



Cunningham

RADIO TUBES

CX-301-A

DETECTOR, AMPLIFIER

The '01-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 max. Volts
GRID VOLTAGE	-4.5	Volts
PLATE CURRENT	2.5	3.0 Milliamperes
PLATE RESISTANCE	11000	10000 Ohms
AMPLIFICATION FACTOR	8	8
MUTUAL CONDUCTANCE	725	800 Micromhos
GRID-PLATE CAPACITANCE	8.1	μmf.
GRID-FILAMENT CAPACITANCE	3.1	μmf.
PLATE-FILAMENT CAPACITANCE	2.2	μmf.
MAXIMUM OVERALL LENGTH		4 11/16"
MAXIMUM DIAMETER		1 13/16"
BULB (See page 42, Fig. 8)		S-14
BASE		Medium 4-Pin

INSTALLATION

The base pins of the '01-A fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position. Cushioning of the socket in the detector stage may be desirable if microphonic disturbances are encountered. For socket connections, see page 39, Fig. 1.

The filament in the '01-A is intended for operation from a 6-volt 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. At this voltage, the most satisfactory operating performance will be obtained.

APPLICATION

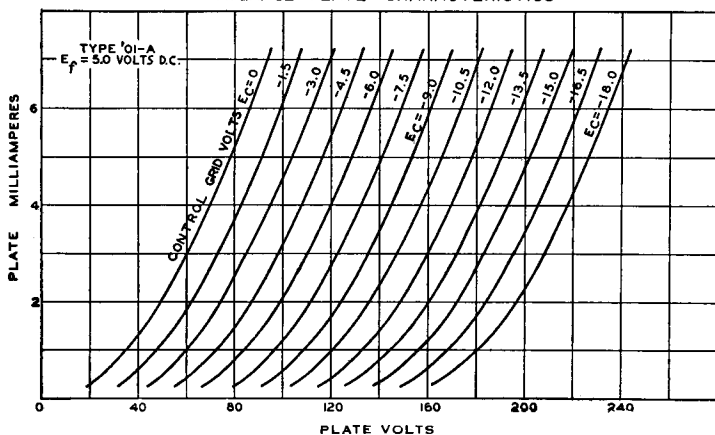
As a detector, the '01-A may be operated either with grid leak and condenser or with grid bias. The recommended plate voltage for the former method is 45 volts. A grid leak of from 1 to 5 megohms used with a grid condenser of 0.00025 μf. is suitable. The grid circuit return should be connected to the positive filament terminal. 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).

As an amplifier, the '01-A is applicable to the audio- or the radio-frequency stages of a receiver. Plate voltages and the corresponding grid voltages for audio amplifier service should be determined from the tabulated characteristics and the curves in order to obtain optimum performance and freedom from distortion. The higher plate voltages will be found advantageous under conditions where the impressed signal is large or where maximum voltage output is desired.

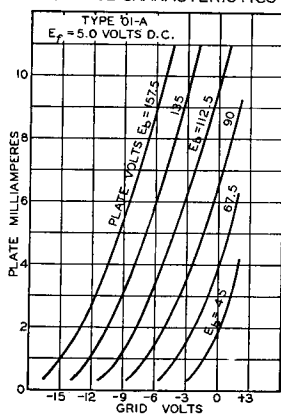
When the '01-A is used as a radio-frequency amplifier, little is gained from the use of plate voltages exceeding 90 volts. The '01-A is well adapted for use as an interstage audio-frequency amplifier but a power output tube is recommended for the final audio stage.

Volume control of the receiver may be accomplished by variation of either the grid bias or the plate voltage applied to the radio-frequency stages.

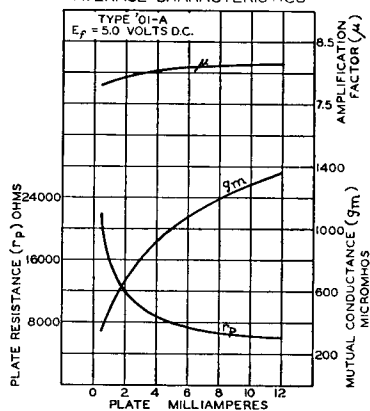
AVERAGE PLATE CHARACTERISTICS

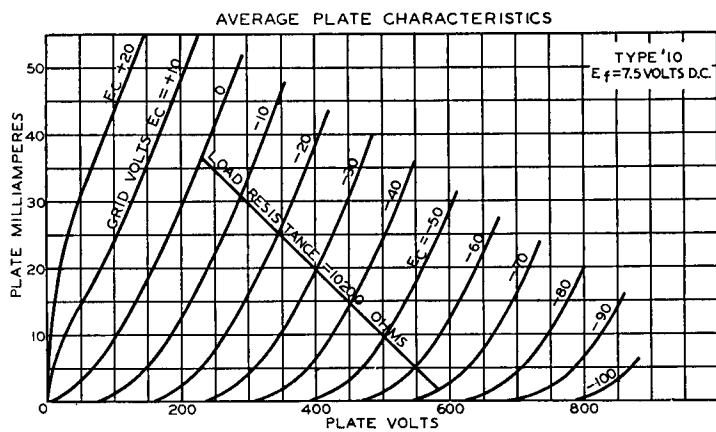


AVERAGE CHARACTERISTICS



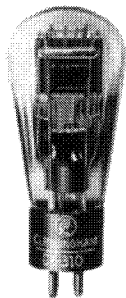
AVERAGE CHARACTERISTICS





Cunningham RADIO TUBES

CX-310



POWER AMPLIFIER, OSCILLATOR

The type '10 is a three-electrode high-vacuum tube suitable for power amplifier use. As an audio-frequency amplifier, it is capable of delivering large undistorted output to the loudspeaker.

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*	-22 -31 -39	Volts
PLATE CURRENT	10 16 18	Milliamperes
PLATE RESISTANCE	6000 5150 5000	Ohms
AMPLIFICATION FACTOR	8 8 8	
MUTUAL CONDUCTANCE	1330 1550 1600	Micromhos
LOAD RESISTANCE	13000 11000 10200	Ohms
UNDISTORTED POWER OUTPUT	400 900 1600	Milliwatts
GRID-PLATE CAPACITANCE	8	$\mu\text{f.}$
GRID-FILAMENT CAPACITANCE	5	$\mu\text{f.}$
PLATE-FILAMENT CAPACITANCE	4	$\mu\text{f.}$
MAXIMUM OVERALL LENGTH		5 $\frac{5}{8}$ "
MAXIMUM DIAMETER		2 $\frac{3}{16}$ "
BULB (See page 42, Fig. 10)		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 3.75 volts and should be referred to the negative end of the filament.

INSTALLATION

The base pins of the '10 fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position with the base down. For socket connections, see page 39, Fig. 1.

The filament of the type '10 is usually operated from the a-c line through a step-down transformer. Most satisfactory operating performance of the tube will be obtained at the rated filament voltage.

With an a-c filament supply, the grid and the plate return should be brought either to a mid-tapped resistor of 20 to 40 ohms across the filament winding, or to a mid-tap on the filament winding itself. With a d-c filament supply, the grid and the plate return should be made to the negative filament terminal.

Grid bias for the type '10 may be obtained from a C-supply or by means of the voltage drop in a resistor connected in the negative plate return lead. The latter method is known as the self-biasing method, since the plate current determines the drop. It is not, however, generally applicable to battery-operated receivers.

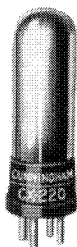
APPLICATION

As an audio power amplifier this tube should be operated under conditions as given under CHARACTERISTICS. To prevent overloading and distortion, the recommended grid bias should always be used. Average plate characteristics (curves) are given on the preceding page.

Cunningham RADIO TUBES

CX-220

POWER AMPLIFIER



The '20 is a three-electrode, high-vacuum, power amplifier tube designed for operation from dry-cells. It is intended for use in the last audio stage of dry-battery-operated receivers using the '99 and/or '22.

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	3.0 6.5	Milliamperes
PLATE RESISTANCE	8000 6300	Ohms
AMPLIFICATION FACTOR	3.3 3.3	
MUTUAL CONDUCTANCE	415 525	Micromhos
LOAD RESISTANCE	9600 6500	Ohms
UNDISTORTED POWER OUTPUT	45 110	Milliwatts
GRID-PLATE CAPACITANCE	4.1	μf.
GRID-FILAMENT CAPACITANCE	2.0	μf.
PLATE-FILAMENT CAPACITANCE	2.3	μf.
MAXIMUM OVERALL LENGTH		4 1/8"
MAXIMUM DIAMETER		1 3/16"
BULB (See page 42, Fig. 1)		T-8
BASE		Small 4-Pin

INSTALLATION

The base pins of the '20 fit the standard four-contact socket. The socket should be installed to operate the tube in a vertical position. For socket connections, see page 39, Fig. 1.

The filament in this tube is designed for operation with three No. 6 dry-cells connected in series. In multi-tube receivers the use of six or nine No. 6 dry-cells connected in series-parallel to give 4.5 volts will decrease the current drain per cell and give a more stable source of filament power. If storage battery operation is preferred, a four-volt storage battery may be used. In any case, a filament rheostat should be provided to maintain the voltage applied to the filament within the stated range.

APPLICATION

For power amplifier service, the '20 will give greatest power output when operated at a plate voltage of 135 volts and the corresponding grid bias of -22.5 volts. At 90 volts on the plate and with a corresponding grid bias of -16.5 volts, good quality of reproduction may be obtained at a lower level of power output.

In receivers employing tubes of the 3.3 volt filament type, the use of the '20 in the output stage will be found desirable.

Cunningham RADIO TUBES

CX-322

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	Volts
GRID VOLTAGE	-1.5	Volts
SCREEN VOLTAGE	67.5**	Volts
PLATE CURRENT	1.5	Milliamperes
SCREEN CURRENT	3.3	Milliamperes
PLATE RESISTANCE	50000	Ohms
AMPLIFICATION FACTOR	300	
MUTUAL CONDUCTANCE	350	Micromhos
EFFECTIVE GRID-PLATE CAPACITANCE	0.025 maximum	μuf.
INPUT CAPACITANCE	3.2	μuf.
OUTPUT CAPACITANCE	12	μuf.
OVERALL LENGTH	4 $\frac{25}{32}$ " to 5 $\frac{1}{32}$ "	
MAXIMUM DIAMETER	1 $\frac{13}{16}$ "	
BULB (See page 42, Fig. 11)	S-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.

INSTALLATION

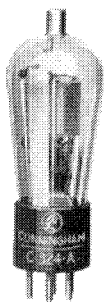
The base pins of the '22 fit the standard four-contact socket. The socket should be installed to hold the tube in a vertical position. Cushioning of the socket may be desirable to avoid microphonic disturbances. For socket connections, see page 39, Figure 4.

For filament operation, refer to INSTALLATION for type '20.

APPLICATION

As a radio-frequency amplifier in multi-stage circuits, it is necessary to shield carefully each stage and to include within the stage shield all of the component parts of that stage. Unless this is done, the amplification possibilities of the '22 cannot be realized.

As an audio-frequency amplifier, this tube may be operated with either the screen-grid or space-charge-grid connection. In either case, the value of plate coupling resistor should be of from 100000 to 250000 ohms. With the screen-grid arrangement, a plate supply voltage of 135 to 180 volts applied through the coupling resistor is recommended. Under these conditions, a screen voltage of 22.5 volts and a negative grid voltage of 0.75 to 1.5 volts are suitable. For the space-charge-grid connection, the inner grid is operated at 22.5 volts, while the outer grid becomes the control grid and is biased negatively by from 0 to 1.5 volts, depending upon conditions of operation.



Cunningham
RADIO TUBES

C-324-A

SCREEN GRID RADIO-FREQUENCY AMPLIFIER

The '24-A is a screen grid amplifier tube containing a 2.5 volt uni-potential heater-cathode which permits operation from alternating current. This tube is recommended for use primarily as a radio-frequency amplifier in carefully shielded circuits especially designed for it. 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
GRID VOLTAGE	-3	-3	Volts
SCREEN VOLTAGE	90	90 max.	Volts
PLATE CURRENT	4	4	Milliamperes
SCREEN CURRENT		Not over 1/3 of	plate current
PLATE RESISTANCE	400000	600000	Ohms
AMPLIFICATION FACTOR	400	615	
MUTUAL CONDUCTANCE	1000	1025	Micromhos
EFFECTIVE GRID-PLATE CAPACITANCE.		0.01 maximum	μf.
INPUT CAPACITANCE		5.0	μf.
OUTPUT CAPACITANCE		10.0	μf.
OVERALL LENGTH		4 25/32" to 5 1/32"	
MAXIMUM DIAMETER		1 13/16"	
BULB (See page 42, Fig. 11)		S-14	
CAP		Small Metal	
BASE		Medium 5-Pin	

* Maximum plate voltage = 275 volts.

INSTALLATION

The base pins of the '24-A fit the standard five-contact socket. The socket may be installed to operate the tube in any position. For socket connections, see page 39, Fig. 9.

The heater of the '24-A is intended for operation from a 2.5 volt winding of the power transformer. The voltage applied to the heater terminals should be the rated value of 2.5 volts under conditions of operating load and average line voltage.

The cathode connection to the heater should be made (1) to the movable arm of a potentiometer connected across the heater winding of the power transformer, or (2) to a mid-tapped resistor across the heater winding, or (3) to the mid-point of the heater winding itself. Recommended practice is to have no voltage difference between heater and cathode. If this practice is not followed, the heater may be made negative by not more than 45 volts.

The positive 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.

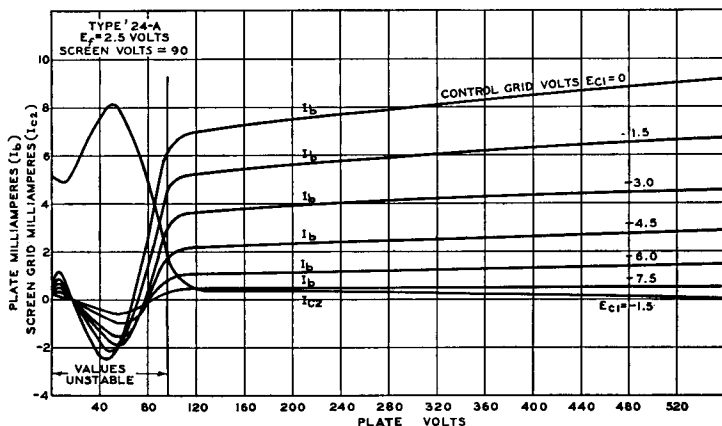
APPLICATION

As a **radio-frequency amplifier**, the '24-A should be operated at the voltages given under CHARACTERISTICS. Plate voltage and screen voltage are not critical. In general, properly designed radio-frequency transformers are preferable to inter-stage coupling impedances, especially in cases where a high impedance B-supply may cause oscillation below radio frequencies.

As a **detector**, the '24-A may be operated either with grid leak and condenser or with grid bias (see page 16). For grid bias detection suitable operating conditions are: plate supply voltage of 275 volts applied through a plate coupling resistor of 250000 ohms, a positive screen voltage of 20 to 45 volts, and a negative grid bias (approximately 5 volts) so adjusted that a plate current of 0.1 milliampere is obtained with no input signal. For grid leak and condenser detection, suitable operating conditions are: plate supply voltage 275 volts applied through a plate coupling resistor of 250000 ohms, a positive screen voltage of 20 to 45 volts, a grid leak of 2 to 5 megohms, and a grid condenser of 0.00025 μ f.

As a screen grid **audio-frequency amplifier** in resistance coupled circuits, the '24-A may be operated under the following conditions: plate supply voltage 250, grid bias -1 volt, screen voltage 25 volts, plate current 0.5 milliampere (approximate), plate load resistor 0.1 to 0.25 megohm, and a grid resistor of 0.25 to 2.0 megohms.

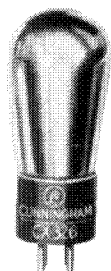
AVERAGE PLATE CHARACTERISTICS



Cunningham RADIO TUBES

CX-326

AMPLIFIER



The '26 is an amplifier tube containing a filament designed for operation on alternating current. It is useful as a radio-frequency amplifier and as a transformer-coupled audio-frequency amplifier. 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	
MUTUAL CONDUCTANCE	935 1100 1150	Micromhos
GRID-PLATE CAPACITANCE	8.1	$\mu\text{mf.}$
GRID-FILAMENT CAPACITANCE	3.5	$\mu\text{mf.}$
PLATE-FILAMENT CAPACITANCE	2.2	$\mu\text{mf.}$
MAXIMUM OVERALL LENGTH		4 11/16"
MAXIMUM DIAMETER		1 3/16"
BULB (See page 42, Fig. 8)		S-14
BASE		Medium 4-Pin

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

INSTALLATION

The base pins of the '26 fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position. For socket connections, see page 39, Fig. 1.

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. For certain applications, it may be operated with a d-c filament power source.

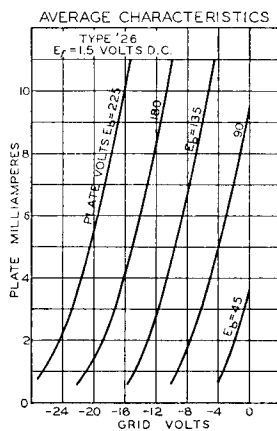
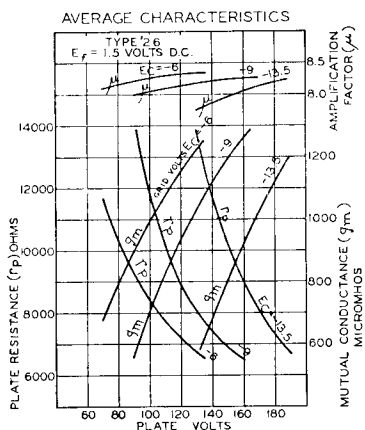
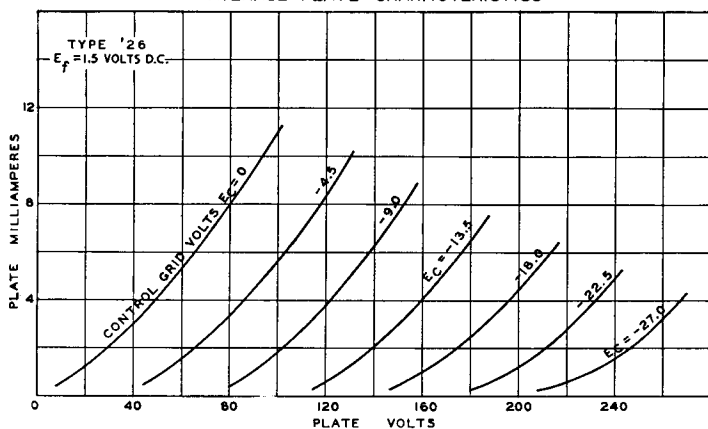
When the filament is a-c operated, the plate and grid return lead should be brought (1) to the movable arm of a 20 to 40 ohm potentiometer across the filament winding, or (2) to the mid-tap of the filament winding itself. When d.c. is used to operate the filament, the grid and plate returns should be connected to the negative filament terminal.

APPLICATION

As an audio-frequency amplifier, the '26 should be used with transformer coupling in order to secure the greatest amplification per stage.

As a radio-frequency amplifier, the '26 may be operated at plate voltages as low as 90 volts with good results.

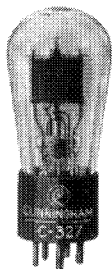
AVERAGE PLATE CHARACTERISTICS



Cunningham RADIO TUBES

C-327

DETECTOR, AMPLIFIER



The '27 is a three-electrode general purpose tube containing a 2.5 volt heater-cathode of the equipotential type which permits operation from alternating current.

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	
MUTUAL CONDUCTANCE	820 1000 1000 975	Micromhos
GRID-PLATE CAPACITANCE	3.3	μ mf.
GRID-CATHODE CAPACITANCE	3.5	μ mf.
PLATE-CATHODE CAPACITANCE	3.0	μ mf.
MAXIMUM OVERALL LENGTH		4 1/16"
MAXIMUM DIAMETER		1 13/16"
BULB (See page 42, Fig. 8)		S-14
BASE		Medium 5-Pin

* Maximum plate voltage = 275 volts.

INSTALLATION

The **base** pins of the '27 fit the standard five-contact socket. The socket may be mounted to hold the tube in any position. For socket connections, see page 39, Fig. 8.

The **heater** of the '27 is intended for operation from a 2.5 volt winding of the power transformer. The voltage applied to the heater terminals should be the rated value of 2.5 volts under conditions of operation and average line voltage.

The **cathode connection** to the heater should be made (1) to the movable arm of a potentiometer connected across the heater winding of the power transformer, or (2) to a mid-tapped resistor across the heater winding, or (3) to the mid-point of the heater winding itself. Recommended practice is to have no potential difference between heater and cathode. If this practice is not followed, the heater may be biased preferably negative, but allowably positive, with respect to the cathode by not more than 45 volts.

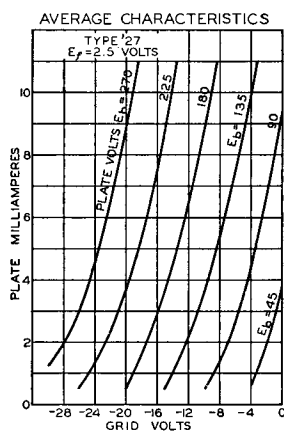
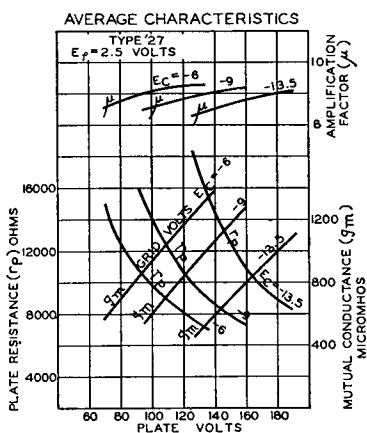
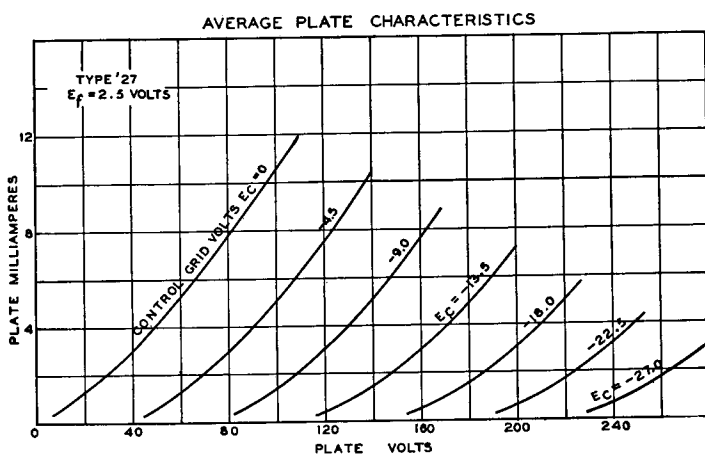
APPLICATION

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 recommended plate voltage for grid leak and condenser detections is 45 volts (see page 16). A grid leak of from 1 to 5 megohms used with a grid condenser of 0.00025 μ f. is suitable. For grid bias detection, a plate voltage of 250 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 milliamperes. For the conditions of 250 volts on plate and transformer coupling, the grid bias will be approximately -30 volts.

THE CUNNINGHAM RADIO TUBE MANUAL

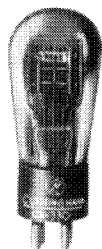
As an **oscillator**, the '27 may be operated with a plate voltage of approximately 90 volts and zero grid bias. A lower value of plate voltage may be found desirable in some applications.



Cunningham RADIO TUBES

CX-330

DETECTOR, AMPLIFIER



The '30 is a detector and amplifier tube of the three-electrode type. It has a coated filament which takes as little power as possible consistent with satisfactory operating performance. This feature makes the '30 particularly suitable in battery-operated radio receivers employing the '32, '34, '31, and/or '33 where economy of filament current drain is important.

CHARACTERISTICS

FILAMENT VOLTAGE (D. C.)	2.0	Volts
FILAMENT CURRENT	0.060	Ampere
PLATE VOLTAGE	90 135 180 <i>max.</i>	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	
MUTUAL CONDUCTANCE	850 900 900	Micromhos
GRID-PLATE CAPACITANCE	6.0	μ mf.
GRID-FILAMENT CAPACITANCE	3.7	μ mf.
PLATE-FILAMENT CAPACITANCE	2.1	μ mf.
MAXIMUM OVERALL LENGTH		4 $\frac{1}{4}$ "
MAXIMUM DIAMETER		1 $\frac{9}{16}$ "
BULB (See page 42, Fig. 6)		S-12
BASE		Small 4-Pin

INSTALLATION

The base pins of the '30 fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position. Cushioning of the socket in the detector stage may be desirable if microphonic disturbances are encountered. For socket connections, see page 39, Fig. 1.

The coated filament of the '30 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 '30 requires no filament resistor. Operation with 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 filaments of these tubes is not recommended.*

APPLICATION

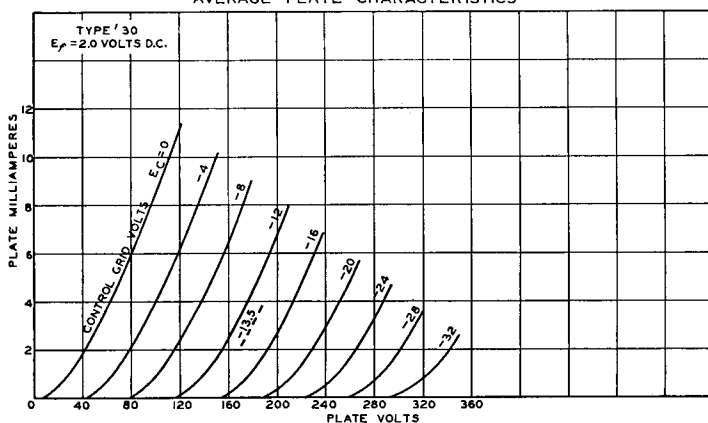
As a **detector**, the '30 may be operated either with grid leak and condenser or with grid bias. The plate voltage for the former method should preferably not be more than 45 volts. A grid leak of from 1 to 5 megohms used with a grid condenser of 0.00025 μ f. is satisfactory. The grid return should 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.

As an **amplifier**, the '30 is applicable to the audio- and the radio-frequency stages of a receiver. Plate voltages and the corresponding grid voltages should be determined from the CHARACTERISTICS and the curves in order to obtain optimum performance and freedom from distortion.

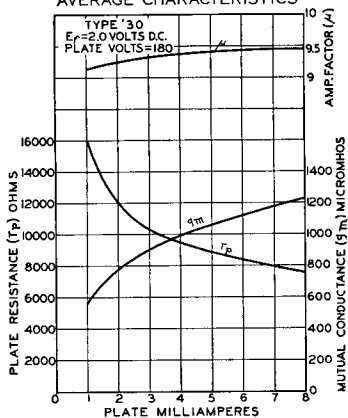
As an **oscillator**, this tube may be used at plate voltages not exceeding 45 volts.

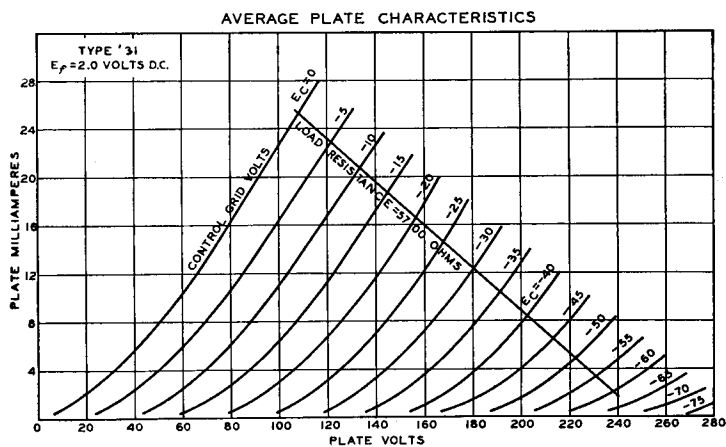
THE CUNNINGHAM RADIO TUBE MANUAL

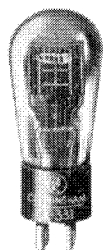
AVERAGE PLATE CHARACTERISTICS



AVERAGE CHARACTERISTICS







Cunningham RADIO TUBES

CX-331

POWER AMPLIFIER

The '31 is a power amplifier tube of the three-electrode type. It has a coated filament which takes as little power as possible consistent with satisfactory operating performance. This feature makes the '31 particularly suitable in battery-operated radio receivers employing the '30, '32, and/or '34 where economy of filament current drain is important.

CHARACTERISTICS

FILAMENT VOLTAGE (D. C.)	2.0	Volts
FILAMENT CURRENT	0.130	Ampere
PLATE VOLTAGE	135	Volts
GRID VOLTAGE	-22.5	Volts
PLATE CURRENT	8.0	Milliamperes
PLATE RESISTANCE	4100	Ohms
AMPLIFICATION FACTOR	3.8	
MUTUAL CONDUCTANCE	925	Micromhos
LOAD RESISTANCE	7000	Ohms
UNDISTORTED POWER OUTPUT	185	Milliwatts
GRID-PLATE CAPACITANCE	5.7	$\mu\text{mf.}$
GRID-FILAMENT CAPACITANCE	3.7	$\mu\text{mf.}$
PLATE-FILAMENT CAPACITANCE	2.2	$\mu\text{mf.}$
MAXIMUM OVERALL LENGTH		4 1/4"
MAXIMUM DIAMETER		1 9/16"
BULB (See page 42, Fig. 6)		S-12
BASE		Small 4-Pin

INSTALLATION

The base pins of the '31 fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position. Although the '31 is very free from microphonic disturbances, cushioning of its socket may be desirable. For socket connections, see page 39, Fig. 1.

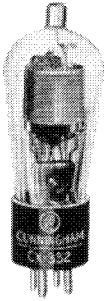
The coated filament of the '31 may be operated conveniently from dry-cells, from a single lead storage-cell, or from an air-cell battery. For dry-cell operation, a filament rheostat may be used together with a permanently installed voltmeter to insure the proper filament voltage. For operation from a 2-volt lead storage-cell, the '31 requires no filament resistor. Operation with 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 filaments of these tubes is not recommended.*

APPLICATION

As a **power amplifier**, the '31 should be operated as shown under CHARACTERISTICS.

Grid voltage for the '31 may be obtained from a C-battery, or by use of the voltage drop in a resistor connected in the negative plate return lead. The latter method is known as the **self-biasing method** and 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. Average plate characteristics (curves) are given on the preceding page.



Cunningham
RADIO TUBES

CX-332

RADIO-FREQUENCY AMPLIFIER

The '32 is a screen grid tube recommended primarily for use as a radio-frequency amplifier. It contains a coated filament which takes as little power as possible consistent with satisfactory operating performance. This feature makes the '32 particularly suitable in battery-operated radio receivers employing the '34, '31, and/or '33 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	67.5	67.5 max. Volts
GRID VOLTAGE	-3	-3 Volts
PLATE CURRENT	1.7	1.7 Milliampere
SCREEN CURRENT (Maximum)	0.4	0.4 Milliampere
PLATE RESISTANCE	950000	1200000 Ohms
AMPLIFICATION FACTOR	610	780
MUTUAL CONDUCTANCE	640	650 Micromhos
EFFECTIVE GRID-PLATE CAPACITANCE	0.015 maximum	μmf.
INPUT CAPACITANCE	6.0	μmf.
OUTPUT CAPACITANCE	11.7	μmf.
OVERALL LENGTH		4 ²⁵ / ₃₂ " to 5 ¹ / ₃₂ "
MAXIMUM DIAMETER		1 ¹³ / ₁₆ "
BULB (See page 42, Fig. 11)		S-14
CAP		Small Metal
BASE		Medium 4-Pin

INSTALLATION

The base pins of the '32 fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position. Although the '32 is very free from microphonic disturbances, cushioning of its socket may be found desirable. For socket connections, see page 39, Fig. 4.

The coated filament of the '32 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 should be used together with a permanently installed voltmeter to insure the proper filament voltage. For operation from a 2-volt lead storage-cell, the '32 requires no filament resistor. Operation with 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 filaments of these tubes is not recommended.

The positive screen voltage may be obtained from a tap on the plate battery or a bleeder circuit across the supply battery in part or in full. 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 very satisfactorily accomplished by variation of the screen voltage between 0 and 67.5 volts. The variation must, however, be accomplished

(Continued on Page 43)

(Continued from Page 38)

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.

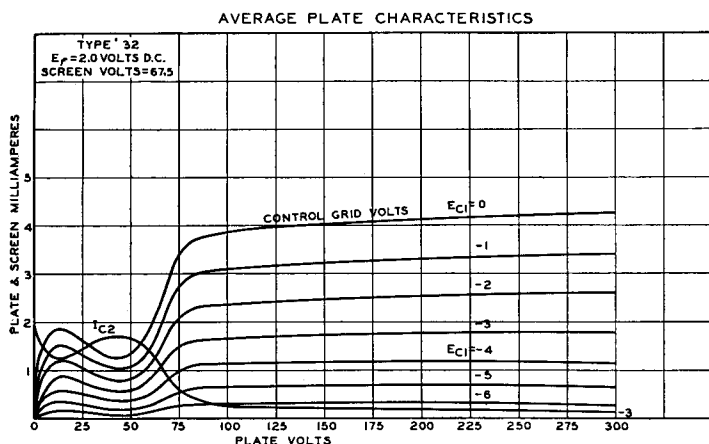
APPLICATION

As a **radio-frequency amplifier**, the '32 is operated as shown under CHARACTERISTICS. Neither the plate voltage nor the screen voltage is critical. 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.

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, 135 volts applied through a plate coupling resistance of 100000 ohms or an equivalent impedance; positive screen voltage, 67.5 volts; and a negative grid bias (approximately 6 volts) so adjusted that a plate current of 0.2 milliampere is obtained with no a-c input signal. For grid leak and condenser detection, suitable operating conditions are: Plate supply voltage, 135 volts applied through a plate coupling resistor of 250000 ohms; a positive screen voltage up to 45 volts; a grid condenser of 0.00025 $\mu\text{f.}$; and a grid leak of 1 to 5 megohms.

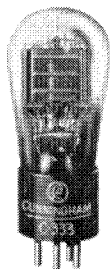
In designing circuits to use the '32 as a detector, it is desirable to work from the detector stage directly into the power output stage.

As an **audio-frequency amplifier** in resistance coupled circuits, the '32 may be operated under the following conditions: Plate supply voltage, 180 volts applied through a plate coupling resistor of 100000 to 250000 ohms (or a 500 henry choke shunted by a 0.25 megohm resistor); plate current, 0.25 milliampere (approximate); grid voltage, -1 volt; and a grid resistor, 0.25 to 2.0 megohms.



Cunningham RADIO TUBES

C-333



POWER AMPLIFIER PENTODE

The '33 is a power amplifier pentode for use in the output stage of battery-operated receivers. The low filament current required by the '33 makes this tube particularly applicable for use in combination with the '30, '32, and/or '34 in radio sets where economy of battery consumption is important.

The '33 is capable of producing greater power output than three-electrode power amplifiers of the same plate current drain. Furthermore, this tube has the design feature of greater amplification than is possible in a three-electrode amplifier without serious sacrifice in power output.

The power-handling ability of the '33 is made possible by the addition of both a suppressor and a screen between the grid and plate. The suppressor is placed next to the plate and is connected inside the tube to the filament. This design practically eliminates the secondary emission effects which limit the power output from four-electrode screen grid tubes. See page 5.

CHARACTERISTICS

FILAMENT VOLTAGE (D. C.)	2.0	Volts
FILAMENT CURRENT	0.260	Ampere
PLATE VOLTAGE	135 max.	Volts
SCREEN VOLTAGE	135 max.	Volts
GRID VOLTAGE	-13.5	Volts
PLATE CURRENT	14.5	Milliamperes
SCREEN CURRENT	3	Milliamperes
PLATE RESISTANCE	50000	Ohms
AMPLIFICATION FACTOR	70	
MUTUAL CONDUCTANCE	1450	Micromhos
LOAD RESISTANCE	7000	Ohms
POWER OUTPUT	700	Milliwatts
EFFECTIVE GRID-PLATE CAPACITANCE	0.9	μ f.
INPUT CAPACITANCE	8.9	μ f.
OUTPUT CAPACITANCE	11.1	μ f.
MAXIMUM OVERALL LENGTH		4 11/16"
MAXIMUM DIAMETER		1 3/16"
BULB (See page 42, Fig. 8)		S-14
BASE		Medium 5-Pin

INSTALLATION

The base pins of the '33 fit the standard five-contact socket. The socket should be installed so that the tube will operate in a vertical position. In some cases, cushioning of the socket may be found desirable. For socket connections, see page 39, Fig. 6.

For filament operation, refer to INSTALLATION for type '32.

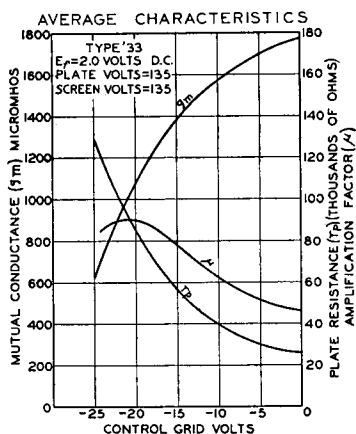
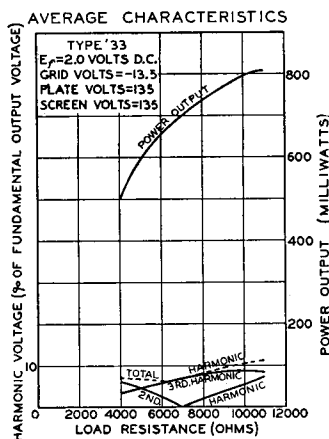
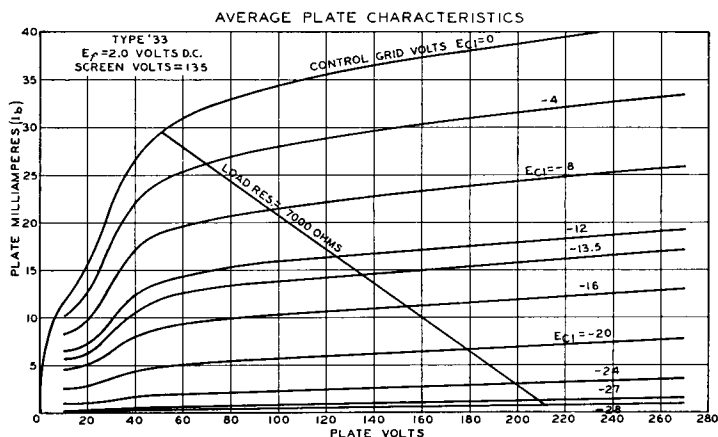
APPLICATION

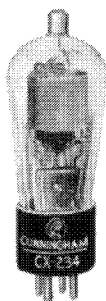
For the power amplifier stage of radio receivers, the '33 is recommended either singly or in push-pull combination. More than one audio stage preceding the '33 is undesirable because of the possibility of microphonic disturbances resulting from the high level of amplification.

If a single '33 is operated self-biased, the self-biasing resistor should be approximately 770 ohms. This resistor should be shunted by a condenser of 4 to 20 μ f. to avoid degeneration effects at low audio frequencies. The use of two '33's in push-pull eliminates the necessity of by-passing the resistor. The self-biasing resistor required for the push-pull stage is approximately 385 ohms.

Any conventional type of **input coupling** may be used, provided that the resistance added to the circuit by this device is not too high. Transformer or impedance coupling devices are preferable. When the input circuit of the '33 is resistance-coupled to the preceding stage, self-bias should be employed. The grid resistor should not exceed a value of more than 1.0 megohm under self-bias conditions; without self-bias, maximum value is 0.5 megohm.

An **output transformer** should be used to couple this tube to the winding of the reproducing unit. The optimum load resistance for the output device is 7000 ohms. For best results, the impedance in the plate circuit of the '33 should be as uniform as possible over the entire audio-frequency range.





Cunningham
RADIO TUBES

CX-234

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 employing the '30, '31, '32, and/or '33 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 15.) This super-control characteristic makes the tube uniquely adaptable to the r-f and i-f stages of receivers employing automatic volume control.

The use of a **suppressor** is an important feature of the '34. In comparison with the usual type of screen grid tube operated under similar conditions, the '34 has a much higher plate resistance and a considerably increased range of voltage swing. Furthermore, a high value of mutual conductance is maintained.

The suppressor is connected inside the tube to the filament. During operation of the tube, the suppressor eliminates the secondary emission effects which limit the voltage swing permissible in the usual screen grid tube at low plate voltage, that is, at a plate voltage approximately equal to the screen voltage. The suppressor in the '34, therefore, makes possible efficient operation of this tube at a relatively low plate voltage. This may be greater than, equal to, or slightly less than the recommended screen voltage.

CHARACTERISTICS

FILAMENT VOLTAGE (D. C.)	2.0	Volts
FILAMENT CURRENT	0.060	Ampere
PLATE VOLTAGE	67.5** 135 180 max.	Volts
SCREEN VOLTAGE (Max.)*	67.5 67.5	Volts
GRID VOLTAGE, Variable (Minimum)	-3 -3 -3	Volts
PLATE CURRENT	2.7 2.8 2.8	Milliamperes
SCREEN CURRENT	1.1 1.0 1.0	Milliamperes
PLATE RESISTANCE	400000 600000 1000000	Ohms
AMPLIFICATION FACTOR	224 360 620	
MUTUAL CONDUCTANCE	560 600 620	Micromhos
MUTUAL CONDUCTANCE, at -22.5 volts bias	15 15 15	Micromhos
EFFECTIVE GRID-PLATE CAPACITANCE	0.020 maximum	μuf.
INPUT CAPACITANCE	6.4	μuf.
OUTPUT CAPACITANCE	12.8	μuf.
OVERALL LENGTH		4 ²⁵ / ₃₂ " to 5 ¹ / ₃₂ "
MAXIMUM DIAMETER		1 ¹³ / ₁₆ "
BULB (See page 42, Fig. 11)		S-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. Although this tube is quite free from microphonic disturbances, cushioning of its socket may sometimes be desirable. For socket connections, see page 39, Fig. 4.

For filament operation, refer to INSTALLATION for type '32.

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, providing 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

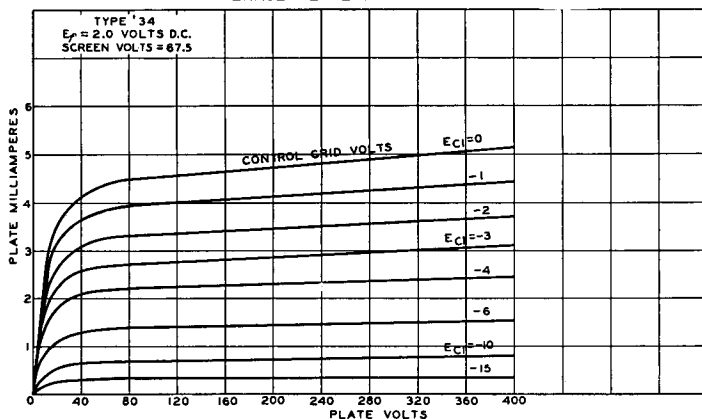
As an **r-f or i-f amplifier**, the '34 is applicable in receivers designed for it. Plate, screen, and minimum grid voltages are given under **CHARACTERISTICS** for a number of operating conditions.

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 **first detector** in superheterodyne circuits, the '34 may be utilized to advantage. In such service, the grid bias may or may not be made variable. With variable bias in the first detector, the peak oscillator voltage should be preferably about one volt less than the lowest operating grid bias. This practice will eliminate the possibility of cross-modulation caused by the first detector drawing grid current. Without variable bias on the first detector, the oscillator peak voltage should be considerably less than the grid bias to prevent grid current on very strong signal swings. It should be noted that by varying the grid bias on the first detector in conjunction with that on the radio-frequency and/or the intermediate-frequency stages, additional control of volume may be accomplished.

AVERAGE PLATE CHARACTERISTICS





Cunningham RADIO TUBES

C-335

SUPER-CONTROL RADIO-FREQUENCY AMPLIFIER

The '35 is a super-control screen grid amplifier tube containing a 2.5 volt heater-cathode of the equi-potential type. It is recommended as a radio-frequency amplifier and an intermediate-frequency 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 15 for Super-Control feature.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	1.75	Amperes
PLATE VOLTAGE*	180 250	Volts
SCREEN VOLTAGE	75 90 max.	Volts
GRID VOLTAGE, Variable (Minimum)	-1.5 -3	Volts
PLATE CURRENT	5.8 6.5	Milliamperes
SCREEN CURRENT (Maximum)	2.5 2.5	Milliamperes
PLATE RESISTANCE	350000 350000	Ohms
AMPLIFICATION FACTOR	385 370	
MUTUAL CONDUCTANCE	1100 1050	Micromhos
MUTUAL CONDUCTANCE { At -40 volts bias	5 15	Micromhos
{ At -50 volts bias	— 1 min.	Micromho
EFFECTIVE GRID-PLATE CAPACITANCE	0.010 maximum	μμf.
INPUT CAPACITANCE	5	μμf.
OUTPUT CAPACITANCE	10	μμf.
OVERALL LENGTH		4 ²⁵ / ₃₂ " to 5 ¹ / ₃₂ "
MAXIMUM DIAMETER		1 ¹³ / ₁₆ "
BULB (See page 42, Fig. 11)		S-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. The socket may be mounted to hold the tube in any position. For socket connections, see page 39, Fig. 9.

The **heater** of the '35 is intended for operation from a 2.5 volt winding of the power transformer. The voltage applied to the heater terminals should be the rated value of 2.5 volts under operating conditions and with average line voltage.

The **cathode connection** to the heater should be made (1) to the movable arm of a potentiometer connected across the heater winding of the power transformer, or (2) to a mid-tapped resistor across the heater winding, or (3) to the mid-point of the heater winding itself.

The positive **screen voltage** for the '35 may be obtained from a fixed or variable tap on a voltage divider across the supply voltage or 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.

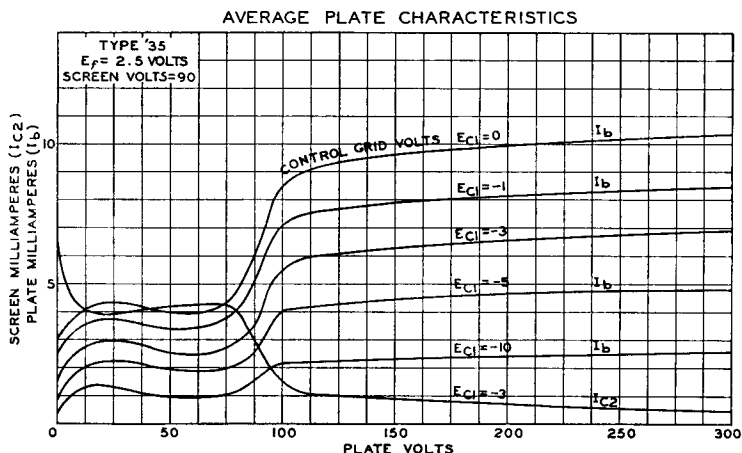
APPLICATION

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.

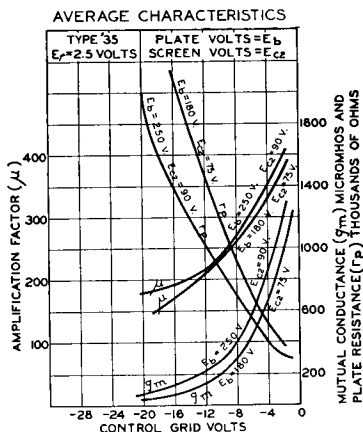
Volume control of receivers designed for the '35 may be accomplished by variation of the negative grid bias of this tube. In order to utilize the full volume-control range of the '35, an available grid bias voltage of approximately 50 volts will be required, depending upon the circuit design and operating conditions. This voltage should preferably be obtained from a potentiometer or bleeder circuit. If, however, the receiver is designed so that the required volume control can be obtained without exceeding 45 volts, the cathode-resistor method of obtaining the grid-bias control is permissible.

As a detector working directly into an audio-frequency amplifier, the '35 is not ordinarily suited. However, this tube does have a very useful application as a first detector in superheterodyne circuits. Suitable operating voltages for such service are: 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 first detector in conjunction with that on the radio-frequency and/or the intermediate-frequency stages, additional control of volume may be accomplished.

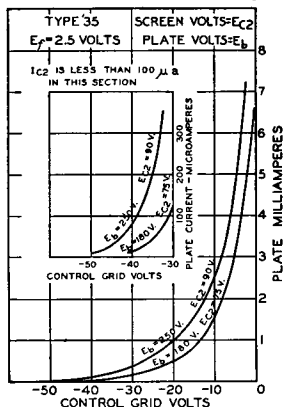
As an audio-frequency amplifier, the '35 may be used in a single stage, resistance-coupled circuit when it is followed by not more than one amplifier stage. Additional stages of amplification are not recommended because of the possibility of noise and microphonic disturbances resulting from the high level of amplification. Suitable operating voltages for such service are: Plate supply voltage, 180 to 250 volts, applied through a load resistor of 100000 to 200000 ohms; screen voltage 25 volts; grid bias, -1 volt. In general, the higher value of load resistor will permit increased amplification but will give poorer fidelity. The higher plate supply voltages allow increased signal swing without distortion but are not required where only small signals are to be amplified. In resistance-coupled circuits employing the '35, the grid resistor should have a value not exceeding 1.0 megohm.



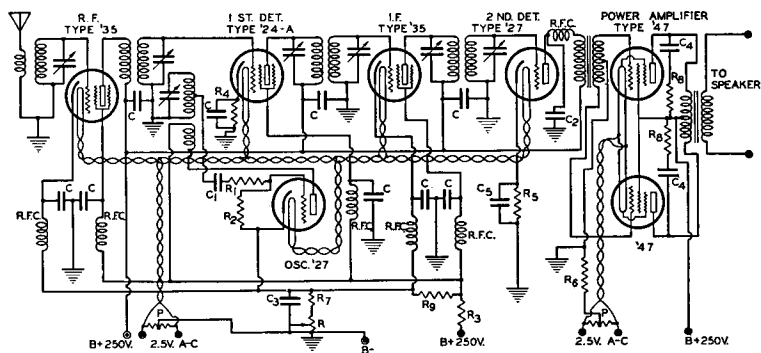
THE CUNNINGHAM RADIO TUBE MANUAL



AVERAGE MUTUAL CHARACTERISTICS



TYPICAL SUPERHETERODYNE RECEIVER FOR A-C OPERATION



$C = R-F$ BY-PASS CONDENSER ($0.1 \mu f$)
 $C_1 =$ OSC. GRID CONDENSER ($0.00075 \mu f$)
 $C_2 = R-F$ BY-PASS CONDENSER ($0.00025 \mu f$)
 $C_3 = R-F$ BY-PASS CONDENSER ($0.5 \mu f$)
 $C_4 =$ CONDENSER ($0.3 \mu f$ APPROX.)
 $R =$ VOLUME CONTROL POTENTIOMETER (8000 OHMS)
 $R_1 =$ RESISTOR (6000 OHMS)
 $R_2 =$ OSCILLATOR GRID LEAK (40000 OHMS)

$R_3 =$ RESISTOR (14000 OHMS)
 $R_4 =$ SELF-BIASING RESISTOR (1500 OHMS)
 $R_5 =$ SELF-BIASING RESISTOR (50000 OHMS)
 $R_6 =$ SELF-BIASING RESISTOR (225 OHMS)
 $R_7 =$ PARTIAL SELF-BIAS RESISTOR (150 OHMS)
 $R_8 =$ RESISTOR (10000 OHMS APPROX.)
 $R_9 =$ RESISTOR (8000 OHMS)
 $P =$ POTENTIOMETER (20 OHMS)
 $C_5 = A-F$ BY-PASS CONDENSER ($2-4 \mu f$)

Optional power amplifier using '45's shown on page 61.

Cunningham RADIO TUBES

C-336



RADIO-FREQUENCY AMPLIFIER

The '36 is a screen grid radio-frequency amplifier and detector for use in automobile receivers or sets operated from d-c power lines. It contains a heater-cathode which is designed for d-c operation. Its design permits uniform tube operation over a comparatively wide range of heater voltages without appreciably affecting either the performance or serviceability of the tube. This feature, together with that of general freedom from microphonic and battery circuit disturbances, makes the '36 well suited to mobile service and other applications where complete d-c operation is desirable.

CHARACTERISTICS

HEATER VOLTAGE (D. C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
PLATE VOLTAGE	90* 135 180 max.	Volts
SCREEN VOLTAGE	55 67.5 90 max.	Volts
GRID VOLTAGE	-1.5 -1.5 -3	Volts
PLATE CURRENT	1.8 3 3.1	Milliamperes
SCREEN CURRENT	Not over $\frac{1}{3}$ of plate current	
PLATE RESISTANCE	250000 300000 350000	Ohms
AMPLIFICATION FACTOR	215 315 370	
MUTUAL CONDUCTANCE	850 1050 1050	Micromhos
EFFECTIVE GRID-PLATE CAPACITANCE	0.01 maximum	$\mu\text{mf.}$
INPUT CAPACITANCE	3.7	$\mu\text{mf.}$
OUTPUT CAPACITANCE	9.2	$\mu\text{mf.}$
OVERALL LENGTH	4 $\frac{9}{32}$ " to 4 $\frac{17}{32}$ "	
MAXIMUM DIAMETER	1 $\frac{1}{16}$ "	
BULB (See page 42, Fig. 9)	S-12	
CAP	Small Metal	
BASE	Small 5-Pin	

* Particularly applicable to receivers designed for operation from 110-volt d.c. power line.

INSTALLATION

The **base** pins of the '36 fit the standard five-contact socket which may be mounted to hold the tubes in any position. For socket connections, see page 39, Fig. 9.

The **heater** of the '36 is designed to operate satisfactorily from a 6-volt automobile storage battery without a rheostat or fixed resistor, despite the voltage fluctuations during the charge and discharge periods. These variations in the applied heater voltage do not seriously affect the performance or serviceability of this tube. The heater may be operated in series with the heaters of the '37, '38 or '39. This feature is especially desirable in receivers designed to operate from d-c house mains. Regardless of the number of heaters connected in series, the current in the heater circuit should be adjusted to 0.3 ampere for the normal supply voltage.

The **cathode** circuit in most d-c receivers is usually tied in either directly or through biasing resistors to the negative side of the heater circuit. The voltage difference thus introduced between heater and cathode should be kept as much as possible below the recommended maximum of 45 volts.

The positive **screen voltage** for the '36 may be obtained from a section of the B-battery, or from a fixed or variable tap on a voltage divider connected across the

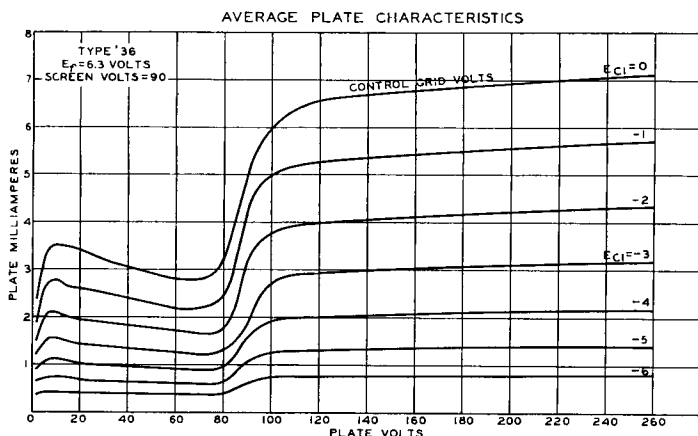
supply voltage, or a portion of the supply. The impedance between the screen and cathode should be kept as low as possible by means of suitable by-pass condensers.

Complete shielding of all stages of the circuit is necessary if maximum gain per stage is to be obtained.

APPLICATION

As a **radio-frequency amplifier**, the '36 should be operated as shown under CHARACTERISTICS. Neither the plate nor the screen voltage is critical. 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.

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, 135 volts applied through a plate coupling resistor of 250000 ohms; positive 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 a-c input signal. When grid leak and condenser detection is employed, a plate voltage of 45 volts applied through a plate coupling resistor of 250000 ohms together with a positive screen voltage up to 45 volts will be satisfactory. A grid leak of 2 to 5 megohms and a grid condenser of 0.00025 μ f. will be suitable.



Cunningham RADIO TUBES

C-337



DETECTOR, AMPLIFIER

The '37 is a three-electrode general purpose tube for use in automobile receivers and in sets operated from d-c power lines. It contains a heater-cathode which is designed for d-c operation. This feature together with that of general freedom from microphonic and battery circuit disturbances makes the '37 well suited to mobile service and other applications where complete d-c operation is desirable.

CHARACTERISTICS

HEATER VOLTAGE (D. C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
PLATE VOLTAGE	90 135 180 max.	Volts
GRID VOLTAGE	-6 -9 -13.5	Volts
PLATE CURRENT	2.5 4.1 4.3	Milliamperes
PLATE RESISTANCE	11500 10000 10000	Ohms
AMPLIFICATION FACTOR	9.2 9.2 9	
MUTUAL CONDUCTANCE	800 925 900	Micromhos
GRID-PLATE CAPACITANCE	2.0	μ f.
GRID-CATHODE CAPACITANCE	3.5	μ f.
PLATE-CATHODE CAPACITANCE	2.2	μ f.
MAXIMUM OVERALL LENGTH		4 $\frac{1}{4}$ "
MAXIMUM DIAMETER		1 $\frac{5}{16}$ "
BULB (See page 42, Fig. 6)		S-12
BASE		Small 5-Pin

INSTALLATION

The base pins of the '37 fit the standard five-contact socket. The socket may be mounted to hold the tube in any position. For socket connections, see page 39, Fig. 8.

The heater of the '37 is designed to operate satisfactorily from a 6-volt automobile storage battery without a rheostat or fixed resistor despite the voltage fluctuations during the charge and discharge periods. These variations in the applied heater voltage do not seriously affect the performance or serviceability of this tube. The heater may be operated in series with the heaters of the '36, '38 or '39. This feature is especially desirable in receivers designed to operate from d-c house mains. Regardless of the number of heaters connected in series, the current in the heater circuit should be adjusted to 0.3 ampere for the normal supply voltage.

The cathode circuit in most d-c receivers is usually tied in either directly or through biasing resistors to the negative side of the heater circuit. The voltage difference thus introduced between heater and cathode should be kept as much as possible below the recommended maximum of 45 volts.

APPLICATION

As a detector, the '37 may be operated with either grid leak and condenser or with grid bias. The recommended plate voltage for the grid leak and condenser method is 45 volts. A grid leak of from 1.0 to 5.0 megohms used with a grid condenser of 0.00025 μ f. is suitable.

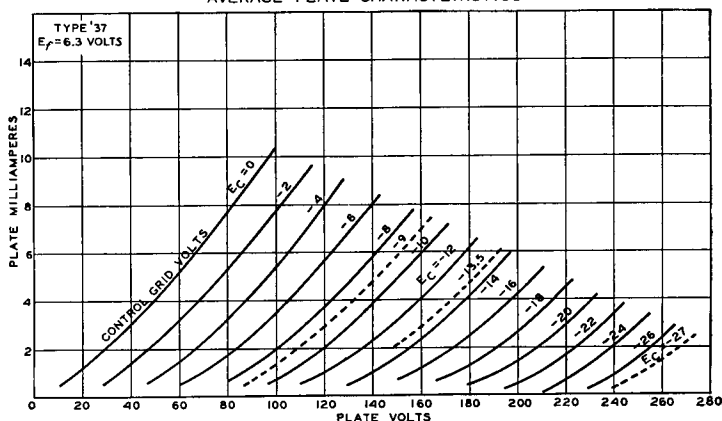
For grid bias detection a plate voltage of 135 volts together with a negative grid bias of approximately 15.5 volts may be used. The plate current should be adjusted to 0.2 milliampere with no a-c input signal. The grid bias voltage may con-

veniently be obtained from the voltage drop in a resistor between the cathode and ground. The value of this self-biasing resistance is not critical, 75000 to 100000 ohms being suitable. The higher value will allow the use of a larger input signal.

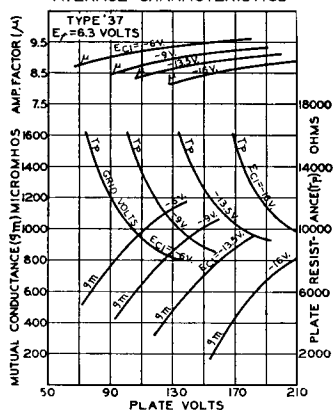
As an **amplifier**, the '37 is applicable to the audio- or the radio-frequency stages of a receiver. Plate voltages and the corresponding grid voltages for amplifier service should be determined from CHARACTERISTICS and curves to obtain optimum performance and freedom from distortion.

As an **oscillator**, the recommended conditions are: Plate voltage, 45 volts (approximately); and grid bias, zero volts. It may be found desirable to use slightly lower values of plate voltage, depending upon the circuit design.

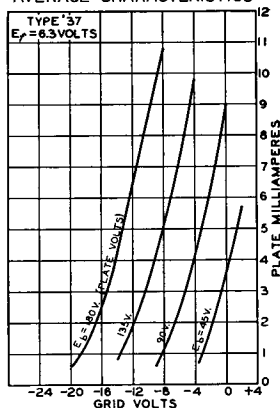
AVERAGE PLATE CHARACTERISTICS



AVERAGE CHARACTERISTICS

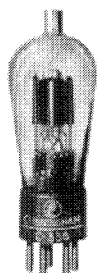


AVERAGE CHARACTERISTICS



Cunningham RADIO TUBES

C-338



POWER AMPLIFIER PENTODE

The '38 is a power amplifier pentode for use in the output stage of automobile receivers and in sets operated from d-c power lines. It is capable of giving a large power output for a relatively small input signal voltage. The '38 contains a heater-cathode which is designed for d-c operation. Its design permits uniform tube operation over a comparatively wide range of heater voltages without appreciably affecting either performance or serviceability of the tube. This feature, together with that of the general freedom from microphonic and battery circuit disturbances makes the '38 well suited to mobile service and other applications where complete d-c operation is desirable.

CHARACTERISTICS

HEATER VOLTAGE (D. C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
PLATE VOLTAGE	100	135 max. Volts
SCREEN VOLTAGE	100	135 max. Volts
GRID VOLTAGE*	-9	-13.5 Volts
PLATE CURRENT	7	9 Milliamperes
SCREEN CURRENT	2	2.5 Milliamperes
PLATE RESISTANCE (Approx.)	84000	102000 Ohms
AMPLIFICATION FACTOR (Approx.)	80	100
MUTUAL CONDUCTANCE	950	975 Micromhos
LOAD RESISTANCE	8500	13500 Ohms
POWER OUTPUT	200	525 Milliwatts
EFFECTIVE GRID-PLATE CAPACITANCE	0.3	μf.
INPUT CAPACITANCE	4.1	μf.
OUTPUT CAPACITANCE	8.5	μf.
OVERALL LENGTH		4 ⁹ / ₃₂ " to 4 ¹⁷ / ₃₂ "
MAXIMUM DIAMETER		1 ⁹ / ₁₆ "
BULB (See page 42, Fig. 9)		S-12
CAP		Small Metal
BASE		Small 5-Pin

* If the '38 is self-biased, the biasing resistor should be by-passed by a large condenser. With self-bias, the resistance of the grid circuit coupling should not exceed 1.0 megohm; without self-bias, the grid resistance should not exceed 0.5 megohm.

INSTALLATION

The base pins of the '38 fit the standard five-contact socket. The socket may be installed to hold the tube in any position. For socket connections, see page 39, Fig. 9.

For heater operation, refer to INSTALLATION for type '37.

The cathode circuit in most d-c receivers is usually 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 should be kept as much as possible below the recommended maximum of 45 volts.

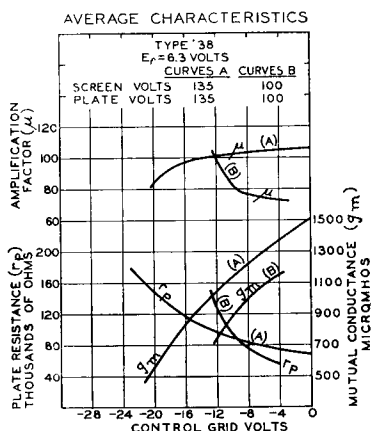
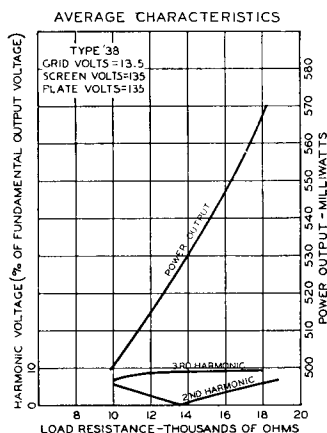
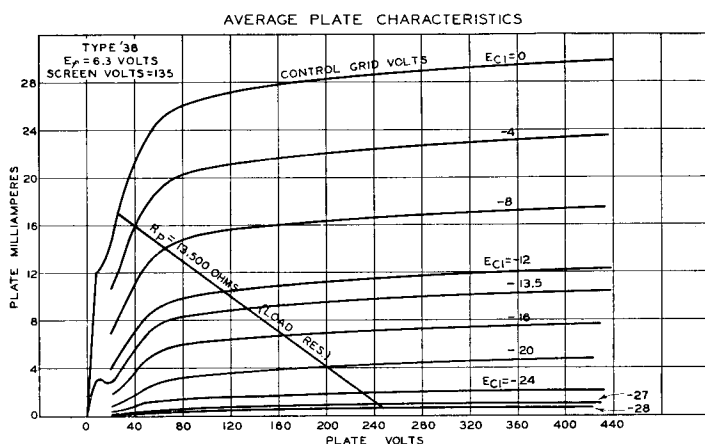
APPLICATION

For the power amplifier stage of radio receivers, the '38 is recommended either singly or in push-pull combination. More than one audio stage preceding the '38 is undesirable because of the possibility of microphonic disturbances resulting from the high level of amplification.

If a single '38 is operated self-biased, the self-biasing resistor for 135 volts on the plate should be approximately 1200 ohms. This resistor should be shunted by a condenser of 4 to 20 μ f. to avoid degeneration effects at low audio frequencies. The use of two '38's in push-pull eliminates the necessity of by-passing the resistor. The self-biasing resistor required for the push-pull stage is approximately 600 ohms.

Any conventional type of **input coupling** may be used provided that the resistance added to the grid circuit by this device is not too high. Transformer or impedance coupling devices are preferable where the '38 follows a '37 detector. If a screen grid detector is used, however, resistance coupling or a combination of impedance-resistance coupling to the '38 will be better. A coupling condenser of 0.005 μ f. will be suitable in such circuits.

An **output transformer** should be used to supply power to the winding of the reproducing unit. The optimum value of load resistance for the output device is 13500 ohms for a plate voltage of 135 volts and 8500 ohms for a plate voltage of 100 volts. For best results, the impedance in the plate circuit of the '38 over the entire audio-frequency range should be as uniform as possible.





installed to hold the tube in any position. For socket connections, see page 39, Fig. 9.

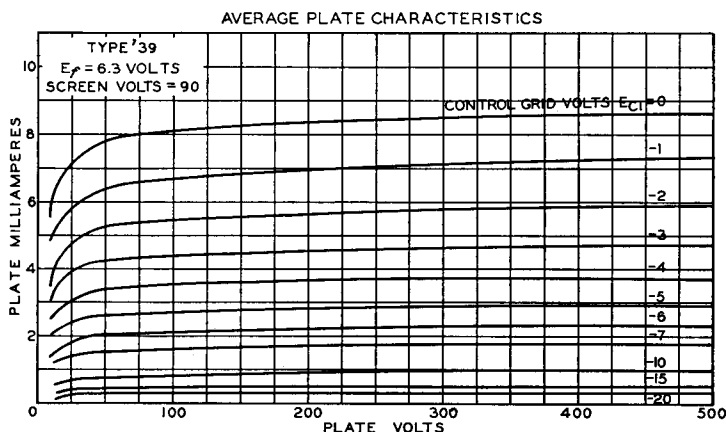
The **heater** of the '39 is designed to operate satisfactorily from a 6-volt automobile storage battery without a rheostat or a fixed resistor, despite the voltage fluctuations during the charge and discharge periods. These variations in heater voltage do not seriously affect the performance or serviceability of this tube. The heater may be operated in series with the heaters of the '36, '37, or '38. This feature is especially desirable in receivers designed to operate from d-c house mains. Regardless of the number of heaters connected in series, the current in the heater circuit should be adjusted to 0.3 ampere for the normal supply voltage.

The **cathode** circuit in most d-c receivers is usually tied in either directly or through biasing resistors to the negative side of the heater circuit. The voltage difference thus introduced between heater and cathode should be kept as much as possible below the recommended maximum of 45 volts.

The positive **screen voltage** for the '39 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 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 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

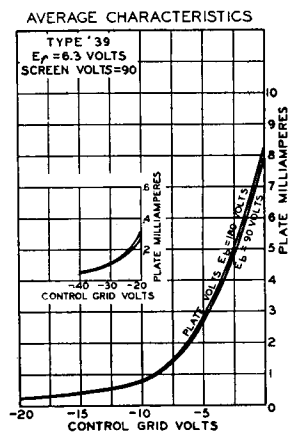
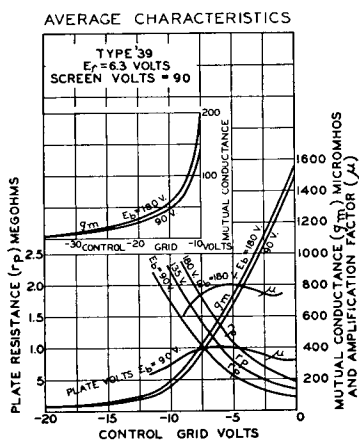
As a **radio-frequency** and **intermediate-frequency amplifier**, the '39 should be operated as shown under **CHARACTERISTICS**. In general, properly designed radio-frequency transformers are preferable to interstage coupling impedances, especially in cases where a high impedance B-supply may cause oscillation below radio frequencies.

Volume control of receivers designed for the '39 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.

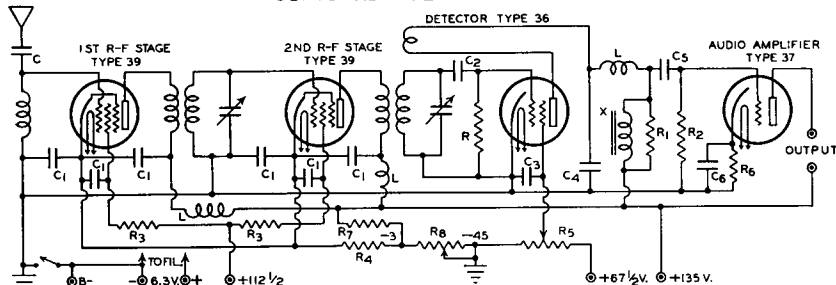
THE CUNNINGHAM RADIO TUBE MANUAL

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. *In any event, the heater to cathode bias for the '39 should not exceed 45 volts.*

As a detector working directly into an audio-frequency amplifier, the '39 is not ordinarily suited. However, it does have a very useful application as the first detector in superheterodyne circuits and may be utilized to advantage in that position. Suitable operating voltages for such service are: Plate voltage, 90 to 180 volts; screen voltage, 90 volts; grid voltage, -7 volts (approx.). With variable bias on the first detector, the peak oscillator voltage should be preferably about one volt less than the minimum grid bias (approximately 7 volts). This practice will eliminate the possibility of cross-modulation caused by the first detector drawing grid current. Without variable bias on the first detector, the oscillator peak voltage should be considerably less than the grid bias to prevent grid current on very strong signal voltage swings.



DIAGRAMMATIC SHORTWAVE RECEIVER USING 6.3-VOLT TUBES



C = ANTENNA COUPLING CONDENSER (APPROX. 30 μ MF)
 C_1 = R-F BY-PASS CONDENSER (0.01 μ MF. TO 0.1 μ MF.)
 C_2 = GRID CONDENSER (0.00025 μ MF.)
 C_3 = R-F BY-PASS CONDENSER (1.0 μ MF.)
 C_4 = R-F BY-PASS CONDENSER (0.00025 μ MF.)
 C_5 = COUPLING CONDENSER (0.005 μ MF. TO 0.1 μ MF.)
 C_6 = A-F BY-PASS CONDENSER (2 μ MF. TO 4 μ MF.)
 L = R-F CHOKE (10 TO 50 MILLIHENRIES)
 R = GRID LEAK RESISTOR (2 TO 5 MEGOHMS)

R_1 = COMPENSATING RESISTOR (0.25 MEGOHM)
 R_2 = GRID COUPLING RESISTOR (1 MEG. MAX.)
 R_3 = SCREEN DECOUPLING RESISTOR (30000 OHMS)
 R_4 = MINIMUM BIAS RESISTOR (275 OHMS)
 R_5 = REGENERATION CONTROL (50000 OHMS)
 R_6 = SELF-BIASING RESISTOR (2000 OHMS APPROX.)
 R_7 = BLEEDER RESISTOR (50000 OHMS, 2 WATT)
 R_8 = VOLUME CONTROL (20000 OHM TAPER RESISTOR)
 X = PLATE CHOKE (300H. OR MORE)

NOTE: TYPES 56, 57 AND 58 MAY BE USED IN THIS CIRCUIT IN PLACE OF THE 37, 36 AND 39 RESPECTIVELY, PROVIDED THAT THEY ARE OPERATED AT THEIR RECOMMENDED HEATER, SCREEN, PLATE AND GRID BIAS VOLTAGES. THE SUPPRESSOR GRID OF THE 57 AND 58 SHOULD BE TIED TO THE CATHODE AT THE SOCKET.



Cunningham RADIO TUBES

CX-345

POWER AMPLIFIER

The '45 is a power amplifier tube for supplying large undistorted output to a loudspeaker. It is for use as an audio-frequency output tube in a-c receivers using 2.5-volt heater and filament type tubes.

CHARACTERISTICS

FILAMENT VOLTAGE (A. C. or D. C.)	2.5	Volts
FILAMENT CURRENT	1.5	Amperes
PLATE VOLTAGE	180 250 275 max.	Volts
GRID VOLTAGE*	-34.5 -50 -56	Volts
PLATE CURRENT	27 34 36	Milliamperes
PLATE RESISTANCE	1900 1750 1670	Ohms
AMPLIFICATION FACTOR	3.5 3.5 3.5	
MUTUAL CONDUCTANCE	1850 2000 2100	Micromhos
LOAD RESISTANCE	3500 3900 4600	Ohms
UNDISTORTED POWER OUTPUT	780 1600 2000	Milliwatts
GRID-PLATE CAPACITANCE	8	μmf.
GRID-FILAMENT CAPACITANCE	5	μmf.
PLATE-FILAMENT CAPACITANCE	3	μmf.
MAXIMUM OVERALL LENGTH		5 5/8"
MAXIMUM DIAMETER		2 3/16"
BULB (See page 42, Fig. 10)		S-17
BASE		Medium 4-Pin

* Referred to mid-point of a-c operated filament. Self-bias is advisable in all cases and is required if a grid resistor (max. value of 1.0 megohm) is used.

INSTALLATION

The base pins of the '45 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 the filament pin holes vertically one above the other. This precaution locates the filament plane vertical for most satisfactory performance. For socket connections, see page 39, Fig. 1. Provision should be made for free circulation of air around the tube since the bulb becomes quite hot during operation.

The coated filament of the '45 is designed to operate from the a-c line through a step-down transformer although it may be operated from a d-c source. In either case, the voltage applied to the filament terminals should be the rated value of 2.5 volts under conditions of load and normal line voltage.

APPLICATION

As a power amplifier, the '45 should be operated as indicated under CHARACTERISTICS. When a.c. is used on the filament, the plate and grid returns should be brought to (1) a mid-tapped resistor of from 20 to 40 ohms across the filament winding, or (2) to the mid-tap of the filament winding itself.

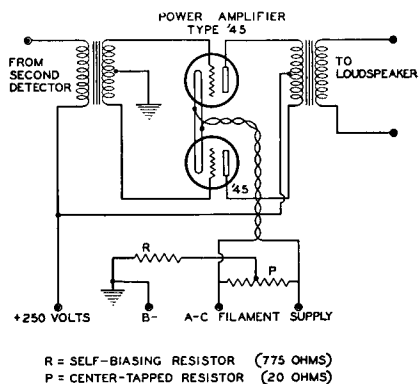
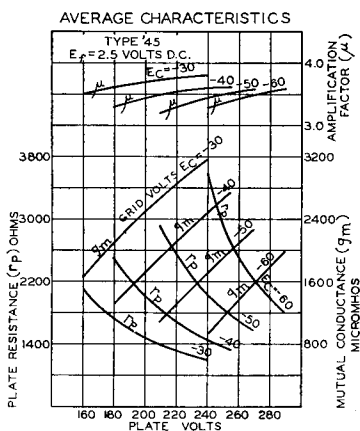
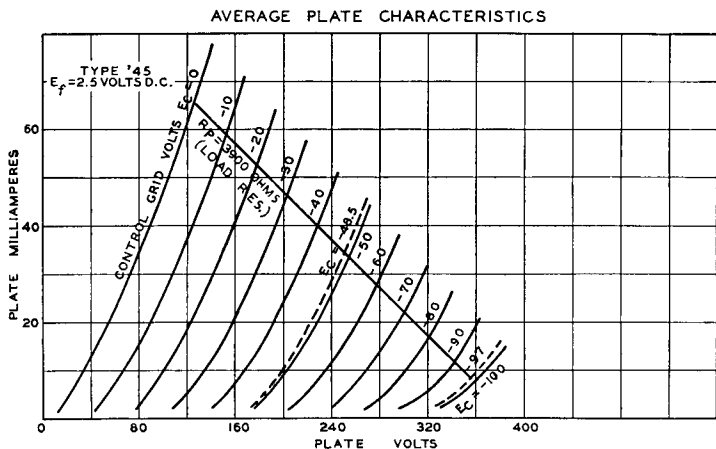
Grid bias for the '45 should be obtained by use of the voltage drop in a resistor connected in the negative plate-return lead. This scheme is known as the self-biasing method. The proper value of the resistor for a single '45 is 1550 ohms

THE CUNNINGHAM RADIO TUBE MANUAL

for a plate voltage of 275 volts; 1475 ohms for a plate voltage of 250 volts; and 1275 ohms for a plate voltage of 180 volts.

If more output is desired than can be obtained from a single '45, two '45's may be operated either in parallel or push-pull connection. See page 13. When two '45's are operated together in the same amplifier stage, the values of the self-biasing resistors will be approximately one-half the values given above for a single tube.

An output device should be used to transfer power to the winding of the reproducing unit.





Cunningham RADIO TUBES

C-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. In such circuits an output stage is preceded by a power amplifier stage designated as the "driver." A pair of '46's in a Class B output stage is capable of supplying an exceptionally large amount of virtually undistorted power; while a single '46, operated in the driver stage as a Class A amplifier, can deliver sufficient power to drive the pair of '46's in the output stage.

The dual application of the '46 to Class B and to Class A amplifier service is made possible by different connections of the two grids incorporated in the tube's structure. Each grid terminates in its respective base pin. For Class B operation, the two grids must be tied together. This connection causes the tube to have an amplification factor so high that negative grid bias is not required for its operation as a Class B amplifier. For Class A operation, the grid adjacent to the plate is tied to the plate in order that the tube will have a low amplification factor. In the latter case, negative grid bias is required for proper operation of the tube. See page 15 for discussion of Class B operation.

CHARACTERISTICS

FILAMENT VOLTAGE (A. C. or D. C.).....	2.5	Volts
FILAMENT CURRENT	1.75	Amperes
MAXIMUM OVERALL LENGTH		5 $\frac{5}{8}$ "
MAXIMUM DIAMETER		2 $\frac{3}{16}$ "
BULB (See page 42, Fig. 10)		S-17
BASE		Medium 5-Pin

As Class B Amplifier

PLATE VOLTAGE	300	400 max.	Volts
GRID VOLTAGE (Both grids tied together) ..	0	0	Volts
PLATE CURRENT (Per tube)	4	6	Milliamperes
PEAK PLATE CURRENT (Per tube)	150	200	Milliamperes
MAX. PLATE DISSIPATION (Avg. per tube) ..	10	10	Watts
LOAD RESISTANCE (Per tube)	1300	1450	Ohms
MAX. SIGNAL VOLTAGE (RMS per tube)	40	41	Volts
MAX. CONTINUOUS POWER OUTPUT (Two tubes)*	16	20	Watts

As Class A Amplifier

PLATE VOLTAGE	250 max.	Volts
GRID VOLTAGE (Grid adjacent to plate tied to plate)	-33	Volts
PLATE CURRENT	22	Milliamperes
PLATE RESISTANCE	2380	Ohms
AMPLIFICATION FACTOR	5.6	
MUTUAL CONDUCTANCE	2350	Micromhos
LOAD RESISTANCE (For max. undistorted power)**..	6400	Ohms
MAX. UNDISTORTED POWER OUTPUT	1.25	Watts

* Power measured across indicated value of resistor in plate circuit of each tube, with indicated signal applied through 250 ohm resistance in the grid circuit.

** Approximately twice this value is recommended for load of driver for Class B stage.

INSTALLATION

The base of the '46 is of the medium five-pin type. Its pins fit the standard five-contact socket which may be installed to operate 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. For socket connections, see page 39, Fig. 7.

The **bulb** of this tube may become very hot under certain conditions of operation. Sufficient ventilation, therefore, should be provided around the tube to prevent overheating.

The **filament** is designed to operate at 2.5 volts. The transformer winding that supplies the filament circuit should operate the filament at this recommended value (as measured at the filament terminals) when rated voltage is applied to the primary of the power transformer operating under average load. 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 plate return for the driver stage should be made to a variable center-tapped resistor across the filament (or heater) 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.

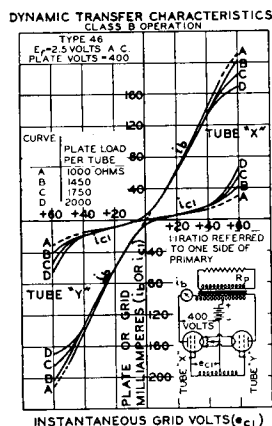
APPLICATION

For **Class B audio power amplifier service**, the '46 is particularly recommended because of its design. In this type of service, the two grids in the tube are connected together and, thus, the signal voltage is applied to both simultaneously. No grid bias voltage is necessary with this connection as the steady plate current at zero bias is only a few milliamperes. The design of the '46 permitting its operation as a Class B amplifier with zero bias is particularly important because it prevents variation of bias with applied signal which would otherwise exist if any self-bias arrangement were employed.

The direct-current requirements of Class B circuits are subject to fluctuation under operating conditions. The power supply, therefore, should have as good regulation as possible to maintain proper operating voltages regardless of the current drain. The use of a mercury-vapor rectifier in the power supply is recommended because it has a low and practically constant space-charge voltage drop within its operating range. As a further means of obtaining good regulation, the filter chokes and transformer windings of the power supply should have as low resistance as possible. In designing the power supply for a Class B amplifier, it should be remembered that such an amplifier may frequently demand peak currents of 200 milliamperes or more.

The grid of the '46 is operated sufficiently positive to cause grid current to flow in its input circuit. This feature imposes a further requirement on the preceding amplifier stage which must supply not only the necessary input voltage to the output stage, but it must be capable of doing so under conditions where appreciable power is taken by the grid of the Class B amplifier tube. Since the power necessary to swing the grid positive is partially dependent on the plate load of the Class B tube, and since the efficiency of power transfer from the preceding stage is dependent on transformer design, it is apparent that the design of a Class B audio power amplifier requires that more than ordinary attention be given to the effects produced by the component parts of the circuit. For this reason, the design of a Class B audio amplifier with its driver stage is somewhat more involved than for a Class A system.

In the design of Class B amplifiers, the interstage transformer is the link interconnecting the driver and the Class B stage. It is usually of the step-down type,

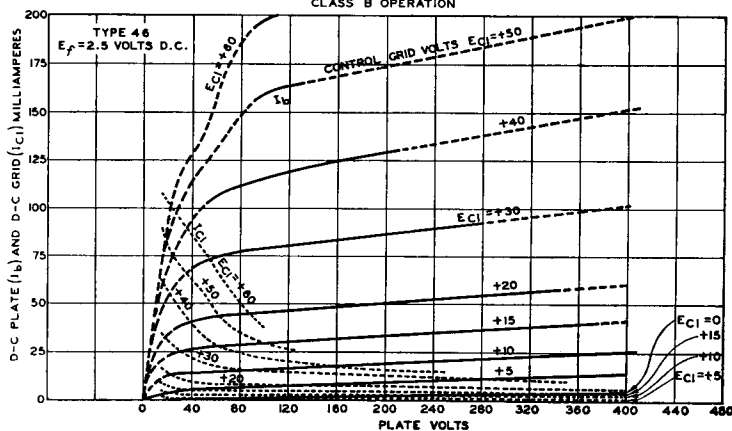


that is, the primary input voltage is higher than the secondary voltage supplied to the grids of the power output tubes. Depending upon conditions, the ratio of the primary of the interstage transformer to one-half of its secondary may range between 1.5 to 1 and 5.5 to 1. The transformer step-down ratio is dependent on the following factors: (1) Type of driver tube, (2) Type of power tube, (3) Load on power tube, (4) Permissible distortion, and (5) Transformer efficiency (peak power).

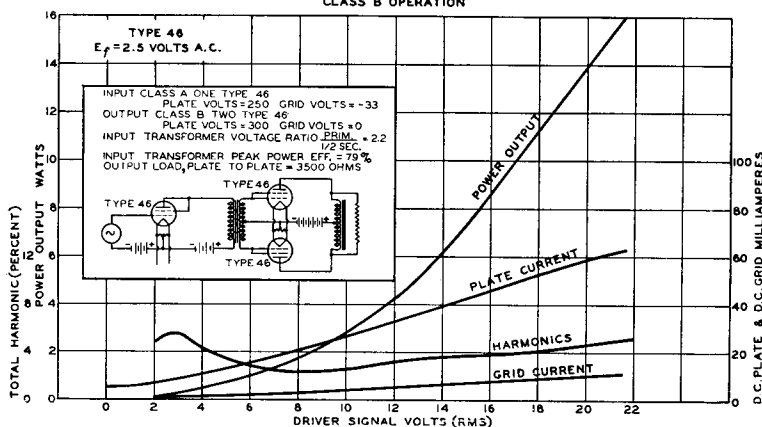
The primary impedance of the interstage transformer is essentially the same as if the transformer were to be operated with no load, that is, into an open grid. Since power is transferred, the transformer should have reasonable power efficiency. It should be noted that the power output and distortion are often critically dependent upon the circuit constants which should therefore be made as near independent of frequency as possible. This applies particularly to the interstage coupling transformer and to the loudspeaker.

The driver tube should be capable of delivering sufficient power to operate the Class B amplifier stage. If low distortion is desired, it is most important that the driver tube be worked substantially below its Class A undistorted output rating, since distortion produced by the driver stage and the power stage will be present in the output.

AVERAGE PLATE CHARACTERISTICS
CLASS B OPERATION

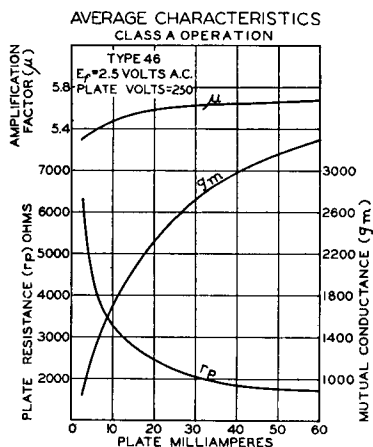
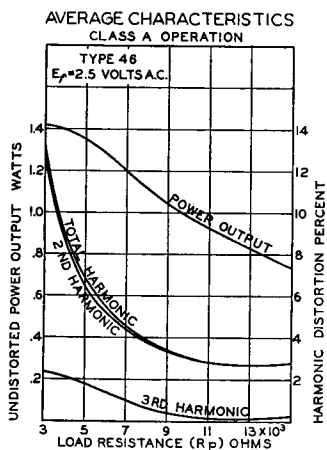
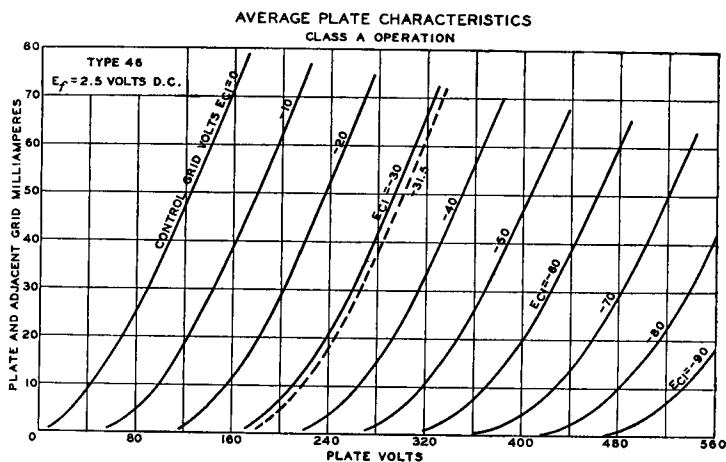


OPERATION CHARACTERISTICS
CLASS B OPERATION



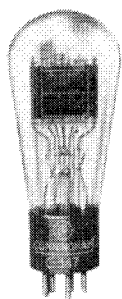
For **Class A operation** of the '46, the grid adjacent to the plate is connected to the plate. The grid next to the filament serves as the control grid. Operation of the tube is then similar to any Class A power amplifier triode. The operation of this tube connected as a Class A amplifier is not indicative of its performance in Class B circuits and should not be confused with the latter.

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.



Cunningham RADIO TUBES

C-347



POWER AMPLIFIER PENTODE

The '47 is a 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. In comparison with three-electrode power amplifiers of the same plate dissipation, the '47 is capable of greater power output with the additional feature of higher amplification. This power-handling ability of the '47 is made possible by the addition of both a suppressor and a screen between the grid and plate. (See page 5 for further information on pentodes.)

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	6.0	Milliamperes
PLATE RESISTANCE	60000	Ohms
AMPLIFICATION FACTOR	150	
MUTUAL CONDUCTANCE	2500	Micromhos
LOAD RESISTANCE	7000	Ohms
POWER OUTPUT	2500	Milliwatts
EFFECTIVE GRID-PLATE CAPACITANCE	1.25	$\mu\text{f.}$
INPUT CAPACITANCE	8.7	$\mu\text{f.}$
OUTPUT CAPACITANCE	13.2	$\mu\text{f.}$
MAXIMUM OVERALL LENGTH		5 $\frac{5}{8}$ "
MAXIMUM DIAMETER		2 $\frac{3}{16}$ "
BULB (See page 42, Fig. 10)		S-17
BASE		Medium 5-Pin

* If filament is operated on d.c., grid bias should be -15.3 volts.

INSTALLATION

The base pins of the '47 fit the standard five-contact socket which should be mounted preferably to hold the tube in a vertical position. For socket connections, see page 39, Fig. 6. 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. Provision should be made for free circulation of air around the tube since the bulb becomes quite hot during operation.

The coated filament of the '47 is intended for operation from a 2.5-volt winding of the power transformer. The voltage applied to the filament terminals should be the rated value of 2.5 volts under operating conditions and average line voltage.

APPLICATION

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.

If a single '47 is operated self-biased, the self-biasing resistor should be approximately 450 ohms. This resistor should be shunted by a condenser of 4 to 20 $\mu\text{f.}$

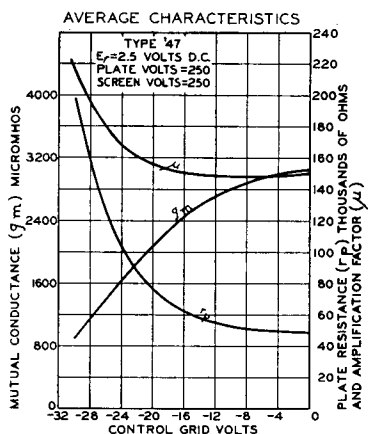
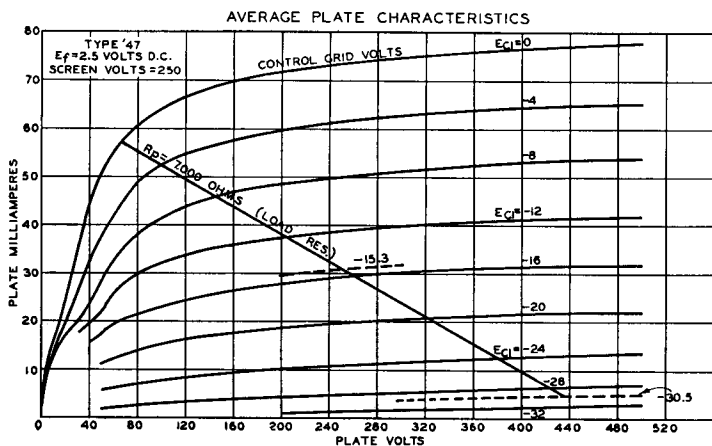
THE CUNNINGHAM RADIO TUBE MANUAL

to avoid degeneration effects at low audio frequencies. The use of two '47's in push-pull eliminates the necessity of by-passing the resistor and is, in addition, effective in reducing hum from filter circuits. The self-biasing resistor required for the push-pull stage is approximately 225 ohms.

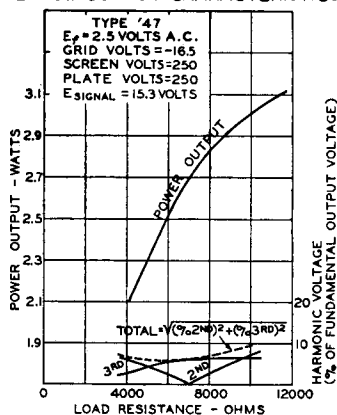
Any conventional type of **input coupling** may be used, provided that the resistance added to the grid circuit by this device is not too high. Transformer or impedance coupling devices are preferable. If input-resistance coupling is used, a grid resistance not to exceed 0.5 megohm may be employed under self-bias conditions. Without self-bias, the grid leak resistance should not exceed 50000 ohms.

An **output transformer** should be used in order to supply power to the winding of the reproducing unit. The optimum value of load resistance for the output device is 7000 ohms. For best results, the impedance in the plate circuit of the '47 over the entire audio-frequency range should be as uniform as possible.

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.



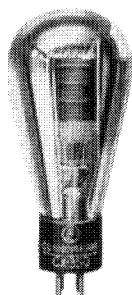
AVERAGE OUTPUT CHARACTERISTICS



Cunningham RADIO TUBES

CX-350

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 unusually large amounts of undistorted power.

CHARACTERISTICS

FILAMENT VOLTAGE (A. C. or D. C.).....	7.5	Volts
FILAMENT CURRENT	1.25	Amperes
PLATE VOLTAGE	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	
MUTUAL CONDUCTANCE	2000 2100 2100	Micromhos
LOAD RESISTANCE	4100 3670 4350	Ohms
UNDISTORTED POWER OUTPUT	2400 3400 4600	Milliwatts
GRID-PLATE CAPACITANCE	9	μ f.
GRID-FILAMENT CAPACITANCE	5	μ f.
PLATE-FILAMENT CAPACITANCE	3	μ f.
MAXIMUM OVERALL LENGTH		6 $\frac{1}{4}$ "
MAXIMUM DIAMETER		2 $\frac{11}{16}$ "
BULB (See page 42, Fig. 13)		S-21
BASE	Medium 4-Pin Bayonet	

* Measured from mid-point of a-c operated filament.

INSTALLATION

The base pins of the '50 fit the standard four-contact socket which should be mounted to hold the tube in a vertical position. For socket connections, see page 39, Fig. 1. Provision should be made for free circulation of air around the tube, since the bulb becomes quite hot during operation.

The coated filament is designed to operate from a 7.5 volt winding of the power transformer. However, if desirable, it may be operated equally as well from a d-c source. In either case the voltage applied to the filament terminals should be the rated value of 7.5 volts.

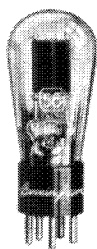
APPLICATION

As a power amplifier, the '50 should be operated as shown under CHARACTERISTICS. Grid bias voltage may be conveniently obtained by means of the voltage drop through a resistor in the plate return lead. The proper value of this resistor is 1400 ohms for a plate voltage of 350 volts; 1275 ohms for a plate potential of 400 volts; and 1530 ohms for a plate potential of 450 volts. The '50 is not recommended for use in resistance-coupled circuits having a grid resistor.

If more output is desired than can be obtained from a single '50, two '50's may be operated either in parallel or push-pull connection. See page 13. When two '50's are operated together in the same amplifier stage, the values of the self-biasing resistors will be approximately one-half those shown above for a single tube.

Cunningham RADIO TUBES

C-56



SUPER-TRIODE AMPLIFIER

The 56 is a three-electrode tube of the uni-potential heater-cathode type recommended for use as detector, amplifier, or oscillator in a-c receivers designed for it. This tube is characterized by its small overall size, its relatively low heater power consumption, its high mutual conductance, and its comparatively high amplification factor. The 56 is especially 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	250 max.	Volts
GRID VOLTAGE*	-13.5	Volts
PLATE CURRENT	5	Milliamperes
PLATE RESISTANCE	9500	Ohms
AMPLIFICATION FACTOR	13.8	
MUTUAL CONDUCTANCE	1450	Micromhos
GRID-PLATE CAPACITANCE	3.2	μ f.
GRID-CATHODE CAPACITANCE	3.2	μ f.
PLATE-CATHODE CAPACITANCE	2.2	μ f.
MAXIMUM OVERALL LENGTH		4 $\frac{1}{4}$ "
MAXIMUM DIAMETER		1 $\frac{9}{16}$ "
BULB (See page 42, Fig. 6)		S-12
BASE		Small 5-Pin

* If a grid coupling resistor is used, its maximum value should not exceed 1.0 megohm.

INSTALLATION

The base of the 56 is of the small five-pin type. Its pins fit the standard five-contact socket which may be installed to operate the tube either in a vertical or in a horizontal position. For horizontal operation, the socket should be positioned with its heater pin openings one vertically above the other. For socket connections, see page 39, Fig. 8.

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 (as measured at the heater terminals) when rated voltage is applied to the primary of the power transformer operating under average load.

The cathode should be connected either to the mid-tap on the heater supply winding or to the mid-tap of a 50 ohm (approximate) resistor shunted across the winding. If this practice is not followed, the heater may be biased negative with respect to the cathode by not more than 45 volts. When the cathode is not connected directly to the heater in a-c receivers, attention should be given to keeping the impedance of the circuit between heater and cathode as low as possible. Unless this is done, hum may arise because of heater to cathode leakage.

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 circuits utilizing resistance coupling, typical operating conditions are as follows: Plate supply voltage, 250 volts; grid bias voltage,

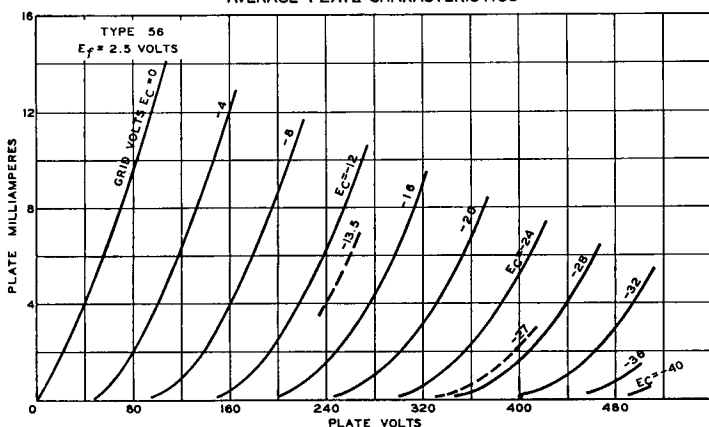
-9 volts (approximate); plate load resistor, 50000 to 100000 ohms; and plate current, 1 to 2 milliamperes.

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 μ f. is satisfactory. For the grid bias method of detection, the maximum 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 milliamperes with no a-c 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-biasing resistor is not critical, 100000 to 150000 ohms being suitable. The higher value will permit the application of a larger input signal.

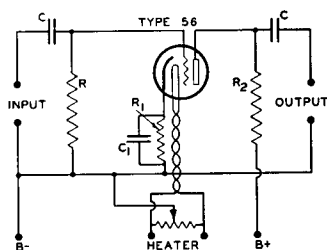
The 56 may be employed as a two-electrode detector preferably by connecting the plate to the cathode for the one electrode and using the grid for the other. With this arrangement, a-c input voltages as high as 40 volts RMS may be applied between grid and cathode.

As an oscillator, the 56 may be operated with a plate voltage of approximately 90 volts and zero grid bias. A lower value of plate voltage may be found desirable in some applications.

AVERAGE PLATE CHARACTERISTICS

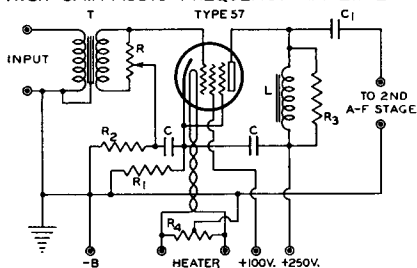


RESISTANCE-COUPLED A-F AMPLIFIER



- R = GRID RESISTOR (1.0 MEGOHM, MAX.)
 R_1 = SELF-BIASING RESISTOR (3000 OHMS)
 R_2 = COUPLING RESISTOR (50000 TO 100000 OHMS)
 C_1 = COUPLING CAPACITOR (0.1 μ f. - 1.0 μ f.)
 C_2 = BY-PASS CAPACITOR (4 μ f.)

HIGH-GAIN AUDIO-FREQUENCY AMPLIFIER



- C = A-F BY-PASS CAPACITOR (0.5 μ f.)
 C_1 = COUPLING CAPACITOR (0.01 μ f.)
 R = VOLUME CONTROL POTENTIOMETER (250000 OHMS)
 R_1 = SELF-BIASING RESISTOR (1000 OHM, 1 WATT)
 R_2 = DECOUPLING RESISTOR (250000 OHMS)
 R_3 = COMPENSATING RESISTOR (250000 OHMS)
 R_4 = CENTER-TAPPED RESISTOR (50 OHMS)
 T = INPUT TRANSFORMER
 L = 300 TO 500 HENRY CHOKE



Cunningham RADIO TUBES

C-57

TRIPLE-GRID AMPLIFIER

The 57 is a triple-grid tube recommended especially for service as a biased detector in a-c 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 57 include its use as a low signal-input, screen grid amplifier tube and as an automatic volume control tube. The 57 is characterized by the small overall size, the dome-top bulb, the internal shield in the dome, the rigidity of electrode assembly, and the fifth electrode or suppressor with its own base pin terminal. Equally significant among its electrical features are its relatively low heater power consumption, its sharp plate current "cut-off" with respect to grid voltage, and its adaptability of electrode combinations to unusual circuit applications.

The internal shield is a distinctive feature in the design of this tube. It is placed in the bulb dome above the electrode assembly and is connected within the tube directly to the cathode. The dome-top bulb makes possible close proximity of the external and internal shields and, therefore, a low effective grid-plate capacitance. The form of the external shield-can may be somewhat modified depending upon the receiver design requirements for minimum grid-plate and output capacitance.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.)	2.5	Volts
HEATER CURRENT	1.0	Ampere
PLATE VOLTAGE	250 max.	Volts
SCREEN VOLTAGE	100 max.	Volts
GRID VOLTAGE	-3	Volts
PLATE CURRENT	2.0	Milliamperes
SCREEN CURRENT	1.0	Milliampere
PLATE RESISTANCE	Greater than 1.5	Megohms
AMPLIFICATION FACTOR	Greater than 1500	
MUTUAL CONDUCTANCE	1225	Micromhos
EFFECTIVE GRID-PLATE CAPACITANCE (with shield can)	0.010 maximum	$\mu\text{f.}$
INPUT CAPACITANCE	5.2	$\mu\text{f.}$
OUTPUT CAPACITANCE	6.8	$\mu\text{f.}$
OVERALL LENGTH		$4\frac{19}{32}"$ to $4\frac{27}{32}"$
MAXIMUM DIAMETER		$1\frac{1}{16}"$
BULB (See page 42, Fig. 7)		ST-12
CAP		Small Metal
BASE		Small 6-Pin

INSTALLATION

For **base** and socket information, refer to **base** for type 58.

For **heater** operation and **cathode** connection, refer to **INSTALLATION** for type 56.

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 57, 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 57 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 capacitor. 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 elements. It should be noted also that condenser plates may cause an audio howl due to mechanical feed-back from the speaker.

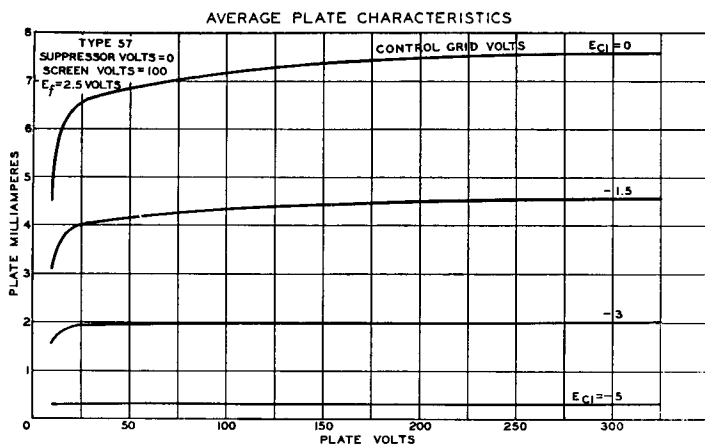
APPLICATION

As a **biased detector**, the 57 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 57 as a biased detector are as follows: Plate voltage, 250 volts; screen voltage, 100 volts; grid bias voltage, -6 volts (approx.); plate load, 250000 ohm resistor, or a 500 henry choke shunted by a 0.25 megohm resistor. For resistance load, the plate voltage will be the supply voltage minus the voltage drop in load caused by specified plate current (adjusted to 0.1 milliampere with no a-c input signal).

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 a **radio-frequency amplifier**, the 57 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 an **audio-frequency amplifier** in resistance-coupled circuits, the 57 may be operated under the following conditions: Plate supply voltage, 250 volts, applied through a plate coupling resistor of 250000 ohms; screen voltage, 100 volts; plate current, 0.75 ma., approx.; grid voltage, -4.5 volts. The grid resistor should have a value not exceeding 1.0 megohm.





Cunningham RADIO TUBES

C-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 characterized by the small overall size, the dome-top bulb, and the fifth electrode or suppressor with its own base pin terminal.

Equally significant among its electrical features are the relatively low heater power consumption, the extended mutual conductance operating range, and the adaptability of electrode combinations to various circuit applications. The ability of this tube to handle usual signal voltages without cross-modulation and modulation-distortion makes it uniquely adaptable to the r-f and i-f stages of receivers employing automatic volume control. Shield construction and bulb shape are discussed under Type 57, which is similar in structural appearance.

When the suppressor is not connected directly to the cathode, its utility may be extended. The suppressor, in suitable circuits, provides a means for obtaining the desirable conditions of reduced selectivity for local reception. This operational characteristic makes possible improved loudspeaker response when the receiver is tuned to powerful nearby stations.

CHARACTERISTICS

HEATER VOLTAGE (A. C. or D. C.).....	2.5	Volts
HEATER CURRENT	1.0	Ampere
PLATE VOLTAGE	250 max.	Volts
SCREEN VOLTAGE	100 max.	Volts
GRID VOLTAGE	-3 min.	Volts
PLATE CURRENT	8.2	Milliamperes
SCREEN CURRENT	3.0 max.	Milliamperes
PLATE RESISTANCE	800000	Ohms
AMPLIFICATION FACTOR	1280	
MUTUAL CONDUCTANCE	1600	Micromhos
MUTUAL CONDUCTANCE { At -40 volts bias	10	Micromhos
{ At -50 volts bias	2	Micromhos
EFFECTIVE GRID-PLATE CAPACITANCE (with shield-can)	0.010 maximum	μuf.
INPUT CAPACITANCE	5.2	μuf.
OUTPUT CAPACITANCE	6.8	μuf.
OVERALL LENGTH	41 ⁹ / ₃₂ " to 42 ⁷ / ₃₂ "	
MAXIMUM DIAMETER	1 ⁹ / ₁₆ "	
BULB (See page 42, Fig. 7)	ST-12	
CAP	Small Metal	
BASE	Small 6-Pin	

INSTALLATION

The base pins of the 58 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 its heater pin openings one vertically above the other. For socket connections, see page 39, Fig. 11.

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 under average line voltage.

For cathode connection, refer to cathode, type 56.

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 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 58, 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.

Shielding requirements are similar to those for type 57.

APPLICATION

As a **radio-frequency amplifier**, the 58 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 58 as an amplifier are given under **CHARACTERISTICS**.

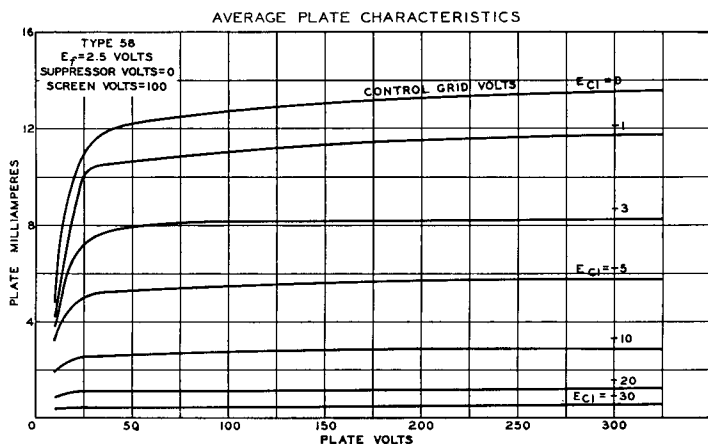
To realize the maximum benefit of the long "cut-off" feature of this tube, it is necessary to apply a variable grid bias and to maintain the screen at a constant potential with respect to the cathode. However, good results may be obtained by using a variable cathode resistance which, of course, reduces the screen potential with respect to the cathode by the same amount that the bias is increased, thus hastening the "cut-off" and reducing the ability of the tube to handle large signals. This undesirable 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 58, 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. When screen and control grid voltages are obtained in this manner, the remote "cut-off" advantage of the 58 may be fully realized.

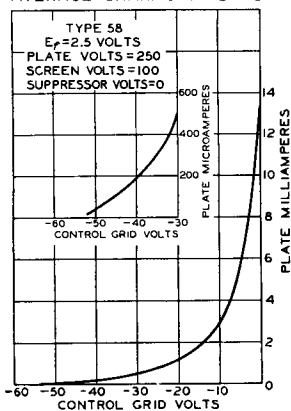
As a **frequency converter** or a **superheterodyne first detector**, the 58 may be used to advantage. It is capable of producing under the proper conditions of grid and local oscillator voltage, a gain in the first detector stage of about one-third that which can be obtained in an intermediate-frequency amplifier stage. In addition, this gain can be controlled as in the case of the radio-frequency amplifier by varying the grid bias either from a separate supply or from a variable resistor in the cathode circuit. This is a particularly 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 58 as a superheterodyne first detector follow: Plate voltage, 250 volts; screen voltage, 100 volts; and

grid bias voltage, -10 volts minimum (with 9-volt oscillator peak swing). With an oscillator peak swing of 1 volt less than the grid bias, these values are not critical and may be chosen to meet circuit design requirements.

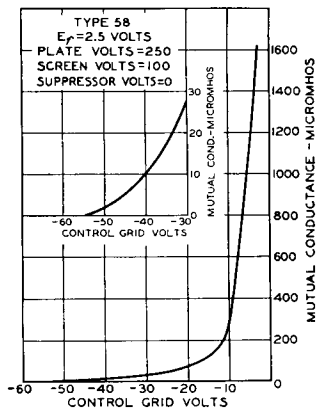
As a **grid bias detector**, the 58 is not recommended. This is because the intentional elimination of a definite "cut-off" makes the 58 rather insensitive and renders any approach to linear detection impracticable.



AVERAGE CHARACTERISTICS



AVERAGE CHARACTERISTICS



Cunningham RADIO TUBES

CX-371-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 (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	12 17.5 20	Milliamperes
PLATE RESISTANCE	2250 1960 1850	Ohms
AMPLIFICATION FACTOR	3 3 3	
MUTUAL CONDUCTANCE	1330 1520 1620	Micromhos
LOAD RESISTANCE	3200 3500 5350	Ohms
UNDISTORTED POWER OUTPUT	125 370 700	Milliwatts
GRID-PLATE CAPACITANCE	7.4	μ mf.
GRID-FILAMENT CAPACITANCE	3.7	μ mf.
PLATE-FILAMENT CAPACITANCE	2.1	μ mf.
MAXIMUM OVERALL LENGTH		4 $\frac{1}{4}$ "
MAXIMUM DIAMETER		1 $\frac{3}{16}$ "
BULB (See page 42, Fig. 8)		S-14
BASE		Medium 4-Pin

* For operation on a-c filament supply, increase grid bias voltage 2.5 volts.

INSTALLATION

The base pins of this tube fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position. For socket connections, see page 39, Fig. 1.

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. Most satisfactory operating performance of the tube will be obtained at the rated filament voltage.

APPLICATION

Operating conditions are given under CHARACTERISTICS for the use of this tube in the power output stage. With a d-c filament supply, the grid and the plate return should be made to the negative filament terminal.

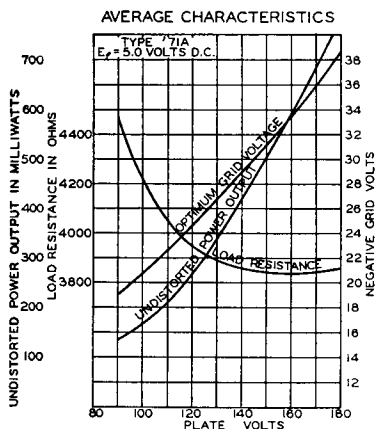
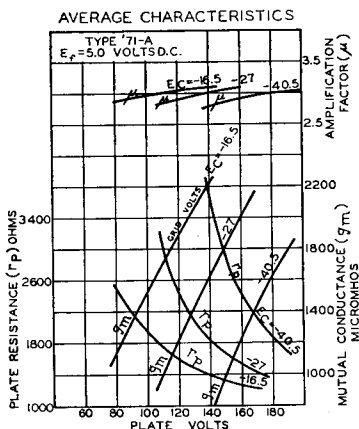
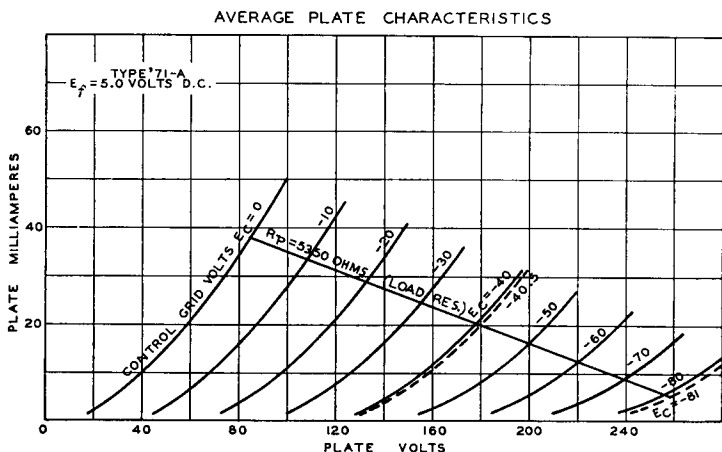
For a-c filament supply, the plate and the grid return should be brought either to a mid-tapped resistor of 20 to 40 ohms across the filament winding, or to a mid-tap of the filament winding. To prevent overloading and distortion, the recommended negative grid bias should always be used.

Grid bias for the '71-A may be obtained from a C-battery or by means of the voltage drop in a resistor connected in the negative plate return lead. This second method is known as the self-biasing method, since the plate current determines the

drop. It is not, however, generally applicable to battery operated receivers. The proper value of this resistor for a plate voltage of 180 volts is 2150 ohms; for a plate voltage of 135 volts, 1700 ohms; and for 90 volts, 1600 ohms.

If more output is desired than can be obtained from a single '71, two '71's may be operated either in parallel or push-pull connection. See page 13. When two '71's are operated together in the same amplifier stage, the values of the self-biasing resistors will be approximately one-half the values given above for a single tube.

An **output device** should be used to transfer power to the winding of the reproducing unit.





Cunningham
RADIO TUBES

CX-380

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 VOLTAGE PER PLATE (RMS)	350	Volts
{ D-C OUTPUT CURRENT	125 max.	Milliamperes
2 { A-C VOLTAGE PER PLATE (RMS)	400 max.	Volts
{ D-C OUTPUT CURRENT	110 max.	Milliamperes
3* { A-C VOLTAGE PER PLATE (RMS)	550 max.	Volts
{ D-C OUTPUT CURRENT	135 max.	Milliamperes
MAXIMUM OVERALL LENGTH		5 $\frac{3}{8}$ "
MAXIMUM DIAMETER		2 $\frac{3}{16}$ "
BULB (See page 42, Fig. 10)		S-17
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. For socket connections, see page 39, Fig. 2. 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.

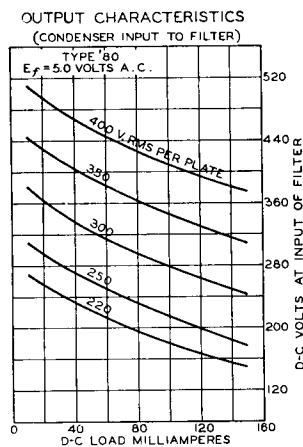
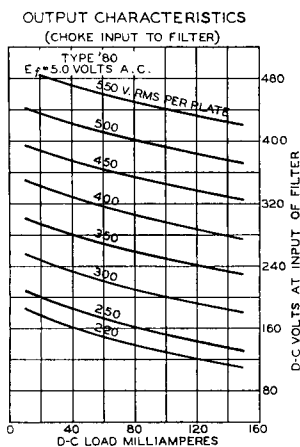
The approximate d-c output voltage of the '80 for various values of a-c input voltages may be obtained from the curves. For the d-c voltage available at the radio set, it is necessary to subtract the voltage drop across the filter from the value read from the curves.

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. 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.

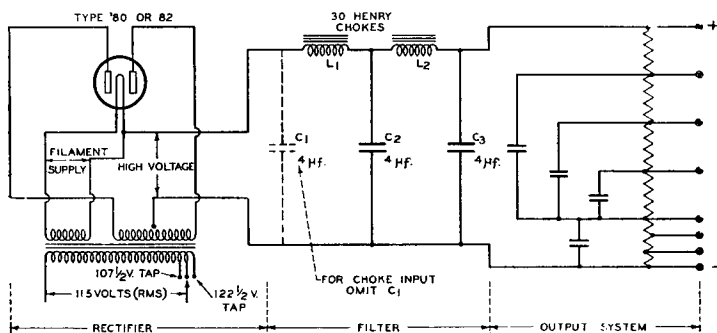
APPLICATION

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.

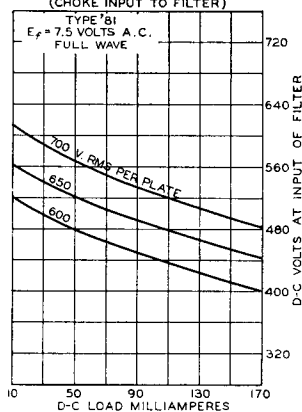
As a half-wave rectifier, two '80's may be operated in a full-wave circuit with reasonable serviceability to deliver more d-c output current than can be obtained from one tube. For this use, the plates of each '80 are tied together at the socket. The allowable voltage and load conditions per tube are the same as for full-wave service.



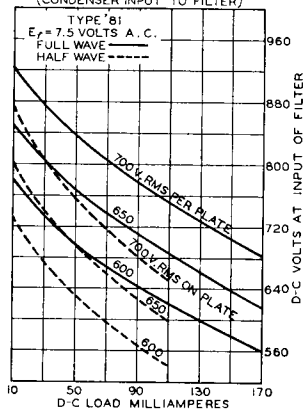
TYPICAL FULL-WAVE RECTIFIER CIRCUIT



OUTPUT CHARACTERISTICS
(CHOKE INPUT TO FILTER)



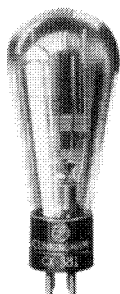
OUTPUT CHARACTERISTICS
(CONDENSER INPUT TO FILTER)



Cunningham RADIO TUBES

CX-381

HALF-WAVE RECTIFIER



The '81 is a half-wave rectifier tube for use in d-c socket-power 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
MAXIMUM OVERALL LENGTH		6 $\frac{1}{4}$ "
MAXIMUM DIAMETER		2 $\frac{3}{16}$ "
BULB (See page 42, Fig. 12)		S-19
BASE		Medium 4-Pin

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. For socket connections, see page 39, Fig. 3. 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 voltages may be obtained from the curves. 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 on preceding page.

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.

APPLICATION

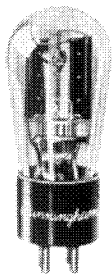
As a **half-wave rectifier**, the '81 may be operated under conditions not to exceed those given under CHARACTERISTICS.

In **full-wave** circuits, two '81's are required to rectify each half 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.

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.

Cunningham RADIO TUBES

CX-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 voltage drop (only about 15 volts) for any current drain up to the full emission of the filament (see page 4). *The 82 is not interchangeable with any other rectifier type.*

CHARACTERISTICS

FILAMENT VOLTAGE (A. C.)	2.5	Volts
FILAMENT CURRENT	3.0	Amperes
MAXIMUM A-C VOLTAGE PER PLATE (RMS)	500	Volts
MAXIMUM PEAK INVERSE VOLTAGE.....	1400	Volts
MAXIMUM D-C OUTPUT CURRENT, Continuous....	125	Milliamperes
MAXIMUM PEAK PLATE CURRENT	400	Milliamperes
TUBE VOLTAGE DROP, Approximate.....	15	Volts
MAXIMUM OVERALL LENGTH		4 $\frac{1}{16}$ "
MAXIMUM DIAMETER		1 $\frac{1}{16}$ "
BULB (See page 42, Fig. 8)		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 of the 82 is of the medium 4-pin type. Its pins fit the standard four-contact socket which should be installed to operate 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 also high internal tube drop with consequent injury to the tube. For socket connections, see page 39, Fig. 2.

The **bulb** becomes hot during continuous operation. Provision should be made, especially if shielding is employed, for adequate natural ventilation to prevent overheating.

The **filament** is of the coated type and 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

The 82 is recommended for supplying d-c power to receivers, particularly those employing Class B audio amplification (see page 15). The direct current requirements of such receivers cause considerable variation in the load impressed on the rectifier tube. The 82 is especially suited to take care of this load demand with excellent regulation.

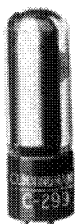
Filter circuits of either the condenser-input or the choke-input type may be employed provided that the maximum voltages and currents tabulated under CHARACTERISTICS are not exceeded. If the condenser-input type of filter is used, consideration must be given to the instantaneous peak value of the a-c input voltage which is about 1.4 times the RMS value measured from plate to filament with an a-c voltmeter. It is important, therefore, that the filter condensers (especially the input one) have a sufficiently high break-down rating to withstand this instantaneous peak value. It should be noted that with condenser input to the filter, the peak plate current of the tube is considerably higher than the load current. With a large condenser in the filter circuit next to the rectifier tube, the peak current is often as much as four times the load current. When, however, choke input to the filter is used, the peak plate current is considerably reduced. This type of circuit, therefore, 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.

Cunningham RADIO TUBES

C-299 AND CX-299

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	
MUTUAL CONDUCTANCE	425	Micromhos
GRID-PLATE CAPACITANCE	3.3	μ mf.
GRID-FILAMENT CAPACITANCE	2.5	μ mf.
PLATE-FILAMENT CAPACITANCE	2.5	μ mf.
	Type '99	X-Type '99
MAXIMUM OVERALL LENGTH	3 1/2"	4 1/8"
MAXIMUM DIAMETER	1 1/16"	1 3/16"
BULB (See Figs. on page 42)	T-8 (Fig. 3)	T-8 (Fig. 1)
BASE	Small 4-Nub	Small 4-Pin

INSTALLATION

The **base** pins of the X-Type '99 fit the standard four-contact socket while the '99 fits only the small shell socket with bayonet slot. The socket should be installed so that the tubes will operate in a vertical position. Cushioning of the socket in the detector stage may be desirable if microphonic disturbances are encountered. For socket connections of X-Type '99 and of '99, see page 39, Fig. 1 and Fig. 10, respectively.

The **filaments** in these tubes are designed for operation with three No. 6 dry-cells connected in series. In multi-tube receivers the use of six or nine No. 6 dry-cells connected in series-parallel to give 4.5 volts will decrease the current drain per cell and give a more stable source of filament power. If storage-battery operation is preferred, a four-volt storage battery may be used. In any case, a filament rheostat should be provided so that the filament voltage can be adjusted to the recommended operating value.

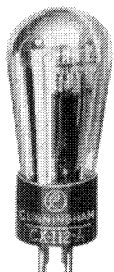
APPLICATION

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 μ f. 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 milliamperes with no a-c input signal.

As **amplifiers**, '99's are applicable to the audio- or the radio-frequency stages of a receiver. Recommended plate and grid voltages are shown under CHARACTERISTICS.

Cunningham RADIO TUBES

CX-112-A



DETECTOR, AMPLIFIER

The 112-A is an improved storage battery tube. It is sensitive as a detector and excellent as a three-electrode radio-frequency and audio-frequency 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	5.2 6.2 7.6	Milliamperes
PLATE RESISTANCE	5600 5300 5000	Ohms
AMPLIFICATION FACTOR	8.5 8.5 8.5	
MUTUAL CONDUCTANCE	1500 1600 1700	Micromhos
LOAD RESISTANCE	5600 8700 10800	Ohms
UNDISTORTED POWER OUTPUT	30 115 260	Milliwatts
GRID-PLATE CAPACITANCE	8.1	μ f.
GRID-FILAMENT CAPACITANCE	4.2	μ f.
PLATE-FILAMENT CAPACITANCE	2.1	μ f.
MAXIMUM OVERALL LENGTH		4 $\frac{1}{16}$ "
MAXIMUM DIAMETER		1 $\frac{3}{16}$ "
BULB (See page 42, Fig. 8)		S-14
BASE		Medium 4-Pin

INSTALLATION

The base pins of the 112-A fit the standard four-contact socket. The socket should be installed so that the tube will operate in a vertical position. Cushioning of the socket in the detector stage may be desirable if microphonic disturbances are encountered. For socket connections, see page 39, Fig. 1.

The coated filament employed in the 112-A may be operated conveniently from a 6-volt 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. At this voltage, the most satisfactory operating performance will be obtained.

APPLICATION

As a **detector**, the 112-A 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 0.25 to 5 megohms used with a grid condenser of 0.00025 μ f. is suitable. The grid circuit return should be connected to the positive filament 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, when no signal is being received, is about 0.2 milliampere. Usually, a plate voltage of 135 volts with a grid bias of approximately -15 volts will be satisfactory.

As an **amplifier**, the 112-A is applicable to the audio- or the radio-frequency stages of a receiver. Plate voltages and the corresponding grid voltages for audio amplifier service should be determined from the tabulated characteristics and the curves in order to obtain optimum performance and freedom from distortion. The

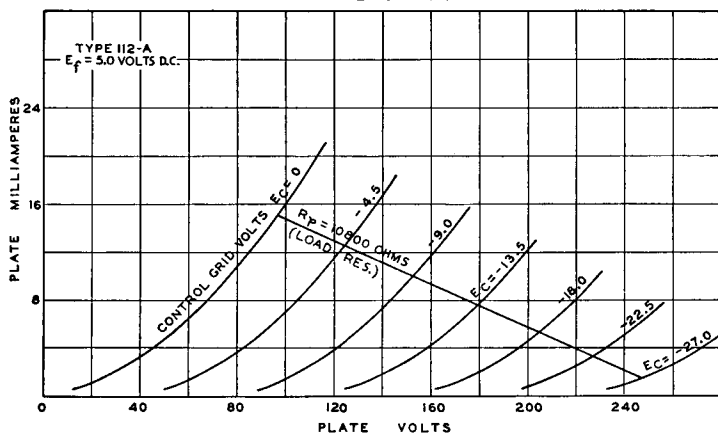
THE CUNNINGHAM RADIO TUBE MANUAL

higher plate voltages will be found advantageous under conditions where the impressed grid signal is large or where maximum power output is desired.

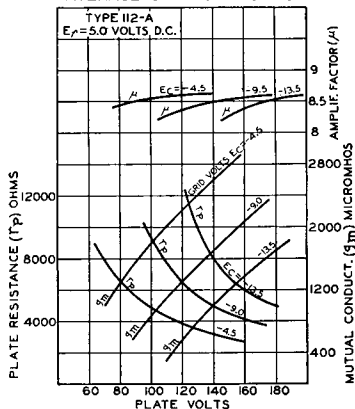
When the 112-A is used as a radio-frequency amplifier, little is gained from plate voltages exceeding 90 volts. If the 112-A is substituted for the '01-A in radio-frequency circuits, it may be necessary to readjust the neutralizing condensers or to increase the value of the grid suppressor resistors to prevent oscillation.

Volume Control of the receiver may be accomplished by variation either of the grid bias or the plate voltage applied to the radio-frequency stages.

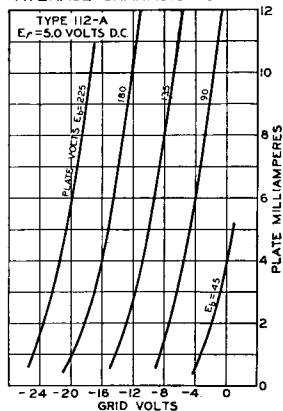
AVERAGE PLATE CHARACTERISTICS



AVERAGE CHARACTERISTICS



AVERAGE CHARACTERISTICS



Cunningham

READ
CAREFULLY

C-327

READ
CAREFULLY

Cunningham C-327 is a General Purpose tube containing a heater element which permits operation from alternating current. It is designed for use either as a Detector or as an Amplifier in AC radio sets operating from the light socket.

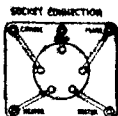
HEATER VOLTAGE -	-	-	-	-	-	-	-	-	-	2.5 VOLTS AC
HEATER CURRENT -	-	-	-	-	-	-	-	-	-	1.75 AMPERES
DETECTOR PLATE VOLTAGE -	-	-	-	-	-	-	-	-	-	45 VOLTS
AMPLIFIER PLATE VOLTAGE -	90	135 VOLTS	For General	180 VOLTS Maximum						
AMPLIFIER GRID VOLTAGE -	-4.5	-9 VOLTS/Amplification	-13.5 VOLTS							

The heater in this tube should be operated at its rated value of 2.5 volts.

A plate voltage of 90 volts used with a negative grid bias of 4.5 volts, or a plate voltage of 135 volts used with a negative grid bias of 9 volts, is recommended for general amplification either in the Radio Frequency stages or in the intermediate Audio stages.

For the last Audio stage, a Power Amplifier tube is recommended for best loudspeaker results. If, however, Cunningham C-327 is used, 180 volts may be applied to the plate and negative 13.5 volts to the grid, in order to avoid distortion.

In some circuits, biasing of the heater approximately 9 volts negative with respect to the cathode may be beneficial for best operation. A heater-cathode bias higher than 9 volts is not recommended.



A TECHNICAL BULLETIN
on this tube is available upon request.

Handle
Tube
Carefully

RC-32997 (1-29)

E. T. CUNNINGHAM, INC.

THIS TUBE
is
GUARANTEED
to be

FREE FROM ELECTRICAL AND MECHANICAL DEFECTS

It has

PASSED THE MOST RIGID TESTS BEFORE SHIPMENT

If this tube does not give the service you have a right to expect, please return it to the dealer from whom it was bought, for test and examination at the Cunningham Service Station. Please tell the dealer when the tube was bought, the make of radio set in which it was used, the voltage at which it was operated, and the circumstances under which it failed to give successful and satisfactory service.

LICENSE NOTICE

The sale of this device carries a license under patent claims on the device itself 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 on combinations of the device with other devices or elements, as for example in various circuits and hook-ups, 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.

Manufactured and sold under rights, patents, and inventions owned and/or controlled by Radio Corporation of America.

CUNNINGHAM

CX-380

FULL WAVE RECTIFIER

RATING

Filament - - - 5 Volts A-C - - - 2 Amperes
 Plate, Maximum - - - 300 Volts A-C per plate
 Output, Maximum - - - 125 Milliamperes D-C
 For approximate D-C Output Voltage to filter see curves below.

USE

Cunningham CX-380 is a Full Wave Rectifying Tube for use in Battery Eliminators operating from alternating current. This tube will operate satisfactorily in devices designed for the CX-313, and will have approximately the same output when used in such devices. The CX-380 will give considerably greater output, when used in devices particularly designed to take advantage of its maximum rating.

MOUNTING

The Large Standard CX Base of this tube will fit both the Navy and Push Type Sockets. It is recommended that, before inserting or removing the tube, the Eliminator be turned off or completely disconnected from the house lighting circuit.

The tube should preferably be mounted in a vertical position. Free circulation of air around it is of great importance and should be considered in Eliminator design, as this factor affects the life of the tube.

FILAMENT

The improved ribbon filament of this Cunningham tube is of the oxide coated type which operates at a red heat. It is usually supplied direct from one of the windings of a power transformer.

D-C OUTPUT VOLTAGE

For a given A-C plate voltage the D-C output voltage of a Rectifier depends largely, but not entirely, upon the current supplied. In order to give an idea, however, of the output of the CX-380 the attached curves have been prepared for as near average conditions encountered in a good eliminator as possible. D-C voltage shown by the curves at V in the accompanying circuit can only be regarded as approximate, since it will be partly governed by many factors which are not always known, such as transformer regulation, wave form, etc. In making the curves it was furthermore assumed that the rectifier was used with a filter having a 4 microfarad condenser where indicated on its input side. An increase in the capacity of this condenser would cause an increase in D-C voltage, but this increase would become smaller as the condenser capacity became large. The effect is so small for usual values of the condenser in question, that it may be disregarded in rough calculation. In determining the maximum smoothed D-C voltage available, the voltage drop (IR) across the filter must be subtracted from the value secured from the curves.

TECHNICAL NOTE

All A-C voltages above are "Root Mean Square" values such as would be shown by most A-C meters. It will be noted that the D-C Voltage Output as shown by the curves approaches for zero current the instantaneous peak voltage which is about 1.4 times the RMS value.

CUNNINGHAM QUALITY AND SERVICE

Every Cunningham Tube is subjected to rigid tests and inspections throughout its various stages of manufacture to insure the highest quality. If, however, any Cunningham Tube is believed not to function properly it should be returned to the dealer from whom it was purchased. The dealer has complete information regarding the proper disposition of such cases.

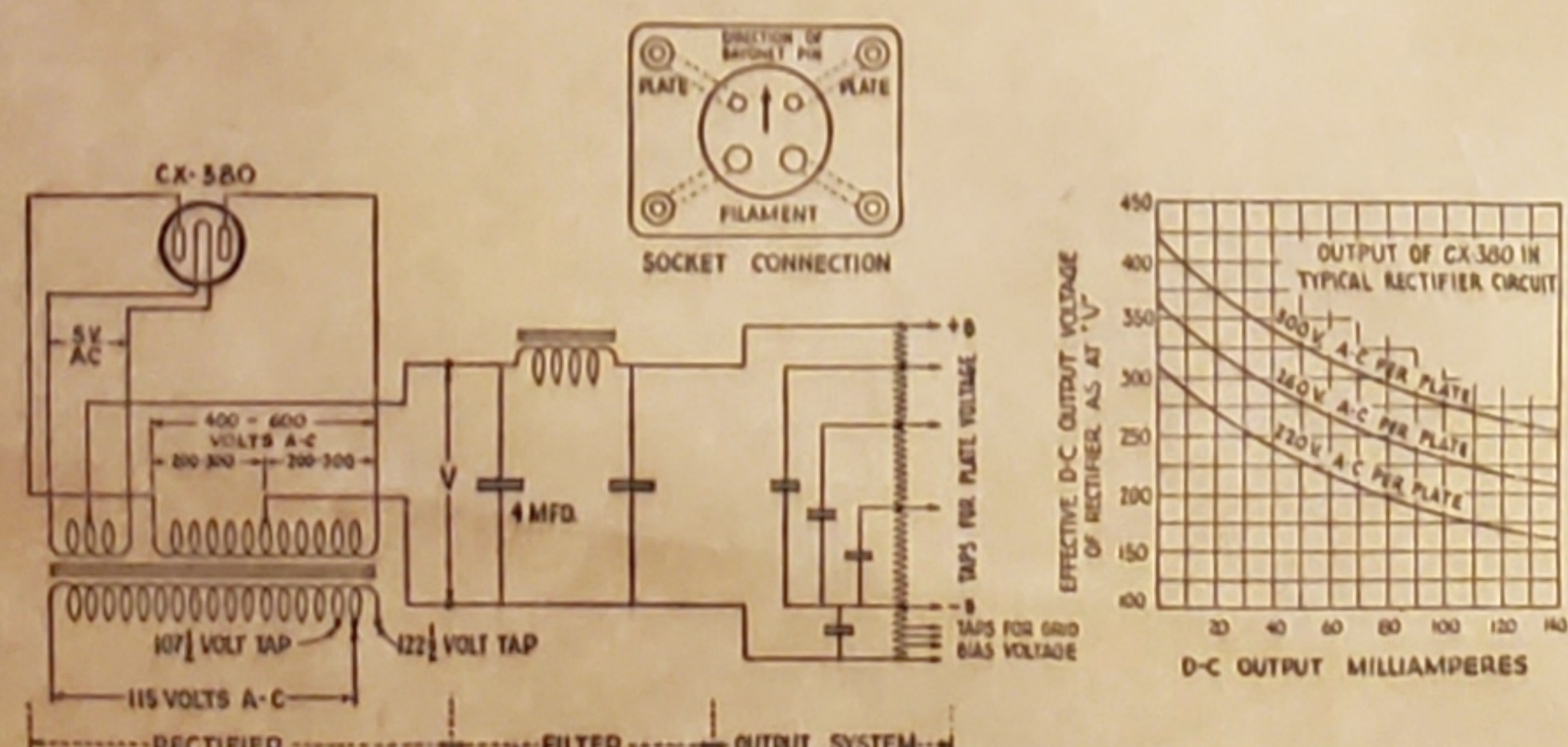
LICENSE NOTICE

The sale of this device carries a license under patent claims on the device itself 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 on combinations of the device with other devices or elements, as for example in various circuits and hook-ups, 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.

Manufactured and sold under rights, patents, and inventions owned and/or controlled by Radio Corporation of America.

HANDLE TUBE CAREFULLY



E. T. CUNNINGHAM, INC.

New York

San Francisco

Chicago