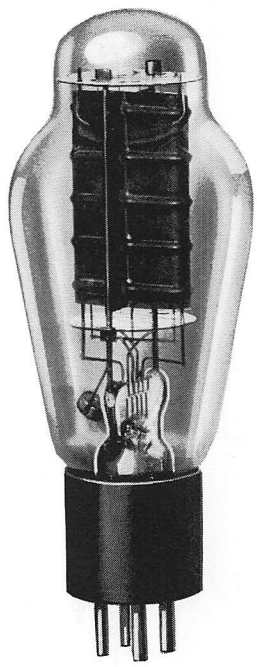
Western Electric

300A and 300B Vacuum Tubes



Classification—Moderate power, filamentary triodes for Class A service

These tubes are identical except for the location of the bayonet pin in the base.

Application—Audio-frequency amplifier in positions where power outputs of approximately ten watts or less are required at relatively low plate voltages.

Dimensions—Dimensions, outline diagrams of the tubes and bases, and the arrangement of electrode connections to the base terminals are shown in Figures 1 and 2.

Base and Mounting—These vacuum tubes employ medium, four-pin thrust type bases suitable for use in Western Electric 143B or similar sockets. The 300B tube has the bayonet pin so located that it may also be mounted in a Western Electric 100M, 115B or similar socket.

The tubes may be mounted in either a vertical or horizontal position. If mounted in a horizontal position, the plane of the filament, which is indicated in Figure 2, should be vertical.

Average Direct Interelectrode Capacitances

Grid to plate	15 $\mu\mu$f.
Grid to filament	9 $\mu\mu$f.
Plate to filament	4.3$\mu\mu$f.

Filament Rating

Filament voltage	5.0 volts, a.c. or d.c.
Nominal filament current	1.2 amperes

The filaments of these tubes are designed to operate on a voltage basis and should be operated at as near the rated voltage as possible. When alternating current is used for heating the filament, the grid and plate returns should be connected to a center tap on the secondary of the filament transformer.

Characteristics—Average characteristics—($E_f = 5.0$ volts, a.c., $E_b = 300$ volts and $E_c = -61$ volts).

Plate current	60 milliamperes
Amplification factor	3.85
Plate resistance	700 ohms
Grid to plate transconductance	5500 micromhos

Plate-current characteristics for a typical tube are shown in Figure 3 as functions of grid bias, for alternating-current filament supply. The corresponding amplification-factor, plate-resistance, and transconductance characteristics are given in Figures 4, 5 and 6, respectively. When direct-current filament supply is used, and the grid and plate returns are connected to the negative end of the filament, the same characteristics are applicable if 3.5 is subtracted from the numerical value of each grid bias.

Limiting Operating Conditions for Safe Operation—not simultaneous ratings

Maximum plate voltage	450 volts
Maximum plate dissipation	40 watts
Maximum plate current of average tube for fixed grid bias	70 milliamperes
Maximum plate current for manually adjusted grid bias or self-biasing circuit	100 milliamperes

Recommended Operating Conditions

Recommended and maximum conditions for alternating-current filament supply are given in the table. Recommended conditions or others of no greater severity should be selected in preference to maximum conditions wherever possible. The life of the tube at maximum operating conditions will be shorter than at the recommended conditions.

Where it is necessary to operate the tube at or near the maximum plate current of 100 milliamperes, provision should be made for adjusting the grid bias of each tube independently, so that the maximum safe plate current will not be exceeded in any tube. Alternatively, a self-biasing circuit may be used, in which the grid bias for the tube is obtained from the voltage drop produced by the plate current of that tube flowing through a resistance.

Where it is necessary to use a fixed grid bias, the plate current of the average tube should be limited to a maximum value of 70 milliamperes, so that tubes having plate currents higher than the average will not exceed the maximum safe plate current.

Power Output and Distortion

Performance data including power output, second and third harmonic levels for a number of operating conditions are given in the table.

The variation of power output and harmonic levels with load resistance for several values of operating plate current are shown in Figures 7, 8 and 9, for a plate voltage of 350 volts.

The peak value of the sinusoidal input voltage, E_{gm}, which gives the indicated power output, P_m, and harmonic levels, F_{2m} and F_{3m}, for each point in both the curves and the table, is numerically equal to the grid biasing voltage at that point. For a smaller input voltage E_g, the approximate levels may be computed from the following relations.

$$P = P_m \left(\frac{E_g}{E_{gm}}\right)^2$$

$$F_2 = F_{2m} + 20 \log_{10} \frac{E_{gm}}{E_g}$$

$$F^3 = F_{3m} + 40 \log_{10} \frac{E_{gm}}{E_g}$$

TABLE

	Plate Voltage	Grid Bias	Plate Current	Load Resistance	Power Output	Second Harmonic	Third Harmonic
	Volts	Volts	Milliamperes	Ohms	Watts	db	db
Recommended	200	— 42	30	2000	3.0	20	31
Operating	200	— 39	40	2500	2.6	26	38
Conditions	200	— 37	50	2500	2.5	30	45
	250	— 55	30	2000	4.9	18	27
	250	— 55	30	4500	3.2	27	40
	250	— 52	40	3000	4.0	26	36
	250	— 50	50	2500	4.4	26	39
	250	— 48	60	2000	4.7	26	38
	250	— 48	60	2700	4.1	30	45
	250	— 45	80	1500	5.0	26	41
	300	— 65	40	2500	6.7	20	30
	300	— 63	50	2000	7.2	21	29
	300	— 63	50	3000	6.1	26	37
	300	— 61	60	2400	6.6	26	37
	300	— 61	60	3400	5.6	30	44
	300	— 58	80	1700	7.5	26	37
	350	— 76	50	3600	7.8	26	38
	350	— 76	50	5000	6.2	30	45
	350	— 74	60	2000	10.2	21	30
	350	— 74	60	3000	8.3	26	38
	350	— 74	60	4000	7.0	30	44
	350	— 71	80	2200	9.6	26	39
	400	— 91	40	5000	8.4	26	37
	400	— 89	50	3000	11.5	21	31
	400	— 89	50	4000	9.4	25	38
	400	— 87	60	3500	10.5	26	38
	400	— 87	60	5000	8.3	30	46
	400	— 84	80	2500	12.5	25	37
Maximum	450	—104	40	6000	9.5	26	38
Operating	450	—102	50	5000	10.7	27	39
Conditions	450	—102	50	6500	9.0	30	45
	450	—100	60	4000	12.5	26	38
	450	—100	60	5500	10.1	30	44
	450	— 97	80	2000	17.8	21	30
	450	— 97	80	3000	14.6	26	37
	450	— 97	80	4500	11.5	31	45

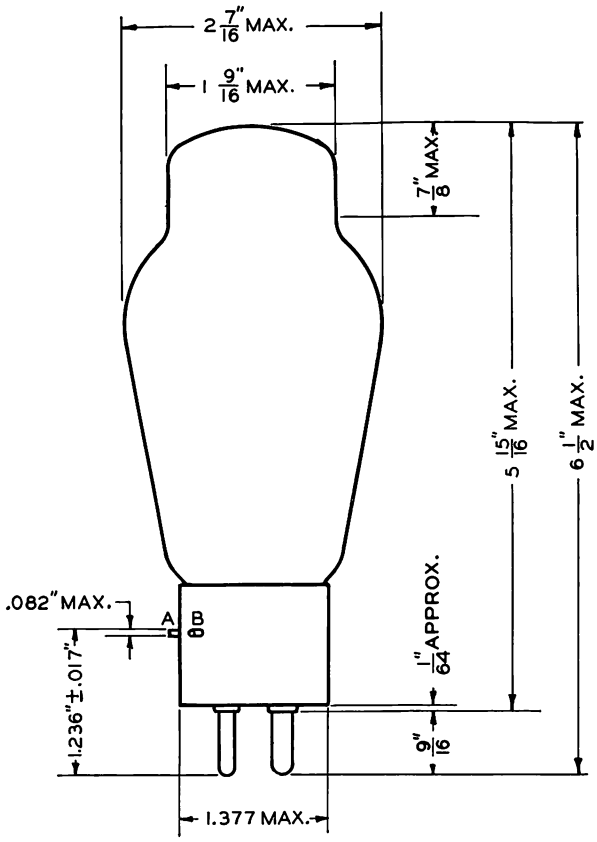


FIG. 1

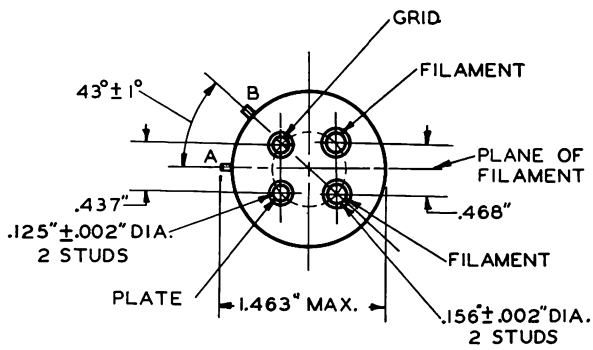


FIG. 2

A—LOCATION OF BAYONET PIN FOR 300A TUBE
B—LOCATION OF BAYONET PIN FOR 300B TUBE

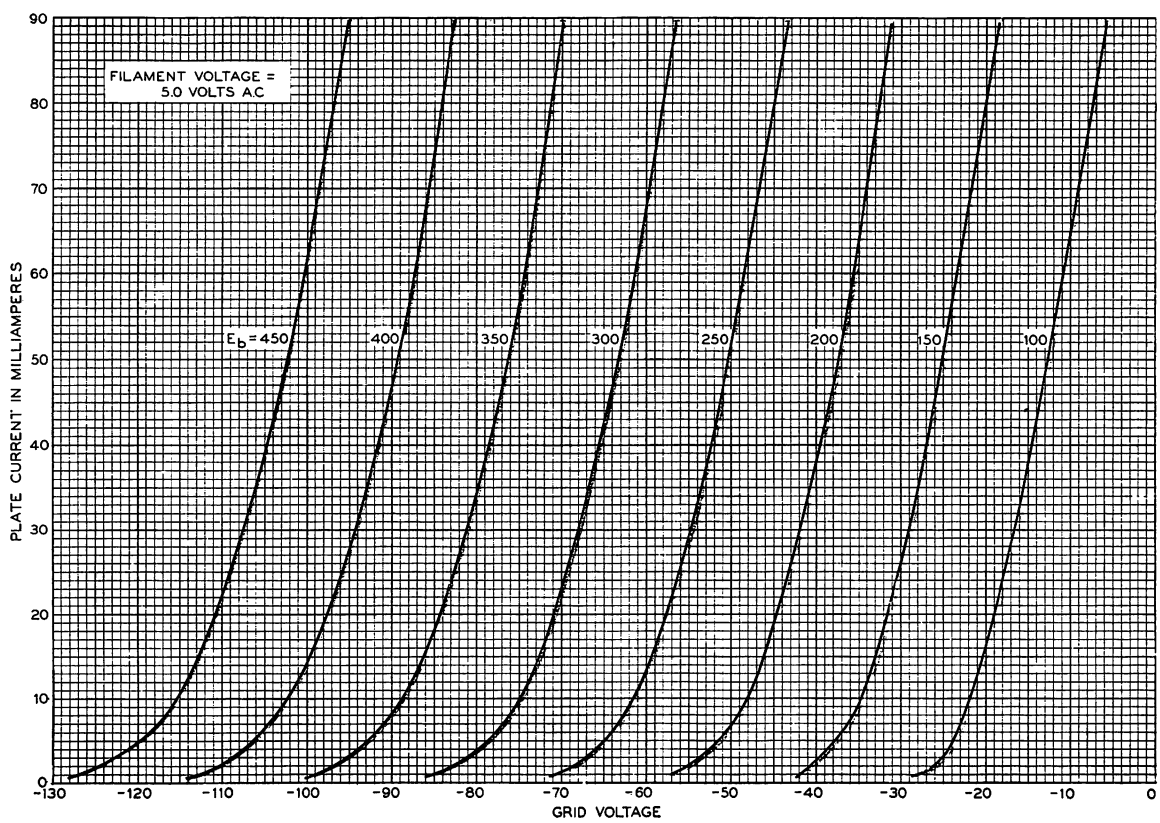


FIG. 3

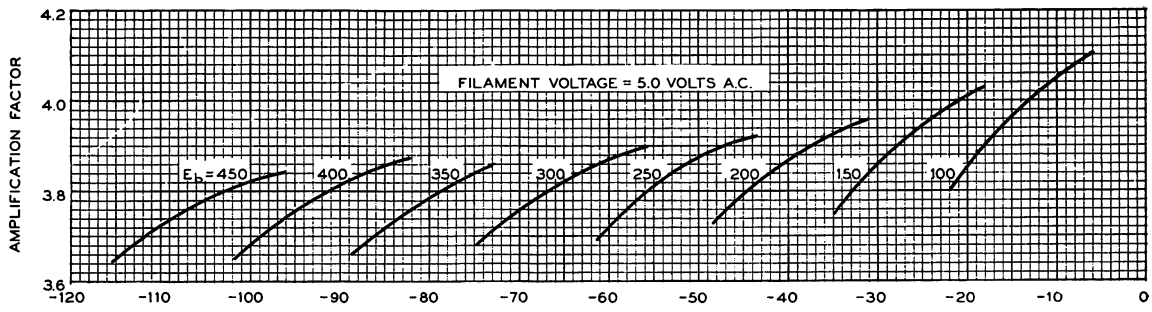


FIG. 4

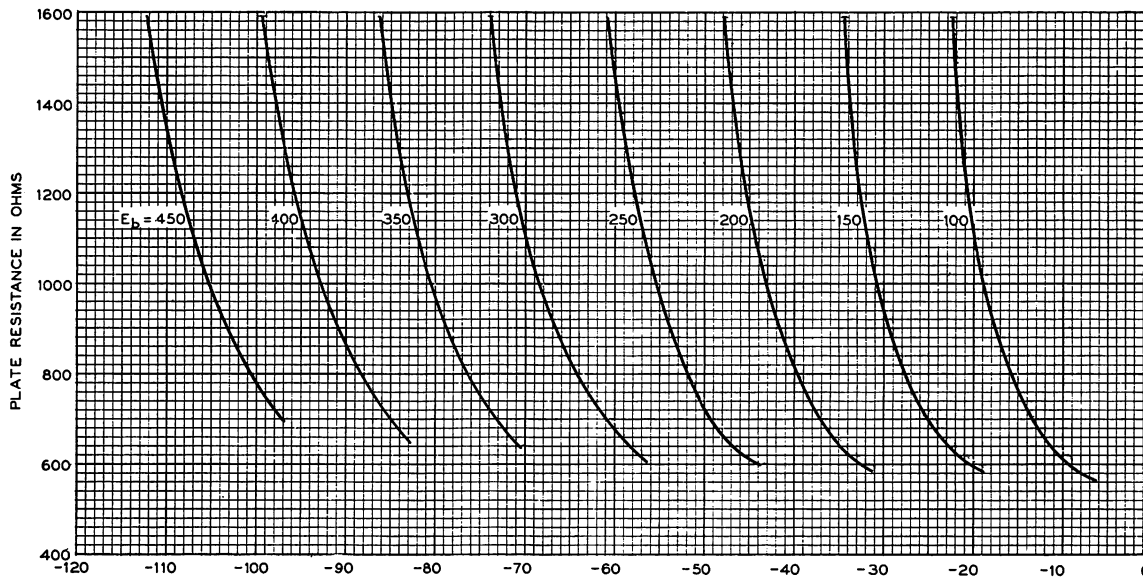


FIG. 5

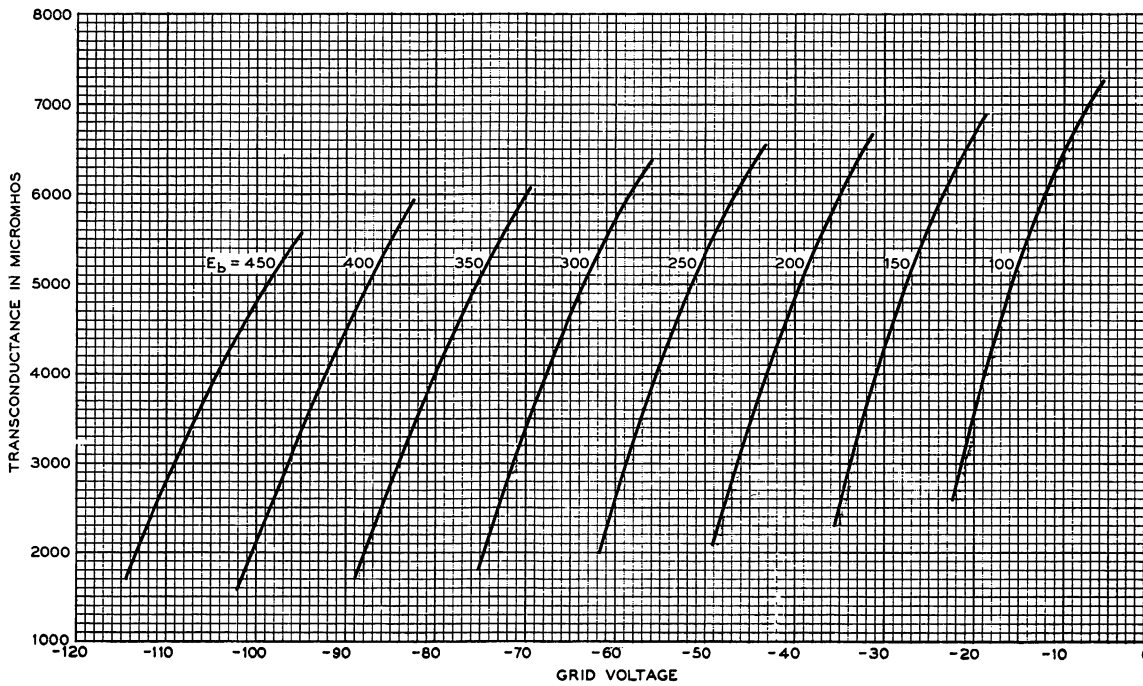


FIG. 6

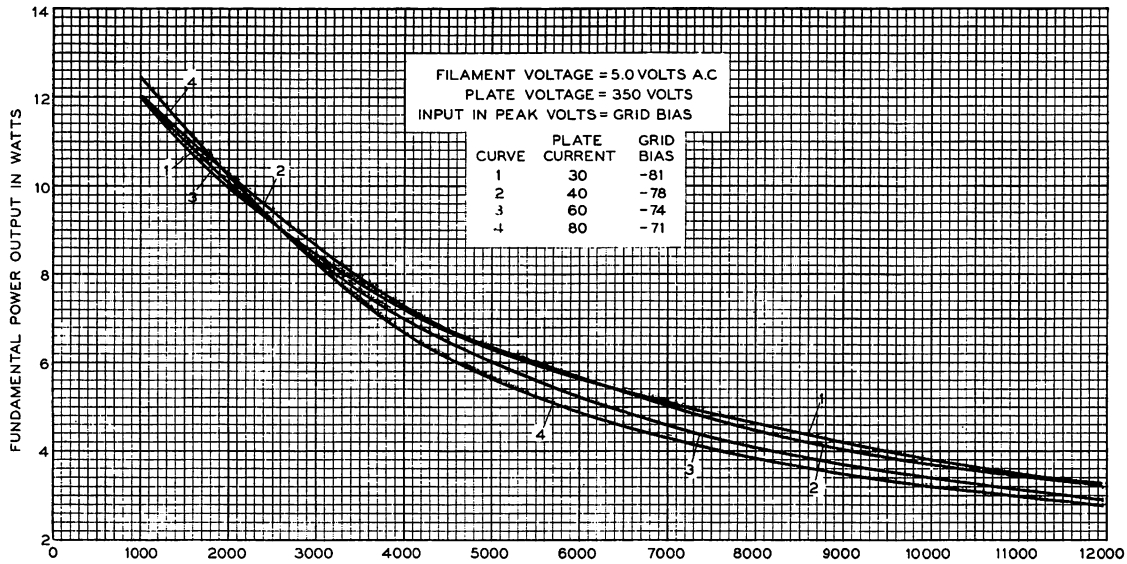


FIG. 7

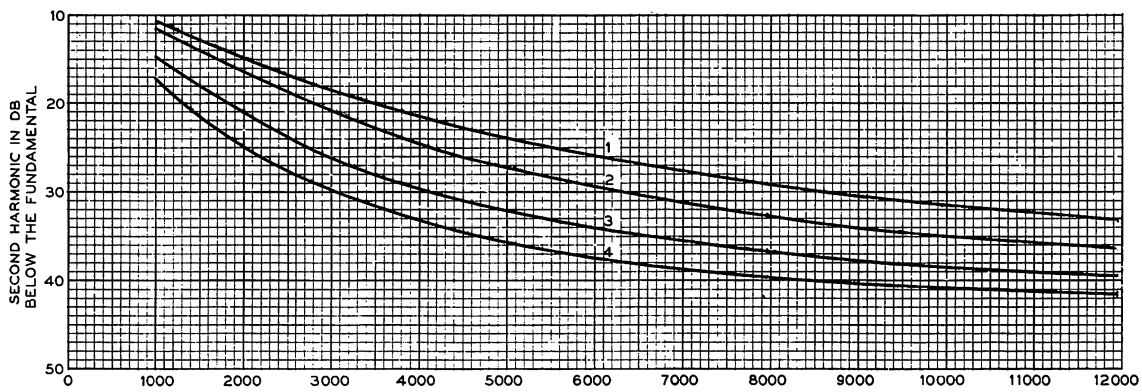


FIG. 8

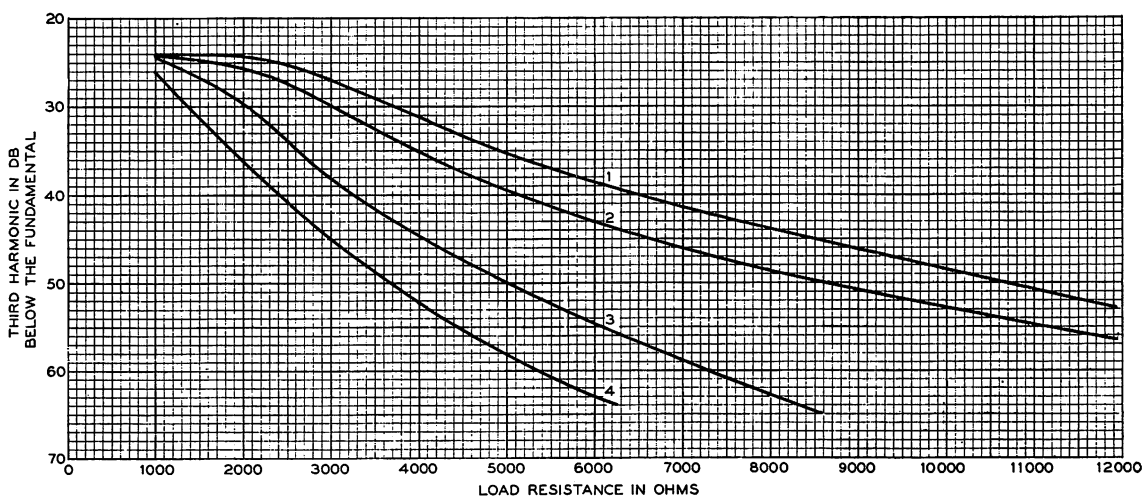
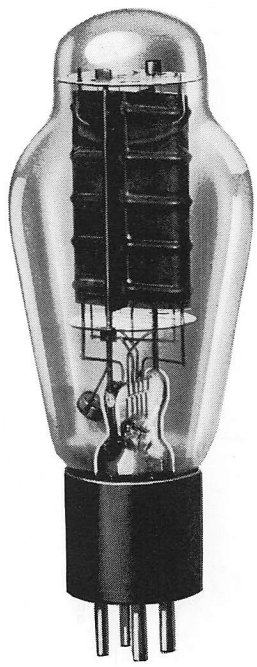


FIG. 9

Western Electric

300A and 300B Vacuum Tubes



Classification—Moderate power, filamentary triodes for Class A service

These tubes are identical except for the location of the bayonet pin in the base.

Application—Audio-frequency amplifier in positions where power outputs of approximately ten watts or less are required at relatively low plate voltages.

Dimensions—Dimensions, outline diagrams of the tubes and bases, and the arrangement of electrode connections to the base terminals are shown in Figures 1 and 2.

Base and Mounting—These vacuum tubes employ medium, four-pin thrust type bases suitable for use in Western Electric 143B or similar sockets. The 300B tube has the bayonet pin so located that it may also be mounted in a Western Electric 100M, 115B or similar socket.

The tubes may be mounted in either a vertical or horizontal position. If mounted in a horizontal position, the plane of the filament, which is indicated in Figure 2, should be vertical.

Average Direct Interelectrode Capacitances

Grid to plate	15 $\mu\mu$f.
Grid to filament	9 $\mu\mu$f.
Plate to filament	4.3$\mu\mu$f.

Filament Rating

Filament voltage	5.0 volts, a.c. or d.c.
Nominal filament current	1.2 amperes

The filaments of these tubes are designed to operate on a voltage basis and should be operated at as near the rated voltage as possible. When alternating current is used for heating the filament, the grid and plate returns should be connected to a center tap on the secondary of the filament transformer.

Characteristics—Average characteristics—($E_f = 5.0$ volts, a.c., $E_b = 300$ volts and $E_c = -61$ volts).

Plate current	60 milliamperes
Amplification factor	3.85
Plate resistance	700 ohms
Grid to plate transconductance	5500 micromhos

Plate-current characteristics for a typical tube are shown in Figure 3 as functions of grid bias, for alternating-current filament supply. The corresponding amplification-factor, plate-resistance, and transconductance characteristics are given in Figures 4, 5 and 6, respectively. When direct-current filament supply is used, and the grid and plate returns are connected to the negative end of the filament, the same characteristics are applicable if 3.5 is subtracted from the numerical value of each grid bias.

Limiting Operating Conditions for Safe Operation—not simultaneous ratings

Maximum plate voltage	450 volts
Maximum plate dissipation	40 watts
Maximum plate current of average tube for fixed grid bias	70 milliamperes
Maximum plate current for manually adjusted grid bias or self-biasing circuit	100 milliamperes

Recommended Operating Conditions

Recommended and maximum conditions for alternating-current filament supply are given in the table. Recommended conditions or others of no greater severity should be selected in preference to maximum conditions wherever possible. The life of the tube at maximum operating conditions will be shorter than at the recommended conditions.

Where it is necessary to operate the tube at or near the maximum plate current of 100 milliamperes, provision should be made for adjusting the grid bias of each tube independently, so that the maximum safe plate current will not be exceeded in any tube. Alternatively, a self-biasing circuit may be used, in which the grid bias for the tube is obtained from the voltage drop produced by the plate current of that tube flowing through a resistance.

Where it is necessary to use a fixed grid bias, the plate current of the average tube should be limited to a maximum value of 70 milliamperes, so that tubes having plate currents higher than the average will not exceed the maximum safe plate current.

Power Output and Distortion

Performance data including power output, second and third harmonic levels for a number of operating conditions are given in the table.

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The peak value of the sinusoidal input voltage, E_{gm}, which gives the indicated power output, P_m, and harmonic levels, F_{2m} and F_{3m}, for each point in both the curves and the table, is numerically equal to the grid biasing voltage at that point. For a smaller input voltage E_g, the approximate levels may be computed from the following relations.

$$P = P_m \left(\frac{E_g}{E_{gm}}\right)^2$$

$$F_2 = F_{2m} + 20 \log_{10} \frac{E_{gm}}{E_g}$$

$$F^3 = F_{3m} + 40 \log_{10} \frac{E_{gm}}{E_g}$$

TABLE

	Plate Voltage	Grid Bias	Plate Current	Load Resistance	Power Output	Second Harmonic	Third Harmonic
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	450	—100	60	4000	12.5	26	38
	450	—100	60	5500	10.1	30	44
	450	— 97	80	2000	17.8	21	30
	450	— 97	80	3000	14.6	26	37
	450	— 97	80	4500	11.5	31	45

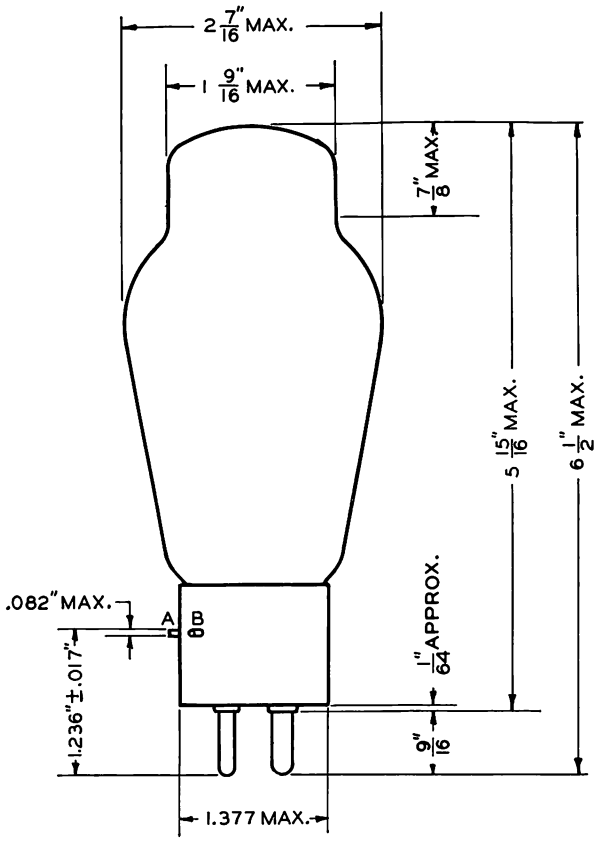


FIG. 1

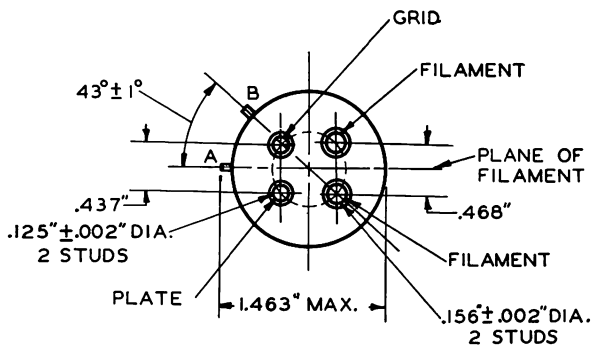


FIG. 2

A—LOCATION OF BAYONET PIN FOR 300A TUBE
B—LOCATION OF BAYONET PIN FOR 300B TUBE

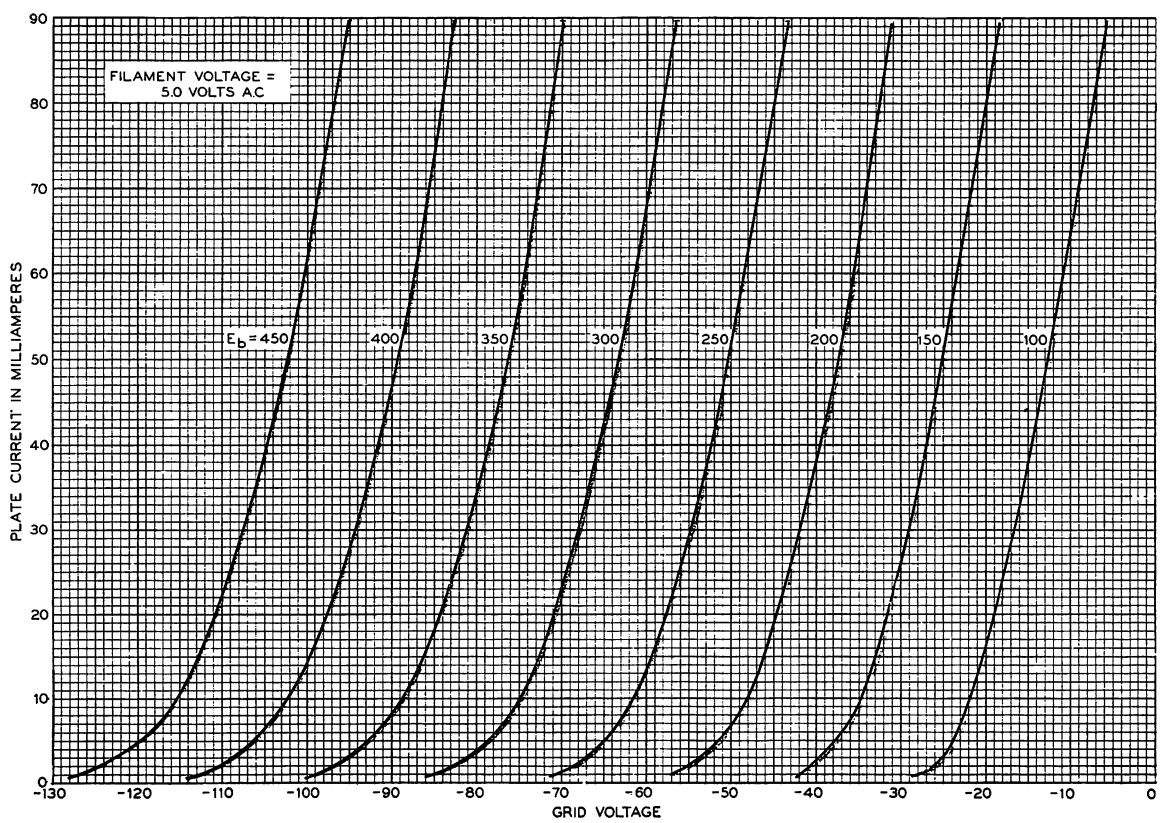


FIG. 3

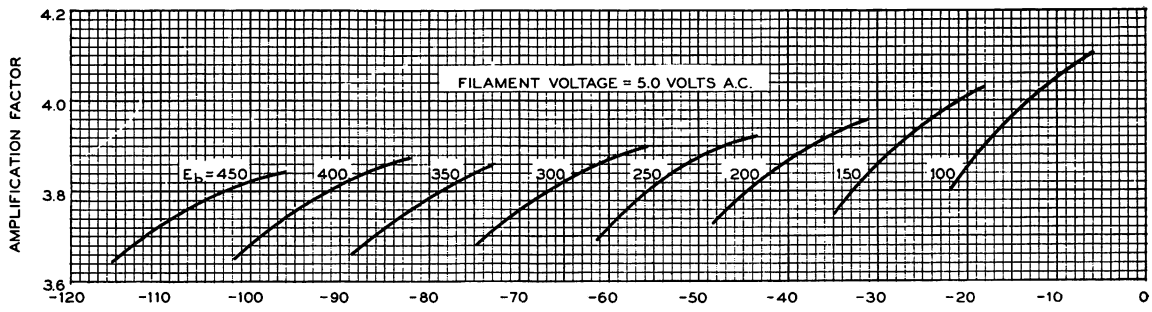


FIG. 4

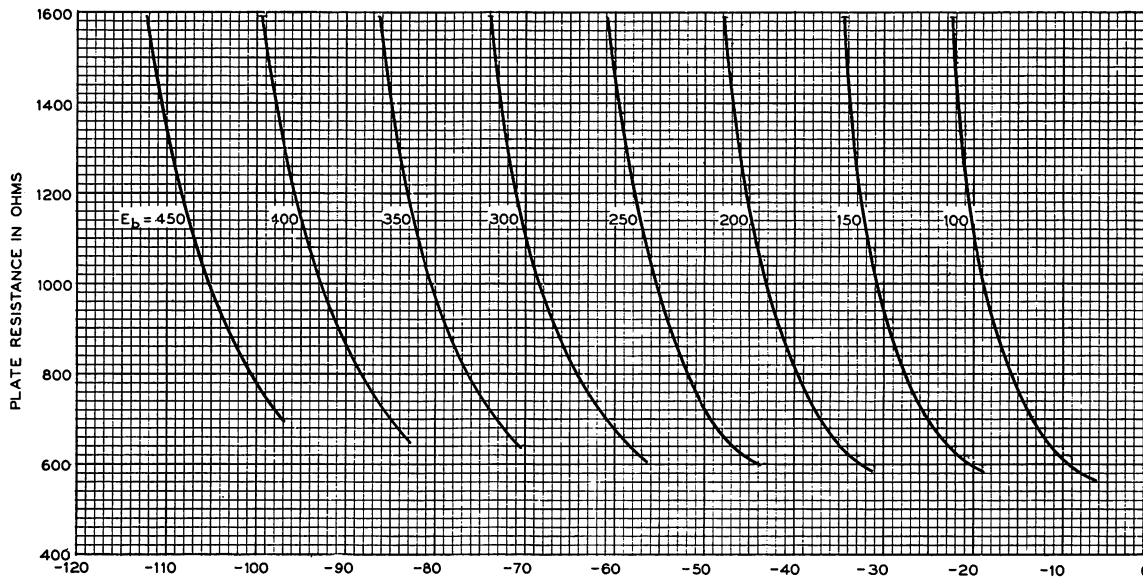


FIG. 5

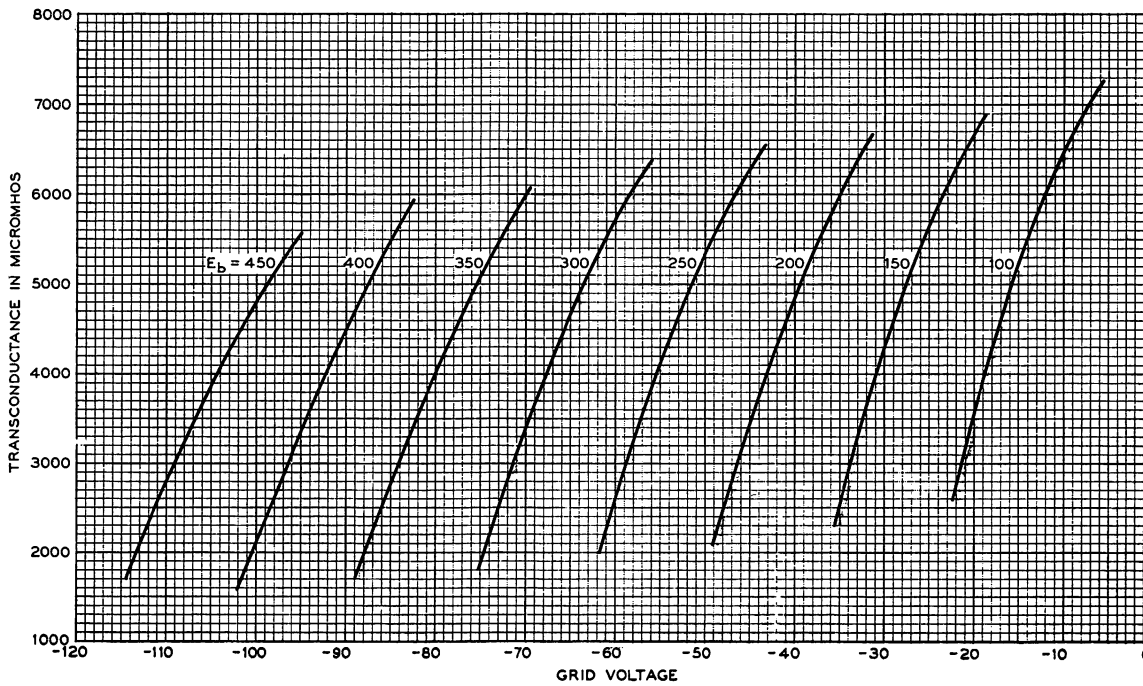


FIG. 6

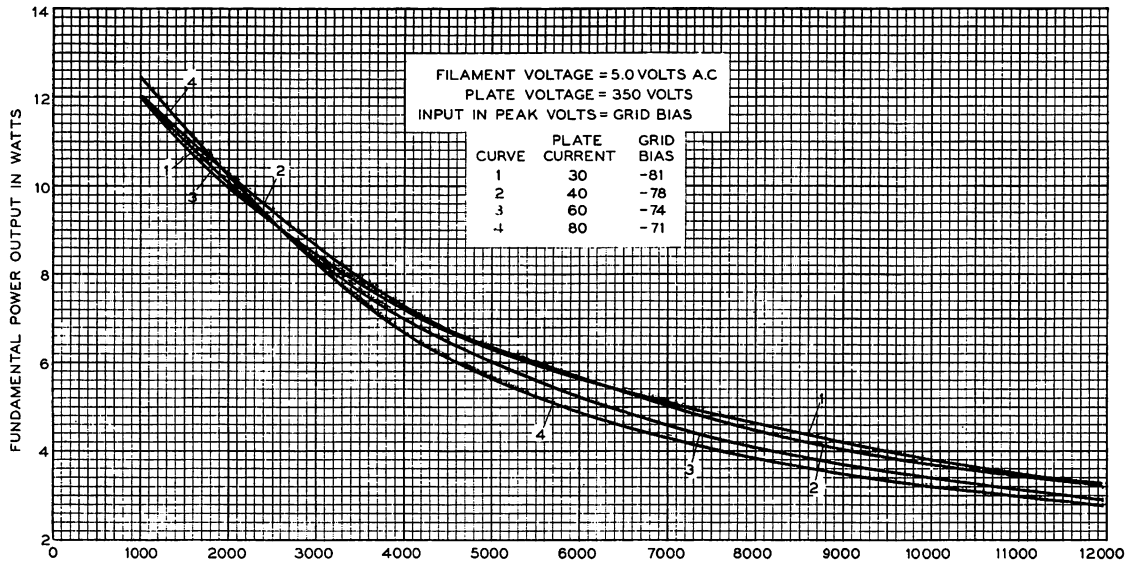


FIG. 7

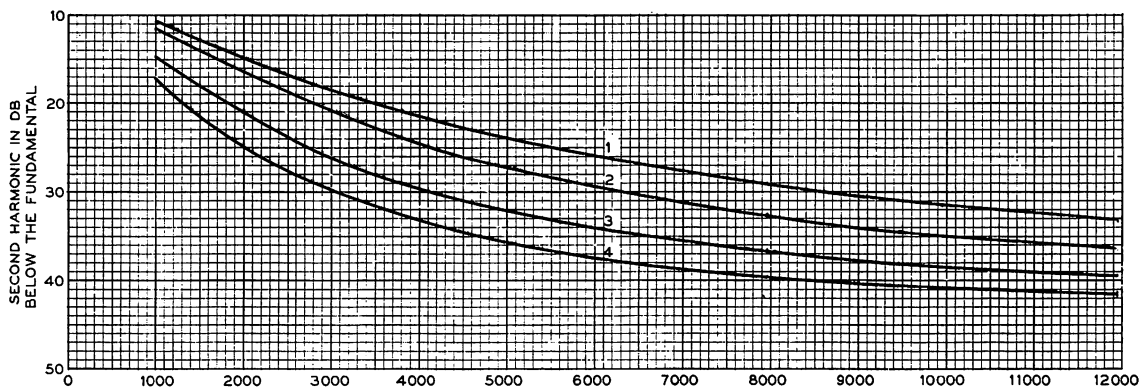


FIG. 8

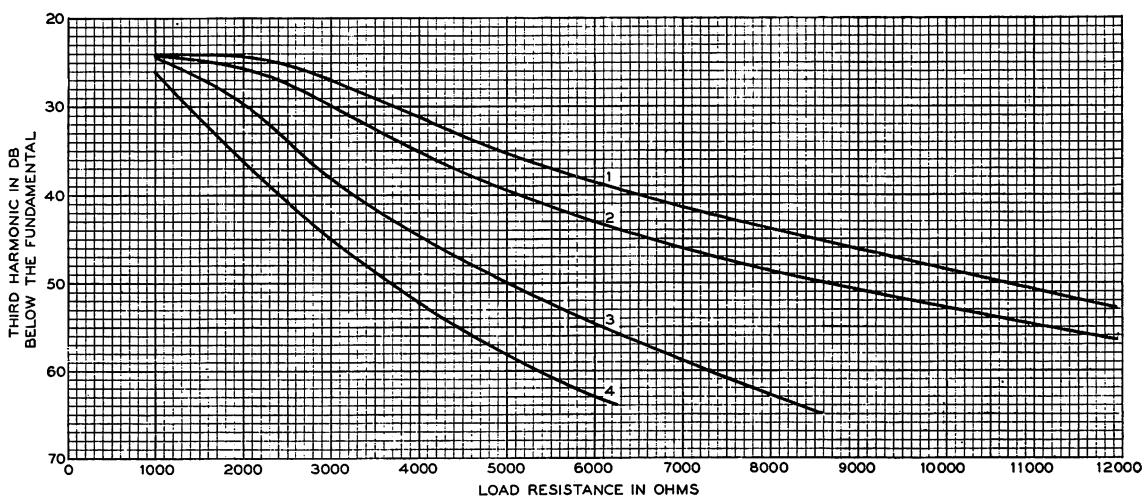
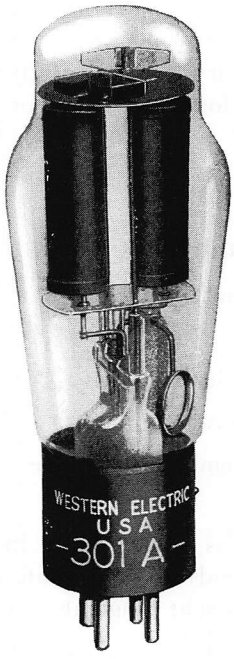


FIG. 9

Western Electric

301A Vacuum Tube



Classification—Full wave, thermionic, mercury vapor rectifier

The 301A vacuum tube is designed to supply direct current from an alternating-current supply.

Dimensions—The dimensions and outline diagrams are given in Figures 1 and 2. The overall dimensions are:

Maximum length	6½″
Maximum diameter	2 7/16″

Mounting—The 301A employs a standard 4 pin thrust type base suitable for use in a Western Electric 143B or similar socket. Base dimensions and the arrangement of electrode connections to the base terminals are shown in Figs. 1 and 2.

The tube should be mounted in a vertical position with the base end down. There should be a free circulation of air around the tube. No object should touch the glass bulb.

Filament Rating

Filament voltage	5.0 volts
Nominal filament current	3.0 amperes

The filament of this tube is designed to operate on a voltage basis from an alternating-current supply. The voltage should be maintained to within 5% of its rated value (5.0 volts). Operation

of the filament at a voltage above the upper limit will definitely reduce the life of the tube while a decrease in voltage below the lower limit may cause immediate failure.

Sufficient time must always be allowed for the filament temperature to reach its normal operating value before the anode potential is applied. If filament circuits with good regulation are used, this time is 30 seconds. If the tube is operated at ambient temperatures below 20° C., a longer period of time is required for the purpose of bringing the mercury vapor pressure to a satisfactory operating value. The minimum filament warming time as a function of ambient temperature is shown in figure 3.

For proper distribution of the mercury a period of 10 to 15 minutes filament warming time should be allowed when the tube is used for the first time or if it has been reinserted in the apparatus after having been removed.

Characteristics and Operating Conditions

Approximate anode-cathode potential drop	10 volts
Maximum peak plate current	1.0 ampere
Maximum peak potential between electrodes	1800 volts
Maximum operating ambient temperature range	0 to 50° C
Recommended operating ambient temperature range	10 to 40° C

The anode-cathode potential drop is substantially independent of the plate current. The exact value varies from tube to tube and during the life of a given tube. Within the specified ambient temperature range and plate current range, it may vary from 5 to 25 volts.

The anode-cathode drop as a function of temperature is shown on fig. 4 for a typical 301A tube after reaching temperature equilibrium and when passing the rated plate current.

The maximum permissible peak plate current (1.0 ampere) is a limitation on the instantaneous value that the tube can carry safely in the direction in which it is designed to conduct and should not be exceeded. The maximum direct load current is not fixed but will depend upon the wave form required by the load and filter circuit.

The maximum permissible peak potential between electrodes (1800 volts) is a limitation on the instantaneous value that the tube can stand safely. If it is exceeded, an arc-back may result which will injure the tube. The maximum direct potential available is not fixed but will depend upon the type of circuit used.

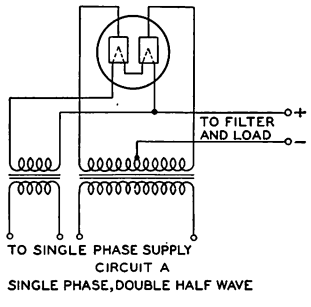
301A vacuum tubes may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode, may be used for this purpose. The size of the reactors or resistors depends upon the circuit design.

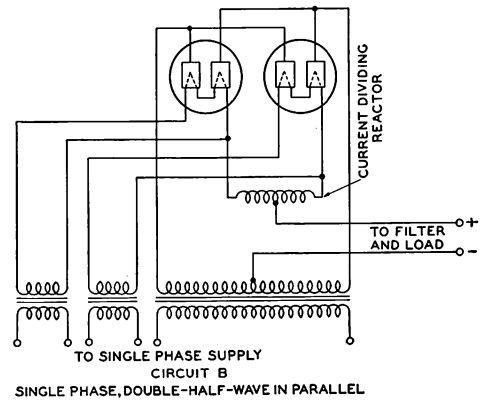
In most cases the termination of the useful life of the 301A tube is due to the loss of filament activity. This causes the tube to fail by arcing between the electrodes. Failures of this kind should be safeguarded by proper fuse protection to prevent injury to other tubes in the circuit and to the auxiliary equipment.

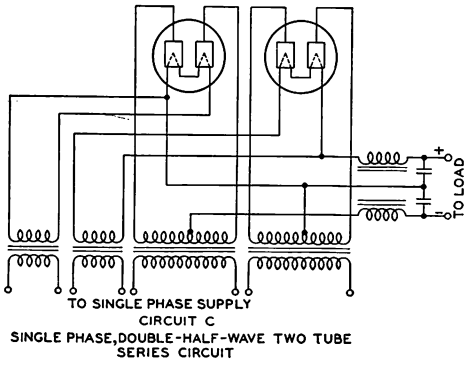
Typical Rectifier Circuits—The 301A vacuum tube may be used in any standard high vacuum rectifier circuit subject to its current, voltage and temperature limitations. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible plate current and inverse voltage are given in Table 1. The values listed are average values of the pulsating current and voltage for an unfiltered circuit.

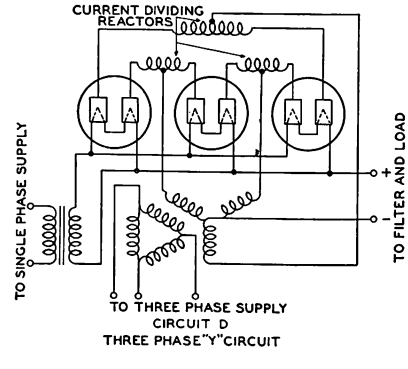
Table 1

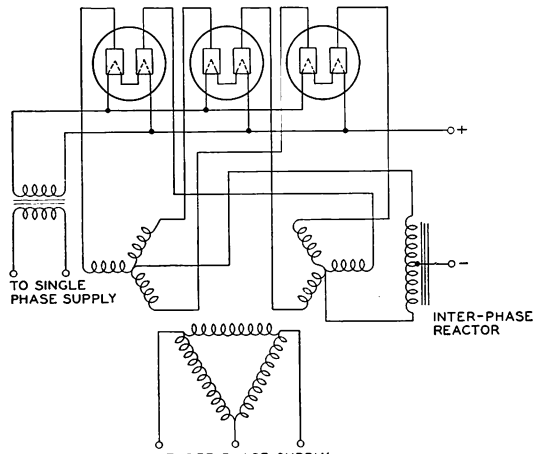
Circuit Designation	Phase Supply	Number Tubes	Load Potential in Volts	Load Current in Amperes
A	1	1	550	0.6
B	1	2	550	1.2
C	1	2	1100	0.6
D	3	3	800	1.6
E	3	3	700	1.8
F	1	3	1100	0.6

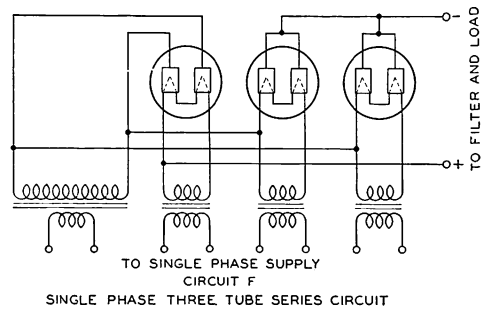









+
−
TO SINGLE PHASE SUPPLY
INTER-PHASE REACTOR
TO THREE PHASE SUPPLY
CIRCUIT E
THREE PHASE, DOUBLE "Y" INTERCONNECTED


−
+
TO FILTER AND LOAD
TO SINGLE PHASE SUPPLY
CIRCUIT F
SINGLE PHASE THREE TUBE SERIES CIRCUIT

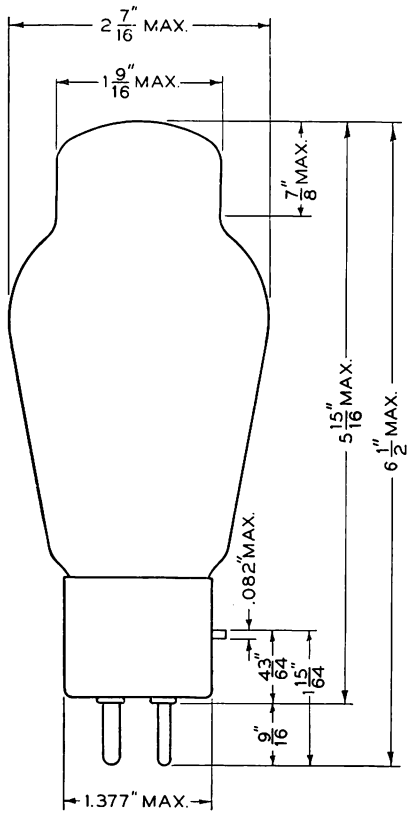

2 7/16" MAX.
1 9/16" MAX.
7/8" MAX.
5 15/16" MAX.
6 1/2" MAX.
.082" MAX.
43/64"
15/64"
9/16"
1.377" MAX.

FIG. 1

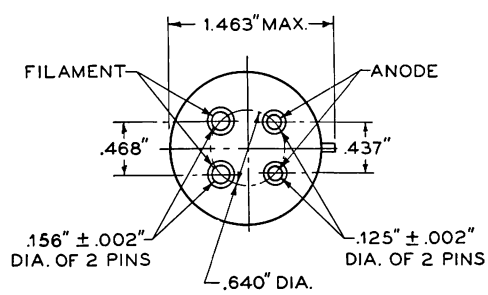

1.463" MAX.
FILAMENT
ANODE
.468"
.437"
.156" ± .002"
DIA. OF 2 PINS
.125" ± .002"
DIA. OF 2 PINS
.640" DIA.

FIG. 2

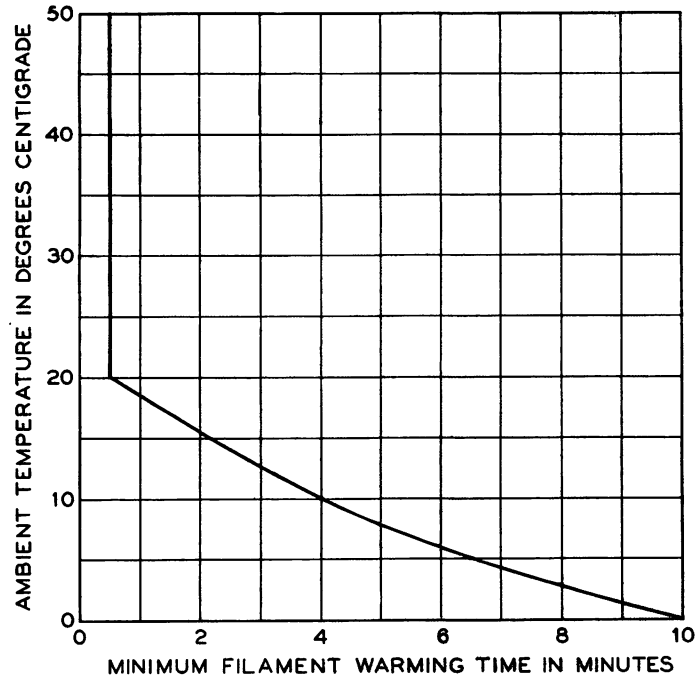


FIG. 3

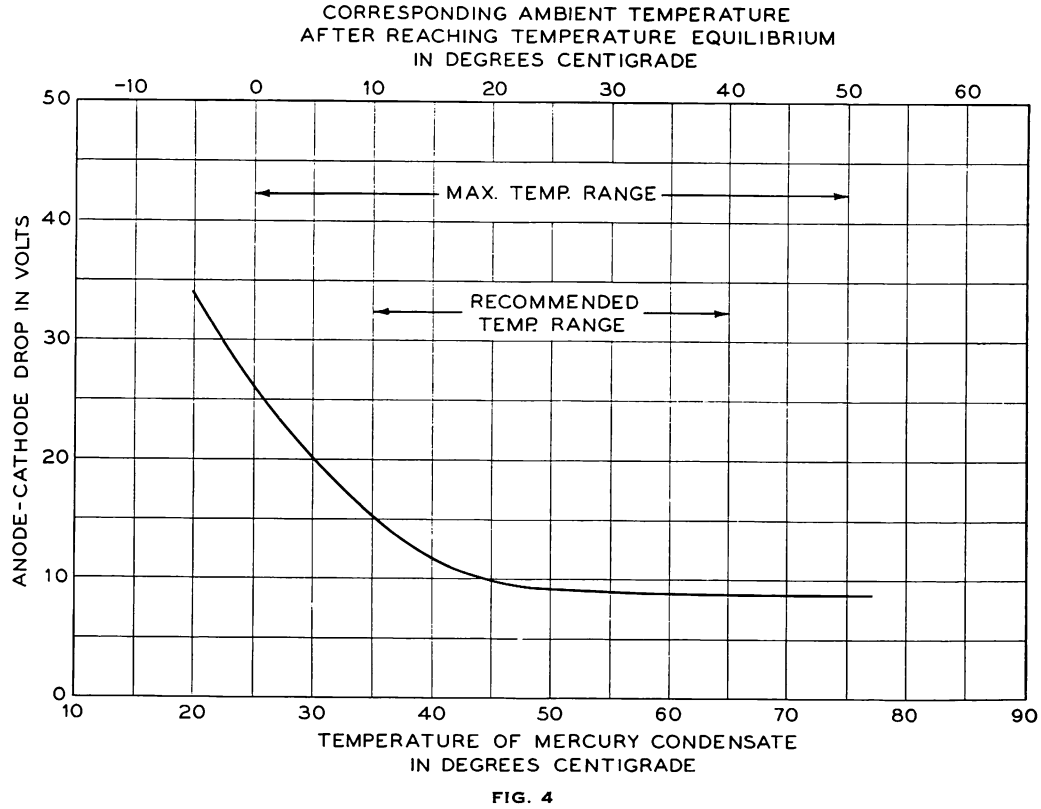
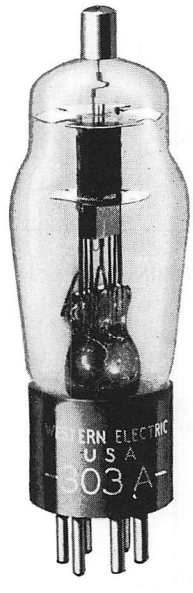


FIG. 4

A development of Bell Telephone Laboratories, Incorporated, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company

Western Electric

303A Vacuum Tube



Classification—Duodiode triode with indirectly heated cathode

The 303A tube comprises three distinct vacuum tube units, which are independent of each other except that sections of a single cathode structure supply electron emission for all three. Two of these units are diodes. The other is a triode. Except for the heater rating the 303A tube is similar to the 292A.

Applications—Diode detector, diode rectifier for automatic volume control voltage, and triode audio-frequency amplifier. If desired, both diodes may be used for detection, connected either in parallel for half-wave rectification or in push-pull for full-wave rectification. The latter connection requires about twice as high an input voltage as the former to give equal detector output. An alternative use of the triode unit is as a direct-current amplifier for the automatic volume control voltage.

Dimensions—Dimensions, outline diagrams of the tube and base, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base—Medium six-pin type. Small metal cap triode grid terminal at the top of the bulb.

Socket—Standard six-contact type, such as the Western Electric 144B socket.

Mounting Positions—The 303A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Triode grid to plate	1.3 μμf.
Triode grid to cathode and heater	1.4 μμf.
Triode plate to cathode and heater	3.7 μμf.
Both diodes to triode grid	0.02 μμf.
Both diodes to triode plate	1.3 μμf.
Both diodes to cathode and heater	6.2 μμf.

Heater Rating

Heater voltage	2.0 volts, a.c. or d.c.
Nominal heater current	1.60 amperes

The heater of this tube is designed to be operated on a voltage basis and should be operated at as near the rated voltage as is practicable.

Cathode Connection—Preferably direct to the heater. If voltage must be applied between the cathode and heater, it should be kept as low as possible and should never exceed 90 volts.

Triode Characteristics—Plate current characteristics of the triode section of a typical 303A tube are shown in Figure 3 as functions of grid bias for several values of plate voltage. Corresponding amplification-factor, plate-resistance, and transconductance characteristics are given in Figures 4, 5, and 6 respectively. Plate current characteristics as functions of plate voltage for several values of grid bias are shown in Figure 7.

Triode Operating Conditions and Output—Permissible operating grid and plate voltages are included within the area, ABCD, in Figure 3. Values of amplification factor and plate resistance and typical performance data are given in the table below for recommended and maximum operating conditions represented by selected points within this area. Recommended conditions or others of no greater severity should be selected in preference to maximum conditions wherever possible. The life of the tube at maximum operating conditions may be shorter than at the recommended conditions.

The performance data include the fundamental voltage output, E_{pm}, in peak volts, the corresponding power output, P_m, in milliwatts, and the second and third harmonic levels, F_{2m} and F_{3m}, in db below the fundamental for the indicated values of input voltage and load resistance. Where the level of the third harmonic is lower than 45 db below the fundamental, its value may be widely different for different tubes. The values given represent a typical tube. The input voltage, E_{gm}, in peak volts, is numerically equal to the grid bias for each operating condition. For a smaller input voltage E_g, the voltage output, power output, and second and third harmonic levels are given approximately by the following relations:

$$P = P_m \left(\frac{E_g}{E_{gm}}\right)^2$$

$$E_p = E_{pm} \frac{E_g}{E_{gm}}$$

$$F_2 = F_{2m} + 20 \log_{10} \frac{E_{gm}}{E_g}$$

$$F_3 = F_{3m} + 40 \log_{10} \frac{E_{gm}}{E_g}$$

Table

	Plate Voltage Volts	Grid Bias Volts	Plate Current Milliamperes	Amplification Factor	Plate Resistance Ohms	Load Resistance Ohms	Input Peak Volts	Voltage Output Peak Volts	Power Output Milliwatts	Second Harmonic db	Third Harmonic db
Recommended Operating Conditions	135	— 4.5	3.0	14.1	17000	20000	4.5	34	29	24	55
						35000	4.5	43	26	27	50
						50000	4.5	47	23	28	50
	135	— 6.0	2.0	13.5	21000	20000	6.0	40	40	19	50
						35000	6.0	51	38	22	60
						50000	6.0	58	33	24	50
	135	— 7.5	1.1	12.7	27000	20000	7.5	42	44	14	37
						35000	7.5	55	43	17	41
						50000	7.5	63	40	19	45
	180	— 7.5	3.2	13.5	17000	20000	7.5	55	75	21	55
						35000	7.5	68	66	24	50
						50000	7.5	76	58	26	50
	180	— 9.0	2.2	13.0	20000	20000	9.0	59	88	17	42
						35000	9.0	75	81	20	55
						50000	9.0	85	73	23	60
	180	—10.5	1.3	12.5	26000	20000	10.5	60	91	13	35
						35000	10.5	78	87	16	38
						50000	10.5	90	81	19	45
Maximum Operating Conditions	200	— 9.0	3.2	13.2	18000	20000	9.0	65	105	20	50
						35000	9.0	82	94	23	55
						50000	9.0	90	81	25	45
	200	—10.5	2.2	12.8	21000	20000	10.5	68	114	16	39
						35000	10.5	87	108	20	50
						50000	10.5	97	95	22	55

Triode Microphonic Noise—With a plate voltage of 135 volts, a grid bias of −6 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the triode section of the 303A tube, measured in a laboratory reference test set, is 44 db below 1 volt. The range of levels of individual tubes extends from 20 to 64 db below 1 volt. Since microphonic noise output depends on the type and intensity of the mechanical disturbance which produces it, the values given here are useful chiefly for comparison with the levels of other types of tubes which have been tested in the same way.

Diode Characteristics—The current-voltage characteristic of a single diode is shown in Figure 8. The potential of each diode plate with respect to the cathode on the positive swing of the input voltage should be limited to a maximum value of +10 volts. Rectification characteristics for a single diode are shown in Figure 9 for a number of values of impressed alternating input valtage. Each of these characteristic curves gives the relation between the direct voltage impressed on the diode plate and the average diode current as indicated by a direct-current microammeter for a constant impressed alternating input voltage of the value specified. Where the diode is used as a detector with the usual condenser-resistance circuit, the direct component of the voltage developed across the resistance by a given alternating-voltage input is given by the intercept of the load line corresponding to the load resistance with the rectification characteristic corresponding to the input voltage. Load lines for zero fixed bias are shown in Figure 9 for load resistance values of 0.25, 0.5 and 1.0 megohm.

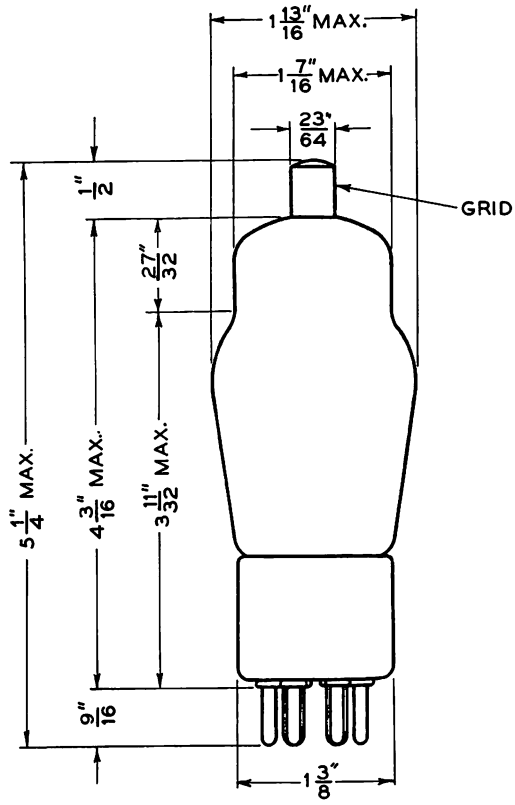


FIG. 1

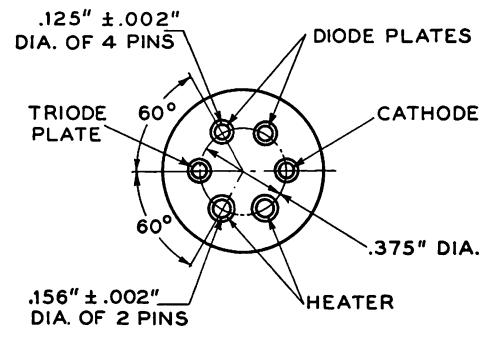


FIG. 2

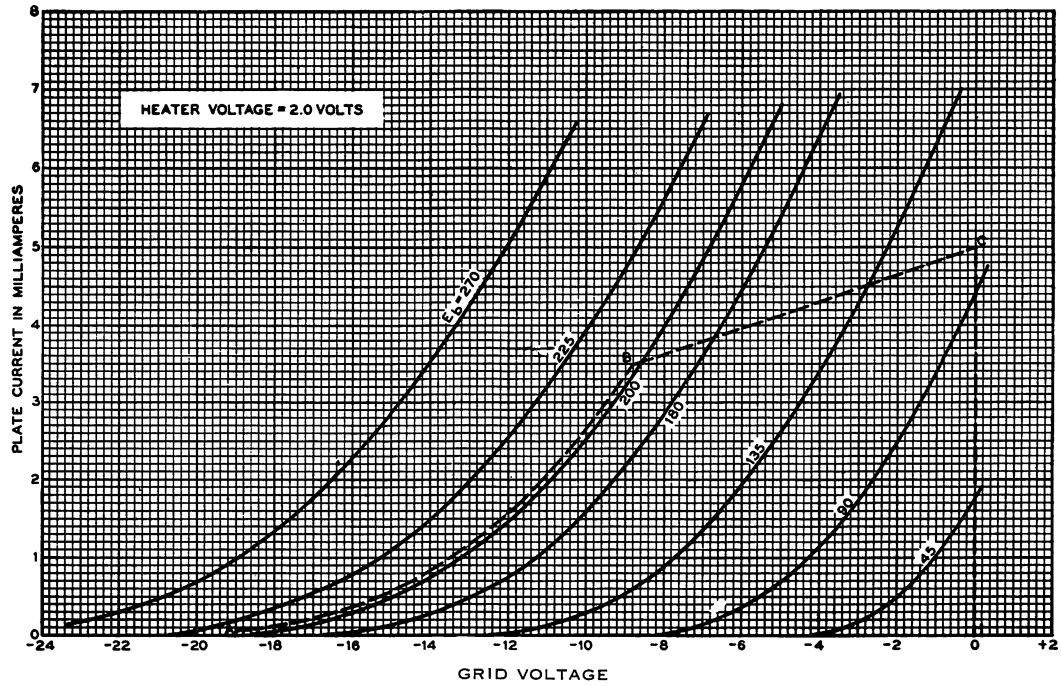


FIG. 3

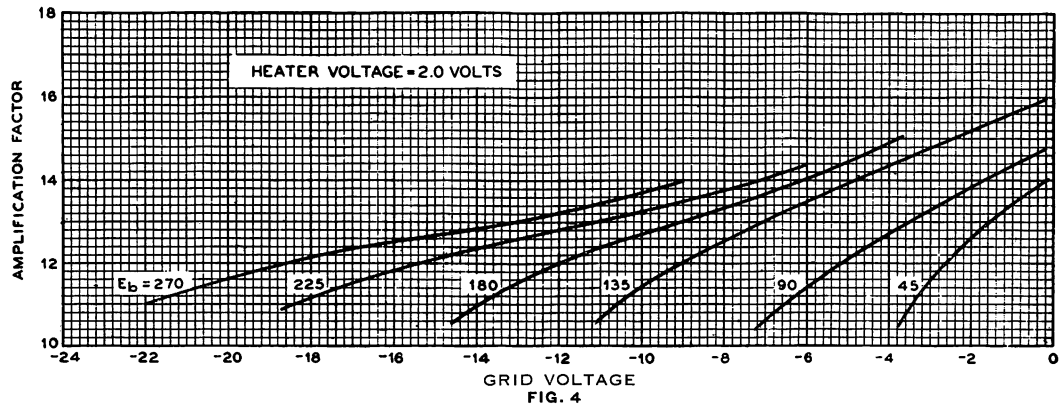


FIG. 4

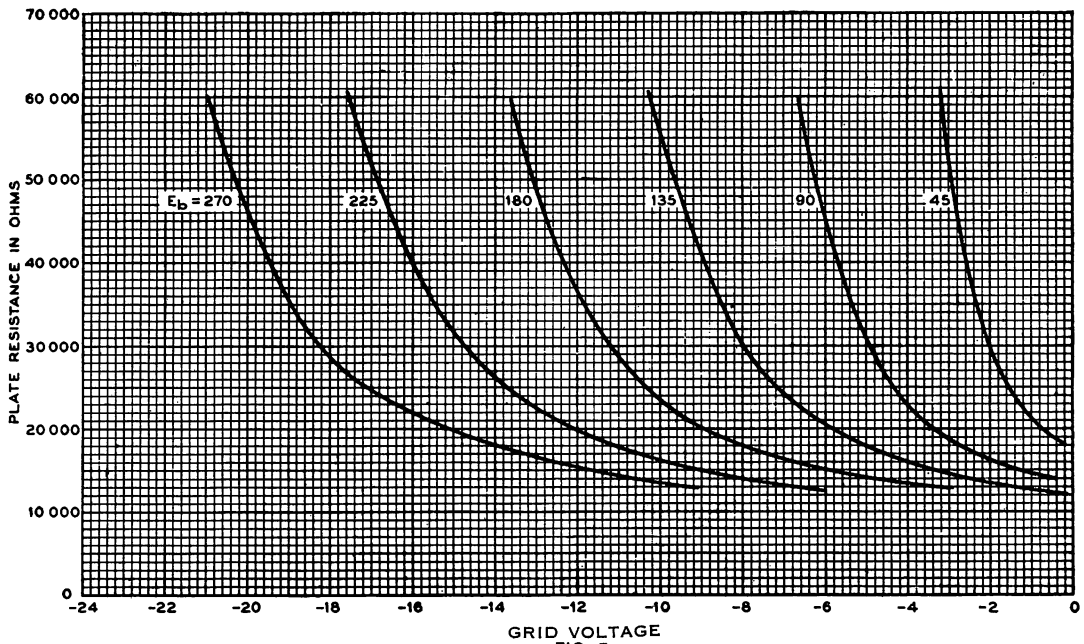


FIG. 5

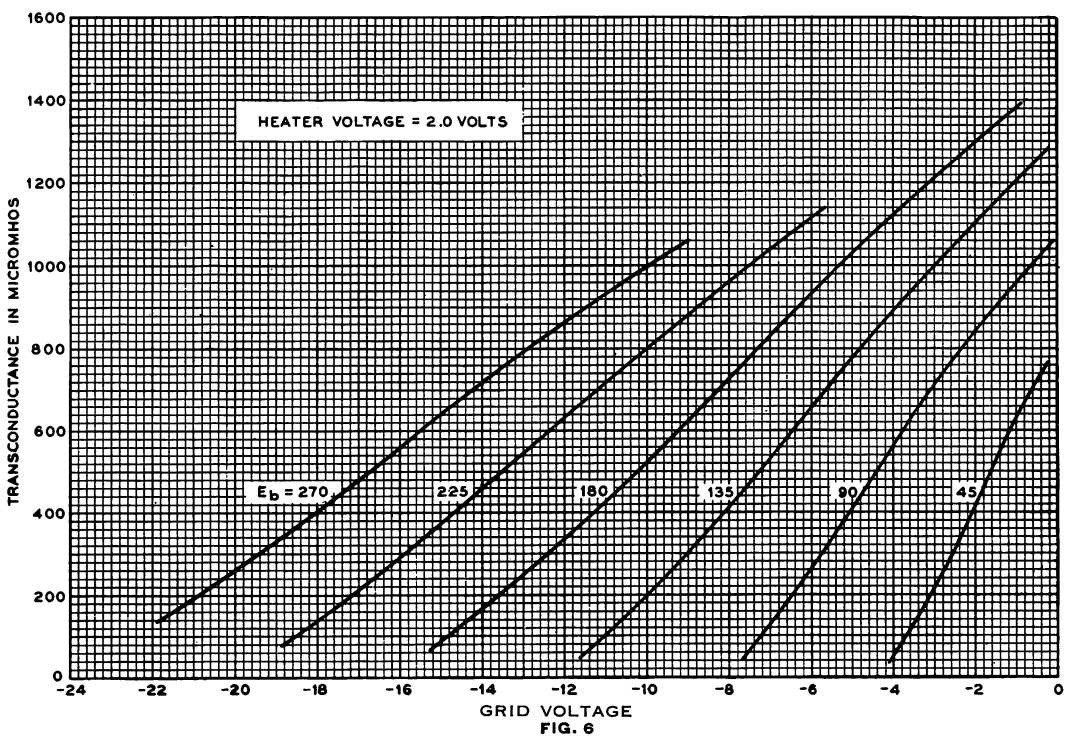


FIG. 6

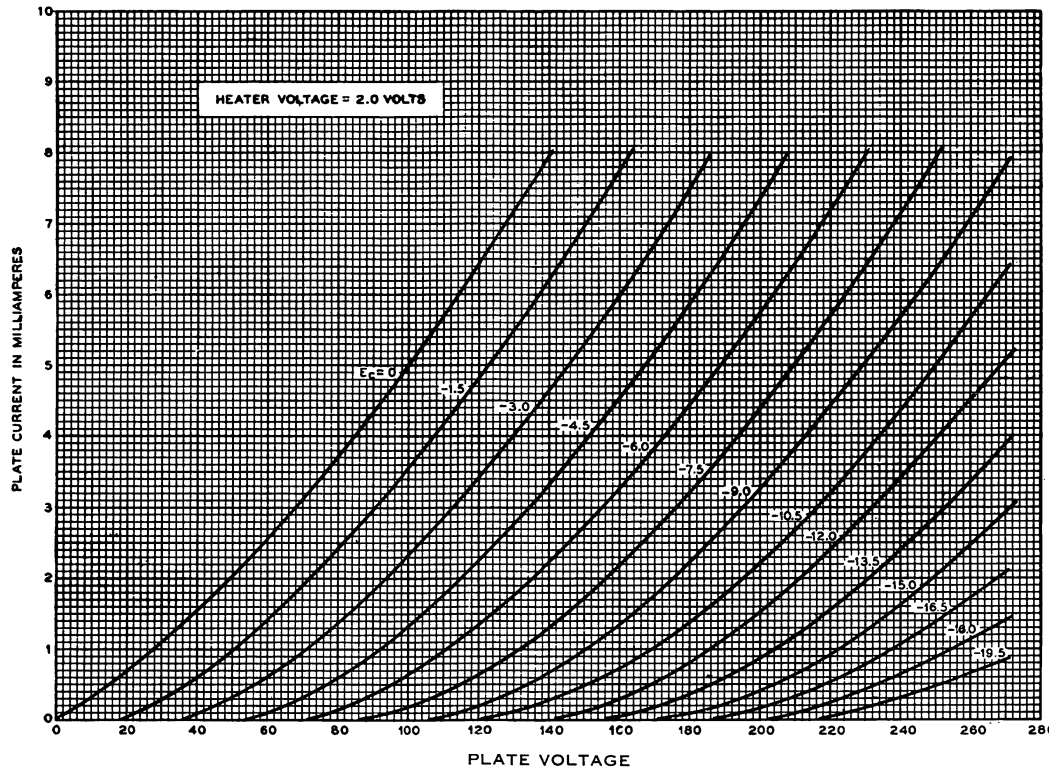

HEATER VOLTAGE = 2.0 VOLTS
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_c=0
-1.5
-3.0
-4.5
-6.0
-7.5
-9.0
-10.5
-12.0
-13.5
-15.0
-16.5
-18.0
-19.5

FIG. 7

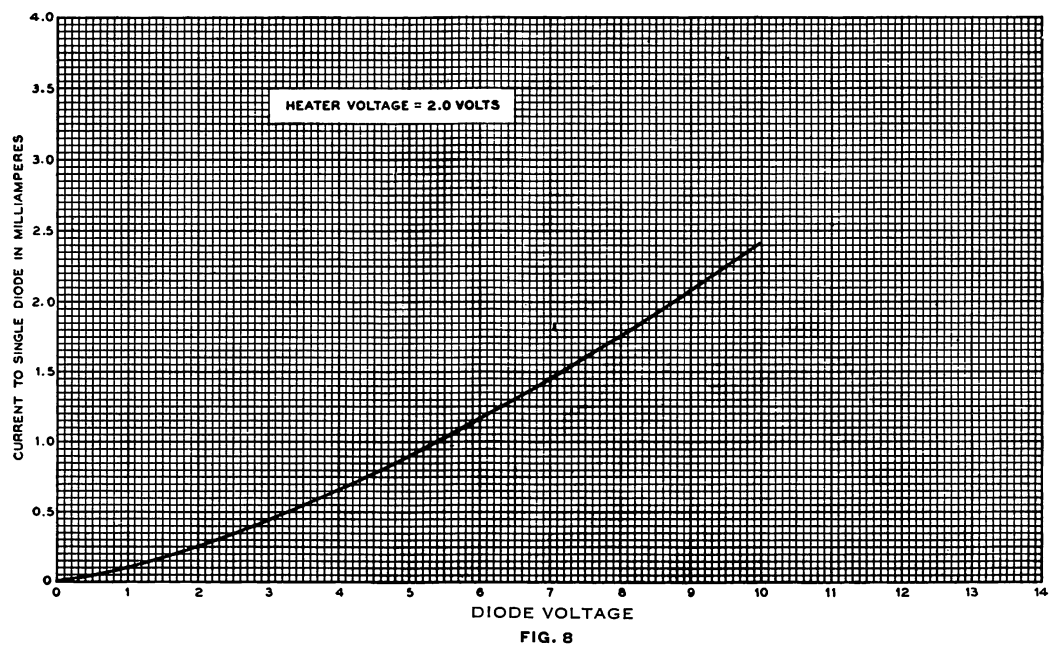

HEATER VOLTAGE = 2.0 VOLTS
CURRENT TO SINGLE DIODE IN MILLIAMPERES
DIODE VOLTAGE

FIG. 8

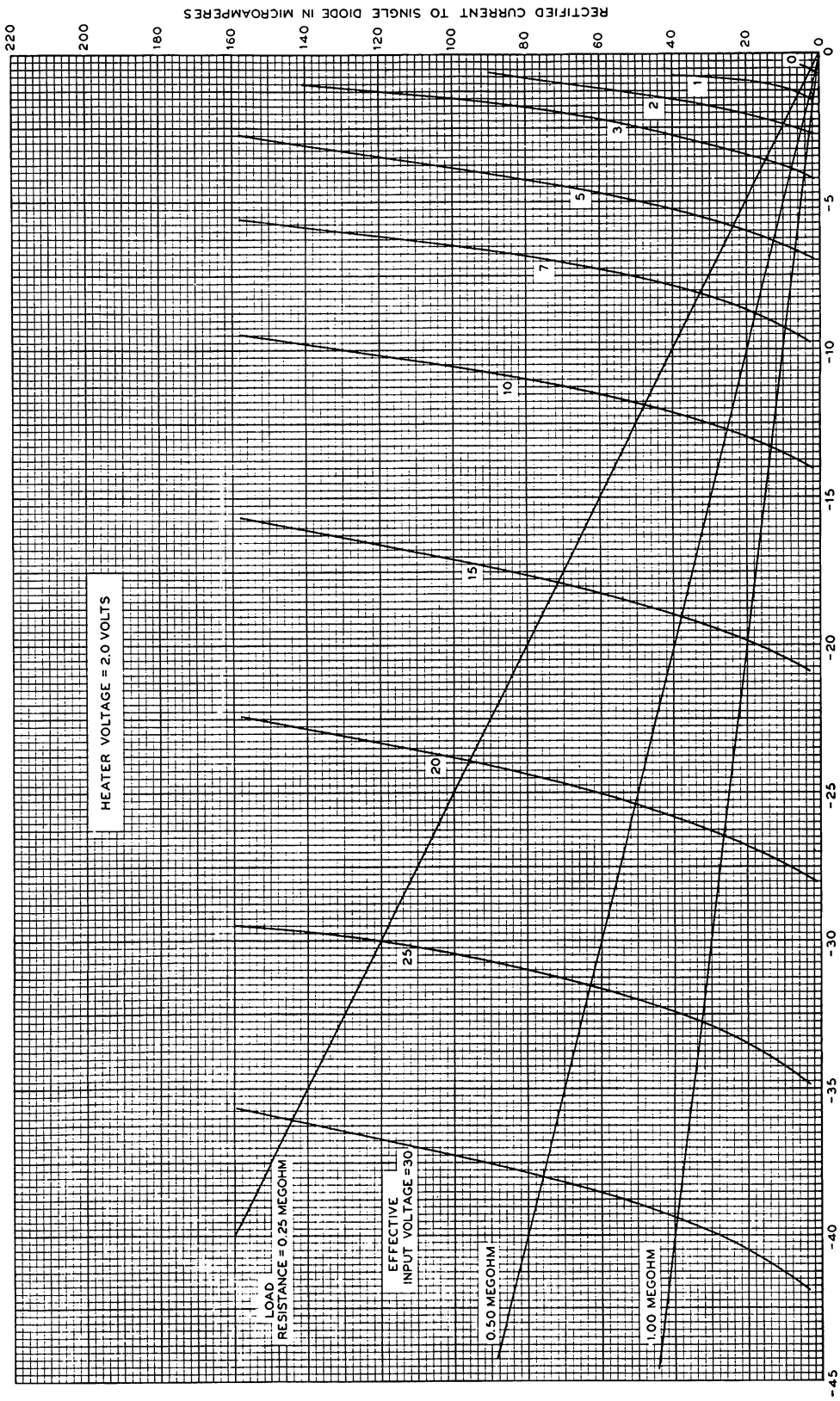
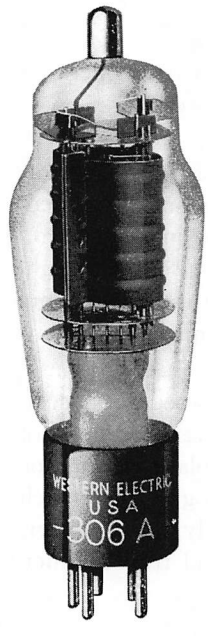

RECTIFIED CURRENT TO SINGLE DIODE IN MICROAMPERES
220
200
180
160
140
120
100
80
60
40
20
0
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
DIRECT DIODE VOLTAGE
HEATER VOLTAGE = 2.0 VOLTS
1
2
3
5
7
10
15
20
25
EFFECTIVE INPUT VOLTAGE = 30
LOAD RESISTANCE = 0.25 MEGOHM
0.50 MEGOHM
1.00 MEGOHM

FIG. 9

Western Electric

306A Vacuum Tube



Classification—Moderate-power, filamentary, suppressor-grid pentode

The 306A tube may be used at relatively high radio frequencies. The suppressor grid is permanently connected to the center point of the filament within the bulb.

Applications

Audio-frequency amplifier in positions where power outputs of approximately 8 watts or less are required.

Radio-frequency amplifier where high overall voltage amplification is not required.

Oscillator.

Modulator and frequency multiplier.

Dimensions—Dimensions, outline diagrams of the tube and base, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base—Medium, five-pin thrust type with bayonet pin. Small, metal cap control-grid terminal at the top of the bulb.

Socket—Standard, five-contact type, such as the Western Electric 141A socket.

Mounting Positions—Either vertical or horizontal. If mounted in a horizontal position, the plane of the filament, which is indicated in Figure 2, should be vertical.

Average Direct Interelectrode Capacitances

Control grid to plate	0.35 μμf.
Control grid to filament, screen grid and suppressor grid	13 μμf.
Plate to filament, screen grid and suppressor grid	13 μμf.

Filament Rating

Filament voltage	2.75 volts, a.c. or d.c.
Nominal filament current	2.0 amperes

The filament of this tube is designed to operate on a voltage basis and should be operated at as near the rated voltage as is practicable.

Filament Connection—The suppressor grid and the center point of the filament are connected to a pin in the base. When alternating current is used for heating the filament, the grid and plate returns may be connected to this point instead of to a center tap of the filament heating transformer secondary. When the tube is used in very high-frequency circuits, 20 megacycles or above, the center point should be connected through low-impedance by-pass condensers to the two end points of the filament in order to minimize the effective filament inductance.

Characteristics—Plate current and screen-grid current characteristics for a typical 306A tube are shown in Figures 3 and 4, respectively, as functions of control-grid voltage for several values of screen-grid and plate voltage. The plate voltage for these characteristics is equal to the screen-grid voltage. Plate current and screen-grid current charcteristics are shown as functions of plate voltage in Figures 5 and 6, respectively, for a screen-grid voltage of 300 volts. Corresponding amplification factor, plate resistance, and transconductance characteristics are shown in Figures 7, 8, and 9, respectively.

The characteristics above and the tabulated values and output curves to follow are for direct-current filament supply with the grid and plate voltages measured from the negative end of the filament. When alternating-current filament supply is used, approximately the same characteristics, tabulated values, and output curves are applicable if 1.6 is added to the numerical value of each control-grid voltage.

Limiting Conditions for Safe Operation

Maximum plate voltage	300 volts
Maximum screen-grid voltage	300 volts
Maximum instantaneous control-grid potential on positive swing of input voltage	+30 volts
Maximum plate current for audio-frequency amplifier applications	60 milliamperes
Maximum plate current for applications other than audio-frequency amplification	50 milliamperes
Maximum plate dissipation	15 watts
Maximum screen-grid current	20 milliamperes
Maximum control-grid current	7 milliamperes

If a tube has been operating for more than one hour in a circuit in which its control-grid potential is continuously negative, as, for example, in an audio-frequency amplifier circuit, it should not thereafter be operated in an oscillator, Class C amplifier, or other circuit in which the control-grid potential is carried positive. If, however, the filament emission has been impaired by not observing this precaution, it can usually be restored by aging the tube for 24 hours in whichever type of circuit is chosen for subsequent operation.

Operating Conditions and Output

Class A—Audio-Frequency Amplifier or Modulator—Permissible operating screen-grid and control-grid voltages for audio-frequency amplifier applications are included within the area, ABCDE, in Figure 3. Amplification factor, plate resistance, transconductance, and performance data are given in the table below for a number of typical operating conditions represented by selected points within this area. Less severe operating conditions should be selected in preference to maximum operating conditions wherever possible. The life of the tube at maximum conditions may be shorter than at less severe conditions.

The performance data include the fundamental power output in watts and the maximum level of any harmonic in db below the fundamental corresponding to the indicated values of load resistance and input voltage. The input for each operating condition has been so chosen that its peak value is numerically equal to the control grid-bias, and the load resistance has been so chosen that for the range of inputs between zero and this maximum value, the maximum levels of the second and third harmonics are equal.

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Plate Current	Screen-Grid Current	Amplification Factor	Plate Resistance	Transconductance	Load Resistance	Input Voltage	Power Output	Maximum Harmonic Level
Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Micromhos	Ohms	Peak Volts	Watts	db
200	200	−12	32	7.0	260	70000	3700	4600	12	3.0	24.5
250	250	−15	43	9.5	250	62000	4050	3800	15	5.0	24.5
*300	300	−20	48	10.0	290	70000	4150	4100	20	8.8	21.0

*Maximum operating conditions

Curves showing the variation of power output and second and third harmonic levels with input voltage for several values of load resistance are shown in Figures 10, 11 and 12, respectively, for a typical operating condition. Figures 13, 14 and 15 extend the data given in the last four columns of the table to other maximum harmonic levels. Each ordinate in Figure 13 gives the maximum power output obtainable from the tube at the indicated operating condition, where both the second and third harmonics are limited to the level given by the corresponding abscissa. The values of input voltage and load resistance which are required at each point are given in Figures 14 and 15, respectively.

Class C—Radio-Frequency Amplifier—Plate and Screen Modulated. Typical operating conditions and output.

Direct plate voltage	300 volts
Direct screen-grid voltage (approximate)	180 volts
Screen-grid circuit resistance	8000 ohms
Total control-grid bias (approximate)	−50 volts
Control-grid circuit resistance	10000 ohms
Fixed control-grid bias	−20 volts
R-F control-grid driving voltage	70 peak volts
Direct plate current	36 milliamperes
Direct screen-grid current	15 milliamperes
Direct control-grid current	3 milliamperes
Effective load resistance	4500 ohms
Carrier power output	7 watts
Power output on a-f peaks	28 watts

For this type of operation, the modulating voltage is applied to the plate through the r-f coil, and to the screen grid through the 8000 ohm screen-grid resistance. No by-pass condenser is used across this resistance so that the actual modulating voltage applied to the screen grid is somewhat lower than that applied to the plate. The by-pass condenser between the screen grid and filament should be as small as practicable to avoid by-passing the higher modulating frequencies.

High Frequency Ratings

The 306A tube may safely be used at full ratings for operating frequencies up to 50 megacycles and at reduced ratings up to 70 megacycles. Ratings for these two frequencies are as follows:

	50 Megacycles	70 Megacycles
Maximum direct plate voltage	300	225 volts
Maximum direct plate current	50	50 milliamperes

For frequencies between these two values proportionate ratings are applicable. The object in reducing the ratings is to limit the charging currents and dielectric losses, which dissipate considable heat in the leads and glass of the tube at high frequencies.

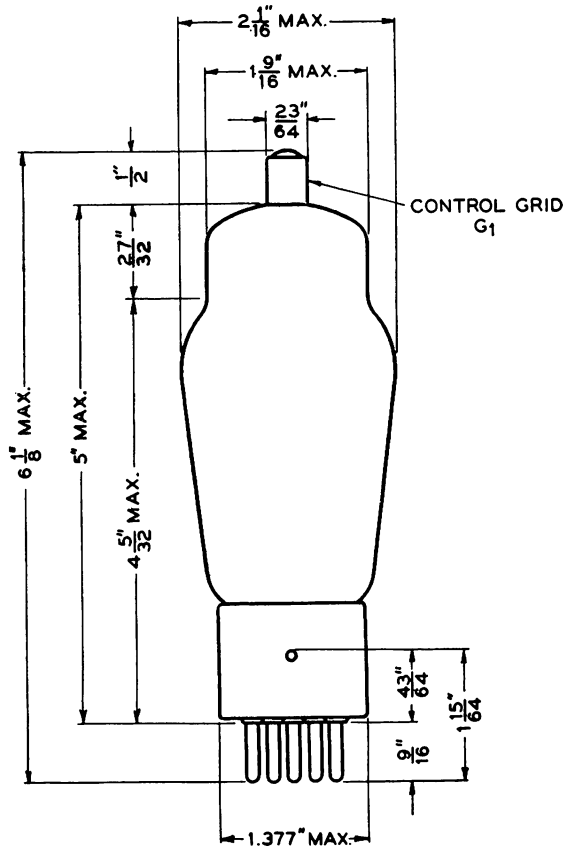


FIG. 1

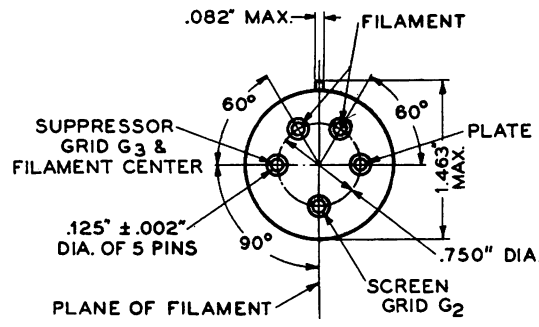


FIG. 2

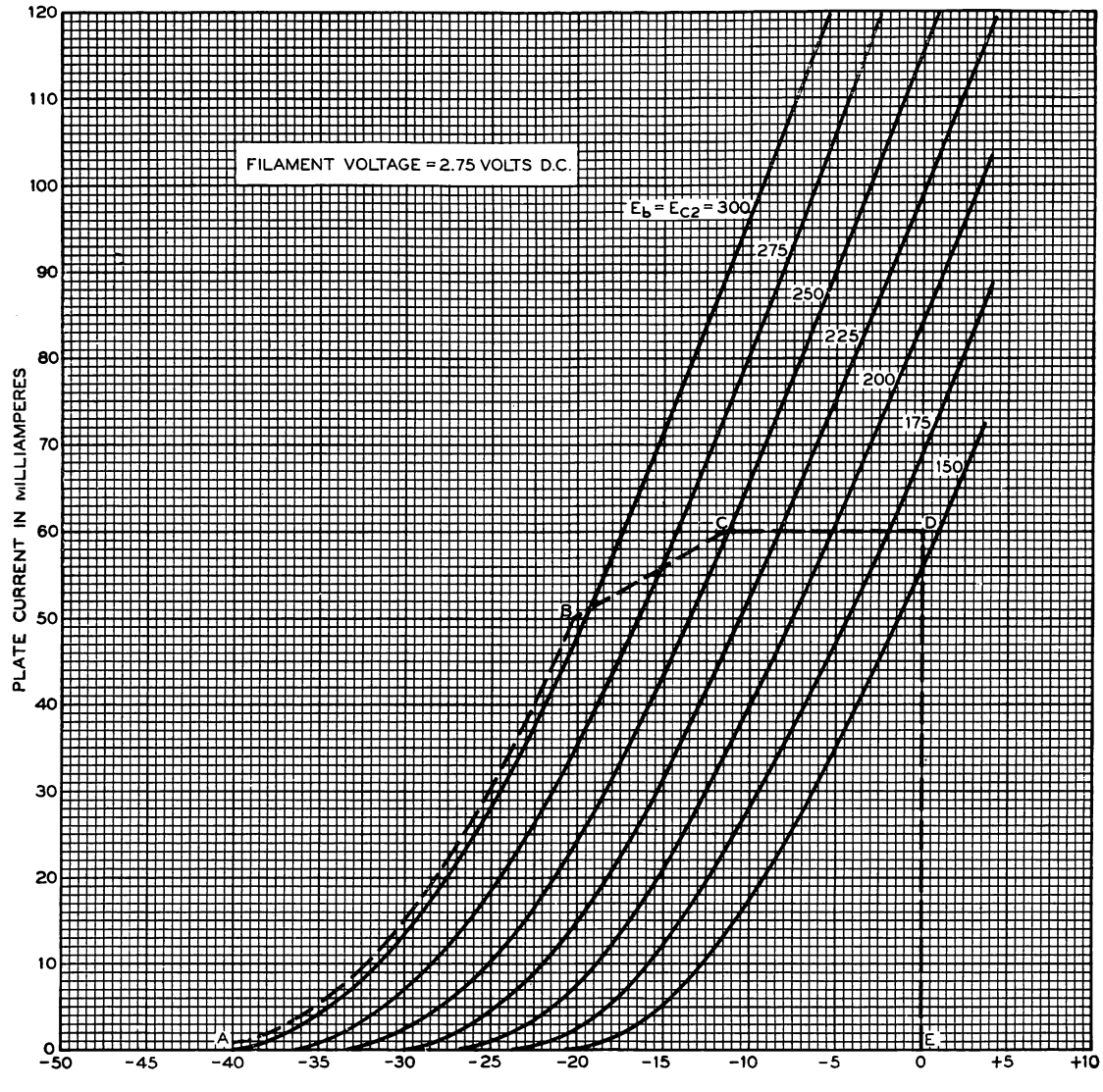

FILAMENT VOLTAGE = 2.75 VOLTS D.C.
$E_b = E_{C2} = 300$
275
250
225
200
175
150
A
B
C
D
E
PLATE CURRENT IN MILLIAMPERES
120
110
100
90
80
70
60
50
40
30
20
10
0
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
+5
+10

FIG. 3

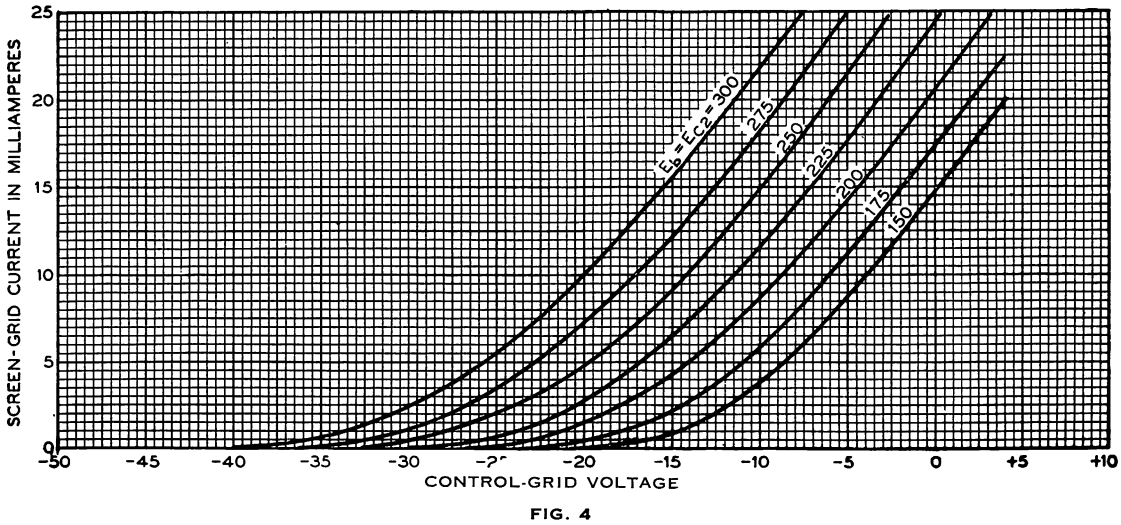

SCREEN-GRID CURRENT IN MILLIAMPERES
25
20
15
10
5
0
$E_b = E_{C2} = 300$
275
250
225
200
175
150
-50
-45
-40
-35
-30
-20
-15
-10
-5
0
+5
+10
CONTROL-GRID VOLTAGE

FIG. 4

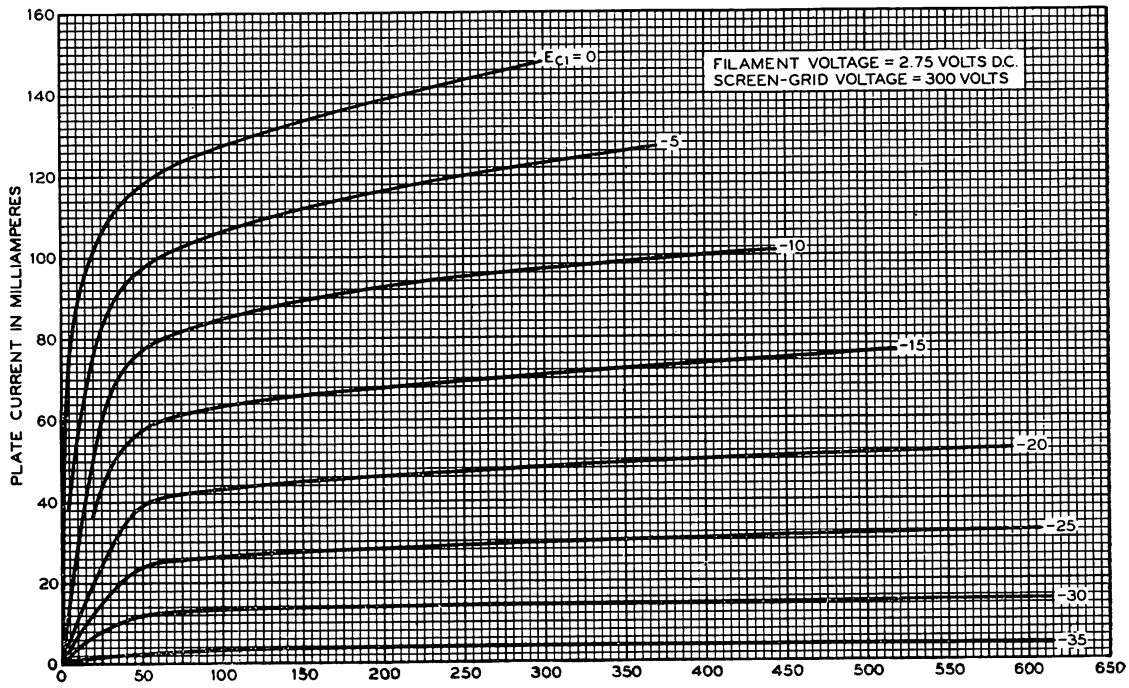

FILAMENT VOLTAGE = 2.75 VOLTS DC.
SCREEN-GRID VOLTAGE = 300 VOLTS
$E_{C1} = 0$
-5
-10
-15
-20
-25
-30
-35
PLATE CURRENT IN MILLIAMPERES
0
20
40
60
80
100
120
140
160
0
50
100
150
200
250
300
350
400
450
500
550
600
650

FIG. 5

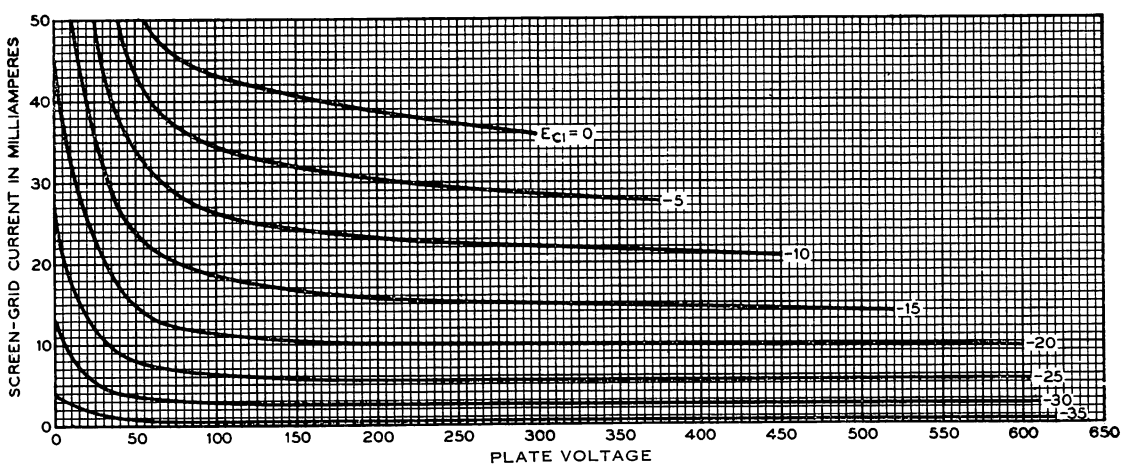

$E_{C1} = 0$
-5
-10
-15
-20
-25
-30
-35
SCREEN-GRID CURRENT IN MILLIAMPERES
0
10
20
30
40
50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
PLATE VOLTAGE

FIG. 6

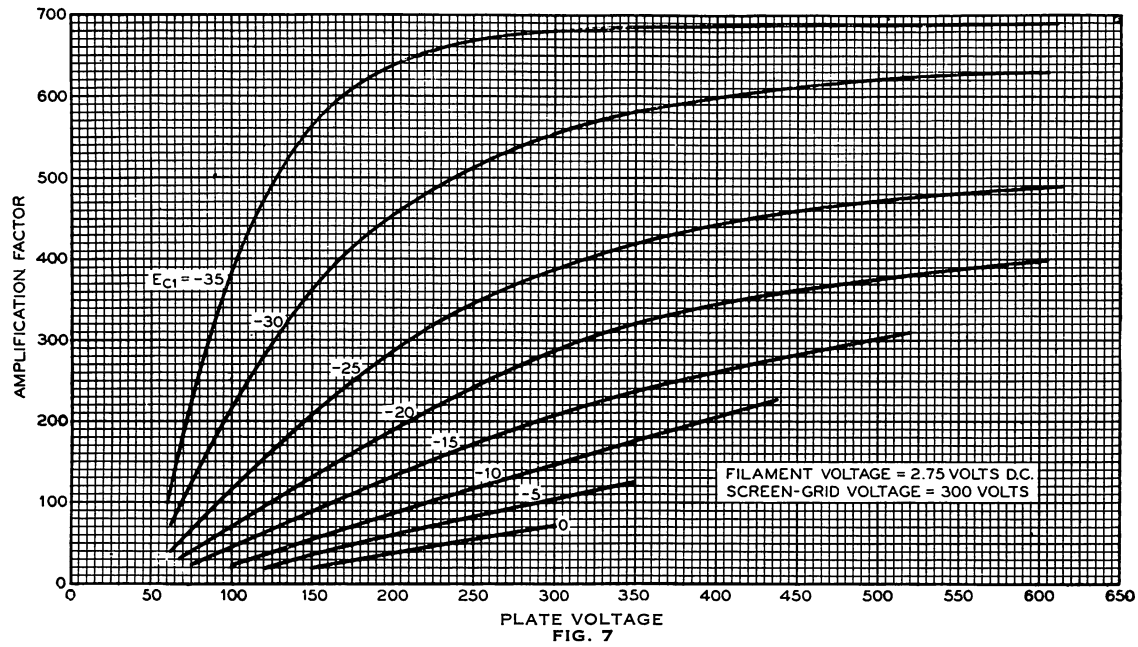


FIG. 7

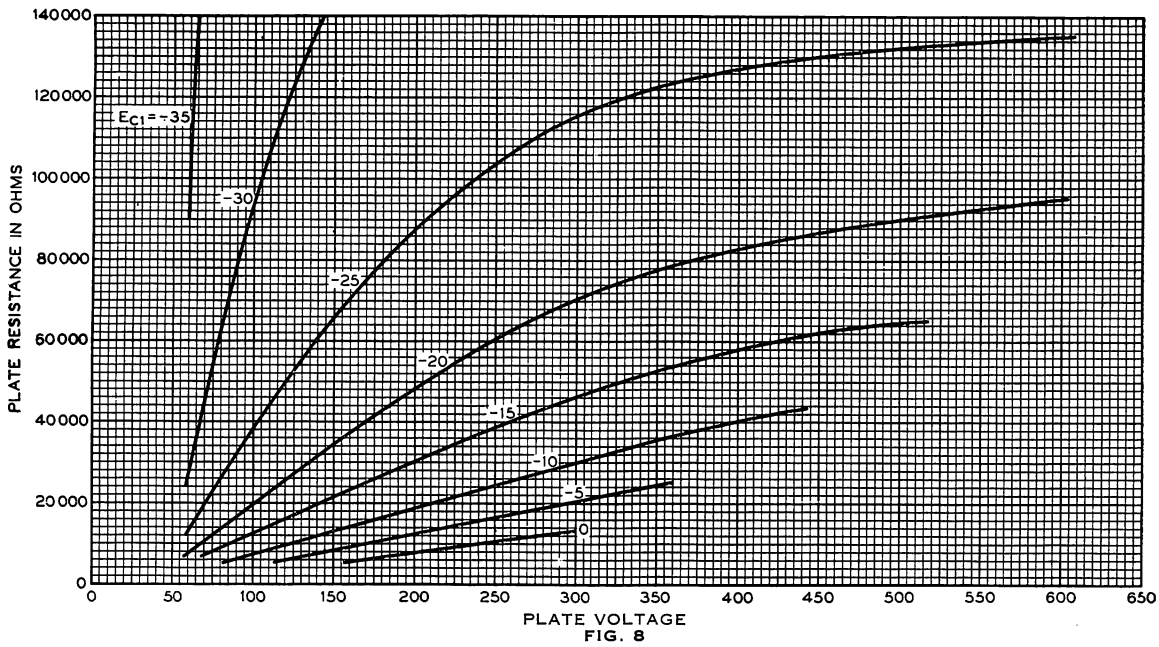


FIG. 8

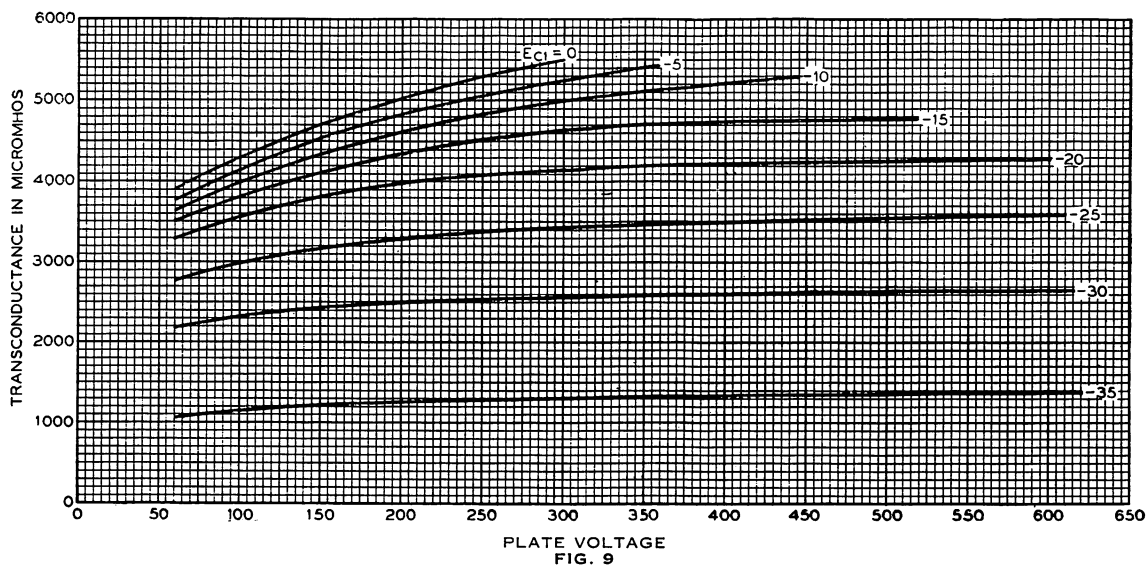


FIG. 9

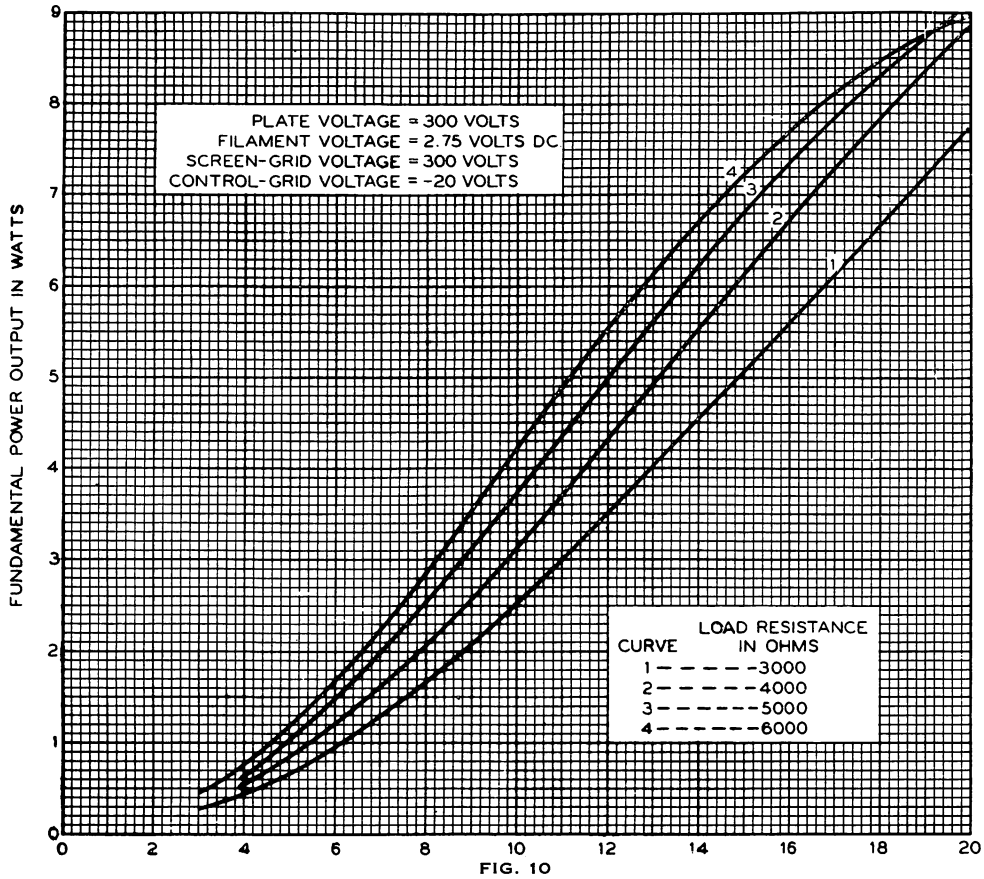


FIG. 10

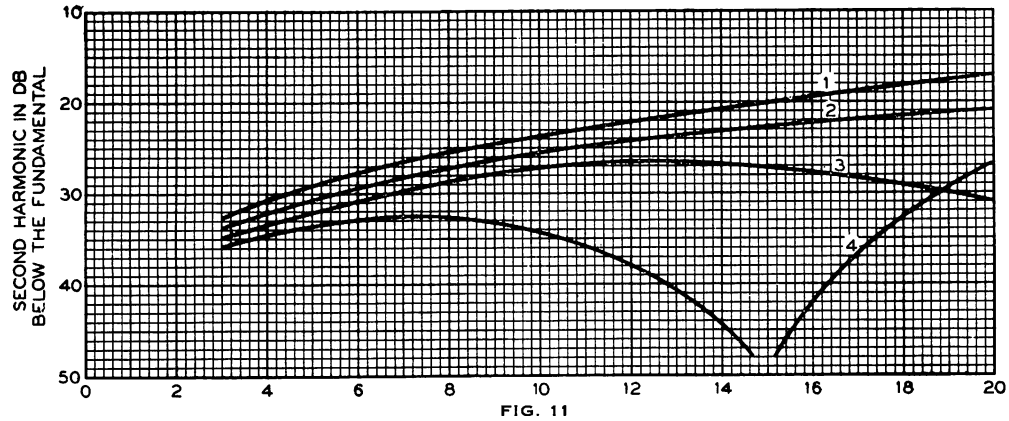


FIG. 11

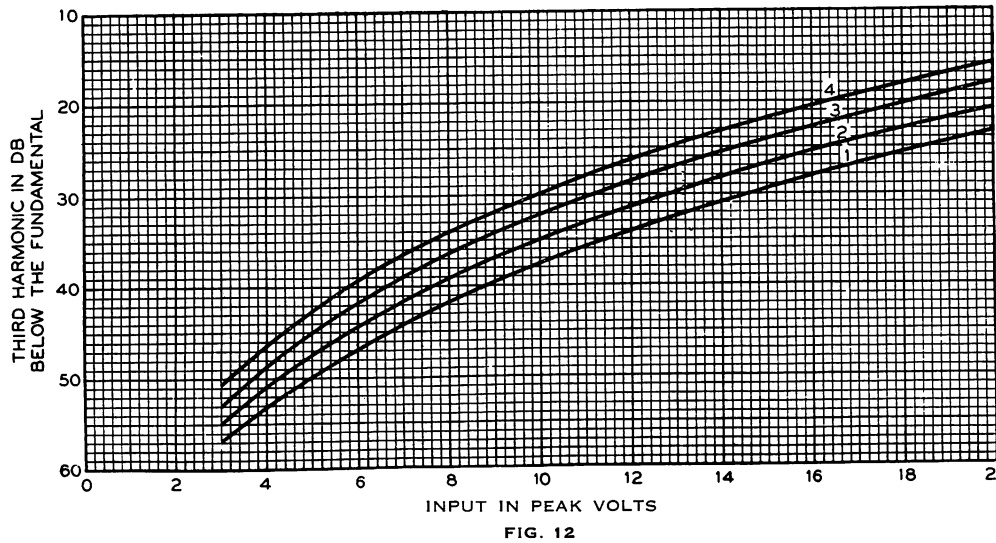


FIG. 12

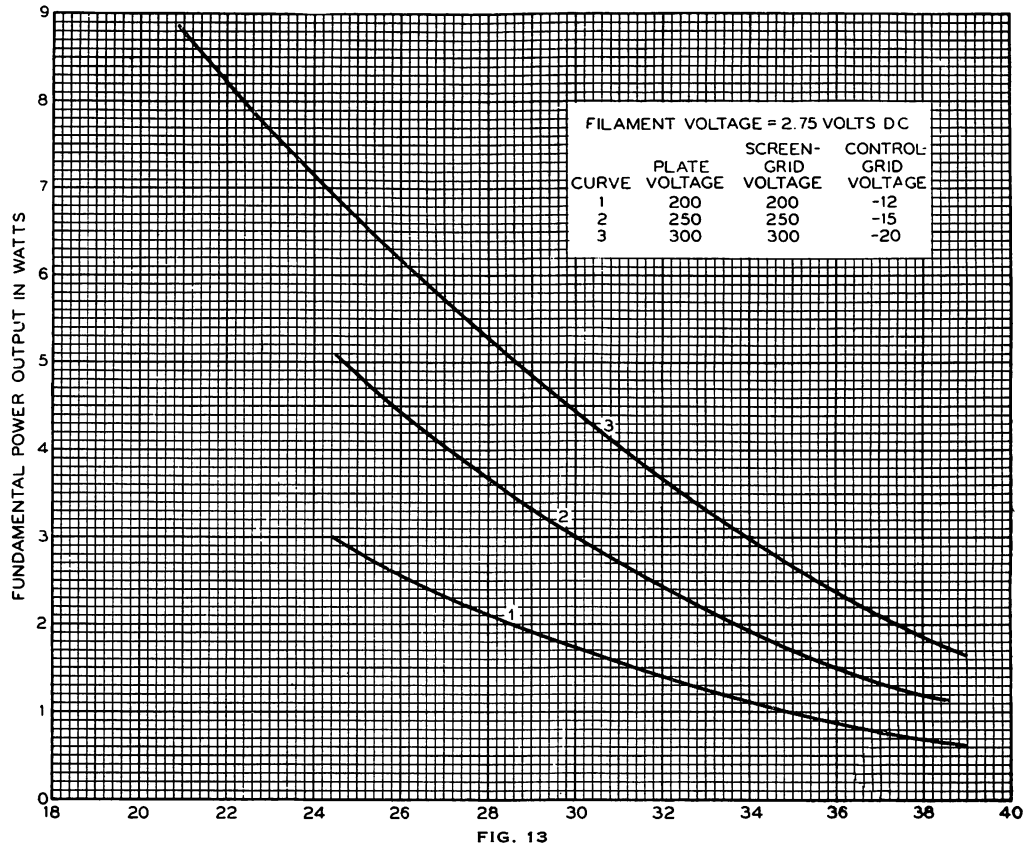


FIG. 13

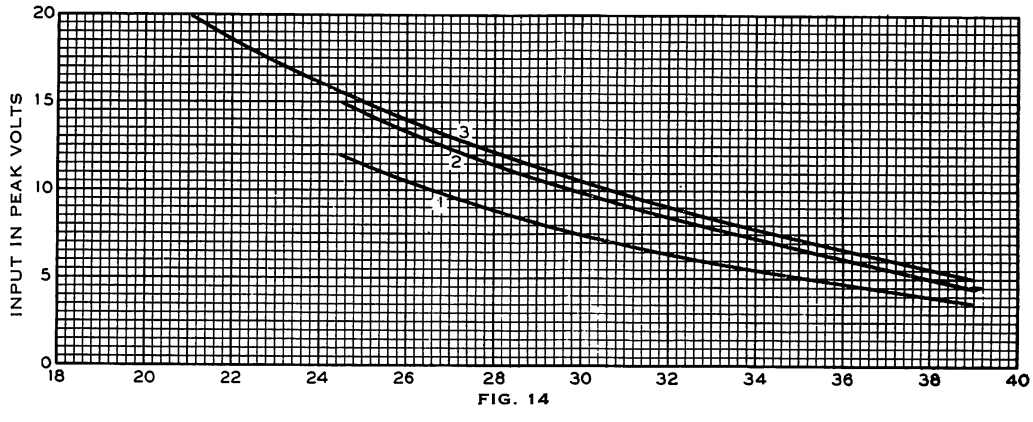


FIG. 14

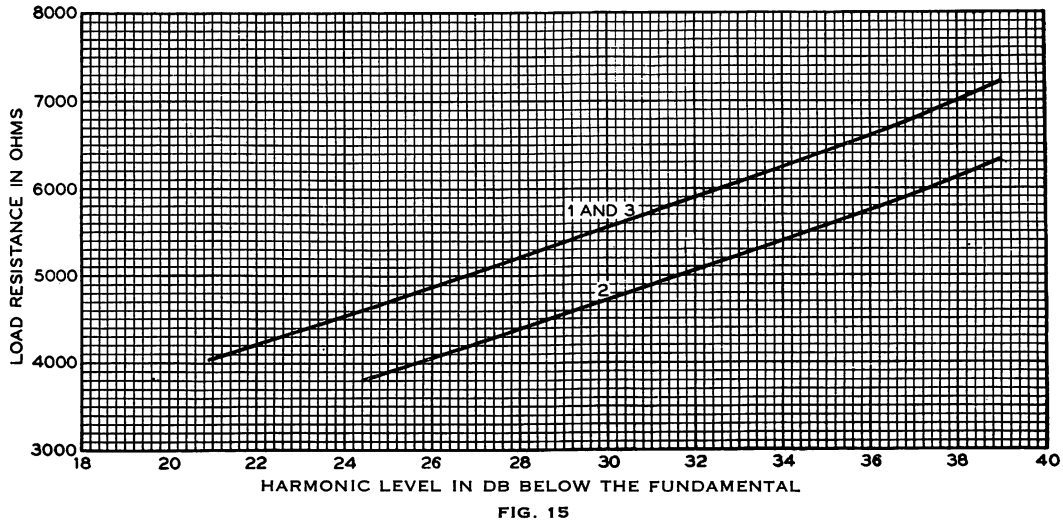
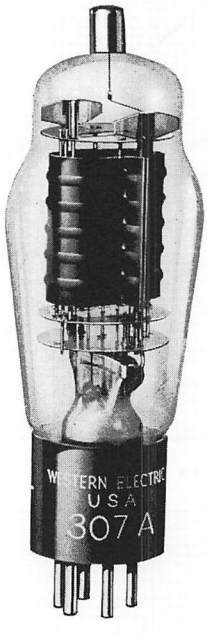


FIG. 15

Western Electric

307A Vacuum Tube



Classification—Moderate-power, filamentary suppressor-grid pentode

All three grids of the 307A tube are connected to separate base terminals.

Applications

Radio-frequency power amplifier

Suppressor-grid modulated amplifier

Frequency multiplier

Oscillator

Audio-frequency amplifier or modulator. The 306A tube gives better performance in this application and is preferable except where its different filament characteristics preclude its use.

Dimensions—Dimensions, outline diagrams of the tube and base, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base—Medium, five-pin base with bayonet pin. Small, metal cap plate terminal at the top of the bulb.

Socket—Standard, five-contact type, such as the Western Electric 141A socket.

Mounting Positions—Either vertical or horizontal. If mounted in a horizontal position, the plane of the filament, which is indicated in Figure 2, should be vertical.

Average Direct Interelectrode Capacitances

Control grid to plate	0.55 μμf.
Control grid to filament, screen grid, and suppressor grid	15 μμf.
Plate to filament, screen grid, and suppressor grid	12 μμf.

Filament Rating

Filament voltage	5.5 volts, a.c. or d.c.
Nominal filament current	1.0 ampere

The filament of this tube is designed to operate on a voltage basis and should be operated at as near the rated voltage as is practicable. When alternating-current filament supply is used, the grid and plate returns should be connected to a center tap on the secondary of the filament transformer or to the center point of a suitable resistance connected across the filament terminals.

Characteristics—Plate current and screen-grid current characteristics of a typical 307A tube are shown in Figures 3 and 4, respectively, as functions of control-grid bias for several values of screen-grid and plate voltages and zero suppressor-grid voltage. The plate voltage for these characteristics is equal to the screen-grid voltage. Plate current and screen-grid current characteristics are shown as functions of plate voltage in Figures 5 and 6, respectively, for a screen-grid voltage of 200 volts and zero suppressor-grid voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are shown in Figures 7, 8 and 9, respectively. Plate current and screen-grid current characteristics are shown as functions of control-grid bias in Figures 10 and 11, respectively, for a plate voltage of 500 volts, a screen-grid voltage of 200 volts, and several values of suppressor-grid voltage.

All of these characteristics are for direct-current filament supply with the grid and plate voltages measured from the negative end of the filament. When alternating-current filament supply is used, the same characteristics may be applied if 3.2 is added to the numerical value of each control-grid bias.

Limiting Conditions For Safe Operation

	Class A Amplifier	*Class C Amplifier or Oscillator	**Class B or Suppressor-Modulated Class C Amplifier
Maximum direct plate voltage	500	500	500 volts
Maximum direct screen-grid voltage	300	250	250 volts
Maximum direct plate current	60	60	45 milliamperes
Maximum direct screen-grid current	25	25	25 milliamperes
Maximum direct control-grid current	—	7	7 milliamperes
Maximum plate dissipation	15	15	15 watts
Maximum screen-grid dissipation	6	6	6 watts
Maximum instantaneous control-grid voltage on positive swing of input	—	+30	+30 volts

*Key-down conditions for intermittent service such as telegraphy.
For continuous operation the direct plate current should be limited to 45 milliamperes.
**Carrier conditions for use with a modulation factor up to 1.0.

Because of secondary emission effects, the suppressor grid should not be driven more than 20 volts positive except where the resistance in the suppressor-grid circuit is small.

Operating Conditions and Output

Class A—Audio-Frequency Amplifier or Modulator.

Permissible operating conditions for Class A operation are included within the area, A B C D E, in Figure 3. Nominal performance data are given in the table on page 3 for typical operating conditions represented by selected points within this area. It is assumed that the plate voltage for every operating condition is equal to the screen-grid voltage. Other plate voltages, however, are per-

missible within the limits set down in the preceding section. A less severe operating condition should be selected in preference to a maximum operating condition wherever possible. The life of the tube at maximum conditions may be shorter than at less severe conditions.

The performance data include the maximum fundamental power output in watts and the maximum levels of the second and third harmonics in decibels below the fundamental for the recommended values of load resistance and the indicated range of input voltages. In designing the 307A tube for optimum characteristics as a suppressor-grid modulated, Class C amplifier, its Class A amplifier characteristics have been sacrificed to some extent. It will deliver approximately the same maximum power output as the 306A tube under similar Class A operating conditions, but the harmonic levels for comparable outputs are somewhat higher.

TABLE

Plate Voltage	Screen Grid Voltage	Suppressor Grid Voltage	Control-Grid Bias	Plate Current	Screen Grid Current	Load Resistance	Input Voltage Range	Maximum Power Output	Maximum Second Harmonic	Maximum Third Harmonic
Volts	Volts	Volts	Volts	Milliamperes	Milliamperes	Ohms	Peak Volts	Watts	db	db
200	200	0	−15	36.5	3.4	4000	0−15	2.9	23.5	24
250	250	0	−20	50	4.0	4000	0−20	5.7	24	23.5
*300	300	0	−30	43	2.6	4500	0−30	9.1	21	17.5

*Maximum operating condition.

Curves showing the variation of power output and second and third harmonic levels for the three operating conditions given in the table are shown in Figures 12, 13 and 14, respectively.

Class C—Radio-Frequency Power Amplifier, Suppressor-Grid Modulated Amplifier, and Oscillator. Typical operating conditions and output.

	Suppressor-Modulated Class C Amplifier	Unmodulated Class C Amplifier or Oscillator	
	Note 1	Note 2	
Direct plate voltage	500	500	500 volts
Direct screen-grid voltage (approx.)	200	250	250 volts
Screen-grid circuit resistance	14000	20000	20000 ohms
Total control-grid bias (approx.)	−35	−35	−35 volts
Control-grid circuit resistance	10000	10000	10000 ohms
Fixed control-grid bias	−20	−20	−20 volts
Suppressor-grid bias	−50	0	0 volts
R-F control-grid voltage	50	50	50 peak volts
Direct plate current	40	45	60 milliamperes
Direct screen-grid current	20	12	13 milliamperes
Direct control-grid current	1.5	1.3	1.4 milliamperes
A-F suppressor-grid voltage	50	0	0 peak volts
Effective load resistance	4000	6500	5000 ohms
Carrier power output	6	15	20 watts
Power output on a-f peaks	24	—	— watts

Note 1—Carrier conditions for use with modulation factors up to 1.0.
Note 2—Conditions permissible only for intermittent service, such as telegraphy.

It is recommended that the screen-grid voltage be obtained from the plate voltage by inserting a resistance in series with the screen grid and plate voltage, and that part of the control-grid bias also be obtained from the voltage drop produced by the control-grid current flowing through a resistance. With this arrangement, using the indicated values of resistance, the output power is

almost independent of carrier input over a wide range of carrier input voltages, the distortion of the signal wave in the modulator application is minimized, and the risk of damaging the tube by overload while making circuit adjustments is reduced.

A radio-frequency output current characteristic of a typical 307A tube is shown in Figure 15 as a function of suppressor-grid voltage for a constant impressed radio-frequency control-grid voltage of 50 peak volts. Corresponding plate current, screen-grid current, control-grid current, and suppressor-grid current characteristics are given in Figure 16. These characteristics correspond to the first column of operating conditions listed above, except that the suppressor-grid voltage is treated as a variable.

High-Frequency Ratings

It is permissible to use the 307A tube at full rating for operating frequencies up to 40 megacycles and at reduced ratings up to 70 megacycles. Ratings for these two frequencies are as follows:

	40 Megacycles	70 Megacycles
Maximum direct plate voltage	500	300 volts
Maximum direct plate current		
For Class C telegraphy (intermittent)	60	45 milliamperes
For all other classes of service	45	45 milliamperes

For intermediate frequencies, proportionate ratings are applicable. The object in reducing the ratings is to limit charging currents and dielectric losses, which produce heat in the leads and glass of the tube at high frequencies.

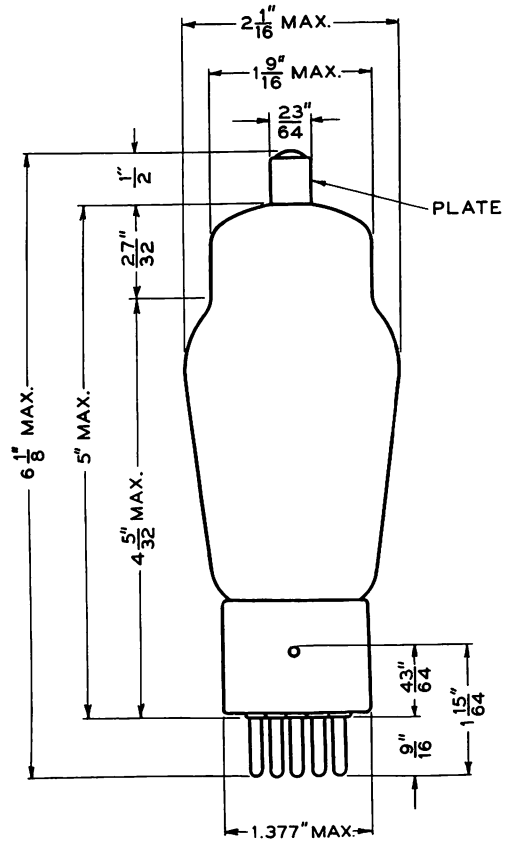


FIG. 1

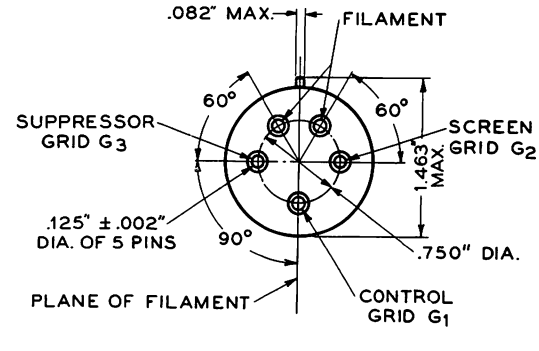


FIG. 2

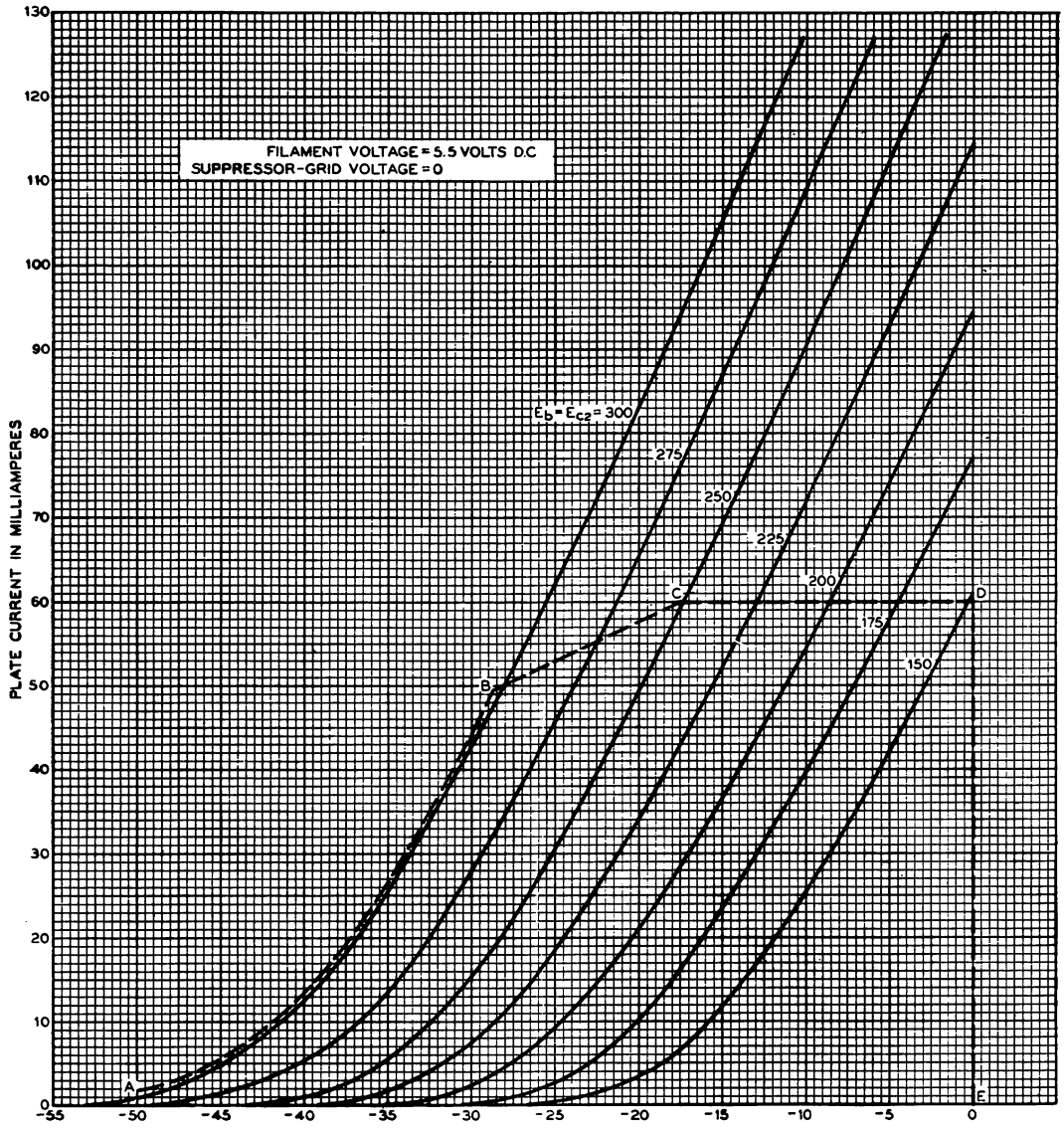

FILAMENT VOLTAGE = 5.5 VOLTS D.C
SUPPRESSOR-GRID VOLTAGE = 0
PLATE CURRENT IN MILLIAMPERES
$E_b = E_{c2}$ = 300
275
250
225
200
175
150
A
B
C
D
E
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-55
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0

FIG. 3

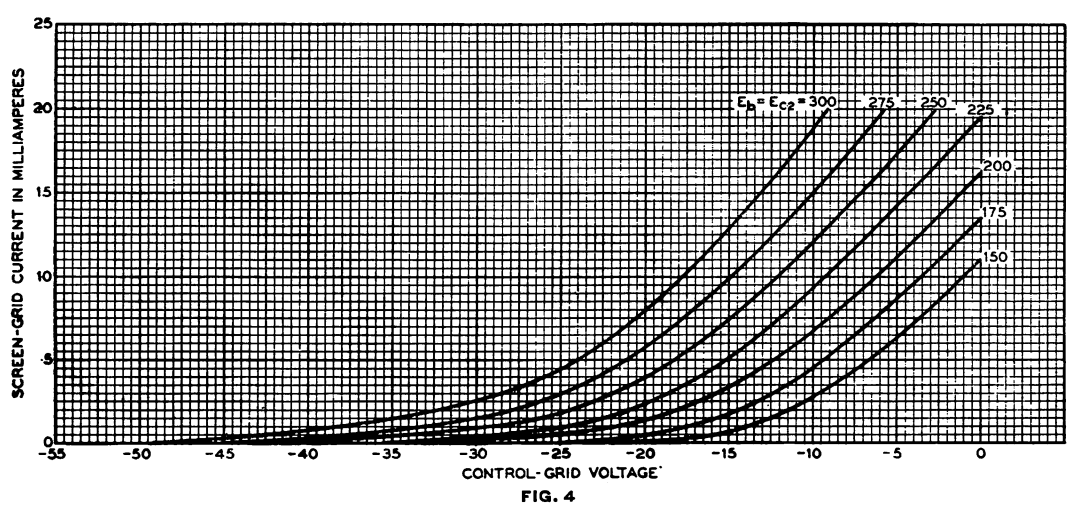

SCREEN-GRID CURRENT IN MILLIAMPERES
$E_b = E_{c2}$ = 300
275
250
225
200
175
150
25
20
15
10
5
0
-55
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
CONTROL-GRID VOLTAGE

FIG. 4

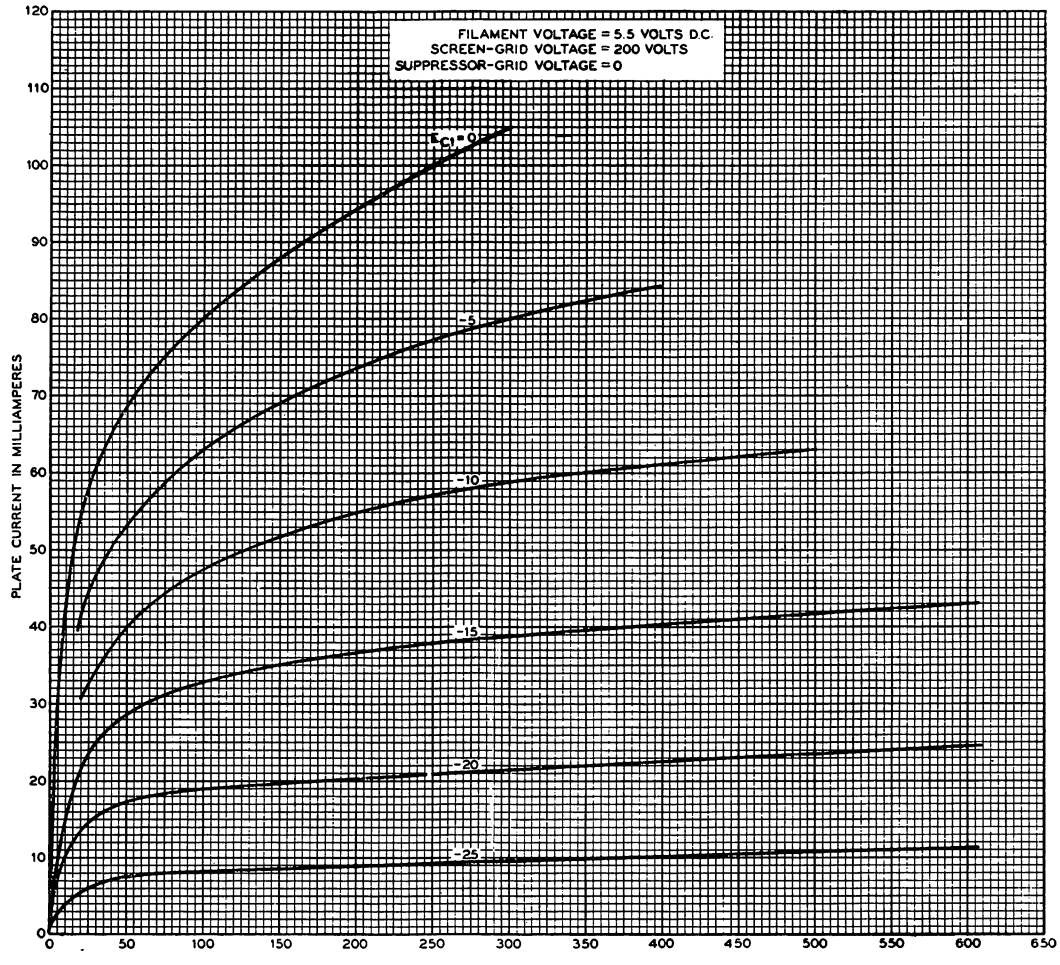

FILAMENT VOLTAGE = 5.5 VOLTS D.C.
SCREEN-GRID VOLTAGE = 200 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE CURRENT IN MILLIAMPERES
$E_{C1}=0$
-5
-10
-15
-20
-25
0
10
20
30
40
50
60
70
80
90
100
110
120
0
50
100
150
200
250
300
350
400
450
500
550
600
650

FIG. 5

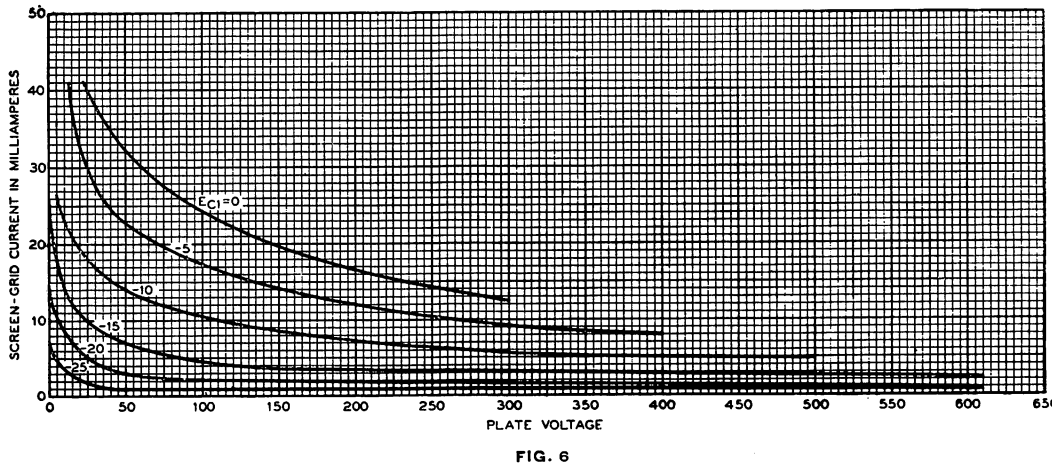

SCREEN-GRID CURRENT IN MILLIAMPERES
$E_{C1}=0$
-5
-10
-15
-20
-25
0
10
20
30
40
50
0
50
100
150
200
250
300
350
400
450
500
550
600
650
PLATE VOLTAGE

FIG. 6

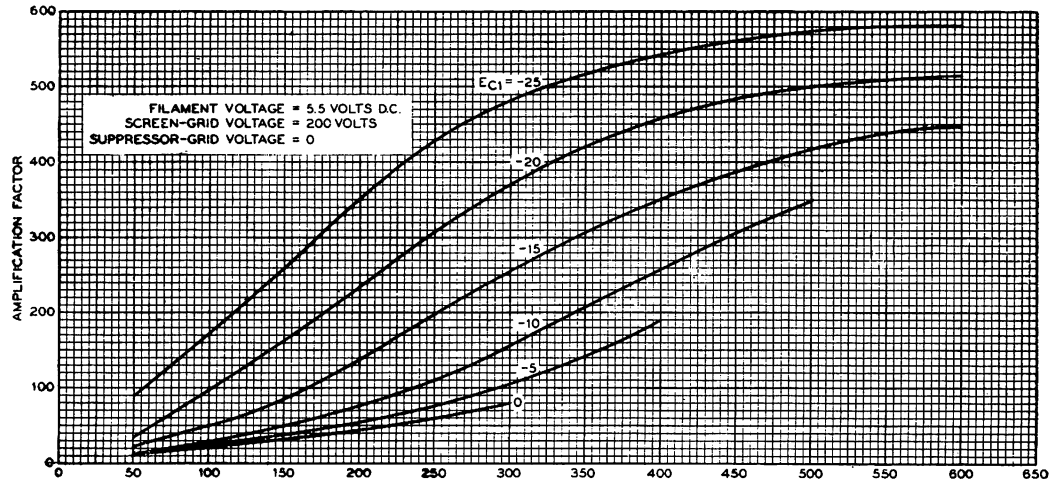


FIG. 7

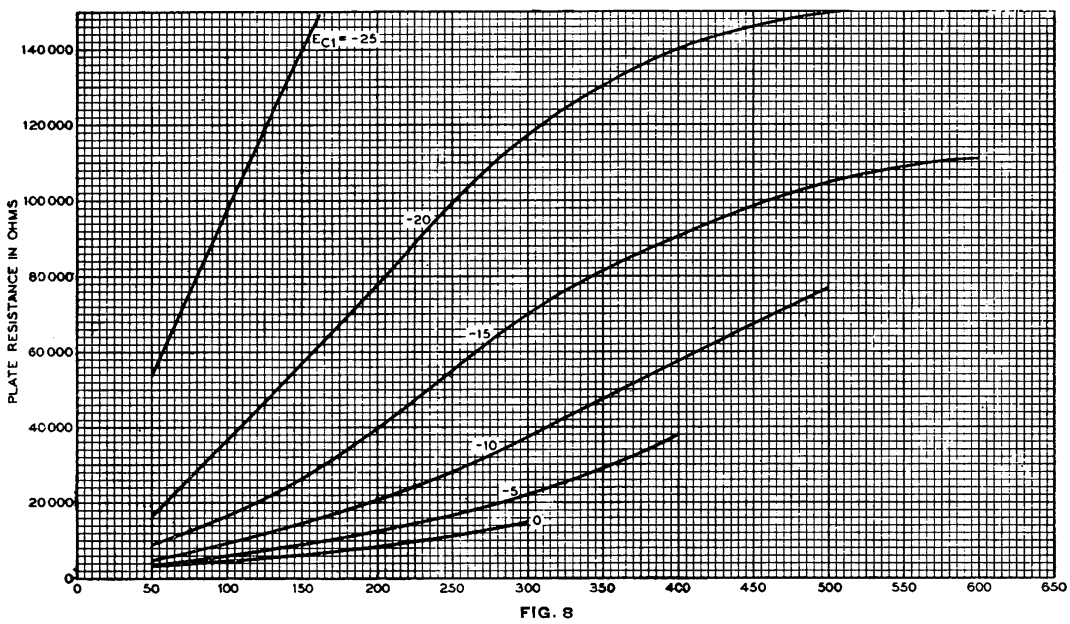


FIG. 8

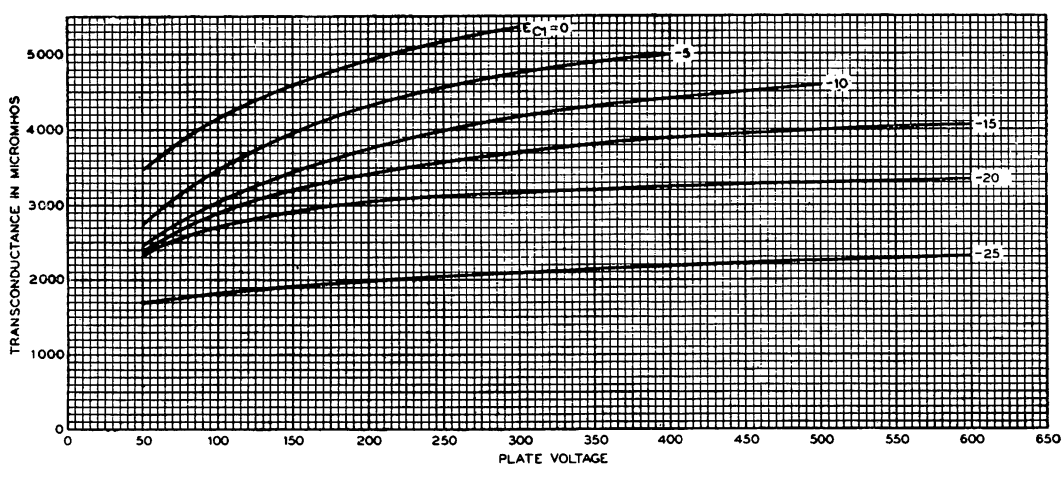


FIG. 9

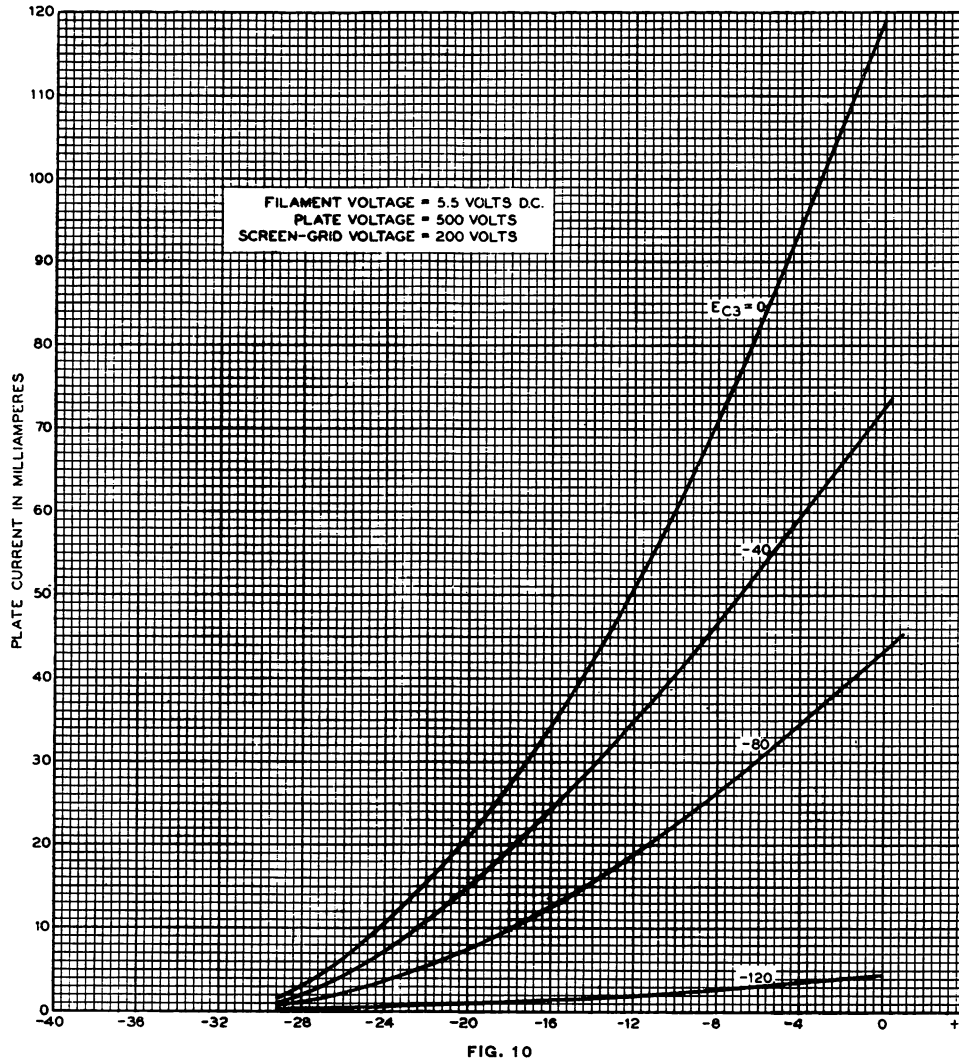

FILAMENT VOLTAGE = 5.5 VOLTS D.C.
PLATE VOLTAGE = 500 VOLTS
SCREEN-GRID VOLTAGE = 200 VOLTS
E_{C3} = 0
-40
-80
-120
PLATE CURRENT IN MILLIAMPERES
120
110
100
90
80
70
60
50
40
30
20
10
0
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4

FIG. 10

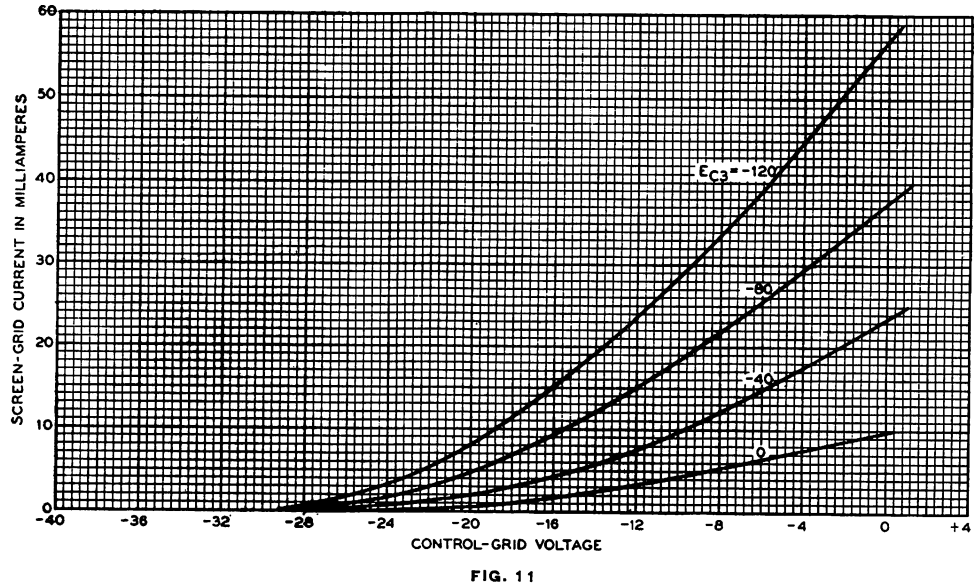

E_{C3} = -120
-80
-40
0
SCREEN-GRID CURRENT IN MILLIAMPERES
60
50
40
30
20
10
0
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4
CONTROL-GRID VOLTAGE

FIG. 11

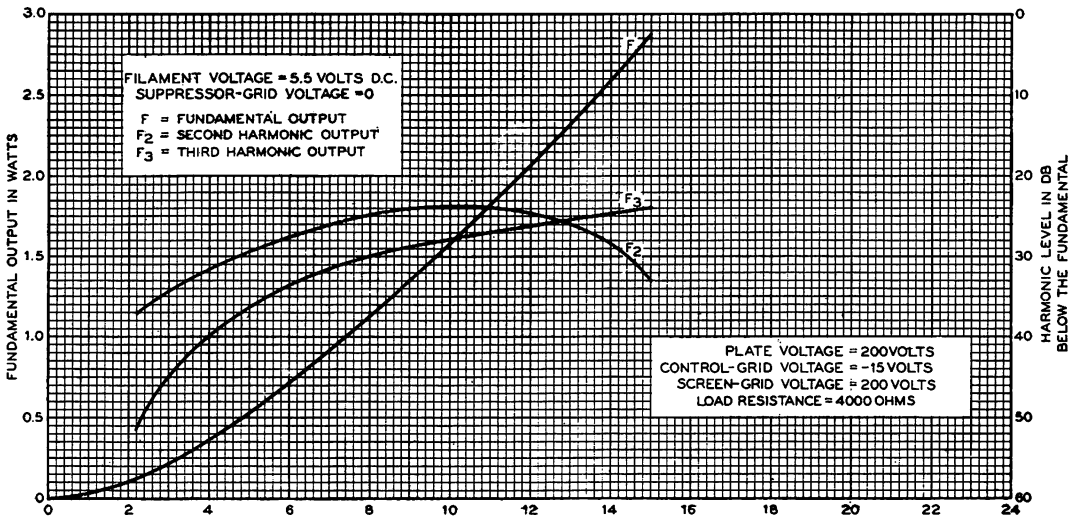


FIG. 12

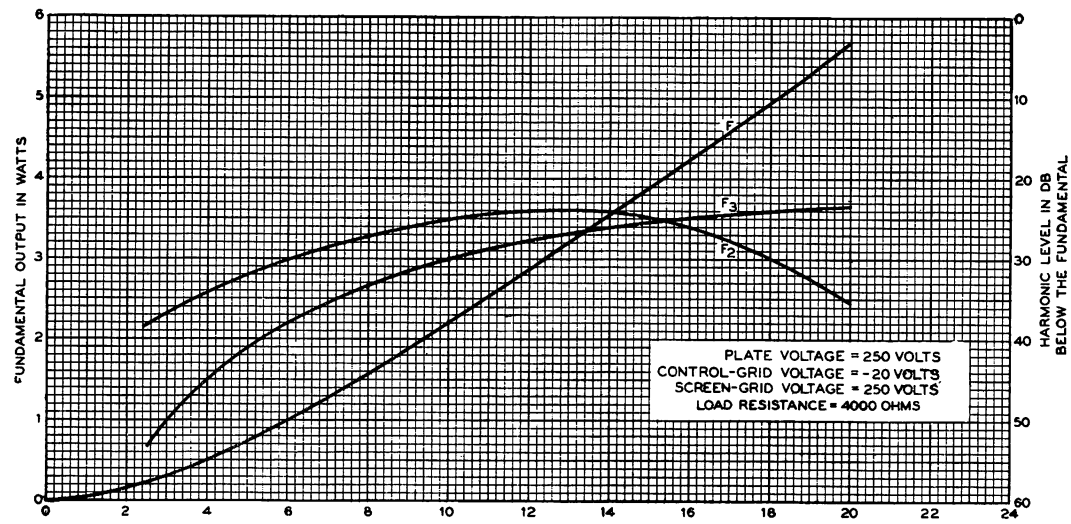


FIG. 13

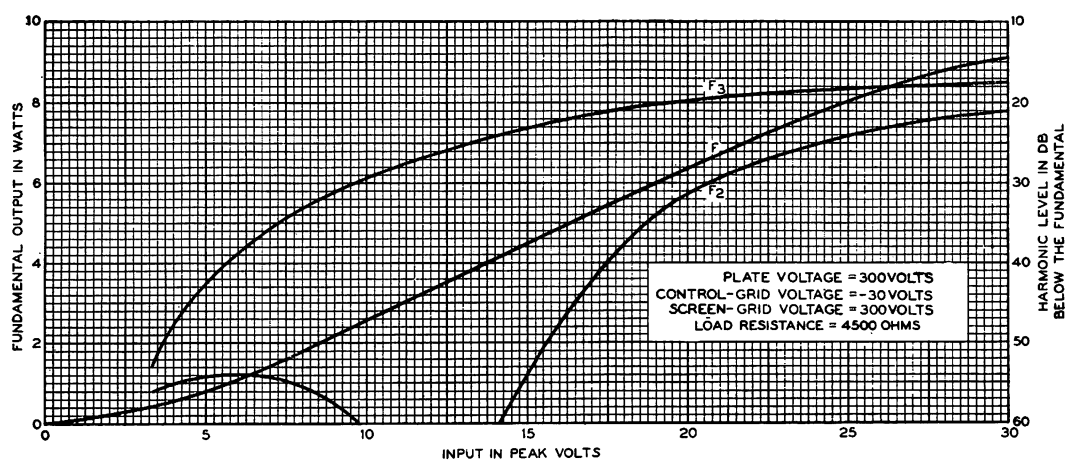


FIG. 14

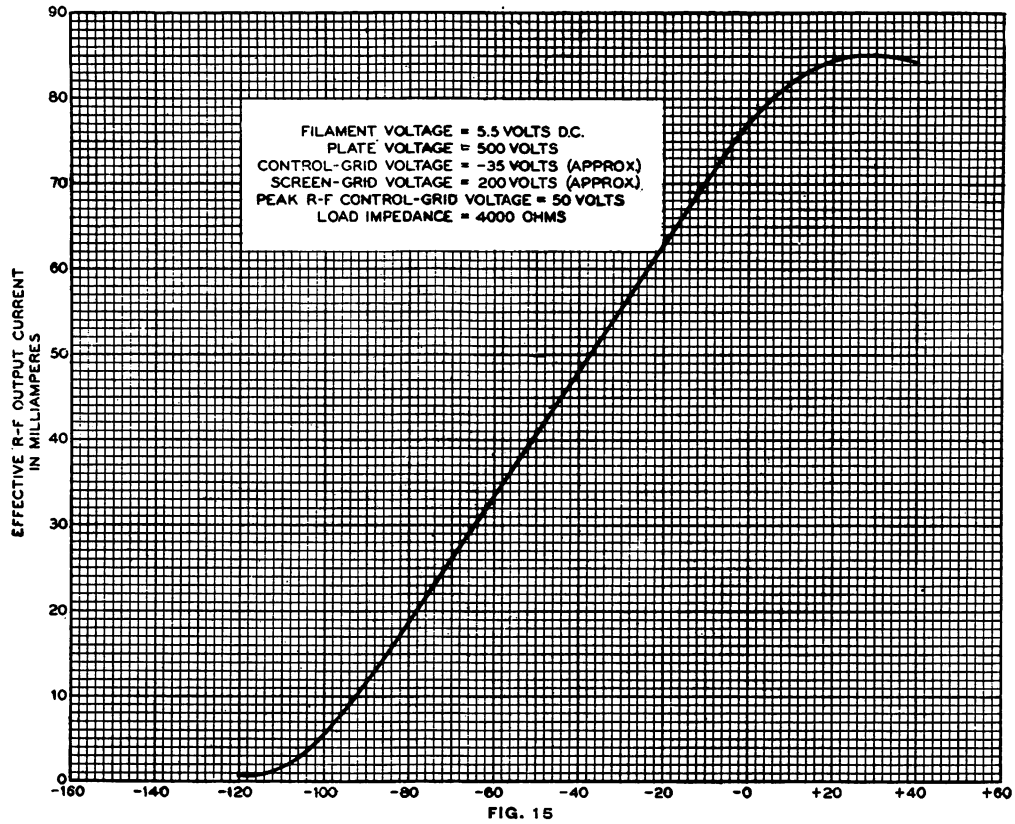

FILAMENT VOLTAGE = 5.5 VOLTS D.C.
PLATE VOLTAGE = 500 VOLTS
CONTROL-GRID VOLTAGE = -35 VOLTS (APPROX.)
SCREEN-GRID VOLTAGE = 200 VOLTS (APPROX.)
PEAK R-F CONTROL-GRID VOLTAGE = 50 VOLTS
LOAD IMPEDANCE = 4000 OHMS
EFFECTIVE R-F OUTPUT CURRENT IN MILLIAMPERES
0
10
20
30
40
50
60
70
80
90
-160
-140
-120
-100
-80
-60
-40
-20
-0
+20
+40
+60

FIG. 15

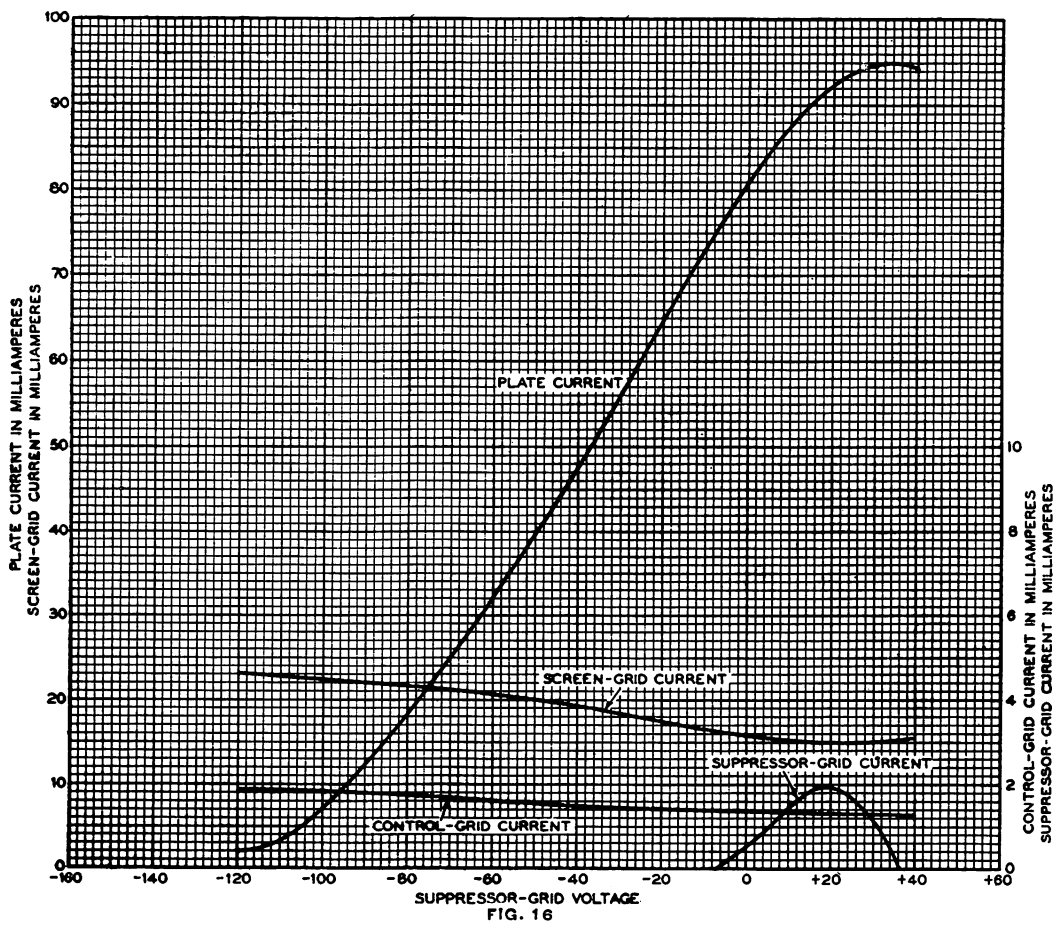
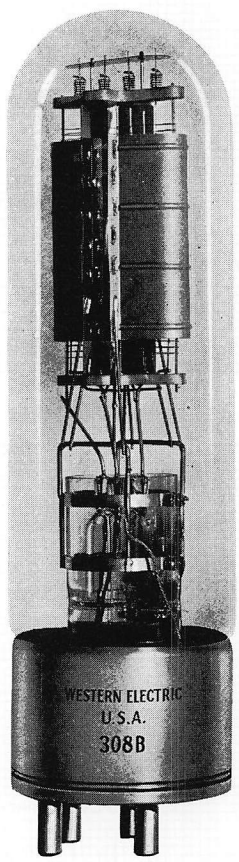

PLATE CURRENT IN MILLIAMPERES
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID CURRENT IN MILLIAMPERES
SUPPRESSOR-GRID CURRENT IN MILLIAMPERES
PLATE CURRENT
SCREEN-GRID CURRENT
SUPPRESSOR-GRID CURRENT
CONTROL-GRID CURRENT
0
10
20
30
40
50
60
70
80
90
100
0
2
4
6
8
10
-160
-140
-120
-100
-80
-60
-40
-20
0
+20
+40
+60
SUPPRESSOR-GRID VOLTAGE

FIG. 16

Western Electric

308B Vacuum Tube



Classification—Filamentary air-cooled triode

This tube was designed primarily for use as an audio-frequency amplifier or modulator; or as a radio-frequency oscillator or amplifier.

Dimensions—Dimensions and outline diagrams are shown in Figures 1 and 2 and are:

Maximum overall length	13⅝″
Maximum diameter	3⅝″

Mounting—Large four-pin bayonet base for use in a W. E. 113A or similar socket, for either vertical or horizontal mounting. If mounted horizontally the plane of the filament, which is indicated in Figure 2, should be vertical.

Filament—Thoriated tungsten.

Filament voltage	14 volts
Nominal filament current	6 amperes
Average thermionic emission	4 amperes

Approximate Direct Interelectrode Capacitances

Plate to grid	17.4 $\mu\mu$f.
Grid to filament	13.6 $\mu\mu$f.
Plate to filament	9.3 $\mu\mu$f.

Characteristics—Performance data given below are based upon a typical set of conditions. Variations can be expected with different circuits and tubes.

Figures 3 and 4 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at 1500 volts direct plate potential and minus 150 volts grid bias, I_b = .167 ampere.

Amplification factor	8
Plate resistance	1070 ohms
Grid to plate tranconductance	7500 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	2250 volts
Max. direct plate current	325 milliamperes
Max. plate dissipation	250 watts
Max. direct grid current	75 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	1.5 megacycles
Max. plate voltage for upper frequency limit of 4.5 Mc	750 volts

Max. plate voltage for frequencies between 1.5 and 4.5 Mc in proportion.

The above are maximum ratings which do not apply simultaneously but depend on the type of service as specified below.

Class A Audio Amplifier or Modulator

Direct plate voltage	1500	1000 volts
Grid bias	−155	−80 volts
Direct plate current	135	210 milliamperes
Plate dissipation	200	210 watts
Load impedance	13000	3000 ohms
Undistorted output	50	35 watts

Class B Audio Amplifier or Modulator—for Balanced 2 Tube Circuit

Direct plate voltage	1750	1500 volts
Grid bias	−215	−180 volts
Direct plate current per tube		
No drive	30	25 milliamperes
Max. drive	300	300 milliamperes
Plate dissipation	240	210 watts
Load resistance plate-to-plate	5200	4280 ohms
Load resistance per tube	1300	1070 ohms
Approximate maximum output	575	475 watts
Recommended power for driving stage	35	35 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	1750	1500 volts
Direct plate current	215	250 milliamperes
Plate dissipation	250	250 watts
Grid bias	−230	−200 volts
Approx. carrier watts for use with 100% modulation	125	125 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1750	1500 volts
Direct plate current	300	300 milliamperes
Grid bias	−345 to −460	−300 to −400 volts
Nominal power output	350	300 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1250	1000 volts
Direct plate current	300	300 milliamperes
Grid bias	−320	−260 volts
Max. direct grid current	75	75 milliamperes
Nominal carrier power output for use with 100% modulation	250	200 watts

Operating Precautions

Mechanical—Figures 1 and 2 show the overall dimensions and basing arrangement for the tube.

The tubes should not be subjected to mechanical shock or excessive vibration. Mechanical vibration may cause breakage of the thoriated tungsten filaments.

A free circulation of air must be provided to insure adequate cooling of the glass during operation.

Electrical—Overload protection should always be provided for the plate circuit. A suitable fuse or circuit breaker should remove the plate voltage if the plate current exceeds 425 milliamperes. Although the tube is sufficiently rugged to withstand momentary overloads, a prolonged overload caused by inefficient adjustment of the circuit, may damage the tube. When adjusting a new circuit, reduced plate voltage or a series resistance of 1000 to 5000 ohms in the plate circuit should be used until it is operating properly.

The filament should always be operated at the rated voltage, measured at the tube terminals. A 5% decrease in filament voltage reduces the thermionic emission approximately 25%. Either direct or alternating current may be used for heating the filament. If direct current is used, the plate and grid circuit returns should be connected to the negative filament terminal. If alternating current is used, the circuit returns should be connected to the center tap of the filament heating transformer winding or to the center tap of a resistor placed between the filament terminals. A resistance of 30 to 40 ohms of ten watt rating is suitable.

In cases where severe and prolonged overload has temporarily impaired the electronic emission of the filament, the activity may be restored by operating the filament, with the plate and grid voltages off, 30% above normal voltage for 10 minutes followed by a longer period at normal voltage.

Audio Amplifier or Modulator

Class A—Peak grid drive equal to or less than the grid bias.

Grid bias may be obtained from the drop across a resistance in the plate current return or from a battery or rectifier supply.

Plate dissipation allowable for this type of service is generally lower than is safe for other uses since the energy is dissipated in the plate in smaller areas due to relatively high voltage drop in the tube.

The plate dissipation is equal to the plate voltage multiplied by the normal plate current. Performance data are based upon the use of a resistance load. Undistorted output is calculated on the basis of 5% second harmonic distortion.

Class B—Grid bias practically at cut-off and grid driving voltage higher than the bias.

Two tubes may be used in a balanced circuit. An adequate driving stage and an input transformer with good regulation must be used so that the grid current drawn during positive grid swings does not produce appreciable distortion. The output transformer must transform the load impedance to the proper value for the tubes used. The power output obtainable will be determined by the quality of the transformer used and the amount of distortion which can be tolerated. The grid bias must be held constant and therefore cannot be obtained by grid leak or series resistor methods. A battery or other source having good regulation is necessary.

The power required of a modulator for complete modulation of a Class C amplifier is one-half the direct power input to the plates of the Class C amplifier.

Radio-Frequency Oscillator or Power Amplifier

Class B—Radio-Frequency Amplifier.

The Class B radio-frequency amplifier is used to amplify a modulated radio-frequency carrier wave without appreciable distortion. It operates similarly to the Class B audio amplifier except that a single tube may be used, the tuned output circuit serving to preserve the wave shape. The push-pull circuit, however, eliminates the even order harmonics and thus increases the efficiency slightly.

Class C—Grid bias below cutoff.

Unmodulated

This type of operation is suitable for telegraphy, or the production of a continuous flow of radio-frequency power for purposes other than communication.

Plate Modulated

This type of operation is for use when the modulating voltage is superimposed on the plate supply voltage and to obtain good quality the output power should vary as the square of the plate voltage. For complete or 100% modulation, the plate voltage varies from zero to twice the applied direct value during a cycle of the audio frequency. With no modulation applied, the plate voltage is, of course, the direct value and the carrier power output is one-fourth of the peak power output under 100% modulation. In this case, since the plate voltage varies with modulation, the direct value must be rated lower than for other types of operation.

High Frequency Ratings

The frequency limits specified under maximum ratings are based on the tube being used as an oscillator. The tube may be used at full rating up to 1.5 megacycles. When operating at higher frequencies, the dielectric losses, charging currents and lead-in heating are increased greatly. The plate voltage and hence plate dissipation must be reduced to values specified for the upper frequency limit and for frequencies between these two limits the plate voltage should be proportionately reduced.

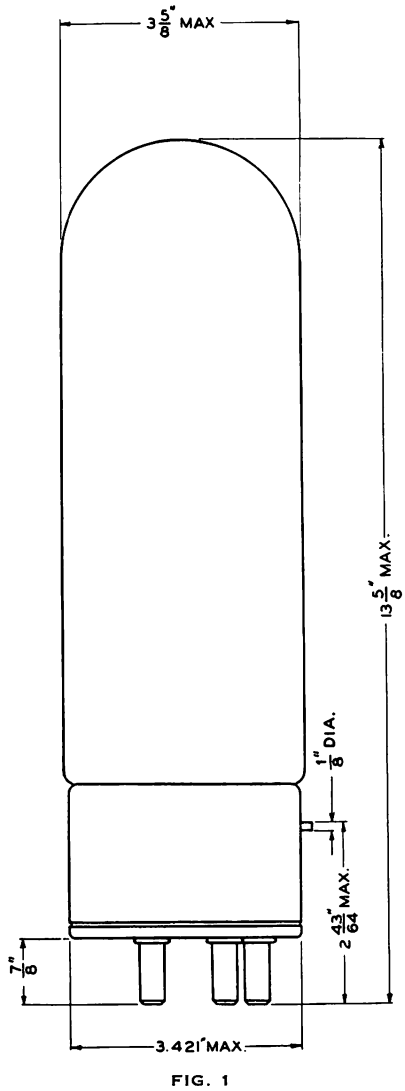


FIG. 1

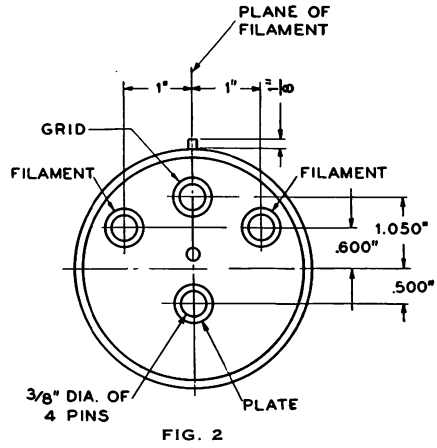


FIG. 2

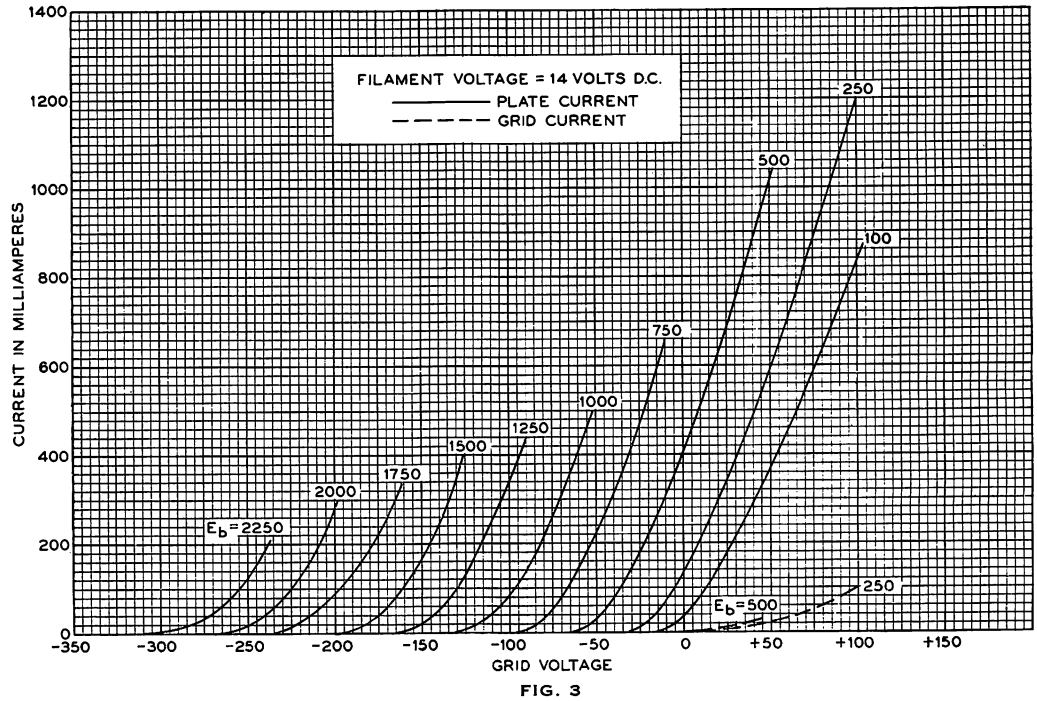

FILAMENT VOLTAGE = 14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
1400
1200
1000
800
600
400
200
0
-350
-300
-250
-200
-150
-100
-50
0
+50
+100
+150
250
500
100
750
1000
1250
1500
1750
2000
E_b=2250
E_b=500
250

FIG. 3

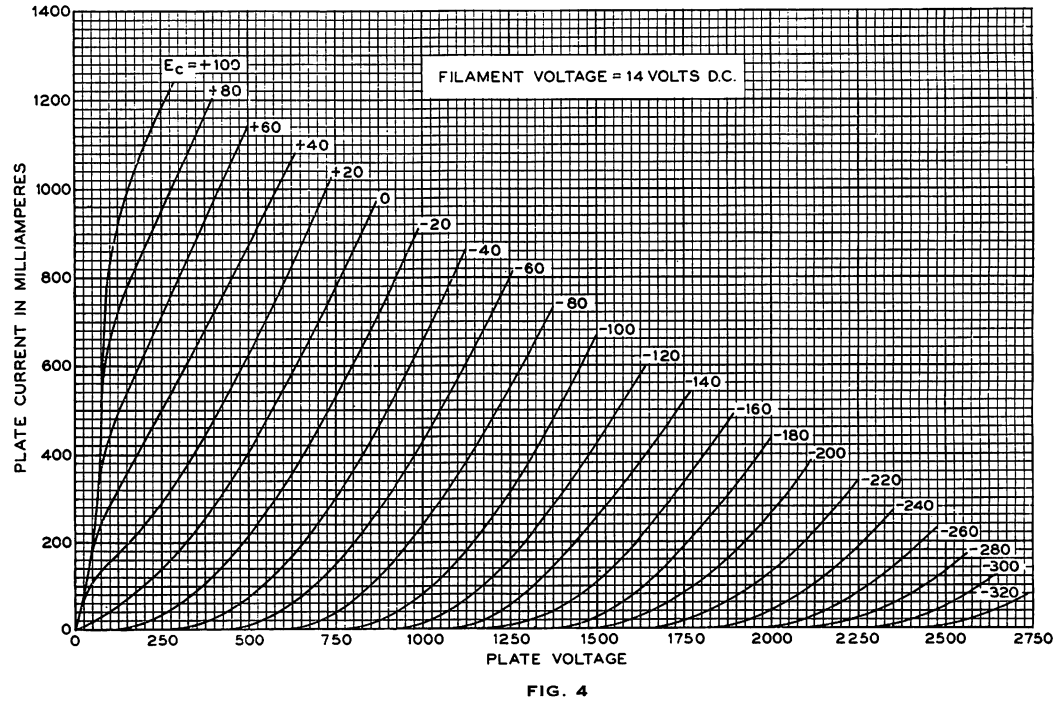
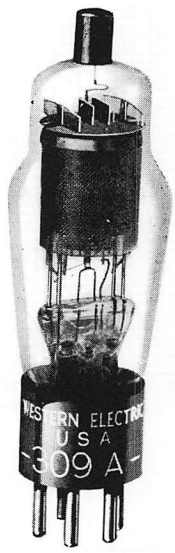

FILAMENT VOLTAGE = 14 VOLTS D.C.
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
1400
1200
1000
800
600
400
200
0
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
2750
E_c = +100
+80
+60
+40
+20
0
-20
-40
-60
-80
-100
-120
-140
-160
-180
-200
-220
-240
-260
-280
-300
-320

FIG. 4

Western Electric

309A Vacuum Tube



Classification—Voltage amplifier, variable-mu, suppressor-grid pentode with indirectly heated cathode

The 309A tube is especially designed to minimize audio-frequency disturbances arising in the tube. The suppressor grid is permanently connected to the cathode within the bulb.

Applications

Audio-frequency voltage amplifier, particularly in circuits in which the amplification is adjusted by varying the control-grid bias, and exceptionally low tube noise is required.

Radio-frequency voltage amplifier.

Dimensions—Dimensions, outline diagrams of the tube and base, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base—Small, five-pin base with pins silver-plated. Small metal cap control-grid terminal at the top of the bulb.

Socket—Standard, five-contact type, preferably provided with silver-plated contacts such as the Western Electric 141A socket.

Mounting Positions—The 309A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Control grid to plate	0.007 μμf.
Control grid to heater, cathode, screen grid and suppressor grid	5.8 μμf.
Plate to heater, cathode, screen grid and suppressor grid	14 μμf.

Heater Rating

Heater voltage	10.0 volts, a.c. or d.c.
Nominal heater current	0.32 ampere

The heater element of this tube is designed to operate on a voltage basis and should be operated at as near the rated voltage as is practicable. In audio-frequency applications where exceptionally low tube noise is required, it may be necessary to use direct-current heater supply.

Cathode Connection—Preferably direct to the heater. If voltage must be applied between the cathode and heater, it should be kept as low as possible and should never exceed 150 volts.

Characteristics—Plate current and screen-grid current characteristics for a typical 309A tube are shown in Figures 3 and 4, respectively, as functions of plate voltage for several values of control-grid voltage and a screen-grid voltage of 75 volts. Corresponding amplification factor, plate resistance, and transconductance characteristics are shown in Figures 5, 6, and 7, respectively. Plate current and transconductance characteristics as functions of control-grid voltage are shown in Figures 8 and 9 respectively, for a screen-grid voltage of 75 volts and a plate voltage of 180 volts. For other plate voltages between 135 and 250 volts, the transconductance of a typical tube, for values above 5 micromhos, does not differ by more than ± 2 per cent from its value at 180 volts. Amplification factor and plate resistance characteristics as functions of control-grid voltage are shown in Figures 10 and 11, respectively, for a screen-grid voltage of 75 volts and several values of plate voltage.

Typical Operating Conditions

Plate Voltage Volts	Screen-Grid Voltage Volts	Control-Grid Bias Volts	Plate Current Milliamperes	Screen-Grid Current Milliamperes	Amplification Factor	Plate Resistance Megohms	Transconductance Micromhos
135	75	−1.5	4.75	1.1	760	0.7	1090
180	75	−1.5	4.80	1.1	1100	1.0	1100
*250	75	−1.5	4.85	1.1	1450	1.3	1110
**135-250	75	−30	—	—	—	—	5

*Maximum operating conditions
**Nominal cut-off

Microphonic Noise—With a plate voltage of 180 volts, a screen-grid voltage of 75 volts, a control-grid bias of −1.5 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 309A tube, measured in a laboratory reference test set, is 17 db below 1 volt. The range of levels of individual tubes extends from 6 to 30 db below 1 volt. Since microphonic noise level depends on the type and intensity of the mechanical disturbance which produces it, the values given here are useful chiefly for comparison with the levels of other tubes which have been tested in the same way.

Fluctuation Noise—An irreducible minimum of noise in a vacuum tube is produced by minute, uncontrollable fluctuations in the rate of flow of electrons to the anode. With a plate voltage of 180 volts, a screen-grid voltage of 75 volts, a control-grid bias of −1.5 volts, and a load resistance of 100,000 ohms, the mean equivalent fluctuation noise input of the 309A tube for the audio-frequency range from 40 to 10,600 cycles is 117 db below 1 volt. The range of levels of individual tubes extends from 112 to 119 db below 1 volt. By reducing the control-grid bias to −1.0 volt and the screen-grid voltage to 18 volts, the mean fluctuation noise level may be reduced by about 2.5 db. The equivalent noise input voltage is equal to the measured output voltage divided by the voltage amplification of the tube in the measuring circuit.

Special Features—By virtue of its variable-mu characteristic and low noise level, the 309A tube is particularly adapted to amplifier applications, both radio-frequency and audio-frequency, where the amplification is adjusted by varying the control-grid bias. As the grid bias is made more negative, the plate current and transconductance approach zero gradually, as shown in Figures 8 and 9, rather than sharply, so that modulation and distortion are relatively small at all values of grid bias.

The 309A tube has been specially designed to minimize both the spontaneous microphonic noise impulses occurring at random intervals, and the sharp, aperiodic noise impulses which sometimes occur in tubes of this general type while the control-grid bias is varied continuously. When the tube is well shielded from external microphonic noise stimuli, it is exceptionally quiet in operation and can be used for the audio-frequency amplification and volume control of exceptionally low level signals.

Circuit Requirements—In order to make use of the high gain per stage of which the 309A tube is capable when used as a voltage amplifier, suitable precautions must be taken, especially where high frequencies are involved, to avoid undesired feed-back in the circuit. It may prove necessary to use a close-fitting shield around each tube, to shield each stage of the amplifier circuit, to connect a low impedance condenser between each screen grid and its corresponding cathode, to filter each battery lead to each tube, and to avoid impedances common to the plate, screen-grid, control-grid, or cathode circuits of two or more tubes.

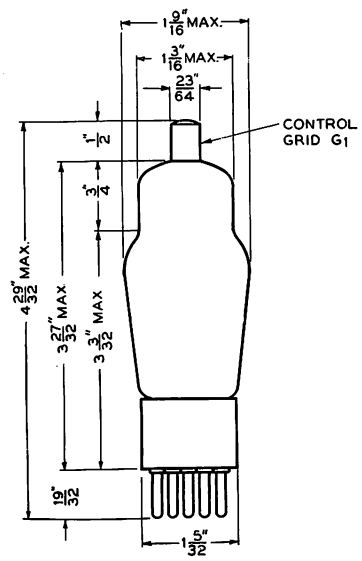


FIG. 1

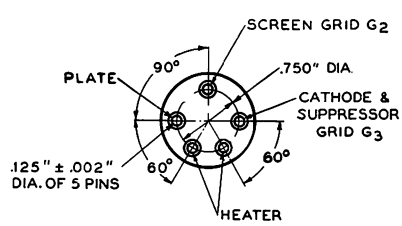


FIG. 2

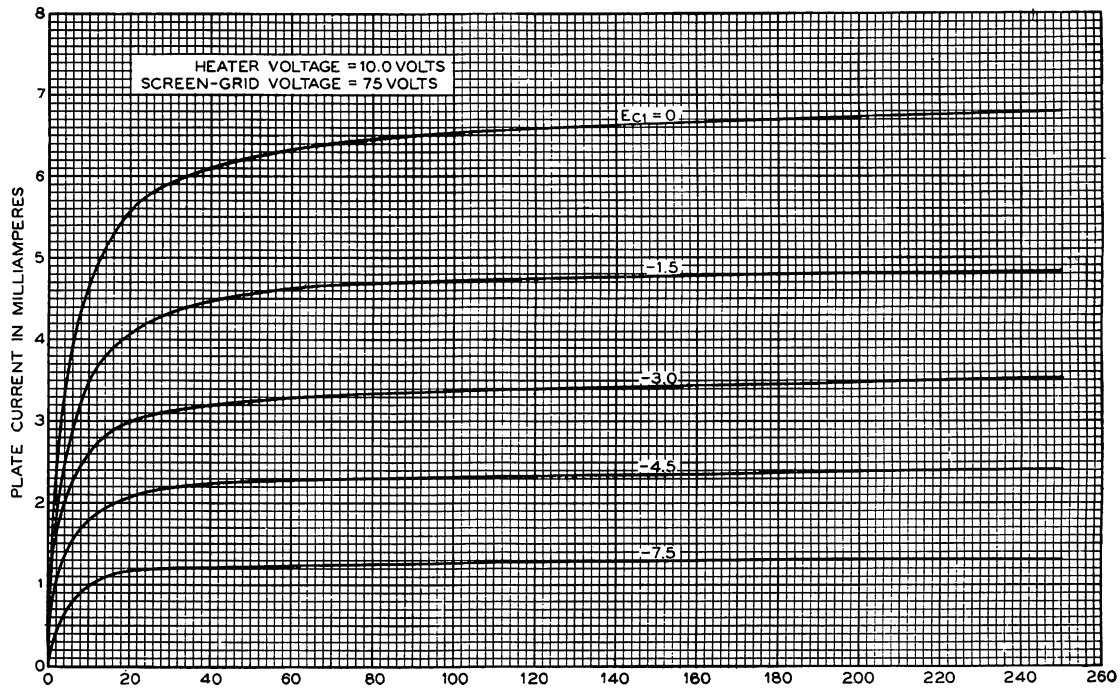

HEATER VOLTAGE = 10.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
E_{C1} = 0
-1.5
-3.0
-4.5
-7.5
PLATE CURRENT IN MILLIAMPERES
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 3

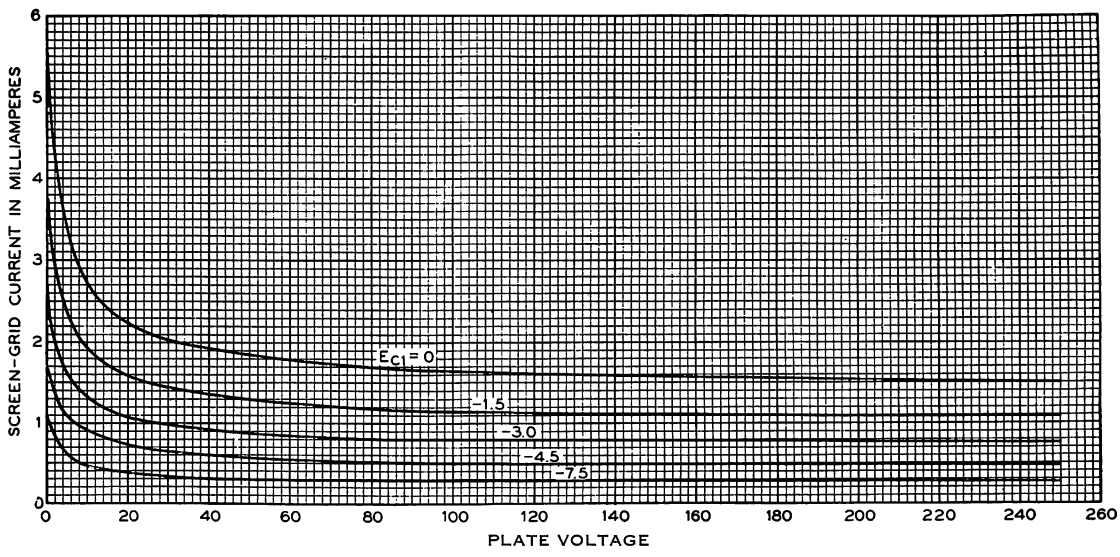

SCREEN-GRID CURRENT IN MILLIAMPERES
E_{C1} = 0
-1.5
-3.0
-4.5
-7.5
0
1
2
3
4
5
6
0
20
40
60
80
100
120
140
160
180
200
220
240
260
PLATE VOLTAGE

FIG. 4

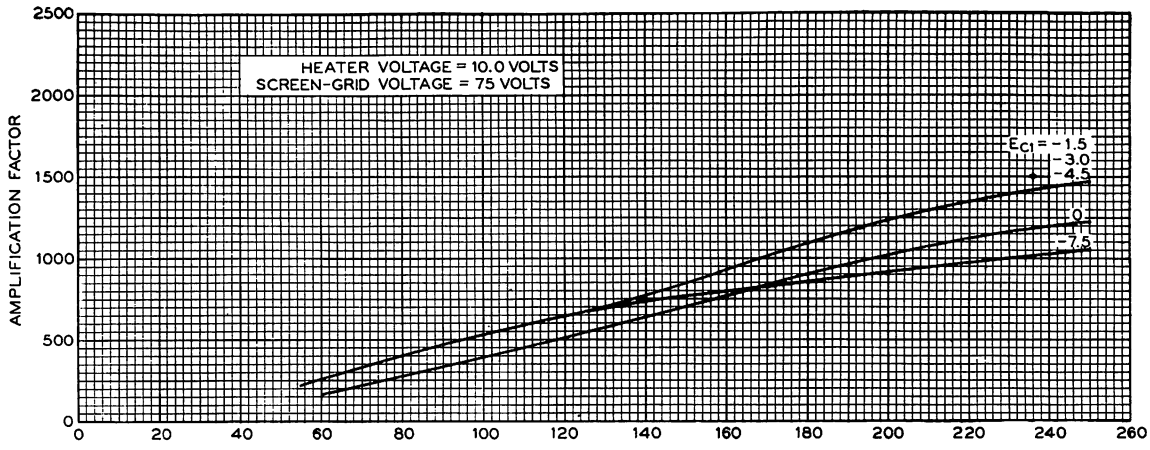


FIG. 5

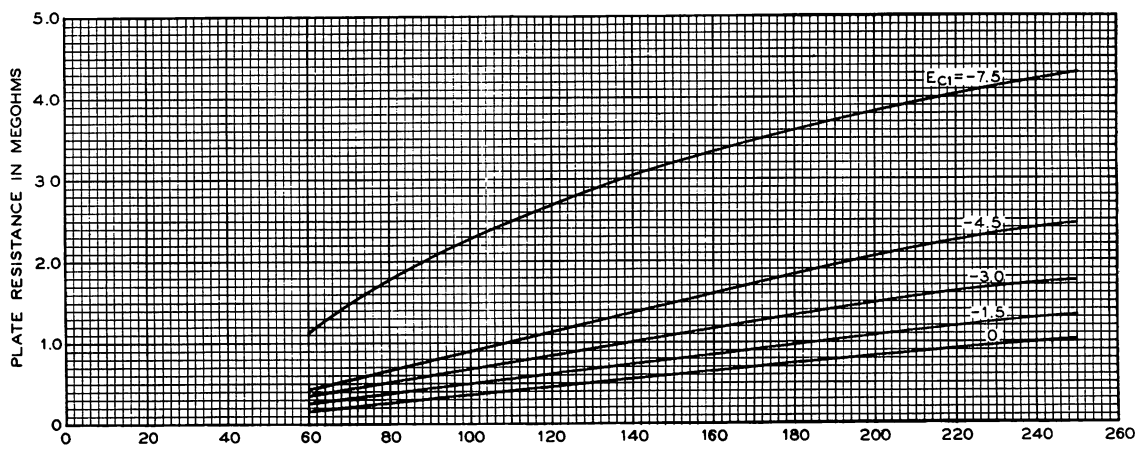


FIG. 6

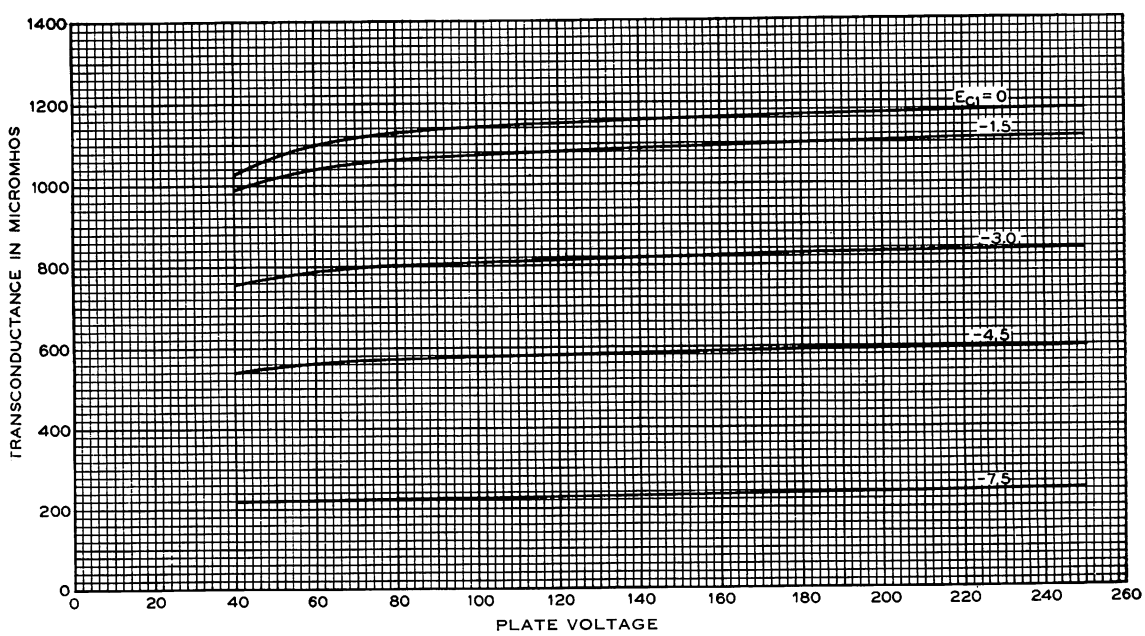


FIG. 7

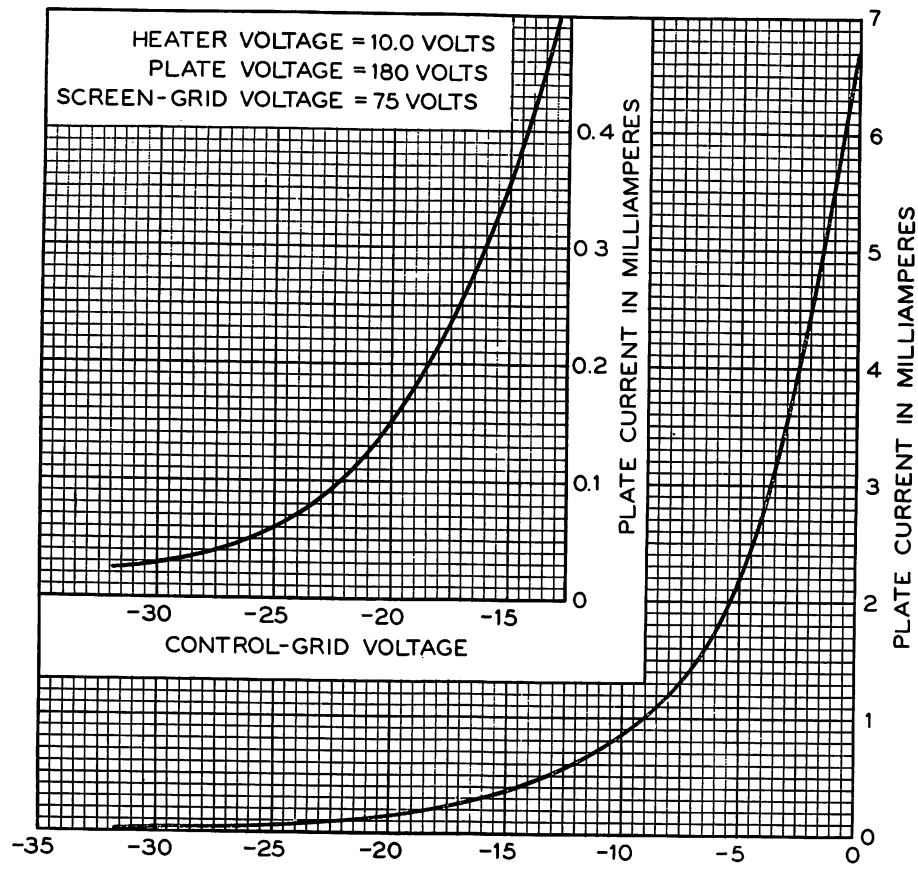

HEATER VOLTAGE = 10.0 VOLTS
PLATE VOLTAGE = 180 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
0.4
0.3
0.2
0.1
0
PLATE CURRENT IN MILLIAMPERES
-30
-25
-20
-15
CONTROL-GRID VOLTAGE
7
6
5
4
3
2
1
0
PLATE CURRENT IN MILLIAMPERES
-35
-30
-25
-20
-15
-10
-5
0
CONTROL-GRID VOLTAGE

FIG. 8

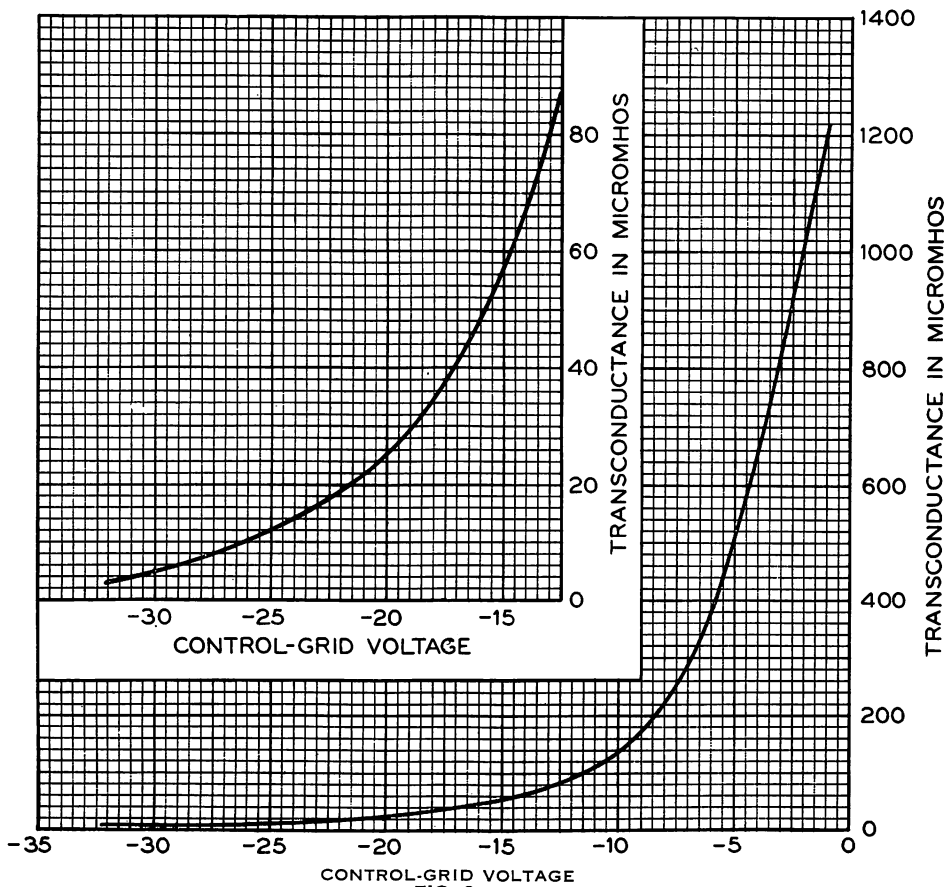

80
60
40
20
0
TRANSCONDUCTANCE IN MICROMHOS
-30
-25
-20
-15
CONTROL-GRID VOLTAGE
1400
1200
1000
800
600
400
200
0
TRANSCONDUCTANCE IN MICROMHOS
-35
-30
-25
-20
-15
-10
-5
0
CONTROL-GRID VOLTAGE

FIG. 9

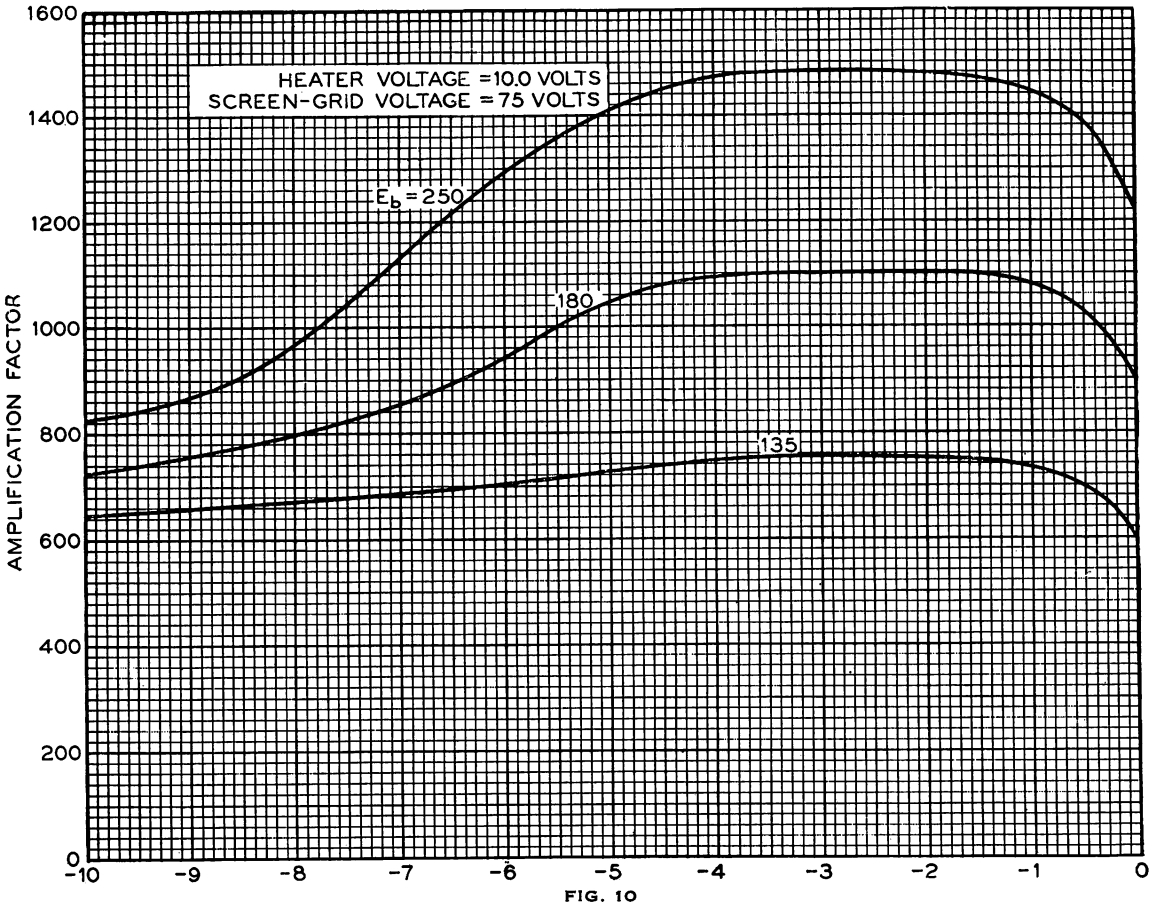

HEATER VOLTAGE =10.0 VOLTS
SCREEN-GRID VOLTAGE =75 VOLTS
E_b=250
180
135
AMPLIFICATION FACTOR
1600
1400
1200
1000
800
600
400
200
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0

FIG. 10

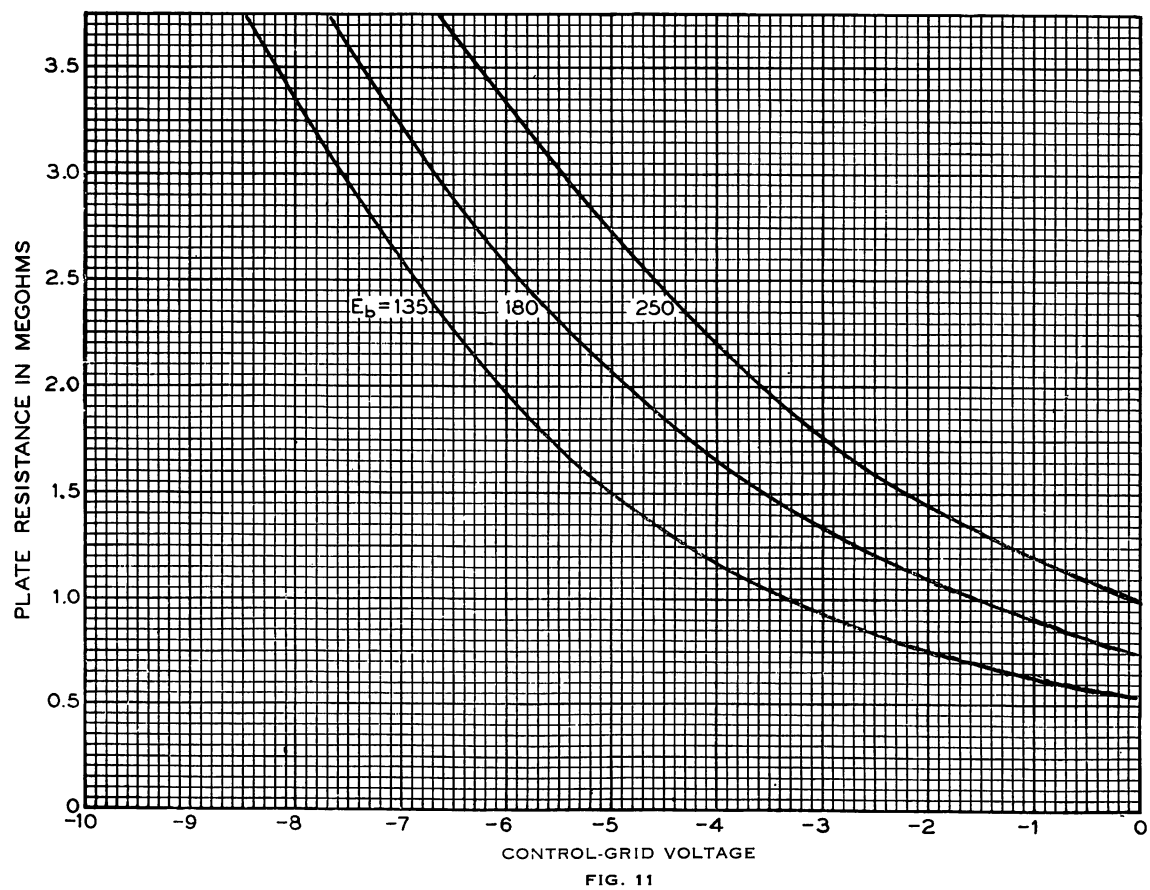
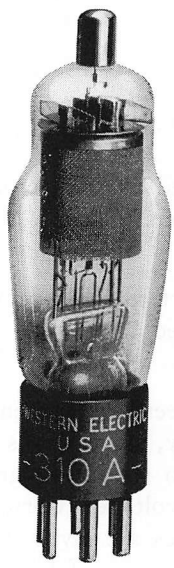

E_b=135
180
250
PLATE RESISTANCE IN MEGOHMS
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
CONTROL-GRID VOLTAGE

FIG. 11

Western Electric

310A Vacuum Tube



Classification—Voltage-amplifier, suppressor-grid pentode with indirectly heated cathode

This tube is intended primarily for use as an audio, or carrier and radio-frequency voltage amplifier, oscillator or modulator. The connection for the suppressor grid has been brought out to an external terminal, thus making the tube more flexible in its applications.

Dimensions—Dimensions, outline diagrams of the tube and base, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base—Small, six-pin type with pins silver-plated. Small, metal cap control-grid terminal at the top of the bulb.

Socket—Standard, six-contact type, preferably provided with silver-plated contacts such as the Western Electric 144B socket.

Mounting Positions—The 310A tube may be mounted in any position

Average Direct Interelectrode Capacitances

	A	B
Control grid to plate	0.025	0.007 μμf.
Suppressor grid to plate	12.5	12.5 μμf.
Plate to heater, cathode and screen grid	2.2	3.2 μμf.
Control grid to suppressor grid	1.8	1.3 μμf.
Control grid to heater, cathode and screen grid	4.0	6.5 μμf.
Suppressor grid to heater, cathode and screen grid	7.5	14.5 μμf.

Column A—Without shield.

Column B—With close-fitting metal shield connected to cathode.

Heater Rating

Heater voltage	10.0 volts, a.c. or d.c.
Nominal heater current	0.32 ampere

The heater element of this tube is designed to operate on a voltage basis and should be operated at as near the rated voltage as is practicable.

Cathode Connection—Preferably direct to the heater. If voltage must be applied between the cathode and heater, it should not exceed 150 volts.

Characteristics—Plate current and screen-grid current characteristics of a typical 310A tube are shown in Figures 3 and 4, respectively, as functions of control-grid voltage for several values of screen-grid and plate voltage and zero suppressor-grid voltage. The screen-grid voltage for these characteristics is equal to the plate voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are given in Figures 5, 6 and 7. Plate current and screen-grid current characteristics as functions of plate voltage are given in Figures 8 and 9, respectively, for several values of control-grid voltage, a screen-grid voltage of 135 volts, and zero suppressor-grid voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are shown in Figures 10, 11 and 12. Plate current, screen-grid current, plate resistance, and transconductance characteristics are shown in Figures 13, 14, 15 and 16 as functions of plate voltage for several values of suppressor-grid voltage, a screen-grid voltage of 135 volts, and a control-grid voltage of −3 volts. These last characteristics are of particular interest in modulator applications where separate inputs are applied to the control and suppressor grids.

Limiting Conditions for Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	180 volts
Maximum cathode current (screen-grid current plus plate current)	10 milliamperes
Maximum screen-grid current	2.5 milliamperes

Operating Conditions and Output—Nominal performance data are given in the table below for a number of typical operating conditions. Less severe operating conditions should be selected in preference to maximum operating conditions wherever possible. The life of the tube at maximum conditions may be shorter than at less severe conditions.

The performance data include the fundamental voltage or power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages no greater than the indicated values. The voltage output is given in peak volts, the power output in milliwatts, and the harmonic levels in decibels below the fundamental.

TABLE

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Suppressor-Grid Voltage	Plate Current	Load Resistance	Input Voltage	Output Voltage	Output Power	Second Harmonic	Third Harmonic
Volts	Volts	Volts	Volts	Milliamperes	Ohms	Peak Volts	Peak Volts	Milliwatts	db	db
135	135	−3	0	5.4	20,000	3.00		250	22	30
					60,000	1.60		130	26	28
					60,000	0.95		60	35	45
					60,000	1.15	100		33	39
					100,000	0.57	75		35	50
					100,000	0.40	50		40	55
180	135	−3	0	5.4	40,000	2.70		340	26	28
					100,000	1.50	175		26	30
225	135	−3	0	5.5	60,000	2.70		425	27	27
					100,000	1.80	220		27	31
*250	135	−3	0	5.5	60,000	2.70		480	26	30
					60,000	1.20		110	30	55
					100,000	2.10	250		26	29
					100,000	1.50	200		30	43

*Maximum operating conditions.

Curves showing the fundamental power and voltage output and the second and third harmonic levels as functions of input voltage for a number of values of load resistance and a typical operating condition are given in Figures 17, 18, 19 and 20.

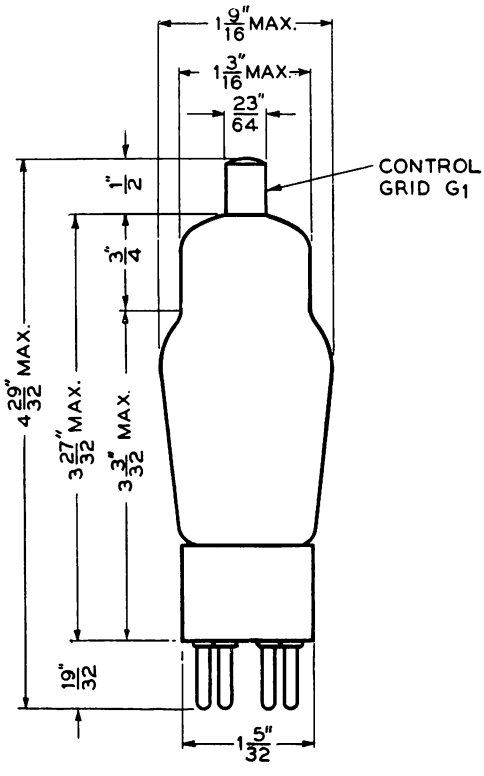


FIG. 1

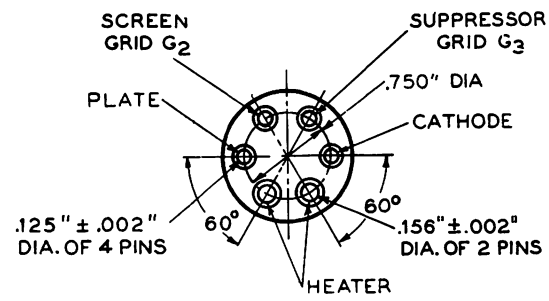


FIG. 2

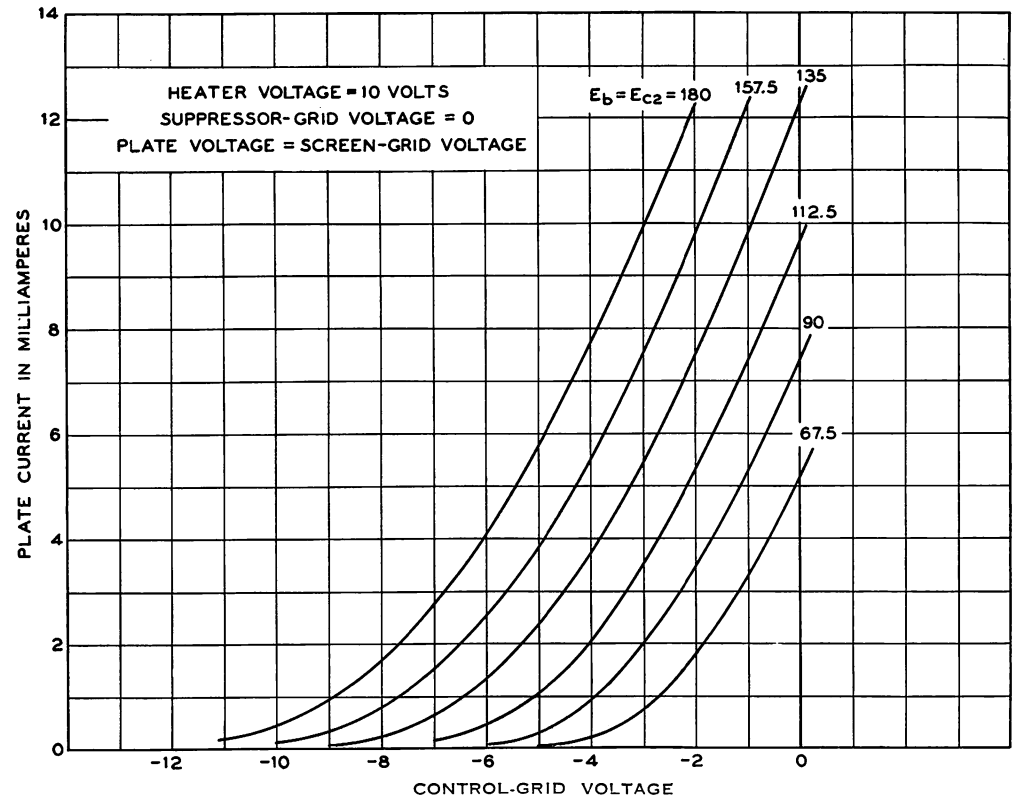

HEATER VOLTAGE = 10 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 180
157.5
135
112.5
90
67.5
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0
2
4
6
8
10
12
14
-12
-10
-8
-6
-4
-2
0

FIG. 3

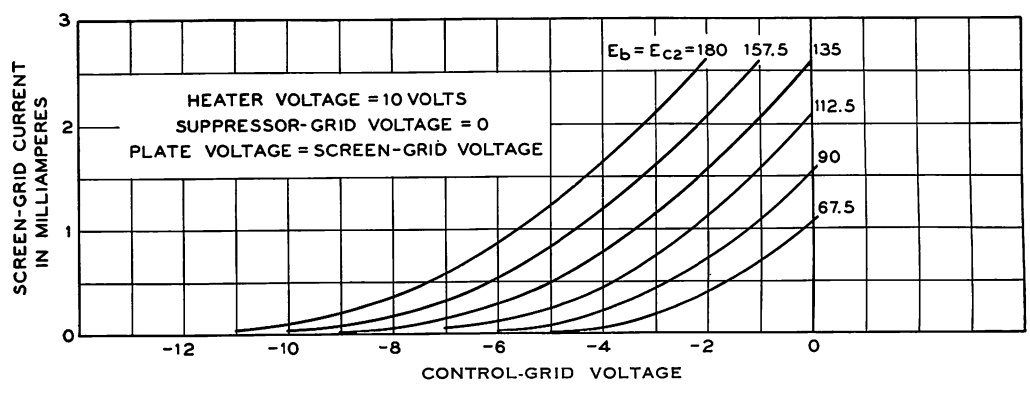

HEATER VOLTAGE = 10 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 180
157.5
135
112.5
90
67.5
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0
1
2
3
-12
-10
-8
-6
-4
-2
0

FIG. 4

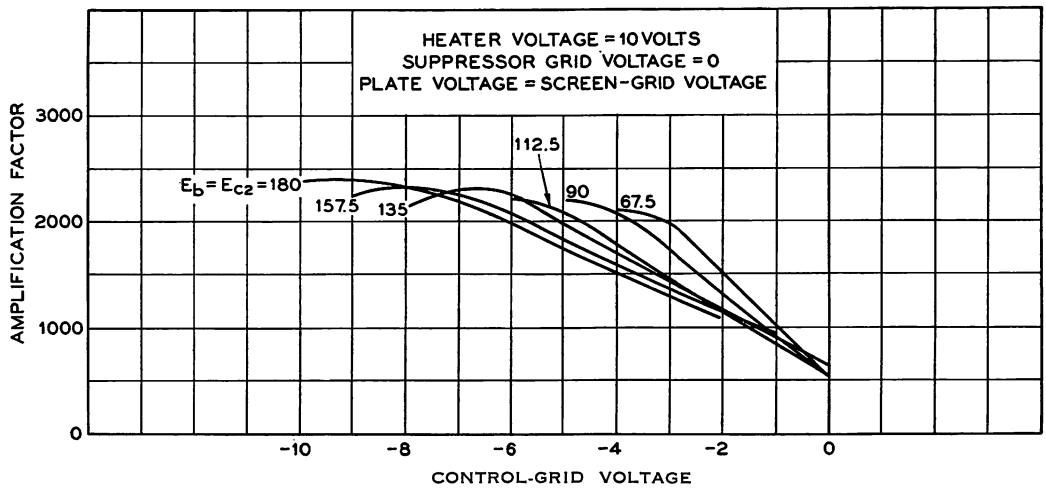


FIG. 5

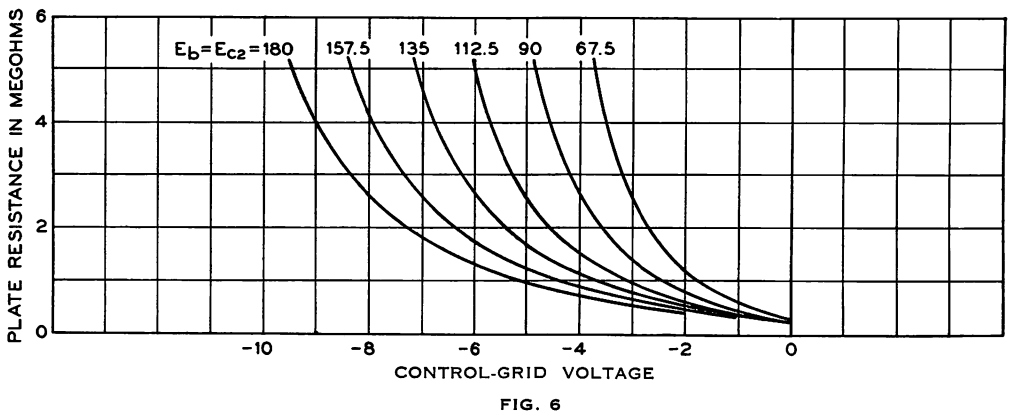


FIG. 6

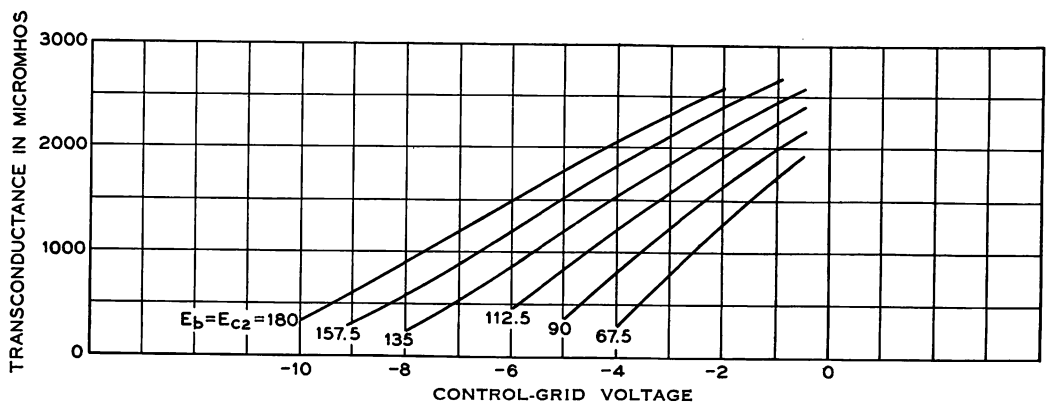


FIG. 7

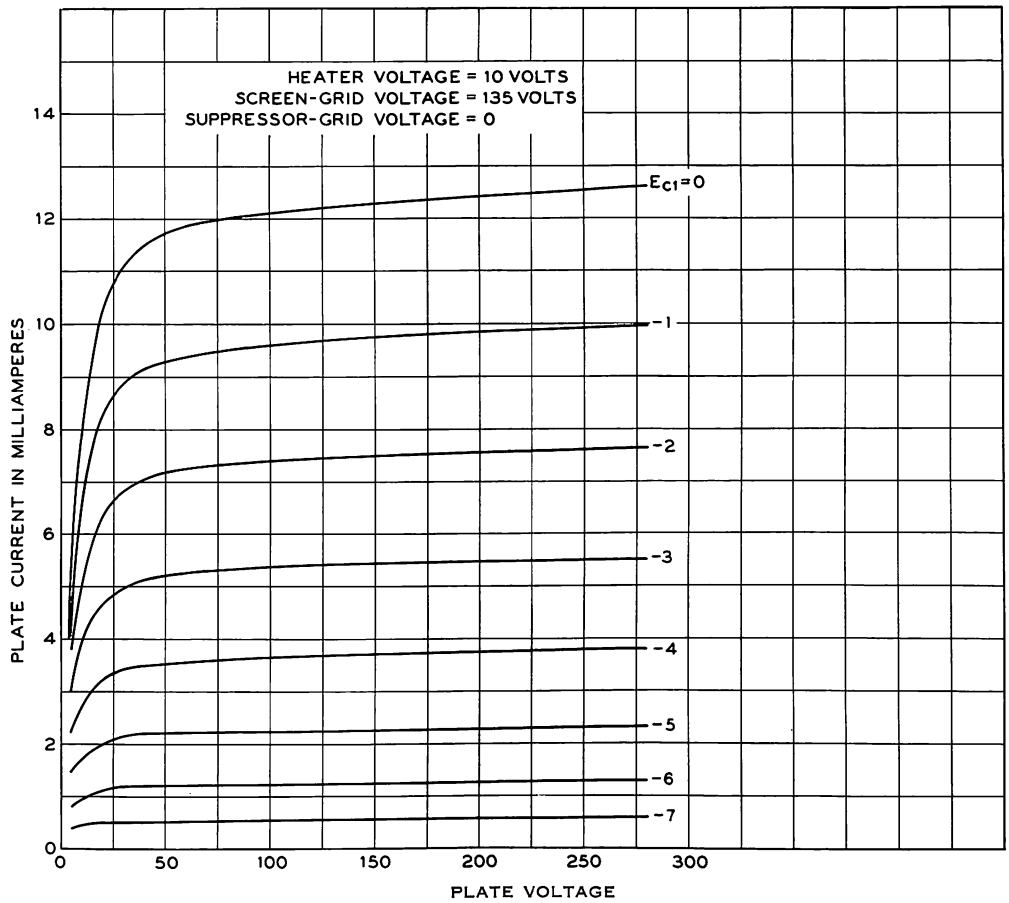

HEATER VOLTAGE = 10 VOLTS
SCREEN-GRID VOLTAGE = 135 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
PLATE CURRENT IN MILLIAMPERES
0
2
4
6
8
10
12
14
0
50
100
150
200
250
300
PLATE VOLTAGE

FIG. 8

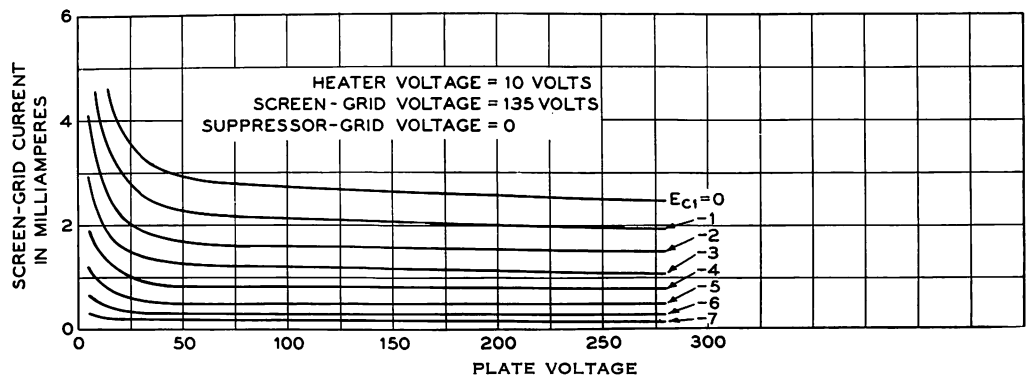

HEATER VOLTAGE = 10 VOLTS
SCREEN-GRID VOLTAGE = 135 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
SCREEN-GRID CURRENT IN MILLIAMPERES
0
2
4
6
0
50
100
150
200
250
300
PLATE VOLTAGE

FIG. 9

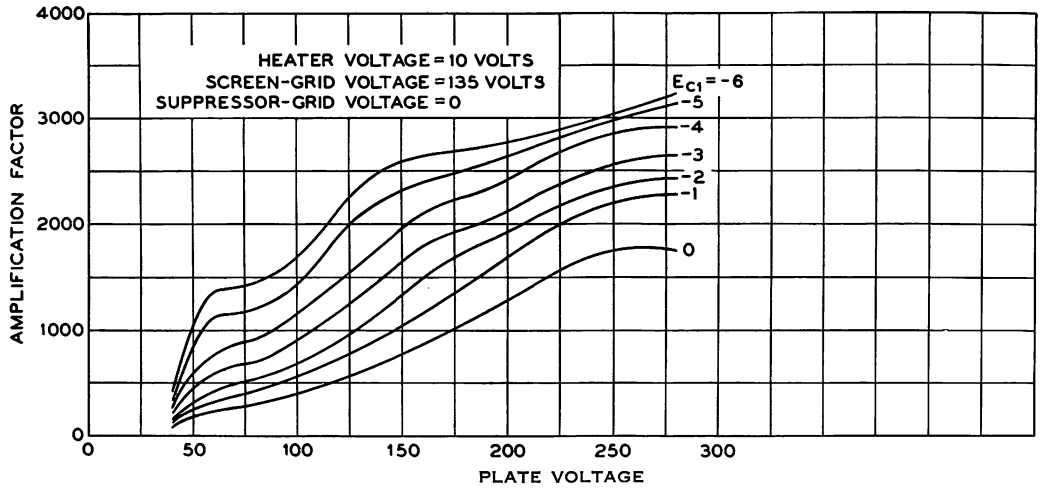


FIG. 10

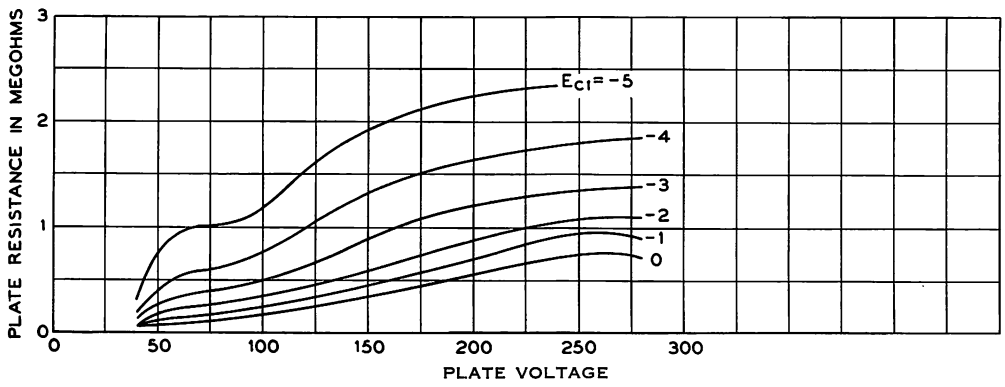


FIG. 11

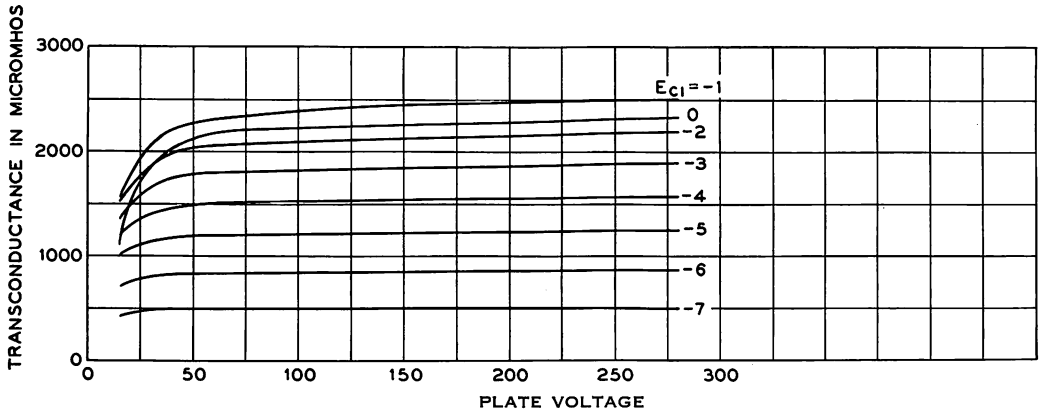


FIG. 12

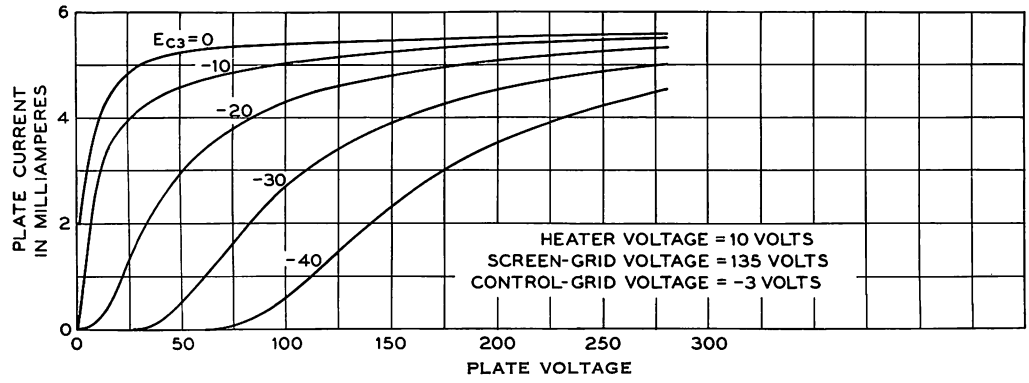


FIG. 13

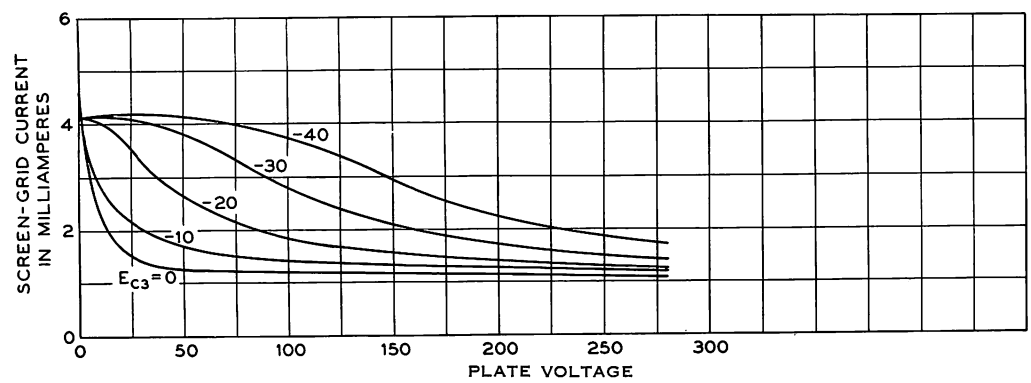


FIG. 14

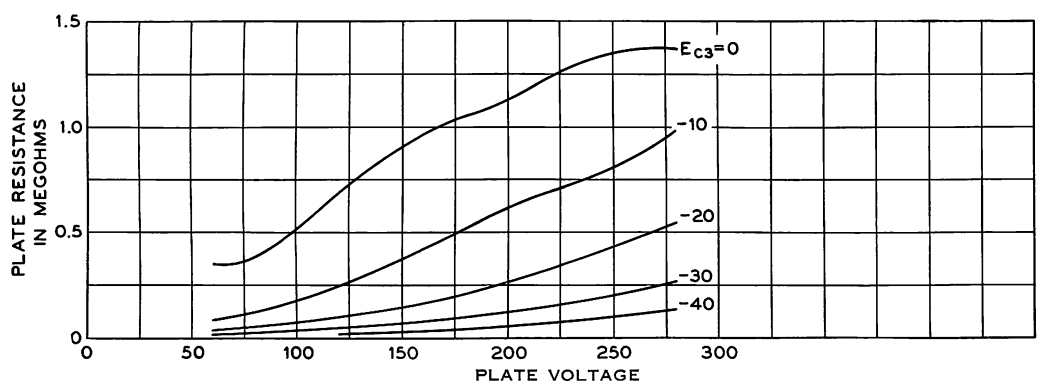


FIG. 15

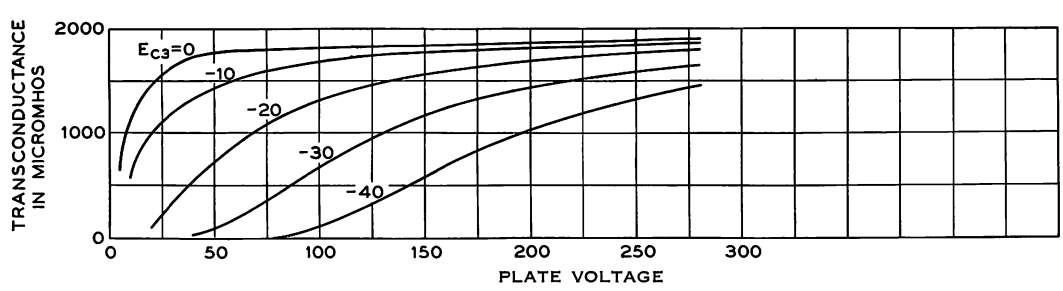


FIG. 16

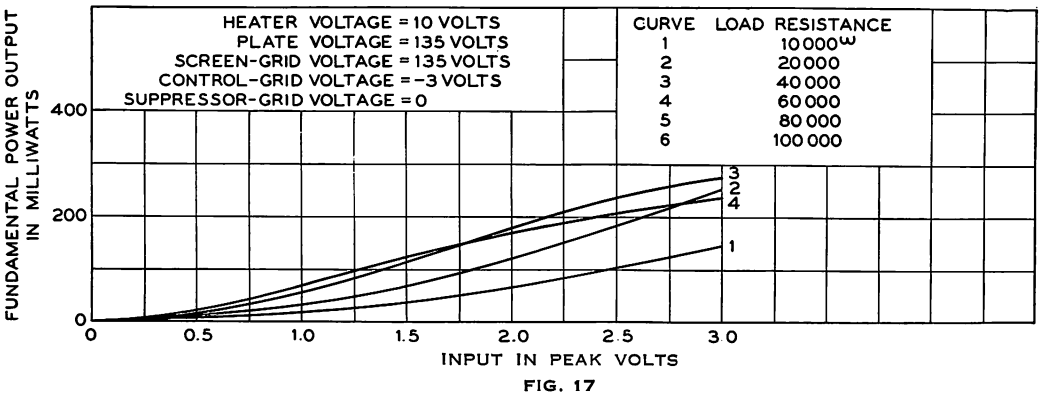


FIG. 17

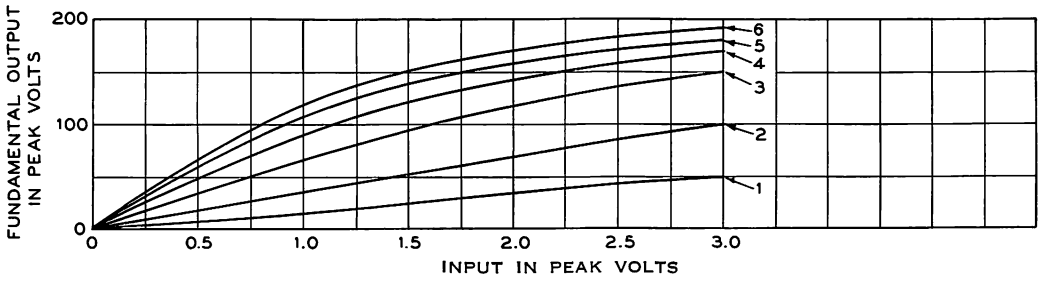


FIG. 18

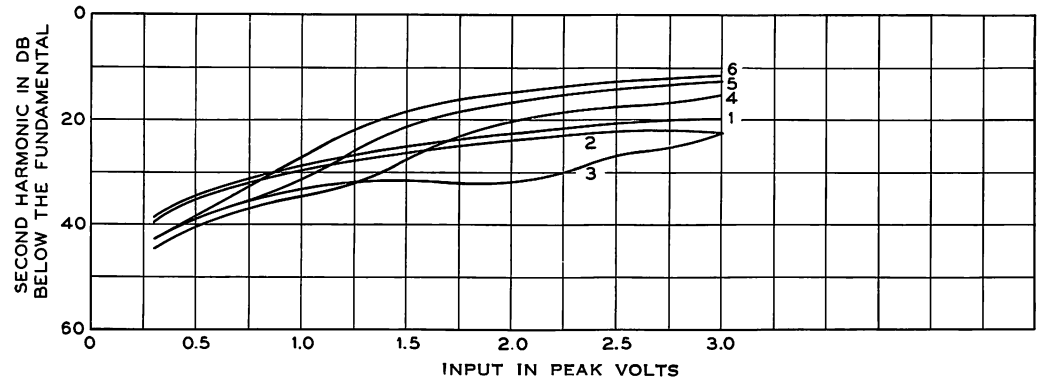


FIG. 19

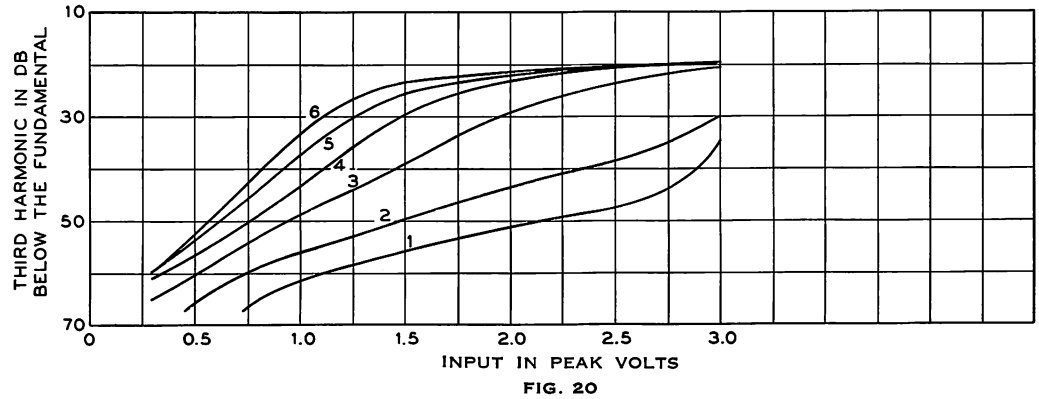
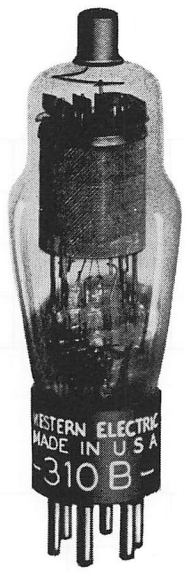
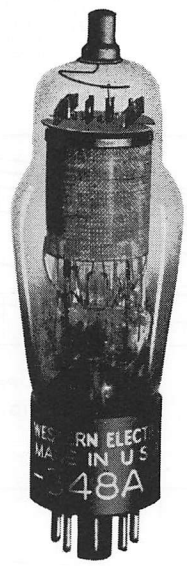


FIG. 20

Western Electric

310B and 348A Vacuum Tubes





Classification—Voltage amplifier, suppressor-grid pentodes with indirectly heated cathodes.

The 310B and 348A tubes differ in heater ratings, type of base and type of grid cap. In all other respects they are identical. They are designed to minimize hum produced by alternating current operation of the heater and to minimize microphonic noise.

The tubes are intended for use in audio-frequency amplifiers where exceptionally low tube noise is required. They may also be used as radio-frequency voltage amplifiers, oscillators or modulators. The connection for the suppressor grid has been brought out to an external terminal, thus making the tubes more flexible in their applications.

Dimensions and Connections—The outline diagrams of the tube and base giving the dimensions and the arrangement of electrode connections to the base terminals for the 310B tube are shown in Figures 1 and 2. Similar information for the 348A tube is shown in Figures 3 and 4.

Base and Mounting—The 310B tube employs a small six-pin thrust type base with silver-plated pins. It is adapted for use in a standard six-contact type socket, preferably one provided with silver-plated contacts such as the Western Electric 144B socket. The control-grid terminal is a small metal cap located at the top of the bulb.

The 348A tube employs a small shell octal, seven-pin base. The control-grid terminal is a skirted miniature metal cap located at the top of the bulb.

The tubes may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B
Control grid to plate	0.025	0.007 μμf
Control grid to heater, cathode, screen grid and suppressor grid	6	7 μμf
Plate to heater, cathode, screen grid and suppressor grid	15	16 μμf

Column A—Without shield.

Column B—With close fitting metal shield connected to the cathode.

Heater Ratings

	310B Tube	348A Tube	
Heater voltage	10.0	6.3	volts, ac or dc
Nominal heater current	0.32	0.50	ampere

The heaters of these tubes are designed to operate on a voltage basis and should be operated at as near to the rated voltage as is practicable.

Cathode Connection— Where alternating heater current is used the cathode should preferably be connected directly to the mid-point of the heater transformer winding or to the mid-point of a low resistance connected across the heater terminals. For direct current operation the cathode may be connected to either end of the heater. If voltage is applied between the heater and cathode, it should be kept low and must not exceed 30 volts.

Characteristics— Figures 5 and 6, respectively, show plate current and screen-grid current as functions of control-grid voltage for several values of screen-grid and plate voltage and zero suppressor-grid voltage. For all curves the plate voltage is equal to the screen-grid voltage. Plate current and screen-grid current are shown as functions of plate voltage in Figures 7 and 8, respectively, for several values of control-grid voltage, a screen-grid voltage of 135 volts and zero suppressor-grid voltage. Transconductance and plate resistance as functions of control-grid voltage are shown in Figure 9 for two values of screen-grid and plate voltage. The plate voltage in each case is equal to the screen-grid voltage and the suppressor-grid voltage is zero. Transconductance and plate resistance as functions of screen-grid voltage are shown in Figure 10 for a plate voltage of 180 volts, zero suppressor-grid voltage and two values of control-grid voltage.

Limiting Conditions For Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	180 volts
Maximum cathode current (screen-grid current plus plate current)	10 milliamperes
Maximum direct screen-grid current	2.5 milliamperes

Operating Conditions and Output— Amplification factor, plate resistance, transconductance and performance data are given in the table below for a number of typical operating conditions. Less severe operating conditions should be selected in preference to maximum operating conditions wherever possible. The life of the tube at maximum conditions will be shorter than at less severe conditions.

The performance data include the fundamental voltage and power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages not exceeding the indicated values. Under certain conditions the maximum second harmonic level occurs at a lower input voltage than that given in the table. The voltage output is given in peak volts, the power output in milliwatts and the harmonic levels in decibels below the fundamental.

TABLE

Control-grid voltage = −3 volts
Screen-grid voltage = 135 volts
Suppressor-grid voltage = 0

Plate Voltage	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Load Resistance	Input Voltage	Output Voltage	Output Power	Second Harmonic	Third Harmonic
Volts	Milliamperes		Megohms	Micromhos	Ohms	Peak Volts	Peak Volts	Milliwatts	db	db
135	5.5	1200	0.65	1800	20,000	3.00	100	250	22	30
					60,000	1.60	125	130	26	28
					60,000	0.95	85	60	35	45
					60,000	1.15	100	80	33	39
					100,000	0.57	75	25	35	50
					100,000	0.40	50	15	40	55
180	5.5	1800	1.00	1810	40,000	2.70	170	340	26	28
					100,000	1.50	175	156	26	30
225	5.6	2300	1.25	1830	60,000	2.70	225	425	27	27
					100,000	1.80	220	245	27	31
*250	5.6	2600	1.40	1840	60,000	2.70	240	480	26	30
					60,000	1.20	115	110	30	55
					100,000	2.10	250	320	26	29
					100,000	1.50	200	200	30	43

*Maximum plate voltage.

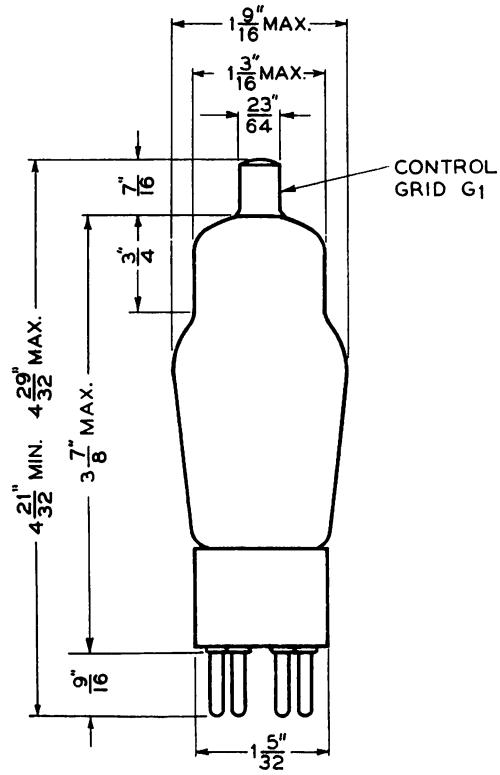


FIG. 1

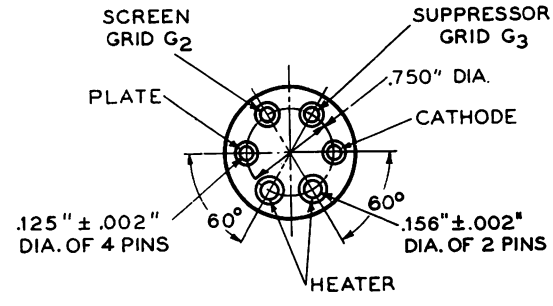


FIG. 2

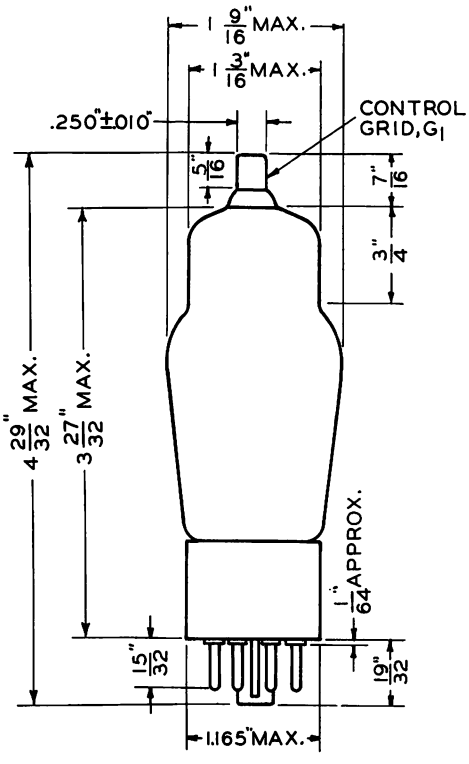


FIG. 3

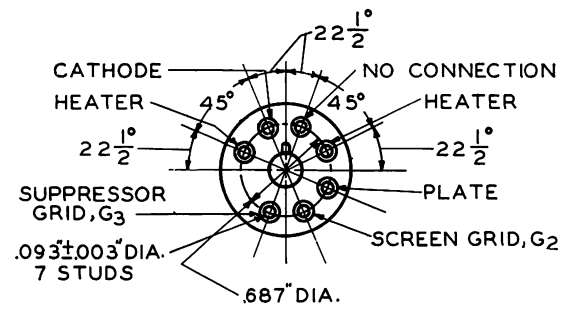


FIG. 4

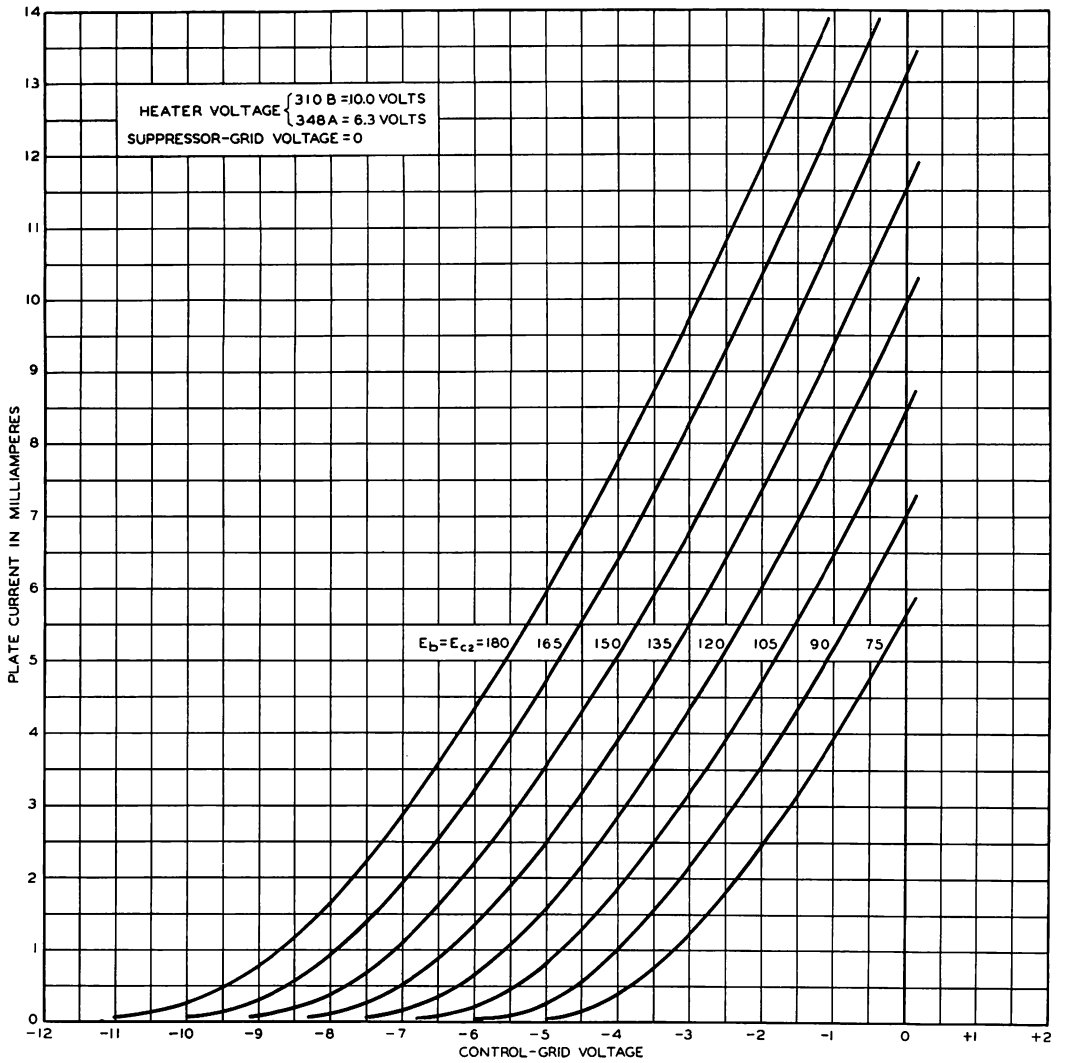

HEATER VOLTAGE { 310 B = 10.0 VOLTS
348 A = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
$E_b = E_{c2}$ = 180 165 150 135 120 105 90 75
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2

FIG. 5

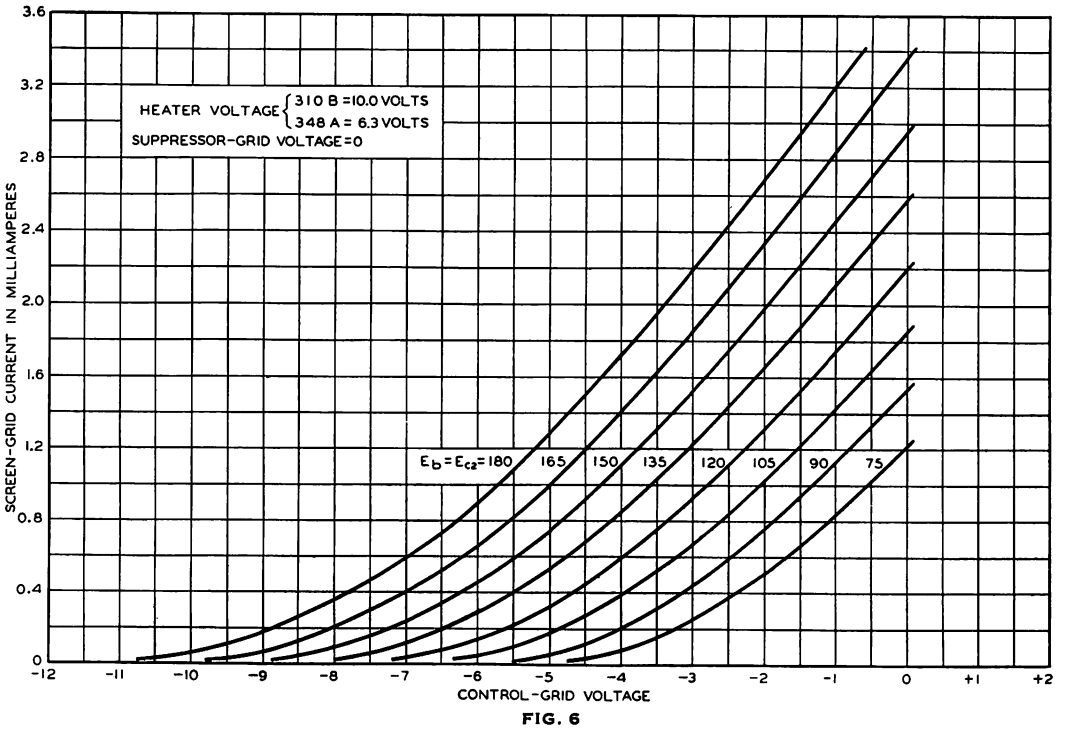

HEATER VOLTAGE { 310 B = 10.0 VOLTS
348 A = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
$E_b = E_{c2}$ = 180 165 150 135 120 105 90 75
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0 0.4 0.8 1.2 1.6 2.0 2.4 2.8 3.2 3.6
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2

FIG. 6

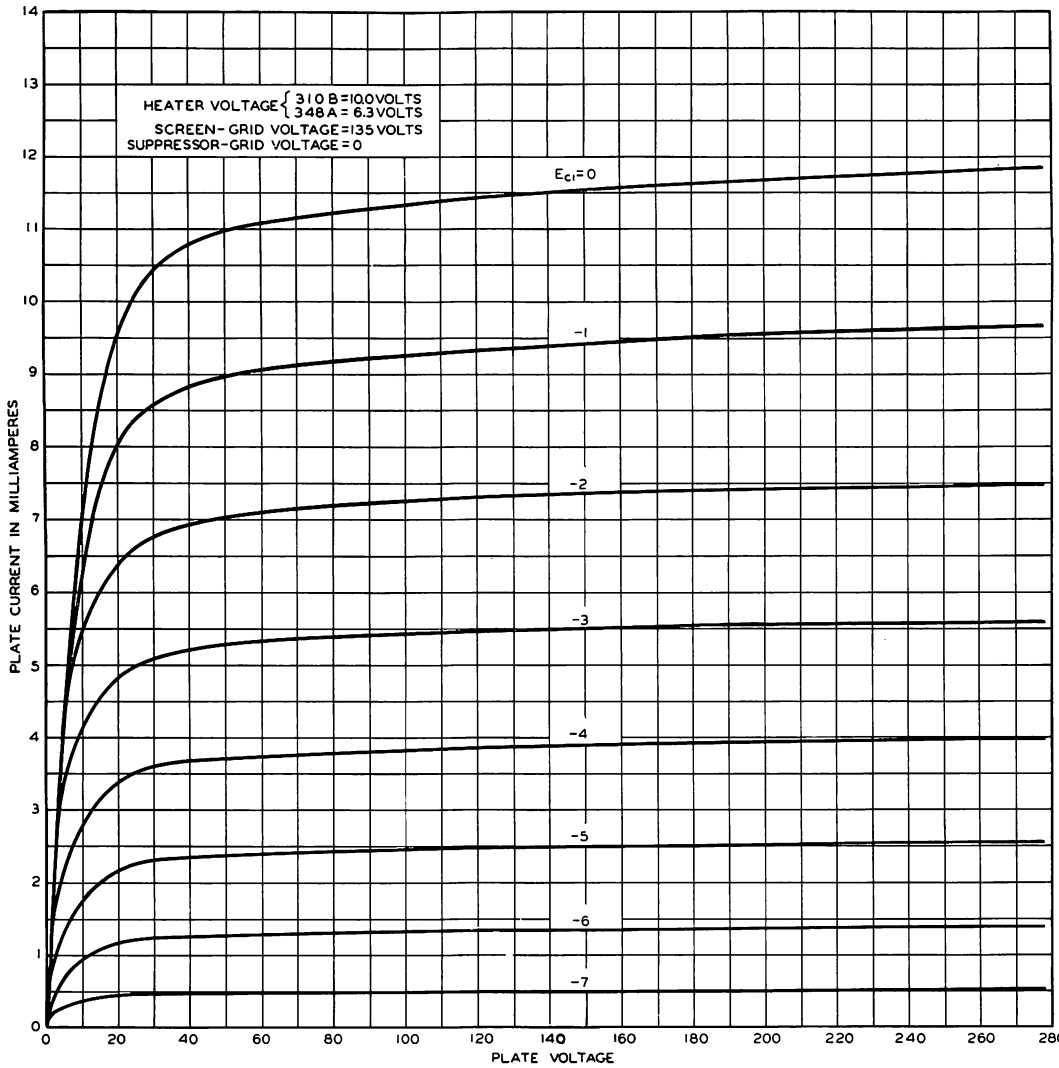

HEATER VOLTAGE { 310B=10.0 VOLTS
348A=6.3 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

FIG. 7

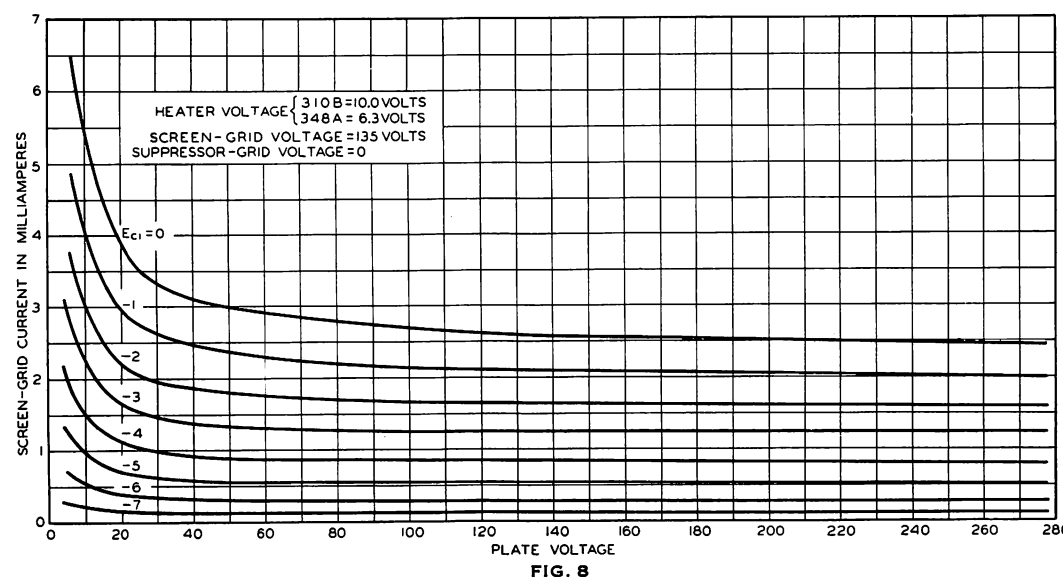

HEATER VOLTAGE { 310B=10.0 VOLTS
348A=6.3 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
0 1 2 3 4 5 6 7

FIG. 8

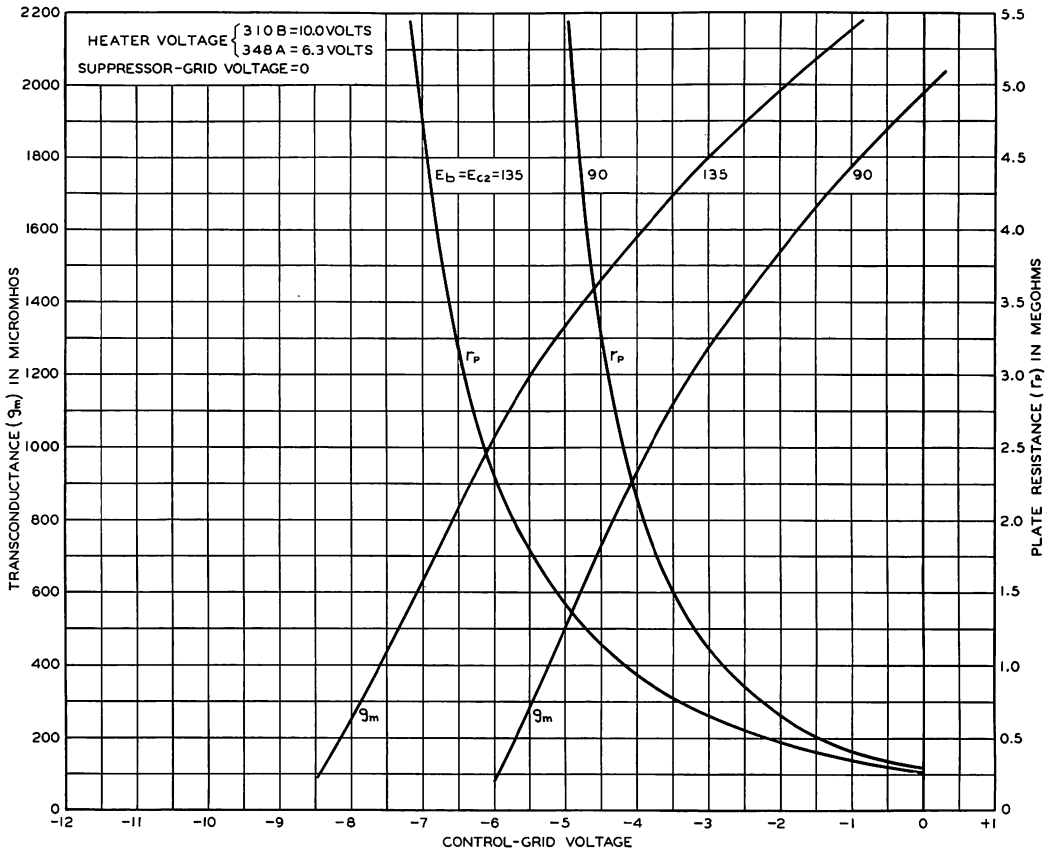

HEATER VOLTAGE { 310B=10.0 VOLTS
348A = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
$E_b=E_{c2}$=135
90
135
90
r_p
r_p
g_m
g_m
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
CONTROL-GRID VOLTAGE
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1

FIG. 9

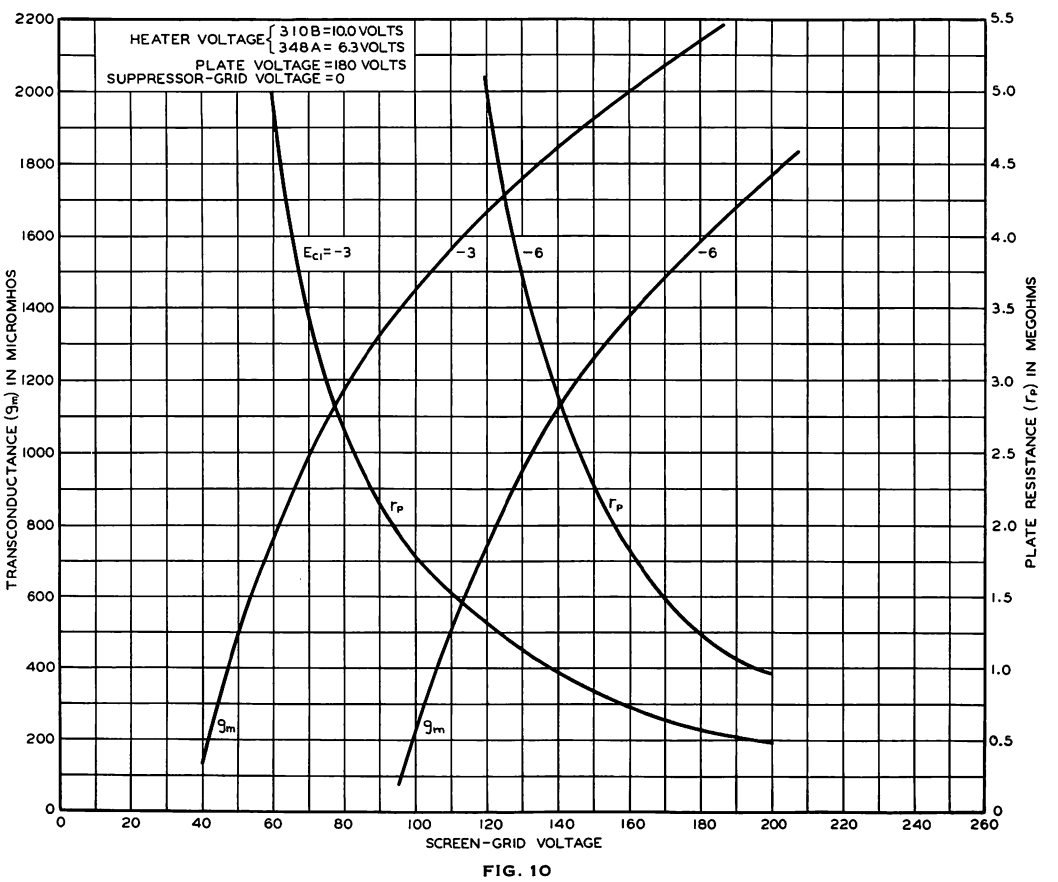
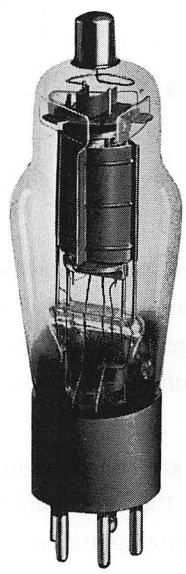

HEATER VOLTAGE { 310B=10.0 VOLTS
348A = 6.3 VOLTS
PLATE VOLTAGE=180 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{c1}=-3
-3
-6
-6
r_p
r_p
g_m
g_m
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
SCREEN-GRID VOLTAGE
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 10

Western Electric

311A and 329A Vacuum Tubes



Classification—Low-power, suppressor-grid pentodes with indirectly heated cathodes

The 311A and 329A tubes are identical except for the heaters.

These tubes are intended primarily for use as audio, carrier or radio-frequency power amplifiers where power outputs of approximately two watts are required and where the plate voltage is not in excess of 180 volts. The suppressor grid is permanently connected to the cathode within the tube.

Dimensions and Connections—Dimensions, outline diagrams of the tubes and bases, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base and Mounting—These vacuum tubes employ small five-pin thrust type bases with silver plated pins. They are adapted for use in standard five-contact type sockets, preferably those provided with silver-plated contacts such as the Western Electric 141A socket. A small metal cap control-grid terminal is located at the top of the bulb.

The tubes may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B	
Control grid to plate	0.29	0.07	μμf.
Control grid to heater, cathode and screen grid	8	9	μμf.
Plate to heater, cathode and screen grid	9	12	μμf.

Column A—Without shield.

Column B—With close fitting metal shield connected to the cathode.

Heater Ratings

	311A Tube	329A Tube	
Heater voltage	10.0	7.5	volts, a.c. or d.c.
Nominal heater current	0.64	0.85	ampere

The heaters should be operated on a voltage basis and at as near the rated voltage as practicable.

The voltage between the cathode and the heater should not exceed 150 volts.

Characteristics—Figures 3 and 4 respectively, show plate current and screen-grid current as functions of control-grid voltage for several values of screen and plate voltage. In all curves the plate voltage is equal to the screen voltage. Amplification factor, plate resistance and transconductance curves for the conditions corresponding to those of Figures 3 and 4 are given respectively in Figures 5, 6 and 7.

Plate current and screen-grid current are shown as functions of plate voltage in Figures 8 and 9 respectively, for a screen-grid voltage of 135 volts and for several values of control-grid voltage. Corresponding curves for amplification factor, plate resistance and transconductance are given in Figures 10, 11 and 12 respectively.

Curves showing the fundamental power output and the second and third harmonic levels as functions of input voltage for a number of values of load resistance for typical operating conditions are given in Figures 13, 14 and 15 respectively.

Limiting Conditions for Safe Operation

Maximum direct plate voltage	180 volts
Maximum direct screen-grid voltage	150 volts
Maximum cathode current (plate current plus screen-grid current)	60 milliamperes
Maximum direct screen-grid current	12 milliamperes

Operating Conditions and Output — Nominal performance data are given in the table on page 3 for a number of typical operating conditions. Less severe operating conditions should be selected in preference to the maximum conditions wherever possible. The life of the tube at maximum conditions will be shorter than at the less severe conditions.

The performance data include the fundamental power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages not exceeding the indicated values. Under certain conditions the maximum second harmonic level occurs at a lower input voltage than that given in the table. The power output is given in watts, and the harmonic levels in decibels below the fundamental.

TABLE

Control-grid voltage = —15 volts

Screen-grid voltage = 135 volts

Plate Voltage	Amplification Factor	Plate Resistance	Transconductance	Plate Current	Load Resistance	Input Voltage	Output Power	Second Harmonic	Third Harmonic
Volts		Ohms	Micromhos	Milliamperes	Ohms	Peak Volts	Watts	db	db
135	122	43,000	2800	30	3000	15	1.9	23	24
					3500	15	2.0	27	21
					4000	15	2.0	29	19
					6000	15	1.9	20	18
180*	146	50,000	2900	31	3000	15	2.5	18	30
					4000	15	2.8	21	24
					7000	15	2.5	23	18

*Maximum plate voltage.

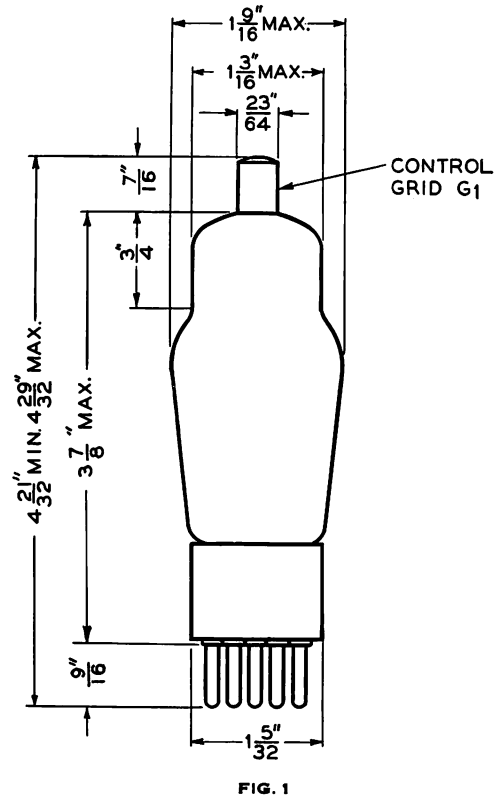


FIG. 1

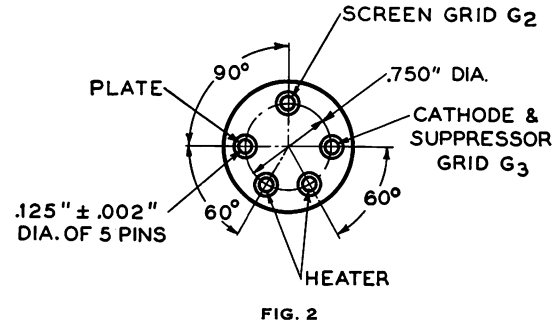


FIG. 2

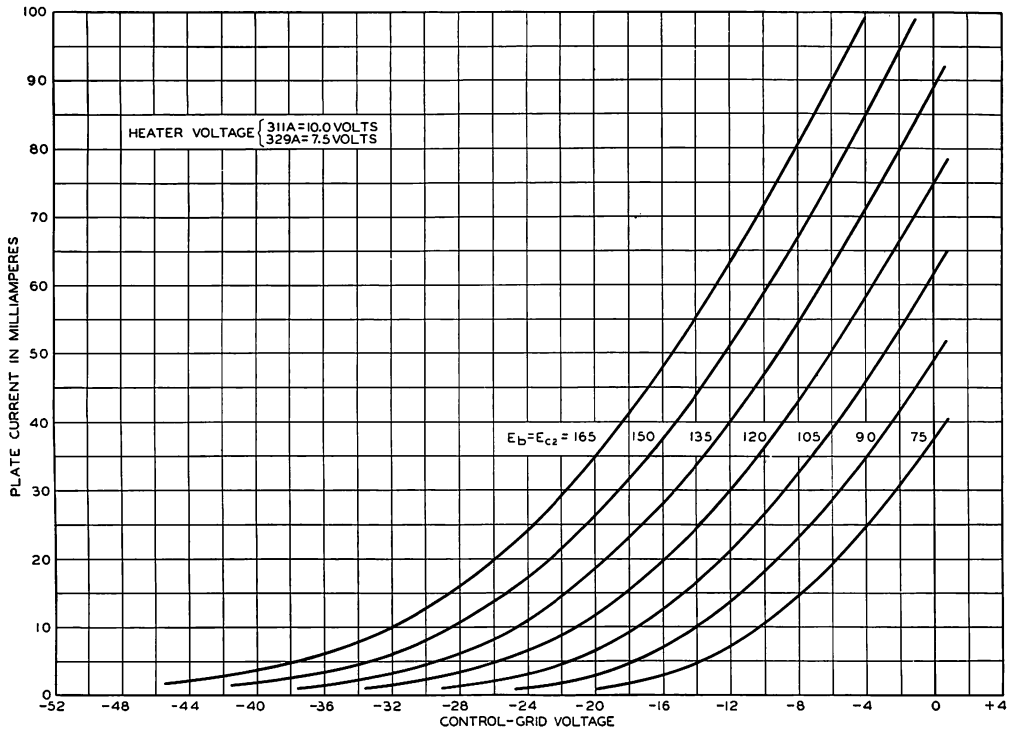

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
$E_b=E_{c2}$= 165
150
135
120
105
90
75
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
100
90
80
70
60
50
40
30
20
10
0
-52
-48
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4

FIG. 3

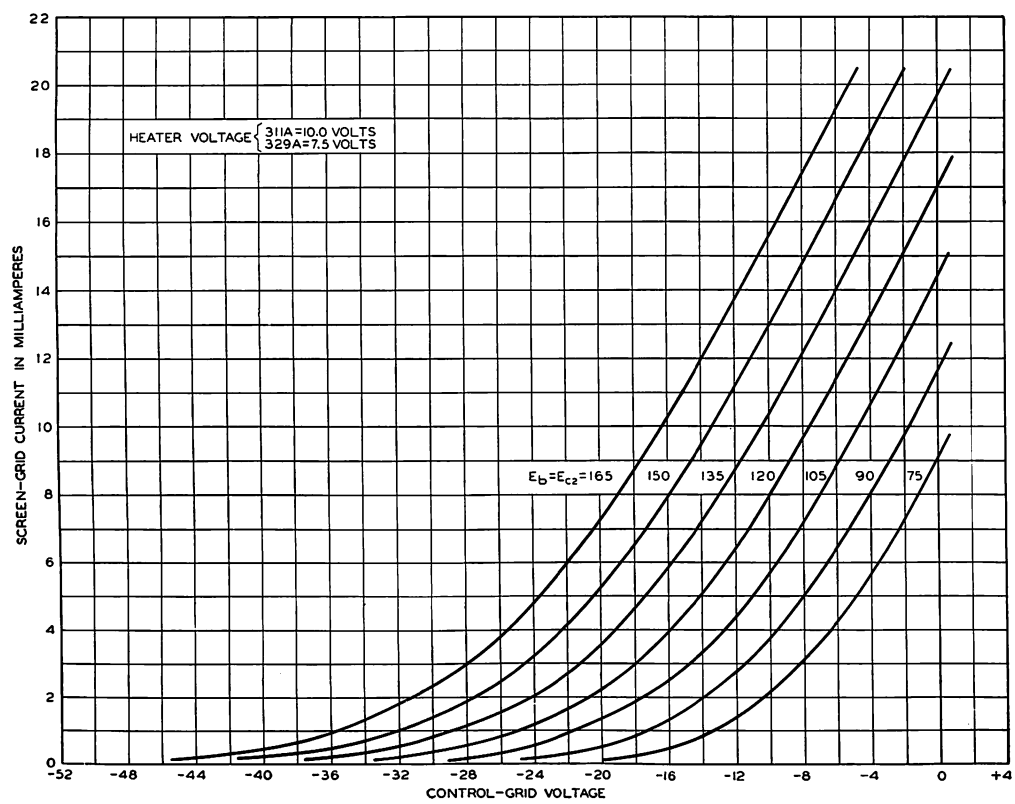

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
$E_b=E_{c2}$=165
150
135
120
105
90
75
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
22
20
18
16
14
12
10
8
6
4
2
0
-52
-48
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4

FIG. 4

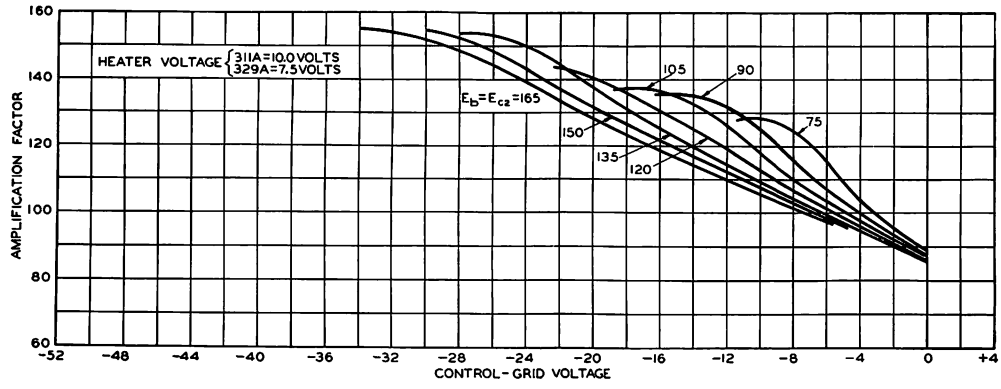


FIG. 5

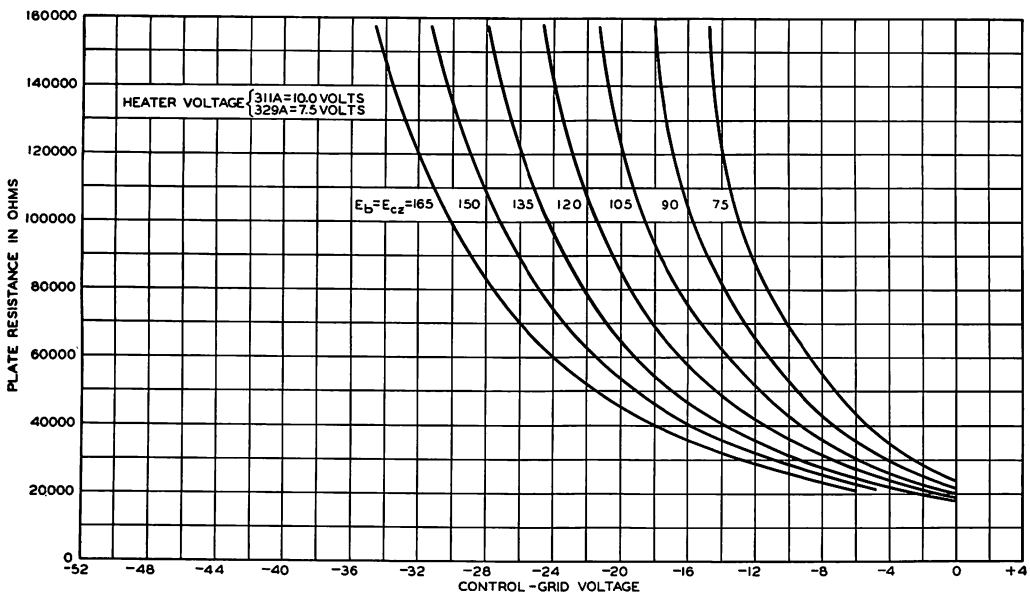


FIG. 6

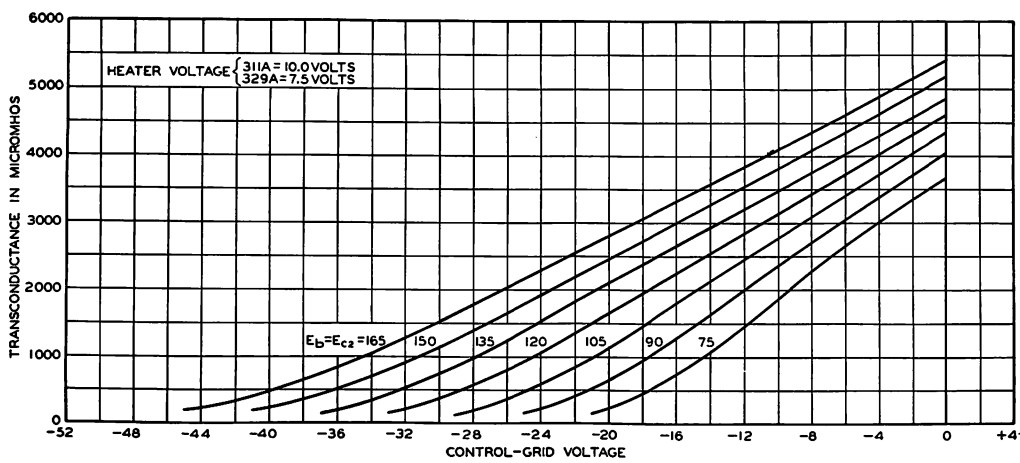


FIG. 7

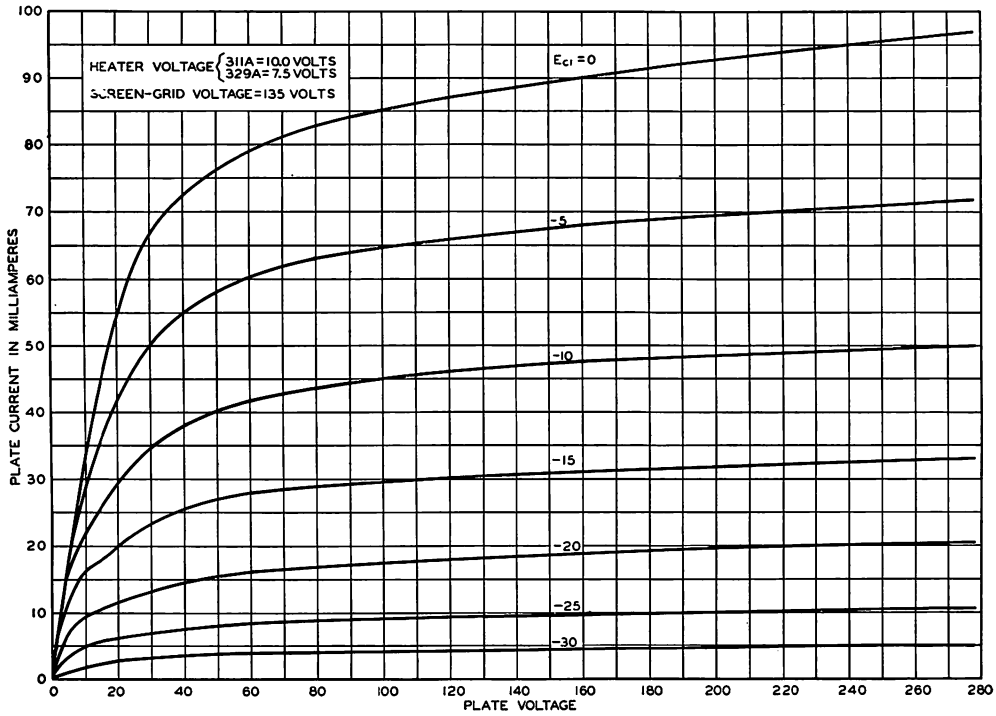

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
Ec1=0
-5
-10
-15
-20
-25
-30
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280

FIG. 8

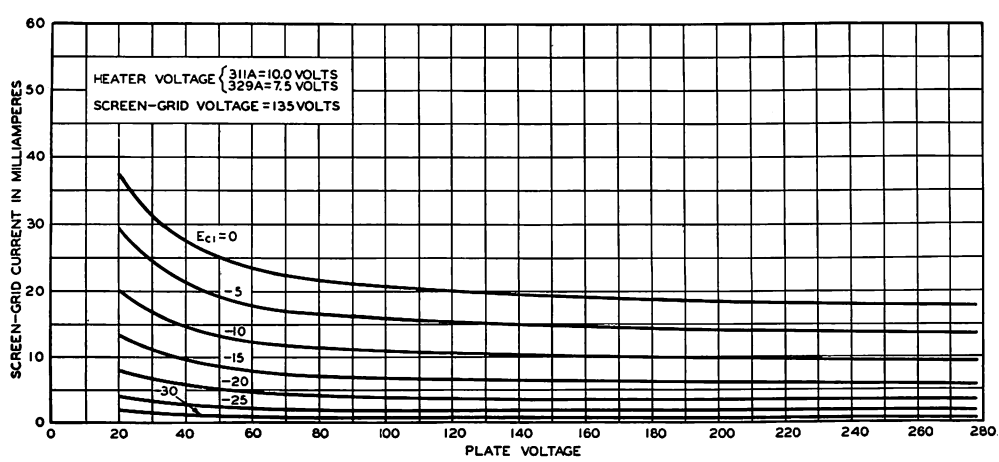

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
Ec1=0
-5
-10
-15
-20
-25
-30
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280

FIG. 9

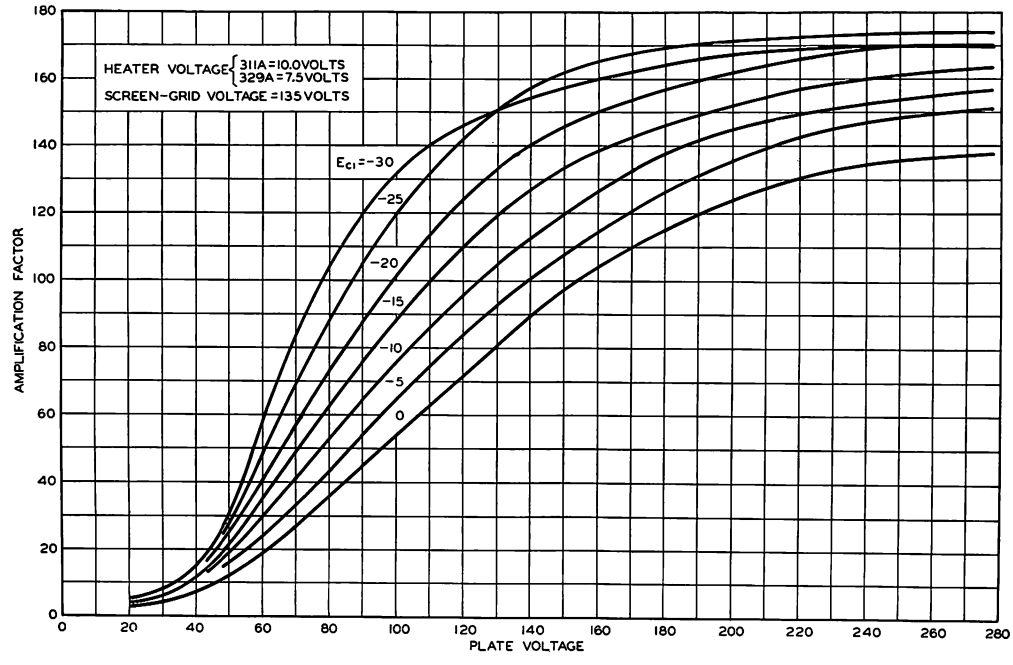


FIG 10

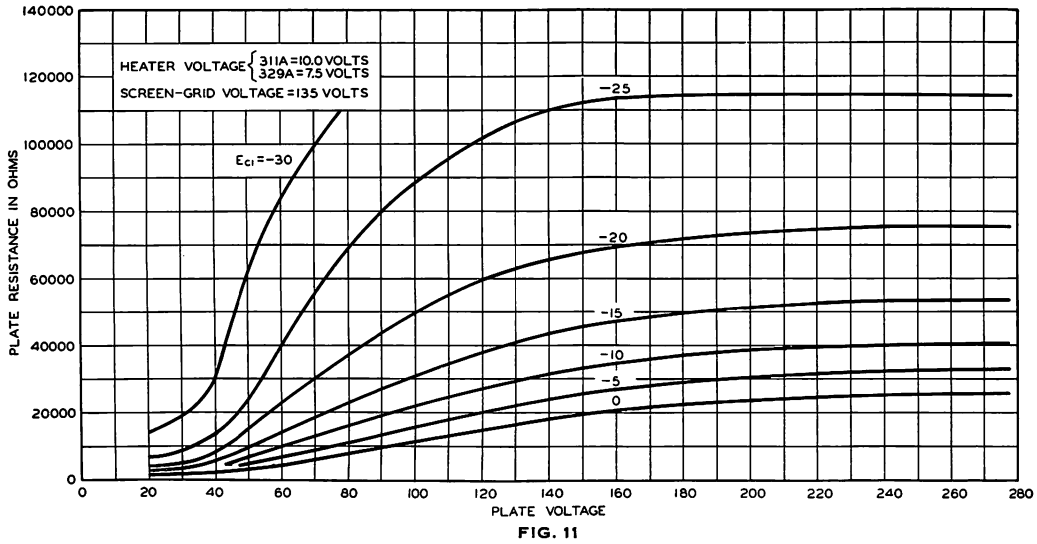


FIG. 11

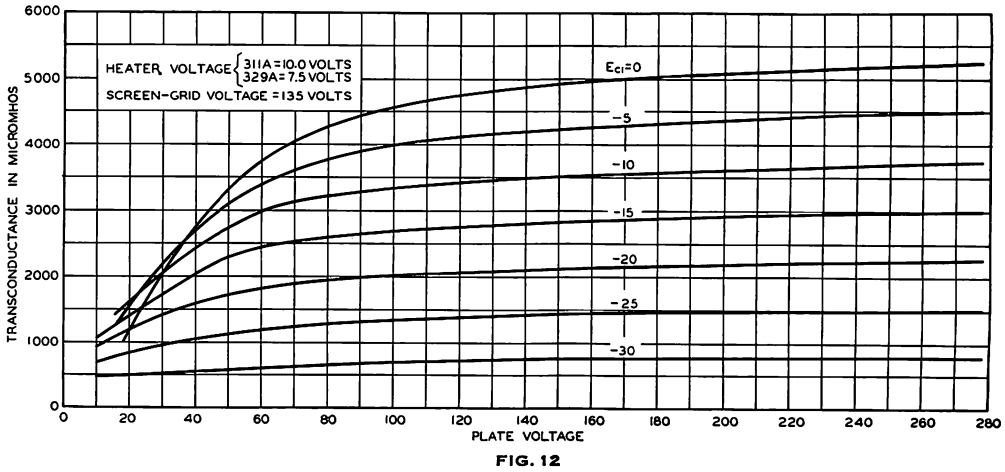


FIG. 12

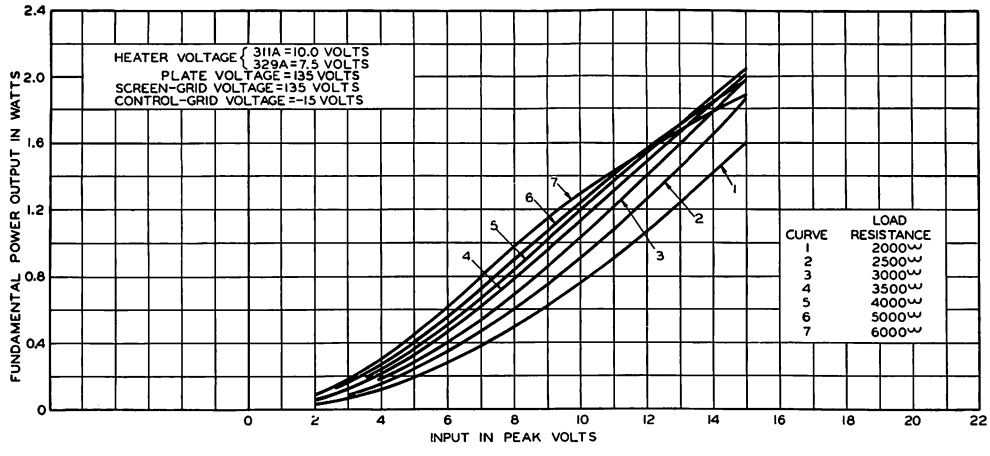


FIG. 13

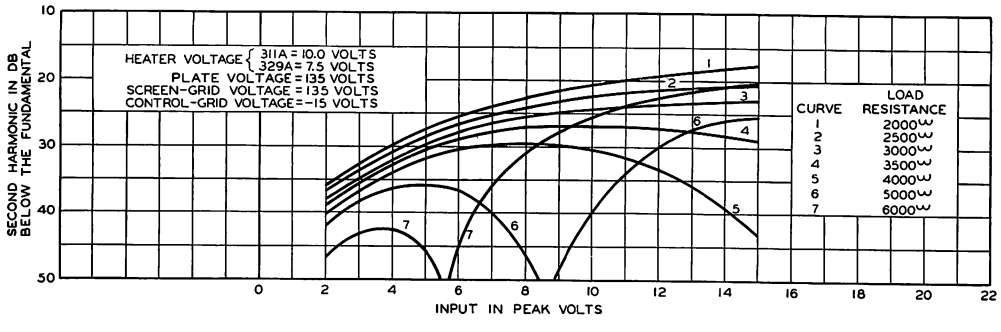


FIG. 14

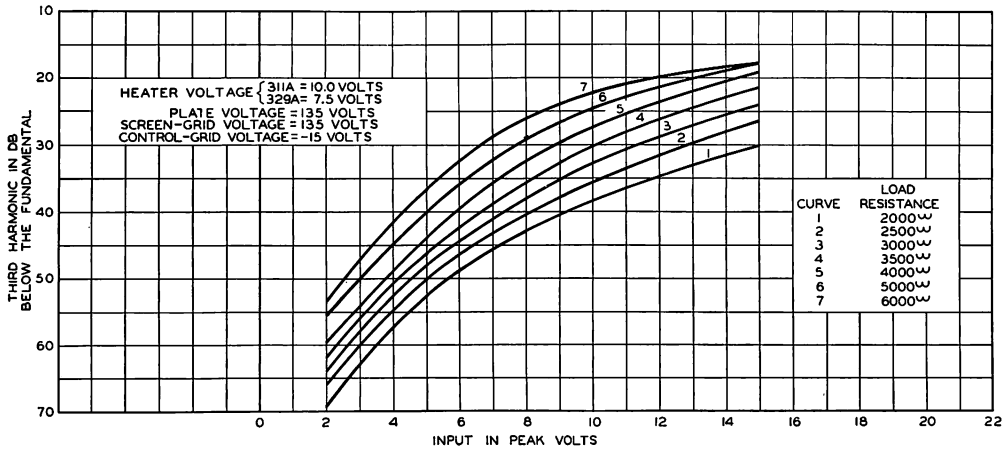


FIG. 15

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 311B ELECTRON TUBE



DESCRIPTION

The 311B is a suppressor grid power pentode having an indirectly heated cathode. It is designed for use as an audio, carrier or radio-frequency amplifier.

CHARACTERISTICS

Heater Voltage		9.0	10.0 volts
Plate Current	$E_b = E_{c2} = 135$ volts, $E_{c1} = -15$ volts	30	33 milliamperes
Transconductance		2800	2900 micromhos
Power Output		2.5	2.5 watts

File: General Purpose Section
Data Sheet Issue 1, 10-60

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GENERAL CHARACTERISTICS

Electrical Data

Heater Voltage, A-C or D-C (Note 1)	9.0	10.0 volts
Heater Current	0.60	0.64 ampere
Direct Interelectrode Capacitances	without external shield	with external shield (RMA #311)
Grid to Plate	0.32	0.09 μμf
Input	8.0	9.5 μμf
Output	8.5	10.4 μμf

Mechanical Data

Cathode	Coated unipotential
Bulb	ST12
Base	Small, 5 pin
Mounting Position	Any

Dimensions and pin connections shown in outline drawing on Page 4

Maximum Ratings, Absolute System (Note 2)

Plate Voltage	200 volts
Screen Grid Voltage	150 volts
Plate Dissipation	9.0 watts
Screen Grid Dissipation	1.8 watts
Cathode Current	60 milliamperes
Heater-Cathode Voltage	150 volts

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

Single Tube Amplifier - Class A

Heater Voltage	9.0	10.0	10.0	volts
Plate Voltage	135	135	180	volts
Screen Grid Voltage	135	135	135	volts
Control Grid Voltage	-15	-15	-15	volts
Peak A-F Grid Voltage	15	15	15	volts
Zero Signal Plate Current	30	33	34	milliamperes
Maximum Signal Plate Current	33	36	38	milliamperes
Zero Signal Screen Grid Current	6.3	6.5	6.0	milliamperes
Maximum Signal Screen Grid Current	11.5	11.0	10.0	milliamperes
Transconductance	2800	2900	3000	micromhos
Plate Resistance	45000	40000	47000	ohms
Load Resistance	3500	3500	4000	ohms
Maximum Signal Power Output	2.0	2.0	2.8	watts
Total Harmonic Distortion	10.0	9.0	10.5	per cent

Note 1: For optimum tube life, a heater voltage of 9 volts is recommended. However, when 9 volts is used, it must be regulated to ± 1%.

Note 2: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

TYPICAL CHARACTERISTIC CURVES

These curves are representative of the characteristics of typical tubes when 9.0 volts are applied to the heater. However, these characteristics do not differ significantly when 10.0 volts are applied to the heater.

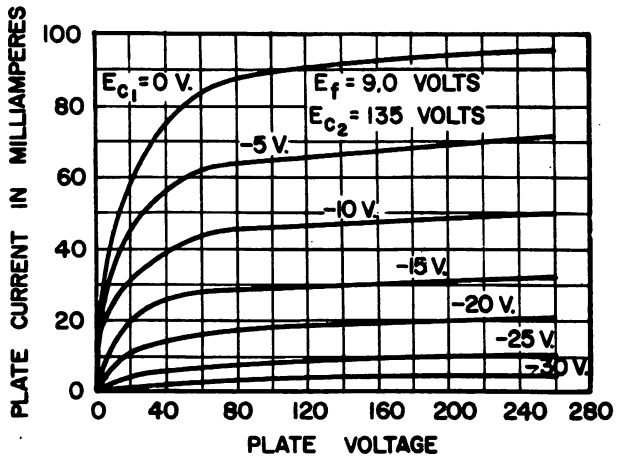


FIG. 1

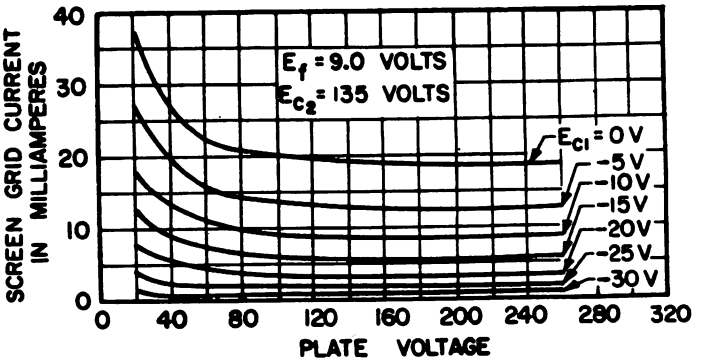


FIG. 2

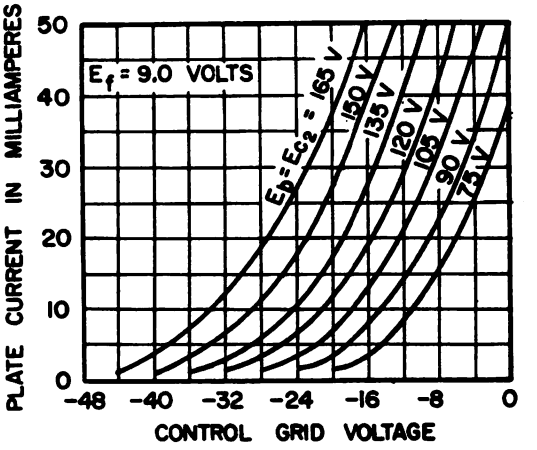


FIG. 3

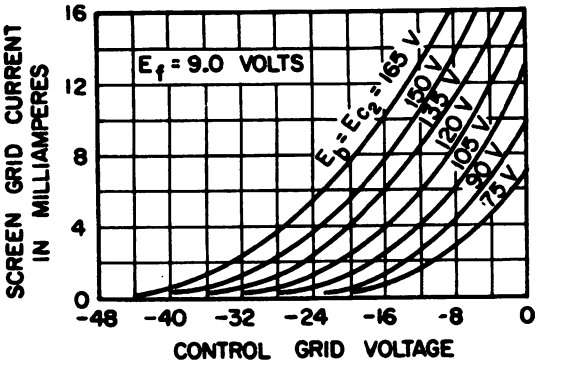


FIG. 4

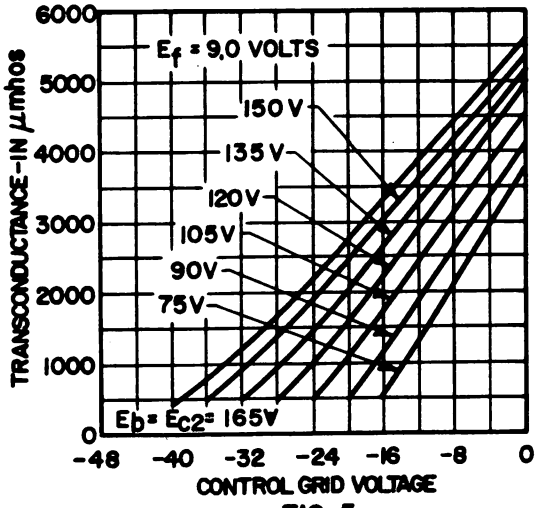


FIG. 5

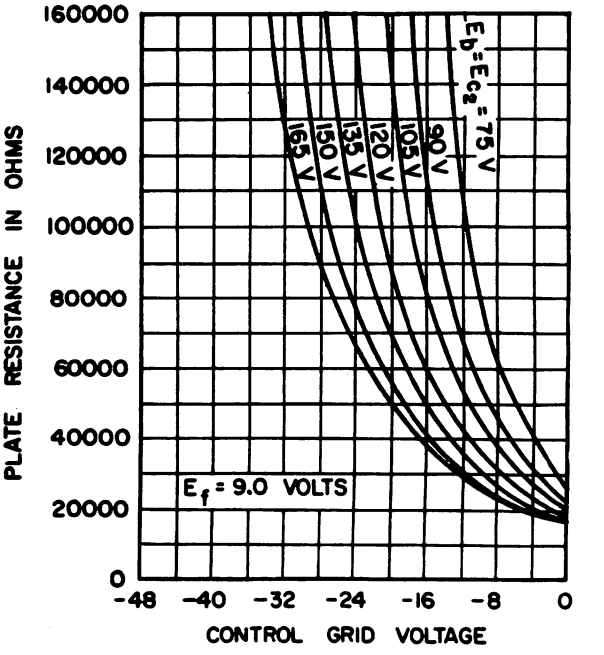


FIG. 6

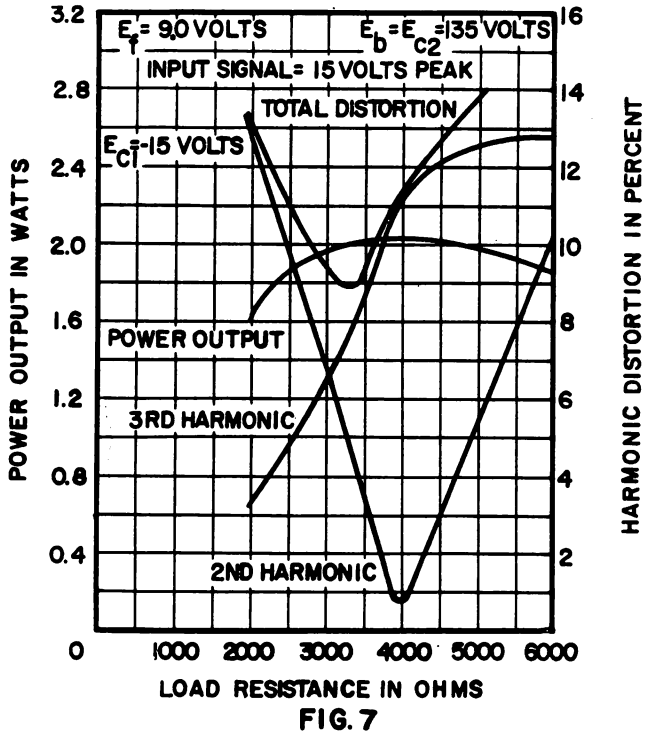
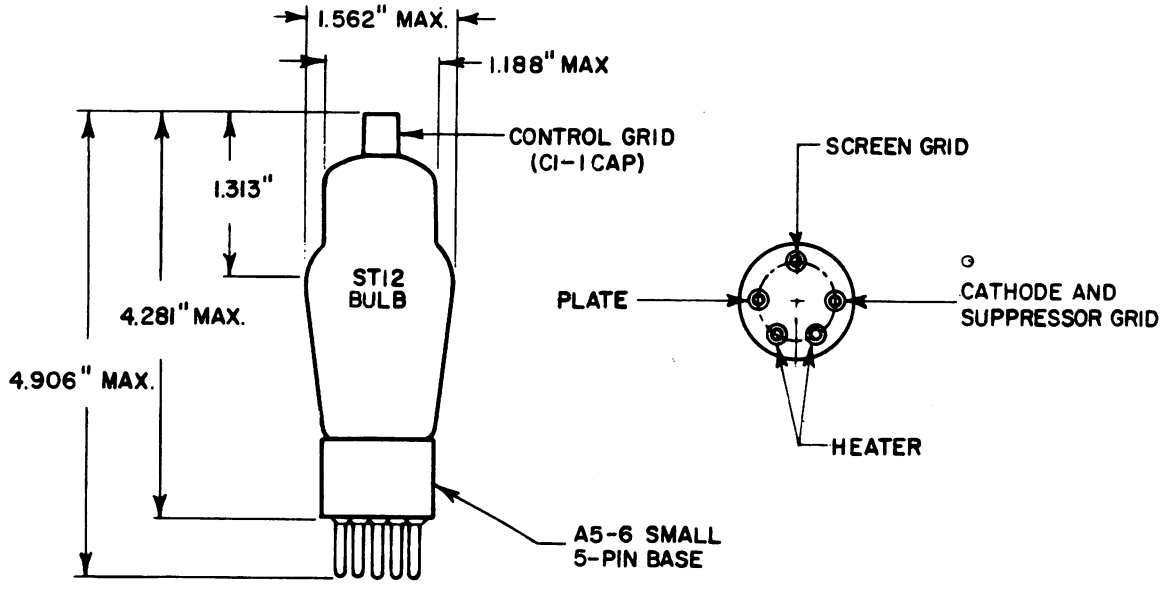


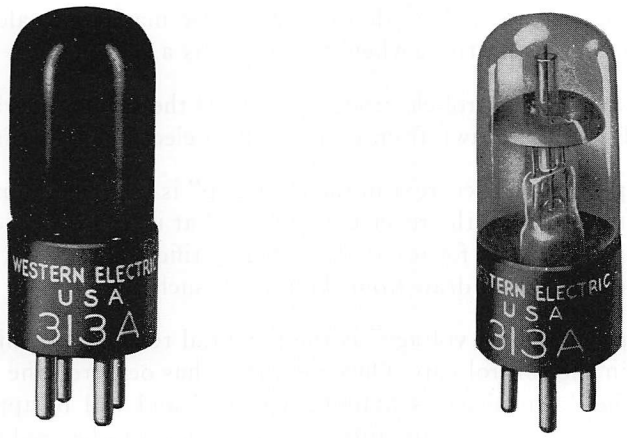
FIG. 7



A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

Western Electric

313A Vacuum Tube



Classification—Double gap, cold cathode, gas-filled tube for use as a relay, rectifier or voltage regulator in special circuits.

The elements of the 313A tube consist of two similar control electrodes and one anode. The conduction path between the control electrodes is known as the control gap. The conduction path between either control electrode and the anode is known as the main gap.

The glass bulb has been given an opaque coating so that the discharge is not visible while the tube is operating. In the photograph at the right the coating has been removed to show the tube elements.

Dimensions—The dimensions and outline diagrams are given in Figs. 1 and 2. The overall dimensions are:

Maximum length	$3\frac{13}{32}$″
Maximum diameter	$1\frac{3}{16}$″

Mounting—The 313A vacuum tube employs a standard four-pin thrust base suitable for use in a Western Electric 143B or similar socket. The arrangement of electrode connections to the base terminals is shown in Fig. 2.

It may be mounted in either a vertical or horizontal position.

Ratings

Maximum peak control-electrode current	30 milliamperes
Maximum average control-electrode current (averaged over 1 second)	10 milliamperes
Maximum peak reverse current in main gap	5 milliamperes

Characteristics

Nominal control gap breakdown voltage	70 volts
Nominal control gap sustaining voltage	60 volts
Nominal main gap breakdown voltage	175 volts
Nominal main gap sustaining voltage	75 volts
Transfer current	5 microamperes (max.)
Nominal deionization time	
Main gap	10 milliseconds
Control gap	3 milliseconds

The "maximum peak control-electrode current" is the maximum value of current which may be drawn from either control electrode when it is acting as a cathode.

The "maximum average control-electrode current" is the maximum value of current (averaged over 1 second) which may be drawn from either control electrode when it is acting as a cathode.

The "maximum peak reverse current in the main gap" is the maximum value of current which may be drawn from the anode in the reverse direction, that is when it is acting as a cathode. The reverse current rating is intended for use in designing rectifier circuits and is the maximum inverse current which it is permissible to draw from the tube in such circuits.

The "control gap breakdown voltage" is the potential required to initiate ionization, thereby starting conduction in the control gap. Once ionization has occurred the potential across the gap will be reduced to the "control gap sustaining voltage" and will be approximately independent of the current. It is this property of the tube which enables it to be used as a voltage regulator.

The "main gap breakdown voltage" is the potential required to start conduction in the main gap when no ionization is occurring in the control gap. After breakdown, conduction will take place at the "main gap sustaining voltage" and will be practically independent of current.

The "main gap sustaining voltage" is substantially independent of current when the current passes through the tube in the forward direction. When the current passes through the main gap in the reverse direction the sustaining voltage increases rapidly with increasing current. It is this asymmetry in the properties of the main gap of the 313A tube which enable it to be used as a rectifier. The current voltage characteristics of the main gap of a typical 313A tube in both forward and reverse directions as shown in Fig. 3. This curve was obtained with a cathode ray oscillograph.

When the anode potential is maintained at a value intermediate between the "main gap breakdown and sustaining voltages" the passage of a small amount of current in the control gap will produce ionization sufficient to initiate conduction in the main gap. It is this property of the tube which enables it to be used as a relay. The amount of current in the control gap required to initiate conduction in the main gap is known as the transfer current. This quantity varies considerably from tube to tube and during the life of a given tube but will in general be less than 5 microamperes and usually only a few tenths of a microampere.

The deionization time is the time during which the voltage must be removed from the tube in order that the discharge shall not be reestablished when the voltage is restored. This time increases with increasing applied voltage and with increasing current through the tube before the deionization period. This rate of increase of deionization time is such that the tube will not deionize with a 60 cycle sine wave main gap voltage if the load is inductive or if the peak voltage is near the main gap breakdown voltage or the current near the maximum rated value.

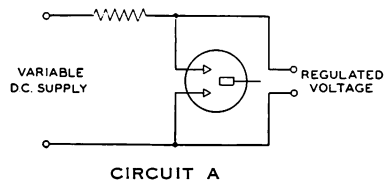
The "transfer time" is the time during which the control gap must be energized in order that the discharge may transfer to the main gap. It depends upon the amount of current flowing in the control gap and on the main gap voltage. For a control gap current of 10 microamperes the "transfer time" is approximately 200 microseconds.

Typical Circuits

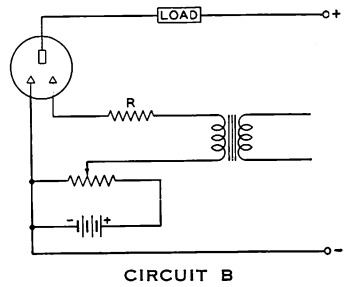
Circuit A shows a circuit using the control gap of the 313A as a voltage regulator.

Circuit B shows a circuit using the 313A as a relay. The anode voltage should be intermediate between the main gap breakdown and sustaining voltages and the control anode may be biased at any desired potential less than the control gap sustaining voltage. The resistance R, in the control anode circuit should be of the order of 100,000 ohms. This circuit possesses a "lock-in" feature, since the anode potential must be removed momentarily to restore the tube to a non-conducting condition. When supplied from alternating current this circuit does not possess a "lock-in" feature unless the frequency of the supply voltage is so high that the tube is not allowed a sufficient interval to deionize.

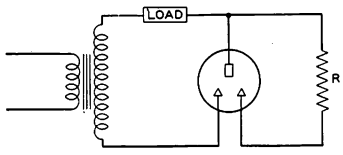
Circuit C shows a circuit using the 313A as a rectifier. The rectifying properties of the main gap are used but the control gap should be connected into the circuit as indicated through a high resistance. This will cause conduction in the forward direction to begin at a voltage much below the main gap breakdown voltage. It is important to note that as a rectifier the 313A tube possesses a unique property not common to other rectifiers in that its impedance is infinite for voltages below the breakdown voltage. In many applications that is of importance since the tube may be used to pass current at the higher potentials without placing a bridge across the line for signals of lower voltage.



CIRCUIT A



CIRCUIT B



CIRCUIT C

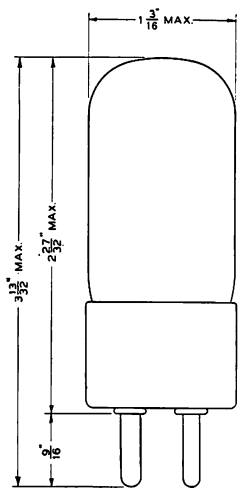


FIG. 1

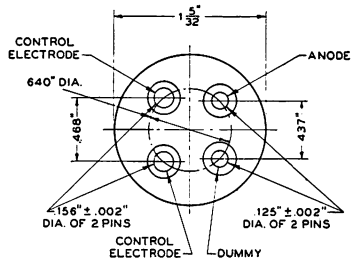


FIG. 2

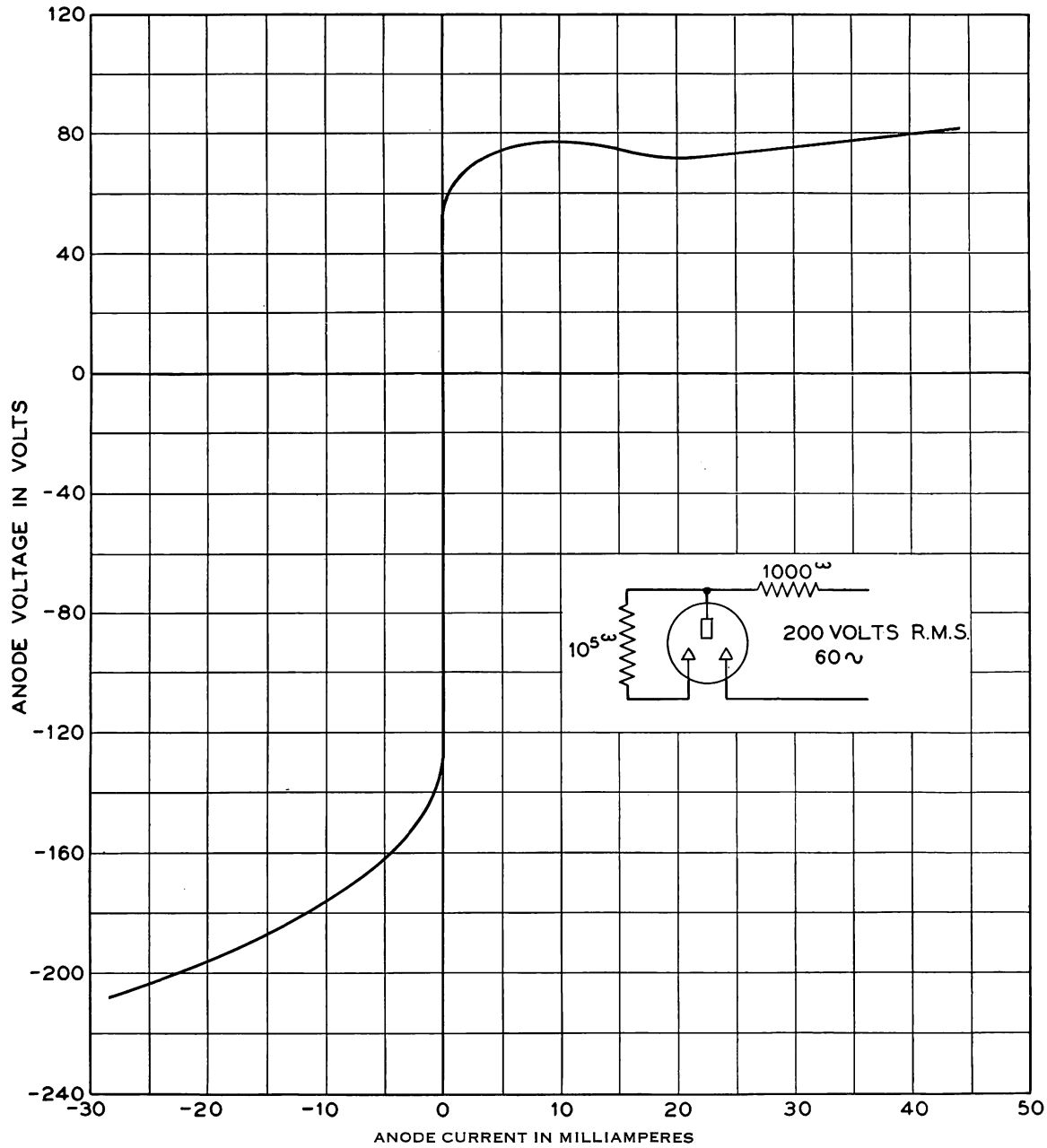
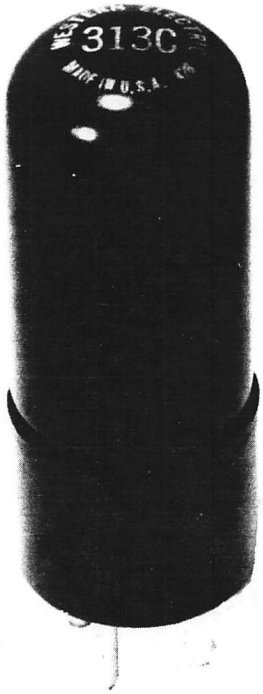

120
80
40
0
-40
-80
-120
-160
-200
-240
ANODE VOLTAGE IN VOLTS
-30
-20
-10
0
10
20
30
40
50
ANODE CURRENT IN MILLIAMPERES
1000Ω
10⁵Ω
200 VOLTS R.M.S.
60~

FIG. 3

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 313C ELECTRON TUBE



DESCRIPTION

The 313C is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator, or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus.

CHARACTERISTICS

Peak Anode Voltage		185	volts
Average Cathode Current	10	100	milliamperes
Average Life, Approximate	10000	10	hours

File: Cold Cathode Section

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MAXIMUM RATINGS, Absolute System (Note 1)

Forward Peak Anode Voltage	185	volts
Forward Cathode Current (Note 2)		
Peak	100	milliamperes
Average	35	milliamperes
Averaging Time	2	seconds
Peak Inverse Anode Current (Note 2)	5	milliamperes
Ambient Temperature Limits	-55 to +85	centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.	
Starter Breakdown Voltage (Note 3)	62	70	89	volts
Starter Voltage Drop at 20 milliamperes	52	60	74	volts
Anode Voltage Drop at 20 milliamperes	68	75	90	volts
Transfer Current	See Curve - Fig. 1			
Ionization Time - Starter Gap (Note 4)	-	6	-	milliseconds
Deionization Time, Approximate				
Starter Gap	-	3	-	milliseconds
Main Gap	-	10	-	milliseconds
Inverse Current at -120 Volts Anode Potential (Note 5)	-	-	3	milliamperes

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	1 Ounce

Dimensions and pin connections shown in outline drawing on page 4.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

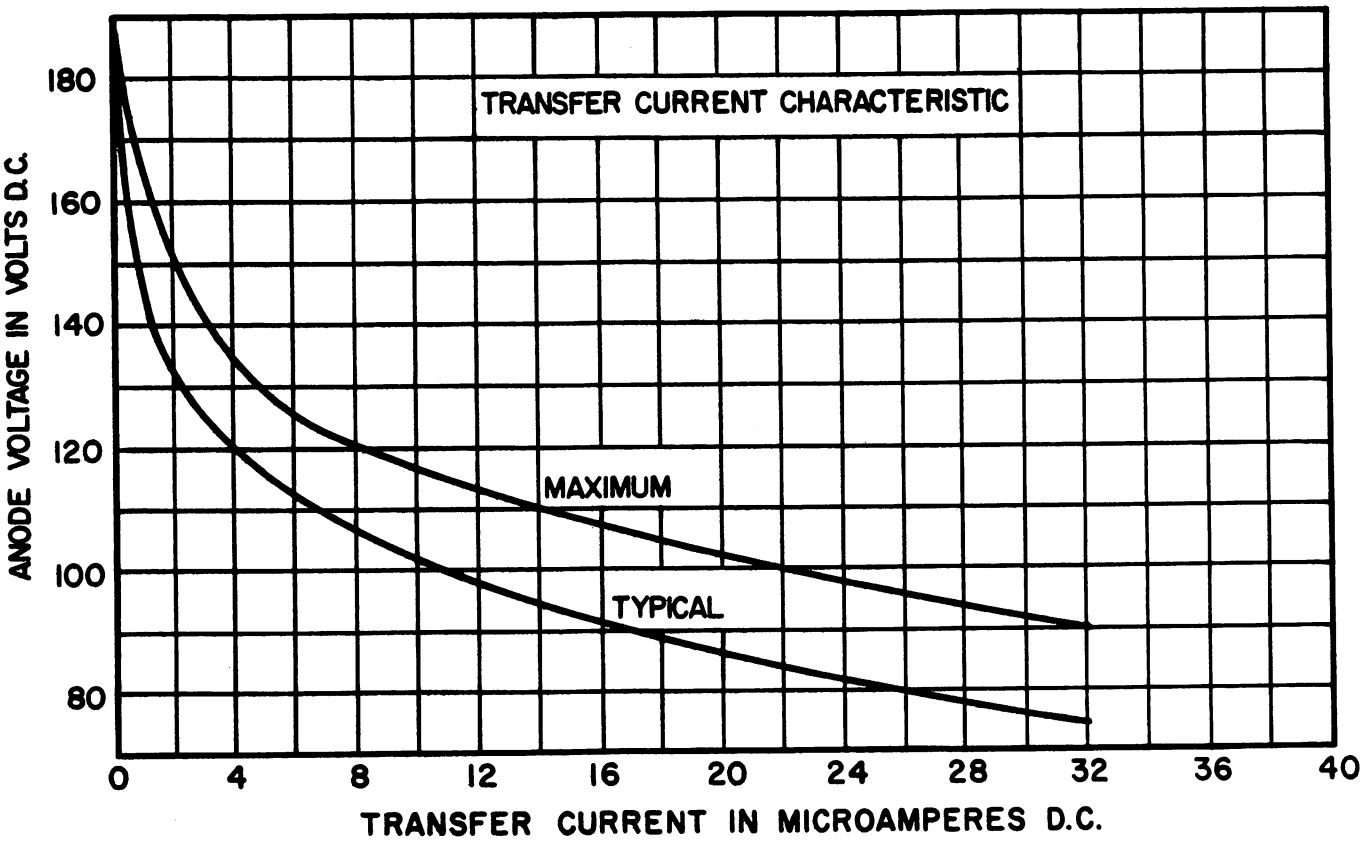


FIG.1

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

Note 2: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed the maximum rated values.

Note 3: Limits apply immediately after tube has conducted current. If tube has been idle, these values initially may be as much as 3 volts higher or lower.

Note 4: With 15 volts overvoltage (15 volts above starter breakdown voltage) with tube in total darkness.

Note 5: Negative anode voltage applied through 8000 ohms. Starter connected to anode through 100,000 ohms.

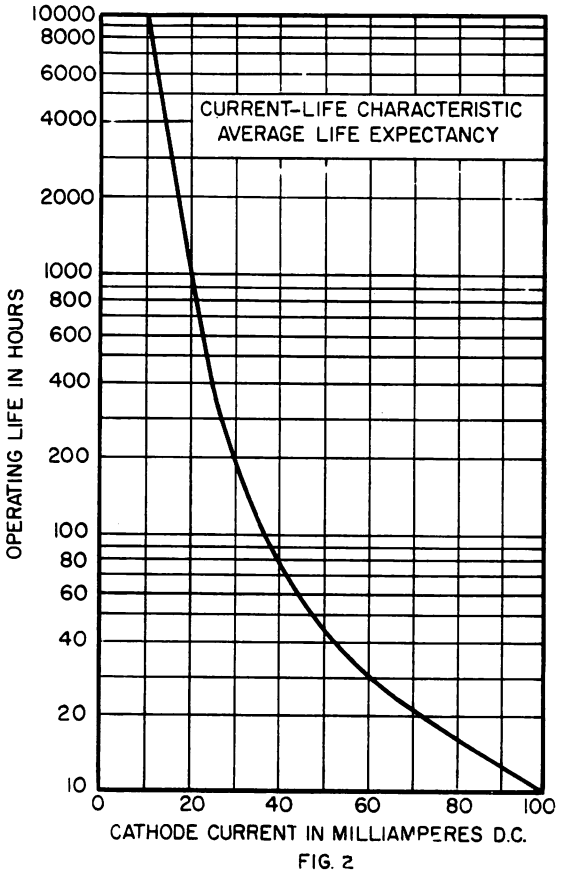


FIG. 2

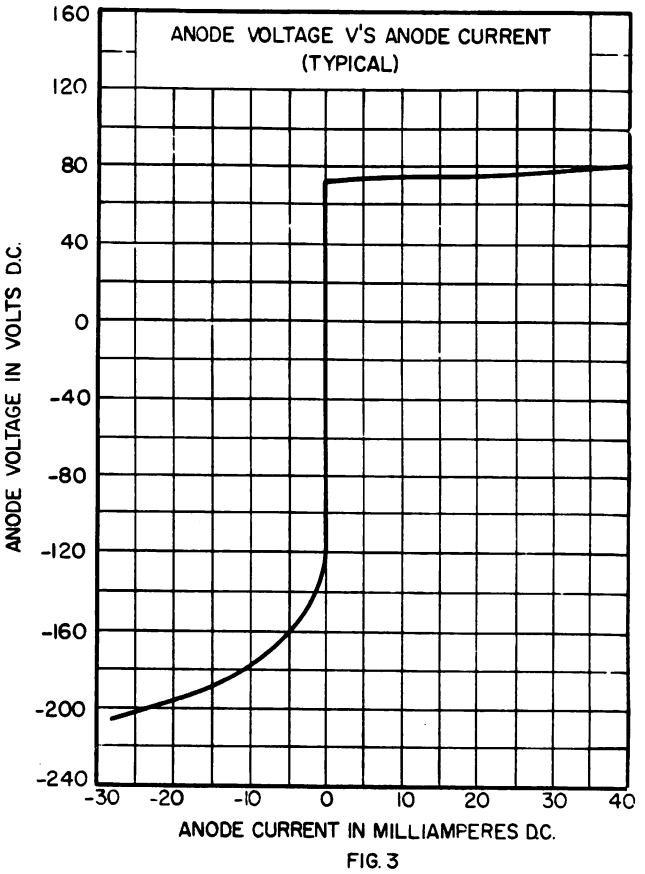
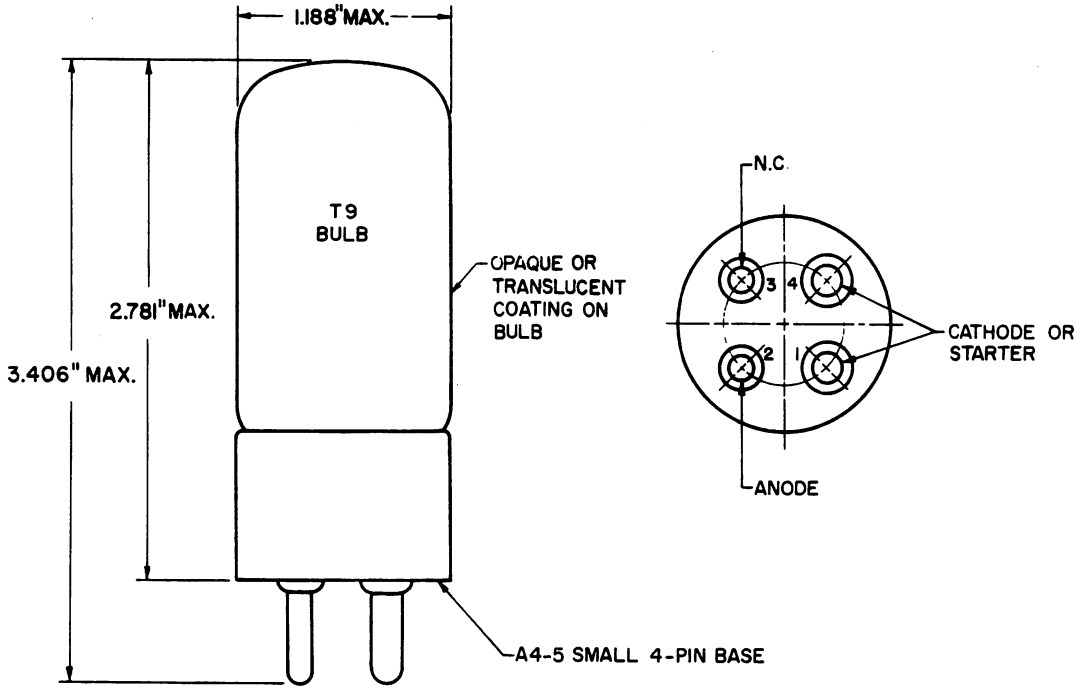


FIG. 3

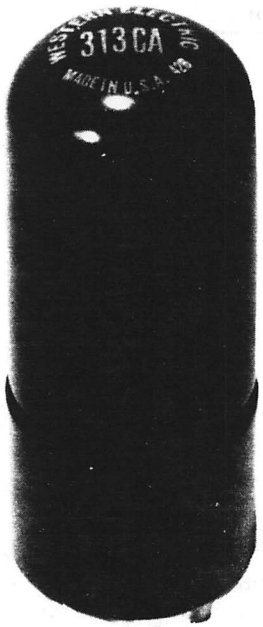


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ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 313CA ELECTRON TUBE



DESCRIPTION

The 313CA is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator, or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus.

CHARACTERISTICS

Peak Anode Voltage		200	volts
Average Cathode Current	7	72	milliamperes
Average Life, Approximate	10000	10	hours

File: Cold Cathode Section

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MAXIMUM RATINGS, Absolute System (Note 1)

Forward Peak Anode Voltage	200	volts
Forward Cathode Current (Note 2)		
Peak	72	milliamperes
Average	25	milliamperes
Averaging Time	2	seconds
Peak Inverse Anode Current (Note 2)	5	milliamperes
Ambient Temperature Limits	-55 to +85	centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.	
Starter Breakdown Voltage (Note 3)	66	72	78	volts
Starter Voltage Drop at 20 milliamperes	52	60	74	volts
Anode Voltage Drop at 20 milliamperes	68	75	88	volts
Transfer Current	See curve - Fig. 1			
Ionization Time - Starter Gap (Note 4)	-	6	-	milliseconds
Deionization Time, Approximate				
Starter Gap	-	3	-	milliseconds
Main Gap	-	10	-	milliseconds
Inverse Current at -120 Volts Anode Potential (Note 5)	-	-	3	milliamperes

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	1 Ounce

Dimensions and Pin Connections shown in outline drawing on page 4.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

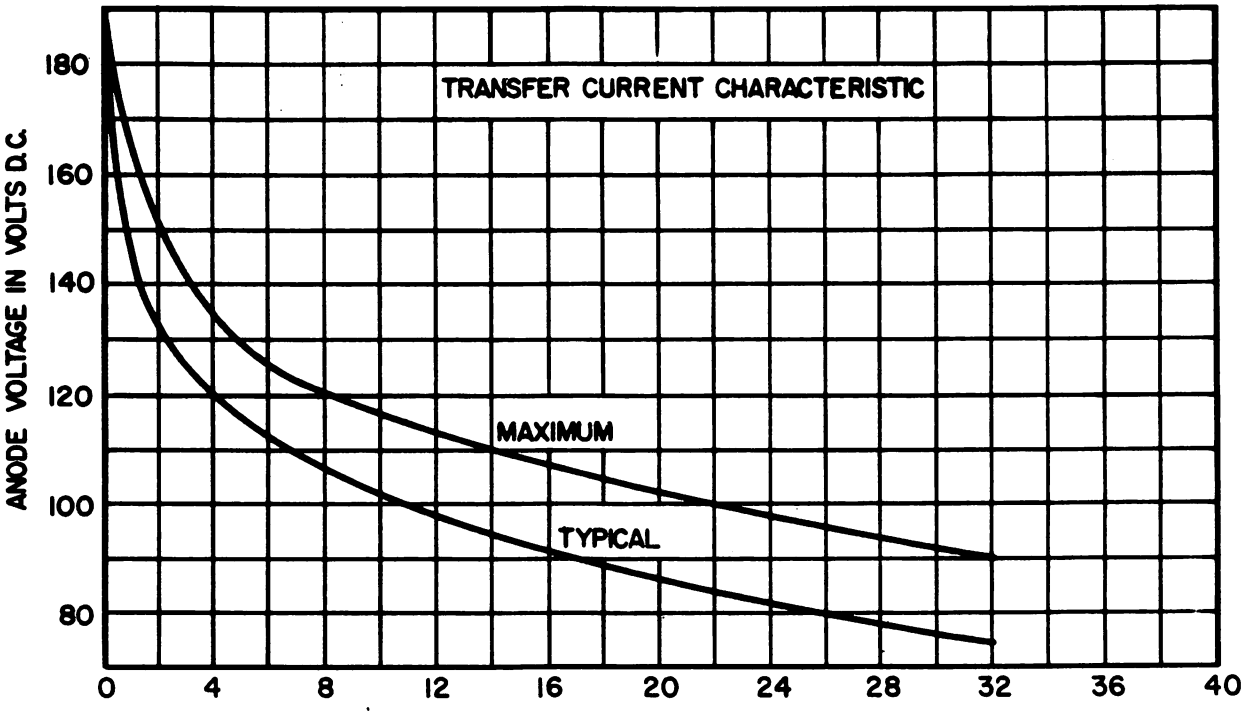


FIG.1

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

Note 2: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed the maximum rated values.

Note 3: Limits apply immediately after tube has conducted current. If tube has been idle, these values initially may be as much as 3 volts higher or lower.

Note 4: With 15 volts overvoltage (15 volts above starter breakdown voltage) with tube in total darkness.

Note 5: Negative anode voltage applied through 8000 ohms. Starter connected to anode through 100,000 ohms.

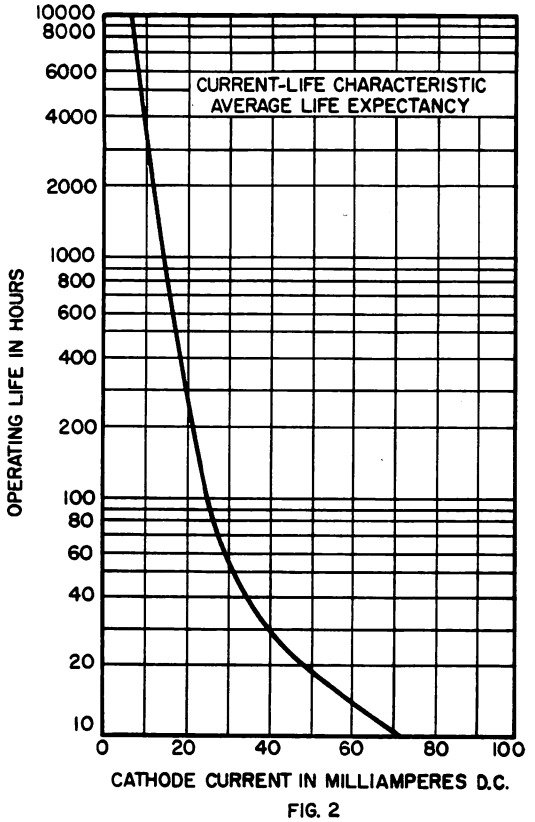


FIG. 2

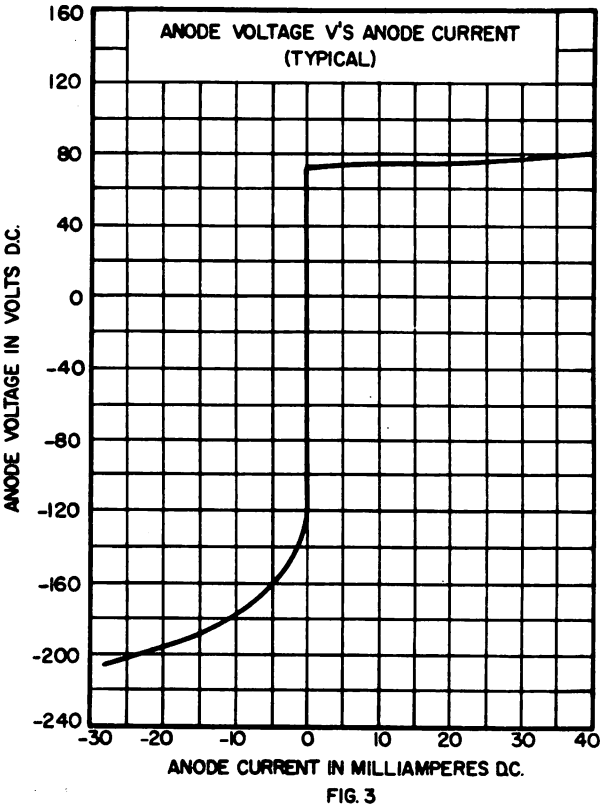
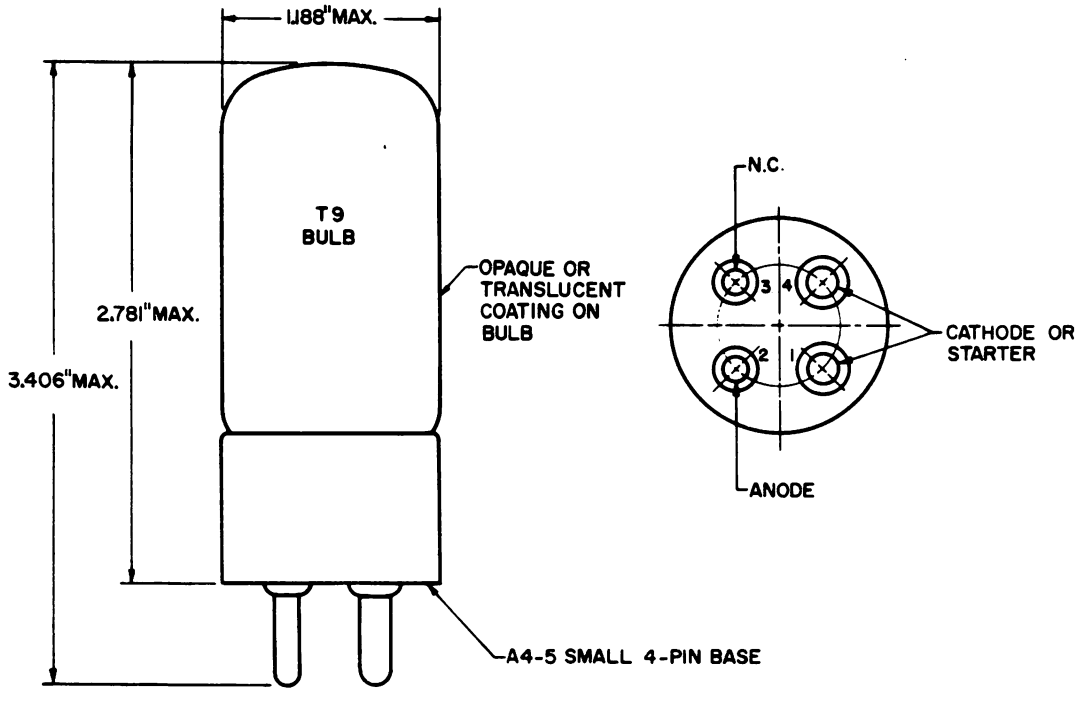


FIG. 3

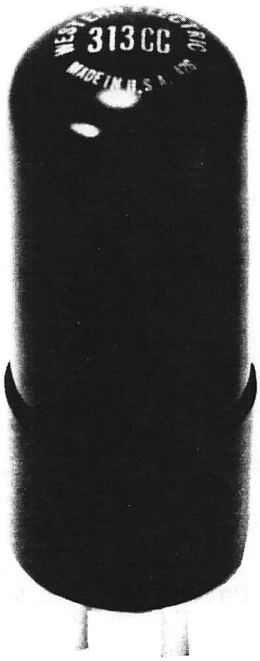


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ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 313CC ELECTRON TUBE



DESCRIPTION

The 313CC is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator, or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus.

CHARACTERISTICS

Peak Anode Voltage		150	volts
Average Cathode Current	7	72	milliamperes
Average Life, Approximate	10000	10	hours

File: Cold Cathode Section

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MAXIMUM RATINGS, Absolute System (Note 1)

Forward Peak Anode Voltage	150	volts
Forward Cathode Current (Note 2)		
Peak	72	milliamperes
Average	25	milliamperes
Averaging Time	2	seconds
Peak Inverse Anode Current (Note 2)	5	milliamperes
Ambient Temperature Limits	-55 to +85	centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.	
Starter Breakdown Voltage (Note 3)	66	72	78	volts
Starter Voltage Drop at 20 milliamperes	52	60	74	volts
Anode Voltage Drop at 20 milliamperes	68	75	88	volts
Transfer Current	See Curve - Fig. 1			
Ionization Time - Starter Gap (Note 4)	-	6	-	milliseconds
Deionization Time, Approximate				
Starter Gap	-	3	-	milliseconds
Main Gap	-	10	-	milliseconds
Inverse Current at -120 volts Anode Potential (Note 5)	-	-	3	milliamperes

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	1 Ounce

Dimensions and pin connections shown in outline drawing on Page 4.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

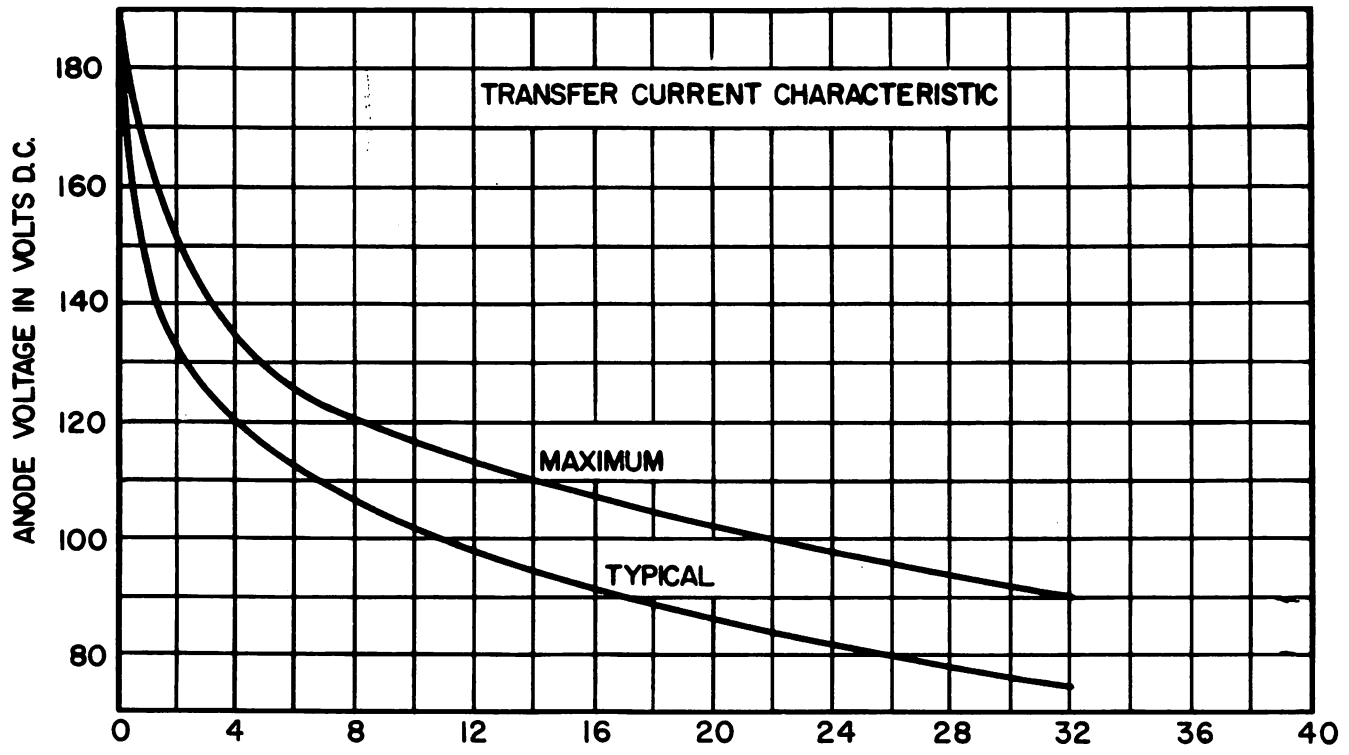


FIG.1

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

Note 2: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed the maximum rated values.

Note 3: Limits apply immediately after tube has conducted current. If tube has been idle, these values initially may be as much as 3 volts higher or lower.

Note 4: With 15 volts overvoltage (15 volts above starter breakdown voltage) with tube in total darkness.

Note 5: Negative anode voltage applied through 8000 ohms. Starter connected to anode through 100,000 ohms.

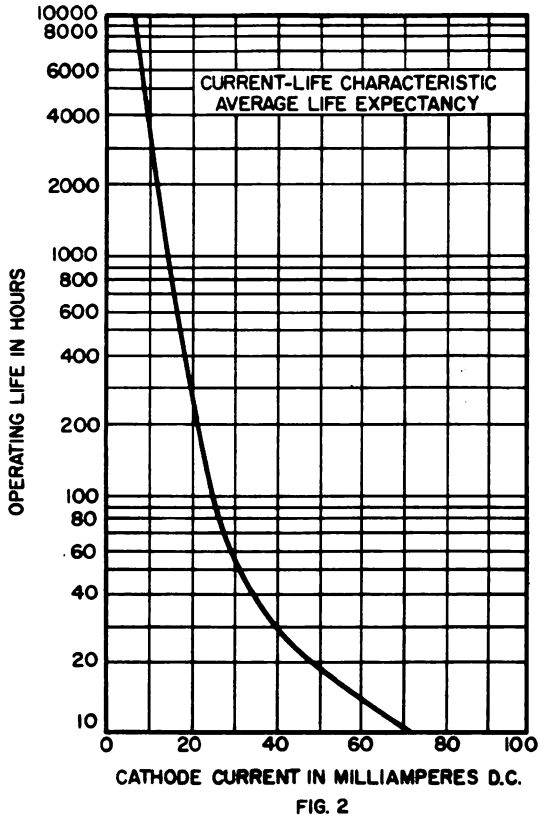


FIG. 2

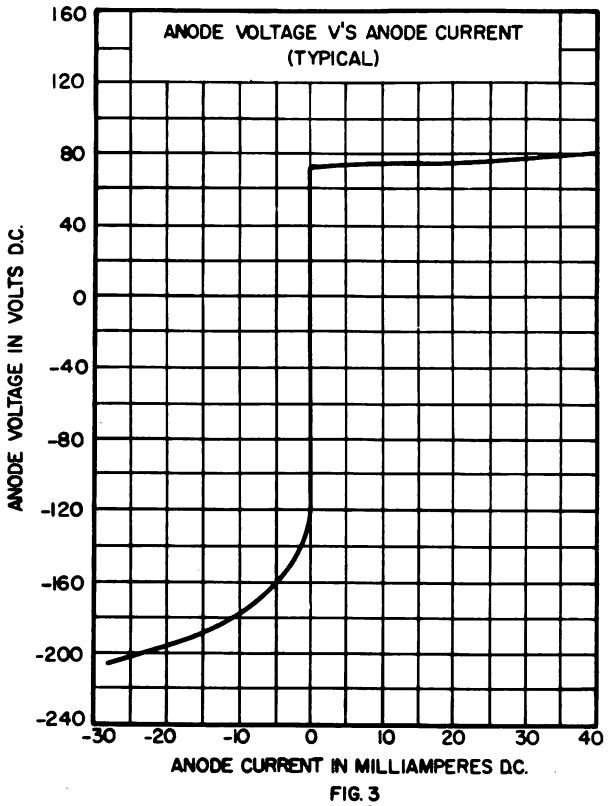
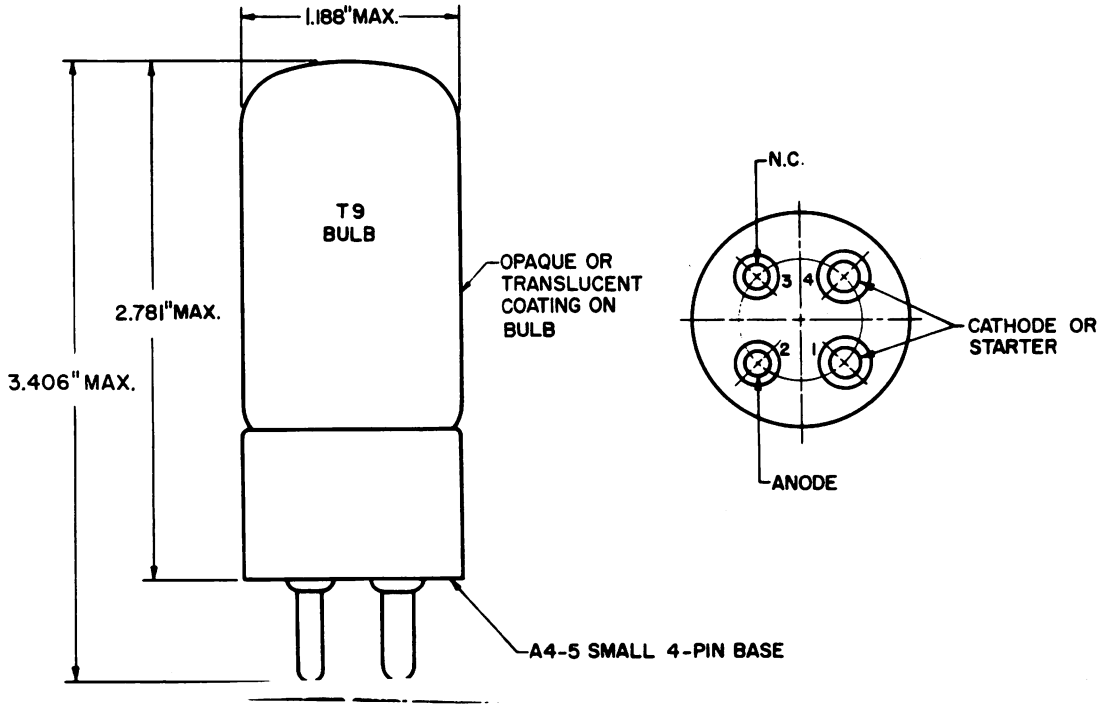


FIG. 3

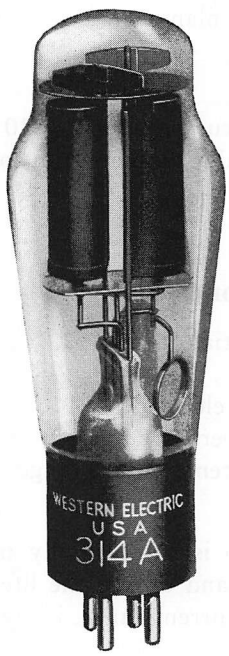


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Western Electric

314A Vacuum Tube



Classification—Full wave, thermionic, mercury vapor rectifier.

The 314A vacuum tube is designed to supply direct current from an alternating-current supply.

Dimensions—The dimensions and outline diagrams are given in Figures 1 and 2. The overall dimensions are:

Maximum length	6½″
Maximum diameter	2 7/16″

Mounting—The 314A employs a standard 4 pin thrust type base suitable for use in a Western Electric 143B or similar socket. Base dimensions and the arrangements of electrode connections to the base terminals are shown in Figs. 1 and 2.

The tube should be mounted in a vertical position with the base end down. There should be a free circulation of air around the tube. No object should touch the glass bulb.

Filament Rating

Filament voltage	5.0 volts
Nominal filament current	5.0 amperes

The filament of this tube is designed to operate on a voltage basis from an alternating-current supply. The voltage should be maintained to within 5% of its rated value (5.0 volts). Operation of the filament at a voltage above the upper limit will definitely reduce the life of the tube while a decrease in voltage below the lower limit may cause immediate failure.

Sufficient time must always be allowed for the filament temperature to reach its normal operating value before the anode potential is applied. If filament circuits with good regulation are used, this time is 30 seconds. If the tube is operated at ambient temperatures below 25° C., a longer period of time is required for the purpose of bringing the mercury vapor pressure to a satisfactory operating value. The minimum filament warming time as a function of ambient temperature is shown in figure 3.

For proper distribution of the mercury a period of 10 to 15 minutes filament warming time should be allowed when the tube is used for the first time or if it has been reinserted in the apparatus after having been removed.

Characteristics and Operating Conditions

Approximate anode-cathode potential drop	10 volts
Maximum peak plate current	2.5 amperes
Maximum peak potential between electrodes	300 volts
Maximum operating ambient temperature range	0 to 50° C.
Recommended operating ambient temperature range	10 to 40° C.

The anode-cathode potential drop is substantially independent of the plate current. The exact value varies from tube to tube and during the life of a given tube. Within the specified ambient temperature range and plate current range, it may vary from 5 to 25 volts.

The anode-cathode drop as a function of temperature is shown on Fig. 4 for a typical 314A tube after reaching temperature equilibrium and when passing the rated plate current.

The maximum permissible peak plate current (2.5 amperes) is a limitation on the instantaneous value that the tube can carry safely in the direction in which it is designed to conduct and should not be exceeded. The maximum direct load current is not fixed but will depend upon the wave form required by the load and filter circuit.

The maximum permissible peak potential between electrodes (300 volts) is a limitation on the instantaneous value that the tube can stand safely. If it is exceeded, an arc-back may result which will injure the tube. The maximum direct potential available is not fixed but will depend upon the type of circuit used.

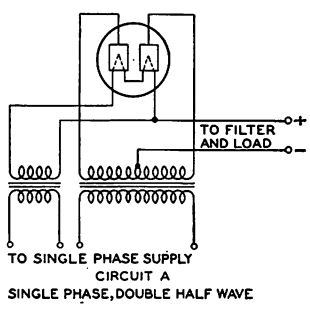
314A vacuum tubes may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode, may be used for this purpose. The size of the reactors or resistors depends upon the circuit design.

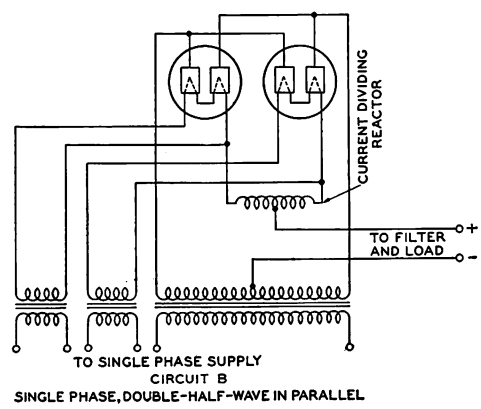
In most cases the termination of the useful life of the 314A tube is due to the loss of filament activity. This causes the tube to fail by arcing between the electrodes. Failures of this kind should be safeguarded by proper fuse protection to prevent injury to other tubes in the circuit and to the auxiliary equipment.

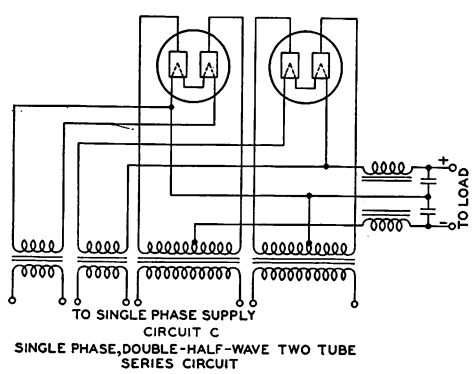
Typical Rectifier Circuits—The 314A vacuum tube may be used in any standard high vacuum rectifier circuit subject to its current, voltage and temperature limitations. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible plate current and inverse voltage are given in Table 1. The values listed are average values of the pulsating current and voltage for an unfiltered circuit.

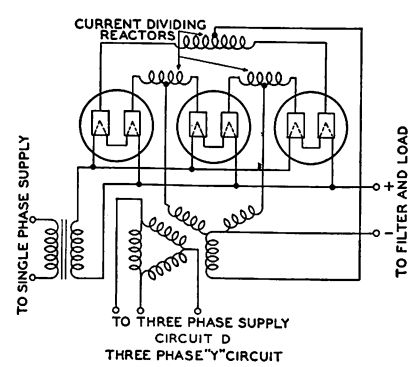
Table 1

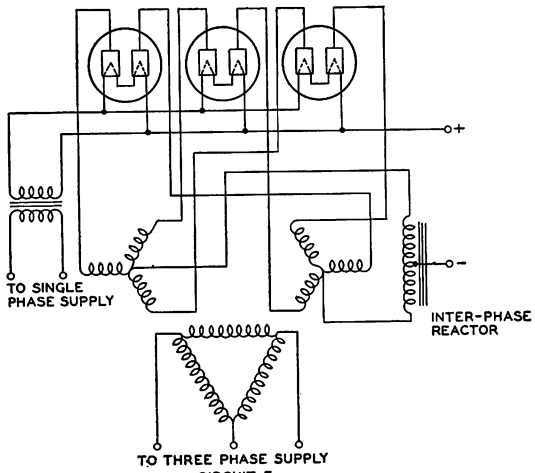
Circuit Designation	Phase Supply	Number of Tubes	Load Potential in Volts	Load Current in Amperes
A	1	1	80	1.6
B	1	2	75	3.2
C	1	2	165	1.6
D	3	3	125	4.2
E	3	3	100	4.6
F	1	3	165	1.6

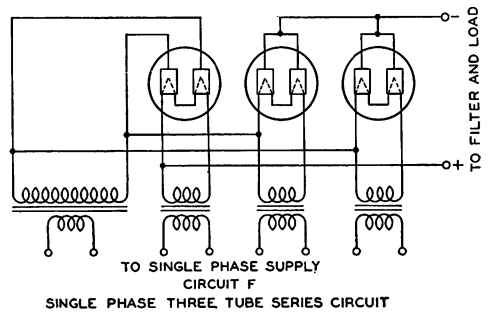









+
-
TO SINGLE PHASE SUPPLY
INTER-PHASE REACTOR
TO THREE PHASE SUPPLY
CIRCUIT E
THREE PHASE, DOUBLE "Y" INTERCONNECTED


-
+
TO FILTER AND LOAD
TO SINGLE PHASE SUPPLY
CIRCUIT F
SINGLE PHASE THREE TUBE SERIES CIRCUIT

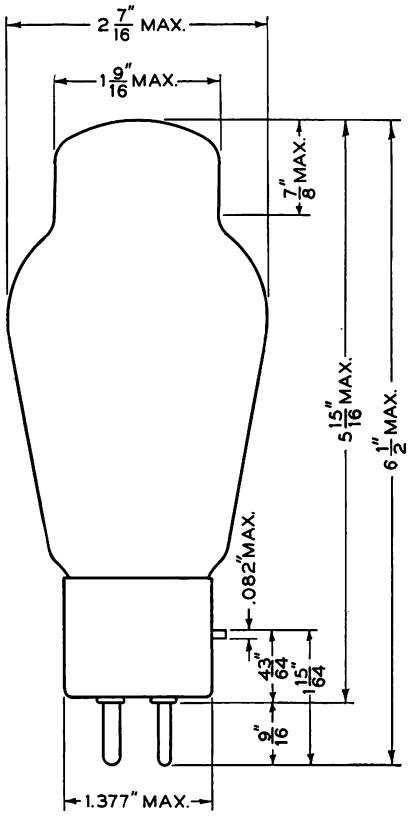

2 7/16" MAX.
1 9/16" MAX.
7/8" MAX.
5 15/16" MAX.
6 1/2" MAX.
.082" MAX.
43/64"
15/64"
9/16"
1.377" MAX.

FIG. 1

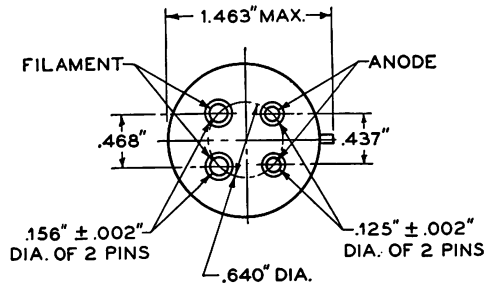

1.463" MAX.
FILAMENT
ANODE
.468"
.437"
.156" ± .002"
DIA. OF 2 PINS
.640" DIA.
.125" ± .002"
DIA. OF 2 PINS

FIG. 2

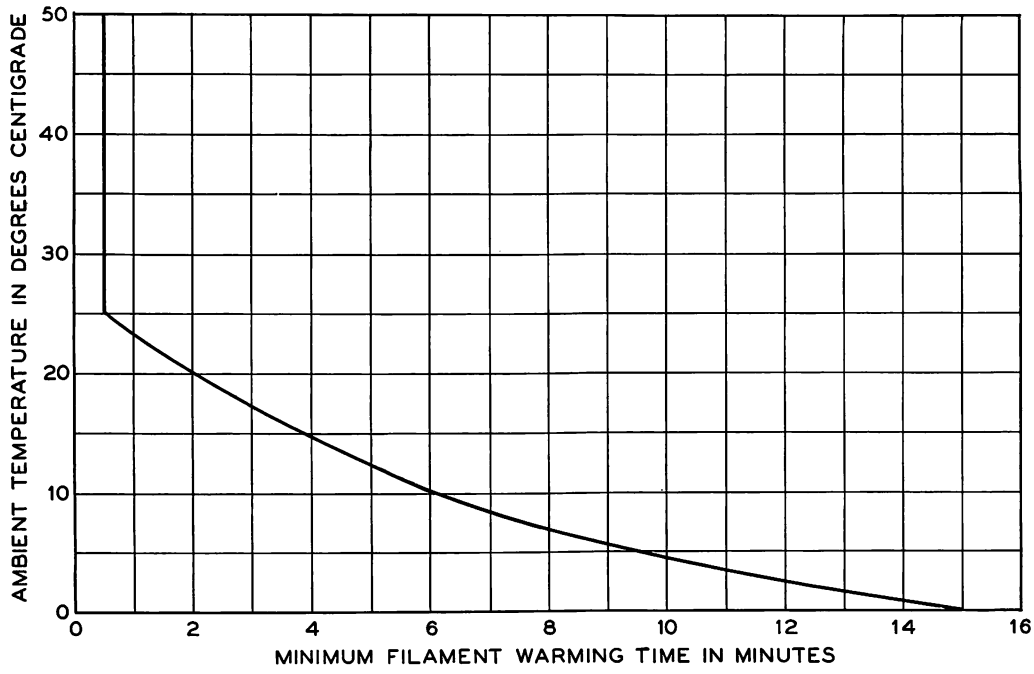


FIG. 3

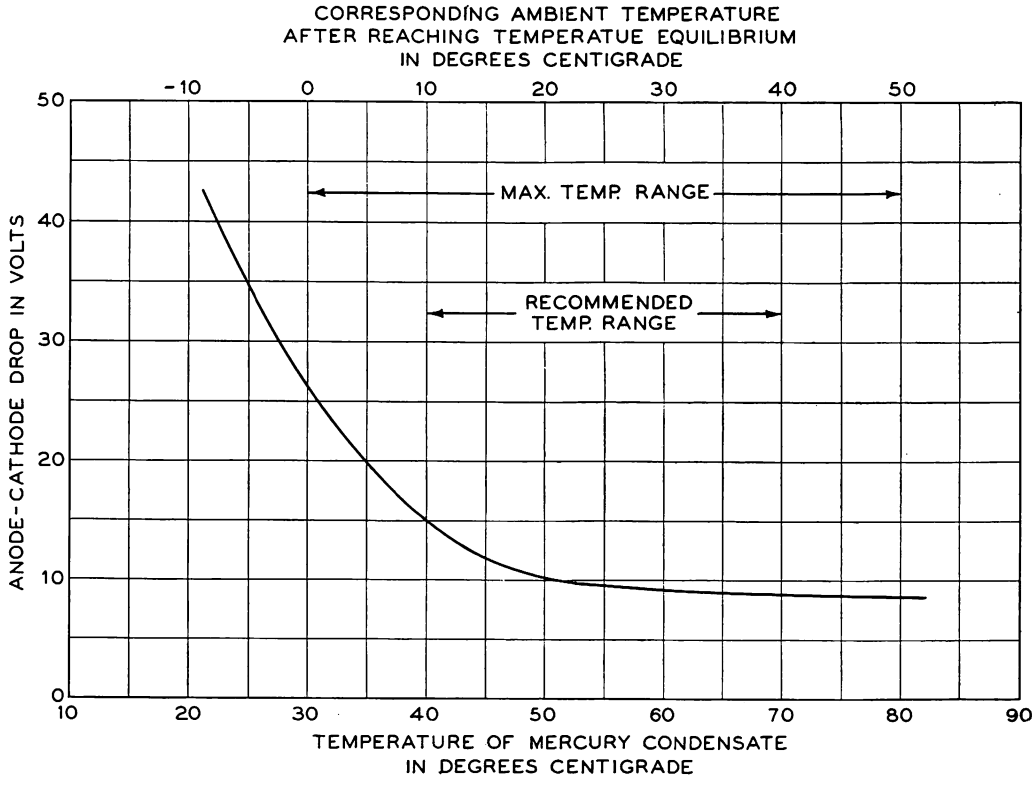


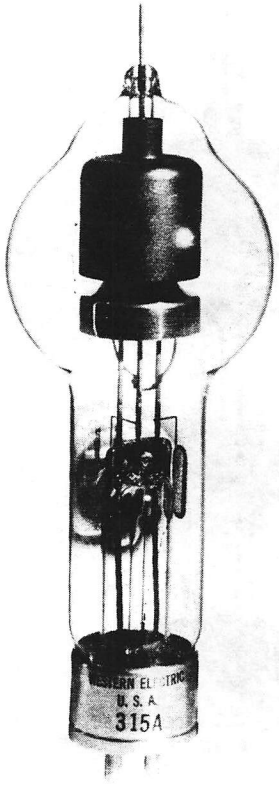
FIG. 4

1-B-37-62C

A development of Bell Telephone Laboratories, Incorporated, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company

V. T. DATA SHEET 314A
ISSUE 1

SECTION AB46.315A
ISSUE 1, APRIL 1948
A.T.&T. CO. STANDARD



RECTIFIER
HALF-WAVE, MERCURY-VAPOR

Western Electric

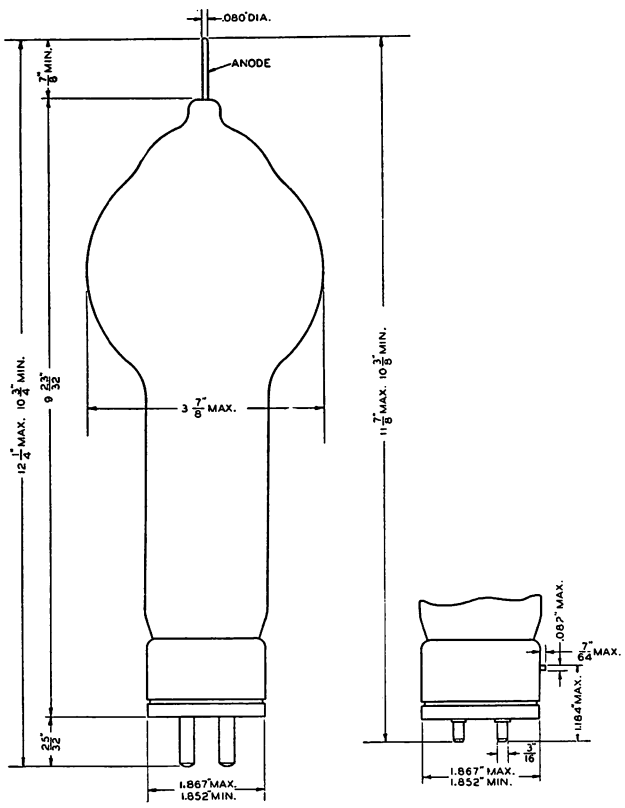
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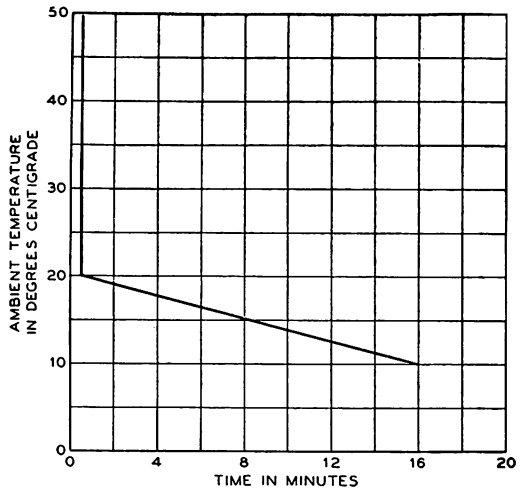
The 315A is a half-wave, mercury-vapor rectifier tube for use in high-voltage rectifier circuits.

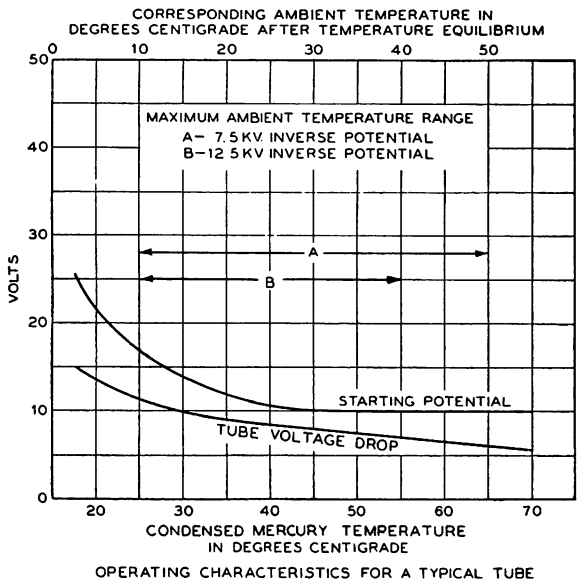
MAXIMUM RATINGS

Peak Inverse Anode Voltage	12500 volts
Average Cathode Current (Quadrature Operation)	2 amperes

315A and 321A Vacuum Tubes







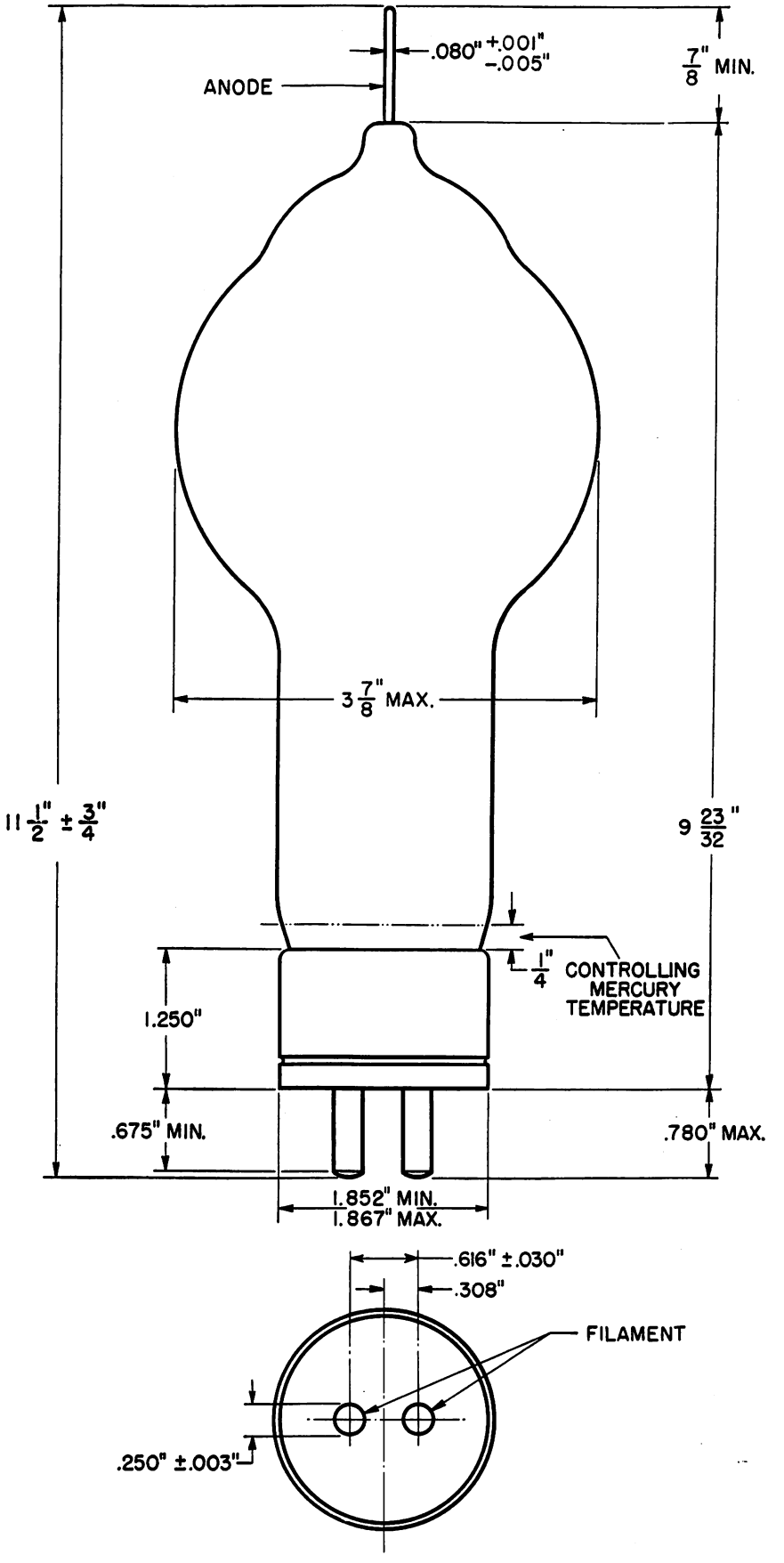
Ratings

Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averaging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	
at 10 to 40° C. ambient temperature	12.5 kilovolts
at 10 to 50° C. ambient temperature	7.5 kilovolts

Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Output Voltage: At 12.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	3800	1	2
B	2	2300	3800	2	4
C	4	2300	3800	4	8
D	4	4600	7600	2	4
E	3	3500	5800	3	6
F	6	7000	11500	3	—
G	6	3000	5000	5	10
H	6	7000	11500	—	6
I	6	7000	11500	—	6



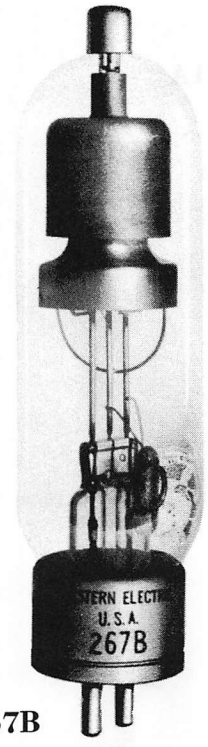
ELECTRON TUBE DATA SHEET
FILE: RECTIFIER SECTION
6-47

Western Electric

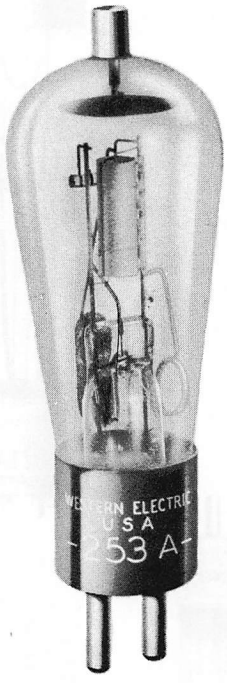
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

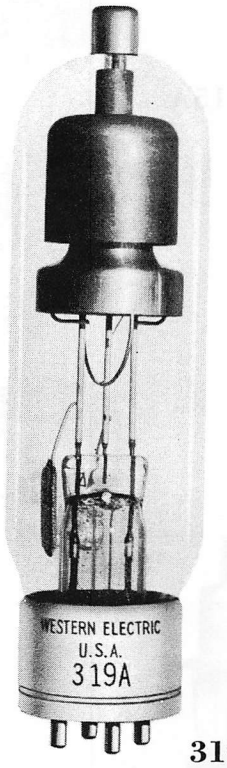
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



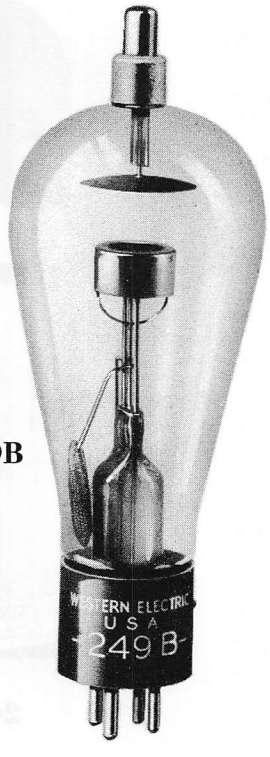
267B



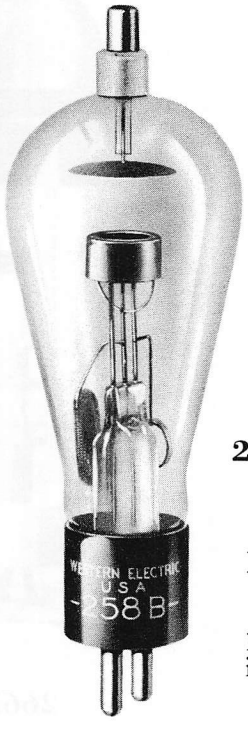
253A



319A



249B

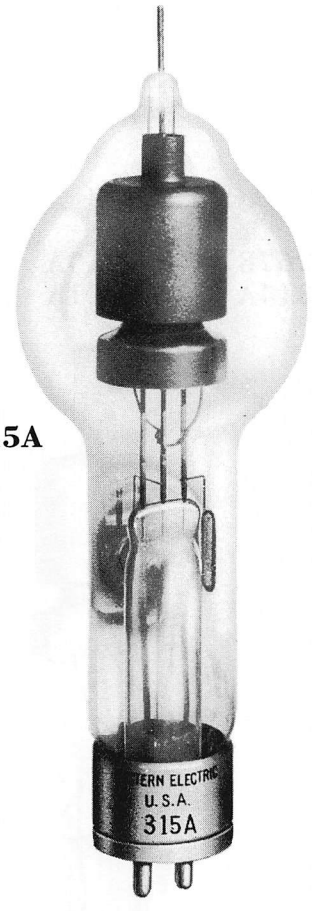


258B

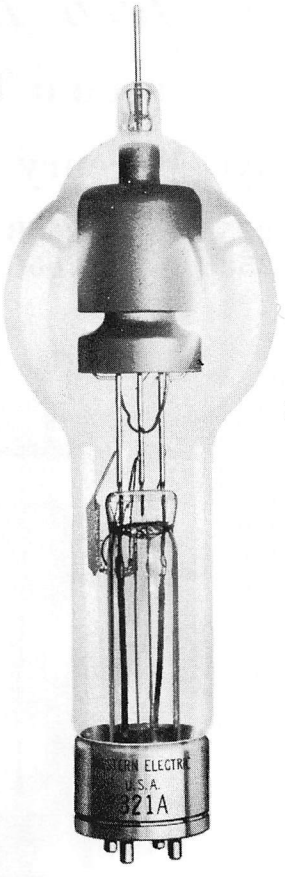
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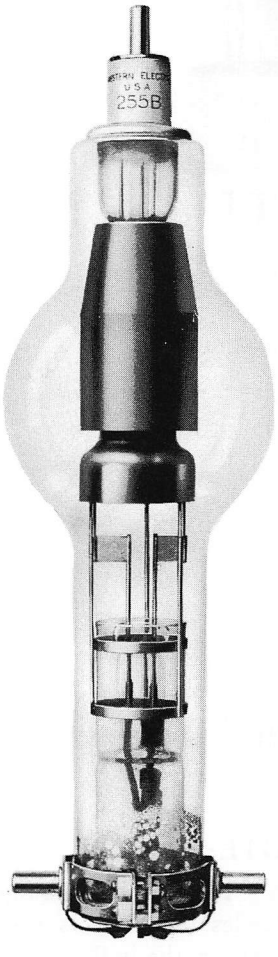
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

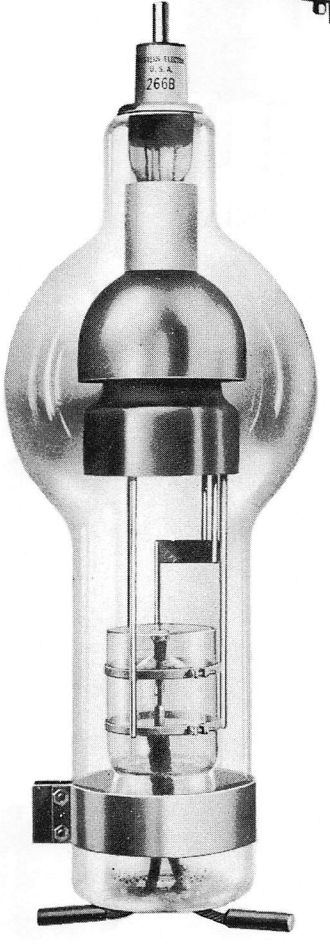


321A

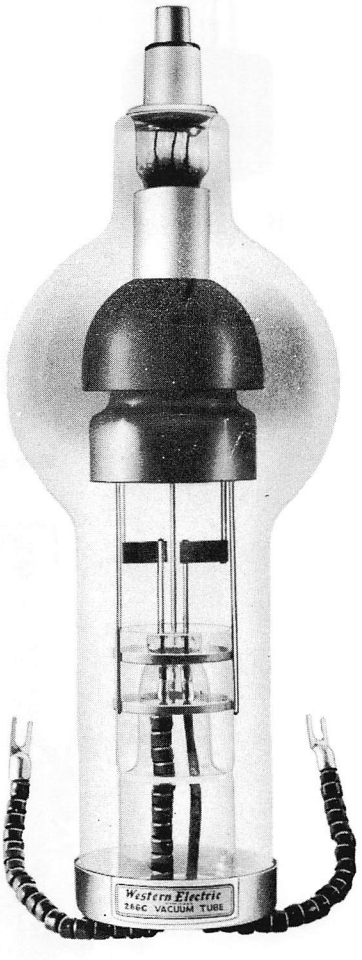




255B



266B



266C

Classification

These tubes are half-wave, thermionic, mercury vapor rectifiers designed to supply direct-current from an alternating-current supply.

Mounting—The tubes should be mounted only in a vertical position with the base or filament end down. Free air circulation must be provided. No object should touch the glass bulb.

Filament—The filaments are designed to operate from alternating current sources. The voltage should be maintained to within 5% of the rated value. Operation of the filaments at a voltage above the upper limit will definitely reduce the life of the tubes while a decrease in voltage below the lower limit may cause immediate failure.

Normal Filament Heating

The anode voltage should not be applied until the filaments have reached a satisfactory operating temperature. When normal filament voltage and circuits with good regulation are used, the minimum time required is specified on the individual tube data sheet as the "Required Heating Time." It is also necessary to allow sufficient filament heating time to evaporate any visible mercury deposits from the upper parts of the tubes.

When the tubes are put into operation at low ambient temperatures, an extended filament heating time is necessary to raise the mercury vapor pressure to a satisfactory operating value. This time is given in graph form on the individual tube data sheet for tubes requiring such heating when operating within the recommended ambient temperature range. A filament heating period of 30 minutes or more should be allowed when the tubes are used for the first time or if they have been subjected to extensive handling or prolonged standing.

Accelerated Filament Heating

In certain applications it may be desirable to reduce the "Required Heating Time" designated for normal filament voltage. This may be accomplished by applying an overvoltage to the filament for a short period after which the rated filament voltage and the anode voltage is applied. The recommended open circuit overvoltage and the corresponding period of application are given on the individual tube data sheet. These ratings apply when the regulation of the filament supply circuit is 10% ± 4%.

Tube Voltage Drop

The tube voltage drop is substantially independent of the anode current. The exact value varies but under the specified operating conditions will normally be between 5 and 25 volts.

Maximum Anode Current

The maximum permissible instantaneous and average anode current ratings are limitations on the current values that the tubes can carry safely in the direction in which they are designed to conduct and should not be exceeded. The current ratings specified under "In-phase Operation" apply when the filament and anode voltages are in phase, or where the relative phase angle is ignored. The "Quadrature Operation" ratings may be used when the circuit is designed so that the phase angle between the filament and anode voltage is approximately 90 electrical degrees. With this type of operation, the filament current goes through zero near the center of the anode conduction period, resulting in a balanced operating condition for the filament, which permits the higher anode currents.

Maximum Peak Inverse Anode Voltage

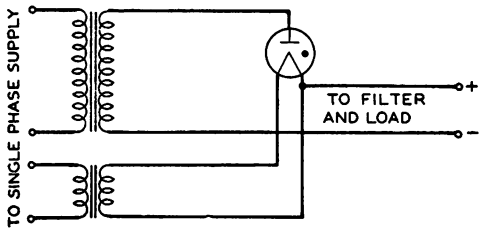
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output voltage available is not fixed but will depend upon the type of circuit used.

Tubes of the same type may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode may be used for this purpose. The size of the reactors or resistors will depend upon the circuit design.

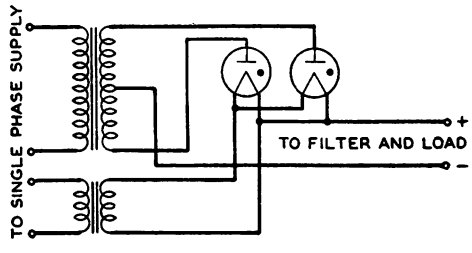
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits this requires a quick acting high-voltage fuse in each anode lead or an equally fast primary fuse or circuit breaker.

Circuits

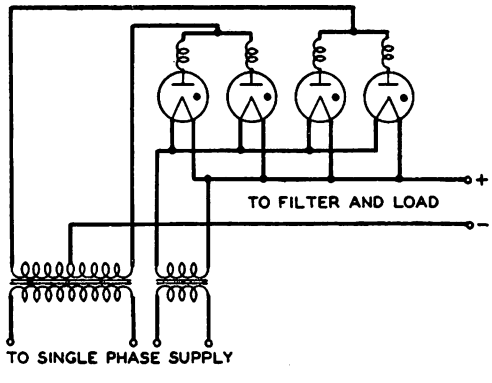
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and inverse voltage is given on the individual tube data sheet. The values listed are average values of the pulsating current and voltage for an unfiltered circuit.



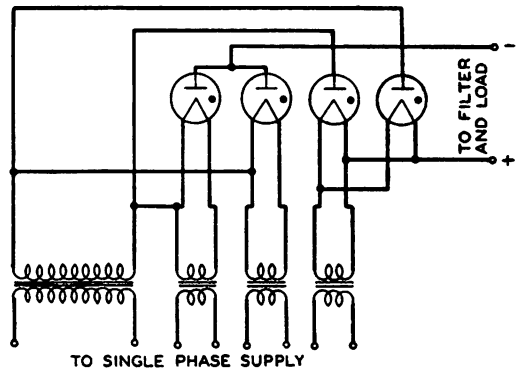
SINGLE PHASE, HALF-WAVE
CIRCUIT A



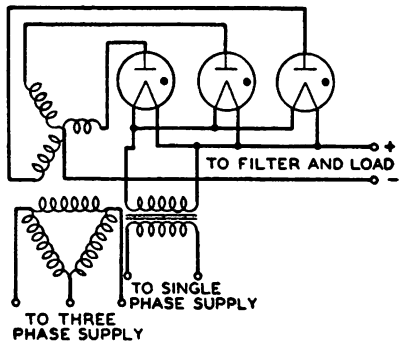
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



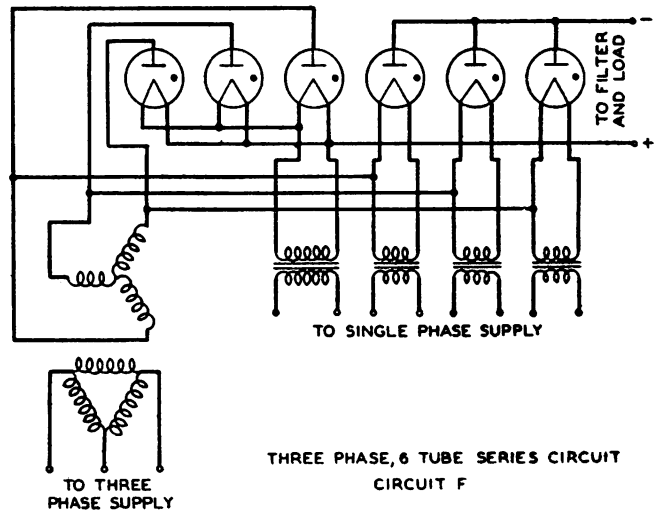
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



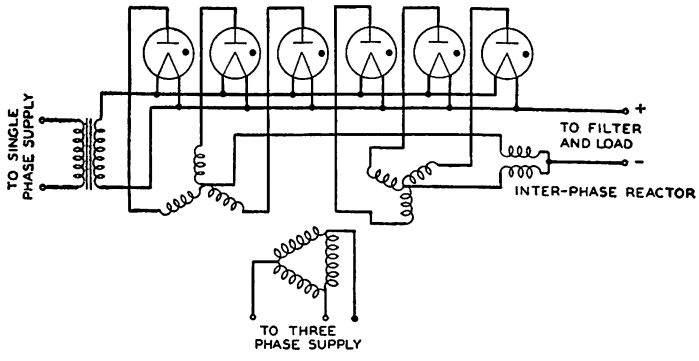
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



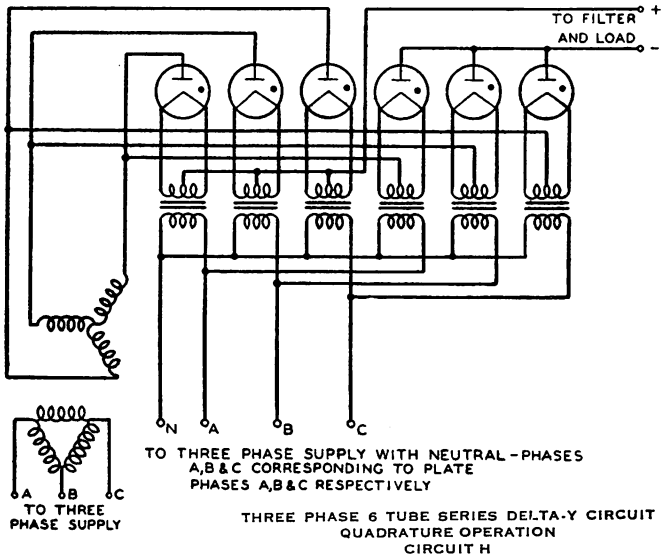
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

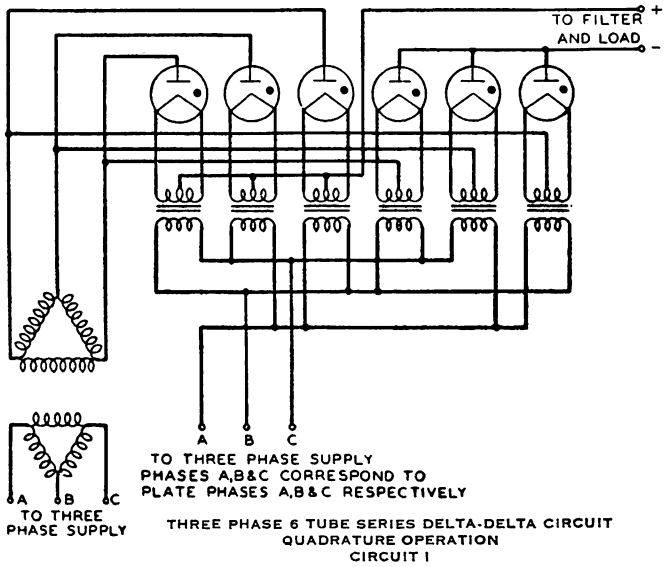


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



TO THREE PHASE SUPPLY WITH NEUTRAL - PHASES
A,B & C CORRESPONDING TO PLATE
PHASES A,B & C RESPECTIVELY

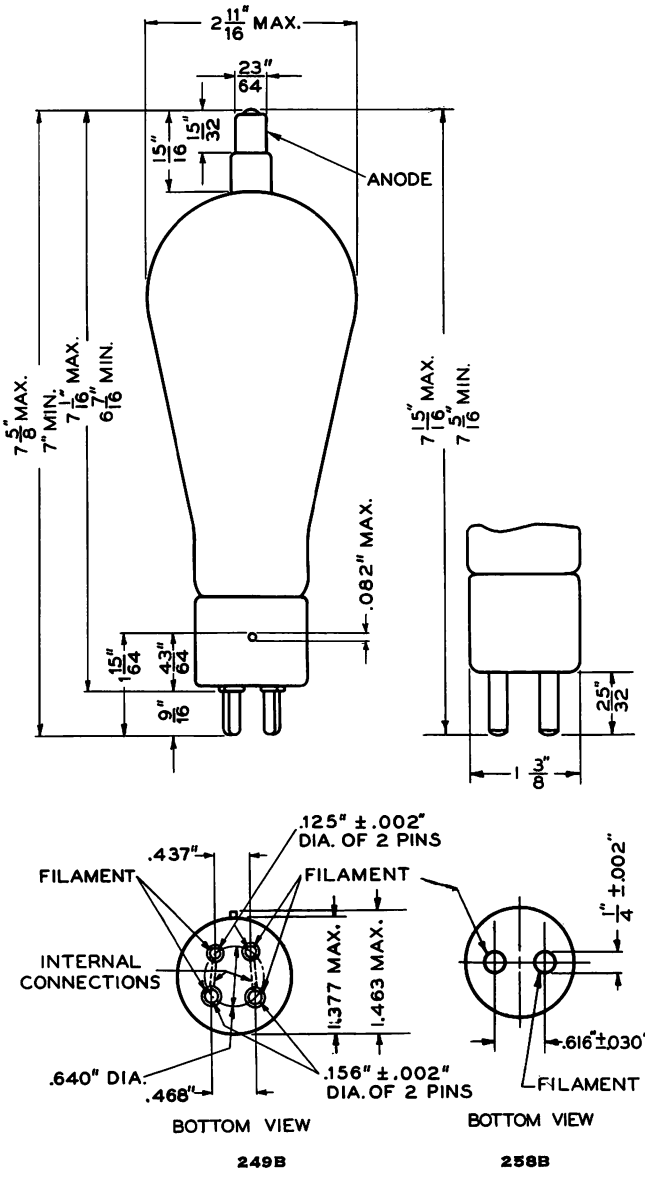
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

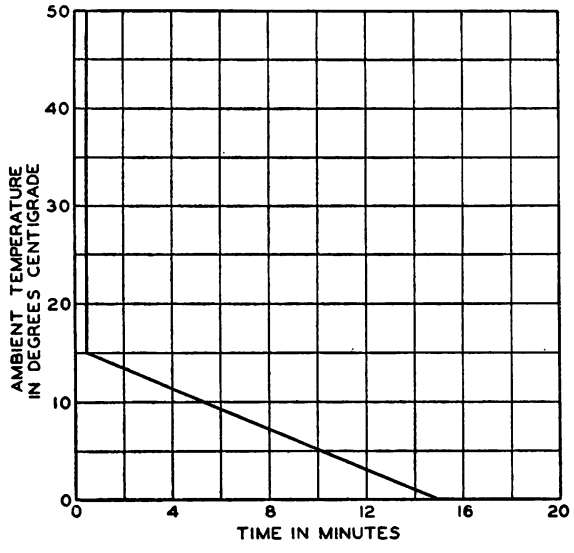


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

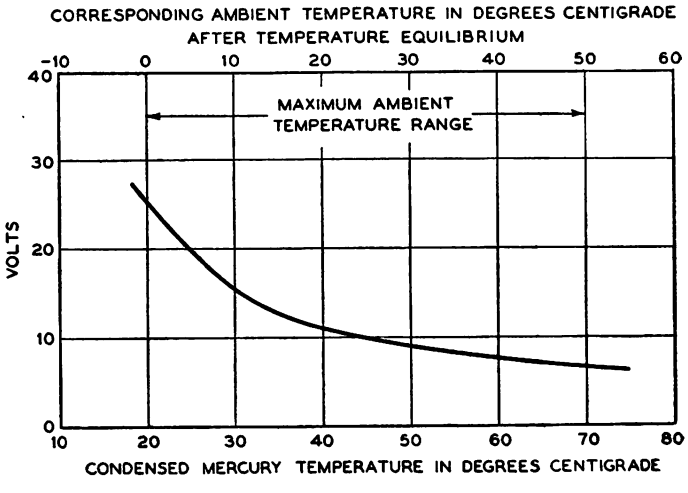
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

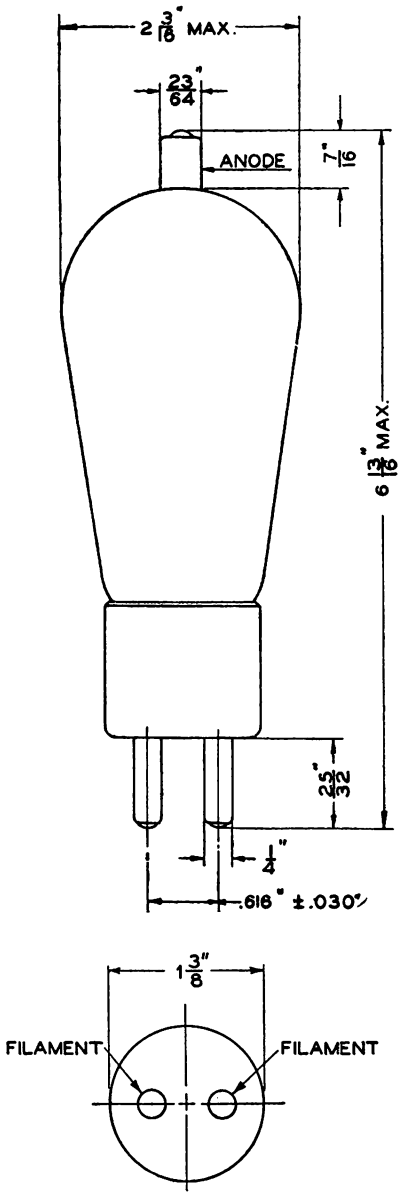
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 amperes
Maximum Average Anode Current	0.64 ampere
Max. Time of Averaging Anode Current	5 seconds
Maximum Peak Inverse Anode Voltage	7.5 kilovolts
Maximum Ambient Temperature Range	0 to 50°C.

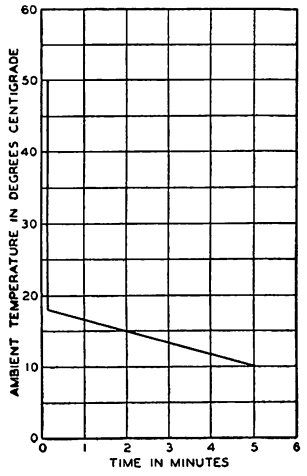
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

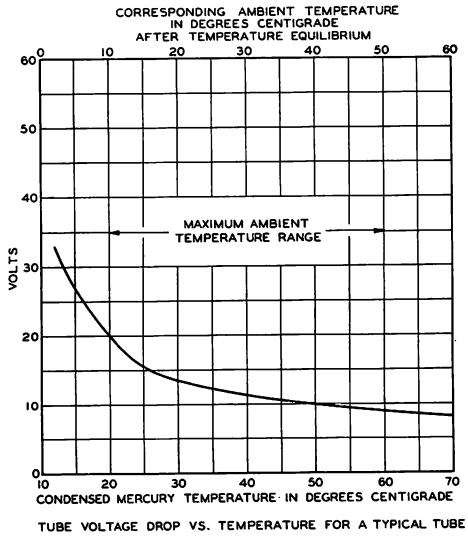
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

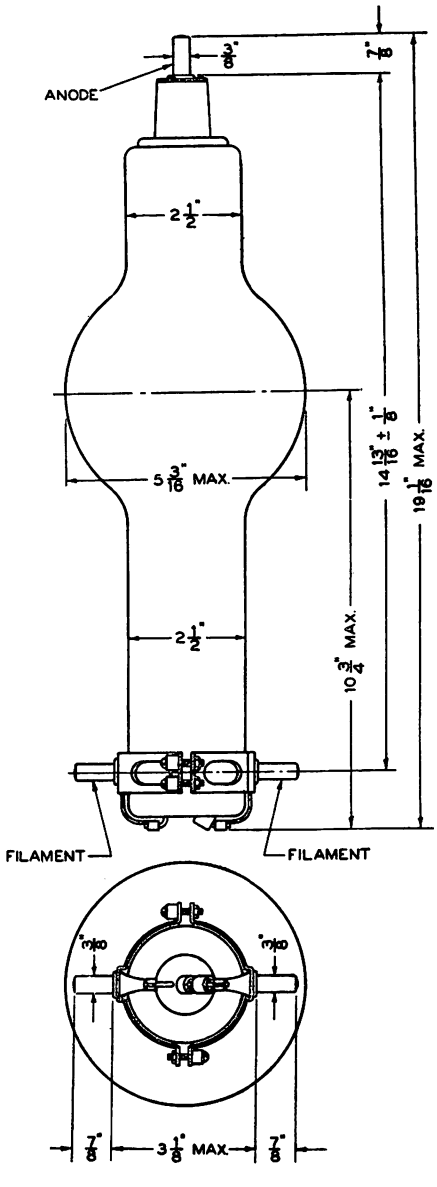
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 ampere
Maximum Average Anode Current	0.25 ampere
Max. Time of Averaging Anode Current	5 seconds
Maximum Peak Inverse Anode Voltage	3500 volts
Maximum Ambient Temperature Range	10 to 50° C.

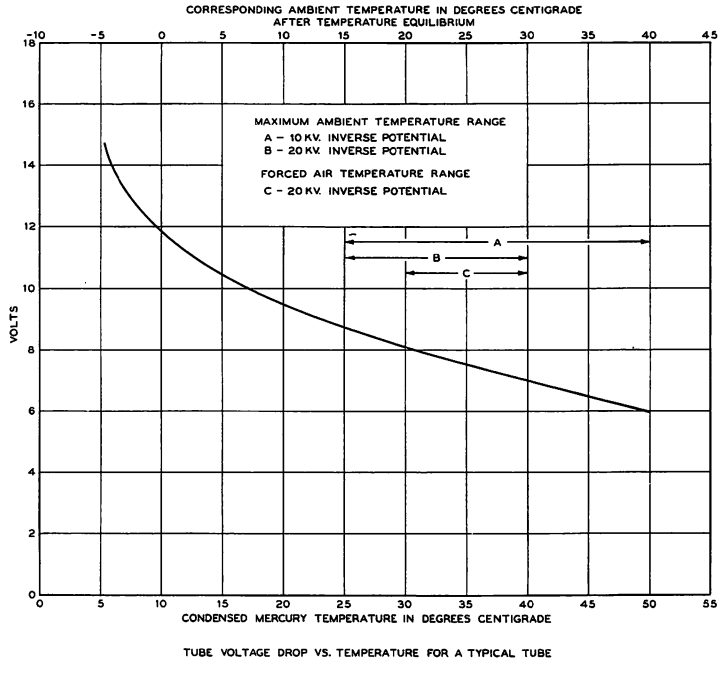
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage At 3500 volts Inverse Voltage	Load Current In DC Amperes
A	1	1000	0.25
B	2	1000	0.50
C	4	1000	1.00
D	4	2000	0.50
E	3	1500	0.75
F	6	3000	0.75
G	6	1400	1.25

255B Vacuum Tube





TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Maximum Peak Inverse Anode Voltage

at 15 to 30° C. ambient temperature	20 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	20 kilovolts

This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 6 cu. ft. per minute from a 1 inch nozzle and directed just above the support collar is recommended.

Mounting—Special mounting is required. Mount in vertical position only—filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be semi-flexible.

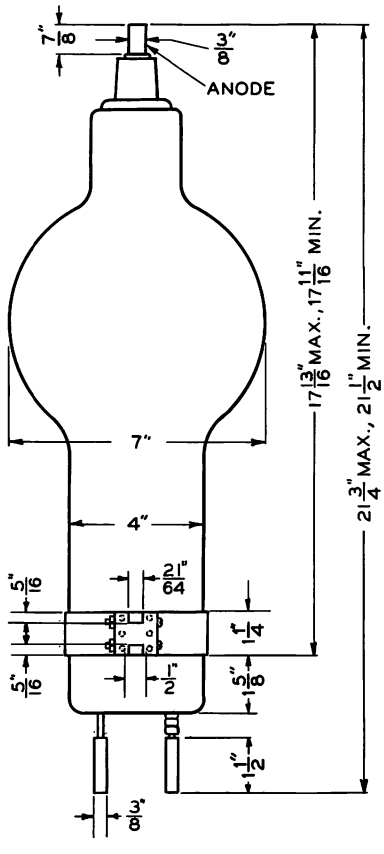
Ratings

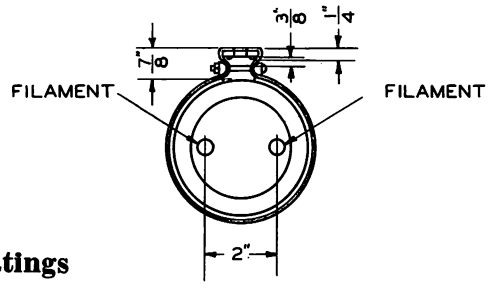
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	8 amperes
Quadrature Operation	16 amperes
Maximum Average Anode Current	
In-Phase Operation	2 amperes
Quadrature Operation	4 amperes
Max. Time of Averaging Anode Current	30 seconds

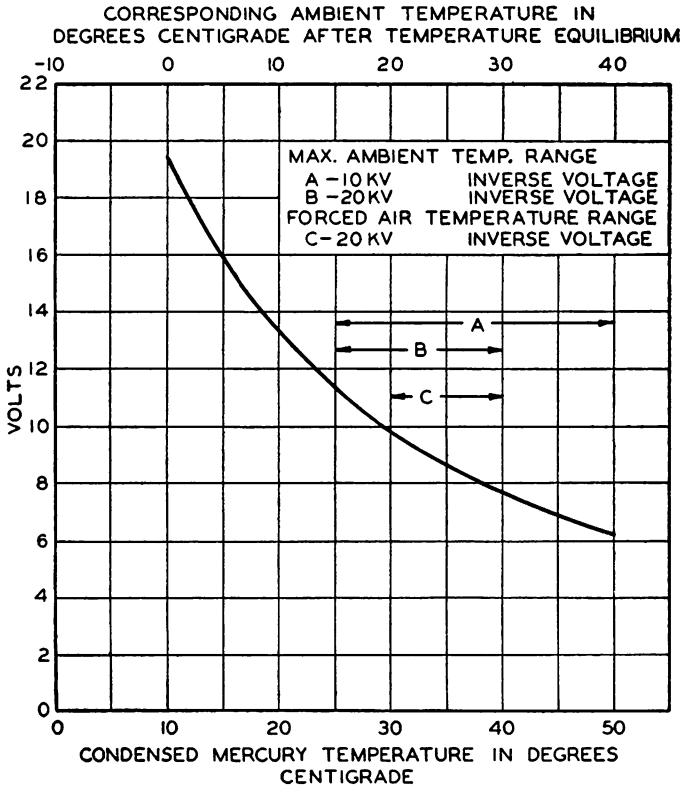
Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 20 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6000	2	4
B	2	3000	6000	4	8
C	4	3000	6000	8	16
D	4	6000	12000	4	8
E	3	4500	9000	6	12
F	6	9000	18000	6	—
G	6	4000	8000	10	20
H	6	9000	18000	—	12
I	6	9000	18000	—	12

266B Vacuum Tube







TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	42.0 amperes
Required Heating Time	300 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	30±5 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	20 amperes
Quadrature Operation	40 amperes
Maximum Average Anode Current	
In-Phase Operation	5 amperes
Quadrature Operation	10 amperes
Max. Time of Averaging Anode Current	60 seconds
Maximum Peak Inverse Anode Voltage	
at 15 to 30° C. ambient temperature	20 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	20 kilovolts

This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 8 cu. ft. per minute from a 1 inch nozzle and directed just below the support collar is recommended.

Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connections to the filament and anode terminals should be flexible.

Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 20 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6000	5	10
B	2	3000	6000	10	20
C	4	3000	6000	20	40
D	4	6000	12000	10	20
E	3	4500	9000	15	30
F	6	9000	18000	15	—
G	6	4000	8000	25	50
H	6	9000	18000	—	30
I	6	9000	18000	—	30

266C Vacuum Tube

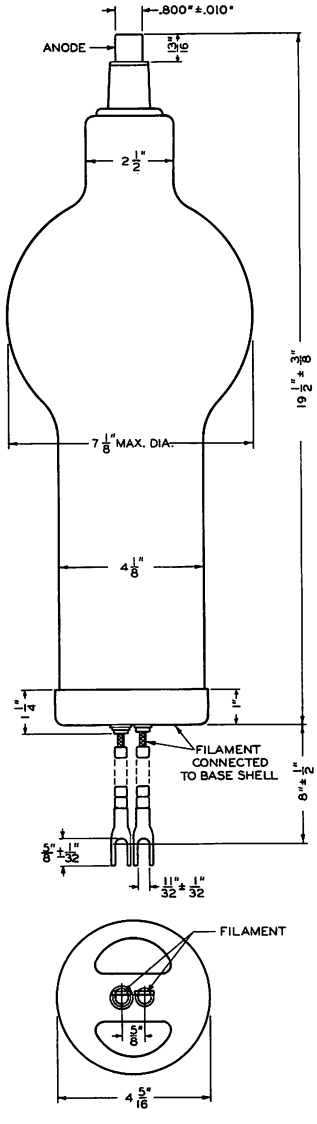
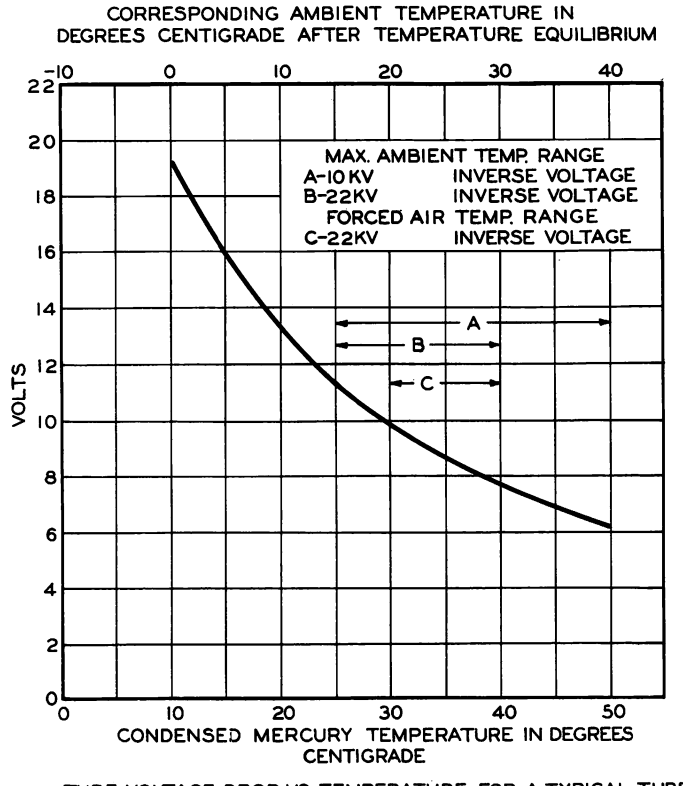


FIG. 1



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	42.0 amperes
Required Heating Time	300 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	30±5 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	20 amperes
Quadrature Operation	40 amperes
Maximum Average Anode Current	
In-Phase Operation	5 amperes
Quadrature Operation	10 amperes
Max. Time of Averaging Anode Current	60 seconds
Maximum Peak Inverse Anode Voltage	
at 15 to 30° C. ambient temperature	22 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	22 kilovolts

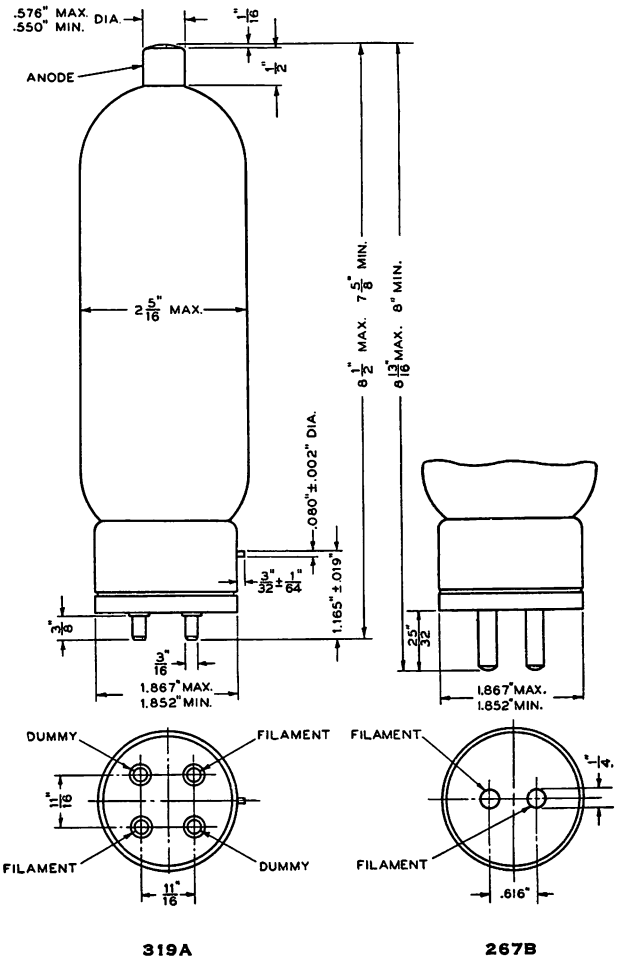
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

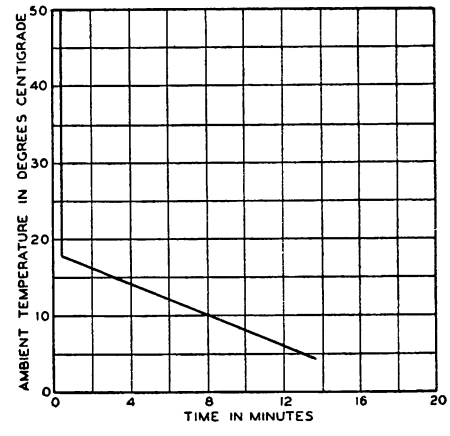
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

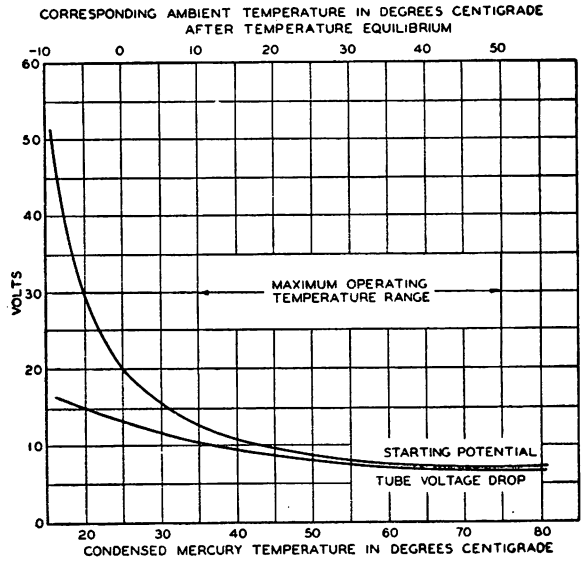
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	15	30
F	6	9000	20000	15	—
G	6	4000	9000	25	50
H	6	9000	20000	—	30
I	6	9000	20000	—	30

267B and 319A Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

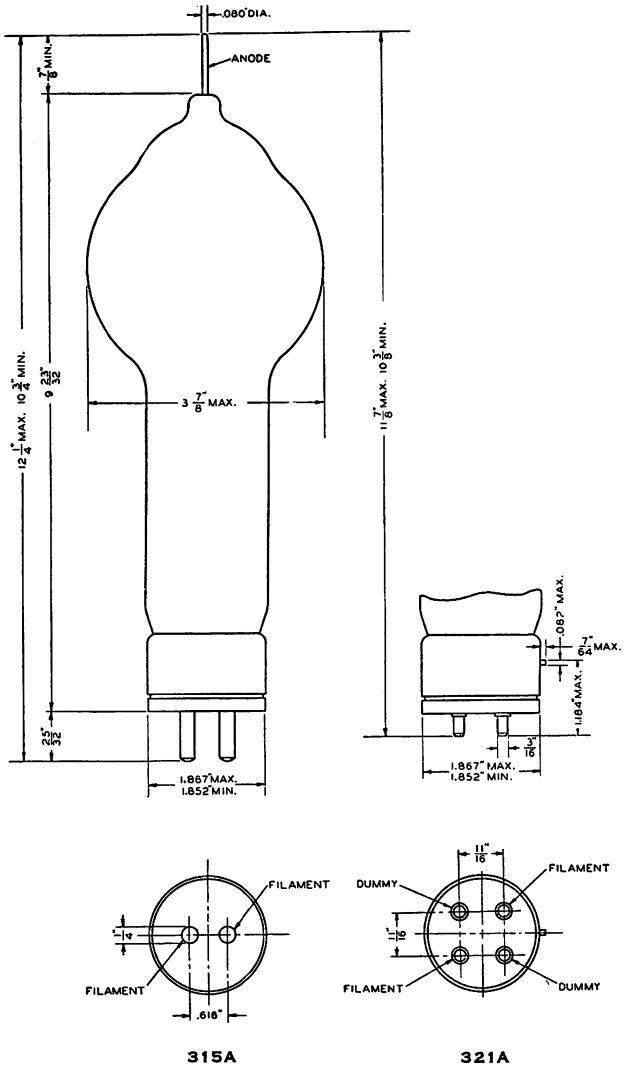
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	7.5 kilovolts
Maximum Ambient Temperature Range	10 to 50° C.

Mounting—The 267B tube requires a W. E. 138B, 139A or similar socket and the 319A tube a W. E. 148A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

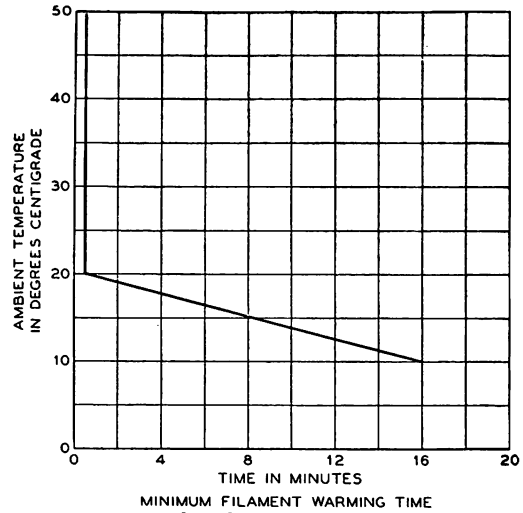
Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	1	2
B	2	2300	2	4
C	4	2300	4	8
D	4	4600	2	4
E	3	3500	3	6
F	6	7000	3	—
G	6	3000	5	10
H	6	7000	—	6
I	6	7000	—	6

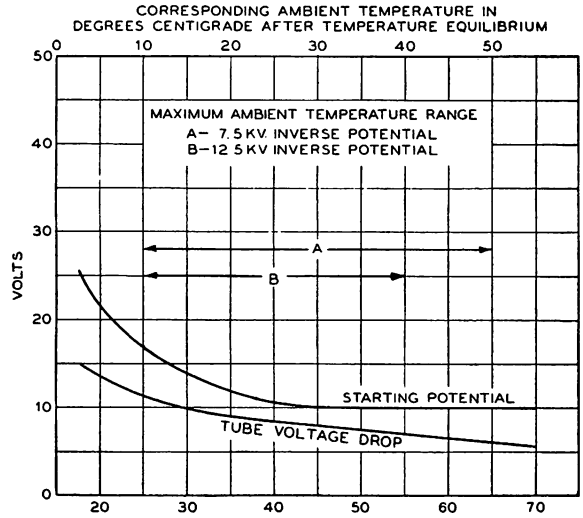
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averaging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	
at 10 to 40° C. ambient temperature	12.5 kilovolts
at 10 to 50° C. ambient temperature	7.5 kilovolts

Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

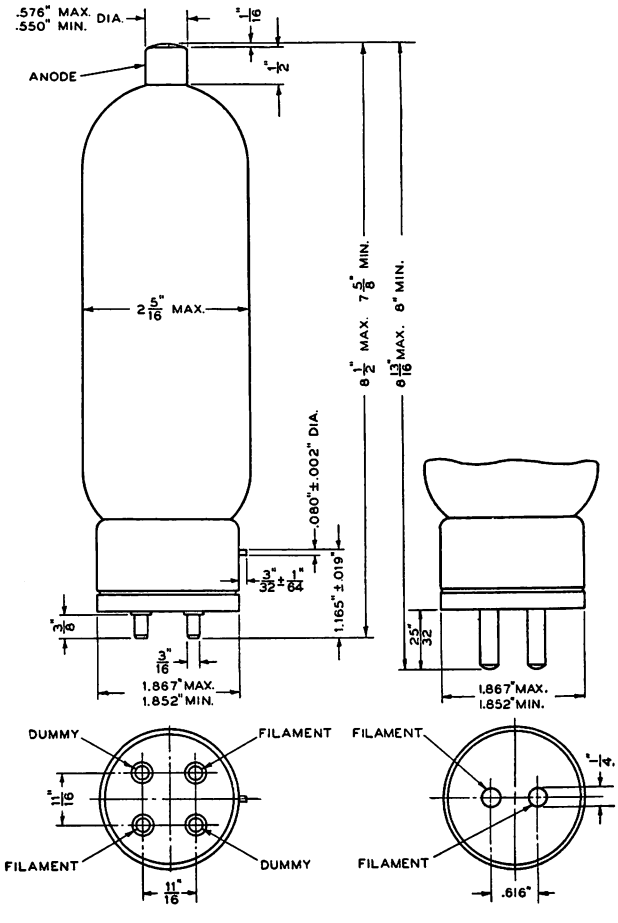
Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Output Voltage: At 12.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	3800	1	2
B	2	2300	3800	2	4
C	4	2300	3800	4	8
D	4	4600	7600	2	4
E	3	3500	5800	3	6
F	6	7000	11500	3	—
G	6	3000	5000	5	10
H	6	7000	11500	—	6
I	6	7000	11500	—	6

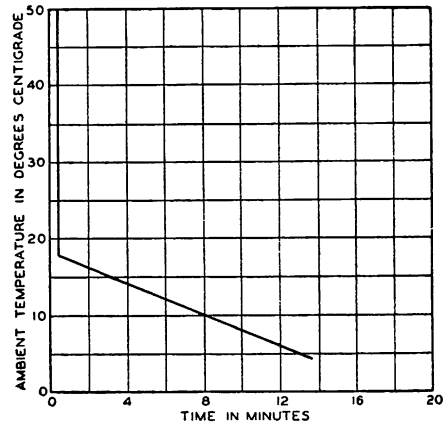
Western Electric

A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company

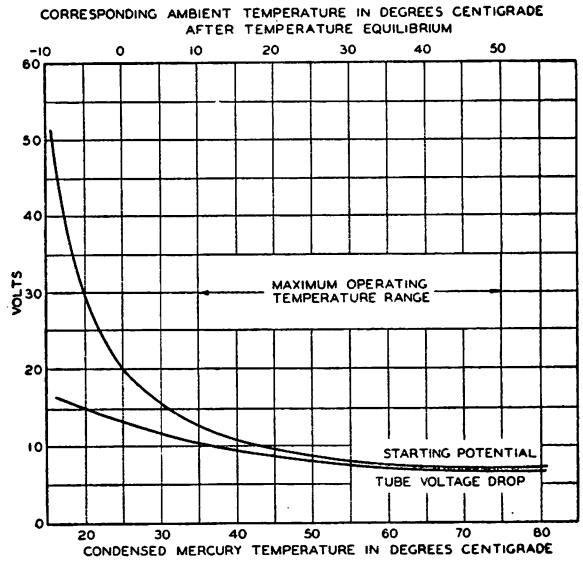
1-A—48—5 PRINTED IN U.S.A. WECO—T2451

267B and 319A Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	7.5 kilovolts
Maximum Ambient Temperature Range	10 to 50° C.

Mounting—The 267B tube requires a W. E. 138B, 139A or similar socket and the 319A tube a W. E. 148A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

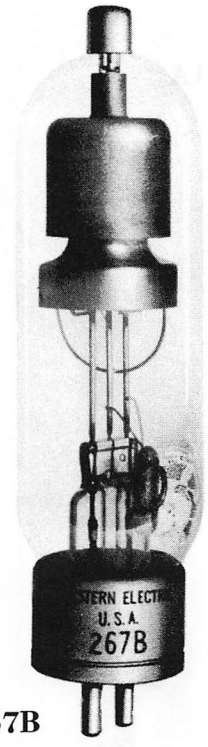
Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	1	2
B	2	2300	2	4
C	4	2300	4	8
D	4	4600	2	4
E	3	3500	3	6
F	6	7000	3	—
G	6	3000	5	10
H	6	7000	—	6
I	6	7000	—	6

Western Electric

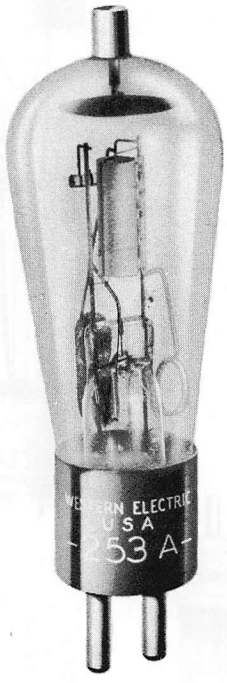
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

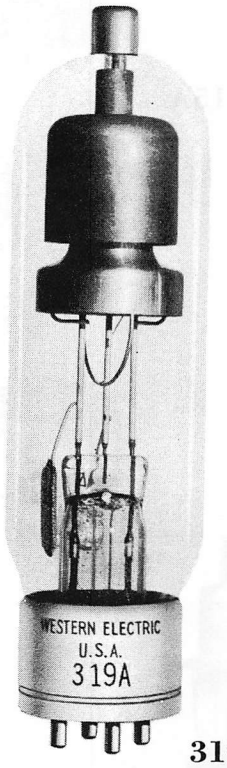
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



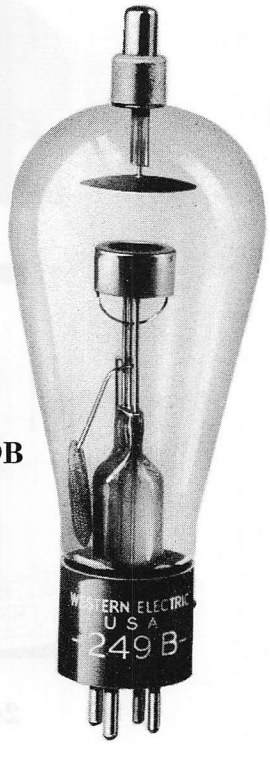
267B



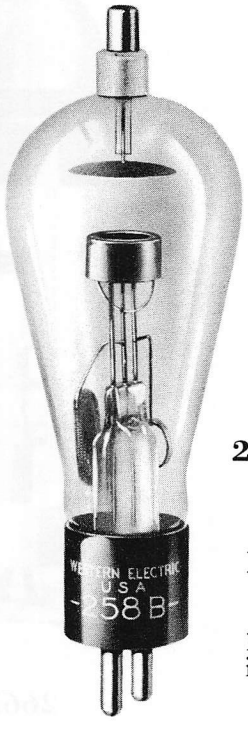
253A



319A



249B

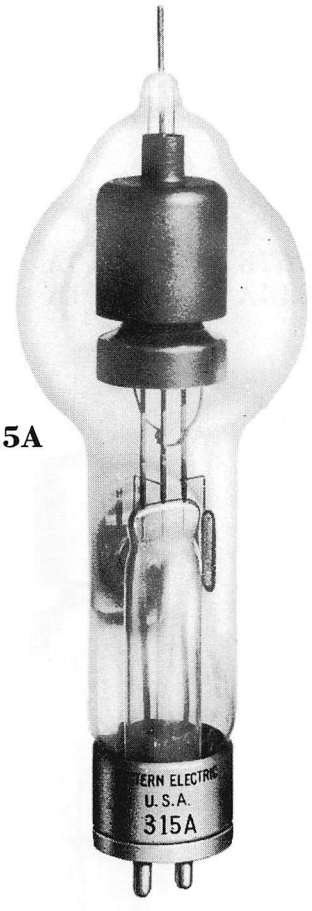


258B

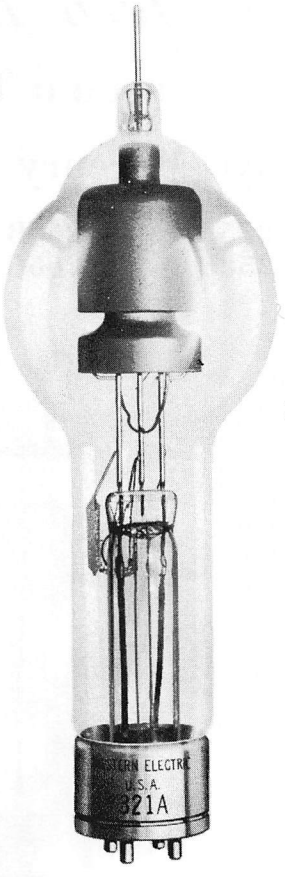
NOTE:

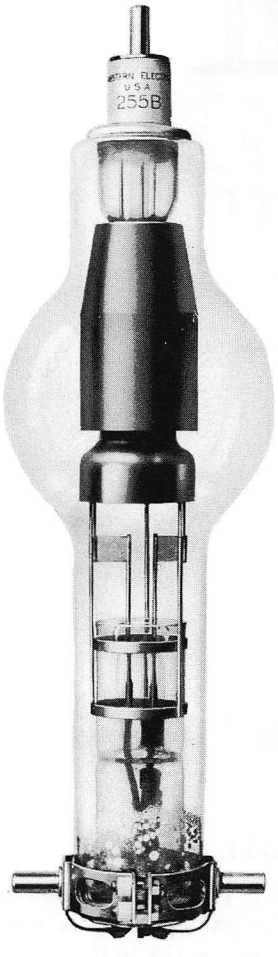
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

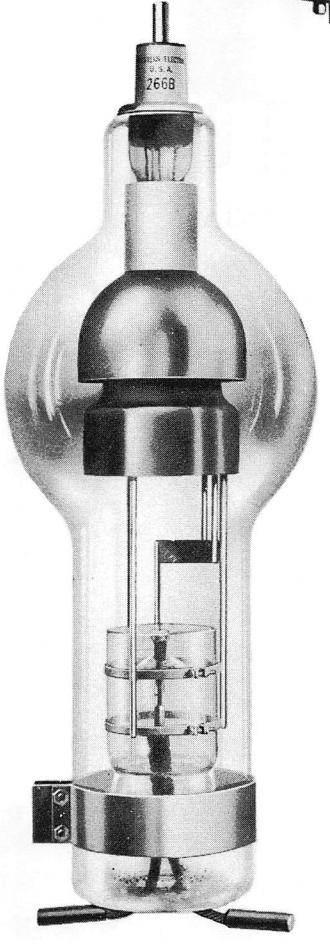


321A

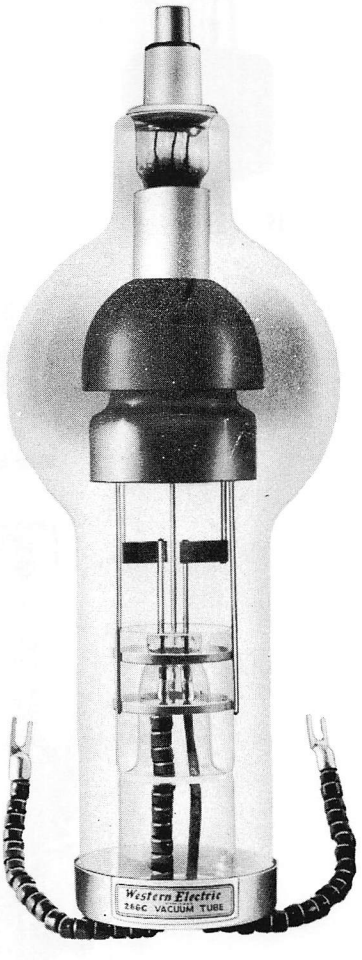




255B



266B



266C

Classification

These tubes are half-wave, thermionic, mercury vapor rectifiers designed to supply direct-current from an alternating-current supply.

Mounting—The tubes should be mounted only in a vertical position with the base or filament end down. Free air circulation must be provided. No object should touch the glass bulb.

Filament—The filaments are designed to operate from alternating current sources. The voltage should be maintained to within 5% of the rated value. Operation of the filaments at a voltage above the upper limit will definitely reduce the life of the tubes while a decrease in voltage below the lower limit may cause immediate failure.

Normal Filament Heating

The anode voltage should not be applied until the filaments have reached a satisfactory operating temperature. When normal filament voltage and circuits with good regulation are used, the minimum time required is specified on the individual tube data sheet as the "Required Heating Time." It is also necessary to allow sufficient filament heating time to evaporate any visible mercury deposits from the upper parts of the tubes.

When the tubes are put into operation at low ambient temperatures, an extended filament heating time is necessary to raise the mercury vapor pressure to a satisfactory operating value. This time is given in graph form on the individual tube data sheet for tubes requiring such heating when operating within the recommended ambient temperature range. A filament heating period of 30 minutes or more should be allowed when the tubes are used for the first time or if they have been subjected to extensive handling or prolonged standing.

Accelerated Filament Heating

In certain applications it may be desirable to reduce the "Required Heating Time" designated for normal filament voltage. This may be accomplished by applying an overvoltage to the filament for a short period after which the rated filament voltage and the anode voltage is applied. The recommended open circuit overvoltage and the corresponding period of application are given on the individual tube data sheet. These ratings apply when the regulation of the filament supply circuit is 10% ± 4%.

Tube Voltage Drop

The tube voltage drop is substantially independent of the anode current. The exact value varies but under the specified operating conditions will normally be between 5 and 25 volts.

Maximum Anode Current

The maximum permissible instantaneous and average anode current ratings are limitations on the current values that the tubes can carry safely in the direction in which they are designed to conduct and should not be exceeded. The current ratings specified under "In-phase Operation" apply when the filament and anode voltages are in phase, or where the relative phase angle is ignored. The "Quadrature Operation" ratings may be used when the circuit is designed so that the phase angle between the filament and anode voltage is approximately 90 electrical degrees. With this type of operation, the filament current goes through zero near the center of the anode conduction period, resulting in a balanced operating condition for the filament, which permits the higher anode currents.

Maximum Peak Inverse Anode Voltage

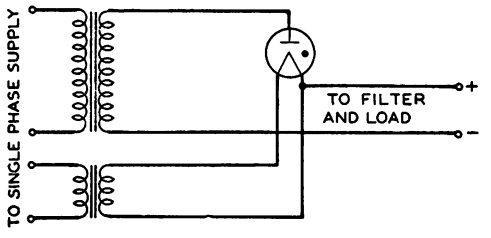
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output voltage available is not fixed but will depend upon the type of circuit used.

Tubes of the same type may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode may be used for this purpose. The size of the reactors or resistors will depend upon the circuit design.

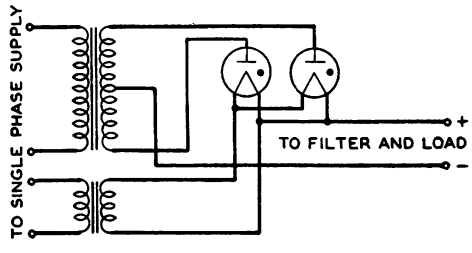
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits this requires a quick acting high-voltage fuse in each anode lead or an equally fast primary fuse or circuit breaker.

Circuits

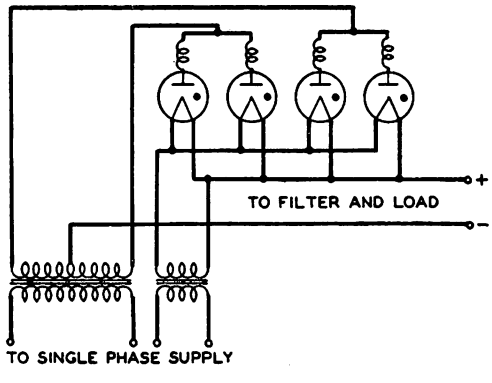
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and inverse voltage is given on the individual tube data sheet. The values listed are average values of the pulsating current and voltage for an unfiltered circuit.



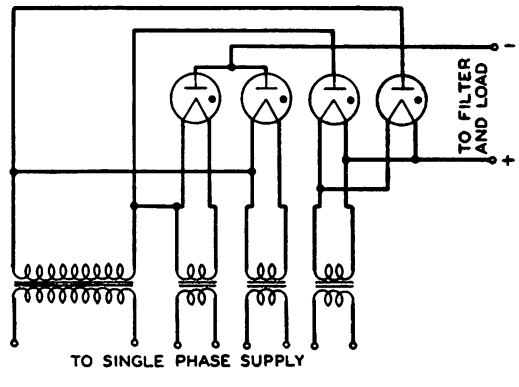
SINGLE PHASE, HALF-WAVE
CIRCUIT A



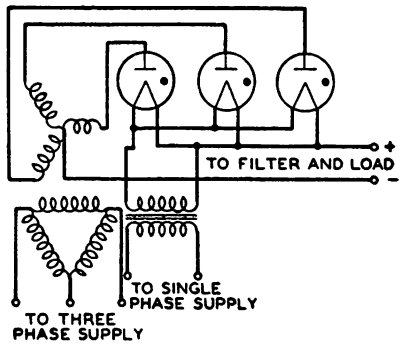
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



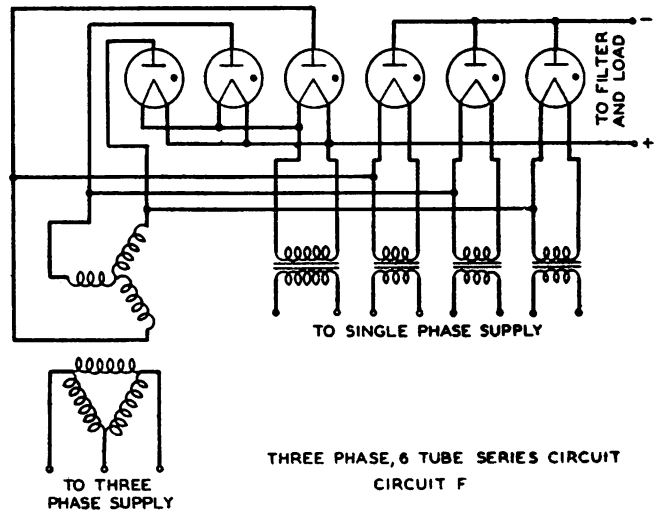
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



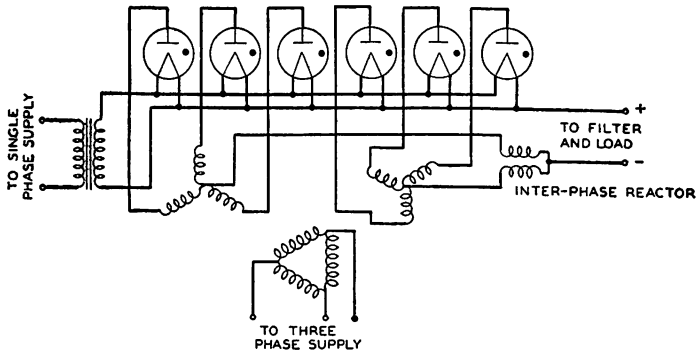
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



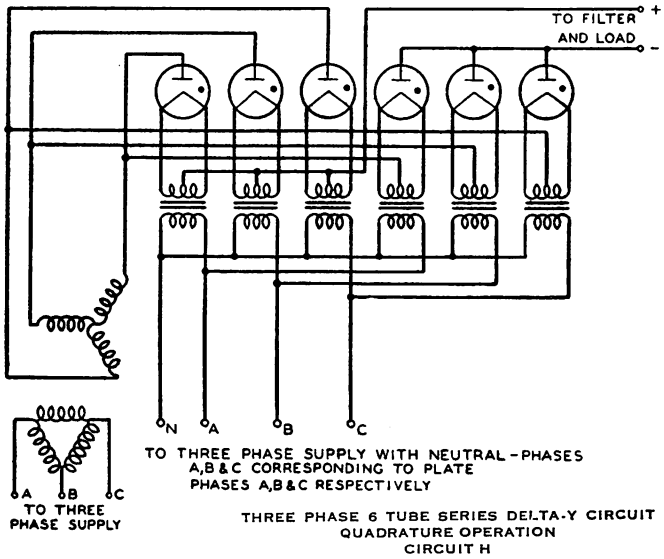
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

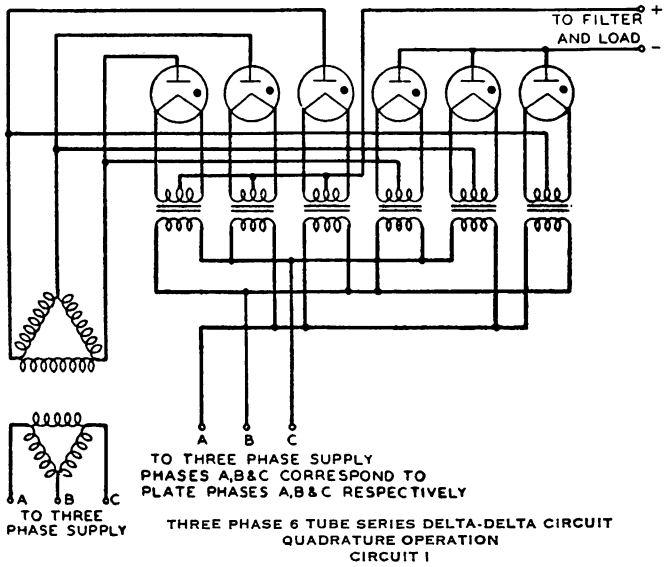


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



TO THREE PHASE SUPPLY WITH NEUTRAL - PHASES
A,B & C CORRESPONDING TO PLATE
PHASES A,B & C RESPECTIVELY

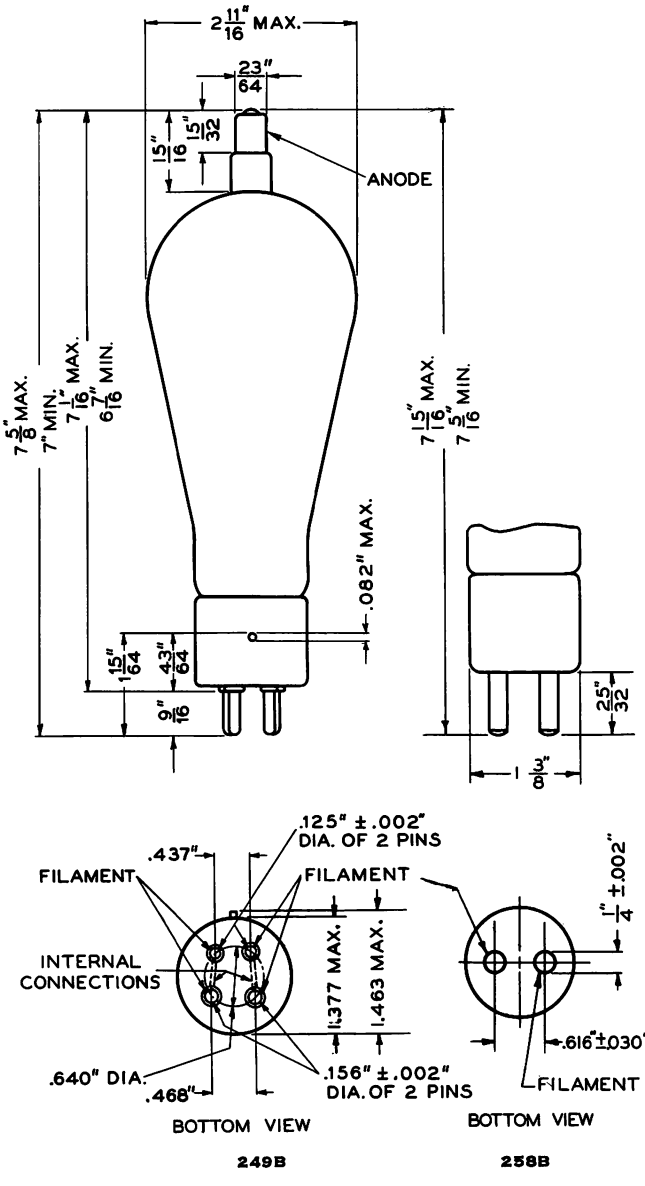
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

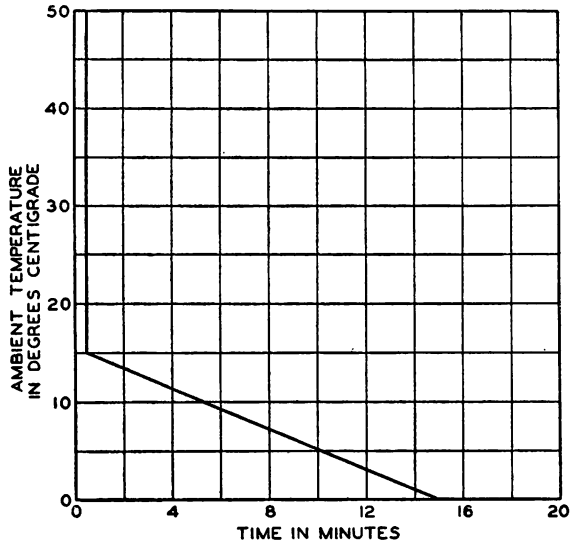


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

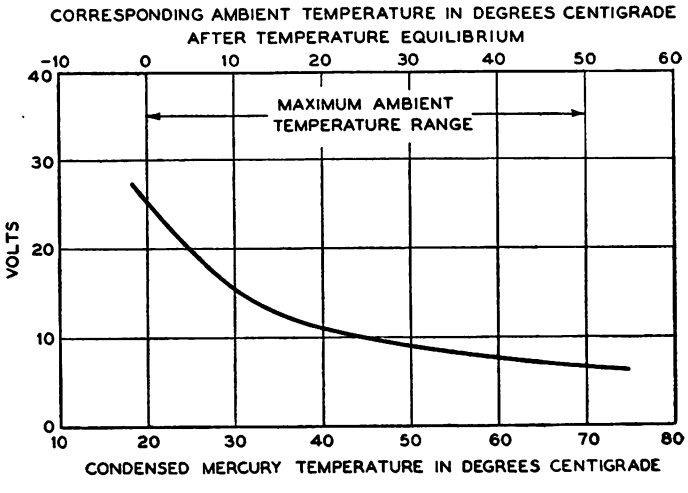
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

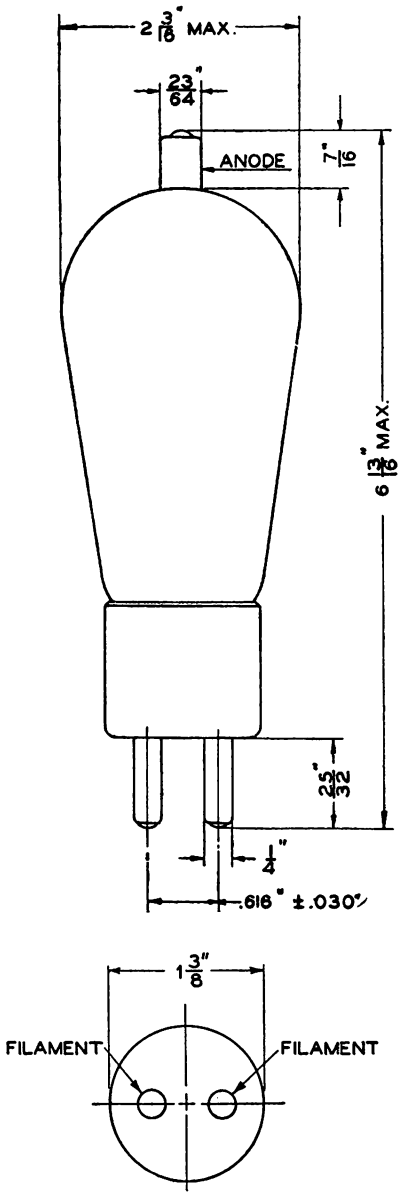
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 amperes
Maximum Average Anode Current	0.64 ampere
Max. Time of Averaging Anode Current	5 seconds
Maximum Peak Inverse Anode Voltage	7.5 kilovolts
Maximum Ambient Temperature Range	0 to 50°C.

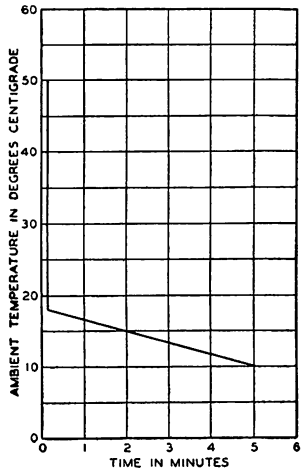
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

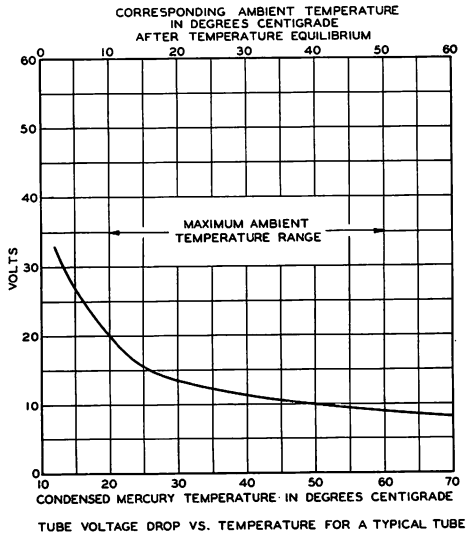
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

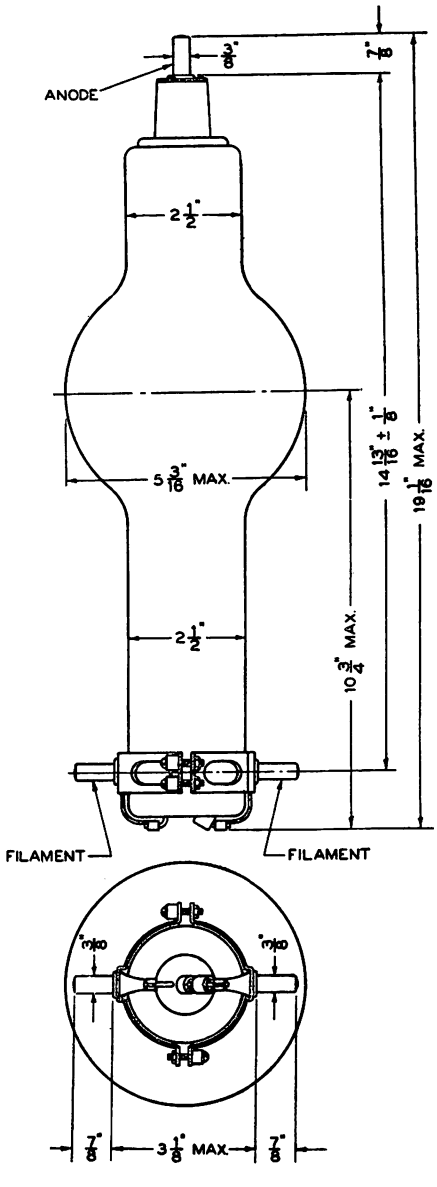
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 ampere
Maximum Average Anode Current	0.25 ampere
Max. Time of Averaging Anode Current	5 seconds
Maximum Peak Inverse Anode Voltage	3500 volts
Maximum Ambient Temperature Range	10 to 50° C.

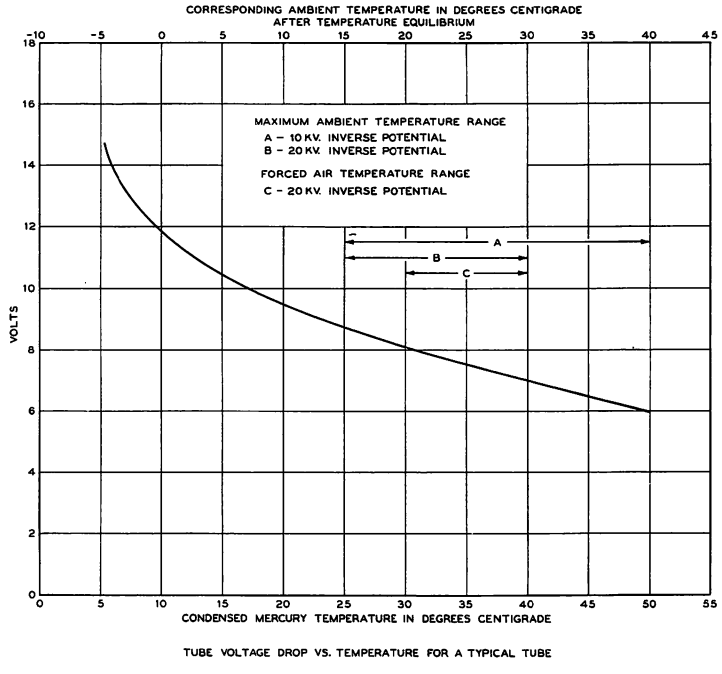
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage At 3500 volts Inverse Voltage	Load Current In DC Amperes
A	1	1000	0.25
B	2	1000	0.50
C	4	1000	1.00
D	4	2000	0.50
E	3	1500	0.75
F	6	3000	0.75
G	6	1400	1.25

255B Vacuum Tube





TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Maximum Peak Inverse Anode Voltage

at 15 to 30° C. ambient temperature	20 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	20 kilovolts

This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 6 cu. ft. per minute from a 1 inch nozzle and directed just above the support collar is recommended.

Mounting—Special mounting is required. Mount in vertical position only—filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be semi-flexible.

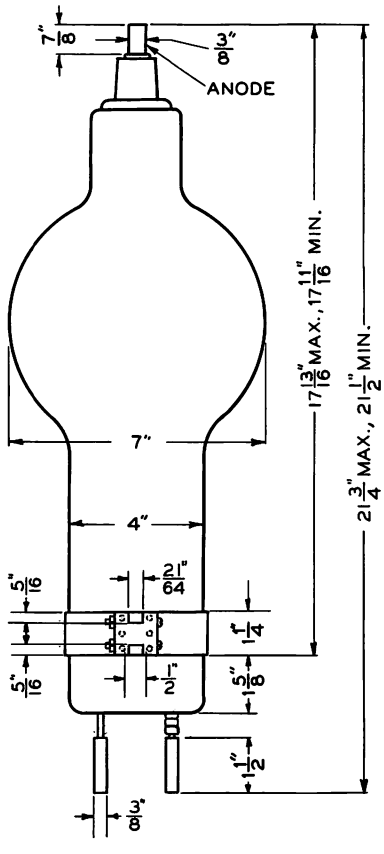
Ratings

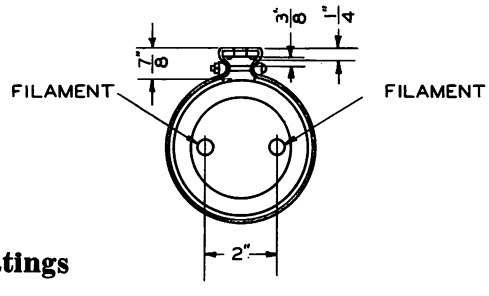
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	8 amperes
Quadrature Operation	16 amperes
Maximum Average Anode Current	
In-Phase Operation	2 amperes
Quadrature Operation	4 amperes
Max. Time of Averaging Anode Current	30 seconds

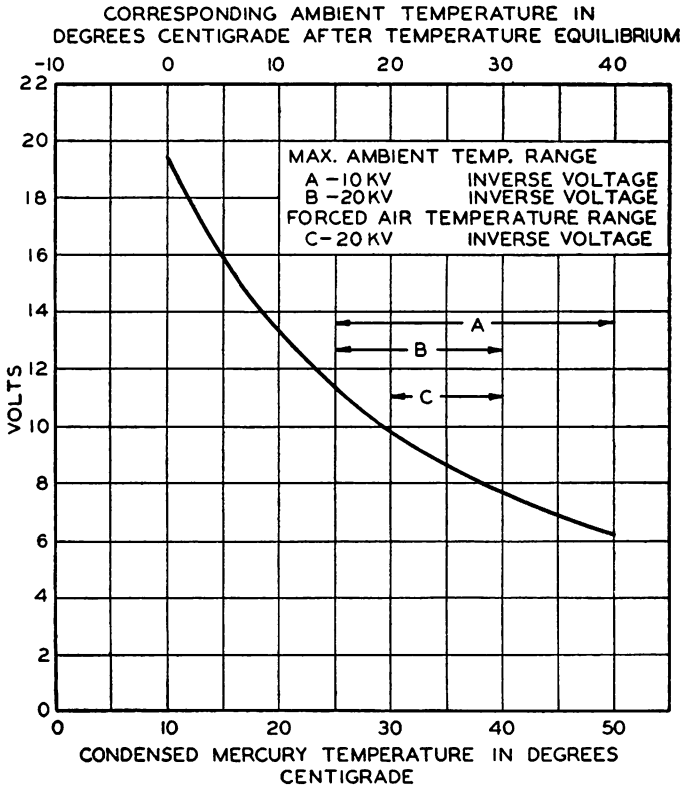
Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 20 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6000	2	4
B	2	3000	6000	4	8
C	4	3000	6000	8	16
D	4	6000	12000	4	8
E	3	4500	9000	6	12
F	6	9000	18000	6	—
G	6	4000	8000	10	20
H	6	9000	18000	—	12
I	6	9000	18000	—	12

266B Vacuum Tube







TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	42.0 amperes
Required Heating Time	300 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	30±5 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	20 amperes
Quadrature Operation	40 amperes
Maximum Average Anode Current	
In-Phase Operation	5 amperes
Quadrature Operation	10 amperes
Max. Time of Averaging Anode Current	60 seconds
Maximum Peak Inverse Anode Voltage	
at 15 to 30° C. ambient temperature	20 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	20 kilovolts

This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 8 cu. ft. per minute from a 1 inch nozzle and directed just below the support collar is recommended.

Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connections to the filament and anode terminals should be flexible.

Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 20 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6000	5	10
B	2	3000	6000	10	20
C	4	3000	6000	20	40
D	4	6000	12000	10	20
E	3	4500	9000	15	30
F	6	9000	18000	15	—
G	6	4000	8000	25	50
H	6	9000	18000	—	30
I	6	9000	18000	—	30

266C Vacuum Tube

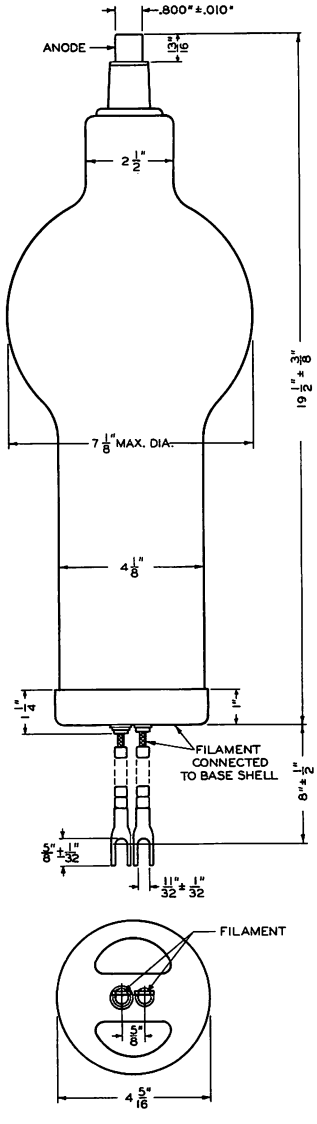
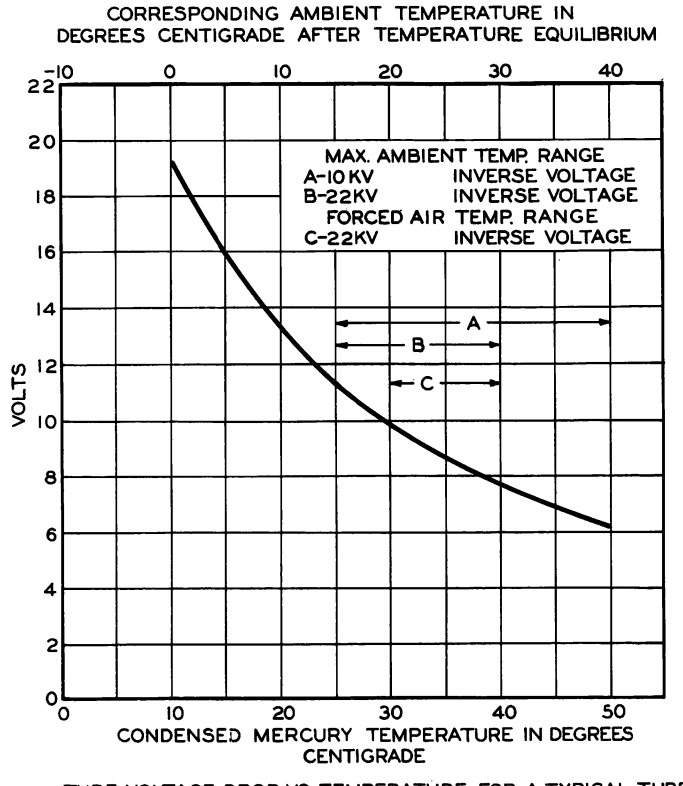


FIG. 1



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	42.0 amperes
Required Heating Time	300 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	30±5 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	20 amperes
Quadrature Operation	40 amperes
Maximum Average Anode Current	
In-Phase Operation	5 amperes
Quadrature Operation	10 amperes
Max. Time of Averaging Anode Current	60 seconds
Maximum Peak Inverse Anode Voltage	
at 15 to 30° C. ambient temperature	22 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	22 kilovolts

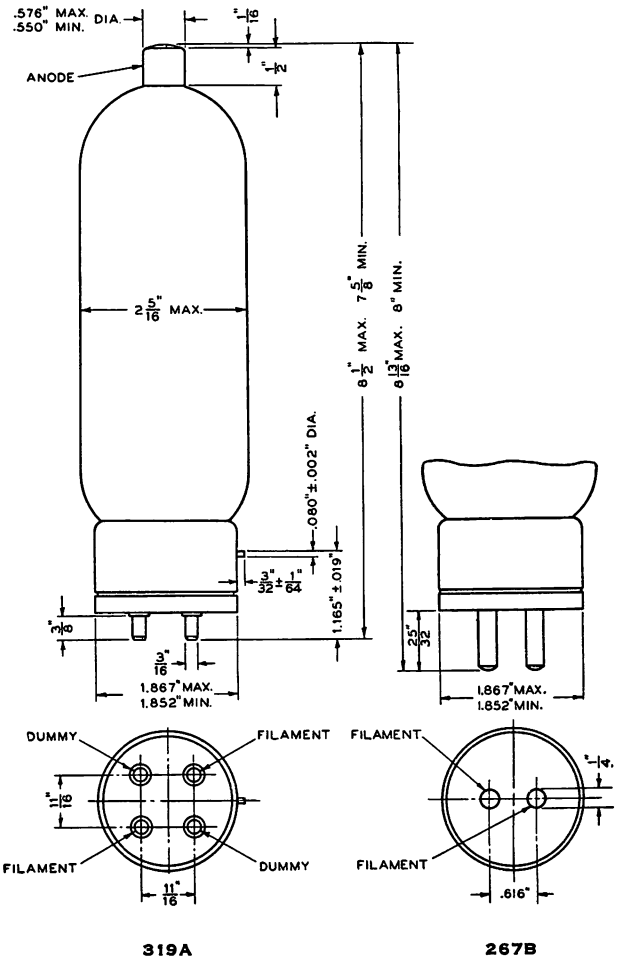
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

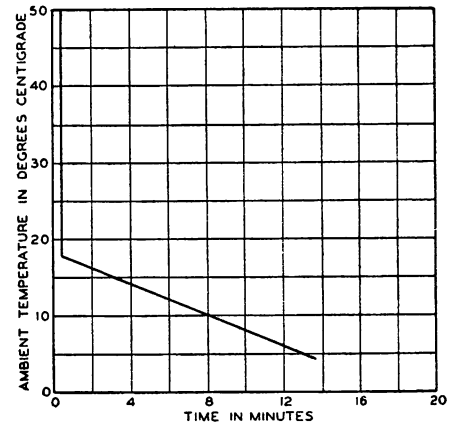
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

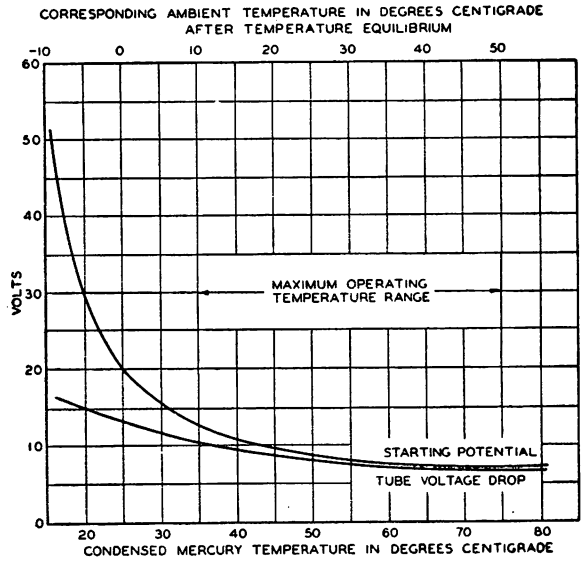
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	15	30
F	6	9000	20000	15	—
G	6	4000	9000	25	50
H	6	9000	20000	—	30
I	6	9000	20000	—	30

267B and 319A Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

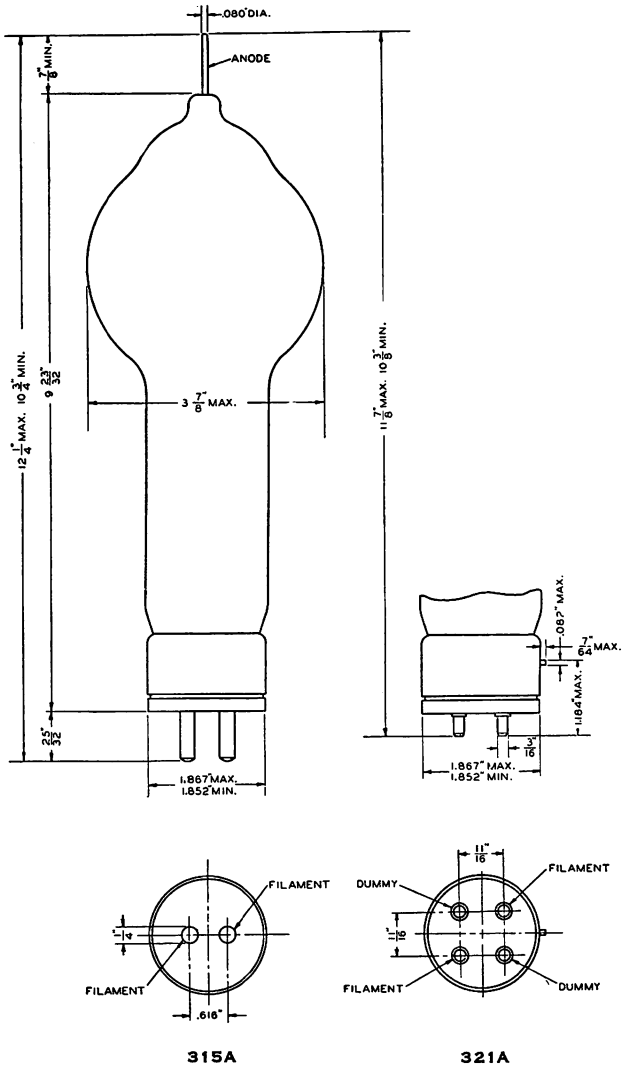
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	7.5 kilovolts
Maximum Ambient Temperature Range	10 to 50° C.

Mounting—The 267B tube requires a W. E. 138B, 139A or similar socket and the 319A tube a W. E. 148A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

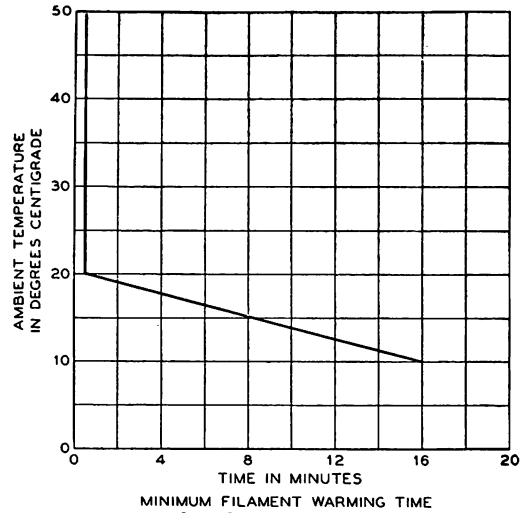
Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	1	2
B	2	2300	2	4
C	4	2300	4	8
D	4	4600	2	4
E	3	3500	3	6
F	6	7000	3	—
G	6	3000	5	10
H	6	7000	—	6
I	6	7000	—	6

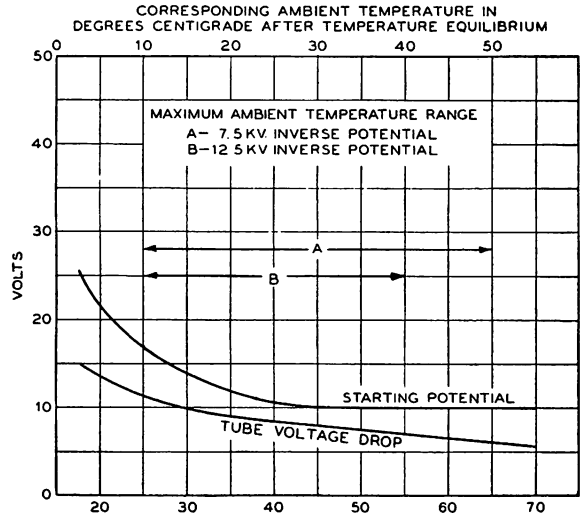
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

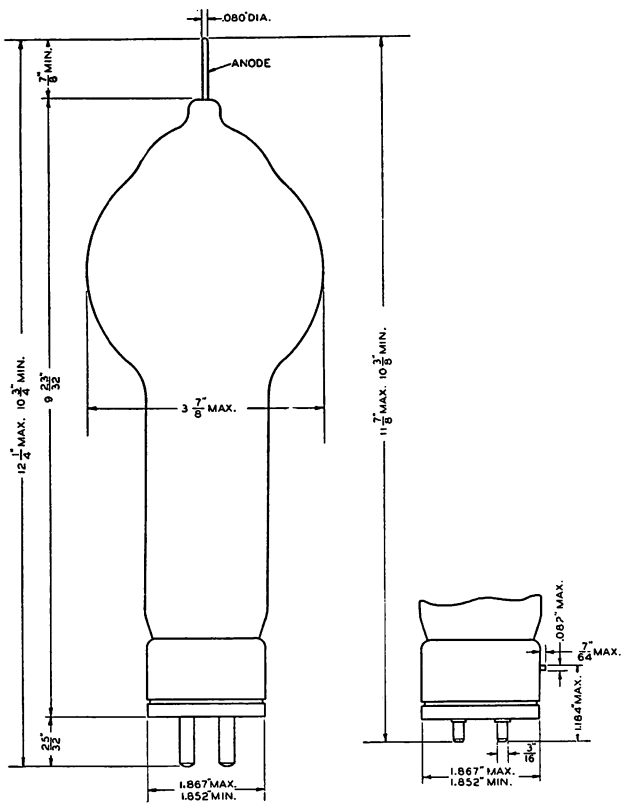
Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averaging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	
at 10 to 40° C. ambient temperature	12.5 kilovolts
at 10 to 50° C. ambient temperature	7.5 kilovolts

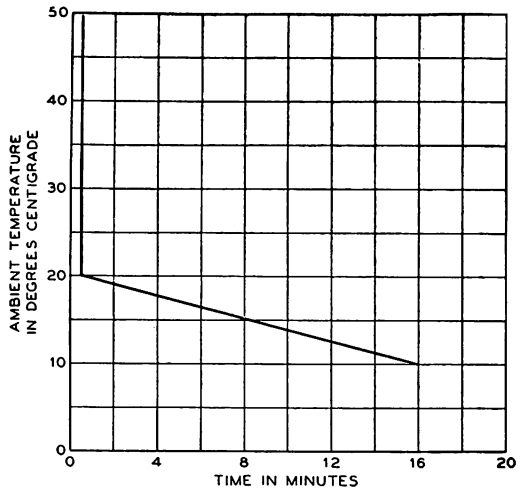
Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

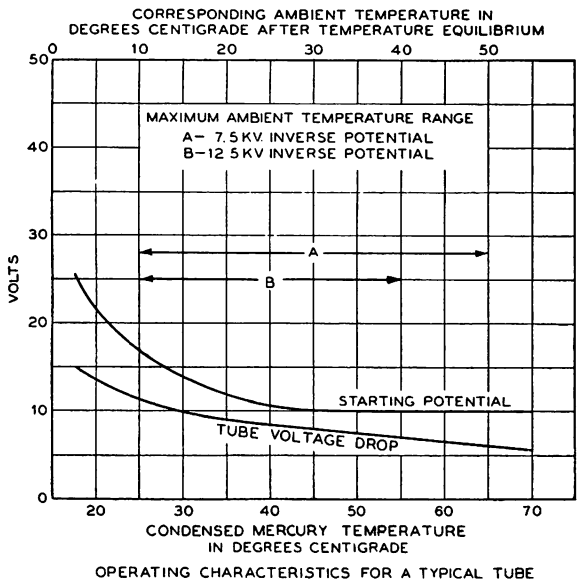
Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Output Voltage: At 12.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	3800	1	2
B	2	2300	3800	2	4
C	4	2300	3800	4	8
D	4	4600	7600	2	4
E	3	3500	5800	3	6
F	6	7000	11500	3	—
G	6	3000	5000	5	10
H	6	7000	11500	—	6
I	6	7000	11500	—	6

315A and 321A Vacuum Tubes







Ratings

Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averaging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	
at 10 to 40° C. ambient temperature	12.5 kilovolts
at 10 to 50° C. ambient temperature	7.5 kilovolts

Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

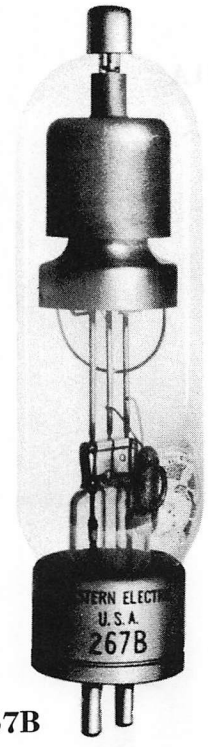
Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Output Voltage: At 12.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	3800	1	2
B	2	2300	3800	2	4
C	4	2300	3800	4	8
D	4	4600	7600	2	4
E	3	3500	5800	3	6
F	6	7000	11500	3	—
G	6	3000	5000	5	10
H	6	7000	11500	—	6
I	6	7000	11500	—	6

Western Electric

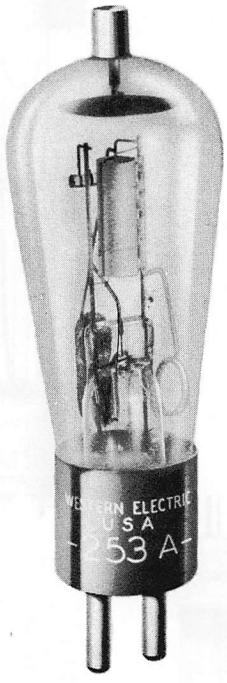
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

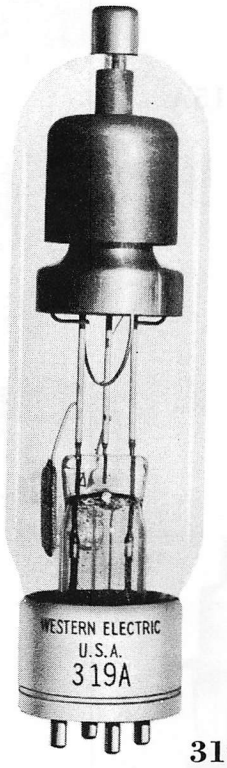
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



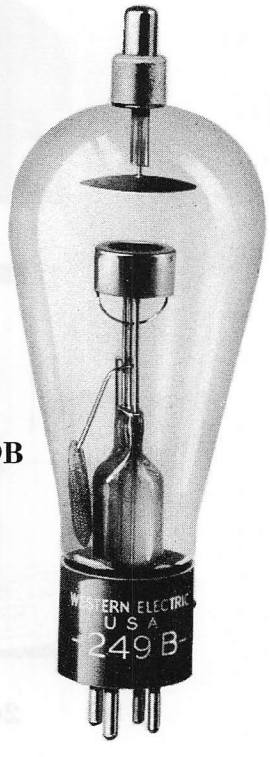
267B



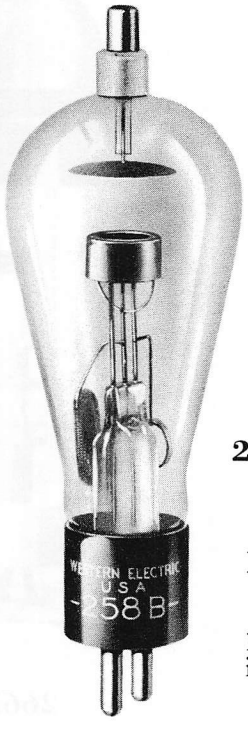
253A



319A



249B

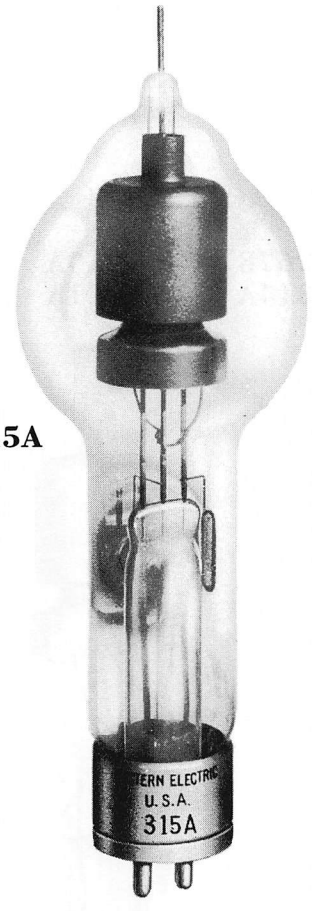


258B

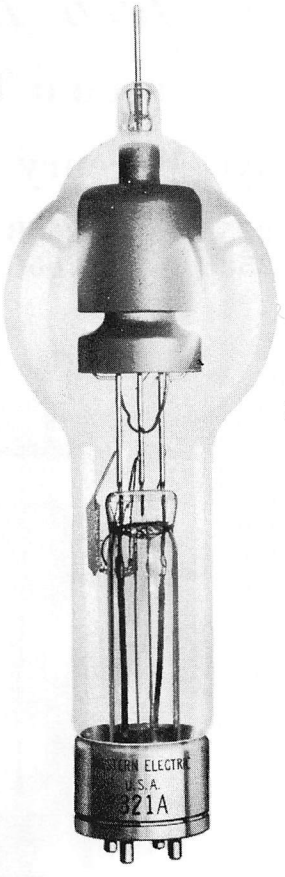
NOTE:

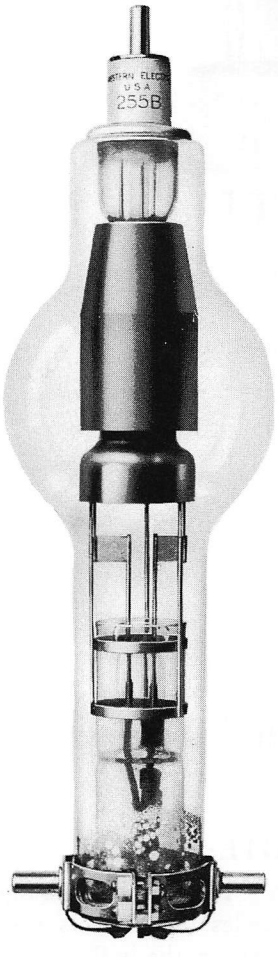
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

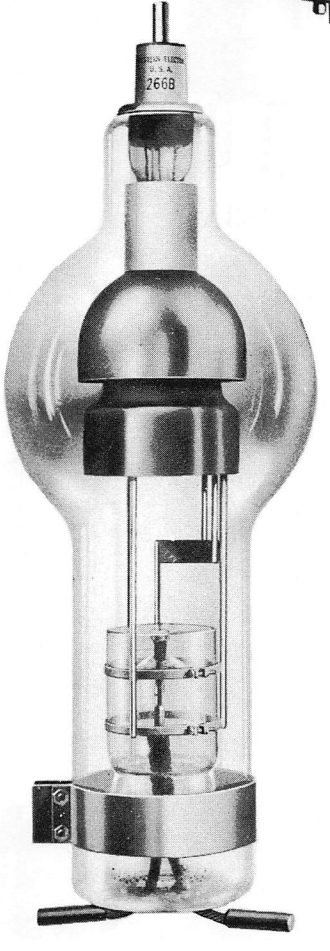


321A

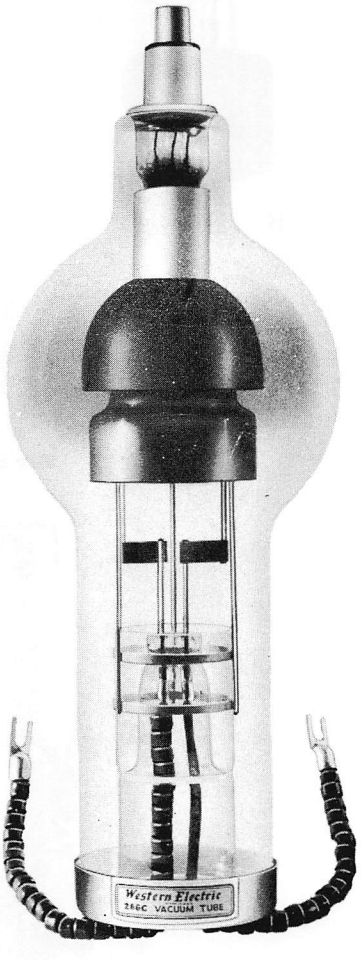




255B



266B



266C

Classification

These tubes are half-wave, thermionic, mercury vapor rectifiers designed to supply direct-current from an alternating-current supply.

Mounting—The tubes should be mounted only in a vertical position with the base or filament end down. Free air circulation must be provided. No object should touch the glass bulb.

Filament—The filaments are designed to operate from alternating current sources. The voltage should be maintained to within 5% of the rated value. Operation of the filaments at a voltage above the upper limit will definitely reduce the life of the tubes while a decrease in voltage below the lower limit may cause immediate failure.

Normal Filament Heating

The anode voltage should not be applied until the filaments have reached a satisfactory operating temperature. When normal filament voltage and circuits with good regulation are used, the minimum time required is specified on the individual tube data sheet as the "Required Heating Time." It is also necessary to allow sufficient filament heating time to evaporate any visible mercury deposits from the upper parts of the tubes.

When the tubes are put into operation at low ambient temperatures, an extended filament heating time is necessary to raise the mercury vapor pressure to a satisfactory operating value. This time is given in graph form on the individual tube data sheet for tubes requiring such heating when operating within the recommended ambient temperature range. A filament heating period of 30 minutes or more should be allowed when the tubes are used for the first time or if they have been subjected to extensive handling or prolonged standing.

Accelerated Filament Heating

In certain applications it may be desirable to reduce the "Required Heating Time" designated for normal filament voltage. This may be accomplished by applying an overvoltage to the filament for a short period after which the rated filament voltage and the anode voltage is applied. The recommended open circuit overvoltage and the corresponding period of application are given on the individual tube data sheet. These ratings apply when the regulation of the filament supply circuit is 10% ± 4%.

Tube Voltage Drop

The tube voltage drop is substantially independent of the anode current. The exact value varies but under the specified operating conditions will normally be between 5 and 25 volts.

Maximum Anode Current

The maximum permissible instantaneous and average anode current ratings are limitations on the current values that the tubes can carry safely in the direction in which they are designed to conduct and should not be exceeded. The current ratings specified under "In-phase Operation" apply when the filament and anode voltages are in phase, or where the relative phase angle is ignored. The "Quadrature Operation" ratings may be used when the circuit is designed so that the phase angle between the filament and anode voltage is approximately 90 electrical degrees. With this type of operation, the filament current goes through zero near the center of the anode conduction period, resulting in a balanced operating condition for the filament, which permits the higher anode currents.

Maximum Peak Inverse Anode Voltage

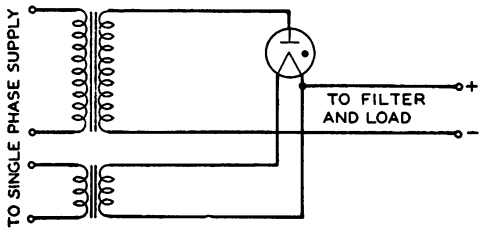
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output voltage available is not fixed but will depend upon the type of circuit used.

Tubes of the same type may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode may be used for this purpose. The size of the reactors or resistors will depend upon the circuit design.

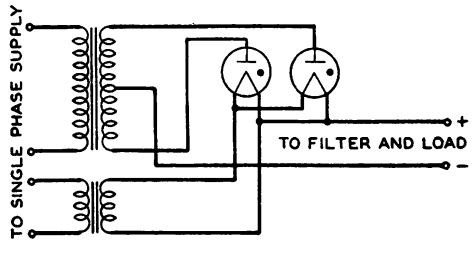
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits this requires a quick acting high-voltage fuse in each anode lead or an equally fast primary fuse or circuit breaker.

Circuits

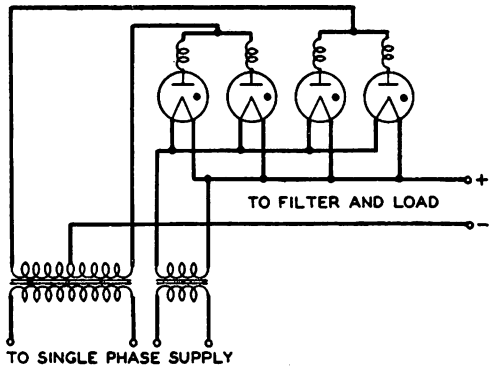
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and inverse voltage is given on the individual tube data sheet. The values listed are average values of the pulsating current and voltage for an unfiltered circuit.



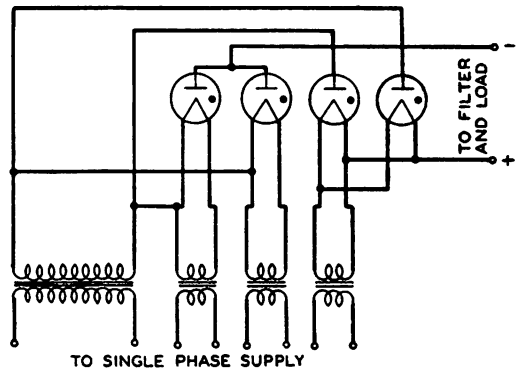
SINGLE PHASE, HALF-WAVE
CIRCUIT A



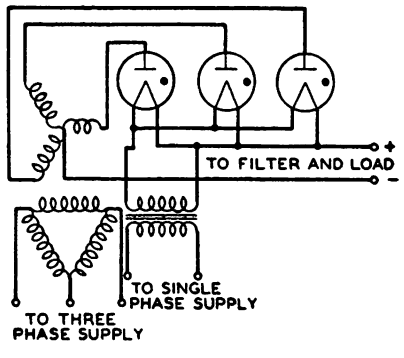
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



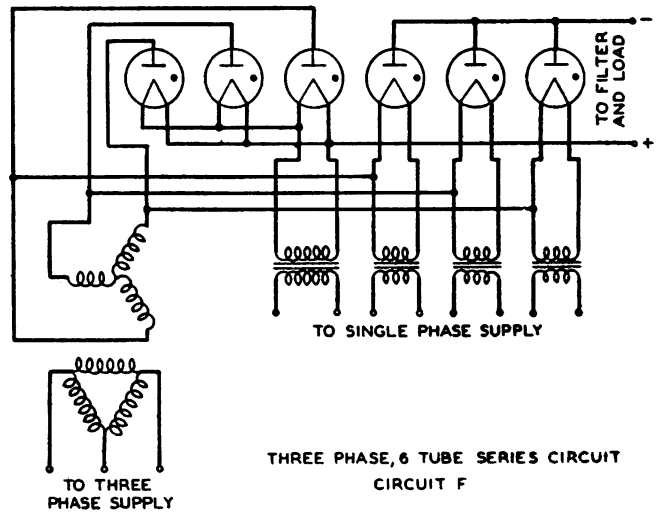
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



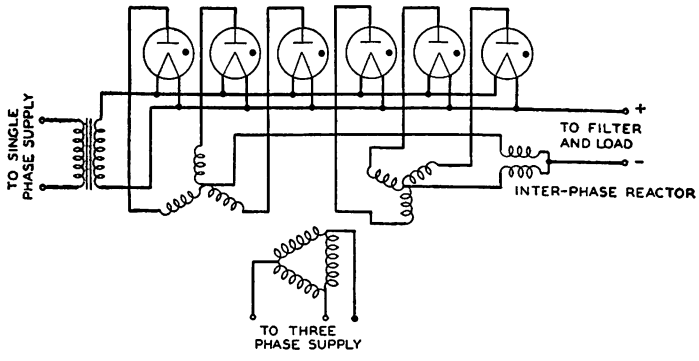
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



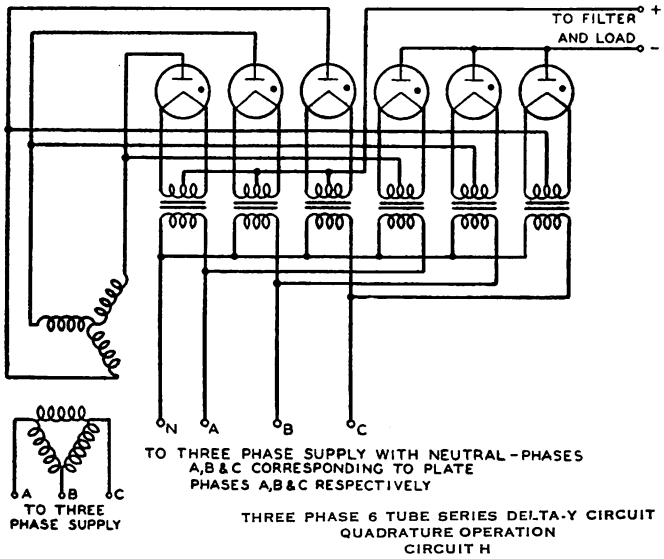
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

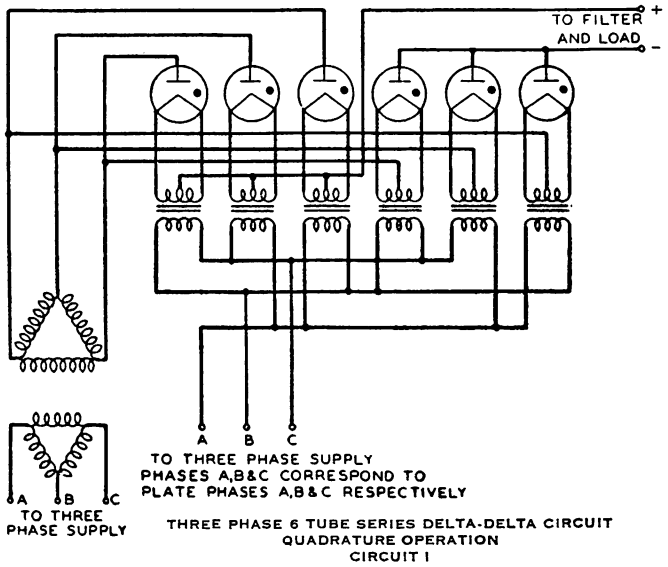


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



TO THREE PHASE SUPPLY WITH NEUTRAL - PHASES
A,B & C CORRESPONDING TO PLATE
PHASES A,B & C RESPECTIVELY

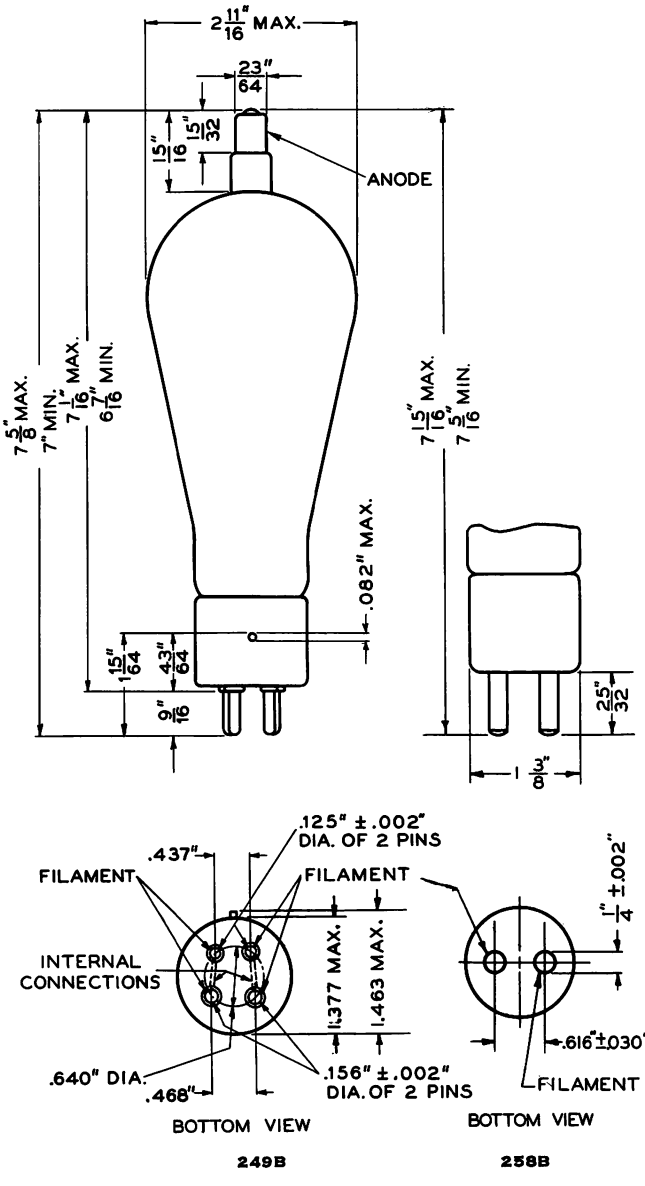
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

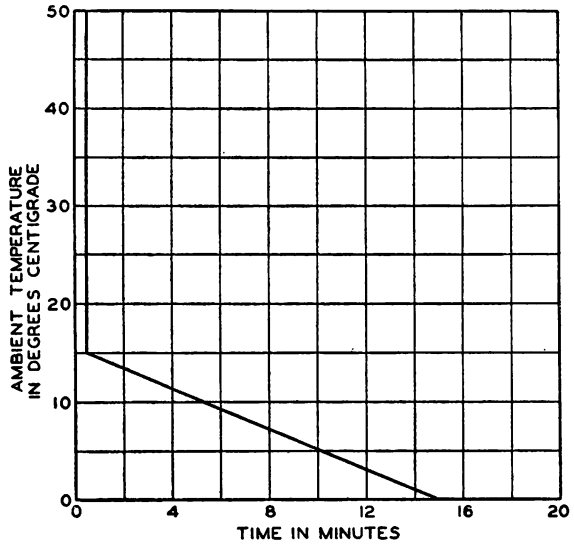


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

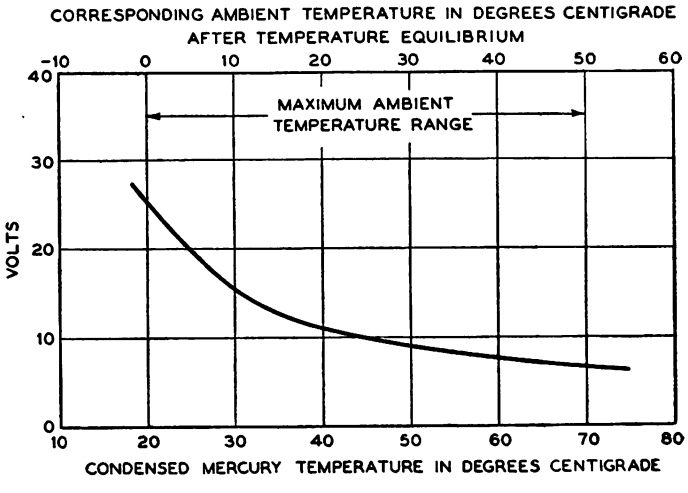
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

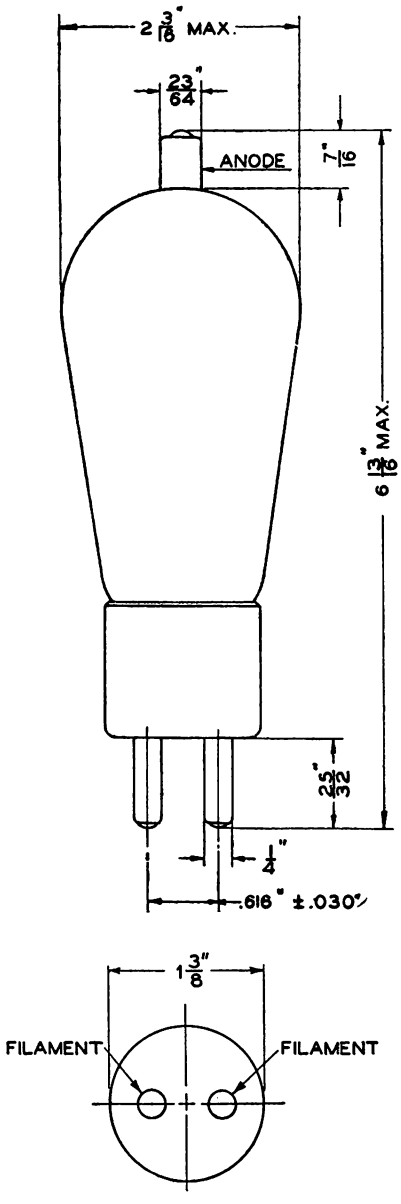
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 amperes
Maximum Average Anode Current	0.64 ampere
Max. Time of Averaging Anode Current	5 seconds
Maximum Peak Inverse Anode Voltage	7.5 kilovolts
Maximum Ambient Temperature Range	0 to 50°C.

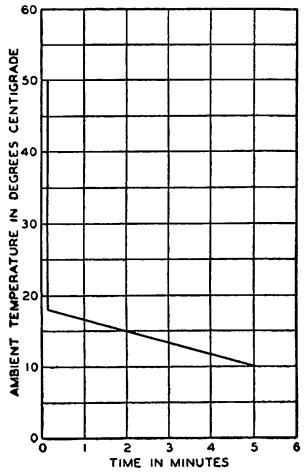
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

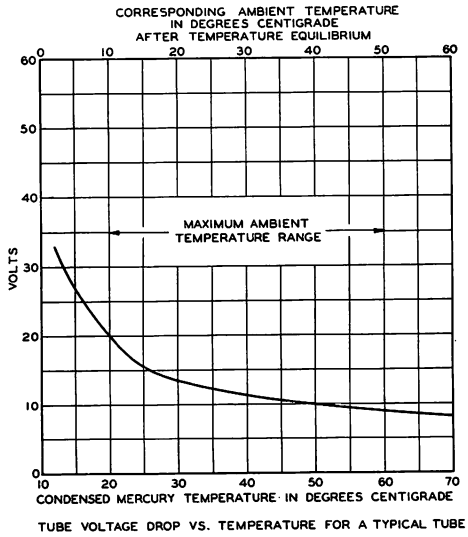
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

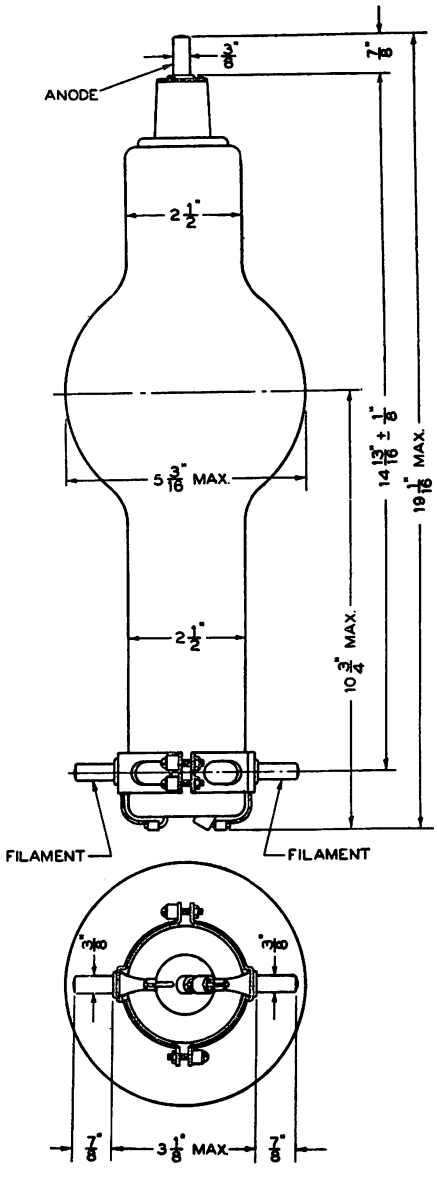
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 ampere
Maximum Average Anode Current	0.25 ampere
Max. Time of Averaging Anode Current	5 seconds
Maximum Peak Inverse Anode Voltage	3500 volts
Maximum Ambient Temperature Range	10 to 50° C.

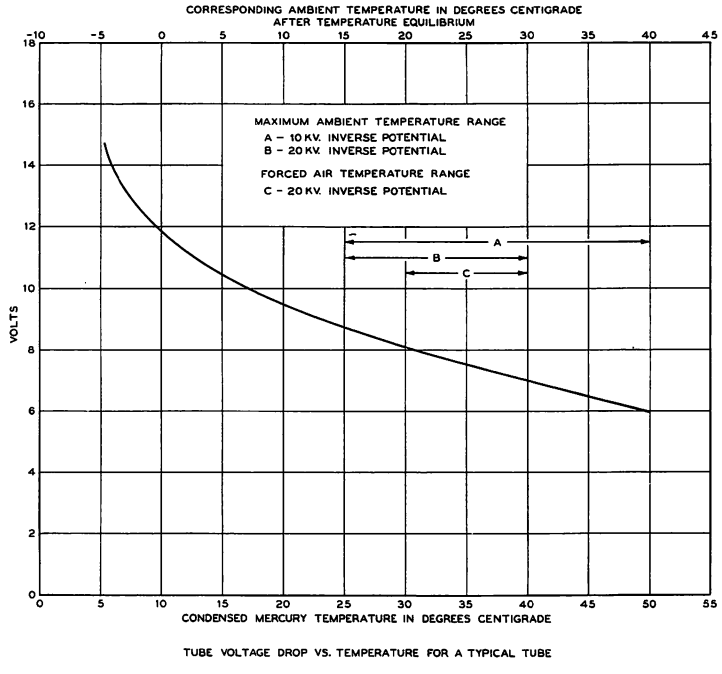
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage At 3500 volts Inverse Voltage	Load Current In DC Amperes
A	1	1000	0.25
B	2	1000	0.50
C	4	1000	1.00
D	4	2000	0.50
E	3	1500	0.75
F	6	3000	0.75
G	6	1400	1.25

255B Vacuum Tube





TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Maximum Peak Inverse Anode Voltage

at 15 to 30° C. ambient temperature	20 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	20 kilovolts

This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 6 cu. ft. per minute from a 1 inch nozzle and directed just above the support collar is recommended.

Mounting—Special mounting is required. Mount in vertical position only—filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be semi-flexible.

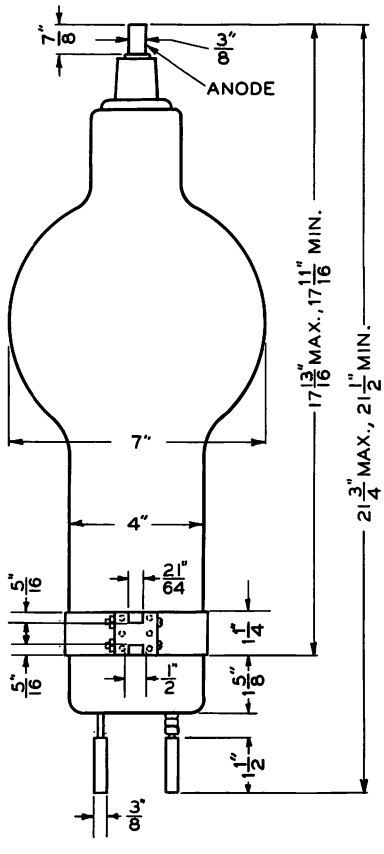
Ratings

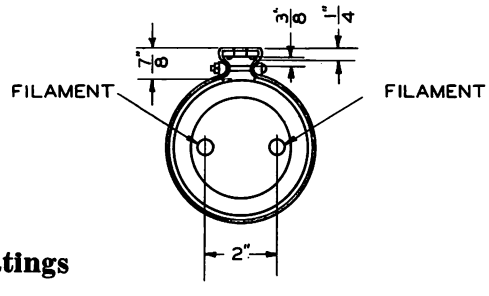
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	8 amperes
Quadrature Operation	16 amperes
Maximum Average Anode Current	
In-Phase Operation	2 amperes
Quadrature Operation	4 amperes
Max. Time of Averaging Anode Current	30 seconds

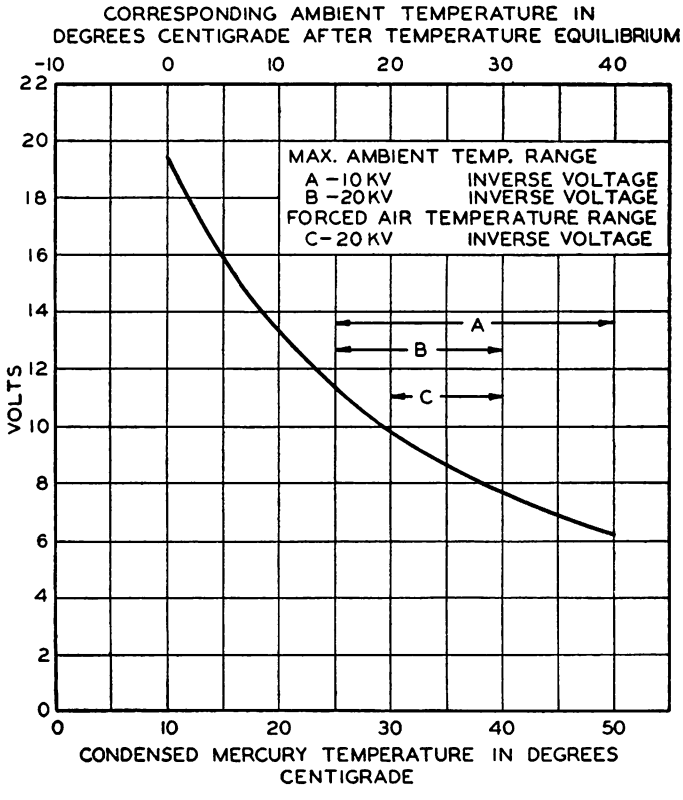
Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 20 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6000	2	4
B	2	3000	6000	4	8
C	4	3000	6000	8	16
D	4	6000	12000	4	8
E	3	4500	9000	6	12
F	6	9000	18000	6	—
G	6	4000	8000	10	20
H	6	9000	18000	—	12
I	6	9000	18000	—	12

266B Vacuum Tube







TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	42.0 amperes
Required Heating Time	300 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	30±5 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	20 amperes
Quadrature Operation	40 amperes
Maximum Average Anode Current	
In-Phase Operation	5 amperes
Quadrature Operation	10 amperes
Max. Time of Averaging Anode Current	60 seconds
Maximum Peak Inverse Anode Voltage	
at 15 to 30° C. ambient temperature	20 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	20 kilovolts

This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 8 cu. ft. per minute from a 1 inch nozzle and directed just below the support collar is recommended.

Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connections to the filament and anode terminals should be flexible.

Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 20 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6000	5	10
B	2	3000	6000	10	20
C	4	3000	6000	20	40
D	4	6000	12000	10	20
E	3	4500	9000	15	30
F	6	9000	18000	15	—
G	6	4000	8000	25	50
H	6	9000	18000	—	30
I	6	9000	18000	—	30

266C Vacuum Tube

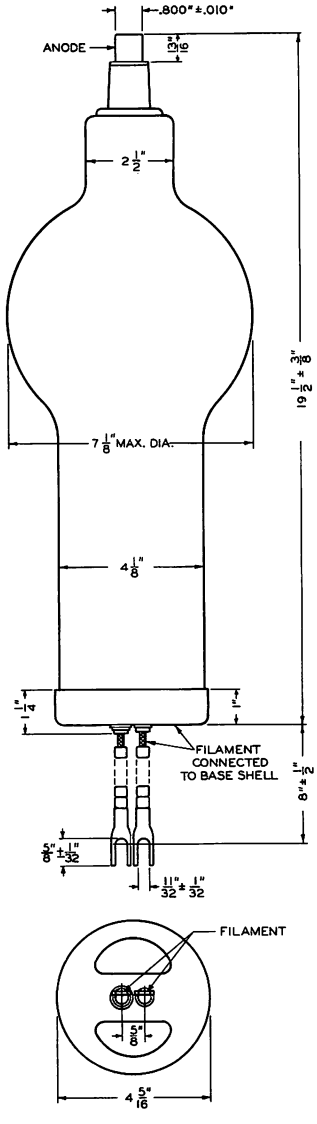
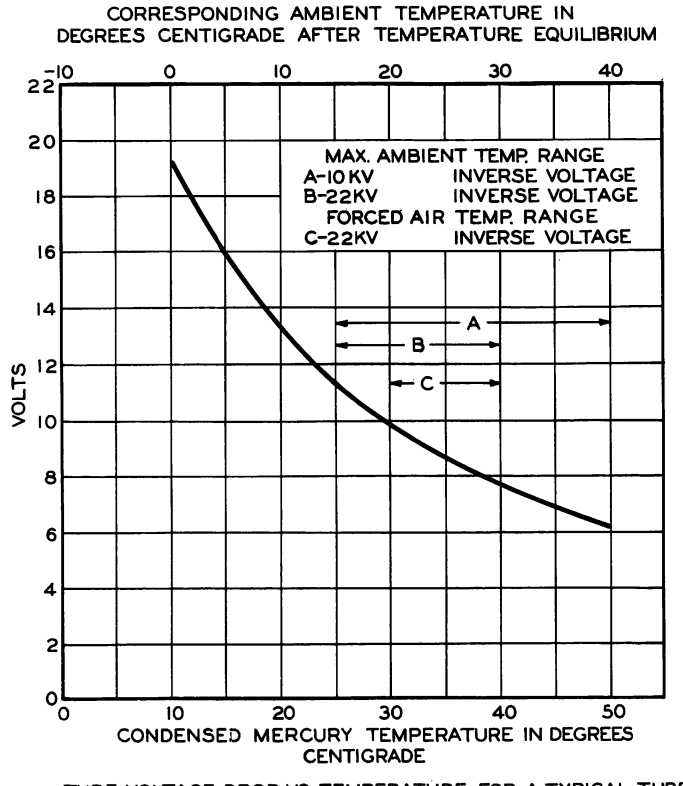


FIG. 1



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	42.0 amperes
Required Heating Time	300 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	30±5 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	20 amperes
Quadrature Operation	40 amperes
Maximum Average Anode Current	
In-Phase Operation	5 amperes
Quadrature Operation	10 amperes
Max. Time of Averaging Anode Current	60 seconds
Maximum Peak Inverse Anode Voltage	
at 15 to 30° C. ambient temperature	22 kilovolts
at 15 to 40° C. ambient temperature	10 kilovolts
at 30 to 40° C. forced air temperature	22 kilovolts

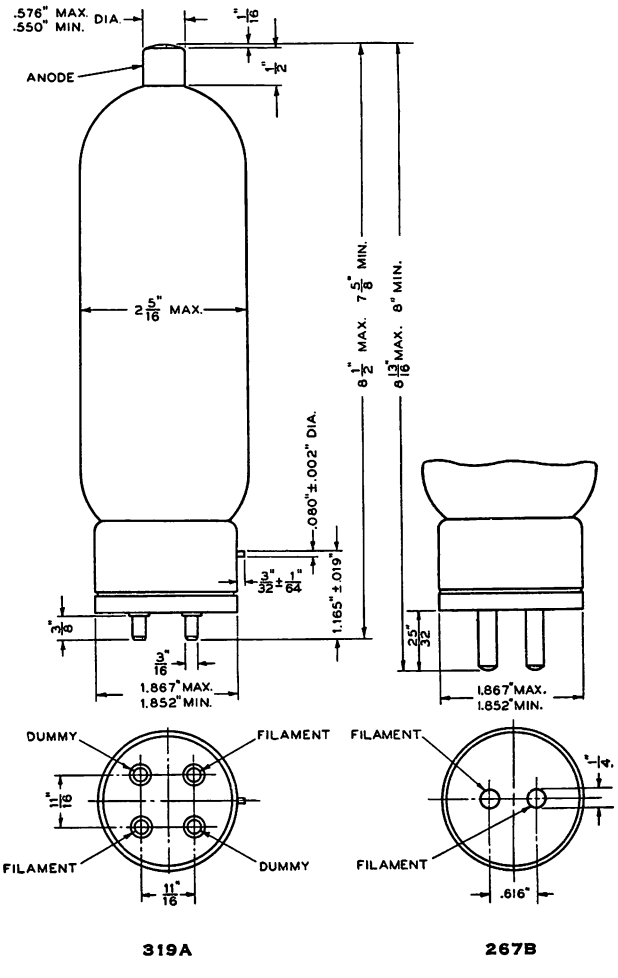
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

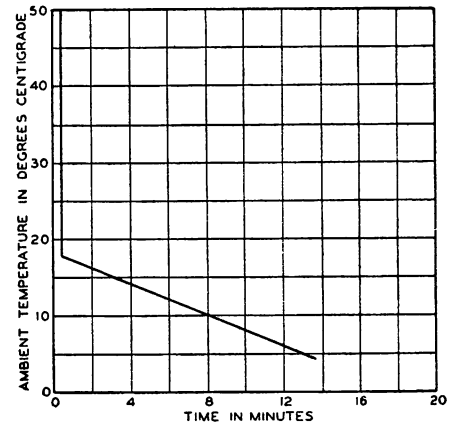
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

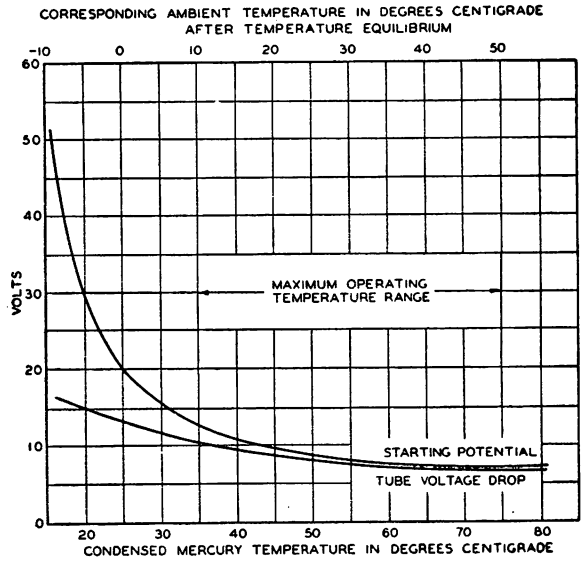
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	15	30
F	6	9000	20000	15	—
G	6	4000	9000	25	50
H	6	9000	20000	—	30
I	6	9000	20000	—	30

267B and 319A Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

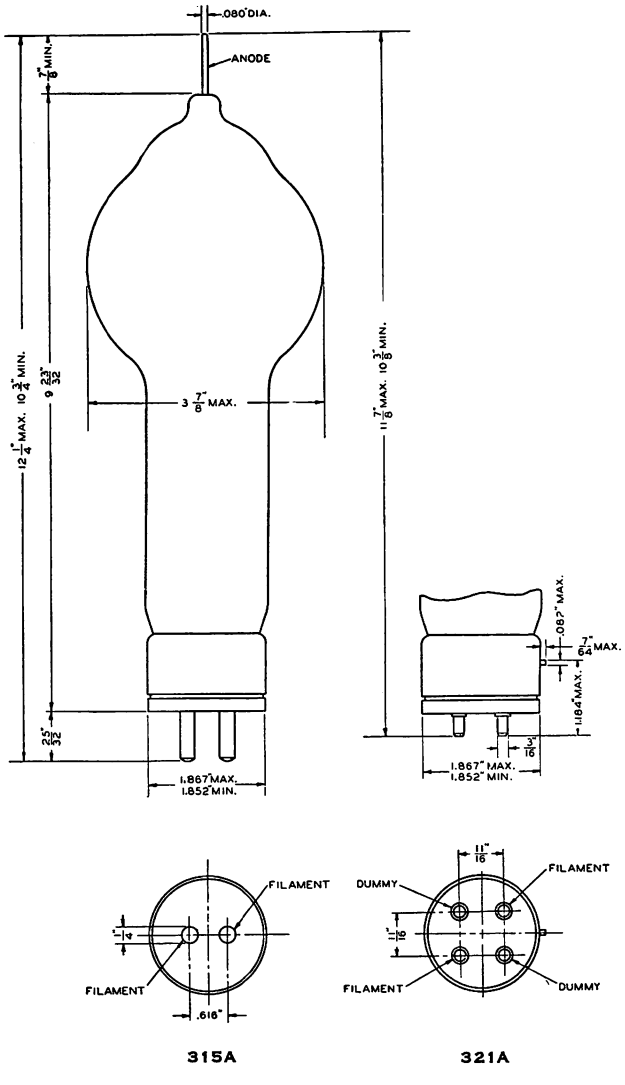
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	7.5 kilovolts
Maximum Ambient Temperature Range	10 to 50° C.

Mounting—The 267B tube requires a W. E. 138B, 139A or similar socket and the 319A tube a W. E. 148A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

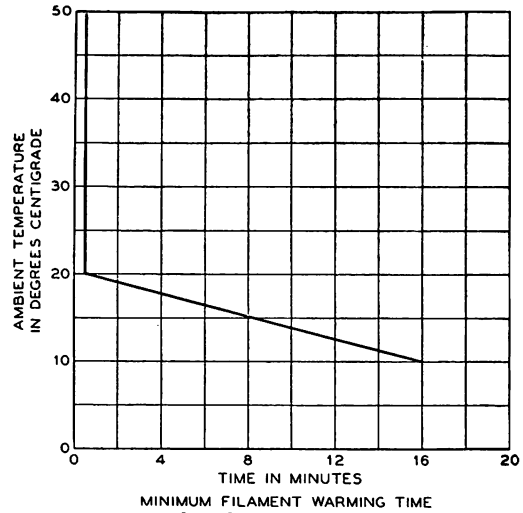
Circuit Outputs:

Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	1	2
B	2	2300	2	4
C	4	2300	4	8
D	4	4600	2	4
E	3	3500	3	6
F	6	7000	3	—
G	6	3000	5	10
H	6	7000	—	6
I	6	7000	—	6

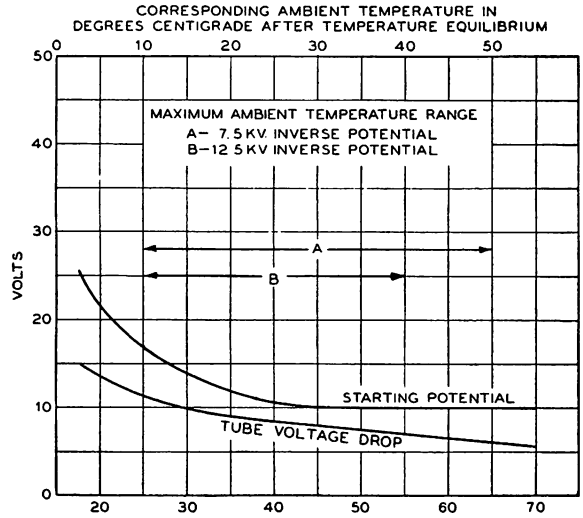
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase Operation	4 amperes
Quadrature Operation	8 amperes
Maximum Average Anode Current	
In-Phase Operation	1 ampere
Quadrature Operation	2 amperes
Max. Time of Averaging Anode Current	15 seconds
Maximum Peak Inverse Anode Voltage	
at 10 to 40° C. ambient temperature	12.5 kilovolts
at 10 to 50° C. ambient temperature	7.5 kilovolts

Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

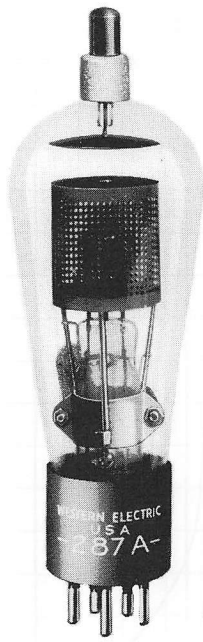
Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Output Voltage: At 12.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	3800	1	2
B	2	2300	3800	2	4
C	4	2300	3800	4	8
D	4	4600	7600	2	4
E	3	3500	5800	3	6
F	6	7000	11500	3	—
G	6	3000	5000	5	10
H	6	7000	11500	—	6
I	6	7000	11500	—	6

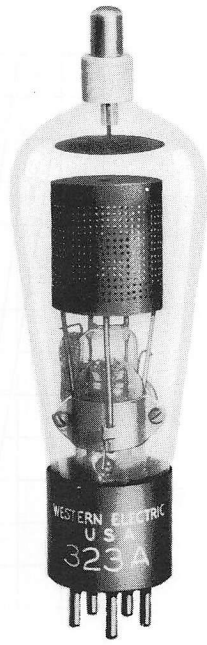
Western Electric

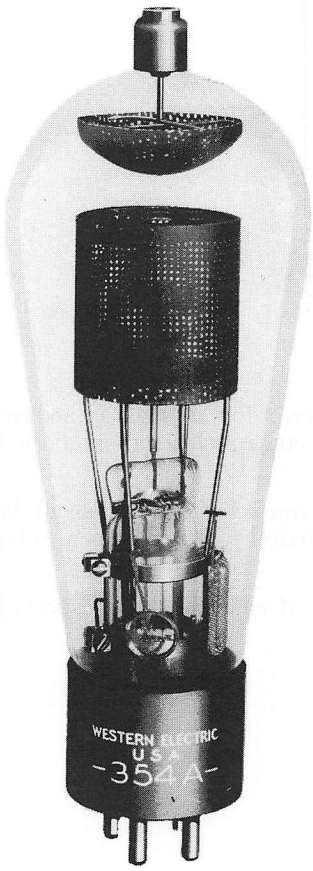
Vacuum Tubes

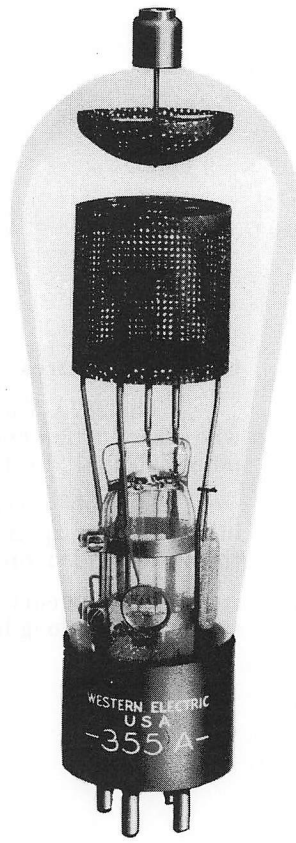
Three Element Power Thyratrons

287A 323A 354A 355A





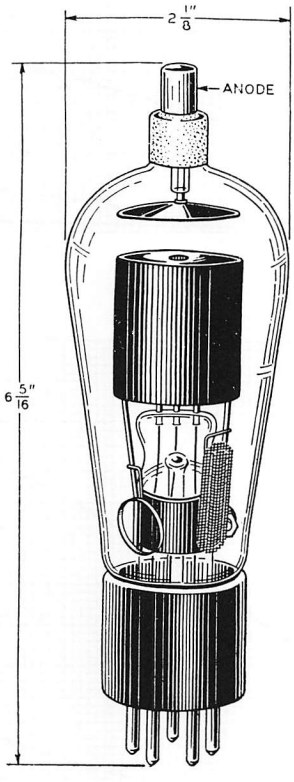


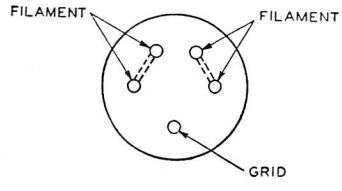


NOTE:

This combined bulletin supersedes data sheets previously issued for the individual tubes.

287A Vacuum Tube





Classification

The 287A is a three-element, mercury-vapor tube which employs an oxide-coated filament. It is intended for use in special circuits as a relay or trigger action device.

Base and Socket

The 287A Vacuum Tube employs a standard five prong thrust type base suitable for use in a Western Electric 137A or similar type socket. It is to be noted from the arrangement of electrode terminals shown above that the filament terminals are tied together in parallel. The corresponding socket terminals should also be connected to insure the best contact conditions for the filament current. The fifth terminal in the base is connected to the control electrode. The anode terminal is located at the top of the bulb and is arranged for a special, quick-release connector.

Rating and Characteristic Data

Filament Voltage	2.5 Volts
Filament Current	7.0 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	15 Volts
Maximum Peak Plate Current	1 Ampere
Maximum Peak Inverse Potential	2500 Volts
Safe Operating Ambient Temperature	10° to 50° C.

The anode-cathode potential drop is substantially independent of the plate current. The exact value varies from tube to tube and during the life of a given tube. Within the specified anode temperature and plate current range it will vary from 5 to 20 volts.

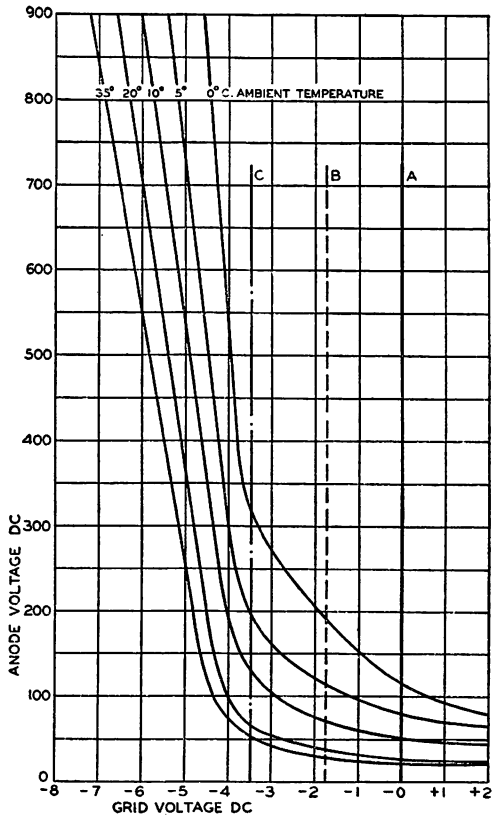
Breakdown Characteristics

Typical curves relating the critical control-electrode potential to the anode potential at various temperatures are given in the accompanying chart. These characteristics may vary from tube to tube and during the life of a given tube.

The 0 of grid bias is shown on the chart as the "A" axis for the case where the filament is heated with alternating current and the anode and control-electrode returns are connected to one side of the filament.

If the filament is heated by alternating current and the anode and control-electrode returns connected to the center tap of the filament transformer, the 0 of grid bias should be taken at the "B" axis.

If the filament is heated by direct current with the anode and control-electrode returns connected to the negative terminal, the 0 of grid bias should be taken at the "C" axis.



General Features

The 287A Vacuum Tube is primarily a mercury-vapor rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous control electrode and anode potentials and also by the ambient temperature.

The tube is suitable for use in variable voltage rectifiers as a circuit breaker and as a relay in a variety of applications requiring very low signal energy. Compared to a mechanical relay, the operation is more rapid and positive.

This mercury-vapor tube has a rugged mesh type oxide-coated cathode. It is especially suitable where long life and dependability of operation are essential.

Classification

These tubes are half-wave, thermionic, three element, negative grid, medium power thyratrons designed to operate at frequencies below 150 cycles. They are primarily intended for use in regulated rectifier, inverter, relay or other applications requiring thyratron characteristics.

Mounting

The tubes should be mounted as indicated on each individual tube data sheet. Free air circulation should be provided.

Filament

The filaments are designed to operate from alternating current sources. The voltage should be maintained to within 5% of the rated value. Operation of the filaments at a voltage above the upper limit will definitely reduce the life of the tubes, while a decrease in voltage below the lower limit may cause immediate failure.

Operating Precautions

Sufficient filament heating time must always be allowed for the filaments to reach a satisfactory operating temperature and for deposits of mercury in the upper parts of the tubes to be evaporated before the anode potential is applied. The "Required Heating Time" specified on the individual tube data sheet is sufficient to bring the filament to a satisfactory operating temperature when filament circuits with good regulation are used. At the low ambient temperatures, tubes containing mercury vapor only may require several minutes filament warming before the tube will start conducting. In most applications the tubes are self protecting during this warming period. A filament heating period of 15 minutes or more should be allowed when the tubes are used for the first time or if they have been subjected to extensive handling or prolonged standing.

Tube Voltage Drop

The tube voltage drop is substantially independent of anode current. The exact value varies, but under the specified operating conditions will normally be between 5 and 25 volts. A curve showing the tube voltage drop as a function of condensed mercury temperature for a typical tube when passing rated average anode current is shown on the individual tube data sheet.

Maximum Anode Current

The maximum permissible instantaneous and average anode current ratings are limitations on the current values that the tubes can safely carry in the direction in which they are designed to conduct and should not be exceeded.

Maximum Time of Averaging Anode Current

This time is the maximum period over which the anode current should be averaged when determining the maximum average anode current.

Maximum Peak Voltage Between Anode and Grid

This is the maximum permissible instantaneous voltage that should be applied between anode and grid or between anode and filament; either as an inverse anode voltage or a forward anode voltage blocked by grid action.

Control Characteristic

These tubes are so designed that for any given positive anode potential there is a critical grid potential. If the grid is held more negative than this value and the tube is not conducting, the anode current will remain zero. If it is made less negative, the tube becomes conducting and the anode current assumes a value determined by the applied potential and the impedance in the anode circuit. When the tube is conducting the Tube Voltage Drop is practically independent of the value of both the grid potential and the anode current. To extinguish the discharge and reestablish control by the grid, the anode potential must be reduced to zero or made negative, for a period at least as long as the deionization time.

The control characteristic curve relating the critical grid potential to the anode potential for a typical tube is shown on each individual tube data sheet. This characteristic may vary from tube to tube and during the life of a given tube. The extreme variation during the normal life of the tube when operating within the recommended limits will fall within the shaded area. The axis "A" should be used if the anode and grid circuit returns are made to the mid-tap of the filament transformer, and the axis "B" if they are made to either end. Return to the mid-tap is the more desirable mode of operation.

The control characteristic, of tubes containing mercury vapor only, shifts appreciably in a positive direction as the condensed mercury vapor temperature is reduced below 30° C. This shift is indicated by the dotted curve.

In some applications the starting of the anode current may be affected by extraneous electrostatic or electromagnetic fields causing ionization within the tube or inducing a voltage in a high impedance grid circuit. In such cases proper shielding will be required.

Maximum Instantaneous Grid Current

The maximum instantaneous grid current is the maximum peak current from the grid to the external circuit and should not be exceeded.

It is generally necessary to provide a means for limiting the grid current, as a conducting path is also established between the grid and filament within the tube when the anode current is flowing. The grid will supply a net positive ion or electron current to the external circuit depending upon the magnitude and polarity of the applied grid voltage.

Maximum Condensed Mercury Temperature Range

This operating temperature range applies to the temperature of the bulb at the area where the free mercury condenses during normal operation. For mercury and inert gas mixture tubes this range should not be exceeded. For tubes containing mercury vapor only, the upper limit should not be exceeded, but it is permissible to apply plate voltage at condensed mercury temperatures between the lower operating limit and zero degrees centigrade. Full output may not be obtained however until the temperature approaches the rated lower limit. (See "Operating Precautions.")

Nominal Deionization Time

The nominal deionization time is the approximate time required for the gas to return to a deionized state after the removal of a positive anode potential. The grid does not regain control until the gas is deionized.

Typical Circuits

These tubes may be used in a variety of circuits where thyratron control characteristics are desired. The following circuits are examples:

Figure 1 shows an application as a relay device. This circuit possesses a "lock in" feature since the anode potential must be removed momentarily in order to restore the tube to the non-conducting condition.

Figure 2 shows a half-wave manually-controlled rectifier. The average load current may be controlled by varying the relative phase relation of the grid and anode potentials by means of the phase shifting network.

Figure 3 shows an inverter circuit for the conversion of direct current to alternating current. The frequency and wave form of the a-c output will be determined by the driving frequency and the circuit constants.

Figure 4 shows a grid-controlled rectifier circuit which has the property of providing a load voltage nearly independent of load current. The magnitude of the load voltage may be adjusted by means of the potentiometer from 10% to full voltage. While a single section filter is shown, additional sections may be added if desired.

Figure 5 shows a grid-controlled rectifier circuit in which the load current may be limited to a predetermined value even under short circuit conditions. Additional filter sections may be added if desired.

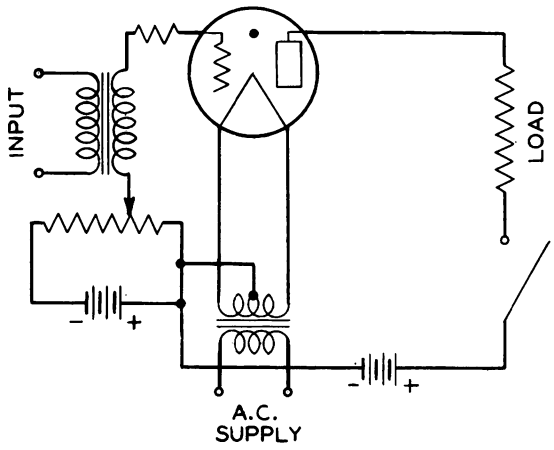


FIG. 1

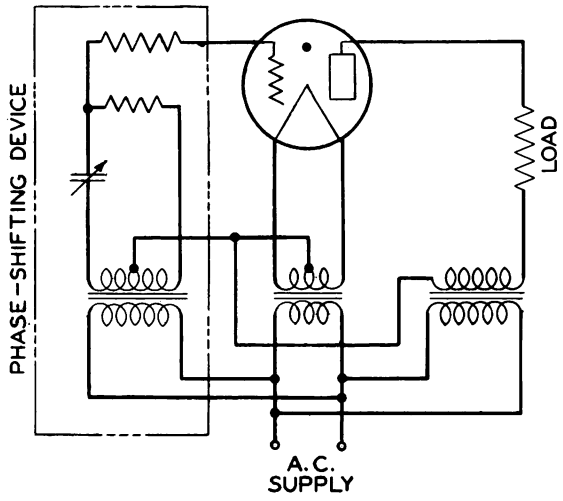


FIG. 2

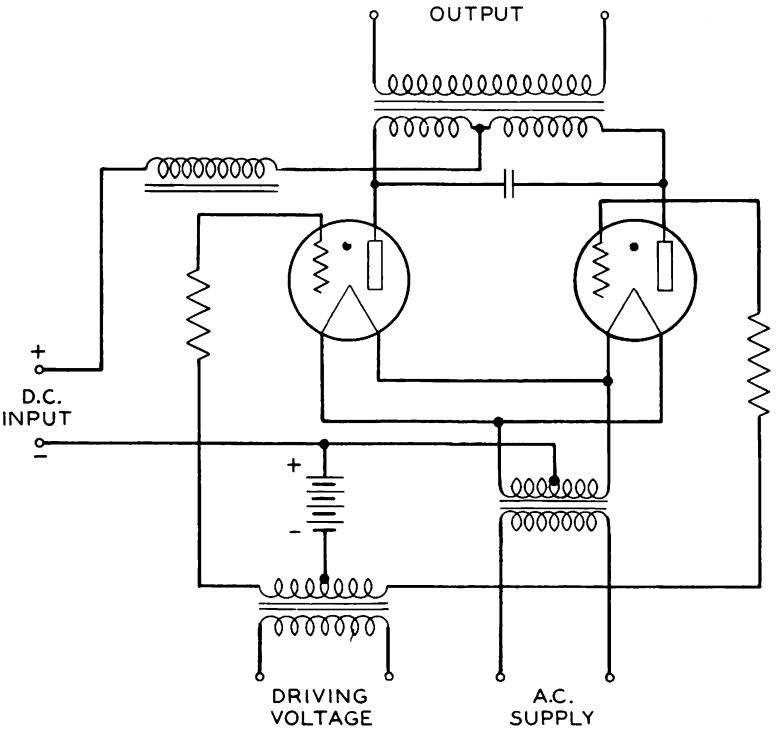


FIG. 3

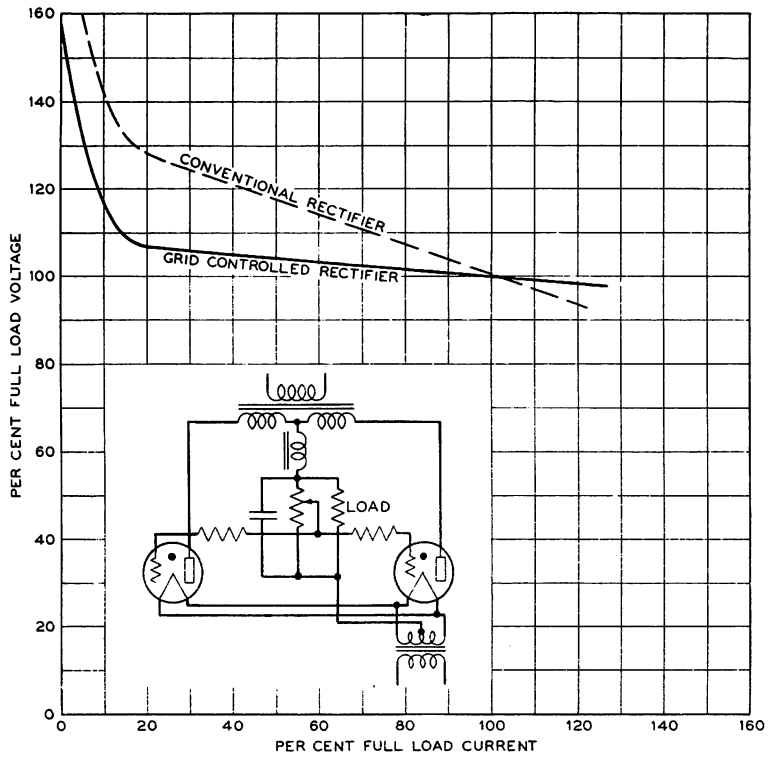

160
140
120
100
80
60
40
20
0
PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
0
20
40
60
80
100
120
140
160
PER CENT FULL LOAD CURRENT

FIG. 4

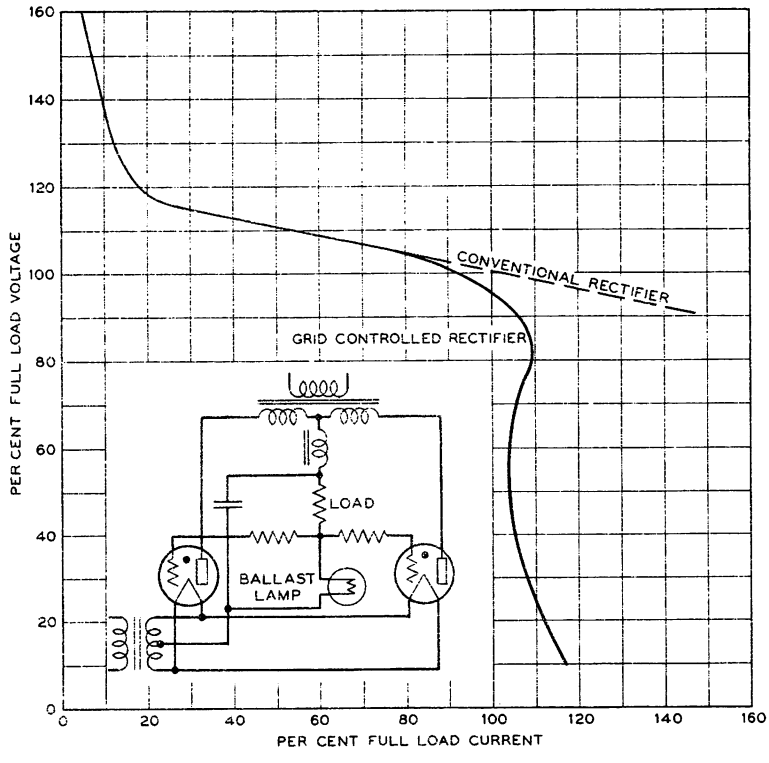
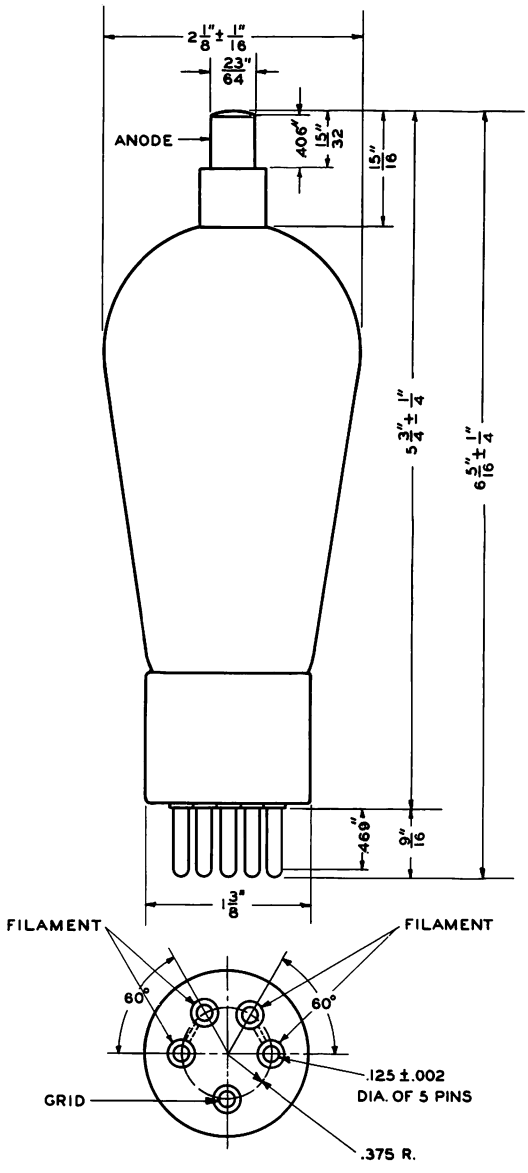
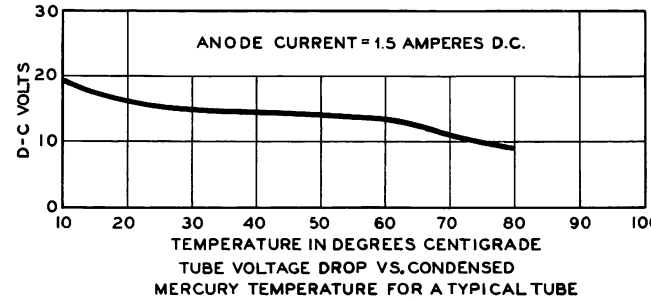

160
140
120
100
80
60
40
20
0
PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
BALLAST LAMP
0
20
40
60
80
100
120
140
160
PER CENT FULL LOAD CURRENT

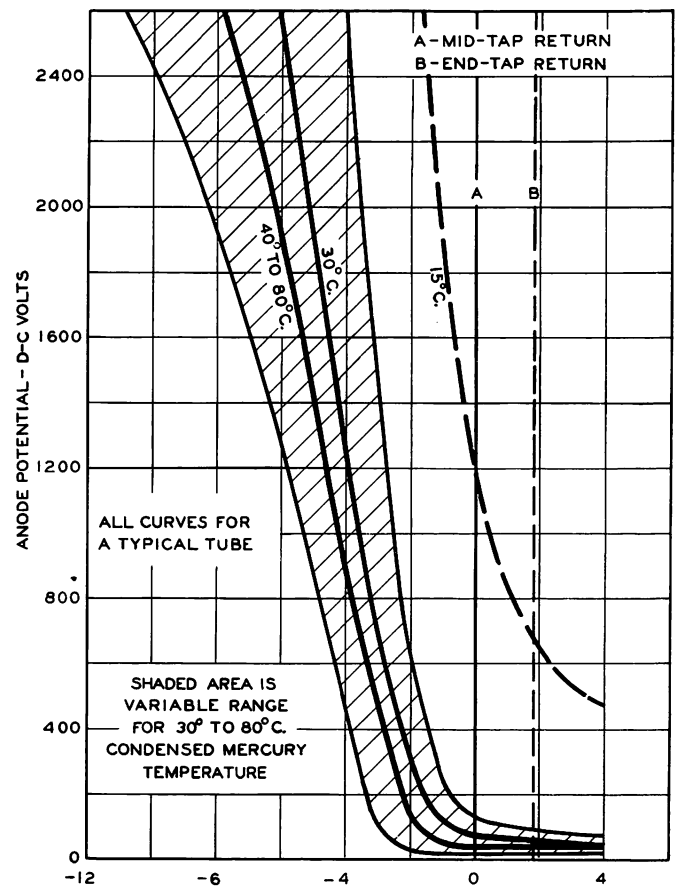
FIG. 5

287A Vacuum Tube
Mercury Vapor Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



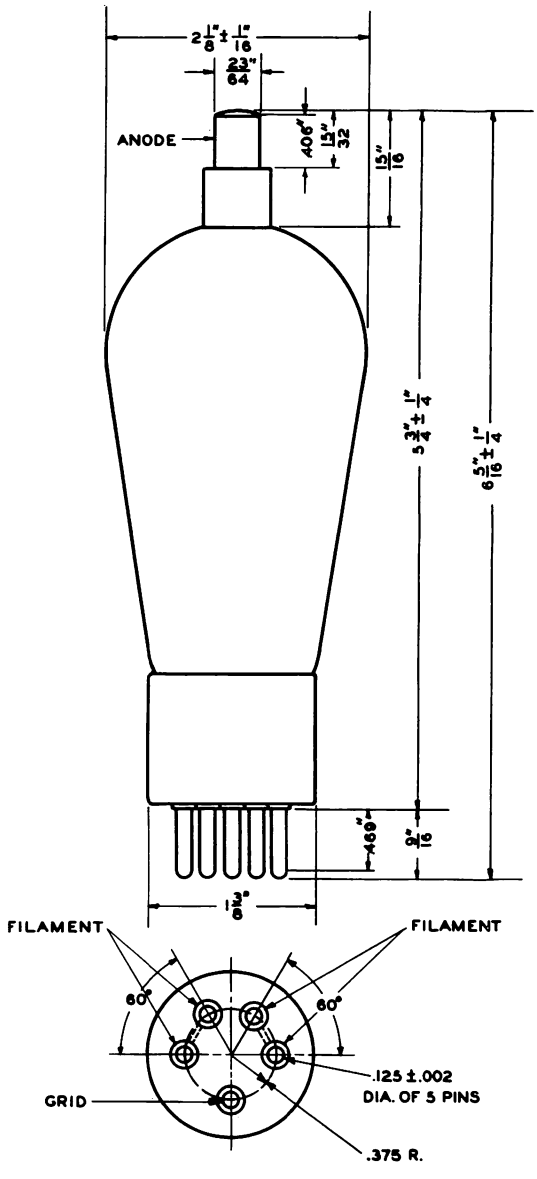
CONTROL CHARACTERISTIC

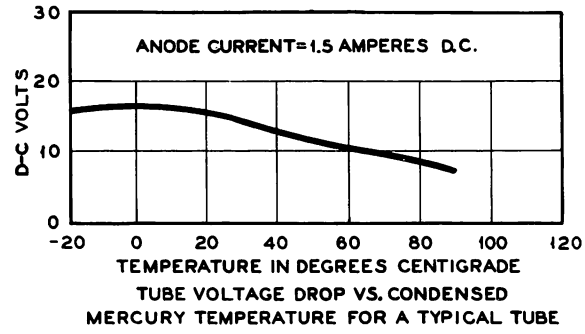
Ratings

Filament		
Voltage	2.5 volts a.c.	
Nominal current	7.0 amperes	
Required heating time	10 seconds	
Approximate tube voltage drop	15 volts	
Maximum peak voltage between anode and grid—volts	500	2500
Maximum instantaneous anode current—amperes	6.0	2.5
Maximum average anode current—amperes	1.5	0.64
Maximum time of averaging anode current	5 seconds	
Maximum instantaneous grid current	50 milliamperes	
Operating condensed mercury temperature range	+30 to +80° C.	
Nominal deionization time	1000 microseconds	

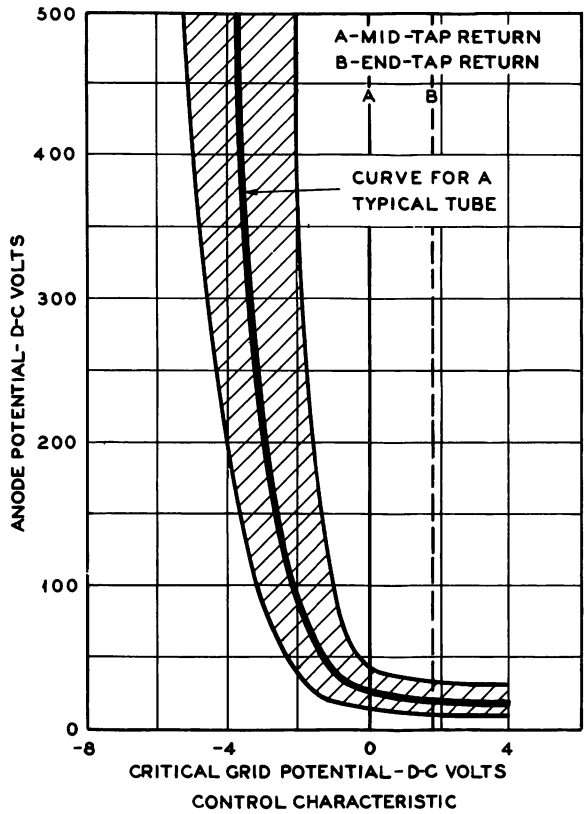
Mounting—The 287A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

323A Vacuum Tube
Mercury Vapor and Argon Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



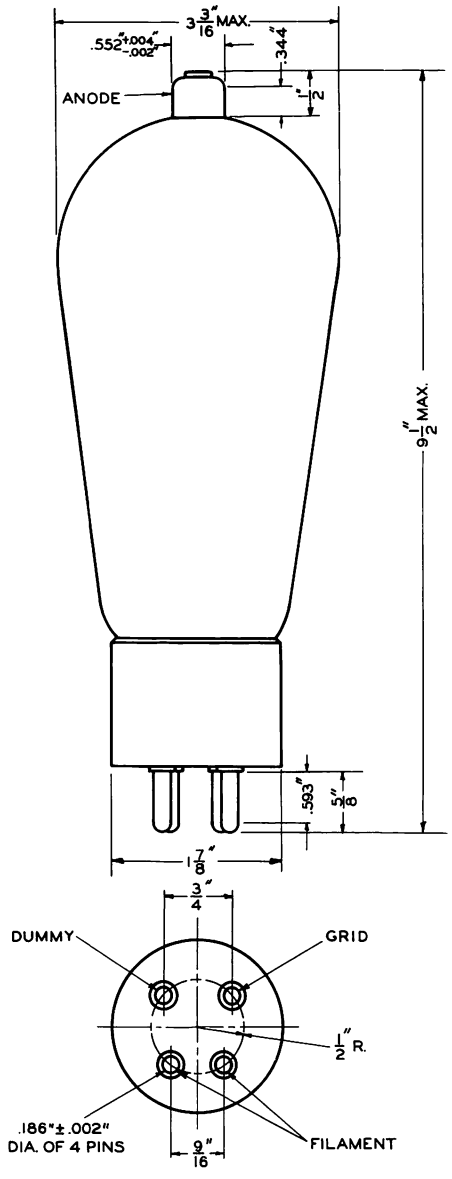
CONTROL CHARACTERISTIC

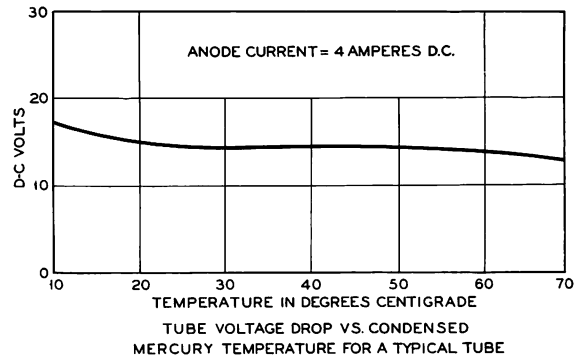
Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	7.0 amperes
Required heating time	10 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	500 volts
Maximum instantaneous anode current	6.0 amperes
Maximum average anode current	1.5 amperes
Maximum time of averaging anode current	5 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	−20 to +90° C.
Nominal deionization time	1000 microseconds

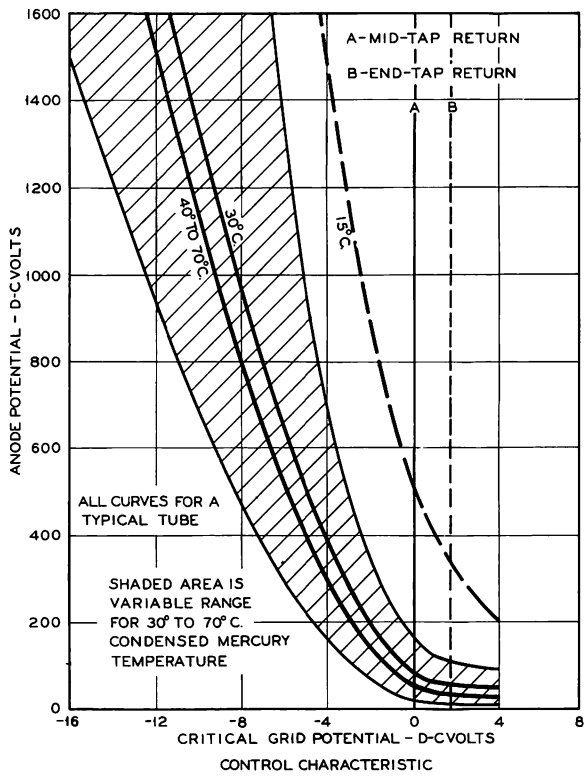
Mounting—The 323A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

354A Vacuum Tube
Mercury Vapor Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



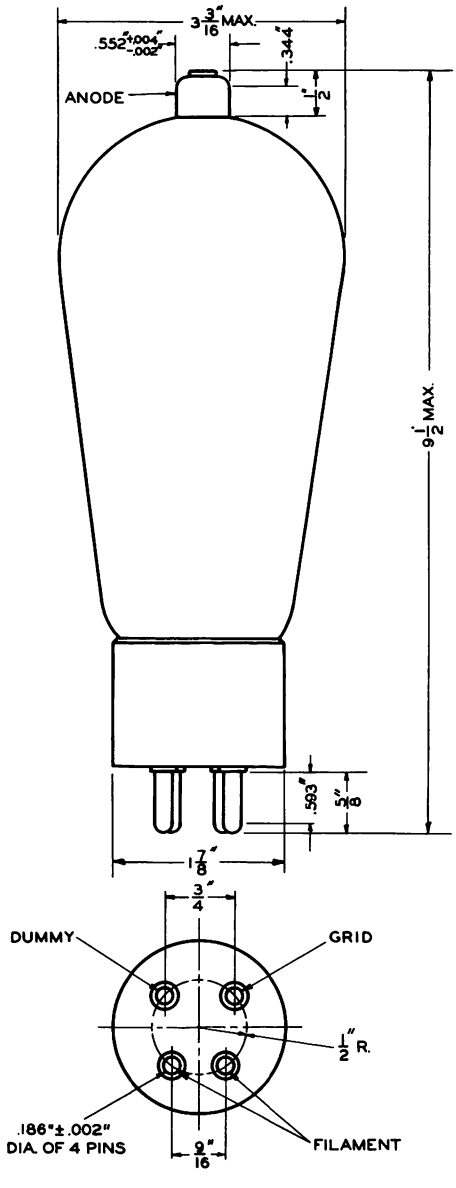
CONTROL CHARACTERISTIC

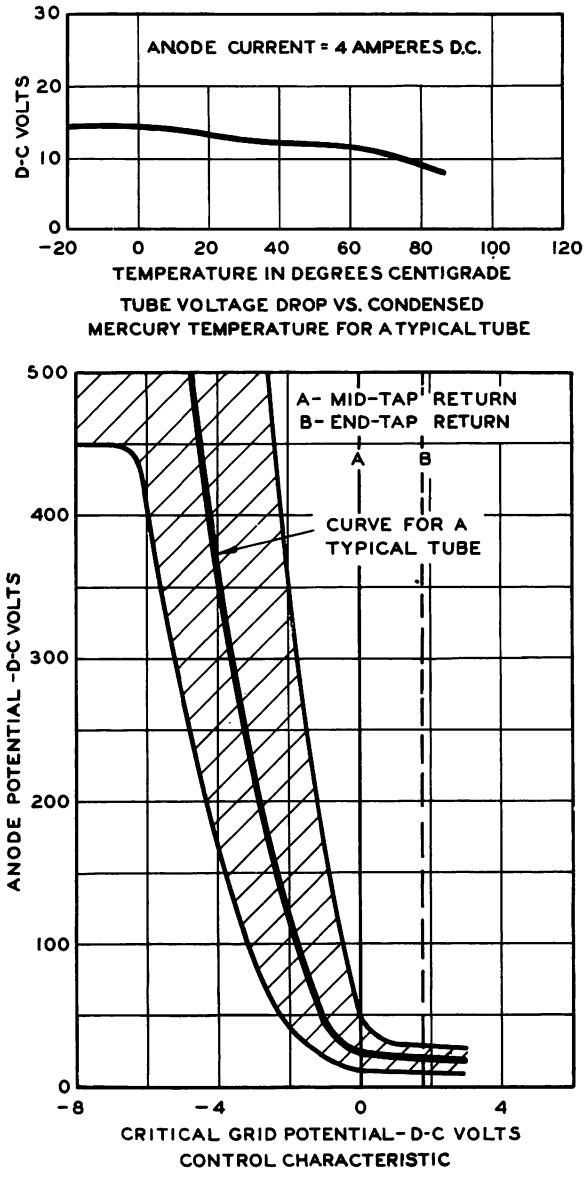
Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	16 amperes
Required heating time	45 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	1500 volts
Maximum instantaneous anode current	16 amperes
Maximum average anode current	4 amperes
Maximum time of averaging anode current	15 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	+30 to +70° C.
Nominal deionization time	1000 microseconds

Mounting—The 354A tube requires a Westinghouse S#793202 or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

355A Vacuum Tube
Mercury Vapor and Argon Filled





Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	16 amperes
Required heating time	45 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	350 volts
Maximum instantaneous anode current	16 amperes
Maximum average anode current	4 amperes
Maximum time of averaging anode current	15 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	−20 to +80° C.
Nominal deionization time	1000microseconds

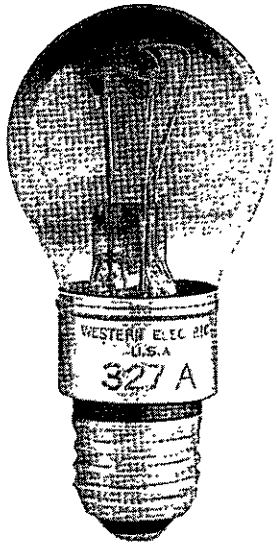
Mounting—The 355A tube requires a Westinghouse S#793202 or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

BELL SYSTEM PRACTICES
Transmission Engineering and Data
Vacuum Tube Data

SECTION AB46.634
Issue 1, February 1938
A T & T Co Standard

Western Electric

327A Vacuum Tube



Classification—Half-wave, tungsten filament, argon filled rectifier.

The 327A vacuum tube is designed to supply direct current from an alternating-current supply in power systems for battery charging and for other purposes.

Dimensions—The dimensions and outline diagram are given in Figure 1. The overall dimensions are:

Maximum length	$4\frac{7}{16}''$
Maximum diameter	$2\frac{1}{4}''$

Mounting—This tube employs a 3 connection, skirted medium screw base. Overall dimensions are shown in Figure 1.

The tube may be mounted either in a vertical or a horizontal position. There should be a free circulation of air around the tube. No object should touch the glass bulb.

Filament Rating

Filament voltage	2.0 volts
Nominal filament current	12 amperes

The filament of this tube is designed to operate on a voltage basis from an alternating-current supply. The voltage should be maintained to within 10% of its rated value (2.0 volts). Operation of the filament outside of these limits may cause the tube to become inoperative. Filament and plate voltage may be applied to the tube simultaneously.

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Characteristic and Operating Conditions

Approximate anode-cathode potential drop	8 volts
Ignition voltage at 60 cycles	7–16 volts, r-m-s
Maximum peak plate current	6.0 amperes
Maximum average plate current	2.0 amperes
Maximum peak inverse potential	275 volts

The anode-cathode potential drop is substantially independent of the plate current. The exact value may vary from tube to tube and during the life of a given tube over the range from 5 to 10 volts.

The ignition voltage is the voltage required to start conduction within the tube. In a-c. circuits this is a function of frequency, increasing as the frequency increases. The values are given for 60 cycles since this frequency will be most generally encountered in circuit design.

The maximum permissible peak plate current (6 amperes) is a limitation on the instantaneous value that the tube can carry safely in the direction in which it is designed to conduct and should not be exceeded. The maximum average load current (2 amperes) is the maximum direct output current which may be obtained from a half-wave circuit using one tube. A full-wave circuit using two tubes will supply a maximum of 4 amperes.

The maximum permissible peak inverse potential (275 volts) is a limitation on the instantaneous value that the tube can stand safely. If it is exceeded, an arc-back may result which may injure the tube. All circuits should be adequately fused to prevent injury to the equipment in event of arc-back due to line surges. The maximum output voltage obtainable in either the half-wave or full-wave circuit is approximately 75 volts.

327A vacuum tubes may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode, may be used for this purpose. The size of the reactors or resistors depends upon the circuit design.

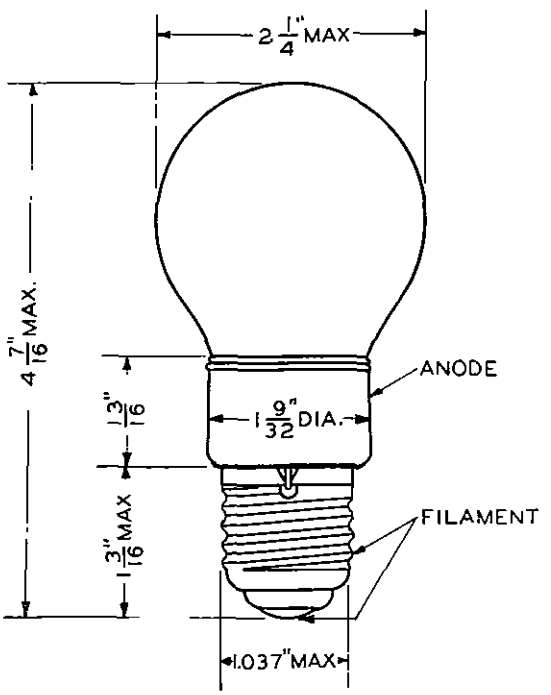


FIG. 1

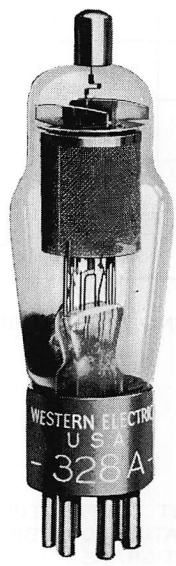
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PRINTED IN U.S.A.

V. T. DATA SHEET 327A
ISSUE 1

Western Electric

328A Vacuum Tube



Classification—Voltage-amplifier, suppressor-grid pentode with indirectly heated cathode

The electrical characteristics of the 328A tube are identical with those of the 310A tube except for the heater voltage and current.

This tube is intended primarily for use in audio, carrier and radio-frequency voltage amplifiers, oscillators or modulators. The connection for the suppressor grid has been brought out to an external terminal, thus making the tube more flexible in its applications.

Dimensions—Dimensions, outline diagrams of the tube and base, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base—Small, six-pin thrust type with pins silver-plated. A small, metal cap control-grid terminal is located at the top of the bulb.

Socket—Standard, six-contact type, preferably provided with silver-plated contacts such as the Western Electric 144B socket.

Mounting Positions—This tube may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B
Control grid to plate	0.025	0.007 μμf.
Suppressor grid to plate	12.5	12.5 μμf.
Plate to heater, cathode and screen grid	2.2	3.2 μμf.
Control grid to suppressor grid	1.8	1.3 μμf.
Control grid to heater, cathode and screen grid	4.0	6.5 μμf.
Suppressor grid to heater, cathode and screen grid	7.5	14.5 μμf.

Column A—Without shield.
Column B—With close-fitting metal shield connected to cathode.

Heater Rating

Heater voltage	7.5 volts, a.c. or d.c.
Nominal heater current	0.425 ampere

The heater element of this tube is designed to operate on a voltage basis and should be operated at as near the rated voltage as is practicable.

Cathode Connection—Preferably direct to the heater. If voltage must be applied between the cathode and heater, it should not exceed 150 volts.

Characteristics—Plate current and screen-grid current characteristics of a typical 328A tube are shown in Figures 3 and 4, respectively, as functions of control-grid voltage for several values of screen-grid and plate voltage and zero suppressor-grid voltage. The screen-grid voltage for these characteristics is equal to the plate voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are given in Figures 5, 6 and 7. Plate current and screen-grid current characteristics as functions of plate voltage are given in Figures 8 and 9, respectively, for several values of control-grid voltage, a screen-grid voltage of 135 volts, and zero suppressor-grid voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are shown in Figures 10, 11 and 12. Plate current, screen-grid current, plate resistance, and transconductance characteristics are shown in Figures 13, 14, 15 and 16 as functions of plate voltage for several values of suppressor-grid voltage, a screen-grid voltage of 135 volts, and a control-grid voltage of −3 volts. These last characteristics are of particular interest in modulator applications where separate inputs are applied to the control and suppressor grids.

Limiting Conditions for Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	180 volts
Maximum cathode current (screen-grid current plus plate current)	10 milliamperes
Maximum screen-grid current	2.5 milliamperes

Operating Conditions and Output—Nominal performance data are given in the table below for a number of typical operating conditions. Less severe operating conditions should be selected in preference to maximum operating conditions wherever possible. The life of the tube at maximum conditions may be shorter than at less severe conditions.

The performance data include the fundamental voltage or power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages no greater than the indicated values. The voltage output is given in peak volts, the power output in milliwatts, and the harmonic levels in decibels below the fundamental.

TABLE

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Suppressor-Grid Voltage	Plate Current	Load Resistance	Input Voltage	Output Voltage	Output Power	Second Harmonic	Third Harmonic
Volts	Volts	Volts	Volts	Milliamperes	Ohms	Peak Volts	Peak Volts	Milliwatts	db	db
135	135	−3	0	5.4	20,000	3.00		250	22	30
					60,000	1.60		130	26	28
					60,000	0.95		60	35	45
					60,000	1.15	100		33	39
					100,000	0.57	75		35	50
					100,000	0.40	50		40	55
180	135	−3	0	5.4	40,000	2.70		340	26	28
					100,000	1.50	175		26	30
225	135	−3	0	5.5	60,000	2.70		425	27	27
					100,000	1.80	220		27	31
*250	135	−3	0	5.5	60,000	2.70		480	26	30
					60,000	1.20		110	30	55
					100,000	2.10	250		26	29
					100,000	1.50	200		30	43

*Maximum operating conditions.

Curves showing the fundamental power and voltage output and the second and third harmonic levels as functions of input voltage for a number of values of load resistance and a typical operating condition are given in Figures 17, 18, 19 and 20.

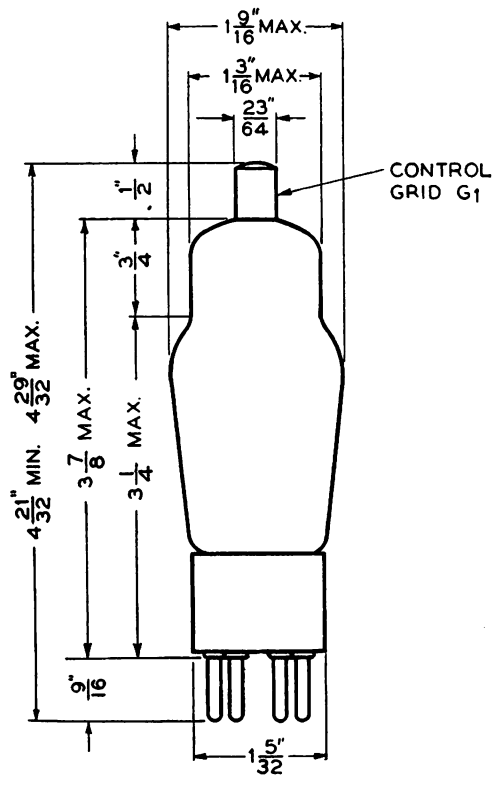


FIG. 1

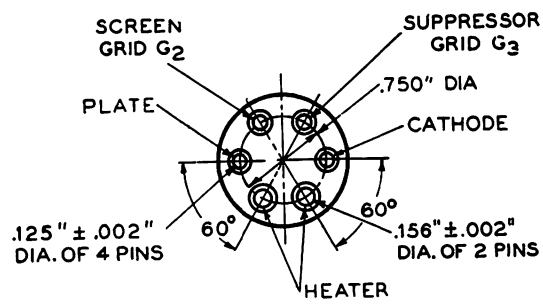


FIG. 2

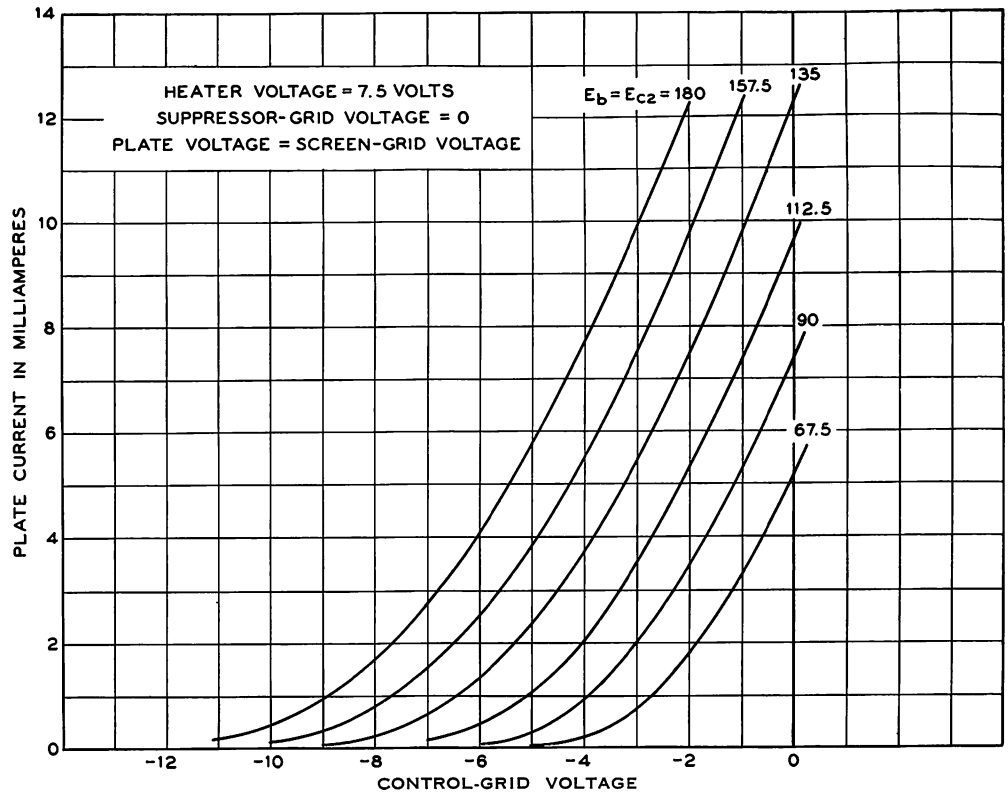

HEATER VOLTAGE = 7.5 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 180
157.5
135
112.5
90
67.5
PLATE CURRENT IN MILLIAMPERES
0
2
4
6
8
10
12
14
-12
-10
-8
-6
-4
-2
0
CONTROL-GRID VOLTAGE

FIG. 3

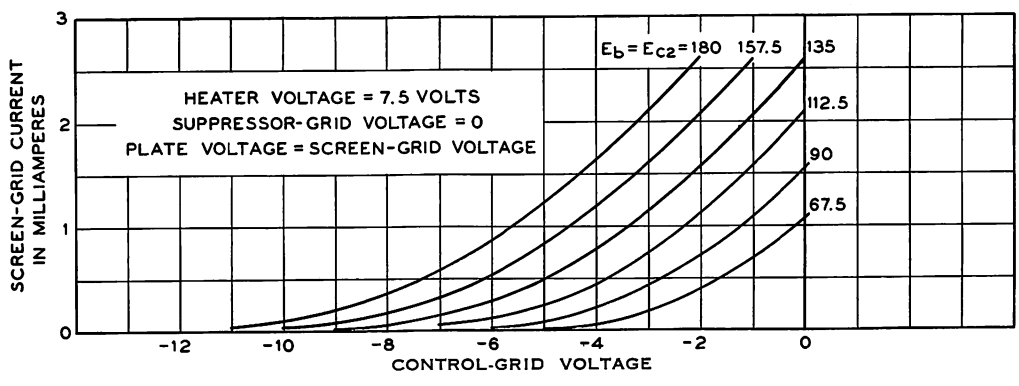

HEATER VOLTAGE = 7.5 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 180
157.5
135
112.5
90
67.5
SCREEN-GRID CURRENT IN MILLIAMPERES
0
1
2
3
-12
-10
-8
-6
-4
-2
0
CONTROL-GRID VOLTAGE

FIG. 4

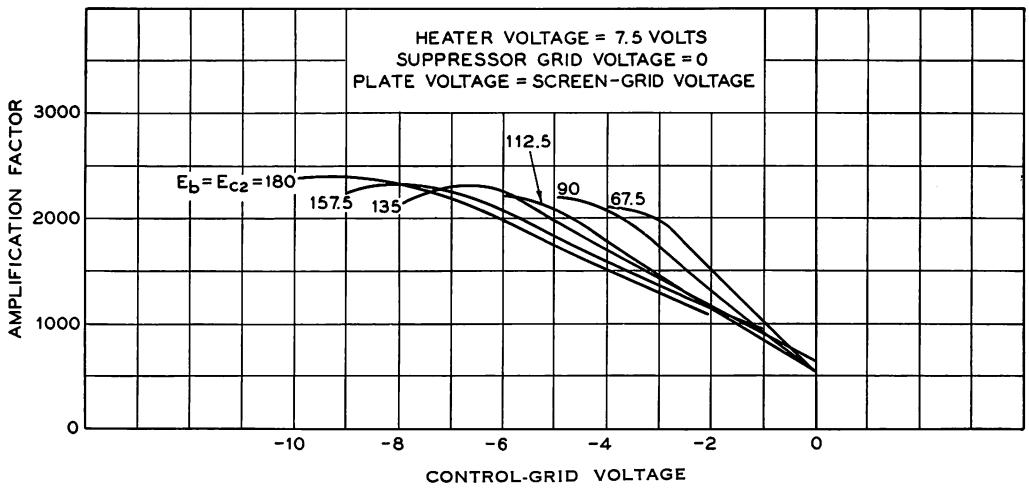


FIG. 5

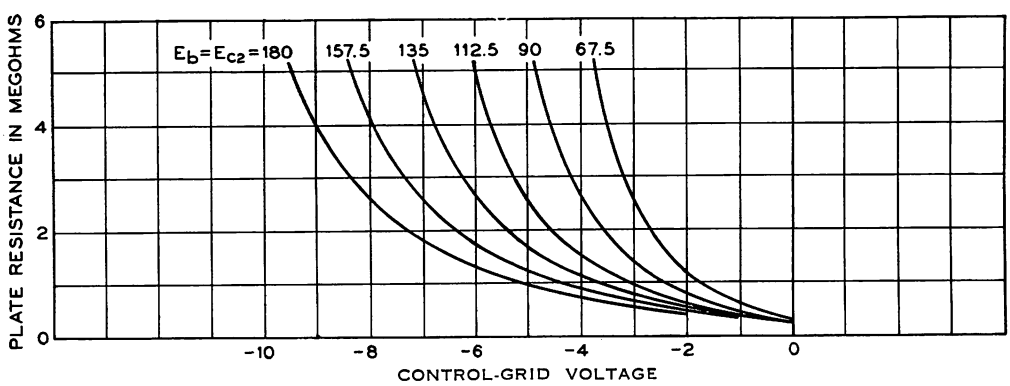


FIG. 6

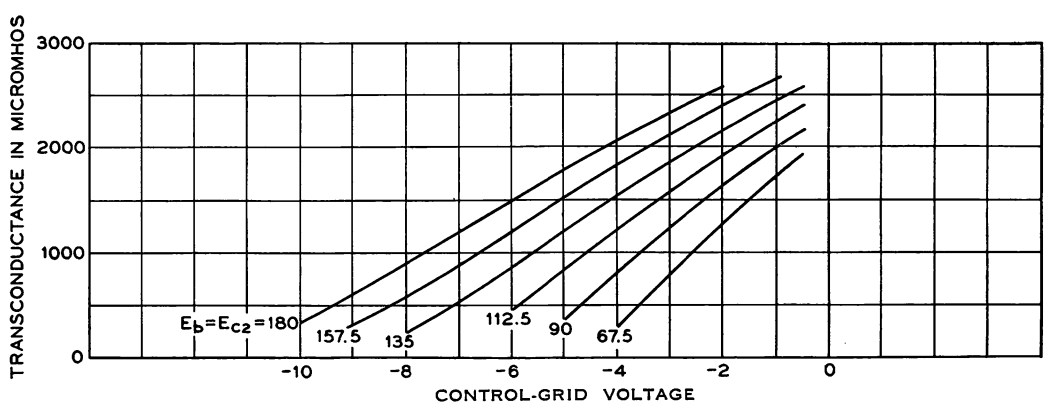


FIG. 7

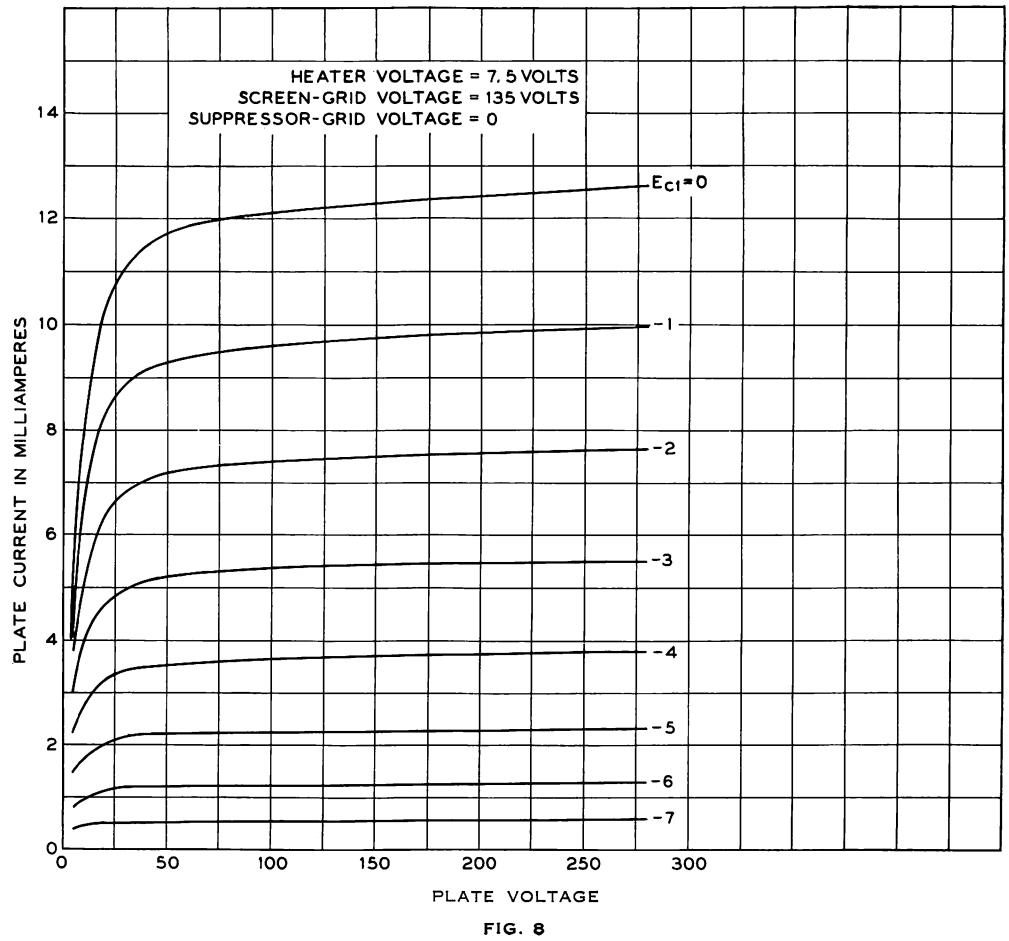

HEATER VOLTAGE = 7.5 VOLTS
SCREEN-GRID VOLTAGE = 135 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
PLATE CURRENT IN MILLIAMPERES
0
2
4
6
8
10
12
14
0
50
100
150
200
250
300
PLATE VOLTAGE

FIG. 8

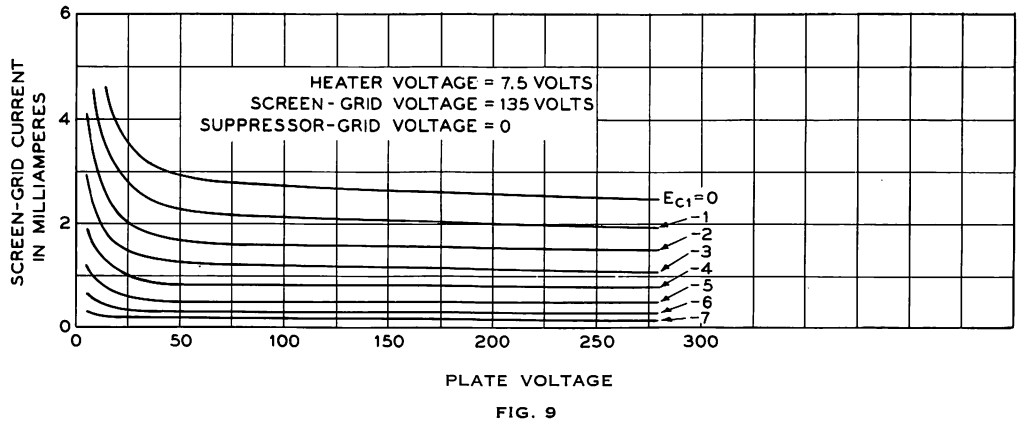

HEATER VOLTAGE = 7.5 VOLTS
SCREEN-GRID VOLTAGE = 135 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
SCREEN-GRID CURRENT IN MILLIAMPERES
0
2
4
6
0
50
100
150
200
250
300
PLATE VOLTAGE

FIG. 9

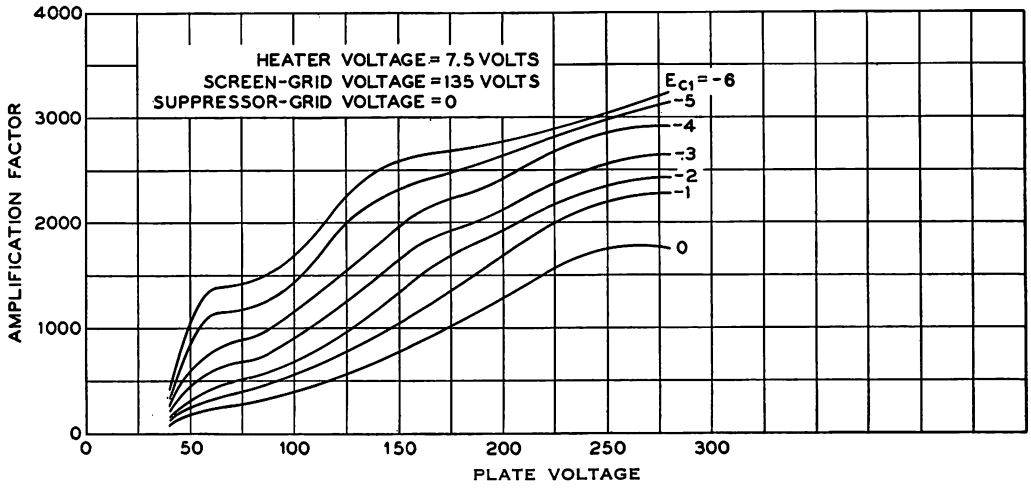


FIG. 10

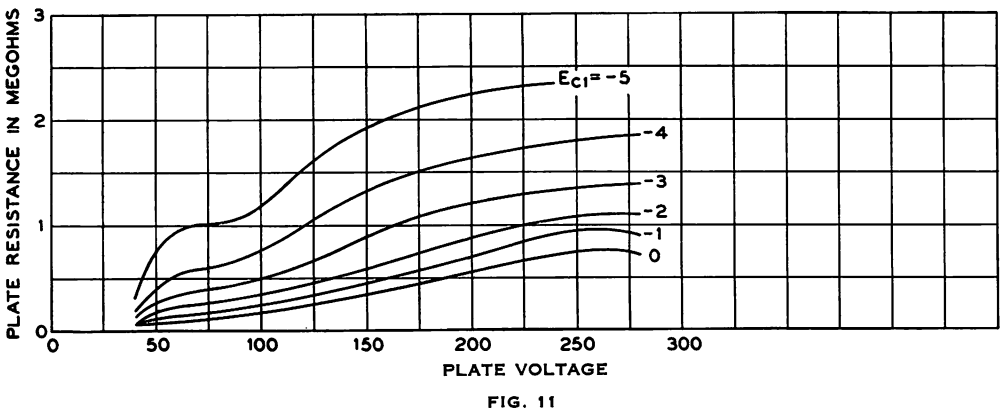


FIG. 11

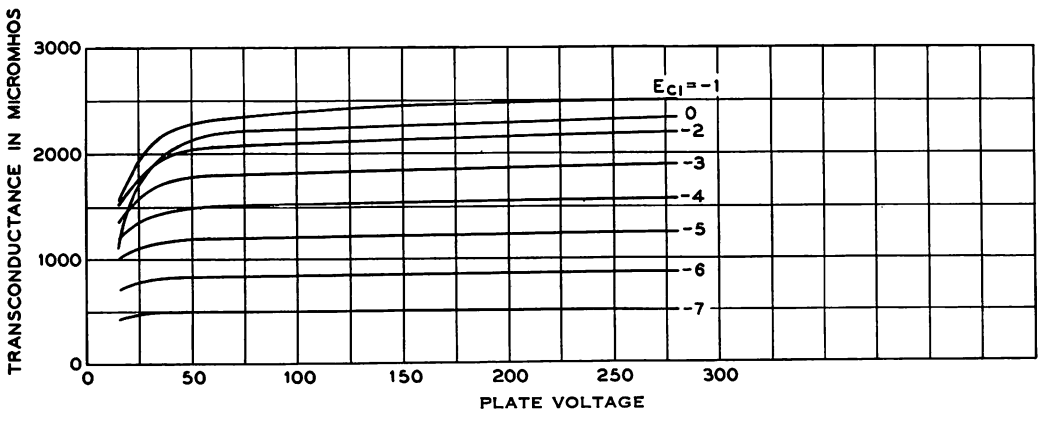


FIG. 12

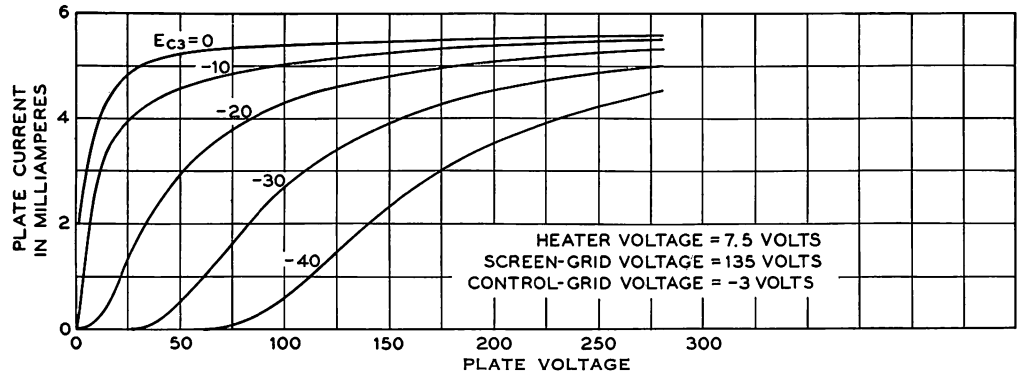


FIG. 13

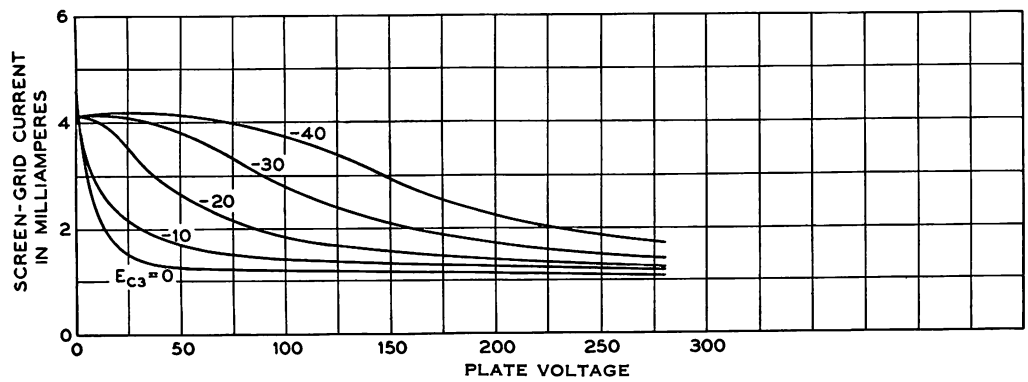


FIG. 14

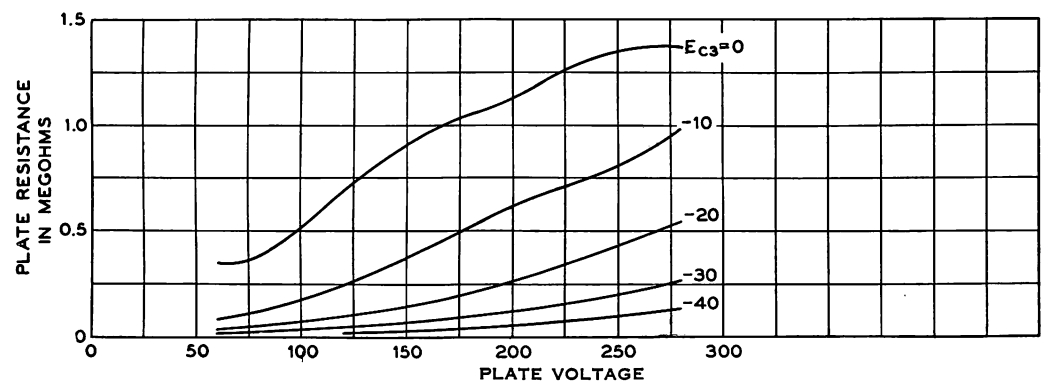


FIG. 15

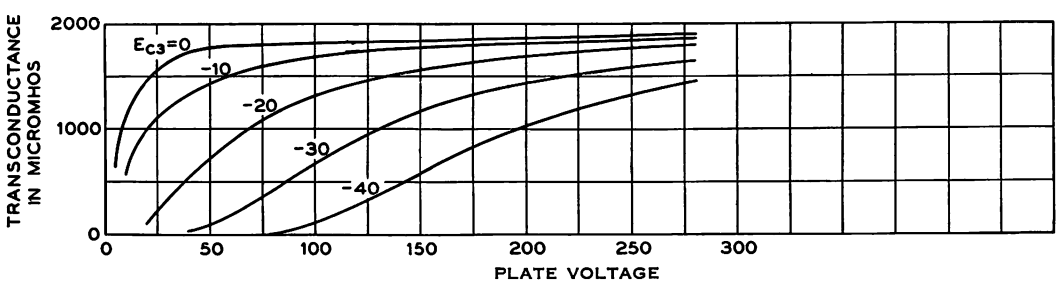


FIG. 16

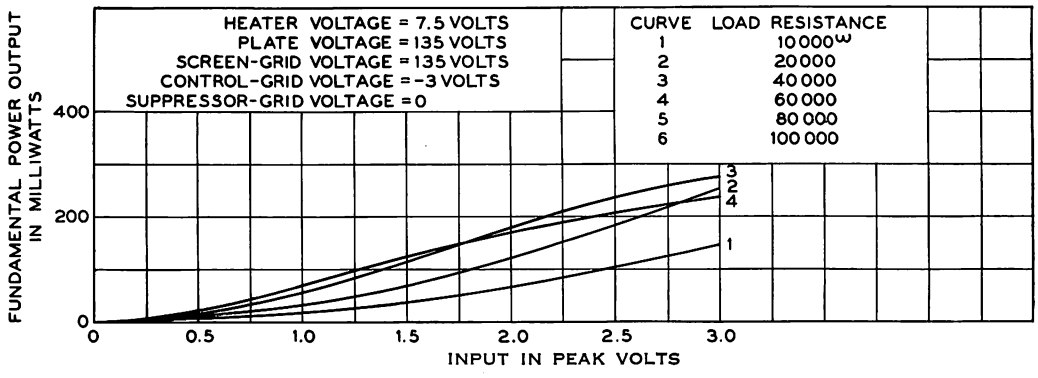


FIG. 17

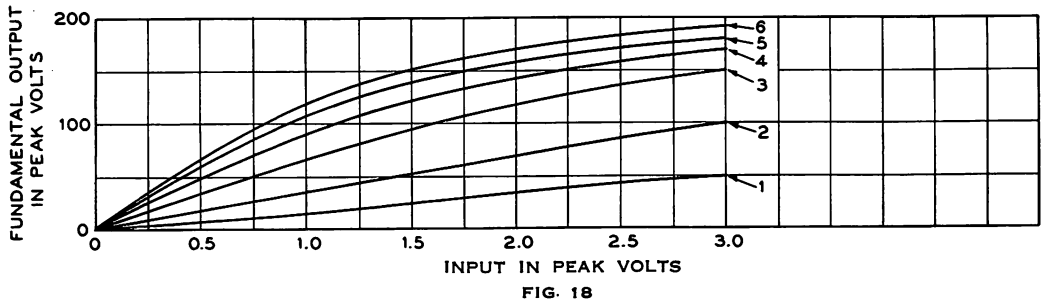


FIG. 18

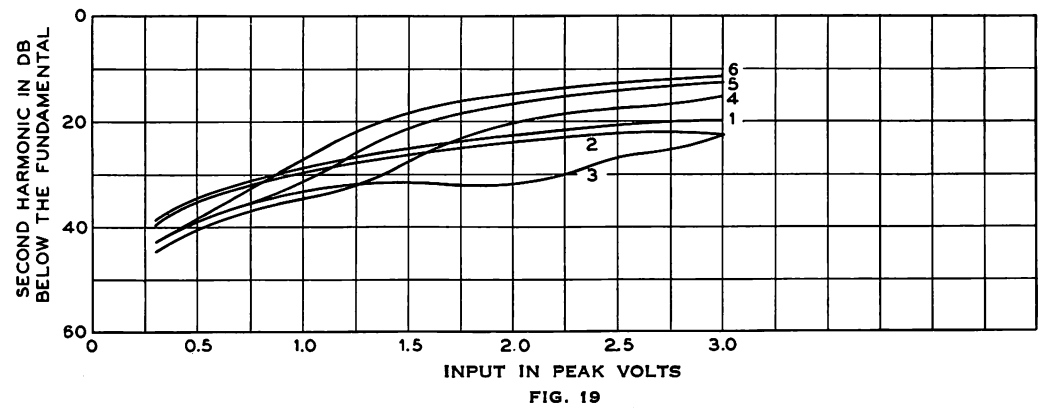


FIG. 19

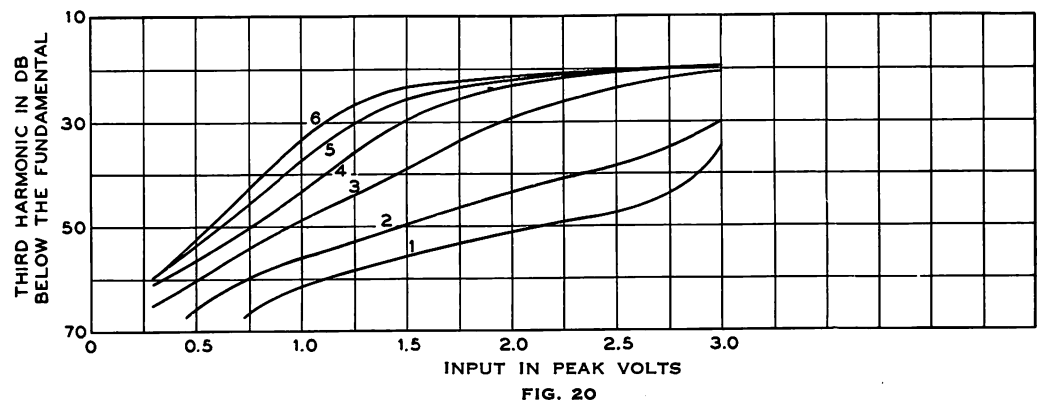
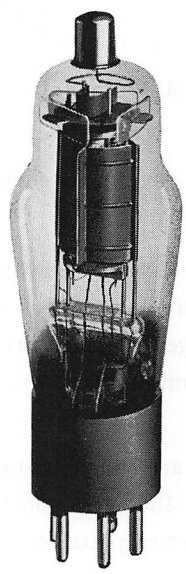


FIG. 20

Western Electric

311A and 329A Vacuum Tubes



Classification—Low-power, suppressor-grid pentodes with indirectly heated cathodes

The 311A and 329A tubes are identical except for the heaters.

These tubes are intended primarily for use as audio, carrier or radio-frequency power amplifiers where power outputs of approximately two watts are required and where the plate voltage is not in excess of 180 volts. The suppressor grid is permanently connected to the cathode within the tube.

Dimensions and Connections—Dimensions, outline diagrams of the tubes and bases, and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base and Mounting—These vacuum tubes employ small five-pin thrust type bases with silver plated pins. They are adapted for use in standard five-contact type sockets, preferably those provided with silver-plated contacts such as the Western Electric 141A socket. A small metal cap control-grid terminal is located at the top of the bulb.

The tubes may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B	
Control grid to plate	0.29	0.07	μμf.
Control grid to heater, cathode and screen grid	8	9	μμf.
Plate to heater, cathode and screen grid	9	12	μμf.

Column A—Without shield.

Column B—With close fitting metal shield connected to the cathode.

Heater Ratings

	311A Tube	329A Tube	
Heater voltage	10.0	7.5	volts, a.c. or d.c.
Nominal heater current	0.64	0.85	ampere

The heaters should be operated on a voltage basis and at as near the rated voltage as practicable.

The voltage between the cathode and the heater should not exceed 150 volts.

Characteristics—Figures 3 and 4 respectively, show plate current and screen-grid current as functions of control-grid voltage for several values of screen and plate voltage. In all curves the plate voltage is equal to the screen voltage. Amplification factor, plate resistance and transconductance curves for the conditions corresponding to those of Figures 3 and 4 are given respectively in Figures 5, 6 and 7.

Plate current and screen-grid current are shown as functions of plate voltage in Figures 8 and 9 respectively, for a screen-grid voltage of 135 volts and for several values of control-grid voltage. Corresponding curves for amplification factor, plate resistance and transconductance are given in Figures 10, 11 and 12 respectively.

Curves showing the fundamental power output and the second and third harmonic levels as functions of input voltage for a number of values of load resistance for typical operating conditions are given in Figures 13, 14 and 15 respectively.

Limiting Conditions for Safe Operation

Maximum direct plate voltage	180 volts
Maximum direct screen-grid voltage	150 volts
Maximum cathode current (plate current plus screen-grid current)	60 milliamperes
Maximum direct screen-grid current	12 milliamperes

Operating Conditions and Output — Nominal performance data are given in the table on page 3 for a number of typical operating conditions. Less severe operating conditions should be selected in preference to the maximum conditions wherever possible. The life of the tube at maximum conditions will be shorter than at the less severe conditions.

The performance data include the fundamental power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages not exceeding the indicated values. Under certain conditions the maximum second harmonic level occurs at a lower input voltage than that given in the table. The power output is given in watts, and the harmonic levels in decibels below the fundamental.

TABLE

Control-grid voltage = —15 volts

Screen-grid voltage = 135 volts

Plate Voltage	Amplification Factor	Plate Resistance	Transconductance	Plate Current	Load Resistance	Input Voltage	Output Power	Second Harmonic	Third Harmonic
Volts		Ohms	Micromhos	Milliamperes	Ohms	Peak Volts	Watts	db	db
135	122	43,000	2800	30	3000	15	1.9	23	24
					3500	15	2.0	27	21
					4000	15	2.0	29	19
					6000	15	1.9	20	18
180*	146	50,000	2900	31	3000	15	2.5	18	30
					4000	15	2.8	21	24
					7000	15	2.5	23	18

*Maximum plate voltage.

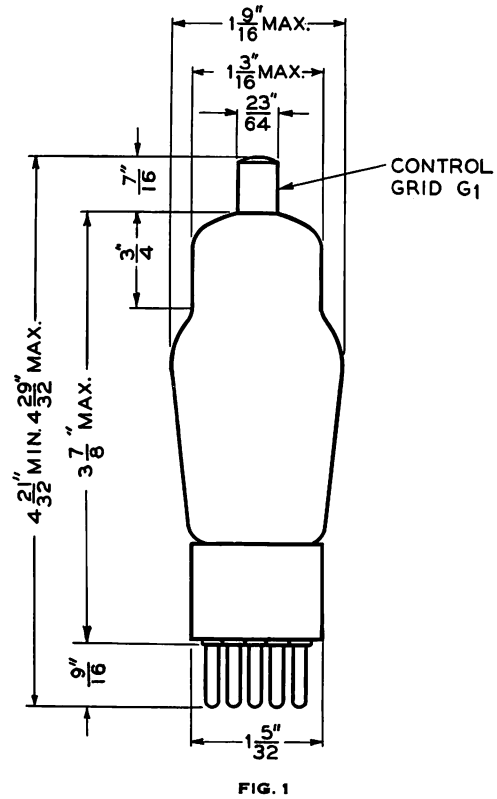


FIG. 1

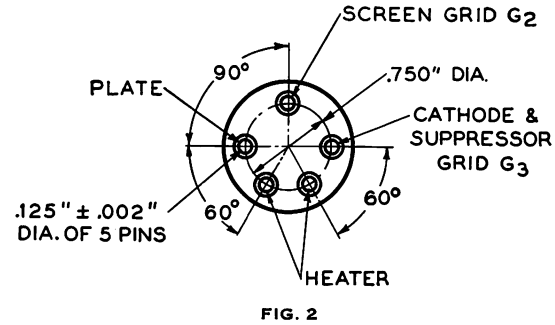


FIG. 2

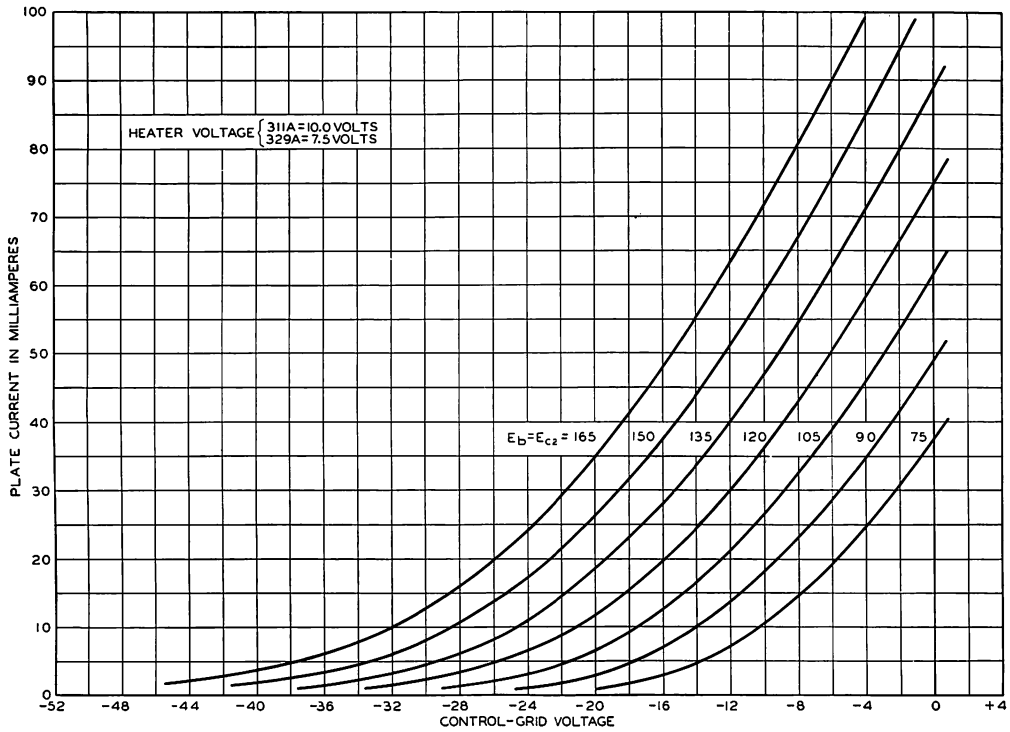

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
$E_b=E_{c2}$= 165
150
135
120
105
90
75
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
100
90
80
70
60
50
40
30
20
10
0
-52
-48
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4

FIG. 3

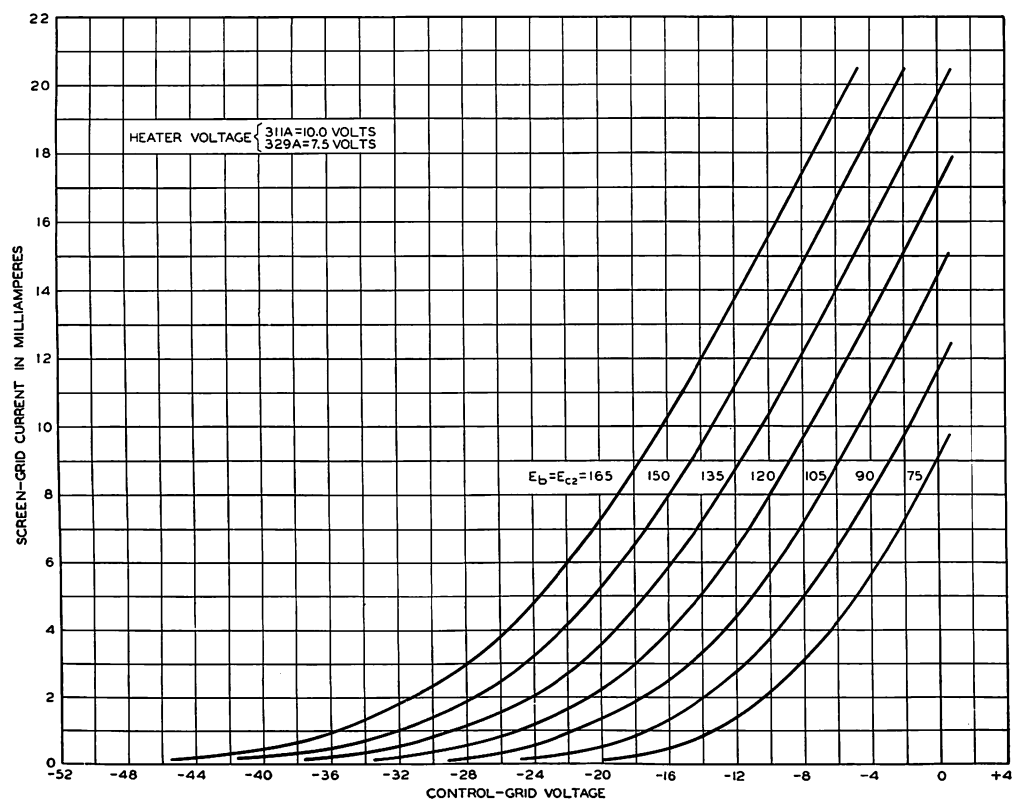

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
$E_b=E_{c2}$=165
150
135
120
105
90
75
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
22
20
18
16
14
12
10
8
6
4
2
0
-52
-48
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4

FIG. 4

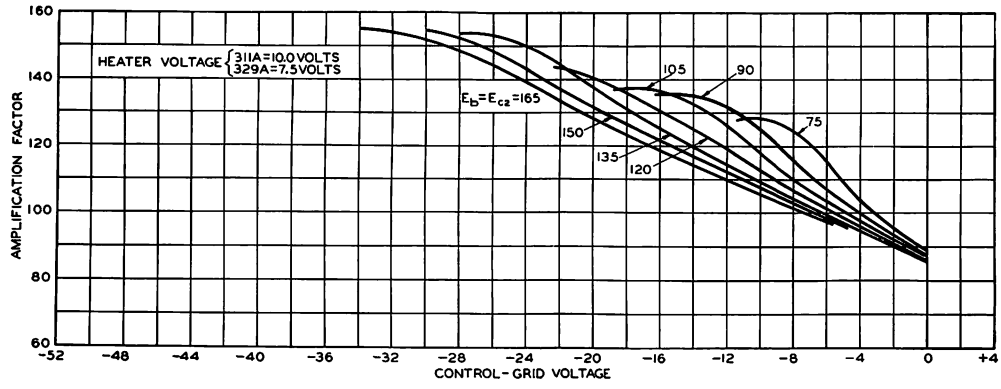


FIG. 5

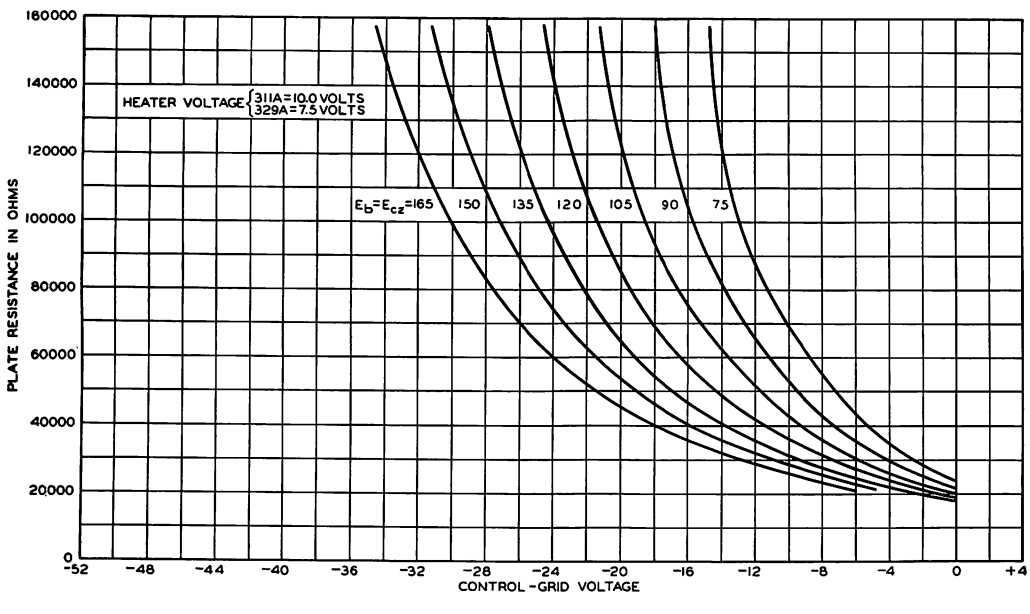


FIG. 6

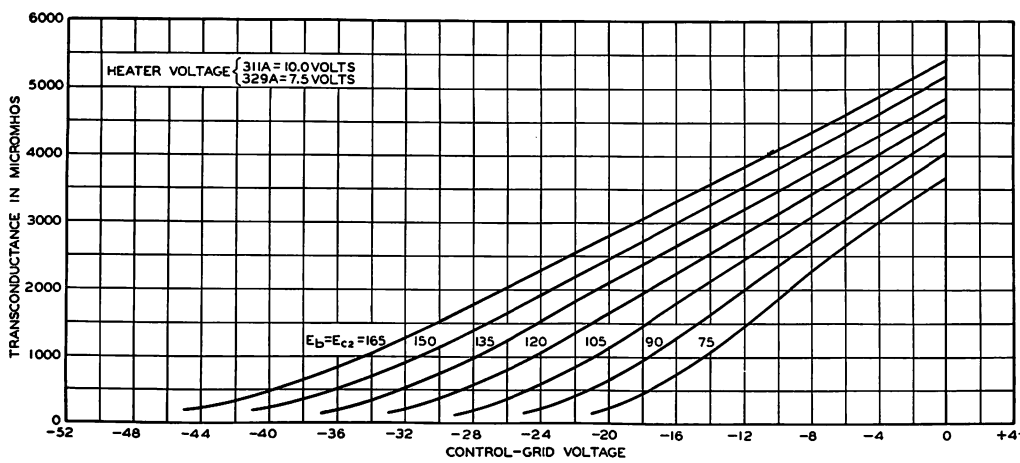


FIG. 7

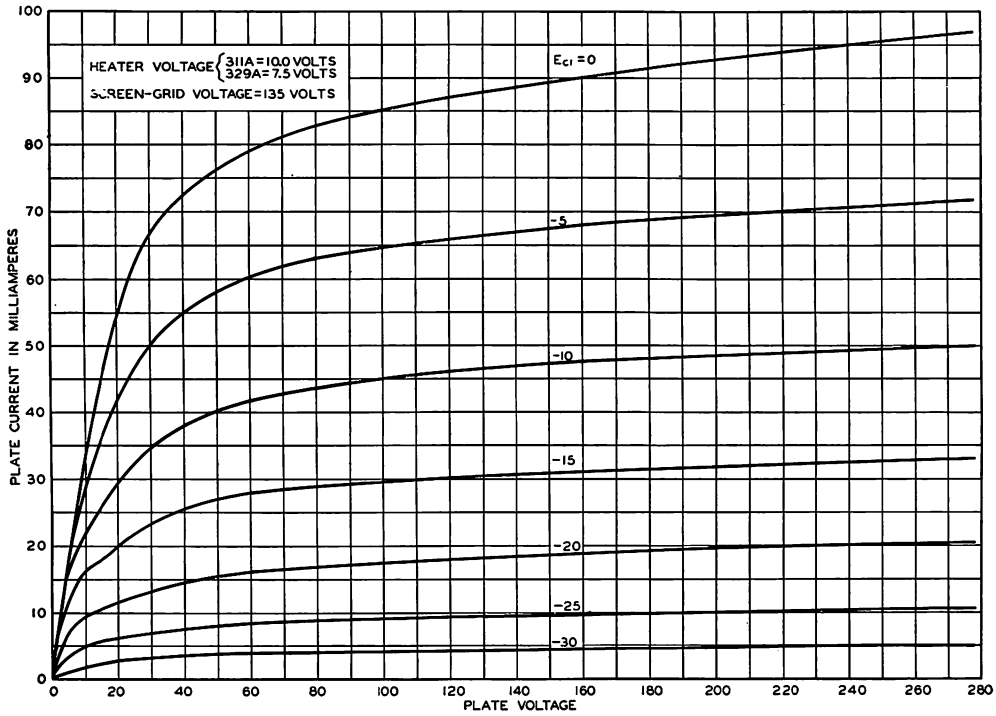

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
Ec1=0
-5
-10
-15
-20
-25
-30
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
70
80
90
100
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280

FIG. 8

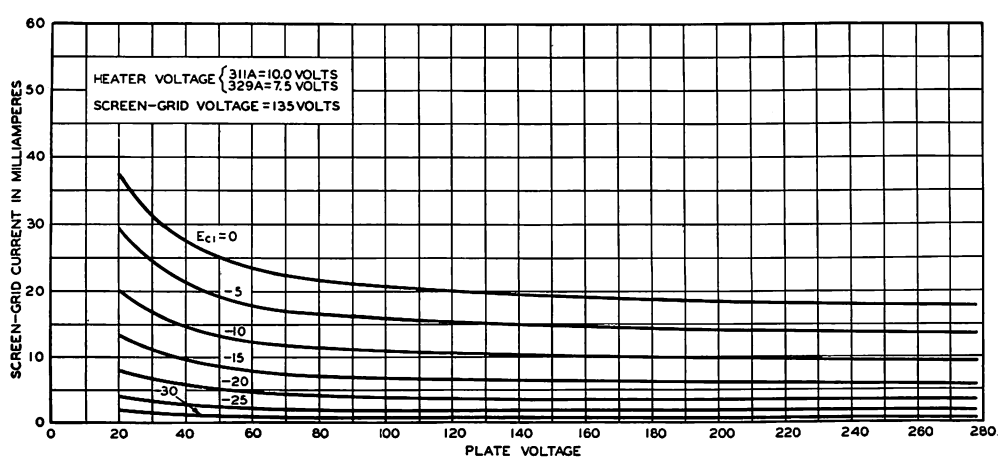

HEATER VOLTAGE { 311A=10.0 VOLTS 329A=7.5 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
Ec1=0
-5
-10
-15
-20
-25
-30
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280

FIG. 9

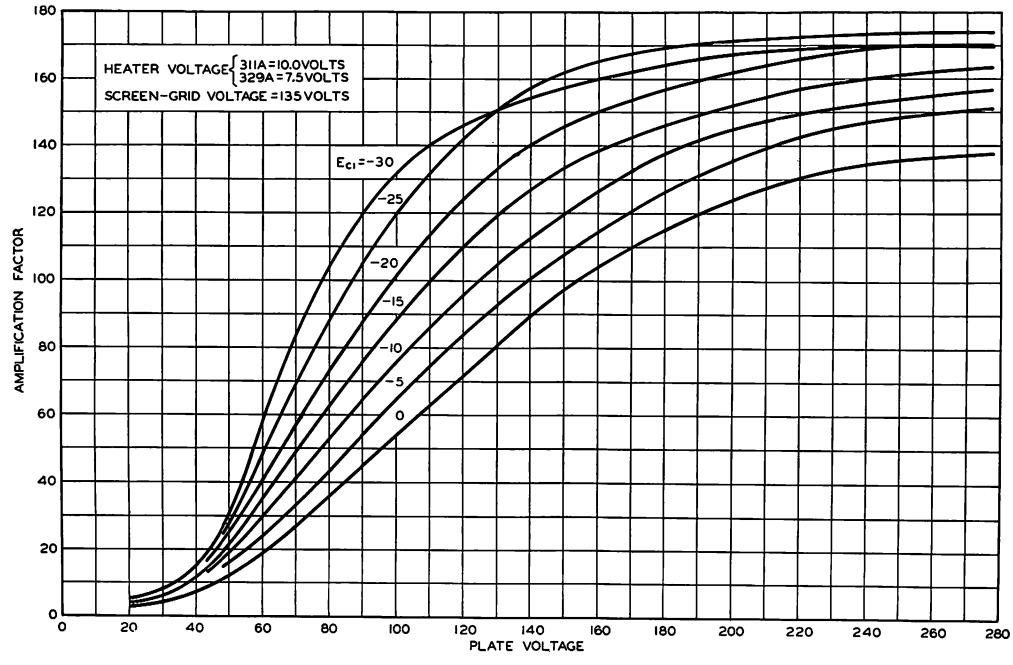


FIG 10

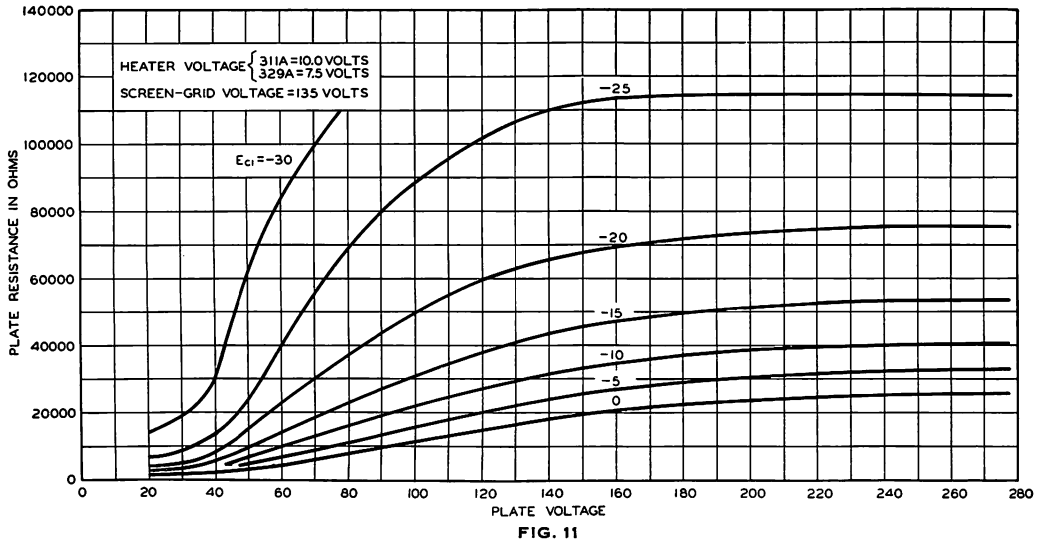


FIG. 11

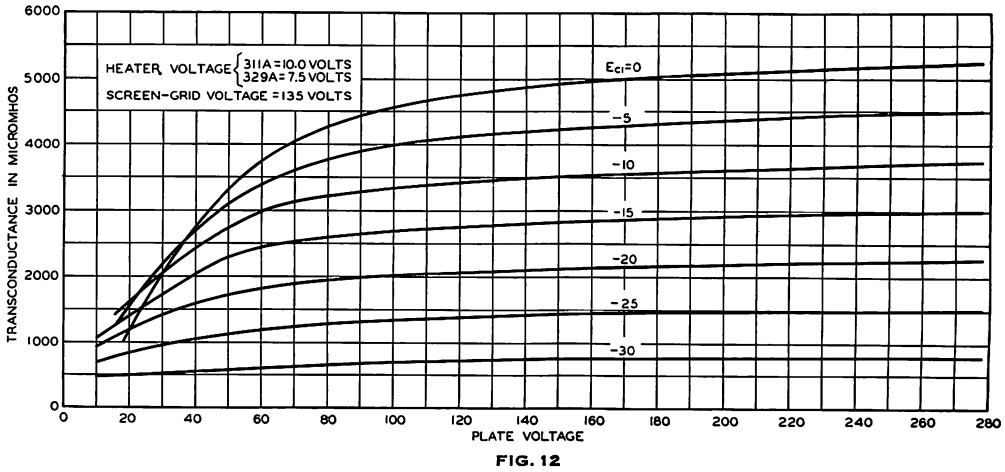


FIG. 12

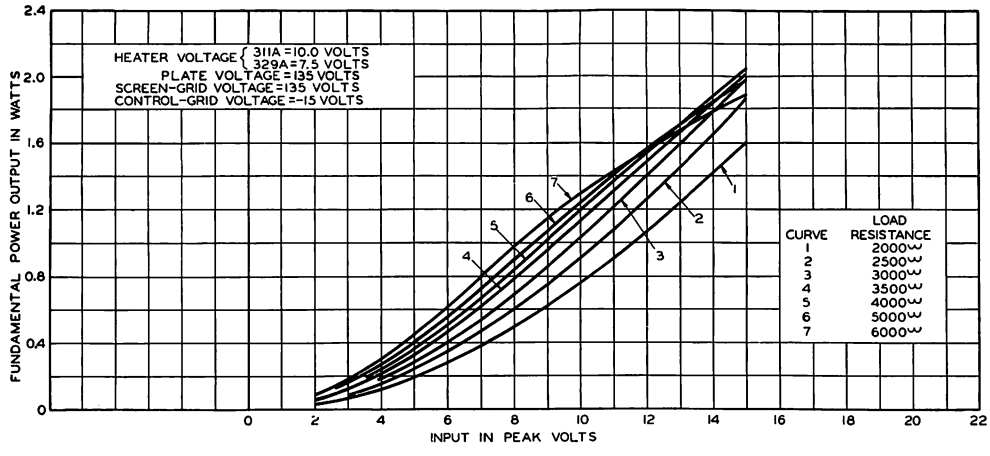


FIG. 13

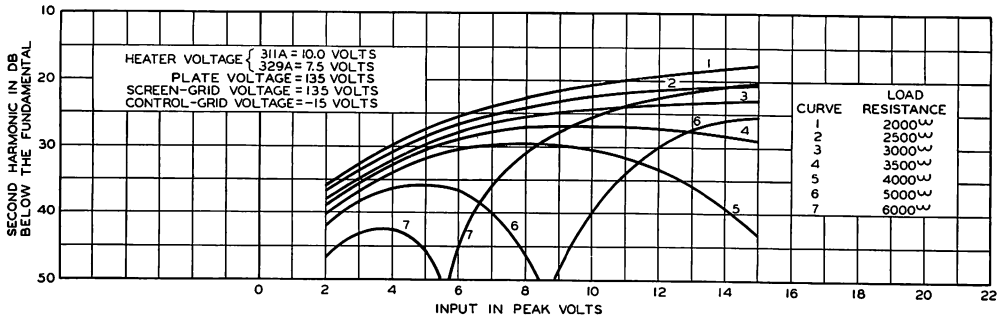


FIG. 14

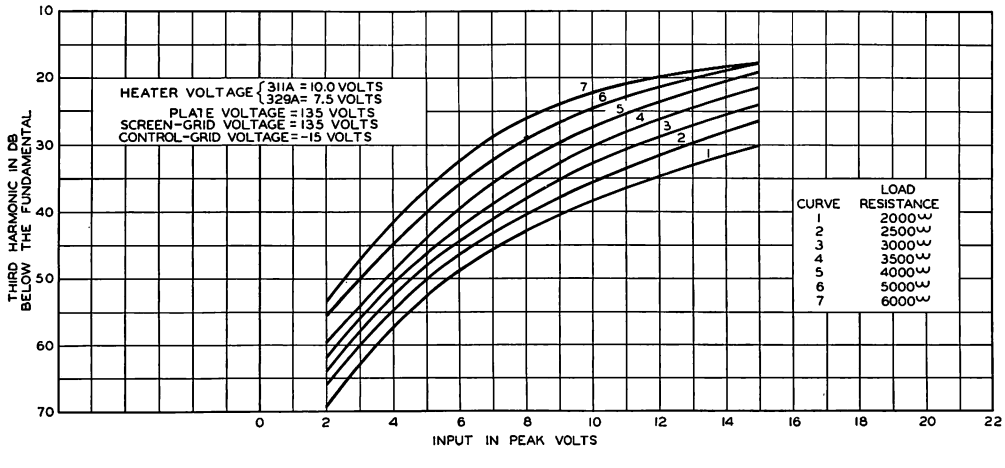
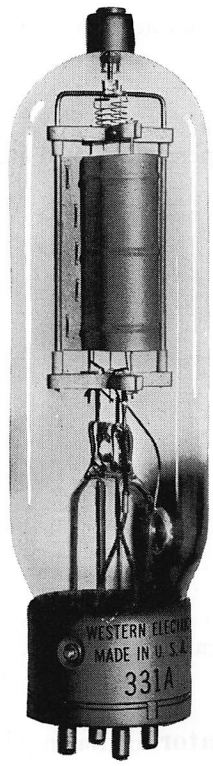


FIG. 15

Western Electric

331A Vacuum Tube



Classification—Filamentary Air-Cooled Triode

This tube is intended primarily for class B audio-frequency use where the variable amplification factor allows the production of high output with minimum distortion. It may also be used as a radio-frequency amplifier or oscillator up to 30 megacycles at full rating.

Dimensions—Dimensions and outline diagrams are shown in Figures 1 and 2 and are

Maximum overall length	8½″
Maximum diameter	2 5/16″

Mounting—This tube employs a large four-pin bayonet type base suitable for use in a Western Electric 145A or similar socket, for either vertical or horizontal mounting. If mounted horizontally, the plane of the filament, which is indicated in Figure 2, should be vertical.

Filament—Thoriated tungsten.

Filament voltage	10 volts, a.c.
Nominal filament current	3.25 amperes
Average thermionic emission	1.5 amperes

Average Direct Interelectrode Capacitances

Plate to grid	6.7 μμf.
Grid to filament	9.0 μμf.
Plate to filament	2.6 μμf.

Characteristics—Performance data given below are based upon a typical set of conditions. Variations can be expected with different circuits and tubes.

Figures 3, 4 and 5 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at 0.085 ampere plate current.

Amplification factor	40
Plate resistance	8900 ohms
Grid to plate transconductance	4500 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1500 volts
Max. direct plate current	200 milliamperes
Max. plate dissipation	125 watts
Max. direct grid current	70 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	30 megacycles

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	1500	1250 volts
Grid bias*	−20	0 volts
Direct plate current per tube		
No drive	40	70 milliamperes
Maximum drive	200	200 milliamperes
Load resistance plate-to-plate	8000	6800 ohms
Load resistance per tube	2000	1700 ohms
Power output depends on distortion requirements		
Approximate maximum output—2 tubes	370	300 watts
Recommended power for driving stage	7	6 watts

*Grid return to filament circuit center tap.

Class B Radio-Frequency Amplifier

Direct plate voltage	1500	1250 volts
Direct plate current for carrier conditions	115	130 milliamperes
Grid bias	−10	0 volts
Approximate carrier power for use with 100% modulation	57.5	55 watts
Driving power (approx.)	7.5	11 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1500	1250 volts
Direct plate current	215	205 milliamperes
Grid bias	−105	−100 volts
Direct grid current (approx.)	40	40 milliamperes
Nominal power output	215	170 watts
Driving power (approx.)	8.5	8.5 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1250 max.	1000 volts
Direct plate current	165	165 milliamperes
Grid bias	−160	−155 volts
Max. direct grid current (approx.)	60	60 milliamperes
Nominal carrier power output for use with 100% modulation	140	110 watts
Driving power (approx.)	16	16 watts

Operating Precautions

Mechanical—Figures 1 and 2 show the overall dimensions and basing arrangement for the tube.

The tubes should not be subjected to mechanical shock or excessive vibration. Mechanical vibration may cause breakage of the thoriated tungsten filaments.

A free circulation of air must be provided to insure adequate cooling of the glass during operation.

Electrical—Overload protection should always be provided for the plate circuit. A suitable fuse or circuit breaker should remove the plate voltage if the plate current exceeds 275 milliamperes. Although the tube is sufficiently rugged to withstand momentary overloads, a prolonged overload caused by inefficient adjustment of the circuit, may damage the tube. When adjusting a new circuit reduced plate voltage or a series resistance of 1000 to 5000 ohms in the plate circuit should be used until it is operating properly.

The filament should always be operated at the rated voltage measured at the tube terminals. A 5% decrease in filament voltage reduces the thermionic emission approximately 25%. Either direct or alternating current may be used for heating the filament. If direct current is used, the plate and grid circuit returns should be connected to the negative filament terminal. If alternating current is used, the circuit returns should be connected to the center tap of the filament heating transformer winding or the center tap of a resistor placed between the filament terminals. A resistance of 20 to 30 ohms of three watt rating is suitable.

In cases where severe and prolonged overload has temporarily impaired the electronic emission of the filament, the activity may be restored by operating the filament, with the plate and grid voltages off, 30% above normal voltage for 10 minutes followed by a longer period at normal voltage.

Audio Amplifier or Modulator

Class B—Grid bias practically at cut-off and grid driving voltage higher than the bias.

Two tubes may be used in a balanced circuit. An adequate driving stage and an input transformer with good regulation must be used so that the grid current drawn during positive

grid swings does not produce appreciable distortion. The output transformer must transform the load impedance to the proper value. The power output obtainable will be determined by the quality of the transformer used and the amount of distortion which can be tolerated. The grid bias must be held constant and therefore cannot be obtained by grid leak or series resistor methods. A battery or other source having good regulation is necessary.

The power required of a modulator for complete modulation of a Class C amplifier is one-half the direct power input to the plates of the Class C amplifier.

Radio-Frequency Oscillator or Power Amplifier

Class B—Radio-Frequency Amplifier—Grid bias practically at cut-off.

The Class B radio-frequency amplifier is used to amplify a modulated radio-frequency carrier wave without appreciable distortion. It operates similarly to the Class B audio amplifier except that only a single tube need be used, the tuned output circuit serving to preserve the wave shape. The push-pull circuit, however, eliminates the even order harmonics and thus increases the efficiency slightly.

Class C—Radio-Frequency Oscillator or Power Amplifier—Grid bias below cut-off.

Unmodulated

This type of operation is suitable for telegraphy, or the production of a continuous flow of radio-frequency power for purposes other than communication.

Plate Modulated

This type of operation is for use when the modulating voltage is superimposed on the plate supply voltage and to obtain good quality the output power should vary as the square of the plate voltage. For complete or 100% modulation, the plate voltage varies from zero to twice the applied direct value during a cycle of the audio frequency. With no modulation applied the plate voltage is, of course, the direct value and the carrier power output is one-fourth of the peak power output under 100% modulation. In this case, since the plate voltage varies with modulation, the direct value must be rated lower than for other types of operation.

High Frequency Ratings

The frequency limits specified under maximum ratings are based on the tube being used as an oscillator. This tube is designed for use at full rating up to 30 megacycles. When operating at higher frequencies, the dielectric losses, charging currents and lead-in heating may be increased to an excessive degree. Accordingly, the plate voltage, and consequently the plate input must be reduced gradually as the frequency is increased beyond 30 megacycles. At 85 megacycles the plate voltage should be one-half the ratings at 30 megacycles.

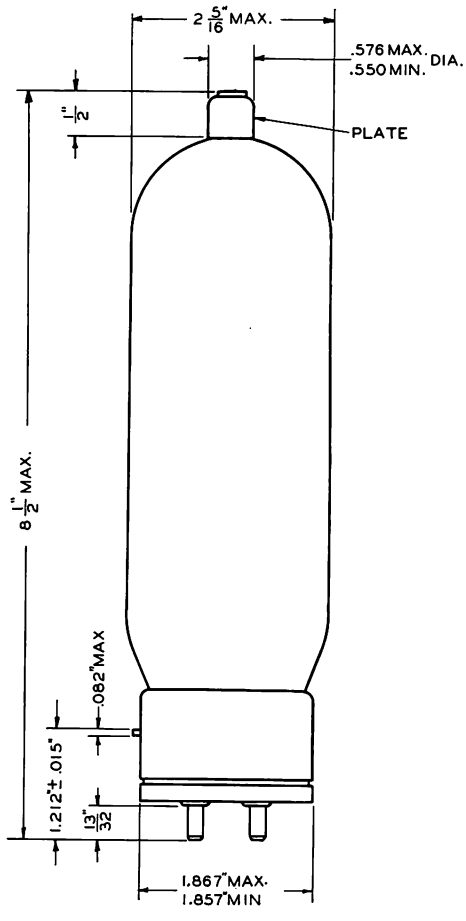


FIG. 1

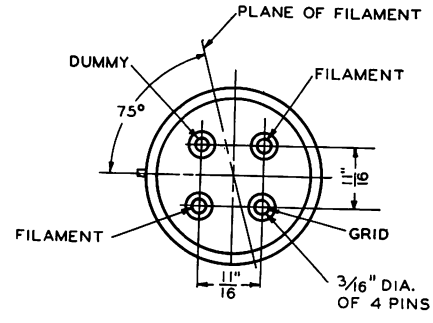


FIG. 2

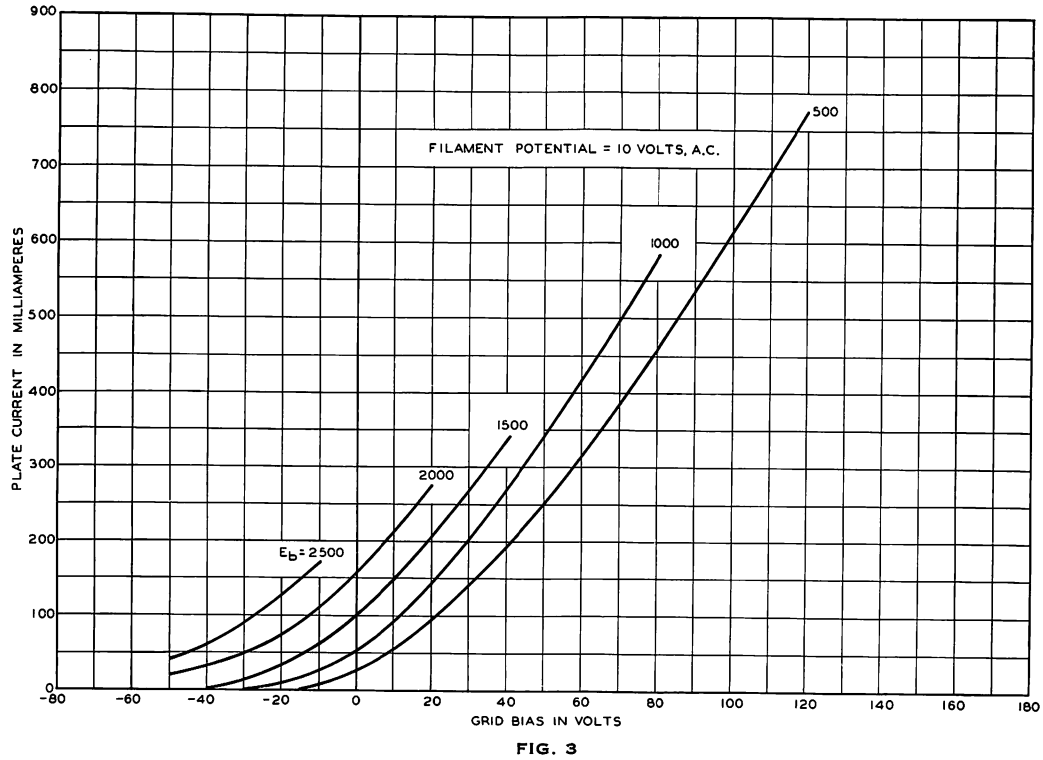


FIG. 3

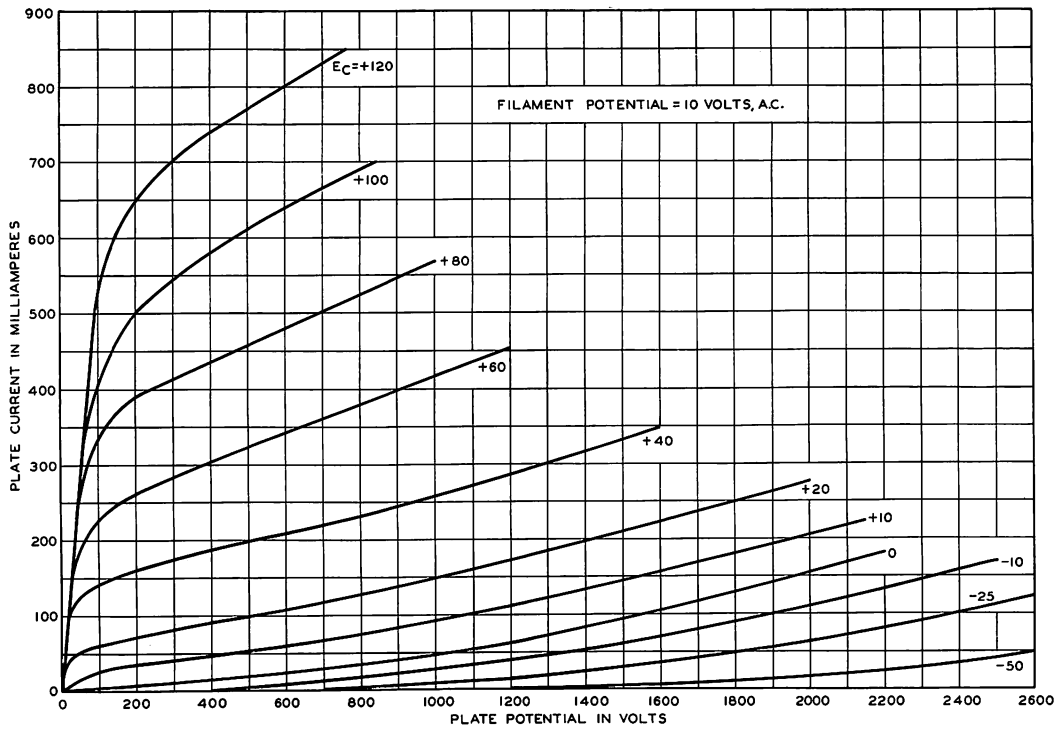

FILAMENT POTENTIAL = 10 VOLTS, A.C.
Ec=+120
+100
+80
+60
+40
+20
+10
0
-10
-25
-50
PLATE CURRENT IN MILLIAMPERES
PLATE POTENTIAL IN VOLTS
0
100
200
300
400
500
600
700
800
900
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600

FIG. 4

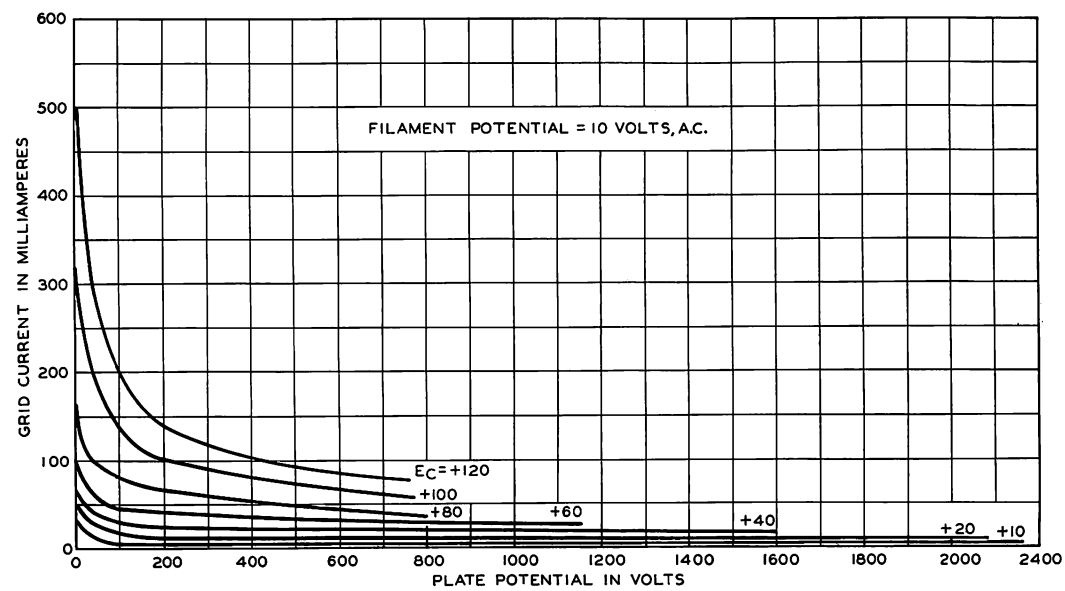

FILAMENT POTENTIAL = 10 VOLTS, A.C.
Ec=+120
+100
+80
+60
+40
+20
+10
GRID CURRENT IN MILLIAMPERES
PLATE POTENTIAL IN VOLTS
0
100
200
300
400
500
600
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2400

FIG. 5

Western Electric

333A Vacuum Tube



Classification—Three element cold cathode, gas-filled tube for use as a relay or rectifier in special circuits

This tube is similar to the 313C except for the base.

The elements of the tube consist of a cathode, an anode and a control anode. A 120,000 ohm resistor, mounted inside the base, is included in the control anode lead. The conduction path between the cathode and the control anode is known as the control gap. The conduction path between the cathode and the anode is known as the main gap.

Dimensions—The dimensions and outline diagrams are given in Figures 1 and 2.

Mounting—This vacuum tube employs a special base suitable for stud mounting on an 8-32 machine screw. A screw is furnished with the tube which allows for mounting on a bracket 1/32" to 1/16" thick. Connections to the electrodes are made through flexible, color-coded leads with spade terminals. The arrangement of electrode connections to the base terminals is shown in Figure 2.

It may be mounted in either a vertical or horizontal position.

Ratings

Maximum peak forward current	30 milliamperes
Maximum average forward current (average over 1 second)	10 milliamperes
Maximum peak reverse current	5 milliamperes

Characteristics

Nominal control-gap breakdown voltage	70 volts
Nominal control-gap sustaining voltage	60 volts
Nominal main-gap breakdown voltage	175 volts
Nominal main-gap sustaining voltage	75 volts
Transfer current	5 microamperes (max.)
Nominal deionization time	
Main gap	10 milliseconds
Control gap	3 milliseconds

The "maximum peak forward current" is the maximum value of current which may be drawn from the cathode.

The "maximum average forward current" is the maximum value of current (averaged over 1 second) which may be drawn from the cathode.

The "maximum peak reverse current" is the maximum value of current which may be drawn from the main anode in the reverse direction, that is when it is acting as a cathode. The reverse current rating is intended for use in designing rectifier circuits and is the maximum inverse current which it is permissible to draw from the tube in such circuits.

The "control-gap breakdown voltage" is the potential required to initiate ionization, thereby starting conduction in the control gap. Once ionization has occurred the potential across the gap will be reduced to the "control-gap sustaining voltage" and will be approximately independent of the current. The voltage between the tube terminals will exceed this value by the voltage drop across the base resistor.

The "main-gap breakdown voltage" is the potential required to start conduction in the main gap when no ionization is occurring in the control gap. After breakdown, conduction will take place at the "main-gap sustaining voltage" and will be practically independent of current.

The "main-gap sustaining voltage" is substantially independent of current when the current passes through the tube in the forward direction. When the current passes through the main gap in the reverse direction the sustaining voltage increases rapidly with increasing current. It is this asymmetry in the properties of the main gap of this tube which enables it to be used as a rectifier. The current-voltage characteristic of the main gap of a typical 333A tube in both forward and reverse directions is shown in Figure 3. This curve was obtained with a cathode ray oscillograph.

When the anode potential is maintained at a value intermediate between the "main-gap breakdown and sustaining voltages" the passage of a small amount of current in the control gap will produce ionization sufficient to initiate conduction in the main gap. It is this property of the tube which enables it to be used as a relay. The amount of current in the control gap required to initiate conduction in the main gap is known as the transfer current. This quantity varies considerably from tube to tube and during the life of a given tube but will in general be less than 5 microamperes and usually only a few tenths of a microampere.

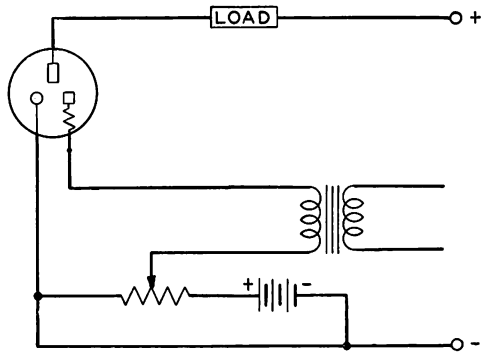
The "deionization time" is the time during which the voltage must be removed from the tube in order that the discharge shall not be reestablished when the voltage is restored. This time increases with increasing applied voltage and with increasing current through the tube before the deionization period. This rate of increase of deionization time is such that the tube will not deionize with a 60 cycle sine wave main-gap voltage if the load is inductive or if the peak voltage is near the main-gap breakdown voltage or the current near the maximum rated value.

The "transfer time" is the time during which the control gap must be energized in order that the discharge may transfer to the main gap. It depends upon the amount of current flowing in the control gap and on the main-gap voltage. For a control-gap current of 10 microamperes the "transfer time" is approximately 200 microseconds.

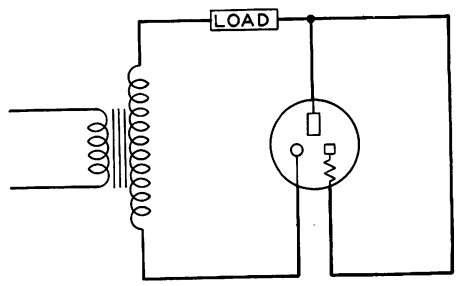
Typical Circuits

Circuit A shows a circuit using the tube as a relay. The supply voltage should be intermediate between the main-gap breakdown and sustaining voltages and the control anode may be biased at any desired potential less than the control-gap sustaining voltage. This circuit possesses a "lock-in" feature, since the main-anode potential must be removed momentarily to restore the tube to a non-conducting condition. When supplied from alternating current this circuit does not possess a "lock-in" feature unless the frequency of the supply voltage is so high that the tube is not allowed a sufficient interval to deionize.

Circuit B shows a circuit with the tube used as a rectifier. The rectifying properties of the main gap are used but the control anode should be connected into the circuit as indicated. This will cause conduction in the forward direction to begin at a voltage much below the main-gap breakdown voltage. It is important to note that as a rectifier this tube possesses a unique property not common to other rectifiers in that its impedance is infinite for voltages below the breakdown voltage. In many applications that is of importance since the tube may be used to pass current at the higher potentials without placing a bridge across the line for signals of lower voltage.



CIRCUIT A



CIRCUIT B

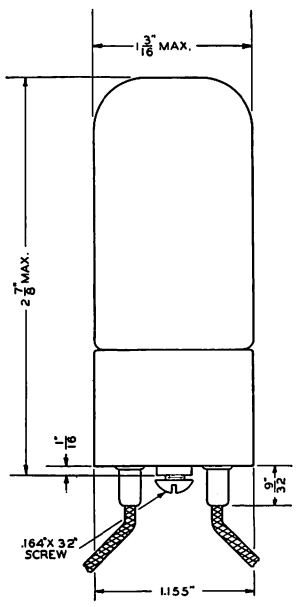


FIG. 1

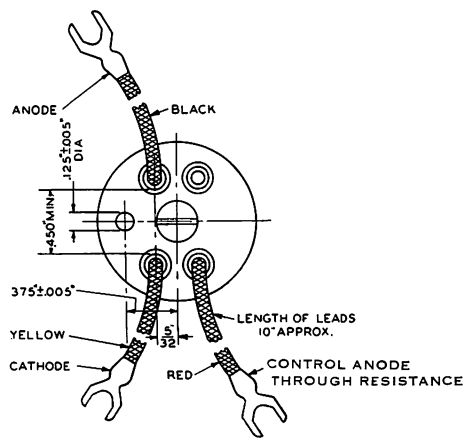


FIG. 2

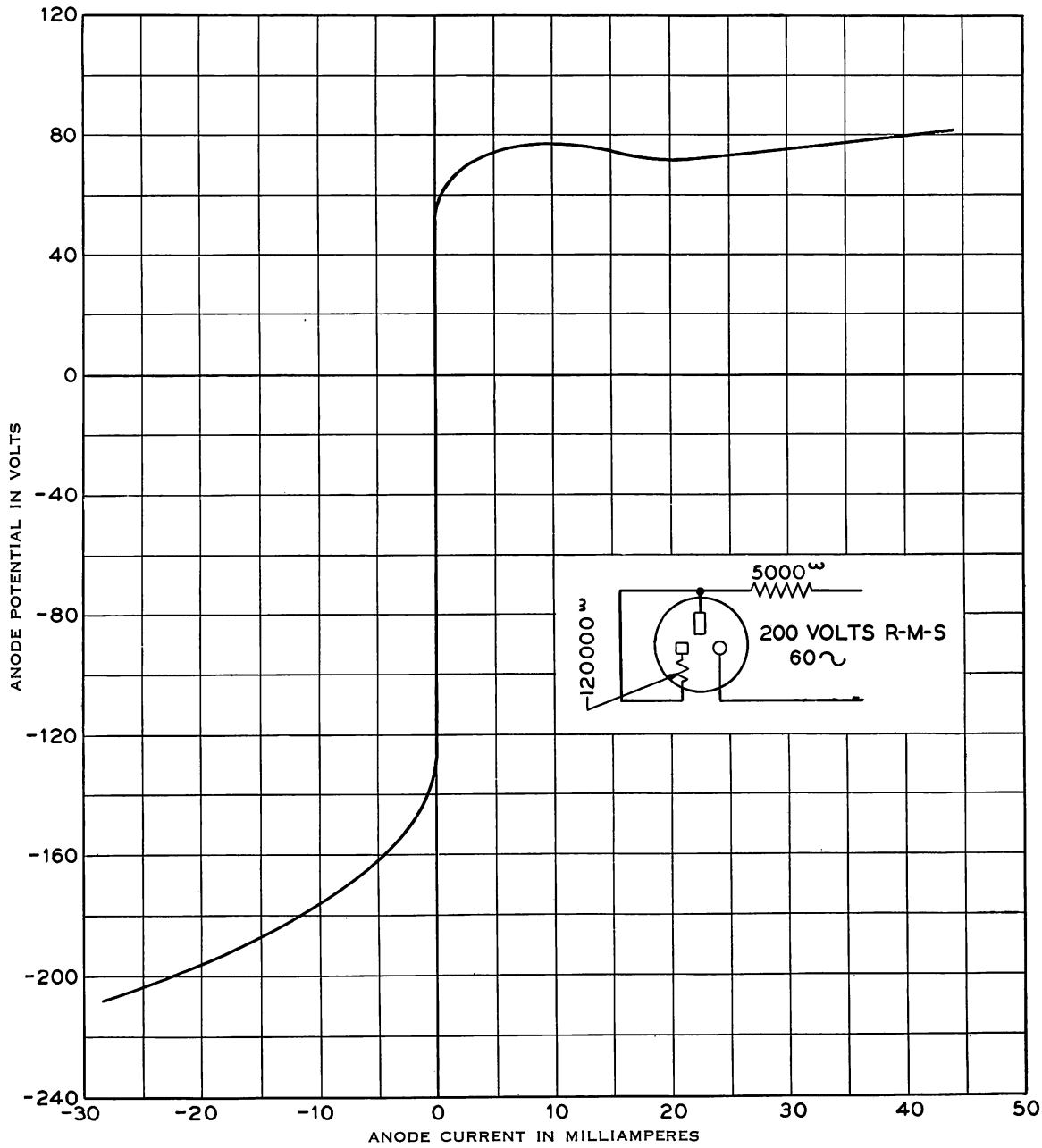
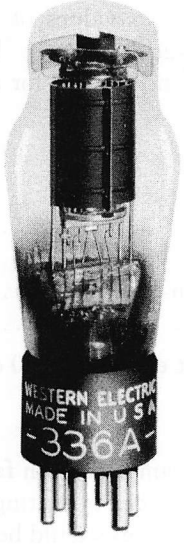
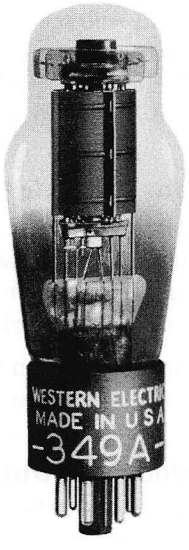

120
80
40
0
-40
-80
-120
-160
-200
-240
-30
-20
-10
0
10
20
30
40
50
ANODE POTENTIAL IN VOLTS
ANODE CURRENT IN MILLIAMPERES
5000Ω
120000Ω
200 VOLTS R-M-S
60~

FIG. 3

Western Electric

336A and 349A Vacuum Tubes





Classification—Suppressor-grid pentodes with indirectly heated cathodes, intended for Class A Service

The 336A and 349A tubes differ in heater ratings and type of base. In all other respects they are identical.

These tubes are intended for use primarily as audio-frequency power amplifiers where power outputs of approximately 3.5 watts are required with a plate voltage not in excess of 250 volts. The suppressor grid is permanently connected to the cathode within the tube.

Dimensions and Connections—The outline diagrams of the tube and base giving the dimensions and the arrangement of electrode connections to the base terminals for the 336A tube are shown in Figure 1. Similar information for the 349A tube is shown in Figure 2.

Base and Mounting—The 336A tube employs a small six-pin thrust type base with silver-plated pins. It is adapted for use in a standard six-contact type socket, preferably one provided with silver-plated contacts such as the Western Electric 144B socket.

The 349A tube employs a small shell octal seven-pin base.

These tubes may be mounted in any position.

Average Direct Interelectrode Capacitances

Control grid to plate	0.65	$\mu\mu f$
Control grid to heater, cathode and screen grid	12	$\mu\mu f$
Plate to heater, cathode and screen grid	9	$\mu\mu f$

Heater Ratings

	336A Tube	349A Tube
Heater voltage	10.0	6.3 volts, a-c or d-c
Nominal heater current	0.64	1.0 ampere

The heater elements of these tubes are designed to operate on a voltage basis and should be operated at as near the rated voltage as practicable.

The voltage between the cathode and heater should not exceed 60 volts.

Characteristics—Figures 3 and 4 show plate current and screen-grid current respectively, as functions of control-grid voltage for several values of screen-grid and plate voltage. In all curves the plate voltage is equal to the screen-grid voltage. Plate current and screen-grid current are shown as functions of plate voltage in Figures 5 and 6, respectively, for a screen-grid voltage of 250 volts and for several values of control-grid voltage. Transconductance and plate resistance as functions of control-grid voltage are shown in Figure 7 for two values of screen-grid and plate voltage. The plate voltage in each case is equal to the screen-grid voltage. Transconductance and plate resistance as functions of screen-grid voltage are shown in Figure 8 for a plate voltage of 250 volts and two values of control-grid voltage.

Limiting Conditions For Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	250 volts
Maximum cathode current (Plate current plus screen-grid current)	50 milliamperes
Maximum direct screen-grid current	10 milliamperes

For fixed bias, the resistance in the grid circuit should not exceed 50,000 ohms. The maximum grid resistance, when self-bias is used, may be 0.5 megohm.

Operating Conditions and Output—Table No. 1 shows amplification factor, plate resistance, transconductance and performance data for a number of typical operating conditions with the tubes operating singly as pentodes. Less severe operating conditions should be selected in preference to maximum operating conditions wherever possible. The life of the tube at maximum conditions will be shorter than at less severe conditions.

The performance data include the fundamental power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages not exceeding the indicated values. Under certain conditions the maximum second harmonic level occurs at a lower input voltage than that given in Table 1. The power output is given in watts and the harmonic levels in decibels below the fundamental.

TABLE 1

SINGLE TUBE-PENTODE

Plate Voltage Volts	Screen-Grid Voltage Volts	Control-Grid Voltage Volts	Plate Current Milliamperes	Amplification Factor	Plate Resistance Ohms	Transconductance Micromhos	Load Resistance Ohms	Input Voltage Peak Volts	Power Output Watts	Second Harmonic db	Third Harmonic db
180	180	−8.0	28	296	70,000	4230	4000	8	1.6	22	31
							7000	5	1.1	34	34
							7000	8	2.0	34	23
							10000	8	2.0	20	20
250	180	−8.0	29	352	81,000	4340	4000	8	1.9	22	38
							7000	5	1.2	26	39
							7000	8	2.7	25	29
							10000	8	3.0	31	23
*250	*250	−14.0	31	336	80,000	4200	4000	14	4.7	17	23
							5000	14	4.9	21	20
							6000	8	2.5	25	31
							6000	14	5.0	25	17
							7000	5	1.2	29	40
							7000	10	3.8	28	22
							7000	14	5.1	28	16
							8000	8	2.8	30	26
							8000	14	5.0	29	16
							9000	14	4.8	23	16
							10000	14	4.5	20	16

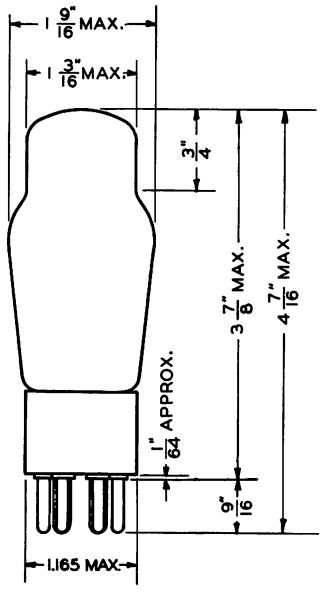
*Maximum operating condition.

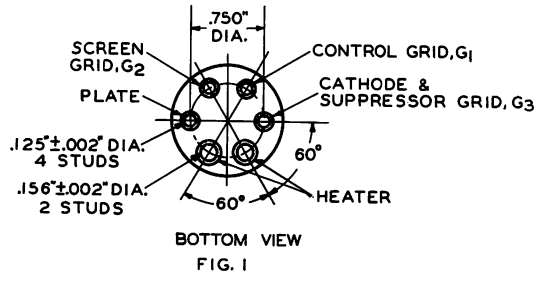
Table No. 2 shows amplification factor, plate resistance, transconductance and performance data for typical operating conditions when the tubes are operated singly as triodes and when two tubes are operated as push-pull pentodes.

TABLE 2

	Single Tube Screen Connected To Plate	Two Tubes Push-Pull Connected
	As A Triode	As Pentodes
Plate voltage	250	250 volts
Screen-grid voltage	—	250 volts
Control-grid voltage	—15	—18 volts
Peak input voltage	15	36 volts
Plate current	*32	*24 milliamperes
Plate current	**35	**65 milliamperes
Screen current	—	*7 milliamperes
Screen current	—	**21 milliamperes
Plate resistance	2150	— ohms
Mutual conductance	4800	— micromhos
Amplification factor	10.3	—
Load Resistance	4000	7000 ohms
Power output	1.2	8.5 watts
Second harmonic	***25	***35 db below fundamental
Third harmonic	***45	26 db below fundamental

*Zero signal **Maximum signal ***Approximate value

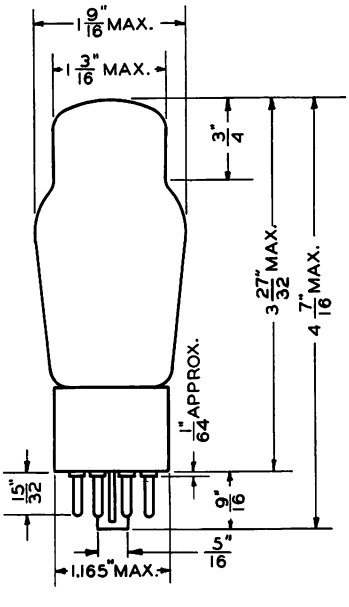


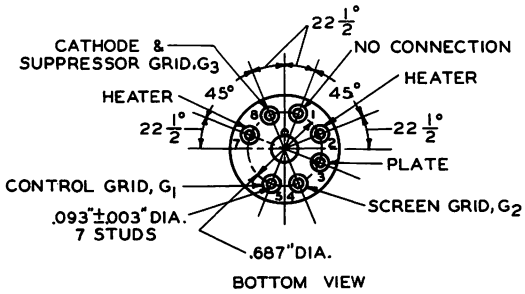


BOTTOM VIEW

FIG. 1

336A





BOTTOM VIEW

FIG. 2

349A

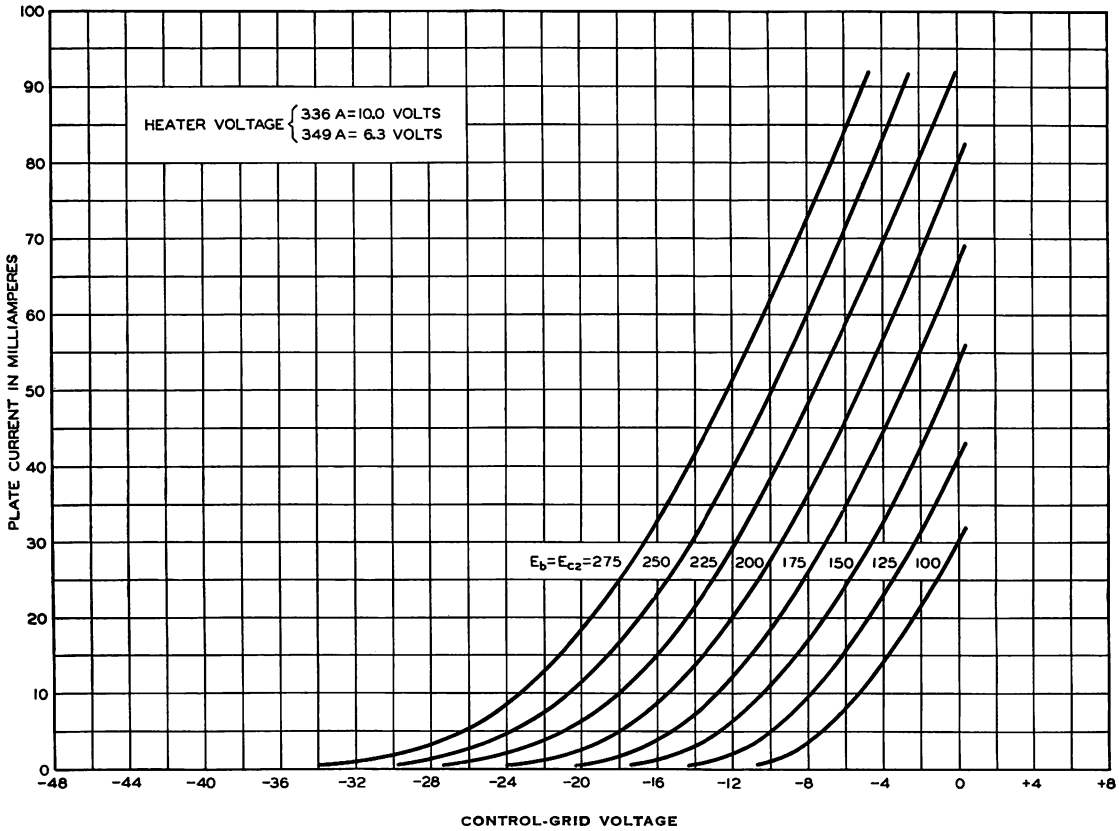

HEATER VOLTAGE { 336 A=10.0 VOLTS
349 A= 6.3 VOLTS
$E_b=E_{c2}$=275 250 225 200 175 150 125 100
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
100 90 80 70 60 50 40 30 20 10 0
-48 -44 -40 -36 -32 -28 -24 -20 -16 -12 -8 -4 0 +4 +8

FIG. 3

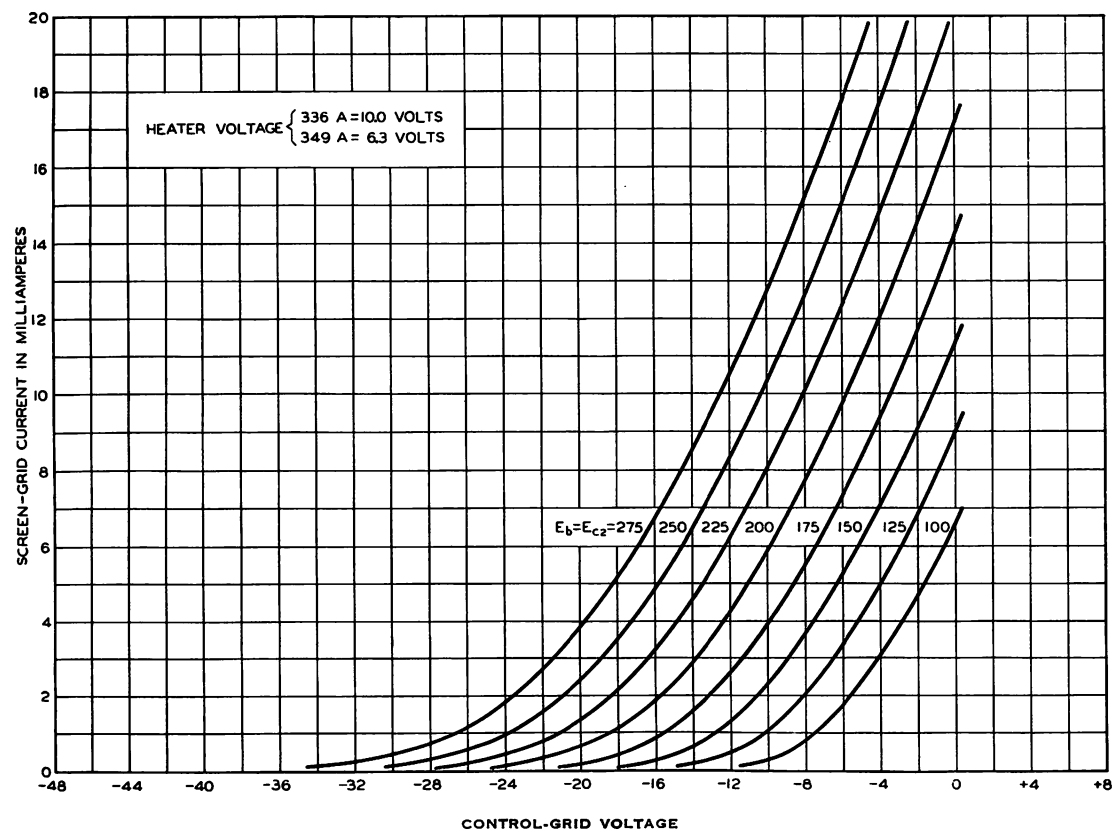

HEATER VOLTAGE { 336 A=10.0 VOLTS
349 A= 6.3 VOLTS
$E_b=E_{c2}$=275 250 225 200 175 150 125 100
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
20 18 16 14 12 10 8 6 4 2 0
-48 -44 -40 -36 -32 -28 -24 -20 -16 -12 -8 -4 0 +4 +8

FIG. 4

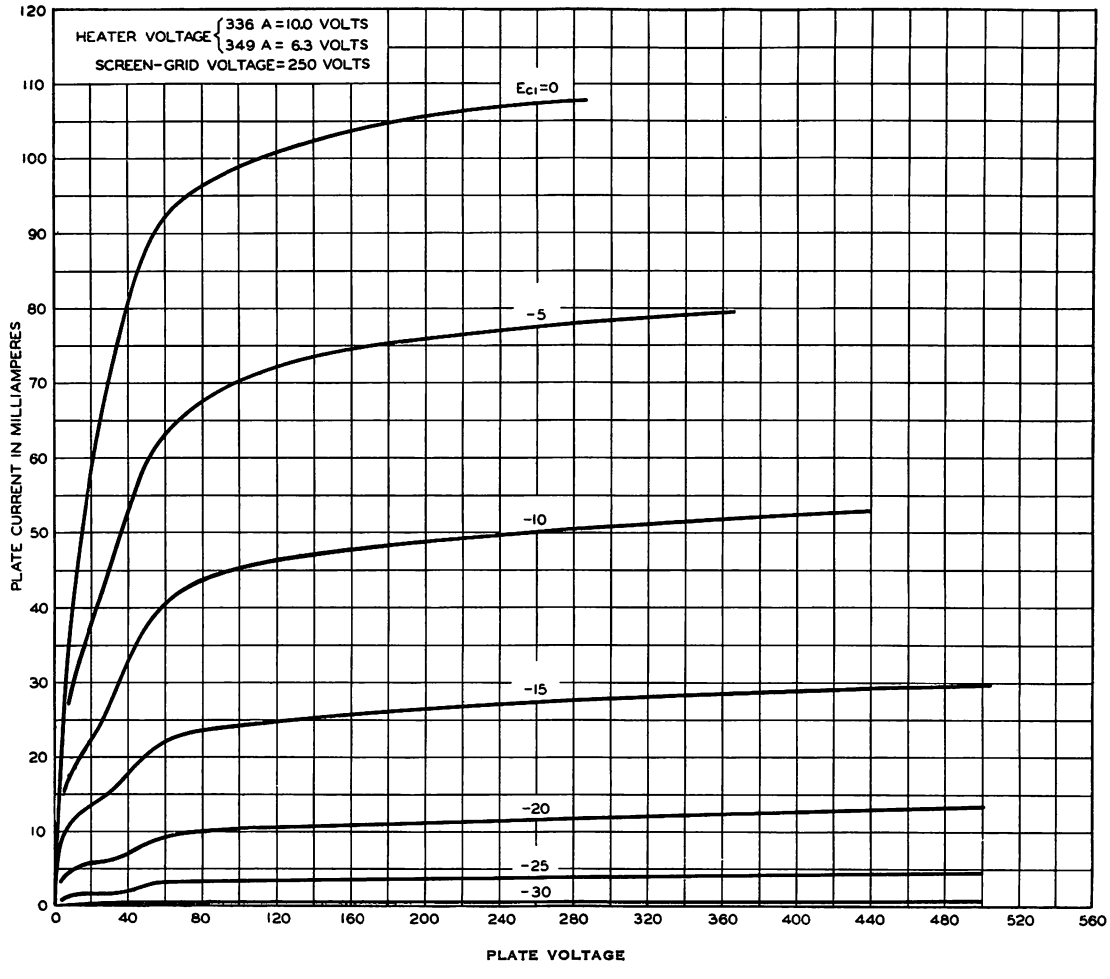

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
SCREEN-GRID VOLTAGE = 250 VOLTS
Ec1=0
-5
-10
-15
-20
-25
-30
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
70
80
90
100
110
120
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560

FIG. 5

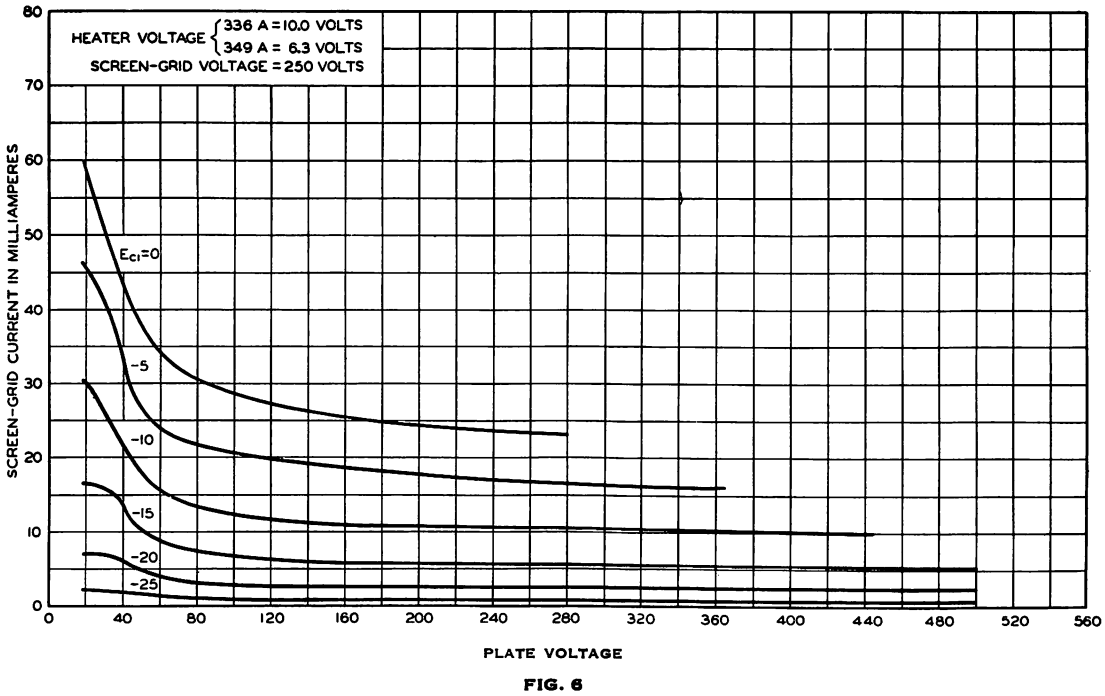

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
SCREEN-GRID VOLTAGE = 250 VOLTS
Ec1=0
-5
-10
-15
-20
-25
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
70
80
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560

FIG. 6

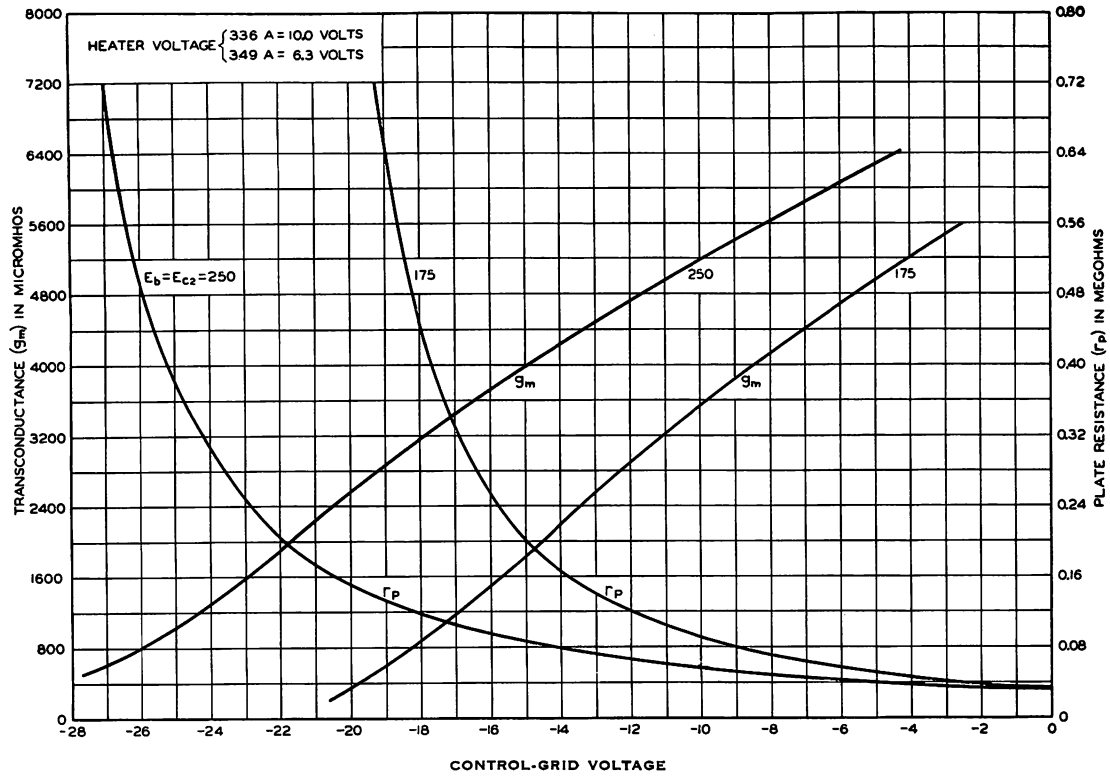

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
$E_b = E_{c2} = 250$
175
250
175
g_m
g_m
g_m
r_p
r_p
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
CONTROL-GRID VOLTAGE

FIG. 7

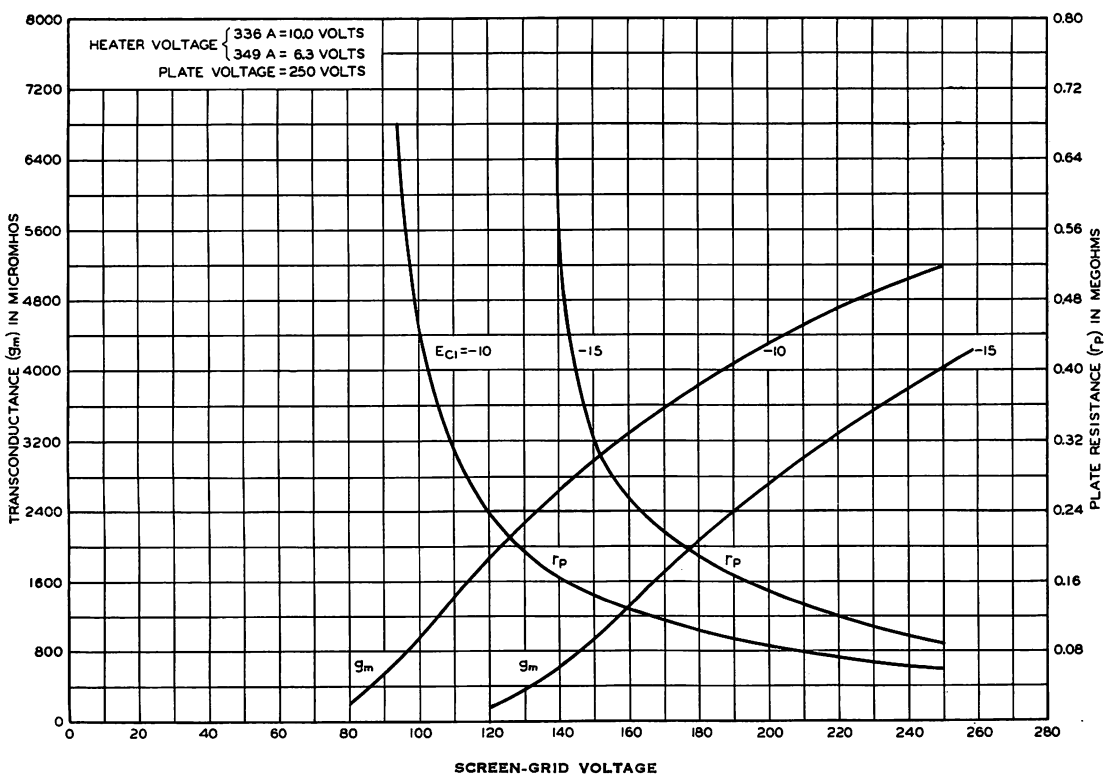
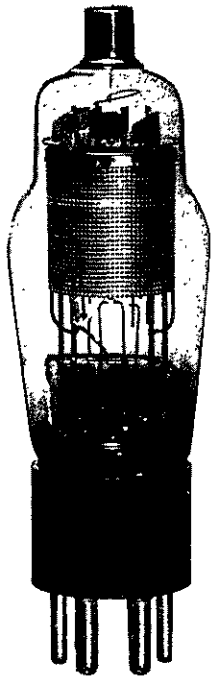

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
PLATE VOLTAGE = 250 VOLTS
$E_{C1} = -10$
-15
-10
-15
g_m
g_m
r_p
r_p
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
SCREEN-GRID VOLTAGE

FIG. 8

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 337A ELECTRON TUBE



DESCRIPTION

The 337A is a variable-mu pentode of the unipotential cathode type. The suppressor grid is connected to a separate base pin to provide flexibility in usage. This tube is designed for use as an audio, carrier or radio-frequency amplifier, oscillator or modulator.

CHARACTERISTICS

Heater Voltage		10 volts
Plate Current	E_b = 180 volts; E_{c2} = 135 volts; E_{c1} = -3 volts	6.3 milliamperes
Transconductance	E_b = 180 volts; E_{c2} = 135 volts; E_{c1} = -3 volts	1740 micromhos

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Heater Voltage, A-C or D-C . . . . . 10 volts

Heater Current . . . . . 320 milliamperes

Direct Interelectrode Capacitances	WITHOUT EXTERNAL SHIELD	WITH EXTERNAL SHIELD (RMA#311)	
Grid to Plate (maximum)	0.016	*0.009	uuf
Input	5.9	* 6.5	uuf
Cutput	12.4	* 13.0	uuf

* With external shield (RMA#311) Connected to Cathode (Pin #5)

MECHANICAL DATA

Cathode . . . . . Coated unipotential

Bulb ST12

Base . . . . . Small 6-pin

Mounting position . . . . . Any

Dimensions and pin connections shown in outline drawing on Page 5

MAXIMUM RATINGS, DESIGN-CENTER VALUES

Plate Voltage . . . . . 250 volts

Screen Grid Voltage . . . . . 180 volts

Plate Dissipation . . . . . 2 watts

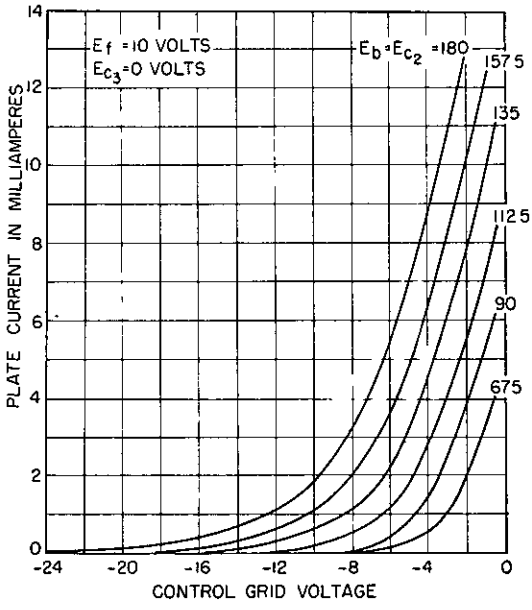
Screen Grid Dissipation . . . . . 0.4 watt

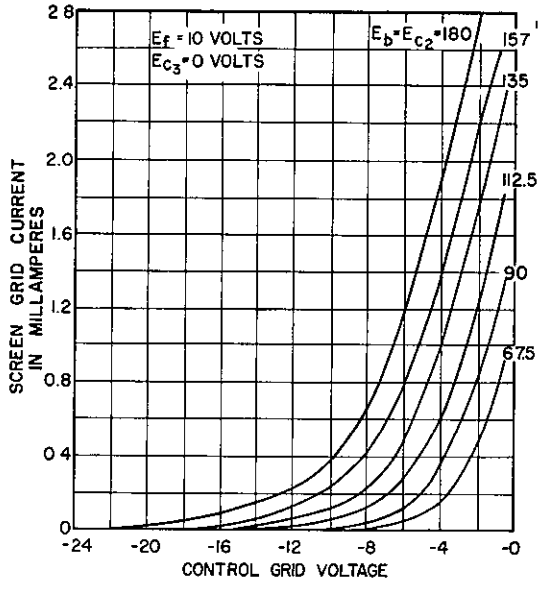
Cathode Current . . . . . 10 milliamperes

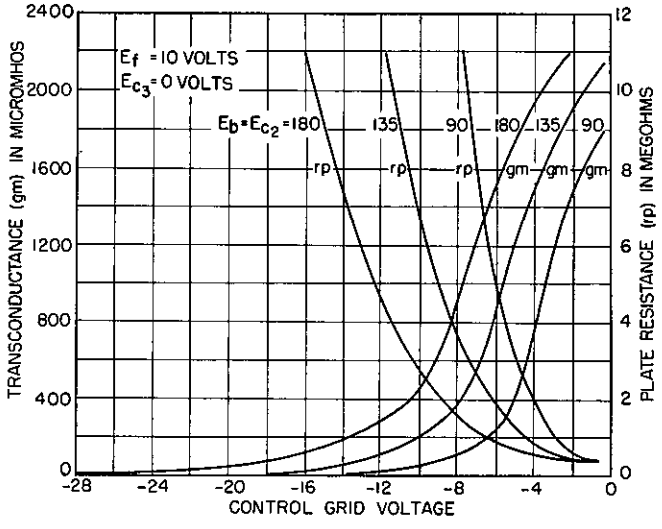
Heater-Cathode Voltage . . . . . 150 volts

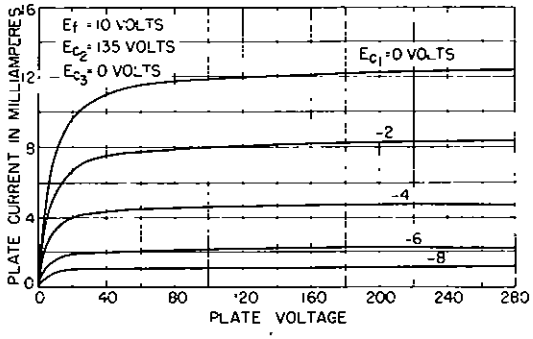
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

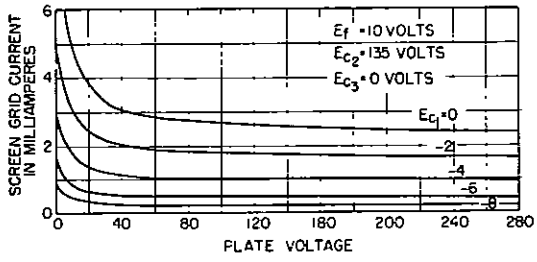
Plate Voltage	135	180	250	volts
Screen Grid Voltage	135	135	135	volts
Control Grid Voltage	-3	-3	-3	volts
Suppressor Grid Voltage	0	0	0	volts
Plate Current	6.2	6.3	6.35	milliamperes
Screen Grid Current	1.3	1.27	1.24	milliamperes
Peak A-F Signal Voltage	3.0	1.5	2.0	volts
Plate Resistance	0.55	0.85	1.16	megohms
Transconductance	1730	1740	1750	micromhos
Load Resistance	30000	100000	100000	ohms
Power Output	230	150	300	milliwatts
Total Harmonic Distortion	6.0	7.0	8.0	per cent
Control Grid Voltage (approximate) for Transconductance of 10 micromhos	-18.5	-18.5	-18.5	volts

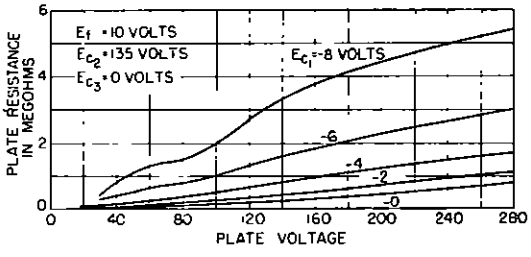

Ef = 10 VOLTS
Ec3 = 0 VOLTS
Eb = Ec2 = 180
157.5
135
112.5
90
67.5
PLATE CURRENT IN MILLIAMPERES
CONTROL GRID VOLTAGE
0
2
4
6
8
10
12
14
-24
-20
-16
-12
-8
-4
0

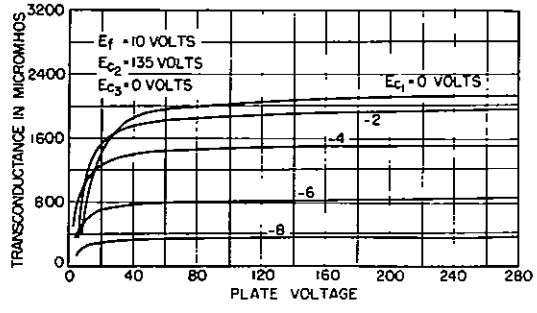

Ef = 10 VOLTS
Ec3 = 0 VOLTS
Eb = Ec2 = 180
157
135
112.5
90
67.5
SCREEN GRID CURRENT IN MILLAMPERES
CONTROL GRID VOLTAGE
0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
-24
-20
-16
-12
-8
-4
-0

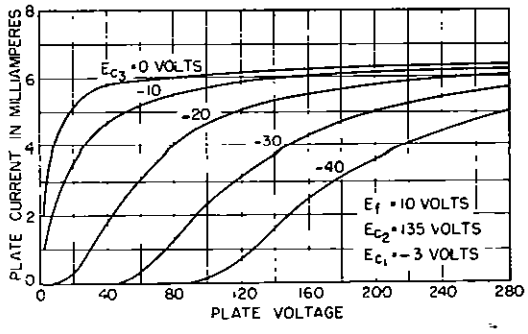

Ef = 10 VOLTS
Ec3 = 0 VOLTS
Eb = Ec2 = 180
135
90
180
135
90
rp
rp
rp
gm
gm
gm
TRANSCONDUCTANCE (gm) IN MICROMHOS
PLATE RESISTANCE (rp) IN MEGOHMS
CONTROL GRID VOLTAGE
0
400
800
1200
1600
2000
2400
0
2
4
6
8
10
12
-28
-24
-20
-16
-12
-8
-4
0

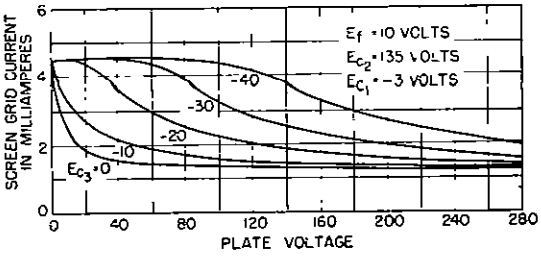

Ef = 10 VOLTS
Ec2 = 135 VOLTS
Ec3 = 0 VOLTS
Ec1 = 0 VOLTS
-2
-4
-6
-8
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE

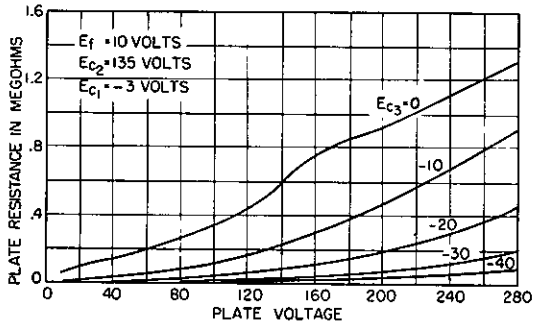

Ef = 10 VOLTS
Ec2 = 135 VOLTS
Ec3 = 0 VOLTS
Ec1 = 0
-2
-4
-6
-8
SCREEN GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE

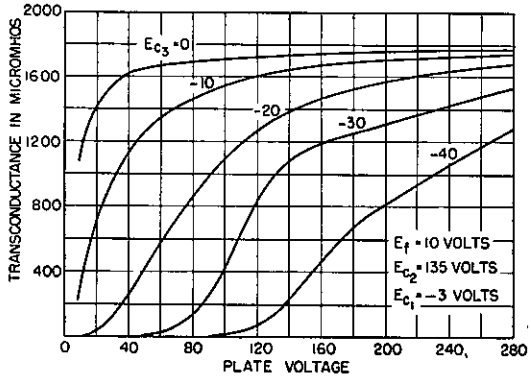

Ef = 10 VOLTS
Ec2 = 135 VOLTS
Ec3 = 0 VOLTS
Ec1 = -8 VOLTS
-6
-4
-2
-0
PLATE RESISTANCE IN MEGOHMS
PLATE VOLTAGE

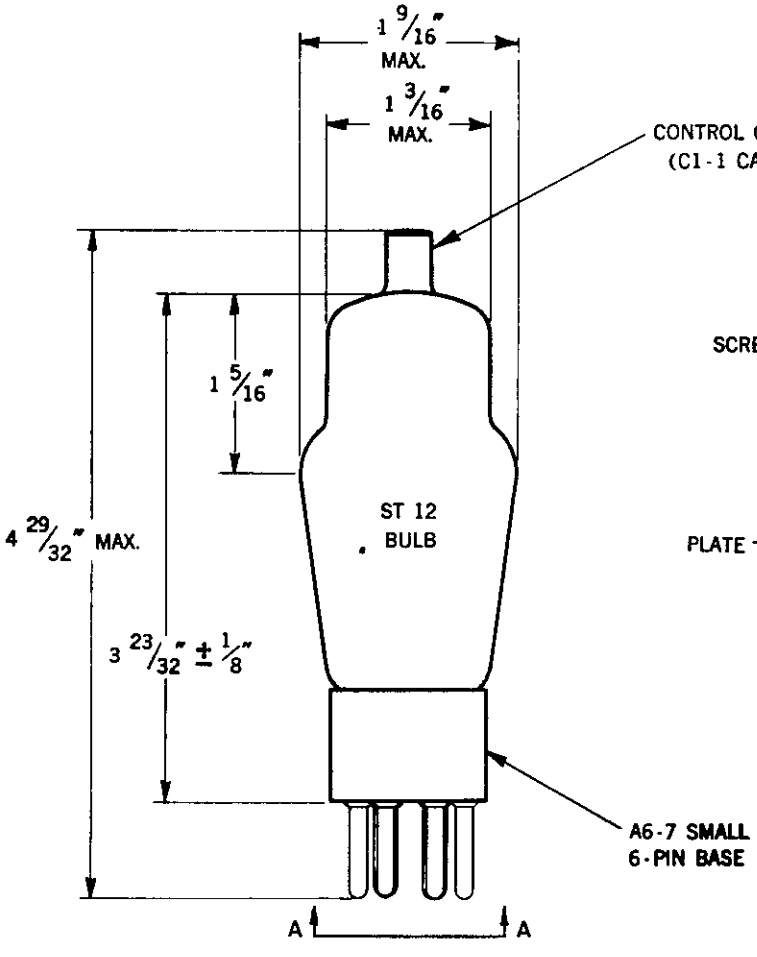

Ef = 10 VOLTS
Ec2 = 135 VOLTS
Ec3 = 0 VOLTS
Ec1 = 0 VOLTS
-2
-4
-6
-8
TRANSCONDUCTANCE IN MICROMHOS
PLATE VOLTAGE

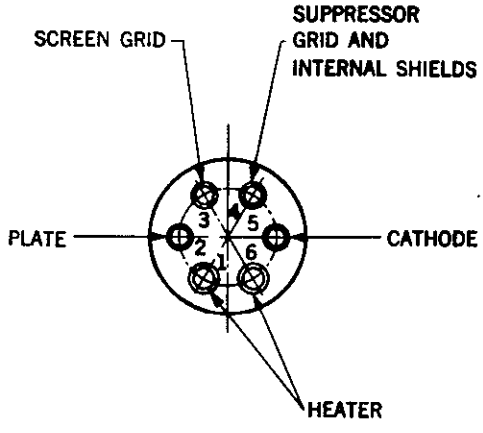

Ec3 = 0 VOLTS
-10
-20
-30
-40
Ef = 10 VOLTS
Ec2 = 135 VOLTS
Ec1 = -3 VOLTS
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE


Ef = 10 VOLTS
Ec2 = 135 VOLTS
Ec1 = -3 VOLTS
-40
-30
-20
-10
Ec3 = 0
SCREEN GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE


PLATE RESISTANCE IN MEGOHMS
1.6
1.2
.8
.4
0
E_f = 10 VOLTS
E_{c_2} = 135 VOLTS
E_{c_1} = −3 VOLTS
E_{c_3} = 0
-10
-20
-30
-40
0 40 80 120 160 200 240 280
PLATE VOLTAGE


TRANSCONDUCTANCE IN MICROMHOS
2000
1600
1200
800
400
E_{c_3} = 0
-10
-20
-30
-40
E_f = 10 VOLTS
E_{c_2} = 135 VOLTS
E_{c_1} = −3 VOLTS
0 40 80 120 160 200 240 280
PLATE VOLTAGE


1 9/16" MAX.
1 3/16" MAX.
CONTROL GRID
(C1-1 CAP)
1 5/16"
4 29/32" MAX.
ST 12
BULB
3 23/32" ± 1/8"
A6-7 SMALL
6-PIN BASE
A
A


SCREEN GRID
SUPPRESSOR
GRID AND
INTERNAL SHIELDS
PLATE
CATHODE
HEATER
3
4
5
2
6
1

VIEW A-A

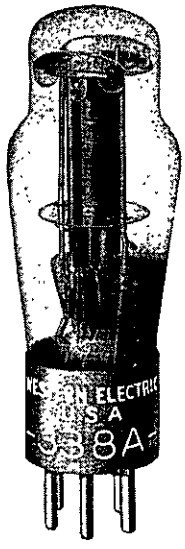
Western Electric

A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

1-D-51-4 PRINTED IN U.S.A. T2691

Western Electric

338A Vacuum Tube



ARCHIVE ONLY

Classification—Three element, argon filled, thyratron, with an indirectly heated cathode

It is primarily a rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous grid and anode potentials. It is intended for use in special circuits as a relay or trigger-action device. A few of its other possible uses are: as a controlled-frequency oscillator giving a square wave-form, as a voltmeter or volume level-indicator, as a source of sweep-voltage for a linear time axis, or as a variable-voltage rectifier.

Dimensions—The dimensions and outline diagrams are given in Figures 1 and 2. The overall dimensions are:

Maximum length	4 7/16″
Diameter	1 9/16″

Mounting—This vacuum tube employs a standard five-pin thrust type base suitable for use in a Western Electric 141A or similar socket. The arrangement of electrode connections to the base terminals is shown in Figure 2.

It may be mounted in either a vertical or horizontal position, although the vertical position is preferable.

FILE: THYRATRON SECTION

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Heater Rating

Heater potential	10.0 volts
Nominal heater current	0.5 ampere
Required heating time	60 seconds

The heater element of this tube is designed to operate on a voltage basis from a direct or alternating current supply. The voltage should be maintained to within 5% of its rated value (10 volts). Operation of the heater element above the upper limit will definitely reduce the life of the tube, while a decrease below the lower limit may cause immediate failure.

Sufficient time should always be allowed for the cathode temperature to reach its normal operating value before anode current is drawn. Failure to allow sufficient time may result in immediate failure.

Operating Conditions

Approximate tube voltage drop	15 volts
Max. peak voltage between anode and grid	325 volts
Max. instantaneous anode current	0.600 ampere
Max. average anode current	0.100 ampere
Max. time of averaging anode current	5 seconds
Max. instantaneous grid current	0.010 ampere
Max. voltage between heater and cathode	50 volts
Operating ambient temperature range	−20° to +50°C.
Normal deionization time	1000 microseconds

The characteristics of the 338A tube are such that, for any given anode potential, there is a critical grid potential. If the grid is held more negative than this value and the tube is non-conducting, the anode current will remain zero. If it is made less negative, the current will assume a value determined by the applied potential and the resistance in the anode circuit. To extinguish the discharge and return the current to zero, the positive anode potential must be removed. When current is flowing a visible discharge occurs in the tube. Under this condition, the tube voltage drop is practically independent of the value of both the anode current and the grid potential. A protective resistance should always be included in the circuit to limit the anode current to the rated values. A typical curve relating the critical grid potential to the anode potential is shown in Figure 3. This charactersitic may vary from tube to tube and during the life of a given tube.

Sufficient resistance must always be included in the grid circuit to limit the negative grid potential to 10 volts when anode current is flowing. Failure to observe this precaution will result in short tube life.

Typical Circuits

The tube may be used in a variety of circuits adapted to the application of thyratrons. Two general types are common. One use of the tube is to produce a saw-toothed, current wave. The circuit for this application is shown in Figure 4. The resistance R should, ordinarily, be at least 100,000 ohms, and the product RC (C in farads) approximately equal to the desired fundamental period.

The second general use for the tube is as a relay device. In this application the anode may be supplied from either alternating or direct current. When supplied from direct current, the circuit, Figure 5, possesses a "lock-in" feature, since the anode potential must be removed momentarily in order to restore the tube to the non-conducting condition. When supplied from alternating current, the circuit possesses no "lock-in" feature, but the average anode current may be controlled by the relative phase of grid and anode potentials. The schematic circuit for this application is shown in Figure 6. Figure 7 is a simplified circuit employing a photoelectric cell in place of the resistance, R, used in the phase shifting device in Figure 6. The photoelectric cell, however, is equivalent to a variable resistance in the sense that the current passed will depend upon the amount of light falling upon it.

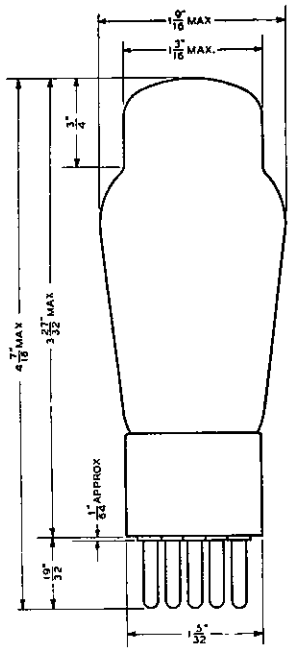


FIG. 1

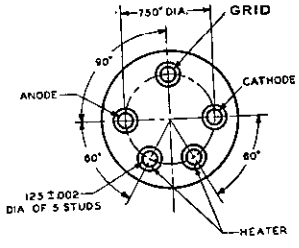


FIG. 2

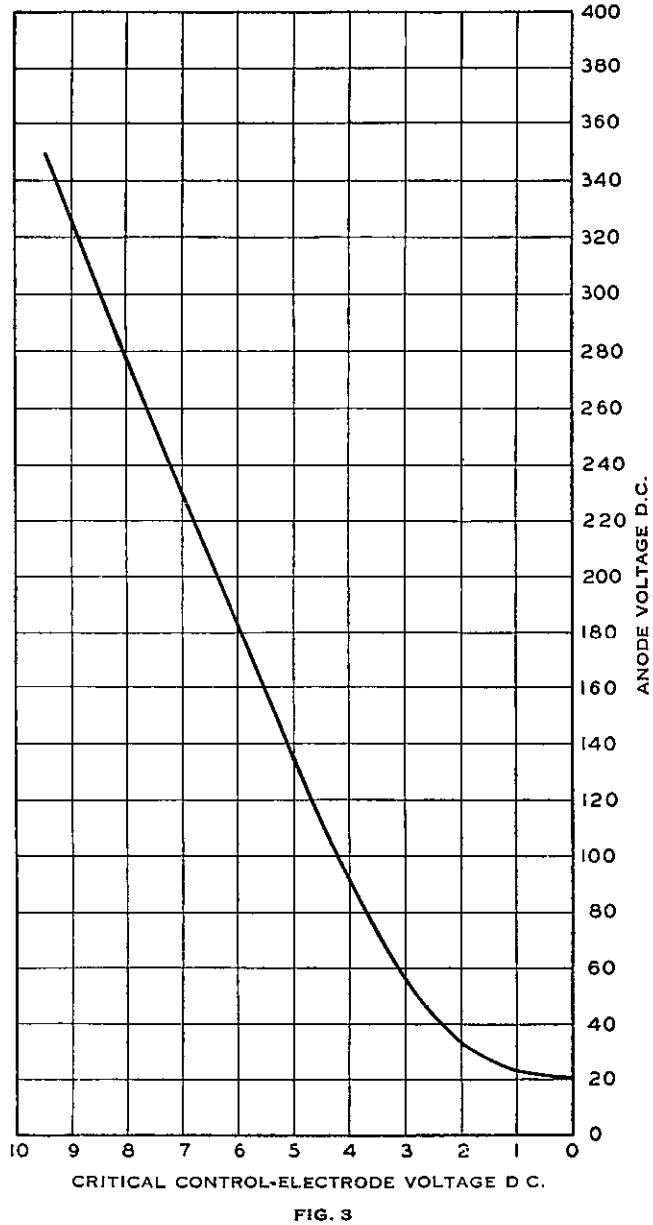


FIG. 3

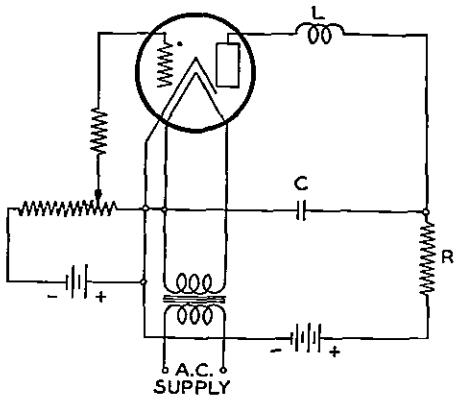


FIG. 4

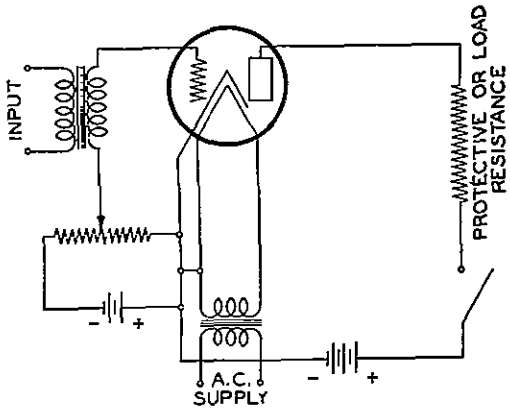


FIG. 5

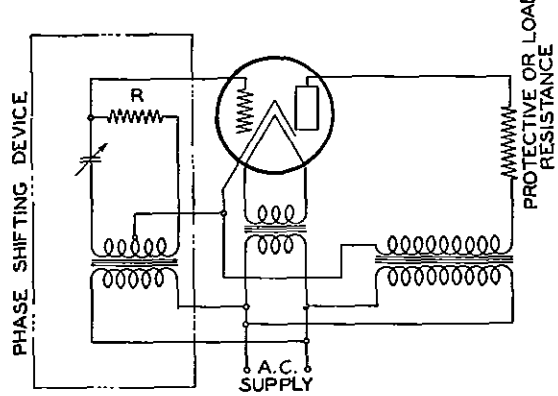


FIG. 6

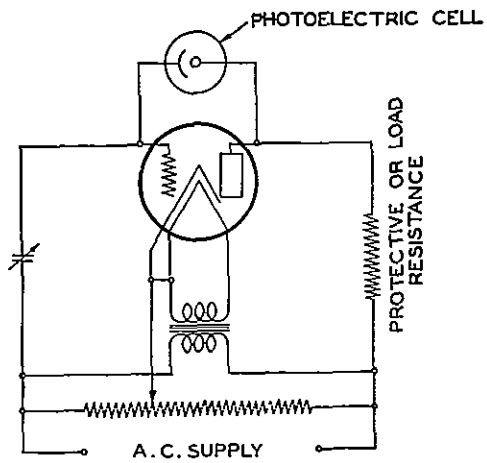
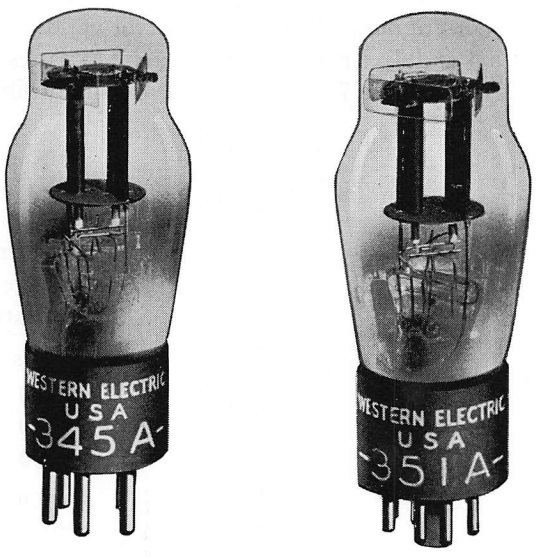


FIG. 7

A development of Bell Telephone Laboratories, Incorporated, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company

Western Electric

345A and 351A Vacuum Tubes



Classification—Full-wave, thermionic high vacuum rectifiers

These tubes are designed to supply direct current up to 100 milliamperes from an alternating current source. The tubes are used as full-wave rectifiers to supply direct current from A.C. power lines or to rectify radio-frequency currents for feedback purposes in broadcast transmitters.

Each tube consists of two diode units with the two heaters connected in parallel and the two cathodes connected together inside the tube. The 345A and 351A tubes are identical except for the bases.

Dimensions and Connections—The outline diagrams of the tube and base giving dimensions and the arrangement of electrode connections to the base terminals for the 345A tube are shown in Figures 1 and 2. Similar information for the 351A is shown in Figures 3 and 4.

Mounting—The 345A vacuum tube employs a small five pin thrust type base suitable for use in a Western Electric 141A or similar socket.

The 351A vacuum tube employs a small shell six pin octal base.

The tubes may be mounted in any position.

Heater Rating

Heater voltage	6.3 volts
Nominal heater current	1.0 ampere

The heater is designed to operate on a voltage basis and should be operated at as near the rated voltage as practicable.

Cathode Connection—Preferably direct to the heater. In applications where it is necessary to apply a voltage between cathode and heater it should not exceed 500 volts.

Characteristics—Figure 5 shows the plate current-plate voltage characteristic of a single diode unit of a typical tube.

The rectified voltage and current output characteristics for various values of applied alternating voltages are shown in Figures 6 and 7. In Figure 6 the characteristics are for a choke-input filter as shown in circuit A and those of Figure 7 are for a condenser-input filter as shown in circuit B.

Operating Conditions

	R-M-S Alternating Voltage Per Plate	Total Rectified Current
	Volts	Milliamperes
Choke-Input Filter	300	100
	350	100
	*400	100
Condenser-Input Filter	300	100
	*350	**100

*Maximum operating conditions
**4MF maximum filter input capacitance

A less severe condition should be selected in preference to a maximum operating condition wherever possible. The life of a tube at maximum conditions may be shorter than at less severe conditions.

Effect of Filter

It is evident from the regulation characteristics of Figures 6 and 7 that for a given output current and voltage, the choke-input filter requires a somewhat higher alternating voltage applied to the plates of the tube than the condenser-input filter. With the condenser input filter, however, the cathode has to supply relatively large peaks of current during the charging period of the condenser. The peak current increases in value as the capacitance of the condenser is increased and may be much greater than the average rectified current, though its duration in such cases is only a short fraction of a cycle. Since the peak current in a choke-input filter is only slightly greater than the rectified currrent and this type filter gives better regulation than the condenser input circuit it is advisable to use it in preference to the condenser-input filter wherever possible. With a condenser input filter the capacitance of the input condenser should preferably not exceed 4 microfarads.

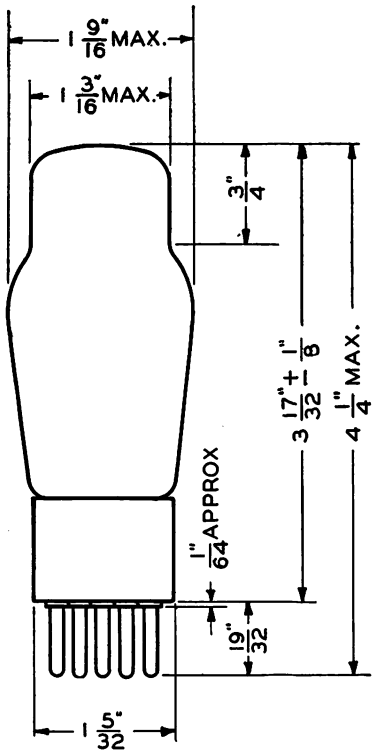


FIG. 1

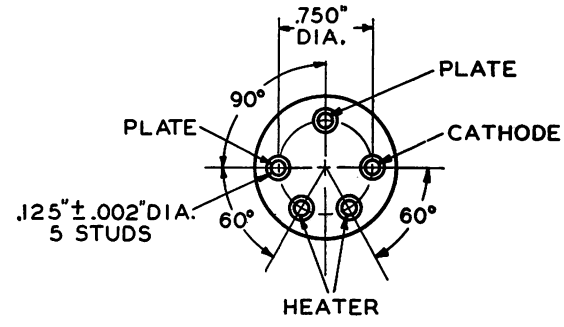


FIG. 2

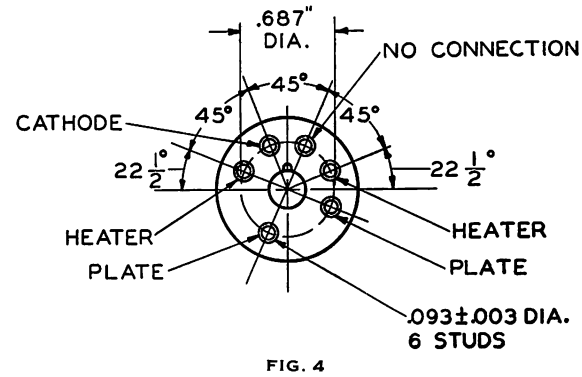


FIG. 4

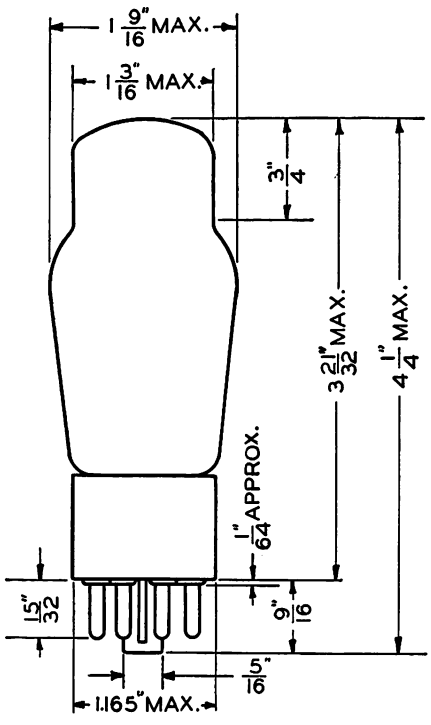


FIG. 3

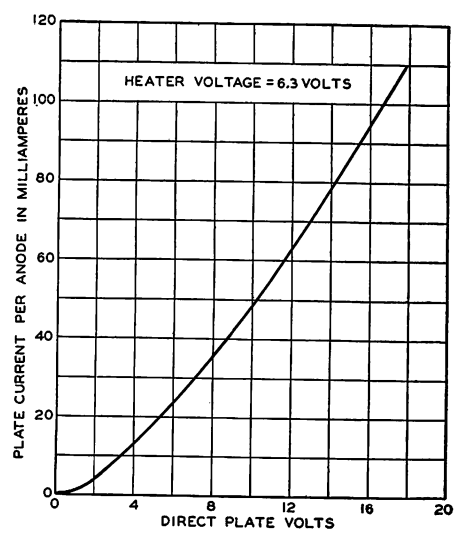


FIG. 5

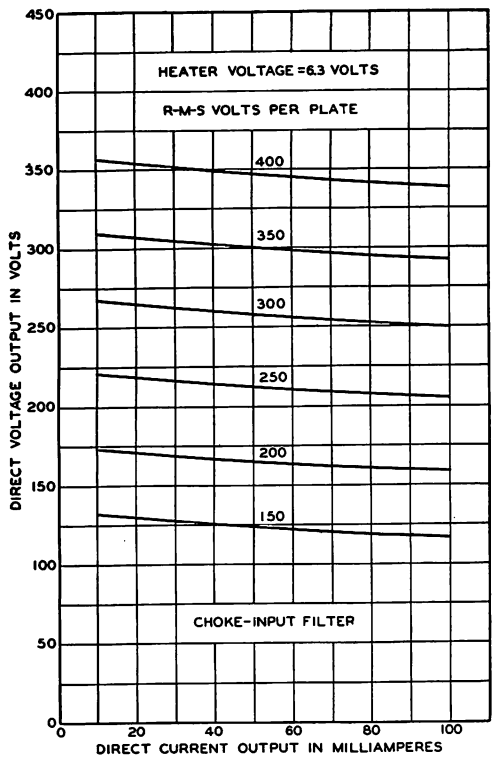


FIG. 6

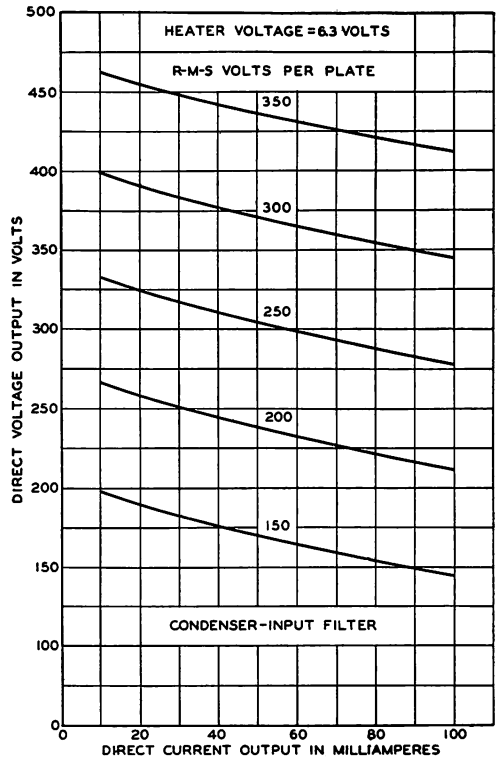
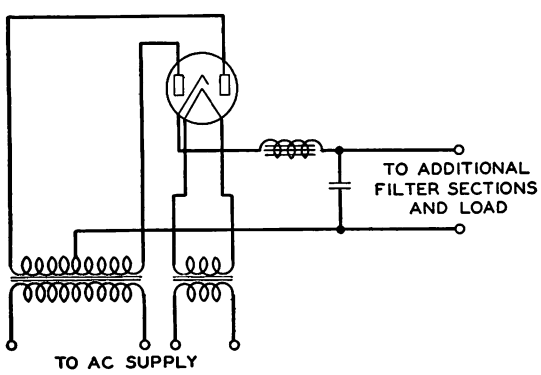
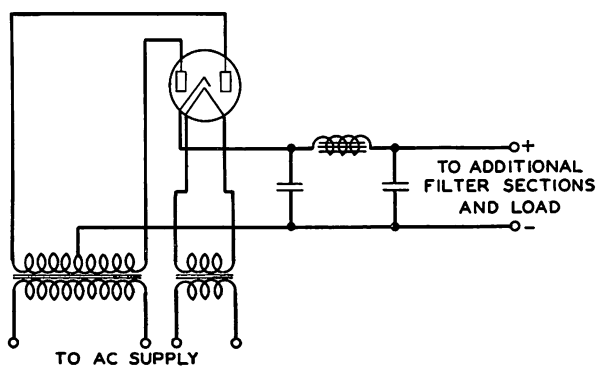


FIG. 7



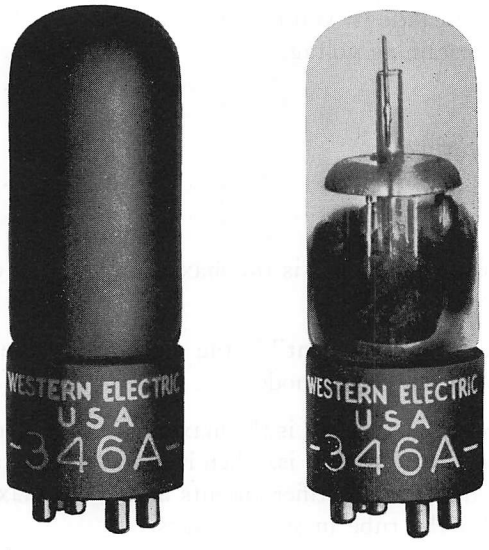
CHOKE INPUT FILTER
CIRCUIT A



CONDENSER INPUT FILTER
CIRCUIT B

Western Electric

346A Vacuum Tube



Classification—Three element cold cathode, gas-filled tube

For use as a relay or rectifier in special circuits.

The elements of the tube consist of a cathode, an anode and a control anode. In this tube the cathode and control anode are similar and may be used interchangeably. The conduction path between the cathode and the control anode is known as the control gap. The conduction path between the cathode and the anode is known as the main gap. A 120,000 ohm resistor, mounted inside the base, may be included in the control anode lead.

The glass bulb has been given an opaque coating so that the discharge is not visible while the tube is operating. In the photograph at the right the coating has been removed to show the tube elements.

Dimensions—The dimensions and outline diagrams are given in Figures 1 and 2.

Mounting—This vacuum tube employs a special base, having a tapped insert, suitable for mounting with an 8-32 machine screw. The base also has a $\frac{1}{8}''$ diameter moulded pin $\frac{1}{8}''$ high, which locates it on the mounting bracket and prevents the tube from rotating. A screw is furnished with the tube which allows for mounting on a bracket $\frac{1}{32}''$ to $\frac{1}{16}''$ thick. Connections to the electrodes are made by soldering to the ends of the base studs. The arrangement of electrode connections to the base terminals is shown in Figure 2.

The tube may be mounted in either a vertical or horizontal position.

Ratings

Maximum peak forward current	30 milliamperes
Maximum average forward current (averaged over 1 second)	10 milliamperes
Maximum peak reverse current	5 milliamperes

Characteristics

Nominal control-gap breakdown voltage	70 volts
Nominal control-gap sustaining voltage	60 volts
Minimum main-gap breakdown voltage	225 volts
Nominal main-gap sustaining voltage	80 volts
Transfer current	100 microamperes (Max.)
Nominal deionization time	
Main gap	10 milliseconds
Control gap	3 milliseconds

The "maximum peak forward current" is the maximum value of current which may be drawn from the cathode.

The "maximum average forward current" is the maximum value of current (averaged over 1 second) which may be drawn from the cathode.

The "maximum peak reverse current" is the maximum value of current which may be drawn from the anode in the reverse direction, that is, when it is acting as a cathode. The reverse current rating is intended for use in designing rectifier circuits and is the maximum inverse current which it is permissible to draw from the tube in such circuits.

The "control-gap breakdown voltage" is the potential required to initiate ionization, thereby starting conduction in the control gap. Once ionization has occurred the potential across the gap will be reduced to the "control-gap sustaining voltage" and will be approximately independent of the current.

The "main-gap breakdown voltage" is the potential required to start conduction in the main gap when no ionization is occurring in the control gap. After breakdown, conduction will take place at the "main-gap sustaining voltage" and will be practically independent of current.

The "main-gap sustaining voltage" is substantially independent of current when the current passes through the tube in the forward direction. When the current passes through the main gap in the reverse direction the sustaining voltage increases rapidly with increasing current. It is this asymmetry in the properties of the main gap of this tube which enables it to be used as a rectifier. The current-voltage characteristic of the main gap of a typical 346A tube in both forward and reverse directions is shown in Figure 3. This curve was obtained with a cathode ray oscillograph.

When the anode potential is maintained at a value intermediate between the "main-gap breakdown and sustaining voltages" the passage of a small amount of current in the control gap will produce ionization sufficient to initiate conduction in the main gap. It is this property of the tube which enables it to be used as a relay. The amount of current in the control gap required to initiate conduction in the main gap is known as the "transfer current." This quantity varies considerably from tube to tube and during the life of a given tube but will in general be less than 100 microamperes.

The "deionization time" is the time during which the voltage must be removed from the tube in order that the discharge shall not be reestablished when the voltage is restored. This time increases with increasing applied voltage and with increasing current through the tube before the deionization period. This rate of increase of deionization time is such that the tube will not deionize with a 60 cycle sine wave main-gap voltage if the load is inductive or if the peak voltage is near the "main-gap breakdown voltage" or the current near the maximum rated value.

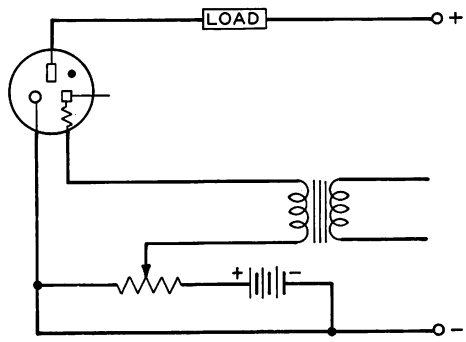
The "transfer time" is the time during which the control gap must be energized in order that the discharge may transfer to the main gap. It depends upon the amount of current flowing in the control gap and on the main-gap voltage. For a control-gap current of 200 microamperes the "transfer time" is approximately 50 microseconds.

Typical Circuits

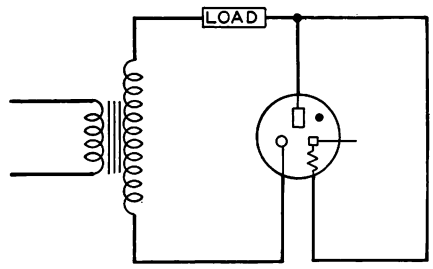
Circuit A shows a circuit using the tube as a relay. The supply voltage should be intermediate between the "main-gap breakdown and sustaining voltages" and the control anode may be biased at any desired potential less than the "control-gap sustaining voltage." This circuit possesses a "lock-in" feature, since the anode potential must be removed momentarily to restore the tube to a non-conducting condition. When supplied from alternating current this circuit does not possess a "lock-in" feature unless the frequency of the supply voltage is so high that the tube is not allowed a sufficient interval to deionize.

Circuit B shows a circuit with the tube used as a rectifier. The rectifying properties of the main gap are used but the control anode should be connected into the circuit as indicated. This will cause conduction in the forward direction to begin at a voltage much below the "main-gap breakdown voltage." It is important to note that as a rectifier this tube possesses a unique property not common to other rectifiers in that its impedance is infinite for voltages below the breakdown voltage. In many applications that is of importance since the tube may be used to pass current at the higher potentials without placing a bridge across the line for signals of lower voltage.

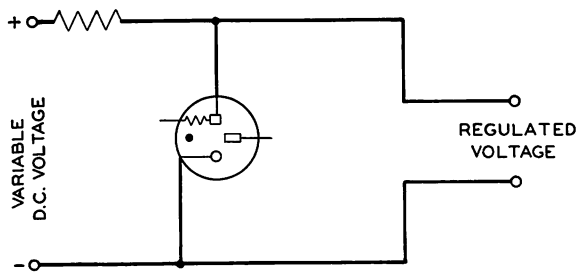
Circuit C shows a circuit using the control gap of the tube as a voltage regulator. In this application the connection is made directly to the control anode instead of through resistance.



CIRCUIT A



CIRCUIT B



CIRCUIT C

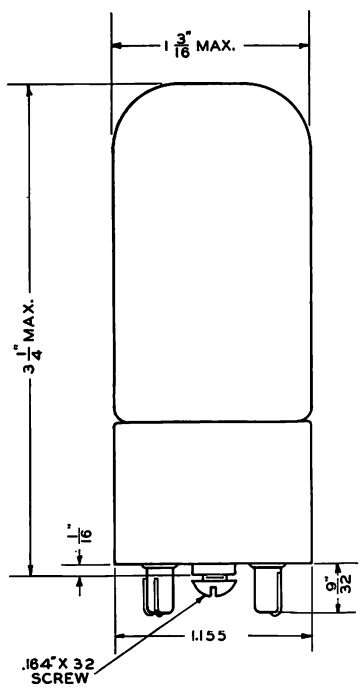


FIG. 1

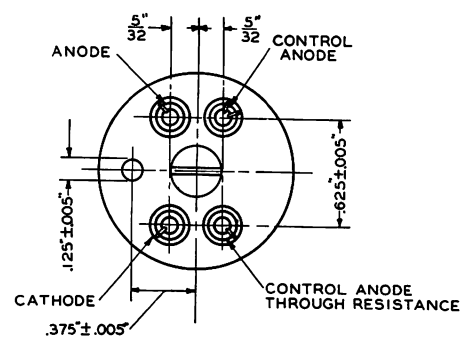


FIG. 2

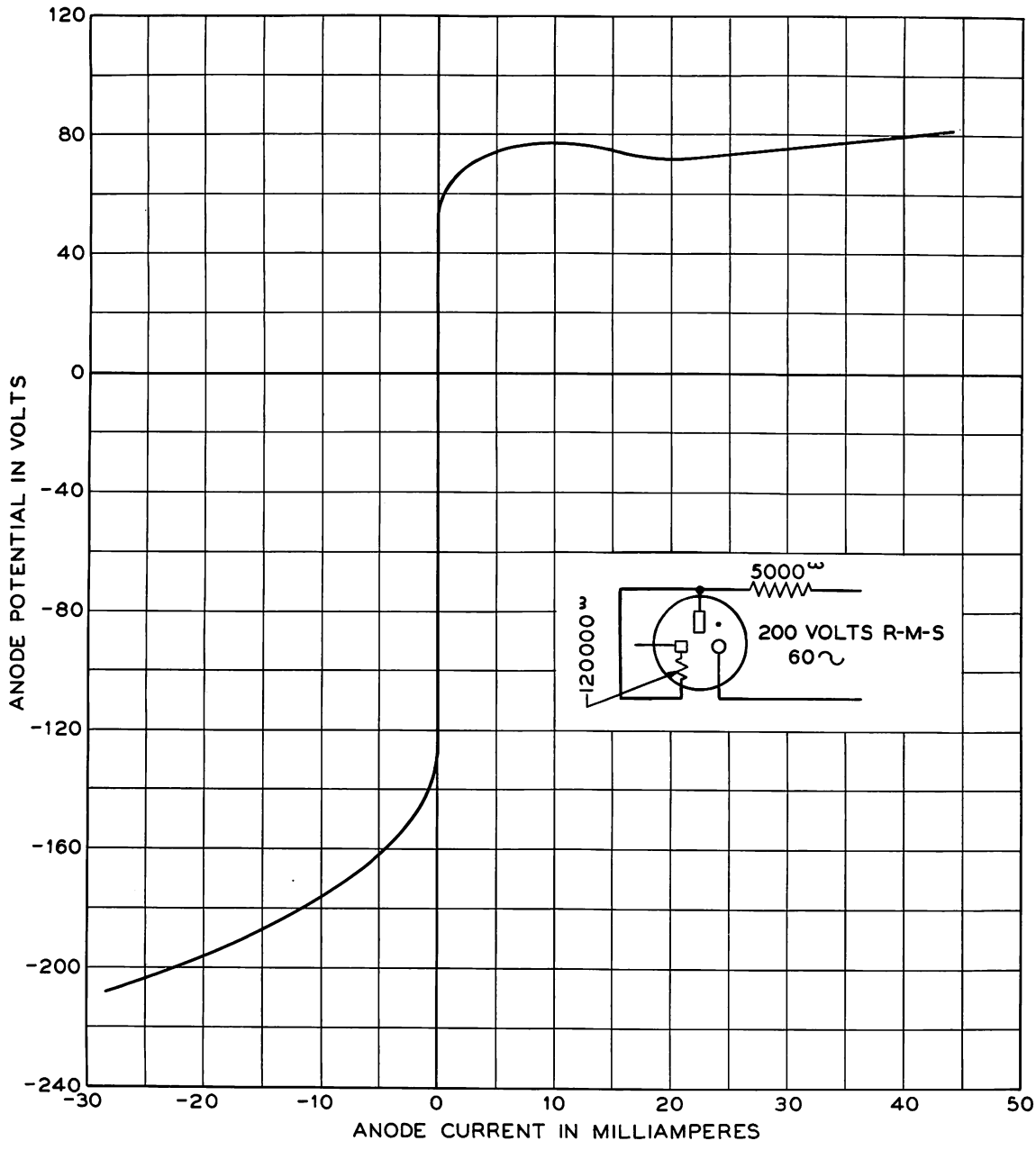
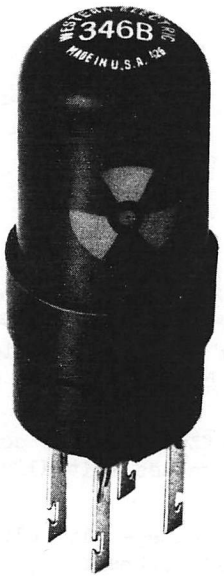

120
80
40
0
-40
-80
-120
-160
-200
-240
ANODE POTENTIAL IN VOLTS
-30
-20
-10
0
10
20
30
40
50
ANODE CURRENT IN MILLIAMPERES
5000Ω
120000Ω
200 VOLTS R-M-S
60~

FIG. 3

AB46.346B
Issue 3, April 1956
A.T.&T. Co. Standard

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 346B ELECTRON TUBE



DESCRIPTION

The 346B is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator, or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus.

MAXIMUM RATINGS

Peak Anode Voltage		225 volts
Average Cathode Current	10	100 milliamperes
Average Life, Approximate	10000	10 hours

File: Cold Cathode Section
Issue 6, April 1956

MAXIMUM RATINGS, Absolute Values

Forward Peak Anode Voltage	225 volts
Forward Cathode Current [1]	
Peak	100 milliamperes
Average	35 milliamperes
Averaging Time	2 seconds
Inverse Peak Anode Current [1]	5 milliamperes
Ambient Temperature Limits	-55 to +85 centigrade

ELECTRICAL DATA

	Min.	Bogey	Max.	
Starter Breakdown Voltage [2]	65	70	89	volts
Starter Voltage Drop at 20 Milliamperes	52	60	74	volts
Anode Voltage Drop at 20 Milliamperes	72	80	90	volts
Transfer Current	See curve - Fig. 3			
Ionization Time - Starter Gap [3]	---	6	---	milliseconds
Deionization Time, Approximate				
Starter Gap	---	2	---	milliseconds
Main Gap	---	8	---	milliseconds
Inverse Current at -120 Volts Anode Potential [4]	---	---	3	milliamperes

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	1 ounce

Dimensions and pin connections shown in outline drawing on page 4

Note 1: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed their maximum rated values.

Note 2: Limits apply immediately after tube has conducted current. If the tube has been idle, these values initially may be as much as 3 volts higher or lower.

Note 3: With 15 volts starter overvoltage (15 volts above Starter Breakdown Voltage) with tube in total darkness.

Note 4: Negative anode voltage applied through 8000 ohms. Starter connected to anode through 100000 ohms.

HANDLING

Western Electric cold cathode tubes contain a minute amount of radium bromide which is a radioactive material. The amount in most types is too small to require any special care in use, handling or disposal.

A few types contain a larger quantity of radium bromide in which the radium approximates that found on a luminous watch dial. These types bear a red three-bladed propeller-shaped symbol on the tube envelope. Instructions for handling such tubes are given below and also in Bell System Practices for Central Office maintenance.

Installations ordinarily require no precautions against radiation. However, quantities of the tubes should not be so installed, or so stored outside the shipping carton, that they will be within a few inches of personnel or in proximity to photographic film for extended periods of time. For example, however, a 40-hour week exposure at about one (1) foot from a bank of 500 tubes (covering an area of 20 inches x 45 inches) is well within the accepted tolerance limits for personnel. Reasonable care should be exercised in handling and disposal of broken tubes. In general, attention should be given to the following:

(a) Avoid breathing dust or vapors from broken tubes.

(b) Avoid contacting broken parts with bare hands.

(c) Use wet rag to pick up broken parts. Wrap broken parts in rag and tie securely so as to form a package. Thoroughly wash hands after disposal.

(d) Dispose of broken or defective tubes as they are taken out of service. One or two tubes at a time may be disposed of with normal waste material. Accumulation of tubes in one concentrated area of the place of final disposition should be avoided.

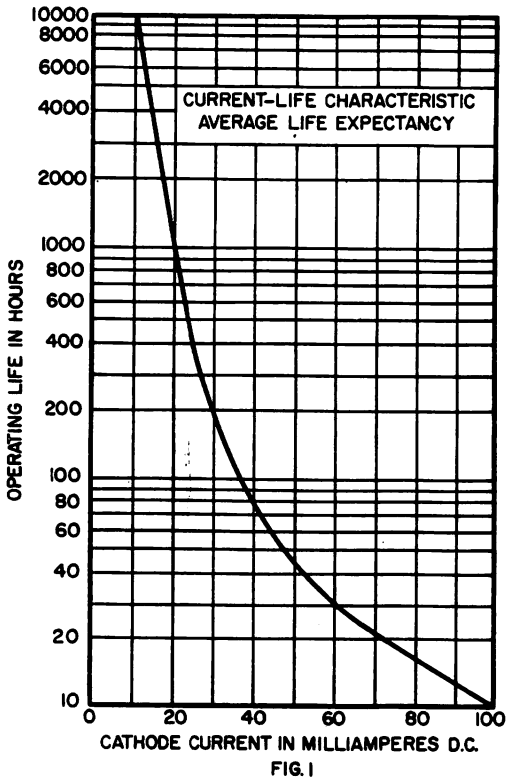


FIG. 1

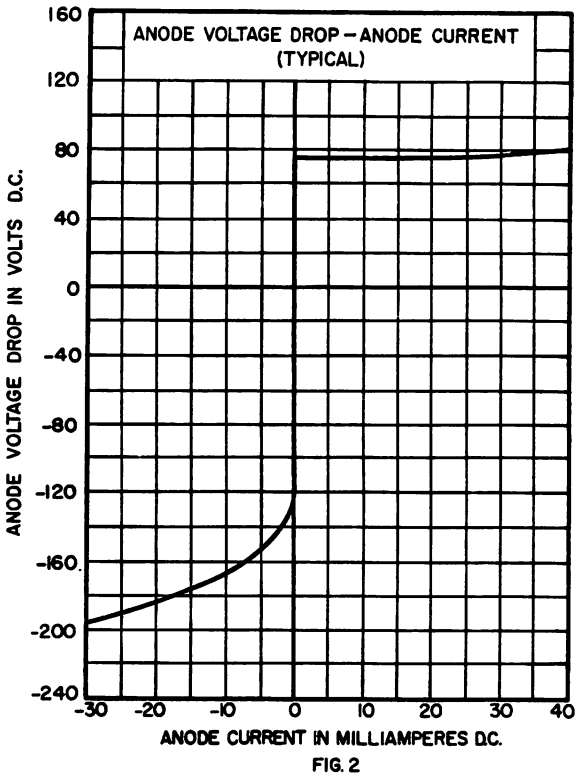


FIG. 2

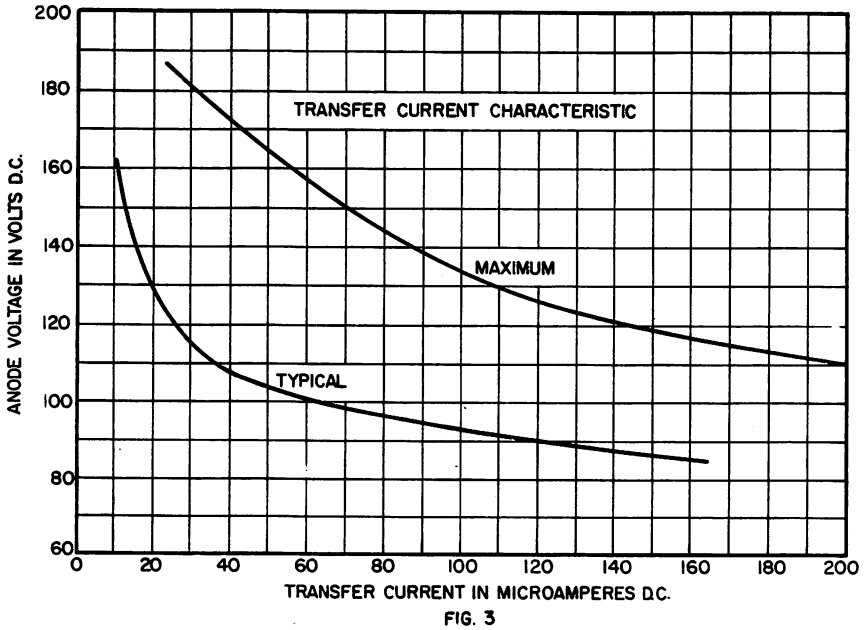
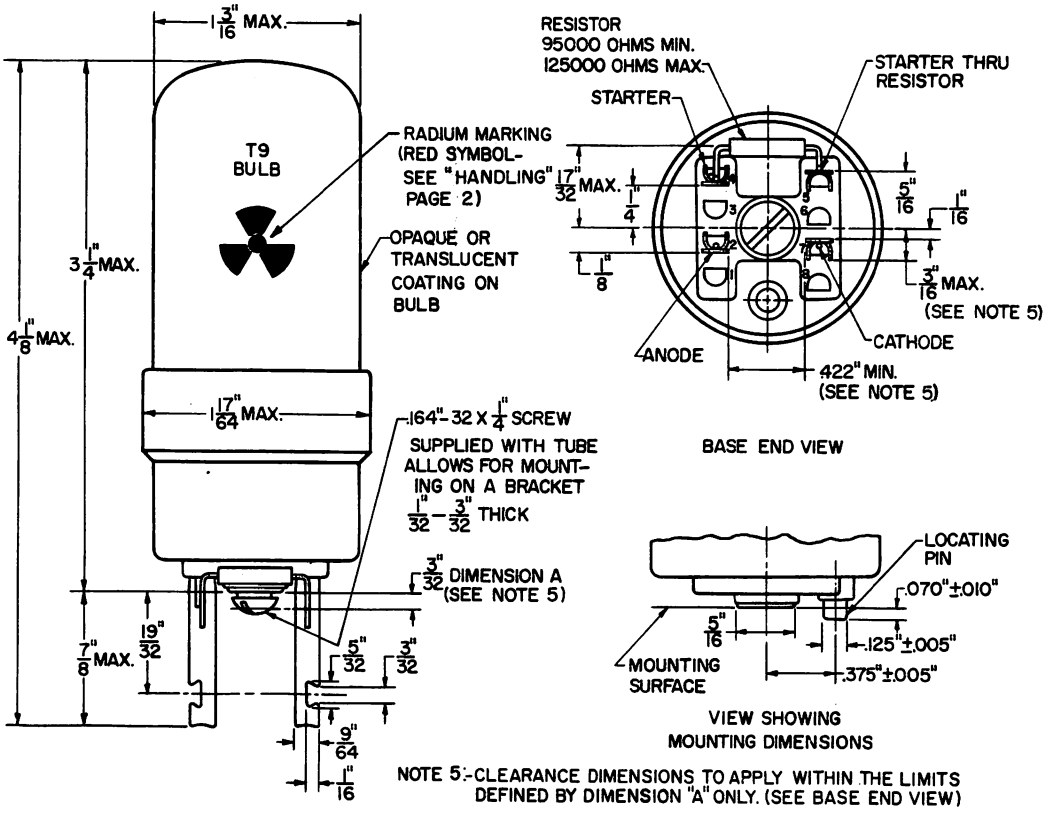


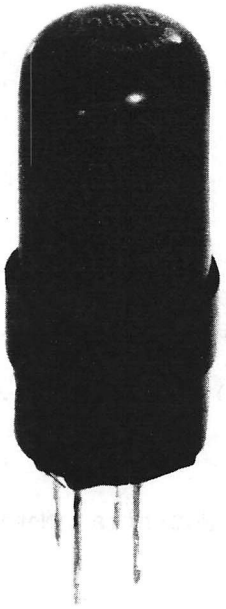
FIG. 3



A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 346C ELECTRON TUBE



DESCRIPTION

The 346C is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator, or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus.

CHARACTERISTICS

Peak Anode Voltage		225	volts
Average Cathode Current	10	100	milliamperes
Average Life, Approximate	10000	10	hours

File: Cold Cathode Section

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MAXIMUM RATINGS, Absolute System (Note 1)

Forward Peak Anode Voltage	225	volts
Forward Cathode Current (Note 2)		
Peak	100	milliamperes
Average	35	milliamperes
Averaging Time	2	seconds
Inverse Peak Anode Current (Note 2)	5	milliamperes
Ambient Temperature Limits	-55 to +85	centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.	
Starter Breakdown Voltage (Note 3)	65	70	89	volts
Starter Voltage Drop at 20 milliamperes	52	60	74	volts
Anode Voltage Drop at 20 milliamperes	72	80	90	volts
Transfer Current	See curve - Fig. 3			
Ionization Time - Starter Gap (Note 4)	-	6	-	milliseconds
Deionization Time, Approximate				
Starter Gap	-	2	-	milliseconds
Main Gap	-	8	-	milliseconds
Inverse Current at -120 Volts Anode Potential (Note 5)	-	-	3	milliamperes

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	1 Ounce

Dimensions and pin connections shown in outline drawing on page 4.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

Note 2: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed their maximum rated values.

Note 3: Limits apply immediately after tube has conducted current. If the tube has been idle, these values initially may be as much as 3 volts higher or lower.

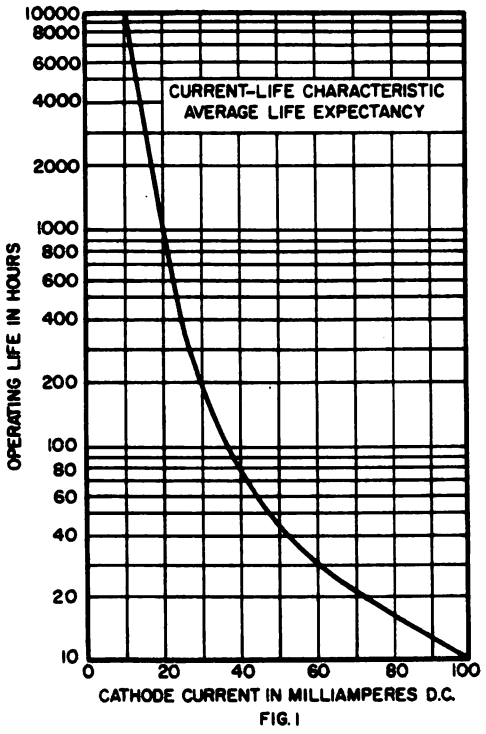


FIG. 1

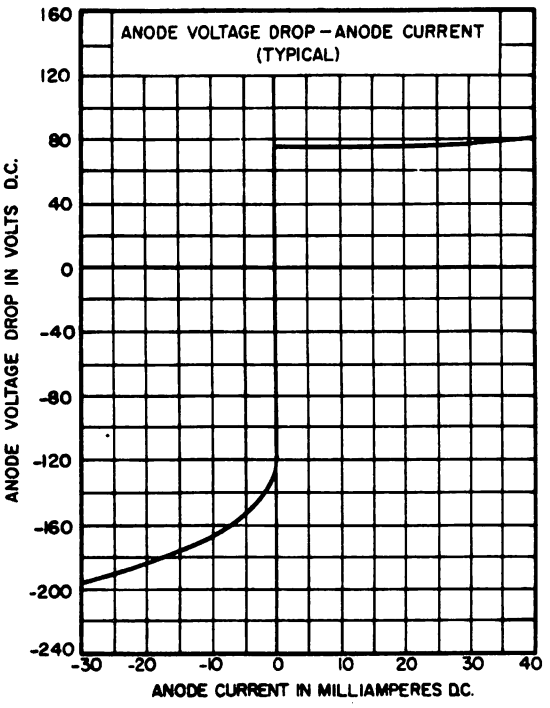


FIG. 2

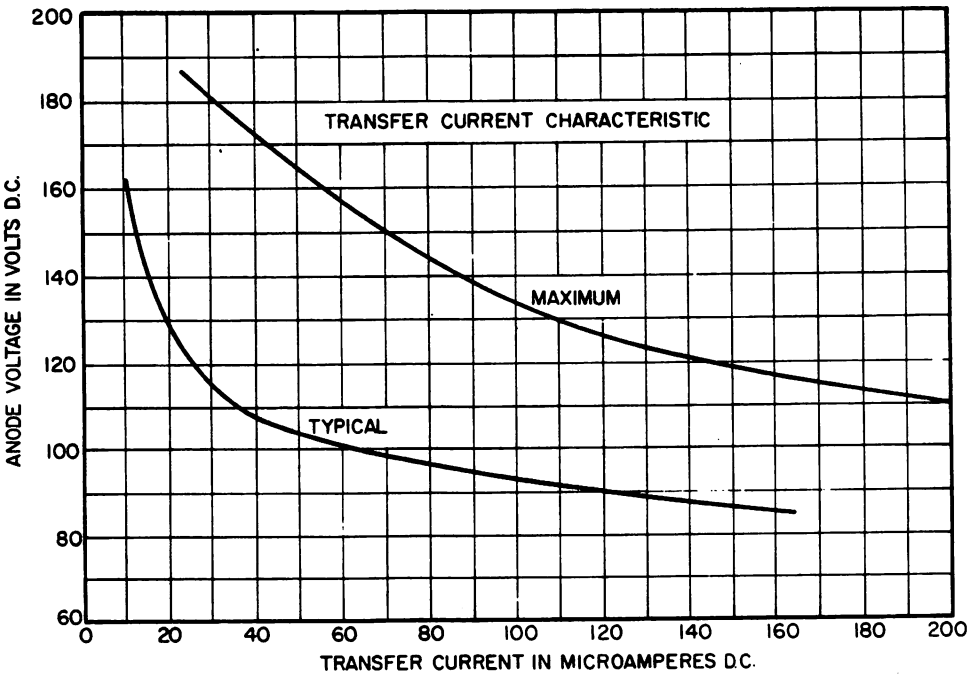
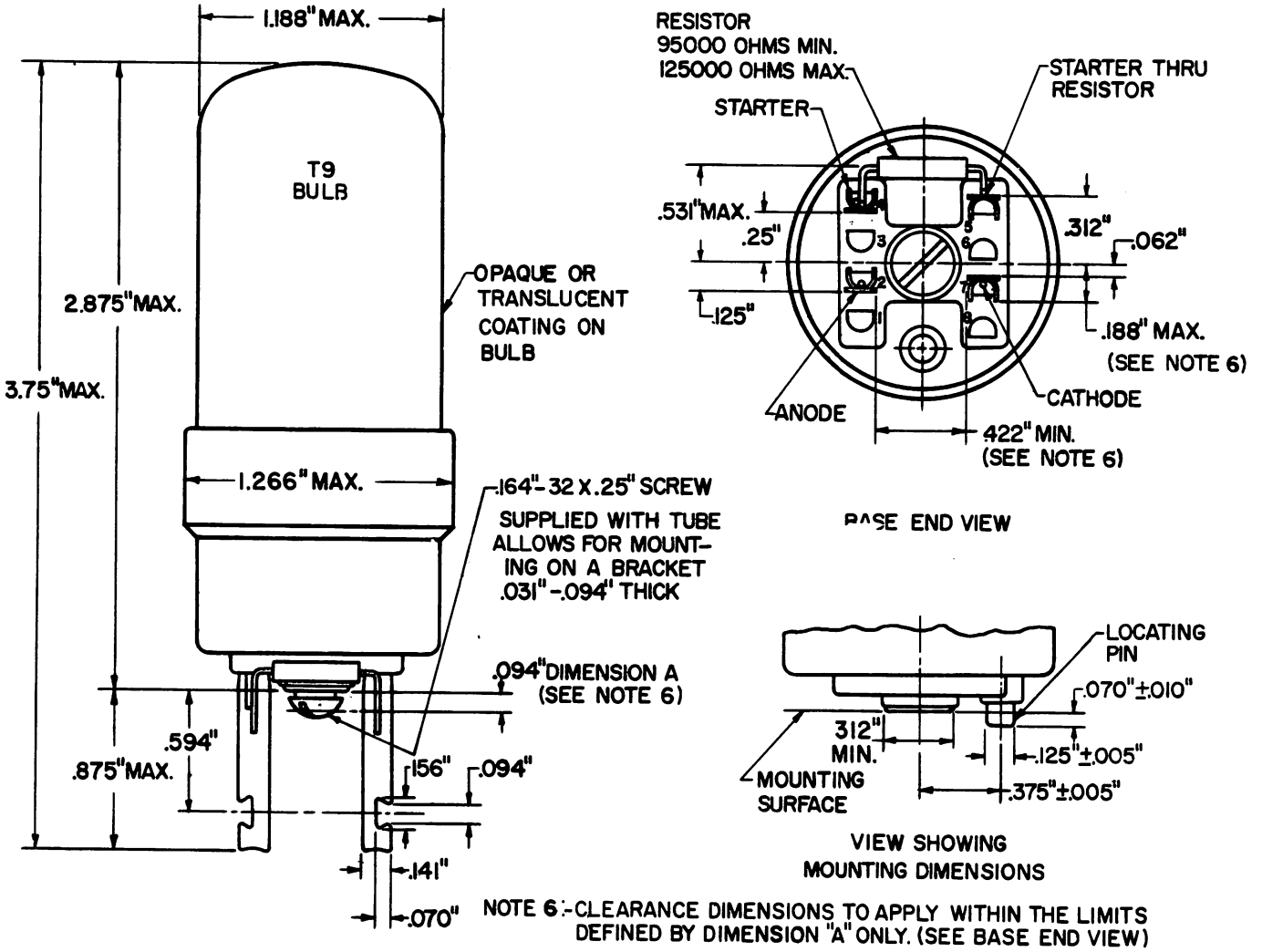


FIG. 3

Note 4: With 15 volts starter overvoltage (15 volts above Starter Breakdown Voltage) with tube in total darkness.

Note 5: Negative anode voltage applied through 8000 ohms. Starter connected to anode through 100,000 ohms.



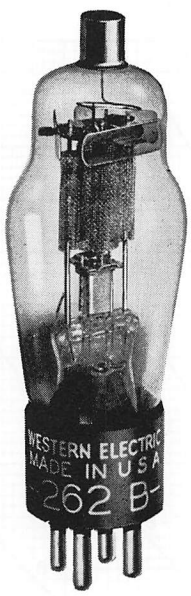
NOTE 6:-CLEARANCE DIMENSIONS TO APPLY WITHIN THE LIMITS DEFINED BY DIMENSION "A" ONLY. (SEE BASE END VIEW)

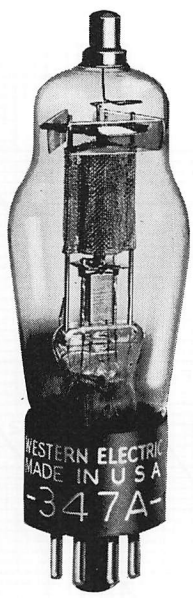
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Western Electric

262B and 347A Vacuum Tubes





Classification—Low-power triodes with indirectly-heated cathodes

These tubes are intended for use in audio-frequency amplifiers where exceptionally low tube noise is required. They are designed to minimize hum produced by alternating current operation of the heater and to minimize microphonic noise.

The two types differ in heater rating, type of base and type of grid cap. In all other respects they are identical.

The 262B tube may be used as a replacement for the 262A tube in all applications where the voltage between heater and cathode is low.

Dimensions and Connections—Outline diagrams of the tube and base giving the dimensions and the arrangement of electrode connections to the base terminals for the 262B tube are shown in Figures 1 and 2. Similar information for the 347A tube is shown in Figures 3 and 4.

Base and Mounting—The 262B tube employs a small four-pin thrust type base suitable for use in a Western Electric 143B or similar socket. The base pins are silver-plated. The grid terminal is a small metal cap located at the top of the bulb.

The 347A tube employs a small shell octal five-pin base. The grid terminal is a skirted miniature metal cap located at the top of the bulb.

These tubes may be mounted in any position.

Average Direct Interelectrode Capacitances

Grid to plate	1.9 μμf.
Grid to cathode and heater	2.3 μμf.
Plate to cathode and heater	4.1 μμf.

Heater Ratings

	262B Tube	347A Tube
Heater voltage	10.0	6.3 volts, a.c. or d.c.
Nominal heater current	0.32	0.50 ampere

The heater elements of these tubes are designed to operate on a voltage basis and should be operated at as near the rated voltage as practicable.

Cathode Connection—Where alternating heater voltage is used the cathode should preferably be connected directly to the mid-point of the heater transformer winding or to the mid-point of a low resistance connected across the heater terminals. For direct current operation the cathode may be connected to either end of the heater. If voltage is applied between the heater and cathode, it should be kept low and must not exceed 30 volts.

Characteristics—Typical curves showing plate current as a function of grid voltage for several values of plate voltage are shown in Figure 5. Corresponding amplification factor, plate resistance and transconductance characteristics are given in Figures 6, 7 and 8, respectively. Plate current is shown as a function of plate voltage for several values of grid voltage in Figure 9.

Operating Conditions and Output—Permissible operating plate and grid voltages are included within the area, ABCD, in Figure 5. Amplification factor, plate resistance, transconductance and performance data for a number of typical operating conditions are given in the table. Recommended conditions or others of no greater severity should be selected in preference to maximum conditions wherever possible. The life of the tube at maximum conditions may be shorter than at less severe conditions.

In the last four columns of the table are given the fundamental power output, P_m, in milliwatts, the fundamental voltage output, E_{pm}, in peak volts, and the second and third harmonic levels, F_{2m} and F_{3m}, in db below the fundamental, corresponding to each of the recommended and maximum operating conditions for the indicated values of load resistance. The peak value of the sinusoidal input voltage, E_{gm}, in each case is numerically equal to the grid biasing voltage. For a smaller input voltage, E_g, the fundamental power, voltage output and the harmonic levels are given approximately by the following relations:

$$P = P_m \left(\frac{E_g}{E_{gm}}\right)^2$$

$$E_p = E_{pm} \frac{E_g}{E_{gm}}$$

$$F_2 = F_{2m} + 20 \log_{10} \frac{E_{gm}}{E_g}$$

$$F_3 = F_{3m} + 40 \log_{10} \frac{E_{gm}}{E_g}$$

Hum—The disturbance produced in the plate circuit of an indirectly heated cathode type tube by alternating current operation of the heater has two main frequency components. One is of the same frequency as the alternating heater voltage and the other is of double this frequency. With a plate voltage of 135 volts, a grid bias of −4.5 volts, a load resistance of 15,000 ohms and with the cathode connected to the mid-point of the heater circuit, the mean hum output level of a typical tube at the supply frequency is 116 db below 1 milliampere. The range of levels of individual tubes extends from 105 to 123 db below 1 milliampere. At double the supply frequency, the mean level is 122 db below 1 milliampere, and the range of levels of individual tubes extends from 114 to 131 db below 1 milliampere.

These tubes have high insulation resistance and low capacitance between grid and heater. When reasonable care is exercised to keep the insulation leakage and capacitance small between the grid and heater leads in the external wiring, a resistance of 2 megohms may be used in the grid circuit without materially affecting the hum level.

To minimize hum it is important that the impedance in the cathode lead be kept low at both the supply frequency and double the supply frequency. If this impedance is 50 ohms or more at either frequency some reduction in hum output may be obtained by biasing the center point of the heater 10 to 15 volts positive with respect to the cathode.

Microphonic Noise—With a plate voltage of 135 volts, a grid bias of −4.5 volts and a load resistance of 100,000 ohms, the mean microphonic noise output level, measured in a laboratory reference test set, is 54 db below 1 volt. The range of levels of individual tubes extends from 38 to 65 db below 1 volt. Since microphonic noise depends on the type and intensity of the mechanical disturbance which produces it, the values given here are useful chiefly for comparison with the levels of other tubes which have been tested in the same way.

Fluctuation Noise—An irreducible minimum of noise in a vacuum tube is produced by minute uncontrollable fluctuations in the rate of flow of electrons to the anode. With a plate voltage of 135 volts, a grid bias of −4.5 volts and a load resistance of 100,000 ohms the mean equivalent fluctuation noise input of a typical tube for the audio-frequency range from 40 to 10,600 cycles is 112 db below 1 volt. The equivalent noise input voltage is equal to the measured output voltage divided by the voltage amplification of the tube in the measuring circuit. Individual tubes may deviate from the average value by as much as 5 db. By changing the plate voltage to 36 volts and the grid bias to −1 volt, the mean fluctuation noise level may be reduced to about 120 db below 1 volt without seriously affecting the voltage amplification.

TABLE

Plate Voltage Volts	Grid Voltage Volts	Plate Current Milli-amperes	Amplification Factor	Plate Resistance Ohms	Transconductance Micro-mhos	Load Resistance Ohms	Power Output Milli-watts	Voltage Output Peak Volts	Second Harmonic db	Third Harmonic db
100	−2.0	3.2	16.6	16,300	1020	16,300	8	16	31	50
						40,000	7	23	35	50
						100,000	4	29	38	50
100	−3.0	2.2	15.9	18,500	860	18,500	15	24	26	55
						40,000	13	33	30	60
						100,000	8	40	33	65
100	−4.0	1.4	15.3	21,800	700	21,800	22	31	22	50
						40,000	20	40	26	65
						100,000	14	52	31	50
120	−3.0	3.4	16.2	16,100	1010	16,100	17	24	27	55
						40,000	15	35	32	60
						100,000	9	42	34	65
120	−4.5	2.1	15.5	19,800	780	19,800	31	35	23	55
						40,000	27	47	27	55
						100,000	17	58	31	50
120	−6.0	1.0	14.8	26,600	560	26,600	39	45	19	35
						40,000	37	55	22	45
						100,000	24	70	28	50
*140	−4.5	3.2	15.8	17,000	930	17,000	38	36	25	65
						40,000	31	50	29	55
						100,000	18	60	32	50
140	−6.0	1.9	15.2	20,700	730	20,700	52	46	21	45
						40,000	46	61	25	55
						100,000	29	76	30	50
140	−7.5	1.0	14.7	28,100	520	100,000	39	88	27	55
*160	−6.0	3.0	15.5	17,700	880	17,700	63	47	23	60
						40,000	53	65	28	50
						100,000	31	79	31	45
160	−7.5	1.8	15.0	22,000	680	22,000	78	58	19	40
						40,000	70	75	24	65
						100,000	44	94	29	50
160	−9.0	0.9	14.5	29,600	490	100,000	54	104	25	60
*180	−7.5	2.8	15.3	18,300	840	18,300	95	59	22	50
						40,000	80	80	26	55
						100,000	48	98	31	50
*180	−9.0	1.7	14.8	22,700	650	22,700	100	68	17	35
						40,000	94	87	22	45
						100,000	61	110	29	50
*180	−10.5	0.8	14.3	30,600	470	100,000	69	117	24	50

*Maximum operating conditions

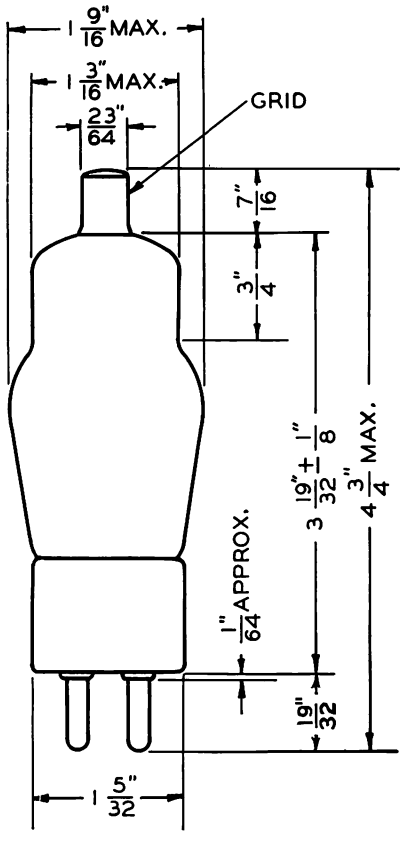


FIG. 1

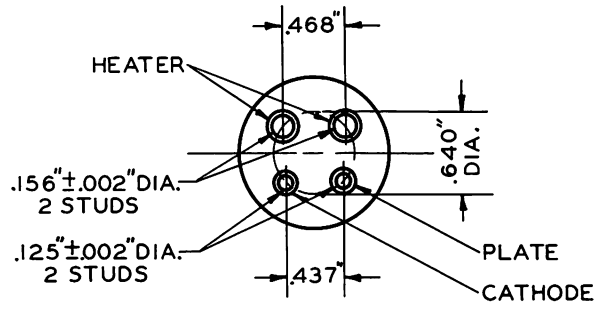


FIG. 2

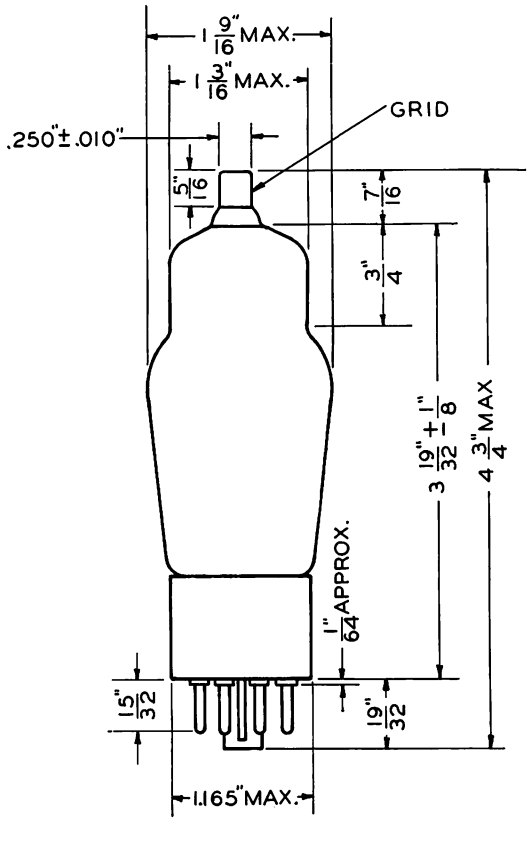


FIG. 3

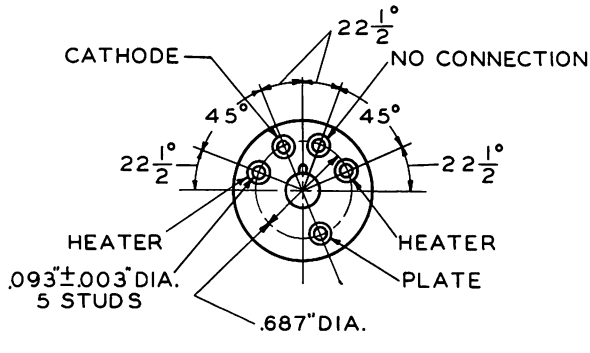


FIG. 4

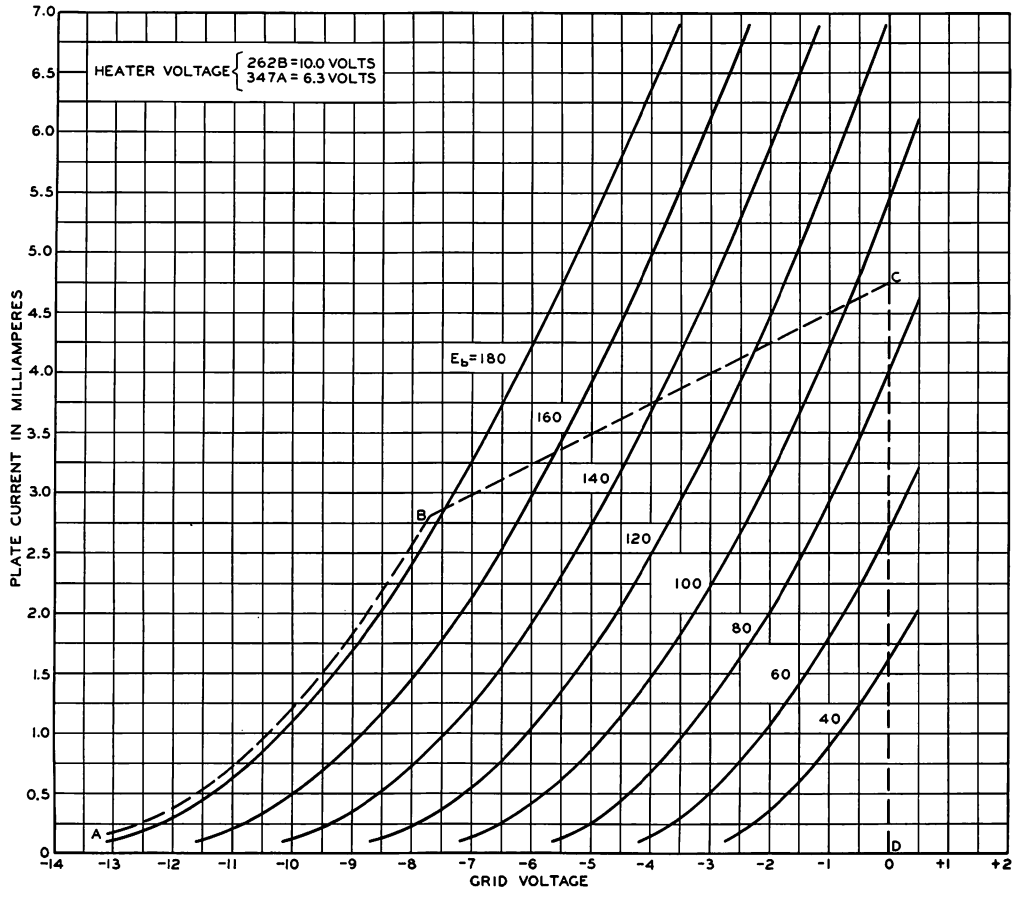

HEATER VOLTAGE { 262B = 10.0 VOLTS
347A = 6.3 VOLTS
E_b=180
160
140
120
100
80
60
40
A
B
C
D
PLATE CURRENT IN MILLIAMPERES
GRID VOLTAGE
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-14
-13
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1
+2

FIG. 5

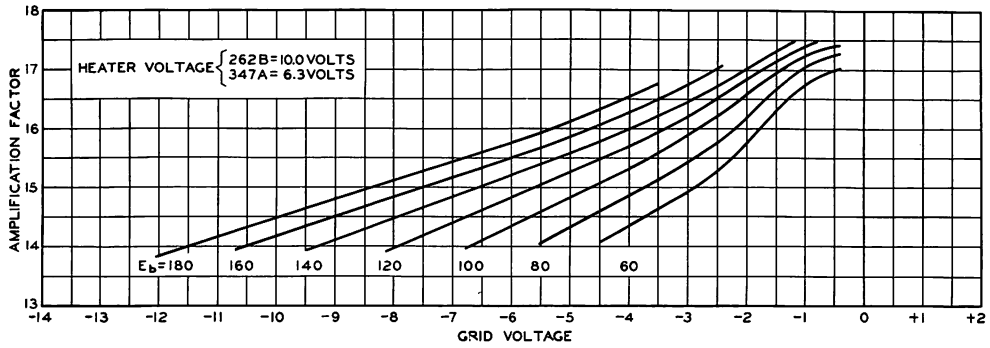


FIG. 6

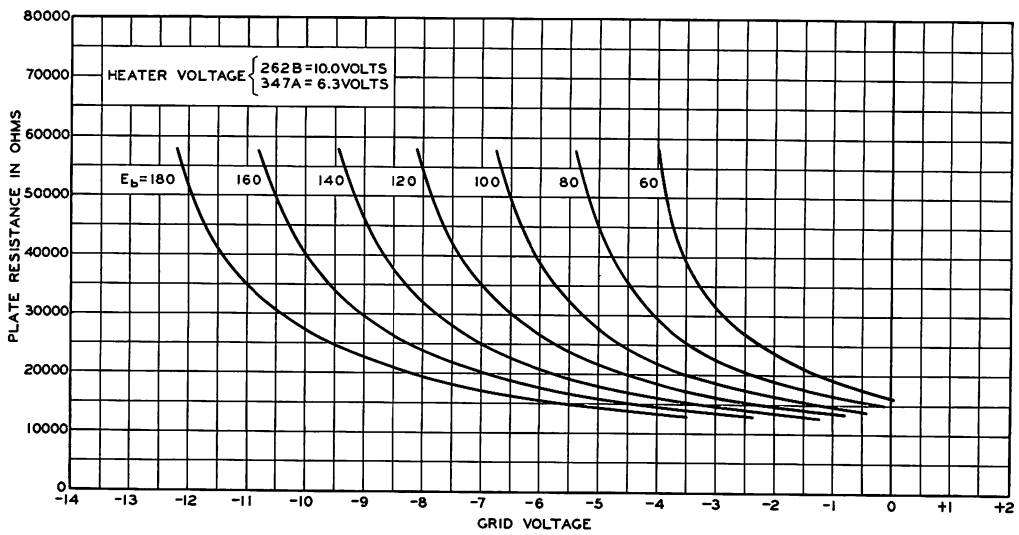


FIG. 7

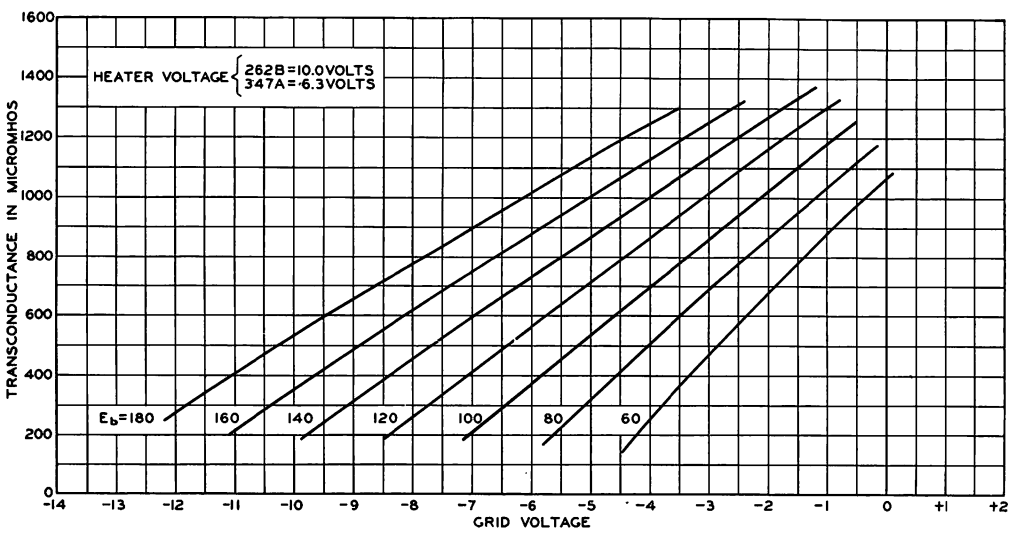


FIG. 8

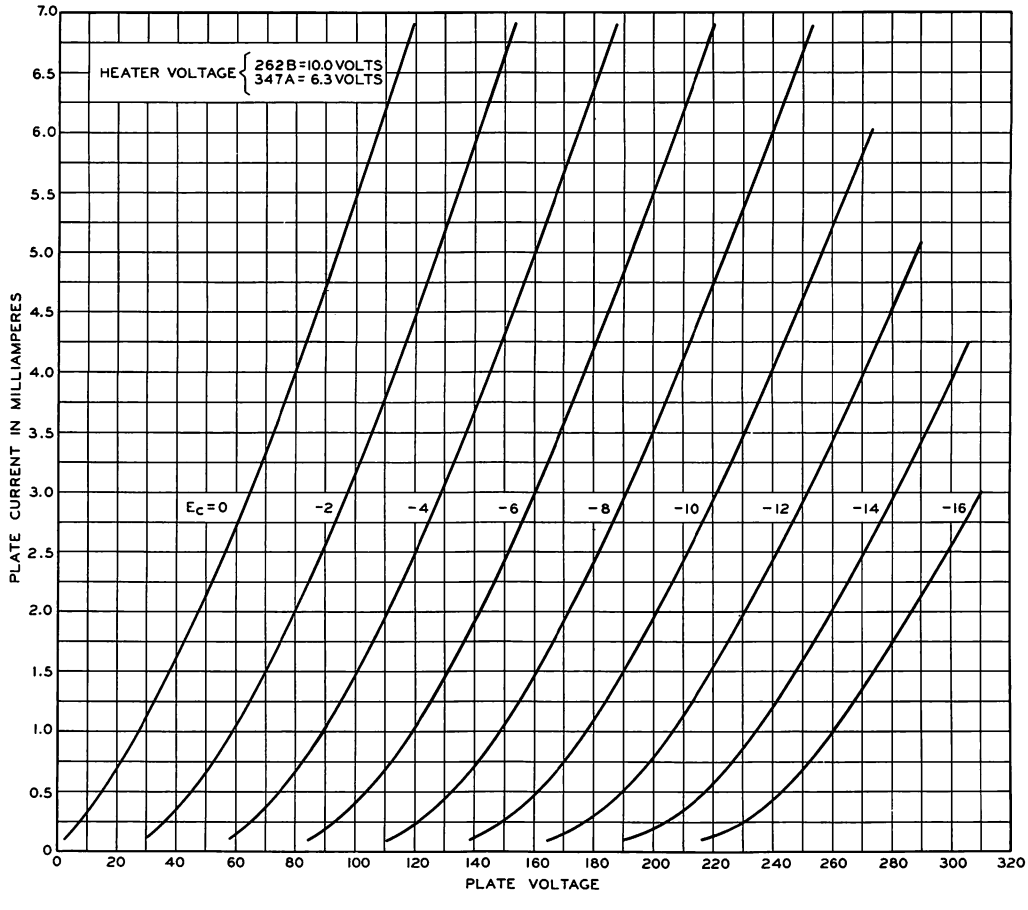
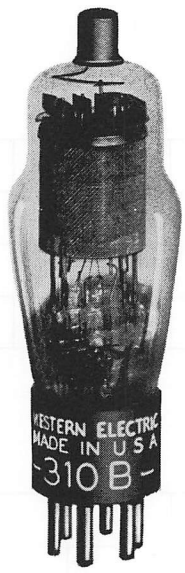
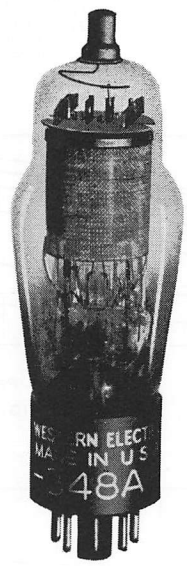

HEATER VOLTAGE { 262B=10.0 VOLTS 347A= 6.3 VOLTS
E_C=0
-2
-4
-6
-8
-10
-12
-14
-16
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320

FIG. 9

Western Electric

310B and 348A Vacuum Tubes





Classification—Voltage amplifier, suppressor-grid pentodes with indirectly heated cathodes.

The 310B and 348A tubes differ in heater ratings, type of base and type of grid cap. In all other respects they are identical. They are designed to minimize hum produced by alternating current operation of the heater and to minimize microphonic noise.

The tubes are intended for use in audio-frequency amplifiers where exceptionally low tube noise is required. They may also be used as radio-frequency voltage amplifiers, oscillators or modulators. The connection for the suppressor grid has been brought out to an external terminal, thus making the tubes more flexible in their applications.

Dimensions and Connections—The outline diagrams of the tube and base giving the dimensions and the arrangement of electrode connections to the base terminals for the 310B tube are shown in Figures 1 and 2. Similar information for the 348A tube is shown in Figures 3 and 4.

Base and Mounting—The 310B tube employs a small six-pin thrust type base with silver-plated pins. It is adapted for use in a standard six-contact type socket, preferably one provided with silver-plated contacts such as the Western Electric 144B socket. The control-grid terminal is a small metal cap located at the top of the bulb.

The 348A tube employs a small shell octal, seven-pin base. The control-grid terminal is a skirted miniature metal cap located at the top of the bulb.

The tubes may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B
Control grid to plate	0.025	0.007 μμf
Control grid to heater, cathode, screen grid and suppressor grid	6	7 μμf
Plate to heater, cathode, screen grid and suppressor grid	15	16 μμf

Column A—Without shield.

Column B—With close fitting metal shield connected to the cathode.

Heater Ratings

	310B Tube	348A Tube	
Heater voltage	10.0	6.3	volts, ac or dc
Nominal heater current	0.32	0.50	ampere

The heaters of these tubes are designed to operate on a voltage basis and should be operated at as near to the rated voltage as is practicable.

Cathode Connection— Where alternating heater current is used the cathode should preferably be connected directly to the mid-point of the heater transformer winding or to the mid-point of a low resistance connected across the heater terminals. For direct current operation the cathode may be connected to either end of the heater. If voltage is applied between the heater and cathode, it should be kept low and must not exceed 30 volts.

Characteristics— Figures 5 and 6, respectively, show plate current and screen-grid current as functions of control-grid voltage for several values of screen-grid and plate voltage and zero suppressor-grid voltage. For all curves the plate voltage is equal to the screen-grid voltage. Plate current and screen-grid current are shown as functions of plate voltage in Figures 7 and 8, respectively, for several values of control-grid voltage, a screen-grid voltage of 135 volts and zero suppressor-grid voltage. Transconductance and plate resistance as functions of control-grid voltage are shown in Figure 9 for two values of screen-grid and plate voltage. The plate voltage in each case is equal to the screen-grid voltage and the suppressor-grid voltage is zero. Transconductance and plate resistance as functions of screen-grid voltage are shown in Figure 10 for a plate voltage of 180 volts, zero suppressor-grid voltage and two values of control-grid voltage.

Limiting Conditions For Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	180 volts
Maximum cathode current (screen-grid current plus plate current)	10 milliamperes
Maximum direct screen-grid current	2.5 milliamperes

Operating Conditions and Output— Amplification factor, plate resistance, transconductance and performance data are given in the table below for a number of typical operating conditions. Less severe operating conditions should be selected in preference to maximum operating conditions wherever possible. The life of the tube at maximum conditions will be shorter than at less severe conditions.

The performance data include the fundamental voltage and power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages not exceeding the indicated values. Under certain conditions the maximum second harmonic level occurs at a lower input voltage than that given in the table. The voltage output is given in peak volts, the power output in milliwatts and the harmonic levels in decibels below the fundamental.

TABLE

Control-grid voltage = −3 volts
Screen-grid voltage = 135 volts
Suppressor-grid voltage = 0

Plate Voltage	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Load Resistance	Input Voltage	Output Voltage	Output Power	Second Harmonic	Third Harmonic
Volts	Milliamperes		Megohms	Micromhos	Ohms	Peak Volts	Peak Volts	Milliwatts	db	db
135	5.5	1200	0.65	1800	20,000	3.00	100	250	22	30
					60,000	1.60	125	130	26	28
					60,000	0.95	85	60	35	45
					60,000	1.15	100	80	33	39
					100,000	0.57	75	25	35	50
					100,000	0.40	50	15	40	55
180	5.5	1800	1.00	1810	40,000	2.70	170	340	26	28
					100,000	1.50	175	156	26	30
225	5.6	2300	1.25	1830	60,000	2.70	225	425	27	27
					100,000	1.80	220	245	27	31
*250	5.6	2600	1.40	1840	60,000	2.70	240	480	26	30
					60,000	1.20	115	110	30	55
					100,000	2.10	250	320	26	29
					100,000	1.50	200	200	30	43

*Maximum plate voltage.

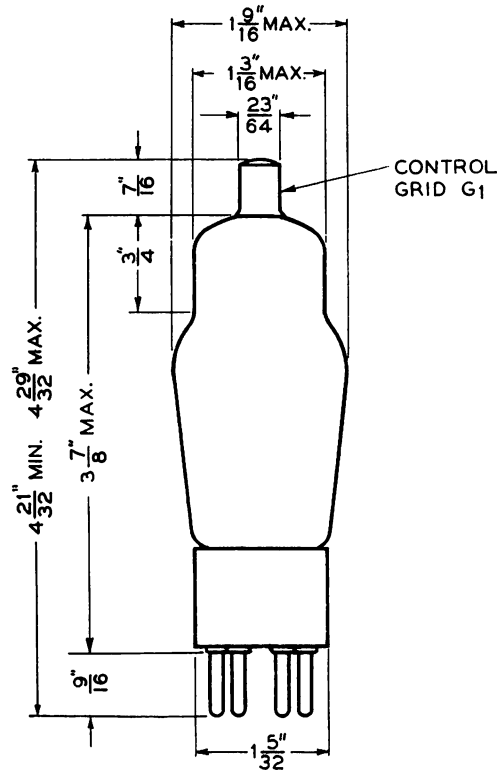


FIG. 1

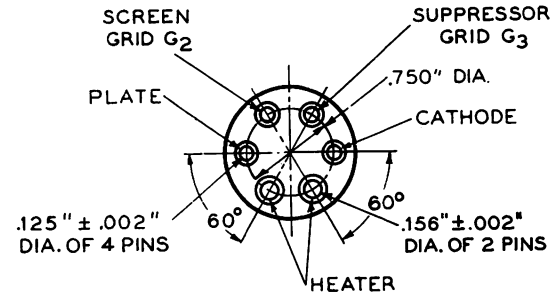


FIG. 2

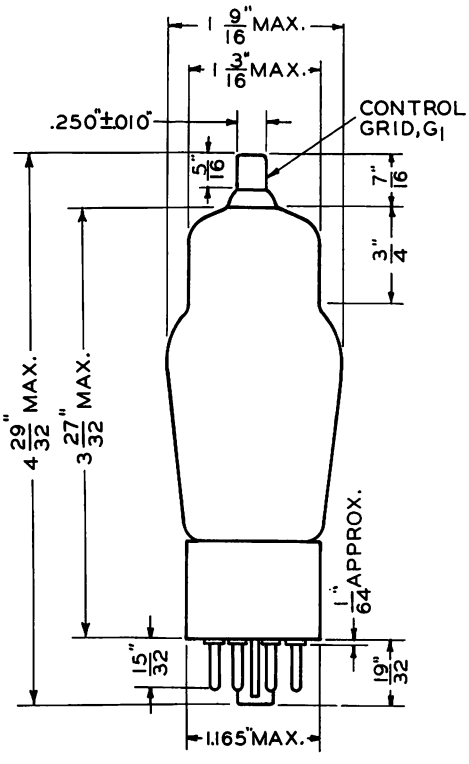


FIG. 3

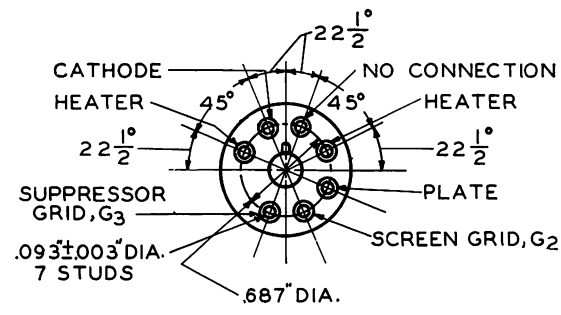


FIG. 4

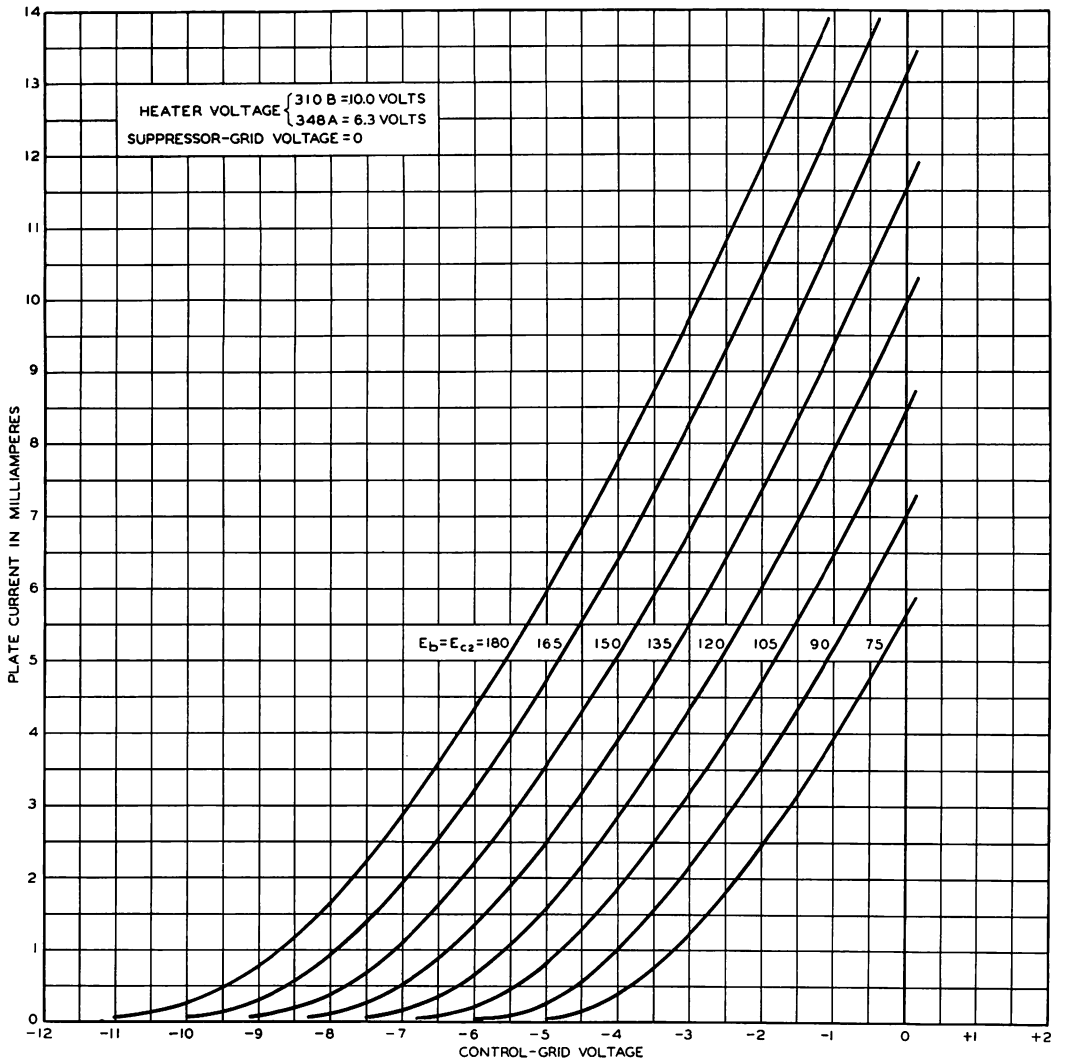

HEATER VOLTAGE { 310 B = 10.0 VOLTS
348 A = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
$E_b = E_{c2}$ = 180 165 150 135 120 105 90 75
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2

FIG. 5

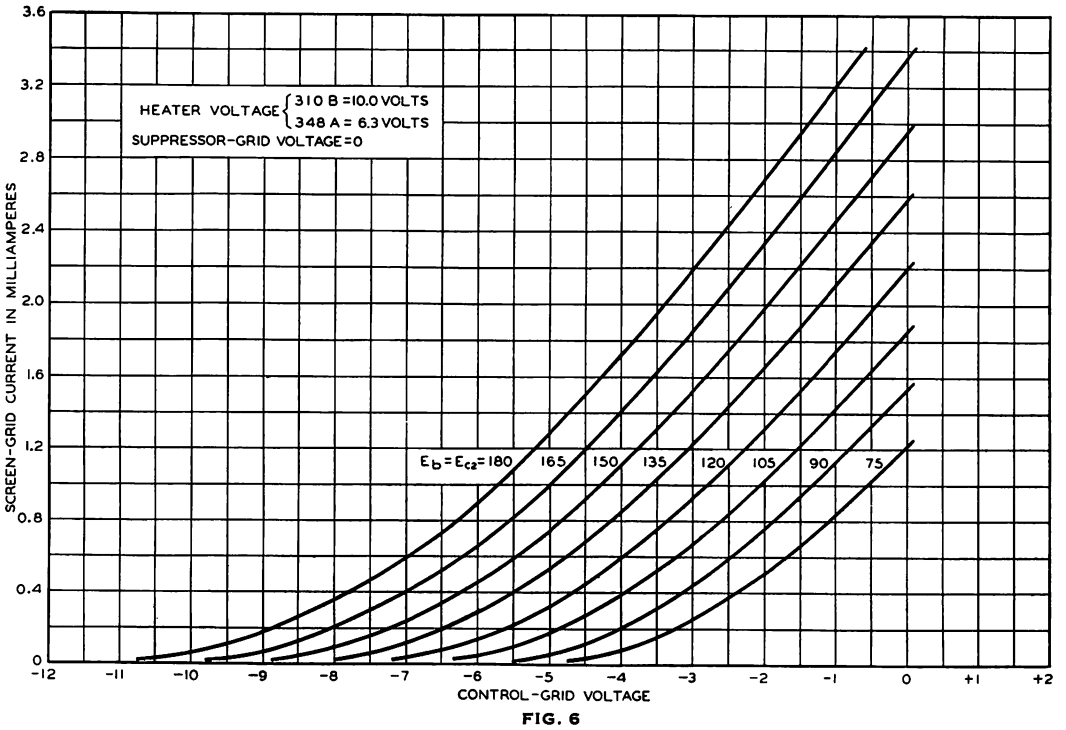

HEATER VOLTAGE { 310 B = 10.0 VOLTS
348 A = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
$E_b = E_{c2}$ = 180 165 150 135 120 105 90 75
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0 0.4 0.8 1.2 1.6 2.0 2.4 2.8 3.2 3.6
-12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0 +1 +2

FIG. 6

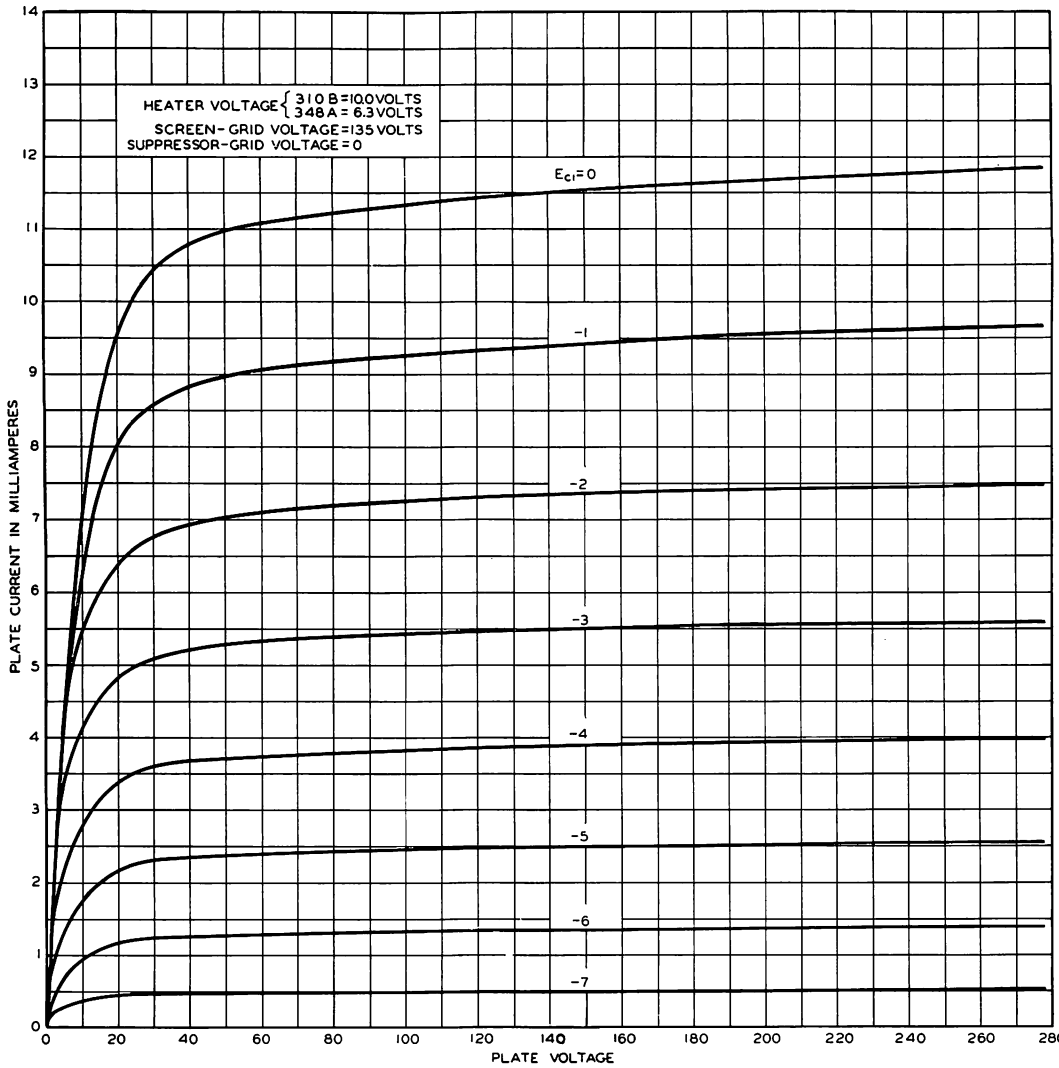

HEATER VOLTAGE { 310B=10.0 VOLTS
348A=6.3 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

FIG. 7

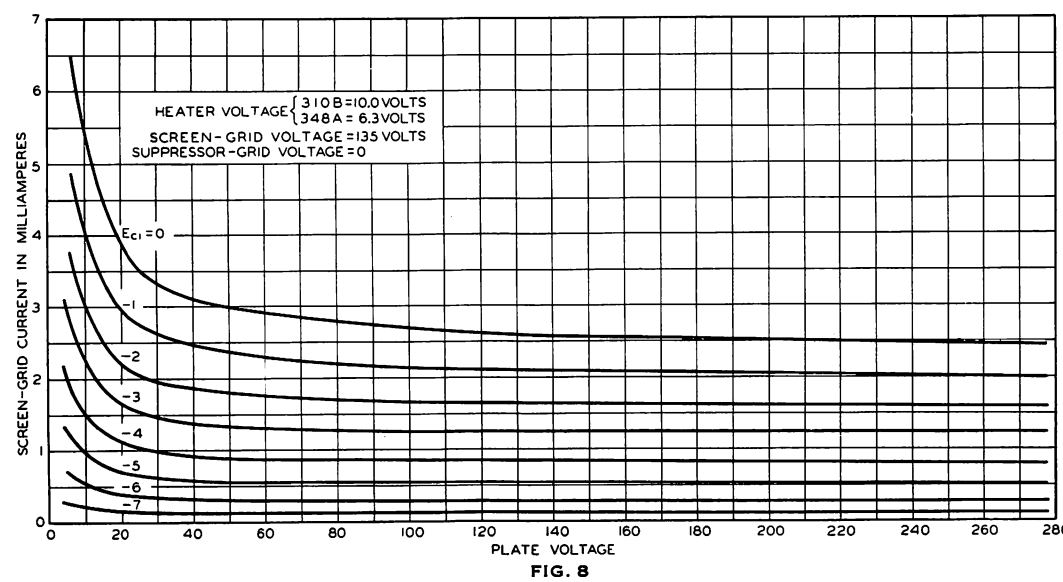

HEATER VOLTAGE { 310B=10.0 VOLTS
348A=6.3 VOLTS
SCREEN-GRID VOLTAGE=135 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{c1}=0
-1
-2
-3
-4
-5
-6
-7
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280
0 1 2 3 4 5 6 7

FIG. 8

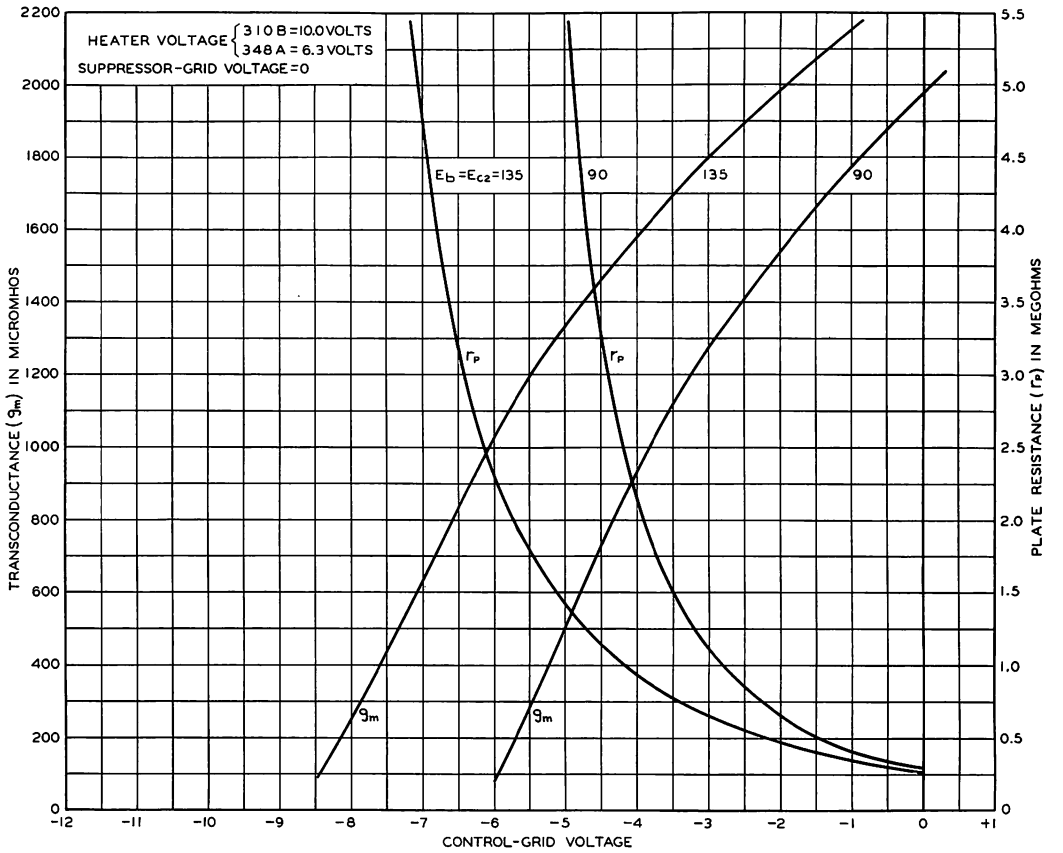

HEATER VOLTAGE { 310B=10.0 VOLTS
348A = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
$E_b=E_{c2}$=135
90
135
90
r_p
r_p
g_m
g_m
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
CONTROL-GRID VOLTAGE
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1

FIG. 9

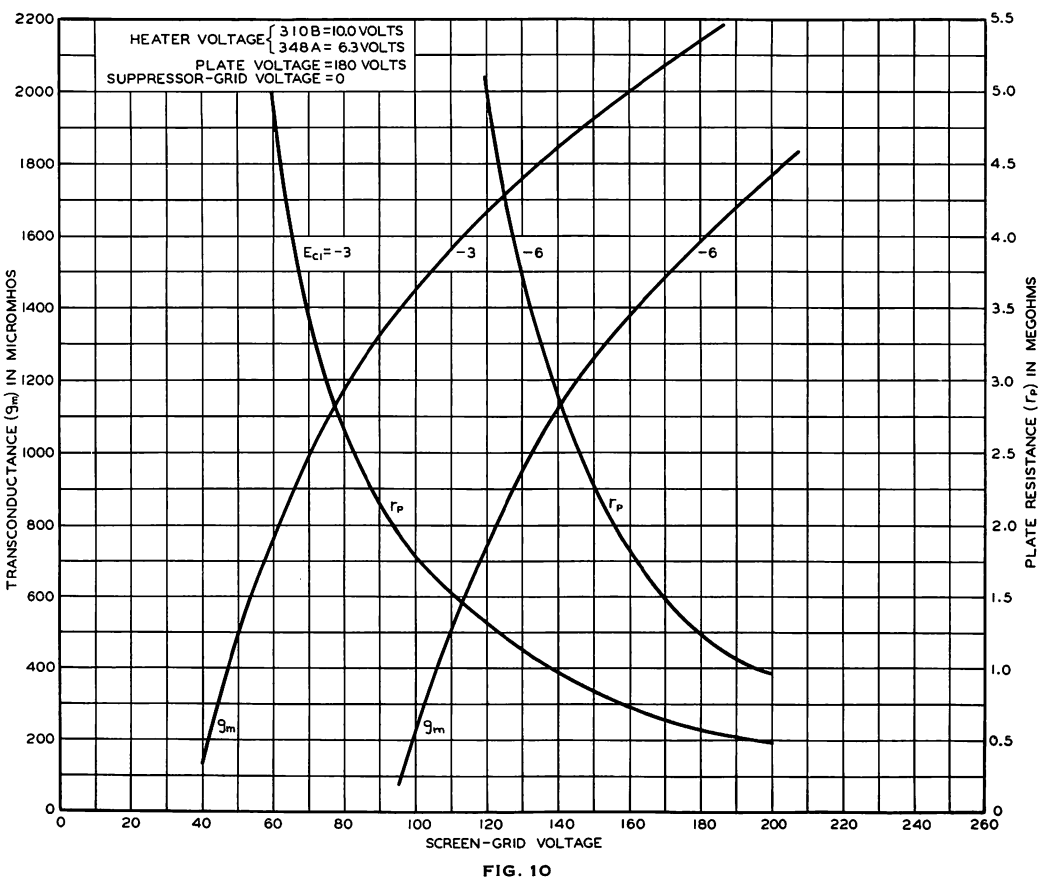
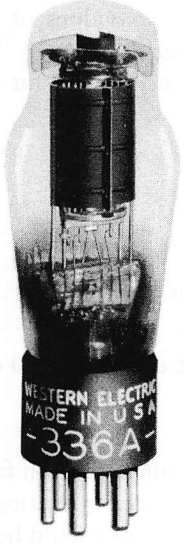
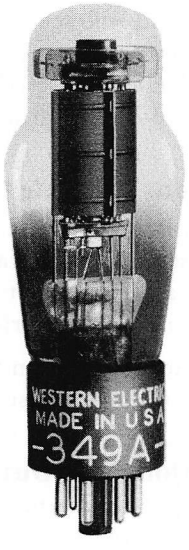

HEATER VOLTAGE { 310B=10.0 VOLTS
348A = 6.3 VOLTS
PLATE VOLTAGE=180 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{c1}=-3
-3
-6
-6
r_p
r_p
g_m
g_m
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
SCREEN-GRID VOLTAGE
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 10

Western Electric

336A and 349A Vacuum Tubes





Classification—Suppressor-grid pentodes with indirectly heated cathodes, intended for Class A Service

The 336A and 349A tubes differ in heater ratings and type of base. In all other respects they are identical.

These tubes are intended for use primarily as audio-frequency power amplifiers where power outputs of approximately 3.5 watts are required with a plate voltage not in excess of 250 volts. The suppressor grid is permanently connected to the cathode within the tube.

Dimensions and Connections—The outline diagrams of the tube and base giving the dimensions and the arrangement of electrode connections to the base terminals for the 336A tube are shown in Figure 1. Similar information for the 349A tube is shown in Figure 2.

Base and Mounting—The 336A tube employs a small six-pin thrust type base with silver-plated pins. It is adapted for use in a standard six-contact type socket, preferably one provided with silver-plated contacts such as the Western Electric 144B socket.

The 349A tube employs a small shell octal seven-pin base.

These tubes may be mounted in any position.

Average Direct Interelectrode Capacitances

Control grid to plate	0.65	$\mu\mu f$
Control grid to heater, cathode and screen grid	12	$\mu\mu f$
Plate to heater, cathode and screen grid	9	$\mu\mu f$

Heater Ratings

	336A Tube	349A Tube
Heater voltage	10.0	6.3 volts, a-c or d-c
Nominal heater current	0.64	1.0 ampere

The heater elements of these tubes are designed to operate on a voltage basis and should be operated at as near the rated voltage as practicable.

The voltage between the cathode and heater should not exceed 60 volts.

Characteristics—Figures 3 and 4 show plate current and screen-grid current respectively, as functions of control-grid voltage for several values of screen-grid and plate voltage. In all curves the plate voltage is equal to the screen-grid voltage. Plate current and screen-grid current are shown as functions of plate voltage in Figures 5 and 6, respectively, for a screen-grid voltage of 250 volts and for several values of control-grid voltage. Transconductance and plate resistance as functions of control-grid voltage are shown in Figure 7 for two values of screen-grid and plate voltage. The plate voltage in each case is equal to the screen-grid voltage. Transconductance and plate resistance as functions of screen-grid voltage are shown in Figure 8 for a plate voltage of 250 volts and two values of control-grid voltage.

Limiting Conditions For Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	250 volts
Maximum cathode current (Plate current plus screen-grid current)	50 milliamperes
Maximum direct screen-grid current	10 milliamperes

For fixed bias, the resistance in the grid circuit should not exceed 50,000 ohms. The maximum grid resistance, when self-bias is used, may be 0.5 megohm.

Operating Conditions and Output—Table No. 1 shows amplification factor, plate resistance, transconductance and performance data for a number of typical operating conditions with the tubes operating singly as pentodes. Less severe operating conditions should be selected in preference to maximum operating conditions wherever possible. The life of the tube at maximum conditions will be shorter than at less severe conditions.

The performance data include the fundamental power output for the indicated values of load resistance and input voltage, and the maximum second and third harmonic levels for input voltages not exceeding the indicated values. Under certain conditions the maximum second harmonic level occurs at a lower input voltage than that given in Table 1. The power output is given in watts and the harmonic levels in decibels below the fundamental.

TABLE 1

SINGLE TUBE-PENTODE

Plate Voltage Volts	Screen-Grid Voltage Volts	Control-Grid Voltage Volts	Plate Current Milliamperes	Amplification Factor	Plate Resistance Ohms	Transconductance Micromhos	Load Resistance Ohms	Input Voltage Peak Volts	Power Output Watts	Second Harmonic db	Third Harmonic db
180	180	−8.0	28	296	70,000	4230	4000	8	1.6	22	31
							7000	5	1.1	34	34
							7000	8	2.0	34	23
							10000	8	2.0	20	20
250	180	−8.0	29	352	81,000	4340	4000	8	1.9	22	38
							7000	5	1.2	26	39
							7000	8	2.7	25	29
							10000	8	3.0	31	23
*250	*250	−14.0	31	336	80,000	4200	4000	14	4.7	17	23
							5000	14	4.9	21	20
							6000	8	2.5	25	31
							6000	14	5.0	25	17
							7000	5	1.2	29	40
							7000	10	3.8	28	22
							7000	14	5.1	28	16
							8000	8	2.8	30	26
							8000	14	5.0	29	16
							9000	14	4.8	23	16
							10000	14	4.5	20	16

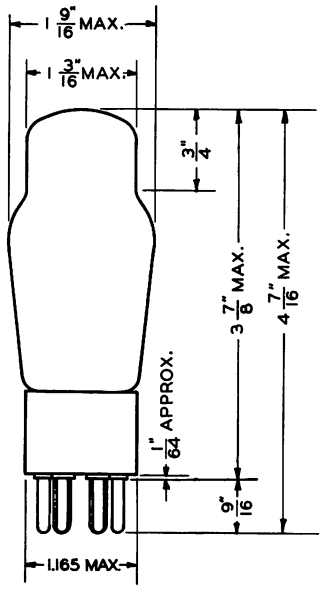
*Maximum operating condition.

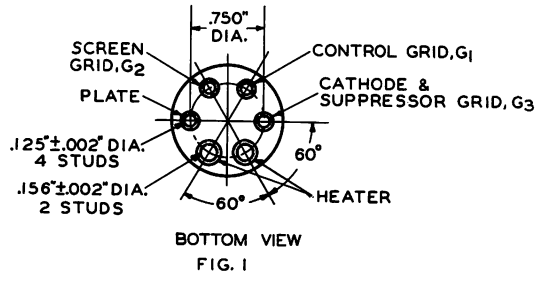
Table No. 2 shows amplification factor, plate resistance, transconductance and performance data for typical operating conditions when the tubes are operated singly as triodes and when two tubes are operated as push-pull pentodes.

TABLE 2

	Single Tube Screen Connected To Plate	Two Tubes Push-Pull Connected
	As A Triode	As Pentodes
Plate voltage	250	250 volts
Screen-grid voltage	—	250 volts
Control-grid voltage	—15	—18 volts
Peak input voltage	15	36 volts
Plate current	*32	*24 milliamperes
Plate current	**35	**65 milliamperes
Screen current	—	*7 milliamperes
Screen current	—	**21 milliamperes
Plate resistance	2150	— ohms
Mutual conductance	4800	— micromhos
Amplification factor	10.3	—
Load Resistance	4000	7000 ohms
Power output	1.2	8.5 watts
Second harmonic	***25	***35 db below fundamental
Third harmonic	***45	26 db below fundamental

*Zero signal **Maximum signal ***Approximate value

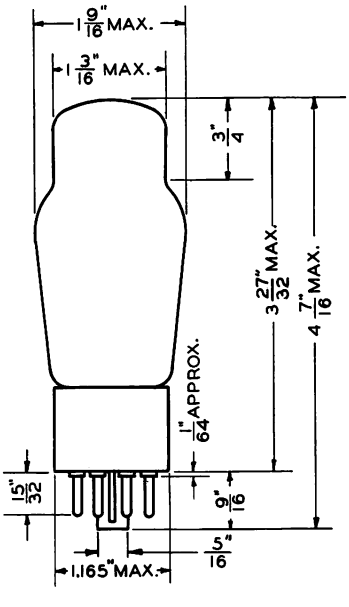


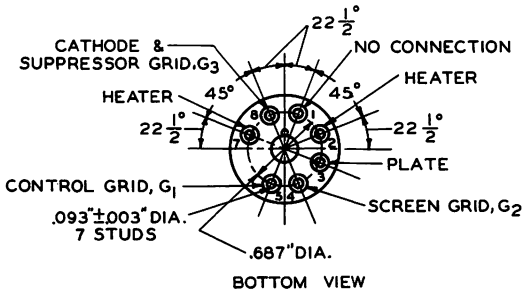


BOTTOM VIEW

FIG. 1

336A





BOTTOM VIEW

FIG. 2

349A

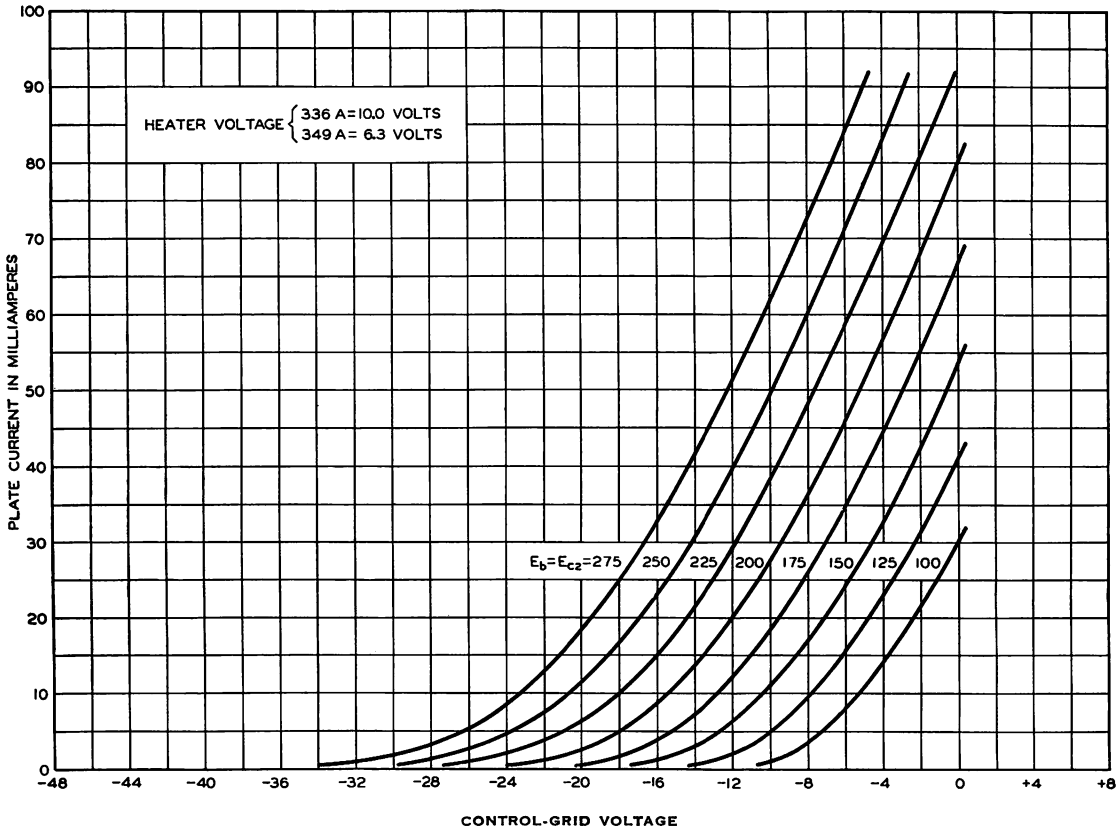

HEATER VOLTAGE { 336 A=10.0 VOLTS
349 A= 6.3 VOLTS
$E_b=E_{c2}$=275 250 225 200 175 150 125 100
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
100 90 80 70 60 50 40 30 20 10 0
-48 -44 -40 -36 -32 -28 -24 -20 -16 -12 -8 -4 0 +4 +8

FIG. 3

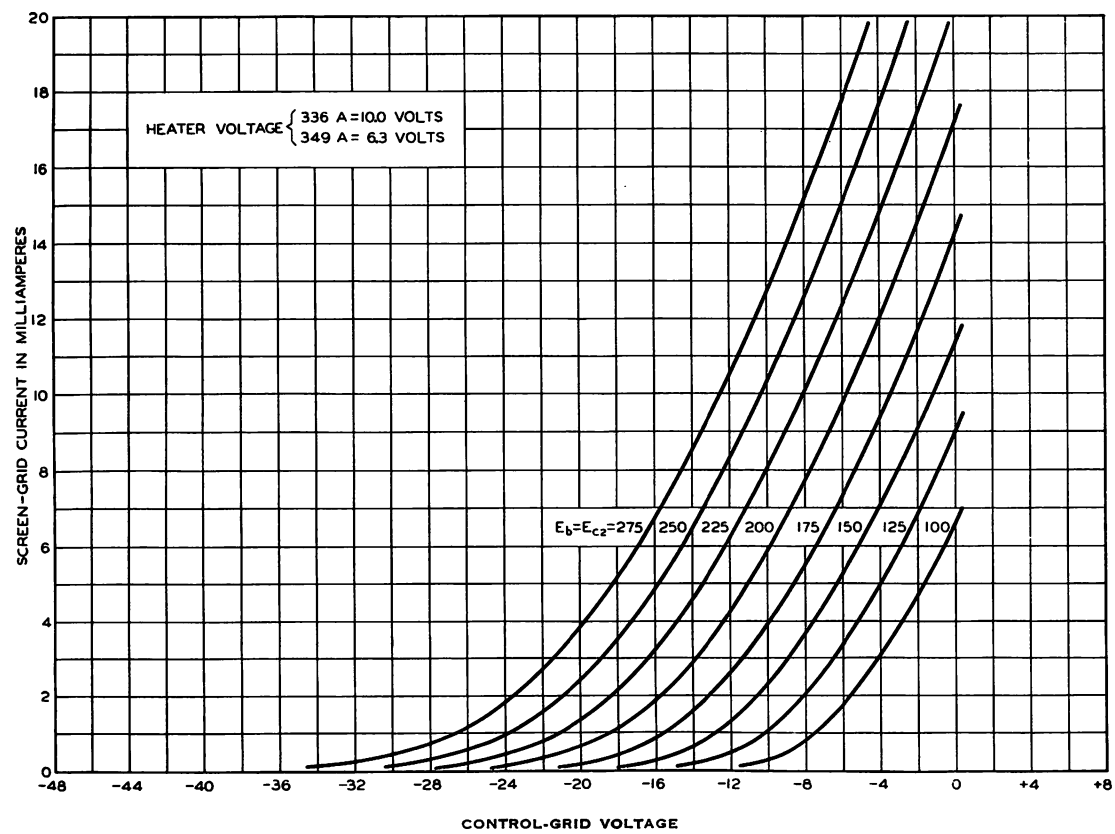

HEATER VOLTAGE { 336 A=10.0 VOLTS
349 A= 6.3 VOLTS
$E_b=E_{c2}$=275 250 225 200 175 150 125 100
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
20 18 16 14 12 10 8 6 4 2 0
-48 -44 -40 -36 -32 -28 -24 -20 -16 -12 -8 -4 0 +4 +8

FIG. 4

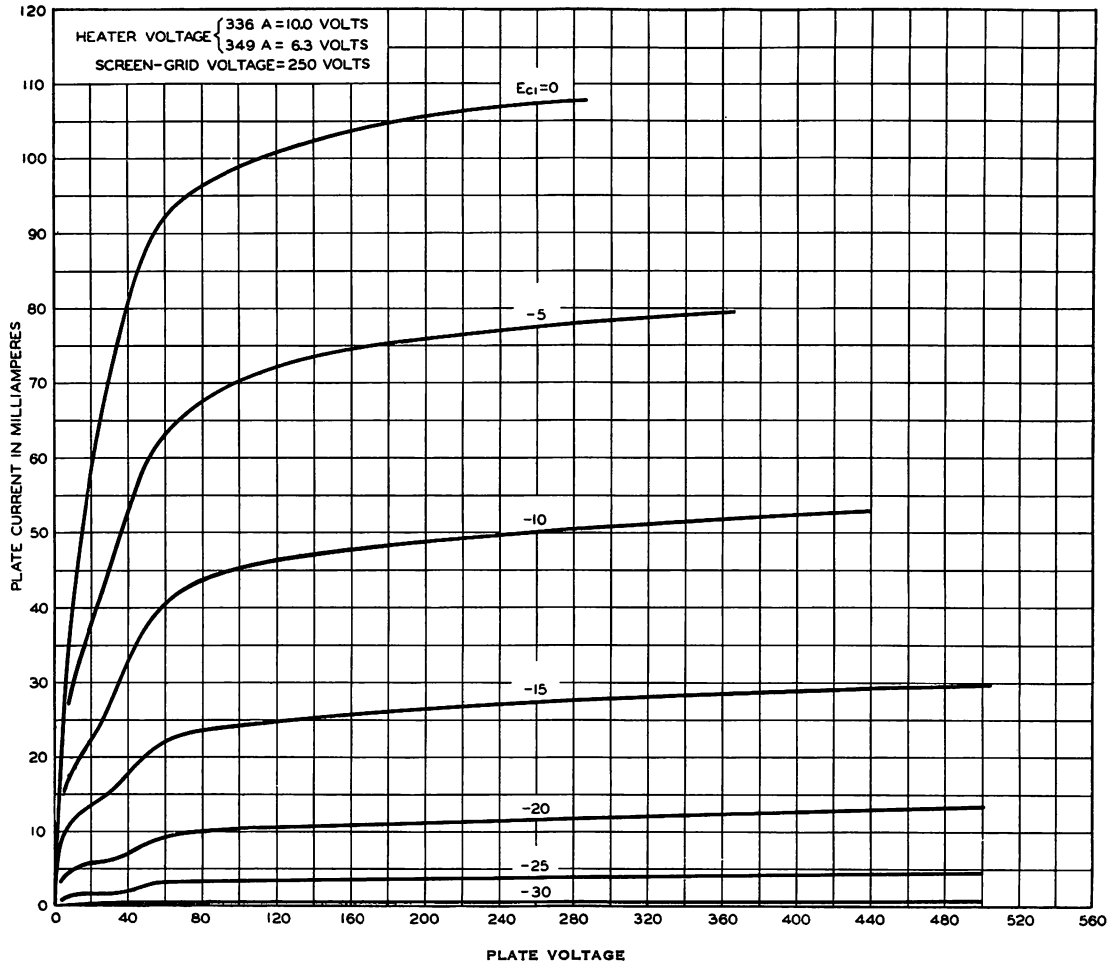

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
SCREEN-GRID VOLTAGE = 250 VOLTS
Ec1=0
-5
-10
-15
-20
-25
-30
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
70
80
90
100
110
120
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560

FIG. 5

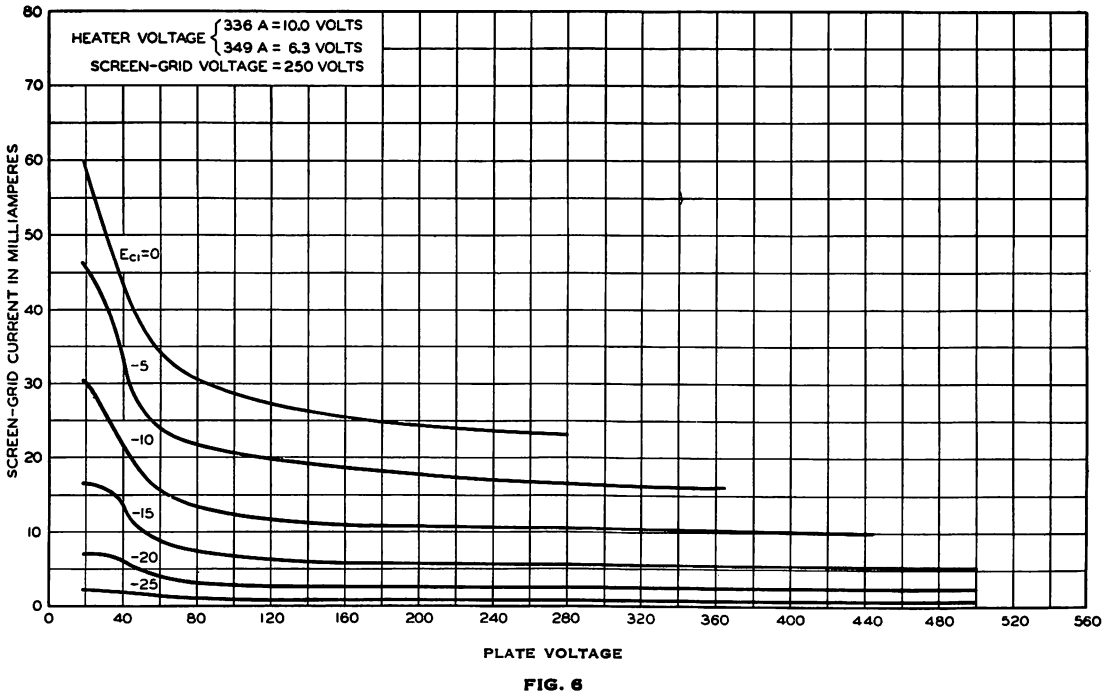

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
SCREEN-GRID VOLTAGE = 250 VOLTS
Ec1=0
-5
-10
-15
-20
-25
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
70
80
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560

FIG. 6

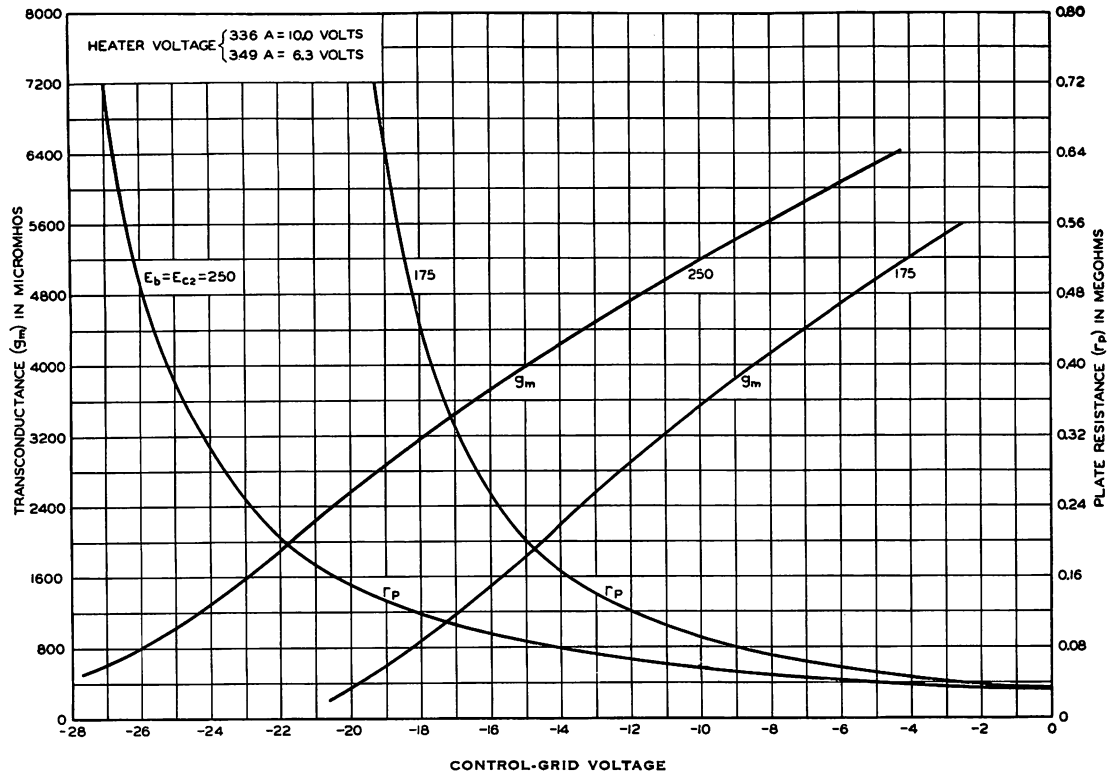

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
$E_b = E_{c2} = 250$
175
250
175
g_m
g_m
g_m
r_p
r_p
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
CONTROL-GRID VOLTAGE

FIG. 7

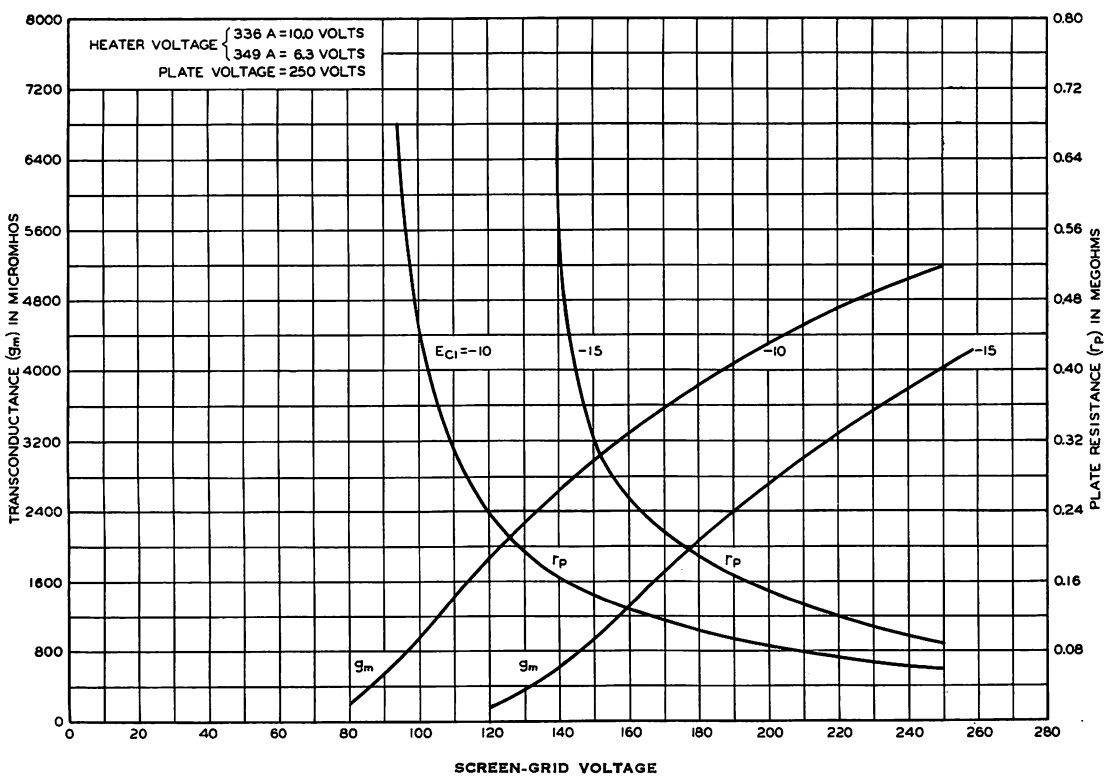
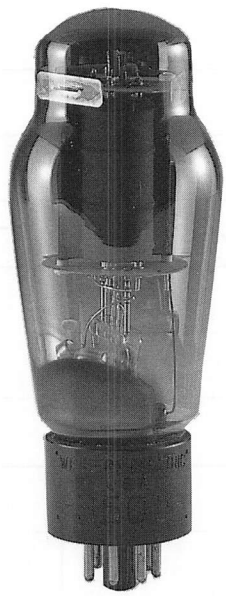

HEATER VOLTAGE { 336 A = 10.0 VOLTS
349 A = 6.3 VOLTS
PLATE VOLTAGE = 250 VOLTS
$E_{C1} = -10$
-15
-10
-15
g_m
g_m
r_p
r_p
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
SCREEN-GRID VOLTAGE

FIG. 8



TETRODE
BEAM POWER AMPLIFIER

Western Electric

DESCRIPTION

The 350B is a beam power tetrode of the neater-cathode type. It is designed for use as an audio-frequency amplifier or as a radio-frequency oscillator.

CHARACTERISTICS

Heater Voltage		6.3 volts
Plate Current	$E_b = Ec_2 = 250$ volts;	93 milliamperes
Transconductance	$E_{c1} = -14$ volts	8300 micromhos
Power Output		10.5 watts

ELECTRON TUBE DATA SHEET
FILE: GENERAL PURPOSE SECTION
3-49

350B
TETRODE

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Heater Voltage, A-C or D-C	6.3 volts
Heater Current	1.6 amperes
Direct Interelectrode Capacitances (without external shield)	
Grid to Plate (maximum)	0.5 uuf
Input	16 uuf
Output	8 uuf

MECHANICAL DATA

Cathode	Coated Unipotential
Bulb	ST16
Base	Medium shell, 7-pin octal
Mounting Position	Any

MAXIMUM RATINGS, Design-Center Values

Plate Voltage	360 volts
Screen Grid Voltage	270 volts
Maximum Signal Plate Current	125 milliamperes
Plate Dissipation	27 watts
Screen Grid Dissipation	4 watts
Maximum Grid Circuit Resistance for	
Fixed Bias	0.1 megohm
Cathode Bias	0.5 megohm

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

SINGLE TUBE AMPLIFIER-CLASS A_1

Plate Voltage	250	350	250 volts
Screen Grid Voltage	250	250	250 volts
Control Grid Voltage	−14	−18	··· volts
Cathode Resistor	···	···	130 ohms
Peak A-F Grid Voltage	14	18	14 volts
Zero Signal Plate Current	93	62	93 milliamperes
Maximum Signal Plate Current	97	81	89 milliamperes
Zero Signal Screen Grid Current	6.0	2.5	5.0 milliamperes
Maximum Signal Screen Grid Current	15	16	16 milliamperes
Transconductance	8300	7100	8500 micromhos
Plate Resistance	37500	57500	34500 ohms
Load Resistance	2000	3200	2500 ohms
Maximum Signal Power Output	10.5	15.8	9.6 watts
Total Harmonic Distortion	11	18	11 per cent

SINGLE TUBE AMPLIFIER (TRIODE CONNECTIONS*)—CLASS A_1

Plate Voltage	250	250 volts
Control Grid Voltage	−20	··· volts
Cathode Resistor	···	350 ohms
Peak A-F Grid Voltage	20	20 volts
Zero Signal Plate Current	50	50 milliamperes
Maximum Signal Plate Current	56.0	52.2 milliamperes
Transconductance	6400	6800 micromhos
Amplification Factor	8	8
Plate Resistance	1250	1180 ohms
Load Resistance	5000	6000 ohms
Maximum Signal Power Output	1.7	1.5 watts
Total Harmonic Distortion	5	3.6 per cent

PUSH-PULL AMPLIFIER—CLASS A_1

Unless otherwise specified, values are for 2 tubes

Plate Voltage	250	270	270 volts
Screen Grid Voltage	250	270	270 volts
Control Grid Voltage	−15	−17.5	··· volts
Cathode Resistor	···	···	75 ohms
Peak A-F Grid-to-Grid Voltage	30	35	32 volts
Zero Signal Plate Current	165	163	184 milliamperes
Maximum Signal Plate Current	203	212	196 milliamperes
Zero Signal Screen Grid Current	13	12	16 milliamperes
Maximum Signal Screen Grid Current	24	28	24 milliamperes
Transconductance	8200	8050	9500 micromhos
Plate Resistance	37500	50000	35500 ohms
Effective Load Resistance (Plate-to-Plate)	2000	2000	3000 ohms
Maximum Signal Power Output	15.5	20.0	18.6 watts
Total Harmonic Distortion	2.5	3.5	6.3 per cent

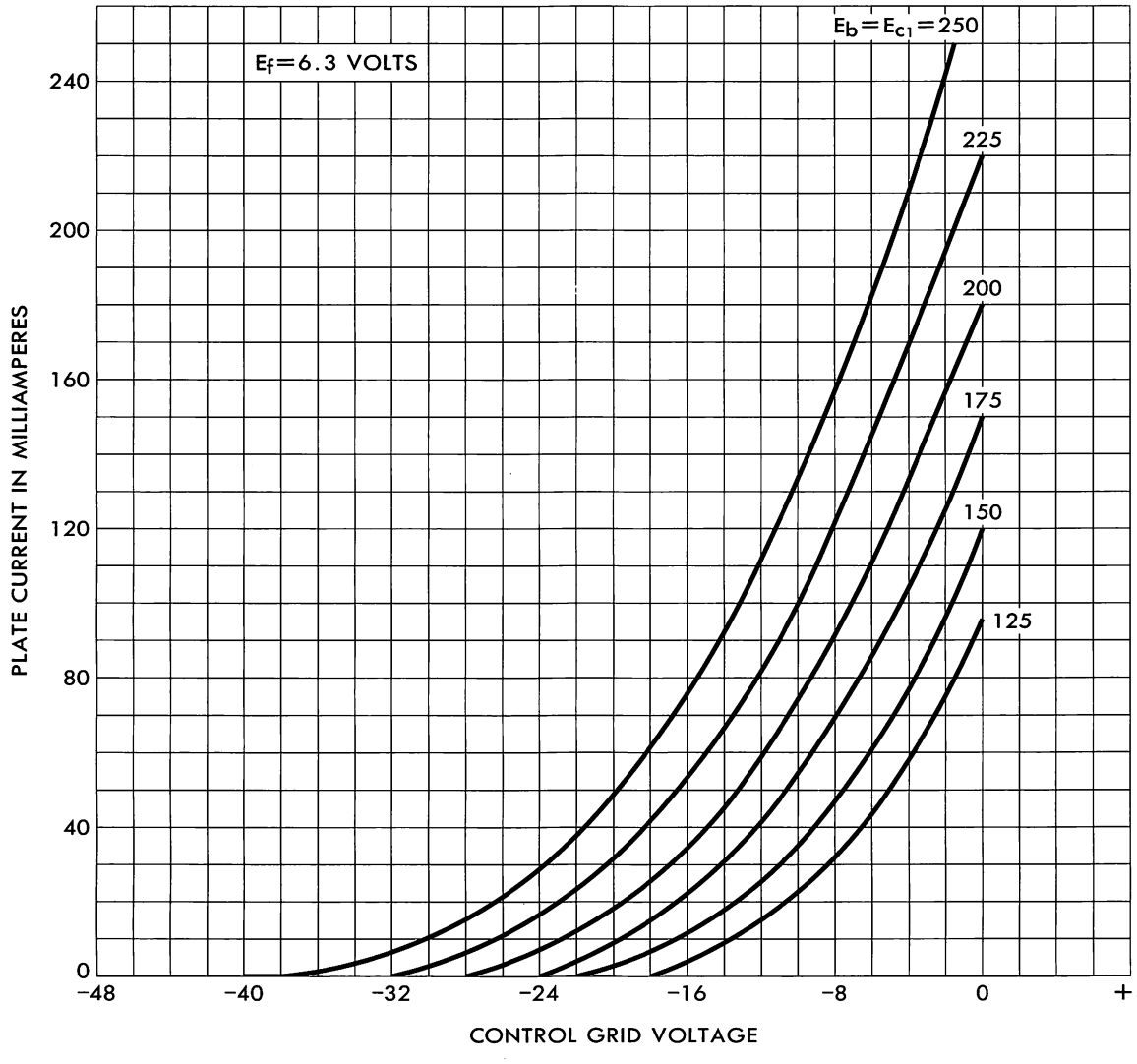
PUSH-PULL AMPLIFIER—CLASS AB_1

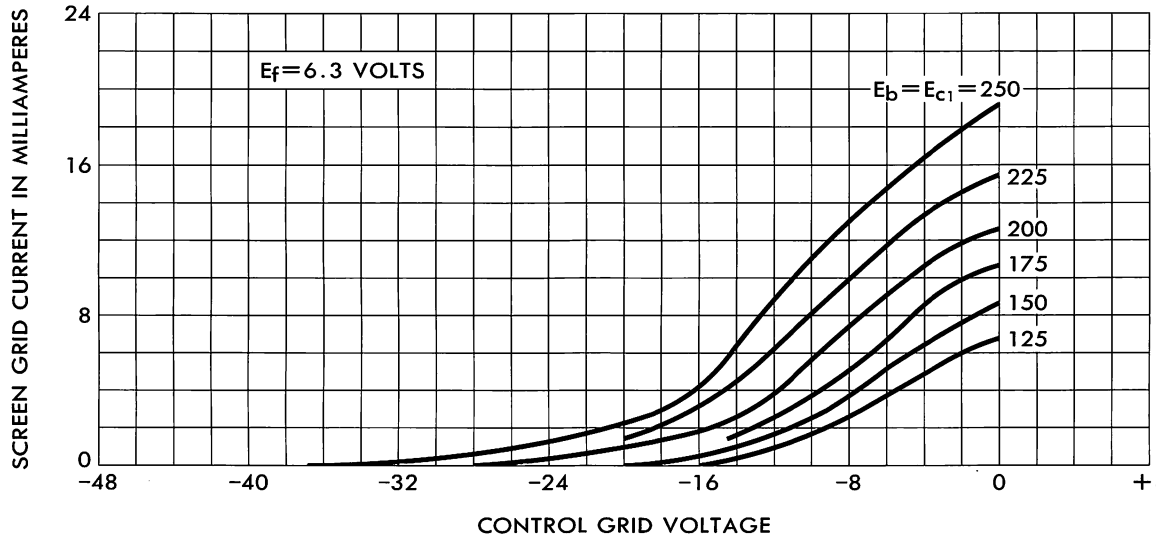
Unless otherwise specified, values are for 2 tubes

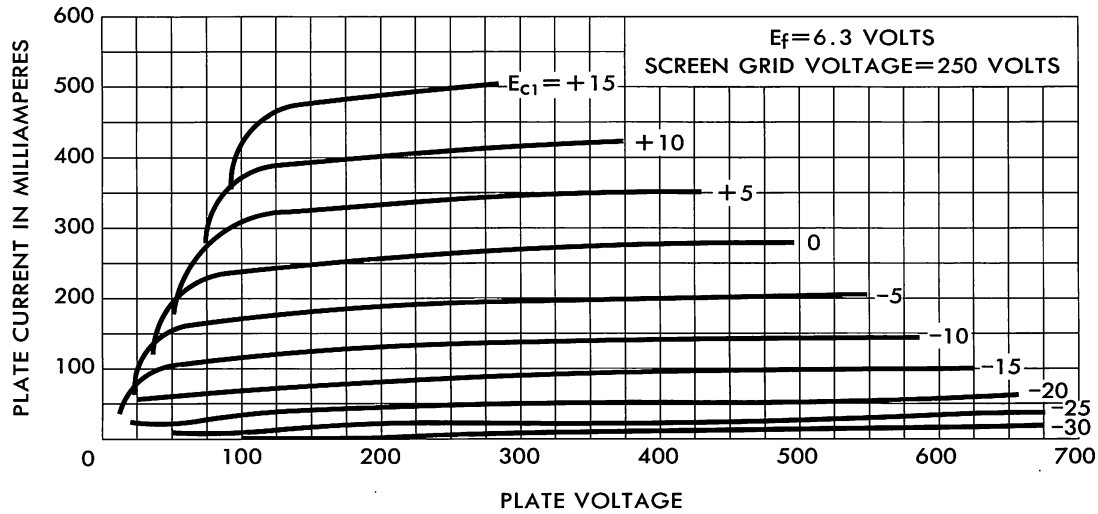
Plate Voltage	360	360 volts
Screen Grid Voltage	270	270 volts
Control Grid Voltage	−25	··· volts
Cathode Resistor	···	130 ohms
Peak A-F Grid-to-Grid Voltage	50	45 volts
Zero Signal Plate Current	68	132 milliamperes
Maximum Signal Plate Current	162	155 milliamperes
Zero Signal Screen Grid Current	2.5	5.5 milliamperes
Maximum Signal Screen Grid Current	24.5	18 milliamperes
Effective Load Resistance (Plate-to-Plate)	3000	5000 ohms
Maximum Signal Power Output	22	25 watts
Total Harmonic Distortion	5	14 per cent

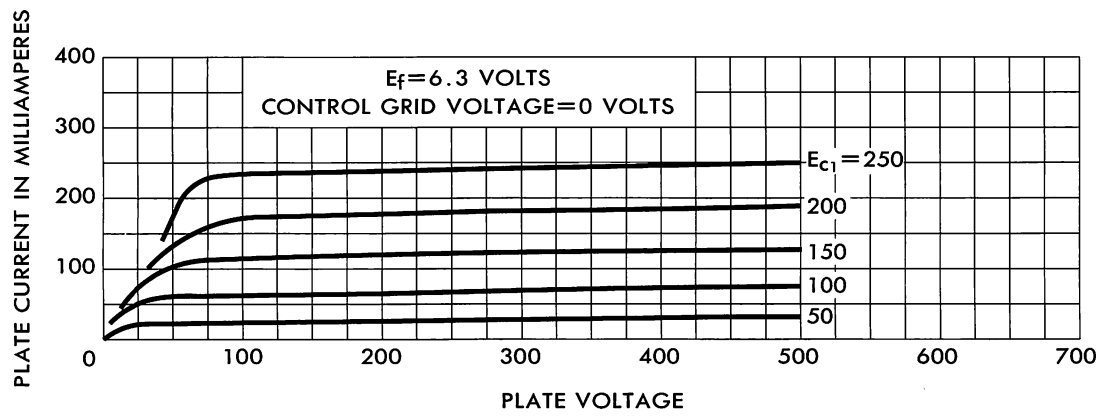
*Screen Grid connected to plate.

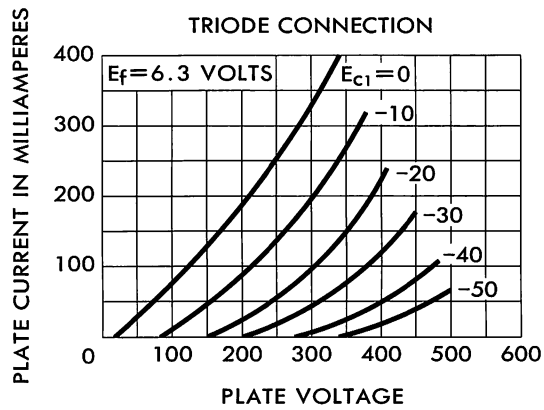
350B – PAGE 4


$E_b = E_{c1} = 250$
$E_f = 6.3$ VOLTS
225
200
175
150
125
240
200
160
120
80
40
0
PLATE CURRENT IN MILLIAMPERES
−48
−40
−32
−24
−16
−8
0
+8
CONTROL GRID VOLTAGE

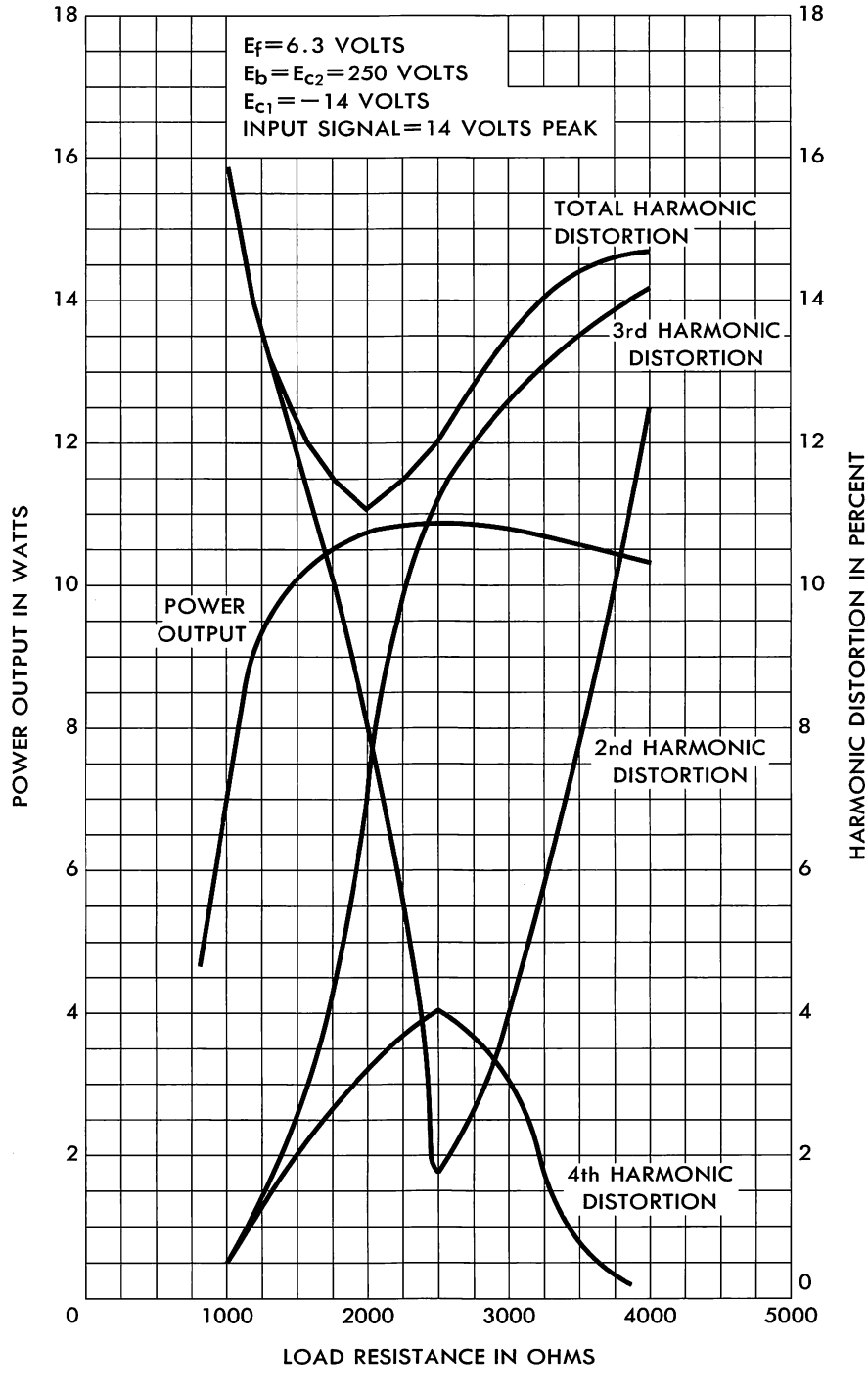

$E_f = 6.3$ VOLTS
$E_b = E_{c1} = 250$
225
200
175
150
125
24
16
8
0
SCREEN GRID CURRENT IN MILLIAMPERES
−48
−40
−32
−24
−16
−8
0
+8
CONTROL GRID VOLTAGE

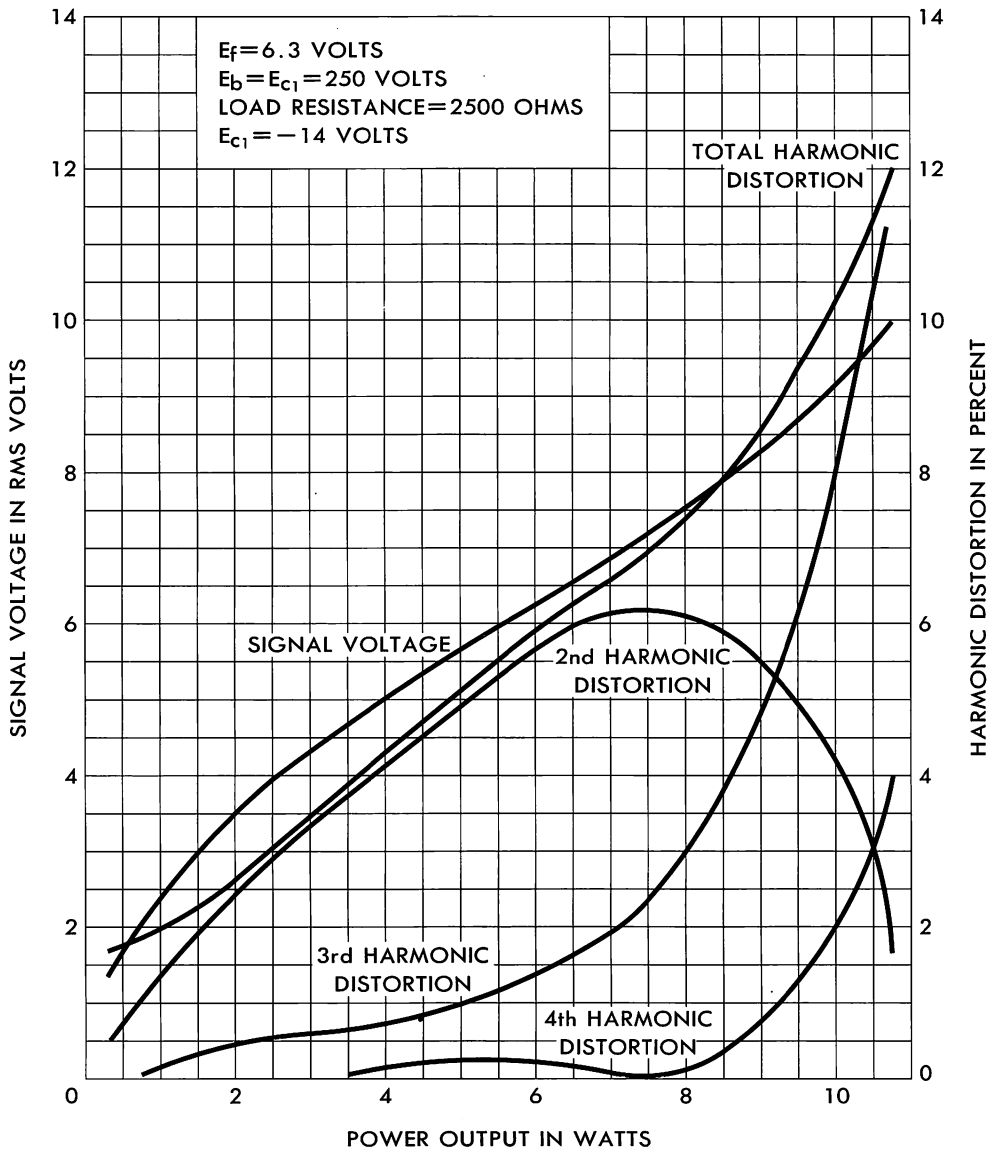




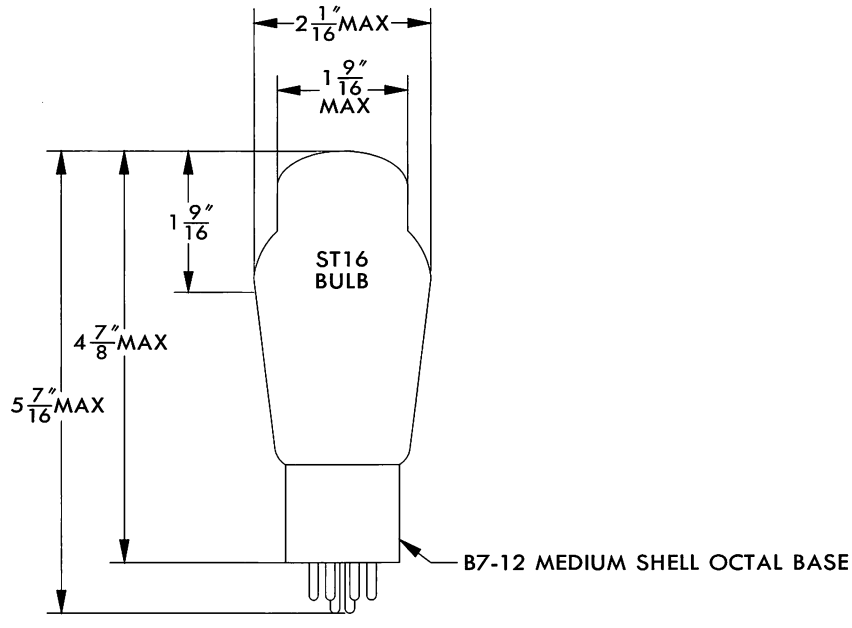


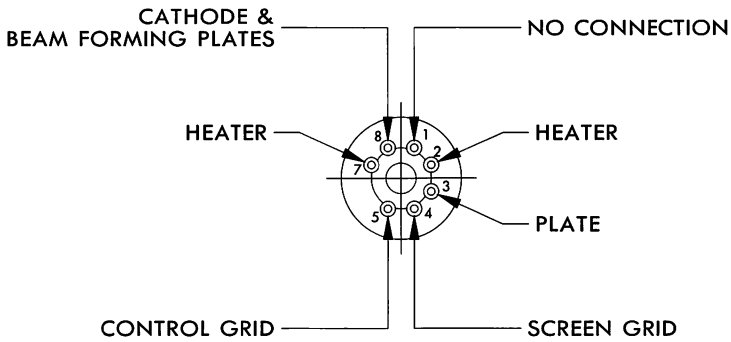
ELECTRON TUBE DATA SHEET
FILE: GENERAL PURPOSE SECTION
3-49


Ef=6.3 VOLTS
Eb=Ec2=250 VOLTS
Ec1=−14 VOLTS
INPUT SIGNAL=14 VOLTS PEAK
TOTAL HARMONIC DISTORTION
3rd HARMONIC DISTORTION
2nd HARMONIC DISTORTION
4th HARMONIC DISTORTION
POWER OUTPUT
POWER OUTPUT IN WATTS
HARMONIC DISTORTION IN PERCENT
LOAD RESISTANCE IN OHMS
0
2
4
6
8
10
12
14
16
18
1000
2000
3000
4000
5000



ELECTRON TUBE DATA SHEET
FILE: GENERAL PURPOSE SECTION
3-49





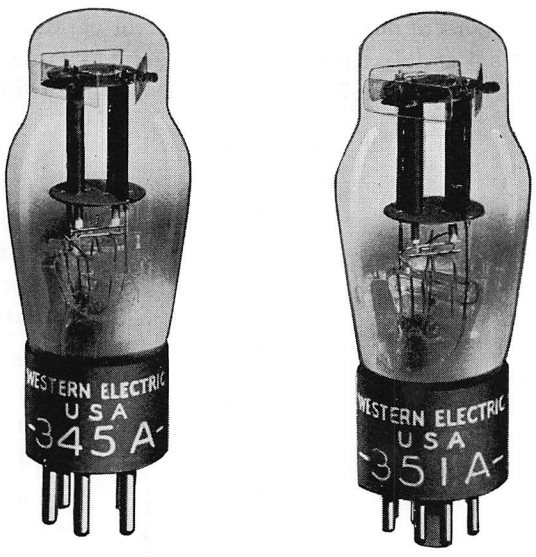
Western Electric

A development of Bell Telephone Laboratories, the research laboratores of the American Telephone and Telegraph Company and the Western Electric Company

T-3648

Western Electric

345A and 351A Vacuum Tubes



Classification—Full-wave, thermionic high vacuum rectifiers

These tubes are designed to supply direct current up to 100 milliamperes from an alternating current source. The tubes are used as full-wave rectifiers to supply direct current from A.C. power lines or to rectify radio-frequency currents for feedback purposes in broadcast transmitters.

Each tube consists of two diode units with the two heaters connected in parallel and the two cathodes connected together inside the tube. The 345A and 351A tubes are identical except for the bases.

Dimensions and Connections—The outline diagrams of the tube and base giving dimensions and the arrangement of electrode connections to the base terminals for the 345A tube are shown in Figures 1 and 2. Similar information for the 351A is shown in Figures 3 and 4.

Mounting—The 345A vacuum tube employs a small five pin thrust type base suitable for use in a Western Electric 141A or similar socket.

The 351A vacuum tube employs a small shell six pin octal base.

The tubes may be mounted in any position.

Heater Rating

Heater voltage	6.3 volts
Nominal heater current	1.0 ampere

The heater is designed to operate on a voltage basis and should be operated at as near the rated voltage as practicable.

Cathode Connection—Preferably direct to the heater. In applications where it is necessary to apply a voltage between cathode and heater it should not exceed 500 volts.

Characteristics—Figure 5 shows the plate current-plate voltage characteristic of a single diode unit of a typical tube.

The rectified voltage and current output characteristics for various values of applied alternating voltages are shown in Figures 6 and 7. In Figure 6 the characteristics are for a choke-input filter as shown in circuit A and those of Figure 7 are for a condenser-input filter as shown in circuit B.

Operating Conditions

	R-M-S Alternating Voltage Per Plate	Total Rectified Current
	Volts	Milliamperes
Choke-Input Filter	300	100
	350	100
	*400	100
Condenser-Input Filter	300	100
	*350	**100

*Maximum operating conditions
**4MF maximum filter input capacitance

A less severe condition should be selected in preference to a maximum operating condition wherever possible. The life of a tube at maximum conditions may be shorter than at less severe conditions.

Effect of Filter

It is evident from the regulation characteristics of Figures 6 and 7 that for a given output current and voltage, the choke-input filter requires a somewhat higher alternating voltage applied to the plates of the tube than the condenser-input filter. With the condenser input filter, however, the cathode has to supply relatively large peaks of current during the charging period of the condenser. The peak current increases in value as the capacitance of the condenser is increased and may be much greater than the average rectified current, though its duration in such cases is only a short fraction of a cycle. Since the peak current in a choke-input filter is only slightly greater than the rectified currrent and this type filter gives better regulation than the condenser input circuit it is advisable to use it in preference to the condenser-input filter wherever possible. With a condenser input filter the capacitance of the input condenser should preferably not exceed 4 microfarads.

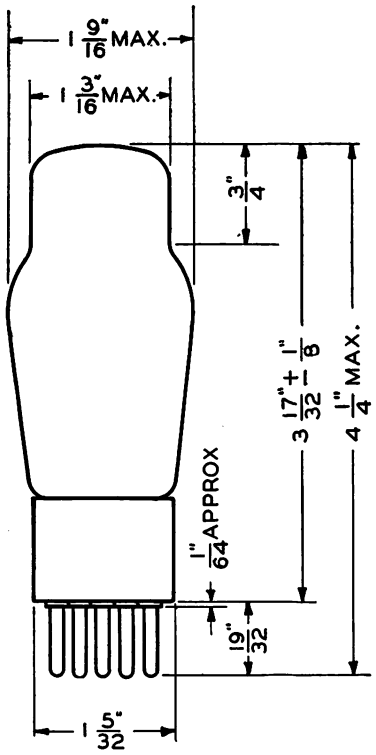


FIG. 1

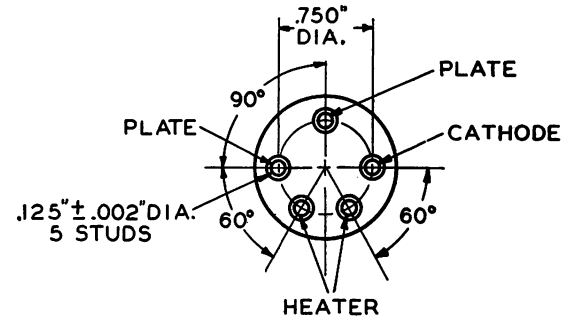


FIG. 2

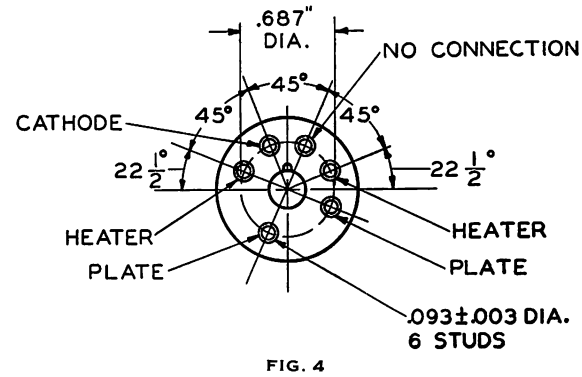


FIG. 4

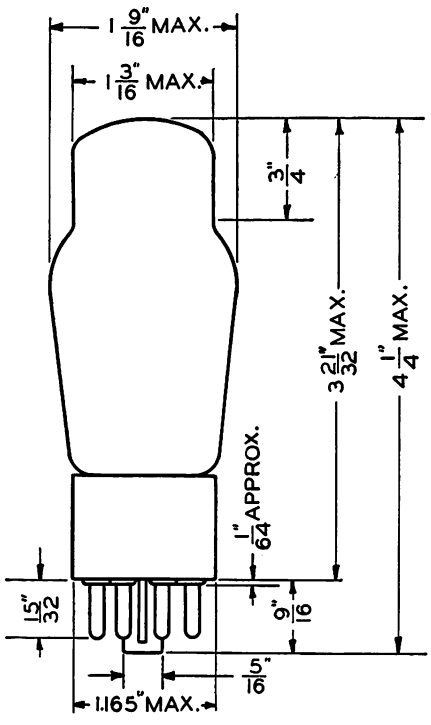


FIG. 3

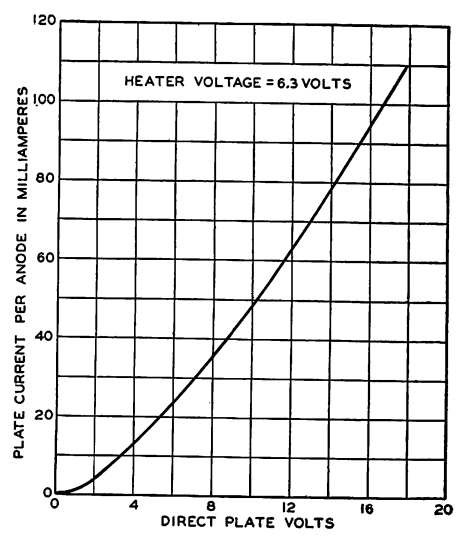


FIG. 5

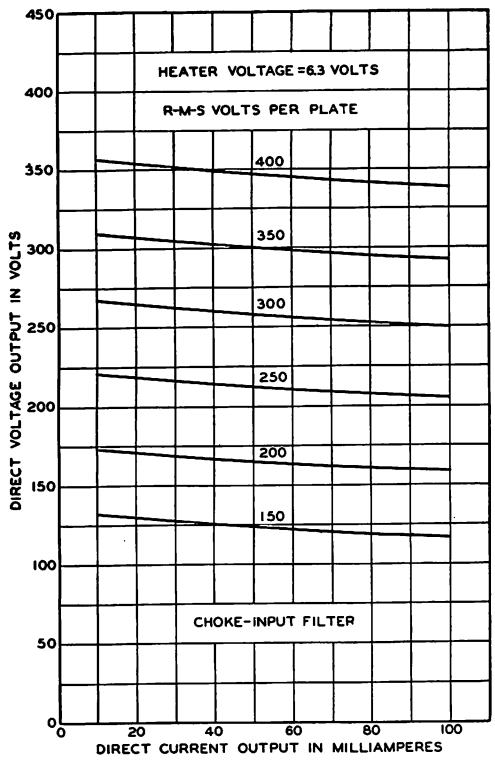


FIG. 6

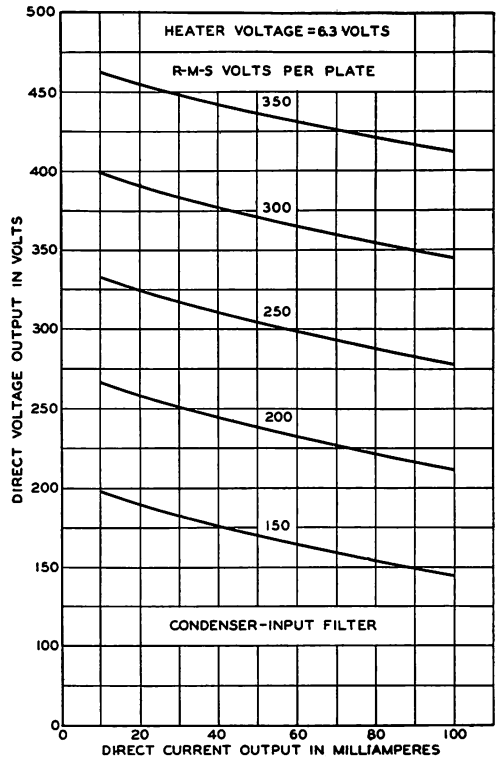
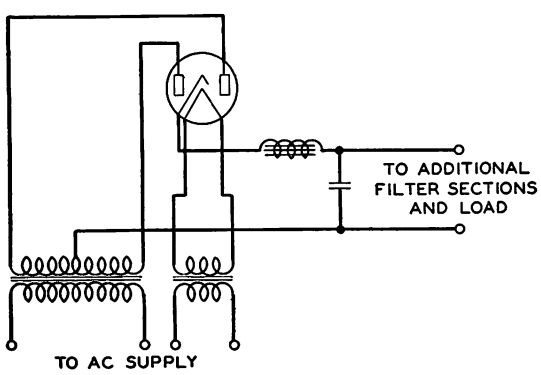
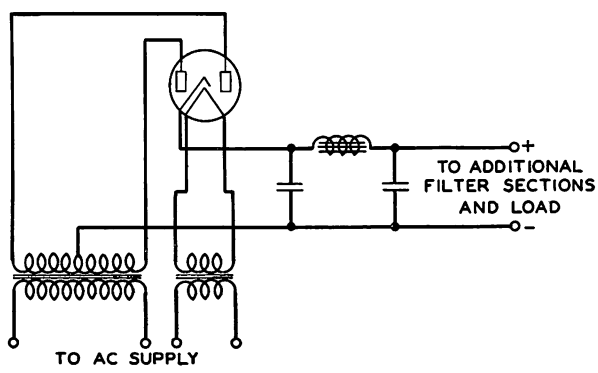


FIG. 7



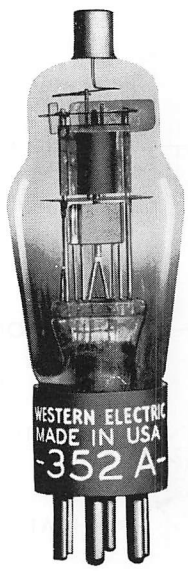
CHOKE INPUT FILTER
CIRCUIT A



CONDENSER INPUT FILTER
CIRCUIT B

Western Electric

352A Vacuum Tube



Classification—Duodiode triode with an indirectly heated cathode

The 352A tube comprises three distinct vacuum tube units which are independent of each other except that sections of a single cathode structure supply electron emission for all three. Two of these units are diodes. The other is a triode.

Applications—Diode detector, diode rectifier for automatic volume control voltage, and triode audio-frequency amplifier. If desired the two diodes may be used for full-wave rectification or they may be connected in parallel to provide a lower impedance half-wave rectifier. The former connection requires about twice as high an input voltage as the latter to give equal detector output.

Dimensions and Connections—Outline diagrams of the tube and base giving the dimensions and the arrangement of the electrode connections to the base terminals are shown in Figures 1 and 2.

Base and Mounting—This tube employs a small six-pin thrust type base suitable for use in a Western Electric 144B or similar socket. The base pins are silver plated. The triode grid terminal is a small metal cap located at the top of the bulb.

This tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Triode grid to plate	1.5	μμf
Triode grid to cathode and heater	1.6	μμf
Triode plate to cathode and heater	3.8	μμf
Both diodes to triode grid	0.015	μμf
Both diodes to triode plate	1.4	μμf
Both diodes to cathode and heater	6.5	μμf

Heater Rating

Heater voltage	10.0 volts, a.c. or d.c.
Nominal heater current	0.32 ampere

The heater of this tube is designed to operate on a voltage basis and should be operated at as near the rated voltage as practicable.

Cathode Connection—Where alternating heater voltage is used the cathode should preferably be connected directly to the mid-point of the heater transformer winding or to the mid-point of a low resistance connected across the heater terminals. For direct current operation the cathode may be connected to either end of the heater. If voltage is applied between the heater and cathode, it should be kept low and must not exceed 50 volts.

Triode Characteristics—Typical curves showing triode plate current as a function of grid voltage for several values of plate voltage are shown in Figure 3. Corresponding amplification factor, plate resistance and transconductance characteristics are given in Figures 4, 5 and 6 respectively. Figure 7 shows plate current as a function of plate voltage for several values of grid voltage.

Triode Operating Conditions and Output

Permissible operating plate and grid voltages are included within the area, ABCD, in Figure 3. Amplification factor, plate resistance, transconductance and performance data for a number of typical operating conditions are given in the table. Recommended conditions or others of no greater severity should be selected in preference to maximum conditions wherever possible. The life of the tube at maximum operating conditions will be shorter than at less severe conditions.

In the last four columns of the table are given the fundamental power output, P_m, in milliwatts, the fundamental voltage output, E_{pm}, in peak volts and the second and third harmonic levels, F_{2m} and F_{3m}, in db below the fundamental, for the indicated values of load resistance. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias in each case. Where the level of the third harmonic is lower than 45 db below the fundamental, its value may be widely different from tube to tube. The values given represent a typical tube.

For a smaller input voltage, E_g, the fundamental power and voltage outputs and the harmonic levels are given approximately by the following relations:

$$P = P_m\left(\frac{E_g}{E_{gm}}\right)^2$$

$$E_p = E_{pm}\frac{E_g}{E_{gm}}$$

$$F_2 = F_{2m} + 20\log_{10}\frac{E_{gm}}{E_g}$$

$$F_3 = F_{3m} + 40\log_{10}\frac{E_{gm}}{E_g}$$

TABLE

Plate Voltage	Grid Voltage	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Load Resistance	Power Output	Voltage Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms	Micromhos	Ohms	Milliwatts	Peak Volts	db	db
135	−4.5	3.2	14.0	17,500	800	20,000	31	35	25	50
						35,000	27	43	28	45
						50,000	23	48	29	45
135	−6.0	2.1	13.3	20,500	650	20,000	42	41	20	55
						35,000	40	53	24	55
						50,000	34	58	26	50
135	−7.5	1.3	12.7	26,000	490	20,000	46	43	16	38
						35,000	45	56	19	45
						50,000	42	65	21	55
180	−7.5	3.4	13.5	18,000	750	20,000	79	56	22	55
						35,000	68	69	25	50
						50,000	59	77	28	45
180	−9.0	2.4	13.0	20,500	630	20,000	90	60	18	45
						35,000	85	77	22	55
						50,000	76	87	24	55
180	−10.5	1.5	12.7	26,000	490	20,000	90	60	15	36
						35,000	87	78	17	38
						50,000	78	88	20	45
*200	−9.0	3.3	13.2	18,000	730	20,000	109	66	20	55
						35,000	96	82	24	55
						50,000	81	90	26	50
*200	−10.5	2.3	12.9	22,000	590	20,000	112	67	17	40
						35,000	106	86	21	50
						50,000	90	95	24	60

*Maximum operating conditions.

Triode Microphonic Noise—With a plate voltage of 135 volts, a grid bias of −6 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the triode section of the tube, measured in a laboratory reference test set, is 45 db below 1 volt. The range of levels of individual tubes extends from 20 to 60 db below 1 volt. Since microphonic noise depends on the type and intensity of the mechanical disturbance which produces it, the values given here are useful chiefly for comparison with the levels of other tubes which have been tested in the same way.

Diode Characteristics—The current-voltage characteristic of a single diode is shown in Figure 8. Rectification characteristics for a single diode are shown in Figure 9 for a number of values of impressed alternating input voltage. Each of these characteristic curves gives the relation between the direct voltage impressed on the diode plate and the average diode current as indicated by a direct-current microammeter for a constant impressed alternating input voltage of the value specified. Where the diode is used as a detector with the usual condenser-resistance circuit, the direct component of the voltage developed across the resistance by any alternating-voltage input is given by the intercept of the load line with the rectification characteristic corresponding to the input voltage. Load lines for zero fixed bias are shown in Figure 9 for load resistance values of 0.25, 0.5 and 1.0 megohm.

The potential of each diode plate with respect to the cathode on the positive swing of the input voltage should be limited to a maximum value of +10 volts.

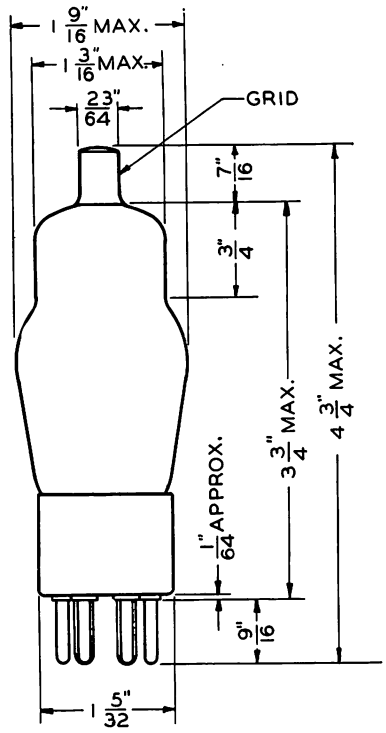


FIG. 1

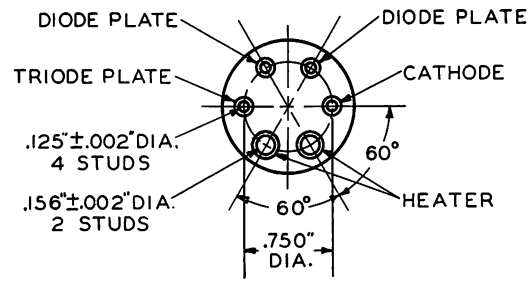


FIG. 2

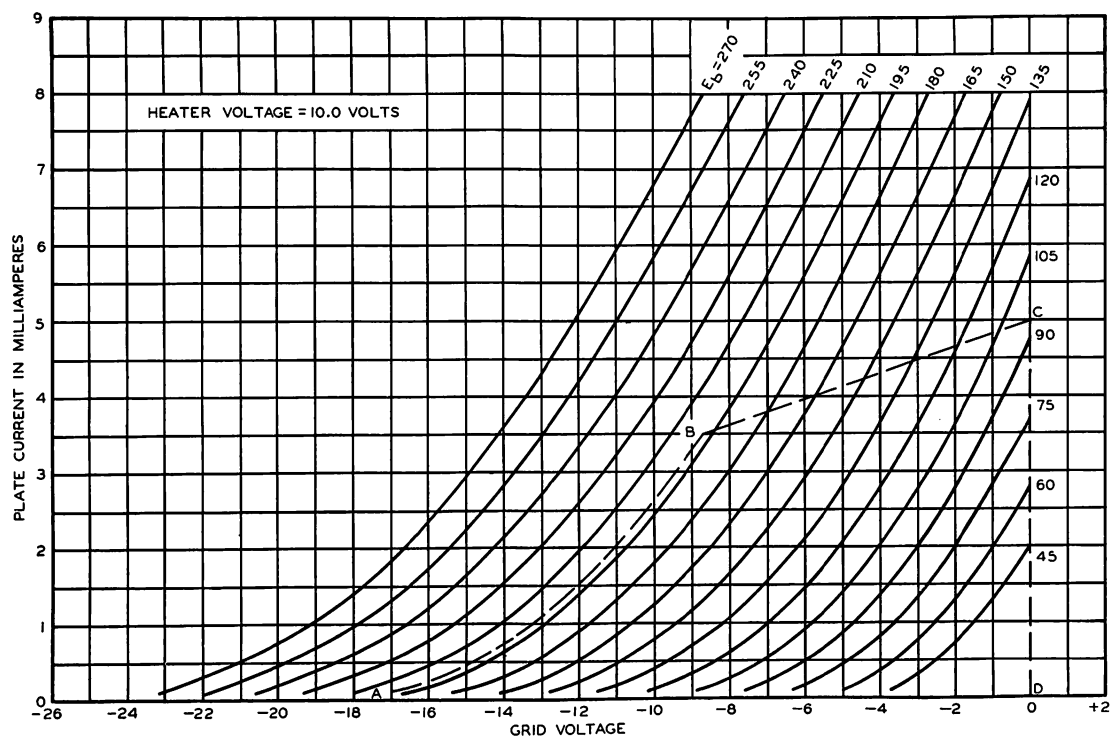


FIG. 3

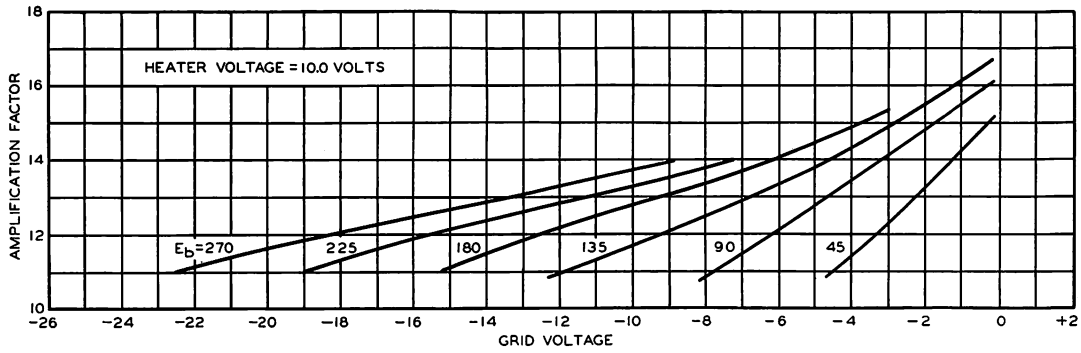


FIG. 4

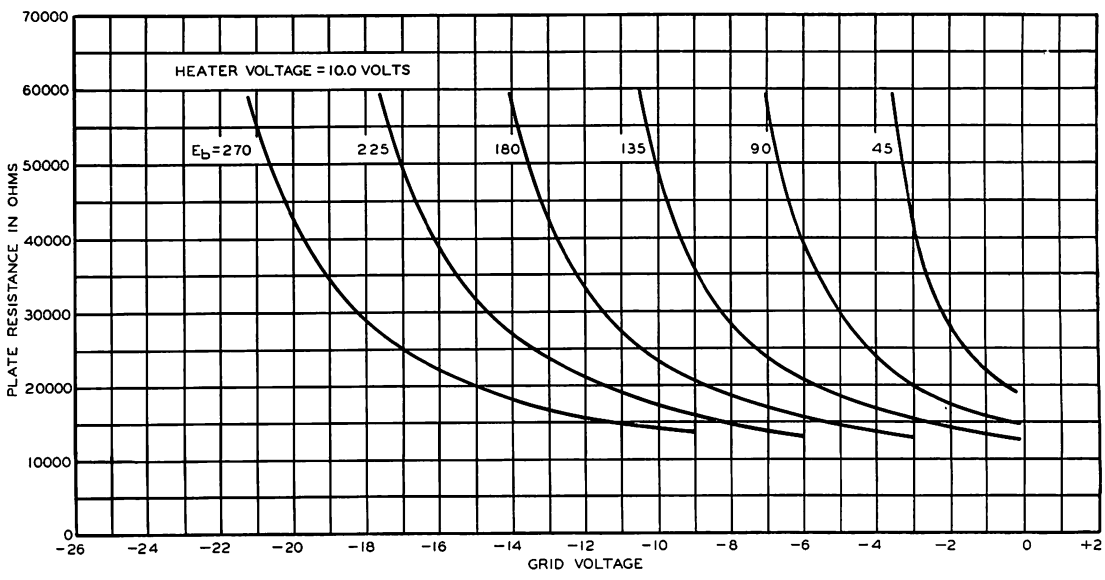


FIG. 5

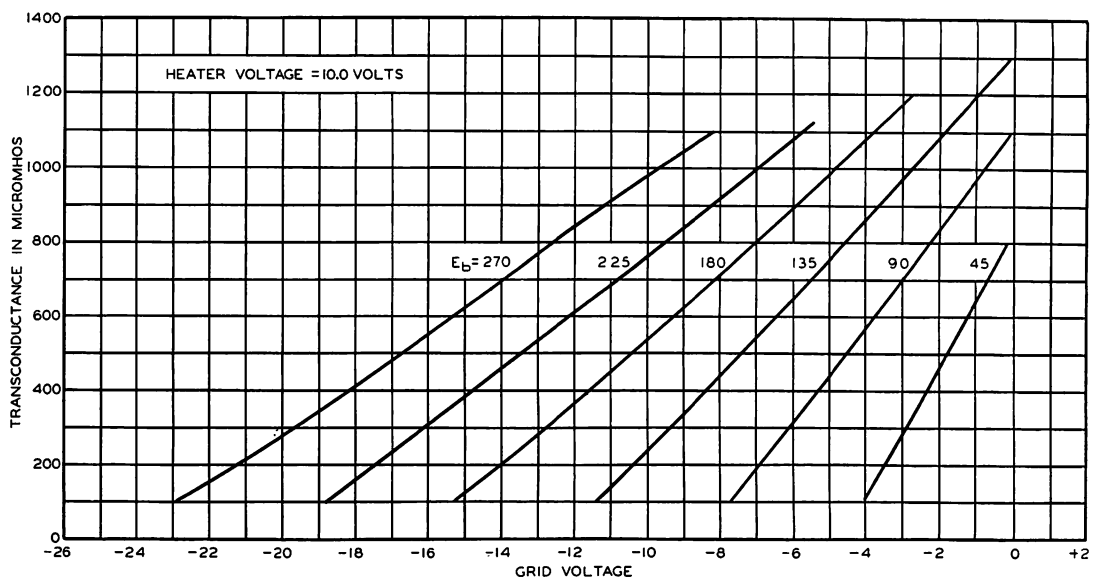


FIG. 6

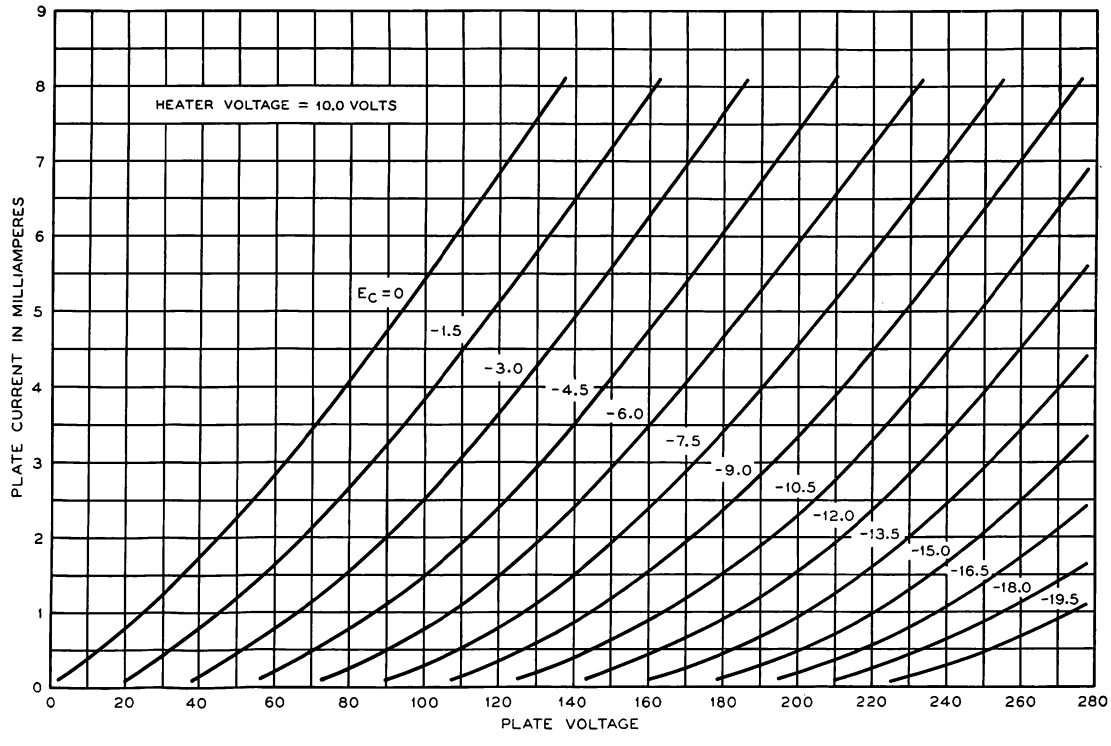

HEATER VOLTAGE = 10.0 VOLTS
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
$E_C = 0$
-1.5
-3.0
-4.5
-6.0
-7.5
-9.0
-10.5
-12.0
-13.5
-15.0
-16.5
-18.0
-19.5
0
1
2
3
4
5
6
7
8
9
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280

FIG. 7

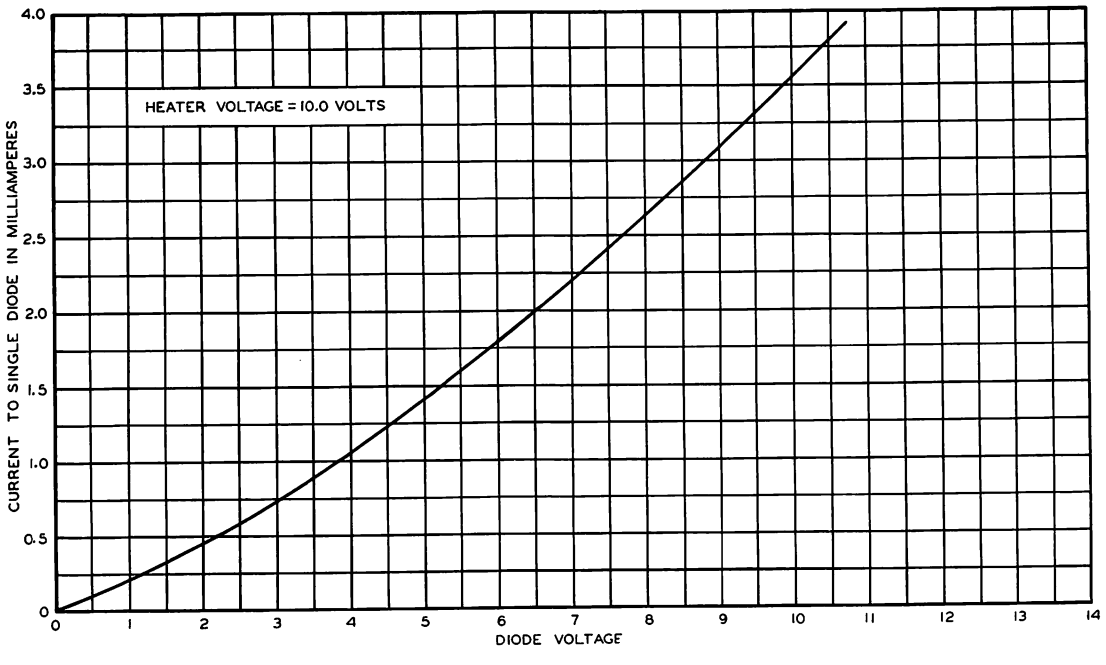

HEATER VOLTAGE = 10.0 VOLTS
CURRENT TO SINGLE DIODE IN MILLIAMPERES
DIODE VOLTAGE
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

FIG. 8

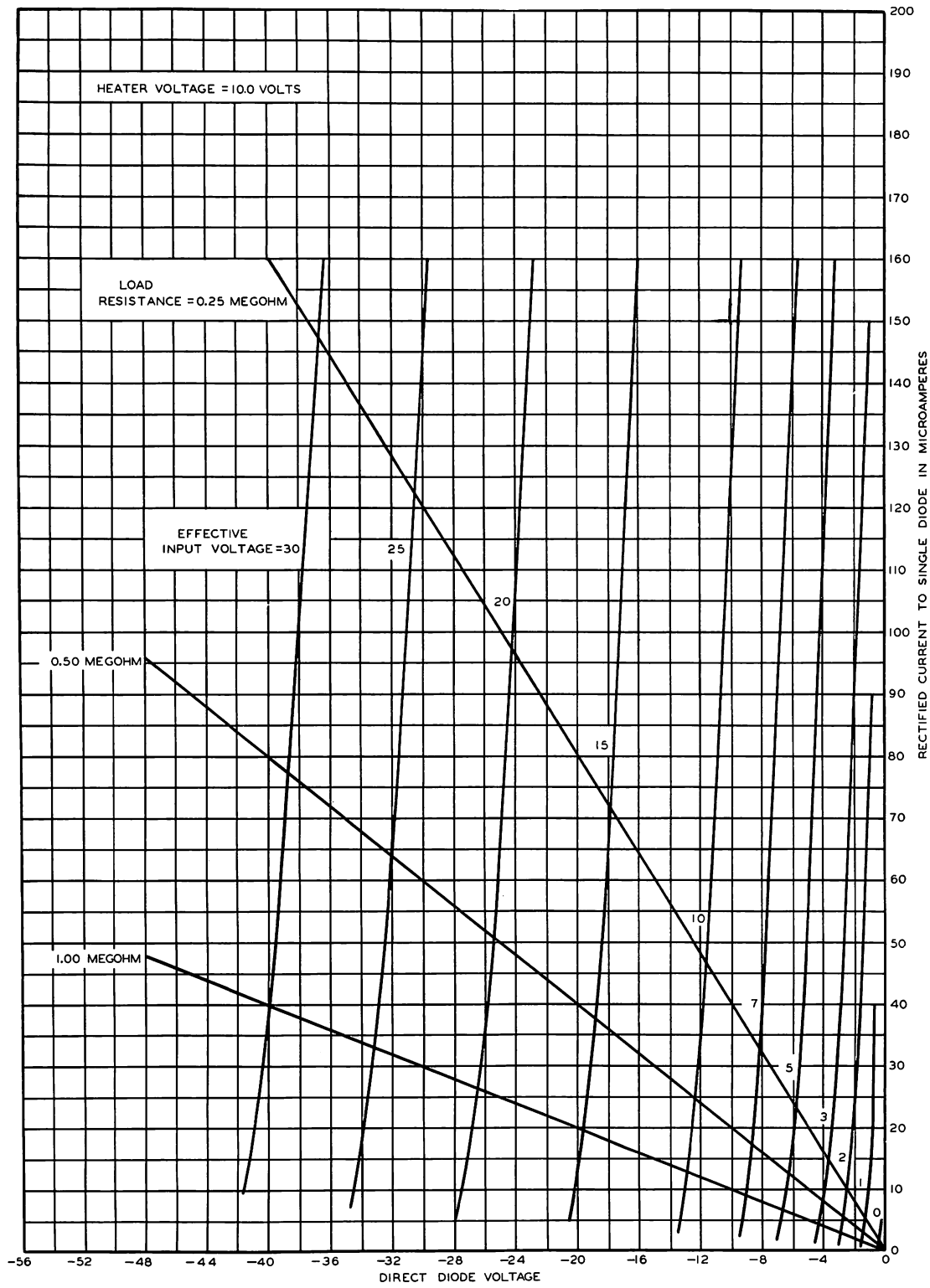


FIG. 9

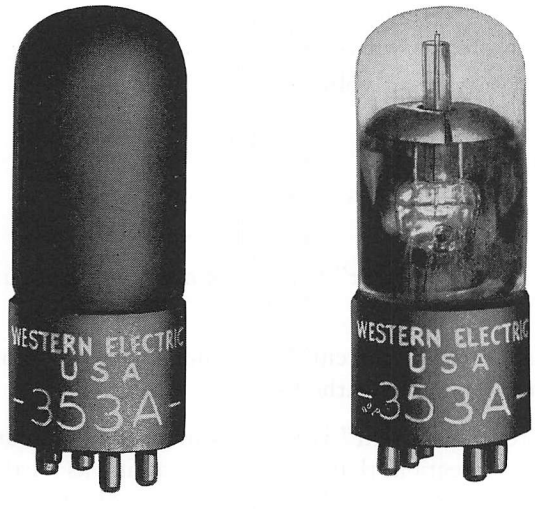
1-J-39-61C

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V. T. DATA SHEET 352A
ISSUE 1

Western Electric

353A Vacuum Tube



Classification—Three element cold cathode, gas-filled tube

This tube may be used as a relay, rectifier or as a voltage regulator in special circuits.

This tube is similar to the 313C except for the base.

The elements of the tube consist of a cathode, an anode and a control anode. In this tube the cathode and control anode are similar and may be used interchangeably. The conduction path between the cathode and the control anode is known as the control gap. The conduction path between the cathode and the anode is known as the main gap. A 120,000 ohm resistor, mounted inside the base, may be included in the control anode lead.

The glass bulb has been given an opaque coating so that the discharge is not visible while the tube is operating. In the photograph at the right the coating has been removed to show the tube elements.

Dimensions—The dimensions and outline diagrams are given in Figures 1 and 2.

Mounting—This vacuum tube employs a special base, having a tapped insert, suitable for mounting with an 8-32 machine screw. The base also has a $\frac{1}{8}$″ diameter moulded pin $\frac{1}{8}$″ high, which locates it on the mounting bracket and prevents the tube from rotating. A screw is furnished with the tube which allows for mounting on a bracket $\frac{1}{32}$″ to $\frac{1}{16}$″ thick. Connections to the electrodes are made by soldering to the ends of the base studs. The arrangement of electrode connections to the base terminals is shown in Figure 2.

The tube may be mounted in either a vertical or horizontal position.

Ratings

Maximum peak forward current	30 milliamperes
Maximum average forward current (averaged over 1 second)	10 milliamperes
Maximum peak reverse current	5 milliamperes

Characteristics

Nominal control-gap breakdown voltage	70 volts
Nominal control-gap sustaining voltage	60 volts
Minimum main-gap breakdown voltage	150 volts
Nominal main-gap sustaining voltage	75 volts
Transfer current	5 microamperes(Max.)
Nominal deionization time	
Main gap	10 milliseconds
Control gap	3 milliseconds

The "maximum peak forward current" is the maximum value of current which may be drawn from the cathode.

The "maximum average forward current" is the maximum value of current (averaged over 1 second) which may be drawn from the cathode.

The "maximum peak reverse current" is the maximum value of current which may be drawn from the anode in the reverse direction, that is, when it is acting as a cathode. The reverse current rating is intended for use in designing rectifier circuits and is the maximum inverse current which it is permissible to draw from the tube in such circuits.

The "control-gap breakdown voltage" is the potential required to initiate ionization, thereby starting conduction in the control gap. Once ionization has occurred the potential across the gap will be reduced to the "control-gap sustaining voltage" and will be approximately independent of the current.

The "main-gap breakdown voltage" is the potential required to start conduction in the main gap when no ionization is occurring in the control gap. After breakdown, conduction will take place at the "main-gap sustaining voltage" and will be practically independent of current.

The "main-gap sustaining voltage" is substantially independent of current when the current passes through the tube in the forward direction. When the current passes through the main gap in the reverse direction the sustaining voltage increases rapidly with increasing current. It is this asymmetry in the properties of the main gap of this tube which enables it to be used as a rectifier. The current-voltage characteristic of the main gap of a typical 353A tube in both forward and reverse directions is shown in Figure 3. This curve was obtained with a cathode ray oscillograph.

When the anode potential is maintained at a value intermediate between the "main-gap breakdown and sustaining voltages" the passage of a small amount of current in the control gap will produce ionization sufficient to initiate conduction in the main gap. It is this property of the tube which enables it to be used as a relay. The amount of current in the control gap required to initiate conduction in the main gap is known as the "transfer current." This quantity varies considerably from tube to tube and during the life of a given tube but will in general be less than 5 microamperes and usually only a few tenths of a microampere.

The "deionization time" is the time during which the voltage must be removed from the tube in order that the discharge shall not be reestablished when the voltage is restored. This time increases with increasing applied voltage and with increasing current through the tube before the deionization period. This rate of increase of deionization time is such that the tube will not deionize

with a 60 cycle sine wave main-gap voltage if the load is inductive or if the peak voltage is near the "main-gap breakdown voltage" or the current near the maximum rated value.

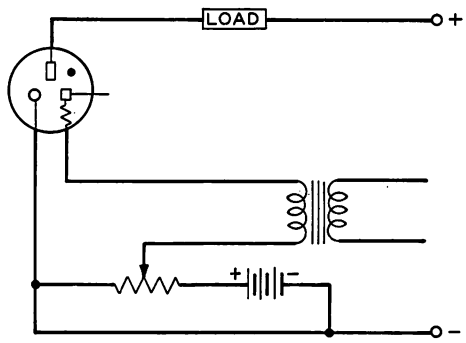
The "transfer time" is the time during which the control gap must be energized in order that the discharge may transfer to the main gap. It depends upon the amount of current flowing in the control gap and on the main-gap voltage. For a control-gap current of 10 microamperes the "transfer time" is approximately 200 microseconds.

Typical Circuits

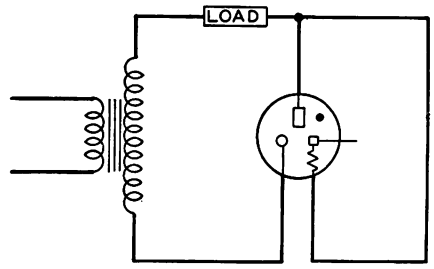
Circuit A shows a circuit using the tube as a relay. The supply voltage should be intermediate between the "main-gap breakdown and sustaining voltages" and the control anode may be biased at any desired potential less than the "control-gap sustaining voltage." This circuit possesses a "lock-in" feature, since the anode potential must be removed momentarily to restore the tube to a nonconducting condition. When supplied from alternating current this circuit does not possess a "lock-in" feature unless the frequency of the supply voltage is so high that the tube is not allowed a sufficient interval to deionize.

Circuit B shows a circuit with the tube used as a rectifier. The rectifying properties of the main gap are used but the control anode should be connected into the circuit as indicated. This will cause conduction in the forward direction to begin at a voltage much below the "main-gap breakdown voltage." It is important to note that as a rectifier this tube possesses a unique property not common to other rectifiers in that its impedance is infinite for voltages below the breakdown. In many applications that is of importance since the tube may be used to pass current at the higher potentials without placing a bridge across the line for signals of lower voltage.

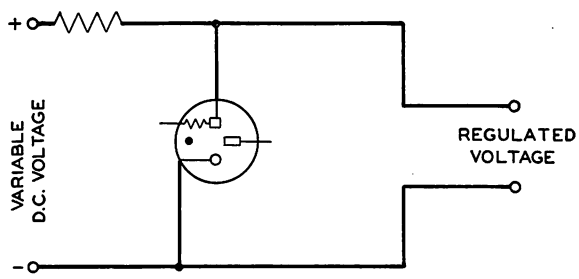
Circuit C shows a circuit using the control gap of the tube as a voltage regulator. In this application the connection is made directly to the control anode instead of through resistance.



CIRCUIT A



CIRCUIT B



CIRCUIT C

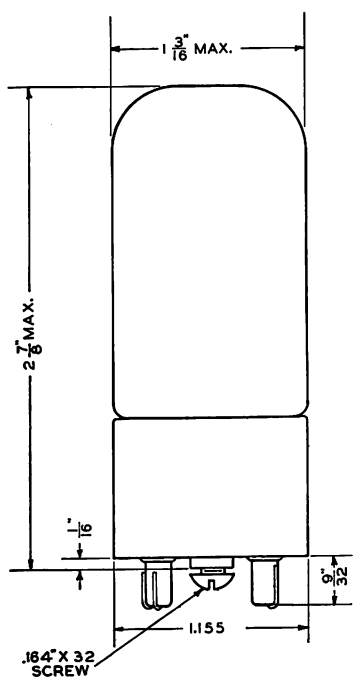


FIG. 1

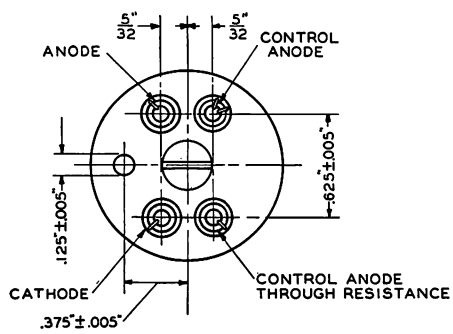


FIG. 2

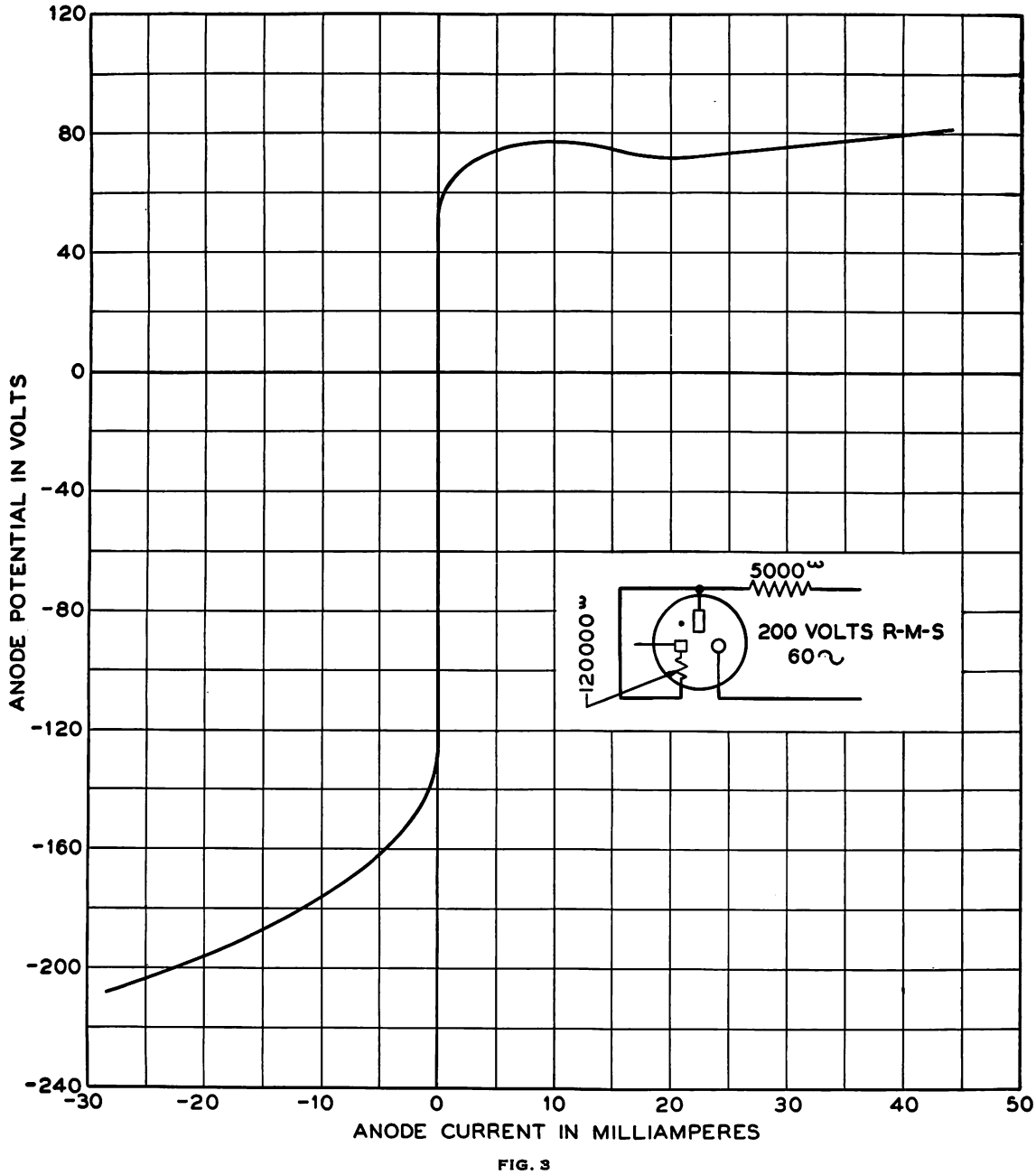

120
80
40
0
-40
-80
-120
-160
-200
-240
ANODE POTENTIAL IN VOLTS
-30
-20
-10
0
10
20
30
40
50
ANODE CURRENT IN MILLIAMPERES
5000Ω
120000Ω
200 VOLTS R-M-S
60~

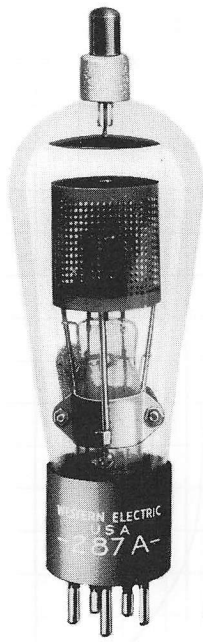
FIG. 3

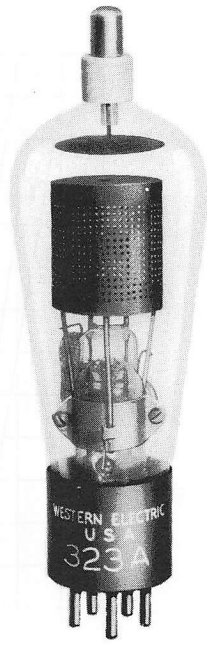
Western Electric

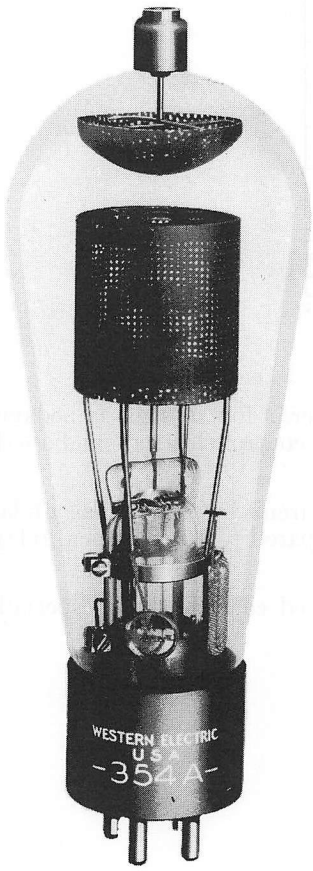
Vacuum Tubes

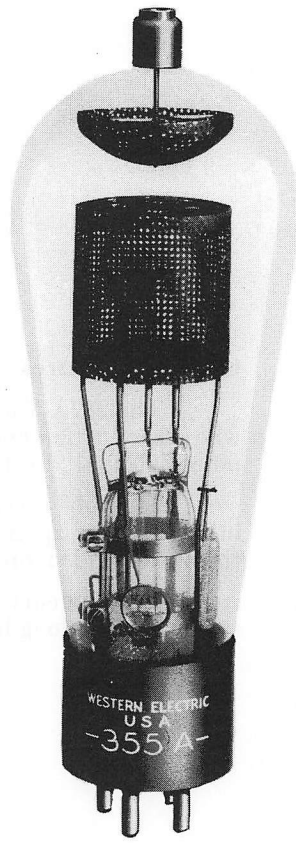
Three Element Power Thyratrons

287A 323A 354A 355A





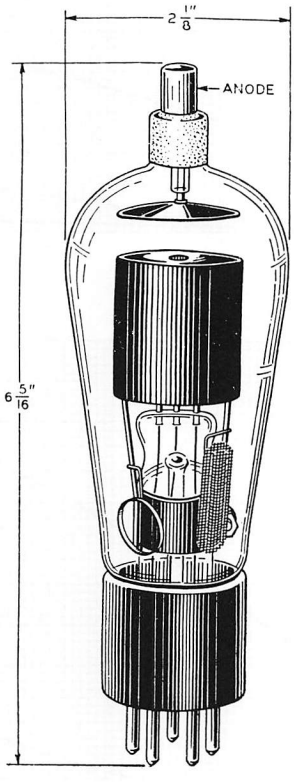


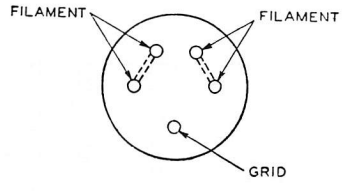


NOTE:

This combined bulletin supersedes data sheets previously issued for the individual tubes.

287A Vacuum Tube





Classification

The 287A is a three-element, mercury-vapor tube which employs an oxide-coated filament. It is intended for use in special circuits as a relay or trigger action device.

Base and Socket

The 287A Vacuum Tube employs a standard five prong thrust type base suitable for use in a Western Electric 137A or similar type socket. It is to be noted from the arrangement of electrode terminals shown above that the filament terminals are tied together in parallel. The corresponding socket terminals should also be connected to insure the best contact conditions for the filament current. The fifth terminal in the base is connected to the control electrode. The anode terminal is located at the top of the bulb and is arranged for a special, quick-release connector.

Rating and Characteristic Data

Filament Voltage	2.5 Volts
Filament Current	7.0 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	15 Volts
Maximum Peak Plate Current	1 Ampere
Maximum Peak Inverse Potential	2500 Volts
Safe Operating Ambient Temperature	10° to 50° C.

The anode-cathode potential drop is substantially independent of the plate current. The exact value varies from tube to tube and during the life of a given tube. Within the specified anode temperature and plate current range it will vary from 5 to 20 volts.

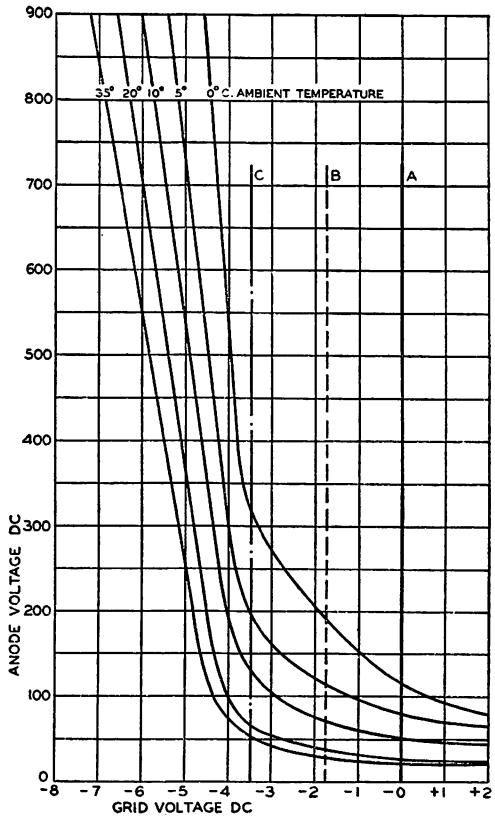
Breakdown Characteristics

Typical curves relating the critical control-electrode potential to the anode potential at various temperatures are given in the accompanying chart. These characteristics may vary from tube to tube and during the life of a given tube.

The 0 of grid bias is shown on the chart as the "A" axis for the case where the filament is heated with alternating current and the anode and control-electrode returns are connected to one side of the filament.

If the filament is heated by alternating current and the anode and control-electrode returns connected to the center tap of the filament transformer, the 0 of grid bias should be taken at the "B" axis.

If the filament is heated by direct current with the anode and control-electrode returns connected to the negative terminal, the 0 of grid bias should be taken at the "C" axis.



General Features

The 287A Vacuum Tube is primarily a mercury-vapor rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous control electrode and anode potentials and also by the ambient temperature.

The tube is suitable for use in variable voltage rectifiers as a circuit breaker and as a relay in a variety of applications requiring very low signal energy. Compared to a mechanical relay, the operation is more rapid and positive.

This mercury-vapor tube has a rugged mesh type oxide-coated cathode. It is especially suitable where long life and dependability of operation are essential.

Classification

These tubes are half-wave, thermionic, three element, negative grid, medium power thyratrons designed to operate at frequencies below 150 cycles. They are primarily intended for use in regulated rectifier, inverter, relay or other applications requiring thyratron characteristics.

Mounting

The tubes should be mounted as indicated on each individual tube data sheet. Free air circulation should be provided.

Filament

The filaments are designed to operate from alternating current sources. The voltage should be maintained to within 5% of the rated value. Operation of the filaments at a voltage above the upper limit will definitely reduce the life of the tubes, while a decrease in voltage below the lower limit may cause immediate failure.

Operating Precautions

Sufficient filament heating time must always be allowed for the filaments to reach a satisfactory operating temperature and for deposits of mercury in the upper parts of the tubes to be evaporated before the anode potential is applied. The "Required Heating Time" specified on the individual tube data sheet is sufficient to bring the filament to a satisfactory operating temperature when filament circuits with good regulation are used. At the low ambient temperatures, tubes containing mercury vapor only may require several minutes filament warming before the tube will start conducting. In most applications the tubes are self protecting during this warming period. A filament heating period of 15 minutes or more should be allowed when the tubes are used for the first time or if they have been subjected to extensive handling or prolonged standing.

Tube Voltage Drop

The tube voltage drop is substantially independent of anode current. The exact value varies, but under the specified operating conditions will normally be between 5 and 25 volts. A curve showing the tube voltage drop as a function of condensed mercury temperature for a typical tube when passing rated average anode current is shown on the individual tube data sheet.

Maximum Anode Current

The maximum permissible instantaneous and average anode current ratings are limitations on the current values that the tubes can safely carry in the direction in which they are designed to conduct and should not be exceeded.

Maximum Time of Averaging Anode Current

This time is the maximum period over which the anode current should be averaged when determining the maximum average anode current.

Maximum Peak Voltage Between Anode and Grid

This is the maximum permissible instantaneous voltage that should be applied between anode and grid or between anode and filament; either as an inverse anode voltage or a forward anode voltage blocked by grid action.

Control Characteristic

These tubes are so designed that for any given positive anode potential there is a critical grid potential. If the grid is held more negative than this value and the tube is not conducting, the anode current will remain zero. If it is made less negative, the tube becomes conducting and the anode current assumes a value determined by the applied potential and the impedance in the anode circuit. When the tube is conducting the Tube Voltage Drop is practically independent of the value of both the grid potential and the anode current. To extinguish the discharge and reestablish control by the grid, the anode potential must be reduced to zero or made negative, for a period at least as long as the deionization time.

The control characteristic curve relating the critical grid potential to the anode potential for a typical tube is shown on each individual tube data sheet. This characteristic may vary from tube to tube and during the life of a given tube. The extreme variation during the normal life of the tube when operating within the recommended limits will fall within the shaded area. The axis "A" should be used if the anode and grid circuit returns are made to the mid-tap of the filament transformer, and the axis "B" if they are made to either end. Return to the mid-tap is the more desirable mode of operation.

The control characteristic, of tubes containing mercury vapor only, shifts appreciably in a positive direction as the condensed mercury vapor temperature is reduced below 30° C. This shift is indicated by the dotted curve.

In some applications the starting of the anode current may be affected by extraneous electrostatic or electromagnetic fields causing ionization within the tube or inducing a voltage in a high impedance grid circuit. In such cases proper shielding will be required.

Maximum Instantaneous Grid Current

The maximum instantaneous grid current is the maximum peak current from the grid to the external circuit and should not be exceeded.

It is generally necessary to provide a means for limiting the grid current, as a conducting path is also established between the grid and filament within the tube when the anode current is flowing. The grid will supply a net positive ion or electron current to the external circuit depending upon the magnitude and polarity of the applied grid voltage.

Maximum Condensed Mercury Temperature Range

This operating temperature range applies to the temperature of the bulb at the area where the free mercury condenses during normal operation. For mercury and inert gas mixture tubes this range should not be exceeded. For tubes containing mercury vapor only, the upper limit should not be exceeded, but it is permissible to apply plate voltage at condensed mercury temperatures between the lower operating limit and zero degrees centigrade. Full output may not be obtained however until the temperature approaches the rated lower limit. (See "Operating Precautions.")

Nominal Deionization Time

The nominal deionization time is the approximate time required for the gas to return to a deionized state after the removal of a positive anode potential. The grid does not regain control until the gas is deionized.

Typical Circuits

These tubes may be used in a variety of circuits where thyratron control characteristics are desired. The following circuits are examples:

Figure 1 shows an application as a relay device. This circuit possesses a "lock in" feature since the anode potential must be removed momentarily in order to restore the tube to the non-conducting condition.

Figure 2 shows a half-wave manually-controlled rectifier. The average load current may be controlled by varying the relative phase relation of the grid and anode potentials by means of the phase shifting network.

Figure 3 shows an inverter circuit for the conversion of direct current to alternating current. The frequency and wave form of the a-c output will be determined by the driving frequency and the circuit constants.

Figure 4 shows a grid-controlled rectifier circuit which has the property of providing a load voltage nearly independent of load current. The magnitude of the load voltage may be adjusted by means of the potentiometer from 10% to full voltage. While a single section filter is shown, additional sections may be added if desired.

Figure 5 shows a grid-controlled rectifier circuit in which the load current may be limited to a predetermined value even under short circuit conditions. Additional filter sections may be added if desired.

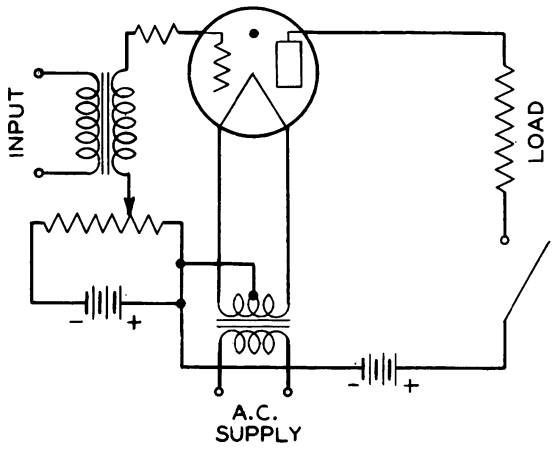


FIG. 1

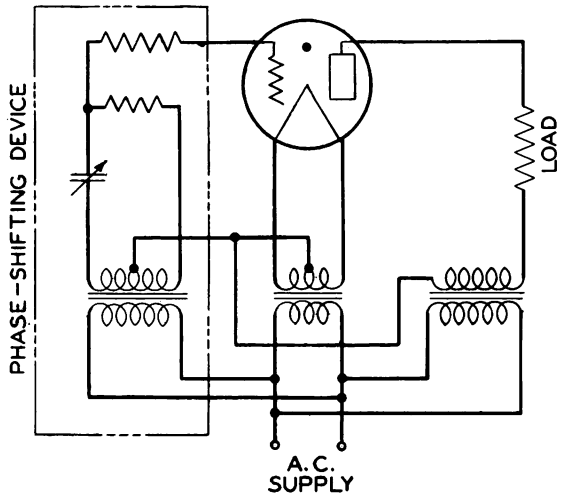


FIG. 2

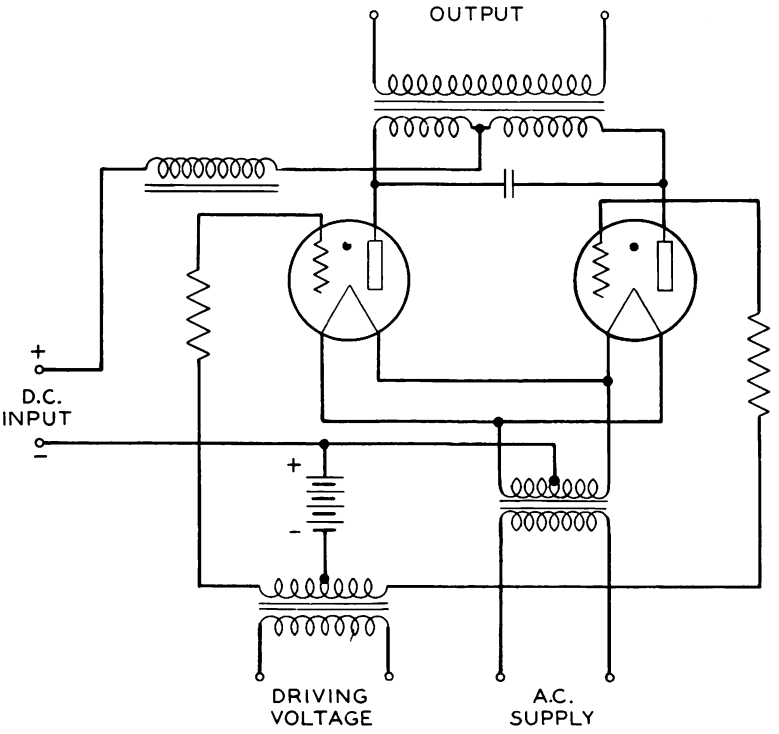


FIG. 3

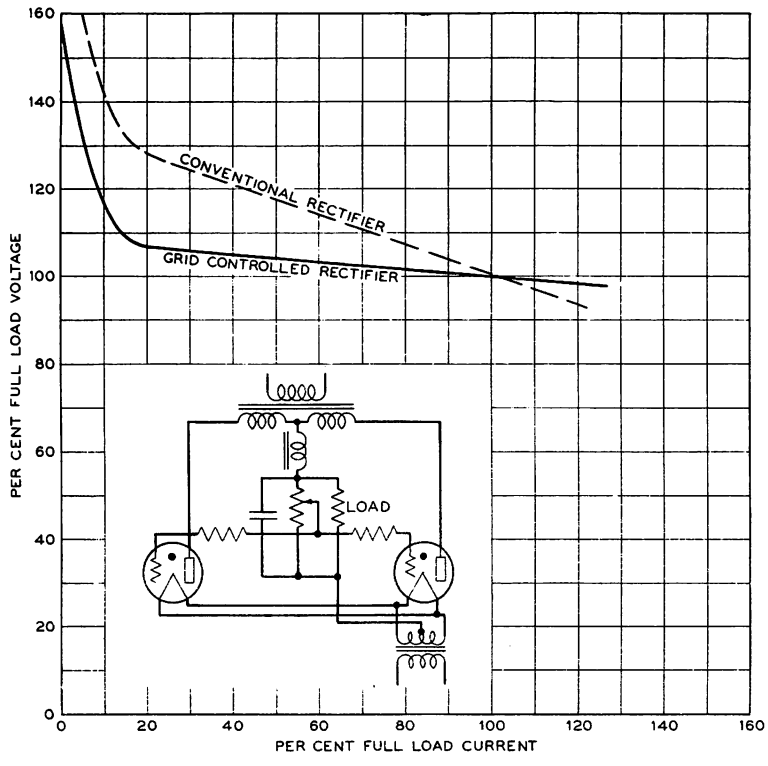

160
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PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
0
20
40
60
80
100
120
140
160
PER CENT FULL LOAD CURRENT

FIG. 4

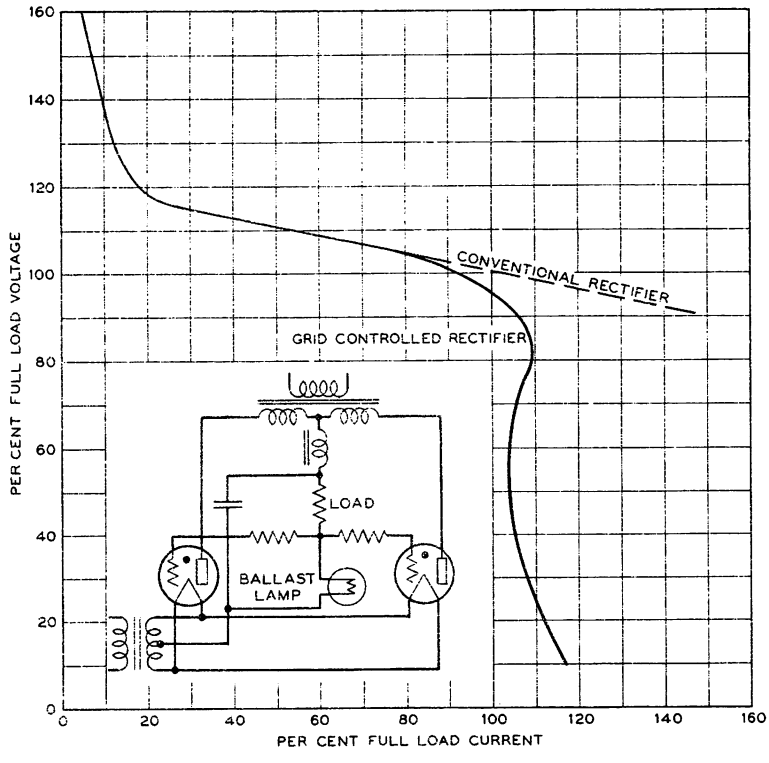
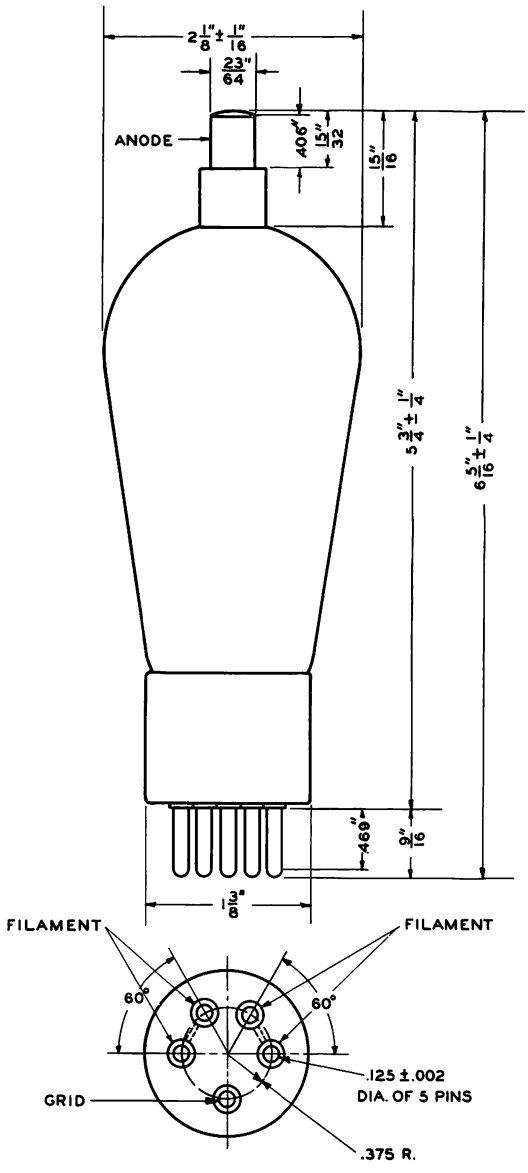
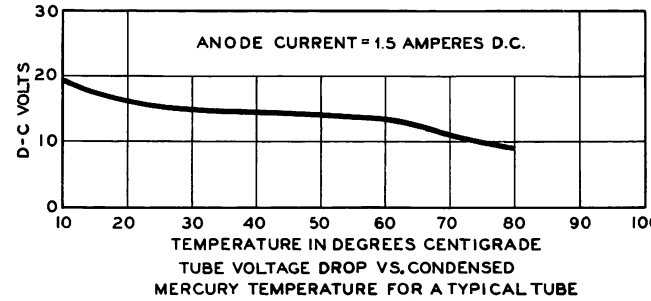

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PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
BALLAST LAMP
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20
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120
140
160
PER CENT FULL LOAD CURRENT

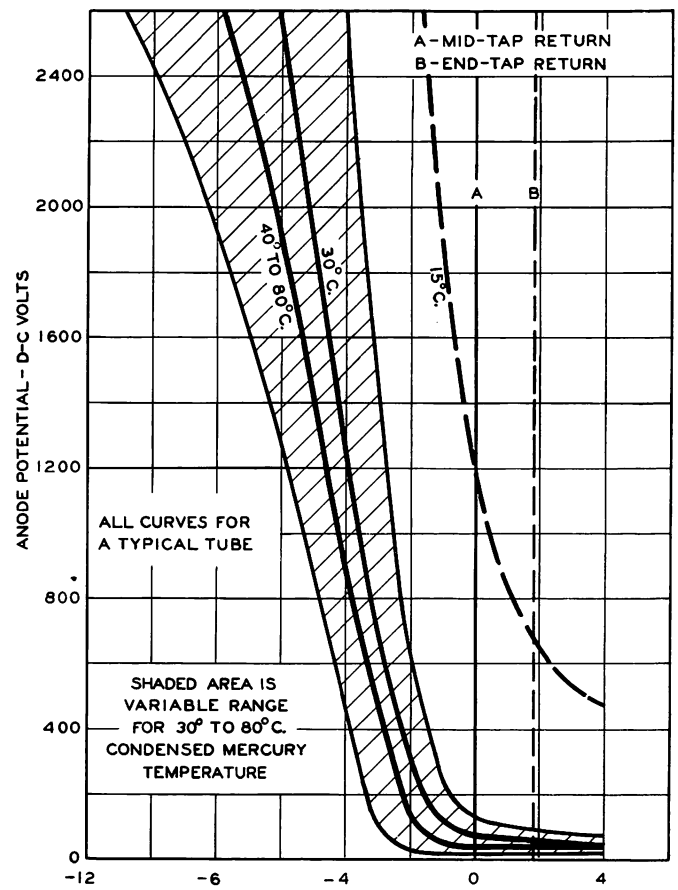
FIG. 5

287A Vacuum Tube
Mercury Vapor Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



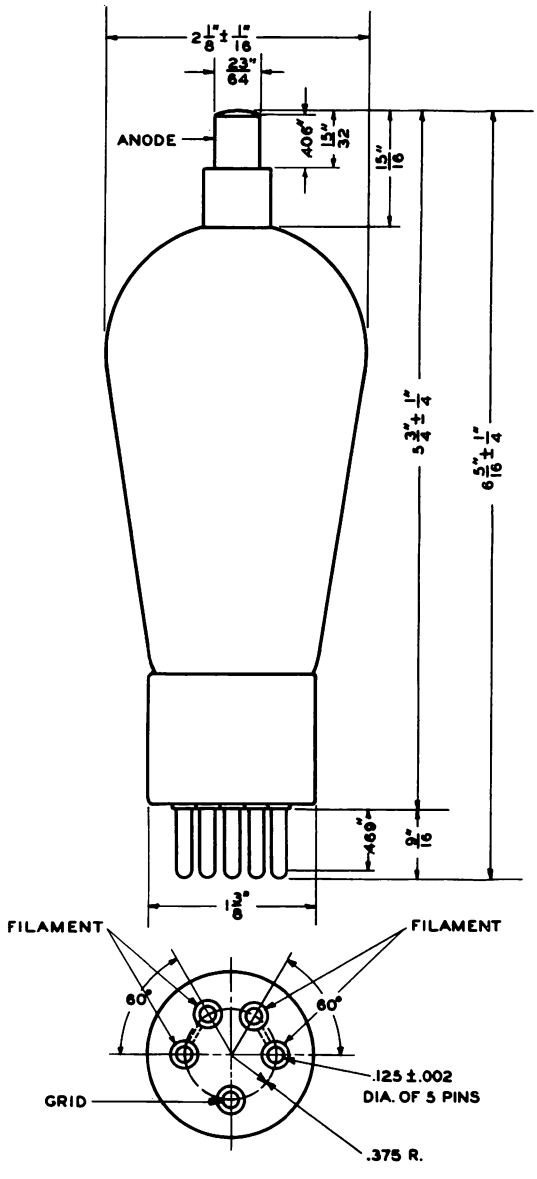
CONTROL CHARACTERISTIC

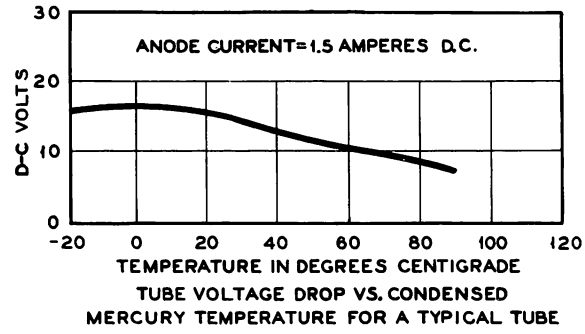
Ratings

Filament		
Voltage	2.5 volts a.c.	
Nominal current	7.0 amperes	
Required heating time	10 seconds	
Approximate tube voltage drop	15 volts	
Maximum peak voltage between anode and grid—volts	500	2500
Maximum instantaneous anode current—amperes	6.0	2.5
Maximum average anode current—amperes	1.5	0.64
Maximum time of averaging anode current	5 seconds	
Maximum instantaneous grid current	50 milliamperes	
Operating condensed mercury temperature range	+30 to +80° C.	
Nominal deionization time	1000 microseconds	

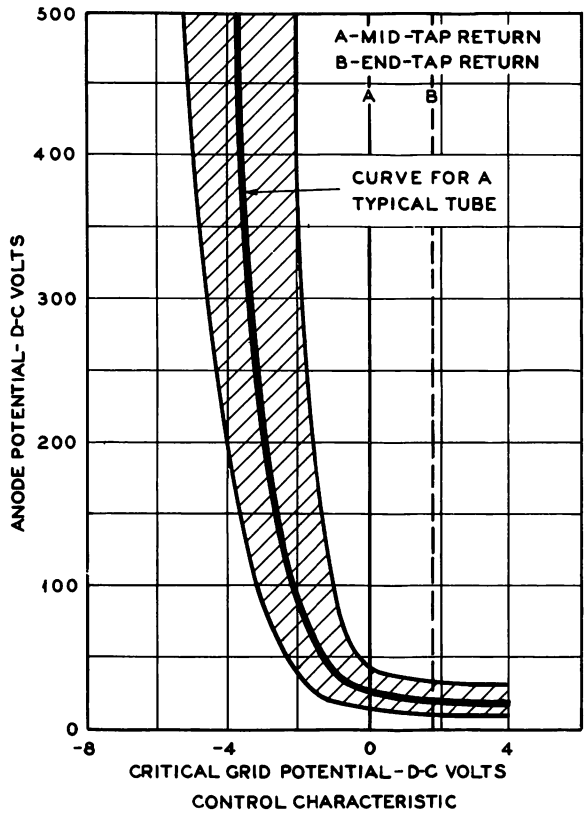
Mounting—The 287A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

323A Vacuum Tube
Mercury Vapor and Argon Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



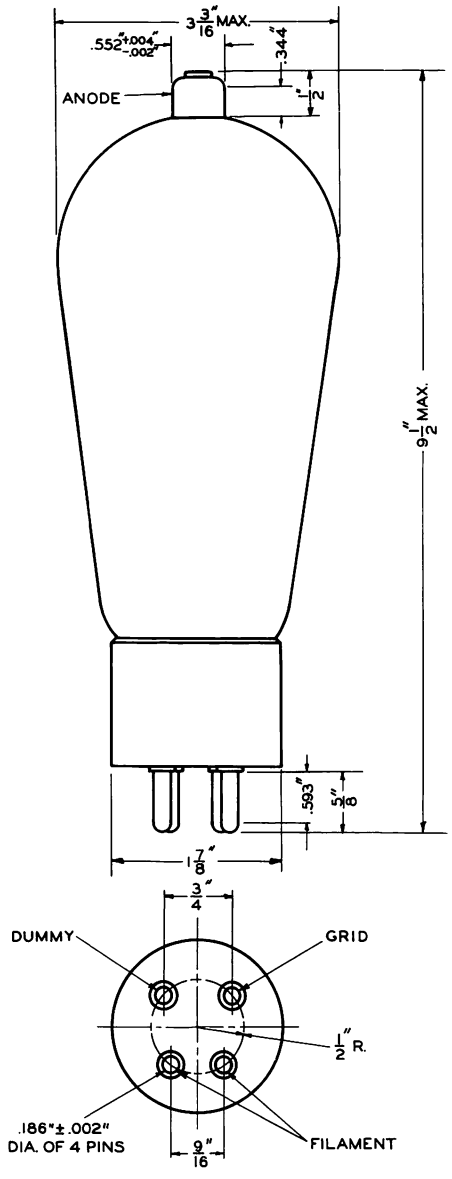
CONTROL CHARACTERISTIC

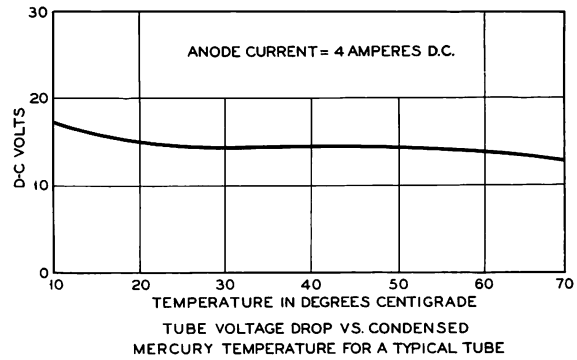
Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	7.0 amperes
Required heating time	10 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	500 volts
Maximum instantaneous anode current	6.0 amperes
Maximum average anode current	1.5 amperes
Maximum time of averaging anode current	5 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	−20 to +90° C.
Nominal deionization time	1000 microseconds

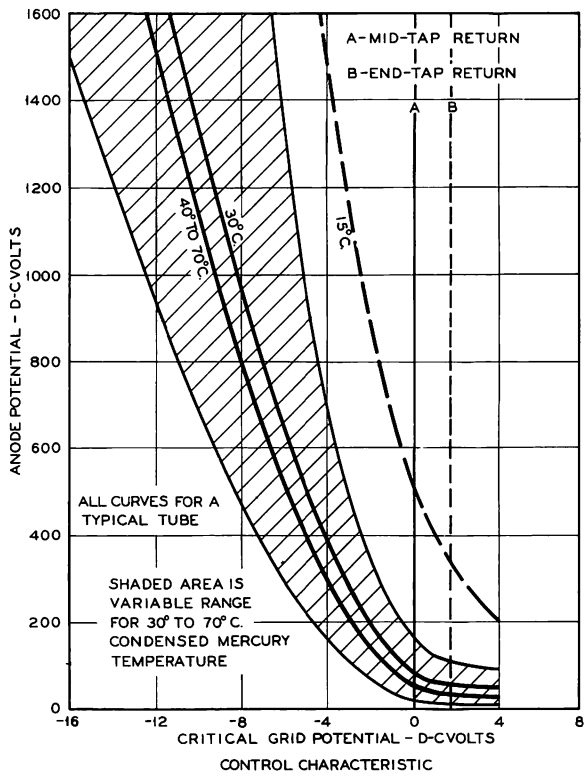
Mounting—The 323A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

354A Vacuum Tube
Mercury Vapor Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



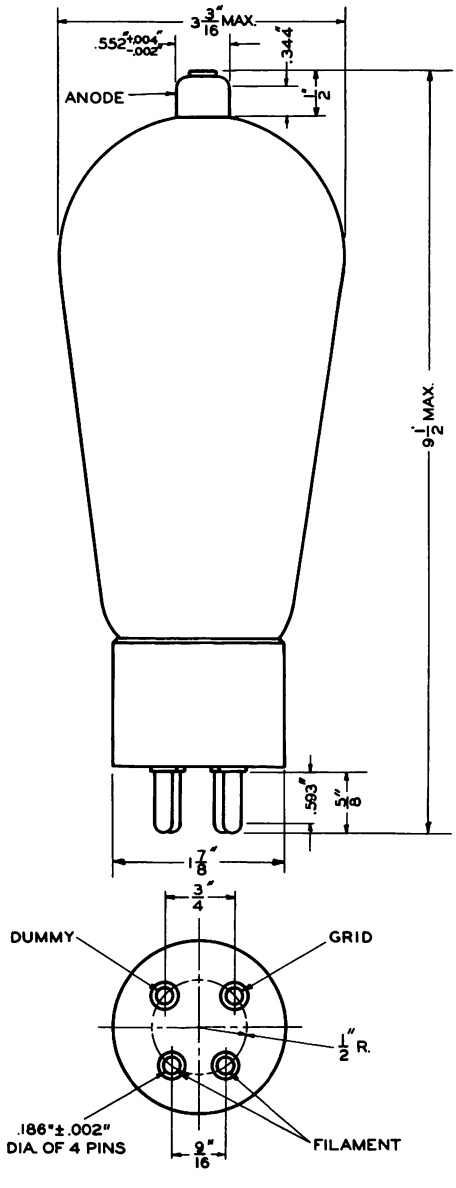
CONTROL CHARACTERISTIC

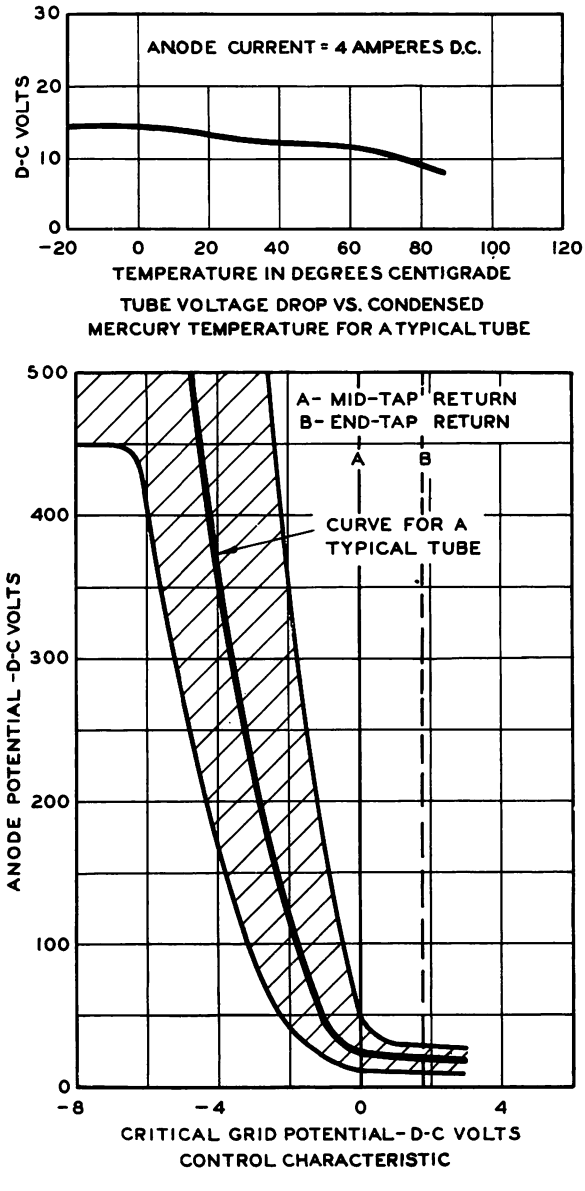
Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	16 amperes
Required heating time	45 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	1500 volts
Maximum instantaneous anode current	16 amperes
Maximum average anode current	4 amperes
Maximum time of averaging anode current	15 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	+30 to +70° C.
Nominal deionization time	1000 microseconds

Mounting—The 354A tube requires a Westinghouse S#793202 or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

355A Vacuum Tube
Mercury Vapor and Argon Filled





Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	16 amperes
Required heating time	45 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	350 volts
Maximum instantaneous anode current	16 amperes
Maximum average anode current	4 amperes
Maximum time of averaging anode current	15 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	−20 to +80° C.
Nominal deionization time	1000microseconds

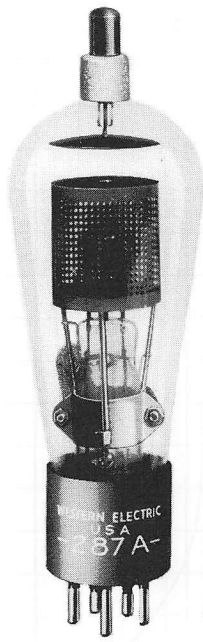
Mounting—The 355A tube requires a Westinghouse S#793202 or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

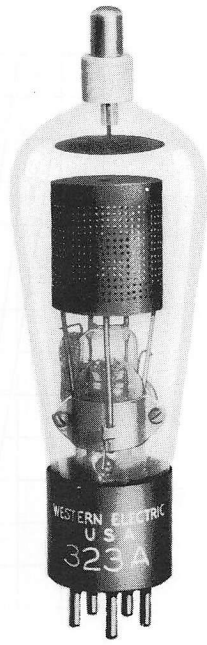
Western Electric

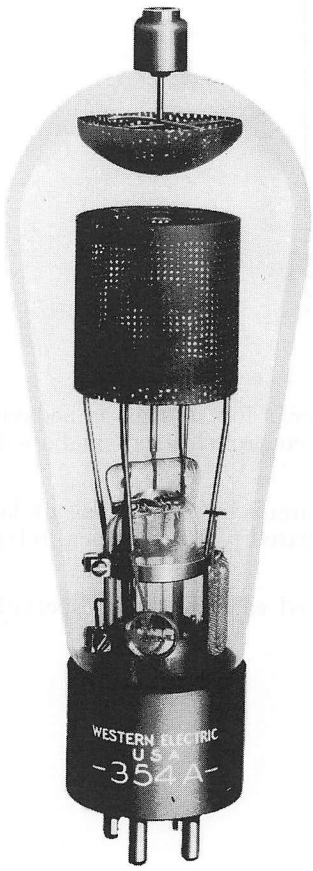
Vacuum Tubes

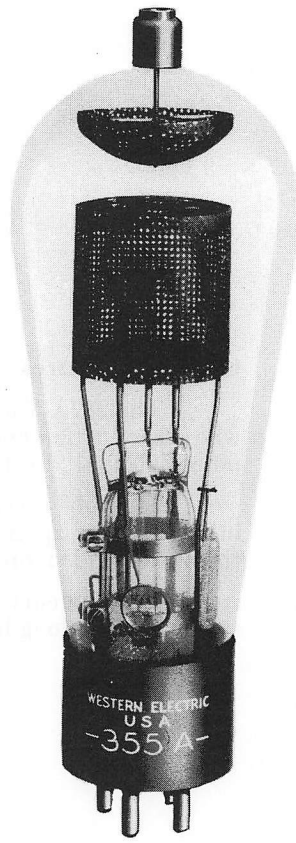
Three Element Power Thyratrons

287A 323A 354A 355A





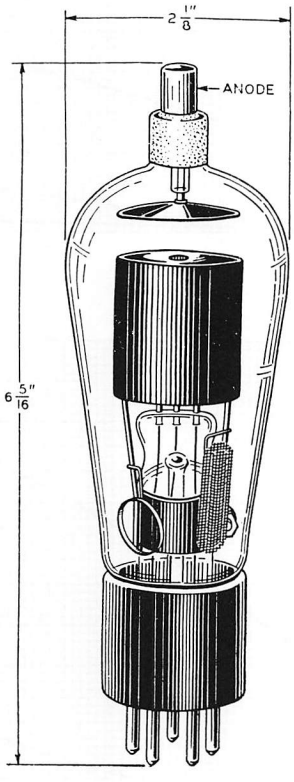


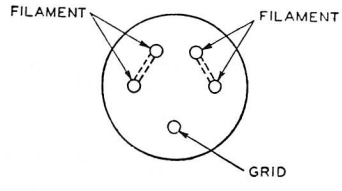


NOTE:

This combined bulletin supersedes data sheets previously issued for the individual tubes.

287A Vacuum Tube





Classification

The 287A is a three-element, mercury-vapor tube which employs an oxide-coated filament. It is intended for use in special circuits as a relay or trigger action device.

Base and Socket

The 287A Vacuum Tube employs a standard five prong thrust type base suitable for use in a Western Electric 137A or similar type socket. It is to be noted from the arrangement of electrode terminals shown above that the filament terminals are tied together in parallel. The corresponding socket terminals should also be connected to insure the best contact conditions for the filament current. The fifth terminal in the base is connected to the control electrode. The anode terminal is located at the top of the bulb and is arranged for a special, quick-release connector.

Rating and Characteristic Data

Filament Voltage	2.5 Volts
Filament Current	7.0 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	15 Volts
Maximum Peak Plate Current	1 Ampere
Maximum Peak Inverse Potential	2500 Volts
Safe Operating Ambient Temperature	10° to 50° C.

The anode-cathode potential drop is substantially independent of the plate current. The exact value varies from tube to tube and during the life of a given tube. Within the specified anode temperature and plate current range it will vary from 5 to 20 volts.

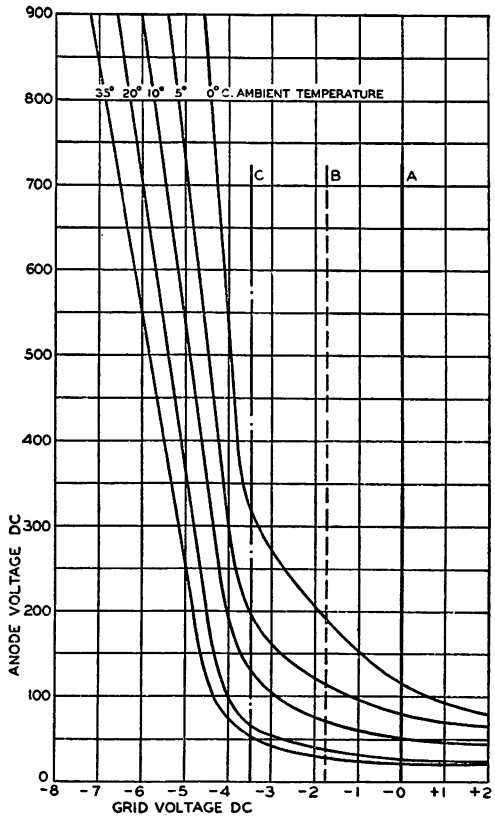
Breakdown Characteristics

Typical curves relating the critical control-electrode potential to the anode potential at various temperatures are given in the accompanying chart. These characteristics may vary from tube to tube and during the life of a given tube.

The 0 of grid bias is shown on the chart as the "A" axis for the case where the filament is heated with alternating current and the anode and control-electrode returns are connected to one side of the filament.

If the filament is heated by alternating current and the anode and control-electrode returns connected to the center tap of the filament transformer, the 0 of grid bias should be taken at the "B" axis.

If the filament is heated by direct current with the anode and control-electrode returns connected to the negative terminal, the 0 of grid bias should be taken at the "C" axis.



General Features

The 287A Vacuum Tube is primarily a mercury-vapor rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous control electrode and anode potentials and also by the ambient temperature.

The tube is suitable for use in variable voltage rectifiers as a circuit breaker and as a relay in a variety of applications requiring very low signal energy. Compared to a mechanical relay, the operation is more rapid and positive.

This mercury-vapor tube has a rugged mesh type oxide-coated cathode. It is especially suitable where long life and dependability of operation are essential.

Classification

These tubes are half-wave, thermionic, three element, negative grid, medium power thyratrons designed to operate at frequencies below 150 cycles. They are primarily intended for use in regulated rectifier, inverter, relay or other applications requiring thyratron characteristics.

Mounting

The tubes should be mounted as indicated on each individual tube data sheet. Free air circulation should be provided.

Filament

The filaments are designed to operate from alternating current sources. The voltage should be maintained to within 5% of the rated value. Operation of the filaments at a voltage above the upper limit will definitely reduce the life of the tubes, while a decrease in voltage below the lower limit may cause immediate failure.

Operating Precautions

Sufficient filament heating time must always be allowed for the filaments to reach a satisfactory operating temperature and for deposits of mercury in the upper parts of the tubes to be evaporated before the anode potential is applied. The "Required Heating Time" specified on the individual tube data sheet is sufficient to bring the filament to a satisfactory operating temperature when filament circuits with good regulation are used. At the low ambient temperatures, tubes containing mercury vapor only may require several minutes filament warming before the tube will start conducting. In most applications the tubes are self protecting during this warming period. A filament heating period of 15 minutes or more should be allowed when the tubes are used for the first time or if they have been subjected to extensive handling or prolonged standing.

Tube Voltage Drop

The tube voltage drop is substantially independent of anode current. The exact value varies, but under the specified operating conditions will normally be between 5 and 25 volts. A curve showing the tube voltage drop as a function of condensed mercury temperature for a typical tube when passing rated average anode current is shown on the individual tube data sheet.

Maximum Anode Current

The maximum permissible instantaneous and average anode current ratings are limitations on the current values that the tubes can safely carry in the direction in which they are designed to conduct and should not be exceeded.

Maximum Time of Averaging Anode Current

This time is the maximum period over which the anode current should be averaged when determining the maximum average anode current.

Maximum Peak Voltage Between Anode and Grid

This is the maximum permissible instantaneous voltage that should be applied between anode and grid or between anode and filament; either as an inverse anode voltage or a forward anode voltage blocked by grid action.

Control Characteristic

These tubes are so designed that for any given positive anode potential there is a critical grid potential. If the grid is held more negative than this value and the tube is not conducting, the anode current will remain zero. If it is made less negative, the tube becomes conducting and the anode current assumes a value determined by the applied potential and the impedance in the anode circuit. When the tube is conducting the Tube Voltage Drop is practically independent of the value of both the grid potential and the anode current. To extinguish the discharge and reestablish control by the grid, the anode potential must be reduced to zero or made negative, for a period at least as long as the deionization time.

The control characteristic curve relating the critical grid potential to the anode potential for a typical tube is shown on each individual tube data sheet. This characteristic may vary from tube to tube and during the life of a given tube. The extreme variation during the normal life of the tube when operating within the recommended limits will fall within the shaded area. The axis "A" should be used if the anode and grid circuit returns are made to the mid-tap of the filament transformer, and the axis "B" if they are made to either end. Return to the mid-tap is the more desirable mode of operation.

The control characteristic, of tubes containing mercury vapor only, shifts appreciably in a positive direction as the condensed mercury vapor temperature is reduced below 30° C. This shift is indicated by the dotted curve.

In some applications the starting of the anode current may be affected by extraneous electrostatic or electromagnetic fields causing ionization within the tube or inducing a voltage in a high impedance grid circuit. In such cases proper shielding will be required.

Maximum Instantaneous Grid Current

The maximum instantaneous grid current is the maximum peak current from the grid to the external circuit and should not be exceeded.

It is generally necessary to provide a means for limiting the grid current, as a conducting path is also established between the grid and filament within the tube when the anode current is flowing. The grid will supply a net positive ion or electron current to the external circuit depending upon the magnitude and polarity of the applied grid voltage.

Maximum Condensed Mercury Temperature Range

This operating temperature range applies to the temperature of the bulb at the area where the free mercury condenses during normal operation. For mercury and inert gas mixture tubes this range should not be exceeded. For tubes containing mercury vapor only, the upper limit should not be exceeded, but it is permissible to apply plate voltage at condensed mercury temperatures between the lower operating limit and zero degrees centigrade. Full output may not be obtained however until the temperature approaches the rated lower limit. (See "Operating Precautions.")

Nominal Deionization Time

The nominal deionization time is the approximate time required for the gas to return to a deionized state after the removal of a positive anode potential. The grid does not regain control until the gas is deionized.

Typical Circuits

These tubes may be used in a variety of circuits where thyratron control characteristics are desired. The following circuits are examples:

Figure 1 shows an application as a relay device. This circuit possesses a "lock in" feature since the anode potential must be removed momentarily in order to restore the tube to the non-conducting condition.

Figure 2 shows a half-wave manually-controlled rectifier. The average load current may be controlled by varying the relative phase relation of the grid and anode potentials by means of the phase shifting network.

Figure 3 shows an inverter circuit for the conversion of direct current to alternating current. The frequency and wave form of the a-c output will be determined by the driving frequency and the circuit constants.

Figure 4 shows a grid-controlled rectifier circuit which has the property of providing a load voltage nearly independent of load current. The magnitude of the load voltage may be adjusted by means of the potentiometer from 10% to full voltage. While a single section filter is shown, additional sections may be added if desired.

Figure 5 shows a grid-controlled rectifier circuit in which the load current may be limited to a predetermined value even under short circuit conditions. Additional filter sections may be added if desired.

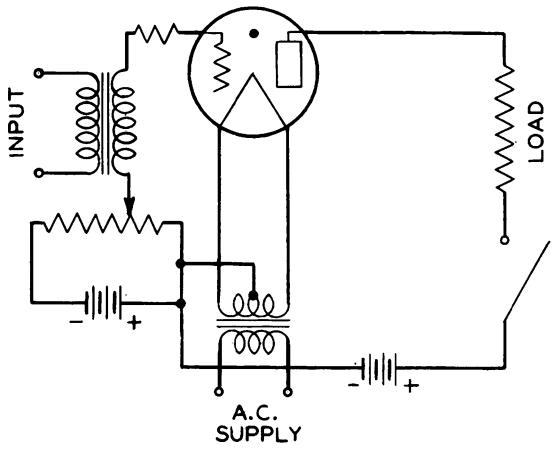


FIG. 1

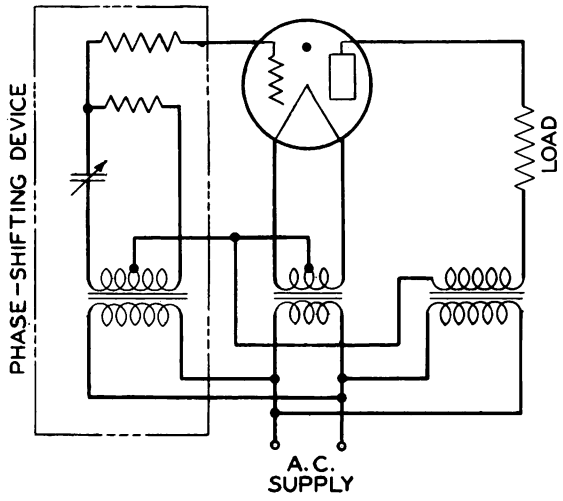


FIG. 2

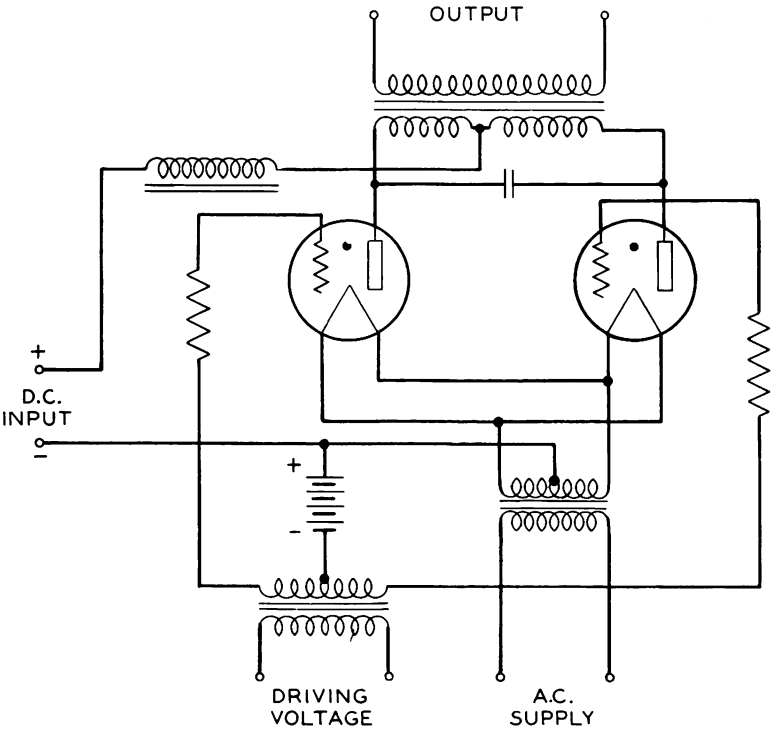


FIG. 3

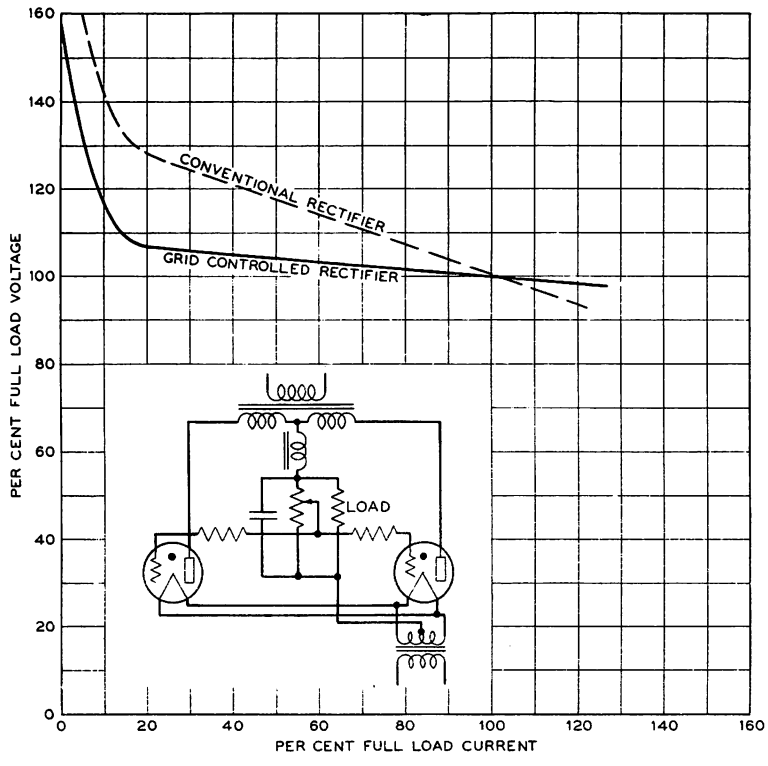

160
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PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
0
20
40
60
80
100
120
140
160
PER CENT FULL LOAD CURRENT

FIG. 4

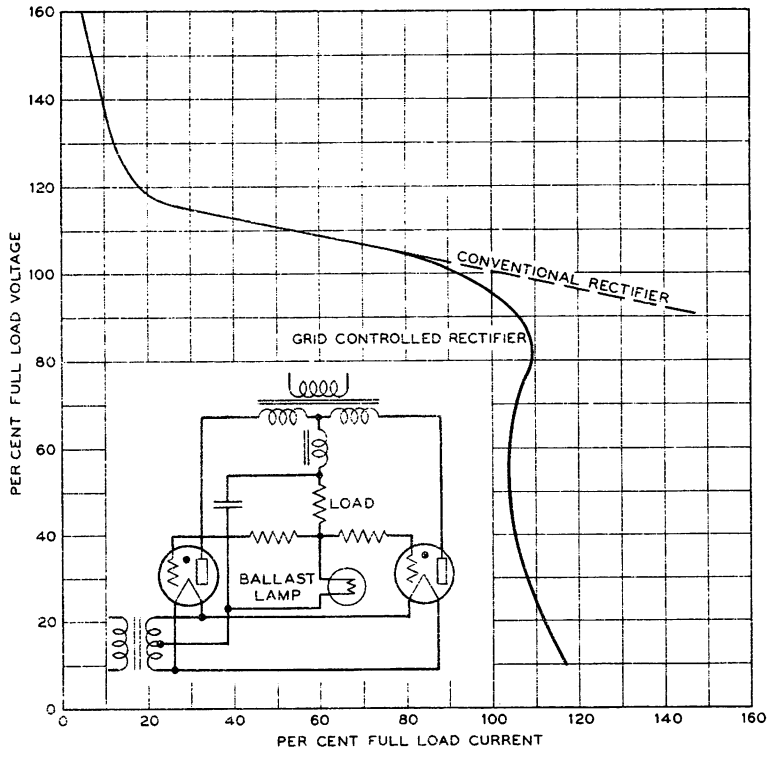
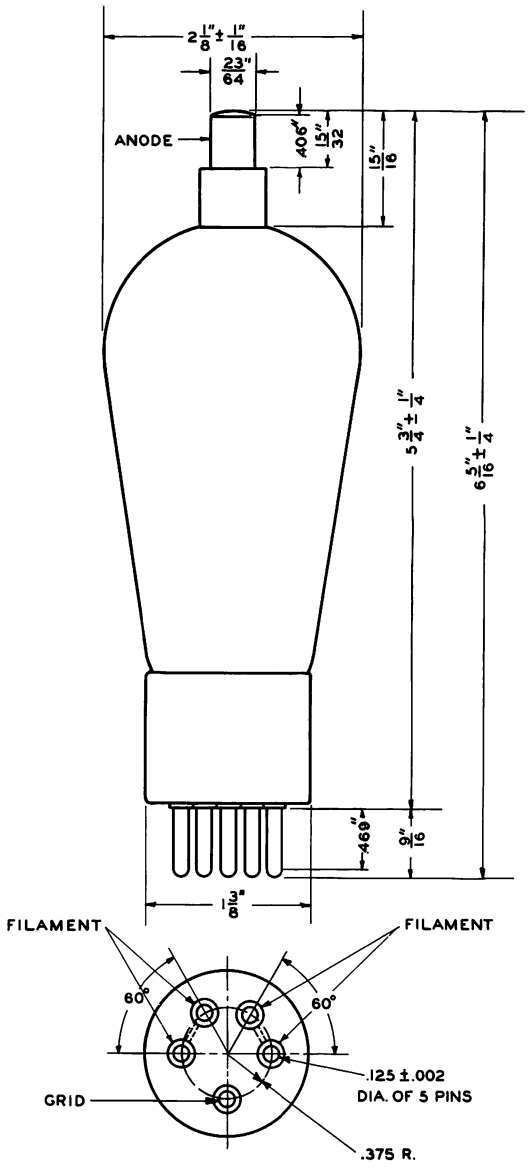
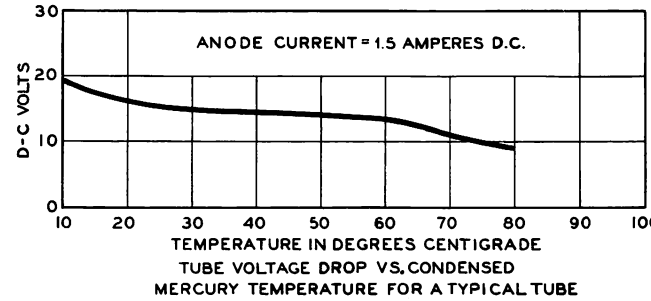

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PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
BALLAST LAMP
0
20
40
60
80
100
120
140
160
PER CENT FULL LOAD CURRENT

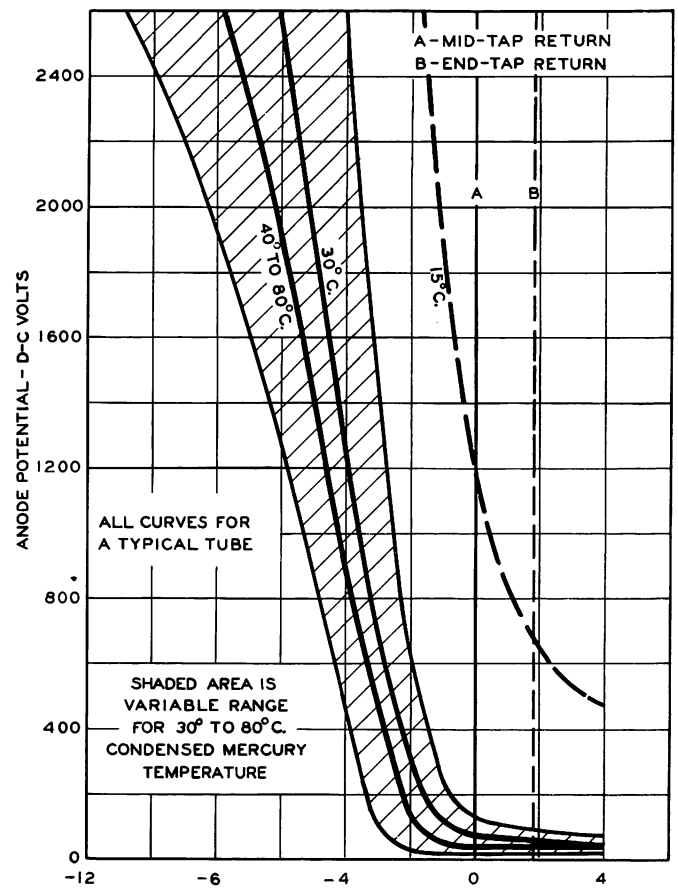
FIG. 5

287A Vacuum Tube
Mercury Vapor Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



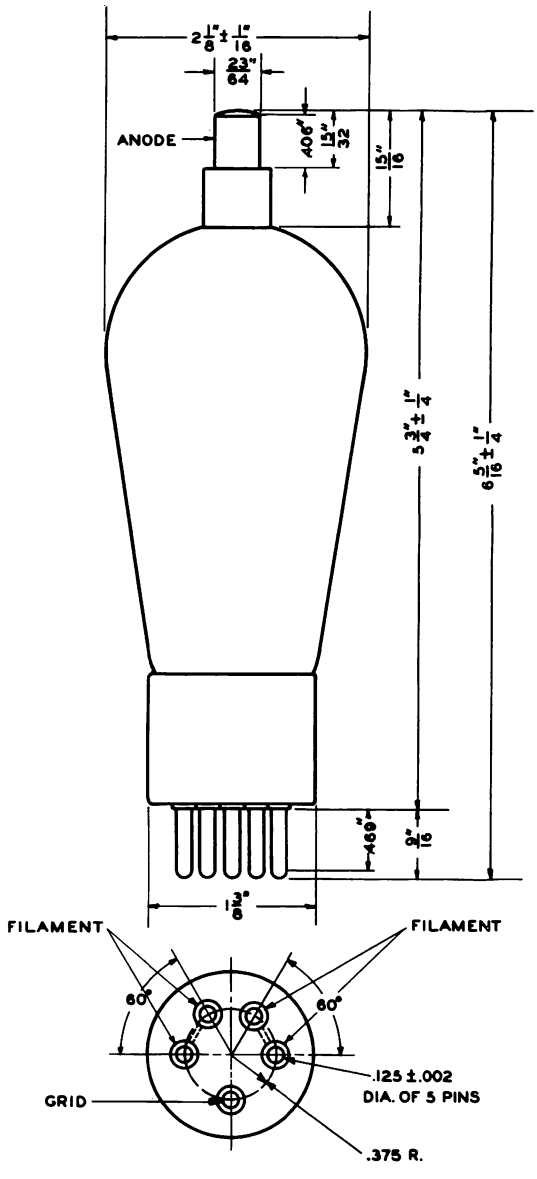
CONTROL CHARACTERISTIC

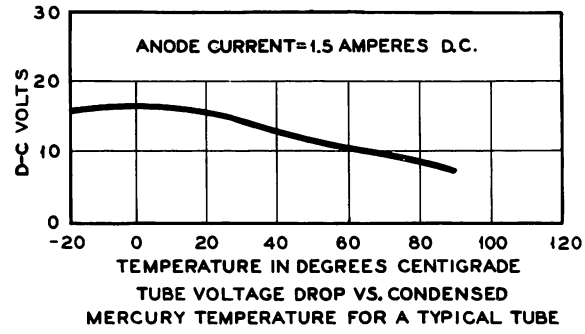
Ratings

Filament		
Voltage	2.5 volts a.c.	
Nominal current	7.0 amperes	
Required heating time	10 seconds	
Approximate tube voltage drop	15 volts	
Maximum peak voltage between anode and grid—volts	500	2500
Maximum instantaneous anode current—amperes	6.0	2.5
Maximum average anode current—amperes	1.5	0.64
Maximum time of averaging anode current	5 seconds	
Maximum instantaneous grid current	50 milliamperes	
Operating condensed mercury temperature range	+30 to +80° C.	
Nominal deionization time	1000 microseconds	

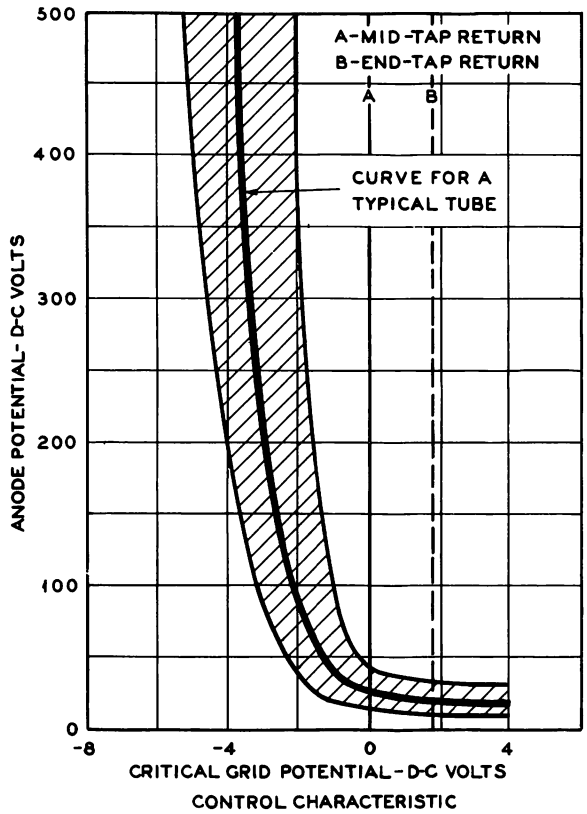
Mounting—The 287A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

323A Vacuum Tube
Mercury Vapor and Argon Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



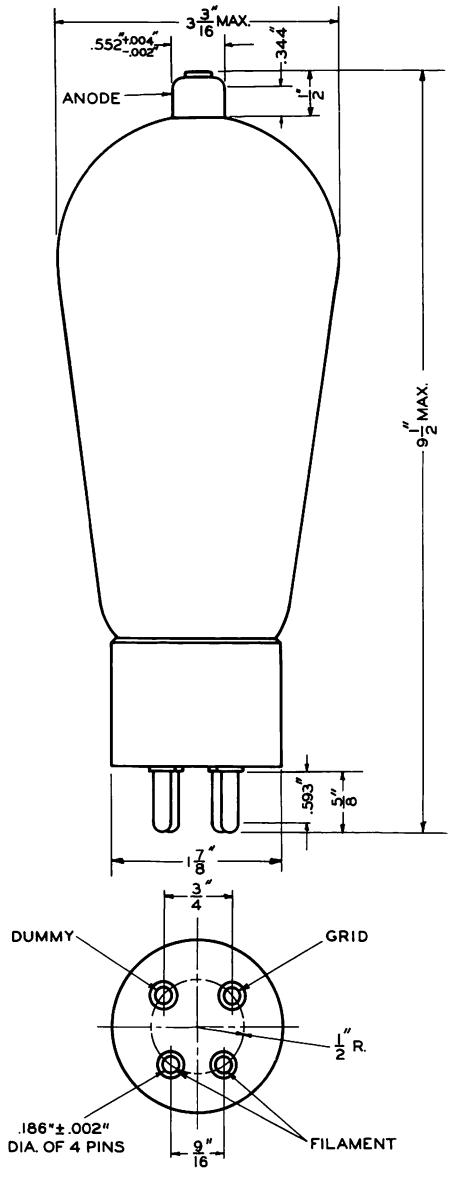
CONTROL CHARACTERISTIC

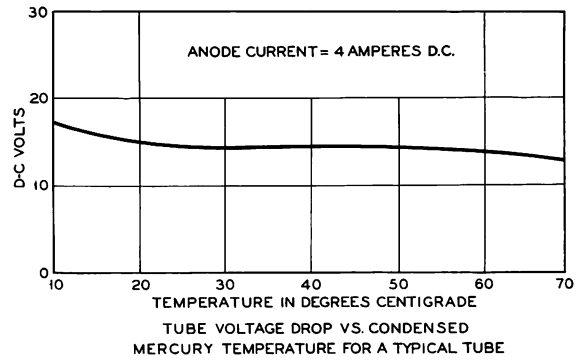
Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	7.0 amperes
Required heating time	10 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	500 volts
Maximum instantaneous anode current	6.0 amperes
Maximum average anode current	1.5 amperes
Maximum time of averaging anode current	5 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	−20 to +90° C.
Nominal deionization time	1000 microseconds

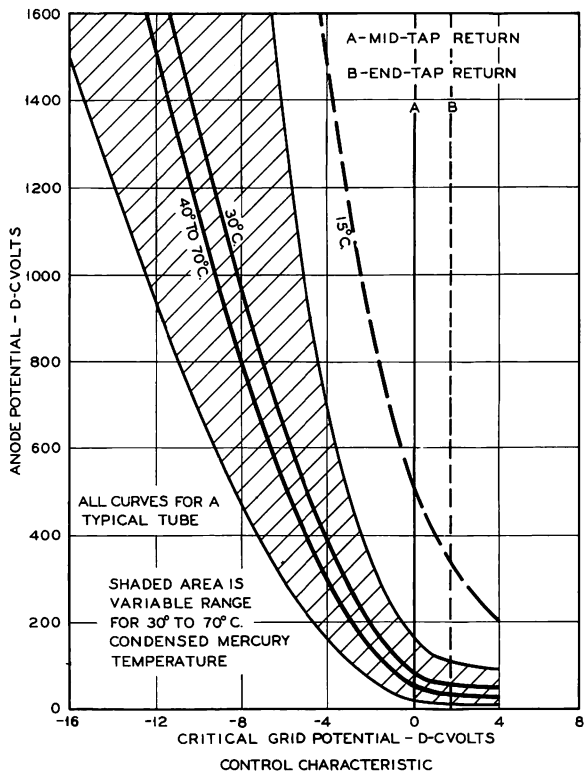
Mounting—The 323A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

354A Vacuum Tube
Mercury Vapor Filled





TUBE VOLTAGE DROP VS. CONDENSED MERCURY TEMPERATURE FOR A TYPICAL TUBE



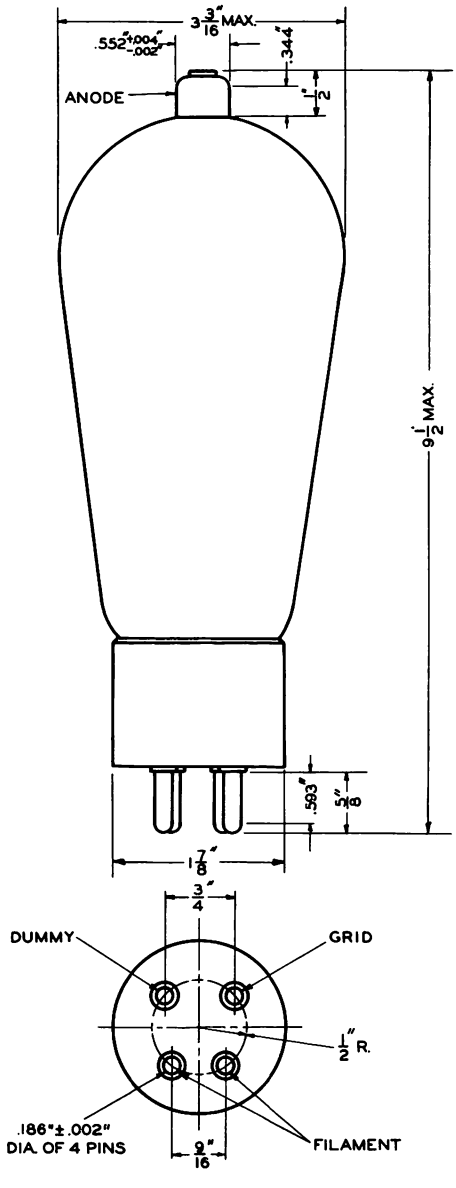
CONTROL CHARACTERISTIC

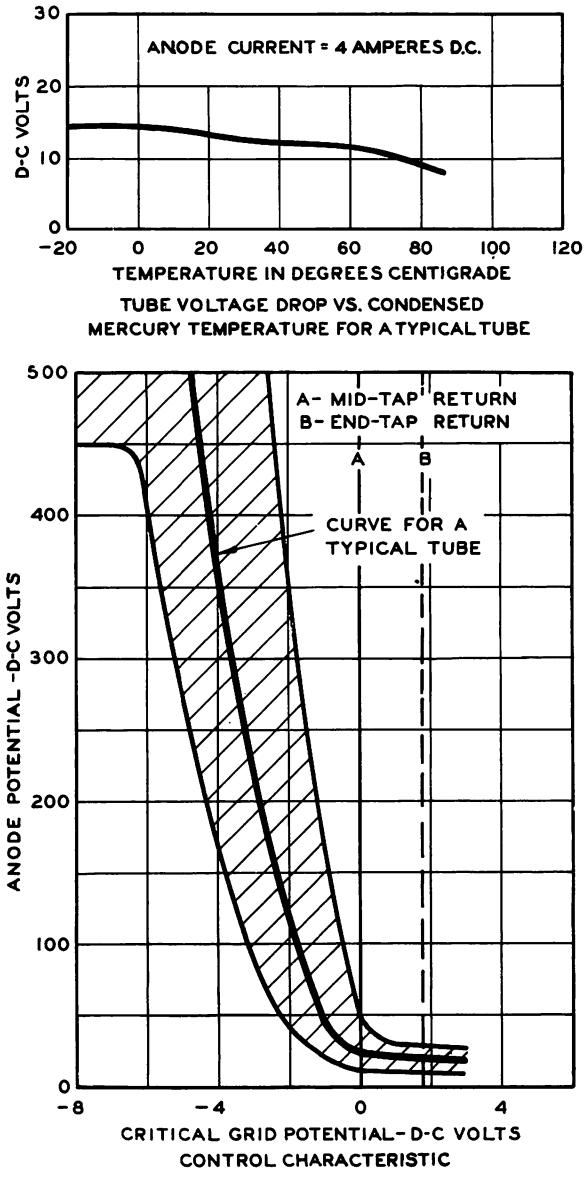
Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	16 amperes
Required heating time	45 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	1500 volts
Maximum instantaneous anode current	16 amperes
Maximum average anode current	4 amperes
Maximum time of averaging anode current	15 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	+30 to +70° C.
Nominal deionization time	1000 microseconds

Mounting—The 354A tube requires a Westinghouse S#793202 or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

355A Vacuum Tube
Mercury Vapor and Argon Filled

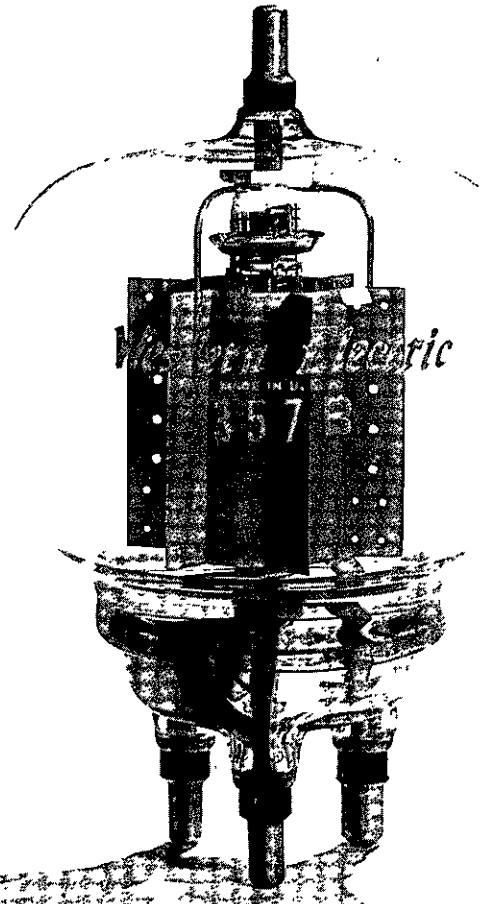




Ratings

Filament	
Voltage	2.5 volts a.c.
Nominal current	16 amperes
Required heating time	45 seconds
Approximate tube voltage drop	15 volts
Maximum peak voltage between anode and grid	350 volts
Maximum instantaneous anode current	16 amperes
Maximum average anode current	4 amperes
Maximum time of averaging anode current	15 seconds
Maximum instantaneous grid current	50 milliamperes
Operating condensed mercury temperature range	−20 to +80° C.
Nominal deionization time	1000microseconds

Mounting—The 355A tube requires a Westinghouse S#793202 or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.



TRIODE
AMPLIFIER, OSCILLATOR OR MODULATOR

Western Electric

DESCRIPTION

The 357B is a three-electrode tube designed for use as a radio-frequency amplifier or oscillator, audio-frequency amplifier or modulator. The anode is capable of dissipating 400 watts. The tube is cooled by radiation at frequencies below 40 megacycles. Forced-air cooling of the envelope is necessary at higher frequencies. The tube is capable of operating up to 100 megacycles at maximum ratings and up to 150 megacycles at reduced ratings. The cathode is a thoriated tungsten filament.

MAXIMUM RATINGS

D-C Plate Voltage	4000 volts
D-C Plate Current	0.500 ampere
Continuous Plate Dissipation	400 watts
D-C Grid Current	0.100 ampere

GENERAL CHARACTERISTICS

ELECTRICAL DATA

	Min.	Bogey	Max.	
Filament Voltage	9.5	10.0	10.5	volts
Filament Current at Bogey Voltage	9.7	10.0	10.5	amperes
Filament Starting Current			50	amperes
Filament Resistance, Cold		0.12		ohm
Amplification Factor				
Conditions: I_b = 200 ma, E_b = 2 kv	27	30	34	
Interelectrode Capacitances				
Grid-Plate	3.5	4.25	5.0	uuf
Grid-Filament	10.0	11.5	13.0	uuf
Plate-Filament	2.0	2.5	4.0	uuf
Maximum Usable Cathode Current[1]			2.5	amperes

MECHANICAL DATA

Mounting Position	Vertical, plate terminal up
Type of Cooling[2]	Radiation or forced-air
Required Air Flow on Envelope	
When Operated Above 40 Megacycles	40 cfm
Maximum Incoming Air Temperature	45 centigrade
Maximum Glass Temperature	200 centigrade
Shock and Vibration	
Ruggedness[3] (duration of 5 milliseconds)	50 G
Natural Frequency of Elements	
Plate	100 cycles
Filament-Grid Structure	75 cycles
Net Weight, approximate	13 ounces

1. Represents maximum usable cathode current for tube as plate current plus grid current for any condition of operation.

2. Radiation cooling is adequate when the tube is operated below 40 megacycles and with a free circulation of air around the tube. If operated in a confined space or at a frequency above 40 megacycles, forced-air cooling is necessary. Satisfactory air cooling will be obtained from a blower delivering approximately 40 cubic feet of air per minute from a 2-inch diameter nozzle. The nozzle outlet should be placed approximately 3 inches from the tube and directed toward the central point of the envelope, midway between the plate and grid terminals.

   The plate terminal connector shall be of a design that will readily conduct heat from the plate terminal.

3. This test is equivalent to a JAN-1A Pendulum Bump Tester 15° test. The data given represent the maximum capabilities of the tube without electrical potentials applied and should not be construed to mean that the tube is capable of withstanding an infinite number of shocks of this magnitude.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS B

MAXIMUM RATINGS, ABSOLUTE VALUES

	CCS	
D-C Plate Voltage	4000	volts
Signal D-C Plate Current[4]	0.50	ampere
Signal Plate Input[4]	1100	watts
Plate Dissipation[4]	400	watts

TYPICAL OPERATION

Unless otherwise specified, values are for 2 tubes

	CCS	CCS	CCS[5]	
D-C Plate Voltage	2000	3500	3000	volts
D-C Grid Voltage	—50	—110	—85	volts
Peak A-F Grid-to-Grid Voltage	490	520	345	volts
Zero Signal D-C Plate Current	0.160	0.120	0.120	ampere
Maximum Signal D-C Plate Current	1.00	0.72	0.43	ampere
Effective Load Resistance, Plate-to-Plate	4360	11500	14700	ohms
Maximum Signal Driving Power, approximate	50.0	35.0	13.5	watts
Maximum Signal Power Output	1400	1840	850	watts

RADIO-FREQUENCY POWER AMPLIFIER—CLASS B

Carrier conditions per tube for use with maximum modulation factor of 1.0

MAXIMUM RATINGS, ABSOLUTE VALUES

	CCS	
D-C Plate Voltage	4000	volts
D-C Plate Current	0.275	ampere
Plate Input	550	watts
Plate Dissipation	400	watts

TYPICAL OPERATION

	CCS	CCS	
D-C Plate Voltage	2000	3500	volts
D-C Grid Voltage	—60	—125	volts
Peak R-F Grid Voltage	135	136	volts
D-C Plate Current	0.260	0.150	ampere
D-C Grid Current, approximate	0.100	0.001	ampere
Driving Power, approximate[6]	25	8.5	watts
Power Output, approximate	175	190	watts

4. Averaged over any audio-frequency cycle of sine wave form.

5. As high level modulator for 1000 watt transmitter. Total harmonics approximately 1.5% at full output.

6. At crest of audio-frequency cycle with modulation factor of 1.0.

PLATE MODULATED RADIO-FREQUENCY POWER AMPLIFIER—CLASS C TELEPHONY

Carrier conditions per tube for use with maximum modulation factor of 1.0

MAXIMUM RATINGS, ABSOLUTE VALUES

	CCS	
D-C Plate Voltage	3000	volts
D-C Grid Voltage	—500	volts
D-C Plate Current	0.400	ampere
D-C Grid Current	0.100	ampere
Plate Input	1100	watts
Plate Dissipation	235	watts

TYPICAL OPERATION

	CCS	CCS	CCS*	
D-C Plate Voltage	2000	3000	3000	volts
D-C Grid Voltage	—310	—320	—270	volts
Peak R-F Grid Voltage	535	520	420	volts
D-C Plate Current	0.390	0.340	0.240	ampere
D-C Grid Current, approximate	0.070	0.065	0.035	ampere
Driving Power, approximate	35	35	20	watts
Power Output, approximate	550	780	550	watts

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR—CLASS C TELEGRAPHY

Key-down conditions per tube without amplitude modulation[8]

MAXIMUM RATINGS, ABSOLUTE VALUES

	CCS	
D-C Plate Voltage	4000	volts
D-C Grid Voltage	—500	volts
D-C Plate Current	0.500	ampere
D-C Grid Current	0.100	ampere
Plate Input	1800	watts
Plate Dissipation	400	watts

TYPICAL OPERATION

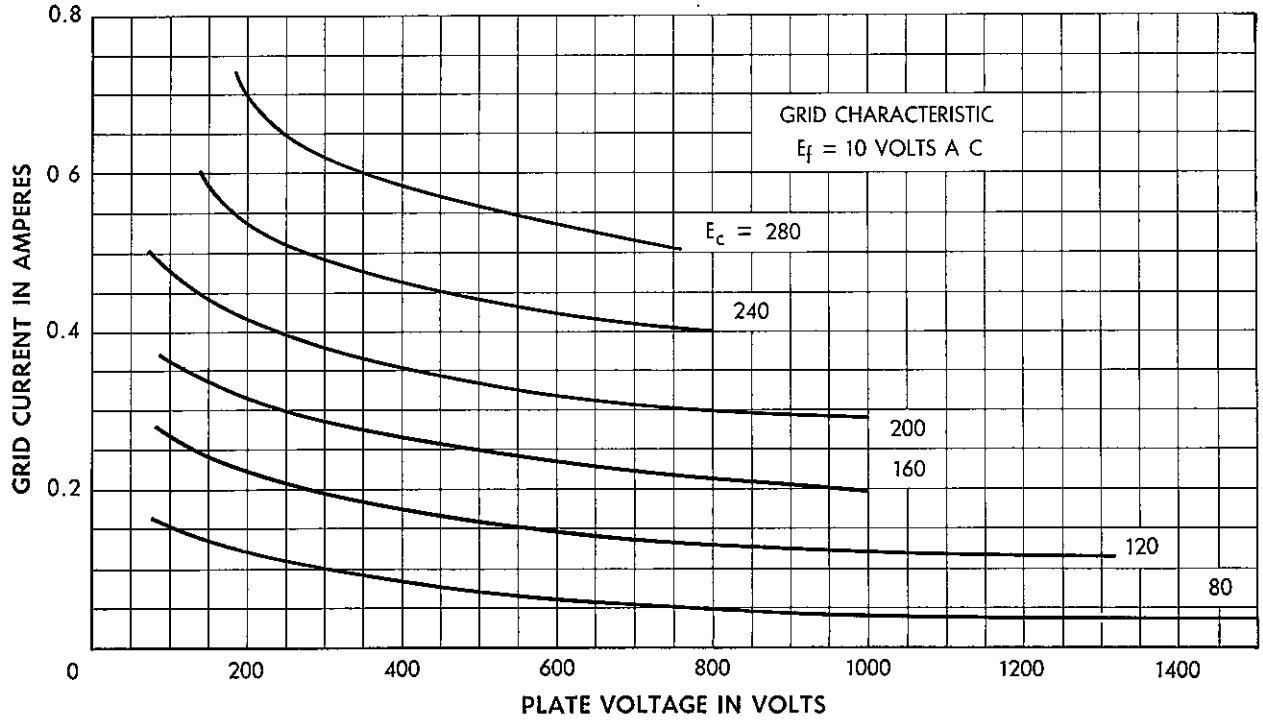
	CCS	CCS	
D-C Plate Voltage	2000	3500	volts
D-C Grid Voltage	—200	—240	volts
Peak R-F Grid Voltage	445	460	volts
D-C Plate Current	0.500	0.450	ampere
D-C Grid Current, approximate	0.085	0.070	ampere
Driving Power, approximate	35	30	watts
Power Output, approximate	780	1200	watts

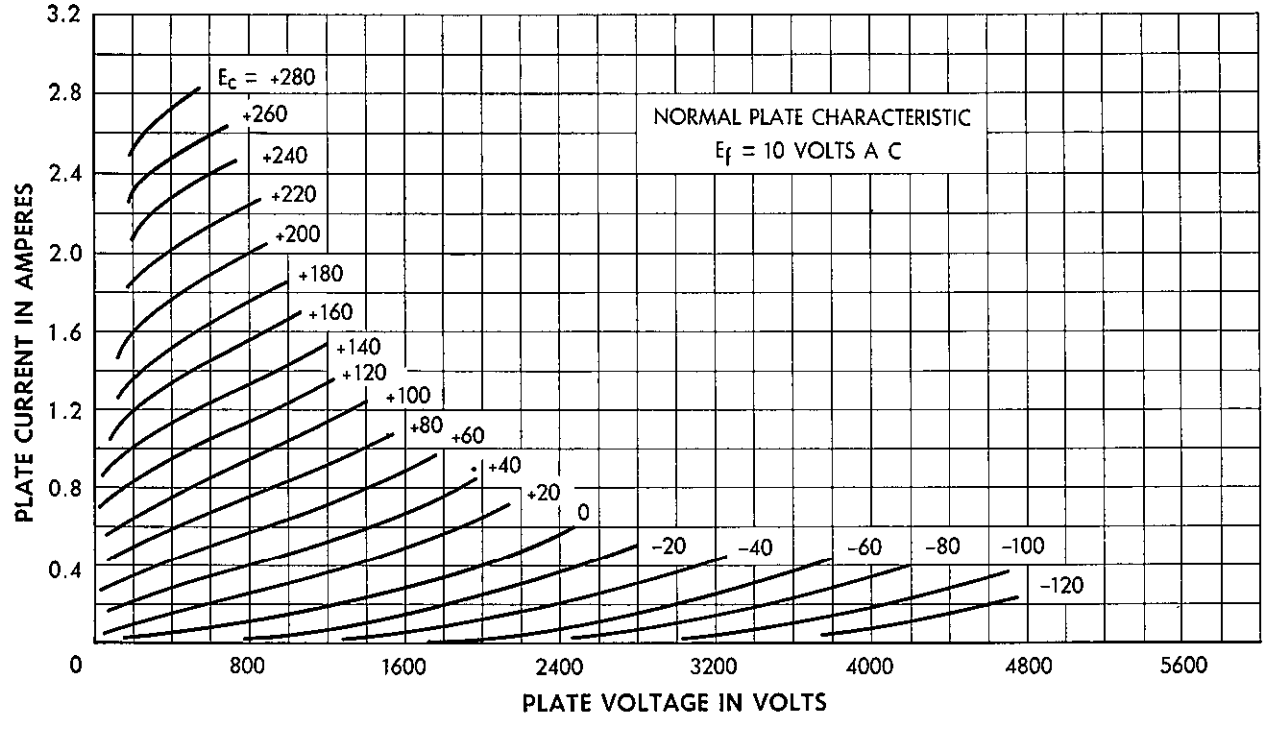
Maximum ratings apply up to 100 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below. Other maximum ratings are not affected. Forced-air cooling of the envelope with an air flow of approximately 40 cfm is required at these frequencies.

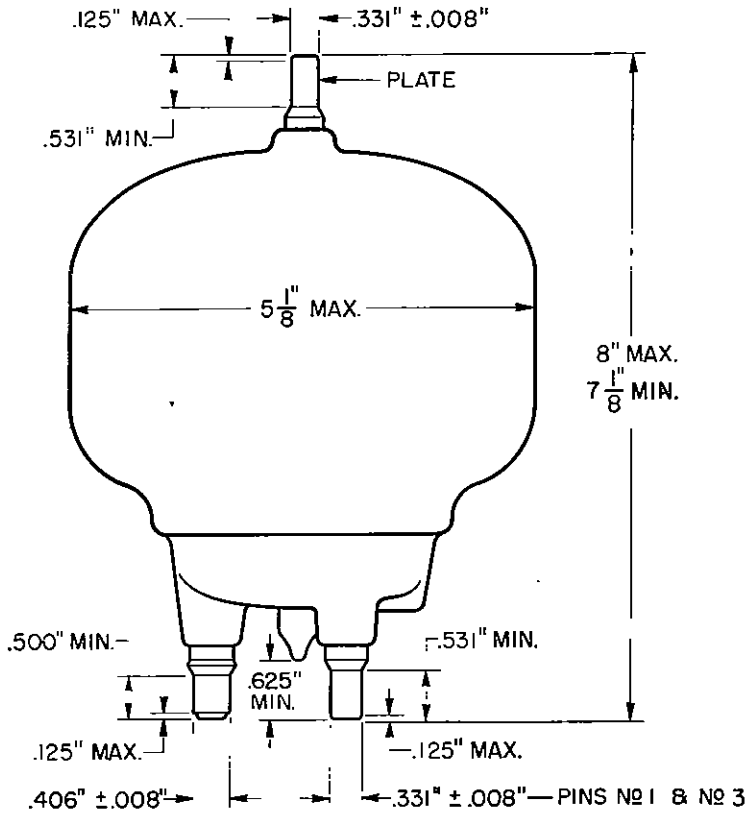
Frequency	100	125	150	megacycles
Percentage of maximum rated plate voltage and plate input.				
Class B	100	85	70	per cent
Class C, plate modulated	100	75	50	per cent
Class C, unmodulated	100	80	60	per cent

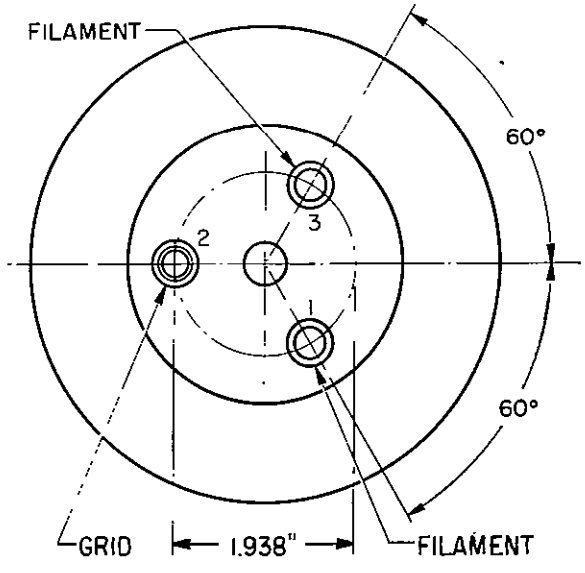
*. For 500 watt broadcast transmitter application.

8. Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of its unmodulated value.


GRID CHARACTERISTIC
E_f = 10 VOLTS A C
E_c = 280
240
200
160
120
80
GRID CURRENT IN AMPERES
0.8
0.6
0.4
0.2
0
200
400
600
800
1000
1200
1400
PLATE VOLTAGE IN VOLTS


NORMAL PLATE CHARACTERISTIC
E_f = 10 VOLTS A C
E_c = +280
+260
+240
+220
+200
+180
+160
+140
+120
+100
+80
+60
+40
+20
0
-20
-40
-60
-80
-100
-120
PLATE CURRENT IN AMPERES
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
800
1600
2400
3200
4000
4800
5600
PLATE VOLTAGE IN VOLTS



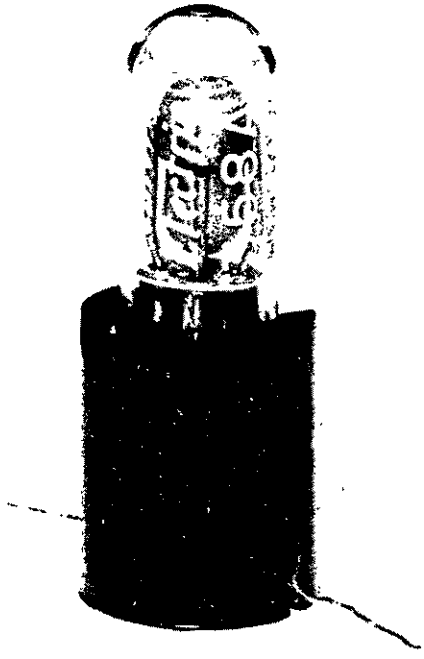


Note:
Base pin positions shall be held to tolerances such that pins will fit a flat - plate gauge having a thickness of .250" with 2 holes of .391" ± .0005" dia. and 1 hole of .469" ± .0005" dia. All holes shall be located on a 1.938" ± .0005" dia. circle at specified centers.

Western Electric A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 358A ELECTRON TUBE



DESCRIPTION

The 358A is a two-electrode, inert-gas-filled, cold cathode tube designed to provide a visual signal for telephone work. When the tube is conducting, a glow will appear near the surface of the negative electrode. If a d.c. voltage supply is used the negative polarity should be applied to the upper electrode. The upper electrode terminal may be identified by the adjacent circular dot of contrasting color on the base. When the tube is operating with an alternating voltage a glow will appear on both electrodes.

CHARACTERISTICS

Anode Breakdown Voltage, Maximum			85	volts
Average Cathode Current.	7.5	10	18	milliamperes
Average Life, (approx. at above currents) . . .	5000	1000	100	hours

File: Cold Cathode Section

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RATINGS, Absolute System (Note 1)

Cathode Currents	
Maximum Peak	55 milliamperes
Maximum Average	18 milliamperes
Ambient Temperature Limits	-55 to +85° centigrade

ELECTRICAL DATA, Throughout Life (Note 2)

	Min.	Bogey	Max.	
Anode Breakdown Voltage	-	65	85	volts
Anode Voltage Drop	-	60	75	volts
Light Output at 15 mAdc	-	0.6	-	lumen

MECHANICAL DATA

Mounting Position . . . . . Any

Dimensions and terminal connections shown in outline drawing on page 3.

APPLICATION DATA

This tube possesses a unique property not common to filamentary type lamps in that its impedance is essentially infinite for voltages below breakdown. In some applications this is an advantageous feature since the tube may be used to pass current at the higher potentials without placing a conducting path across the line for signals of lower voltage.

Unlike filamentary type lamps the light output of this tube is proportional to the current through the tube instead of varying as a power of this current. This tube is well adapted to furnishing a visual signal from a varying voltage source.

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

Note 2: When the tube is operating from a direct current supply, the upper electrode shall be used as the cathode.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

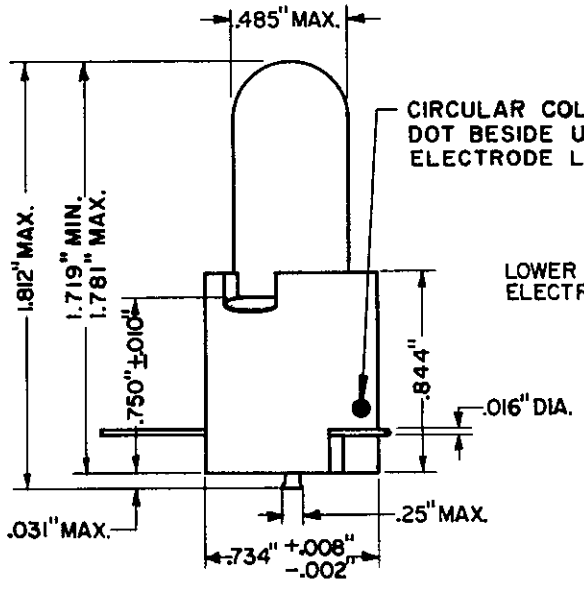


FIG. 1

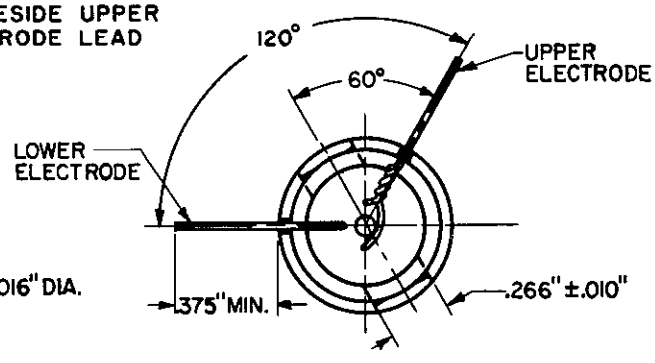


FIG. 2

A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

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Western Electric Company

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 359A ELECTRON TUBE



DESCRIPTION

The 359A is a three-electrode, inert-gas-filled, cold cathode tube for use primarily as a relay in communication circuits. It is also suitable for use in control circuits such as in triggering, counting or switching apparatus and as a visual indicator. This tube, by reason of small size and provision for wiring directly into the circuits, may be used to advantage in equipment having limited space for components.

CHARACTERISTICS

Peak Anode Voltage, Maximum	165	165	volts
Average Cathode Current	4	40	milliamperes
Average Life, Approximate	10000	10	hours

FILE: COLD CATHODE SECTION

Indicates a change←

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MAXIMUM RATINGS, Absolute System (Note 1)

Peak Anode Voltage (Note 2)		
Forward	165	volts
Inverse	165	volts
Forward Cathode Current (Note 3)		
Peak	40	milliamperes
Average	15	milliamperes
Averaging Time	1	second
Peak Inverse Current, Anode or Starter (Note 3)	1	milliampere
Ambient Temperature Limits	-55° to +85°	centigrade

ELECTRICAL DATA (Throughout Life)

	Min.	Bogey	Max.	
Starter Breakdown Voltage (Notes 2 & 4)	67	80	89	volts
Starter Voltage Drop at 10 Milliamperes	52	65	74	volts
Anode Voltage Drop at 10 Milliamperes	66	80	90	volts
Transfer Current	See curve, Figure 1			
Required Transfer Current at 130 Anode Volts	50	-	-	microamperes
Deionization Time, Main Gap	-	1	-	millisecond
Ionization Time, Starter Gap (Note 5)	-	0.05	-	millisecond

MECHANICAL DATA

Mounting Position		Any
New Weight, Approximate	0.4	ounce

Dimensions and lead connections shown in outline drawings on page 4.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

→ Indicates a change

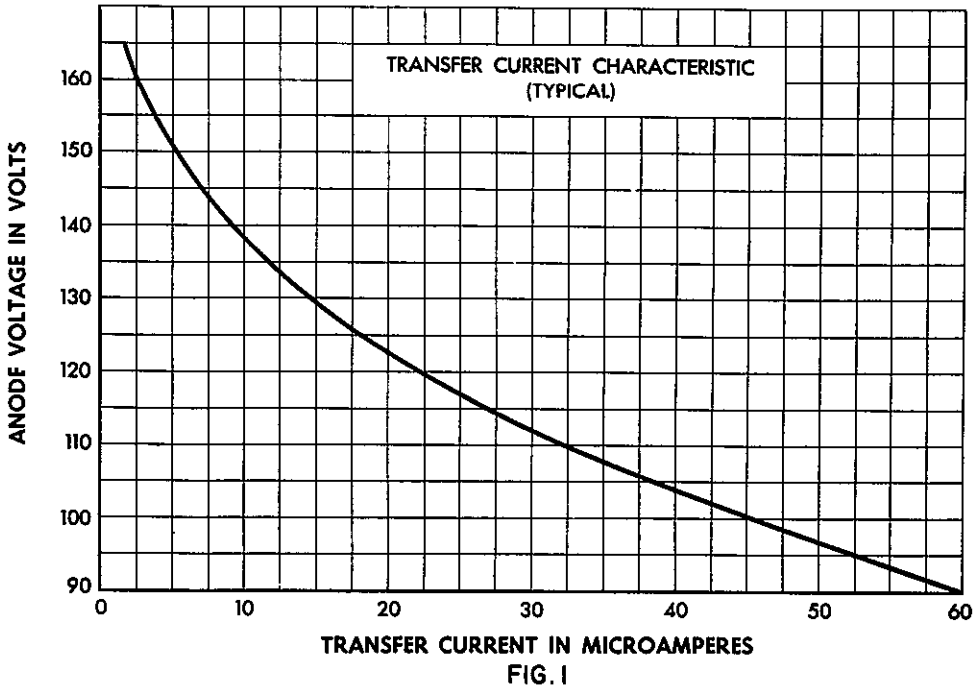


FIG. 1

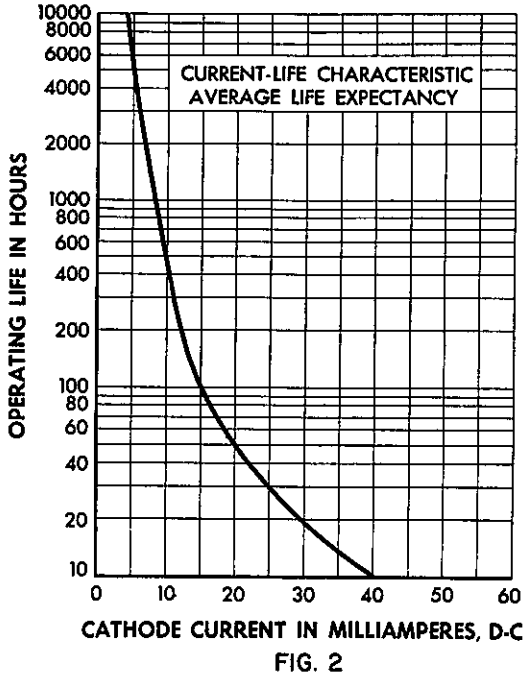


FIG. 2

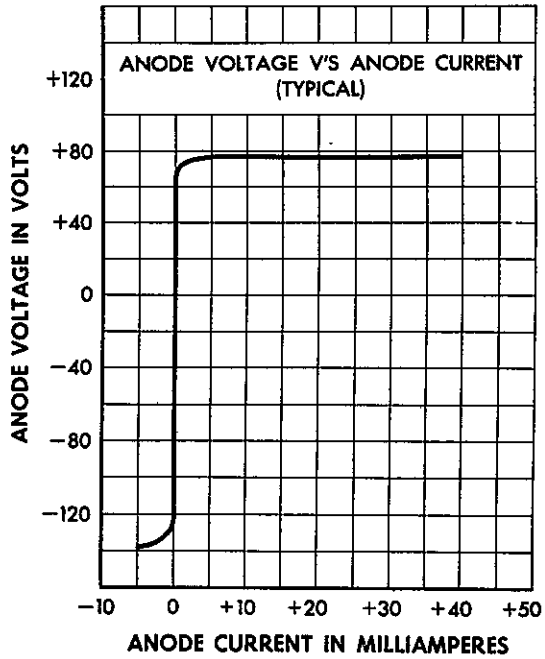


FIG. 3

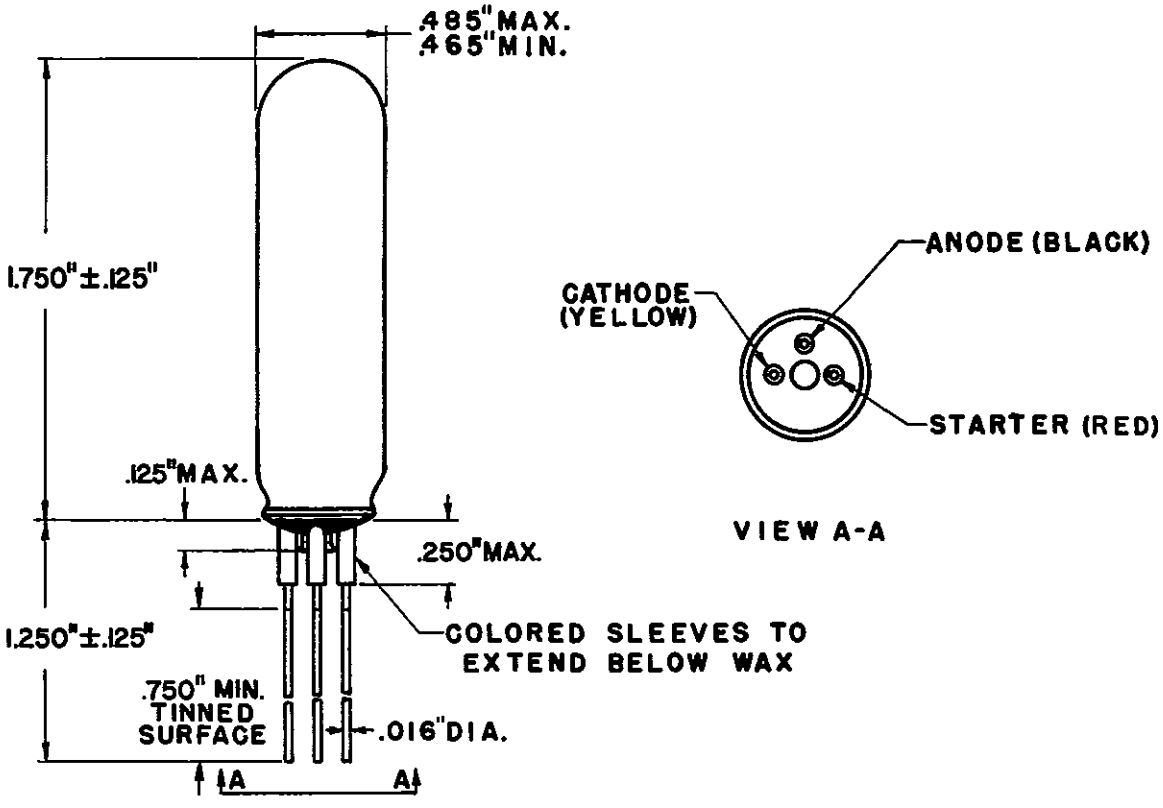
Note 2: Values apply with the tube exposed to light in the order of 5 to 30 foot-candles. Exposure to direct sunlight may reduce peak anode voltage rating by as much as 45 volts and starter breakdown voltage by as much as 2 volts.

Note 3: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed the maximum rated valves.

Note 4: Limits apply immediately after the tube has conducted current. If the tube has been idle, initially these values may be as much as 3 volts higher or lower.

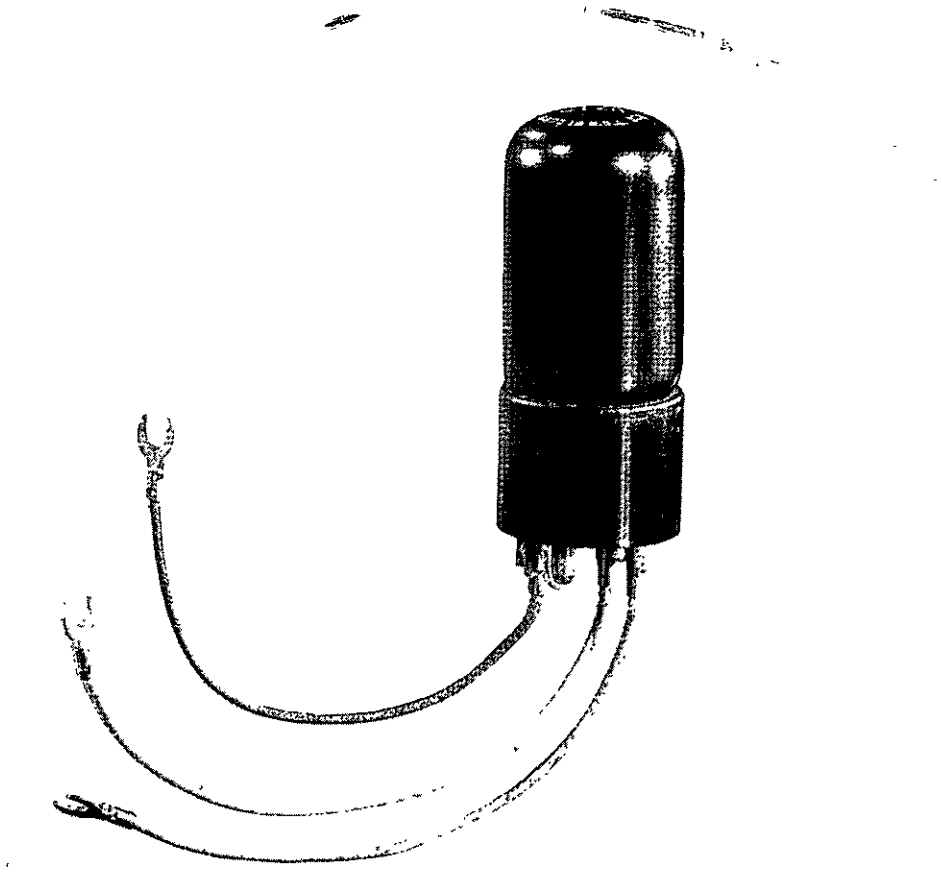
Note 5: With 15 volts starter overvoltage. This value applies with the tube exposed to light in the order of 5 to 30 foot-candles. In darkness, ionization time will increase to a bogey value of 5 milliseconds.

← Indicates a change



A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

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COLD CATHODE

Western Electric

DESCRIPTION

The 372A is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator, or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus.

MAXIMUM RATINGS

Peak Anode Voltage		150 volts
Average Cathode Current	10	100 milliamperes
Average Life, approximate	10000	10 hours
Transfer Current		5 microamperes

MAXIMUM RATINGS, Absolute Values

Forward Peak Anode Voltage	150	volts
Forward Cathode Current		
Peak	100	milliamperes
Average	35	milliamperes
Averaging Time	2	seconds
Peak Inverse Anode Current	5	milliamperes
Ambient Temperature Limits	−55 to +85	centigrade

ELECTRICAL DATA

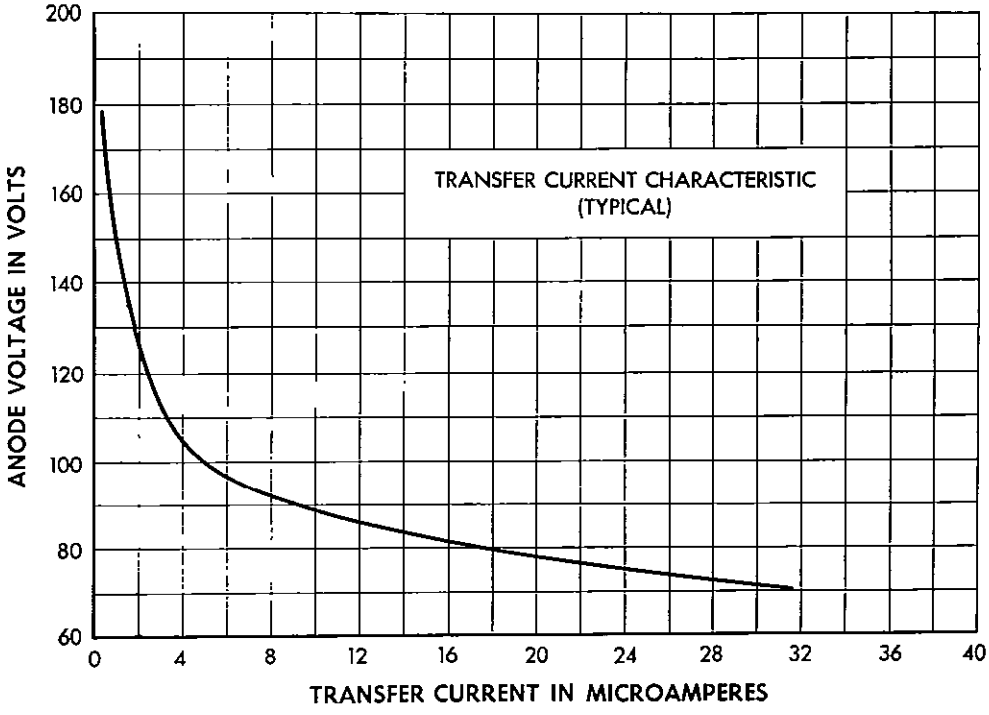
	Min.	Bogey	Max.	
Starter Breakdown Voltage*	62	70	89	volts
Starter Voltage Drop at 20 milliamperes	52	60	74	volts
Anode Voltage Drop at 20 milliamperes	68	75	90	volts
Transfer Current at 130 Anode Volts (D.C.)	5			microamperes
Deionization Time, approximate				
Starter Gap		3		milliseconds
Main Gap		10		milliseconds
Inverse Current at −120 Volts Anode Potential**			3	milliamperes

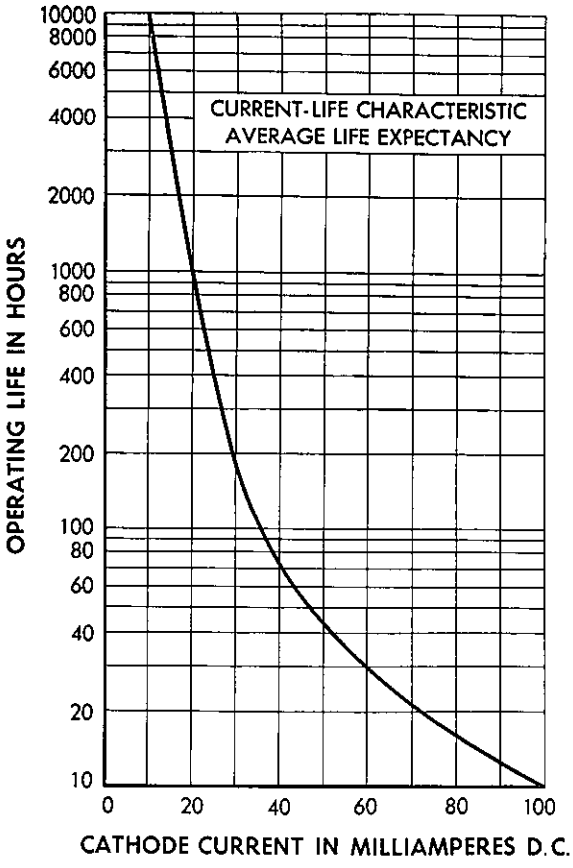
MECHANICAL DATA

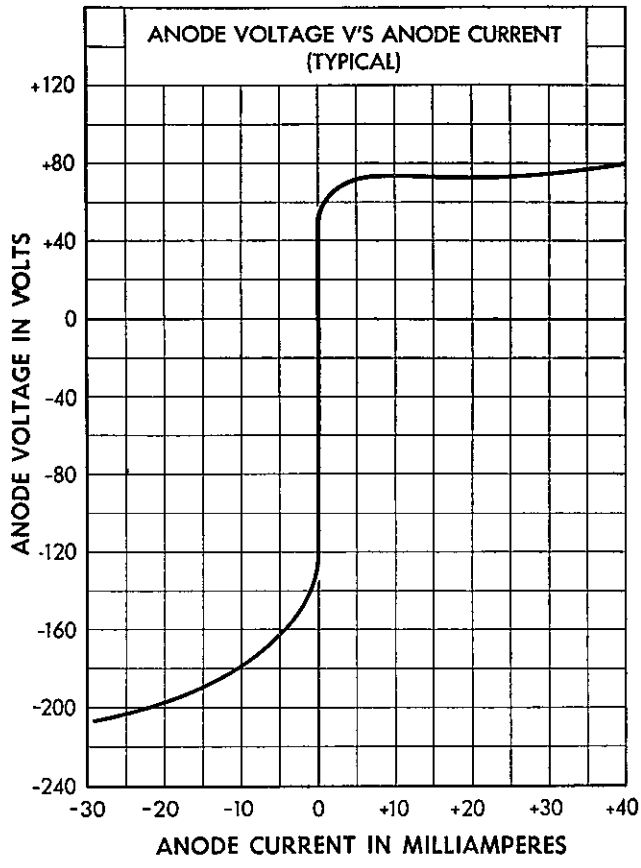
Mounting Position	Any	
Net Weight, approximate	1	ounce

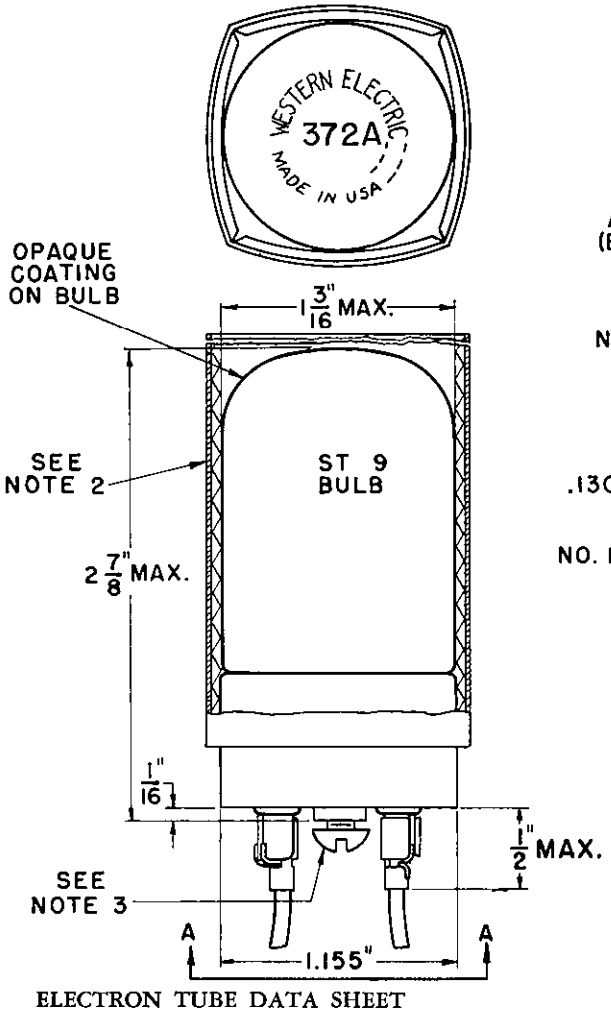
* Limits apply immediately after tube has conducted current. If tube has been idle, these values initially may be as much as 3 volts higher or lower.

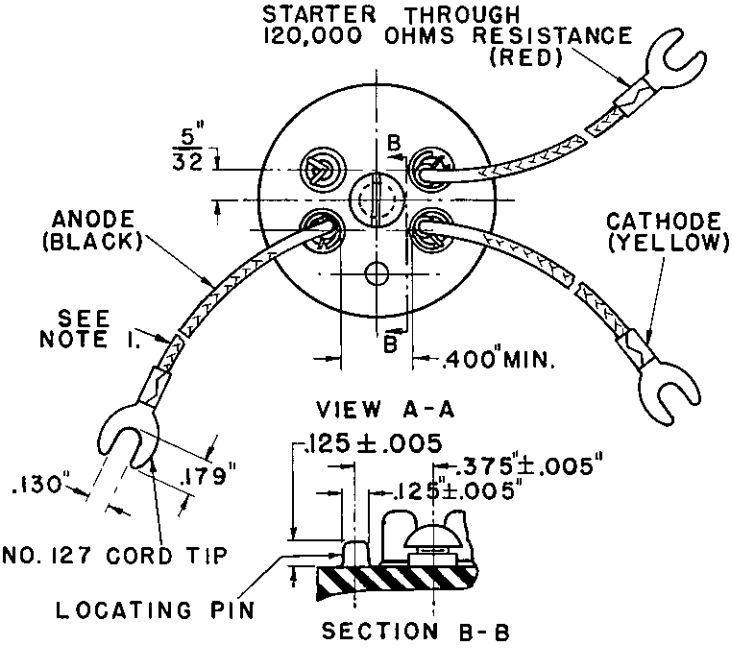
** Negative anode voltage applied through 8,000 ohms. Starter connected to anode through 100,000 ohms.











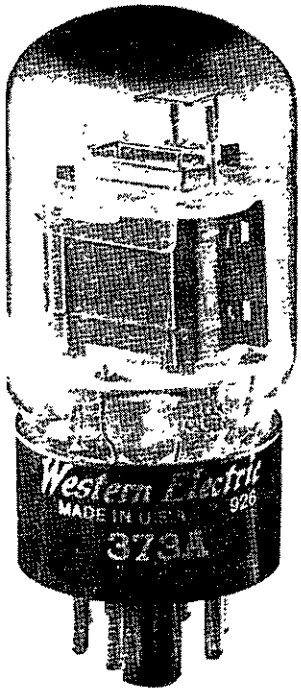
NOTES –

1. LENGTH OF LEADS FROM END OF BASE SHELL TO END OF SPADE $5" \pm \frac{3}{4}"$
2. TUBE SHIPPED WITH CORRUGATED PAPER SHOCK PROTECTIVE SLEEVE COVERING ENVELOPE AND PART OF BASE. SLEEVE SHOULD REMAIN ON TUBE WHEN INSTALLED IN TELEPHONE SET APPLICATIONS.
3. THE .164-32 × $\frac{3}{16}"$ SCREW ALLOWS FOR MOUNTING ON A BRACKET $\frac{3}{64}"$ THICK. (SCREW NOT SUPPLIED WITH TUBE.)

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1-1—50—7 PRINTED IN U.S.A. WECO—T2677



PENTODE

Western Electric

DESCRIPTION

The 373A is a filamentary type suppressor grid pentode. It is designed for use as an audio, carrier or radio-frequency voltage amplifier, oscillator or modulator.

CHARACTERISTICS

Filament Voltage, A-C		2.0 volts
Plate Current	$E_b = E_{c2} = 150$ volts;	2 milliamperes
Transconductance	$E_{c1} = -3$ volts; $E_{c3} = 0$	1280 micromhos

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Filament Voltage, A-C	2.0 volts
Filament Current	250 milliamperes
Direct Interelectrode Capacitances	
Grid to Plate (maximum)	0.07 uuf
Input	5.9 uuf
Output	5.0 uuf

MECHANICAL DATA

Cathode	Coated Filament
Bulb	T11
Base[1]	Short intermediate shell, 7-pin octal
Mounting Position	Vertical — or horizontal with plane of filament vertical.

Dimensions and pin connections shown in outline drawing on Page 4

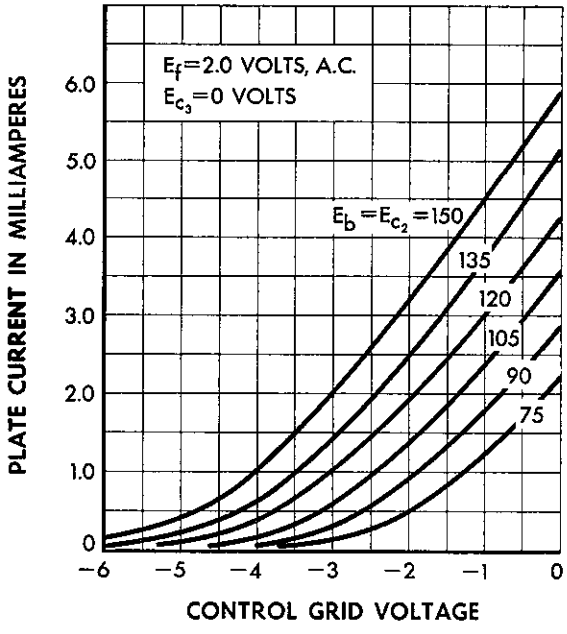
MAXIMUM RATINGS, Design-Center Values

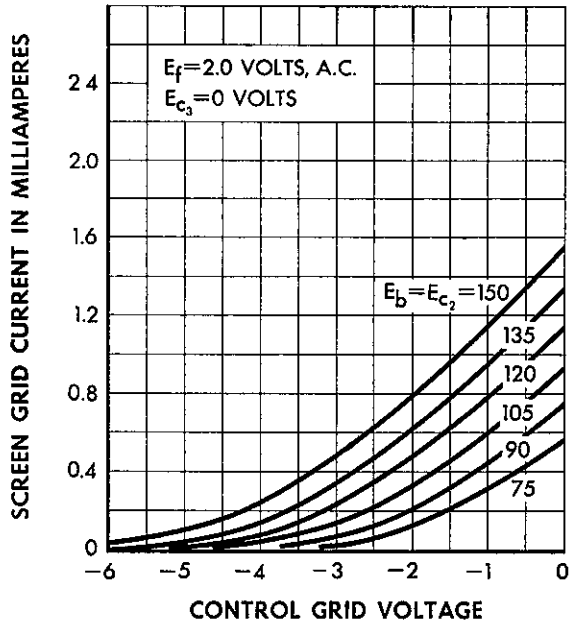
Plate Voltage	250 volts
Screen Grid Voltage	150 volts
Plate Dissipation	2 watts
Screen Grid Dissipation	0.45 watt

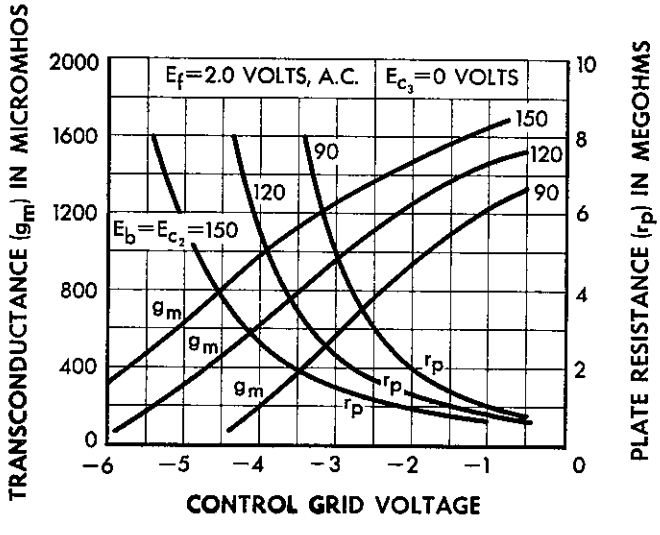
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

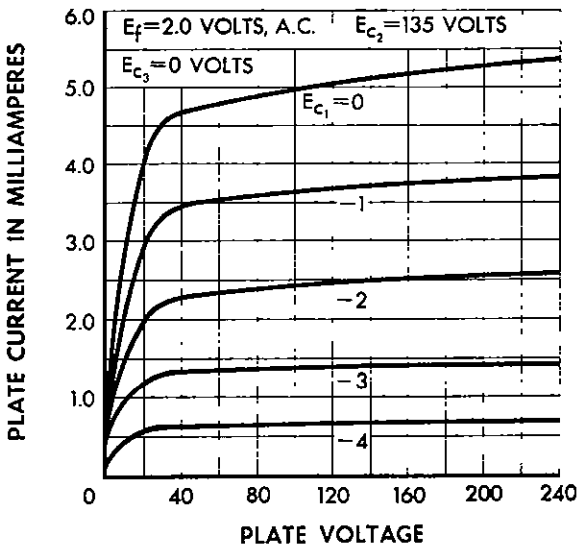
Filament Voltage, A-C	2.0	2.0	volts
Plate Voltage	150	250	volts
Screen Grid Voltage	150	150	volts
Control Grid Voltage	−3	−3	volts
Suppressor Grid Voltage	0	0	volts
Plate Current	2.0	2.1	milliamperes
Screen Grid Current	0.47	0.45	milliampere
Peak A-F Signal Voltage	2	2	volts
Plate Resistance	1.5	2.0	megohms
Transconductance	1280	1310	micromhos
Load Resistance	100000	250000	ohms
Power Output	120	160	milliwatts
Total Harmonic Distortion	8.5	7.8	per cent
Control Grid Voltage, Approximate, for 10 Microamperes Plate Current	−7.0	−7.4	volts

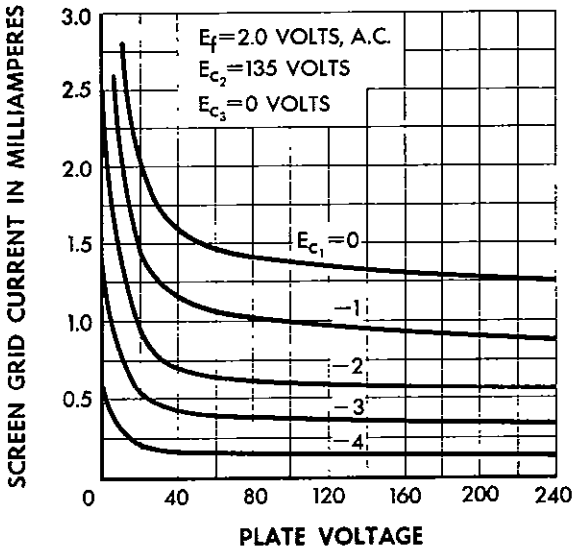
1. Pin #6 is connected internally to pin #5 and is approximately 3/32 inch shorter than the other pins to minimize noise when changing tubes while in service.

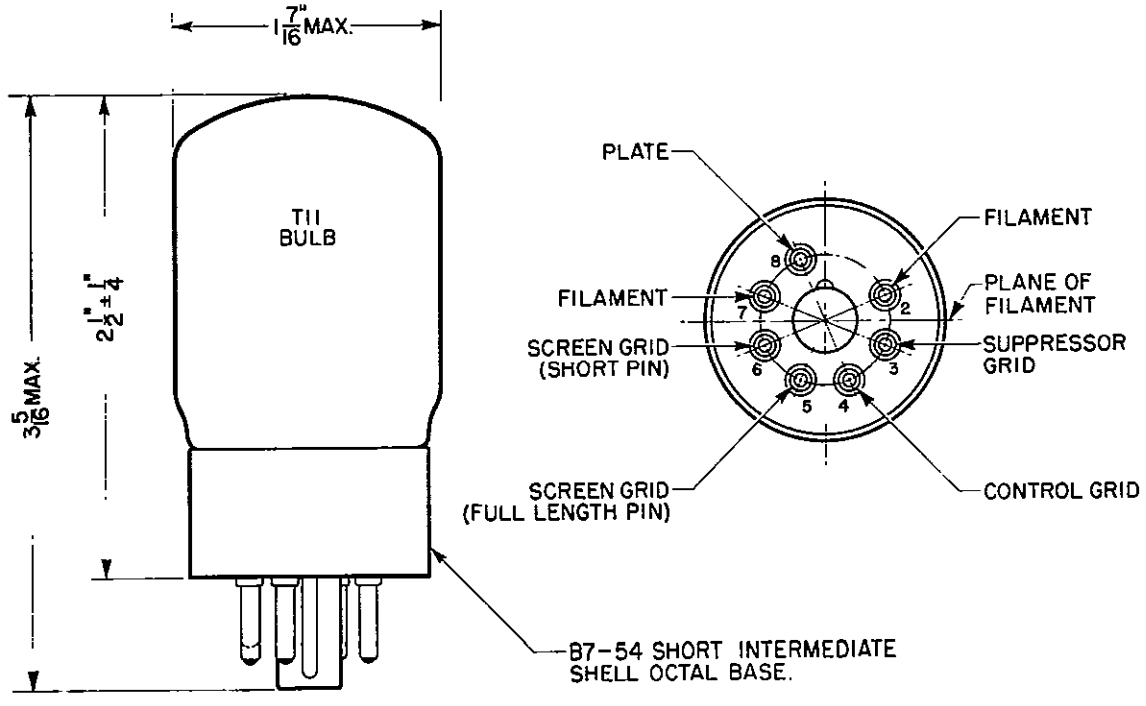

PLATE CURRENT IN MILLIAMPERES
E_f=2.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
E_b=E_{c_2}=150
135
120
105
90
75
6.0
5.0
4.0
3.0
2.0
1.0
0
−6 −5 −4 −3 −2 −1 0
CONTROL GRID VOLTAGE


SCREEN GRID CURRENT IN MILLIAMPERES
E_f=2.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
E_b=E_{c_2}=150
135
120
105
90
75
2.4
2.0
1.6
1.2
0.8
0.4
0
−6 −5 −4 −3 −2 −1 0
CONTROL GRID VOLTAGE


TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN MEGOHMS
E_f=2.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
E_b=E_{c_2}=150
150
120
90
120
90
g_m
g_m
g_m
r_p
r_p
r_p
2000
1600
1200
800
400
0
10
8
6
4
2
0
−6 −5 −4 −3 −2 −1 0
CONTROL GRID VOLTAGE







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PENTODE

Western Electric

DESCRIPTION

The 374A is a filamentary type suppressor grid power pentode. It is designed for use as an audio-frequency power amplifier or as an oscillator.

CHARACTERISTICS

Filament Voltage, A-C		3.0 volts
Plate Current	$E_b = E_{c2} = 150$ volts;	24 milliamperes
Transconductance	$E_{c1} = -18$ volts; $E_{c3} = 0$	3400 micromhos
Power Output		2.0 watts

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Filament Voltage, A-C	3.0 volts
Filament Current	0.53 ampere
Direct Interelectrode Capacitances	
Grid to Plate	0.18 uuf
Input	9.2 uuf
Output	6.5 uuf

MECHANICAL DATA

Cathode	Coated Filament
Bulb	T11
Base[1]	Short intermediate shell, 7-pin octal
Mounting Position	Vertical — or horizontal with plane of filament vertical.

Dimensions and pin connections shown in outline drawing on Page 6

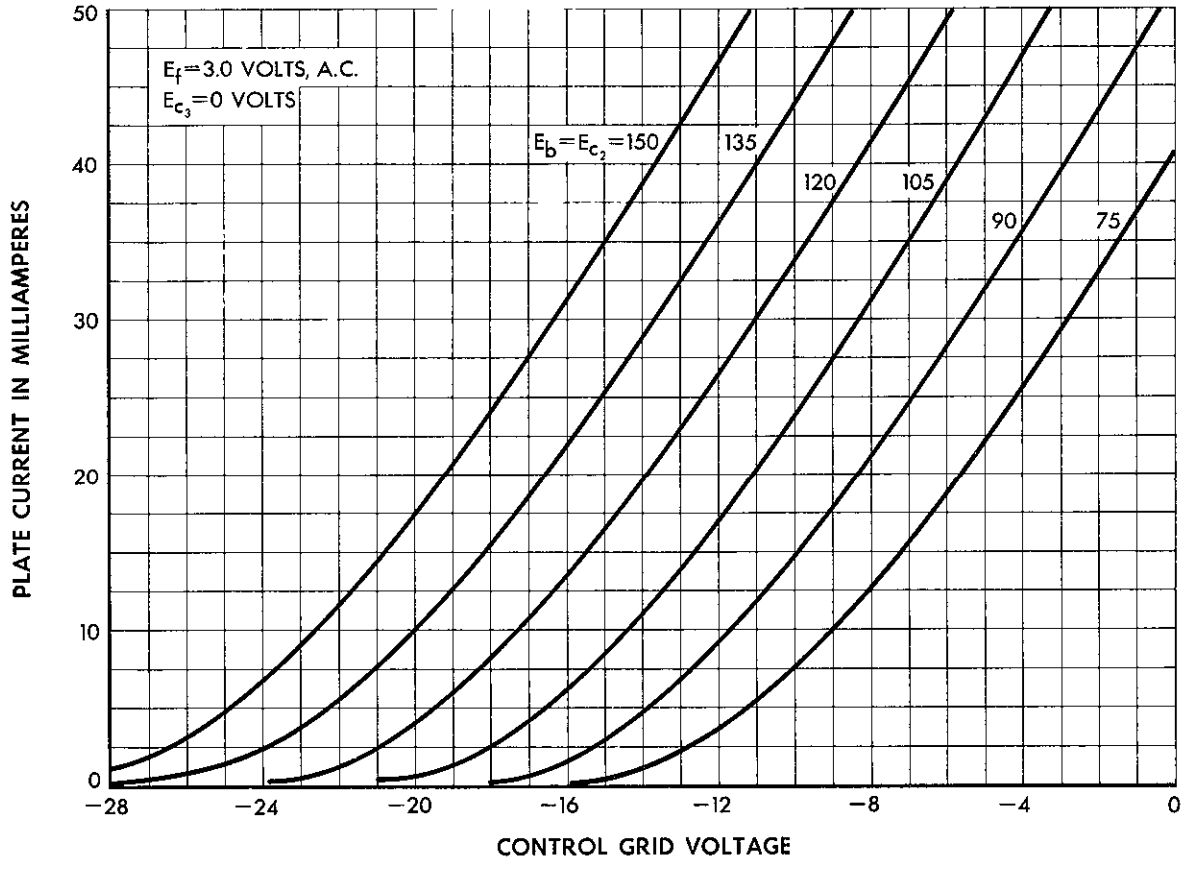
MAXIMUM RATINGS, Design-Center Values

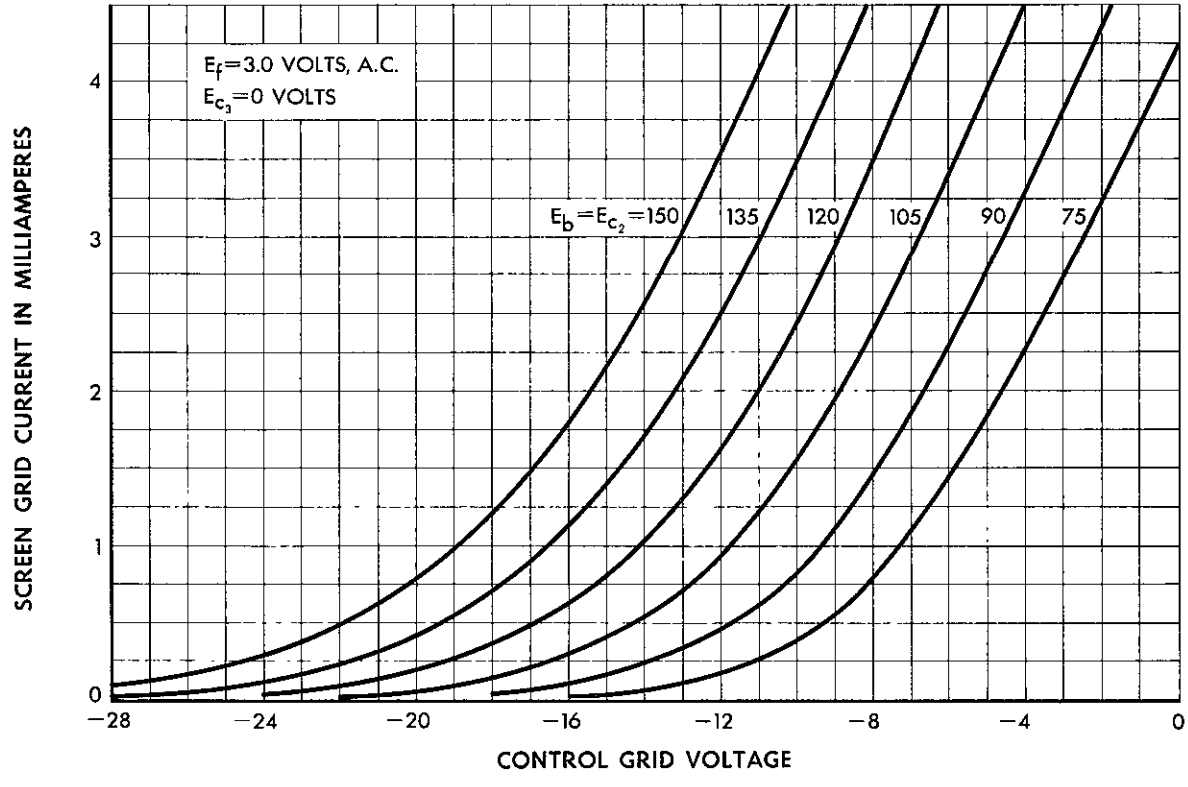
Plate Voltage	150 volts
Screen Grid Voltage	150 volts
Plate Dissipation	4.8 watts
Screen Grid Dissipation	1.0 watt

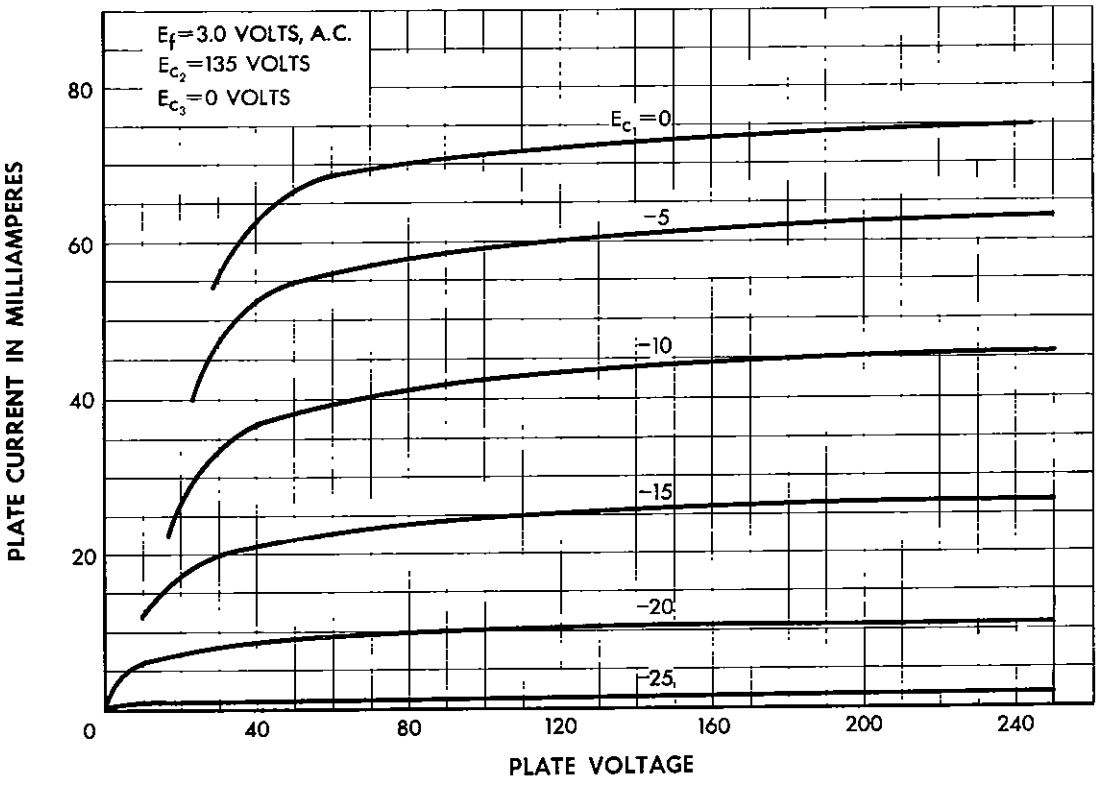
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

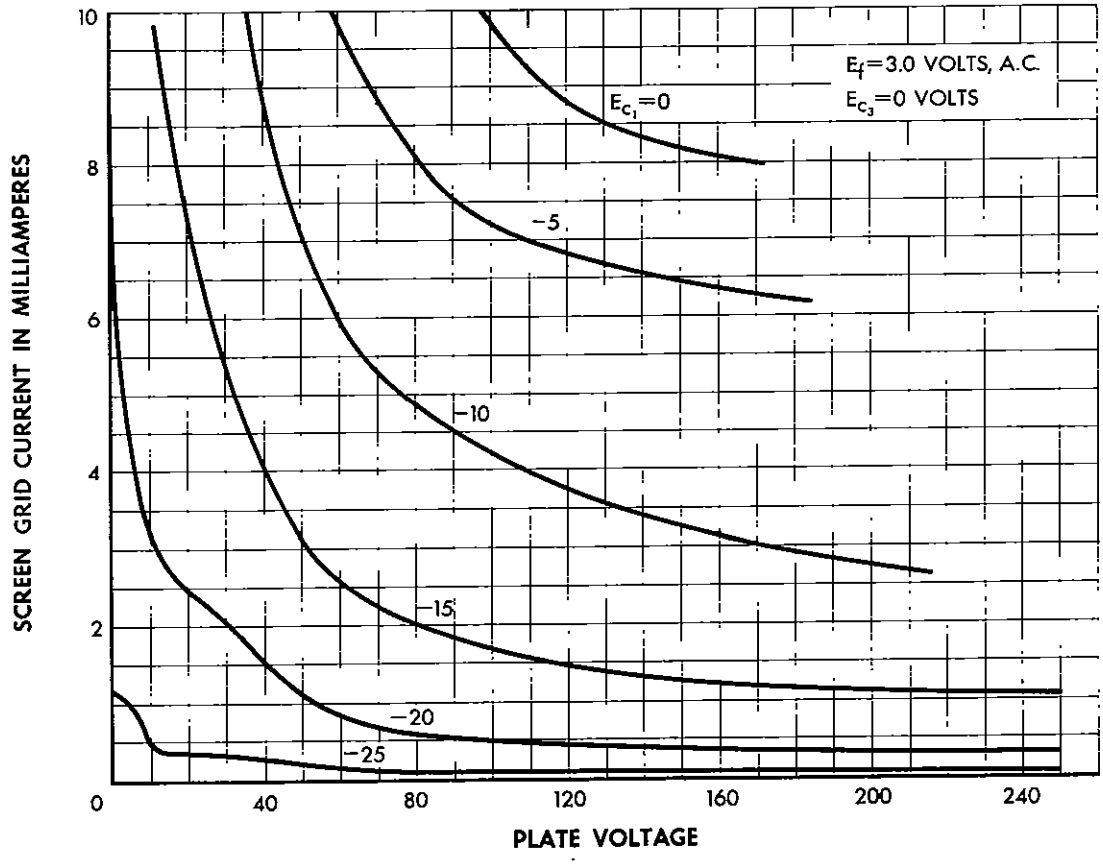
Filament Voltage, A-C	3.0	3.0	volts
Plate Voltage	135	150	volts
Screen Grid Voltage	135	150	volts
Control Grid Voltage	—16	—18	volts
Suppressor Grid Voltage	0	0	volts
Peak A-F Grid Voltage	12	12	volts
Zero Signal Plate Current	22	24	milliamperes
Maximum Signal Plate Current	24.5	26	milliamperes
Zero Signal Screen Grid Current	1.1	1.2	milliamperes
Maximum Signal Screen Grid Current	5.5	4.8	milliamperes
Transconductance	3250	3400	micromhos
Plate Resistance	60000	60000	ohms
Load Resistance	4500	4000	ohms
Maximum Signal Power Output	1.8	2.0	watts
Total Harmonic Distortion	12.5	12.0	per cent

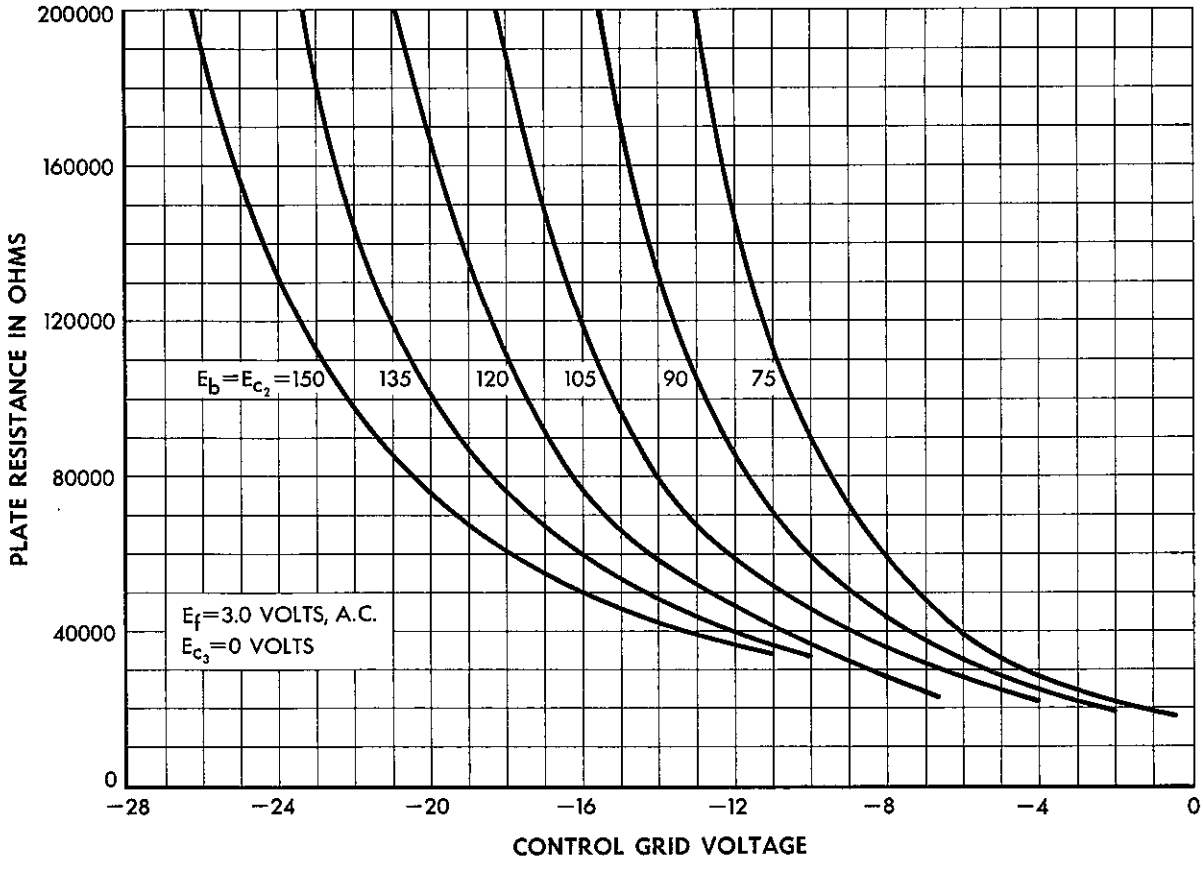
1. Pin # 6 is approximately 3/32 inch shorter than the other pins to minimize noise when changing tubes while in service.

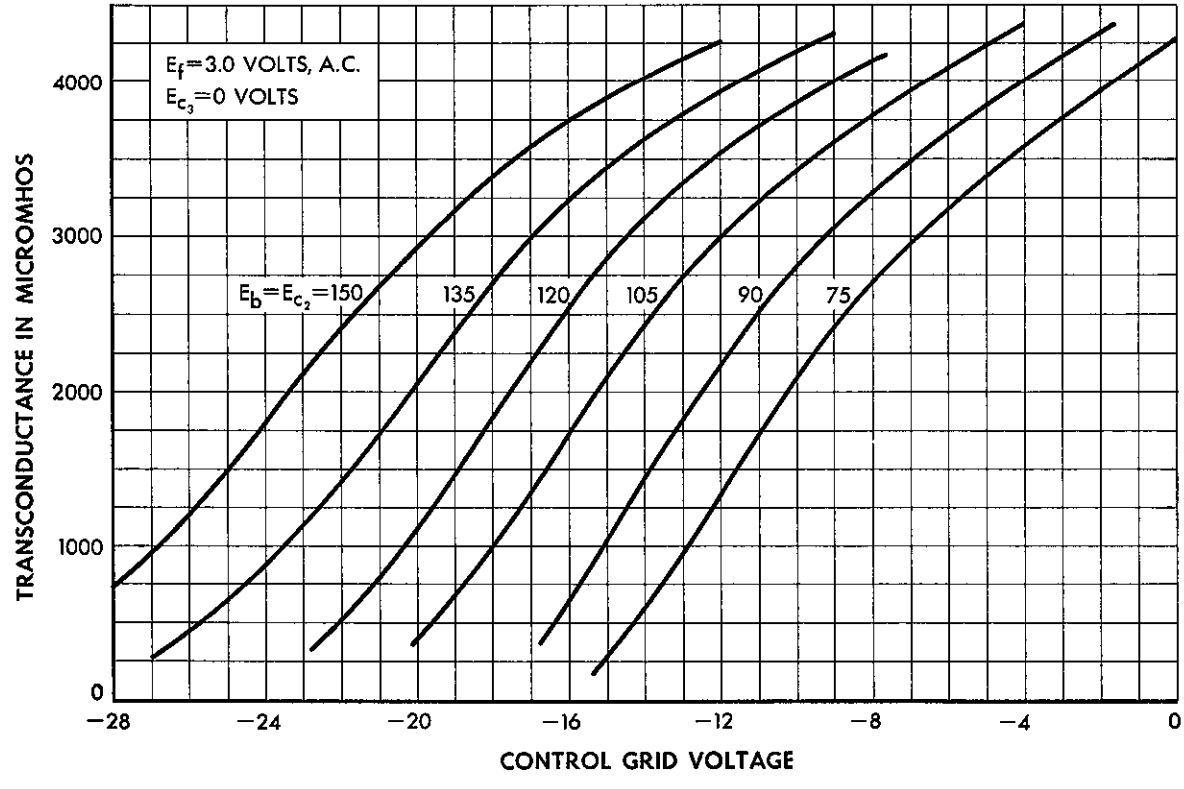

E_f=3.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
E_b=E_{c_2}=150
135
120
105
90
75
PLATE CURRENT IN MILLIAMPERES
50
40
30
20
10
0
−28
−24
−20
−16
−12
−8
−4
0
CONTROL GRID VOLTAGE

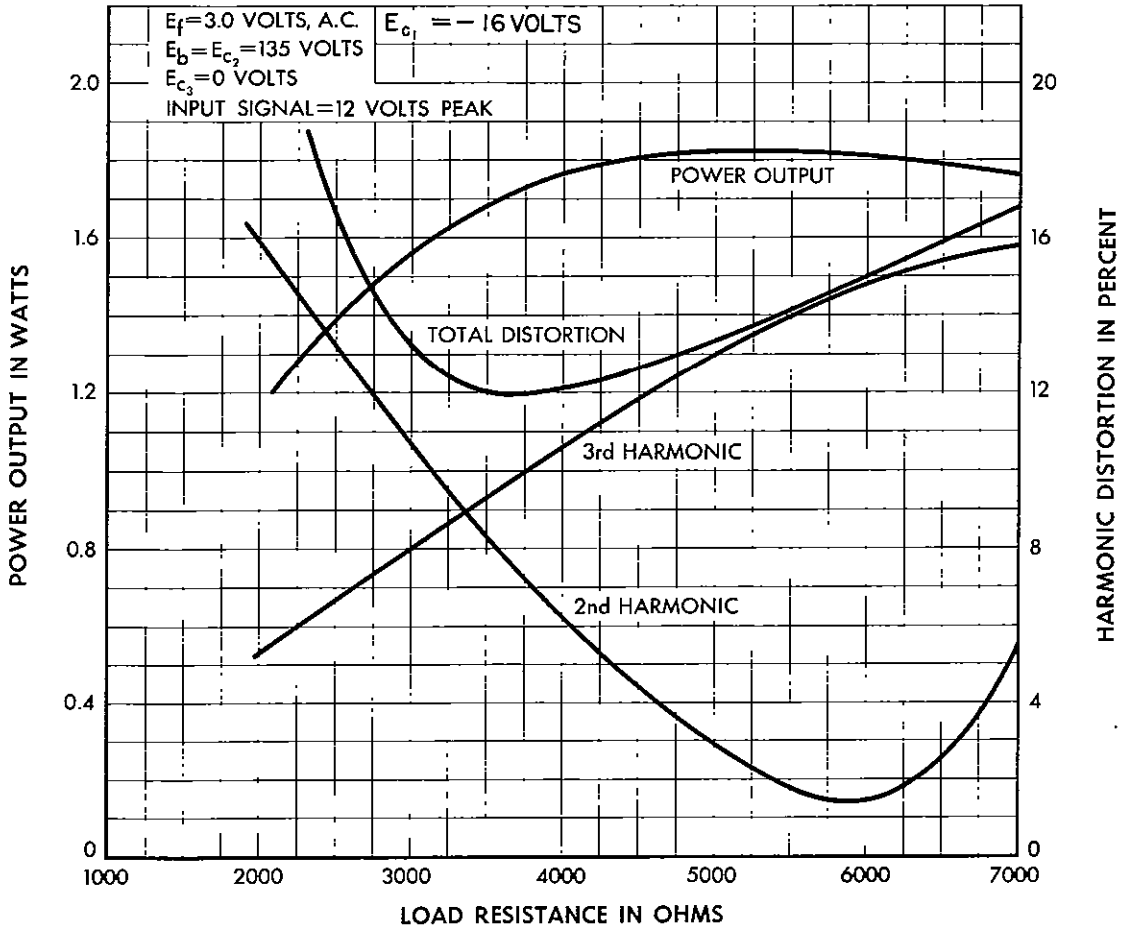

E_f=3.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
E_b=E_{c_2}=150
135
120
105
90
75
SCREEN GRID CURRENT IN MILLIAMPERES
4
3
2
1
0
−28
−24
−20
−16
−12
−8
−4
0
CONTROL GRID VOLTAGE

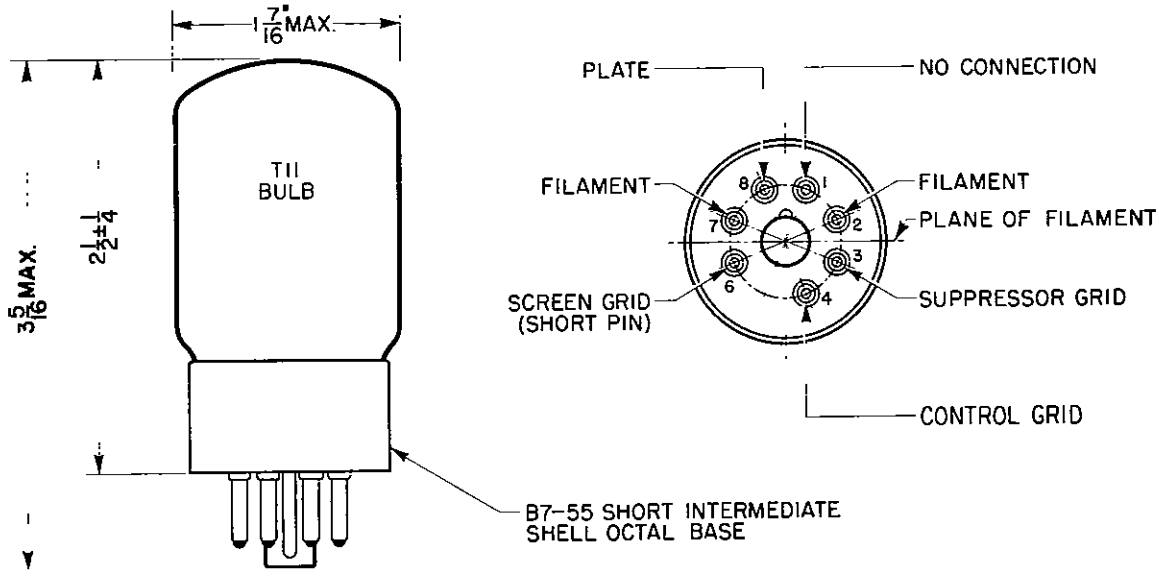

E_f=3.0 VOLTS, A.C.
E_{c_2}=135 VOLTS
E_{c_3}=0 VOLTS
E_{c_1}=0
-5
-10
-15
-20
-25
PLATE CURRENT IN MILLIAMPERES
0
20
40
60
80
40
80
120
160
200
240
PLATE VOLTAGE


E_f=3.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
E_{c_1}=0
-5
-10
-15
-20
-25
SCREEN GRID CURRENT IN MILLIAMPERES
0
2
4
6
8
10
40
80
120
160
200
240
PLATE VOLTAGE


200000
160000
120000
80000
40000
0
PLATE RESISTANCE IN OHMS
$E_b=E_{c_2}$=150
135
120
105
90
75
E_f=3.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
−28
−24
−20
−16
−12
−8
−4
0
CONTROL GRID VOLTAGE


4000
3000
2000
1000
0
TRANSCONDUCTANCE IN MICROMHOS
E_f=3.0 VOLTS, A.C.
E_{c_3}=0 VOLTS
$E_b=E_{c_2}$=150
135
120
105
90
75
−28
−24
−20
−16
−12
−8
−4
0
CONTROL GRID VOLTAGE





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PENTODE

Western Electric

DESCRIPTION

The 375A is a beam power pentode of the heater cathode type. It is designed for use as an audio-frequency amplifier at plate voltages up to 130 volts. It is particularly suitable for use in communication installations where the available plate supply is only 48 volts.

CHARACTERISTICS

Heater Voltage	$E_b = E_c = 45$ volts;	20 volts
Transconductance	$E_{c1} = -4$ volts	4800 micromhos
Power Output	$E_{c1} = -4$ volts	0.25 watt

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Heater Voltage, A-C or D-C	20.0 volts
Heater Current	320 milliamperes
Direct Interelectrode Capacitances (without external shield)	
Grid to Plate	1.0 uuf
Input	13.5 uuf
Output	8.5 uuf

MECHANICAL DATA

Cathode	Coated Unipotential
Bulb	T11
Base	Medium shell, 6-pin octal
Mounting Position	Any

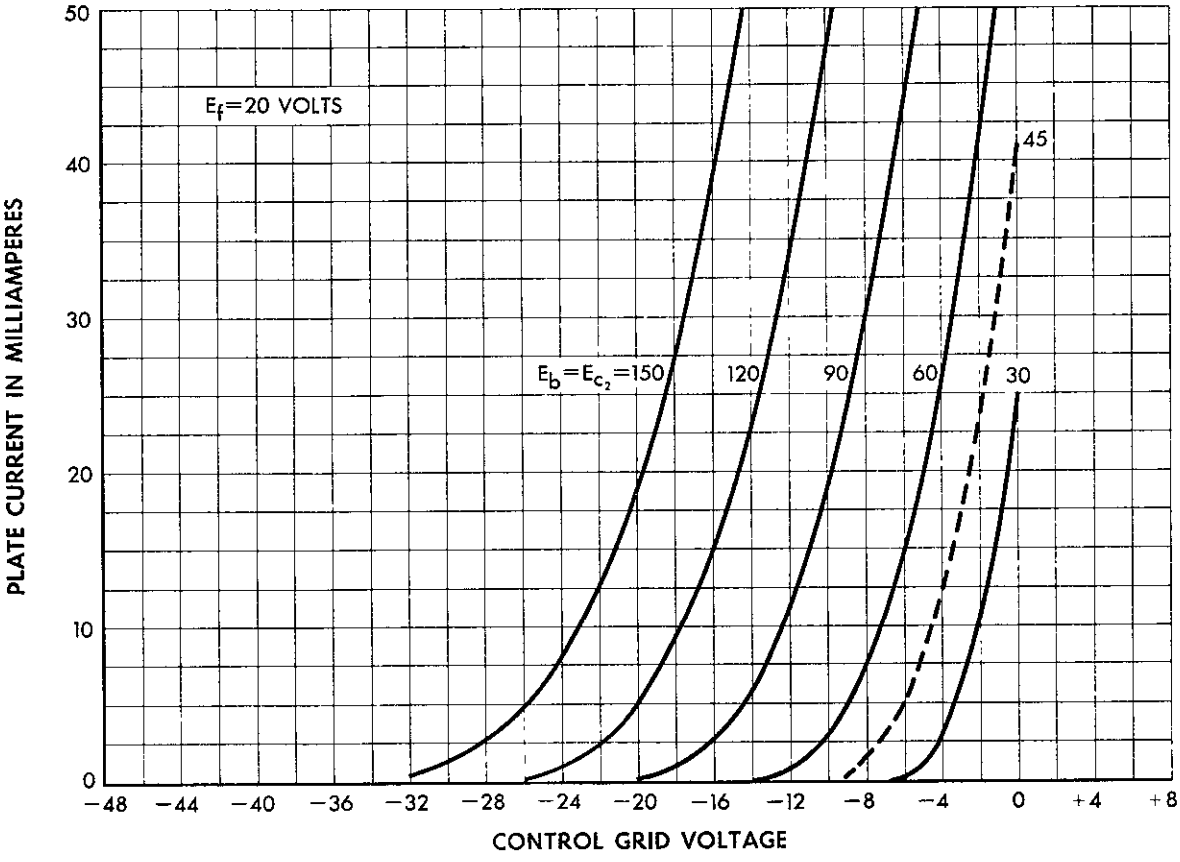
Dimensions and pin connections shown in outline drawing on Page 6

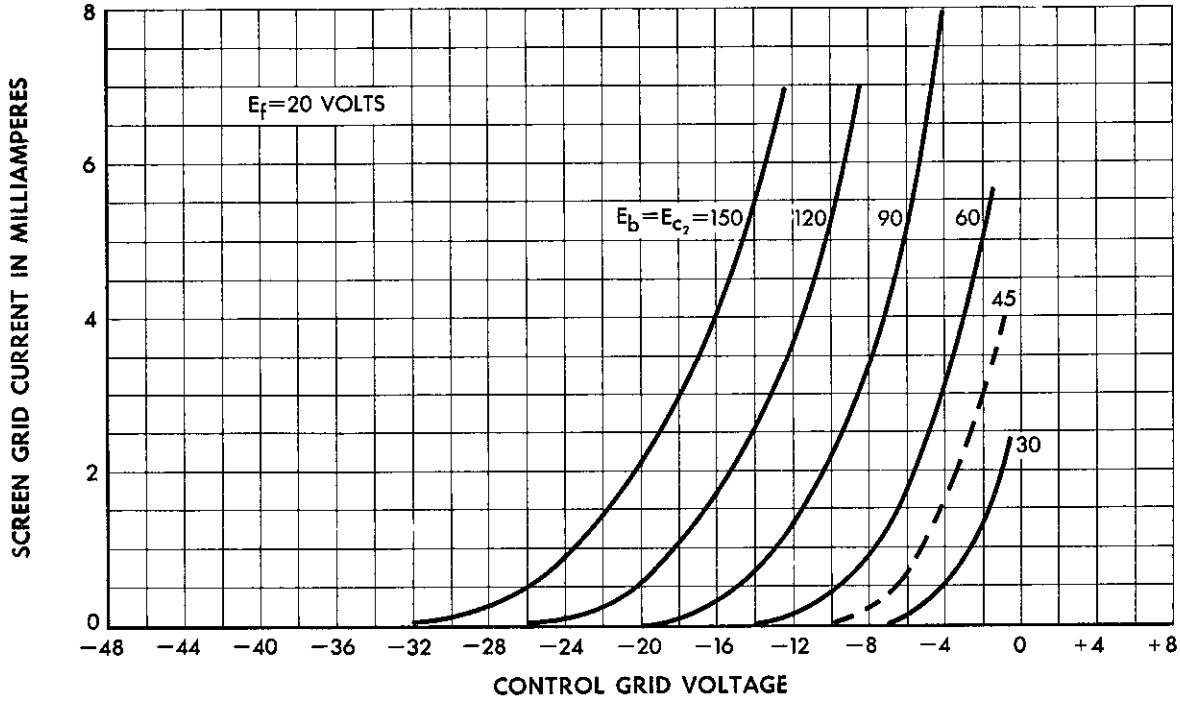
MAXIMUM RATINGS, Design-Center Values

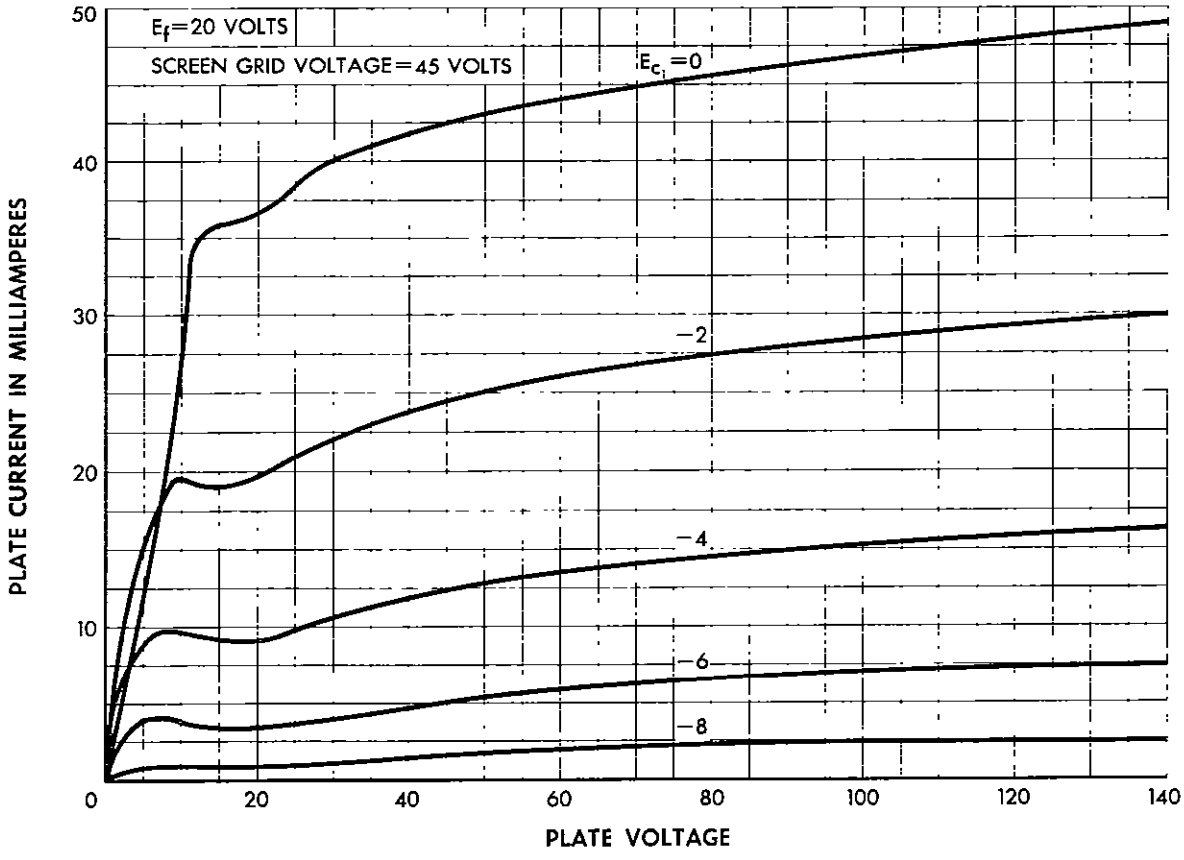
Plate Voltage	130 volts
Screen Grid Voltage	130 volts
Maximum Signal Plate Current	50 milliamperes
Plate Dissipation	6 watts
Screen Grid Dissipation	1.3 watts
Maximum Grid Circuit Resistance for	
Fixed Bias	0.1 megohm
Cathode Bias	0.5 megohm

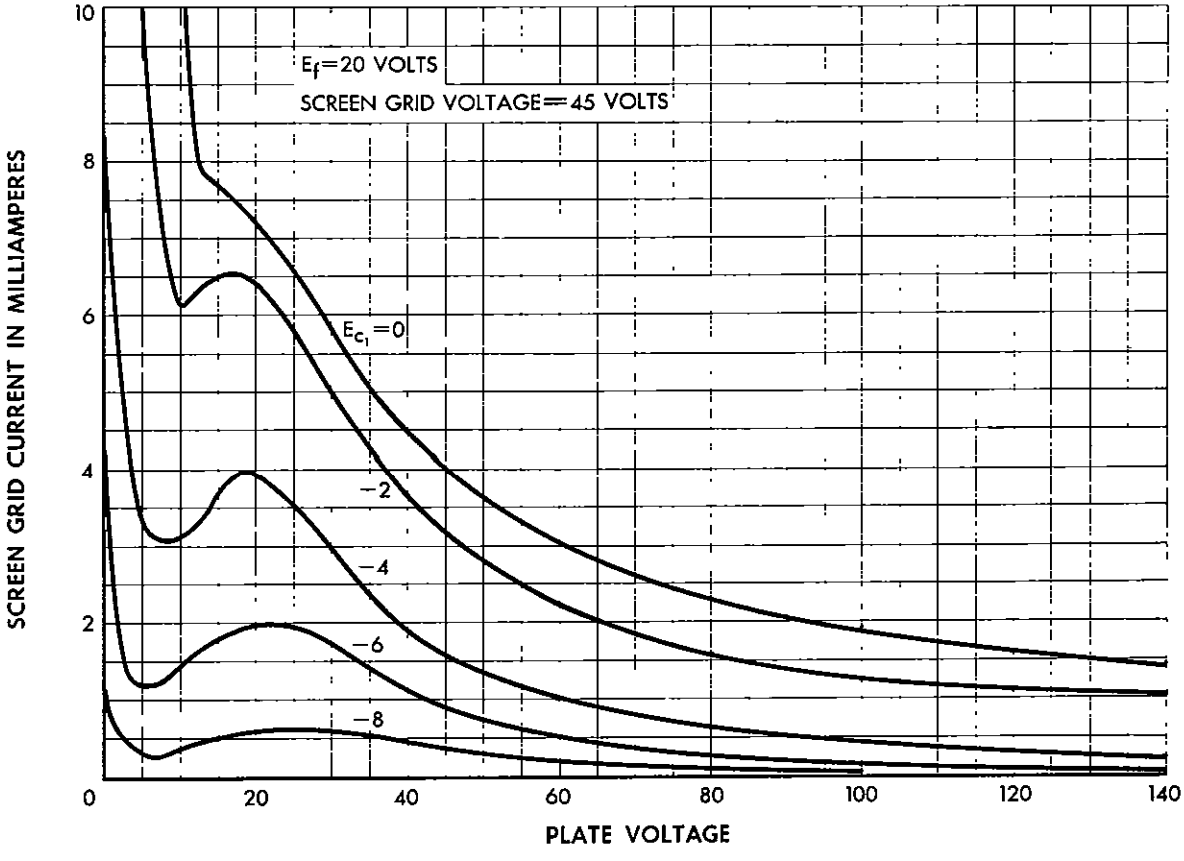
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

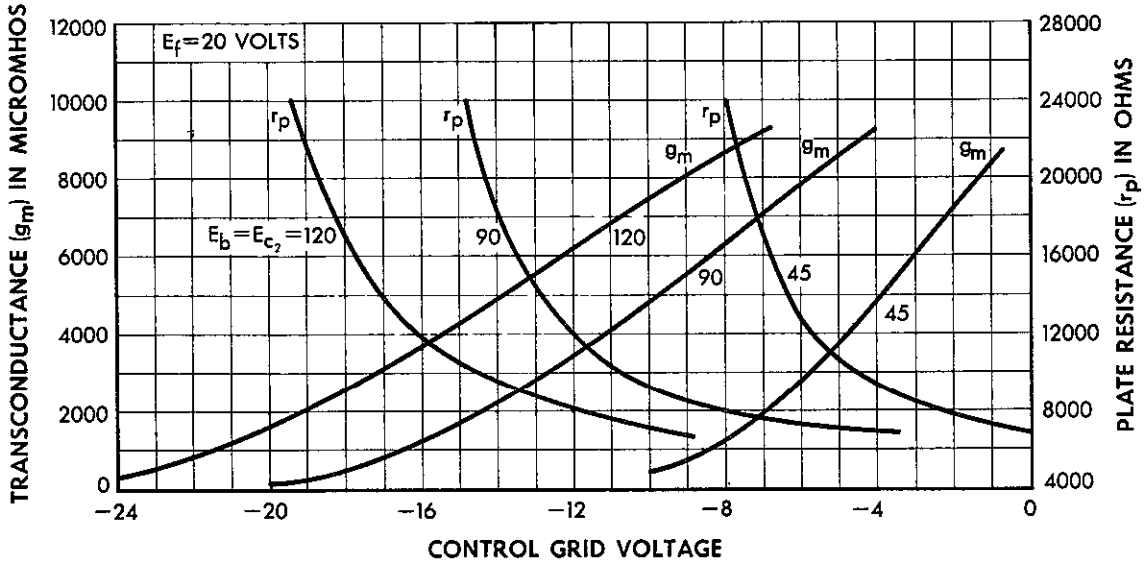
Plate Voltage	45	90	120	volts
Screen Grid Voltage	45	90	120	volts
Control Grid Voltage	−4	−7.5	−12	volts
Peak A-F Grid Voltage	4	7.5	12	volts
Zero Signal Plate Current	12.5	33	34	milliamperes
Maximum Signal Plate Current	13.8	34	37	milliamperes
Zero Signal Screen Grid Current	1.5	3.7	3.7	milliamperes
Maximum Signal Screen Grid Current	4.0	11.7	19.0	milliamperes
Transconductance	4800	6600	6200	micromhos
Plate Resistance	9300	7800	8000	ohms
Load Resistance	2800	2500	2500	ohms
Maximum Signal Power Output	0.25	1.4	2.5	watts
Total Harmonic Distortion	10	8	14	per cent

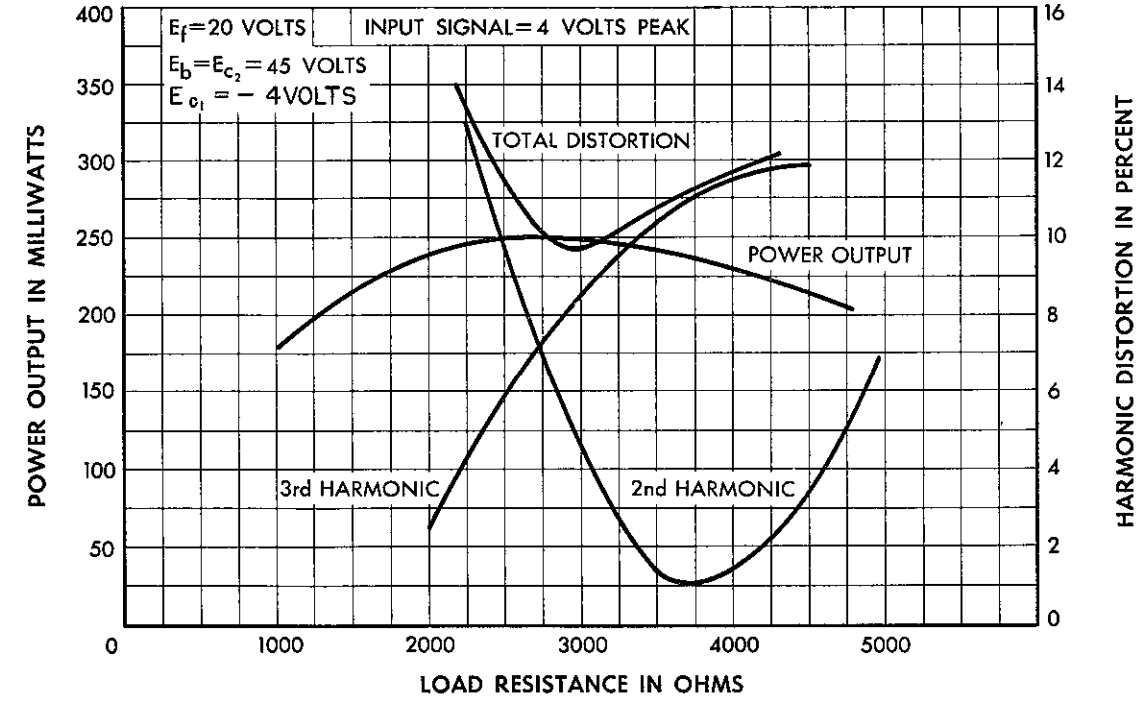

PLATE CURRENT IN MILLIAMPERES
50
40
30
20
10
0
E_f=20 VOLTS
E_b=E_{c_2}=150
120
90
60
45
30
−48 −44 −40 −36 −32 −28 −24 −20 −16 −12 −8 −4 0 +4 +8
CONTROL GRID VOLTAGE

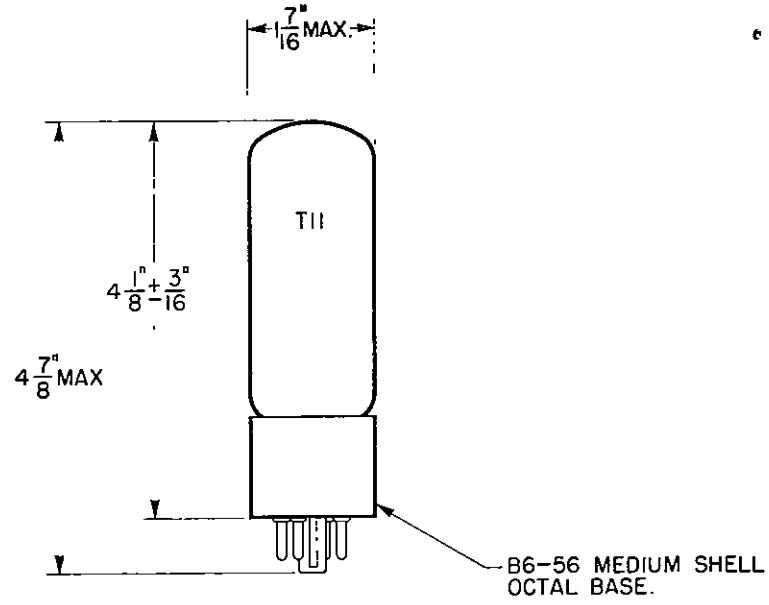

SCREEN GRID CURRENT IN MILLIAMPERES
8
6
4
2
0
E_f=20 VOLTS
E_b=E_{c_2}=150
120
90
60
45
30
−48 −44 −40 −36 −32 −28 −24 −20 −16 −12 −8 −4 0 +4 +8
CONTROL GRID VOLTAGE

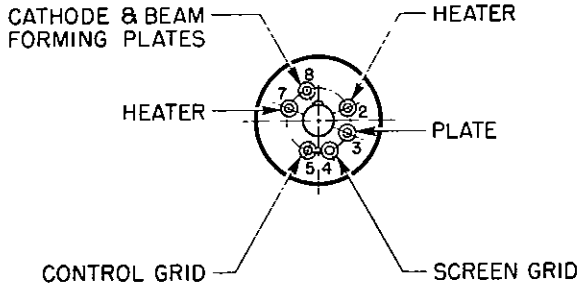

E_f=20 VOLTS
SCREEN GRID VOLTAGE=45 VOLTS
E_{c_1}=0
−2
−4
−6
−8
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
10
20
30
40
50
60
80
100
120
140


E_f=20 VOLTS
SCREEN GRID VOLTAGE=45 VOLTS
E_{c_1}=0
−2
−4
−6
−8
SCREEN GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
2
4
6
8
10
20
40
60
80
100
120
140


E_f=20 VOLTS
E_b=E_{c_2}=120
r_p
g_m
90
120
45
TRANSCONDUCTANCE (g_m) IN MICROMHOS
PLATE RESISTANCE (r_p) IN OHMS
CONTROL GRID VOLTAGE
12000
10000
8000
6000
4000
2000
0
28000
24000
20000
16000
12000
8000
4000
−24
−20
−16
−12
−8
−4
0


E_f=20 VOLTS
INPUT SIGNAL=4 VOLTS PEAK
E_b=E_{c_2}=45 VOLTS
E_{c_1} = − 4VOLTS
TOTAL DISTORTION
POWER OUTPUT
3rd HARMONIC
2nd HARMONIC
POWER OUTPUT IN MILLIWATTS
HARMONIC DISTORTION IN PERCENT
LOAD RESISTANCE IN OHMS
400
350
300
250
200
150
100
50
0
16
14
12
10
8
6
4
2
0
1000
2000
3000
4000
5000

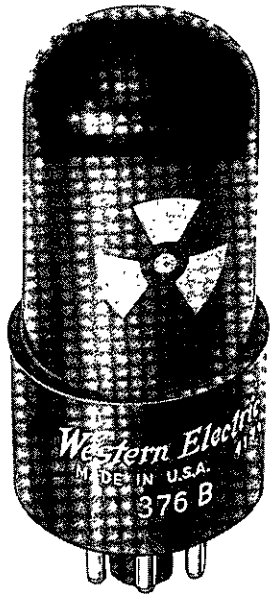




Western Electric

A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

ELECTRON TUBE DATA SHEET
WESTERN ELECTRIC 376B ELECTRON TUBE



DESCRIPTION

The 376B is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus requiring a high current rated tube.

MAXIMUM RATINGS

Peak Anode Voltage	----	275 volts
Average Cathode Current	20	200 milliamperes
Average Life, Approximate	10000	10 hours

MAXIMUM RATINGS, Absolute Values

Inverse Peak Anode Voltage	200 volts
Forward Peak Anode Voltage	275 volts
Forward Cathode Current [1]	
Peak	200 milliamperes
Average	70 milliamperes
Averaging Time	2 seconds
Inverse Peak Anode Current [1]	5 milliamperes
Peak Starter Current	
Forward	100 milliamperes
Inverse	1 milliampere
Ambient Temperature Limits	-55 to +85 centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.
Starter Breakdown Voltage	67	75	85*volts
Starter Voltage Drop at 20 Milliamperes	52	60	74 volts
Anode Voltage Drop at 30 Milliamperes	60	70	80 volts
Transfer Current	See curve - Fig. 3		
Ionization Time, Starter Gap[2]	---	2	--- milliseconds
Deionization Time, Main Gap, Approximate	---	3	--- milliseconds

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	1 ounce
Dimensions and pin connections shown in outline drawing	Page 4

* Limit applies immediately after tube has conducted current. If tube has been idle, this value initially may be as much as 3 volts higher or lower.

Note 1: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed their maximum rated values.

Note 2: With 15 volts starter overvoltage (15 volts above Starter Breakdown Voltage) with tube in total darkness.

HANDLING

Western Electric cold cathode tubes contain a minute amount of radium bromide which is a radioactive material. The amount in most types is too small to require any special care in use, handling or disposal.

A few types contain a larger quantity of radium bromide in which the radium approximates that found on a luminous watch dial. These types bear a red three-bladed propeller-shaped symbol on the tube envelope. Instructions for handling such tubes are given below and also in Bell System Practices for Central Office maintenance.

Installations ordinarily require no precautions against radiation. However, quantities of the tubes should not be so installed, or so stored outside the shipping carton, that they will be within a few inches of personnel or in proximity to photographic film for extended periods of time. For example, however, a 40-hour week exposure at about one (1) foot from a bank of 500 tubes (covering an area of 20 inches x 45 inches) is well within the accepted tolerance limits for personnel. Reasonable care should be exercised in handling and disposal of broken tubes. In general, attention should be given to the following:

(a) Avoid breathing dust or vapors from broken tubes.

(b) Avoid contacting broken parts with bare hands.

(c) Use wet rag to pick up broken parts. Wrap broken parts in rag and tie securely so as to form a package. Thoroughly wash hands after disposal.

(d) Dispose of broken or defective tubes as they are taken out of service. One or two tubes at a time may be disposed of with normal waste material Accumulation of tubes in one concentrated area of the place of final disposition should be avoided.

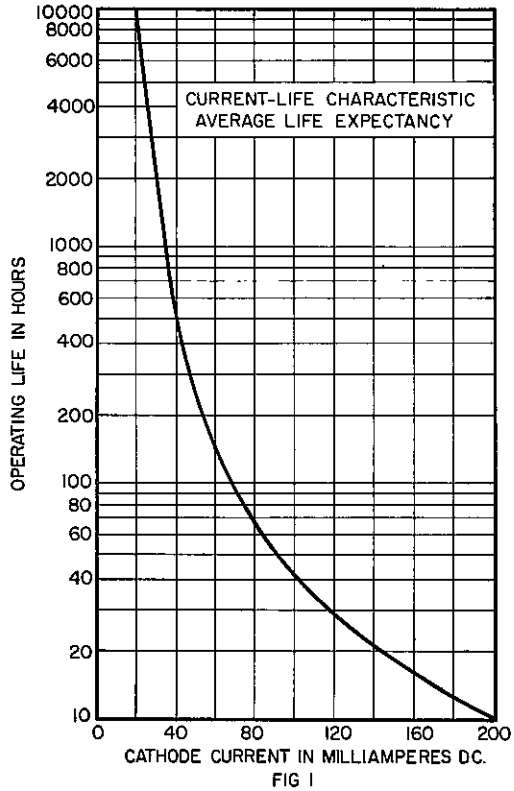


FIG 1

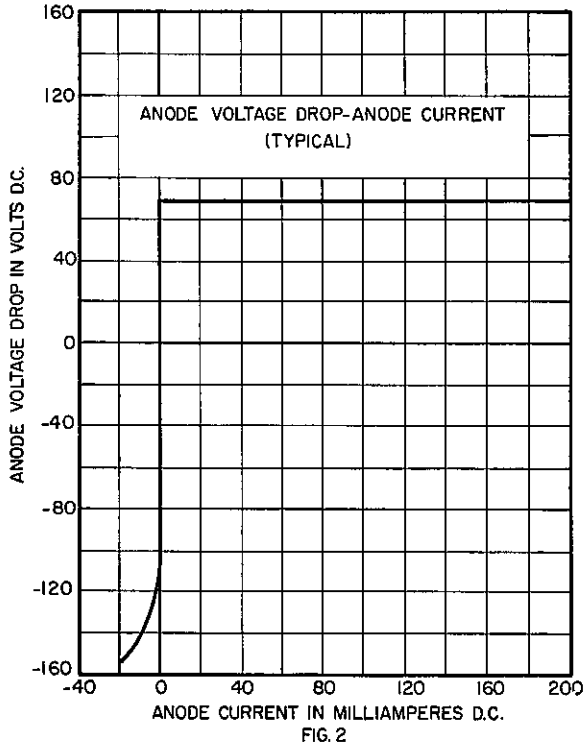


FIG. 2

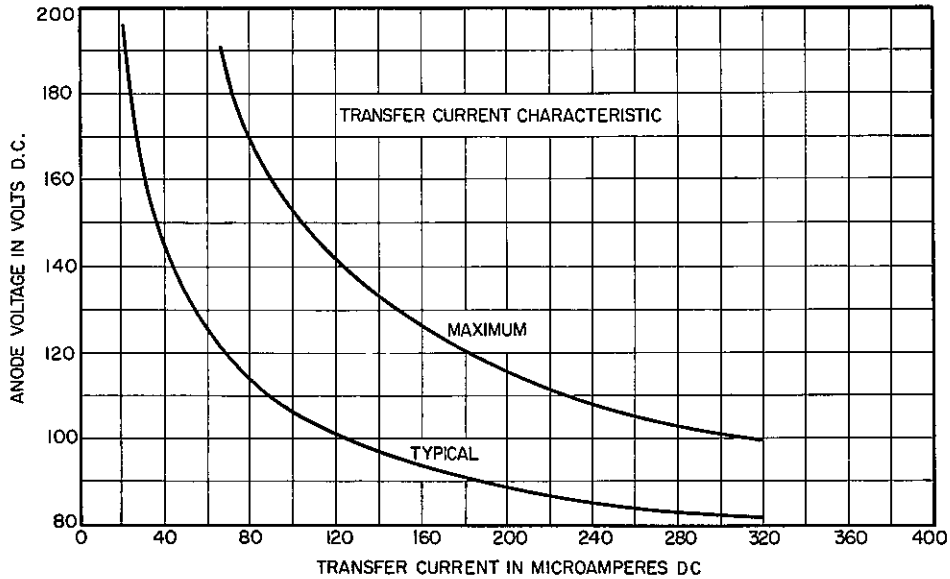
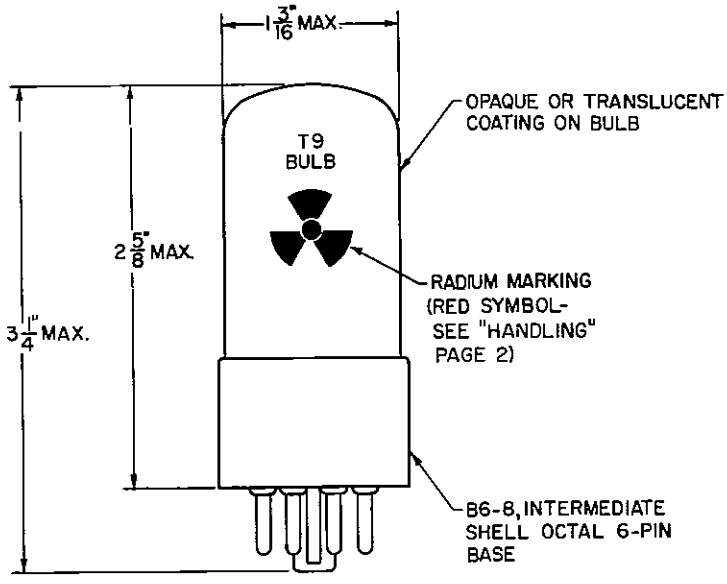
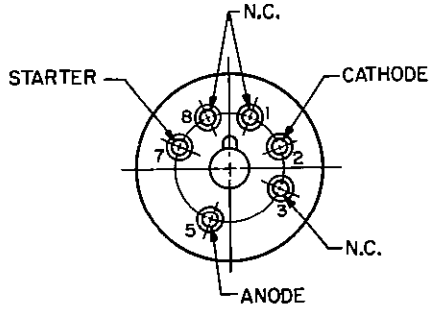


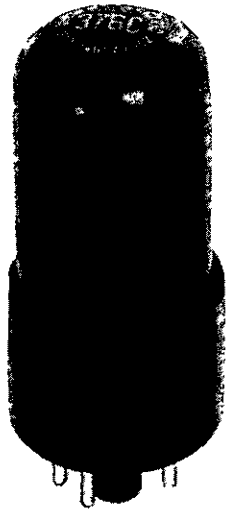
FIG 3





A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

ELECTRON TUBE DATA SHEET
WESTERN ELECTRIC 376C ELECTRON TUBE



DESCRIPTION

The 376C is a three-electrode, inert-gas-filled, cold cathode tube for use in relay, voltage regulator or rectifier circuits. This tube is especially suitable for use in control circuits such as in triggering, counting, or switching apparatus requiring a high current rated tube.

CHARACTERISTICS

Peak Anode Voltage	-	275	volts
Average Cathode Current	20	200	milliamperes
Average Life, Approximate	10000	10	hours

File: Cold Cathode Section

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MAXIMUM RATINGS, Absolute System (Note 1)

Inverse Peak Anode Voltage	200	volts
Forward Peak Anode Voltage	275	volts
Forward Cathode Current (Note 2)		
Peak	200	milliamperes
Average	70	milliamperes
Averaging Time	2	seconds
Inverse Peak Anode Current (Note 2)	5	milliamperes
Peak Starter Current (Note 2)		
Forward	100	milliamperes
Inverse	1	milliampere
Ambient Temperature Limits	-55 to +85	centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.	
Starter Breakdown Voltage (Note 3)	67	75	85	volts
Starter Voltage Drop at 20 Milliamperes	52	60	74	volts
Anode Voltage Drop at 30 Milliamperes	60	70	80	volts
Transfer Current	See curve - Fig. 3			
Ionization Time, Starter Gap (Note 4)	-	2	-	milliseconds
Deionization Time, Main Gap, Approximate	-	3	-	milliseconds

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	1 Ounce

Dimensions and pin connections shown in outline drawing on Page 4.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

Note 2: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed their maximum rated values.

Note 3: Limit applies immediately after tube has conducted current. If tube has been idle, this value initially may be as much as 3 volts higher or lower.

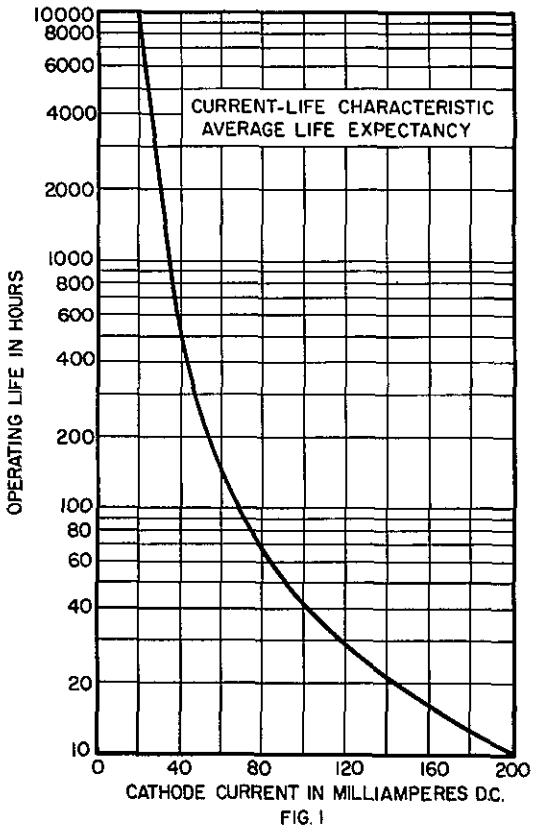


FIG. 1

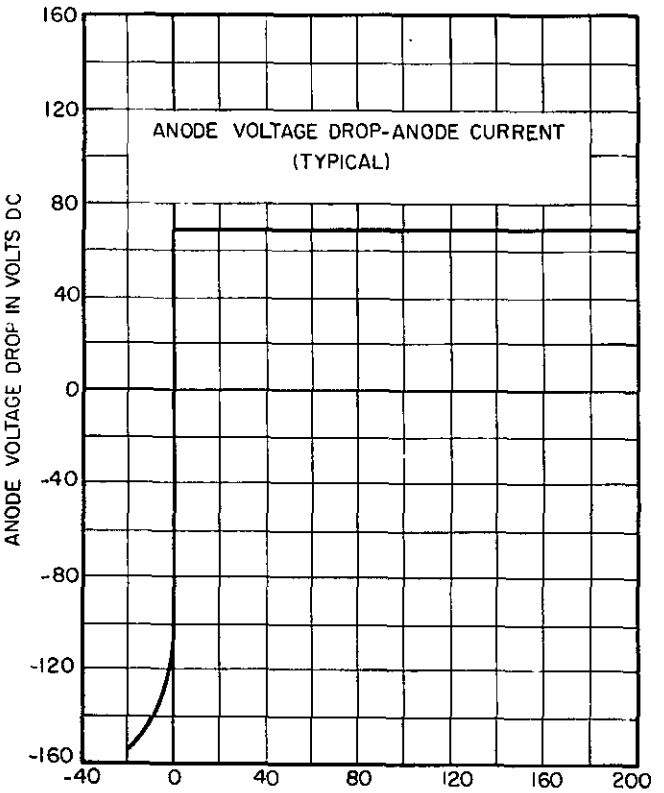


FIG 2

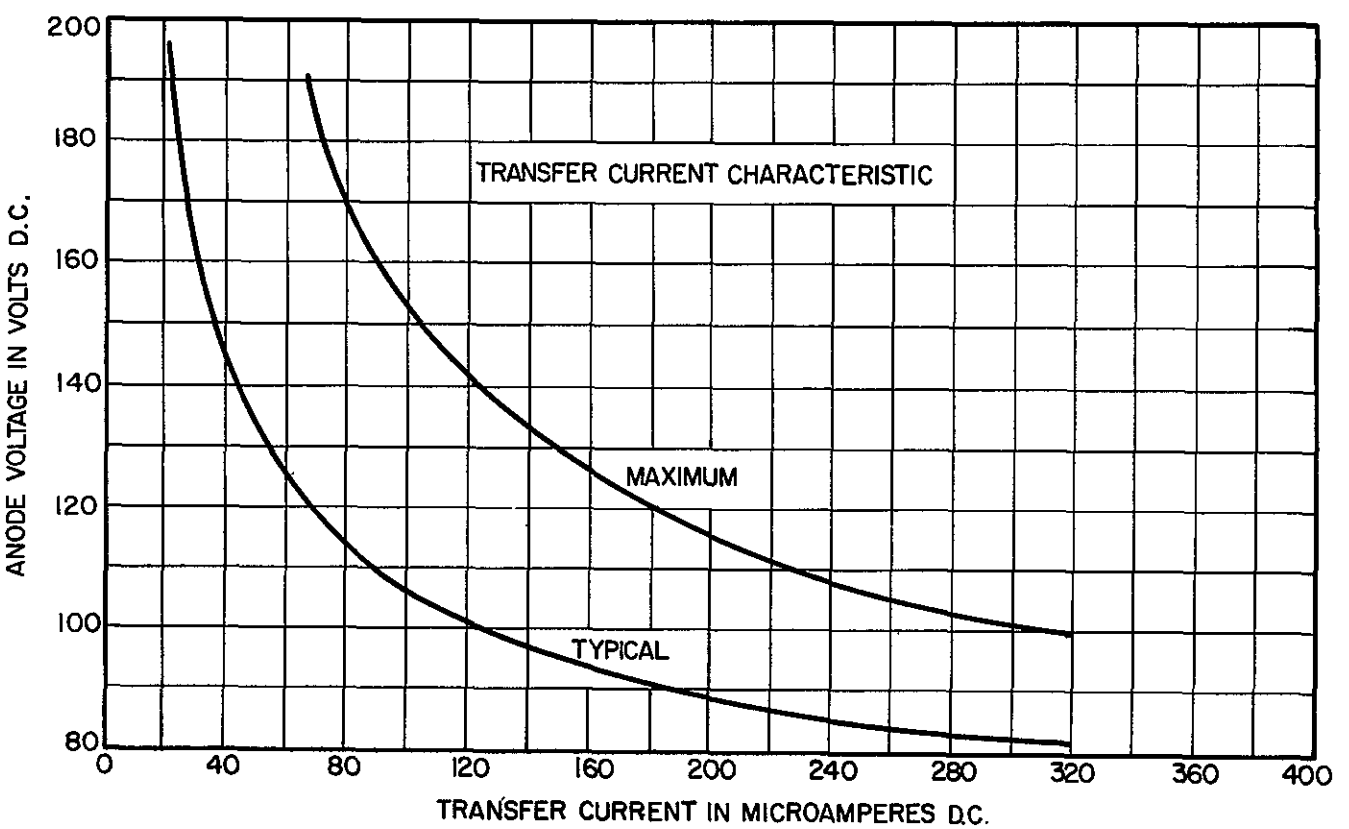
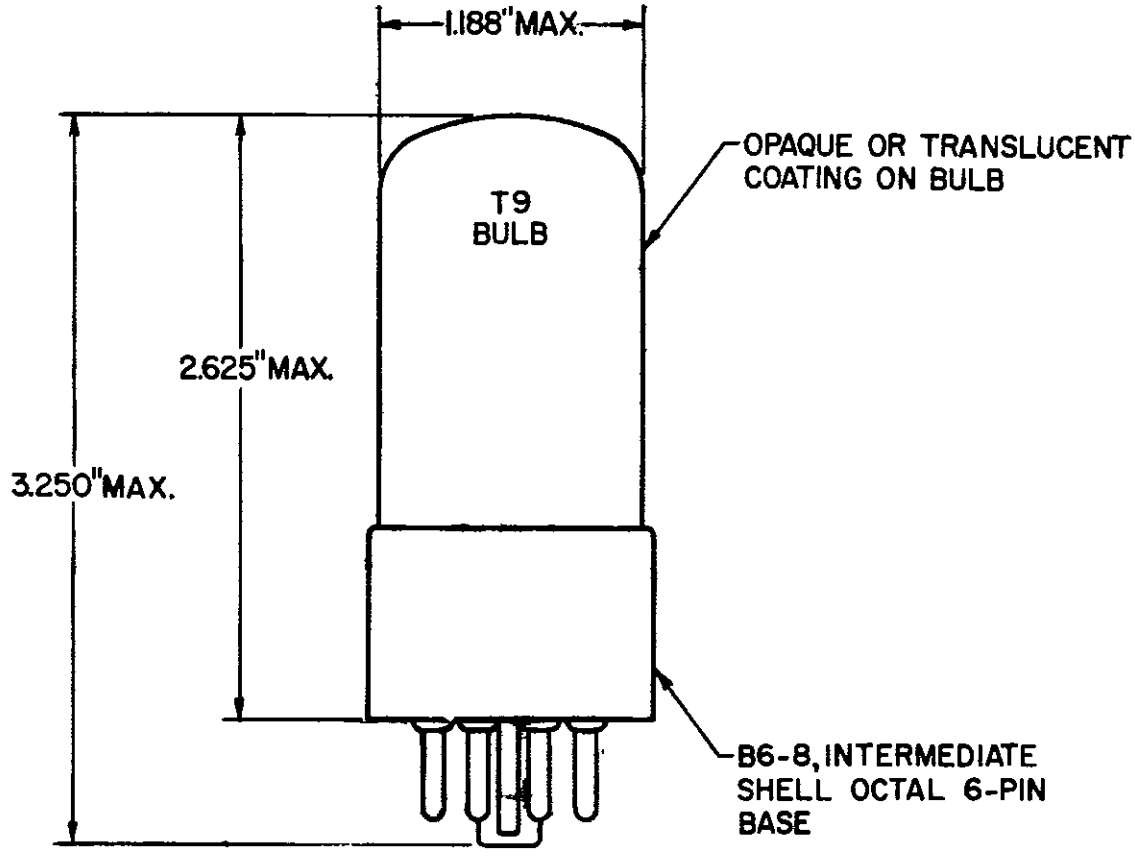
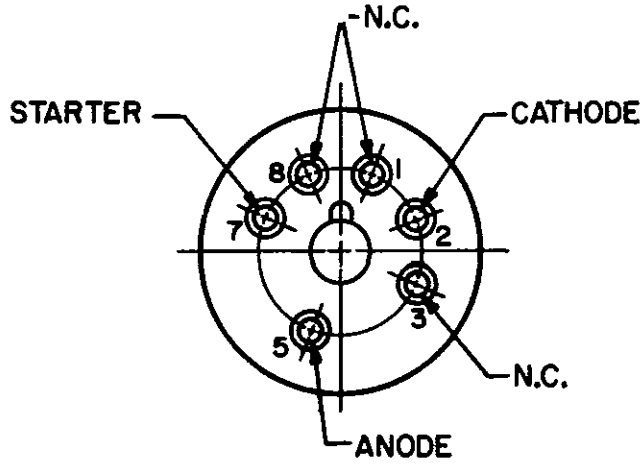


FIG. 3

Note 4: With 15 volts starter overvoltage (15 volts above Starter Breakdown Voltage) with tube in total darkness.





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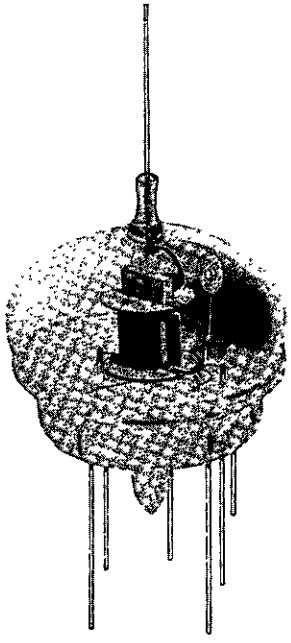
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BELL SYSTEM PRACTICES
Transmission Engineering and Data
Vacuum Tube Data

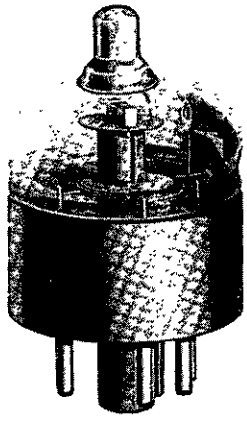
SECTION AB46.640
Issue 1, August 1941
A T & T Co Standard

Western Electric

384A and 385A Vacuum Tubes



384A



385A

Classification—Voltage Amplifier, Suppressor-Grid Pentodes with Indirectly Heated Cathodes

The 384A and 385A vacuum tubes are identical except that the 385A is provided with a base.

Applications—These tubes are intended primarily for miscellaneous low-power applications at audio, carrier, and ultra-high frequencies. The connection for the suppressor-grid is brought out to an external terminal.

Dimensions—Figures 1, 2, 3 and 4 show dimensions, outline diagrams of the tubes and the arrangement of the electrode connections.

Base—384A—Not based or capped. Connections are made by soldering the leads directly to the circuit elements.

385A—Six-pin, short-shell, intermediate, octal type with silver-plated pins. Small metal cap plate terminal at the top of the bulb.

Socket—384A—No socket is required. Ordinarily, no additional support other than that of the leads will be required. Where the tube is subjected to vibration or where a definite orientation of the tube is desired, a felt-covered spring clip, bearing against the top of the bulb to hold the tube firmly in a circular seat located under the shoulder of the tube, may be provided.

385A—Standard octal type socket, preferably provided with silver-plated contacts.

Mounting Positions—The tubes may be mounted in any position.

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Average Direct Inter-Electrode Capacitances

	384A	385A
Control-grid to plate	0.02	0.02 $\mu\mu$f
Control-grid to heater, cathode, screen-grid and suppressor-grid	3.1	3.6 $\mu\mu$f
Plate to heater, cathode, screen-grid and suppressor-grid	2.1	2.4 $\mu\mu$f

384A—The control-grid to plate capacitance is measured with the tube resting in a circular seat consisting of a one-inch-diameter hole in a metal sheet located under the shoulder of the tube. The metal sheet is connected to the cathode of the tube.

No shielding is used in the measurement of the input and output capacitances.

385A—The control-grid to plate capacitance is measured with the tube in an octal wafer socket located approximately one-half inch above a metal sheet. A close fitting metal shield is placed around the bulb and base of the tube and connected, together with the metal sheet, to the cathode. The lead from the control-grid terminal of the socket is brought through a small opening in the metal sheet.

No shielding or socket is used in the measurement of the input and output capacitances.

Heater Rating

Heater voltage.....6.3 volts, a-c or d-c
Nominal heater current.....0.15 ampere

The heaters of these tubes are designed to operate on a voltage basis and should be operated as near the rated voltage as practicable.

Cathode Connection—Where alternating heater voltage is used, the cathode should preferably be connected directly to the mid-point of the heater transformer winding or to the mid-point of a low resistance connected across the heater terminals. For direct current operation the cathode may be connected to either end of the heater. If voltage is applied between the heater and cathode, it should be kept low and must not exceed 50 volts.

Characteristics—Figures 5 and 6 show plate current and screen-grid current characteristics of typical tubes as functions of control-grid voltage for several values of screen-grid and plate voltage and zero suppressor-grid voltage. The screen-grid voltage for these characteristics is equal to the plate voltage. Figures 7, 8 and 9 show corresponding amplification factor, plate resistance, and transconductance characteristics. Figures 10 and 11 show plate current and screen-grid current characteristics as functions of plate voltage for three values of control-grid voltage, a screen-grid voltage of 120 volts, and zero suppressor-grid voltage. Figures 12, 13 and 14 show corresponding amplification factor, plate resistance, and transconductance characteristics.

Limiting Conditions for Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	120 volts
Maximum suppressor-grid voltage	120 volts
Maximum cathode current (total space current)	12 milliamperes
Maximum screen-grid current	5 milliamperes

Operating Conditions and Output—Nominal performance data are given in the table below for a number of typical operating conditions. Since the life of the tubes may be shortened when operated under the maximum conditions, less severe conditions should be selected wherever possible.

The performance data include the fundamental power output and the second and third harmonic levels for the indicated values of load resistance and input voltage. The power output is given in dbm (decibels above one milliwatt), and the harmonic levels in decibels below the fundamental.

TABLE

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Suppressor-Grid Voltage	Plate Current	Load Resistance	Input Voltage	Output Power	Second Harmonic	Third Harmonic
Volts	Volts	Volts	Volts	Milliamperes	Ohms	Peak Volts	dbm	db	db
120	120	−2	0	5.6	1,000	0.5	−1	35	69
					1,000	2.0	11	22	42
					10,000	0.5	9	37	66
					10,000	2.0	21	24	38
					30,000	0.5	13	46	59
					30,000	2.0	23	28	23
					60,000	0.5	15	36	45
					60,000	2.0	23	12	21
					100,000	0.5	17	25	37
					100,000	2.0	23	10	29
180	120	−2	0	5.7	10,000	0.5	9	36	69
					10,000	2.0	21	23	39
					30,000	0.5	14	40	68
					30,000	2.0	25	31	31
250*	120*	−2	0	5.7	10,000	0.5	9	36	68
					10,000	2.0	21	23	40
					30,000	0.5	14	37	67
					30,000	2.0	25	26	34

*Maximum voltages.

Curves showing the fundamental power output and the second and third harmonic levels as functions of input voltage for a number of values of load resistance and a typical operating condition are given in Figures 15, 16 and 17.

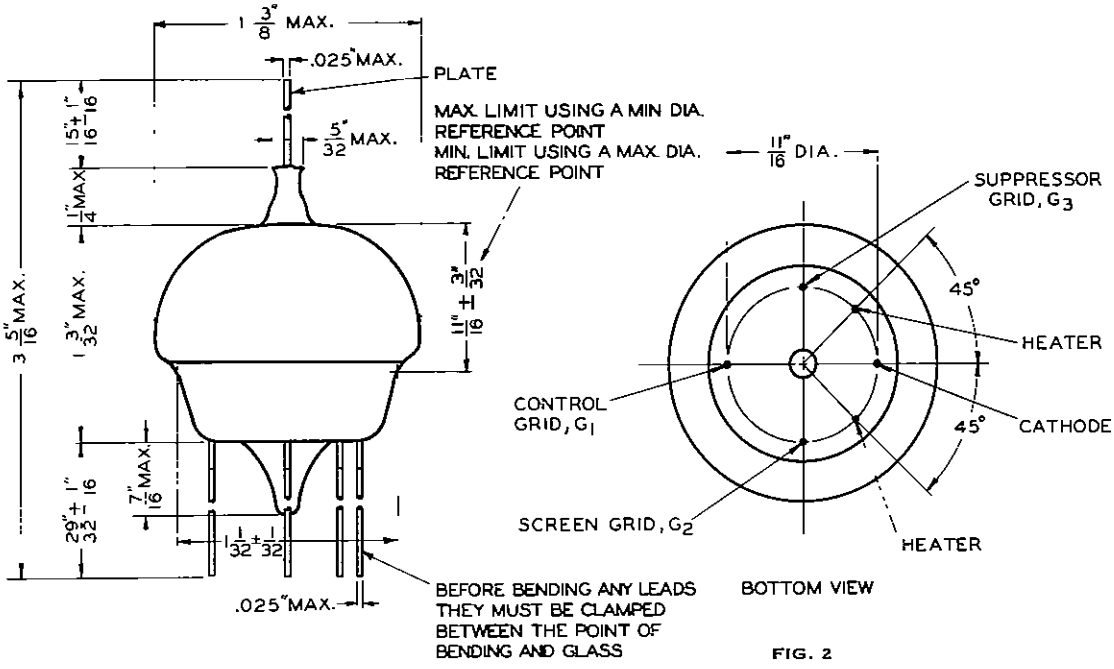


FIG. 1

FIG. 2

384 A

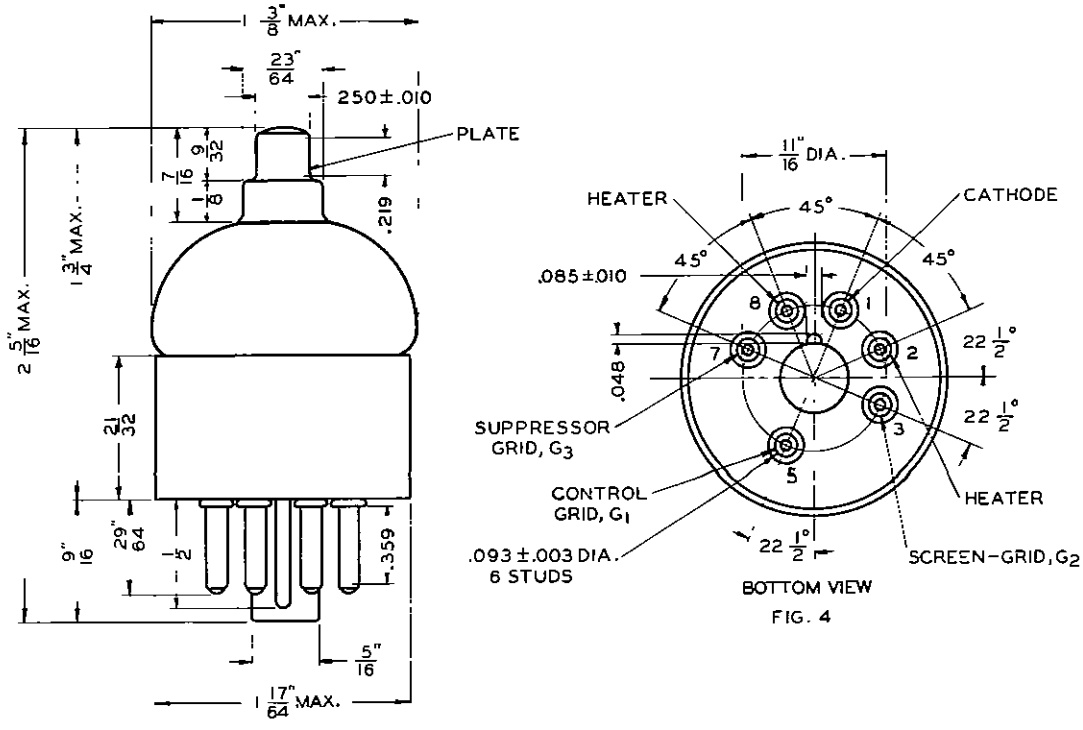


FIG. 3

FIG. 4

385 A

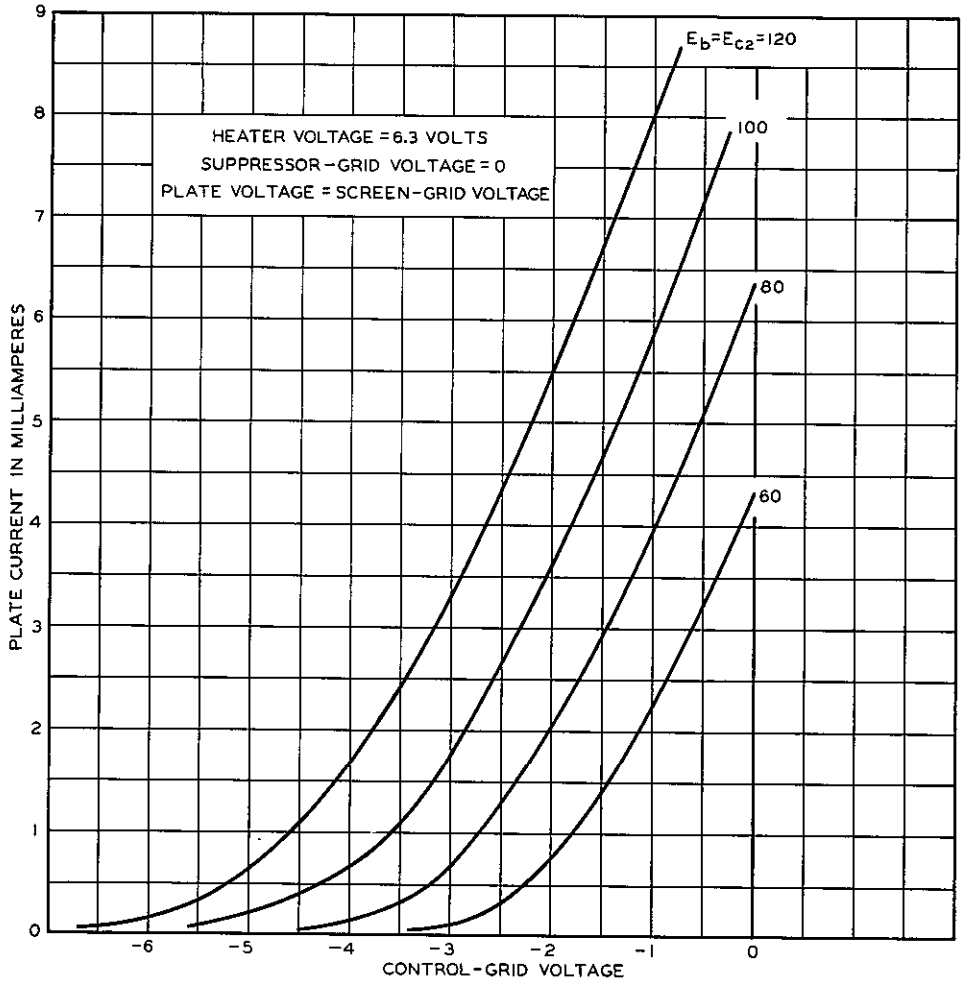

HEATER VOLTAGE = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 120
100
80
60
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0
1
2
3
4
5
6
7
8
9
-6
-5
-4
-3
-2
-1
0

FIG. 5

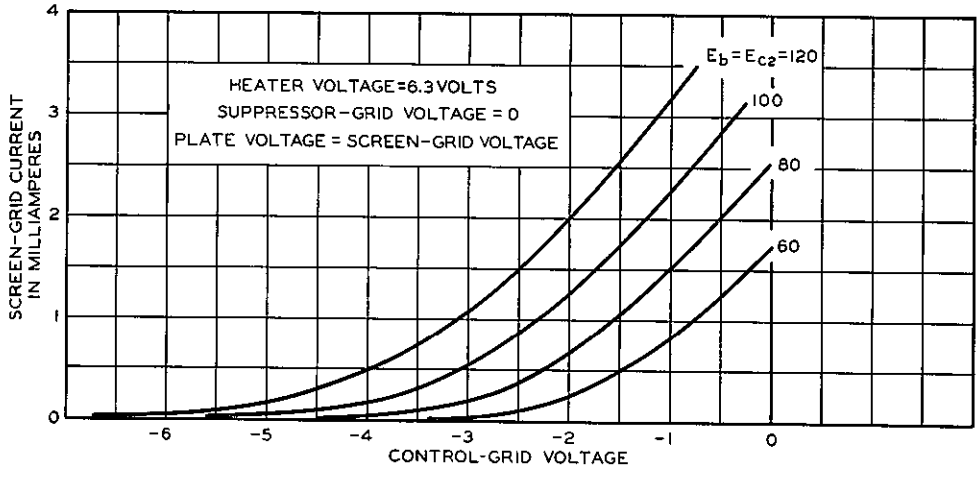

HEATER VOLTAGE = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 120
100
80
60
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0
1
2
3
4
-6
-5
-4
-3
-2
-1
0

FIG. 6

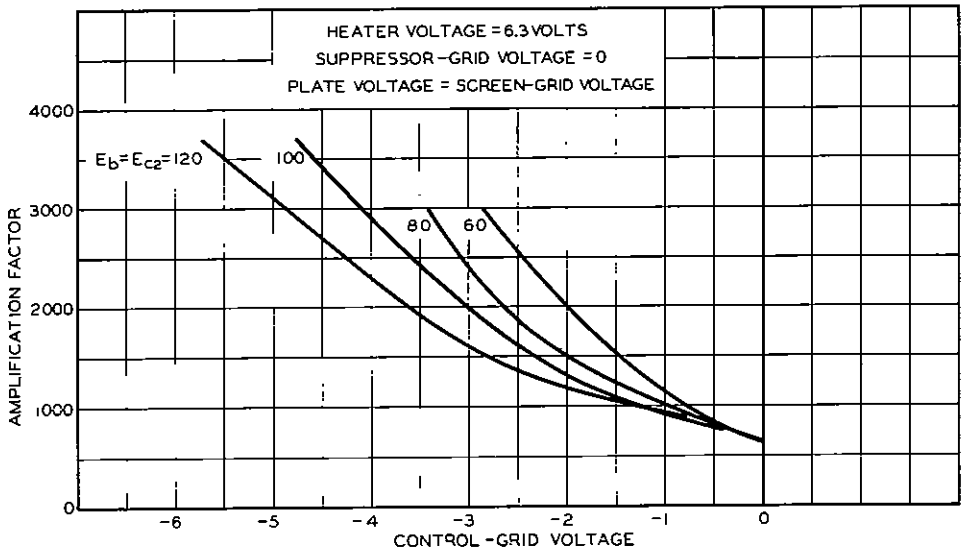


FIG. 7

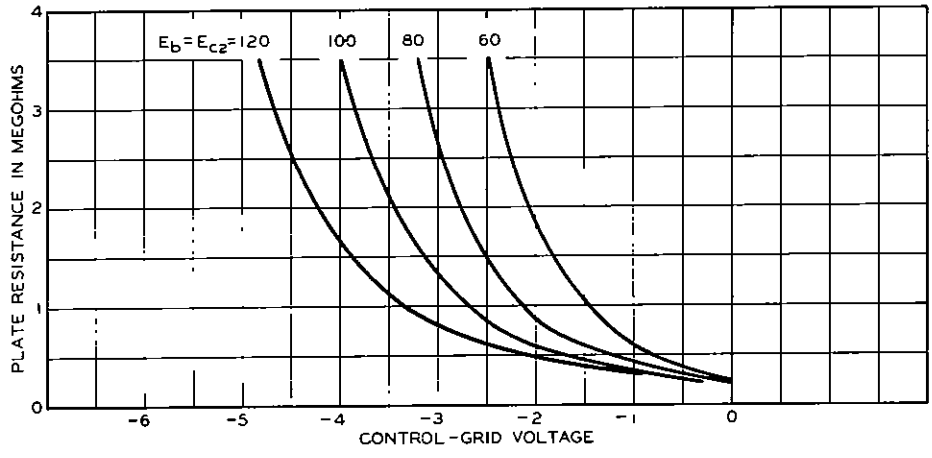


FIG. 8

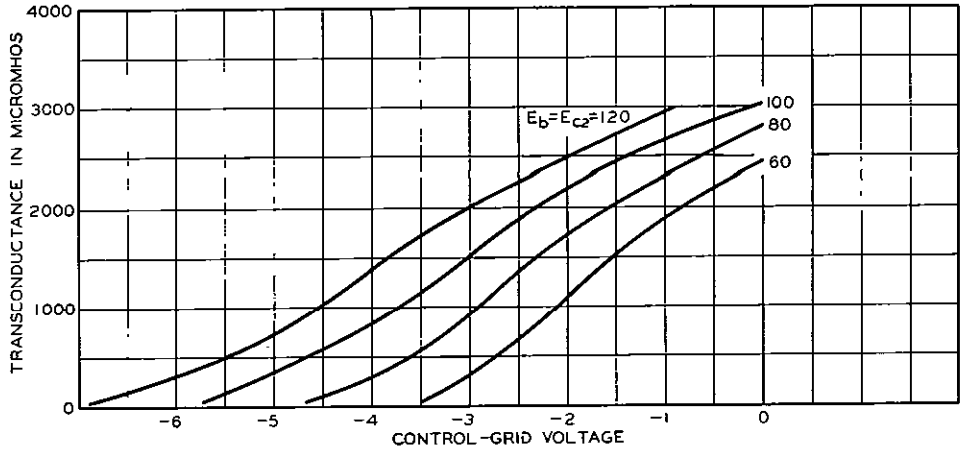


FIG. 9

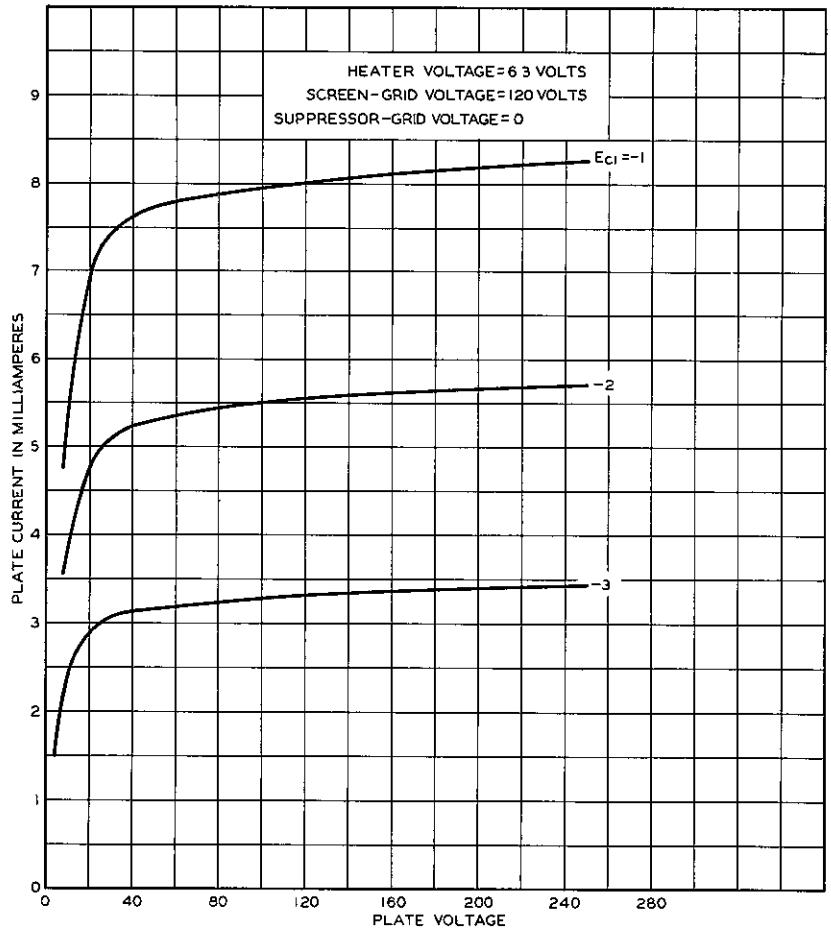

HEATER VOLTAGE=6.3 VOLTS
SCREEN-GRID VOLTAGE=120 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{C1}=-1
-2
-3
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
7
8
9
0
40
80
120
160
200
240
280

FIG. 10

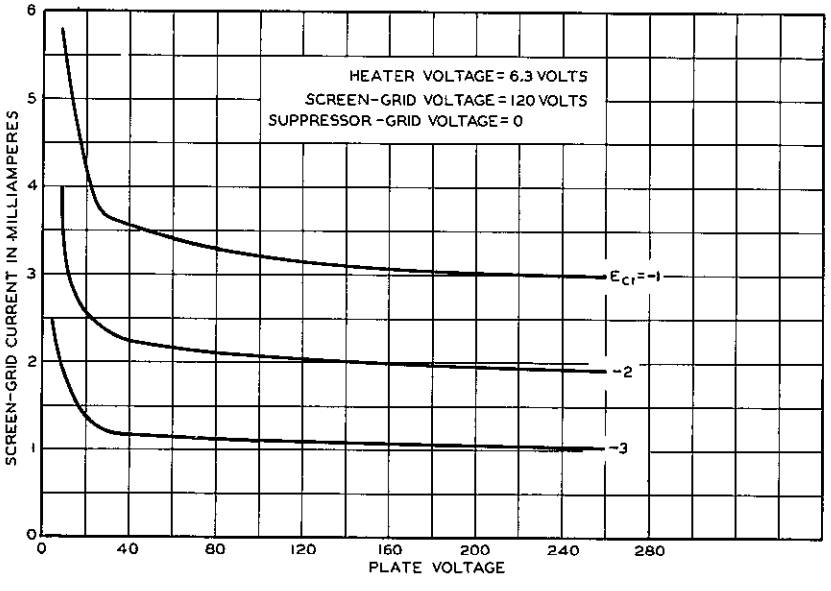

HEATER VOLTAGE=6.3 VOLTS
SCREEN-GRID VOLTAGE=120 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{C1}=-1
-2
-3
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
0
40
80
120
160
200
240
280

FIG. 11

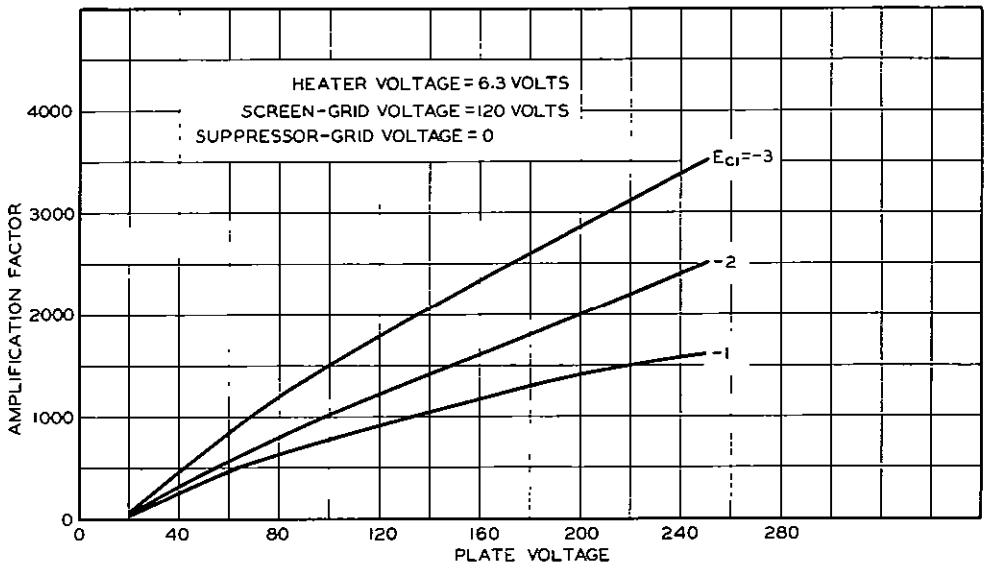


FIG. 12

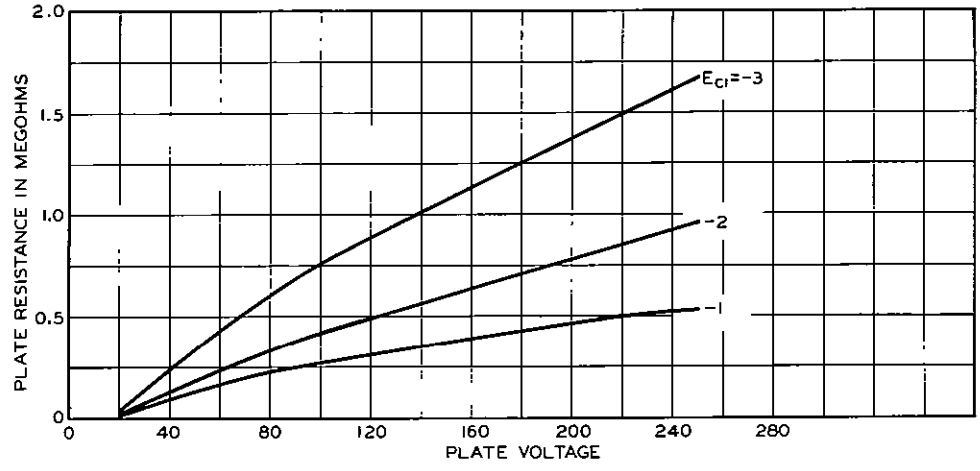


FIG. 13

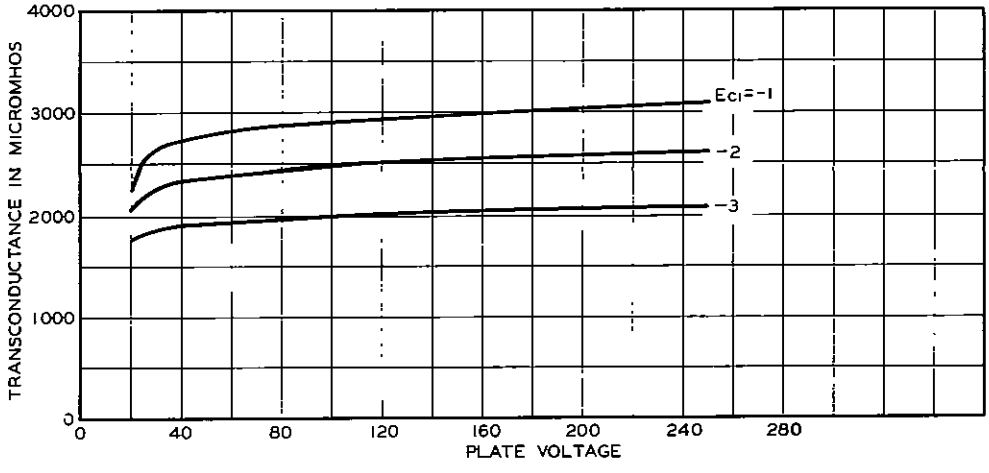


FIG. 14

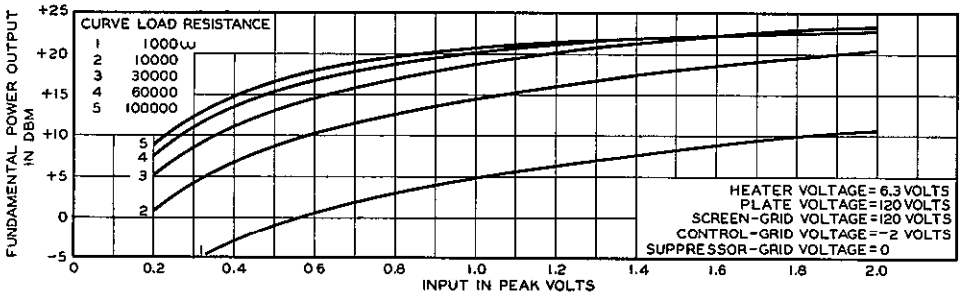


FIG. 15

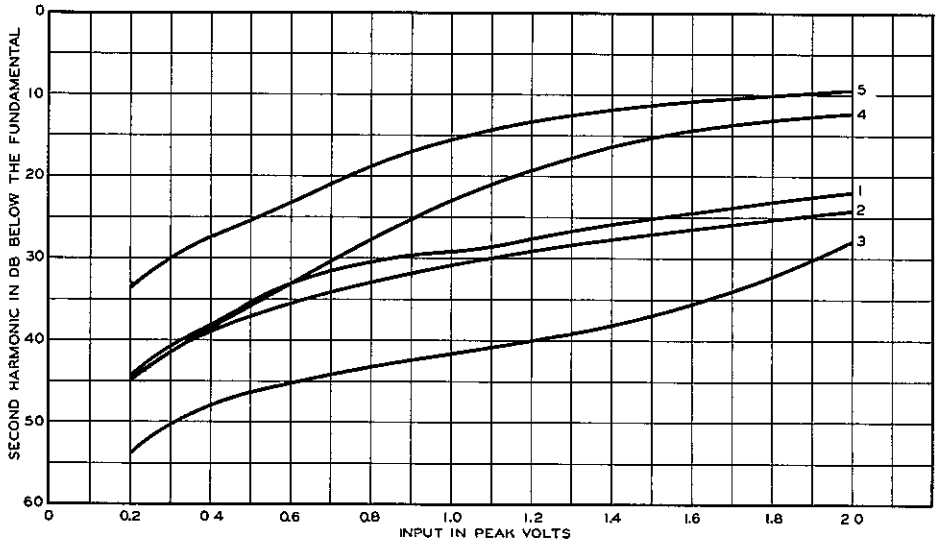


FIG. 16

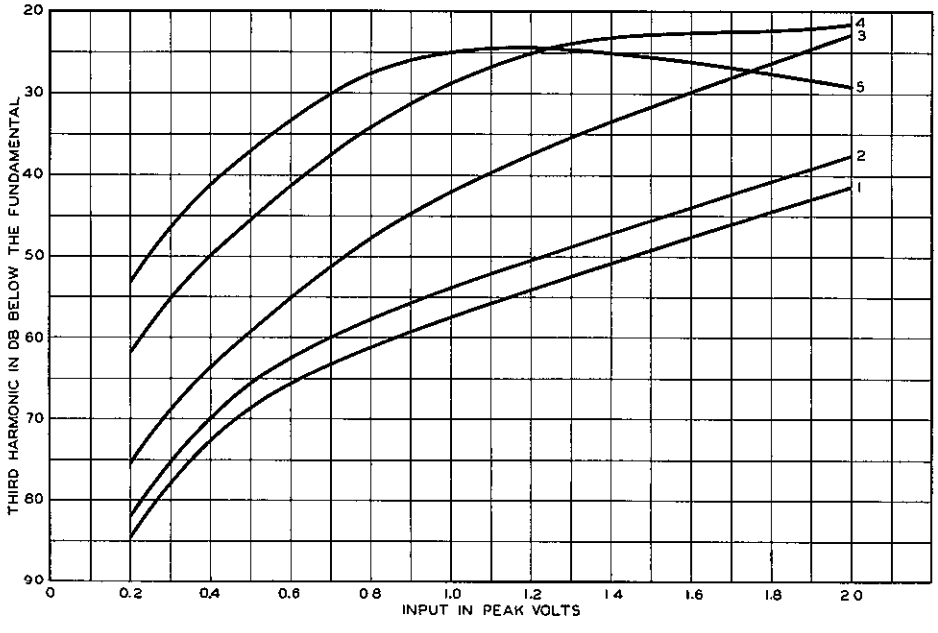


FIG. 17

Western Electric

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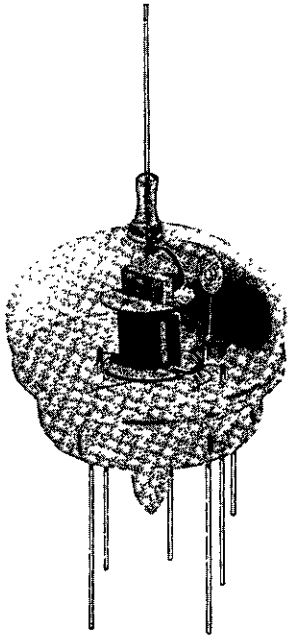
V. T. DATA SHEET 384A 385A
ISSUE 1

BELL SYSTEM PRACTICES
Transmission Engineering and Data
Vacuum Tube Data

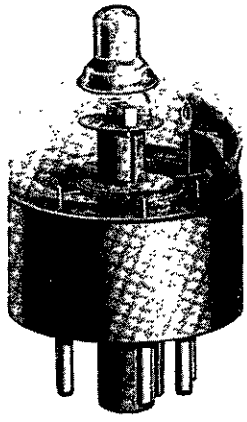
SECTION AB46.640
Issue 1, August 1941
A T & T Co Standard

Western Electric

384A and 385A Vacuum Tubes



384A



385A

Classification—Voltage Amplifier, Suppressor-Grid Pentodes with Indirectly Heated Cathodes

The 384A and 385A vacuum tubes are identical except that the 385A is provided with a base.

Applications—These tubes are intended primarily for miscellaneous low-power applications at audio, carrier, and ultra-high frequencies. The connection for the suppressor-grid is brought out to an external terminal.

Dimensions—Figures 1, 2, 3 and 4 show dimensions, outline diagrams of the tubes and the arrangement of the electrode connections.

Base—384A—Not based or capped. Connections are made by soldering the leads directly to the circuit elements.

385A—Six-pin, short-shell, intermediate, octal type with silver-plated pins. Small metal cap plate terminal at the top of the bulb.

Socket—384A—No socket is required. Ordinarily, no additional support other than that of the leads will be required. Where the tube is subjected to vibration or where a definite orientation of the tube is desired, a felt-covered spring clip, bearing against the top of the bulb to hold the tube firmly in a circular seat located under the shoulder of the tube, may be provided.

385A—Standard octal type socket, preferably provided with silver-plated contacts.

Mounting Positions—The tubes may be mounted in any position.

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Average Direct Inter-Electrode Capacitances

	384A	385A
Control-grid to plate	0.02	0.02 $\mu\mu$f
Control-grid to heater, cathode, screen-grid and suppressor-grid	3.1	3.6 $\mu\mu$f
Plate to heater, cathode, screen-grid and suppressor-grid	2.1	2.4 $\mu\mu$f

384A—The control-grid to plate capacitance is measured with the tube resting in a circular seat consisting of a one-inch-diameter hole in a metal sheet located under the shoulder of the tube. The metal sheet is connected to the cathode of the tube.

No shielding is used in the measurement of the input and output capacitances.

385A—The control-grid to plate capacitance is measured with the tube in an octal wafer socket located approximately one-half inch above a metal sheet. A close fitting metal shield is placed around the bulb and base of the tube and connected, together with the metal sheet, to the cathode. The lead from the control-grid terminal of the socket is brought through a small opening in the metal sheet.

No shielding or socket is used in the measurement of the input and output capacitances.

Heater Rating

Heater voltage.....6.3 volts, a-c or d-c
Nominal heater current.....0.15 ampere

The heaters of these tubes are designed to operate on a voltage basis and should be operated as near the rated voltage as practicable.

Cathode Connection—Where alternating heater voltage is used, the cathode should preferably be connected directly to the mid-point of the heater transformer winding or to the mid-point of a low resistance connected across the heater terminals. For direct current operation the cathode may be connected to either end of the heater. If voltage is applied between the heater and cathode, it should be kept low and must not exceed 50 volts.

Characteristics—Figures 5 and 6 show plate current and screen-grid current characteristics of typical tubes as functions of control-grid voltage for several values of screen-grid and plate voltage and zero suppressor-grid voltage. The screen-grid voltage for these characteristics is equal to the plate voltage. Figures 7, 8 and 9 show corresponding amplification factor, plate resistance, and transconductance characteristics. Figures 10 and 11 show plate current and screen-grid current characteristics as functions of plate voltage for three values of control-grid voltage, a screen-grid voltage of 120 volts, and zero suppressor-grid voltage. Figures 12, 13 and 14 show corresponding amplification factor, plate resistance, and transconductance characteristics.

Limiting Conditions for Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	120 volts
Maximum suppressor-grid voltage	120 volts
Maximum cathode current (total space current)	12 milliamperes
Maximum screen-grid current	5 milliamperes

Operating Conditions and Output—Nominal performance data are given in the table below for a number of typical operating conditions. Since the life of the tubes may be shortened when operated under the maximum conditions, less severe conditions should be selected wherever possible.

The performance data include the fundamental power output and the second and third harmonic levels for the indicated values of load resistance and input voltage. The power output is given in dbm (decibels above one milliwatt), and the harmonic levels in decibels below the fundamental.

TABLE

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Suppressor-Grid Voltage	Plate Current	Load Resistance	Input Voltage	Output Power	Second Harmonic	Third Harmonic
Volts	Volts	Volts	Volts	Milliamperes	Ohms	Peak Volts	dbm	db	db
120	120	−2	0	5.6	1,000	0.5	−1	35	69
					1,000	2.0	11	22	42
					10,000	0.5	9	37	66
					10,000	2.0	21	24	38
					30,000	0.5	13	46	59
					30,000	2.0	23	28	23
					60,000	0.5	15	36	45
					60,000	2.0	23	12	21
					100,000	0.5	17	25	37
					100,000	2.0	23	10	29
180	120	−2	0	5.7	10,000	0.5	9	36	69
					10,000	2.0	21	23	39
					30,000	0.5	14	40	68
					30,000	2.0	25	31	31
250*	120*	−2	0	5.7	10,000	0.5	9	36	68
					10,000	2.0	21	23	40
					30,000	0.5	14	37	67
					30,000	2.0	25	26	34

*Maximum voltages.

Curves showing the fundamental power output and the second and third harmonic levels as functions of input voltage for a number of values of load resistance and a typical operating condition are given in Figures 15, 16 and 17.

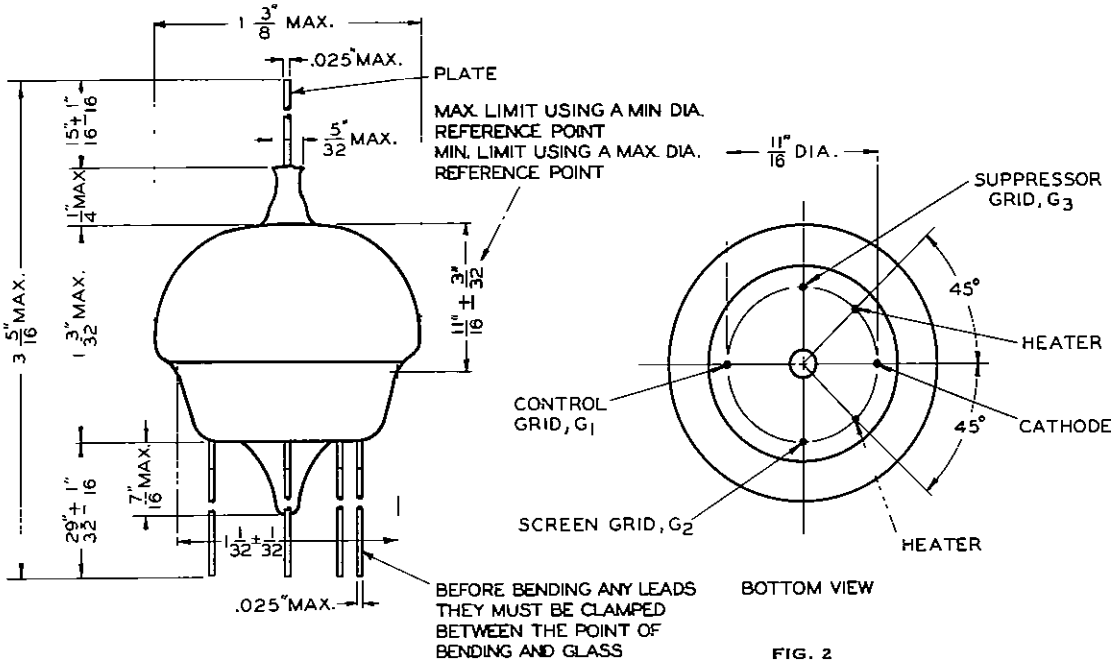


FIG. 1

FIG. 2

384 A

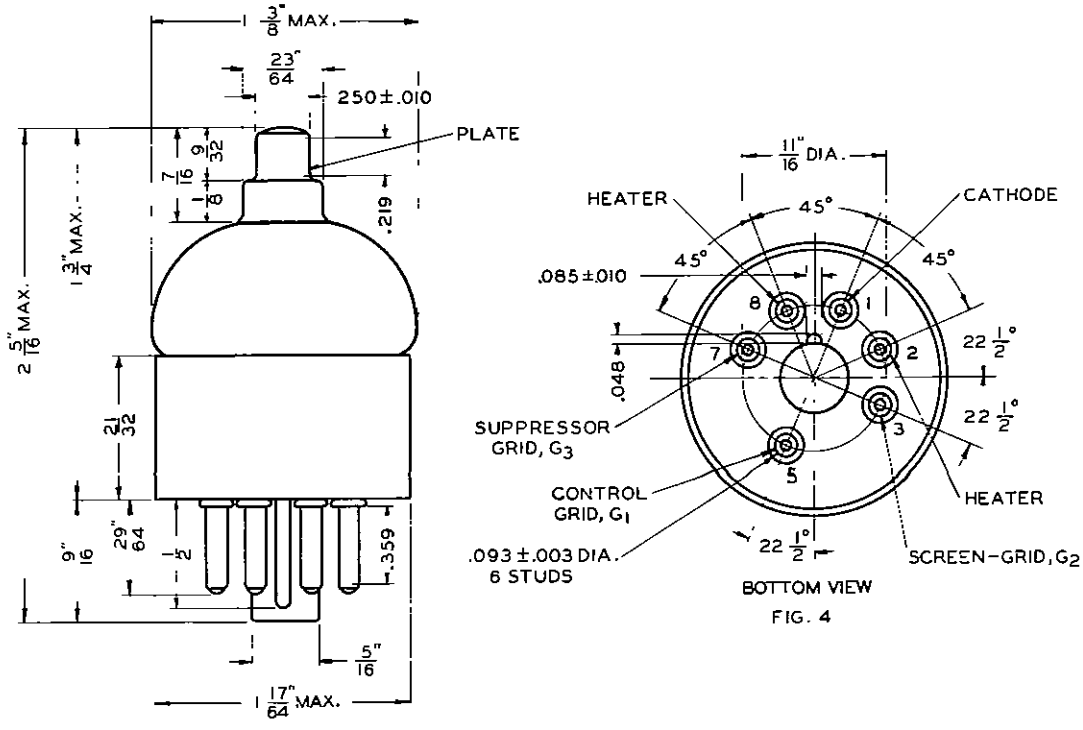


FIG. 3

FIG. 4

385 A

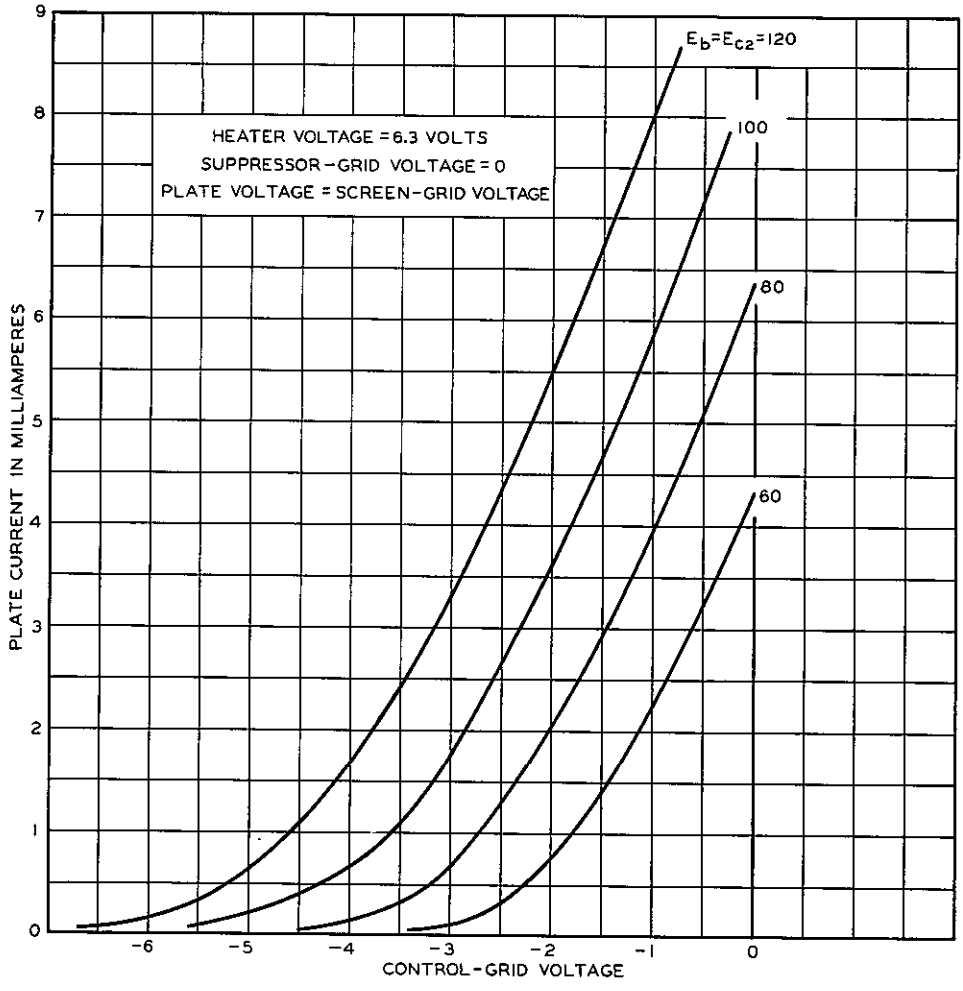

HEATER VOLTAGE = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 120
100
80
60
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0
1
2
3
4
5
6
7
8
9
-6
-5
-4
-3
-2
-1
0

FIG. 5

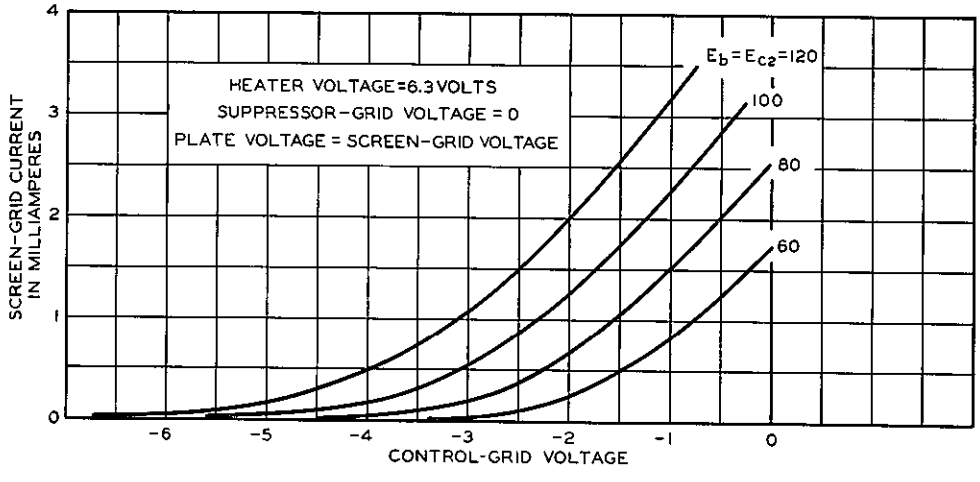

HEATER VOLTAGE = 6.3 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE VOLTAGE = SCREEN-GRID VOLTAGE
$E_b = E_{c2}$ = 120
100
80
60
SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
0
1
2
3
4
-6
-5
-4
-3
-2
-1
0

FIG. 6

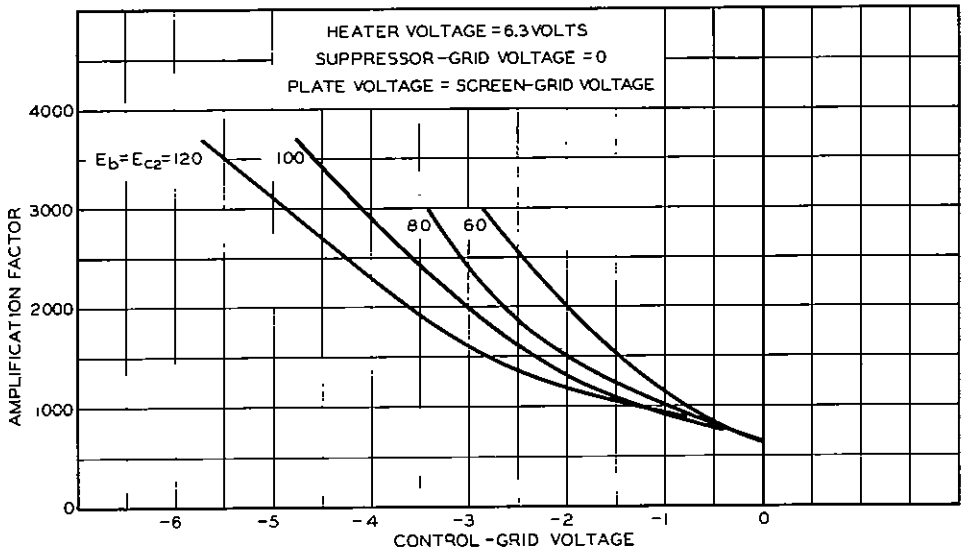


FIG. 7

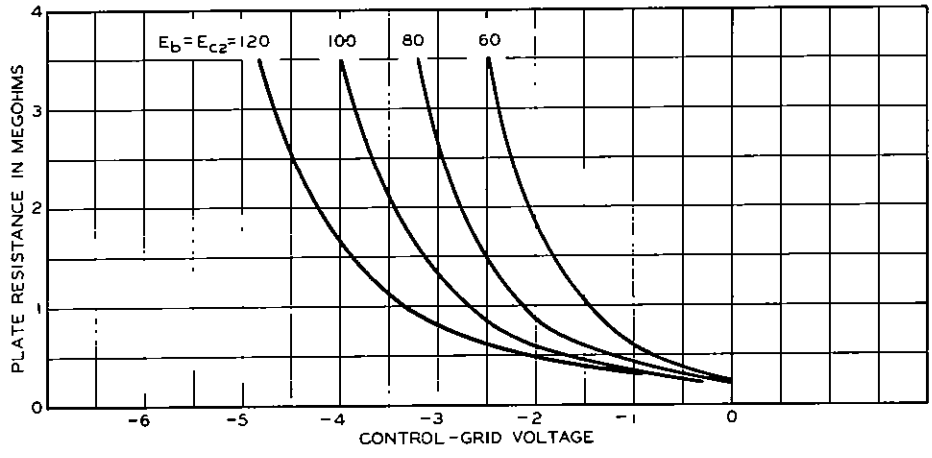


FIG. 8

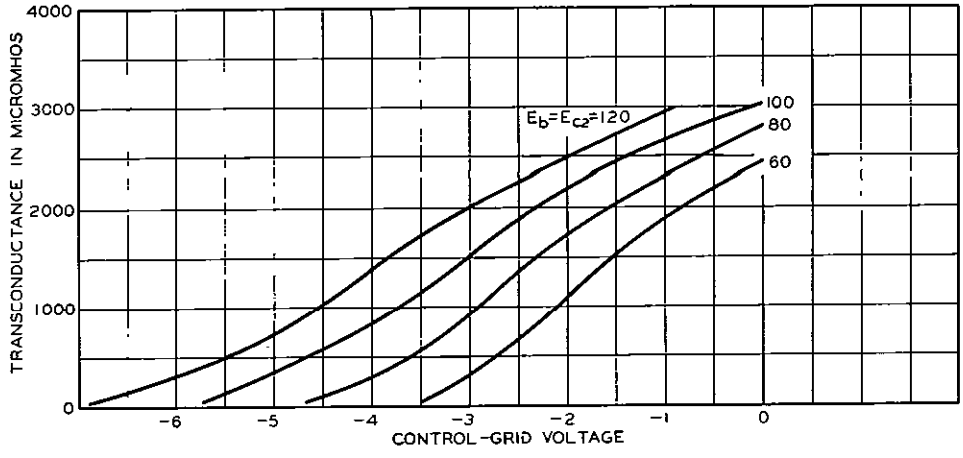


FIG. 9

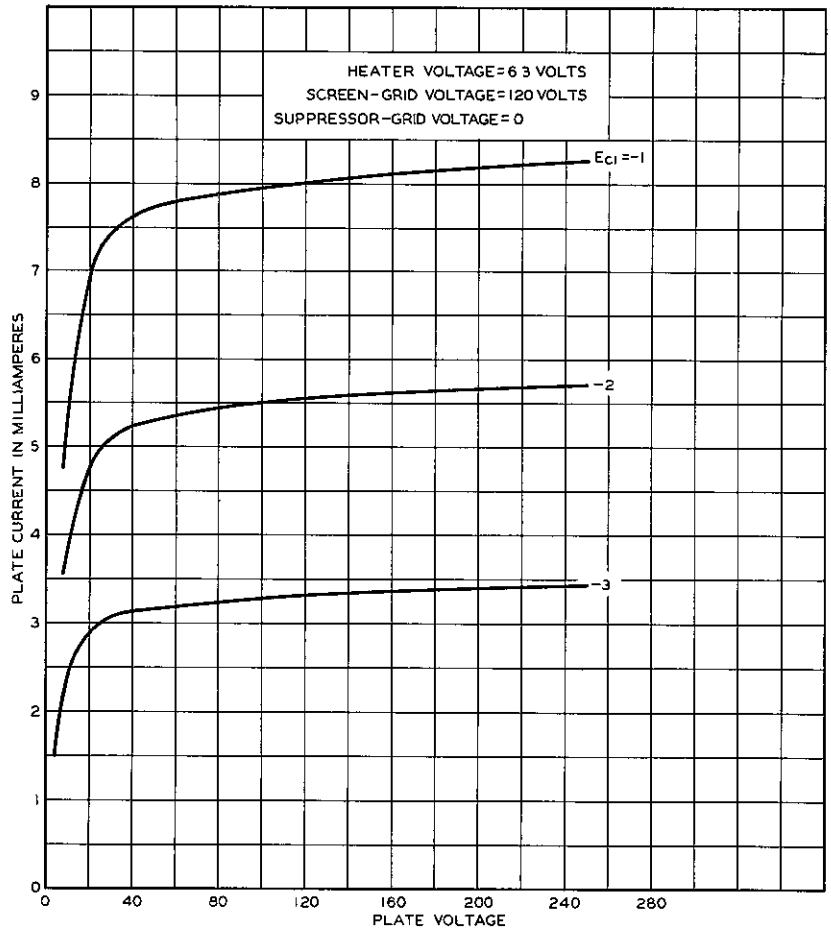

HEATER VOLTAGE=6.3 VOLTS
SCREEN-GRID VOLTAGE=120 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{C1}=-1
-2
-3
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
7
8
9
0
40
80
120
160
200
240
280

FIG. 10

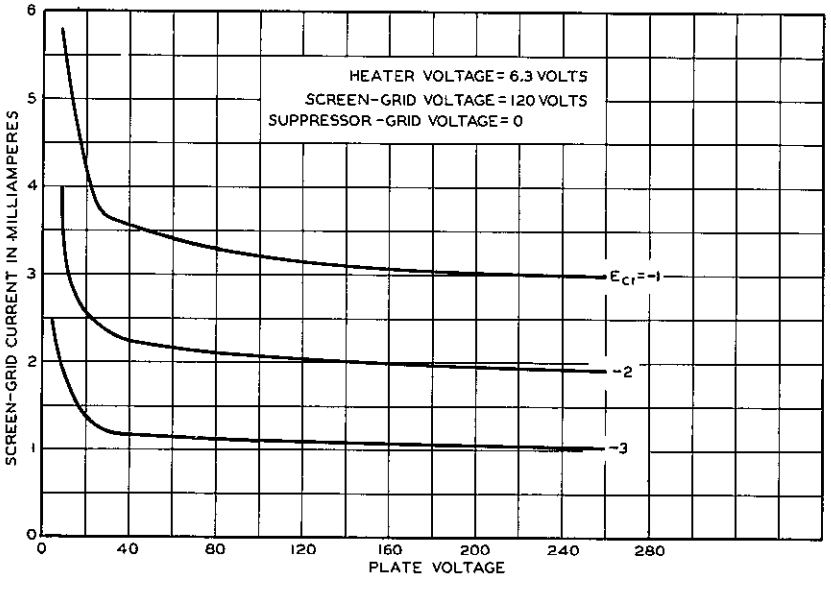

HEATER VOLTAGE=6.3 VOLTS
SCREEN-GRID VOLTAGE=120 VOLTS
SUPPRESSOR-GRID VOLTAGE=0
E_{C1}=-1
-2
-3
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
0
40
80
120
160
200
240
280

FIG. 11

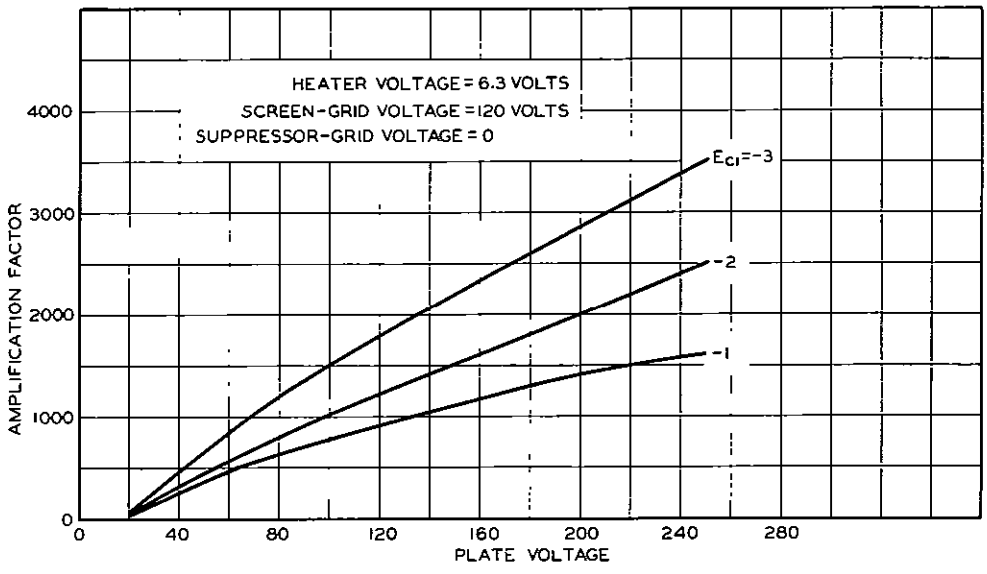


FIG. 12

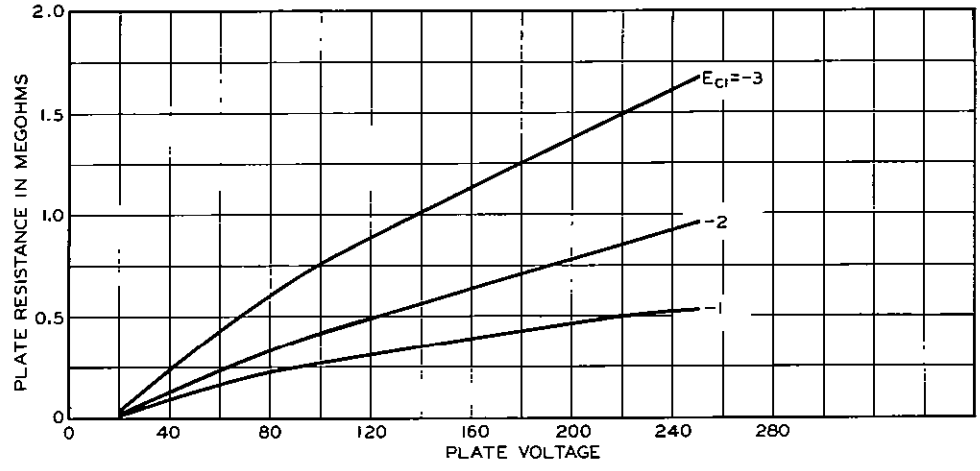


FIG. 13

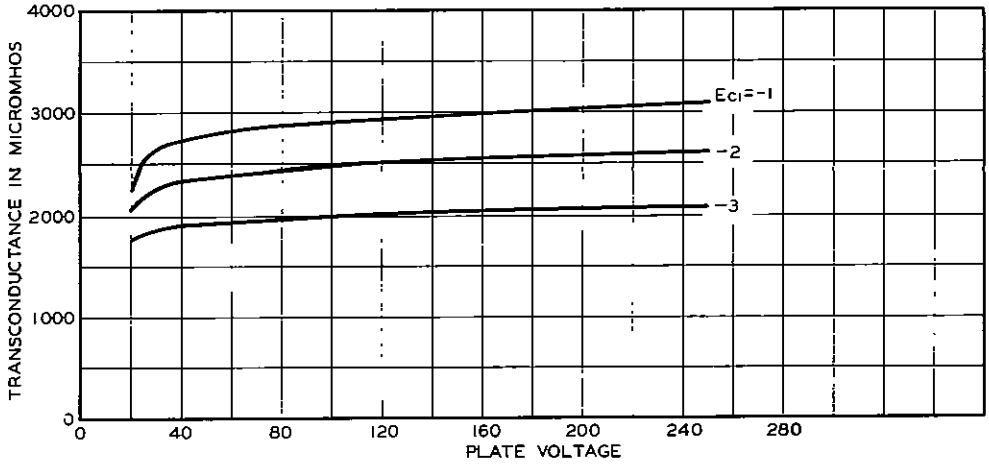


FIG. 14

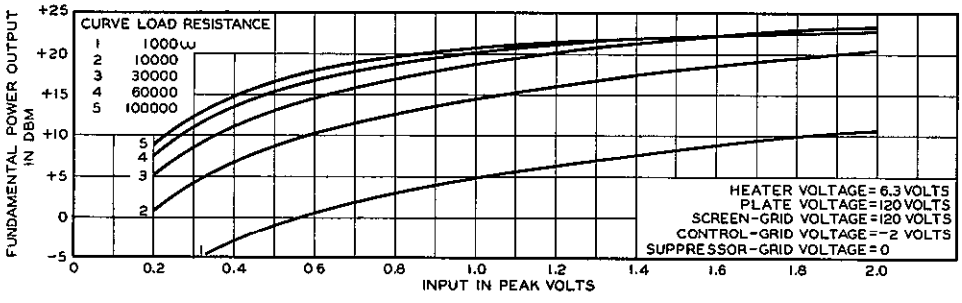


FIG. 15

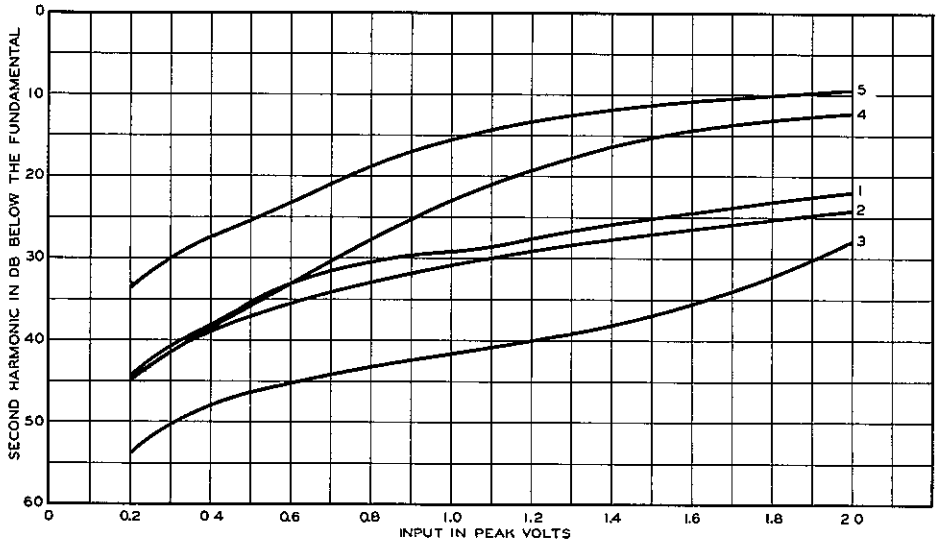


FIG. 16

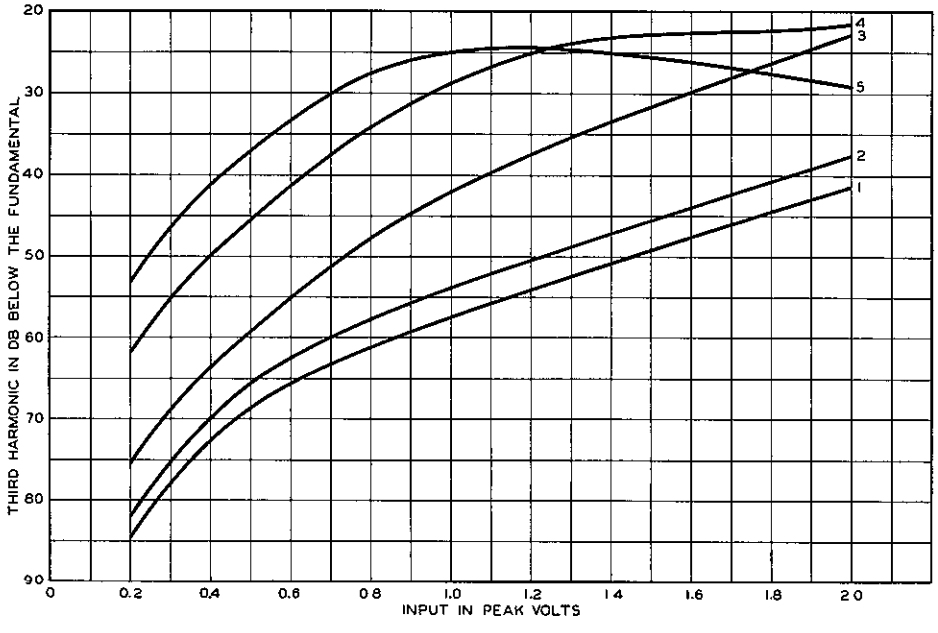


FIG. 17

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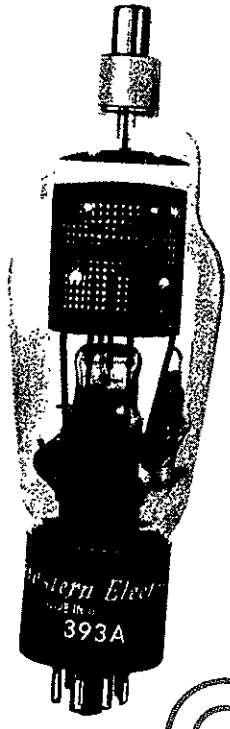
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V. T. DATA SHEET 384A 385A
ISSUE 1

ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 393A ELECTRON TUBE



A&M ONLY

DESCRIPTION

The 393A is a three-electrode mercury-vapor and gas-filled thyratron with a negative control characteristic. This tube is designed for use in regulated or controlled rectifiers.

MAXIMUM RATINGS

Peak Anode Voltage	1250 volts
Average Cathode Current.	1.5 amperes

FILE:THYRATRON SECTION

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MAXIMUM RATINGS, Absolute Values

Peak Anode Voltage	
Inverse	1250 volts
Forward	1250 volts
Cathode Current	
Peak	6 amperes
Average	1.5 amperes
Surge (maximum duration 0.1 second)	120 amperes
Averaging Time	5 seconds
Negative Grid Voltage	
Before Conduction	500 volts
During Conduction	10 volts
Positive Grid Current, Average	
(averaging time - one cycle)	.010 ampere
Condensed Mercury Temperature Limits[1]	-55 to +80 centigrade

ELECTRICAL DATA

	Min.	Bogey	Max.	
Filament Voltage	2.37	2.5	2.62	volts
Filament Current at 2.5 Volts	---	7.0	7.75	amperes
Filament Heating Time Required	15	---	---	seconds
Anode to Grid Capacitance	---	1.8	---	uuf
Grid to Filament Capacitance	---	5.0	---	uuf
Deionization Time, Approximate[2]				
E_{bb}=1250 volts;THg=80C;I_b=6 amperes;				
E_{cc}=-18 volts; R_g=20,000 ohms	---	1200	---	microseconds
Ionization Time, Approximate[3]				
E_{bb}=100 volts;THg=40C;grid overvoltage=5 volts	---	35	---	microseconds
E_{bb}=100 volts;THg=80C;grid overvoltage=25 volts.	---	0.5	---	microseconds
Anode Voltage Drop	---	15	---	volts
Critical Grid Current at 220 Anode Volts	---	---	5	microamperes
Change in Critical Grid Voltage at				
500 Anode Volts from +20 to +80THg	---	0.2	---	volt

MECHANICAL DATA

Type of Cooling	Convection
Equilibrium Condensed Mercury Temperature Rise Above Ambient, Approximate	
At Full Load	30 centigrade
At No Load	20 centigrade
Mounting Position	Vertical-base down
Net Weight, Approximate	3 ounces

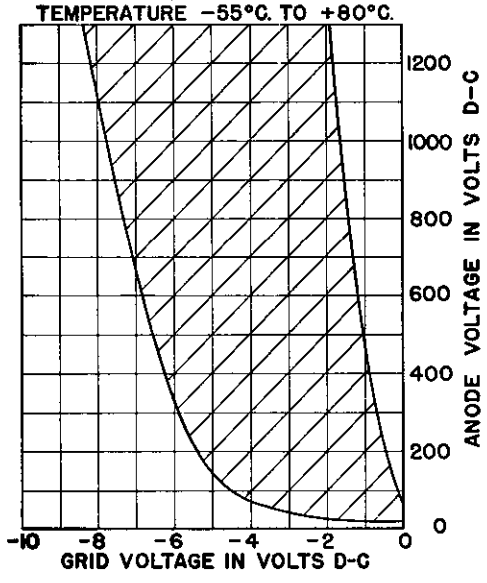
Dimensions and pin connections shown in outline drawing on Page 4.

1. For starting conditions only. Equilibrium operation is limited to +20C minimum condensed mercury temperature.

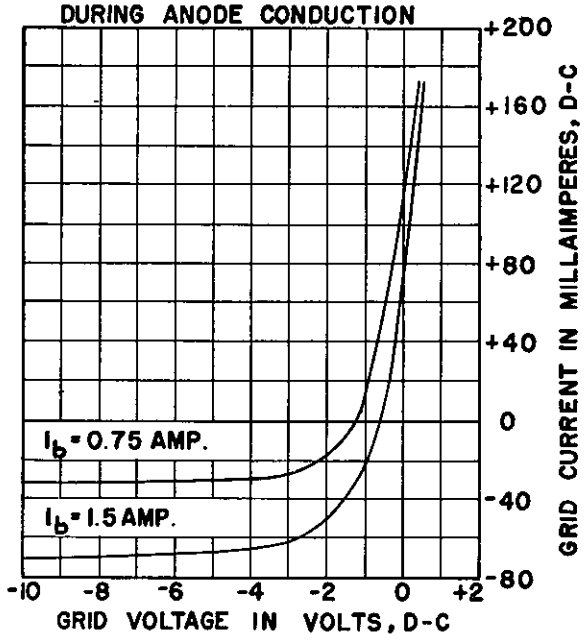
2. Deionization time decreases with an increase in negative grid voltage or with a decrease in (a) condensed mercury temperature (THg), (b) grid resistance or (c) anode current immediately preceding the end of conduction.

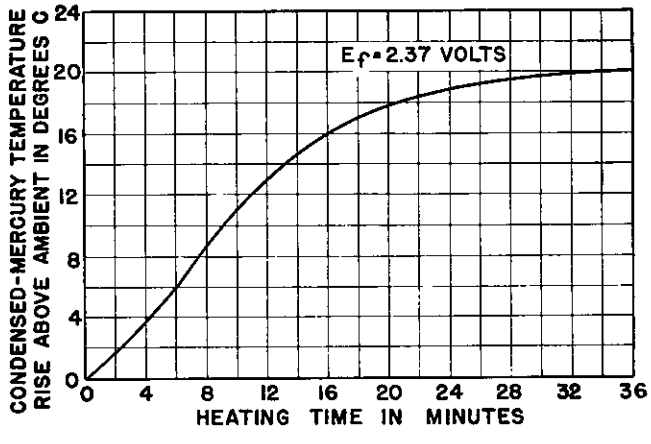
3. Ionization time decreases with an increase in (a) anode voltage, (b) condensed mercury temperature (THg) or (c) grid overvoltage. Grid overvoltage is defined as the magnitude by which the applied voltage exceeds, in a positive direction, the critical grid voltage value. Critical grid voltage is the instantaneous value of grid voltage at the time when anode current starts to flow.

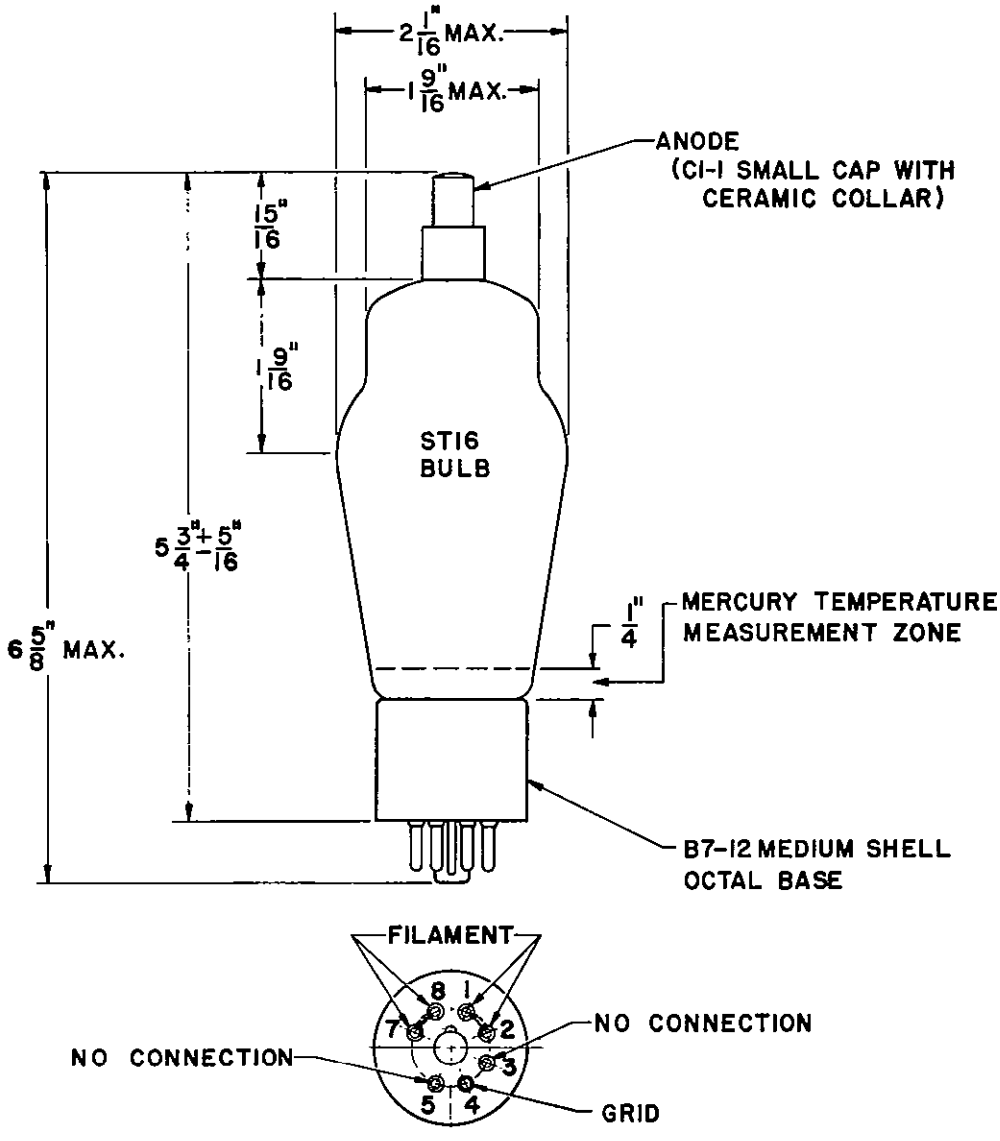
TYPICAL CONTROL CHARCTERISTICS. SHADED AREA SHOWS RANGE OF CHARACTERISTICS, CONDENSED MERCURY TEMPERATURE −55°C. TO +80°C.



TYPICAL GRID CURRENT CHARACTERISTICS DURING ANODE CONDUCTION





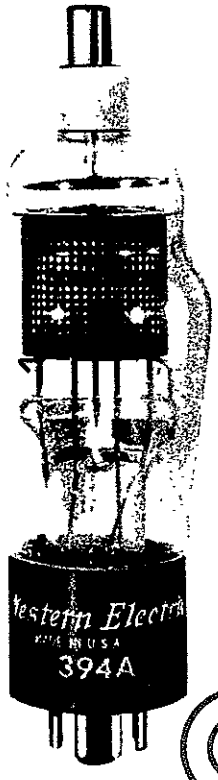


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ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 394A ELECTRON TUBE



A&M ONLY

DESCRIPTION

The 394A is a three-electrode mercury-vapor and gas-filled thyratron with a negative control characteristic. This tube is designed for regulated or controlled rectifiers.

MAXIMUM RATINGS

Peak Anode Voltage	1250 volts
Average Cathode Current	0.64 ampere

FILE:THYRATRON SECTION

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MAXIMUM RATINGS, Absolute Values

Peak Anode Voltage	
Inverse	1250 volts
Forward	1250 volts
Cathode Current	
Peak	2.5 amperes
Average	0.64 ampere
Surge (maximum duration 0.1 second)	25 amperes
Averaging Time	5 seconds
Negative Grid Voltage	
Before Conduction	500 volts
During Conduction	10 volts
Positive Grid Current, Average (Averaging time=one cycle)	0.010 ampere
Condensed Mercury Temperature Limits[1]	-55 to +80 centigrade

ELECTRICAL DATA

	Min.	Bogey	Max.	
Filament Voltage	2.37	2.5	2.62	volts
Filament Current at 2.5 Volts	---	3.25	3.50	amperes
Filament Heating Time Required	15	---	---	seconds
Anode to Grid Capacitance	---	1.6	---	uuf.
Grid to Filament Capacitance	---	5.5	---	uuf.
Deionization Time, Approximate[2]				
E_{bb}=1250 volts; I_b=2.5 amperes;				
E_{cc}=-18 volts; THg=80C; R_g=20000 ohms	---	1000	---	microseconds
Ionization Time, Approximate[3]				
E_{bb}=100 volts; THg=40C; Grid Overvoltage=5 volts	---	25	---	microseconds
E_{bb}=100 volts; THg=80C; Grid Overvoltage=25 volts	---	0.5	---	microseconds
Anode Voltage Drop	---	15	---	volts
Critical Grid Current at 220 Anode Volts	---	---	5	microamperes
Change in Critical Grid Voltage at				
500 Anode Volts from +20 to +80THg	---	0.2	---	volts

MECHANICAL DATA

Type of Cooling	Convection
Equilibrium Condensed Mercury Temperature Rise Above Ambient	
At Full Load (Approximate)	17 Centigrade
At No Load (Approximate)	12 Centigrade
Mounting Position	Vertical-base down
Net Weight, Approximate	3 ounces

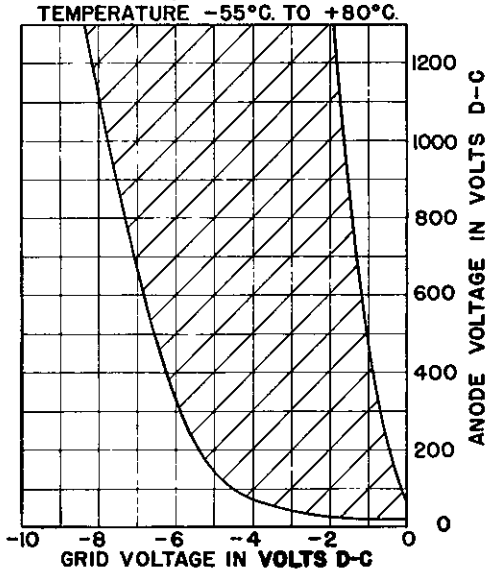
Dimensions and pin connections shown in outline drawing on Page 4.

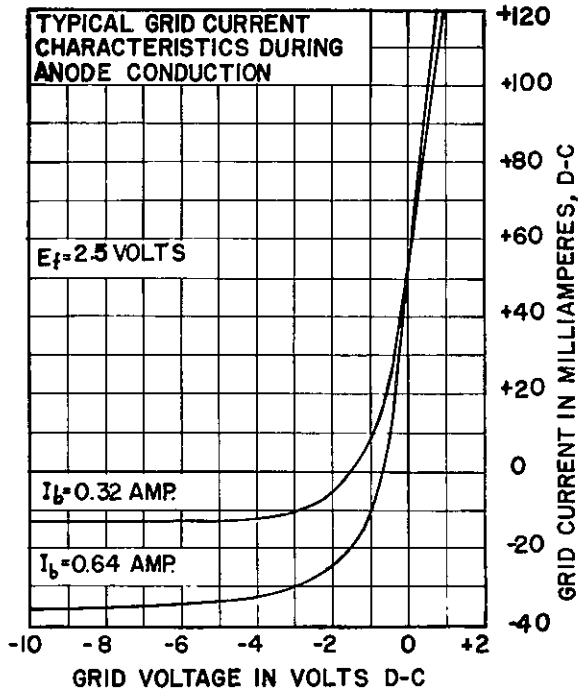
1. For starting conditions only. Equilibrium operation is limited to +20C minimum condensed mercury temperature.

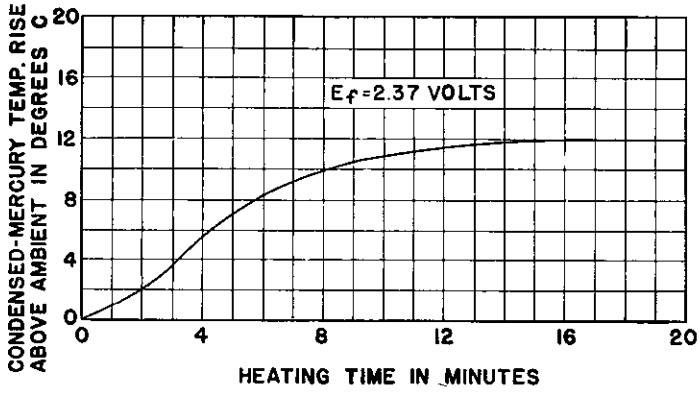
2. Deionization time decreases with an increase in negative grid voltage or with a decrease in (a) condensed mercury temperature (THg), (b) grid resistance or (c) anode current immediately preceding the end of conduction.

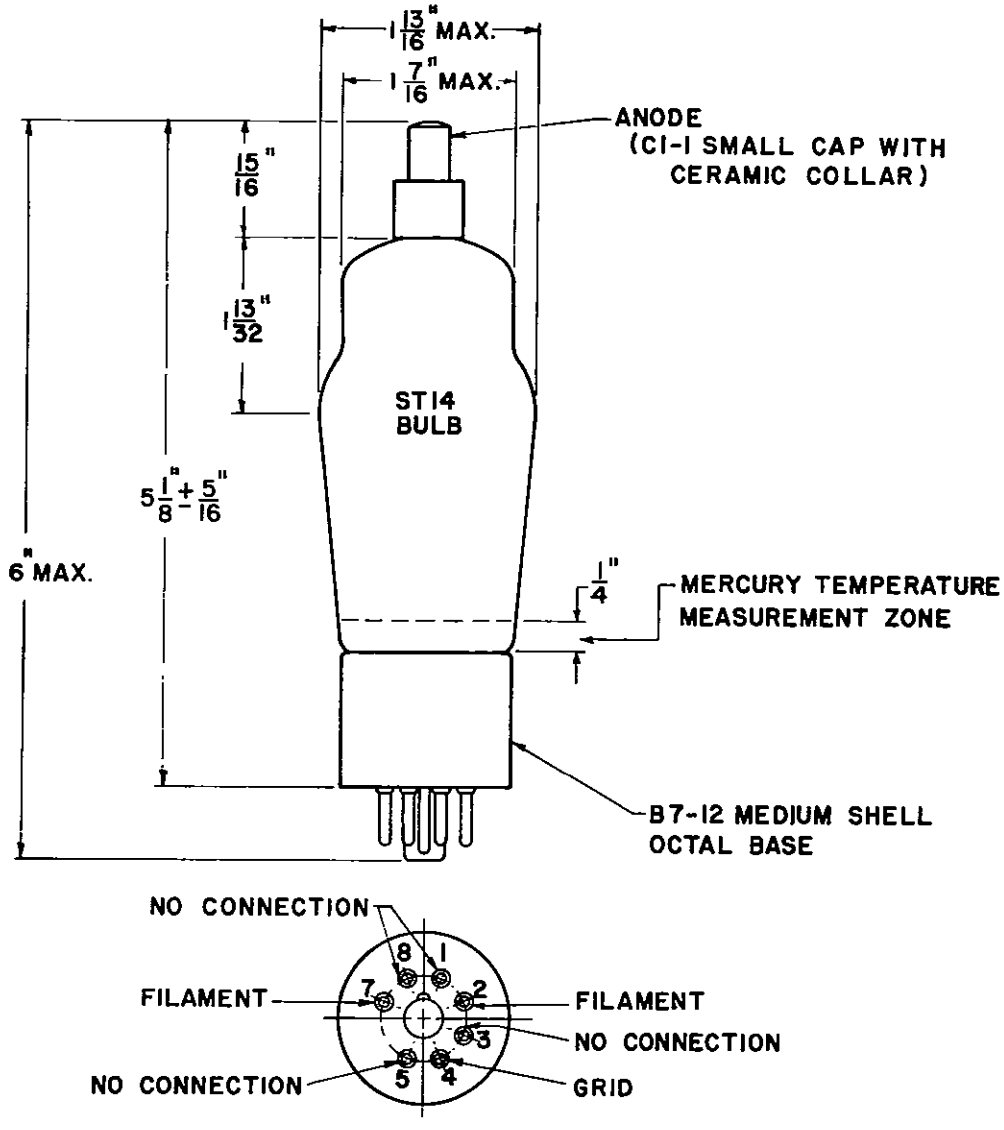
3. Ionization time decreases with an increase in (a) anode voltage, (b) condensed mercury temperature (THg) or (c) grid overvoltage. Grid overvoltage is defined as the magnitude by which the applied voltage exceeds, in a positive direction, the critical grid voltage value. Critical grid voltage is the instantaneous value of grid voltage at the time when anode current starts to flow.

TYPICAL CONTROL CHARCTERISTICS. SHADED AREA SHOWS RANGE OF CHARACTERISTICS, CONDENSED MERCURY TEMPERATURE −55°C. TO +80°C.









A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

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ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 395A ELECTRON TUBE



DESCRIPTION

The 395A electron tube is a ruggedized three-electrode inert-gas-filled cold cathode tube for use primarily in triggering circuits. This tube is designed to withstand a 1000 G centrifuge test. The 395A is also suitable for use in control circuits such as in relay, counting or switching apparatus. Small size and provisions for wiring directly into the circuits makes this tube especially suitable for use in small equipment.

CHARACTERISTICS

Peak Anode Voltage		140	volts
Average Cathode Current	4	35	milliamperes
Average Life, Approximate	10000	10	hours

File: Cold Cathode Section

Indicates a change ←

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MAXIMUM RATINGS, Absolute System (Note 1)

Peak Anode Voltage (Note 2)		
Forward	140	volts
Inverse	140	volts
→ Forward Cathode Current (Note 3)		
Peak	35	milliamperes
Average	13	milliamperes
Averaging Time	1	second
→ Peak Inverse Current, Anode or Starter (Note 3)	1	milliampere
Ambient Temperature Limits	-55 to +85	centigrade

ELECTRICAL DATA, Throughout Life

	Min.	Bogey	Max.	
Starter Breakdown Voltage (Notes 2 & 4)	71	80	84	volts
Starter Voltage Drop at 10 Milliamperes	52	65	74	volts
Anode Voltage Drop at 10 Milliamperes	68	80	85	volts
Transfer Current			See Curve - Fig. 1	
Required Transfer Current at 130 Anode Volts	10	-	-	microamperes
Deionization Time, Main Gap	-	2	-	milliseconds
Ionization Time, Starter Gap (Note 5)	-	0.05	-	millisecond

MECHANICAL DATA

Mounting Position	Any
Net Weight, Approximate	0.4 ounce
Ruggedness (Note 6)	1000 G

Dimensions and lead connections shown in outline drawing on Page 4.

HANDLING

This tube contains a small amount of krypton-85 gas which is a by-product radioactive material. The amount of krypton-85 is less than five microcuries, which is too small an amount to require any special care in use.

Atomic Energy Commission regulations require that the individual tube carton for tubes containing by-product radioactive material be appropriately marked. The marking includes the statement that tube disposal should be in approved manner.

Approved instructions for disposal of tubes containing krypton-85 are as follows;

> Tubes to be disposed of should be broken or crushed in a well ventilated place releasing any resulting vapors to the outside atmosphere. The residual broken or crushed tubes should be disposed of in a normal public trash disposal system. Tubes should be disposed of at a rate of not more than 100 each week from any one location. Avoid breathing vapors from broken tubes.

Note 1: In the "Absolute System" the maximum ratings specified are limiting values above which the serviceability of the device may be impaired from the viewpoint of life and satisfactory performance. Maximum ratings, as such, do not constitute a set of operating conditions and all values may not, therefore, be attained simultaneously.

Note 2: Values apply with the tube exposed to light in the order of 5 to 30 foot-candles. Exposure to direct sunlight may reduce peak anode voltage rating by as much as 45 volts and starter breakdown voltage as much as 5 volts.

→ Indicates a change

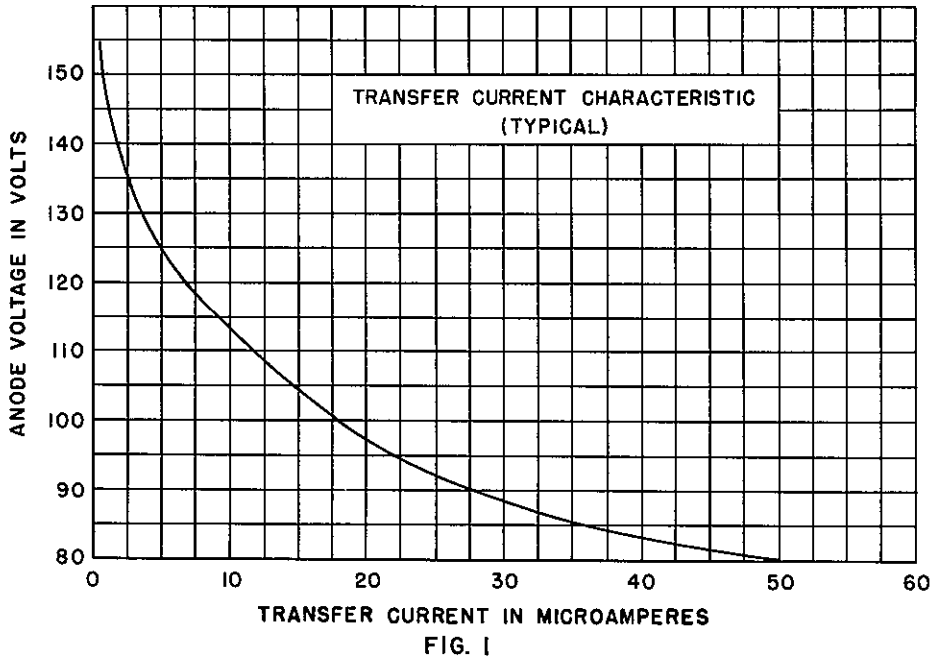


FIG. 1

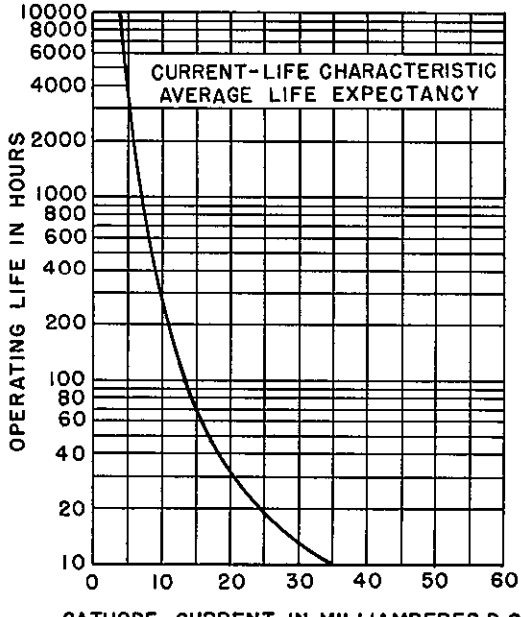


FIG. 2

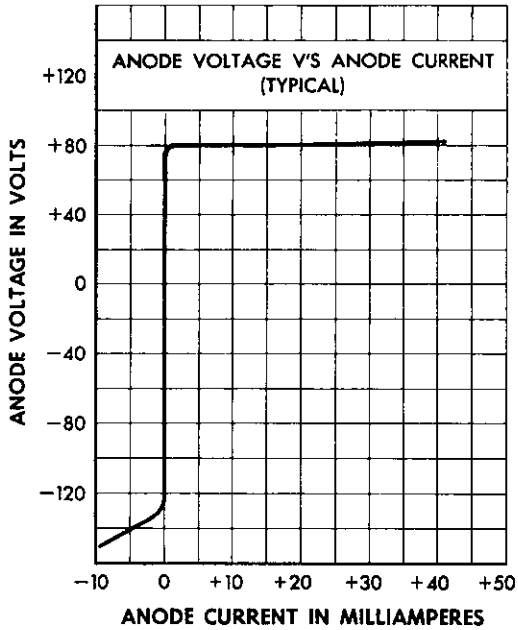


FIG. 3

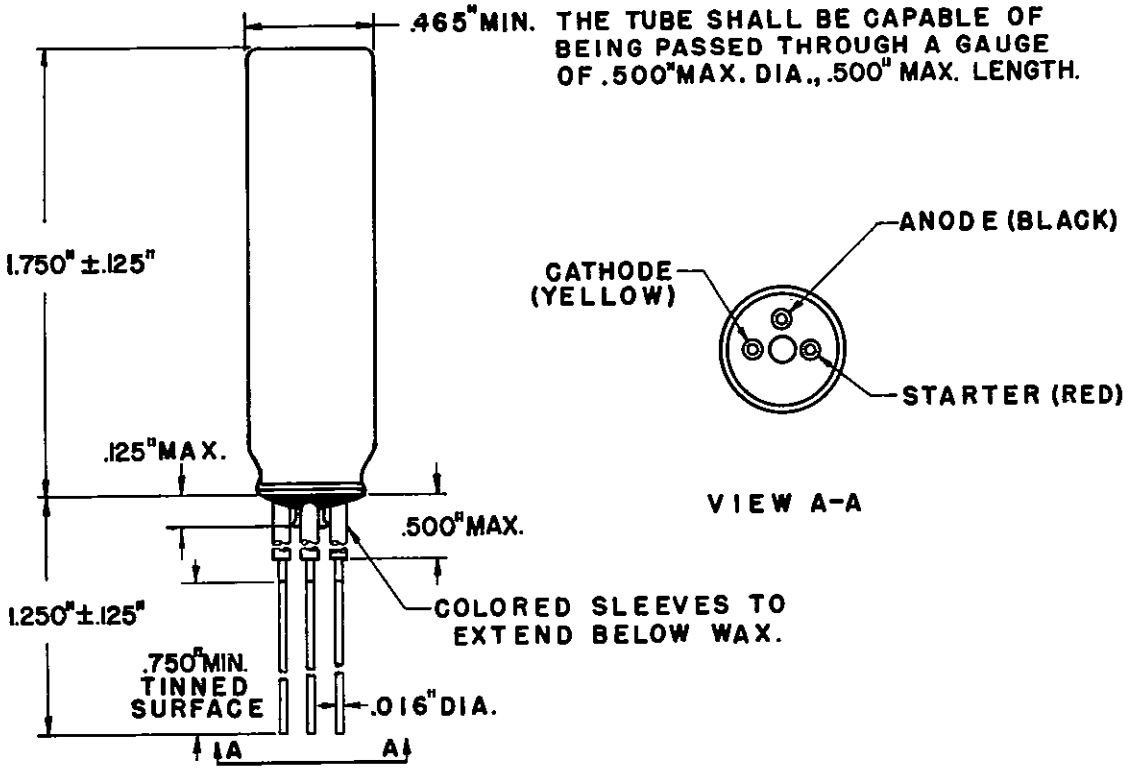
Note 3: Sufficient resistance must be used in series with the tube to assure that the electrode currents do not exceed their maximum rated values.

Note 4: Limits apply immediately after the tube has conducted current. If the tube has been idle, initially these values may be as much as 3 volts higher or lower.

Note 5: With 15 volts starter overvoltage. This value applies with the tube exposed to light in the order of 5 to 30 foot-candles. In total darkness ionization time will increase to a bogey of 5 milliseconds.

Note 6: Determined by centrifuge test.

Indicates a change ←



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ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 396A* ELECTRON TUBE



DESCRIPTION

The 2C51/396A* is a 9-pin miniature double triode having separate indirectly heated cathodes. It is designed for use in amplifier, mixer, oscillator, multivibrator and clamp circuits. The useful frequency extends through the VHF range.

CHARACTERISTICS

Heater Voltage		6.3 volts
Plate Current per Section	E_b = 150 volts; E_c = -2.0 volts	8.2 milliamperes
Transconductance per Section		5500 micromhos

File: Miniature Section
Issue 5, 11-54

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Heater Voltage	6.3 volts
Heater Current	300 milliamperes

Direct Interelectrode Capacitances	without external shield	with external shield (RETMA #315)
Grid to Plate per Section	1.3	*1.3 uuf
Input per Section: g to (h+k+i.s.)	2.2	*2.3 uuf
Output per Section: p to (h+k+i.s.)	1.0	*1.3 uuf
Plate-to-Plate	0.04	**0.03 uuf
Plate-to-Plate, Maximum	0.11	**0.10 uuf

MECHANICAL DATA

Cathode	Coated Unipotential
Bulb	T6 1/2
Base	Small Button, 9-pin
Mounting Position	Any

Dimensions and pin connections shown in outline drawing on Page 4

MAXIMUM RATINGS, Design-Center Values (Each Section)

Plate Voltage	300 volts
Plate Dissipation	1.5 watts
Plate Current	18 milliamperes
Grid Dissipation	0.1 watt
Heater-Cathode Voltage	90 volts
Bulb Temperature	120° centigrade

Maximum Grid Circuit Resistance for	
Fixed Bias	1 megohm
Cathode Bias	2 megohms

TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS - CLASS A_1 AMPLIFIER

(Each Section)

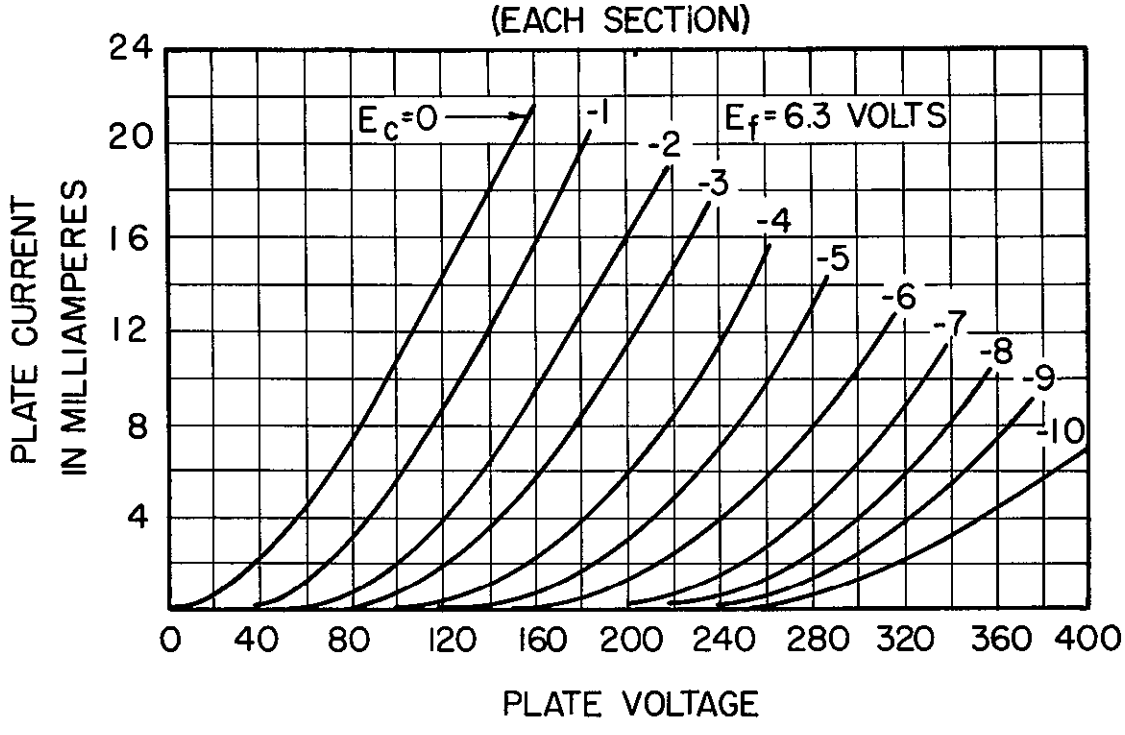
Plate Voltage	150	150 volts
Grid Voltage	-2.0	--- volts
Cathode Resistor	---	240 ohms
Plate Current	8.2	8.2 milliamperes
Transconductance	5500	5500 micromhos
Amplification Factor	35	35
Grid Voltage (approximate) for Plate Current of 10 microamperes	-8	--- volts

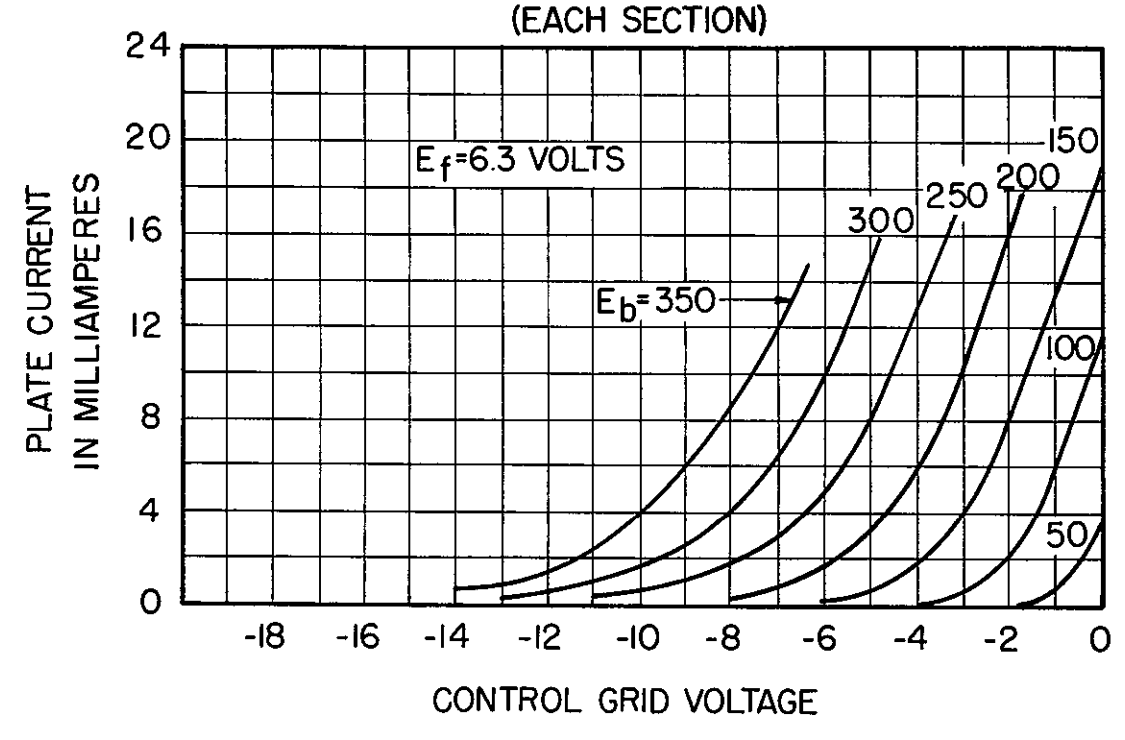
* Pin 5 and external shield (RETMA #315) connected to cathode pin of section under test. Elements of other section grounded.

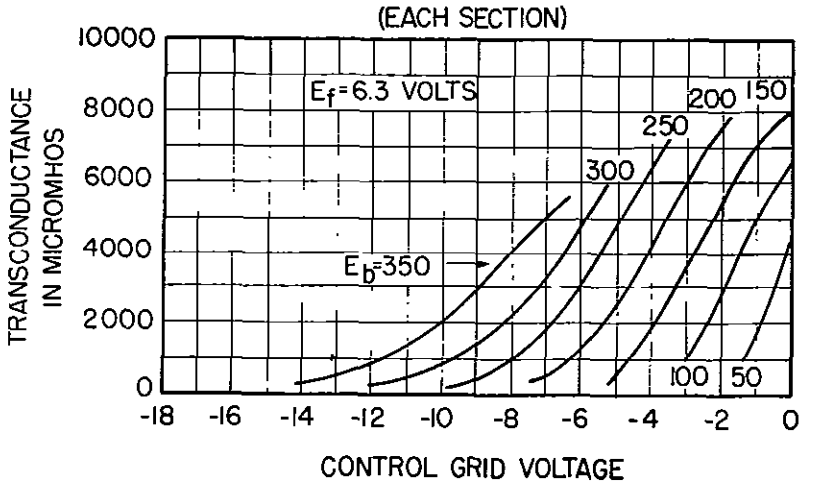
** Pin 5 and external shield (RETMA #315) connected to ground with other elements.

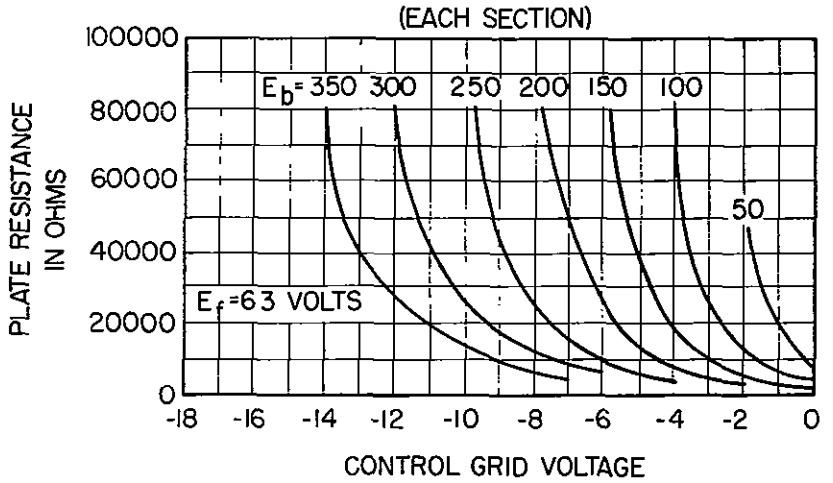
TYPICAL OPERATING CONDITIONS - CLASS AB_1 PUSH-PULL AMPLIFIER

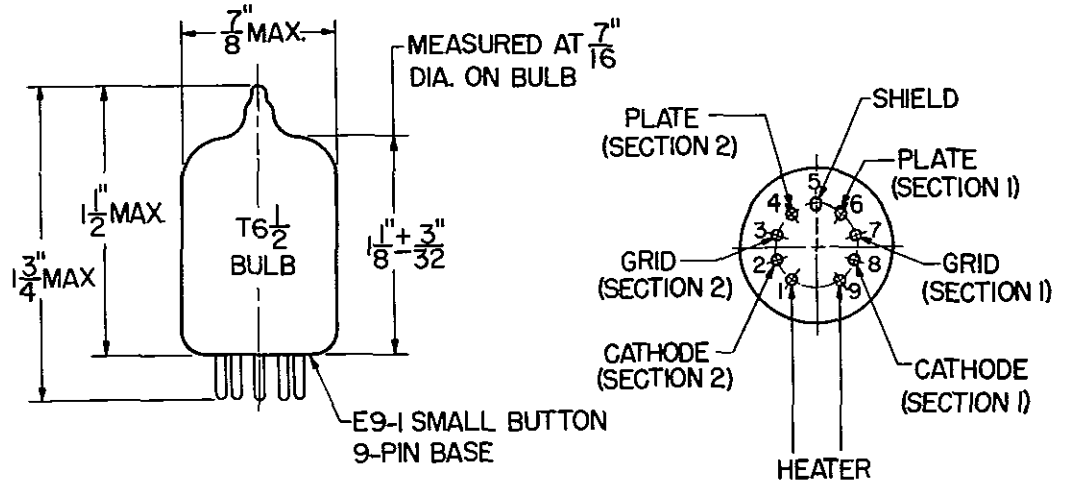
Plate Voltage	200	300 volts
Cathode Resistor (Cathodes Tied Together)	400	800 ohms
Peak A-F Grid-to-Grid Voltage	9.0	20 volts
Zero Signal Plate Current per Section	5.0	4.7 milliamperes
Maximum Signal Plate Current per Section	5.6	6.0 milliamperes
Load Impedance, Plate-to-Plate	30000	40000 ohms
Signal Power Output	0.40	0.95 watt
Total Harmonic Distortion Less Than	5	10 percent









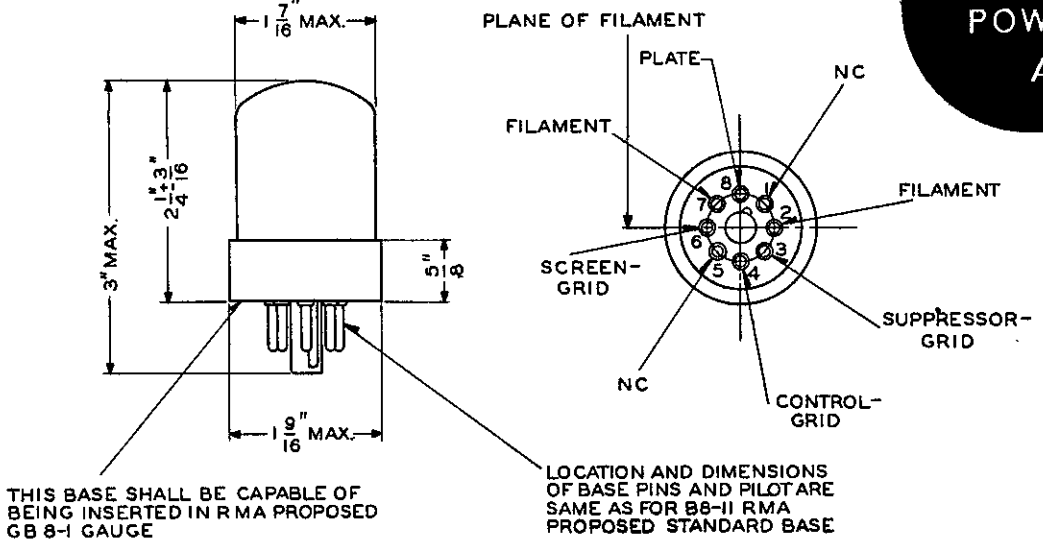


A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company

ADVANCE ELECTRON TUBE DATA SHEET

WESTERN ELECTRIC 5603/398A ELECTRON TUBE

5603/398A
POWER PENTODE AMPLIFIER



CLASSIFICATION

Filamentary Power Pentode Amplifier

MOUNTING

The tube should be mounted preferably in a vertical position. If mounted in a horizontal position, the plane through contact pins 2 and 6 must be vertical.

MAXIMUM RATINGS (DESIGN-CENTER VALUES)

Plate Voltage	150	volts
Plate Dissipation	8.0	watts
Screen Voltage	150	volts
Screen Dissipation	2.5	watts
Cathode Current	75	milliamperes

OPERATING CONDITIONS AND CHARACTERISTICS

Filament Voltage	6.3	volts
Filament Current	0.5	amp.
Plate Voltage	135	volts
Plate Current	50	milliamperes
Screen Voltage	135	volts
Screen Current	4	milliamperes
Suppressor-Grid Voltage	0	volts
Cathode Bias Resistor	230	ohms
Amplification Factor	92	
Plate Resistance	17000	ohms
Transconductance	5400	micromhos
Signal Grid Voltage	8.5	volts a-c
Load Resistance	2500	ohms
Power Output	2.2	watts

INTERELECTRODE CAPACITANCES (NO SHIELD)

Control-grid to filament, screen-grid and suppressor-grid	9.5	mmf
Plate to control-grid	0.3	mmf
Plate to filament, screen-grid and suppressor-grid	7.5	mmf

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