 10 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristic curves, shown in Fig. 4, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. Low operating voltage between dynode No. 10 and anode reduces the dark current. To obtain the indicated operating voltage between dynode No. 10 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

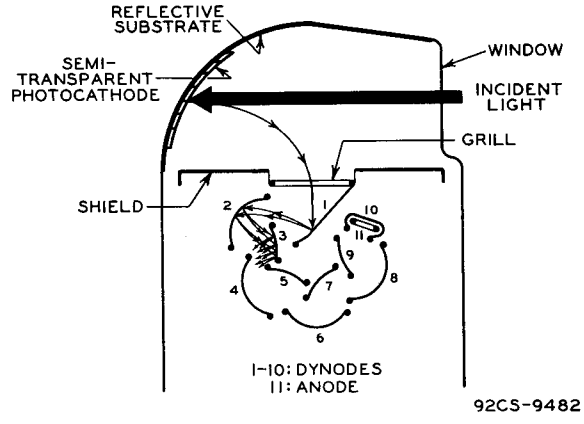


Fig. 3 - Schematic Arrangement of Type 7029.

In applications where it is desired to keep the statistical fluctuations to a minimum, the potential between cathode and dynode No. 1 may be increased to the rated maximum value of 300 volts.

A very small *dark current* is observed when voltage is applied to the electrodes of the 7029 in complete darkness. This current has a component caused by leakage, and a component consisting of pulses produced by electrons thermionically released from the cathode, by secondary electrons released by ionic bombardment of the dynodes or cathode, or by cold emission from the electrodes. The magnitude of the dark current establishes a limit below which the exciting radiation on the cathode can not be detected.

When the application utilizes *continuous luminous excitation and dc anode current* and it is desired to have a high ratio of signal output to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig. 5 which shows the equivalent anode-dark-current input as a function of luminous sensitivity for the 7029, and the curves in Fig. 6 which show luminous sensitivity as a function of the supply voltage.

In applications involving *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 750 to 1000 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise power spectrum is essentially flat up to about 50 megacycles per second. At voltages above 1000 volts, regenerative phenomena usually contribute to the noise.

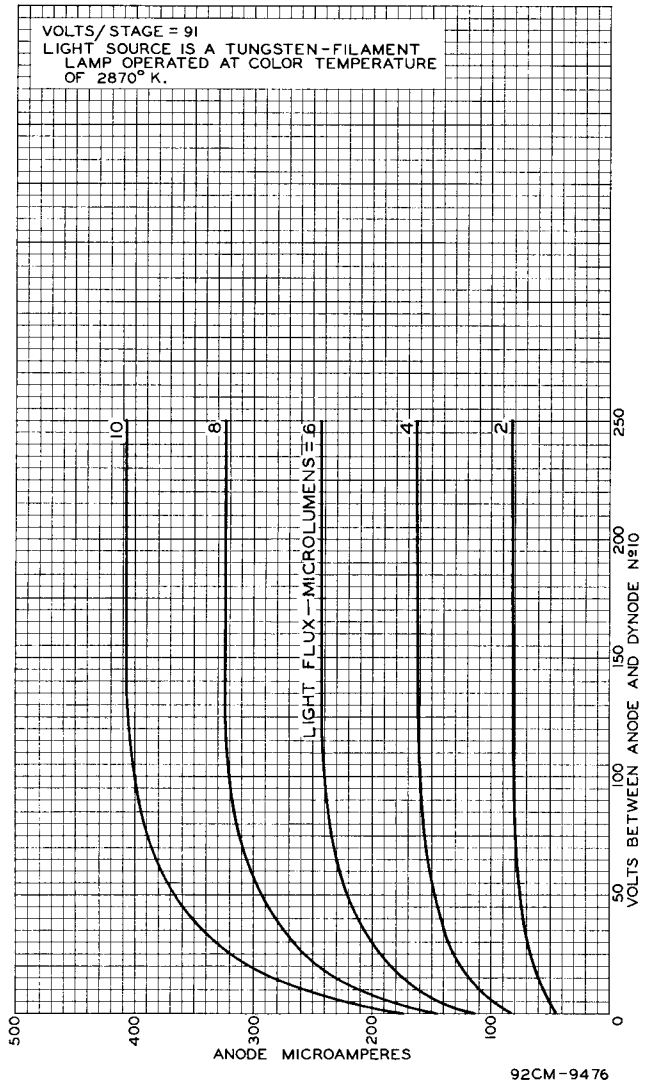


Fig. 4 - Average Anode Characteristics of Type 7029.

The noise spectrum of the 7029 is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of the exciting signal in order to eliminate as much noise as possible.

In either dc or ac applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice, to cool the bulb of the 7029 is recommended. The refrigerant reduces the thermionic emission, and thereby lowers the detection threshold to give improved operation.

Exposing the 7029 to strong ultraviolet radiation may cause an increase in dark current. After cessation of such irradiation, the dark current drops rapidly.

The *operating stability* of the 7029 is dependent on the magnitude of the anode current and its duration. When the 7029 is operated at high values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 7029 usually recovers a substantial percentage of such loss in sensitivity.

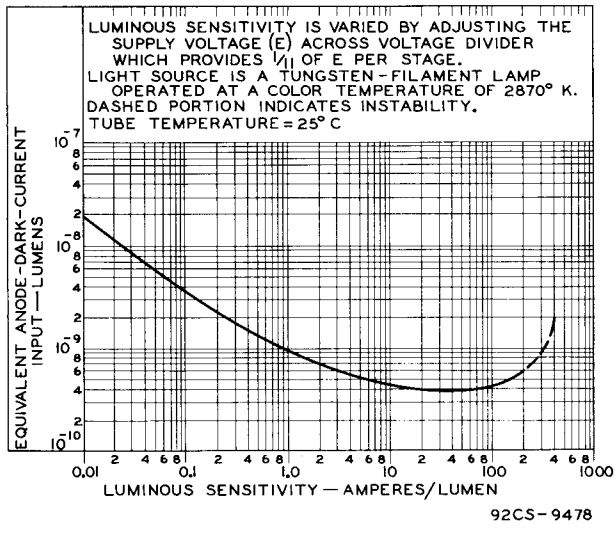


Fig. 5 - Typical Anode-Dark-Current Characteristic of Type 7029.

The use of an average anode current well below the maximum rated value of 20 microamperes is recommended when stability of operation is important. When greater stability is required, the anode current should not exceed 10 microamperes.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the *n*th power, where *n* is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for designers to provide adequate adjustment of the supply voltage per stage so as to be able to adjust the amplification of indi-

vidual tubes to the desired design value. The voltage-adjustment range required to take care of variations between individual tubes may be determined from Fig.6. For example, if a sensitivity of 10 amperes per lumen is desired, it will be observed that this value on the "minimum" sensitivity curve corresponds to a supply voltage of 1000 volts, and on the "maximum" sensitivity curve to a supply voltage of about 700 volts. Therefore, provision should be made to adjust the supply voltage over the range from 700 to 1000 volts.

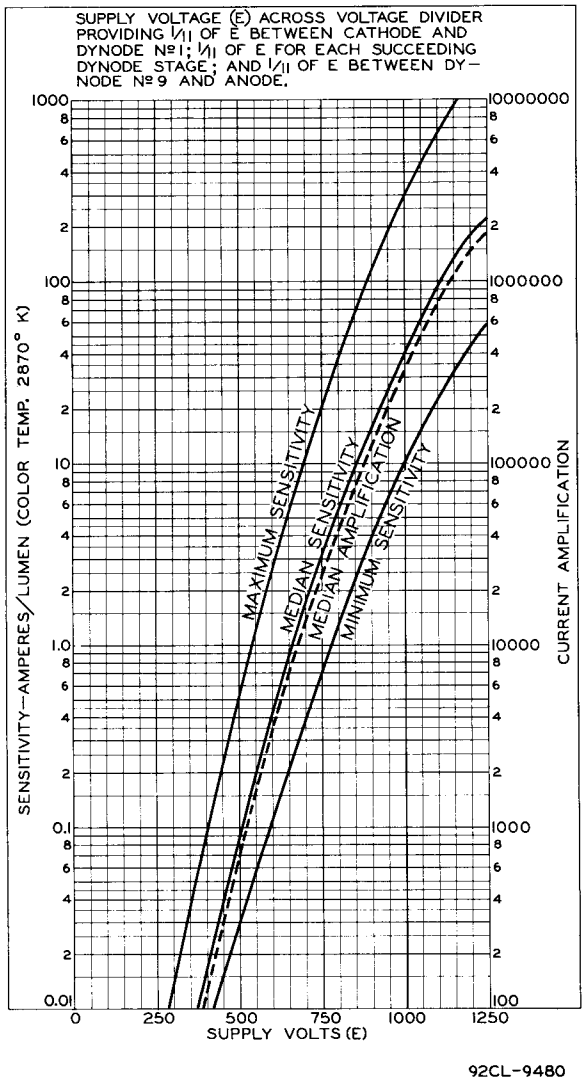


Fig. 6 - Characteristics of Type 7029.

Electrostatic and/or magnetic shielding of the 7029 may be necessary. The metallic coating on the inner wall of the glass bulb acts as an electrostatic shield to prevent the coated portion of the bulb wall from charging to a positive potential. However, the uncoated area of the bulb wall tends to charge to a potential near that of the anode, especially when the 7029 is operated at voltages near the maximum, with the result that an internal discharge phenomenon may occur and cause an increase in noise. To prevent this possibility, it is suggested that a shield be closely fitted over the uncoated area and be connected as a safety precaution (see below) through a high impedance in the order of 10 megohms to a potential near that of the cathode. The shield may consist of a conductive

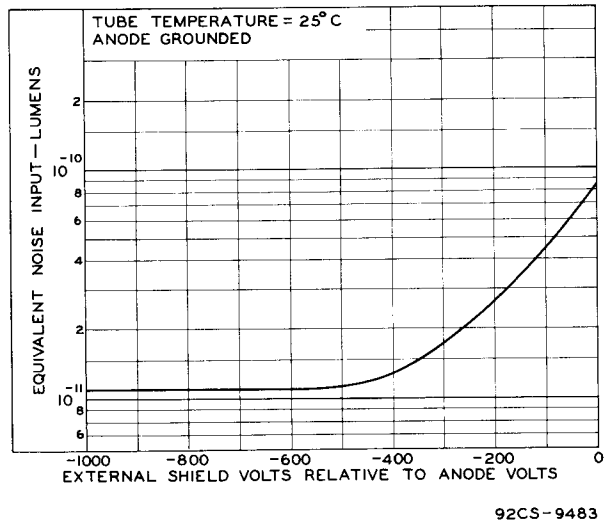


Fig. 7 - Effect of External-Shield Potential on Equivalent Noise Input of Type 7029.

coating painted on the clear portion of the bulb or metallic foil wrapped around the clear area. The curve in Fig.7 illustrates the effect of shield potential on the equivalent noise input.

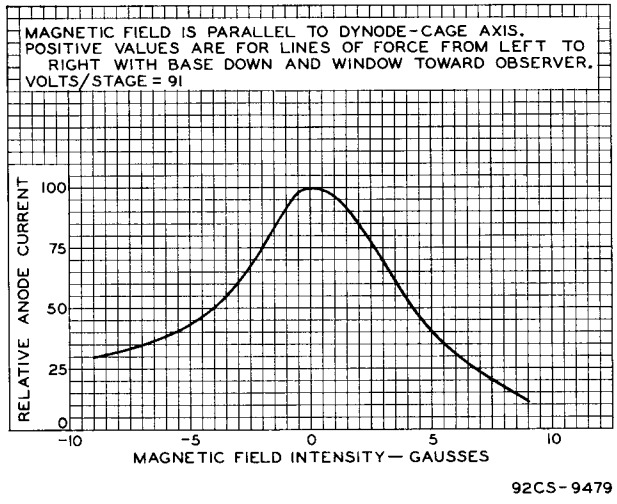


Fig. 8 - Effect of Magnetic Field on Anode Current of Type 7029.

With certain orientations of the 7029, it will be observed that the earth's magnetic field

is sufficient to cause a noticeable decrease in the response of the tube. The curve in Fig.8 shows the effect on anode current of variation in magnetic field strength under the conditions indicated. With increase in voltage above 100 volts between cathode and dynode No.1, the effect of the magnetic field will cause less decrease in anode current.

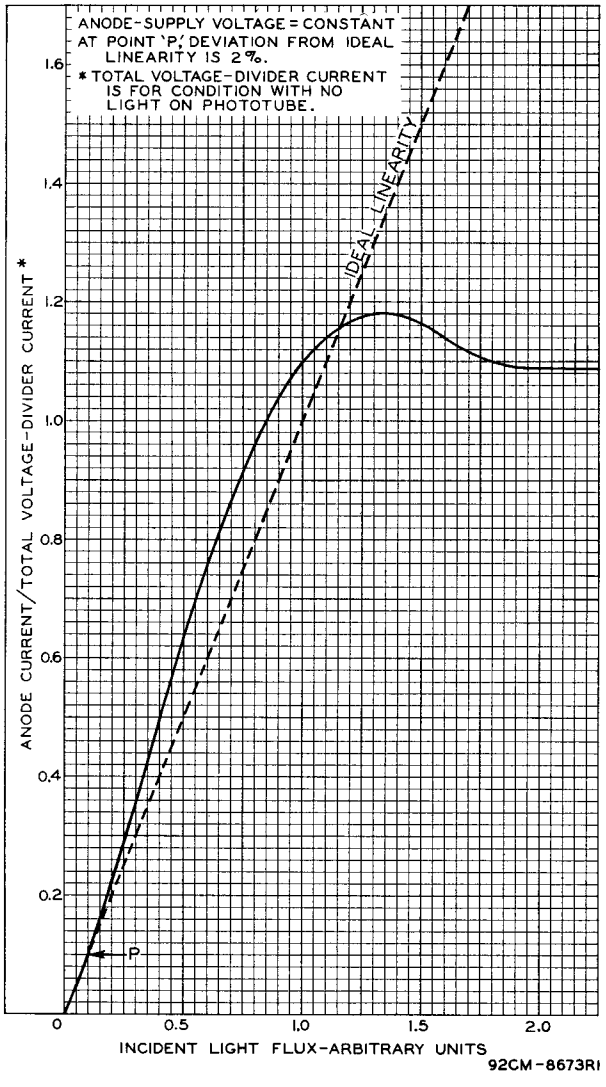


Fig.9 - Linearity Characteristic of Type 7029 as Affected by Ratio of Anode Current to Total Divider Current.

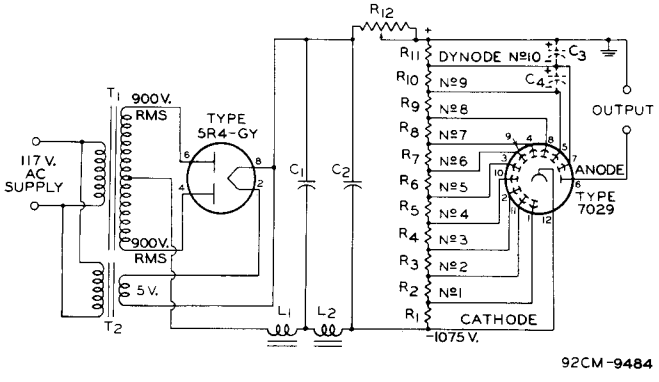
To prevent such decrease in response of the tube, magnetic shielding should be provided. When connected to cathode potential, this shielding may closely fit the bulb and serves the dual purpose of providing both magnetic and electrostatic shielding. When connected to anode potential, this shielding should be spaced at least 1/2 inch from the bulb wall to prevent the internal discharge phenomenon described above.

It is to be noted that the use of an external magnetic and/or electrostatic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 7029. Although the metallic coating on the inner wall of the glass bulb serves to reduce the amount of extraneous light reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous light.

Whenever frequency response is important, the leads from the 7029 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each dynode and for the anode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation required by the application. In general,



C1 C2: 2 μf, 1000 volts (dc working)
C3 C4: 0.1 μf, 150 volts (dc working).
Required only if high peak currents are drawn.
L1 L2: United Transformer Corp. No.R-17, or equivalent
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10: 18000 ohms, 1 watt
R11: 12000 ohms, 1 watt
R12: 200000 ohms, 12 watts, adjustable, General Radio Type 471-A, or equivalent
T1: United Transformer Corp. No.S-45, or equivalent
T2: United Transformer Corp. No.FT-6, or equivalent

Fig.10 - Full-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 7029 in Applications Critical as to Hum Modulation.

the current in the divider should be about 10 times the maximum value of total dynode current flowing through the divider. Such a value will prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will

ordinarily be provided by a well-designed two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Due to critical dependence of the gain of the 7029 on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum-tube regulator circuit of the mu-bridge type.

The relationship between the ratio of anode current-to-voltage-divider current and incident light flux is shown in Fig.9. For operation along the *ideal linearity* curve of Fig.9, the anode current-to-voltage-divider current ratio should be less than 0.1.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.

The high voltages at which the 7029 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 7029, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

A typical power-supply circuit for the 7029 is shown in Fig.10.

REFERENCES

Ralph W. Engstrom, *"Multiplier Phototube Characteristics; Application to Low Light Levels,"* Journal of the Optical Society of America, Vol.37, pp.420-431, June, 1947.

F. V. Hunt and R. W. Hickman, *"On Electronic Voltage Stabilizers,"* Review of Scientific Instruments, Vol.10, pp.6-21, January, 1939.

R. W. Engstrom, R. G. Stoudenheimer, and A. M. Glover, *"Production Testing of Multiplier Phototubes Designed for Scintillation Counter Applications,"* Nucleonics, Vol.10, No.4, pp.58-62, April, 1952.

R. W. Engstrom, E. Fischer, *"Effects of Voltage-Divider Current Characteristics on Multiplier Phototube Response,"* Review of Scientific Instruments, Vol.28, No.7, July 1957.

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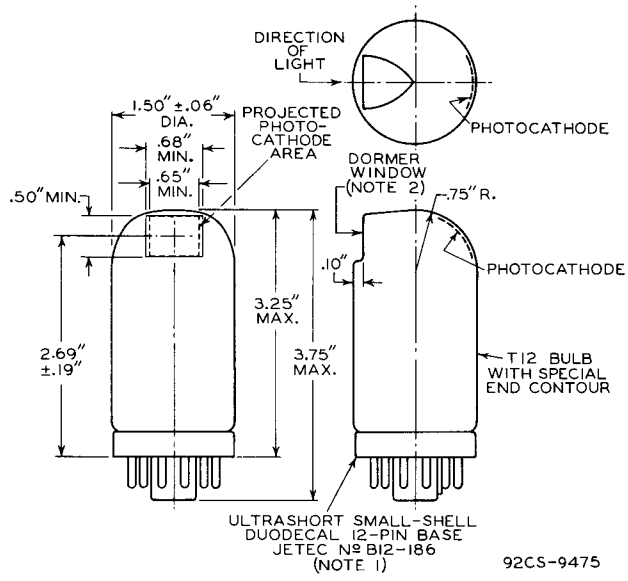
DIMENSIONAL OUTLINE

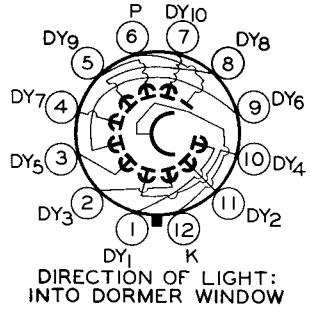


NOTE 1: ℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE 2: DORMER WINDOW IS ON OPPOSITE SIDE OF TUBE FROM BASE KEY.

SOCKET CONNECTIONS

Bottom View



PIN 1: DYNODE NO.1
PIN 2: DYNODE NO.3
PIN 3: DYNODE NO.5
PIN 4: DYNODE NO.7
PIN 5: DYNODE NO.9
PIN 6: ANODE

PIN 7: DYNODE NO.10
PIN 8: DYNODE NO.8
PIN 9: DYNODE NO.6
PIN 10: DYNODE NO.4
PIN 11: DYNODE NO.2
PIN 12: CATHODE

DIRECTION OF LIGHT:
INTO DORMER WINDOW

12AH

This bulletin also applies to RCA-7035/4X150D which is identical with RCA-7034/4X150A except for its heater rating of 26.5 ± 10% volts, 0.58 ampere.

7035/4X150D

7034/4X150A

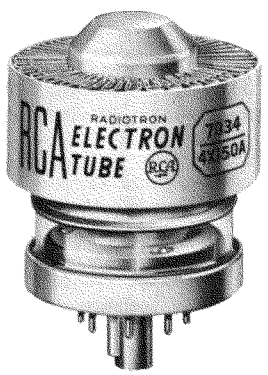
BEAM POWER TUBE

Unipotential Cathode
Coaxial-Electrode Structure
Compact Design

For Use at Frequencies Up to 500 Mc
Forced-Air Cooled
370 Watts CW Output up to 150 Mc
140 Watts CW Output at 500 Mc

2-15/32" Max. Length
1.635" Max. Diameter
Integral Radiator

RCA-7034/4X150A is a very small and compact, forced-air-cooled beam power tube designed for service at frequencies up to 500 Mc. It is useful as an af power amplifier and modulator, a wide-band amplifier in video applications, a linear rf power amplifier in single-sideband suppressed-carrier equipment, and a class C amplifier or oscillator. The maximum plate dissipation of the 7034 is 250 watts.



The 7034 is unilaterally interchangeable with the 4X150A. At frequencies up to 150 Mc, it offers substantially higher power-output capability than the 4X150A because of its higher plate-voltage rating. Furthermore, the specially designed, high-efficiency louvered radiator which is hard soldered directly to the plate of the 7034 for better heat transfer, makes possible the maximum plate-dissipation rating of 250 watts with no sacrifice in tube reliability.

The terminal arrangement of the 7034 facilitates use of the tube with tank circuits of the coaxial type. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the ring terminal for grid No.2. A base-pin termination for grid No.2 is also available for operation of the 7034 at the lower frequencies.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)§	6.0 ± 10%	volts
Current at 6.0 volts	2.6	amperes
Minimum heating time	30	seconds
Mu-Factor, Grid No.2 to Grid No.1, for grid-No.2 volts = 300 and grid-No.2 ma. = 60	5	
Direct Interelectrode Capacitances:□		
Grid No.1 to plate	0.03	μμf
Grid No.1 to cathode, grid No.2, and heater	16	μμf
Plate to cathode, grid No.2, and heater	4.4	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2-15/32"
Maximum Seated Length	1.850"
Maximum Diameter	1.640"
Base	Special 8-Pin
Socket	Air-System Socket, such as Johnson No.124-110-1■ (Supplied with Air Chimney)
Radiator	Integral part of tube

Air Flow:

Through Indicated Air-System Socket--This fitting directs the air over the base seals; past the grid-No.2 seal, glass envelope, and plate seal; and through the radiator to provide effective cooling with minimum air flow. When the tube is operated at maximum plate dissipation for each class of service, a minimum air flow of 5.6 cfm through the system is required. The corresponding pressure drop is 0.45 inch of water. These requirements are for operation at sea level and at an ambient temperature of 20° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the plate temperature within maximum ratings.

Without Air-System Socket--If an air-system socket is not used, it is essential that adequate cooling air be directed over the base seals, past the envelope, and through the radiator. Under these conditions and with the tube operating at maximum plate dissipation for each class of service, a minimum air flow of 5.3 cfm must pass through the radiator. The corresponding pressure drop is 0.28 inch of water. These requirements are for operation at sea level and at an ambient temperature of 20° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the plate temperature within maximum ratings.

Plate Temperature (Measured on base end of plate surface at junction with fins).	250 max.	°C
Temperature of Plate Seal	200 max.	°C
Temperature of Base Seals and Grid-No.2 Seal	175 max.	°C
Weight (Approx.)	4	ounces

AF POWER AMPLIFIER & MODULATOR - Class AB1♦

Maximum CCS● Ratings, *Absolute-Maximum Values:*★

DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE*	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	250 max.	ma
PLATE DISSIPATION*	250 max.	watts
GRID-No.2 DISSIPATION*	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

■ Available from E. F. Johnson Co., Waseca, Minn.

Trademark(s) ® Registered
Marca(s) Registrada(s)

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	800	1000	1500	2000	volts
DC Grid-No.2 Voltage	300	300	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage	-40	-43	-50	-50	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	80	86	100	100	volts
Zero-Signal DC Plate Current	210	165	100	100	ma
Max.-Signal DC Plate Current	435	450	456	470	ma
Zero-Signal DC Grid-No.2 Current	0	0	0	0	ma
Max.-Signal DC Grid-No.2 Current	76	52	42	36	ma
Effective Load Resistance (Plate to plate)	4400	4250	6570	8760	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	0	watts
Max.-Signal Power Output (Approx.)	170	230	400	580	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance (Per tube)	0.1 max.	megohm

AF POWER AMPLIFIER & MODULATOR - Class AB_2#

Maximum CCS● Ratings, *Absolute-Maximum Values:*★

DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	250 max.	ma
PLATE DISSIPATION*	250 max.	watts
GRID-No.2 DISSIPATION*	12 max.	watts
GRID-No.1 (CONTROL-GRID) DISSIPATION	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	800	1000	1500	2000	volts
DC Grid-No.2 Voltage	300	300	300	300	volts
DC Grid-No.1 Voltage	-40	-45	-50	-50	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	90	98	106	106	volts
Zero-Signal DC Plate Current	210	166	100	100	ma
Max.-Signal DC Plate Current	500	493	500	500	ma
Zero-Signal DC Grid-No.2 Current	0	0	0	0	ma
Max.-Signal DC Grid-No.2 Current	80	58	46	36	ma
Effective Load Resistance (Plate to plate)	3140	3950	5970	8100	ohms
Max.-Signal Driving Power (Approx.)	0.15	0.15	0.2	0.2	watt
Max.-Signal Power Output (Approx.)	215	270	440	630	watts

RF POWER AMPLIFIER - Class B Television Service

Synchronizing-level conditions per tube unless otherwise specified

Maximum CCS● Ratings, *Absolute-Maximum Values:*★

	54 to 216 Mc	
DC PLATE VOLTAGE	1250 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-250 max.	volts
DC PLATE CURRENT (AVERAGE)⊕	250 max.	ma
PLATE DISSIPATION	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	watts
GRID-No.1 DISSIPATION	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Operation (With bandwidth of 5 Mc):

DC Plate Voltage	750	1000	1250	volts
DC Grid-No.2 Voltage	300	300	300	volts
DC Grid-No.1 Voltage	-60	-65	-70	volts
Peak RF Grid-No.1 Voltage:				
Synchronizing level	85	95	100	volts
Pedestal level	65	70	75	volts
DC Plate Current:				
Synchronizing level	335	330	305	ma
Pedestal level	245	240	230	ma
DC Grid-No.2 Current:				
Synchronizing level	50	45	45	ma
Pedestal level	20	15	10	ma
DC Grid-No.1 Current:				
Synchronizing level	15	20	25	ma
Pedestal level	4	4	4	ma
Driver Power Output (Approx.):◆				
Synchronizing level	7	8	9	watts
Pedestal level	4.25	4.7	5.5	watts
Useful Power Output (Approx.):				
Synchronizing level	135	200	250	watts
Pedestal level	75	110	140	watts

LINEAR RF POWER AMPLIFIER - Single-Sideband Suppressed-Carrier Service

Maximum Ratings, *Absolute-Maximum Values:*★

	Up to 150 Mc		*Up to 500 Mc*	
	CCS●	*ICAS*●●	*CCS*●	
DC PLATE VOLTAGE	2000 max.	2250 max.	1250 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT	250 max.	280 max.	250 max.	ma
PLATE DISSIPATION	250 max.	300 max.	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	12 max.	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:				
Heater negative with respect to cathode	150 max.	150 max.	150 max.	volts
Heater positive with respect to cathode	150 max.	150 max.	150 max.	volts

Typical Class AB_1 "Single-Tone" Operation up to 150 Mc:◆◆

	CCS●			*ICAS*●●	
DC Plate Voltage	1000	1500	1800	2000	volts
DC Grid-No.2 Voltage‡	300	300	300	300	volts
DC Grid-No.1 (Control-Grid) Voltage	-50	-50	-50	-48	volts
Zero-Signal DC Plate Current	50	50	50	60	ma
Zero-Signal DC Grid-No.2 Current	0	0	0	0	ma
Effective RF Load Resistance	1860	3280	4140	4270	ohms
Max.-Signal DC Plate Current	225	225	225	250	ma
Max.-Signal DC Grid-No.2 Current	11	11	11	9	ma
Max.-Signal Peak RF Grid-No.1 Voltage	50	50	50	48	volts
Max.-Signal Driving Power (Approx.)	0	0	0	0	watts
Max.-Signal Power Output (Approx.)	115	200	250	290	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under Any Condition:		
With fixed bias	25000 max.	ohms
With cathode bias	Not recommended	

PLATE-MODULATED RF POWER AMP. - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS● Ratings, *Absolute-Maximum Values:*★

	Up to 150 Mc	*150 to 500 Mc*	
DC PLATE VOLTAGE	1600 max.	1000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	300 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-250 max.	-250 max.	volts
DC PLATE CURRENT	200 max.	200 max.	ma
PLATE DISSIPATION	165 max.	165 max.	watts
GRID-No.2 DISSIPATION	10 max.	10 max.	watts
GRID-No.1 DISSIPATION	2 max.	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150 max.	150 max.	volts
Heater positive with respect to cathode	150 max.	150 max.	volts

Typical CCS Operation at Frequencies up to 150 Mc:

DC Plate Voltage	1200	1600	volts
DC Grid-No.2 Voltage (Modulated approx. 55%)▲	250	250	volts
DC Grid-No.1 Voltage★★	-118	-118	volts
Peak AF Grid-No.2 Voltage (For 100% modulation)	180	200	volts
Peak RF Grid-No.1 Voltage	136	136	volts
DC Plate Current	200	200	ma
DC Grid-No.2 Current	23	23	ma
DC Grid-No.1 Current (Approx.)	5	5	ma
Driving Power (Approx.)	2	3	watts
Power Output (Approx.)	160	230	watts

Typical CCS Operation at 165 Mc:

DC Plate Voltage	400	600	800	1000	volts
DC Grid-No.2 Voltage (Modulated approx. 55%)▲	250	250	250	250	volts
DC Grid-No.1 Voltage	-90	-95	-100	-105	volts
Peak AF Grid-No.2 Voltage (For 100% modulation)	140	150	160	170	volts
Peak RF Grid-No.1 Voltage	110	120	120	125	volts
DC Plate Current	200	200	200	200	ma
DC Grid-No.2 Current	40	35	25	20	ma
DC Grid-No.1 Current (Approx.)	7	8	10	15	ma
Driving Power (Approx.)	1	1	1.5	2	watts
Power Output (Approx.)	55	80	100	140	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under Any Condition	25000 max.	ohms

RF POWER AMPLIFIER & OSC. — Class C Telegraphy† and RF POWER AMPLIFIER — Class C FM Telephony

Maximum CCS● Ratings, *Absolute-Maximum Values:*★

	Up to 150 Mc	*150 to 500 Mc*	
DC PLATE VOLTAGE	2000 max.	1250 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	300 max.	300 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-250 max.	-250 max.	volts
DC PLATE CURRENT	250 max.	250 max.	ma
PLATE DISSIPATION	250 max.	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	12 max.	watts
GRID-No.1 DISSIPATION	2 max.	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150 max.	150 max.	volts
Heater positive with respect to cathode	150 max.	150 max.	volts

Typical CCS Operation at Frequencies up to 150 Mc:

DC Plate Voltage	1500	2000	volts
DC Grid-No.2 Voltage	250	250	volts
DC Grid-No.1 Voltage	-88	-88	volts
Peak RF Grid-No.1 Voltage	110	110	volts
DC Plate Current	250	250	ma
DC Grid-No.2 Current	24	24	ma
DC Grid-No.1 Current (Approx.)	8	8	ma
Driving Power (Approx.)	1.5	2.5	watts
Power Output (Approx.)	260	370	watts

Typical CCS Operation at 165 Mc:

DC Plate Voltage	600	750	1000	1250	volts
DC Grid-No.2 Voltage	250	250	250	250	volts
DC Grid-No.1 Voltage	-75	-80	-80	-90	volts
Peak RF Grid-No.1 Voltage	91	96	95	106	volts
DC Plate Current	200	200	200	200	ma
DC Grid-No.2 Current	37	37	31	20	ma
DC Grid-No.1 Current (Approx.)	11	11	10	11	ma
Driving Power (Approx.)	1	1	1	1.2	watts
Power Output (Approx.)	85	110	150	195	watts

Typical CCS Operation at Frequency of 500 Mc with Coaxial Cavity:

DC Plate Voltage	600	800	1000	1250	volts
DC Grid-No.2 Voltage	250	250	250	280	volts
DC Grid-No.1 Voltage	-110	-110	-110	-115	volts
DC Plate Current	170	200	200	200	ma
DC Grid-No.2 Current	6	7	7	5	ma
DC Grid-No.1 Current (Approx.)	6	10	10	10	ma
Driver Power Output (Approx.)◆	15	20	25	30	watts
Useful Power Output (Approx.)	50	95	120	140	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance under Any Condition	25000 max.	ohms

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current:				
Type 7034	1	2.3	2.9	amp
Type 7035	2	0.50	0.62	amp
Direct Interelectrode Capacitances:□				
Grid No.1 to plate	–	–	0.05	μμf
Grid No.1 to cathode, grid No.2, and heater	–	14.5	17.0	μμf
Plate to cathode, grid No.2, and heater	–	4.0	4.8	μμf
Grid-No.1 Voltage:				
Type 7034	1,3,4,7	-32	-46	volts
Type 7035	2,3,4,7			
Grid-No.2 Current:				
Type 7034	1,3,4,7	-5	+3	ma
Type 7035	2,3,4,7			
Power Output:				
Type 7034	4,5,7	100	–	watts
Type 7035	4,6,7			

Note 1: With 6.0 volts on heater.

Note 2: With 26.5 volts on heater.

Note 3: With dc plate voltage of 1000 volts, dc grid-No.2 voltage of 300 volts, and grid-No.1 voltage adjusted to give plate current of 150 ma.

Note 4: Heater voltage must be applied for at least 30 seconds before application of other voltages.

Note 5: With heater voltage of 5.5 volts and with dc plate voltage of 1000 volts, dc grid-No.2 voltage of 250 volts, dc grid-No.1 bias of -90 volts, dc grid-No.1 current of 20 ma maximum, grid-No.1 signal voltage adjusted to produce dc plate current of 200 ma, and a frequency of 475 Mc.

Note 6: Same as Note 5 except heater voltage is 24.5 volts.

Note 7: With Forced-Air Cooling as specified under GENERAL DATA for *Air System Socket*.

SPECIAL PERFORMANCE DATA

Interelectrode Leakage:

This test is destructive and is performed on a sample lot of tubes from each production run under the following conditions: ac heater volts = 6.6 for type 7034 or 29.1 for type 7035, no voltage on other elements, and specified forced-air cooling for *Air-System Socket*. At the end of 500 hours, with tube at 25° C, and with no voltage applied to heater, the minimum resistance between indicated electrodes as measures with a 500-volt Megger-type ohmmeter having an internal impedance of 2.5 megohms, will be:

Grid No.1 and Grid No.2	10 min.	megohms
Grid No.1 and Cathode	10 min.	megohms
Grid No.2 and Cathode	10 min.	megohms

§ Because the cathode is subjected to considerable back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should be reduced depending on operating conditions and frequency to prevent overheating the cathode and resultant short life.

□ With cylindrical shield JEDEC No.320 surrounding radiator; and with a cylindrical shield JEDEC No.321 surrounding the grid-No.2 ring terminal. Both shields are connected to ground.

♦ Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

★ The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

* Averaged over any audio-frequency cycle of sine-wave form.

⋕ Subscript 2 indicates that grid-No.1 current flows during some part of the input cycle.

⊕ Averaged over any frame.

♦ The driver stage is required to supply tube losses and rf circuit losses. The driver stage should be designed to provide an excess of power above the indicated values to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

●● Intermittent Commercial and Amateur Service.

♦♦ "Single-Tone" operation refers to that class of amplifier service in which the grid-No.1 input consists of a monofrequency rf signal having constant amplitude. This signal is produced in a single-sideband suppressed-carrier system when a single audio frequency of constant amplitude is applied to the input of the system.

‡ Preferably obtained from a fixed supply.

▲ The dc grid-No.2 voltage must be modulated approximately 55% in phase with the plate modulation in order to obtain 100% modulation of the 7034. The use of a series grid-No.2 resistor or reactor may not give satisfactory performance and is therefore not recommended.

★★ Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

† Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

OPERATING CONSIDERATIONS

The maximum temperatures in the tabulated data for the base seals, grid-No.2 seal, plate seal, and plate are tube ratings and are to be observed in the same manner as other tube ratings. The temperature of the respective seals and of the plate may conveniently be measured with temperature-sensitive paint such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y. in the form of liquid and stick.

The *socket* for the 7034 should be of a type (such as that indicated in the tabulated data) which permits adequate air-cooling of the tube. Although the base will fit a conventional lock-in socket, the latter does not permit adequate cooling and its use is therefore not recommended.

The *plate connection* is made by a metal band or spring contacts to the cylindrical surface of the radiator. It is essential that the contact areas be kept clean to minimize rf losses especially at the higher frequencies.

The *plate circuit* should be provided with a time-delay relay which will prevent the application of plate voltage before the cathode has reached normal operating temperature.

Protective devices should be used to protect not only the plate but also grid-No.2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current.

A protective device in the grid-No.2 supply lead should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

The rated plate and grid-No.2 voltages of this tube are extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break

the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

Forced-air cooling of the 7034 is required as indicated under GENERAL DATA. A suitable air filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air through the socket and radiator.

The cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the heater and plate power supplies. This arrangement is necessary to make sure that the tube is supplied with air simultaneously with electrode voltages. Air-flow interlocks which open the power transformer primaries are desirable for protecting the tube when the air flow is insufficient or ceases.

The *unipotential cathode* is connected within the tube to base pins 2, 4, 6, and 8. The corresponding socket terminals should all be used for connection to the circuit. The leads should have ample cross-section and be as short as possible to minimize cathode-lead inductance.

The cathode of the 7034 in uhf service is subjected to considerable bombardment resulting from transit-time effects. This back bombardment raises the temperature of the cathode. The magnitude of the heating caused by back bombardment is a function of the operating conditions and frequency, and must be compensated by reduction of heater input in order to prevent over-

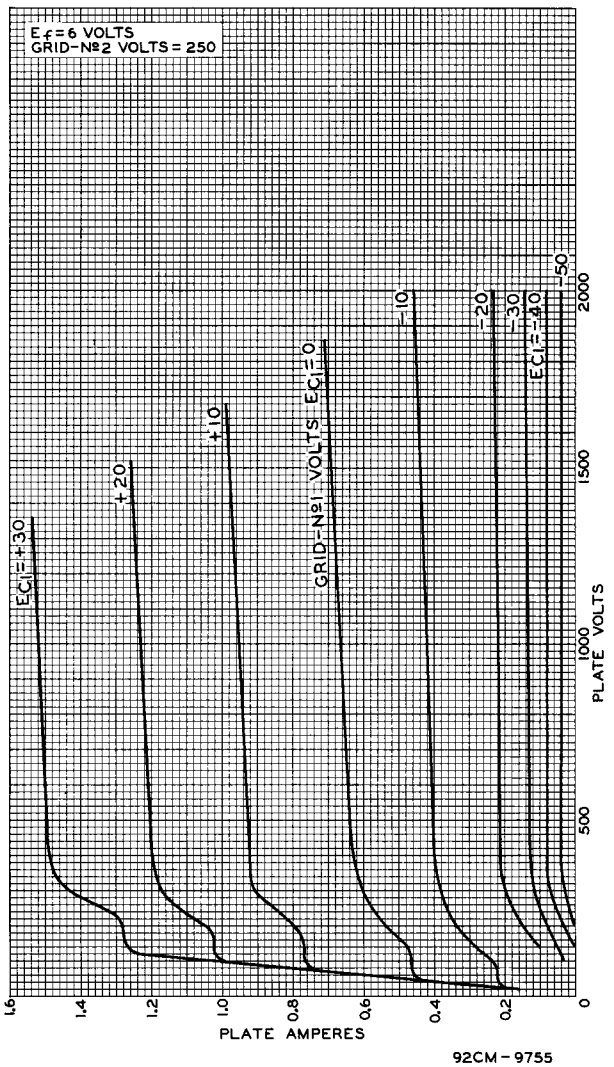


Fig. 1 - Typical Plate Characteristics of Type 7034.

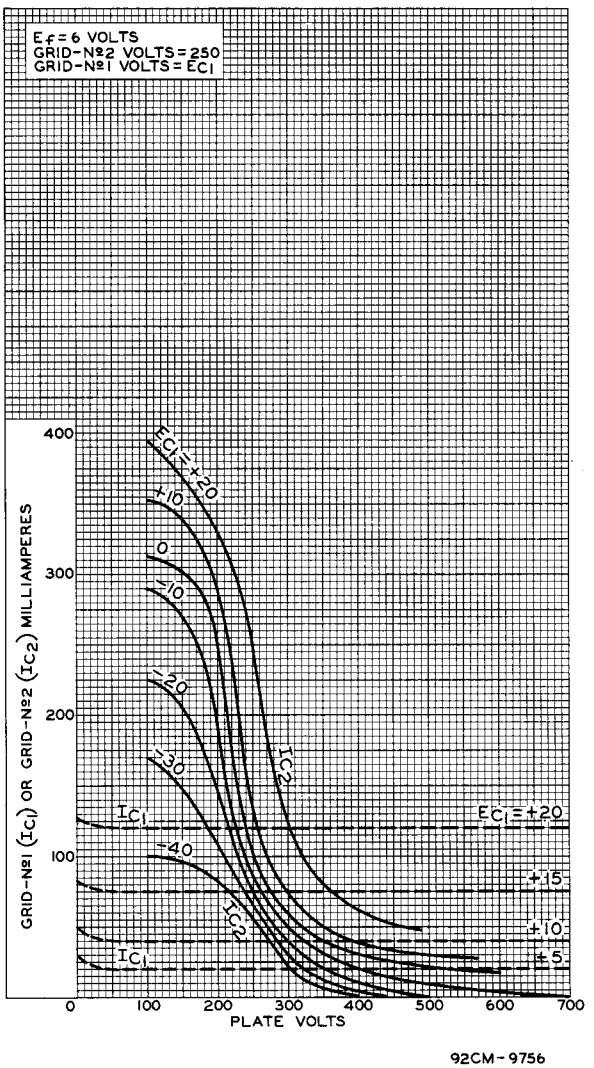


Fig. 2 - Typical Characteristics of Type 7034.

heating of the cathode and resultant short life. When long life in continuous service is desired, the 7034 should always be put in operation with full rated heater voltage (6 volts) which should than be reduced to a value depending on the operating conditions and frequency.

The proper operating value may be found by reducing the heater voltage, with normal modulation applied to the transmitter, until a reduction in output is observed. The heater voltage must then be increased by an amount equivalent to the maximum percentage regulation of the heater-voltage supply, and then further increased by about 2 per cent to allow for other variations. After the heater voltage is reduced, circuit readjustment may be necessary. It is suggested that the adjustment procedure be carried out daily. However, if no significant changes in the operating voltage are found necessary, the adjustment procedure can be scheduled less frequently. Good regulation of the heater voltage is in general economically advantageous from the viewpoint of tube life.

Grid-No. 1 of the 7034 in uhf service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid-No.1 current, but also by bombardment due to transit-time effects and by circulating rf currents. For these reasons, more than ordinary care must be taken during operation to prevent overloading grid-No.1.

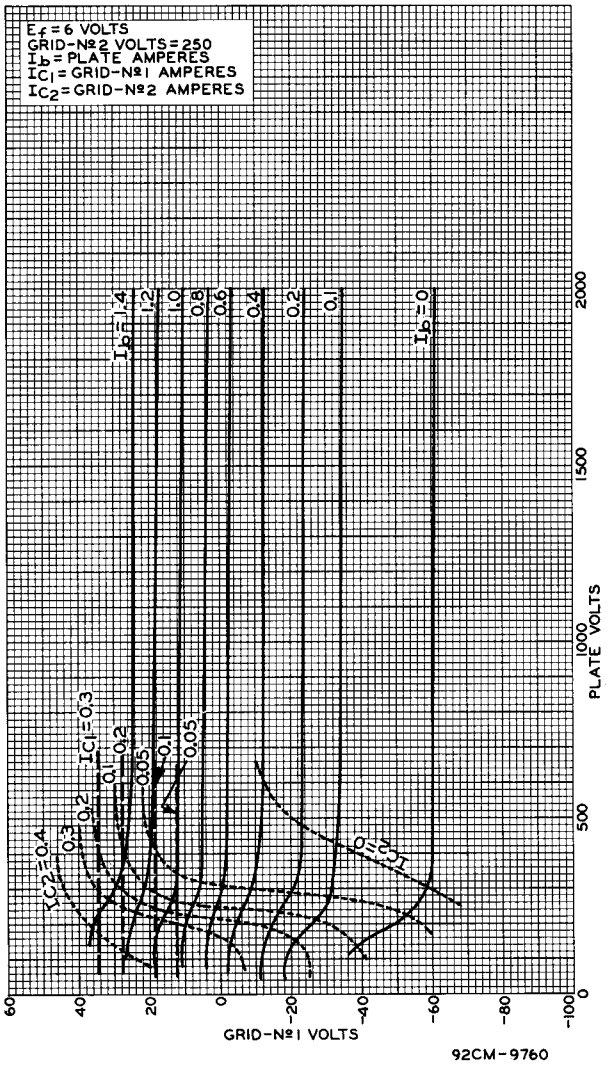


Fig. 3 - Typical Constant-Current Characteristics of Type 7034.

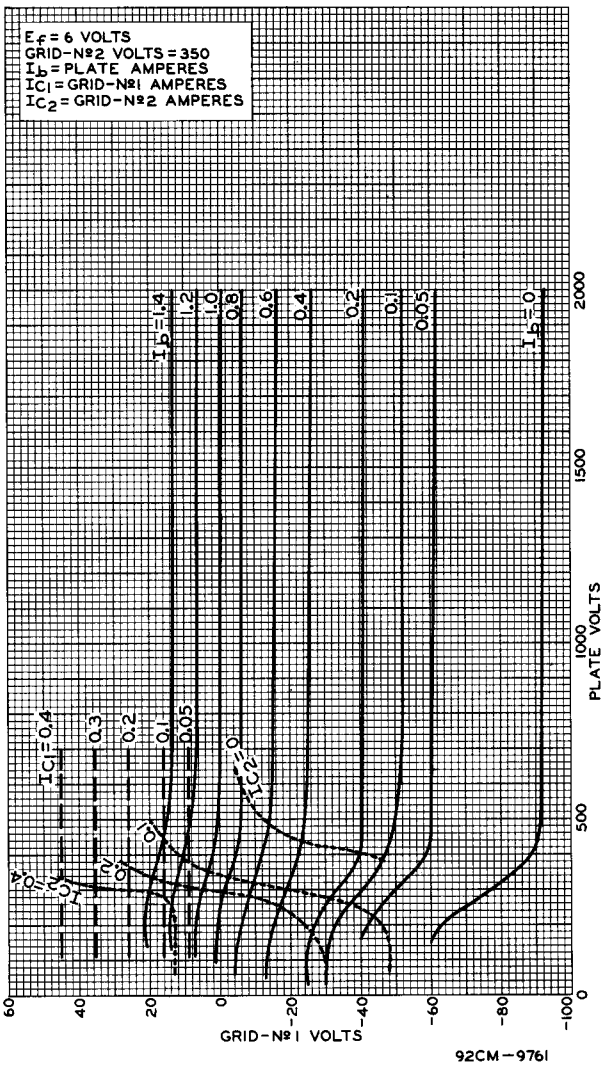
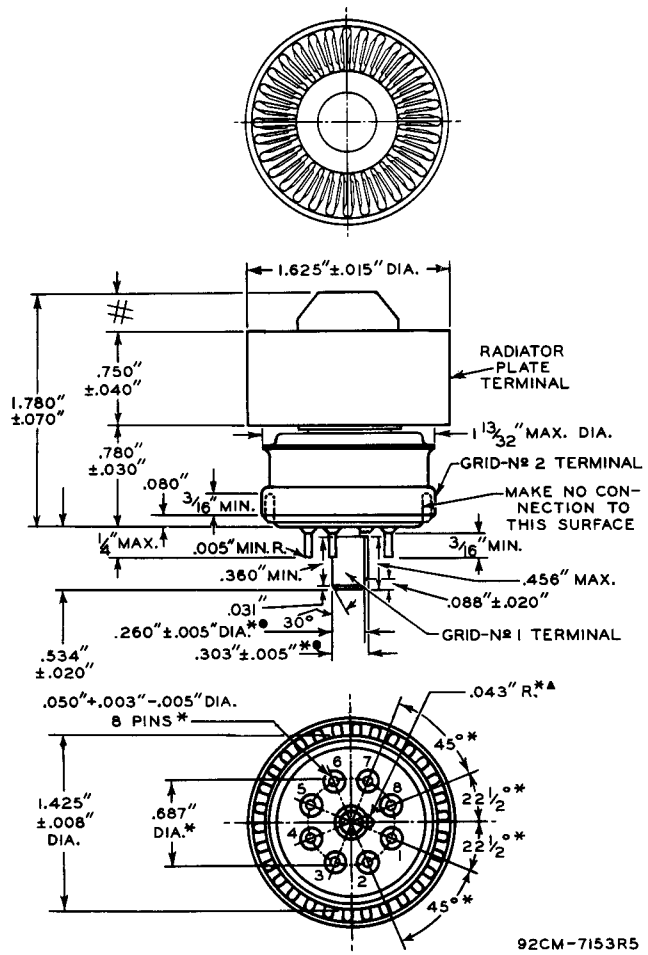


Fig. 4 - Typical Constant-Current Characteristics of Type 7034.

Grid-No. 2 voltage should be obtained from a source of good regulation. The plate voltage should be applied before or simultaneously with the grid-No.2 voltage; otherwise, with voltage on grid-No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the screen dissipation determined.

DIMENSIONAL OUTLINE



Grid-No.1 plug dimensions are measured by the use of the series of gauges shown in Sketches G_1 and G_2. In the following instructions for the use of these gauges, "Go" indicates that the entire grid-No.1 plug key will enter the gauge; and "No-Go" indicates that the grid-No.1 plug key will not enter the gauge more than 1/16". Instructions for the use of the gauges follow:

▲ GAUGES G_1-1, G_1-2, G_1-3, and G_1-4

Using only slot C, try these gauges in numerical order until one is found that will accept the entire grid-No.1 plug. Using the first gauge thus found, it will not be possible to insert the grid-No.1 plug in Slot B.

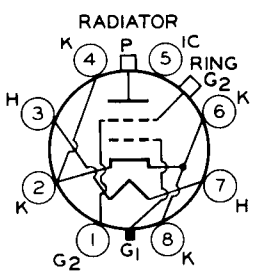
● GAUGES G_2-1, G_2-2, and G_2-3

The grid-No.1 plug will be rejected by gauges G_2-1 and G_2-2, but will be accepted by gauge G_2-3.

* Base-pin positions are held to tolerances such that the entire length of the pins will, without undue force, pass into and disengage from the flat-plate gauge shown in Sketch G_3.

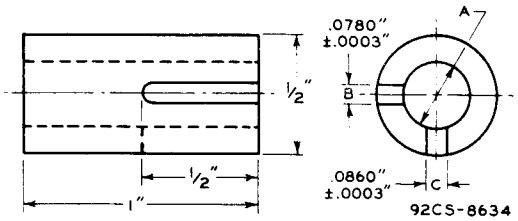
\# Dome shape will fall within shaded area of the comparator contour template.

BASING DIAGRAM
Bottom View



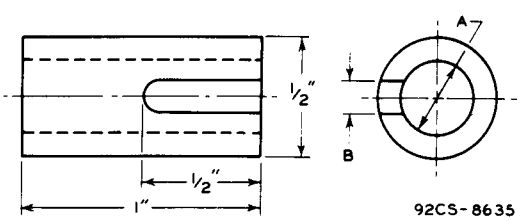
PIN 1: GRID No.2 (For use at the lower frequencies)
PIN 2: CATHODE
PIN 3: HEATER
PIN 4: CATHODE
PIN 5: INTERNAL CONNECTION—Do Not Use
PIN 6: CATHODE
PIN 7: HEATER
PIN 8: CATHODE
BASE INDEX PLUG: GRID No.1
RADIATOR: PLATE
RING TERMINAL: Grid No.2 (For use at the higher frequencies)

Gauge Sketch G_1



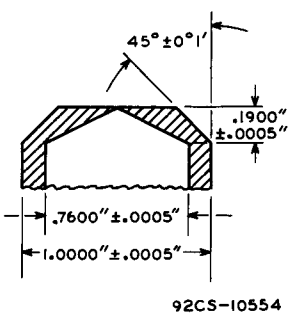
Gauge	Dimension A
G_1-1	.2575" + .0000" − .0005"
G_1-2	.2600" + .0000" − .0005"
G_1-3	.2625" + .0000" − .0005"
G_1-4	.2650" + .0000" − .0005"

Gauge Sketch G_2

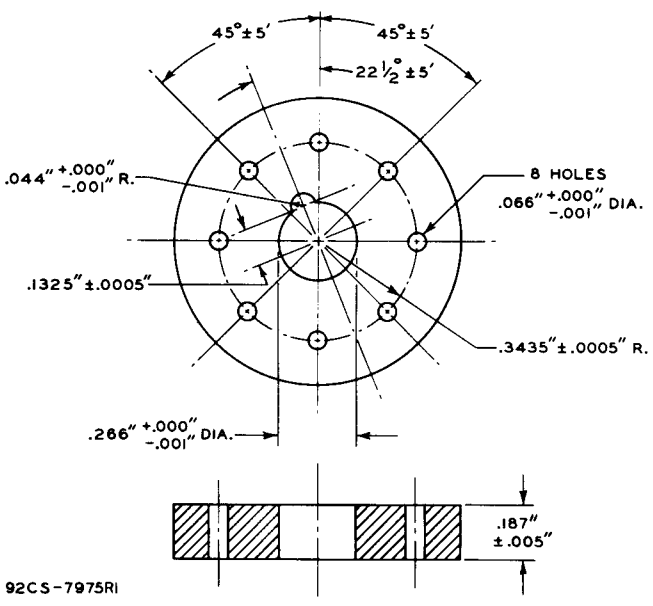


Gauge	Dimension	
	A	B
G_2-1	.2550" + .0000" − .0005"	.125"
G_2-2	.2980" + .0000" − .0005"	none
G_2-3	.3080" + .0000" − .0005"	none

COMPARATOR CONTOUR TEMPLATE

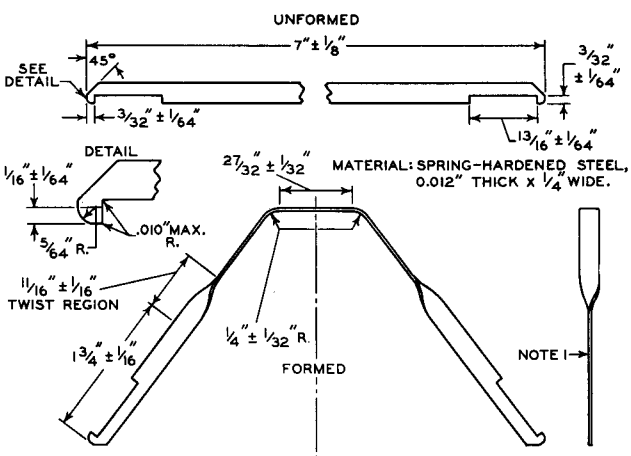


Gauge Sketch G_3



TOLERANCES ARE NOT CUMULATIVE

Suggested Design for Extractor to Remove Tube from Cavity



NOTE 1: BURR MUST NOT EXCEED 0.002" IN DIRECTION PERPENDICULAR TO FLAT SURFACES. THE CORRESPONDING FLAT SURFACES OF THE TWO LEGS SHOULD BE IN THE SAME PLANE WITHIN 1/16".

92CS-9800RI

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7037

IMAGE ORTHICON

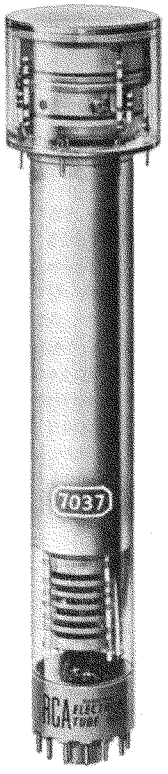
Magnetic Focus
Magnetic Deflection

For Simultaneous Color Pickup
Exceptionally High Sensitivity

3"-Diameter Bulb
15-1/4" Length

TENTATIVE DATA

RCA-7037 is a television camera tube intended for use in color cameras utilizing the method of simultaneous pickup of the studio or outdoor scene to be televised. This method employs three 7037's --one for each channel--to produce the information necessary for the formation of a color-television image.



The 7037 has exceptionally high sensitivity combined with a spectral response approaching that of the eye, and good resolution capability. With a color camera employing a suitably designed optical system and utilizing efficient color filters, commercially acceptable color pictures can be obtained with about 175 foot-candles of incident incandescent illumination on the scene and a lens stop of f:5.6.

The photocathode utilized in the 7037 is an improved type featuring very high sensitivity. Its relatively wide spectral response has high blue sensitivity, high green sensitivity, good red sensitivity, and practically no infrared sensitivity. This spectral characteristic enables the tube to translate colors very accurately when operated in a color camera with appropriate color filters and optical arrangements.

The *spectral response* of the 7037 is shown in Fig. 1 and is not subject to appreciable variation from tube to tube.

Other features of the 7037 include its *"stabilized" target*, its *micro-mesh screen*, and its *super-dynode design*. The "stabilized" target greatly reduces any tendency toward an increase in picture retention throughout the life of the tube and thus contributes to longer service-hours.

The *micro-mesh screen*, which has a fineness of 750 lines per inch, eliminates mesh pattern and moiré effect without defocusing, minimizes beat pattern between color subcarrier frequency and the frequency generated by the beam scanning the mesh-screen pattern, permits operation of the tube with aperture-correction circuit to provide 100 per cent response for 350-line information, and improves picture-detail contrast.

The *super-dynode design* offers freedom from dynode burn, saves adjustment time on dark-shading, reduces color shift in dark areas, provides more uniform picture background with reduced undesirable texture in lowlight areas, and makes it possible to set the decelerator-grid voltage at optimum value for highlight uniformity throughout the useful life of the tube.

The 7037 is designed to operate on a substantially linear signal-output curve, and is thus capable of producing a picture having natural tone value and accurate detail. Furthermore, the 7037 features a signal-to-noise ratio and contrast range commensurate with the requirements of color reproduction.

The 7037 may be used in place of the 6474/1854 in color cameras with the resultant advantage of substantial reduction in illumination on the televised scene. Under most conditions, no change in color filters is required because of the close similarity in the spectral responses of the two types.

PRINCIPLES OF OPERATION

The 7037 has three sections--an image section, a scanning section, and a multiplier section, as shown in Fig. 2.

Image Section

The image section contains a semitransparent photocathode on the inside of the faceplate, a

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grid (grid No.6) to provide an electrostatic accelerating field, and a target which consists of a thin glass disc with a fine mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a magnetic field produced by an external coil, and by varying the photocathode voltage.

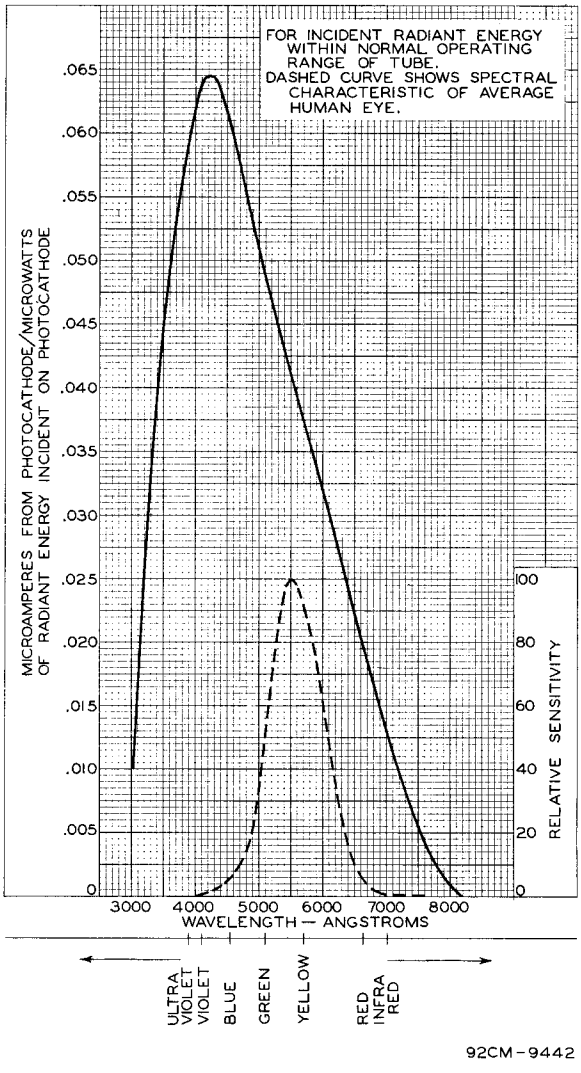


Fig. 1 - Spectral Sensitivity Characteristic of Type 7037.

Light from the scene being televised is picked up by an optical system and focused on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focused on the target by the magnetic and accelerating fields.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite potential of several volts with respect to target-voltage cutoff. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive charges which corresponds with the pattern of light from the scene being televised. Because of the thinness of the glass, the charges set up a similar potential pattern on the opposite or scanned side of the glass.

Scanning Section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No.1), and an accelerating grid (grid No.2). The beam is focused at the target by the magnetic field of an external focusing coil and the electrostatic field of grid No.4.

Grid No.5 serves to adjust the shape of the decelerating field between grid No.4 and the target in order to obtain uniform landing of electrons over the entire target area. The electrons stop their forward motion at the surface of the glass and are turned back and focused into a five-stage signal multiplier, except when they approach the positively charged portions of the pattern on the glass. When this condition occurs, they are deposited from the scanning beam in quantities sufficient to neutralize the potential pattern on the glass. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode side. These charges neutralize each other by conductivity through the glass in less than the time of one frame.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by an external coil located at the gun end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

Multiplier Section

The return beam is directed to the first dynode of a five-stage electrostatically focused multiplier. This utilizes the phenomenon of secondary emission to amplify signals composed of electron beams. The electrons in the beam impinging on the first-dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid

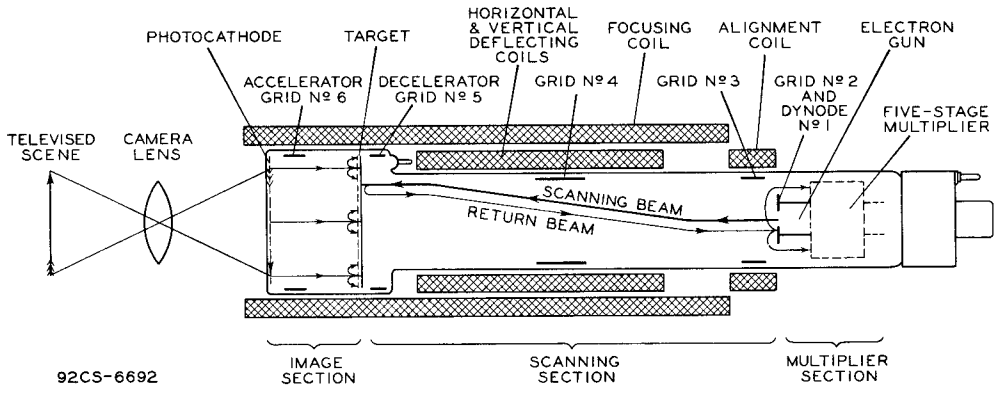


Fig. 2 - Schematic Arrangement of Type 7037.

No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No.5 are collected by the anode and constitute the current utilized in the output circuit. The multiplier section amplifies the modulated beam about 500 times. This multiplication permits the use of a video amplifier with fewer stages.

The signal-to-noise ratio of the output signal from the 7037 is high. The gain of the multiplier is such as to raise the output signal sufficiently above the noise level of the video amplifier stages so that they contribute no noise to the final video signal. The signal-to-noise ratio of the video signal, therefore, is determined only by the random variations of the modulated electron beam.

It can be seen that when the beam moves from a less-positive portion on the target to a more-positive portion, the signal-output voltage across the load resistor (R25 in Fig.3) changes in the positive direction. Hence, for highlights in the scene, the grid of the first video amplifier stage swings in the positive direction.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ±10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Anode to all other electrodes	12	μμf
Photocathode, Semitransparent:		
Response	See Fig.1	
Rectangular Image (4 x 3 aspect ratio):		
Useful size of	1.8" max. Diagonal	
Note: The size of the optical image focused on the photocathode should be adjusted so that its maximum diagonal does not exceed the specified value. The corresponding electron image on the target should have a size such that the corners of the rectangle just touch the target ring.		
Orientation of	Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through center of faceplate and pin No.7 of the shoulder base.	
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	15.20" ± 0.25"	
Greatest Diameter of Bulb	3.00" ± 0.06"	
Shoulder Base	Keyed Jumbo Annular 7-Pin	
End Base	Small-Shell Diheptal 14-Pin Base (JETEC No.B14-45)	
Operating Position	See Text	
Weight (Approx.)	1 lb 6 oz	
Minimum Deflecting-Coil Inside Diameter	2-3/8"	
Deflecting-Coil Length	5"	
Focusing-Coil Length	10"	
Alignment-Coil Length	15/16"	
Photocathode Distance Inside End of Focusing Coil	1/2"	

Maximum Ratings, *Absolute Values:*

PHOTOCATHODE:		
Voltage	-550 max.	volts
Illumination	50 max.	ft-c
OPERATING TEMPERATURE:		
Of any part of bulb	50 max.	°C
Of bulb at large end of tube (Target section)	40 min.	°C
TEMPERATURE DIFFERENCE:		
Between target section and any part of bulb hotter than target section	5 max.	°C
GRID-No.6 VOLTAGE	-550 max.	volts
TARGET VOLTAGE:		
Positive value	10 max.	volts
Negative value	10 max.	volts
GRID-No.5 VOLTAGE	150 max.	volts
GRID-No.4 VOLTAGE	300 max.	volts
GRID-No.3 VOLTAGE	400 max.	volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
ANODE-SUPPLY VOLTAGE*	1350 max.	volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	volts

Typical Operation and Characteristics Range Values:

Photocathode Voltage (Image Focus)	-400 to -540	volts
Grid-No.6 Voltage (Accelerator)-- Approx. 75% of photocathode voltage	-300 to -405	volts
Target-Cutoff Voltage○	-3 to +1	volts
Grid-No.5 Voltage (Decelerator)	0 to 125	volts
Grid-No.4 Voltage (Beam Focus)	140 to 180	volts
Grid-No.3 Voltage#	225 to 330	volts
Grid-No.2 & Dynode-No.1 Voltage	300	volts
Grid-No.1 Voltage for Picture Cutoff	-45 to -115	volts

Dynode-No.2 Voltage	600	volts
Dynode-No.3 Voltage	800	volts
Dynode-No.4 Voltage	1000	volts
Dynode-No.5 Voltage	1200	volts
Anode Voltage	1250	volts
Anode Current (DC)	30	μamp
Signal-Output Current (Peak to peak)	3 to 24	μamp
Target Temperature Range (See Text)	40 to 45	°C
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current (Approx.)	60	
Minimum Peak-to-Peak Blanking Voltage	5	volts
Field Strength at Center of Focusing Coil▲	75	gausses
Field Strength of Alignment Coil (Approx.)	0 to 3	gausses

* Ratio of dynode voltages is shown under *Typical Operation*.

° Normal setting of target voltage is +2 volts from target cutoff. The target supply voltage should be adjustable from −3 to +5 volts.

Adjust to give the most uniformly shaded picture near maximum signal.

▲ Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

INSTALLATION

The *end-base pins* of the 7037 fit the small diheptal 14-contact socket. The *annular-base pins* fit the keyed jumbo annular 7-contact socket which should be rigidly fastened to the deflecting-coil assembly.

The 7037 has two complementary guides for inserting the tube correctly in the annular socket, i.e., the large pin (No.7) on the annular base, and the white radial line on the face of the bulb. The annular socket should be positioned so that the key pin (No.7) of the annular base is in a vertical plane through the common axis of the deflecting-coil assembly and the focusing-coil assembly.

The 7037 is installed by inserting the diheptal-base end of the tube through the coil assembly and then turning the tube until the annular-base pins, keyed by pin No.7, can be inserted in the annular socket. Proper insertion aligns the white radial line on the face with center of the key-pin hole in the annular socket. The diheptal socket is then put on the 14-pin base.

Proper orientation of the annular socket with respect to the horizontal-deflecting field is essential, and is obtained when the plane which is perpendicular to the plane of the annular socket and which passes through the center of the annular socket and the center line between pins 3 and 4 of the annular base is at right angles to the horizontal scanning field. This orientation minimizes beat-pattern effects by placing the sides of the mesh holes at an angle of 45° with respect to the horizontal scanning lines.

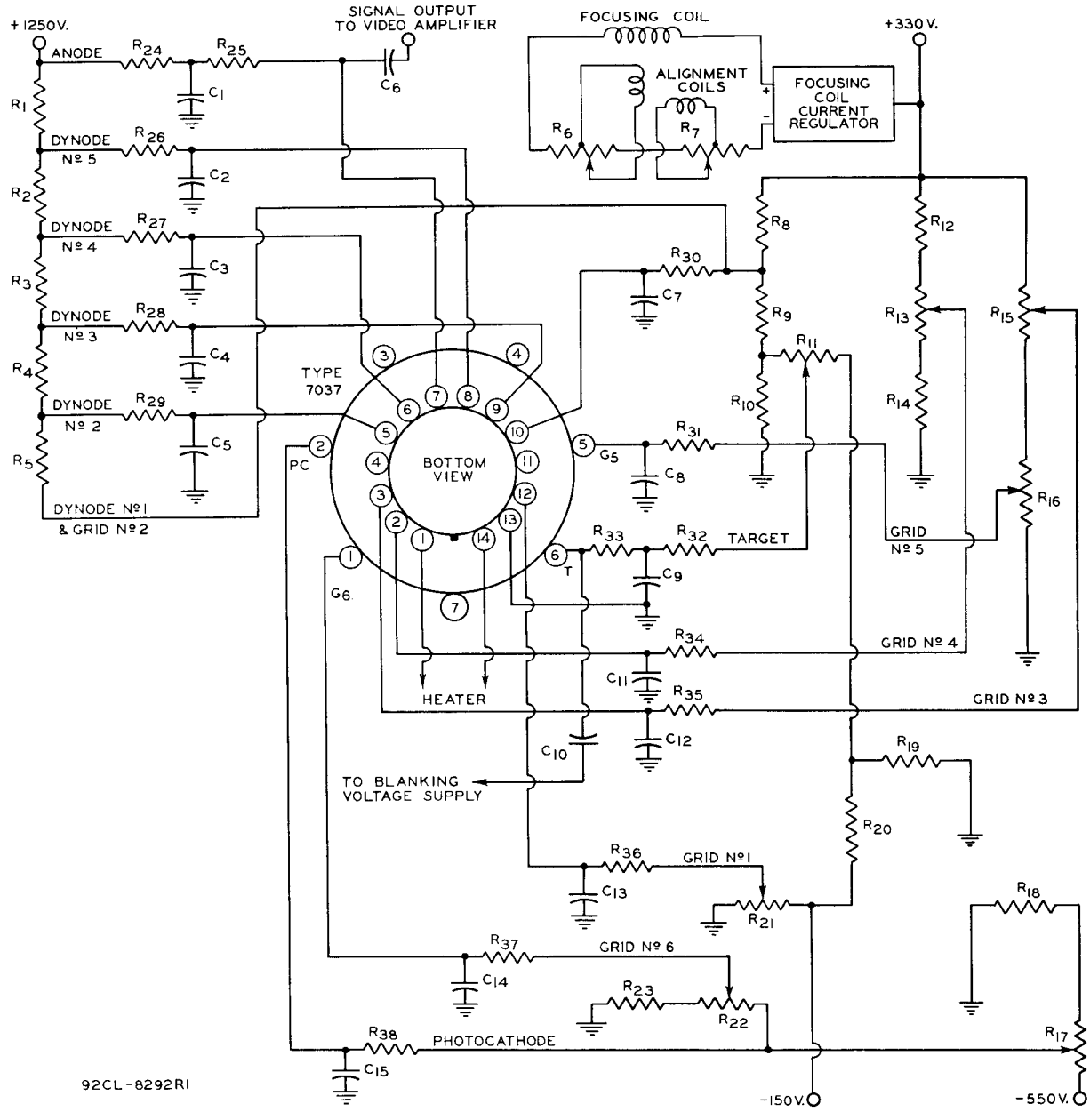
The *operating position* of the 7037 should preferably be such that any loose particles in the neck of the tube will not fall down and strike or become lodged on the target. Therefore, it is recommended that the tube never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical.

A *mask* having a diagonal or diameter of 1.8 inches should always be used on the photocathode to set limits for the maximum size of scan, and to reduce the amount of light reaching unused parts of the photocathode.

The *optical system* used with the 7037 should be designed according to basic optical principles and should incorporate an iris to control the amount of light entering the television camera lens. The entire optical system should have all inside surfaces finished in mat black to prevent internal reflections from reaching the photocathode. Under almost all conditions, the use of a lens shade is beneficial.

Proper shielding of the image section can be provided by wrapping around the outside of the focusing coil directly over the center of the deflecting coils a triple layer of Mumetal strip 0.006" thick and 5" wide, or equivalent. Then, wrap another triple layer of Mumetal strip 0.006" thick and 3" wide around the focusing coil directly over the image section of the 7037. Additional shielding is provided by fitting the inside of the focusing coil directly over the image section with a copper cylinder having a length of approximately 2-1/4" and a wall thickness of 1/32". The Mumetal shielding effectively shunts the field-rate deflection field, while the copper cylinder shields the higher frequency line-scanning field from the electron path in the image section. Unless proper shielding is provided, "cross talk" from the deflecting yoke into the image section will result in loss of picture sharpness.

For the *high dc voltages* required by the 7037, the use of two pulse supplies for which the plate voltage is provided by a well-regulated B-supply may be used. Each of these supplies should be actuated by the horizontal driving pulse which is obtained from the synchronizing generator. One of the pulse supplies should be capable of furnishing 1250 volts with an output current of 1 milliampere for the multiplier section; the other pulse supply should be capable of furnishing −550 volts with an output current of 1 milliampere for the image section. In addition to supplying the plate voltage and current for the pulse supplies, the B-supply should also provide an output current of approximately 90 milliamperes for the focusing and alignment coils and for the voltage divider which is used to supply the voltages for the electrodes in the scanning section of the 7037. Provision should be made for regulating the focusing-coil current.



C1 C2: 0.05 μf, 1600 v working voltage
C3: 0.01 μf mica, 1600 v working voltage
C4: 0.001 μf mica, 1000 v working voltage
C5: 0.001 μf mica, 600 v working voltage
C6: 0.03 μf, 1600 v working voltage. See text under *voltage divider*.
C7 C8 C9 C11 C12 C13 C14 C15: 0.001 μf mica, 400 v working voltage
C10: 1 μf, 400 v working voltage
R1: 47000 ohms, 1/2 watt
R2 R3 R4: 220000 ohms, 1/2 watt
R5: 270000 ohms, 1/2 watt
R6 R7: 200-ohm potentiometer, center-tapped, 2 watts
R8: 5100 ohms, 1/2 watt
R9: 51000 ohms, 2 watts
R10: 510 ohms, 1/2 watt
R11: 150000-ohm potentiometer, 1/2 watt
R12: 125000 ohms, 1/2 watt
R13: 75000-ohm potentiometer, 1 watt
R14: 125000 ohms, 1/2 watt
R15: 250000-ohm potentiometer, 1 watt
R16: 150000-ohm potentiometer, 1 watt
R17: 250000-ohm potentiometer, 1 watt
R18: 510000 ohms, 1 watt
R19: 11000 ohms, 1/2 watt
R20: 310000 ohms, 1/2 watt
R21: 500000-ohm potentiometer, 1 watt
R22: 250000 ohms, 1 watt
R23: 560000 ohms, 1/2 watt
R24: 47000 ohms, 1/2 watt
R25: 20000 ohms, 1/2 watt
R26 R27: 100000 ohms, 1/2 watt
R28 R29 R31 R32 R34 R35 R36 R37 R38: 200000 ohms, 1/2 watt
R30: 50000 ohms, 1/2 watt
R33: 100000 ohms, 1/2 watt

Fig. 3 – Voltage-Divider Circuit for Type 7037 with Recommended Arrangement for Connecting the Focusing Coil and Alignment Coils.

A *voltage divider* to provide the required operating voltages for the various electrodes of the 7037 is shown in Fig.3. It is to be noted that the blocking capacitor C_6 should be of sufficiently high quality so that its leakage current will not introduce disturbing effects into the picture.

In designing a voltage divider for the multiplier stages of the 7037, engineers should recognize that the dc output of individual 7037's may have a range of 10 to 1. This range, therefore, must be considered in the choice of bleeder-resistor values. If the values are too high, the distribution of voltages applied to the dynodes will be upset by a 7037 with a dc output at the upper end of the range. As a result, there will be an abrupt drop in the ac output of the tube as the beam current is increased. When this drop occurs before the beam is at its optimum value, the ratio of signal to noise will be lessened, and compression of the signal information will result.

Even with satisfactory bleeder-resistor values, it is possible to overload the tube itself. For 7037's having high dc outputs, a current reversal can occur at the 5th dynode stage of the multiplier as the beam current is increased. This current reversal will also produce a sharp drop in the ac output of the tube. To prevent such current reversal, it is recommended that provision be made to reduce the overall multiplier voltage for tubes with dc outputs at the upper end of the range. A reduction to 1000 volts should be adequate.

A *blanking signal* should be supplied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must be constant to prevent fluctuation of the target voltage. During the blanking period, the full beam current without video-signal modulation is returned to the multiplier and its multiplied output flows through the load resistance. Excessive amounts of blanking voltage applied to the target will impair resolution, since during retrace the target is out of focus to the continuously flowing photocathode current. A desirable amount of target blanking is 6 volts peak to peak.

Shading may be required even with optimum adjustment of voltage on grid No.3 in order to obtain a uniformly shaded picture. Sawtooth and parabolic waveforms of adjustable amplitude and polarity at both the vertical- and horizontal-scanning frequency should be provided for insertion in the video amplifier to aid in obtaining a flat background. The shading signal should be introduced in the amplifier after clamping is performed, since clamping circuits will remove the vertical-frequency shading component if added previous to the clamp-circuit location.

The *video amplifier* should be designed to cover a range of ac signal voltages corresponding to signal-output current of 3 to 24 microamperes peak to peak in the load resistor (R_{25} in Fig.3). For bandwidth, refer to *Resolution* under OPERATING CONSIDERATIONS.

Failure of scanning even for a few minutes when light is incident on the photocathode may permanently damage the surface of the target. The damaged area shows up as a spot or line in the picture during subsequent operation.

To avoid damaging the 7037 during scanning failure, provision should be made to prevent automatically the scanning beam from reaching the target. The scanning beam can be prevented from reaching the target by (1) cutting off the scanning beam, or (2) making the target sufficiently negative. The scanning beam can be cut off by a relay which applies -115 to -125 volts bias to grid No.1. The target can be made sufficiently negative by a relay which applies a bias of at least -10 volts to it. Either relay is actuated by a tube which is controlled by a portion of the scanning pulse voltage developed across either the horizontal or the vertical deflecting coils, or both. It is important to insure that the horizontal scanning pulse and the vertical scanning pulse should each independently actuate the relay in case either one fails.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 7037 are limiting values above which the serviceability of the 7037 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

new 7037's should be placed in service immediately upon receipt. They should be operated for several hours before being set aside as spares.

Spare 7037's should be placed in service for several hours at least once a month in order to keep them free from traces of gas which may be liberated within the tube during prolonged storage.

Occasionally, a *white spot* which does not change in size when the beam-focus voltage is varied, may be observed in the center of the picture. Such a spot, especially if it is visible on the monitor with the camera lens capped, is probably an ion spot. If the spot begins to grow in size with continuous operation, the 7037

should be removed from service at once, and returned for re-processing. Continued operation of an image orthicon with an ion spot will eventually damage the target permanently.

The *operating temperature* of any part of the glass bulb should never exceed 50°C, and no part of the bulb at the large end of the tube (target section) should ever fall below 40°C during operation. The temperature of the target is essentially the same as that of the adjacent glass bulb and can, therefore, be determined by measuring the temperature of the glass bulb adjacent to the target. For best results, it is recommended that the temperature of the entire bulb be held between 40° and 45°C. Operation at too low a temperature will be characterized by the appearance of a rapidly disappearing "sticking picture" of opposite polarity from the original when the picture is moved. Operation at too high a temperature will cause loss of resolution and possibly permanent damage to the tube. The loss of resolution is caused by the decreasing resistivity of the target glass disc with increasing temperature. As a result, lateral leakage of the image charge occurs. Resolution is regained by waiting for the temperature to drop below 50°C. *No part of the bulb should run more than 5° hotter than the target section to prevent cesium migration to the target.* Such migration will result in loss of resolution and in probable permanent damage to the tube. Like other photosensitive devices employing cesium, the 7037 may show fluctuations in performance from time to time. Strict observance of the above recommendations with respect to operating temperature will not completely eliminate these variations but will greatly improve the stability of the characteristics during the life of the tube.

When the equipment design or operating conditions are such that the maximum temperature rating or maximum temperature difference as given under *Maximum Ratings* will be exceeded, provision should be made to direct a blast of cooling air from the diheptal-base end of the tube along the entire length of the bulb surface, i.e., through the space between the bulb surface and the surrounding deflecting-coil assembly and its extension. Any attempt to effect cooling of the tube by circulating even a large amount of air around the focusing coil will do little good, but a small amount of air directly in contact with the bulb surface will effectively drop the bulb temperature. For this purpose, a small blower is satisfactory, but it should be run at low speed to prevent vibration of the 7037 and the associated amplifier equipment. Unless vibration is prevented, distortion of the picture may occur.

Ordinarily, the temperature in a camera equipped with a blower will not exceed 45°C, except in very hot weather or unless the target heater is left on accidentally for a long period.

To keep the operating temperature of the large end of the tube from falling below 45°C, some form of controlled heating should be employed. Ordinarily, adequate heat will be supplied by the focusing coil, deflecting coils, and associated amplifier tubes so that the temperature can be controlled by the amount of cooling air directed along the bulb surface. If, in special cases, a target heater is required, it should fit between the focusing coil and the bulb near the shoulder of the tube, and be non-inductively wound.

Full-size scanning of the target should always be used during on-the-air operation. Full-size scanning can be assured by first adjusting the deflection circuits to overscan the target sufficiently to cause the corners of the target to be visible in the picture, and then reducing the scanning until the corners just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. Note that overscanning the target produces a smaller-than-normal picture on the monitor.

Underscanning the target, i.e., scanning an area of the target less than its sensitive area, should never be permitted. Underscanning produces a larger-than-normal picture on the monitor. If the target is underscanned for any length of time, a permanent change in target-cutoff voltage of the underscanned area takes place with the result that the underscanned area thenceforth is visible in the picture when full-size scanning is restored.

Resolution in excess of 500 lines at the center of the picture can be produced by the 7037 when operated for color reproduction.

To utilize the resolution capability of the 7037 in the horizontal direction with the standard scanning rate of 525 lines, it is necessary to use a video amplifier having a bandwidth of at least 6 megacycles.

Even with a wide-band amplifier, the resolution may be limited in the image section by "cross-talk" caused by the scanning fields. Unless prevented by proper shielding from extending into the image section (see *Proper shielding* under INSTALLATION), these fields will cause the electron image on the target to move at scanning frequency. As a result, the picture will lack definition.

The *dynode aperture* appears as a small white spot near the center of the image of the dynode surface. The white spot is most evident when it falls within dark areas of the scene. Little defocusing of the beam is required to minimize the effect of dynode aperture when the scene is brightly illuminated, but in dark scenes, the effect of dynode aperture is a limiting item on resolution.

The *light transfer characteristics* of the 7037 change for different illumination levels (see Reference 6). The basic light transfer characteristic of the 7037 is shown in Fig.4. The light values shown are applicable only for white light incident on the photocathode. This curve is representative only for small-area highlights.

The bend or "knee" of the curve is explained by the fact that the charge accumulated by the target can not exceed the charge which raises the voltage of the target to the collector-mesh potential. As a result, when the 7037 is operated with highlights at or above the knee, not all of the secondary electrons emitted by the target glass disc are collected by the adjacent mesh. Those not collected are randomly distributed over adjacent picture areas. For black-and-white picture transmission, this random distribution is not objectionable if the image orthicon is operated so that the highlights bring the signal output only slightly above the knee. However, for color-picture transmission, any random distribution represents color dilution or contamination and, therefore, the image orthicon must be operated in such a manner that substantially all of the secondary electrons from the target are collected by the adjacent mesh.

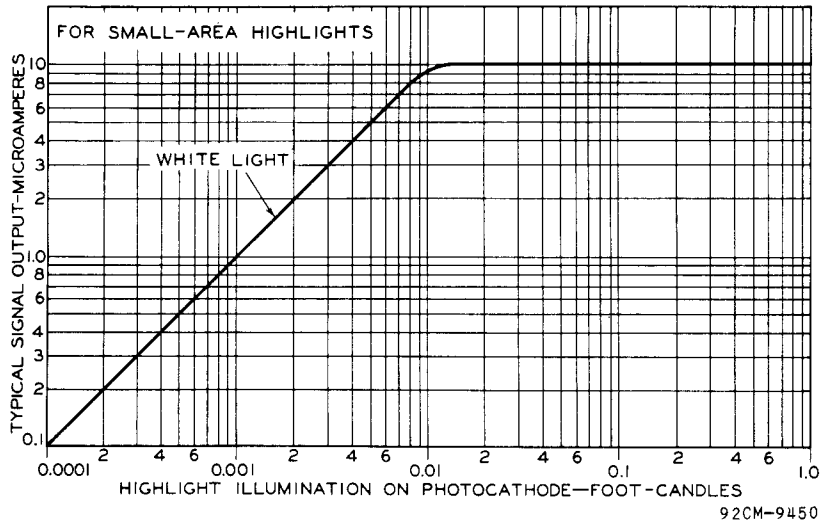


Fig.4 - Basic Light Transfer Characteristic of Type 7037.

In order to operate the 7037 in this manner which makes possible the achievement of a substantially linear transfer characteristic, it is essential that the target voltage be properly adjusted. Fig.5 shows the "knee" portion of the transfer characteristic with the 100%-signal-output level limited by the charge buildup which occurs when the target voltage is adjusted to 2 volts (see *setup procedure*). It also shows how the "knee" is straightened out to give a more accurate color picture when the target voltage is then increased to 4 volts (see *setup procedure*) while retaining the same signal-output level that was established by the 2-volt adjustment.

When the target voltage is adjusted as described above, nearly all of the secondary electrons from the target are collected by the adjacent mesh, the electrons in the scanning beam land more uniformly over the entire target area, and the prominence of after-image is reduced.

Landing of the primary electrons is more uniform because, with almost complete collection of secondary electrons by the mesh, the charge neutralized in each frame by the scanning beam will equal the charge deposited on the target by the photoelectrons. Hence, variation in target-to-mesh spacing and capacitance will not affect the signal output. Furthermore, the relatively large difference between the fixed potential of the mesh and the average potential to which the target is driven by the scanning beam reduces to a negligible value the effect of variations in target potential caused by radial- and tangential-velocity components in the scanning beam.

The prominence of after-image is greatly reduced because the potential developed across the target glass disc due to polarization becomes a much smaller percentage of the mesh potential.

The set-up procedure described below should be followed carefully to obtain optimum performance from the 7037. All three tubes in the color camera should be set up individually in accord with the prescribed procedure.

The *setup procedure* for operating the 7037 is as follows: After the tube has been inserted in its sockets and the voltages applied as indicated under *Typical Operation*, allow it to warm up for 1/2 to 1 hour with the camera lens capped. Uncap the lens momentarily while adjusting the grid-No.1 voltage to give a small amount of beam current. This procedure will prevent the mesh from being electrostatically pulled into contact with the glass disc. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the target. Adjust the deflection circuits so that the beam will "overscan" the target, i.e., so that the area of the target scanned is greater than its sensitive area. This procedure during the warming-up period is recommended to prevent burning on the target a raster smaller than that used for on-the-air operation. Note that overscanning the target results in a smaller-than-normal picture on the monitor.

With the lens still capped and the target voltage set at approximately 2 volts negative, adjust the grid-No.1 voltage until noise or a rough-textured picture of dynode No.1 appears on the monitor. Then adjust the alignment-coil current so that the small white dynode spot does not move when the beam-focus control (grid No.4) is varied, but simply goes in and out of focus. During alignment of the beam, and also during operation of the tube, always keep the beam current as low as possible to give the best picture quality and also to prevent excessive noise.

Next, uncap the lens and open the lens iris partially. Focus the camera on a test pattern. The target voltage is then advanced until a reproduction of the test pattern is just discernable on the monitor. This value of target voltage is known as the "target cutoff voltage". The target voltage should then be raised exactly two volts above the cutoff-voltage value, and the beam-current control adjusted to give just sufficient beam current to discharge the highlights.

Then adjust the lens to produce best optical focus, and the voltage on the photocathode as well as the voltage on grid No.4 to produce the sharpest picture.

At this point, attention should be given to the grid-No.5 and grid-No.3 voltage controls. Grid No.5 is used to control the landing of the beam on the target and consequently the uniformity of signal output. The grid-No.5 voltage control should be adjusted to produce a picture that has most uniform shading from center to edge with the lens iris opened sufficiently to permit operation with the highlights above the knee of the light transfer characteristic. The value of grid-No.5 voltage should be as high as possible consistent with uniform shading. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The grid-No.3 voltage control should be adjusted to produce the maximum signal output.

Now with a test pattern consisting of a straight line centered on the face of the 7037, adjust the voltage on grid No.6 along with the voltage on the photocathode to produce a sharply focused straight line on the monitor. Improper adjustment of the grid-No.6 voltage control will result in the straight-line pattern being reproduced with a slight S-shape.

The above adjustments constitute a rough setup of the 7037. Final adjustments necessary for the 7037 to produce the best possible picture for color or black-and-white transmission are as follows: With the lens capped, realign the beam. Beam alignment is necessary after each change of the grid-No.5 voltage control and sometimes after each adjustment of the grid-No.3 voltage control.

The proper illumination level for color-camera operation should next be determined. Adjust the target voltage accurately to 2 volts above the target-cutoff value. Remove the lens cap and focus the camera on a neutral (black and white) test pattern consisting of progressive tonal steps from black to white. Open the lens iris just to the point where the highest step of the test pattern does not rise as fast as the lower steps when viewed on a video waveform oscilloscope. This operating point assures that the highlights of the scene will not run above the knee of the light transfer characteristic. If the highlights run above the knee of the light transfer characteristic, color dilution or contamination will occur.

Then adjust the grid-No.1 voltage control to just discharge the brightest highlight of the pattern.

Cap the lens and adjust the grid-No.3 voltage control so that the video signal when viewed on a video waveform oscilloscope has the flattest possible trace. This represents the black level of the picture. Unwanted variations in the black level of a color picture are much more evident and objectionable than in a black-and-white picture.

From this point on, the waveform monitor for the camera should be used to determine the lens opening necessary to produce the maximum desired highlight signal as determined with the neutral step pattern.

Improved linearity of signal output and color purity can be achieved by next raising the target voltage to approximately 4 volts above the target-cutoff value. A value slightly less then 4 volts will sometimes give the desired results. A value greater than 4 volts is not recommended because any tendency toward microphonics may be enhanced. This increase in the target voltage assures

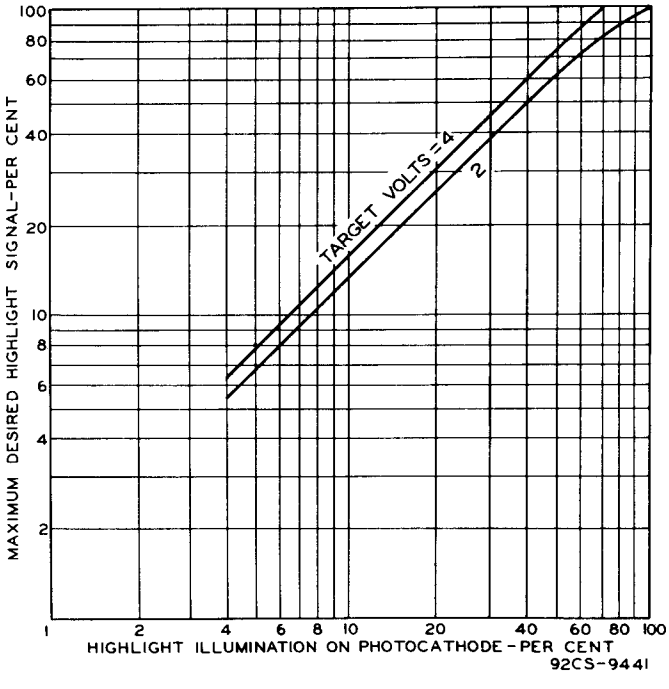


Fig. 5 - Light Transfer Characteristics of Type 7037.

nearly complete collection of the secondary electrons by the target mesh. As a result of this increase, the highlights will no longer be fully discharged by the beam as previously adjusted. DO NOT ATTEMPT TO DISCHARGE THE HIGHLIGHTS BY ADJUSTING THE GRID-No.1 VOLTAGE TO INCREASE THE BEAM CURRENT. Instead, the lens iris should be closed until the highlight signal output again

reaches the previously determined maximum-signal amplitude as measured on the waveform oscilloscope. In no case should the highlight signal output be greater than the maximum previously determined with the neutral test pattern and controlled by the iris setting. If higher signal output is obtained by increased illumination and beam current, resolution will suffer due to random attraction of the low-velocity scanning beam by the adjacent image charge, and tube life will be shortened.

Retention of a scene by the 7037, sometimes called a "sticking picture", may be observed to a slight degree even initially. However, any initial sticking will decrease during the first few hours of tube operation and then remain at an acceptable low value, or actually decrease, throughout life. Sticking may be aggravated if the 7037 is allowed to remain focused on a stationary bright scene, or if it is focused on a bright scene before reaching operating temperature in the range from 40° to 45°C. Often the retained image will disappear in a few seconds, but sometimes it may persist for long periods before it completely disappears. A retained image can generally be removed by focusing the 7037 on a clear white screen and allowing it to operate for several hours with an illumination of about 1 foot-candle on the photocathode.

To minimize retention of a scene, it is recommended that the 7037 always be allowed to warm up in the camera for 1/2 to 1 hour with the lens iris closed and with a slight amount of beam current. Never allow the 7037 to remain focused on a stationary bright scene, and never use more illumination than is necessary.

Further detailed information on use of the image orthicon in a three-tube image orthicon color camera is given in Reference 7.

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   Part III--Electro-Optical Characteristics of Camera Systems", RCA Review, September, 1948;
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DOS and DON'TS
on Use of RCA-7037

Here are the "dos"--

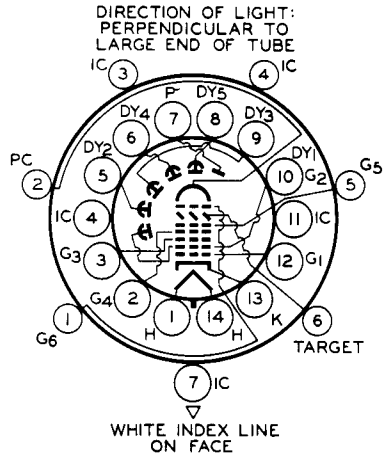
1. Allow the 7037 to warm up prior to operation.
2. Hold temperature of the 7037 within operating range.
3. Make sure alignment coil is properly aligned.
4. Adjust beam-focus control for best usable resolution.
5. Condition spare 7037's by operating several hours once each month.
6. Determine proper operating point with target voltage adjusted to exactly 2 volts above target cutoff.
7. Cap lens during standby operation.

Here are the "don'ts"--

1. Don't force the 7037 into its shoulder socket.
2. Don't operate the 7037 without scanning.
3. Don't underscan target.
4. Don't focus the 7037 on a stationary bright scene.
5. Don't operate a 7037 having an ion spot.
6. Don't use more beam current than necessary to discharge the highlights of the scene.
7. Don't turn off beam while voltages are applied to photocathode, grid No.6, target, dynodes, and anode during warmup or standby operation.

The significance of each of the above "dos" and "don'ts" in obtaining optimum performance from the 7037 is explained in the preceding pages of this bulletin.

SOCKET CONNECTIONS
Bottom View



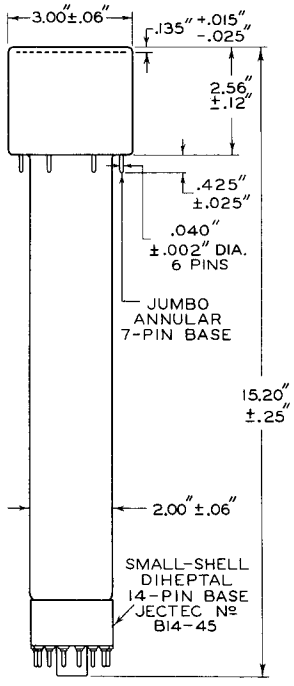
SMALL-SHELL DIHEPTAL 14-PIN BASE

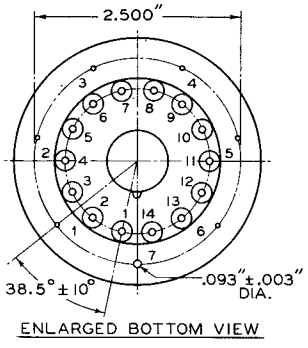
PIN 1: HEATER
PIN 2: GRID No.4
PIN 3: GRID No.3
PIN 4: INTERNAL CONNECTION--DO NOT USE
PIN 5: DYNODE No.2
PIN 6: DYNODE No.4
PIN 7: ANODE.
PIN 8: DYNODE No.5
PIN 9: DYNODE No.3
PIN 10: DYNODE No.1, GRID No.2
PIN 11: INTERNAL CONNECTION--DO NOT USE
PIN 12: GRID No.1
PIN 13: CATHODE
PIN 14: HEATER

KEYED JUMBO ANNULAR 7-PIN BASE

PIN 1: GRID No.6
PIN 2: PHOTOCATHODE
PIN 3: INTERNAL CONNECTION--DO NOT USE
PIN 4: INTERNAL CONNECTION--DO NOT USE
PIN 5: GRID No.5
PIN 6: TARGET
PIN 7: INTERNAL CONNECTION--DO NOT USE

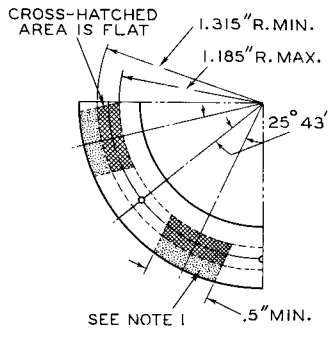
DIMENSIONAL OUTLINE





ENLARGED BOTTOM VIEW

DETAIL OF BOTTOM VIEW OF JUMBO ANNULAR BASE



NOTE 1: DOTTED AREA IS FLAT OR EXTENDS TOWARD DIHEPTAL-BASE END OF TUBE BY 0.060" MAX.

ANNULAR BASE GAUGE

ANGULAR VARIATIONS BETWEEN PINS AS WELL AS ECCENTRICITY OF NECK CYLINDER WITH RESPECT TO PHOTOCATHODE CYLINDER ARE HELD TO TOLERANCES SUCH THAT PINS AND NECK CYLINDER WILL FIT FLAT-PLATE GAUGE WITH:

a. SIX HOLES HAVING DIAMETER OF 0.065" ± 0.001" AND ONE HOLE HAVING DIAMETER OF 0.150" ± 0.001". ALL HOLES HAVE DEPTH OF 0.265" ± 0.001". THE SIX 0.065" HOLES ARE ENLARGED BY 45° TAPER TO DEPTH OF 0.047". ALL HOLES ARE SPACED AT ANGLES OF 51°26' ± 5' ON CIRCLE DIAMETER OF 2.500" ± 0.001".

b. SEVEN STOPS HAVING HEIGHT OF 0.187" ± 0.001", CENTERED BETWEEN PIN HOLES, TO BEAR AGAINST FLAT AREAS OF BASE.

c. RIM EXTENDING OUT A MINIMUM OF 0.125" FROM 2.812" DIAMETER AND HAVING HEIGHT OF 0.126" ± 0.001".

d. NECK-CYLINDER CLEARANCE HOLE HAVING DIAMETER OF 2.200" ± 0.001".

92CM-8293R3

7038

VIDICON

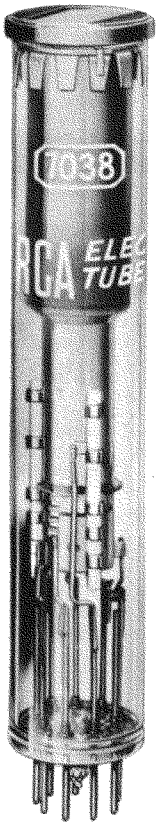
Magnetic Focus
Magnetic Deflection

For Live and Film Pickup
With Color or Black-and-White TV Cameras
600-Line Resolution

1"-Diameter Bulb
6.25" Length

TENTATIVE DATA

RCA-7038 is a small camera tube intended for use in television cameras designed for televising live scenes as well as cameras designed for film pickup. The 7038 is particularly suitable for use in compact color television cameras utilizing the method of simultaneous pickup of the live or film subjects to be televised. This method employs three 7038's--one for each channel--to produce the information necessary for the formation of a color television image. In either color or black-and-white service, the 7038 can provide a picture of high quality for broadcasting or industrial television applications. Its resolution capability is about 600 television lines.



The 7038 utilizes a unique photoconductive surface having uniform thickness which permits constant voltage gradient and uniform dark current across the scanned area. Because of the uniform thickness of its photoconductive surface, the 7038 can produce substantially uniform sensitivity over the entire scanned area. Therefore, the 7038 exhibits a degree of uniformity of characteristics from tube to tube that makes it possible to obtain excellent color uniformity and balance when used in three-vidicon color cameras. While dark current and sensitivity both increase with target voltage, the uniformity of the dark current makes it possible to operate the 7038 at higher values of target voltage and dark current than are permissible with previous types of vidicons. As a result, higher effective sensitivity can be obtained with the 7038.

Featured in the design of the 7038 are nonmagnetic materials in the front end, an extremely flat faceplate free from optical distortion, and an envelope without a side tip. The elimination of magnetic materials from the front end and the use of an optically flat faceplate make it easier to register three pictures when these tubes are used in three-vidicon color cameras. The tipless envelope allows the use of a longer deflecting yoke. The longer yoke offers the advantage of less deflecting power, and a narrower deflecting angle which effectively reduces deflection distortion and improves the center-to-edge focus of the beam. In addition, the tipless structure simplifies the layout of optical arrangements for light splitting in a color camera.

Full advantage of the uniform photoconductive layer of the 7038, particularly in film-pickup applications, may be realized by applying a modulating voltage of suitable waveform to the cathode, grid No.1, and grid No.2 in order to correct for the scanning-beam landing errors introduced by the deflecting and focusing fields.

PRINCIPLES OF OPERATION

The structural arrangement of the 7038, shown in Fig.1, consists of a target composed of a transparent conducting film (the signal electrode) on the inner surface of the faceplate and a thin photoconductive layer deposited on the film; a fine mesh screen (grid No.4) located adjacent to the photoconductive layer; a beam-focusing electrode (grid No.3) connected to grid No.4; and an electron gun for producing a beam of electrons.

Each element of the photoconductive layer is an insulator in the dark but becomes slightly conductive when it is illuminated and acts like a leaky capacitor having one plate at the positive potential of the signal electrode and the other floating. When light from the scene

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or film being televised is focused on the photoconductive-layer surface next to the faceplate, each illuminated layer element conducts slightly depending on the amount of illumination on the element and thus causes the potential of its opposite surface (on the gun side) to rise in less than the time of one frame toward that of the signal-electrode potential. Hence, there appears on the gun side of the entire layer surface a positive potential pattern, composed of the various element potentials, corresponding to the pattern of light imaged on the layer.

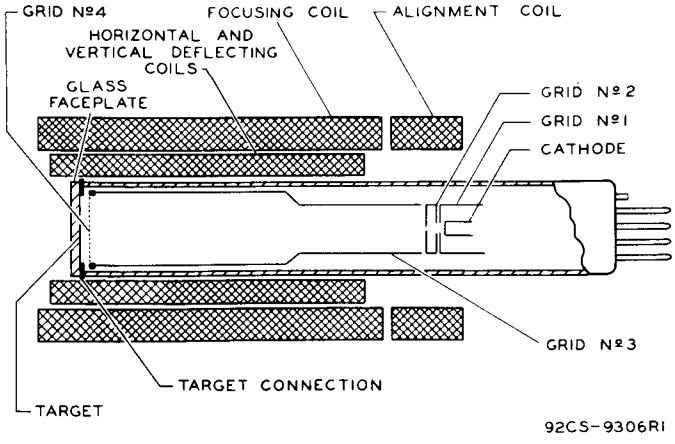


Fig. 1 - Schematic Arrangement of Type 7038.

The gun side of the photoconductive layer is scanned by a low-velocity electron beam produced by the electron gun. This gun contains a thermionic cathode, a control grid (grid No. 1), and an accelerating grid (grid No. 2). The beam is focused at the surface of the photoconductive layer by the combined action of the uniform magnetic field of an external coil and the electrostatic field of grid No. 3. Grid No. 4 serves to provide a uniform decelerating field between itself and the photoconductive layer so that the electron beam will tend to approach the layer in a direction perpendicular to it--a condition necessary for driving the surface to cathode potential. The beam electrons approach the layer at low velocity because of the low operating potential of the signal electrode.

When the gun side of the photoconductive layer with its positive potential pattern is scanned by the electron beam, electrons are deposited from the beam until the surface potential is reduced to that of the cathode, and thereafter are turned back to form a return beam which is not utilized. Deposition of electrons on the scanned surface of any particular element of the layer causes a change in the difference of potential between the two surfaces of the element. When the two surfaces of the element, which in effect is a charged capacitor, are connected through the external target (signal-electrode) circuit and the scanning beam, a capacitive current is produced and constitutes the video signal. The magnitude of the current is proportional to the surface potential of the element being scanned and to the rate of scan. The video-signal current is then used to develop a signal-output voltage across a load resistor. The signal polarity is such that for highlights in the image, the grid of the first video-amplifier tube swings in a negative direction.

Alignment of the beam is accomplished by a transverse magnetic field produced by external coils located at the base end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	amp
Direct Interelectrode Capacitance:		
Target to all other electrodes	4.6	μμf
Spectral Response	See curves in Fig. 12	
Photoconductive Layer:		
Maximum useful diagonal of rectangular image (4 x 3 aspect ratio)	0.62	inch
Orientation of quality rectangle--Proper orientation is obtained when the horizontal scan is essentially parallel to the straight sides of the masked portions of the faceplate. The straight sides are parallel to the plane passing through the tube axis and short index pin. The masking is for orientation only and does not define the proper scanned area of the photoconductive layer.		
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	6.25" ± 0.25"	
Greatest Diameter	1.125" ± 0.010"	
Bulb	T8	
Base	Small-Button Ditetrar 8-Pin (JETEC No. E8-11)	
Socket	Cinch No. 54A18088, or equivalent	
Operating Position	Approx. horizontal, or faceplate up	
Weight (Approx.)	2 oz	

Maximum Ratings, *Absolute Values:*

For scanned area of 1/2" x 3/8"

GRID-No. 3 & GRID-No. 4 VOLTAGE	350 max.	volts
GRID-No. 2 VOLTAGE	350 max.	volts
GRID-No. 1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
DARK CURRENT	0.25 max.	μa
PEAK TARGET CURRENT	0.55 max.	μa
FACEPLATE:		
Illumination	1000 max.	ft-c
Temperature	60 max.	°C

Typical Operation:

For scanned area of 1/2" x 3/8"
Faceplate temperature of 30° to 35° C

Grid-No. 4 (Decelerator) & Grid-No. 3 (Beam-Focus Electrode*) Voltage	250□ to 300	volts

Grid-No.2 (Accelerator) Voltage. .	300	volts
Grid-No.1 Voltage for Picture Cutoff●	-45 to -100	volts
Average "Gamma" of Transfer Characteristic for signal-output current between 0.02 μa and 0.2 μa	0.65	
Visual Equivalent Signal-to-Noise Ratio (Approx.)○	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No.1. . . .	75	volts
When applied to cathode.	20	volts
Field Strength at Center of Focusing Coil (Approx.).	40	gausses
Field Strength of Adjustable Alignment Coil⊕.	0 to 4	gausses

Maximum-Sensitivity Operation for Live-Scene Pickup

Faceplate Illumination (Highlight)	2	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.2 μa in Any Tube**.	110	volts
Target Voltage†.	60 to 100	volts
Dark Current▲.	0.2	μa
Target Current (Highlight)■. . . .	0.4 to 0.5	μa
Signal-Output Current:#		
Peak	0.2 to 0.3	μa
Average.	0.08 to 0.1	μa

Average-Sensitivity Operation for Live-Scene Pickup

Faceplate Illumination (Highlight)	15	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.02 μa in Any Tube**.	60	volts
Target Voltage†.	30 to 50	volts
Dark Current	0.02	μa
Target Current (Highlight)■. . . .	0.3 to 0.4	μa
Signal-Output Current:#		
Peak	0.3 to 0.4	μa
Average.	0.1 to 0.2	μa

Minimum-Lag Operation for Film Pickup

Faceplate Illumination (Highlight)	100	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.004 μa in Any Tube**.	30	volts
Target Voltage†.	15 to 25	volts
Dark Current	0.004	μa
Target Current (Highlight)■	0.3 to 0.4	μa
Signal-Output Current:#		
Peak	0.3 to 0.4	μa
Average.	0.1 to 0.2	μa

● This capacitance, which effectively is the output impedance of the 7038, is increased when the tube is mounted in the deflecting-yoke and focusing-coil assembly. The resistive component of the output impedance is in the order of 100 megohms.

* Beam focus is obtained by combined effect of grid-No.3 voltage which should be adjustable over indicated range, and a focusing coil having an average field strength of 40 gausses.

□ Definition, focus uniformity, and picture quality decrease with decreasing grid-No.4 and grid-No.3 voltage. In general, grid No.4 and grid No.3 should be operated above 250 volts.

● With no blanking voltage on grid No.1.

○ Measured with high-gain, low-noise, cascode-input-type amplifier having bandwidth of 5 Mc. Because the noise in such a system is predominately of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of highlight video-signal current to rms noise current, multiplied by a factor of 3.

⊕ The alignment coil should be located on the tube so that its center is at a distance of 3-11/16 inches from the face of the tube, and be positioned so that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil.

† Indicated range for each type of service serves only to illustrate the operating target-voltage range normally encountered.

** The target voltage for each 7038 must be adjusted to that value which gives the desired operating dark current.

▲ The deflecting circuits must provide extremely linear scanning for good black-level reproduction. Dark-current signal is proportional to the scanning velocity. Any change in scanning velocity produces a black-level error in direct proportion to the change in scanning velocity.

■ Video amplifiers must be designed properly to handle target currents of this magnitude to avoid amplifier overload or picture distortion.

\# Defined as the component of the target current after the dark-current component has been subtracted.

OPERATING CONSIDERATIONS

The *maximum ratings* shown for the 7038 are limiting values above which its serviceability may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

In the *handling* of the 7038, precautions should be taken to keep the tube in a vertical position with the faceplate up. This procedure will prevent any loose particles in the tube from causing possible damage to the photoconductive layer.

The *base pins* of the 7038 fit the ditetrar 8-pin connector, such as Cinch No.54A18088*, or equivalent.

The *target connection* is made by a suitable spring contact bearing against the edge of the metal ring at the face end of the tube. This spring contact may conveniently be provided as part of the focusing-coil design.

Support for the 7038 is provided by a suitable spring-finger suspension at the face end of the tube and by a clamping mechanism near the base end. Orientation of the 7038 in its support should be such that the horizontal scan is essentially parallel to the straight sides of the masked portions of the faceplate. The straight sides are parallel to the plane passing through the tube axis and short index pin.

The *optical system* associated with the 7038 should be of high quality and provide depth of focus sufficient to focus a sharp image on the photoconductive layer.

The *deflecting yoke* and *focusing coil* should extend 1/4 to 1/2 inch beyond the faceplate of the tube, as shown in Fig.1. A long yoke, in comparison with a short yoke, not only requires

* Made by Cinch Manufacturing Corporation, 1026 S. Homan Ave., Chicago 24, Illinois.

less deflecting power but also deflects the beam through a narrower angle which effectively gives better center-to-edge focus and reduces geometric distortion of the image. Freedom from such distortion is particularly important

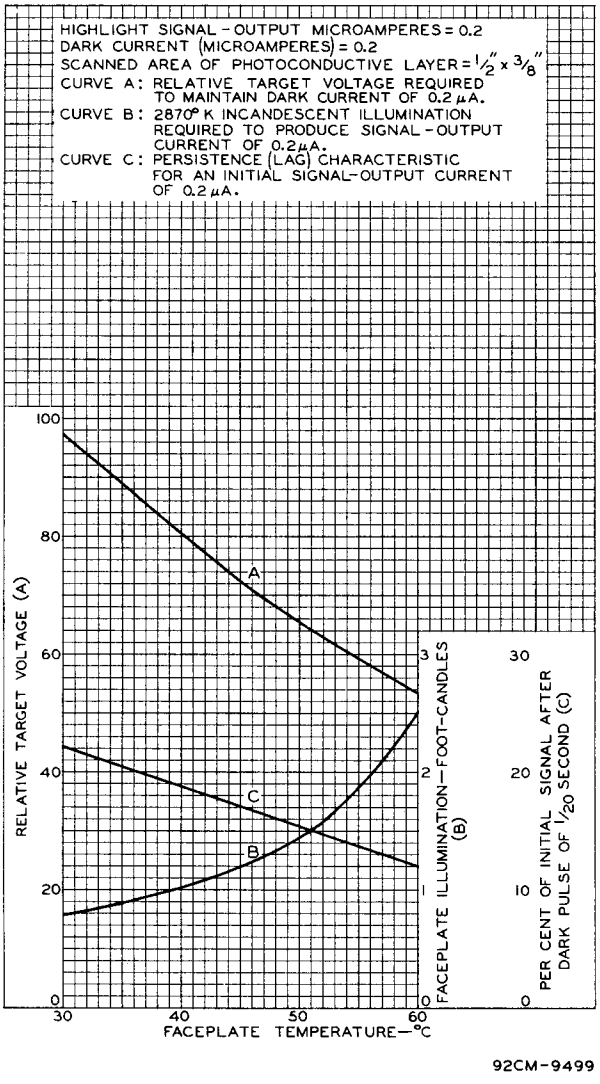


Fig. 2 - Typical Characteristics of Type 7038.

in color cameras utilizing the method of simultaneous pickup in which three images must be identical for proper registration of the three video signals.

The yoke should be positioned so that the end of the deflecting coils toward the base of the tube will not extend more than 3-1/2 inches from the faceplate.

The *scanning speed* must be constant in order to obtain good black-level reproduction when the 7038 is operated at high dark current with resultant higher effective sensitivity. The dark-current signal is proportional to the scanning speed. Therefore, any change in scanning speed will produce a nonuniformity in black level in direct proportion to the change in scanning speed.

The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

The *alignment coil* should be located on the tube so that its center is at a distance of 3-11/16 inches from the face of the tube, and be positioned so that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil.

Electrostatic shielding of the target from external fields is required to prevent interference effects in the picture. Effective shielding from the fields produced by the deflecting components is ordinarily provided by grounding a shield on the inside of the faceplate end of the focusing coil and by grounding a shield on the inside of the deflecting yoke at a point near the input of the video amplifier.

The *temperature of the faceplate* should not exceed 60° C (140° F), either during operation or storage of the 7038. Operation with a faceplate temperature in the range from about 25° to 35° C (77° to 99° F) is recommended. The temperature of the faceplate is determined by the combined heating effects of the incident illumination on the faceplate, the associated components, and the tube itself. To reduce these heating effects in film-pickup cameras and permit operation in the preferred temperature range with a high value of illumination, the use of an infrared filter between the projector and faceplate as well as a blast of cooling air directed aross the faceplate from a blower is recommended.

The dark current is doubled for every 10° C rise in the temperature of the faceplate, and halved for every 10° C decrease in the temperature of the faceplate. To obtain optimum performance, it is desirable to operate the 7038 at a pre-established value of dark current. Therefore, if the temperature of the faceplate is allowed to vary it will be necessary to adjust the target voltage to maintain the desired dark current, as shown in Fig. 2. Since the sensitivity of the tube decreases with increasing temperature, the amount of faceplate illumination necessary to produce a given signal as a function of faceplate temperature is also shown in Fig. 2. In addition, the lag will decrease with increasing temperature as shown in Fig. 2. For live pickup, it is desirable to select an operating temperature which provides the best balance between lag and sensitivity. The faceplate should be held close to this temperature to assure stability of black level and signal-output level.

The *target voltage* should be obtained from an adjustable dc source. As the target voltage is increased, the dark current increases as shown in

Fig.3. The target voltage must be adjusted to produce the desired value of dark current depending on the type of operation. *It should be noted that individual 7038's may operate with the same value of dark current and have identical performance characteristics, but each may require a different value of target voltage. The difference may be as much as 2 to 1, as shown in Fig.4.* For proper adjustment of the target voltage on each 7038, see *sequence of adjustments* on page 9.

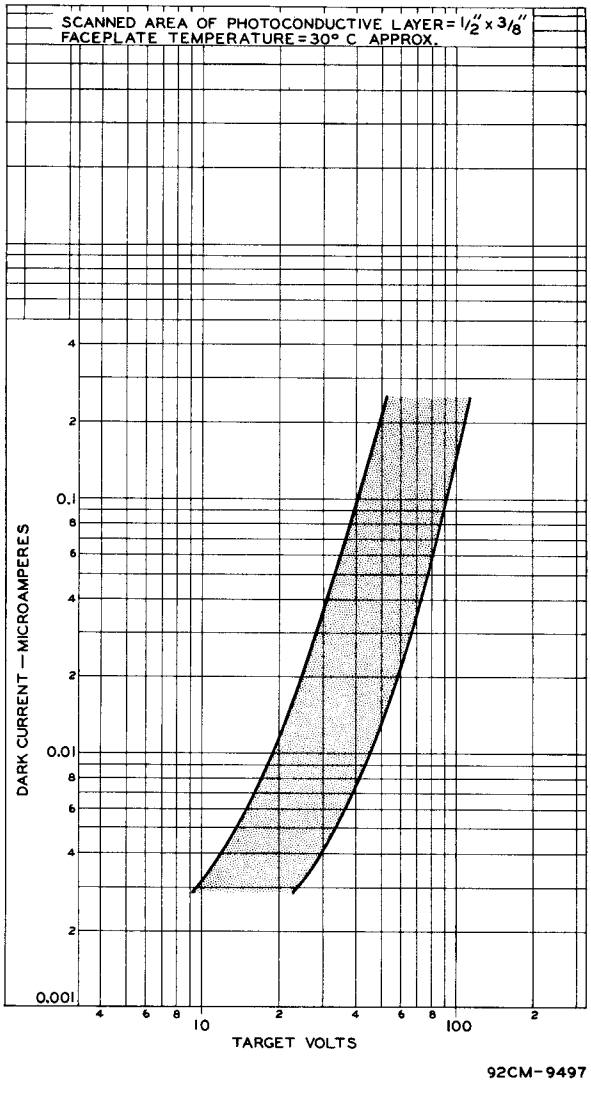


Fig.3 - Range of Dark Current for Type 7038.

The target voltage required for a particular type of operation may change gradually during the life of the tube. Therefore, it will be necessary to check this adjustment periodically. The equipment designer should make the target-voltage supply adjustable to provide means to compensate for any such change.

The *focusing-electrode (grid No.3) voltage* may be fixed at a value of about 280 volts when focusing control is obtained by adjusting the current through the focusing coil. In general, resolution decreases with decreasing grid-No.3 voltage. Operation at a grid-No.3 voltage below 250 volts is not recommended. The necessary range of current adjustment will depend on the design of the coil, but should be such as to provide a field-strength range of 36 to 44 gausses. When it is desired to use a fixed value of focusing-coil current capable of providing a fixed strength of 40 gausses at the center of the focusing device, the grid-No.3 voltage should be adjustable over a range from 250 to 300 volts.

Definition, focus uniformity, and picture quality decrease with decreasing grid-No.4 and grid-No.3 voltage. In general, grid No.4 and grid No.3 should be operated above 250 volts.

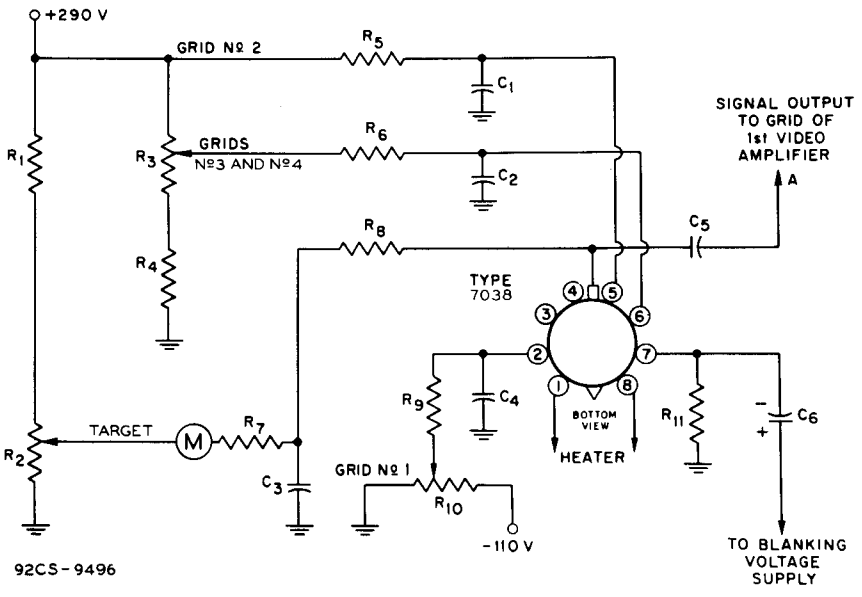
The *grid-No.1 voltage* should be adjustable from 0 to -110 volts.

The *dc voltages* required by the 7038 can be provided by the circuit shown in Fig.4.

A *blanking signal* should be supplied to grid No.1 or to the cathode to prevent the electron beam from striking the photoconductive layer during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the reproduced picture. The blanking signal is a series of negative voltage pulses when it is applied to grid No.1, or a series of positive voltage pulses when it is applied to the cathode.

Beam intensity is controlled by the amount of negative voltage on grid No.1. The beam must have adequate intensity to drive the highlight elements of the photoconductive-layer surface to cathode potential on each scan. When the beam has an intensity sufficient only to drive the lowlight elements to cathode potential, the highlight elements are not returned to cathode potential. As a result, the picture highlights all have the same brightness and show no detail. Also, when the beam has insufficient intensity, the photoconductive-layer surface which normally rises in potential by only a small fraction of the signal-electrode potential during each scan, gradually rises in potential to a value approaching nearly the full signal-electrode potential in the highlights. Under this condition, many scans are required to drive to cathode potential any element which has changed from a highlight to a lowlight because of movement of the image. As a result, the highlights tend to "stick". The loss of highlight detail and sticking of the highlights is referred to as "bloom".

On the other hand, a beam with excessively high intensity should not generally be used because the size of the scanning spot increases with resultant decrease in resolution.



C1 C4: 0.1 μf, 300 volts (working voltage)
C2: 0.1 μf, 300 volts (working voltage)
C3 C5: 0.1 μf, 200 volts (working voltage)
C6: 4 μf, electrolytic, 300 volts (working voltage)
M: Target-Current Meter, RCA Ultra-sensitive Microammeter WV-84B, or equivalent

R1: 120000 ohms, 1/2 watt
R2: 100000-ohm potentiometer, 2 watts
R3: 50000-ohm potentiometer, 2 watts
R4: 70000 ohms, 1/2 watt
R5: 5000 ohms, 1/2 watt
R6: 10000 ohms, 1/2 watt
R7: 200000 ohms, 1/2 watt
R8: 50000 ohms, 1/2 watt, non-inductive
R9: 100000 ohms, 1/2 watt
R10: 500000-ohm potentiometer, 2 watts
R11: 1000 ohms, 1/2 watt, non-inductive

Fig.4 - Typical Voltage Dividers for Supplying DC Electrode Voltages to Type 7038.

The *video amplifier system* should be designed to handle peak ac voltages corresponding to a highlight target current of 0.5 microampere through the target load resistor. Such a system is shown by the block diagram in Fig.5 (a). This system employs a low-noise, cascode preamplifier having an 8-Mc bandwidth as shown in Fig.5 (b).

Aperture correction compensates for the aperturing effect of the scanning beam in the 7038. This effect produces a horizontal square-wave response shown by the "uncompensated" curve in Fig.6. When this effect is compensated, the horizontal square-wave response of the video system is raised to approximately 100 per cent over the entire broadcast bandwidth of 4.5 Mc, and is shown by the "compensated" curve in Fig.6. This compensation, however, does not affect the vertical resolution. Combining the compensated horizontal resolution and the uncorrected vertical resolution yields the equivalent square-wave response which is shown in Fig.6 and is expressed by the equation

$$\text{Equiv. Square-Wave Response} = \sqrt{R_v \times R_h}$$

where R_v and R_h are the vertical square-wave response and the horizontal square-wave response, respectively.

The *illumination* incident on the faceplate will range from relatively high values for film pickup to relatively low values for direct pickup. For satisfactory operation of the 7038 at these extremely different light levels, it is essential that the target voltage be properly adjusted with reference to the curves in Figs.7, 8, and 11 to give the proper value of dark current for the desired service. Adjustment of the target voltage to obtain the desired dark current, is covered in *sequence of adjustments* on page 9.

For *live pickup involving low illumination levels*, a good picture can be obtained with a highlight illumination of 1 to 3 foot-candles on the faceplate of the 7038. Such a low illumination level, however, requires maximum-sensitivity operation of the 7038. For this type of operation, a dark current of 0.2 microampere is required. This value will be obtained for a target voltage within the range of 60 to 100 volts. Under such low-level illumination conditions, the lag will be somewhat greater and the black-level uniformity will be somewhat poorer than for live-pickup conditions with higher faceplate illumination and lower dark current.

When the 7038 is used for live pickup with illumination levels of 10 to 20 foot-candles on the faceplate, a dark current of 0.02 microampere is required. This value will be obtained for a target voltage within the range of 30 to 50 volts.

For *film pickup*, an average highlight illumination of 50 to 200 foot-candles is required on the faceplate of the 7038 for minimum lag and best black-level uniformity. For this range of illumination, a dark current of about 0.004 microampere is required, and the target voltage will range between 15 and 25 volts.

The exact value of target voltage to give the required dark current will depend on the individual tube and on the temperature at which its faceplate is operated. It is important that the tube be allowed to reach a stable operating temperature before the operating dark current is determined; otherwise the dark current will change as the temperature of the tube changes.

In all cases, the illumination level and/or dark current must be limited or adjusted so that the peak signal-output current does not exceed

those values shown under Typical Operation. In order that the signal-output current and dark current will be known at all times, it is recommended that the camera be provided with a suitable microammeter in the target circuit of each 7038 for each 7038. From these curves, it will also be noted that the illumination must be increased about 30 times to produce an increase of 10 times in signal-output current for any given value of dark current.

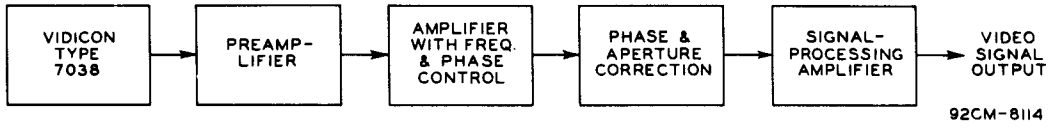
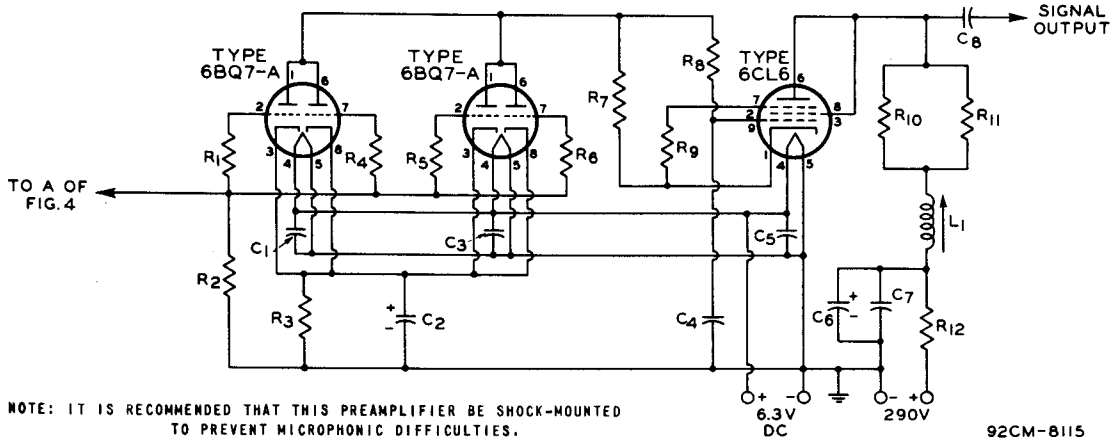


Fig. 5 (a) - Block Diagram of Video System.



NOTE: IT IS RECOMMENDED THAT THIS PREAMPLIFIER BE SHOCK-MOUNTED TO PREVENT MICROPHONIC DIFFICULTIES.

All capacitor voltages are working values

C1 C3 C5: 0.01 μf, 100 volts
C2: 2000 μf, electrolytic, 3 volts
C4: 0.01 μf, 350 volts
C6: 90 μf, electrolytic, 350 volts
C7: 0.1 μf, 350 volts
C8: 0.1 μf, 300 volts
L1: 12 μh peaking coil, adjustable core to cover range from 9 to 15 μh

All resistors are of the carbon-composition type

R1 R4 R5 R6: 100 ohms, 1/2 watt
R2: 500000 ohms, 1/2 watt
R3: 15 ohms, 1/2 watt
R7: 12 ohms, 1/2 watt
R8: 100000 ohms, 1/2 watt
R9: 1 megohm, 1/2 watt
R10 R11: 1800 ohms, 2 watts
R12: 470 ohms, 2 watts

Fig. 5 (b) - Low-Noise Cascode Preamplifier Having 8-Mc Bandwidth.

to read average target current, or that a calibration pulse of the proper magnitude be fed into the input of the video preamplifier to indicate peak target currents.

The maximum amount of illumination on the photoconductive layer is limited primarily by the temperature of the faceplate which should never exceed 60° C and should preferably be maintained within the operating range from 25° C to 35° C for most satisfactory performance.

Signal Output and Light Transfer Characteristics. Typical signal output as a function of uniform 2870° K tungsten illumination on the photoconductive layer for different values of dark current is shown in Fig. 8. It is to be noted that these curves are for a typical 7038 under the conditions indicated. Because the target voltage needed to give maximum sensitivity at a dark current of 0.2 microampere may range between 60 and 100 volts, it is essential that the best operating target voltage be determined

The average "gamma", or slope, of the light transfer characteristic curves shown in Fig. 8 is approximately 0.65. This value is relatively constant over an adjustment range of 4 to 1 in target voltage, or 50 to 1 in dark current, for a signal-output current range between 0.01 and 0.3 microampere. Close uniformity in the value of gamma between individual 7038's is maintained to insure satisfactory operation of color cameras in which the signal-output currents of the three 7038's must match closely over a wide range of scene illumination. Because its transfer characteristic is approximately the complement of the transfer characteristic of a picture tube, the 7038 can produce a picture having proper tone rendition.

Uniform sensitivity over the scanned area of the 7038 can be achieved by compensating for the beam landing errors that are introduced by the deflecting and focusing components used with the tube. Without compensation for these errors,

variations in sensitivity over the scanned area will occur. These variations resulting from beam landing errors are in the form of lower signal from the edges of the scanned area than from the center. However, because of the uniformity of the photoconductive layer, these variations in sensitivity are the same from tube to tube. Compensation for the beam landing errors to achieve uniform sensitivity can be obtained by supplying a modulating voltage of a suitable waveform to the cathode of the 7038. The desired waveform is parabolic in shape and of such a polarity that the cathode voltage is lowered as the beam approaches the edges of the scanned area. The modulating waveform should contain parabolic components of both the horizontal and vertical scanning frequencies. The horizontal component should have the greater amplitude and will be the most effective in obtaining uniform sensitivity.

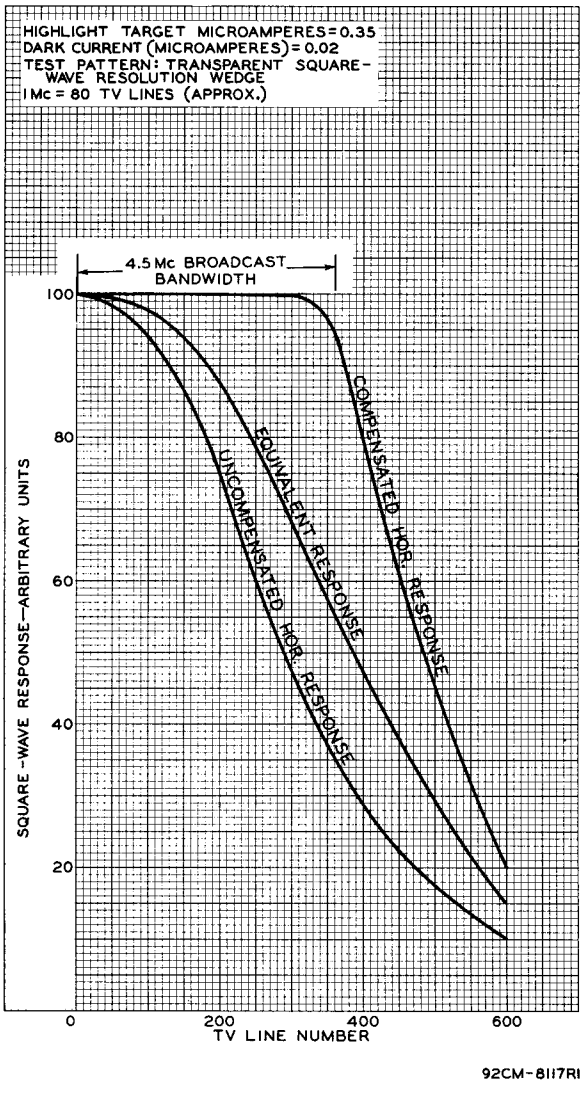


Fig. 6 - Curves Showing Uncompensated Horizontal Square-Wave Response of Type 7038 as well as Compensated Horizontal Square-Wave Response and Equivalent Square-Wave Response of the Video System Including Type 7038.

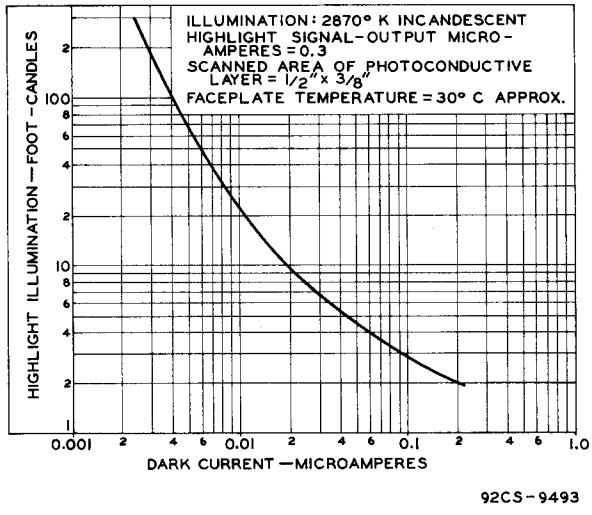


Fig. 7 - Typical Characteristic of Type 7038.

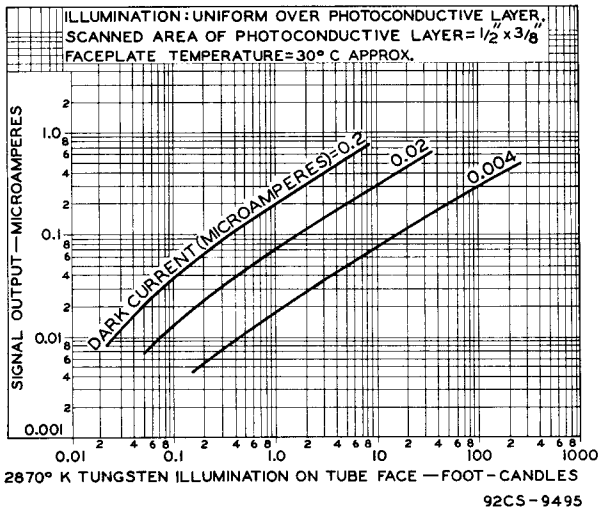
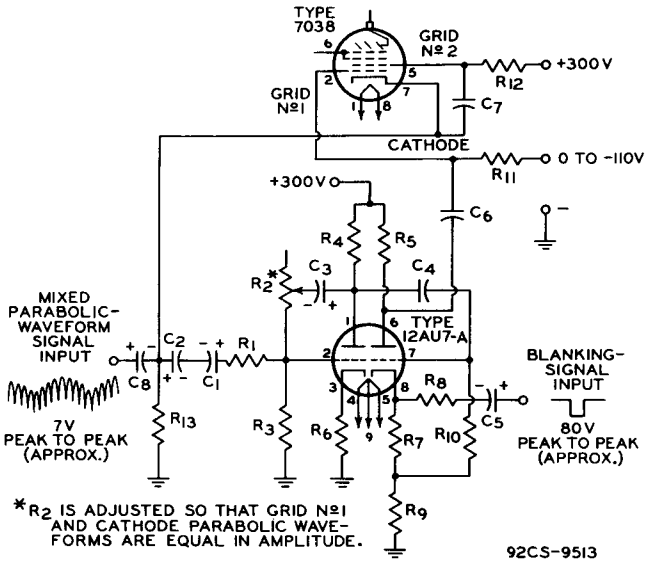


Fig. 8 - Light Transfer Characteristics of a Typical 7038 Vidicon.

The circuit of Fig. 9 shows the amount of parabolic-waveform voltage required and the method of applying the waveform to the cathode, grid No. 1, and grid No. 2 of a 7038 which utilizes a deflecting-yoke and focusing-coil system of conventional design. The modulating voltage is applied to grid No. 1 and grid No. 2 as well as to the cathode to prevent modulation of the scanning beam.

The use of this modulating waveform also improves the center-to-edge focus of the vidicon

and assures that sensitivity over the scanned area will be uniform for the recommended dark current for any specific service. Care must be taken that identical waveforms are applied to electrodes of each of the three tubes when using



All capacitor voltages are working values

C1 C2: 8 μf, electrolytic, 25 volts
C3: 8 μf, electrolytic, 450 volts
C4: 0.1 μf, paper tubular, 400 volts
C5: 8 μf, electrolytic, 450 volts
C6: 1 μf, paper tubular, 400 volts
C7: 30 μf, electrolytic, 450 volts
C8: 125 μf, electrolytic, 350 volts

All resistors are of the carbon-composition type

R1: 10000 ohms, 1/2 watt
R2: 50000 ohm-potentiometer, linear taper
R3: 1 megohm, 1/2 watt
R4: 20000 ohms, 1 watt
R5: 10000 ohms, 1 watt
R6: 1000 ohms, 1/2 watt
R7: 1800 ohms, 1/2 watt
R8: 10000 ohms, 1/2 watt
R9: 8200 ohms, 1 watt
R10: 1 megohm, 1/2 watt
R11: 100000 ohms, 1/2 watt
R12: 5100 ohms, 1/2 watt
R13: 1000 ohms, 1/2 watt

Fig. 9 - Typical Circuit for Applying Waveform to Compensate for Beam Landing Errors in Type 7038.

the 7038 in 3-vidicon color cameras to insure good registration of all signals over the entire scanned area.

Persistence or lag of the photoconductive layer is given in Fig. 10 for two values of dark current. Each curve shows the decay in signal-output current from an initial value of 0.3 microampere after the illumination is cut off. The effect of faceplate temperature on persistence is shown in Fig. 2.

Persistence of the photoconductive layer for different values of dark current is given by the curve in Fig. 11. It is to be noted that the initial signal-output current is held constant for each value of dark current. This curve shows decreasing lag with decreasing dark current, and a small value of lag for the low value of dark current recommended for film pickup.

Signal-output-current buildup when light is applied to the photoconductive layer previously in the dark is as fast or faster than the rate of decay.

The *spectral response* of the 7038 is shown by curves A and C in Fig. 12. Curve A is on the basis of equal values of signal-output current at all wavelengths, whereas curve C is on the basis of equal values of signal-output current with radiant flux from a tungsten source at 2870° K. For comparison purposes, the response of the eye is shown in curve B.

Full-size scanning of the 1/2" x 3/8" area of the photoconductive layer should always be used. This condition can be assured by first adjusting the deflection circuits to overscan the photoconductive layer sufficiently so that the edges of the sensitive area can be seen on the monitor. Then, after centering the image on the sensitive area (see Fig. 13), reduce scanning until the edges of the image just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. It should be noted that overscanning the photoconductive layer produces a smaller-than-normal picture on the monitor.

Underscanning of the photoconductive layer, i.e., scanning an area of the layer less than 1/2" x 3/8", should never be permitted. This condition which produces a larger-than-normal picture on the monitor, not only causes sacrifice in signal-to-noise ratio and resolution, but also may cause permanent change in sensitivity and dark current of the underscanned area. An underscanned area showing such a change will be visible in the picture when full-size scanning is restored.

Failure of scanning even for a few seconds may permanently damage the photoconductive layer. The damaged area shows up as a spot or line in the picture during subsequent operation. To avoid damaging the 7038 during scanning failure, it is necessary to prevent the scanning beam from reaching the layer. The scanning beam can conveniently be prevented from reaching the layer by increasing the grid-No. 1 voltage to cutoff.

The *sequence of adjustments* in operating the 7038 for live pickup is as follows: With the Grid-No. 1 Voltage Control set for maximum negative bias (beam cutoff), Target Voltage Control set for the minimum voltage shown under *Typical Operation*, and Deflection Controls set for maximum overscan, apply other voltages to the 7038 as indicated under *Typical Operation*.

Next, with a 1/2" x 3/8" mask centered on the face of the tube, and with the iris set for minimum opening, decrease the grid-No. 1 bias to just bring out the highlight details of the

picture on the monitor. Adjust the Beam-Focus Voltage Control, the lens stop, and the optical focus to obtain the best picture. Reduce horizontal and vertical scanning so that the edges of the image extend just outside the scanned

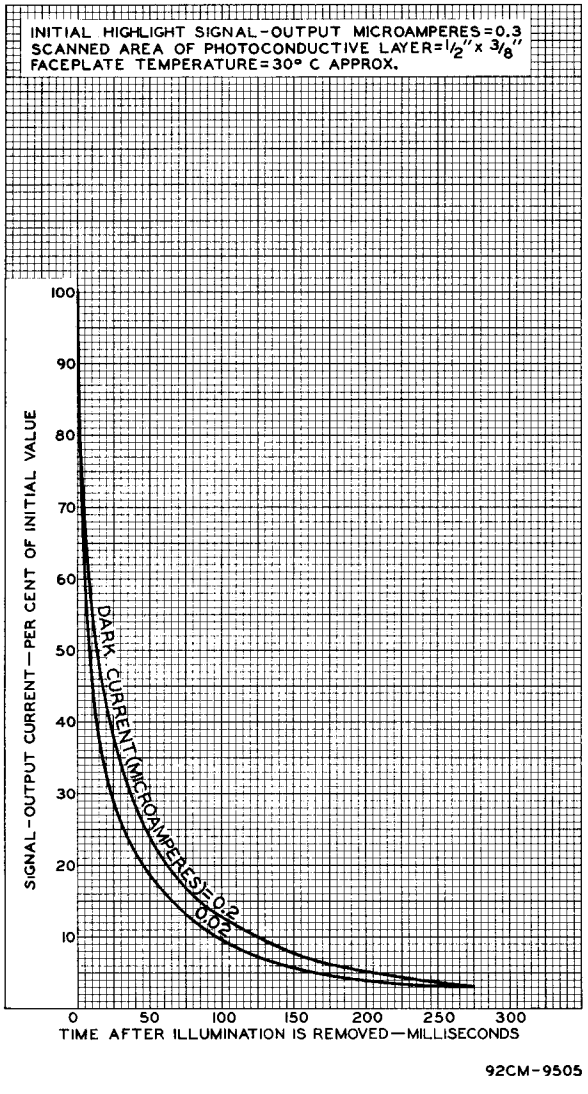


Fig. 10 - Typical Persistence Characteristics of Type 7038.

area on the monitor. Then adjust the alignment field so that the center of the picture does not move as the beam-focus voltage is varied. Some readjustment of horizontal and vertical centering may be necessary after alignment.

For maximum-sensitivity operation of the 7038 in live-pickup service, proceed as follows. With no illumination on the face of the tube, increase the target voltage until a dark current of 0.2 microampere is measured. The current should be measured with a sensitive microammeter such as the RCA Type WV-84B Microammeter.

Next, open the lens and adjust the aperture to give a peak signal-output current of 0.2 to 0.3 microampere. A good procedure for doing this is to focus the camera on a uniform white area having the same brightness as the highlights in the scene to be televised. The image of this white area must at least cover the scanned area of the tube face. The current read on the microammeter will be the dark current plus the peak signal-output current, i.e., highlight target current.

A waveform-oscilloscope monitor can be used to compare the peak signal-output current produced by any scene to the peak value measured

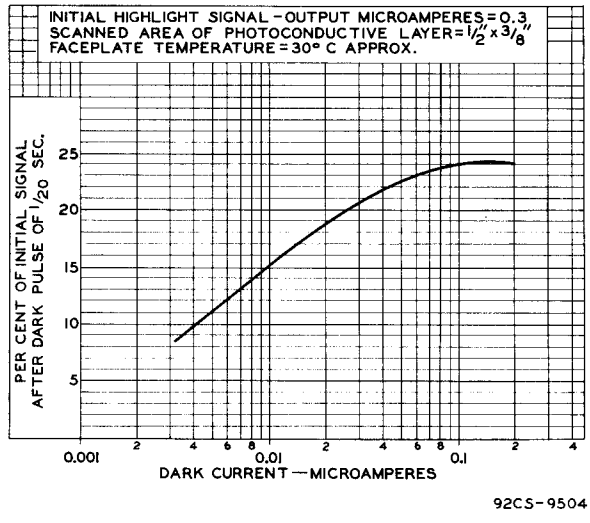


Fig. 11 - Typical Persistence Characteristic of Type 7038.

with the microammeter when the camera is focused on a uniformly bright scene. When a camera is adjusted in this manner, video gain should be kept constant and the light level on the tube face should be controlled to maintain the constant predetermined value of peak signal as observed on the oscilloscope.

After adjusting the light level to obtain the correct signal-output current, the grid-No. 1-bias voltage should be adjusted to just discharge the highlights. Too much current will result in poor resolution and poor picture quality. After the grid-No. 1 bias is properly adjusted, it will be necessary to check and readjust the dark current and the peak signal-output current.

Proper adjustment of the dark current, the peak signal-output current, and the grid-No. 1 bias, will result in a picture of good quality with minimum smearing of moving objects.

For average-sensitivity operation of the 7038 in live-pickup service, the adjustments are similar to those for maximum-sensitivity operation except that the target voltage should be adjusted to produce a dark current of 0.02 microampere. When sufficient light is available, decreased lag can be obtained by operating with this lower value of dark current.

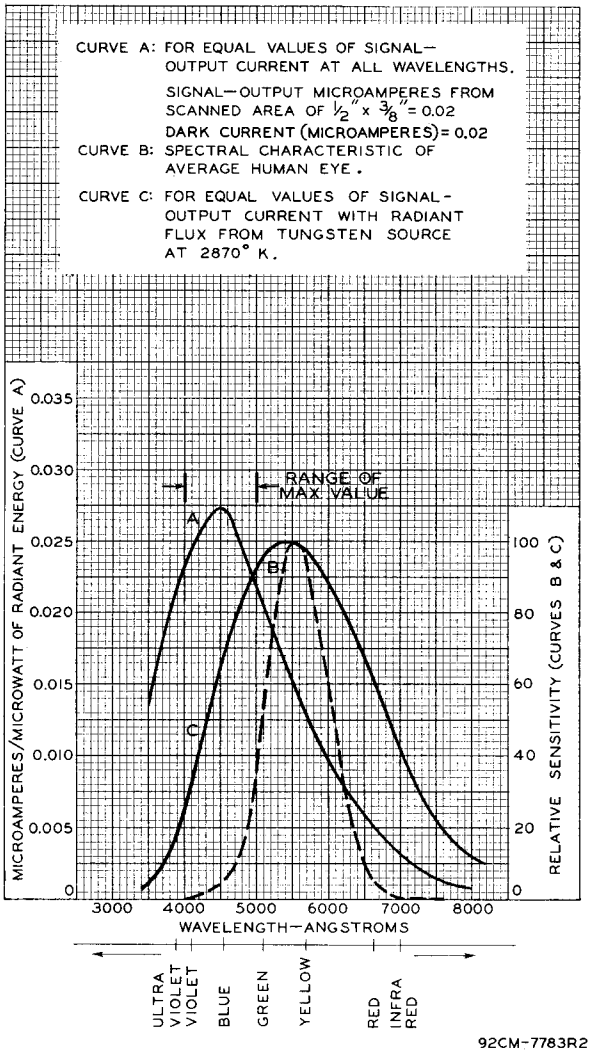


Fig. 12 - Spectral Sensitivity Characteristics of Type 7038.

For film-pickup operation of the 7038, the adjustments will be similar to those for live pickup except that the target voltage should be adjusted to produce a dark current of 0.004 microampere and the peak signal-output current should be adjusted to the desired value by controlling the light level on the faceplate of the tube.

In setting up three 7038's in a color camera, particular attention must be given to proper alignment, best obtainable focus, and identical centering of scanned areas on the photoconductive layers. For best color balance and color tracking over a wide range of light levels, the light level in each color channel should be controlled so that each of the three 7038's develops the same value of peak signal output for white portions of a scene. Observation of these operating conditions will assure good registration and good color balance.

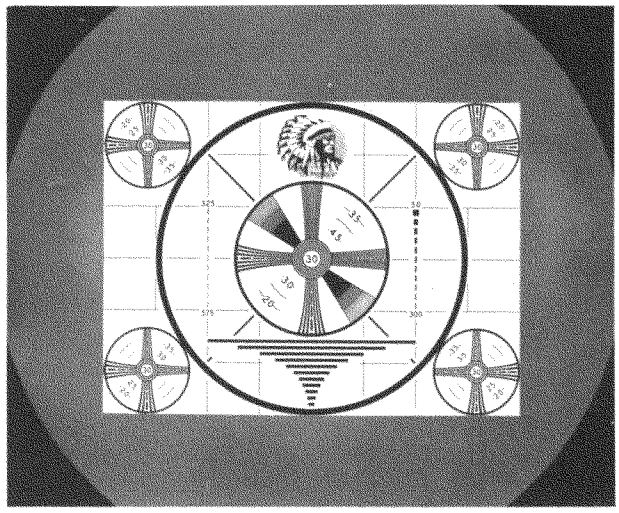


Fig. 13 - Illustration Showing Proper Positioning of Image on the Face of the Vidicon.

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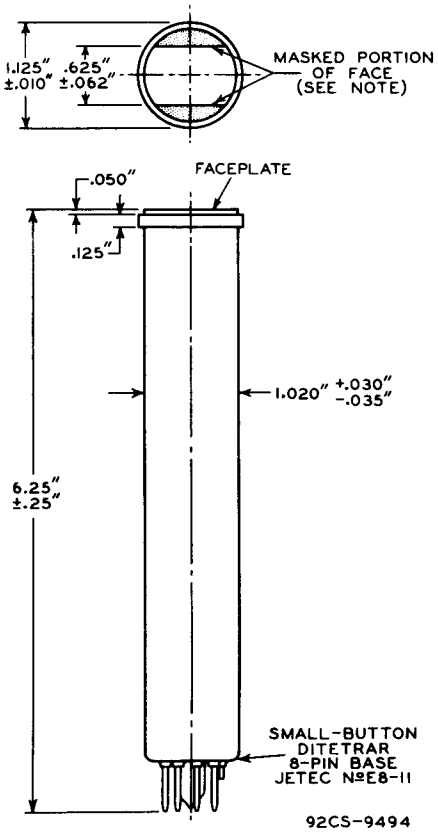
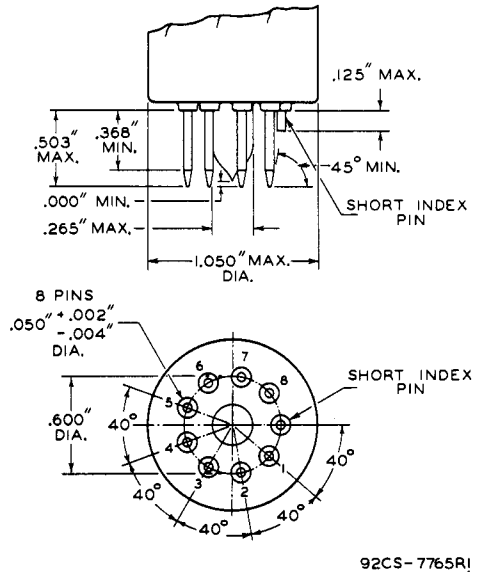
DIMENSIONAL OUTLINE



NOTE: STRAIGHT SIDES OF MASKED PORTIONS ARE PARALLEL TO THE PLANE PASSING THROUGH TUBE AXIS AND SHORT INDEX PIN.

BASE DRAWING

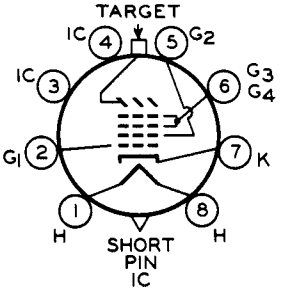
SMALL-BUTTON DITETRAR
8-PIN BASE
JETEC NºE8-11



BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, PASS INTO AND DISENGAGE FROM FLAT-PLATE GAUGE HAVING THICKNESS OF 1/4" AND NINE HOLES WITH DIAMETERS OF 0.0700" ± 0.0005" SO LOCATED ON A 0.6000" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.2052" ± 0.0005". GAUGE IS ALSO PROVIDED WITH A HOLE HAVING DIAMETER OF 0.300" ± 0.001" CONCENTRIC WITH THE PIN CIRCLE.

SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: INTERNAL CONNECTION—DO NOT USE
PIN 4: INTERNAL CONNECTION—DO NOT USE
PIN 5: GRID No.2
PIN 6: GRIDS No.3 and No.4
PIN 7: CATHODE
PIN 8: HEATER
FLANGE: TARGET
SHORT INDEX PIN: INTERNAL CONNECTION—MAKE NO CONNECTION

DIRECTION OF LIGHT:
INTO FACE END OF TUBE

8HM

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7046

MULTIPLIER PHOTOTUBE

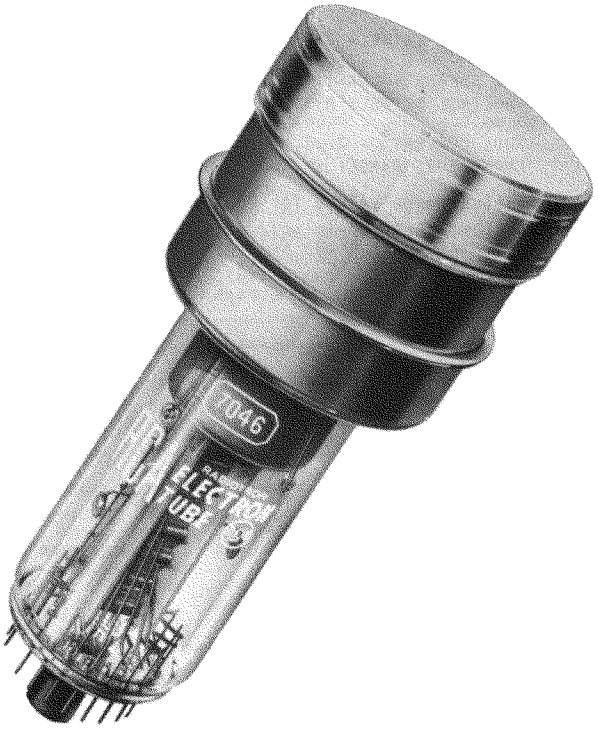
4-7/16" Dia. Curved Circular Semitransparent Photocathode

14-Stage, Head-On, Flat-Faceplate Type
Extended S-11 Response
Very-Short Time-Resolution Capability

11-1/8" Max. Length
5-1/4" Max. Diameter
Thirtyfivar 21-Pin Base

TENTATIVE DATA

RCA-7046 is a head-on type of multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear radiation, and applications involving the measurement of low-level light sources. Its



fast response, high current gain, high peak-current capability, relative freedom from after-pulses, and its very small spread in electron-transit time make it particularly useful for fast coincidence scintillation counting.

The 7046 is capable of delivering pulse currents having magnitudes up to 0.5 ampere without space-charge effects causing appreciable deviation from linearity. Consequently, the need for an associated wide-band amplifier to amplify the output pulse is eliminated in many applications.

The spectral response of the 7046 covers the range from about 2500 to 6500 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 4200 angstroms. The 7046, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation. Because of its spectral response, the 7046 is well suited for use with organic phosphors such as anthracene as well as with inorganic materials such as thallium-activated sodium iodide.

Design features of the 7046 include a semi-transparent cathode on the curved inner surface of the face end of the bulb; a minimum cathode diameter of 4-7/16 inches; a faceplate of ultra-violet transmitting glass with a flat external surface to facilitate the mounting of flat phosphor crystals in direct contact with the surface; fourteen electrostatically focused multiplying (dynode) stages; two focusing electrodes with external connections for shaping the field which directs the photoelectrons from the cathode onto the first dynode; and an accelerating electrode with external connection for minimizing the space-charge effect in the region of dynode No. 12. The material of which the dynodes are made has stable, high-current-carrying capabilities and permits tube processing to minimize regenerative effects, such as after-pulses.

The internal leads from dynode No. 14 and anode to their respective base-pin terminals are short and direct. This arrangement makes possible the use of a load circuit having a short time constant--an essential feature in pulse service.

The curved cathode surface of the 7046 assures very good collection by dynode No. 1 of electrons from all parts of the useful cathode area. The curved surface together with the electrode configuration employed in the 7046 provides minimum spread in electron-transit time. As a result, the 7046 has very short time-resolution capability, i.e., in the order of 1 millimicrosecond or less. The 7046 is, therefore, capable of good pulse-height resolution in gamma-ray spectrometry and good time resolution in measurement of short, closely spaced radiation pulses.

The 7046 is capable of multiplying feeble photoelectric current produced at the cathode by a median value of 3,000,000 times when operated with a supply voltage of 2400 volts. The output current of the 7046 is a linear function of the exciting illumination under normal operating conditions.

TMK ®, Marca Registrada
Printed in U.S.A

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

The focusing electrodes permit optimizing the magnitude, uniformity, or speed of response in critical applications. The accelerating electrode reduces space charge and thus permits higher peak output current in pulse service than would otherwise be possible.

The various outstanding features of the 7046 commend its use in the design of scintillation counters, and its use in nuclear and "time-of-flight" measurements.

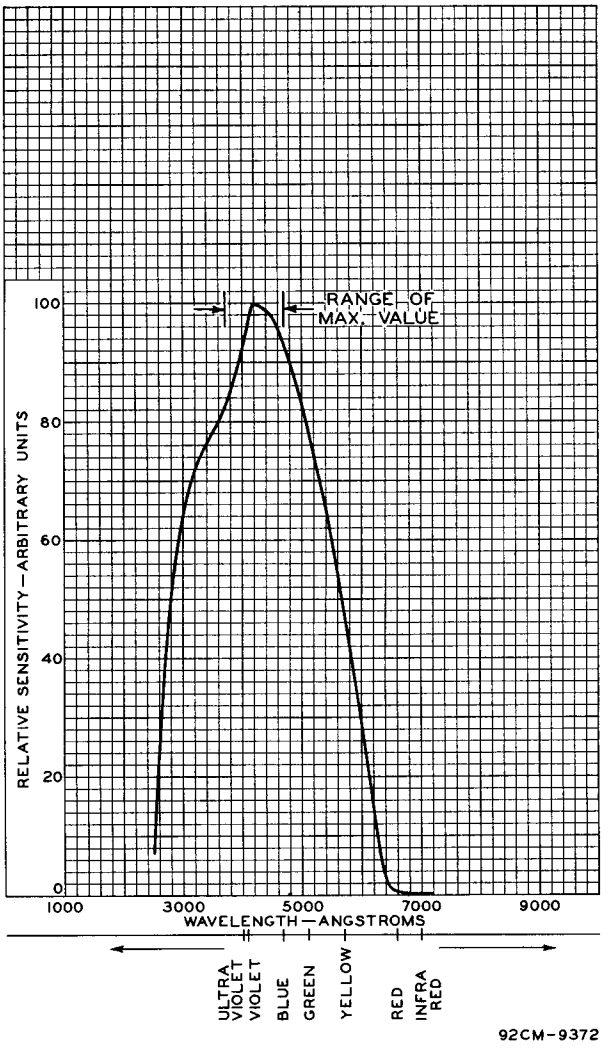


Fig. 1 - Tentative Spectral Sensitivity Characteristic of Type 7046. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

DATA

General:

Spectral Response	Extended S-11 (See Fig. 1)	
Wavelength of Maximum Response	4200 ± 500	angstroms
Faceplate, with flat external surface	Ultraviolet Transmitting Glass	
Cathode, Semitransparent:		
Shape	Curved Circular	
Window:		
Area	15.5	sq. in.
Minimum diameter	4-7/16	in.
Index of refraction	1.468	
Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.14	2.4	μμf
Anode to all other electrodes	5	μμf
Dynode No.14 to all other electrodes	7	μμf
Maximum Overall Length	11-1/8"	
Seated Length	9-3/4" ± 1/4"	
Envelope	See *Dimensional Outline*	
Cathode Terminal	Metal Flange	
Base	Small-Button Thirtyfivar 21-Pin (JETEC No.E21-40)	
Mounting Position	Any	
Weight (Approx.)	1 lb. 14 oz.	

Maximum Ratings, *Absolute Values:*

DC ANODE-SUPPLY VOLTAGE	3400 max.	volts
DC SUPPLY VOLTAGE BETWEEN DYNODE No.14 AND ANODE	400 max.	volts
DC SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES	400 max.	volts
DC SUPPLY VOLTAGE BETWEEN GRID No.3 AND DYNODE No.13	500 max.	volts
DC GRID-No.2 SUPPLY VOLTAGE	1500 max.	volts
DC SUPPLY VOLTAGE BETWEEN GRID No.2 AND ANODE	2300 max.	volts
DC GRID-No.1 SUPPLY VOLTAGE	1200 max.	volts
DC SUPPLY VOLTAGE BETWEEN DYNODE No.1 AND GRID No.2	400 max.	volts
AVERAGE ANODE CURRENT	2 max.	ma
AMBIENT TEMPERATURE RANGE	-125 to +75	°C

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across a voltage divider providing electrode voltages shown in Table I

With E = 2800 volts (except as noted), and with Grid-No.3, Grid-No.1, and Dynode-No.1 Voltages Adjusted to Give Maximum Gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms	-	0.140	-	amp/μw
Cathode Radiant, at 4200 angstroms	-	0.046	-	μa/μw
Luminous:#				
At 0 cps	40	180	1500	amp/lumen
With dynode No.14 as output electrode†	-	108	-	amp/lumen
Cathode Luminous:				
With tungsten light source▲	40	60	-	μa/lumen
With blue light source (See Fig.2)**	4	-	-	μa
Current Amplification	-	3×10^6	-	
Equivalent Anode-Dark-Current Input#■	-	2×10^{-9}	1.2×10^{-8}	lumen
	-	26×10^{-5}	156×10^{-5}	watt
Equivalent Noise Input★	-	1×10^{-11}	-	lumen
	-	13×10^{-7}	-	watt
Greatest Transit-Time Spread:				
Within a circle centered on tube face and having a diameter of—				
3 inches	-	0.5	-	milliμsec
4 inches	-	4	-	milliμsec

With E = 3400 volts (except as noted), and with Grid-No.3, Grid-No.1, and Dynode-No.1 Voltages Adjusted to Give Maximum Gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms	-	0.91	-	amp/μw
Cathode Radiant, at 4200 angstroms	-	0.046	-	μa/μw

Luminous:#				
At 0 cps	–	1200	–	amp/lumen
With dynode No.14 as output electrode†.	–	800	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲.	40	60	–	μa/lumen
With blue light source (See Fig.2)**	4	–	–	μa
Current Amplification. .	–	20×10^6	–	

TABLE 1

VOLTAGE TO BE PROVIDED BY DIVIDER	
Between	**3.8% of Supply Voltage (E) Multiplied By**
Cathode and Grid No.1	2 approx.*
Cathode and Grid No.2	11.5
Grid No.2 and Dynode No.1	1 approx.*
Grid No.2 and Dynode No.2	2
Dynode No.2 and Dynode No.3	1
Dynode No.3 and Dynode No.4	1
Dynode No.4 and Dynode No.5	1
Dynode No.5 and Dynode No.6	1
Dynode No.6 and Dynode No.7	1
Dynode No.7 and Dynode No.8	1
Dynode No.8 and Dynode No.9	1
Dynode No.9 and Dynode No.10	1
Dynode No.10 and Dynode No.11	1
Dynode No.11 and Dynode No.12	1
Dynode No.12 and Dynode No.13	1
Dynode No.13 and Dynode No.14	1
Dynode No.14 and Anode	1
Anode and Cathode	26.5

* Adjusted to Give Maximum Gain.

● Averaged over any interval of 30 seconds maximum.

\# Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870°K. A light input of 0.1 microlumen is used. The load resistor has a value of 0.01 megohm.

† An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.14 as the output electrode. With this arrangement, the load is connected in the dynode-No.14 circuit and the anode serves only as collector. This type of operation is suitable only for small output signals or for applications where linearity is not required.

▲ Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870°K. The value of light flux is 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected together as anode. The load resistor has a value of 0.01 megohm.

** Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870°K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 200 volts are applied between cathode and all other electrodes connected together as anode.

Measured at 4200 angstroms.

Measured at a tube temperature of 25°C and with the supply voltage (E) adjusted to give a luminous sensitivity of 500 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

■ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 2000 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 2800 volts, 25°C tube temperature, tungsten light source of 2870°K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

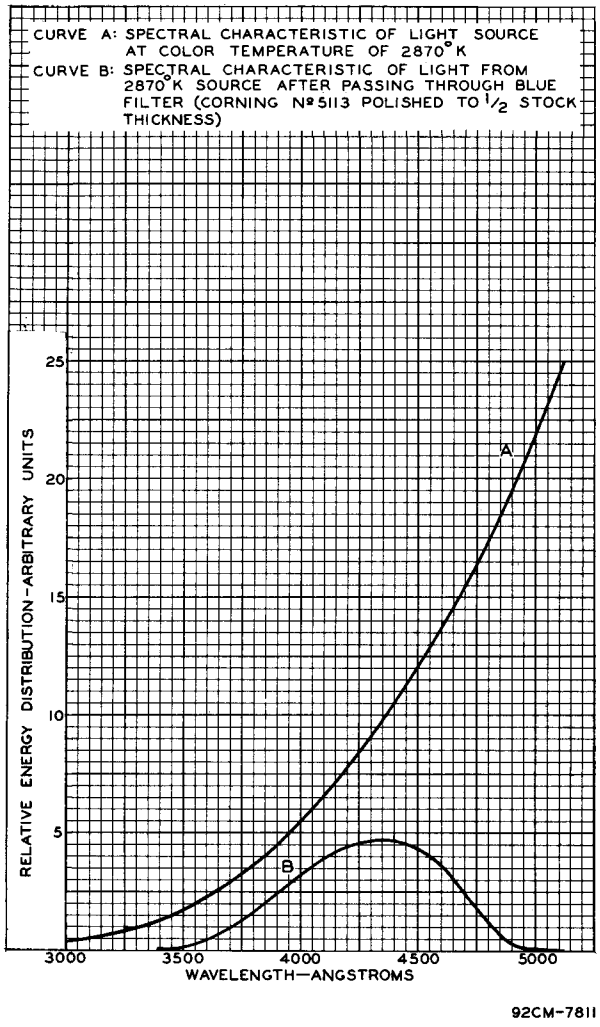


Fig.2 - Spectral Characteristic of 2870°K Light Source, and Spectral Characteristic of Light from 2870°K after Passing through Indicated Filter.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Transit-Time Spread. The increase in width of the output pulse over that of the input pulse. Pulse width is measured at 50% of the pulse height.

GENERAL CONSIDERATIONS

The 7046 is a phototube incorporating an electron multiplier. An electron multiplier utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 7046 multiplier phototube, represented in Fig.3, the electrons emitted from the illuminated curved cathode are directed by fixed electrostatic fields provided by grids No.1 and No.2 to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed electrostatic fields along curved paths to the second dynode

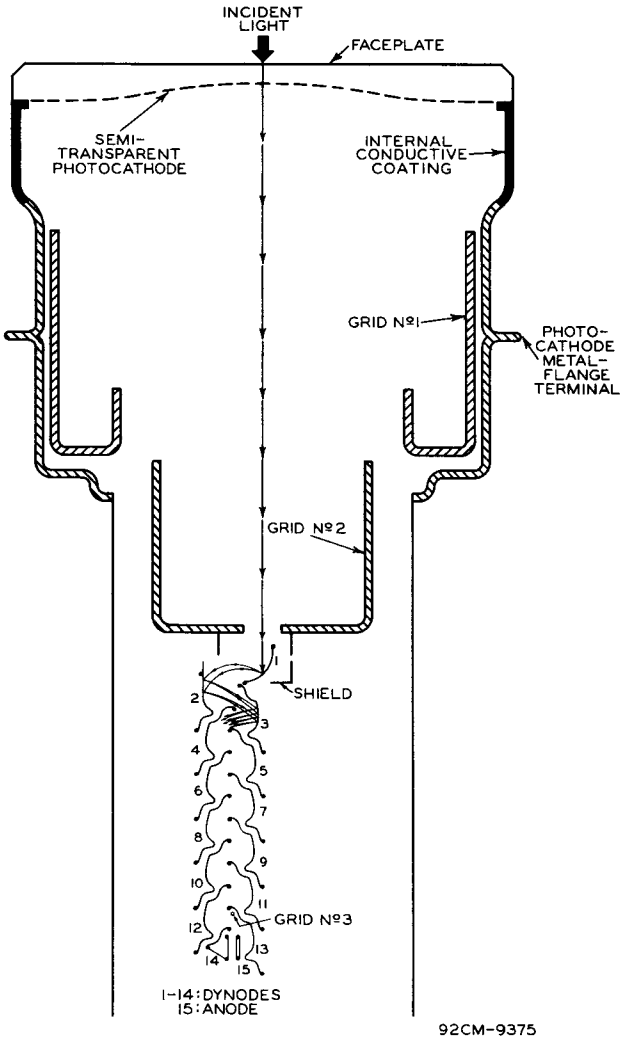


Fig.3 - Schematic Arrangement of Type 7046 Structure.

where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons, until those emitted from the last dynode (dynode No.14) are collected by the anode and constitute the current utilized in the output circuit.

The anode consists of a grating which allows the electrons from dynode No.13 to pass through it to dynode No.14. Spacing between dynode No.14 and anode creates a collecting field such that all the electrons emitted by dynode No.14 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 7046 can be coupled to any practical load impedance.

The shield which is adjacent to dynode No.1 shields dynode No.1 and the cathode and prevents ion feedback. If positive ions produced in the high-current region near the anode were allowed to reach the cathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration. The metallic coating on the inner side wall of the faceplate end of the envelope is connected to the cathode and to the metal portion of the envelope, and serves to direct the electrons from the cathode toward dynode No.1.

The focusing electrodes (grid No.1 and grid No.2) shape the fields which direct photoelectrons from the cathode onto dynode No.1. For consideration of the operating voltage applied to the focusing electrodes, see INSTALLATION AND APPLICATION.

The accelerating electrode (grid No.3) serves to minimize the effect of space charge in the region of dynode No.12. For consideration of the operating potential of dynode No.12 with respect to dynode No.13, see INSTALLATION and APPLICATION.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 7046 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a tube temperature may cause the volatile cathode surface to evaporate with consequent decrease in the life and sensitivity of the tube.

Terminal Connections. The *base pins* of the 7046 fit the thirtyfivar 35-contact socket, such as Alden Part No.435SBA, or equivalent. The socket should be made of high-grade, low-leakage material, and should be installed so that the

incident light falls on the face end of the tube. Connection to the *metal flange* is made by a spring-finger ring, bearing against the edge of the flange.

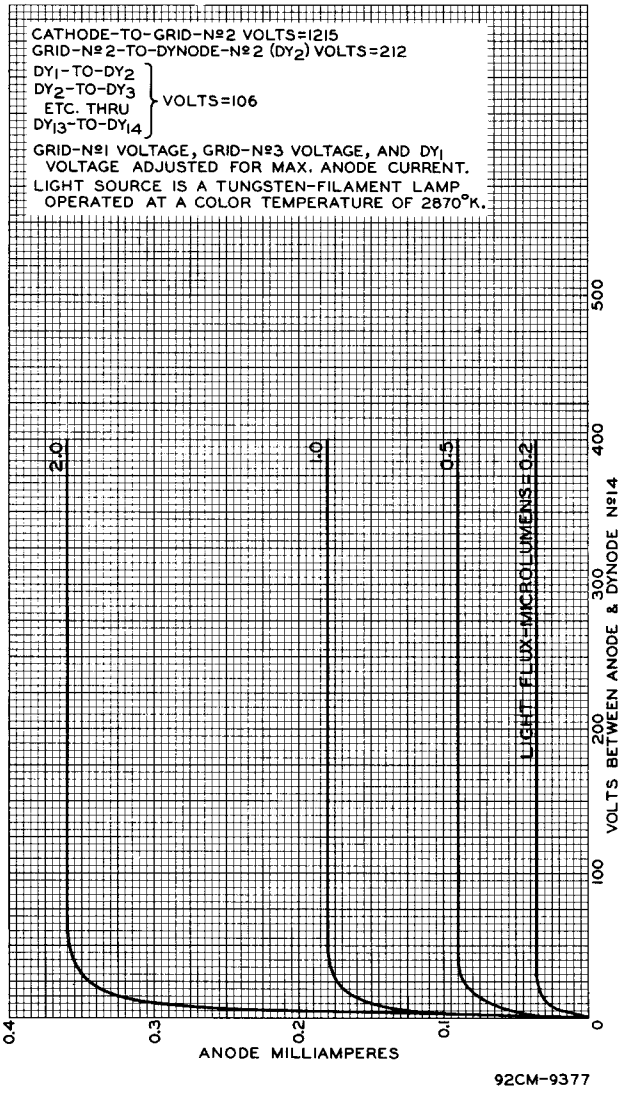


Fig.4 - Average Anode Characteristics of Type 7046.

In general, *supply voltages* for the electrodes of the 7046 may be provided as shown in Table 1. The voltage distribution shown in Table 1 gives the highest current amplification consistent with best collection of photoelectrons. The operating voltage between dynode No.14 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristic curves, shown in Fig.4, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. Low operating voltages between dynode No.14 and anode reduces the dark current. As a result, the operating stability of the 7046 is improved without sacrifice in sensitivity. To obtain the indicated operating voltage between dynode No.14 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

For operation involving high-current pulses, the overall supply voltage should be reapportioned so that the voltages applied between dynodes near the anode are increased. Successive interdynode voltages should not be more than 5/4 of the preceding interdynode stage.

Two *focusing electrodes* are provided to optimize the magnitude, uniformity, or speed of the response. In applications where an increased

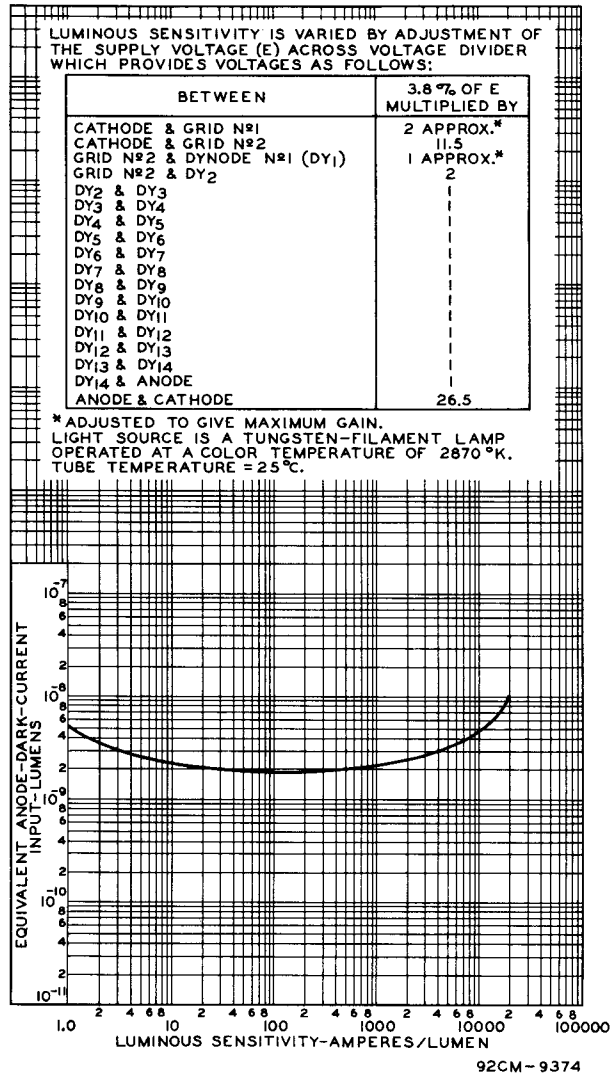


Fig.5 - Typical Anode-Dark-Current Characteristic of Type 7046.

number of collected photoelectrons is the primary consideration, the grid-No.1 voltage should be adjusted for maximum anode current while the cathode is uniformly flooded with light.

The *accelerating electrode*, when operated at a suitable potential with respect to dynode No.13, serves to minimize the effect of space charge in the region of dynode No.12. Provision should be made to adjust the accelerating-electrode voltage over a range extending from the

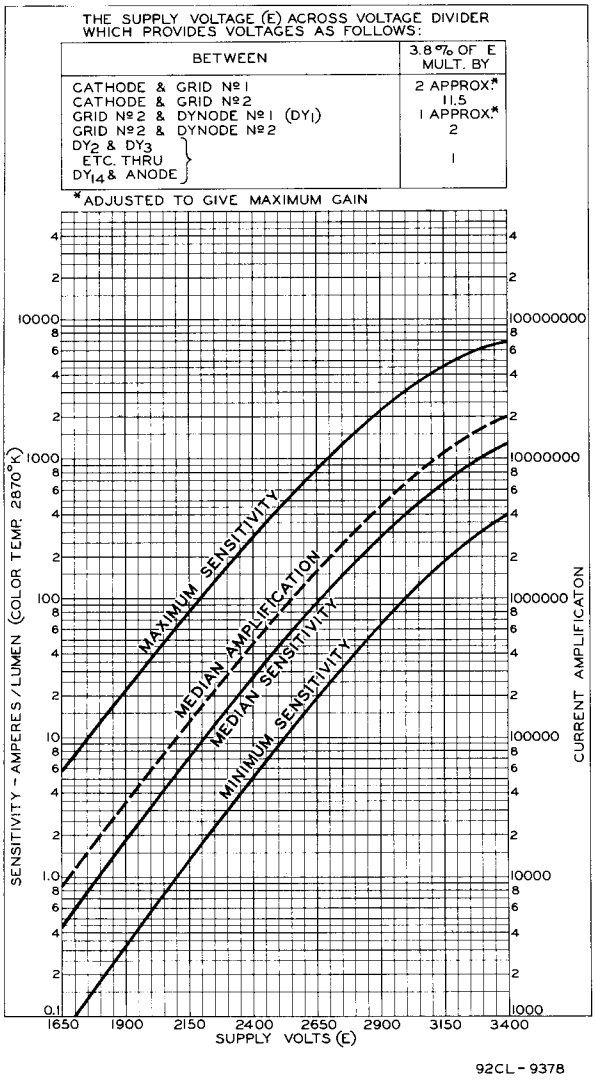


Fig.6 - Characteristics of Type 7046.

value at which dynode No.13 operates to that at which the anode operates. The adjustment may be accomplished by means of a high-resistance potentiometer connected between the voltage-divider tap for dynode No.13 and the anode end of the voltage divider. Since the accelerating electrode draws at most only negligible current, the potentiometer can have sufficiently high resistance so that it will not substantially affect the voltage distribution at the taps of the shunted section of the divider. Within the specified adjustment range, it will be found that the accelerating-electrode voltage may be adjusted to obtain either maximum gain or maximum peak output current. In general, the adjustment to apply the highest voltage to the accelerating electrode will permit the highest peak current with some sacrifice in gain.

A very small *dark current* is observed when voltage is applied to the electrodes of the 7046 in complete darkness. This current has a component caused by leakage, and a component consisting of pulses produced by electrons thermionically released from the cathode, by secondary electrons released by ionic bombardment of the dynodes or cathode, or by cold emission from the electrodes. The magnitude of the dark current establishes a limit below which the exciting radiation on the cathode can not be detected. Dark current may be kept at a minimum by storing tubes in light-proof containers.

When the application utilizes *continuous luminous excitation and dc anode current* and it is desired to have a high ratio of signal output

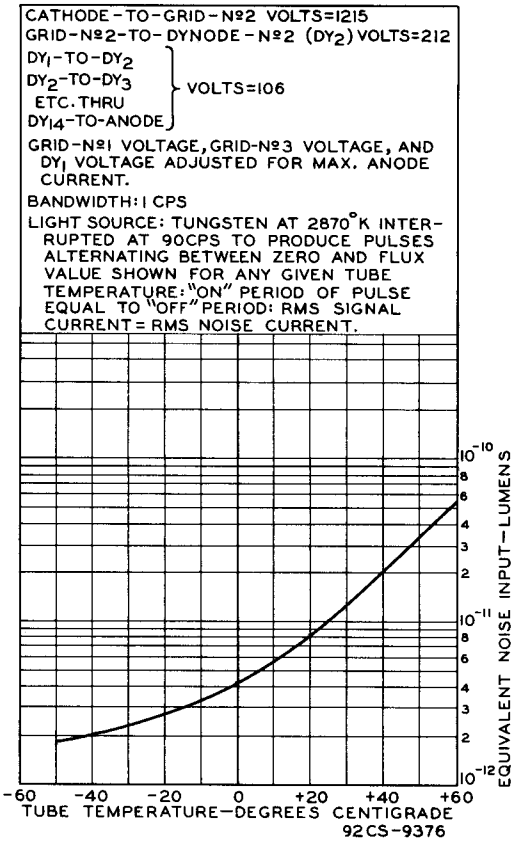


Fig.7 - Equivalent-Noise-Input Characteristic of Type 7046.

to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig.5 which shows the equivalent anode-dark-current input as a function of luminous sensitivity for the 7046, and the curves in Fig.6 which show luminous sensitivity

as a function of the supply voltage. The voltage between dynode No.14 and the anode should be kept as low as will permit operation at a point just giving anode-current saturation. This point on the anode characteristic curves, shown in Fig.4, occurs in the approximate range of 50 to 100 volts.

In applications involving low-light level *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 2300 to 3200 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise power spectrum is essentially flat up to about 50 megacycles per second. At voltages above 3200 volts, regenerative phenomena usually contribute to the noise.

The noise spectrum of the 7046 is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of the exciting signal in order to eliminate as much noise as possible.

In either dc or ac applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice or liquid air, to cool the bulb of the 7046 is recommended. The resulting reduction in thermionic emission from the cathode lowers the detection threshold to give improved operation. The curve in Fig.7 shows the equivalent noise input as a function of the temperature of the 7046.

Exposing the 7046 to strong ultraviolet radiation may cause an increase in anode dark current. After cessation of such irradiation, the dark current drops rapidly.

The *operating stability* of the 7046 is dependent on the magnitude of the anode current and its duration. When the 7046 is operated at high average values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 7046 usually recovers a substantial percentage of such less in sensitivity.

The use of an average anode current well below the maximum rated value of 2 milliamperes is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 100 microamperes.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity can be expected between individual tubes of a given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the *nth* power, where *n* is the number of stages. Thus, very small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for the equipment designer to provide adequate adjustment of the supply voltage so that the amplification of individual tubes can be adjusted to the desired design value. The voltage-adjustment range required to take care

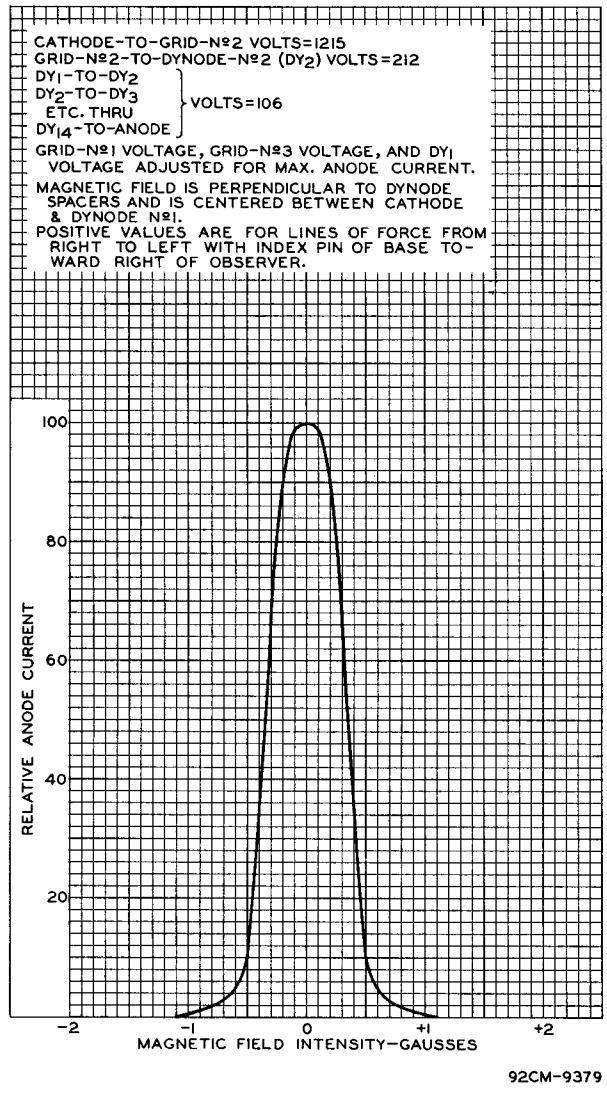


Fig.8 - Effect of Magnetic Field on Anode Current of Type 7046.

of variations between individual tubes may be determined from Fig.6 for low-light-level service. For example, if a sensitivity design value of 200 amperes per lumen is desired, it will be observed that this value on the "minimum" sensitivity curve corresponds to a supply voltage of about 3180 volts, and on the "maximum" sensitivity curve to a supply voltage of 2340 volts. Therefore, provision should be made to adjust the supply voltage over the range from 2340 to 3180 volts.

Electrostatic shielding of the 7046 is not required. The metallic coating on the inner side

of the face end of the envelope together with the metal portion of the envelope act as an electrostatic shield to prevent the envelope wall from charging to a positive potential.

With certain orientations of the 7046, it will be observed that the earth's magnetic field is sufficient to cause a noticeable decrease in the response of the tube. The curve in Fig.8 shows the effect on anode current of variation in magnetic-field strength under the conditions indicated. With increase in voltage between cathode and dynode No.1, the effect of the magnetic field will cause less decrease in anode current. When grid No.1 is operated at a potential near that of the cathode, the effect of the magnetic field will be increased. For orientations of the 7046 other than that indicated in Fig.8, the effect of the magnetic field is less pronounced. When the magnetic field is parallel to the axis of the tube, the effect is least.

To prevent such decrease in response of the tube, magnetic shielding must be provided. A suitable shield may be obtained from James Millen Mfg. Co., Malden, Mass. by ordering Part No.80805P. In general, it is recommended that the shield be connected to cathode potential. When connected to anode potential, this shielding should be spaced sufficiently from the envelope or otherwise insulated to prevent voltage breakdown between the shield and the metal portion of the envelope.

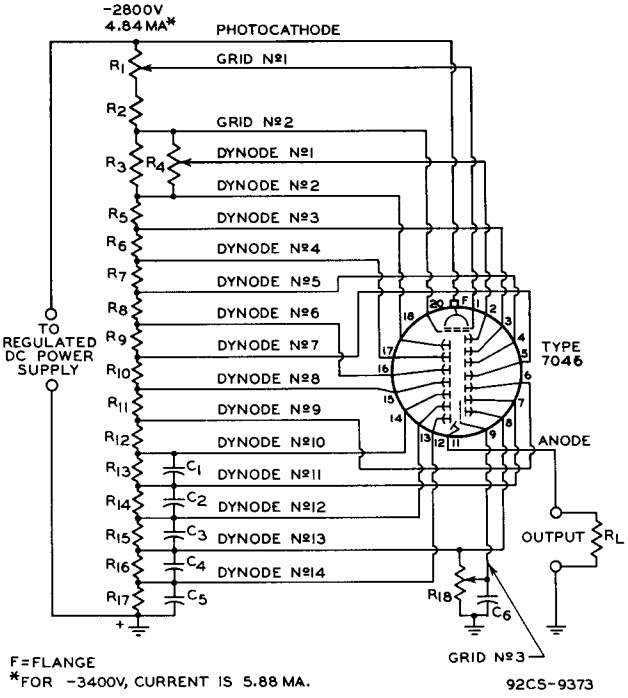
It is to be noted that the use of an external magnetic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safe-guards to prevent personnel from coming in contact with the high potential of the shield.*

Magnetization of the metal portion of the envelope will result in reduced or nonuniform collection of photoelectrons and hence a reduction in sensitivity. The tube may be demagnetized by subjecting it to an ac magnetic field which is gradually reduced in intensity.

Adequate *light and ultraviolet-radiation shielding* should be provided to prevent extraneous radiation from reaching any part of the 7046. Although the metallic coating on the inner side wall of the face end of the envelope serves to reduce the amount of extraneous radiation reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous radiation.

Whenever frequency response is important, the leads from the 7046 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each electrode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage divider will depend on the voltage regulation and the linearity required by the application. In general, the current in the divider should be several times the maximum value of anode current. The value should also be adequate to prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will ordinarily be provided by a well-designed two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Inasmuch as the gain of the 7046 is critically dependent on voltage, rapid



C_1 = 25 μμf, disk ceramic, 600 volts (dc working)
C_2 = 50 μμf, disk ceramic, 600 volts (dc working)
C_3 = 100 μμf, disk ceramic, 600 volts (dc working)
C_4 = 250 μμf, disk ceramic, 600 volts (dc working)
C_5 = 500 μμf, disk ceramic, 600 volts (dc working)
C_6 = 100 μμf, disk ceramic, 600 volts (dc working)
R_1 = 50000 ohms, 2 watts, adjustable
R_2 = 200000 ohms, 10 watts
R_3 = 43000 ohms, 2 watts, adjustable
R_4 = 1 megohm, .2 watts, adjustable
R_5 through R_{17} = 22000 ohms, 1 watt
R_{18} = 10 megohms, 2 watts, adjustable
R_L = Value will depend upon magnitude of peak pulse voltage desired.
Note: Capacitors C_1 through C_6 should be connected at tube socket.

Fig. 9 - Voltage-Divider Arrangement for Type 7046.

changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum tube regulator circuit of the mu-bridge type.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.

A typical voltage-divider arrangement for use with the 7046 is shown in Fig.9.

The high voltages at which the 7046 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 7046, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

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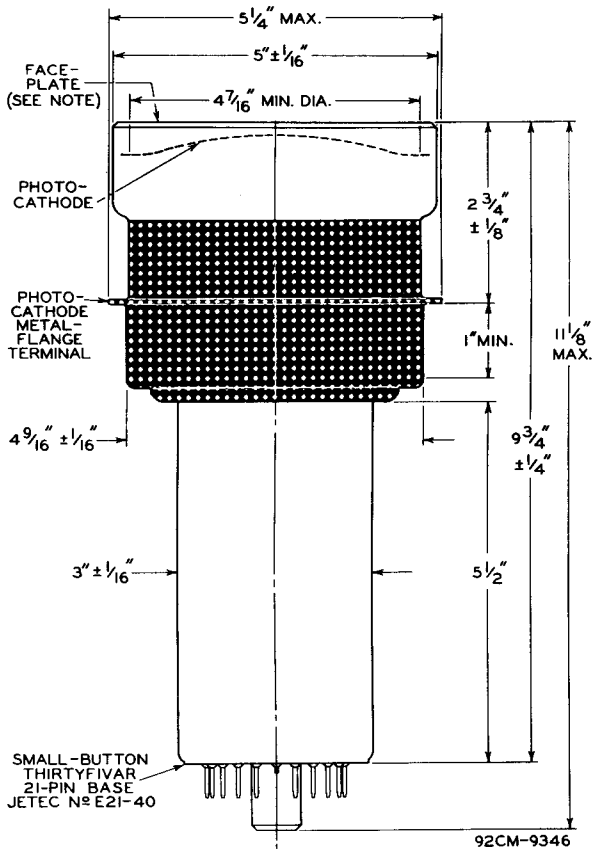
DIMENSIONAL OUTLINE



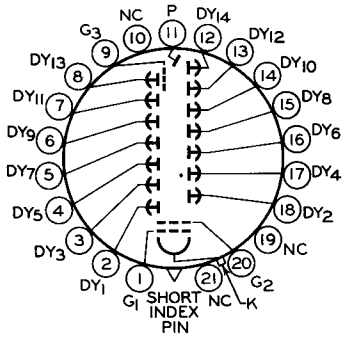
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: WITHIN 4-7/16" DIAMETER, DEVIATION FROM FLATNESS OF EXTERNAL SURFACE OF FACEPLATE WILL NOT EXCEED 0.015" FROM PEAK TO VALLEY.

SOCKET CONNECTIONS

Bottom View

PIN 1: GRID No.1
PIN 2: DYNODE No.1
PIN 3: DYNODE No.3
PIN 4: DYNODE No.5
PIN 5: DYNODE No.7
PIN 6: DYNODE No.9
PIN 7: DYNODE No.11
PIN 8: DYNODE No.13
PIN 9: GRID No.3 (Accelerating Electrode)
PIN 10: NO CONNECTION
PIN 11: ANODE



DIRECTION OF LIGHT: INTO END OF BULB

21-A

PIN 12: DYNODE No.14
PIN 13: DYNODE No.12
PIN 14: DYNODE No.10
PIN 15: DYNODE No.8
PIN 16: DYNODE No.6
PIN 17: DYNODE No.4
PIN 18: DYNODE No.2
PIN 19: NO CONNECTION
PIN 20: GRID No.2
PIN 21: NO CONNECTION
METAL FLANGE: CATHODE

7086

XENON THYRATRON

Forced-Air Cooled
High Peak Current

Negative-Control Triode Type
TENTATIVE DATA

11-3/4" Overall Length
4-1/2" Diameter Bulb

RCA-7086 is a three-electrode, forced-air cooled xenon thyratron having a negative-control characteristic, high commutation factor, and relatively short deionization time. It is designed primarily for use in applications in which high peak currents are required such as in welding and in X-ray tube operation. It can also be used for grid-controlled rectifier or inverter service.

In a typical two-tube inverse-parallel X-ray tube control circuit in which the anode-supply voltage is 220 volts rms and in which the tubes are operated with an "on" period of 2 seconds and an "off" period of 34 seconds, each tube can provide a peak anode current of 400 amperes and an average anode current of 127 amperes during the "on" period. Such current capability in combination with this circuit permits the control of 280 amperes rms through the primary of the power transformer of a single-phase full-wave rectifier delivering a dc current of 100 milliamperes at a voltage suitable for X-ray tube operation.

In grid-controlled rectifier or inverter service, the 7086 can deliver a maximum peak anode current of 160 amperes and a maximum average anode current of 40 amperes.

The negative-control characteristic of the 7086 is essentially independent of ambient temperature over the wide range from -55° to +75° C by virtue of the xenon gas content.

Design features of the 7086 include the use of a copper grid having high heat conductivity to provide cool operation of the grid and resultant reduced grid emission; a large cup-shaped anode with a copper face to provide uniform heat distribution over the faced area; and heavy copper filament leads and terminals. The cup-shaped anode forms one end of the tube and is in direct contact with the ambient air. The grid is terminated in a large area metal band which is a part of the tube envelope and thus is effectively cooled by the ambient air.

GENERAL DATA

Electrical:

Filamentary Cathode, Coated:*		
Voltage (AC)	2.5 ± 5%	volts
Current at 2.5 volts	92	amp
Minimum heating time, prior to tube conduction	60	sec
Direct Interelectrode Capacitances (With no external shield):		
Grid to anode	44	μμf
Grid to filament	7.5	μμf
Ionization Time (Approx.)	10	μsec
Deionization Time#	1000	μsec
Maximum Critical Grid Current for instantaneous anode volts = 650	50	μamp
Peak Tube Voltage Drop . See *Characteristics Range Values*		
Maximum Commutation Factor⊕	400	va/μsec²
Grid Control Ratio (Approx.):		
Under conditions: 10000-ohm grid resistor, returns to filament terminal FS, voltage on filament terminal F in phase with anode voltage (with respect to voltage at FS), anode voltage between 100 and 700 volts, and plate load of 2000 ohms	100	

Mechanical:

Operating Position	Any
Maximum Overall Length	11.8"
Maximum Radius (Including grid terminal)	2.88"
Maximum Diameter (Excluding grid terminal)	4.62"
Air Flow	60 cfm

The specified air flow, from a 2- to 3-inch diameter nozzle located about 12 inches from the anode end of the tube and on the tube axis, should be directed at the anode cup and permitted to flow freely around the outside of the anode cup, grid-seal band, and glass bulb. These requirements are for operation at sea level and at an ambient temperature of 30° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the anode temperature within maximum ratings.

TMK ®, Marca Registrada
Printed in U.S.A

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

Anode Temperature (Measured within 1/2 inch of region where anode terminal blade joins the anode surface)	300 max.	°C
Temperature of Anode Seal, Grid Seals, and Filament Seals	180 max.	°C
Weight (Approx.)	3	lbs

Maximum Ratings, *Absolute Values:*

For supply frequency of 25 to 60 cps

	Continuous ■	*Intermittent* 🌡	
PEAK ANODE VOLTAGE:			
Forward	650 max.	650 max.	volts
Inverse	650 max.	650 max.	volts
GRID VOLTAGE:			
Peak, before tube conduction	−150 max.	−150 max.	volts
Average, during tube conduction	−10 max.	−10 max.	volts
ANODE CURRENT:			
Peak	160 max.	400 max. ★□	amp
Average	40 max. ●□	7 max. ★□	amp
Fault, for duration of 0.1 second maximum	4000 max.	4000 max.	amp
GRID CURRENT:			
Average positive	2.0 max.	2.0 max.	amp
Peak positive with anode negative	0.1 max.	0.1 max.	amp
AMBIENT-TEMPERATURE RANGE	−55 to +75	−55 to +75	°C

Typical Operation--Intermittent AC Control of X-Ray Tube Power Utilizing Inverse-Parallel Circuit of Fig.6:

For anode-supply frequency of 60 cps

"On" (Conduction) Period	2	sec
"Off" (Non-Conduction) Period	34	sec
AC Anode-Supply Voltage (RMS)	220	volts
Grid-Bias Voltage	−50	volts
Grid-Circuit Resistance	0.1	megohm
Grid-Pulse Voltage	60	volts
Anode Current (Per Tube):		
Peak	400	amp
Average ▲	127	amp
Load RMS Demand Current	280	amp

Maximum Circuit Values:

For Continuous or Intermittent Service

Grid-Circuit Resistance	0.1 max.	megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Throughout Tube Life

	Note	*Min.*	*Max.*	
Filament Current	1	87	97	amp
Peak Tube Voltage Drop	1,2	–	40	volts
Critical Anode Voltage	1,3	–	100	peak volts

Note 1: With 2.5 volts rms on filament.

Note 2: With peak anode current of 400 amperes provided by a half-cycle pulse from a 60 cps sine wave. Pulse recurs once each second. Tube drop is measured by an oscilloscope connected between anode and the filament terminal FS. The grid is tied to anode through a 10,000-ohm resistor.

Note 3: The voltage at terminal F is in phase with the anode voltage (with respect to voltage at filament terminal FS). Circuit returns are made to terminal FS. Grid resistor = 0 to 100,000 ohms.

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* In single-phase applications, to avoid excessive heating of the filament and for maximum tube life, the voltage at filament terminal F should be in phase with the voltage at the anode terminal (with respect to voltage at filament terminal FS). All returns should be made to filament terminal FS in order to reduce the amount of rms current flowing through the filament and filament leads. In polyphase installations, quadrature operation of the filament is recommended to reduce excessive heating of the filament and filament leads by the anode-return current. In quadrature operation, the filament and anode voltages should be 90° out of phase for optimum results. However in practical applications, nearly full realization of the advantages of this type of excitation is possible with the filament and anode voltages between 60° and 120° out of phase. In polyphase operation where the anode voltage transfers from one phase to another during the current-conduction period, quadrature operation is obtained when the filament voltage passes through zero at the center of the current-conduction period.

\# Measured by Capacitor-Discharge Method as described in "Standard on Electron Tubes: Methods of Testing, 1950 (50 IRE 7.S2)" available from The Institute of Radio Engineers, 1 East 79 St, New York 21, N. Y. Also available in "Proceedings of the I.R.E.", Vol.38, No.9, page 1092 (September 1950). Conditions of measurement involve anode supply voltage (E_{bb}) of 300 volts, grid supply voltage (E_{cc}) of −150 volts, grid resistor (r_g) of 5000 ohms and anode current (I_b) of 23 amperes.

⊕ Commutation factor is the product of the rate of current decay in amperes per microsecond just before conduction ceases and the rate of inverse voltage rise in volts per microsecond following current conduction.

■ Continuous Service is defined as service where conduction recurs for each cycle of the anode-supply voltage.

🌡 Intermittent Service is defined as service where conduction does not take place as often as every cycle of the anode-supply voltage.

● Averaged over any period of 15 seconds maximum.

★ Averaged over any period of 36 seconds maximum.

▲ Averaged over the "on" period of 2 seconds.

□ This rating applies when the average or the rms load current is at a maximum with respect to the phase-retard angle. This condition obtains with zero phase-retard angle. As the phase-retard angle is increased, the average or the rms load current is reduced but the severity of duty on the 7086 is not reduced.

The angle of phase retard is the angle by which the grid signal (or the resultant tube conduction) lags the time at which the incoming and outgoing tubes have equal instantaneous values of voltage from the sinusoidal supply.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 7086 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum fault anode current rating* shown in the tabulated data is the highest value of abnormal peak current of short duration (0.1 second maximum) that should pass through the tube under the most adverse conditions of service. This rating is intended to assist the equipment designer in a choice of circuit components such that the tube will not be subjected to disastrous currents under abnormal conditions approximating a short circuit. It is not intended for use under normal operating conditions because even a single fault current at the maximum value may impair tube life. Repeated fault currents will seriously reduce or even terminate

tube life. The equipment designer should also note that if the maximum fault-current rating is exceeded, the thyratron may cease to conduct

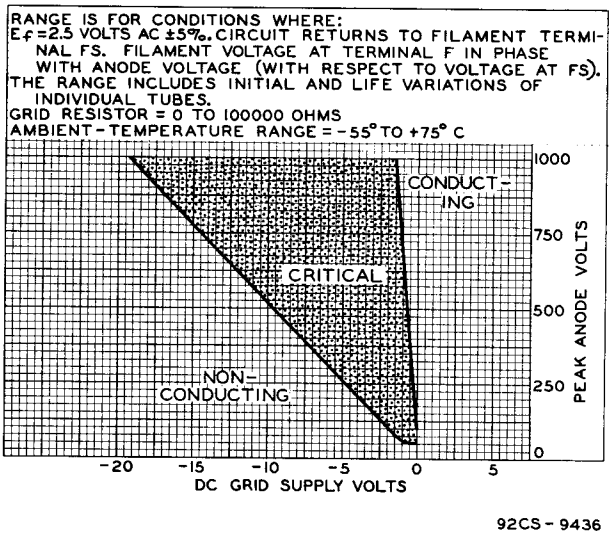

Fig.1 - Operational Range of Critical Grid Voltage.

momentarily with the result that excessive surge voltages are developed in the associated components, thereby causing their failure. The magnitude of any fault current which might occur under abnormal conditions should be limited by the internal impedance of the transformer or other circuit components, to the rated value.

The *maximum temperatures* in the tabulated data for the anode seal, grid seal, and filament seals are tube ratings and are to be observed in the same manner as other tube ratings. The temperature of the respective seals and of the anode may conveniently be measured with temperature-sensitive paint such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y. in the form of liquid and stick.

The *mounting* may support the 7086 in any position. A suitable mounting arrangement is provided by the use of three insulated 1/4-inch diameter studs set perpendicularly in a rigid surface at locations which are spaced to correspond with the spacing of the terminal holes as shown on the Dimensional Outline. The studs should extend a minimum distance of 5 inches out from the surface, and should be threaded for a minimum length of 2 inches on their free end. Place a nut followed by a brass or copper washer on each stud so that 1-1/2 inches of the free end extends beyond the washer. Then mount the tube by slipping the holes of the tube's terminals onto the studs. The terminal lugs of the connecting leads to the tube can then be slipped onto their respective studs. Tighten the connection with a second nut on each stud. *In order not to subject the glass-to-metal seals to stress which may damage them, use two wrenches*--one on each side of the tube terminals when tightening a connection.

Filament leads should be made of No.2 stranded copper wire, or equivalent. The tube end of the wire lead should be hard soldered to a 225-ampere (minimum) copper terminal lug. Be sure that this terminal lug is placed in direct contact with the filament terminal before tightening the nut.

The anode lead should be made of No.5 copper wire, or equivalent, and terminate at the tube end in a 150-ampere (minimum) copper terminal lug.

The grid lead should terminate at the tube end in a lug that may be fastened to the grid terminal by a No.6 screw & nut.

The *filament voltage*, measured directly at the filament terminals, should not vary more than ±5 per cent from the rated value. Less than the rated value may result in a high tube drop with consequent bombardment of the filament and eventual loss of emission. Greater than rated voltage will cause excessive evaporation of the filament coating with resultant increase in grid emission and shortened filament life.

It is essential that the filament terminals of the tube be kept clean at all times to minimize contact resistance. Always be sure that connections are securely tightened because of the high current involved. The filament terminal FS not only carries the normal filament current but also the anode-return current. The combined currents may reach a value as high as 120 amperes when the tube delivers full anode current. For operating procedure to reduce the magnitude of combined currents, refer to note * under tabulated data.

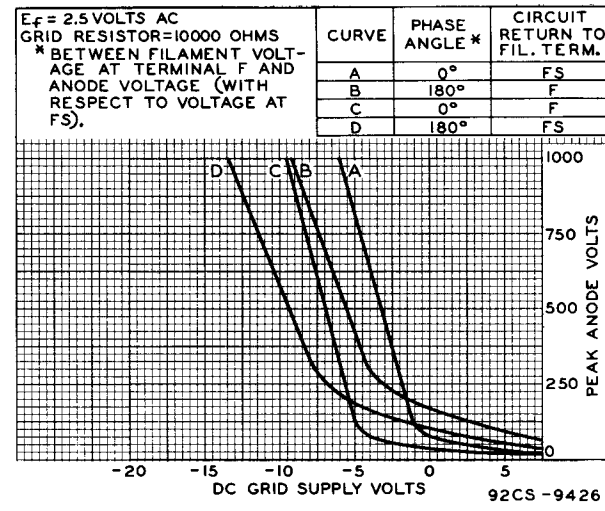

Fig.2 - Shift of Typical Control Characteristics With Change in Filament Phasing and Circuit Return.

The filament should be allowed to reach operating temperature before tube conduction is permitted to start. The delay period should be

not less than 60 seconds after application of filament voltage. Unless this recommendation is followed, the filament may be damaged. Tube conduction may be delayed by the application of adequate negative bias to the grid for the specified minimum filament heating time.

Circuit returns should be made to filament terminal FS.

Sufficient anode-circuit resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings of the tube.

The anode voltages at which the 7086 is operated are extremely dangerous to the user. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical systems. The interlock devices should function to break the primary circuit of the anode supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

The 7086 has a *critical grid voltage* which will initiate tube conduction for any positive anode voltage. If the grid is maintained more negative than this critical voltage, the tube does not conduct and the anode current remains zero.

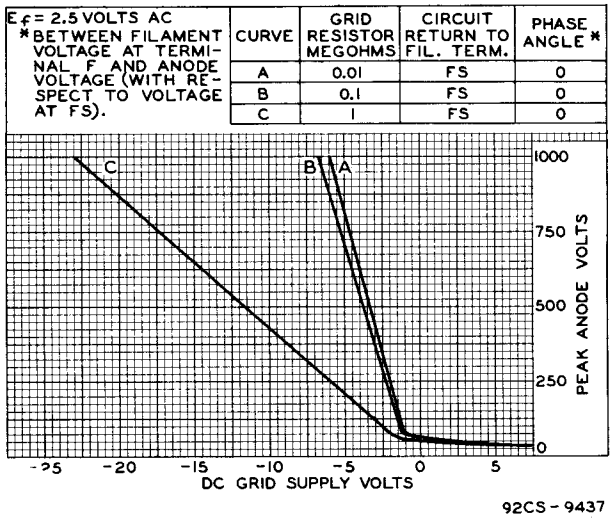

Fig.3 - Shift of Control Characteristics With Change in Grid-Resistor Value.

If the grid is made less negative than this critical voltage, the tube will conduct and the anode current assumes a value determined by the applied anode voltage and the impedance in the anode circuit. In the conducting condition, the 7086 has a voltage drop which is relatively low, substantially constant over the rated anode-current range, and independent of grid bias. Conduction may be stopped and the grid allowed to regain control by reducing the anode voltage to zero or making it negative.

The value of critical grid voltage is affected by several factors including: the operating anode voltage, variation of filament-supply voltage,

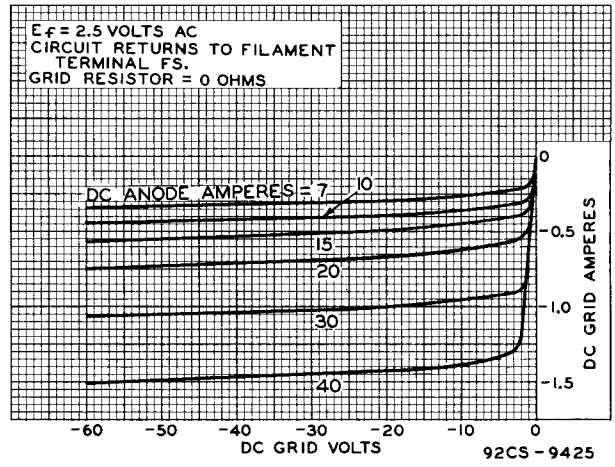

Fig.4 - Typical Grid Characteristics During Tube Conduction.

filament phasing and circuit return, value of grid resistor, and individual tube variation both initially and during life. Fig.1 shows the range of critical grid voltage. The equipment designer should give careful consideration to the range values shown in Fig.1. From them he can determine for specified operating conditions not only the proper value of grid bias necessary to prevent conduction until it is desired, but also the magnitude of the signal (triggering) voltage necessary to initiate conduction. Ample triggering voltage should always be provided to insure anode conduction even under the worst operating conditions to which the equipment will usually be subjected.

The effect of change in filament phasing and circuit return is shown in Fig.2; and the effect of change in value of grid resistor is shown in Fig.3.

The *grid characteristics* of the 7086 during tube conduction are shown in Fig.4.

The *anode voltage* for the 7086 may be obtained from either an ac or dc source. When a dc supply is used, the circuit has a lock-in feature because the grid loses control when conduction starts. In order for the grid to regain control and restore the tube to the non-conducting condition, it is necessary to remove the anode voltage momentarily. When an ac supply is used, the circuit has no lock-in feature because the anode becomes negative during the negative half of the ac cycle and thus allows the grid to resume control before the next positive half-cycle.

With ac supply, control of the firing of the 7086 may be accomplished by varying the amplitude of an ac grid voltage, by varying a dc bias applied to the grid, by phasing a sinusoidal grid voltage with respect to the anode voltage, by phasing a peaked grid voltage with respect to the anode voltage, or by a combination of these methods.

With *ac amplitude control*, several degrees of control are available depending on the phase angle of the grid voltage relative to the anode voltage. If the grid voltage lags the anode voltage by 180°, change in amplitude of the grid voltage will initiate tube conduction early in the positive half-cycle of the anode voltage, and thus effectively connect the load to the anode voltage supply for most of the half-cycle to provide maximum dc voltage output. This type of operation gives abrupt change from zero to full dc output voltage as the amplitude is decreased. If the grid voltage lags the anode voltage by something less than 180°, change in amplitude of the grid voltage can be used to cause the tube to conduct at only a few points in the positive half-cycle with the result that the dc output voltage can not be varied smoothly from the maximum value to zero.

The *dc bias method of control* can initiate tube conduction only over the first 90° of the positive half-cycle of anode voltage. Initiation of conduction at the beginning of the half-cycle will connect the load to the anode voltage supply for most of the half-cycle to provide maximum dc voltage output. If conduction is initiated at the 90° point, the dc voltage output will be approximately one half of the maximum value. If it is desired to control the output voltage over a wider range, then this method by itself is not practical.

With the *phase-shift method of control utilizing a sinusoidal grid voltage*, a wide range of control is available. If the grid voltage lags the anode voltage by about 170°, conduction occurs near the end of the positive half-cycle, and consequently the load is connected to the anode voltage supply for a small part of the half-cycle to provide minimum dc voltage output. If the phase of the grid voltage is advanced so that the grid voltage lags the anode voltage by less than 170°, tube conduction is initiated over a greater part of the positive half-cycle, and the dc output voltage will vary gradually from the minimum value to maximum. With this method, the use of adequate grid voltage will insure reliable control of the dc output voltage.

The *phase-shift method of control utilizing a peaked grid voltage* is a preferred method in that it provides a wide range of control with the most accurate timing for initiating conduction, positive blocking of anode current, and optimum conditions for deionization. If the peaked grid voltage lags the anode voltage up to 180°, tube conduction is initiated whenever the peak occurs in the positive half-cycle. The conduction angle, or time during which anode current flows, is equal to 180° minus the angle of lag. Maximum dc output voltage occurs when the peaked voltage swings positive at the same time as the anode voltage. If the peaked voltage leads the anode voltage up to 180°, no conduction occurs.

Since the 7086 is a negative-control tube, provision must be made to supplement the peaked grid voltage with a bias voltage which may be either dc or ac that is 180° out of phase with the anode voltage. With this control method, the magnitude of the peaked grid voltage should be adequate to swing the grid well into the positive region.

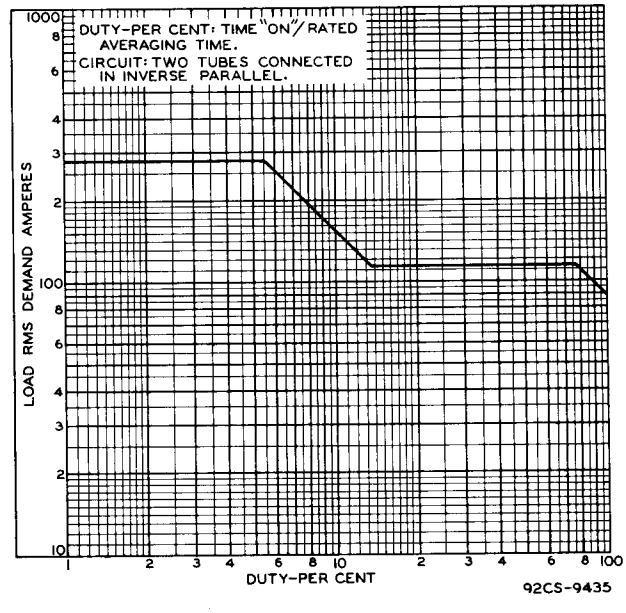

Fig. 5 - Current Demand Characteristic of Type 7086 in AC Voltage Control Service.

As indicated above, these methods may be combined to give additional flexibility of control. For example, a variable dc grid bias can be obtained with an ac voltage having constant amplitude and lagging the anode voltage by about 90°, to provide control of the dc output voltage from zero to maximum value.

A complete discussion of these control methods will be found in the references below. These references will also provide other references.

Fig. 5 is a graph showing demand current versus duty for the two-tube inverse-parallel ac control circuit of Fig. 6. When the timed gate provides a grid pulse every cycle of the supply frequency, the continuous operating ratings in the tabulated data apply. The duty is then 100%. These ratings permit a maximum average anode current of 40 amperes which when multiplied by the value of 2.22 shown in Table I gives the load current of 89 amperes. Starting at the 89-ampere, 100%-duty

AC Voltage Control

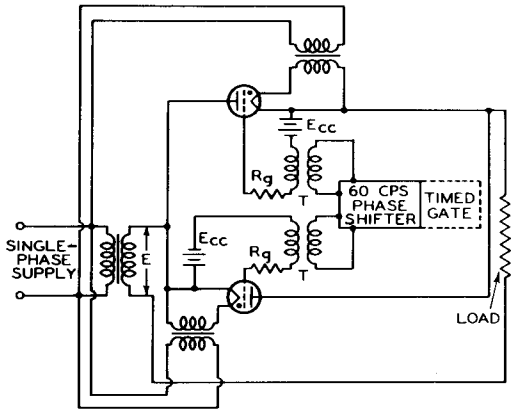

FIG.6 SINGLE-PHASE INVERSE-PARALLEL

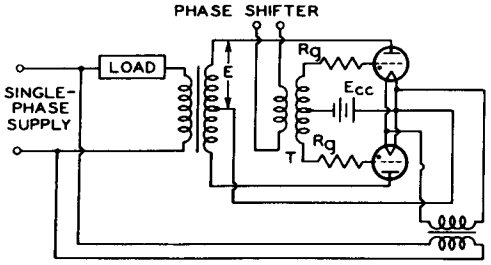

FIG.7 FULL-WAVE SINGLE-PHASE REFLECTED IMPEDANCE

DC Voltage Control

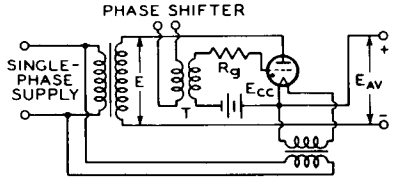

FIG.8 HALF-WAVE SINGLE-PHASE

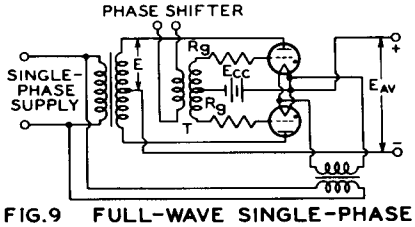

FIG.9 FULL-WAVE SINGLE-PHASE

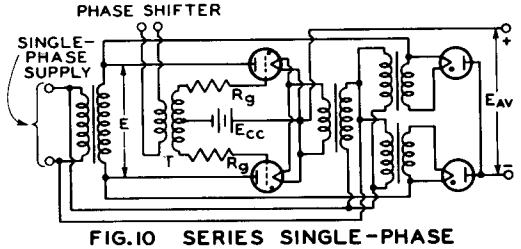

FIG.10 SERIES SINGLE-PHASE

92CL-9438

TABLE I

E = Trans. Sec. Voltage (RMS)
E_{av} = Average DC Output Voltage
E_{bmf} = Peak Forward Anode Voltage
E_{bmi} = Peak Inverse Anode Voltage
E_m = Peak DC Output Voltage
E_r = Major Ripple Voltage (RMS)
f = Supply Frequency
f_r = Major Ripple Frequency
I_{av} = Average DC Output Current
I_b = Average Anode Current
I_l = RMS Load Current
I_p = Anode Current (RMS)
I_{pm} = Peak Anode Current
P_{ac} = Average Power in Load
P_{al} = Line Volt-Amperes
P_{ap} = Trans. Pri. Volt-Amperes
P_{as} = Trans. Sec. Volt-Amperes
P_{dc} = DC Power ($E_{av} \times I_{av}$)
P_p = Peak Load Volt-Amperes

NOTE: Conditions assumed involve sine-wave supply; zero voltage drop in tubes; no losses in transformer and circuit; no back emf in the load circuit; and no phase-back.

RATIO	Fig.6	Fig.7	Fig.8	Fig.9	Fig.10
Voltage Ratios					
E/E_{av}	-	-	2.22	1.11	1.11
E_{bmi}/E	1.41	1.41	1.41	2.83	1.41
E_{bmi}/E_{av}	-	-	3.14	3.14	1.57
E_m/E_{av}	-	-	3.14	1.57	1.57
E_r/E_{av}	-	-	1.11	0.472	0.472
E_{bmf}/E:					
Resistive Load	1.41	1.41	1.41	1.41	1.41
Inductive Load■	1.41	1.41	1.41	2.83	1.41
Frequency Ratio					
f_r/f	-	-	1	2	2
Current Ratios					
I_b/I_{av}	-	-	1	0.5	0.5
Resistive Load					
I_p/I_{av}	-	-	1.57	0.785	0.785
I_{pm}/I_{av}	-	-	3.14	1.57	1.57
I_{pm}/I_b	3.14	3.14	3.14	3.14	3.14
I_l/I_b	2.22	2.22k*	-	-	-
Inductive Load■					
I_p/I_{av}	-	-	-	0.707	0.707
I_{pm}/I_{av}	-	-	-	1	1
I_{pm}/I_b	-	-	-	2	2
I_b/I_{av}	-	-	-	0.5	0.5
Power Ratios					
P_{ac}/I_bE_{bmf}	1.57	1.57	-	-	-
Resistive Load					
P_{as}/P_{dc}	-	-	3.49	1.74	1.24
P_{ap}/P_{dc}	-	-	2.69	1.23	1.24
P_{al}/P_{dc}	-	-	2.69	1.23	1.24
Inductive Load■					
P_{as}/P_{dc}	-	-	-	1.57	1.11
P_{ap}/P_{dc}	-	-	-	1.11	1.11
P_{al}/P_{dc}	-	-	-	1.11	1.11

■ The use of a large filter-input choke is assumed except for the circuit of Figs.6 and 7.

* k = 1/2 number of turns in secondary of transformer T_p divided by the number of turns in the primary of T_p

NOTES

E_{cc} = GRID-BIAS SUPPLY VOLTAGE
R_g = GRID-CIRCUIT RESISTANCE
T = PEAKING TRANSFORMER

IN FIG.10, THE RECTIFIER TUBES MAY BE 7086'S USED AS DIODES. THE 7086 IS USED AS A DIODE BY CONNECTING THE GRID TO FILAMENT TERMINAL F5.

TABLE II

For circuits, see Figs. 6, 7, 8, 9 and 10.

CIRCUIT	MAX. TRANSFORMER SEC. VOLTS (RMS) E	APPROX. DC OUTPUT VOLTS TO FILTER E_{av}	MAX. DC OUTPUT AMPERES I_{av}	MAX. DC OUTPUT TO FILTER P_{dc}	MAX. AV. AC OUTPUT KVA P_{ac}
Fig.6 Single-Phase Inverse-Parallel (AC Voltage Control)					
Intermittent Service	460	-	-	-	{130▲ 7♦
Continuous Service	460	-	-	-	40♦
Fig.7 Full-Wave Single-Phase Reflected Impedance (AC Voltage Control)	460	-	-	-	40♦
Fig.8 Half-Wave Single-Phase (DC Voltage Control)	460	205	40	8	-
Fig.9 Full-Wave Single-Phase (DC Voltage Control)					
With Resistive Load	230	205	80	16	-
With Inductive Load	230	205	80	16	-
Fig.10 Series Single-Phase (DC Voltage Control)	460	410	80	32.5	-

▲ Under conditions with "on" period of 2 seconds and "off" period of 34 seconds.

♦ Averaged over any period of 36 seconds maximum.
♦ Averaged over any period of 15 seconds maximum.

point, a 45° line extends up and to the left. Along this 45° line, the average current through each tube is 40 amperes because demand and duty are inversely proportional. Below 78.7% duty, a horizontal line is drawn through the value of 113 amperes. This value is the maximum permissible rms demand current through the load when the peak anode current is limited to 160 amperes. Below 13.8% duty, the intermittent ratings in the tabulated data take effect. If the 45° line through the 113-ampere, 13.8%-duty point is extended to 100% duty, it will pass through an rms demand (load) current for the circuit of 15.5 amperes. Dividing by 2.22 to obtain the average current for each tube gives the 7 amperes which is the average current rating as shown in the tabulated data. Everywhere along this 45° line, the average current through each tube is 7 amperes. Below 5.5% duty ("on" time of 2 seconds divided by averaging time of 36 seconds), the rms demand current is limited by the maximum intermittent peak anode current rating. The peak anode current rating of 400 amperes multiplied by 0.707 gives the maximum permissible rms demand current of 280 amperes (left horizontal line of Fig.5)

Fig.6 shows a typical single-phase two-tube inverse-parallel circuit for ac voltage control. In intermittent operation of this circuit, a timed gate permits the 7086 to be triggered to pass any number of half-cycle sine-wave pulses while its companion 7086 passes the alternate half-cycle pulses, thus allowing the passage of any number of full-cycle sine-waves to the load. Pulse duration may be varied by the use of phase-back. When this circuit does not utilize a timed gate, the tubes operate in continuous service and are triggered each cycle. In this case, also, the pulse duration may be varied by the use of phase-back. This circuit with timed gate is also used commonly in spot resistance-welding service.

The *full-wave, single-phase ac control circuit of Fig.7* is sometimes known as the *reflected-impedance circuit* since the impedance as represented by the maximum voltage and current ratings of the thyratron is reflected to the primary cir-

cuit through the power transformer. The turns ratio of the power transformer is selected so that the maximum voltage and maximum current ratings of the tube are matched to the required ac load impedance. When the phase of the grid signal is such as to permit the grid bias to block the thyratrons, the input impedance of the transformer is a maximum; and the ac load voltage is a minimum. When the phase of the grid signal is such as to fire the thyratrons near the start of their positive half-cycle, the transformer secondary is short circuited. The reflected short-circuit permits maximum ac voltage to be applied to the load. Intermediate phase settings permit intermediate rms values of ac voltage to be applied to the load. A further advantage of this circuit over that of Fig.6 is that both cathodes are at the same potential. This circuit, therefore, permits the use of a common grid-bias supply.

Grid-controlled rectifier circuits suitable for use with the 7086 are shown in Figs.8, 9, and 10.

The simplicity of the *half-wave, single-phase circuit* in Fig.8 makes this circuit useful for special applications but its performance is characterized by poor transformer utilization factor, low output voltage, and high ripple output.

In Fig.9 is shown a *full-wave, single-phase circuit* which retains the simplicity of the circuit of Fig.8 but in comparison has improved transformer utilization factor and lower ripple output. This circuit is popular for applications requiring relatively low power.

In the *series, single-phase* circuit of Fig.10, two tubes conduct in series. This arrangement provides high output voltage for a given peak inverse anode voltage per tube.

Table I shows the numerical relationships among the various electrical quantities in the circuits of Figs.6, 7, 8, 9, and 10 when they employ the 7086 operated with a grid signal such that it behaves as a conventional gas control tube.

Table II shows the maximum transformer-secondary voltage which can be safely applied to the 7086 when operated in the circuits of Figs.6, 7, 8, 9, and 10. For the circuits of Figs.8, 9, and 10, the table shows the corresponding approximate dc output voltage to filter which may be varied between zero and the tabulated value by adjusting the phase of grid voltage with respect to the anode voltage. Also shown is the maximum dc output current which can be supplied by each of these circuits. When phase-back is employed, care should be taken not to exceed the peak anode current rating of the 7086. For the circuits of Figs.6 & 7 the table shows the maximum ac output obtainable.

Filter circuits for the 7086 should be of the choke-input type, except for the circuits shown in Figs.6 and 7, in order to limit the magnitude of the peak anode current.

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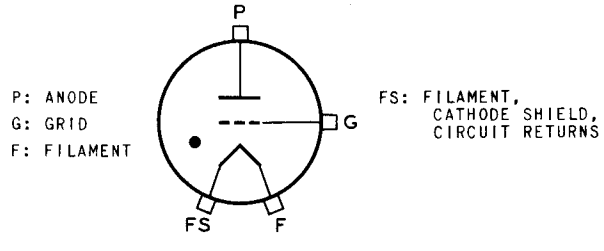
TERMINAL CONNECTIONS



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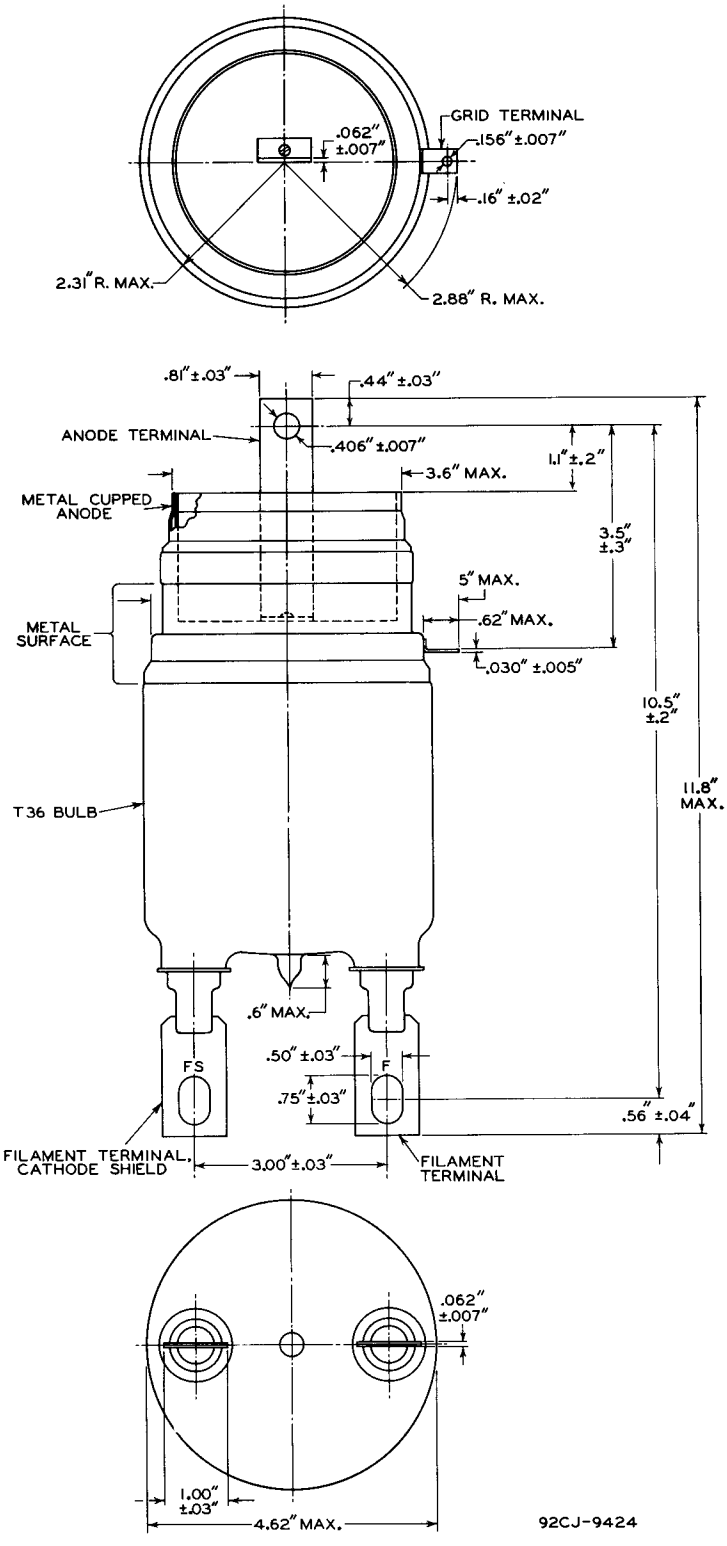
DIMENSIONAL OUTLINE



7094

BEAM POWER TUBE

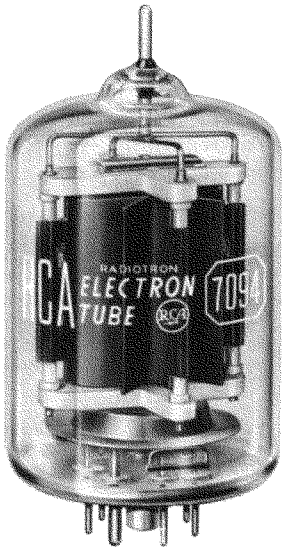
High Power Gain
Sturdy Structure

500 Watts CW Input (ICAS) Up to 60 Mc
335 Watts CW Input (ICAS) at 175 Mc
Forced-Air Cooled at Max. Ratings

5" Max. Length
2.56" Max. Diameter

TENTATIVE DATA

RCA-7094 is a high-perveance beam power tube with high power gain. It is useful in fixed and mobile equipment as an rf power amplifier and oscillator, as well as an af power amplifier and modulator.



The 7094 has a maximum plate dissipation of 125 watts under ICAS conditions in modulator service and in cw service. In the latter service it can be operated with full input to 60 Mc and with reduced input to 175 Mc.

Because of its high power gain, the 7094 can be operated with relatively low plate voltage to give large power output with small driving power.

Small and compact for its power-output capability, the 7094 has a rugged button-stem construction with short internal leads, internal shield connected to grid No.2 within the tube, triple base-pin connections for grid No.2 to permit effective rf grounding, plate structure with large radiating fins for effective cooling, and ceramic mount supports to provide additional sturdiness to the electrode structure. The plate lead is brought out of bulb to a rigid terminal opposite the base to facilitate separation of input and output circuits.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	3.2	amperes
Transconductance (Approx.) for plate volts = 300, grid-No.2 volts = 300, and plate ma = 250	10000	μmhos
Mu-Factor, grid No.2 to grid No.1 for plate volts = 300, grid-No.2 volts = 300, and plate ma = 250.	7	
Direct Interelectrode Capacitances (With no external shield):		
Grid No.1 to plate⊕	0.5	μμf
Grid No.1 to grid No.2 & internal shield⊕	9	μμf
Grid No.1 to cathode and heater⊕	9	μμf
Grid No.2 & internal shield to plate⊕	9	μμf
Grid No.2 & internal shield to cathode and heater⊕	2.8	μμf
Plate to cathode and heater⊕	1.8	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	5"
Seated Length	4.44" ± 0.08"
Maximum Diameter	2.56"
Base	Jumbo-Button Septar 7-Pin (JETEC No.E7-46)
Socket	NATIONAL* HX29
Weight (Approx.)	6 oz
Bulb Temperature (At hottest point)	250 max. °C

Cooling: Free circulation of air around the tube is required. Under operating conditions at maximum ratings, some forced-air cooling will be required from a small fan to prevent exceeding the specified maximum bulb temperature.

AF POWER AMPLIFIER & MODULATOR -- Class AB1♦

	CCS●	ICAS●●	
Maximum Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	1500 max.	2000 max.	volts
DC GRID-NO.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT□	350 max.	350 max.	ma
MAX.-SIGNAL PLATE INPUT□	300 max.	400 max.	watts
MAX.-SIGNAL GRID-NO.2 INPUT□	20 max.	20 max.	watts
PLATE DISSIPATION□	100 max.	125 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical Operation: *Values are for 2 tubes*			
DC Plate Voltage	1500	2000	volts
DC Grid-No.2 Voltage§	400	400	volts
DC Grid-No.1 (Control-Grid) Voltage**	-50	-50	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	88	88	volts
Zero-Signal DC Plate Current	60	60	ma
Max.-Signal DC Plate Current	400	400	ma
Max.-Signal DC Grid-No.2 Current	70	70	ma
Effective Load Resistance (Plate to plate)	8700	12000	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	410	560	watts

* National Company, Inc., 61 Sherman Street, Malden, Mass.

TMK ®, Marca Registrada
Printed in U.S.A

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

LINEAR RF POWER AMPLIFIER -- Class AB$_1$ Single-Sideband Suppressed-Carrier Service

	CCS●	ICAS●●	
Maximum Ratings, *Absolute Values up to 60 Mc:*			
DC PLATE VOLTAGE	1500 max.	2000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT	350 max.	350 max.	ma
MAX.-SIGNAL PLATE INPUT	300 max.	400 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT	20 max.	20 max.	watts
PLATE DISSIPATION	100 max.	125 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical Operation for "Single-Tone Modulation" at 60 Mc:●●			
DC Plate Voltage	1500	2000	volts
DC Grid-No.2 Voltage§	400	400	volts
DC Grid-No.1 (Control-Grid) Voltage**	−50	−50	volts
Max.-Signal Peak RF Grid-No.1 Voltage	44	44	volts
Zero-Signal DC Plate Current	30	30	ma
Max.-Signal DC Plate Current	200	200	ma
Max.-Signal Grid-No.2 Current	35	35	ma
Effective RF Load Resistance	4350	6000	ohms
Max.-Signal Driver Power Output (Approx.)	4	4	watts
Output-Circuit Efficiency (Approx.)	90	90	%
Max.-Signal Useful Power Output (Approx.)	185㊥	250㊥	watts

PLATE-MODULATED RF POWER AMPLIFIER-- Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	CCS●	ICAS●●	
Maximum Ratings, *Absolute Values:*			
For max. plate voltage and max. plate input above 60 Mc, see Rating Chart I			
DC PLATE VOLTAGE	1000 max.	1200 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	−300 max.	−300 max.	volts
DC PLATE CURRENT	280 max.	280 max.	ma
DC GRID-No.1 CURRENT	25 max.	30 max.	ma
PLATE INPUT	250 max.	335 max.	watts
GRID-No.2 INPUT	13.5 max.	13.5 max.	watts
PLATE DISSIPATION	67 max.	83 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical Operation at 60 Mc:			
DC Plate Voltage	1000	1200	volts
DC Grid-No.2 Voltage▲	400	400	volts
DC Grid-No.1 Voltage★	−130	−130	volts
Peak RF Grid-No.1 Voltage	145	150	volts
DC Plate Current	250	275	ma
DC Grid-No.2 Current	20	20	ma
DC Grid-No.1 Current (Approx.)	5	5	ma
Driver Power Output (Approx.)★▲▲	5	5	watts
Output-Circuit Efficiency (Approx.)	90	90	%
Useful Power Output (Approx.)	165㊥	240㊥	watts
Typical Operation at 175 Mc:			
DC Plate Voltage	700	820	volts
DC Grid-No.2 Voltage▲	400	400	volts
DC Grid-No.1 Voltage★	−130	−130	volts
DC Plate Current	250	275	ma
DC Grid-No.2 Current	8	8	ma
DC Grid-No.1 Current (Approx.)	6	6	ma
Driver Power Output (Approx.)▲▲	8	8	watts
Output-Circuit Efficiency (Approx.)	85	85	%
Useful Power Output (Approx.)	105㊥	135㊥	watts
Maximum Circuit Values:			
Grid-No.1-Circuit Resistance‡	30000 max.	30000 max.	ohms

RF POWER AMPLIFIER & OSC.--Class C Telegraphy† and RF POWER AMPLIFIER--Class C FM Telephony

	CCS●	ICAS●●	
Maximum Ratings, *Absolute Values:*			
For max. plate voltage and max. plate input above 60 Mc, see Rating Chart II			
DC PLATE VOLTAGE	1250 max.	1500 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	400 max.	400 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	−300 max.	−300 max.	volts
DC PLATE CURRENT	340 max.	340 max.	ma
DC GRID-No.1 CURRENT	25 max.	30 max.	ma
PLATE INPUT	375 max.	500 max.	watts
GRID-No.2 INPUT	20 max.	20 max.	watts
PLATE DISSIPATION	100 max.	125 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts
Typical Operation at 60 Mc:			
DC Plate Voltage	1000	1250	1500 volts
DC Grid-No.2 Voltage□□	400	400	400 volts
DC Grid-No.1 Voltage⊕⊕	−100	−100	−100 volts
Peak RF Grid-No.1 Voltage	125	120	125 volts
DC Plate Current	330	300	330 ma
DC Grid-No.2 Current	20	18	20 ma
DC Grid-No.1 Current (Approx.)	5	5	5 ma
Driver Power Output (Approx.)★▲▲	4	4	4 watts
Output-Circuit Efficiency (Approx.)	90	90	90 %
Useful Power Output (Approx.)	215㊥	225㊥	340㊥ watts
Typical Operation at 175 Mc:			
DC Plate Voltage	665	875	1000 volts
DC Grid-No.2 Voltage□□	400	400	400 volts
DC Grid-No.1 Voltage⊕⊕	−100	−100	−100 volts
DC Plate Current	335	300	335 ma
DC Grid-No.2 Current	8	7	8 ma
DC Grid-No.1 Current (Approx.)	5	5	5 ma
Driver Power Output (Approx.)▲▲	8	7	8 watts
Output-Circuit Efficiency (Approx.)	85	85	85 %
Useful Power Output (Approx.)	130㊥	170㊥	215㊥ watts
Maximum Circuit Values:			
Grid-No.1-Circuit Resistance‡	30000 max.		ohms

⊕ All other elements are grounded.

♦ Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

●● Intermittent Commercial and Amateur Service.

□ Averaged over any audio-frequency cycle of sine-wave form.

§ Obtained preferably from a fixed supply.

** Obtained from a fixed supply.

♧ This value of useful power is measured at load of output circuit having indicated efficiency.

♦♦ "Single-Tone Modulation" operation refers to that class of amplifier service in which the grid-No.1 input consists of a monofrequency rf signal having constant amplitude. This signal is produced in a single-sideband suppressed-carrier system when a single audio frequency of constant amplitude is applied to the input of the system.

▲ Obtained preferably from a separate source modulated along with the plate supply, or from the modulated plate supply through a series resistor. It is recommended that this resistor be adjustable to permit obtaining the desired operating plate current after initial tuning adjustments are made.

★ Obtained from a grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor. The combination of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

♣ Indicated values are for operation at 60 Mc. Less driver power output is required at frequencies below 60 Mc.

▲▲ Driver stage is required to supply tube losses and rf circuit losses. The driver stage should be designed to provide an excess of power above the indicated values to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

‡ When grid No.1 is driven positive the total dc grid-No.1-circuit resistance should not exceed the specified maximum value of 30000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply.

† Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

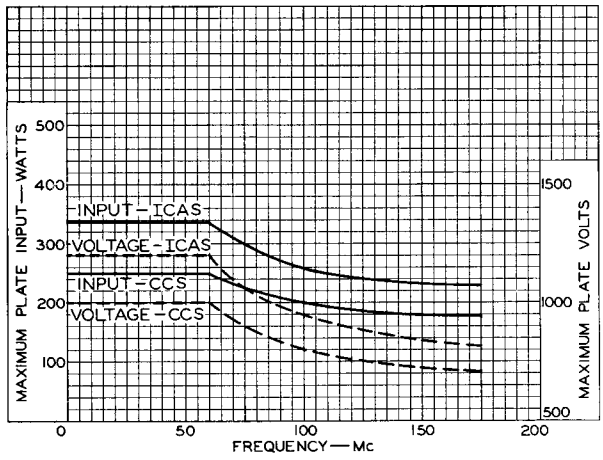
□□ Obtained preferably from a separate source or from the plate-voltage supply with a voltage divider. If a series resistor is used, it should be adjustable to permit obtaining the desired operating plate current after initial tuning adjustments are completed. Grid-No.2 voltage must not exceed 500 volts under key-up conditions.

⊕⊕ Obtained from a grid-No.1 resistor, or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

OPERATING CONSIDERATIONS

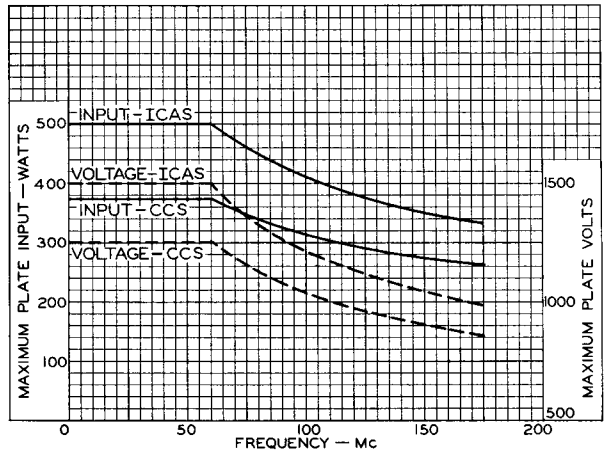
The *maximum ratings* in the tabulated data for the 7094 are limiting values above which the serviceability of the 7094 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum bulb temperature* of 250° C is a tube rating and is to be observed in the same manner as other ratings. The temperature should be measured at the hottest point on the bulb with the tube operating in the completely assembled equipment with all covers in place, and delivering the maximum output under the highest ambient-temperature conditions and the most severe operating cycle for which the equipment is designed. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y., in the form of liquid and stick.



92CS-9492

Rating Chart I for Type 7094 in Class C Telephony Service.



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Rating Chart II for Type 7094 in Class C Telegraphy Service.

Operation of the 7094 at frequencies above 60 Mc requires reduction in the applied plate

voltage and plate input as shown by the Rating Charts I and II. In using these charts, it is to be noted that the maximum plate input that can be applied to the 7094 operating at any given frequency must be chosen, depending on circuit efficiency, so that the plate-dissipation rating of the 7094 will not be exceeded.

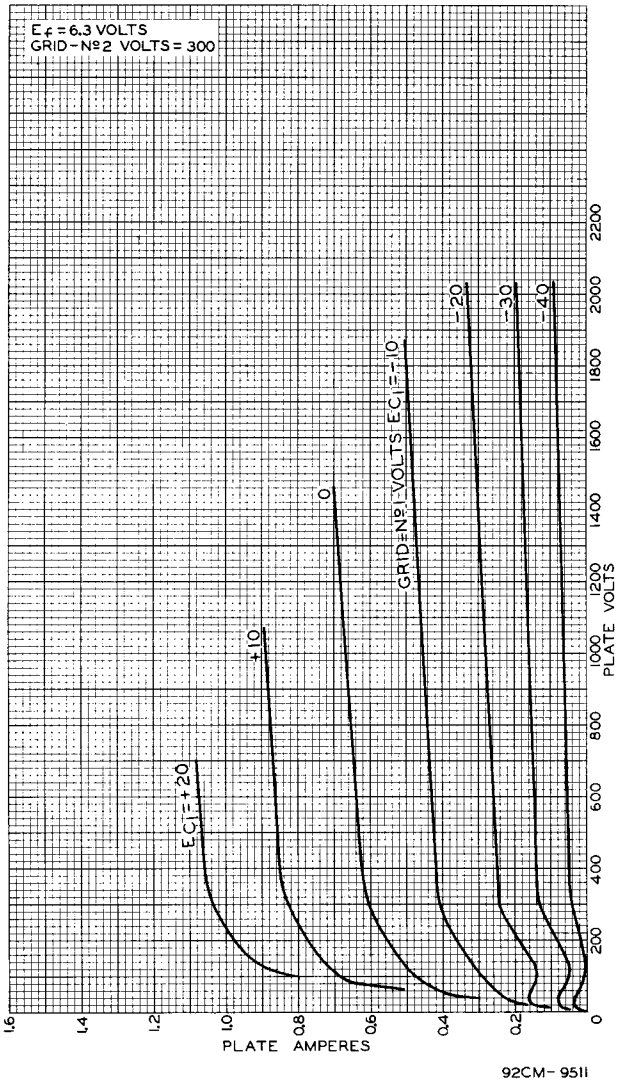


Fig. 1 - Typical Plate Characteristics of Type 7094.

The rated plate voltage and grid-No. 2 voltage of this tube are high enough to be dangerous to the user. Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

When a new circuit is tried or when adjustments are made, it is advisable to reduce the plate voltage and grid-No. 2 voltage.

A *protective device*, such as a fuse, should be used to protect not only the plate but also grid No. 2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the plate circuit should be fused. Similarly, a fuse in the lead to grid No. 2 should remove the grid-No. 2 voltage when the dc grid-No. 2 current reaches a value slightly higher than normal.

The *base pins* of the 7094 fit the standard transmitting seven-contact socket designed for use with the septar 7-pin base, such as Johnson No. 122-105.

Shielding of the 7094 in rf service is required for stable operation. A convenient method

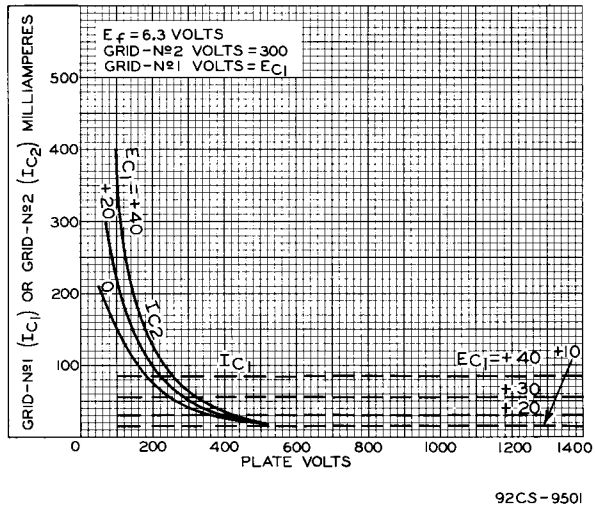


Fig. 2 - Typical Characteristics for Type 7094.

of shielding is to mount the socket approximately 5/8" beneath a hole in the chassis plate so that when the 7094 is inserted in the socket, the internal shield *(see Dimensional Outline)* of the tube will be close to the edge of the hole and in the same plane as the chassis plate. This arrangement provides an effective shield to isolate the grid-No. 1 circuit from the plate circuit.

The connection to the plate terminal should be flexible in order to prevent subjecting the plate-terminal seal to any strain. The connection should never be soldered to the plate terminal. A plate connector of the heat-radiating type is recommended.

Heavy leads and conductors together with suitable insulation should be used in all parts of the rf plate tank circuit so that losses due to rf voltages and currents may be kept at a minimum. At the higher frequencies, it is essential that short, heavy leads be used for circuit connections in order to minimize lead inductance and losses.

The *plate* shows no color when the 7094 is operated at maximum rated plate dissipation under CCS conditions. At maximum rated plate dissipation under ICAS conditions, the plate may show a barely discernible color in a dark room.

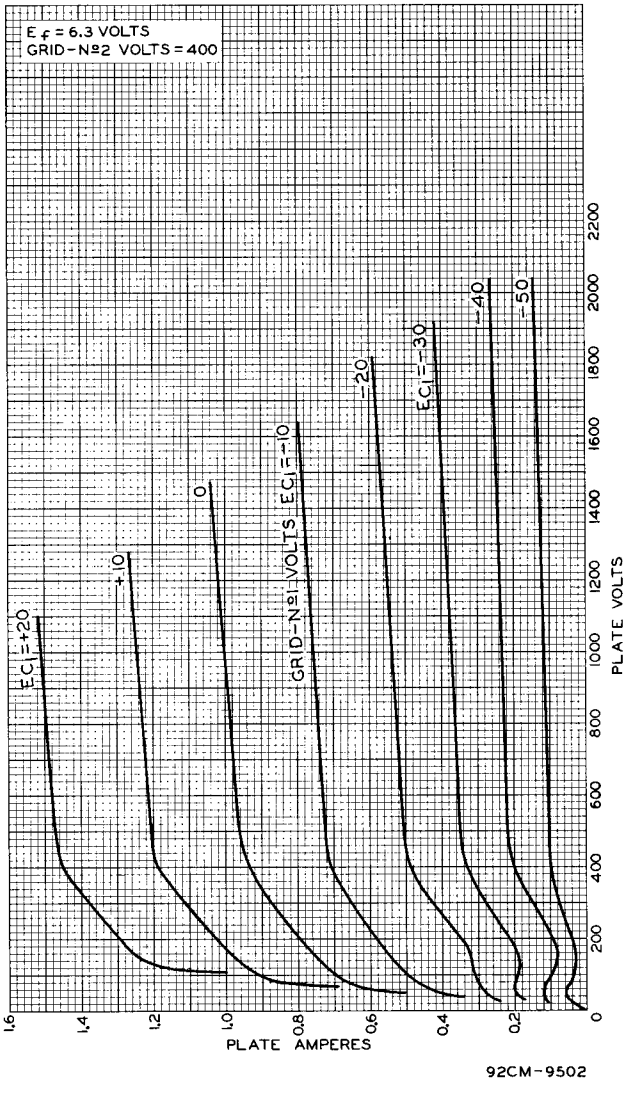


Fig. 3 - Typical Plate Characteristics of Type 7094.

The *cathode* should preferably be connected to one side of the heater. When, in some circuit designs, the heater is not connected directly to the cathode, precautions must be taken to hold the peak heater-cathode voltage to the maximum values shown in the tabulated data.

When *grid-No. 2 voltage* is obtained from a separate source, the plate voltage should be applied before or simultaneously with the grid-No. 2 voltage; otherwise, with voltage on grid No. 2 only, its current would be large enough to cause excessive grid-No. 2 dissipation even though some protective bias is employed. When the grid-No. 2 voltage is obtained from a voltage divider or through a series resistor from the plate supply, it is recommended that the resistor be adjustable so that the plate current of individual tubes can be adjusted to maintain the desired input. By thus compensating for the normal plate-current variation between tubes, the dc plate input can be held constant to provide more uniform power output and better performance. A dc milliammeter should be used in the grid-No. 2 circuit so that its current may be measured and the dc power input determined.

The *rf impedance between grid No. 2 and the cathode* must be kept low, usually by means of a

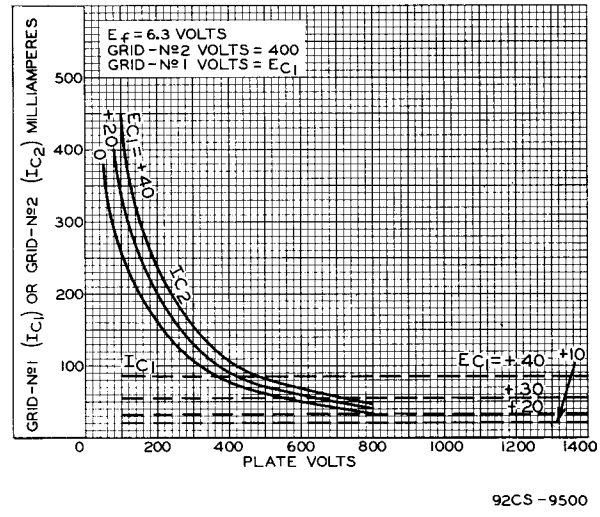


Fig. 4 - Typical Characteristics for Type 7094.

suitable bypass capacitor. In telephony service when grid No. 2 is modulated, a smaller bypass capacitor than is used for telegraphy service may be required in order to avoid excessive af bypassing. However, if the capacitance value is too small, rf feedback may occur between plate and grid No. 1, depending on the circuit layout, operating frequency, and power gain of the stage. AF bypassing difficulties can usually be eliminated if the grid-No. 2 bypass capacitor is replaced by a series-resonant circuit which is tuned to resonate at the operating frequency. This circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.

The *grid-No. 2 current* is a very sensitive indication of plate-circuit loading. When the amplifier is operated without load, the grid-No. 2 current rises excessively, often to a value which damages the tube. Therefore, care should be taken when tuning the 7094 under no-load or

lightly loaded conditions to prevent exceeding the grid-No.2 input rating of the tube. In this connection, reduction of the grid-No.2 voltage will be helpful.

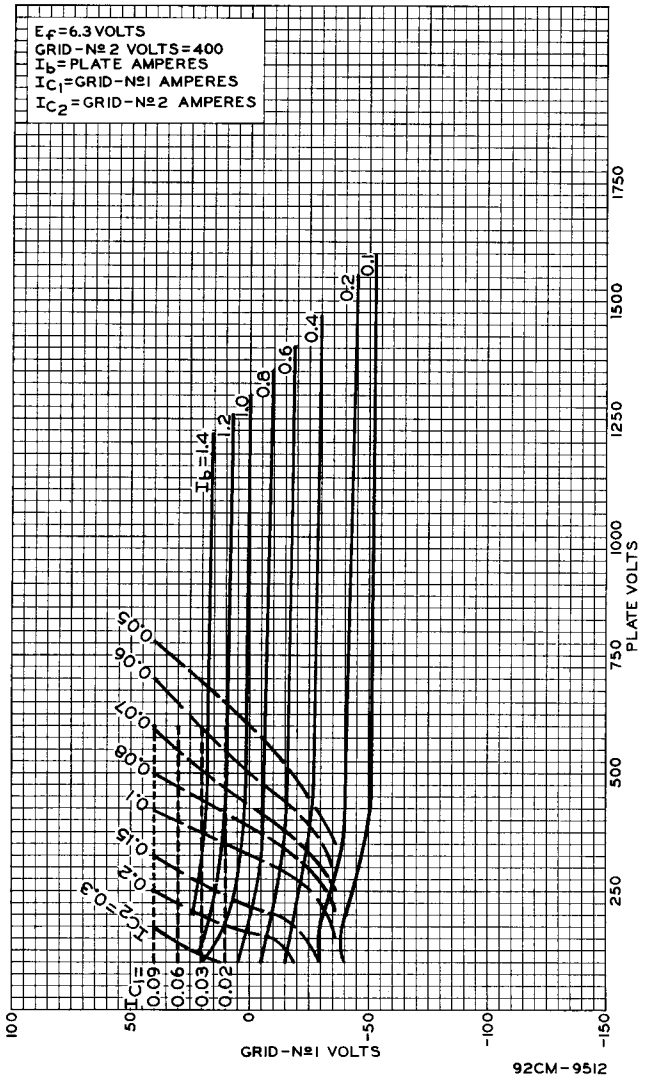


Fig.5 - Typical Constant-Current Characteristics for Type 7094.

The *driver stage* for the 7094 in either class C telephony or telegraphy service should have considerably more output capability than the typical driving power shown in the tabulated data in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuit and the coupling circuit. This recommendation is particularly important near the rated maximum frequency where circuit losses, radiation losses, and transit-time losses increase. These losses have been taken into account in the values of driver power output shown under Typical Operation.

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 7094 is operated under load conditions such that the maximum rated plate current flows at the plate voltage which will give maximum rated input.

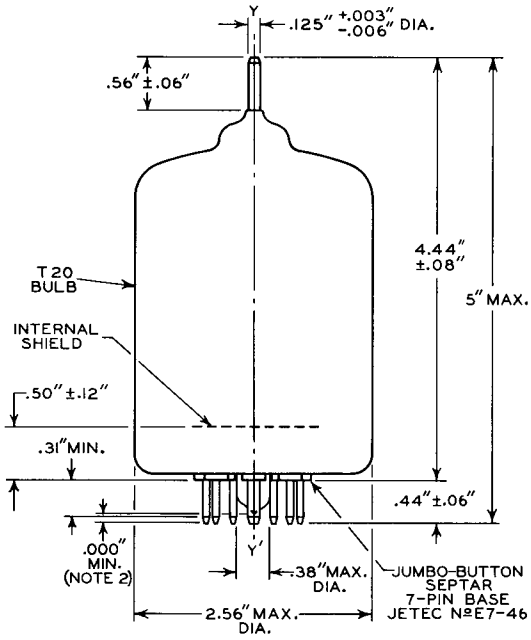
In *plate-modulated class C amplifier service*, the 7094 can be modulated 100 per cent. The grid-No.2 voltage must be modulated simultaneously with the plate voltage so that the ratio of grid-No.2 voltage to plate voltage remains constant. Modulation of the grid-No.2 voltage can be accomplished either by connecting grid No.2 through a separate winding on the modulation transformer to the fixed grid-No.2 voltage supply, or by connecting grid No.2 through an audio-frequency choke of suitable impedance for low audio frequencies to the fixed grid-No.2 supply voltage. The supply end of the choke should be well bypassed to ground.

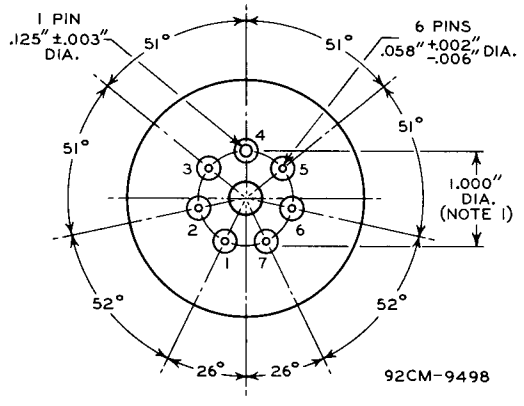
During standby periods in intermittent operation, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; and that it be reduced to 80 per cent of normal when the period is between 15 minutes and 2 hours. For longer periods, the heater voltage should be turned off.

Push-pull or parallel circuit arrangements can be used when more radio-frequency power is required than can be obtained from a single 7094. Two 7094's in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage from that required for a single tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE





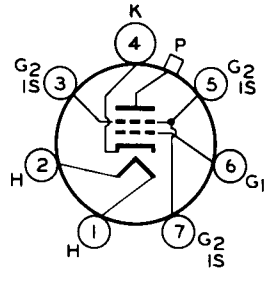
THE REFERENCE AXIS Y-Y' IS DEFINED AS THE AXIS OF THE BASE PIN GAUGE DESCRIBED IN NOTE 1:

NOTE 1: ANGULAR VARIATIONS BETWEEN PINS AND VARIATION IN PIN-CIRCLE DIAMETER ARE HELD TO TOLERANCES SUCH THAT PINS WILL ENTER TO A DISTANCE OF 0.375" A FLAT-PLATE BASE-PIN GAUGE HAVING SIX HOLES 0.0800" ± 0.0005" AND ONE HOLE 0.1450" ± 0.0005" ARRANGED ON A 1.0000" ± 0.0005" CIRCLE AT SPECIFIED ANGLES WITH TOLERANCE OF ± 5' FOR EACH ANGLE. GAUGE IS ALSO PROVIDED WITH A HOLE 0.500" ± 0.010" CONCENTRIC WITH PIN CIRCLE WHOSE CENTER IS ON THE AXIS Y-Y'.

NOTE 2: EXHAUST TIP WILL NOT EXTEND BEYOND THE PLANE WHICH PASSES THROUGH THE ENDS OF THE THREE LONGEST PINS.

SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER
PIN 2: HEATER
PIN 3: GRID No.2, INTERNAL SHIELD
PIN 4: CATHODE
PIN 5: GRID No.2, INTERNAL SHIELD
PIN 6: GRID No.1
PIN 7: GRID No.2, INTERNAL SHIELD
P: PLATE

7102

MULTIPLIER PHOTOTUBE

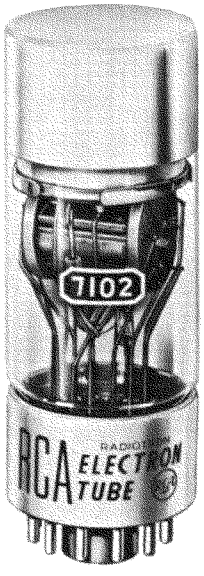
1.24" Dia. Flat Semitransparent Photocathode

10-Stage, Head-On Type
S-1 Response
Capable of Very Short Time-Resolution

4.57" Max. Length
1.56" Max. Diameter
Duodecal 12-Pin Base

TENTATIVE DATA

RCA-7102 is a head-on type of multiplier phototube intended for use in the detection and measurement of low-level red and near-infrared radiation. It is well suited for use in red and near-infrared spectrometry, infrared ranging, astronomical measurements involving near-infrared radiation, optical pyrometry, and in applications utilizing near-infrared radiation for communications.



The spectral response of the 7102 covers the range from about 4200 to 11000 angstroms as shown in Fig.1. Maximum response occurs at approximately 8000 angstroms.

Design features of the 7102 include a semitransparent cathode having a minimum diameter of 1.24 inches on the inner surface of the face end of the bulb and ten electrostatically focused dynode stages. The relatively large cathode permits efficient collection of the radiation from sources of scattered radiation.

The 7102 is capable of very short time-resolution. For an input pulse having a duration of 1 millimicrosecond or less, the time spread of the pulse at the anode is about 5 millimicroseconds measured at 50 per cent of the maximum pulse height. This time spread corresponds to an electron transit-time spread of about 4 millimicroseconds. The transit-time spread can be reduced to about 2 millimicroseconds by irradiating only a small central area of the photocathode.

DATA

General:

Spectral Response	S-1	
Wavelength of Maximum Response	8000 ± 1000	angstroms
Cathode, Semitransparent:		
Shape	Circular	
Window:		
Area	1.2	sq. in.
Minimum diameter	1.24	in.
Index of refraction	1.51	
Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.10	4	μμf
Anode to all other electrodes	7	μμf
Maximum Overall Length	4.57"	
Seated Length	3.88" ± 0.19"	
Maximum Diameter	1.56"	
Bulb	T-12	
Base	Small-Shell Duodecal 12-Pin (JETEC No.B12-43) Non-hygroscopic	
Socket	Eby No.160, or equivalent	
Operating Position	Any	
Weight (Approx.)	2	oz

Maximum Ratings, *Absolute Values:*

ANODE-SUPPLY VOLTAGE (DC or Peak AC)	1500 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.10 AND ANODE (DC or Peak AC)	250 max.	volts
SUPPLY VOLTAGE BETWEEN CATHODE AND DYNODE No.1 (DC or Peak AC)	400 max.	volts
AVERAGE ANODE CURRENT●	10 max.	μa
AMBIENT TEMPERATURE	75 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with supply voltage (E) across voltage divider providing 1/6 of E between cathode and dynode No.1; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode.

With E = 1250 volts (except as noted)

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 8000 angstroms	–	400	–	μa/μw
Cathode Radiant, at 8000 angstroms	–	0.0027	–	μa/μw
Luminous:♦				
At 0 cps	1	4.5	30	amp/lumen
With dynode No.10 as output electrode*	–	2.7	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲	10	30	–	μa/lumen
With infrared source (see Fig.2)⊕	0.012	0.036	–	μa
Current Amplification	–	150000	–	
Equivalent Anode-Dark-Current Input⊞	–	3×10^{-7}	5×10^{-6}	lumen
	–	3.3×10^{-9}†	5.5×10^{-8}†	watt
Equivalent Noise Input★	–	1.5×10^{-10}	7.5×10^{-10}	lumen
	–	1.7×10^{-12}†	8.4×10^{-12}†	watt

With E = 1500 volts (except as noted)

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 8000 angstroms	–	1250	–	μa/μw
Cathode Radiant, at 8000 angstroms	–	0.0027	–	μa/μw
Luminous:♦				
At 0 cps	–	14	–	amp/lumen
With dynode No.10 as output electrode*	–	8.4	–	amp/lumen

TMK ®, Marca Registrada
Printed in U.S.A

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

	Min.	Median	Max.	
Cathode Luminous:				
With tungsten light source▲ .	10	30	–	μa/lumen
With infrared source (See Fig.2)⊕	0.012	0.036	–	μa
Current Amplification.	–	465000	–	

● Averaged over any interval of 30 seconds maximum.

🌡 For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K. A light input of 10 microlumens is used. The load resistance has a value of 0.01 megohm.

* An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.10 as the output electrode. With this arrangement, the load is connected in the dynode-No.10 circuit and the anode serves only as collector.

▲ For conditions the same as shown under (🌡) except that the value of light flux is 0.01 lumen and 150 volts are applied between cathode and all other electrodes connected together as anode.

⊕ Under the following conditions: 2870° K tungsten light source; light flux of 0.01 lumen incident on Corning No.2540 Infrared Filter (Melt 1613, 2.61 mm thick, or equivalent); irradiated area of photocathode is 1.24 inch in diameter.

† Measured at 8000 angstroms.

⊕ Measured at a tube temperature of 25° C and with the supply voltage (E) adjusted to give a luminous sensitivity of 4 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

★ Under the following conditions: Supply voltage (E) 1250 volts, 25° C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at color temperature of 2870° K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Cathode Luminous Sensitivity. The quotient of current leaving the photocathode by the incident luminous flux.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity or the radiant sensitivity.

Equivalent Noise Input. That value of incident radiant flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Transit-Time Spread. The increase in width of the output pulse over that of the input pulse. Pulse width is measured at 50% of the pulse height.

GENERAL CONSIDERATIONS

The 7102 is a phototube incorporating an electron multiplier. An electron multiplier utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the 7102 multiplier phototube, represented in Fig.4, the electrons emitted from the irradiated cathode are directed by fixed electrostatic fields to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed by fixed-electrostatic fields along curved paths to the second dynode where they produce more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing

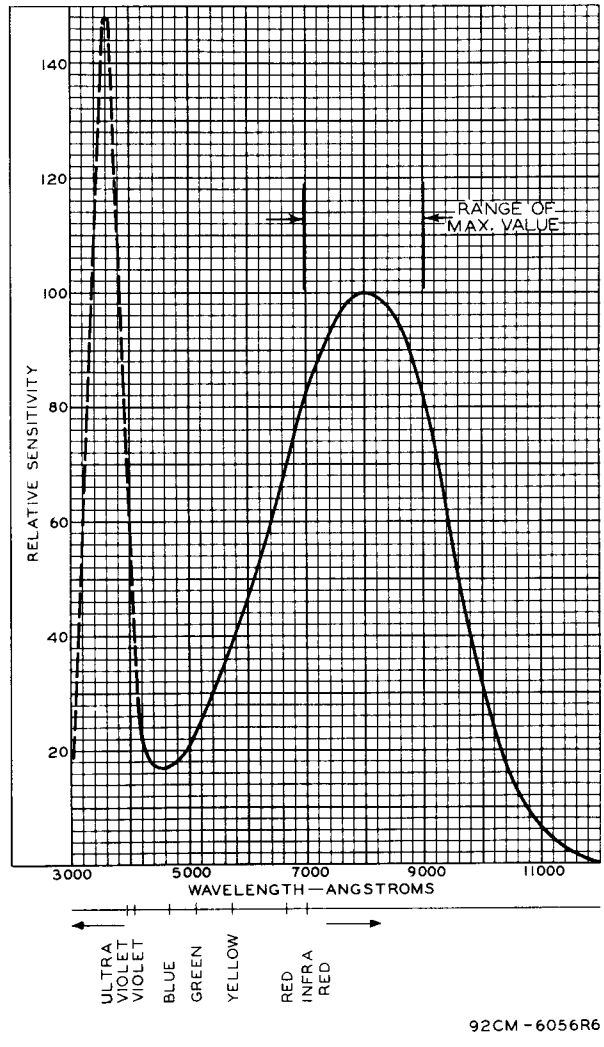


Fig. 1 - Spectral Sensitivity Characteristic of Type 7102 which has S-1 Response. Curve is shown for Equal Values of Radiant Flux of All Wavelengths.

stream of electrons, until those emitted from the last dynode (dynode No.10) are collected by the anode and constitute the current utilized in the output circuit.

Dynode No.10 is so shaped as to enclose partially the anode and to serve as a shield for it in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the interdynode region. Actually the anode consists of a grating which allows the electrons from dynode No.9 to pass through it to dynode No.10. Spacing between dynode No.10 and

anode creates a collecting field such that all the electrons emitted by dynode No. 10 are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 7102 can be coupled to any practical load impedance.

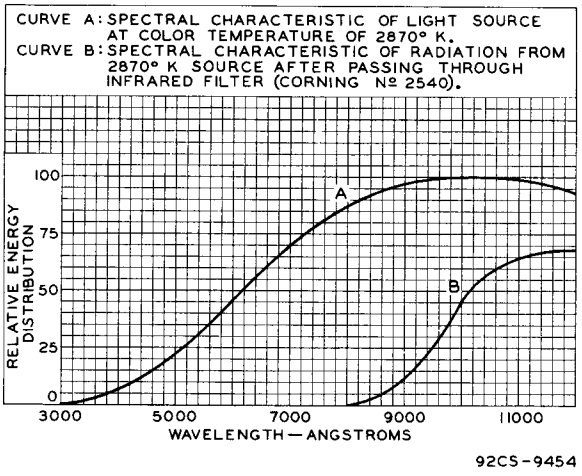


Fig. 2 - Spectral Characteristic of 2870° K Light Source, and Spectral Characteristic of Radiation from 2870° K Source after Passing Through Indicated Filter.

The metallic coating on the inner side wall of the glass bulb is connected to the cathode, and serves to direct the electrons from the cathode toward dynode No. 1. The grill through which the electrons reach dynode No. 1, is connected to dynode No. 1 and serves along with the accelerating electrode as an electrostatic shield for the open side of the electrode structure.

INSTALLATION and APPLICATION

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 7102 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum ambient temperature* as shown in the tabulated data is a tube rating which is to be observed in the same manner as other ratings. This rating should not be exceeded because too high a bulb temperature may cause the volatile cathode surface and dynode surfaces to evaporate with consequent decrease in the life and sensitivity of the tube.

The *base pins* of the 7102 fit the duodecal 12-contact socket. The socket should be made of high-grade, low-leakage material, and should be installed so that the incident radiation falls on the face end of the tube. It is to be noted that the basing arrangement is such that the voltage between anode pin and adjacent pins is not more than twice the voltage per stage. As a result, external leakage between anode pin and adjacent pins is kept low.

In general, the *operating voltages* for the 7102 are as follows. The cathode-to-dynode-No. 1 potential is about twice the potential applied between the successive dynodes. The steps for the successive stages are generally chosen as 100 to 125 volts. The voltage between dynode No. 10 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristic curves, shown in Fig. 5, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. Low operating voltage between dynode No. 10 and anode reduces the dark current. To obtain the indicated operating voltage between dynode No. 10 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

In applications where it is desired to keep the statistical fluctuations to a minimum, e.g., as in astronomical measurements, the potential

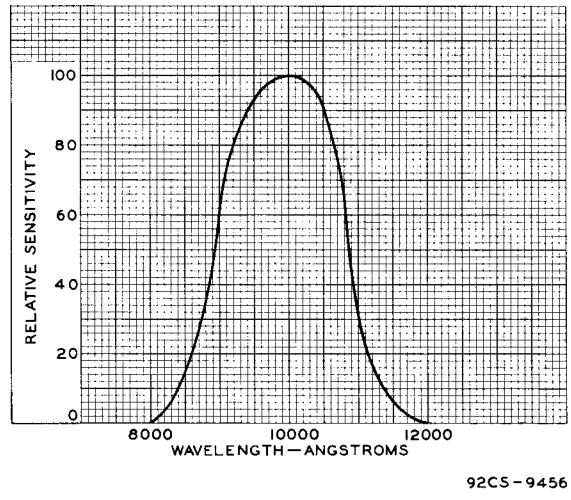


Fig. 3 - Spectral Characteristic of Type 7102 when Irradiated with Infrared Flux Obtained by Passing Radiant Flux from a 2870° K Tungsten Source Through Infrared Filter (Corning No. 2540).

between cathode and dynode No. 1 may be increased to the rated maximum value of 400 volts.

Dark current observed when voltage is applied to the electrodes of the 7102 in complete darkness is caused primarily by electrons thermionically released from the cathode and establishes a limit below which the incident radiation on

the cathode can not be detected. The dark current can be substantially reduced by cooling the photocathode. Dark current is reduced by about 50 per cent for each 6° reduction in temperature beginning at 25° C.

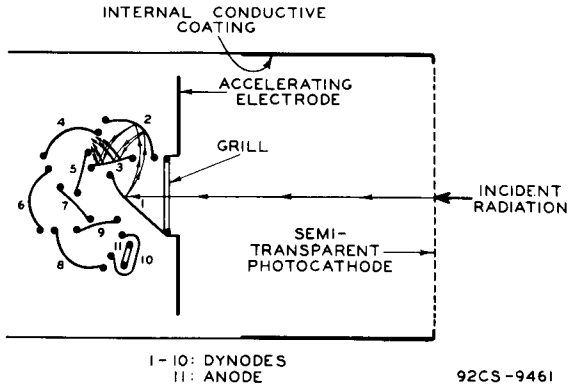


Fig. 4 – Schematic Arrangement of Type 7102 Structure.

When the application utilizes *continuous luminous excitation and dc anode current* and it is desired to have a high ratio of signal output to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig.6 which shows the equivalent anode-dark-current input as a function of luminous sensitivity for the 7201, and the curves in Fig.7 which show luminous sensitivity as a function of the supply voltage.

In applications involving *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 1000 to 1250 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise power spectrum is essentially flat up to about 50 megacycles per second. At voltages above 1250 volts, regenerative phenomena usually contribute to the noise.

The noise spectrum of the 7201 is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of the exciting signal in order to eliminate as much noise as possible.

In either dc or ac applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice, to cool the bulb of the 7201 is recommended. The refrigerant reduces the thermionic emission, and thereby lowers the detection threshold to give improved operation. The curves in Fig.8 show the equivalent noise input as a function of the temperature of the 7201.

When stability of operation is important, the use of an average anode current well below the maximum rated value of 10 microamperes is recommended. This maximum rating should never be exceeded because operation at higher average output currents may cause a permanent decrease in infrared sensitivity and a consequent decrease in the tube life.

A small temporary loss of infrared sensitivity may be observed after long periods of operation. The sensitivity recovers during idle periods but only very slowly at temperatures below 25° C.

The *range of sensitivity values* is dependent on the respective amplification of each dynode stage. Hence large variations in sensitivity can be expected between individual tubes of a

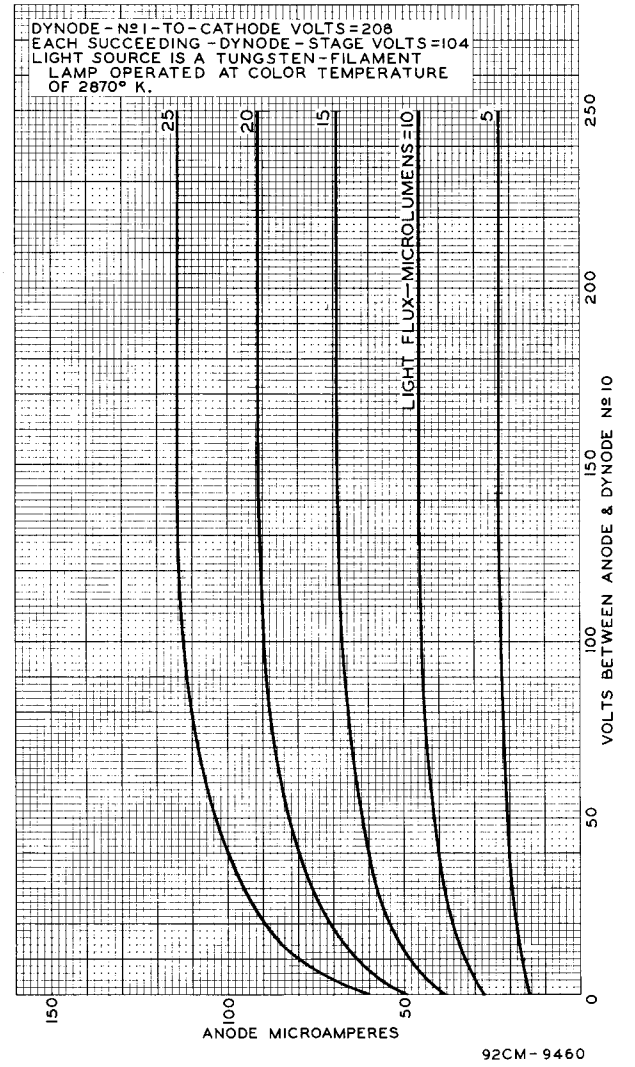


Fig. 5 – Average Anode Characteristics of Type 7102.

given type. The overall amplification of a multiplier phototube is equal to the average amplification per stage raised to the nth power, where n is the number of stages. Thus, very

small variations in amplification per stage produce very large changes in overall tube amplification.

Because these overall changes are very large, it is advisable for designers to provide adequate adjustment of the supply voltage per stage so as to be able to adjust the amplification of indi-

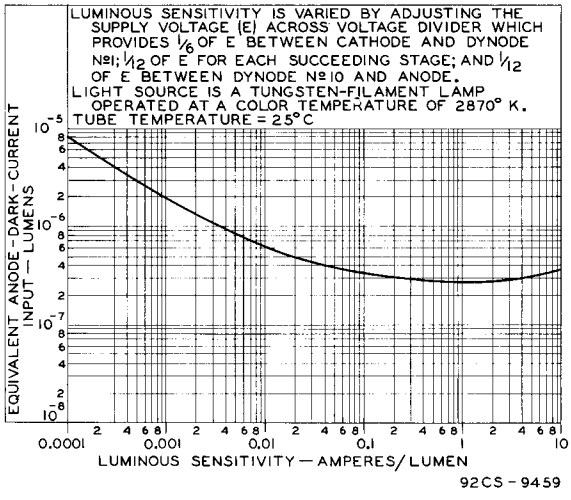


Fig. 6 - Typical Anode-Dark-Current Characteristic of Type 7102.

vidual tubes to the desired design value. The voltage-adjustment range required to take care of variations between individual tubes may be determined from Fig.7. For example, if a sensitivity of 1 ampere per lumen is desired, it will be observed that this value on the "minimum" sensitivity curve corresponds to a supply voltage of about 1250 volts, and on the "maximum" sensitivity curve to a supply voltage of 910 volts. Therefore, provision should be made to adjust the supply voltage over the range from 910 to 1250 volts.

Electrostatic and/or magnetic shielding of the 7102 may be necessary. The metallic coating on the inner side wall of the glass bulb acts as an electrostatic shield to prevent the coated portion of the bulb wall from charging to a positive potential. However, the uncoated area of the bulb wall tends to charge to a potential near that of the anode, especially when the 7102 is operated at voltages near the maximum, with the result that an internal discharge phenomenon may occur and cause an increase in noise. To prevent this possibility, it is suggested that a shield be closely fitted over the uncoated area and be connected as a safety precaution (see below), through a high impedance in the order of 10 megohms to a potential near that of the cathode. The shield may consist of a conductive coating painted on the clear portion of the bulb above the base, or metallic foil wrapped around the clear area.

With certain orientations of the 7102, it will be observed that the earth's magnetic field is sufficient to cause a noticeable decrease in the response of the tube. The curve in Fig.9 shows the effect on anode current of variation in magnetic-field strength under the conditions indicated. With increase in voltage above 100 volts between cathode and dynode No.1, the effect of the magnetic field will cause less decrease in anode current.

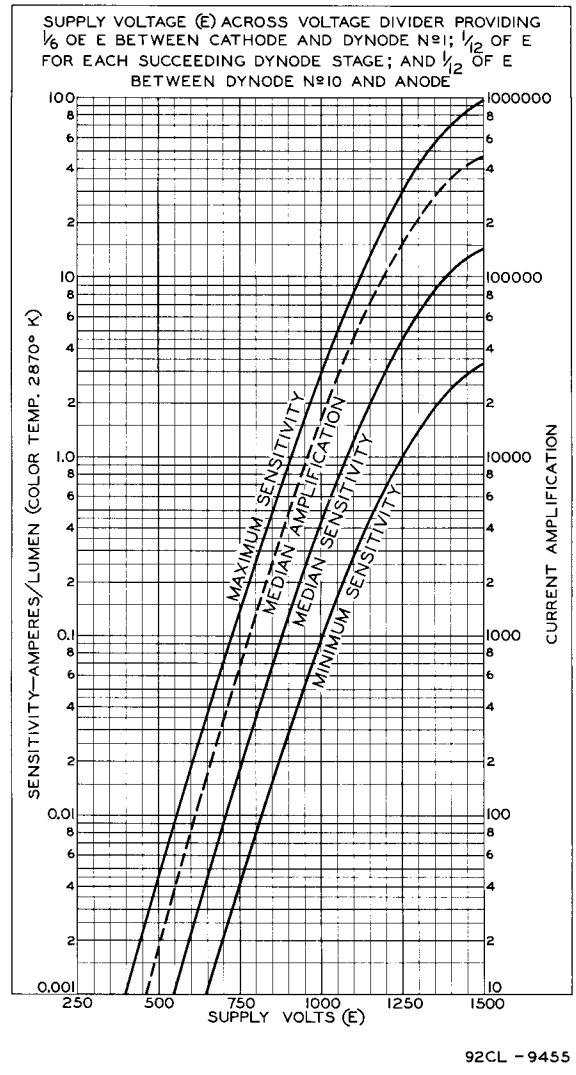


Fig. 7 - Characteristics of Type 7102.

To prevent such decrease in response of the tube, magnetic shielding should be provided. When connected to cathode potential, this shielding may closely fit the bulb and serves the dual purpose of providing both magnetic and electrostatic shielding. When connected to anode potential, this shielding should be spaced at least 1/2 inch from the bulb wall to prevent the internal discharge phenomenon described above.

It is to be noted that the use of an external magnetic and/or electrostatic shield at high

negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme*

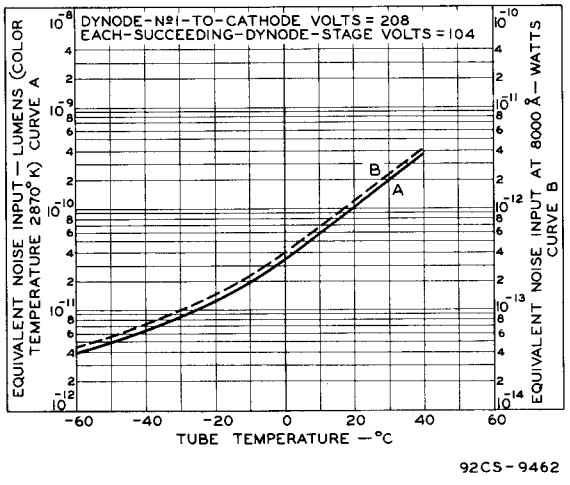


Fig. 8 - Equivalent Noise-Input Characteristics of Type 7102.

care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.

Adequate *light and infrared-radiation shielding* should be provided to prevent extraneous radiation from reaching any part of the 7102. Although the metallic coating on the inner side

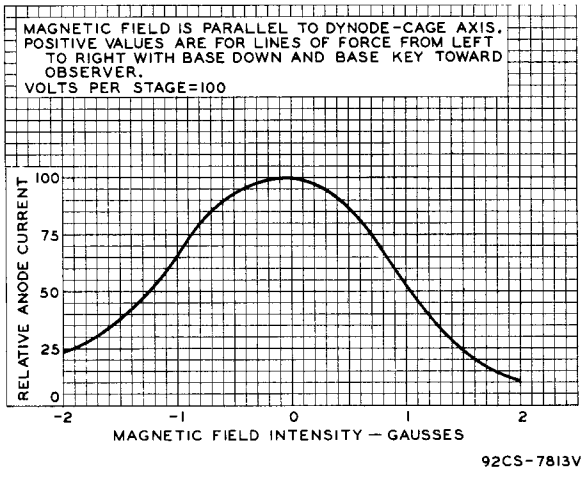


Fig. 9 - Effect of Magnetic Field on Anode Current of Type 7102.

wall of the glass bulb serves to reduce the amount of extraneous radiation reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous radiation.

Whenever frequency response is important, the leads from the 7102 to the amplifier should be short so as to minimize capacitance shunting of the phototube load.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage, vacuum-tube rectifier. The voltage for each dynode and for the anode can be supplied by spaced taps on a voltage divider across the rectified power supply. The current through the voltage

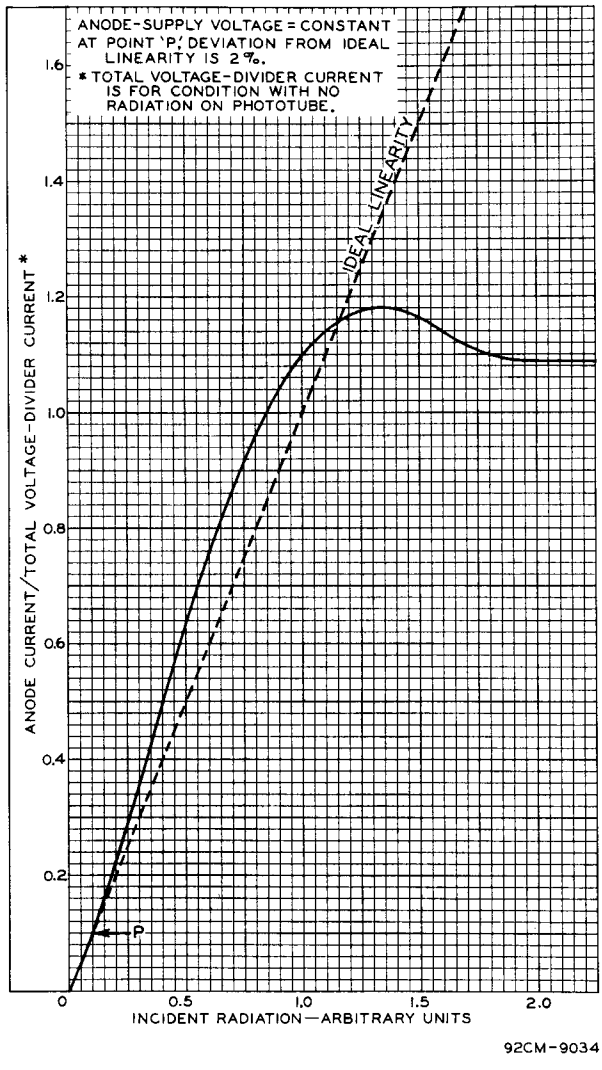
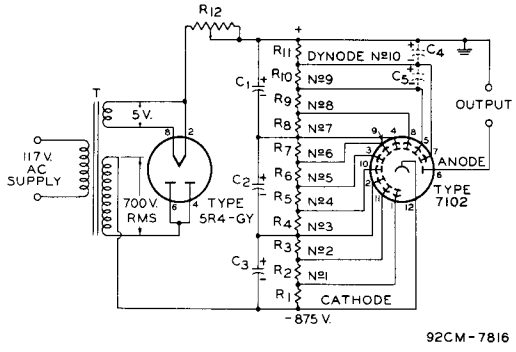


Fig. 10 - Linearity Characteristic of Type 7102 as Affected by Ratio of Anode Current to Total Divider Current.

divider will depend on the voltage regulation, required by the application. In general, the current in the divider should be about 10 times the maximum value of total dynode current flowing through the divider. Such a value will prevent variations of the dynode potentials by the signal current. Because of the relatively large divider current required for good regulation, the use of a rectifier of the full-wave type is

recommended. Sufficient filtering will ordinarily be provided by a well-designed, two-section filter of the capacitor-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Due to critical dependence of the gain of the 7102 on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output. When the dc supply voltage is provided by means of a rectifier, satisfactory regulation can be obtained by the use of a vacuum-tube regulator circuit of the mu-bridge type.



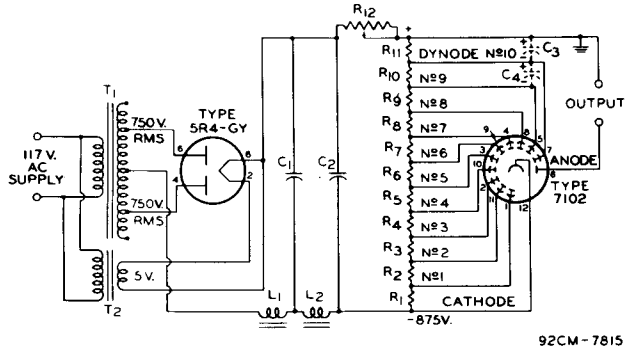
C1 C2 C3: 16 μf, electrolytic, 450 volts (dc working)
C4 C5: 8 μf, electrolytic, 150 volts (dc working)
Required only if high peak currents are drawn.
R1: 100000 ohms, 1/2 watt
R2 R3 R4 R5 R6 R7 R8 R9 R10: 50000 ohms, 1/2 watt
R11: 33000 ohms, 1/2 watt
R12: 100000 ohms, 1 watt, adjustable, Centralab A122, or equivalent
T: United Transformer Corp. No.R-2, or equivalent

Fig. 11 - Simple Half-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 7102.

The relationship between the ratio of anode current-to-voltage-divider current and incident radiation is shown in Fig. 10. For operation along the *ideal linearity* curve of Fig. 10, the anode current-to-voltage-divider current ratio should be less than 0.1.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.

The high voltages at which the 7102 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.



C1 C2: 2 μf, 1000 volts (dc working)
C3 C4: 8 μf, electrolytic, 150 volts (dc working).
Required only if high peak currents are drawn.
L1 L2: United Transformer Corp. No.R-17, or equivalent
R1: 39000 ohms, 2 watts
R2 R3 R4 R5 R6 R7 R8 R9 R10: 18000 ohms, 1 watt
R11: 12000 ohms, 1 watt
R12: 200000 ohms, 12 watts, adjustable, General Radio Type 471-A, or equivalent
T1: United Transformer Corp. No.S-45, or equivalent
T2: United Transformer Corp. No.FT-6, or equivalent

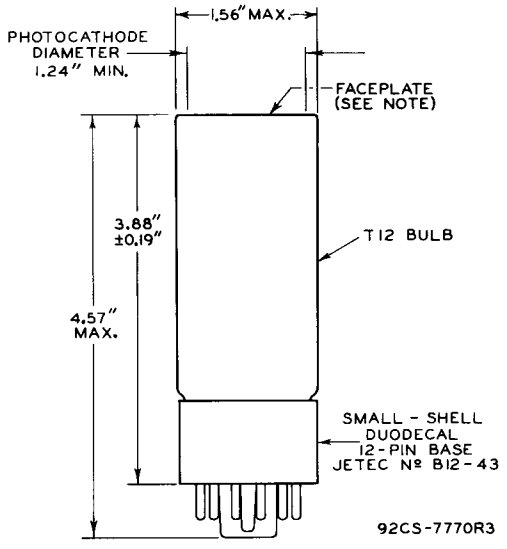
Fig. 12 - Full-Wave Rectifier Power-Supply Circuit with Voltage Divider for Supplying DC Voltages to Type 7102 in Applications Critical as to Hum Modulation.

In the use of the 7102, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

Typical power-supply circuits for the 7012 are shown in Fig. 11 and 12. The circuit in Fig. 11 utilizes a half-wave rectifier to provide the dc power for the 7102. In applications where better regulation and minimum hum modulation are essential, the circuit of Fig. 12 may be used.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



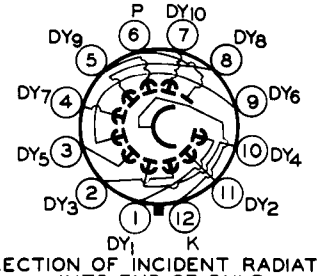
NOTE: WITHIN 1.24" DIAMETER, DEVIATION FROM FLATNESS OF EXTERNAL SURFACE OF FACEPLATE WILL NOT EXCEED 0.010" FROM PEAK TO VALLEY.

℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

SOCKET CONNECTIONS

Bottom View

PIN 1: DYNODE No.1
PIN 2: DYNODE No.3
PIN 3: DYNODE No.5
PIN 4: DYNODE No.7
PIN 5: DYNODE No.9
PIN 6: ANODE



PIN 7: DYNODE No.10
PIN 8: DYNODE No.8
PIN 9: DYNODE No.6
PIN 10: DYNODE No.4
PIN 11: DYNODE No.2
PIN 12: CATHODE

DIRECTION OF INCIDENT RADIATION: INTO END OF BULB

12AE

from JETEC release #2320, Nov. 17, 1958

7110, 7111, 7112

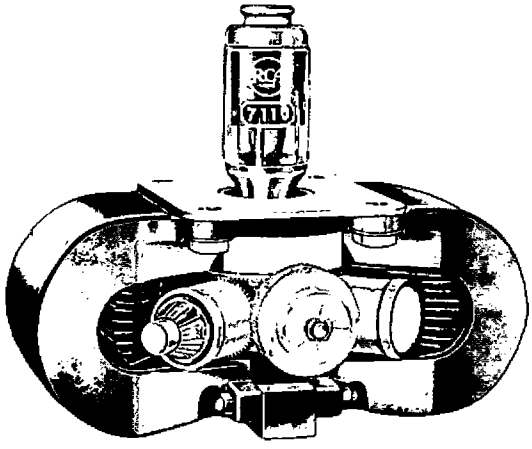
TUNABLE MAGNETRONS

Integral Magnet
Forced-Air Cooled

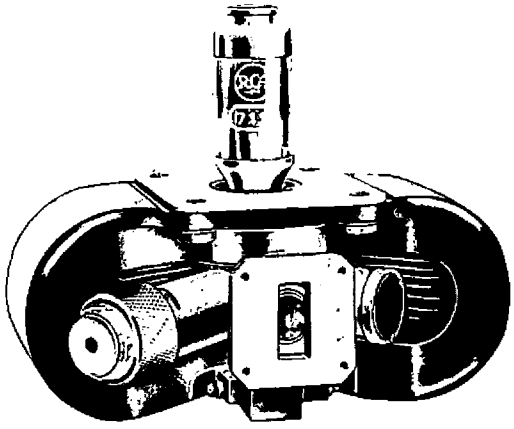
8500 - 9600 Mc
For Pulsed-Oscillator Service
TENTATIVE DATA

230 Kw Peak
Power Output

RCA-7110, -7111, and -7112 are tunable magnetrons intended for pulsed oscillator service at frequencies between 8500 and 9600 megacycles per second. They offer the advantage of providing



an adjustable frequency for radar equipment without requiring appreciably more space than that occupied by a fixed-frequency magnetron having comparable power output.



These three magnetron types differ only mechanically in the location of the tuning controls and the micrometer-type indicator provided to facilitate frequency calibration of each tube.

Type 7110 utilizes a knurled tuning knob equipped with a locking nut. On type 7111, the tuning knob must be pushed in to engage the tuning mechanism. Type 7112 (not illustrated) features a tuning shaft which permits the use of a remote control for adjustment.

Each of these types operates with high efficiency and with full power ratings at pulse durations up to 2.6 microseconds. Each type has a maximum peak input power rating of 630 kilowatts, a maximum peak anode voltage rating of 23 kilovolts, and a maximum peak anode current rating of 27.5 amperes. When operated at a peak anode current of 27.5 amperes, corresponding to a peak anode voltage of about 22 kilovolts. Each type is capable of giving a peak power output of approximately 230 kilowatts.

The design of the 7110, 7111, and 7112 features excellent stability at a high rate of rise of anode voltage and provides good spectrum shape, low pushing figure, good frequency stabilization, low thermal drift during warm-up and after tuning, and a relatively uniform power output over the operating frequency range.

RCA-7110, -7111, and -7112 are ruggedly constructed. Samples of their design have withstood a shock impulse of 30 g for a period of 11 milliseconds. Furthermore, these types exhibit a negligible amount of frequency modulation under vibration accelerations of 2 g from 50 to 500 cps.

Employed in these types are: an axial cathode having good structural rigidity; a getter to maintain a high vacuum and minimize any tendency toward arcing after a period of storage; a double-helical heater to minimize mechanical resonance of the heater and to reduce hum modulation at the power-line frequency; and an output waveguide which can be coupled to a standard JAN RG-51/U waveguide by means of a modified JAN UG-52A/U choke flange. The output waveguide flange and the mounting flange are designed to

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7110, 7111, 7112 10-58
Printed in U.S.A.

permit use of pressure seals. The heater-cathode stem will operate without electrical breakdown at atmospheric pressures as low as 600 mm of mercury.

Types 7110, 7111, and 7112 are electrically similar to the servo-tunable type 7008, as well as to the fixed-frequency type 4J50. All of these types have a similar mounting arrangement.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	13.75 ± 10%	volts
Current at 13.75 volts	3.15	amperes
Starting Current	Must never exceed 12 amperes even momentarily	
Minimum Cathode Heating Time	2.5	minutes
Frequency	8500 - 9600	Mc
Maximum Frequency Pulling at VSWR of 1.5	15	Mc

Mechanical:

Operating Position . . . . . Any

Dimensions . . . . See *Dimensional Outline* for Each Type

Air Flow:

To Pins--An air stream should be directed along the cooling fins toward the body of the tube. Adequate flow should be provided so that the temperature of the anode block does not exceed 150° C. Typical air-flow requirements are shown in Fig.1.

To Heater Cathode Terminal--Adequate flow should be provided to maintain the temperature of the heater-cathode terminal below 165° C.

Waveguide Output Flange. . . . . .Mates with Modified JAN UG-52A/U Flange

Heater & Heater-Cathode Connector with built-in capacitor. . . . . Jettron No. 9000-C* or Ucinite No. 11536#**

Tuning Shaft with Associated Calibrated Indicator:

Revolutions (Approx.) to cover full range of 8500 to 9600 Mc—	
Type 7110	12
Type 7111	8-1/2
Type 7112	25
Maximum Torque (Absolute) at tuning-range stops	200 oz-in.
Typical Torque between -55° and +150° C (Approx.)	50 oz-in.
Weight (Approx.)	12 lbs

PULSED OSCILLATOR SERVICE

Maximum and Minimum Ratings, *Absolute Values:*

For Duty Cycle up to 0.0011 max.

PEAK ANODE VOLTAGE	23 max.	kv
PEAK ANODE CURRENT	27.5 max.	amp
PEAK POWER INPUT●	630 max.	kw
AVERAGE POWER INPUT	0.630 max.	kw
PULSE DURATION	2.6 max.	μsec
RATE OF RISE OF VOLTAGE PULSE	200 max.	kv/μsec
	70 min.	kv/μsec
ANODE-BLOCK TEMPERATURE	150 max.	°C
HEATER-CATHODE TERMINAL TEMPERATURE	165 max.	°C
LOAD VOLTAGE STANDING WAVE RATIO	1.5 max.	

Typical Operation# with Load Voltage Standing Wave Ratio Equal to or Less than 1.05, except as noted:

With Duty Cycle of 0.001

Heater Voltage			See Text
Peak Anode Voltage	22	22	kv
Peak Anode Current	27.5	27.5	amp
Pulse Repetition Rate	400	4000	pps
Pulse Duration	2.5	0.25	μsec
RF Bandwidth with worst phasing of 1.5 VSWR	0.5	5	Mc
Side Lobes with worst phasing of 1.5 VSWR	8	10	db
Pulling Figure at VSWR of 1.5	10	10	Mc
Pushing Figure	0.2	0.2	Mc/amp
Thermal Factor for any 30° range of anode-block temperature between -55° C and 150° C	0.2	0.2	Mc/°C
Frequency Deviation due to Tuning Backlash	8	8	Mc
Peak Power Output (Approx.)	230	230	kw

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	2.9	3.3	amp
Peak Anode Voltage	2	20	23	kv
Peak Power Output	3	200	—	kw
Pulses Missing from Total	4,5	—	0.25	%

Note 1: With 13.75 volts ac or dc on heater.

Note 2: With peak anode current of 27.5 amperes. For heater voltage value, see page 5.

Note 3: With peak anode current of 27.5 amperes corresponding to a peak anode voltage in the order of 22 kv, anode-block temperature of 115° C approx., pulse duration of 2.5 microseconds, and maximum load voltage standing wave ratio equal to or less than 1.05. For heater voltage value, see page 5.

Note 4: Pulses are considered to be missing if the energy level at the operating frequency is less than 70% of the normal value.

Note 5: With peak anode current of 27.5 amperes corresponding to a peak anode voltage in the order of 22 kv, anode-block temperature of 115° C approx., pulse duration of 0.25 microsecond, load voltage standing wave ratio of 1.5 adjusted in phase to produce maximum instability. For heater voltage value, see page 5.

● For atmospheric pressure greater than 600 millimeters of mercury in the vicinity of the heater-cathode stem. Operation at pressures lower than 600 millimeters of mercury may result in arc-over across the stem with consequent damage to the tube. The waveguide must always be pressurized to a minimum of 15 psi absolute to prevent arcing, especially when there is a mismatched load. Arcing in the waveguide due to lack of pressure can damage the tube.

\# It is essential that the input circuit be designed so that if arcing occurs the energy per pulse delivered to the tube cannot greatly exceed the normal energy per pulse. To satisfy this requirement, it is recommended that pulsers of the discharging-network type be used.

* Manufactured by Jettron Products, Hanover, N. J.

** Manufactured by Ucinite Div. of United-Carr Fastener Corp., Newtonville 60, Mass.

OPERATING CONSIDERATIONS

The 7110, 7111, and 7112 are rated in accordance with the following definition of the Absolute-Maximum Rating System for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the de-

vice, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

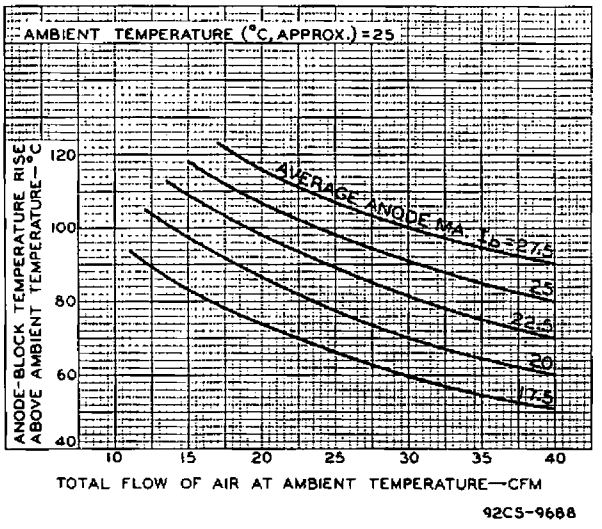


Fig. 1 – Typical Cooling Requirements for Anode Block of Types 7110, 7111, and 7112 with Cooling Arrangement Described in Text.

The equipment manufacturer should design so that initially and throughout life no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

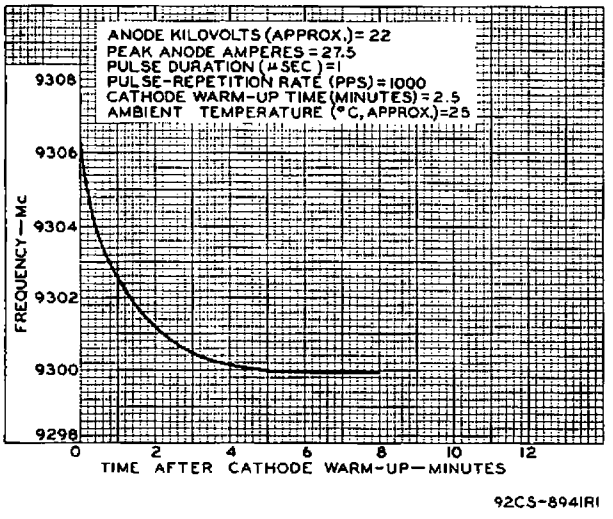


Fig. 2 – Typical Stabilization Characteristic of Types 7110, 7111, and 7112.

The *high voltage at which the 7110, 7111, and 7112 is operated is very dangerous.* Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltage. Precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is required.

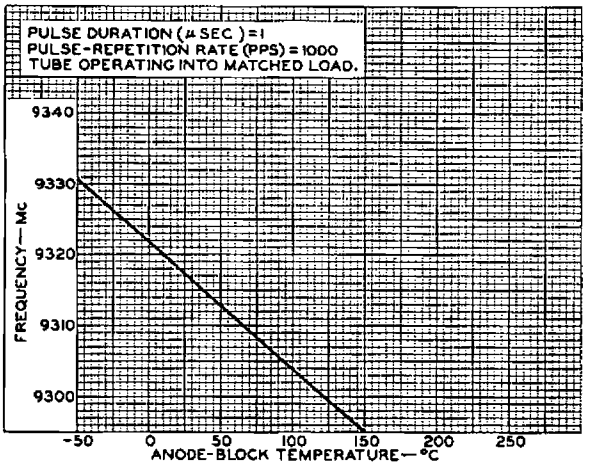


Fig. 3 – Typical Thermal-Factor Characteristics of Types 7110, 7111, and 7112.

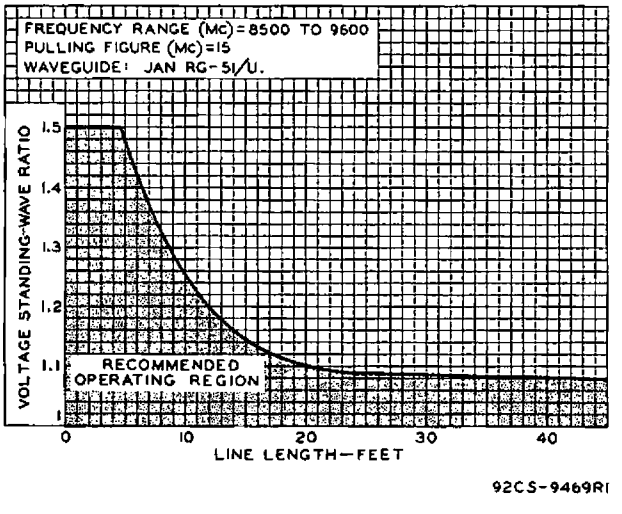


Fig. 4 – Effect of Length of Transmission Line between Output Flange and Load on Allowable Voltage Standing Wave Ratio.

Magnetic-Field Precautions. In general, magnetrons with integral magnets should be stored so as to maintain a minimum distance of 6 inches between tubes. If this precaution is not

followed, excessive interaction may occur with consequent decrease in the strength of the magnetic fields. In addition, it is important to maintain a minimum distance of 2 inches between the magnet and any magnetic materials and to use non-ferrous tools during installation. Failure to observe this latter precaution may subject the magnet to sharp mechanical shocks which may result in demagnetization of the magnet. Furthermore, precautions should be observed to insure that the magnetic field of the 7110, 7111, and 7112 does not affect nearby instruments and tubes.

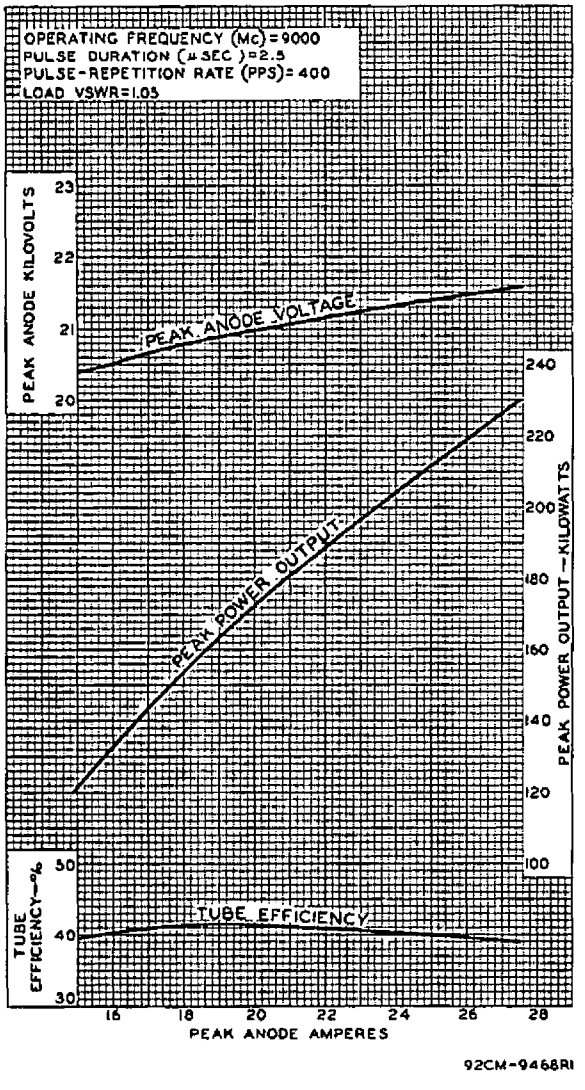


Fig. 5 - Typical Performance Curves for Types 7110, 7111, and 7112.

In the *handling* of the 7110, 7111, and 7112, exercise care to prevent rough treatment which might distort the metal structure and cooling fins. Any such distortion may result in loss of vacuum or impairment of the electrical characteristics. *The tube should never be held by the heater-cathode stem* because undue strain on the cathode assembly will weaken the structure and will result in permanent damage to the tube.

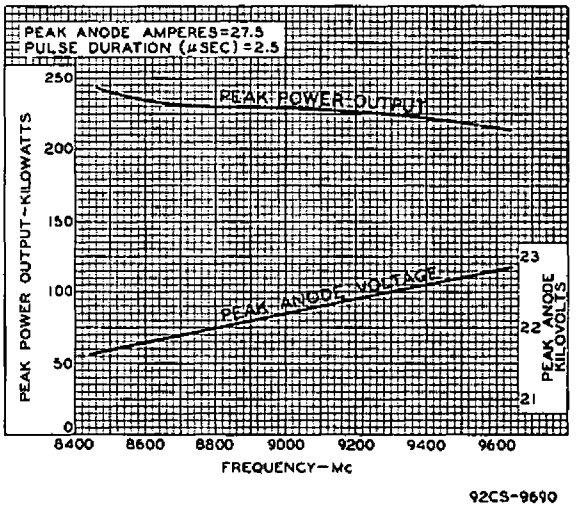


Fig. 6 - Typical Performance Curves for Types 7110, 7111 and 7112.

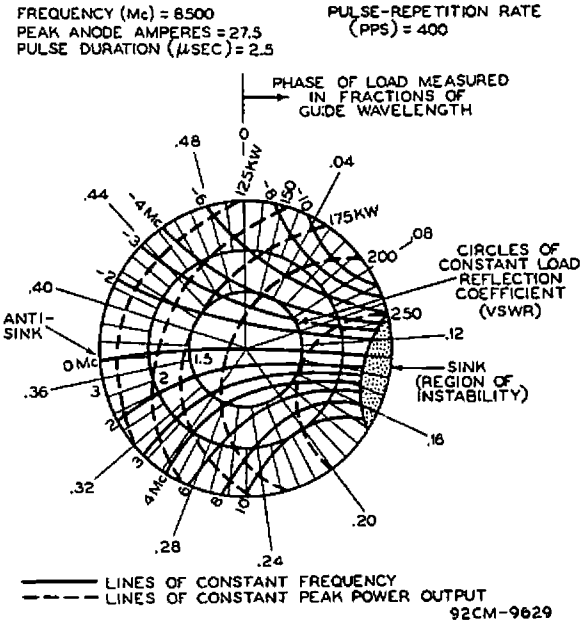


Fig. 7 - Rieke Diagram for Types 7110, 7111, and 7112.

Mounting of each of these three magnetron types should be accomplished by means of its mounting flange which may be positioned to operate the tube in any orientation. This flange is made to permit use of each type in applications

requiring a pressure seal. Care should be taken by the equipment designer to insure that the tube is mounted on a surface having adequate flatness so as to avoid possible distortion of the mounting flange when it is bolted to the mounting surface.

Fastening the JAN RG-51/U waveguide to the waveguide output flange of the tube is accomplished in the following manner. A JAN UG-52A/U choke flange or equivalent should be modified by drilling out the screw threads from the four mounting holes in the choke flange using a No.15 drill. This operation will permit four size 8-32

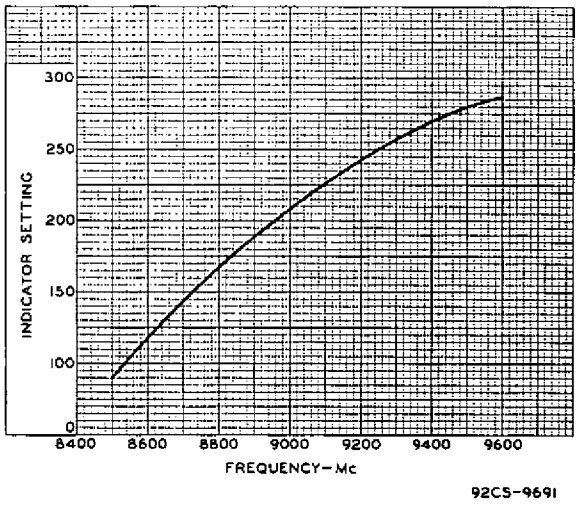


Fig.8 - Representative Tuning Characteristic of Types 7110, 7111, and 7112.

bolts inserted through the flange mounting holes, to engage the threaded waveguide output flange of the tube.

Cooling of the anode block is accomplished by directing a separate stream of clean air through each set of cooling fins toward the anode block. The two streams are provided from two 3/4-inch-diameter ducts placed 1/2" to 3/4" from the fins.

After the *heater voltage* is raised gradually to its rated value of 13.75 volts, allow the cathode to warm up for at least 2-1/2 minutes to make sure that the cathode reaches operating temperature. When the cathode has reached full operating temperature, high-voltage pulses, negative with respect to anode (ground), can be applied to the heater-cathode terminal. As soon as the high-voltage pulses are applied, the heater voltage (E_f) should preferably be reduced in accordance with the following formula, depending on the average power input (P_i) to the tube:

P_i up to 450 watts: $E_f = 13.75\left(1-\frac{P_i}{450}\right)$ volts

P_i greater than 450 watts: $E_f = 0$ volts

In those cases where these types are used as replacements for the fixed-frequency type 4J50, it is permissible to apply the following formula which is specified for reducing the heater voltage on the 4J50.

P_i up to 100 watts: $E_f = 13.75$ volts

P_i greater than 100 watts: $E_f = 14\left(1-\frac{P_i}{1120}\right)$ volts

For *standby operation*, during which the high-voltage pulses are not applied to the tube, the heater voltage should be restored to 13.75 volts.

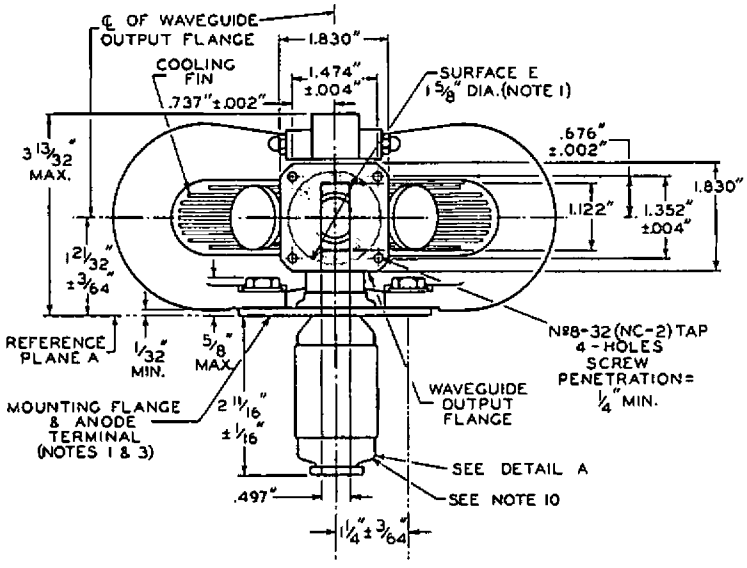
Tuning of the 7110 is accomplished by turning the tuning knob until the setting of the micrometer-type indicator is reached which corresponds to the desired frequency, as determined from the calibration chart prepared for each tube. Then lock the tuning knob by tightening the locking nut. Type 7111 is tuned by pushing in on the knurled tuning knob and turning it until the desired setting of the calibrated indicator is reached. Releasing the knob allows a spring to disengage it from the tuning mechanism. The 7112 can be tuned in the same manner as the 7110 except that a screw-driver slot is provided in the tuning shaft. If desired, a flexible coupling may be attached to this shaft and the tube tuned remotely. The designs of the 7111 and 7112 provide an essentially constant operating frequency without requiring a positive mechanical lock even though the tube is subjected to vibration.

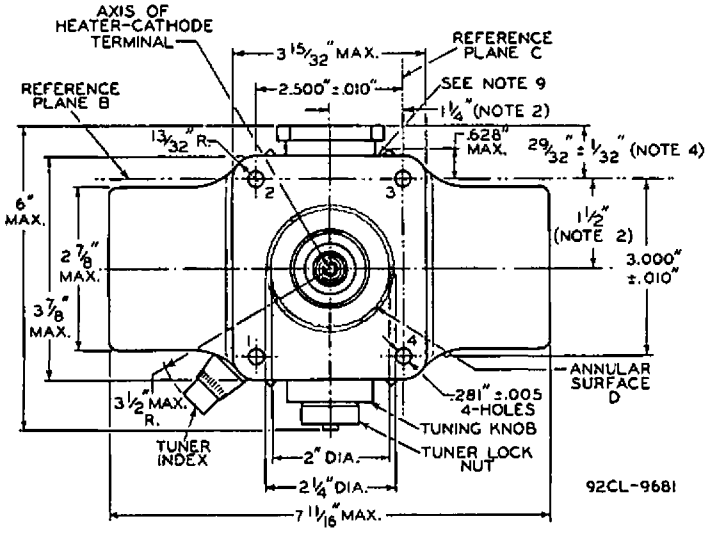
For precise tuning adjustment, the final indicator setting should be approached using the same direction of rotation of the tuning shaft. There is little frequency drift after changing tuner setting.

Our engineers are ready to assist you in circuit applications of the 7110, 7111, and 7112. For further information, write to Commercial Engineering, RCA, Harrison, New Jersey, giving complete details as to the proposed service.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE
for Type 7110





REFERENCE PLANE A IS DEFINED AS THE PLANE THROUGH THAT PORTION OF THE MOUNTING FLANGE DESIGNATED AS ANNULAR SURFACE D.

REFERENCE PLANE B IS DEFINED AS THE PLANE WHICH IS PERPENDICULAR TO PLANE A AND PASSES THROUGH THE EXACT CENTERS OF MOUNTING-FLANGE HOLES NO.2 & NO.3.

REFERENCE PLANE C IS DEFINED AS THE PLANE WHICH IS PERPENDICULAR TO PLANE A & PLANE B AND PASSES THROUGH THE EXACT CENTERS OF MOUNTING-FLANGE HOLES NO.3 & NO.4.

NOTE 1: SURFACE E OF THE WAVEGUIDE OUTPUT FLANGE, AND THE ENTIRE SURFACE OF THE MOUNTING FLANGE ARE MADE SO THAT THEY MAY BE USED TO PROVIDE A HERMETIC SEAL.

NOTE 2: THE AXIS OF THE HEATER-CATHODE TERMINAL WILL BE WITHIN THE CONFINES OF A CYLINDER WHOSE RADIUS IS 3/64" AND WHOSE AXIS IS PERPENDICULAR TO REFERENCE PLANE A AT THE SPECIFIED LOCATION.

NOTE 3: ALL POINTS ON THE MOUNTING FLANGE WILL LIE WITHIN 0.015" ABOVE OR BELOW REFERENCE PLANE A.

NOTE 4: THE LIMITS INCLUDE ANGULAR AS WELL AS LATERAL DEVIATIONS.

NOTE 5: THESE DIMENSIONS DEFINE EXTREMITIES OF THE 0.169" INTERNAL DIAMETER OF THE CYLINDRICAL HEATER TERMINAL.

NOTE 6: THESE DIMENSIONS DEFINE EXTREMITIES OF THE 0.540" INTERNAL DIAMETER OF THE CYLINDRICAL HEATER-CATHODE TERMINAL.

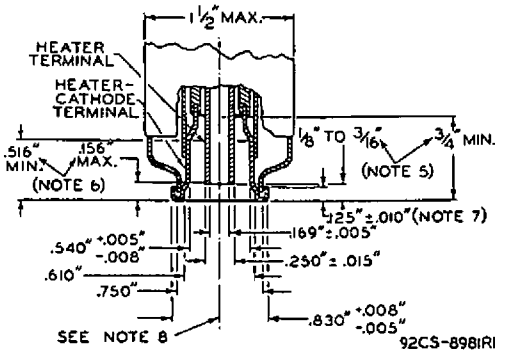
NOTE 7: NO PART OF THE CONNECTOR DEVICE FOR THE HEATER AND HEATER-CATHODE TERMINALS SHOULD BEAR AGAINST THE UNDERSIDE OF THIS LIP.

NOTE 8: THE HEATER TERMINAL AND THE HEATER-CATHODE TERMINAL ARE CONCENTRIC WITHIN 0.010".

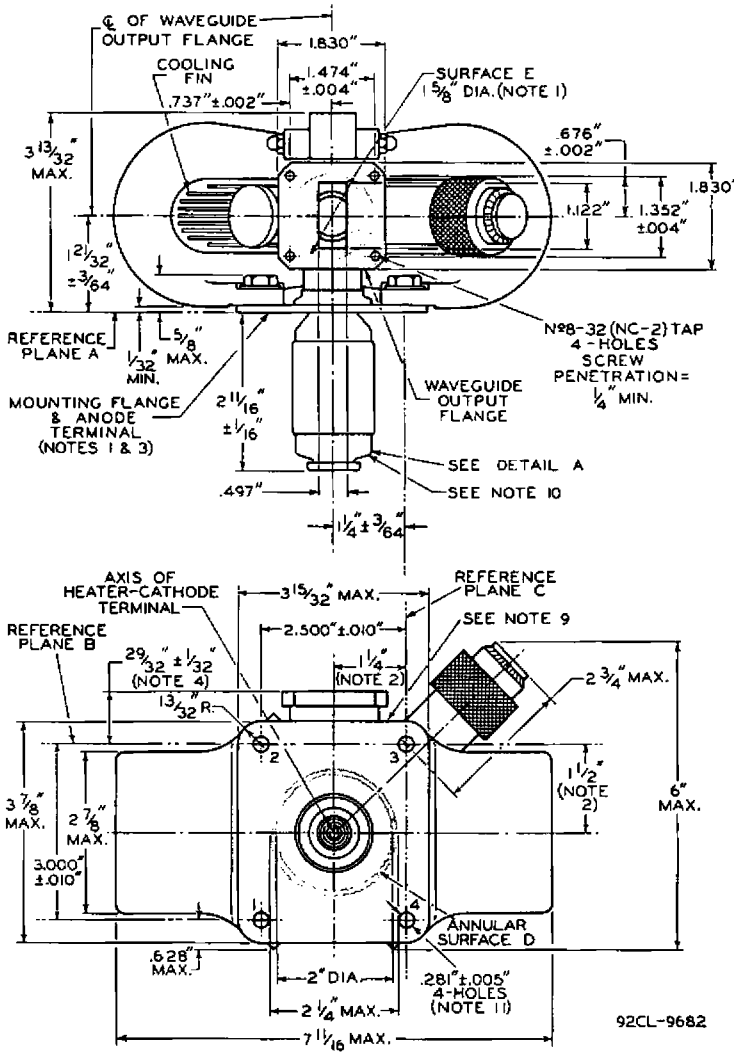
NOTE 9: ANODE TEMPERATURE MEASURED AT JUNCTION OF WAVEGUIDE AND ANODE BLOCK.

NOTE 10: CATHODE TEMPERATURE MEASURED HERE.

DETAIL A



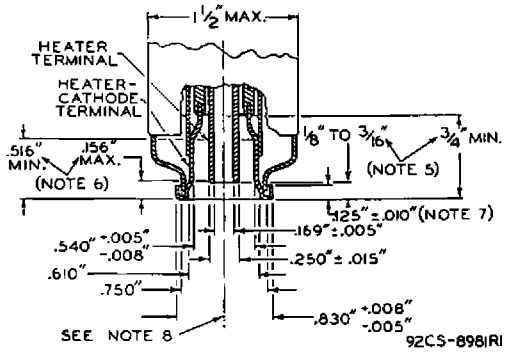
DIMENSIONAL OUTLINE
for Type 7111



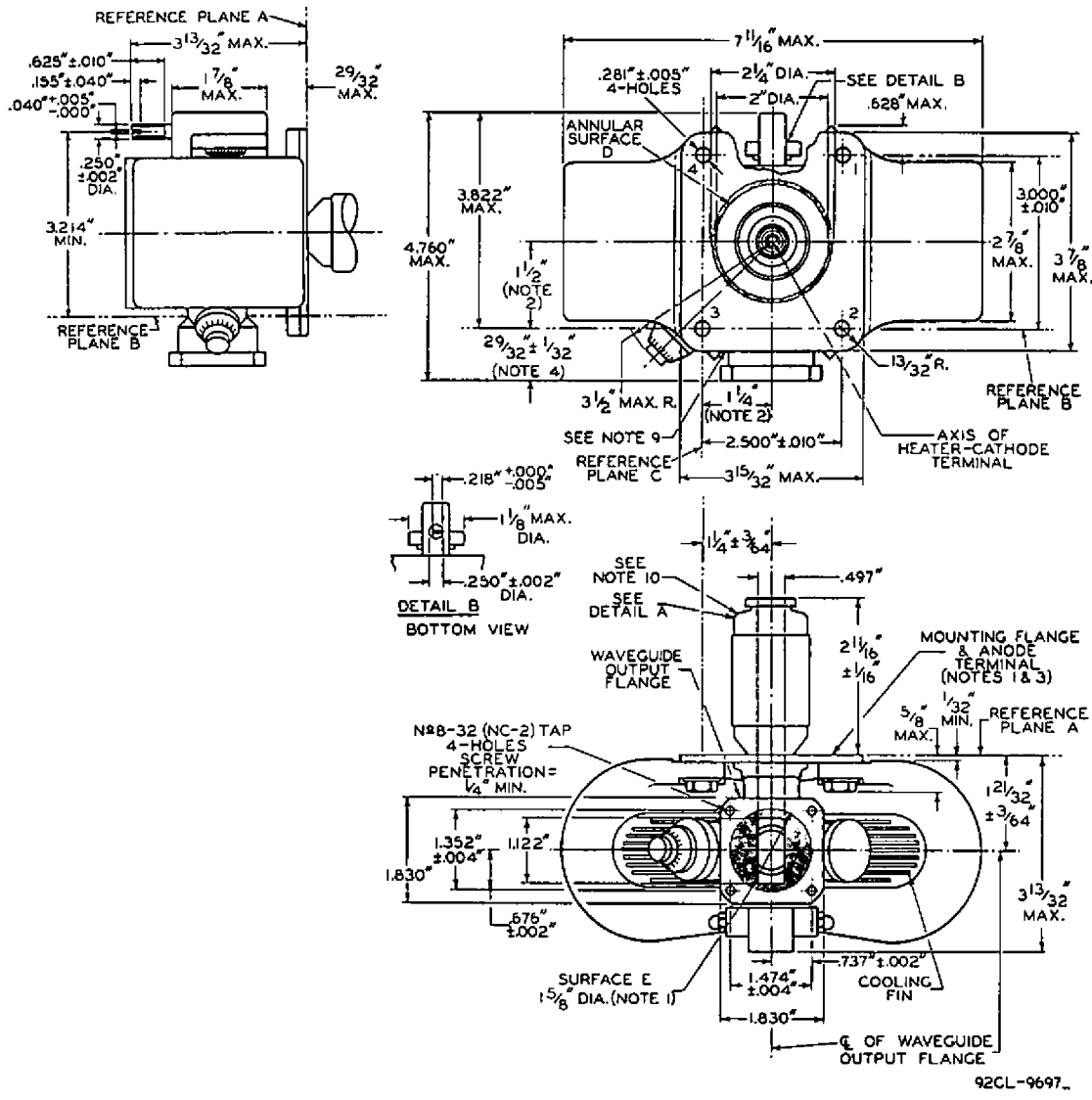
For Reference-Plane Definitions and Notes 1 - 10, See Page 6.

NOTE 11: THE ENDS OF THE MOUNTING STUDS MUST NOT PENETRATE THROUGH THE MOUNTING HOLES MORE THAN 1-3/32" FROM THE MOUNTING FLANGE SURFACE.

DETAIL A

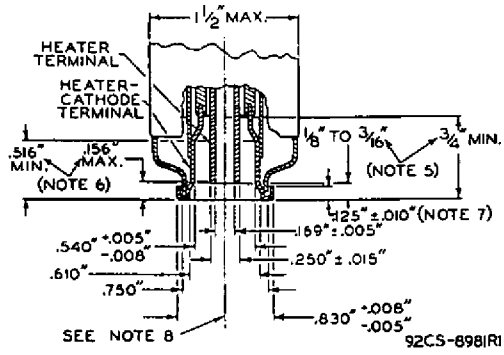


DIMENSIONAL OUTLINE
for Type 7112



For Reference-Plane Definitions and Notes 1-10, See Page 6.

DETAIL A



7183

DISPLAY STORAGE TUBE

Writing Gun: Magnetic Deflection, Electrostatic Focus
Viewing Gun: No Deflection, No Focus

Direct-View Type
4"-Diameter Display
Non-Equilibrium Writing
Grid-Control Reading (Viewing)

5"-Diameter Bulb
11-5/8" Overall Length
Writing-Gun Neck
Viewing-Gun Neck

TENTATIVE DATA

RCA-7183 is a 5-inch display storage tube of the direct-view type designed for use in applications where it is desired to have a bright, non-flickering display of stored information for 20 or more seconds after writing has ceased. Practical applications of the 7183 include: airplane-cockpit radar display; airport surveillance; data transmission including half-tones; and visual communications requiring steady, non-flickering, narrow bandwidth transmission over telephone lines.

Performance of the 7183 when operated with 8,500 volts on the screen is characterized by a full 4-inch-diameter display having brightness of about 1500 foot-lamberts, and good resolution capability in half-tone displays.

The 7183 utilizes two electron guns--a writing gun and a viewing gun, each in its own neck. The writing gun utilizes electrostatic focus and produces an electron beam which is magnetically deflected by external deflecting coils. The viewing gun produces an electron stream which floods the electrodes controlling the storage function and the brightness of the display.

PRINCIPLES OF OPERATION

As shown in Fig. 1, the 7183 has a writing section and a viewing section. The *writing section* contains an electrostatically focused gun that produces an electron beam which is magnetically deflected. The *viewing section* contains an aluminized screen on the inside surface of a flat faceplate, a backplate capacitively coupled to a storage grid, and a viewing gun having five grids.

The Viewing Operation

In addition to the viewing gun with its grids No. 1 and No. 2, the viewing section contains a grid No. 3, a grid No. 4, a grid No. 5, a storage grid, a backplate capacitively coupled to the storage grid, and a screen having excellent visual efficiency. The spectral-energy emission characteristic of the screen phosphor is shown in Fig. 2.

The viewing gun provides a low-velocity electron stream which continuously floods the electrodes (grid No. 5, storage grid, and backplate) controlling the storage function and the brightness of the display. A display with high brightness is possible because of the high viewing-gun current. The high current can be utilized because the viewing beam is not controlled by methods ordinarily employed in cathode-ray tube guns and is consequently not limited by focusing, deflection, and modulation requirements.

Grids No. 3 and No. 4 each consist of a conductive-coating band positioned on the bulb-wall interior as shown in Fig. 1. These electrodes collimate (make parallel) the paths of the electrons in the stream before they reach grid No. 5. Collimation is required so that the low-velocity electrons will approach the storage grid in paths perpendicular (normal) to the plane of the storage grid. This normal approach of the electrons to every point on the storage grid together with their uniform velocity makes possible uniform control of the electrons by the storage grid.

Grid No. 5 consists of a fine metal mesh together with a conductive-coating band on the bulb-wall interior. It serves to accelerate electrons in the beam; to repel any positive ions, produced by collision of electrons with residual gas molecules in the region between base and grid No. 5, from landing on the storage grid and thus rapidly wiping out a stored charge pattern; and to collect beam electrons turned back near the storage grid when its potential is negative.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7183 4-58
Printed in U.S.A.

The storage grid consists of a very thin deposit of excellent insulating material covering the gun side of the backplate which is the framework of a fine metallic mesh. The deposit leaves

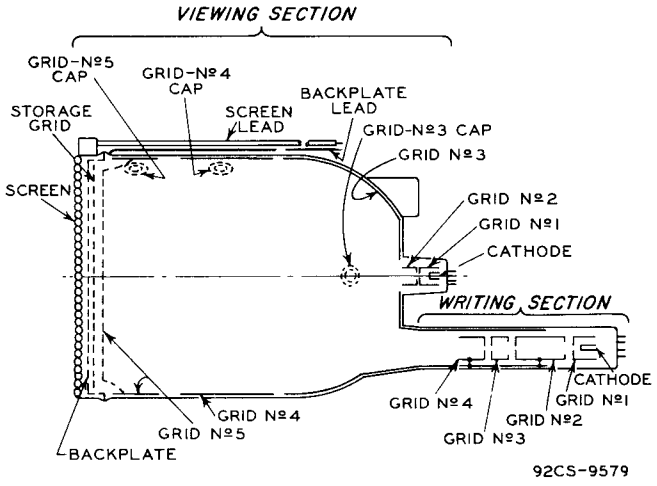


Fig. 1 - Schematic Arrangement of Type 7183.

the size of the openings in the mesh essentially unchanged. In effect the storage grid consists of a multiplicity of storage elements, each capacitively coupled to the mesh.

The storage grid serves to control the viewing beam so that the stored information can be displayed on the phosphor (screen). If the storage-grid potential is made sufficiently negative with respect to the viewing-gun cathode, electrons in the viewing beam are turned back as they approach the storage grid and are collected by grid No.5. Under this condition, the viewing beam is cut off.

When the storage grid is at the same potential as the viewing-gun cathode, electrons in the viewing beam approach sufficiently near the plane of the storage grid to be attracted by the viewing-screen field which penetrates the openings in the storage grid. Under the influence of this field, a majority of the viewing-beam electrons which have passed through grid No.5 are accelerated through the storage-grid and backplate openings to the phosphor (screen), and cause it to fluoresce brightly over its entire area. Under this condition, the brightness of the screen is designated as "saturated brightness".

Light output from the screen under conditions of saturated brightness varies with the voltage applied to the screen. This relationship is shown in Fig.3 for a typical 7183 operating under conditions of optimum collimation. Because the screen is aluminized, the light output drops off very rapidly at screen voltages below 5000 volts. Operation below this value is not recommended.

At values of storage-grid potential between those which produce viewing-beam cutoff and those which produce saturation brightness, the number of electrons which penetrate the storage-grid openings, and hence the amount of light emitted by the screen, is a function of the storage-grid potential, as shown in Fig.4 for conditions with a screen voltage of 8500 volts and a backplate voltage of 0 volts. For backplate and/or screen voltages more positive than those indicated in Fig.4, the storage-grid characteristic tends to shift to the left and to exhibit less slope. For backplate and/or screen voltages less positive than those indicated in Fig.4, the characteristic tends to shift to the right and to exhibit more slope.

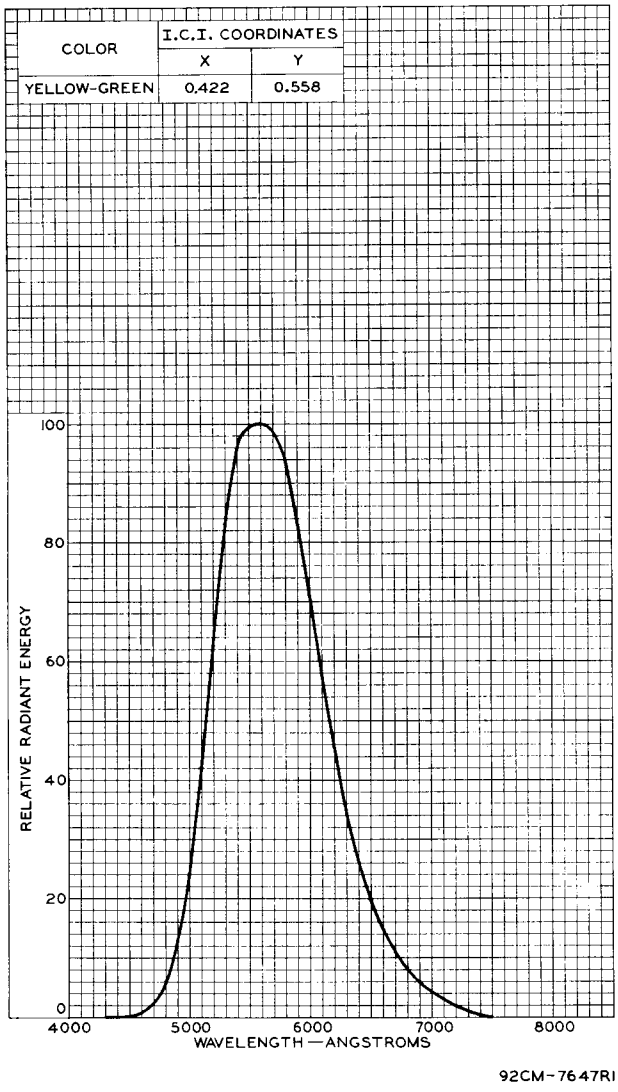


Fig. 2 - Spectral-Energy Emission Characteristic of Phosphor P20 Used in Type 7183.

Within the range of storage-grid potentials considered thus far, no viewing-beam electrons are attracted to the surface of the storage grid. Hence, in the absence of deliberate writing,

leakage through the insulating material, or spurious charging such as might be caused by positive-ion bombardment, a charge pattern once established on the storage grid should remain indefinitely. If, however, the storage grid is made positive with respect to the viewing-gun cathode, viewing-beam electrons are attracted to the surface of the storage grid and land on it. If the electrons which land do not have sufficient energy to produce a secondary-electron emission ratio in excess of unity, a net flow of current into the storage grid will result. Because the storage grid is conductively isolated from the metallic backplate, the storage grid is free to charge negatively under the influence of this current.

This negative-charging phenomenon provides a mechanism by means of which an undesired charge pattern on the storage grid can be removed, i.e., erased. For example, assume that the entire storage grid has been charged, by writing, to zero potential with respect to the cathode of the viewing gun. The cathode of the viewing gun is usually taken as a ground reference. Now, assume that the backplate is suddenly shifted from its "dc" potential level of 0 volts to a positive potential of 10 volts. Because of the very close capacitive coupling between the backplate and the storage grid, the storage grid also rises to a potential of 10 volts. Viewing-beam electrons are now able to land on the storage grid and negative charging of the storage grid takes place, as explained above. Charging continues until the storage-grid potential is reestablished at zero volts. When this occurs, viewing-beam electrons can no longer land on the storage grid. Now, if the backplate potential is returned to its initial value of zero volts, the storage-grid potential drops correspondingly to -10 volts. This negative voltage, as may be seen by referring to Fig.4, essentially cuts off the viewing beam of a typical 7183 and thus erases any charge pattern on the storage grid.

Following erasure, the time available for writing and viewing is limited by the presence of positive ions produced by collision of electrons in the viewing beam with residual traces of gas in the region between the screen and grid No.5. These positive ions are attracted to the most negative elements of the storage grid. On landing, the ions cause the elements to assume a less-negative charge and thus to increase the flow of viewing-beam electrons to the screen. Thus, the limit of viewing duration is determined by loss of contrast in the viewed pattern rather than by a decay of brightness as in the case of long-persistence phosphors.

In some applications, it may be desirable to sacrifice brightness for a viewing duration longer than that indicated in the tabulated data. Extended viewing duration may be obtained by modulating the viewing beam with rectangular pulses applied to grid No.1 of the viewing gun at a pulse repetition frequency above that which produces display flickering. The minimum usable frequency is determined by the persistence characteristic of the screen phosphor and is in

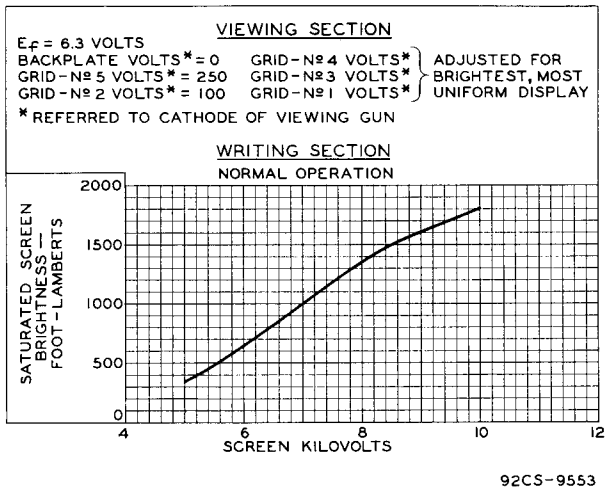


Fig.3 - Typical Characteristic of Type 7183.

the order of 30 pulses per second. Screen brightness varies directly and viewing duration varies inversely with the grid-No.1-pulse duty cycle.

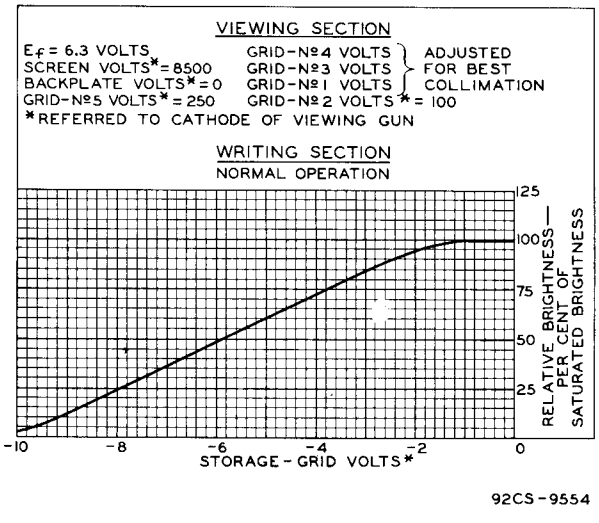


Fig.4 - Typical Storage-Grid Characteristic of Type 7183.

The Writing Operation

The writing gun is similar to that used in electrostatically focused and magnetically deflected oscillograph tubes, and produces a well-defined focused beam having exceptionally small effective area at the storage grid. This beam may be deflected and modulated in the same manner

as for oscillograph tubes. It has a control function and contributes little to the total light output from the tube.

The cathode of the writing gun is generally operated at -2500 volts with respect to the viewing-gun cathode.

The writing-beam electrons landing on the storage grid have sufficient velocity to produce a secondary-electron emission ratio greater than unity. Thus, more electrons leave the storage grid than arrive, and those elements on the storage grid scanned by the beam assume a less-negative charge wherever the writing beam strikes. Because the secondary electrons are attracted to grid No.5 of the viewing gun, the writing beam tends to charge the storage grid to the potential of grid No.5 of the viewing gun. However, the maximum potential to which an element of the storage grid rises above cutoff is limited in normal operation of the tube by the viewing-gun beam to a potential just slightly more positive than that of the viewing-gun cathode.

The writing-beam electrons which land on a storage element determine the voltage built up across the dielectric and the corresponding net charge stored in the dielectric. By controlling the amplitude and duration of the writing-beam current, it is possible to establish on any storage element a positive charge having a value which will partially or completely counteract that element's negative charge. Consequently, a storage element can be charged to any potential intermediate between the storage-grid-cutoff voltage and zero voltage.

As considered previously, the potential of any storage element determines the number of viewing-beam electrons passing through the storage grid in the immediate vicinity of that element. When the potential is such as to allow passage of electrons, these electrons are accelerated and strike the screen directly opposite the storage element. As a result, they produce a luminescent spot having a size only slightly larger than that of the storage element and a brightness which is directly proportional to their density and their velocity which is determined by the screen potential.

Because the potential of a storage element is not changed by the viewing operation, a charge pattern established by the writing gun on the storage grid produces a corresponding visible pattern on the screen which may be viewed for a period determined by positive-ion build-up or by the predetermined erasure rate when dynamic erasure is employed.

The multiplicity of storage elements on the storage grid permits storage of half-tone patterns and their display. At a display brightness approximately 50 per cent of saturated brightness, half-tone patterns have a resolution of about 50 lines per inch as measured by the "shrinking raster" method.

The Erasing Operation

In the section headed *The Viewing Operation*, a technique for erasing stored charge patterns was described. This technique, known as *static erasure*, has the following disadvantage. During the erasing cycle and the time thereafter required

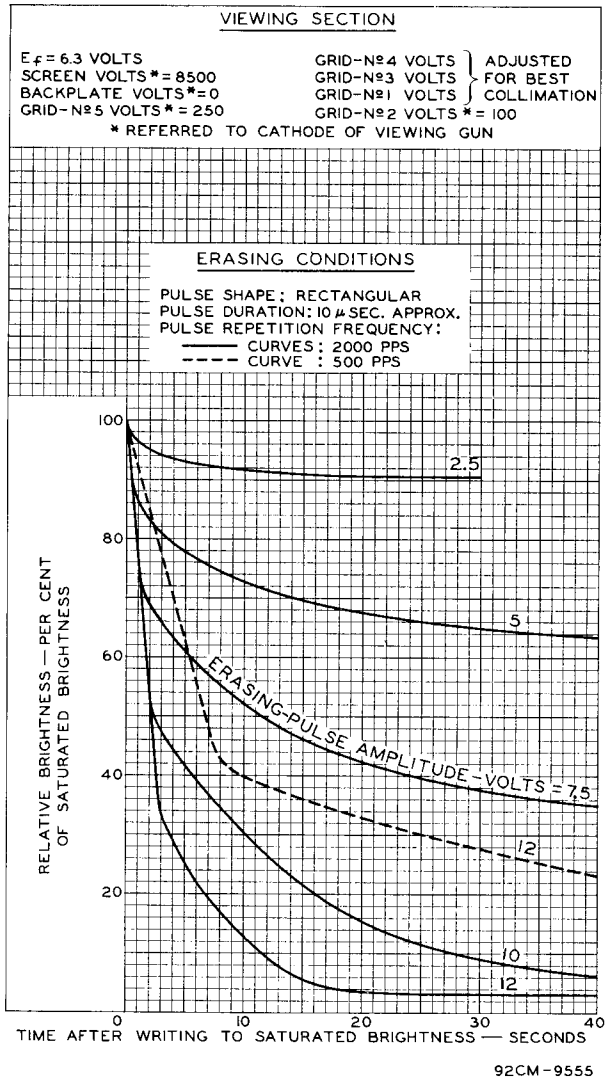


Fig.5 - Typical Erasure Characteristics of Type 7183.

to write a new pattern, the display conveys no information or incomplete information. It is also to be noted that during the static erasing cycle, the screen is uniformly illuminated at a level equal to, or greater than, the saturated brightness level.

In most applications of the 7183, it is desired that writing be followed by a gradual decay of stored information. This kind of performance is obtained by applying a continuous series of pulses to the backplate at a rate no lower than the phosphor flicker frequency (refer to section

headed *The Viewing Operation*). The technique of erasing by applying a series of pulses to the backplate is known as *dynamic erasure*.

The amount of charge erased during each erasing pulse is dependent on the duration, amplitude, and shape of the pulse. These factors together with the erasing-pulse repetition frequency determine the observed rate of decay of stored information.

Brightness-decay characteristics for a typical 7183 erased dynamically are shown in Fig.5. Each of these curves may be described as consisting of a linear portion followed by a quasi-exponential portion. It will be observed that erasing pulses whose amplitude is smaller than the magnitude of the viewing-beam cutoff voltage do not permit complete erasure. On the other hand, erasing pulses whose amplitude is greater than the magnitude of the viewing-beam cutoff voltage eventually drive the storage grid beyond cutoff, i.e., to a value "blacker than black".

The choice of erasing-pulse amplitude depends on the application contemplated by the equipment designer. When a linear decay is required, the erasing-pulse amplitude should be set so that the transition of the decay characteristic from linear to quasi-exponential occurs at or near viewing-beam cutoff. If at the same time it is desired to display weak input signals, it is necessary to adjust the writing-beam "unblanking" level in the absence of input signals so that the writing beam charges the storage grid just to the cutoff level at the instant of writing.

The characteristics shown in Fig.5 represent typical performance at two settings of erasing-pulse duty cycle. Decay performance at other duty cycles may be estimated by noting that the slope of the linear portion of these curves is directly proportional to the erasing-pulse duty cycle. The effect of erasing-pulse duty on the quasi-exponential portion of the curves is less well defined. For purposes of estimation, the following rough approximation may be used: the initial slope of the quasi-exponential portion varies as the 1-1/2 power of the erasing-pulse duty cycle for values of duty cycle between about 0.01 and 0.1.

It will also be observed in Fig.5 that in no case does the dynamic-erasure process result in zero screen brightness. The reason is that some screen illumination is caused by the application of the erasing-pulse series. The background brightness for a given erasing duty cycle may be estimated by multiplying 1.5 times the saturated-brightness value by the erasing duty cycle.

In the above considerations, the use of rectangular erasing pulses is assumed. When triangular erasing pulses are used, the linear portion of the dynamic decay curves in Fig.5 is transformed into an exponential shape and the remaining portion of the curves is changed into an ever-more-slowly-varying function.

DATA

General:

	Writing Section	Viewing Section	
Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3 ± 10%	6.3 ± 10%	volts
Current	0.6	0.6	amp
Cathode Heating Time (Minimum) before other electrode voltages are applied	–	30	sec
Direct Interelectrode Capacitances (Approx., without external shield):			
Grid No.1 to all other tube electrodes	7	7.5	μμf
Cathode to all other tube electrodes	5	5	μμf
Backplate to all other tube electrodes	–	300	μμf
Focusing Method	Electrostatic	None	
Deflection Method	Magnetic	None	
Deflection Angle	See Fig.7	–	
Phosphor	–	P20, Aluminized	
Fluorescence	–	Yellow-Green	
Phosphorescence	–	Yellow-Green	
Minimum Useful Screen Diameter			4"
Maximum Overall Length			11.62"
Seated Length			11.16" ± 0.10"
Maximum Tube Radius			3.00"
Maximum Tube Diameter			5.19"
Greatest Bulb Diameter			5.00" ± 0.06"
Base:			
Writing Gun	Small-Button Neoditetrar 8-Pin (JETEC No.E8-49)		
Viewing Gun	Small-Button Miniature 7-Pin (JETEC No.E7-1)		
Bulb Terminals:			
Caps (Three)	Recessed Small Cavity (JETEC No.J1-21)		
Flexible leads (Two)	See *Dimensional Outline*		
Temperature Range			-65° to $+100^{\circ}$ C
Operating Position			Any
Weight (Approx.)			1-3/4 lbs

Maximum Ratings, *Absolute Values:*

	Writing Section		Viewing Section		
SCREEN VOLTAGE	–		10000 max.**		volts
BACKPLATE VOLTAGE (Peak)	–		30 max.**		volts
	Equivalent Values		*Equivalent Values*		
GRID-No.5 VOLTAGE	–	–	–	300 max.**	volts
GRID-No.4 VOLTAGE	2900 max.*▲	150 max.**	–	150 max.**	volts
GRID-No.3 VOLTAGE	1200 max.*	–	2900 max.*▲	150 max.**	volts
GRID-No.2 VOLTAGE	2900 max.*▲	150 max.**	–	150 max.**	volts
CATHODE VOLTAGE	–	-2750 max.**	–	–	volts
GRID-No.1 VOLTAGE:					
Negative bias value	200 max.*		100 max.**		volts
Positive bias value	0 max.*		0 max.**		volts
Positive peak value	2 max.*		0 max.**		volts
PEAK HEATER-CATHODE VOLTAGE:					
Heater negative with respect to cathode	125 max.*		125 max.**		volts
Heater positive with respect to cathode	125 max.*		125 max.**		volts

VIEWING SECTION**

Operating Values and Typical Performance Characteristics:

To prevent possible damage to the tube, allow the viewing-gun beam current to reach normal operating value before turning on the writing-gun beam current, and keep the viewing beam on till the writing beam is turned off.

Screen Voltage	8500	volts
Backplate Voltage (DC)	0	volts
Grid-No.5 Voltage#	220 to 250	volts
Grid-No.4 Voltage#	40 to 100	volts
Grid-No.3 Voltage#▲	10 to 40** / 2510 to 2540*	volts / volts
Grid-No.2 Voltage#	100	volts
Grid-No.1 Voltage#	0 to −75	volts
Maximum Screen Current	0.6	ma
Maximum Backplate Current (Peak)	2	ma
Maximum Grid-No.5 Current🌡	2.4	ma
Maximum Grid-No.4 Current🌡	0.3	ma
Maximum Grid-No.3 Current🌡	0.5	ma
Maximum Grid-No.2 Current🌡	0.08	ma
Maximum Cathode Current🌡	4	ma
Number of Half-Tone Steps□	5	
Viewing Duration▲▲	20	sec
Maximum Erasing-Uniformity Factor:□□		
For 4"-diameter area (A_4)	0.65	
For the 3.5"-diameter portion ($A_{3.5}$) centered on A_4	0.50	
Resolution⊕	50	lines/in.
Brightness🌡🌡	1500	fl

WRITING SECTION●

Operating Values:

	Equivalent Values		
Grid-No.4 Voltage#▲	2510 to 2540*	10 to 40**	volts
Grid-No.3 Voltage for Focus	425 to 925*	–	volts
Grid-No.2 Voltage#▲	2510 to 2540*	10 to 40**	volts
Maximum Grid-No.1 Voltage for Cutoff of Undeflected Focused Spot	−130*	−2630**	volts
Cathode Voltage	–	−2500**	volts
Maximum Grid-No.3 Current	−15 to +10		μa
Maximum Peak Cathode Current	4.5		ma

VIEWING SECTION and WRITING SECTION

Circuit Values:

Grid-No.1-Circuit Resistance (Either gun)	1.0 max.	megohm
Series Current-Limiting Resistor (Unbypassed) in Grid-No.5 (Viewing Section) Circuit	0.005 min.	megohm
Backplate-Circuit Resistance	0.005 max.	megohm
Series Current-Limiting Resistance in Screen Circuit	1.0 min.	megohm

** Voltages are shown with respect to cathode of Viewing Gun.

* Voltages are shown with respect to cathode of Writing Gun.

▲ Grids No.2 and No.4 of Writing Gun are connected together and to grid-No.3 of Viewing Gun within the tube.

Adjusted for brightest, most uniform pattern.

🌡 For conditions with combined adjustment of grid-No.1 voltage, grid-No.2 voltage, grid-No.3 voltage, and grid-No.4 voltage to give brightest, most uniform pattern. After final adjustment, the grid-No.1 voltage should not be more positive than −20 volts to maintain electrode current within the maximum value indicated.

□ Observed with an RCA-2F21 Monoscope display.

▲▲ Expressed in terms of the time required for the brightness of the unwritten background to rise from just zero brightness (viewing-beam cutoff) to 10% of saturated brightness.

□□ Determined as follows: With no erasing pulse, overscan the storage surface with writing beam to obtain maximum pattern brightness. Then cut off writing beam and adjust erasing pulse to obtain complete erasure in approximately 10 seconds. Measure time (t_1) from start of erasing to the instant at which any area within the 4" diameter (or the 3.5"-diameter portion) is reduced to background-brightness level, and time (t_2) from start of erasing to the instant at which the entire area within the 4" diameter area (or the 3.5"-diameter portion) is reduced to background-brightness level. The erasing-uniformity factor is defined as $(t_2-t_1)/t_2$.

⊕ Measured by shrinking-raster method at a display brightness of 50% of saturated brightness and with grids No.2 and No.4 of Writing Gun at about +2500 volts with respect to cathode of Writing Gun.

🌡🌡 Measured with entire storage grid written to produce saturated brightness and with screen at indicated voltage.

● The cathode of the Writing Gun is operated at about −2500 volts with respect to the cathode of the Viewing Gun which is usually operated at ground potential.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data for the 7183 are limiting values above which the serviceability of the 7183 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself. Information as to altitudes at which the maximum voltage rating applies may be obtained on request.

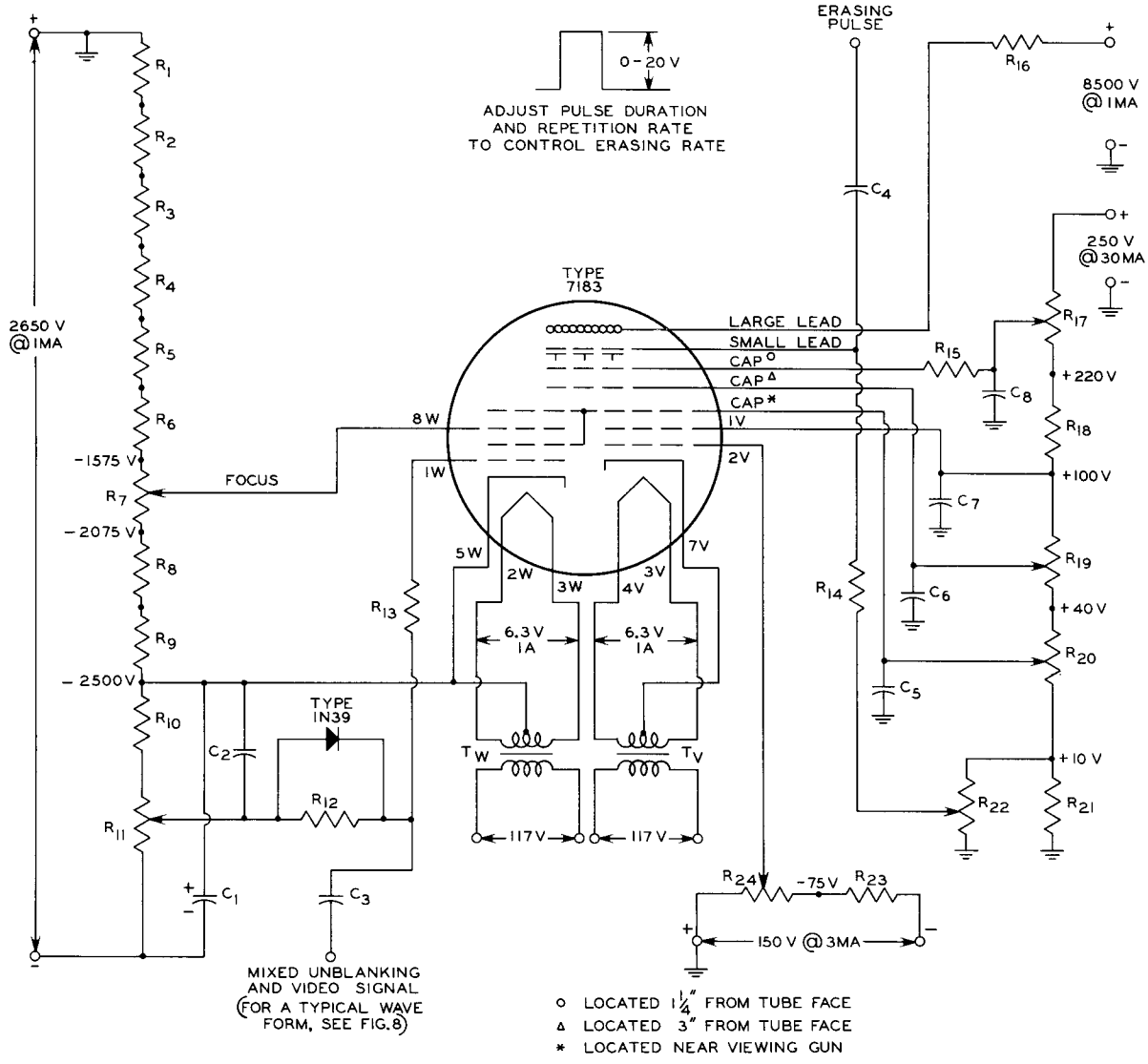
Handling. The 7183 should preferably be transported or handled with the face up to prevent any loose particles in the tube from striking the storage surface and adhering to it. Care should be taken to prevent knocking or bumping the encapsulated junction of the screen lead with the bulb, or striking the tape-covered backplate flange. Such rough treatment will cause either immediate or delayed cracking of the respective metal-glass seals. The flexible leads should not be bent at a sharp angle. Doing so may crack their insulation.

Support and shielding for the 7183 may be provided by a shield made of properly annealed high-permeability material. A working drawing No.92CM-9584 of a suitable shield for the 7183 may be obtained on request from Commercial Engineering, RCA, Harrison, N.J. Support members of nonmagnetic material may be fastened to the shield for mounting in the equipment. In working with high-permeability material, it is essential to follow standard practice to prevent altering the shielding properties of the material. The screen lead and the backplate lead should be placed outside the shield.

Terminal Connections. The *base pins* of the neoditetrar 8-pin base on the Writing-Gun neck fit the ditetrar 8-contact connector, such as Cinch No.54A18088, or equivalent. The *base pins* of the miniature 7-pin base on the Viewing-Gun neck fit the miniature 7-contact socket. The *recessed cavity caps* require standard flexible-lead connectors as used for television picture tubes. The *screen* is terminated in a large-diameter, flexible, high-voltage lead integral with the tube. The *backplate* is terminated in a small-diameter, flexible lead integral with the tube.

Power-Supply Requirements. A typical power-supply circuit to provide the operating voltages for the 7183 is shown in Fig.6.

For the Writing Gun, the dc supply should be well regulated so that focus will not change with the video modulation. The heater winding



C_1: 20 μf, electrolytic, 250 v working voltage
C_2: 1 μf, paper, 200 v working voltage
C_3: 0.05 μf, plastic film, 3000 v working voltage
C_4: 0.01 μf, paper, 600 v working voltage
C_5: 1 μf, paper, 100 v working voltage
C_6 C_7: 1 μf, paper, 200 v working voltage
C_8: 1 μf, paper, 400 v working voltage
R_1 R_2 R_3 R_4 R_5: 270,000 ohms, 1/2 watt
R_6: 220,000 ohms, 1/2 watt
R_7: 500,000-ohm potentiometer, 1/2 watt
R_8: 270,000 ohms, 1/2 watt
R_9: 150,000 ohms, 1/2 watt
R_{10}: 51,000 ohms, 1/2 watt
R_{11}: 100,000-ohm potentiometer, 1/2 watt
R_{12}: 1 megohm, 1/2 watt
R_{13}: 5100 ohms, 1/2 watt
R_{14}: 4700 ohms, 1/2 watt
R_{15}: 5000 ohms, 10 watts
R_{16}: 1 megohm, 1 watt
R_{17}: 1000-ohm potentiometer, 2 watts
R_{18}: 4000 ohms, 10 watts
R_{19}: 2000-ohm potentiometer, 4 watts
R_{20}: 1000-ohm potentiometer, 2 watts
R_{21}: 510 ohms, 1 watt
R_{22}: 1000-ohm potentiometer, 1/2 watt
R_{23}: 24,000 ohms, 1/2 watt
R_{24}: 25,000-ohm potentiometer, 1/2 watt
T_V: Heater transformer
T_W: Heater transformer with secondary insulated for 3000 volts

Fig. 6 - Typical Power-Supply Circuit for Type 7183.

should be insulated to withstand operation at high negative potential with respect to ground.

For the Viewing Gun, it is recommended that the +100 volts for grid No.2 as well as the +250 volts for grid No.4 be stable. An unbypassed resistor of at least 5000 ohms, should be connected in series with the grid-No.5 terminal cap. This provision will protect the tube against possible damage if internal sparking should occur.

The high-voltage dc supply for the screen should have its negative terminal grounded, and should have at least a 1-megohm resistor in

series with the screen terminal. This provision will protect the tube against possible damage if internal sparking should occur.

The high voltages at which the 7183 is operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Safety precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is desired.

In the use of high-voltage tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit as a result of capacitor breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off, and both terminals of any capacitors grounded.

Deflection Considerations. The undeflected focused writing beam normally strikes the storage-grid surface at its point of intersection with the writing-gun axis. The writing-gun axis is perpendicular to the plane of the storage grid and intersects the tube face at a distance 1-1/2 inches from its center.

The writing beam may be deflected by either a mechanically rotating pair of coils diametrically opposite each other, or by two stationary pairs of coils. In the latter case, one pair is used for horizontal deflection; and the other, for vertical deflection.

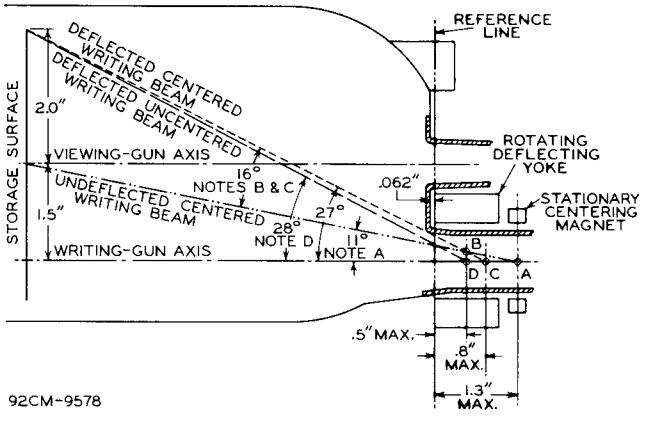
When a rotating pair of coils* is used, centering of the undeflected writing beam, as required for a PPI scan, may be accomplished by means of a centering device of either the electromagnetic or permanent-magnet type. This device is mounted on the writing-gun neck back of the rotating deflecting coils.

When stationary coils are used, centering of the undeflected writing beam is preferably accomplished by passing direct current of the required value through each pair of deflecting coils.

To avoid neck shadow, it is essential that the center of deflection of the rotating 2-coil yoke be located not more than 0.5 inch from the Reference Line (see Fig.7), and the center of deflection of the associated centering magnet be located not more than 1.3 inch from the Reference Line. For the stationary 4-coil yoke, the center of deflection should be located not more than 0.8 inch from the Reference Line. For each of the deflection centers, the corresponding angles through which the writing beam is deflected from the writing-gun axis are also shown in Fig.7.

* For rotating yokes to be used with the 7183, consult manufacturers such as Syntronic Instruments Inc., 100 Industrial Road, Addison, Ill.; and Industrial Electronic Products 15-5, RCA, Camden, N.J.

Video-Drive Considerations. The information to be stored and displayed by the tube should be applied as a video signal to the control grid (grid No.1) or cathode of the Writing Gun. In determining the writing drive requirements, it should



NOTE A: Centering of the writing beam on the storage surface is necessary for a centered PPI display. The beam is centered by shifting it from the writing-gun axis through an angle of 11° with a centering magnet whose effective center (A) is located 1.3" from Reference Line.

NOTE B: With rotating yoke whose effective center of deflection (B) is located 0.5" from Reference Line, the centered writing beam (NOTE A) must be deflected through an angle of 32° to sweep fully the storage surface.

NOTE C: With stationary TV-type yoke whose effective center of deflection (C) is located 0.8" from Reference Line, the centered writing beam must be deflected through an angle of 32° to sweep fully the storage surface.

NOTE D: When rotating yoke is used with uncentered display, i.e., the writing beam is not centered (NOTE A) but strikes the storage surface on the writing-gun axis, and with the effective center of deflection of the rotating yoke located 0.5" from the Reference Line, the uncentered writing beam must be deflected through an angle of 56° to sweep fully the storage surface.

Fig.7 - Angles of Deflection and Centers of Deflection for Writing Gun of Type 7183 When Used With Rotating 2-Coil Yoke and Stationary 4-Coil Yoke.

be remembered that writing is essentially a charge-depositing process. The instantaneous writing-beam current needed for saturated writing varies nearly directly with the speed at which the writing beam is deflected across the storage grid and varies inversely with the number of times a given storage element is written upon in one complete scan period.

The dc bias and the video-signal amplitude applied to grid No.1 or cathode of the Writing Gun should be adjusted to give a writing speed appropriate to the rate of scanning used.

In applications where a PPI-type display is contemplated, it is necessary to arrange for the application of "tilt" to the "unblanking" gate on which the video input signal is superimposed. In some cases, it is also necessary to modulate the gain of the video-amplifier system as a function of the applied deflection current. For example, in the case of a PPI display off-centered by

1.5 inches from the center of the useful display area, it has been found that the writing-grid-No.1 waveform illustrated in Fig.8 gives a satisfactory display with a typical 7183.

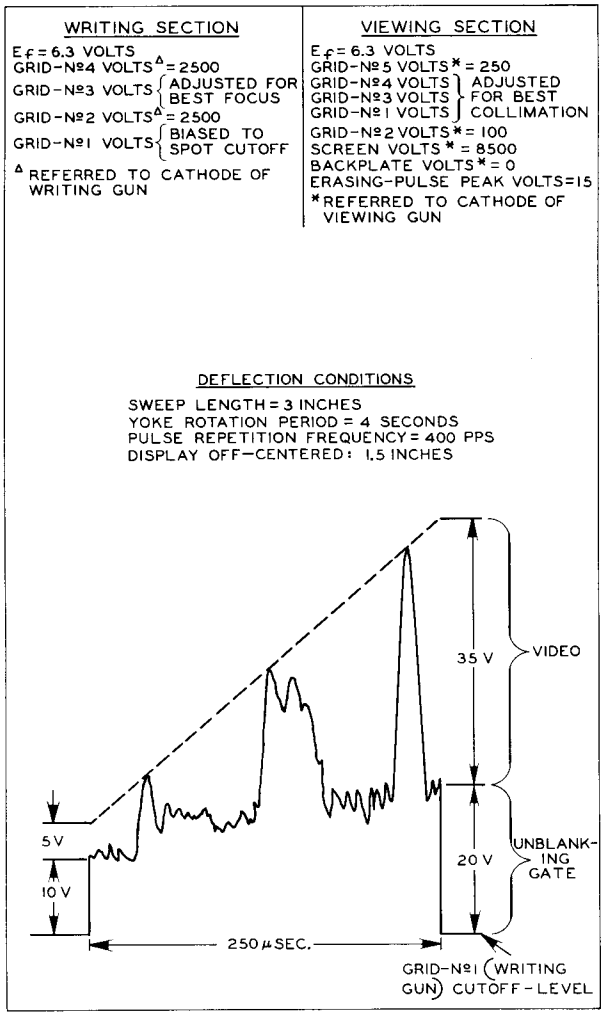


Fig.8 - Writing-Grid-No.1 Driving Waveform for Typical 7183 in a Specific PPI Display Application.

Runaway Charging. A condition of runaway charging of the storage grid may result if the writing beam is allowed to land on the storage grid with the viewing beam turned off, if the writing beam is incident on an area of the storage grid not covered by the viewing beam, or if the density of the writing beam exceeds that of the viewing beam. Such a runaway condition can occur because of the non-equilibrium writing process involved.

Because the electrons in the writing beam land with an energy such that the secondary-emission ratio of the storage-grid surface is greater than unity, this surface charges positive toward the potential of grid No.5 of the viewing section. Normally, the landing on the storage grid of the viewing-beam electrons keeps any portion of the storage-grid surface from charging above viewing-beam cathode potential. When this limiting action of the viewing beam is not present, the storage-grid surface may charge under the action of the writing beam to a value such that sparking occurs through the insulating layer between the storage-grid surface and the backplate. This sparking is observed as random bright flashes on the screen. If the writing process is quickly stopped, generally no permanent damage (loss of

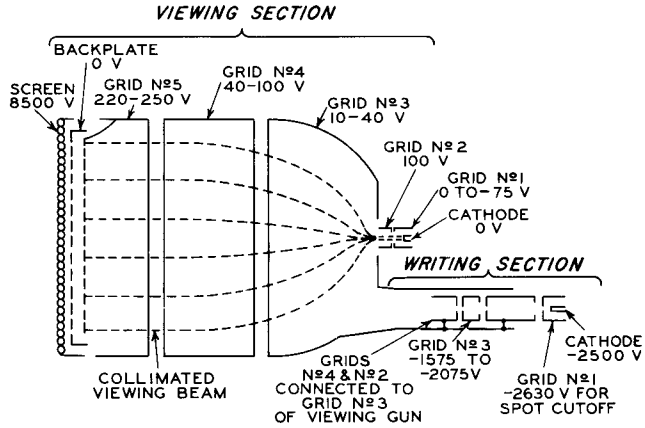


Fig.9 - Schematic Representation of Electron-Lens System With Electrode Voltages, and Collimated Viewing Beam, in Type 7183.

the ability to store a signal in localized areas) will occur to the insulating layer.

A condition of runaway charging and/or damage to the aluminized screen can also occur if an unmodulated writing beam is allowed to remain stationary in a spot on the storage grid even with the viewing beam turned on.

If runaway charging has occurred, portions of the storage-grid surface may be in the order of 100 volts positive with respect to the backplate. To remove this charge, the following procedure is necessary. First, the screen supply is turned off. Then, the backplate lead is disconnected from its normal voltage source and connected for a few seconds to the grid-No.5 (viewing section) voltage of about 250 volts. Since there is then no collecting field at the storage-grid surface, secondary electrons can not leave it and its positive potential will be decreased by the viewing-beam electrons to a value near that of the backplate. The backplate is then connected to its normal voltage supply, and the screen supply is turned on. The storage-grid surface should now erase in the normal manner. In carrying out this procedure, it is

important that the backplate be switched discontinuously between the potentials involved and not be varied gradually between them as would be done by adjusting a potentiometer. Switching discontinuously from initial to final potentials will prevent re-establishment of a high potential across the dielectric, whereas gradual adjustment will re-establish such a potential.

Set-Up Procedure. The following steps should be followed when first placing the 7183 in operation. *Electrode voltages are referred to the cathode of the viewing gun unless otherwise specified.*

To prevent possible damage to the tube, allow the viewing-gun beam current to reach normal operating value before turning on the writing-gun beam current, and keep the viewing beam on till the writing beam is turned off.

1. Apply power to the heater of the *viewing gun* and allow 30 seconds for the cathode to reach normal operating temperature. Then, set the voltages on the viewing-gun electrodes, with reference to Fig.9 as follows:

   Grid No.1 ($G1_V$): -10 volts
   Grid No.2 ($G2_V$): 100 volts
   Grid No.3 ($G3_V$): 40 volts
   Grid No.4 ($G4_V$): 100 volts
   Grid No.5 ($G5_V$): 250 volts
   Backplate: 0 volts
   Screen: 8500 volts

2. Apply power to the heater of the *writing gun* and allow 30 seconds for the cathode to reach normal operating temperature. Then, with reference to Fig.9 and to the typical operating values shown in the tabulated data under *Writing Section*, set the grid-No.1 voltage to cutoff, and apply dc voltages to the electrodes of the writing gun. With the storage surface newly erased (refer to The *Erasing Operation*), the grid-No.1 bias is slowly reduced until the writing beam is seen as a spot on the screen. If the beam is caused to move, either by centering adjustment or by application of deflection field, it should leave a bright trace. After an area has been written to full brightness, the writing-beam spot may be seen as a slightly brighter spot on the bright background. Writing-beam focus can then be optimized by adjusting the grid-No.3 voltage of the writing gun.

3. Write over the full screen area until bright areas show saturation. For example, a PPI sweep speed of approximately 10000 inches per second at a pulse-repetition frequency of approximately 400 pps and a rotation rate of 15 rpm, with a writing-gun drive of about 15 volts from grid-No.1 cutoff should stabilize the storage surface, i.e., bring all of the storage elements into condition such that they will transmit the viewing beam, in about 10 sweeps. When other deflection methods, such as TV-type or "B"-type scanning, are employed, some overscanning should be permitted to charge all of the storage elements in the normal viewing-beam field.

4. Stop writing. It is to be noted that the entire screen may not be uniformly bright at this point in the adjustment procedure.

5. Readjust the voltage on $G1_V$ toward cutoff until the display size is approximately 1-1/2 inches.

6. Decrease $G3_V$ voltage *slowly* until displayed spot diameter just reaches a maximum. Record the value of $G3_V$ voltage at which this maximum spot diameter occurs.

7. Decrease *slowly* the voltage on $G1_V$ (thus making it more positive) until the display just reaches maximum diameter. This maximum diameter may coincide with the useful screen diameter of 4 inches. Record the value of $G1_V$ voltage at which the diameter of the display is a maximum.

8. Decrease voltage on $G4_V$ until diameter of display starts to decrease. Record the voltage at which the decrease in diameter begins.

9. Write full screen area to maximum brightness and then stop writing.

10. Erase partially so that no part of the display is at full brightness and then stop erasing.

11. Readjust voltage first on $G3_V$ and then on $G4_V$ to obtain the most uniform brightness (optimum uniformity) over the entire 4-inch-diameter display area. The readjustment should not involve changing the voltage on $G3_V$ by more than ± 2 volts, nor the voltage on $G4_V$ by more than ± 6 volts, from the recorded values in steps 6 and 8.

    NOTE: Due to charging of the storage surface by ion landing, and resultant non-uniformity, adjustment of the voltage on $G3_V$ and on $G4_V$ in this step should be made within 30 seconds after erasing is completed. If this time limit is exceeded, it will be necessary to restabilize the storage surface by repeating steps 9 and 10.

12. Repeat steps 9 and 10 and then readjust the voltage on $G1_V$ over a range not exceeding ± 5 volts to establish optimum uniformity. Completion of this step should provide a full 4-inch-diameter display having satisfactory uniformity.

The above procedure may be carried out for other voltages applied to $G5_V$ within its operating range (220 to 250 volts) to determine the voltage giving best uniformity.

REFERENCES

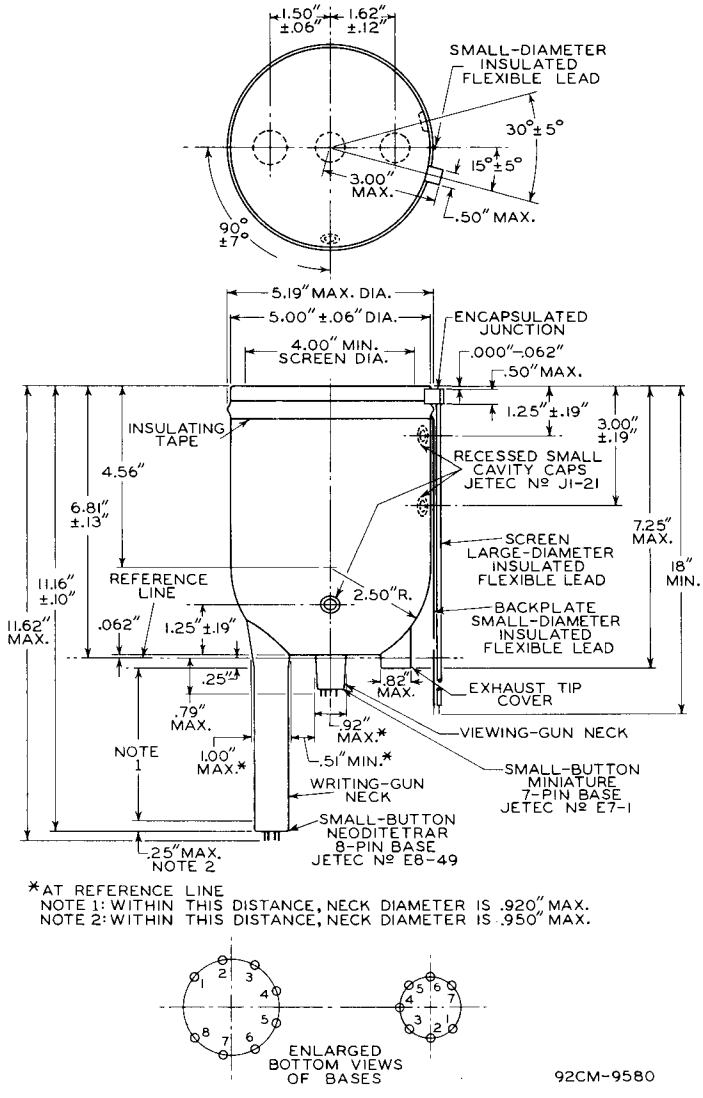
MIT Radar School Staff, *"Principles of Radar"*, McGraw-Hill Book Co., Inc.

M. Knoll and B. Kazan, *"Storage Tubes and Their Basic Principles"*, John Wiley and Sons, Inc.

M. Knoll, P. Rudnick, and H. O. Hook *"Viewing Storage Tube with Halftone Display"*, RCA Review, Vol.14, No.4, December, 1953.

M. Knoll, H. O. Hook, and R. P. Stone, *"Characteristics of a Transmission Control Viewing Storage Tube with Halftone Display"*, Proc. I.R.E., Vol.42, No.10, October, 1954.

DIMENSIONAL OUTLINE

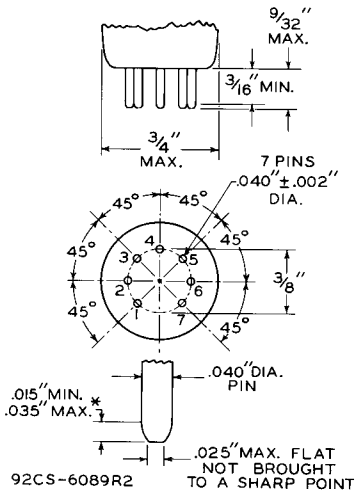


*AT REFERENCE LINE
NOTE 1: WITHIN THIS DISTANCE, NECK DIAMETER IS .920" MAX.
NOTE 2: WITHIN THIS DISTANCE, NECK DIAMETER IS .950" MAX.

92CM-9580

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

SMALL-BUTTON MINIATURE 7-PIN BASE

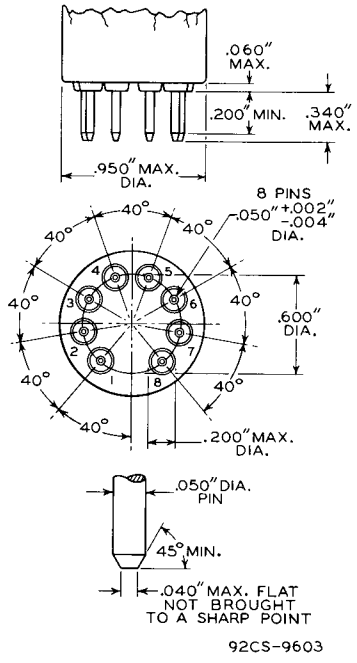


* This dimension around the periphery of any individual pin may vary within the limits shown.

BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, PASS INTO AND DISENGAGE FROM FLAT-PLATE GAUGE (PART OF GAUGE JETEC No. GE7-1) HAVING THICKNESS OF 1/4" AND EIGHT HOLES WITH DIAMETERS OF 0.0520" ± 0.0005" SO LOCATED ON A 0.3750" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.1434" ±0.0005".

THE DESIGN OF THE SOCKET SHOULD BE SUCH THAT CIRCUIT WIRING CAN NOT IMPRESS LATERAL STRAINS THROUGH THE SOCKET CONTACTS ON THE BASE PINS. THE POINT OF BEARING OF THE CONTACTS ON THE BASE PINS SHOULD NOT BE CLOSER THAN 1/8" FROM THE BOTTOM OF THE SEATED TUBE.

SMALL-BUTTON NEODITETRAR 8-PIN BASE



BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, PASS INTO AND DISENGAGE FROM FLAT-PLATE GAUGE HAVING THICKNESS OF 1/4" AND NINE HOLES WITH DIAMETER OF 0.0700" ± 0.0005" SO LOCATED ON A 0.6000" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.2052" ± 0.0005".

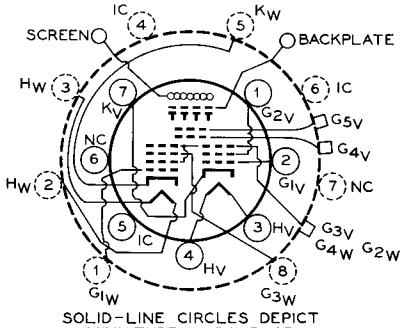
SOCKET CONNECTIONS

Bottom View

VIEWING SECTION

Small-Button Miniature 7-Pin Base

PIN 1: GRID No.2
PIN 2: GRID No.1
PIN 3: HEATER
PIN 4: HEATER
PIN 5: INTERNAL CONNECTION--DO NOT USE
PIN 6: NO CONNECTION
PIN 7: CATHODE
FLEXIBLE LEAD (LARGE): SCREEN
FLEXIBLE LEAD (SMALL): BACKPLATE
RECESSED CAVITY CAP:
LOCATED 1-1/4" FROM TUBE FACE--
GRID No.5
LOCATED 3" FROM TUBE FACE--
GRID No.4
LOCATED NEAR VIEWING GUN--GRID No.3 AND GRIDS No.4 & No.2 OF WRITING GUN



SOLID-LINE CIRCLES DEPICT MINIATURE 7-PIN BASE
BROKEN-LINE CIRCLES DEPICT NEODITETRAR 8-PIN BASE

WRITING SECTION

Small-Button Neoditetrar 8-Pin Base

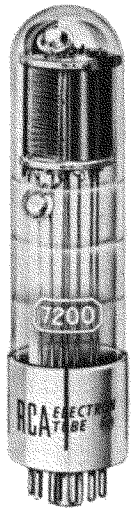
PIN 1: GRID No.1
PIN 2: HEATER
PIN 3: HEATER
PIN 4: INTERNAL CONNECTION--DO NOT USE
PIN 5: CATHODE
PIN 6: INTERNAL CONNECTION--DO NOT USE
PIN 7: NO CONNECTION
PIN 8: GRID No.3
NOTE: GRIDS No.4 & No.2 ARE CONNECTED INTERNALLY TO GRID No.3 OF VIEWING GUN.

7200

MULTIPLIER PHOTOTUBE

Sturdy Structure | **9-Stage Type**
S-19 Response
TENTATIVE DATA | **5.69" Max. Length**

RCA-7200 is a multiplier phototube intended especially for the detection and measurement of ultraviolet radiation, and in other applications involving low-level radiation sources. It employs an envelope consisting of a fused-silica section and a graded-seal section. The fused-silica section transmits radiant energy in the ultraviolet region down to and below 2000 angstroms.



The spectral response of the 7200 covers the range from about 1800 to 6000 angstroms, as shown in Fig. 1. Maximum response occurs at approximately 3300 angstroms. The 7200, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation.

DATA

General:

Spectral Response	S-19	
Wavelength of Maximum Response	3300 ± 500	angstroms
Cathode:		
Minimum projected length●	0.94	inch
Minimum projected width●	0.31	inch
Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.9	4.4	μμf
Anode to all other electrodes	6.0	μμf
Maximum Overall Length	5.69"	
Maximum Seated Length	5.12"	
Length from Base Seat to Center of Useful Cathode Area	3.94" ± 0.09"	
Maximum Diameter	1.31"	
Bulb	Fused-Silica Section with Graded Seal	
Base	Small-Shell Submagnal 11-Pin (JETEC No.B11-88) Non-hygroscopic	
Socket	Amphenol Part No.78RS-11T, or equivalent	
Operating Position	Any	
Weight (Approx.)	1.8	oz

Maximum Ratings, *Absolute Values:*

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE (DC or Peak AC)	1250 max.	volts
SUPPLY VOLTAGE BETWEEN ANODE AND DYNODE No.9 (DC or Peak AC)	250 max.	volts
AVERAGE ANODE CURRENT*	0.5 max.	ma
AMBIENT TEMPERATURE RANGE	-80 to +75	°C

Characteristics:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/10 of E between cathode and dynode No.1; 1/10 of E for each succeeding dynode stage; and 1/10 of E between dynode No.9 and anode.

With E = 1000 volts dc (except as noted)

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 3300 angstroms.	-	65000	-	μa/μw
Cathode Radiant, at 3300 angstroms.	-	0.065	-	μa/μw
Luminous:#				
At 0 cps.	15	40	300	amp/lumen
Cathode luminous●	20	40	-	μa/lumen
Current Amplification.	-	1000000	-	
Equivalent Anode Dark Current Input▲□	-	2×10^{-10}	2×10^{-9}	lumen
Equivalent Noise Input:				
Luminous★--				
At +25° C	-	7.5×10^{-13}	-	lumen
At -78° C		4×10^{-14}	-	lumen
Ultraviolet†--				
At +25° C	-	6.6×10^{-16}	-	watt
At -78° C		4×10^{-17}	-	watt

● On plane perpendicular to the indicated direction of incident light.

* Averaged over any interval of 30 seconds maximum.

\# For conditions where the light source is a tungsten-filament lamp operated at a color temperature of 2870° K. A light input of 10 microlumens is used. The load resistor has a value of 0.01 megohm.

For conditions the same as shown under (#) except that the value of light flux is 0.01 lumen and 100 volts are applied between cathode and all other electrodes connected together as anode.

▲ Supply voltage (E) adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current caused by thermionic emission and ion feedback may be reduced by the use of a refrigerant.

□ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1000 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 1000 volts, external shield operated at -1000 volts with respect to anode, 25° C tube temperature, ac-amplifier bandwidth of 1 cycle per second, tungsten light source at color temperature of 2870° K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

† Determined under the same conditions as shown under (★) except that use is made of monochromatic source having radiation of 2537 angstroms.

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Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7200 4-58
Printed in U.S.A.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Cathode Luminous Sensitivity. The quotient of current leaving the photocathode by the incident luminous flux.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux or incident radiant power which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

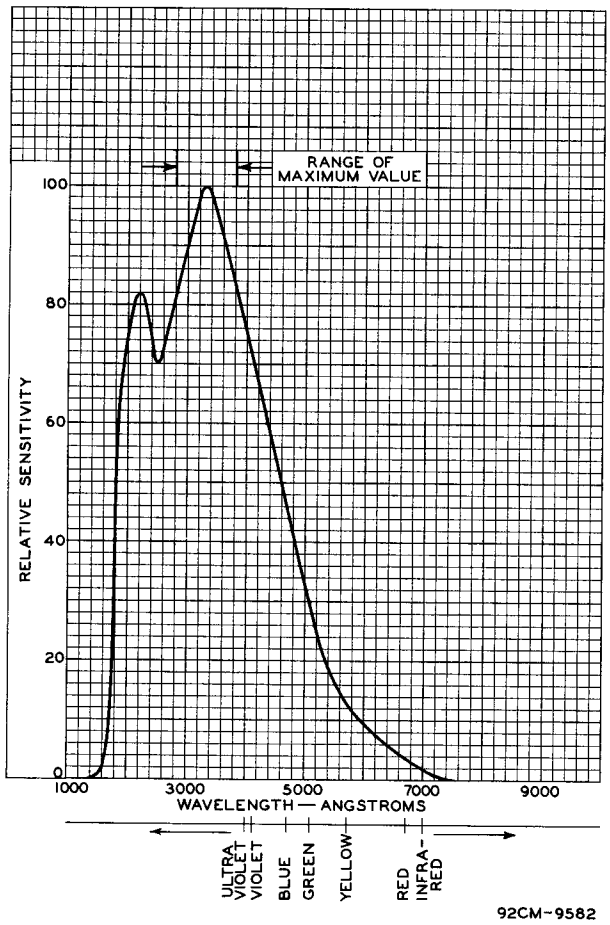


Fig. 1 - Tentative Spectral Sensitivity Characteristic of Type 7200 which has S-19 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 7200 may be impaired from the viewpoint of life and satisfactory performance. Therefore, the equipment designer has the responsibility of determining an average design value below each absolute rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

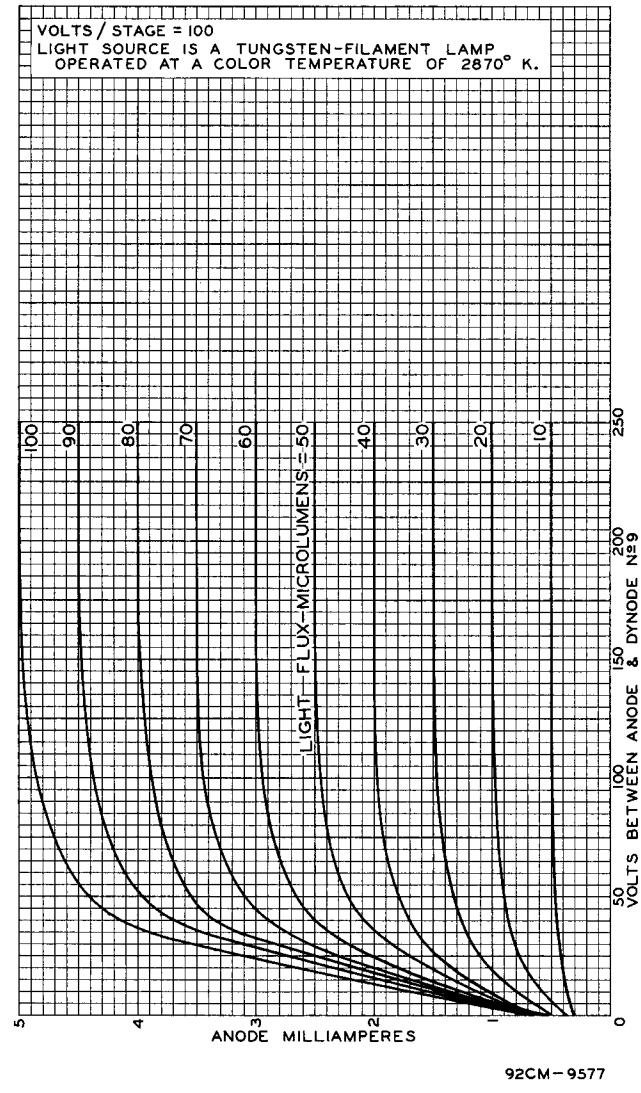


Fig. 2 - Average Anode Characteristics of Type 7200.

The use of an *average anode current* well below the maximum rated value of 0.5 milliampere is recommended when stability of operation is important.

Electrostatic and/or magnetic shielding of the 7200 may be necessary.

The high voltages at which the 7200 is operated are very dangerous. Before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

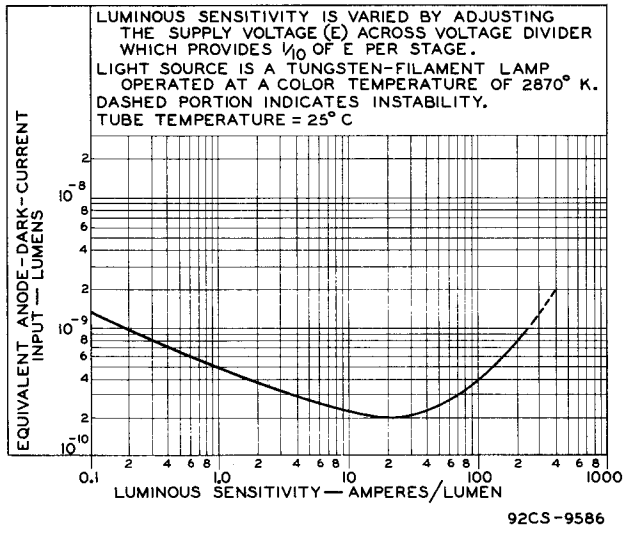


Fig. 3 - Typical Anode-Dark-Current Characteristic of Type 7200.

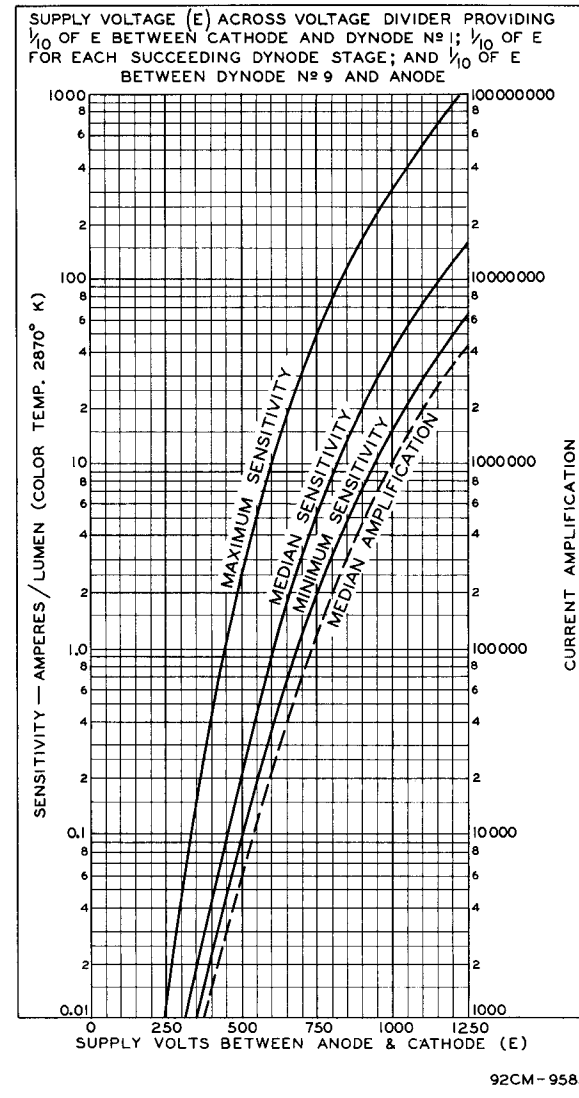
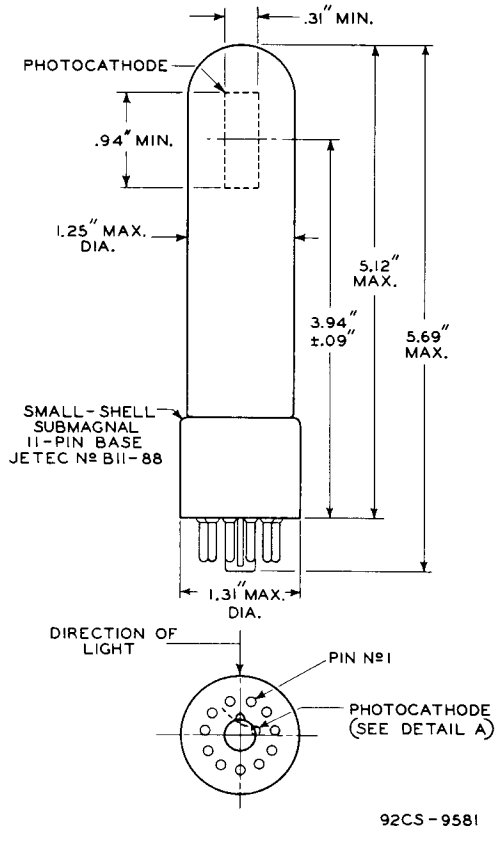
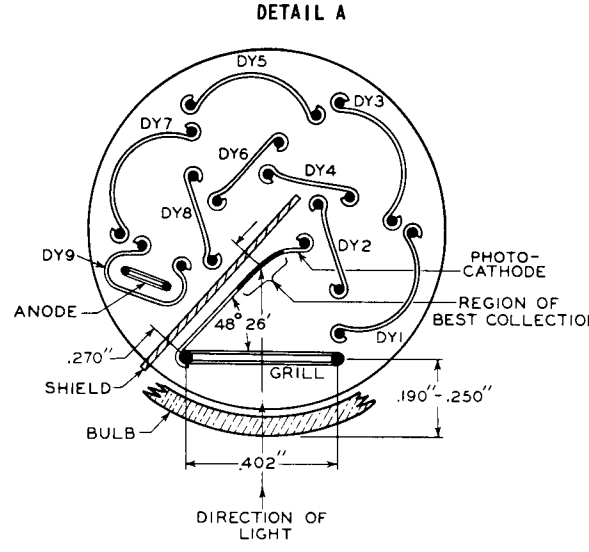


Fig. 4 - Characteristics of Type 7200.

DIMENSIONAL OUTLINE



92CS-9581



92CS-8674R1

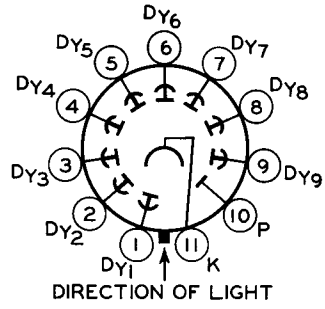
NOTE 1: CENTER LINE OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

NOTE 2: THE MAXIMUM ANGULAR VARIATION BETWEEN THE PLANE THROUGH PINS NO.1 AND NO.11 AND THE PLANE OF THE GRILL WILL NOT EXCEED 6°.

SOCKET CONNECTIONS

Bottom View

PIN 1: DYNODE NO.1
PIN 2: DYNODE NO.2
PIN 3: DYNODE NO.3
PIN 4: DYNODE NO.4
PIN 5: DYNODE NO.5
PIN 6: DYNODE NO.6



PIN 7: DYNODE NO.7
PIN 8: DYNODE NO.8
PIN 9: DYNODE NO.9
PIN 10: ANODE
PIN 11: PHOTOCATHODE

11K

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

This bulletin also applies to RCA-7204/4CX250F which is identical with RCA-7203/4CX250B except for its heater rating of 26.5 ± 10% volts, 0.58 ampere. The 7204 is unilaterally interchangeable with the 4X250F and bilaterally interchangeable with the 4CX250F.

7204/4CX250F

7203/4CX250B

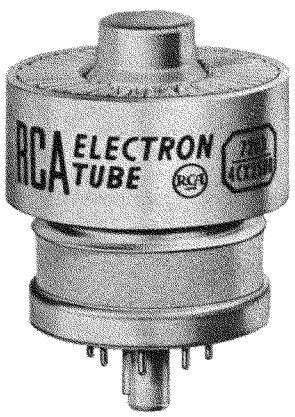
BEAM POWER TUBE

Ceramic-Metal Seals
Coaxial-Electrode Structure
Compact Design

For Use at Frequencies up to 500 Mc
Forced-Air Cooled
400 Watts CW Output to 175 Mc
250 Watts CW Output at 500 Mc

2.464" Max. Length
1.640" Max. Diameter
Integral Radiator

RCA-7203/4CX250B is a very small and compact forced-air-cooled beam power tube constructed with ceramic-metal seals throughout and having a maximum plate dissipation of 250 watts. It is intended for service as an af power amplifier and modulator, a wide-band amplifier in video applications, a linear rf power amplifier in single-sideband suppressed-carrier equipment, and a class C amplifier and oscillator. The 7203 can be used with full ratings at frequencies up to 500 megacycles per second.



The ceramic-metal-seal construction employed in the 7203 permits operation at higher temperatures than a glass-seal construction and thus provides improved reliability. The specially designed, high-efficiency radiator which is brazed directly to the plate for better heat transfer, makes possible the maximum plate-dissipation rating of 250 watts with no sacrifice in tube reliability.

The terminal arrangement of the 7203 facilitates use of the tube with tank circuits of the coaxial type. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the ring terminal for grid No.2. A base-pin termination for grid No.2 is also available for operation of the 7203 at the lower frequencies.

The 7203 is unilaterally interchangeable with the 4X250B and bilaterally interchangeable with the 4CX250B.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)§	6.0 ± 10%	volts
Current at 6.0 volts	2.6	amp
Minimum heating time	30	seconds
Mu-Factor, Grid No.2 to Grid No.1, for grid-No.2 volts = 300 and grid-No.2 ma. = 50	5.0	
Direct Interelectrode Capacitances (Approx.):□		
Grid No.1 to plate	0.03	μμf
Grid No.1 to cathode, grid No.2, and heater	16	μμf
Plate to cathode, grid No.2, and heater	4.4	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2.464"
Maximum Seated Length	1.910"
Maximum Diameter	1.640"
Base	Special 8-Pin
Socket	Air-System Socket, such as SK-600■ and SK-606 Air Chimney■; or 124-110-1▬ (Supplied with Air Chimney)
Radiator	Integral part of tube

Air Flow:

Through Indicated Air-System Socket--This fitting directs the air over the base seals; past the grid-No.2 seal, envelope, and plate seal; and through the radiator to provide effective cooling with minimum air flow. When the tube is operated at maximum plate dissipation for each class of service, a minimum air flow of 3.8 cfm through the system is required. The corresponding pressure drop is approximately 0.3 inch of water. These requirements are for operation at sea level and at an ambient temperature of 20° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the plate temperature within maximum ratings.

Without Air-System Socket--If an air-system socket is not used, it is essential that adequate cooling air be directed over the base seals, past the envelope, and through the radiator. Under these conditions and with the tube operating at maximum plate dissipation for each class of service, a minimum air flow of 3.6 cfm must pass through the radiator. The corresponding pressure drop is approximately 0.1 inch of water. These requirements are for operation at sea level and at an ambient temperature of 20° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the plate temperature within maximum ratings.

Plate Temperature (Measured on base end of plate surface at junction with fins)	250 max.	°C
Temperature of Plate Seal, Grid-No.2 Seal, and Base Seals	250 max.	°C
Weight (Approx.)	4	ounces

■ Available from Eitel-McCullough, Inc., San Bruno, Calif.
▬ Available from E. F. Johnson Co., Waseca, Minn.

Trademark(s) ® Registered
Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7203/4CX250B 2-61
Printed in U.S.A.

AF POWER AMPLIFIER & MODULATOR—Class AB_1 ♦

Maximum CCS● Ratings, *Absolute-Maximum Values:*#

DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 VOLTAGE	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT*	250 max.	ma
PLATE DISSIPATION*	250 max.	watts
GRID-No.2 DISSIPATION*	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	1000	1500	2000	volts
DC Grid-No.2 Voltage	350	350	350	volts
DC Grid-No.1 Voltage	-55	-55	-55	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	94	94	94	volts
Zero-Signal DC Plate Current	166	166	166	ma
Max.-Signal DC Plate Current	500	500	500	ma
Zero-Signal DC Grid-No.2 Current	0	0	0	ma
Max.-Signal DC Grid-No.2 Current (Approx.)	10	8	8	ma
Effective Load Resistance (Plate to plate)	3300	6000	8700	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	watts
Max.-Signal Power Output (Approx.)	220	400	590	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance (Per tube). 0.1 max. megohm

RF POWER AMPLIFIER—Class B Television Service

Synchronizing-level conditions per tube unless otherwise specified

Maximum CCS● Ratings, *Absolute-Maximum Values:*#

	54 to 216 Mc	
DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 VOLTAGE	400 max.	volts
DC GRID-No.1 VOLTAGE	-250 max.	volts
DC PLATE CURRENT (Average)⊕	250 max.	ma
PLATE DISSIPATION	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	watts
GRID-No.1 DISSIPATION	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Operation with Bandwidth of 5 Mc:

DC Plate Voltage	1000	1500	2000	volts
DC Grid-No.2 Voltage	350	350	350	volts
DC Grid-No.1 Voltage	-60	-65	-70	volts
Peak RF Grid-No.1 Voltage:				
Synchronizing level	65	71	76	volts
Pedestal level	52	57	62	volts
DC Plate Current:				
Synchronizing level	355	360	360	ma
Pedestal level	250	250	250	ma
DC Grid-No.2 Current:				
Synchronizing level	27	29	29	ma
Pedestal level	4	0	0	ma
DC Grid-No.1 Current:				
Synchronizing level	2	5	5	ma
Pedestal level	0	0	0	ma
Driving Power (Approx.):♦				
Synchronizing level	0.4	1.2	1.2	watts
Pedestal level	0	0	0	watts
Power Output (Approx.):				
Synchronizing level	160	300	440	watts
Pedestal level	90	170	250	watts

LINEAR RF POWER AMPLIFIER
Single-Sideband Suppressed-Carrier Service

Maximum CCS● Ratings, *Absolute-Maximum Values:*#

	Up to 500 Mc	
DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 VOLTAGE	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT	250 max.	ma
PLATE DISSIPATION	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Class AB_1 ♦ "Single-Tone" Operation up to 175 Mc:♦♦

DC Plate Voltage	1000	1500	2000	volts
DC Grid-No.2 Voltage‡	350	350	350	volts
DC Grid-No.1 Voltage	-55	-55	-55	volts
Zero-Signal DC Plate Current	83	83	83	ma
Zero-Signal DC Grid-No.2 Current	0	0	0	ma
Effective RF Load Resistance	1650	3000	4350	ohms
Max.-Signal DC Plate Current	250	250	250	ma
Max.-Signal DC Grid-No.2 Current	5	4	4	ma
Max.-Signal Peak RF Grid-No.1 Voltage	47	47	47	volts
Max.-Signal Driving Power (Approx.)	0	0	0	watts
Max.-Signal Power Output (Approx.)	110	200	295	watts

Typical CCS Operation with "Two-Tone Modulation" at 30 Mc:□□

DC Plate Voltage	1000	1500	2000	volts
DC Grid-No.2 Voltage‡	350	350	350	volts
DC Grid-No.1 Voltage**	-55	-55	-55	volts
Zero-Signal DC Plate Current	83	83	83	ma
Effective RF Load Resistance	1650	3000	4350	ohms
DC Plate Current at Peak of Envelope	250	250	250	ma
Average DC Plate Current	175	175	175	ma
DC Grid-No.2 Current at Peak of Envelope	30	30	30	ma
Average DC Grid-No.2 Current	6	9.5	15	ma
Average DC Grid-No.1 Current	0	0	0	ma
Peak-Envelope Driver Power (Approx.)	1	1	1	watt
Output-Circuit Efficiency (Approx.)	95	95	95	%
Distortion Products Level:⊕				
Third Order	29	29	30	db
Fifth Order	40	38	35	db
Useful Power Output (Approx.):♠				
Average	55	100	147.5	watts
Peak Envelope	110	200	295	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:

With fixed bias	25000 max.	ohms
With cathode bias	.Not recommended	

PLATE-MODULATED RF POWER AMP.—Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS● Ratings, *Absolute-Maximum Values:*#

	Up to 500 Mc	
DC PLATE VOLTAGE	1500 max.	volts
DC GRID-No.2 VOLTAGE	300 max.	volts
DC GRID-No.1 VOLTAGE	-250 max.	volts
DC PLATE CURRENT	200 max.	ma

PLATE DISSIPATION	165 max.		watts
GRID-No.2 DISSIPATION	8 max.		watts
GRID-No.1 DISSIPATION	2 max.		watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150 max.		volts
Heater positive with respect to cathode	150 max.		volts

Typical CCS Operation at Frequencies up to 175 Mc:

DC Plate Voltage	500	1000	1500	volts
DC Grid-No.2 Voltage (Modulated approx. 55%)▲	250	250	250	volts
DC Grid-No.1 Voltage★	-100	-100	-100	volts
Peak RF Grid-No.1 Voltage	113	113	113	volts
DC Plate Current	200	200	200	ma
DC Grid-No.2 Current	32	31	31	ma
DC Grid-No.1 Current (Approx.)	6	6	6	ma
Driving Power (Approx.)♦	0.7	0.7	0.7	watt
Power Output (Approx.)	50	140	235	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition	25000 max.	ohms

RF POWER AMPLIFIER & OSC.—Class C Telegraphy† and RF POWER AMPLIFIER—Class C FM Telephony

Maximum CCS● Ratings, *Absolute-Maximum Values:*#

	Up to 500 Mc	
DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 VOLTAGE	300 max.	volts
DC GRID-No.1 VOLTAGE	-250 max.	volts
DC PLATE CURRENT	250 max.	ma
PLATE DISSIPATION	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	watts
GRID-No.1 DISSIPATION	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Operation at Frequencies up to 175 Mc:

DC Plate Voltage	500	1000	1500	2000	volts
DC Grid-No.2 Voltage	250	250	250	250	volts
DC Grid-No.1 Voltage	-90	-90	-90	-90	volts
Peak RF Grid-No.1 Voltage	109	109	109	109	volts
DC Plate Current	250	250	250	250	ma
DC Grid-No.2 Current	48	45	36	30	ma
DC Grid-No.1 Current (Approx.)	12	12	11	11	ma
Driving Power (Approx.)	1	1	1	1	watt
Power Output (Approx.)	65	180	290	400	watts

Typical CCS Operation at Frequency of 500 Mc with Coaxial Cavity:

DC Plate Voltage	2000	volts
DC Grid-No.2 Voltage	300	volts
DC Grid-No.1 Voltage	-90	volts
DC Plate Current	250	ma
DC Grid-No.2 Current	10	ma
DC Grid-No.1 Current (Approx.)	25	ma
Driver Power Output (Approx.)♦	18	watts
Useful Power Output (Approx.)	250	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition	25000 max.	ohms

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current:				
Type 7203	1	2.3	2.9	amp
Type 7204	2	0.50	0.62	amp
Direct Interelectrode Capacitances (Types 7203 & 7204):□				
Grid No.1 to plate	-	-	0.06	μμf
Grid No.1 to cathode, grid No.2, and heater	-	14.2	17.2	μμf
Plate to cathode, grid No.2, and heater	-	4.0	4.8	μμf
Grid-No.1 Voltage:				
Type 7203	1,3,7,8	-32	-46	volts
Type 7204	2,3,7,8			
Grid-No.2 Current:				
Type 7203	1,3,7,8	-7	+3	ma
Type 7204	2,3,7,8			
Useful Power Output:				
Type 7203	5,7,8	225	-	watts
Type 7204	6,7,8			

Note 1: With 6.0 volts on heater.

Note 2: With 26.5 volts on heater.

Note 3: With dc plate voltage of 1000 volts, dc grid-No.2 voltage of 300 volts, and grid-No.1 voltage adjusted to give plate current of 150 ma.

Note 4: With plate floating, dc grid-No.2 voltage of 300 volts, and grid-No.1 voltage adjusted to give grid-No.2 current of 50 ma.

Note 5: With heater voltage of 5.5 volts, dc plate voltage of 2000 volts, dc grid-No.2 voltage of 300 volts, dc grid-No.1 bias of -90 volts, dc grid-No.1 current of 25 ma maximum, grid-No.1 signal voltage adjusted to produce dc plate current of 250 ma, and coaxial-cavity amplifier circuit operating at a frequency of 475 Mc.

Note 6: Same as Note 5 except heater voltage is 24.3 volts.

Note 7: With Forced-Air Cooling as specified under GENERAL DATA—*Air-System Socket.*

Note 8: Heater voltage must be applied for at least 30 seconds before application of other voltages.

SPECIAL PERFORMANCE DATA

Interelectrode Leakage:

This test is destructive and is performed on a sample lot of tubes from each production run under the following conditions: ac heater volts = 6.6 for type 7203 or 29.1 for type 7204, no voltage on other elements, and specified forced-air cooling for *Air-System Socket.* At the end of 500 hours, with tube at 25° C, and with no voltage applied to heater, the minimum resistance between indicated electrodes as measured with a 500-volt Megger-type ohmmeter having an internal impedance of 2.5 megohms, will be:

Grid No.1 and Grid No.2	10 min.	megohms
Grid No.1 and Cathode	10 min.	megohms
Grid No.2 and Cathode	10 min.	megohms

§ Because the cathode is subjected to considerable back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should be reduced depending on operating conditions and frequency to prevent overheating the cathode and resultant short life.

□ With cylindrical shield JEDEC No.320 surrounding radiator; and with a cylindrical shield JEDEC No.321 surrounding the grid-No.2 ring terminal. Both shields are connected to ground.

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no Absolute-Maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

♦ Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

* Averaged over any audio-frequency cycle of sine-wave form.

⊕ Averaged over any frame.

♦ The driver stage is required to supply tube losses and rf circuit losses. The driver stage should be designed to provide an excess of power above the indicated values to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

♦♦ "Single-Tone" operation refers to that class of amplifier service in which the grid-No.1 input consists of a monofrequency rf signal having constant amplitude. This signal is produced in a single-sideband suppressed-carrier system when a single audio frequency of constant amplitude is applied to the input of the system.

‡ Preferably obtained from a fixed supply.

□□ "Two-Tone Modulation" operation refers to that class of amplifier service in which the input consists of two equal monofrequency rf signals having constant amplitude. These signals are produced in a single-sideband suppressed-carrier system when two equal-and-constant-amplitude audio frequencies are applied to the input of the system.

** Obtained from a fixed supply.

⊕ Without the use of feedback to enhance linearity.

♠ Measured at load of output circuit having indicated efficiency.

▲ The dc grid-No.2 voltage must be modulated approximately 55% in phase with the plate modulation in order to obtain 100% modulation of the 7203. The use of a series grid-No.2 resistor or reactor may not give satisfactory performance and is therefore not recommended.

★ Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

† Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

OPERATING CONSIDERATIONS

The *maximum temperatures* in the tabulated data for the base seals, grid-No.2 seal, plate seal, and plate are tube ratings and are to be observed in the same manner as other tube ratings. The temperature of the respective seals and of the plate may conveniently be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y. in the form of liquid and stick.

The *socket* for the 7203 should be of a type (such as is indicated in the tabulated data) which permits adequate air-cooling of the tube. Although the base will fit a conventional lock-in socket, the latter does not permit adequate cooling and its use is therefore not recommended.

The *plate connection* is made by means of a metal band or spring contacts to the cylindrical surface of the radiator. It is essential that the contact areas be kept clean to minimize rf losses especially at the higher frequencies.

The rated plate and grid-No.2 voltages of this tube are extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

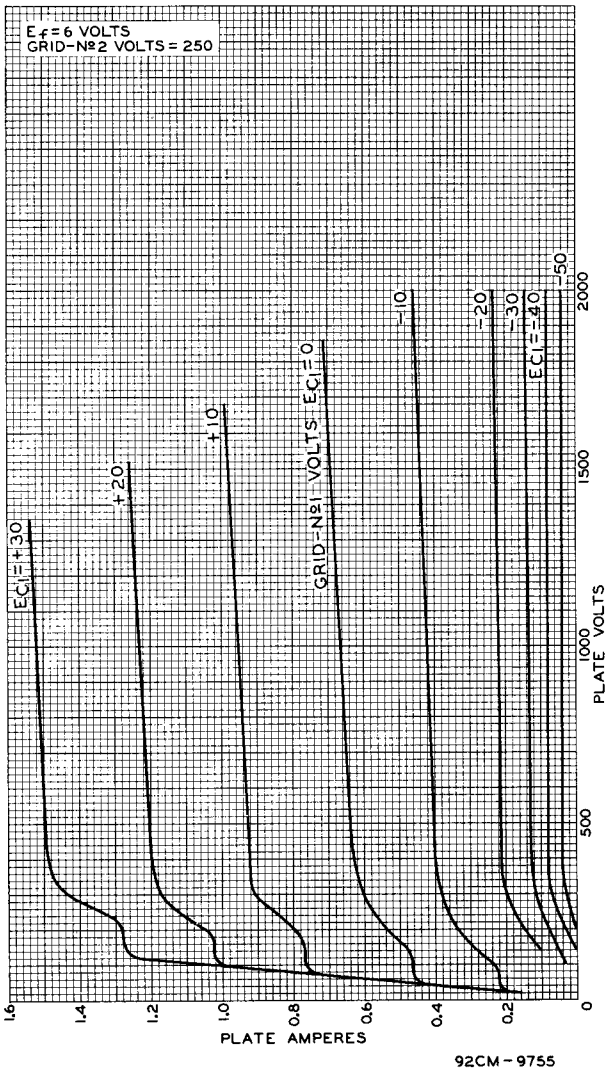


Fig. 1 - Typical Plate Characteristics of Type 7203.

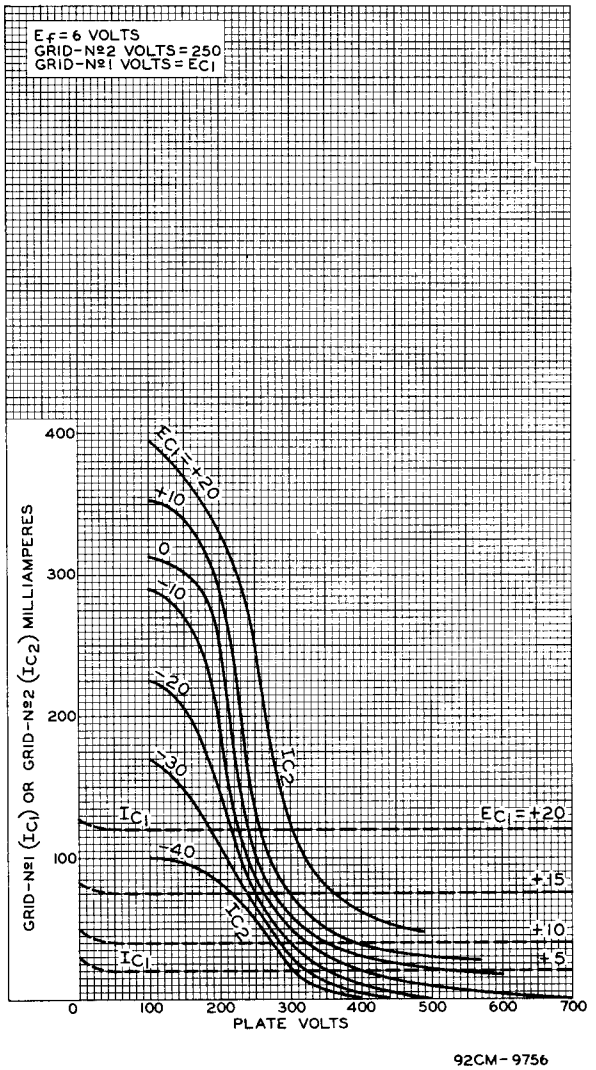


Fig. 2 - Typical Characteristics of Type 7203.

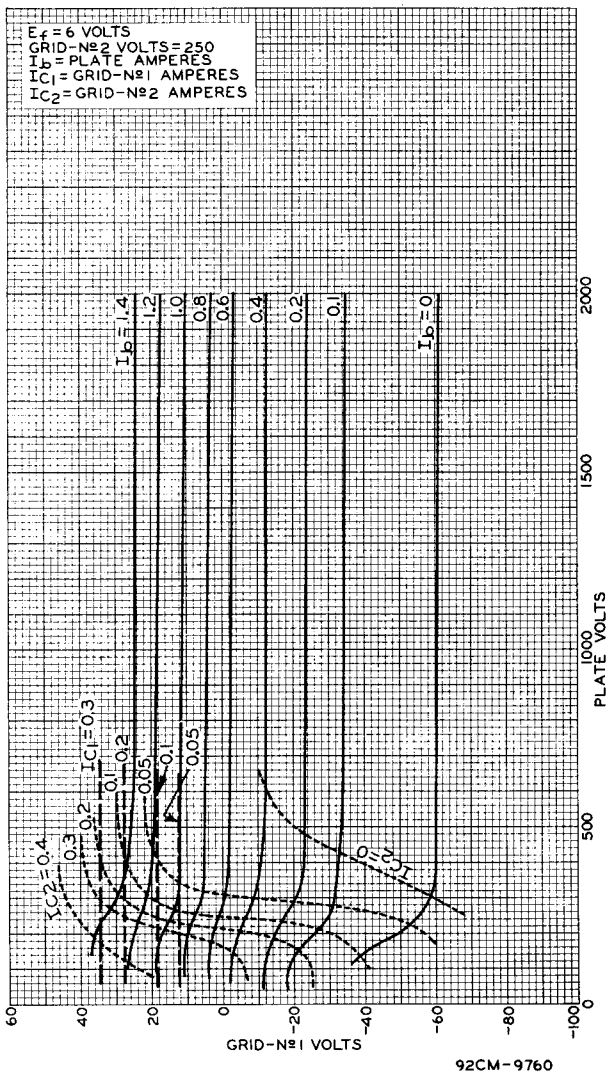


Fig. 3 – Typical Constant-Current Characteristics of Type 7203.

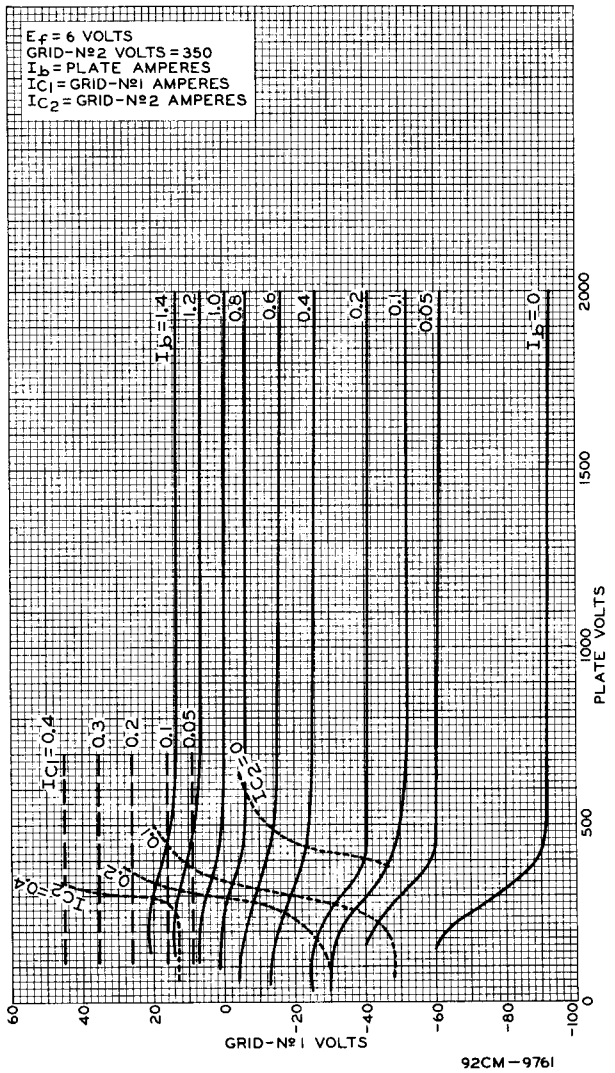
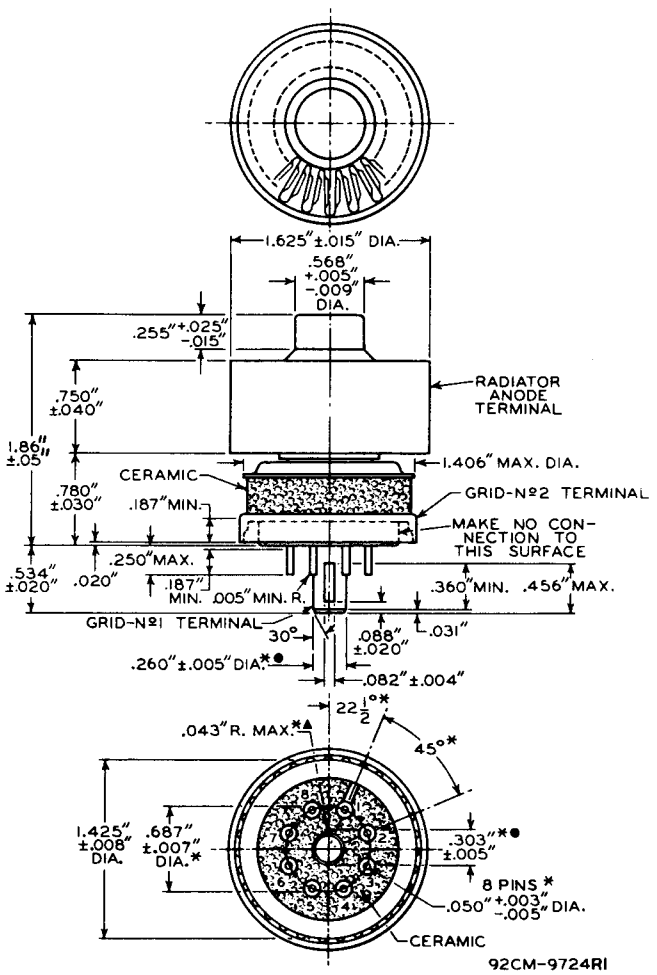


Fig. 4 – Typical Constant-Current Characteristics of Type 7203.

DIMENSIONAL OUTLINE



GRID-No.1 PLUG DIMENSIONS ARE MEASURED BY THE USE OF THE SERIES OF GAUGES SHOWN IN SKETCHES G_1 AND G_2. IN THE FOLLOWING INSTRUCTIONS FOR THE USE OF THESE GAUGES, "GO" INDICATES THAT THE ENTIRE GRID-No.1 PLUG KEY WILL ENTER THE GAUGE; AND "NO-GO" INDICATES THAT THE GRID-No.1 PLUG KEY WILL NOT ENTER THE GAUGE MORE THAN 1/16". INSTRUCTIONS FOR THE USE OF THE GAUGES FOLLOW:

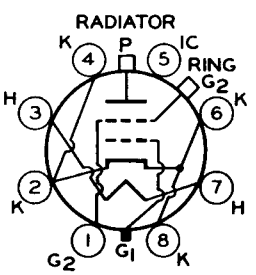
▲ GAUGES G_1-1, G_1-2, G_1-3, AND G_1-4:
USING ONLY SLOT C, TRY THESE GAUGES IN NUMERICAL ORDER UNTIL ONE IS FOUND THAT WILL ACCEPT THE ENTIRE GRID-No.1 PLUG. USING THE FIRST GAUGE THUS FOUND, IT WILL NOT BE POSSIBLE TO INSERT THE GRID-No.1 PLUG IN SLOT B.

● GAUGES G_2-1, G_2-2, AND G_2-3:
THE GRID-No.1 PLUG WILL BE REJECTED BY GAUGES G_2-1 AND G_2-2, BUT WILL BE ACCEPTED BY GAUGE G_2-3.

* BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT THE ENTIRE LENGTH OF THE PINS WILL, WITHOUT UNDUE FORCE, PASS INTO AND DISENGAGE FROM THE FLAT-PLATE GAUGE SHOWN IN SKETCH G_3.

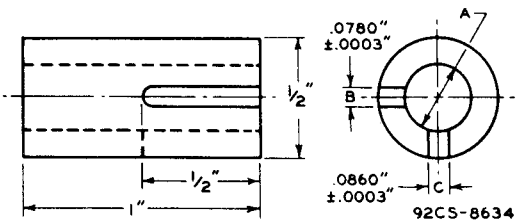
BASING DIAGRAM

Bottom View



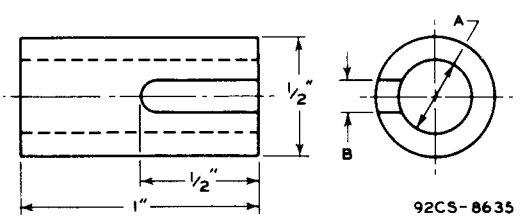
PIN 1: GRID No.2 (For use at the lower frequencies)
PIN 2: CATHODE
PIN 3: HEATER
PIN 4: CATHODE
PIN 5: INTERNAL CONNECTION--DO NOT USE
PIN 6: CATHODE
PIN 7: HEATER
PIN 8: CATHODE
BASE INDEX PLUG: GRID No.1
RADIATOR: PLATE
RING TERMINAL: GRID No.2 (For use at the higher frequencies)

Gauge Sketch G_1



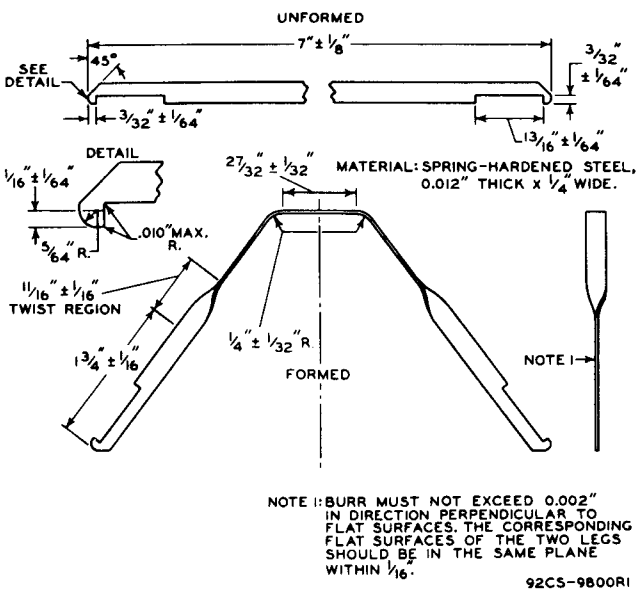
Gauge	Dimension A
G_1-1	.2575" $^{+\ .0000"}_{-\ .0005"}$
G_1-2	.2600" $^{+\ .0000"}_{-\ .0005"}$
G_1-3	.2625" $^{+\ .0000"}_{-\ .0005"}$
G_1-4	.2650" $^{+\ .0000"}_{-\ .0005"}$

Gauge Sketch G_2

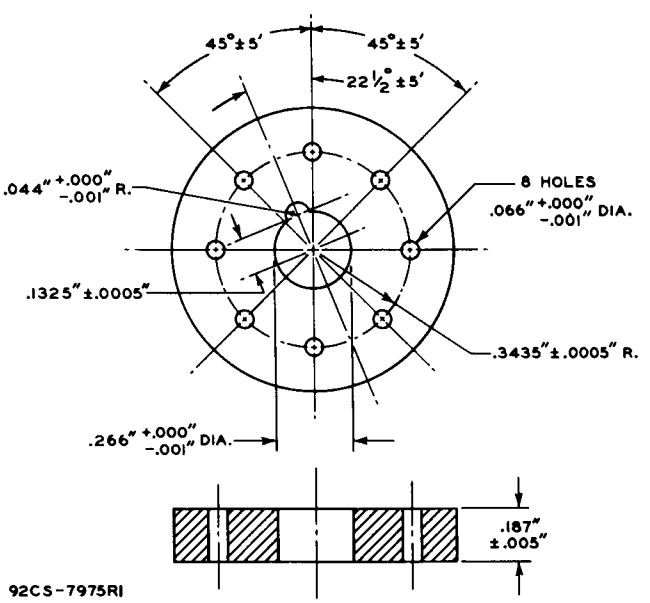


Gauge	Dimension	
	A	B
G_2-1	.2550" $^{+\ .0000"}_{-\ .0005"}$	.125"
G_2-2	.2980" $^{+\ .0000"}_{-\ .0005"}$	none
G_2-3	.3080" $^{+\ .0000"}_{-\ .0005"}$	none

Suggested Design for Extractor to Remove Tube from Cavity



Gauge Sketch G_3



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7212

BEAM POWER TUBE

Small Size
High Power Gain
T-12 Bulb

For Use Under Severe Shock and Vibration
90 Watts CW Input (ICAS) up to 60 Mc
60 Watts CW Input (ICAS) at 175 Mc

TENTATIVE DATA

3-13/16" Max. Length
1-21/32" Max. Diameter
Octal 8-Pin Base

RCA-7212 is a small beam power tube designed specifically for applications where dependable performance under severe shock and vibration is essential. It is intended for use as an rf power amplifier and oscillator as well as an af power amplifier and modulator.

The 7212 has a maximum plate dissipation of 25 watts under ICAS conditions in modulator service and in cw service. In the latter service, it can be operated with full input to 60 Mc and with reduced input to 175 Mc.

Because of its high power gain and high efficiency, the 7212 can be operated with relatively low plate voltage to give large power output with small driving power.

Small in size for its power-output capability, the 7212 has a rugged button-stem construction with short internal leads, a T-12 bulb, triple base-pin connections for grid No.3 and cathode (both joined to internal shield inside the tube) to permit effective rf grounding, and a small-wafer octal base with metal sleeve having its own base-pin terminal. The sleeve shields the input to the tube and isolates it from the output circuit so completely that no other external shielding is required. Separation of input and output circuits is accomplished by bringing the plate lead out of the bulb to a cap opposite the base.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	1.25	amperes
Transconductance, for plate volts = 200, grid-No.2 volts = 200, and plate ma. = 100.	7000	μmhos
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 200, grid-No.2 volts = 200, and plate ma. = 100.	4.5	
Direct Interelectrode Capacitances:*		
Grid No.1 to plate	0.24 max.	μμf
Grid No.1 to cathode & grid No.3 & internal shield, base sleeve, grid No.2, and heater.	13.5	μμf
Plate to cathode & grid No.3 & internal shield, base sleeve, grid No.2, and heater.	8.5	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	3-13/16"
Seated Length	3-1/8" ± 1/8"
Maximum Diameter	1-21/32"
Bulb	T-12
Cap	Small (JETEC No.C1-1)
Socket	Standard Octal 8-Contact
Base	Small Micanol-Wafer Octal 8-Pin "770" Sleeve (JETEC Group 1, No.B8-150)
Bulb Temperature (At hottest point).	220 max. °C
Weight (Approx.)	2 oz

AF POWER AMPLIFIER & MODULATOR--Class AB_1†

Triode Connection--Grid No.2 Connected to Plate

	CCS●	ICAS●●	
Maximum Ratings, *Absolute Values:*			
DC PLATE VOLTAGE	400 max.	400 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	90 max.	90 max.	ma
MAX.-SIGNAL PLATE INPUT**	35 max.	35 max.	watts
PLATE DISSIPATION**	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	250	400	400	volts
DC Grid-No.1 Voltage	-50	-100	-100	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage○	100	200	200	volts
Zero-Signal DC Plate Current	120	40	40	ma

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7212 5-58
Printed in U.S.A.

	CCS●		ICAS●	
Typical Operation (Cont'd):				
Max.-Signal DC Plate Current	125	100	100	ma
Effective Load Resistance (Plate to plate)	5000	8000	8000	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	watts
Max.-Signal Power Output (Approx.)	10	22	22	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1 Circuit Resistance under Any Condition:○○✠		
With fixed bias	0.1 max.	megohm
With cathode bias	0.5 max.	megohm

AF POWER AMPLIFIER & MODULATOR--Class AB_1†

Maximum Ratings, *Absolute Values:*

	CCS●	ICAS●●	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	125 max.	135 max.	ma
MAX.-SIGNAL PLATE INPUT**	60 max.	85 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT**	3 max.	3 max.	watts
PLATE DISSIPATION**	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	400	500	600	volts
DC Grid-No.2 Voltage▲	190	185	180	volts
DC Grid-No.1 (Control-Grid) Voltage:				
With fixed-bias source	-40	-40	-45	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	80	80	90	volts
Zero-Signal DC Plate Current	63	57	26	ma
Max.-Signal DC Plate Current	228	215	200	ma
Zero-Signal DC Grid-No.2 Current	2.5	2	1	ma
Max.-Signal DC Grid-No.2 Current	25	25	23	ma
Effective Load Resistance (Plate to plate)	4000	5500	7000	ohms
Max.-Signal Driving Power (Approx.)	0	0	0	watts
Max.-Signal Power Output (Approx.)	55	70	82	watts

Typical ICAS Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No.2 Voltage▲	200	195	volts
DC Grid-No.1 (Control-Grid) Voltage:			
From fixed-bias source	-50	-50	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	100	100	volts
Zero-Signal DC Plate Current	28	23	ma
Max.-Signal DC Plate Current	229	220	ma
Zero-Signal DC Grid-No.2 Current	1	1	ma
Max.-Signal DC Grid-No.2 Current	27	26	ma
Effective Load Resistance (Plate to plate)	6000	8000	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	95	120	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance under Any Condition:○○✠		
With fixed bias	0.1 max.	megohm
With cathode bias	Not recommended	

AF POWER AMPLIFIER & MODULATOR--Class AB_2#

Maximum Ratings, *Absolute Values:*

	CCS●	ICAS●●	
DC PLATE VOLTAGE	600 max.	750 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT**	125 max.	135 max.	ma
MAX.-SIGNAL PLATE INPUT**	62.5 max.	90 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT**	3 max.	3 max.	watts
PLATE DISSIPATION**	20 max.	25 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	135 max.	135 max.	volts
Heater positive with respect to cathode	135 max.	135 max.	volts

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	400	500	600	volts
DC Grid-No.2 Voltage▲	175	175	165	volts
DC Grid-No.1 (Control-Grid) Voltage:				
From fixed-bias source	-41	-44	-44	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	95	102	97	volts
Zero-Signal DC Plate Current	33	27	22	ma
Max.-Signal DC Plate Current	232	242	207	ma
Zero-Signal DC Grid-No.2 Current	1.1	0.7	0.6	ma
Max.-Signal DC Grid-No.2 Current	18	18	17	ma
Max.-Signal DC Grid-No.1 Current	1.6	1.9	1.1	ma
Effective Load Resistance (Plate to plate)	3700	4600	6800	ohms
Max.-Signal Driving Power (Approx.)◆	0.2	0.3	0.2	watt
Max.-Signal Power Output (Approx.)	62	83	90	watts

Typical ICAS Operation:

Values are for 2 tubes

DC Plate Voltage	600	750	volts
DC Grid-No.2 Voltage▲	190	165	volts
DC Grid-No.1 (Control-Grid) Voltage:			
From fixed-bias source	-48	-46	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	109	108	volts
Zero-Signal DC Plate Current	28	22	ma
Max.-Signal DC Plate Current	270	240	ma
Zero-Signal DC Grid-No.2 Current	1.2	0.3	ma
Max.-Signal DC Grid-No.2 Current	20	20	ma
Max.-Signal DC Grid-No.1 Current	2	2.6	ma
Effective Load Resistance (Plate to plate)	5000	7400	ohms
Max.-Signal Driving Power (Approx.)◆	0.3	0.4	watt
Max.-Signal Power Output (Approx.)	113	131	watts

Maximum Circuit Values (CCS or ICAS):

Grid-No.1-Circuit Resistance:◆		
With fixed bias	30000 max.	ohms
With cathode bias	Not recommended	

PLATE-MODULATED RF POWER AMPLIFIER--
Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	CCS●		ICAS●●		
Maximum Ratings, *Absolute Values:*					
DC PLATE VOLTAGE	480 max.		600 max.		volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.		250 max.		volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-150 max.		-150 max.		volts
DC PLATE CURRENT	117 max.		125 max.		ma
DC GRID-No.1 CURRENT	3.5 max.		4.0 max.		ma
PLATE INPUT	45 max.		67.5 max.		watts
GRID-No.2 INPUT	2 max.		2 max.		watts
PLATE DISSIPATION	13.3 max.		16.7 max.		watts
PEAK HEATER-CATHODE VOLTAGE:					
Heater negative with respect to cathode	135 max.		135 max.		volts
Heater positive with respect to cathode	135 max.		135 max.		volts
Typical Operation up to 60 Mc:					
DC Plate Voltage	400	475	600		volts
DC Grid-No.2 Voltage[†]	150	135	150		volts
From a series resistor of	33000	51000	56000		ohms
DC Grid-No.1 Voltage[★]	-87	-77	-87		volts
From a grid resistor of	27000	27000	27000		ohms
Peak RF Grid-No.1 Voltage	107	95	107		volts
DC Plate Current	112	94	112		ma
DC Grid-No.2 Current	7.8	6.4	7.8		ma
DC Grid-No.1 Current (Approx.)	3.4	2.8	3.4		ma
Driving Power (Approx.)	0.4	0.3	0.4		watt
Power Output (Approx.)	32	34	52		watts
Maximum Circuit Values (CCS or ICAS):					
Grid-No.1-Circuit Resistance[‡]			30000 max.		ohms

RF POWER AMPLIFIER & OSC.--Class C Telegraphy[□]
and
RF POWER AMPLIFIER--Class C FM Telephony

	CCS●		ICAS●●		
Maximum Ratings, *Absolute Values:*					
DC PLATE VOLTAGE	600 max.		750 max.		volts
DC GRID-No.2 (SCREEN) VOLTAGE	250 max.		250 max.		volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-150 max.		-150 max.		volts
DC PLATE CURRENT	140 max.		150 max.		ma
DC GRID-No.1 CURRENT	3.5 max.		4.0 max.		ma
PLATE INPUT	67.5 max.		90 max.		watts
GRID-No.2 INPUT	3 max.		3 max.		watts
PLATE DISSIPATION	20 max.		25 max.		watts
PEAK HEATER-CATHODE VOLTAGE:					
Heater negative with respect to cathode	135 max.		135 max.		volts
Heater positive with respect to cathode	135 max.		135 max.		volts
Typical Operation as Amplifier up to 60 Mc:					
DC Plate Voltage	500	600	600	750	volts
DC Grid-No.2 Voltage[⊕⊕]	170	150	180	160	volts
From a series resistor of	36000	51000	43000	56000	ohms
DC Grid-No.1 Voltage[■]	-66	-58	-71	-62	volts
From a grid-No.1 resistor of	27000	20000	24000	20000	ohms
From a cathode resistor of	470	470	430	470	ohms
Peak RF Grid-No.1 Voltage	84	73	91	79	volts
DC Plate Current	135	112	150	120	ma
DC Grid-No.2 Current	9	9	10	11	ma
DC Grid-No.1 Current (Approx.)	2.5	2.8	2.8	3.1	ma
Driving Power (Approx.)	0.2	0.2	0.3	0.2	watt
Power Output (Approx.)	48	52	66	70	watts
Typical Operation as Amplifier at 175 Mc:					
DC Plate Voltage	320		400		volts
DC Grid-No.2 Voltage[⊕⊕]	180		190		volts
From a series resistor of	13000		20000		ohms
DC Grid-No.1 Voltage[■]	-51		-54		volts
From a grid resistor of	27000		24000		ohms
From a cathode resistor of	330		330		ohms
Peak RF Grid-No.1 Voltage	64		68		volts
DC Plate Current	140		150		ma
DC Grid-No.2 Current	10		10.4		ma
DC Grid-No.1 Current (Approx.)	2		2.2		ma
Driving Power (Approx.)	3		3		watts
Power Output (Approx.)	25		35		watts
Maximum Circuit Values (CCS or ICAS):					
Grid-No.1 Circuit Resistance[‡]			30000 max.		ohms

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Max.	
Heater Current	1	1.175	1.325	amperes
Direct Interelectrode Capacitances:				
Grid No.1 to plate	2	-	0.24	μμf
Grid No.1 to cathode & grid No.3 & internal shield, base sleeve, grid No.2, and heater	2	12.0	15.0	μμf
Plate to cathode & grid No.3 & internal shield, base sleeve, grid No.2, and heater	2	7.3	9.5	μμf
Plate Current	3	46	94	ma
Grid-No.2 Current	3	-	5.5	ma
Heater-Cathode Leakage Current:				
Heater 100 volts negative with respect to cathode	1	-	100	μa
Heater 100 volts positive with respect to cathode	1	-	100	μa
Useful Power Output	4	47	-	watts

Note 1: With 6.3 volts ac on heater.

Note 2: With no external shield.

Note 3: With 6.3 volts ac on heater, dc plate voltage of 300 volts, dc grid-No.2 voltage of 200 volts, and dc grid-No.1 voltage of -33 volts.

Note 4: In a single-tube, self-excited oscillator circuit, and with 6.3 volts ac on heater, dc plate voltage of 600 volts, dc grid-No.2 voltage of 180 volts, grid-No.1 resistor of 30000 ± 10% ohms, dc plate current of 100 - 112 ma., dc grid-No.2 current of 23 ma. maximum, dc grid-No.1 current of 2 to 2.5 ma., and frequency of 15 Mc.

---

* With no external shield.

† Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

●● Intermittent Commercial and Amateur Service.

** Averaged over any audio-frequency cycle of sine-wave form.

○ The driver stage should be capable of supplying the No.1 grids of the class AB_1 stage with the specified driving voltage at low distortion.

○○ The type of input coupling network used should not introduce too much resistance in the grid-No.1 circuit. Transformer or impedance coupling devices are recommended.

✠ When the 7212 is connected as a triode and its grid No.1 is operated with fixed bias, the dc grid-No.1 circuit resistance should never exceed the specified value of 0.1 megohm. If higher values of grid-No.1 circuit resistance are desired, cathode bias must be employed. Under no circumstances should the dc grid-No.1 resistance exceed the specified value of 0.5 megohm.

♣ When the 7212 is operated as a beam power tube in class AB_1 service, only fixed bias should be used, and the dc grid-No.1 circuit resistance should never exceed the specified value of 0.1 megohm.

▲ Preferably obtained from a separate source or from the plate-voltage supply with a voltage divider.

Subscript 2 indicates that grid-No.1 current flows during some part of the input cycle.

♦ Driver stage should be capable of supplying the specified driving power at low distortion to the No.1 grids of the AB_2 stage. To minimize distortion, the effective resistance per grid-No.1 circuit of the AB_2 stage should be held at a low value. For this purpose, the use of transformer coupling is recommended. In no case, however, should the total dc grid-No.1-circuit resistance exceed 30000 ohms when the 7212 is operated at maximum ratings. For operation at less than maximum ratings, the dc grid-No.1-circuit resistance may be as high as 100000 ohms.

● Obtained preferably from a separate source modulated along with the plate supply or from the modulated plate supply through a series resistor.

★ Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

‡ When grid No.1 is driven positive and the 7212 is operated at maximum ratings, the total dc grid-No.1-circuit resistance should not exceed the specified value of 30000 ohms. If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply. For operation at less than maximum ratings, the dc grid-No.1-circuit resistance may be as high as 100000 ohms.

□ Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

⊕⊕ Obtained preferably from a separate source, or from the plate-supply voltage with a voltage divider, or through a series resistor. A series grid-No.2 resistor should be used only when the 7212 is used in a circuit which is not keyed. Grid-No.2 voltage must not exceed 400 volts under key-up conditions.

■ Obtained from fixed supply, by grid-No.1 resistor, by cathode resistor, or by combination methods.

SPECIAL RATINGS AND PERFORMANCE DATA

Shock Rating:

This test is performed (per MIL-E-1C*, Par.4.9.20.5) on a sample lot of tubes from each production run. Tubes are held rigid and are subjected in four different positions to an impact acceleration of 500 g.

At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet the following limits:

Useful RF Power Output . . . . . 42 min. watts
For conditions shown under *Characteristics Range Values, Note 4.*

Heater-Cathode
Leakage Current. .See *Characteristics Range Values*

The tubes must also meet the established limit for low-frequency vibration (see below).

Fatigue Rating:

This test is performed (per MIL-E-1C, par.4.9.20.6) on a sample lot of tubes from each production run. Tubes are rigidly mounted and subjected to 2.5 g vibrational acceleration at 25 cycles per second for 32 hours in each of three positions. At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet the following limits:

Useful RF Power Output . . . . . 42 min. watts
For conditions shown under *Characteristics Range Values, Note 4.*

Heater-Cathode
Leakage Current. .See *Characteristics Range Values*

The tubes must also meet the established limit for low-frequency vibration (see below).

Low-Frequency Vibration Performance:

This test is performed (per MIL-E-1C, par.4.9.19.1) on a sample lot of tubes from each production run under the following conditions: Heater voltage of 6.3 volts, plate supply voltage of 250 volts, grid-No.2 voltage of 200 volts, grid-No.1 voltage varied to give a plate current of 10 milliamperes, plate load resistor of 2000 ohms, and vibrating frequency of 25 cycles per second with a fixed amplitude of 0.040 inch (total excursion 0.080 inch). The rms output voltage across the plate load resistor as a result of vibration of the tube must not exceed 500 millivolts.

Variable-Frequency Vibration Performance (1):

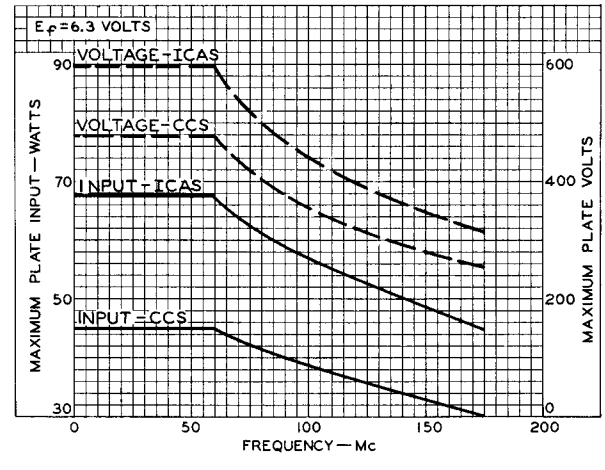
This test is performed (per MIL-E-1C, par.4.9.20.3) on a sample lot of tubes from each production run. Tubes are vibrated in each of 3 positions through frequency range of from 10 to 50 cycles per second and back to 10 cycles per second. The tubes are vibrated under the same conditions as specified for *Low-Frequency Vibration Performance.* During the test, the tubes will not show an rms output voltage across the plate load resistor in excess of 500 millivolts.

At the end of this test, the tubes will not show tap or permanent interelectrode shorts or defects that cause the tubes to be inoperable. The tubes will exhibit no pronounced mechanical resonance during this test.

Variable-Frequency Vibration Performance (2):

This test is performed on a sample lot of tubes from each production run. Tubes are vibrated in each of 3 positions, perpendicular and parallel to major axis of the tube, and parallel to longitudinal axis of the tube, through the frequency range from 50 to 120 cycles per second at a fixed acceleration of 10 g under the same voltage, current and load conditions as specified for *Low-Frequency Vibration Performance.*

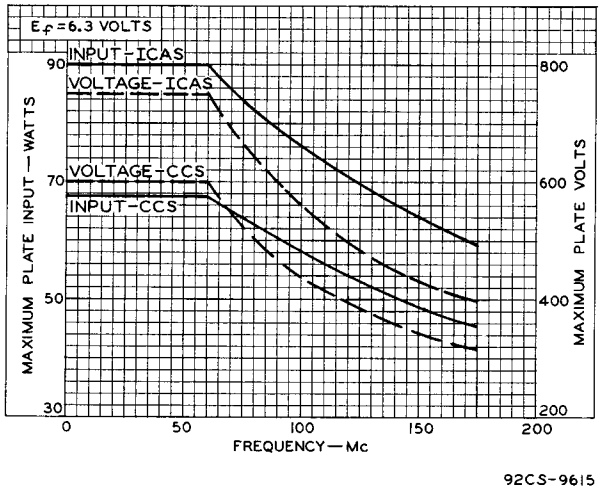
During this test, the tubes will not show an rms output voltage across the plate load resistor in excess of 500 millivolts. The tubes will exhibit no pronounced mechanical resonance below 120 cycles per second during this test.



92CS-9614

Rating Chart I for Type 7212 in Class C Telephony Service.

* 3 October 1955, Military Specification, Electron Tubes and Crystal Rectifiers.



Rating Chart II for Type 7212 in Class C Telegraphy Service.

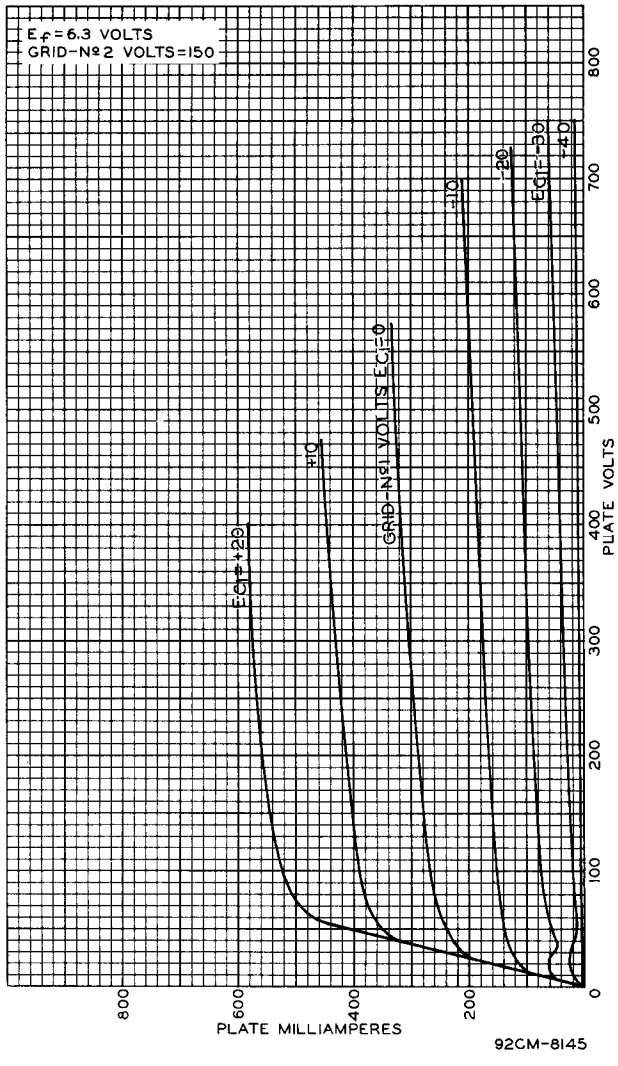


Fig. 1 - Average Plate Characteristics of Type 7212.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer choses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

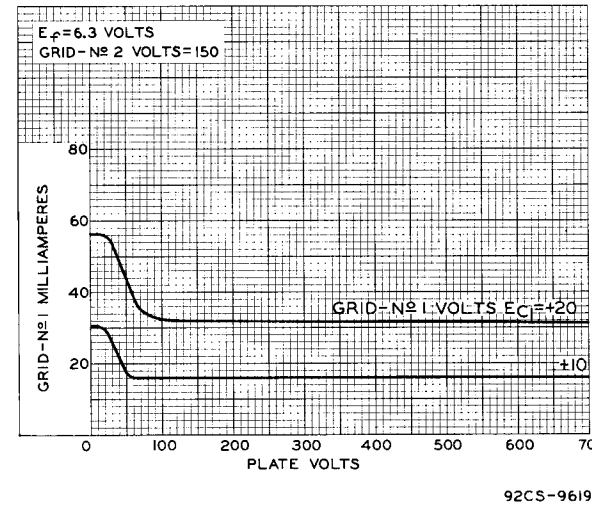


Fig. 2 - Average Characteristics of Type 7212.

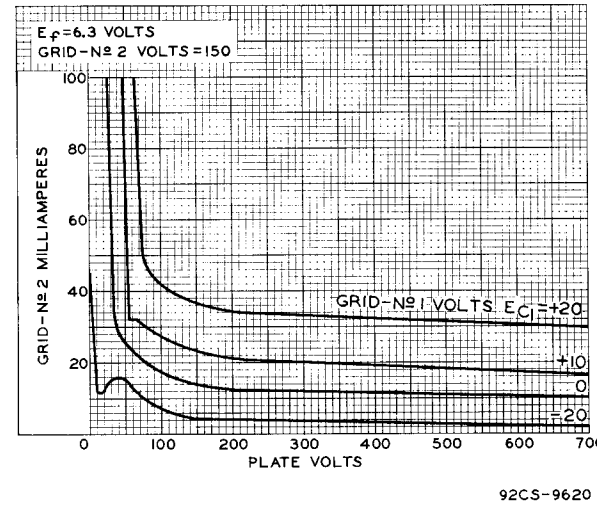


Fig. 3 - Average Characteristics of Type 7212.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The *rated plate voltage and grid-No. 2 voltage of this tube are high enough to be dangerous to the user.* Care should be taken during adjustment of circuits, especially when exposed circuit parts are at high dc potential.

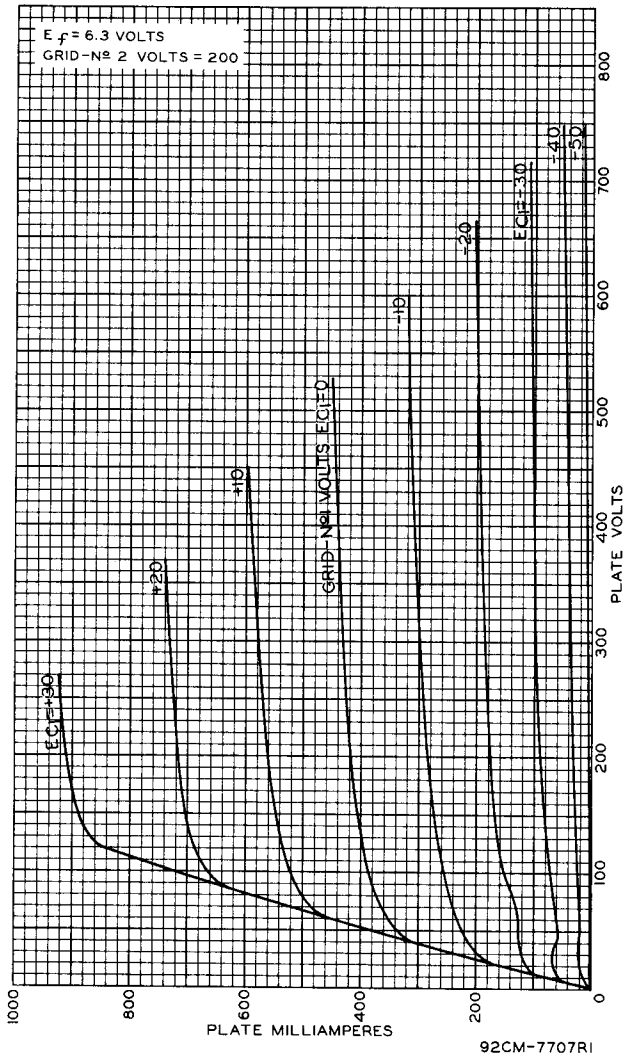


Fig. 4 - Average Plate Characteristics of Type 7212.

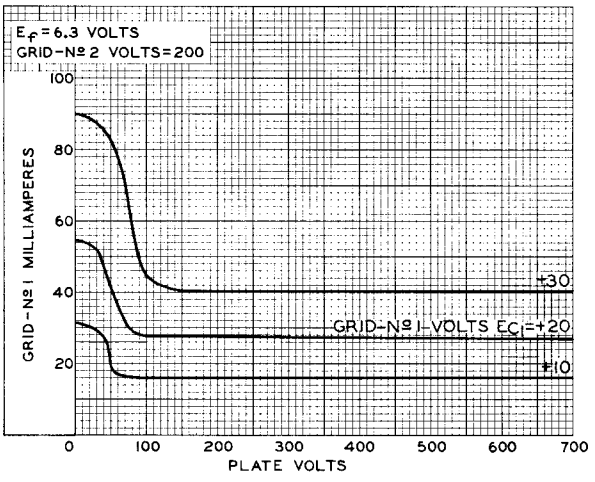


Fig. 5 - Average Characteristics of Type 7212.

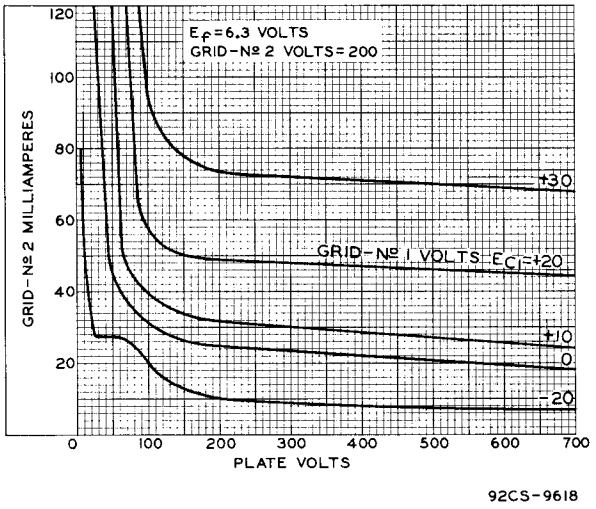


Fig. 6 - Average Characteristics of Type 7212.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

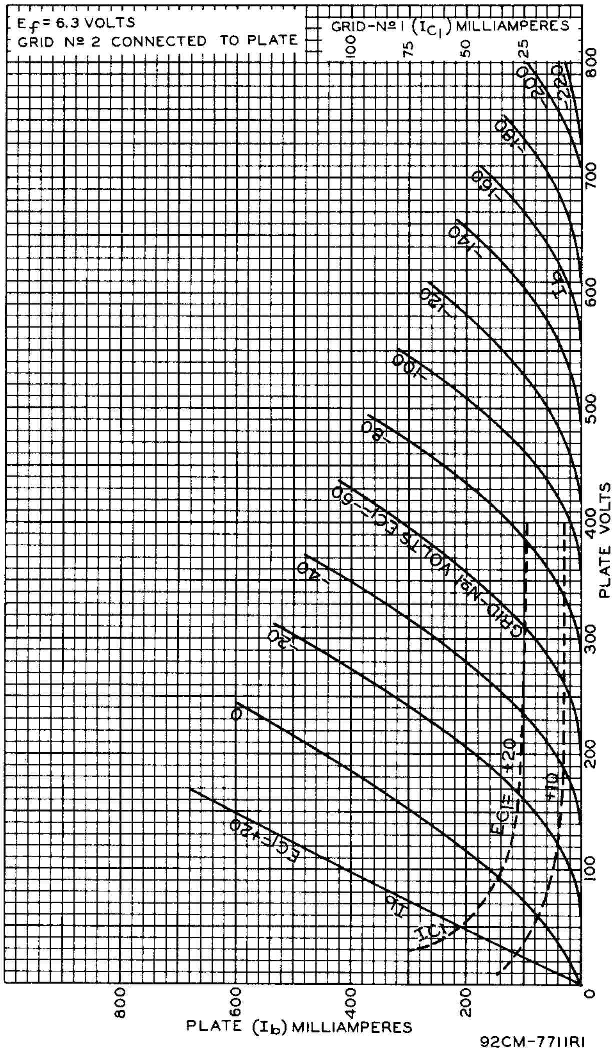
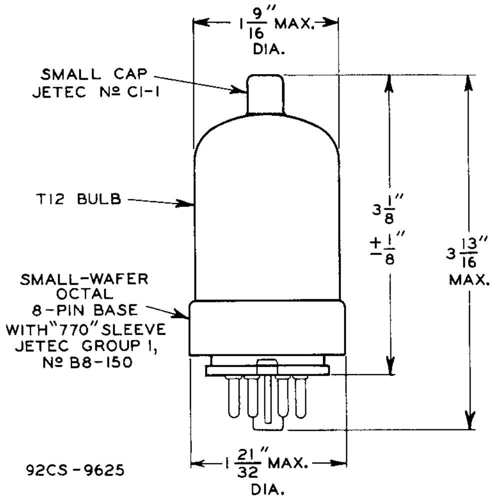


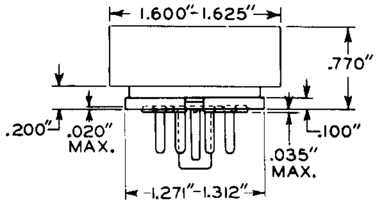
Fig. 7 - Average Characteristics of Type 7212 with Triode Connection.

DIMENSIONAL OUTLINE



BASE DRAWING

SMALL-WAFER OCTAL WITH "770" SLEEVE
JETEC GROUP 1, No. B8-150



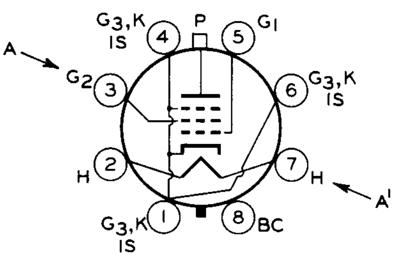
BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT ENTIRE LENGTH OF PINS WILL ENTER FLAT-PLATE GAUGE (JETEC No.GB8-1) HAVING THICKNESS OF 1/4" AND EIGHT HOLES WITH DIAMETERS OF 0.1030" ± 0.0005" SO LOCATED ON A 0.6870" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.2629" ± 0.0005".

PIN FIT IN GAUGE IS SUCH THAT GAUGE TOGETHER WITH SUPPLEMENTARY WEIGHT TOTALING 2 POUNDS WILL NOT BE LIFTED WHEN PINS ARE WITHDRAWN.

SOCKET CONNECTIONS

Bottom View

PIN 1: CATHODE, GRID No.3, INTERNAL SHIELD
PIN 2: HEATER
PIN 3: GRID No.2
PIN 4: SAME AS PIN 1



PIN 5: GRID No.1
PIN 6: SAME AS PIN 1
PIN 7: HEATER
PIN 8: BASE SLEEVE
CAP: PLATE

AA' = PLANE OF ELECTRODES

8EC

7213

BEAM POWER TUBE

Ceramic-Metal Seals
Matrix-Type Oxide-Coated Unipotential Cathode
Coaxial-Electrode Structure

Full Ratings Up To 1215 Mc
2500 Watts CW Input
Forced-Air Cooled
TENTATIVE DATA

3-1/4" Length
3-3/4" Diameter
Unitized-Electrode Design
Integral Radiator

RCA-7213 is a small, forced-air-cooled beam power tube designed for use as a linear rf power amplifier and as a class C rf power amplifier in airborne and fixed-station equipment. The 7213

can be used with full ratings at frequencies up through the Aeronautical Radio-Navigation Band of 960 to 1215 Mc. It has a maximum plate-dissipation rating of 1500 watts.

When used under CCS conditions as an rf power amplifier and oscillator in class C telegraphy service, the 7213 has a maximum plate-voltage rating of 2500 volts and a maximum plate-input rating of 2500 watts. Under these conditions in a grid-drive circuit, the 7213 is capable of delivering useful power output of 1350 watts with a power gain of 20 at 600 Mc.

As a linear rf power amplifier in class AB_1 single-sideband suppressed-carrier service, the 7213 is capable of providing a maximum-signal power output (CCS) of 1250 watts.

Featured in the design of the 7213 is a coaxial-electrode structure in which unitized-electrode design combines each electrode, its support, and its gold-plated external contact surface. This type of construction facilitates accurate assembly of the electrodes and provides low-inductance, high-conductivity paths to the electrodes themselves. The respective electrode contact surfaces are insulated from each other by low-loss ceramic bushings. Another structural feature of the 7213 is its unipotential cathode of the oxide-coated matrix type for stability and long life, and its associated sturdy heater.

The coaxial structure with its ring-type ceramic-metal seals having graduated diameters makes the 7213 particularly useful in either coaxial-cylinder cavity or parallel-line circuits. Its small size for its power capability facilitates the construction of compact equipment utilizing grid-drive or cathode-drive circuits.

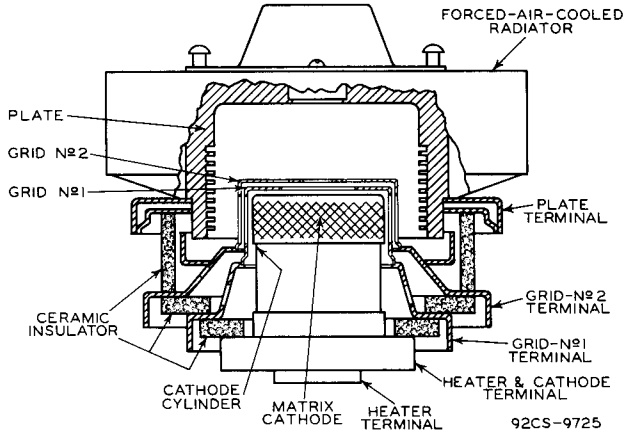


Fig. 1 - Structural Arrangement of Type 7213.

GENERAL DATA

Electrical:

Heater, for Matrix-Type Oxide-Coated Unipotential Cathode:		
Voltage (AC or DC)♦	5.5 typical 6.0 max.	volts volts
Current at 5.5 volts.	17.5	amp
Minimum heating time at 5.5 volts	5	minutes

Trademark(s) ® Registered
Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7213 8-58
Printed in U.S.A.

Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 2500, grid-No.2 volts = 600, and plate ma = 600 .	17	
Direct Interelectrode Capacitances:		
Grid No.1 to plate*	0.17 max.	μμf
Grid No.1 to cathode.	42	μμf
Plate to cathode & heater*,** . .	0.014 max.	μμf
Grid No.1 to grid No.2.	55	μμf
Grid No.2 to plate.	16	μμf
Grid No.2 to cathode & heater** .	1.4 max.	μμf

Mechanical:

Operating Position.	Any
Overall Length.	3.24" ± 0.10"
Greatest Diameter (See *Dimensional Outline*) .	3.70" ± 0.05"
Terminal Connections.	See *Dimensional Outline*
Radiator.	Integral part of tube

Air Flow:

Through radiator--Adequate air flow to limit the plate-seal temperature to 250° C should be delivered by a blower through the radiator before and during the application of heater, plate, grid-No.2, and grid-No.1 voltages. Typical values of air flow directed through the radiator versus percentage of maximum rated plate dissipation for each class of service are shown in Fig.2. Plate power, grid-No.2 power, heater power, and air flow may be removed simultaneously.

To Grid-No.2, Grid-No.1, Cathode, and Heater Seals--A sufficient quantity of air should be directed at the heater terminal and allowed to flow past each of these seals so that its temperature does not exceed the specified maximum value of 250° C. An air flow of 10 cfm is usually adequate.

Seal Temperature (Plate, Grid No.2, Grid No.1, Cathode, and Heater) . .	250 max.	°C
Weight (Approx.).	2	lbs

LINEAR RF POWER AMPLIFIER
Single-Sideband Suppressed-Carrier Service

Maximum CCS● Ratings, *Absolute Values:*

	Up to 1215 Mc	
DC PLATE VOLTAGE	2500 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE. . .	1000 max.	volts
MAX.-SIGNAL DC PLATE CURRENT . . .	1.0 max.	amp
MAX.-SIGNAL DC GRID-No.1 (CONTROL-GRID) CURRENT	0.2 max.	amp
MAX.-SIGNAL PLATE INPUT.	2500 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT. . . .	50 max.	watts
PLATE DISSIPATION.	1500 max.	watts

Typical CCS Class AB$_1$ "Single-Tone" Operation:●●

	Up to 60 Mc		
DC Plate Voltage	2250	2500	volts
DC Grid-No.2 Voltage▲.	700	700	volts
DC Grid-No.1 Voltage	-50	-50	volts
Zero-Signal DC Plate Current . . .	0.2	0.2	amp
Zero-Signal DC Grid-No.2 Current .	0	0	amp
Effective RF Load Resistance . . .	1100	1100	ohms
Max.-Signal DC Plate Current . . .	0.9	1.0	amp
Max.-Signal DC Grid-No.2 Current .	0.45	0.45	amp
Max.-Signal DC Grid-No.1 Current .	0	0	amp
Max.-Signal Peak RF Grid-No.1 Voltage.	50	50	volts
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	1000	1250	watts

PLATE-MODULATED RF POWER AMP.--Class C Telephony

Carrier conditions per tube for use with max. modulation factor of 1.0

Maximum CCS● Ratings, *Absolute Values:*

	Up to 1215 Mc	
DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE. . .	1000 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE.	-300 max.	volts
DC PLATE CURRENT	0.85 max.	amp
DC GRID-No.1 CURRENT	0.2 max.	amp
PLATE INPUT.	1700 max.	watts
GRID-No.2 INPUT.	35 max.	watts
PLATE DISSIPATION.	1000 max.	watts

Typical CCS Operation in Grid-Drive Circuit at 600 Mc:

DC Plate Voltage	1800	2000	volts
DC Grid-No.2 Voltage●●	500	500	volts
DC Grid-No.1 Voltage★	-30	-30	volts
DC Plate Current	0.75	0.83	amp
DC Grid-No.2 Current	0.015	0.015	amp
DC Grid-No.1 Current (Approx.) . .	0.04	0.04	amp
Driver Power Output (Approx.)■ . .	50	55	watts
Useful Power Output (Approx.). . .	650†	800†	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance: Under any condition.	5000‡ max.	ohms

RF POWER AMPLIFIER & OSC.--Class C Telegraphy□
and
RF POWER AMPLIFIER--Class C FM Telephony

Maximum CCS● Ratings, *Absolute Values:*

	Up to 1215 Mc	
DC PLATE VOLTAGE	2500 max.	volts
DC GRID-No.2 (SCREEN) VOLTAGE. . .	1000 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE.	-300 max.	volts
DC PLATE CURRENT	1.0 max.	amp
DC GRID-No.1 CURRENT	0.2 max.	amp
PLATE INPUT.	2500 max.	watts
GRID-No.2 INPUT.	50 max.	watts
PLATE DISSIPATION.	1500 max.	watts

Typical CCS Operation in Grid-Drive Circuit at 600 Mc:

DC Plate Voltage	2250	2500	volts
DC Grid-No.2 Voltage⊕.	500	500	volts
DC Grid-No.1 Voltage⊕⊕	-30	-30	volts
DC Plate Current	0.9	1.0	amp
DC Grid-No.2 Current	0.02	0.02	amp
DC Grid-No.1 Current (Approx.) . .	0.07	0.07	amp
Driver Power Output (Approx.)■ . .	70	75	watts
Useful Power Output (Approx.). . .	1050†	1350†	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance: Under any condition.	5000‡ max.	ohms

SPECIAL PERFORMANCE DATA

Design samples of the 7213 have been subjected to the following tests without adverse effects.

Variable-Frequency Vibration Performance:

This test was performed (per MIL-E-1C°, par.4.9.20.3) under the following conditions: Heater voltage of 5.5 volts, plate supply voltage of 450 volts, grid-No.2 voltage of 300 volts, grid-No.1 voltage varied to give a plate current of 10 milliamperes, and plate load resistor of 2000 ohms. The tubes were vibrated in each of 3 positions through frequency range from 10 to 50 to 10 cycles per second. The vibrating frequency had a fixed amplitude of 0.040 inch (total excursion of 0.080 inch). During the test, the tubes did not show an rms output voltage across the plate load resistor in excess of 250 millivolts.

At the end of this test, the tubes did not show tap or permanent interelectrode shorts or defects that would cause the tubes to be inoperable. The tubes exhibited no pronounced mechanical resonance during this test.

° Military Specification, Electron Tubes and Crystal Rectifiers, 3 October 1955.

Fatigue Performance:

In this test (per MIL-E-1C, par.4.9.20.6), the tubes were rigidly mounted and subjected to 2.5g vibrational acceleration at 25 cycles per second for 32 hours in each of three positions with 5.5 volts applied to the heater. At the end of this test, the tubes did not show permanent or temporary shorts or open circuits, and passed all electrical tests.

🌡 Because the cathode is subjected to considerable back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should be reduced depending on operating conditions and frequency to prevent overheating the cathode and resultant short life.

* With external flat metal shield having diameter of 8", and center hole approximately 3" in diameter provided with spring fingers that connect the shield to grid-No.2 terminal. Shield is located in plane of grid-No.2 terminal perpendicular to the tube axis.

** With external flat metal shield having diameter of 8", and center hole approximately 2-3/8" in diameter provided with spring fingers that connect the shield to grid-No.1 terminal. Shield is located in plane of grid-No.1 terminal perpendicular to the tube axis.

● Continuous Commercial Service.

●● "Single-Tone" operation refers to that class of amplifier service in which the grid-No.1 input consists of a monofrequency rf signal having constant amplitude. This signal is produced in a single-sideband suppressed-carrier system when a single audio frequency of constant amplitude is applied to the input of the system.

▲ Preferably obtained from a fixed supply.

●● Obtained preferably from a separate source modulated along with the plate supply.

★ Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

■ The driver stage is required to supply tube losses and rf circuit losses. It should be designed to provide an excess of power above the indicated value to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

† This value of useful power is measured in load of out-out circuit.

‡ If this value is insufficient to provide adequate bias, the additional required bias must be supplied by a cathode resistor or fixed supply.

□ Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

⊕ Obtained preferably from a fixed supply, or from the plate-supply voltage with a voltage divider.

⊕⊕ Obtained from fixed supply, by grid-No.1 resistor, by cathode resistor, or by combination methods.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage

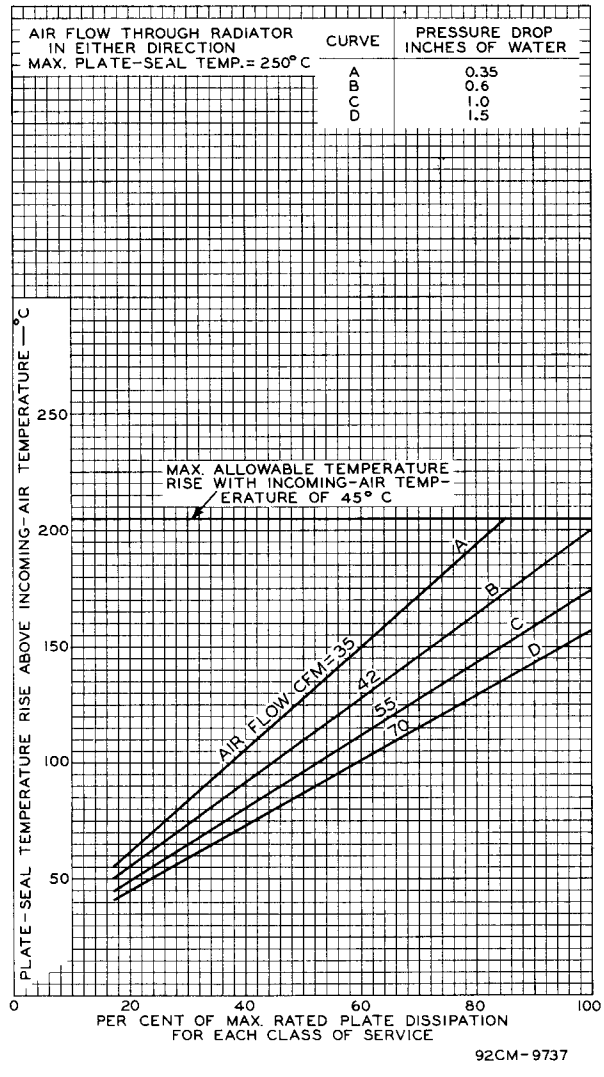


Fig. 2 - Typical Cooling Requirements for Type 7213.

variation, equipment-component variation, equipment-control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The *maximum seal temperature* of 250° C is a tube rating and is to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, New York in the form of liquid and stick.

The rated plate and grid-No.2 voltages of this tube are extremely dangerous to the user.

Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

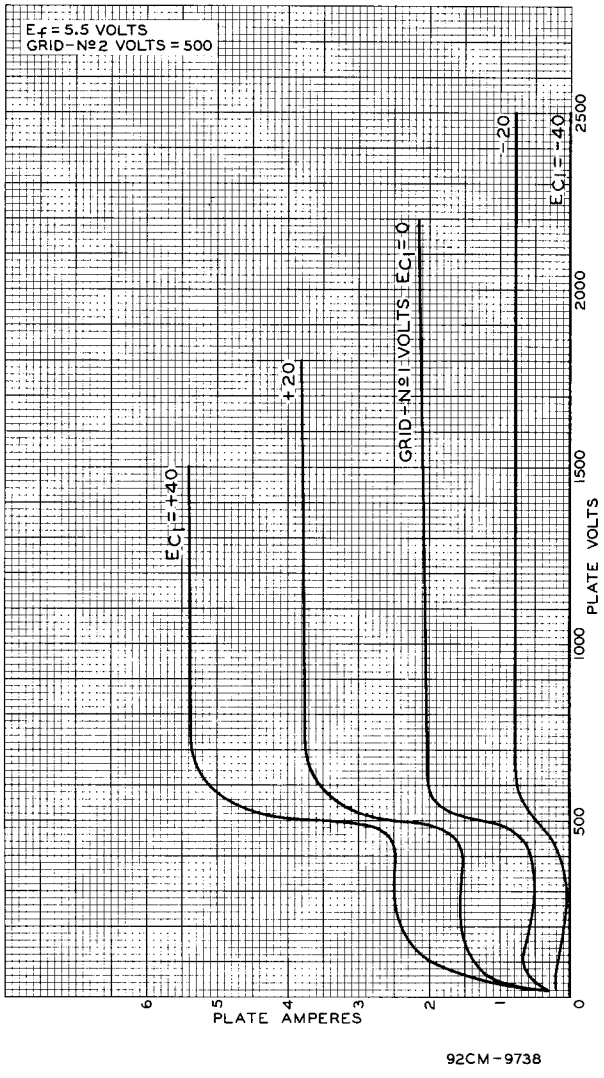


Fig. 3 - Typical Plate Characteristics of Type 7213.

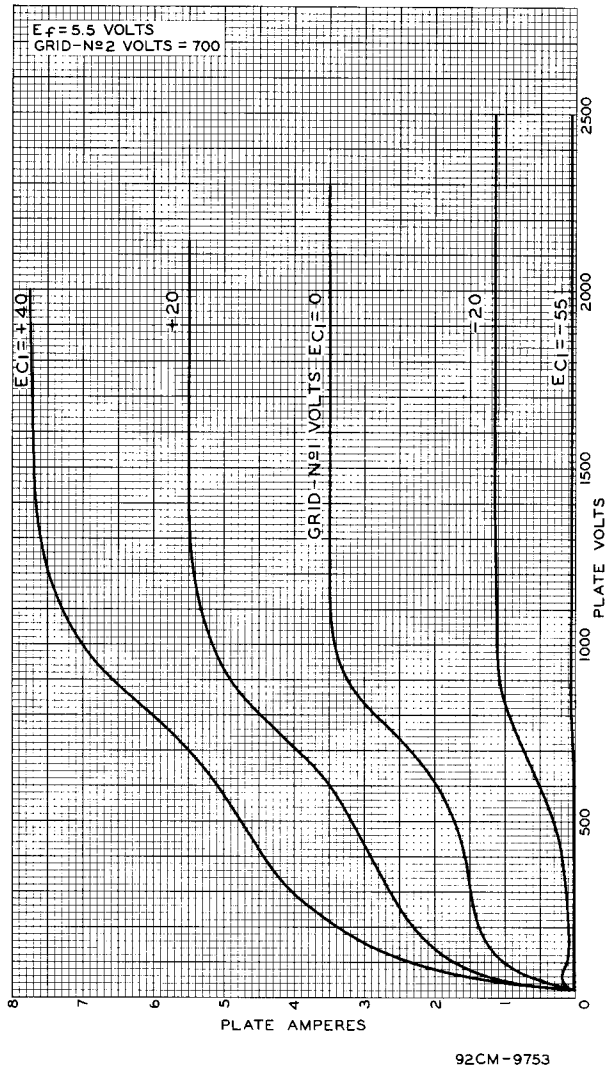


Fig. 4 - Typical Plate Characteristics of Type 7213.

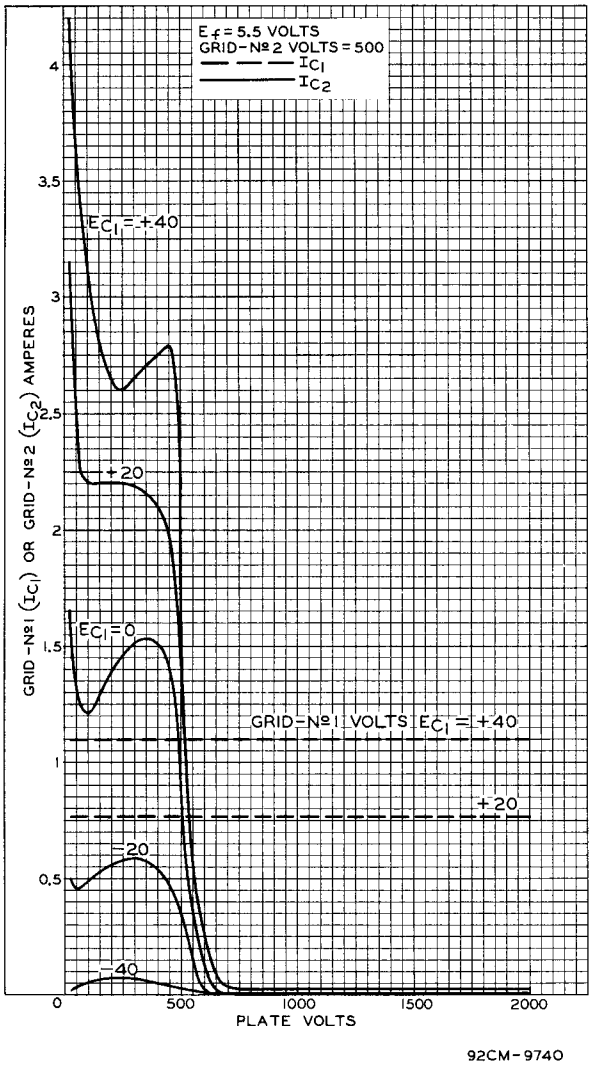


Fig. 5 - Typical Characteristics of Type 7213.

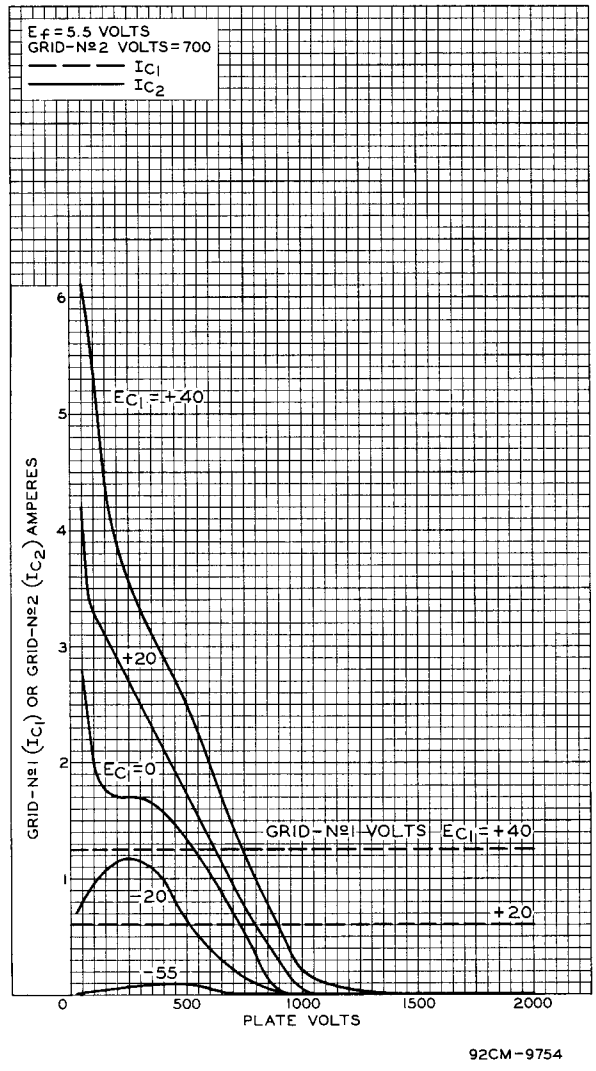


Fig. 6 - Typical Characteristics of Type 7213.

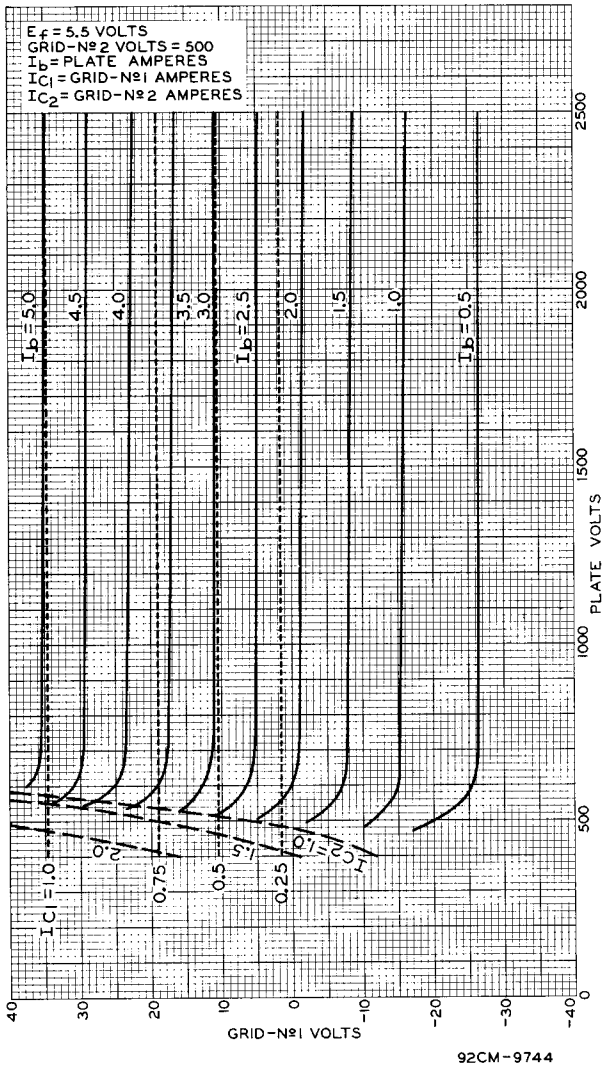


Fig. 7 - Typical Constant-Current Characteristics of Type 7213.

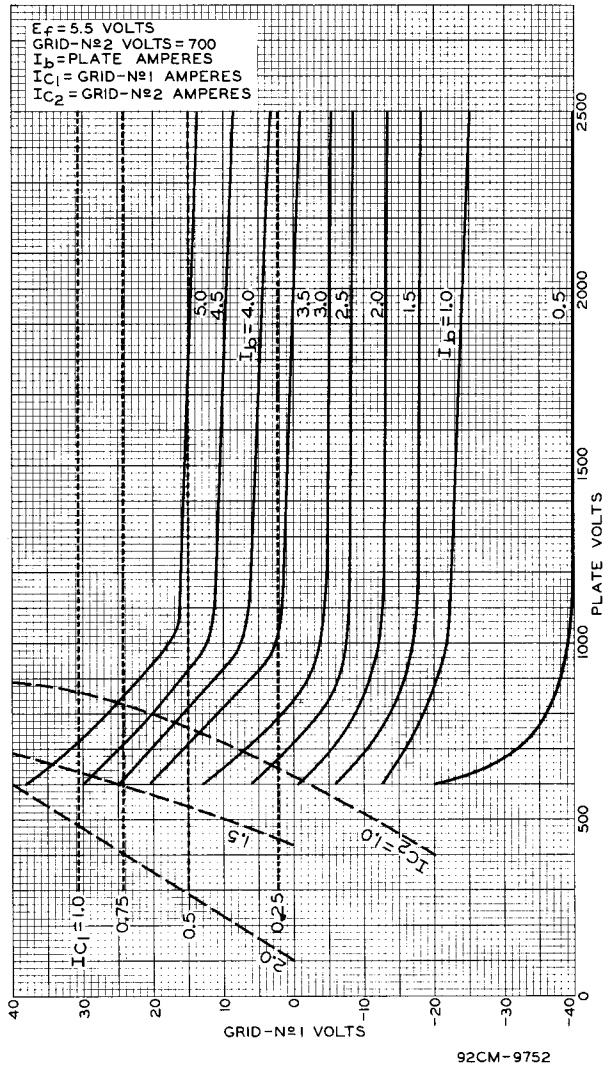


Fig. 8 - Typical Constant-Current Characteristics of Type 7213.

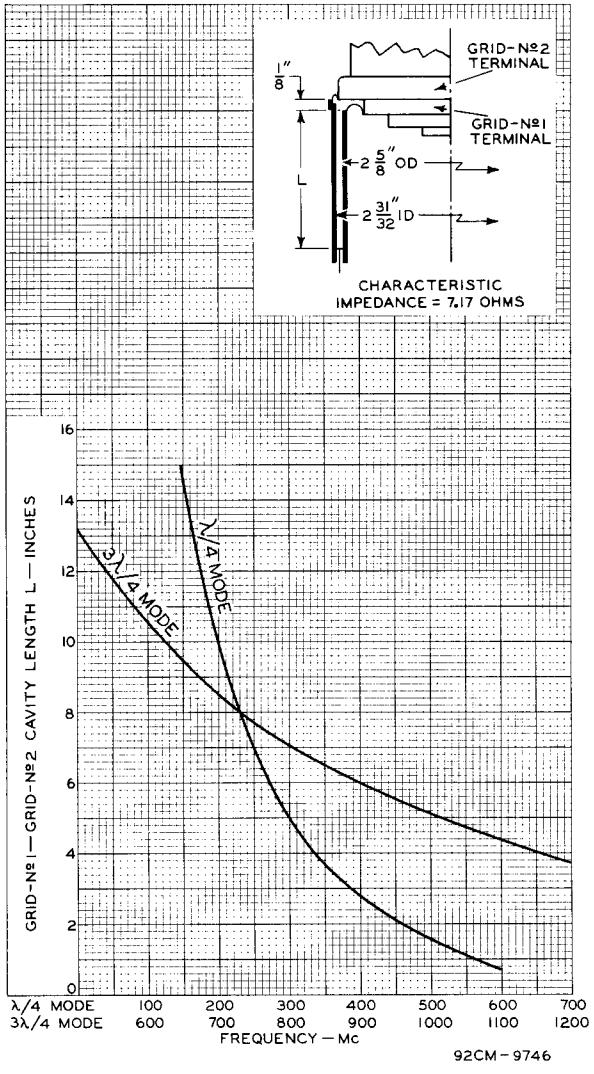


Fig. 9 - Grid No. 1--Grid No. 2 Tuning Curves.

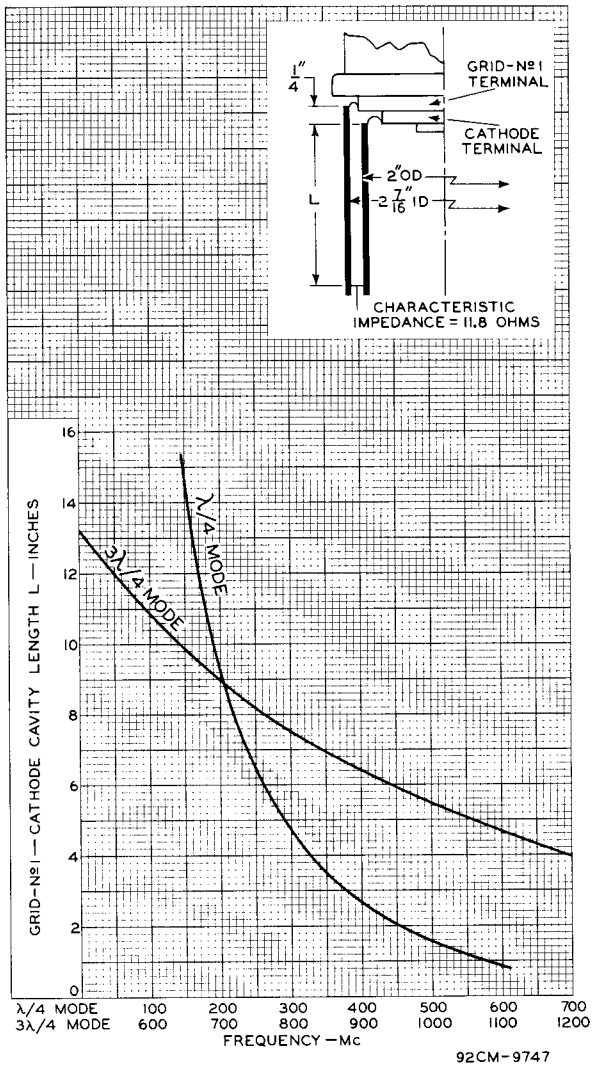


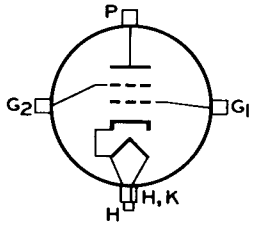
Fig. 10 - Grid No. 1--Cathode Tuning Curves.

TERMINAL CONNECTIONS

G_1 = Grid-No.1 Terminal Contact Surface (Adjacent to Cathode & Heater Terminal Contact Surface)

G_2 = Grid-No.2 Terminal Contact Surface (Adjacent to Grid-No.1 Terminal Contact Surface)

H = Heater Terminal Contact Surface (Cup at end opposite Air-Cooled Radiator)



H,K = Cathode & Heater Terminal Contact Surface (Adjacent to Heater Terminal Contact Surface)

P = Plate Terminal Contact Surface (Adjacent to Air-Cooled Radiator)

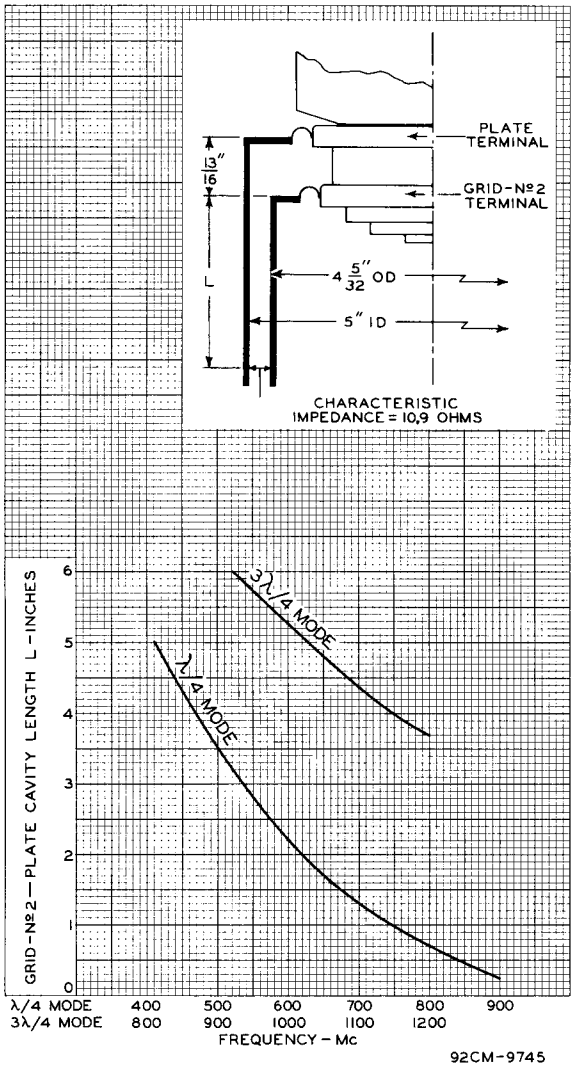
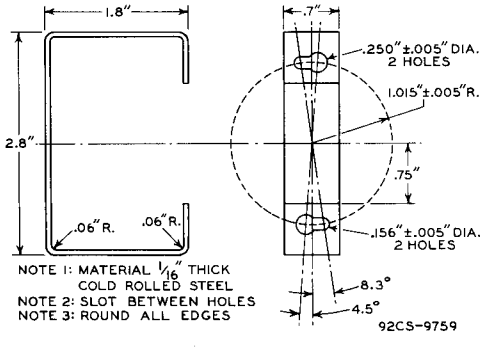
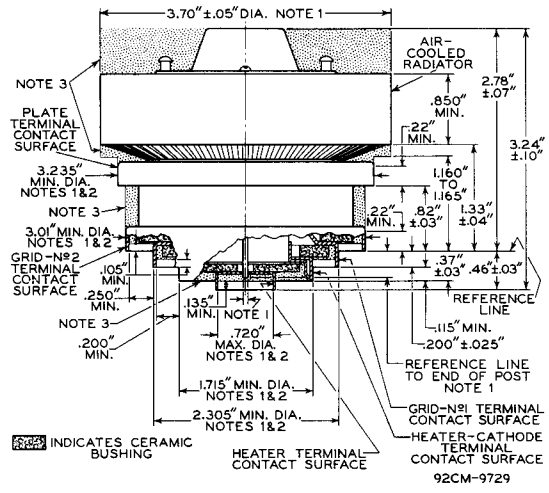


Fig. 11 - Grid No. 2--Plate Tuning Curves.

SUGGESTED DESIGN OF HANDLE FOR EXTRACTING 7213 FROM CAVITY



DIMENSIONAL OUTLINE

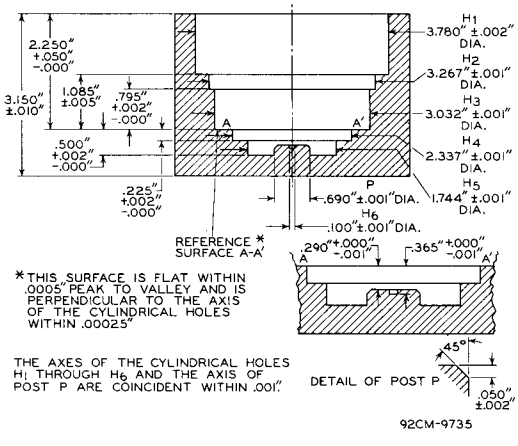


NOTE 1: WITH THE CYLINDRICAL SURFACES OF THE RADIATOR BAND, PLATE TERMINAL, GRID-No.2 TERMINAL, GRID-No.1 TERMINAL, HEATER-CATHODE TERMINAL, AND HEATER TERMINAL CLEAN, SMOOTH, AND FREE OF BURRS, THE TUBE WILL ENTER A GAUGE AS SHOWN IN SKETCH G_1. PROPER ENTRY OF THE TUBE IS OBTAINED WHEN THE GRID-No.2 TERMINAL IS SEATED ON THE SHOULDER A - A'. THE TUBE IS PROPERLY SEATED ON THE SHOULDER WHEN A 0.010" THICKNESS GAUGE 1/8" WIDE WILL NOT ENTER MORE THAN 1/16" BETWEEN THE SHOULDER SURFACE AND THE GRID-No.2 TERMINAL. THE GAUGE IS PROVIDED WITH SLOTS TO PERMIT MAKING MEASUREMENT OF SEATING OF GRID-No.2 TERMINAL ON SHOULDER A - A'.

NOTE 2: THE DIAMETER OE EACH TERMINAL IS HELD TO INDICATED VALUES ONLY OVER THE INDICATED MINIMUM LENGTH OF ITS CONTACT SURFACE.

NOTE 3: KEEP ALL STIPPLED REGIONS CLEAR. DO NOT ALLOW CONTACTS OR CIRCUIT COMPONENTS TO PROTRUDE INTO THESE ANNULAR VOLUMES.

GAUGE SKETCH G_1



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7262

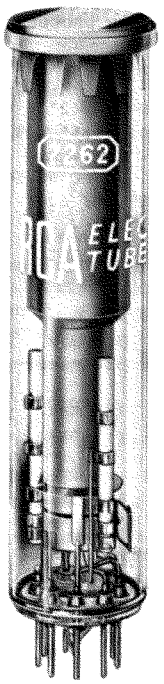
VIDICON

Magnetic Focus
Magnetic Deflection

For Use in Small, Compact Transistorized TV Cameras
Low-Power (0.6-Watt) Heater
600-Line Resolution
TENTATIVE DATA

1"-Diameter Bulb
5.12" Length

RCA-7262 is a small, sturdy camera tube intended primarily for use in small, compact, transistorized television cameras. The use of this type in such cameras--black-and-white or color--is facilitated by its low-power heater which requires only 0.6 watt and its short overall length of only 5-1/8".



In either live or film pick-up service, the 7262 can provide a picture of high quality for broadcasting or industrial television applications. Its resolution capability is about 600 television lines.

The 7262 utilizes a unique photoconductive surface having uniform thickness which permits constant voltage gradient and uniform dark current across the scanned area. Because of the uniform thickness of its photoconductive surface, the 7262 can produce substantially uniform sensitivity over the entire scanned area. Therefore, the 7262 exhibits a degree of uniformity of characteristics from tube to tube that makes it possible to obtain excellent color uniformity and balance when used in three-vidicon color cameras. While dark current and sensitivity both increase with target voltage, the uniformity of the dark current makes it possible to operate the 7262 at relatively high values of target voltage and dark current. As a result, high effective sensitivity can be obtained with the 7262.

The design of the 7262 utilizes nonmagnetic materials in the front end, an extremely flat faceplate free from optical distortion, and an envelope without a side tip.

Full advantage of the uniformity of the photoconductive layer in the 7262 is realized only when the associated deflecting and focusing components do not introduce scanning-beam landing errors. These errors, if introduced by deflecting and focusing components, can be corrected by applying a modulating voltage of suitable waveform to the cathode, grid No.1, and grid No.2.

PRINCIPLES OF OPERATION

The structural arrangement of the 7262, shown in Fig.1, consists of a target composed of a transparent conducting film (the signal electrode) on the inner surface of the faceplate and a thin photoconductive layer deposited on the film; a fine mesh screen (grid No.4) located adjacent to the photoconductive layer; a beam-focusing electrode (grid No.3) connected to grid No.4; and an electron gun for producing a beam of electrons.

Each element of the photoconductive layer is an insulator in the dark but becomes slightly conductive when it is illuminated and acts like a leaky capacitor having one plate at the positive potential of the signal electrode and the other floating. When light from the scene or film being televised is focused on the photoconductive-layer surface next to the faceplate, each illuminated layer element conducts slightly depending on the amount of illumination on the element and thus causes the potential of its opposite surface (on the gun side) to rise in less than the time of one frame toward that of the signal-electrode potential. Hence, there appears on the gun side of the entire layer surface a positive potential pattern, composed of the various element potentials, corresponding to the pattern of light imaged on the layer.

The gun side of the photoconductive layer is scanned by a low-velocity electron beam produced by the electron gun. This gun contains a thermionic cathode, a control grid (grid No.1), and an accelerating grid (grid No.2). The beam is focused at the surface of the photoconductive layer by the combined action of the uniform magnetic field of an external coil and the

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

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electrostatic field of grid No.3. Grid No.4 serves to provide a uniform decelerating field between itself and the photoconductive layer so that the electron beam will tend to approach the layer in a direction perpendicular to it--a condition necessary for driving the surface to cathode potential. The beam electrons approach the layer at low velocity because of the low operating potential of the signal electrode.

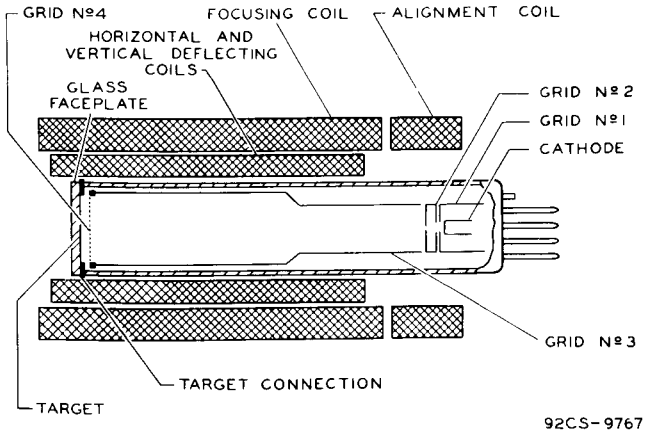


Fig. 1 - Schematic Arrangement of Type 7262.

When the gun side of the photoconductive layer with its positive potential pattern is scanned by the electron beam, electrons are deposited from the beam until the surface potential is reduced to that of the cathode, and thereafter are turned back to form a return beam which is not utilized. Deposition of electrons on the scanned surface of any particular element of the layer causes a change in the difference of potential between the two surfaces of the element. When the two surfaces of the element, which in effect is a charged capacitor, are connected through the external target (signal-electrode) circuit and the scanning beam, a capacitive current is produced and constitutes the video signal. The magnitude of the current is proportional to the surface potential of the element being scanned and to the rate of scan. The video-signal current is then used to develop a signal-output voltage across a load resistor. The signal polarity is such that for highlights in the image, the grid of the first video-amplifier tube swings in a negative direction.

Alignment of the beam is accomplished by a transverse magnetic field produced by external coils located at the base end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.095	amp
Direct Interelectrode Capacitance:		
Target to all other electrodes	4.6	μμf
Spectral Response	See curves in Fig.12	
Photoconductive Layer:		
Maximum useful diagonal of rectangular image (4 x 3 aspect ratio)	0.62	inch
Orientation of quality rectangle--Proper orientation is obtained when the horizontal scan is essentially parallel to the straight sides of the masked portions of the faceplate. The straight sides are parallel to the plane passing through the tube axis and short index pin. The masking is for orientation only and does not define the proper scanned area of the photoconductive layer.		
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	5.12" ± 0.06"	
Greatest Diameter	1.125" ± 0.010"	
Bulb	T8	
Base	Small-Button Ditetrar 8-Pin (JETEC No.E8-11)	
Socket	Cinch No.54A18088[♣], or equivalent	
Operating Position	Any	
Weight (Approx.)	2 oz	

Maximum Ratings, *Absolute Values:*

For scanned area of 1/2" x 3/8"

GRID-No.3 & GRID-No.4 VOLTAGE	350 max.	volts
GRID-No.2 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
DARK CURRENT	0.25 max.	μa
PEAK TARGET CURRENT	0.55 max.	μa
FACEPLATE:		
Illumination	1000 max.	ft-c
Temperature	60 max.	°C

Typical Operation:

For scanned area of 1/2" x 3/8"
Faceplate temperature of 30° to 35° C

Grid-No.4 (Decelerator) & Grid-No.3 (Beam-Focus Electrode*) Voltage	250[□] to 300	volts
Grid-No.2 (Accelerator) Voltage	300	volts
Grid-No.1 Voltage for Picture Cutoff	-45 to -100	volts
Average "Gamma" of Transfer Characteristic for signal-output current between 0.02 μa and 0.2 μa.	0.65	
Visual Equivalent Signal-to-Noise Ratio (Approx.)[★]	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No.1	75	volts
When applied to cathode	20	volts
Field Strength at Center of Focusing Coil (Approx.)	40	gausses
Field Strength of Adjustable Alignment Coil[⊕]	0 to 4	gausses

[♣] Made by Cinch Manufacturing Corporation, 1026 S. Homan Ave., Chicago 24, Illinois.

Maximum-Sensitivity Operation for Live-Scene Pickup

Faceplate Illumination (Highlight)	2	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.2 μa in Any Tube**	110	volts
Target Voltage†	60 to 100	volts
Dark Current▲	0.2	μa
Target Current (Highlight)■	0.4 to 0.5	μa
Signal-Output Current:#		
Peak	0.2 to 0.3	μa
Average	0.08 to 0.1	μa

Average-Sensitivity Operation for Live-Scene Pickup

Faceplate Illumination (Highlight)	15	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.02 μa in Any Tube**	60	volts
Target Voltage†	30 to 50	volts
Dark Current	0.02	μa
Target Current (Highlight)■	0.3 to 0.4	μa
Signal-Output Current:#		
Peak	0.3 to 0.4	μa
Average	0.1 to 0.2	μa

Minimum-Lag Operation for Film Pickup

Faceplate Illumination (Highlight)	100	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.004 μa in Any Tube**	30	volts
Target Voltage†	15 to 25	volts
Dark Current	0.004	μa
Target Current (Highlight)■	0.3 to 0.4	μa
Signal-Output Current:#		
Peak	0.3 to 0.4	μa
Average	0.1 to 0.2	μa

♦ This capacitance, which effectively is the output impedance of the 7262, is increased when the tube is mounted in the deflecting-yoke and focusing-coil assembly. The resistive component of the output impedance is in the order of 100 megohms.

* Beam focus is obtained by combined effect of grid-No.3 voltage which should be adjustable over indicated range, and a focusing coil having an average field strength of 40 gausses.

□ Definition, focus uniformity, and picture quality decrease with decreasing grid-No.4 and grid-No.3 voltage. In general, grid No.4 and grid No.3 should be operated above 250 volts.

● With no blanking voltage on grid No.1.

★ Measured with high-gain, low-noise, cascode-input-type amplifier having bandwidth of 5 Mc. Because the noise in such a system is predominately of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of the highlight video-signal current to rms noise current, multiplied by a factor of 3.

⊕ The alignment coil should be located on the tube so that its center is at a distance of 3-11/16 inches from the face of the tube, and be positioned so that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil.

† Indicated range for each type of service serves only to illustrate the operating target-voltage range normally encountered.

** The target voltage for each 7262 must be adjusted to that value which gives the desired operating dark current.

▲ The deflecting circuits must provide extremely linear scanning for good black-level reproduction. Dark-current signal is proportional to the scanning velocity. Any change in scanning velocity produces a black-level error in direct proportion to the change in scanning velocity.

■ Video amplifiers must be designed properly to handle target currents of this magnitude to avoid amplifier overload or picture distortion.

Defined as the component of the target current after the dark-current component has been substracted.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The *target connection* is made by a suitable spring contact bearing against the edge of the metal ring at the face end of the tube. This spring contact may conveniently be provided as part of the focusing-coil design.

Support for the 7262 is provided by a suitable spring-finger suspension at the face end of the tube and by a clamping mechanism near the base end. Orientation of the 7262 in its support should be such that the horizontal scan is essentially parallel to the straight sides of the masked portions of the faceplate. The straight sides are parallel to the plane passing through the tube axis and short index pin.

The *optical system* associated with the 7262 should be of high quality and provide depth of focus sufficient to focus a sharp image on the photoconductive layer.

The *deflecting yoke and focusing coil* should be designed so that no beam landing errors are produced in the 7262. Properly designed yokes and focusing coils will cause the beam to land perpendicularly to the target at all points of the scanned area with resultant superior uniformity of sensitivity and focus over the scanned area.

The yoke should be positioned so that the end of the deflecting coils toward the base of the tube will not extend more than 3-1/2 inches from the faceplate.

The *scanning speed* must be constant in order to obtain good black-level reproduction when the

7262 is operated at high dark current with resultant higher effective sensitivity. The dark-current signal is proportional to the scanning speed. Therefore, any change in scanning speed will produce a nonuniformity in black level in direct proportion to the change in scanning speed.

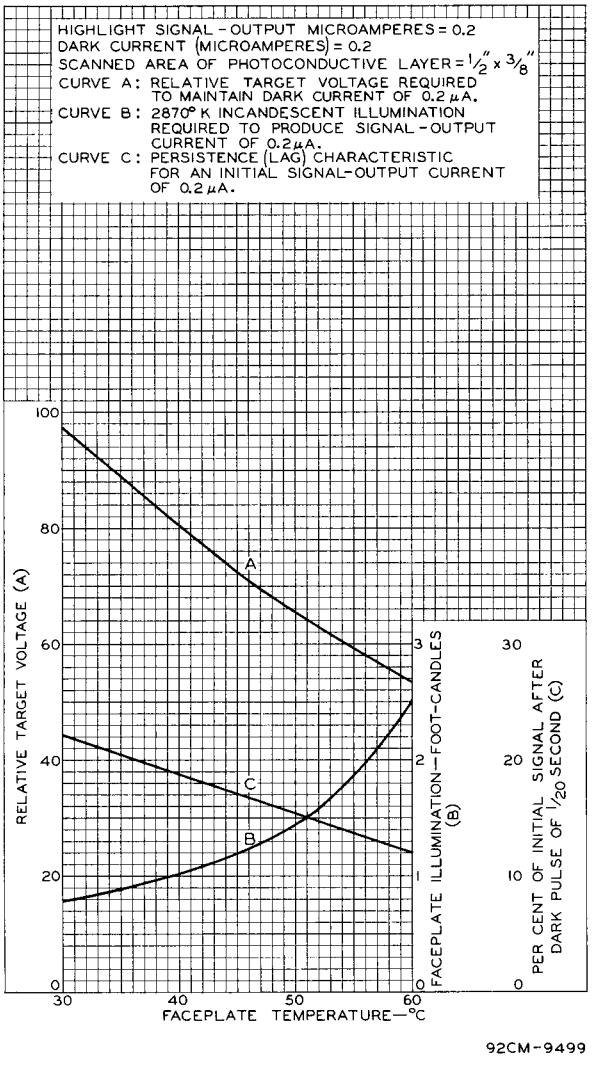


Fig. 2 - Typical Characteristics of Type 7262.

The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

The *alignment coil* should be located on the tube so that its center is at a distance of 3-11/16 inches from the face of the tube, and be positioned so that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil.

Electrostatic shielding of the target from external fields is required to prevent interference effects in the picture. Effective shielding from the fields produced by the deflecting components is ordinarily provided by grounding a shield on the inside of the faceplate end of the focusing coil and by grounding a shield on the inside of the deflecting yoke at a point near the input of the video amplifier.

The *temperature of the faceplate* should not exceed 60° C (140° F), either during operation or storage of the 7262. Operation with a faceplate temperature in the range from about 25° to 35° C (77° to 99° F) is recommended. The temperature of the faceplate is determined by the combined heating effects of the incident illumination on the faceplate, the associated components, and the tube itself. To reduce these heating effects in film-pickup cameras and permit operation in the preferred temperature range with a high value of illumination, the use of an infrared filter between the projector and faceplate as well as a blast of cooling air directed across the faceplate from a blower is recommended.

The dark current is doubled for every 10° C rise in the temperature of the faceplate, and halved for every 10° C decrease in the temperature of the faceplate. To obtain optimum performance, it is desirable to operate the 7262 at a preestablished value of dark current. Therefore, if the temperature of the faceplate is allowed to vary it will be necessary to adjust the target voltage to maintain the desired dark current, as shown in Fig.2. Since the sensitivity of the tube decreases with increasing temperature, the amount of faceplate illumination necessary to produce a given signal as a function of faceplate temperature is also shown in Fig.2. In addition, the lag will decrease with increasing temperature as shown in Fig.2. For live pickup, it is desirable to select an operating temperature which provides the best balance between lag and sensitivity. The faceplate should be held close to this temperature to assure stability of black level and signal-output level.

The *target voltage* should be obtained from an adjustable dc source. As the target voltage is increased, the dark current increases as shown in Fig.3. The target voltage must be adjusted to produce the desired value of dark current depending on the type of operation. The target-voltage range of the 7262 for a given value of dark current is small, as shown in Fig.3. This feature permits utilization of simplified circuits in cameras where automatic change in target voltage is desired to compensate for varying light levels. *It should be noted that individual 7262's will have substantially identical performance characteristics when operated with an identical value of dark current.* For proper adjustment of the target voltage on each 7262, see *sequence of adjustments* on page 9.

The *focusing-electrode (grid-No.3) voltage* may be fixed at a value of about 280 volts when focusing control is obtained by adjusting the current through the focusing coil. In general, resolution decreases with decreasing grid-No.3 voltage. Operation at a grid-No.3 voltage below 250 volts is not recommended. The necessary

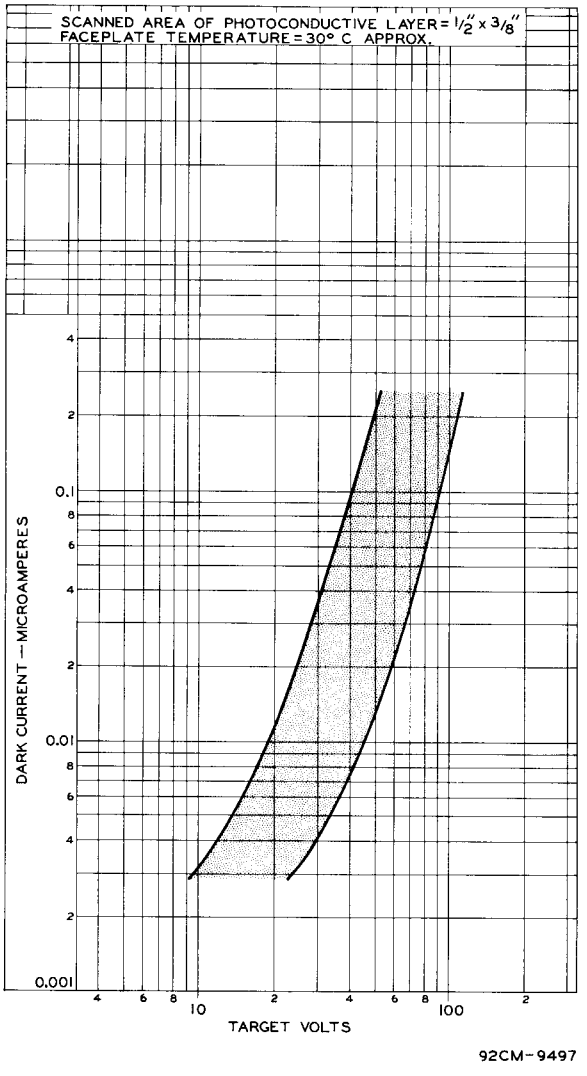


Fig.3 - Range of Dark Current for Type 7262.

range of current adjustment will depend on the design of the coil, but should be such as to provide a field-strength range of 36 to 44 gausses. When it is desired to use a fixed value of focusing-coil current capable of providing a fixed strength of 40 gausses at the center of the focusing device, the grid-No.3 voltage should be adjustable over a range from 250 to 300 volts.

Definition, focus uniformity, and picture quality decrease with decreasing grid-No.4 and grid-No.3 voltage. In general, grid No.4 and grid No.3 should be operated above 250 volts.

The *grid-No.1 supply voltage* should be adjustable from 0 to -110 volts.

The *dc voltages* required by the 7262 can be provided by the circuit shown in Fig.4.

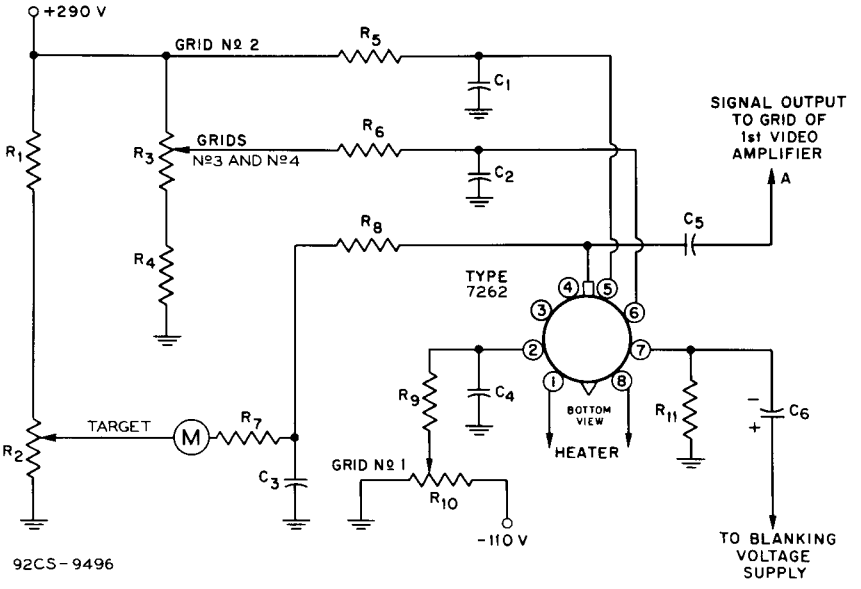
A *blanking signal* should be supplied to grid No.1 or to the cathode to prevent the electron beam from striking the photoconductive layer during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the reproduced picture. The blanking signal is a series of negative voltage pulses when it is applied to grid No.1, or a series of positive voltage pulses when it is applied to the cathode.

Beam intensity is controlled by the amount of negative voltage on grid No.1. The beam must have adequate intensity to drive the highlight elements of the photoconductive-layer surface to cathode potential on each scan. When the beam has an intensity sufficient only to drive the lowlight elements to cathode potential, the highlight elements are not returned to cathode potential. As a result, the picture highlights all have the same brightness and show no detail. Also, when the beam has insufficient intensity, the photoconductive-layer surface which normally rises in potential by only a small fraction of the signal-electrode potential during each scan, gradually rises in potential to a value approaching nearly the full signal-electrode potential in the highlights. Under this condition, many scans are required to drive to cathode potential any element which has changed from a highlight to a lowlight because of movement of the image. As a result, the highlights tend to "stick". The loss of highlight detail and sticking of the highlights is referred to as "bloom".

On the other hand, a beam with excessively high intensity should not generally be used because the size of the scanning spot increases with resultant decrease in resolution.

The *video amplifier system* should be designed to handle peak ac voltages corresponding to a highlight target current of 0.5 microampere through the target load resistor. Such a system is shown by the block diagram in Fig.5 (a). This system employs a low-noise, cascode preamplifier having an 8-Mc bandwidth as shown in Fig.5 (b).

Aperture correction compensates for the aperturing effect of the scanning beam in the 7262. This effect produces a horizontal square-wave response shown by the "uncompensated" curve in Fig.6. When this effect is compensated, the horizontal square-wave response of the video system is raised to approximately 100 per cent over the entire broadcast bandwidth of 4.5 Mc, and is shown by the "compensated" curve in Fig.6. This compensation, however, does not affect the vertical resolution. Combining the



C1 C4: 0.1 μf, 300 volts (working voltage)
C2: 0.1 μf, 300 volts (working voltage)
C3 C5: 0.1 μf, 200 volts (working voltage)
C6: 4 μf, electrolytic, 300 volts (working voltage)
M: Target-Current Meter, RCA Ultra-sensitive Microammeter WV-84B, or equivalent

R1: 120000 ohms, 1/2 watt
R2: 100000-ohm potentiometer, 2 watts
R3: 50000-ohm potentiometer, 2 watts
R4: 70000 ohms, 1/2 watt
R5: 5000 ohms, 1/2 watt
R6: 10000 ohms, 1/2 watt
R7: 200000 ohms, 1/2 watt
R8: 50000 ohms, 1/2 watt, non-inductive
R9: 100000 ohms, 1/2 watt
R10: 500000-ohm potentiometer, 2 watts
R11: 1000 ohms, 1/2 watt, non-inductive

Fig.4 - Typical Voltage Dividers for Supplying DC Electrode Voltages to Type 7262.

compensated horizontal resolution and the uncorrected vertical resolution yields the equivalent square-wave response which is shown in Fig.6 and is expressed by the equation

$$\text{Equiv. Square-Wave Response} = \sqrt{R_v \times R_h}$$

where R_v and R_h are the vertical square-wave response and the horizontal square-wave response, respectively.

The *illumination* incident on the faceplate will range from relatively high values for film pickup to relatively low values for direct pickup. For satisfactory operation of the 7262 at these extremely different light levels, it is essential that the target voltage be properly adjusted with reference to the curves in Figs.7, 8, and 11 to give the proper value of dark current for the desired service. Adjustment of the target voltage to obtain the desired dark current, is covered in *sequence of adjustments* on page 9.

For *live pickup involving low illumination levels*, a good picture can be obtained with a highlight illumination of 1 to 3 foot-candles on the faceplate of the 7262. Such a low illumination level, however, requires maximum-sensitivity operation of the 7262. For this type of operation, a dark current of 0.2 microampere is required. This value will be obtained for a target voltage within the range of 60 to 100 volts. Under such low-level illumination conditions, the lag will be somewhat greater and the black-level uniformity will be somewhat poorer than for live-pickup conditions with higher faceplate illumination and lower dark current.

When the 7262 is used for live pickup with illumination levels of 10 to 20 foot-candles on the faceplate, a dark current of 0.02 microampere is required. This value will be obtained for a target voltage within the range of 30 to 50 volts.

For *film pickup*, an average highlight illumination of 50 to 200 foot-candles is required on the faceplate of the 7262 for minimum lag and best black-level uniformity. For this range of illumination, a dark current of about 0.004 microampere is required, and the target voltage will range between 15 and 25 volts.

The exact value of target voltage to give the required dark current will depend on the individual tube and on the temperature at which its faceplate is operated. It is important that the tube be allowed to reach a stable operating temperature before the operating dark current is determined; otherwise the dark current will change as the temperature of the tube changes.

In all cases, the illumination level and/or dark current must be limited or adjusted so that the peak signal-output current does not exceed those values shown under Typical Operation. In order that the signal-output current and dark current will be known at all times, it is recommended that the camera be provided with a suitable microammeter in the target circuit of each 7262 to read average target current, or that a calibration pulse of the proper magnitude be fed into the input of the video preamplifier to indicate peak target currents.

The maximum amount of illumination on the photoconductive layer is limited primarily by the temperature of the faceplate which should never exceed 60° C and should preferably be maintained within the operating range from 25° C to 35° C for most satisfactory performance.

Signal Output and Light Transfer Characteristics. Typical signal output as a function of uniform 2870° K tungsten illumination on the photoconductive layer for different values of dark current is shown in Fig.8. It is to be noted that these curves are for a typical 7262 under the conditions indicated. Because the target voltage needed to give maximum sensitivity at a dark current of 0.2 microampere may range between 60 and 100 volts, it is essential that the best operating target voltage be determined for each 7262. From these curves, it will also be noted that the illumination must be increased about 30 times to produce an increase of 10 times in signal-output current for any given value of dark current.

The average "gamma", or slope, of the light transfer characteristic curves shown in Fig.8 is approximately 0.65. This value is relatively constant over an adjustment range of 4 to 1 in target voltage, or 50 to 1 in dark current, for a signal-output current range between 0.01 and 0.3 microampere. Close uniformity in the value of gamma between individual 7262's is maintained to insure satisfactory operation of color cameras in which the signal-output currents of the three 7262's must match closely over a wide range of scene illumination. Because its transfer characteristic is approximately the complement of the transfer characteristic of a picture tube, the 7262 can produce a picture having proper tone rendition.

Because uniformity of sensitivity of the photoconductive layer in the 7262 is excellent, uniform signal output over the scanned area can be obtained if the 7262 is operated with a deflecting-yoke and focusing-coil system designed so that no beam landing errors are produced in the vidicon. If the 7262 is to be utilized with designs of focusing and deflecting systems which introduce such errors, uniform sensitivity over the scanned area of the 7262 can be achieved by compensating for the beam landing errors thus introduced. Without compensation for these errors, variations in sensitivity over the scanned area will occur. These variations resulting from beam landing errors are in the form of lower signal from the edges of the scanned area than

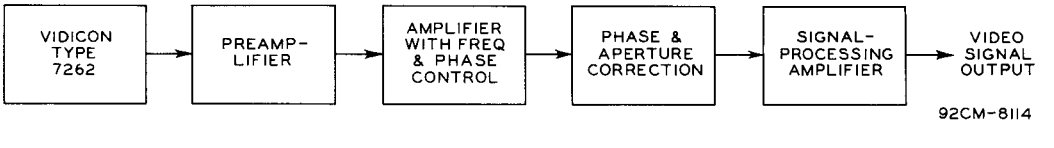
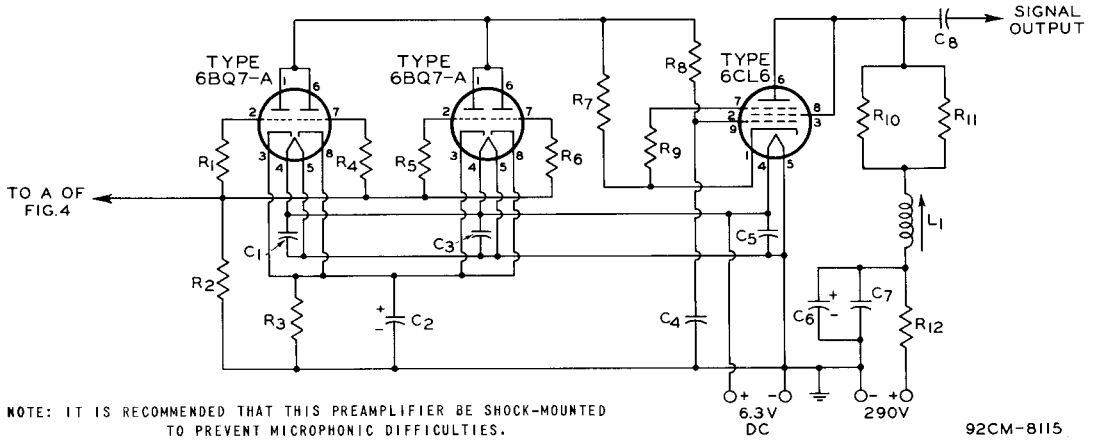


Fig.5 (a) - Block Diagram of Video System.



NOTE: IT IS RECOMMENDED THAT THIS PREAMPLIFIER BE SHOCK-MOUNTED TO PREVENT MICROPHONIC DIFFICULTIES.

All capacitor voltages are working values

C1 C3 C5: 0.01 μf, 100 volts
C2: 2000 μf, electrolytic, 3 volts
C4: 0.01 μf, 350 volts
C6: 90 μf, electrolytic, 350 volts
C7: 0.1 μf, 350 volts
C8: 0.1 μf, 300 volts
L1: 12 μh peaking coil, adjustable core to cover range from 9 to 15 μh

All resistors are of the carbon-composition type

R1 R4 R5 R6: 100 ohms, 1/2 watt
R2: 500000 ohms, 1/2 watt
R3: 15 ohms, 1/2 watt
R7: 12 ohms, 1/2 watt
R8: 100000 ohms, 1/2 watt
R9: 1 megohm, 1/2 watt
R10 R11: 1800 ohms, 2 watts
R12: 470 ohms, 2 watts

Fig.5 (b) - Low-Noise Cascode Preamplifier Having 8-Mc Bandwidth.

from the center. However, because of the uniformity of the photoconductive layer, these variations in sensitivity are the same from tube to tube. Compensation for the beam landing errors to achieve uniform sensitivity can be obtained by supplying a modulating voltage of a suitable waveform to the cathode of the 7262. The desired waveform is parabolic in shape and of such a polarity that the cathode voltage is lowered as the beam approaches the edges of the scanned area. The modulating waveform should contain parabolic components of both the horizontal and vertical scanning frequencies. The horizontal component should have the greater amplitude and will be the most effective in obtaining uniform sensitivity.

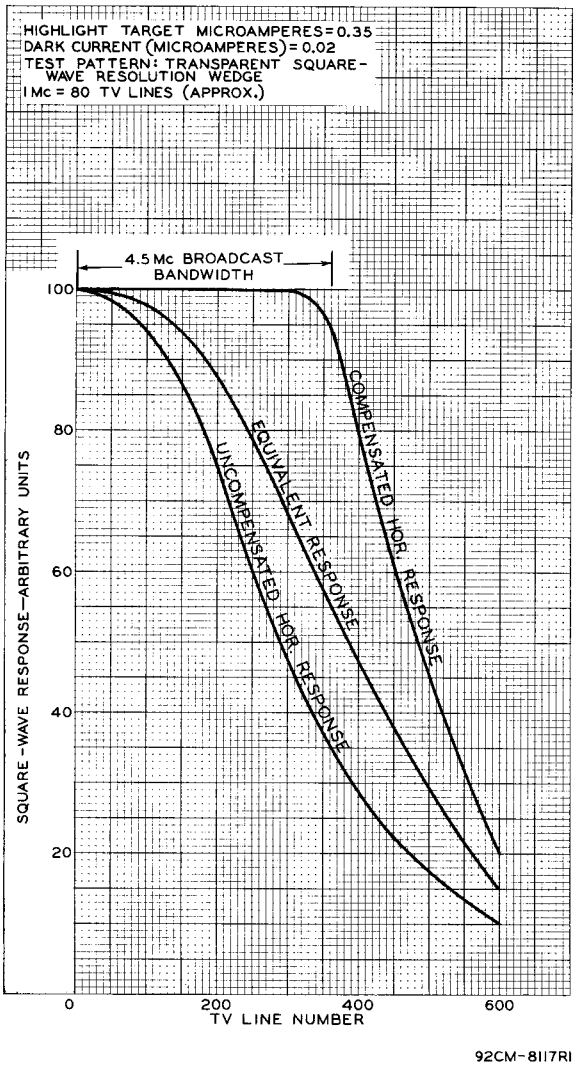


Fig. 6 - Curves Showing Uncompensated Horizontal Square-Wave Response of Type 7262 as well as Compensated Horizontal Square-Wave Response and Equivalent Square-Wave Response of the Video System Including Type 7262.

The circuit of Fig. 9 shows the amount of parabolic-waveform voltage required and the method of applying the waveform to the cathode, grid No. 1, and grid No. 2 of a 7262 which utilizes a deflecting-yoke and focusing-coil system that introduces beam landing errors. The modulating voltage is applied to grid No. 1 and grid No. 2 as well as to the cathode to prevent modulation of the scanning beam.

The use of this modulating waveform also improves the center-to-edge focus of the vidicon and assures that sensitivity over the scanned area will be uniform for the recommended dark current for any specific service. Care must be taken that identical waveforms are applied to

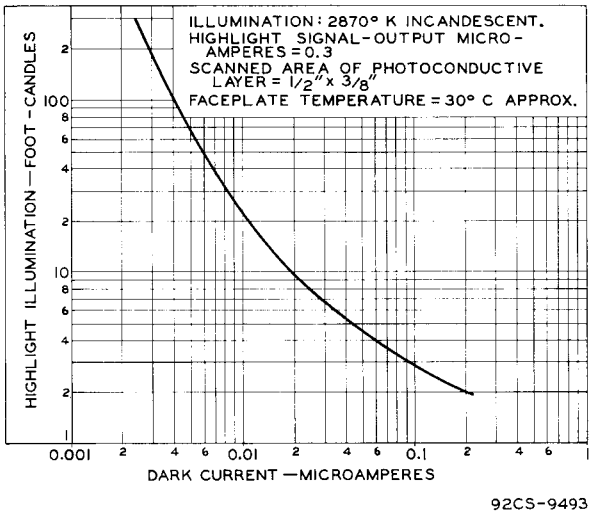


Fig. 7 - Typical Characteristic of Type 7262.

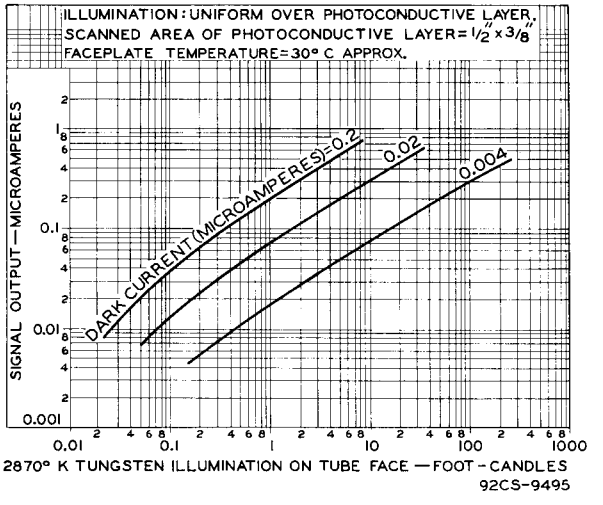
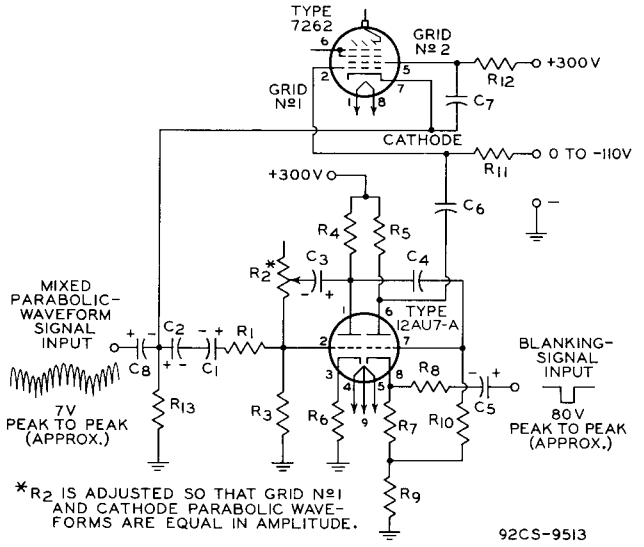


Fig. 8 - Light Transfer Characteristics of a Typical 7262 Vidicon.

electrodes of each of the three tubes when using the 7262 in 3-vidicon color cameras to insure good registration of all signals over the entire scanned area.

Persistence or lag of the photoconductive layer is given in Fig.10 for two values of dark



All capacitor voltages are working values

C1 C2: 8 μf, electrolytic, 25 volts
C3: 8 μf, electrolytic, 450 volts
C4: 0.1 μf, paper tubular, 400 volts
C5: 8 μf, electrolytic, 450 volts
C6: 1 μf, paper tubular, 400 volts
C7: 30 μf, electrolytic, 450 volts
C8: 125 μf, electrolytic, 350 volts

All resistors are of the carbon-composition type

R1: 10000 ohms, 1/2 watt
R2: 50000 ohm-potentiometer, linear taper
R3: 1 megohm, 1/2 watt
R4: 20000 ohms, 1 watt
R5: 10000 ohms, 1 watt
R6: 1000 ohms, 1/2 watt
R7: 1800 ohms, 1/2 watt
R8: 10000 ohms, 1/2 watt
R9: 8200 ohms, 1 watt
R10: 1 megohm, 1/2 watt
R11: 100000 ohms, 1/2 watt
R12: 5100 ohms, 1/2 watt
R13: 1000 ohms, 1/2 watt

Fig.9 - Typical Circuit for Applying Waveform to Compensate for Beam Landing Errors in Type 7262.

current. Each curve shows the decay in signal-output current from an initial value of 0.3 microampere after the illumination is cut off. The effect of faceplate temperature on persistence is shown in Fig.2.

Persistence of the photoconductive layer for different values of dark current is given by the curve in Fig.11. It is to be noted that the initial signal-output current is held constant for each value of dark current. This curve shows decreasing lag with decreasing dark current, and a small value of lag for the low value of dark current recommended for film pickup.

Signal-output-current buildup when light is applied to the photoconductive layer previously in the dark is as fast or faster than the rate of decay.

The *spectral response* of the 7262 is shown by curves A and C in Fig.12. Curve A is on the basis of equal values of signal-output current at all wavelengths, whereas curve C is on the basis of equal values of signal-output current with radiant flux from a tungsten source at 2870° K. For comparison purposes, the response of the eye is shown in curve B.

Full-size scanning of the 1/2" x 3/8" area of the photoconductive layer should always be used. This condition can be assured by first adjusting the deflection circuits to overscan the photoconductive layer sufficiently so that the edges of the sensitive area can be seen on the monitor. Then, after centering the image on the sensitive area (see Fig.13), reduce scanning until the edges of the image just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. It should be noted that overscanning the photoconductive layer produces a smaller-than-normal picture on the monitor.

Underscanning of the photoconductive layer, i.e., scanning an area of the layer less than 1/2" x 3/8", should never be permitted. This condition which produces a larger-than-normal picture on the monitor, not only causes sacrifice in signal-to-noise ratio and resolution, but also may cause permanent change in sensitivity and dark current of the underscanned area. An underscanned area showing such a change will be visible in the picture when full-size scanning is restored.

Failure of scanning even for a few seconds may permanently damage the photoconductive layer. The damaged area shows up as a spot or line in the picture during subsequent operation. To avoid damaging the 7262 during scanning failure, it is necessary to prevent the scanning beam from reaching the layer. The scanning beam can conveniently be prevented from reaching the layer by increasing the grid-No.1 voltage to cutoff.

The *sequence of adjustments* in operating the 7262 for live pickup is as follows: With the Grid-No.1 Voltage Control set for maximum negative bias (beam cutoff), Target Voltage Control set for the minimum voltage shown under *Typical Operation*, and Deflection Controls set for maximum overscan, apply other voltages to the 7262 as indicated under *Typical Operation*.

Next, with a 1/2" x 3/8" mask centered on the face of the tube, and with the iris set for minimum opening, decrease the grid-No.1 bias to just bring out the highlight details of the picture on the monitor. Adjust the Beam-Focus Voltage Control, the lens stop, and the optical

focus to obtain the best picture. Reduce horizontal and vertical scanning so that the edges of the image extend just outside the scanned area on the monitor. Then adjust the alignment field so that the center of the picture does not

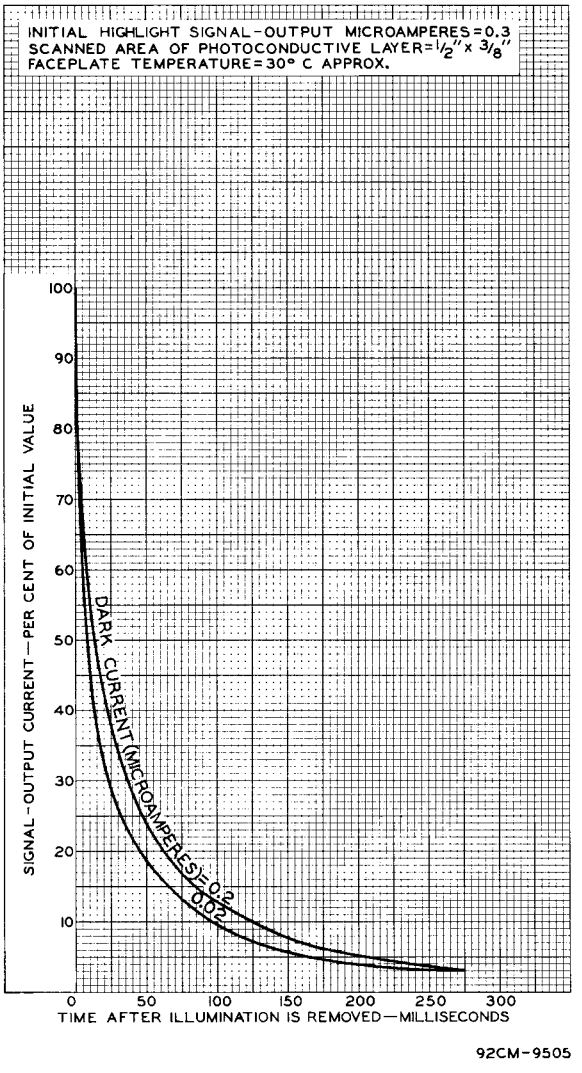


Fig. 10 - Typical Persistence Characteristics of Type 7262.

move as the beam-focus voltage is varied. Some readjustment of horizontal and vertical centering may be necessary after alignment.

For maximum-sensitivity operation of the 7262 in live-pickup service, proceed as follows: With no illumination on the face of the tube, increase the target voltage until a dark current of 0.2 microampere is measured. The current should be measured with a sensitive microammeter such as the RCA Type WV-84B Microammeter.

Next, open the lens and adjust the aperture to give a peak signal-output current of 0.2 to 0.3 microampere. A good procedure for doing this is to focus the camera on a uniform white area having the same brightness as the highlights in the scene to be televised. The image of this white area must at least cover the scanned area of the tube face. The current read on the microammeter will be the dark current plus the peak signal-output current, i.e., highlight target current.

A waveform-oscilloscope monitor can be used to compare the peak signal-output current produced by any scene to the peak value measured with the microammeter when the camera is focused on a uniformly bright scene. When a camera is

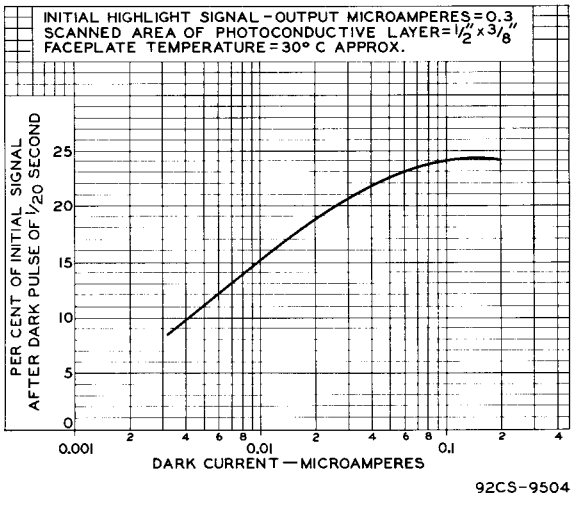


Fig. 11 - Typical Persistence Characteristic of Type 7262.

adjusted in this manner, video gain should be kept constant and the light level on the tube face should be controlled to maintain the constant predetermined value of peak signal as observed on the oscilloscope.

After adjusting the light level to obtain the correct signal-output current, the grid-No.1-bias voltage should be adjusted to just discharge the highlights. Too much current will result in poor resolution and poor picture quality. After the grid-No.1 bias is properly adjusted, it will be necessary to check and readjust the dark current and the peak signal-output current.

Proper adjustment of the dark current, the peak signal-output current, and the grid-No.1 bias, will result in a picture of good quality with minimum smearing of moving objects.

For average-sensitivity operation of the 7262 in live-pickup service, the adjustments are

similar to those for maximum-sensitivity operation except that the target voltage should be adjusted to produce a dark current of 0.02 microampere. When sufficient light is available, decreased lag can be obtained by operating with this lower value of dark current.

For film-pickup operation of the 7262, the adjustments will be similar to those for live

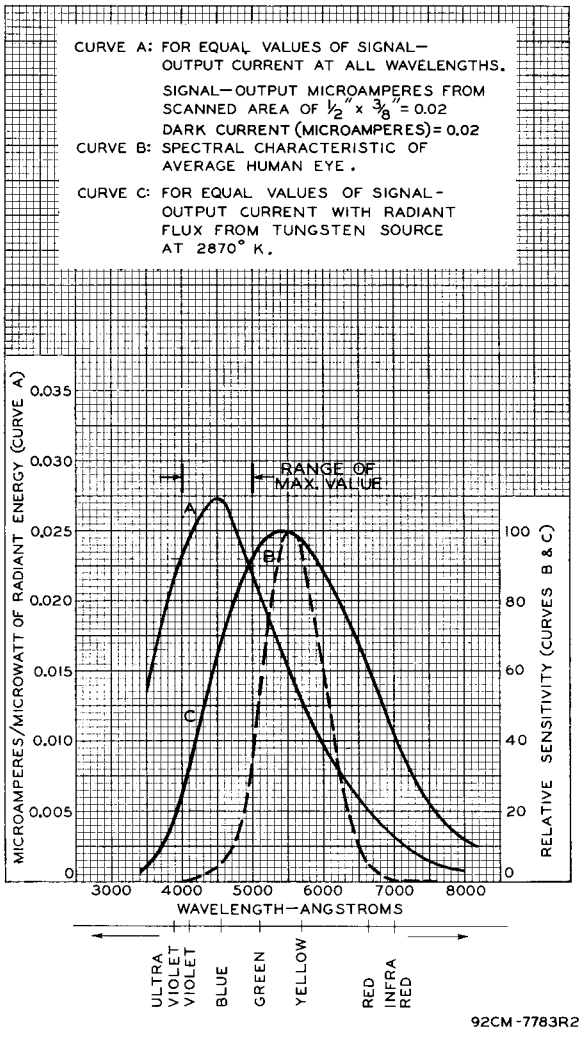


Fig. 12 - Spectral Sensitivity Characteristics of Type 7262.

pickup except that the target voltage should be adjusted to produce a dark current of 0.004 microampere and the peak signal-output current should be adjusted to the desired value by controlling the light level on the faceplate of the tube.

In setting up three 7262's in a color camera, particular attention must be given to proper alignment, best obtainable focus, and identical centering of scanned areas on the photoconductive layers. For best color balance and color tracking over a wide range of light levels, the light level in each color channel should be controlled

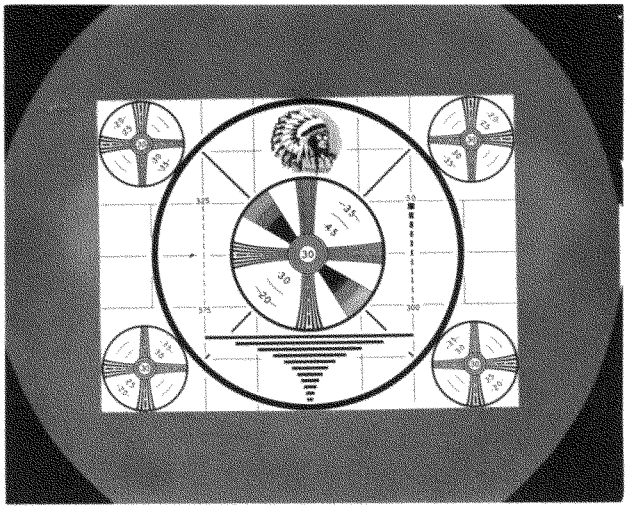


Fig. 13 - Illustration Showing Proper Positioning of Image on the Face of the Vidicon.

so that each of the three 7262's develops the same value of peak signal output for white portions of a scene. Observation of these operating conditions will assure good registration and good color balance.

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"Part III -- Electro-Optical Characteristics of Camera Systems," RCA Review, September, 1948.

"Part IV -- Correlation and Evaluation of Electro-Optical Characteristics of Imaging Systems," RCA Review, December, 1948.

R. G. Neuhauser, *"Vidicon for Film Pickup,"* Jour. of S.M.P.T.E., Vol.62, No.2, February, 1954.

H. N. Kozanowski, *"Vidicon Film-Reproduction Cameras,"* Jour. of S.M.P.T.E., Vol.62, February, 1954.

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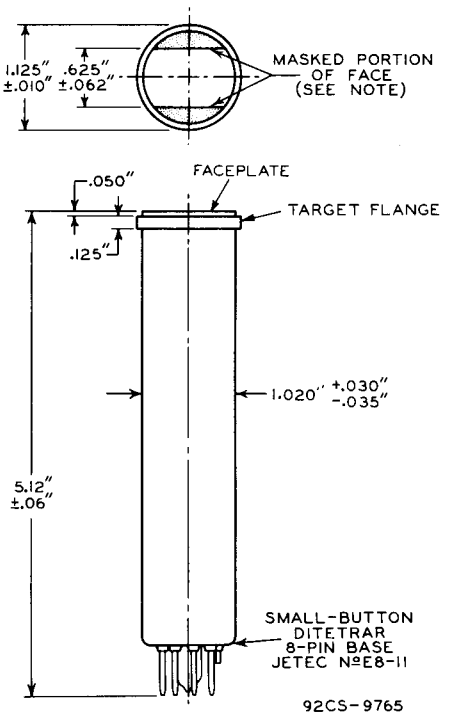
R. G. Neuhauser and L. D. Miller, *"Beam-Landing Errors and Signal-Output Uniformity of Vidicons"*, Jour. of S.M.P.T.E., Vol.67, March, 1958.

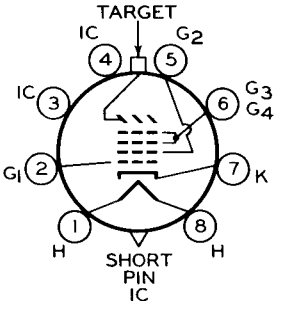
L. D. Miller and B. H. Vine, *"An Improved Developmental One-Inch Vidicon for Television Cameras"*, Jour. of S.M.P.T.E., Vol.67, March, 1958.

DIMENSIONAL OUTLINE



NOTE: STRAIGHT SIDES OF MASKED PORTIONS ARE PARALLEL TO THE PLANE PASSING THROUGH TUBE AXIS AND SHORT INDEX PIN.

SOCKET CONNECTIONS
Bottom View



PIN 1: HEATER
PIN 2: GRID No.1
PIN 3: INTERNAL CONNECTION-- DO NOT USE
PIN 4: INTERNAL CONNECTION-- DO NOT USE
PIN 5: GRID No.2
PIN 6: GRIDS No.3 and No.4
PIN 7: CATHODE
PIN 8: HEATER
FLANGE: TARGET
SHORT INDEX PIN: INTERNAL CONNECTION-- MAKE NO CONNECTION

DIRECTION OF LIGHT:
INTO FACE END OF TUBE

8HM

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7263

VIDICON

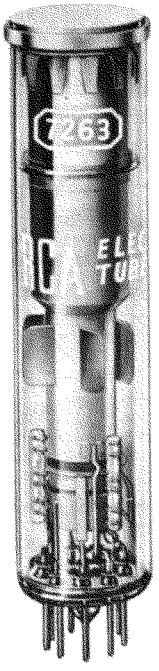
Magnetic Focus
Magnetic Deflection

For Use Under Severe Shock and Vibration
Low-Power (0.6-watt) Heater
600-Line Resolution

1"-Diameter Bulb
5.12" Length

TENTATIVE DATA

RCA-7263 is a short camera tube of the vidicon type designed primarily to provide reliable performance in black-and-white or color-TV cameras for industrial or military service. In such service, the 7263 is capable of withstanding operating conditions involving severe shock and vibration, altitudes up to 50,000 feet, and high humidity.



Because of its short length and its low-power heater, the 7263 is well suited for use in small, compact transistorized TV cameras.

In either live or film pickup service, the 7263 can provide a picture of high quality for broadcasting or industrial television applications. Its resolution capability is about 600 television lines.

The 7263 utilizes a unique photoconductive surface having uniform thickness which permits constant voltage gradient and uniform dark current across the scanned area. Because of the uniform thickness of its photoconductive surface, the 7263 can produce substantially uniform sensitivity over the entire scanned area. Therefore, the 7263 exhibits a degree of uniformity of characteristics from tube to tube that makes it possible to obtain excellent color uniformity and balance when used in three-vidicon color cameras. While dark current and sensitivity both increase with target voltage, the uniformity of the dark current makes it possible to operate the 7263 at relatively high values of target voltage and dark current. As a result, high effective sensitivity can be obtained with the 7263.

The design of the 7263 utilizes nonmagnetic materials in the front end, an extremely flat faceplate free from optical distortion, and an envelope without a side tip.

Full advantage of the uniformity of the photoconductive layer in the 7263 is realized only when the associated deflecting and focusing components do not introduce scanning-beam landing errors. These errors, if introduced by deflecting and focusing components, can be corrected by applying a modulating voltage of suitable waveform to the cathode, grid No.1, and grid No.2 (see page 9).

PRINCIPLES OF OPERATION

The structural arrangement of the 7263, shown in Fig.1, consists of a target composed of a transparent conducting film (the signal electrode) on the inner surface of the faceplate and a thin photoconductive layer deposited on the film; a fine mesh screen (grid No.4) located adjacent to the photoconductive layer; a beam-focusing electrode (grid No.3) connected to grid No.4; and an electron gun for producing a beam of electrons.

Each element of the photoconductive layer is an insulator in the dark but becomes slightly conductive when it is illuminated and acts like a leaky capacitor having one plate at the positive potential of the signal electrode and the other floating. When light from the scene or film being televised is focused on the photoconductive-layer surface next to the faceplate, each illuminated layer element conducts slightly depending on the amount of illumination on the element and thus causes the potential of its opposite surface (on the gun side) to rise in less than the time of one frame toward that of the signal-electrode potential. Hence, there appears on the gun side of the entire layer surface a positive potential pattern, composed of the various element potentials, corresponding to the pattern of light imaged on the layer.

The gun side of the photoconductive layer is scanned by a low-velocity electron beam produced by the electron gun. This gun contains a thermionic cathode, a control grid (grid No.1), and an accelerating grid (grid No.2). The beam is

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7263 1-59
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focused at the surface of the photoconductive layer by the combined action of the uniform magnetic field of an external coil and the electrostatic field of grid No.3. Grid No.4 serves to provide a uniform decelerating field between itself and the photoconductive layer so that the electron beam will tend to approach the layer in a direction perpendicular to it--a condition necessary for driving the surface to cathode potential. The beam electrons approach the layer at low velocity because of the low operating potential of the signal electrode.

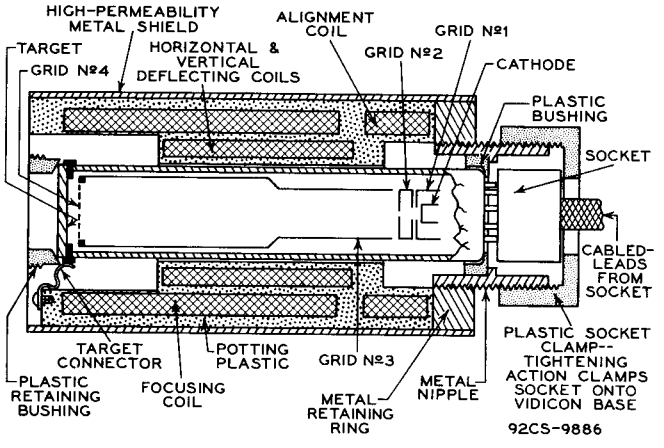


Fig. 1 - Schematic Arrangement of Type 7263.

When the gun side of the photoconductive layer with its positive potential pattern is scanned by the electron beam, electrons are deposited from the beam until the surface potential is reduced to that of the cathode, and thereafter are turned back to form a return beam which is not utilized. Deposition of electrons on the scanned surface of any particular element of the layer causes a change in the difference of potential between the two surfaces of the element. When the two surfaces of the element, which in effect is a charged capacitor, are connected through the external target (signal-electrode) circuit and the scanning beam, a capacitive current is produced and constitutes the video signal. The magnitude of the current is proportional to the surface potential of the element being scanned and to the rate of scan. The video-signal current is then used to develop a signal-output voltage across a load resistor. The signal polarity is such that for highlights in the image, the grid of the first video-amplifier tube swings in a negative direction.

Alignment of the beam is accomplished by a transverse magnetic field produced by external coils located at the base end of the focusing coil.

Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.095	amp
Direct Interelectrode Capacitance:		
Target to all other electrodes	4.6	μμf
Spectral Response	See Curves in Fig.12	
Photoconductive Layer:		
Maximum useful diagonal of rectangular image (4 x 3 aspect ratio)	0.62	inch
Orientation of quality rectangle--Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.		
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	5.12" ± 0.06"	
Greatest Diameter	1.125" ± 0.010"	
Bulb	T8	
Base	Small-Button Ditetrar 8-Pin (JEDEC No.E8-11)	
Socket	Cinch No.54A18088♡, or equivalent	
Operating Position	Any	
Weight (Approx.)	2 oz	

Maximum Ratings, *Absolute-Maximum Values:*

For altitudes up to 50,000 feet and scanned area of 1/2" x 3/8"

GRID-No.3 & GRID-No.4 VOLTAGE	350 max.	volts
GRID-No.2 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative-bias value	125 max.	volts
Positive-bias value	0 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts
DARK CURRENT	0.25 max.	μa
PEAK TARGET CURRENT	0.55 max.	μa
FACEPLATE:		
Illumination	1000 max.	ft-c
Temperature (Operating or storage)	60 max.	°C

Typical Operation:

For scanned area of 1/2" x 3/8"
Faceplate temperature of 30° to 35° C

Grid-No.4 (Decelerator) & Grid-No.3 (Beam-Focus Electrode*) Voltage	250□ to 300	volts
Grid-No.2 (Accelerator) Voltage	300	volts
Grid-No.1 Voltage for Picture Cutoff●	-45 to -100	volts
Average "Gamma" of Transfer Characteristic for signal-output current between 0.02 μa and 0.2 μa	0.65	
Visual Equivalent Signal-to-Noise Ratio (Approx.)○	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No.1	75	volts
When applied to cathode	20	volts
Field Strength at Center of Focusing Coil (Approx.)	40	gausses
Field Strength of Adjustable Alignment Coil⊕	0 to 4	gausses

Maximum-Sensitivity Operation for Live-Scene Pickup

Faceplate Illumination (Highlight)	2	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.2 μa in Any Tube**	110	volts
Target Voltage†	60 to 100	volts

♡ Made by Cinch Manufacturing Corporation, 1026 S. Homan Ave., Chicago 24, Illinois.

Dark Current▲	0.2	μa
Target Current (Highlight)■	0.4 to 0.5	μa
Signal-Output Current:#		
Peak	0.2 to 0.3	μa
Average	0.08 to 0.1	μa
Average-Sensitivity Operation for Live-Scene Pickup		
Faceplate Illumination (Highlight)	15	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.02 μa in Any Tube**	60	volts
Target Voltage†	30 to 50	volts
Dark Current	0.02	μa
Target Current (Highlight)■	0.3 to 0.4	μa
Signal-Output Current:#		
Peak	0.3 to 0.4	μa
Average	0.1 to 0.2	μa
Minimum-Lag Operation for Film Pickup		
Faceplate Illumination (Highlight)	100	ft-c
Max. Target Voltage Required to Produce Dark Current of 0.004 μa in Any Tube**	30	volts
Target Voltage†	15 to 25	volts
Dark Current	0.004	μa
Target Current (Highlight)■	0.3 to 0.4	μa
Signal-Output Current:#		
Peak	0.3 to 0.4	μa
Average	0.1 to 0.2	μa

▼ This capacitance, which effectively is the output impedance of the 7263, is increased when the tube is mounted in the deflecting-yoke and focusing-coil assembly. The resistive component of the output impedance is in the order of 100 megohms.

* Beam focus is obtained by combined effect of grid-No.3 voltage which should be adjustable over indicated range, and a focusing coil having an average field strength of 40 gausses.

□ Definition, focus uniformity, and picture quality decrease with decreasing grid-No.4 and grid-No.3 voltage. In general, grid No.4 and grid No.3 should be operated above 250 volts.

● With no blanking voltage on grid No.1.

○ Measured with high-gain, low-noise, cascode-input-type amplifier having bandwidth of 5 Mc. Because the noise in such a system is predominately of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of highlight video-signal current to rms noise current, multiplied by a factor of 3.

⊕ The alignment coil should be located on the tube so that its center is at a distance of 3-11/16 inches from the face of the tube, and be positioned so that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil.

† Indicated range for each type of service serves only to illustrate the operating target-voltage range normally encountered.

** The target voltage for each 7263 must be adjusted to that value which gives the desired operating dark current.

▲ The deflecting circuits must provide extremely linear scanning for good black-level reproduction. Dark-current signal is proportional to the scanning velocity. Any change in scanning velocity produces a black-level error in direct proportion to the change in scanning velocity.

■ Video amplifiers must be designed properly to handle target currents of this magnitude to avoid amplifier overload or picture distortion.

\# Defined as the component of the target current after the dark-current component has been subtracted.

SPECIAL PERFORMANCE DATA

In connection with the following tests, sample 7263's will maintain resolution as determined with a RETMA Resolution Chart, or equivalent, and will faithfully reproduce all resolution wedges and grey scales of the chart.

Vibration Tests. These tests are performed under conditions for *Average-Sensitivity Operation for Live-Scene Pickup* on a sample lot of tubes from each production run. Tubes and their associated components§ are vibrated on apparatus providing dynamic conditions similar to those described in MIL-E-5272B◆, par.4.7.1.

Resonance. Tubes and associated components§ are vibrated (per the method of MIL-E-5272B◆, par.4.7.1.1) for 1 hour at +25° C, for 15 minutes at 0° C, and for 15 minutes at +55° C.

Cycling. Tubes and associated components§ are vibrated (per the method of MIL-E-5272B◆, par.4.7.1.2 pertaining to specimen without vibration isolators) for 1 hour at +25° C, for 15 minutes at 0° C, and for 15 minutes at +55° C.

Temperature-Pressure (Altitude) Tests. Tubes and associated components§ are subjected (per the method of MIL-E-5400⊕ par.3.2.20, 3.2.20.1, and 3.2.20.1.1) to the separate and combined effects of varying temperature 0° to +55° C and varying barometric pressure 30" to 3.4" of mercury. The pressures correspond to sea level and to an altitude of 50,000 feet, respectively.

Shock Tests. These tests are performed with no voltages applied and on a sample lot of tubes from each production run. Tubes and their associated components§ are subjected in these tests (per MIL-E-5400⊕, par.3.2.21.2.1) to 18 impact shocks of 15g consisting of 3 shocks in opposite directions along each of three mutually perpendicular axes of the tube. Each shock impulse has a duration of 11 ± 1 milliseconds with a maximum impact acceleration occurring at approximately 5.5 milliseconds.

Temperature-Humidity Tests. These tests are performed with no voltages applied to the 7263. The 7263 and associated components§ are subjected (per the method of MIL-E-5400⊕, par.3.2.20.2B) to relative humidities up to and including 100 per cent at temperatures up to and including +50° C.

§ Tube socket such as Cinch No.54A18088 and RCA Assembly No.200SDU501, or equivalent, which consists of the deflecting coils, focusing coil, alignment coil, shield, and target connector.

◆ 5 June 1957, Procedure I of Military Specification.

⊕ 1 January 1956.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded

with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

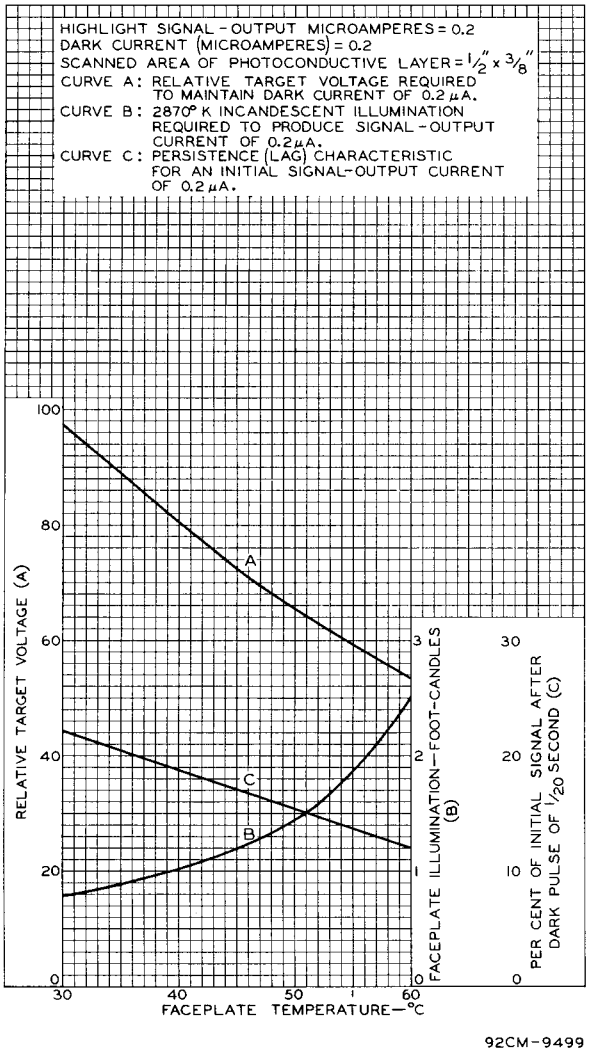


Fig. 2 - Typical Characteristics of Type 7263.

The *target connection* is made by a suitable spring contact bearing against the edge of the metal ring at the face end of the tube. This spring contact may conveniently be provided as part of the focusing-coil design.

Support for the 7263 should be provided such that, under vibration and shock, the tube will not be displaced with respect to the focusing, deflecting, and alignment fields. Suitable support is provided for the tube and its socket in the RCA Deflection Assembly 200SDU501, or equivalent. Orientation of the 7263 in its support should be such that the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.

The *optical system* associated with the 7263 should be of high quality and provide depth of focus sufficient to focus a sharp image on the photoconductive layer.

The *deflecting yoke and focusing coil* should be designed so that no beam landing errors are produced in the 7263. Properly designed yokes and focusing coils will cause the beam to land perpendicularly to the target at all points of the scanned area with resultant superior uniformity of sensitivity and focus over the scanned area.

The yoke should be positioned with respect to the tube as shown in Fig. 1. The end of the deflecting coils toward the base of the tube should not extend more than 3-1/2 inches from the faceplate.

The *scanning speed* must be constant in order to obtain good black-level reproduction when the 7263 is operated at high dark current with resultant higher effective sensitivity. The dark-current signal is proportional to the scanning speed. Therefore, any change in scanning speed will produce a nonuniformity in black level in direct proportion to the change in scanning speed.

The polarity of the focusing coil should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

The *alignment coil* should be located on the tube so that its center is at a distance of 3-11/16 inches from the face of the tube, and be positioned so that its axis is coincident with the axis of the tube, the deflecting yoke, and the focusing coil.

Electrostatic shielding of the target from external fields is required to prevent interference effects in the picture. Effective shielding from the fields produced by the deflecting components is ordinarily provided by grounding a shield on the inside of the faceplate end of the focusing coil and by grounding a shield on the inside of the deflecting yoke at a point near the input of the video amplifier.

The *temperature of the faceplate* should not exceed 60° C (140° F), either during operation or storage of the 7263. Operation with a faceplate temperature in the range from about 25° to 35° C (77° to 99° F) is recommended. The temperature of the faceplate is determined by the combined heating effects of the incident illumination on the faceplate, the associated components, and the tube itself. To reduce these heating effects in film-pickup cameras and permit operation in the preferred temperature range with a high value of illumination, the use of an infrared filter between the projector and faceplate as well as a

blast of cooling air directed across the faceplate from a blower is recommended.

The dark current is doubled for every 10° C rise in the temperature of the faceplate, and halved for every 10° C decrease in the temperature of the faceplate. To obtain optimum performance,

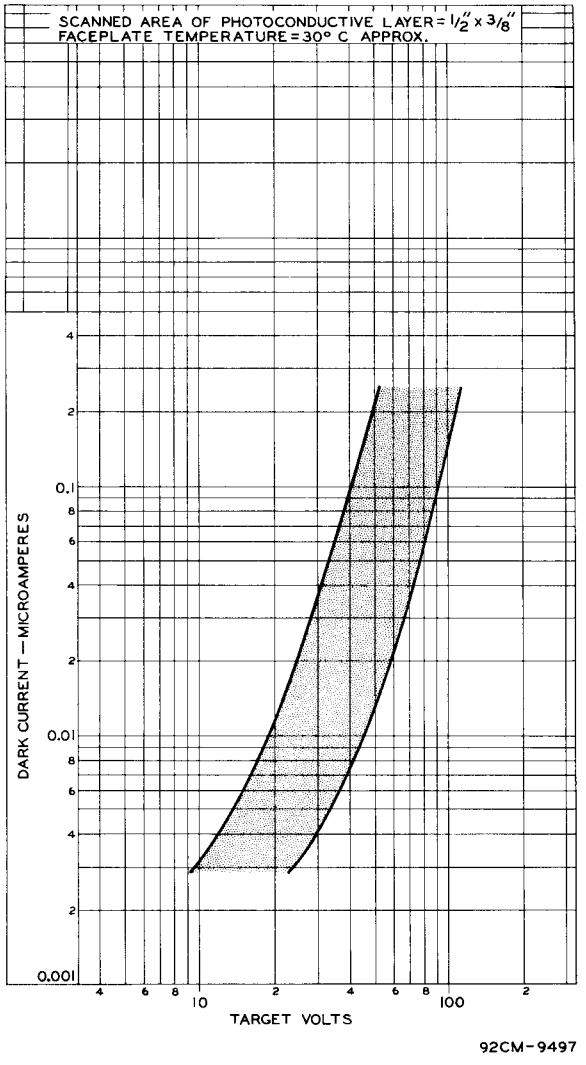


Fig. 3 – Range of Dark Current for Type 7263.

it is desirable to operate the 7263 at a pre-established value of dark current. Therefore, if the temperature of the faceplate is allowed to vary it will be necessary to adjust the target voltage to maintain the desired dark current, as shown in Fig.2. Since the sensitivity of the tube decreases with increasing temperature, the amount of faceplate illumination necessary to produce a given signal as a function of faceplate temperature is also shown in Fig.2. In addition, the lag will decrease with increasing temperature as shown in Fig.2. For live pickup, it is desirable to select an operating temperature which provides the best balance between lag and sensitivity. The faceplate should be held close to this temperature to assure stability of black level and signal-output level.

The *target voltage* should be obtained from an adjustable dc source. As the target voltage is increased, the dark current increases as shown in Fig.3. The target voltage must be adjusted to produce the desired value of dark current depending on the type of operation. The target-voltage range of the 7263 for a given value of dark current is small, as shown in Fig.3. This feature permits utilization of simplified circuits in cameras where automatic change in target voltage is desired to compensate for varying light levels. *It should be noted that individual 7263's will have substantially identical performance characteristics when operated with an identical value of dark current.* For proper adjustment of the target voltage on each 7263, see *sequence of adjustments* on page 10).

The *focusing-electrode (grid No.3) voltage* may be fixed at a value of about 280 volts when focusing control is obtained by adjusting the current through the focusing coil. In general, resolution decreases with decreasing grid-No.3 voltage. Operation at a grid-No.3 voltage below 250 volts is not recommended. The necessary range of current adjustment will depend on the design of the coil, but should be such as to provide a field-strength range of 36 to 44 gausses. When it is desired to use a fixed value of focusing-coil current capable of providing a fixed strength of 40 gausses at the center of the focusing device, the grid-No.3 voltage should be adjustable over a range from 250 to 300 volts.

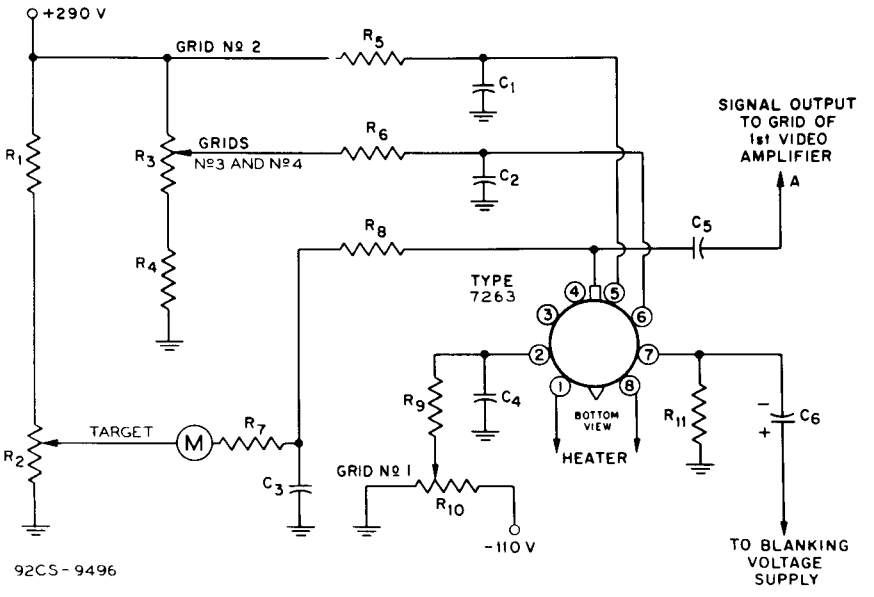
Definition, focus uniformity, and picture quality decrease with decreasing grid-No.4 and grid-No.3 voltage. In general, grid No.4 and grid No.3 should be operated above 250 volts.

The *grid-No.1 supply voltage* should be adjustable from 0 to -110 volts.

The *dc voltages* required by the 7263 can be provided by the circuit shown in Fig.4.

A *blanking signal* should be supplied to grid No.1 or to the cathode to prevent the electron beam from striking the photoconductive layer during the return portions of the horizontal and vertical deflecting cycles. Unless this is done, the camera-tube return lines will appear in the reproduced picture. The blanking signal is a series of negative voltage pulses when it is applied to grid No.1, or a series of positive voltage pulses when it is applied to the cathode.

Beam intensity is controlled by the amount of negative voltage on grid No.1. The beam must have adequate intensity to drive the highlight elements of the photoconductive-layer surface to



C1 C4: 0.1 μf, 300 volts (working voltage)
C2: 0.1 μf, 300 volts (working voltage)
C3 C5: 0.1 μf, 200 volts (working voltage)
C6: 4 μf, electrolytic, 300 volts (working voltage)
M: Target-Current Meter, RCA Ultra-sensitive Microammeter WV-84B, or equivalent

R1: 120000 ohms, 1/2 watt
R2: 100000-ohm potentiometer, 2 watts
R3: 50000-ohm potentiometer, 2 watts
R4: 70000 ohms, 1/2 watt
R5: 5000 ohms, 1/2 watt
R6: 10000 ohms, 1/2 watt
R7: 200000 ohms, 1/2 watt
R8: 50000 ohms, 1/2 watt, non-inductive
R9: 100000 ohms, 1/2 watt
R10: 500000-ohm potentiometer, 2 watts
R11: 1000 ohms, 1/2 watt, non-inductive

Fig.4 - Typical Voltage Dividers for Supplying DC Electrode Voltages to Type 7263.

cathode potential on each scan. When the beam has an intensity sufficient only to drive the lowlight elements to cathode potential, the highlight elements are not returned to cathode potential. As a result, the picture highlights all have the same brightness and show no detail. Also, when the beam has insufficient intensity, the photoconductive-layer surface which normally rises in potential by only a small fraction of the signal-electrode potential during each scan, gradually rises in potential to a value approaching nearly the full signal-electrode potential in the highlights. Under this condition, many scans are required to drive to cathode potential any element which has changed from a highlight to a lowlight because of movement of the image. As a result, the highlights tend to "stick". The loss of highlight detail and sticking of the highlights is referred to as "bloom".

On the other hand, a beam with excessively high intensity should not generally be used because the size of the scanning spot increases with resultant decrease in resolution.

The *video amplifier system* should be designed to handle peak ac voltages corresponding to a highlight target current of 0.5 microampere through the target load resistor. Such a system is shown by the block diagram in Fig.5 (a). This system employs a low-noise, cascode preamplifier having an 8-Mc bandwidth as shown in Fig.5 (b).

Aperture correction compensates for the aperturing effect of the scanning beam in the 7263. This effect produces a horizontal square-wave response shown by the "uncompensated" curve in Fig.6. When this effect is compensated, the horizontal square-wave response of the video system is raised to approximately 100 per cent over the entire broadcast bandwidth of 4.5 Mc, and is shown by the "compensated" curve in Fig.6. This compensation, however, does not affect the vertical resolution. Combining the compensated horizontal resolution and the uncorrected vertical resolution yields the equivalent square-wave response which is shown in Fig.6 and is expressed by the equation

$$\text{Equiv. Square-Wave Response} = \sqrt{R_v \times R_h}$$

where R_v and R_h are the vertical square-wave response and the horizontal square-wave response, respectively.

The *illumination* incident on the faceplate will range from relatively high values for film pickup to relatively low values for direct pickup. For satisfactory operation of the 7263 at these extremely different light levels, it is essential that the target voltage be properly adjusted with reference to the curves in Figs.7, 8, and 11 to give the proper value of dark current for the desired service. Adjustment of the target voltage to obtain the desired dark current, is covered in *sequence of adjustments* on page 10.

For *live pickup involving low illumination levels*, a good picture can be obtained with a highlight illumination of 1 to 3 foot-candles on the faceplate of the 7263. Such a low illumination level, however, requires maximum-sensitivity operation of the 7263. For this type of operation, a dark current of 0.2 microampere is required. This value will be obtained for a target voltage within the range of 60 to 100 volts. Under such low-level illumination conditions, the lag will be somewhat greater and the black-level uniformity will be somewhat poorer than for live-pickup conditions with higher faceplate illumination and lower dark current.

When the 7263 is used for live pickup with illumination levels of 10 to 20 foot-candles on the faceplate, a dark current of 0.02 microampere

is required. This value will be obtained for a target voltage within the range of 30 to 50 volts.

For *film pickup*, an average highlight illumination of 50 to 200 foot-candles is required on the faceplate of the 7263 for minimum lag and best black-level uniformity. For this range of illumination, a dark current of about 0.004 microampere is required, and the target voltage will range between 15 and 25 volts.

The exact value of target voltage to give the required dark current will depend on the individual tube and on the temperature at which its faceplate is operated. It is important that the tube be allowed to reach a stable operating temperature before the operating dark current is determined; otherwise the dark current will change as the temperature of the tube changes.

In all cases, the illumination level and/or dark current must be limited or adjusted so that the peak signal-output current does not exceed those values shown under Typical Operation. In order that the signal-output current and dark current will be known at all times, it is recommended that the camera be provided with a suitable microammeter in the target circuit of each 7263 to read average target current, or that a calibration pulse of the proper magnitude be fed into the input of the video preamplifier to indicate peak target currents.

The maximum amount of illumination on the photoconductive layer is limited primarily by the temperature of the faceplate which should never exceed 60° C and should preferably be maintained within the operating range from 25° C to 35° C for most satisfactory performance.

Signal Output and Light Transfer Characteristics. Typical signal output as a function of uniform 2870° K tungsten illumination on the photoconductive layer for different values of dark current is shown in Fig.8. It is to be noted that these curves are for a typical 7263 under the conditions indicated. Because the target voltage needed to give maximum sensitivity at a dark current of 0.2 microampere may range

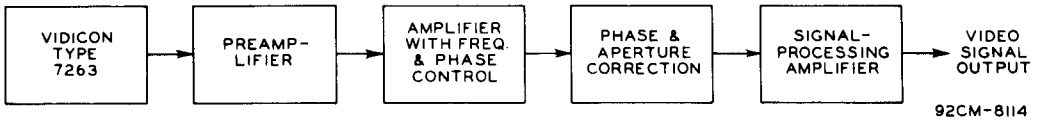
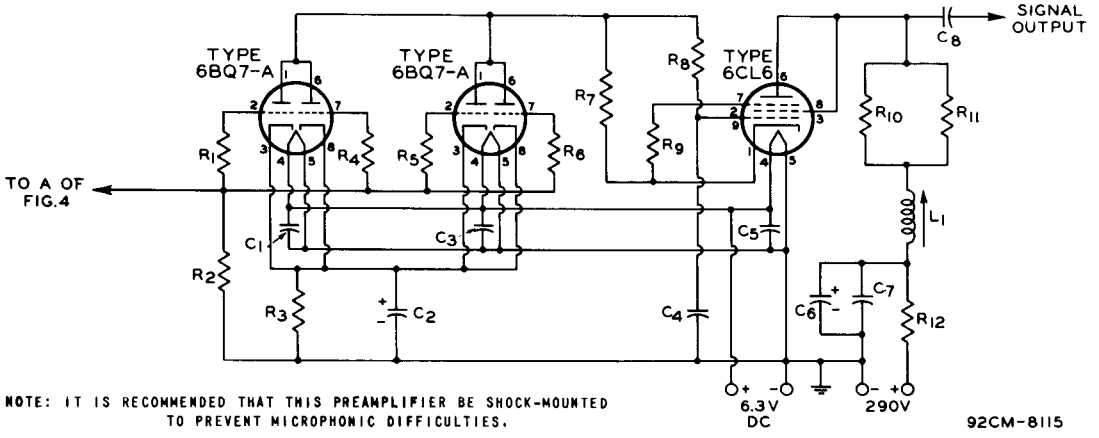


Fig.5 (a) - Block Diagram of Video System.



All capacitor voltages are working values

C1 C3 C5: 0.01 μf, 100 volts
C2: 2000 μf, electrolytic, 3 volts
C4: 0.01 μf, 350 volts
C6: 90 μf, electrolytic, 350 volts
C7: 0.1 μf, 350 volts
C8: 0.1 μf, 300 volts
L1: 12 μh peaking coil, adjustable core to cover range from 9 to 15 μh

All resistors are of the carbon-composition type

R1 R4 R5 R6: 100 ohms, 1/2 watt
R2: 500000 ohms, 1/2 watt
R3: 15 ohms, 1/2 watt
R7: 12 ohms, 1/2 watt
R8: 100000 ohms, 1/2 watt
R9: 1 megohm, 1/2 watt
R10 R11: 1800 ohms, 2 watts
R12: 470 ohms, 2 watts

Fig.5 (b) - Low-Noise Cascode Preamplifier Having 8-Mc Bandwidth.

between 60 and 100 volts, it is essential that the best operating target voltage be determined for each 7263. From these curves, it will also be noted that the illumination must be increased about 30 times to produce an increase of 10 times in signal-output current for any given value of dark current.

The average "gamma", or slope, of the light transfer characteristic curves shown in Fig.8 is approximately 0.65. This value is relatively constant over an adjustment range of 4 to 1 in target voltage, or 50 to 1 in dark current, for a signal-output current range between 0.01 and 0.3 microampere. Close uniformity in the value of gamma between individual 7263's is maintained to insure satisfactory operation of color cameras in which the signal-output currents of the three 7263's must match closely over a wide range of scene illumination. Because its transfer characteristic is approximately the complement of the transfer characteristic of a picture tube, the 7263 can produce a picture having proper tone rendition.

Because uniformity of sensitivity of the photoconductive layer in the 7263 is excellent, uniform signal output over the scanned area can be obtained if the 7263 is operated with a deflecting-yoke and focusing-coil system designed

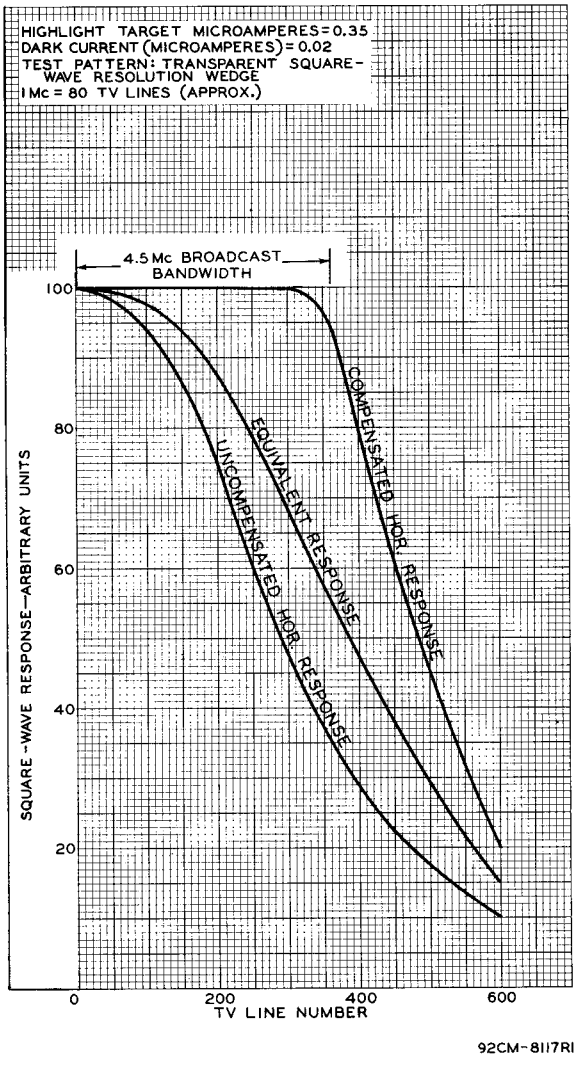


Fig.6 - Curves Showing Uncompensated Horizontal Square-Wave Response of Type 7263 as well as Compensated Horizontal Square-Wave Response and Equivalent Square-Wave Response of the Video System Including Type 7263.

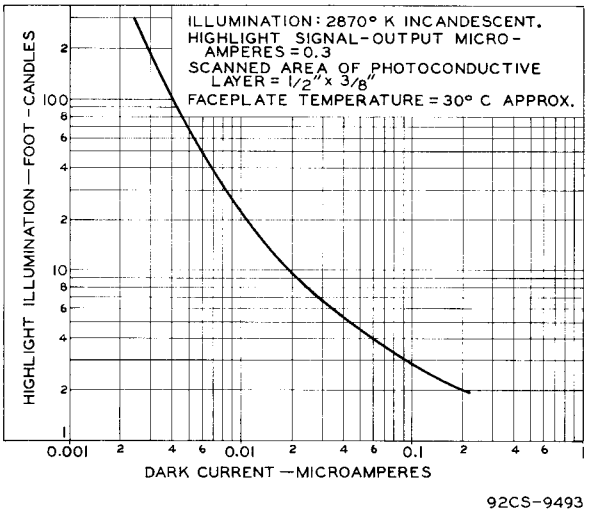


Fig.7 - Typical Characteristic of Type 7263.

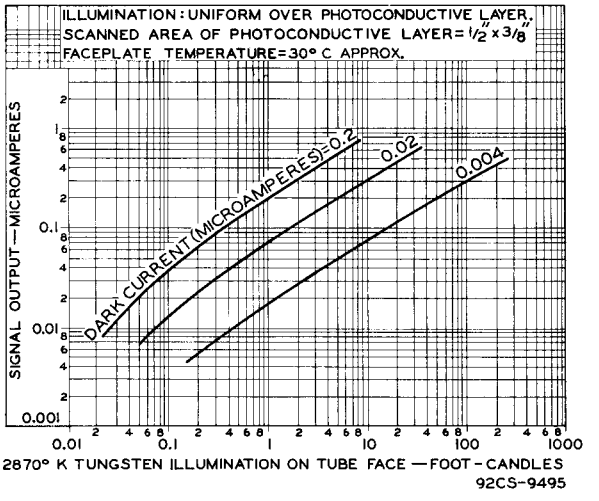
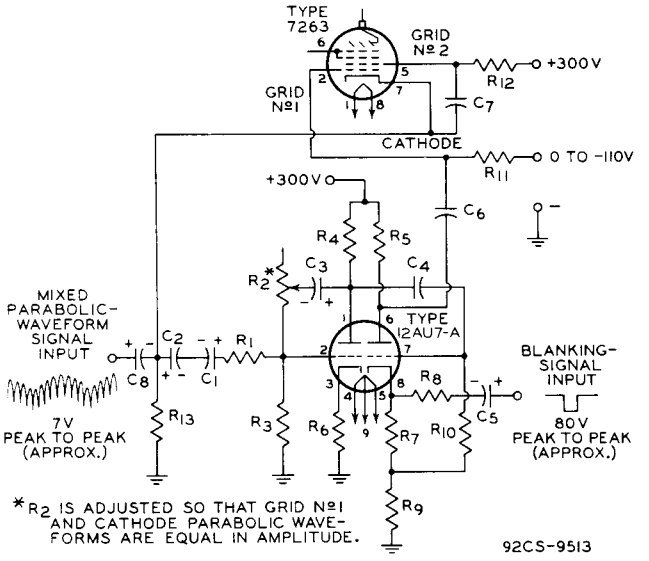


Fig.8 - Light Transfer Characteristics of a Typical 7263 Vidicon.

so that no beam landing errors are produced in the vidicon. If the 7263 is to be utilized with designs of focusing and deflecting systems which introduce such errors, uniform sensitivity over the scanned area of the 7263 can be achieved by



All capacitor voltages are working values

C1 C2: 8 μf, electrolytic, 25 volts
C3: 8 μf, electrolytic, 450 volts
C4: 0.1 μf, paper tubular, 400 volts
C5: 8 μf, electrolytic, 450 volts
C6: 1 μf, paper tubular, 400 volts
C7: 30 μf, electrolytic, 450 volts
C8: 125 μf, electrolytic, 350 volts

All resistors are of the carbon-composition type

R1: 10000 ohms, 1/2 watt
R2: 50000 ohm-potentiometer, linear taper
R3: 1 megohm, 1/2 watt
R4: 20000 ohms, 1/2 watt
R5: 10000 ohms, 1 watt
R6: 1000 ohms, 1/2 watt
R7: 1800 ohms, 1/2 watt
R8: 10000 ohms, 1/2 watt
R9: 8200 ohms, 1 watt
R10: 1 megohm, 1/2 watt
R11: 100000 ohms, 1/2 watt
R12: 5100 ohms, 1/2 watt
R13: 1000 ohms, 1/2 watt

Fig. 9 - Typical Circuit for Applying Waveform to Compensate for Beam Landing Errors in Type 7263.

compensating for the beam landing errors thus introduced. Without compensation for these errors, variations in sensitivity over the scanned area will occur. These variations resulting from beam landing errors are in the form of lower signal from the edges of the scanned area than from the center. However, because of the uniformity of the photoconductive layer, these variations in sensitivity are the same from tube to tube. Compensation for the beam landing errors to achieve uniform sensitivity can be obtained by supplying a modulating voltage of a suitable waveform to the cathode of the 7263. The desired waveform is parabolic in shape and of such a polarity that the cathode voltage is lowered as the beam approaches the edges of the scanned area. The modulating waveform should contain parabolic components of both the horizontal and vertical scanning frequencies. The horizontal component should have the greater amplitude and will be the most effective in obtaining uniform sensitivity.

The circuit of Fig. 9 shows the amount of parabolic-waveform voltage required and the method of applying the waveform to the cathode, grid No. 1, and grid No. 2 of a 7263 which utilizes a deflecting-yoke and focusing-coil system that introduces beam landing errors. The modulating voltage is applied to grid No. 1 and grid No. 2 as well as to the cathode to prevent modulation of the scanning beam.

The use of this modulating waveform also improves the center-to-edge focus of the vidicon and assures that sensitivity over the scanned area will be uniform for the recommended dark current for any specific service. Care must be taken that identical waveforms are applied to electrodes of each of the three tubes when using the 7263 in 3-vidicon color cameras to insure good registration of all signals over the entire scanned area.

Persistence or lag of the photoconductive layer is given in Fig. 10 for two values of dark current. Each curve shows the decay in signal-output current from an initial value of 0.3 microampere after the illumination is cut off. The effect of faceplate temperature on persistence is shown in Fig. 2.

Persistence of the photoconductive layer for different values of dark current is given by the curve in Fig. 11. It is to be noted that the initial signal-output current is held constant for each value of dark current. This curve shows decreasing lag with decreasing dark current, and a small value of lag for the low value of dark current recommended for film pickup.

Signal-output-current buildup when light is applied to the photoconductive layer previously in the dark is as fast or faster than the rate of decay.

The *spectral response* of the 7263 is shown by curves A and C in Fig. 12. Curve A is on the basis of equal values of signal-output current at all wavelengths, whereas curve C is on the basis of equal values of signal-output current with radiant flux from a tungsten source at 2870° K. For comparison purposes, the response of the eye is shown in curve B.

Full-size scanning of the 1/2" x 3/8" area of the photoconductive layer should always be used. This condition can be assured by first adjusting the deflection circuits to overscan the photoconductive layer sufficiently so that the edges of the sensitive area can be seen on the monitor. Then, after centering the image on

the sensitive area (see Fig.13), reduce scanning until the edges of the image just disappear. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. It should be noted that overscanning the photoconductive

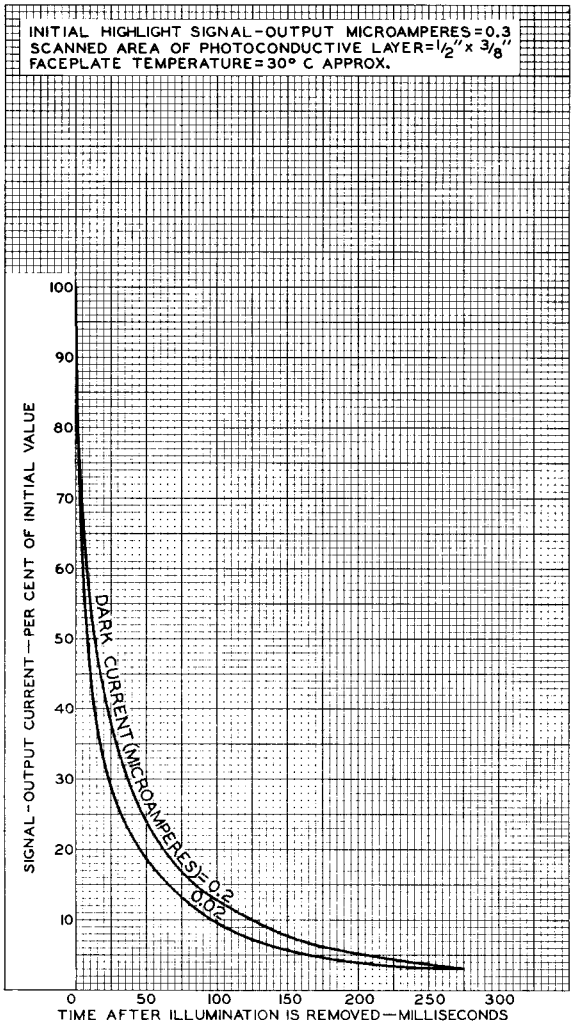


Fig. 10 - Typical Persistence Characteristics of Type 7263.

layer produces a smaller-than-normal picture on the monitor.

Underscanning of the photoconductive layer, i.e., scanning an area of the layer less than 1/2" x 3/8", should never be permitted. This condition which produces a larger-than-normal picture on the monitor, not only causes sacrifice in signal-to-noise ratio and resolution, but also may cause permanent change in sensitivity and dark current of the underscanned area. An underscanned area showing such a change will be visible in the picture when full-size scanning is restored.

Failure of scanning even for a few seconds may permanently damage the photoconductive layer. The damaged area shows up as a spot or line in the picture during subsequent operation. To avoid damaging the 7263 during scanning failure, it is necessary to prevent the scanning beam from reaching the layer. The scanning beam can conveniently be prevented from reaching the layer by increasing the grid-No.1 voltage to cutoff.

The *sequence of adjustments* in operating the 7263 for live pickup is as follows: With the Grid-No.1 Voltage Control set for maximum negative bias (beam cutoff), Target Voltage Control set

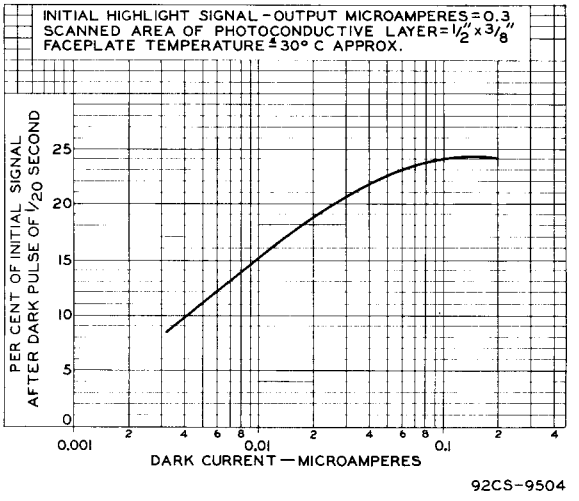


Fig. 11 - Typical Persistence Characteristic of Type 7263.

for the minimum voltage shown under *Typical Operation*, and Deflection Controls set for maximum overscan, apply other voltages to the 7263 as indicated under *Typical Operation*.

Next, with a 1/2" x 3/8" mask centered on the face of the tube, and with the iris set for minimum opening, decrease the grid-No.1 bias to just bring out the highlight details of the picture on the monitor. Adjust the Beam-Focus Voltage Control, the lens stop, and the optical focus to obtain the best picture. Reduce horizontal and vertical scanning so that the edges of the image extend just outside the scanned area on the monitor. Then adjust the alignment field so that the center of the picture does not move as the beam-focus voltage is varied. Some readjustment of horizontal and vertical centering may be necessary after alignment.

For maximum-sensitivity operation of the 7263 in live-pickup service, proceed as follows. With no illumination on the face of the tube, increase

the target voltage until a dark current of 0.2 microampere is measured. The current should be measured with a sensitive microammeter such as the RCA Type WV-84B Microammeter.

Next, open the lens and adjust the aperture to give a peak signal-output current of 0.2 to 0.3 microampere. A good procedure for doing this is to focus the camera on a uniform white area

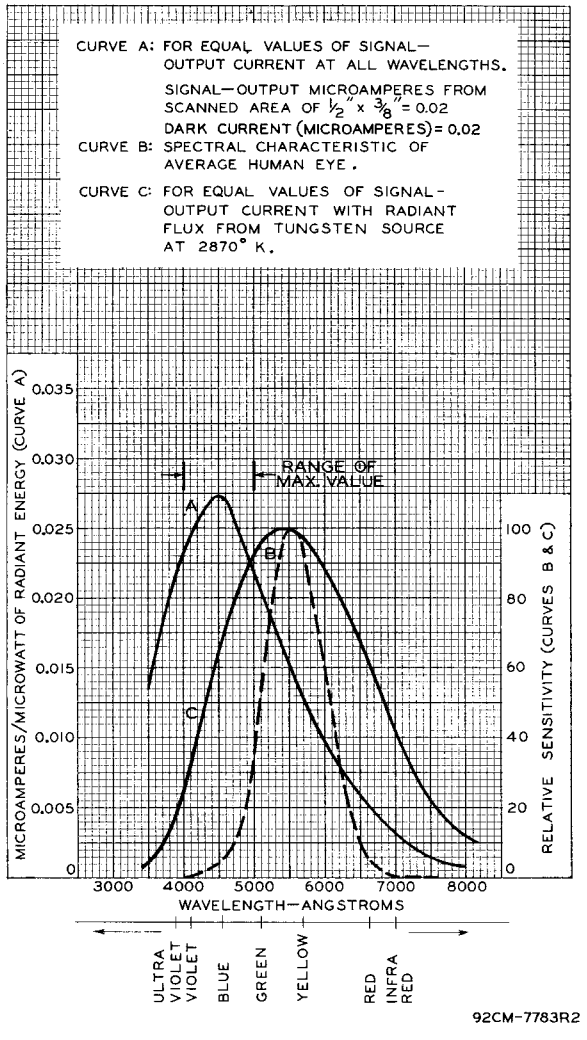


Fig. 12 - Spectral Sensitivity Characteristics of Type 7263.

having the same brightness as the highlights in the scene to be televised. The image of this white area must at least cover the scanned area of the tube face. The current read on the microammeter will be the dark current plus the peak signal-output current, i.e., highlight target current.

A waveform-oscilloscope monitor can be used to compare the peak signal-output current produced by any scene to the peak value measured with the microammeter when the camera is focused on a uniformly bright scene. When a camera is adjusted in this manner, video gain should be kept constant and the light level on the tube

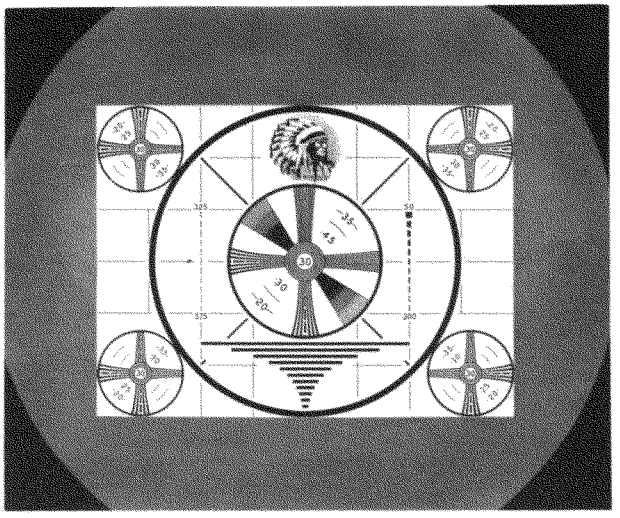


Fig. 13 - Illustration Showing Proper Positioning of Image on the Face of the Vidicon.

face should be controlled to maintain the constant predetermined value of peak signal as observed on the oscilloscope.

After adjusting the light level to obtain the correct signal-output current, the grid-No.1-bias voltage should be adjusted to just discharge the highlights. Too much current will result in poor resolution and poor picture quality. After the grid-No.1 bias is properly adjusted, it will be necessary to check and readjust the dark current and the peak signal-output current.

Proper adjustment of the dark current, the peak signal-output current, and the grid-No.1 bias, will result in a picture of good quality with minimum smearing of moving objects.

For average-sensitivity operation of the 7263 in live-pickup service, the adjustments are similar to those for maximum-sensitivity operation except that the target voltage should be adjusted to produce a dark current of 0.02 microampere. When sufficient light is available, decreased lag can be obtained by operating with this lower value of dark current.

For film-pickup operation of the 7263, the adjustments will be similar to those for live pickup except that the target voltage should be adjusted to produce a dark current of 0.004 microampere and the peak signal-output current should be adjusted to the desired value by controlling the light level on the faceplate of the tube.

In setting up three 7263's in a color camera, particular attention must be given to proper alignment, best obtainable focus, and identical centering of scanned areas on the photoconductive layers. For best color balance and color tracking over a wide range of light levels, the light level in each color channel should be controlled so that each of the three 7263's develops the same value of peak signal output for white portions of a scene. Observation of these operating conditions will assure good registration and good color balance.

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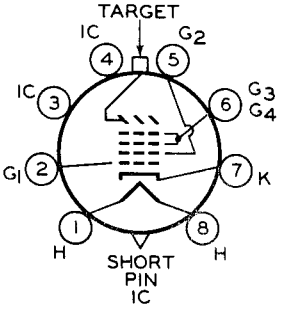
SOCKET CONNECTIONS
Bottom View



DIRECTION OF LIGHT:
INTO FACE END OF TUBE

8HM

PIN 1: HEATER

PIN 2: GRID No.1

PIN 3: INTERNAL CONNECTION—DO NOT USE

PIN 4: INTERNAL CONNECTION—DO NOT USE

PIN 5: GRID No.2

PIN 6: GRIDS No.3 AND No.4

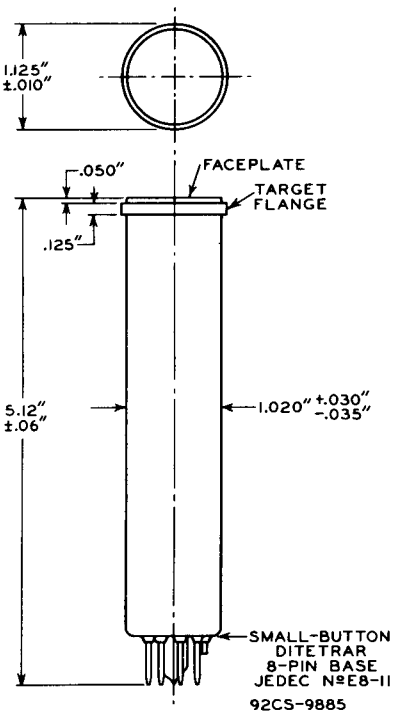
PIN 7: CATHODE

PIN 8: HEATER

FLANGE: TARGET

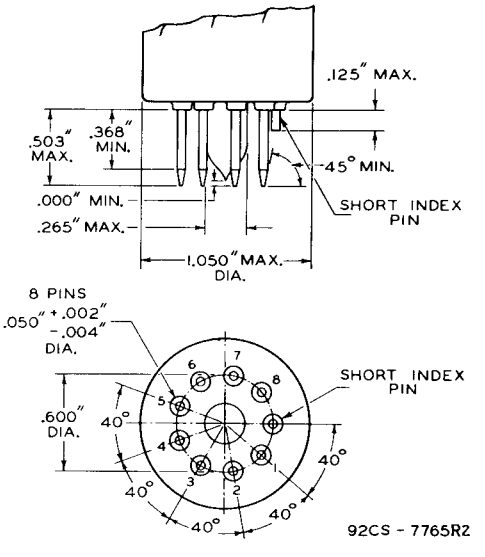
SHORT INDEX PIN: INTERNAL CONNECTION—MAKE NO CONNECTION

DIMENSIONAL OUTLINE



BASE DRAWING

SMALL-BUTTON DITETRAR
8-PIN BASE
JEDEC NºE8-11



BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT ENTIRE LENGTH OF PINS WILL, WITHOUT UNDUE FORCE, PASS INTO AND DISENGAGE FROM FLAT-PLATE GAUGE HAVING THICKNESS OF 1/4" AND NINE HOLES WITH DIAMETERS OF 0.0700" ± 0.0005" SO LOCATED ON A 0.6000" ± 0.0005" DIAMETER CIRCLE THAT THE DISTANCE ALONG THE CHORD BETWEEN ANY TWO ADJACENT HOLE CENTERS IS 0.2052" ± 0.0005". GAUGE IS ALSO PROVIDED WITH A HOLE HAVING DIAMETER OF 0.300" ± 0.001" CONCENTRIC WITH THE PIN CIRCLE.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

7264

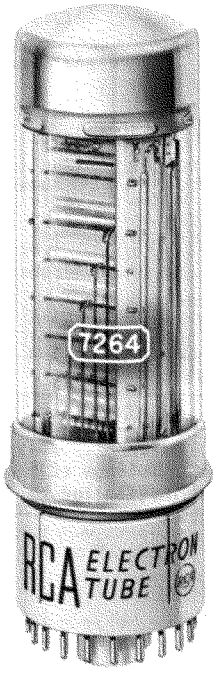
MULTIPLIER PHOTOTUBE

1.68" Dia. Semitransparent Spherical Photocathode

14-Stage, Head-On Type, Spherical Faceplate
S-11 Response
Very-Short Time Resolution Capability
TENTATIVE DATA

7.5" Max. Length
2.38" Max. Diameter
Bidecal 20-Pin Base

RCA-7264 is a head-on type of multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear radiation, and in applications involving the measurement of low-level light sources. Its fast response, high current gain, high peak-current capability, relative freedom from afterpulses, and extremely small spread in electron-transit time make it particularly useful for fast coincidence scintillation counting.



Design features of the 7264 include dynodes with stable high-current-carrying capability; focusing electrode with external connection for shaping the field which directs photoelectrons from the photocathode onto the first dynode; an accelerating electrode with external connection for minimizing the space-charge effect in the region of dynode No.12; and a semitransparent photocathode on the inner surface of the spherical face end of the bulb.

The focusing electrode permits optimizing the magnitude, uniformity, or speed of the response in critical applications.

The spherical photocathode surface of the 7264 assures very good collection by dynode No.1 of electrons from all parts of the useful photocathode area, and thus makes possible a typical pulse-height resolution of about 8 per cent. The use of the spherical surface together with the electrode configuration employed in the 7264 results in extremely small variation in electron-transit time between the photocathode and dynode No.1.

The 7264 is capable of delivering pulse currents having magnitudes up to 0.5 ampere without appreciable deviation from linearity. Consequently, the need for an associated wide-band amplifier to amplify the output pulse is eliminated in many applications.

The spectral response of the 7264 covers the range from about 3000 to 6500 angstroms, as shown in Fig.1. Maximum response occurs at approximately 4400 angstroms. The 7264, therefore, has high sensitivity to blue-rich light and negligible sensitivity to red radiation.

The internal leads from dynode No.14 and anode to their respective base-pin terminals are short and direct. This arrangement makes possible the use of a load circuit having a short time constant--an essential feature in pulse service.

The 7264 is capable of multiplying feeble photoelectric current produced at the cathode by a median value of 12,500,000 times when operated with a supply voltage of 2000 volts. The output current of the 7264 is a linear function of the exciting illumination under normal operating conditions.

DATA

General:

Spectral Response		S-11
Wavelength of Maximum Response		4400 ± 500 angstroms
Cathode, Semitransparent:		
Shape		Spherical
Window:		
Area	2.2	sq.in.
Minimum diameter	1.68	in.
Index of refraction	1.51	
Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.14	2.4	μμf
Anode to all other electrodes	5.5	μμf
Dynode No.14 to all other electrodes	7.5	μμf
Maximum Overall Length		7.5"
Seated Length		6.69" ± 0.19"
Maximum Diameter		2.38"
Bulb		T-16
Base		Small-Shell Bidecal 20-Pin (JETEC No.B20-102)
Socket		Alden No.220FT with 20 Contacts, or equivalent

Trademark(s) ® Registered
Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7264 7-58
Printed in U.S.A.

Operating Position . . . . . .Any
Weight (Approx.) . . . . . 8 oz

VERY-LOW-LIGHT-LEVEL, LOW-NOISE HIGH-GAIN SERVICE

With Supply Voltage (E) Across Voltage Divider Providing Electrode Voltages Shown in Table I--Column A

Maximum Ratings, *Absolute Values:*

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE (DC)	2400 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.14 AND ANODE (DC)	400 max.	volts
SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES (DC)	500 max.	volts
SUPPLY VOLTAGE BETWEEN ACCELERATING-ELECTRODE AND DYNODE No.13 (DC)	±500 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC)	400 max.	volts
FOCUSING-ELECTRODE SUPPLY VOLTAGE (DC)	400 max.	volts
AVERAGE ANODE CURRENT●	2 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics Range Values for Equipment Design:

With E = 2000 volts (except as noted) and Focusing-Electrode as well as Accelerating-Electrode Voltage adjusted to give maximum gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	–	0.7	–	amp/μw
Cathode Radiant, at 4400 angstroms	–	0.056	–	μa/μw
Luminous:#				
At 0 cps	120	875	4500	amp/lumen
With dynode No.14 as output electrode†	–	612	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲	50	70	–	μa/lumen
With blue light source**	0.05	–	–	μa
Current Amplification	–	12.5×10^6	–	
Equivalent Anode-Dark-Current Input⊕■	–	5×10^{-10}	2×10^{-9}	lumen
Equivalent Noise Input:★				
At +25° C.	–	3.3×10^{-12}	1.5×10^{-11}	lumen
At −50° C.	–	9×10^{-13}	–	lumen
Anode-Pulse Rise Time□	–	3	–	milliμsec
Greatest Delay Between Anode Pulses: Due to position from which electrons are simultaneously released within a circle centered on tube face and having a diameter of--				
1.12"	–	0.5‡	–	milliμsec
1.5"	–	1‡	–	milliμsec

HIGH-OUTPUT-PULSE SERVICE

With Supply Voltage (E) Across Voltage Divider Providing Electrode Voltages Shown in Table I--Column B

Maximum Ratings, *Absolute Values:*

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE (DC)	2800 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.14 AND ANODE (DC)	400 max.	volts
SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES (DC)	500 max.	volts
SUPPLY VOLTAGE BETWEEN ACCELERATING-ELECTRODE AND DYNODE No.13 (DC)	±500 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC)	400 max.	volts
FOCUSING-ELECTRODE SUPPLY VOLTAGE (DC)	400 max.	volts
AVERAGE ANODE CURRENT●	2 max.	ma
AMBIENT TEMPERATURE	75 max.	°C

Characteristics Range Values for Equipment Design:

With E = 2400 volts (except as noted) and Focusing-Electrode as well as Accelerating-Electrode Voltage adjusted to give maximum gain

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4400 angstroms	–	0.7	–	amp/μw
Cathode Radiant, at 4400 angstroms	–	0.056	–	μa/μw
Luminous:#				
At 0 cps	–	875	–	amp/lumen
With dynode No.14 as output electrode†	–	612	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲	50	70	–	μa/lumen
With blue light source**	0.05	–	–	μa
Current Amplification	–	12.5×10^6	–	
Equivalent Anode-Dark-Current Input⊕	–	1.1×10^{-9}	–	lumen
Equivalent Noise Input:★★				
At +25° C.	–	4.6×10^{-12}	–	lumen
At −50° C.	–	1.2×10^{-12}	–	lumen

TABLE I

VOLTAGE TO BE PROVIDED BY DIVIDER		
Between	**COLUMN A** 5.4% of Supply Voltage (E) multiplied by	**COLUMN B** 2.75% of Supply Voltage (E) multiplied by
Cathode and Focusing Electrode	♣	♣
Cathode and Dynode No.1	2	2
Dynode No.1 and Dynode No.2	1	1
Dynode No.2 and Dynode No.3	1	1
Dynode No.3 and Dynode No.4	1	1
Dynode No.4 and Dynode No.5	1	1
Dynode No.5 and Dynode No.6	1	1
Dynode No.6 and Dynode No.7	1	1.2
Dynode No.7 and Dynode No.8	1	1.5
Dynode No.8 and Dynode No.9	1	1.9
Dynode No.9 and Dynode No.10	1	2.4
Dynode No.10 and Dynode No.11	1	3.0
Dynode No.11 and Dynode No.12	1.25	3.8
Dynode No.12 and Dynode No.13	1.5	4.8
Dynode No.13 and Dynode No.14	1.75	6
Dynode No.14 and Anode	2	4.8
Anode and Cathode	18.5	36.4

● Averaged over any interval of 30 seconds maximum.

\# Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870° K. A light input of 0.1 microlumen is used. The load resistor has a value of 0.01 megohm.

† An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.14 as the output electrode. With this arrangement, the load is connected in the dynode-No.14 circuit and the anode serves only as collector.

▲ Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux is 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected together as anode. The load resistor has a value of 0.01 megohm.

** Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm and 200 volts are applied between cathode and all other electrodes connected together as anode.

⊕ Measured at a tube temperature of 25° C and with the supply voltage (E) adjusted to give a luminous sensitivity of 2000 amperes per lumen. Dark current caused by thermionic emission may be reduced by the use of a refrigerant.

■ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 2000 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 2000 volts, 25° C tube temperature, external shield potential of -2000 volts, ac-amplifier bandwidth of 1 cycle per second, tungsten light source of 2870° K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

□ Measured between 10 per cent and 90 per cent of maximum anode-pulse height. This anode-pulse rise time is determined primarily by transit-time variations in the multiplier stages and with an incident light spot approximately 1 millimeter in diameter centered on the photocathode.

‡ These values also represent the difference in time of transit between the photocathode and dynode No.1 for electrons simultaneously released from the center and from the periphery of the specified areas.

● Measured at a tube temperature of 25° C and with the supply voltage (E) adjusted to give a luminous sensitivity of 2000 amperes per lumen. Dark current caused by thermionic emission may be reduced by the use of a refrigerant.

⊕ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 2300 volts is recommended.

★★ Same as (★) except the supply voltage (E) is 2400 volts, and the external shield potential is -2400 volts.

♣ Focusing electrode is connected to arm of potentiometer between cathode and dynode No.1. Focusing-electrode voltage is adjusted to give maximum gain.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Pulse Rise Time. The time required for the instantaneous amplitude of the pulse to go from 10 per cent to 90 per cent of the peak value.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

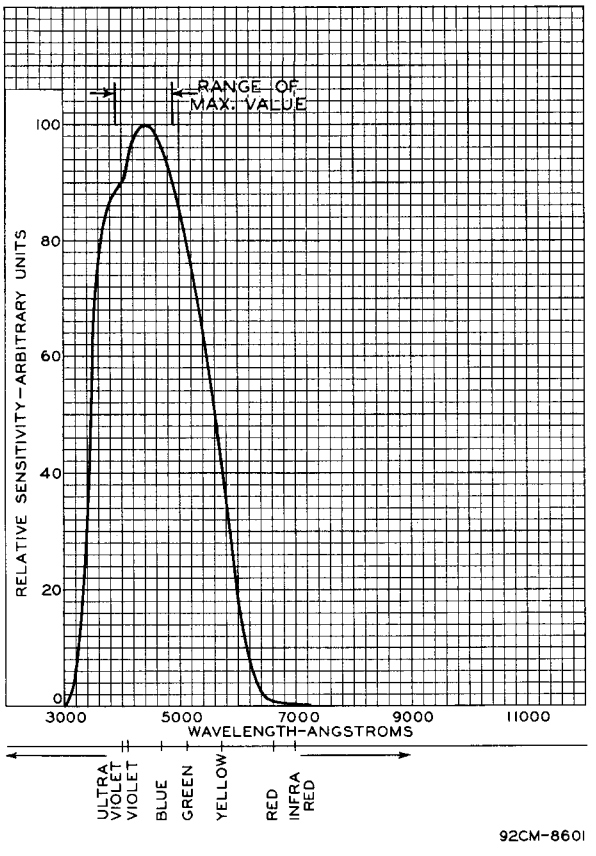


Fig. 1 - Spectral Sensitivity Characteristic of Type 7264 which has S-11 Response. Curve is shown for Equal Values of Radiant Power at All Wavelengths.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation,

equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

In general, *supply voltages* for the electrodes of the 7264 should be provided as shown in Table I. For *applications involving very low light levels and requiring high signal-to-noise ratio and high gain*, supply voltages should be provided as shown in Table I--Column A. For *applications requiring high output pulses*, higher operating voltages may be used as shown in Table I--Column B.

The operating voltage between dynode No. 14 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristics curves, shown in Fig. 2, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. With low operating voltage between dynode No. 14 and anode, the dark current is reduced. As a result, the operating stability of the 7264 is improved without sacrifice in sensitivity. To obtain the indicated operating voltage between dynode No. 14 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

The *focusing-electrode potential* may be adjusted between that of the photocathode and that of dynode No. 1 to optimize the magnitude, uniformity, or speed of the response. The voltage for the focusing electrode can be obtained by

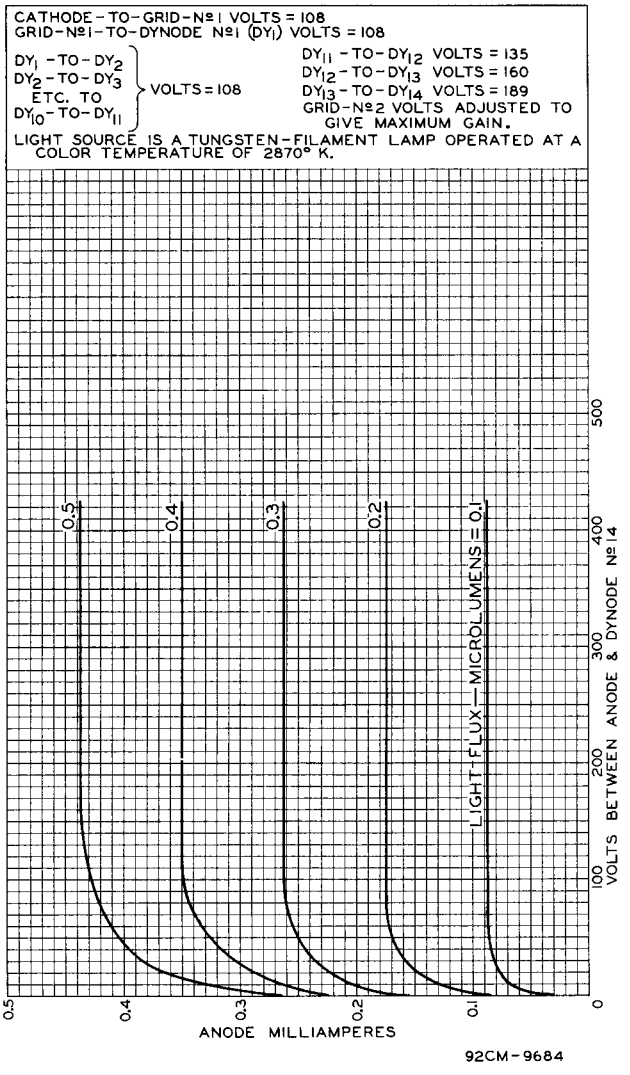


Fig. 2 - Typical Anode Characteristics of Type 7264 Used in Low-Light-Level, Low-Noise, High-Gain Service.

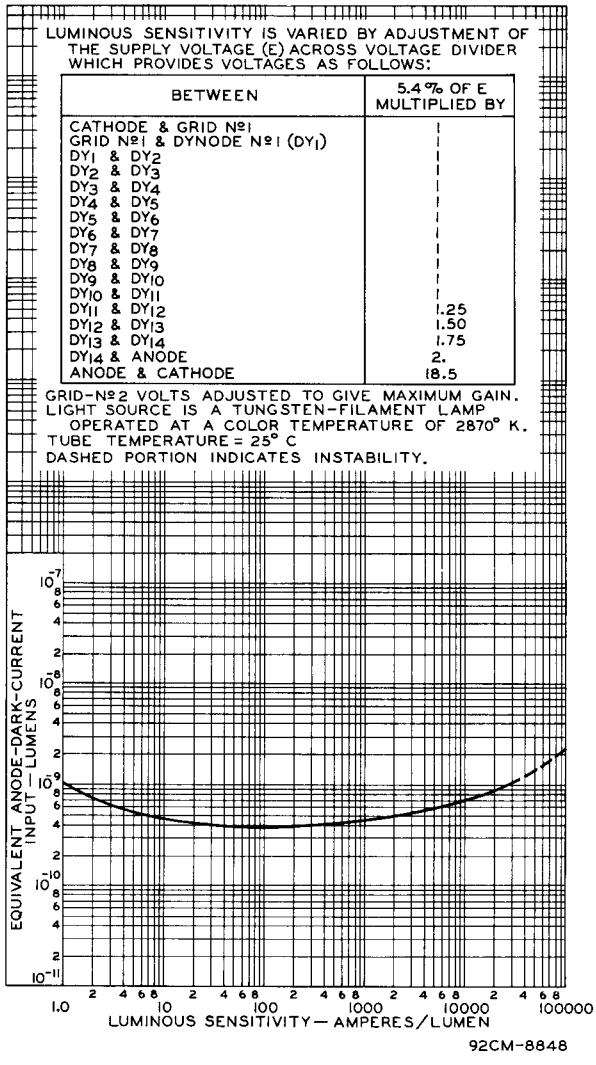


Fig. 3 - Typical Anode-Dark-Current Characteristic of Type 7264 Used in Low-Light-Level, Low-Noise, High-Gain Service.

connecting it to the arm of a potentiometer between cathode and dynode No. 1 in the voltage divider.

The *accelerating electrode*, when operated at a suitable potential with respect to dynode No. 13, serves to minimize the effect of space charge in the region of dynode No. 12. Provision should be made to adjust the accelerating-electrode voltage over a range extending from the value at which dynode No. 13 operates to that at which the anode operates. The adjustment may be accomplished by means of a high-resistance potentiometer connected between the voltage-divider tap for dynode No. 13 and the anode end of the voltage divider. Since the accelerating electrode draws at most only negligible current, the potentiometer can have sufficiently high resistance so that it will not substantially affect the voltage distribution at the taps of the shunted section of the divider. Within the specified adjustment range, it will be found that the accelerating-electrode voltage may be adjusted to obtain either maximum gain or maximum peak output current. In general, the adjustment to apply the highest voltage to the accelerating electrode will permit the highest peak current with some sacrifice in gain.

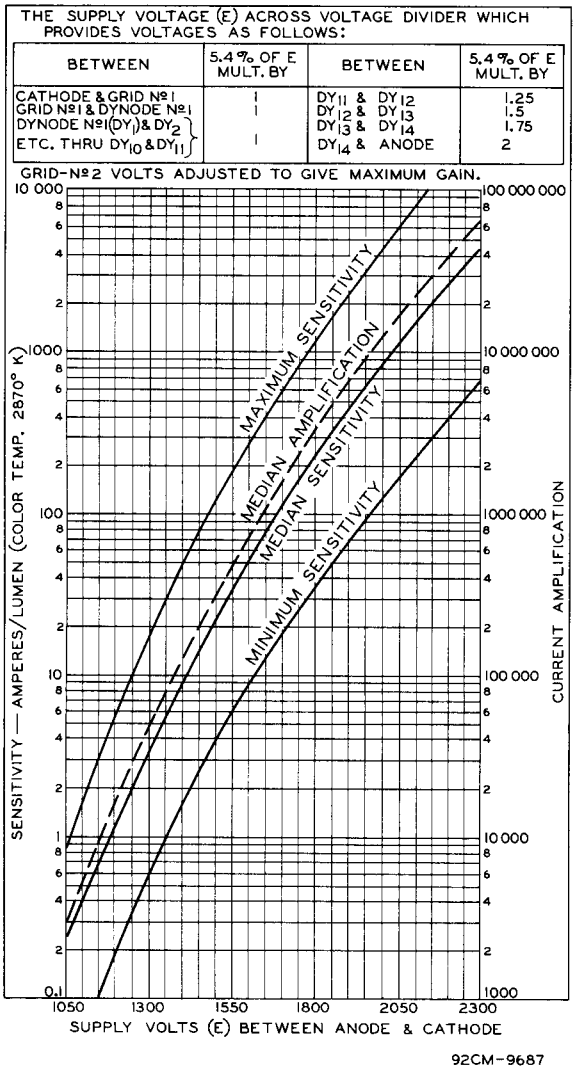


Fig. 4 - Characteristics of Type 7264 Used in Low-Light-Level, Low-Noise, High-Gain Service.

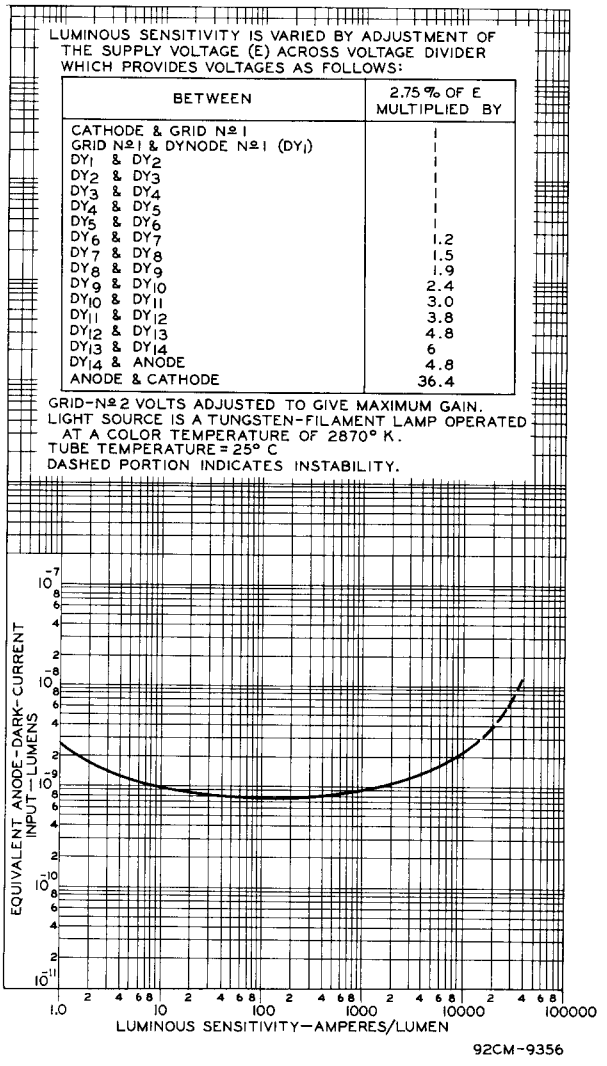


Fig. 5 - Typical Anode-Dark-Current Characteristic of Type 7264 Used in High-Output-Pulse Service.

In applications where it is desired to keep the statistical fluctuations to a minimum, e.g., as in nuclear radiation spectroscopy, the potential between cathode and dynode No. 1 may be increased to the rated maximum value of 400 volts.

A very small *dark current* is observed when voltage is applied to the electrodes of the 7264

in complete darkness. This current has a component caused by leakage, and a component consisting of pulses produced by electrons thermionically released from the cathode, by secondary electrons released by ionic bombardment of the dynodes or cathode, or by cold emission from the electrodes.

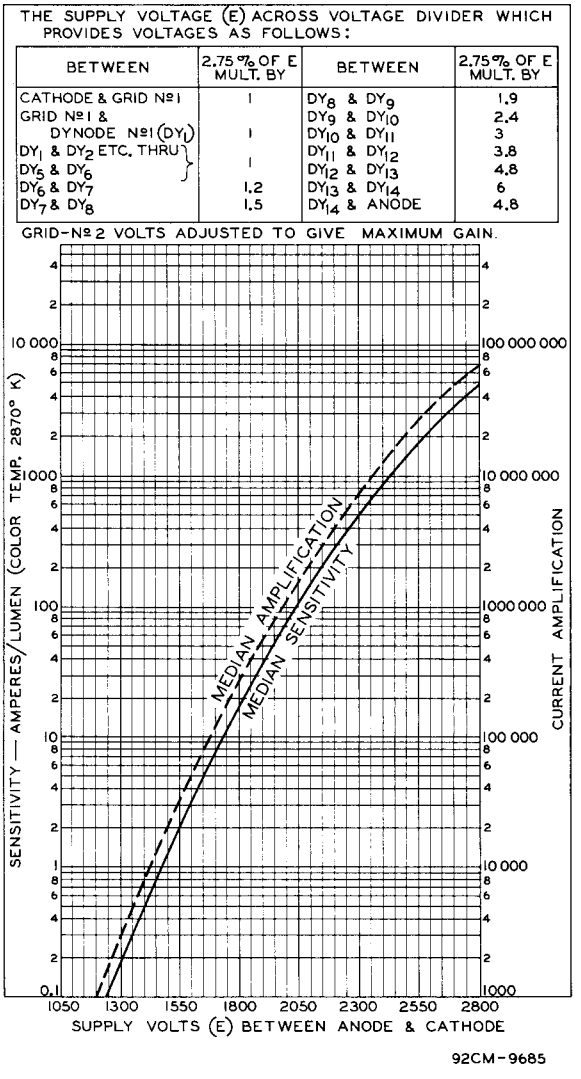


Fig. 6 - Characteristics of Type 7264 Used in High-Output-Pulse Service.

The magnitude of the dark current establishes a limit below which the exciting radiation on the cathode can not be detected.

When the application utilizes *continuous luminous excitation and dc anode current*, and it is desired to have a high ratio of signal output to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig. 3 or Fig. 5 which shows the equivalent anode-dark-current input as a function of luminous sensitivity for the 7264 and the curve in Fig. 4 or Fig. 6 which shows luminous sensitivity as a function of the supply voltage. The voltage between dynode No. 14 and the anode should be kept as low as will permit operation at a point just giving anode-current saturation.

In applications involving low-light-level *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 1500 to 2000 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise power spectrum is essentially flat up to about 50 megacycles per second. Regenerative phenomena, which may occur at voltages above 2000 volts, contribute to the noise.

The noise spectrum of the 7264 is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of the exciting signal in order to eliminate as much noise as possible.

In applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice, to cool the bulb of the 7264 is recommended. The resulting reduction in thermionic emission from the cathode lowers the detection threshold to give improved operation.

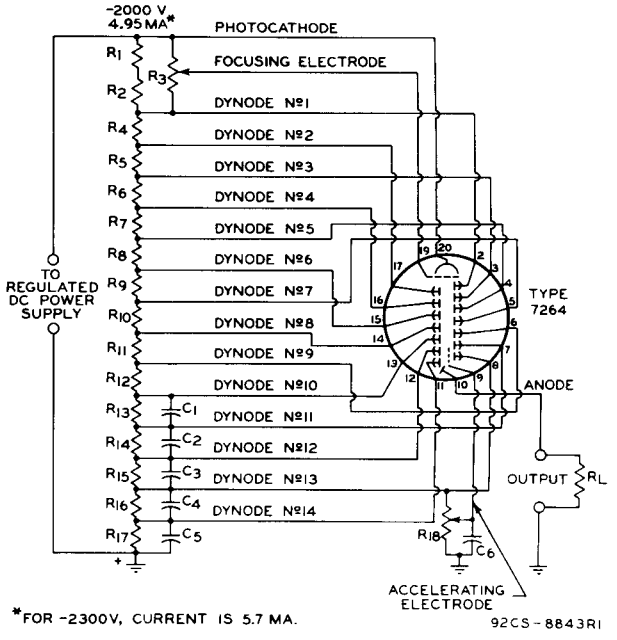
Exposing the 7264 to strong ultraviolet radiation may cause an increase in anode dark current. After cessation of such irradiation, the dark current drops rapidly.

The *operating stability* of the 7264 is dependent on the magnitude of the anode current and its duration. When the 7264 is operated at high average values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 7264 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 2 milliamperes is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 250 microamperes.

Electrostatic and/or magnetic shielding of the 7264 may be necessary. It is to be noted that the use of an external magnetic and/or electrostatic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 7264. Although the metallic coating on the inner side wall of the glass bulb serves to reduce the amount of extraneous light reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous light.



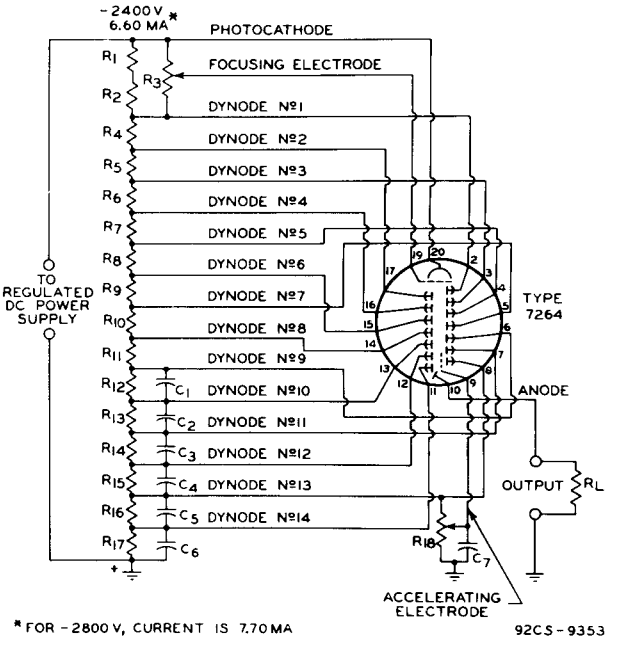
C_1 = 25 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_2 = 50 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_3 = 100 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_4 = 250 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_5 = 500 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_6 = 100 $\mu\mu$f, disk ceramic, 1000 volts (dc working)
R_1 = 24000 ohms, 1 watt
R_2 = 22000 ohms, 1 watt
R_3 = 1 megohm, 2 watts, adjustable
R_4 through R_{13} = 22000 ohms, 1 watt
R_{14} = 27000 ohms, 2 watts
R_{15} = 33000 ohms, 2 watts
R_{16} = 39000 ohms, 2 watts
R_{17} = 43000 ohms, 2 watts
R_{18} = 10 megohms, 2 watts, adjustable
R_L = Value will depend on magnitude of peak pulse voltage desired. For a peak pulse amplitude of 100 volts, the value is approximately 300 ohms.

Note: Capacitors C_1 through C_6 should be connected at tube socket.

Fig.7 - Voltage-Divider Arrangement for Type 7264 Used in Low-Light-Level, Low-Noise, High-Gain Service.

The *dc supply voltages* for each dynode and for the anode can be supplied by spaced taps on a voltage divider across a regulated dc power supply. The current through the voltage divider will depend on the voltage regulation and the linearity required by the application. In general, the current in the divider should be several times the maximum value of anode current. The value should also be adequate to prevent variations of the dynode potentials by the signal current.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.



C_1 = 25 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_2 = 39 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_3 = 150 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_4 = 750 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_5 = 4000 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_6 = 40000 $\mu\mu$f, (4-10000 $\mu\mu$f disk ceramic, 600 volts (dc working) connected in parallel)
C_7 = 150 $\mu\mu$f, disk ceramic, 1000 volts (dc working)
R_1 = 10000 ohms, 1 watt
R_2 = 10000 ohms, 1 watt
R_3 = 1 megohm, 2 watts, adjustable
R_4 through R_8 = 10000 ohms, 1 watt
R_9 = 12000 ohms, 1 watt
R_{10} = 15000 ohms, 1 watt
R_{11} = 20000 ohms, 2 watts
R_{12} = 24000 ohms, 2 watts
R_{13} = 30000 ohms, 2 watts
R_{14} = 39000 ohms, 4 watts
R_{15} = 47000 ohms, 4 watts
R_{16} = 60000 ohms, 4 watts
R_{17} = 47000 ohms, 4 watts
R_{18} = 1 megohm, 2 watts, adjustable
R_L = Value will depend on magnitude of peak pulse voltage desired. For a peak pulse amplitude of 100 volts, the value is approximately 200 ohms.

Note: Capacitors C_1 through C_7 should be connected at tube socket.

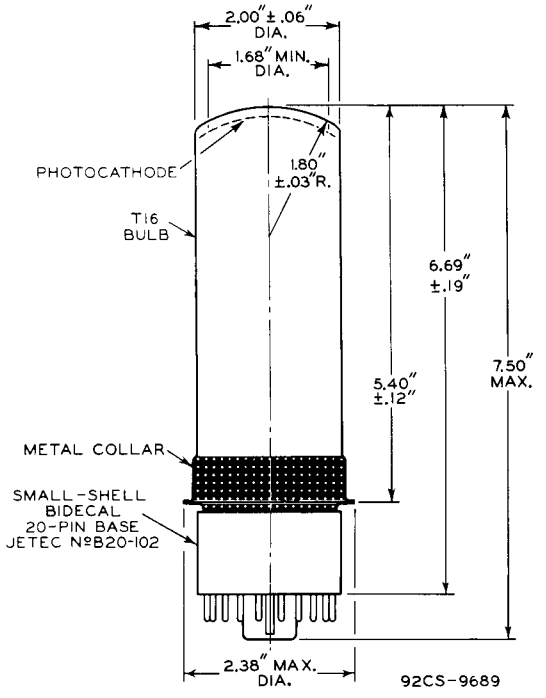
Fig.8 - Voltage-Divider Arrangement for Type 7264 Used in High-Output-Pulse Service.

Typical voltage-divider arrangements for use with the 7264 are shown in Figs.7 and 8.

The high voltages at which the 7264 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 7264, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

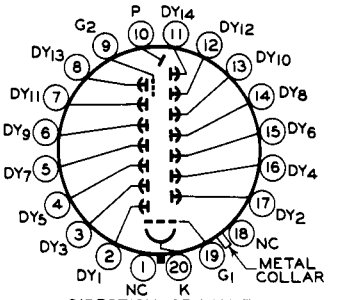
DIMENSIONAL OUTLINE



℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF THE BOTTOM OF THE BASE.

SOCKET CONNECTIONS

Bottom View



20D

PIN 1: NO CONNECTION
PIN 2: DYNODE No.1
PIN 3: DYNODE No.3
PIN 4: DYNODE No.5
PIN 5: DYNODE No.7
PIN 6: DYNODE No.9
PIN 7: DYNODE No.11
PIN 8: DYNODE No.13
PIN 9: GRID No.2 (ACCELERATING ELECTRODE)
PIN 10: ANODE
PIN 11: DYNODE No.14
PIN 12: DYNODE No.12
PIN 13: DYNODE No.10
PIN 14: DYNODE No.8
PIN 15: DYNODE No.6
PIN 16: DYNODE No.4
PIN 17: DYNODE No.2
PIN 18: NO CONNECTION
PIN 19: GRID No.1 (FOCUSING ELECTRODE)
PIN 20: PHOTOCATHODE
METAL COLLAR: NO CONNECTION. NOTE - If used, connect only to photocathode.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

7265

MULTIPLIER PHOTOTUBE

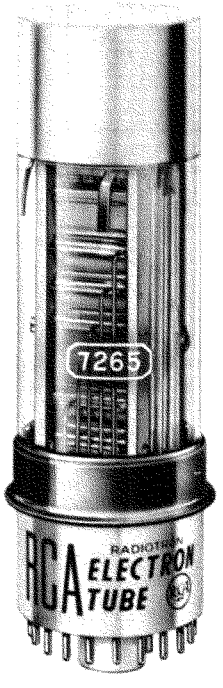
1.68" Dia. Curved Circular Semitransparent Photocathode

14-Stage, Head-On Type, Flat Faceplate
S-20 Response
Very-Short Time Resolution Capability

7.5" Max. Length
2.38" Max. Diameter
Bidecal 20-Pin Base

TENTATIVE DATA

RCA-7265 is a head-on type of multiplier phototube intended for use in scintillation counters for the detection and measurement of nuclear radiation, and in applications such as flying-spot scanning and low-level photometry, which require low dark current as well as high sensitivity over the entire visible spectrum.



The spectral response of the 7265 covers the range from about 3000 to 7500 angstroms, with maximum response at approximately 4200 angstroms, as shown in Fig. 1. It will be noted that the response extends beyond the visible region into the blue region on the one end and well into the red region on the other end.

The 7265 utilizes a new and improved semitransparent photocathode characterized by high sensitivity, low thermionic dark current, and high conductivity even at low temperatures. The photocathode may be cooled to liquid-air temperature to reduce its low thermionic dark current to an extremely low value without sacrificing its conductivity to such an extent that its current-carrying capability is impaired.

Design features of the 7265 include dynodes with stable high-current-carrying capability; focusing electrode with external connection for shaping the field which directs photoelectrons from the photocathode onto the first dynode; an accelerating electrode with external connection for minimizing the space-charge effect in the region of dynode No. 12; and a semitransparent photocathode on the curved inner surface of the face end of the bulb.

The focusing electrode permits optimizing the magnitude, uniformity, or speed of the response in critical applications.

The curved photocathode surface of the 7265 assures very good collection by dynode No. 1 of electrons from all parts of the useful photocathode area, and thus makes possible a typical pulse-height resolution of about 8 per cent. The use of the curved surface together with the electrode configuration employed in the 7265 results in extremely small variation in electron-transit time between the photocathode and dynode No. 1.

The 7265 is capable of delivering pulse currents having magnitudes up to 0.5 ampere without appreciable deviation from linearity. Consequently, the need for an associated wide-band amplifier to amplify the output pulse is eliminated in many applications.

The internal leads from dynode No. 14 and anode to their respective base-pin terminals are short and direct. This arrangement makes possible the use of a load circuit having a short time constant--an essential feature in pulse service.

The 7265 is capable of multiplying feeble photoelectric current produced at the cathode by a median value of 9,350,000 times when operated with a supply voltage of 2400 volts. The output current of the 7265 is a linear function of the exciting illumination under normal operating conditions.

DATA

General:

Spectral Response		S-20
Wavelength of Maximum Response		4200 ± 500 angstroms
Cathode, Semitransparent:		
Shape		Curved Circular
Window:		
Area	2.2	sq. in.
Minimum diameter	1.68	in.
Index of Refraction	1.51	

Trademark(s) ® Registered
Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7265 9-58
Printed in U.S.A.

Direct Interelectrode Capacitances (Approx.):		
Anode to dynode No.14	2.8	μμf
Anode to all other electrodes	6	μμf
Dynode No.14 to all other electrodes	7.5	μμf
Maximum Overall Length	7.5"	
Seated Length	6.69" ± 0.19"	
Maximum Diameter	2.38"	
Bulb	T-16	
Base	Small-Shell Bidecal 20-Pin (JETEC No.B20-102)	
Socket	Alden No.220FT with 20 Contacts⊕, or equivalent	
Operating Position	Any	
Weight (Approx.)	8 oz	

Maximum Ratings, *Absolute Values:*

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE (DC)	3000 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.14 AND ANODE (DC)	500 max.	volts
SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES (DC)	600 max.	volts
SUPPLY VOLTAGE BETWEEN ACCELERATING ELECTRODE AND DYNODE No.13 (DC)	±600 max.	volts
DYNODE-No.1 SUPPLY VOLTAGE (DC)	500 max.	volts
FOCUSING-ELECTRODE SUPPLY VOLTAGE (DC)	500 max.	volts
AVERAGE ANODE CURRENT●	1 max.	ma
AMBIENT TEMPERATURE	85 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing electrode voltages shown in Table 1.

With E = 2400 volts (except as noted) and Accelerating-Electrode Voltage adjusted to give maximum gain.

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms	–	0.6	–	amp/μw
Cathode Radiant, at 4200 angstroms	–	0.064	–	μa/μw
Luminous:#				
At 0 cps	165	1400	6800	amp/lumen
With dynode No.14 as output electrode†	–	980	–	amp/lumen
Cathode Luminous:				
With tungsten light source▲	100	150	–	μa/lumen
With blue light source**	0.05	–	–	μa
With red light source□	0.30	–	–	μa
Current Amplification	–	9.35×10^6	–	
Equivalent Anode-Dark-Current Input⊕■	–	2×10^{-10}	8×10^{-10}	lumen
Equivalent Noise input:★				
At +25° C	–	7.5×10^{-13}	3.3×10^{-12}	lumen
At −80° C	–	1×10^{-13}	–	lumen
Anode-Pulse Rise Time‡	–	3	–	milliμsec
Greatest Delay Between Anode Pulses:				
Due to position from which electrons are simultaneously released within a circle centered on tube face and having a diameter of--				
1-1/8"	–	1●	–	milliμsec
1-9/16"	–	3●	–	milliμsec

⊕ Made by Alden Products Company, Brockton, Massachusetts.

TABLE 1

VOLTAGE TO BE PROVIDED BY DIVIDER	
Between	**5.4% of Supply Voltage (E) multiplied by**
Cathode and Focusing Electrode*	1.6
Cathode and Dynode No.1	2
Dynode No.1 and Dynode No.2	1
Dynode No.2 and Dynode No.3	1
Dynode No.3 and Dynode No.4	1
Dynode No.4 and Dynode No.5	1
Dynode No.5 and Dynode No.6	1
Dynode No.6 and Dynode No.7	1
Dynode No.7 and Dynode No.8	1
Dynode No.8 and Dynode No.9	1
Dynode No.9 and Dynode No.10	1
Dynode No.10 and Dynode No.11	1
Dynode No.11 and Dynode No.12	1.25
Dynode No.12 and Dynode No.13	1.5
Dynode No.13 and Dynode No.14	1.75
Dynode No.14 and Anode	2
Anode and Cathode	18.5

* The metal collar (See *Dimensional Outline*) is connected internally to the focusing electrode. Extreme care should be taken in the design of apparatus to prevent operating personnel from coming in contact with the collar when the circuit application is such that the collar is at high potential.

● Averaged over any interval of 30 seconds maximum.

\# Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870° K. A light input of 0.1 microlumen is used. The load resistor has a value of 0.01 megohm.

† An output current of opposite polarity to that obtained at the anode may be provided by using dynode No.14 as the output electrode. With this arrangement, the load is connected in the dynode-No.14 circuit and the anode serves only as collector.

▲ Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux is 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected together as anode. The load resistor has a value of 0.01 megohm.

** Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 200 volts are applied between cathode and all other electrodes connected together as anode.

□ Under the following conditions: Light incident on the cathode is transmitted through a red filter (Corning, Glass Code No.2418, or equivalent) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 200 volts are applied between cathode and all other electrodes connected together as anode.

⊕ Measured at a tube temperature of 25° C and with the supply voltage (E) adjusted to give a luminous sensitivity of 1000 amperes per lumen. Dark current caused by thermionic emission may be reduced by the use of a refrigerant.

■ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 2400 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 2400 volts, external shield connected to metal

collar, ac-amplifier bandwidth of 1 cycle per second, tungsten light source of 2870° K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

‡ Measured between 10 per cent and 90 per cent of the maximum anode-pulse height. This anode-pulse rise time is determined primarily by transit-time variations in the multiplier stages only and with an incident light spot approximately 1 millimeter in diameter centered on the photocathode.

♦ These values also represent the difference in time of transit between the photocathode and dynode No.1 for electrons simultaneously released from the center and from the periphery of the specified area.

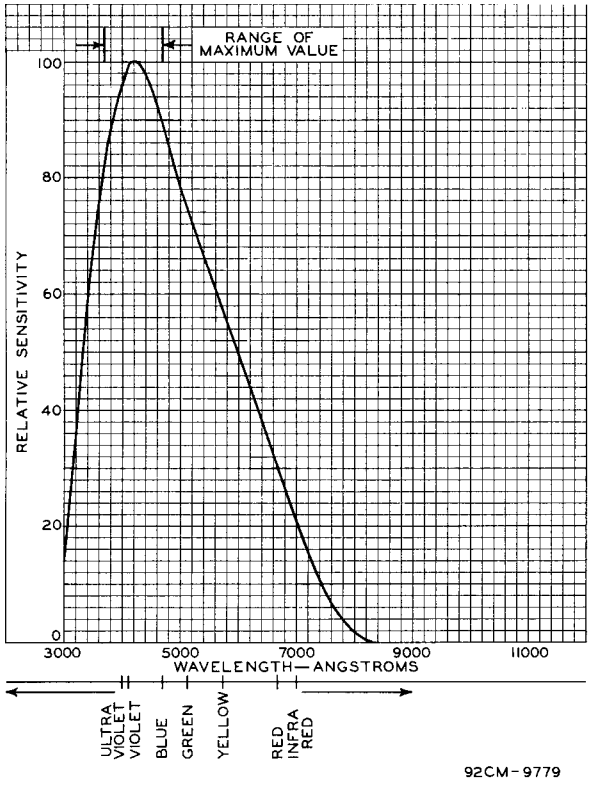


Fig. 1 - Tentative Spectral Sensitivity Characteristic of Type 7265 which has S-20 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Pulse Rise Time. The time required for the instantaneous amplitude of the pulse to go from 10 per cent to 90 per cent of the peak value.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

In general, *supply voltages* for the electrodes of the 7265 should be provided as shown in Table 1.

The operating voltage between dynode No.14 and anode should be kept as low as will permit operation with anode-current saturation. Referring to the anode characteristics curves, shown in Fig.2, it will be seen that saturation occurs in the approximate range of 50 to 100 volts. With low operating voltage between dynode No.14 and anode, the dark current is reduced. As a result, the operating stability of the 7265 is improved without sacrifice in sensitivity. To obtain the indicated operating voltage between dynode No.14 and anode, it will be necessary to increase the supply voltage between these electrodes above the operating voltage by an amount to allow for the signal-output voltage desired.

The *focusing-electrode potential* may be adjusted between that of the photocathode and that of dynode No.1 to optimize the magnitude uniformity or speed of the response. The voltage for the focusing electrode can be obtained by connecting it to the arm of a potentiometer between cathode and dynode No.1 in the voltage divider.

The *accelerating electrode,* when operated at a suitable potential with respect to dynode No.13, serves to minimize the effect of space charge in the region of dynode No.12. Provision should be made to adjust the accelerating-electrode voltage over a range extending from the value at which dynode No.13 operates to that at which the

anode operates. The adjustment may be accomplished by means of a high-resistance potentiometer connected between the voltage-divider tap for dynode No.13 and the anode end of the voltage divider. Since the accelerating electrode draws at most only negligible current, the potentiometer can have sufficiently high resistance so that it will not substantially affect the voltage distribution at the taps of the shunted section of the divider. Within the specified adjustment range, it will be found that the accelerating-electrode voltage may be adjusted to obtain either maximum gain or maximum peak output current. In general, the adjustment to apply the highest voltage to the accelerating electrode will permit the highest peak current with some sacrifice in gain.

In applications where it is desired to keep the statistical fluctuations to a minimum, e.g., as in nuclear radiation spectroscopy, the potential between cathode and dynode No.1 may be increased to the rated maximum value of 500 volts.

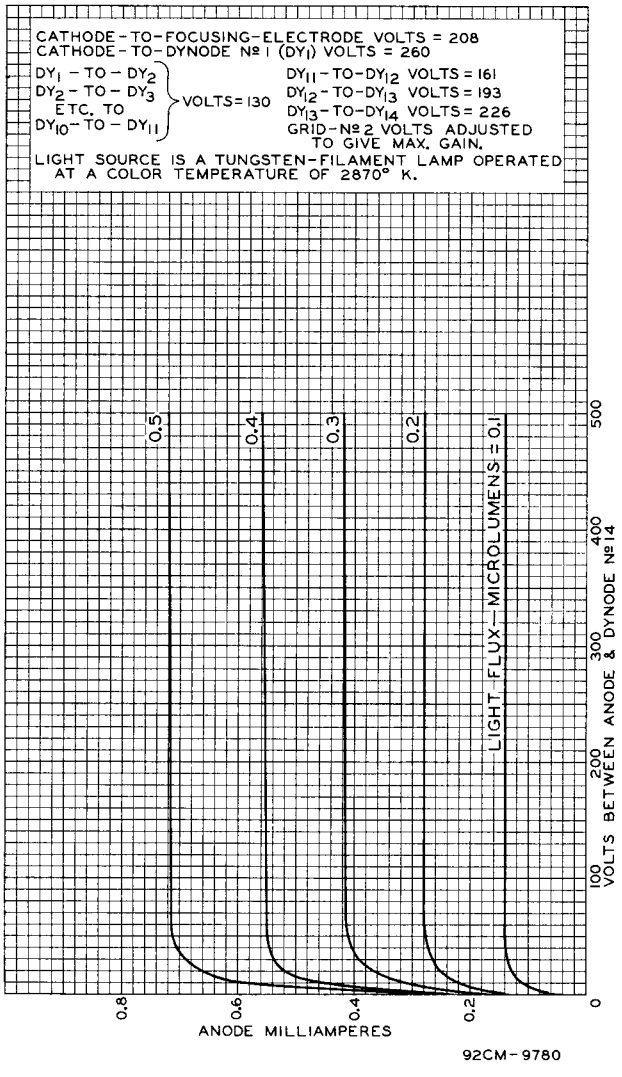


Fig. 2 - Average Anode Characteristics of Type 7265.

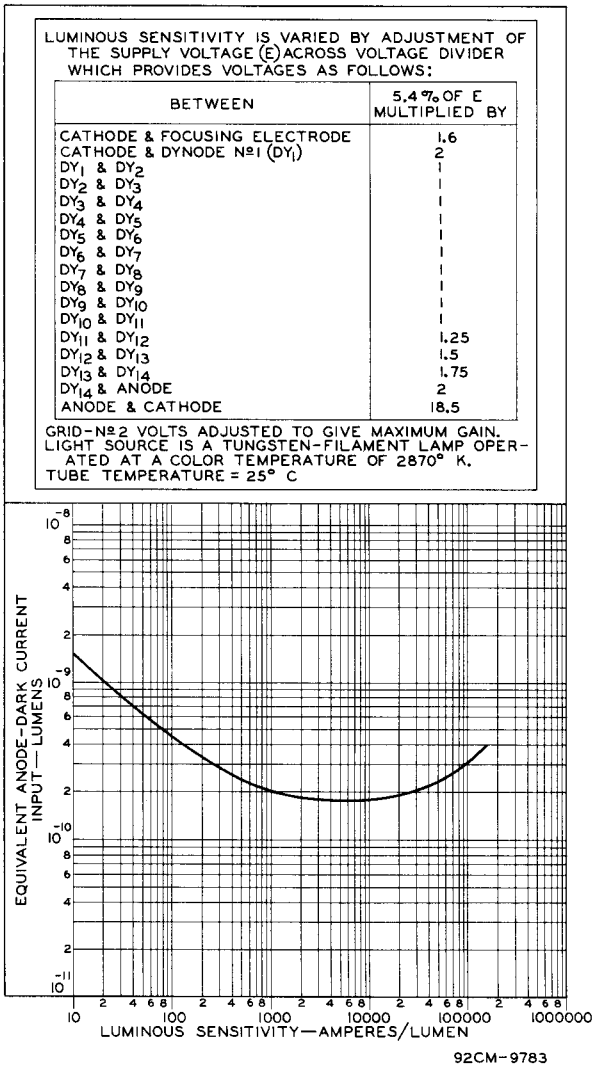


Fig. 3 - Typical Anode-Dark-Current Characteristic of Type 7265.

A very small *dark current* is observed when voltage is applied to the electrodes of the 7265 in complete darkness. This current has a component caused by leakage, and a component consisting of pulses produced by electrons thermionically released from the cathode, by secondary electrons released by ionic bombardment of the dynodes or cathode, or by cold emission from the electrodes. The magnitude of the dark current establishes a limit below which the exciting radiation on the cathode can not be detected.

When the application utilizes *continuous luminous excitation and dc anode current*, and it is desired to have a high ratio of signal output to dark current, it is recommended that the operating supply voltage (E) be determined with reference to the curve in Fig.3 which shows the equivalent anode-dark-current input as a function of luminous sensitivity for the 7265 and the curve in Fig.4 which shows luminous sensitivity as a function of the supply voltage.

In applications involving low-light-level *pulsed excitation and ac coupling at the anode*, the best signal-to-noise ratio is obtained with a supply voltage (E) in the range from 2200 to 2600 volts. Within this range, the noise at the anode is produced primarily by the statistical release of thermal electrons, and the noise power spectrum is essentially flat up to about 50 megacycles per second. Regenerative phenomena, which may occur at voltages above 2000 volts, contribute to the noise.

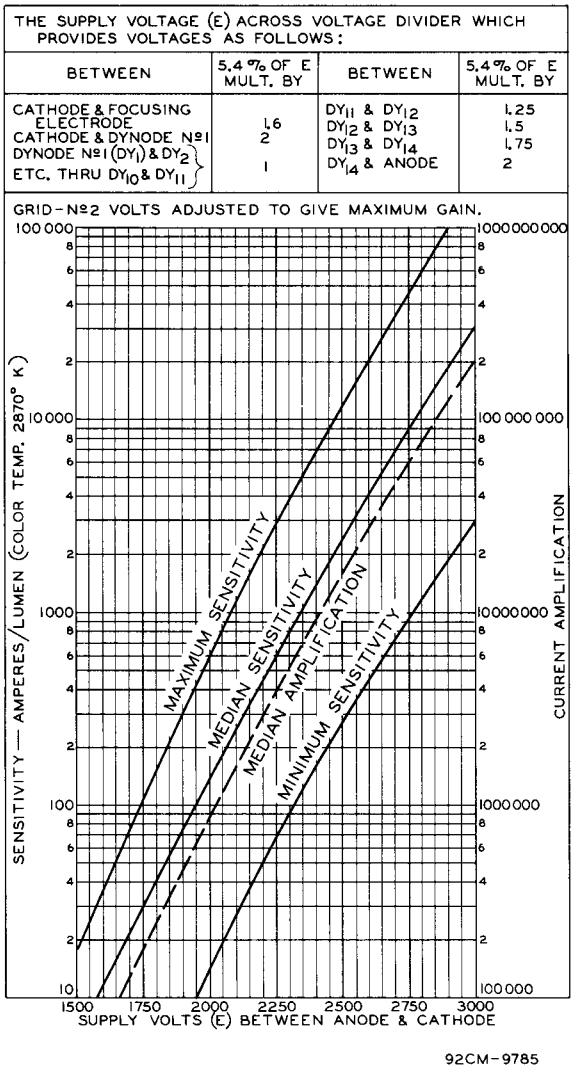
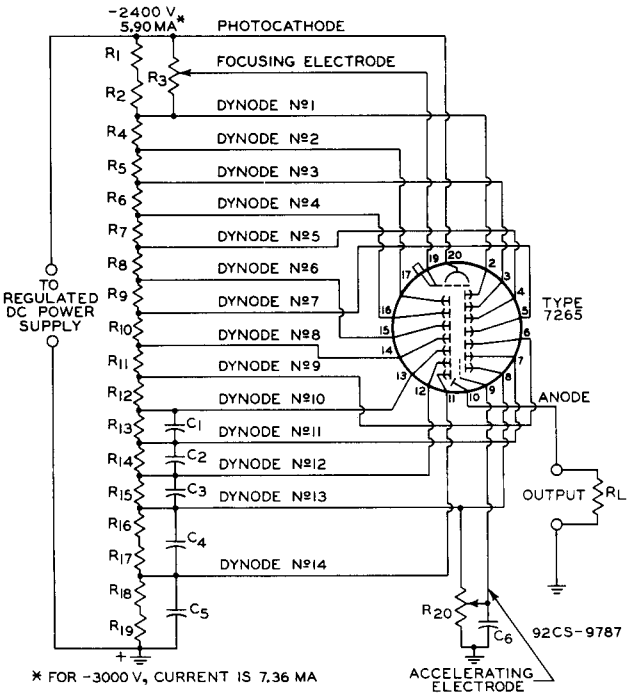


Fig.4 - Characteristics of Type 7265.



C_1 = 25 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_2 = 50 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_3 = 100 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_4 = 250 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_5 = 500 $\mu\mu$f, disk ceramic, 600 volts (dc working)
C_6 = 100 $\mu\mu$f, disk ceramic, 1000 volts (dc working)
R_1 = 24000 ohms, 1 watt
R_2 = 22000 ohms, 1 watt
R_3 = 1 megohm, 2 watts, adjustable
R_4 through R_{13} = 22000 ohms, 1 watt
R_{14} = 27000 ohms, 2 watts
R_{15} = 33000 ohms, 2 watts
R_{16} = 22000 ohms, 2 watts
R_{17} = 18000 ohms, 2 watts
R_{18} = 22000 ohms, 2 watts
R_{19} = 22000 ohms, 2 watts
R_{20} = 10 megohms, 2 watts, adjustable
R_L = Value will depend on magnitude of peak pulse voltage desired. For a peak pulse amplitude of 100 volts, the value is approximately 300 ohms.

Note: Capacitors C_1 through C_6 should be connected at tube socket.

Fig.5 - Voltage-Divider Arrangement for Type 7265.

The noise spectrum of the 7265 is such that the threshold of pulse detection depends on the associated circuitry. The bandpass filter should be designed to pass only the frequency range of the exciting signal in order to eliminate as much noise as possible.

In applications where maximum gain with unusually low dark current is required, the *use of a refrigerant*, such as dry ice or liquid air,

to cool the bulb of the 7265 is recommended. The resulting reduction in thermionic emission from the cathode lowers the detection threshold to give improved operation.

Exposing the 7265 to strong ultraviolet radiation may cause an increase in anode dark current. After cessation of such irradiation, the dark current drops rapidly.

The *operating stability* of the 7265 is dependent on the magnitude of the anode current and its duration. When the 7265 is operated at high average values of anode current, a drop in sensitivity (sometimes called fatigue) may be expected. The extent of the drop below the tabulated sensitivity values depends on the severity of the operating conditions. After a period of idleness, the 7265 usually recovers a substantial percentage of such loss in sensitivity.

The use of an average anode current well below the maximum rated value of 1 milliampere is recommended when stability of operation is important. When maximum stability is required, the anode current should not exceed 250 microamperes.

Electrostatic and/or magnetic shielding of the 7265 may be necessary. The shield should be connected to a potential near that of the cathode. It is to be noted that the use of an external magnetic and/or electrostatic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

Adequate *light shielding* should be provided to prevent extraneous light from reaching any part of the 7265. Although the metallic coating on the inner side wall of the glass bulb serves to reduce the amount of extraneous light reaching the electrodes, it is inadequate to shield completely the entire structure from extraneous light.

The *dc supply voltages* for each dynode and for the anode can be supplied by spaced taps on a voltage divider across a regulated dc power supply. The current through the voltage divider will depend on the voltage regulation and the linearity required by the application. In general, the current in the divider should be several times the maximum value of anode current. The value should also be adequate to prevent variations of the dynode potentials by the signal current.

In most applications, it is recommended that the positive high-voltage terminal be grounded in order that the output signal will be produced between anode and ground. This method prevents power-supply fluctuations from being coupled directly into the signal-output circuit.

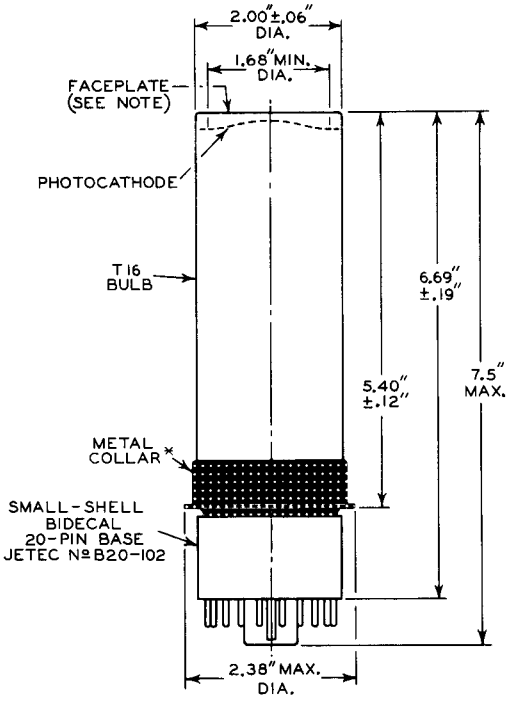
A typical voltage-divider arrangement for use with the 7265 is shown in Fig.5.

The high voltages at which the 7265 is operated are very dangerous. Care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In the use of the 7265, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, because of defective circuit parts or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



* MUST BE ADEQUATELY INSULATED

92CS-9786

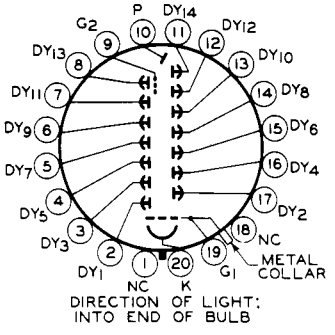
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: WITHIN 1.68" DIAMETER, DEVIATION FROM FLATNESS OF EXTERNAL SURFACE OF FACEPLATE WILL NOT EXCEED 0.005" FROM PEAK TO VALLEY.

SOCKET CONNECTIONS

Bottom View

PIN 1: NO CONNECTION
PIN 2: DYNODE No.1
PIN 3: DYNODE No.3
PIN 4: DYNODE No.5
PIN 5: DYNODE No.7
PIN 6: DYNODE No.9
PIN 7: DYNODE No.11
PIN 8: DYNODE No.13
PIN 9: GRID No.2 (ACCELERATING ELECTRODE)
PIN 10: ANODE
PIN 11: DYNODE No.14
PIN 12: DYNODE No.12
PIN 13: DYNODE No.10
PIN 14: DYNODE No.8



PIN 15: DYNODE No.6
PIN 16: DYNODE No.4
PIN 17: DYNODE No.2
PIN 18: NO CONNECTION
PIN 19: GRID No.1 (FOCUSING ELECTRODE)
PIN 20: PHOTOCATHODE
METAL COLLAR: CONNECTED INTERNALLY TO FOCUSING ELECTRODE--DO NOT MAKE ELECTRICAL CONNECTION TO COLLAR.
NOTE - THE METAL COLLAR MAY BE AT HIGH POTENTIAL DEPENDING ON THE CIRCUIT APPLICATION AND SHOULD BE INSULATED ACCORDINGLY.

20C

from JEDEC release #2809, Aug. 1, 1960

7295-A

IMAGE ORTHICON

For High-Quality Black-and-White TV Cameras

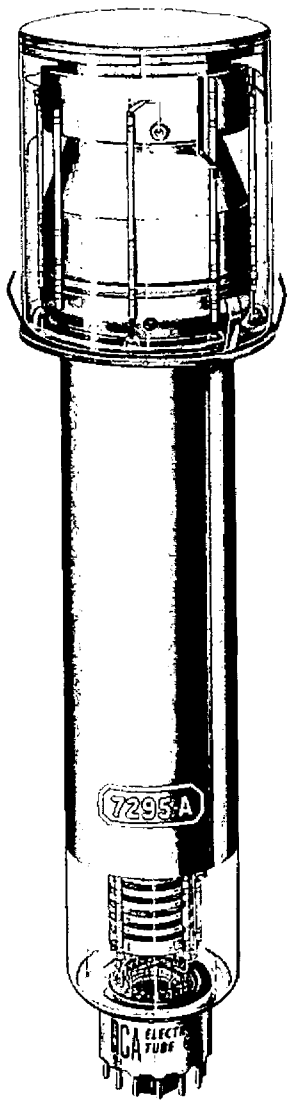
Magnetic Focus
Magnetic Deflection

Outdoor and Studio Pickup
Excellent Resolution Capability

4.500" Diameter
19.375" Length

This Type is Unilaterally Interchangeable with the 7295.

RCA-7295-A is a versatile 4-1/2-inch camera tube of the image-orthicon type intended for use in high-quality black-and-white TV cameras. The 7295-A requires only a very narrow range of camera control adjustment for optimum performance and stable day-to-day operation. Because of its excellent performance capability over a wide range of different lighting conditions, the 7295-A is well suited for either outdoor or studio pickup.



The superior quality of the picture signal from the 7295-A also permits the making of a series of successive recordings while still retaining excellent picture quality.

The 7295-A features a high signal-to-noise ratio, excellent resolution capability, good sensitivity, and a spectral response that approaches that of the eye. The 7295-A has high blue sensitivity, high green sensitivity, and negligible infrared sensitivity. The spectral sensitivity characteristic of the 7295-A is shown in Fig.1.

Other features of the 7295-A include a high-capacitance target assembly which has a usable area almost 3 times greater than that of conventional 3-inch image orthicons, a micro-mesh target-screen, and a field mesh.

The increased area of the high-capacitance target greatly improves the resolution capability of the 7295-A and provides black-and-white TV pictures, which in addition to having greater contrast, are sharper, clearer, and more realistic. Despite the increased size of its image section, the 7295-A uses the same optics and same optical-image size that are required with 3-inch tubes.

The micro-mesh screen, which has a fineness of 750 lines per inch, prevents mesh pattern and moiré effect without the need for defocusing and permits operation of the tube with aperture-correction circuitry to provide full response for fine-detail information.

The *field mesh* reduces "white-edge" effects and geometric distortion due to beam bending and, as a consequence, a picture of better photographic quality and realism is obtained. The field mesh also improves the beam trajectory and thus eliminates dark corners in the picture area.

PRINCIPLES OF OPERATION

The 7295-A has three sections — an image section, a scanning section, and a multiplier section — as shown in Fig.2.

Image Section

The image section contains a semitransparent photocathode, on the inside of the faceplate, a grid (grid No.6) which together with the photocathode provides an electrostatic accelerating field, and a target which consists of a very thin glass disc with a fine micro-mesh screen very closely spaced to it on the photocathode side. Focusing is accomplished by means of a non-uniform graded magnetic field produced by an external coil, and by the electrostatic accelerating field produced between the photocathode and grid No.6. Control of the electrostatic field shape for best focus is effected by the proper selection of photocathode voltage and adjustment of grid-No.6 voltage.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7295-A 6-60
Printed in U.S.A.

Light from the scene being televised is picked up by an optical system and focused on the photocathode which emits electrons from each illuminated area in proportion to the intensity of the light striking the area. The streams of electrons are focused on the target by the magnetic and electrostatic accelerating fields. The shape of the graded magnetic field is such that the optically-focused photocathode image is electro-optically magnified between the photocathode and the target.

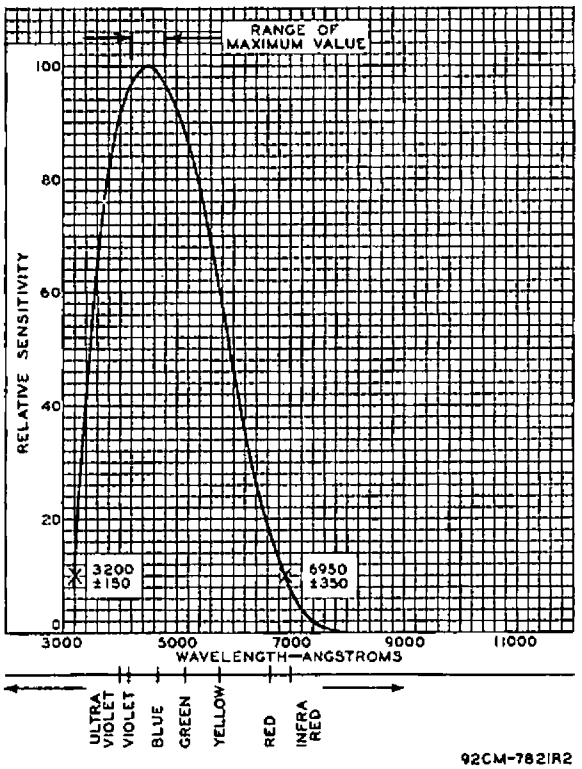


Fig. 1 - Spectral Sensitivity Characteristic of Type 7295-A which has S-10 Response. Curve is shown for Equal Values of Radiant Flux at All Wavelengths.

On striking the target, the electrons cause secondary electrons to be emitted by the glass. The secondaries thus emitted are collected by the adjacent mesh screen which is held at a definite small positive potential with respect to target-cutoff voltage. Therefore, the potential of the glass disc is limited for all values of light and stable operation is achieved. Emission of the secondaries leaves on the photocathode side of the glass a pattern of positive charges which corresponds to the pattern of light from the scene being televised. Because of the thinness of the glass, the charges set up a similar potential pattern on the opposite or scanned side of the glass.

Scanning Section

The opposite side of the glass is scanned by a low-velocity electron beam produced by the electron gun in the scanning section. This gun contains a thermionic cathode, a control grid (grid No. 1), and an accelerating grid (grid No. 2). The beam is focused at the target by the magnetic field of an external focusing coil and the electrostatic field of grid No. 4.

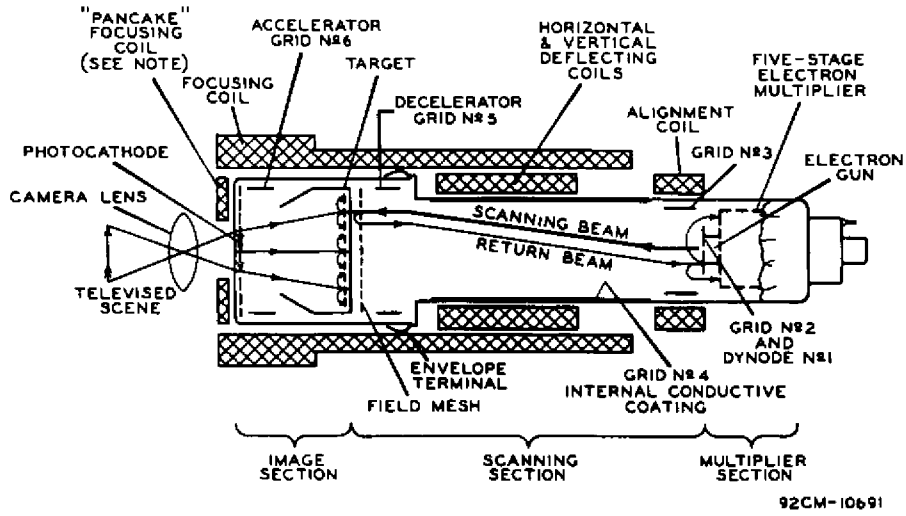
Deflection of the beam is accomplished by transverse magnetic fields produced by external deflecting coils.

Alignment of the beam from the gun is accomplished by a transverse magnetic field produced by external coils located at the gun end of the focusing coil.

By proper adjustment of potentials including that of grid No. 5 and the field mesh, the beam is caused to approach the target perpendicularly and with zero or nearly zero velocity. Electrons which approach uncharged portions of the pattern on the glass stop their forward motion at the surface of the glass and are turned back and focused into a five-stage signal multiplier. Beam electrons that approach positively charged portions of the pattern on the glass are deposited from the scanning beam in quantities sufficient to neutralize the potential pattern on the glass before the beam is turned back and focused into the signal multiplier. Such deposition leaves the glass with a negative charge on the scanned side and a positive charge on the photocathode side. These charges neutralize each other by conductivity through the glass in less than the time of one frame.

The electrons turned back at the target form the return beam which has been amplitude modulated by absorption of electrons at the target in accord with the charge pattern whose more positive areas correspond to the highlights of the televised scene.

The *field mesh*—a fine-mesh screen of high electron transmission—acts to increase the strength of the decelerating field immediately in front of the target. The field mesh also defocuses the return beam so that the texture of the first dynode does not appear in the background of the picture. The uniform gradient of the decelerating field over the scanned area causes the beam to approach the target perpendicularly at all points on the target. The enhanced field also prevents the charge pattern on the target from bending the beam away from its proper trajectory. The over-all result of these two effects is to enable the 7295-A to produce a picture that is relatively free of unwanted bright edges or overshoots at the boundary of brightly illuminated portions of a scene. The strong decelerating field also allows the 7295-A to be operated with high values of target voltage, and thereby, to produce high signal-to-noise ratios.



NOTE: "PANCAKE" FOCUSING COIL IS CONNECTED IN SERIES AIDING WITH MAIN FOCUSING COIL.

Fig. 2 – Schematic Arrangement of Type 7295-A and Associated Components.

Multiplier Section

The return beam is directed to the first dynode of a five-stage electrostatically focused multiplier. This utilizes the phenomenon of secondary emission to amplify the modulated beam current more than 500 times. The electrons in the beam impinging on the first-dynode surface produce many other electrons. These secondary electrons are then directed to the second dynode and knock out more new electrons. Grid No.3 facilitates a more complete collection by dynode No.2 of the secondaries from dynode No.1. The multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from dynode No.5 are collected by the anode and constitute the current utilized in the output circuit.

The signal-to-noise ratio of the output signal from the 7295-A is very high. The gain of the multiplier is such as to raise the output signal sufficiently above the noise level of the video amplifier stages so that they contribute no noise to the final video signal. The signal-to-noise ratio of the video signal, therefore, is determined primarily by random variation in the quantity of the electrons in the modulated electron beam.

As the beam moves from a less-positive portion on the target to a more-positive portion, the signal-output voltage across the load resistor changes in the positive direction. Hence, for highlights in the scene, the grid of the first video amplifier stage swings in the positive direction.

DATA

General:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current at 6.3 volts	0.6	ampere
Direct Interelectrode Capacitance:		
Anode to all other electrodes	12	μμf
Target-to-Mesh Spacing	0.002	inch
Spectral Response		S-10
Wavelength of Maximum Response	4500 ± 300	angstroms
Photocathode, Semitransparent:		
Rectangular image (4 x 3 aspect ratio):		
Useful size of	1.6" max.	Diagonal

Note: The size of the optical image focused on the photocathode should be adjusted so that its maximum diagonal does not exceed the specified value. The corresponding electron image on the target should have a size such that the corners of the rectangle just touch the target ring.

Orientation of . . . .Proper orientation is obtained when the vertical scan is essentially parallel to the plane passing through the center of the faceplate and the grid No.6 terminal. The horizontal and vertical scan should start at the corner of the picture between the grid No.6 and the photocathode terminals.

Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	19.375" ± 0.310"
Greatest Diameter of Bulb	4.500" ± 0.094"
Envelope Terminals	5
End Base	Small-Shell Diheptal 14-Pin Base (JEDEC Group 5, No.B14-45)

Operating Position. The tube should never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with the base up makes an angle of less than 20° with the vertical.

Weight (Approx.)	2.3 lbs
Minimum Deflecting-Coil Inside Diameter	3.2"
Deflecting-Coil Length	7"
Focusing-Coil Length	15"
Alignment Coil:	
Position on neck	Centerline of magnetic field should be located 9.25" from the flat area of the shoulder.

Maximum Ratings, *Absolute-Maximum Values:*♦

PHOTOCATHODE:		
Voltage	−700 max.	volts
Illumination	50 max.	fc
OPERATING TEMPERATURE:		
Any part of bulb	65 max.	°C
Of bulb at large end of tube (Image section)	35 min.	°C
TEMPERATURE DIFFERENCE:		
Between image section and any part of bulb hotter than image section	5 max.	°C
GRID-No.6 VOLTAGE	−700 max.	volts
TARGET VOLTAGE:		
Positive value	10 max.	volts
Negative value	10 max.	volts
FIELD-MESH VOLTAGE##	30 max.	volts
GRID-No.5 VOLTAGE	300 max.	volts
GRID-No.4 VOLTAGE	350 max.	volts
GRID-No.3 VOLTAGE	400 max.	volts
GRID-No.2 & DYNODE-No.1 VOLTAGE	350 max.	volts
GRID-No.1 VOLTAGE:		
Negative bias value	125 max.	volts
Positive bias value	0 max.	volts
VOLTAGE PER MULTIPLIER STAGE	350 max.	volts
ANODE-SUPPLY VOLTAGE#	1650 max.	volts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	125 max.	volts
Heater positive with respect to cathode	10 max.	volts

Typical Operating Values:*

Photocathode Voltage	−600	volts
Grid-No.6 Voltage (Image Focus) Approx. 50% of Photocathode Voltage□	−250 to −350	volts
Target Voltage Above Cutoff○	2 to 3	volts
Field Mesh Voltage##	15 to 25	volts
Grid-No.5 Voltage (Decelerator)	40	volts
Grid-No.4 Voltage (Beam Focus)	70 to 90	volts
Grid-No.3 Voltage⊕	250 to 275	volts
Grid-No.2 & Dynode-No.1 Voltage	280	volts
Grid-No.1 Voltage for Picture Cutoff	−45 to −115	volts
Dynode-No.2 Voltage	600	volts
Dynode-No.3 Voltage	800	volts
Dynode-No.4 Voltage	1000	volts
Dynode-No.5 Voltage	1200	volts
Anode Voltage	1250	volts
Target Temperature Range	35 to 45	°C
Minimum Peak-to-Peak Blanking Voltage	5	volts
Field Strength of Focusing Coil:▲		
At center of scanning section (Approx.)	60	gausses
In plane of photocathode (Approx.)	120	gausses
Field Strength of Alignment Coil	0 to 3	gausses

Performance Data:

With conditions shown under Typical Operating Values, target voltage adjusted to 3 volts above cutoff, and with the camera lens adjusted so that the picture highlights are twice those required to reach the "knee" of the light transfer characteristic except as otherwise specified.

	Min.	*Average*	*Max.*	
Cathode Radiant Sensitivity at 4500 angstroms	−	0.028	−	μa/μw
Anode Current (DC)	−	30	−	μa
Signal-Output Current (Peak to Peak)	5	−	30	μa
Ratio of Peak-to-Peak Highlight Video-Signal Current to RMS Noise Current for Bandwidth of 4.5 Mc	−	65:1	−	
Photocathode Illumination at 2870° K Required to Reach "Knee" of Light Transfer Characteristic	−	0.040	0.075	fc
Amplitude Response at 400 TV Lines per Picture Height (Per cent of large-area black to large-area white)**	40	56	−	%

♦ The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

With respect to grid No.4.

\# Dynode-voltage values are shown under *Typical Operating Values.*

* With 7295-A operated in RCA TK-12 camera at fixed photocathode voltage.

□ Adjust for optimum focus.

○ The target supply voltage should be adjustable from −5 to +5 volts.

⊕ Adjust to give the most uniformly shaded picture near maximum signal.

▲ Direction of current should be such that a north-seeking pole is attracted to the image end of the focusing coil, with the indicator located outside of and at the image end of the focusing coil.

** Measured with amplifier having flat frequency response.

OPERATING CONSIDERATIONS

Support for the 7295-A should be designed so that vibration and shock will not cause the tube to be displaced with respect to the focusing, deflecting, and alignment fields.

Proper orientation of the envelope terminal socket with respect to the deflecting field is essential, and is obtained when the plane that passes through the key on the diheptal base, the grid-No.6 terminal on the tube envelope, and the tube axis is parallel to the vertical deflection field. This orientation minimizes beat-pattern effects by placing the sides of the mesh holes at an angle of 45° with respect to the horizontal scanning lines.

The *deflecting yoke and focusing coil* used with the 7295-A incorporate means to prevent the magnetic field produced by the deflecting yoke from extending into the image section of the tube. Unless proper shielding is provided, cross talk from the deflecting yoke into the image section will cause the electron image to "jitter". This jitter produces a loss of picture sharpness.

A *blanking signal* should be supplied to the target to prevent the electron beam from striking the target during the return portions of the horizontal and vertical deflecting cycles.

Unless this is done, the camera-tube return lines will appear in the received picture.

The blanking signal is a series of negative voltage pulses. The voltage between pulses must be constant to prevent fluctuation of the target voltage. During the blanking period, the full beam current without video-signal modulation is returned to the multiplier and its multiplied output flows through the load resistance. Excessive amounts of blanking voltage applied to the target will impair resolution, because during retrace the emitted photoelectrons are no longer in focus with the target. A desirable amount of target blanking is 6 volts peak to peak.

Shading may be required even with optimum adjustment of voltage on grid No.3 in order to obtain a more uniformly shaded picture. A sawtooth waveform of adjustable amplitude and polarity at both the vertical- and horizontal-scanning frequency should be provided for insertion in the video amplifier to aid in obtaining a flat background.

Failure of scanning even for a few seconds may permanently damage the surface of the target. The damaged area shows up as a spot or line in the picture during subsequent operation.

The *operating temperature* of any part of the glass bulb should never exceed 65° C, and no part of the bulb at the large end of the tube (image section) should ever fall below 35° C during operation. For best results, it is recommended that the temperature of the entire bulb be held between 35° and 45° C. Operation at too low a temperature will be characterized by the appearance of a rapidly disappearing "sticking picture" of opposite polarity from the original when the picture is moved. Operation at too high a temperature will cause loss of resolution and possibly permanent damage to the tube. The loss of resolution is caused by the decreasing resistivity of the target glass disc with increasing temperature. As a result, lateral leakage of the image charge occurs. Tube temperature should always be checked if a loss in resolution occurs during tube operation. Resolution is regained by waiting for the temperature to drop. *No part of the bulb should run more than 5° C hotter than the image section to prevent cesium migration to the target.* Such migration will result in loss of resolution and in probable permanent damage to the tube. Like other photosensitive devices employing cesium, the 7295-A may show fluctuations in performance from time to time. Strict observance of the above recommendations with respect to operating temperature will not completely eliminate these variations but will greatly improve stability of the characteristics during the life of the tube.

When the operating conditions are such that the maximum temperature rating or maximum temperature difference as given under *Maximum Ratings* will be exceeded, provision should be made to direct a blast of cooling air from the diheptal-base end of the tube along the entire length of the bulb surface, i.e., through the space between the bulb surface and the surrounding deflecting-coil assembly and its extension.

To keep the operating temperature of the large end of the tube from falling below 35° C, some form of controlled heating should be employed. Ordinarily, adequate heat will be supplied by the focusing coil, deflecting coils, and associated amplifier tubes so that the temperature can be controlled by the amount of cooling air directed along the bulb surface. If, in special cases, an image-section heater is required, it should fit between the focusing coil and the bulb near the shoulder of the tube, and be non-inductively wound.

A *mask* having a diagonal or diameter of 1.6 inches should always be used on the photocathode to reduce the amount of light reaching unused parts of the photocathode.

The *optical system* used with the 7295-A should be of high quality and should incorporate control of the amount of light entering the television camera lens. This control may consist of an iris or an iris and suitable neutral-density filters. The entire optical system should have all inside surfaces finished in mat black to prevent internal reflections from reaching the photocathode. Under almost all conditions, the use of a lens shade is beneficial.

OPERATING INSTRUCTIONS

The 7295-A is designed to have stable operating characteristics which ensure optimum performance from day-to-day with minimum camera control adjustment.

Installation of the 7295-A in the camera is accomplished by inserting the diheptal-base end of the tube through the coil assembly and then inserting the tube in the envelope terminal socket. Proper insertion aligns the white radial line on the face with the bottom terminal socket for grid No.6. The 7295-A has two complementary guides for inserting the tube correctly, the grouping of the envelope terminals and a white radial line on the face of the envelope.

The *operating position* of the 7295-A should preferably be such that any loose particles in the neck of the tube will not fall down and strike or become lodged on the target. Therefore, it is recommended that the tube never be operated in a vertical position with the diheptal-base end up nor in any other position where the axis of the tube with base up makes an angle of less than 20° with the vertical.

Full-size scanning of the target should always be used during operation. Full-size

scanning can be assured by first adjusting the deflection circuits to overscan the target sufficiently to cause the edge of the target ring to be visible in the corners of the picture, and then reducing the scanning until the edge of the target ring just disappears. In this way, the maximum signal-to-noise ratio and maximum resolution can be obtained. Note that overscanning the target produces a smaller-than-normal picture on the monitor.

Underscanning the target, i.e., scanning an area of the target less than its sensitive area, should never be permitted. Underscanning produces a larger-than-normal picture on the monitor. If the target is underscanned for any length of time, a permanent change in target-cutoff voltage of the underscanned area takes place with the result that the underscanned area thenceforth is visible in the picture when full-size scanning is restored.

Retention of a scene by the 7295-A, sometimes called a "sticking picture", may be observed if the 7295-A is allowed to remain focused on a stationary bright scene, or if it is focused on a bright scene before reaching operating temperature in the range from 35° to 45° C. Often the retained image will disappear in a few seconds, but sometimes it may persist for long periods before it completely disappears. A persisting retained image can generally be removed by focusing the 7295-A on a clear white screen and allowing it to operate with an illumination of about 1 footcandle on the photocathode until the retained image disappears.

To minimize retention of a scene, it is recommended that the 7295-A always be allowed to warm up in the camera for 1/4 hour with the lens capped. Never allow the 7295-A to remain focused on a stationary bright scene, and never use more illumination than is necessary.

Occasionally, a *white spot* which does not change in size when the beam-focus voltage is varied, may be observed in the center of the picture. Such a spot, especially if it is visible on the monitor with the camera lens capped, is probably an ion spot. If the spot begins to grow in size with continuous operation, the 7295-A should be removed from service at once, and returned for re-processing. Continued operation of an image orthicon with an ion spot will eventually damage the target permanently.

Video Gain is controlled over a wide range by reducing the voltage on one of the multiplier dynodes. Provision to vary the voltage on dynode No.3 is generally provided in the camera as the *Video-Gain Control*. Because individual 7295-A's may have a dc output range of 10 to 1, such a gain control is required to prevent possible overload of the video amplifier when a 7295-A having a high signal output or high current amplification is used. However, this control should not be adjusted to reduce the output signal of the 7295-A to such a low value that noise in the video amplifier stages is contributed to the final video signal.

During *standby operation*, the lens of the camera should always be closed or capped. An effective method of performing the same end result is to cut off the photocathode voltage by means of a switch. The camera will instantly be ready for operation when the photocathode voltage is again turned on.

PERFORMANCE CHARACTERISTICS

The *light transfer characteristic* of the 7295-A changes for different illumination levels (see Reference 5). The basic light transfer characteristic of the 7295-A is shown in Fig.3. The light values shown are applicable only for the indicated kinds of illumination incident on the photocathode. This curve is representative only for small-area highlights.

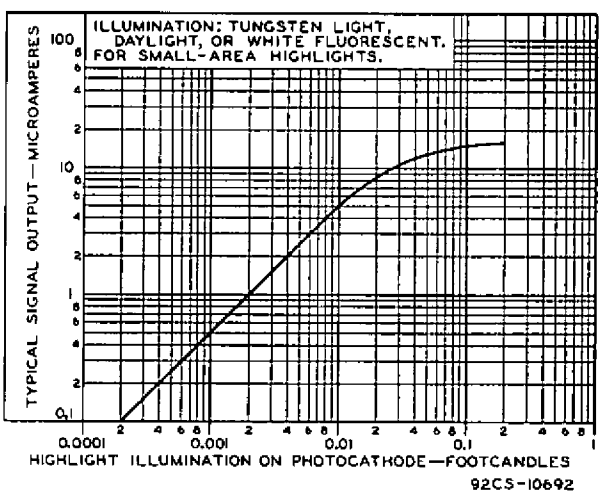


Fig. 3 - Basic Light Transfer Characteristic of Type 7295-A.

Sensitivity and Illumination. The image orthicon is a device exceeding in relative sensitivity most high-speed photographic film. When related to photographic film and compared at shutter speeds of 1/60 second which is the effective storage time of the image orthicon in a standard broadcast television system, the 7295-A exposed with the highlights on the photocathode of 0.060 footcandle will have an equivalent ASA exposure index of approximately 3000. This equivalent film-speed rating can be used in conjunction with a photographic exposure meter set for a shutter speed of 1/60 second to determine the approximate light level or lens-stop setting necessary for operating the 7295-A in a standard broadcast system.

The illumination on the photocathode of the 7295-A is related to the scene illumination as follows:

$$I_s = \frac{4f^2\ I_{pc}\ (m+1)^2}{TR}$$

where

I_s = scene illumination in footcandles

f = f-number setting of lens

I_{pc} = photocathode illumination in footcandles

m = linear magnification from scene to photocathode

T = total transmission of lens

R = reflectance of principal subject in scene

Except for very close shots, the linear magnification (m) from scene to photocathode may be neglected.

For example, assume that the lens is set at f:8, that it has a transmission (T) of 75%, that the required photocathode highlight illumination is 0.060 footcandle, and that the highlight reflectance (R) is 50%.

Then,

$$I_s = \frac{4 \times 8^2 \times 0.060}{0.75 \times 0.50} = 41 \text{ footcandles}$$

Optimum resolution and best performance is obtained when the 7295-A is operated with the lens set no more than one lens stop above the knee of the light transfer characteristic. Under certain lighting conditions, such as direct sunlight, it may not be possible to stop the lens down far enough to obtain this level of highlight illumination on the photocathode. When such a condition is encountered, the use of a neutral-density filter selected to give the required reduction in illumination is recommended.

The low illumination level utilized on the photocathode of the 7295-A makes it necessary that no stray light from without or within the camera fall on the face of the tube. See *optical system* under *Operating Considerations*.

SET-UP PROCEDURE

The *set-up procedure* described below should be followed carefully to obtain optimum performance from the 7295-A. Before the proper voltages are applied to the tube as indicated under *Typical Operating Values*, the lens should be uncapped and the lens iris opened to allow light to fall on the photocathode. *This is a very important step for this type of image orthicon.* The proper voltages should then be applied to the 7295-A. Grid-No.1 voltage should immediately be adjusted to produce a small amount of beam current. This procedure will prevent the mesh from being electrostatically pulled into contact with the glass disc. Make certain that the deflection circuits are functioning properly to cause the electron beam to scan the target. Adjust the deflection circuits so that the beam will "overscan" the target, i.e., so that the area of the target scanned is greater than its sensitive area. This procedure during the warm-up period is recommended to prevent burning on the target a raster smaller than that used for on-the-air operation. Note that overscanning the target results in a smaller-than-normal picture on the monitor. The lens should then be capped and the tube allowed to warm up for 15 minutes before use or before other adjustments are made.

Next, uncap the lens and partially close the lens iris. Increase the target voltage until information appears on the monitor. Then adjust beam focus, image focus, and optical focus until detail can be discerned in the picture. Adjust the alignment-coil-current controls until picture response is maximum. If the picture appears in negative contrast, increase the beam current. Further adjust the alignment-coil current so that the center of the picture does not move when the beam-focus control (grid No.4) is varied, but simply goes in and out of focus. During alignment of the beam, and also during operation of the tube, always keep the beam current as low as possible to give the best picture quality and also to prevent excessive noise.

Next, focus the camera on a test pattern. The target voltage is then advanced or reduced to the point where a reproduction of the test pattern is just discernable on the monitor. This value of target voltage is known as the "target-cutoff voltage". The target voltage should then be increased to between two and three volts above cutoff, and the beam-current control adjusted to give just sufficient beam current to discharge the highlights. If two or more cameras are to be used concurrently in the studio, it is important that each camera use the same value of target voltage so that the reproduced pictures are easily matched. It is to be noted that the use of high target voltage produces a higher signal-to-noise ratio and better contrast than the signal-to-noise ratio and contrast produced using low target voltages. However, high target voltages result in shorter tube life and may introduce microphonic noise.

The lens is then adjusted to produce best optical focus, and the voltages on grid No.6 and grid No.4 adjusted to produce the sharpest picture.

If the 7295-A is used in cameras other than RCA TK-12, the range of grid-No.4 voltage should be varied to obtain that focus mode which yields the "flattest" picture, produces the least interference from mesh in the background at low lights, eliminates dark corners, and gives the best center-to-edge focus.

In cameras where both grid-No.6 and the photocathode voltages are variable, the photocathode voltage should be adjusted to produce the best focus with grid No.6 set at approximately 50% of the photocathode voltage. This value of grid-No.6 voltage should minimize picture distortion and produce best center-to-edge focus.

At this point, attention should be given to the grid-No.5 control. If grid-No.5 voltage is adjustable, it should be varied to produce the best center-to-edge focus and the best picture geometry. When changing grid-No.5 voltage, it will be necessary to refocus the scanning section by adjusting grid-No.4 voltage control.

After the above-mentioned controls are properly set, the grid-No.3 control should be adjusted for maximum signal output. The deflecting yoke and 7295-A should be rotated, if necessary, so that the horizontal scanning of the camera is parallel to the horizontal plane of the scene.

The above adjustments constitute a rough setup for the 7295-A. Final adjustments necessary for the 7295-A to produce the best possible picture are as follows:

The proper illumination level should first be determined. Adjust the target voltage to 2 or 3 volts above the target-cutoff value. Focus the camera on a neutral (black-and-white) test pattern consisting of progressive tonal steps from black to white. Open the lens iris just to the point where the highest step of the test pattern does not rise as fast as the lower steps when viewed on a video-waveform oscilloscope. Then open the camera lens 1 stop above this setting. This operating point assures the maximum signal, best gray scale, freedom from "black borders", and the sharpest picture.

Then adjust the grid-No.1 voltage control to just discharge the brightest highlight of the pattern.

Next, adjust the grid-No.3 voltage control so that the video signal has a maximum value consistent with a flat-background signal when the lens is capped. This background represents the black level of the picture.

The video gain control is adjusted to produce the maximum output signal without overloading the camera amplifier.

From this point on, the waveform monitor for the camera should be used to determine the lens opening necessary to produce the maximum desired highlight signal as determined with the neutral step pattern, and no changes should be made on the video-amplifier or image-orthicon multiplier-gain controls.

If a wider range of tonal values is desired, black-stretch circuitry or gamma-correction circuitry should be used instead of opening the lens further. The high value of signal-to-noise ratio produced by the 7295-A permits the use of gamma-correction circuitry to achieve a good range of tonal values in the picture without encountering excessive noise. In addition, operation with this correction will prolong the life of the tube by reducing the amount of current pulled through the target glass.

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   Part I—*Characteristics of Vision and Visual Systems"*, RCA Review, March, 1948;
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   Part III—*Electro-Optical Characteristics of Camera Systems"*, RCA Review, September, 1948;
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5. R.B. Janes, and A.A. Rotow, *"Light Transfer Characteristics of Image Orthicons"*, RCA Review, September, 1950.
6. A.A. Rotow, *"Reduction of Spurious Signals in Image Orthicon Cameras"*, Broadcast News, February, 1955.
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DOS and DON'TS
on Use of RCA-7295-A

Here are the "dos"—

1. Allow the 7295-A to warm up prior to operation.
2. Hold temperature of the 7295-A within operating range.
3. Make sure alignment coil is properly aligned.
4. Adjust beam-focus control for best usable resolution.
5. Condition spare 7295-A's by operating several hours once each month.
6. Determine proper operating point with target voltage adjusted to the desired voltage above target-cutoff.
7. Open lens before voltages are applied to the 7295-A.

Here are the "don'ts"—

1. Don't force the 7295-A into its envelope terminal socket.
2. Don't operate the 7295-A without scanning.
3. Don't underscan target.
4. Don't focus the 7295-A on a stationary bright scene.
5. Don't operate a 7295-A having an ion spot.
6. Don't use more beam current than necessary to discharge the highlights of the scene.
7. Don't operate 7295-A with target voltage greater than 3 volts above cutoff.
8. Don't turn off beam while voltages are applied to photocathode, grid No.6, target, dynodes, and anode during warmup or standby operation.

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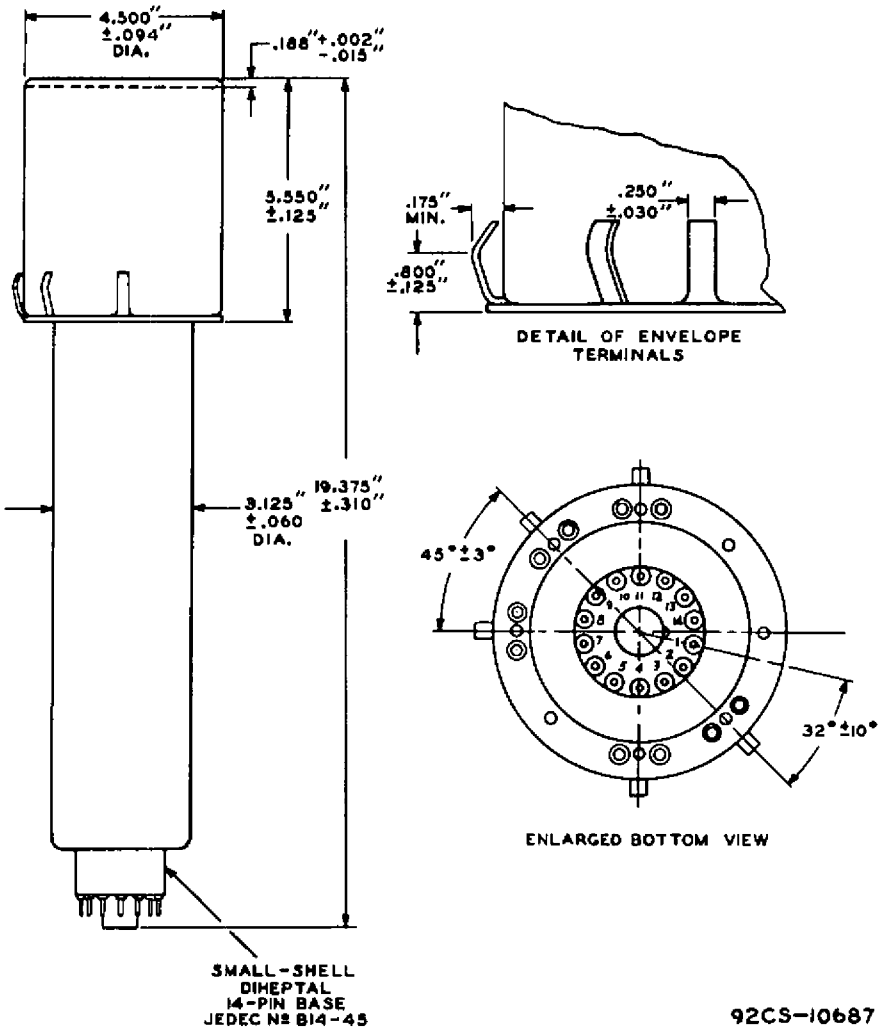
DIMENSIONAL OUTLINE



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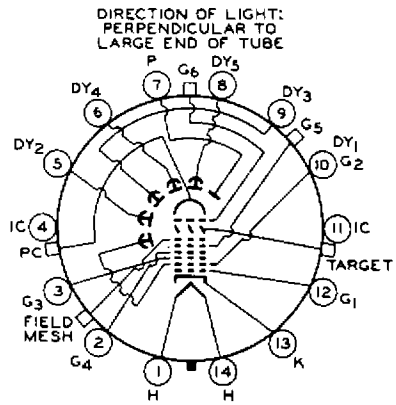
BASING DIAGRAM
Bottom View



SMALL-SHELL DIHEPTAL 14-PIN BASE

PIN 1: HEATER
PIN 2: GRID No.4
PIN 3: GRID No.3
PIN 4: INTERNAL CONNEC-TION—DO NOT USE
PIN 5: DYNODE No.2
PIN 6: DYNODE No.4
PIN 7: ANODE
PIN 8: DYNODE No.5
PIN 9: DYNODE No.3
PIN 10: DYNODE No.1
GRID No.2
PIN 11: INTERNAL CONNEC-TION—DO NOT USE
PIN 12: GRID No.1
PIN 13: CATHODE
PIN 14: HEATER

ENVELOPE TERMINALS

TERMINAL OVER PIN 2: FIELD MESH
TERMINAL OVER PIN 4: PHOTOCATHODE
TERMINAL ON SIDE OF ENVELOPE OPPOSITE BASE KEY: GRID No.6
TERMINAL OVER PIN 9: GRID No.5
TERMINAL OVER PIN 11: TARGET

7315

DISPLAY STORAGE TUBE

Writing Gun
Viewing Gun
Good Resolution

Direct-View Type
3.8" -Diameter Display
Non-Equilibrium Writing
Grid-Control Reading (Viewing)
TENTATIVE DATA

5.25" -Diameter Bulb
13.64" Max. Overall Length
Diheptal 14-Pin Base

RCA-7315 is a 5-inch display storage tube of the direct-view type designed for use in applications where it is desired to have a bright, non-flickering display of stored information for as long as 40 seconds after writing has ceased. Practical applications of the 7315 include: long-range radar display; airport surveillance; data transmission including half-tones; and visual communications requiring steady, non-flickering, narrow bandwidth transmission over telephone lines.

Performance of the 7315 when operated with 10,000 volts on the screen is characterized by a 3.8-inch-diameter display having brightness of about 2750 foot-lamberts; good resolution capability in half-tone displays; and a writing speed of about 3000 inches per second--a speed sufficiently slow to permit taking full advantage of the integrating and half-tone capabilities of the tube.

The 7315 utilizes two electron guns--a writing gun and a viewing gun. The writing gun utilizes electrostatic focus and produces an electron beam which is electrostatically deflected by two sets of deflecting electrodes. The viewing gun produces an electron stream which floods the electrodes controlling the storage function and the brightness of the display.

PRINCIPLES OF OPERATION

As shown in Fig. 1, the 7315 has a writing section and a viewing section. The *writing section* contains an electrostatically focused gun that produces an electron beam which is electrostatically deflected by two sets of deflecting electrodes. The *viewing section* contains an aluminized screen on the inside surface of a flat faceplate, a backplate capacitively coupled to a storage grid, and a viewing gun having five grids.

The Viewing Operation

In addition to the viewing gun with its grids No. 1 and No. 2, the viewing section contains a grid No. 3, a grid No. 4, a grid No. 5, a storage grid, a backplate capacitively coupled to the storage grid, and a screen having excellent visual efficiency. The spectral-energy emission characteristic of the screen phosphor is shown in Fig. 2.

The viewing gun provides a low-velocity electron stream which continuously floods the electrodes (grid No. 5, storage grid, and backplate) controlling the storage function and the brightness of the display. A display with high brightness is possible because the very efficient phosphor is continuously excited, rather than intermittently as in conventional cathode-ray tubes, by the high-current viewing beam. The high current can be utilized because the viewing beam is not controlled by methods ordinarily employed in cathode-ray tube guns and is consequently not limited by focusing, deflection, and modulation requirements.

Grid No. 3 consists of a conductive-coating band positioned on the bulb-wall interior as shown in Fig. 1. This figure also shows the location of grid No. 4 which consists of a metal cylinder. Grids No. 3 and No. 4 collimate (make parallel) the paths of the electrons in the stream before they reach grid No. 5. Collimation is required so that the low-velocity electrons will approach the storage grid in paths perpendicular (normal) to the plane of the storage grid. This normal approach of the electrons to every point on the storage grid together with their uniform velocity makes possible uniform control of the electrons by the storage grid.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7315 11-58
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Grid No.5 consists of a fine metal mesh. It serves to accelerate electrons in the beam; to repel any positive ions, produced by collision of electrons with residual gas molecules in the region between base and grid No.5, from landing

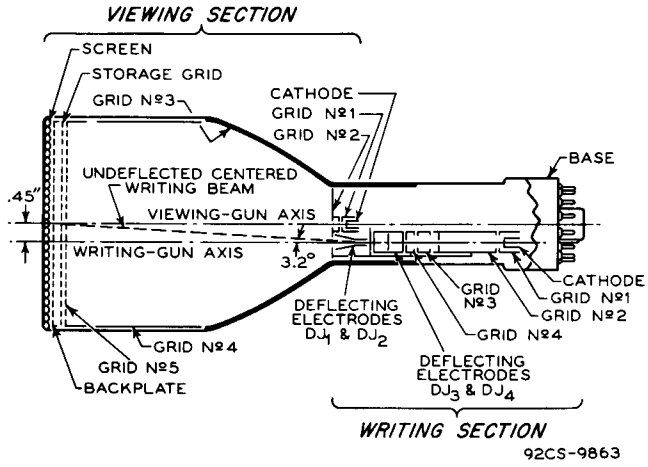


Fig. 1 - Schematic Arrangement of Type 7315.

on the storage grid and thus rapidly wiping out a stored charge pattern; and to collect viewing-beam electrons turned back near the storage grid when its potential is negative.

The storage grid consists of a very thin deposit of material which has excellent insulating properties and covers the gun side of the backplate which is a fine metallic mesh. The deposit leaves the size of the openings in the mesh essentially unchanged. In effect the storage grid consists of a multiplicity of storage elements, each capacitively coupled to the mesh.

The storage grid serves to control the viewing beam so that the stored information can be displayed on the phosphor (screen). If the storage-grid potential is made sufficiently negative with respect to the viewing-gun cathode, electrons in the viewing beam are turned back as they approach the storage grid and are collected by grid No.5. Under this condition, the viewing beam is cut off.

When the storage grid is at the same potential as the viewing-gun cathode, electrons in the viewing beam approach sufficiently near the plane of the storage grid to be attracted by the viewing-screen field which penetrates the openings in the storage grid. Under the influence of this field, a majority of the viewing-beam electrons which have passed through grid No.5 are accelerated through the storage-grid and backplate openings to the phosphor (screen), and cause it to fluoresce brightly over its entire area. Under this condition, the brightness of the screen is designated as "saturated brightness".

Light output from the screen under conditions of saturated brightness varies with the voltage applied to the screen. This relationship is shown in Fig.3 for a typical 7315 operating under conditions of optimum collimation. Because the screen is aluminized, the light output drops off very rapidly at screen voltages below 5000 volts. Operation below this value is not recommended.

At values of storage-grid potential between those which produce viewing-beam cutoff and those which produce saturation brightness, the number of electrons which penetrate the storage-grid openings, and hence the amount of light emitted

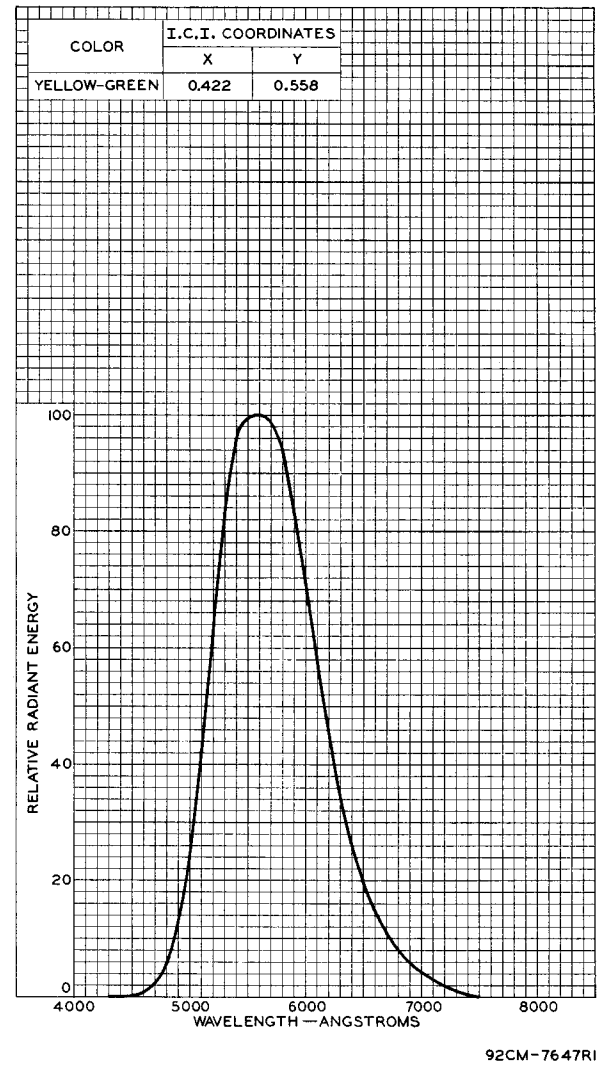


Fig. 2 - Spectral-Energy Emission Characteristic of Phosphor P20 Used in Type 7315.

by the screen, is a function of the storage-grid potential, as shown in Fig.4 for conditions with a screen voltage of 10000 volts and a backplate voltage of 2 volts. For backplate and/or screen

voltages more positive than those indicated in Fig.4, the storage-grid characteristic tends to shift to the left and to exhibit less slope. For backplate and/or screen voltages less positive than those indicated in Fig.4, the characteristic tends to shift to the right and to exhibit more slope.

Within the range of storage-grid potentials considered thus far, no viewing-beam electrons are attracted to the surface of the storage grid. Hence, in the absence of deliberate writing, leakage through the insulating material, or spurious charging such as might be caused by positive-ion bombardment, a charge pattern once established on the storage grid should remain indefinitely. If, however, the storage grid is made positive with respect to the viewing-gun cathode, viewing-beam electrons are attracted to the surface of the storage grid and land on it. If the electrons which land do not have sufficient energy to produce a secondary-electron emission ratio in excess of unity, a net flow of current into the storage grid will result. Because the storage grid is conductively isolated from the metallic backplate, the storage grid is free to charge negatively under the influence of this current.

This negative-charging phenomenon provides a mechanism by means of which an undesired charge pattern on the storage grid can be removed, i.e., erased. For example, assume that the entire storage grid has been charged, by writing, to zero potential with respect to the cathode of the viewing gun. The cathode of the viewing gun is usually taken as a ground reference. Now, assume that the backplate is suddenly shifted from its "dc" potential level of 2 volts to a positive potential of 10 volts. Because of the very close capacitive coupling between the backplate and the storage grid, the storage grid rises from its initial potential of zero volts to a potential of 8 volts. Viewing-beam electrons are now able to land on the storage grid and negative charging of the storage grid takes place, as explained above. Charging continues until the storage-grid potential is reestablished at zero volts. When this occurs, viewing-beam electrons can no longer land on the storage grid. Now, if the backplate potential is returned to its initial value of 2 volts, the storage-grid potential drops correspondingly to -8 volts. This negative voltage, as may be seen by referring to Fig.4, essentially cuts off the viewing beam of a typical 7315 and thus erases any charge pattern on the storage grid.

Following erasure, the time available for writing and viewing is limited by the presence of positive ions produced by collision of electrons in the viewing beam with residual traces of gas in the region between the screen and grid No.5. These positive ions are attracted to the most negative elements of the storage grid. On landing, the ions cause the elements to assume a less-negative charge and thus to increase the flow of viewing-beam electrons to the screen. Thus, the limit of viewing duration is determined by

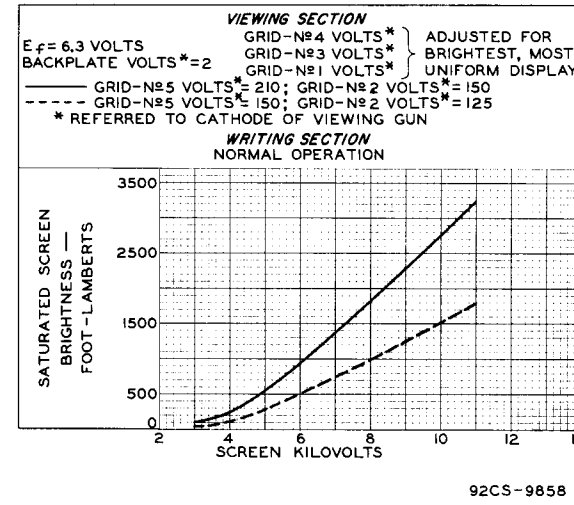


Fig.3 - Typical Characteristics of Type 7315.

loss of contrast in the viewed pattern rather than by a decay of brightness as in the case of conventional cathode-ray tubes employing long-persistence phosphors.

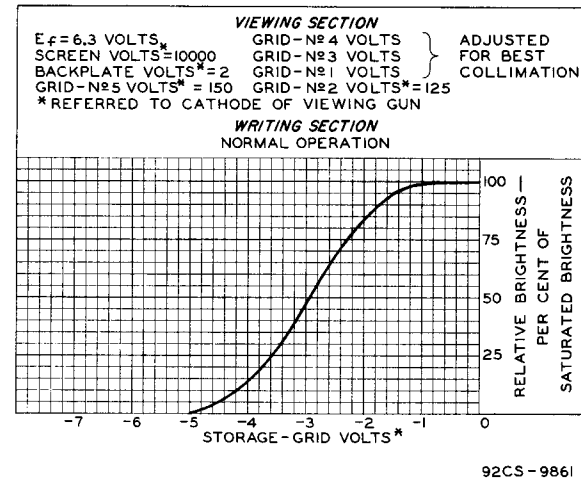


Fig.4 - Typical Storage-Grid Characteristic of Type 7315.

The Writing Operation

The writing gun is similar to that used in electrostatically focused and electrostatically deflected oscillograph tubes, and produces a well-defined focused beam. This beam may be deflected and modulated in the same manner as for oscillograph

tubes. It has a control function and contributes little to the total light output from the tube.

The cathode of the writing gun is generally operated at -2000 volts with respect to the viewing-gun cathode.

The writing-beam electrons landing on the storage grid have sufficient velocity to produce a secondary-electron emission ratio greater than unity. Thus, more electrons leave the storage grid than arrive, and those elements on the storage grid scanned by the beam assume a less-negative charge wherever the writing beam strikes. Because the secondary electrons are attracted to grid No.5 of the viewing gun, the writing beam tends to charge the storage grid to the potential of grid No.5 of the viewing gun. However, the maximum potential to which an element of the storage grid rises above cutoff is limited in normal operation of the tube by the viewing-gun beam to a potential just slightly more positive than that of the viewing-gun cathode.

The writing-beam electrons which land on a storage element determine the voltage built up across the dielectric and the corresponding net charge stored in the dielectric. By controlling the amplitude and duration of the writing-beam current, it is possible to establish on any storage element a positive charge having a value which will partially or completely counteract that element's negative charge. Consequently, a storage element can be charged to any potential intermediate between the storage-grid-cutoff voltage and zero voltage.

As considered previously, the potential of any storage element determines the number of viewing-beam electrons passing through the storage grid in the immediate vicinity of that element. When the potential is such as to allow passage of electrons, these electrons are accelerated and strike the screen directly opposite the storage element. As a result, they produce a luminescent spot having a size only slightly larger than that of the storage element and a brightness which is directly proportional to their density and their velocity which is determined by the screen potential.

Because the potential of a storage element is not changed by the viewing operation, a charge pattern established by the writing gun on the storage grid produces a corresponding visible pattern on the screen which may be viewed for a period determined by positive-ion build-up or by the predetermined erasure rate when dynamic erasure is employed.

The multiplicity of storage elements on the storage grid permits storage of half-tone patterns and their display. At a display brightness approximately 50 per cent of saturated brightness, half-tone patterns have a resolution of about 50 lines per inch as measured by the "shrinking raster" method.

The Erasing Operation

In the section headed *The Viewing Operation*, a technique for erasing stored charge patterns was described. This technique, known as *static erasure*, has the following disadvantage. During the erasing cycle and the time thereafter required to write a new pattern, the display conveys no information or incomplete information. It is also to be noted that during the static erasing cycle, the screen is uniformly illuminated at a level equal to, or greater than, the saturated brightness level.

In most applications of the 7315, it is desired that writing be followed by a gradual decay of stored information. This kind of performance is obtained by applying a continuous series of pulses to the backplate at a rate no lower than the phosphor flicker frequency (refer to section headed *The Viewing Operation*). The technique of erasing by applying a series of pulses to the backplate is known as *dynamic erasure*.

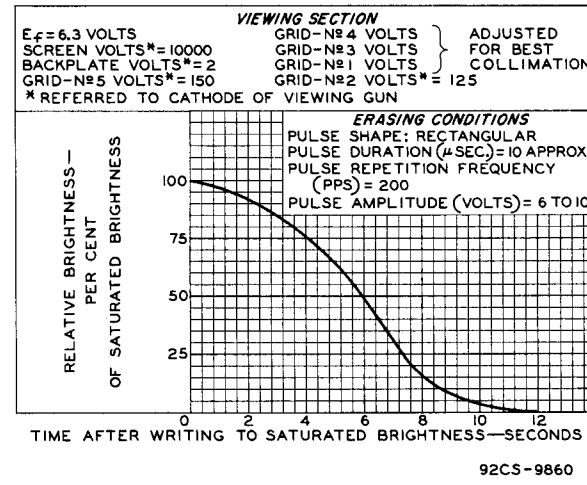


Fig.5 - Typical Erasure Characteristic of Type 7315.

The amount of charge erased during each erasing pulse is dependent on the duration, amplitude, and shape of the pulse. These factors together with the erasing-pulse repetition frequency determine the observed rate of decay of stored information.

Brightness-decay characteristic for a typical 7315 erased dynamically is shown in Fig.5.

Erasing pulses whose amplitude is smaller than the magnitude of the viewing-beam cutoff voltage do not permit complete erasure. On the other hand, erasing pulses whose amplitude is greater than the magnitude of the viewing-beam cutoff voltage eventually drive the storage grid beyond cutoff, i.e., to a value "blacker than

black". The erasing-pulse amplitude should not be used to adjust the erasing speed.

With a rectangular type of erasing pulse, all storage elements are erased at nearly the same rate regardless of the charge on any storage element. The brightest elements of the viewed pattern, therefore, are visible for longer periods than half-tones.

When the pulse used for erasing is of the positive-going sawtooth type, the most positive storage elements are erased more rapidly than the others, because electrons in the viewing-beam land on these elements for a longer period. With this kind of erasure, half-tones persist as long as bright elements.

In applications where half-tone display is involved, the amplitude of the rectangular erasing pulse should be adjusted so that the storage surface is charged to exactly cutoff potential by the erasing operation.

In applications, such as radar, where it is desired to suppress noise in the display, a higher-amplitude erasing pulse may be used to lower the potential of the unwritten storage elements several volts below cutoff. A number of addresses by the writing beam is then required to charge the storage elements less negative than cutoff. Ideally, the erasing-pulse amplitude should be adjusted so that the noise component in the modulated writing beam charges the storage surface to just cutoff. Then, the signal superimposed on the noise signal charges the storage elements to a potential less negative than cutoff and thus is effectively displayed on the screen devoid of noise background.

DATA

General:

	Writing Section	Viewing Section	
Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3 ± 5%	6.3 ± 5%	volts
Current	0.6	0.6	amp
Cathode Heating Time (Minimum) before other electrode voltages are applied	–	30	sec
Direct Interelectrode Capacitances (Approx., without external shield):			
Grid No.1 to all other tube electrodes	6.5	11	μμf
Cathode to all other tube electrodes	5.5	8	μμf
Backplate to all other tube electrodes	–	116	μμf
Deflecting electrode DJ_1 to deflecting electrode DJ_2	1.9	–	μμf
Deflecting electrode DJ_3 to deflecting electrode DJ_4	2	–	μμf
DJ_1 to all other tube electrodes	6	–	μμf
DJ_2 to all other tube electrodes	7	–	μμf
DJ_3 to all other tube electrodes	5.5	–	μμf
DJ_4 to all other tube electrodes	4.8	–	μμf
Focusing Method	Electrostatic	None	
Deflection Method	Electrostatic	None	
Deflecting-electrode arrangement	See *Dimensional Outline*	–	

Phosphor	– P20, Aluminized
Fluorescence	– Yellow-Green
Phosphorescence	– Yellow-Green
Minimum Useful Viewing Diameter♥	3.8"
Maximum Overall Length	13.64"
Seated Length	12.50" ± 0.39"
Greatest Bulb Diameter	5.25" ± 0.06"
Maximum Tube Radius	2.69"
Base	Medium-Shell Diheptal 14-Pin (JEDEC Group 5, No.B14-38)
Bulb Terminals:	
Caps (Three)	Recessed Small Ball (JEDEC No.J1-22)
Cap	Recessed Small Cavity (JEDEC No.J1-21)
Temperature Range	-65° to +100° C
Operating Position	Any
Weight (Approx.)	2-3/4 lbs

Maximum Ratings, *Absolute Values:*

	Writing Section		Viewing Section		
SCREEN VOLTAGE	–		11000 max.**		volts
BACKPLATE VOLTAGE (Peak)	–		20 max.**		volts
	Equivalent Values		*Equivalent Values*		
GRID-No.5 VOLTAGE	–	–	–	300 max.**	volts
GRID-No.4 VOLTAGE	2950 max.*▲	200 max.**	–	300 max.**	volts
GRID-No.3 VOLTAGE	1200 max.*	-1550 max.**	–	200 max.**	volts
PEAK VOLTAGE BETWEEN GRID No.3 AND GRIDS No.2 & No.4	–	2950 max.	–	–	volts
GRID-No.2 VOLTAGE	2950 max.*▲	200 max.**	2950 max.*▲	200 max.**	volts
CATHODE VOLTAGE	–	-2750 max.**	–	–	volts
GRID-No.1 VOLTAGE:					
Negative bias value	200 max.*		200 max.**		volts
Positive bias value	0 max.*		0 max.**		volts
Positive peak value	2 max.*		0 max.**		volts
PEAK VOLTAGE BETWEEN GRIDS No.2 & No.4 AND ANY DEFLECTING ELECTRODE	500 max.		–		volts
PEAK HEATER-CATHODE VOLTAGE:					
Heater negative with respect to cathode	125 max.*		–		volts
Heater positive with respect to cathode	125 max.*		–		volts

VIEWING SECTION**

Operating Values and Typical Performance Characteristics:

To prevent possible damage to the tube, allow the viewing-gun beam current to reach normal operating value before turning on the writing-gun beam current, and keep the viewing-gun beam on till the writing beam is turned off.

Screen Voltage	10000	10000	volts
Backplate Voltage (DC)	2	2	volts
Grid-No.5 Voltage	210	150	volts
Grid-No.4 Voltage#	50 to 150	30 to 90	volts
Grid-No.3 Voltage#	0 to 50	0 to 40	volts
Grid-No.2 Voltage▲	150	125	volts
Grid-No.1 Voltage#	0 to -80	0 to -60	volts
Maximum Screen Current	0.75	0.5	ma

Maximum Backplate Current (Peak)	2.0	1.5	ma
Maximum Grid-No.5 Current	3.0	2.5	ma
Maximum Grid-No.4 Current	3.0	2.5	ma
Maximum Grid-No.3 Current	5.0	4.0	ma
Maximum Grid-No.2 Current	3.0	2.5	ma
Maximum Cathode Current	8.0	6.5	ma
Number of Half-Tone Steps□	5	5	
Viewing Duration▲▲	20	40	sec
Maximum Erasing-Uniformity Factor□□	0.5	0.5	
Resolution#	50	50	lines/in
Brightness♦♦	2750	1500	fl

WRITING SECTION●

Range Values for Equipment Design:*

For any grids-No.2 & No.4 voltage (Ec_{2+4})▲ between 1500 and 2750 volts

Grid-No.3 Voltage for Focus	17.5% to 37.5% of Ec_{2+4}	volts
Maximum Grid-No.1 Voltage for Cutoff of Undeflected Focused Spot	-4.6% of Ec_{2+4}	volts
Maximum Grid-No.3 Current	-15 to +10	μa
Maximum Cathode Current	See Fig.6	
Deflection Factors:		
DJ_1 & DJ_2	36 to 48	v dc/in./kv of Ec_{2+4}
DJ_3 & DJ_4	35 to 47	v dc/in./kv of Ec_{2+4}
Focused Beam Position	##	
Writing Speed††	3000	in/sec

Examples of Use of Design Ranges:*

For grids-No.2 & No.4 voltage (Ec_{2+4})▲	*2000*	*volts*
Grid-No.3 Voltage for Focus	350 to 750	volts
Maximum Grid-No.1 Voltage for Cutoff of Undeflected Focused Spot	-92	volts
Deflection Factors:		
DJ_1 & DJ_2	72 to 96	volts
DJ_3 & DJ_4	70 to 94	volts

Equivalent Values of Writing-Gun Voltages Referred to Cathode of Viewing Gun:

Cathode Voltage	-1875	-1850	volts
Grid-No.3 Voltage for Focus	-1125 to -1525	-1100 to -1500	volts
Grids-No.2 & No.4 Voltage▲	+125	+150	volts

VIEWING SECTION and WRITING SECTION

Circuit Values:

Grid-No.1-Circuit Resistance (Either gun)	1.0 max.	megohm
Resistance in Any Deflecting-Electrode Circuit■	0.1 max.	megohm
Series Current-Limiting Resistor (Unbypassed) in Grid-No.5 (Viewing Section) Circuit	0.010 min.	megohm
Backplate-Circuit Resistance	0.005 max.	megohm
Series Current-Limiting Resistance in Screen Circuit	1.0 min.	megohm

♥ Minimum useful viewing area may be eccentric with respect to the tube face.

** Voltages are shown with respect to cathode of Viewing Gun.

* Voltages are shown with respect to cathode of Writing Gun.

▲ Grids No.2 and No.4 of Writing Gun are connected together and to grid No.2 of Viewing Gun within the tube.

\# Adjusted for brightest, most uniform pattern.

□ Observed with an RCA-2F21 Monoscope display.

▲▲ Expressed in terms of the time required for the brightness of the unwritten background to rise from just zero brightness (viewing-beam cutoff) to 10% of saturated brightness.

□□ Determined as follows: With no erasing pulse, overscan the storage surface with writing beam to obtain maximum pattern brightness. Then cut off writing beam. Apply erasing pulses having an amplitude of between 8 to 10 volts and adjust duty cycle to obtain complete erasure in approximately 10 seconds. Measure time (t_1) from start of erasing to the instant at which any area within the minimum useful viewing diameter is reduced to background-brightness level, and time (t_2) from start of erasing to the instant at which the entire area within the minimum useful viewing diameter area is reduced to background-brightness level. The erasing-uniformity factor is defined as $(t_2 - t_1)/t_2$.

\# Measured by shrinking-raster method at a display brightness of 50% of saturated brightness and with grids No.2 & No.4 of Writing Gun at about +2000 volts with respect to cathode of Writing Gun.

♦♦ Measured with entire storage grid written to produce saturated brightness and with screen at indicated voltage.

● The cathode of the Writing Gun is operated at about -2000 volts with respect to the cathode of the Viewing Gun which is usually operated at ground potential.

The center of the undeflected focused beam will fall within a circle having a 10-mm radius and having its center on the Writing-Gun axis (see *Dimensional Outline*) under the following conditions: grids No.2 & No.4 of Writing Gun at +2000 volts with respect to cathode of Writing Gun, grid No.3 of Writing Gun at voltage to give focus, grid No.1 of Writing Gun at voltage which will permit storage of a charge just sufficient to give a barely perceptible spot on screen, Viewing Section operating under normal conditions, and tube shielded against extraneous fields.

†† Measured under conditions of writing from just zero brightness (viewing-beam cutoff) to maximum brightness with grid No.1 of Writing Gun at -10 volts with respect to cathode of Writing Gun, and grids No.2 & No.4 of Writing Gun at +2000 volts with respect to cathode of Writing Gun.

■ It is recommended that the deflecting-electrode-circuit resistances be approximately equal.

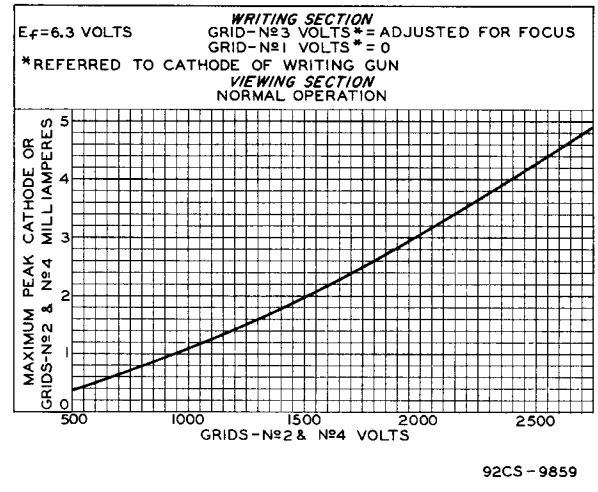


Fig.6 - Current Characteristic for Writing Gun of Type 7315.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

Handling. The 7315 should preferably be transported or handled with the face up to prevent any loose particles in the tube from striking the storage surface and adhering to it. Care should be taken to prevent knocking or bumping the bulb caps. Such rough treatment will cause either immediate or delayed cracking of the metal-glass seals.

Support for the 7315 within the external magnetic shield may be provided by a padded clamp around the neck of the tube and by sponge-rubber supports around the tube, except near the bulb caps. The tube should not be supported by the base or socket.

Shielding. Magnetic shielding must be provided to prevent external fields from interfering with the required accurate control of the low-velocity viewing beam. A cylindrical shield of properly annealed high-permeability material about 1/16-inch thick is usually satisfactory.

Degaussing. During transportation, the 7315 can become magnetized with the result that its performance will be impaired. Before it is placed in operation, it should be degaussed as indicated below.

A suitable degaussing coil may be made by winding 900 turns of No.14 enameled wire on a 6-inch diameter form 2 inches long. After connecting the coil to an ac supply line (117 volts), slowly (taking at least 30 seconds) pass the 7315 through the coil and then slowly withdraw it completely from the ac magnetic field. Finally, disconnect the coil from the supply line. A coil having greater magnetic-field strength than that specified should not be employed because it may cause the internal elements of the tube to vibrate excessively and cause damage to the tube.

Terminal Connections. The *base pins* of the 7315 fit the diheptal 14-contact socket. The *recessed small ball caps* and the *recessed small cavity cap* require standard flexible-lead connectors.

Power-Supply Requirements. A typical power-supply circuit to provide operating voltages for the 7315 is shown in Fig.7.

The dc supply voltage for the Writing Gun should be well regulated to prevent shift in the grid-No.1 bias level. For the Writing Gun the heater winding should be insulated to withstand operation at high negative potential with respect to ground.

The high-voltage dc supply for the screen should have its negative terminal grounded, and should have at least a 1-megohm resistor in series with the screen terminal. The supply for grid No.5 of the Viewing Gun should have at least a 10,000-ohm unbypassed resistor in series with the grid-No.5 terminal.

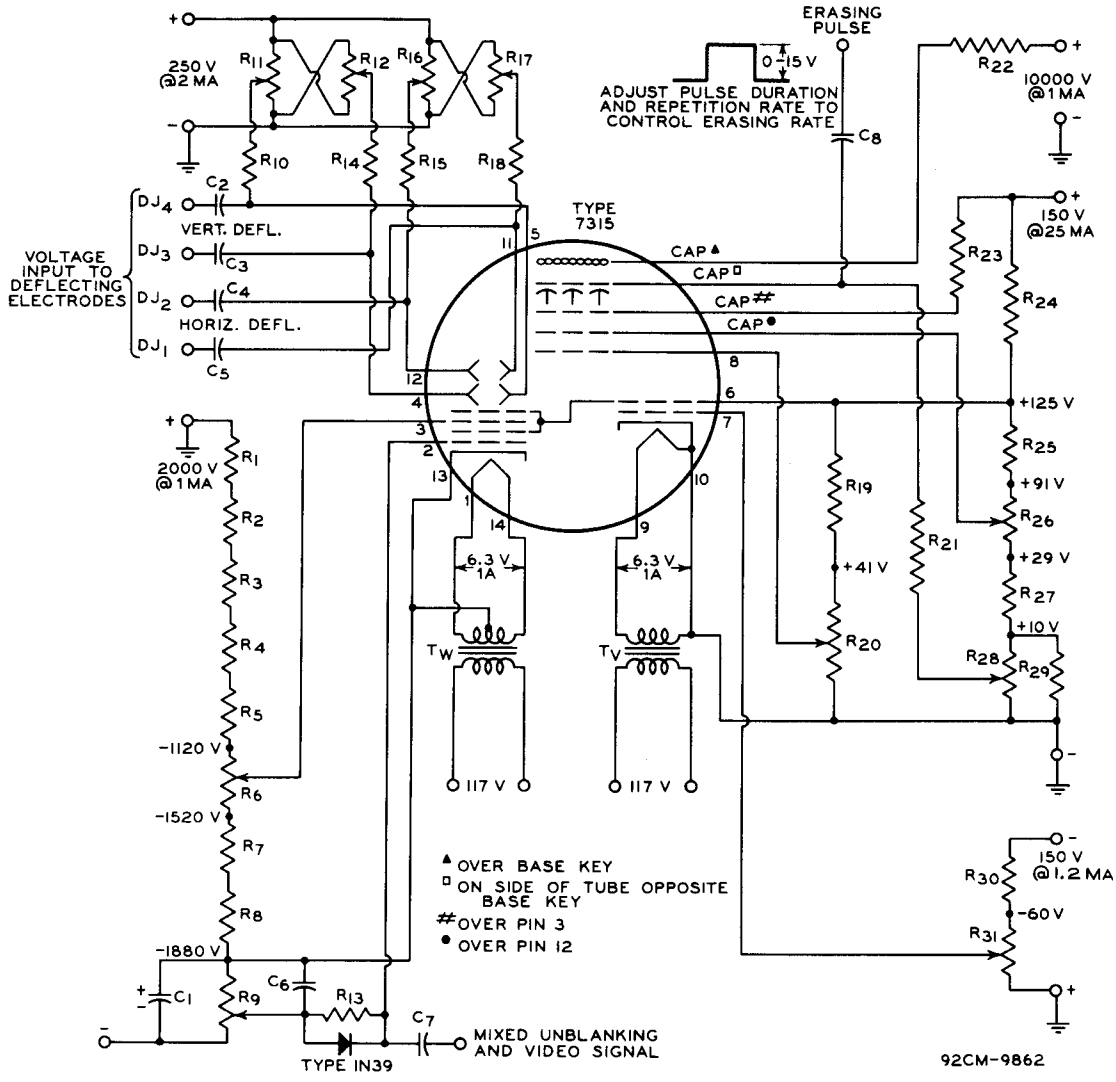
The high voltages at which the 7315 is operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Safety precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is desired.

In the use of high-voltage tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit as a result of capacitor breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off, and both terminals of any capacitors grounded.

Deflection Considerations. As with conventional oscillograph tubes, balanced electrostatic-deflection circuits should be employed to prevent distortion of the writing beam. *Each pair of the deflecting electrodes should be operated at an average potential the same as that of grids No.2 & No.4 of the Writing Gun.*

The undeflected focused writing beam is normally close to the Writing-Gun axis (see *Dimensional Outline*). However, to compensate for variation from tube to tube, designers should provide an adjustable and reversible supply of at least 20 volts dc per kilovolt of grids-No.2 & No.4 voltage (Writing Gun) for application between deflecting electrodes DJ_3 and DJ_4, and a supply adjustable from 2 to 42 volts dc per kilovolt of grids-No.2 & No.4 voltage for application between DJ_1 and DJ_2. The positive side of the supply should be connected to DJ_1. By adjustment of these dc voltages on each pair of the deflecting electrodes, the beam may be centered. The circuit shown in Fig.7 will supply sufficient centering voltage to position the writing beam anywhere on the storage grid.

Video-Drive Considerations. The information to be stored and displayed by the tube should be applied as a video signal to the control grid (grid No.1) or cathode of the Writing Gun. In determining the writing drive requirements, it should be remembered that writing is essentially a charge-depositing process. The instantaneous



C_1: 20μf, electrolytic, 250 volts
C_2 C_3 C_4 C_5: Values depend on frequency of deflecting-voltage waveforms
C_6: 1μf, paper, 200 volts
C_7: 0.05μf, plastic film, 2500 volts
C_8: 0.01μf, paper, 600 volts
R_1: 240,000 ohms, 0.5 watt
R_2 R_3 R_4 R_5: 220,000 ohms, 0.5 watt
R_6: 400,000-ohm potentiometer, 2 watts
R_7 R_8: 180,000 ohms, 0.5 watt
R_9: 125,000-ohm potentiometer, 2 watts
R_{10}: 75,000 ohms, 0.5 watt
R_{11} R_{12}: Dual 50,000-ohm potentiometer, 2 watts
R_{13}: 1 megohm, 0.5 watt
R_{14} R_{15}: 75,000 ohms, 0.5 watt
R_{16} R_{17}: Dual 50,000-ohm potentiometer, 2 watts
R_{18}: 75,000 ohms, 0.5 watt
R_{19}: 8200 ohms, 2 watts
R_{20}: 4000-ohm potentiometer, 2 watts
R_{21}: 4300 ohms, 0.5 watt
R_{22}: 1 megohm, 1 watt
R_{23}: 10,000 ohms, 1 watt
R_{24}: 1000 ohms, 2 watts
R_{25}: 2200 ohms, 1 watt
R_{26}: 4000-ohm potentiometer, 2 watts
R_{27}: 1200 ohms, 1 watt
R_{28}: 1000-ohm potentiometer, 2 watts
R_{29}: 2000 ohms, 0.5 watt
R_{30}: 75,000 ohms, 0.5 watt
R_{31}: 50,000-ohm potentiometer, 2 watts
T_W: Heater transformer with secondary insulated for 2500 volts
T_V: Heater transformer

Fig.7 - Typical Power-Supply Circuit for Type 7315.

writing-beam current needed for saturated writing varies nearly directly with the speed at which the writing beam is deflected across the storage grid and varies inversely with the number of times a given storage element is written upon in one complete scan period.

Operating Procedure. The following steps should be followed when first placing the 7315 in

operation. *Electrode voltages are referred to the cathode of the viewing gun unless otherwise specified.*

To prevent possible damage to the tube, allow the viewing-gun beam current to reach normal operating value before turning on the writing-gun beam current, and keep the viewing beam on till the writing beam is turned off.

1. *Viewing Gun*--Apply power to the heater of the viewing gun and allow 30 seconds for the cathode to reach normal operating temperature. Then in turn apply grid-No.2 voltage (+125 volts); adjust grid-No.1 voltage to zero volts; apply grid-No.5 voltage (+150 volts); set backplate voltage to +2 volts; set grid-No.3 voltage to about +30 volts; set grid-No.4 voltage to about +70 volts; and apply screen voltage (+10000 volts). The storage property of the tube can be observed by increasing the backplate voltage to +8 volts for several seconds and then reducing it to +2 volts. As the backplate voltage is reduced the screen should go dark. The 7315 is now storing an overall "black picture" and stays in this condition until the screen begins to brighten as a result of the storage grid being gradually discharged by positive ions landing on it.

2. *Writing Gun*--Apply power to the heater of the writing gun and allow 30 seconds for the cathode to reach normal operating temperature. Then, with reference to the typical operating values shown in the tabulated data under *Writing Section--Examples of Use of Design Ranges, and Equivalent Values for Examples of Writing-Gun Voltages Referred to Cathode of Viewing Gun*, set the grid-No.1 voltage to cutoff, and apply dc voltages to the electrodes of the writing gun. With the screen made dark by the charging method described under (1), the grid-No.1 bias is reduced until the writing beam is seen as a spot on the screen. If the beam is caused to move, either by centering adjustment or by application of deflection voltage, it should leave a bright trace. After an area has been written to full brightness, the writing-beam spot may be seen as a slightly brighter spot on the bright background. Writing-beam focus can then be optimized by adjusting the grid-No.3 voltage.

3. *Collimating Adjustments* (Refer to *Principles of The Viewing Operation* on Page 1)--Now make adjustments to provide full coverage of the useful viewing area of the screen by the viewing beam and the best uniformity of cutoff over this area as follows: bias off the writing beam and leave the viewing beam on. Increase the backplate voltage to +8 volts for a few seconds and then reduce it to +2 volts. Observe the uniformity of cutoff. Then discharge the storage grid by turning on the writing beam and scanning over the entire surface of the storage grid. Adjust the viewing-gun grid-No.3 voltage, grid-No.4 voltage, and the grid-No.1 voltage to obtain the combination which gives full coverage of the useful viewing area of the screen by the viewing beam and which produces the most uniform cutoff over this area of the screen. For the most uniform collimation, it is recommended that the grid-No.3 voltage and the grid-No.4 voltage be adjusted to the minimum values which will still supply a full-size display. Grid-No.1 voltage should be adjusted to eliminate "flaring" at the edge of the display. Repeat the charging and cutoff cycle and voltage adjustments if necessary to obtain best collimation and cutoff. When dynamic erasure is to be used, erasing pulses may be employed in adjusting for optimum collimation.

4. *Writing-Gun Drive Adjustments*--The dc bias and the video-signal amplitude applied to grid No.1 or cathode of the writing gun should be adjusted to set the black level and the highlight level in the display. These adjustments depend on the scanning rate used. Resolution decreases with increasing writing-gun beam current. Excessive writing-gun beam current will produce screen saturation and any further beam-current increase will not produce additional highlight brightness and may also decrease half-tone rendition. It is recommended that the writing-beam current always be adjusted to a minimum value to produce the best display without saturation of highlight brightness.

Runaway Charging. A condition of runaway charging of the storage grid may result if the writing beam is allowed to land on the storage grid with the viewing beam turned off, if the writing beam is incident on an area of the storage grid not covered by the viewing beam, or if the density of the writing beam exceeds that of the viewing beam. Such a runaway condition can occur because of the non-equilibrium writing process involved.

Because the electrons in the writing beam land with an energy such that the secondary-emission ratio of the storage-grid surface is greater than unity, this surface charges positive toward the potential of grid No.5 of the viewing section. Normally, the landing on the storage grid of the viewing-beam electrons keeps any portion of the storage-grid surface from charging above viewing-beam cathode potential. When this limiting action of the viewing beam is not present, the storage-grid surface may charge under the action of the writing beam to a value such that sparking occurs through the insulating layer between the storage-grid surface and the backplate. This sparking is observed as random bright flashes on the screen. In the event of sparking, permanent damage (loss of the ability to store a signal in localized areas) to the storage grid may result. Such damage can usually be avoided if the writing process is quickly stopped.

A condition of runaway charging can also occur if the writing beam is allowed to move slowly or

to remain stationary in a spot on the storage grid even with the viewing beam turned on.

Failure of scanning while the writing beam is turned on may permanently damage the storage grid. Therefore, provision should be made to cut off automatically the writing-beam current in case of a scanning failure. The writing-beam current can be cut off by an electronic switch which applies -200 volts bias to grid No.1 of the writing gun. This switch should be actuated by a portion of the scanning voltages applied to both sets of deflecting electrodes.

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MIT Radar School Staff, *"Principles of Radar"*, McGraw-Hill Book Co., Inc.

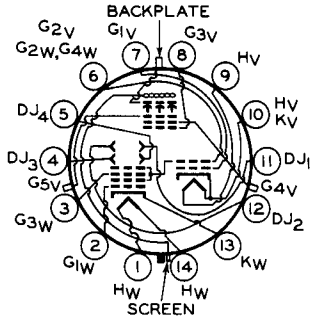
M. Knoll and B. Kazan, *"Storage Tubes and Their Basic Principles"*, John Wiley and Sons, Inc.

M. Knoll, P. Rudnick and H.O. Hook, *"Viewing Storage Tube with Halftone Display"*, RCA Review, Vol.14, No.4, December, 1953.

M. Knoll, H. O. Hook, and R. P. Stone, *"Characteristics of a Transmission Control Viewing Storage Tube with Halftone Display"*, Proc. I.R.E., Vol.42, No.10, October, 1954.

SOCKET CONNECTIONS

Bottom View



PIN 1: HEATER OF THE WRITING GUN

PIN 2: GRID No.1 OF THE WRITING GUN

PIN 3: GRID No.3 OF THE WRITING GUN

PIN 4: DEFLECTING ELECTRODE DJ_3 OF THE WRITING GUN

PIN 5: DEFLECTING ELECTRODE DJ_4 OF THE WRITING GUN

PIN 6: GRID No.2 OF THE VIEWING GUN, GRID No.2 AND GRID No.4 OF THE WRITING GUN

PIN 7: GRID No.1 OF THE VIEWING GUN

PIN 8: GRID No.3 OF THE VIEWING GUN

PIN 9: HEATER OF THE VIEWING GUN

PIN 10: HEATER AND CATHODE OF THE VIEWING GUN

PIN 11: DEFLECTING ELECTRODE DJ_1 OF THE WRITING GUN

PIN 12: DEFLECTING ELECTRODE DJ_2 OF THE WRITING GUN

PIN 13: CATHODE OF THE WRITING GUN

PIN 14: HEATER OF THE WRITING GUN

RECESSED BALL CAP:
Over Pin 3 -- GRID No.5 OF THE VIEWING GUN

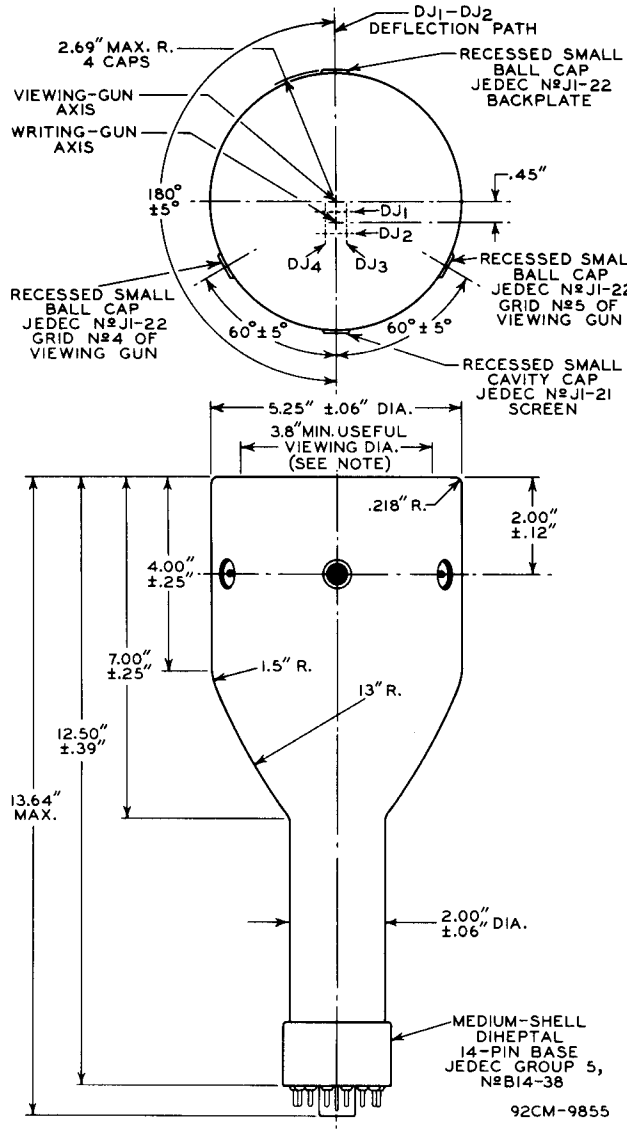
Over Pin 12 -- GRID No.4 OF THE VIEWING GUN

On Side of Tube Opposite Base Key -- BACKPLATE

RECESSED CAVITY CAP:
Over Base Key -- SCREEN

Devices and arrangements shown or described herein may use patents of RCA or others. Information contained herein is furnished without responsibility by RCA for its use and without prejudice to RCA's patent rights.

DIMENSIONAL OUTLINE



NOTE: MINIMUM USEFUL VIEWING AREA MAY BE ECCENTRIC WITH RESPECT TO THE TUBE FACE. THE MINIMUM USEFUL VIEWING AREA WILL HAVE DIAMETER OF 3.8".

CENTER LINE OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

DEFLECTING ELECTRODES DJ_1 AND DJ_2 ARE NEARER THE SCREEN: DEFLECTING ELECTRODES DJ_3 AND DJ_4 ARE NEARER THE BASE. WITH DJ_1 POSITIVE WITH RESPECT TO DJ_2, THE SPOT WILL BE DEFLECTED TOWARD PIN No.8; LIKEWISE, WITH DJ_3 POSITIVE WITH RESPECT TO DJ_4, THE SPOT WILL BE DEFLECTED TOWARD PIN No.4.

THE ANGLE BETWEEN THE DEFLECTION PATH PRODUCED BY DJ_1 AND DJ_2 MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND THE BASE KEY BY ANGULAR TOLERANCE (MEASURED ABOUT THE TUBE AXIS) OF $\pm 10^{\circ}$. ANGLE BETWEEN $DJ_1 - DJ_2$ DEFLECTION PATH AND $DJ_3 - DJ_4$ DEFLECTION PATH IS $90^{\circ} \pm 3^{\circ}$.

7326

MULTIPLIER PHOTOTUBE

1.68" Dia. Curved Circular Semitransparent Photocathode

10-Stage, Head-On Type, Flat Faceplate S-20 Response

TENTATIVE DATA

6.78" Max. Length 2.38" Max. Diameter Diheptal 14-Pin Base

RCA-7326 is a head-on type of multiplier phototube intended for use in applications such as flying-spot scanning and photometry, which require low dark current as well as high sensitivity over the entire visible spectrum. In addition, its high blue sensitivity, fast response, relative freedom from afterpulses, and small spread in electron-transit time make the 7326 particularly useful in scintillation counters.

The spectral response of the 7326 covers the range from about 3000 to 7500 angstroms, with maximum response at approximately 4200 angstroms, as shown in Fig. 1. It will be noted that the response extends beyond the visible region into the blue region on the one end and well into the red region on the other end.

The 7326 utilizes a new and improved semitransparent photocathode characterized by high sensitivity, low thermionic dark current, and high conductivity even at low temperatures. The photocathode may be cooled to liquid-air temperature to reduce its low thermionic dark current to an extremely low value without sacrificing its conductivity to such an extent that its current-carrying capability is impaired.

Design features of the 7326 include stable dynodes, a focusing electrode with external connection for shaping the field which directs photoelectrons from the photocathode onto the first dynode, and a semitransparent photocathode on the curved inner surface of the face end of the bulb.

The focusing electrode permits optimizing the magnitude, uniformity, or speed of the response in critical applications.

The curved photocathode surface of the 7326 assures very good collection by dynode No. 1 of electrons from all parts of the useful photocathode area. The curved surface together with the electrode configuration employed in the 7326 minimizes variation in electron-transit time between the photocathode and dynode No. 1.

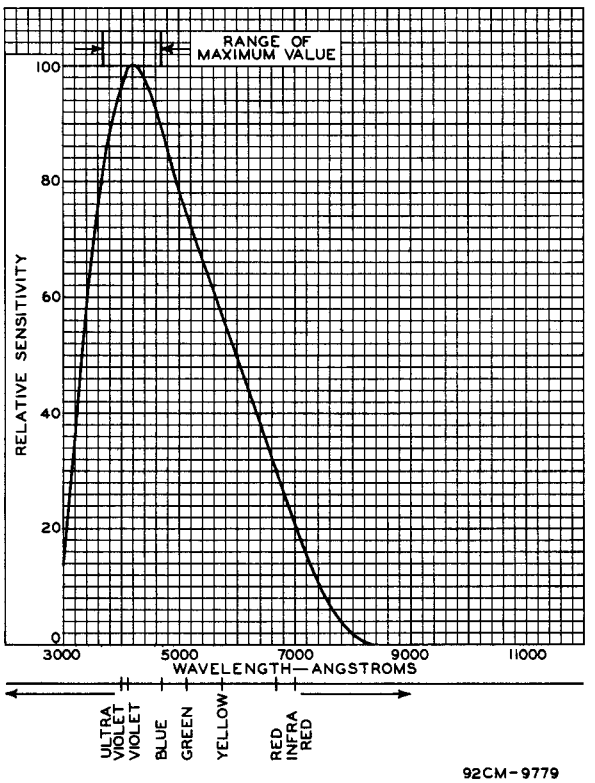


Fig. 1 - Tentative Spectral Sensitivity Characteristic of Type 7326 Which Has S-20 Response. Curve is Shown For Equal Values of Radiant Flux at All Wavelengths.

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7326 10-58
Printed in U.S.A.

DEFINITIONS

Radiant Sensitivity. The quotient of output current by incident radiant power of a given wavelength, at constant electrode voltages.

Cathode Radiant Sensitivity. The quotient of current leaving the photocathode by incident radiant power of a given wavelength.

Luminous Sensitivity. The quotient of output current by incident luminous flux, at constant electrode voltages.

Current Amplification. Ratio of the output current to the photocathode current, at constant electrode voltages.

Equivalent Anode-Dark-Current Input. The quotient of the anode dark current by the luminous sensitivity.

Equivalent Noise Input. That value of incident luminous flux which when modulated in a stated manner produces an rms output current equal to the rms noise current within a specified bandwidth.

Pulse Rise Time. The time required for the instantaneous amplitude of the pulse to go from 10 per cent to 90 per cent of the peak value.

DATA

General:

Spectral Response	S-20
Wavelength of Maximum Response	4200 ± 500 angstroms
Cathode, Semitransparent:	
Shape	Curved Circular
Window:	
Area	2.2 sq.in.
Minimum diameter	1.68 in.
Index of refraction	1.51
Direct Interelectrode Capacitances (Approx.):	
Anode to dynode No.10	2.4 μμf
Anode to all other electrodes	5.5 μμf
Dynode No.10 to all other electrodes	6.5 μμf
Maximum Overall Length	6.78"
Seated Length	5.84" ± 0.19"
Maximum Diameter	2.38"
Bulb	T-16
Base	Medium-Shell Diheptal 14-Pin, (JEDEC Group 5, No.B14-38) Non-hygroscopic
Operating Position	Any
Weight (Approx.)	6 oz

Maximum Ratings, *Absolute Values:*

SUPPLY VOLTAGE BETWEEN ANODE AND CATHODE (DC)	2400 max.	volts
SUPPLY VOLTAGE BETWEEN DYNODE No.10 AND ANODE (DC)	500 max.	volts
SUPPLY VOLTAGE BETWEEN CONSECUTIVE DYNODES (DC)	600 max.	volts
DYNODE No.1 SUPPLY VOLTAGE (DC)	500 max.	volts
FOCUSING-ELECTRODE SUPPLY VOLTAGE (DC)	500 max.	volts
AVERAGE ANODE CURRENT●	1 max.	ma
AMBIENT TEMPERATURE	85 max.	°C

Characteristics Range Values for Equipment Design:

Under conditions with dc supply voltage (E) across a voltage divider providing 1/6 of E between cathode and dynode No.1; 1/8 of E between cathode and focusing electrode; 1/12 of E for each succeeding dynode stage; and 1/12 of E between dynode No.10 and anode.

With E = 1800 volts (except as noted)

	Min.	*Median*	*Max.*	
Sensitivity:				
Radiant, at 4200 angstroms	–	9600	–	μa/μw
Cathode Radiant, at 4200 angstroms	–	0.064	–	μa/μw
Luminous🌡	5	22.5	150	amp/lumen
Cathode Luminous:				
With tungsten light source▲	120	150	–	μa/lumen
Cathode Luminous (Cont'd):				
With blue light source**	0.05	–	–	μa
With red light source□	0.30	–	–	μa
Current Amplification	–	1.5×10^5	–	
Equivalent Anode-Dark-Current Input⊕■	–	3×10^{-10}	1.4×10^{-9}	lumen
Equivalent Noise Input:★				
At +25° C	–	1.9×10^{-12}	4.3×10^{-12}	lumen
At −80° C	–	3×10^{-13}	6×10^{-13}	lumen
Anode-Pulse Rise Time⊕	–	2.5	–	milliμsec
Greatest Delay Between Anode Pulses:				
Due to position from which electrons are simultaneously released within a circle centered on tube face and having a diameter of--				
1.12"	–	1†	–	milliμsec
1.56"	–	3†	–	milliμsec

● Averaged over any interval of 30 seconds maximum.

🌡 Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870° K. A light input of 0.1 microlumen is used. The load resistor has a value of 0.01 megohm.

▲ Under the following conditions: The light source is a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux is 0.01 lumen and 200 volts are applied between cathode and all other electrodes connected together as anode. The load resistor has a value of 0.01 megohm.

** Under the following conditions: Light incident on the cathode is transmitted through a blue filter (Corning, Glass Code No.5113 polished to 1/2 stock thickness) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm and 200 volts are applied between cathode and all other electrodes connected together as anode.

□ Under the following conditions: Light incident on the cathode is transmitted through a red filter (Corning, Glass Code No.2418, or equivalent) from a tungsten-filament lamp operated at a color temperature of 2870° K. The value of light flux on the filter is 0.01 lumen. The load resistor has a value of 0.01 megohm, and 200 volts are applied between cathode and all other electrodes connected together as anode.

⊕ Measured at a tube temperature of 25° C and with the supply voltage (E) adjusted to give a luminous sensitivity of 20 amperes per lumen. Dark current caused by thermionic emission may be reduced by the use of a refrigerant.

■ For maximum signal-to-noise ratio, operation with a supply voltage (E) below 1800 volts is recommended.

★ Under the following conditions: Supply voltage (E) is 1800 volts, external shield potential of −1800 volts, ac-amplifier bandwidth of 1 cycle per second, tungsten light source of 2870° K interrupted at a low audio frequency to produce incident radiation pulses alternating between zero and the value stated. The "on" period of the pulse is equal to the "off" period. The output current is measured through a filter which passes only the fundamental frequency of the pulses.

⊕ Measured between 10 per cent and 90 per cent of maximum anode-pulse height. This anode-pulse rise time is determined primarily by transit-time variations in the multiplier stages and with an incident light spot approximately 1 millimeter in diameter centered on the photocathode.

† These values also represent the difference in time of transit between the photocathode and dynode No.1 for electrons simultaneously released from the center and from the periphery of the specified areas.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

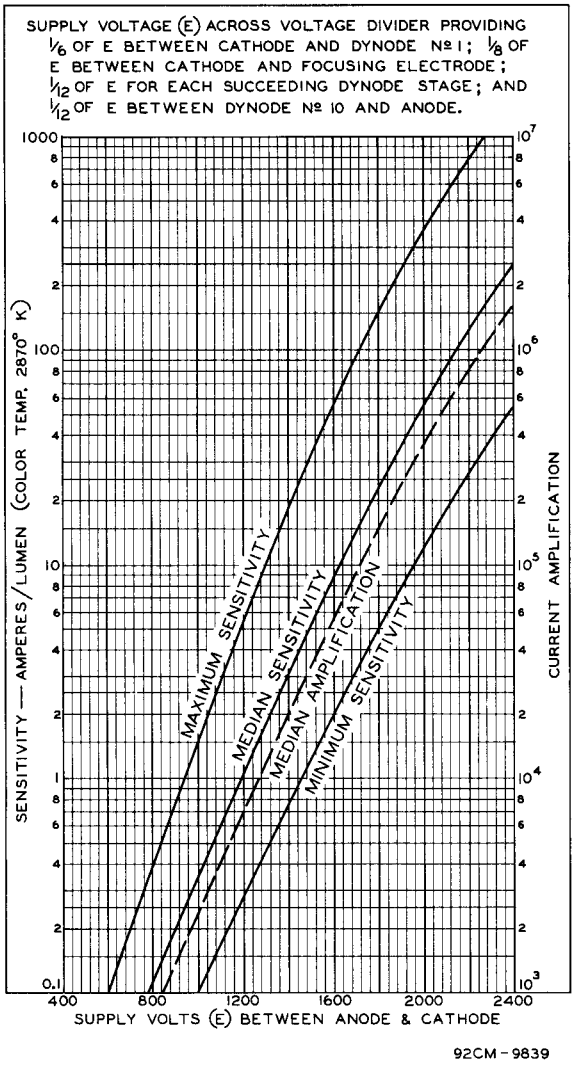

Fig. 2 - Characteristics of Type 7326.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

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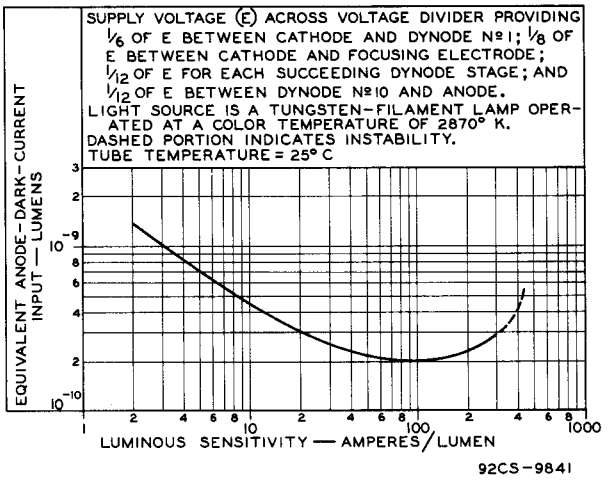


Fig. 3 - Typical Anode-Dark-Current Characteristics of Type 7326.

The use of an *average anode current* well below the maximum rated value of 1 milliampere is recommended when stability of operation is important.

Electrostatic and/or magnetic shielding of the 7326 may be necessary. When a shield is used it should be connected to a potential near that of the cathode. It is to be noted that the use of an external magnetic and/or electrostatic shield at high negative potential presents a safety hazard unless the shield is connected through a high impedance in the order of 10 megohms to the potential. If the shield is not so connected, *extreme care should be observed in providing adequate safeguards to prevent personnel from coming in contact with the high potential of the shield.*

The high voltages at which the 7326 is operated are very dangerous. Before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any capacitors grounded.

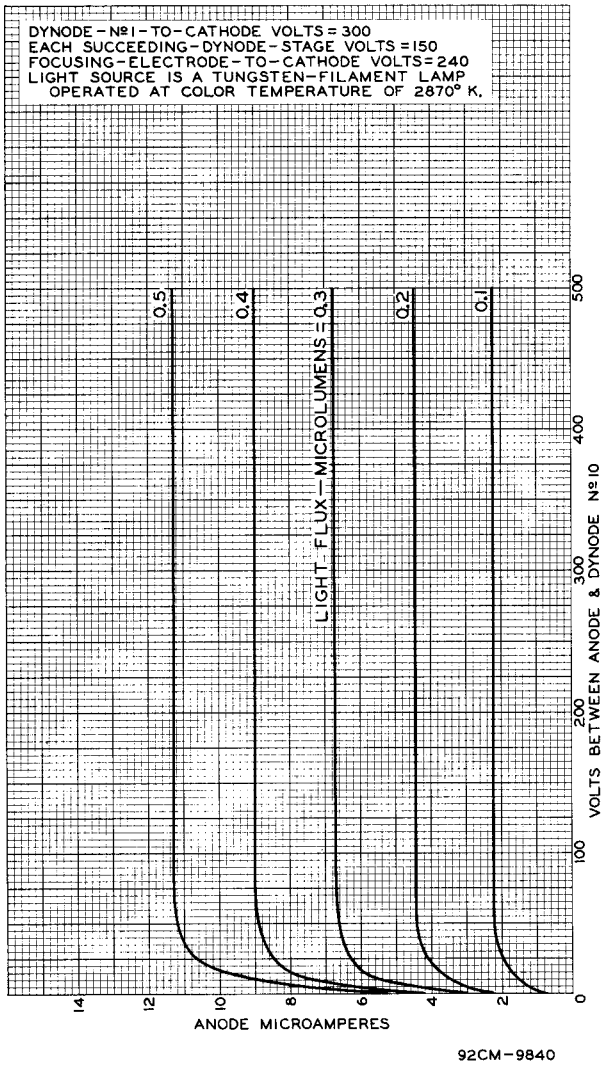
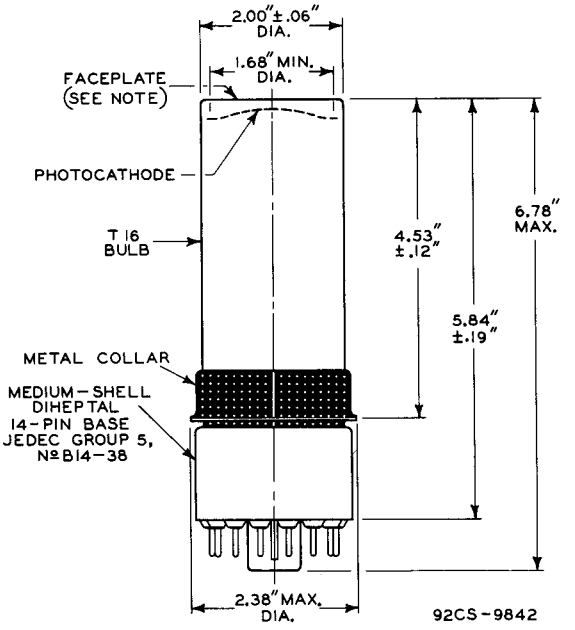


Fig. 4 - Typical Anode Characteristics of Type 7326.

DIMENSIONAL OUTLINE



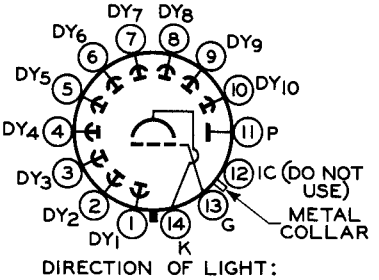
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT THE CENTER OF BOTTOM OF THE BASE.

NOTE: WITHIN 1.68" DIAMETER, DEVIATION FROM FLATNESS OF EXTERNAL SURFACE OF FACEPLATE WILL NOT EXCEED 0.005" FROM PEAK TO VALLEY.

SOCKET CONNECTIONS

Bottom View

PIN 1: DYNODE No.1
PIN 2: DYNODE No.2
PIN 3: DYNODE No.3
PIN 4: DYNODE No.4
PIN 5: DYNODE No.5
PIN 6: DYNODE No.6
PIN 7: DYNODE No.7
PIN 8: DYNODE No.8
PIN 9: DYNODE No.9
PIN 10: DYNODE No.10



14AM

PIN 11: ANODE
PIN 12: INTERNAL CONNECTION--DO NOT USE
PIN 13: FOCUSING ELECTRODE
PIN 14: PHOTOCATHODE
METAL COLLAR: NO CONNECTION
NOTE - If used, connect only to photocathode.

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from JEDEC release #2783, April 11, 1960

7539

GRAPHECHON

Scan-Conversion Storage Tube

Writing Gun:	Magnetic Deflection Electrostatic Focus	Bombardment-Induced- Conductivity Writing	26" Max. Length 3.4" Max. Diameter
Reading Gun:	Magnetic Deflection Magnetic Focus	Capacitance-Charge Reading	Coaxial Construction Two Duodecal Bases

RCA-7539 is a sturdy charge-storage tube designed for use in data-processing applications where signal information must be continuously transformed, with minimum loss in detail, from one time base or scanning presentation to another. In addition, the 7539 provides a means of obtaining bright displays having a continuous range of halftone information under conditions of high ambient illumination.

In a typical systems application, PPI (Plan Position Indicator) information generated by radar installations is transformed by the 7539 into TV-type signals so that the information can be viewed on direct-view and projection television monitors. If desired, a large number of such monitors may be used to repeat the display at locations remote from the master-display unit. For example, the 7539 may be used in airport-surveillance applications where aircraft-traffic-condition information may be sent over ordinary TV-type distribution systems to distant cities. Also, information from several radar installations as well as ground-map or special command information picked up by TV cameras may be readily mixed and presented as a composite display.

The characteristics of the 7539 are such that the stored information may be extracted and displayed at high-brightness levels for a period corresponding to many TV scanning frames. Depending on the signal-to-noise ratio required, this period may be adjusted from several seconds to more than a minute by suitable choice of tube operating voltages.

The resolution capability of the 7539 is 150 range rings per display radius with a response of 50 per cent or better. To utilize fully the resolution capability of the 7539, the TV monitor system must be designed for resolution in excess of 1000 TV lines.

Design features of the 7539 include a sturdy construction utilizing special bulb supports, glass beading which locks the electrodes in permanent relation to each other, and a precision alignment of the coaxial elements. These features insure both dependable performance and close uniformity in characteristics from tube to tube. Another feature of the 7539 is the use of small recessed cavity caps as envelope terminals.

PRINCIPLES OF OPERATION

The 7539 has three sections—a writing section, a reading section, and a target section—as shown in Fig. 1.

Writing Section

The writing section contains an electron gun consisting of an indirectly heated cathode, a control grid (grid No. 1), an accelerating grid (grid No. 2), a focusing grid (grid No. 3), and a final accelerating electrode (grid No. 4) connected to the external conductive coating. The writing gun produces a high-velocity electron beam which is focused electrostatically and deflected by the magnetic fields of external deflecting coils.

Reading Section

The reading section contains an electron gun consisting of an indirectly heated cathode, a control grid (grid No. 1), and an accelerating grid (grid No. 2). The reading gun produces a

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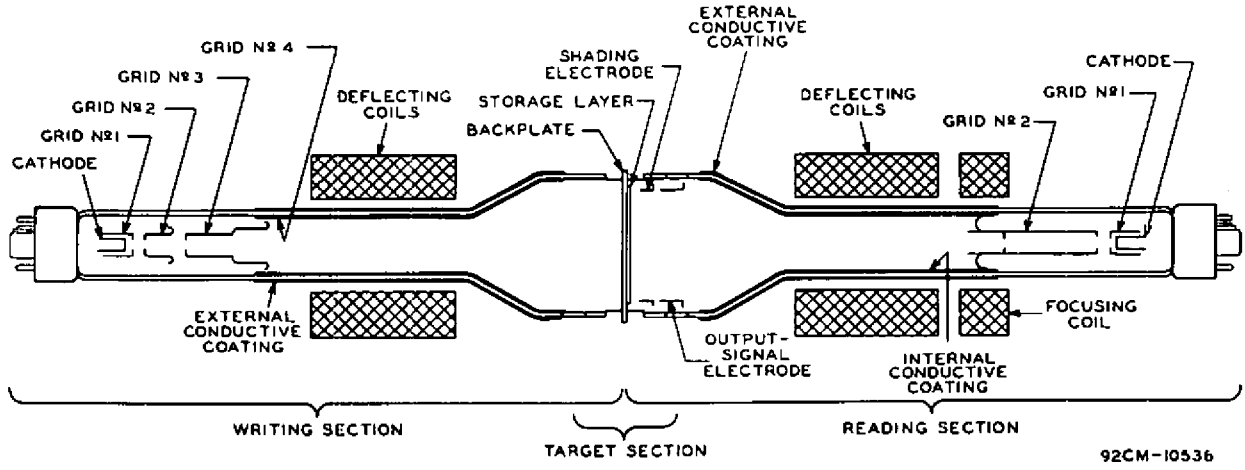


Fig. 1 - Schematic Arrangement of Type 7539.

medium-velocity electron beam which is focused and deflected by the magnetic fields of external focusing and deflecting coils.

Target Section

The target section contains a target, a shading-electrode, and an output-signal electrode. The target consists of a very thin layer of a high-resistivity material deposited on the front—the reading-gun side—of the backplate. The backplate is composed of an extremely thin layer of metal deposited on the reading-gun side of a very fine metal mesh. The backplate allows high transmission of incident writing-beam electrons. The thin layer of high-resistivity material is called the storage layer. The storage layer, under normal operating conditions, has a secondary emission ratio greater than unity. The storage layer also serves as a dielectric for the capacitor formed between the backplate and the front surface of the storage layer.

When the front surface of the storage layer is bombarded by the medium-velocity electron beam of the reading gun, secondary electrons are emitted. As the secondary-electron emission ratio of the front surface is greater than unity, the surface begins to charge in the positive direction. Under continued bombardment, the surface becomes increasingly positive with respect to the output-signal electrode until a retarding potential of a few volts is built up and equilibrium is established.

The opposite side of the storage layer—the back side—is in mechanical and electrical contact with the backplate. Because the backplate is at a negative potential with respect to the output-signal electrode, a difference of potential exists between the two surfaces of the storage layer during conditions of equilibrium. During the writing process, the high-velocity electron beam bombards the target. It passes through the backplate and penetrates the storage layer. The resulting bombardment-induced-conductivity produced in the storage layer lowers the potentials of the front surface elements by varying degrees toward the negative potential of the backplate. The front surface of the storage layer thus acquires a pattern of potential variations which corresponds to the input video signal. When the writing beam is removed, the storage layer gradually regains normal resistivity.

Because the output signal from any given area of the storage layer is a continuous function of the input signal, providing that area is not written beyond saturation, storage of a continuous range of halftone information is possible.

The writing or discharging characteristic of the 7539 is a function of writing-beam current, writing-beam velocity, scanning speed, and width as well as repetition rate of the input-pulse signal.

The change in potential of the storage-surface elements caused by writing-beam bombardment upsets the equilibrium conditions established by the reading beam. Secondary electrons, produced by reading-gun bombardment of the storage-surface elements that have been driven toward the negative backplate voltage by writing, are now accelerated to the output-signal electrode and constitute the output-signal current. The reading process, therefore, serves as an erasing process by removing the stored potential pattern and driving the storage surface back toward the equilibrium value. Because the storage layer does not immediately regain its normal resistivity after the writing beam is removed, and because there is relatively large capacitance between the front surface and the back surface of the storage layer, a large number of scans are required before equilibrium is reestablished. The stored signal accordingly "persists" for some time.

The reading or charging characteristic of the 7539 is a function of backplate potential and reading-gun current. Increasing backplate potential and decreasing reading-beam current result in increased charging time. By suitably adjusting these operating values, the reading time can be varied from a few seconds to over a minute.

Because the reading process removes the stored-charge pattern and brings the storage-surface elements to the equilibrium potential essential for writing, an erasing process is not ordinarily required.

The maximum number of scanning frames (copies) obtainable during the reading process depends on the magnitude of the potential variations produced on the storage-surface elements during the writing process, and the minimum value of reading-beam current that can be used in relation to the noise level of the associated amplifier.

The shading-electrode is used to reduce variation in the equilibrium potential of the storage-surface elements as a function of their location on the surface. As a result of its action, the output signal is relatively free from the effect commonly called "shading". The shading-electrode is operated at a potential somewhat positive with respect to that of the backplate.

DATA

General:

	Writing Gun	*Reading Gun*	
Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3 ± 10%	6.3 ± 10%	volts
Current at 6.3 volts	0.6	0.6	amp
Direct Interelectrode Capacitances:			
Grid No.1 to all other electrodes	7	6	μμf
Cathode to all other electrodes	4.8	5	μμf
Output-signal electrode to all other electrodes	15		μμf
Backplate to all other electrodes	26		μμf
Focusing Method	Electrostatic	Magnetic	
Deflection Method	Magnetic	Magnetic	
Deflection Angles (Approx.)	30°	30°	
Overall Length	25.5" ± 0.5"		
Maximum Diameter	3.40"		
Minimum Useful Target Diameter	2.25"		
Base:			
Writing Gun	Tan—Small-Shell Duodecal 7-Pin, Arrangement 1, (JEDEC No.B7-51)		
Reading Gun	Black—Small-Shell Duodecal 6-Pin, Arrangement 1, (JEDEC No.B6-63)		
Socket (For either base)	Alden★ No.212FTSC, or Cinch★★ No.9464-12, or equivalent		
Bulb Terminals:			
Cap (Three)	Recessed Small Cavity (JEDEC No.J1-21)		
Flange	See *Dimensional Outline*		
Operating Position	Tube Axis Horizontal, or with the Black-Base End Down		
Weight (Approx.)	1.2 lbs		

Maximum and Minimum Ratings, *Absolute-Maximum Values:*♦

OUTPUT-SIGNAL ELECTRODE-TO-BACKPLATE VOLTAGE:		
Positive value	100 max.	volts
Negative value	10 max.	volts
OUTPUT-SIGNAL ELECTRODE-TO-SHADING-ELECTRODE VOLTAGE	100 max.	volts
OUTPUT-SIGNAL ELECTRODE-TO-GRID-No.2 (Reading Gun) VOLTAGE	100 max.	volts
OUTPUT-SIGNAL ELECTRODE-TO-EXTERNAL CONDUCTIVE COATING (Reading Gun) VOLTAGE	100 max.	volts
SHADING-ELECTRODE-TO-BACKPLATE VOLTAGE	100 max.	volts
SHADING-ELECTRODE-TO-EXTERNAL CONDUCTIVE COATING (Reading Gun) VOLTAGE	100 max.	volts
BACKPLATE-TO-GRID-No.4 (Writing Gun) VOLTAGE	100 max.	volts

Voltages are referred to cathode of respective gun unless otherwise indicated

	Writing Gun	*Reading Gun*	
GRID-No.4 VOLTAGE	11000 max.	–	volts
GRID-No.3 VOLTAGE	3000 max.	–	volts
GRID-No.2 VOLTAGE	300 max.	2500 max.	volts
GRID-No.1 VOLTAGE:			
Negative bias value	180 max.	0 max.	volts
	*	0 min.	volts
PEAK HEATER-CATHODE VOLTAGE:§			
Heater negative with respect to cathode	125 max.	125 max.	volts
Heater positive with respect to cathode	10 max.	10 max.	volts

Typical Operating Conditions and Characteristics:

Voltages are referred to ground⊕ unless otherwise indicated

	Writing Gun	*Reading Gun*	
Grid-No.4 Voltage	0	–	volts
Grid-No.3 Voltage for Focus	-7000 to -9000	–	volts
Grid-No.2 Voltage	-9800	0 to -30#	volts
Grid-No.1-to-Cathode Voltage for Beam-Current Cutoff	-40 to -100	-40 to -100	volts
Cathode Voltage	-10,000	-2000	volts
Cathode Current:			
Maximum Operating Value (Approx.)	50□	200	μa
Maximum Zero-Bias Value	▲	3.8	ma
Focusing-Coil Current□□	–	23	ma
Backplate Voltage♦	-4 to -7		volts
Shading-Electrode Voltage	10		volts
Output-Signal-Electrode Voltage	0		volts

Maximum Circuit Values:

	Writing Gun	*Reading Gun*	
Grid-No.1-Circuit Resistance	1.5 max.	1.5 max.	megohms

Characteristics Range Values for Equipment Design:

	Note	*Min.*	*Max.*	
Peak Output-Signal Current	1	0.3	–	μa
Relative Response of Output Video Signal	2	50	–	%
Maximum Time to Erase Stored Signal to 10% of Value Immediately Following Writing	–	–	30	sec
Minimum Number of Discernible Output-Signal Levels	3	4	–	
Storage Factor for Essentially Saturated Writing	1.4	3	–	μa-sec

Note 1: Under the following conditions: The writing-gun beam is modulated with pulses whose half-amplitude

duration is between 0.5 and 1.0 microsecond. The modulated beam scans the back side of the target to produce a PPI display of 150 concentric rings. The 150th ring utilizes the maximum usable diameter of the storage-tube target.

PPI radial-scan repetition rate. . .	1000	cps
PPI radial range period.	610	μsec
PPI scan rotational rate (Approx.) .	6	rpm

The reading-gun beam scans the front side of the target to produce a square raster whose usable edges (exclusive of blanked portions) are tangent to the usable target circumference.

Vertical scan rate	60	cps
Horizontal scan rate	28350	cps
Frames per second.	30	
Fields per frame (Interlaced). . . .	2	
Lines per frame.	945	
Active field time.	90	%
Active line time	83	%
Aspect ratio	1	

The reading-beam current and/or backplate voltage is adjusted so that the output signal from the range rings drops to approximately 50% of its initial level in one PPI rotational period.

Note 2: Relative response of output video signal is defined by the expression h/H in per cent where "H" is the peak-to-peak value of output signal produced when the reading beam is scanning a 35-concentric-ring display immediately following writing and "h" is the peak-to-peak value of output signal produced when the reading beam is scanning a 150-concentric-ring display immediately following writing. This ratio is determined under the same writing and reading conditions of Note 1 except the writing section is initially scanned to produce the PPI display on the target of 35 concentric rings and then, after erasure, is scanned to produce the PPI display on the target of 150 concentric rings.

Note 3: The minimum number of discernible output-signal levels is defined as the number of output-signal levels, each related to a different input signal, which can be just distinguished from each other regardless of their relative location on the storage surface.

Note 4: Storage factor is defined as the product of the initial value of the peak amplitude of the output-signal current (above background or equilibrium level) and the time required for the peak amplitude of the output-signal current to drop to 50% of its initial value.

★ Alden Products Company, 117 N. Main Street, Brockton, Mass.

★★ Cinch Manufacturing Corporation, 1026 S. Homan Avenue, Chicago 24, Illinois.

♦ The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

* Static bias-voltage value should never be less negative than value required for beam cutoff.

§ To prevent the possibility of inadvertantly exceeding these ratings, it is recommended that the cathode should be connected to the center tap or one side of heater transformer.

⊕ External conductive coatings of the 7539 should be grounded.

Adjust for optimum stored-signal uniformity.

□ Peak value. Average cathode current is much lower due to nature of radar video signals.

▲ Writing gun must never be operated at zero-bias voltage.

⊟ With Syntronic F10B Focusing Coil, or equivalent. Focusing-coil air-gap should be approximately 6.5" from target flange.

♦ Adjusted for desired storage-time characteristics.

OPERATING CONSIDERATIONS

Handling. The 7539 should preferably be transported or handled with either the black-base end down or with the tube axis horizontal to prevent any loose particles within the tube from striking the storage surface and adhering to it. Care should be taken to prevent striking the glass-to-metal seals. Such rough treatment will cause either immediate or delayed cracking of these seals.

Shielding. Electrostatic, magnetic, and light shielding are required by the 7539 for satisfactory performance.

Electrostatic shielding of the target section must be provided to prevent external radiation from causing spurious signals in the output circuit. This shield must make good electrical contact with the external conductive coatings of both the reading section and the writing section of the 7539. A suitable contact to each of the external conductive coatings can be provided by phosphor-bronze spring-finger ring contacts close to and on each side of the backplate flange. Holes for terminal leads should be made through the shield material.

Magnetic shielding of the 7539 and its focusing coil and deflecting coils must also be provided to prevent external magnetic fields from affecting the writing-gun beam and the reading-gun beam, and therefore, tube performance. The amount and nature of the shielding necessary is dependent on the location and intensity of the magnetic fields produced by the components of associated equipment. The use of a canister-type shield made of a high-permeability material is suggested. The canister wall should be at least 1/32" thick with provisions for adding additional layers of shielding material if they are required.

Light shielding, which may be provided by either the electrostatic or magnetic shielding, is necessary because the storage-layer material of the target is photoconductive. Failure to provide adequate light shielding for the 7539 results in unstable output-current storage-time characteristics and unsatisfactory erasing performance.

Operating Position. The 7539 may be operated either horizontally or vertically with the black-base end down. Support for the 7539 can be effected by mounting the tube on a set of right-angle "V" blocks within the magnetic shield. Suitable straps may hold the tube in place. Care must be taken, however, not to exert excessive

radial forces on the glass necks of the tube. The V-blocks should be of a non-magnetic material and should support the tube at no more than two axial positions.

Terminal Connections. The pins of both the black and the tan duodecal bases fit a duodecal socket. Connection to the backplate flange may be made by a spring-loaded contact bearing against the rim of the flange. Connections to the output-signal electrode, the shading electrode, and grid No.4 of the writing-gun section are made to recessed small cavity caps.

Deflection Considerations. The writing beam may be deflected by either a mechanically rotating pair of coils diametrically opposite each other or by two stationary pairs of coils. In the latter case, one pair is used for horizontal deflection; and the other, for vertical deflection.

When a rotating pair of coils is used, centering of the undeflected writing beam, as required for a PPI scan, may be accomplished by means of a centering device of either the electromagnetic or permanent-magnet type. This device is mounted on the writing-gun neck behind the rotating deflecting coils.

When stationary coils are used, centering of the undeflected writing beam is preferably accomplished by passing direct current of the required value through each pair of deflecting coils.

Application will govern the choice of deflecting yokes for the reading and writing guns. It is recommended that equipment designers select yokes providing deflection angles of at least 50° even though the tube requires substantially less deflection. The use of deflecting coils providing at least 50° deflection minimizes cross-sectional beam-distortion effects.

For PPI to TV-scan conversion, any of the deflecting coils in the Syntronic* Y15-5, Y17-5, Y25-R or Y27-R series, or their equivalents, are suggested for the writing gun. Deflecting coils in the Syntronic Y16-6 series, or equivalents, are suggested for the reading gun.

Positioning of the Deflecting Coils and Focusing Coil. Because the glass necks of the 7539 have mutual axial alignment and in turn are each aligned with the undeflected beams of the writing and reading guns, the external deflecting coils and the focusing coil must be mounted coaxially with the necks to prevent distortion in the scan-conversion process. Interference to writing-gun and reading-gun beam formation by the magnetic fields of these coils is minimized if the axial-position limitations shown in Fig.2 are observed.

Having noted these limitations, the designer may position the deflecting coils and the focusing coil where they may best serve the requirements of this particular system, keeping in mind the following considerations:

1. Power requirements for the deflecting coils increase as the yokes are moved closer to the backplate flange.
2. Cross-sectional beam-distortion effects resulting from off-axis deflection increase as the yokes are moved closer to the backplate flange. If yokes designed for 50° total deflection angle or more are used, this consideration is of secondary significance.
3. Resolution capabilities of the 7539 are slightly improved as the reading-gun focusing coil is moved closer to the backplate flange.
4. The overall effect of pattern distortions associated with beam scanning of a flat target is minimized if the effective deflection center of each yoke is located equidistant from the backplate flange.
5. Depending on the physical and electrical configurations of the reading-gun deflecting coils and the focusing coil chosen, moderate spacing between these components should be used.

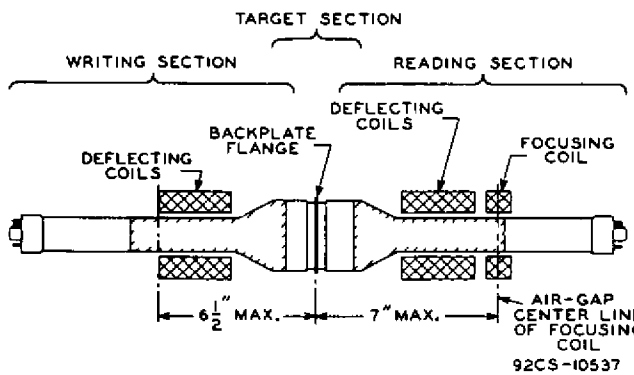


Fig.2 - Limitations to be Observed in Positioning External Deflecting and Focusing Coils for Type 7539.

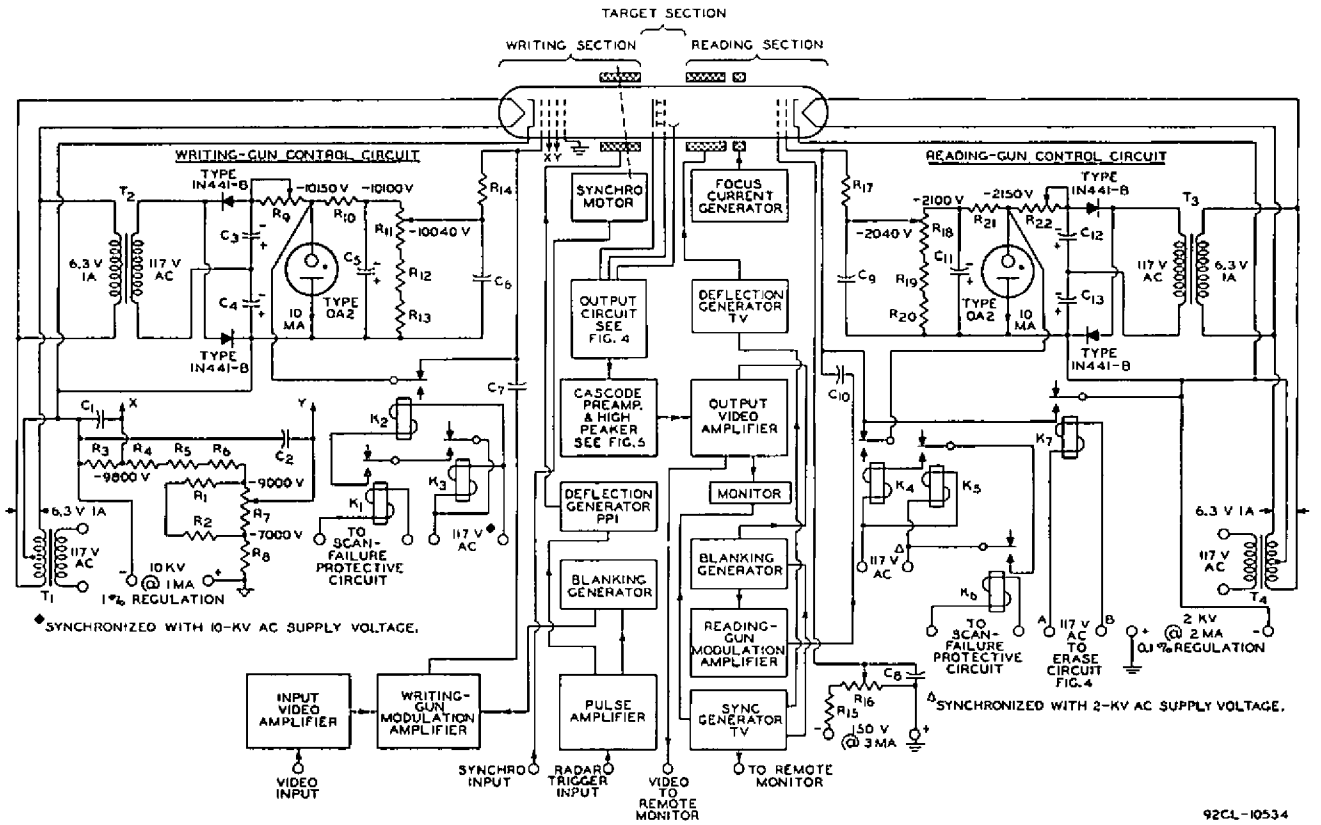
Power-Supply and Gun-Control Considerations. Typical power-supply and gun-control circuits for use with the 7539 are shown in Fig.3. This figure also shows in block-diagram form the associated equipment required for operation of the 7539.

The coupling capacitors C_7 and C_{10} of the writing- and reading-gun control circuits have much higher voltage ratings, and therefore are larger, than the capacitors normally encountered in video circuitry. Stray wiring capacitance in these circuits should be minimized by using short, direct leads wherever possible.

The external conductive coatings of the 7539 should be grounded not only for safety reasons, but also to prevent excessive pickup of noise by the target section.

Because the cathodes of both guns are at high negative voltages, the transformers used to supply current to the heaters as well as the

* Syntronic Instruments, Inc., 100 Industrial Road, Addison, Illinois.



All resistors may have tolerance of ±10 per cent unless otherwise indicated

C_1: 0.1 μf, paper, 400 v working voltage
C_2: 0.1 μf, plastic film, 5 kv working voltage
C_3, C_4: 20 μf, electrolytic, 150 v working voltage
C_5: 4 μf, electrolytic, 150 v working voltage
C_6: 0.5 μf, paper, 200 v working voltage
C_7: 0.05 μf, plastic film, 15 kv working voltage
C_8: 1 μf, paper, 100 v working voltage
C_9: 0.1 μf, paper, 200 v working voltage
C_{10}: 0.1 μf, plastic film, 3 kv working voltage
C_{11}: 4 μf, electrolytic, 150 v working voltage
C_{12}, C_{13}: 20 μf, electrolytic, 150 v working voltage
K_1: S.P.S.T. relay, normally open. Voltage rating is dependent on particular scan-failure circuit used.
K_2: S.P.S.T. vacuum relay, normally closed. Insulated for 15 kv.
K_3: S.P.S.T. relay, 10-second time-delay, normally open, 117 v ac
K_4: S.P.S.T. relay, normally closed, 117 v ac. Insulated for 3 kv.
K_5: S.P.S.T. relay, 10-second time-delay, normally open, 117 v ac
K_6: S.P.S.T. relay, normally open. Voltage rating is dependent on particular scan-failure circuit used.
K_7: S.P.S.T. relay, normally open, 117 v ac. Insulated for 3 kv.
R_1: 2 megohms, 5 watts, 2500 volts
R_2: 300000 ohms, 2 watts
R_3, R_4: 200000 ohms, 1 watt
R_5, R_6: 300000 ohms, 1 watt
R_7: 15-megohm potentiometer, IRC type HV-15, or equivalent
R_8: 7 megohms, 25 watts, 10000 volts
R_9: 10000 ohms, 10 watts, adjustable
R_{10}: 82000 ohms, 1/2 watt
R_{11}: 100000-ohm potentiometer, 1/2 watt. Bias-voltage control.
R_{12}, R_{13}: 33000 ohms, 1/2 watt
R_{14}: 1 megohm, 1 watt
R_{15}: 39000 ohms, 1 watt
R_{16}: 10000-ohm potentiometer, 1/2 watt. Uniformity control.
R_{17}: 1 megohm, 1 watt
R_{18}: 100000-ohm potentiometer, 1/2 watt. Bias-voltage control.
R_{19}, R_{20}: 33000 ohms, 1/2 watt
R_{21}: 82000 ohms, 1/2 watt
R_{22}: 10000 ohms, 10 watts, adjustable
T_1: Heater transformer with secondary insulated for 15 kv.
T_2, T_3: Heater transformer
T_4: Heater transformer with secondary insulated for 3 kv.

Fig. 3 – Typical Power-Supply and Gun-Control Circuits with Block Diagram of Associated Equipment for Type 7539.

sources of control-grid signals must be adequately insulated from ground. It is recommended that the cathode of each gun be connected directly to the mid-tap of its associated heater winding.

The high voltages at which the 7539 is operated may be very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with the high voltages. Safety precautions include the enclosing of high-potential terminals and the use of interlocking switches to break the primary circuit of the power supply when access to the equipment is desired.

In the use of high-voltage tubes, it should always be remembered that high voltages may appear at normally low-potential points in the circuit as a result of capacitor breakdown or incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off, and both terminals of any capacitors grounded.

Failure of Scanning. Failure of scanning while either beam is turned on may permanently damage the target. Provision should therefore be made to cut off beam current of both guns automatically in case of scanning failure. Cutoff may be effected by making the control grids—grid No. 1 of the writing gun and the reading gun—sufficiently negative with respect to the gun cathodes. The beams must be cut off nearly as rapidly as the decrease in scanning current occurs. The protective circuit for the 7539 should be capable of cutting off the writing beam and the reading beam within 50 milliseconds after scanning failure. The protective circuit may be actuated by a tube that is controlled by a portion of the scanning pulse voltage developed across the deflecting coils. It is important that the horizontal and vertical scanning each independently actuate the protective circuit in case either should fail.

Regulation of Bias Supplies. Because the output signal and reading duration are critically dependent on the beam current of both the reading gun and the writing gun, it is essential that grid-No. 1 bias supplies have good regulation if variations in output signal and in reading duration are to be avoided. In addition, the voltage supply providing the writing-beam accelerating potential must have substantially less ripple than is permitted in ordinary cathode-ray tube circuits. Ripple in this supply should be kept to a value substantially less than 0.1 volt.

Crosstalk. At a writing-gun accelerating-electrode (Grid No. 4) voltage of 10 kilovolts, less than 20 per cent of the writing-beam current appears in the output-signal electrode circuit. For most applications, writing beam current is low and feed-through is not discernible in the output display. However, if cancellation of crosstalk is desired, simple mixing, in opposite phase or polarity, of a writing-beam sample with the output signal of the tube should be adequate. RF carrier separation techniques need not be used. Operating the writing gun of the 7539 at reduced accelerating voltages also reduces crosstalk to a negligible value but this procedure also reduces tube resolution.

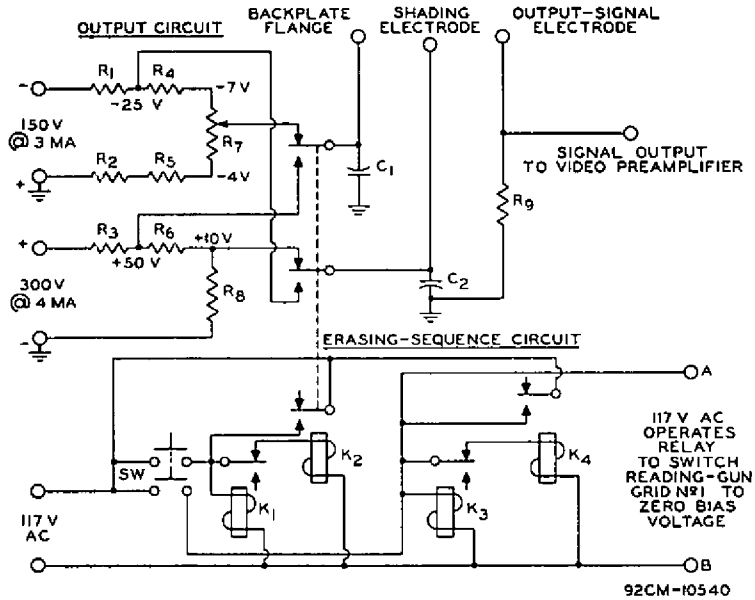
Reading Duration Control. Reading duration may be adjusted by control of reading-beam current and to a lesser degree by control of backplate voltage. The basic control of this performance characteristic should be effected by adjustment of reading-gun beam current.

Erasure. Ordinarily there is no need to program an erasing sequence but under certain conditions—such as radar-range changes—rapid clearing of information may be desirable. The following procedure should be used for erasure:

1. Simultaneously adjust backplate voltage to +50 volts, shading-electrode voltage to −25 volts, and the reading-gun grid-No. 1 bias voltage to 0 volts.
2. After a 10-second interval, readjust backplate- and shading-electrode voltages to their normal operating voltages.
3. Allow a 10-second interval before readjusting the reading-gun grid-No. 1 bias voltage to its normal operating voltage.
4. An additional 10-second delay permits associated equipment to regain stability.

As indicated in Fig. 4, the erasing sequence may be effected by using time-delay relay circuitry.

Video-Drive Considerations. Information to be stored by the 7539 should be applied as a video signal to the control grid (grid No. 1) or the cathode of the writing gun. Video signals are treated the same as if they were to be displayed on ordinary cathode-ray display tubes. Grid-No. 1 bias voltage is first adjusted to cut-off completely writing-beam current. An unblanking pulse, coincident in time with the writing-beam scanning waveform, is then applied to grid No. 1 to allow the writing-beam current to reach the threshold of writing. For PPI displays, a larger writing-beam current is required to obtain this threshold at the edges of the PPI pattern than is required at the center. The necessary current waveshape is obtained by additively mixing a sawtooth waveform with the basic rectangular unblanking pulse. The amplitude of the sawtooth component depends on the range and azimuth repetition rates, and the scanning times associated with the particular radar system. The video signal may be either mixed with this composite unblanking signal and applied to grid No. 1 of the writing gun, or the video signal may be applied directly to the cathode of the writing gun with the composite unblanking signal applied to grid No. 1 of the writing gun. Regardless of the method used, the amplitude of the video signal is dependent on the particular parameters of the radar system used.



All resistors may have tolerance of ±10 per cent unless otherwise indicated

C_1, C_2: 1 μf, paper, 100 v working voltage

K_1: S.P.S.T. relay, 10-second time-delay, normally closed, 117 v ac

K_2: 3 P.D.T. relay, 117 v ac

K_3: S.P.S.T. relay, 20-second time-delay, normally closed, 117 v ac

K_4: S.P.S.T. relay, normally open, 117 v ac

R_1: 43000 ohms, 1 watt

R_2: 1000 ohms, 1/2 watt

R_3: 62000 ohms, 2 watts

R_4: 6200 ohms, 1/2 watt

R_5: 330 ohms, 1/2 watt

R_6: 10000 ohms, 1/2 watt

R_7: 1000-ohm potentiometer, 1/2 watt. Storage-time control.

R_8: 2400 ohms, 1/2 watt

R_9: 47000 ohms, 1/2 watt. Representative value.

Sw: D.P.S.T. momentary contact (spring return), normally open. "Push-to-erase" switch.

Fig. 4 - Output Circuit and Erasing-Sequence Circuit for Type 7539.

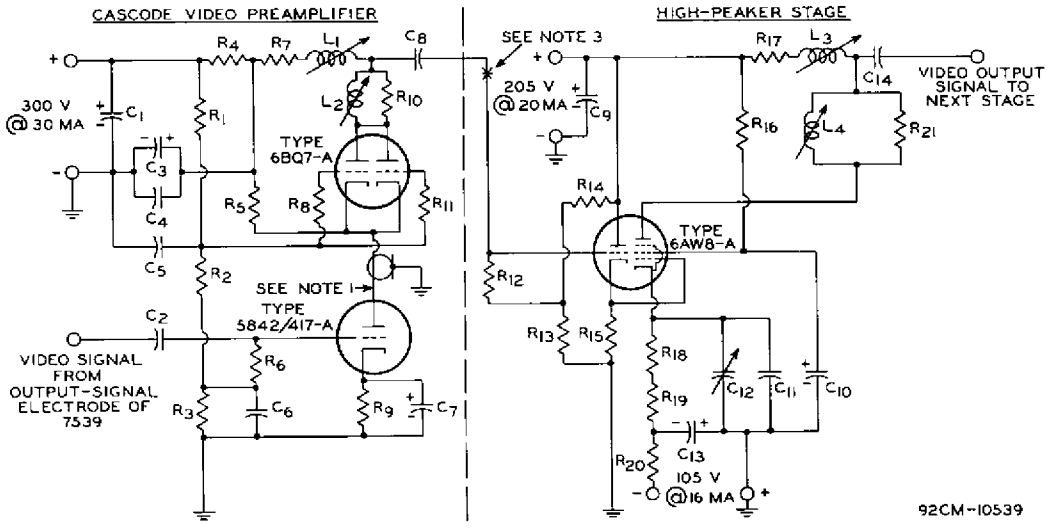
Video-Amplifier Circuitry. Typical video amplifier circuits for the 7539 are shown in Fig. 5. In most applications, the peak-to-peak output signal current of the 7539 is in the order of tenths of a microampere. Video amplifiers should, therefore, be designed for high gain and low noise. A cascode-type preamplifier followed by appropriate high-peaker stages is highly recommended because of the extremely low equivalent-noise-input current that can be realized with this type of amplifier system. For example, such a system designed for a noise-equivalent bandwidth of 18 Mc may have an equivalent-noise-input current of less than 0.02 microampere rms value. An amplifier having a noise-equivalent-bandwidth of at least 18 Mc is necessary to fully utilize the capabilities of the 7539 in scan-conversion systems employing 945 lines per frame and 30 frames per second.

The designer may wish to add one or more video-amplifier stages between the cascode preamplifier and the high-peaker stage. It is good practice to amplify the output signal from the cascode preamplifier to a high level—avoiding overload conditions—before feeding the signal into the high-peaker stage. In Fig. 5 the output signal of the preamplifier stage is approximately 0.25 volt. If additional amplification is desired, one or two video-amplifier stages each having a gain of 5 are recommended.

SET-UP PROCEDURE

The following steps should be followed when first placing the 7539 in operation:

1. Insert the 7539 in its mount, position the external deflecting and focusing coils, and attach sockets.
2. Make certain that the deflection circuits are functioning properly to cause the beams to scan the target.
3. Be sure the grid-No. 1 voltage of each gun is adjusted beyond beam cutoff and then apply voltages as indicated under *Typical Operation*. This procedure is essential to avoid possible damage to the target.
4. Adjust the reading-gun grid-No. 1 bias voltage so that a picture of the 7539 target becomes visible on the system display monitor.
5. Adjust reading-beam deflection circuitry as required. In a typical PPI to TV system, the edges of the useful target area should lie tangent to the reading raster.
6. Adjust reading-gun focusing-coil current for sharpest picture of the 7539 target as seen on the system display monitor.
7. Set backplate voltage to -4 volts and reading-gun grid-No. 2 voltage to -25 volts.
8. Without applying the input video signal,



All resistors may have tolerance of ±10 per cent unless otherwise indicated

C_1: 10 μf, electrolytic, 450 v working voltage
C_2: 0.1 μf, paper, 100 v working voltage
C_3: 10 μf, electrolytic, 450 v working voltage
C_4: 0.01 μf, paper, 400 v working voltage
C_5: 0.22 μf, paper, 200 v working voltage
C_6: 0.001 μf, ceramic disc, 600 v working voltage
C_7: 500 μf, electrolytic, 25 v working voltage
C_8: 0.22 μf, paper, 400 v working voltage
C_9, C_{10}: 40 μf, electrolytic, 250 v working voltage
C_{11}: 150 μf, mica, 500 v working voltage
C_{12}: 20 to 200 μμf, ceramic trimmer, 500 volts. This trimmer provides compensation over a range of 30 to 50 μμf for the high-frequency-response attenuation caused by the capacitance at the 5842/417-A grid.
C_{13}: 300 μf, electrolytic, 150 v working voltage
C_{14}: 0.1 μf, paper, 400 v working voltage
L_1: 5 μh
L_2: 10 μh
L_3: 5 μh
L_4: 10 μh
R_1: 330000 ohms, 1/2 watt
R_2: 270000 ohms, 1/2 watt
R_3: 47000 ohms, 1/2 watt
R_4: 750 ohms, 2 watts
R_5: 12000 ohms, 2 watts
R_6: 510000 ohms, 1/2 watt
R_7: 750 ohms, 2 watts
R_8: 200 ohms, 1/2 watt
R_9: 680 ohms, 1 watt
R_{10}: 4700 ohms, 1/2 watt
R_{11}: 200 ohms, 1/2 watt
R_{12}: 1 megohm, 1/2 watt
R_{13}: 82000 ohms, 1/2 watt
R_{14}: 1 megohm, 1/2 watt
R_{15}: 5600 ohms, 1/2 watt
R_{16}: 22000 ohms, 1 watt
R_{17}: 750 ohms, 1 watt
R_{18}, R_{19}: 3600 ohms, 2 watts, 5 per cent tolerance
R_{20}: 1000 ohms, 1/2 watt, 5 per cent tolerance
R_{21}: 4700 ohms, 1/2 watt

NOTE 1: BECAUSE THIS IS A LOW-IMPEDANCE PART OF THE CIRCUIT, THE 5842/417-A SHOULD BE LOCATED CLOSE TO THE 7539 TO PERMIT USE OF A SHORT, DIRECT INPUT LEAD TO MINIMIZE STRAY INPUT CAPACITANCE. THE CONNECTION FROM THE 5842/417-A PLATE TO THE 6BQ7-A CATHODE MAY BE A LOW-IMPEDANCE CABLE UP TO 18" IN LENGTH.

NOTE 2: VALUES SHOWN FOR L_1, L_2, L_3, L_4, R_7, R_{10}, R_{17}, AND R_{21} ARE APPROXIMATE VALUES FOR AN AMPLIFIER BANDWIDTH OF 15 MC. THE INDUCTORS SHOULD BE SLUG-TUNED FOR INDIVIDUAL TRIMMING OF THE FREQUENCY RESPONSE CHARACTERISTIC.

NOTE 3: THE INDIVIDUAL DESIGNER MAY WISH TO ADD ONE OR MORE ADDITIONAL VIDEO-AMPLIFIER STAGES BETWEEN THE CASCODE PREAMPLIFIER AND THE HIGH-PEAKER STAGE.

Fig. 5 - Typical Video Preamplifier Circuit and High-Peaker Amplifier Circuit for Type 7539.

adjust writing-gun grid No. 1 and/or unblanking signal level so that bombardment of the 7539 target by the writing beam is just evident.

9. Adjust writing-beam deflection circuitry as required.

10. Adjust the shape of the sawtooth waveform which is superimposed on unblanking pulse and concurrently adjust writing-gun grid-No. 1 bias voltage for threshold writing over all areas encompassed by the writing scanning pattern.

11. Adjust reading-gun grid-No. 1 bias voltage so that writing is just below threshold.

12. Apply video signals (e.g. range marks) to produce writing pattern. Adjust input video-signal amplitude to a value just below that which produces visual evidence of crosstalk on system display monitor.

13. Adjust writing-gun grid-No. 3 voltage for best focus of writing pattern as seen on system display monitor.

14. Readjust reading-gun grid-No. 2 voltage for minimum variation of intensity of output signals. At optimum value of reading-gun grid-No. 2 voltage, the output display will show more detail than otherwise.

15. Apply video signal which is to be processed for display.

16. The reading-gun grid-No.1 bias voltage may now be adjusted to give the desired reading duration (i.e. display persistence). Secondary control of reading duration may be effected by adjustment of backplate voltage within range shown under *Typical Operation*.

REFERENCES

L. Pensak, *"Picture Storage Tube"*, Electronics, Vol.22, No.7, pp.84-88 (July, 1949).

L. Pensak, *"The Graphechon—A Picture Storage Tube"*, RCA Review, Vol.X, No.1, pp.59-73 (March, 1949).

A.H. Benner and L.M. Seeberger, *"Graphechon Writing Characteristics"*, RCA Review, Vol.XII, No.2, pp.230-250 (June, 1951).

M. Knoll and B. Kazan, *"Storage Tubes and Their Basic Principles"*, John Wiley & Sons, Inc., New York, (1952).

DOS and DON'TS on Use of RCA-7539

Here are the "dos"—

1. Handle the 7539 with care.
2. Use extreme caution when installing the 7539.
3. Be sure that both beams are always cut off before applying operating voltages.
4. Operate the reading gun first so that effects of subsequent writing-beam operation may be observed on monitor.

Here are the "don'ts"—

1. Don't strike glass-metal seals of the 7539.
2. Don't operate the 7539 without scanning.
3. Don't use excessive writing-beam current.

The significance of each of these "dos" and "don'ts" in obtaining optimum performance from the 7539 is explained in the preceding pages of this bulletin.

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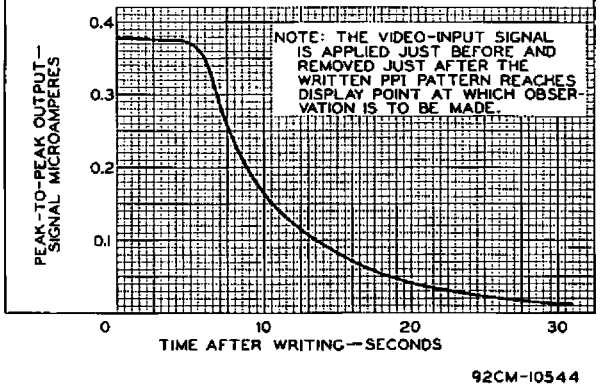
E_f = 6.3 VOLTS—EACH GUN
BACKPLATE VOLTS * = −5
OUTPUT-SIGNAL-ELECTRODE VOLTS * = 0
SHADING-ELECTRODE VOLTS * = +10

	Writing Gun	*Reading Gun*
GRID-№4 VOLTS *	0	—
GRID-№3 VOLTS *	ADJUSTED FOR BEST FOCUS	—
GRID-№2 VOLTS *	−9800	ADJUSTED FOR MOST UNIFORM DISPLAY
GRID-№1 VOLTS *	ADJUSTED FOR THRESHOLD OF WRITING IN ABSENCE OF VIDEO-INPUT SIGNAL	ADJUSTED FOR READING DURATION AS SHOWN
CATHODE VOLTS *	−10000	−2000
FOCUSING-COIL MA	—	ADJUSTED FOR BEST FOCUS
SCANNING:	PPI	TV
RADIAL REPETITION RATE (CPS)	1000	—
RADIAL RANGE PERIOD (μSEC)	610	—
ROTATIONAL RATE (RPM)	6	—
VERTICAL RATE (CPS)	—	60
HORIZONTAL RATE (CPS)	—	28350
VIDEO-INPUT SIGNAL:		
PULSE LENGTH (μSEC)	30	—
PEAK-TO-PEAK VOLTS ABOVE CUTOFF	5	—

*REFERRED TO GROUND.



92CM-10544

Fig. 6 – Typical Storage Characteristic of Type 7539.

E_f = 6.3 VOLTS—EACH GUN
BACKPLATE VOLTS * = −5
OUTPUT-SIGNAL-ELECTRODE VOLTS * = 0
SHADING-ELECTRODE VOLTS * = +10

	Writing Gun	*Reading Gun*
GRID-№4 VOLTS *	0	—
GRID-№3 VOLTS *	ADJUSTED FOR BEST FOCUS	—
GRID-№2 VOLTS *	−9800	ADJUSTED FOR MOST UNIFORM DISPLAY
GRID-№1 VOLTS *	ADJUSTED FOR THRESHOLD OF WRITING IN ABSENCE OF VIDEO-INPUT SIGNAL	ADJUSTED FOR READING DURATION OF 10 SEC
CATHODE VOLTS *	−10000	−2000
FOCUSING-COIL MA	—	ADJUSTED FOR BEST FOCUS
SCANNING:	PPI	TV
RADIAL REPETITION RATE (CPS)	1000	—
RADIAL RANGE PERIOD (μSEC)	610	—
ROTATIONAL RATE (RPM)	6	—
VERTICAL RATE (CPS)	—	60
HORIZONTAL RATE (CPS)	—	28350
VIDEO-INPUT SIGNAL:		
PULSE LENGTH (μSEC)	0.75	—
PEAK-TO-PEAK VOLTS ABOVE CUTOFF	5	—

*REFERRED TO GROUND.

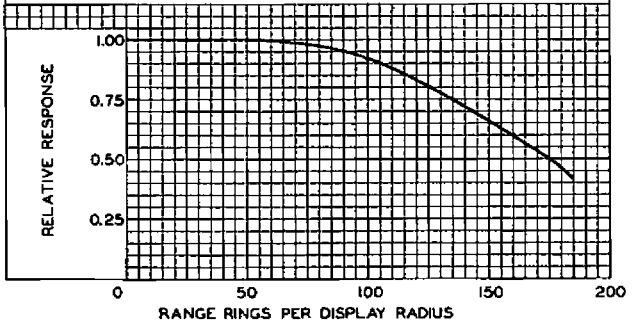


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Fig. 7 – Typical Resolution Characteristic of Type 7539.

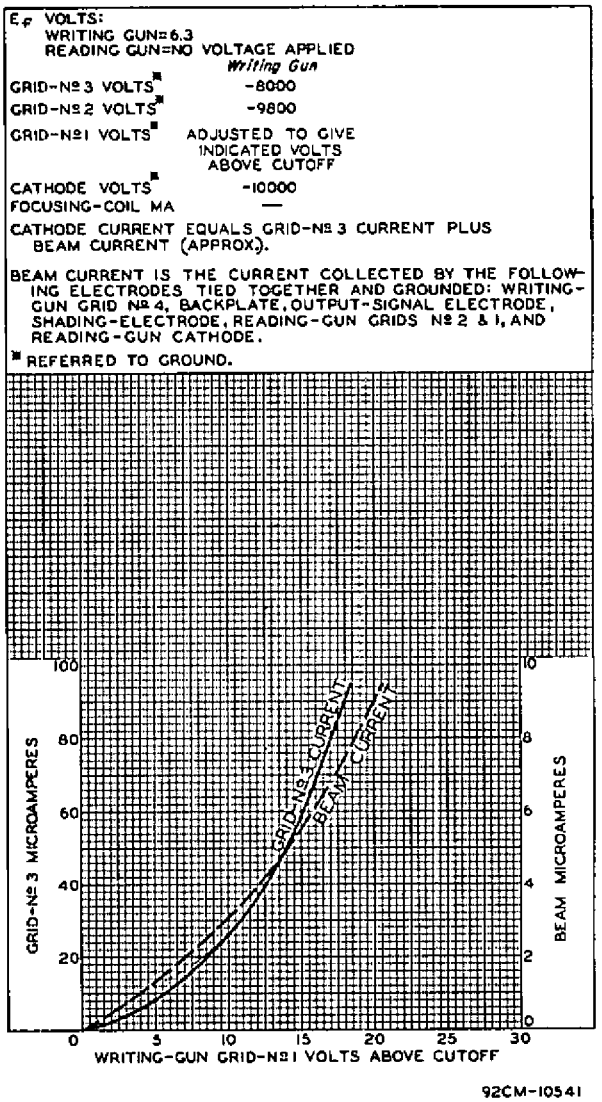


Fig. 8 - Writing-Gun Control-Grid Characteristics of Type 7539.

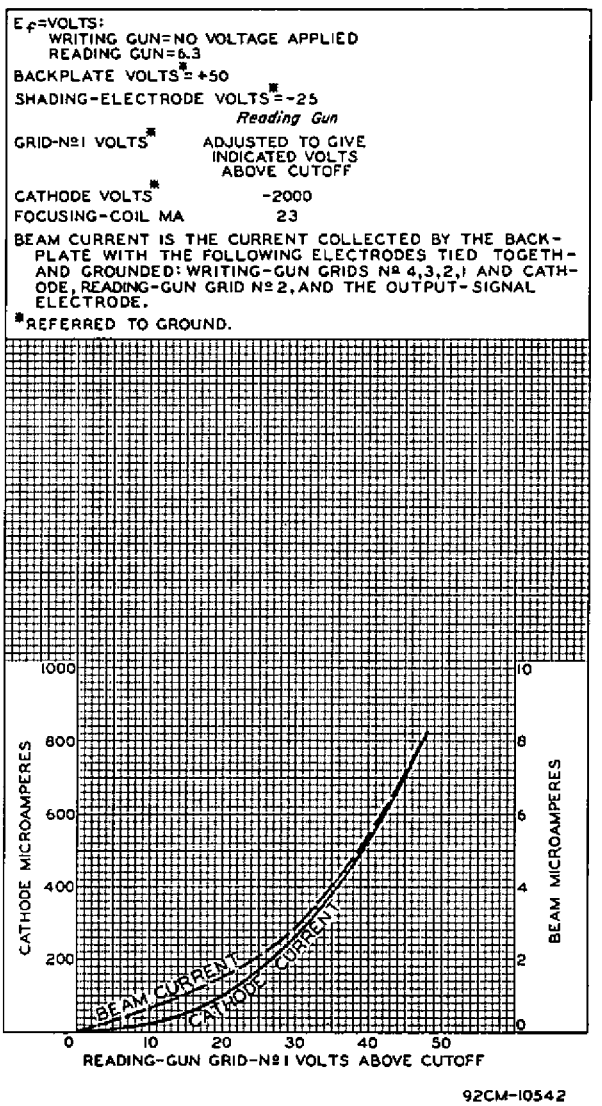
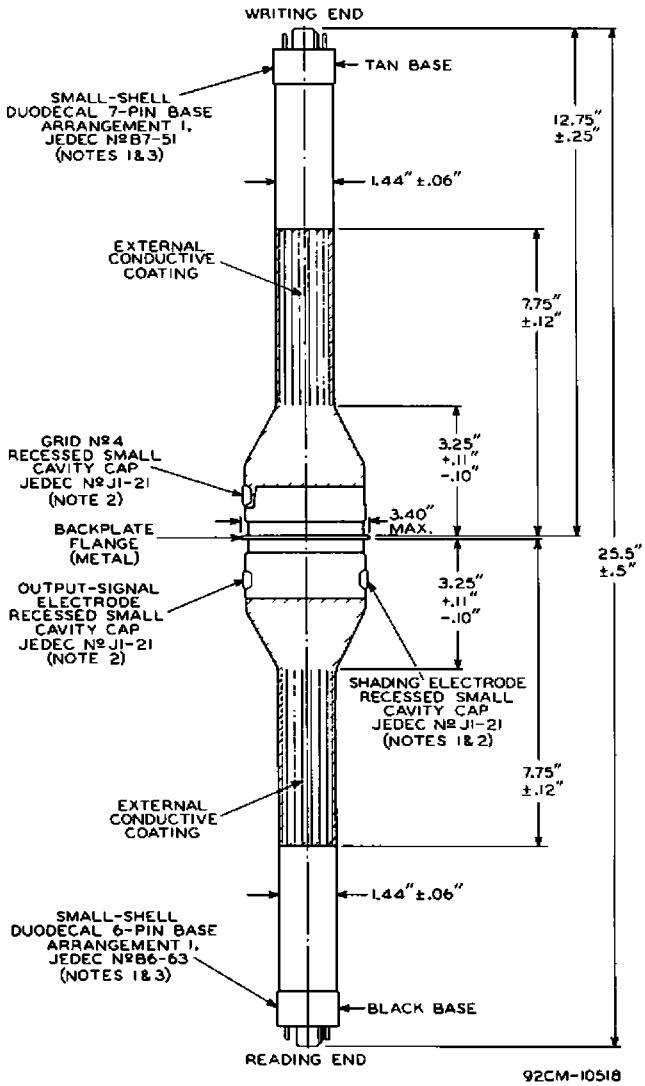
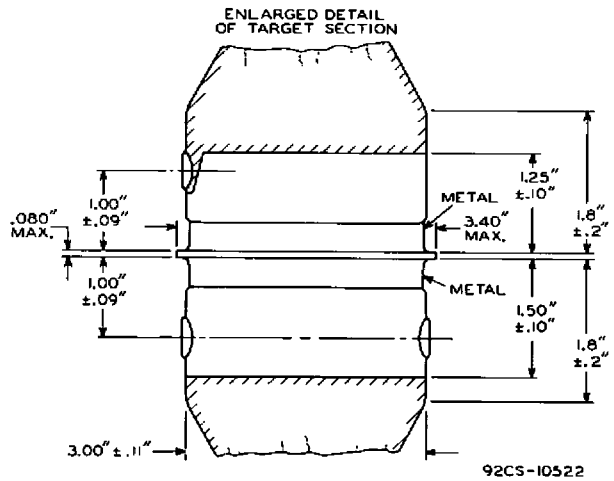


Fig. 9 - Reading-Gun Control-Grid Characteristics of Type 7539.

DIMENSIONAL OUTLINE



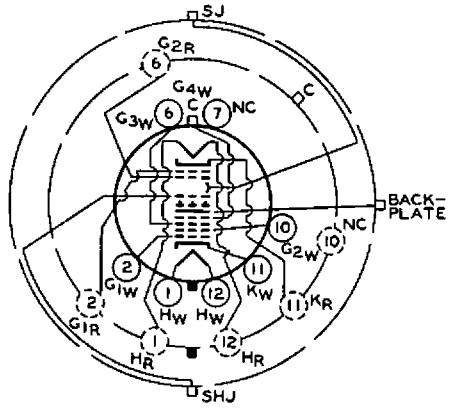


NOTE 1: THE PLANE THROUGH THE TUBE AXIS AND THE KEY OF EITHER DUODECAL BASE MAY VARY FROM THE PLANE THROUGH THE TUBE AXIS AND ℄ OF THE SHADING-ELECTRODE CAP BY AN ANGULAR TOLERANCE OF ±10° MEASURED ABOUT THE TUBE AXIS.

NOTE 2: THE PLANE THROUGH ℄ OF THE OUTPUT-SIGNAL-ELECTRODE CAP AND GRID-No.4 CAP MAY VARY FROM THE PLANE THROUGH ℄ OF THE SHADING-ELECTRODE CAP AND THE TUBE AXIS BY AN ANGULAR TOLERANCE OF ±10° MEASURED ABOUT THE TUBE AXIS.

NOTE 3: THE AXIS OF EITHER DUODECAL BASE WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE AXIS OF THE TUBE ENVELOPE.

BASING DIAGRAM



WRITING SECTION

End View of Duodecal 7-Pin Base Depicted by Solid Lines

PIN 1: HEATER
PIN 2: GRID NO.1
PIN 6: GRID NO.3
PIN 7: NO CONNECTION
PIN 10: GRID NO.2
PIN 11: CATHODE
PIN 12: HEATER
CAP ON WRITING GUN SIDE OF FLANGE (Cap located on side of tube opposite base key): GRID NO.4, EXTERNAL CONDUCTIVE COATING

READING SECTION

End View of Duodecal 6-Pin Base Depicted by Dashed Lines

PIN 1: HEATER
PIN 2: GRID NO.1
PIN 6: GRID NO.2
PIN 10: NO CONNECTION
PIN 11: CATHODE
PIN 12: HEATER
C: EXTERNAL CONDUCTIVE COATING

TARGET SECTION

FLANGE: BACKPLATE
CAP ON READING GUN SIDE OF FLANGE (Cap located on side of tube over base key): SHADING ELECTRODE
CAP ON READING GUN SIDE OF FLANGE (Cap located on side of tube opposite base key): OUTPUT-SIGNAL ELECTRODE

from JEDEC release #2602, Oct. 12, 1959

7558

BEAM POWER TUBE

20.5 Watts Output Class AB_1 Push-Pull AF Amplifier Service | **For Use in Fixed-Station Communications Equipment** | **24 Watts CW Input (ICAS) at 175 Mc.**

RCA-7558 is a beam power tube of the 9-pin miniature type designed for use primarily in fixed-station communications equipment. In such equipment, the 7558 is particularly useful in class C radio-frequency amplifier, oscillator, and frequency-multiplier service at frequencies up to 175 Mc. It may also be used in modulator and audio-frequency power amplifier applications.

Features which contribute to the efficient performance of the 7558 at high frequencies are low lead inductance, small interelectrode capacitances, and low rf losses. Low lead inductance for both cathode and grid No.2 is achieved by the use of two pin connections for each of these electrodes. The use of two cathode base pins provide two separate cathode returns thereby minimizing the possibility of degeneration. The two base-pin connections for grid No.2 facilitates rf bypassing. The low rf losses and high input resistance of the 7558 permit use of relatively high values of grid-No.1-circuit resistance, thus minimizing loading of the driver stage.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 5%	volts
Current	0.8	amp
Direct Interelectrode Capacitances (Without external shield):		
Grid No.1 to plate	0.15 max.	μμf
Grid No.1 to cathode, grid No.3, grid No.2, and heater	10	μμf
Plate to cathode, grid No.3, grid No.2, and heater	5.5	μμf

Characteristics, Class A_1 Amplifier:

Plate Voltage	250	volts
Grid No.3 (Suppressor Grid)	Connected to cathode	
Grid-No.2 (Screen-Grid) Voltage	250	volts
Grid-No.1 (Control-Grid) Voltage	-18	volts
Mu-Factor, Grid No.2 to Grid No.1	8.7	
Transconductance	5300	μmhos
Plate Current	40	ma
Grid-No.2 Current	3	ma

Mechanical:

Operating Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length, Base Seat to Bulb Top (Excluding tip)	2" ± 3/32"
Diameter:	
Maximum	0.875"
Minimum	0.750"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin (JEDEC No.E9-1)

AF POWER AMPLIFIER & MODULATOR — Class AB_1♦

Maximum CCS● Ratings, *Absolute-Maximum Values:*

DC PLATE VOLTAGE	300 max.	volts
GRID-No.3 VOLTAGE	0 max.	volts
DC GRID-No.2 VOLTAGE	250 max.	volts
MAX.-SIGNAL DC PLATE CURRENT□	70 max.	ma
MAX.-SIGNAL PLATE INPUT□	21 max.	watts
MAX.-SIGNAL GRID-No.2 INPUT□	2 max.	watts
PLATE DISSIPATION□	10 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts
BULB TEMPERATURE (At hottest point)	225 max.	°C

Typical CCS● Operation:

Values are for 2 tubes

DC Plate Voltage	300	volts
Grid No.3	Connected to cathode	
DC Grid-No.2 Voltage§	250	volts
DC Grid-No.1 Voltage§	-21	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	40	volts
Zero-Signal DC Plate Current	40	ma
Max.-Signal DC Plate Current	125	ma
Zero-Signal DC Grid-No.2 Current	2	ma
Max.-Signal DC Grid-No.2 Current	14	ma
Effective Load Resistance (Plate to plate)	5000	ohms
Max.-Signal Driving Power	0	watts
Total Harmonic Distortion	5	per cent
Max.-Signal Power Output (Approx.)	20.5	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	0.1 max.	megohm

RF POWER AMPLIFIER & OSC. — Class C Telegraphy† and RF POWER AMPLIFIER — Class C FM Telephony

Maximum Ratings, *Absolute-Maximum Values up to 175 Mc:*

	CCS●	*ICAS●●*	
DC PLATE VOLTAGE	300 max.	300 max.	volts
GRID No.3	Connected to cathode		
DC GRID-No.2 VOLTAGE	250 max.	250 max.	volts

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ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

7558 10-59
Printed in U.S.A.

	CCS●	ICAS●●	
DC GRID-No.1 VOLTAGE	−125 max.	−125 max.	volts
DC PLATE CURRENT	70 max.	80 max.	ma
DC GRID-No.2 CURRENT	15 max.	15 max.	ma
DC GRID-No.1 CURRENT	5 max.	5 max.	ma
PLATE INPUT	21 max.	24 max.	watts
GRID-No.2 INPUT	2 max.	2 max.	watts
PLATE DISSIPATION	10 max.	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	volts
Heater positive with respect to cathode	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point)	225 max.	225 max.	°C

Typical Operation as Amplifier at 175 Mc:

	CCS●		ICAS●●	
DC Plate Voltage	250	300	300	volts
Grid No.3	Connected to cathode			
DC Grid-No.2 Voltage□□	200	200	250	volts
DC Grid-No.1 Voltage⊕⊕	−40	−42	−55	volts
Peak RF Grid-No.1 Voltage	47	52	62	volts
DC Plate Current	60	70	80	ma
DC Grid-No.2 Current	3.7	3.7	5.1	ma
DC Grid-No.1 Current (Approx.)	1.5	2.1	1.6	ma
Driver Power Output (Approx.)▲▲	1	1	1.5	watts
Useful Power Output (Approx.)*	6.5	8.5	10	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	0.1 max.	0.1 max.	megohm

PLATE-MODULATED RF POWER AMPLIFIER — Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, *Absolute-Maximum Values Up to 175 Mc:*

	CCS●	ICAS●●	
DC PLATE VOLTAGE	250 max.	250 max.	volts
DC GRID-No.3 VOLTAGE	0 max.	0 max.	volts
DC GRID-No.2 VOLTAGE	250 max.	250 max.	volts
DC GRID-No.1 VOLTAGE	−125 max.	−125 max.	volts
DC PLATE CURRENT	60 max.	70 max.	ma
DC GRID-No.2 CURRENT	10 max.	10 max.	ma
DC GRID-No.1 CURRENT	5 max.	5 max.	ma
PLATE INPUT	15 max.	17.5 max.	watts
GRID-No.2 INPUT	1.4 max.	1.4 max.	watts
PLATE DISSIPATION	7 max.	8 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	volts
Heater positive with respect to cathode	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point)	225 max.	225 max.	°C

Typical Operation at 175 Mc:

DC Plate Voltage	250	250	volts
Grid-No.3	Connected to cathode		
DC Grid-No.2 Voltage▲	250	250	volts
DC Grid-No.1 Voltage★	−70	−75	volts
From a grid resistor of	33000	33000	ohms
RF Grid-No 1 Voltage	75	80	volts
DC Plate Current	60	70	ma
DC Grid-No.2 Current	2.5	3.0	ma
DC Grid-No.1 Current (Approx.)	2.1	2.3	ma
Driving Power (Approx.)▲▲	1.0	1.0	watt
Useful Power Output*	6.5	7.5	watts

Maximum Circuit Values:	CCS●	ICAS●●	
Grid-No.1-Circuit Resistance	0.1 max.	0.1 max.	megohm

FREQUENCY MULTIPLIER

Maximum Ratings, *Absolute-Maximum Values:*

	CCS●	ICAS●●	
DC PLATE VOLTAGE	300 max.	300 max.	volts
DC GRID-No.3 VOLTAGE	0 max.	0 max.	volts
DC GRID-No.2 VOLTAGE	250 max.	250 max.	volts
DC GRID-No.1 VOLTAGE	−125 max.	−125 max.	volts
DC PLATE CURRENT	50 max.	60 max.	ma
DC GRID-No.2 CURRENT	15 max.	15 max.	ma
DC GRID-No.1 CURRENT	5 max.	5 max.	ma
PLATE INPUT	13 max.	15 max.	watts
GRID-No.2 INPUT	2 max.	2 max.	watts
PLATE DISSIPATION	10 max.	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	volts
Heater positive with respect to cathode	100 max.	100 max.	volts
BULB TEMPERATURE (At hottest point)	225 max.	225 max.	°C

Typical Operation as Doubler to 175 Mc:

DC Plate Voltage	250	300	volts
DC Grid-No.3	Connected to cathode		
DC Grid-No.2 Voltage	200	250	volts
DC Grid-No.1 Voltage⊕⊕	−53	−66	volts
From a grid resistor of	53000	44000	ohms
Peak RF Grid-No.1 Voltage	60	74	volts
DC Plate Current	50	60	ma
DC Grid-No.2 Current	2.6	3.5	ma
DC Grid-No.1 Current (Approx.)	1.0	1.5	ma
Driving Power (Approx.)▲▲	0.4	0.6	watt
Useful Power Output*	3.0	4.5	watts

Typical Operation as Tripler to 175 Mc:

DC Plate Voltage	200	250	volts
DC Grid-No.3	Connected to cathode		
DC Grid-No.2 Voltage	200	250	volts
DC Grid-No.1 Voltage⊕⊕	−90	−120	volts
From a grid resistor of	50000	70000	ohms
Peak RF Grid-No.1 Voltage	105	130	volts
DC Plate Current	50	60	ma
DC Grid-No.2 Current	3.0	3.9	ma
DC Grid-No.1 Current (Approx.)	1.85	1.7	ma
Driving Power (Approx.)▲▲	0.4	0.6	watt
Useful Power Output*	1.4	2.3	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	0.1 max.	0.1 max.	megohm

▲ Subscript 1 indicates that grid-No.1 current does not flow during any part of the input cycle.

● Continuous Commercial Service.

●● Intermittent Commercial and Amateur Service.

□ Averaged over any audio-frequency cycle of sine-wave form.

§ Obtained preferably from a fixed supply.

† Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

□□ Obtained preferably from a separate source or from the plate-voltage supply with a voltage divider. If a series resistor is used, it should be adjustable to

permit obtaining the desired operating plate current after initial tuning adjustments are completed.

⊕⊕ Obtained from a grid-No.1 resistor, or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

▲▲ Driver stage is required to supply tube losses and rf circuit losses. The driver stage should be designed to provide an excess of power above the indicated values to take care of variations in line voltage, in components, in initial tube characteristics, and in tube characteristics during life.

* Measured at load.

▲ Obtained preferably from a separate source modulated along with the plate supply, or from the modulated plate supply through a series resistor. It is recommended that this resistor be adjustable to permit obtaining the desired operating plate current after initial tuning adjustments are made.

★ Obtained from a grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor. The combination of grid resistor and fixed supply has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.745	0.855	amp
Transconductance	1,2	4200	6400	μmhos
Plate Current	1,2	30	50	ma
Plate Current	1,3	–	50	μa
Grid-No.2 Current	1,2	–	7.5	ma
Reverse Grid-No.1 Current	1,4	–	2	μa
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,5	–	20	μa
Heater positive with respect to cathode	1,5	–	20	μa
Leakage Resistance:				
Between grid and all other electrodes tied together	1,6	100	–	megohms
Between plate and all other electrodes tied together	1,7	100	–	megohms

Note 1: With 6.3 volts ac or dc on heater.

Note 2: With plate voltage of 250 volts, grid-No.3 connected to cathode, grid-No.2 voltage of 250 volts, and grid-No.1 voltage of -18 volts.

Note 3: With plate voltage of 250 volts, grid-No.3 connected to cathode, grid-No.2 voltage of 250 volts, and grid-No.1 voltage of -48 volts.

Note 4: With plate voltage of 180 volts, grid-No.3 connected to cathode, grid-No.2 voltage of 250 volts, grid-No.1 resistor of 0.1 megohm, and cathode resistor of 170 ohms.

Note 5: With 100 volts dc between heater and cathode.

Note 6: With grid No.1 100 volts negative.

Note 7: With plate 300 volts negative.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices:

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

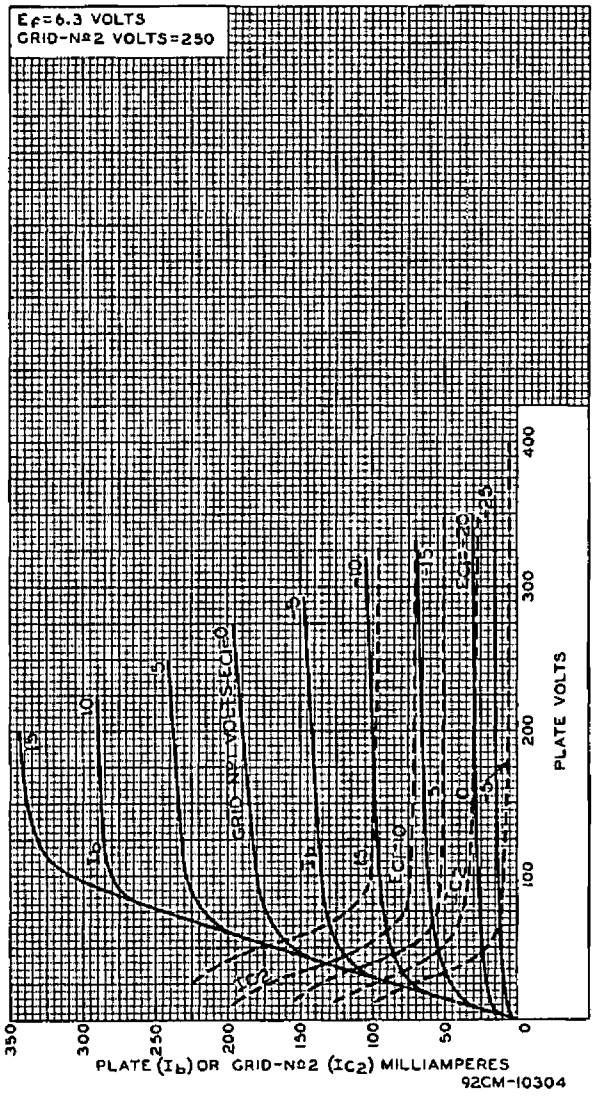
The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The *maximum bulb temperature* of 225° C is a tube rating and is to be observed in the same manner as other ratings. The temperature should be measured at the hottest point on the bulb with the tube operating in the completely assembled equipment with all covers in place, and delivering the maximum output under the highest ambient-temperature conditions and the most severe operating cycle for which the equipment is designed. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y. in the form of liquid and stick.

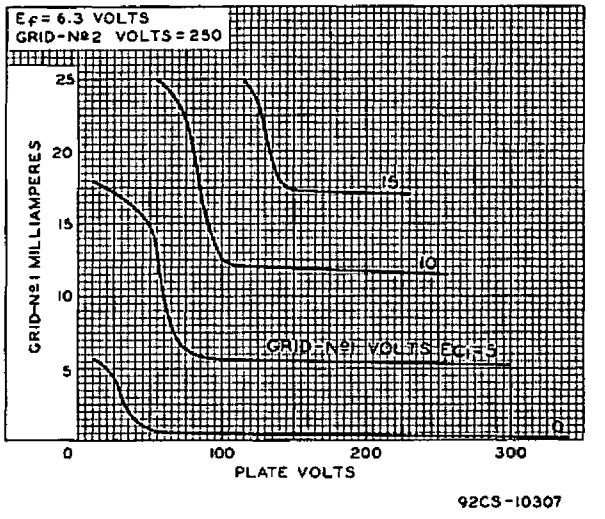
Shielding of the 7558 in "straight-through" rf amplifier service is required for stable operation. To minimize external feedback from the plate to grid No.1, a grounded shield crossing the terminal end of the tube socket through the space between pins 2 and 3 and the space between pins 8 and 9, is generally adequate for this purpose.

The heater may be effectively bypassed by grounding one heater pin at the tube socket and bypassing the other heater pin to ground with a low inductance capacitor. To reduce degeneration in the cathode circuit, two base-pin connections (pins 1 and 9) are provided. The cathode circuit should be arranged so that the input ac current flows through the cathode connection and the output ac current flows through the other. This circuit arrangement will reduce the effect of the cathode lead inductance. Both cathode circuit returns should be grounded through the shortest possible connection.

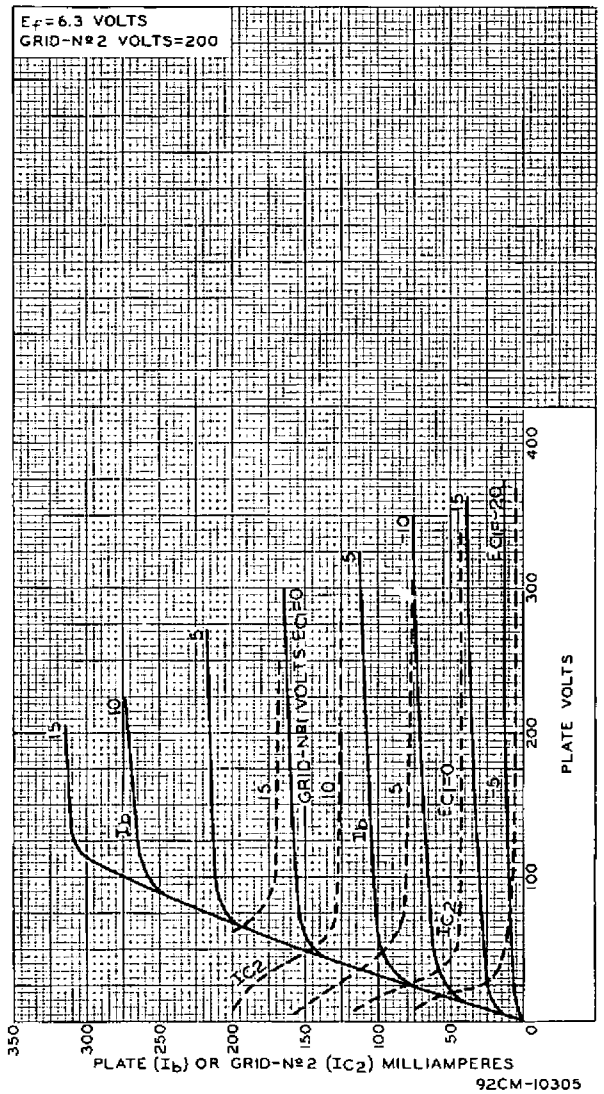
The *rf impedance between grid No.2 and the cathode* must be kept low, usually by means of a suitable bypass capacitor. In telephony service when grid No.2 is modulated, a smaller bypass capacitor than is used for telegraphy service may be required in order to avoid excessive af bypassing. However, if the capacitance value is too small, rf feedback may occur between plate and grid No.1, depending on the circuit layout, operating frequency, and power gain of the stage. AF bypassing difficulties can usually be eliminated if the grid-No.2 bypass capacitor is replaced by a series-resonant circuit which is tuned to resonate at the operating frequency. This circuit presents a high impedance to audio frequencies but a very low impedance to its resonant frequency.



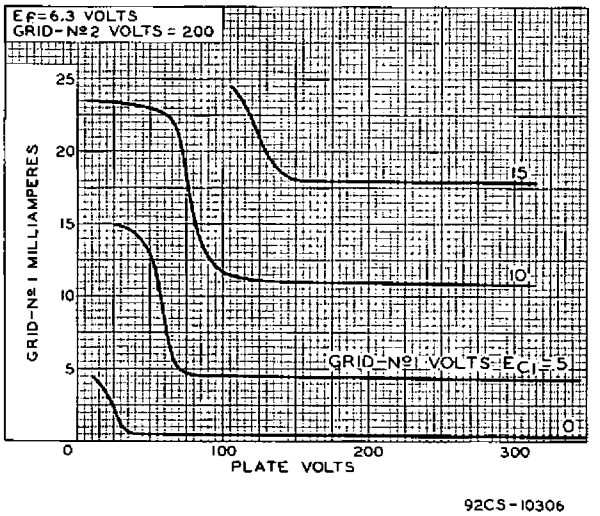
Average Characteristics of Type 7558.



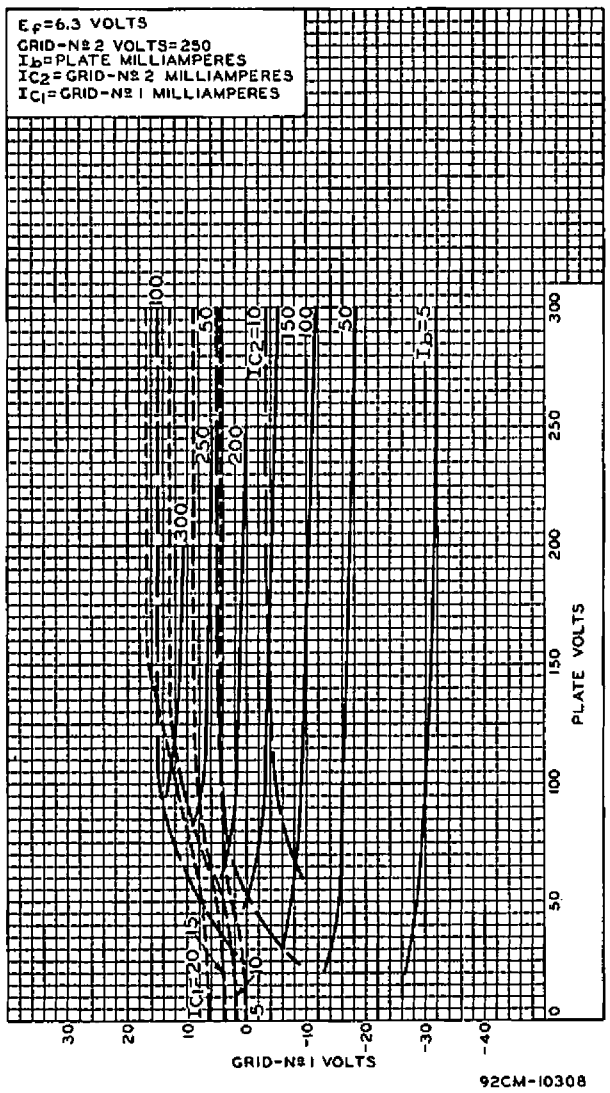
Average Characteristics of Type 7558.



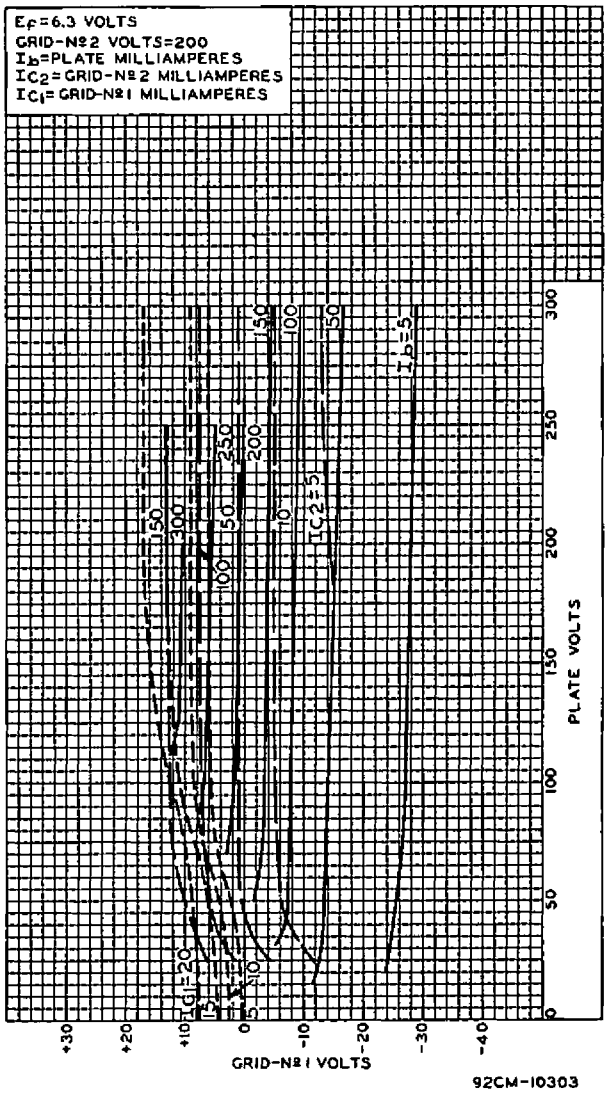
Average Characteristics of Type 7558.



Average Characteristics of Type 7558.

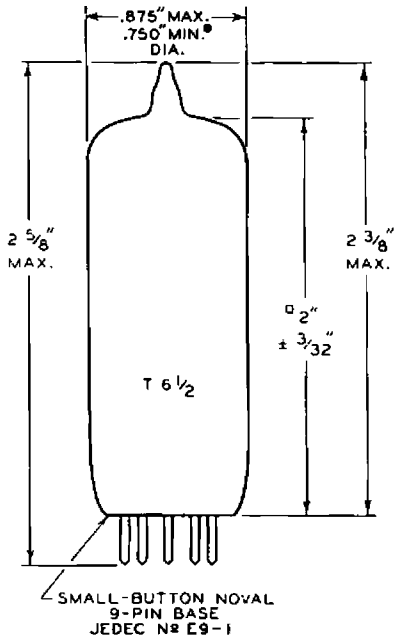


Average Constant-Current Characteristics of Type 7558.



Average Constant-Current Characteristics of Type 7558.

DIMENSIONAL OUTLINE

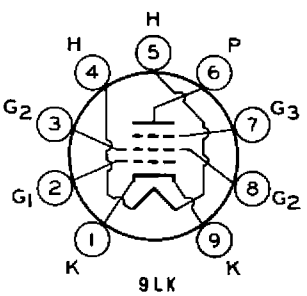


● APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

□ MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

SOCKET CONNECTIONS
Bottom View

PIN 1: CATHODE
PIN 2: GRID NO.1
PIN 3: GRID NO.2
PIN 4: HEATER
PIN 5: HEATER



9LK

PIN 6: PLATE
PIN 7: GRID NO.3
PIN 8: GRID NO.2
PIN 9: CATHODE

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7580

BEAM POWER TUBE

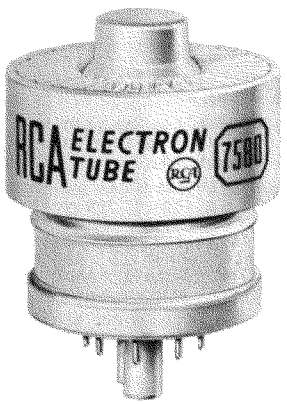
Ceramic-Metal Seals
Coaxial-Electrode Structure
Compact Design

For Use in Linear Amplifier Service at Frequencies up to 500 Mc

400 Watts PEP Output at 30 Mc
360 Watts PEP Output at 500 Mc

2.464" Max. Length
1.640" Max. Diameter
Integral Radiator

RCA-7580 is a very small and compact forced-air-cooled beam power tube constructed with ceramic-metal seals throughout and having a maximum plate dissipation of 250 watts. It is intended for use in single-sideband suppressed-carrier service, and in other linear rf power amplifier applications. The 7580 can be used with full ratings at frequencies up to 500 megacycles per second.



The ceramic-metal-seal construction employed in the 7580 permits operation at higher temperatures than a glass-seal construction and thus provides improved reliability. The specially designed, high-efficiency louvered radiator which is brazed directly to the plate for better heat transfer, makes possible the maximum plate-dissipation rating of 250 watts with no sacrifice in tube reliability.

The terminal arrangement of the 7580 facilitates use of the tube with tank circuits of the coaxial type. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the ring terminal for grid No.2. A base-pin termination for grid No.2 is also available for operation of the 7580 at the lower frequencies.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.0 ± 10%	volts
Current at 6.0 volts	2.6	amp
Minimum heating time	30	seconds
Mu-Factor, Grid No.2 to Grid No.1, for grid-No.2 volts = 300 and grid-No.2 ma. = 50	4	
Direct Interelectrode Capacitances:		
Grid No.1 to plate	0.03	μμf
Grid No.1 to cathode, grid No.2, and heater	17	μμf
Plate to cathode, grid No.2, and heater	4.5	μμf

Mechanical:

Operating Position	Any
Maximum Overall Length	2.464"
Maximum Seated Length	1.910"
Maximum Diameter	1.640"
Base	Special 8-Pin
Socket	Air-System Socket, such as Johnson No.124-110-1■ (Supplied with Air Chimney)
Radiator	Integral part of tube

Air Flow:

Through Indicated Air-System Socket--This fitting directs the air over the base seals; past the grid-No.2 seal, envelope, and plate seal; and through the radiator to provide effective cooling with minimum air flow. When the tube is operated at maximum plate dissipation for each class of service, a minimum air flow of 3.8 cfm through the system is required. The corresponding pressure drop is approximately 0.3 inch of water. These requirements are for operation at sea level and at an ambient temperature of 20° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the plate temperature within maximum ratings.

Without Air-System Socket--If an air-system socket is not used, it is essential that adequate cooling air be directed over the base seals, past the envelope, and through the radiator. Under these conditions and with the tube operating at maximum plate dissipation for each class of service, a minimum air flow of 3.6 cfm must pass through the radiator. The corresponding pressure drop is approximately 0.1 inch of water. These requirements are for operation at sea level and at an ambient temperature of 20° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the plate temperature within maximum ratings.

Plate Temperature (Measured on base end of plate surface at junction with fins)	250 max.	°C
Temperature of Plate Seal, Grid-No.2 Seal, and Base Seals	250 max.	°C
Weight (Approx.)	4	ounces

LINEAR RF POWER AMPLIFIER
Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

Maximum CCS● Rating, *Absolute-Maximum Values:*

For Altitude up to 20000 ft

	Up to 500 Mc	
DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 (SCREEN-GRID) VOLTAGE	500 max.	volts

■ Available from E. F. Johnson Co., Waseca, Minn.

Trademark(s) ® Registered
Marca(s) Registrada(s)

DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-250 max.†	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE	350 max.†	ma
PLATE DISSIPATION	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Operation with "Two-Tone Modulation":▲

	At 30 Mc	*At 500 Mc*	
DC Plate Voltage	2000	2000	volts
DC Grid-No.2 Voltage‡	400	400	volts
DC Grid-No.1 Voltage:			
From fixed supply	-77	-77	volts
Zero-Signal DC Plate Current	70	70	ma
Effective RF Load Resistance	3050	3050	ohms
DC Plate Current at Peak of Envelope	350	350	ma
Average DC Plate Current	225	225	ma
DC Grid-No.2 Current at Peak of Envelope	35	25	ma
Average DC Grid-No.2 Current	16	10	ma
Average DC Grid-No.1 Current	0.05⊕	0.05⊕	ma
Peak-Envelope Driver Power Output (Approx.)○○	1	12	watts
Output-Circuit Efficiency (Approx.)	95	85	%
Distortion Products Level:●			
Third order	21	-	db
Fifth order	29	-	db
Useful Power Output (Approx.):			
Average	200⊕	180⊕	watts
Peak envelope	400⊕	360⊕	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:		
With fixed bias	25000 max.	ohms
With cathode bias	Not recommended	

LINEAR RF POWER AMPLIFIER — AM Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS● Ratings, *Absolute-Maximum Values:*

For Altitude up to 20000 ft

	Up to 500 Mc	
DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 (SCREEN-GRID) VOLTAGE	500 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-250 max.	volts
DC PLATE CURRENT	180 max.	ma
PLATE DISSIPATION	250 max.	watts
GRID-No.2 DISSIPATION	12 max.	watts
GRID-No.1 DISSIPATION	2 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	150 max.	volts
Heater positive with respect to cathode	150 max.	volts

Typical CCS Operation:

	At 30 Mc	*At 500 Mc*	
DC Plate Voltage	2000	2000	volts
DC Grid-No.2 Voltage‡	400	400	volts
DC Grid-No.1 Voltage:			
From fixed supply	-77	-77	volts
DC Plate Current	175	175	ma
DC Grid-No.2 Current	6	4	ma
Effective RF Load Resistance	3050	3050	ohms
Driver Power Output (Approx.)○○	0.25	3	watts
Output-Circuit Efficiency (Approx.)	95	85	%
Useful Power Output (Approx.)	100⊕	90⊕	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:		
With fixed bias	25000 max.	ohms
With cathode bias	Not recommended	

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	2.3	2.9	amp
Direct Interelectrode Capacitances:□				
Grid No.1 to plate	-	-	0.06	μμf
Grid No.1 to cathode, grid No.2, and heater	-	16.0	18.5	μμf
Plate to cathode, grid No.2, and heater	-	4.0	5.0	μμf
Grid-No.1 Voltage:				
Negative	1,2,5,6	55	100	volts
Positive	1,5,6,7	3	12	volts
Grid-No.2 Current (1)	1,3,5,6	-7	+3	ma
Grid-No.2 Current (2)	1,5,6,7	-	260	ma
Grid-No.1 Current	1,5,6,7	-	150	ma
Useful Power Output	4,5,6	225	-	watts

Note 1: With 6.0 volts on heater.

Note 2: With dc plate voltage of 2000 volts, dc grid-No.2 voltage of 400 volts, and grid-No.1 voltage adjusted to give plate current of 67 ma.

Note 3: With dc plate voltage of 1000 volts, dc grid-No.2 voltage of 300 volts, and grid-No.1 voltage adjusted to give plate current of 150 ma.

Note 4: With heater voltage of 5.5 volts, dc plate voltage of 2000 volts, dc grid-No.2 voltage of 300 volts, dc grid-No.1 bias of -90 volts, dc grid-No.1 current of 25 ma maximum, grid-No.1 signal voltage adjusted to produce dc plate current of 250 ma, and coaxial-cavity amplifier circuit operating at a frequency of 475 Mc.

Note 5: With Forced-Air Cooling as specified under GENERAL DATA--*Air-System Socket.*

Note 6: Heater voltage must be applied for at least 30 seconds before application of other voltages.

Note 7: With dc plate voltage of 250 volts, dc grid-No.2 voltage of 250 volts, and grid-No.1 voltage adjusted to give peak plate current of 1.0 ampere. This test is performed using pulse technique to prevent tube damage. Square pulses of 4500 μs duration at a repetition rate of 11 ± 1 pps are used.

SPECIAL PERFORMANCE DATA

Interelectrode Leakage:

This test is destructive and is performed on a sample lot of tubes from each production run under the following conditions: ac heater volts = 6.6, no voltage on other elements, and specified forced-air cooling for *Air-System Socket.* At the end of 500 hours, with tube at 25° C, and with no voltage applied to heater, the minimum resistance between indicated electrodes as measured with a 500-volt Megger-type ohmmeter having an internal impedance of 2.5 megohms, will be:

Grid No.1 and Grid No.2	10 min.	megohms
Grid No.1 and Cathode	10 min.	megohms
Grid No.2 and Cathode	10 min.	megohms

§ Because the cathode is subjected to considerable back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should be reduced depending on operating conditions and frequency to prevent overheating the cathode and resultant short life.

□ With cylindrical shield JEDEC No.320 surrounding radiator; and with a cylindrical shield JEDEC No.321 surrounding the grid-No.2 ring terminal. Both shields are connected to ground.

● Continuous Commercial Service.

† The maximum rating for a signal having a minimum peak-to-average power ratio less than 2, such as is obtained in "Single-Tone" operation, is 250 ma. During short

periods of circuit adjustment under "Single-Tone" conditions, the average plate current may be as high as 350 ma.

▲ *Two-Tone Modulation* operation refers to that class of amplifier service in which the input consists of two equal monofrequency rf signals having constant amplitude. These signals are produced in a single-sideband suppressed-carrier system when two equal-and-constant amplitude audio frequencies are applied to the input of the system.

‡ Obtained preferably from a fixed supply.

⊕ This value represents the approximate grid-No.1 current obtained due to initial electron velocities and contact-potential effects when grid No.1 is driven to zero volts at maximum signal.

oo Driver power output represents circuit losses and is the actual power measured at input to grid-No.1 circuit of the 7580. The actual power required depends on the operating frequency and the circuit used. The tube driving power is approximately zero watts.

This value of useful power is measured at load of output circuit having indicated efficiency.

Without the use of feedback to enhance linearity.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

The maximum temperatures in the tabulated data for the base seals, grid-No.2 seal, plate seal, and plate are tube ratings and are to be observed in the same manner as other tube ratings. The temperature of the respective seals and of the plate may conveniently be measured with temperature-sensitive paint such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y. in the form of liquid and stick.

The *socket* for the 7580 should be of a type (such as that indicated in the tabulated data) which permits adequate air-cooling of the tube. Although the base will fit a conventional lock-in socket, the latter does not permit adequate cooling and its use is therefore not recommended.

The *plate connection* is made by a metal band or spring contacts to the cylindrical surface of the radiator. It is essential that the contact areas be kept clean to minimize rf losses especially at the higher frequencies.

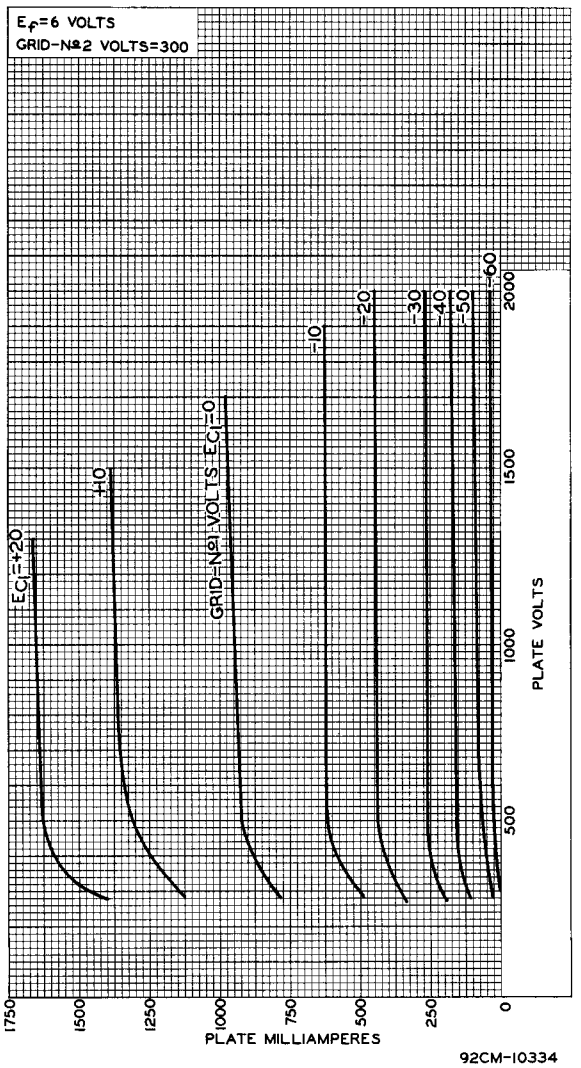


Fig. 1 - Typical Plate Characteristics of Type 7580.

The *plate circuit* should be provided with a time-delay relay which will prevent the application of plate voltage before the cathode has reached normal operating temperature.

Protective devices should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers

in the primary of the rectifier transformer at slightly higher than normal plate current.

A protective device in the grid-No.2 supply lead should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

Forced-air cooling of the 7580 is required as indicated under GENERAL DATA. A suitable air

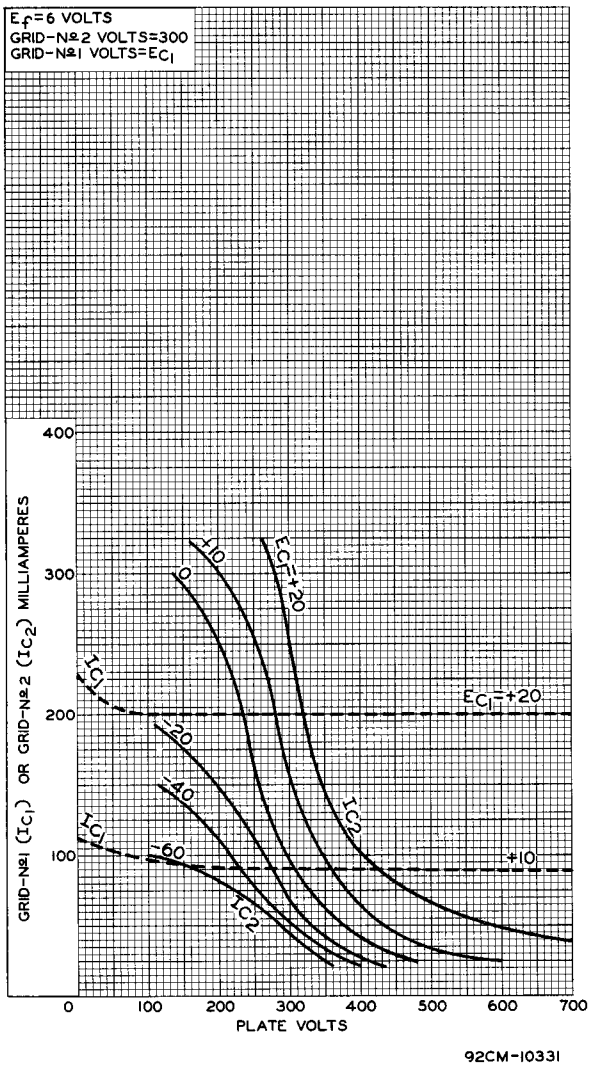


Fig. 2 - Typical Characteristics of Type 7580.

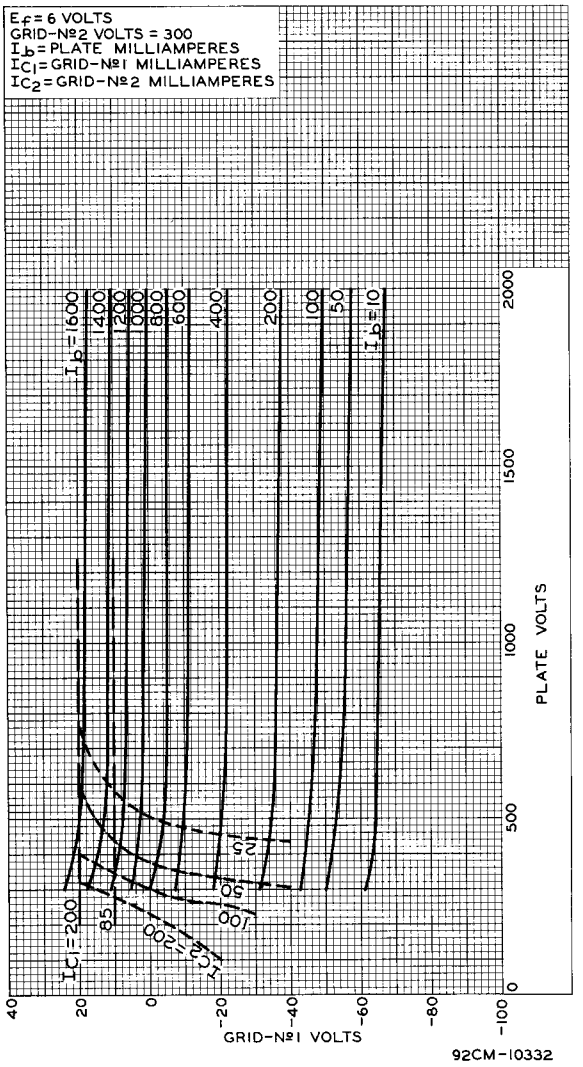


Fig. 3 - Typical Constant-Current Characteristics of Type 7580.

The rated plate and grid-No.2 voltages of this tube are extremely dangerous to the user. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break

filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air through the socket and radiator.

The cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the heater and plate power supplies. This arrangement is

necessary to make sure that the tube is supplied with air simultaneously with electrode voltages. Air-flow interlocks which open the power transformer primaries are desirable for protecting the tube when the air flow is insufficient or ceases.

cathode. The magnitude of the heating caused by back bombardment is a function of the operating conditions and frequency, and must be compensated by reduction of heater input in order to prevent overheating of the cathode and resultant short life. When long life in

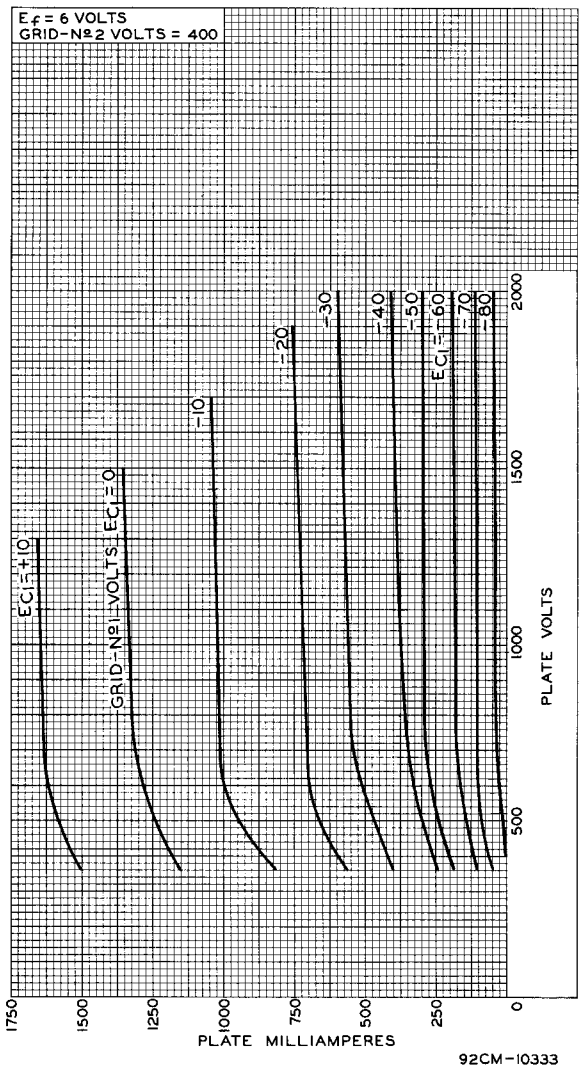


Fig. 4 - Typical Plate Characteristics of Type 7580.

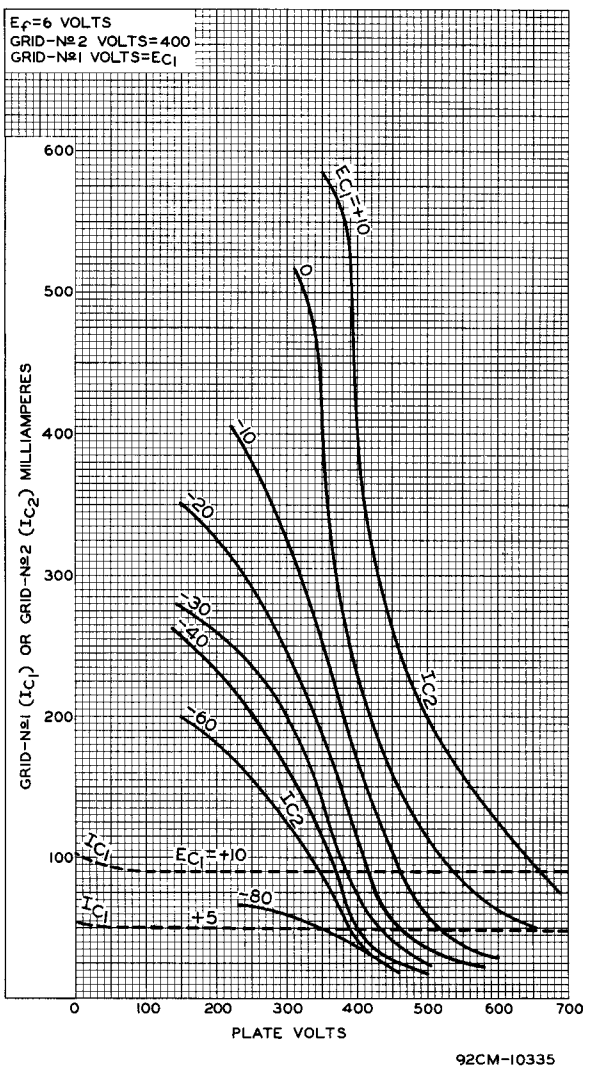


Fig. 5 - Typical Characteristics of Type 7580.

The *unipotential cathode* is connected within the tube to base pins 2, 4, 6, and 8. The corresponding socket terminals should all be used for connection to the circuit. The leads should have ample cross-section and be as short as possible to minimize cathode-lead inductance.

The cathode of the 7580 in uhf service is subjected to considerable bombardment resulting from transit-time effects. This back bombardment raises the temperature of the

continuous service is desired, the 7580 should always be put in operation with full rated heater voltage (6 volts) which should then be reduced to a value depending on the operating conditions and frequency.

The proper operating value may be found by reducing the heater voltage, with normal modulation applied to the transmitter, until a reduction in output is observed. The heater voltage must then be increased by an amount equivalent to the maximum percentage regulation of the heater-

voltage supply, and then further increased by about 2 percent to allow for other variations. After the heater voltage is reduced, circuit readjustment may be necessary. It is suggested that the adjustment procedure be carried out daily. However, if no significant changes in the operating voltage are found necessary, the adjustment procedure can be scheduled less frequently. Good regulation of the heater voltage is in general economically advantageous from the viewpoint of tube life.

Grid-No.2 voltage should be obtained from a source of good regulation. The plate voltage should be applied before or simultaneously with the grid-No.2 voltage; otherwise, with voltage on grid No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation. A dc milliammeter should be used in the grid-No.2 circuit so that its current may be measured and the screen dissipation determined.

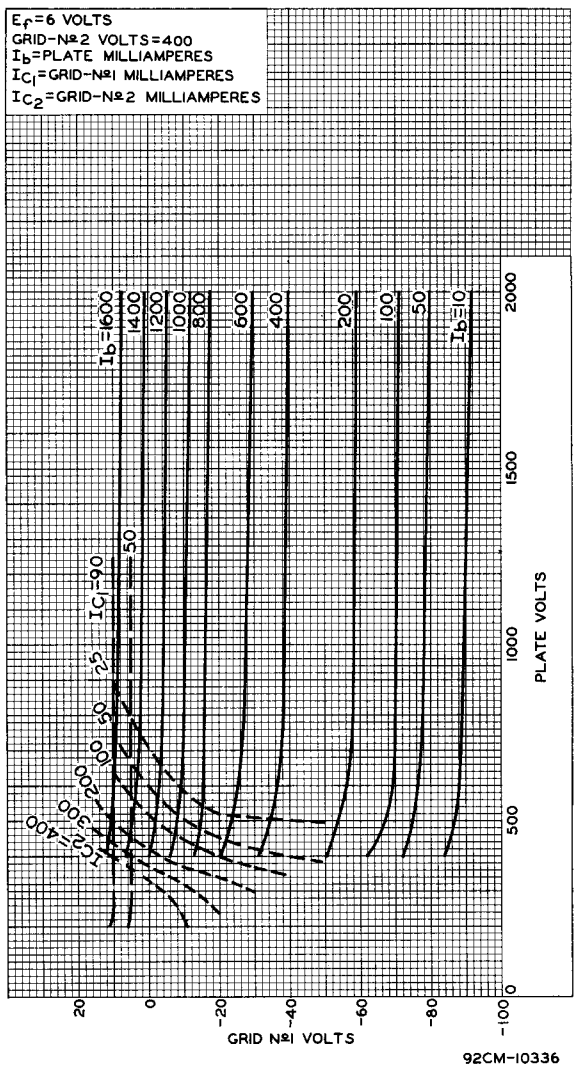
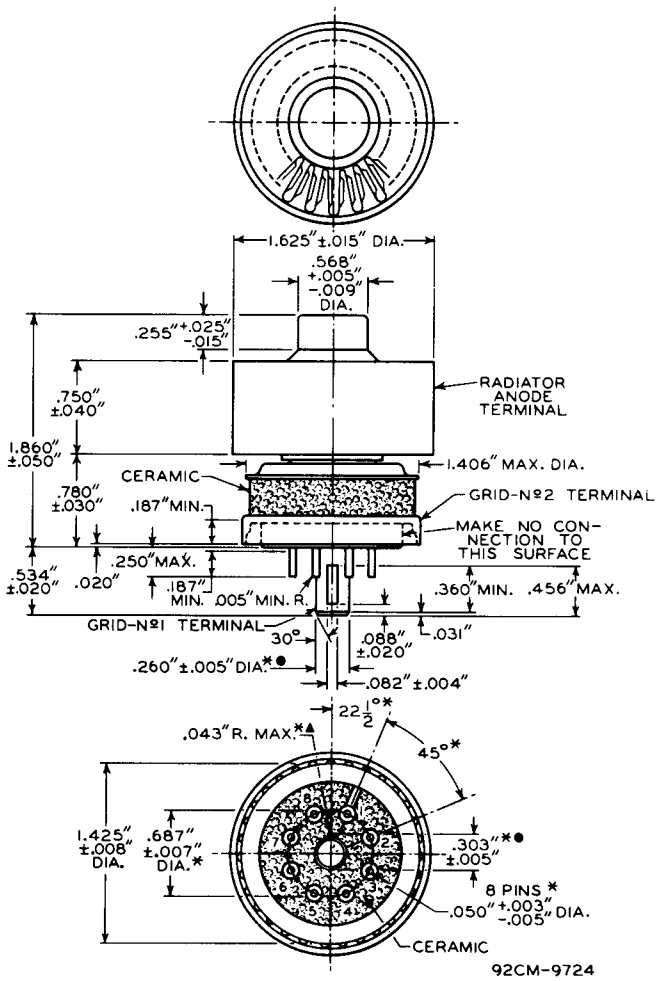


Fig. 6 - Typical Constant-Current Characteristics of Type 7580.

DIMENSIONAL OUTLINE



GRID-No.1 PLUG DIMENSIONS ARE MEASURED BY THE USE OF THE SERIES OF GAUGES SHOWN IN SKETCHES G_1 AND G_2. IN THE FOLLOWING INSTRUCTIONS FOR THE USE OF THESE GAUGES, "GO" INDICATES THAT THE ENTIRE GRID-No.1 PLUG KEY WILL ENTER THE GAUGE; AND "NO-GO" INDICATES THAT THE GRID-No.1 PLUG KEY WILL NOT ENTER THE GAUGE MORE THAN 1/16". INSTRUCTIONS FOR THE USE OF THE GAUGES FOLLOW:

▲ GAUGES G_1-1, G_1-2, G_1-3, AND G_1-4:
USING ONLY SLOT C, TRY THESE GAUGES IN NUMERICAL ORDER UNTIL ONE IS FOUND THAT WILL ACCEPT THE ENTIRE GRID-No.1 PLUG. USING THE FIRST GAUGE THUS FOUND, IT WILL NOT BE POSSIBLE TO INSERT THE GRID-No.1 PLUG IN SLOT B.

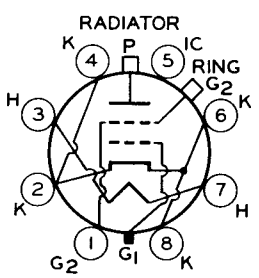
● GAUGES G_2-1, G_2-2, AND G_2-3:
THE GRID-No.1 PLUG WILL BE REJECTED BY GAUGES G_2-1 AND G_2-2, BUT WILL BE ACCEPTED BY GAUGE G_2-3.

* BASE-PIN POSITIONS ARE HELD TO TOLERANCES SUCH THAT THE ENTIRE LENGTH OF THE PINS WILL, WITHOUT UNDUE FORCE, PASS INTO AND DISENGAGE FROM THE FLAT-PLATE GAUGE SHOWN IN SKETCH G_3.

SOCKET CONNECTIONS

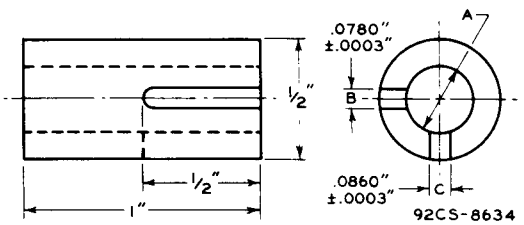
Bottom View

PIN 1: GRID No.2 (For use at the lower frequencies)
PIN 2: CATHODE
PIN 3: HEATER
PIN 4: CATHODE
PIN 5: INTERNAL CONNECTION--DO NOT USE
PIN 6: CATHODE



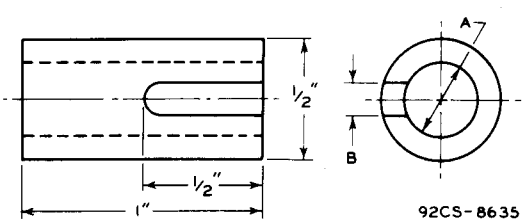
PIN 7: HEATER
PIN 8: CATHODE
BASE INDEX PLUG: GRID No.1
RADIATOR: PLATE
RING TERMINAL: GRID No.2 (For use at the higher frequencies)

Gauge Sketch G_1



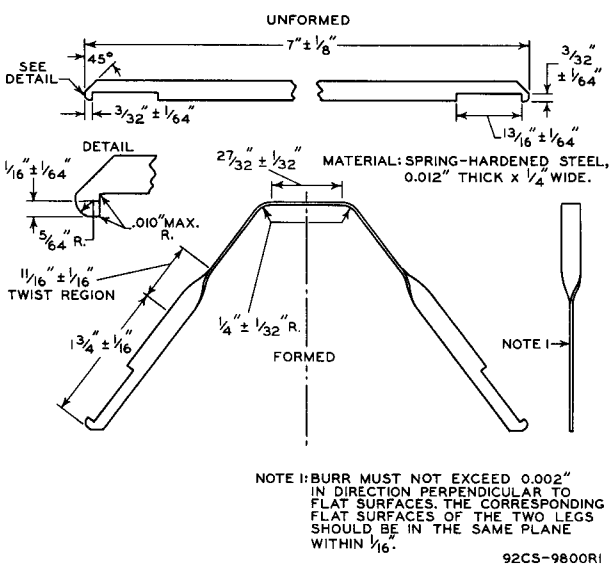
Gauge	Dimension A
G_1-1	.2575" + .0000" − .0005"
G_1-2	.2600" + .0000" − .0005"
G_1-3	.2625" + .0000" − .0005"
G_1-4	.2650" + .0000" − .0005"

Gauge Sketch G_2



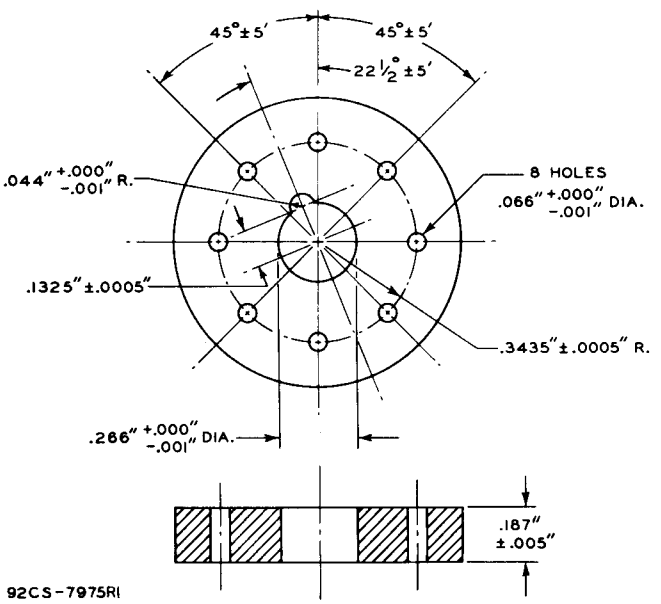
Gauge	Dimension	
	A	B
G_2-1	.2550" + .0000" − .0005"	.125"
G_2-2	.2980" + .0000" − .0005"	none
G_2-3	.3080" + .0000" − .0005"	none

Suggested Design for Extractor to Remove Tube from Cavity



NOTE 1: BURR MUST NOT EXCEED 0.002" IN DIRECTION PERPENDICULAR TO FLAT SURFACES. THE CORRESPONDING FLAT SURFACES OF THE TWO LEGS SHOULD BE IN THE SAME PLANE WITHIN 1/16".

Gauge Sketch G_3



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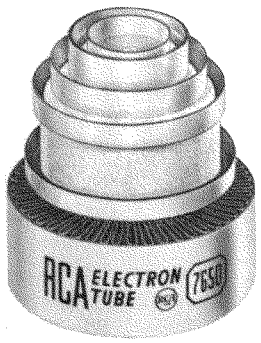

CERMOLOX®
Ruggedized
Matrix-Type Cathode
Forced-Air Cooled
800 Watts CW Power Output at 400 Mc
680 Watts PEP Output at 30 Mc

7650
BEAM POWER TUBE

RCA-7650 is a small, forced-air cooled uhf beam power tube designed for applications where dependable performance under severe shock and vibration is essential. It is intended for use in compact aircraft, mobile and stationary equipment. It is rated as an af power amplifier and modulator and to frequencies up to 1215 Mc as a linear rf power amplifier in single-sideband suppressed-carrier service, as a plate-modulated rf power amplifier in Class C telephony service, as an rf power amplifier and oscillator in Class C telegraphy service, and as an rf power amplifier in Class C FM telephony service.

The 7650 and variants of its basic design may also be useful in applications such as frequency multipliers, linear rf power amplifiers (AM or television), pulse modulators, pulsed-rf amplifiers, regulators, or other special services. Variations in cooling structure or other parameters are also possible. For information on variants, contact your RCA field representative, the nearest District Sales Office, or Manager, Power Tube Marketing, RCA, Lancaster, Pa.

The 7650 features the Cermolox construction, a unipotential cathode of the oxide-coated matrix type, and an integral louvered-fin radiator. In addition, it contains an axial ceramic pin which rigidly holds grid No.1, grid No.2, and cathode in fixed positions with respect to each other. Details of these features are described in the **Application Guide for RCA Power Tubes, ICE-300***.

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* This bulletin is to be used in conjunction with the publication **Application Guide for RCA Power Tubes, ICE-300.** For a copy, write RCA, Commercial Engineering, Harrison, N. J.

GENERAL DATA

Electrical:

Heater for Matrix-Type Oxide-Coated Unipotential Cathode:		
Voltage (ac or dc)	6.3 typical 6.9 max.	volts volts
Current at 6.3 volts	7.5	amp
Minimum heating time	2	minutes

See further information on the heater in **Application Guide for RCA Power Tubes, ICE-300;** *Section V.A.3,* **Filament or Heater.**

Mu-Factor, Grid No.2 to Grid No.1	13	
Direct Interelectrode Capacitances[a]:		
Grid No.1 to plate	0.11 max.	pf
Grid No.1 to cathode & heater	28	pf
Plate to cathode & heater	0.011 max.	pf
Grid No.1 to grid No.2	38	pf
Grid No.2 to plate	5.5	pf
Grid No.2 to cathode & heater	1.1 max.	pf

Mechanical:

Operating Position	Any
Overall Length	2.40" max.
Greatest Diameter	2.09" max.
Terminal Connections	See *Dimensional Outline*
Radiator	Integral part of tube
Weight (Approx.)	3/4 lb

Thermal:

Terminal Temperature (Plate, grid No.2, grid No.1, cathode, and heater)	250 max.	°C
Plate-Core Temperature	250 max.	°C

See Dimensional Outline for temperature-measurement points

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7650 7-64
Supersedes 7650 2-60
Printed in U.S.A.

AF POWER AMPLIFIER & MODULATOR[b]

Maximum CCS Ratings, *Absolute-Maximum Values:*

DC PLATE VOLTAGE	3000 max.	volts
DC GRID-No.2 VOLTAGE	1200 max.	volts
MAX.-SIGNAL DC PLATE CURRENT	500 max.	ma
MAX.-SIGNAL GRID-No.1 CURRENT	100 max.	ma
MAX.-SIGNAL GRID-No.2 INPUT	25 max.	watts
PLATE DISSIPATION	600 max.	watts

Maximum Circuit Values:

Grid-No.1 Circuit Resistance Under Any Condition:		
With fixed bias	15,000 max.	ohms
With cathode bias	Not Recommended	

Typical CCS Operation:

Values are for 2 tubes

DC Plate Voltage	2700	3000	volts
DC Grid-No.2 Voltage	450	450	volts
DC Grid-No.1 Voltage: From fixed-bias source	-40	-40	volts
Peak AF Grid-No.1-to-Grid-No.1 Voltage	80	80	volts
Zero-Signal DC Plate Current	200	200	ma
Max.-Signal DC Plate Current	900	1000	ma
Zero-Signal DC Grid-No.2 Current	0	0	ma
Max.-Signal DC Grid-No.2 Current	6	5	ma
Effective Load Resistance (Plate to plate)	6000	6400	ohms
Max.-Signal Driving Power (Approx.)	0	0	watts
Max.-Signal Power Output (Approx.)	1400	1600	watts

LINEAR RF POWER AMPLIFIER, CLASS AB1[b]

Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 1215 Mc	
DC PLATE VOLTAGE	2500 max.	volts
DC GRID-No.2 VOLTAGE	1200 max.	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE	700[c] max.	amp
PLATE DISSIPATION	600 max.	volts

Maximum Circuit Values:

Grid-No.1 Circuit Resistance Under Any Condition:		
With fixed bias	15,000 max.	ohms
With fixed bias (in Class AB1 operation)	50,000 max.	ohms
With cathode bias	Not recommended	
Grid-No.2 Circuit Impedance	*See Note* d	
Plate Circuit Impedance	*See Note* e	

Typical CCS Operation with "Two-Tone Modulation":

	at 30 Mc		
DC Plate Voltage	2250	2500	volts
DC Grid-No.2 Voltage	450	450	volts
DC Grid-No.1 Voltage	-37	-37	volts
Zero-Signal DC Plate Current	160	160	ma
Effective RF Load Resistance	2500	2700	ohms
DC Plate Current at Peak of Envelope	450	500	ma
Average DC Plate Current	315	350	ma
DC Grid-No.2 Current at Peak of Envelope	3	4	ma
Average DC Grid-No.2 Current	1.8	2.5	ma
Average DC Grid-No.1 Current	0.005	0.05	ma
Peak Envelope Driver Power Output (Approx.)	1	1	watt
Output-Circuit Efficiency (Approx.)	90	90	%
Distortion Products Level:			
Third order	-31	-31	db
Fifth order	-36	-36	db
Useful Power Output (Approx.)			
Average	290	340	watts
Peak envelope	580	680	watts

PLATE-MODULATED RF POWER AMPLIFIER – Class C Telephony[b]

Carrier conditions per tube for use with max. modulation factor of 1.0

Maximum CCS Ratings, *Absolute Values:*

	Up to 1215 Mc	
DC PLATE VOLTAGE	2000 max.	volts
DC GRID-No.2 VOLTAGE	1200 max.	volts
DC GRID-No.1 VOLTAGE	-250 max.	volts
DC PLATE CURRENT	500 max.	ma
DC GRID-No.1 CURRENT	100 max.	ma
PLATE INPUT	1000 max.	watts
GRID-No.2 INPUT	17 max.	watts
PLATE DISSIPATION	400 max.	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
Under any condition	15,000 max.	ohms

Typical CCS Operation in Cathode-Drive Circuit at 400 Mc:

DC Plate Voltage	1800	2000	volts
DC Grid-No.2 Voltage	400	400	volts
DC Grid-No.1 Voltage	-45	-35	volts
DC Plate Current	450	500	ma
DC Grid-No.2 Current	6	8	ma
DC Grid-No.1 Current (Approx.)	15	12	ma
Output Circuit Efficiency (Approx.)	80	80	%
Driver Power Output (Approx.)	35	35	watts
Useful Power Output (Approx.)	500	600	watts

RF POWER AMPLIFIER & OSC.--Class C Telegraphy[b] and RF POWER AMPLIFIER--Class C FM Telephony[b]

Maximum CCS Ratings, *Absolute Values:*

	Up to 1215 Mc	
DC PLATE VOLTAGE	2500 max.	volts
DC GRID-No.2 VOLTAGE	1200 max.	volts
DC GRID-No.1 VOLTAGE	-250 max.	volts
DC PLATE CURRENT	500 max.	ma
DC GRID-No.1 CURRENT	100 max.	ma
PLATE INPUT	1250 max.	watts
GRID-No.2 INPUT	25 max.	watts
PLATE DISSIPATION	700 max.	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
Under any condition	15,000 max.	ohms

Typical CCS Operation in Cathode-Drive Circuit at 400 Mc:

DC Plate Voltage	2250	2500	volts
DC Grid-No.2 Voltage	400	400	volts
DC Grid-No.1 Voltage	-45	-35	volts
DC Plate Current	450	500	ma
DC Grid-No.2 Current	7	8	ma
DC Grid-No.1 Current (Approx.)	10	12	ma
Output Circuit Efficiency (Approx.)	80	80	%
Driver Power Output (Approx.)	30	35	watts
Useful Power Output (Approx.)	650	800	watts

Typical CCS Operation in Cathode-Drive Circuit at 1215 Mc:

DC Plate Voltage	2500	volts
DC Grid-No.2 Voltage	400	volts
DC Grid-No.1 Voltage	-50	volts
DC Plate Current	500	ma
DC Grid-No.2 Current	6	ma
DC Grid-No.1 Current	10	ma
Output Circuit Efficiency (Approx.)	70	%
Driver Power Output (Approx.)	80	watts
Useful Power Output (Approx.)	375	watts

FOOTNOTES

[a] Measured with special shield adapter.

[b] See Section V.C. of 1CE-300.

[c] The maximum rating for a signal having a minimum peak-to-average power ratio less than 2, such as is obtained in "Single-Tone" operation, is 500 ma. During short periods of circuit adjustment under "Single-Tone" conditions, the average plate current may be as high as 700 ma.

[d] See Section V.B.2 of 1CE-300.

[e] See Section V.B.1 of 1CE-300.

CHARACTERISTICS RANGE VALUES

	Note	*Min.*	*Max.*	
1. Heater Current	1	6.9	8.3	amp
2. Direct Interelectrode Capacitances:				
Grid No.1 to plate	2	-	0.11	pf
Grid No.1 to cathode & heater	2	26	32	pf
Plate to cathode & heater	2	-	0.011	pf
Grid No.1 to grid No.2	2	34	41	pf
Grid No.2 to plate	2	4.3	6.3	pf
Grid No.2 to cathode & heater	2	-	1.1	pf
3. Reverse Grid-No.1 Current	1,3	-	-50	μa
4. Peak Emission	1,4	80	-	amp
5. Interelectrode Leakage Resistance	5	8.0	-	megohms
6. Cutoff Grid-No.1 Voltage	1,6	-	-87	volts

Note 1: With 6.3 volts, ac or dc on heater.

Note 2: Measured with special shield adapter.

Note 3: With dc plate voltage of 2500 volts, dc grid-No.2 voltage of 400 volts, and dc grid-No.1 voltage adjusted to give a plate current of 240 ma.

Note 4: For conditions with grid No.1, grid No.2, and plate tied together; and pulse voltage source of 850 peak volts between plate and cathode. Pulse duration is 2 microseconds, pulse repetition frequency is 60 pps, and duty factor is 0.00012. Peak emission current is read after 1 minute.

Note 5: Under conditions with tube at 20° to 30° C for at least 30 minutes without any voltages applied to the tube. The minimum resistance between any two electrodes (except across heater terminals) is measured with a 200-volt Megger-type ohmmeter having an internal impedance of 1.0 megohm.

Note 6: With dc plate voltage of 2500 volts, dc grid-No.2 voltage of 400 volts, and dc grid-No.1 voltage adjusted to give a plate current of 5 ma.

SPECIAL TESTS AND PERFORMANCE DATA

The environmental conditions shown for the tests below are those applied directly to the tube. Extreme care must be used in the design of the mountings to minimize mounting resonances.

50g, 11-Millisecond Shock Test:

This test is performed on samples of tubes to determine the ability of the tube to withstand the specified long-duration impact acceleration. Tubes are held rigid in six different positions in a medium impact shock machine and are subjected to three blows in each position.

At the end of this test, tubes will not show permanent or temporary shorts or open circuits.

500g, Nominal 3/4-Millisecond Shock Test:

This test is performed on samples of tubes to determine the ability of the tube to withstand the specified impact acceleration. Tubes are held rigid in four different positions in a high-impact shock machine and are subjected to five blows in each position.

At the end of this test, tubes will not show permanent or temporary shorts or open circuits.

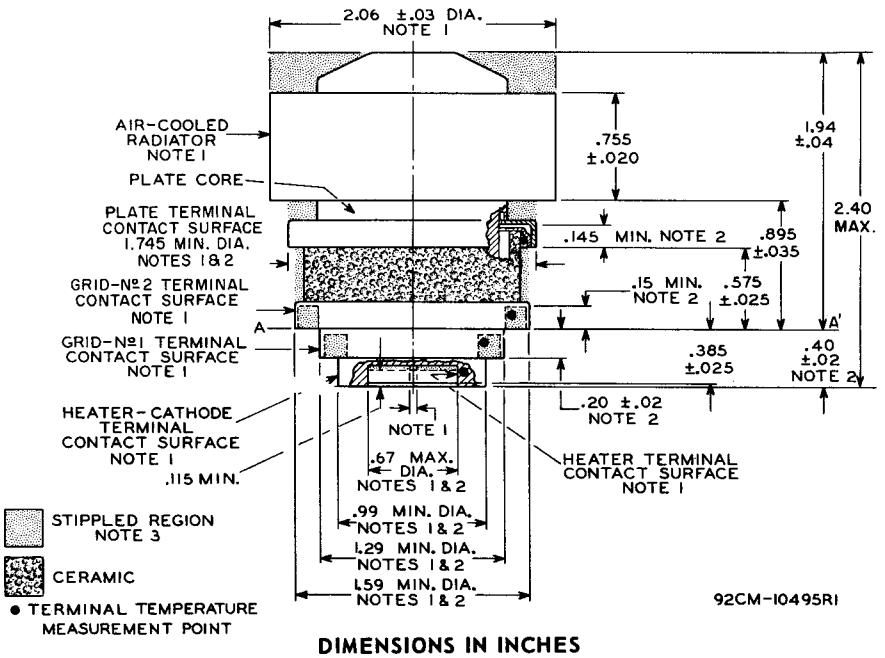
5-2000 cps Variable Frequency Vibration Test:

This test is performed on samples of tubes to determine the ability of the tube to withstand variable frequency vibration. With heater voltage of 6.3 volts ac or dc, dc plate supply voltage of 300 volts, dc grid-No.2 voltage of 250 volts, grid-No.1 voltage adjusted to give dc plate current of 10 ma, and plate load resistor of 2000 ohms. This tube is vibrated along each of three mutually perpendicular axes over an 8-minute sweep consisting of:

a. 5-10 cps with fixed double amplitude of 0.080 inch ± 10%.
b. 10-15 cps at fixed acceleration of 0.41g ± 10%.
c. 15-105 cps with fixed double amplitude of 0.036 inch ± 10%.
d. 105-2000 cps at fixed acceleration of 20g ± 10%.

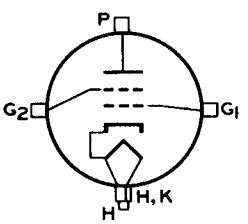
At the end of this test, tubes will not show permanent or temporary shorts or open circuits.

DIMENSIONAL OUTLINE



DIMENSIONS IN INCHES

TERMINAL DIAGRAM



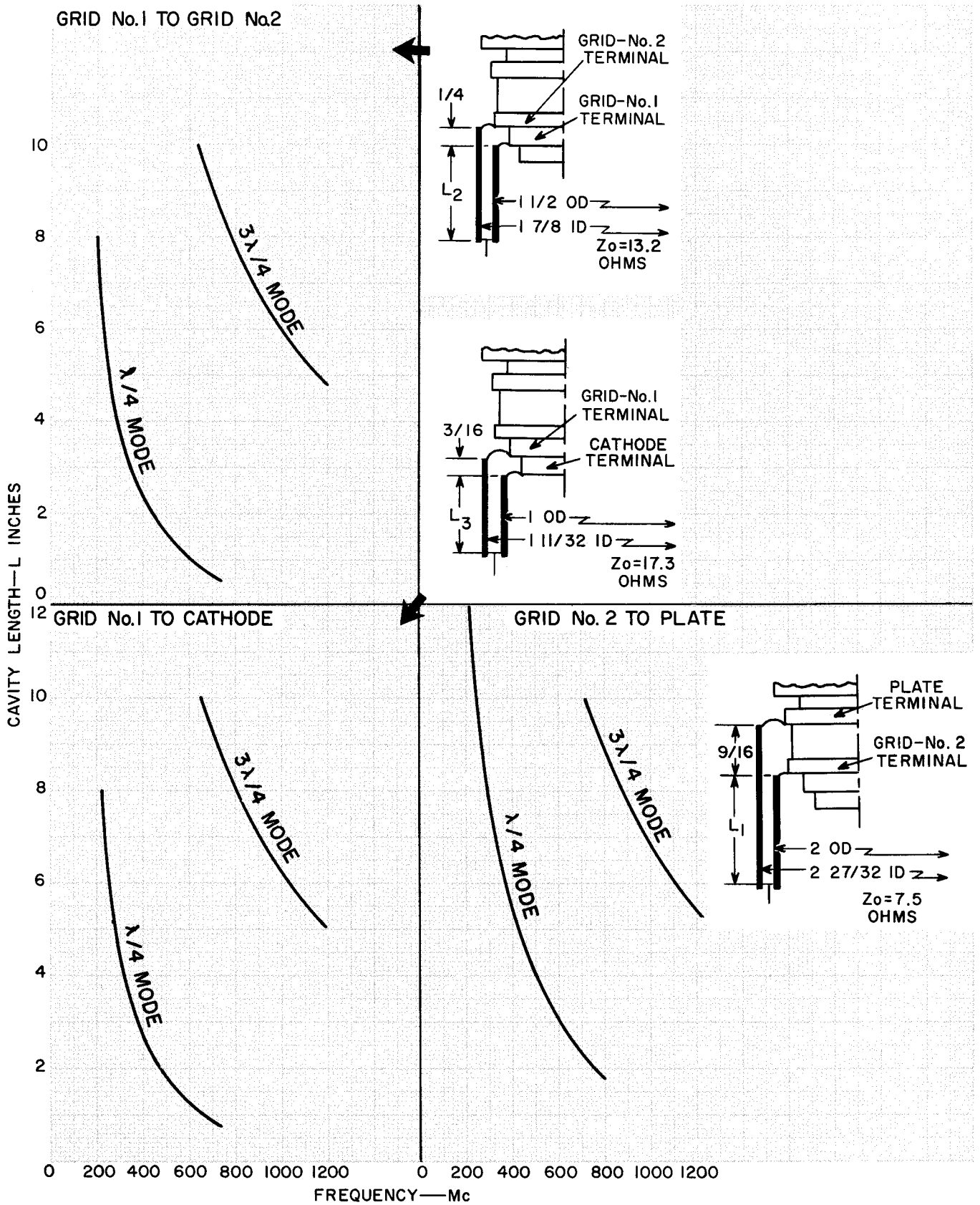
NOTE 1: THE FOLLOWING DIAMETRICAL SPACE REQUIREMENTS ACCOMMODATE THE CONCENTRICITY OF THE CYLINDRICAL SURFACES OF THE RADIATOR BAND AND EACH ELECTRODE TERMINAL:

a. Radiator Band - 2.112"
b. Plate Terminal - 1.801"
c. Grid-No.2 Terminal - 1.611"
d. Grid-No.1 Terminal - 1.321"
e. Heater-Cathode Terminal - 1.021"
f. Heater Terminal - 0.621"

NOTE 2: THE DIAMETER OF EACH TERMINAL IS HELD TO INDICATED VALUES ONLY OVER THE INDICATED MINIMUM LENGTH OF ITS CONTACT SURFACE.

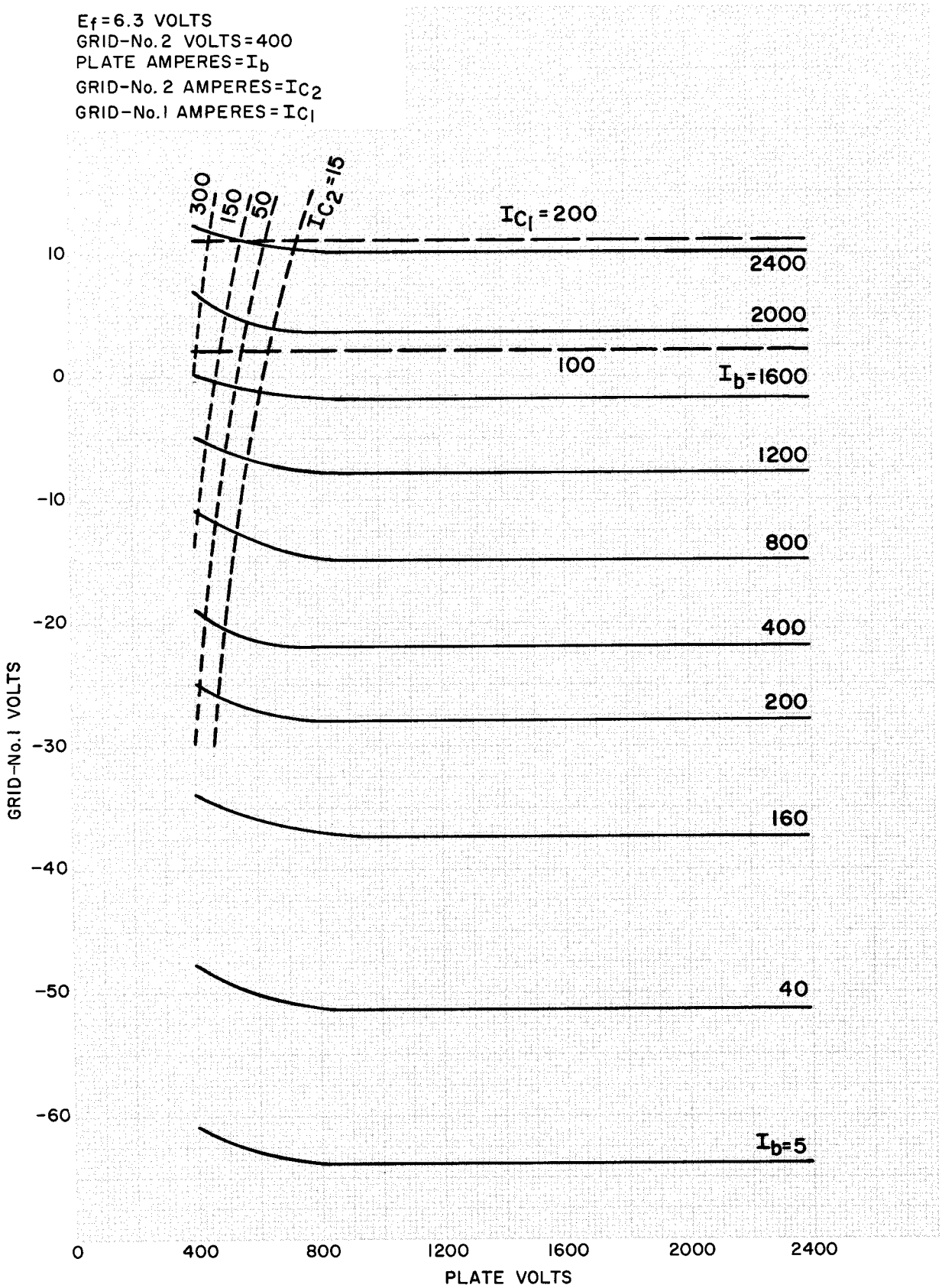
NOTE 3: KEEP ALL STIPPLED REGIONS CLEAR. DO NOT ALLOW CONTACTS OR CIRCUIT COMPONENTS TO PROTRUDE INTO THESE ANNULAR VOLUMES. DIAMETERS OF STIPPLED AREAS ABOVE AIR-COOLED RADIATOR, PLATE TERMINAL CONTACT SURFACE, AND GRID-No.2 TERMINAL CONTACT SURFACE SHALL NOT BE GREATER THAN ITS ASSOCIATED DIAMETER.

TUNING CHARACTERISTICS



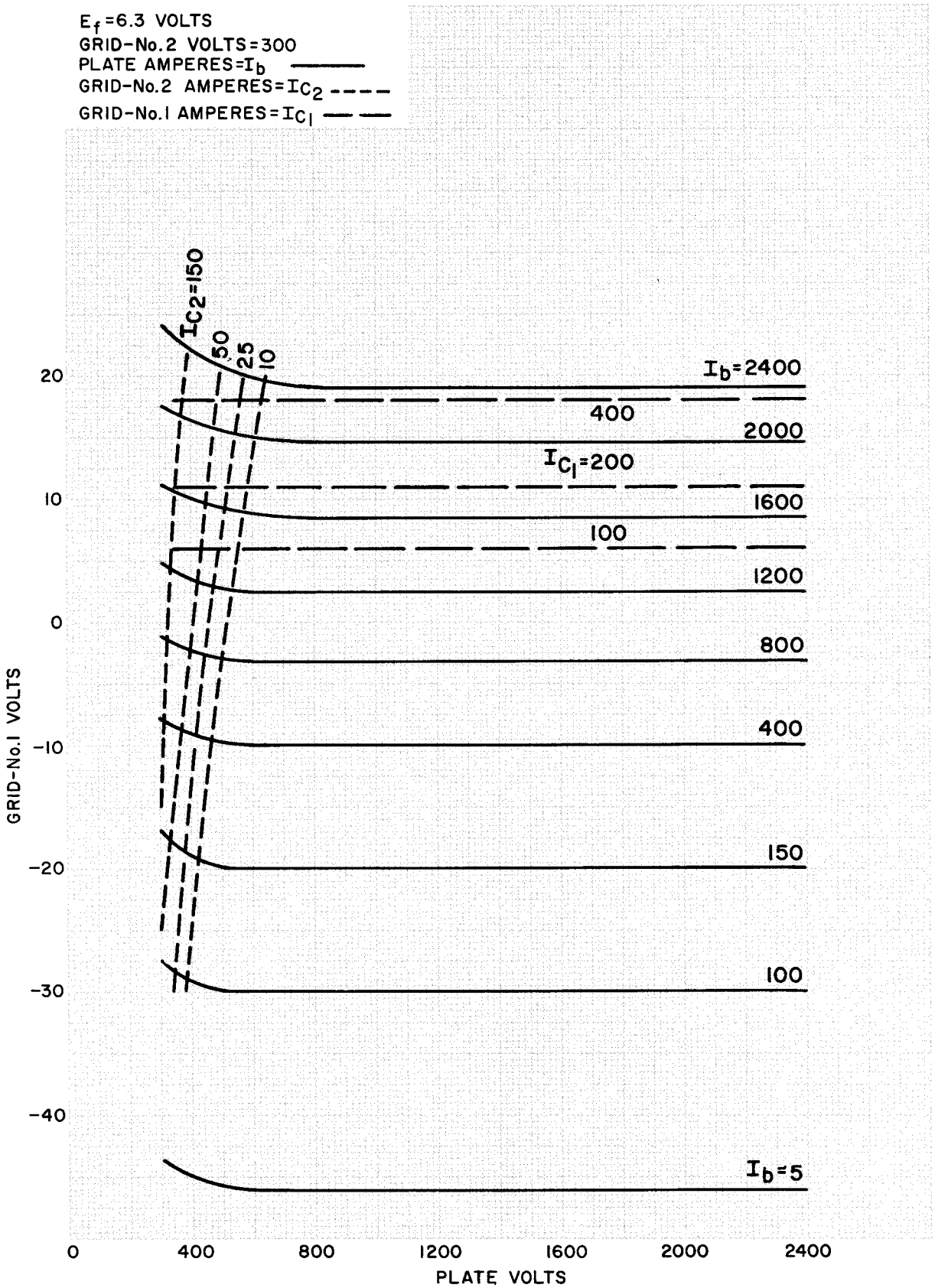
92CM-12637

TYPICAL CONSTANT-CURRENT CHARACTERISTICS
For Grid-No.2 Voltage = 400 Volts



92CM-12630

TYPICAL CONSTANT-CURRENT CHARACTERISTICS
For Grid-No.2 Voltage = 300 Volts



92CM-12627

FORCED-AIR COOLING

Air Flow:

Through radiator — Adequate air flow to limit the plate core temperature to 250° C should be delivered by a blower, such as Rotron* AS-301, AXIMAX 1, or equivalent, through the radiator before and during the application of heater, plate, grid-No.2, and grid-No.1 voltages.

Typical values of air flow directed through the radiator to maintain the plate core (See *Dimensional Outline*) at 250° C with an incoming air temperature of 25° C and with no restrictions at the plate contact flange are:

Plate Dissipation (watts)	Air Flow (cubic ft/min)	Static Pressure (inches of water)
100	2	0.04
300	4	0.14
600	11	0.66
700	16	0.96

To Plate, Grid-No.2, Grid-No.1, Heater-Cathode, and Heater Terminals — A sufficient quantity of air should be allowed to flow past each of these terminals so that their temperature does not exceed the specified maximum value of 250° C. An air flow of 2.5 cfm is usually adequate.

During Standby Operation — Cooling air is required to the Heater-Cathode and Heater Terminals when only heater voltage is applied to the tube.

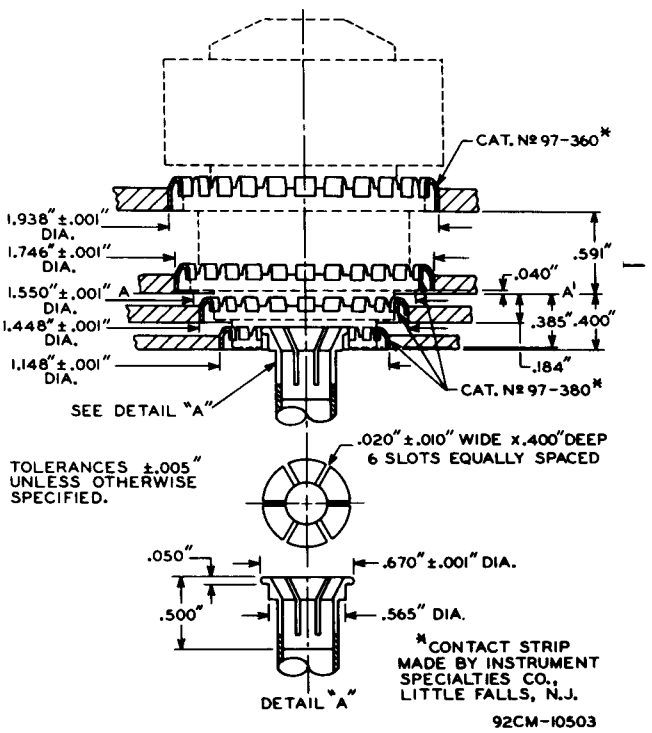
During Shutdown Operation — Air flow should continue for a few minutes after all electrode power is removed.

* Rotron Mfg. Co., Inc., Woodstock, N. Y.

Mounting

See the preferred mounting arrangement below. See section III.C.3.a of ICE-300 for a description of the fixed method of mounting. The adjustable method is not recommended for the 7650.

PREFERRED MOUNTING ARRANGEMENT
and Layout of Associated Contacts



DIMENSIONS IN INCHES

8012

U-H-F TRANSMITTING TRIODE

The 8012 supersedes the Type 1628.

Filament**	Thoriated Tungsten	
Voltage	6.3	a-c or d-c volts
Current	1.92	amp.
Amplification Factor	18	
Direct Interelectrode Capacitances:		
Grid to Plate	2.8	μμf
Grid to Filament	2.7	μμf
Plate to Filament	0.35	μμf
Maximum Overall Length, Maximum Diameter	Refer to tube outline drawing	
Bulb		T-8
Terminal Connections		Special
Cooling		Forced Air◊

Maximum Ratings Are Absolute Values

MAXIMUM CCS RATINGS with TYPICAL OPERATING CONDITIONS

CCS = Continuous Commercial Service

GRID-MODULATED R-F POWER AMPLIFIER - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	CCS	
D-C Plate Voltage	1000 max.	volts
D-C Grid Voltage	-200 max.	volts
D-C Plate Current	65 max.	ma.
Plate Input	50 max.	watts
Plate Dissipation	40 max.	watts
Typical Operation:		
D-C Plate Voltage	1000	volts
D-C Grid Voltage □	-135	volts
	2500	ohms
Peak R-F Grid Voltage	155	volts
Peak A-F Grid Voltage	65	volts
D-C Plate Current	50	ma.
D-C Grid Current*	4.0 approx.	ma.
Driving Power ▲*	3.5 approx.	watts
Power Output	20 approx.	watts

□ Obtained from fixed supply or by cathode resistor of value shown.
▲ At crest of audio-frequency cycle with modulation factor of 1.0.

PLATE-MODULATED R-F POWER AMPLIFIER - Class C Telephony

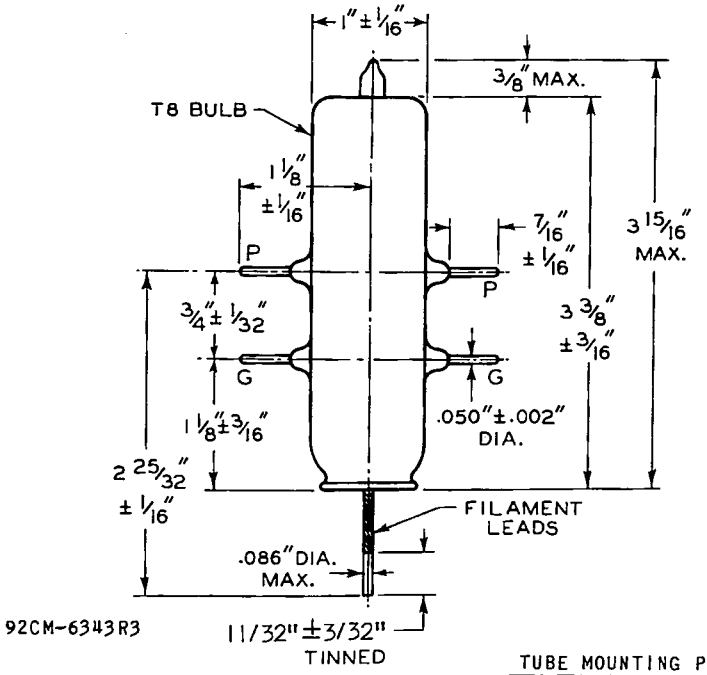
Carrier conditions per tube for use with a max. modulation factor of 1.0

	CCS	
D-C Plate Voltage	800 max.	volts
D-C Grid Voltage	-200 max.	volts
D-C Plate Current	65 max.	ma.
D-C Grid Current	20 max.	ma.
Plate Input	33 max.	watts
Plate Dissipation	27 max.	watts
Typical Operation:		
D-C Plate Voltage	800	volts
D-C Grid Voltage ‡	-105	volts
	10000	ohms

**, *, ‡, ◊: See next page.

8012

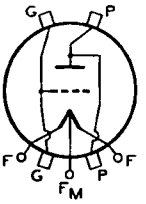
U-H-F TRANSMITTING TRIODE



TUBE MOUNTING POSITION

Vertical only

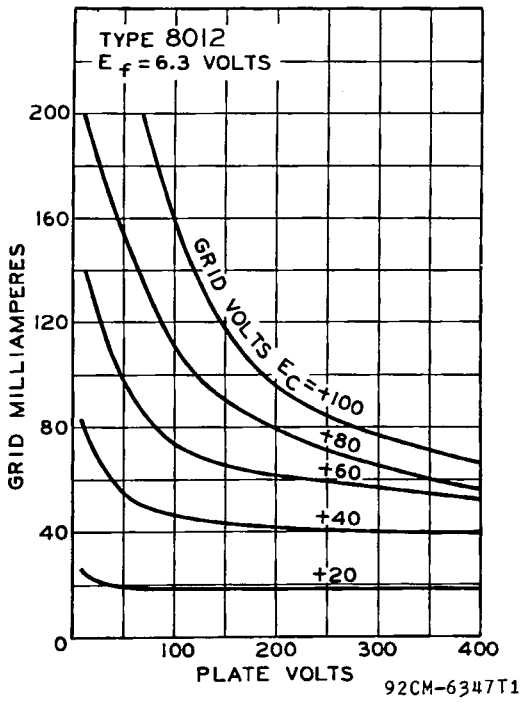
TERMINAL CONNECTIONS



G TERMINALS NEARER FILAMENT LEADS
P TERMINALS NEARER BULB TIP

F – FILAMENT
F_M – FILAMENT MID-TAP
G – GRID
P – PLATE

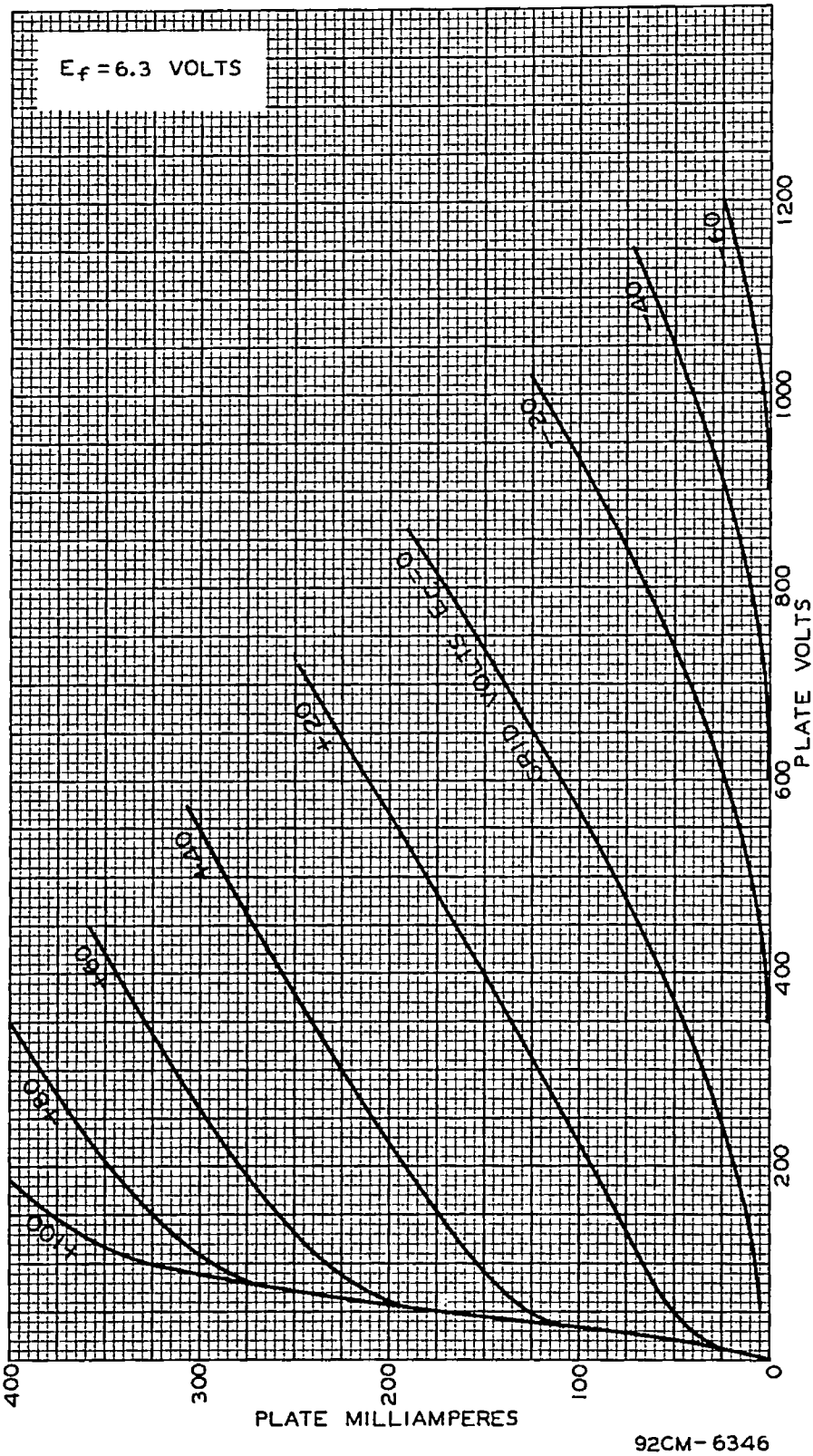
TYPICAL CHARACTERISTICS



RCA

8012

AVERAGE PLATE CHARACTERISTICS



92CM-6346

RMA Release # 326 Feb. 26, 1943

8025

U-H-F TRANSMITTING TRIODE

The 8025 is a three-electrode transmitting tube designed especially for use at the ultra-high frequencies. It has high perveance and low transit time. The tube may be operated at maximum ratings at frequencies as high as 500 megacycles and at reduced ratings at higher frequencies. The maximum plate dissipation rating with forced-air cooling is 40 watts for class C telegraph service.

The thoriated-tungsten filament of the 8025 is of the double-helical type, and is center-tapped within the tube to minimize the effects of filament-lead inductance. Heavy double leads reduce lead inductance and eliminate within the tube common impedances between the tank and neutralizing circuits. The tube is provided with a small four-pin base for the filament terminals.

TENTATIVE CHARACTERISTICS and RATINGS

FILAMENT VOLTAGE (A.C. or D.C.)	6.3	Volts
FILAMENT CURRENT	1.92	Amperes
AMPLIFICATION FACTOR	18	
DIRECT INTERELECTRODE CAPACITANCES:		
Grid-Plate	2.8	μμf
Grid-Filament	2.7	μμf
Plate-Filament	0.35	μμf
DIMENSIONS	See *OUTLINE DRAWING* T-8	
BULB		
CAPS (four)	Saddle Skirted Miniature, with Nub	
BASE	Small 4-Pin Micanol	

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

CCS = Continuous Commercial Service
ICAS = Intermittent Commercial and Amateur Service

As Grid-Modulated R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	Forced-Air Cooling - CCS	*Natural Cooling ICAS*	
D-C PLATE VOLTAGE	1000 max.	1000 max.	Volts
D-C GRID VOLTAGE	-200 max.	-200 max.	Volts
D-C PLATE CURRENT	65 max.	65 max.	Ma.
PLATE INPUT	60 max.	50 max.	Watts
PLATE DISSIPATION	40 max.	30 max.	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	1000		Volts
D-C Grid Voltage			
From a fixed supply of	-135		Volts
From a cathode resistor of	2500		Ohms
Peak R-F Grid Voltage	155		Volts
Peak A-F Grid Voltage	65		Volts
D-C Plate Current	50		Ma.
D-C Grid Current (Approx.)*	4		Ma.
Driving Power (Approx.)* o	3.5		Watts
Power Output (Approx.)	20		Watts

As Plate-Modulated R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	Forced-Air Cooling - CCS.	*Natural Cooling ICAS*	
D-C PLATE VOLTAGE	800 max.	800 max.	Volts
D-C GRID VOLTAGE	-200 max.	-200 max.	Volts
D-C PLATE CURRENT	65 max.	65 max.	Ma.
D-C GRID CURRENT	20 max.	20 max.	Ma.
PLATE INPUT	50 max.	33 max.	Watts
PLATE DISSIPATION	27 max.	20 max.	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	800		Volts
D-C Grid Voltage			
From a fixed supply of	-105		Volts
From a grid resistor of	10000		Ohms
Peak R-F Grid Voltage	145		Volts
D-C Plate Current	40		Ma.
D-C Grid Current (Approx.)*	10.5		Ma.
Driving Power (Approx.)*	1.4		Watts
Power Output (Approx.)	22		Watts

As R-F Power Amplifier and Oscillator - Class C Telegraphy

Key-down conditions per tube without modulation #

	Forced-Air Cooling - CCS	*Natural Cooling ICAS*	
D-C PLATE VOLTAGE	1000 max.	1000 max.	Volts
D-C GRID VOLTAGE	-200 max.	-200 max.	Volts
D-C PLATE CURRENT	80 max.	80 max.	Ma.
D-C GRID CURRENT	20 max.	20 max.	Ma.
PLATE INPUT	75 max.	50 max.	Watts
PLATE DISSIPATION	40 max.	30 max.	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	1000		Volts
D-C Grid Voltage			
From a fixed supply of	-90		Volts
From a grid resistor of	6400		Ohms
From a cathode resistor of	1400		Ohms
Peak R-F Grid Voltage	130		Volts
D-C Plate Current	50		Ma.
D-C Grid Current (Approx.)*	14		Ma.
Driving Power (Approx.)*	1.6		Watts
Power Output (Approx.)	35		Watts

* Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of supplying considerably more than the required driving power.

\# Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

o At crest of audio-frequency cycle with modulation factor of 1.0.

INSTALLATION

The *base* of the 8025 fits the standard four-contact socket, such as RCA stock No.9919, which should be installed to hold the tube in a vertical position. Connections to the grid and plate caps should have large contact surfaces but they should be of small size in order to minimize circuit capacitances. These connections must be flexible enough so that normal expansion will not place a strain on the caps and the seals, yet heavy enough to carry the high circulating r-f currents. The cap connectors should be fastened to the caps before the tube is mounted in position. The connectors should be sprung slightly so that they can be slipped easily over their respective caps. Connections should never be soldered directly to the caps because the heat of soldering may result in cracking of the lead

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seals. The caps should not be used to support circuit parts.

The *bulb* becomes very hot during continuous operation of the tube so that either forced ventilation or the free circulation of air (depending on operating conditions) should be provided. In the case of forced ventilation, a fan directed at the bulb is recommended. The installation of all wires and connections should be made so that they will not be close to or touch the bulb in order to avoid puncture of the glass bulb due to peak voltage effects.

The *thoriated-tungsten filament* of the 8025 is center-tapped within the tube. The center lead is brought out to a separate base pin. With this arrangement, it is possible to minimize the effect of filament-lead inductance by connecting all three leads in parallel through by-pass condensers. The center lead of this parallel connection should not be returned directly to the center tap of the filament-transformer winding or to ground, although it may be by-passed to either of these points if desired. Under normal full-load conditions, the filament should be maintained at the rated voltage within ± 5%; with light loads, reduction of the filament voltage by as much as 5% is permissible. In the latter case, care must be taken that the reduction of filament voltage and, therefore, of emission, is not so great the peak current requirements cannot be supplied. It is recommended that, in intermittent service where the standby periods are no longer than 15 minutes, the filament voltage be reduced to 80% of normal during standbys; for longer periods, the filament voltage should be shut off. The filament should be operated at constant voltage rather than constant current and must be allowed to reach operating temperature before other voltages are applied.

Overheating of the 8025 by severe overload may decrease the filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or longer with no voltage on plate and grid. This process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The positive high-voltage supply lead should be provided with a protective device such as a relay. This device should remove the plate voltage instantly when the d-c plate current reaches a value 50% greater than normal.

The *plate* of the 8025 shows a dull red color at its maximum plate-dissipation rating for each class of service.

R-f by-passing of the grid and plate return circuits should be made to the center lead of the filament. It is important that the returns be made to this common connection in order to avoid r-f interaction through common return circuits. In some applications, it may also be advisable to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the voltage-supply leads.

In order that the maximum ratings given under CHARACTERISTICS and RATINGS will not be exceeded changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case circuit adjustments are incorrect. It is advisable to use a protective resistance of about 6000 ohms in series with the plate lead during such adjustments.

The rated plate voltage of the 8025 is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c potential.

APPLICATION

In *grid-modulated class C telephone service*, the 8025 may be supplied with d-c grid bias from a cathode resistor, unbypassed for audio frequencies, or from a fixed supply. The audio power required in this service is very small. It need be only sufficient to meet the peak power requirement of the grid of the class C amplifier on the crest of the input signal. The actual peak value is generally never more than 3 watts.

In *plate-modulated class C r-f service*, the 8025 may be supplied with grid bias from a grid resistor, or from a combination of grid resistor with either fixed supply or cathode resistor. The cathode resistor should be suitably by-passed for both a.f. and r.f. The combination method has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

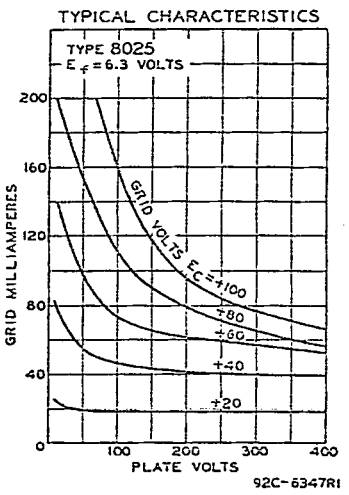
In *class C r-f telegraph service*, the 8025 may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. If the 8025 is operated at the maximum rated plate voltage of 1000 volts, a fixed bias of at least -40 volts should be used.

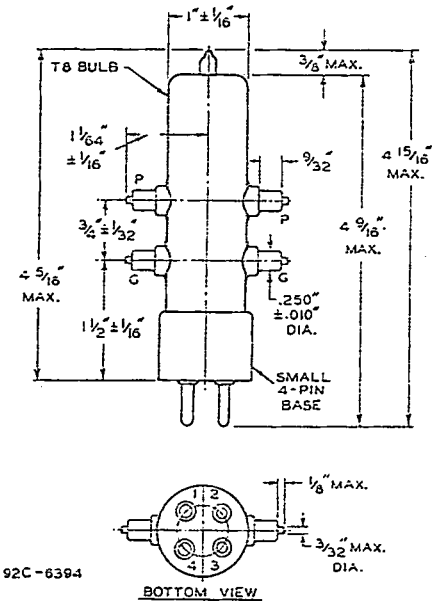
The 8025 may be operated with maximum ratings at frequencies as high as 500 Mc but as the frequency is raised, the efficiency and power output fall off. The 8025 may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced (rated maxi-

mum plate input may be used up to 600 Mc); other maximum ratings are the same as shown under CHARACTERISTICS and RATINGS. The table below shows the highest percentage of maximum plate voltage that can be used up to 600 Mc. Special attention should be given to adequate cooling at these frequencies.

When the 8025 is operated at the ultra-high frequencies, push-pull operation is recommended. This connection has the advantage of simplifying the balancing of high-frequency circuits by providing symmetry of layout. In oscillator service, it is desirable to connect the two grid terminals and the two plate terminals of each tube in parallel in order to reduce their respective lead inductances.

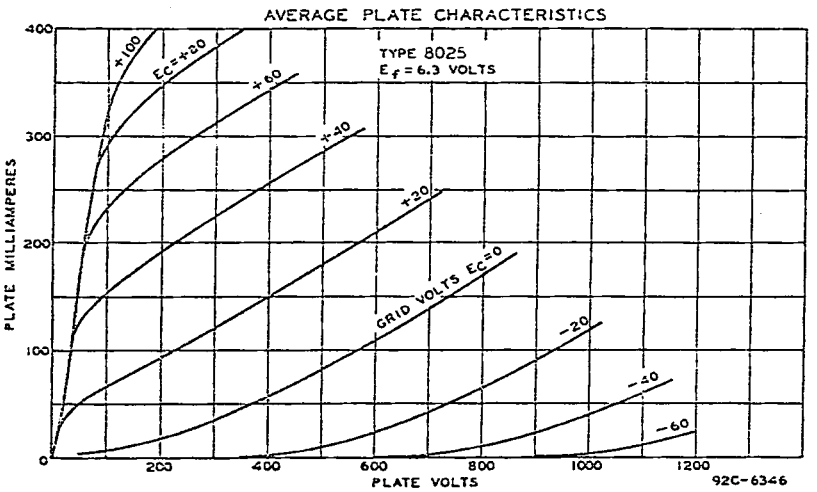
FREQUENCY	500	600	Mc
MAX. PERMISSIBLE PERCENTAGE of MAX. RATED PLATE VOLTAGE:			
class C telephony, grid-mod.	100	77	Per cent
class C telephony, plate-mod.	100	63	Per cent
class C telegraphy	100	63	Per cent



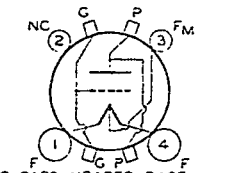


℄ OF EACH CAP SHALL NOT DEVIATE MORE THAN 3° FROM PLANE NORMAL TO THE PLANE OF PINS NO.1 & NO.4 AND PASSING THROUGH CENTER OF BOTTOM OF BASE.

℄ OF BULB SHALL NOT DEVIATE MORE THAN 5° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.



Bottom View of Socket Connections



G-CAPS NEARER BASE
P-CAPS NEARER BASE TIP
4AQ

P = PLATE
G = GRID
F = FILAMENT
F_M = FILAMENT MID-TAP

8025-A

U-H-F TRANSMITTING TRIODE

The 8025-A is a three-electrode transmitting tube designed especially for use at the ultra-high frequencies. It has high perveance and low transit time. The tube may be operated at maximum ratings at frequencies as high as 500 megacycles and at reduced ratings at higher frequencies. The maximum plate dissipation rating with forced-air cooling is 40 watts for class C telegraph service.

The thoriated-tungsten filament of the 8025-A is of the double-helical type, and is center-tapped within the tube to minimize the effects of filament-lead inductance. Heavy double leads reduce lead inductance and eliminate within the tube common impedances between the tank and neutralizing circuits. The tube is provided with a small four-pin base for the filament terminals.

TENTATIVE CHARACTERISTICS and RATINGS

FILAMENT VOLTAGE (A.C. or D.C.)	6.3	Volts
FILAMENT CURRENT	1.92	Amperes
AMPLIFICATION FACTOR	18	
DIRECT INTERELECTRODE CAPACITANCES:		
Grid-Plate	3.0	μμf
Grid-Filament	2.7	μμf
Plate-Filament	0.4	μμf
DIMENSIONS	See *OUTLINE DRAWING*	
BULB	T-8	
CAPS (four)	Saddle Skirted Miniature, with Nub	
BASE	Small 4-Pin Micanol	

Maximum Ratings Are Absolute Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

CCS = Continuous Commercial Service
ICAS = Intermittent Commercial and Amateur Service

As Grid-Modulated R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	Forced-Air Cooling - CCS	*Natural Cooling ICAS*	
D-C PLATE VOLTAGE	1000 max.	1000 max.	Volts
D-C GRID VOLTAGE	-200 max.	-200 max.	Volts
D-C PLATE CURRENT	65 max.	65 max.	Ma.
PLATE INPUT	60 max.	50 max.	Watts
PLATE DISSIPATION	40 max.	30 max.	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	1000		Volts
D-C Grid Voltage			
From a fixed supply of	-135		Volts
From a cathode resistor of	2500		Ohms
Peak R-F Grid Voltage	155		Volts
Peak A-F Grid Voltage	65		Volts
D-C Plate Current	50		Ma.
D-C Grid Current (Approx.)*	4		Ma.
Driving Power (Approx.)* o	3.5		Watts
Power Output (Approx.)	20		Watts

As Plate-Modulated R-F Power Amplifier - Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

	Forced-Air Cooling - CCS	*Natural Cooling ICAS*	
D-C PLATE VOLTAGE	800 max.	800 max.	Volts
D-C GRID VOLTAGE	-200 max.	-200 max.	Volts
D-C PLATE CURRENT	65 max.	65 max.	Ma.
D-C GRID CURRENT	20 max.	20 max.	Ma.
PLATE INPUT	50 max.	33 max.	Watts
PLATE DISSIPATION	27 max.	20 max.	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	800		Volts
D-C Grid Voltage			
From a fixed supply of	-105		Volts
From a grid resistor of	10000		Ohms
Peak R-F Grid Voltage	145		Volts
D-C Plate Current	40		Ma.
D-C Grid Current (Approx.)*	10.5		Ma.
Driving Power (Approx.)*	1.4		Watts
Power Output (Approx.)	22		Watts

As R-F Power Amplifier and Oscillator - Class C Telegraphy

Key-down conditions per tube without modulation #

	Forced-Air Cooling - CCS	*Natural Cooling ICAS*	
D-C PLATE VOLTAGE	1000 max.	1000 max.	Volts
D-C GRID VOLTAGE	-200 max.	-200 max.	Volts
D-C PLATE CURRENT	80 max.	80 max.	Ma.
D-C GRID CURRENT	20 max.	20 max.	Ma.
PLATE INPUT	75 max.	50 max.	Watts
PLATE DISSIPATION	40 max.	30 max.	Watts
TYPICAL OPERATION:			
D-C Plate Voltage	1000		Volts
D-C Grid Voltage			
From a fixed supply of	-90		Volts
From a grid resistor of	6400		Ohms
From a cathode resistor of	1400		Ohms
Peak R-F Grid Voltage	130		Volts
D-C Plate Current	50		Ma.
D-C Grid Current (Approx.)*	14		Ma.
Driving Power (Approx.)*	1.6		Watts
Power Output (Approx.)	35		Watts

* Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should be capable of supplying considerably more than the required driving power.

\# Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

o At crest of audio-frequency cycle with modulation factor of 1.0.

INSTALLATION

The *base* of the 8025-A fits the standard four-contact socket, such as RCA stock No.9919, which should be installed to hold the tube in a vertical position. Connections to the grid and plate caps should have large contact surfaces but they should be of small size in order to minimize circuit capacitances. These connections must be flexible enough so that normal expansion will not place a strain on the caps and the seals, yet heavy enough to carry the high circulating r-f currents. The cap connectors should be fastened to the caps before the tube is mounted in position. The connectors should be sprung slightly so that they can be slipped easily over their respective caps. Connections should never be soldered directly to the caps because the heat of soldering may result in cracking of the lead

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seals. The caps should not be used to support circuit parts.

The *bulb* becomes very hot during continuous operation of the tube so that either forced ventilation or the free circulation of air (depending on operating conditions) should be provided. In the case of forced ventilation, a fan directed at the bulb is recommended. The installation of all wires and connections should be made so that they will not be close to or touch the bulb in order to avoid puncture of the glass bulb due to peak voltage effects.

The *thoriated-tungsten filament* of the 8025-A is center-tapped within the tube. The center lead is brought out to a separate base pin. With this arrangement, it is possible to minimize the effect of filament-lead inductance by connecting all three leads in parallel through by-pass condensers. The center lead of this parallel connection should not be returned directly to the center tap of the filament-transformer winding or to ground, although it may be by-passed to either of these points if desired. Under normal full-load conditions, the filament should be maintained at the rated voltage within $\pm$ 5%; with light loads, reduction of the filament voltage by as much as 5% is permissible. In the latter case, care must be taken that the reduction of filament voltage and, therefore, of emission, is not so great the peak current requirements cannot be supplied. It is recommended that, in intermittent service where the standby periods are no longer than 15 minutes, the filament voltage be reduced to 80% of normal during standbys; for longer periods, the filament voltage should be shut off. The filament should be operated at constant voltage rather than constant current and must be allowed to reach operating temperature before other voltages are applied.

Overheating of the 8025-A by severe overload may decrease the filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or longer with no voltage on plate and grid. This process may be accelerated by raising the filament voltage to 7.5 volts (not higher) for a few minutes. The positive high-voltage supply lead should be provided with a protective device such as a relay. This device should remove the plate voltage instantly when the d-c plate current reaches a value 50% greater than normal.

The *plate* of the 8025-A shows a dull red color at its maximum plate-dissipation rating for each class of service.

R-f by-passing of the grid and plate return circuits should be made to the center lead of the filament. It is important that the returns be made to this common connection in order to avoid r-f interaction through common return circuits. In some applications, it may also be advisable to supplement the action of the by-pass condensers by r-f chokes placed close to the condensers in the voltage-supply leads.

In order that the maximum ratings given under CHARACTERISTICS and RATINGS will not be exceeded changes in plate and filament voltages due to line-voltage fluctuation, load variation, and manufacturing variation of the associated apparatus must be determined. An average value of plate and filament voltage should then be chosen so that under the usual voltage variations the maximum rated voltages will not be exceeded.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced in order to prevent damage to the tube or associated apparatus in case circuit adjustments are incorrect. It is advisable to use a protective resistance of about 6000 ohms in series with the plate lead during such adjustments.

The rated plate voltage of the 8025-A is high enough to be dangerous to the user. Care should be taken during the adjustment of circuits, especially when the exposed circuit parts are at high d-c potential.

APPLICATION

In *grid-modulated class C telephone service*, the 8025-A may be supplied with d-c grid bias from a cathode resistor, unbypassed for audio frequencies, or from a fixed supply. The audio power required in this service is very small. It need be only sufficient to meet the peak power requirement of the grid of the class C amplifier on the crest of the input signal. The actual peak value is generally never more than 3 watts.

In *plate-modulated class C r-f service*, the 8025-A may be supplied with grid bias from a grid resistor, or from a combination of grid resistor with either fixed supply or cathode resistor. The cathode resistor should be suitably by-passed for both a.f. and r.f. The combination method has the advantage of not only protecting the tube from damage through loss of excitation but also of minimizing distortion by bias-supply compensation.

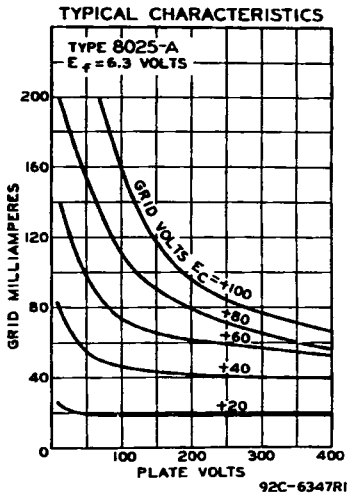
In *class C r-f telegraph service*, the 8025-A may be supplied with bias by any convenient method. When the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current at a safe value. If the 8025-A is operated at the maximum rated plate voltage of 1000 volts, a fixed bias of at least -40 volts should be used.

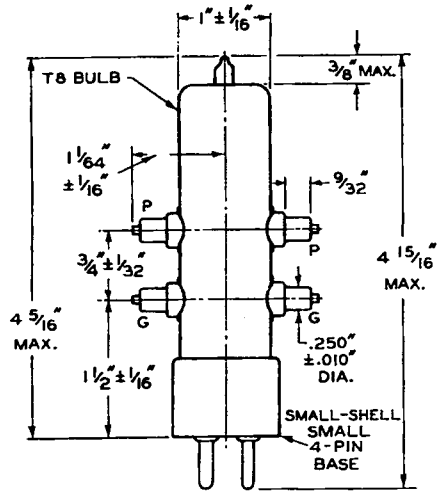
The 8025-A may be operated with maximum ratings at frequencies as high as 500 Mc but as the frequency is raised, the efficiency and power output fall off. The 8025-A may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced (rated maxi-

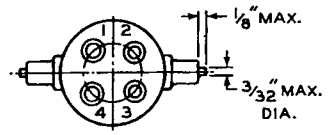
mum plate input may be used up to 600 Mc); other maximum ratings are the same as shown under CHARACTERISTICS and RATINGS. The table below shows the highest percentage of maximum plate voltage that can be used up to 600 Mc. Special attention should be given to adequate cooling at these frequencies.

When the 8025-A is operated at the ultra-high frequencies, push-pull operation is recommended. This connection has the advantage of simplifying the balancing of high-frequency circuits by providing symmetry of layout. In oscillator service, it is desirable to connect the two grid terminals and the two plate terminals of each tube in parallel in order to reduce their respective lead inductances.

FREQUENCY	500	600	Mc
MAX. PERMISSIBLE PERCENTAGE of MAX. RATED PLATE VOLTAGE:			
class C telephony, grid-mod.	100	80	Per cent
class C telephony, plate-mod.	100	70	Per cent
class C telegraphy	100	70	Per cent



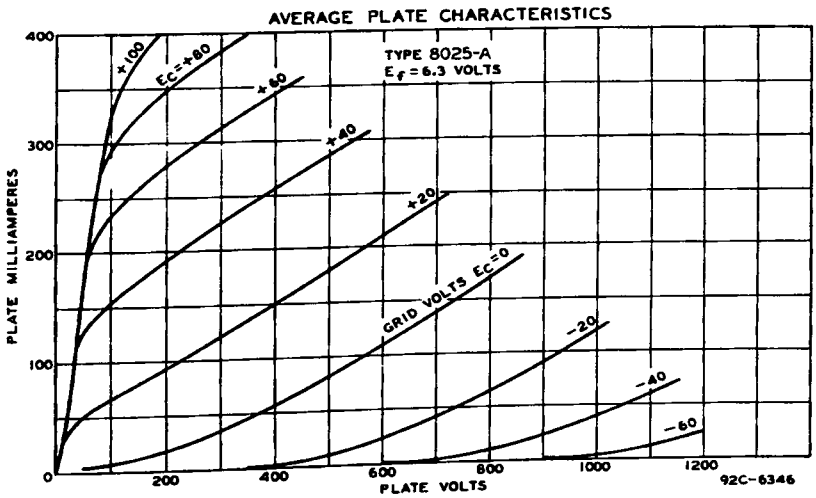




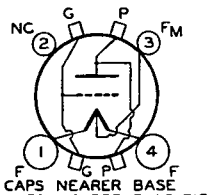
℄ OF EACH CAP SHALL NOT DEVIATE MORE THAN 3° FROM PLANE NORMAL TO THE PLANE OF PINS No. 1 & No. 4 AND PASSING THROUGH CENTER OF BOTTOM OF BASE.

℄ OF BULB SHALL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

92CM-6394R1



Bottom View of Socket Connections



G CAPS NEARER BASE
P CAPS NEARER BULB TIP
3M

P = PLATE
G = GRID
F = FILAMENT
F_M = FILAMENT MID-TAP

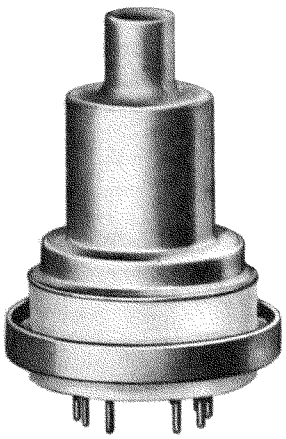
RCA-8072
BEAM POWER TUBE

2.26" Max. Length
1.44" Max. Diameter
Conduction Cooled

For Use in Low-Voltage Mobile Equipment at Frequencies Up to 500 Mc.

Coaxial-Electrode Structure
Ceramic-Metal Seals
Unipotential Cathode

RCA-8072 is a very small, low-cost, conduction-cooled beam power tube designed for use as an rf power amplifier, oscillator, regulator, distributed amplifier, or linear rf power amplifier in mobile or fixed equipment.



Actual Size

Because of its high power sensitivity and high efficiency, the 8072 can be operated with relatively low plate voltage to give large power output with small driving power. In CW operation with a plate voltage of only 700 volts, the 8072 can provide useful power outputs of 110 watts at 50 Mc, 105 watts at 175 Mc, and 85 watts at 470 Mc.

The heater of this tube may be operated by ac or dc voltage, but it is designed to operate over a voltage range of 12 to 15 volts and will take momentary excursion from 11 to 17 volts in battery operation. The heater design insures dependable performance in mobile equipment under operating conditions encountered during battery charging and discharging. Suitably designed mobile equipment using the 8072 will meet the requirements of EIA Standard RS 152A, Minimum Standards for Land-Mobile Communications FM or PM Transmitters 25-470 Mc.

The 8072 employs a large-area, nickel-plated-copper cylindrical-plate terminal for both high electrical conductivity to the electrical circuit and high thermal conductivity for intimate thermal contact to the conduction-cooling system.

The 8072 features a light-weight, cantilever-supported cylindrical electrode structure within a ceramic-metal envelope. This construction provides a very sturdy tube and permits high-temperature operation.

The terminal arrangement of the 8072 facilitates use of the tube with tank circuits of the coaxial or strip-line type. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the low-inductance ring terminal for grid No.2. A base-pin termination for grid No.2 is also available for operation of the 8072 at the lower frequencies.

The tripod arrangement of both the cathode and the grid-No.1 leads not only simplifies construction, but enhances electrical characteristics. The three cathode leads reduce the inductance path to rf ground and reduce the input admittance at high frequencies. One of the cathode leads (preferably No.4 pin) may be series tuned to ground with a capacitor to provide broadband neutralization in the upper frequency range of the tube. The three grid-No.1 leads to separate pins accommodate a split-input circuit for distributed amplifier service.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage range (AC or DC)[a]	12.0 to 15.0	volts
Current at 13.5 volts	1.3	amp
Minimum heating time	60	sec
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 250, grid-No.2 volts = 200, and plate amperes = 1.2	11	
Direct Interelectrode Capacitances:[b]		
Grid No.1 to plate	0.13 max.	pf
Grid No.1 to cathode	16	pf
Plate to cathode	0.011	pf
Grid No.1 to grid No.2	22	pf
Grid No.2 to plate	6.5	pf
Grid No.2 to cathode	2.6	pf
Cathode to heater	3.4	pf

Mechanical:

Operating Position	Any
Maximum Overall Length	2.26"
Seated Length	1.920" ± 0.065"
Greatest Diameter	1.426" ± 0.010"
Base	Large-Wafer Elevenar 11-Pin with Ring E.F. Johnson Co.▲ No.124-311-100, (JEDEC No.E11-81)
Socket	Mycalex* No.CP464-2, or equivalent
Grid-No.2 Bypass Capacitor	E.F. Johnson Co.▲ No.124-113-1, or equivalent
Weight (Approx.)	2 oz

Thermal:

Terminal Temperature (All Terminals)	250 max.	°C
Plate Core Temperature (See *Dimensional Outline*)	250 max.	°C

▲ E.F. Johnson Co., 1921 10th Ave. S.W., Waseka, Minn.
* Mycalex Corp. of America, 725 Clifton Blvd., Clifton, N.J.

Cooling, Conduction:

The plate terminal must be thermally coupled to a constant temperature device (heat sink—solid or liquid) to limit the plate terminal to the specified maximum value of 250° C. The grid No.2, grid No.1, cathode, and heater terminals may also require coupling to the heat sink to limit their respective terminal temperature to the specified maximum value of 250° C.

LINEAR RF POWER AMPLIFIER
Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 Mc		
DC PLATE VOLTAGE	2200	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE	450[c]	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
PLATE DISSIPATION	100[d]	max.	watts
GRID No.2 DISSIPATION	8	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150	max.	volts
Heater positive with respect to cathode	150	max.	volts

Typical CCS Operation with "Two-Tone Modulation":

	At 30 Mc	
DC Plate Voltage	700	volts
DC Grid-No.2 Voltage[e]	250	volts
DC Grid-No.1 Voltage[e]	-20	volts
Zero-Signal DC Plate Current	100	ma
Effective RF Load Resistance	1420	ohms
DC Plate Current at Peak of Envelope	205	ma
Average DC Plate Current	150	ma
DC Grid-No.2 Current at Peak of Envelope	16	ma
Average DC Grid-No.2 Current	10	ma
Average DC Grid-No.1 Current	1.0[f]	ma
Peak-Envelope Driver Power Output (Approx.)[g]	0.3	watt
Output-Circuit Efficiency (Approx.)	95	%
Distortion Products Level:[h]		
Third order	30	db
Fifth order	35	db
Useful Power Output (Approx.):		
Average	40[j]	watts
Peak envelope	80[j]	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:			
With fixed bias	25,000	max.	ohms
With fixed bias (in Class AB_1 operation)	100,000	max.	ohms
With cathode bias	Not recommended		
Grid-No.2 Circuit Impedance	10,000		ohms
Plate Circuit Impedance	See Note k		

PLATE-MODULATED RF POWER AMPLIFIER — Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS Ratings, *Absolute-Maximum Values up to 500 Mc:*

DC PLATE VOLTAGE	1800	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT	250	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
GRID-No.2 INPUT	5	max.	watts
PLATE DISSIPATION	70	max.	watts

Typical CCS Operation:

In grid-drive circuit at 50 Mc

DC Plate Voltage	500	700	volts
DC Grid-No.2 Voltage[n]	150	150	volts
DC Grid-No.1 Voltage[p]	-20	-25	volts
DC Plate Current	200	250	ma
DC Grid-No.2 Current	35	40	ma
DC Grid-No.1 Current	20	35	ma
Driver Power Output (Approx.)[m]	1.2	2	watts
Output Circuit Efficiency (Approx.)	90	90	%
Useful Power Output Approx.)	54	105	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:			
With fixed bias	25,000	max.	ohms
Grid-No.2 Circuit Impedance	10,000	max.	ohms
Plate Circuit Impedance	See Note k		

RF POWER AMP. & OSCILLATOR — Class C Telegraphy
and
RF POWER AMPLIFIER — Class C FM Telephony

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 Mc		
DC PLATE VOLTAGE	2200	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT	300	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
GRID-No.2 DISSIPATION	8	max.	watts
PLATE DISSIPATION	100[d]	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150	max.	volts
Heater positive with respect to cathode	150	max.	volts

Typical CCS Operation:

In Grid-Drive Circuit at 50 Mc

DC Plate Voltage	500	700	volts
DC Grid-No.2 Voltage	160	175	volts
DC Grid-No.1 Voltage	-10	-10	volts
DC Plate Current	300	300	ma
DC Grid-No.2 Current	25	25	ma
DC Grid-No.1 Current	50	50	ma
Driver Power Output (Approx.)[m]	1.2	1.2	watts
Useful Power Output	85[j]	110[j]	watts

In Grid-Drive Circuit at 175 Mc

DC Plate Voltage	500	700	volts
DC Grid-No.2 Voltage	200	200	volts

DC Grid-No.1 Voltage	-30	-30	volts
DC Plate Current	300	300	ma
DC Grid-No.2 Current	30	20	ma
DC Grid-No.1 Current	40	40	ma
Driver Power Output (Approx.)[m]	3	3	watts
Useful Power Output	70[j]	105[j]	watts

In Grid-Drive Circuit at 470 Mc

DC Plate Voltage	700	volts
DC Grid-No.2 Voltage	200	volts
DC Grid-No.1 Voltage	-30	volts
DC Plate Current	300	ma
DC Grid-No.2 Current	10	ma
DC Grid-No.1 Current	20	ma
Driver Power Output (Approx.)[m]	5	watts
Useful Power Output	85[j]	watts

For minimum power output, see Test No. 8 under **Characteristics Range Values**

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:		
With fixed bias	25,000 max.	ohms
Grid-No.2 Circuit Impedance	10,000 max.	ohms
Plate Circuit Impedance	See Note k	

CHARACTERISTICS RANGE VALUES

		Note	*Min.*	*Max.*	
1.	Heater Current	1	1.15	1.45	amp
2.	Direct Interelectrode Capacitances:				
	Grid No.1 to plate	2	-	0.13	pf
	Grid No.1 to cathode	2	14.3	17.7	pf
	Plate to cathode	2	0.0065	0.0155	pf
	Grid No.1 to grid No.2	2	19.8	24.2	pf
	Grid No.2 to plate	2	5.7	7.1	pf
	Grid No.2 to cathode	2	2.0	3.0	pf
	Cathode to heater	2	2.5	4.1	pf
3.	Grid-No.1 Voltage	1,3	-8	-19	volts
4.	Reverse Grid-No.1 Current	1,3	-	-25	μa
5.	Grid-No.2 Current	1,3	-7	+6	ma
6.	Peak Emission	1,4	13	-	peak amp
7.	Interelectrode Leakage Resistance	5	50	-	megohms
8.	Useful Power Output	1,6	75	-	watts
9.	Cutoff Grid-No.1 Voltage	1,7	-	-44	volts

Note 1: With 13.5 volts ac or dc on heater.

Note 2: Measured with special shield adapter.

Note 3: With dc plate voltage of 700 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage adjusted to give a dc plate current of 185 ma.

Note 4: For conditions with grid No.1, grid No.2, and plate tied together; and pulse voltage source connected between plate and cathode. Pulse duration is 2.0 max. microseconds and duty factor is 0.0002 max. The voltage-pulse amplitude is 200 volts peak. After 1 minute at this value, the current-pulse amplitude will not be less than the value specified.

Note 5: Under conditions with tube at 20° to 30° C for at least 30 minutes without any voltages applied to the tube. The resistance between any two electrodes is measured with a 200-volt Megger-type ohmmeter, or equivalent, having an internal impedance of 1.0 megohm.

Note 6: In a CW grid-driven, conduction-cooled amplifier circuit at 470 Mc and for conditions: dc plate voltage of 700 volts, grid-No.1 voltage of -28 to -32 volts, driven power output of 5 watts, and grid-No.2 voltage varied to obtain a plate current of 300 ma.

Note 7: With dc plate voltage of 2000 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage varied to obtain a plate current of 5 ma.

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[a] Because the cathode is subjected to back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should, for optimum life, be reduced to a value such that at the heater voltage obtained at minimum supply voltage conditions (all other voltages constant) the tube performance just starts to show some degradation; e.g., at 470 Mc, heater volts = 12.5 (Approx.).

[b] Measured with special shield adapter.

[c] The maximum rating for a signal having a minimum peak-to-average power ratio less than 2, such as is obtained in "Single-Tone" operation, is 300 ma. During short periods of circuit adjustment under "Single-Tone" conditions, the average plate current may be as high as 450 ma.

[d] Maximum plate dissipation is limited by the maximum plate core temperature and the cooling system to maintain tube operation below the specified maximum plate core temperature. With simple low-cost cooling techniques, maximum plate dissipation may be only about 100 watts; with more sophisticated cooling techinques, maximum plate dissipation may be as high as 300 watts.

[e] Obtained preferably from a separate well-regulated source.

[f] This value represents the approximate grid-No.1 current obtained due to initial electron velocities and contact-potential effects when grid No.1 is driven to zero volts at maximum signal.

[g] Driver power output represents circuit losses and is the actual power measured at input to grid-No.1 circuit. The actual power required depends on the operating frequency and the circuit used. The tube driving power is approximately zero watts.

[h] Referenced to either of the two tones, and without the use of feedback to enhance linearity.

[j] This value of useful power is measured at load of output circuit.

[k] The tube should see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes.

[m] Driver power output includes circuit losses and is the actual power measured at the input to the grid circuit. It will vary depending upon the frequency of operation and the circuit used.

[n] Obtained preferably from a separate source modulated along with the plate supply.

[p] Obtained from grid-No.1 resistor or from a combination of grid-No.1 resistor with either fixed supply or cathode resistor.

DEFINITIONS

CCS — Continuous Commercial Service.

Rating System — The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices:

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

Two-Tone Modulation — Two-Tone Modulation operation refers to that class of amplifier service in which the input consists of two monofrequency rf signals having equal peak amplitude.

GENERAL CONSIDERATIONS

Temperature

The maximum terminal temperature of 250° C and the maximum plate core temperature of 250° C are tube ratings and are to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W.22nd Street, New York 11, N.Y.

Mounting

The 8072 may be mounted by a variety of techniques; however, the frequency of operation and the heat sink to be used will narrow the selection. The base socket, finger-stock grid-No.2 ring (if used), or plate-conduction clamp used in the tube mounting may be fixed. The remaining connector (s) must be adjustable in a plane normal to the major tube axis to compensate for variations in concentricity for the associated parts of the tube.

STRUCTURAL ARRANGEMENT

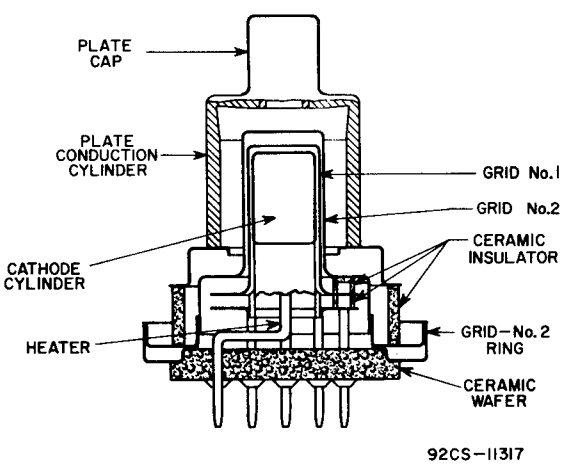

Fig. 1

The plate cap is primarily a protective covering for the exhaust tip-off but may be used as the plate terminal by using a flexible cap connector; it may not be clamped, nor form a portion of the cooling system.

ELECTRICAL CONSIDERATIONS

Grid No.1

Grid No.1 of the 8072 in uhf service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid current, but also by radiation from the cathode circulating rf currents. For these reasons, more than ordinary care must be taken during operation to prevent exceeding the grid-No.1 current rating and the maximum grid-No.1 terminal temperature rating.

Grid No.2

The grid-No.2 current of the 8072 may be negative under certain operating conditions. The voltage for grid No.2 should be obtained from a source of good regulation; if a separate source is used, a maximum impedance of 10,000 ohms and a minimum divider current of 40 milliamperes are required; if a voltage divider from the plate supply is used, a maximum impedance of 10,000 ohms between the grid-No.2 and ground is required. The plate voltage should be applied before or simultaneously with grid-No.2 voltage; otherwise, with voltage on grid-No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation.

The grid-No.2 current is a very sensitive indication of plate-circuit loading. When the 8072 is operated without load, the grid-No.2 current rises excessively, often to a value which damages the tube. Therefore, care should be taken when tuning the 8072 circuit under no-load or lightly loaded conditions to prevent exceeding the grid-No.2 input rating of the tube. In this connection, reduction of the grid-No.2 voltage will be helpful.

Plate

In tubes, such as the 8072, having very closely spaced electrodes, extremely high voltage gradients occur even with moderate tube operating voltages. Any tube flash-arcing may be destructive. It is recommended that each tube see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes. Failure of the tubes due to internal flashing is more prevalent when the circuit is not tuned to optimum conditions. Even though laboratory tests indicate that no such protection is needed, poor circuit adjustment in the field may result in shortened tube life.

Driver

The driver power output shown in the typical operation of the 8072 in rf service is considerably more than is normally calculated for typical driving power input in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuits and the coupling circuits. This consideration is particularly important at the higher frequencies where circuit losses, radiation losses, and transit-time losses increase, and the effects of cathode-lead inductive reactance becomes significant.

Cathode-Drive Circuits

In cathode-drive circuits, driver power output and the developed rf power output act in series to supply the load circuit. If the driving voltage and grid-No.1 current are increased, the output will always increase. Such is not the case in a grid-drive circuit where a saturation effect takes place, i.e., above a certain value of driving voltage and current, the output increases very slowly and may even decrease. It is important to recognize this difference and not to try to saturate a cathode-drive stage because the maximum grid-No.2 input may easily be exceeded.

TYPICAL PLATE CHARACTERISTICS

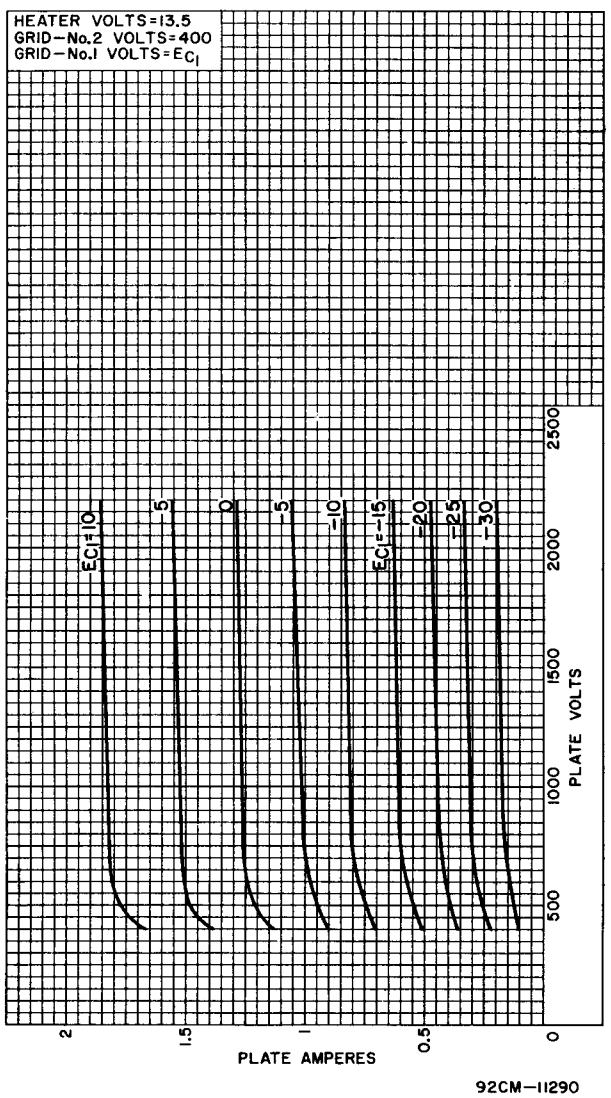

Fig. 2

In tuning a cathode-drive rf amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

Class C RF Telegraphy Service

In class C rf telegraphy service, the 8072 may be supplied with bias by any convenient method except when the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying. In this case, an amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value.

Standby Operation

During standby periods in intermittent operation, the heater voltage may be maintained at normal operating value for most applications.

TYPICAL CHARACTERISTICS

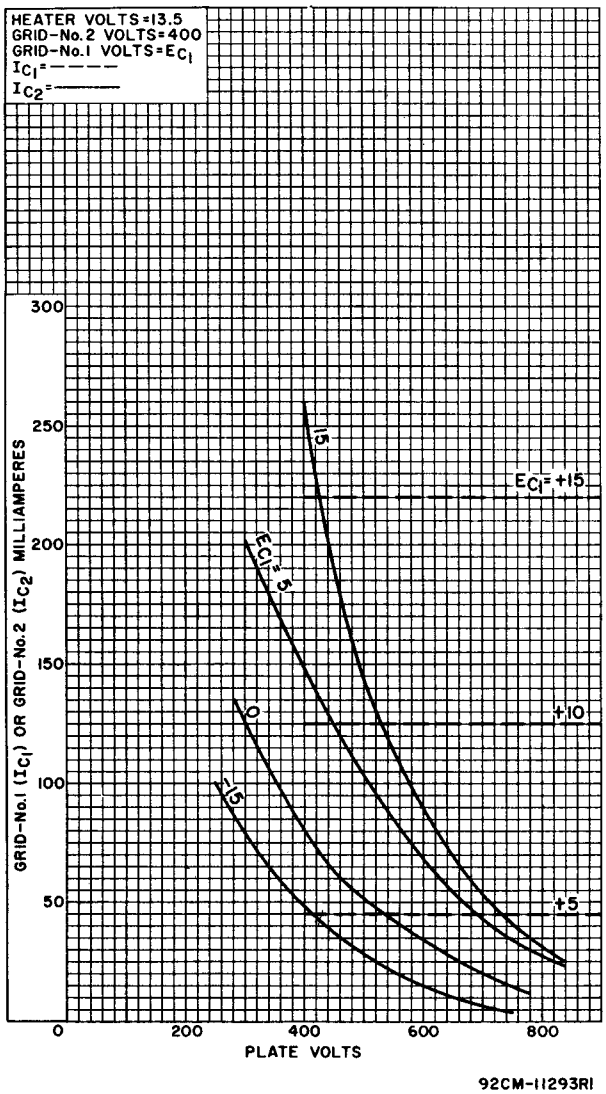

Fig. 3

In those applications which require maximum reliability, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; that it be reduced to 80 per cent of normal when the period is between 15 minutes and 2 hours; and that for longer periods, the heater voltage should be turned off.

Protective Devices

Protective devices should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the dc plate and grid-No.2 voltage when the average value of plate current reaches a value slightly higher than normal plate current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

CONSTANT-CURRENT CHARACTERISTICS

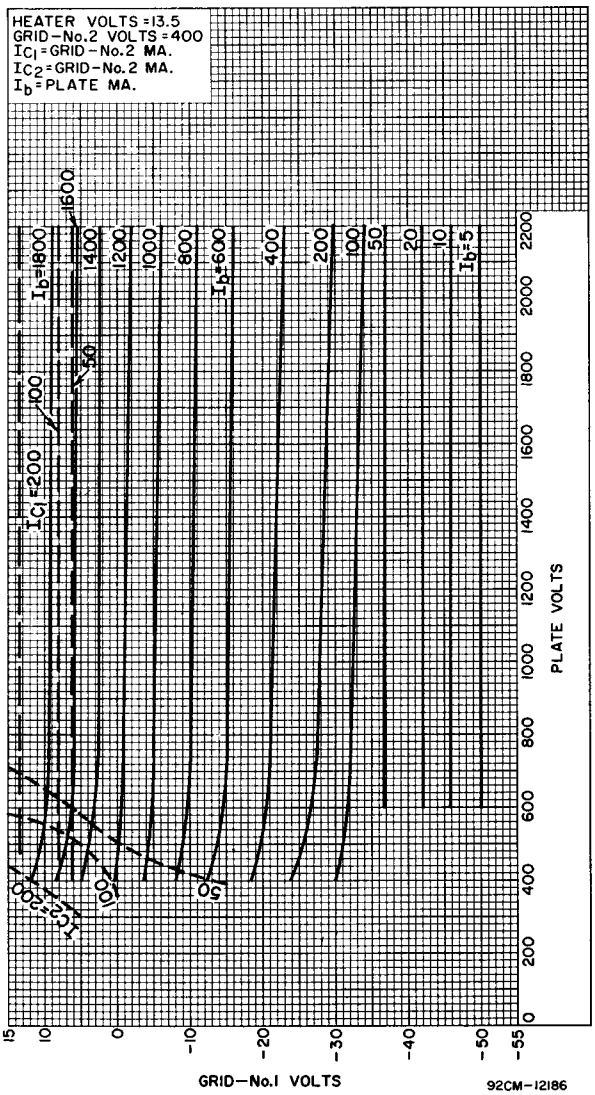

Fig.4

Precautions

The rated plate and grid-No.2 voltages of this tube are extremely dangerous. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

COOLING CONSIDERATIONS

System

The conduction-cooling system consists, in general, of a constant temperature device (heat sink) and suitable heat-flow path (coupling) between the heat sink and tube. Primary consideration of the system should be given to the design of a heat-flow path (coupling device) with high thermal conductivity.

Thermal conductivity is defined as the time rate of transfer of heat by conduction, through unit thickness, across unit area for unit difference of temperature. It is measured in watts per square inch for a thickness of one inch and a difference of temperature of 1° C (See *Table of Conversion Factors for Thermal Conductivity*) as shown in the following equation:

$$K = \frac{W}{A\,\frac{(T_2 - T_1)}{L}} \qquad (1)$$

where;

K = thermal conductivity of the material

W = power transfer in watts

A = area measured at right angles to the direction of the flow of heat in square inches

T_1, T_2 = temperature in degrees Centigrade of planes or surfaces under consideration

L = length of heat path in inches through coupling material to produce temperature gradient

For a given system Equation (1) must be integrated to consider changes in area (A) dependent on the coupling configuration and changes in thermal conductivity (k) dependent on various coupling materials and interfaces. Equation (1) may now be reduced to the following:

$$K_s = \frac{W_p}{T_2 - T_1} \qquad (2)$$

where;

K_s = thermal conductance of the system

W_p = maximum permissible plate dissipation in watts

T_2 = temperature in degrees Centigrade at tube terminal

Note: *This value may never exceed the specified maximum rating for terminal temperature.*

T_1 = temperature in degrees Centigrade of heat sink

Heat Sink

The heat sink should be designed to act as a constant-temperature device; that is, to prevent any increase in temperature by dissipating the heat beyond the equipment compartment. Heat sinks can take the form of solids or liquids. In most applications such a heat sink is available in the form of equipment chassis, plate line, or output cavity. Mechanically, the equipment chassis is the most practical heat sink as shown in Reference 1. At uhf frequencies, coaxial elements, tuned lines or cavities become more feasible because of increasing rf losses across supports to equipment chassis.

Coupling

There are numerous insulating materials available to serve as the heat-coupling device such as beryllium oxide (beryllia), high-aluminum oxide (high alumina), mica and other insulating bodies. The thermal conductivity of these insulators varies considerably. The choice of insulator will then be dependent primarily on the plate dissipation in the given application. As shown in Fig.6, beryllia has much higher thermal conductivity than its nearest competitor, high alumina.

Beryllia provides the unique properties required for coupling the tube to the heat sink:

TYPICAL PLATE CHARACTERISTICS

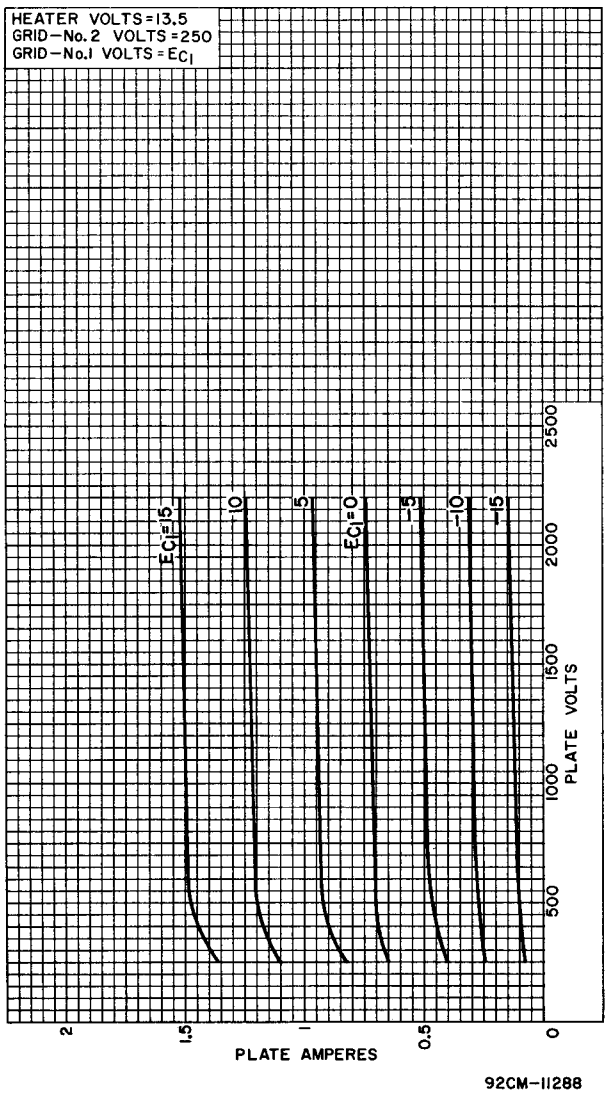

Fig.5

TYPICAL CHARACTERISTICS

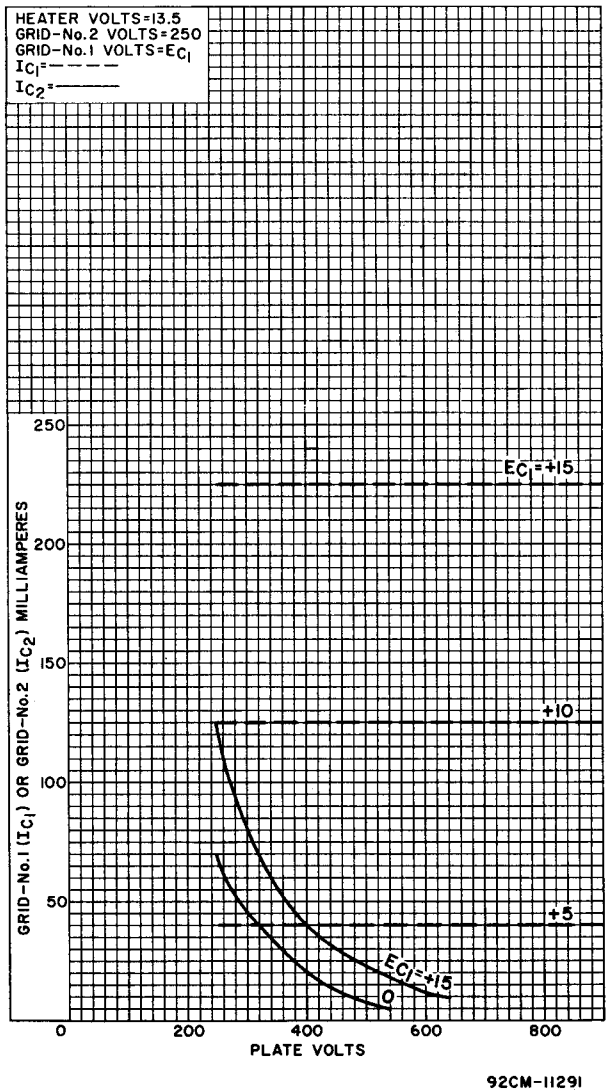

Fig.6

low electric conductivity (volume resistivity-10^{16} ohm-cm) and high thermal conductivity (2.9 watts/in^2 - °C at 200° C).

Precaution: Beryllia dust and fumes are highly toxic to mucous membrane and may cause serious ulcers when imbedded under the skin. See References 2,3, and 4.

At low frequencies the inductive element of the plate circuit is usually a relatively long coil which does not provide a good thermal path from anode to chassis. The shunt capacity is large, however, and heat can be conducted through

a portion of it to the chassis. At high frequencies the shunt capacity of the plate circuit is limited but the inductive element is short and can be made with sufficient cross-sectional area to form an excellent thermal path.

Conduction Properties of the Tube

The cylindrical plate terminal is nickel-plated copper with high thermal conductivity to conduct the heat of plate dissipation to the surface of the plate terminal. The cooling system for a given application should be designed to dissipate the heat from the tube. The matching coupler to the tube should have a surface to provide intimate thermal contact with the plate terminal. See Reference 7.

It may also be necessary to couple grid No.2, grid No.1, cathode, and heater terminals to the heat sink. In all cases it is necessary to maintain all terminals at a temperature under the maximum temperature of 250° C. *Tube life can be increased by maintaining all terminal temperatures substantially below the maximum temperature rating.*

CONSTANT-CURRENT CHARACTERISTICS

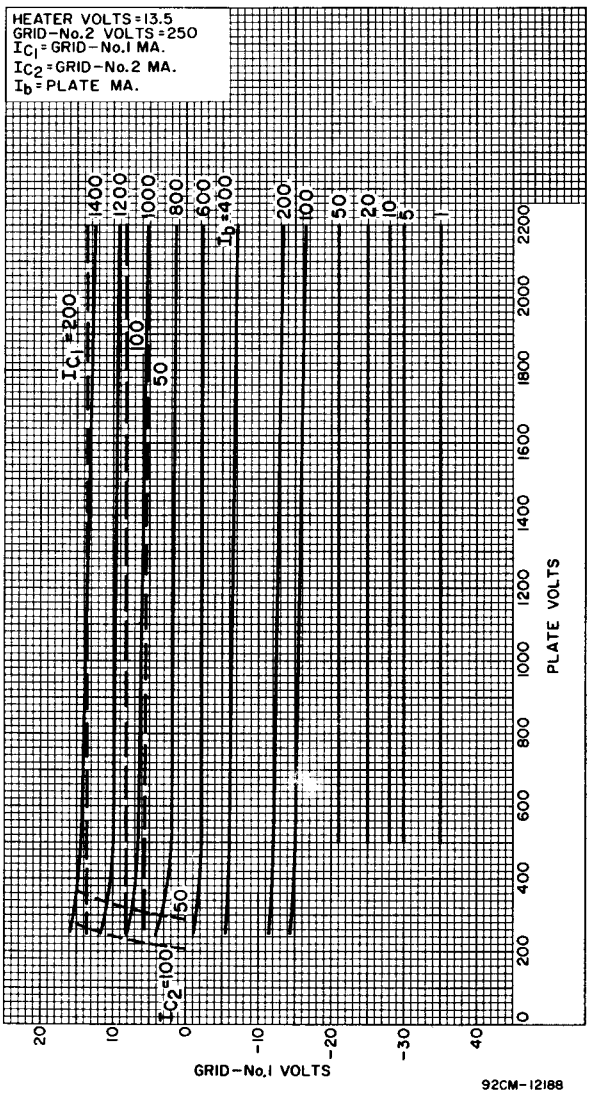

Fig. 7

CONSTANT-CURRENT CHARACTERISTICS

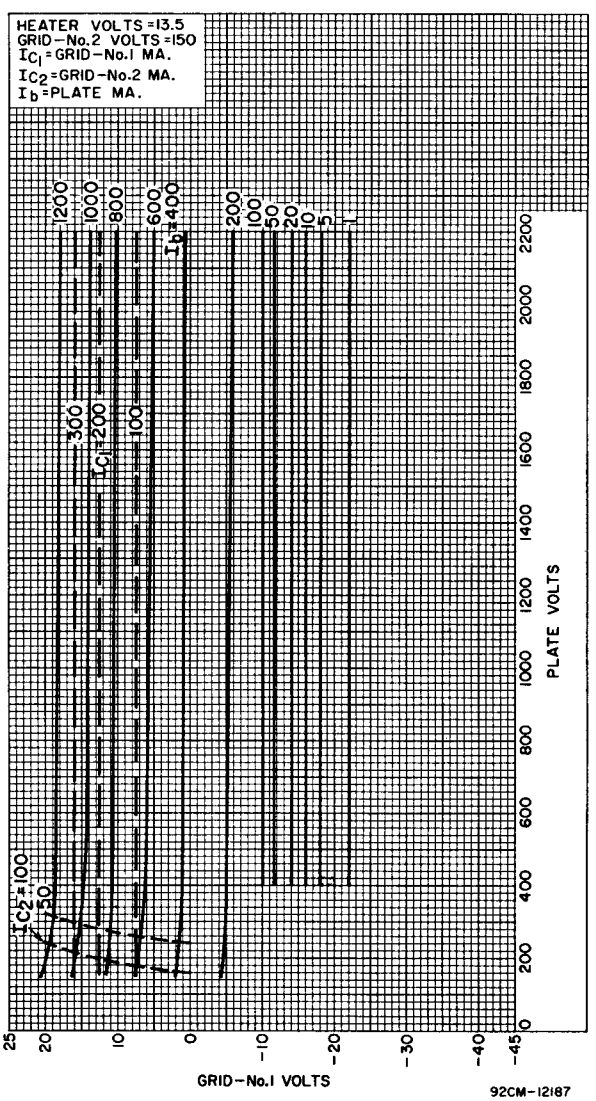

Fig. 8

HEAT-TRANSFER CHARACTERISTICS OF VARIOUS MATERIALS

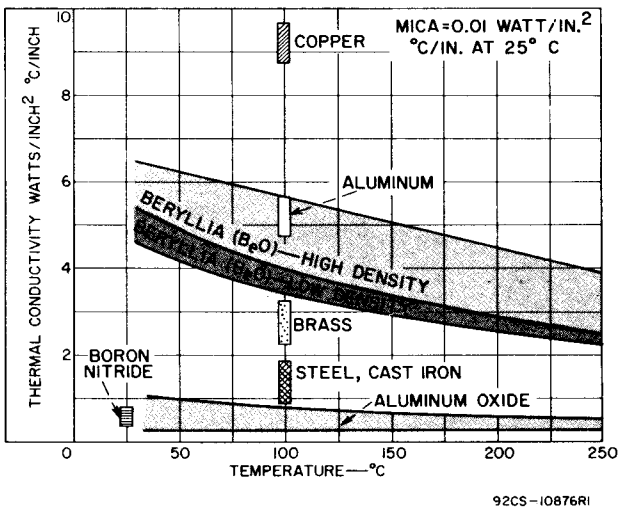

Fig. 9

TYPICAL PLATE CHARACTERISTICS

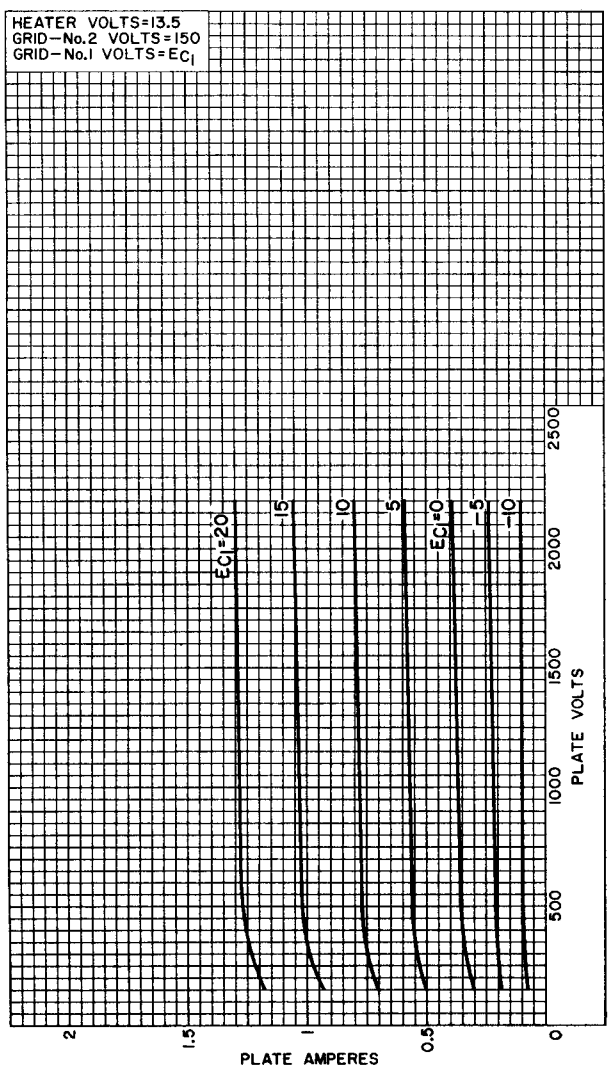

Fig. 10

TYPICAL CHARACTERISTICS

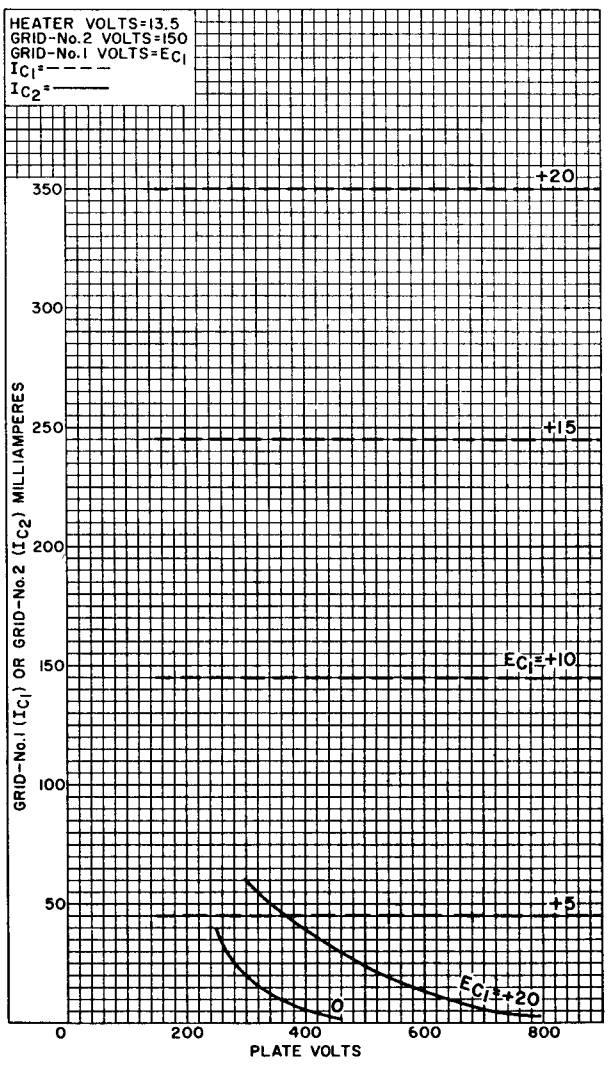

Fig. 11

TABLE OF CONVERSION FACTORS FOR THERMAL CONDUCTIVITY

Multiply	by	To Get
B.T.U./(sq ft)(hr)(^{o}F/ft)	.0440	watts/(sq in)(^{o}C/in)
B.T.U./(sq ft)(hr)(^{o}F/in)	.00367	watts/(sq in)(^{o}C/in)
calories/(sq cm)(sec)(^{o}C/cm)	10.66	watts/(sq in)(^{o}C/in)
watts/(sq cm)(^{o}C/cm)	2.54	watts/(sq in)(^{o}C/in)

REFERENCES

1. J.E. Brosz and R.H. Decker, *"Beryllia Aids Equipment Cooling"*, Electronic Equipment Engineering, Jan. 1960.
2. D.W. White, Jr. and J.E. Burke, *"The Metal Beryllium"* (book), published by the American Society for Metals, Cleveland, Ohio.
3. Donald P. O'Neil, *"Toxic Materials Machined Safely"*, American Machinist, June 4, 1955.
4. Sidney Laskin, Robert A.N. Turner, and Herbert E. Stockinger, *"Analysis of Dust and Fume Hazards in a Beryllium Plant"*, U.S. Atomic Energy Commission, MDDC-1355.
5. James J. Gangler, *"Some Physical Properties of Eight Refractory Oxides and Carbides"*, American Ceramic Society Journal, Vol.33, December 1950.
6. W.D. Kingery, J. Francl, R.L. Coble, and T. Vasilos, *"Thermal Conductivity X -- Data for Several Pure Oxide Materials Corrected to Zero Porosity"*, American Ceramic Society Journal, Vol.37, February 1954.
7. Graff, *"Thermal Conductance Across Metal Joints"*, Machine Design, September 15, 1960.
8. John W. Gaylord, *"Conduction Cooling of Power Tubes in Vehicular Communication Equipment"*, IEEE, PTGVC Transactions, Vol.12, September 1963.

BERYLLIA PRODUCTS MAY BE OBTAINED FROM THE FOLLOWING REPRESENTATIVE LIST OF SUPPLIERS:

National Beryllia Corp.
First & Haskell Aves.
Haskell, N.J.

Brush Beryllium Corp.
5209 Euclid Ave.
Cleveland 3, Ohio

The Beryllium Corp. of America
P.O. Box 1462
Reading, Pennsylvania

Frenchtown Porcelain Co.
Eighth & Harrison Sts.
Frenchtown, New Jersey

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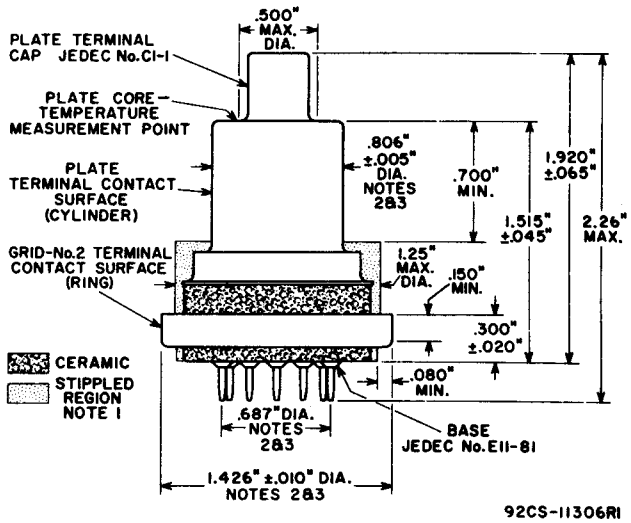
DIMENSIONAL OUTLINE



NOTE 1: KEEP ALL STIPPLED REGIONS CLEAR. DO NOT ALLOW CONTACTS OR CIRCUIT COMPONENTS TO PROTRUDE INTO THESE ANNULAR VOLUMES.

NOTE 2: THE DIAMETERS OF THE PLATE TERMINAL CONTACT SURFACE, GRID-No.2 TERMINAL CONTACT SURFACE, AND PIN CIRCLE TO BE CONCENTRIC WITHIN THE FOLLOWING VALUES OF MAXIMUM FULL INDICATOR READING:

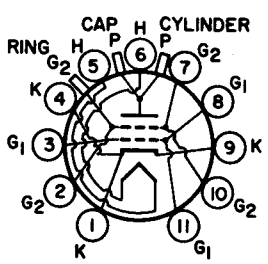
Plate Terminal Contact Surface to Grid-No.2 Terminal Contact Surface.	0.030"
Plate Terminal Contact Surface to Pin Circle	0.040"
Grid-No.2 Terminal Contact Surface to Pin Circle	0.030"

NOTE 3: THE FULL INDICATOR READING IS THE MAXIMUM DEVIATION IN RADIAL POSITION OF A SURFACE WHEN THE TUBE IS COMPLETELY ROTATED ABOUT THE CENTER OF THE REFERENCE SURFACE. IT IS A MEASURE OF THE TOTAL EFFECT OF RUN-OUT AND ELLIPTICITY.

BASING DIAGRAM

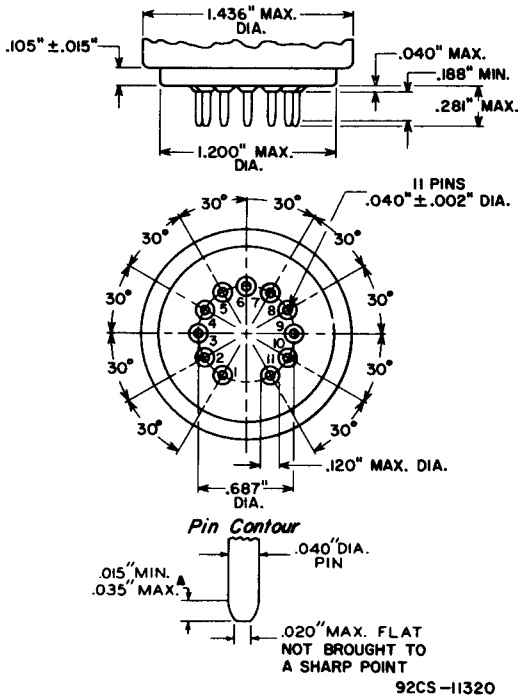
Bottom View

Pin 1 – Cathode
Pin 2 – Grid No.2
Pin 3 – Grid No.1
Pin 4 – Cathode
Pin 5 – Heater
Pin 6 – Heater
Pin 7 – Grid No.2
Pin 8 – Grid No.1
Pin 9 – Cathode



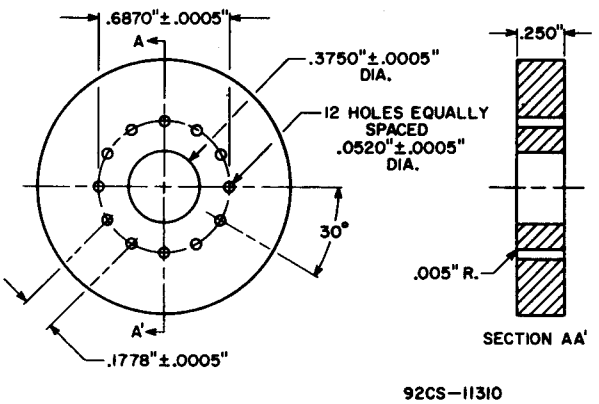
Pin 10 – Grid No.2
Pin 11 – Grid No.1
Cap – Plate Terminal Connection
Cylinder – Plate Terminal Contact Surface (To contact to conduction-cooling system)
Ring – Grid-No.2 Terminal Contact Surface (For use at higher frequencies)

BASE DRAWING
LARGE-WAFER ELEVENAR
11-PIN WITH RING
JEDEC No.E11-81



* THIS DIMENSION AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN MAY VARY WITHIN THE LIMITS SHOWN.

GAUGE DRAWING
JEDEC No.GE11-1



8077/7054

POWER PENTODE

For Use in Mobile Communications Equipment Operating from 6-Cell Storage-Battery Systems

9-Pin Miniature Type

RCA-8077/7054 is a power pentode of the 9-pin miniature type intended to provide reliable service in mobile communications equipment operating from 6-cell storage battery systems. It is like the 7054 except that it has a shorter bulb for compact equipment designs. In such equipment, the 8077/7054 is particularly useful in class C radio-frequency power amplifier, oscillator, and frequency-multiplier service at frequencies up to 40 Mc. It may also be used in modulator and audio-frequency power amplifier applications.

The heater of this tube is designed to operate over a voltage range of 12 to 15 volts and will take momentary excursions from 11 to 16 volts. The heater design insures dependable performance in mobile equipment under operating conditions encountered during battery charging and discharging.

During manufacture, the 8077/7054 is subjected to rigid controls and rigorous tests for heater-cathode leakage, interelectrode leakage, intermittent shorts, heater-cycling, low frequency vibration performance, and 500-hour intermittent life performance.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage Range (AC or DC)	12 to 15	volts
Current (Approx.) at 13.5 volts	0.275	amp
Direct Interelectrode Capacitances (Approx., without external shield):		
Grid No.1 to plate	0.063	μμf
Grid No.1 to all other electrodes except plate	10.2	μμf
Plate to all other electrodes except grid No.1	3.5	μμf

Characteristics, Class A_1 Amplifier:

Heater Voltage	13.5	volts
Plate Supply Voltage	250	volts
Grid No.3	Connected to cathode at socket	
Grid-No.2 Voltage	150	volts
Cathode Resistor	120	ohms
Plate Resistance (Approx.)	0.1	megohm
Transconductance	11500	μmhos
Plate Current	19	ma
Grid-No.2 Current	3.5	ma
Grid-No.1 Voltage (Approx.) for plate current of 20 μa	-10	volts

Mechanical:

Operating Position	Any
Maximum Overall Length	2-3/16"
Maximum Seated Length	1-15/16"
Length, Base Seat to Bulb Top (Excluding tip)	1-9/16" ± 3/32"
Diameter	0.750" to 0.875"
Bulb	T6-1/2
Base	Small-Button Noval 9-Pin (JEDEC No.E9-1)

AMPLIFIER — Class A_1

Maximum Ratings, *Absolute-Maximum Values:*

PLATE VOLTAGE	330 max.	volts
GRID-No.3 (SUPPRESSOR-GRID) VOLTAGE	0 max.	volts
GRID-No.2 (SCREEN-GRID) VOLTAGE	180 max.	volts
GRID-No.1 (CONTROL-GRID) VOLTAGE:		
Positive-bias value	0 max.	volts
Negative-bias value	55 max.	volts
GRID-No.2 INPUT	1 max.	watt
PLATE DISSIPATION	5 max.	watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	120 max.	volts
Heater positive with respect to cathode	120 max.	volts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance:		
For fixed-bias operation	0.1 max.	megohm
For cathode-bias operation	0.25 max.	megohm

RF POWER AMPLIFIER & OSCILLATOR — Class C Telegraphy[a]

and

RF POWER AMPLIFIER — Class C FM Telephony

Maximum CCS[b] Ratings, *Absolute-Maximum Values:*

DC PLATE VOLTAGE	300 max.	volts
DC GRID-No.3 (SUPPRESSOR-GRID) VOLTAGE	0 max.	volts
DC GRID-No.2 (SCREEN-GRID) VOLTAGE	175 max.	volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE	-50 max.	volts
DC PLATE CURRENT	33 max.	ma
DC GRID-No.2 CURRENT	5.5 max.	ma
DC GRID-No.1 CURRENT	3 max.	ma
GRID-No.2 INPUT	1 max.	watt
PLATE DISSIPATION	5 max.	watts

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Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

8077/7054 10-61
Printed in U.S.A.

PEAK HEATER-CATHODE VOLTAGE:				
Heater negative with respect to cathode		120 max.		volts
Heater positive with respect to cathode		120 max.		volts
Typical Operation at Frequencies up to 40 Mc:				
Heater Voltage	13.5	13.5	13.5	volts
DC Plate Voltage	200	250	300	volts
Grid No.3	Connected to cathode at socket			
DC Grid-No.2 Voltage	115	145	175	volts
DC Grid-No.1 Voltage	−7	−9	−12	volts
Peak RF Grid-No.1 Voltage	9	11	16	volts
DC Plate Current	14.5	20	26	ma
DC Grid-No.2 Current	3	4.1	5.5	ma
DC Grid-No.1 Current (Approx.)	0.6	0.85	1	ma
Driving Power (Approx.)	10	12	15	mw
Power Output (Approx.)	1.5	2.7	4	watts
Maximum Circuit Values:				
Grid-No.1-Circuit Resistance		0.1 max.		megohm

FREQUENCY MULTIPLIER

Maximum CCS[b] Ratings, *Absolute-Maximum Values:*				
DC PLATE VOLTAGE		300 max.		volts
DC GRID-No.3 (SUPPRESSOR-GRID) VOLTAGE		0 max.		volts
DC GRID-No.2 (SCREEN-GRID) VOLTAGE		175 max.		volts
DC GRID-No.1 (CONTROL-GRID) VOLTAGE		−50 max.		volts
DC PLATE CURRENT		33 max.		ma
DC GRID-No.2 CURRENT		5.5 max.		ma
DC GRID-No.1 CURRENT		3 max.		ma
GRID-No.2 INPUT		1 max.		watt
PLATE DISSIPATION		5 max.		watts
PEAK HEATER-CATHODE VOLTAGE:				
Heater negative with respect to cathode		120 max.		volts
Heater positive with respect to cathode		120 max.		volts
Typical Operation as Doubler to 40 Mc:				
DC Plate Voltage	200	250	300	volts
Grid No.3	Connected to cathode at socket			
DC Grid-No.2 Voltage	115	145	175	volts
DC Grid-No.1 Voltage	−16	−20	−25	volts
Peak RF Grid-No.1 Voltage	19	24	31	volts
DC Plate Current	11	15	20	ma
DC Grid-No.2 Current	2	3	4	ma
DC Grid-No.1 Current (Approx.)	0.3	0.45	0.6	ma
Driving Power (Approx.)	5	9	13	mw
Useful Power Output (Approx.)	1.4	1.9	2.5	watts
Maximum Circuit Values:				
Grid-No.1-Circuit Resistance		0.1 max.		megohm

[a] Key-down conditions per tube without amplitude modulation. Amplitude modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

[b] Continuous Commercial Service.

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.260	0.290	amp
Transconductance	1,2	8500	14500	μmhos
Plate Current	1,3	13	25	ma
Grid-No.2 Current	1,3	2	5	ma
Reverse Grid-No.1 Current	1,4	−	1.5	μa
Heater-Cathode Leakage Current:				
Heater negative with respect to cathode	1,5	−	20	μa
Heater positive with respect to cathode	1,5	−	20	μa
Leakage Resistance:				
Between grid and all other electrodes tied together	1,6	50	−	megohms
Between plate and all other electrodes tied together	1,7	50	−	megohms

Note 1: With 13.5 volts ac or dc on heater.

Note 2: With dc plate-supply voltage of 250 volts, grid-No.2 supply voltage of 150 volts, grid No.3 connected to cathode at socket, cathode resistor of 120 ohms, and cathode-bypass capacitor of 1000 μf.

Note 3: With dc plate-supply voltage of 250 volts, grid-No.2 voltage of 150 volts, grid No.3 connected to cathode at socket, and cathode resistor of 120 ohms.

Note 4: With dc plate-supply voltage of 250 volts, grid-No.2 voltage of 150 volts, grid No.3 connected to cathode at socket, cathode resistor of 120 ohms, and grid-No.1 resistor of 1 megohm.

Note 5: With 100 volts dc between heater and cathode.

Note 6: With grid No.1 100 volts negative with respect to all other electrodes tied together.

Note 7: With plate 300 volts negative with respect to all other electrodes tied together.

SPECIAL RATINGS AND PERFORMANCE DATA

Heater-Cycling Life Performance:

This test is performed on a sample lot of tubes from each production run. Tubes will withstand a minimum of 2000 cycles of intermittent operation under the following conditions: Heater voltage of 17 volts cycled one minute on-two minutes off, heater 135 negative with respect to cathode, and all other elements connected to ground. At the end of this test, tubes are checked for heater-cathode shorts and open circuits.

Low-Frequency Vibration Performance:

This test is performed on a sample lot of tubes from each production run under the following conditions: Heater voltage of 13.5 volts, plate-supply voltage of 250 volts, grid No.3 connected to cathode, grid-No.2 supply voltage of 150 volts, cathode resistor of 120 ohms, cathode-bypass capacitor of 1000 μf, plate load resistor of 2000 ohms, and vibrational acceleration of 2.5 g at 25 cps. In this test, the rms output voltage must not exceed 150 millivolts.

500-Hour Intermittent Life Performance:

This test is performed on a sample lot of tubes from each production run to insure high quality of the individual tube and to guard against epidemic failures. Life testing is conducted under the following conditions: Heater voltage of 15 volts and maximum-rated plate dissipation and grid-No.2 input.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices:

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life

no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

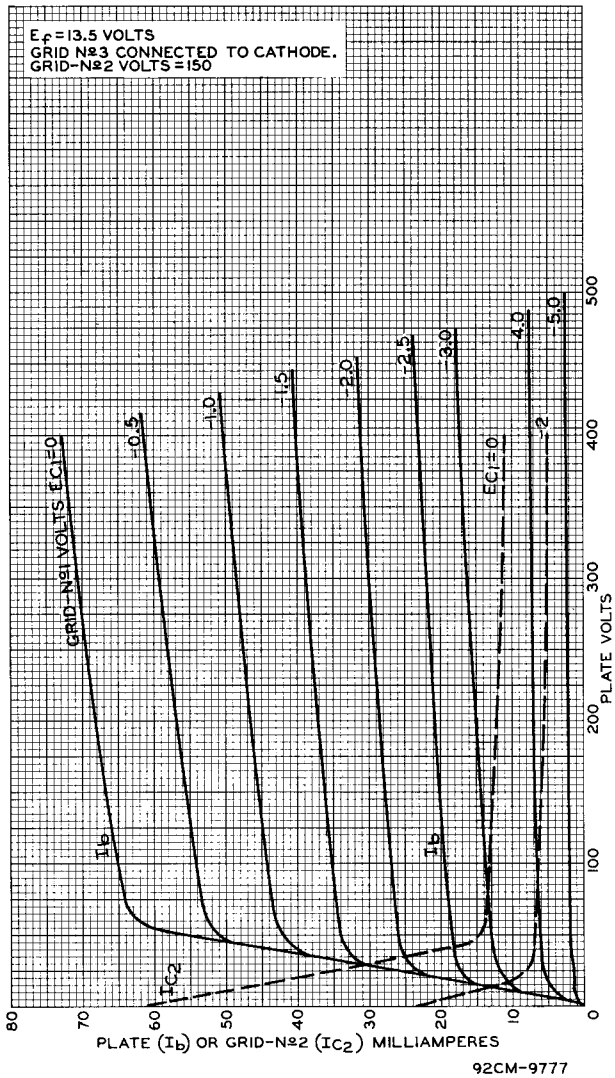

Fig. 1 - Average Characteristics of Type 8077/7054.

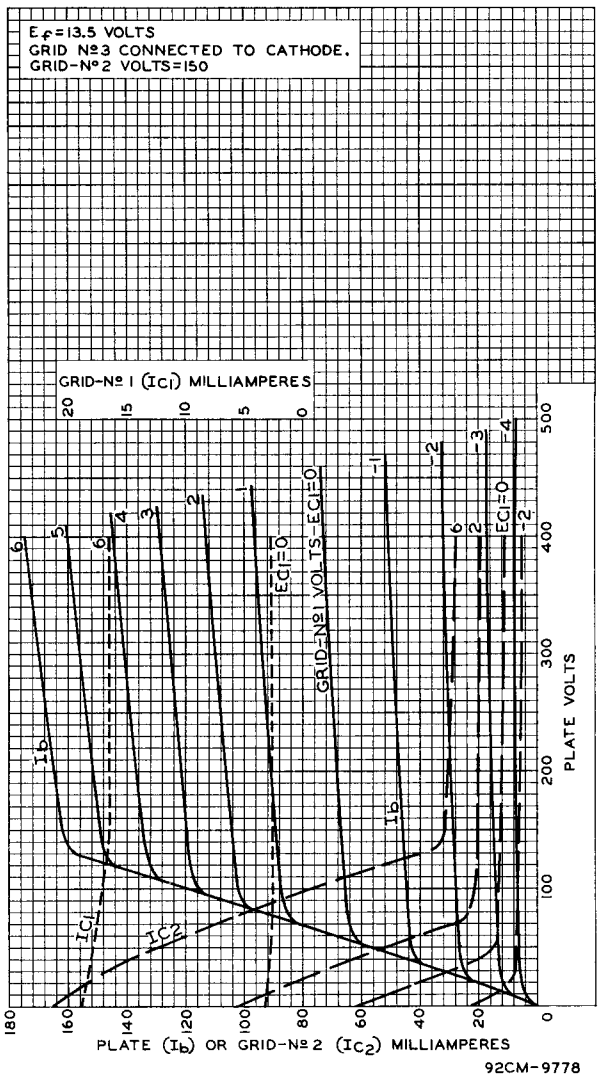

Fig. 2 - Average Characteristics of Type 8077/7054.

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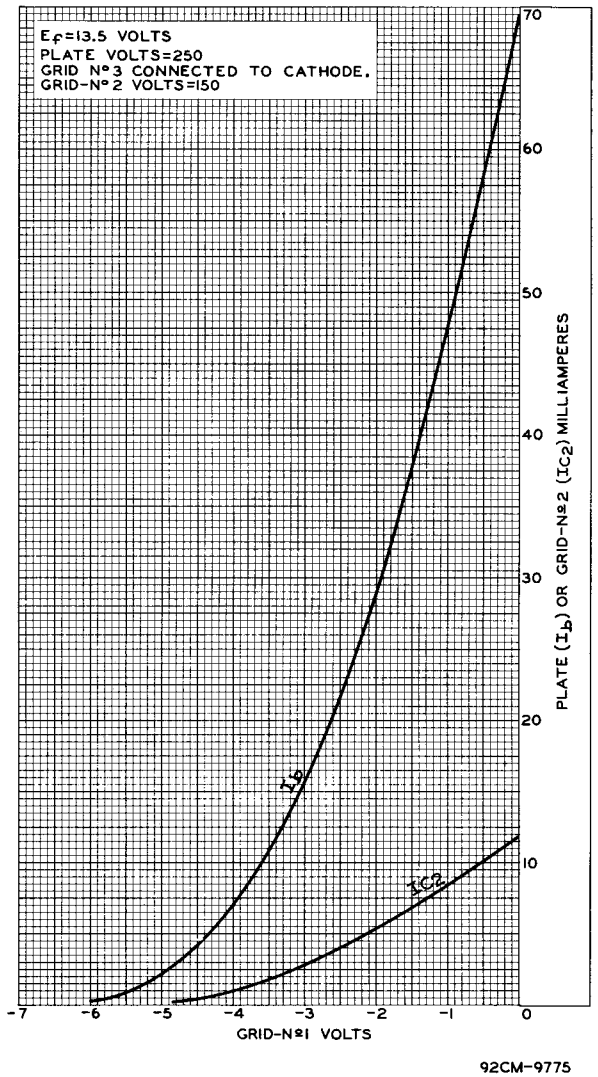


Fig. 3 - Average Characteristics of Type 8077/7054.

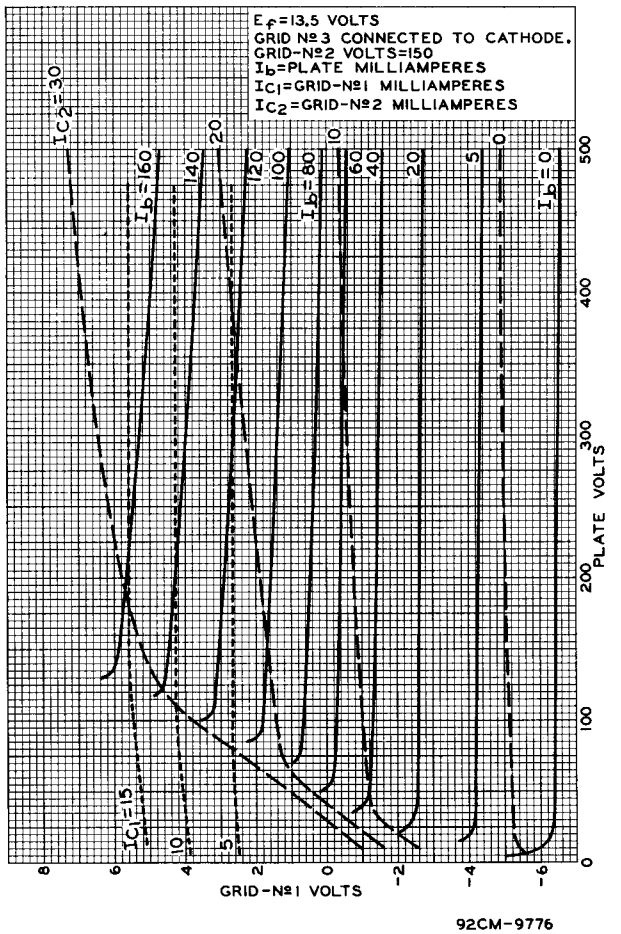
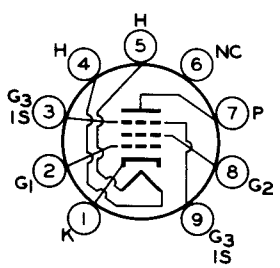


Fig. 4 - Average Constant-Current Characteristics of Type 8077/7054.

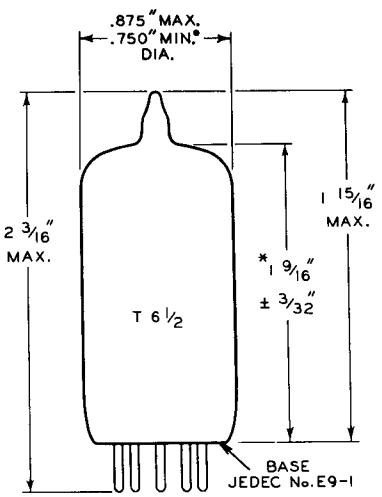
BASING DIAGRAM
Bottom View



9GK

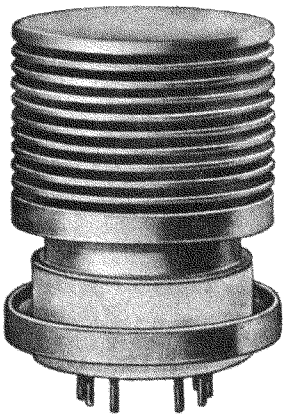
PIN 1 – CATHODE
PIN 2 – GRID No.1
PIN 3 – GRID No.3, INTERNAL SHIELD
PIN 4 – HEATER
PIN 5 – HEATER
PIN 6 – NO CONNECTION
PIN 7 – PLATE
PIN 8 – GRID No.2
PIN 9 – GRID No.3, INTERNAL SHIELD

DIMENSIONAL OUTLINE



● APPLIES IN ZONE STARTING 0.375" FROM BASE SEAT.

* MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.



Actual Size

8121

BEAM POWER TUBE

2.20" Max. Length
1.475" Max. Diameter
Integral Radiator

Full Ratings up to 500 Mc
Forced-Air Cooled
170 Watts PEP Output at 30 Mc
235 Watts CW Output at 470 Mc

Coaxial-Electrode Structure
Ceramic-Metal Seals
Unipotential Cathode

RCA-8121 is a very small, low-cost, forced-air-cooled beam power tube designed for use as an rf power amplifier, oscillator, regulator, distributed amplifier, or linear rf power amplifier in mobile or fixed equipment.

Because of its high power sensitivity and high efficiency, the 8121 can be operated with relatively low plate voltage to give large power output with small driving power. In CW operation with a plate voltage of 1500 volts, the 8121 can provide useful power outputs of 235 watts up to 500 Mc.

The specially designed radiator makes possible a simplified arrangement for the air to flow in a transverse direction to the major axis of the radiator permitting a maximum plate dissipation of 150 watts.

The 8121 features a light-weight, cantilever-supported cylindrical electrode structure within a ceramic-metal envelope. This construction provides a very sturdy tube and permits high-temperature operation.

The terminal arrangement of the 8121 facilitates use of the tube with tank circuits of the coaxial or strip-line type. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the low-inductance ring terminal for grid No.2. A base-pin termination for grid No.2 is also available for operation of the 8121 at the lower frequencies.

The tripod arrangement of both the cathode and the grid-No.1 leads not only simplifies construction, but enhances electrical characteristics. The three cathode leads reduce the inductance path to rf ground and reduce the input admittance at high frequencies. One of the cathode leads (preferably No.4 pin) may be series tuned to ground with a capacitor to provide broadband neutralization in the upper frequency range of the tube. The three grid-No.1 leads to separate pins accommodate a split-input circuit for distributed amplifier service.

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)[a]	13.5 ± 10%	volts
Current at 13.5 volts	1.3	amp
Minimum heating time	60	sec
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 450, grid-No.2 volts = 325, and plate amperes = 1.2	12	
Direct Interelectrode Capacitances:[b]		
Grid No.1 to plate	0.13 max.	pf
Grid No.1 to cathode	16	pf
Plate to cathode	0.011	pf
Grid No.1 to grid No.2	22	pf
Grid No.2 to plate	6.5	pf
Grid No.2 to cathode	3.2	pf
Cathode to heater	3.4	pf

Mechanical:

Operating Position	Any
Maximum Overall Length	2.196"
Seated Length	1.850" ± 0.065"
Greatest Diameter	1.460" ± 0.015"
Base—Large Wafer Elevenar 11-Pin with Ring (JEDEC No.E11-81)	
Socket	Mycalex* No.CP464-2, or equivalent
Weight (Approx.)	3 oz

Thermal:

Terminal Temperature (All Terminals)	250 max.	°C
Radiator Core Temperature (See *Dimensional Outline*)	250 max.	°C
Air Flow: See Fig.8 – *Typical Cooling Requirements for Type 8121.*		

LINEAR RF POWER AMPLIFIER
Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 Mc	
DC PLATE VOLTAGE	2200 max.	volts
DC GRID-No.2 VOLTAGE	400 max.	volts

* Mycalex Corp. of America, 125 Clifton Blvd., Clifton, N.J.

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Marca(s) Registrada(s)

ELECTRON TUBE DIVISION
RADIO CORPORATION OF AMERICA, HARRISON, NEW JERSEY

8121 10-62
Printed in U.S.A.

DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE [c]	450	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
PLATE DISSIPATION	150	max.	watts
GRID No.2 DISSIPATION	8	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150	max.	volts
Heater positive with respect to cathode	150	max.	volts

Typical CCS Operation with "Two-Tone Modulation":

	At 30 Mc		
DC Plate Voltage	1000	1500	volts
DC Grid-No.2 Voltage [d]	250	250	volts
DC Grid-No.1 Voltage [d]	-20	-20	volts
Zero-Signal DC Plate Current	100	100	ma
Effective RF Load Resistance	2270	3800	ohms
DC Plate Current at Peak of Envelope	210	210	ma
Average DC Plate Current	160	160	ma
DC Grid-No.2 Current at Peak of Envelope	10	10	ma
Average DC Grid-No.2 Current	7	7	ma
Average DC Grid-No.1 Current	0.05 [e]	0.05 [e]	ma
Peak-Envelope Driver Power Output (Approx.) [f]	0.3	0.3	watt
Output-Circuit Efficiency (Approx.)	90	85	%
Distortion Products Level: [g]			
Third Order	35	35	db
Fifth Order	40	40	db
Useful Power Output (Approx.):			
Average	55 [h]	85 [h]	watts
Peak envelope	110 [h]	170 [h]	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:			
With fixed bias	25000	max.	ohms
With fixed bias (In Class AB_1 operation)	100000	max.	ohms
With cathode bias	Not recommended		
Grid-No.2 Circuit Impedance	10000	max.	ohms
Plate Circuit Impedance	See *Note j*		

RF POWER AMP. & OSCILLATOR — Class C Telegraphy and RF POWER AMPLIFIER — Class C FM Telephony

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 Mc		
DC PLATE VOLTAGE	2200	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT	300	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
GRID-No.2 DISSIPATION	8	max.	watts
PLATE DISSIPATION	150	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150	max.	volts
Heater positive with respect to cathode	150	max.	volts

Typical CCS Operation:

	In Grid-Drive Circuit at 50 Mc			
DC Plate Voltage	700	1000	1500	volts
DC Grid-No.2 Voltage	175	200	200	volts
DC Grid-No.1 Voltage	-10	-30	-30	volts
DC Plate Current	300	300	300	ma
DC Grid-No.2 Current	25	20	20	ma
DC Grid-No.1 Current	50	40	40	ma
Driver Power Output (Approx.) [k]	1.2	2.0	2.0	watts
Useful Power Output	120 [h]	175 [h]	275 [h]	watts
In Grid-Drive Circuit at 470 Mc				
DC Plate Voltage	700	1000	1500	volts
DC Grid-No.2 Voltage	200	200	200	volts
DC Grid-No.1 Voltage	-30	-30	-30	volts
DC Plate Current	300	300	300	ma
DC Grid-No.2 Current	10	10	5	ma
DC Grid-No.1 Current	30	30	30	ma
Driver Power Output (Approx.) [k]	5	5	5	watts
Useful Power Output	100 [m]	165 [m]	235 [m]	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:			
With fixed bias	25000	max.	ohms
Grid-No.2 Circuit Impedance	10000	max.	ohms
Plate Circuit Impedance	See *Note j*		

CHARACTERISTICS RANGE VALUES

	Note	*Min.*	*Max.*	
1. Heater Current	1	1.15	1.45	amp
2. Direct Interelectrode Capacitances:				
Grid-No.1 to plate	2	—	0.13	pf
Grid-No.1 to cathode	2	14.3	17.7	pf
Plate to cathode	2	0.0065	0.0155	pf
Grid-No.1 to grid-No.2	2	19.8	24.2	pf
Grid-No.2 to plate	2	5.7	7.1	pf
Grid-No.2 to cathode	2	2.6	3.6	pf
Cathode to heater	2	2.5	4.1	pf
3. Grid-No.1 Voltage	1,3	-8	-19	volts
4. Reverse Grid-No.1 Current	1,3	—	-25	μa
5. Grid-No.2 Current	1,3	-7	+6	ma
6. Peak Emission	1,4	13	—	peak amp
7. Interelectrode Leakage Resistance	5	1.0	—	megohm

Note 1: With 13.5 volts ac or dc on heater.

Note 2: Measured with special shield adapter.

Note 3: With dc plate voltage at 700 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage adjusted to give a dc plate current of 185 ma.

Note 4: For conditions with grid No.1, grid No.2, and plate tied together; and pulse voltage source connected between plate and cathode. Pulse duration is 2.5 microseconds and pulse repetition frequency is 60 pps. The voltage-pulse amplitude is 200 volts peak. After 1 minute at this value, the current-pulse amplitude will not be less than the value specified.

Note 5: Under conditions with tube at 20° to 30° C for at least 30 minutes without any voltages applied to the tube. The minimum resistance between any two electrodes as measured with a 200-volt Megger-type ohmmeter having an internal impedance of 1.0 megohm, will be 1.0 megohm.

[a] Because the cathode is subjected to back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should, for optimum life, be reduced to a value such that at the heater voltage obtained at minimum supply voltage conditions (all other voltages constant) the tube performance just starts to show some degradation; e.g., at 470 Mc, heater volts = 12.5 (Approx.).

[b] Measured with special shield adapter.

[c] The maximum rating for a signal having a minimum peak-to-average power ratio less than 2, such as is obtained in "Single-Tone" operation, is 300 ma. During short periods of circuit adjustment under "Single-Tone" conditions, the average plate current may be as high as 450 ma.

[d] Obtained preferably from a separate, well regulated source.

[e] This value represents the approximate grid-No.1 current obtained due to initial electron velocities and contact-potential effects when grid No.1 is driven to zero volts at maximum signal.

[f] Driver power output represents circuit losses and is the actual power measured at input to grid-No.1 circuit. The actual power required depends on the operating frequency and the circuit used. The tube driving power is approximately zero watts.

[g] With maximum signal output used as a reference, and without the use of feedback to enhance linearity.

[h] This value of useful power is measured at load of output circuit.

[j] The tube should see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes.

[k] Driver power output includes circuit losses and is the actual power measured at the input to the grid circuit. It will vary depending upon the frequency of operation and the circuit used.

[m] Measured in a typical coaxial-cavity circuit.

DEFINITIONS

CCS - Continuous Commercial Service

Rating System - The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices:

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

Two-Tone Modulation - Two-Tone Modulation operation refers to that class of amplifier service in which the input consists of two monofrequency rf signals having equal peak amplitude.

GENERAL CONSIDERATIONS

Temperature

The maximum terminal temperature of 250° C and the maximum radiator core temperature of 250° C are tube ratings and are to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y.

Mounting

The plate connection to the 8121 may be made by a metal band or spring contacts to the larger fin of the radiator which is located at the base end.

If rigid connections are made to more than one plane (base, flange, and radiator), adjustment must be made in a plane normal to the major tube axis to compensate for variations in concentricity for the associated parts of the tube. See *Dimensional Outline*.

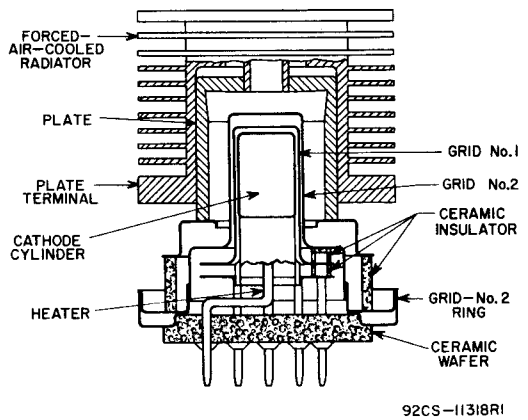


Fig.1 - Structural Arrangement of Type 8121.

ELECTRICAL CONSIDERATIONS

Grid No.1

Grid No.1 of the 8121 in uhf service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid current, but also by radiation from the cathode and circulating rf currents. For these reasons, more than ordinary care must be taken during operation to prevent exceeding the grid-No.1 current rating and the maximum grid-No.1 terminal temperature rating.

Grid No.2

The grid No.2 current of the 8121 may be negative under certain operating conditions. The voltage for grid No.2 should be obtained from a source of good regulation; if a separate source is used, a maximum impedance of 10000 ohms and a minimum divider current of 40 ma are required; if a voltage divider from the plate supply is used, a maximum impedance of 10000 ohms between the grid-No.2 and ground is required. The plate voltage should be applied before or simultaneously with grid-No.2 voltage; otherwise, with voltage on grid-No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation.

The grid-No.2 current is a very sensitive indication of plate-circuit loading. When the 8121 is operated without load, the grid-No.2 current rises excessively, often to a value which damages the tube. Therefore, care should be taken when tuning the 8121 circuit under no-load or lightly loaded conditions to prevent exceeding the grid-No.2 input rating of the tube. In this connection, reduction of the grid-No.2 voltage will be helpful.

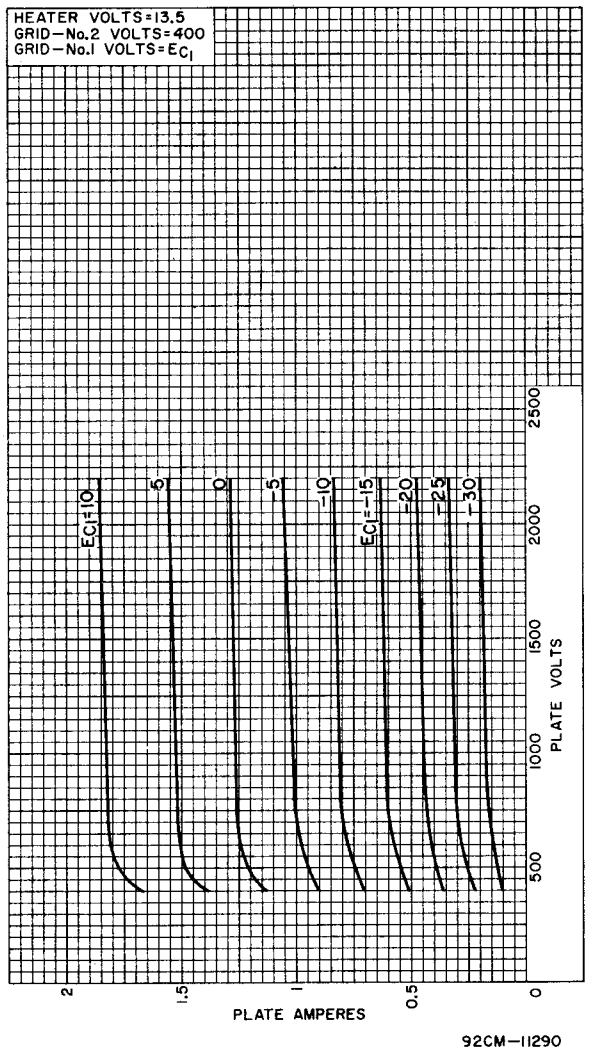


Fig.2 - Typical Plate Characteristics of Type 8121.

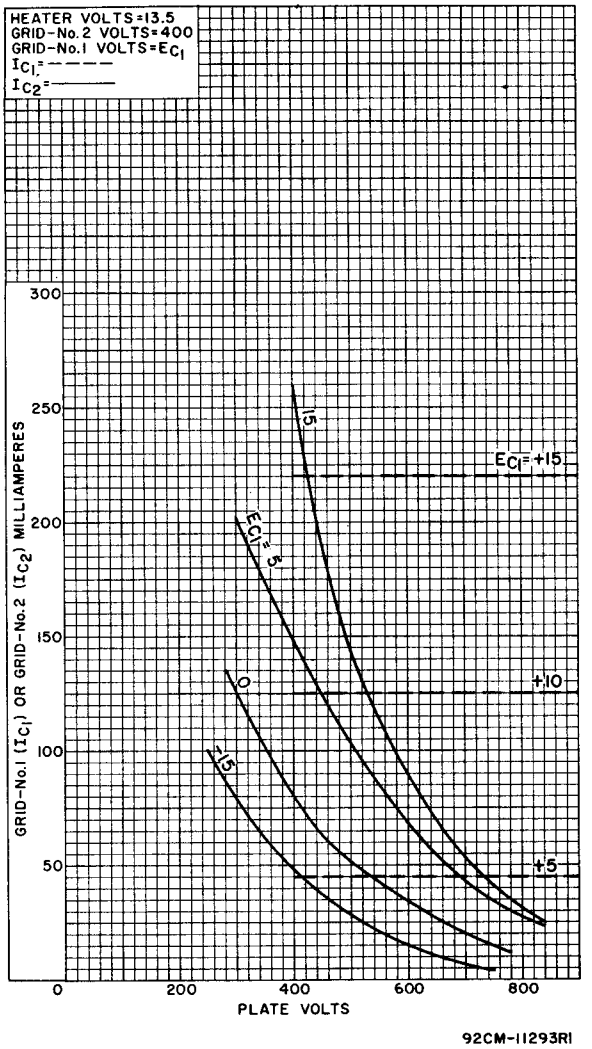


Fig.3 - Typical Characteristics of Type 8121.

Plate

In tubes, such as the 8121, having very closely spaced electrodes, extremely high voltage gradients occur even with moderate tube operating voltages. Any tube flash-arcing may be destructive. It is recommended that each tube see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes. Failure of the tubes due to internal flashing is more prevalent when the circuit is not tuned to optimum conditions. Even though laboratory tests indicate that no such protection is needed, poor circuit adjustment in the field may result in shortened tube life.

Driver

The driver power output shown in the typical operation for the 8121 in rf service is considerably more than is normally calculated for typical driving power input in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuits and the coupling circuits. This consideration is particularly important at the higher frequencies where circuit losses, radiation losses, and transit-time losses increase, and the effects of cathode-lead inductive reactance becomes significant.

Cathode-Drive Circuits

In cathode-drive circuits, driver power output and the developed rf power output act in series to supply the load circuit. If the driving voltage and grid-No.1 current are increased, the output will always increase. Such is not the case in a grid-drive circuit where a saturation effect takes place, i.e., above a certain value of driving voltage and current, the output increases very slowly and may even decrease. It is important to recognize this difference and not try to saturate a cathode-drive stage because the maximum grid-No.2 input may easily be exceeded.

In tuning a cathode-drive rf amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

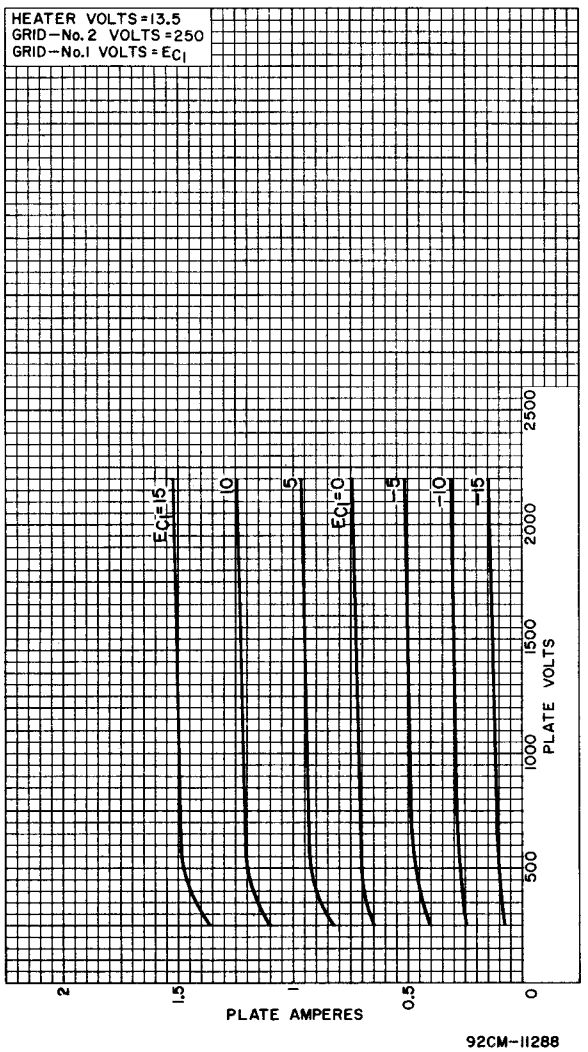


Fig.4 - Typical Plate Characteristics of Type 8121.

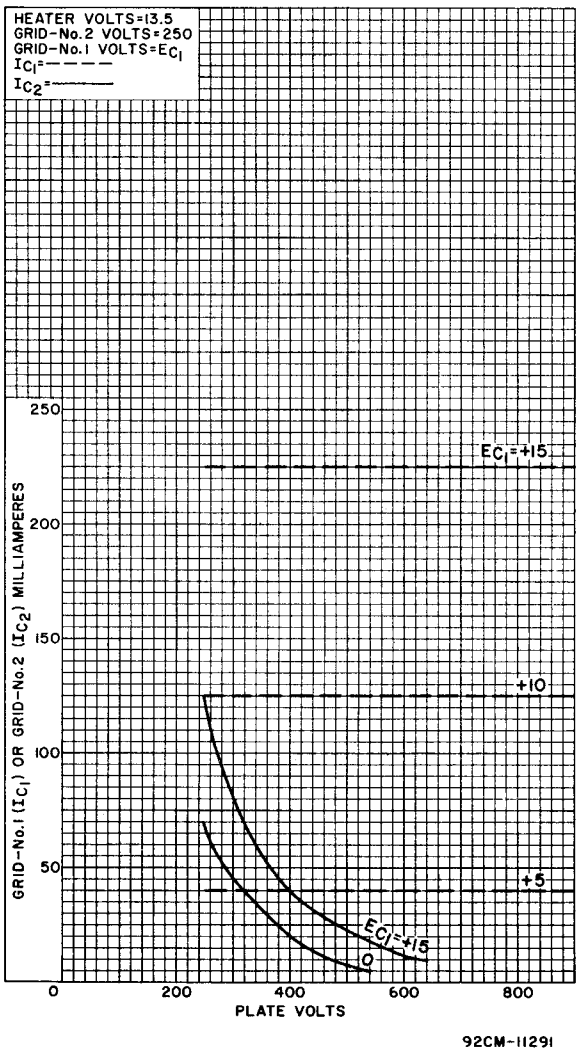


Fig.5 - Typical Characteristics of Type 8121.

Class C RF Telegraphy Service

In class C rf telegraphy service, the 8121 may be supplied with bias by any convenient method except when the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying. In this case, an amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value.

Standby Operation

During standby periods in intermittent operation, the heater voltage may be maintained at normal operating value for most applications.

In those applications which require maximum reliability, it is recommended that the heater voltage be maintained at normal operating value when the period is less than 15 minutes; that it be reduced to 80 per cent of normal when the period is between 15 minutes and 2 hours; and that for longer periods, the heater voltage should be turned off.

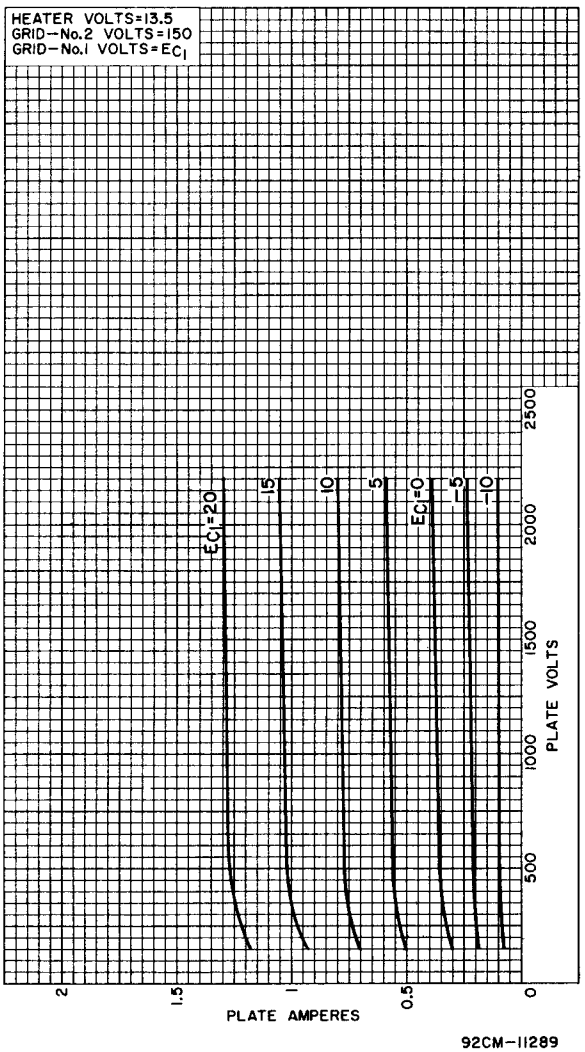


Fig. 6 - Typical Plate Characteristics of Type 8121.

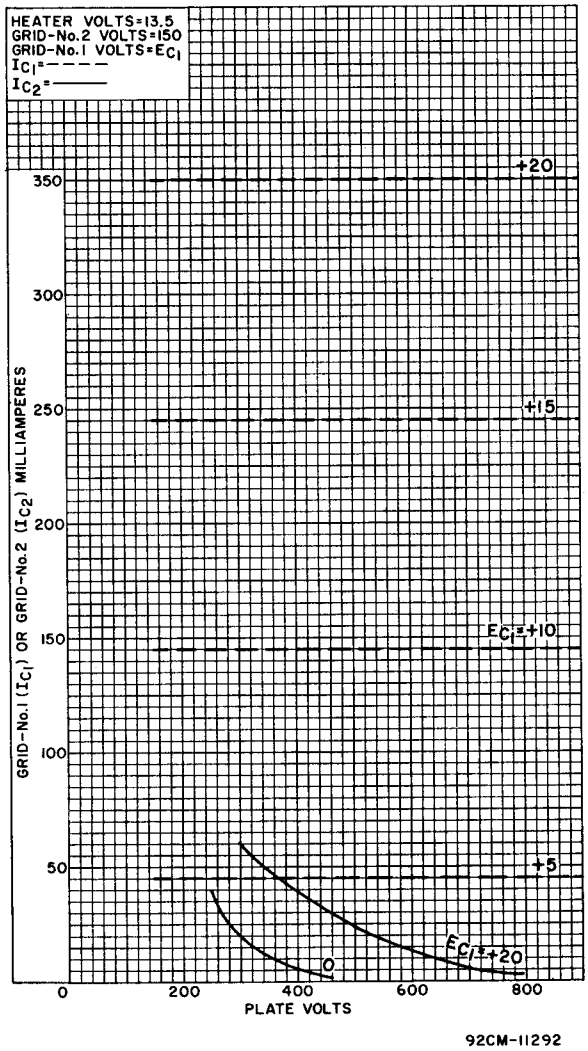


Fig. 7 - Typical Characteristics of Type 8121.

Protective Devices

Protective devices should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the dc plate and grid-No.2 voltage when the average value of plate current reaches a value slightly higher than normal plate current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

Precautions

The rated plate and grid-No.2 voltages of this tube are extremely dangerous. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened,

and should prevent the closing of the primary circuit until the door is again locked.

COOLING CONSIDERATIONS

System

Forced-air cooling of the 8121 is required as indicated in Fig.8. A suitable air filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air through the radiator.

Precautions

The cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the heater and plate power supplies. This arrangement is necessary to make sure that the tube is supplied with air simultaneously with electrode voltages. Airflow interlocks which open the power transformer primaries are desirable for protecting the tube when the air flow is insufficient or ceases.

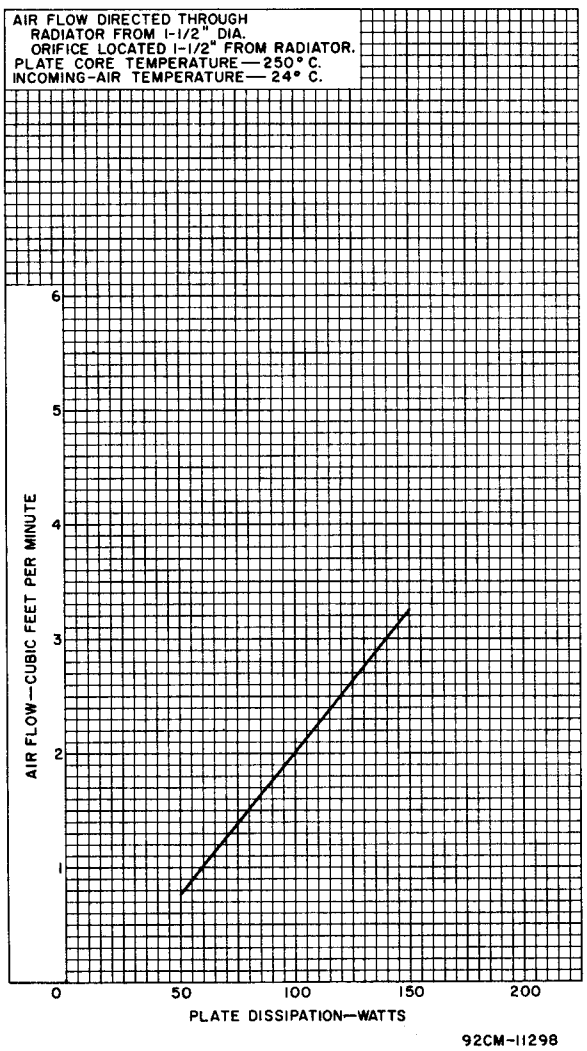
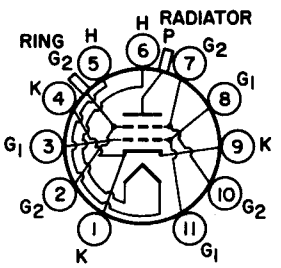


Fig.8 - Typical Cooling Requirements for Type 8121.

BASING DIAGRAM

Bottom View



PIN 1: CATHODE
PIN 2: GRID No.2
PIN 3: GRID No.1
PIN 4: CATHODE
PIN 5: HEATER
PIN 6: HEATER
PIN 7: GRID No.2
PIN 8: GRID No.1
PIN 9: CATHODE
PIN 10: GRID No.2
PIN 11: GRID No.1
RADIATOR: PLATE TERMINAL
RING: GRID-No.2 TERMINAL CONTACT SURFACE (For use at higher frequencies)

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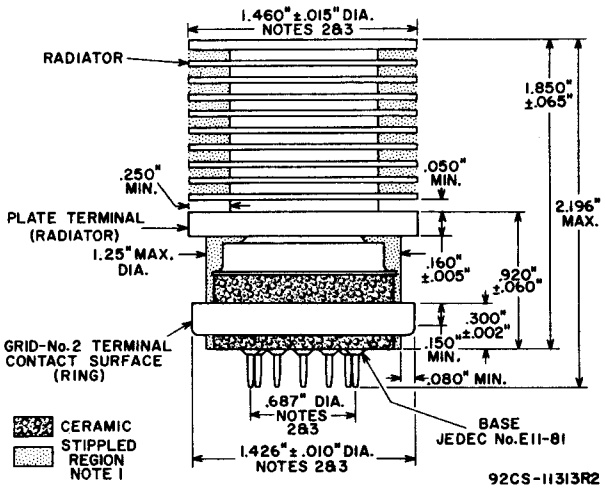
DIMENSIONAL OUTLINE



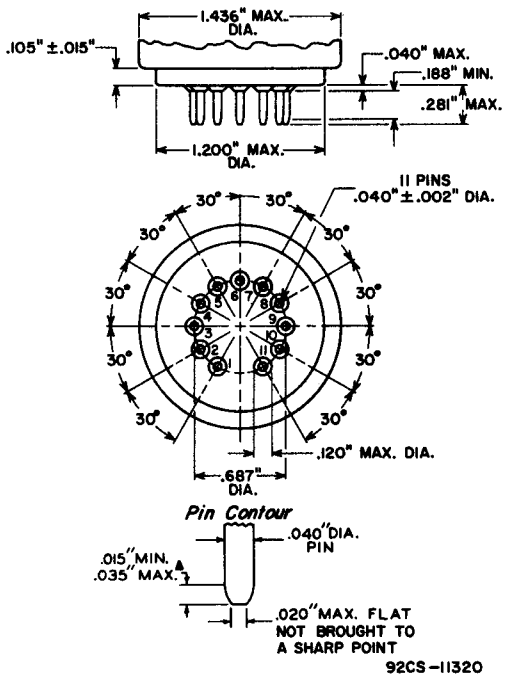
NOTE 1: KEEP ALL STIPPLED REGIONS CLEAR. DO NOT ALLOW CONTACTS OR CIRCUIT COMPONENTS TO PROTRUDE INTO THESE ANNULAR VOLUMES.

NOTE 2: THE DIAMETERS OF THE RADIATOR, GRID-No.2 TERMINAL CONTACT SURFACE, AND PIN CIRCLE TO BE CONCENTRIC WITHIN THE FOLLOWING VALUES OF MAXIMUM FULL INDICATOR READING:

Radiator to Grid-No.2 Terminal Contact Surface	0.030" max.
Radiator to Pin Circle	0.040" max.
Grid-No.2 Terminal Contact Surface to Pin Circle	0.030" max.

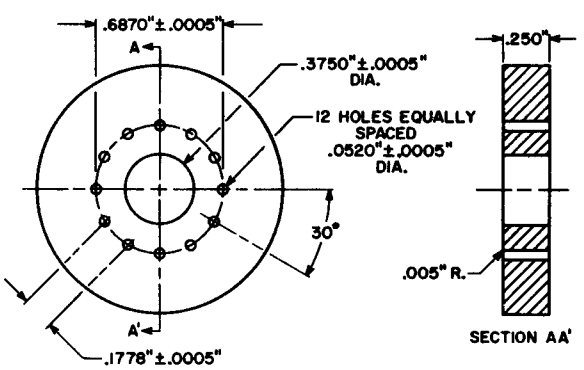
NOTE 3: THE FULL INDICATOR READING IS THE MAXIMUM DEVIATION IN RADIAL POSITION OF A SURFACE WHEN THE TUBE IS COMPLETELY ROTATED ABOUT THE CENTER OF THE REFERENCE SURFACE. IT IS A MEASURE OF THE TOTAL EFFECT OF RUN-OUT AND ELLIPTICITY.

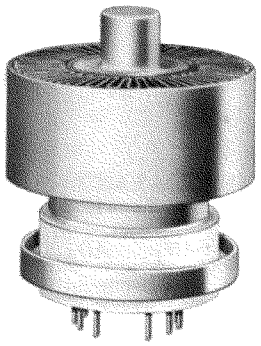
BASE DRAWING
LARGE-WAFER ELEVENAR
11-PIN WITH RING
JEDEC No.E11-81



▲ THIS DIMENSION AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN MAY VARY WITHIN THE LIMITS SHOWN.

GAUGE DRAWING
JEDEC No.GE11-1





Coaxial-Electrode Structure
Ceramic-Metal Seals
Full Ratings Up to 500 MHz
Forced-Air Cooled
380 Watts PEP Output at 30 MHz AB_1
570 Watts PEP Output at 30 MHz AB_2
300 Watts CW Output at 470 MHz

RCA-8122

BEAM POWER TUBE

RCA-8122 is a very small, low-cost, forced-air-cooled beam power tube designed for use as an rf power amplifier, oscillator, regulator, distributed amplifier, or linear rf power amplifier in mobile or fixed equipment.

The 8122 features a light-weight, cantilever-supported cylindrical electrode structure within a ceramic-metal envelope. This construction provides a very sturdy tube and permits high-temperature operation.

The terminal arrangement of the 8122 facilitates use of the tube with tank circuits of the coaxial or strip-line type. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the low-inductance ring terminal for grid-No.2. A base-pin termination for grid-No.2 is also available for operation of the 8122 at the lower frequencies.

The tripod arrangement of both the cathode and the grid-No.1 leads not only simplifies construction, but enhances electrical characteristics. The three cathode leads reduce the inductance path to rf ground and reduce the input admittance at high frequencies.

The three grid-No.1 leads to separate pins accomodate a split-input circuit for distributed amplifier service.

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III. GENERAL APPLICATIONS	
This bulletin is to be used in conjunction with the publication **Application Guide for RCA Power Tubes, 1CE-300.** For a copy, write RCA, Commercial Engineering, Harrison, N. J.	

GENERAL DATA

Electrical:

Heater, for Unipotential:Cathode:		
Voltage (AC or DC)[a]	13.5 ± 10%	volts
Current at 13.5 volts	1.3	A
Minimum heating time	60	s
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 450, Grid-No.2 volts = 325, and plate amperes = 1.2	12	
Direct Interelectrode Capacitances:[b]		
Grid No.1 to plate	0.13 max.	pF
Grid No.1 to cathode	16	pF
Plate to cathode	0.011	pF
Grid No.1 to grid No.2	24	pF
Grid No.2 to plate	7.0	pF
Grid No.2 to cathode	2.6	pF
Cathode to heater	3.4	pF

Mechanical:

Operating Position	Any
Maximum Overall Length	2.26"
Seated Length	1.920" ± 0.065"
Greatest Diameter	1.625" ± 0.015"
Base	Large-Wafer Elevenar 11-Pin with Ring (JEDEC No.E11-81)
Socket	Erie▲No. 9802-000 and 9804-000, Johnson■No. 124-311-110, Mycalex* No. CP464-2, or equivalent
Grid No.2 Bypass Capacitor	Erie▲No. 2943-002, Johnson■No. 124-121, or equivalent
Weight (Approx.)	3.5 oz

▲ Erie Technological Products, Inc., 645 West 12th Street, Erie, Pa.
■ E. F. Johnson Co., 1921 10th Ave., S. W., Waseca, Minn.
* Mycalex Corp. of America, 775 Clifton Blvd., Clifton, N. J.

Thermal:

Terminal Temperature (All terminals)	250 max.	°C
Radiator Core Temperature (See *Dimensional Outline*)	250 max.	°C
Air Flow: See *Typical Cooling Requirements* on page 5.		

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Electronic Components and Devices Harrison, N. J.

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8122 6-66
Supersedes 8122 10-61
Printed in U.S.A.

LINEAR RF POWER AMPLIFIER
Single-Sideband Suppressed-Carrier Service[c]

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

Maximum CCS Ratings, *Absolute-Maximum Values:*

DC PLATE VOLTAGE:			
Up to 30 MHz	3000[d]	max.	volts
Up to 500 MHz	2200	max.	volts
	Up to 500 MHz		
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	−100	max.	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE	450[e]	max.	mA
DC GRID-No.1 CURRENT	100	max.	mA
PLATE DISSIPATION	400	max.	watts
GRID-No.2 DISSIPATION	8	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150	max.	volts
Heater positive with respect to cathode	150	max.	volts
Maximum Circuit Values:			
Grid-No.1 Circuit Resistance Under Any Condition:[i]			
With fixed bias	25000	max.	ohms
With fixed bias (In Class AB_1 operation)	100000	max.	ohms
With cathode bias	Not recommended		
Grid-No.2 Circuit Impedance[h]	10000	max.	ohms
Plate Circuit Impedance[d]	See Note[f]		

Typical CCS Operation at 30 MHz with "Two-Tone Modulation":

	AB_1	AB_2	
DC Plate Voltage	2000	2500	volts
DC Grid-No.2 Voltage	400	400	volts
DC Grid-No.1 Voltage	−35	−35	volts
Zero-Signal DC Plate Current	100	115	mA
Effective RF Load Resistance	3050	3500	ohms
DC Plate Current at Peak of Envelope	335	400	mA
Average DC Plate Current	250	275	mA
DC Grid-No.2 Current at Peak of Envelope	10	6	mA
Average DC Grid-No.2 Current	7	4	mA
DC Grid-No.1 Current at Peak of Envelope	0.05[g]	3	mA
Peak-Envelope Driver Power Output (Approx.)	0.3	0.5	watt
Output-Circuit Efficiency (Approx.)	90	90	%
Distortion Products Level:			
Third order	29[k]	28	dB
Fifth order	32	32	dB
Useful Power Output (Approx.):			
Average	190	285	watts
Peak envelope	380	570	watts

RF POWER AMPLIFIER & OSCILLATOR – Class C Telegraphy[c]
and
RF POWER AMPLIFIER – Class C FM Telephony[c]

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 MHz		
DC PLATE VOLTAGE	2200	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	−100	max.	volts
DC PLATE CURRENT	300	max.	mA
DC GRID-No.1 CURRENT	100	max.	mA
GRID-No.2 DISSIPATION	8	max.	watts
PLATE DISSIPATION	400	max.	watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	150	max.	volts
Heater positive with respect to cathode	150	max.	volts
Maximum Circuit Values:			
Grid-No.1 Circuit Resistance Under Any Condition:			
With fixed bias	25000	max.	ohms
Grid-No.2 Circuit Impedance	10000	max.	ohms
Plate Circuit Impedance	See Note[f]		

Typical CCS Operation:

In Grid-Drive Circuit at 50 MHz					
DC Plate Voltage	700	1000	1500	2000	volts
DC Grid-No.2 Voltage	175	200	200	200	volts
DC Grid-No.1 Voltage	−10	−30	−30	−30	volts
DC Plate Current	300	300	300	300	mA
DC Grid-No.2 Current	25	20	20	20	mA
DC Grid-No.1 Current	50	40	40	30	mA
Driver Power Output (Approx.)	1.2	2	2	2	watts
Useful Power Output	120	175	275	375	watts
In Grid-Drive Circuit at 470 MHz					
DC Plate Voltage	700	1000	1500	2000	volts
DC Grid-No.2 Voltage	200	200	200	200	volts
DC Grid-No.1 Voltage	−30	−30	−30	−30	volts
DC Plate Current	300	300	300	300	mA
DC Grid-No.2 Current	10	10	5	5	mA
DC Grid-No.1 Current	30	30	30	30	mA
Driver Power Output (Approx.)	5	5	5	5	watts
Useful Power Output	100	165	235	300	watts

PLATE-MODULATED RF POWER AMPLIFIER – Class C Telephony

Carrier conditions per tube for use with a max. modulation factor of 1.0

Maximum CCS Ratings, *Absolute-Maximum Values up to 500 MHz:*

DC PLATE VOLTAGE	1800	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	−100	max.	volts
DC PLATE CURRENT	250	max.	mA
DC GRID-No.1 CURRENT	100	max.	mA
GRID-No.2 INPUT	5	max.	watts
PLATE DISSIPATION	280	max.	watts

CHARACTERISTICS RANGE VALUES

	Note	Min.	Max.	
1. Heater Current	1	1.15	1.45	A
2. Direct Interelectrode Capacitances:				
Grid No.1 to plate . . .	2	–	0.13	pF
Grid No.1 to cathode .	2	14.3	17.7	pF
Plate to cathode	2	0.0065	0.0155	pF
Grid No.1 to grid No.2	2	20.8	25.2	pF
Grid No.2 to plate . . .	2	6.3	7.7	pF
Grid No.2 to cathode .	2	2.0	3.0	pF
Cathode to heater . . .	2	2.5	4.1	pF
3. Grid-No.1 Voltage	1,3	–8	–19	volts
4. Reverse Grid-No.1 Current	1,3	–	–25	μA
5. Grid-No.2 Current	1,3	–5	+6	mA
6. Peak Emission	1,4	13	–	peak A
7. Interelectrode Leakage Resistance	5	50	–	megohm
8. Zero Bias Plate Current .	1,6	1.0	1.8	A

Note 1: With 13.5 volts ac or dc on heater.

Note 2: Measured with special shield adapter.

Note 3: With dc plate voltage at 700 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage adjusted to give a dc plate current of 185 mA.

Note 4: For conditions with grid No.1, grid No.2, and plate tied together; and pulse voltage source connected between plate and cathode. Pulse duration is 2.5 microseconds and pulse repetition frequency is 60 pps. The voltage-pulse amplitude is 200 volts peak. After 1 minute at this value, the current-pulse amplitude will not be less than the value specified.

Note 5: Under conditions with tube at 20° to 30° C for at least 30 minutes without any voltages applied to the tube. The minimum resistance between any two electrodes as measured with a 200-volt Megger-type ohmmeter having an internal impedance of 1.0 megohm, will be no less than the valve specified.

Note 6: With dc plate voltage of 450 volts, dc grid No.2 voltage of 400 volts, dc grid No.1 voltage of –100 volts, grid drive voltage to zero. With pulse duration of 4500 to 5000 μs and pulse repetition frequency is 10 to 12 pps.

FOOTNOTES

[a]Because the cathode is subjected to back bombardment as the frequency is increased with resultant increase in temperature, the heater voltage should, for optimum life, be reduced to a value such that at the heater voltage obtained at minimum supply voltage conditions (all other voltages constant) the tube performance just starts to show some degradation; e.g., at 470 MHz heater volts = 12.5 (approx.).

[b]Measured with special shield adapter.

[c]See Section V.C. of 1CE-300.

[d]For operation above 2200 plate volts, the tube shall see an effective plate-supply impedance of no less than 750 ohms. A fault current limiting resistor of no less than 15 ohms is to be used between the output filter capacitance and the tube plate. The plate-supply-output-filter capacitance is to be no greater than 10 μF.

[e]The maximum rating for a signal having a minimum peak-to-average power ratio less than 2, such as is obtained in "Single-Tone" operation, is 300 mA. During short periods of circuit adjustment under "Single-Tone" conditions, the average plate current may be as high as 450 mA.

[f]The tube should see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes.

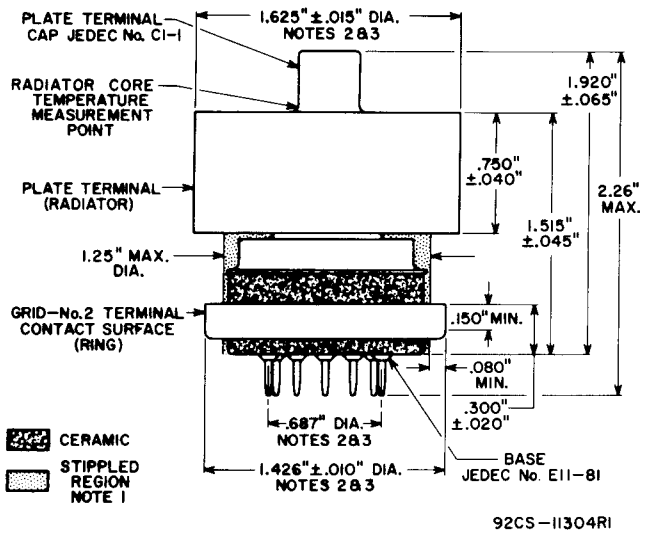
[g]This value represents the approximate grid-No.1 current obtained due to initial electron velocities and contact-potential effects when grid No.1 is driven to zero volts at maximum signal.

[h]A fault current limiting resistor of no less than 320 ohms is to be used between the screen output filter capacitance and the tube screen. The screen supply output filter capacitance is to be no greater than 80 μF.

[i]A fault current limiting resistor of no less than 20 ohms is to be used between the bias supply output filter capacitance and the tube grid-No.1. The bias supply output filter capacitance is to be no greater than 150 μF.

[k]The value of third order distortion product level shown may be improved by approximately 5 dB by utilizing an unbypassed, non-inductive 20-ohm resistor between the cathode and ground; a slight increase in drive power will be required.

DIMENSIONAL OUTLINE



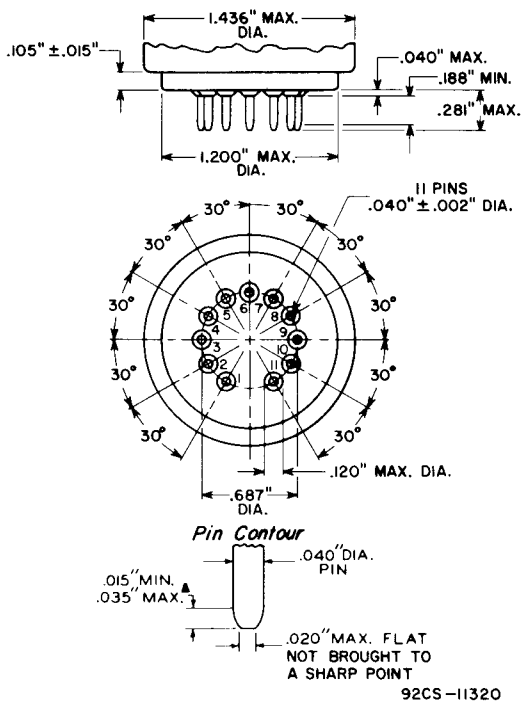
NOTE 1: Keep all stippled regions clear. Do not allow contacts or circuit components to protrude into these annular volumes.

NOTE 2: The diameters of the radiator, grid-No.2 terminal contact surface, and pin circle to be concentric within the following values of maximum full indicator reading:

Radiator to Grid-No.2	
Terminal Contact Surface	0.030" max.
Radiator to Pin Circle	0.040" max.
Grid-No.2 Terminal Contact.	
Surface to Pin Circle	0.030" max.

NOTE 3: The full indicator reading is the maximum deviation in radial position of a surface when the tube is completely rotated about the center of the reference surface. It is a measure of the total effect of run-out and ellipticity.

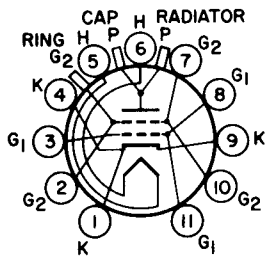
BASE DRAWING
LARGE-WAFER ELEVENAR
11-PIN WITH RING
JEDEC No.E11-81



* This dimension around the periphery of any individual pin may vary within the limits shown.

BASING DIAGRAM

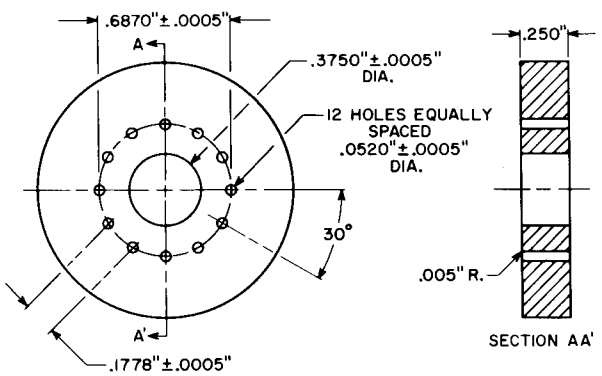
Bottom View



Pin 1: Cathode
Pin 2: Grid No.2
Pin 3: Grid No.1
Pin 4: Cathode
Pin 5: Heater
Pin 6: Heater
Pin 7: Grid No.2
Pin 8: Grid No.1
Pin 9: Cathode
Pin 10: Grid No.2
Pin 11: Grid No.1
Cap: Plate Terminal
Radiator: Plate Terminal
Ring: Grid-No.2 Terminal Contact Surface (For use at higher frequencies)

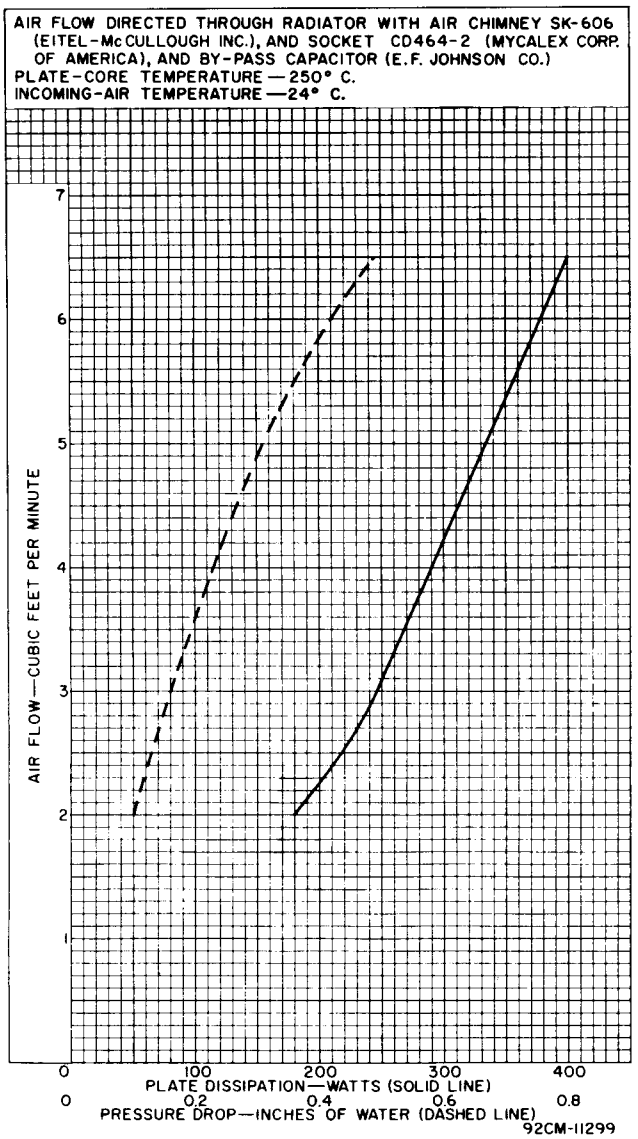
GAUGE DRAWING

JEDEC No.GE11-1



92CS-11310

TYPICAL COOLING REQUIREMENTS



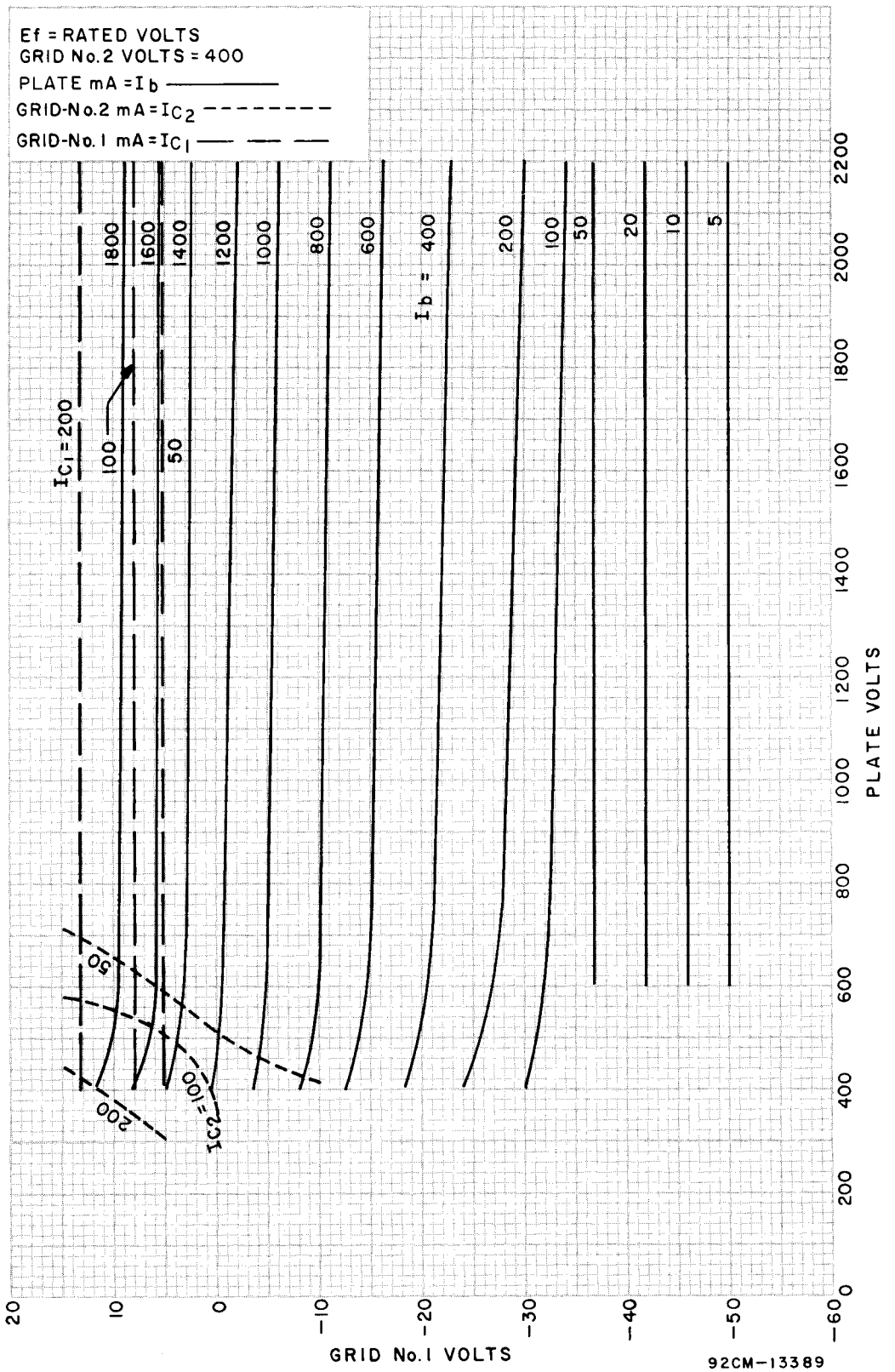
92CM-11299

REFERENCES

1. Application Guide for RCA Power Tubes, 1CE-300.
2. J. F. Gaylord, "The Conduction Cooling of Power Tubes in Vehicular Communication Equipment", IEEE Transactions on Vehicular Communication, September, 1963.

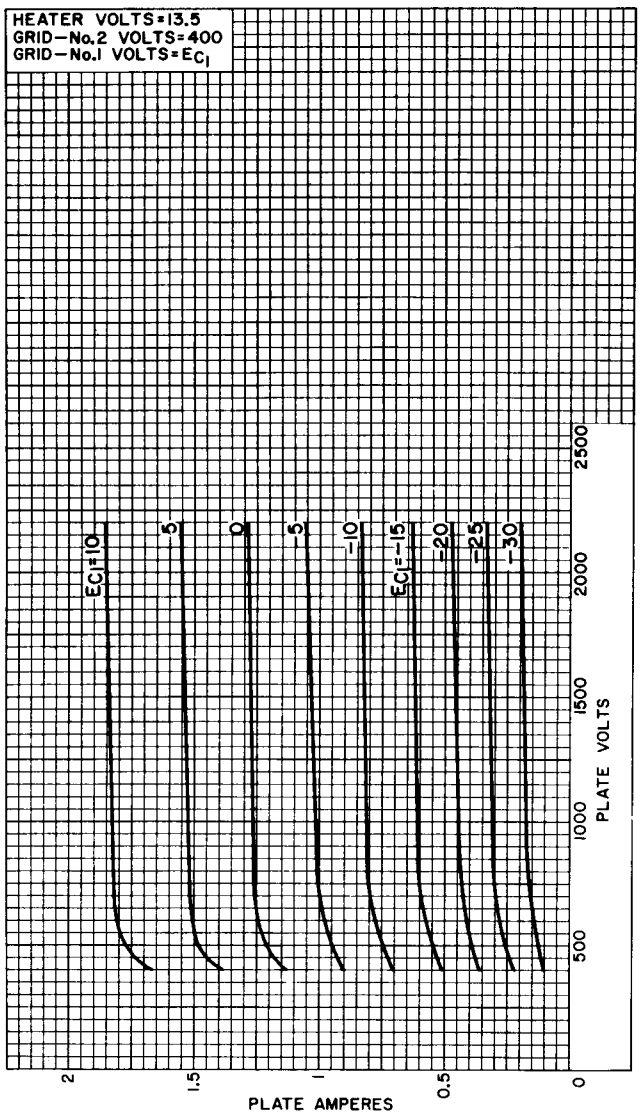
TYPICAL CONSTANT-CURRENT CHARACTERISTICS

For Grid-No.2 Voltage = 400 Volts



TYPICAL PLATE CHARACTERISTICS

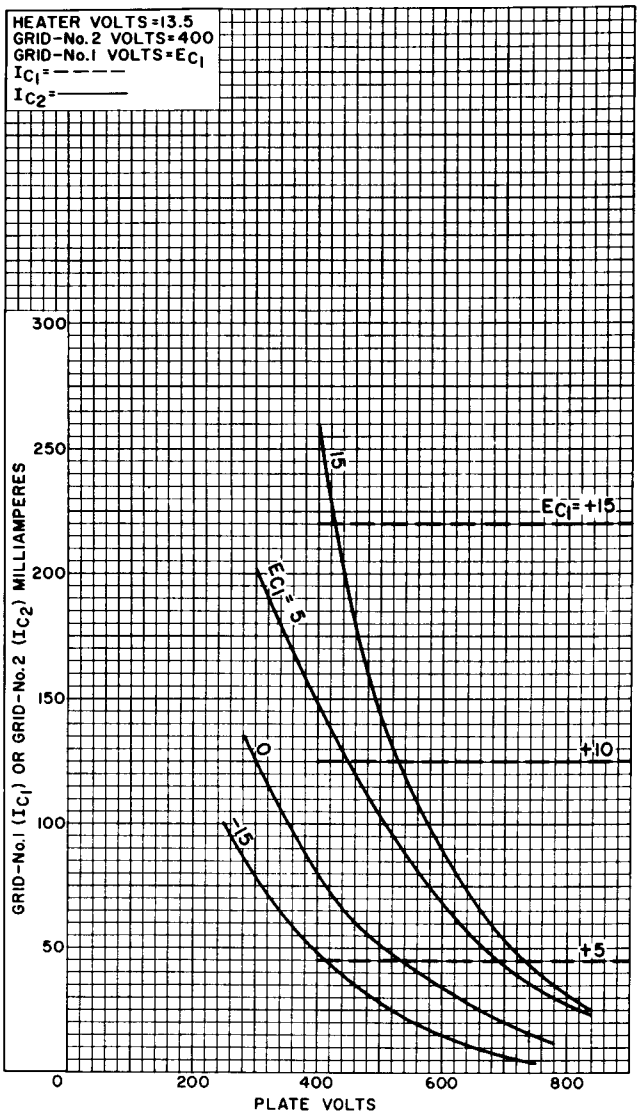
For Grid-No.2 Voltage = 400 Volts



92CM-11290

TYPICAL CHARACTERISTICS

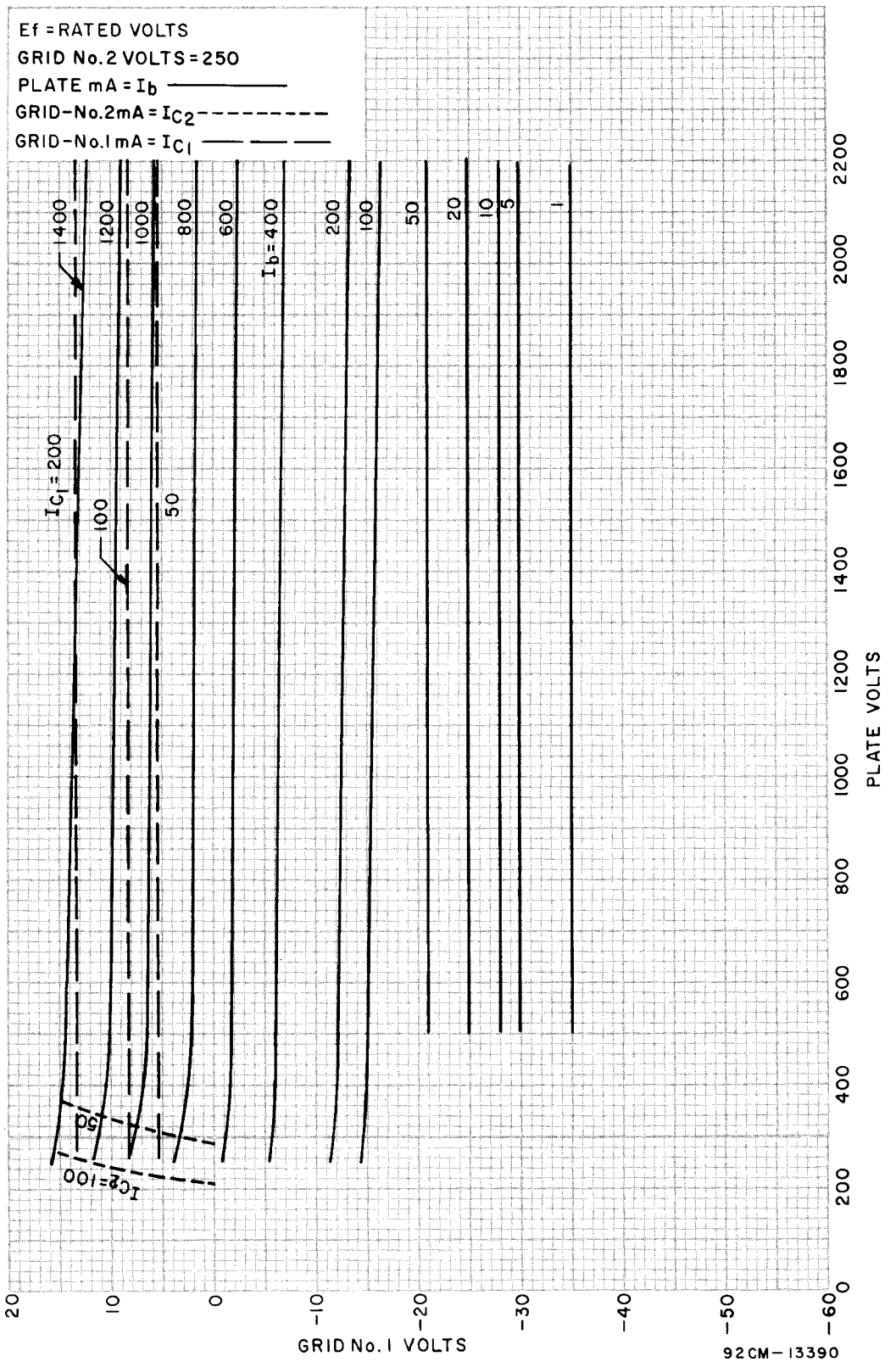
For Grid-No.2 Voltage = 400 Volts



92CM-11293R1

TYPICAL CONSTANT-CURRENT CHARACTERISTICS

For Grid-No.2 Voltage = 250 Volts



RCA-8462

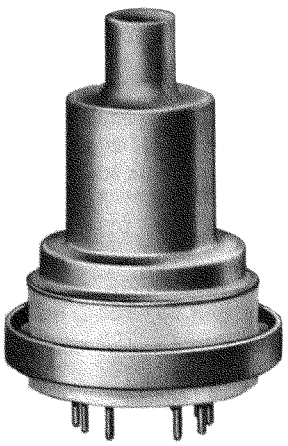
BEAM POWER TUBE

Coaxial-Electrode Structure
Ceramic-Metal Seals
Mesh Filament

Less Than 1-Second Warm-Up
For Use in Low-Voltage Mobile
Equipment Up to 500 Mc

2.26" Max. Length
1.44" Max. Diameter
Conduction Cooled

RCA-8462 is a very small, low-cost, conduction-cooled beam power tube designed for use as an rf power amplifier, oscillator, regulator, distributed amplifier, or linear rf power amplifier in mobile or stationary equipment.



Because of its high power sensitivity and high efficiency, the 8462 can be operated with relatively low plate voltage to provide high power output with low driving power. In CW operation with a plate voltage of only 700 volts, the 8462 can provide useful power outputs of 110 watts at 50 Mc, 105 watts at 175 Mc, and 85 watts at 470 Mc.

Less than one-second is required from a cold start to 70% of useful power output. This fast warm-up eliminates stand-by filament power in "push-to-talk" emergency equipment.

The heating time of the mesh filament, however, is a function of filament voltage and the impedance of the filament power supply. To achieve the longest life, the filament voltage should be reduced to the lowest possible value to provide satisfactory operation. Extremely fast "warm-up", less than 100 milliseconds, is also possible by the use of a suitably designed overvoltage control circuit, or "hot-shot" circuit.

The elimination of standby-power and the reduction of operating filament power combine to make the 8462 ideal for mobile equipment.

Featured in the design of the 8462 is its hollow, cylindrical, quick-heating, filamentary cathode comprised of oxide-coated woven wire mesh. This construction provides greater mechanical strength, more emitting surface in a limited space, and lower filament-voltage gradient than conventional filaments.

The 8462 employs a large-area, nickel-plated-copper cylindrical-plate terminal for both high electrical conductivity to the external circuit and high thermal conductivity to the conduction-cooling system.

A low-cost socket may be used to accommodate the 8462. Effective isolation of the output circuit from the input circuit is provided at the higher frequencies by the low-inductance grid-No.2 ring terminal. Grid-No.2 base pins are also available for operation of the 8462 at the lower frequencies.

The three filament-cathode leads provide a low inductance path to rf ground. One of the cathode leads may be series tuned to ground with a capacitor to provide broadband neutralization in the upper frequency range of the tube. The two grid-No.1 leads permit the use of a split-input circuit for distributed amplifier service.

GENERAL DATA

Electrical:

Filamentary Cathode, Woven-Wire-Mesh Type, Oxide-Coated:		
Voltage (AC or DC)	2.9	volts
Current at 2.9 volts	4.6	amp
Minimum heating time	less than 1[a]	sec
See further information on Filament under Electrical Considerations.		
Mu-Factor, Grid No.2 to Grid No.1 for plate volts = 250, grid-No.2 volts = 200, and plate amperes = 1.2	11	
Direct Interelectrode Capacitances:[b]		
Grid No.1 to plate	0.13 max.	pf
Grid No.1 to cathode	16	pf
Plate to cathode	0.03 max.	pf
Grid No.1 to grid No.2	22	pf
Grid No.2 to plate	7	pf
Grid No.2 to cathode	3	pf

Mechanical:

Operating Position	Any
Maximum Overall Length	2.26"
Seated Length	1.920" ± 0.065"
Greatest Diameter	1.426" ± 0.010"
Base	Large-Wafer Elevenar 11-Pin with Ring (JEDEC No.E11-81)
Socket	E. F. Johnson Co.† No.124-311-110, Mycalex* No.CP464-2, or equivalent
Grid-No.2 Bypass Capacitor	E. F. Johnson Co.† No.124-113-1, or equivalent
Weight (Approx.)	2 oz

Thermal:

Terminal Temperature (All Terminals)	250 max.	°C
Plate Core Temperature (See *Dimensional Outline*)	250 max.	°C

Cooling, Conduction:

The plate terminal must be thermally coupled to a constant temperature device (heat sink—solid or liquid) to limit the plate terminal temperature to the specified maximum value of 250° C. The grid-No.2, grid-No.1, and filament terminals may also require coupling to the heat sink to limit their respective terminal temperature to the specified maximum value of 250° C.

† E. F. Johnson Co., 1921 10th Ave. S. W., Waseka, Minnesota.

* Mycalex Corp. of America, 725 Clifton Blvd., Clifton, New Jersey.

LINEAR RF POWER AMPLIFIER
Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 Mc		
DC PLATE VOLTAGE	2200	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT AT PEAK OF ENVELOPE	450[c]	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
PLATE DISSIPATION	100[d]	max.	watts
GRID No.2 INPUT	8	max.	watts

Typical CCS Operation with "Two-Tone Modulation":

	At 30 Mc	
DC Plate Voltage	700	volts
DC Grid-No.2 Voltage[e]	250	volts
DC Grid-No.1 Voltage[e]	-20	volts
Zero-Signal DC Plate Current	100	ma
Effective RF Load Resistance	1420	ohms
DC Plate Current at Peak of Envelope	205	ma
Average DC Plate Current	150	ma
DC Grid-No.2 Current at Peak of Envelope	16	ma
Average DC Grid-No.2 Current	10	ma
Average DC Grid-No.1 Current	1.0[f]	ma
Peak-Envelope Driver Power Output (Approx.)[g]	0.3	watt
Output-Circuit Efficiency (Approx.)	95	%
Distortion Products Level:[h]		
Third order	30	db
Fifth order	35	db
Useful Power Output (Approx.):		
Average	40[j]	watts
Peak envelope	80[j]	watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:		
With fixed bias	25,000 max.	ohms
With fixed bias (In Class AB_1 operation)	100,000 max.	ohms
With cathode bias	Not recommended	
Grid-No.2 Circuit Impedance	10,000	ohms
Plate Circuit Impedance	See Note k	

RF POWER AMP. & OSCILLATOR — Class C Telegraphy and RF POWER AMPLIFIER — Class C FM Telephony

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 500 Mc		
DC PLATE VOLTAGE	2200	max.	volts
DC GRID-No.2 VOLTAGE	400	max.	volts
DC GRID-No.1 VOLTAGE	-100	max.	volts
DC PLATE CURRENT	300	max.	ma
DC GRID-No.1 CURRENT	100	max.	ma
GRID-No.2 INPUT	8	max.	watts
PLATE DISSIPATION	100[d]	max.	watts

Typical CCS Operation:

In Grid-Drive Circuit at 50 Mc

DC Plate Voltage	500	700	volts
DC Grid-No.2 Voltage	160	175	volts
DC Grid-No.1 Voltage	-10	-10	volts
DC Plate Current	300	300	ma
DC Grid-No.2 Current	25	25	ma
DC Grid-No.1 Current	50	50	ma
Driver Power Output (Approx.)[m]	1.2	1.2	watts
Useful Power Output	85[j]	110[j]	watts

In Grid-Drive Circuit at 175 Mc

DC Plate Voltage	500	700	volts
DC Grid-No.2 Voltage	200	200	volts
DC Grid-No.1 Voltage	-30	-30	volts
DC Plate Current	300	300	ma
DC Grid-No.2 Current	30	20	ma
DC Grid-No.1 Current	40	40	ma
Driver Power Output (Approx.)[m]	3	3	watts
Useful Power Output	70[j]	105[j]	watts

In Grid-Drive Circuit at 470 Mc

DC Plate Voltage	700		volts
DC Grid-No.2 Voltage	200		volts
DC Grid-No.1 Voltage	-30		volts
DC Plate Current	300		ma
DC Grid-No.2 Current	10		ma
DC Grid-No.1 Current	20		ma
Driver Power Output (Approx.)[m]	5		watts
Useful Power Output	85[j]		watts

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:		
With fixed bias	25,000 max.	ohms
Grid-No.2 Circuit Impedance	10,000 max.	ohms
Plate Circuit Impedance	See Note k	

CHARACTERISTICS RANGE VALUES

	Note	*Min.*	*Max.*	
1. Filament Current	1	3.6	5.6	amp
2. Direct Interelectrode Capacitances:				
Grid No.1 to plate	2	-	0.13	pf
Grid No.1 to cathode	2	14	18.5	pf
Plate to cathode	2	-	0.03	pf
Grid No.1 to grid No.2	2	18	24	pf
Grid No.2 to plate	2	5.7	8.0	pf
Grid No.2 to cathode	2	2.0	4.0	pf
3. Grid-No.1 Voltage	1,3	-6	-24	volts
4. Grid-No.2 Current	1,3	-7	+8	ma

Note 1: With 2.9 volts (AC or DC) on filament.

Note 2: Measured with special shield adapter.

Note 3: With dc plate voltage of 700 volts, dc grid-No.2 voltage of 250 volts, and dc grid-No.1 voltage adjusted to give a dc plate current of 185 ma.

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[a] The heating time required for adequate cathode emission is a function of the filament voltage and the impedance of the filament-voltage supply. It may be drastically reduced by employing a suitably designed overvoltage control circuit.

[b] Measured with special shield adapter.

[c] The maximum rating for a signal having a minimum peak-to-average power ratio less than 2, such as is obtained in "Single-Tone" operation, is 300 ma. During short periods of circuit adjustment under "Single-Tone" conditions, the average plate current may be as high as 450 ma.

[d] Maximum plate dissipation is limited by the maximum plate core temperature and the cooling system to maintain tube operation below the specified maximum plate core temperature. With simple low-cost cooling techniques, maximum plate dissipation may be only about 100 watts; with more sophisticated cooling techniques, maximum plate dissipation may be as high as 300 watts.

[e] Obtained preferably from a separate well-regulated source.

[f] This value represents the approximate grid-No.1 current obtained due to initial electron velocities and contact-potential effects when grid No.1 is driven to zero volts at maximum signal.

[g] Driver power output represents circuit losses and is the actual power measured at input to grid-No.1 circuit. The actual power required depends on the operating frequency and the circuit used. The tube driving power is approximately zero watts.

[h] With maximum signal output used as a reference, and without the use of feedback to enhance linearity.

[j] This value of useful power is measured at load of output circuit.

[k] The tube should see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes.

[m] Driver power output includes circuit losses and is the actual power measured at the input to the grid circuit. It will vary depending upon the frequency of operation and the circuit used.

DEFINITIONS

CCS — Continuous Commercial Service.

Rating System — The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

Two-Tone Modulation — Two-Tone Modulation operation refers to that class of amplifier service in which the input consists of two monofrequency rf signals having equal peak amplitude.

GENERAL CONSIDERATIONS

Temperature

The maximum terminal temperature of 250° C and the maximum plate core temperature of 250° C are tube ratings and are to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. The latter is made by the Tempil Corporation, 132 W.22nd Street, New York 11, N.Y.

Mounting

The 8462 may be mounted by a variety of techniques; however, the frequency of operation and the heat sink to be used will narrow the selection. The base socket, finger-stock grid-No.2 ring (if used), or plate-conduction clamp used in the tube mounting may be fixed. The remaining connector (s) must be adjustable in a plane normal to the major tube axis to compensate for variations in concentricity for the associated parts of the tube.

STRUCTURAL ARRANGEMENT

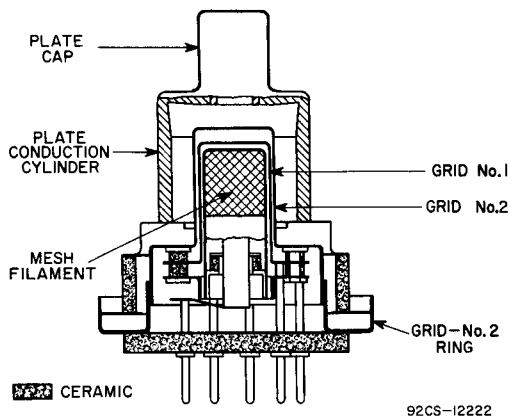

Fig.1

The plate cap is primarily a protective covering for the exhaust tip-off but may be used as the plate terminal by using a flexible cap connector; it may not be clamped, nor form a portion of the cooling system.

ELECTRICAL CONSIDERATIONS

Filament

The filament of the 8462 should be operated at constant voltage rather than constant current. Voltages to other electrodes may be applied simultaneously with the rated filament voltage.

The life of the cathode can be conserved by operating at the lowest filament supply voltage which will give the desired performance. Good regulation of the filament supply voltage is, in general, economically advantageous from the viewpoint of tube life; for constant voltage operation, the voltage fluctuations should not be more than 5%. This recommendation is particularly applicable at the higher operating frequencies.

Grid No.1

Grid No.1 of the 8462 in uhf service is subjected to heating caused not only by the normal electron bombardment as indicated by the grid current, but also by radiation from the cathode and circulating rf currents. For these reasons, more than ordinary care must be taken during operation to prevent exceeding the grid-No.1 current rating and the maximum grid-No.1 terminal temperature rating.

Grid No.2

The grid-No.2 current of the 8462 may be negative under certain operating conditions. The voltage for grid No.2 should be obtained from a source of good regulation; if a separate source is used, a maximum impedance of 10,000 ohms and a minimum divider current of 40 milliamperes are required; if a voltage divider from the plate supply is used, a maximum impedance of 10,000 ohms between the grid-No.2 and ground is required. The plate voltage should be applied before or simultaneously with grid-No.2 voltage; otherwise, with voltage on grid-No.2 only, its current may be large enough to cause excessive grid-No.2 dissipation.

The grid-No.2 current is a very sensitive indication of plate-circuit loading. When the 8462 is operated without load, the grid-No.2 current rises excessively, often to a value which

TYPICAL PLATE CHARACTERISTICS
At a Constant Grid-No.2 Voltage of 400 Volts

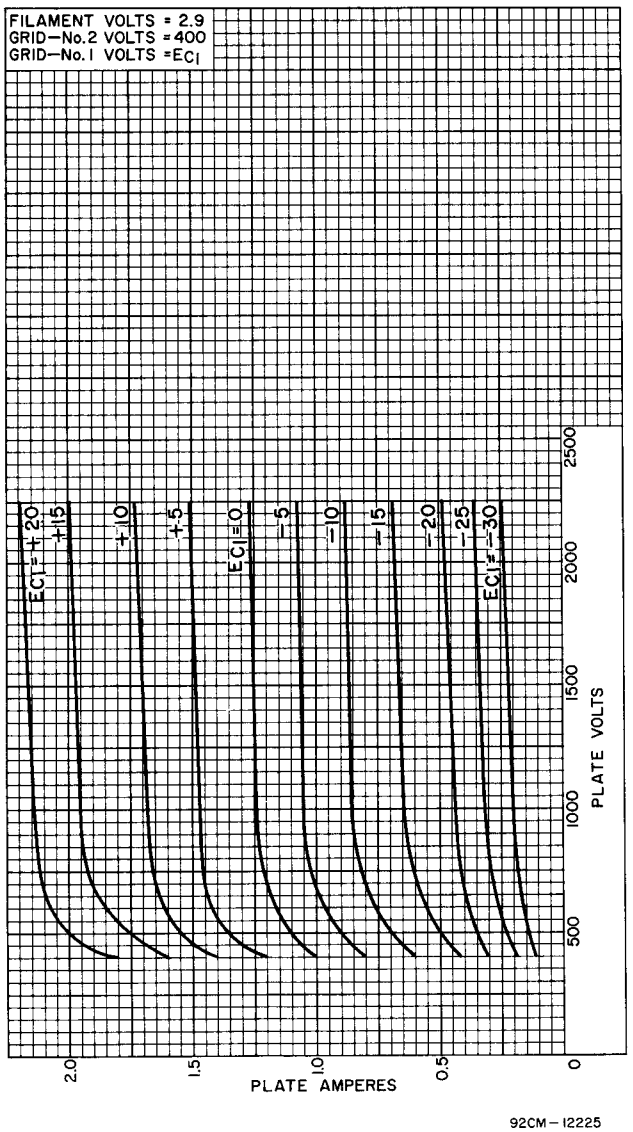

Fig.2

TYPICAL CHARACTERISTICS
At a Constant Grid-No.2 Voltage of 400 Volts

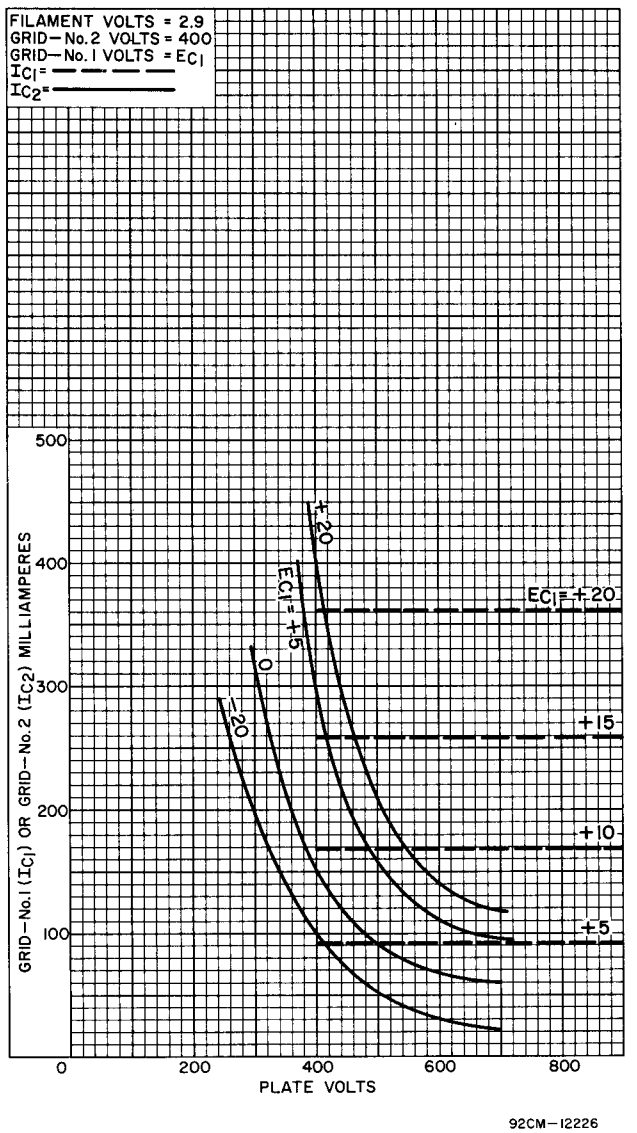

Fig.3

damages the tube. Therefore, care should be taken when tuning the 8462 circuit under no-load or lightly loaded conditions to prevent exceeding the grid-No.2 input rating of the tube. In this connection, reduction of the grid-No.2 voltage will be helpful.

tubes due to internal flashing is more prevalent when the circuit is not tuned to optimum conditions. Even though laboratory tests indicate that no such protection is needed, poor circuit adjustment in the field may result in shortened tube life.

TYPICAL CONSTANT-CURRENT CHARACTERISTICS

At a Constant Grid-No.2 Voltage of 400 Volts

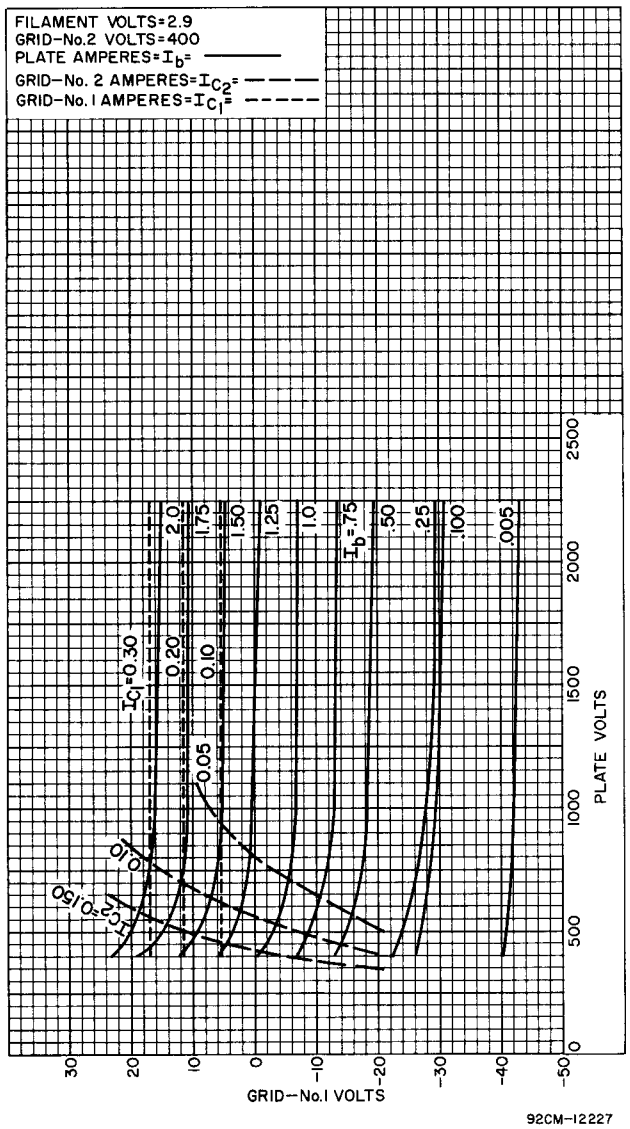

Fig.4

TYPICAL PLATE CHARACTERISTICS

At a Constant Grid-No.2 Voltage of 250 Volts

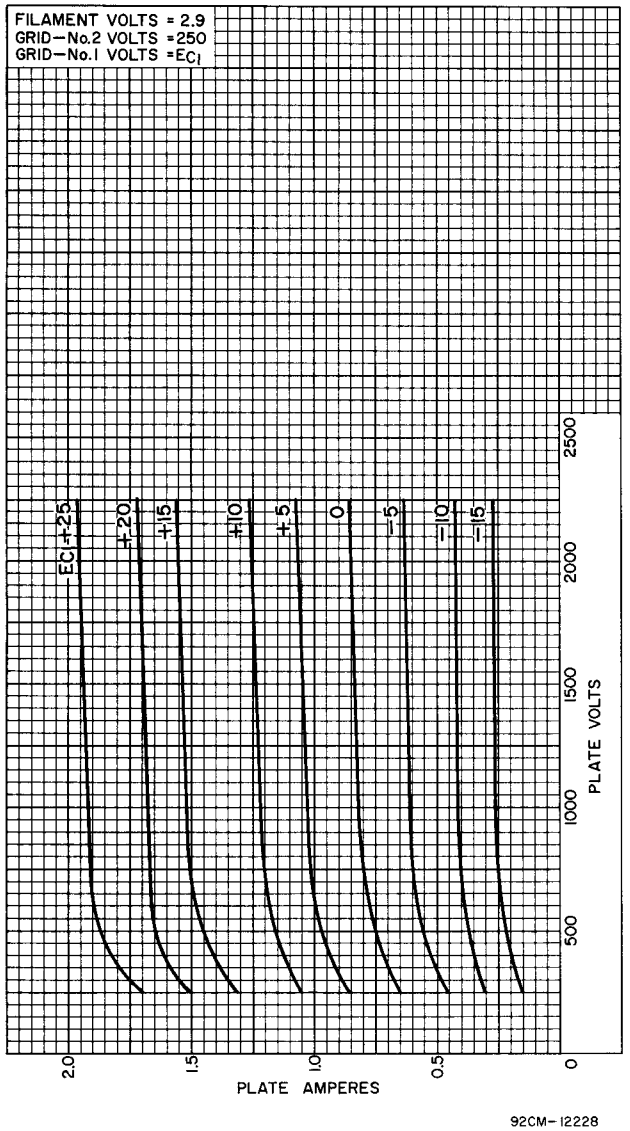

Fig.5

Plate

In tubes, such as the 8462, having very closely spaced electrodes, extremely high voltage gradients occur even with moderate tube operating voltages. Any tube flash-arcing may be destructive. It is recommended that each tube see an effective plate supply impedance which limits the peak current through the tube under surge conditions to 15 amperes. Failure of the

Driver

The driver power output shown in the typical operation of the 8462 in rf service is considerably more than is normally calculated for typical driving power input in order to permit considerable range of adjustment, and also to provide for losses in the grid-No.1 circuits and the coupling circuits. This consideration is particularly important at the higher frequencies where circuit

losses, radiation losses, and transit-time losses increase, and the effects of cathode-lead inductive reactance becomes significant.

Class C RF Telegraphy Service

In class C rf telegraphy service, the 8462 may be supplied with bias by any convenient method except when the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying. In this case, an amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value.

Protective Devices

Protective devices should be used to protect not only the plate but also grid No.2 against overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the common ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the dc plate and grid-No.2 voltage when the average value of plate current reaches a value slightly higher than normal plate current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the dc grid-No.2 current reaches a value slightly higher than normal.

Precautions

The rated plate and grid-No.2 voltages of this tube are extremely dangerous. Great care should be taken during the adjustment of circuits.

TYPICAL CHARACTERISTICS
At a Constant Grid-No.2 Voltage of 250 Volts

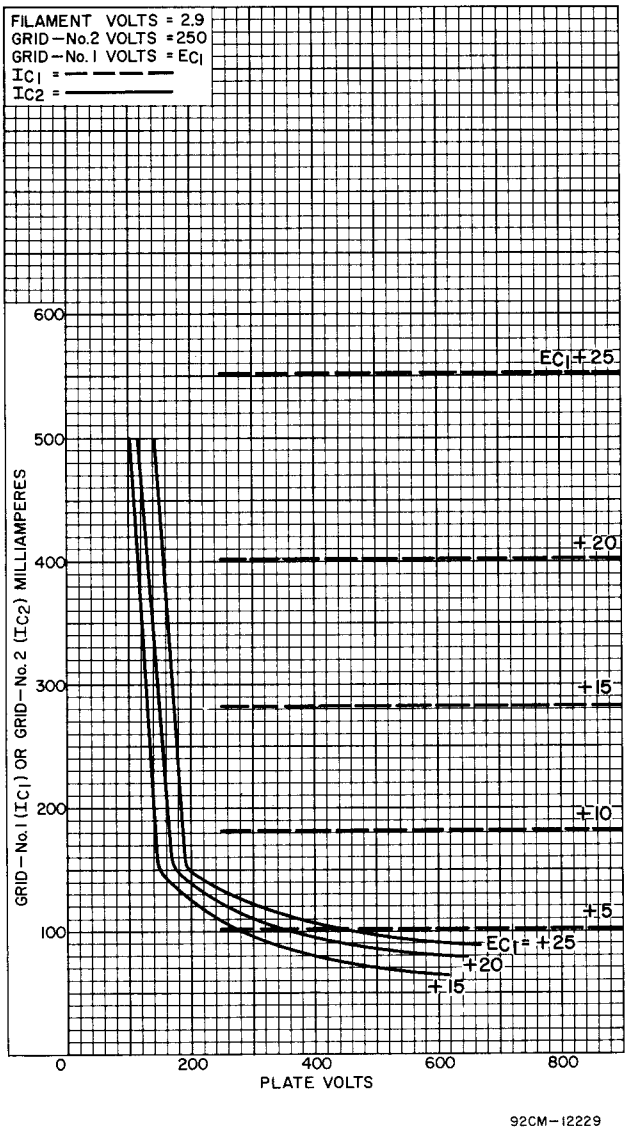

Fig.6

TYPICAL CONSTANT-CURRENT CHARACTERISTICS
At a Constant Grid-No.2 Voltage of 250 Volts

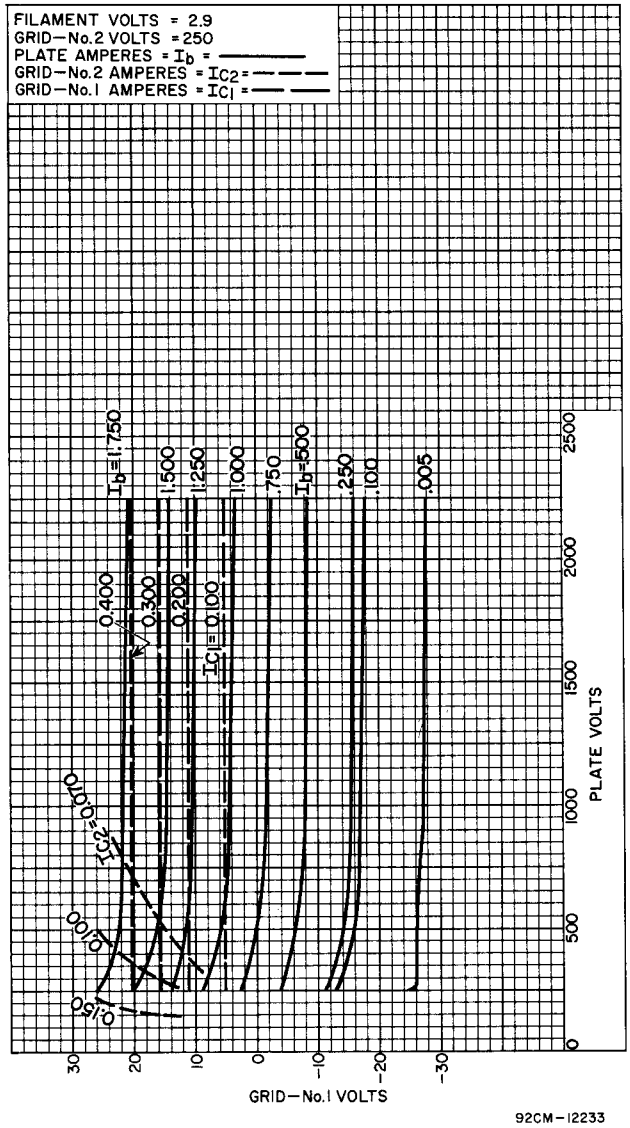

Fig.7

The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies when any gate or door on the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

TYPICAL PLATE CHARACTERISTICS
At a Constant Grid-No.2 Voltage of 150 Volts

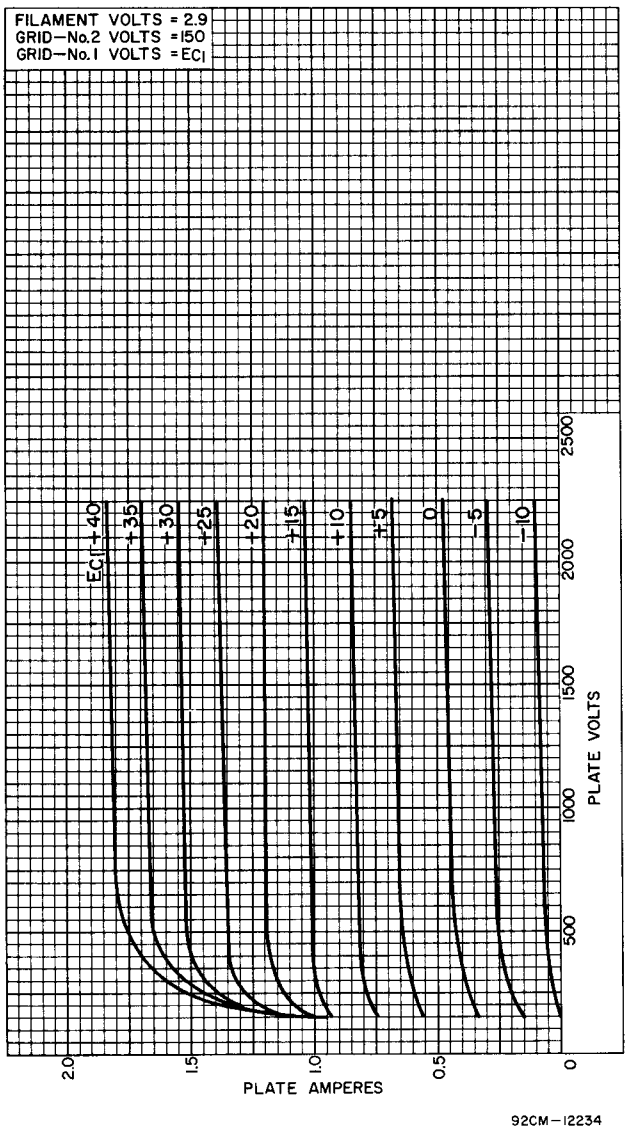

Fig.8

COOLING CONSIDERATIONS

System

The conduction-cooling system consists, in general, of a constant temperature device (heat sink) and suitable heat-flow path (coupling) between the heat sink and tube. Primary consideration of the system should be given to the design of a heat-flow path (coupling device) with high thermal conductivity.

Thermal conductivity is defined as the time rate of transfer of heat by conduction, through unit thickness, across unit area for unit difference of temperature. It is measured in watts per square inch for a thickness of one inch and a difference of temperature of 1° C (See *Table of Conversion Factors for Thermal Conductivity)* as shown in the following equation:

$$K = \frac{W}{A\frac{(T_2 - T_1)}{L}} \qquad (1)$$

TYPICAL CHARACTERISTICS
At a Constant Grid-No.2 Voltage of 150 Volts

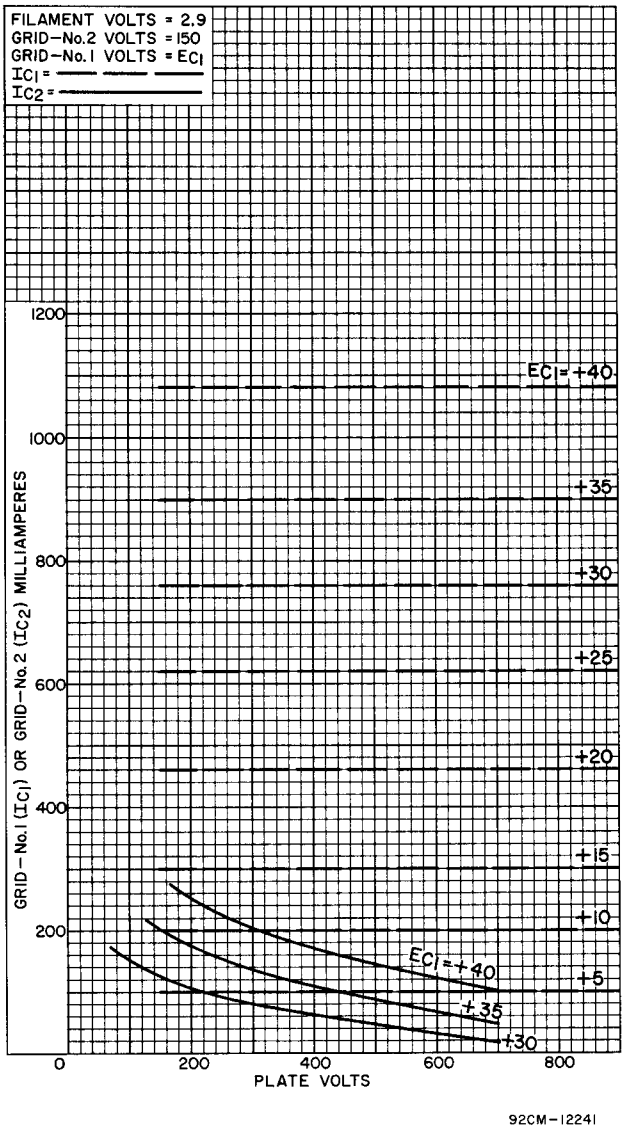

Fig.9

where;

K = thermal conductivity of the material

W = power transfer in watts

A = area measured at right angles to the direction of the flow of heat in square inches

T_1, T_2 = temperature in degrees Centigrade of planes or surfaces under consideration

L = length of heat path in inches through coupling material to produce temperature gradient

For a given system Equation (1) must be integrated to consider changes in area (A) dependent on the coupling configuration and changes in thermal conductivity (K) dependent on various coupling materials and interfaces. Equation (1) may now be reduced to the following:

$$K_s = \frac{W_p}{T_2 - T_1} \qquad (2)$$

where;

K_s = thermal conductance of the system

W_p = maximum permissible plate dissipation in watts

T_2 = temperature in degrees Centigrade at tube terminal

Note: *This value may never exceed the specified maximum rating for terminal temperature.*

T_1 = temperature in degrees Centigrade of heat sink

Heat Sink

The heat sink should be designed to act as a constant-temperature device; that is, to prevent any increase in temperature by dissipating the heat beyond the equipment compartment. Heat sinks can take the form of solids or liquids. In most applications such a heat sink is available in the form of equipment chassis, plate line, or output cavity. Mechanically, the equipment chassis is the most practical heat sink as shown in Reference 1. At uhf frequencies, coaxial elements, tuned lines or cavities become more feasible because of increasing rf losses across supports to equipment chassis.

Coupling

There are numerous insulating materials available to serve as the heat-coupling device such as beryllium oxide (beryllia), high-aluminum oxide (high alumina), mica and other insulating bodies. The thermal conductivity of these insulators varies considerably. The choice of insulator will then be dependent primarily on the plate dissipation in the given application. As shown in Fig. 11 beryllia has much higher thermal conductivity than its nearest competitor, high alumina.

Beryllia provides the unique properties required for coupling the tube to the heat sink: low electric conductivity (volume resistivity-

TYPICAL CONSTANT-CURRENT CHARACTERISTICS
At a Constant Grid-No.2 Voltage of 150 Volts

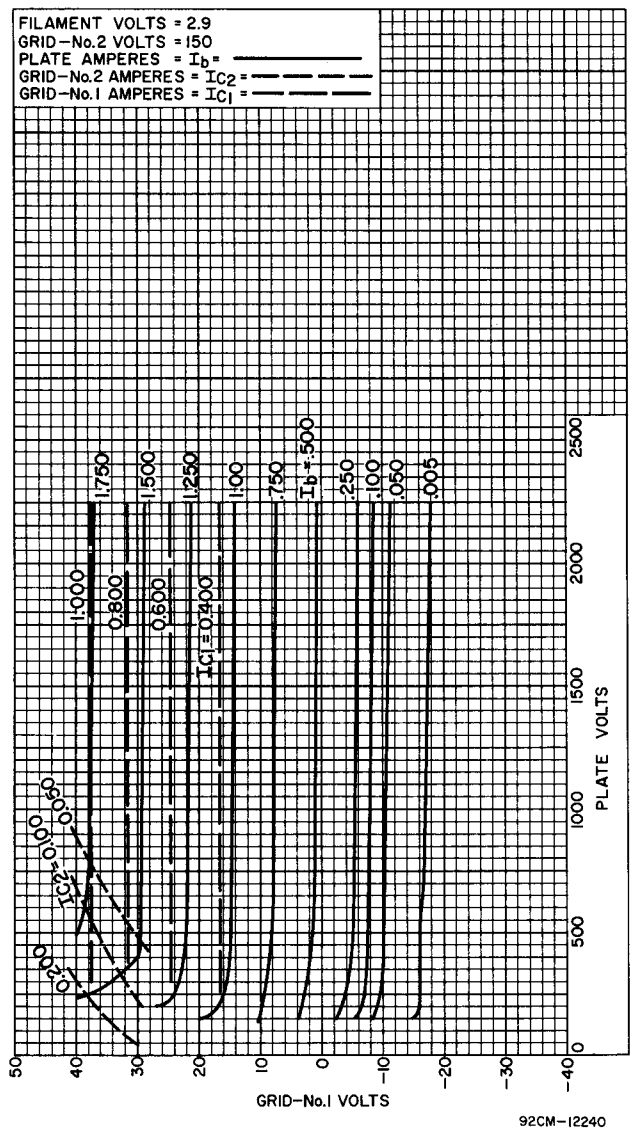

Fig.10

10^{16} ohm-cm) and high thermal conductivity (2.9 watts/in^2 - °C at 200° C).

Precaution: Beryllia dust and fumes are highly toxic to mucous membranes and may cause serious ulcers when imbedded under the skin. See References 2, 3, and 4.

At low frequencies the inductive element of the plate circuit is usually a relatively long coil which does not provide a good thermal path

from plate to chassis. The shunt capacity is large, however, and heat can be conducted through a portion of it to the chassis. At high frequencies the shunt capacity of the plate circuit is limited but the inductive element is short and can be made with sufficient cross-sectional area to form an excellent thermal path.

Conduction Properties of the Tube

The cylindrical plate terminal is nickel-plated copper with high thermal conductivity to conduct the heat of plate dissipation to the surface of the plate terminal. The cooling system for a given application should be designed to dissipate the heat from the tube. The matching coupler to the tube should have a surface to provide intimate thermal contact with the plate terminal. See Reference 7.

It may also be necessary to couple grid No.2, grid No.1, filament-cathode, and filament terminals to the heat sink. In all cases it is necessary to maintain all terminals at a temperature under the maximum temperature of 250° C. Tube life can be increased by maintaining all terminal temperatures substantially below the maximum temperature rating.

HEAT-TRANSFER CHARACTERISTICS
of Various Materials

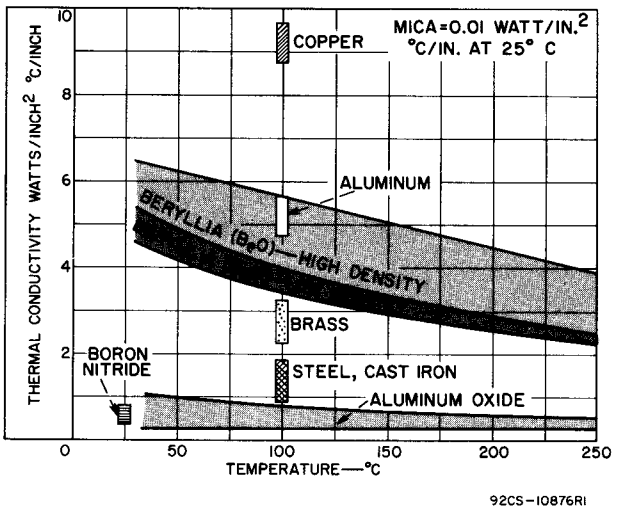

Fig.11

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TABLE OF CONVERSION FACTORS FOR THERMAL CONDUCTIVITY

Multiply	by	To Get
B.T.U./(sq ft)(hr)(^{o}F/ft)	.0440	watts/(sq in)(^{o}C/in)
B.T.U./(sq ft)(hr)'^{o}F/in)	.00367	watts/(sq in)(^{o}C/in)
calories/(sq cm)(sec)(^{o}C/cm)	10.66	watts/(sq in)(^{o}C/in)
watts/(sq cm)(^{o}C/cm)	2.54	watts/(sq in)(^{o}C/in)

REFERENCES

1. J.E. Brosz and R.H. Decker, *"Beryllia Aids Equipment Cooling"*, Electronic Equipment Engineering, Jan. 1960.
2. D.W. White, Jr., and J.E. Burke, *"The Metal Beryllium"* (book), published by the American Society for Metals, Cleveland, Ohio.
3. Donald P. O'Neil, *"Toxic Materials Machined Safely"*, American Machinist, June 4, 1955.
4. Sidney Laskin, Robert A.N. Turner, and Herbert E. Stokinger, *"Analysis of Dust and Fume Hazards in a Beryllium Plant"*, U.S. Atomic Energy Commission, MDDC-1355.
5. James J. Gangler, *"Some Physical Properties of Eight Refractory Oxides and Carbides"*, American Ceramic Society Journal, Vol. 33, December 1950.
6. W.D. Kingery, J. Francl, R.L. Coble, and T. Vasilos, *"Thermal Conductivity X — Data for Several Pure Oxide Materials Corrected to Zero Porosity"*, American Ceramic Society Journal, Vol. 37, February 1954.
7. Graff, *"Thermal Conductance Across Metal Joints"*, Machine Design, September 15, 1960.
8. John W. Gaylord, *"Conduction Cooling of Power Tubes in Vehicular Communication Equipment"*, IEEE PTGVC Transactions, Vol. 12, September 1963.

BERYLLIA PRODUCTS MAY BE OBTAINED FROM THE FOLLOWING REPRESENTATIVE LIST OF SUPPLIERS:

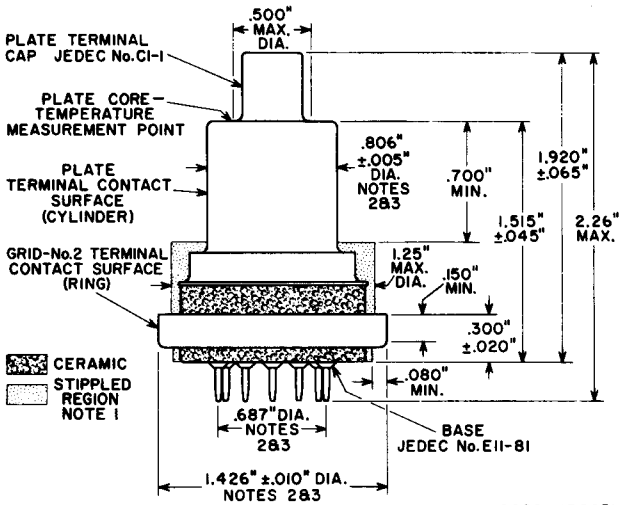
National Beryllia Corp.
First & Haskell Aves.
Haskell, N.J.

Brush Beryllium Corp.
5209 Euclid Ave.
Cleveland 3, Ohio

The Beryllium Corp. of America
P.O. Box 1462
Reading, Pennsylvania

Frenchtown Porcelain Co.
Eighth & Harrison Sts.
Frenchtown, New Jersey

DIMENSIONAL OUTLINE



NOTE 1: KEEP ALL STIPPLED REGIONS CLEAR. DO NOT ALLOW CONTACTS OR CIRCUIT COMPONENTS TO PROTRUDE INTO THESE ANNULAR VOLUMES.

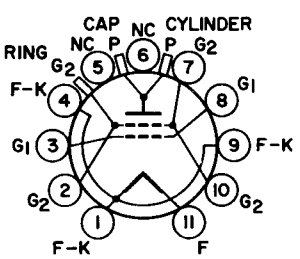
NOTE 2: THE DIAMETERS OF THE PLATE TERMINAL CONTACT SURFACE, GRID-No.2 TERMINAL CONTACT SURFACE, AND PIN CIRCLE TO BE CONCENTRIC WITHIN THE FOLLOWING VALUES OF MAXIMUM FULL INDICATOR READING:

Plate Terminal Contact Surface to Grid-No.2 Terminal Contact Surface. . .	0.030"
Plate Terminal Contact Surface to Pin Circle.	0.040"
Grid-No.2 Terminal Contact Surface to Pin Circle.	0.030"

NOTE 3: THE FULL INDICATOR READING IS THE MAXIMUM DEVIATION IN RADIAL POSITION OF A SURFACE WHEN THE TUBE IS COMPLETELY ROTATED ABOUT THE CENTER OF THE REFERENCE SURFACE. IT IS A MEASURE OF THE TOTAL EFFECT OF RUN-OUT AND ELLIPTICITY.

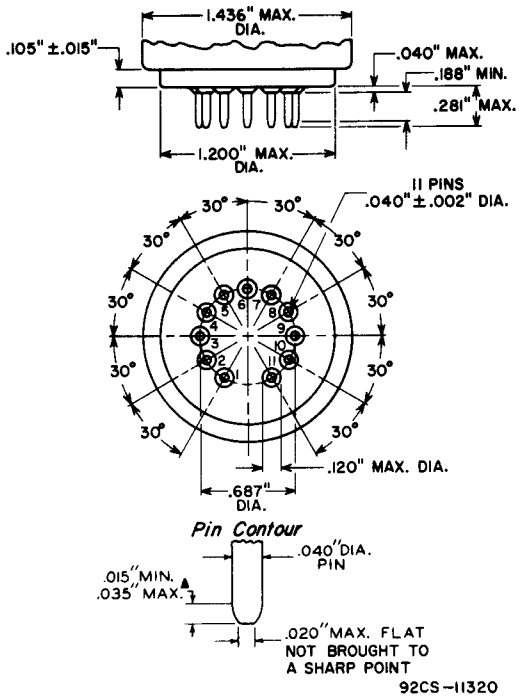
TERMINAL CONNECTIONS

PIN 1: FILAMENT-CATHODE
PIN 2: GRID No.2
PIN 3: GRID No.1
PIN 4: FILAMENT-CATHODE
PIN 5: NO CONNECTION
PIN 6: NO CONNECTION
PIN 7: GRID No.2
PIN 8: GRID No.1
PIN 9: FILAMENT-CATHODE



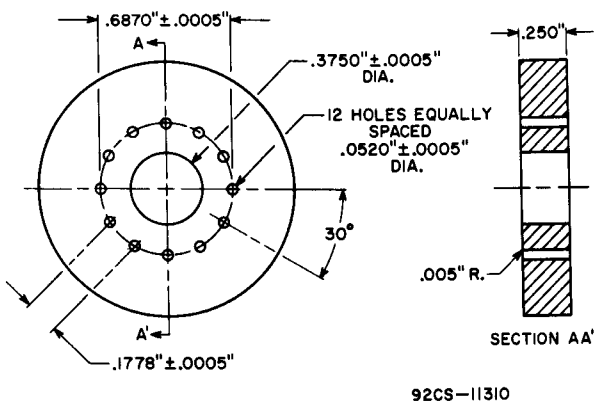
PIN 10: GRID No.2
PIN 11: FILAMENT
CAP: PLATE TERMINAL CONNECTION
CYLINDER: PLATE TERMINAL CONTACT SURFACE (To contact to conduction-cooling system)
RING: GRID-No.2 TERMINAL CONTACT SURFACE (For use at higher frequencies)

BASE DRAWING
LARGE-WAFER ELEVENAR 11-PIN WITH RING JEDEC No.E11-81



* THIS DIMENSION AROUND THE PERIPHERY OF ANY INDIVIDUAL PIN MAY VARY WITHIN THE LIMITS SHOWN.

GAUGE DRAWING
JEDEC No.GE11-1



H-1587

CERMOLOX®
500 W PEP Output
38 dB Open Loop Third Order Distortion
43 dB Third Order Distortion w/Cathode R
Full Input to 400 MHz
Ruggedized, Reliable
Matrix Oxide Cathode

RCA-8791

Beam Power Tube

The RCA-8791* is designed specifically to meet the high linearity and low noise requirements of modern HF, single sideband equipments. In these equipments it can deliver 500 watts peak envelope power output at an open loop third order distortion level of better than 38 dB and a fifth order distortion level of better than 44 dB.

Its high gain, CERMOLOX tube construction and full input rating to 400 MHz also make it ideally suited for higher frequency applications such as VHF-TV modulated driver service and VHF or UHF Class B linear service where it will deliver one kilowatt peak sync. or 200 watts carrier output respectively.

The ruggedized, low inductance, coaxial construction of the 8791 enables the use of simple, economical circuit techniques in all HF, VHF, and UHF applications.

Its matrix oxide cathode enhances system reliability while the efficient, forced-air cooled radiator reduces system air requirements and permits more reliable, lower temperature operation.

To assure compliance with environmental design objectives, sample tubes are regularly subjected to 50g-11 millisecond shock; 500g-3/4 millisecond shock; and also 20g-2000 hertz vibration testing.

*Formerly RCA Dev. Type A2912

General Data

Electrical:

Heater-Cathode:		
Type	Unipotential, Oxide Coated, Matrix Type	
Voltage[a] (ac or dc)	6.3 typ.	V
	6.6 max.	V
Current at 6.3 volts	7.5	A
Minimum heating time	120	s
Mu-Factor, (Grid No.2 to Grid No.1)	13	
Direct Interelectrode Capacitances[b]:		
Grid No.1 to plate	0.11 max.	pF
Grid No.1 to cathode & heater	28	pF
Plate to cathode & heater	0.011 max.	pF
Grid No.1 to grid No.2	38	pF
Grid No.2 to plate	5.5	pF
Grid No.2 to cathode & heater	1.1 max.	pF

Mechanical:

Operating Position	Any
Overall Length (61.0 mm)	2.40 max. in
Greatest Diameter (64.8 mm)	2.55 max. in
Terminal Connections	See *Dimensional Outline*
Sockets	See page 7
Radiator	Integral part of tube
Weight (Approx.) (0.3 kg)	3/4 lb

Thermal:

Seal Temperature[c] (Plate, grid No.2, grid No.1, cathode-heater and heater)	250 max. °C
Plate-Core Temperature	250 max. °C

Footnotes for General Data

[a] See V.A.3 of 1CE-300.
[b] Measured with special Adapter.
[c] See *Dimensional Outline* for temperature measurement points.

This bulletin gives application information unique to the RCA 8791. General information, covering the installation and operation of this tube type, is given in the **"Application Guide for RCA Power Tubes"**, 1CE-300. Close attention to the instructions contained therein will assure longer tube life, safer operation, less equipment downtime, and fewer tube handling accidents.

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Printed in U.S.A. | 3-68

Linear RF Power Amplifier, Class AB_1[d]
Single-Sideband Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 400 MHz	
DC PLATE VOLTAGE	3,000 max.	V
DC GRID-No.2 VOLTAGE	750 max.	V
DC PLATE CURRENT AT PEAK OF ENVELOPE[e]	750 max.	mA
GRID No.2 INPUT	25 max.	W
PLATE DISSIPATION	1,000 max.	W

Maximum Circuit Values:

GRID-No.1 CIRCUIT RESISTANCE		
With fixed bias	15,000 max.	Ω
With cathode bias	Not recommended	
PLATE CIRCUIT IMPEDANCE	See Note f	
GRID-No.2 CIRCUIT IMPEDANCE	See Note g	

Typical Class AB_1 CCS Operation with "Two-Tone Modulation":

		at 30 Mc		
DC Plate Voltage	2000	2000	2500	V
DC Grid-No.2 Voltage	450	450	350	V
DC Grid-No.1 Voltage	–34	–32	–26	V
Zero-Signal DC Plate Current	250	250	200	mA
Effective RF Load Resistance	1850	1850	2750	Ω
DC Plate Current at Peak of Envelope	535	545	430	mA
Average DC Plate Current	400	410	320	mA
DC Grid-No.2 Current at Peak of Envelope	–1.2	+0.2	–4.0	mA
Average DC Grid-No.2 Current	–4.0	–4.0	–3.0	mA
Peak RF Grid-No.1 Voltage	30	40	22	V
Output-Circuit Efficiency (Approx.)	90	90	90	%
Distortion Products Level:				
Third Order	37	42	37	dB
Fifth Order	49	54	53	dB
Unbypassed Cathode Resistor	0	10	0	Ω
Useful Power Output (Approx.)				
Average	250	250	250	W
Peak envelope	500	500	500	W

Linear RF Power Amplifier[d]
Class AB or Class B Telephony

Carrier conditions for use with a maximum modulation factor of 1.0

Maximum CCS Ratings, *Absolute-Maximum Values:*

DC PLATE VOLTAGE	3000 max.	V
DC GRID-No.2 VOLTAGE	750 max.	V
DC PLATE CURRENT	500 max.	mA
GRID-No.2 INPUT	25 max.	W
PLATE DISSIPATION	1000 max.	W

Calculated CCS Operation as a Class AB_1 Amplifier

In a cathode drive circuit, at 400 MHz with an output circuit bandwidth of 10.0 MHz.[h]

DC Plate Voltage	2500	V
DC Grid-No.2 Voltage	450	V
DC Grid-No.1 Voltage	–45	V
DC Plate Current	340	mA
DC Grid-No.1 Current	0	A
DC Grid-No.2 Current	–2.0	mA
Drive Power	8.0	W
Output Circuit Efficiency (Approx.)	80	%
Useful Power Output	200	W

Footnotes for Ratings

[d] See Section V.C. of 1CE-300.

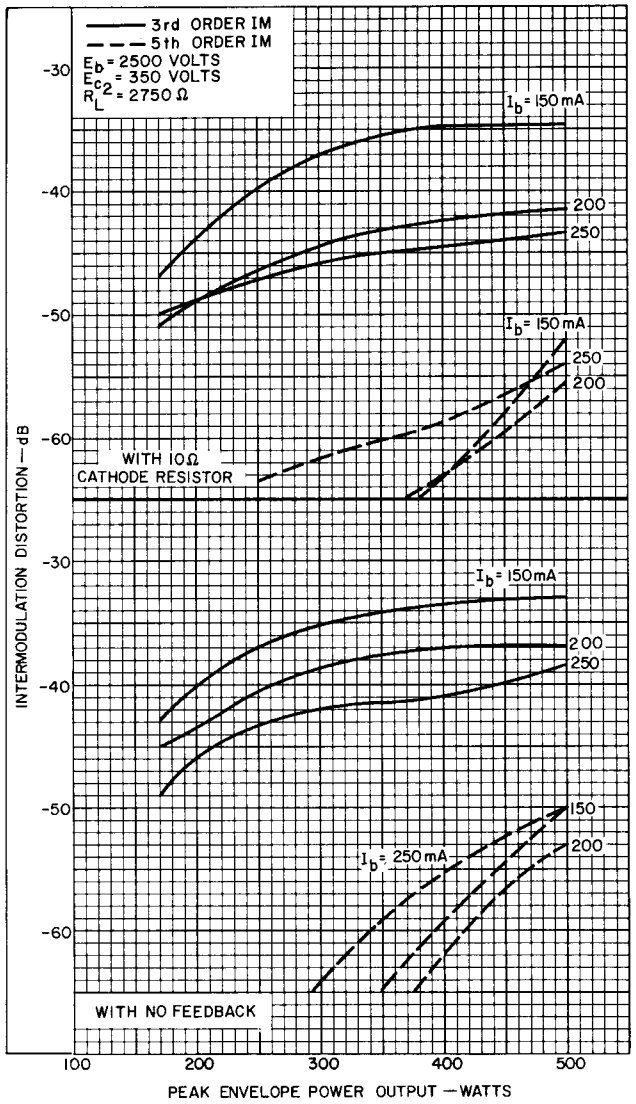
[e] During short periods of circuit adjustment, under "Single Tone" conditions, the average plate current may be as high as 750 mA.

[f] See Sections V.B. and V.B.1 of 1CE-300.

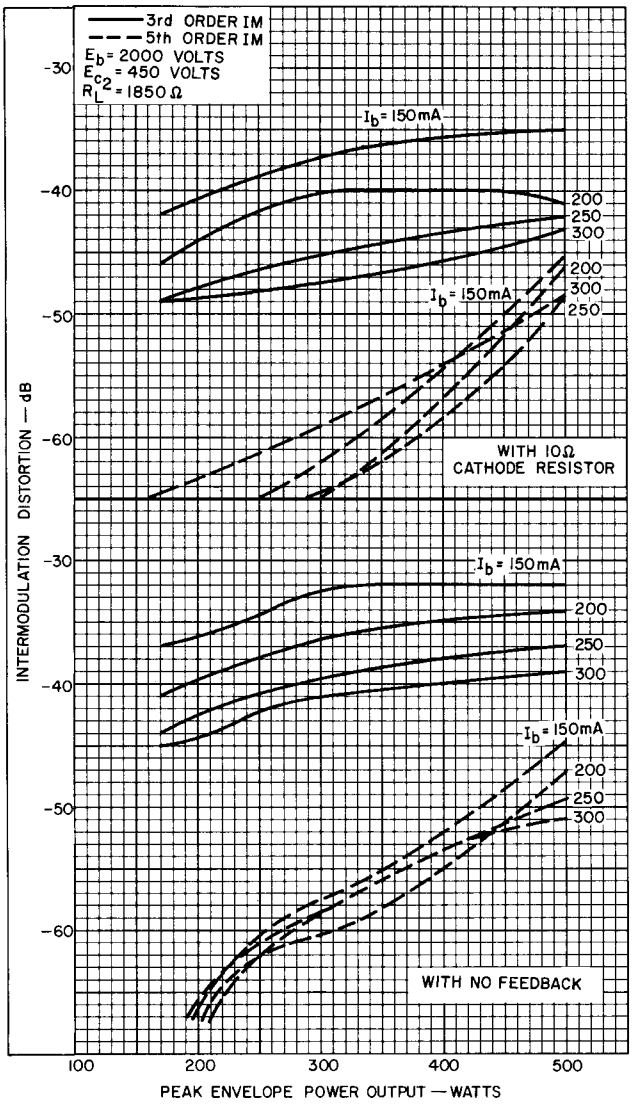
[g] See Section V.B.2 of 1CE-300.

[h] Computed between half power points and based on 1-1/2 times tube output capacity.

Intermodulation Distortion Versus Power Output



92LM-2389



92LM-2390

Grid-Modulated RF Power Amplifier — Class C Television Service[d]

Synchronizing-level conditions per tube unless otherwise specified

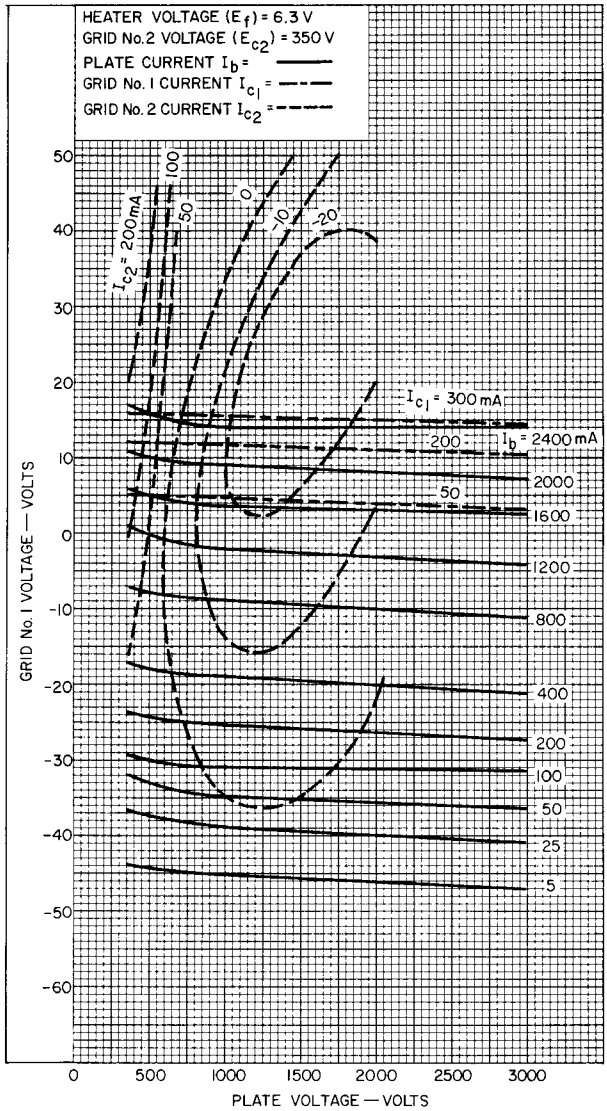
Maximum CCS Ratings, *Absolute-Maximum Values:*

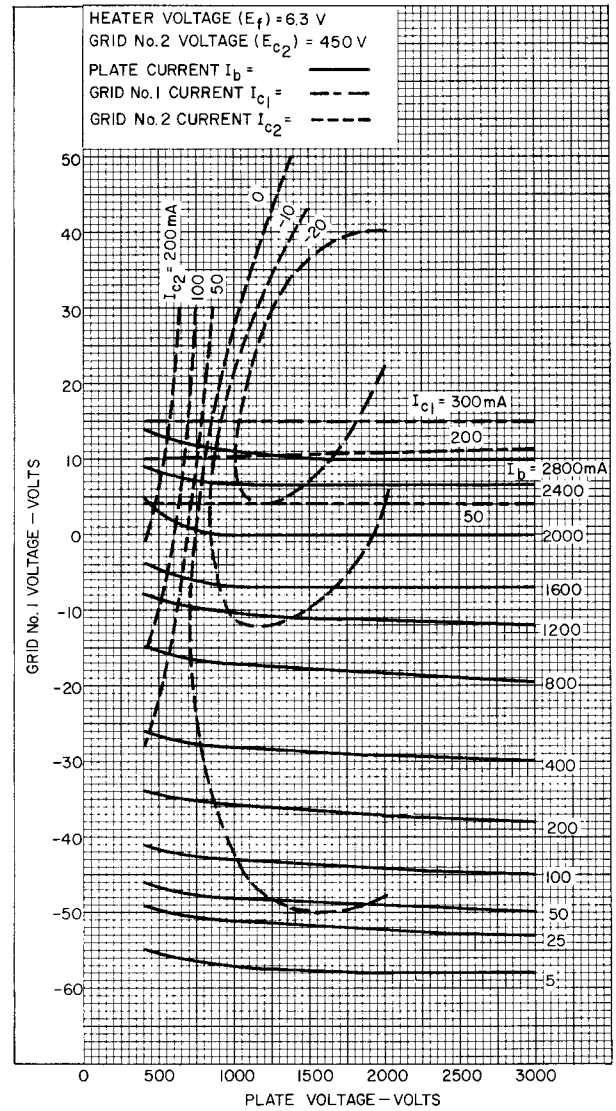
	Up to 216 MHz	
DC PLATE VOLTAGE	3000 max.	V
DC GRID-No.2 VOLTAGE	750 max.	V
DC GRID-No.1 VOLTAGE (White level)	−250 max.	V
DC PLATE CURRENT	750 max.	mA
GRID-No.2 INPUT	25 max.	W
PLATE DISSIPATION	1000 max.	W
GRID-No.1 CURRENT	100 max.	mA

Calculated Operation in Grid-Drive Circuit at 216 MHz Bandwidth of 8.5 MHz[h]

DC Plate Voltage	2700	V
DC Grid-No.2 Voltage	450	V
DC Grid-No.1 Voltage:		
Synchronizing level	−70	V
Pedestal level	−80	V
White level	−110	V
Peak RF Grid-No.1 Voltage	70	V
DC Plate Current:		
Synchronizing level	700	mA
Pedestal level	500	mA
DC Grid-No.1 Current (Approx.):		
Synchronizing level	0	A
Pedestal level	0	A
Driver Power Output (Approx.):		
Synchronizing level	8	W
Pedestal level	4.5	W
Useful Power Output (Approx.):		
Synchronizing level	1100	W
Pedestal level	615	W

Typical Constant Current Characteristics





Characteristics Range Values	Note	Min.	Max.	Unit
1. Heater Current	j	6.9	8.3	A
2. Direct Interelectrode Capacitances:				
Grid No.1 to plate	k	—	0.11	pF
Grid No.1 to cathode & heater	k	26	32	pF
Plate to cathode & heater	k		0.011	pF
Grid No.1 to grid No.2	k	34	41	pF
Grid No.2 to plate	k	4.3	6.3	pF
Grid No.2 to cathode & heater	k	—	1.1	pF
3. Reverse Grid-No.1 current	j,m	—	–50	μA
4. Peak Emission	n,p	80	—	A
5. Interelectrode Leakage Resistance	r	8.0	—	MΩ
6. Cutoff Grid-No.1 Voltage	j,s	—	–87	V

Footnotes for Range Values

[i] With 6.3 V ac or dc on heater.

[k] Measured with special shield adapter.

[m] With dc plate voltage of 2500 volts, dc grid-No.2 voltage of 400 volts, and dc grid-No.1 voltage adjusted to give a plate current of 240 mA.

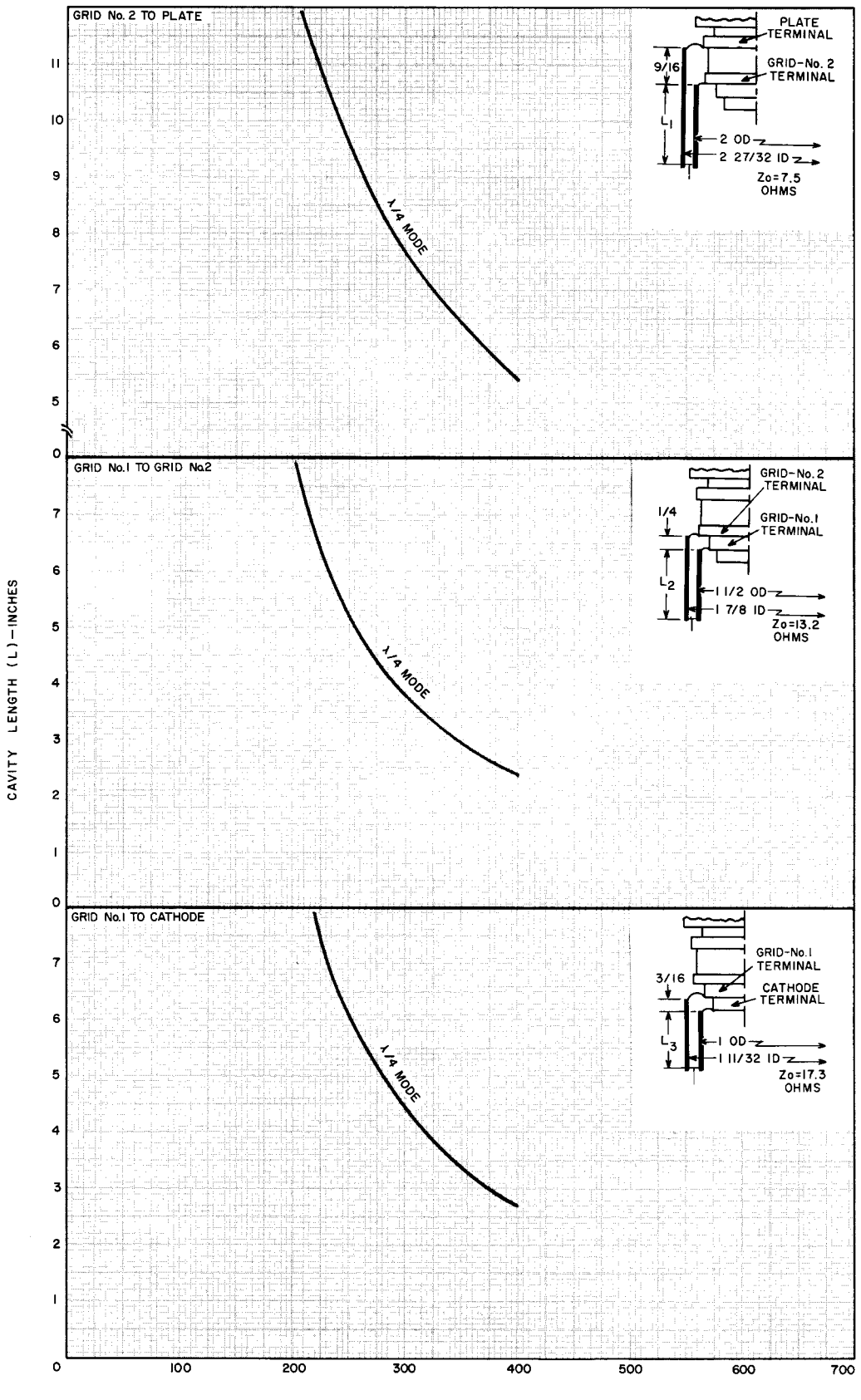
[n] See V.A.3 of 1CE-300.

[p] For conditions with grid-No.1, grid-No.2, and plate tied together; and pulse voltage source of 850 peak volts, between plate and cathode. Pulse duration is 2 microseconds, pulse repetition frequency is 60 pps, and duty factor is 0.00012. Peak emission current is read after 1 minute.

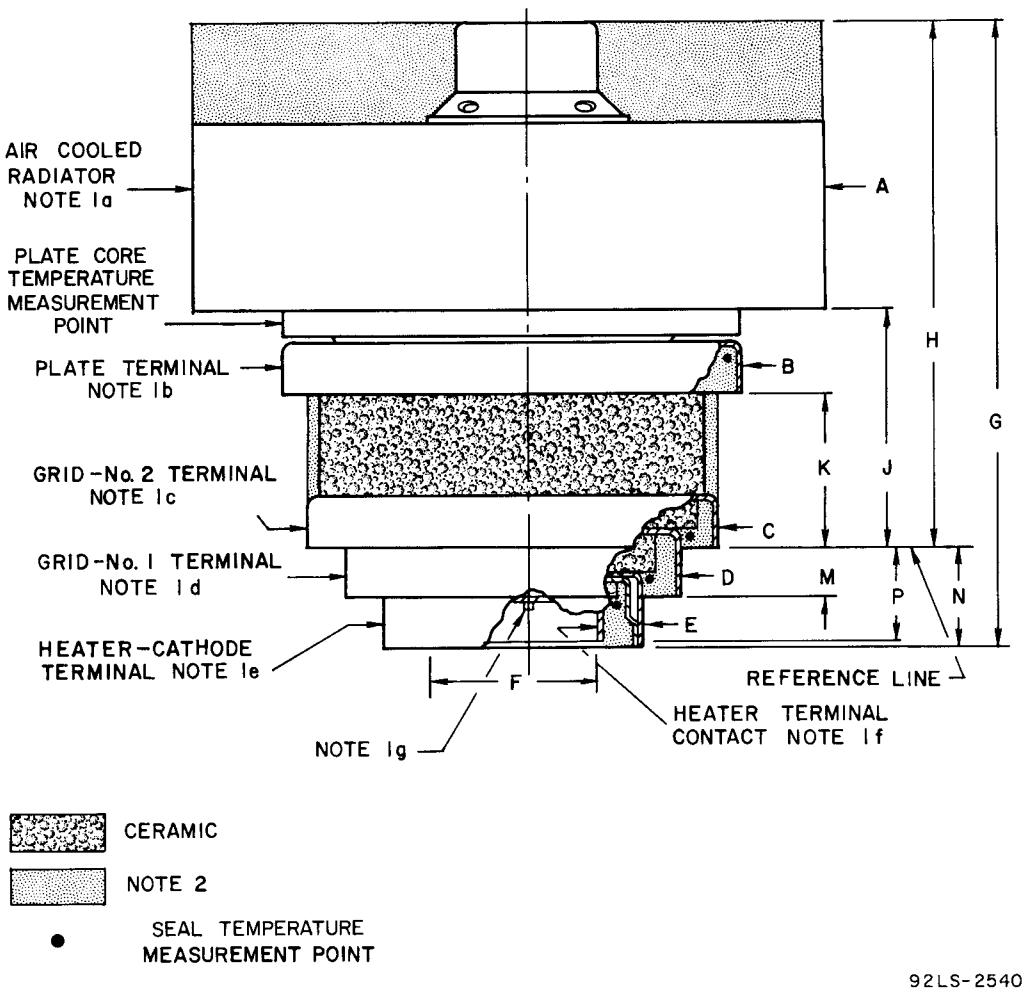
[r] Under conditions with tube at 20° to 30° C for at least 30 minutes without any voltages applied to the tube. The minimum resistance between any two electrodes (except across heater terminals) is measured with a 200-volt Megger-type ohmmeter having an internal impedance of 1.0 megohm.

[s] With dc plate voltage of 2500 volts, dc grid-No.2 voltage of 400 volts, and dc grid-No.1 voltage adjusted to give a plate current of 5 mA.

Electrode Cavity Tuning Characteristics



Dimensional Outline



Tabulated Dimensions *

Dimension	Value		
A	2.52	(64.0)	Max. Dia.
B	1.745	(44.32)	Min. Dia.
C	1.590	(40.38)	Min. Dia.
D	1.290	(32.76)	Min. Dia.
E	0.99	(25.14)	Min. Dia.
F	0.67	(17.02)	Max. Dia.
G	2.40	(60.96)	Max.
H	1.94 ± .04	(49.28 ± 1.01)	
J	0.895 ± .035	(22.73 ± .88)	
K	0.575 ± .025	(14.61 ± .63)	
M	0.20 ± .02	(6.08 ± .50)	
N	0.40 ± .020	(10.16 ± .50)	
P	0.385 ± .025	(9.78 ± .63)	

*Dimensions are in inches unless otherwise stated. Dimensions in parentheses are in millimeters and are derived from the basic inch dimension (1 inch = 25.4 mm).

Note 1: The contact distance* listed is the indicated, uniform length as measured from the edge of the terminal. Concentricity between the various diameters is maintained within such tolerances that the tube will enter a gauge having suitably spaced apertures or post of the indicated diameters*.

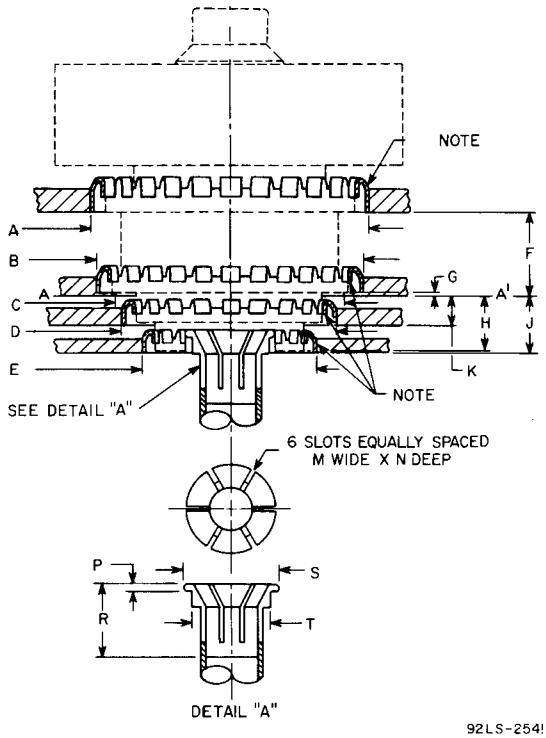
Note	Element	Contact Distance	Gauge Diameter
1a.	Radiator	0.755 (19.1) min.	2.550 (64.70)
1b.	Plate Terminal	0.145 (3.68) min.	1.801 (45.75)
1c.	Grid-No.2 Terminal	0.150 (3.81) min.	1.611 (40.92)
1d.	Grid-No.1 Terminal	0.180 (4.57) min.	1.321 (33.56)
1e.	Heater-Cathode Terminal	0.160 (4.06) min.	1.021 (25.94)
1f.	Heater Terminal(post)	0.115 (2.92) max.	0.619 (15.72)
1g.	Pin		0.062 (1.58)

Note 2: Keep all stippled regions clear. Do not allow contacts or circuit components to protrude into these annular volumes. Diameters of stippled areas above air-cooled radiator, plate terminal contact surface, and grid-No.2 terminal contact surface shall not be greater than its associated diameter.

Mounting

See the preferred mounting arrangement below. See section III.C.3a of 1CE-300 for a description of the fixed method of mounting. The adjustable method is not recommended for the 8791. Special sockets are available.

Preferred Mounting Arrangement and Layout of Associated Contacts



Note: Contact Strip: No.97-360A as made by: Instrument Specialties Co., Little Falls, N.J.

Socket (with G_2 bypass)	Erie 9806-002 or equivalent
Socket (w/o bypass)	Jettron 89-081 or equivalent
Grid-No.2 Bypass	Erie 9811-000 or equivalent

Sockets may be obtained from:

Erie Technological Products Inc.
644 West 12th Street, Erie, Pa. 16512

Jettron Products Incorporated
56 Route 10, Hanover, N.J. 07936

Tabulated Dimensions*

Dimension	Value		
A	1.938 ± .001	(49.225 ± .025)	Dia.
B	1.746 ± .001	(44.348 ± .025)	Dia.
C	1.550 ± .001	(39.370 ± .025)	Dia.
D	1.448 ± .001	(36.779 ± .025)	Dia.
E	1.148 ± .001	(29.159 ± .025)	Dia.
F	0.591 ± .005	(15.01 ± .12)	
G	0.040 ± .005	(1.02 ± .12)	
H	0.385 ± .005	(9.78 ± .12)	
J	0.400 ± .005	(10.16 ± .12)	
K	0.184 ± .005	(4.67 ± .12)	
M	0.020 ± .010	(0.51 ± .25)	
N	0.400 ± .005	(10.16 ± .12)	
P	0.050 ± .005	(1.27 ± .12)	
R	0.500 ± .005	(12.70 ± .12)	
S	0.670 ± .001	(17.018 ± .025)	Dia.
T	0.565 ± .005	(14.35 ± .12)	Dia.

*Dimensions are in inches unless otherwise stated. Dimensions in parentheses are in millimeters and are derived from the basic inch dimension (1 inch = 25.4 mm).

Forced-Air Cooling

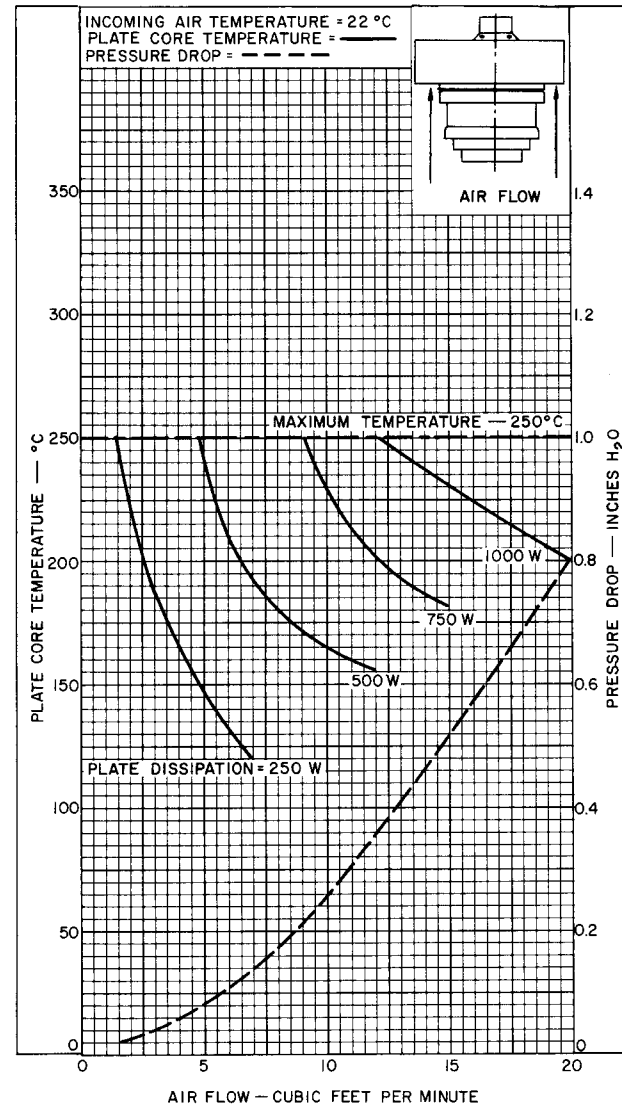
Air Flow:

Through radiator – Adequate air flow to limit the plate-core temperature to 250° C should be delivered by a blower through the radiator before and during the application of filament, plate, grid-No.2, and grid-No.1 voltages. In typical operation at 750 watts plate dissipation and 200° C plate core temperature 12 cfm at 0.36 inch of water at 22° C ambient air temperature should be sufficient as shown on Air Flow Chart.

To Plate, Grid-No.2, Grid-No.1, Cathode-Filament, and Filament Terminals – A sufficient quantity of air should be allowed to flow past each of these terminals so that their temperature does not exceed the specified maximum value of 250° F.

During Standby Operation – Cooling air is required when only filament voltage is applied to the tube.

During Shutdown Operation – Air flow should continue for a few minutes after all electrode power is removed



H-1588

CERMOLOX®

1000 Watts PEP Output

37 dB Open Lood Third Order Distortion

42 dB Third Order Distortion w/Cathode R

Full Input to 400 MHz

Sturdy, Reliable

Matrix Oxide Cathode

RCA-8792

Beam Power Tube

The RCA-8792* is designed specifically to meet the high linearity and low noise requirements of modern HF, single sideband equipments. In these equipments it can deliver one kilowatt, peak envelope power output at an open loop, 3rd order distortion level of better than 37 dB and 5th order distortion level of better than 45 dB.

Its high gain, CERMOLOX tube construction also makes it ideally suited to modern FM broadcast equipment where it can deliver one kilowatt output at 70% efficiency with a gain of better than 20 dB.

It is equally well suited to VHF-TV applications where it will deliver over one kilowatt of peak sync power output, and to UHF, Class B linear service, where it will deliver 300 watts carrier power output.

The sturdy, coaxial, CERMOLOX tube construction minimizes tube inductances and feed-thru capacitances. This enables the use of simple, economical circuit techniques for HF and UHF operation and also minimizes induced noise problems in linear systems. Its efficient, forced-air-cooled radiator reduces blower noise problems and increases overall system efficiency, while the rugged matrix cathode increases system reliability.

*Formerly RCA Dev. No. A2887A.

General Data

Electrical:

Heater-Cathode:		
Type	Unipotential, Oxide Coated, Matrix Type	
Voltage[a] (ac or dc)	5.5 typ. / 5.8 max.	V
Current (@ 5.5 V)	17.3	A
Minimum Heating Time	180	s
Mu Factor[b] (Grid No.1 to Grid No.2)	6.5	
Direct Interelectrode Capacitances:		
Grid No.1 to Plate[c]	0.14	pF
Grid No.1 to Cathode-Heater	38	pF
Plate to Cathode-Heater[c]	0.02	pF
Grid No.1 to Grid No.2	52	pF
Grid No.2 to Plate	16	pF
Grid No.2 to Cathode-Heater[c]	1.4	pF

Mechanical:

Operating Position	Any
Maximum Length	(84.8 mm) 3.34 in
Greatest Diameter	(95.3 mm) 3.75 in
Terminal Connection	See *Dimensional Outline*
Socket	See page 7
Radiator	Integral part of tube
Weight (approx.)	(0.9 kg) 2 lbs

Thermal:

Seal Temperature[d] (Plate, Grid No.1, Grid No.2 Cathode-Heater, and Heater)	250 max. °C
Plate Core Temperature[d]	250 max. °C

Footnotes for General Data

[a] See Section V.A. 3 of 1CE-300.

[b] For: plate voltage = 2500 V
grid No.2 voltage = 600 V
plate current = 600 mA

[c] With special shield adapter.

[d] See Dimensional Outline for temperature measurement points.

This bulletin gives application information unique to the RCA-8792. General information, covering the installation and operation of this tube type, is given in the **"Application Guide for RCA Power Tubes"**, 1CE-300. Close attention to the instructions contained therein will assure longer tube life, safer operation, less equipment downtime, and fewer tube handling accidents.

Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

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Linear RF Power Amplifier[e]

Single-Sideband, Suppressed-Carrier Service

Peak envelope conditions for a signal having a minimum peak-to-average power ratio of 2.

Maximum CCS Ratings, *Absolute-Maximum Values:*

	up to 400 MHz	
DC PLATE VOLTAGES[f]	3500 max.	V
DC GRID-No.2 VOLTAGE[g]	1000 max.	V
DC PLATE CURRENT AT PEAK OF ENVELOPE	1.25 max.	A
GRID-No.2 INPUT[g]	50 max.	W
PLATE DISSIPATION	1.5 max.	kW

Maximum Circuit Values:

Grid-No.1-Circuit Resistance Under Any Condition:	
With fixed bias	5000 max. Ω
With cathode bias	Not recommended
Grid-No.2 Circuit Impedance	See note g
Plate Circuit Impedance	See note f

Typical Class AB_1 CCS Operation with "Two-Tone" Modulation

In a grid-drive circuit at 30 MHz

DC Plate Voltage	2500	2500	V
DC Grid-No.2 Voltage	600	600	V
DC Grid-No.1 Voltage[h]	-65	-61	V
Zero-Signal DC Plate Current	0.5	0.6	A
Effective RF Load Resistance	1050	1050	Ω
DC Plate Current at Peak of Envelope	1.0	1.1	A
Average DC Plate Current	0.75	0.85	A
DC Grid-No.2 Current at Peak of Envelope	-0.020	-0.022	A
Average DC Grid-No.2 Current	-0.014	-0.017	A
Peak RF Grid Voltage	50	47	V
Output Circuit Efficiency (Approx.)	90	90	%
Useful Power Output (Approx.):			
Average	530	600	W
Peak Envelope	1060	1200	W
Distortion Products Level[i]			
Third Order	35	37	dB
Fifth Order	45	47	dB

RF Power Amplifier & Oscillator–Class C Telegraphy[e] and RF Power Amplifier–Class C FM Telephony[e]

Maximum CCS Ratings, *Absolute-Maximum Values:*

	up to 400 MHz	
DC PLATE VOLTAGE[f]	3500 max.	V
DC GRID-No.2 VOLTAGE[g]	1000 max.	V
DC GRID-No.1 VOLTAGE[k]	-300 max.	V
DC PLATE CURRENT	1.0 max.	A
DC GRID-No.1 CURRENT	0.2 max.	A
GRID-No.2 INPUT[g]	50 max.	W
PLATE DISSIPATION	1500 max.	W

Maximum Circuit Values:

Grid-No.1-Circuit Resistance	5000 max. Ω
Grid-No.2-Circuit Impedance	See note g
Plate-Circuit Impedance	See note f

Calculated CCS Operation:

In a grid-drive citcuit at 108 MHz with an output circuit bandwidth of 2.0 MHz[n]

DC Plate Voltage	3350 V
DC Grid-No.2 Voltage	500 V
DC Grid-No.1 Voltage	-120 V
DC Plate Current	0.55 A
DC Grid-No.2 Current	-0.010 A
DC Grid-No.1 Current	0 A
Drive Power (Approx.)	15 W
Output-Circuit Efficiency (Approx.)	95 %
Useful Power Output	1250 W

Linear RF Power Amplifier[e]
Class AB or Class B Telephony

Carrier conditions for use with a maximum modulation factor of 1.0

Maximum CCS Ratings, *Absolute-Maximum Values:*

DC PLATE VOLTAGE[f]	3500 max.	V
DC GRID-No.2 VOLTAGE[g]	1000 max.	V
DC PLATE CURRENT	700 max.	mA
GRID-No.2 INPUT	50 max.	W
PLATE DISSIPATION	1500 max.	W

Calculated CCS Operation as a Class AB_1 Amplifier:

In a cathode drive circuit at 400 MHz with an output circuit bandwidth of 3.5 MHz[n]

DC Plate Voltage	2600	V
DC Grid-No.2 Voltage[g]	500	V
DC Grid-No.1 Voltage[m]	-65	V
DC Plate Current	550	mA
DC Grid-No.1 Current	0	A
DC Grid-No.2 Current	-10	mA
Drive Power (Approx.)	25	W
Output Circuit Eff. (Approx.)	90	%
Useful Power Output	300	W

Grid-Modulated RF Power Amplifier[e] –
Class C Television Service

Synchronizing-level conditions per tube unless otherwise specified

Maximum CCS Ratings, *Absolute-Maximum Values:*

	Up to 400 MHz	
DC PLATE VOLTAGE[f]	3500 max.	V
DC GRID-No.2 VOLTAGE[g]	1000 max.	V
DC PLATE CURRENT	1.25 max.	A
GRID-No.2 INPUT	50 max.	W
PLATE DISSIPATION	1500 max.	W
GRID-No.1 CURRENT	200 max.	mA

Typical Operation in Grid-Drive Circuit at 216 MHz

	Bandwidth[p] of 6.0 MHz	
DC Plate Voltage	2500	V
DC Grid-No.2 Voltage	500	V
Peak RF Grid-No.1 Voltage:		
Synchronizing level	80	V
Pedestal level	60	V
DC Grid-No.1 Voltage	-70	V
DC Plate Current:		
Synchronizing level	1.2	A
Pedestal level	0.9	A
DC Grid No.2 Current Pedestal level	-40	mA
DC Grid-No.1 Current (Approx.):		
Synchronizing level	5.0	mA
Pedestal level	00	A
Driver Power Output (Approx.):		
Synchronizing level	110	W
Pedestal level	65	W
Useful Power Output (Approx.):		
Synchronizing level	1350	W
Pedestal level	750	W

Footnotes for Ratings

[e] See Section V.C. of 1CE-300.

[f] See Section V.B. and V.B.1 of 1CE-300.

[g] See Section V.B.2 of 1CE-300.

[h] Adjust to specified zero-signal DC plate current.

[i] The figures for 3rd and 5th order distortion levels are based upon operation with no feedback or neutralization employed to enhance performance. This performance can be improved by approximately five dB by the insertion of a ten ohm, unbypassed cathode resistor. See also Section V.C.2.c.(1) of 1CE-300.

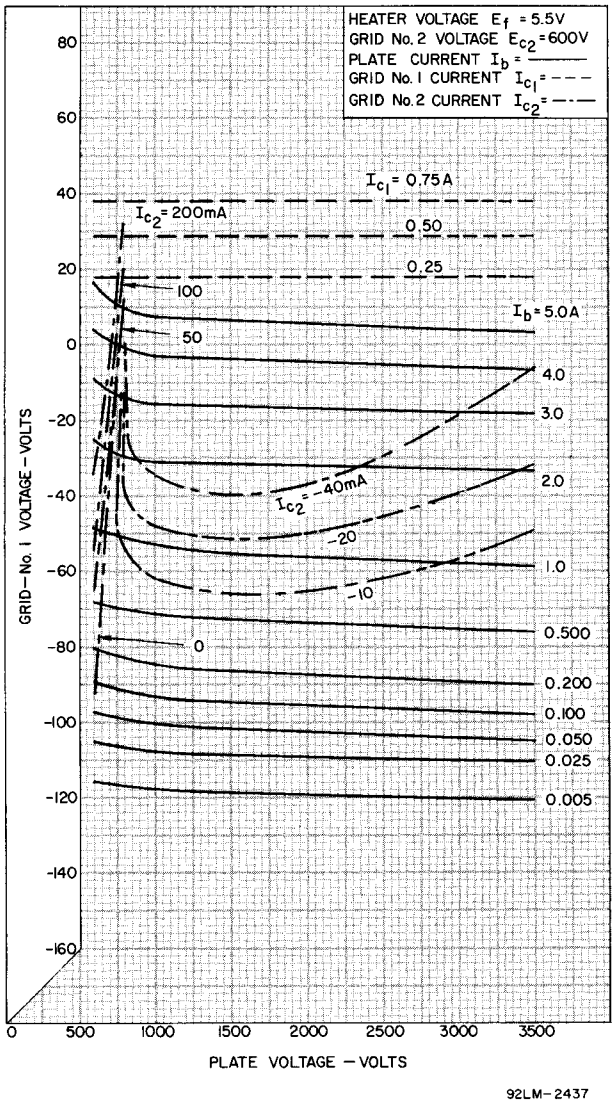
[k] See Section V.B.3 of 1CE-300.

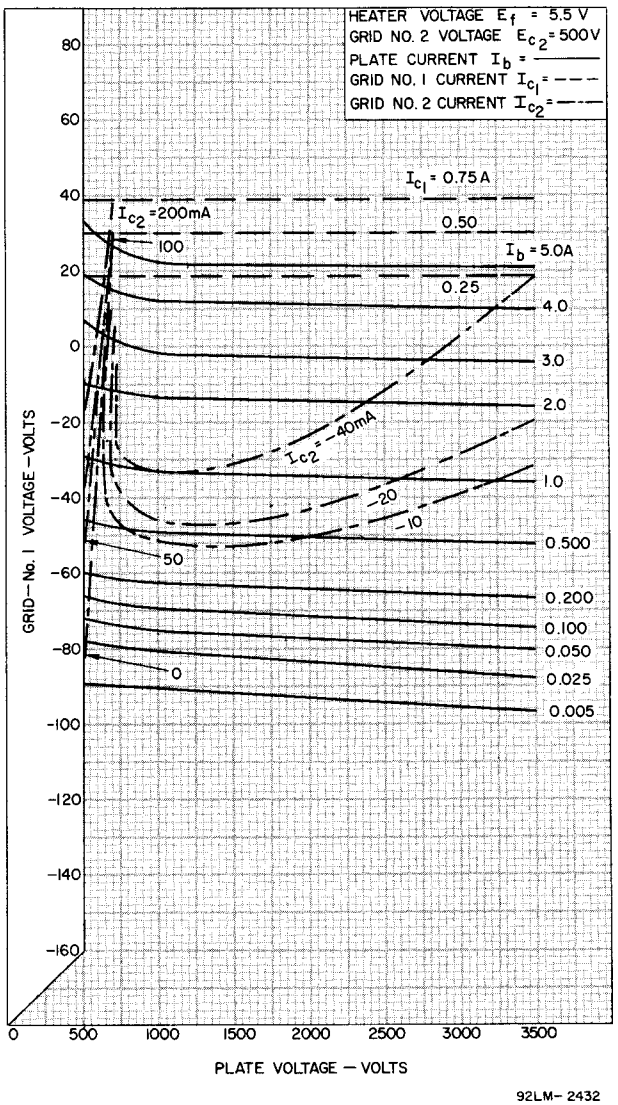
[m] Adjust for zero-signal DC plate current of 0.2 A.

[n] Computed between half-power points using two times tube capacity.

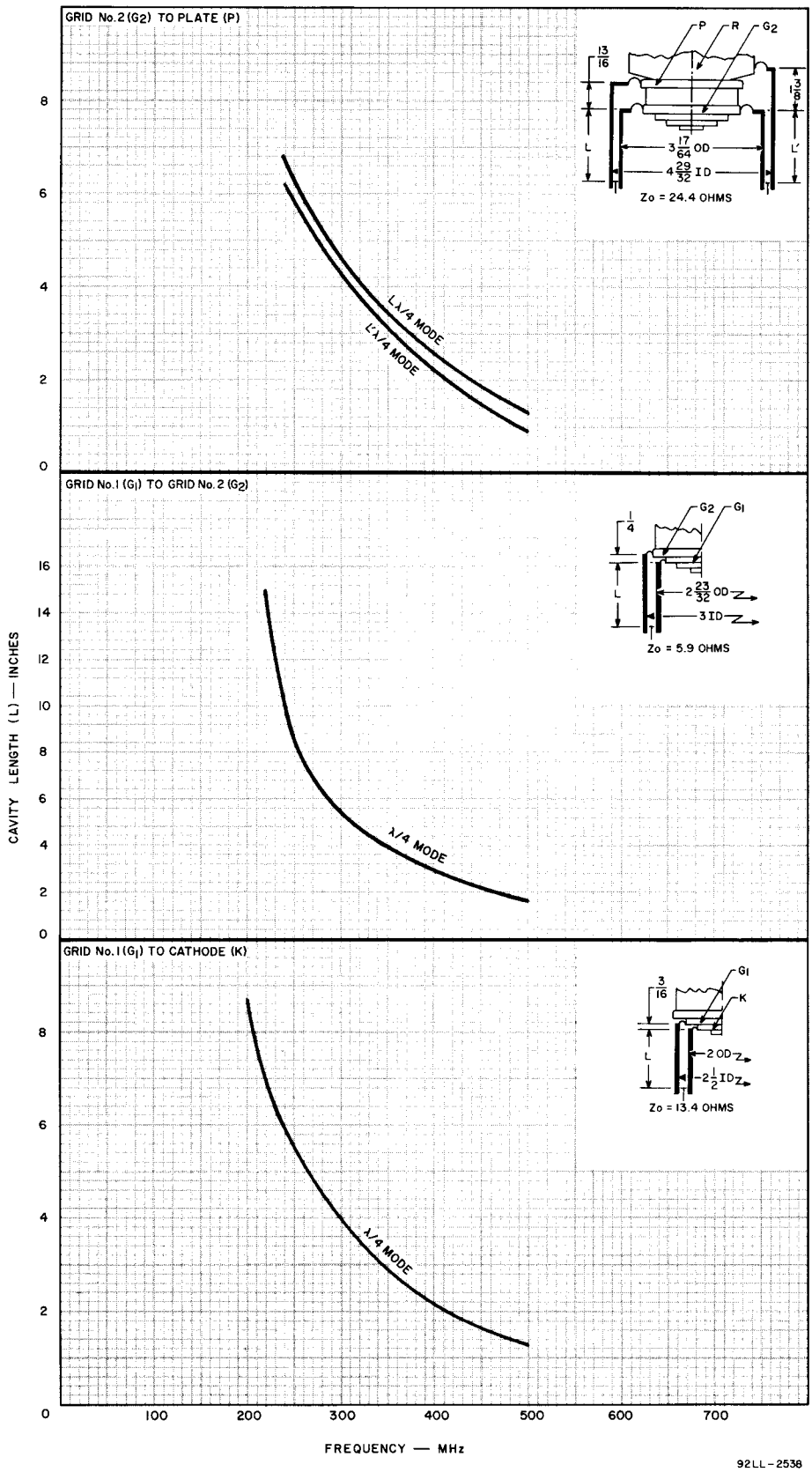
[p] Measured at the -1.0 dB point of a double tuned output circuit.

Typical Constant Current Characteristics

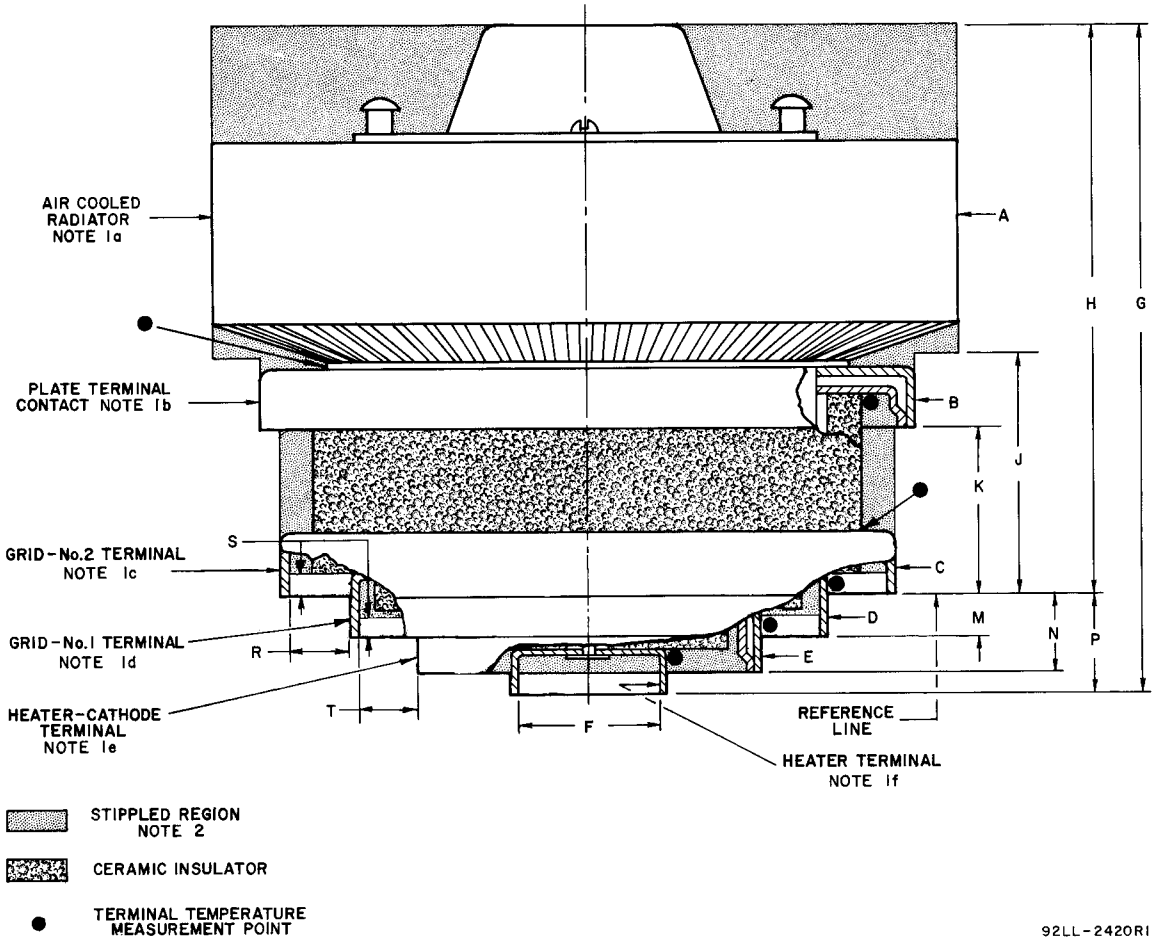




Electrode Cavity Tuning Characteristics



Dimensional Outline



Tabulated Dimensions*

Dim.	Value			
A	3.72 ± .03	(94.49 ± .76)	Dia.	
B	3.210	(81.54)	Dia.	Min.
C	3.010	(76.45)	Dia.	Min.
D	2.307	(58.60)	Dia.	Min.
E	1.710	(43.44)	Dia.	Min.
F	0.725	(18.41)	Dia.	Max.
G	3.24 ± .10	(82.3 ± 2.5)		
H	2.78 ± .07	(70.61 ± 1.78)		
J	$1.160^{+.005}_{-.000}$	$(29.464^{+.127}_{-.000})$		
K	0.82 ± .03	(20.83 ± .76)		
M	0.200 ± .025	(5.08 ± .63)		
N	0.37 ± .03	(9.40 ± .76)		
P	0.46 ± .03	(11.68 ± .76)		
R	0.250	(6.35)		Min.
S	0.105	(2.66)		Min.
T	0.200	(5.08)		Min.

*Dimensions are in inches unless otherwise stated. Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions (1 inch = 25.4 mm).

Note 1: The contact distance* indicated is the minimum uniform length as measured from the edge of the terminal. Concentricity between the various diameters is maintained within such tolerances that the tube will enter a gauge having suitably spaced, concentric apertures or post of the indicated diameters*.

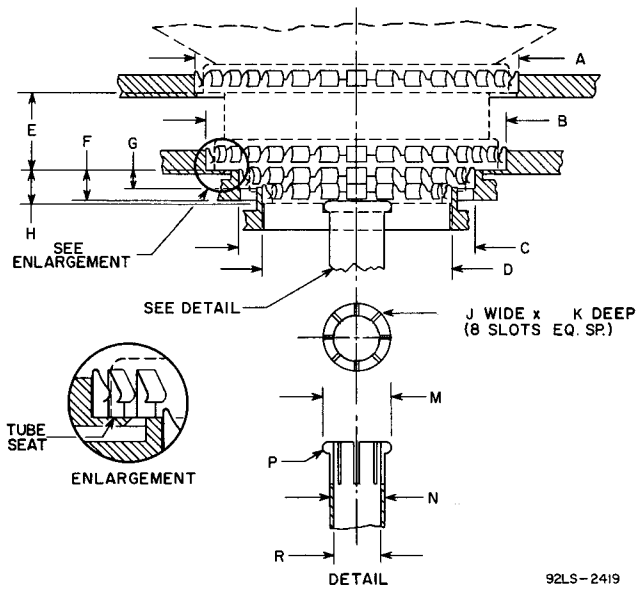
	Contact Distance	Gauge Diameter
1.a Radiator	0.850 (21.59)	3.7805 (96.024)
1.b Plate Terminal	0.220 (5.59)	3.2605 (82.816)
1.c Grid No.2 Terminal	0.220 (5.59)	3.0605 (77.736)
1.d Grid No.1 Terminal	0.175 (4.45)	2.3375 (59.372)
1.e Heater-Cathode Terminal	0.115 (2.92)	1.7445 (41.310)
1.f Heater Terminal (post)	0.135 (3.43)	0.6945 (17.640)

Note 2: Keep all stippled regions clear. In general do not allow contacts to protrude into these annular regions. If special connectors are required which may intrude on these regions, contact RCA Power Tube Application Engineering, Lancaster, Pa., for guidance.

Mounting

See the preferred mounting arrangement below. See section III.C.3.a of 1CE-300 for a description of the fixed method of mounting. The adjustable method is not recommended for the 8792. Special sockets are available.

Preferred Mounting Arrangement and Layout of Associated Contacts



Note: Finger stock is No.97-360A made by Instrument Specialities Co., Little Falls, N.J.

Sockets may be obtained from:

Erie Technological Products, Inc.
644 West 12th Street, Erie, Pa. 16512

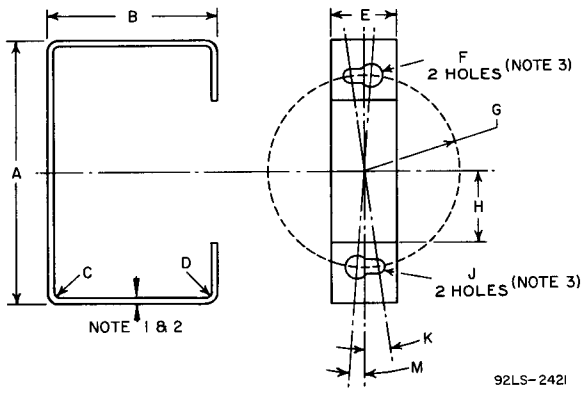
Jettron Products Incorporated
56 Route 10, Hanover, N.J. 07936

Tabulated Dimensions*

Dim.	Value	
A	3.425 (87.00)	Dia.
B	3.210 (81.53)	Dia.
C	2.505 (63.63)	Dia.
D	1.912 (48.56)	Dia.
E	0.820 (20.83)	
F	0.330 (8.38)	
G	0.200 (5.08)	
H	0.370 (9.40)	
J	0.025 (0.64)	
K	0.500 (12.70)	
M	0.725 (18.42)	Dia.
N	0.594 (15.09)	Dia.
P	0.062 (1.57)	Radius
R	0.500 (12.70)	Dia.

*Dimensions are in inches unless otherwise stated. Dimensions in parentheses are in millimeters and are derived from the basic inch dimensions (1 inch = 25.4 mm).

Tube Extractor Suggested Design



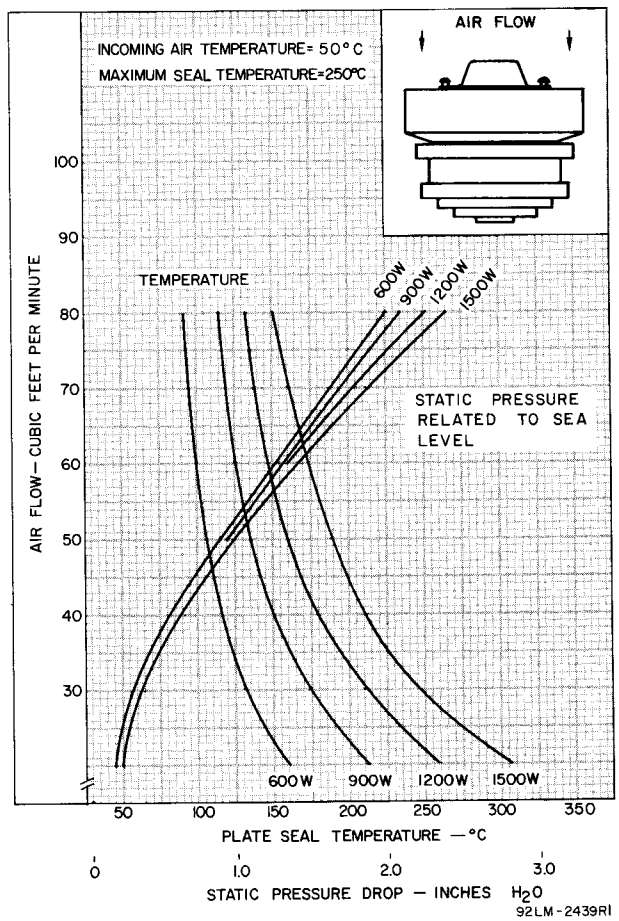
Notes:

1. Material 1/16" thick cold rolled steel
2. Round all edges
3. Slot between holes

Tabulated Dimensions*

Dim.	Value		
A	2.8	(71.)	
B	1.8	(46.)	
C	0.06	(1.5)	Radius
D	0.06	(1.5)	Radius
E	0.7	(18.)	
F	0.250 ± .005	(6.350 ± .127)	Dia.
G	1.015 ± .005	(25.781 ± .127)	Radius
H	0.75	(19.)	
J	0.140 ± .005	(3.556 ± .127)	Dia.
K	8.3°	0.145 radians	
M	4.5°	0.078 radians	

Typical Cooling Characteristics



Forced-Air Cooling

Air Flow:

Through radiator – Adequate air flow to limit the plate-core temperature to 250° C should be delivered by a blower through the radiator before and during the application of filament, plate, grid-No.2, and grid-No.1 voltages. In typical operation at 1500 watts, plate dissipation, and 225° C plate seal temperature, 29 cfm at 0.35 inches of water at 28°C ambient air temperature should be sufficient.

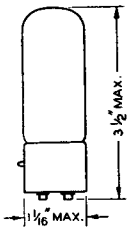
To Plate, Grid-No.2, Grid-No.1, Cathode-Filament, and Filament Terminals – A sufficient quantity of air should be allowed to flow past each of these terminals so that their temperature does not exceed the specified maximum value of 250° C.

During Standby Operation – Cooling air is required when only filament voltage is applied to the tube.

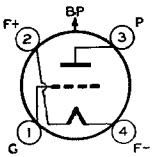
During Shutdown Operation – Air flow should continue for a few minutes after all electrode power is removed.

For further information on forced-air cooling, see section IV.C of 1CE-300.

RCA-V99
and
RCA-X99



V-99



V-99

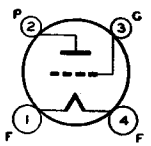
DETECTORS, AMPLIFIERS

The 99 types are three-electrode, general-purpose tubes designed for dry-cell operation. The low power consumption of these tubes makes them applicable to portable receivers and services where power economy is important. The two types have different bases.

CHARACTERISTICS

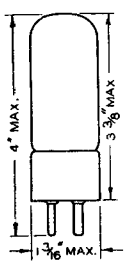
Filament Voltage (D. C.)	3.0- 3.3	Volts
Filament Current	0.060-0.063	Ampere
Plate Voltage	90 *max.*	Volts
Grid Voltage	−4.5	Volts
Plate Current	2.5	Milliamperes
Plate Resistance	15500	Ohms
Amplification Factor	6.6	
Transconductance	425	Micromhos
Grid-Plate Capacitance	3.3	μμf
Grid-Filament Capacitance	2.5	μμf
Plate-Filament Capacitance	2.5	μμf
	Type V99	Type X99
Bulb	T-8	T-9
Base	Small 4-Nub	Small 4-Pin

INSTALLATION



X-99

The base pins of the X99 fit the standard four-contact socket; the V99 fits only the small shell socket with bayonet slot. The sockets should be installed so that the tubes will operate in a vertical position. Cushioning of the sockets in the detector stage may be desirable if microphonic disturbances are encountered.



X-99

APPLICATION

As **detectors,** 99's may be operated either with grid leak and condenser or with grid bias. The recommended plate voltage for the former method is 45 volts. A grid leak of from 1 to 5 megohms used with a grid condenser of 0.00025 μf is satisfactory. The grid-circuit return should be connected to the positive filament terminal. For grid-bias detection the maximum plate voltage of 90 volts may be used with the corresponding negative grid bias of 10.5 volts. The grid bias should be adjusted so that the plate current is 0.2 milliampere with no input signal.

As **amplifiers,** the 99's are applicable to the audio- or the radio-frequency stages of a receiver. Recommended plate and grid voltages are shown under CHARACTERISTICS.

These two types are used principally for renewal purposes.

RADIOTRON
Model WX-12

RATING

Filament Volts - - -	1.1
Filament Amperes - -	.25
Plate Volts (Maximum) -	135

GENERAL

The WX-12 Radiotron is a high vacuum tube designed for use as a detector, radio and audio amplifier. It is electrically identical with the Model WD-12 Radiotron, being intended primarily for dry cell operation.

MOUNTING

The Radiotron WX-12 should be mounted vertically, with the base downward wherever possible. It is also desirable to use cushion supports, especially when this Radiotron is used as a detector.

LARGE STANDARD RADIOTRON BASE

The new large standard Radiotron base with which the WX-12 Radiotron is equipped will fit practically all of the present Navy bayonet type sockets as well as the new "push-type" socket. The connections of the Radiotron elements to the contact pins in the base are shown in the diagram below.

FILAMENT SUPPLY

The filament of the WX-12 is oxide coated and gives great electron emission at low temperatures, at which it is designed to operate. At its rated voltage the filament will glow at a dull red heat, usually invisible in daylight and frequently barely visible in darkness. If the filament voltage, which is controlled by the rheostat, is allowed to exceed its rated value, the Radiotron may be permanently damaged.

While the WX-12 Radiotron may be operated from one dry cell, greater battery economy will be realized by using two cells per Radiotron. All "A" battery cells should be connected in parallel so that the total "A" battery potential remains at 1.5 volts. While primarily intended for dry battery operation, the WX-12 Radiotron may be used with a 2 volt storage "A" battery.

The recommended rheostat resistance for one Radiotron is 6 ohms.

CONNECTIONS

All wires from other apparatus to Radiotrons should be as short as possible. All joints should be soldered or clamped tightly under screws or nuts.

Particular care should be taken to prevent the connection of the plate battery to the filament through any part of the filament circuit. It is advisable to remove Radiotrons from their sockets when making or changing connections. It is also advisable to connect the filament battery first and to make sure that the filaments work properly before connecting the plate or "B" battery.

FOR DETECTION

The characteristics of the WX-12 are such that it works best as a detector when the grid return lead is connected to the positive end of the filament, as shown in Fig. 2. Normal plate voltage for detection is 20. In some circuits it may be advisable to use more than 20. A mica grid condenser of .00025 microfarad and a grid leak of from 2 to 5 megohms should be used.

FOR AMPLIFICATION

With Plate Voltages Exceeding 45 Volts:

When the WX-12 Radiotron is employed as an amplifier, a "C" battery is employed when the plate potential exceeds 45 volts. The filament rheostat should be placed in the negative lead of the "A" battery, and the grid return lead should be connected to the negative side of the "C" battery. The positive side of the "C" battery is connected to the negative side of the Radiotron filament, as shown in Fig. 1.

PLATE VOLTAGE	NEG. GRID BIAS
22.5 Volts	0.0 Volts
45.0 Volts	1.5 Volts
67.5 Volts	3.0 Volts
90.0 Volts	4.5 Volts
112.5 Volts	6.0 Volts
135.0 Volts	7.5 Volts

With Plate Voltages of 45 Volts or Less:

When no "C" battery is used, and the plate voltage is 45 volts or less, it is important that the filament rheostat should be placed in the negative lead of the "A" battery, and that the return lead from the grid circuit should be connected to the negative side of the "A" battery and not to the negative side of the filament. This method places a desirable negative bias on the grid.

RETURN OF DEFECTIVE APPARATUS

ANY RADIOTRON WHICH IS BELIEVED DEFECTIVE SHOULD BE RETURNED TO THE DEALER OR DISTRIBUTOR FROM WHOM IT WAS PURCHASED, WHO HAS COMPLETE INSTRUCTIONS FOR HANDLING SUCH CASES.

THE MOST SATISFACTORY RESULTS CAN BE OBTAINED BY THE CONSISTENT USE OF RADIOTRONS IN RADIOLAS.

PATENT NOTICE

In connection with devices it sells, Radio Corporation of America has rights under patents having claims (a) on the devices themselves and (b) on combinations of the devices with other devices or elements, as for example in various circuits and hook-ups.

The sale of this device carries a license under the patent claims of (a), but only for (1) talking machine uses, (2) radio amateur uses, (3) radio experimental uses and (4) radio broadcast reception; and only where no business features are involved.

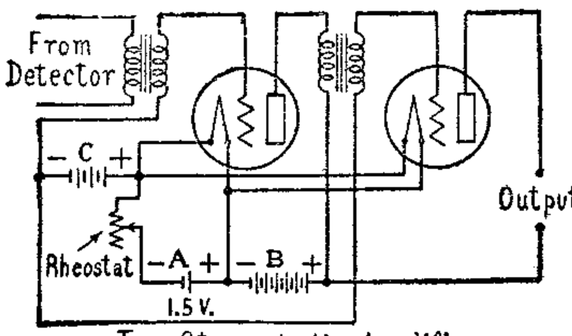
The sale does not carry a license under patent claims of (b) except only (1) for legitimate renewals and repairs in apparatus and systems already licensed for use under such patent claims on combinations, (2) for assembling by amateurs and experimenters, and not by others, with other licensed parts or devices, or with parts or devices made by themselves, but only for their own amateur and experimental radio uses where no business features are involved, and not for sale to or for use by others, and (3) for use with licensed talking machines and licensed radio broadcast receiving devices; and only where no business features are involved.

Radio Corporation of America

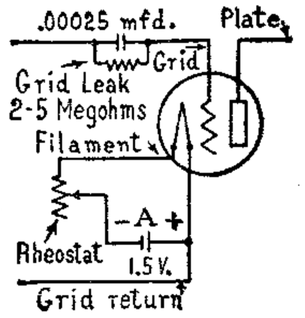
CAUTION!

DO NOT USE EXCESSIVE FILAMENT OR PLATE VOLTAGE.

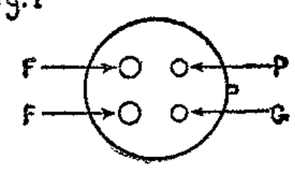
HANDLE RADIOTRON CAREFULLY.



Two Stage Audio Amplifier
Fig.1



Detector
Fig.2



Bottom of Base
Fig.3

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