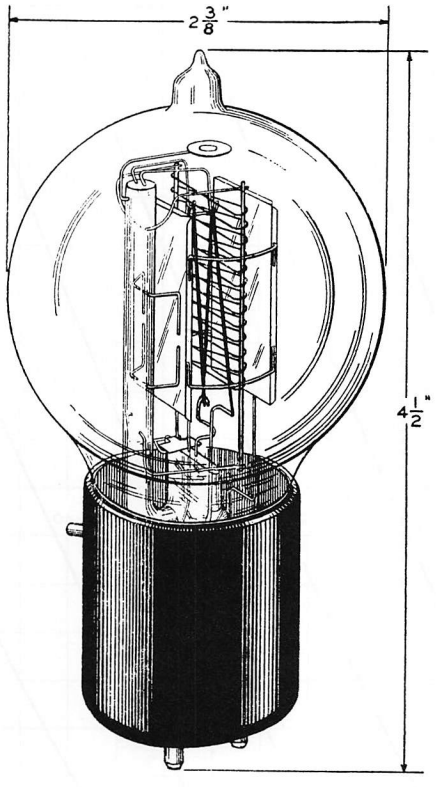
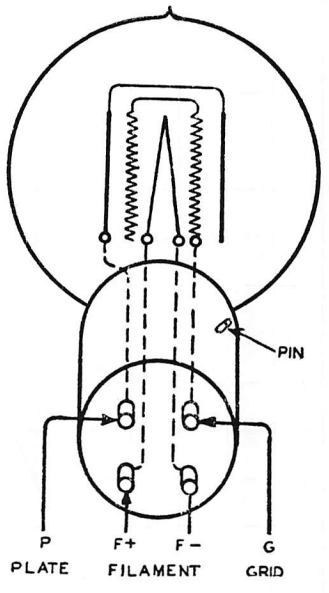
205D Vacuum Tube





Classification

The No. 205D is a three-element filamentary type tube intended for use as a radio-frequency amplifier, oscillator, modulator, and audio-frequency amplifier in output stages when moderate powers are required.

Base and Socket

The No. 205D Vacuum Tube employs a four-prong bayonet pin type base suitable for use in a Western Electric 100M (front panel mounting), 115B (rear panel mounting), or similar type socket.

General Ratings and Information

Filament Voltage	4.5 Volts, AC or DC
Filament Current	1.6 Amperes
Average Amplification Factor	7.3
Approximate Direct Interelectrode Capacities (measured without socket)	
Plate to Grid	4.8 MMF
Plate to Filament	3.3 MMF
Grid to Filament	5.2 MMF
Audio-Amplifier or Modulator Rating—Peak Grid Input Equal to or less than grid Bias—Class A Service.	
Maximum Plate Voltage	400 Volts
Maximum Plate Current	50 Milliamperes
Maximum Plate Dissipation	14 Watts

Typical outputs obtainable within the recommended operating conditions for resistance loads equal to twice the plate resistance and for inputs on the grid equal to the grid bias.

Plate Volts	Grid Volts	Approx. Plate Current (Milli-amperes)	Approx. Plate Resist-ance Rp (Ohms)	Fundamental Power Output (Milli-watts)	Second Harmonic. % of Funda. Output	Third Harmonic. % of Funda. Output
250	—10	27.5	4000	160	1.5	.1
300	—24	15	5000	670	5.5	.5
	—18	25	4150	480	3.0	.2
350	—22.5	30	3900	800	3.0	.3
	—20	35	3750	675	2.5	.2
370	—30	21	4450	1200	5.0	.5

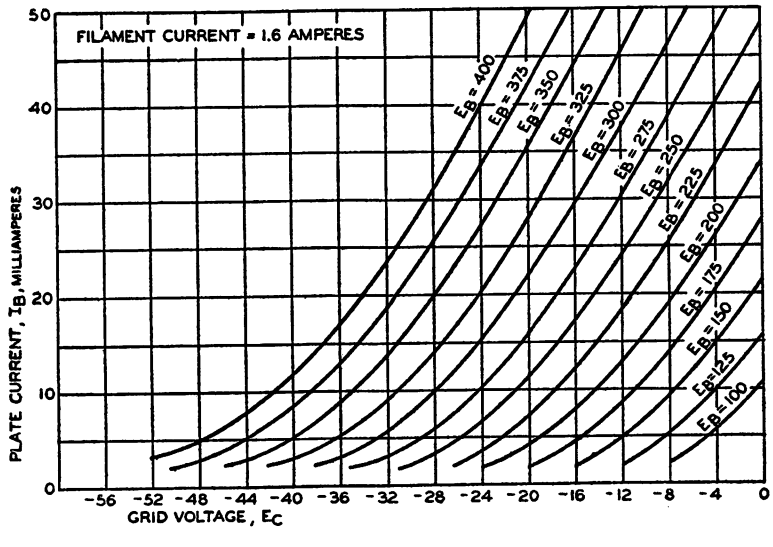
When two tubes are operated in a push-pull circuit the second harmonic in the output is reduced by the balancing action in the circuit. Due to the uniformity in the characteristics of the No. 205D Tube the second harmonic output, in the push-pull circuit, is reduced to the general level of the third harmonic output. With a plate voltage of 375 volts, and a total plate current of approximately 42 milliamperes, two No. 205D Tubes will give 2.4 watts output with a total harmonic content of the order of 1.0 per cent.

Radio-Frequency Amplifier—Grid Bias practically at Plate Cut-Off—Class B Service.

Maximum Plate Voltage	400 Volts
Maximum DC Plate Current	50 Milliamperes
Maximum Plate Dissipation	14 Watts
Peak Power Output	12 Watts

Oscillator or Radio-Frequency Amplifier—Grid Bias greater than Plate Current Cut-Off—Class C Service.

Maximum Non-modulated DC Plate Voltage	400 Volts
Maximum Modulated DC Plate Voltage	350 Volts
Maximum DC Plate Current	50 Milliamperes
Maximum Plate Dissipation	14 Watts
Peak Power Output	12 Watts



Average Static Characteristics

The accompanying curve gives the average static characteristics for the No. 205D Tube. These curves have been obtained with the filament operating on direct current and the grid and plate returns connected to the negative ends of the filament.

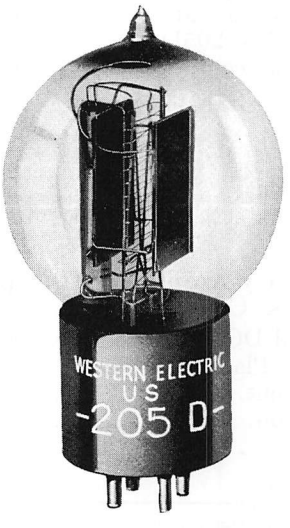
General Features

The No. 205D Tube will operate satisfactorily at or above 30,000 kilocycles if the radio-frequency charging current is limited to a value that will not cause excessive heating of the lead-in wires or di-electric parts.

The filament is of a particularly rugged oxide coated type insuring a long tube life.

Western Electric

205D Vacuum Tube



Classification—Moderate power, filamentary triode

Applications

Audio-frequency amplifier or modulator where power outputs of approximately 1 watt or less are required.

Radio-frequency power amplifier.

Oscillator.

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, four-pin, bayonet type with the bayonet pin offset.

Socket—Four-contact, bayonet-slot type, such as the Western Electric 100M for front of panel mounting or 115B for rear of panel mounting.

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

	A	B	C
Grid to plate, $\mu\mu f$	4.8	4.3	4.3
Grid to filament, $\mu\mu f$	5.2	6.4	6.9
Plate to filament, $\mu\mu f$	3.3	5.2	5.5

Column A—Based tube without socket.

Column B—Tube alone when measured in 100M socket mounted on metal plate; socket and mounting plate connected to filament.

Column C—Tube alone when measured in 115B socket mounted in metal plate; socket and mounting plate connected to filament.

Filament—Oxide-coated

Filament voltage	4.5 volts, a.c. or d.c.
Nominal filament current	1.6 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. 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.

Characteristics—Plate current charcteristics of a typical 205D tube are shown in Figure 3 as functions of grid voltage 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 voltage are shown in Figure 7. 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 are applicable if 2.6 is added to the numerical value of each grid bias.

Microphonic Noise—With a plate voltage of 350 volts, a grid bias of −22.5 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 205D tube measured in a laboratory reference test set is 25 decibels below 1 volt. The range of levels of individual tubes extends from 16 to 33 decibels 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.

Limiting Conditions for Safe Operation

	Class A Amp.	*Class B R-F Amp.	Class C R-F Amp. or Osc.	*Class C R-F Amp. Plate Modulated
Maximum direct plate voltage	400	400	400	350 volts
Maximum direct plate current	50	35	50	40 milliamperes
Maximum plate dissipation	14	14	14	10 watts
Maximum direct grid current	—	10	10	10 milliamperes

*Carrier conditions for use with modulation factors up to 1.0.

Operating Conditions and Output

Class A—Amplifier or Modulator

Permissible operating grid and plate voltages for Class A operation are included within the area, ABCD, in Figure 3. Amplification factor, plate resistance, transconductance, and performance data are given in Table I for a number of typical operating conditions represented by selected points within this area. 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 fundamental power output in milliwatts and the levels of the second and third harmonics in decibels below the fundamental for values of load resistance, R, equal to one, two, and in some cases three times the plate resistance, r_p. 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}, in each case, is numerically equal to the grid bias. For a smaller input voltage, E_g, the output and harmonic levels are given approximately by 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 I

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms r_p	Micromhos	Peak Volts	R	Milliwatts	db	db
200	− 6	22.5	7.4	4000	1840	6	$R=r_p$	60	35	65
							$R=2r_p$	55	40	70
250	−22	9	6.9	6000	1160	22	$R=r_p$	500	18	33
							$R=2r_p$	450	22	40
							$R=3r_p$	380	26	47
250	−15	19	7.2	4350	1670	15	$R=r_p$	310	26	45
							$R=2r_p$	280	30	55
250	−10	27.5	7.4	3800	1950	10	$R=r_p$	180	33	60
							$R=2r_p$	160	38	65
250	− 5	37.5	7.5	3500	2150	5	$R=r_p$	50	40	70
							$R=2r_p$	45	43	70
300	−30	8	6.7	6700	1000	30	$R=r_p$	800	15	28
							$R=2r_p$	720	20	35
							$R=3r_p$	600	24	42
300	−24	15.5	7.1	4800	1460	24	$R=r_p$	750	20	36
							$R=2r_p$	670	25	45
300	−18	25	7.3	4000	1830	18	$R=r_p$	540	27	46
							$R=2r_p$	480	31	55
350	−22.5	29	7.3	3800	1940	22.5	$R=r_p$	875	26	44
							$R=2r_p$	800	30	50
375	−30	22	7.1	4300	1660	30	$R=r_p$	1300	20	36
							$R=2r_p$	1200	26	45
*300	−10	41	7.4	3350	2220	10	$R=r_p$	200	37	65
							$R=2r_p$	180	41	70
*350	−20	34	7.3	3600	2060	20	$R=r_p$	750	28	50
							$R=2r_p$	675	32	55
*375	−24	32	7.3	3650	1990	24	$R=r_p$	1000	26	44
							$R=2r_p$	900	30	55
*400	−29	30	7.2	3800	1890	29	$R=r_p$	1400	23	39
							$R=2r_p$	1300	28	48

*Maximum operating conditions.

Class B—Amplifier

Radio-telephone applications, particularly the amplification of a modulated carrier wave with a minimum of distortion. Typical carrier conditions for use with modulation factors up to 1.0 are shown in Table II.

TABLE II

Direct Plate Voltage	Grid Bias	Direct Plate Current	Driving Voltage		Power Output		Effective Load Resistance	Peak Driving Power
			Carrier	A-F Peak	Carrier	A-F Peak		
Volts	Volts	Milli-amperes	Peak Volts	Volts	Watts	Watts	Ohms	Watts
350	−48	28	69	138	2.5	10	3100	1
400	−56	28	73	146	3.0	12	3700	1

Class C—Amplifier or Oscillator

Radio-telegraph or other continuous wave applications. Typical operating conditions are shown in Table III.

TABLE III

Direct Plate Voltage	Grid Bias	Direct Plate Current	Driving Voltage	Power Output	Effective Load Resistance	Driving Power
Volts	Volts	Milli-amperes	Peak Volts	Watts	Ohms	Watts
350	− 96	45	186	8.3	3750	1.3
400	−112	45	202	10.0	4500	1.5

Class C—Amplifier—Plate modulated

Radio-telephone applications. Typical carrier conditions for use with modulation factors up to 1.0 are shown in Table IV.

TABLE IV

Direct Plate Voltage	Grid Bias	Direct Plate Current	Driving Voltage	Power Output	Effective Load Resistance	Driving Power
Volts	Volts	Milli-amperes	Peak Volts	Watts	Ohms	Watts
300	−120	35	205	6.0	4000	1.3
350	−144	35	229	7.1	5000	1.7

High Frequency Ratings

If the 205D tube is to be used at frequencies higher than 15 megacycles, the plate voltage and plate dissipation ratings given above should be reduced to avoid excessive high-frequency currents, excessive heating due to dielectric losses, and consequent injury to the tube. At the limiting frequency of 30 megacycles, the maximum ratings should be as follows:

Maximum plate voltage	300 volts
Maximum plate dissipation	10 watts
Maximum r-f grid current	3 amperes

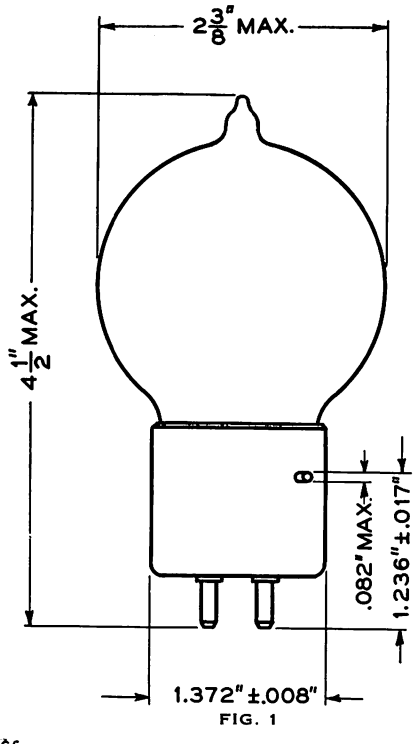


FIG. 1

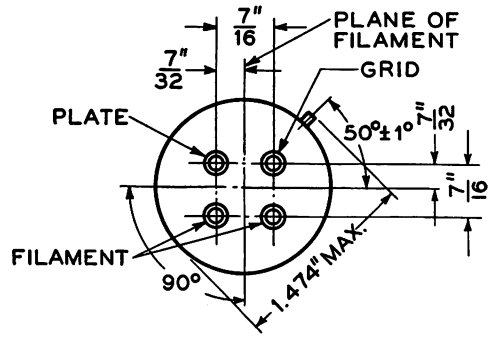


FIG. 2

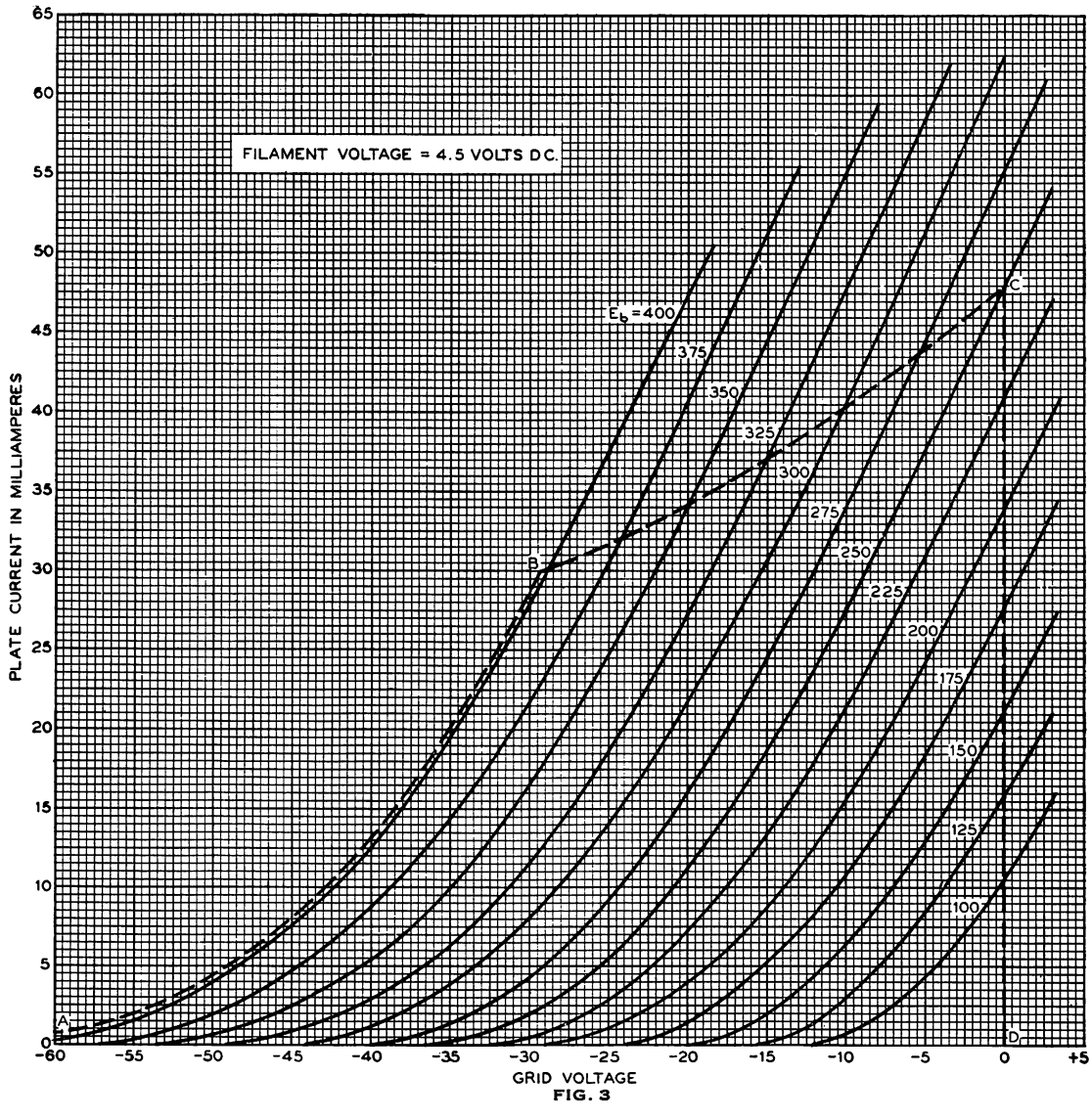


FIG. 3

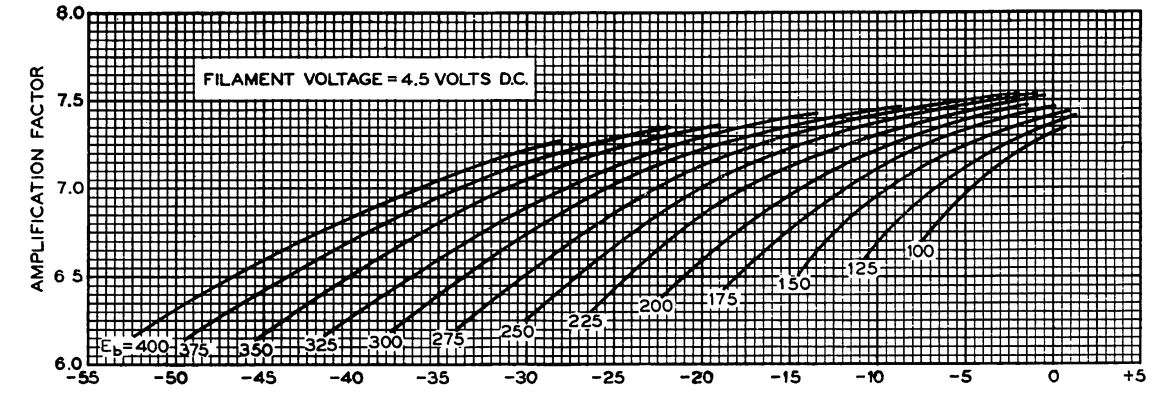


FIG. 4

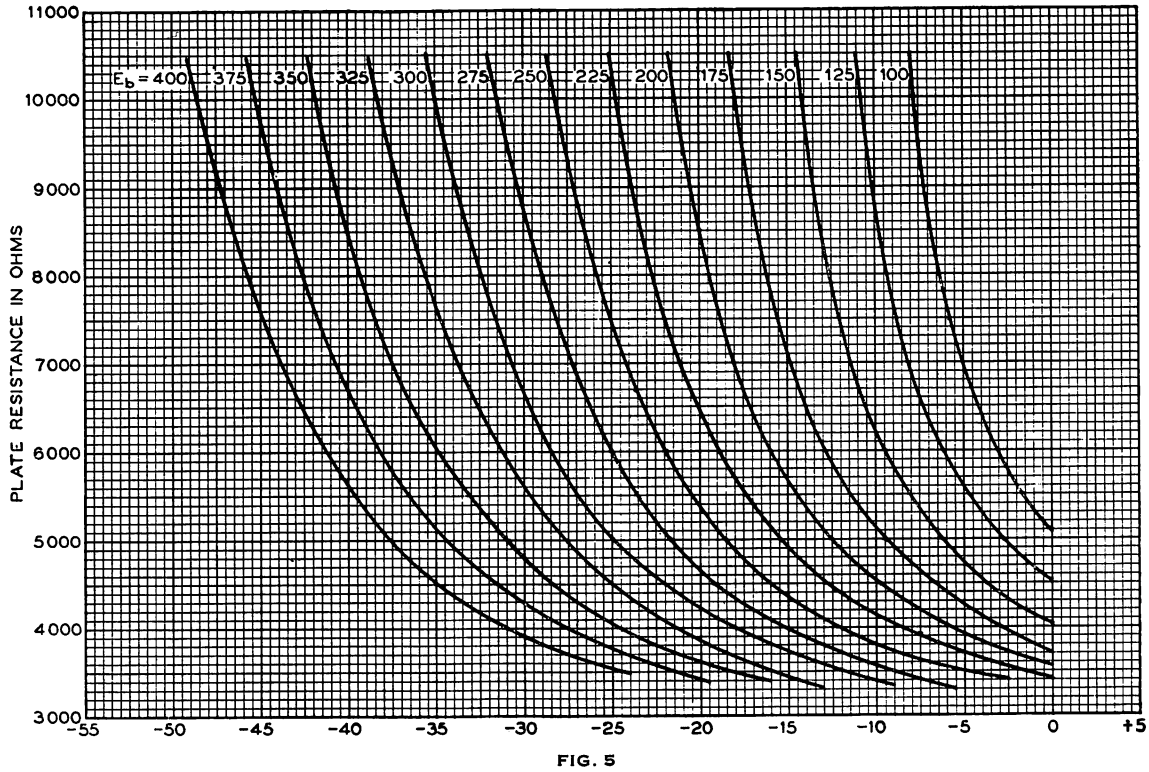


FIG. 5

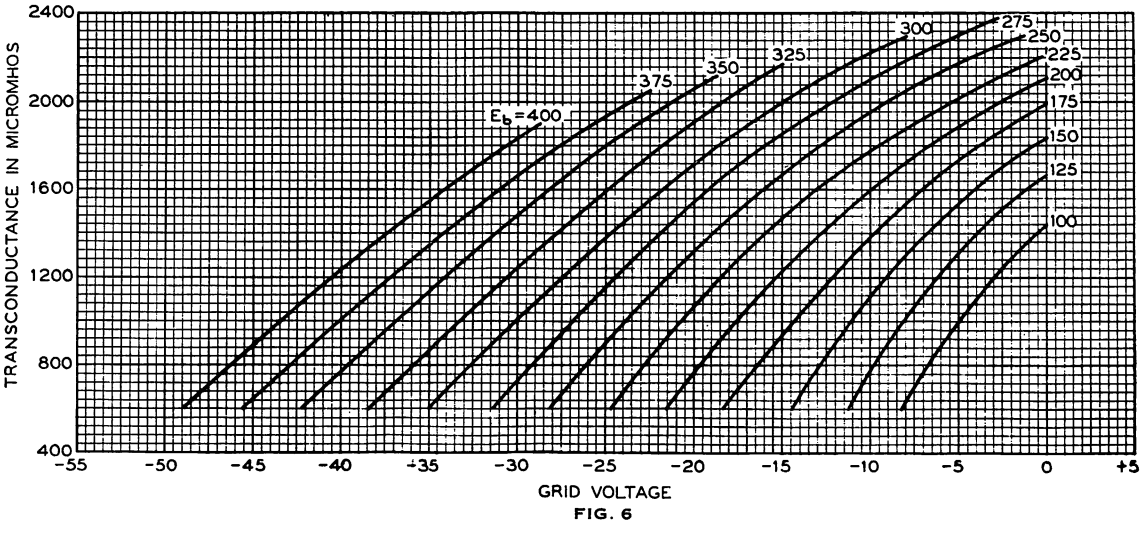


FIG. 6

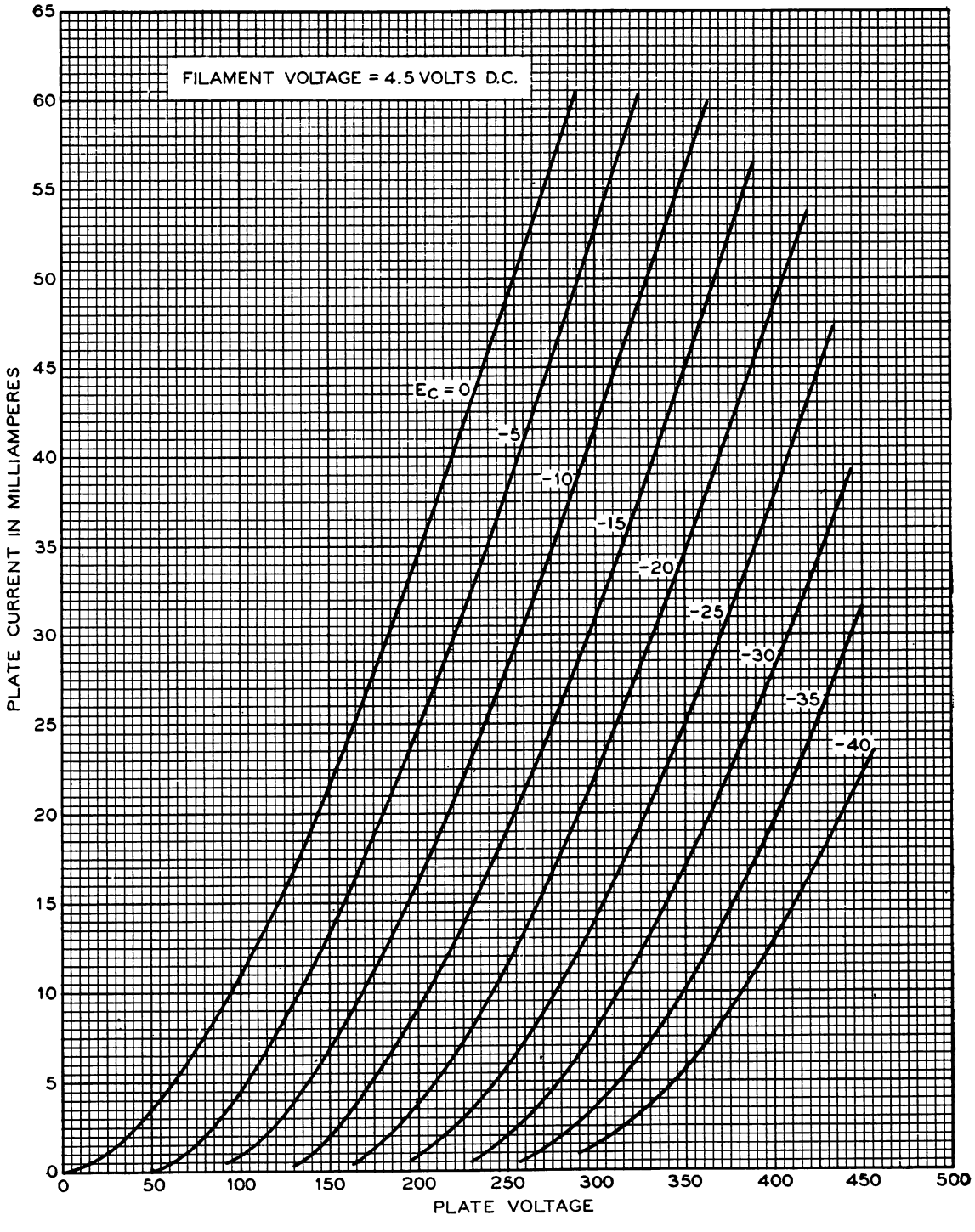
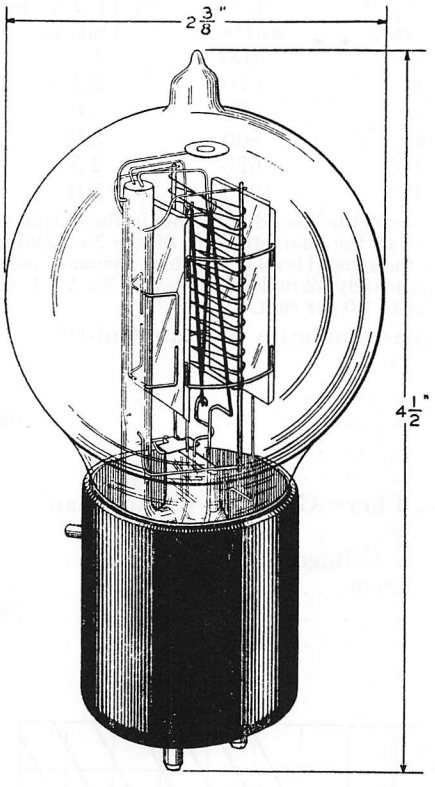
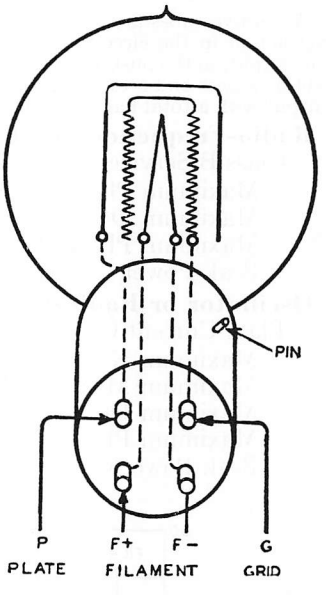

FILAMENT VOLTAGE = 4.5 VOLTS D.C.
$E_C = 0$
-5
-10
-15
-20
-25
-30
-35
-40
PLATE CURRENT IN MILLIAMPERES
0
5
10
15
20
25
30
35
40
45
50
55
60
65
0
50
100
150
200
250
300
350
400
450
500
PLATE VOLTAGE

FIG. 7

205E Vacuum Tube





Classification

The No. 205E is a three-element filamentary type tube intended for use as a radio-frequency amplifier, oscillator, modulator, and audio-frequency amplifier in output stages when moderate powers are required.

Base and Socket

The No. 205E Vacuum Tube employs a four-prong bayonet pin type base suitable for use in a Western Electric 100M (front panel mounting), 115B (rear panel mounting), or similar type socket.

General Ratings and Information

Filament Voltage	4.5 Volts, AC or DC
Filament Current	1.6 Amperes
Average Amplification Factor	7.3
Approximate Direct Interelectrode Capacities (measured without socket)	
Plate to Grid	4.8 MMF
Plate to Filament	3.3 MMF
Grid to Filament	5.2 MMF
Audio-Amplifier or Modulator Rating—Peak Grid Input Equal to or less than grid Bias—Class A Service.	
Maximum Plate Voltage	400 Volts
Maximum Plate Current	50 Milliamperes
Maximum Plate Dissipation	14 Watts

Typical outputs obtainable within the recommended operating conditions for resistance loads equal to twice the plate resistance and for inputs on the grid equal to the grid bias.

Plate Volts	Grid Volts	Approx. Plate Current (Milli-amperes)	Approx. Plate Resistance Rp (Ohms)	Fundamental Power Output (Milli-watts)	Second Harmonic. % of Funda. Output	Third Harmonic. % of Funda. Output
250	—10	27.5	4000	160	1.5	.1
300	—24	15	5000	670	5.5	.5
	—18	25	4150	480	3.0	.2
350	—22.5	30	3900	800	3.0	.3
	—20	35	3750	675	2.5	.2
370	—30	21	4450	1200	5.0	.5

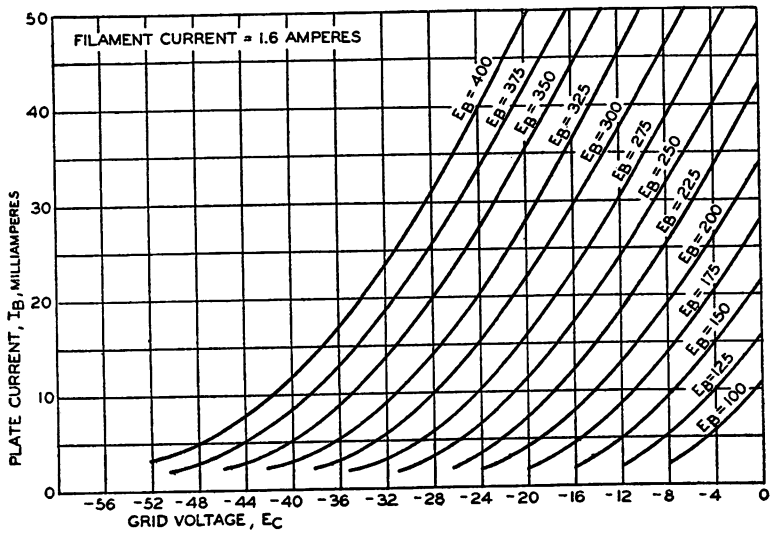
When two tubes are operated in a push-pull circuit the second harmonic in the output is reduced by the balancing action in the circuit. Due to the uniformity in the characteristics of the No. 205E tube the second harmonic output, in the push-pull circuit, is reduced to the general level of the third harmonic output. With a plate voltage of 375 volts and a total plate current of approximately 42 milliamperes, two No. 205E tubes will give 2.4 watts output with a total harmonic content of the order of 1.0 per cent.

Radio-Frequency Amplifier—Grid Bias practically at Plate Cut-Off—Class B Service.

Maximum Plate Voltage	400 Volts
Maximum DC Plate Current	50 Milliamperes
Maximum Plate Dissipation	14 Watts
Peak Power Output	12 Watts

Oscillator or Radio-Frequency Amplifier—Grid Bias greater than Plate Current Cut-Off—Class C Service.

Maximum Non-modulated DC Plate Voltage	400 Volts
Maximum Modulated DC Plate Voltage	350 Volts
Maximum DC Plate Current	50 Milliamperes
Maximum Plate Dissipation	14 Watts
Peak Power Output	12 Watts



Average Static Characteristics

The accompanying curve gives the average static characteristics for the No. 205E Tube. These curves have been obtained with the filament operating on direct current and the grid and plate returns connected to the negative ends of the filament.

General Features

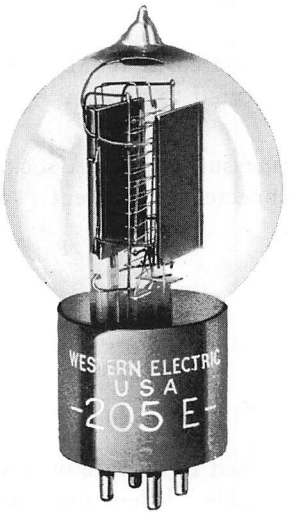
The No. 205E Tube will operate satisfactorily at or above 30,000 kilocycles if the radio frequency charging current is limited to a value that will not cause excessive heating of lead-in wires or di-electric parts.

It is similar to the No. 205D except that the internal structure is designed to reduce noise disturbance outputs due to variable contacts within the tube. The prongs of the base are equipped with special contact metal tips to prevent noise disturbance due to poor electrical contact with the springs of the socket.

The filament is of a particularly rugged oxide coated type insuring a long tube life.

Western Electric

205E Vacuum Tube



Classification—Moderate power, filamentary triode

The 205E tube is similar to the 205D tube except that special precautions have been taken in the 205E tube to minimize sputter noise in the tube and contact noise between the contact pins and the socket.

Applications

Audio-frequency amplifier or modulator where power outputs of approximately 1 watt or less are required.

Radio-frequency power amplifier.

Oscillator.

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, four-pin, bayonet type having special contact metal at the ends of the contact pins. The bayonet pin is offset.

Socket—Four-contact, bayonet-slot type, preferably provided with contact-metal contacts, such as the Western Electric 100M for front of panel mounting or 116A for rear of panel mounting.

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

	A	B	C
Grid to plate, $\mu\mu$f	4.8	4.3	4.3
Grid to filament, $\mu\mu$f	5.2	6.4	6.9
Plate to filament, $\mu\mu$f	3.3	5.2	5.5

Column A—Based tube without socket.

Column B—Tube alone when measured in 100M socket mounted on metal plate; socket and mounting plate connected to filament.

Column C—Tube alone when measured in 116A socket mounted in metal plate; socket and mounting plate connected to filament.

Filament—Oxide-coated

Filament voltage	4.5 volts, a.c. or d.c.
Nominal filament current	1.6 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. 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.

Characteristics—Plate current charcteristics of a typical 205E tube are shown in Figure 3 as functions of grid voltage 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 voltage are shown in Figure 7. 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 are applicable if 2.6 is added to the numerical value of each grid bias.

Microphonic Noise—With a plate voltage of 350 volts, a grid bias of −22.5 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of 205E tube measured in a laboratory reference test set is 25 decibels below 1 volt. The range of levels of individual tubes extends from 16 to 33 decibels 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.

Sputter Noise—A particularly disagreeable type of noise, characterized by an unmusical crackling or sputtering sound, occurs in many vacuum tubes, sometimes as a result of slight mechanical agitation. The sputter noise spectrum covers a wide band and may be of appreciable intensity even at radio frequencies. Such noise is usually due either to discontinuously variable insulation leaks

between electrodes or to intermittent contacts involving conducting members such as filament supports which, at times of no contact, are insulated from other parts of the tube. Special precautions have been taken in the design of the 205E tube to eliminate this type of noise.

Limiting Conditions for Safe Operation

	Class A Amp.	*Class B R-F Amp.	Class C R-F Amp. or Osc.	*Class C R-F Amp. Plate Modulated
Maximum direct plate voltage	400	400	400	350 volts
Maximum direct plate current	50	35	50	40 milliamperes
Maximum plate dissipation	14	14	14	10 watts
Maximum direct grid current	—	10	10	10 milliamperes

*Carrier conditions for use with modulation factors up to 1.0.

Operating Conditions and Output

Class A—Amplifier or Modulator

Permissible operating grid and plate voltage for Class A operation are included within the area, ABCD, in Figure 3. Amplification factor, plate resistance, transconductance, and performance data are given in Table I for a number of typical operating conditions represented by selected points within this area. A less severe operating condition should be selected in preference to a maximum operating condition wherever possible. The life of the tube at maximum operating conditions may be shorter than at less severe conditions.

The performance data include the fundamental power output in milliwatts and the levels of the second and third harmonics in decibels below the fundamental for values of load resistance, R, equal to one, two, and in some cases three times the plate resistance, r_p. 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}, in each case, is numerically equal to the grid bias. For a smaller input voltage, E_g, the output and harmonic levels are given approximately by 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 I

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms r_p	Micromhos	Peak Volts	R	Milliwatts	db	db
200	− 6	22.5	7.4	4000	1840	6	$R=r_p$	60	35	65
							$R=2r_p$	55	40	70
250	−22	9	6.9	6000	1160	22	$R=r_p$	500	18	33
							$R=2r_p$	450	22	40
							$R=3r_p$	380	26	47
250	−15	19	7.2	4350	1670	15	$R=r_p$	310	26	45
							$R=2r_p$	280	30	55
250	−10	27.5	7.4	3800	1950	10	$R=r_p$	180	33	60
							$R=2r_p$	160	38	65
250	− 5	37.5	7.5	3500	2150	5	$R=r_p$	50	40	70
							$R=2r_p$	45	43	70
300	−30	8	6.7	6700	1000	30	$R=r_p$	800	15	28
							$R=2r_p$	720	20	35
							$R=3r_p$	600	24	42
300	−24	15.5	7.1	4800	1460	24	$R=r_p$	750	20	36
							$R=2r_p$	670	25	45
300	−18	25	7.3	4000	1830	18	$R=r_p$	540	27	46
							$R=2r_p$	480	31	55
350	−22.5	29	7.3	3800	1940	22.5	$R=r_p$	875	26	44
							$R=2r_p$	800	30	50
375	−30	22	7.1	4300	1660	30	$R=r_p$	1300	20	36
							$R=2r_p$	1200	26	45
*300	−10	41	7.4	3350	2220	10	$R=r_p$	200	37	65
							$R=2r_p$	180	41	70
*350	−20	34	7.3	3600	2060	20	$R=r_p$	750	28	50
							$R=2r_p$	675	32	55
*375	−24	32	7.3	3650	1990	24	$R=r_p$	1000	26	44
							$R=2r_p$	900	30	55
*400	−29	30	7.2	3800	1890	29	$R=r_p$	1400	23	39
							$R=2r_p$	1300	28	48

*Maximum operating conditions.

Class B—Amplifier

Radio telephone applications, particularly the amplification of a modulated carrier wave with a minimum of distortion. Typical carrier conditions for use with a modulation factor up to 1.0 are shown in Table II.

TABLE II

Direct Plate Voltage	Grid Bias	Direct Plate Current	Driving Voltage		Power Output		Effective Load Resistance	Peak Driving Power
			Carrier	A-F Peak	Carrier	A-F Peak		
Volts	Volts	Milli-amperes	Peak Volts	Volts	Watts	Watts	Ohms	Watts
350	−48	28	69	138	2.5	10	3100	1
400	−56	28	73	146	3.0	12	3700	1

Class C—Amplifier or Oscillator

Radio telegraph or other continuous-wave applications. Typical operating conditions are shown in Table III.

TABLE III

Direct Plate Voltage	Grid Bias	Direct Plate Current	Driving Voltage	Power Output	Effective Load Resistance	Driving Power
Volts	Volts	Milli-amperes	Peak Volts	Watts	Ohms	Watts
350	− 96	45	186	8.3	3750	1.3
400	−112	45	202	10.0	4500	1.5

Class C—Amplifier—Plate modulated

Radio telephone applications. Typical carrier conditions for use with modulation factors up to 1.0 are shown in Table IV.

TABLE IV

Direct Plate Voltage	Grid Bias	Direct Plate Current	Driving Voltage	Power Output	Effective Load Resistance	Driving Power
Volts	Volts	Milli-amperes	Peak Volts	Watts	Ohms	Watts
300	−120	35	205	6.0	4000	1.3
350	−144	35	229	7.1	5000	1.7

High Frequency Ratings

If the 205E tube is to be used at frequencies higher than 15 megacycles, the plate voltage and plate dissipation ratings given above should be reduced to avoid excessive high-frequency currents, excessive heating due to dielectric losses, and consequent injury to the tube. At the limiting frequency of 30 megacycles, the maximum ratings should be as follows:

Maximum plate voltage	300 volts
Maximum plate dissipation	10 watts
Maximum r-f grid current	3 amperes

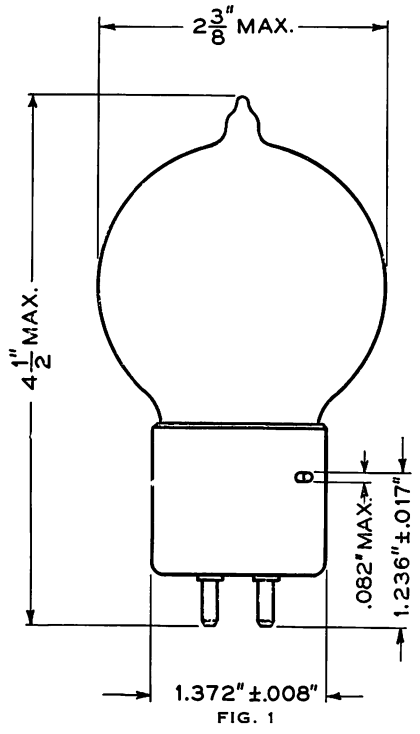


FIG. 1

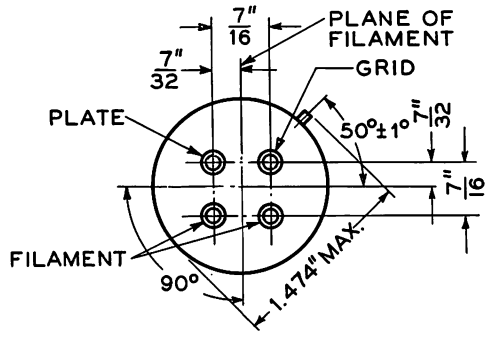


FIG. 2

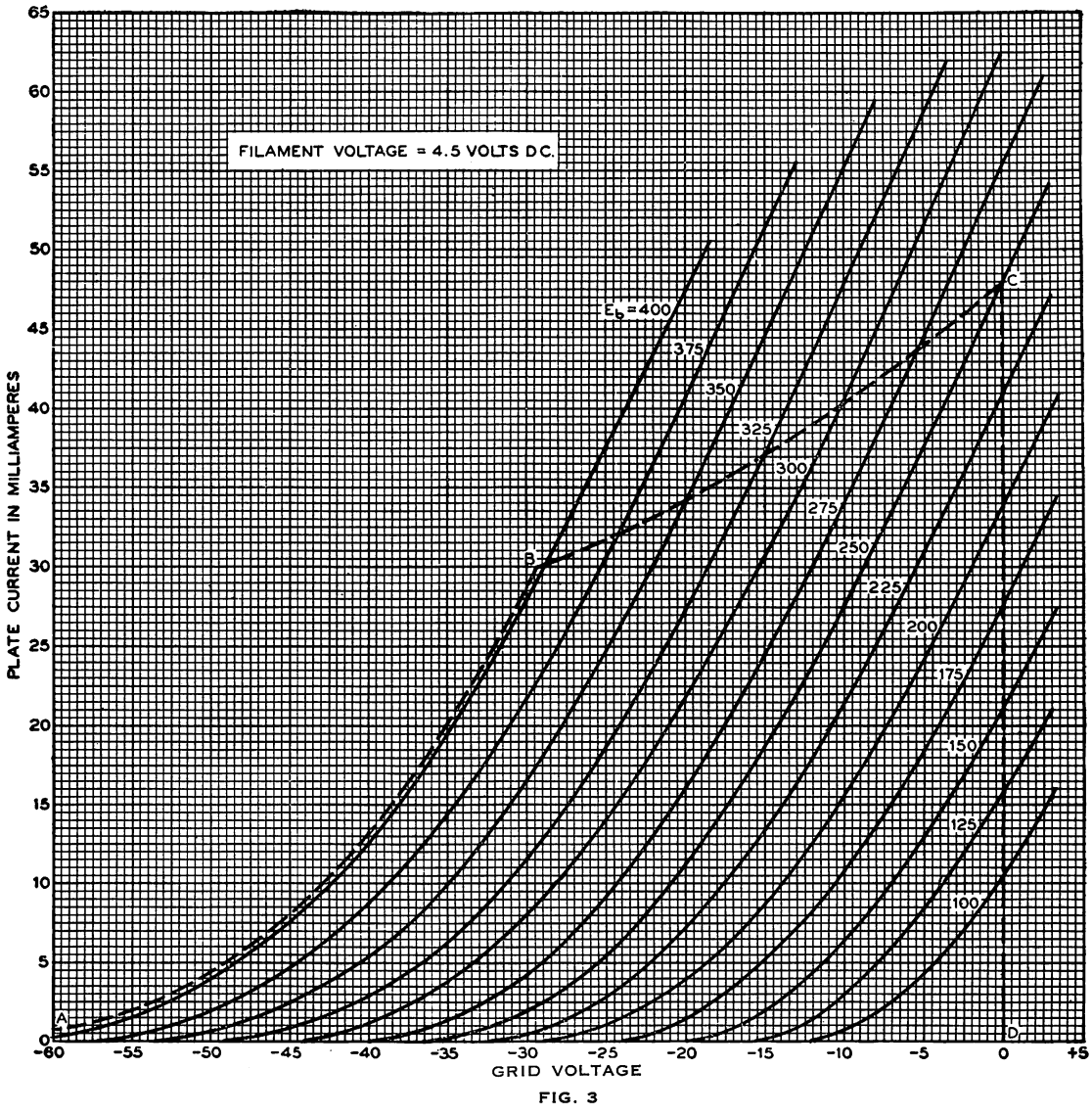


FIG. 3

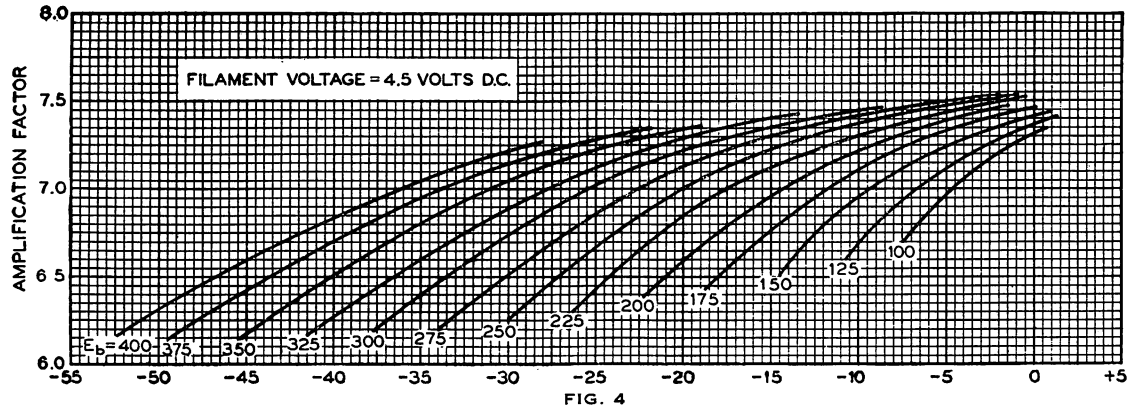


FIG. 4

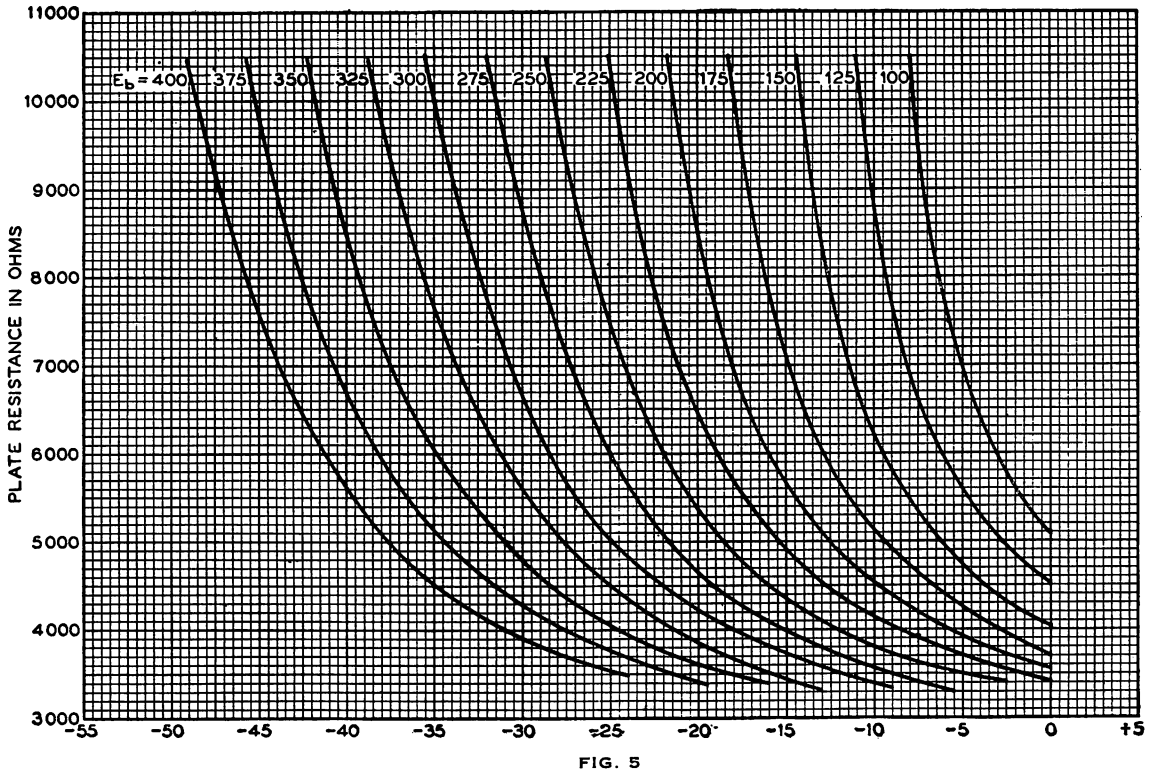


FIG. 5

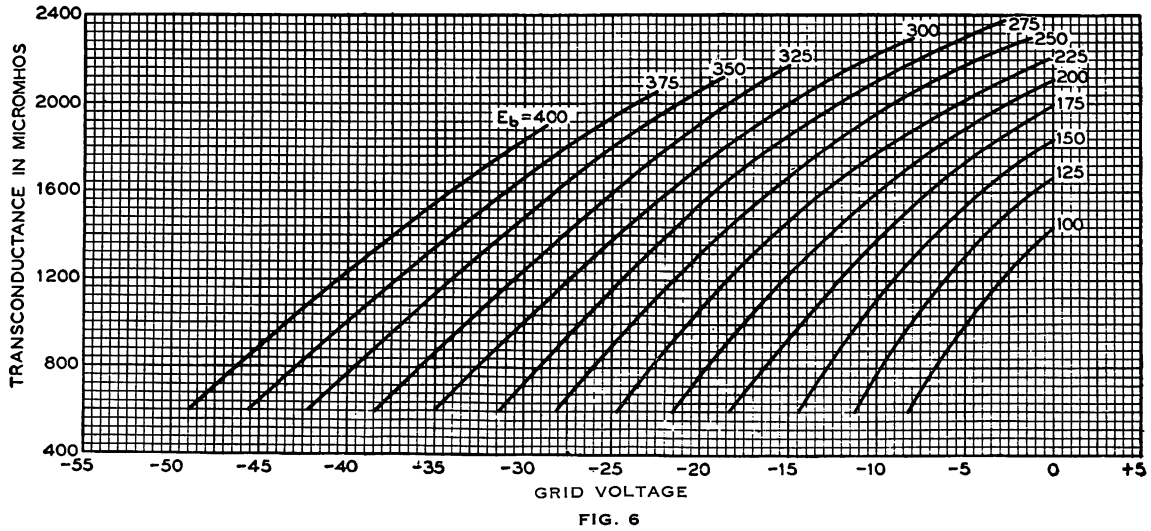


FIG. 6

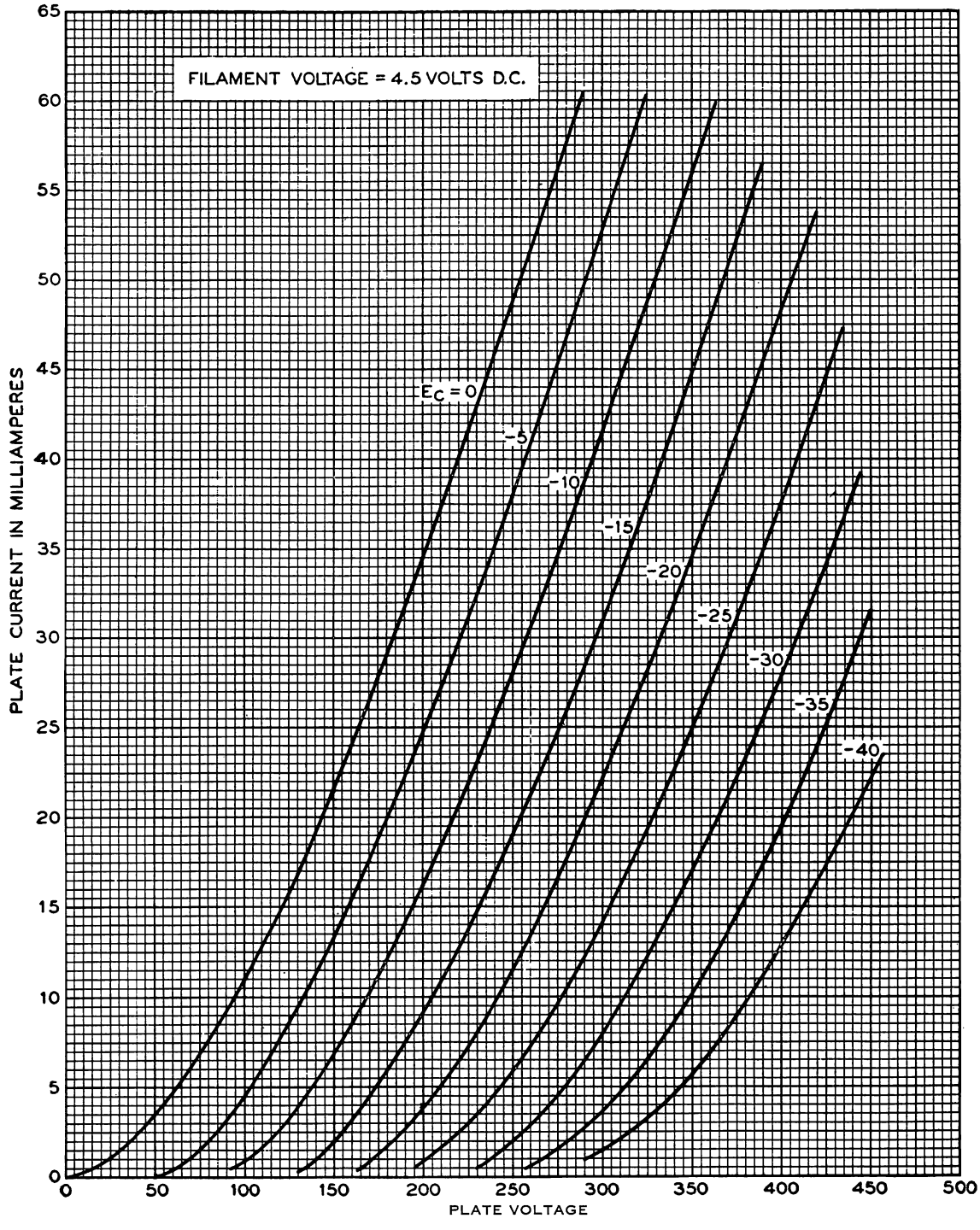
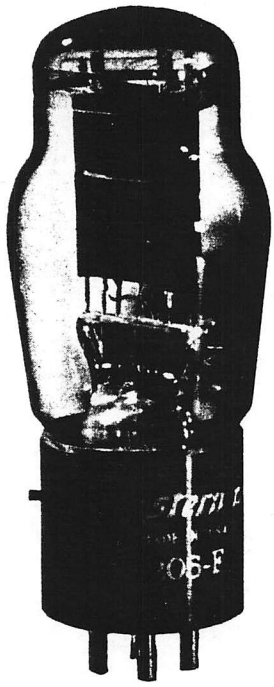

FILAMENT VOLTAGE = 4.5 VOLTS D.C.
$E_C = 0$
-5
-10
-15
-20
-25
-30
-35
-40
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
5
10
15
20
25
30
35
40
45
50
55
60
65
0
50
100
150
200
250
300
350
400
450
500

FIG. 7



TRIODE
POWER AMPLIFIER

Western Electric

DESCRIPTION

The 205F is a filamentary triode designed for use as an audio-frequency power amplifier or modulator.

CHARACTERISTICS

Filament Voltage		4.5 volts
Plate Current	E_b = 350 volts;	35 milliamperes
Power Output	E_c = −22.5 volts	880 milliwatts

GENERAL CHARACTERISTICS

Heater Voltage, A-C or D-C	4.5 volts
Filament Current	1.6 amperes
Direct Interelectrode Capacitances	
Grid to Plate	5.9 uuf
Input	4.1 uuf
Output	2.2 uuf

MECHANICAL DATA

Cathode	Coated Filament
Base	Medium 4-pin, bayonet type with bayonet pin offset
Mounting Position	Preferably vertical; if horizontal, pins #1 and #2 must lie in same vertical plane

Dimensions and pin connections shown in outline drawing on Page 5

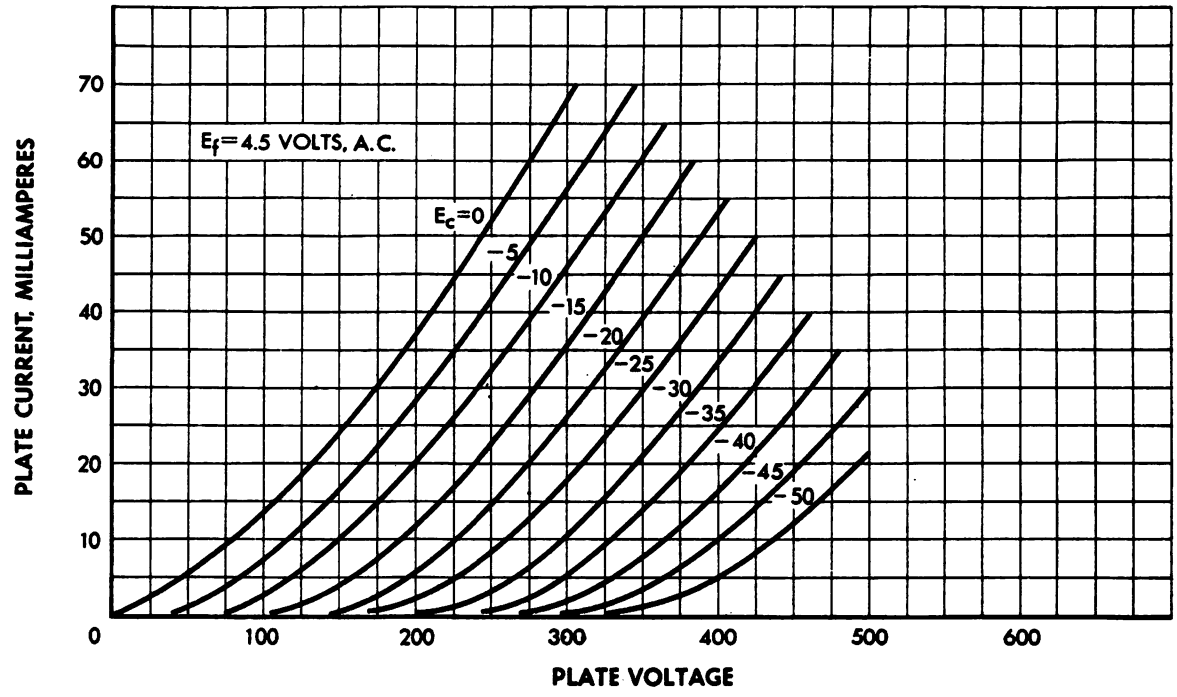
MAXIMUM RATINGS, Design-Center Values

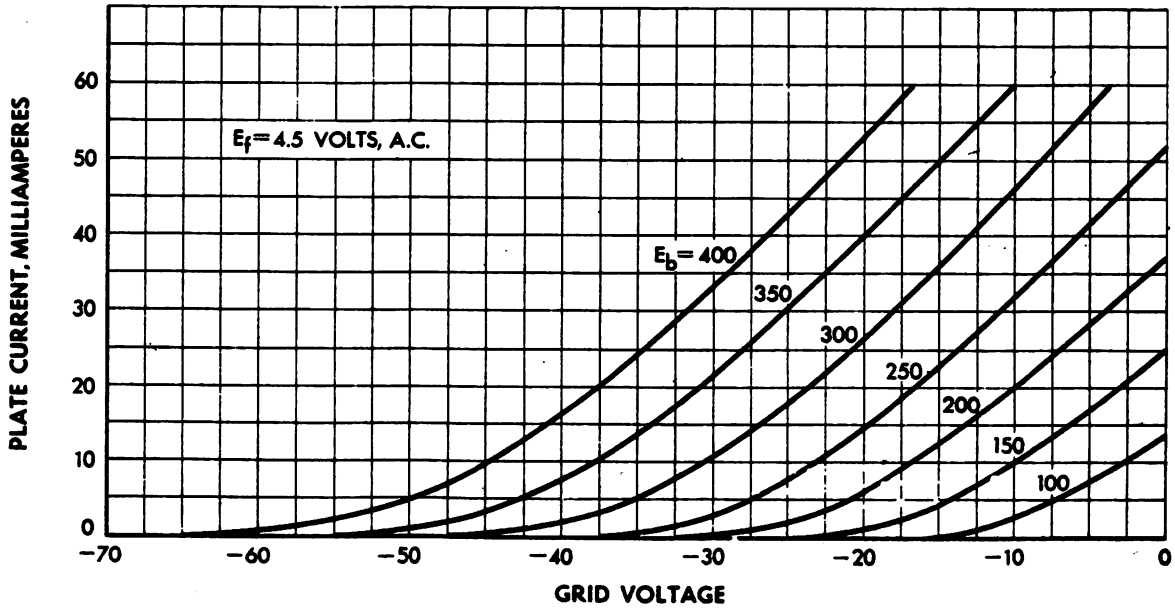
Plate Voltage	360 volts
Plate Current	50 milliamperes
Plate Dissipation	12.5 watts

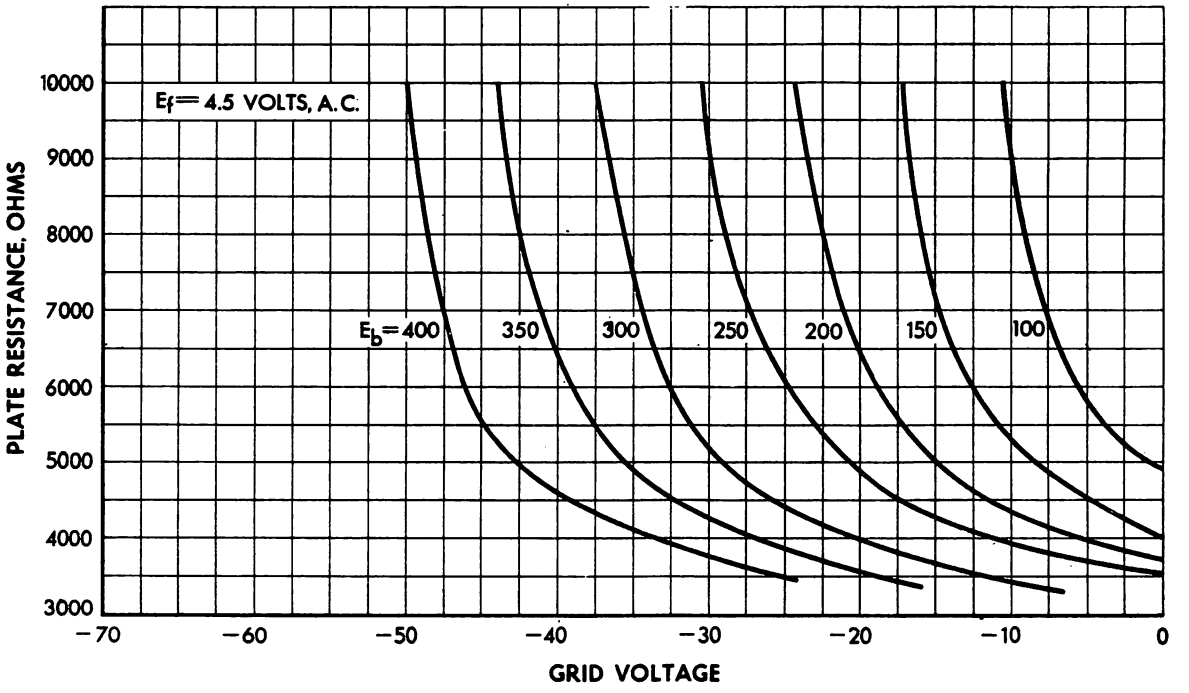
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

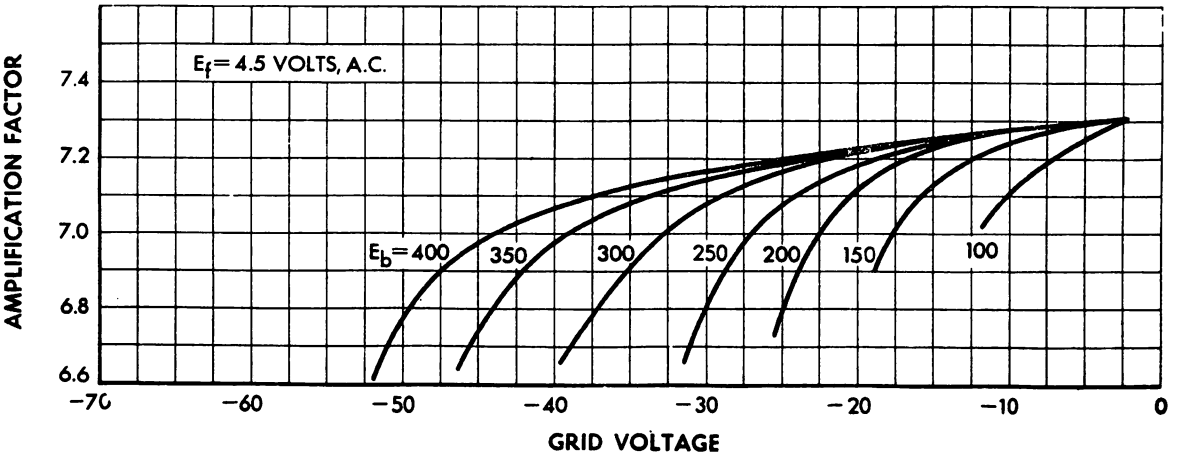
Filament Voltage, A-C	4.5	4.5	4.5	4.5	volts
Plate Voltage	250	300	350	350	volts
Grid Voltage*	−22	−18	−22.5	−22.5	volts
Peak A-F Signal Voltage	22	18	22.5	22.5	volts
Zero Signal Plate Current	11.5	30	35	35	milliamperes
Maximum Signal Plate Current	12	30.5	36	36	milliamperes
Transconductance	1350	1880	1950	1950	micromhos
Plate Resistance	5300	3800	3700	3700	ohms
Load Resistance	12000	8000	4000	8000	ohms
Amplification Factor	7.2	7.2	7.2	7.2	
Maximum Signal Power Output	550	450	880	760	milliwatts
Total Harmonic Distortion	4.6	1.6	2.8	1.4	per cent

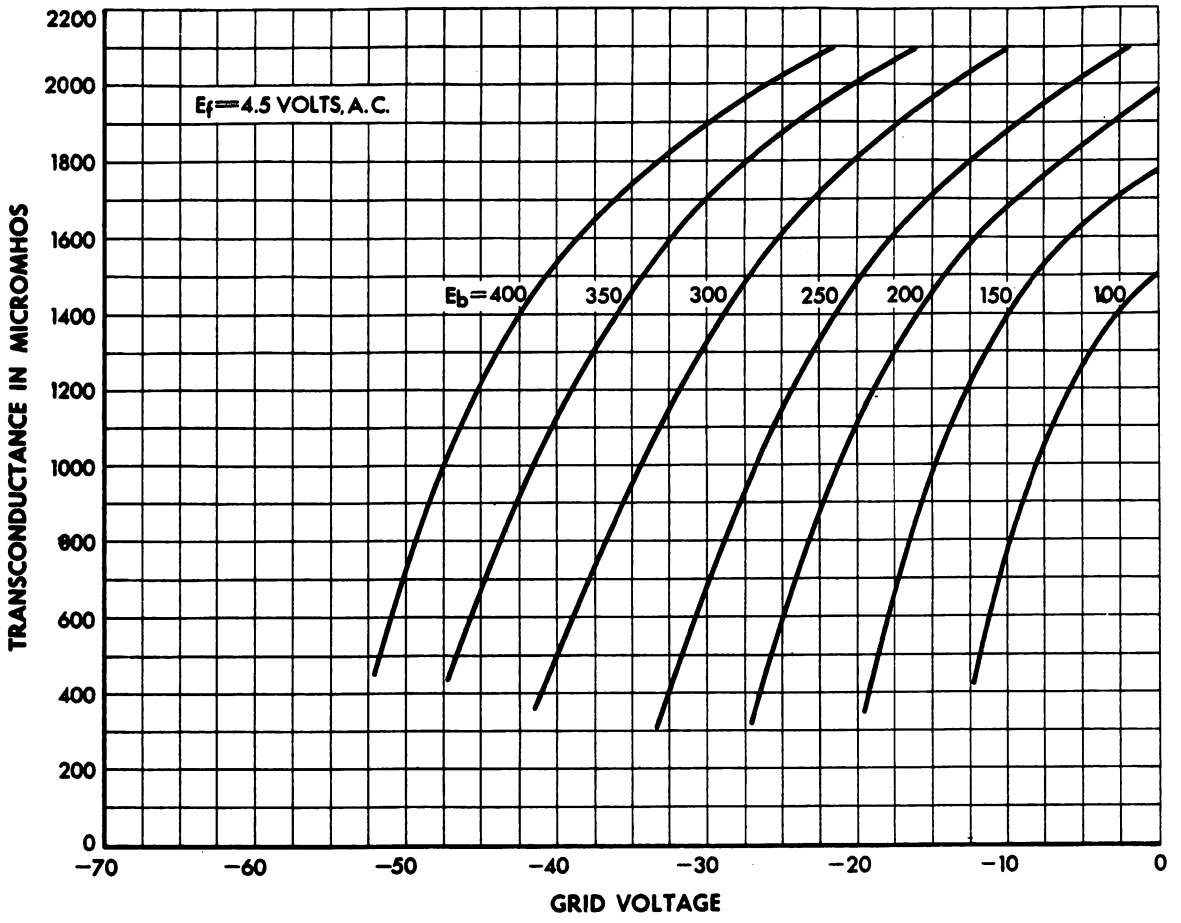
*If the filament is operated on D.C., the characteristics will be approximately the same if the grid voltage, measured from the negative filament, is decreased by 2.3 volts.

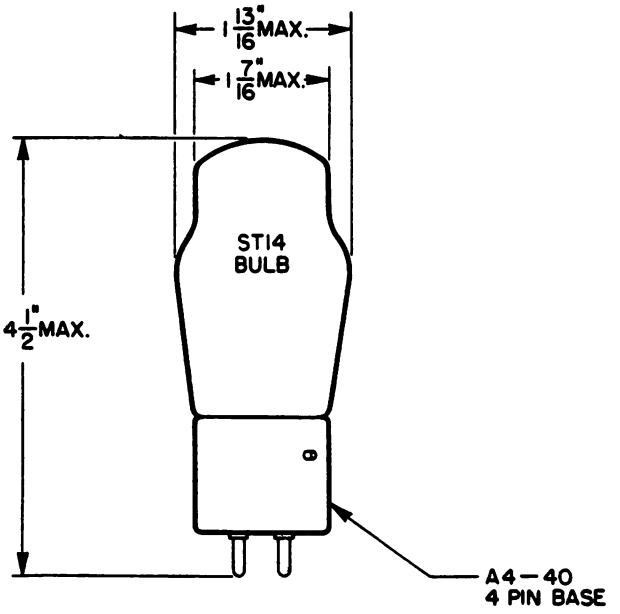

PLATE CURRENT, MILLIAMPERES
70
60
50
40
30
20
10
0
100
200
300
400
500
600
PLATE VOLTAGE
E_f=4.5 VOLTS, A.C.
E_c=0
−5
−10
−15
−20
−25
−30
−35
−40
−45
−50

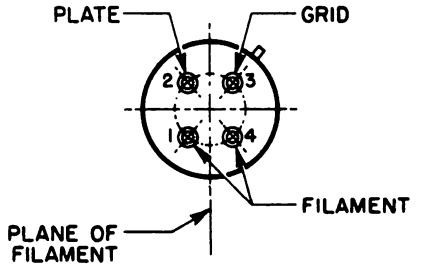

PLATE CURRENT, MILLIAMPERES
60
50
40
30
20
10
0
−70
−60
−50
−40
−30
−20
−10
0
GRID VOLTAGE
E_f=4.5 VOLTS, A.C.
E_b=400
350
300
250
200
150
100


PLATE RESISTANCE, OHMS
10000
9000
8000
7000
6000
5000
4000
3000
E_f = 4.5 VOLTS, A.C.
E_b = 400
350
300
250
200
150
100
−70
−60
−50
−40
−30
−20
−10
0
GRID VOLTAGE


AMPLIFICATION FACTOR
7.4
7.2
7.0
6.8
6.6
E_f = 4.5 VOLTS, A.C.
E_b = 400
350
300
250
200
150
100
−70
−60
−50
−40
−30
−20
−10
0
GRID VOLTAGE







ELECTRON TUBE DATA SHEET
FILE: GENERAL PURPOSE SECTION
12-48

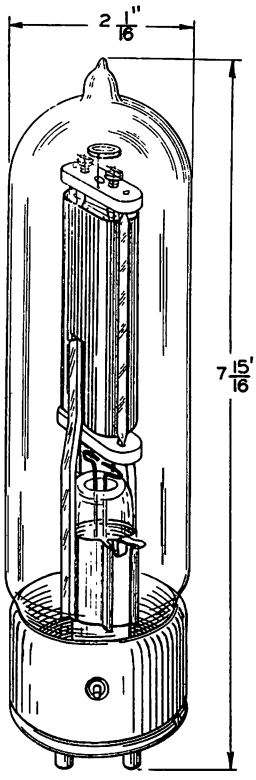
Western Electric

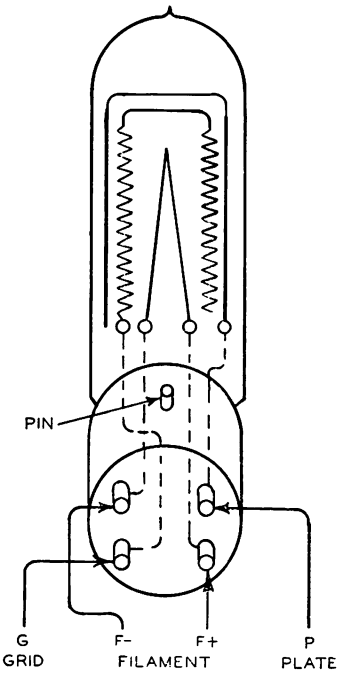
A development of Bell Telephone Laboratories, the research laboratories of the American Telephone and Telegraph Company and the Western Electric Company.

1-D-50-4 PRINTED IN U. S. A. T-2644

211-D Vacuum Tube

Used with Western Electric Vacuum Tube Socket No. 112-A.





USE — AMPLIFIER — OSCILLATOR — MODULATOR

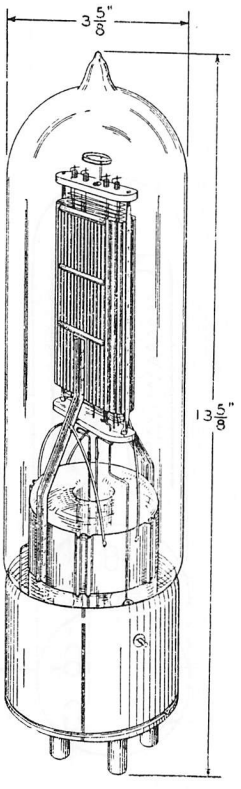
Normal filament current	3 amperes
Normal filament voltage	10 volts
Normal plate current for plate voltage 750 volts and grid voltage—30 volts	65 milliamperes
Normal plate voltage	750 to 1000 volts
Normal grid voltage	—30 to —60 volts
Average plate to filament impedance	3000 to 4000 ohms
Maximum safe continuous dissipation by plate	65 watts
Maximum safe intermittent dissipation by plate	100 watts
Output as unmodulated oscillator	50 watts
Inter-electrode Capacitances	
Grid to filament	6.3 mmf.
Grid to plate	9.0 mmf.
Plate to filament	3.6 mmf.
Amplification constant	11 to 13

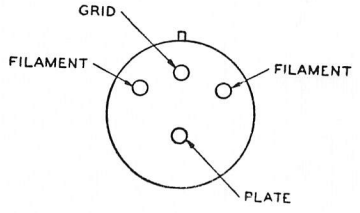
NOTE

This tube replaces the 211-A tube (except in 10-A Amplifier) and is interchangeable with it, except that it operates at a lower filament current. It has a longer life. For maximum useful life the filament voltage should be kept as low as possible to secure the desired output and should not exceed 10 volts, since an increase of 10% in the voltage may shorten the life by as much as 50%.

The discoloration of the bulb is due to a manufacturing process and has no effect on the operation of the tube.

212D Vacuum Tube





Classification

The 212D Vacuum Tube is a three-element, air-cooled, general purpose tube. It may be used as an audio-frequency power amplifier or modulator.

Base and Socket

The 212D Vacuum Tube employs a four prong, bayonet pin, type base suitable for use in a Western Electric 113A or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

General Ratings and Information

Filament Voltage	14 Volts A. C.
Nominal Filament Current	6 Amperes
Maximum Plate Voltage	2000 Volts
Maximum Plate Current	.300 Ampere
Average Amplification Factor	16
Average Plate Resistance	2000 Ohms
Average Mutual Conductance	8000 Micromhos

Approximate Direct Interelectrode Capacities

Plate to Grid	19 MMF.
Plate to Filament	12 MMF.
Grid to Filament	19 MMF.

***Impedance Classification**

With a plate voltage of 1500 volts grid potential at —60 volts and a filament voltage of 14, the plate current will be as follows:

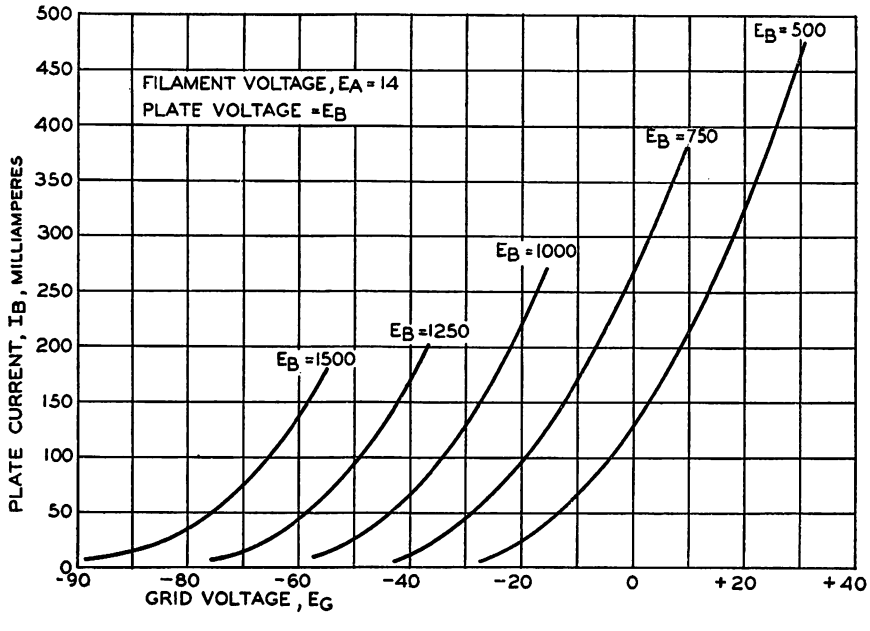
If marked No. 1.....110–129 Milliamperes inclusive
If marked No. 2.....130–148 Milliamperes inclusive
If marked No. 3.....149–167 Milliamperes inclusive
If marked No. 4.....168–185 Milliamperes inclusive

Audio-Frequency Amplifier or Modulator Rating—Peak Grid Drive Equal to or less than the Bias—Class A Service

Maximum Plate Dissipation	250 Watts
Plate Voltage	1500 Volts
Plate Current	.167 Ampere
Grid Bias Voltage	—55 Volts
Load Impedance	5000 Ohms
Undistorted Output	50 Watts

Average Static Characteristics

The accompanying curves give the static characteristics of an average 212D Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid circuit returns connected to the center point of the filament transformer.



General Features

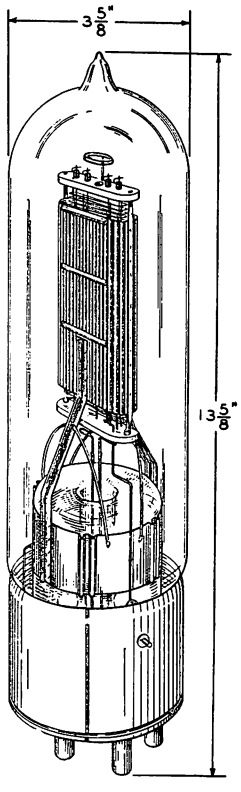
The 212D Vacuum Tube was designed primarily for audio-frequency applications or where the grid is never driven positive. For radio-frequency applications, the 270A vacuum tube is recommended because of its superior grid characteristics.

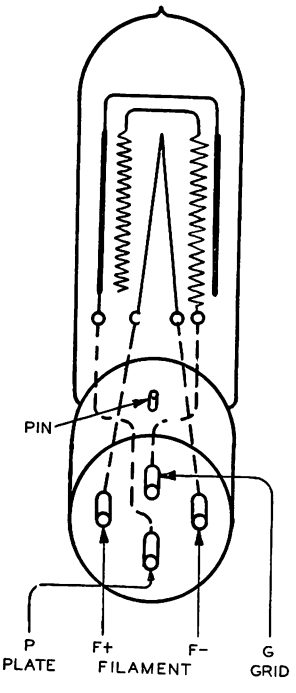
This tube employs a plate which is oxidized to improve its radiation properties. It has the highest power rating of any tube employing the efficient oxide coated type of filament.

*The impedance classification of the tube is not in any way a gradation of quality, but is to facilitate parallel operation in the ordinary system using a common grid battery. It is essential to select tubes of the same or adjacent classes in order that the load may be evenly distributed. When only single tubes are used, no one of these classes has any advantage over the other. 212D tubes cannot be ordered according to impedance classification.

212-D Vacuum Tube

Used with Western Electric Vacuum Tube Socket No. 113-A.





USE—OSCILLATOR—MODULATOR

Normal filament current ..... 6.0 ± 0.3 amperes
Normal filament voltage ..... 14 volts
Normal plate current for plate voltage 1500 volts and grid voltage—60 volts... 130 milliamperes
Normal plate voltage ..... 1000 to 1500 volts
Maximum safe plate voltage ..... 2000 volts
Normal grid voltage ..... —30 to —80 volts
Normal plate to filament impedance under conditions: plate voltage 1500 volts, grid voltage—60 volts and plate current 130 milliamperes ..... 2000 ohms
Maximum safe intermittent output ..... 250 watts
Maximum safe continuous output ..... 200 watts
Output as unmodulated oscillator ..... 250 watts
Maximum instantaneous peak voltage between filament and plate ..... 3000 volts
Inter-electrode Capacitances
Grid to filament ..... 19.0 mmf.
Grid to plate ..... 19.0 mmf.
Plate to filament ..... 12.4 mmf.
Amplification constant ..... 15 to 17

With a plate voltage at 1500 volts, the grid potential at —60 volts and the filament voltage 14: the plate current will be as follows: (See note 1).

If marked	No. 1	110-129	milliamperes inclusive
" "	No. 2	130-148	" "
" "	No. 3	149-167	" "
" "	No. 4	168-185	" "

NOTE

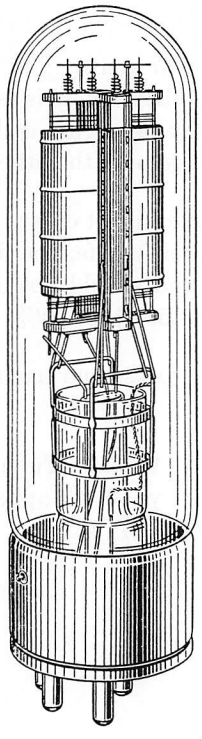
1. This classification of tubes is not in any way a gradation of quality, but is only to facilitate parallel operation in the ordinary system using a common grid battery. It is essential to select tubes of the same or adjacent classes, in order that the load may be evenly distributed. When only single tubes are used no one of these classes has any advantage over the other.

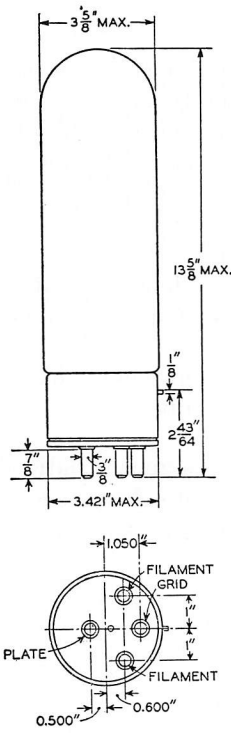
2. This tube replaces the 212-A Tube and is interchangeable with it except that it operates at a lower filament current. It has a longer life. For maximum useful life, the filament voltage should be kept as low as possible to secure the desired output and should not exceed 14 volts, since an increase of 10% in the voltage may shorten the life by as much as 50%.

The discoloration of the bulb is due to a manufacturing process and has no effect on the operation of the tube.

3. The resistance variation in the filament used in the 212-D Vacuum Tube is small enough so that division into classes according to resistance is not necessary. On all apparatus equipped with compensating resistances, the flexible lead should be connected to "E."

212E Vacuum Tube





Classification

The No. 212E Vacuum Tube is a three element, air-cooled general purpose tube. It may be used as an audio-frequency power amplifier, modulator or as a radio-frequency oscillator or amplifier.

Base and Socket

The No. 212E employs a four prong bayonet pin type base suitable for use in a Western Electric No. 113A (or similar type) Socket. The arrangement of electrode connections to the base terminals is shown above.

General Rating Information

Filament Voltage	14 Volts
Nominal Filament Current	6 Amperes
Maximum Plate Voltage	2,000 Volts
Maximum Plate Current	0.300 Ampere

With 1500 volts D.C. on the plate and -60 volts on the grid the following values are characteristic:

Average Plate Resistance	1,900 Ohms
Average Amplification Factor	16
Average Grid Plate Transconductance	8,500 Micromhos

Approximate Direct Interelectrode Capacities

Plate to Grid	18.8 MMF
Plate to Filament	8.6 MMF
Grid to Filament	14.9 MMF

Each No. 212E Vacuum Tube falls within one of four impedance classes and is stamped accordingly. These classifications are 1, 2, 3 and 4 and are in no way a gradation of quality but are to facilitate parallel operation in the ordinary systems using a common grid battery. Wherever more than one tube is used, those of the same adjacent classes should be employed so that the load may be evenly distributed. When only a single tube is used, no one of these classes has any advantage over the other.

With a plate voltage of 1500, a grid bias of -60, and a filament voltage of 14, the plate current will be as follows for the impedance classes.

1—110 to 129 milliamperes, inclusive
2—130 to 148 milliamperes, inclusive
3—149 to 167 milliamperes, inclusive
4—168 to 185 milliamperes, inclusive

Operating Limits

When the tube is used in the following various types of circuits the limits specified should be observed.

Audio-Frequency Amplifier or Modulator Rating—Peak Grid Drive Equal to or less than the Bias—Class "A" Service

Maximum Plate Dissipation	250 Watts
Maximum Plate Voltage	1,500 Volts
Plate Current	167 Milliamperes
Approximate Grid Bias Voltage	-57 Volts
Load Impedance	5,000 Ohms
Undistorted Output	50 Watts

Operating Limits — Continued

Radio-Frequency Amplifier—Grid Bias Practically at Plate Current Cutoff, Grid Drive Greater than the Bias—Class "B" Service

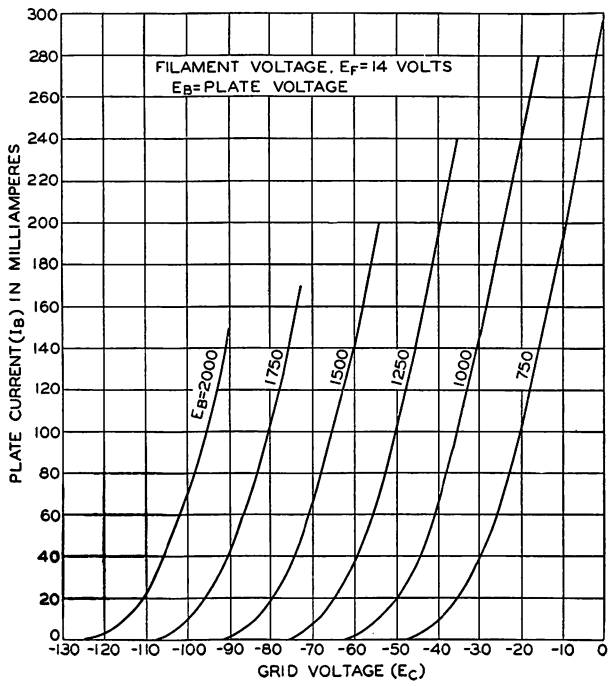
Maximum Plate Voltage (D.C.)	2,000 Volts
Maximum Plate Dissipation	275 Watts
Maximum Plate Current (D.C.)	300 Milliamperes
Approximate Grid Bias Voltage	-125 Volts
Peak Output	400 Watts

Oscillator or Radio-Frequency Amplifier—Grid Bias Below Cut-off—Class "C" Service

Maximum Modulated Plate Voltage (D.C.)	1,500 Volts
Maximum Non-Modulated Plate Voltage (D.C.)	2,000 Volts
Maximum Plate Dissipation	275 Watts
Maximum Plate Current	300 Milliamperes
Maximum Radio-Frequency Charging Current in Grid and Plate Leads	5 Amperes
Approximate Grid Bias Voltage	200 Volts
Maximum Output	500 Watts

Average Static Characteristics

The accompanying curves give the static characteristics of an average No. 212E Vacuum Tube. These curves are plotted from values taken with the filament operating on direct current and with the plate and grid returns connected to the negative filament terminal.



Frequency

The operating limits specified for this tube are for frequencies lower than 7,500 kilocycles. The tube however will operate satisfactorily at even higher frequencies if the radio-frequency charging current is limited to a value that will not cause excessive heating of lead-in wires or dielectric parts.

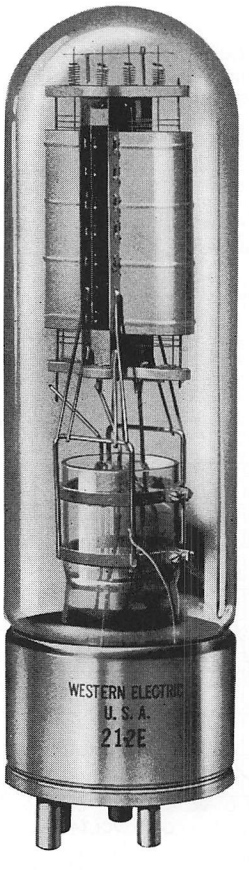
General Features

The No. 212E Vacuum Tube is completely interchangeable with the No. 212-D which it supersedes. The No. 212E is an improvement both electrically and mechanically over the No. 212D. It is capable of withstanding greater overloads and under rated operating conditions will give a much longer life. The major design features which contribute to this improvement are:

1. Wide base of anode supporting unit insures mechanical ruggedness, and safety in shipment and handling.
2. Heavy channel reinforcement along entire plate length insures mechanical ruggedness, and constancy in plate characteristics.
3. Unit type structure first employed in the original No. 212D. The three electrodes are held as a unit by insulating supports at top and bottom and mounted on an adequately sturdy stem.
4. Greater uniformity in electrical characteristics throughout life.
5. Double M of filament makes possible uniform distribution of electron current over both anode planes, eliminates hot-spotting and local heating. Each V of filament held in positive alignment by new mica baffle guide.
6. Increased electron emission permitting 100% modulation with less distortion.
7. Greater plate dissipation capacity giving increased safety from trouble during overloads.

Western Electric

212E Vacuum Tube



Classification—Filamentary air-cooled triode

May be used 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. The overall dimensions are:

Maximum overall length	13 5/8″
Maximum diameter	3 5/8″

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

Average Direct Interelectrode Capacitances

Plate to grid	18.8 $\mu\mu$f
Grid to filament	14.9 $\mu\mu$f
Plate to filament	8.6 $\mu\mu$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 2000 volts direct plate potential and minus 90 volts grid bias:

Amplification factor	16
Plate resistance	1900 ohms
Grid to plate transconductance	8500 micromhos

Each 212E vacuum tube falls within one of four impedance classes and is stamped accordingly. These classifications are #1, #2, #3 and #4, and are in no way a gradation of quality, but are to facilitate parallel operation in the ordinary system using a common grid battery. Where more than one tube is used, those of the same or adjacent classes should be employed so that the load may be evenly distributed. When only a single tube is used no one of the classes has any advantage over the other. Tubes may not be ordered according to impedance classification.

With a plate voltage of 1500 volts, a grid bias of −60 volts and a filament voltage of 14, the plate current will be as follows for each impedance class:

#1	110-129	milliamperes, inclusive
#2	130-148	" "
#3	149-167	" "
#4	168-185	" "

Operation

Maximum Ratings

Max. direct plate voltage	3000 volts
Max. direct plate current	350 milliamperes
Max. plate dissipation	275 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	1000 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	1250 volts
Grid bias	−57	−40 volts
Direct plate current	170	200 milliamperes
Plate dissipation	250	250 watts
Load impedance	5000	3000 ohms
Undistorted output	50	40 watts

Grid Bias Modulator

Direct plate voltage	3000 volts
Grid bias	−260 volts
Plate dissipation	175 watts
Load impedance	8000 ohms
Peak power output	200 watts

Class B Audio Amplifier or Modulator for balanced 2 tube circuit

Direct plate voltage	2000	1500 volts
Grid bias	−105	−75 volts
Direct plate current per tube		
No drive	40	50 milliamperes
Max. drive	300	300 milliamperes
Plate dissipation	250	250 watts
Load res. plate-to-plate	8000	5900 ohms
Load res. per tube	2000	1475 ohms
Approx. max. output	650	500 watts
Recommended power for driving stage	50	50 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	2000	1500 volts
Direct plate current	300	300 milliamperes
Plate dissipation	275	275 watts
Grid bias	−120	−90 volts
Approx. carrier watts for use with 100% modulation	200	150 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	2000	1500 volts
Direct plate current	300	300 milliamperes
Grid bias	−185 to −250	−150 to −200 volts
Nominal power output	400	300 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1500	1000 volts
Direct plate current	300	300 milliamperes
Grid bias	−200	−125 volts
Max. direct grid current	75	75 milliamperes
Nominal carrier power output for use with 100% modulation	300	200 watts

Operating Precautions

Mechanical—Figures 1 and 2 show the overall dimensions and basing arrangements 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 350 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 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—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. 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.

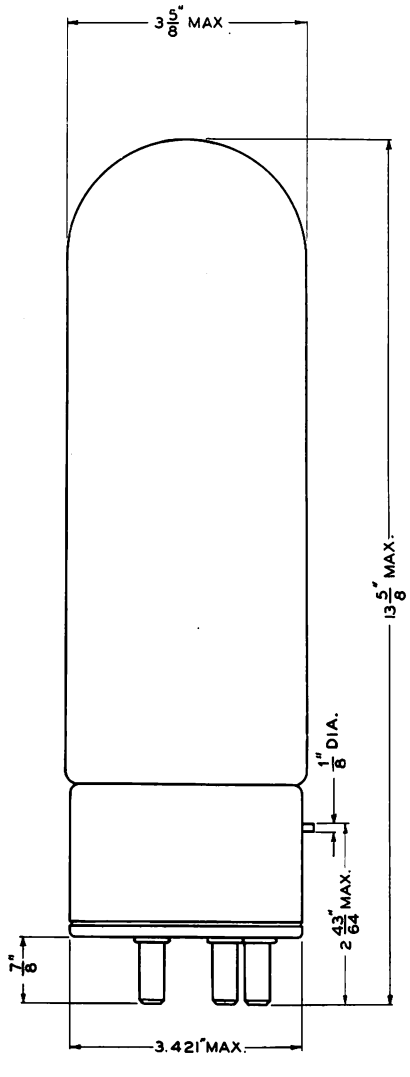


FIG. 1

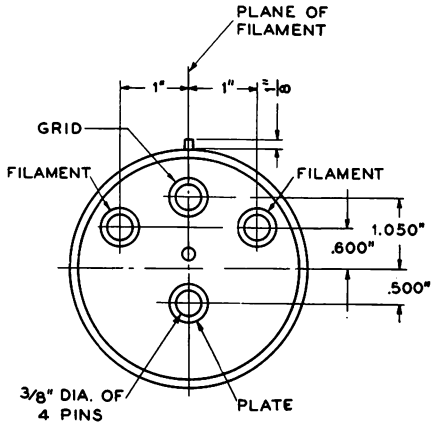


FIG. 2

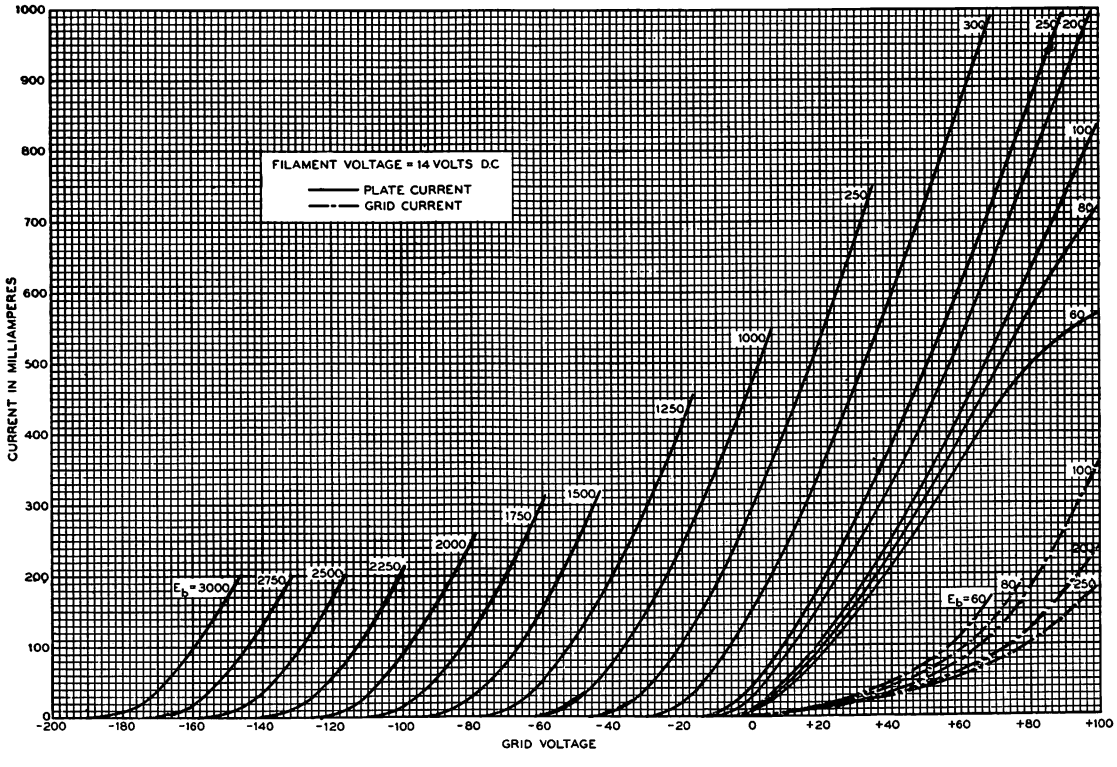

FILAMENT VOLTAGE = 14 VOLTS D.C
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
1000
900
800
700
600
500
400
300
200
100
0
-200
-180
-160
-140
-120
-100
-80
-60
-40
-20
0
+20
+40
+60
+80
+100
E_b = 3000
2750
2500
2250
2000
1750
1500
1250
1000
250
E_b = 60

FIG. 3

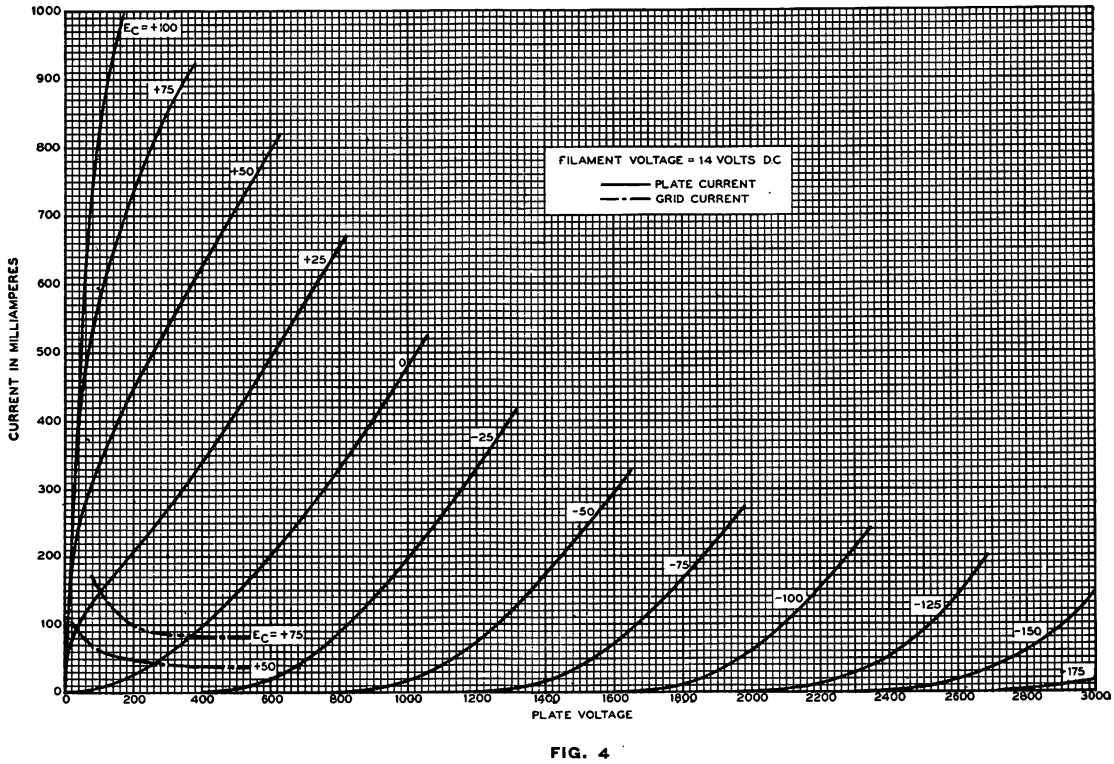
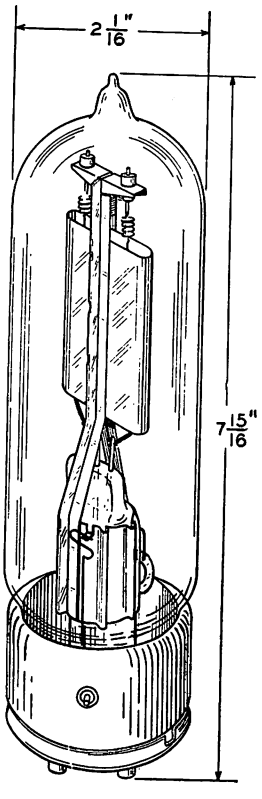
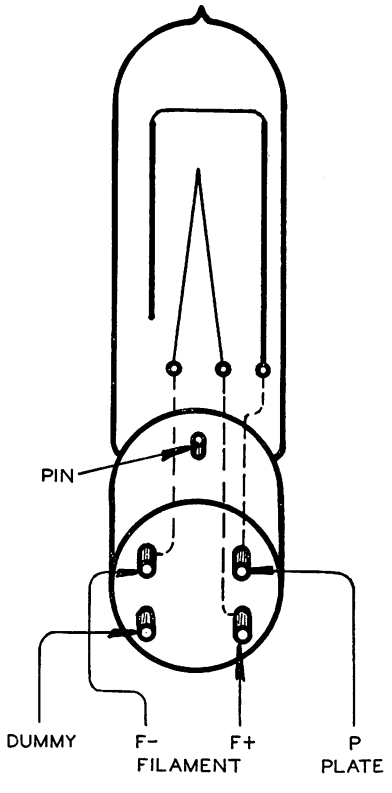

FILAMENT VOLTAGE = 14 VOLTS D.C
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
1000
900
800
700
600
500
400
300
200
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
E_C = +100
+75
+50
+25
0
-25
-50
-75
-100
-125
-150
-175
E_C = +75
+50

FIG. 4

214-E Vacuum Tube

Used with Western Electric Vacuum Tube Sockets Nos. 112-A or 118-A.





USE—RECTIFIER

Normal filament current.....3.25 ± 0.15 amperes
Normal filament voltage.....10 volts

NOTE

This is a two element tube used in rectifying systems to supply D.C. voltages up to 750 volts.

Two tubes used for rectifying a single phase A.C. supply voltage will give .150 ampere D.C. plate output at 750 volts.

This tube replaces the 214-D and is interchangeable with it. However, it operates at a higher filament current.

For maximum useful life the filament voltage should be kept as low as possible to secure the desired output and should not exceed 10 volts.

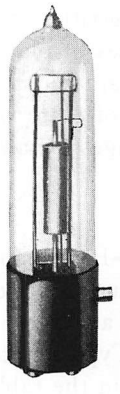
The resistance variation in the filament used in the 214-E Vacuum Tube is small enough so that division into classes according to filament resistance is not necessary.

On all apparatus equipped with compensating resistances the flexible lead should be connected to "E."

The filament can be reactivated to its normal value by running the filament at 10 volts for from 10 to 30 minutes. No voltage should be applied to the plate during this reactivation.

Western Electric

215A Vacuum Tube



Classification—Small, filamentary triode

Important features of the 215A tube are its small size and low filament power consumption.

Applications

Audio-frequency and intermediate-frequency amplifier

Detector

Oscillator

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, four-terminal, bayonet base having silver contacts.

Socket—Four-contact, bayonet-slot type preferably provided with contact-metal contacts, such as the Western Electric 125B socket.

Mounting Positions—The 215A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Grid to plate	2.6 μμf.
Grid to filament	1.6 μμf.
Plate to filament	1.2 μμf.

Filament Rating

Filament current	0.25 ampere, d.c.
Nominal filament voltage	1.0 volt

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

Characteristics—Plate current characteristics of a typical 215A tube are shown in Figure 3 as functions of grid voltage 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 are shown in Figure 7 for several values of grid voltage. The grid and plate voltages for all of these characteristics are measured from the negative end of the filament.

Operating Conditions and Output—Permissible operating conditions are included within the area, ABCD, in Figure 3. Amplification factor, plate resistance, transconductance, and performance data are given in the table on page 3 for a number of typical amplifier operating conditions represented by selected points within this area. Typical detector operating conditions for both plate current and grid current detection are also listed in the table. The 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 or voltage output and the second and third harmonic levels for the indicated values of load resistance and input voltage. The fundamental output is given in terms of the power, P_m, in milliwatts for values of load resistance, R, equal to and double the value of the plate resistance, r_p, and in terms of the voltage, E_{pm}, in peak volts for values of load resistance five times the plate resistance. The second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the output and harmonic levels, except for the lowest values of third harmonic, are given approximately by the following relations:

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

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

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

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

The level of the third harmonic in the 215A tube is usually low and may differ widely in individual tubes. The values given in the table are for a typical tube.

TABLE

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Voltage Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms r_p	Micromhos	Peak Volts	R	Milliwatts	Peak Volts	db	db
45.0	−3.0	1.0	5.7	16500	340	3.0	$R=r_p$	2.2		29	50
							$R=2r_p$	1.9		34	60
							$R=5r_p$		14.0	39	65
45.0	−1.5	1.6	5.8	14500	400	1.5	$R=r_p$	0.60		40	65
							$R=2r_p$	0.55		45	70
							$R=5r_p$		7.2	49	70
60.0	−3.0	2.0	5.7	13500	420	3.0	$R=r_p$	2.9		35	60
							$R=2r_p$	2.6		40	65
							$R=5r_p$		14.5	45	70
67.5	−6.0	1.4	5.6	15500	360	6.0	$R=r_p$	9.4		25	45
							$R=2r_p$	8.3		30	50
							$R=5r_p$		28.5	35	60
67.5	−4.5	2.0	5.7	14000	410	4.5	$R=r_p$	6.0		31	50
							$R=2r_p$	5.5		36	60
							$R=5r_p$		22.0	40	70
*67.5	−4.0	2.2	5.7	13500	420	4.0	$R=r_p$	5.0		34	55
							$R=2r_p$	4.5		38	60
							$R=5r_p$		19.5	43	70
*90.0	−8.0	2.2	5.6	14000	400	8.0	$R=r_p$	18		26	45
							$R=2r_p$	16		31	55
							$R=5r_p$		40.0	37	65
*100.0	−10.0	2.1	5.6	14500	390	10.0	$R=r_p$	26		24	35
							$R=2r_p$	23		29	40
							$R=5r_p$		47.0	36	40
22.5	−4.0	0.01									
45.0	−9.0	0.01	Plate current detection.								
67.5	−14.0	0.01									
22.5	+1.0	1.0	Grid current detection. Grid bias usually obtained by connecting grid return to positive end of filament.								
*45.0	+1.0	2.6									

*Maximum operating conditions

Microphonic Noise—With a plate voltage of 60 volts, a grid bias of −3 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 215A tube, measured in a laboratory reference test set, is 27 decibels below 1 volt. The range of levels of individual tubes extends from 12 to 42 decibels. 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.

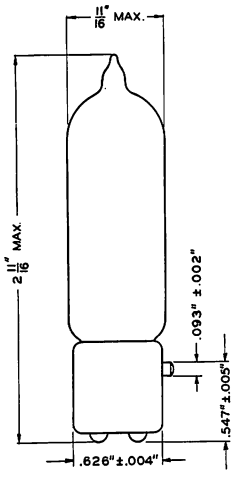


FIG. 1

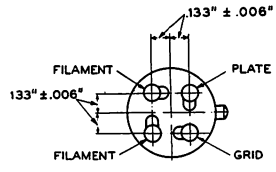


FIG. 2

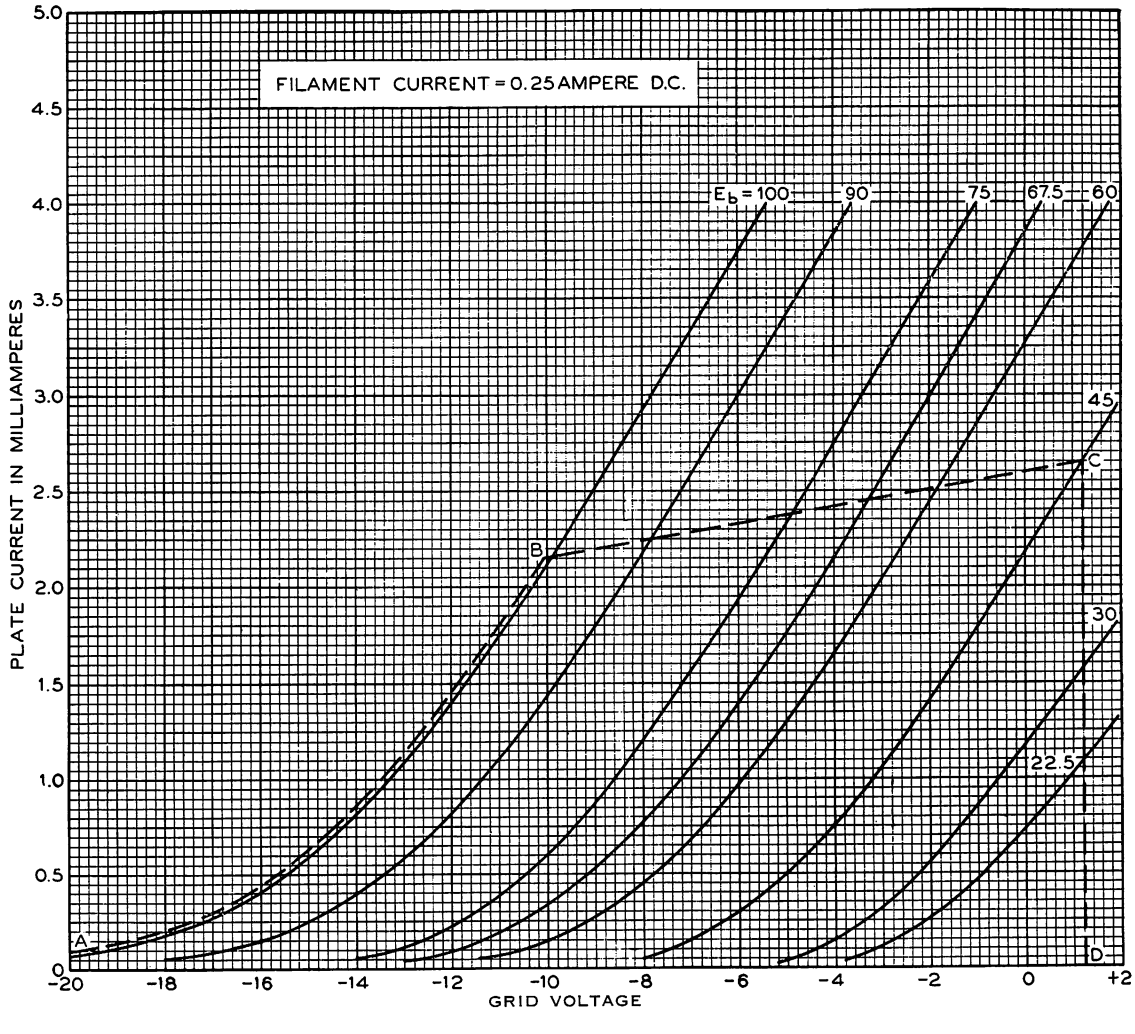


FIG. 3

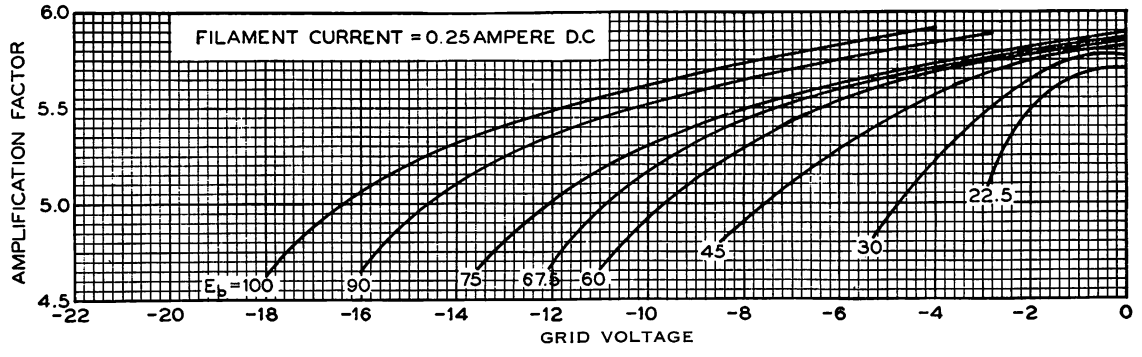


FIG. 4

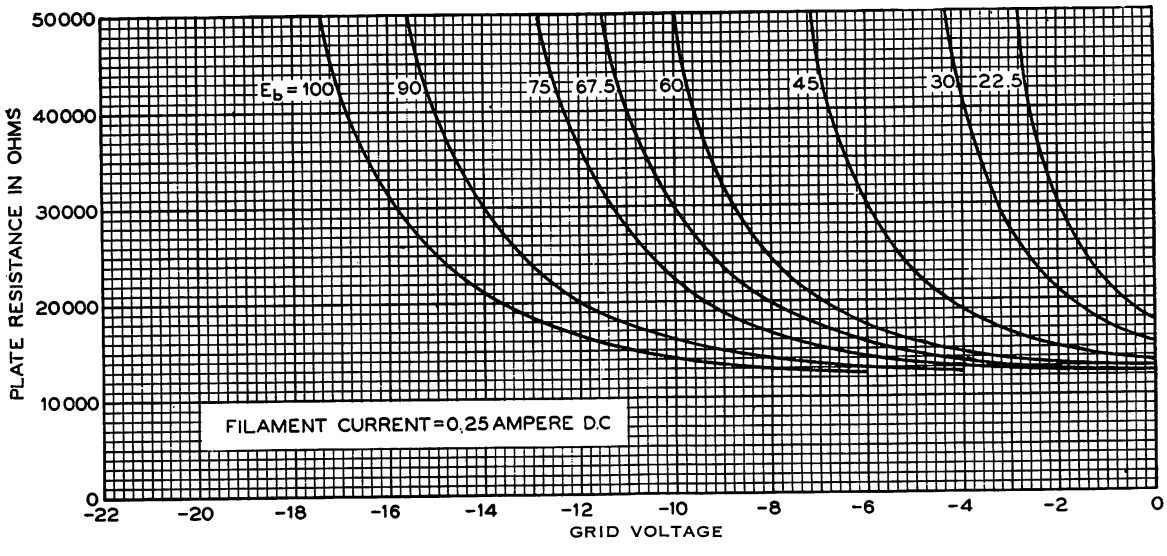


FIG. 5

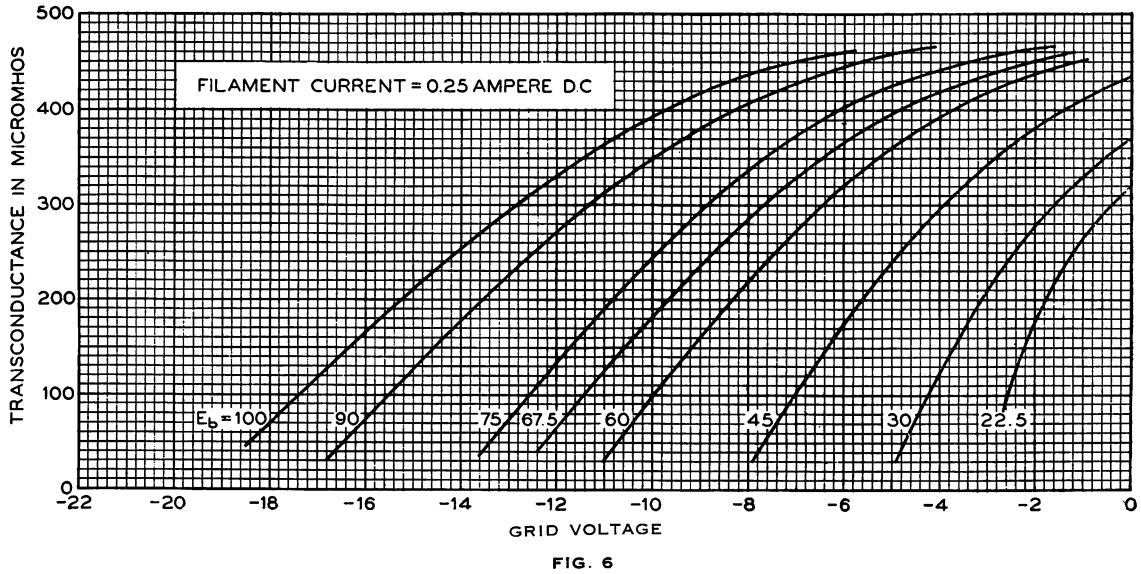


FIG. 6

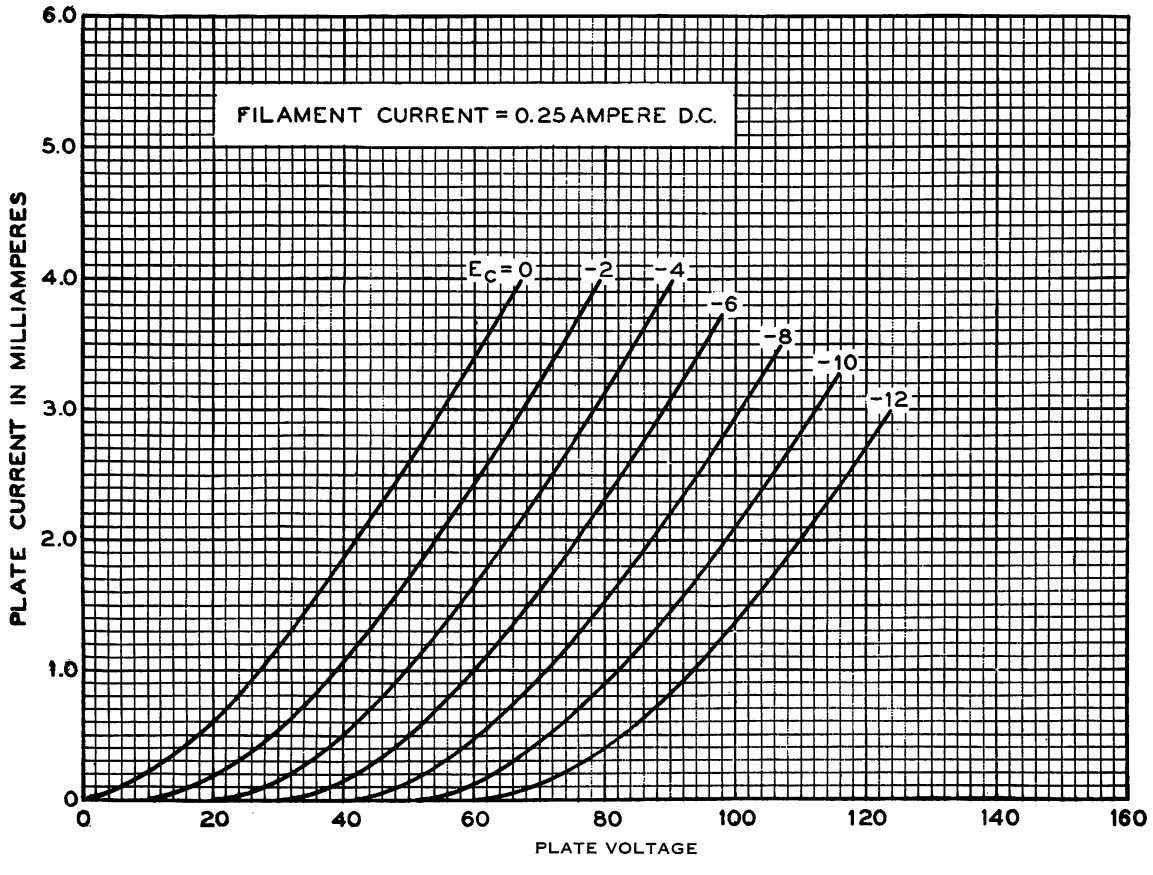
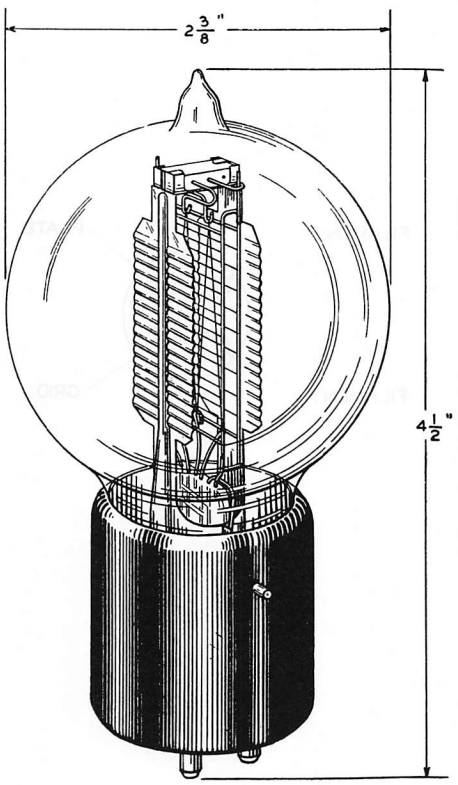
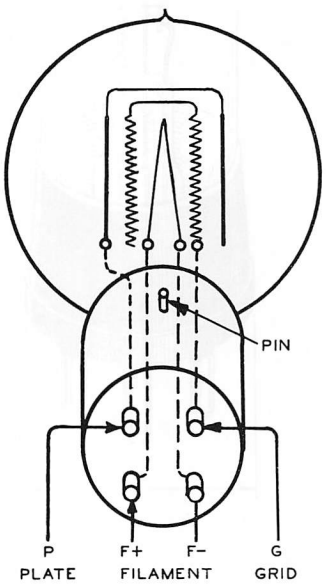

FILAMENT CURRENT = 0.25 AMPERE D.C.
E_C = 0
-2
-4
-6
-8
-10
-12
PLATE CURRENT IN MILLIAMPERES
6.0
5.0
4.0
3.0
2.0
1.0
0
0
20
40
60
80
100
120
140
160
PLATE VOLTAGE

FIG. 7

216-A Vacuum Tube

Used with Western Electric Vacuum Tube Sockets Nos. 100-L or 100-R





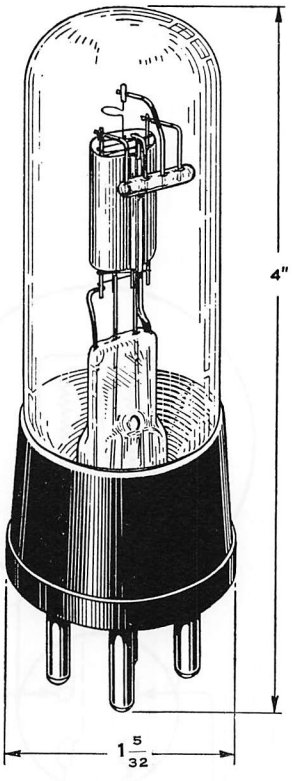
USE—AMPLIFIER—OSCILLATOR

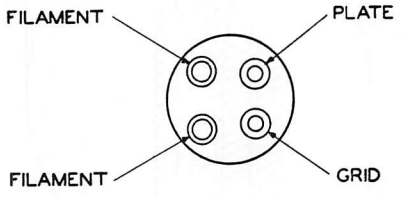
Normal filament current	1.0 ampere
Normal filament voltage	5 to 6 volts
Normal plate current	6.5 milliamperes
Normal plate voltage	130 volts
Maximum safe plate voltage	160 volts
Normal grid voltage	—9 volts
Plate-filament impedance	5900 ohms
Amplification constant	5.9

NOTE

An increase of 10% in the filament current may cause as much as 50% decrease in the useful life. For maximum life, therefore, the current should be kept as low as possible to secure the desired output.

231D Vacuum Tube





Classification

The No. 231D Vacuum Tube is a three-element filament type tube for use as an audio-frequency amplifier in the first and intermediate stages requiring a low filament power consumption.

Base and Socket

The No. 231D Vacuum Tube employs a standard four-prong, thrust-type base suitable for use in a Western Electric No. 130B (rigid) or No. 131A (cushion) Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

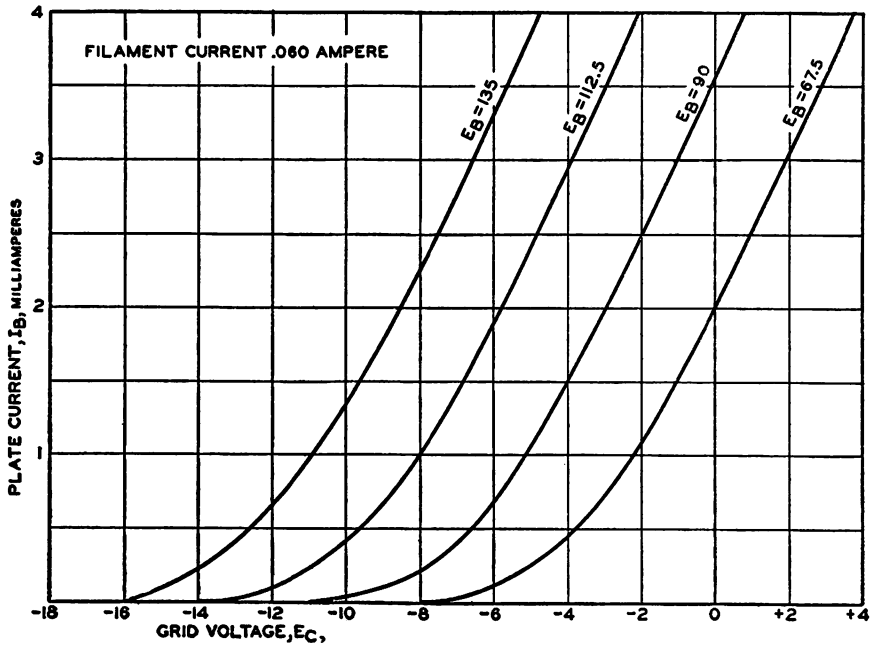
Filament Voltage		2.9 to 3.4 Volts, DC
Average Filament Current		0.060 Ampere
Plate Voltage	90	135 Volts Maximum
Grid Voltage	—3.0	—7.5 Volts
Average Plate Current	2	2.5 Milliamperes
Average Plate Resistance	15,600	14,600 Ohms
Average Amplification Factor	7.8	7.8

Approximate Direct Interelectrode Capacities

Plate to Grid	3.2 MMF
Plate to Filament	2.5 MMF
Grid to Filament	2.4 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 231D Vacuum Tube.



General Features

The very low power consumed by the filament of the No. 231D Vacuum Tube makes it particularly adaptable for use in portable equipment or wherever a low current drain is necessary.

By careful control of the manufacturing processes, uniform characteristics are obtained over an unusually long life for a filament of such small size.

Western Electric

231D Vacuum Tube



Classification—Small, filamentary triode

An important feature of the 231D tube is its low filament power consumption.

Applications

Audio-frequency and intermediate-frequency amplifier.

Detector.

Oscillator.

Dimensions—Outline diagrams showing dimensions of the tube and base, and the arrangement of the electrode connections to the base terminals are given in Figures 1 and 2.

Base—Small, four-pin, thrust type.

Socket—Standard four-contact type such as the Western Electric 143B 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

Grid to plate	3.6 μμf.
Grid to filament	2.5 μμf.
Plate to filament	2.5 μμf.

Filament Rating

Filament current	0.060 ampere, d.c.
Nominal filament voltage	3.1 volts

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

Characteristics—Plate current characteristics of a typical 231D tube are shown in Figure 3 as functions of grid voltage for several values of plate voltage. The grid and plate voltages are measured from the negative end of the filament. 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 are shown in Figure 7 for several values of grid voltage.

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 are given in the table on page 3 for a number of typical operating conditions represented by selected points within this area. The 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 or voltage output and the second and third harmonic levels for the indicated values of load resistance. The fundamental output is given in terms of the power, P_m, in milliwatts for values of load resistance, R, equal to and double the value of the plate resistance, r_p, and in terms of the voltage, E_{pm}, in peak volts for values of load resistance five times the plate resistance. The second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the fundamental power and voltage output and the harmonic levels are given approximately by the following relations:

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

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

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

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

TABLE

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Voltage Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms r_p	Micromhos	Peak Volts	R	Milliwatts	Peak Volts	db	db
67.5	−3.0	.93	8.5	22500	380	3.0	$R=r_p$	3.0		29	50
							$R=2r_p$	2.5		36	60
							$R=5r_p$		20	47	70
67.5	−1.5	1.55	8.5	18300	460	1.5	$R=r_p$	1.0		39	70
							$R=2r_p$	0.9		46	80
90.0	−5.0	1.15	8.5	20700	410	5.0	$R=r_p$	10		26	43
							$R=2r_p$	9		33	50
							$R=5r_p$		35	42	65
90.0	−3.0	2.10	8.4	16300	510	3.0	$R=r_p$	4.5		36	60
							$R=2r_p$	4.0		42	70
							$R=5r_p$		22	50	75
112.5	−8.0	1.00	8.5	22200	390	8.0	$R=r_p$	23		21	34
							$R=2r_p$	20		27	42
							$R=5r_p$		55	38	60
112.5	−6.0	1.90	8.4	17200	490	6.0	$R=r_p$	17		29	45
							$R=2r_p$	15		35	55
							$R=5r_p$		42	44	70
135.0	−11.5	0.70	8.5	27000	320	11.5	$R=r_p$	45		17	28
							$R=2r_p$	40		23	34
							$R=5r_p$		76	33	47
135.0	−10.0	1.25	8.5	20300	420	10.0	$R=r_p$	40		21	32
							$R=2r_p$	35		28	41
							$R=5r_p$		67	37	55
135.0	−8.5	1.95	8.5	17200	490	8.5	$R=r_p$	35		26	40
							$R=2r_p$	30		33	50
							$R=5r_p$		57	42	65
*90.0	−1.5	2.90	8.4	14500	580	1.5	$R=r_p$	1.2		46	75
							$R=2r_p$	1.0		50	85
*112.5	−4.5	2.65	8.4	15000	560	4.5	$R=r_p$	10		34	55
							$R=2r_p$	9		40	65
							$R=5r_p$		30	50	70
*135.0	−7.5	2.50	8.4	15600	540	7.5	$R=r_p$	27		29	47
							$R=2r_p$	24		36	55
							$R=5r_p$		48	45	70

*Maximum operating conditions.

Microphonic Noise—With a plate voltage of 90 volts, a grid bias of −3 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 231D tube, measured in a laboratory reference test set, is 16 decibels below 1 volt. The range of levels of individual tubes extends from 2 to 28 decibels. 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.

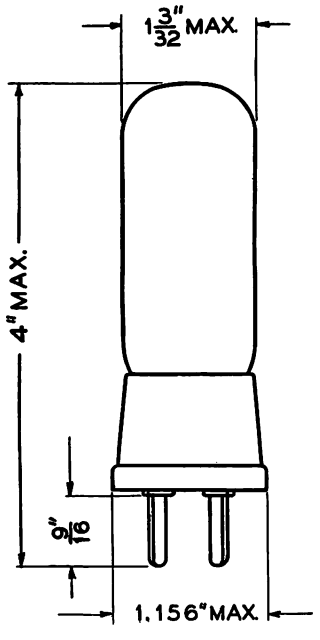


FIG. 1

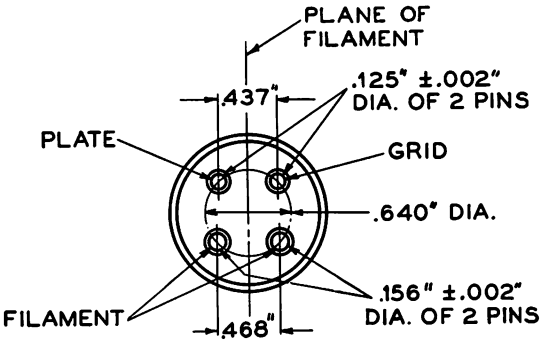


FIG. 2

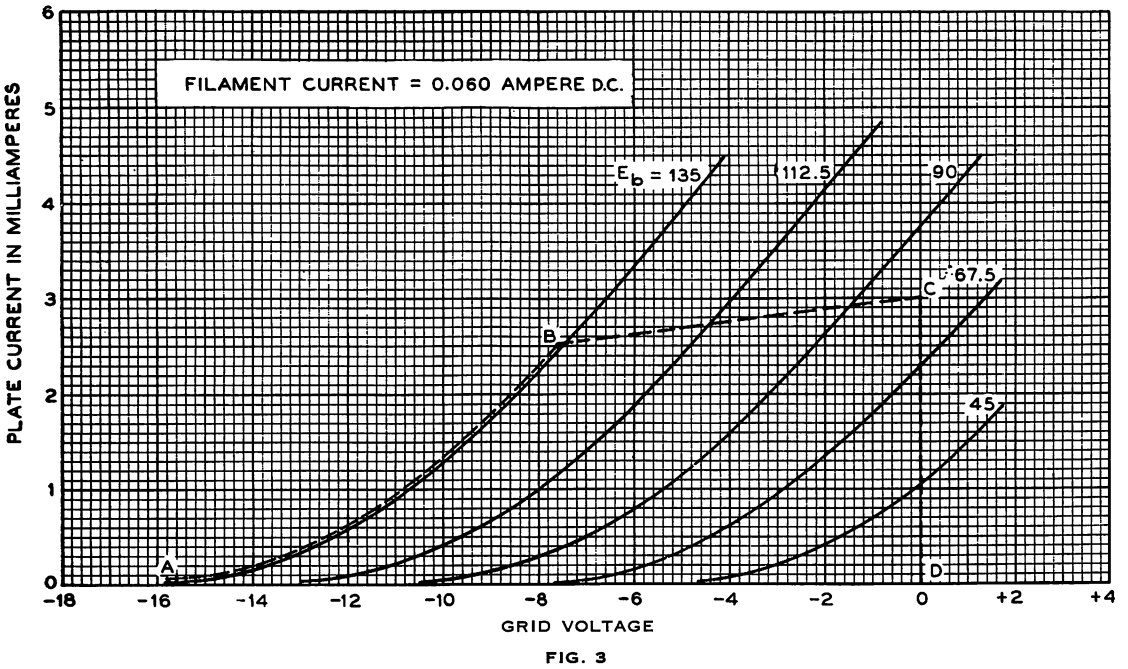


FIG. 3

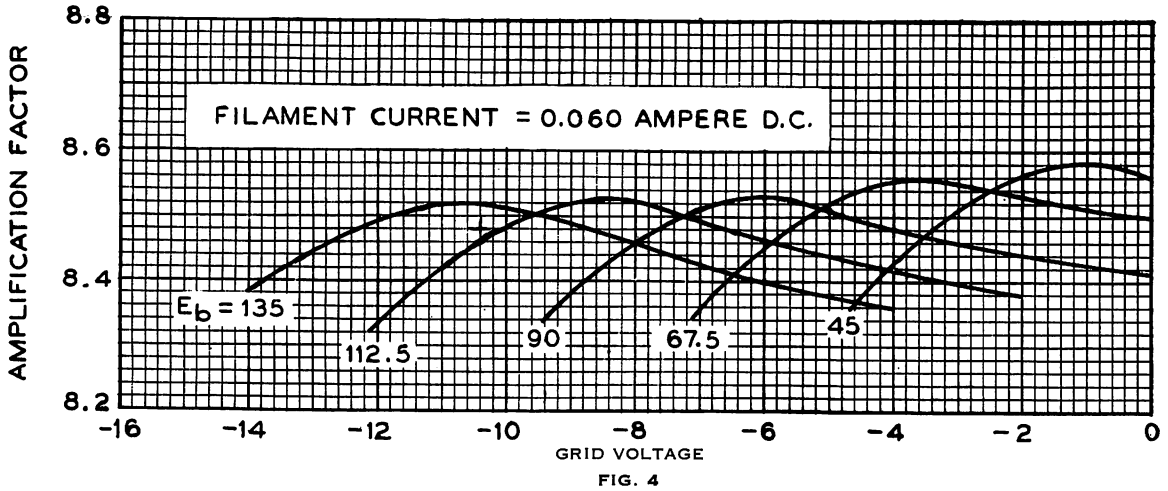


FIG. 4

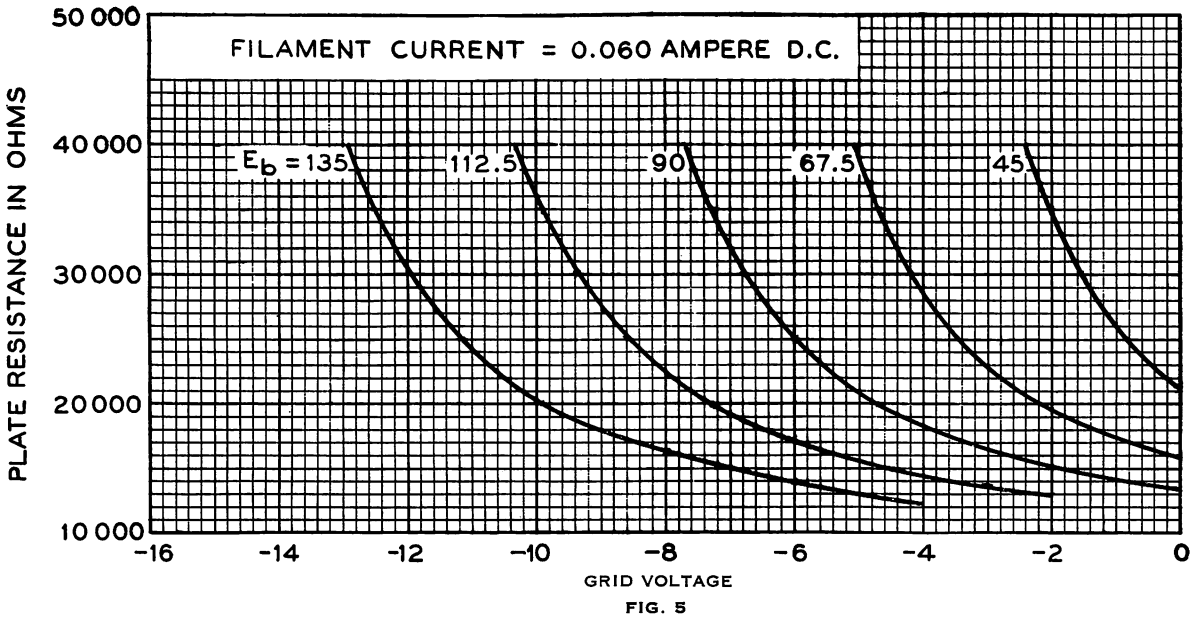


FIG. 5

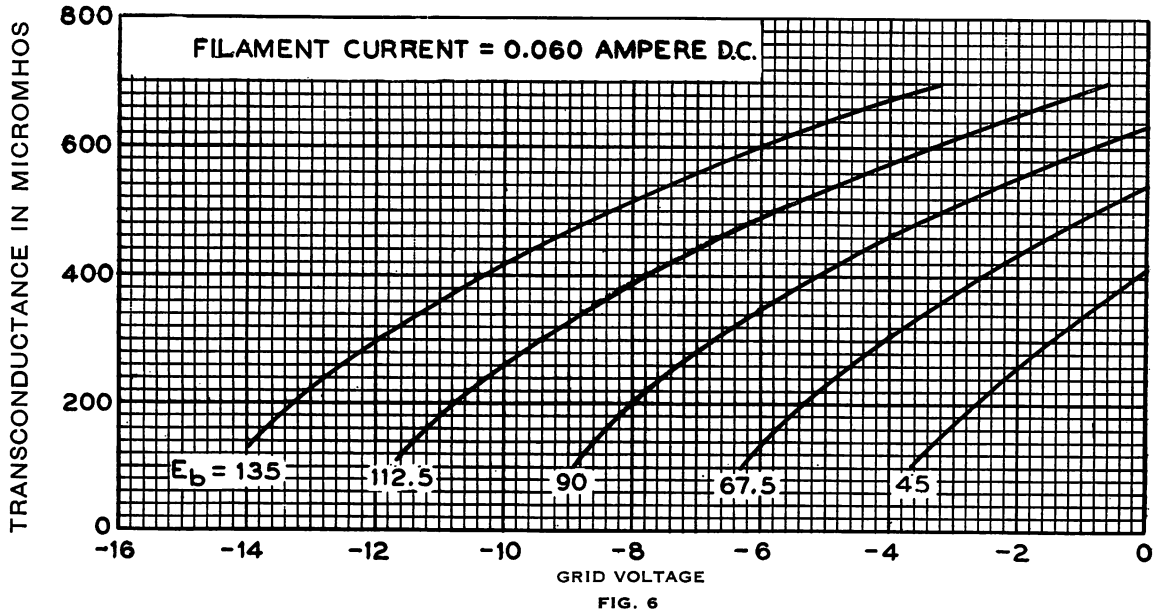


FIG. 6

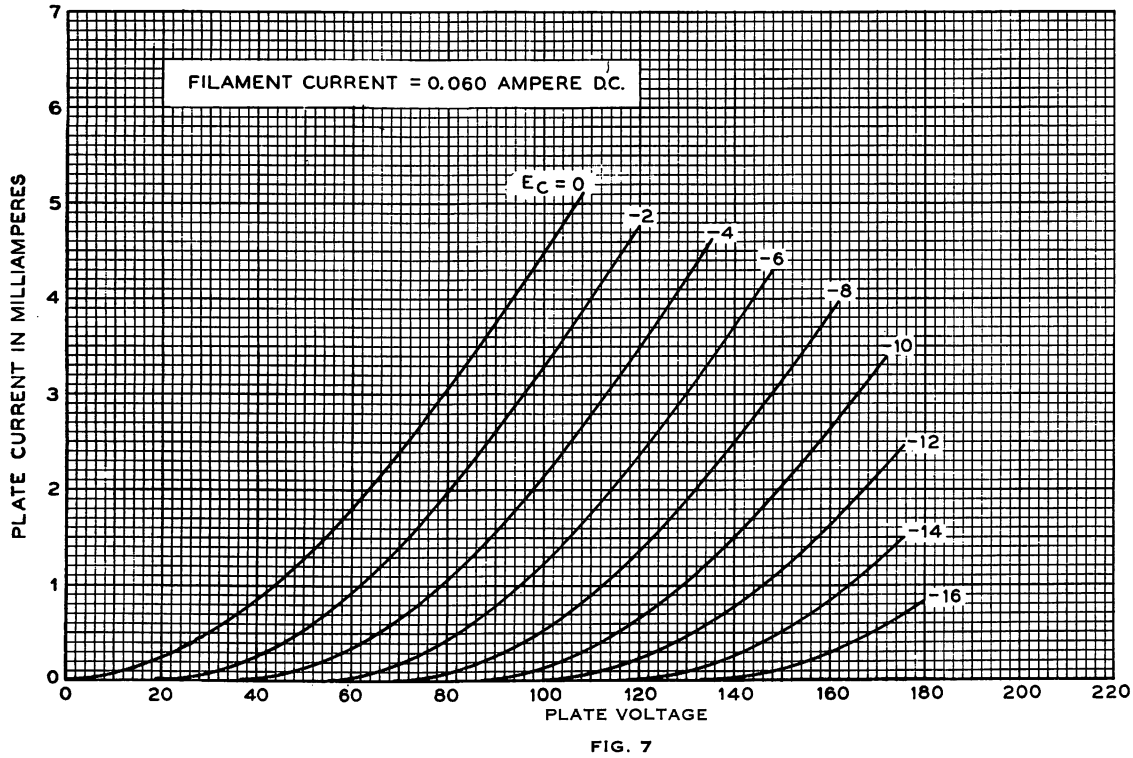

FILAMENT CURRENT = 0.060 AMPERE D.C.
$E_C = 0$
-2
-4
-6
-8
-10
-12
-14
-16
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
180
200
220

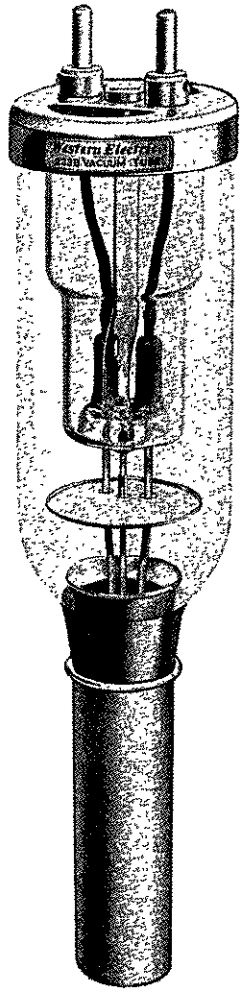
FIG. 7

BELL SYSTEM PRACTICES
Transmission Engineering and Data
Vacuum Tube Data

SECTION AB46.175
Issue 1, August 1941
A T & T Co [redacted] Special

Western Electric

233B Vacuum Tube



Classification—Half wave, high voltage, water-cooled rectifier

Designed to supply direct current from an alternating current supply. This tube entirely replaces the 233A tube.

Dimensions—Figure 1 shows the dimensions and outline diagrams. The overall dimensions are:

Maximum overall length	20⅞″
Diameter of bulb	4⅛″

Mounting—This vacuum tube should be mounted only in a vertical position with the anode end down in a Western Electric socket made in accordance with ESR-611038, Details 1 and 2 or the equivalent.

Filament—Tungsten

Filament voltage	21.5 volts, a.c.
Nominal filament current	41 amperes
Average thermionic emission	7 amperes

Characteristics and Operating Condition

Maximum peak inverse voltage	50,000 volts
Maximum peak plate current	5 amperes

The maximum permissible peak plate current (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 rectified load current is not fixed but will depend upon the wave form required by the load and filter circuit.

The maximum permissible peak inverse voltage (50,000 volts) is a limitation on the instantaneous value that the tube can stand safely in the opposite direction to that in which it is designed to conduct. 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.

233B vacuum tubes may be operated in parallel if some provision is made to insure a proper division of the load current. Resistors in the heating circuit of each filament may be used for this purpose.

Operating Precautions

Mechanical—Figure 1 shows 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 tungsten filament. Care should always be used in handling the tube to avoid scratches on the glass envelope as these may develop into cracks which result in leaks.

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

The cooling water should be of sufficient purity to retard the tendency to form scale on the anode. Formation of scale would have the effect of insulating the anode from the water and the ineffective cooling of the anode would result in failure of the tube. It is therefore recommended that distilled water be used in the cooling system.

The temperature of the water and rate of flow should be such that there is no tendency for the water to boil, as indicated by a hissing sound, under maximum dissipation. In general, the outlet water temperature should not exceed 75° C. and the rate of flow should be not less than 1 gallon per minute. The minimum length of water column which can be used to insulate the plate from the water supply, which is usually grounded, will depend upon the resistivity of the water used and the leakage current that can be tolerated. This length should not be less than 15 feet. The cooling connections must always be made so that the water flows in at the center port of the tube socket.

The number of water coils required will depend upon the type of circuit in which the tubes are used. For example in Circuit B, although there are four tubes used, only two cooling coils are required since two of the anodes are permanently at ground potential. On the other hand the corresponding filament circuits reach peak alternating potential above ground and must be insulated accordingly.

Provision should be made in the circuit to safeguard against filament and plate voltages being applied until cooling water is circulating at the proper rate and temperatures, and for immediate cut-off of filament and plate voltages if the circulating rate falls below the allowed minimum or the temperature exceeds the allowable maximum. A momentary interruption of the water circulation during operation of the tube may cause immediate failure.

Electrical—Overload protection should always be provided for the plate circuit. Although the tube is sufficiently rugged to withstand momentary overloads, a prolonged overload caused by inefficient adjustment of the circuit, may damage the tube.

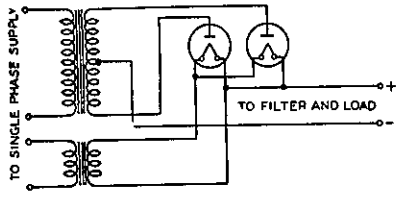
Some provision should be made to limit the initial filament current when the filament is cold, to a value of approximately 90 amperes. This may be done by inserting additional resistance or reactance in the filament circuit when voltage is first applied or by using a transformer having sufficiently high reactance.

Figure 2 shows the impedance characteristic and the effect of lowering the filament voltage of a typical tube, and Figure 3 shows the resistance characteristic of the filament.

Typical Rectifier Circuits—This vacuum tube may be used in any conventional rectifier circuit subject to its current and voltage 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 the table. The values listed below are average values of the pulsating current and voltage for an unfiltered circuit.

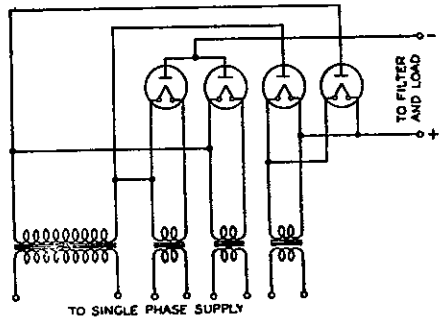
TABLE

Circuit Designation	Number of Tubes	Load Potential in Volts	Load Current in Amperes
A	2	15,000	3
B	4	30,000	3
C	6	45,000	5
D	6	20,000	8.5



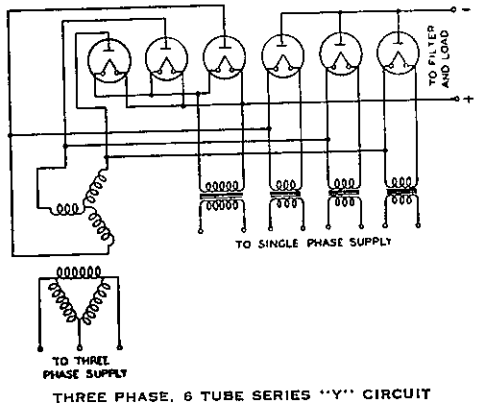
SINGLE PHASE, DOUBLE HALF-WAVE

CIRCUIT A



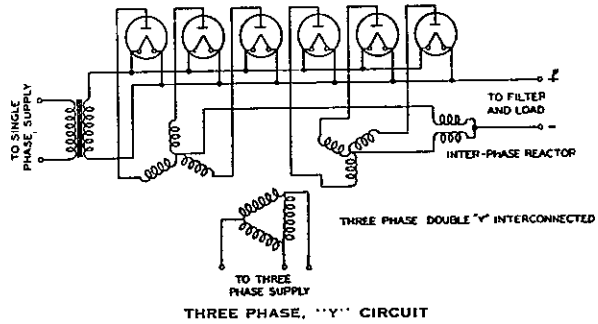
SINGLE PHASE, DOUBLE HALF-WAVE, 4 TUBE SERIES CIRCUIT

CIRCUIT B



THREE PHASE, 6 TUBE SERIES "Y" CIRCUIT

CIRCUIT C



THREE PHASE, "Y" CIRCUIT

CIRCUIT D

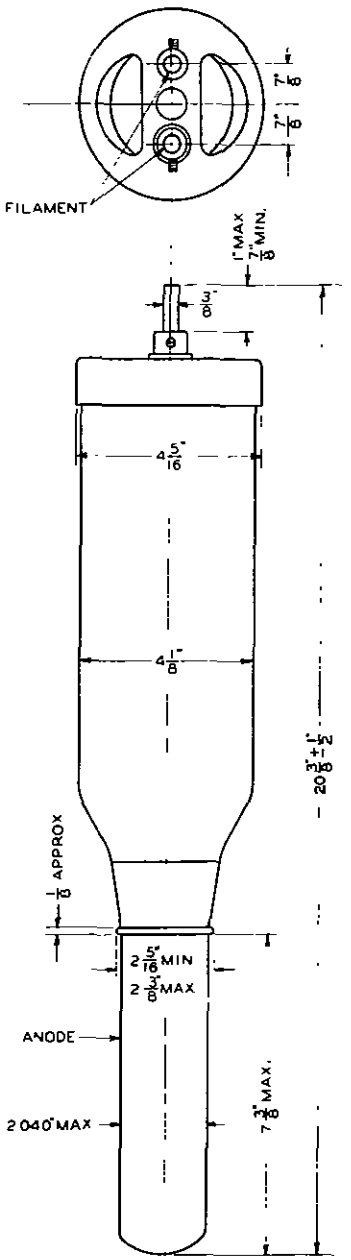


FIG. 1

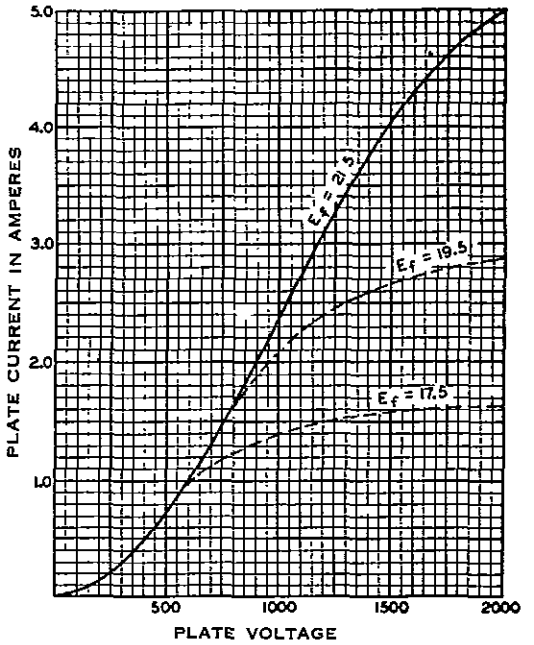


FIG. 2

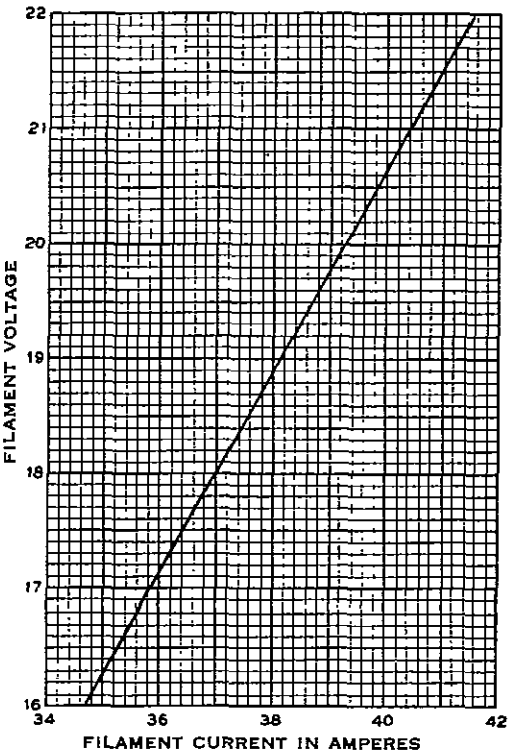


FIG. 3

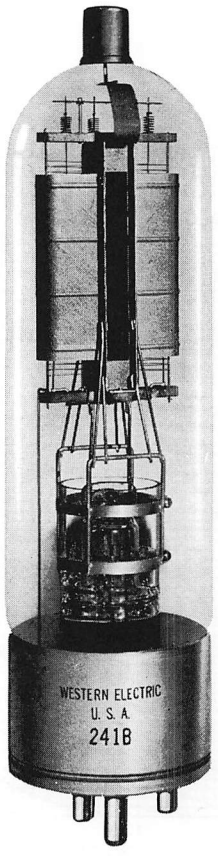
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A development of Bell Telephone Laboratories, Incorporated, the research laboratories of the American Telephone and Telegraph Company, and the Western Electric Company

V. T. DATA SHEET 233B
ISSUE 1

Western Electric

241B Vacuum Tube



Classification—Filamentary air-cooled triode

This tube may be used as an audio-frequency amplifier or modulator; or as a radio-frequency oscillator or amplifier.

Dimensions—Dimensions and outline diagrams are shown in Figs. 1 and 2 and are:

Maximum overall length	14½″
Maximum diameter	3⅝″

Mounting—Large three-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 Fig. 2, should be vertical.

Filament—Thoriated tungsten.

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

Average Direct Interelectrode Capacitances

Plate to grid	18.8 *uuf.*
Grid to filament	14.9 *uuf.*
Plate to filament	8.6 *uuf.*

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 2000 volts direct plate potential and minus 90 volts grid bias.

Amplification factor	16
Plate resistance	1900 ohms
Grid to plate transconductance	8500 micromhos

Operation

Maximum Ratings

Maximum direct plate voltage	3000 volts
Maximum direct plate current	350 milliamperes
Maximum plate dissipation	275 watts
Maximum direct grid current	75 milliamperes
Maximum r-f grid current	5 amperes
Maximum frequency for the above ratings	7.5 megacycles
Maximum plate voltage for upper frequency limit of 22.5 Mc	1000 volts

Maximum plate voltage for frequencies between 7.5 and 22.5 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	1250 volts
Grid bias	−58	−40 volts
Direct plate current	170	200 milliamperes
Plate dissipation	250	250 watts
Load impedance	5000	3000 ohms
Undistorted output	50	40 watts

Grid Bias Modulator

Direct plate voltage	3000 volts (Max.)
Grid bias	−260 volts
Plate dissipation	175 watts
Load impedance	8000 ohms
Peak power output	200 watts

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

Direct plate voltage	2000 (Max.)	1500 volts
Grid bias	−110	−75 volts
Direct plate current per tube		
No drive	40	50 milliamperes
Maximum drive	300	300 milliamperes
Plate dissipation	275	200 watts
Load resistance plate-to-plate	8000	5900 ohms
Load resistance per tube	2000	1475 ohms
Approximate maximum output	650	500 watts
Recommended power for driving stage	50	50 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	2000 (Max.)	1300 volts
Direct plate current	200	270 milliamperes
Plate dissipation	275	275 watts
Grid bias	−120	−90 volts
Approx. carrier watts for use with 100% modulation	150	130 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	2000 (Max.)	1500 volts
Direct plate current	300	300 milliamperes
Grid bias	−185 to −250	−150 to −200 volts
Nominal power output	400	300 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1500 (Max.)	1000 volts
Direct plate current	300	300 milliamperes
Grid bias	−200	−125 volts
Maximum direct grid current	75	75 milliamperes
Nominal carrier power output for use with 100% modulation	300	200 watts

Operating Precautions

Mechanical—Figs. 1 and 2 show the overall dimensions and basing arrangements 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 450 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.

Grid Bias Modulator

For some types of use where feedback can be applied to reduce distortion, grid bias modulation is particularly advantageous in simplifying circuit design. The tube is biased to a cutoff voltage higher than would be used for Class B radio frequency. The grid is driven with sufficient voltage to obtain four times the carrier output power.

An audio voltage is superimposed on the grid driving voltage to modulate the signal 100%. The rating for this class of service is lower than for an ordinary Class B amplifier. The applied voltages for this type of service are the highest to which the electrodes may be subjected, since the plate dissipation is maintained lower than the maximum rating.

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 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. The tube may be used at full rating up to 7.5 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 of 22.5 megacycles and for frequencies between these two limits the plate voltage should be proportionately reduced.

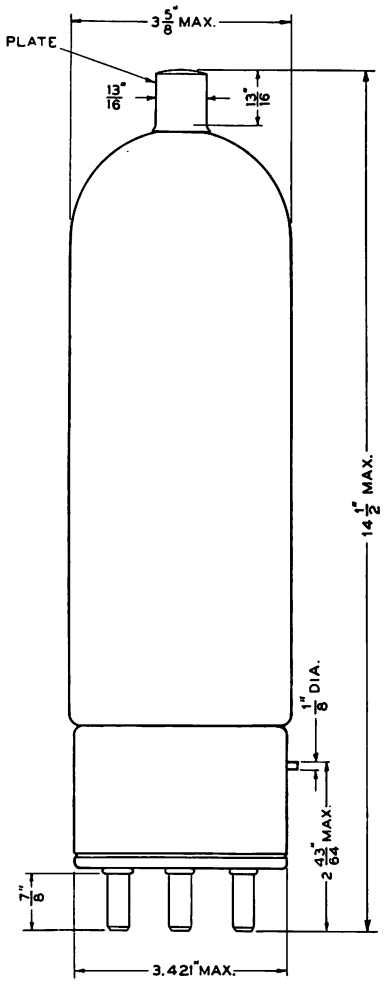

3 5/8" MAX.
PLATE
13/16"
13/16"
14 1/2" MAX.
1/8" DIA.
2 43/64" MAX.
7/8"
3.421" MAX.

FIG. 1

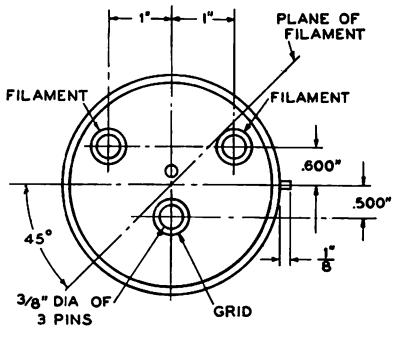

1"
1"
PLANE OF FILAMENT
FILAMENT
FILAMENT
.600"
.500"
45°
1/8"
3/8" DIA OF 3 PINS
GRID

FIG. 2

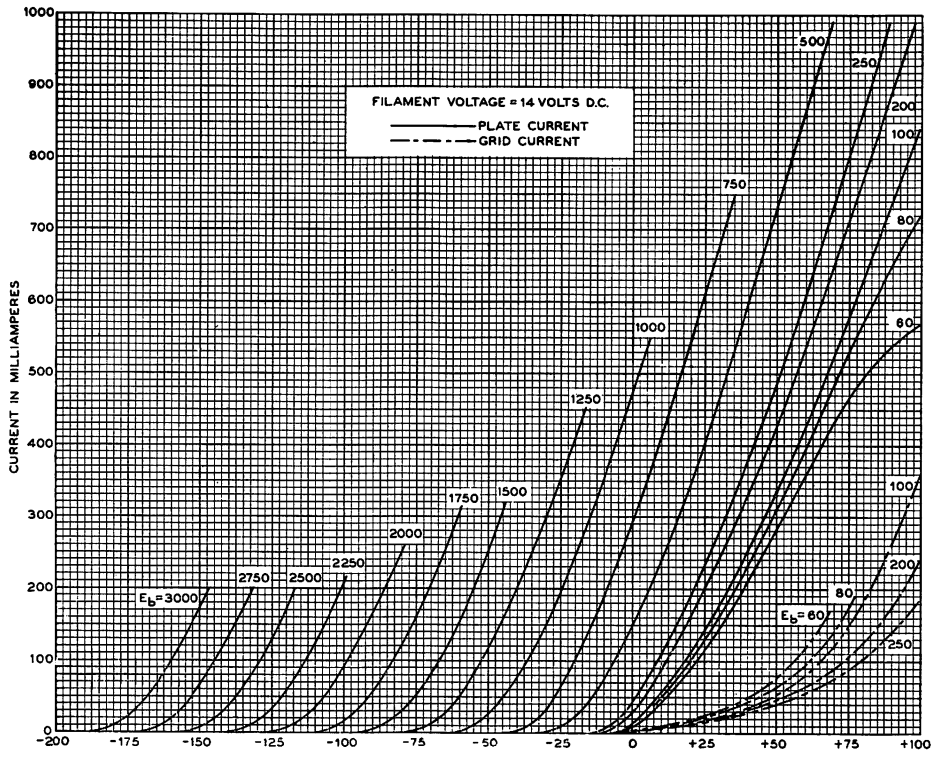

FILAMENT VOLTAGE = 14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
500
250
200
100
80
60
750
1000
1250
1500
1750
2000
2250
2500
2750
E_b=3000
E_b=60

FIG. 3

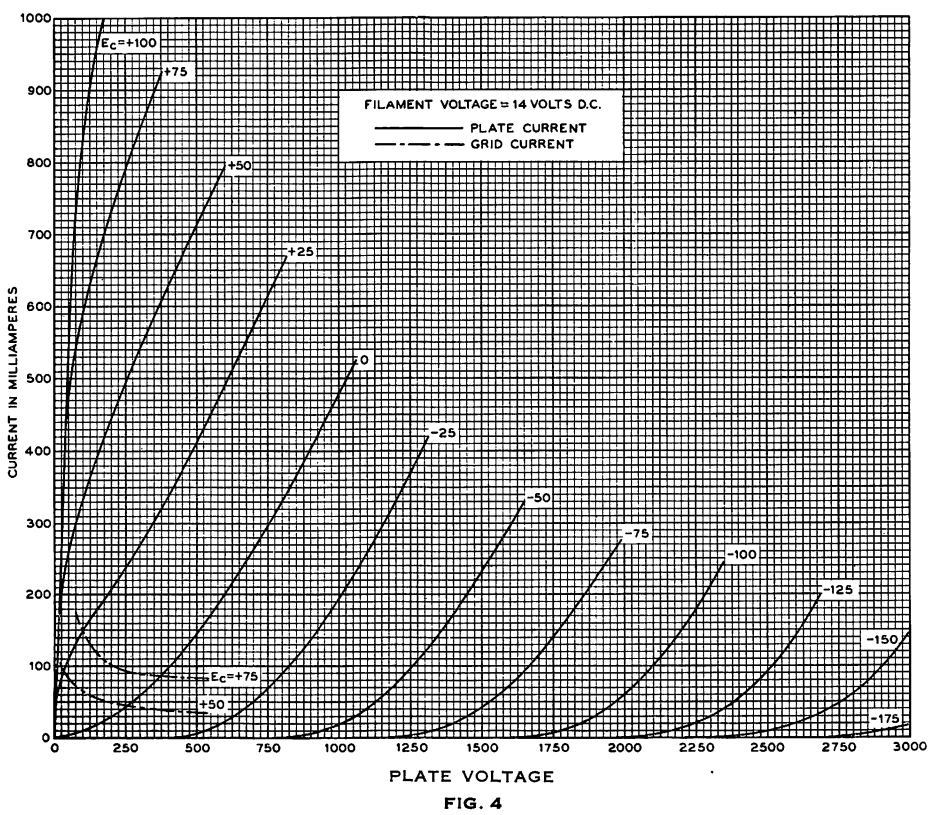
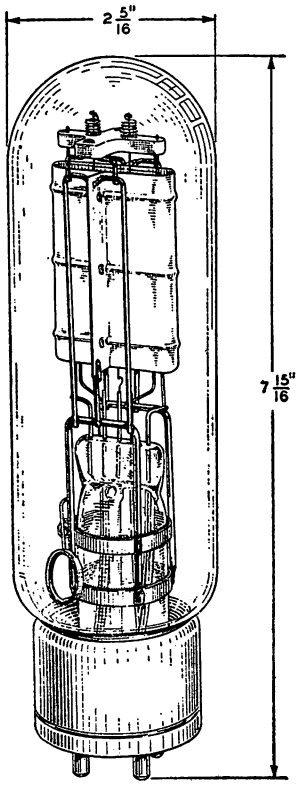
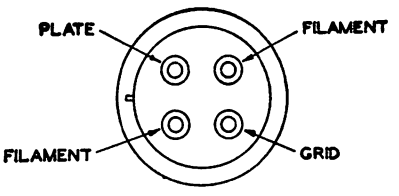

FILAMENT VOLTAGE = 14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_c=+100
+75
+50
+25
0
-25
-50
-75
-100
-125
-150
-175
E_c=+75
+50

FIG. 4

242A Vacuum Tube





Classification

The No. 242A Vacuum Tube is a three-element tube used as an oscillator, radio-frequency amplifier, modulator or audio-frequency amplifier.

Base and Socket

The No. 242A Vacuum Tube employs a standard four-prong, bayonet pin type base suitable for use in a Western Electric 112A socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Ratings and Characteristic Data

Filament Voltage	10 Volts
Nominal Filament Current	3.25 Amperes
Maximum Plate Voltage	1,250 Volts
Maximum Plate Current	0.150 Ampere
Average Plate Resistance	3,500 Ohms
Average Amplification Factor	12.5
Approximate Direct Interelectrode Capacities	
Plate to Grid	13.0 MMF
Plate to Filament	4.0 MMF
Grid to Filament	6.5 MMF

Audio-Amplifier or Modulator Rating—Peak Grid Drive equal to or less than the Bias —Class A Service

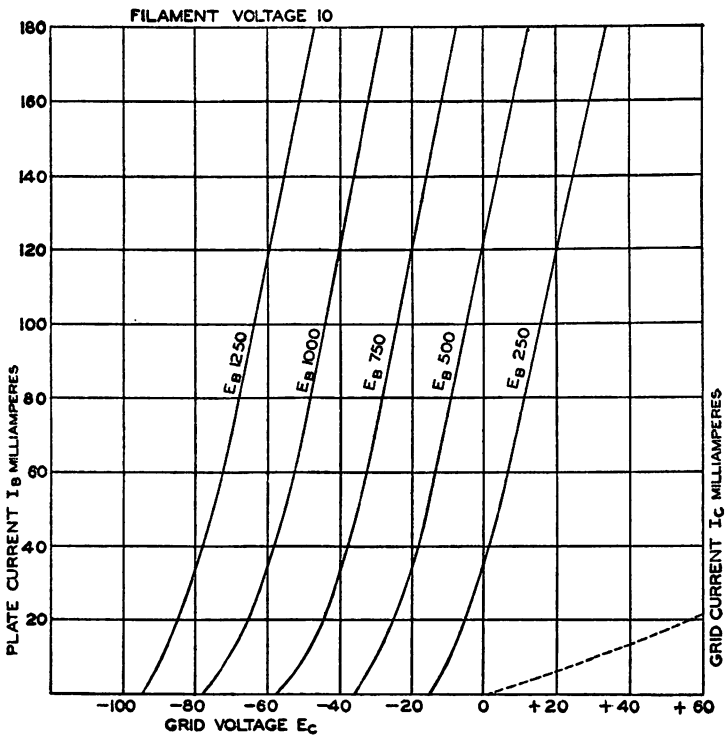
Maximum Plate Voltage	1000
Maximum Plate Current	0.85 Ampere
Maximum Plate Dissipation	85 Watts
Grid Bias Voltage	—50 Volts
Load Impedance	7,000 Ohms
Undistorted Output	10 Watts

Radio-Frequency Amplifier—Grid Bias practically at Cut-Off, Grid Drive higher than the Bias—Class B Service

Maximum Plate Voltage	1,250
Maximum Plate Current	0.150 Ampere
Maximum Plate Dissipation	100 Watts
Grid Bias Voltage	—100 Volts
Peak Output	125 Watts

Oscillator or Radio-Frequency Amplifier—Grid Bias below Cut-Off—Class C Service

Maximum Modulated Plate Voltage (DC)	1,000 Volts
Maximum Non-modulated Plate Voltage (DC)	1,250 Volts
Maximum Plate Current	0.150 Ampere
Maximum Plate Dissipation	100 Watts
Maximum Radio-Frequency Charging Current in Grid and Plate Leads	5 Amperes
Approximate Grid Bias	—150 Volts
Maximum Output	125 Watts



Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 242A Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid returns connected to a center point of the filament transformer.

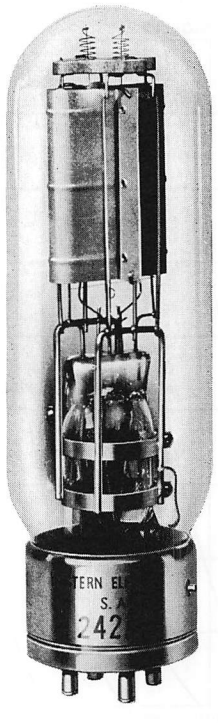
General Features

The No. 242A Vacuum Tube has an unusually rugged type of structure which insures against breakage in shipment and in service and makes possible the maintenance of uniform electrical characteristics.

The manufacturing process control, long aging together with an adequate thoriated tungsten filament, insure this tube of electrical stability and extremely long life when operated under rated conditions.

Western Electric

242A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

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

Maximum overall length	$7\frac{15}{16}$″
Maximum diameter	$2\frac{5}{16}$″

Mounting—Large four-pin bayonet base for use in a W.E. 112A 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. or d.c.
Nominal filament current	3.25 amperes
Average thermionic emission	1.5 amperes

Average Direct Interelectrode Capacitances

Plate to grid	13.0$\mu\mu$f
Grid to filament	6.5$\mu\mu$f
Plate to filament	4.0$\mu\mu$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 maximum direct plate voltage and dissipation—Class A (E_b = 1250 volts, I_b = 60 milliamperes)

Amplification factor	12.5
Plate resistance	3500 ohms
Grid to plate transconductance	3600 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1250 volts
Max. direct plate current	150 milliamperes
Max. plate dissipation	85 watts
Max. direct grid current	50 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	6 megacycles
Max. plate voltage for upper frequency limit of 30 Mc	600 volts
Max. plate voltage for frequencies between 6 and 30 Mc in proportion.	

Class A Audio Amplifier or Modulator

Direct plate voltage	1250	1000	750 volts
Grid bias	−70	−46	−25 volts
Direct plate current	60	75	100 milliamperes
Plate dissipation	75	75	75 watts
Load impedance	10,000	7000	6000 ohms
Undistorted output	18.0	12.0	5.0 watts

Class B Audio Amplifier or Modulator for balanced 2 Tube Circuit

Direct plate voltage	1250	1000 volts
Grid bias	−80	−55 volts
Direct plate current per tube		
No drive	30	30 milliamperes
Max. drive	150	150 milliamperes
Plate dissipation	80	70 watts
Load resistance, plate-to-plate	8000	6000 ohms
Load resistance, per tube	2000	1500 ohms
Approximate maximum output—2 tubes	200	165 watts
Recommended power for driving stage	25	25 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	1250	1000 volts
Direct plate current for carrier conditions	106	130 milliamperes
Grid bias	−90	−70 volts
Approx. carrier watts for use with 100% modulation	44	43 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1250	1000 volts
Direct plate current	150	150 milliamperes
Grid bias	−150 to −200	−120 to −160 volts
Nominal power output	130	100 watts
Plate dissipation	57.5	50 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1000	750 volts
Direct plate current	150	130 milliamperes
Grid bias	−160	−120 volts
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	100	65 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 175 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 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 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 is 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—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. The tube may be used at full rating up to 6 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.

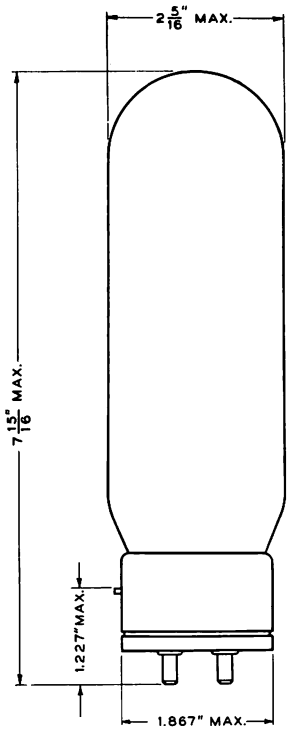


FIG. 1

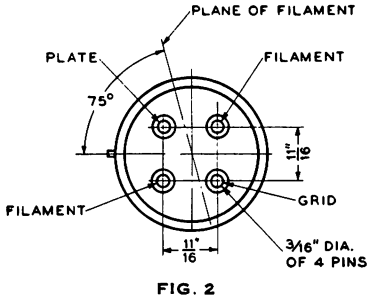


FIG. 2

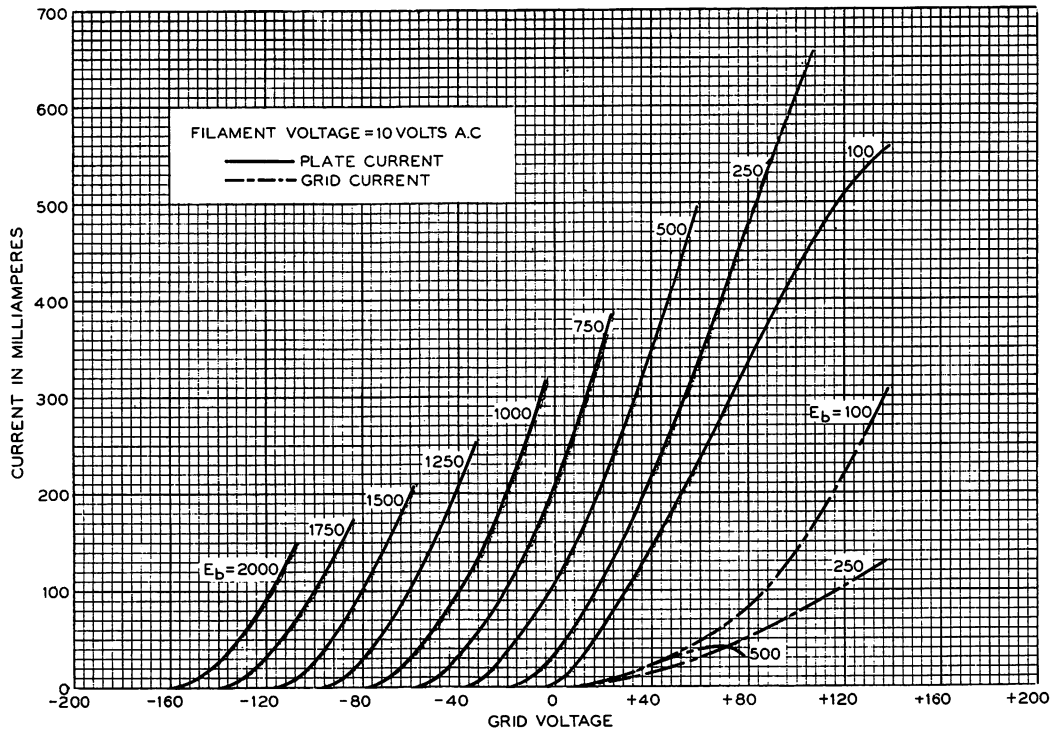

FILAMENT VOLTAGE = 10 VOLTS A.C
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
700
600
500
400
300
200
100
0
-200
-160
-120
-80
-40
0
+40
+80
+120
+160
+200
100
250
500
750
1000
1250
1500
1750
E_b = 2000
E_b = 100
250
500

FIG. 3

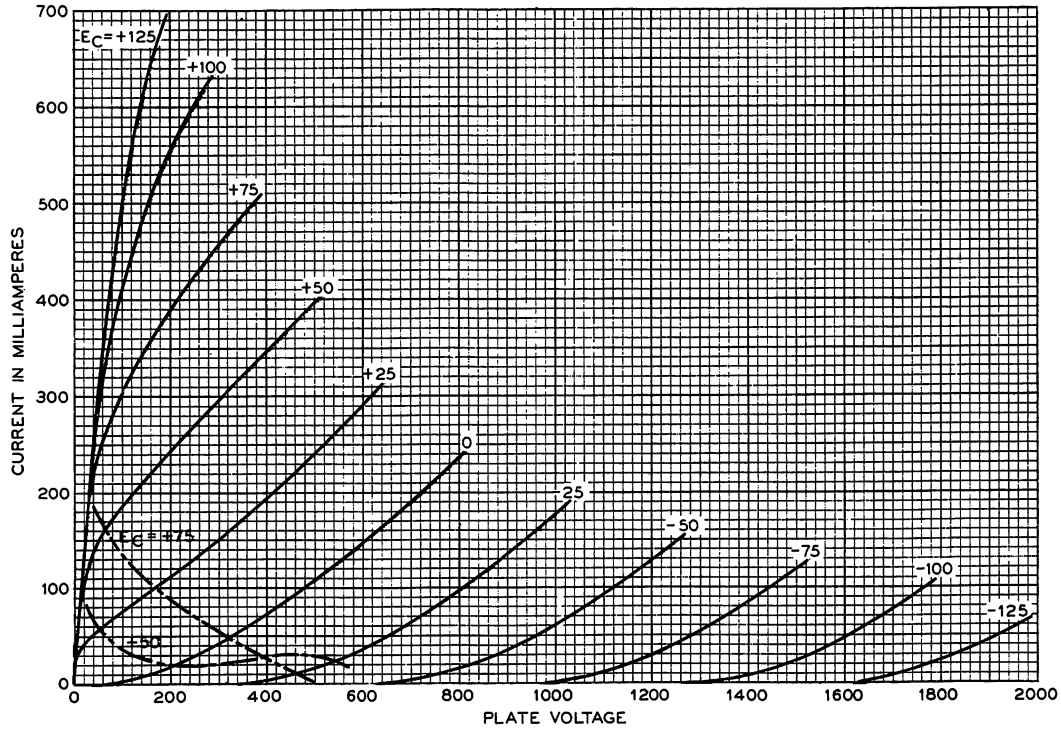
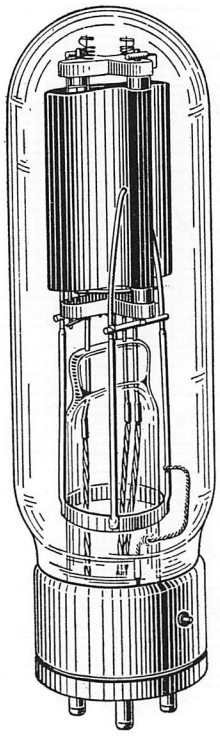
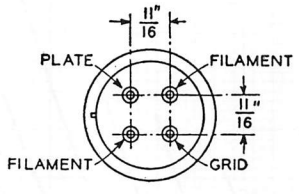
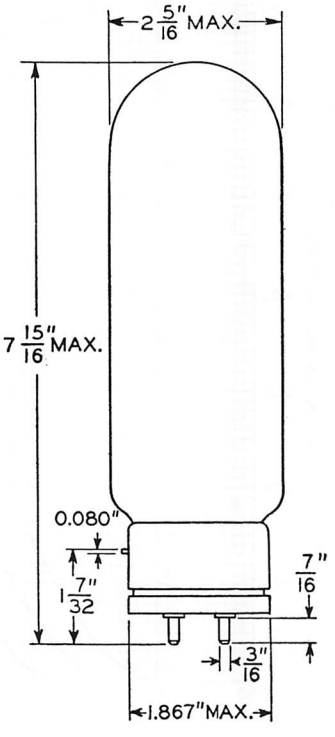

CURRENT IN MILLIAMPERES
PLATE VOLTAGE
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
E_C = +125
+100
+75
+50
+25
0
-25
-50
-75
-100
-125
E_C = +75
+50

FIG. 4

242B Vacuum Tube







Classification

The Western Electric No. 242B vacuum tube is a three element tube intended for use as an oscillator, radio-frequency amplifier, modulator or audio-frequency amplifier. It is similar to the No. 242A and is interchangeable with it.

Base and Socket

The No. 242B Vacuum Tube employs a standard four-prong, bayonet pin type base suitable for use in a Western Electric No. 112A Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

Filament Voltage	10 Volts
Nominal Filament Current	3.25 Amperes
Maximum Plate Voltage	1,250 Volts
Maximum Plate Current	0.150 Ampere

Average Characteristics with Plate Voltage, E_B, of 1000, Grid Voltage, E_C, of -50 and Filament Voltage E_A, of 10 volts D.C.

Plate Resistance	3,500 Ohms
Amplification Factor	12.5
Mutual Conductance	3,570 Micromhos

Approximate Direct Interelectrode Capacities

Plate to Grid	13.6 MMF
Plate to Filament	6.0 MMF
Grid to Filament	7.0 MMF

Audio-Amplifier or Modulator Rating—Peak Grid Drive Equal to or less than the Bias—Class A Service

Maximum Plate Voltage	1,000 Volts
Maximum Plate Current	0.85 Ampere
Maximum Plate Dissipation	85 Watts
Grid Bias Voltage	-50 Volts

Rating and Characteristic Data—Continued

Load Impedance	7,000 Ohms
Undistorted Output	10 Watts

Radio-Frequency Amplifier—Grid Bias Practically at Cut-Off, Grid Drive Higher than the Bias—Class B Service

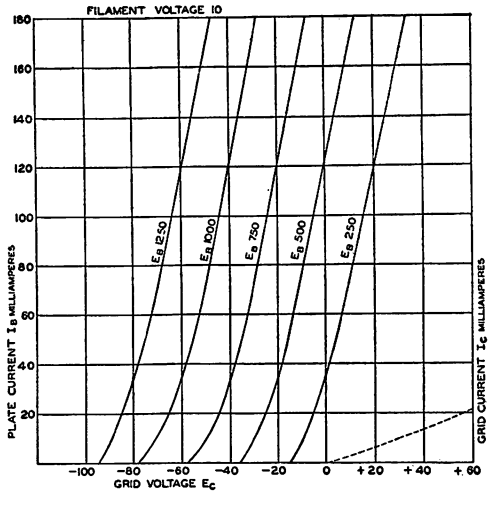
Maximum Plate Voltage	1,250
Maximum Plate Current	0.150 Ampere
Maximum Plate Dissipation	100 Watts
Grid Bias Voltage	-100 Volts
Peak Output	125 Watts

Oscillator or Radio-Frequency Amplifier—Grid Bias below Cut-off—Class C Service

Maximum Modulated Plate Voltage (D.C.)	1,000 Volts
Maximum Non-modulated Plate Voltage (D.C.)	1,250 Volts
Maximum Plate Current	0.150 Ampere
Maximum Plate Dissipation	100 Watts
Maximum Radio-Frequency Charging Current in Grid and Plate Leads	5 Amperes
Approximate Grid Bias	-150 Volts
Maximum Output	125 Watts

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 242B Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid returns connected to a center point of the filament transformer.



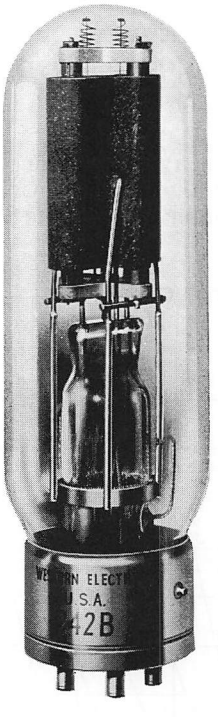
General Features

The No. 242B vacuum tube is similar to the No. 242A except that it employs a carbon plate. It has an unusually rugged type of structure which insures against breakage in shipment and in service and makes possible the maintenance of uniform electrical characteristics.

The manufacturing process control, long aging together with an adequate thoriated tungsten filament, insure this tube of electrical stability and extremely long life when operated under rated conditions.

Western Electric

242B Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

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

Maximum overall length	$7\frac{15}{16}''$
Maximum diameter	$2\frac{5}{16}''$

Mounting—Large four-pin bayonet base for use in a W.E. 112A 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. or d.c.
Nominal filament current	3.25 amperes
Average thermionic emission	1.5 amperes

Average Direct Interelectrode Capacitances

Plate to grid	13.6μμf
Grid to filament	7.0μμf
Plate to filament	6.0μμf

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 maximum direct plate voltage and dissipation—Class A (E_b = 1250 volts, I_b = 68 milliamperes)

Amplification factor	12.5
Plate resistance	3500 ohms
Grid to plate transconductance	3600 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1250 volts
Max. direct plate current	150 milliamperes
Max. plate dissipation	100 watts
Max. direct grid current	50 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	6 megacycles
Max. plate voltage for upper frequency limit of 30 Mc	600 volts
Max. plate voltage for frequencies between 6 and 30 Mc in proportion.	

Class A Audio Amplifier or Modulator

Direct plate voltage	1250	1000 volts
Grid bias	−68	−42 volts
Direct plate current	68	85 milliamperes
Plate dissipation	85	85 watts
Load impedance	8000	7000 ohms
Undistorted output	22.0	12.0 watts

Class B Audio Amplifier or Modulator for balanced 2 Tube Circuit

Direct plate voltage	1250	1000 volts
Grid bias	−80	−55 volts
Direct plate current per tube		
No drive	30	30 milliamperes
Max. drive	150	150 milliamperes
Plate dissipation	100	100 watts
Load resistance, plate-to-plate	7600	6000 ohms
Load resistance, per tube	1900	1500 ohms
Approximate maximum output—2 tubes	200	165 watts
Recommended power for driving stage	25	25 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	1250	1000 volts
Direct plate current for carrier conditions	120	150 milliamperes
Grid bias	−80	−60 volts
Approx. carrier watts for use with 100% modulation	50	50 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1250	1000 volts
Direct plate current	150	150 milliamperes
Grid bias	−150 to −200	−120 to −160 volts
Nominal power output	130	100 watts
Plate dissipation	57.5	50 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1000	750 volts
Direct plate current	150	150 milliamperes
Grid bias	−160	−120 volts
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	100	65 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. The graphite anode should not show a red color, typical for molybdenum plates during operation, as such color indicates excessive dissipation.

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 175 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 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 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 is 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 output can be increased or the distortion decreased by the use of degenerative feedback. 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—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. The tube may be used at full rating up to 6 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.

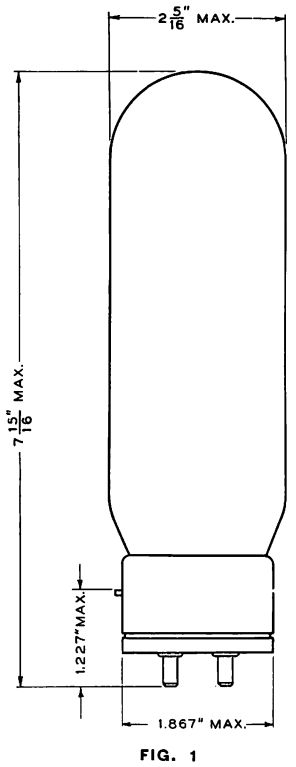


FIG. 1

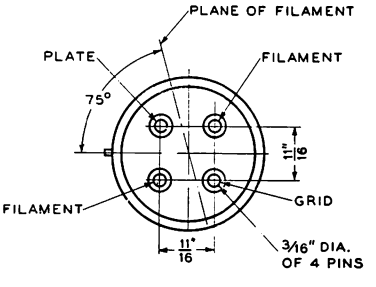


FIG. 2

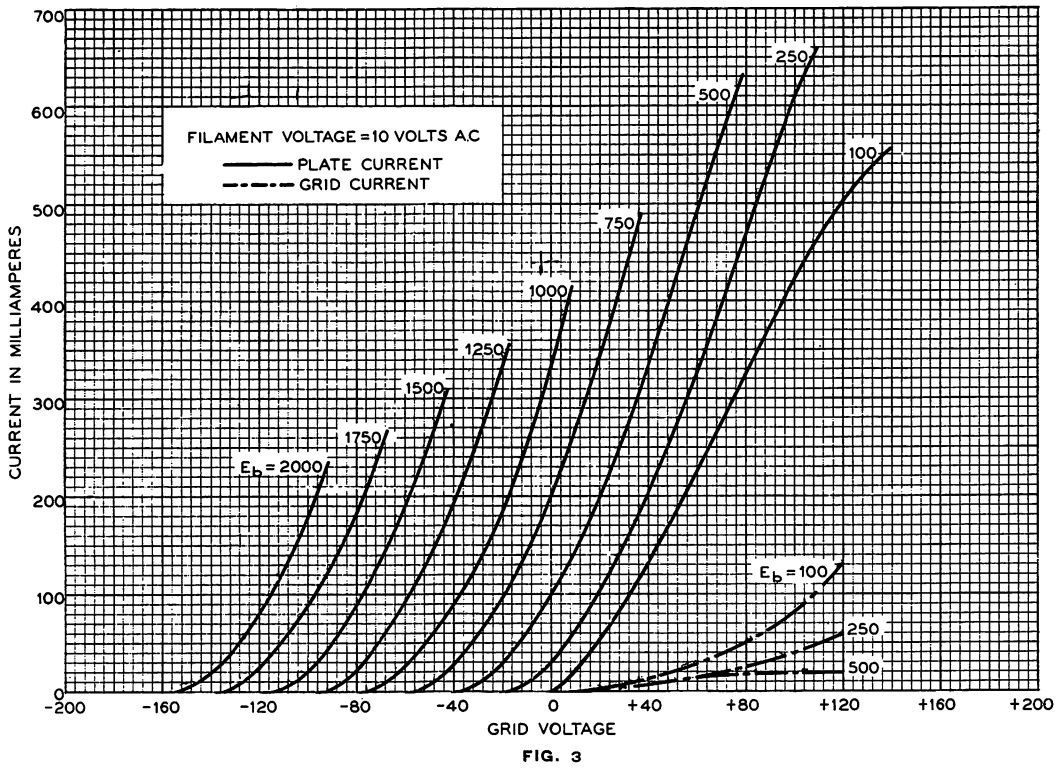

FILAMENT VOLTAGE = 10 VOLTS A.C
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
700
600
500
400
300
200
100
0
-200
-160
-120
-80
-40
0
+40
+80
+120
+160
+200
250
500
100
750
1000
1250
1500
1750
E_b = 2000
E_b = 100
250
500

FIG. 3

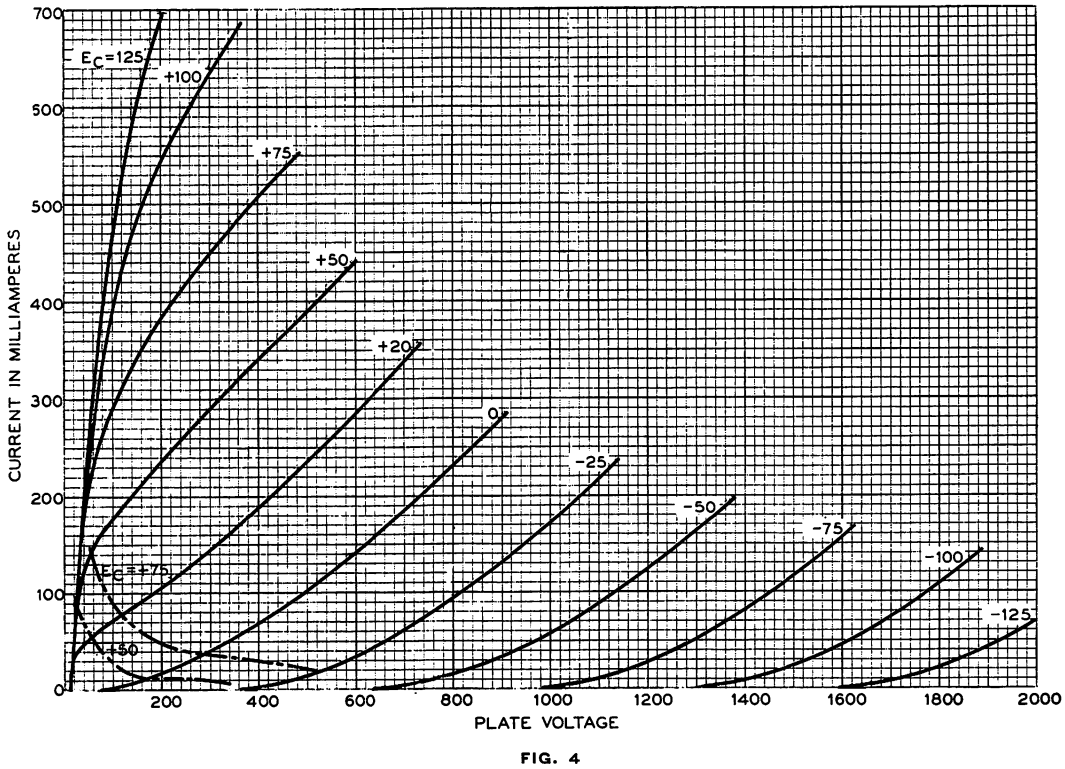
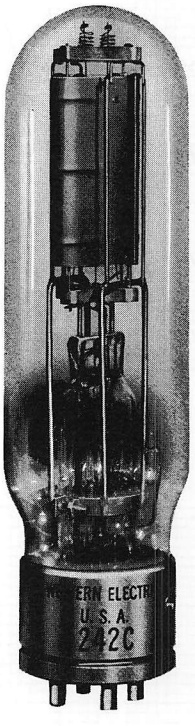

CURRENT IN MILLIAMPERES
PLATE VOLTAGE
700
500
400
300
200
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
E_C = 125
+100
+75
+50
+25
0
-25
-50
-75
-100
-125
E_C = +75
+50

FIG. 4

Western Electric

242C Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

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

Maximum overall length	$7\frac{15}{16}''$
Maximum diameter	$2\frac{5}{16}''$

Mounting—Large four-pin bayonet type base for use in a W.E. 112A 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. or d.c.
Nominal filament current	3.25 amperes
Average thermionic emission	1.5 amperes

Average Direct Interelectrode Capacitances

Plate to grid	13.0 μμf
Grid to filament	6.1 μμf
Plate to filament	4.7 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 and 4 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at maximum direct plate voltage and dissipation Class A—(E_b = 1250 volts, I_b = 68 milliamperes).

Amplification factor	12.5
Plate resistance	3500 ohms
Grid to plate transconductance	3600 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1250 volts
Max. direct plate current	150 milliamperes
Max. plate dissipation	100 watts
Max. direct grid current	50 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	6 megacycles
Max. plate voltage for upper frequency limit of 30 Mc	600 volts
Max. plate voltage for frequencies between 6 and 30 Mc in proportion	

Class A Audio Amplifier or Modulator

Direct plate voltage	1250	1000 volts
Grid bias	−68	−42 volts
Direct plate current	68	85 milliamperes
Plate dissipation	85	85 watts
Load impedance	8000	7000 ohms
Undistorted output	22	12 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	1250	1000 volts
Grid bias	−80	−60 volts
Direct plate current per tube		
No drive	25	25 milliamperes
Max. drive	150	150 milliamperes
Plate dissipation	100	100 watts
Load resistance plate-to-plate	7600	6000 ohms
Load resistance per tube	1900	1500 ohms
Approximate max. output—2 tubes	200	165 watts
Recommended power for driving stage	25	25 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	1250	1000 volts
Direct plate current for carrier conditions	120	150 milliamperes
Grid bias	−90	−70 volts
Approximate carrier watts for use with 100% modulation	50	50 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1250	1000 volts
Direct plate current	150	150 milliamperes
Grid bias	−150 to −200	−120 to −160 volts
Nominal power output	130	100 watts
Plate dissipation	57.5	50 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1000	750 volts
Direct plate current	150	150 milliamperes
Grid bias	−160	−120 volts
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	100	65 watts

Operating Instructions

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 175 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 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 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 is 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 output can be increased or the distortion decreased by the use of degenerative feedback. 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—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. The tube may be used at full rating up to 6 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.

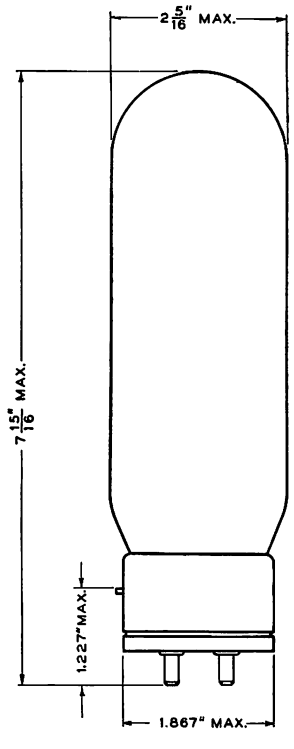

2 5/16" MAX.
7 15/16" MAX.
1.227" MAX.
1.867" MAX.

FIG. 1

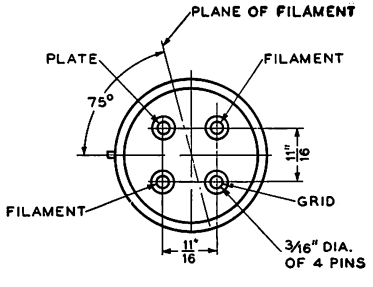

PLANE OF FILAMENT
PLATE
FILAMENT
75°
11/16"
GRID
FILAMENT
11/16"
3/16" DIA.
OF 4 PINS

FIG. 2

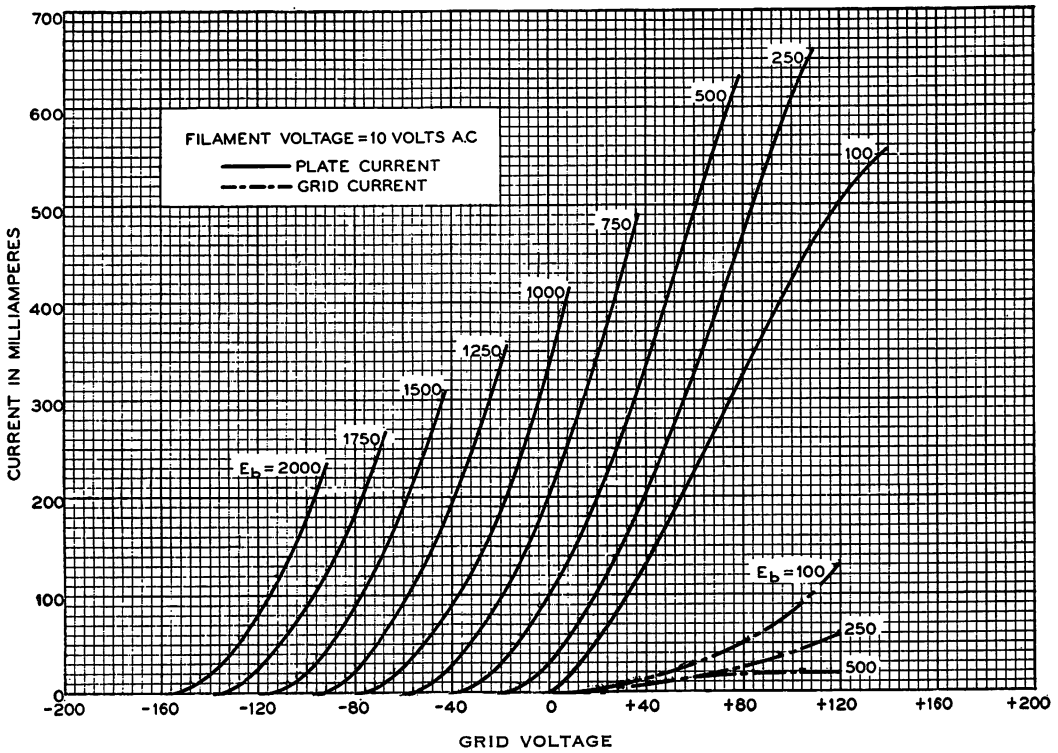

FILAMENT VOLTAGE = 10 VOLTS A.C
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
700
600
500
400
300
200
100
0
-200
-160
-120
-80
-40
0
+40
+80
+120
+160
+200
250
500
100
750
1000
1250
1500
1750
E_b = 2000
E_b = 100
250
500

FIG. 3

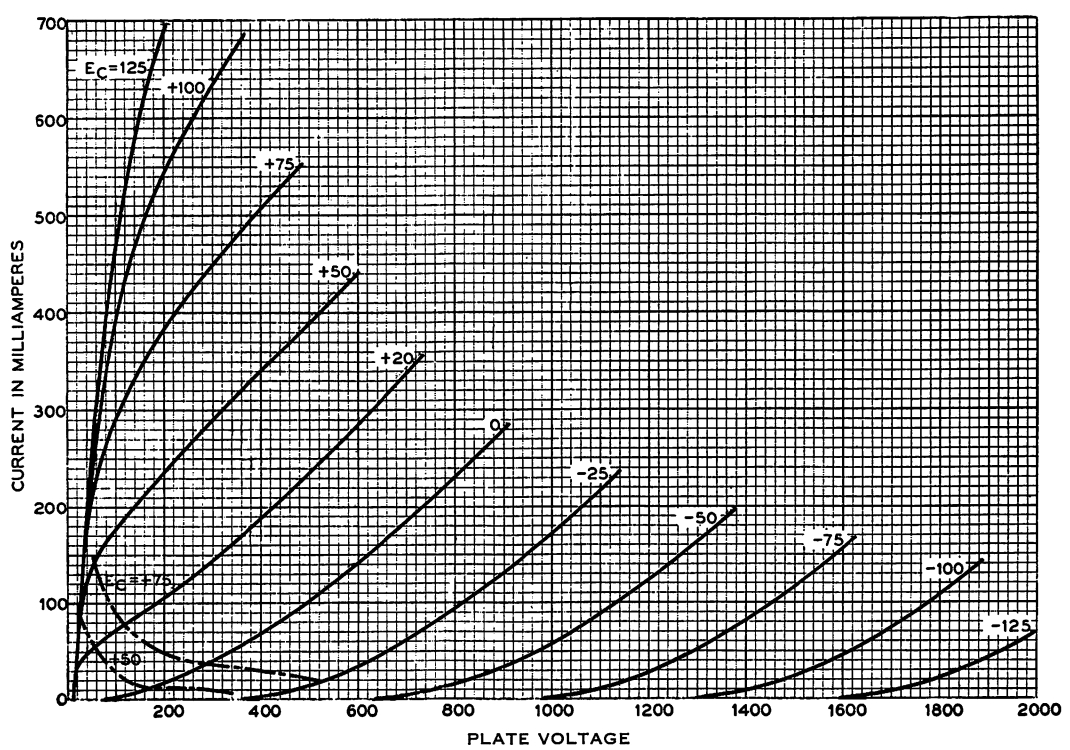
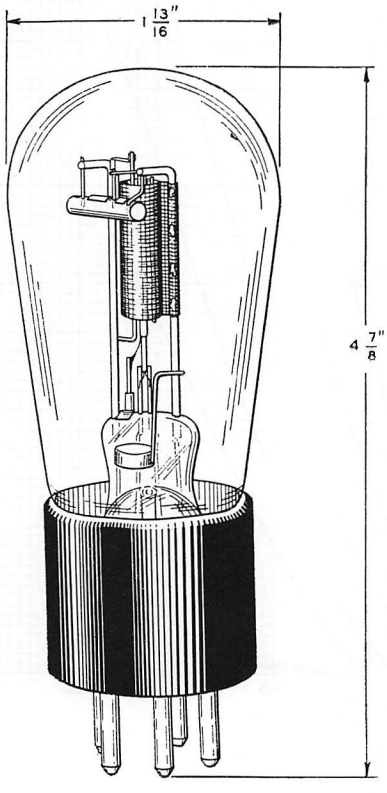
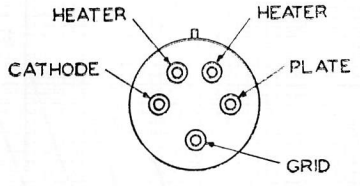

CURRENT IN MILLIAMPERES
PLATE VOLTAGE
700
600
500
400
300
200
100
0
200
400
600
800
1000
1200
1400
1600
1800
2000
E_C = 125
+100
+75
+50
+20
0
-25
-50
-75
-100
-125
E_C = +75
+50

FIG. 4

244-A Vacuum Tube





Classification

The No. 244A Vacuum Tube is a general purpose tube having an indirectly heated cathode which permits operation of the heater element directly on alternating current. The tube is for use as an audio-frequency amplifier in intermediate stages but may also be used satisfactorily as a detector or as a power amplifier tube for applications requiring small values of output power.

Base and Socket

The No. 244A Vacuum Tube employs a standard five-prong base suitable for use in a Western Electric No. 134A (cushion) or No. 137A (rigid) socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

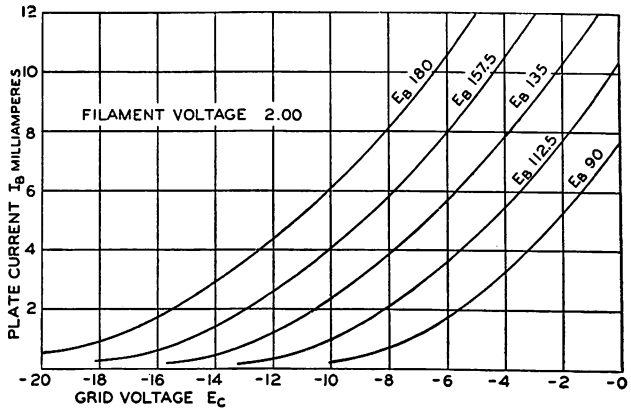
Heater Voltage		2 Volts, AC or DC
Average Heater Current		1.6 Amperes
Plate Voltage	135	180 Volts Maximum
Grid Voltage	—6	—10 Volts
Average Plate Current	5.5	6.0 Milliamperes
Average Plate Resistance	10,000	10,000 Ohms
Average Amplification Factor	10.0	9.7

Approximate Direct Interelectrode Capacities

Plate to Grid	3.3 MMF
Plate to Cathode	3.7 MMF
Grid to Cathode	3.8 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 244A Vacuum Tube.



General Features

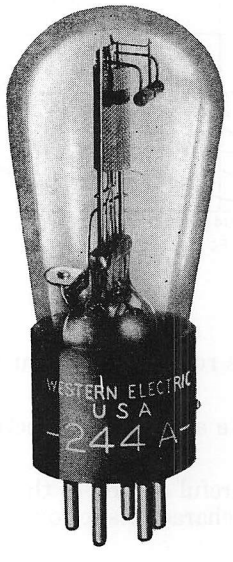
The No. 244A Vacuum Tube is rugged in construction which insures it against breakage in shipment and in service.

The cathode is designed to have a very large electron emission compared with the space current drain.

These features together with careful control of the manufacturing processes make possible the maintenance of uniform electrical characteristics over a very long life.

Western Electric

244A Vacuum Tube



Classification—Low-power triode with indirectly heated cathode

For most applications, the heater element of the 244A tube may be operated on alternating current.

Applications

Audio-frequency voltage amplifier.
Audio-frequency power amplifier where small amounts of power are required.
Oscillator.

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 type with bayonet pin.

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

Mounting Positions—The 244A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B
Grid to plate, $\mu\mu f$	3.3	3.2
Grid to heater and cathode, $\mu\mu f$	3.1	3.3
Plate to heater and cathode, $\mu\mu f$	2.8	3.2

Column A—Based tube without socket.

Column B—Tube alone when measured in 141A socket mounted in metal plate; mounting plate connected to heater and cathode.

Heater Rating

Heater voltage	2.0 volts, a.c. or d.c.
Nominal heater current	1.6 amperes

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—When the heater is operated on alternating current, a reduction of hum in the tube may usually be obtained by connecting the cathode to a center tap on the secondary of the heater transformer or to the center point of a suitable resistance connected across the heater terminals. If voltage must be applied between the heater and cathode, it should be kept as low as possible and should not exceed 90 volts.

Characteristics—Plate current characteristics of a typical 244A 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 are shown as functions of plate voltage for several values of grid bias in Figure 7.

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 are given in the table on page 3 for a number of typical operating conditions represented by selected points within this area. The 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 milliwatts and the second and third harmonic levels in decibels below the fundamental for values of the load resistance, R, equal to one, two, three, or five times the plate resistance, r_p. The peak value of the sinusoidal input, E_{gm}, which gives the indicated power output, P_m, and harmonic levels, F_{2m} and F_{3m}, in each case, is numerically equal to the grid bias. For a smaller input, E_g, the output and harmonic levels, except for very low third harmonic levels, are given approximately by the following relations:

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

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

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

The level of the third harmonic in the 244A tube is usually low and may differ widely in individual tubes. The values given in the table are for a typical tube.

Microphonic and Sputter 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 244A tube, measured in a laboratory reference test set, is 32 decibels below 1 volt. The range of levels of individual tubes extends from 24 to 43 decibels 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.

Improvements in the design of the 244A tube have practically eliminated both the disagreeable sputtering sounds and the isolated microphonic noise impulses which sometimes occur spontaneously at random intervals in tubes of this general type. When the tube is shielded from external microphonic noise impulses, it is quiet in operation and can be used for the audio-frequency amplification of exceptionally low level signals.

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms r_p	Micromhos	Peak Volts	R	Milliwatts	db	db
90	− 6	1.9	9.5	15100	630	6	$R=r_p$	32	21	50
							$R=2r_p$	29	25	45
90	− 4	3.3	10.1	11800	850	4	$R=r_p$	20	25	55
							$R=2r_p$	17	28	50
120	− 8	2.6	9.5	13600	700	8	$R=r_p$	58	21	50
							$R=2r_p$	51	25	50
							$R=3r_p$	46	27	50
120	− 6	4.1	9.9	11200	890	6	$R=r_p$	43	24	50
							$R=2r_p$	39	27	50
120	− 4	6.1	10.4	9500	1090	4	$R=r_p$	24	27	65
							$R=2r_p$	22	30	60
135	−10	2.4	9.3	14600	640	10	$R=r_p$	84	19	35
							$R=2r_p$	75	23	45
							$R=3r_p$	63	26	50
135	− 8	3.8	9.7	11800	820	8	$R=r_p$	69	22	45
							$R=2r_p$	60	26	50
135	− 6	5.5	10.1	10000	1010	6	$R=r_p$	49	25	50
							$R=2r_p$	43	28	50
150	−12	2.1	9.1	15800	580	12	$R=2r_p$	98	22	40
							$R=3r_p$	86	25	45
150	−10	3.4	9.5	12500	760	10	$R=r_p$	100	21	50
							$R=2r_p$	89	25	45
							$R=3r_p$	76	27	45
150	− 8	5.1	9.8	10600	930	8	$R=r_p$	80	23	50
							$R=2r_p$	70	27	50
*135	− 4	7.7	10.5	8800	1200	4	$R=r_p$	26	28	65
							$R=2r_p$	24	31	70
*150	− 6	7.1	10.2	9200	1110	6	$R=r_p$	54	26	50
							$R=2r_p$	47	29	50
*180	−16	1.8	8.9	17800	500	16	$R=3r_p$	128	23	45
							$R=5r_p$	104	27	50
*180	−14	2.9	9.2	14000	660	14	$R=2r_p$	150	22	45
							$R=3r_p$	130	25	50
*180	−12	4.4	9.5	11600	820	12	$R=r_p$	153	20	45
							$R=2r_p$	136	24	50
*180	−10	6.2	9.8	10000	980	10	$R=r_p$	128	23	50
							$R=2r_p$	112	26	45

*Maximum operating conditions.

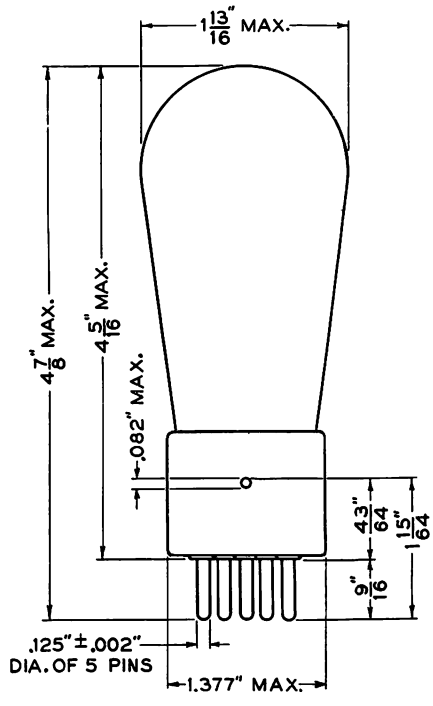


FIG. 1

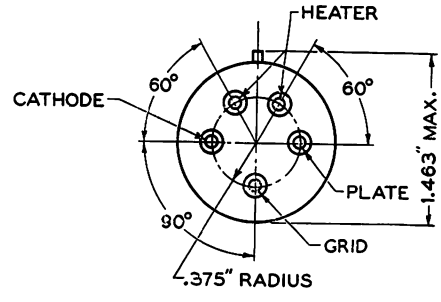


FIG. 2

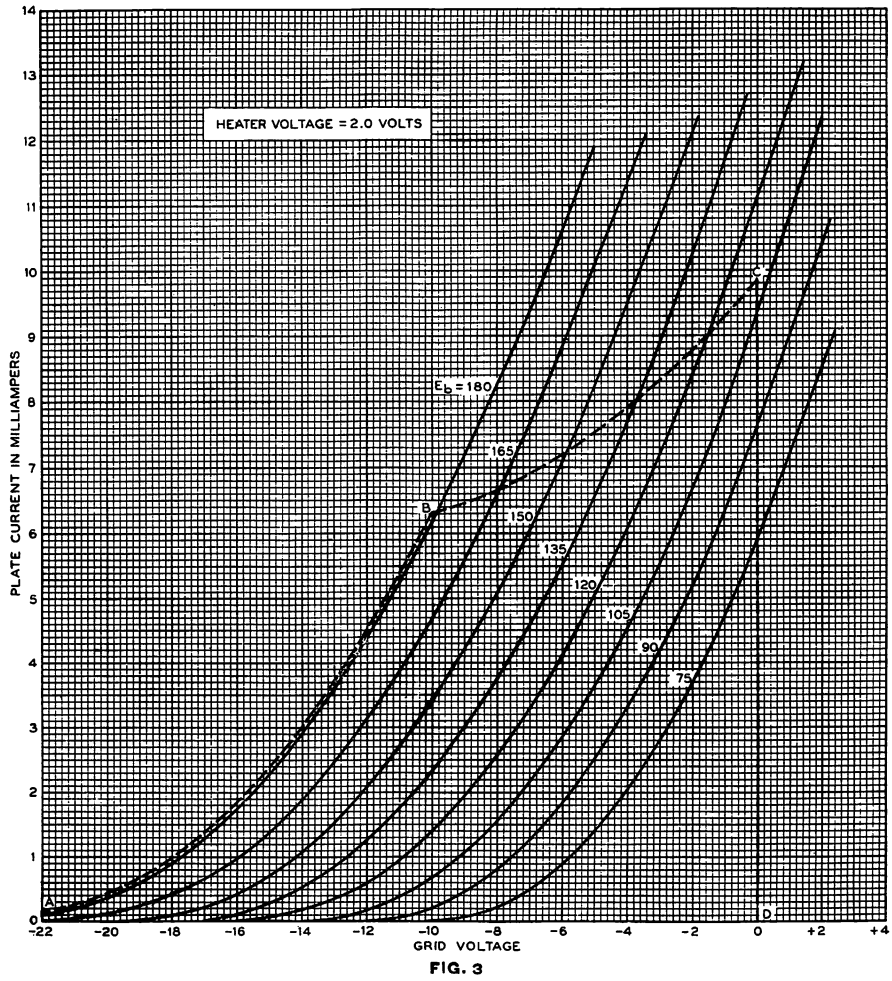


FIG. 3

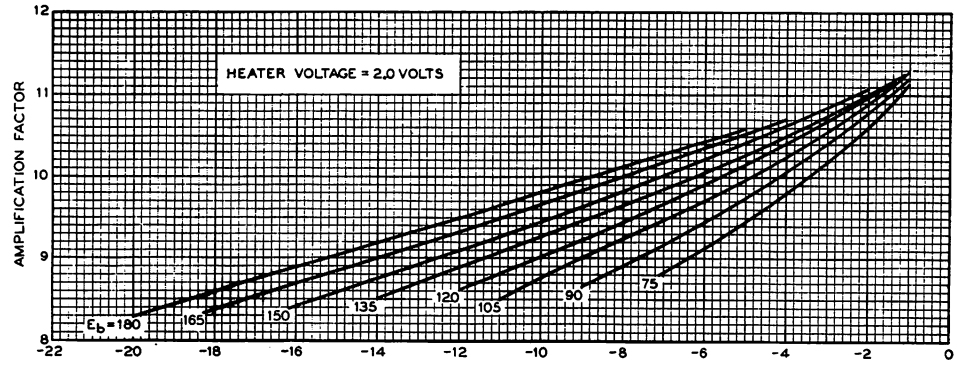


FIG. 4

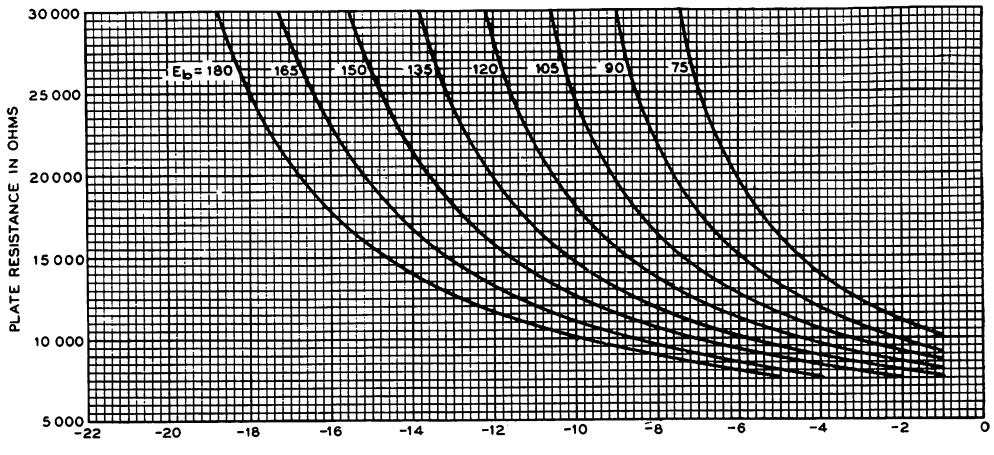


FIG. 5

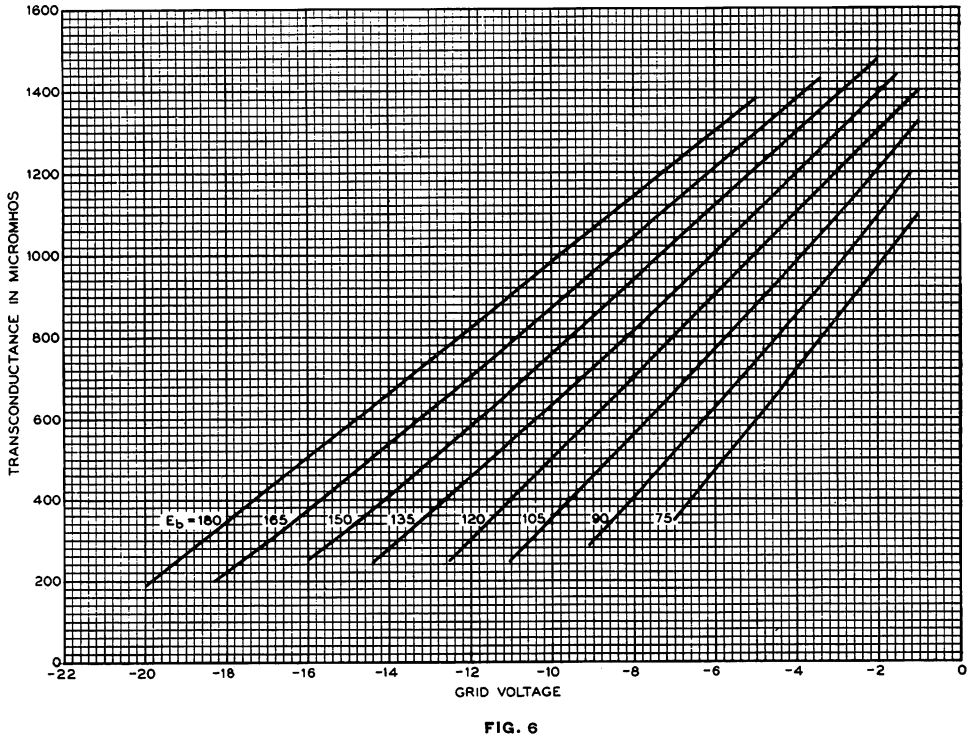


FIG. 6

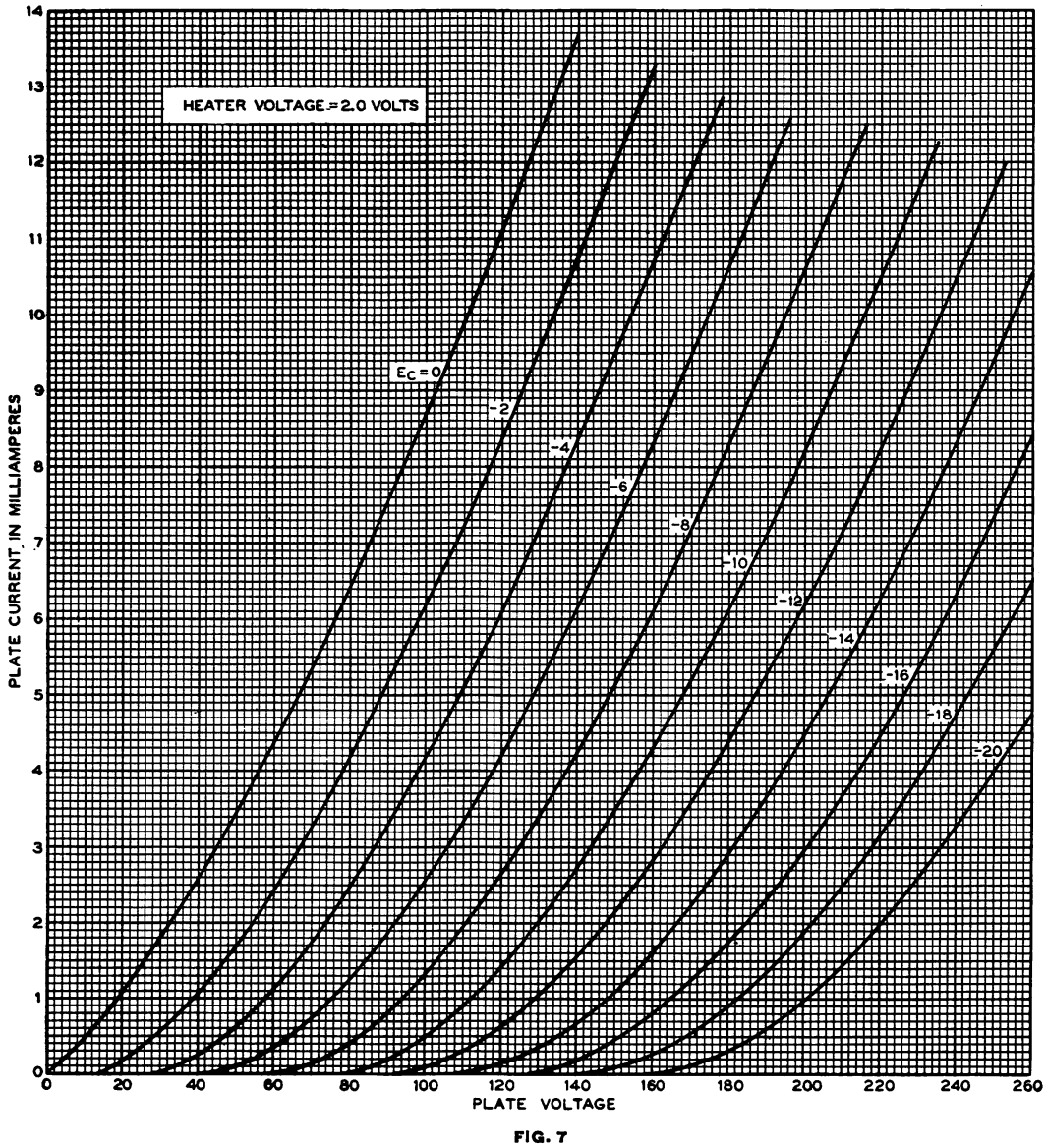
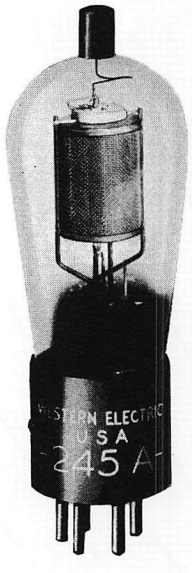

HEATER VOLTAGE = 2.0 VOLTS
$E_C = 0$
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 7

Western Electric

245A Vacuum Tube



Classification—Voltage-amplifier, screen-grid tetrode with indirectly heated cathode

Applications

Carrier-frequency and radio-frequency voltage amplifier.
Detector.
Audio-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—Medium, five-pin 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—The 245A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B
Control grid to plate	0.025	0.015 μμf
Control grid to heater, cathode and screen grid	4.5	5.5 μμf
Plate to heater, cathode and screen grid	8.0	8.5 μμf

Column A—Without shield.

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

Heater Rating

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

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 is applied between the cathode and heater, it should be kept as low as possible and should never exceed 90 volts.

Characteristics—Plate current and screen-grid current characteristics for a typical 245A tube are shown as functions of plate voltage for several values of control-grid voltage in Figures 3 and 4 for screen-grid voltages of 45 and 67.5 volts, respectively. Plate current, screen-grid current, and transconductance characteristics are given in Figures 5, 6 and 7, respectively, as functions of control-grid voltage for the same two values of screen-grid voltage and three values of plate voltage. Corresponding amplification factor, and plate resistance characteristics are given in Figures 8, 9, 10 and 11.

Typical Operating Conditions

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Plate Current	Screen-Grid Current	Amplification Factor	Plate Resistance	Transconductance
Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Micromhos
135	45.0	−1.5	4.8	1.6	135	180,000	750
*135	67.5	−4.5	6.7	2.4	85	110,000	780
*180	45.0	−1.5	5.1	1.5	170	220,000	770

*Maximum operating conditions.

Microphonic Noise—With a plate voltage of 135 volts, a screen-grid voltage of 45 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 245A tube measured in a laboratory reference test set is 29 decibels below 1 volt. The range of levels of individual tubes extends from 16 to 40 decibels. 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.

Circuit Requirements—Screen-grid tubes are particularly well suited for use in high-frequency amplifiers and are capable of developing comparatively high gain per stage. In order to avoid undesired feed-back in the circuit, it is usually necessary to observe the following precautions: (1) use of a close-fitting shield around each tube, (2) shielding of each stage of the amplifier circuit, (3) use of a low-impedance condenser between the screen grid and cathode of each tube, (4) filtering of each battery lead to each tube, and (5) minimization of impedances common to the plate, screen-grid, control-grid, or cathode circuits of two or more tubes.

The screen-grid voltage should be obtained either directly from a low-resistance source or from a voltage divider. The use of a series resistance to reduce a high voltage supply to the desired value is not recommended because screen-grid currents differ widely in different tubes and vary during life in individual tubes.

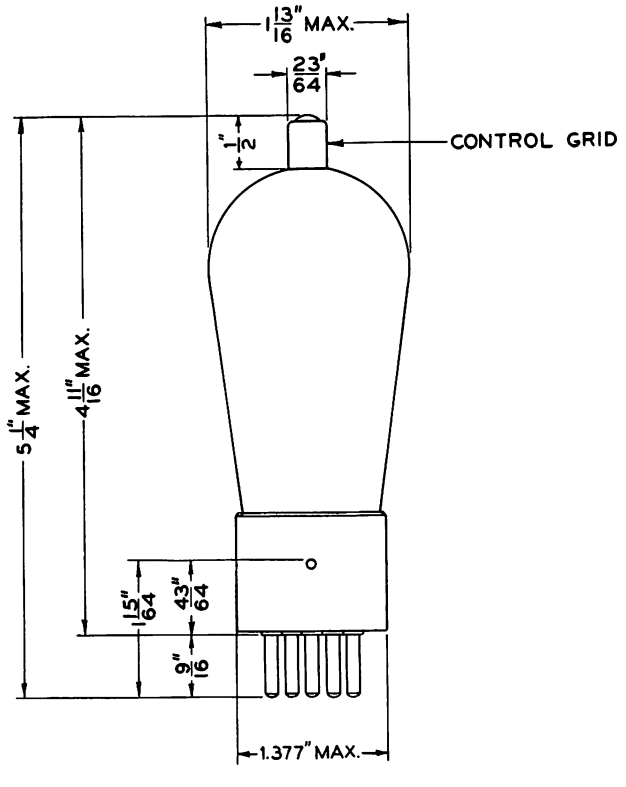


FIG. 1

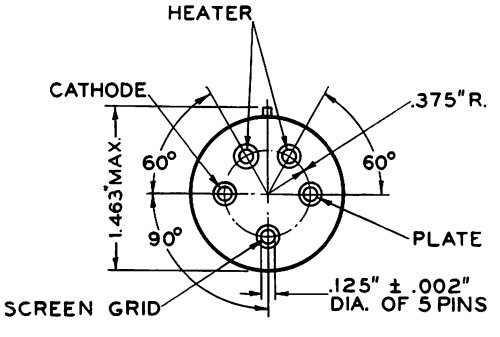


FIG. 2

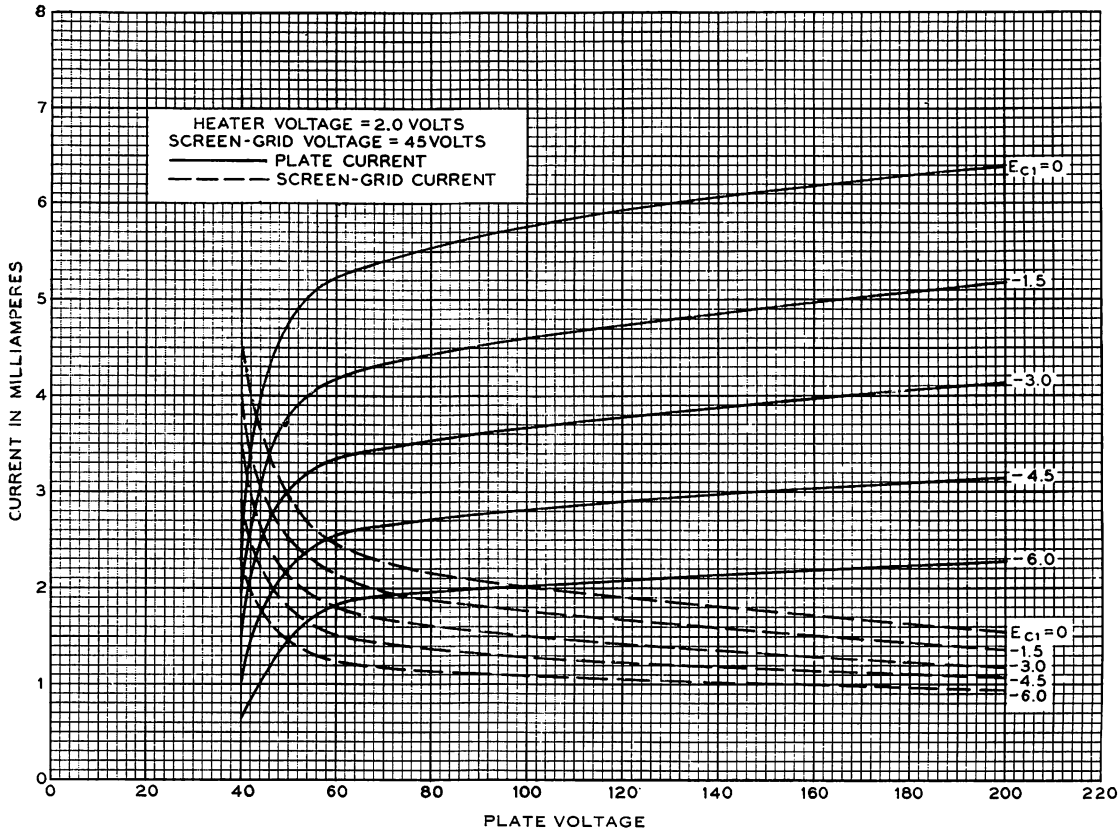

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 45VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
140
160
180
200
220
E_{C1}=0
-1.5
-3.0
-4.5
-6.0
E_{C1}=0
-1.5
-3.0
-4.5
-6.0

FIG. 3

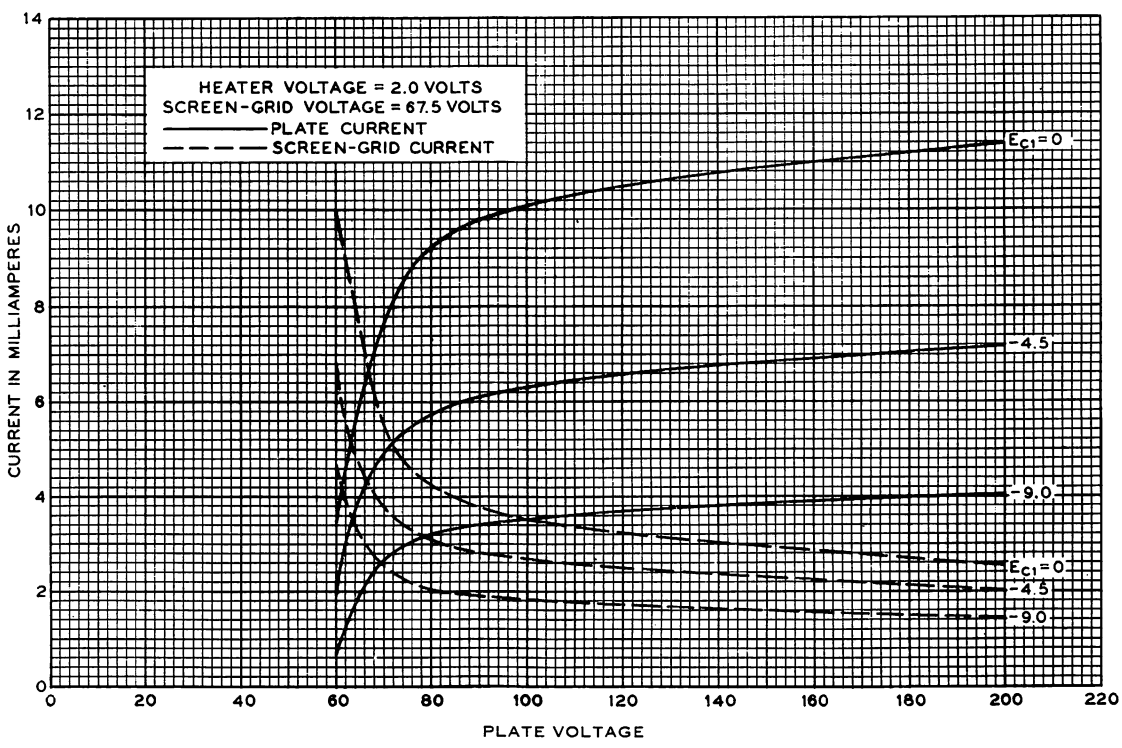

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 67.5 VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
2
4
6
8
10
12
14
0
20
40
60
80
100
120
140
160
180
200
220
E_{C1}=0
-4.5
-9.0
E_{C1}=0
-4.5
-9.0

FIG. 4

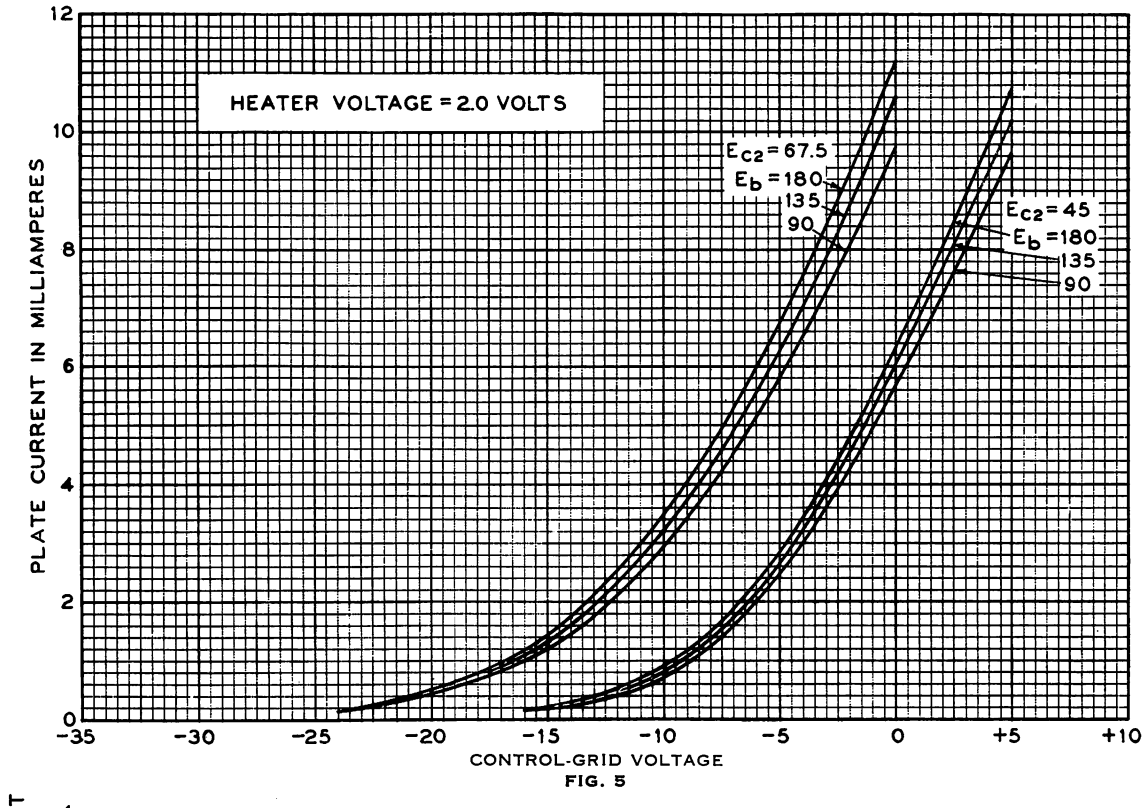


FIG. 5

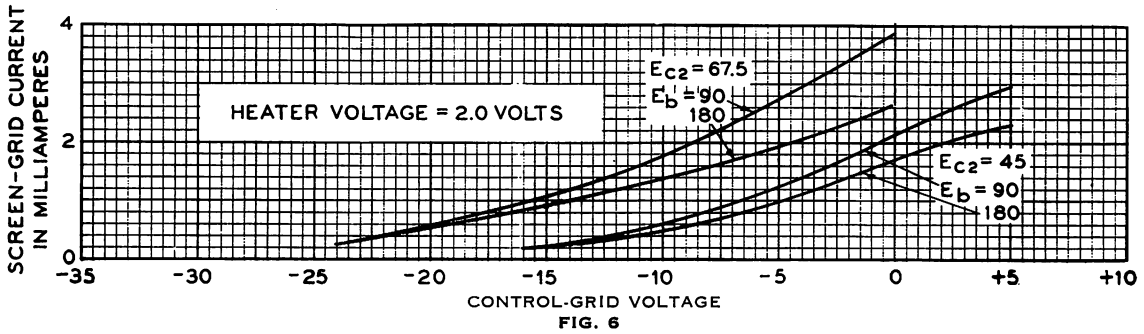


FIG. 6

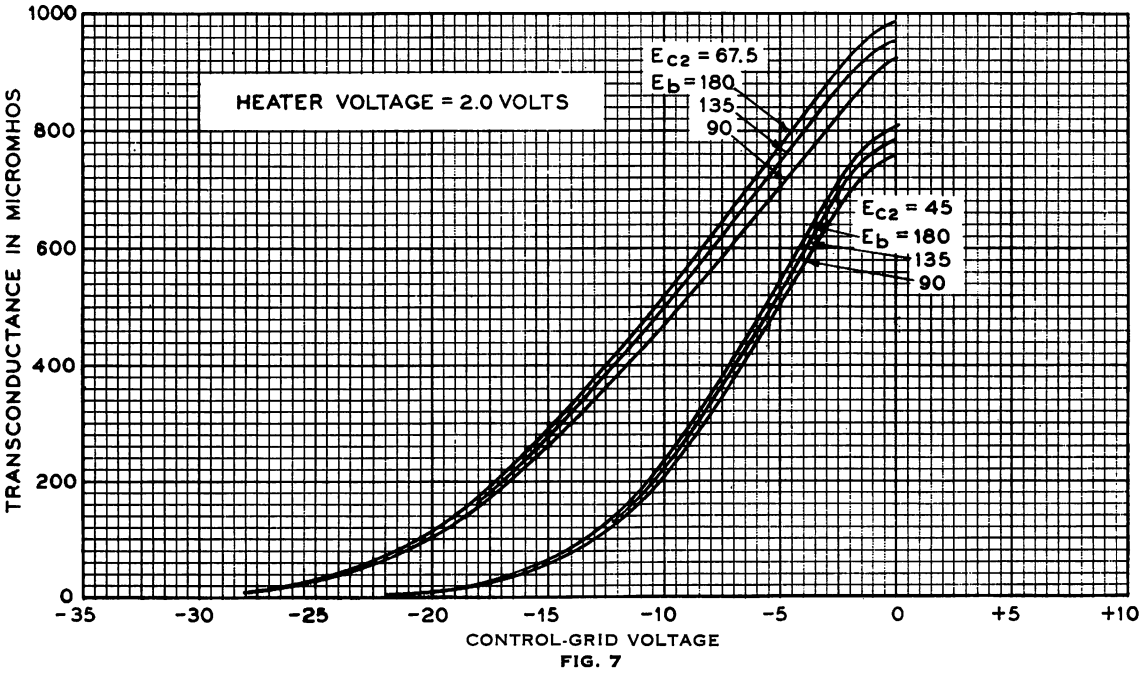


FIG. 7

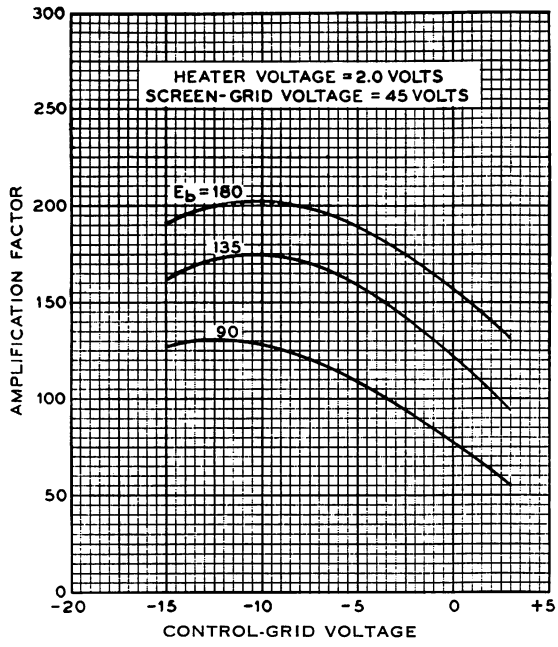


FIG. 8

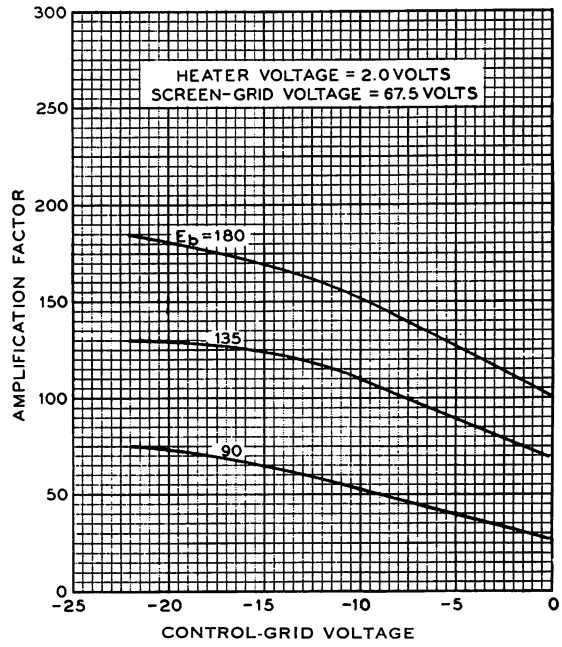


FIG. 9

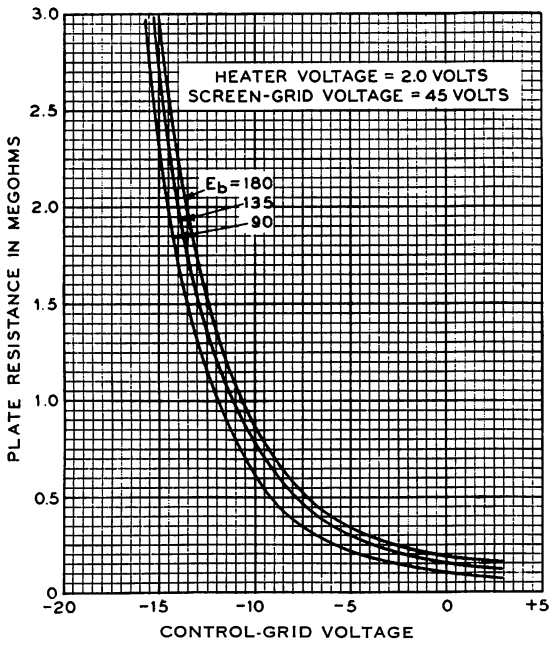


FIG. 10

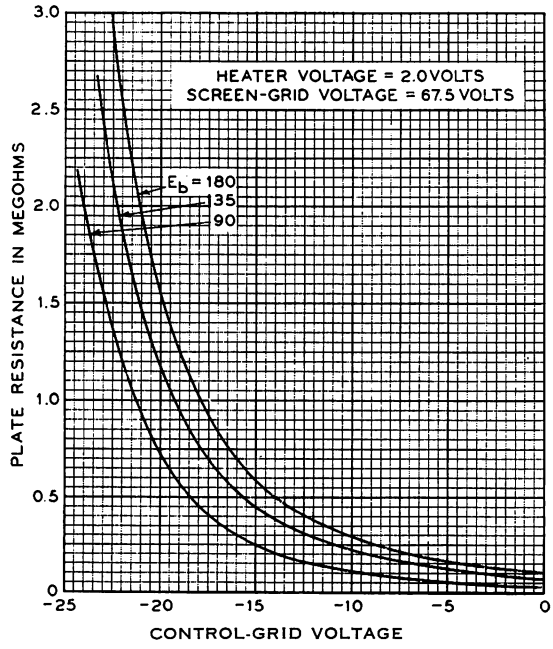
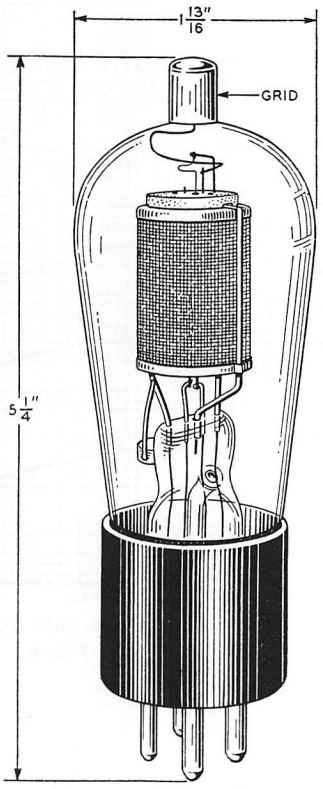
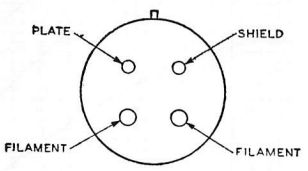


FIG. 11

246A Vacuum Tube





Classification

The 246A Vacuum Tube is a four-element, screen-grid, tube having a filamentary type cathode. The tube is intended for use as a high-frequency amplifier, but may also be used as a low-frequency amplifier or as a detector.

Base and Socket

The 246A Vacuum Tube employs a standard four prong, thrust type base suitable for use in a Western Electric 130B (rigid), 131A (cushion), or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The control-grid terminal is located at the top of the bulb and is arranged for a special, quick-release connector.

Rating and Characteristic Data

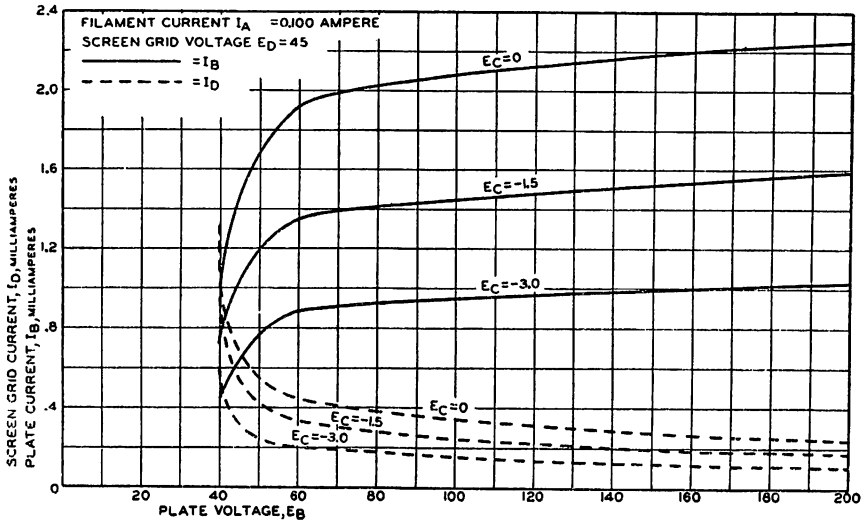
Filament Current			0.10 Amperes
Filament Voltage			3.3 Volts
Plate Voltage	135	180	135 Max.
Screen-Grid Voltage	45	45	67.5
Control-Grid Voltage	—1.5	—1.5	—3.0
Average Plate Current—Milliamperes	1.50	1.55	2.85
Average Plate Resistance—Ohms	725,000	830,000	325,000
Average Mutual Conductance—Micromhos	390	400	510
Average Amplification Factor	285	335	165

Approximate Direct Interelectrode Capacities (measured without socket)

Plate to Control-Grid	0.025 MMF.
Control-Grid to Filament and Screen-Grid	4.5 MMF.
Plate to Filament and Screen-Grid	8.8 MMF.

Average Static Characteristics

The accompanying curves give the average static characteristics of the 246A Vacuum Tube. These curves have been obtained with the filament operating on direct current and with the plate, screen and control-grid circuit returns connected to the negative filament terminal.



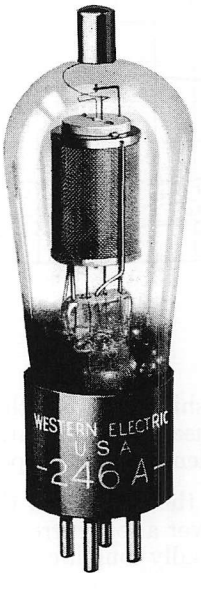
General Features

The presence of an electrostatic shield between the plate and the control-grid of the 246A Vacuum Tube makes unnecessary the use of neutralization for prevention of oscillation or feedback, provided the rest of the circuit elements are properly shielded.

The very low power required for the filament of this tube makes it particularly adaptable for use in portable equipment or wherever a low current drain is necessary. Uniform characteristics are obtained throughout an unusually long life for a filament of this rating.

Western Electric

246A Vacuum Tube



Classification—Voltage-amplifier, filamentary, screen-grid tetrode

An important feature of the 246A tube is its low filament power consumption.

Applications

Carrier and radio-frequency voltage amplifier

Detector

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

Socket—Standard, four-contact type, such as the Western Electric 143B socket.

Mounting Positions—The 246A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B
Control grid to plate	0.020	0.010 μμf
Control grid to filament and screen grid	4.0	5.2 μμf
Plate to filament and screen grid	8.3	8.8 μμf

Column A—Without shield.

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

Filament Rating

Filament current	0.100 ampere, d.c.
Nominal filament voltage	3.3 volts

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

Characteristics—Plate current and screen-grid current characteristics of a typical 246A tube are shown as functions of plate voltage for several values of control-grid voltage in Figures 3 and 4 for screen-grid voltages of 45 and 67.5 volts, respectively. The plate, screen-grid, and control-grid voltages are measured from the negative end of the filament. Plate current, screen-grid current, and transconductance characteristics are given in Figures 5, 6 and 7, respectively, as functions of control-grid voltage for the same two values of screen-grid voltage and three values of plate voltage. Corresponding amplification factor and plate resistance characteristics are given in Figures 8, 9, 10 and 11.

Typical Operating Conditions

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Plate Current	Screen-Grid Current	Amplification Factor	Plate Resistance	Transconductance
Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Micromhos
135	45.0	−1.5	1.50	0.20	285	725000	390
*135	67.5	−3.0	2.85	0.30	165	325000	510
*180	45.0	−1.5	1.55	0.15	335	820000	410

*Maximum operating conditions.

Circuit Requirements—Screen-grid tubes are particularly well suited for use in high-frequency amplifiers and are capable of developing comparatively high gain per stage. In order to avoid undesired feed-back in the circuit, it is usually necessary to observe the following precautions: (1) use of a close-fitting shield around each tube, (2) shielding of each stage of the amplifier circuit, (3) use of a low-impedance condenser between the screen grid and filament of each tube, (4) filtering of each battery lead to each tube, and (5) minimization of impedances common to the plate, screen-grid, control-grid, or filament circuits of two or more tubes.

The screen-grid voltage should be obtained either directly from a low-resistance source or from a voltage divider. The use of a series resistance to reduce a high voltage supply to the desired value is not recommended because screen-grid currents differ widely in different tubes and vary during life in individual tubes.

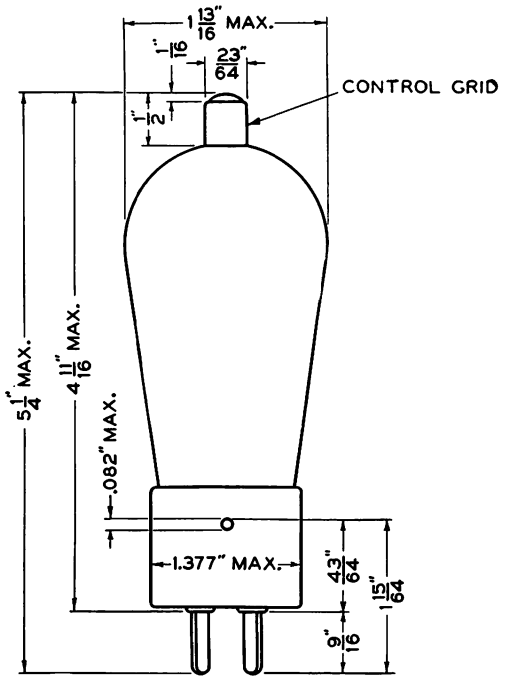

1 13/16" MAX.
1"/16
23"/64
CONTROL GRID
1"/2
5 1/4" MAX.
4 11/16" MAX.
.082" MAX.
1.377" MAX.
43"/64
15"/64
9"/16

FIG. 1

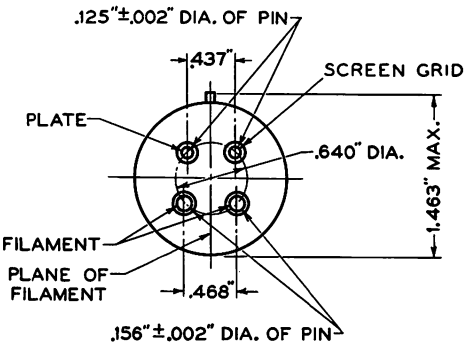

.125"±.002" DIA. OF PIN
.437"
SCREEN GRID
PLATE
.640" DIA.
1.463" MAX.
FILAMENT
PLANE OF FILAMENT
.468"
.156"±.002" DIA. OF PIN

FIG. 2

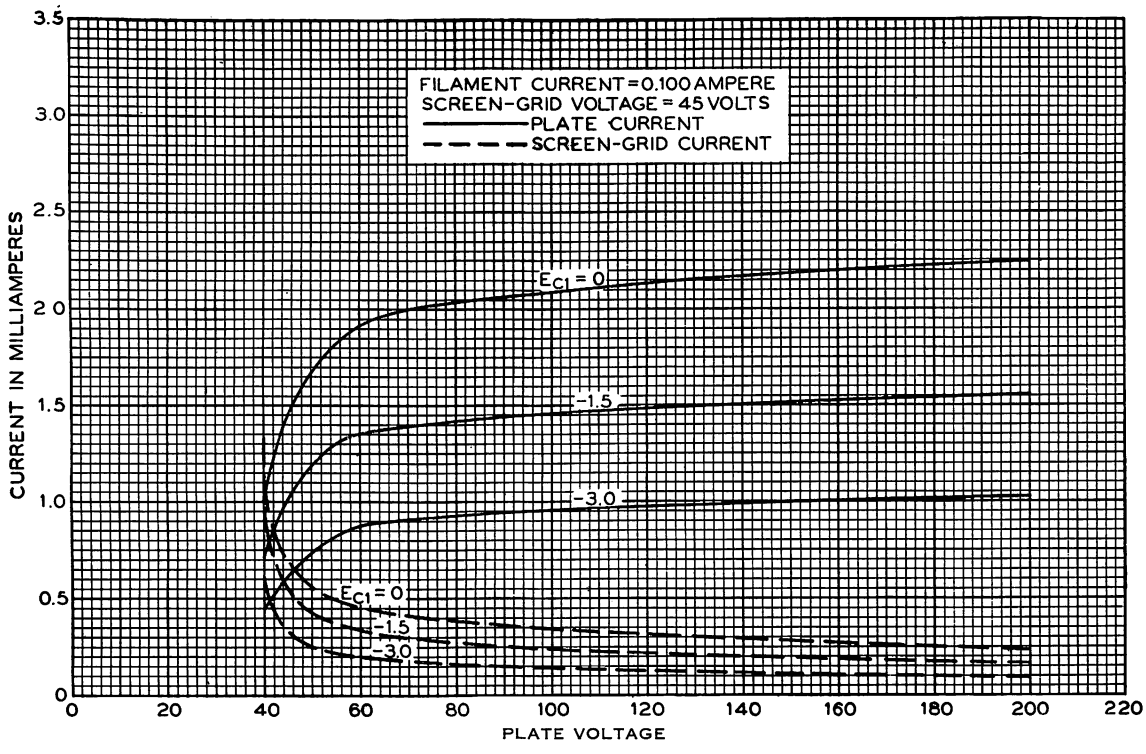

FILAMENT CURRENT = 0.100 AMPERE
SCREEN-GRID VOLTAGE = 45 VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
E_{c1} = 0
-1.5
-3.0
E_{c1} = 0
-1.5
-3.0
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
0
20
40
60
80
100
120
140
160
180
200
220

FIG. 3

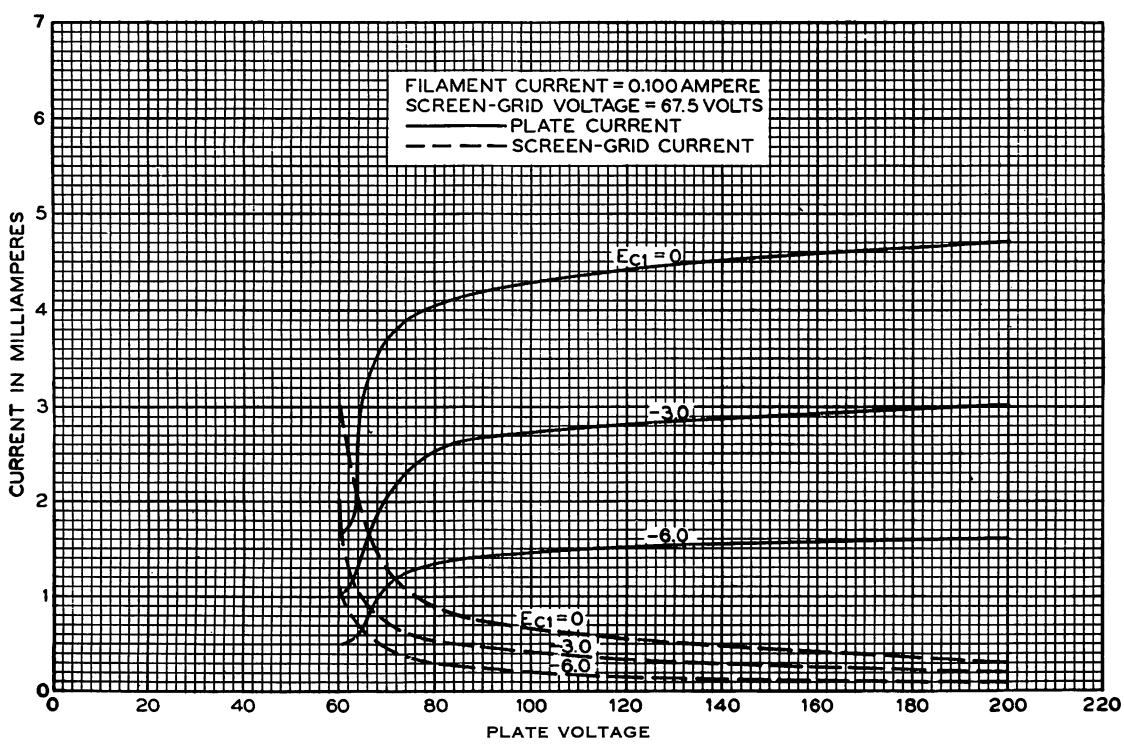

FILAMENT CURRENT = 0.100 AMPERE
SCREEN-GRID VOLTAGE = 67.5 VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
E_{c1} = 0
-3.0
-6.0
E_{c1} = 0
-3.0
-6.0
CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
180
200
220

FIG. 4

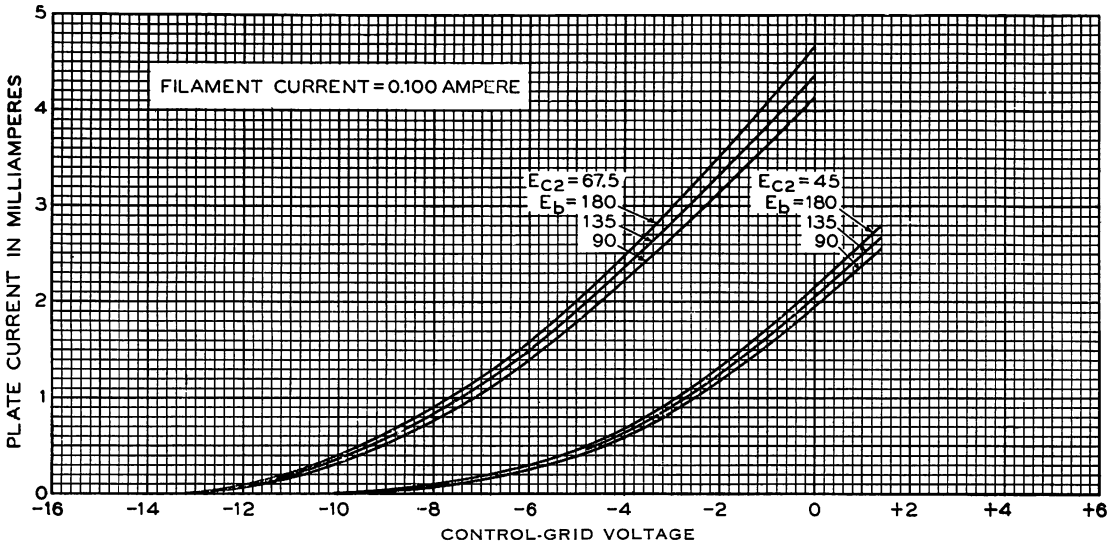


FIG. 5

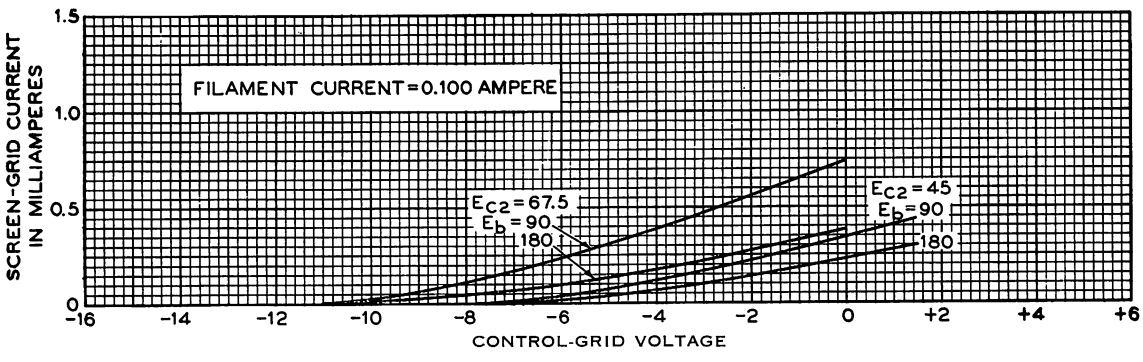


FIG. 6

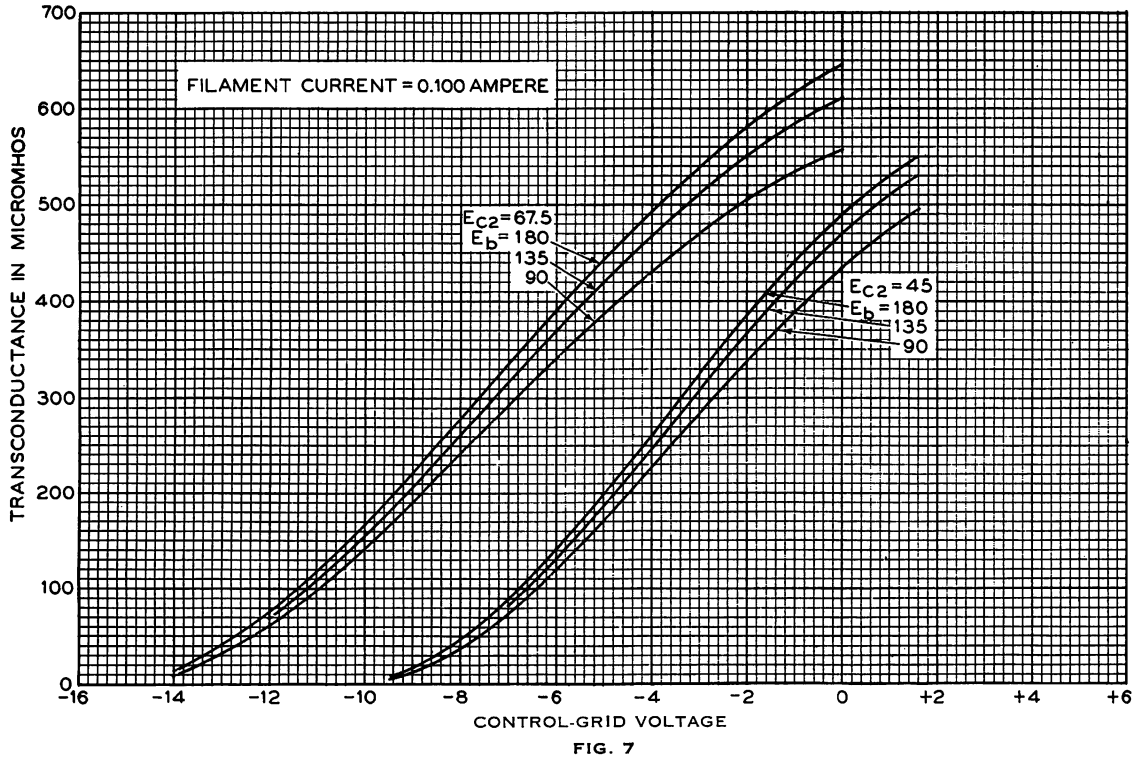


FIG. 7

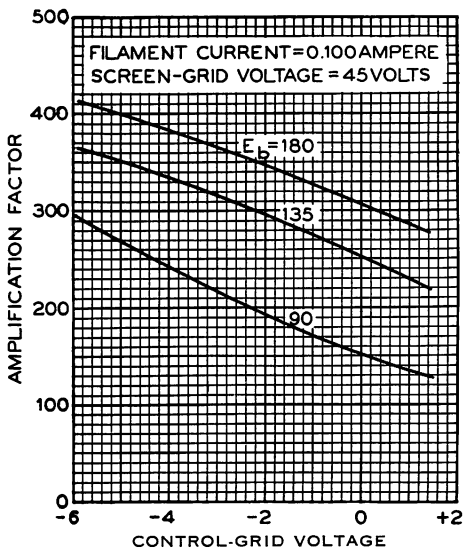


FIG. 8

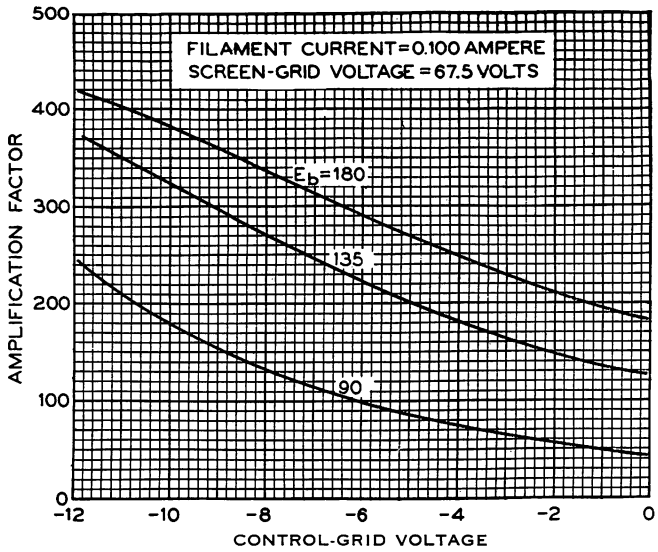


FIG. 9

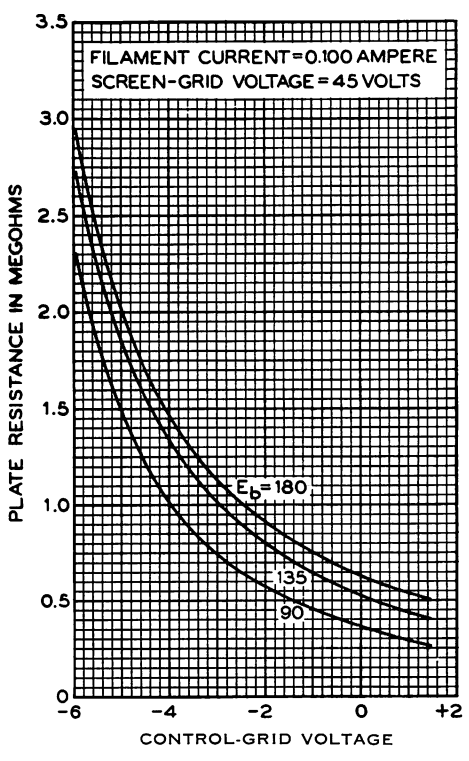


FIG. 10

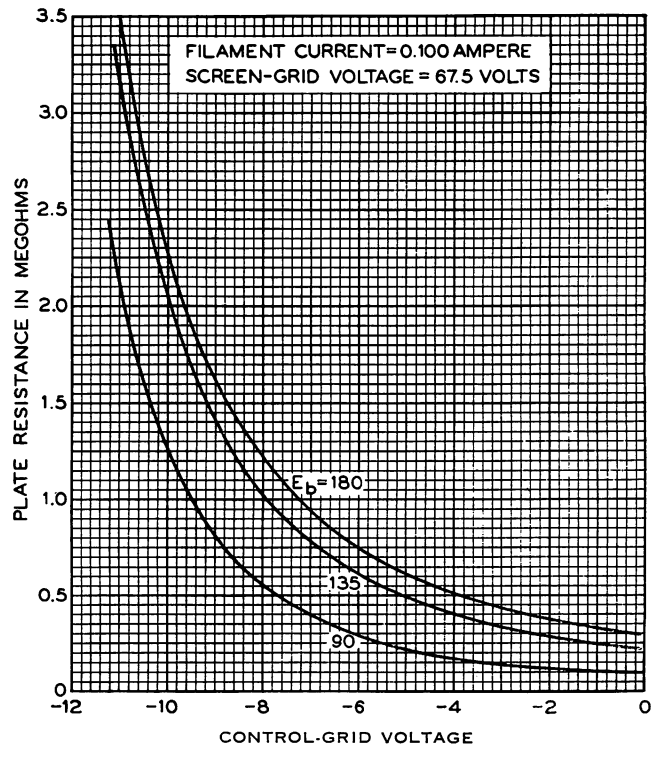
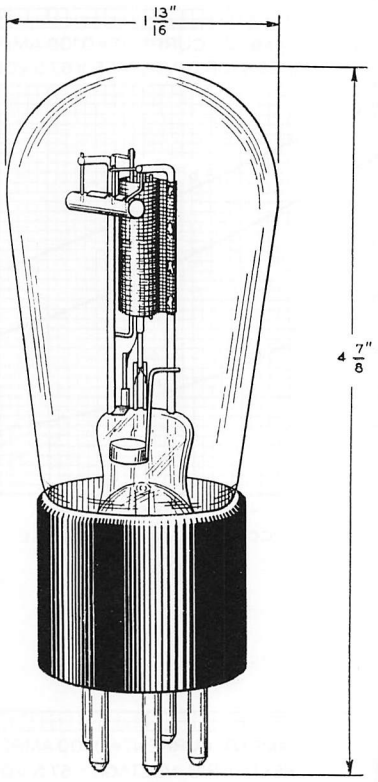
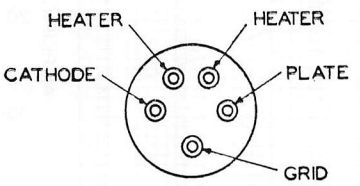


FIG. 11

247-A Vacuum Tube





Classification

The No. 247A Vacuum Tube is a general purpose tube having an indirectly heated cathode which permits operation of the heater element directly on alternating current. The tube is for use as an audio-frequency amplifier in intermediate stages but may also be used satisfactorily as a detector or as a power amplifier tube for applications requiring small values of output power.

Base and Socket

The No. 247A Vacuum Tube employs a standard five-prong base suitable for use in a Western Electric No. 134A (cushion) or No. 137A (rigid) socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

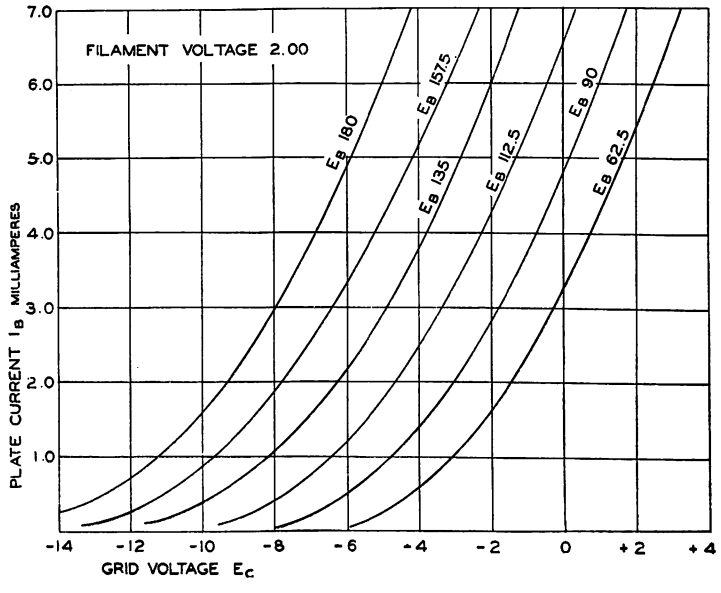
Heater Voltage	2 Volts, AC or DC	
Average Heater Current	1.6 Amperes	
Plate Voltage	135	180 Volts
Grid Voltage	—4.5	—7 Volts
Average Plate Current	3.25	3.80 Milliamperes
Average Plate Resistance	16,200	16,000 Ohms
Average Amplification Factor	14.9	14.6

Approximate Direct Interelectrode Capacities

Plate to Grid	3.2 MMF
Plate to Cathode	2.7 MMF
Grid to Cathode	3.4 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 247A Vacuum Tube.



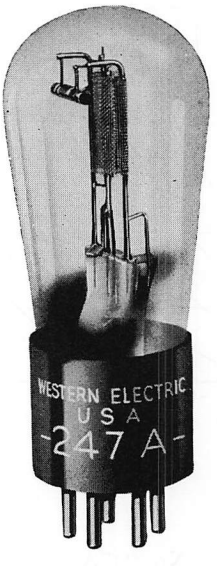
General Features

The low plate current drain of the No. 247A Vacuum Tube makes it particularly adaptable for use in intermediate stages of audio-frequency amplifiers when resistance coupling is used. However, its plate resistance is sufficiently low that it is also well adapted for use with transformer coupling.

The total electron emission of the cathode is very large compared with the maximum space current drain. This together with special features of design and careful control of the manufacturing processes enables this tube to meet exacting service requirements throughout a very long life.

Western Electric

247A Vacuum Tube



Classification—Low-power triode with indirectly heated cathode

For most applications, the heater element of the 247A tube may be operated on alternating current.

Applications

Audio-frequency voltage amplifier.

Audio-frequency power amplifier where small amounts of power are required.

Oscillator.

Detector.

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 type.

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

Mounting Positions—The 247A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

	A	B
Grid to plate, $\mu\mu$f	3.4	3.3
Grid to heater and cathode, $\mu\mu$f	3.2	3.3
Plate to heater and cathode, $\mu\mu$f	2.7	3.2

Column A—Based tube without socket.

Column B—Tube alone when measured in 141A socket mounted in metal plate; mounting plate connected to heater and cathode.

Heater Rating

Heater voltage	2.0 volts, a.c. or d.c.
Nominal heater current	1.6 amperes

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—When the heater is operated on alternating current, a reduction of hum in the tube may usually be obtained by connecting the cathode to a center tap on the secondary of the heater transformer or to the center point of a suitable resistance connected across the heater terminals. If voltage must be applied between the heater and cathode, it should be kept as low as possible and should not exceed 90 volts.

Characteristics—Plate current characteristics of a typical 247A tube are shown in Figure 3 as functions of grid voltage 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 are shown as functions of plate voltage for several values of grid voltage in Figure 7.

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 are given in the table on pages 3-4 for a number of typical operating conditions represented by selected points within this area. The 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 or voltage output and the second and third harmonic levels for the indicated values of load resistance. The fundamental output is given in terms of the power, P_m, in milliwatts for values of load resistance, R, equal to and double the value of the plate resistance, r_p, and in terms of the voltage, E_{pm}, in peak volts for values of load resistance five times the plate resistance. The second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the output and harmonic levels are given approximately by the following relations:

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

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

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

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

Microphonic and Sputter 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 of the 247A tube, measured in a laboratory reference test set, is 32 decibels below 1 volt. The range of levels of individual tubes extends from 24 to 43 decibels 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.

Improvements in the design of the 247A tube have practically eliminated both the disagreeable sputtering sounds and the isolated microphonic noise impulses which sometimes occur spontaneously at random intervals in tubes of this general type. When the tube is shielded from external microphonic noise stimuli, it is quiet in operation and can be used for the audio-frequency amplification of exceptionally low level signals.

TABLE

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Voltage Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms	Micromhos	Peak Volts	R	Milliwatts	Peak Volts	db	db
60	−2	1.2	15.3	21500	710	2	$R=r_p$	5.5		28	39
							$R=2r_p$	5.0		32	42
							$R=5r_p$		24	35	42
75	−2	2.0	15.7	18100	860	2	$R=r_p$	6.8		31	41
							$R=2r_p$	6.1		37	42
							$R=5r_p$		25	43	43
90	−3	2.0	15.3	18800	810	3	$R=r_p$	14		27	40
							$R=2r_p$	12.5		31	43
							$R=5r_p$		37	36	45
105	−4	2.0	14.9	19000	780	4	$R=r_p$	24		24	42
							$R=2r_p$	21		28	46
							$R=5r_p$		51	33	50
105	−2	3.8	15.9	14800	1070	2	$R=r_p$	9		39	44
							$R=2r_p$	8		47	45
							$R=5r_p$		26	60	46
120	−6	1.3	14.2	23500	600	6	$R=r_p$	40		18	37
							$R=2r_p$	36		23	45
							$R=5r_p$		73	27	60
120	−4	2.8	15.2	16900	900	4	$R=r_p$	28		26	42
							$R=2r_p$	25		30	45
							$R=5r_p$		51	35	48
120	−2	4.8	16.0	13700	1170	2	$R=r_p$	10		42	45
							$R=2r_p$	9		55	46
							$R=5r_p$		26	55	46
135	−7.5	1.0	13.8	26700	520	7.5	$R=r_p$	54		16	35
							$R=2r_p$	48		21	42
							$R=5r_p$		90	26	55
135	−6	2.0	14.5	19600	730	6	$R=r_p$	50		20	32
							$R=2r_p$	45		25	48
							$R=5r_p$		75	30	65

TABLE (Cont'd)

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Voltage Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms	Micromhos	Peak Volts	R	Milliwatts	Peak Volts	db	db
135	−4.5	3.2	15.2	16000	940	4.5	$R=r_p$	37		26	43
							$R=2r_p$	33		30	47
							$R=5r_p$		58	35	49
135	−3	4.8	15.8	13800	1140	3	$R=r_p$	20		34	43
							$R=2r_p$	18		39	45
							$R=5r_p$		40	47	48
150	−8	1.4	13.9	24100	580	8	$R=r_p$	67		16	35
							$R=2r_p$	60		21	43
							$R=5r_p$		95	26	55
150	−6	2.8	14.8	17400	850	6	$R=r_p$	57		22	41
							$R=2r_p$	52		27	47
							$R=5r_p$		75	32	55
150	−4	4.7	15.4	14000	1100	4	$R=r_p$	35		30	44
							$R=2r_p$	31		34	47
							$R=5r_p$		52	40	49
165	−9	1.4	13.8	24500	560	9	$R=r_p$	84		16	35
							$R=2r_p$	75		21	42
							$R=5r_p$		107	26	55
165	−7	2.8	14.6	17600	820	7	$R=r_p$	75		21	41
							$R=2r_p$	68		26	48
							$R=5r_p$		87	31	65
*165	−5	4.6	15.4	14200	1080	5	$R=r_p$	50		27	44
							$R=2r_p$	45		31	47
							$R=5r_p$		65	36	50
*180	−11	1.0	13.3	31500	430	11	$R=r_p$	96		14	33
							$R=2r_p$	85		19	38
							$R=5r_p$		130	23	45
*180	−9	2.0	14.1	20200	690	9	$R=r_p$	100		18	36
							$R=2r_p$	90		22	45
							$R=5r_p$		108	27	65
*180	−7	3.6	14.9	15700	940	7	$R=r_p$	87		22	32
							$R=2r_p$	78		26	49
							$R=5r_p$		88	31	60

*Maximum operating conditions.

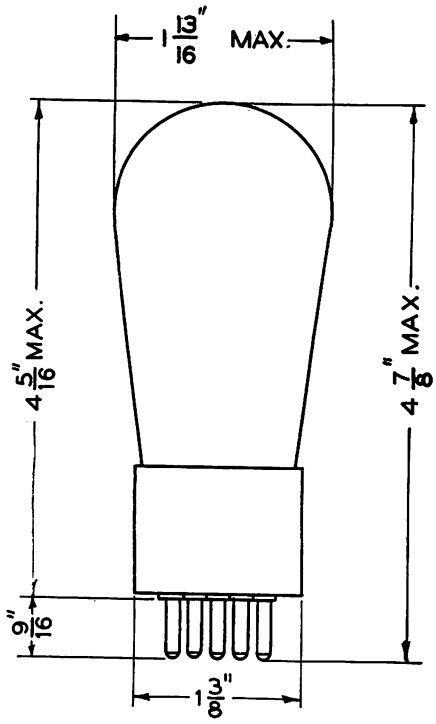


FIG. 1

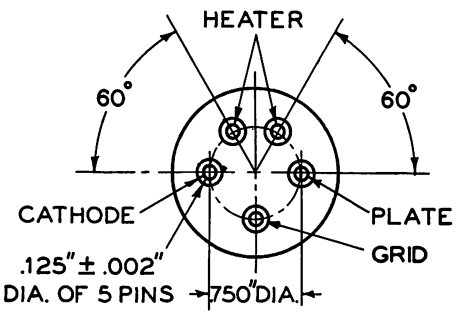


FIG. 2

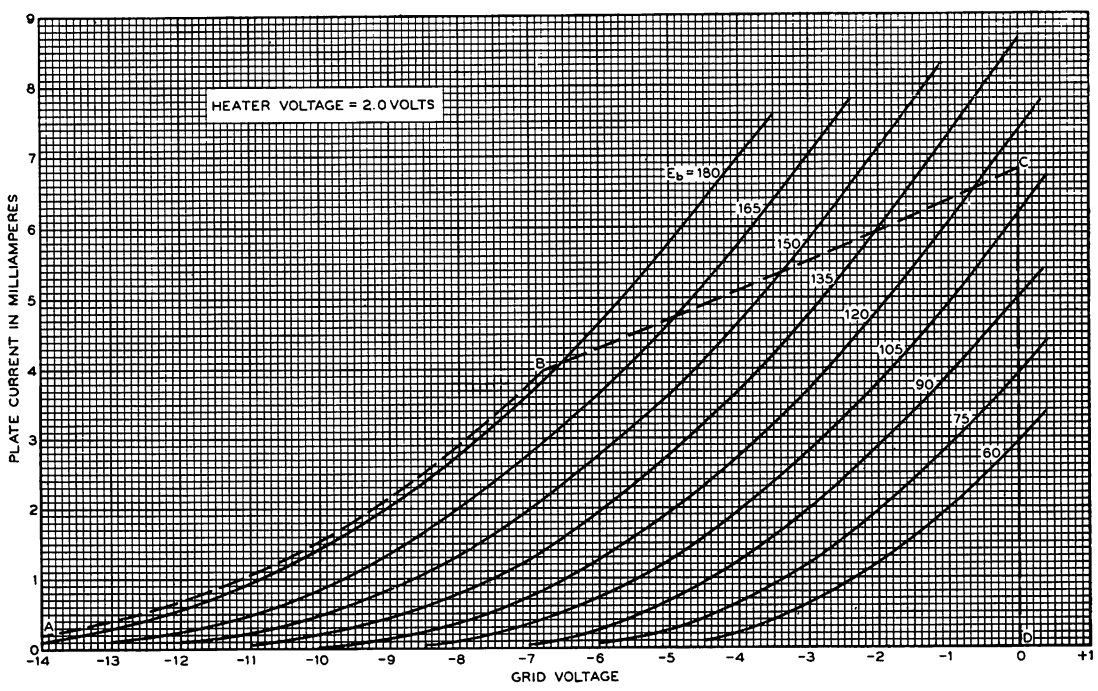


FIG. 3

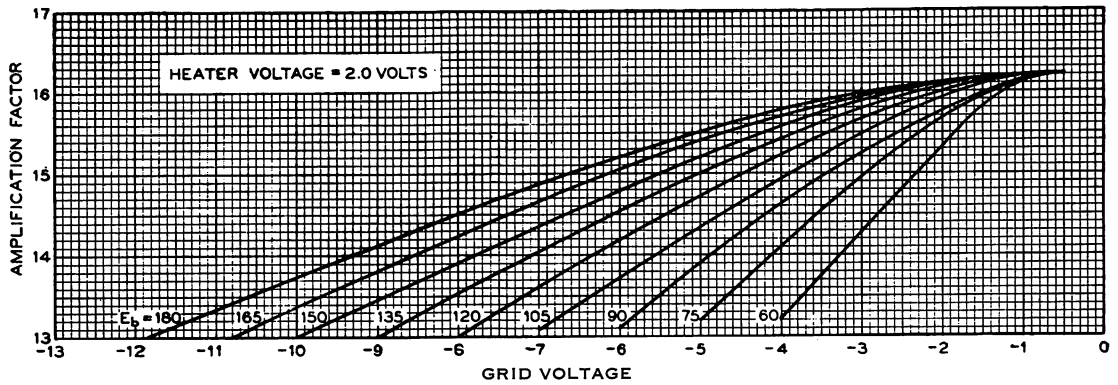


FIG. 4

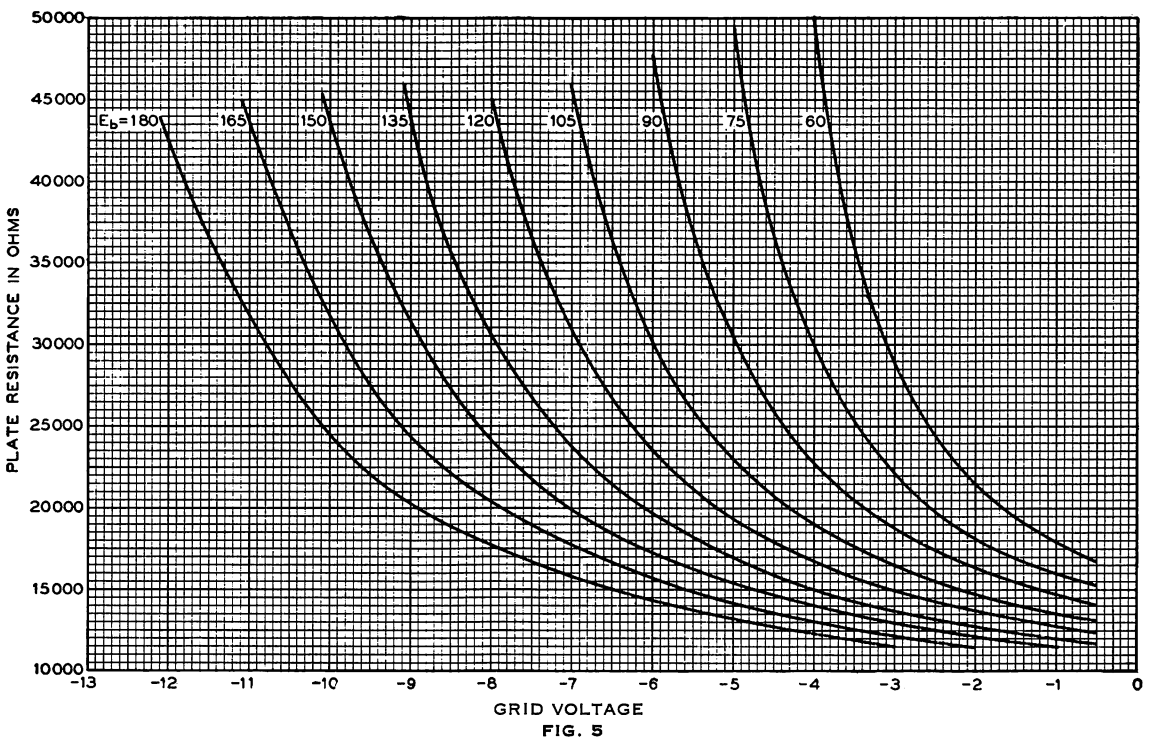


FIG. 5

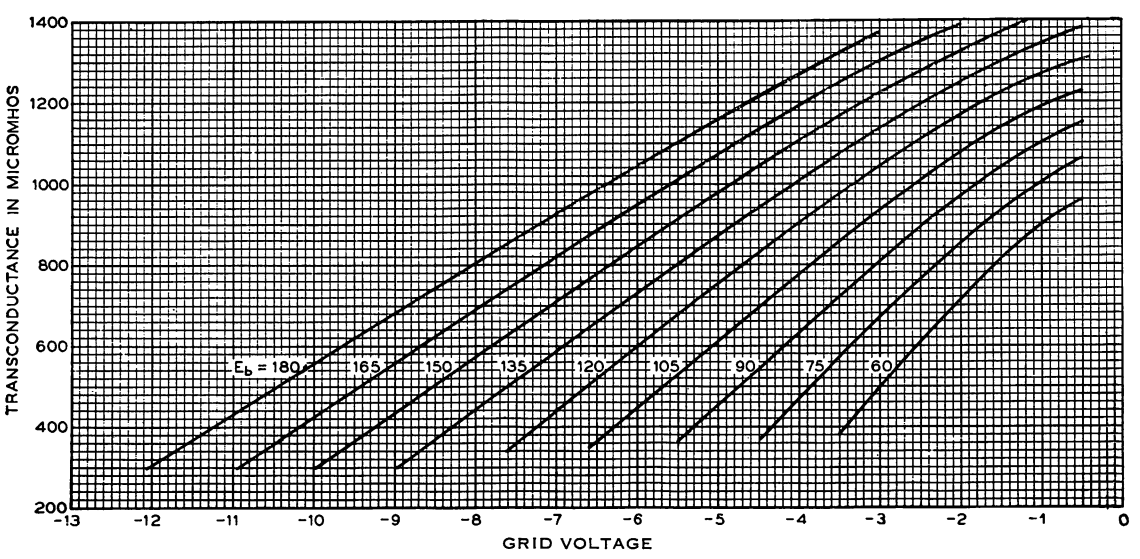


FIG. 6

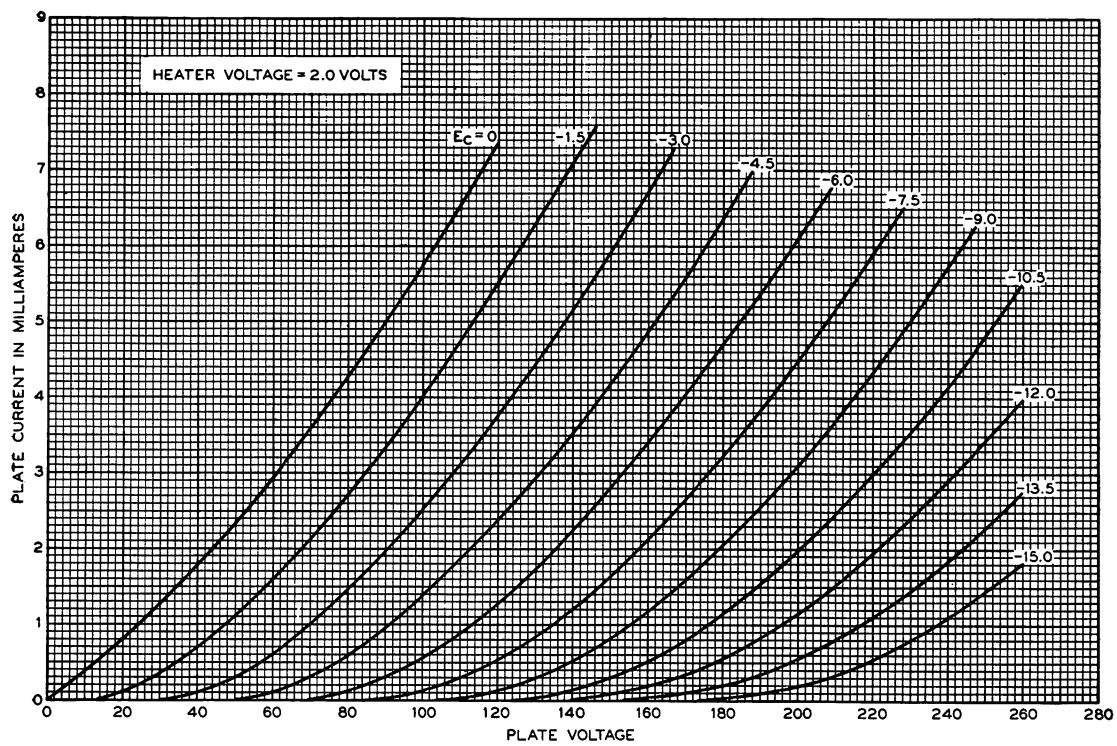
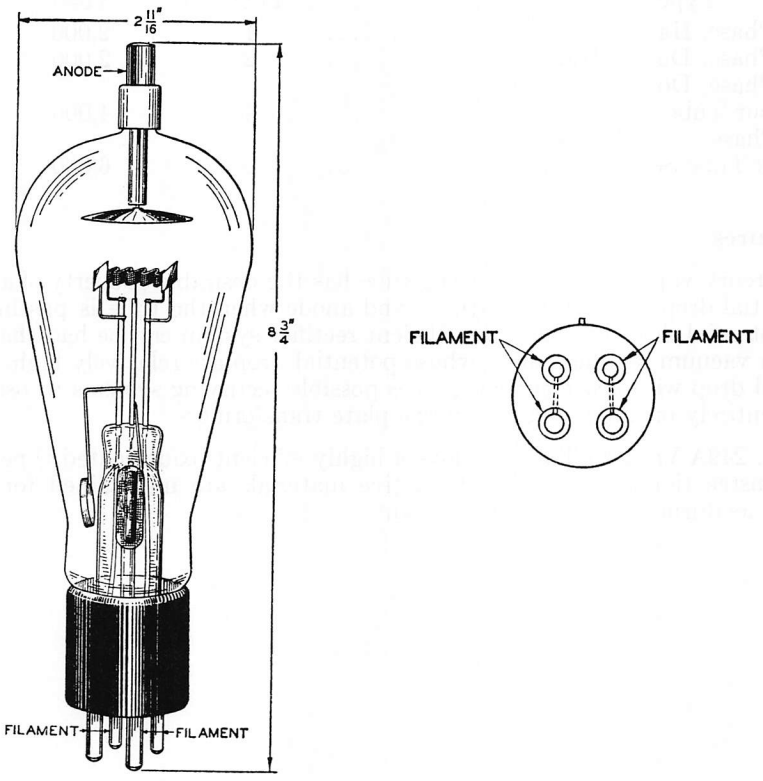

HEATER VOLTAGE = 2.0 VOLTS
E_c = 0
-1.5
-3.0
-4.5
-6.0
-7.5
-9.0
-10.5
-12.0
-13.5
-15.0
PLATE CURRENT IN MILLIAMPERES
0
1
2
3
4
5
6
7
8
9
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
PLATE VOLTAGE

FIG. 7

249A Vacuum Tube



Classification

The No. 249A Vacuum Tube is a half-wave, thermionic, mercury-vapor rectifier for use in rectifying circuits designed to supply direct current from an alternating current supply.

Base and Socket

The No. 249A Vacuum Tube employs a standard four-prong thrust-type base suitable for use in the Western Electric No. 130B 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 connections for the filament current. The anode terminal is located at the top of the bulb and is arranged for a special quick release connector. The tube can be mounted only in a vertical position with the base end down.

Rating and Characteristic Data

Filament Voltage	2.5 Volts, AC
Nominal Filament Current	7.0 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	15 Volts
Maximum Peak Plate Current	1.1 Amperes
Maximum Peak Inverse Potential	6,500 Volts
Safe Operating Ambient Temperature	0 to 50 Degrees C

The anode-cathode potential 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 will vary from 5 to 25 volts.

Typical Rectifying Circuits

For specific circuits the following ratings apply:

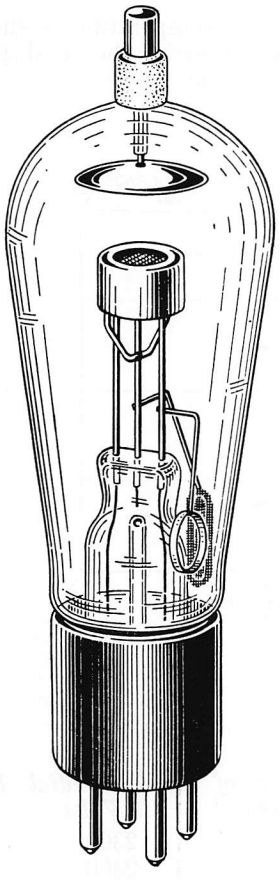
Type of Circuit	Number Tubes	Load Potential Volts	Load Current Amperes
Single-Phase, Half-Wave	1	2,000	0.4
Single-Phase, Double Half-Wave	2	2,000	0.8
Single-Phase, Double Half-Wave (Four Tube Series Circuit)	4	4,000	0.8
Three-Phase (Six Tube Series "Y" Circuit)	6	6,000	1.0

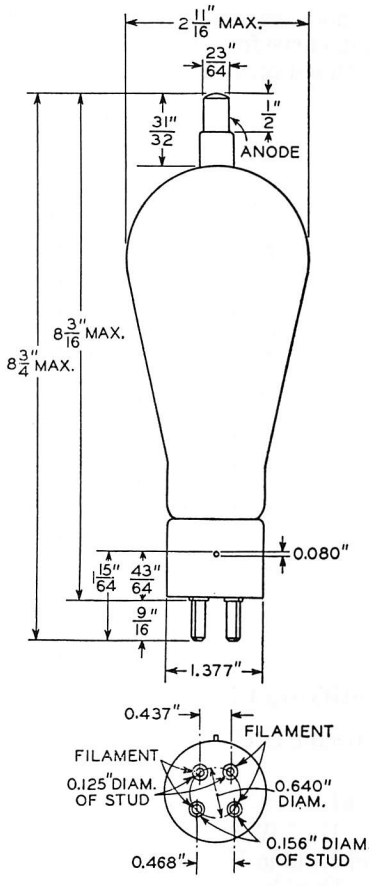
General Features

The mercury vapor type of rectifying tube has the desirable property of a low and almost constant potential drop between the cathode and anode when the tube is passing current. Due to their low potential drop a much more efficient rectifier system can be had than is possible by the use of high vacuum rectifier tubes, whose potential drop are relatively high. The constancy of the potential drop with space current makes possible rectifying systems whose regulation depends almost entirely on the regulation of the plate transformers.

The No. 249A Vacuum Tube employs a highly efficient oxide-coated type of cathode. Its mechanical construction is such that the active materials are maintained for long operating periods as well as during shelf life and shipment.

249B Vacuum Tube





Classification

The No. 249B Vacuum Tube is a half wave thermionic mercury vapor rectifier for use in rectifying circuits designed to supply direct current from an alternating current supply. It is the same as the No. 258B electrically but is equipped with a different type base.

Base and Socket

The No. 249B Vacuum Tube employs a standard four-prong thrust-type base suitable for use in the Western Electric No. 130B (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 connections for the filament current. The anode terminal is located at the top of the bulb and is arranged for a special quick release connector. The tube can be mounted only in a vertical position with the base end down.

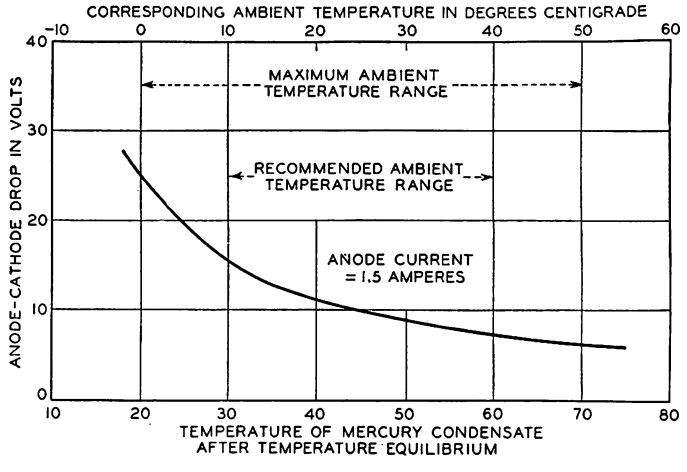
Rating and Characteristic Data

Filament Voltage	2.5 Volts A.C.
Nominal Filament Current	7.5 Amperes
Approximate Direct Anode-Cathode Drop when Conducting	15 Volts
Maximum Peak Plate Current	1.5 Amperes
Maximum Peak Inverse Potential	7,500 Volts
Safe Operating Ambient Temperature Range	0 to 50° C.

Rating and Characteristic Data—Continued

The anode-cathode potential 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 will vary from 5 to 25 volts.

The anode cathode potential drop as a function of the temperature is shown on the accompanying curve for a typical No. 249-B Vacuum Tube when passing the rated space current. The recommended operating temperature range is also shown on this curve.



Typical Rectifying Circuits

For specific circuits the following ratings apply.

Type of Circuit	*Number of Tubes*	*Load Potential in Volts*	*Load Current in Amperes*
Single Phase, Half-Wave	1	2300	0.50
Single Phase, Double Half-Wave	2	2300	1.0
Single Phase, Double Half-Wave (4 tube series circuit)	4	4500	1.0
Three Phase, (6 tube series "Y" circuit)	6	7000	1.3

General Features

The mercury vapor type of rectifying tube has the desirable property of a low and almost constant potential drop between the cathode and anode when the tube is passing current. Due to their low potential drop a much more efficient rectifier system can be had than is possible by the use of most high vacuum rectifier tubes, whose potential drops are relatively high. The constancy of the potential drop with space current makes possible rectifying systems whose regulation depends almost entirely on the regulation of the plate transformers.

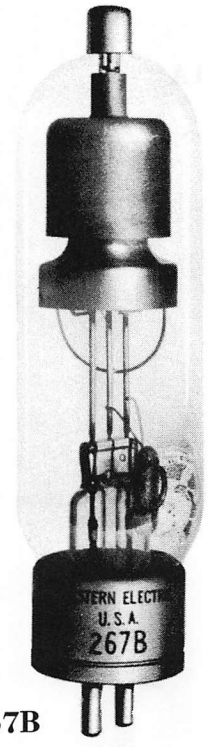
The No. 249B Vacuum Tube employs an improved oxide coated mesh type filament encased in a metallic shield which insures a uniform cathode temperature. The mechanical construction is such as to preserve the active materials for long operating periods at high inverse voltages as well as during shelf life and shipment. These features make possible the maximum operating life. The No. 249B Vacuum Tube has an increased rating over the No. 249A and may be used to replace it.

Western Electric

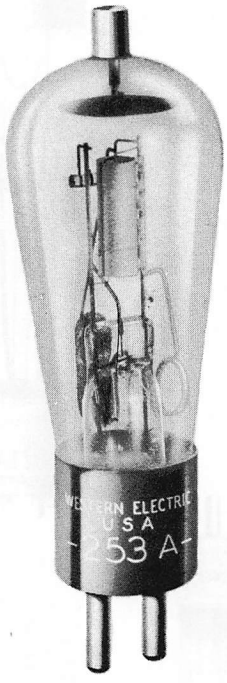
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

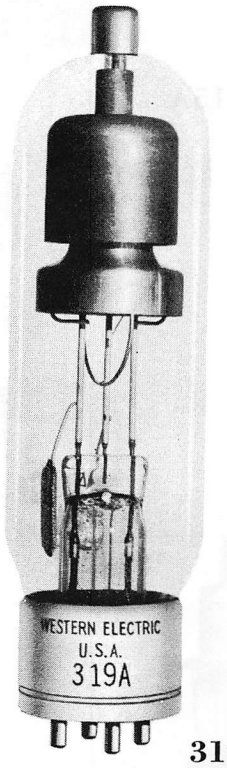
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



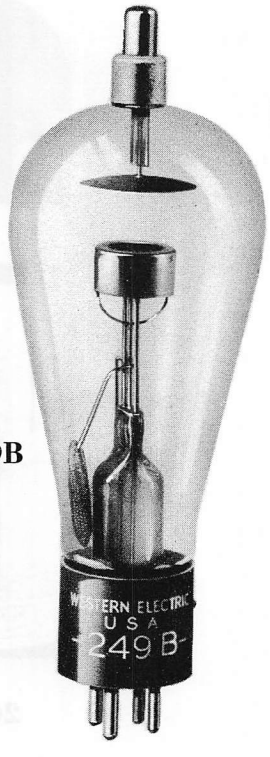
267B



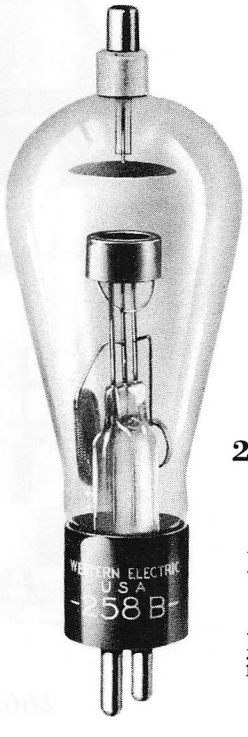
253A



319A



249B

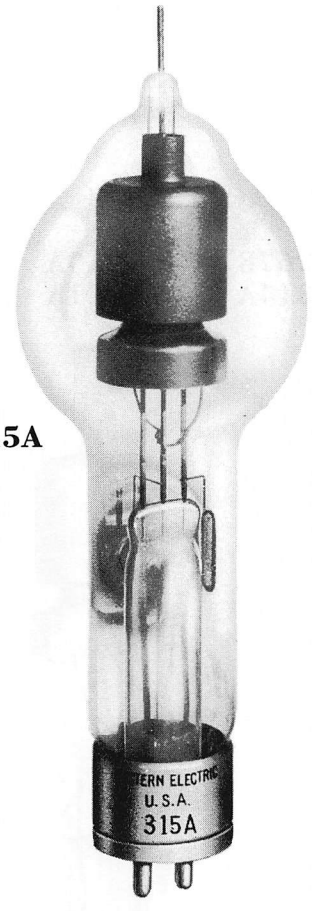


258B

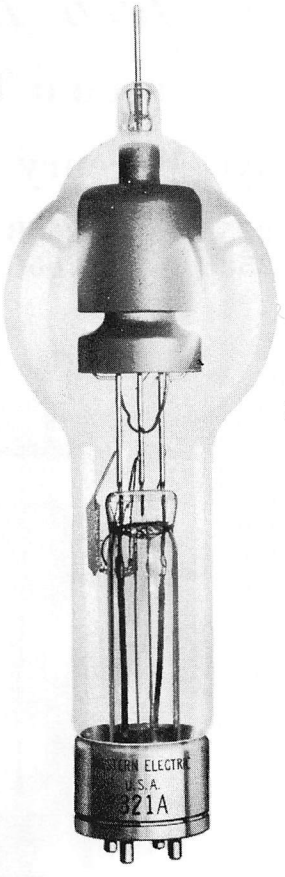
NOTE:

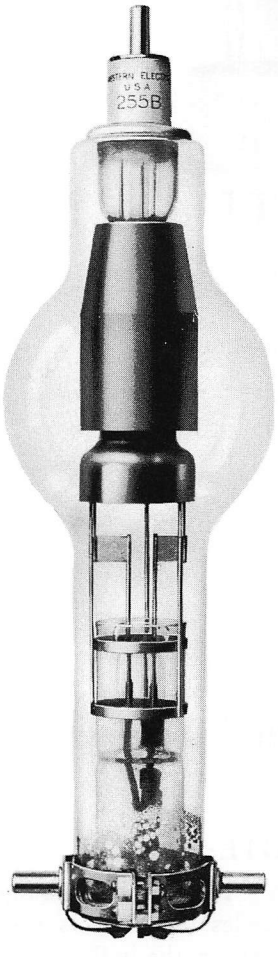
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

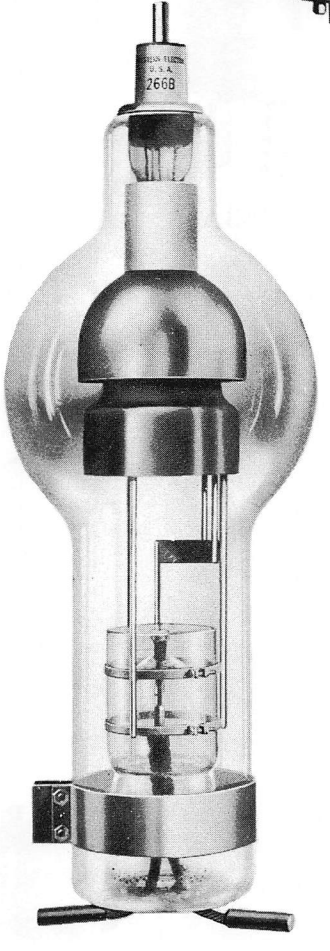


321A

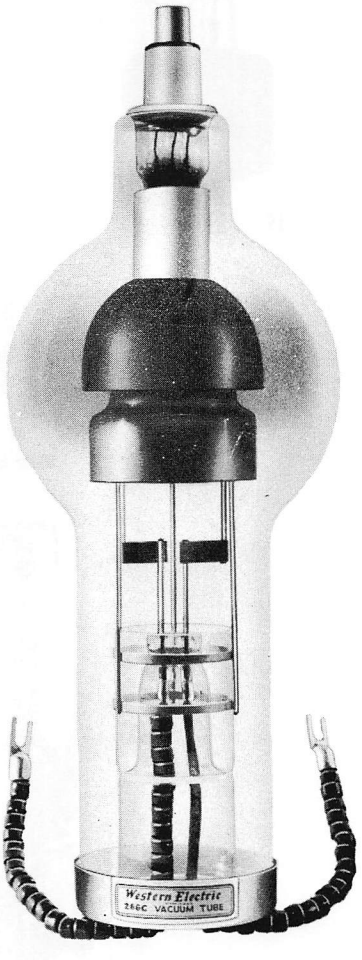




255B



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

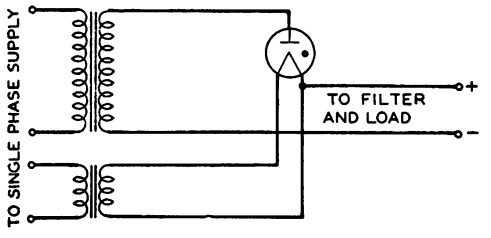
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output 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.

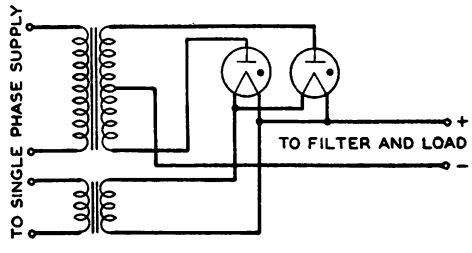
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits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

Circuits

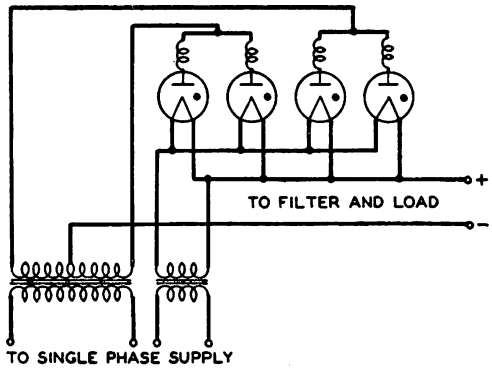
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and 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.



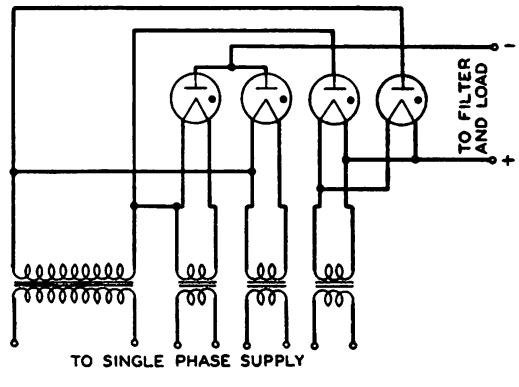
SINGLE PHASE, HALF-WAVE
CIRCUIT A



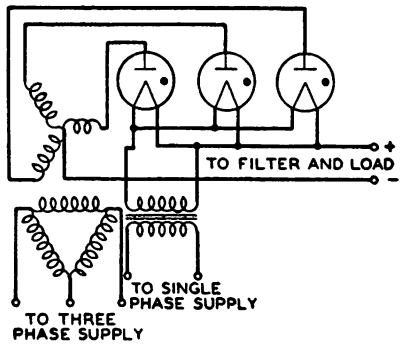
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



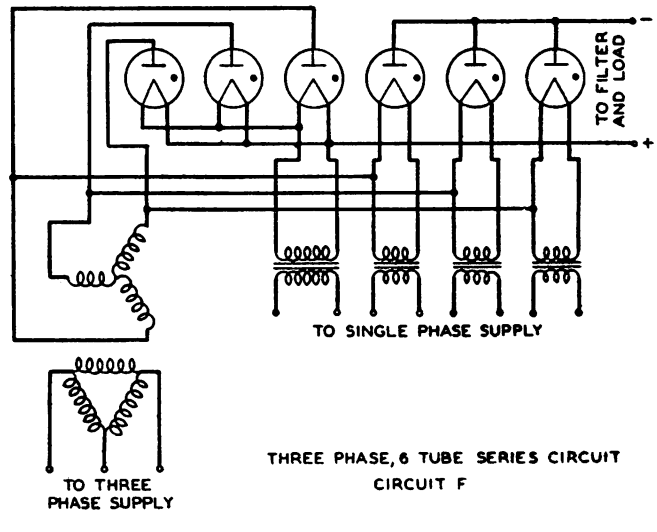
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



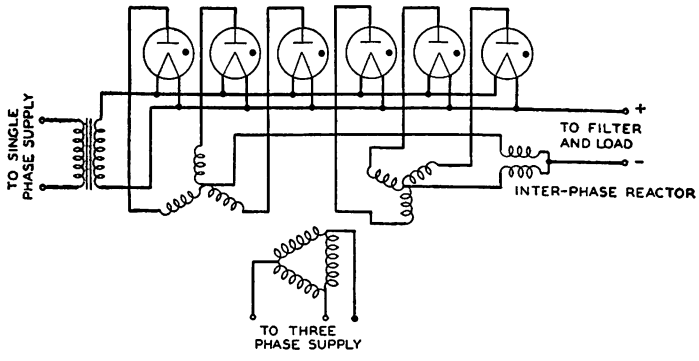
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



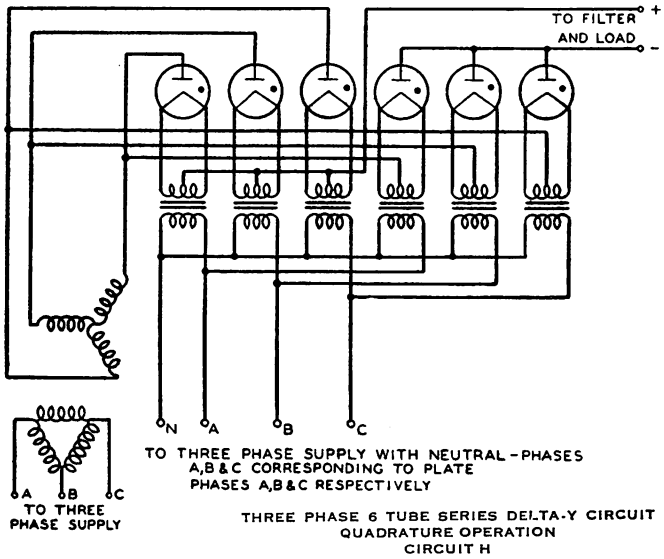
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

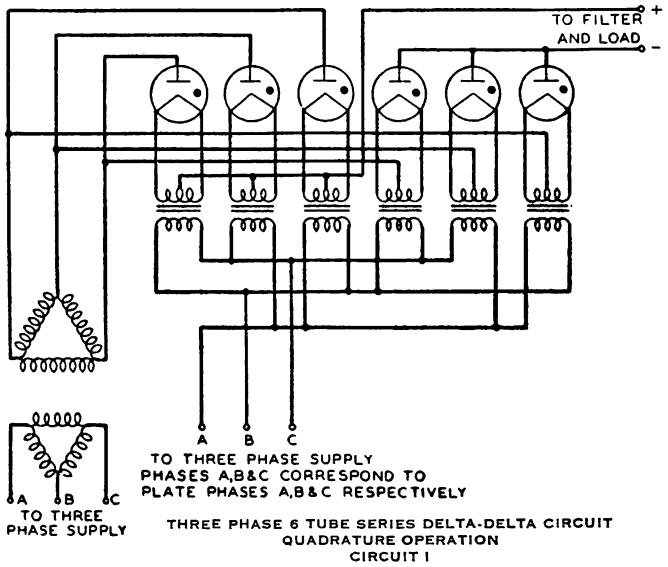


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



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

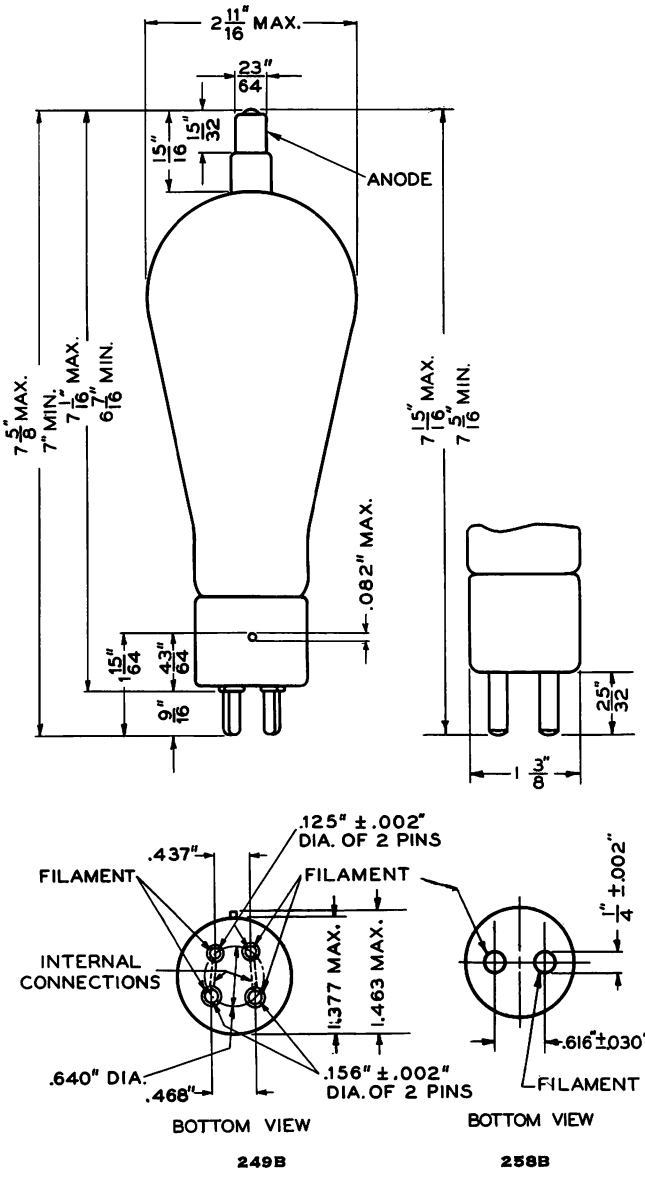
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

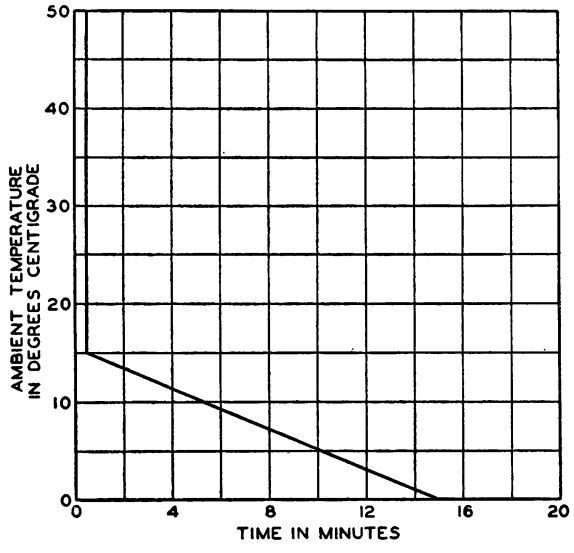


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

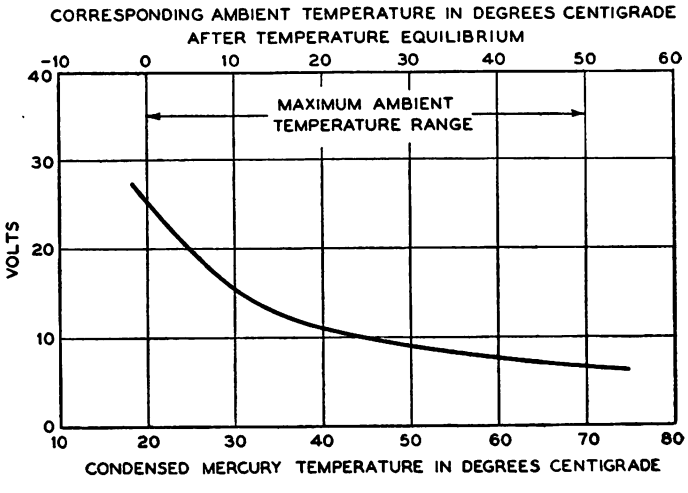
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

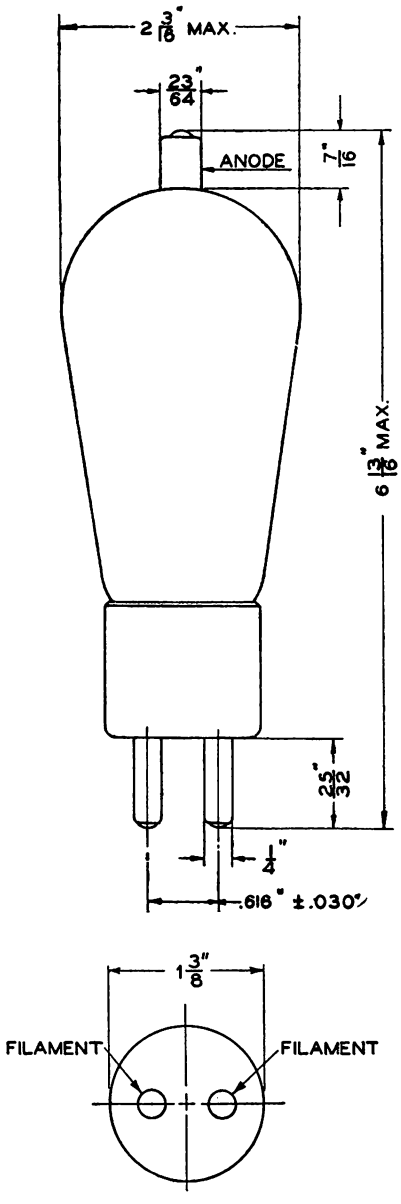
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 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.

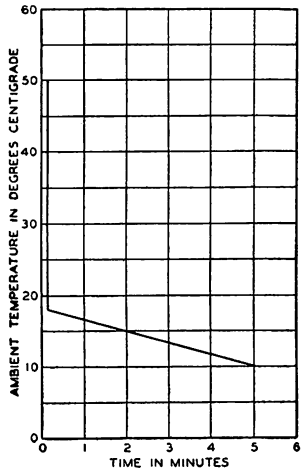
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

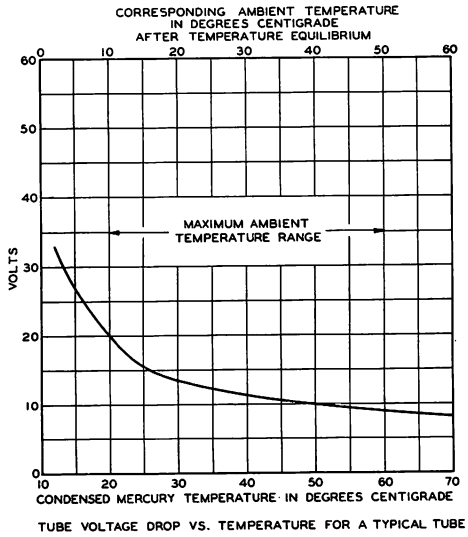
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

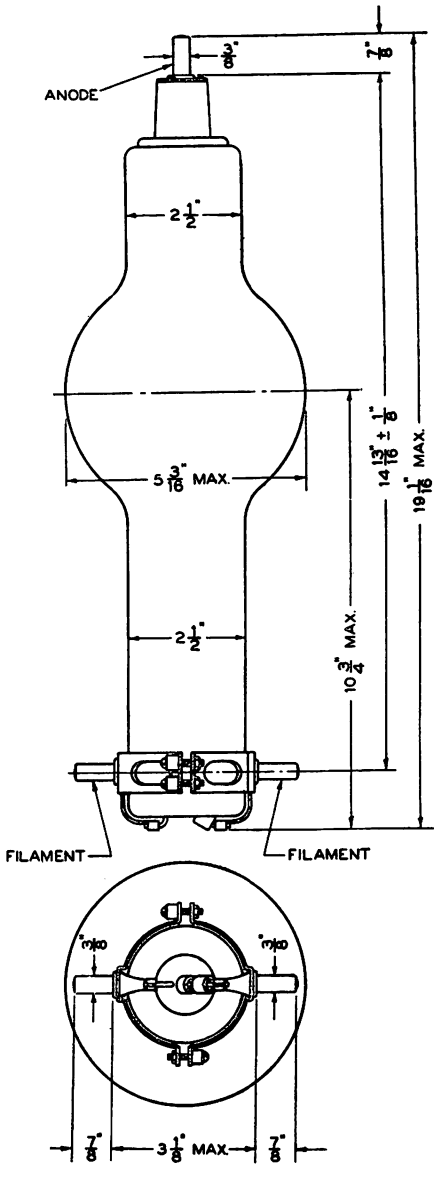
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

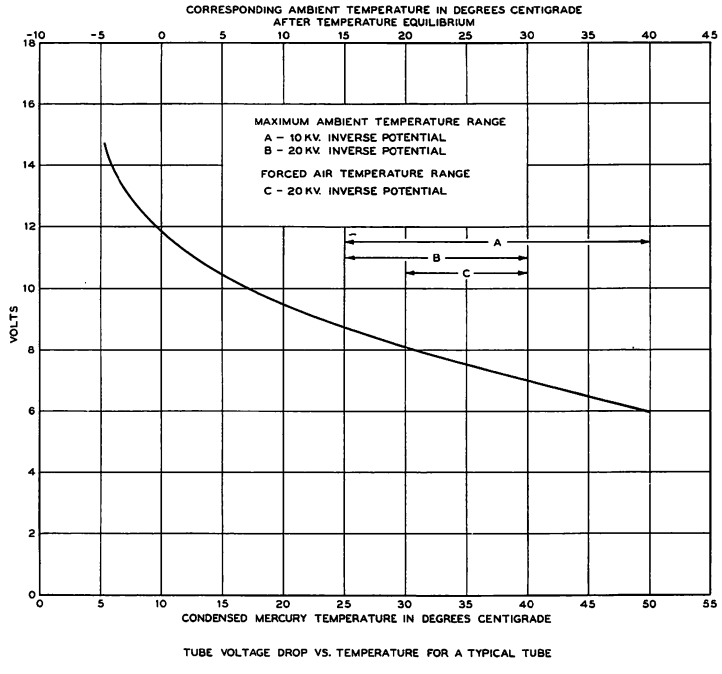
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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.

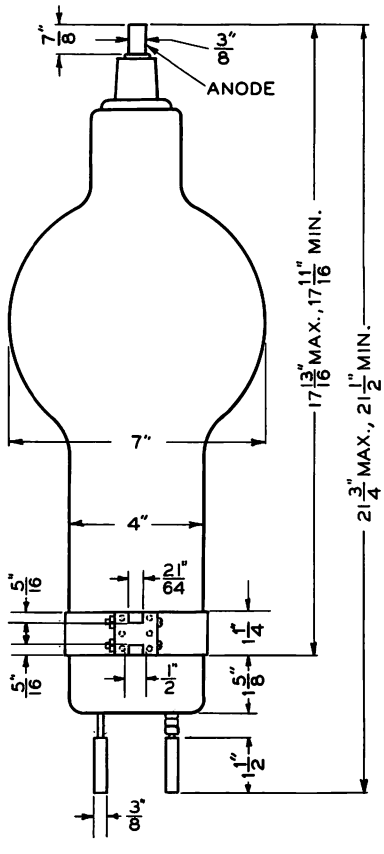
Ratings

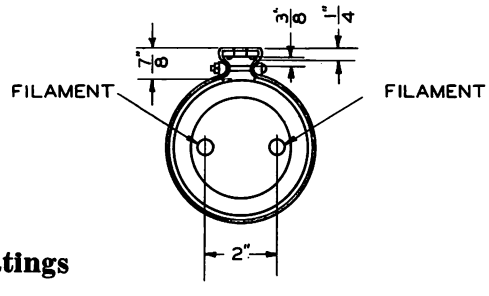
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
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

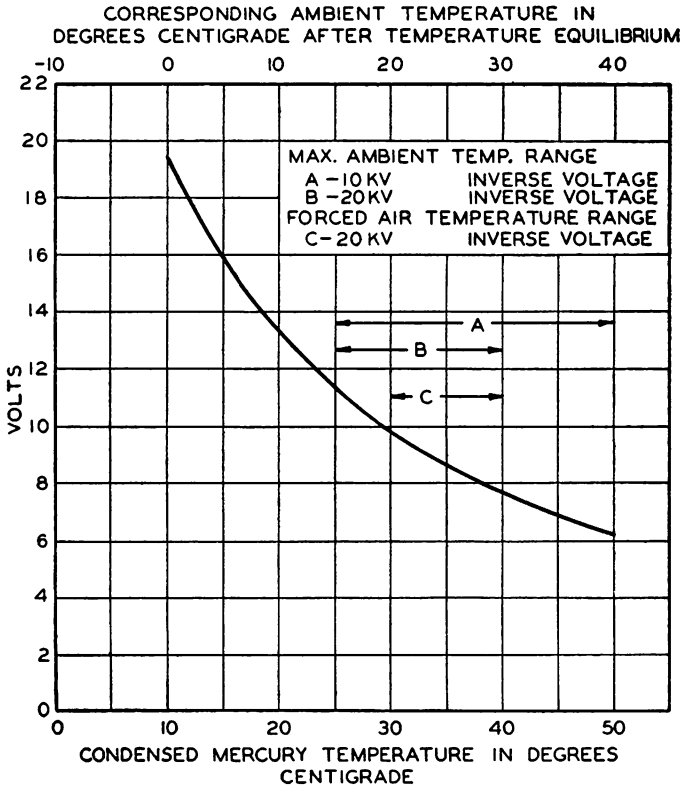
Circuit Outputs:

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

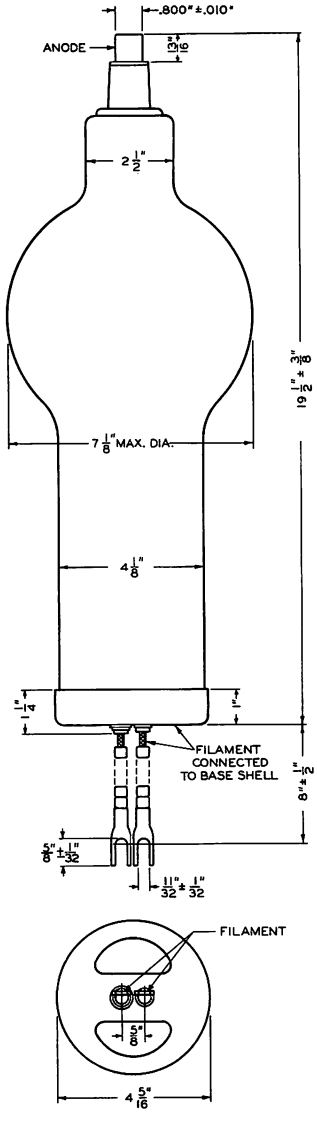
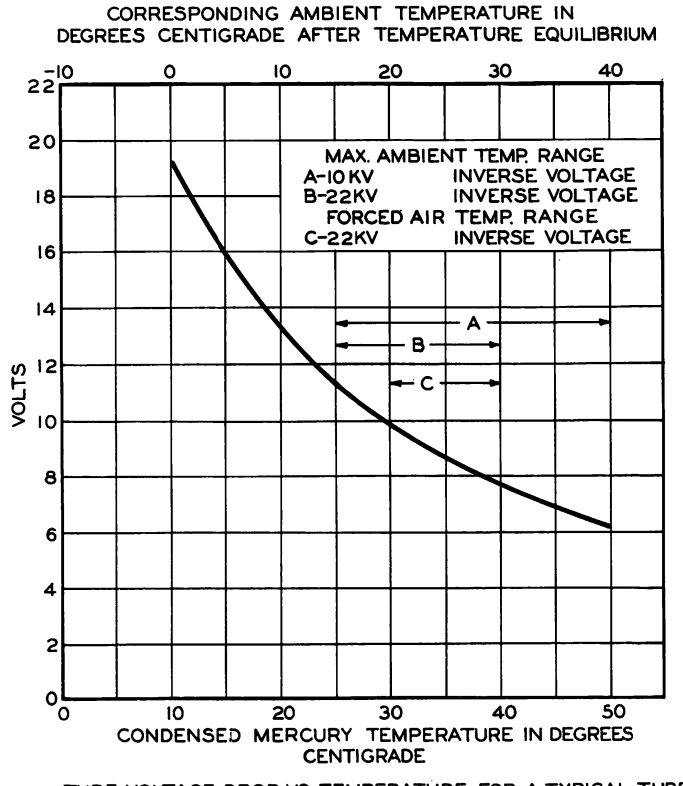


FIG. 1



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

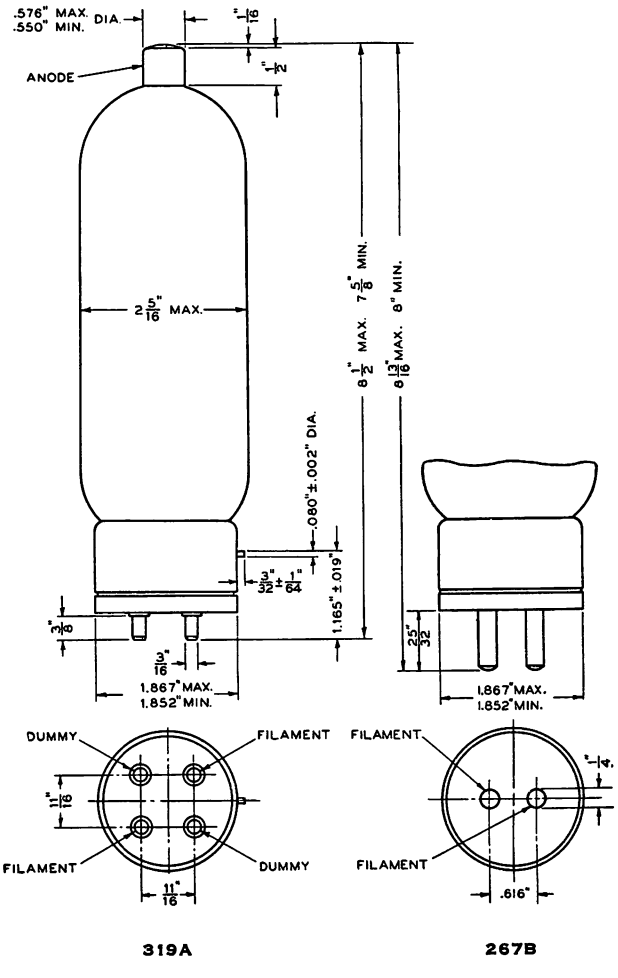
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

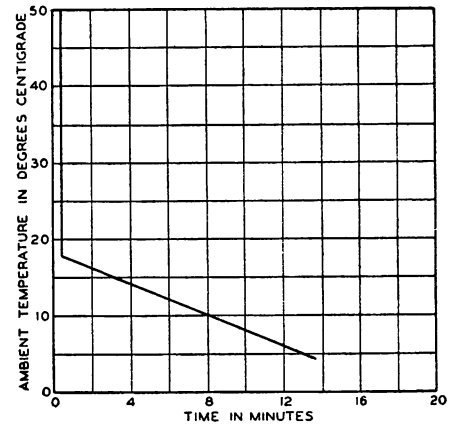
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

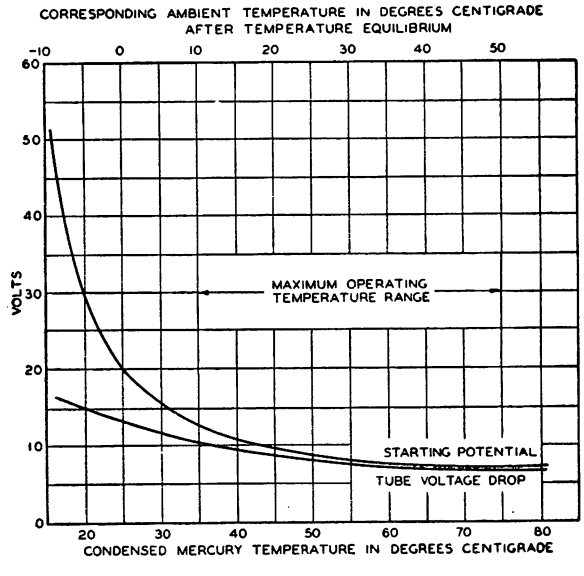
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	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

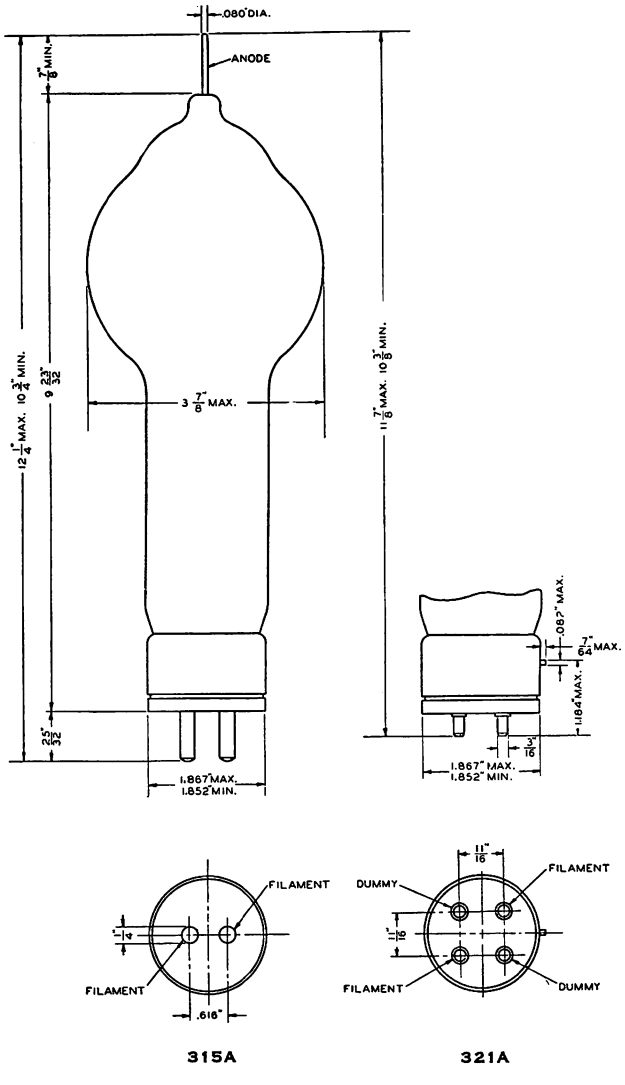
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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.

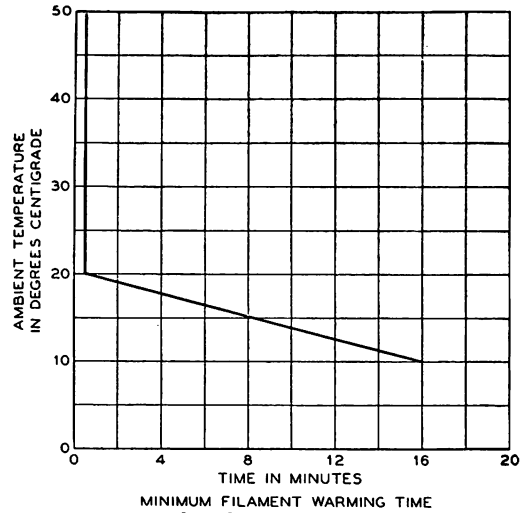
Circuit Outputs:

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

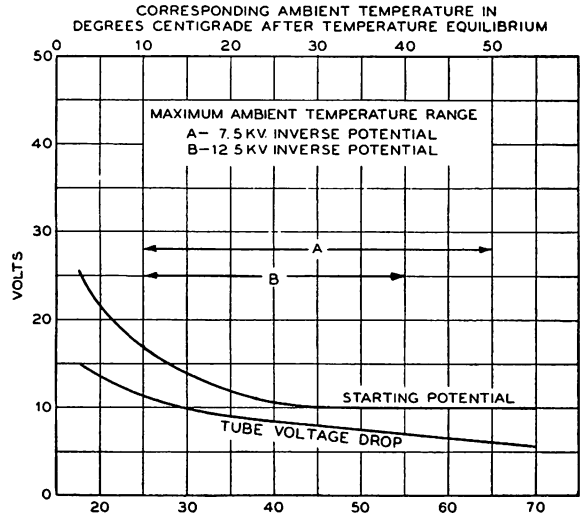
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

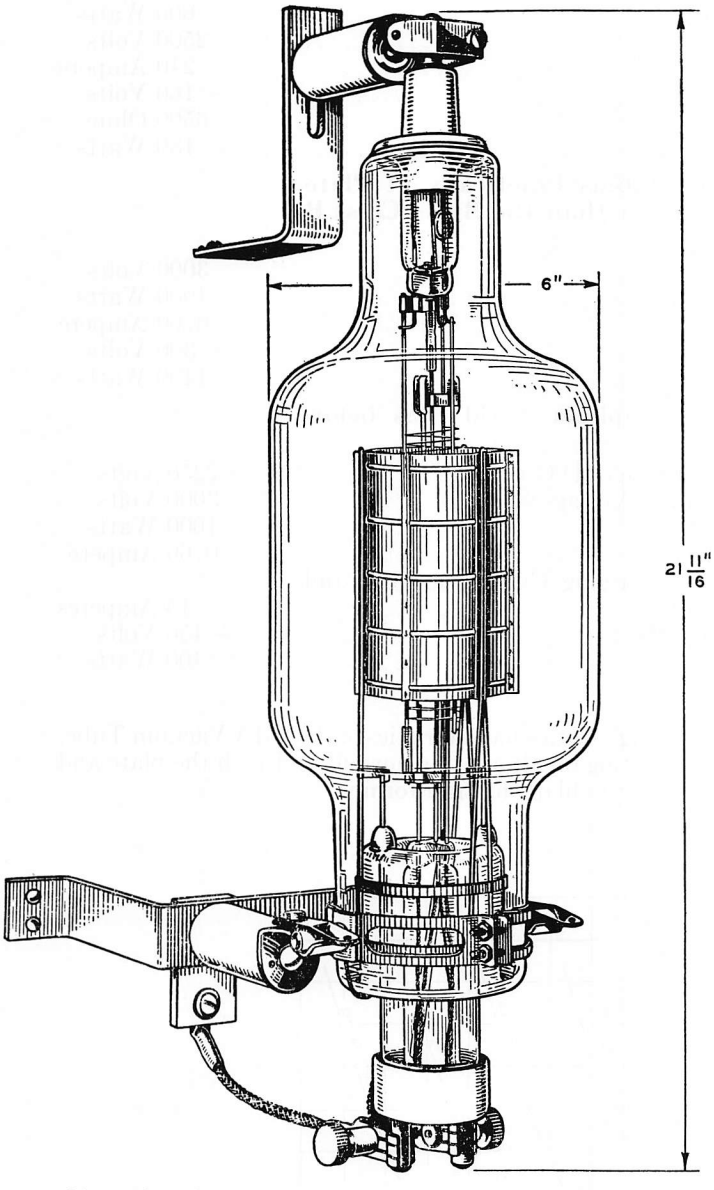
Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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

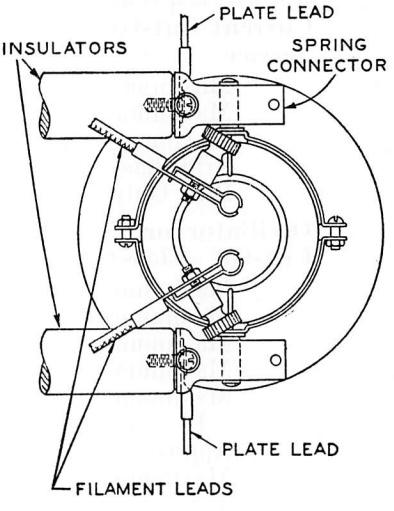
Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

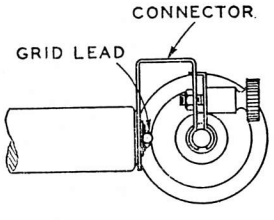
Circuit Outputs:

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

251A Vacuum Tube







Classification

The 251A Vacuum Tube is a three element, air-cooled, tube intended for use as a high-frequency oscillator or amplifier. It may also be used as a modulator or low-frequency power amplifier.

Installation

The arrangement of electrode connections to the base terminals together with the type of mounting recommended is shown above.

Rating and Characteristic Data

Filament Voltage	10 Volts A.C.
Nominal Filament Current	16 Amperes
Maximum Plate Voltage	3000 Volts
Maximum Plate Current	0.60 Ampere
Average Amplification Factor	10.3
Average Plate Resistance	2250 Ohms
Average Mutual Conductance	4550 Micromhos
Approximate Direct Interelectrode Capacities	
Plate to Grid	8 MMF.
Plate to Cathode	6 MMF.
Grid to Cathode	10 MMF.

Audio-Frequency Amplifier or Modulator Rating—Peak Grid Drive Equal to or less than the Bias—Class A Service.

Maximum Plate Dissipation	600 Watts
Plate Voltage (D.C.)	2500 Volts
Plate Current (D.C.)	.240 Ampere
Grid Bias Voltage	—160 Volts
Load Impedance	6500 Ohms
Undistorted Output	130 Watts

Radio-Frequency Amplifier—Grid Bias Practically at Plate Current Cut-Off, Grid Drive Greater than the Bias—Class B Service

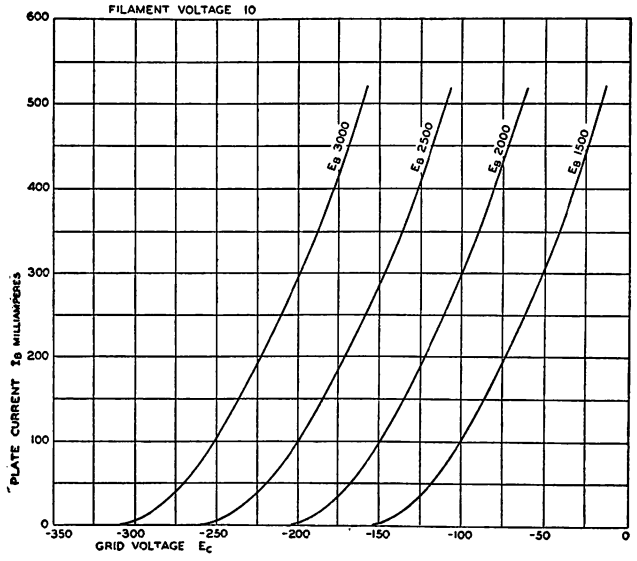
Maximum Plate Voltage (D.C.)	3000 Volts
Maximum Plate Dissipation	1000 Watts
Maximum Plate Current (D.C.)	0.60 Ampere
Grid Bias Voltage	—300 Volts
Peak Output	1400 Watts

Oscillator or Radio-Frequency Amplifier—Grid Bias below Cut-Off—Class C Service

Maximum Modulated Plate Voltage (D.C.)	2250 Volts
Maximum Non-Modulated Plate Voltage (D.C.)	3000 Volts
Maximum Plate Dissipation	1000 Watts
Maximum Plate Current (D.C.)	0.60 Ampere
Maximum Radio-Frequency Charging Current in Grid and Plate Leads	15 Amperes
Approximate Grid Bias Voltage	—450 Volts
Maximum Output	1400 Watts

Average Static Characteristics

The accompanying curves give the average static characteristics of the 251A Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid returns connected to the center point on the filament transformer.



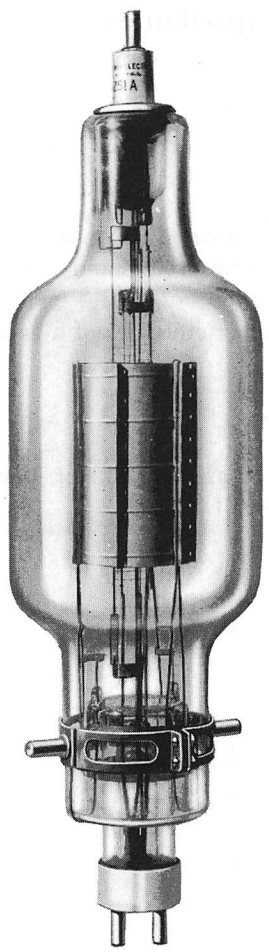
General Features

The 251A Vacuum Tube has been designed with very low interelectrode capacities which make it entirely suitable for operation over a very wide frequency range. The special terminal arrangements make for a simple and rugged mounting and also make the tube operative in circuits at the highest radio frequencies.

The design of the internal structure gives rise to negligible primary emission and relatively low secondary emission thereby assuring satisfactory grid characteristics. The above features together with an adequate thoriated tungsten filament make possible long life with uniform electrical characteristics.

Western Electric

251A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

Dimensions—Dimensions and outline diagrams are shown in Figure 1. The overall dimensions are:

Maximum overall length	$21\frac{11}{16}$″
Maximum diameter	6″

Mounting—W.E. 142A or similar socket. See Figure 1 for mounting arrangements. The tube should be mounted in a vertical position.

Filament—Thoriated tungsten.

Filament voltage	10 volts a.c.
Nominal filament current	16.0 amperes
Average thermionic emission	6.0 amperes

Average Direct Interelectrode Capacitances

Plate to grid	8.0 $\mu\mu f$
Grid to filament	10.0 $\mu\mu f$
Plate to filament	6.0 $\mu\mu f$

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

Figures 2 and 3 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at maximum direct plate voltage and dissipation—Class A (E_b = 2500 volts, I_b = 240 milliamperes.)

Amplification factor	10.5
Plate resistance	2750 ohms
Grid to plate transconductance	3800 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	3000 volts
Max. direct plate current	600 milliamperes
Max. plate dissipation	1000 watts
Max. grid dissipation	50 watts
Max. r-f grid current	15 amperes
Max. frequency for the above ratings	30 megacycles
Max. plate voltage for upper frequency limit of 50 Mc	2000 volts

Max. plate voltage for frequencies between 30 and 50 Mc in proportion.

Class A Audio Amplifier or Modulator

Direct plate voltage	2500	2000 volts
Grid bias	−150	−90 volts
Direct plate current	240	300 milliamperes
Plate dissipation	600	600 watts
Load impedance	6500	4000 ohms
Undistorted output	130	85 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	3000	2500 volts
Grid bias	−250	−205 volts
Direct plate current per tube		
No drive	75	75 milliamperes
Max. drive	600	600 milliamperes
Plate dissipation	800	675 watts
Load resistance, plate-to-plate	4500	3700 ohms
Load resistance, per tube	1125	925 ohms
Approximate maximum output—2 tubes	2000	1650 watts
Recommended power for driving stage	100	100 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	3000	2500 volts
Direct plate current for carrier conditions	400	500 milliamperes
Grid bias	−300	−250 volts
Approximate carrier watts for use with 100% modulation	400	420 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	3000	2500 volts
Direct plate current	600	600 milliamperes
Grid bias	−450 to −600	−375 to −500 volts
Max. direct grid current	150	100 milliamperes
Nominal power output	1200	1000 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	2250	1750 volts
Direct plate current	400	500 milliamperes
Grid bias	−470	−370 volts
Max. direct grid current	100	100 milliamperes
Max. grid dissipation	50	50 watts
Nominal carrier power output for use with 100% modulation	900	700 watts

Operating Precautions

Mechanical—Figure 1 shows 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 675 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 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 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 is 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—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. The tube may be used at full rating up to 30 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 upper frequency limit and for frequencies between these two limits the plate voltage should be proportionately reduced.

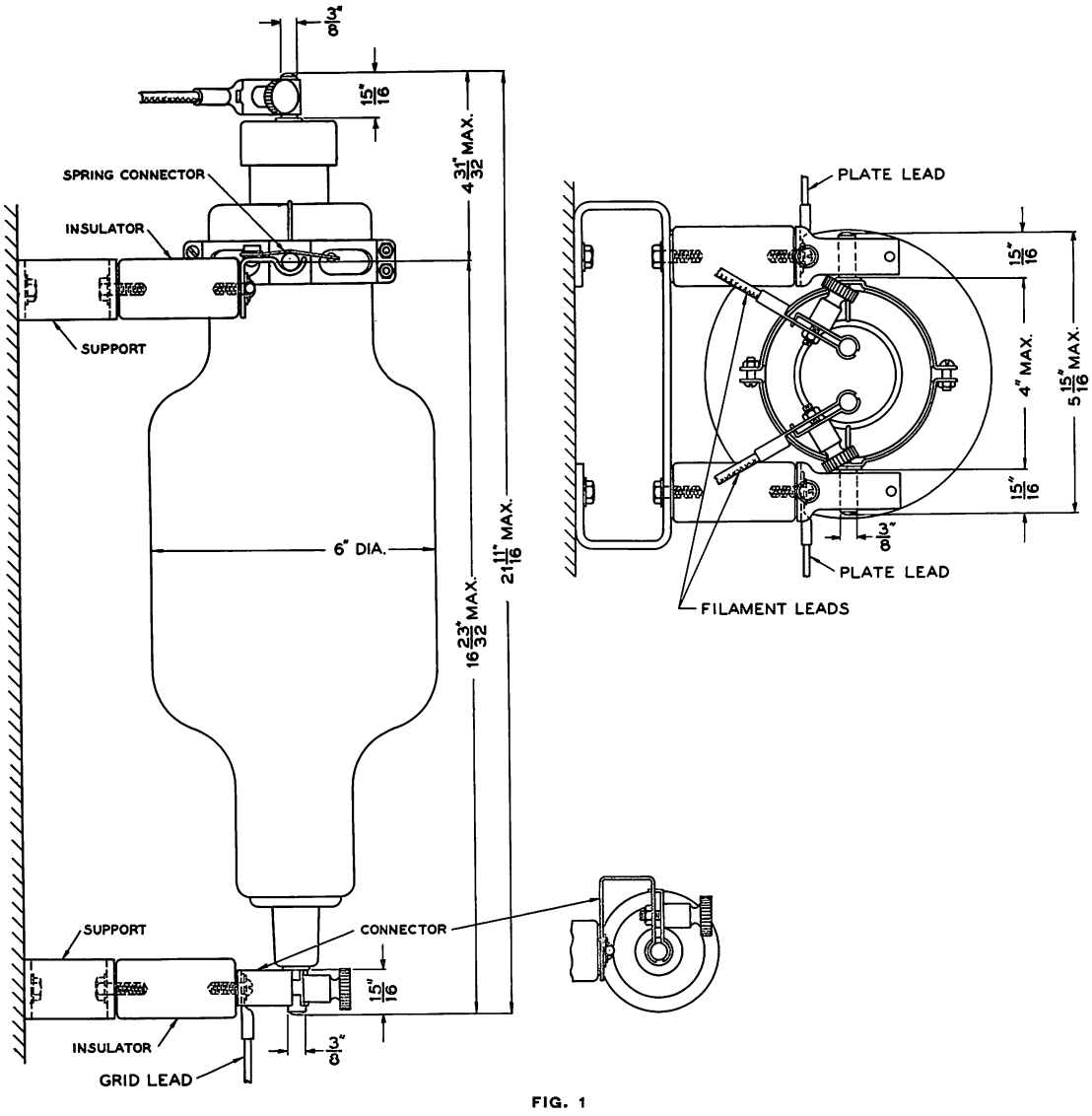


FIG. 1

251A

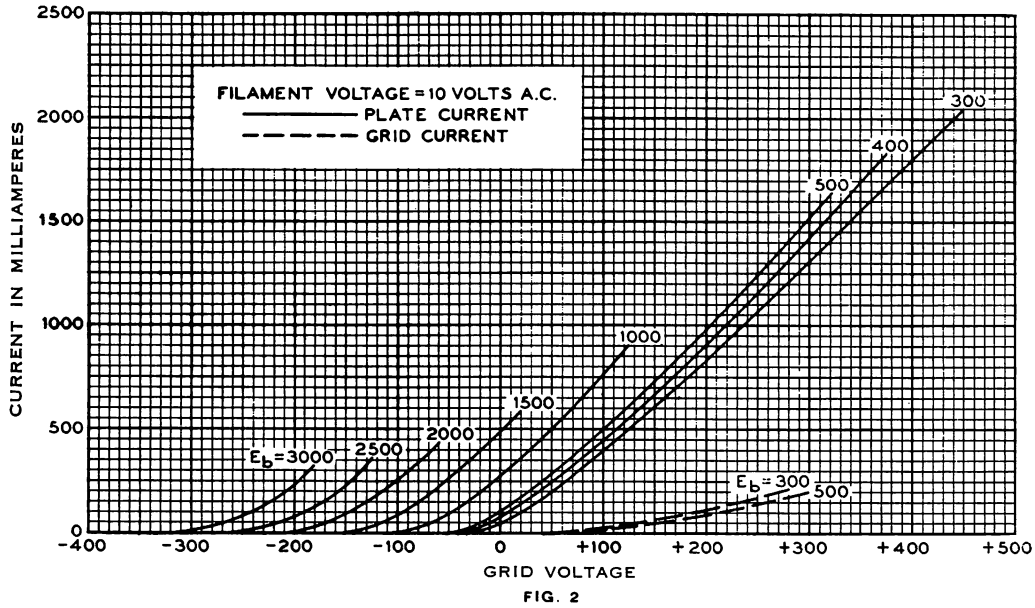


FIG. 2

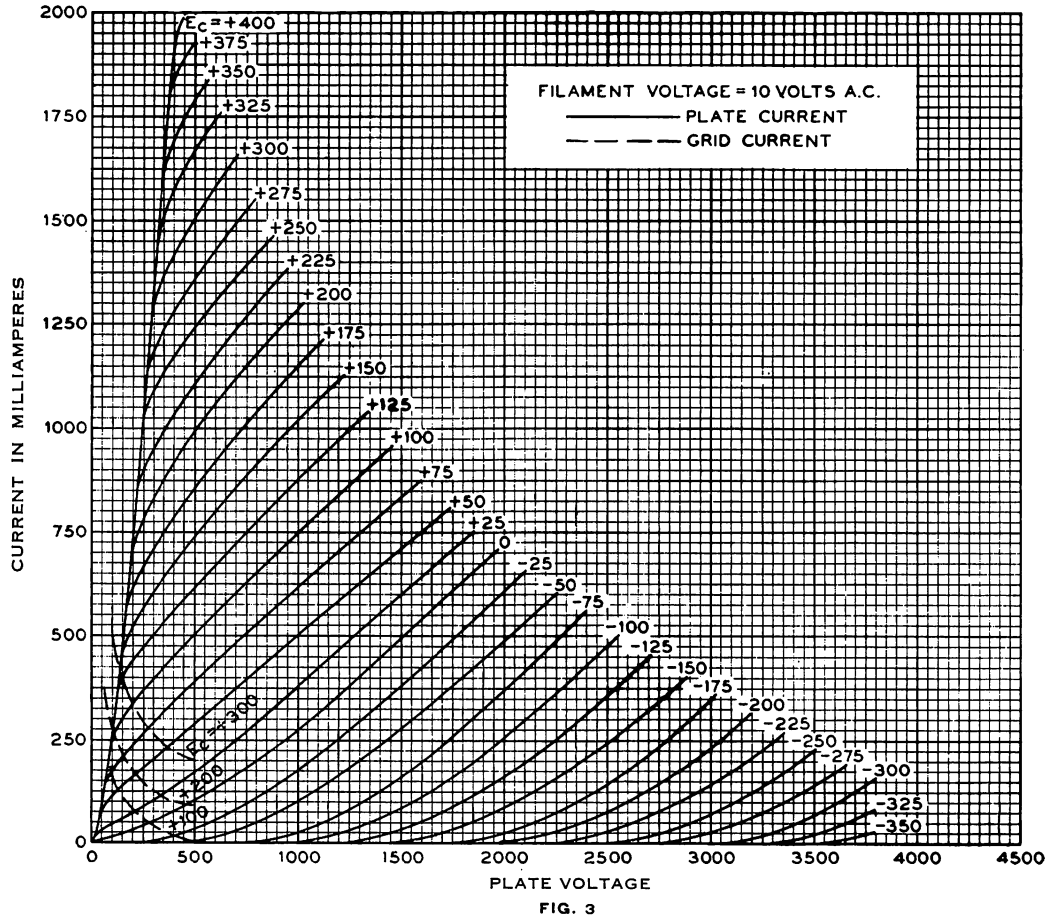
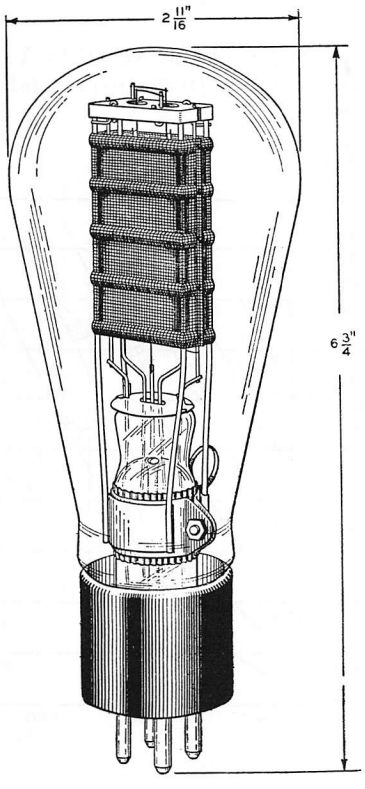
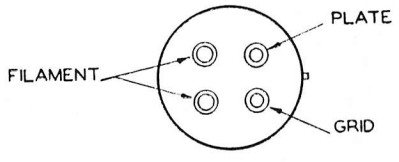


FIG. 3

252-A Vacuum Tube





Classification

The No. 252A Vacuum Tube is a three-element tube having a filamentary type of cathode. The tube is for use as an audio-frequency amplifier in output stages where moderate powers are required. It may also be used as an oscillator or modulator.

Base and Socket

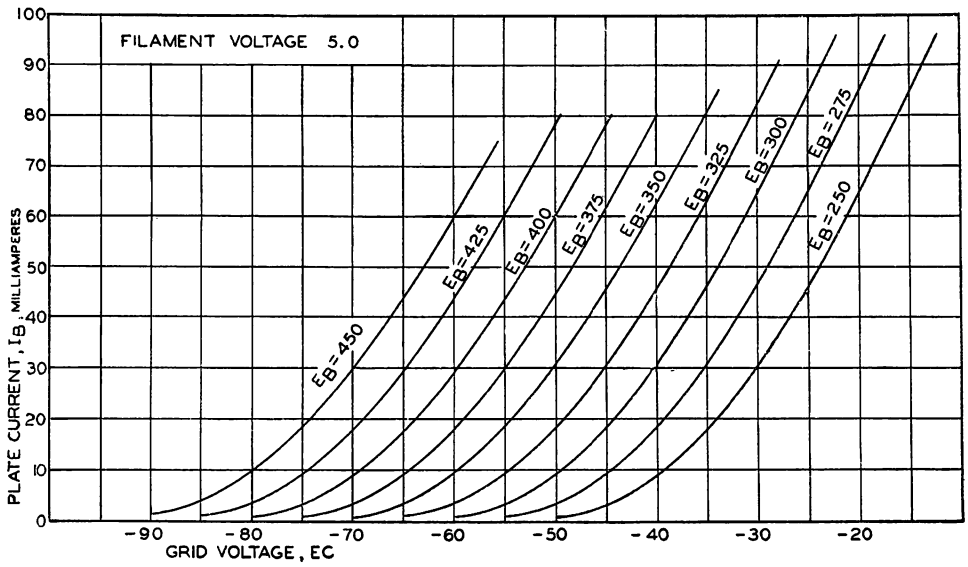
The No. 252A Vacuum Tube employs a standard four-prong, thrust-type base suitable for use in a Western Electric No. 130B (rigid) or No. 131A (cushion) socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

Filament Voltage	5 Volts, AC or DC
Average Filament Current	2 Amperes
For Fixed Grid Bias	
Maximum Plate Voltage	450 Volts
Maximum Grid Bias	—65 Volts
Average Plate Current	43 Milliamperes
Average Plate Resistance	1,700 Ohms
Average Amplification Factor	5.0
For Self-Biasing Grid	
Maximum Plate Voltage	450 Volts
Maximum Grid Bias	—60 Volts
Average Plate Current	60 Milliamperes
Average Plate Resistance	1,500 Ohms
Average Amplification Factor	5.1
Approximate Direct Interelectrode Capacities	
Plate to Grid	12.0 MMF
Plate to Filament	4.0 MMF
Grid to Filament	6.5 MMF

Average Static Characteristics

The accompanying curves give the static characteristics of the No. 252A Vacuum Tube. These curves have been obtained with the filament operating on direct current and the grid and plate returns connected to the negative filament terminal.



General Features

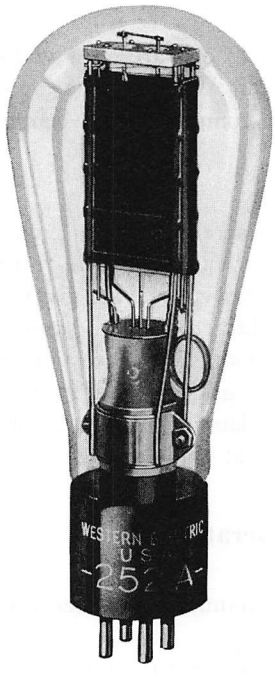
The tube has been designed with an unusually large plate area for its energy dissipation rating. The total electron emission of the filament is very large compared to the maximum space current drain. Both factors insure the delivery of full output power throughout a long life.

An unusually low output of hum, when alternating current is used for filament supply, is obtained through the design characteristics of the filament.

The rugged structure insures against breakage in shipment and in service and makes possible the maintenance of uniform electrical characteristics.

Western Electric

252A Vacuum Tube



Classification—Moderate-power, filamentary triode

Applications—Audio-frequency amplifier where power outputs up to about 8 watts are required.

Oscillator

Modulator

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, four-pin thrust base with bayonet pin.

Socket—Standard, four-contact type such as the Western Electric 143B socket.

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

Average Direct Interelectrode Capacitances

Grid to plate	12.0 μμf.
Grid to filament	6.5 μμf.
Plate to filament	4.0 μμf.

Filament Rating

Filament voltage	5.0 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. 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—Plate current characteristics of a typical 252A tube are shown in Figure 3 as functions of grid voltage for a number of values of plate voltage. Similar characteristics as functions of plate voltage for several values of grid voltage are given in Figure 4. Amplification factor, plate resistance, and transconductance characteristics are shown in Figures 5, 6 and 7, respectively as functions of grid voltage for several values of plate voltage. All of these characteristics are for direct-current filament supply with the grid and plate returns connected to the negative end of the filament. With alternating-current filament supply, approximately the same characteristics are obtained if 3.0 is added to the numerical value of each grid bias.

Limiting Conditions for Safe Operation

Maximum plate voltage	500 volts
Maximum plate current for manually adjusted grid bias or self-biasing circuit	*90 milliamperes
Maximum plate current of average tube for fixed grid bias	**75 milliamperes
Maximum instantaneous grid potential on positive swing of input voltage	+10 volts

*Modified as indicated in Figure 3 for plate voltages between 425 and 500 volts.
**Except between plate voltages of 425 and 500 volts, where limits should be 15 milliamperes less than those indicated in Figure 3 for a given plate voltage.

Operating Conditions and Output—Permissible combinations of operating plate voltage and plate current are included within the area, ABCDE, in Figure 3. Amplification factor, plate resistance, transconductance, and performance data are listed in the table on page 3 for a number of typical operating conditions represented by selected points within this area. 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.

Where it is necessary to operate a 252A tube at or near a maximum permissible plate current, 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 each tube is obtained from the voltage drop produced by the plate current passing 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 value 15 milliamperes below the maximum safe plate current, so that tubes having plate currents higher than the average will not exceed the maximum rating.

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, P_m, is given in watts and the second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the output and harmonic levels are given approximately by the following relations:

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

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

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

Curves showing the variation of power output and harmonic levels with load resistance for several values of operating plate current are shown in Figures 8, 9 and 10 for a plate voltage of 450 volts.

TABLE

Plate Voltage Volts	Grid Bias Volts	Plate Current Milliamperes	Amplification Factor	Plate Resistance Ohms	Transconductance Micromhos	Input Voltage Peak Volts	Load Resistance Ohms	Output Power Watts	Second Harmonic db	Third Harmonic db
300	−45	19	5.08	2300	2250	45	8000	2.0	26	36
300	−40	31	5.14	1850	2800	40	4000	2.5	25	37
							5000	2.2	28	41
300	−35	46	5.20	1600	3300	35	2500	2.4	26	41
350	−50	30	5.10	1850	2700	50	6000	3.1	27	39
350	−45	45	5.16	1600	3200	45	3500	3.6	27	40
400	−60	29	5.08	1900	2650	60	8000	3.7	28	40
400	−55	44	5.12	1650	3100	55	2500	5.4	21	39
							4000	5.0	26	38
							5000	4.5	28	42
400	−50	60	5.18	1500	3500	50	2500	5.2	26	38
							3000	5.0	28	41
400	−45	78	5.20	1350	3850	45	1500	4.9	25	38
450	−70	30	5.06	1950	2600	70	8000	5.2	26	37
450	−65	44	5.10	1650	3050	65	5000	6.2	26	38
450	−60	60	5.14	1500	3450	60	3000	6.9	25	37
475	−70	43	5.10	1700	3050	70	6000	6.5	27	39
475	−65	59	5.14	1500	3450	65	4000	7.3	27	40
*450	−55	78	5.18	1350	3800	55	2500	6.8	27	41
*500	−75	43	5.08	1700	3050	75	6000	7.4	25	38
*500	−70	58	5.12	1500	3450	70	4000	8.3	26	38

*Maximum operating conditions.

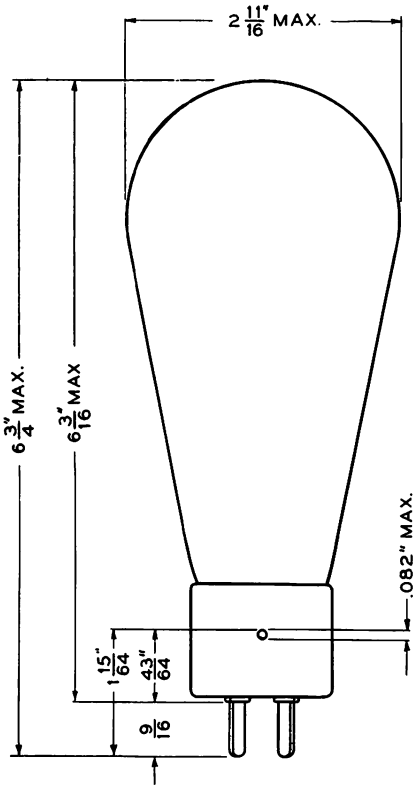

2 11/16" MAX.
6 3/4" MAX.
6 3/16" MAX
.082" MAX.
1 15/64"
43/64"
9/16

FIG. 1

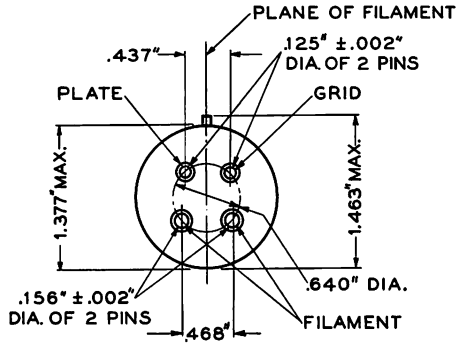

PLANE OF FILAMENT
.437"
.125" ±.002"
DIA. OF 2 PINS
PLATE
GRID
1.377" MAX.
1.463" MAX.
.640" DIA.
.156" ±.002"
DIA. OF 2 PINS
.468"
FILAMENT

FIG. 2

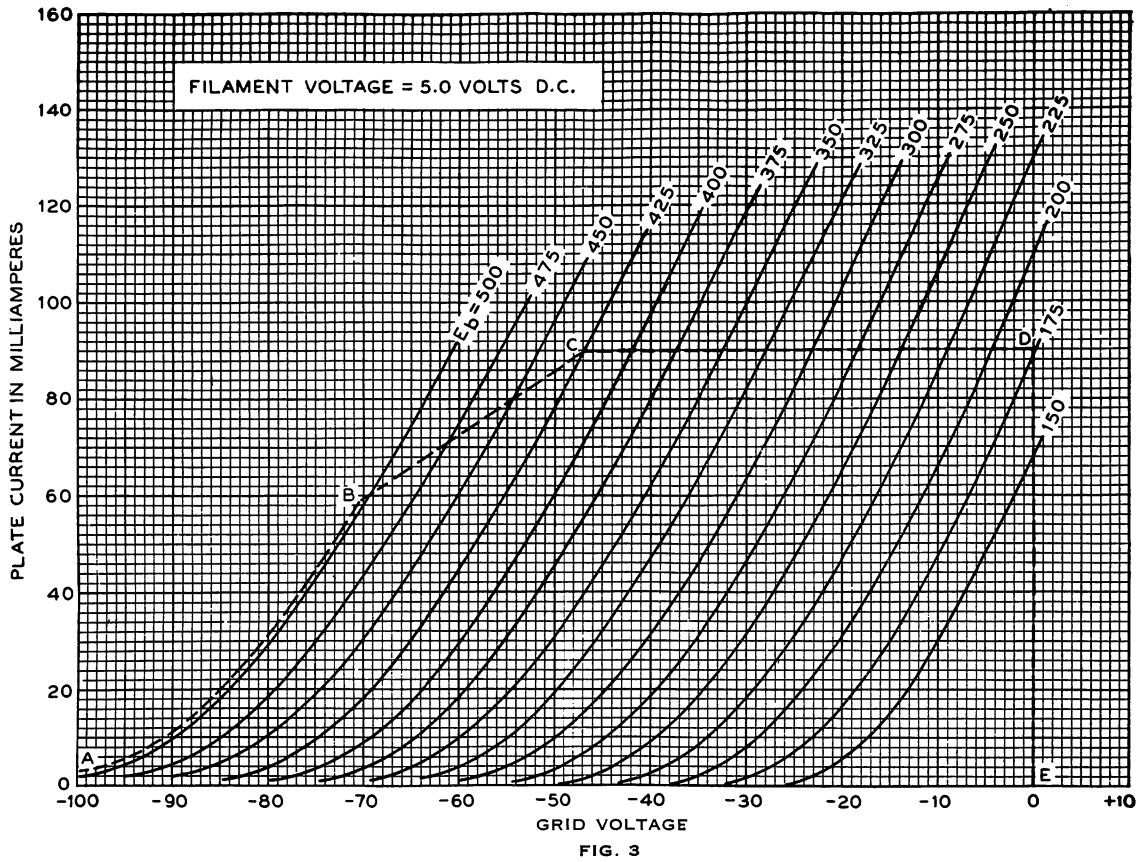

FILAMENT VOLTAGE = 5.0 VOLTS D.C.
PLATE CURRENT IN MILLIAMPERES
GRID VOLTAGE
160
140
120
100
80
60
40
20
0
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0
+10
E_b=500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
A
B
C
D
E

FIG. 3

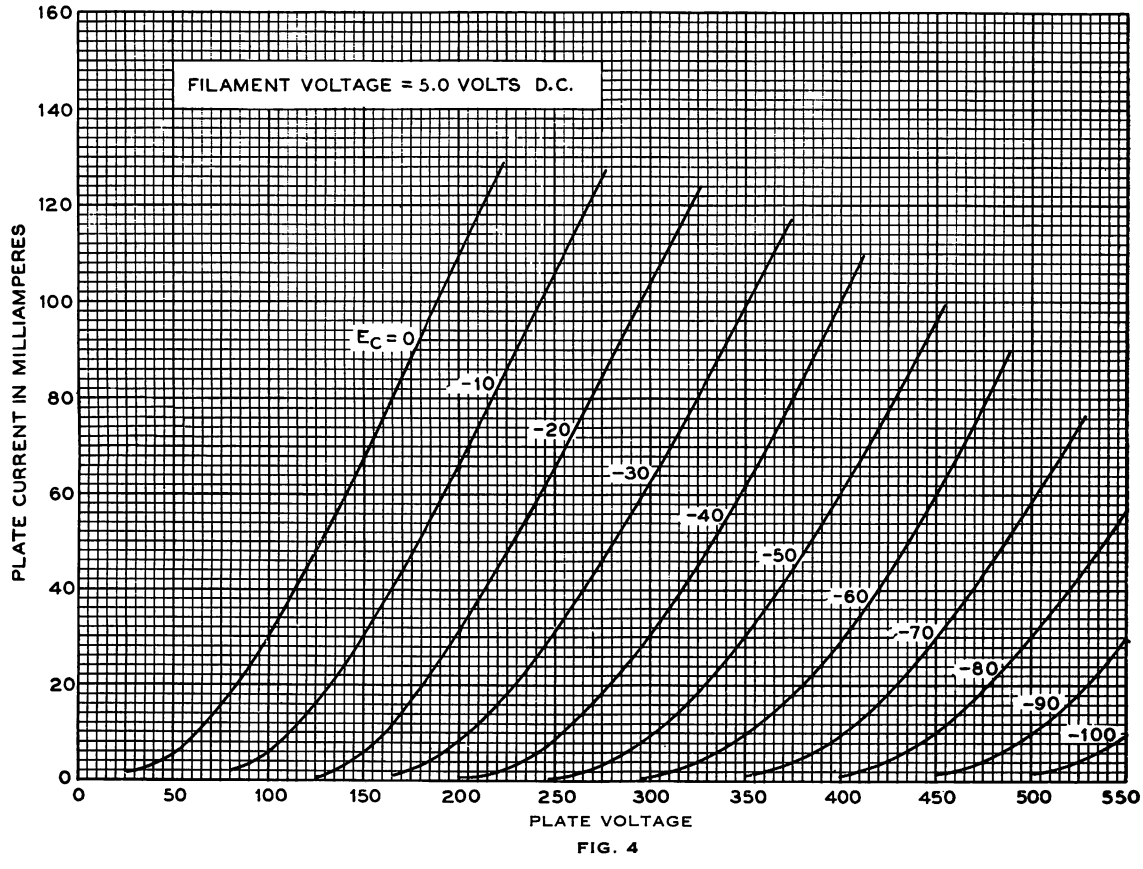

FILAMENT VOLTAGE = 5.0 VOLTS D.C.
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
160
140
120
100
80
60
40
20
0
0
50
100
150
200
250
300
350
400
450
500
550
E_c = 0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100

FIG. 4

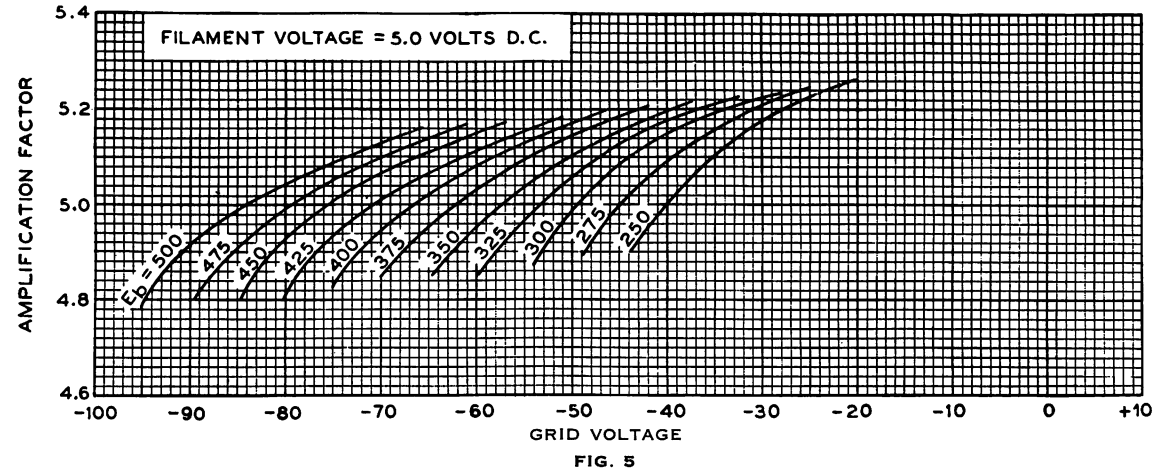


FIG. 5

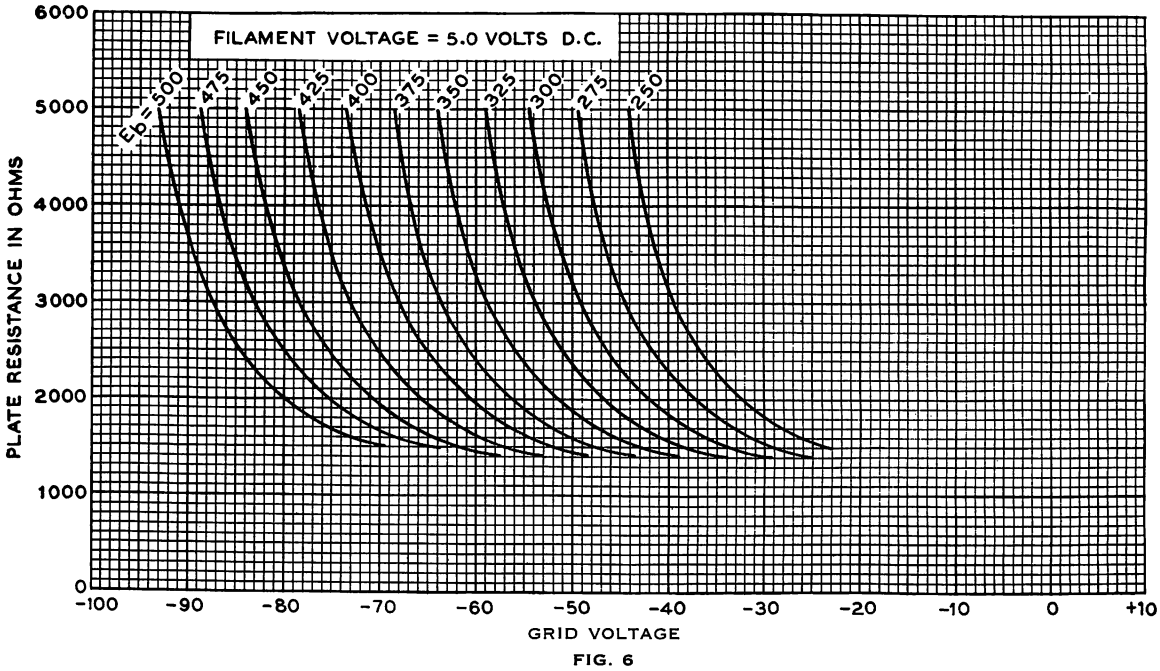


FIG. 6

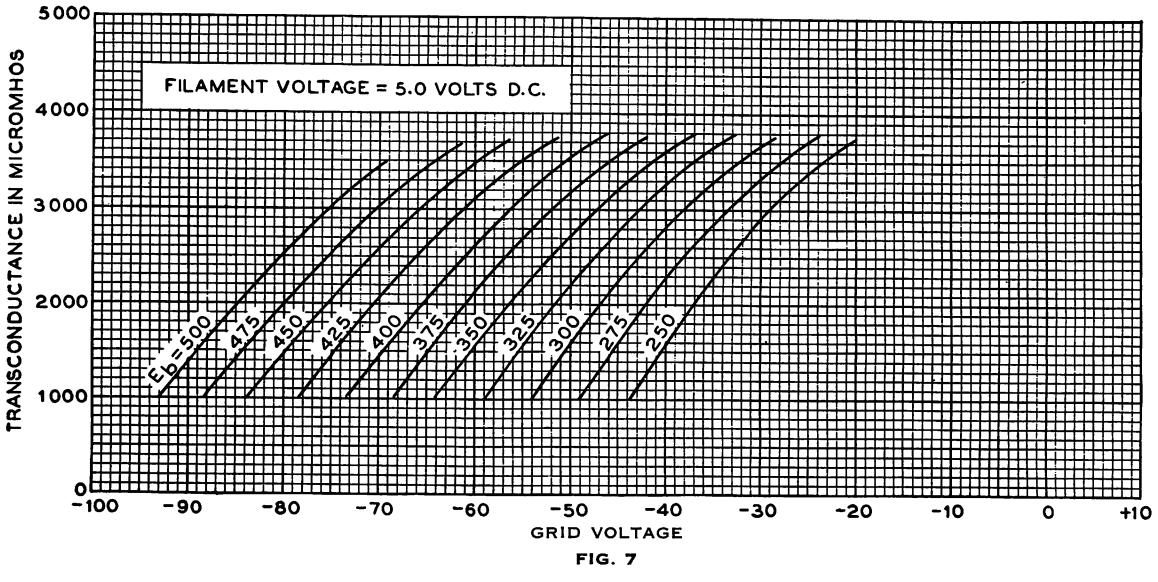


FIG. 7

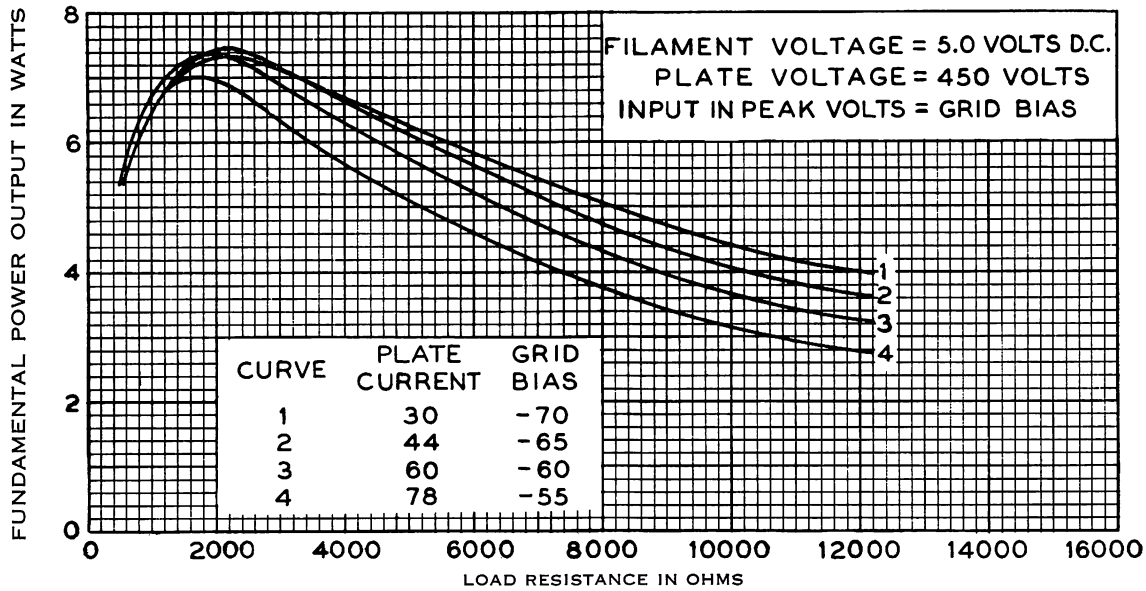


FIG. 8

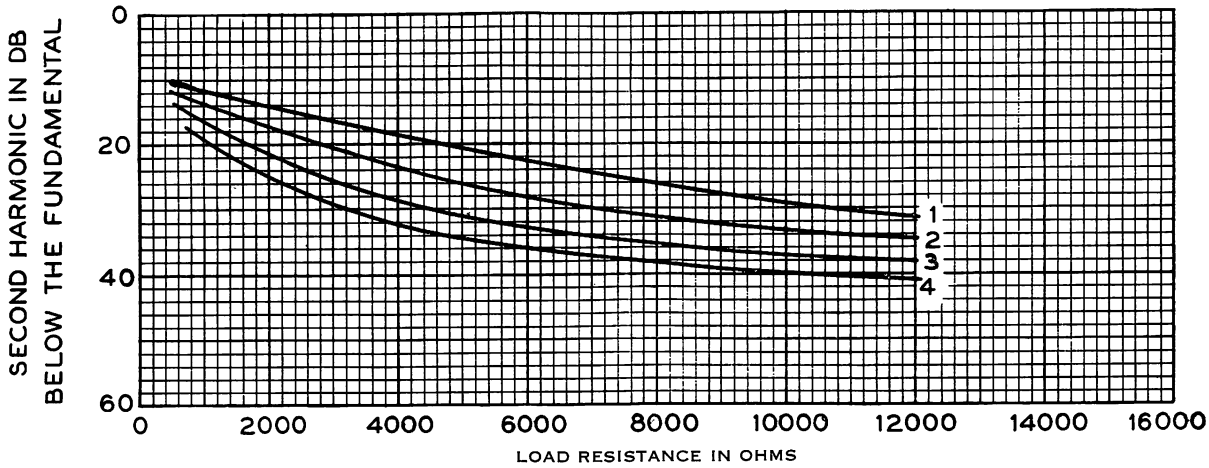


FIG. 9

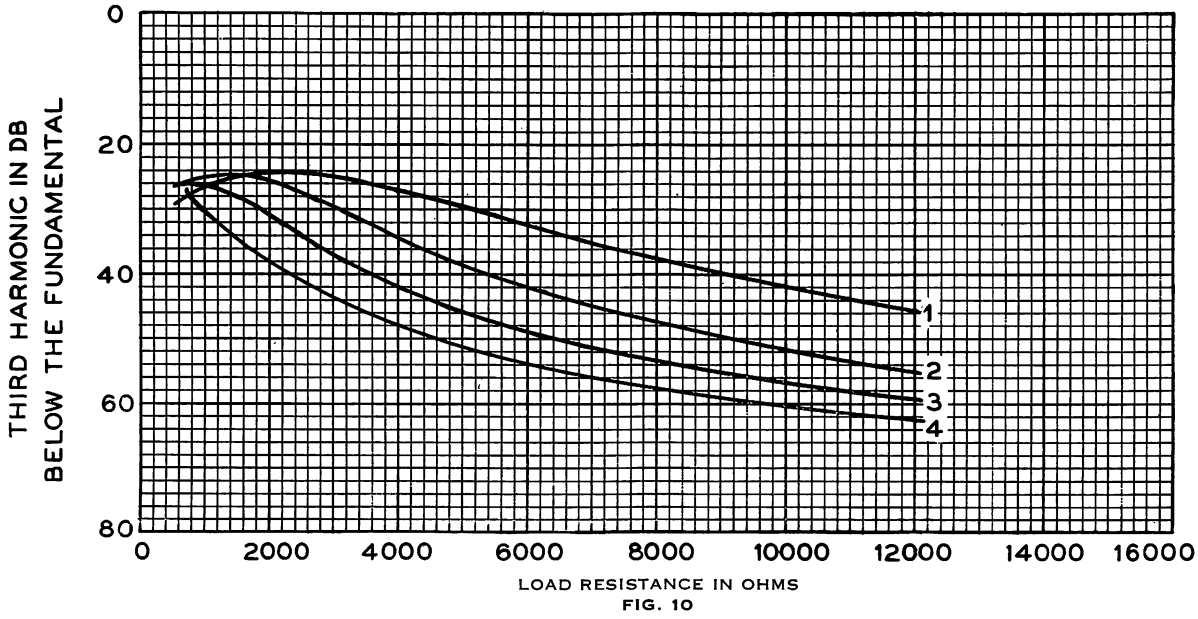
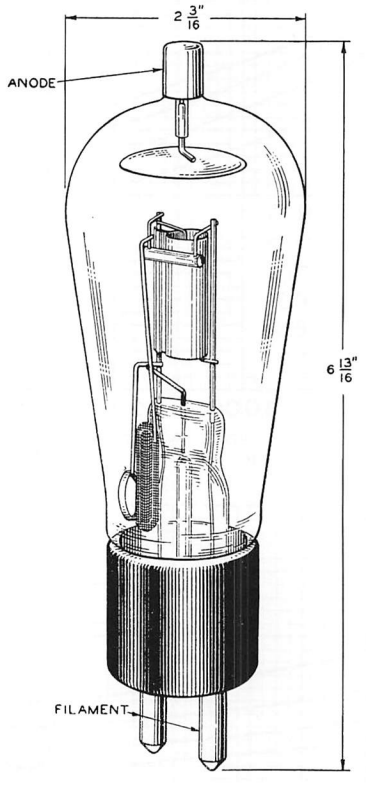


FIG. 10

253A Vacuum Tube



Classification

The No. 253A Vacuum Tube is a half-wave, thermionic, mercury-vapor rectifier for use in rectifying circuits designed to supply direct current from an alternating current supply.

Base and Socket

The No. 253A Vacuum Tube employs a two-prong base suitable for use in a Western Electric No. 138A or No. 139A Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The anode terminal is located at the top of the bulb and is arranged for a special quick-release connector. The tube should be mounted only in a vertical position with the base end down.

Rating and Characteristic Data

Filament Voltage	2.5 Volts
Nominal Filament Current	3 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	15 Volts
Maximum Peak Plate Current	0.5 Ampere
Maximum Peak Inverse Potential	3,500 Volts
Safe Operating Ambient Temperature	10 to 50 Degrees 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 will vary from 5 to 25 volts.

Typical Rectifying Circuits

For specific circuits the following ratings apply:

Type of Circuit	Number of Tubes	Load Potential Volts	Load Current Amperes
Single-Phase, Half-Wave	1	1,000	0.15
Single-Phase, Double Half-Wave	2	1,000	0.30
Single-Phase, Double Half-Wave (Four Tube Series Circuit)	4	2,000	0.30
Three-Phase (Six Tube Series "Y" Circuit)	6	3,000	0.45

General Features

The mercury vapor type of rectifying tube has the desirable property of a low and almost constant potential drop between the cathode and anode when the tube is passing current. Due to their low potential drop a much more efficient rectifier system can be had than is possible by the use of high vacuum rectifier tubes, whose potential drop are relatively high. The constancy of the potential drop with space current makes possible rectifying systems whose regulation depends almost entirely on the regulation of the plate transformers.

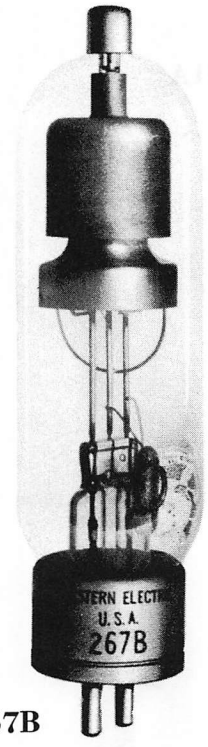
The No. 253A Vacuum Tube employs a highly efficient oxide-coated type of cathode. It's mechanical construction is such that the active materials are maintained for long operating periods as well as during shelf life and shipment.

Western Electric

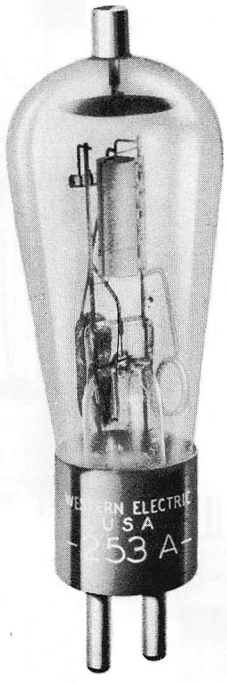
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

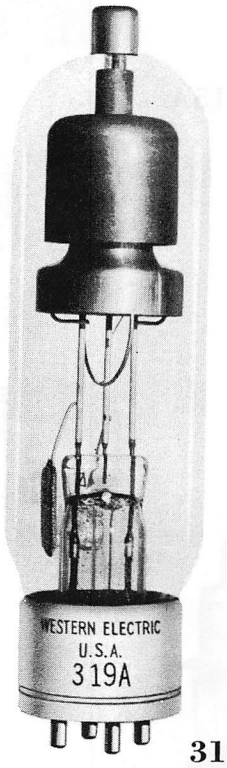
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



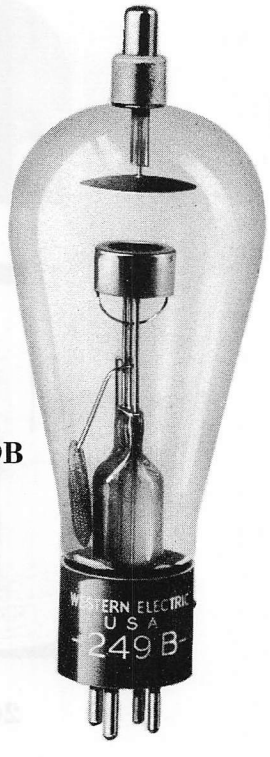
267B



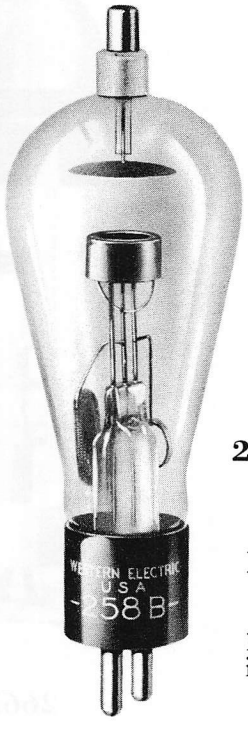
253A



319A



249B

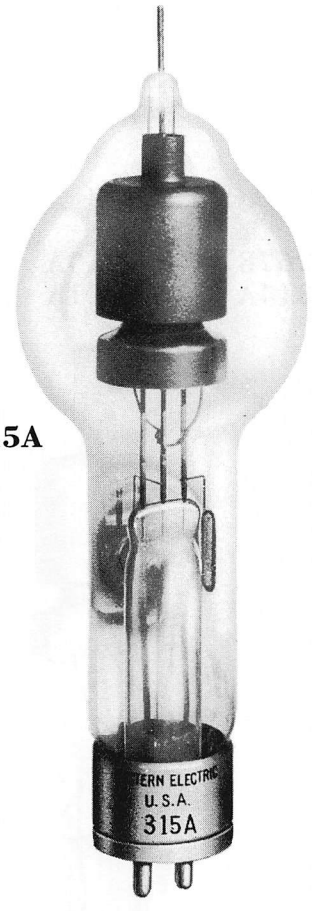


258B

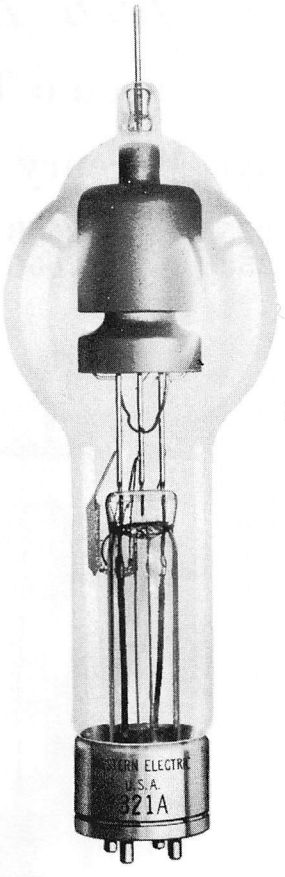
NOTE:

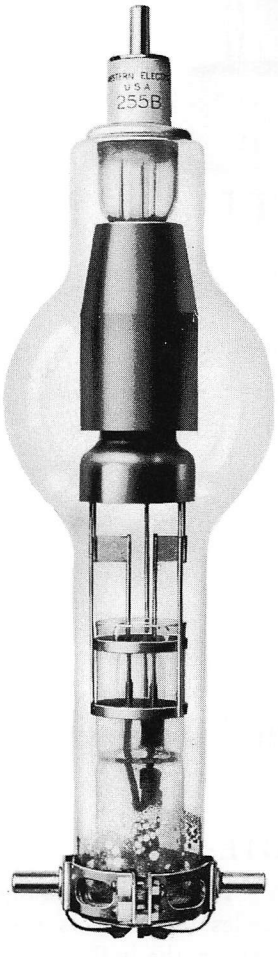
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

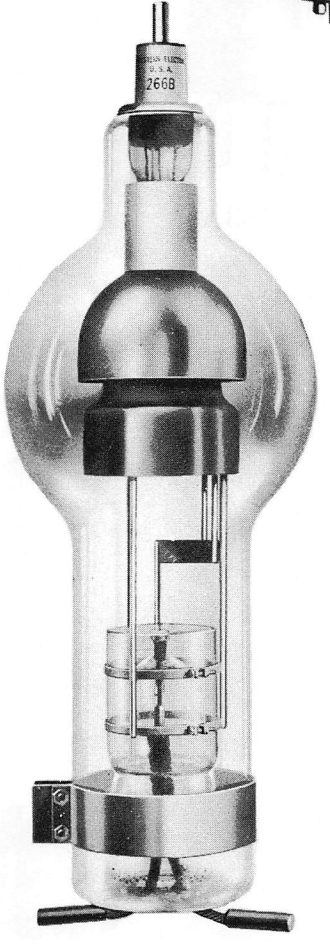


321A

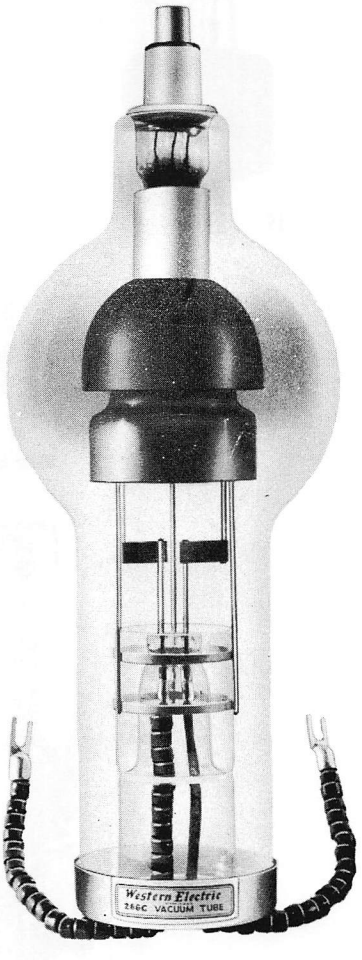




255B



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

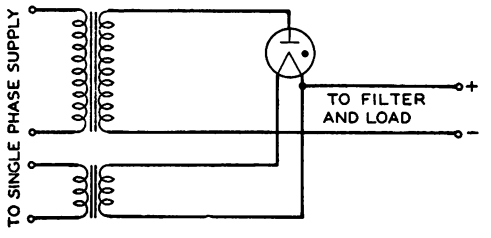
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output 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.

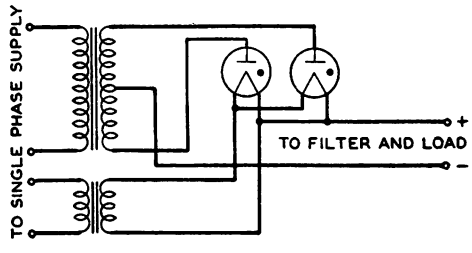
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits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

Circuits

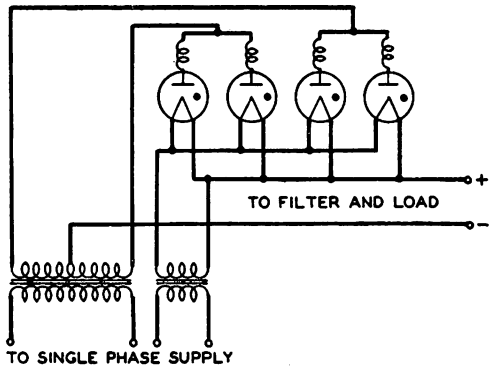
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and 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.



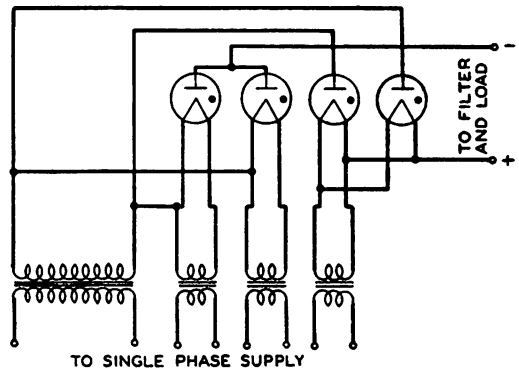
SINGLE PHASE, HALF-WAVE
CIRCUIT A



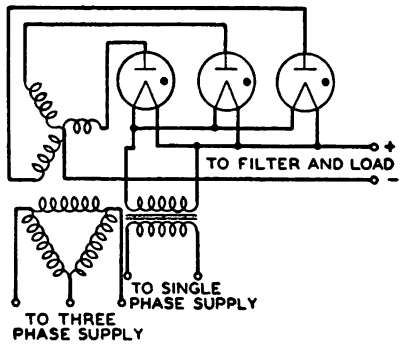
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



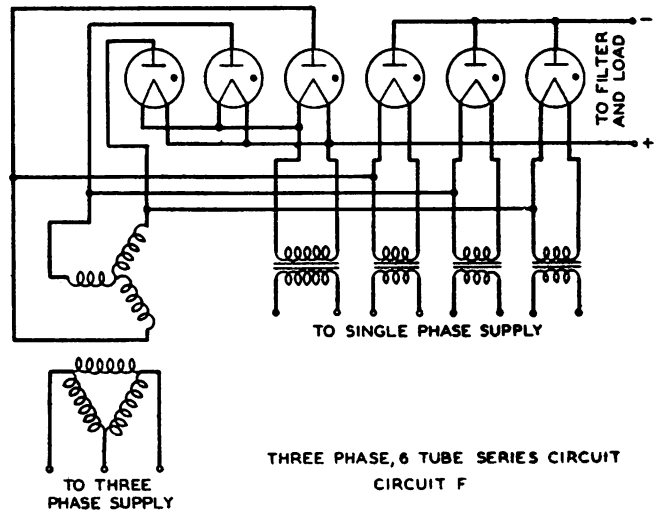
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



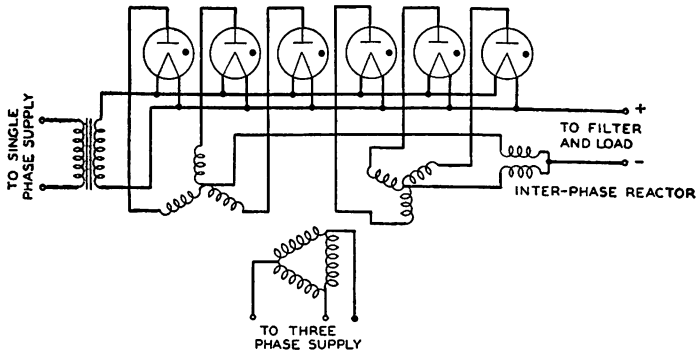
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



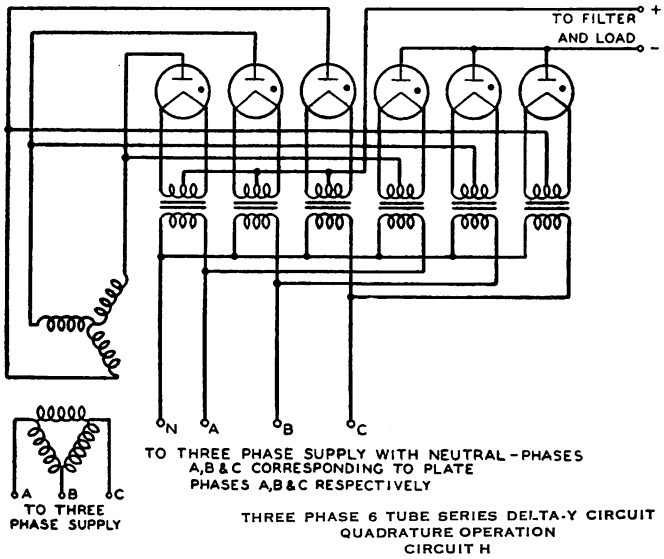
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

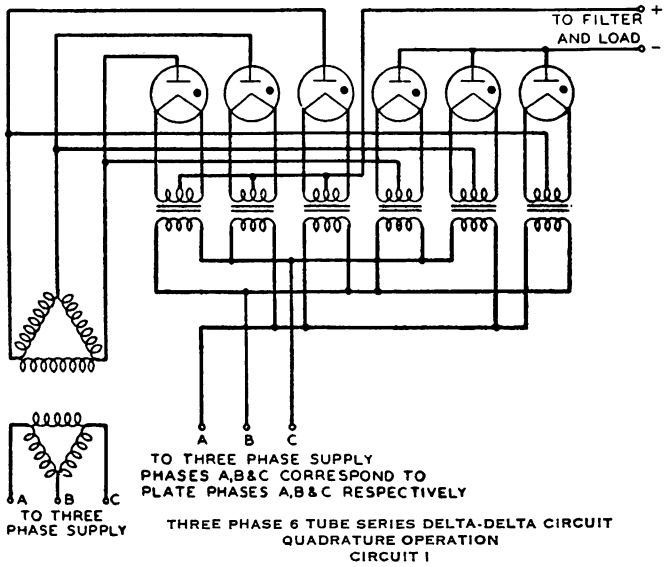


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



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

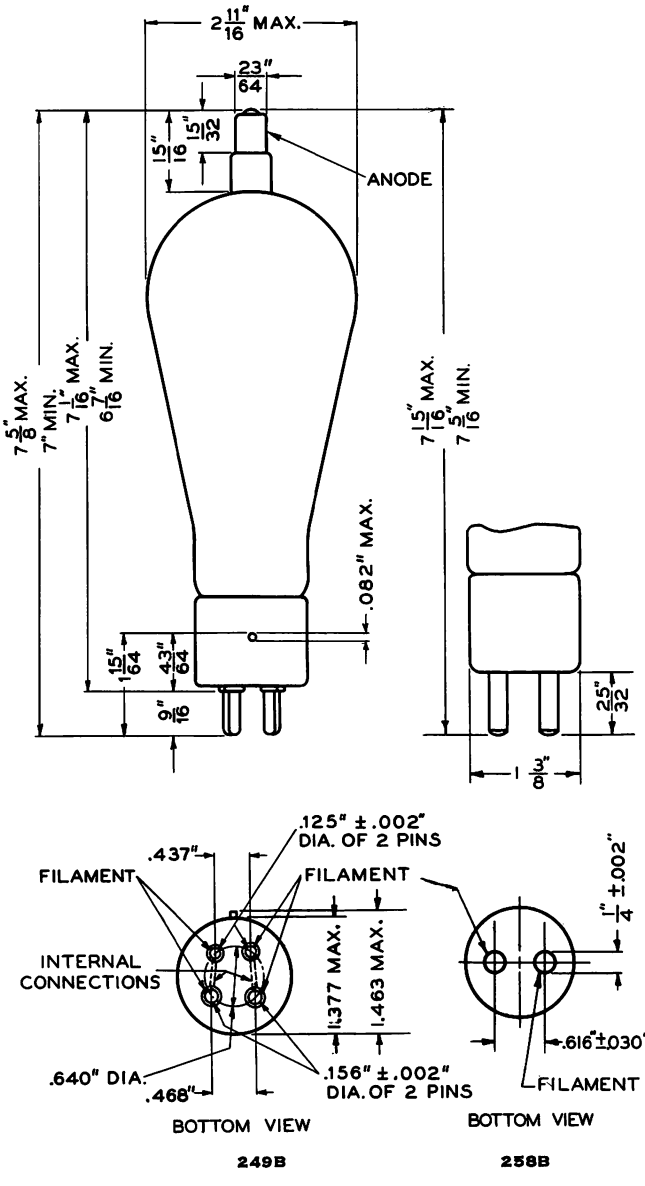
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

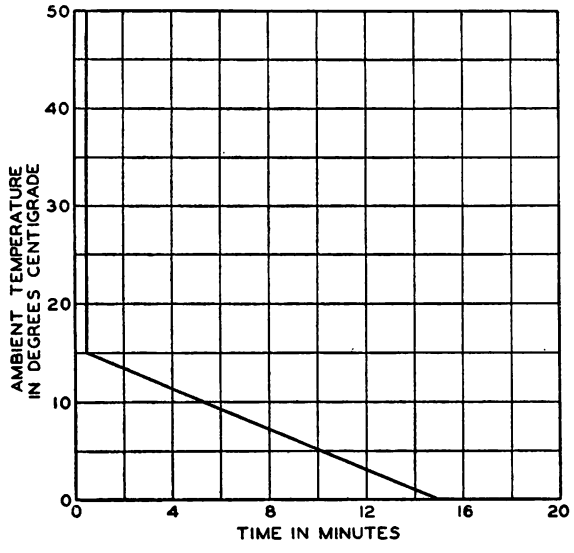


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

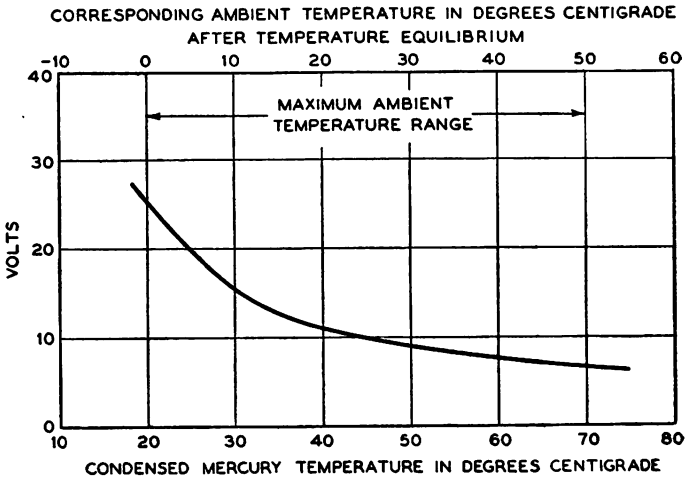
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

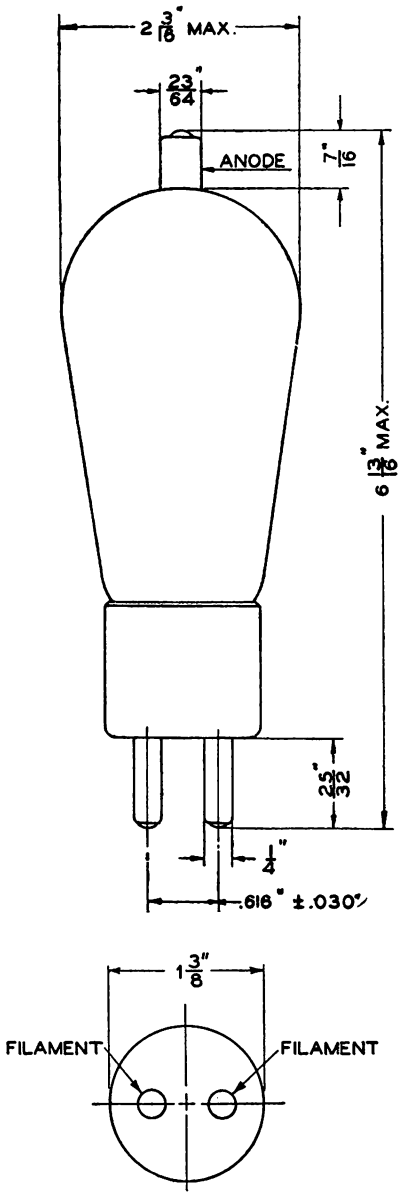
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 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.

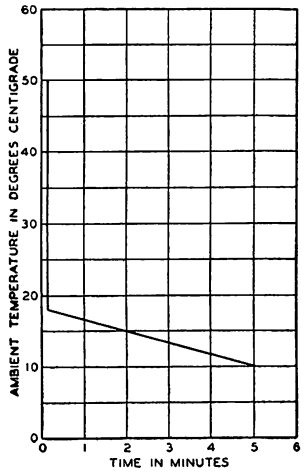
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

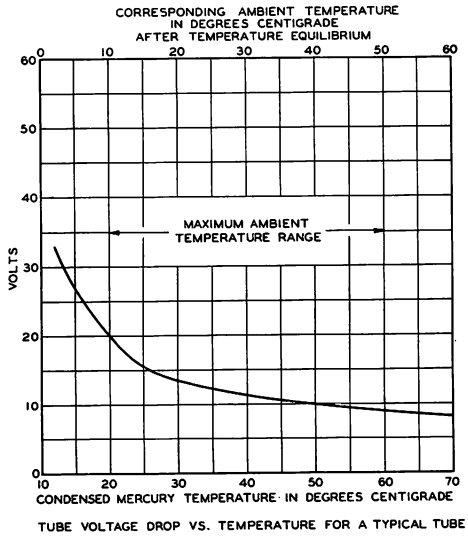
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

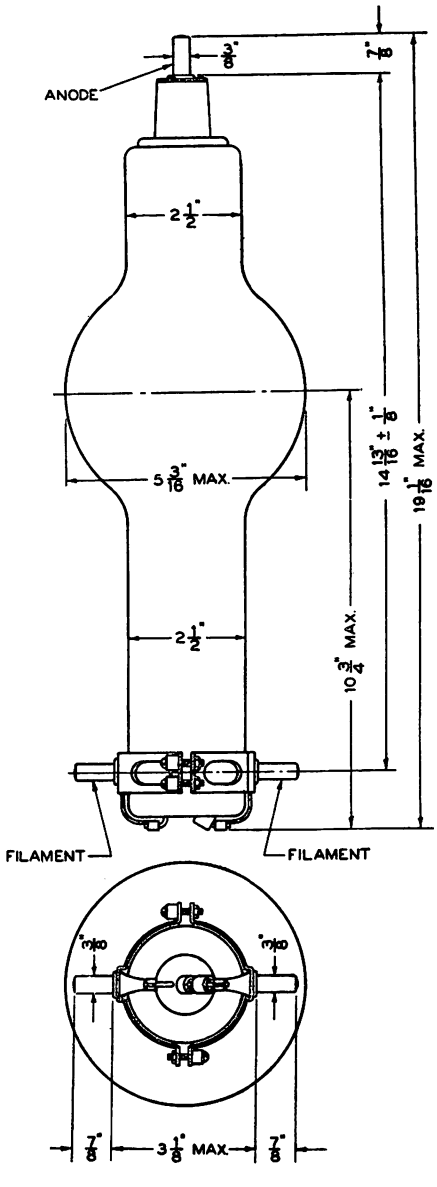
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

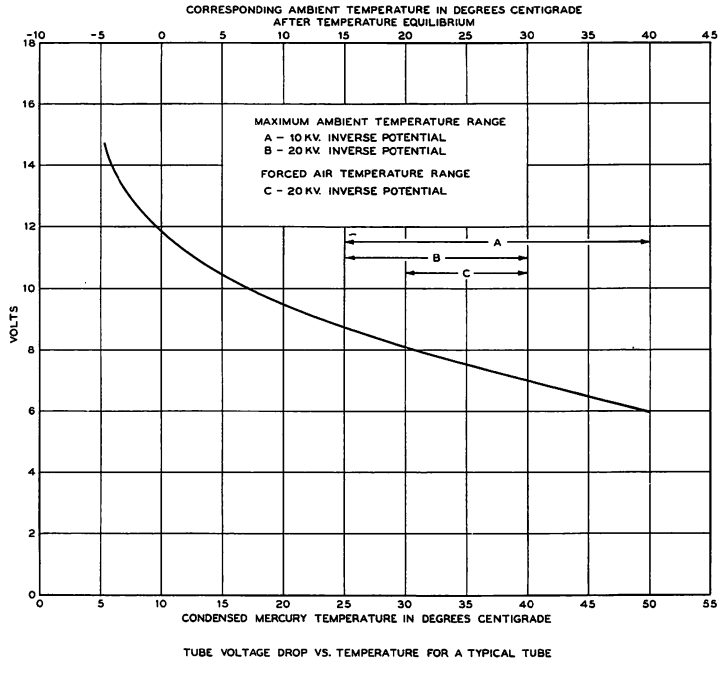
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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.

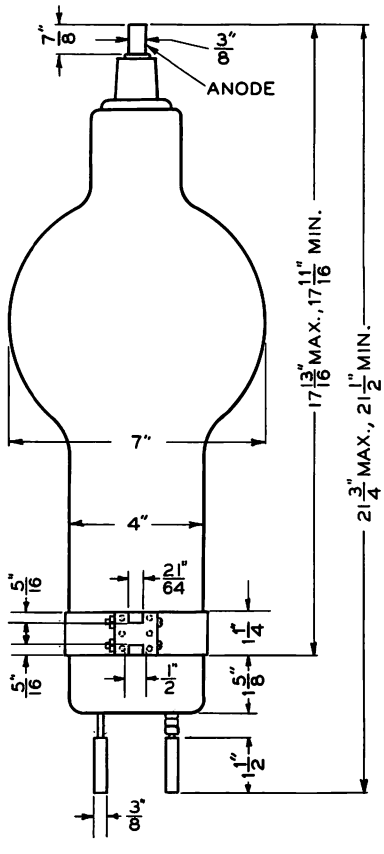
Ratings

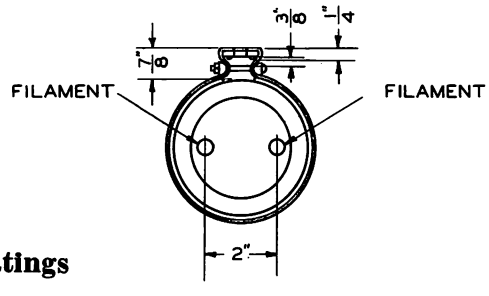
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
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

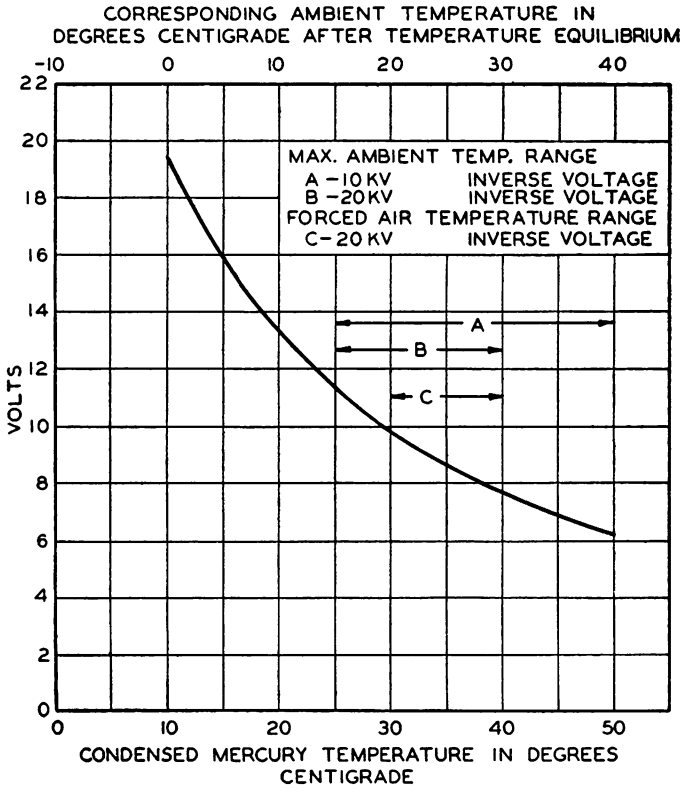
Circuit Outputs:

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

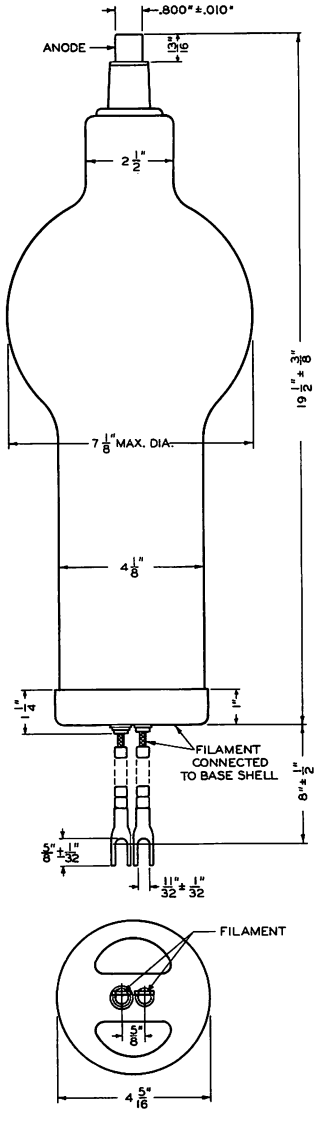
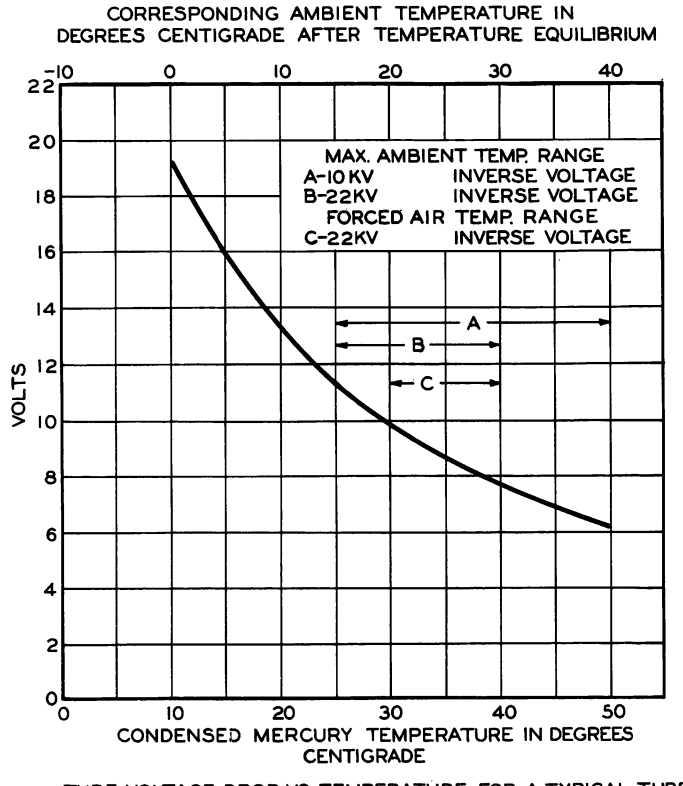


FIG. 1



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

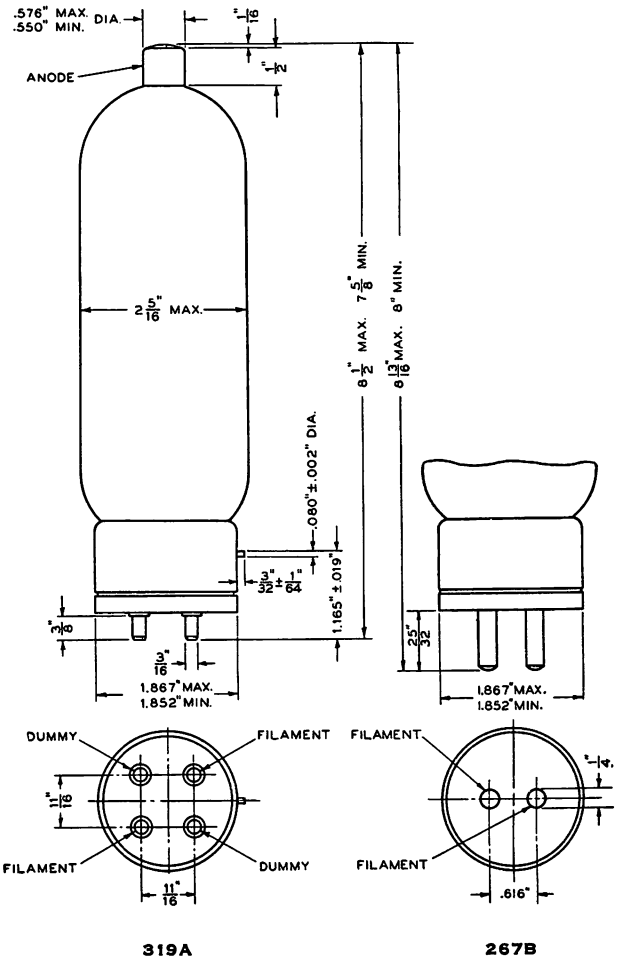
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

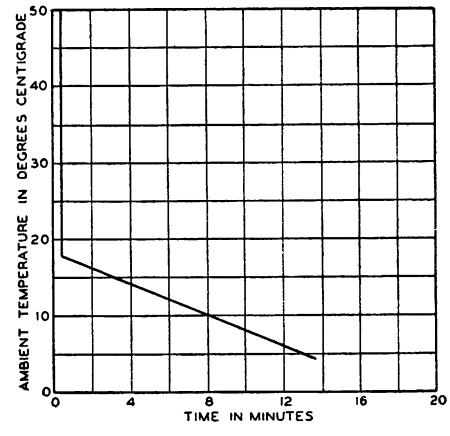
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

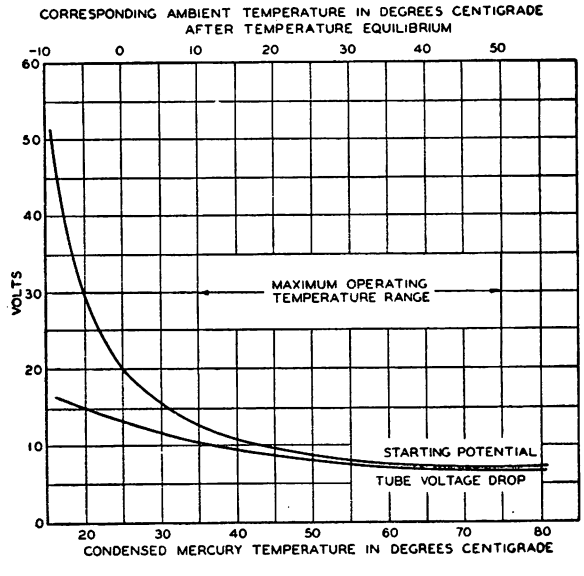
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	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

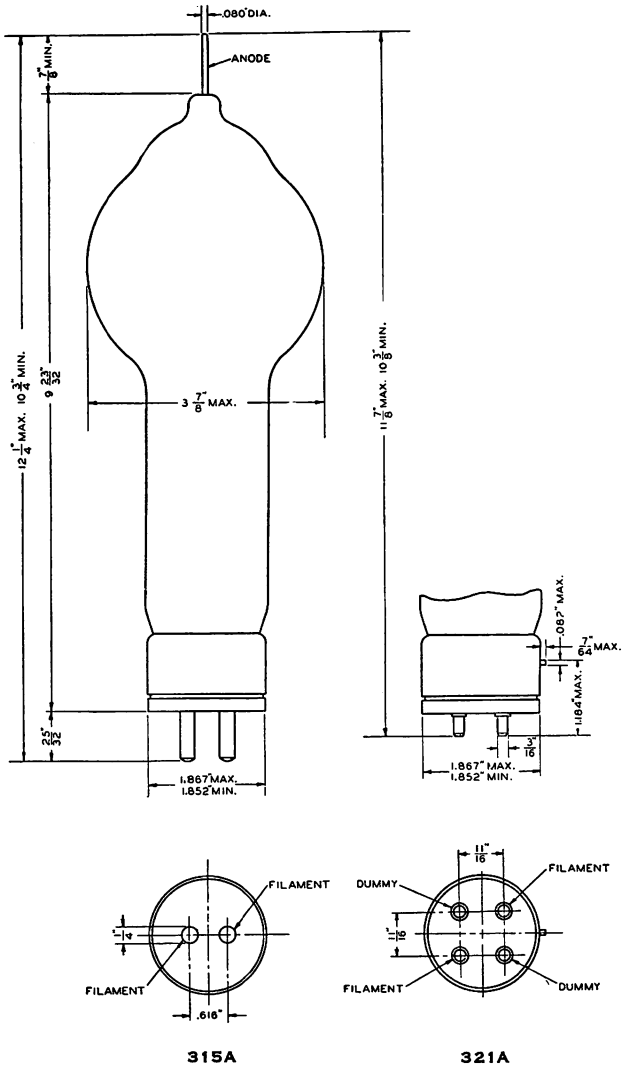
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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.

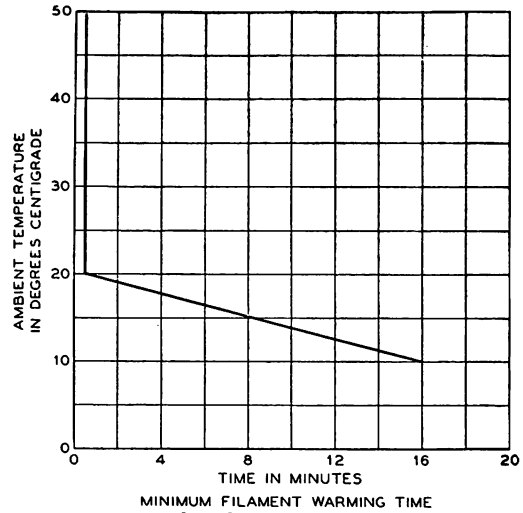
Circuit Outputs:

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

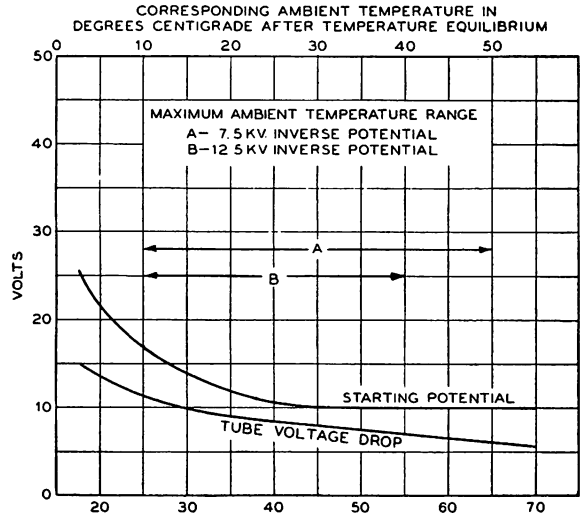
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

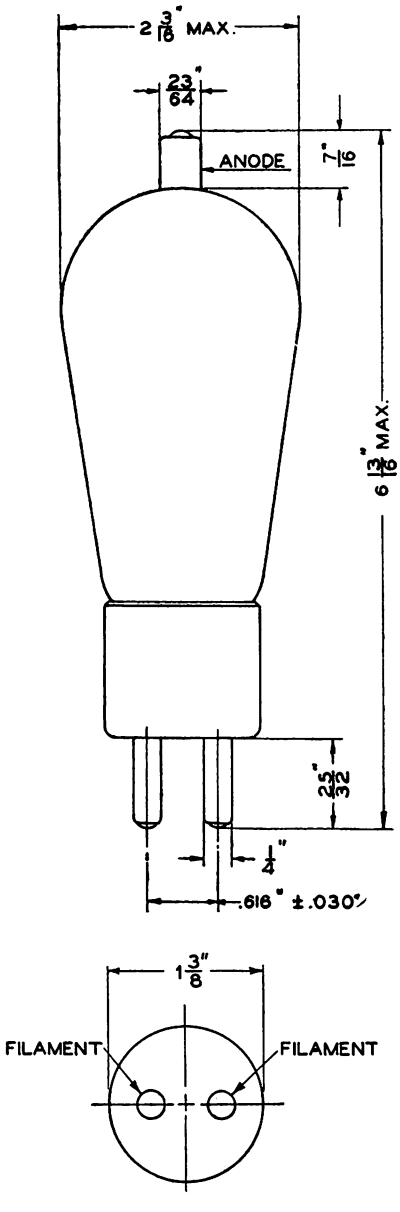
Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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

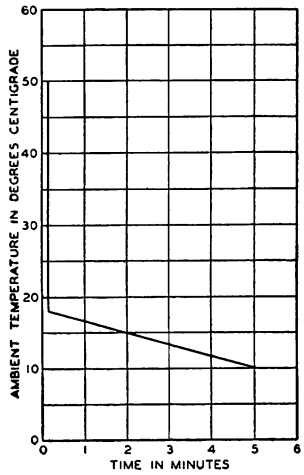
Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

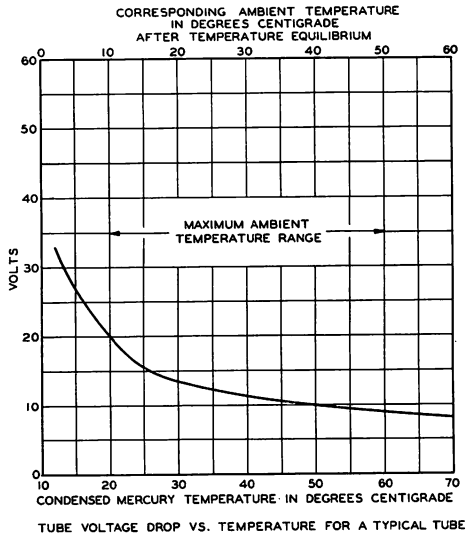
Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Output Voltage: At 12.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	3800	1	2
B	2	2300	3800	2	4
C	4	2300	3800	4	8
D	4	4600	7600	2	4
E	3	3500	5800	3	6
F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

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

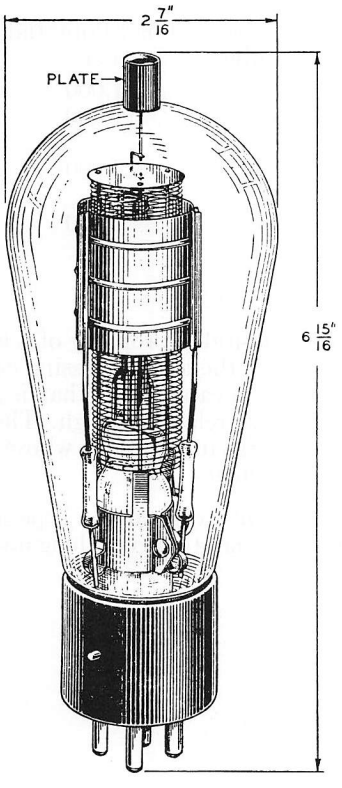
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

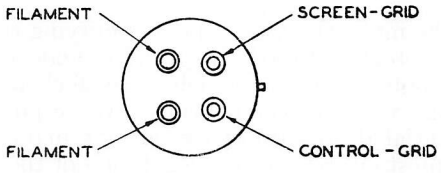
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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

254A Vacuum Tube





Classification

The No. 254A Vacuum Tube is a four-element, screen-grid tube for use as a radio-frequency power-amplifier and as a harmonic-generator at intermediate power levels at high frequencies. It may also be used as an oscillator at high frequencies where the reduced plate to control-grid capacity will be of advantage.

Base and Socket

The No. 254A Vacuum Tube employs a standard four-prong, thrust-type base suitable for use in a Western Electric No. 130B (rigid) or No. 131A (cushion) Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The anode terminal is located at the top of the bulb and is arranged for a special quick-release connector.

Rating and Characteristic Data

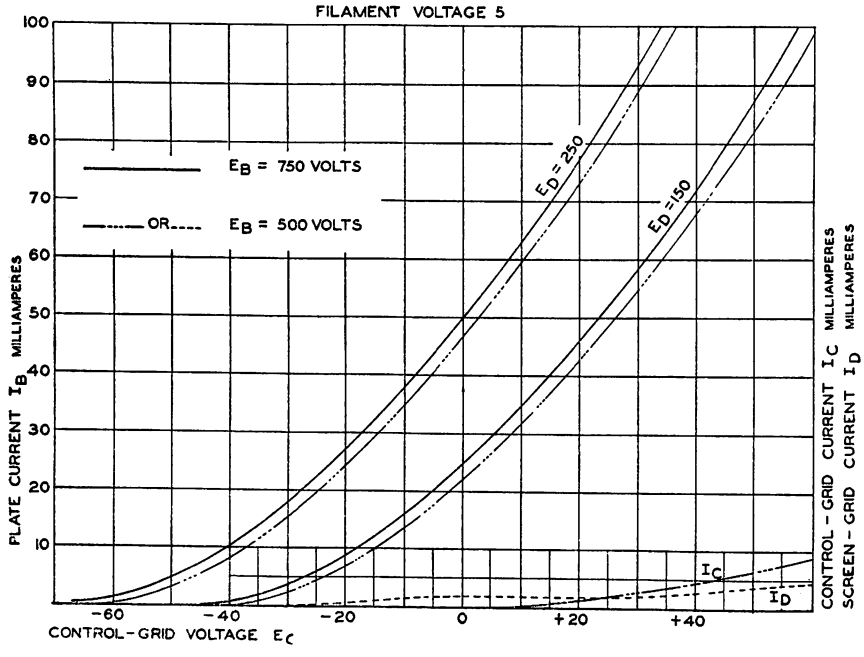
Filament Voltage	5
Filament Current	3.25 Amperes
Average Thermionic Emission	0.6 Ampere
Maximum Plate Voltage	750 Volts
Maximum Plate Current	0.06 Ampere
Maximum Plate Dissipation	20 Watts
Screen Grid Potential	175 Volts
Maximum Screen Grid Dissipation	5 Watts
Average Amplification Factor	80
Average Plate Resistance	80,000 Ohms
Average Mutual Conductance	1,000 Micromhos

Approximate Direct Interelectrode Capacities

Plate to Control Grid	0.1 MMF
Plate to Filament and Screen Grid	9.4 MMF
Control Grid to Filament and Screen Grid	4.6 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 254A Vacuum Tube. These curves are taken with the filament operating on alternating current with the plate, screen and control grid circuit returns connected to a midpoint of the filament transformer.



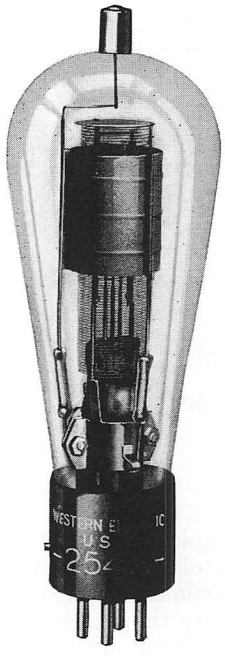
General Features

The No. 254A Vacuum Tube employs an extra grid or screen which provides an electrostatic shield between the plate and control grid. When the potential of the screen is held constant, variations of the plate potential have little effect upon the potential fields around the inner electrodes. Such internal shielding eliminates the necessity of neutralization to prevent unwanted oscillations or feedback if the rest of the circuit elements are properly shielded.

The thoriated tungsten filament of this tube is made in a spiral of such form as to maintain the tube internal impedance low and constant during its life. The mechanical structure has adequate strength for severe usages.

Western Electric

254A Vacuum Tube



Classification—Filamentary air-cooled tetrode

May be used as a radio-frequency amplifier, oscillator or harmonic generator.

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

Maximum overall length	$6\frac{15}{16}$″
Maximum diameter	$2\frac{7}{16}$″

Mounting—Four-pin bayonet type base for use in a W.E. 143B, or similar socket. The anode terminal is located at the top of the bulb.

Filament—Thoriated tungsten

Filament voltage	5.0 volts, a.c. or d.c.
Nominal filament current	3.25 amperes
Average thermionic emission	0.60 ampere

Average Direct Interelectrode Capacitances

Plate to control grid	0.1 $\mu\mu$f
Control grid to filament and screen grid	4.6 $\mu\mu$f
Plate to filament and screen grid	9.4 $\mu\mu$f

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

Figure 3 gives the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at maximum direct plate voltage and dissipation (E_b=750 volts, I_b=27 milliamperes)

Amplification factor	80
Plate resistance	80000 ohms
Grid to plate transconductance	1000 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	750 volts
Max. direct plate current	60 milliamperes
Max. plate dissipation	20 watts
Max. direct grid current	25 milliamperes
Max. r-f grid current	5 amperes
Max screen-grid dissipation	4 watts
Max. frequency for the above ratings	15 megacycles
Max. plate voltage for upper frequency limit of 20 Mc	500 volts
Max. plate voltage for frequencies between 15 and 20 Mc in proportion	

Class B Radio-Frequency Amplifier

Direct plate voltage	750	500 volts
Direct plate current for carrier conditions	40	60 milliamperes
Control-grid bias	−40	−40 volts
Direct screen-grid voltage	175	175 volts
Approx. carrier watts for use with 100% modulation	10	10 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	750	500 volts
Direct plate current	60	60 milliamperes
Control-grid bias	−60 to −80	−60 to −80 volts
Direct screen-grid voltage	175	175 volts
Nominal power output	30	20 watts
Plate dissipation	15	10 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	500	350 volts
Direct plate current	60	60 milliamperes
Control-grid bias	−80	−75 volts
Direct screen-grid voltage	175	175 volts
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	20	14 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 75 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 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.

The voltage for the screen grid may be obtained from a separate source or from a potentiometer or series resistor in the plate supply. The screen-grid voltage should not be applied without the plate voltage.

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—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. The tube may be used at full rating up to 15 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.

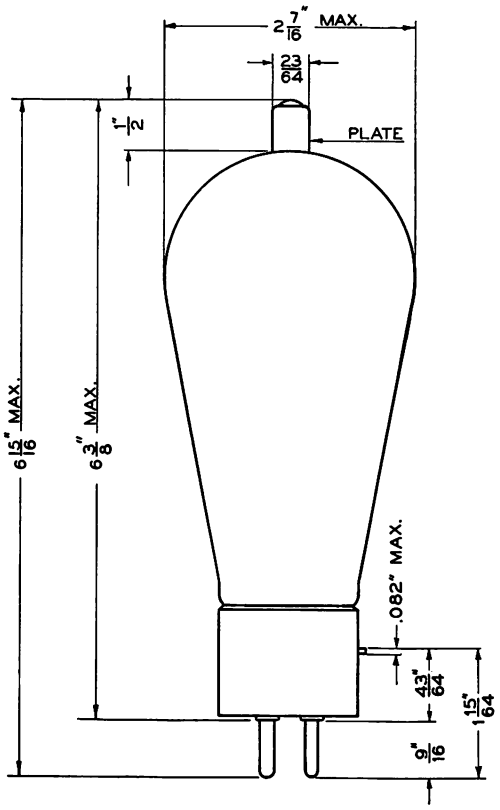


FIG. 1

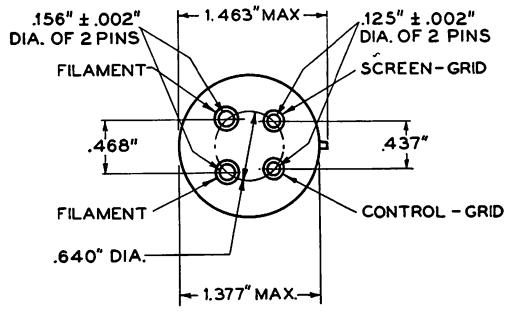


FIG. 2

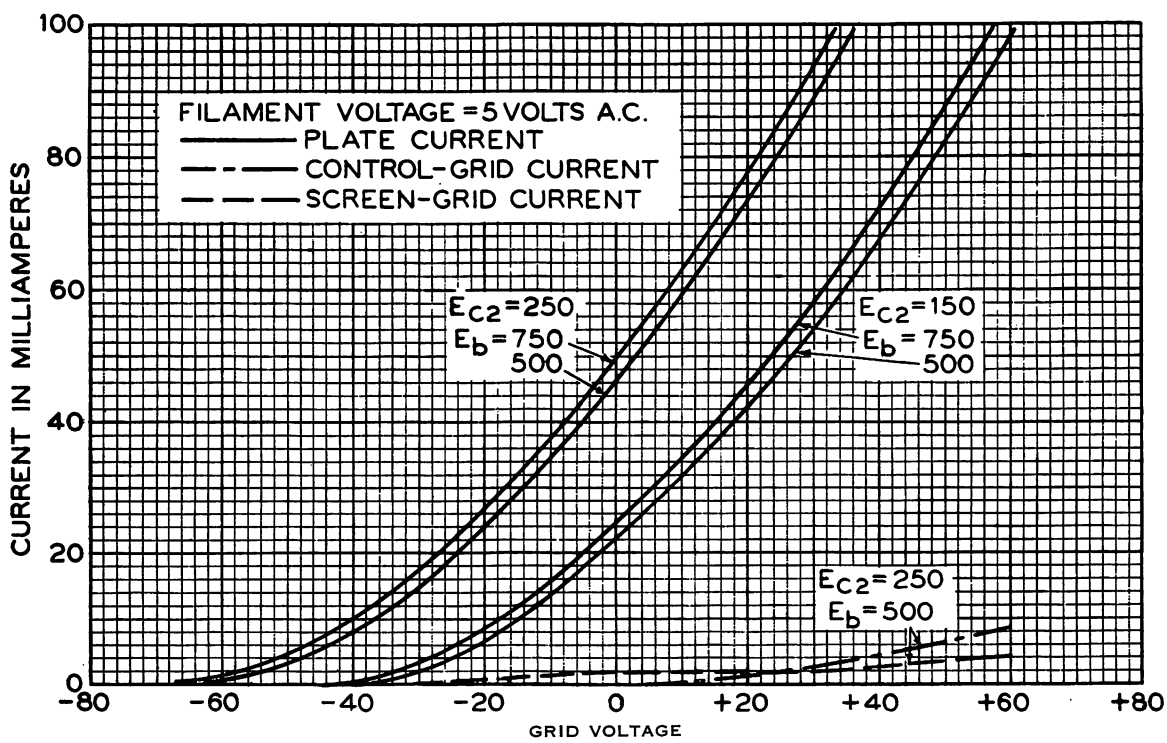
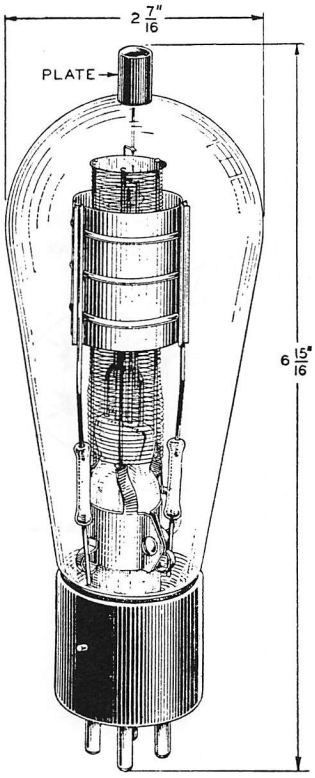
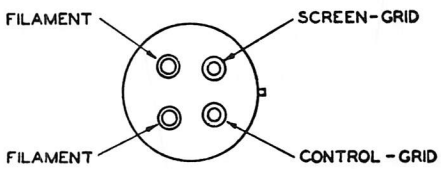


FIG. 3

254B Vacuum Tube





Classification

The No. 254B Vacuum Tube is a four-element, screen-grid tube for use as a radio-frequency power-amplifier and as a harmonic-generator at intermediate power levels at high frequencies. It may also be used as an oscillator at high frequencies where the reduced plate to control-grid capacity will be of advantage.

Base and Socket

The No. 254B Vacuum Tube employs a standard four-prong, thrust-type base suitable for use in a Western Electric No. 130B (rigid) or No. 131A (cushion) Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The anode terminal is located at the top of the bulb and is arranged for a special, quick-release connector.

Rating and Characteristic Data

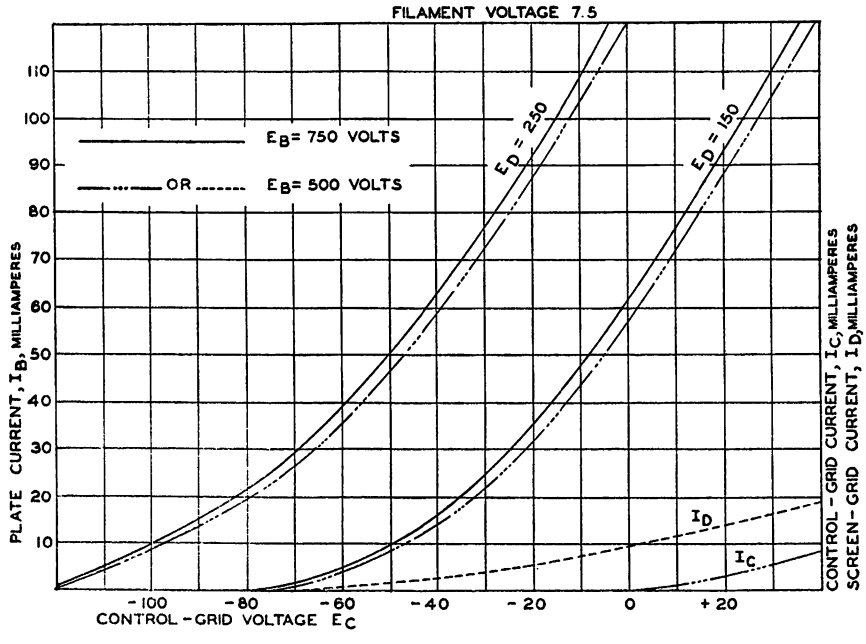
Filament Voltage	7.5
Filament Current	3.25 Amperes
Average Thermionic Emission	1.0 Ampere
Maximum Plate Voltage	750 Volts
Maximum Plate Current	0.075 Ampere
Maximum Plate Dissipation	25 Watts
Screen Grid Potential	150 Volts
Maximum Screen Grid Dissipation	5 Watts
Average Amplification Factor	100
Average Plate Resistance	75,000 Ohms
Average Mutual Conductance	1,330 Micromhos

Approximate Direct Interelectrode Capacities

Plate to Control Grid	0.085 MMF
Plate to Filament and Screen Grid	5.4 MMF
Control Grid to Filament and Screen Grid	11.2 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 254B Vacuum Tube. These curves are taken with the filament operating on alternating current with the plate, screen and control grid circuit returns connected to a midpoint of the filament transformer.



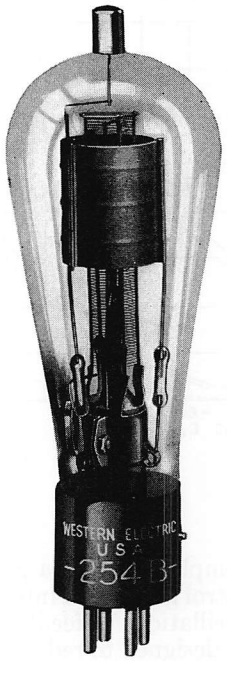
General Features

The No. 254B Vacuum Tube employs an extra grid or screen which provides an electrostatic shield between the plate and control grid. Such internal shielding eliminates the necessity of neutralization to prevent unwanted oscillations or feedback if the rest of the circuit elements are properly shielded. The screen has been designed to reduce secondary emission to a minimum.

The thoriated tungsten filament of this tube is made in a spiral of such form as to maintain the tube internal impedance low and constant during its life. The mechanical structure has adequate strength for severe usages.

Western Electric

254B Vacuum Tube



Classification—Filamentary air-cooled tetrode

May be used as a radio-frequency amplifier, oscillator or modulator.

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

Maximum overall length	$6\frac{15}{16}$″
Maximum diameter	$2\frac{7}{16}$″

Mounting—Four-pin bayonet type base for use in a W.E. 143B, or similar socket. The anode terminal is located at the top of the bulb.

Filament—Thoriated tungsten

Filament voltage	7.5 volts, a.c. or d.c.
Nominal filament current	3.25 amperes
Average thermionic emission	1.0 ampere

Average Direct Interelectrode Capacitances

Plate to control grid	.085 $\mu\mu$f
Control grid to filament and screen grid	11.2 $\mu\mu$f
Plate to filament and screen grid	5.4 $\mu\mu$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 maximum direct plate voltage and dissipation ($E_b = 750$ volts, $I_b = 33$ milliamperes, $E_{c2} = 150$ volts)

Amplification factor	100
Plate resistance	86,000 ohms
Grid to plate transconductance	1,160 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	750 volts
Max. direct plate current	75 milliamperes
Max. plate dissipation	25 watts
Max. direct grid current	25 milliamperes
Max. r-f grid current	5 amperes
Max. screen-grid dissipation	4 watts
Max. frequency for the above ratings	15 megacycles
Max. plate voltage for upper frequency limit of 20 Mc	500 volts
Max. plate voltage for frequencies between 15 and 20 Mc in proportion	

Class B Radio-Frequency Amplifier

Direct plate voltage	750	500 volts
Direct plate current for carrier conditions	50	75 milliamperes
Control grid bias	−70	−70 volts
Direct screen-grid voltage	150	150 volts
Approx. carrier watts for use with 100% modulation	12.5	12.5 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	750	500 volts
Direct plate current	75	75 milliamperes
Control grid bias	−105 to −140	−105 to −140 volts
Direct screen-grid voltage	150	150 volts
Nominal power output	37.5	25 watts
Plate dissipation	18.5	12.5 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	500	350 volts
Direct plate current	75	75 milliamperes
Control grid bias	−140	−140 volts
Direct screen-grid voltage	150	150 volts
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	25	17.5 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 100 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 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.

The voltage for the screen grid may be obtained from a separate source or from a potentiometer or series resistor in the plate supply. The screen-grid voltage should not be applied without the plate voltage.

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—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. The tube may be used at full rating up to 15 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.

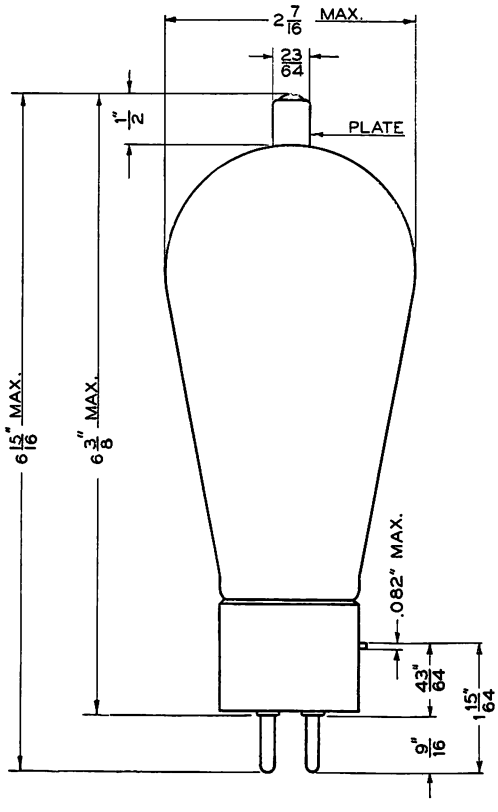


FIG. 1

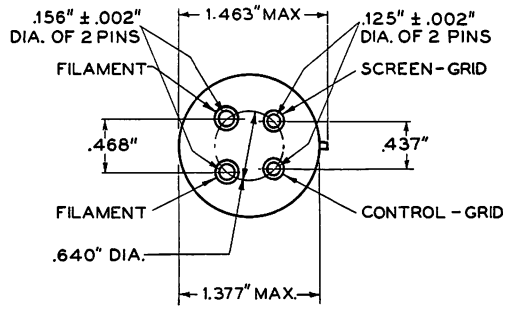


FIG. 2

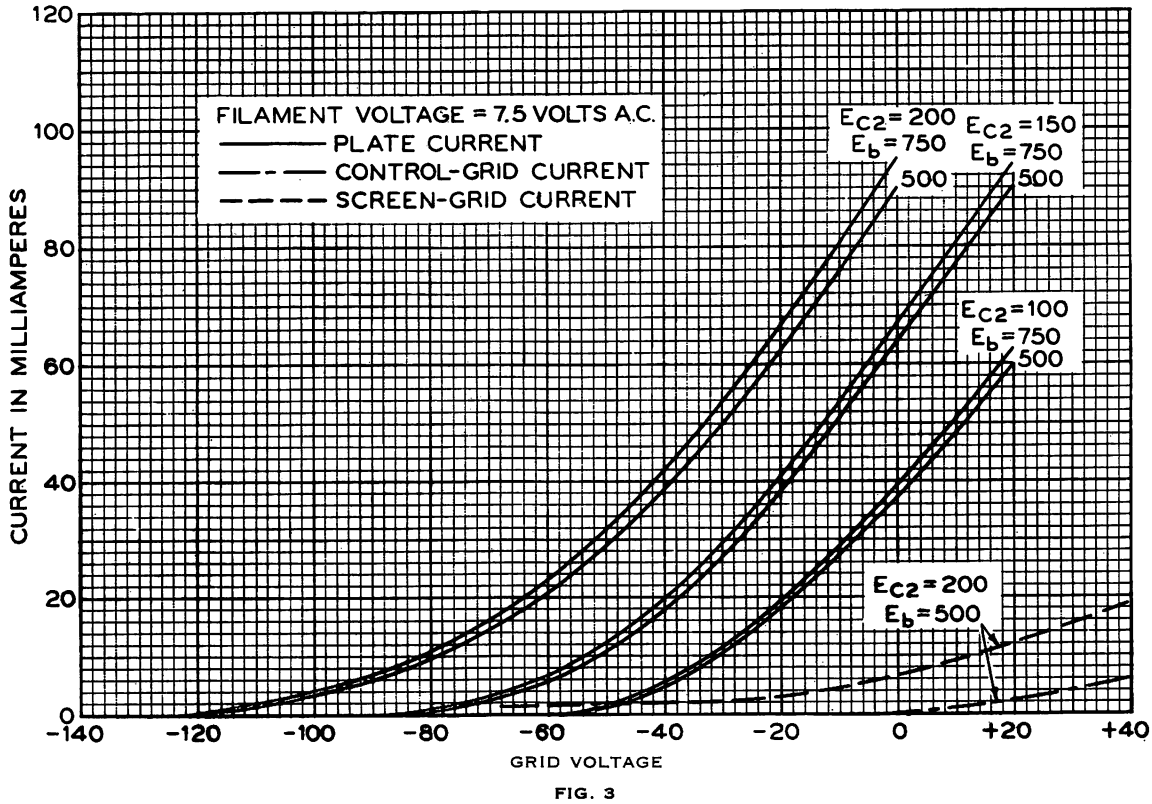


FIG. 3

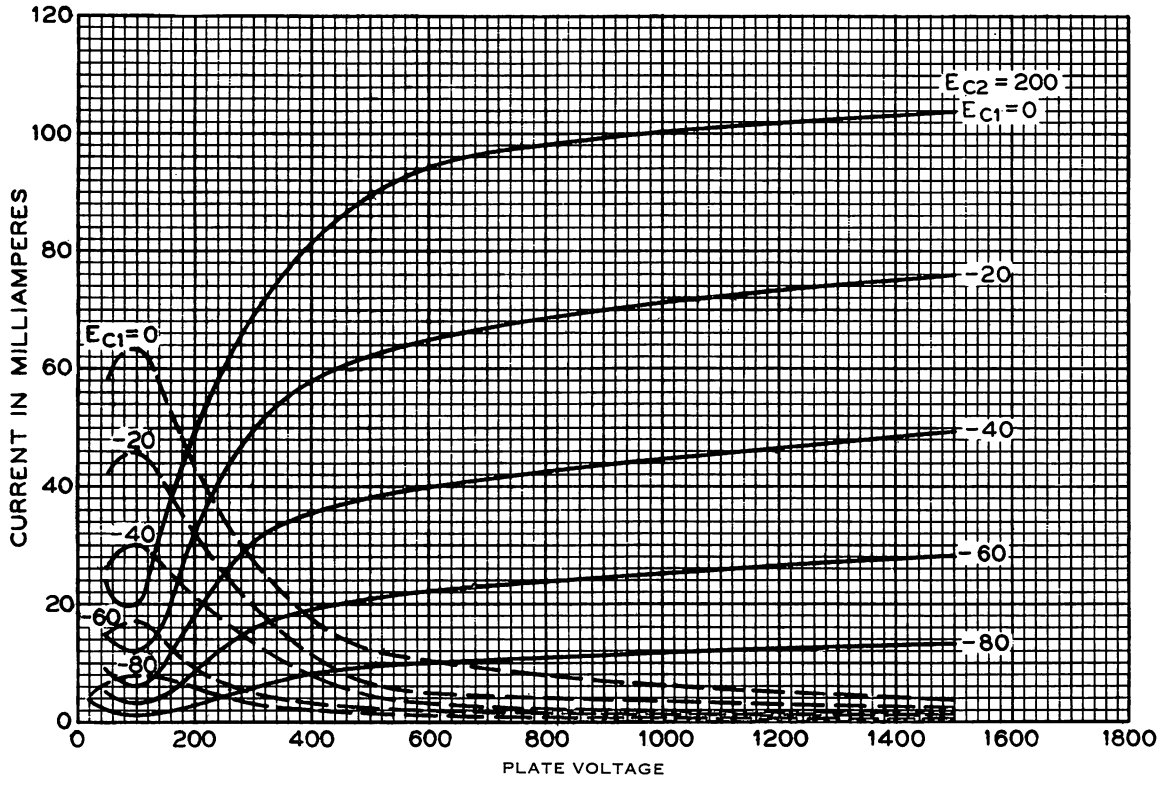

120
100
80
60
40
20
0
CURRENT IN MILLIAMPERES
0
200
400
600
800
1000
1200
1400
1600
1800
PLATE VOLTAGE
E_{C2} = 200
E_{C1} = 0
-20
-40
-60
-80
E_{C1} = 0
-20
-40
-60
-80

FIG. 4

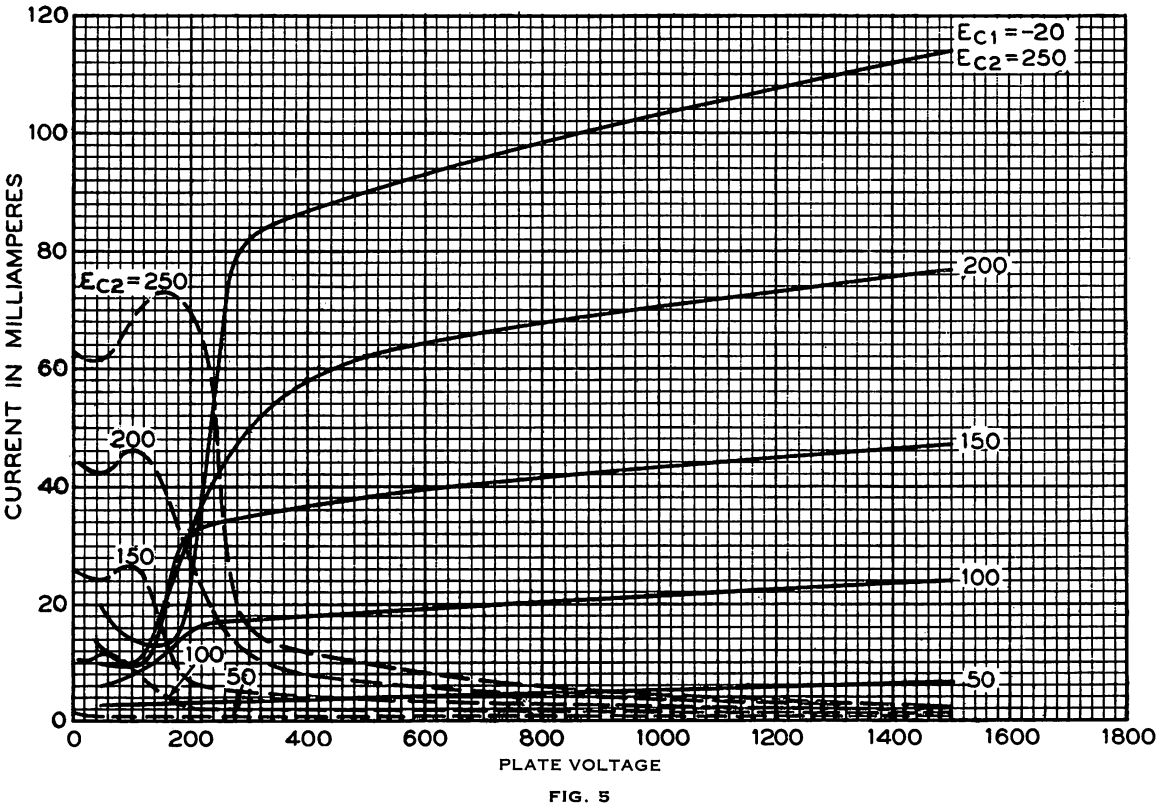
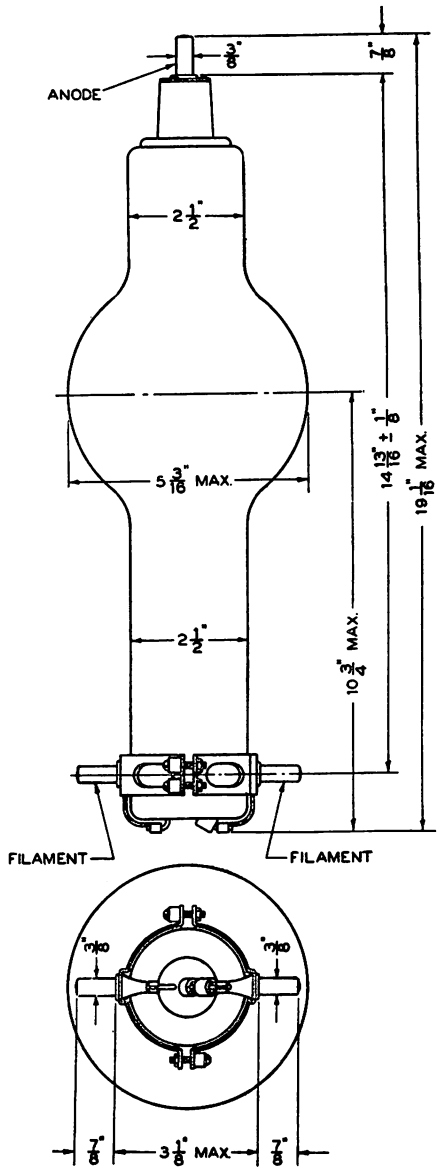
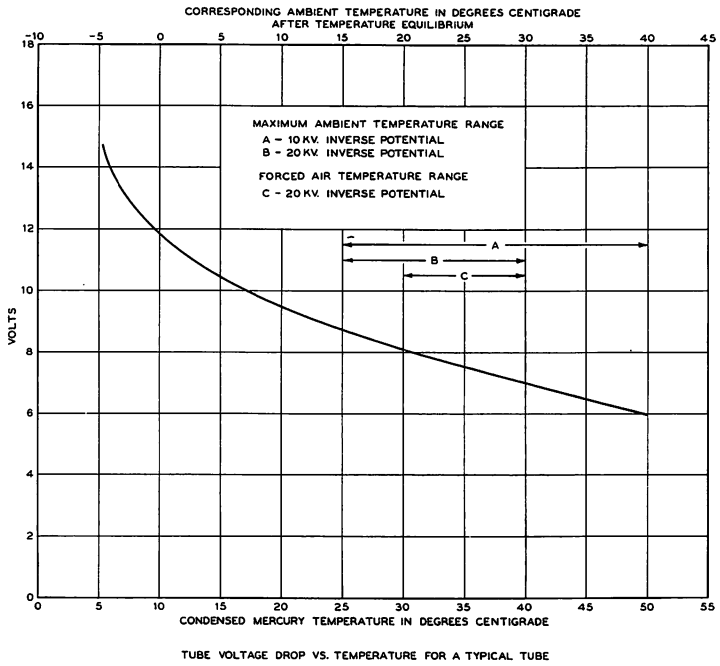

120
100
80
60
40
20
0
CURRENT IN MILLIAMPERES
0
200
400
600
800
1000
1200
1400
1600
1800
PLATE VOLTAGE
E_{C1} = -20
E_{C2} = 250
200
150
100
50
E_{C2} = 250
200
150
100
50

FIG. 5

255B Vacuum Tube





TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

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

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.

Circuit Outputs:

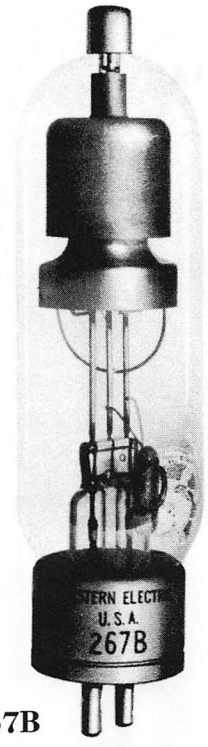
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 20 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6000	2	4
B	2	3000	6000	4	8
C	4	3000	6000	8	16
D	4	6000	12000	4	8
E	3	4500	9000	6	12
F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

Western Electric

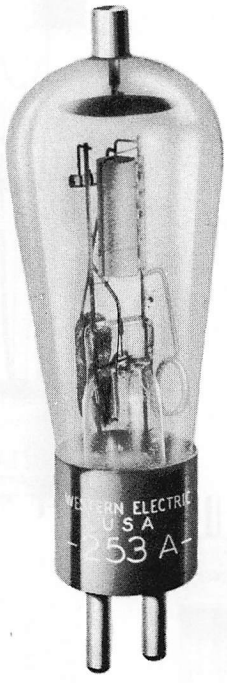
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

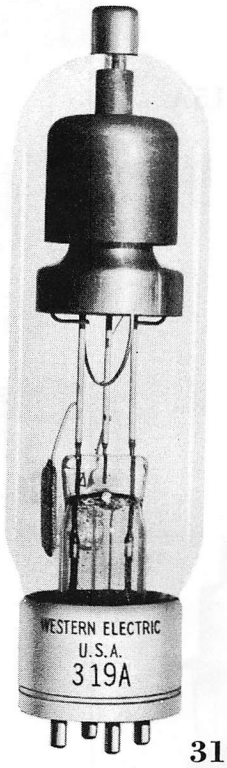
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



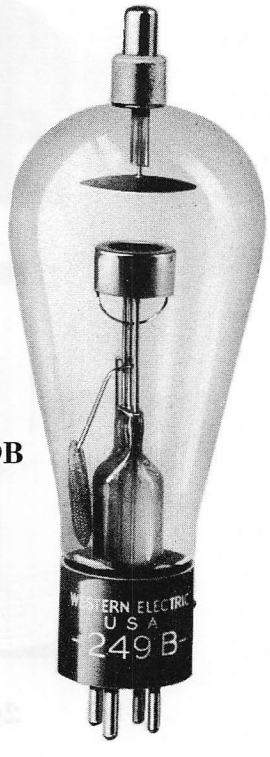
267B



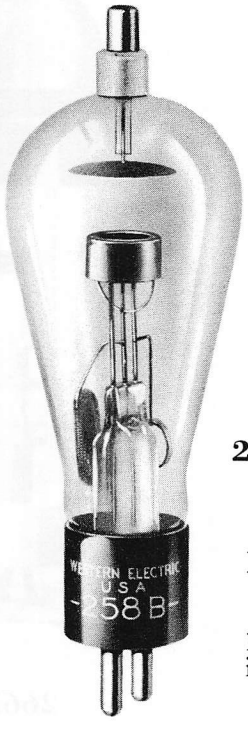
253A



319A



249B

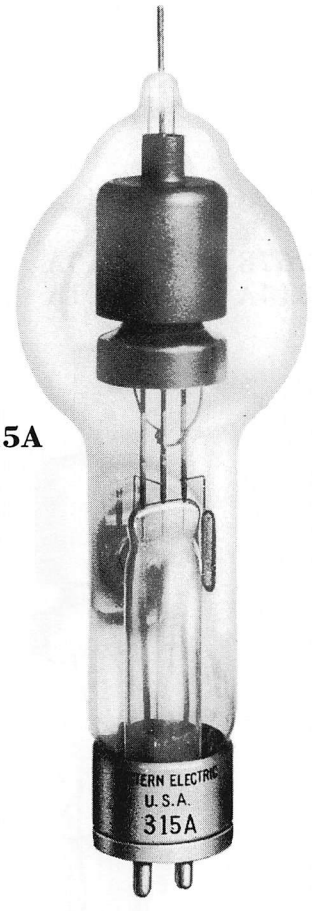


258B

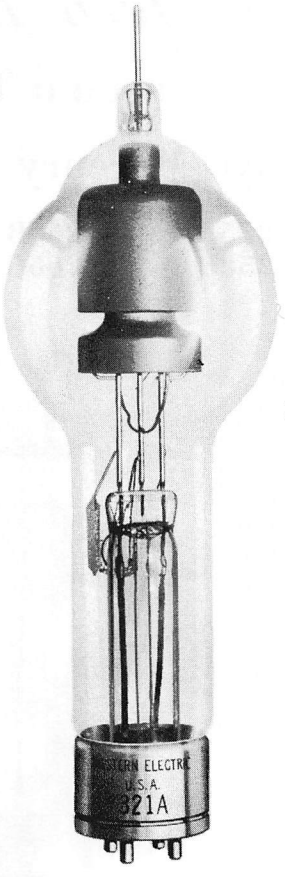
NOTE:

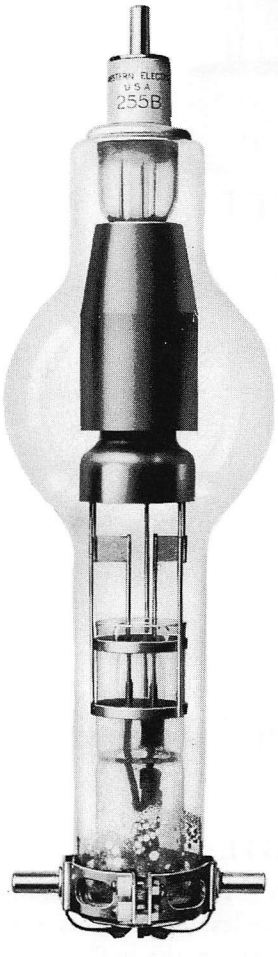
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

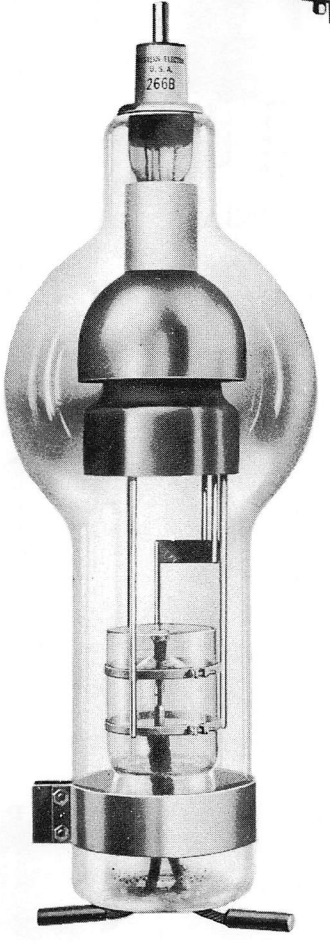


321A

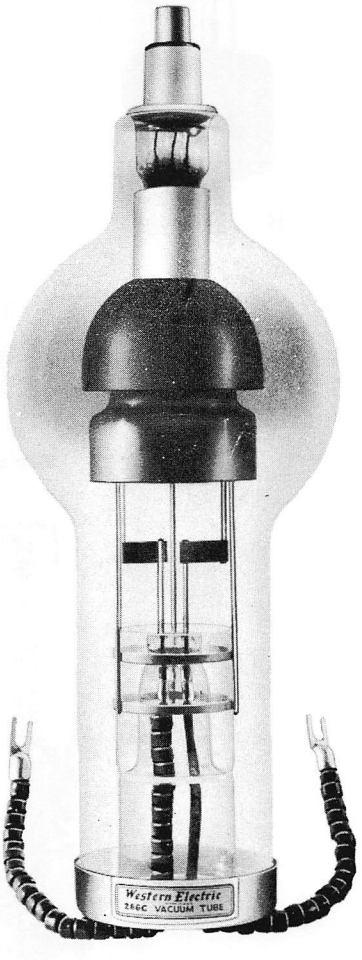




255B



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

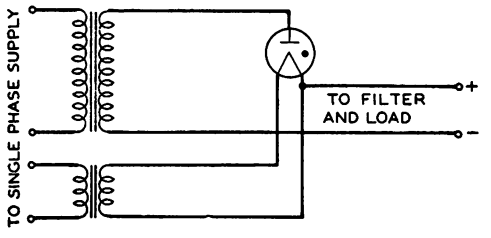
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output 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.

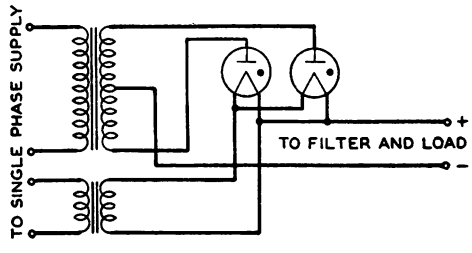
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits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

Circuits

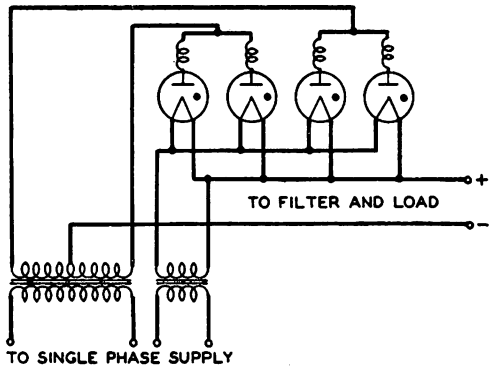
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and 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.



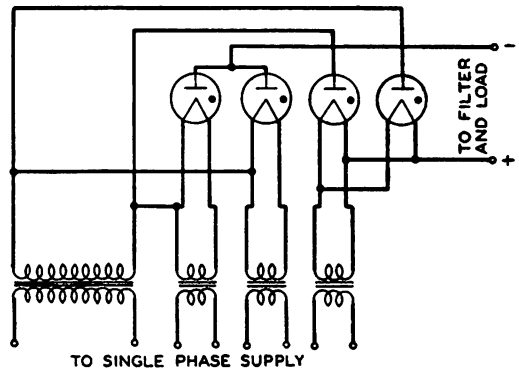
SINGLE PHASE, HALF-WAVE
CIRCUIT A



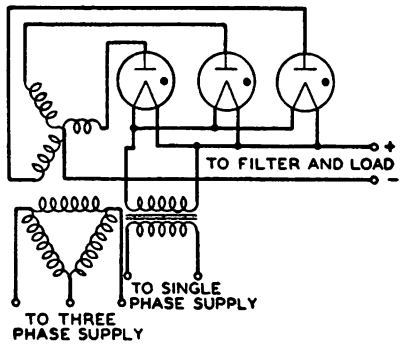
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



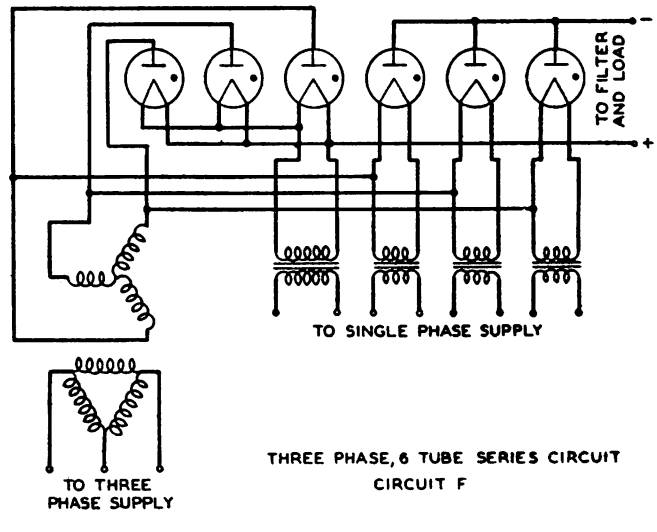
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



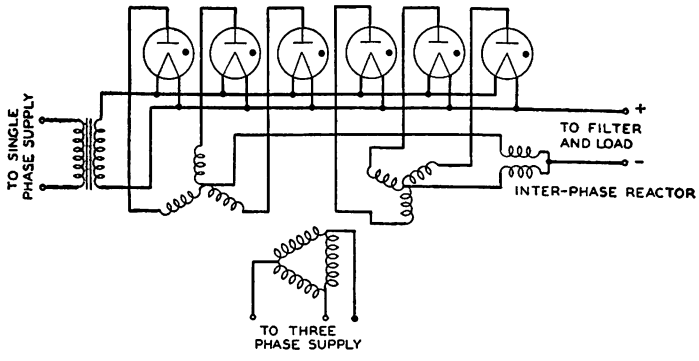
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



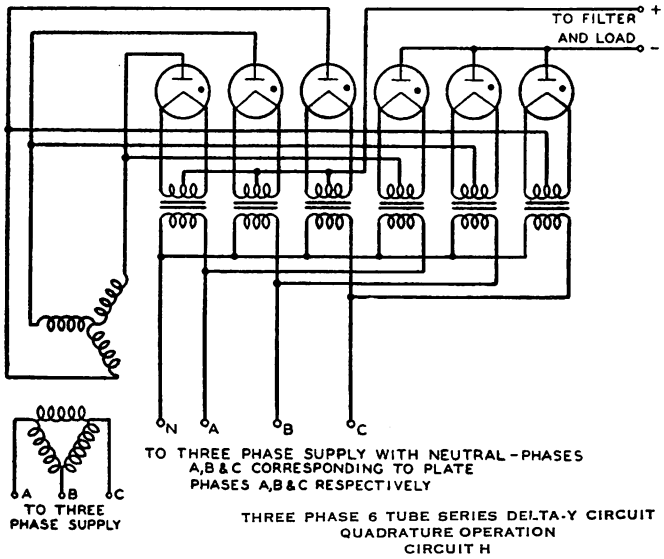
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

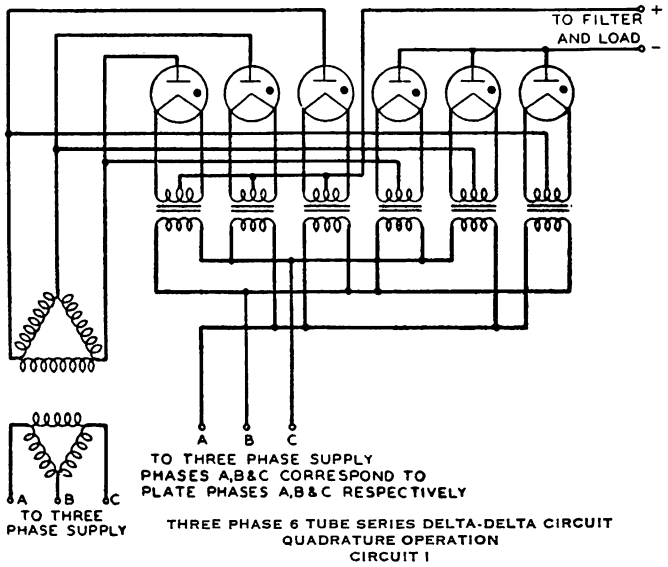


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



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

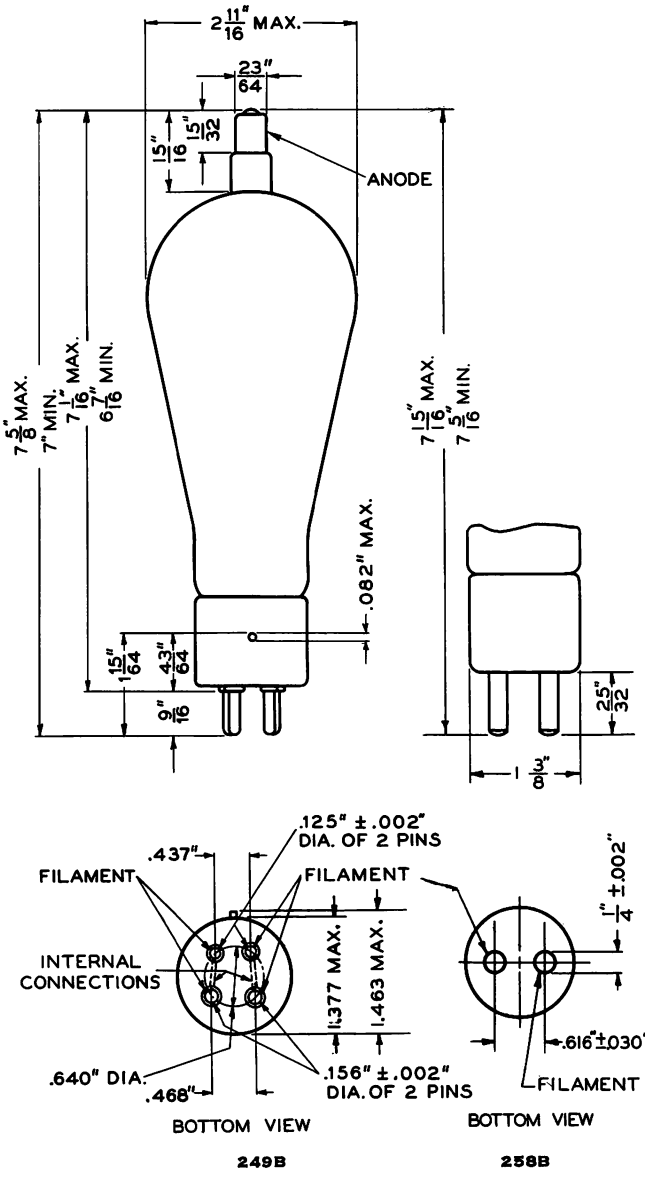
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

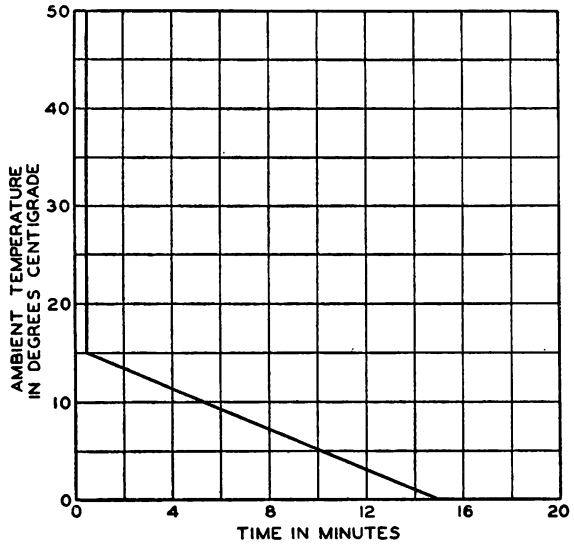


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

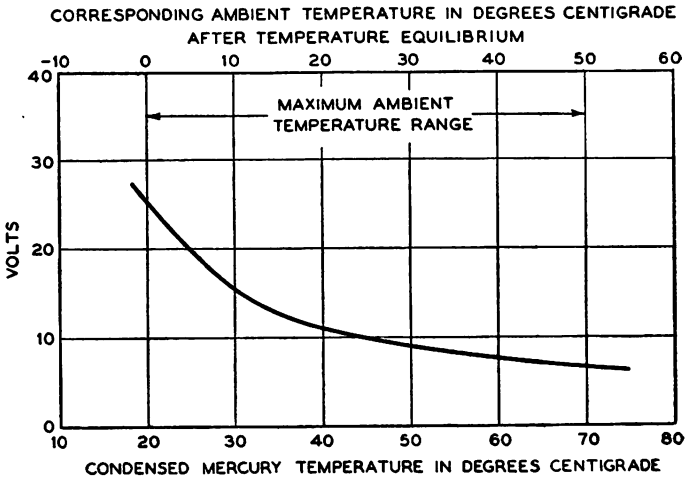
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

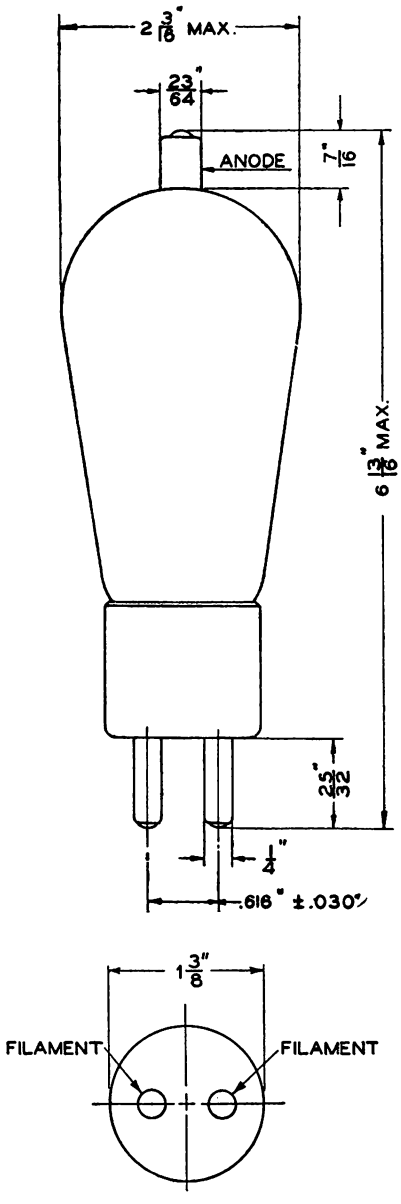
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 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.

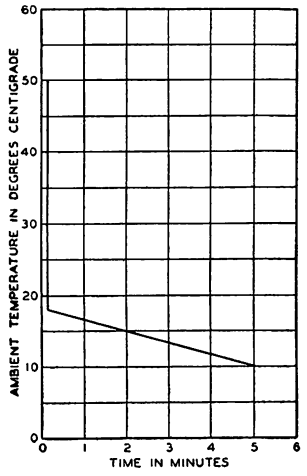
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

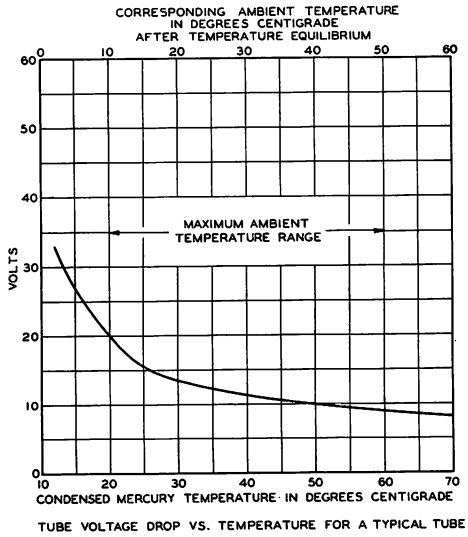
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

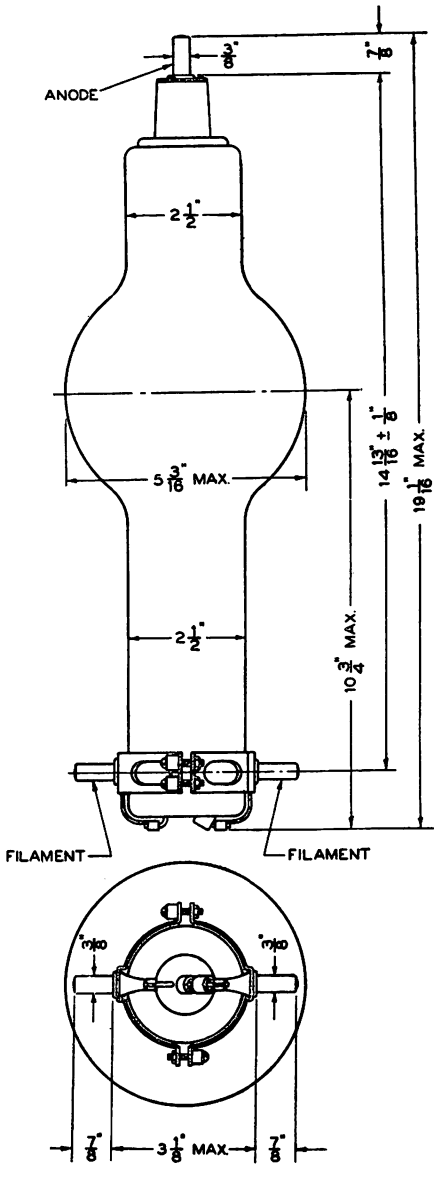
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

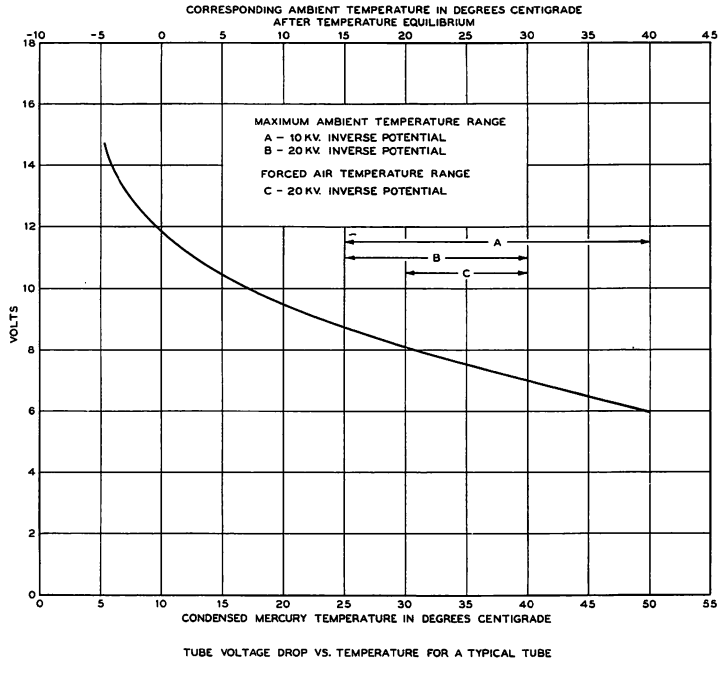
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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.

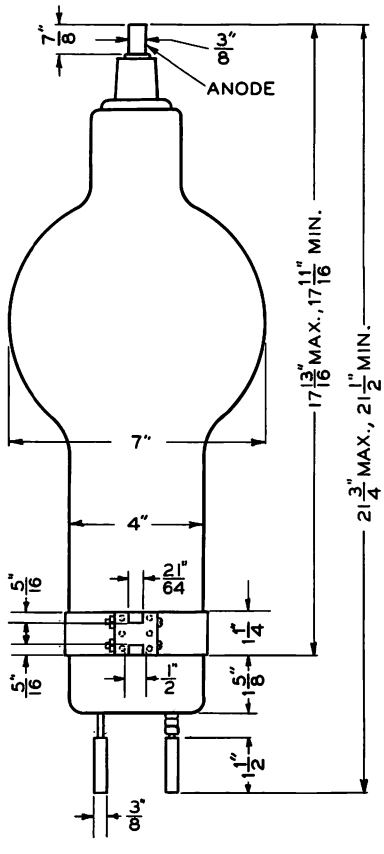
Ratings

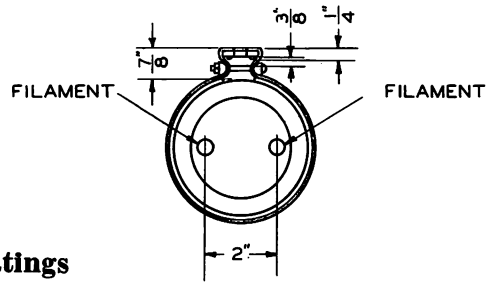
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
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

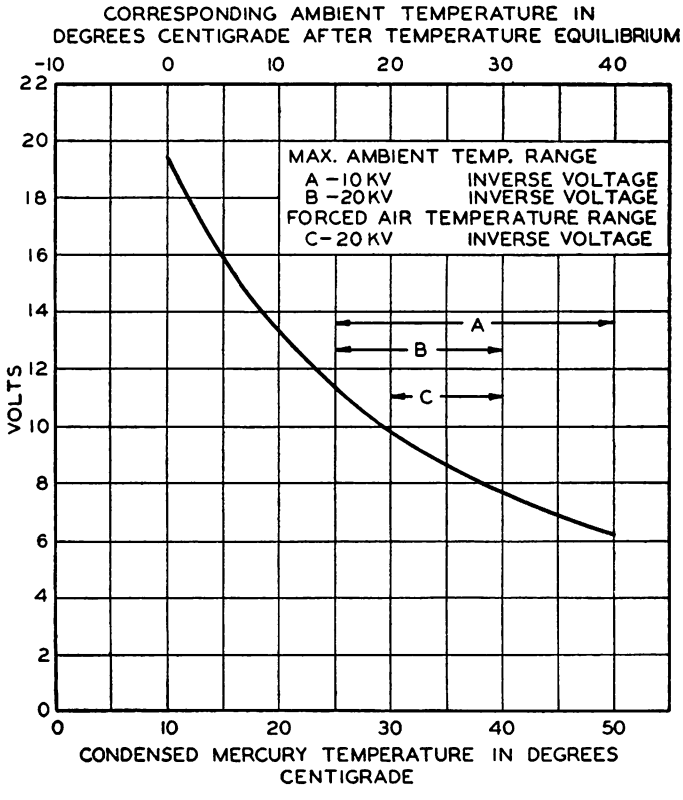
Circuit Outputs:

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

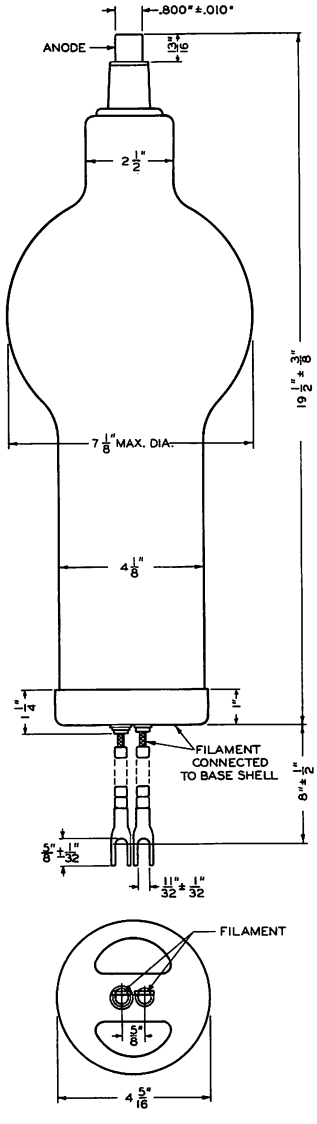
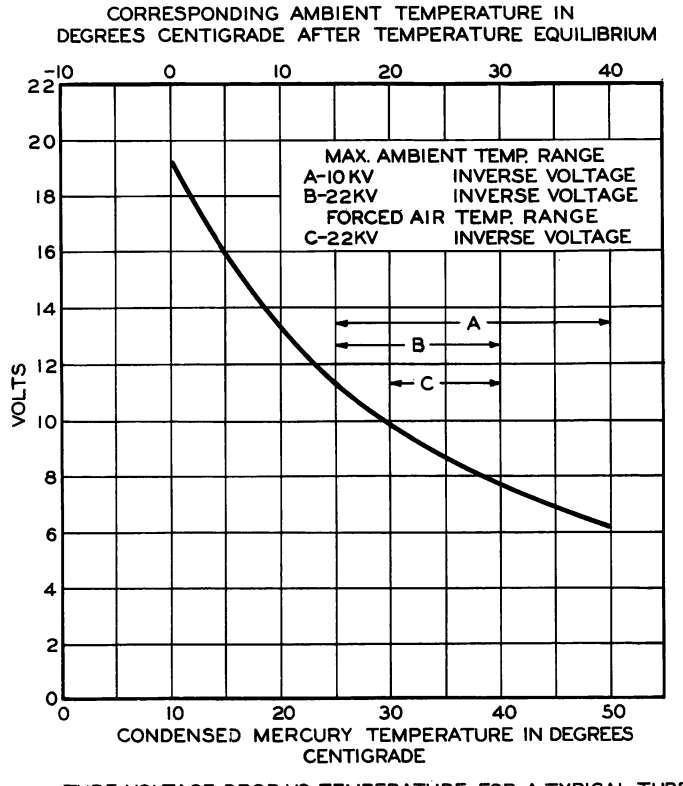


FIG. 1



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

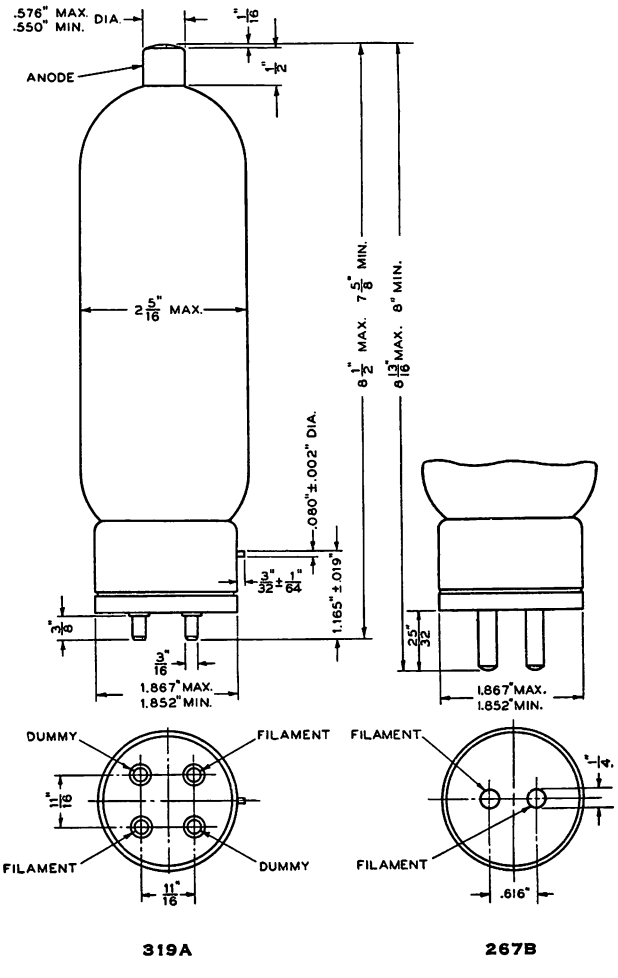
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

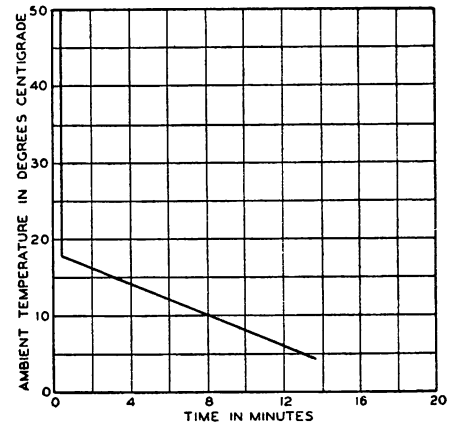
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

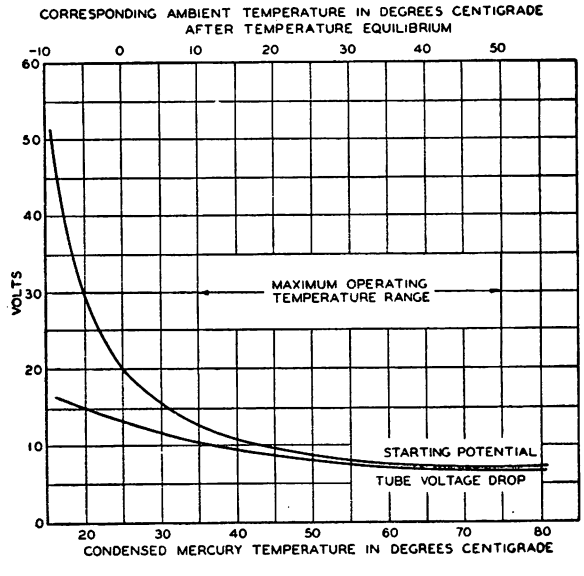
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	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

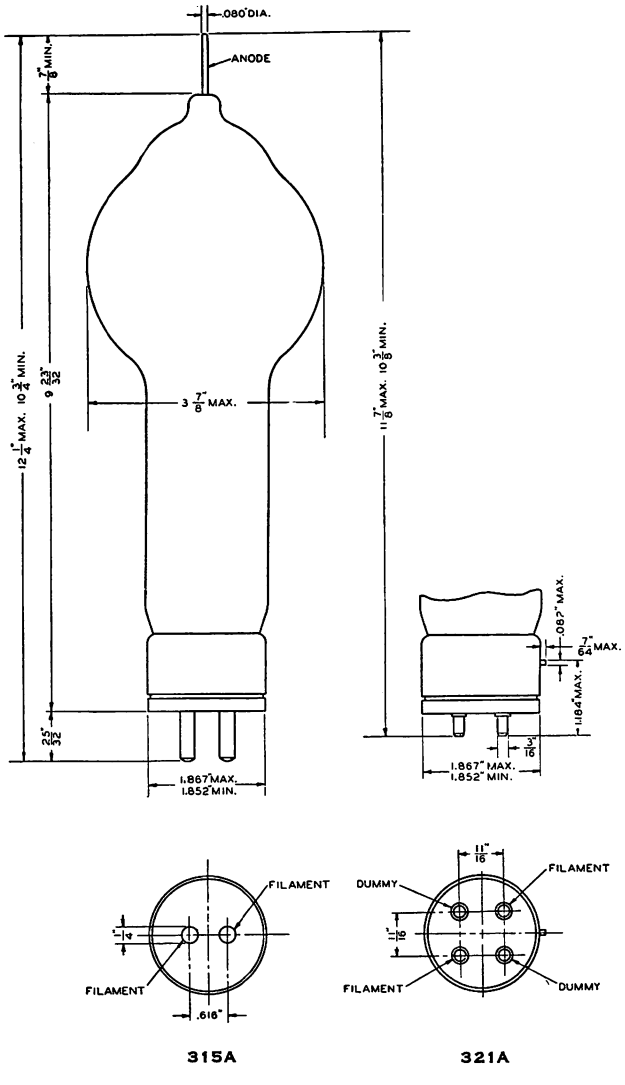
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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.

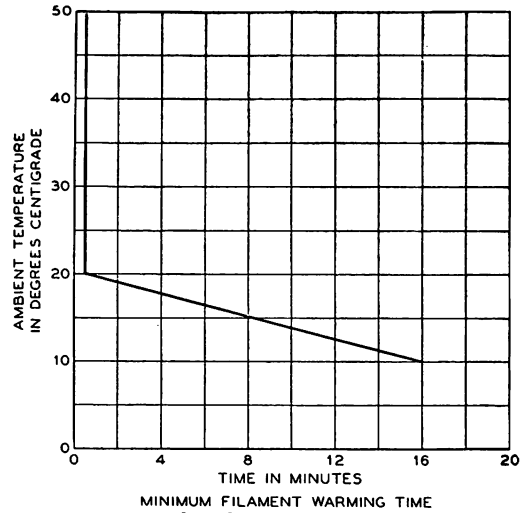
Circuit Outputs:

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

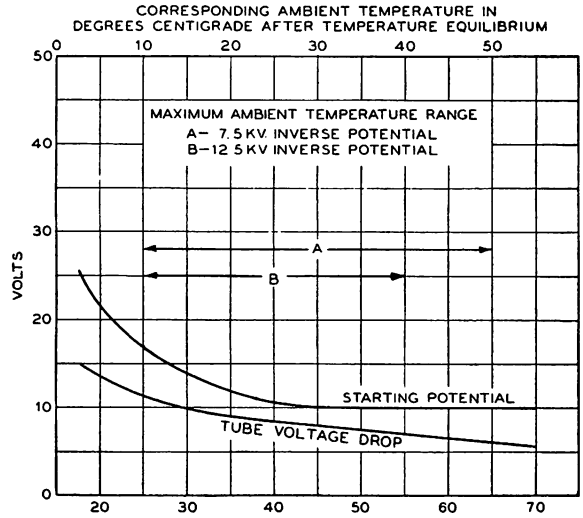
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

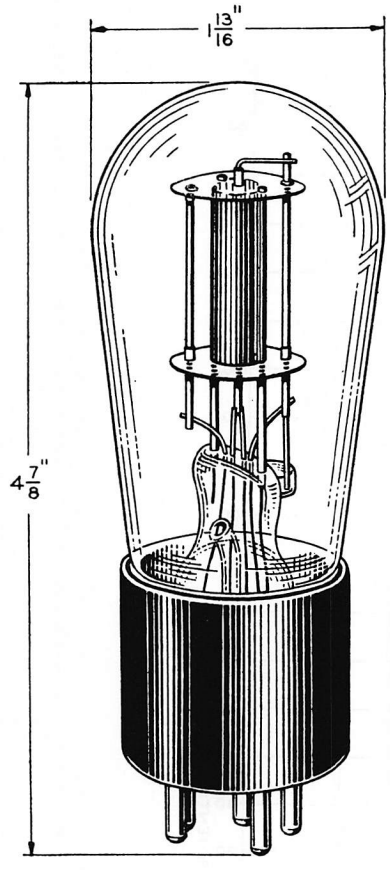
Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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

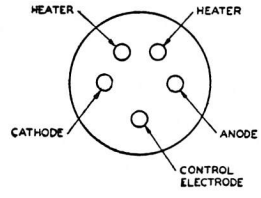
Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

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

256A Vacuum Tube





Classification

The No. 256A Vacuum Tube is a three-element tube which employs an indirectly heated cathode and contains argon gas at a low pressure. It is intended for use in special circuits as a relay or trigger-action device.

Base and Socket

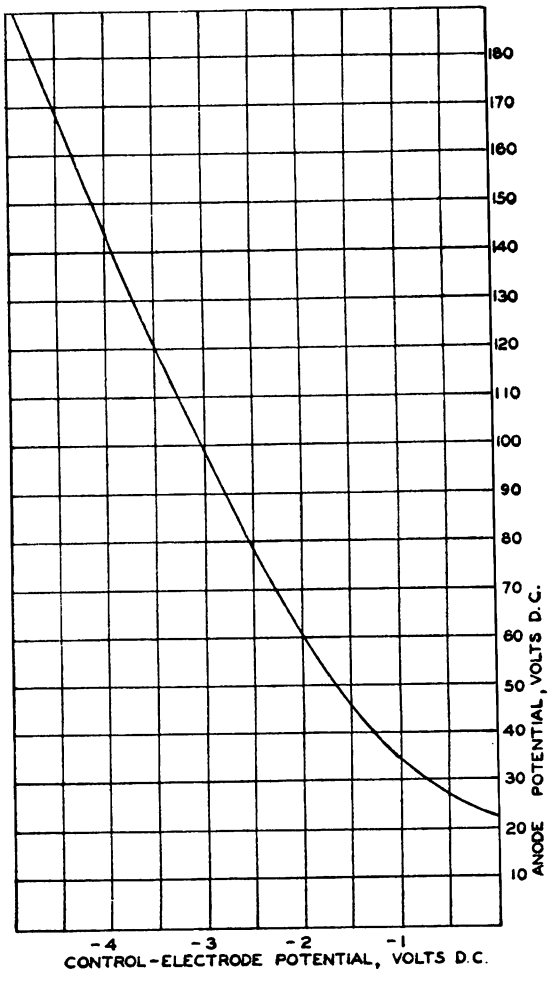
The No. 256A Vacuum Tube employs a standard five-prong, thrust-type base suitable for use in a Western Electric 137A or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

Heater Voltage	2.3 Volts AC
Nominal Heater Current	1.7 Amperes
Anode-Cathode Potential Drop when Conducting	10-20 Volts
Maximum Instantaneous Space Current	75 Milliamperes
Maximum Instantaneous Potential between Anode and Control-Electrode	325 Volts
Maximum Potential between Cathode and Heater	12 Volts

Breakdown Characteristics

A typical curve relating the critical control-electrode potential to the anode potential is given in the accompanying chart. This characteristic may vary from tube to tube and during the life of a given tube.

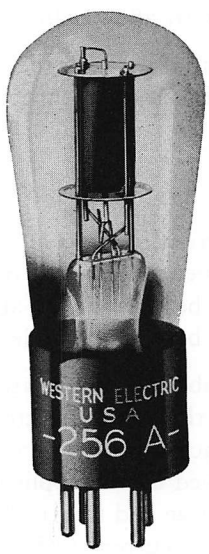


General Features

The No. 256A Vacuum Tube is primarily a rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous control-electrode and anode potentials. The special treatment of electrode elements and the use of argon gas whose pressure remains practically constant over wide temperature ranges are outstanding design features. The above qualities insure uniform and reproducible characteristics essential to various circuit applications such as; controlled frequency oscillators giving a square wave form, peak voltmeters or volume level indicators, photoelectric cell control and recording equipments, and variable voltage rectifiers.

Western Electric

256A Vacuum Tube



Classification—Three element, argon filled, grid-controlled rectifier with an indirectly heated cathode

It is primarily a rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous control-electrode 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	$4\frac{7}{8}''$
Diameter	$1\frac{13}{16}''$

Mounting—The 256A vacuum tube employs a standard five-pin trust 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.

Heater Rating

Heater potential	2.3 volts
Nominal heater current	1.7 amperes

The heater element 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 (2.3 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 space current is drawn. If filament transformers with good regulation are used, this time is one minute. Failure to allow sufficient time may result in immediate failure.

The maximum instantaneous potential between the cathode and any point of the heater circuit must not exceed 12 volts. The cathode may be connected to the heater.

Operating Conditions

Anode-cathode potential drop	10—20 volts
Maximum instantaneous space current (sine wave)	75 milliamperes
Maximum instantaneous space current (condenser discharge)	200 milliamperes
Maximum instantaneous potential between anode and control-electrode	325 volts
Maximum instantaneous potential between cathode and heater	12 volts

The characteristics of the 256A tube are such that, for any given anode potential, there is a critical control-electrode potential. If the control-electrode is held more negative than this value and the tube is non-conducting, the space current will remain zero. If it is made less negative, the space current assumes a value determined by the applied anode potential and the resistance in the anode circuit. To extinguish the discharge and return the space current to zero, the positive anode potential must be removed. When space current is flowing, a visible discharge occurs in the tube. Under this condition, the anode-cathode potential is practically independent of the value of both the space current and the control-electrode potential. A protective resistance should always be included in the anode circuit to limit the maximum instantaneous space current to the rated values. A typical curve relating the critical control-electrode potential to the anode potential is shown in Figure 3. This characteristic 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 space 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 gas-filled tubes. 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 control-electrode 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.

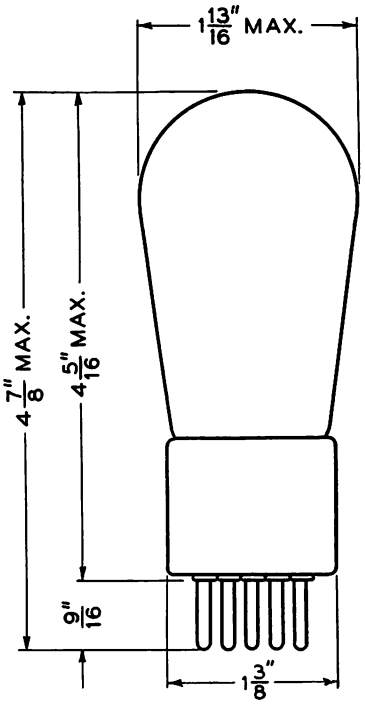


FIG. 1

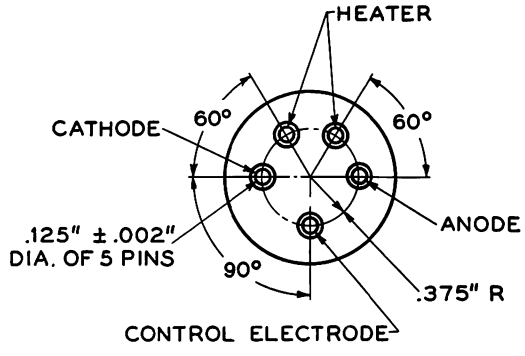


FIG. 2

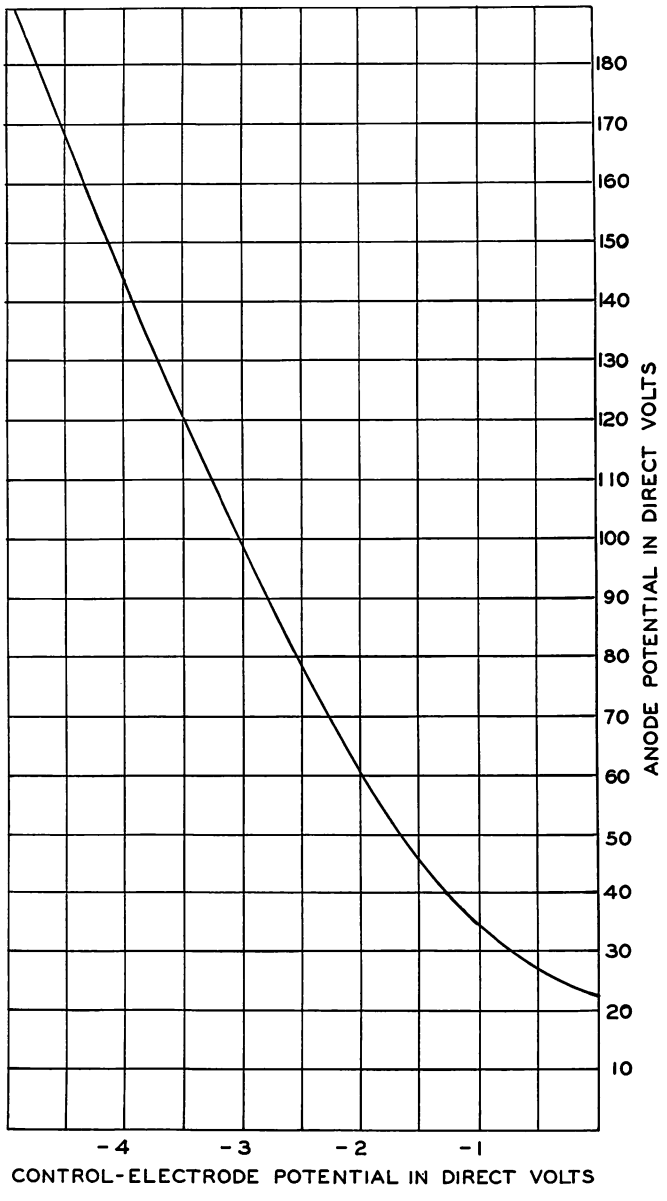


FIG. 3

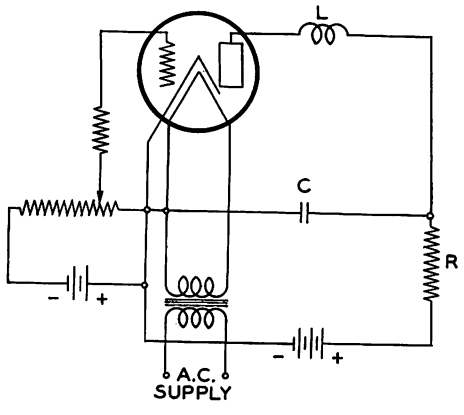


FIG. 4

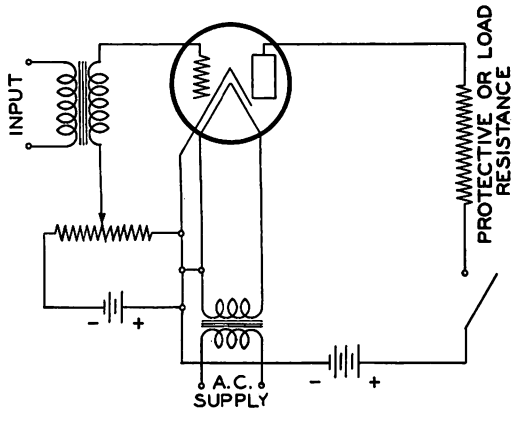


FIG. 5

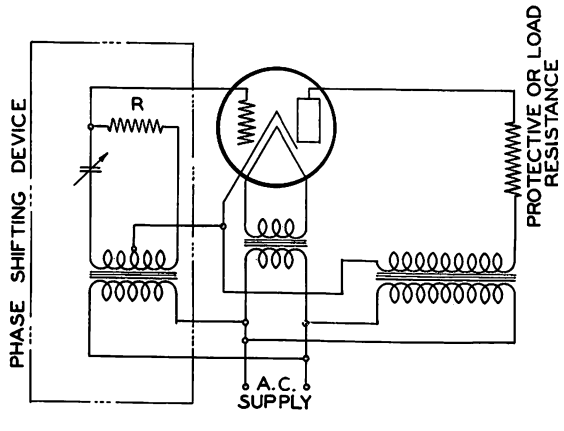


FIG. 6

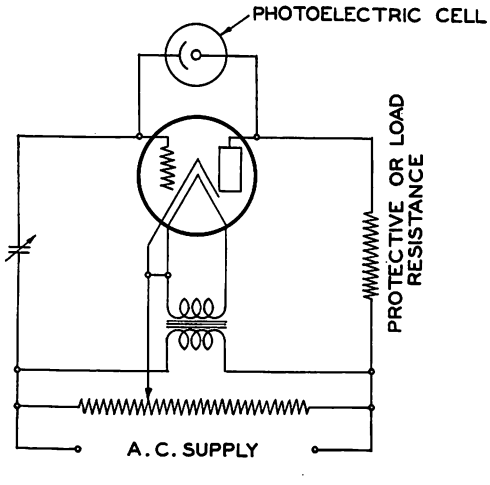
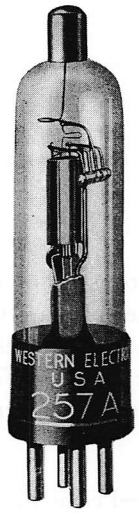


FIG. 7

Western Electric

257A Vacuum Tube



Classification—Small, filamentary triode

The 257A tube is similar to the 231D tube except that the grid terminal of the 257A tube is at the top of the bulb. An important feature of the 257A tube is its low filament power consumption.

Applications

Audio-frequency and intermediate-frequency amplifier.

Detector.

Oscillator.

Dimensions—Outline diagrams showing dimensions of the tube and base, and the arrangement of the electrode connections to the base terminals are given in Figures 1 and 2.

Base—Small, four-pin, thrust base. Small metal cap grid terminal at the top of the bulb. One base contact pin is unconnected.

Socket—Standard four-contact type such as the Western Electric 143B socket.

Mountings 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

Grid to plate	3.0 μμf.
Grid to filament	1.8 μμf.
Plate to filament	2.3 μμf.

Filament Rating

Filament current	0.060 ampere, d.c.
Nominal filament voltage	3.1 volts

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

Characteristics—Plate current characteristics of a typical 257A tube are shown in Figure 3 as functions of grid voltage for several values of plate voltage. The grid and plate voltages are measured from the negative end of the filament. 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 are shown in Figure 7 for several values of grid voltage.

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 are given in the table on page 3 for a number of typical operating conditions represented by selected points within this area. The 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 or voltage output and the second and third harmonic levels for the indicated values of load resistance. The fundamental output is given in terms of the power, P_m, in milliwatts for values of load resistance, R, equal to and double the value of the plate resistance, r_p, and in terms of the voltage, E_{pm}, in peak volts for values of load resistance five times the plate resistance. The second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the fundamental power and voltage output and the harmonic levels are given approximately by the following relations:

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

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

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

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

TABLE

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Voltage Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms r_p	Micromhos	Peak Volts	R	Milliwatts	Peak Volts	db	db
67.5	−3.0	.93	8.5	22500	380	3.0	$R=r_p$	3.0		29	50
							$R=2r_p$	2.5		36	60
							$R=5r_p$		20	47	70
67.5	−1.5	1.55	8.5	18300	460	1.5	$R=r_p$	1.0		39	70
							$R=2r_p$	0.9		46	80
90.0	−5.0	1.15	8.5	20700	410	5.0	$R=r_p$	10		26	43
							$R=2r_p$	9		33	50
							$R=5r_p$		35	42	65
90.0	−3 0	2.10	8.4	16300	510	3.0	$R=r_p$	4.5		36	60
							$R=2r_p$	4.0		42	70
							$R=5r_p$		22	50	75
112.5	−8.0	1.00	8.5	22200	390	8.0	$R=r_p$	23		21	34
							$R=2r_p$	20		27	42
							$R=5r_p$		55	38	60
112.5	−6.0	1.90	8.4	17200	490	6.0	$R=r_p$	17		29	45
							$R=2r_p$	15		35	55
							$R=5r_p$		42	44	70
135.0	−11.5	0.70	8.5	27000	320	11.5	$R=r_p$	45		17	28
							$R=2r_p$	50		23	34
							$R=5r_p$		76	33	47
135.0	−10.0	1.25	8.5	20300	420	10.0	$R=r_p$	40		21	32
							$R=2r_p$	35		28	41
							$R=5r_p$		67	37	55
135.0	−8.5	1.95	8.5	17200	490	8.5	$R=r_p$	35		26	40
							$R=2r_p$	30		33	50
							$R=5r_p$		57	42	65
*90.0	−1.5	2.90	8.4	14500	580	1.5	$R=r_p$	1.2		46	75
							$R=2r_p$	1.0		50	85
*112.5	−4.5	2.65	8.4	15000	560	4.5	$R=r_p$	10		34	55
							$R=2r_p$	9		40	65
							$R=5r_p$		30	50	70
*135.0	−7.5	2.50	8.4	15600	540	7.5	$R=r_p$	27		29	47
							$R=2r_p$	24		36	55
							$R=5r_p$		48	45	70

*Maximum operating conditions.

Microphonic Noise—With a plate voltage of 90 volts, a grid bias of −3 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 257A tube measured in a laboratory reference test set, is 22 decibels below 1 volt. The range of levels of individual tubes extends from 12 to 36 decibels. 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.

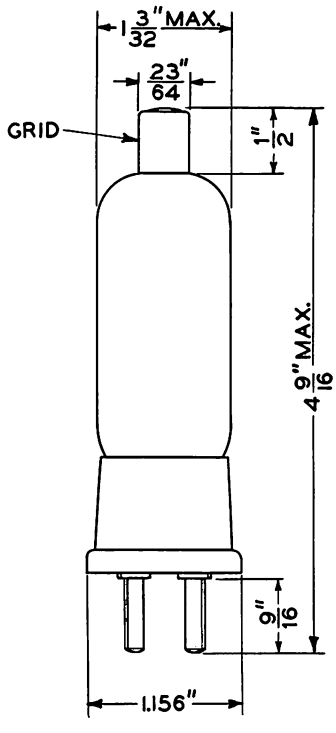


FIG. 1

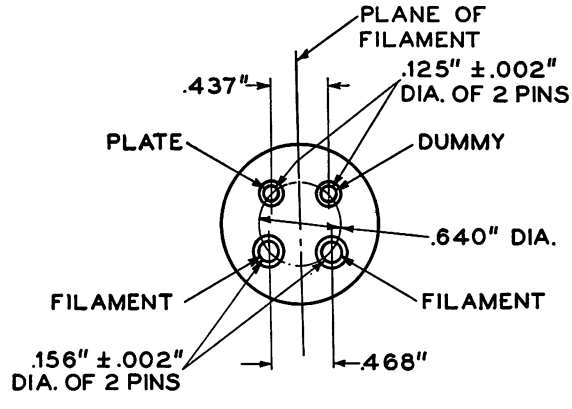


FIG. 2

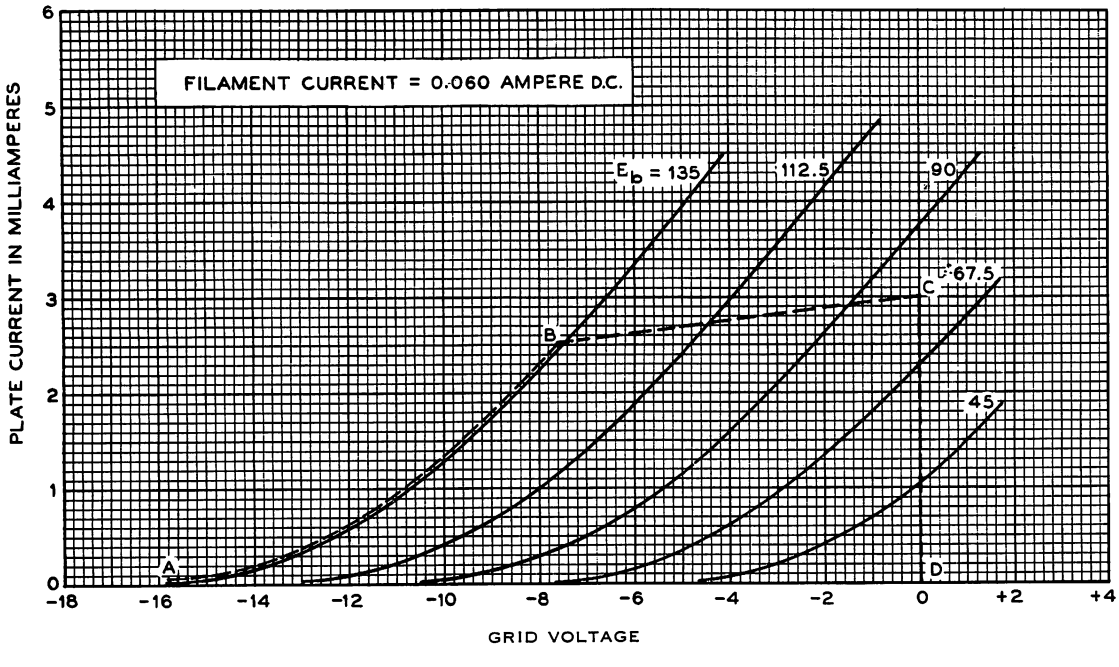


FIG. 3

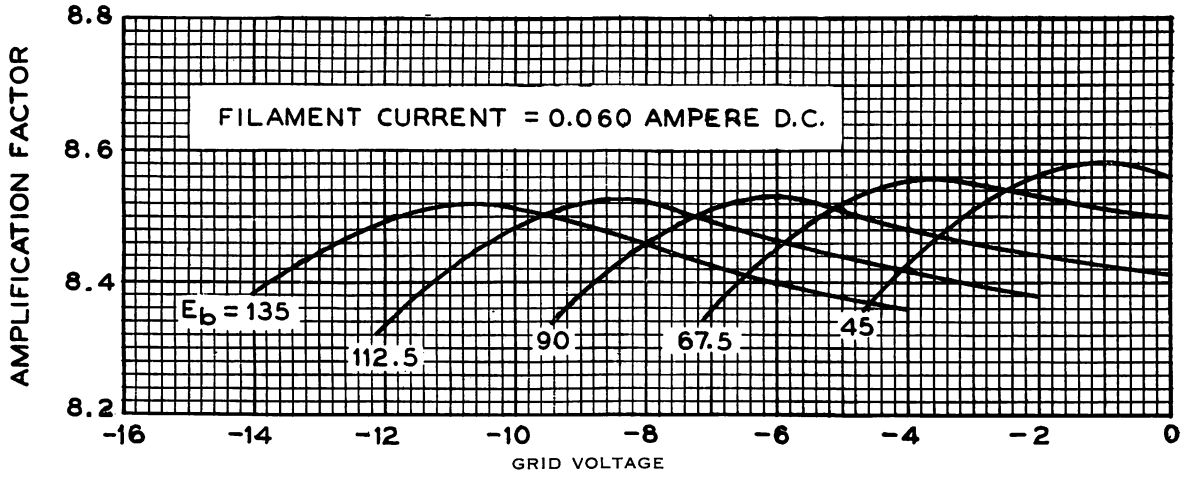


FIG. 4

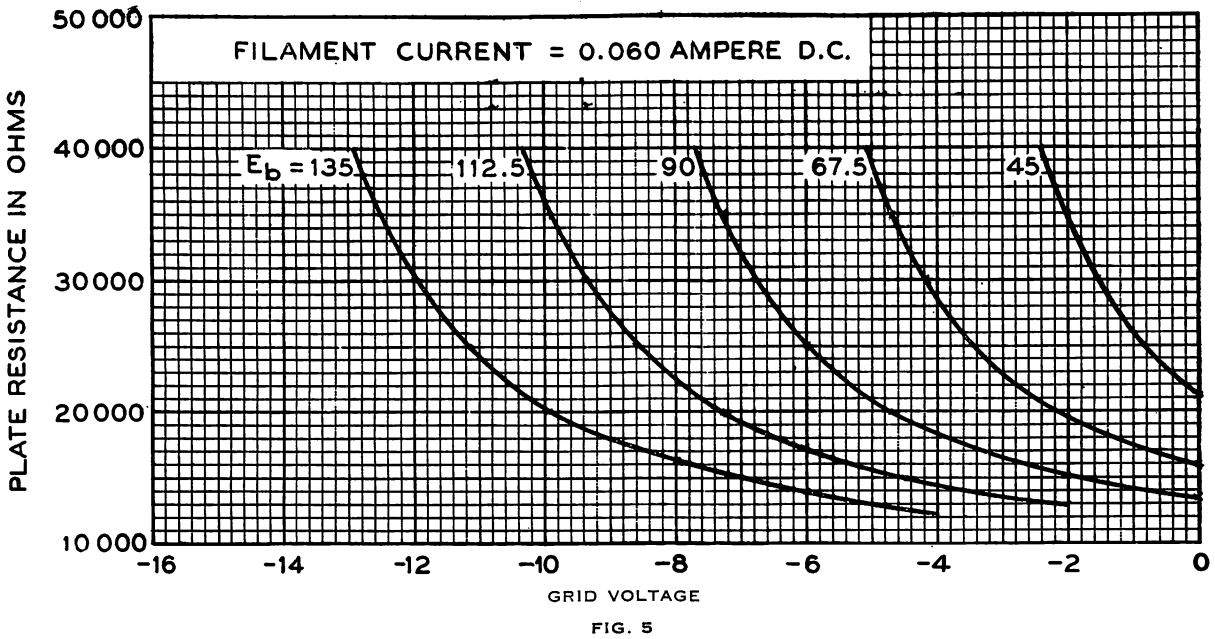


FIG. 5

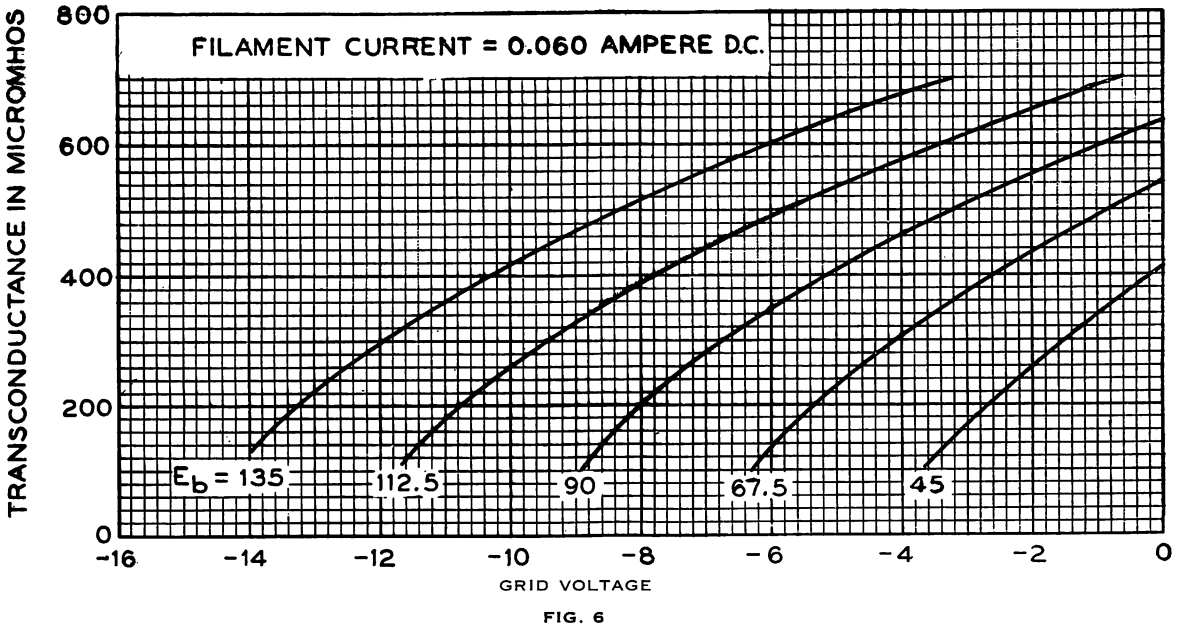


FIG. 6

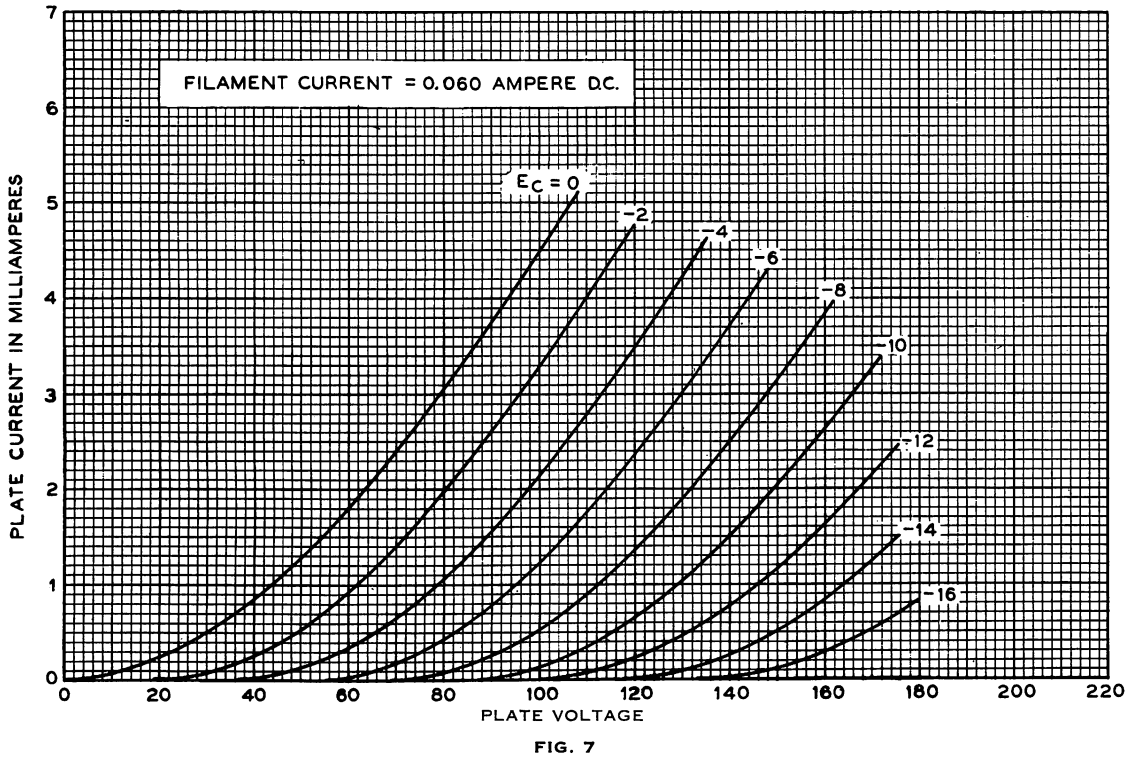
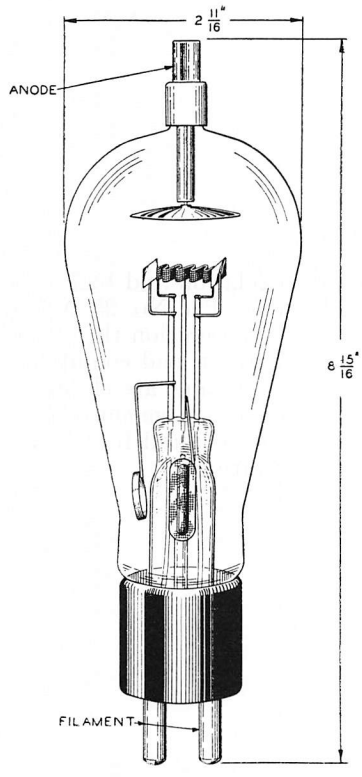

FILAMENT CURRENT = 0.060 AMPERE D.C.
$E_C = 0$
-2
-4
-6
-8
-10
-12
-14
-16
PLATE CURRENT IN MILLIAMPERES
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
180
200
220
PLATE VOLTAGE

FIG. 7

258A Vacuum Tube



Classification

The No. 258A Vacuum Tube is a half-wave, thermionic, mercury-vapor rectifier for use in rectifying circuits designed to supply direct current from an alternating current supply.

Base and Socket

The No. 258A Vacuum Tube employs a two-prong base suitable for use in a Western Electric No. 138A or No. 139A Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The anode terminal is located at the top of the bulb and is arranged for a special quick-release connector. The tube can be mounted only in a vertical position with the base end down.

Rating and Characteristic Data

Filament Voltage	2.5 Volts, AC
Nominal Filament Current	7 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	15 Volts
Maximum Peak Plate Current	1.1 Amperes
Maximum Peak Inverse Potential	6,500 Volts
Safe Operating Ambient Temperature	10 to 50 Degrees 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 will vary from 5 to 25 volts.

Typical Rectifying Circuits

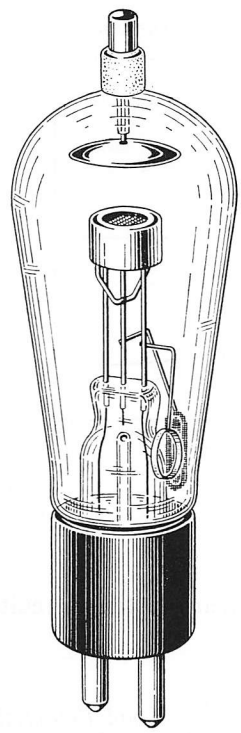
For specific circuits the following ratings apply:

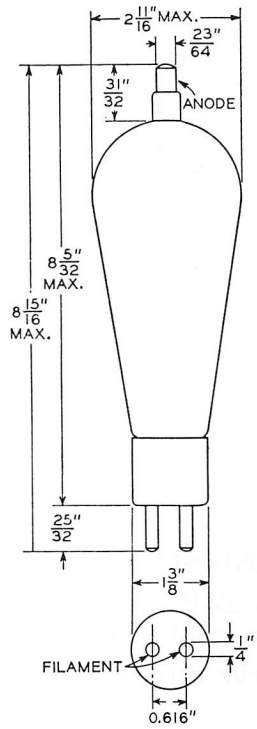
Type of Circuit	Number Tubes	Load Potential Volts	Load Current Amperes
Single-Phase, Half-Wave	1	2,000	0.4
Single-Phase, Double Half-Wave	2	2,000	0.8
Single-Phase, Double Half-Wave (Four Tube Series Circuit)	4	4,000	0.8
Three-Phase (Six Tube Series "Y" Circuit)	6	6,000	1.0

General Features

Rectifier units with improved regulation and high efficiency are obtained by the use of thermionic mercury vapor rectifying tubes. The No. 258A Vacuum Tube has special features of anode design which insure its satisfactory operation throughout a long life under the maximum peak inverse potential and peak plate current load conditions. Flash overs at the anode, which are much more prevalent with this type of tube, are eliminated by special design features. The special mesh type, oxide coated cathode has a large emitting area and is capable of supplying an electron current considerably above that required for the maximum peak plate current. This insures a long life with full space current rating.

258B Vacuum Tube





Classification

The No. 258B Vacuum Tube is a half-wave, thermionic, mercury vapor rectifier for use in rectifying circuits to supply high voltage direct current from an alternating current supply. It is the same as the No. 249B electrically but is equipped with a different type base.

Base and Socket

The No. 258B Vacuum Tube employs a two prong base suitable for use in a Western Electric No. 138B, 139A, or similar type Socket. The arrangement of the electrode connections to the base terminals is shown above. The anode terminal is located at the top of the bulb and is arranged for a special quick release connector.

The tube should be mounted only in a vertical position with the base end down.

Rating and Characteristic Data

Filament Voltage	2.5 Volts
Nominal Filament Current	7.5 Amperes
Approximate Direct Anode Cathode Drop when Conducting	15 Volts
Maximum Peak Plate Current	1.5 Amperes
Maximum Peak Inverse Potential	7,500 Volts
Maximum Operating Ambient Temperature Range	0 to 50° C.

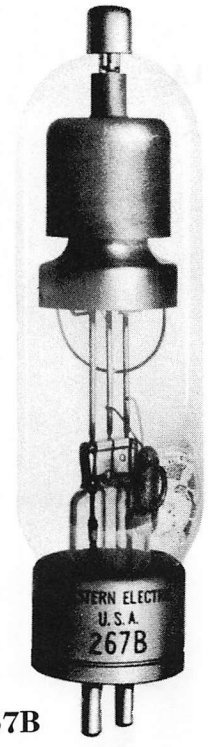
The anode cathode potential drop is substantially independent of the plate current. The exact value varies from tube to tube and during the life of a given tube. Within the specified ambient temperature range and plate current range it will vary from 5 to 25 volts.

Western Electric

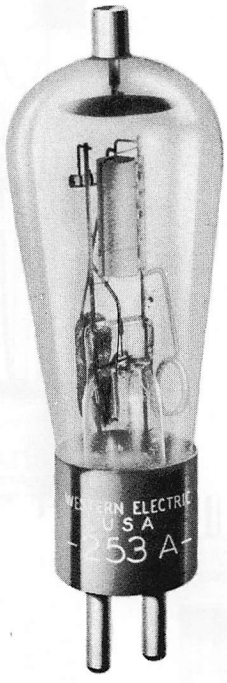
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

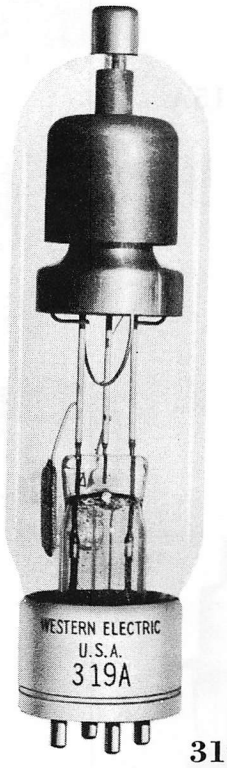
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



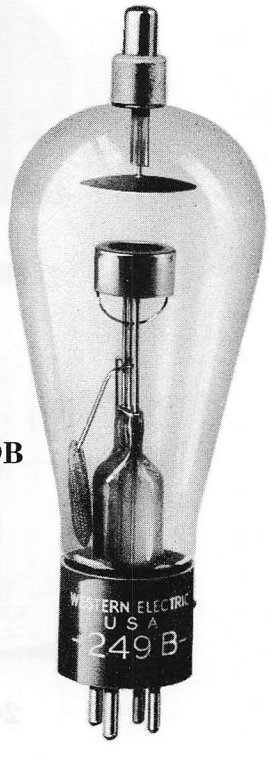
267B



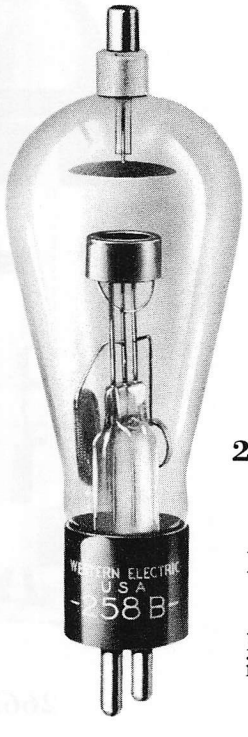
253A



319A



249B

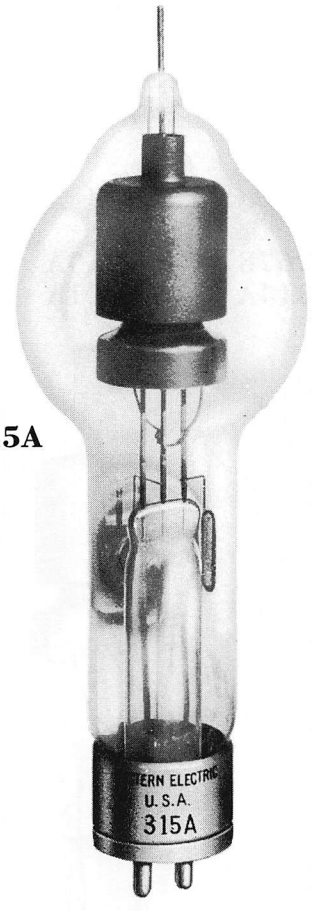


258B

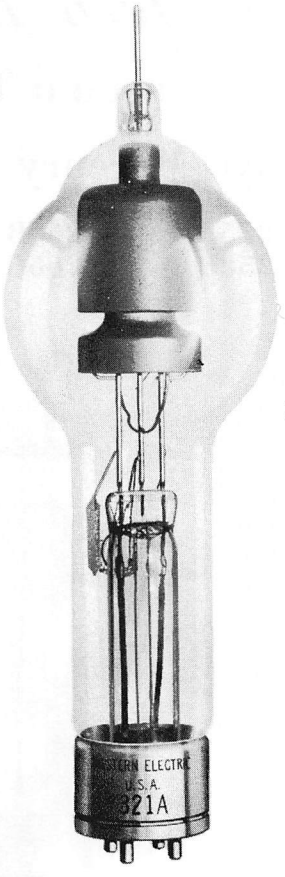
NOTE:

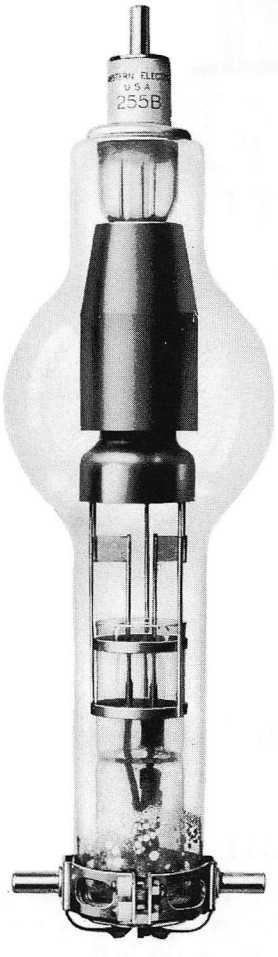
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

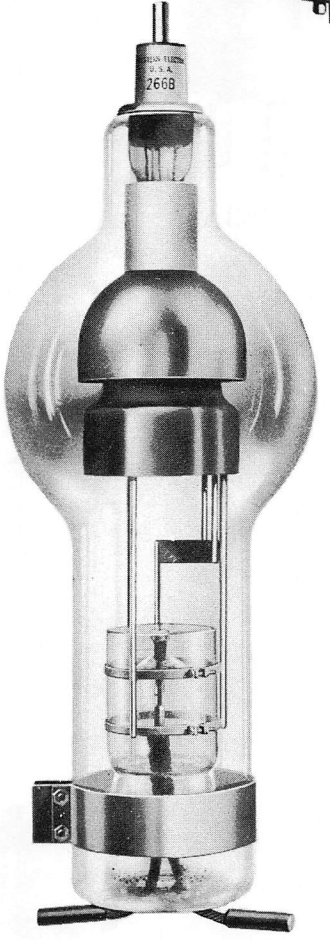


321A

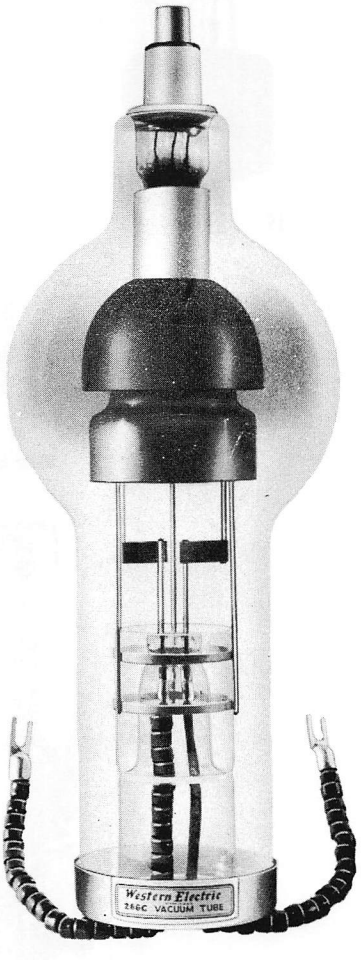




255B



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

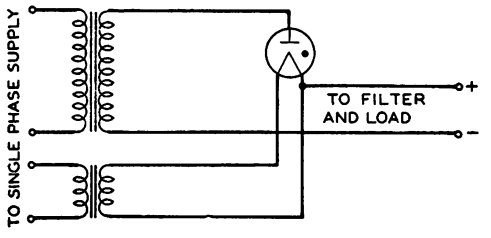
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output 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.

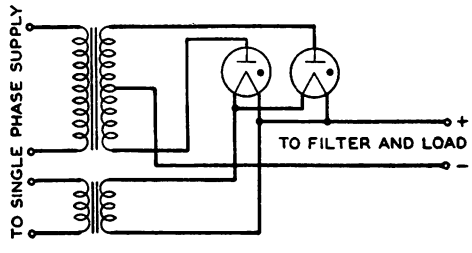
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits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

Circuits

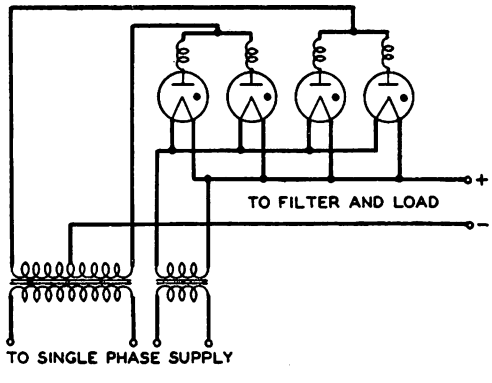
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and 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.



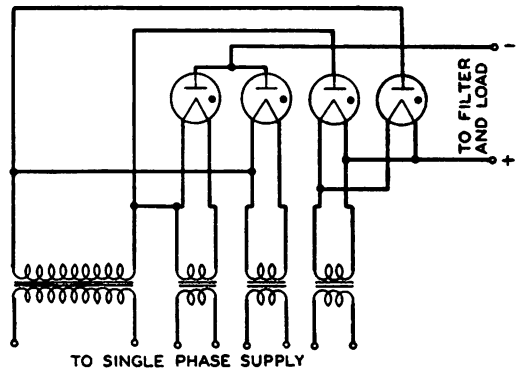
SINGLE PHASE, HALF-WAVE
CIRCUIT A



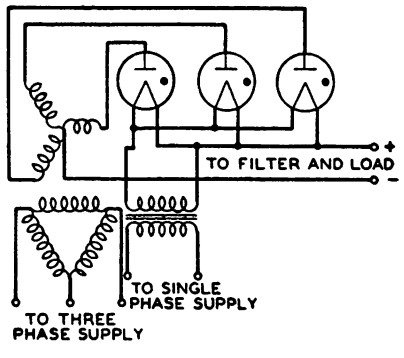
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



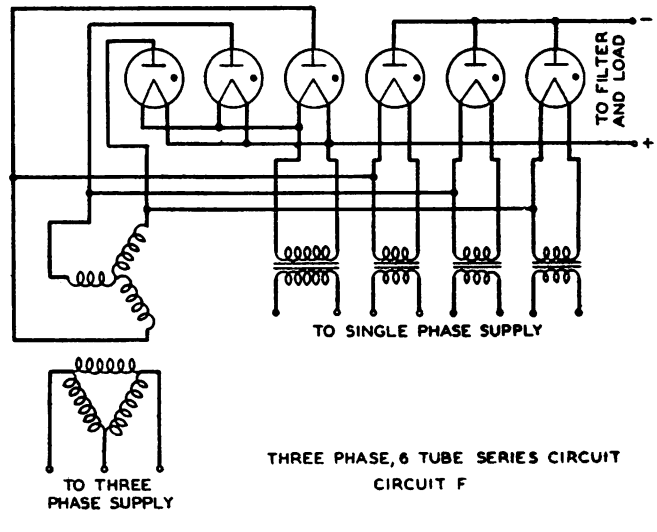
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



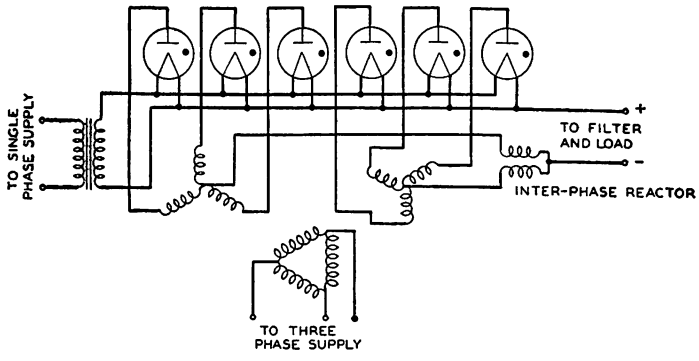
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



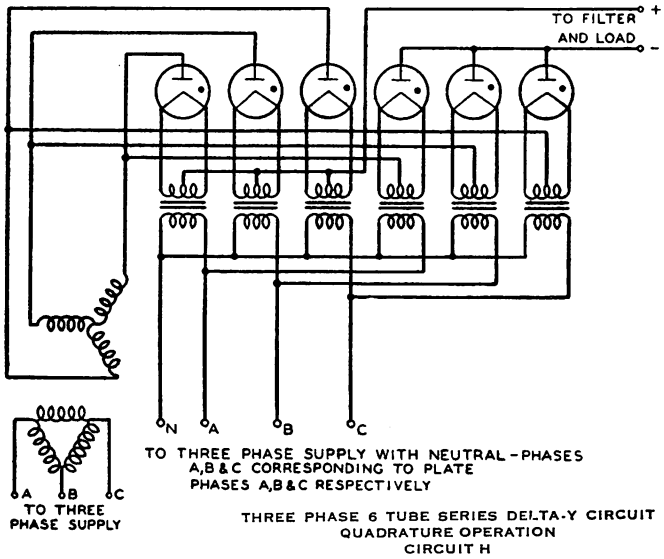
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

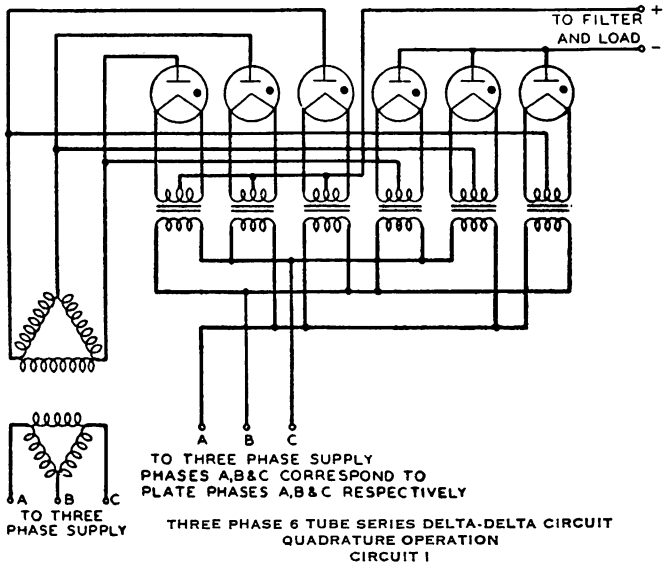


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



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

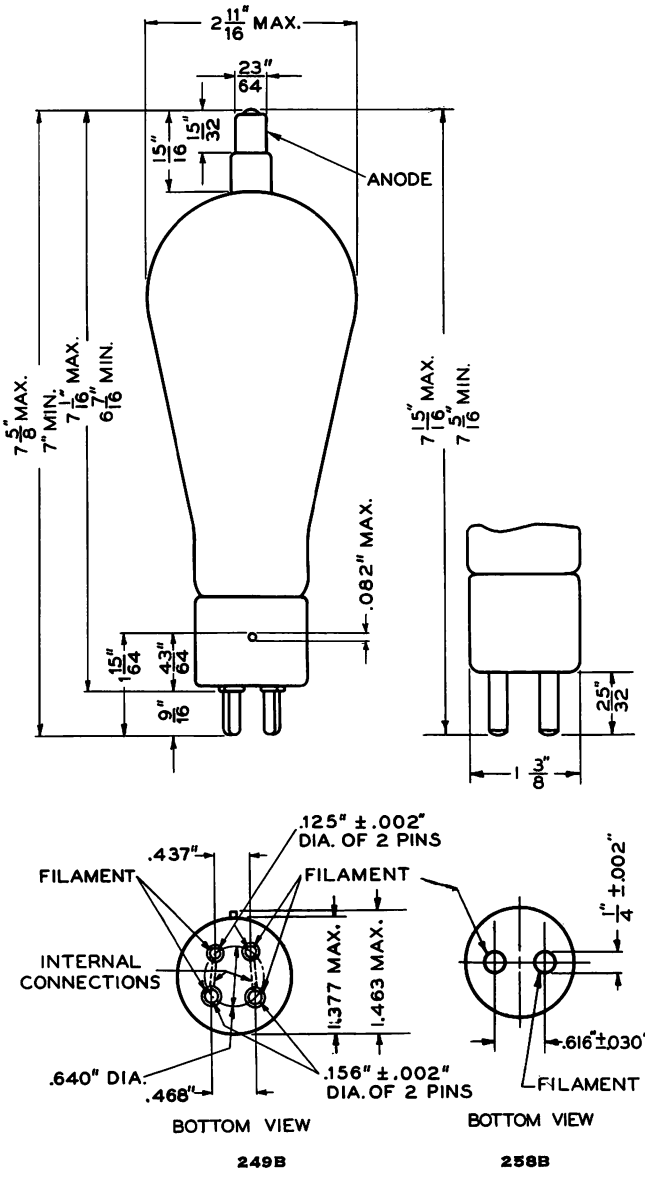
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

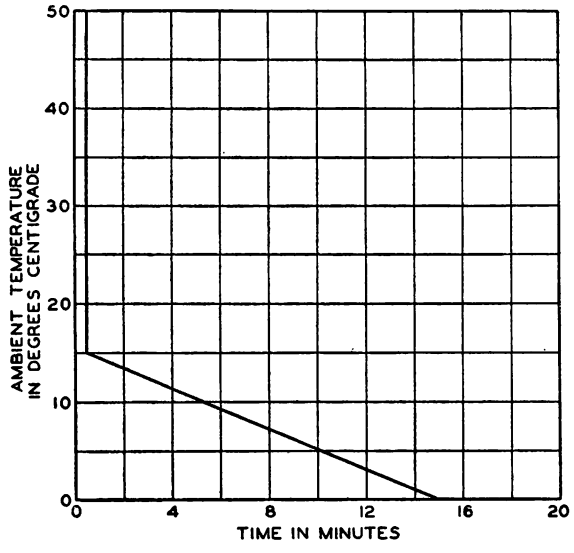


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

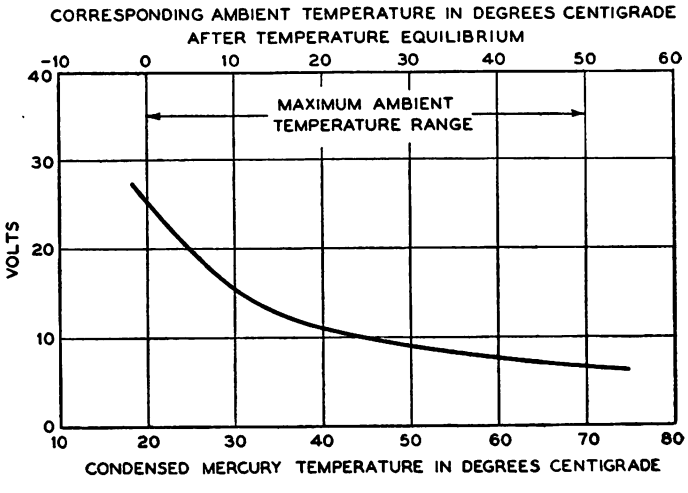
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

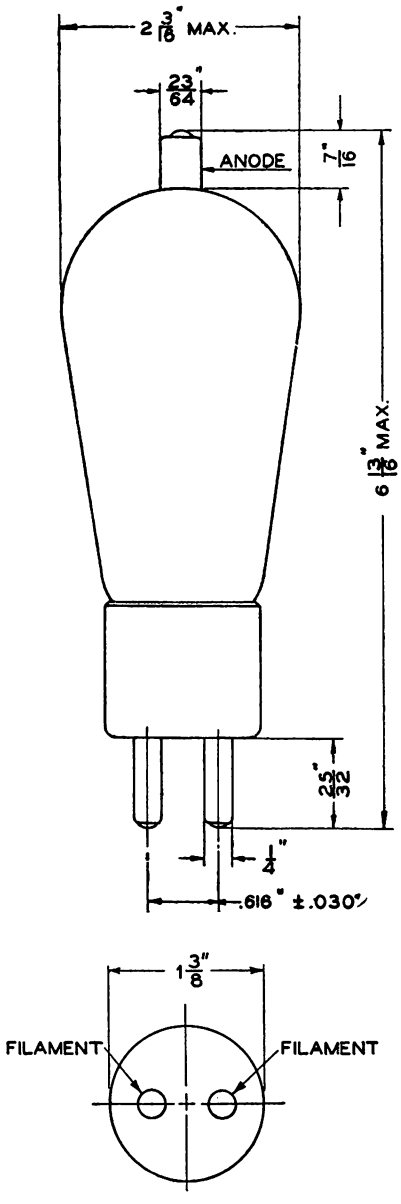
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 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.

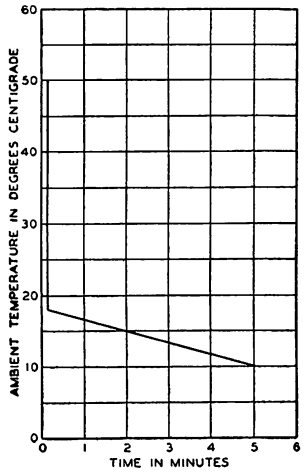
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

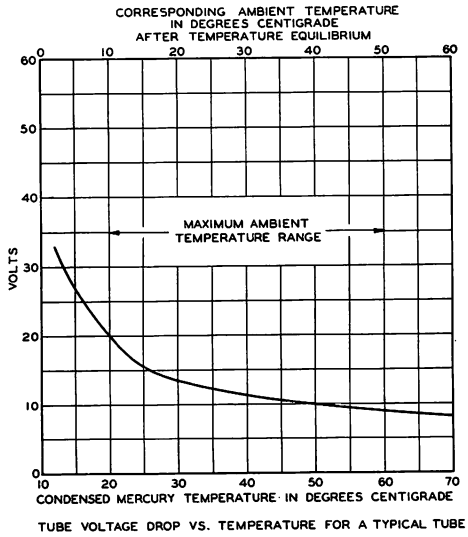
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

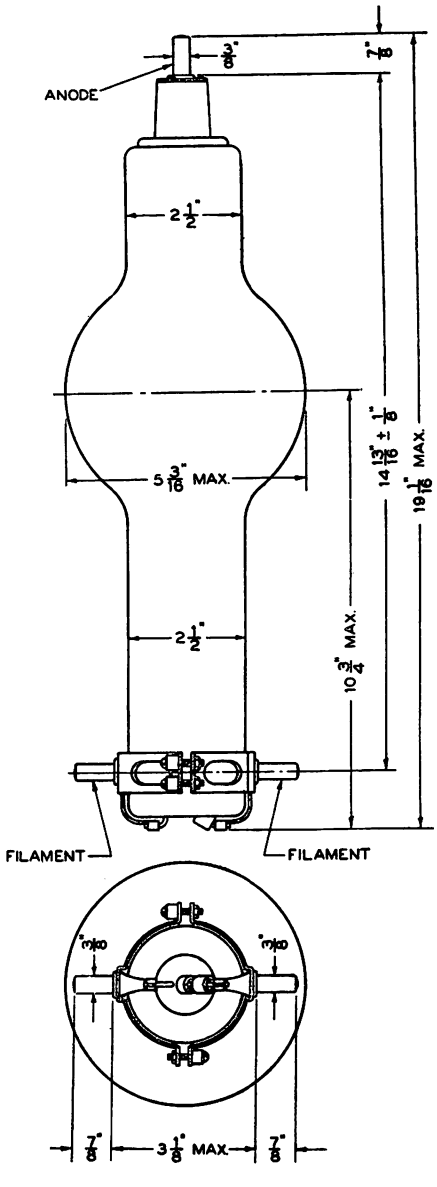
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

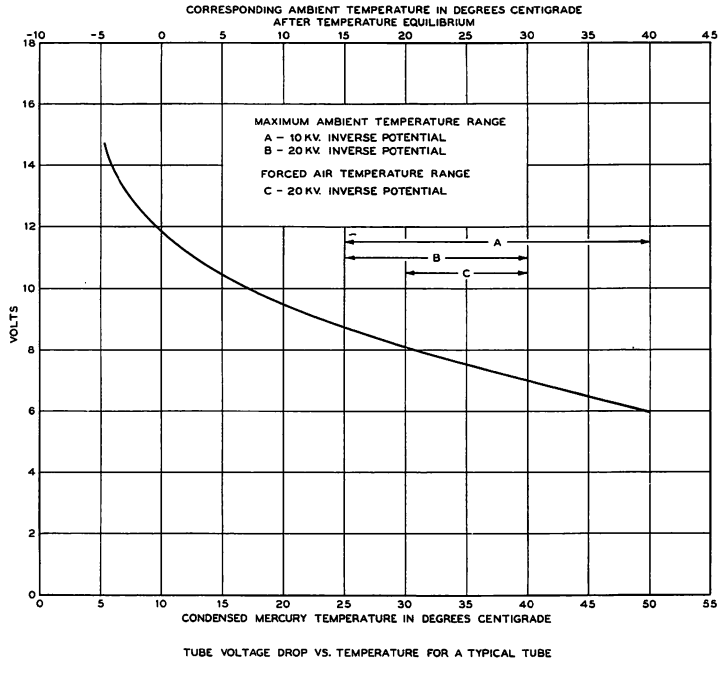
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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.

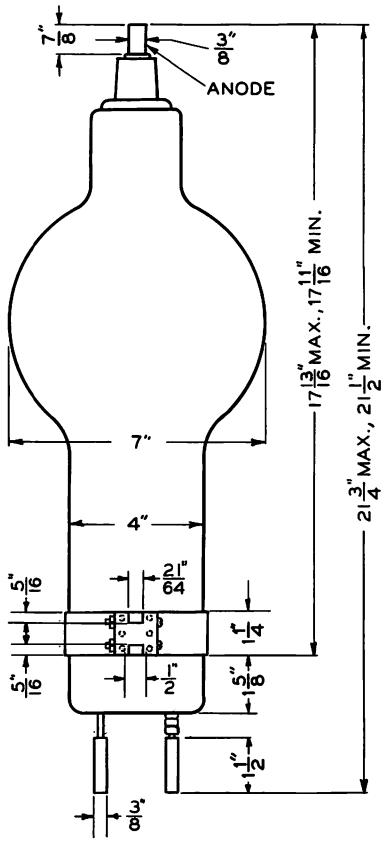
Ratings

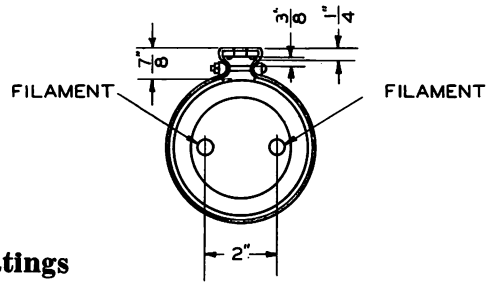
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
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

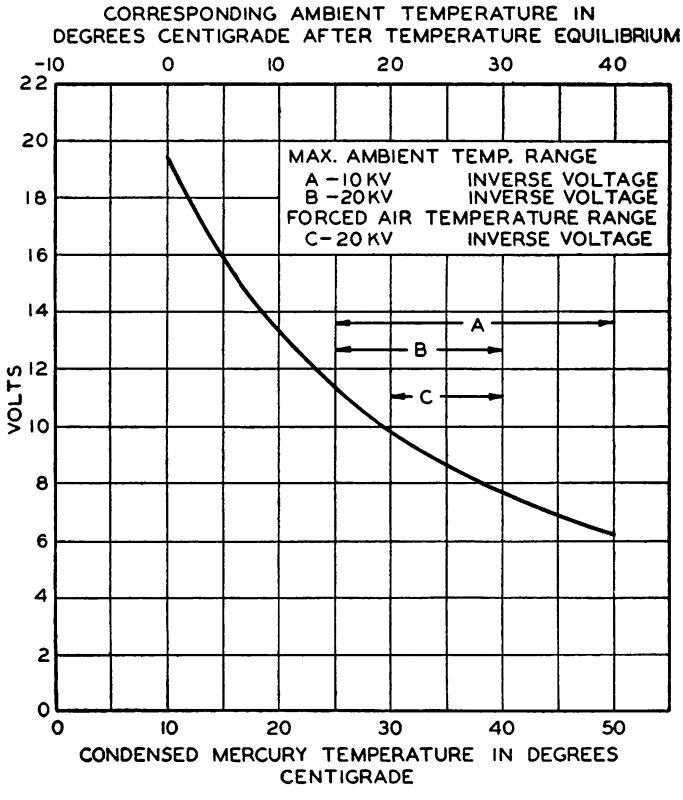
Circuit Outputs:

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

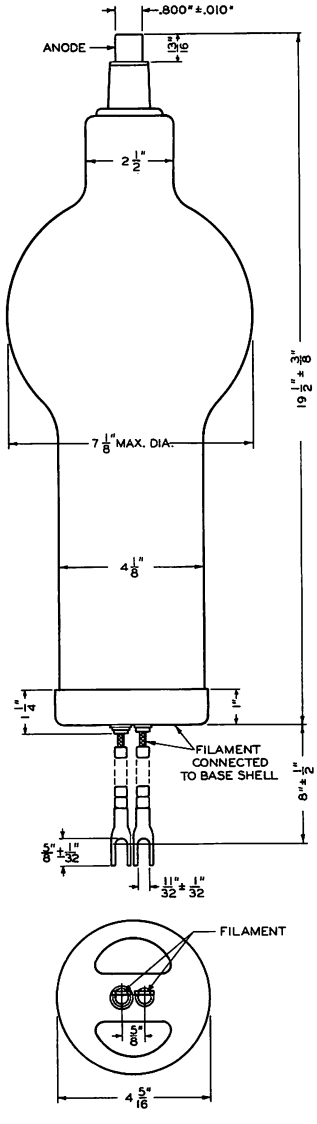
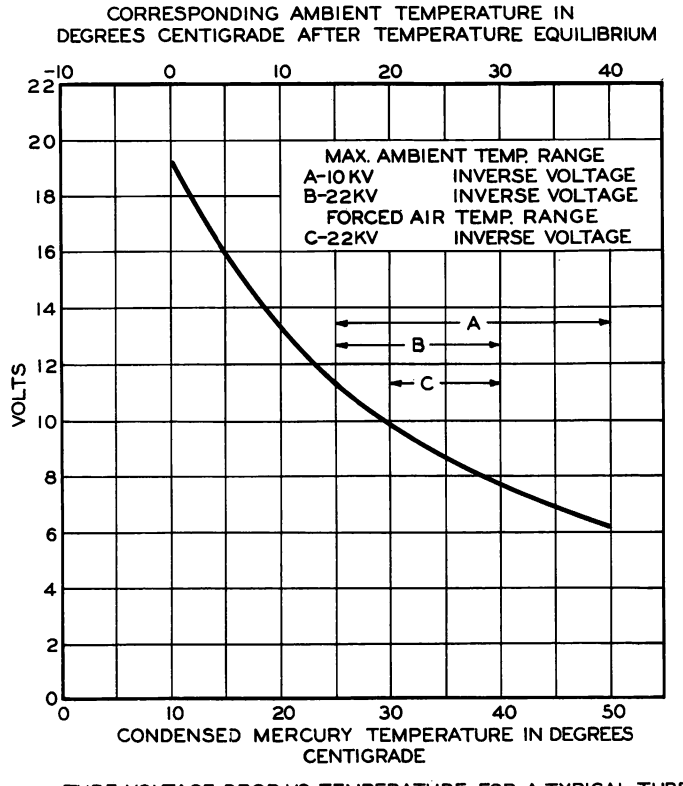


FIG. 1



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

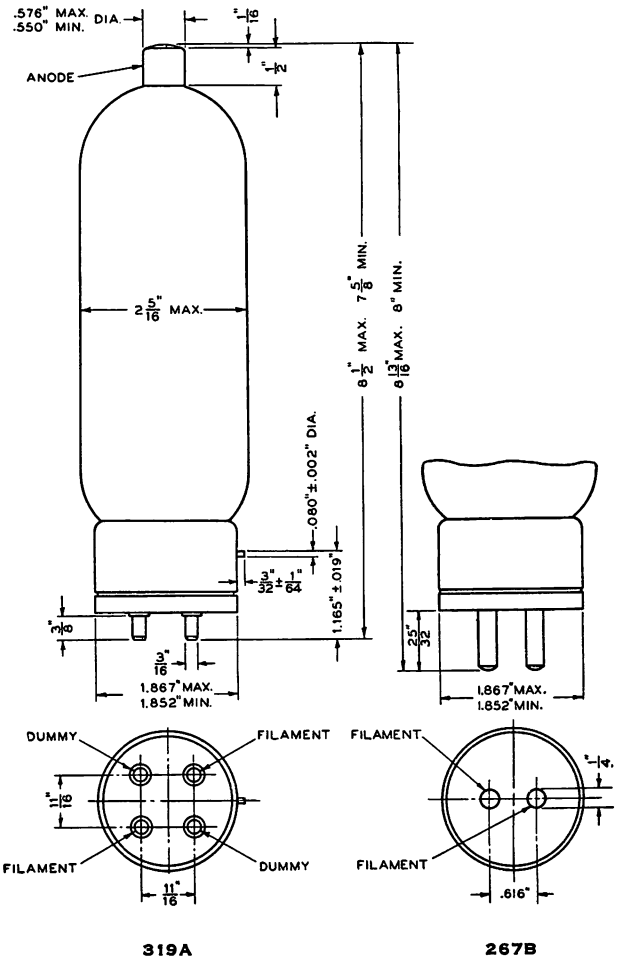
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

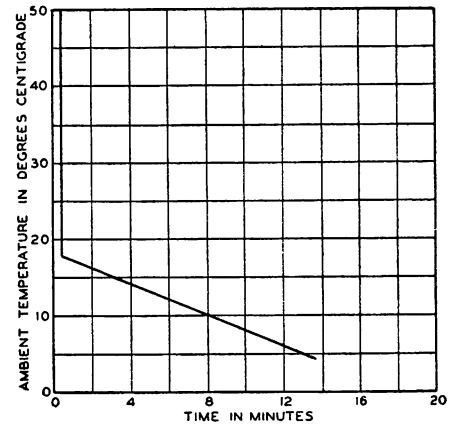
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

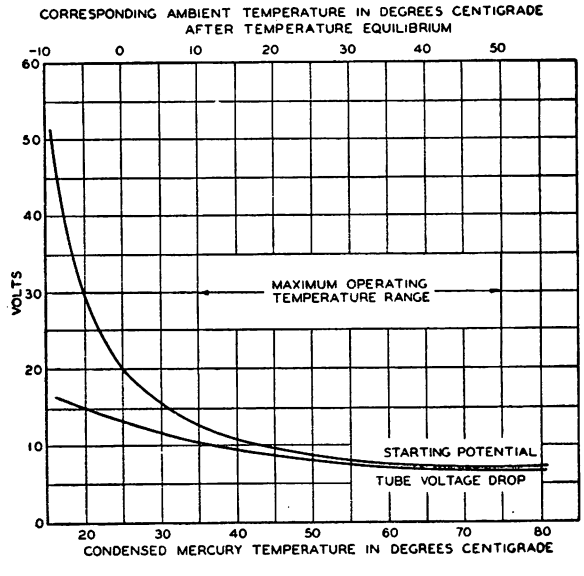
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	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

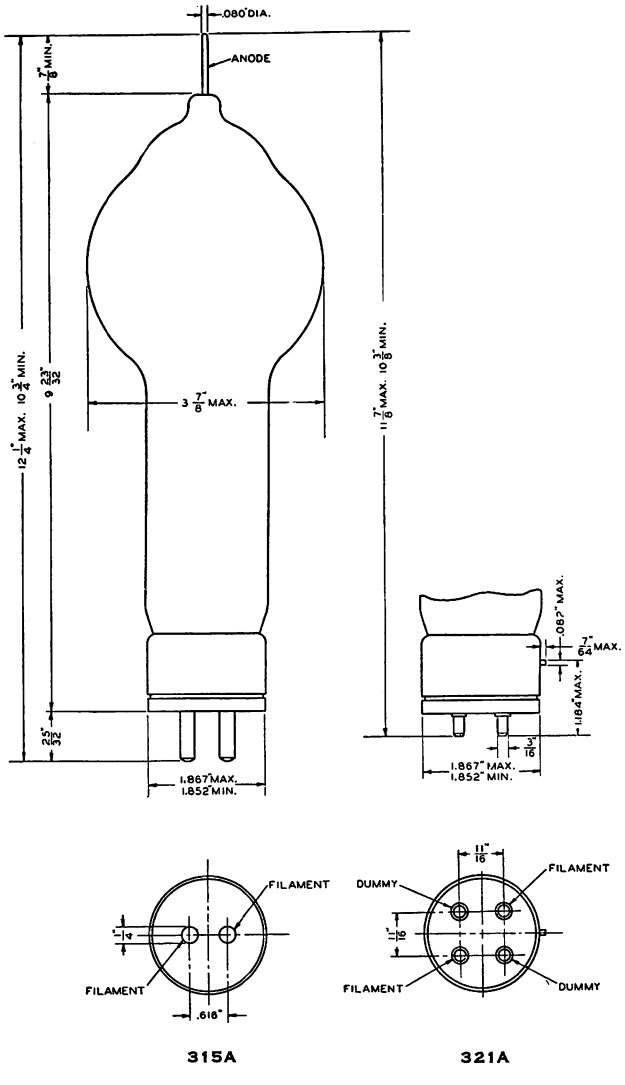
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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.

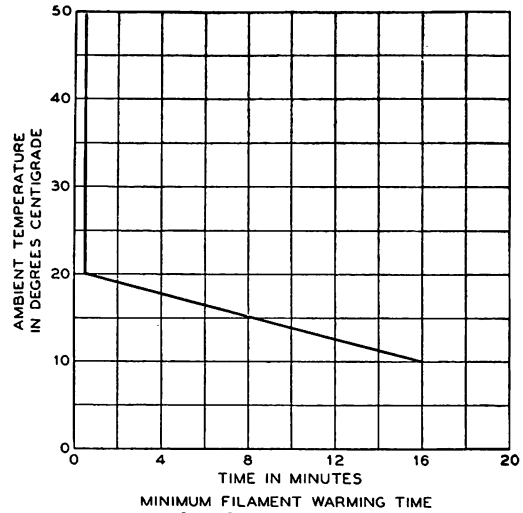
Circuit Outputs:

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

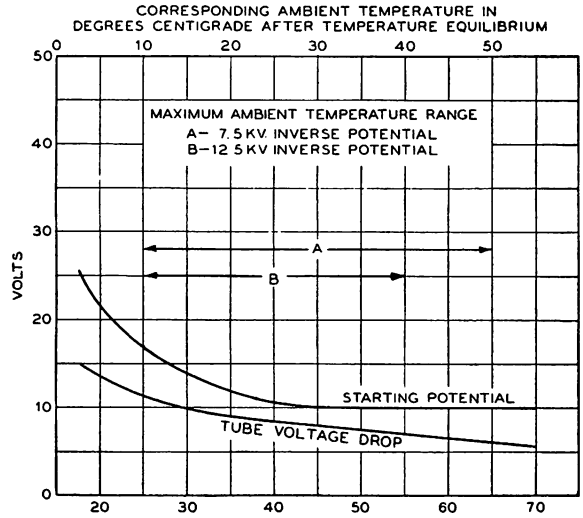
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

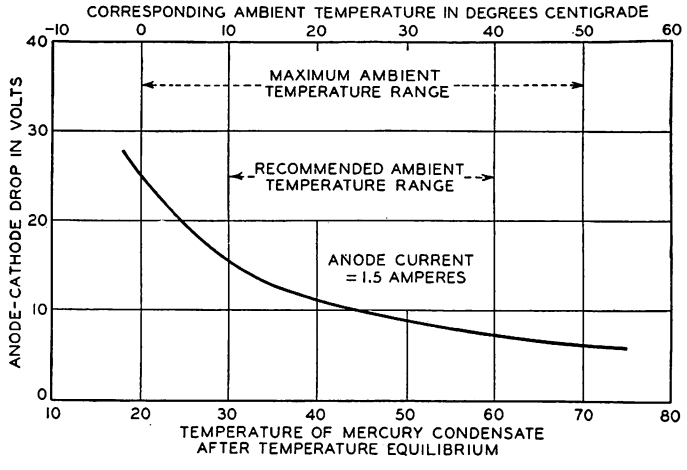
Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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

The anode cathode potential drop as a function of the temperature is shown in the accompanying curve for a typical No. 258-B Vacuum Tube when passing rated space current. The recommended operating temperature range is also shown on this curve.



Typical Rectifying Circuits

The No. 258B Vacuum Tube may be used in any standard rectifier circuits subject to its current, voltage and temperature limitations.

For specific circuits the following ratings apply.

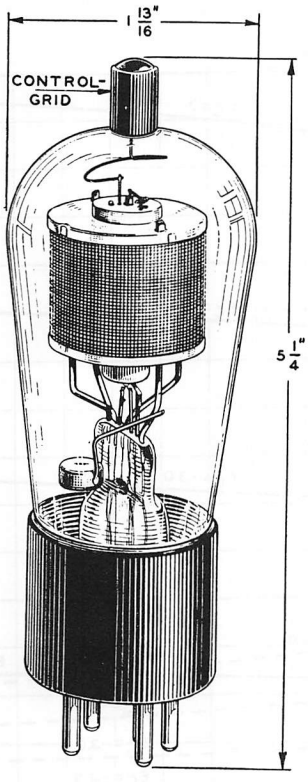
Type of Circuit	*Number of Tubes*	*Load Potential Volts*	*Load Current Amperes*
Single Phase, Half-Wave	1	2300	0.5
Single Phase, Double Half-Wave	2	2300	1.0
Single Phase, Double Half-Wave (4 tube series circuit)	4	4500	1.0
Three Phase, (6 tube series "Y" circuit)	6	7000	1.3

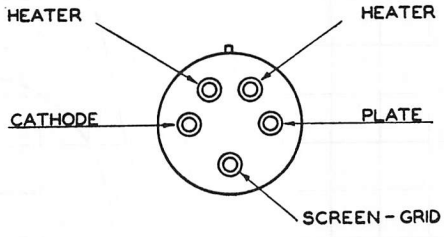
General Features

The mercury vapor type of rectifying tube has the desirable property of a low and almost constant potential drop between the cathode and anode when the tube is passing current. Due to their low potential drop a much more efficient rectifier system can be had than is possible by the use of most high vacuum rectifier tubes, whose potential drops are relatively high. The constancy of the potential drop with space current makes possible rectifying systems whose regulation depends almost entirely on the regulation of the plate transformers.

The No. 258B Vacuum Tube employs an improved oxide coated mesh type filament encased in a metallic shield which insures a uniform cathode temperature. The mechanical construction is such as to preserve the active materials for long operating periods at high inverse voltages as well as during shelf life and shipment. These features make possible the maximum operating life. The No. 258B Vacuum Tube has an increased rating over the No. 258A and may be used to replace it.

259A Vacuum Tube





Classification

The No. 259A Vacuum Tube is a four-element, screen-grid tube having an indirectly heated cathode which permits operation of the heater element directly on alternating current. The tube is for use as a screened grid, high-frequency amplifier, but also may be used as a detector or audio-frequency voltage amplifier.

Base and Socket

The No. 259A Vacuum Tube employs a standard five-prong base suitable for use in a Western Electric No. 134A (cushion) or No. 137A (rigid) Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The control-grid terminal is located at the top of the bulb and is arranged for a special, quick-release connector.

Rating and Characteristic Data

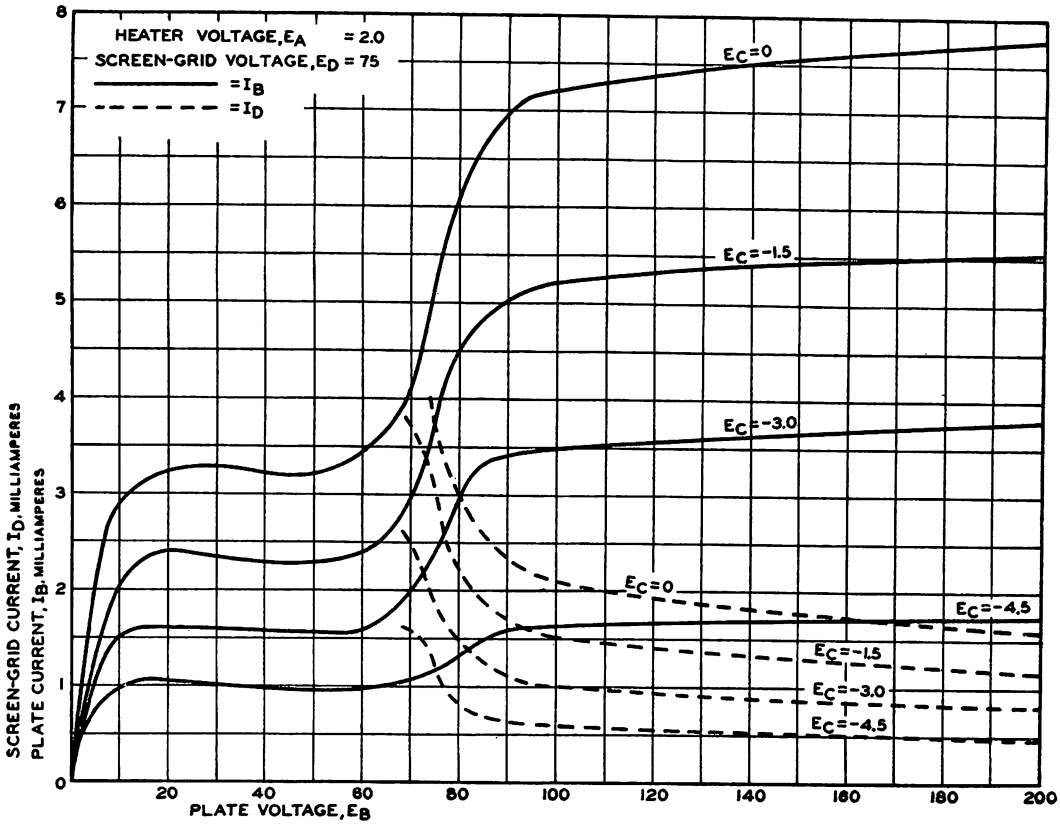
Heater Voltage		2 Volts, AC or DC
Average Heater Current		1.60 Amperes
Plate Voltage	180	180 Volts
Screen-Grid Voltage	75	90 Volts Maximum
Control-Grid Voltage	—1.5	—1.5 Volts
Average Plate Current	5.5	7.5 Milliamperes
Average Plate Resistance	400,000	320,000 Ohms
Average Mutual Conductance	1,380	1,500 Micromhos
Average Amplification Factor	550	480

Approximate Direct Interelectrode Capacities

Plate to Control-Grid	0.004 MMF
Control-Grid to Heater, Cathode and Screen-Grid	5.8 MMF
Plate to Heater, Cathode and Screen-Grid	14.0 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 259A Vacuum Tube.



General Features

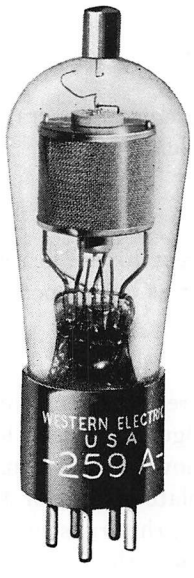
The No. 259A Vacuum Tube employs an extra grid or a screen which provides an electrostatic shield between the plate and control grid. Such internal shielding eliminates the necessity of neutralization to prevent unwarranted oscillation or feed-back if the rest of the circuit elements are properly shielded.

The structure has been so designed as to give an unusually high mutual conductance for a tube of its rating, thereby making possible a comparatively high amplification.

The cathode is designed to provide a very large electron emission compared with the space current drain, thus assuring the maintenance of uniform electrical characteristics over a long life.

Western Electric

259A Vacuum Tube



Classification—Voltage amplifier, screen-grid tetrode with indirectly heated cathode

Applications

Screen-grid high frequency amplifier.

Audio-frequency amplifier. Where exceptionally low tube noise is required the 259B tube is preferable.

Detector.

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 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—The 259A tube may be mounted in any position.

Average Direct Interelectrode Capacitances—

Control grid to plate	0.004	μμf.
Control grid to heater, cathode and screen-grid	5.8	μμf.
Plate to heater, cathode and screen-grid	14	μμf.

Heater Rating

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

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 practicable.

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

Characteristics—Plate current and screen-grid current characteristics of a typical 259A tube are given as functions of plate voltage in Figures 3 and 4 for screen-grid voltages of 75 and 90 volts, respectively. The same quantities are shown as functions of control-grid voltage in Figures 5 and 6. Transconductance characteristics for a plate voltage of 180 volts are shown in Figure 7. For other plate voltages between 135 and 250 volts, the transconductance of a typical tube for values higher than 100 micromhos does not differ by more than ± 3% from its value at 180 volts. The amplification factor and plate resistance characteristics corresponding to Figure 5 are given in Figures 8, 9, 10, and 11.

Typical Operating Conditions

Plate Voltage Volts	Screen-Grid Voltage Volts	Control-Grid Voltage Volts	Plate Current Milliamperes	Screen-Grid Current Milliamperes	Amplification Factor	Plate Resistance Ohms	Transconductance Micromhos
135	75	−1.5	5.3	1.4	400	300,000	1,330
180	75	−1.5	5.5	1.2	550	400,000	1,380
*180	90	−1.5	7.5	1.7	480	320,000	1,500
*250	75	−1.5	5.7	1.1	610	430,000	1,420

*Maximum operating conditions.

Circuit Requirements—In order to make use of the high gain per stage which is obtainable with the 259A tube, special precautions must be taken in high-frequency, multi-stage amplifiers to eliminate feed-back in the associated circuit. In order to do so effectively, it is usually necessary to use shielding between successive stages, a close fitting shield around each tube, and a resistance or choke coil in the screen-grid lead of each tube. When such an impedance is used in the screen-grid lead, a low impedance condenser should be connected from the screen-grid to the cathode. Impedances common to two or more plate or grid circuits should be avoided.

The screen-grid voltage should be obtained either directly from a low resistance source or from a voltage divider. The use of a series resistance to reduce a high voltage supply to the desired value is not recommended because screen-grid currents differ widely in different tubes and vary during life in individual tubes.

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 259A tube measured in a laboratory reference test set is 20 db below 1 volt. The range of levels of individual tubes extends from 2 to 36 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 tubes which have been tested in the same way.

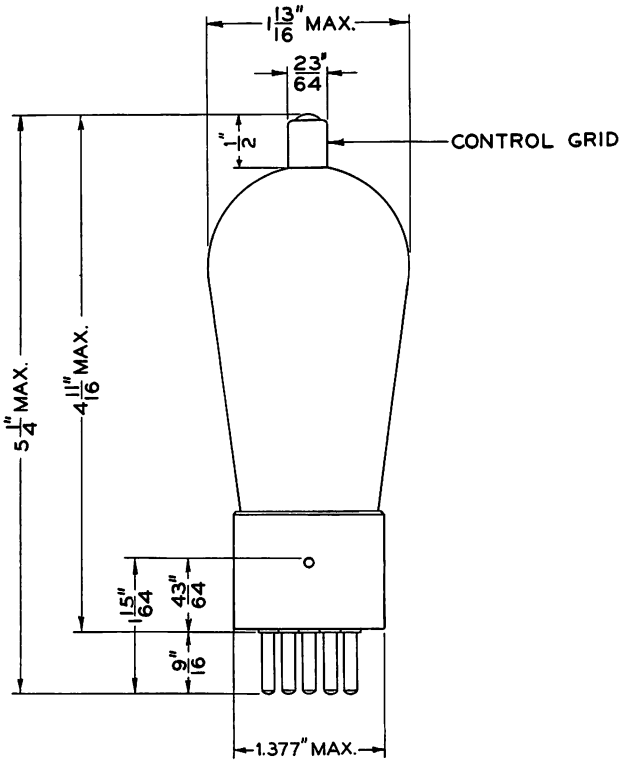


FIG. 1

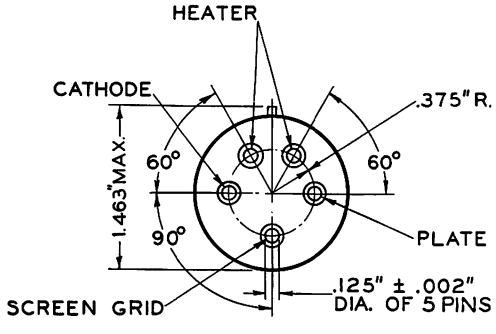


FIG. 2

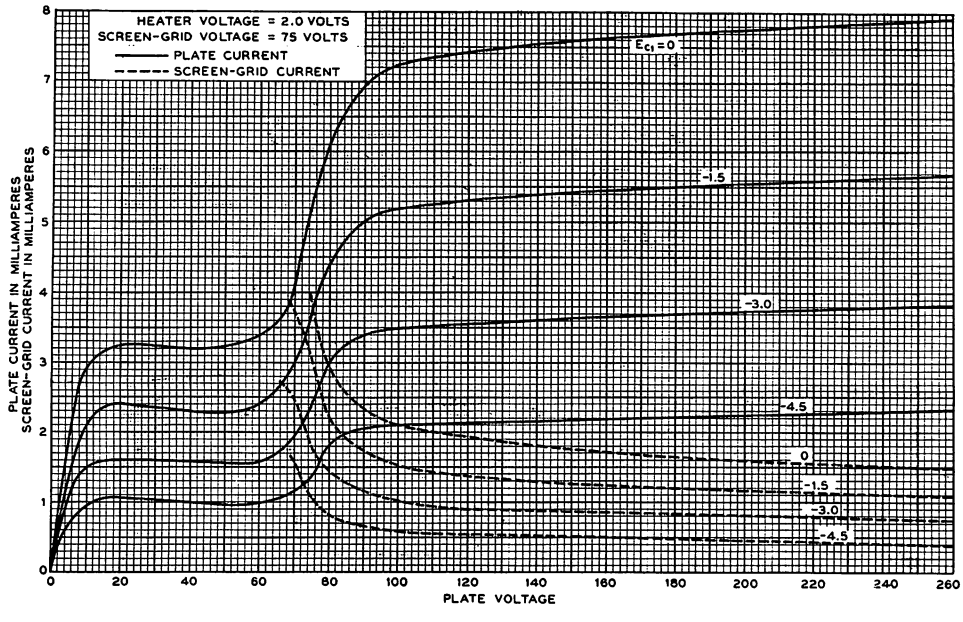

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
$E_{c1}=0$
-1.5
-3.0
-4.5
0
-1.5
-3.0
-4.5
PLATE CURRENT IN MILLIAMPERES
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0 20 40 60 80 100 120 140 160 180 200 220 240 260
0 1 2 3 4 5 6 7 8

FIG. 3

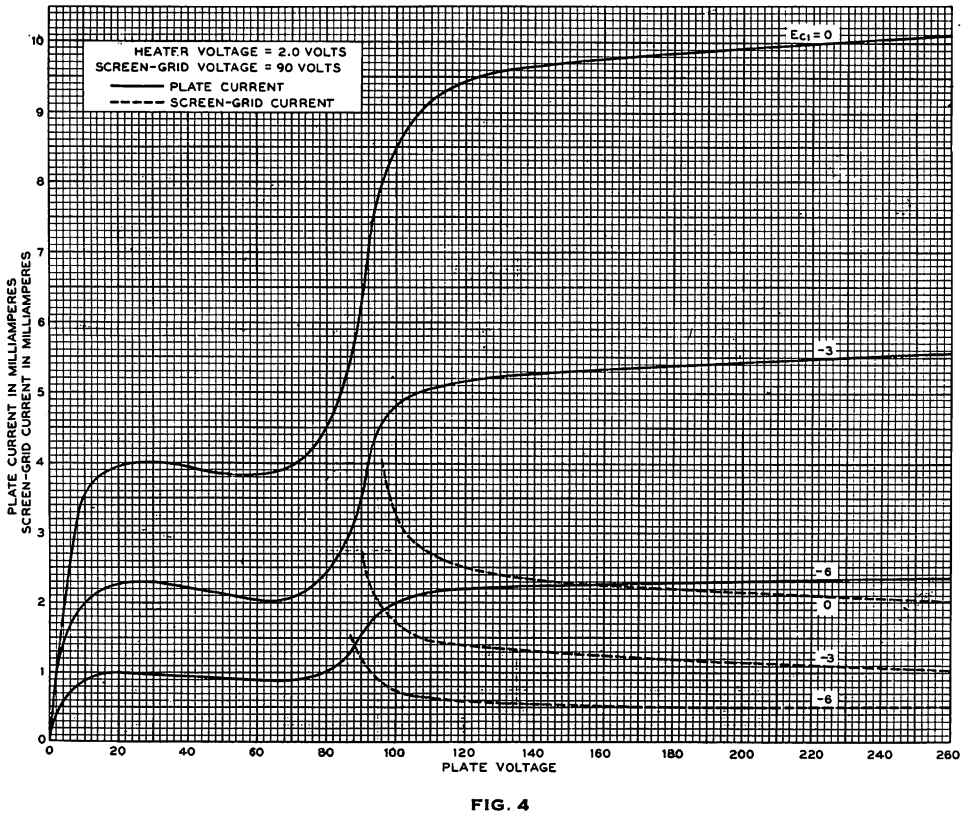

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 90 VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
$E_{c1}=0$
-3
-6
0
-3
-6
PLATE CURRENT IN MILLIAMPERES
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0 20 40 60 80 100 120 140 160 180 200 220 240 260
0 1 2 3 4 5 6 7 8 9 10

FIG. 4

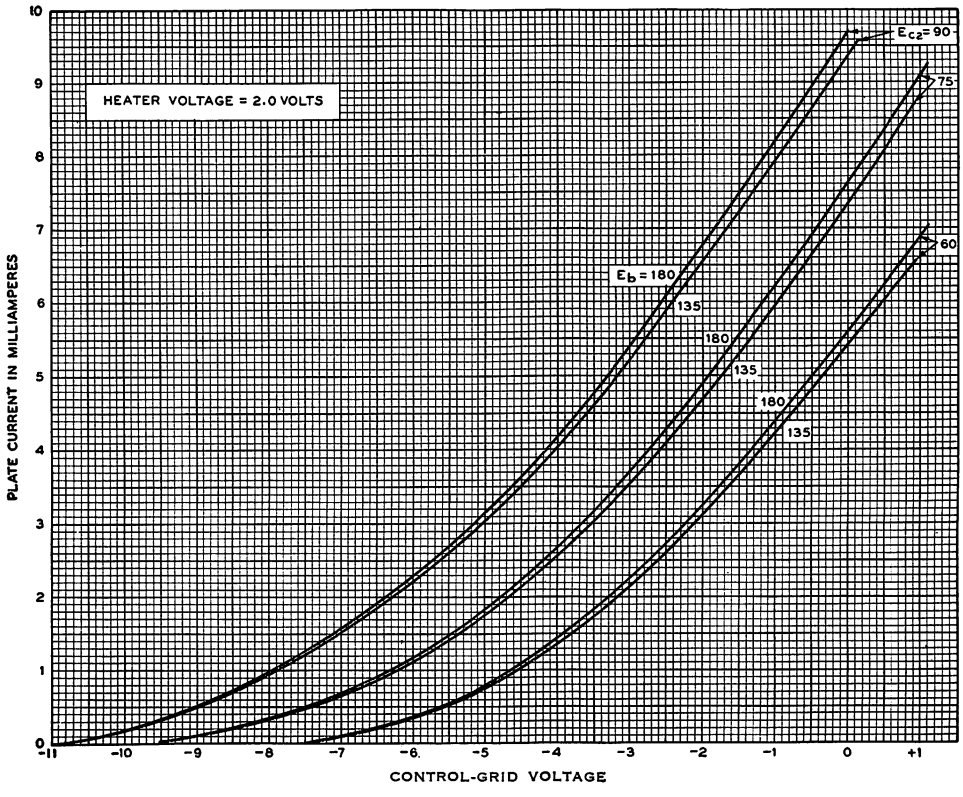

HEATER VOLTAGE = 2.0 VOLTS
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
E_{c2}=90
75
60
E_b=180
135
180
135
180
135
0
1
2
3
4
5
6
7
8
9
10
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1

FIG. 5

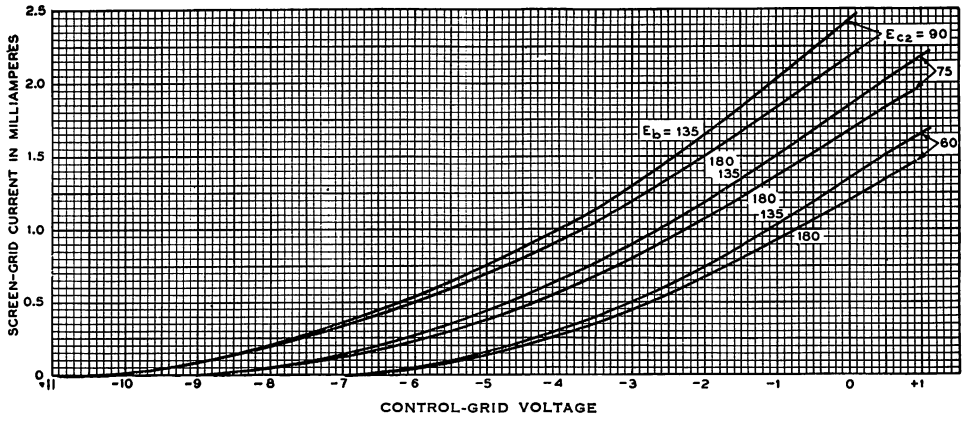

SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
E_{c2} = 90
75
60
E_b= 135
180
135
180
135
180
0
0.5
1.0
1.5
2.0
2.5
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1

FIG. 6

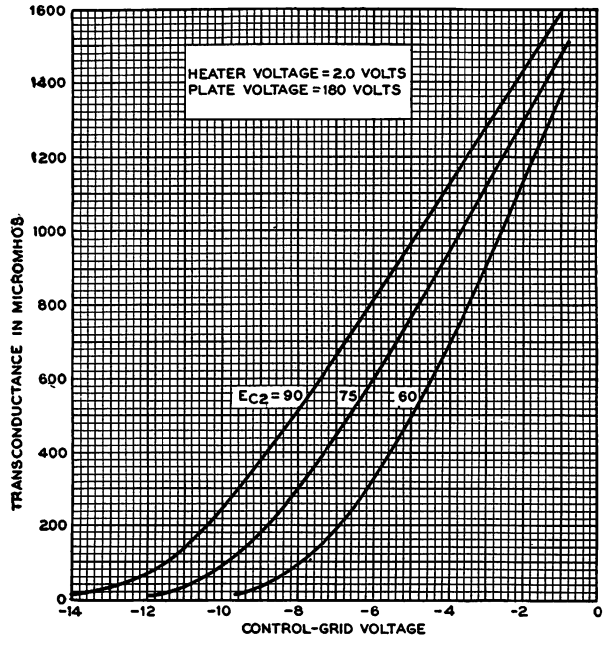


FIG. 7

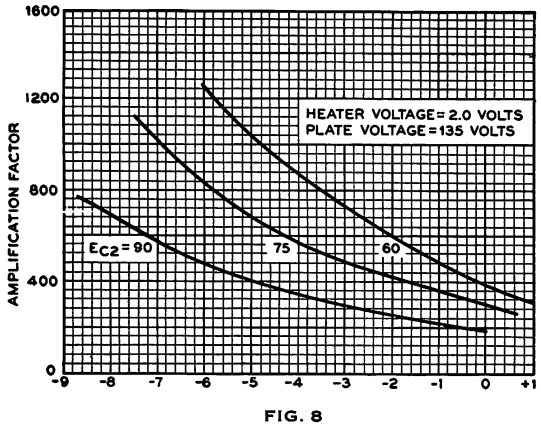


FIG. 8

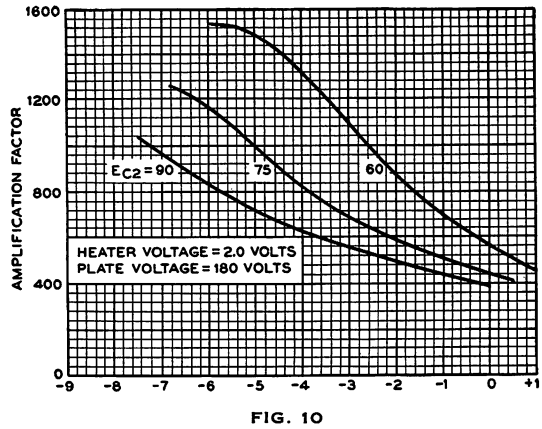


FIG. 10

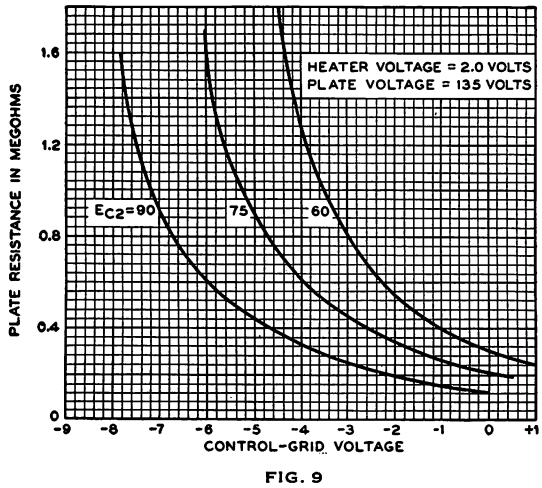


FIG. 9

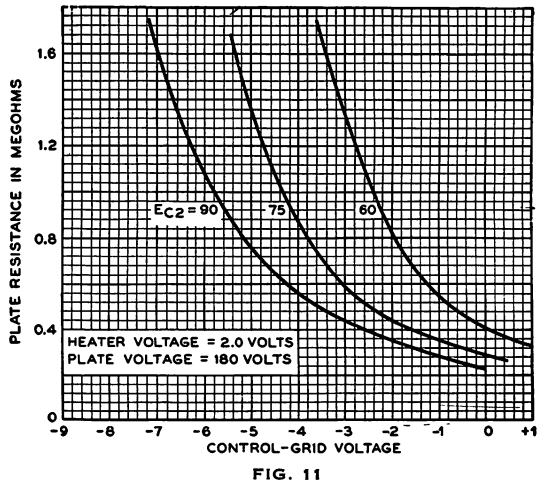
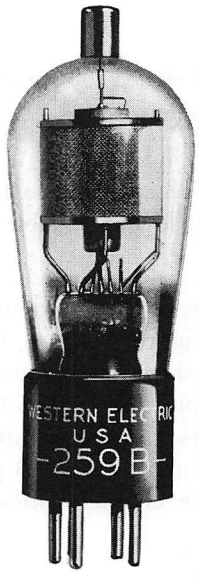


FIG. 11

Western Electric

259B Vacuum Tube



Classification—Voltage amplifier, screen-grid tetrode with indirectly heated cathode

The 259B tube has the same dimensions and characteristics as the 259A, but is designed to minimize audio-frequency disturbances arising in the tube.

Applications

Screen-grid high-frequency amplifier.

Audio-frequency amplifier for applications where exceptionally low tube noise is required. For other applications the 259A tube is appropriate.

Detector.

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; and a 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—The 259B tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Control grid to plate	0.004 μμf.
Control grid to heater, cathode, and screen grid	5.8 μμf.
Plate to heater, cathode, and screen grid	14.0 μμf.

Heater Rating and Supply

Heater voltage	2.0 volts a.c. or d.c.
Nominal heater current	1.6 amperes

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 practicable.

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

Characteristics—Plate-current and screen-grid current characteristics of a typical 259B tube are given as functions of plate voltage in Figures 3 and 4, for screen-grid voltages of 75 and 90 volts, respectively. The same quantities are shown as functions of control-grid bias in Figures 5 and 6. Transconductance characteristics for a plate voltage of 180 volts are shown in Figure 7. For other plate voltages between 135 and 250 volts, the transconductance of a typical tube, for values higher than 100 micromhos, does not differ by more than ±3 per cent from its value at 180 volts. The amplification-factor and plate-resistance characteristics corresponding to Figure 5 are given in Figures 8, 9, 10, and 11.

Typical Operating Conditions

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Plate Current	Screen-Grid Current	Amplification Factor	Plate Resistance	Transconductance
Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Micromhos
135	75	−1.5	5.3	1.4	400	300,000	1,330
180	75	−1.5	5.5	1.2	550	400,000	1,380
*180	90	−1.5	7.5	1.7	480	320,000	1,500
*250	75	−1.5	5.7	1.1	610	430,000	1,420

*Maximum operating conditions.

Circuit Requirements—In order to make use of the high gain per stage which is obtainable with the 259B tube, special precautions must be taken in high-frequency, multi-stage amplifiers, to eliminate feed-back in the associated circuit. In order to do this effectively, it is usually necessary to use shielding between successive stages, a close-fitting shield around each tube, and a resistance or choke coil in the screen-grid lead of each tube. When such an impedance is used in the screen-grid lead, a low-impedance condenser should be connected from the screen grid to the cathode. Impedances common to two or more plate or grid circuits should be avoided.

The screen-grid voltage should be obtained directly from a low resistance source or through a voltage divider. The use of a series resistance to reduce a high voltage supply to the desired value is not recommended because screen-grid currents differ widely in different tubes and vary during life in individual tubes.

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 259B tube, measured in a laboratory reference test set, is 20 db below 1 volt. The range of levels of individual tubes extends from 2 to 36 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 tubes which have been tested in the same way.

Low Level Audio-Frequency Amplification—The 259B tube has been specially designed to eliminate the microphonic noise impulses which sometimes occur spontaneously at random intervals in tubes of this general type. When the tube is well shielded from external microphonic noise impulses, it is exceptionally quiet in operation and can be used for the audio-frequency amplification of exceptionally low level signals. For the highest signal-to-noise ratio in such applications, the screen-grid and plate voltages should be reduced to about 22.5 and 100 volts, respectively. For ion counters or other applications where the control grid is left floating, most quiet operation is obtained with screen-grid and plate voltages of about 16.5 and 30 volts, respectively, and a reduced value of heater voltage. Under such conditions, the limiting noise is the thermal agitation noise in the input resistance of the tube added to the shot-effect noise from the residual grid current.

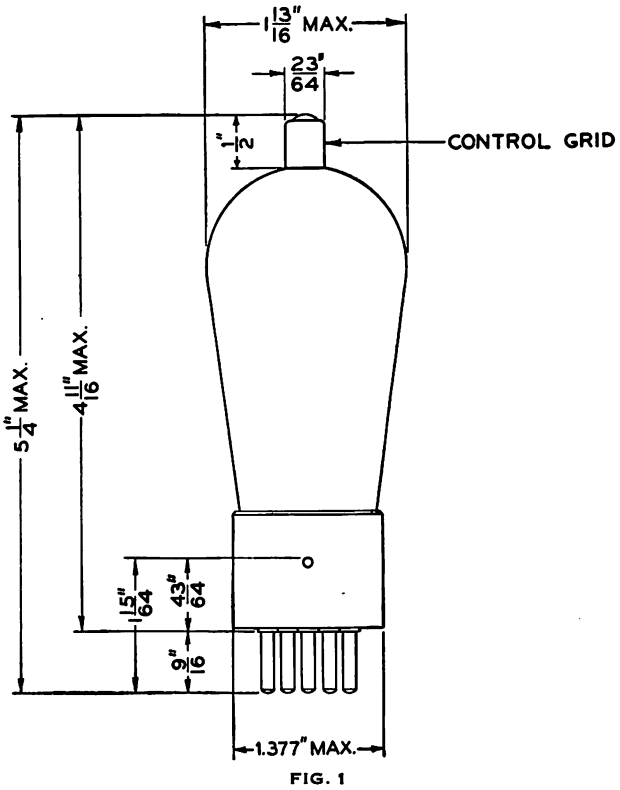


FIG. 1

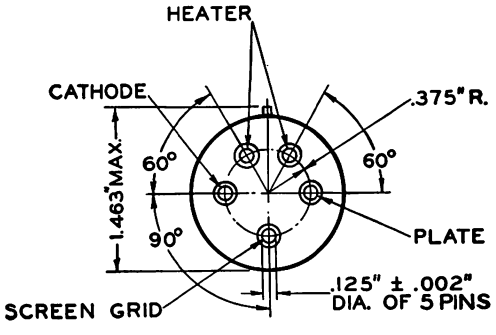


FIG. 2

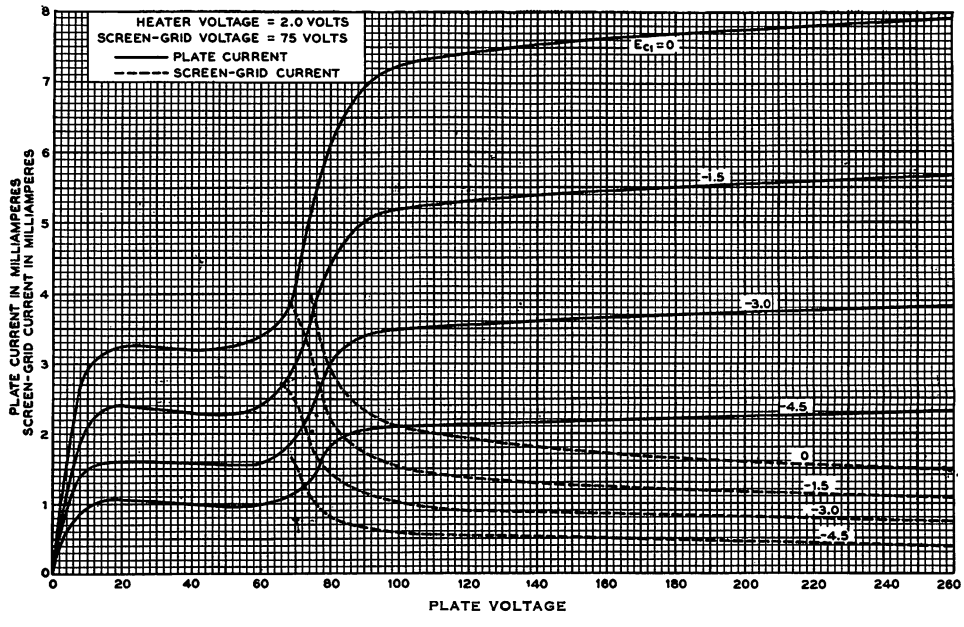

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
$E_{c1}=0$
-1.5
-3.0
-4.5
0
-1.5
-3.0
-4.5
PLATE CURRENT IN MILLIAMPERES
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE

FIG. 3

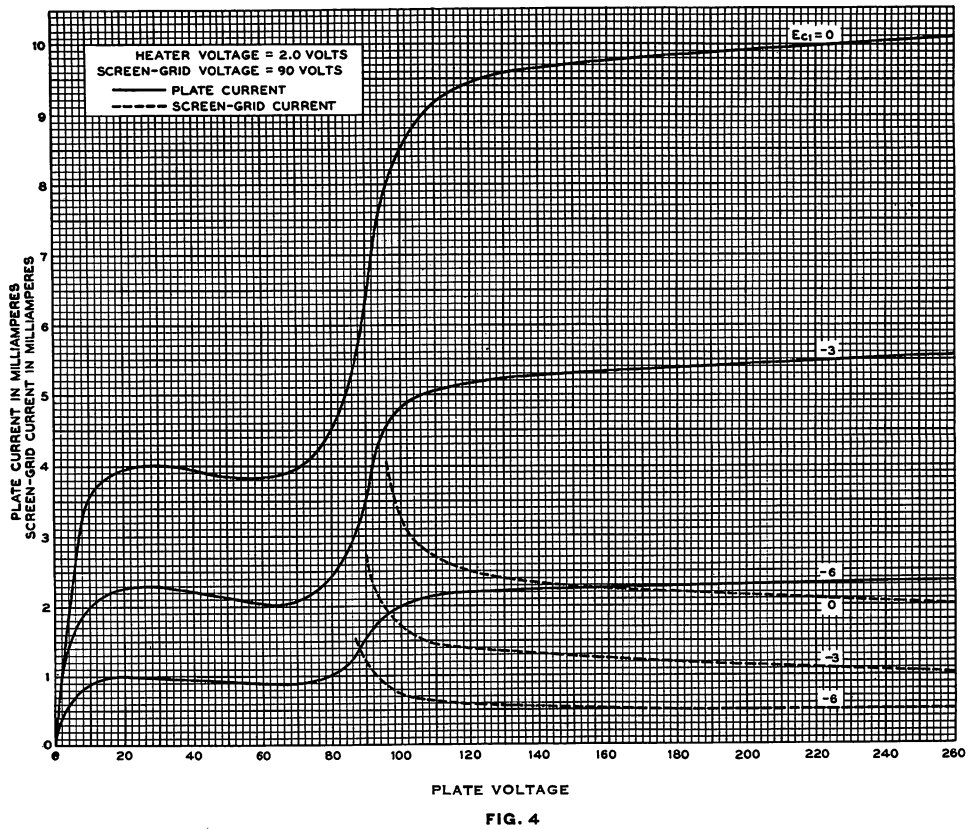

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 90 VOLTS
PLATE CURRENT
SCREEN-GRID CURRENT
$E_{c1}=0$
-3
-6
0
-3
-6
PLATE CURRENT IN MILLIAMPERES
SCREEN-GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE

FIG. 4

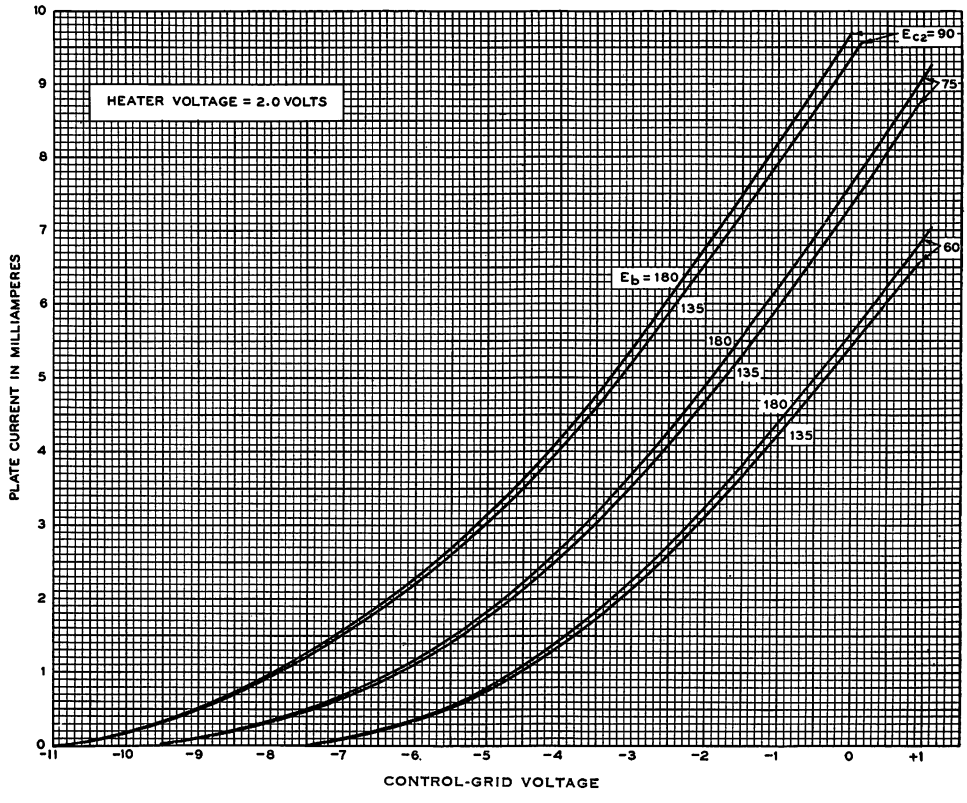

HEATER VOLTAGE = 2.0 VOLTS
PLATE CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
E_{c2}=90
75
60
E_b=180
135
180
135
180
135
10
9
8
7
6
5
4
3
2
1
0
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1

FIG. 5

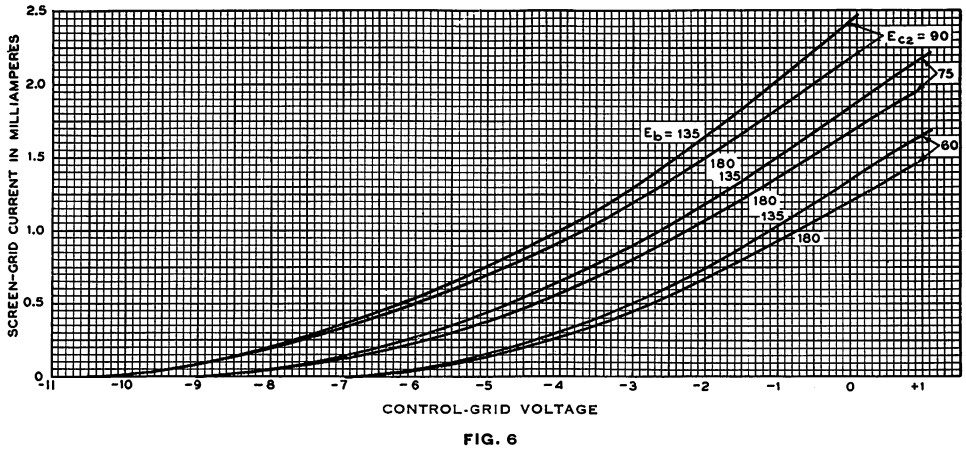

SCREEN-GRID CURRENT IN MILLIAMPERES
CONTROL-GRID VOLTAGE
E_{c2} = 90
75
60
E_b = 135
180
135
180
135
180
2.5
2.0
1.5
1.0
0.5
0
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1

FIG. 6

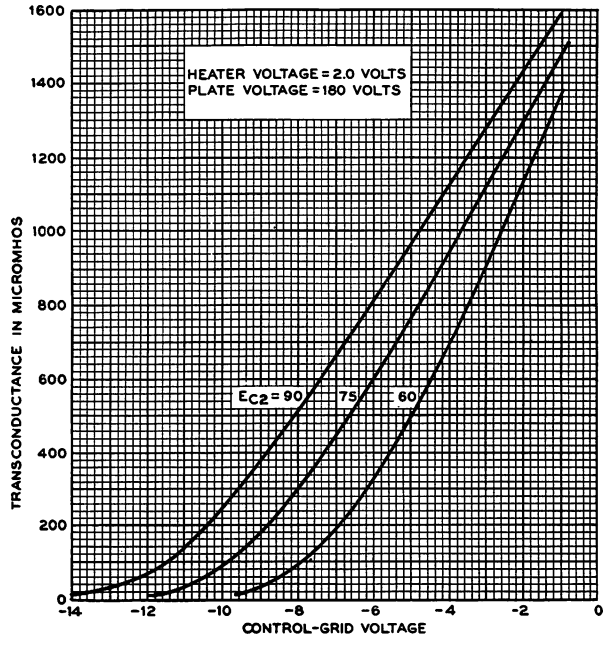


FIG. 7

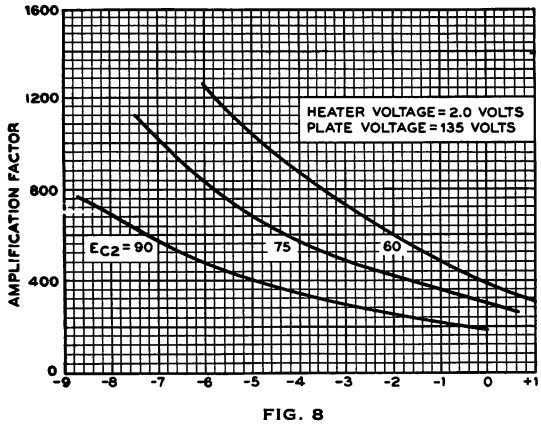


FIG. 8

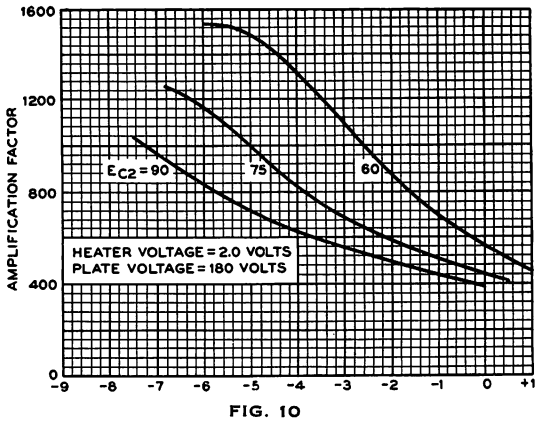


FIG. 10

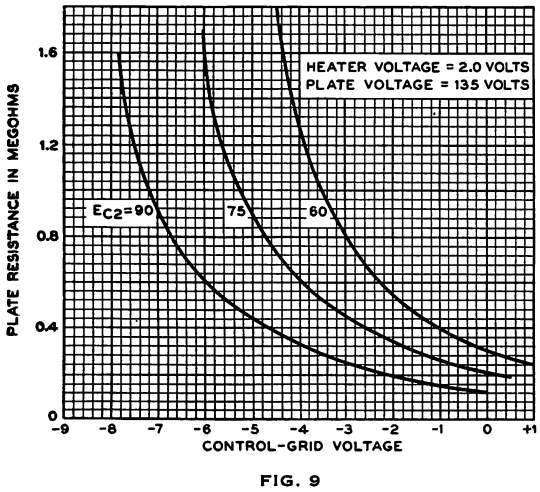


FIG. 9

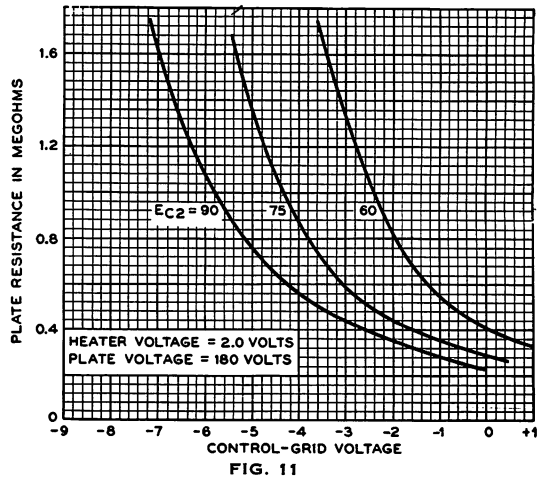
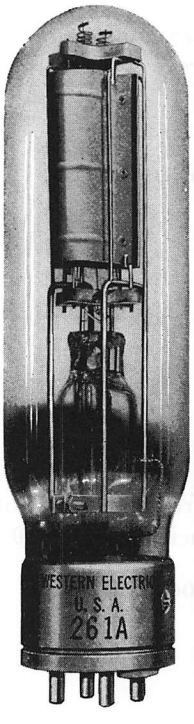


FIG. 11

Western Electric

261A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

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

Maximum overall length	$7\frac{15}{16}$″
Maximum diameter	$2\frac{5}{16}$″

Mounting—Large four-pin bayonet base suitable for use in a W.E. 112A 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 ampere

Average Direct Interelectrode Capacitances

Plate to grid	9.0 μμf
Grid to filament	6.5 μμf
Plate to filament	4.0 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 and 4 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at maximum direct plate voltage and dissipation—Class A (E_b = 1250 volts, I_b = 68 milliamperes)

Amplification factor	12
Plate resistance	3000 ohms
Grid to plate transconductance	4000 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1250 volts
Max. direct plate current	150 milliamperes
Max. plate dissipation	100 watts
Max. direct grid current	50 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	30 megacycles
Max. plate voltage for upper frequency limit of 40 Mc	750 volts
Max. plate voltage for frequencies between 30 and 40 Mc in proportion	

Class A Audio Amplifier or Modulator

Direct plate voltage	1250	1000 volts
Grid bias	−75	−50 volts
Direct plate current	68	85 milliamperes
Plate dissipation	85	85 watts
Load impedance	8000	7000 ohms
Undistorted output	20	10 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	1250	1000 volts
Grid bias	−90	−67 volts
Direct plate current per tube		
No drive	20	20 milliamperes
Max. drive	150	150 milliamperes
Plate dissipation	85	67.5 watts
Load resistance plate-to-plate	7200	6320 ohms
Load resistance per tube	1800	1580 ohms
Approximate max. output—2 tubes	200	175 watts
Recommended power for driving stage	25	25 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	1250	1000 volts
Grid bias	−100	−80 volts
Direct plate current for carrier conditions	125	150 milliamperes
Approximate carrier watts for use with 100% modulation	50	50 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1250	1000 volts
Grid bias	−150 to −200	−120 to −160 volts
Direct plate current	125	125 milliamperes
Nominal power output	100	85 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1000	750 volts
Grid bias	−160	−120 volts
Direct plate current	150	150 milliamperes
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	100	75 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 175 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 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 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 output can be increased or the distortion decreased by the use of degenerative feedback. 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—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. The tube may be used at full rating up to 30 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.

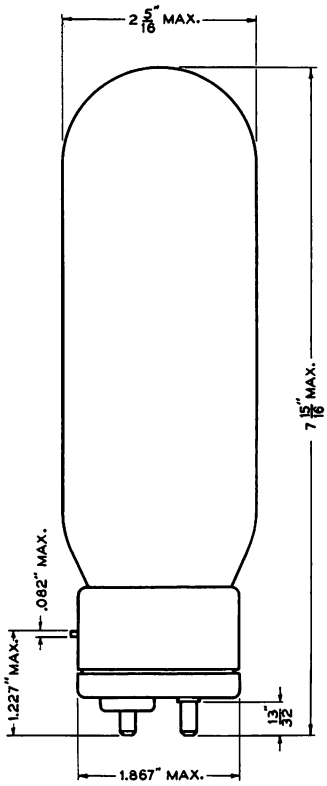

2 5/16" MAX.
7 15/16" MAX.
.082" MAX.
1.227" MAX.
13/32"
1.867" MAX.

FIG. 1

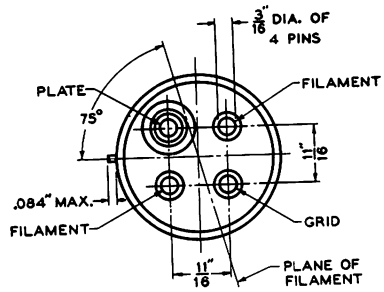

3/16" DIA. OF 4 PINS
PLATE
75°
FILAMENT
11/16"
.084" MAX.
FILAMENT
GRID
11/16"
PLANE OF FILAMENT

FIG. 2

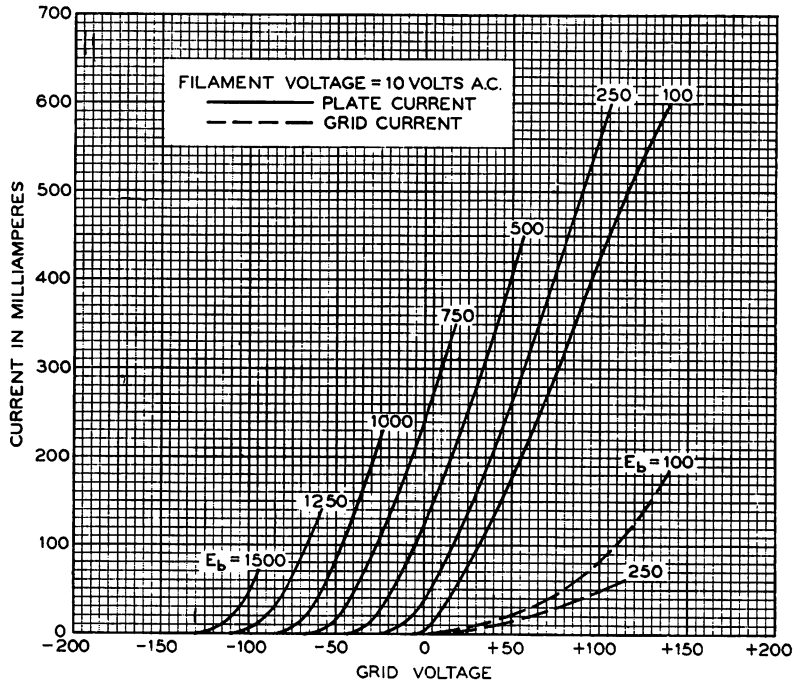

FILAMENT VOLTAGE = 10 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
700
600
500
400
300
200
100
0
−200
−150
−100
−50
0
+50
+100
+150
+200
250
100
500
750
1000
1250
E_b = 1500
E_b = 100
250

FIG. 3

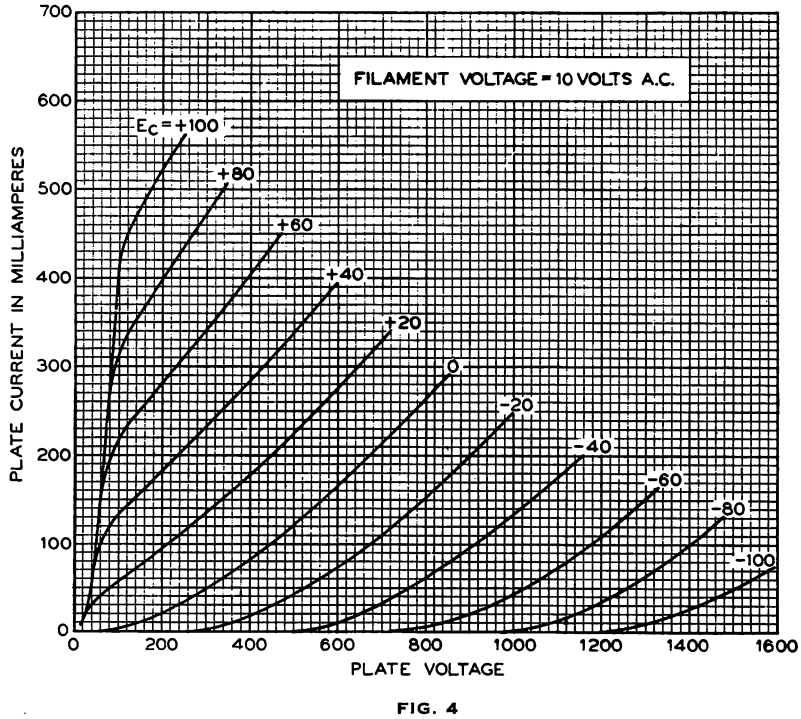
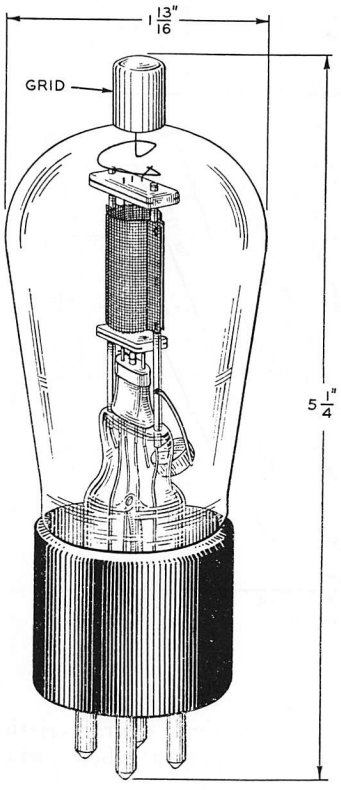
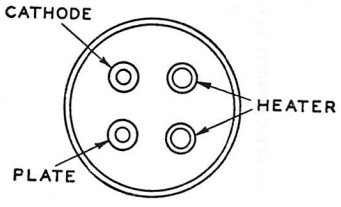

FILAMENT VOLTAGE = 10 VOLTS A.C.
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
1600
E_C = +100
+80
+60
+40
+20
0
-20
-40
-60
-80
-100

FIG. 4

262A Vacuum Tube





Classification

The No. 262A Vacuum Tube is a general purpose tube having an indirectly heated cathode designed to permit operation of the heater element directly on alternating current. The tube is for use as an audio-frequency amplifier in high gain circuits.

Base and Socket

The No. 262A Vacuum Tube employs a standard four-prong base suitable for use in a Western Electric No. 130B (rigid) or No. 131A (cushion) socket or similar type socket. The arrangement of the electrode connections to the base terminals is shown above. The grid terminal is located at the top of the bulb.

Rating and Characteristic Data

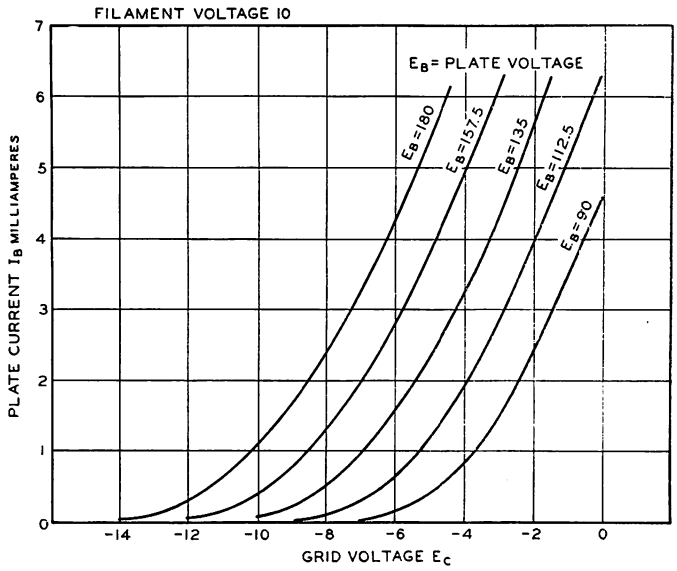
Heater Voltage		10 Volts, AC or DC
Average Heater Current		0.32 Amperes
Plate Voltage	135	180 Volts Maximum
Grid Voltage	—6.0	—7.5 Volts
Average Plate Current	1.6	2.8 Milliamperes
Average Plate Resistance	21,200	17,500 Ohms
Average Amplification Factor	14.7	14.9

Approximate Direct Interelectrode Capacities

Plate to Grid	1.9 MMF
Plate to Cathode	4.0 MMF
Grid to Cathode	1.8 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 262A Vacuum Tube.



General Features

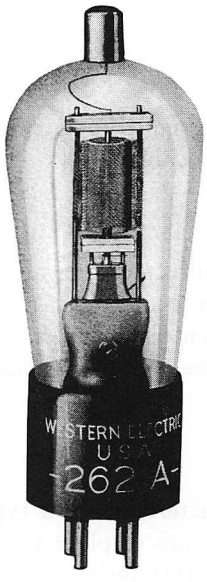
The No. 262A Vacuum Tube is designed with electrical characteristics particularly suitable for use in intermediate stages of audio-frequency amplifiers where either resistance or transformer coupling is used.

By special features in design and by careful control of the manufacturing processes the disturbing hum output due to the use of alternating current in the heater is maintained at an extremely low level. This makes the tube especially suitable, when alternating current filament supply is used, for the early stages of high gain audio-frequency amplifiers where the use of ordinary heater type tubes would be entirely impracticable.

The rigid and non-resonating structure of this tube makes it unusually non-microphonic. Its microphonic response to a given mechanical stimulus is from 10 to 20 db below that of heater tubes of conventional design.

Western Electric

262A Vacuum Tube



Classification—Low-power triode with indirectly-heated cathode

The 262A tube is designed to minimize hum produced by alternating current operation of the heater, and to minimize microphonic noise.

Application—Audio-frequency amplifier where alternating current is used for heating the cathode and exceptionally low tube noise is required.

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

Base—Medium, four-pin thrust type having silver-plated pins. Small metal cap grid terminal at the top of the bulb.

Socket—Standard, four-contact type, preferably provided with silver-plated contacts such, as the Western Electric 143B socket.

Mounting Positions—The 262A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Grid to plate	1.9 μμf.
Grid to cathode and heater	1.8 μμf.
Plate to cathode and heater	4.0 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.

Cathode Connection—Preferably direct to the mid-point of the heater transformer winding or to the mid-point of a low resistance connected across the heater terminals, where alternating heater voltage is used. This connection usually reduces the hum produced in the tube. Where voltage must be applied between the heater and cathode, it should be kept as low as possible and should not exceed 90 volts.

Characteristics—Plate current characteristics of a typical 262A tube are shown in Figure 3 as functions of grid voltage 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 are given as functions of plate voltage for several values of grid voltage in Figure 7.

Operating Conditions and Output—Permissible operating plate and grid voltages are included within the area, ABCD, in Figure 3. A number of recommended and maximum operating conditions represented by selected points within this area and the corresponding values of amplification factor, plate resistance and transconductance are given in the table on page 4. 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 the recommended conditions.

In the latter part 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, R. The fundamental output is given in terms of power for values of load resistance equal to and double the value of the plate resistance, r_p, and in terms of voltage for values of load resistance five times the plate 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 and 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. The other, often larger in magnitude, is of double this frequency. With a plate voltage of 135 volts, a grid bias of −4.5 volts, a load resistance equal to the plate resistance of the tube, and with the cathode connected to the mid-point of the heater circuit, the mean hum output level of the 262A tube at the supply frequency is 110 db below 1 milliampere. The range of levels of individual tubes extends from 95 to 125 db below 1 milliampere. At double the supply frequency, the mean level is 111 db below 1 milliampere, and the range of levels of individual tubes extends from 104 to 118 db below 1 milliampere.

The 262A tube has high insulation resistance and low capacitance between the grid and the 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.

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 of the 262A tube measured in a laboratory reference test set is 50 db below 1 volt. The range of levels of individual tubes extends from 38 to 62 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 uncontrollable, minute 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 the 262A tube for the audio-frequency range from 40 to 10,600 cycles is 112.4 db below 1 volt. Individual 262A tubes may differ from this value by as much as 5 db. By reducing the plate voltage to 36 volts and the grid bias to −1 volt, the mean fluctuation noise level may be reduced by about 7.5 db, without seriously affecting the voltage amplification. The equivalent noise input voltage is equal to the measured output voltage divided by the voltage amplification of the tube in the measuring circuit.

TABLE

	Plate Voltage Volts	Grid Bias Volts	Plate Current Milliamperes	Amplification Factor	Plate Resistance Ohms r_p	Transconductance Micromhos	Load Resistance R	Power Output Milliwatts	Voltage Output Peak Volts	Second Harmonic db	Third Harmonic db
Recommended Operating Conditions	90	−4.0	0.9	14.3	23800	600	$R=r_p$	17	—	21	42
							$R=2r_p$	15	—	23	55
							$R=5r_p$	—	50	30	55
	90	−3.0	1.6	15.0	18500	810	$R=r_p$	13	—	23	55
							$R=2r_p$	12	—	27	60
							$R=5r_p$	—	40	32	55
	90	−2.0	2.5	15.6	15700	990	$R=r_p$	8	—	28	55
							$R=2r_p$	7	—	31	60
							$R=5r_p$	—	30	36	70
	112.5	−4.5	1.6	14.7	19100	770	$R=r_p$	30	—	20	47
							$R=2r_p$	25	—	25	65
							$R=5r_p$	—	67	30	55
	112.5	−3.0	2.9	15.5	15000	1030	$R=r_p$	17	—	26	60
							$R=2r_p$	15	—	30	70
							$R=5r_p$	—	40	33	60
	*135	−7.5	0.7	13.7	29000	470	$R=5r_p$	—	95	25	50
	135	−6.0	1.6	14.4	19600	730	$R=r_p$	45	—	19	42
							$R=2r_p$	40	—	23	55
							$R=5r_p$	—	75	29	50
	135	−4.5	2.8	15.1	15400	980	$R=r_p$	35	—	23	60
							$R=2r_p$	30	—	27	60
							$R=5r_p$	—	60	31	55
	*157.5	−8.0	1.4	14.0	22000	640	$R=5r_p$	—	100	26	50
	157.5	−7.0	2.0	14.5	18200	800	$R=r_p$	65	—	18	42
							$R=2r_p$	60	—	23	55
							$R=5r_p$	—	90	29	50
Maximum Operating Conditions	112.5	−2.0	4.0	16.0	13400	1190	$R=r_p$	9	—	31	55
							$R=2r_p$	8	—	34	60
							$R=5r_p$	—	30	38	65
	135	−3.5	3.8	15.6	13700	1140	$R=r_p$	25	—	26	55
							$R=2r_p$	20	—	30	70
							$R=5r_p$	—	47	33	70
	157.5	−5.5	3.3	15.1	14800	1020	$R=r_p$	55	—	22	55
							$R=2r_p$	50	—	27	60
							$R=5r_p$	—	70	31	50
	*180	−10.5	0.9	13.6	28800	470	$R=5r_p$	—	130	23	42
	*180	−9.0	1.7	14.1	20200	700	$R=5r_p$	—	110	27	50
	180	−7.5	2.8	14.7	16200	910	$R=r_p$	90	—	20	46
							$R=2r_p$	80	—	24	60
							$R=5r_p$	—	95	30	50

*Operating conditions applicable primarily for voltage amplification.

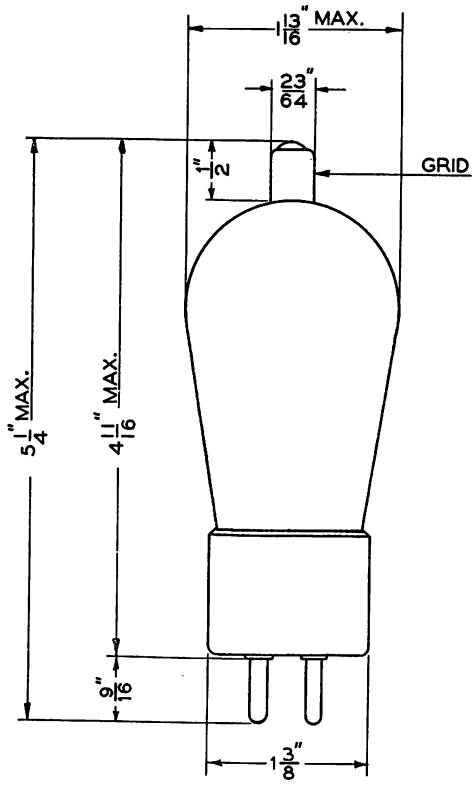


FIG. 1

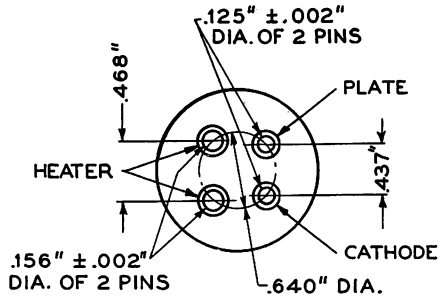


FIG. 2

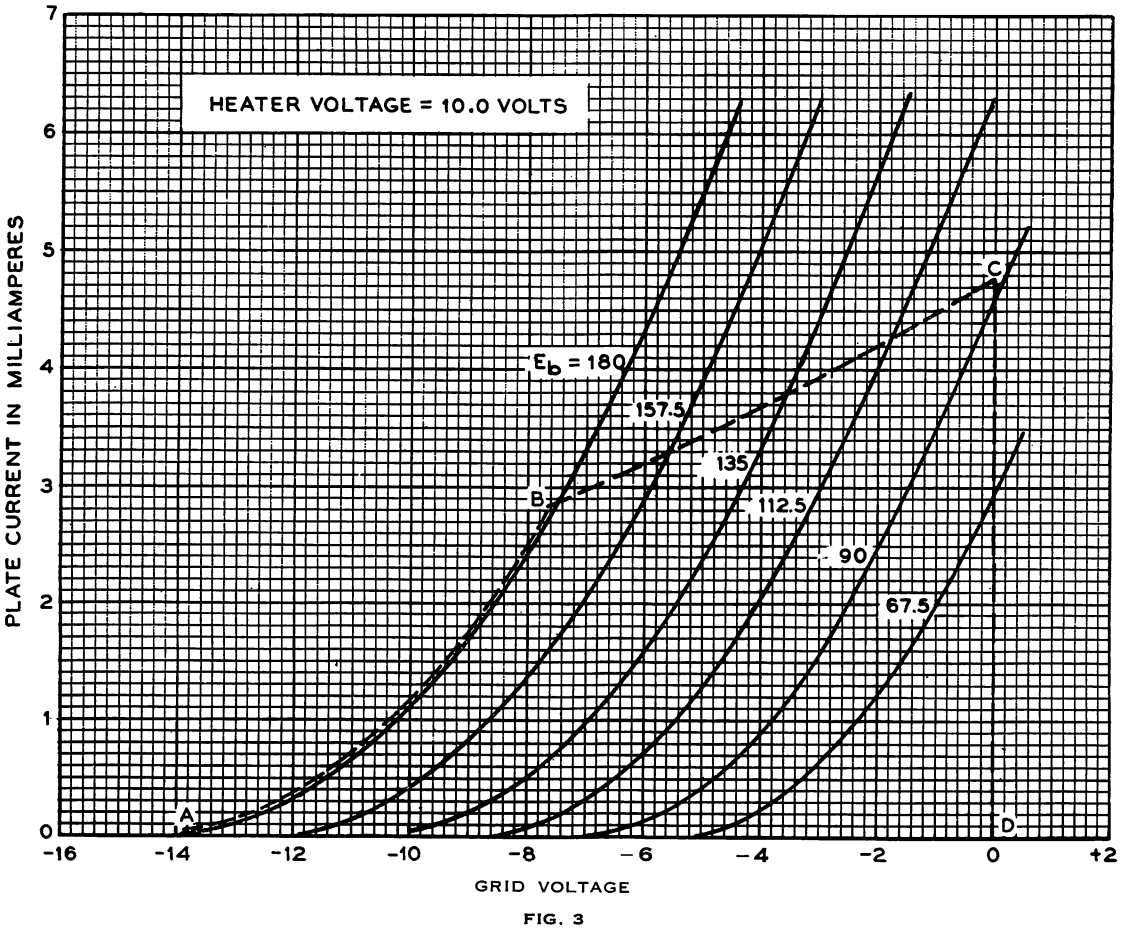


FIG. 3

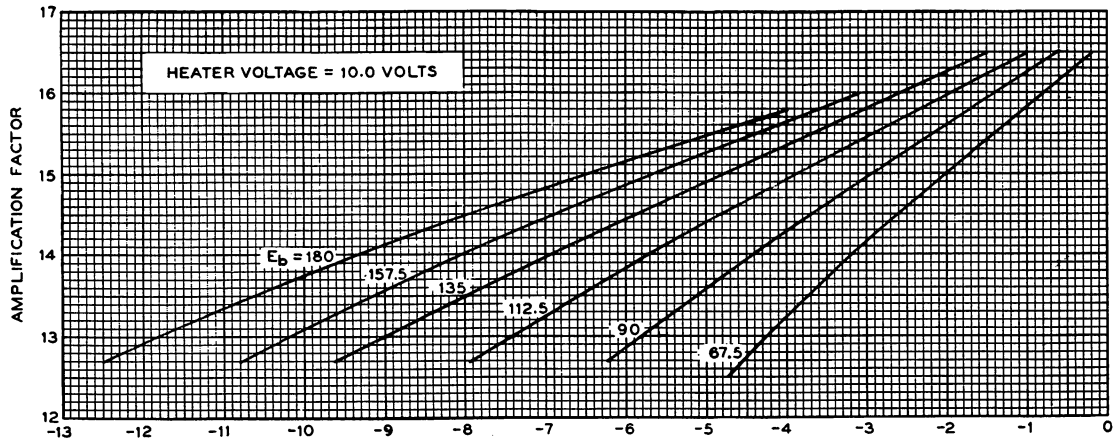


FIG. 4

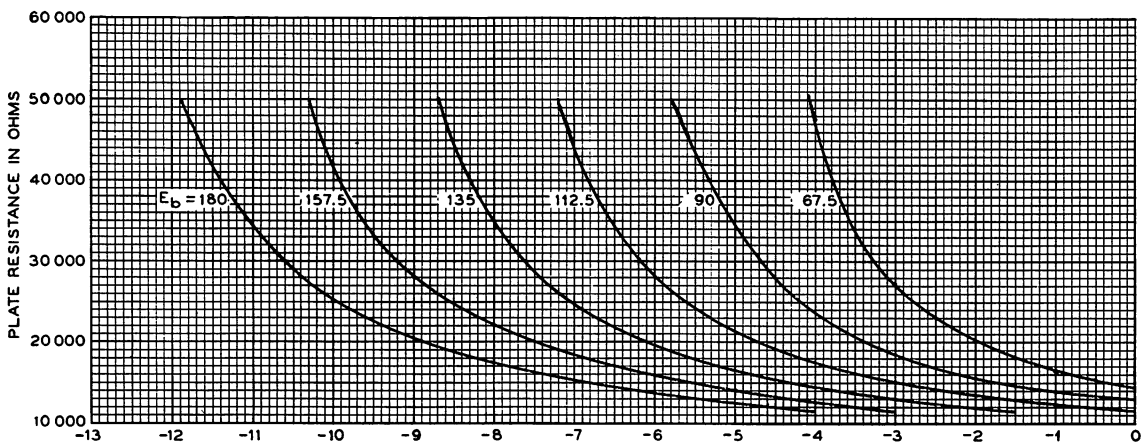


FIG. 5

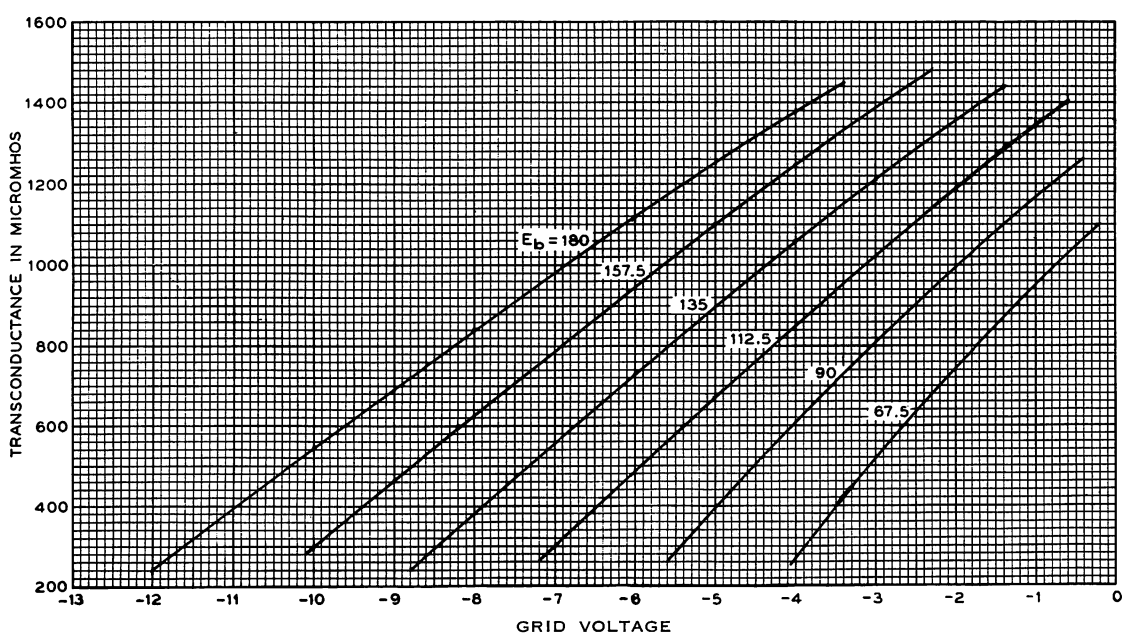


FIG. 6

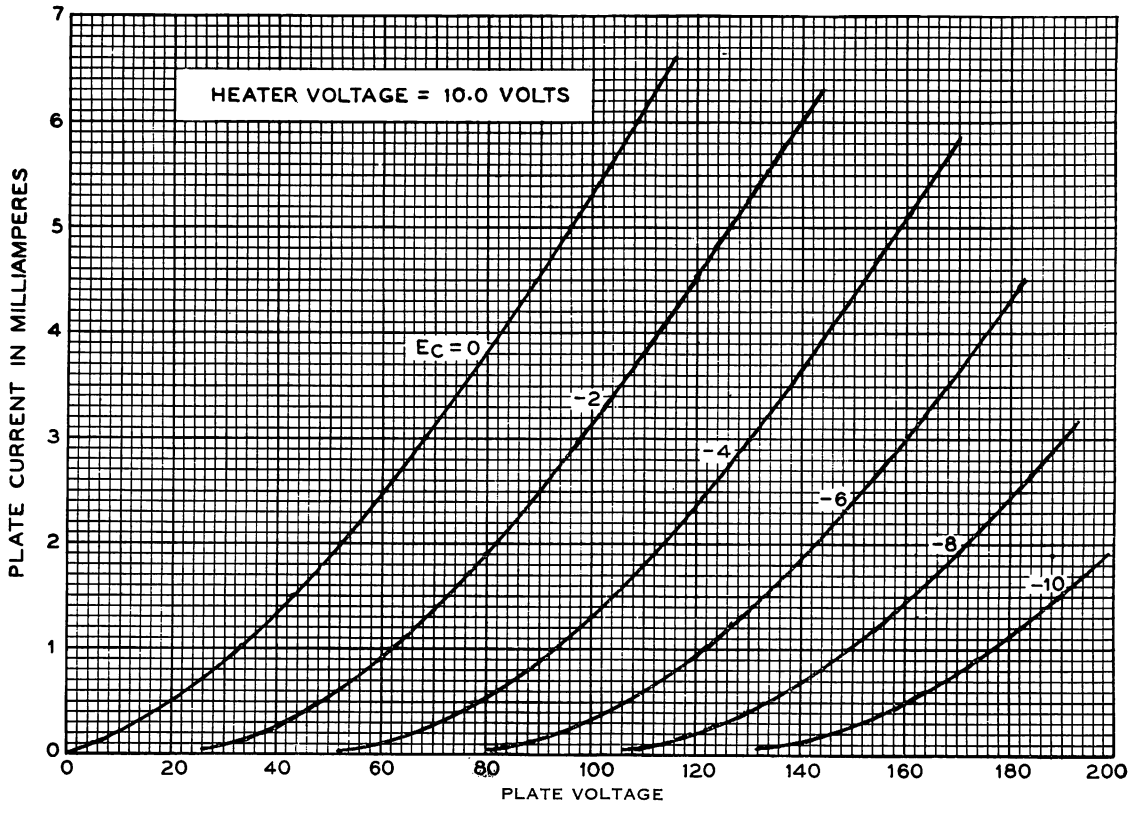
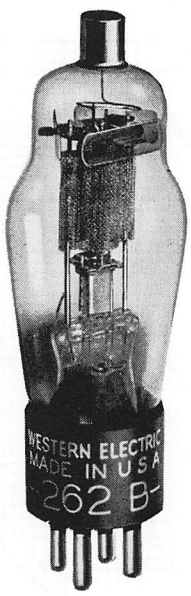
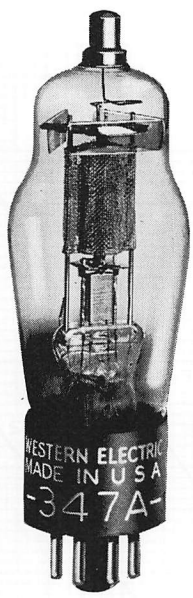

HEATER VOLTAGE = 10.0 VOLTS
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
EC = 0
-2
-4
-6
-8
-10
0
1
2
3
4
5
6
7
0
20
40
60
80
100
120
140
160
180
200

FIG. 7

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

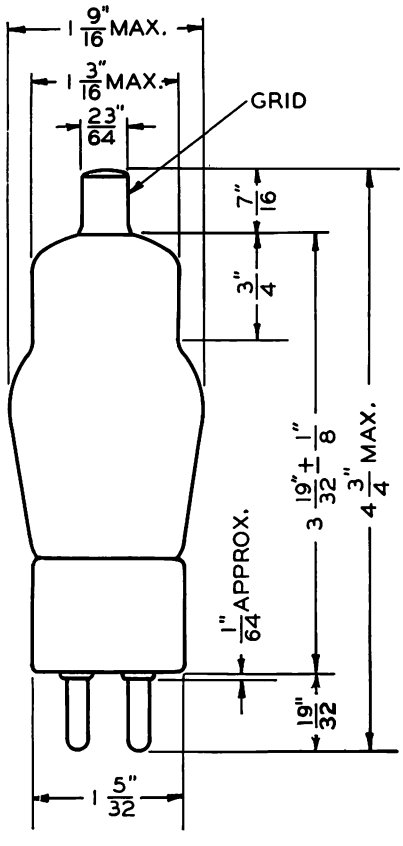


FIG. 1

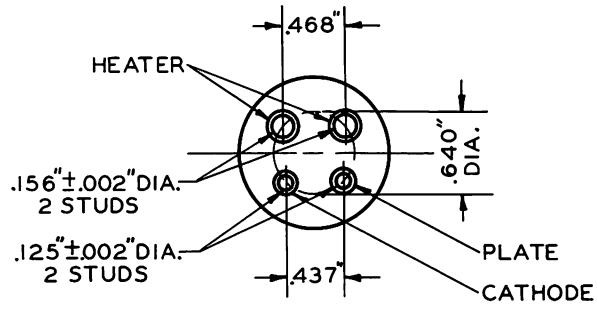


FIG. 2

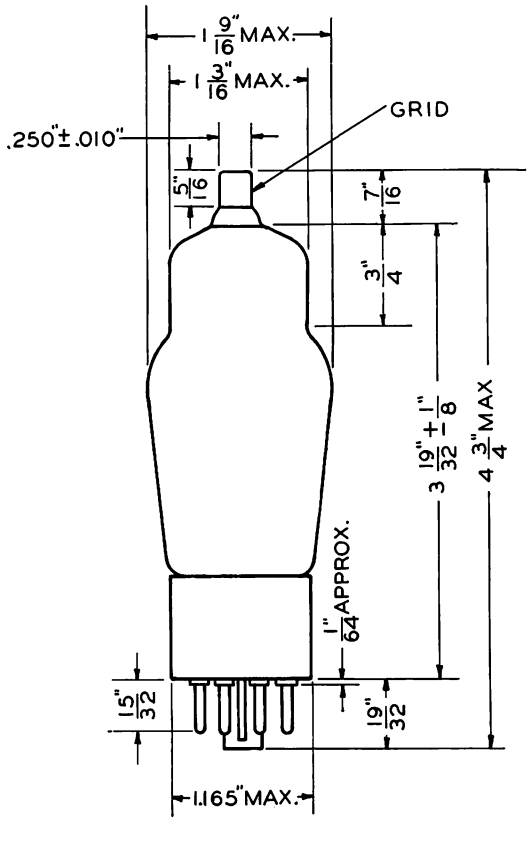


FIG. 3

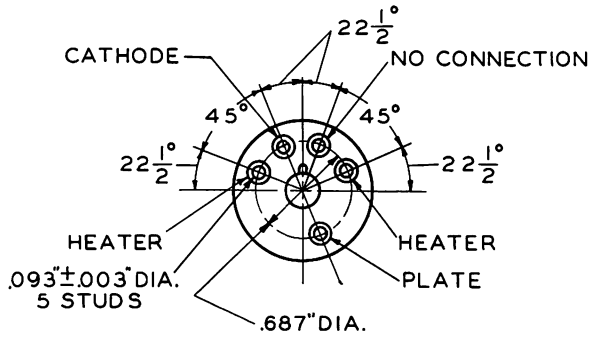


FIG. 4

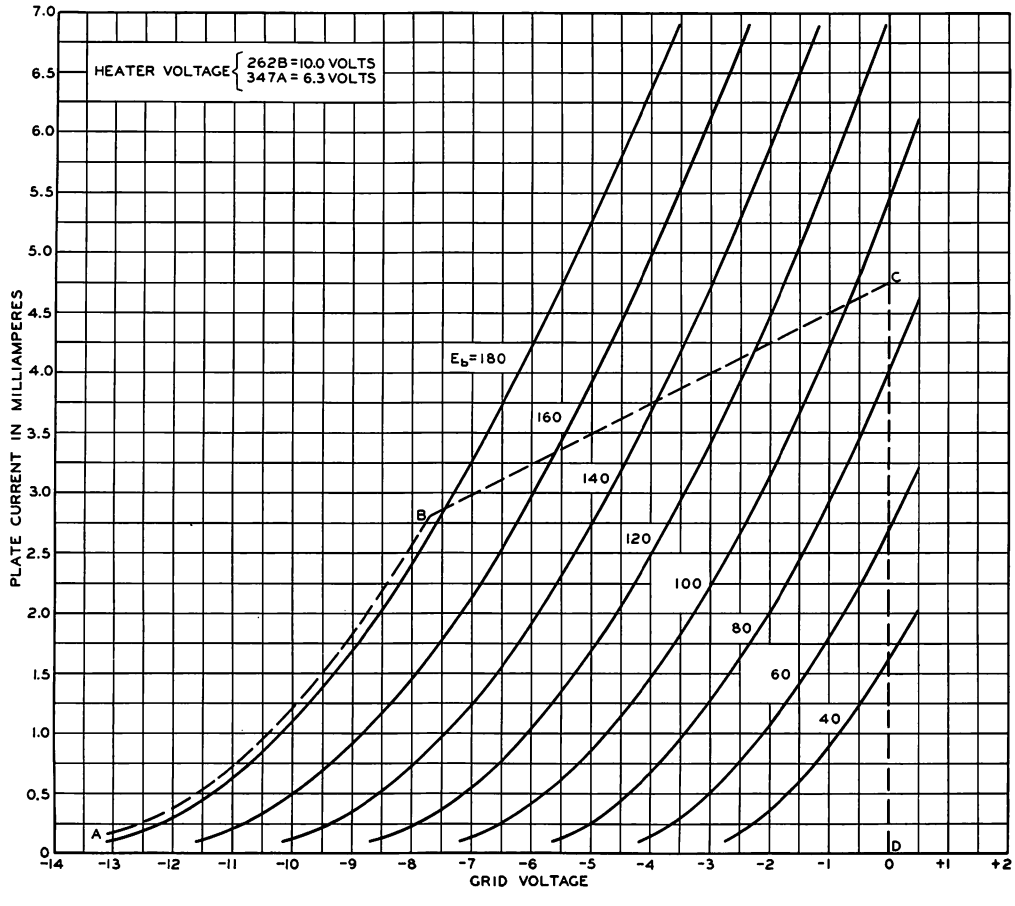

HEATER VOLTAGE { 262B = 10.0 VOLTS
347A = 6.3 VOLTS
E_b=180
160
140
120
100
80
60
40
A
B
C
D
PLATE CURRENT IN MILLIAMPERES
GRID VOLTAGE
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-14
-13
-12
-11
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
+1
+2

FIG. 5

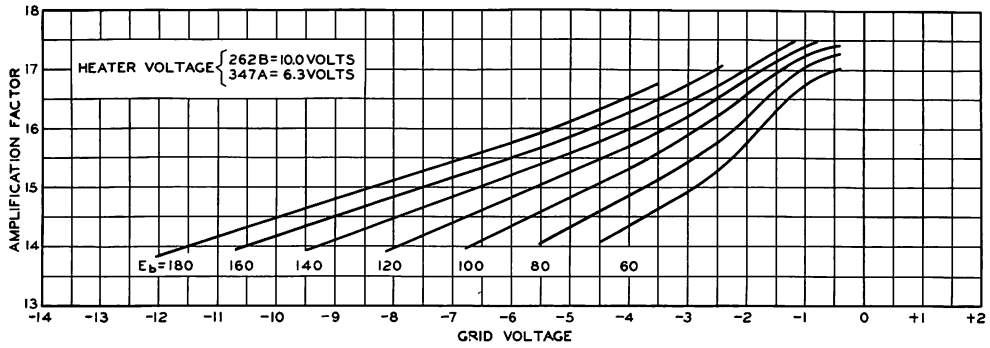


FIG. 6

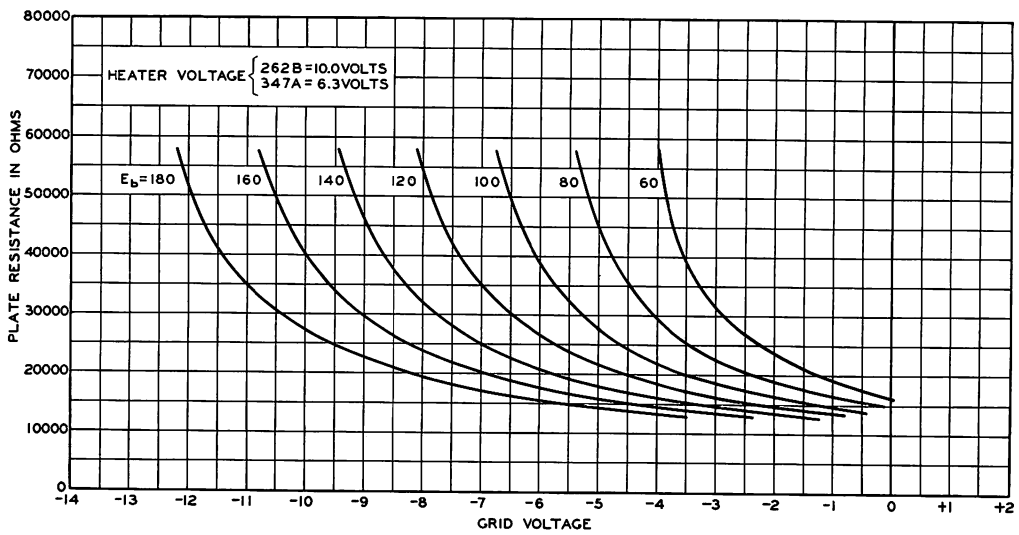


FIG. 7

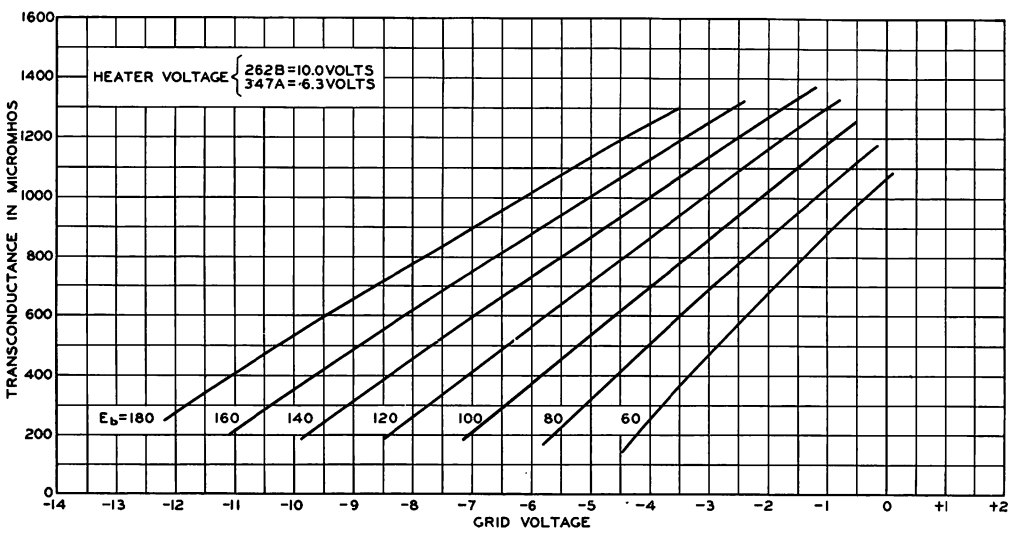


FIG. 8

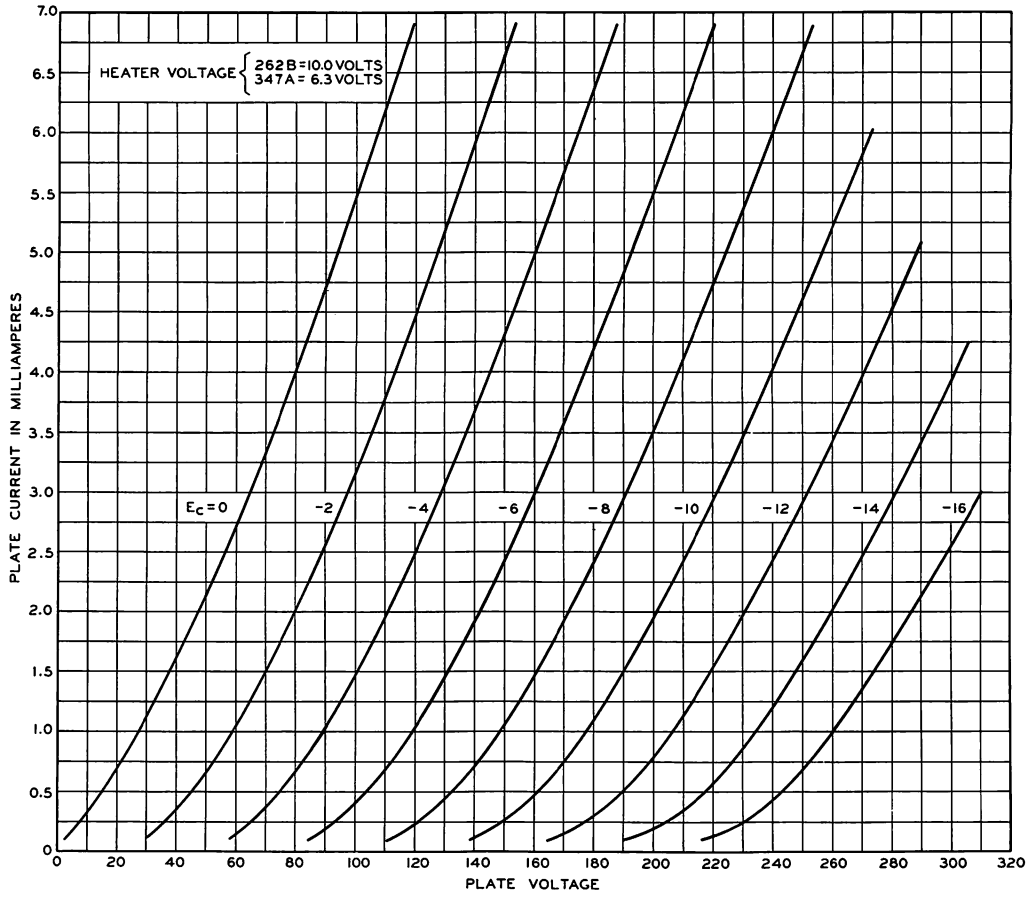
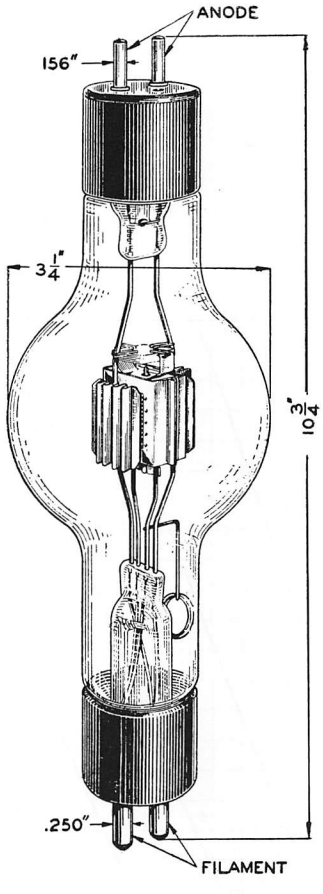

HEATER VOLTAGE { 262B=10.0 VOLTS 347A= 6.3 VOLTS
E_C=0
-2
-4
-6
-8
-10
-12
-14
-16
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320

FIG. 9

263A Vacuum Tube



Classification

The No. 263A Vacuum Tube is a double half wave, thermionic, gas-filled rectifier for use in rectifying circuits designed to supply direct current at a low voltage from an alternating current supply.

Base and Socket

The No. 263A Vacuum Tube is a double-ended tube employing a two-prong, push-type base suitable for use in a Western Electric 139B socket or similar type socket. The anode terminals at the top are arranged for use with a Western Electric 280A plug or with flexible lead connectors. The tube should be mounted only in a vertical position with the filament terminal end down. The arrangement of electrode connections to the tube terminals is shown above.

Rating and Characteristic Data

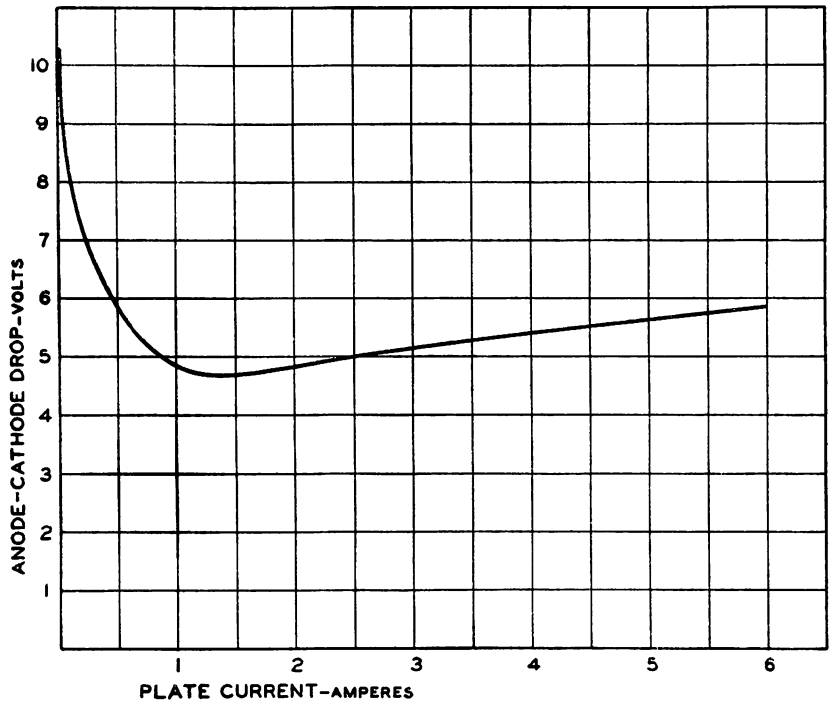
Filament Voltage	2.5 Volts
Filament Current	15 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	8 Volts
Maximum Peak Plate Current	6 Amperes
Maximum Continuous Potential between Electrodes	100 Volts

For specific rectifying circuits the following ratings apply:

Type of Circuit	No. of Tubes	Load Potential Volts	Load Current Amperes
Single Phase—Double Half-Wave	1	25	4
Single Phase—Double Half-Wave in Parallel	2	25	8
Single Phase—Double Half-Wave (Two Tube Series Circuit)	2	50	4
Three Phase—"Y" Circuit	3	40	10
Three Phase—Double "Y" Inter-connected	3	30	10

Average Static Characteristics

The accompanying curve gives the anode-cathode potential drop with respect to the plate current for a typical 263A Vacuum Tube. The exact value varies from tube to tube and during the life of a given tube. Within the specified plate current range, it will vary from 4 to 12 volts.



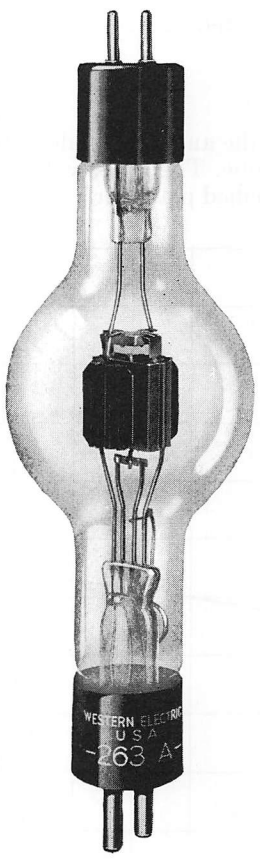
General Features

The No. 263A Vacuum Tube employs two anodes in the same bulb, thereby making one tube serve the purpose of two tubes when used in full wave rectifying circuits. The bulb is filled with argon gas which makes the current and voltage outputs independent of ambient temperatures. This gas-filling makes the 263A tube suitable for rectifier equipment subject to wide range of ambient temperatures and where a very constant voltage supply is necessary. For other power supply applications, the 263B mercury vapor tube should be used.

The tube uses a very efficient and rugged type of oxide coated cathode employed in other gas-filled rectifiers. The elements are tied together in such a manner as to form a very rugged mechanical structure. This lends itself to a simple and adequate circuit mounting.

Western Electric

263A Vacuum Tube



Classification—Full-wave, thermionic, argon-filled rectifier

The 263A vacuum tube is designed to supply direct current from an alternating-current supply.

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

Maximum length	$10\frac{3}{4}''$
Maximum diameter	$3\frac{1}{4}''$

Mounting—The 263A is a double-ended vacuum tube employing a two-pin, thrust type base suitable for use in a Western Electric 139A or similar socket. The anode terminals at the top of the bulb are arranged for use with a Western Electric 280A plug or with flexible lead connectors. Since the anode and filament terminals cannot be held in exactly the same plane, rigid mounting connectors should not be used for both sets of terminals.

Base—Dimensions and the arrangement of electrode connections to the base terminals are shown in Figure 1.

Mounting Positions—The tube should be mounted preferably in a vertical position with the filament terminal end down. If the tube is mounted horizontally, the plane of the anode and filament terminals should also be horizontal. There should be a free circulation of air around the tube. No object should touch the glass bulb.

Filament Rating

Filament voltage	2.5 volts
Nominal filament current	15 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 (2.5 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 transformers with good regulation are used, this time is 2 minutes.

Characteristics and Operating Conditions

Approximate anode-cathode potential drop	8 volts
Maximum peak plate current	6 amperes
Maximum peak potential between electrodes	100 volts

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, ranging from 4 to 12 volts.

The anode-cathode potential drop as a function of plate current is shown in Figure 2, for a typical 263A vacuum tube.

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 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 (100 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 rectified potential available is not fixed but will depend upon the type of circuit used.

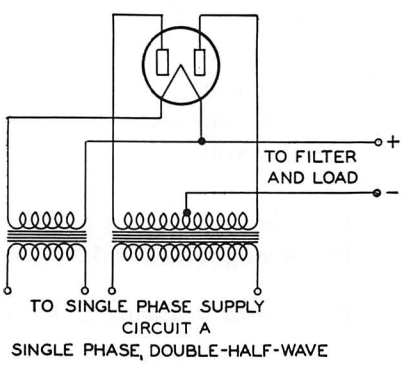
263A vacuum tubes may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode, may be used for this purpose. The size of the reactors or resistors depends upon the circuit design.

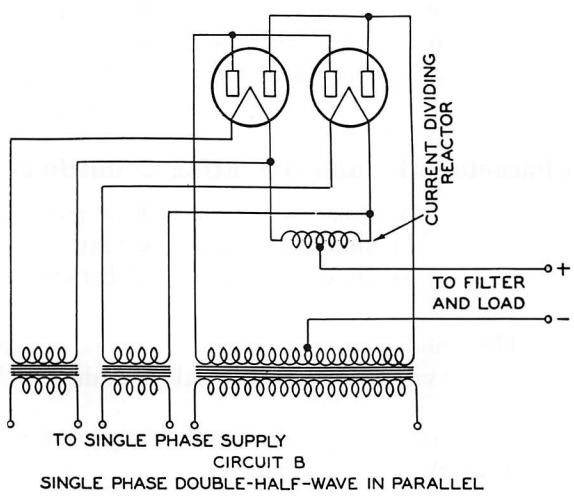
In most cases the termination of the useful life of the 263A tube is due to the loss of filament activity. This causes the tube to fail by arcing between the anodes. Failures of this kind should be safeguarded by proper fuse protection to prevent injury to other tubes in the circuit and to the auxiliary equipment.

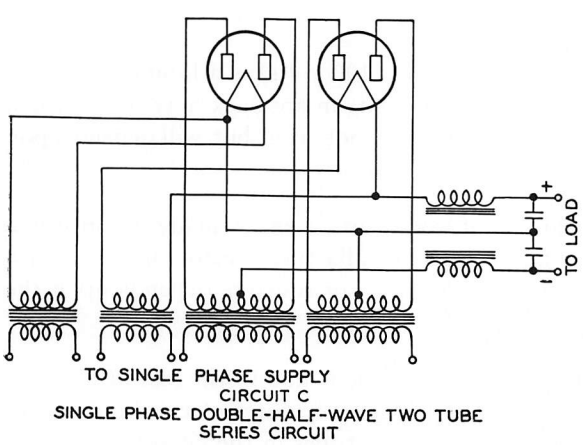
Typical Rectifier Circuits—The 263A vacuum tube may be used in any standard high vacuum rectifier circuit subject to its current and voltage limitations. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible plate current and inverse voltage are given in Table 1. The values listed below are average values of the pulsating current and voltage for an unfiltered circuit.

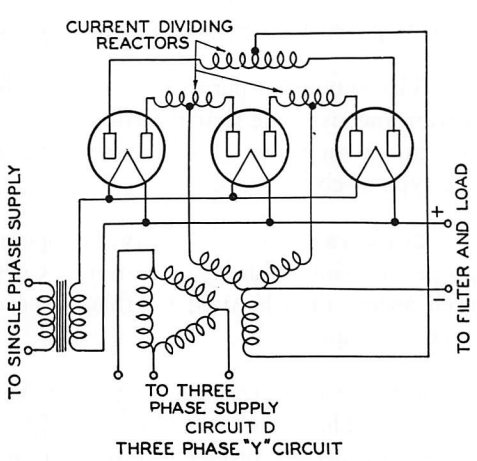
Table 1

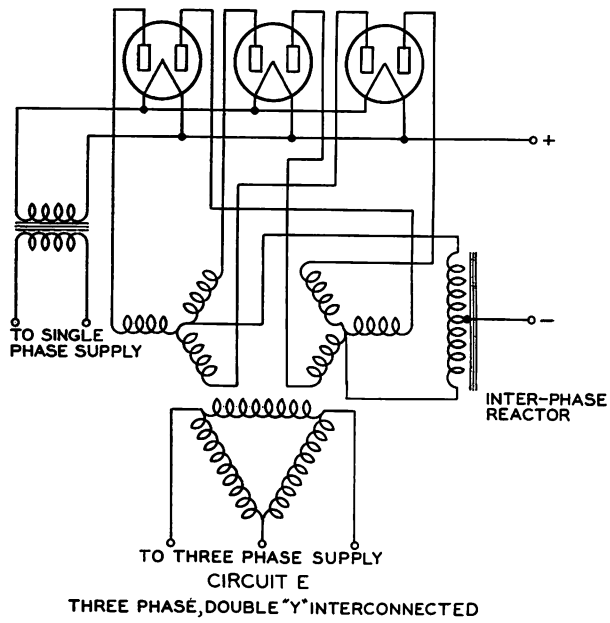
Circuit Designation	Phase Supply	Number of Tubes	Load Potential in Volts	Load Current in Amperes
A	1	1	25	4
B	1	2	25	8
C	1	2	50	4
D	3	3	40	10
E	3	3	30	10











CIRCUIT E
THREE PHASE, DOUBLE "Y" INTERCONNECTED

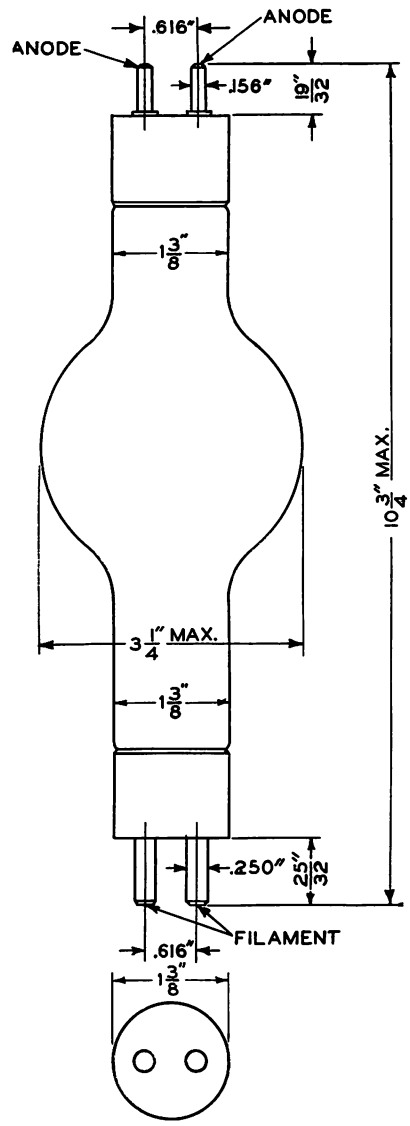


FIG. 1

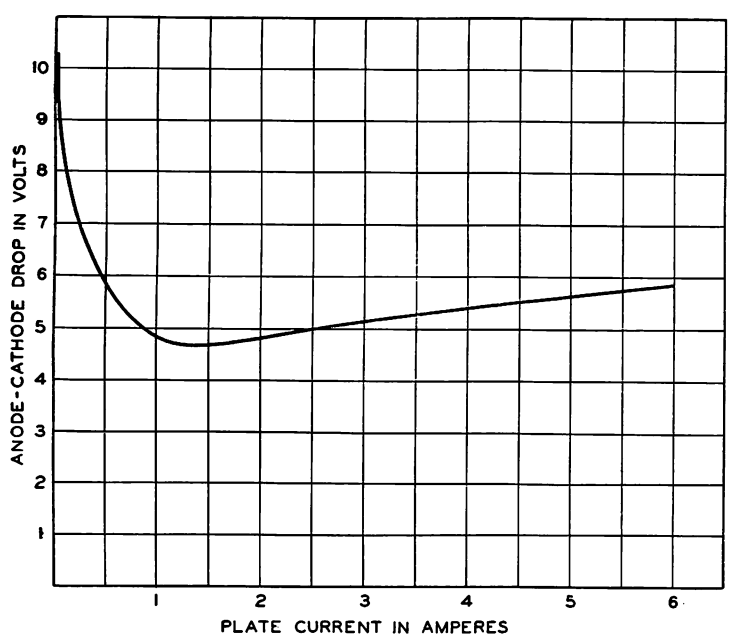
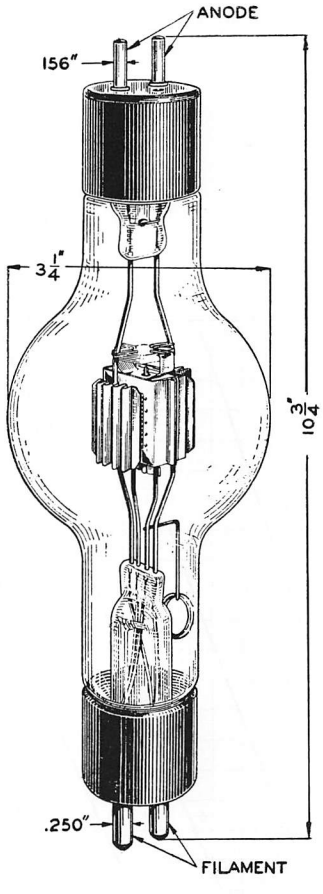


FIG. 2

263A Vacuum Tube



Classification

The No. 263A Vacuum Tube is a double half wave, thermionic, gas-filled rectifier for use in rectifying circuits designed to supply direct current at a low voltage from an alternating current supply.

Base and Socket

The No. 263A Vacuum Tube is a double-ended tube employing a two-prong, push-type base suitable for use in a Western Electric 139B socket or similar type socket. The anode terminals at the top are arranged for use with a Western Electric 280A plug or with flexible lead connectors. The tube should be mounted only in a vertical position with the filament terminal end down. The arrangement of electrode connections to the tube terminals is shown above.

Rating and Characteristic Data

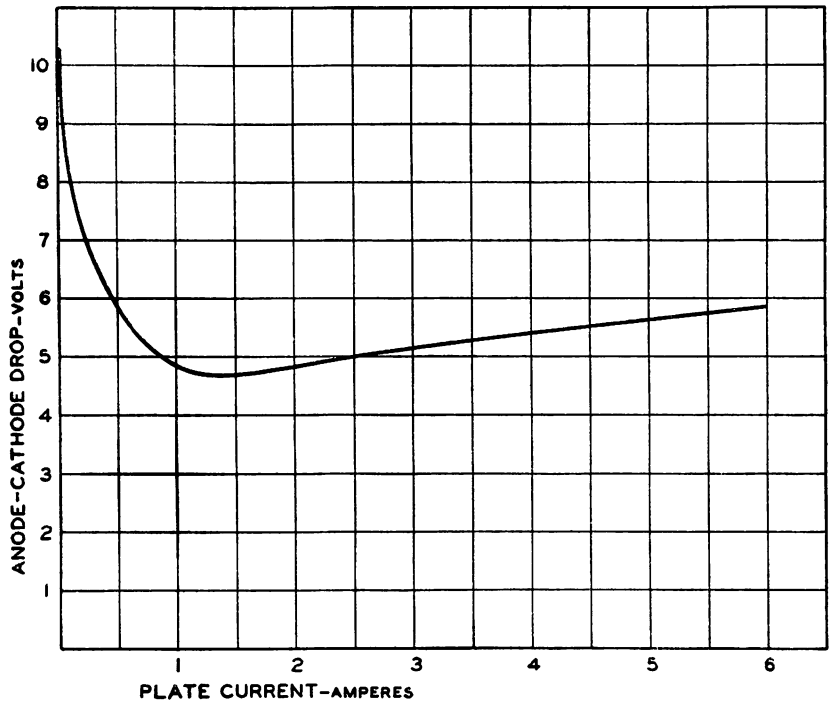
Filament Voltage	2.5 Volts
Filament Current	15 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	8 Volts
Maximum Peak Plate Current	6 Amperes
Maximum Continuous Potential between Electrodes	100 Volts

For specific rectifying circuits the following ratings apply:

Type of Circuit	No. of Tubes	Load Potential Volts	Load Current Amperes
Single Phase—Double Half-Wave	1	25	4
Single Phase—Double Half-Wave in Parallel	2	25	8
Single Phase—Double Half-Wave (Two Tube Series Circuit)	2	50	4
Three Phase—"Y" Circuit	3	40	10
Three Phase—Double "Y" Inter-connected	3	30	10

Average Static Characteristics

The accompanying curve gives the anode-cathode potential drop with respect to the plate current for a typical 263A Vacuum Tube. The exact value varies from tube to tube and during the life of a given tube. Within the specified plate current range, it will vary from 4 to 12 volts.



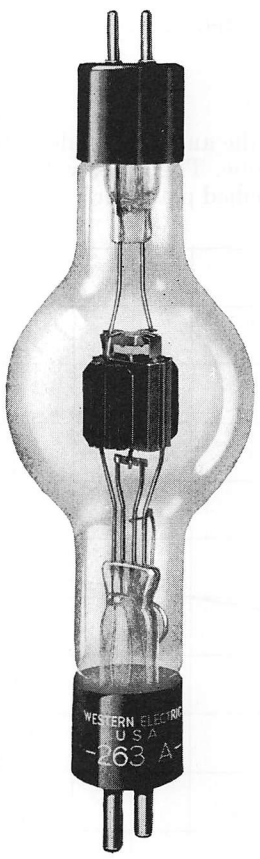
General Features

The No. 263A Vacuum Tube employs two anodes in the same bulb, thereby making one tube serve the purpose of two tubes when used in full wave rectifying circuits. The bulb is filled with argon gas which makes the current and voltage outputs independent of ambient temperatures. This gas-filling makes the 263A tube suitable for rectifier equipment subject to wide range of ambient temperatures and where a very constant voltage supply is necessary. For other power supply applications, the 263B mercury vapor tube should be used.

The tube uses a very efficient and rugged type of oxide coated cathode employed in other gas-filled rectifiers. The elements are tied together in such a manner as to form a very rugged mechanical structure. This lends itself to a simple and adequate circuit mounting.

Western Electric

263A Vacuum Tube



Classification—Full-wave, thermionic, argon-filled rectifier

The 263A vacuum tube is designed to supply direct current from an alternating-current supply.

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

Maximum length	$10\frac{3}{4}''$
Maximum diameter	$3\frac{1}{4}''$

Mounting—The 263A is a double-ended vacuum tube employing a two-pin, thrust type base suitable for use in a Western Electric 139A or similar socket. The anode terminals at the top of the bulb are arranged for use with a Western Electric 280A plug or with flexible lead connectors. Since the anode and filament terminals cannot be held in exactly the same plane, rigid mounting connectors should not be used for both sets of terminals.

Base—Dimensions and the arrangement of electrode connections to the base terminals are shown in Figure 1.

Mounting Positions—The tube should be mounted preferably in a vertical position with the filament terminal end down. If the tube is mounted horizontally, the plane of the anode and filament terminals should also be horizontal. There should be a free circulation of air around the tube. No object should touch the glass bulb.

Filament Rating

Filament voltage	2.5 volts
Nominal filament current	15 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 (2.5 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 transformers with good regulation are used, this time is 2 minutes.

Characteristics and Operating Conditions

Approximate anode-cathode potential drop	8 volts
Maximum peak plate current	6 amperes
Maximum peak potential between electrodes	100 volts

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, ranging from 4 to 12 volts.

The anode-cathode potential drop as a function of plate current is shown in Figure 2, for a typical 263A vacuum tube.

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 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 (100 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 rectified potential available is not fixed but will depend upon the type of circuit used.

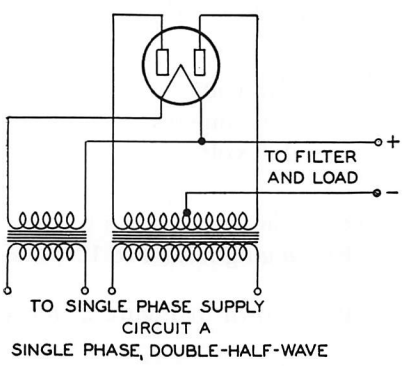
263A vacuum tubes may be operated in parallel if some provision is made to insure a proper division of the load current. Current dividing reactors or ballasting resistors in series with each anode, may be used for this purpose. The size of the reactors or resistors depends upon the circuit design.

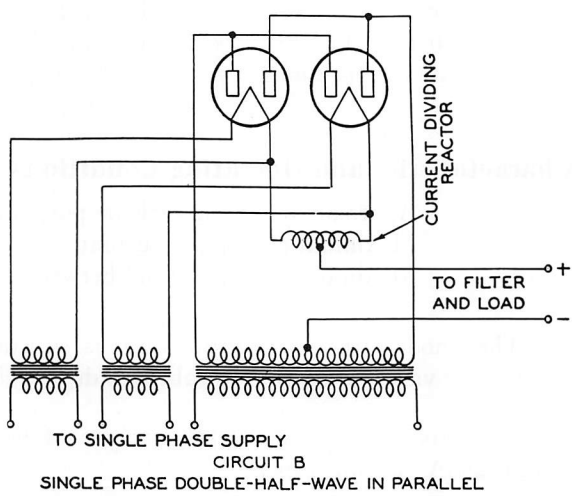
In most cases the termination of the useful life of the 263A tube is due to the loss of filament activity. This causes the tube to fail by arcing between the anodes. Failures of this kind should be safeguarded by proper fuse protection to prevent injury to other tubes in the circuit and to the auxiliary equipment.

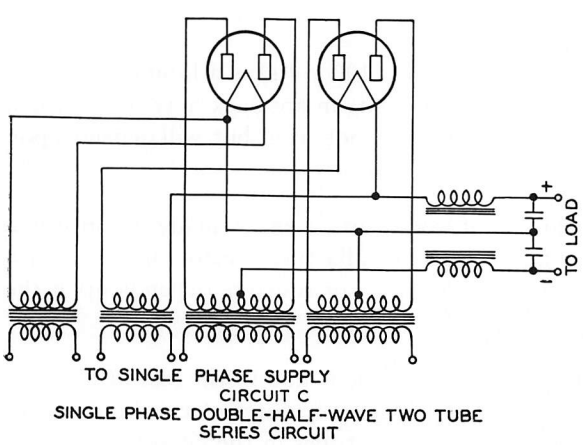
Typical Rectifier Circuits—The 263A vacuum tube may be used in any standard high vacuum rectifier circuit subject to its current and voltage limitations. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible plate current and inverse voltage are given in Table 1. The values listed below are average values of the pulsating current and voltage for an unfiltered circuit.

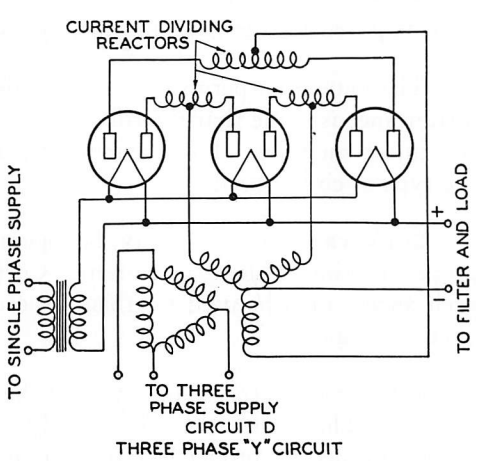
Table 1

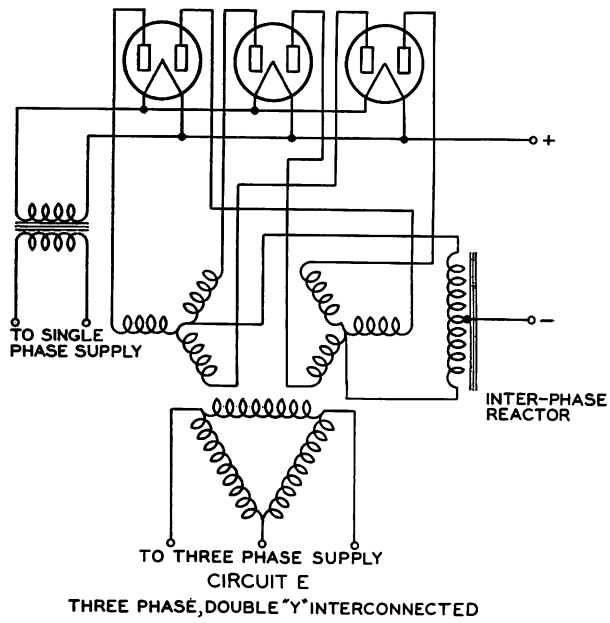
Circuit Designation	Phase Supply	Number of Tubes	Load Potential in Volts	Load Current in Amperes
A	1	1	25	4
B	1	2	25	8
C	1	2	50	4
D	3	3	40	10
E	3	3	30	10











CIRCUIT E
THREE PHASE, DOUBLE "Y" INTERCONNECTED

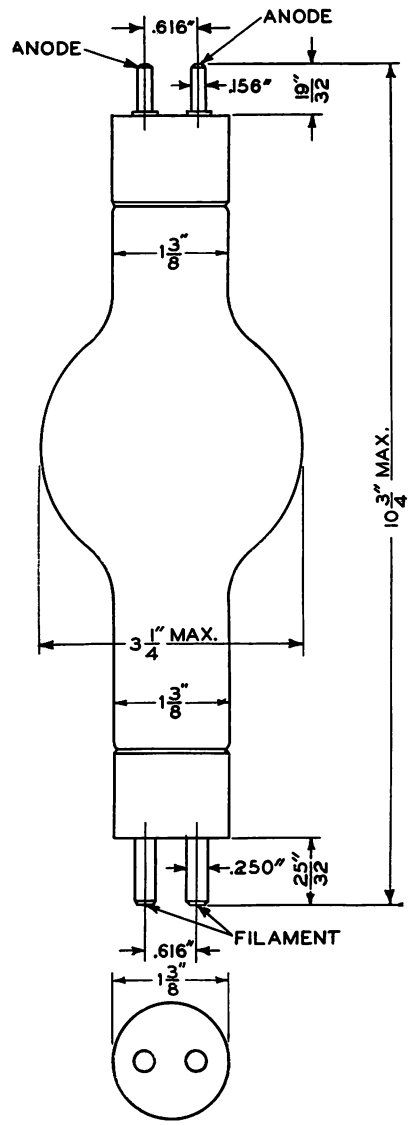


FIG. 1

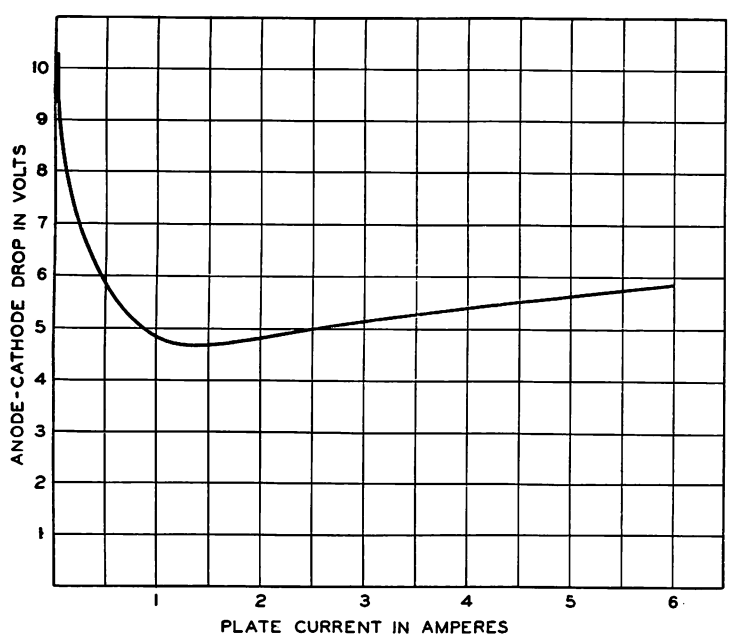
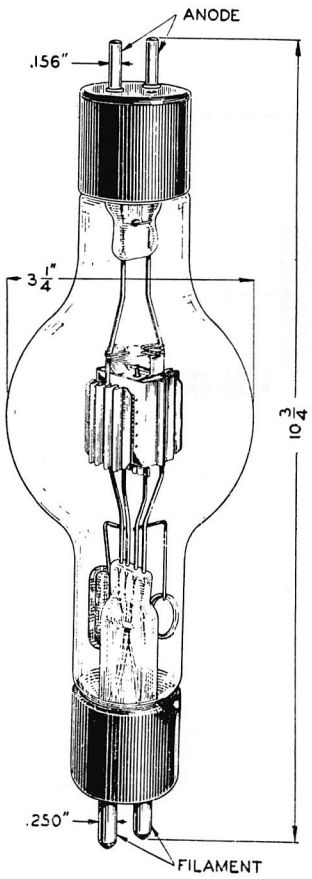


FIG. 2

263B Vacuum Tube



Classification

The 263B Vacuum Tube is a double half-wave, mercury-vapor rectifier intended for use in rectifying circuits designed to supply direct current at a low voltage, from an alternating-current supply.

Base and Socket

The 263B Vacuum Tube is a double-ended tube employing a two-prong, push-type base suitable for use in a Western Electric 139A or similar type socket. The anode terminals at the top are arranged for use with a Western Electric 280A plug or with flexible lead connectors. Since the anode and the filament terminals cannot be held in exactly the same planes rigid mounting connections should not be used for both terminals. The tube should be mounted preferably in a vertical position with the filament terminal end down. If it is mounted horizontally, the plane of the anode and filament terminals should also be horizontal. The arrangement of the electrode connections to the tube terminals is shown above.

Rating and Characteristic Data

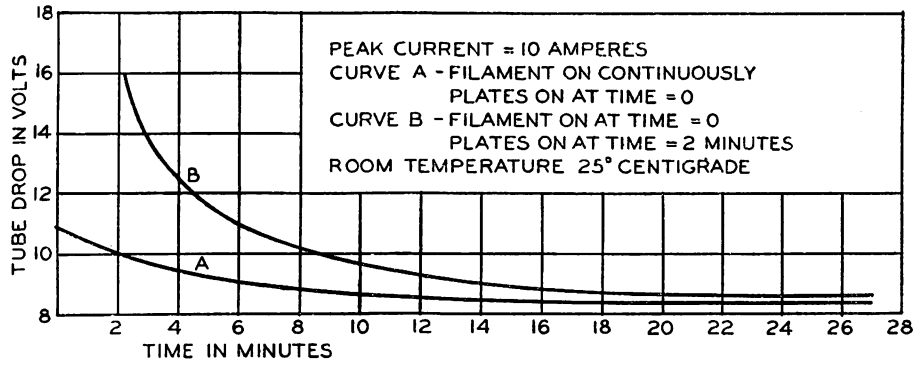
Filament Voltage	2.5 Volts
Filament Current	15 Amperes
Recommended Potential between Anodes	100 Volts
Peak Space Current	10 Amperes
Approximate Anode-Cathode Potential Drop when Conducting	10 Volts
Safe Operating Ambient temperature	10° to 50° C.

Approximate D.C. output currents and voltages for different types of circuits are shown below.

Type of Circuit	No. of Tubes	D.C. Load Potential Volts	D.C. Load Current Amperes
Single-Phase, Double Half-Wave	1	25	6
Single-Phase, Double Half-Wave in Parallel	2	25	12
Single-Phase, Double Half-Wave (Two Tube Series Circuit)	2	50	6
Three-Phase, "Y" Circuit	3	40	15
Three-Phase, Double "Y" Interconnected	3	30	15

Average Static Characteristics

The accompanying curves give the anode-cathode potential drop for full load current as the tube warms up. Curve "B" shows the characteristic change which obtains after the recommended two minute filament heating period. Curve "A" shows the smaller characteristic change which obtains if the filament is preheated at least 15 minutes. The exact value varies with ambient temperature, from tube to tube, and during the life of a given tube. Within the specified current and temperature range, it may vary from 5 to 20 volts.



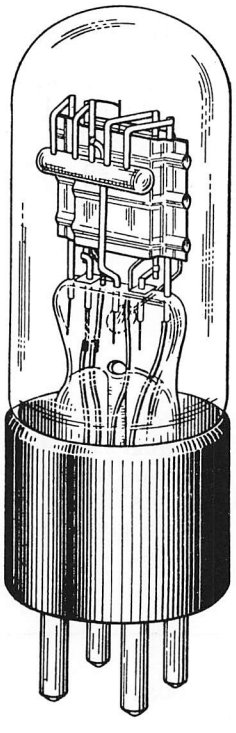
General Features

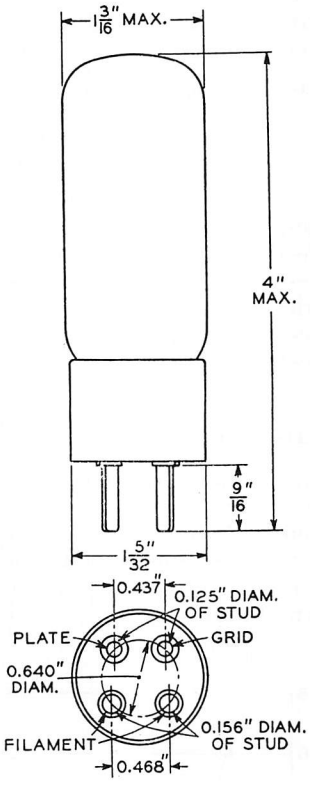
The 263B Vacuum Tube employs two anodes in the same bulb, thereby making one tube serve the purpose of two tubes when used in full-wave rectifying circuits. The tube contains a small amount of mercury whose vapor pressure varies with the ambient temperature. This mercury vapor filled tube can operate at a higher voltage and current than the corresponding 263A argon gas-filled tube.

The 263B is recommended in place of the 263A for all power supply applications except where the filtered voltage and current outputs must be entirely free from small fluctuations or transients due to thermal effects.

The tube uses a very efficient and rugged type of oxide-coated cathode employed in other mercury vapor rectifiers. The elements are tied together in such a manner as to form a very rugged mechanical structure. The double ended construction also lends itself to a simple and adequate circuit mounting.

264B Vacuum Tube





Classification

The No. 264B Vacuum Tube is a three-element filament type tube for use as an audio-frequency amplifier in applications requiring a tube with low microphonic noise response in apparatus where high input resistance is necessary.

It replaces the No. 264A Vacuum Tube and is the same electrically and mechanically except that it is equipped with a base employing silver plated contact studs.

Base and Socket

The No. 264B Vacuum Tube employs a four-prong thrust-type base suitable for use in a Western Electric No. 143A Vacuum Tube Socket which is equipped with silver plated contact springs.

Rating and Characteristic Data

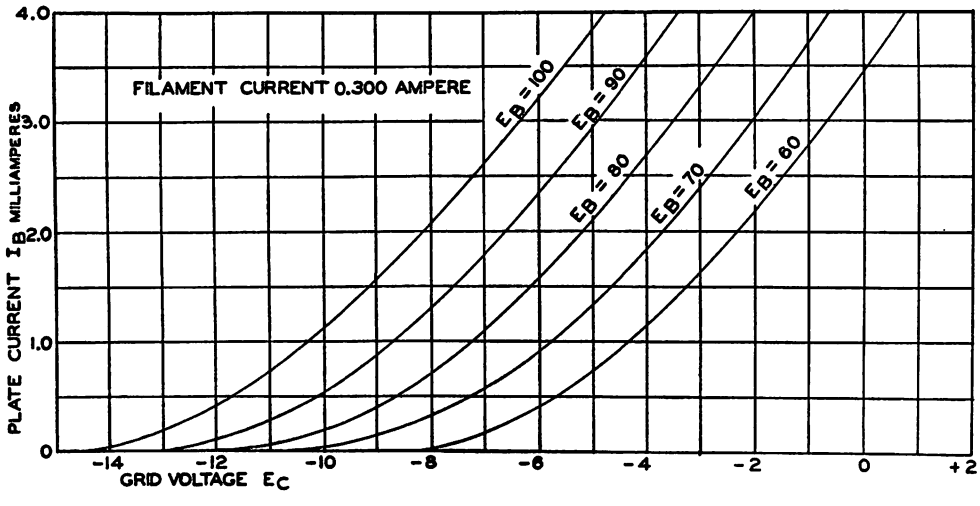
Filament Voltage	1.5 Volts, D.C.
Nominal Filament Current	0.3 Ampere
Maximum Plate Voltage	100 Volts
Grid Voltage	-7.0 Volts
Average Plate Current	2.6 Milliamperes
Average Plate Resistance	11,800 Ohms
Average Amplification Factor	7.05

Approximate Direct Interelectrode Capacities

Plate to Grid	5.3 MMF
Plate to Filament	2.2 MMF
Grid to Filament	3.5 MMF

Average Static Characteristics

The accompanying curves give the static characteristics of the No. 264B Vacuum Tube. These curves have been obtained with the filament operating on direct current and the grid and plate returns connected to the negative filament terminal.



General Features

Due to the rigid construction and the short filament which has been designed to reduce vibration to a minimum, the microphonic response of the No. 264B Vacuum Tube is very low.

The base prongs have been silver coated to eliminate contact noises which develop at the interface between base prong and socket spring when both are of base metal.

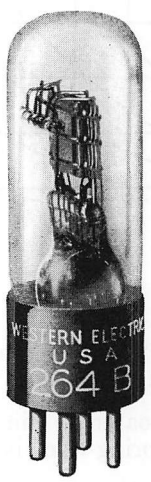
Care in manufacture and also inspection tests insure a high input resistance.

These features together with its low power consumption make this tube particularly suitable for use in the early stages of high gain amplifiers.

The rugged construction of the tube and ample electron emission supplied by the filament operating at a low temperature, insure the maintenance of uniform electrical characteristics throughout a long life.

Western Electric

264B Vacuum Tube



Classification—Small, low-noise, filamentary triode

The 264B tube replaces the 264A and is identical with it except that the base pins of the 264B tube are silver-plated to minimize contact noise.

Application—Audio-frequency amplifier particularly where exceptionally low tube noise or exceptionally high input resistance are required.

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

Base—Small, four-pin thrust type, with pins silver-plated.

Socket—Standard, four-contact type, preferably with contacts silver-plated, such as the Western Electric 143B socket.

Mounting Positions—The 264B tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Grid to plate	5.3 μμf.
Grid to filament	3.5 μμf.
Plate to filament	2.2 μμf.

Filament Rating

Filament current	0.300 ampere, d.c.
Nominal filament voltage	1.5 volts

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

Characteristics—Grid-plate characteristics of a typical 264B tube are shown in Figure 3 for several values of plate voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are given in Figures 4, 5, and 6, respectively. Plate characteristics for several values of grid bias are shown in Figure 7. In each case, the grid and plate voltages are measured from the negative end of the filament.

Operating Conditions and Output—Permissible grid and plate voltages are included within the area, ABCD, in Figure 3. Values of amplification factor, plate resistance, and transconductance, and typical performance data are given in the table on page 3 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 power or voltage output and the second and third harmonic levels for the indicated values of load resistance. The fundamental output is given in terms of the power, P_m, in milliwatts, for values of load resistance, R, equal to and double the value of the plate resistance, r_p, and in terms of the voltage, E_{pm}, in peak volts, for values of load resistance five times the plate resistance. The second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the fundamental power and voltage output and the harmonic levels are given approximately by the following relations:

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

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

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

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

Table

	Plate Voltage Volts	Grid Bias Volts	Plate Current Milliamperes	Amplification Factor	Plate Resistance Ohms r_p	Transconductance Micromhos	Load Resistance R	Power Output Milliwatts	Voltage Output Peak Volts	Second Harmonic db	Third Harmonic db
Recommended Operating Conditions	60	−2.0	2.35	7.3	11,700	620	$R=r_p$	2.4	—	38	65
							$R=2r_p$	2.1	—	44	70
							$R=5r_p$	—	12	51	85
	90	−7.0	1.90	7.2	12,800	560	$R=r_p$	25	—	24	39
							$R=2r_p$	23	—	31	49
							$R=5r_p$	—	41	39	65
	100	−8.0	2.10	7.2	12,400	580	$R=r_p$	33	—	24	37
							$R=2r_p$	30	—	31	47
							$R=5r_p$	—	48	39	60
Maximum Operating Conditions	90	−5.5	2.80	7.2	11,300	640	$R=r_p$	18	—	30	50
							$R=2r_p$	16	—	36	60
							$R=5r_p$	—	33	44	70
	100	−7.0	2.70	7.2	11,400	630	$R=r_p$	28	—	28	44
							$R=2r_p$	25	—	34	55
							$R=5r_p$	—	42	42	65

Microphonic Noise—With a plate voltage of 100 volts, a grid bias of −8 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 264B tube measured in a laboratory reference test set is 41 db below 1 volt. The range of levels of individual tubes extends from 30 to 52 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 uncontrollable, minute fluctuations in the rate of flow of electrons to the anode. With a plate voltage of 100 volts, a grid bias of −8 volts, and a load resistance of 100,000 ohms, the mean equivalent fluctuation noise input of the 264B tube for the audio-frequency range from 40 to 10,600 cycles is 116 db below 1 volt. Individual 264B tubes may differ from this value by as much as 5 db. By reducing the plate voltage to 26 volts and the grid bias to −0.5 volt, the mean fluctuation noise level may be reduced by about 4.5 db without seriously affecting the voltage amplification for small signals. The equivalent noise input voltage is equal to the measured output voltage divided by the voltage amplification of the tube in the measuring circuit.

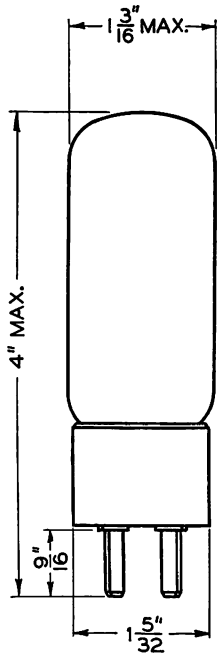


FIG. 1

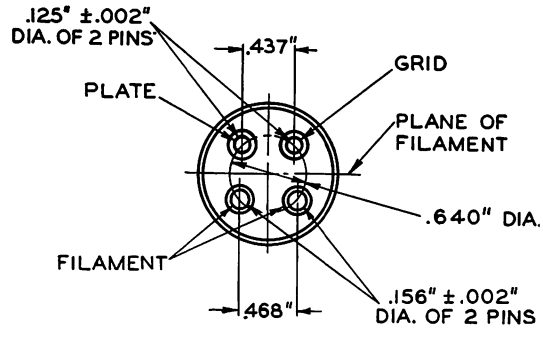


FIG. 2

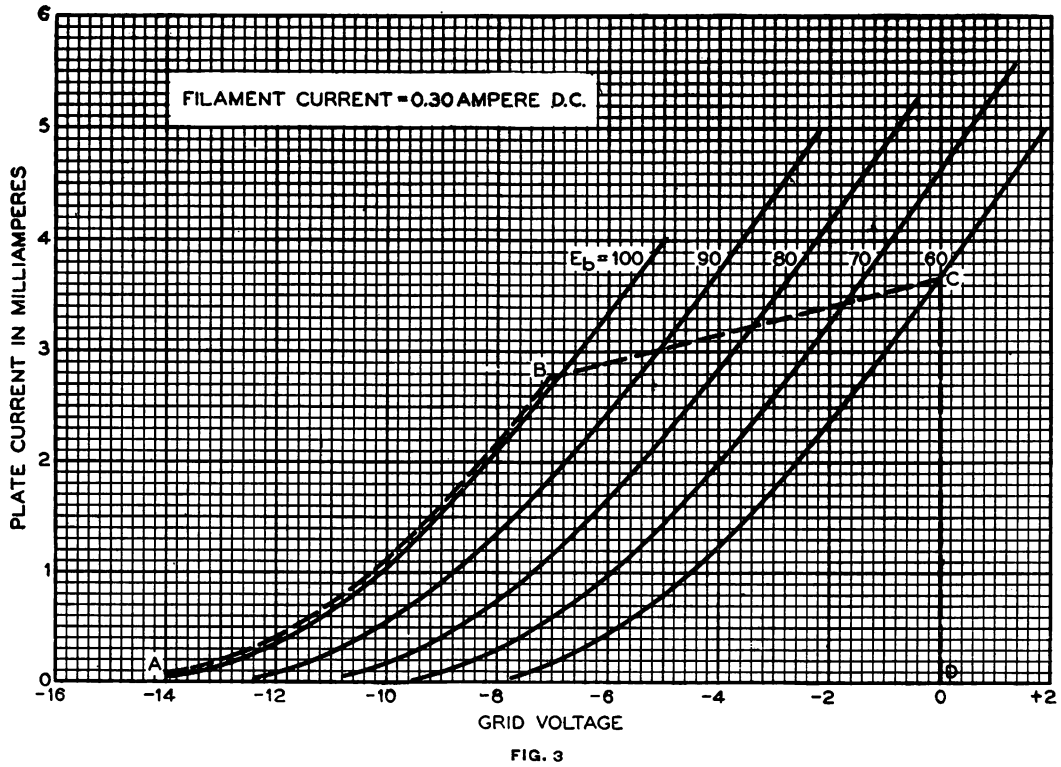


FIG. 3

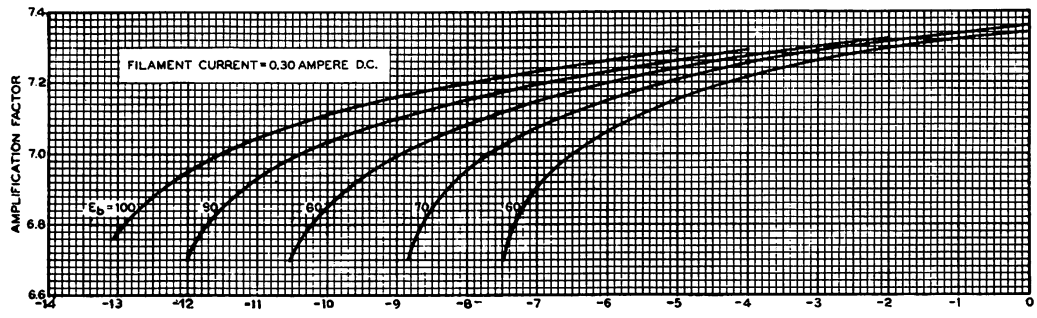


FIG. 4

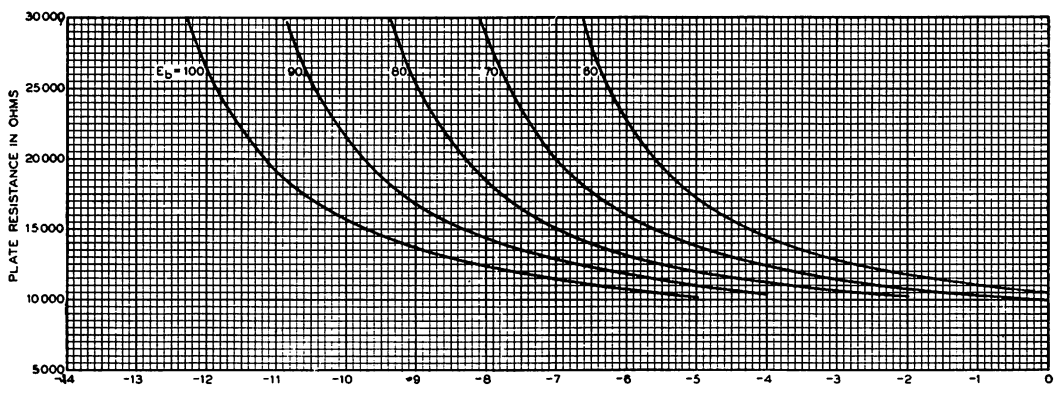


FIG. 5

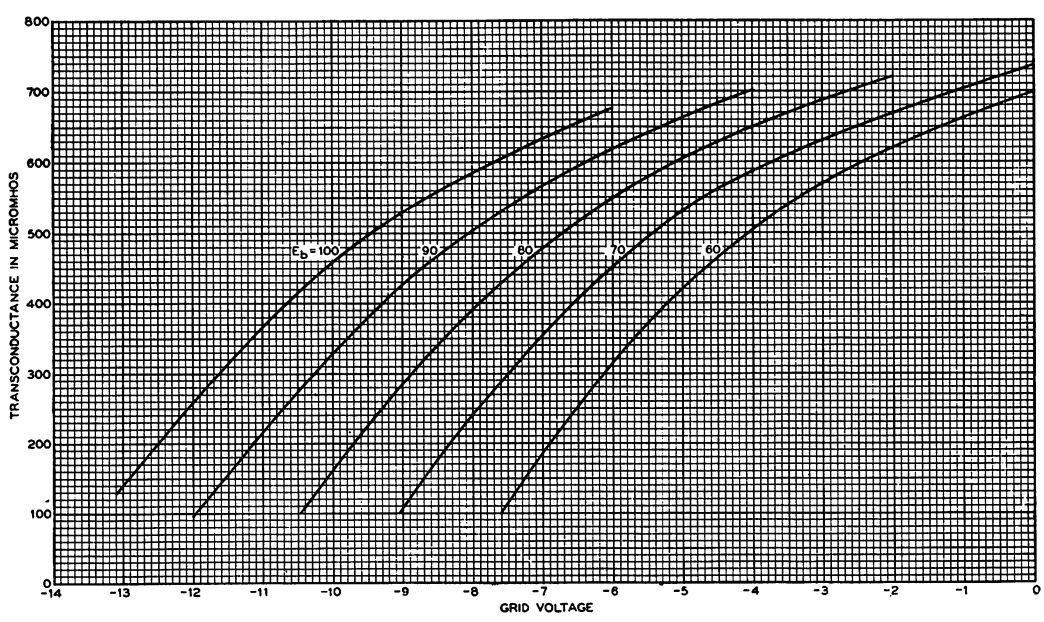


FIG. 6

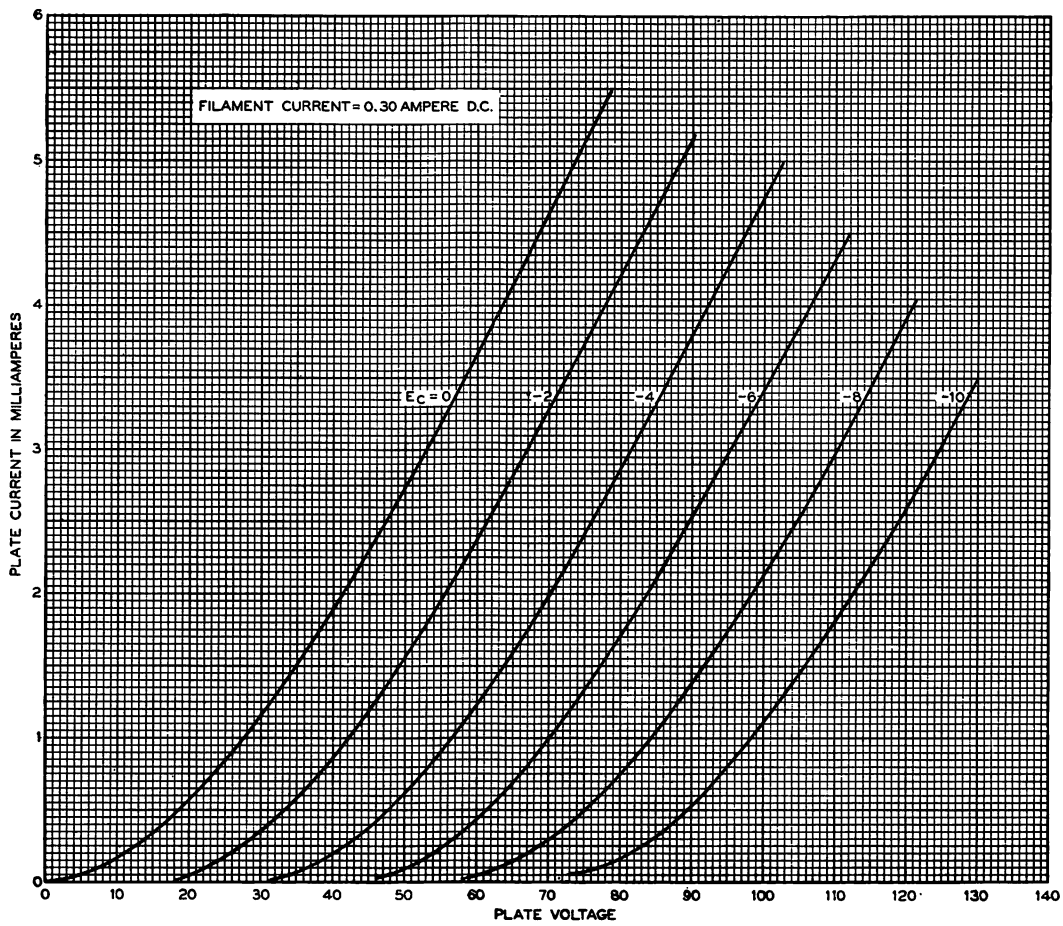
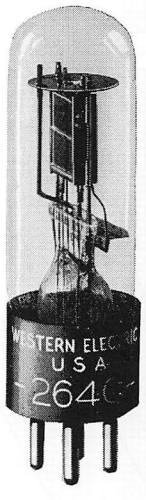

FILAMENT CURRENT = 0.30 AMPERE D.C.
$E_C = 0$
-2
-4
-6
-8
-10
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

FIG. 7

Western Electric

264C Vacuum Tube



Classification—Small, low noise, filamentary triode

The 264C tube replaces the 264B. It includes a new mechanical design and an improved filament. The electrical characteristics are identical with those of the 264B tube except for a lower average microphonic level, and a slight change in the interelectrode capacitances.

Application—Audio-frequency amplifier particularly where exceptionally low tube noise or exceptionally high-input resistance are required.

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

Base—Small, four-pin thrust type, with pins silver-plated.

Socket—Standard, four-contact type, preferably with contacts silver-plated, such as the Western Electric 143B socket.

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

Average Direct Interelectrode Capacitances

Grid to plate	4.9 μμf.
Grid to filament	3.2 μμf.
Plate to filament	2.2 μμf.

Filament Rating

Filament current	0.300 ampere, d.c.
Nominal filament voltage	1.5 volts

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

Characteristics—Grid-plate characteristics of a typical 264C tube are shown in Figure 3 for several values of plate voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are given in Figures 4, 5 and 6, respectively. Plate characteristics for several values of grid bias are shown in Figure 7. In each case, the grid and plate voltages are measured from the negative end of the filament.

Operating Conditions and Output—Permissible grid and plate voltages are included within the area, ABCD, in Figure 3. Values of amplification factor, plate resistance, and transconductance, and typical performance data are given in the table 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 power or voltage output and the second and third harmonic levels for the indicated values of load resistance. The fundamental output is given in terms of the power, P_m, in milliwatts, for values of load resistance, R, equal to and double the value of the plate resistance, r_p, and in terms of the voltage, E_{pm}, in peak volts, for values of load resistance five times the plate resistance. The second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the fundamental power and voltage output and the harmonic levels are given approximately by the following relations:

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

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

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

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

Table

	Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Load Resistance	Power Output	Voltage Output	Second Harmonic	Third Harmonic
	Volts	Volts	Milliamperes		Ohms r_p	Micromhos	R	Milliwatts	Peak Volts	db	db
Recommended Operating Conditions	60	−2.0	2.35	7.3	11,700	620	$R=r_p$	2.4	—	38	65
							$R=2r_p$	2.1	—	44	70
							$R=5r_p$	—	12	51	85
	90	−7.0	1.90	7.2	12,800	560	$R=r_p$	25	—	24	39
							$R=2r_p$	23	—	31	49
							$R=5r_p$	—	41	39	65
	100	−8.0	2.10	7.2	12,400	580	$R=r_p$	33	—	24	37
							$R=2r_p$	30	—	31	47
							$R=5r_p$	—	48	39	60
Maximum Operating Conditions	90	−5.5	2.80	7.2	11,300	640	$R=r_p$	18	—	30	50
							$R=2r_p$	16	—	36	60
							$R=5r_p$	—	33	44	70
	100	−7.0	2.70	7.2	11,400	630	$R=r_p$	28	—	28	44
							$R=2r_p$	25	—	34	55
							$R=5r_p$	—	42	42	65

Microphonic Noise—With a plate voltage of 100 volts, a grid bias of −8 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of this tube measured in a laboratory reference test set is 43 db below 1 volt. The range of levels of individual tubes extends from 30 to 54 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 uncontrollable, minute fluctuations in the rate of flow of electrons to the anode. With a plate voltage of 100 volts, a grid bias of −8 volts, and a load resistance of 100,000 ohms, the mean equivalent fluctuation noise input of this tube for the audio-frequency range from 40 to 10,600 cycles is 114 db below 1 volt. Individual tubes may differ from this value by as much as 5 db. By reducing the plate voltage to 30 volts and the grid bias to −0.5 volt, the mean fluctuation noise level may be reduced by about 4.5 db without seriously affecting the voltage amplification for small signals. The equivalent noise input voltage is equal to the measured output voltage divided by the voltage amplification of the tube in the measuring circuit.

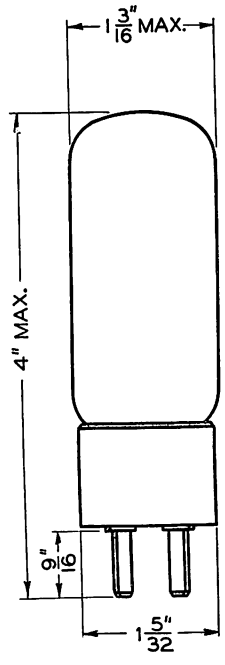


FIG. 1

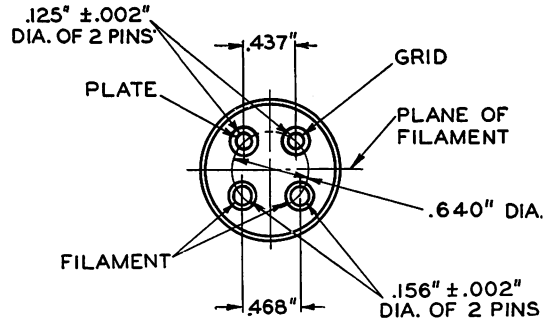


FIG. 2

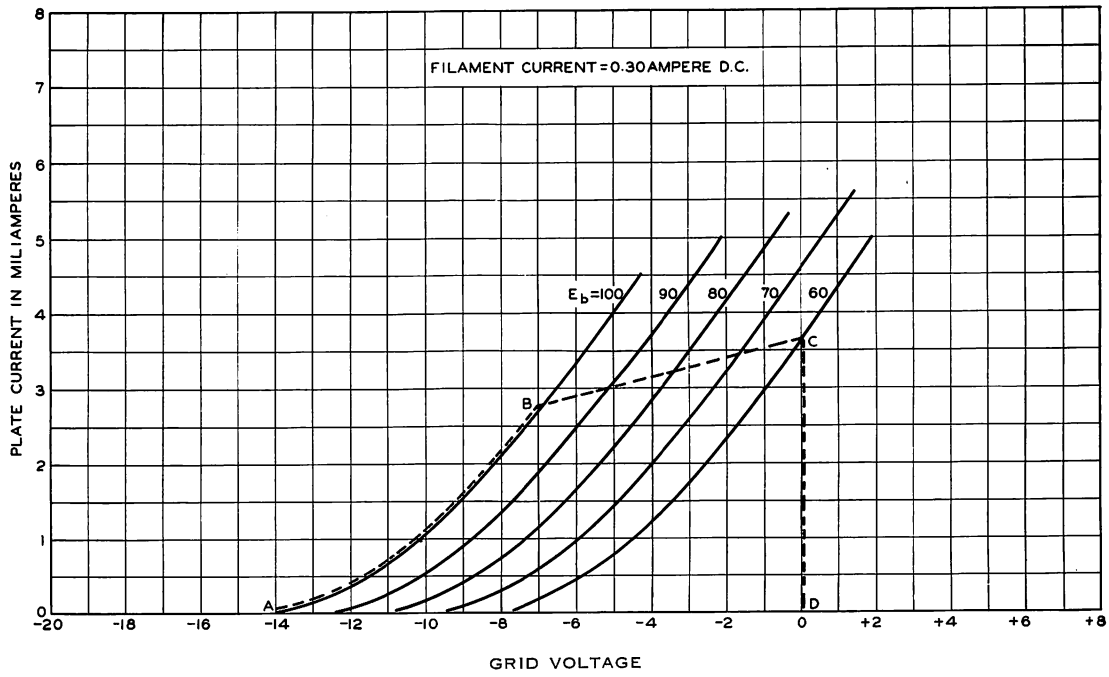


FIG. 3

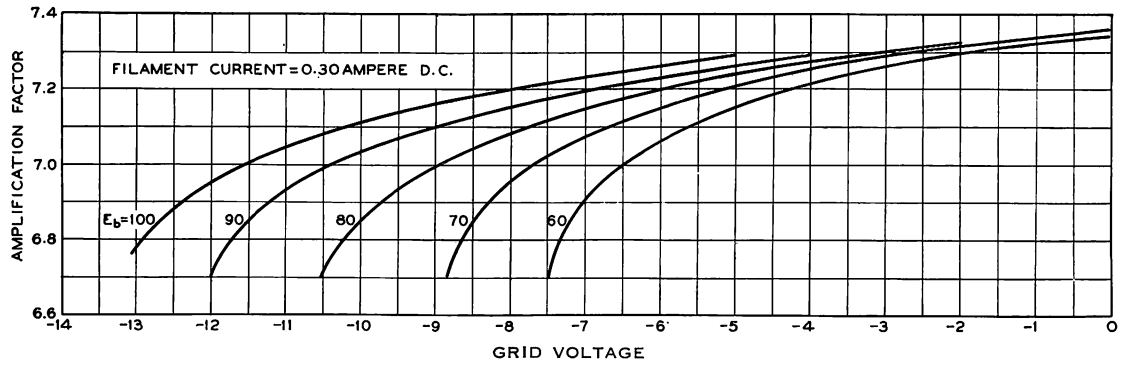


FIG. 4

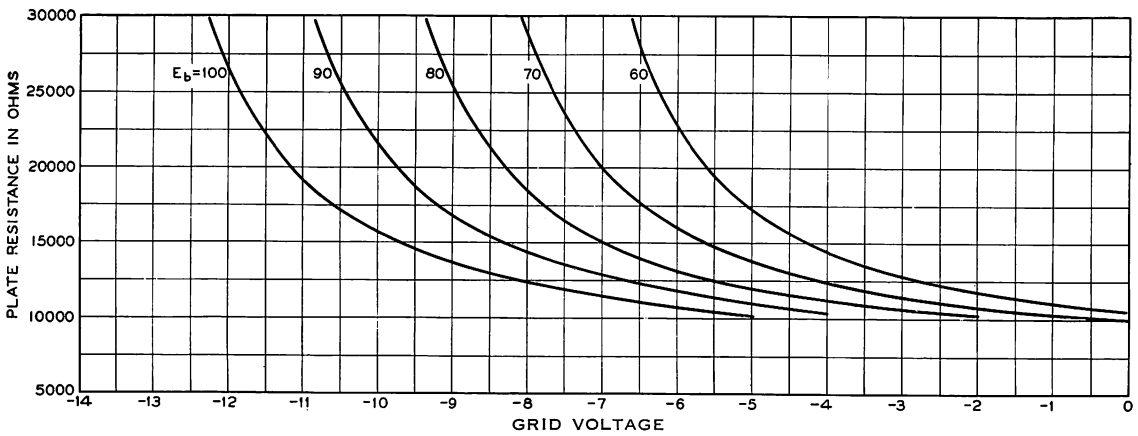


FIG. 5

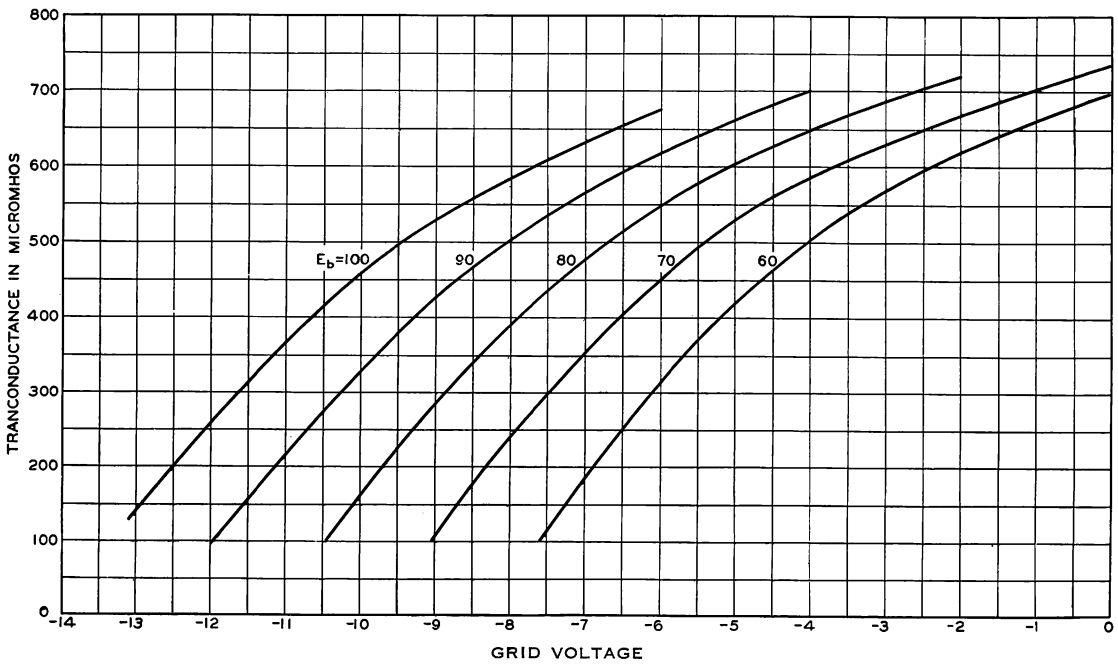


FIG. 6

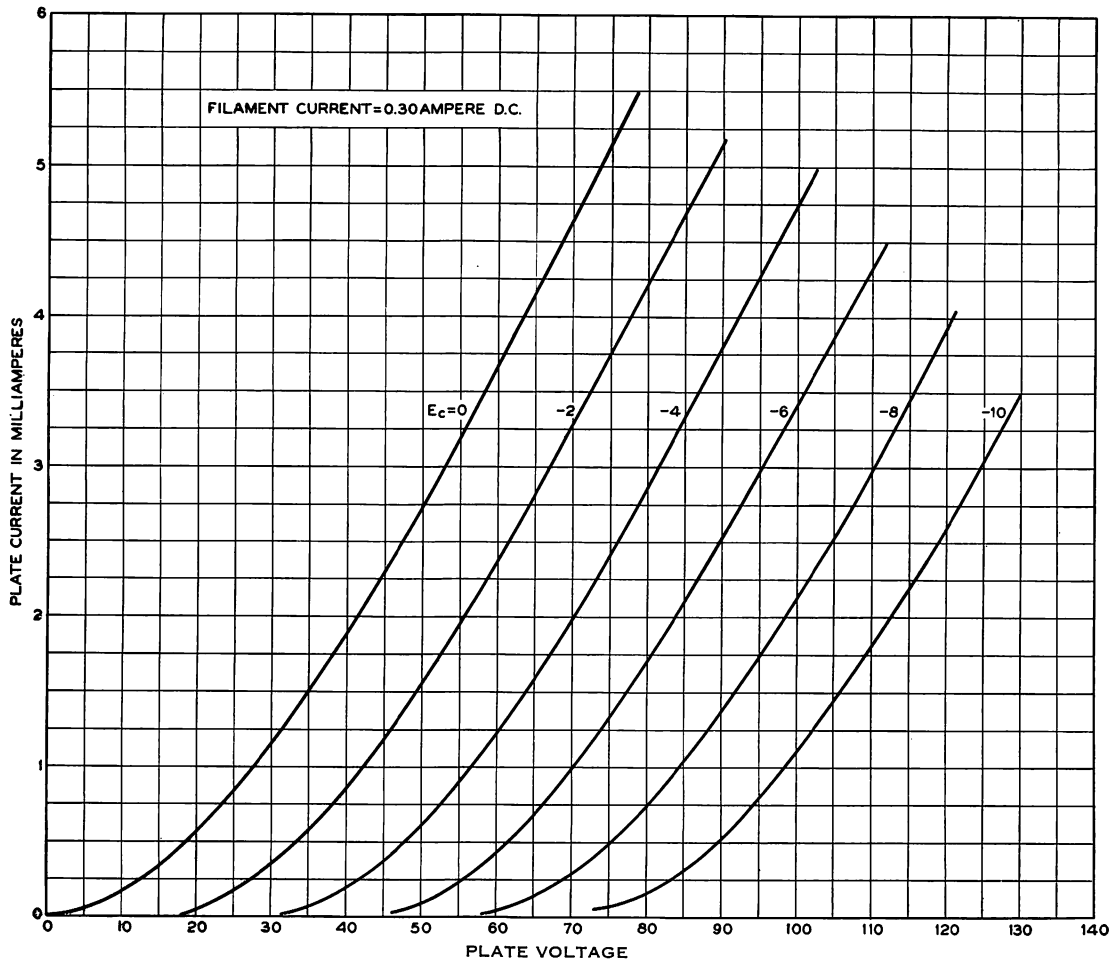
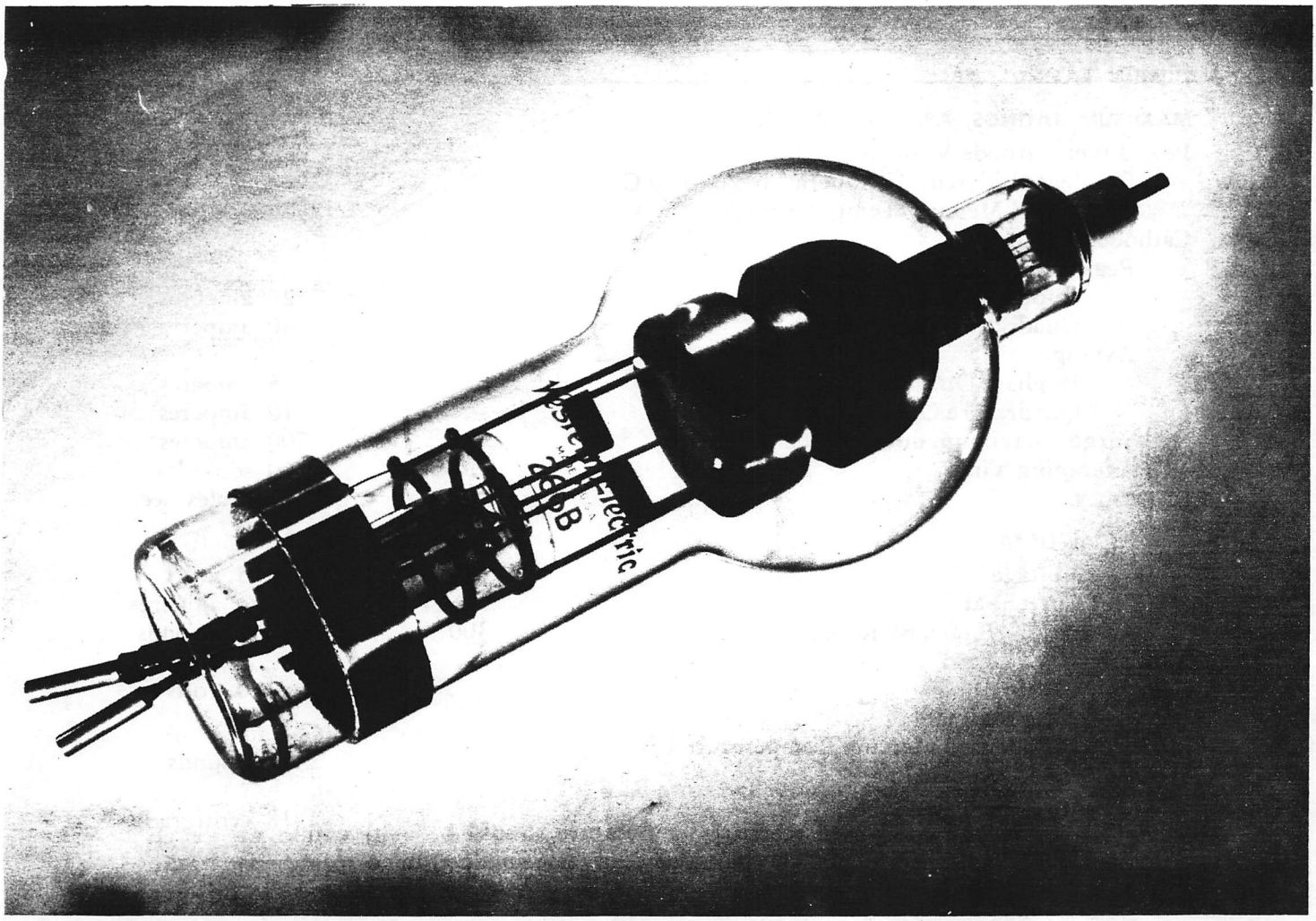

FILAMENT CURRENT=0.30AMPERE D.C.
Ec=0
-2
-4
-6
-8
-10
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140

FIG. 7



RECTIFIER
HALF-WAVE, MERCURY-VAPOR

Western Electric

DESCRIPTION

The 266B is a half-wave, mercury-vapor rectifier tube for use in high-voltage rectifier circuits.

MAXIMUM RATINGS

Peak Inverse Anode Voltage	22000 volts
Average Cathode Current (Quadrature Operation)	10 amperes

MAXIMUM RATINGS, ABSOLUTE VALUES

Peak Inverse Anode Voltage for	
Condensed Mercury Temperature 20 to 40 C	22000 volts
Condensed Mercury Temperature 20 to 50 C	12500 volts
Cathode Current	
Peak	
In-phase Operation	20 amperes
Quadrature Operation	40 amperes
Average	
In-phase Operation	5 amperes
Quadrature Operation	10 amperes
Surge (maximum duration 0.2 second)	200 amperes
Averaging Time	60 seconds
Frequency	150 cycles/sec.

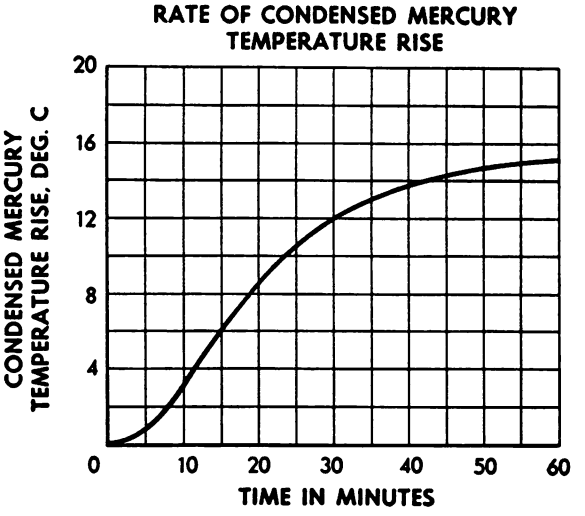
ELECTRICAL DATA	Min.	Bogey	Max.	
Filament Voltage	4.75	5.0	5.25	volts
Filament Current at 5.0 Volts	.....	42	46	amperes
Cathode Heating Time, Required	300	.....	.....	seconds
Anode Voltage Drop	.....	15	.....	volts
Critical Anode Voltage	.....	.....	100	volts

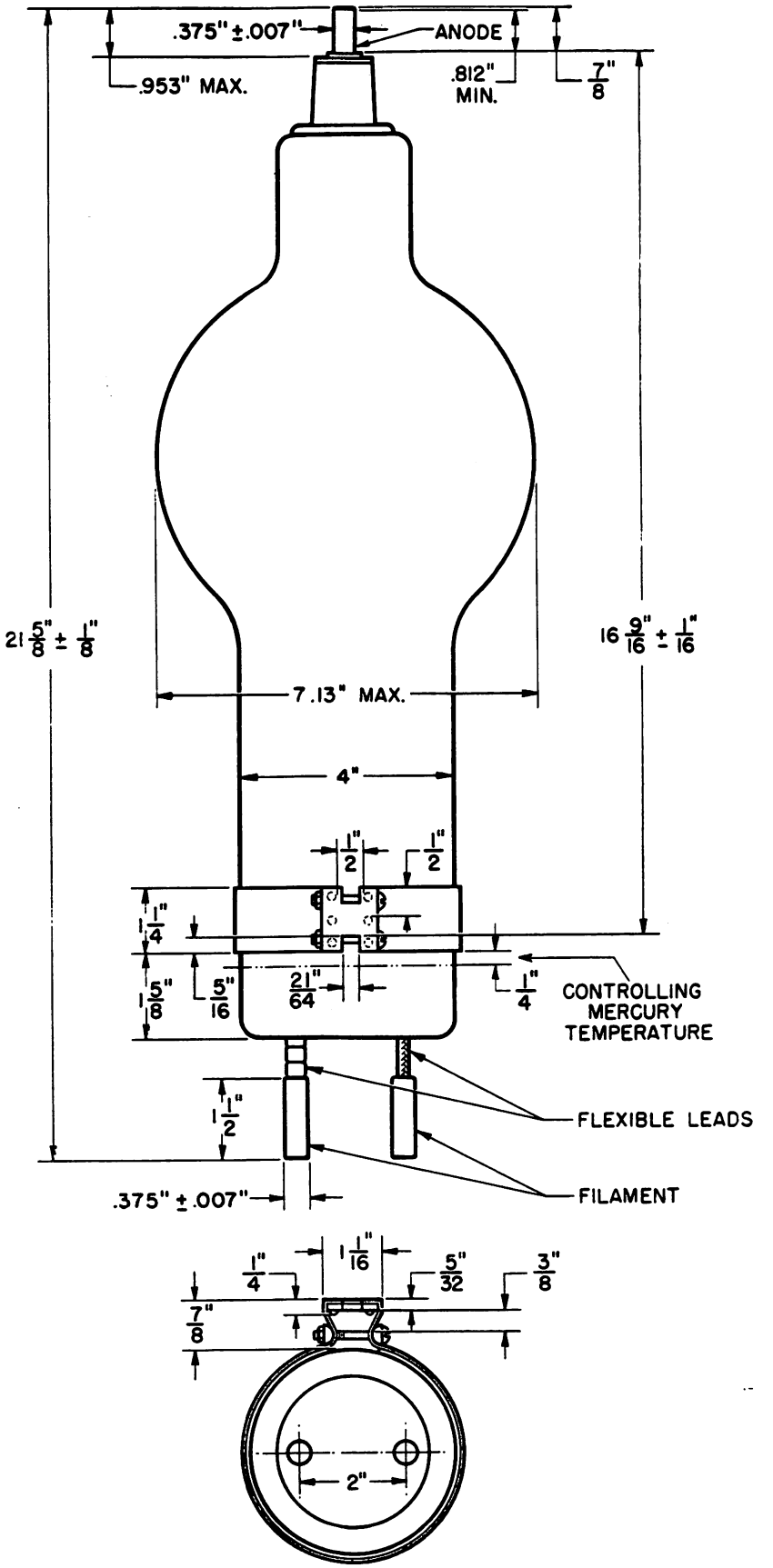
MECHANICAL DATA

Net Weight, Approximate	4¼ pounds
Equilibrium Condensed Mercury Temperature Rise	
At Full Load, Approximate	18 centigrade
At No Load, Approximate	15 centigrade

Cooling — The condensed mercury temperature should be held within the range specified for the maximum peak inverse anode voltage appropriate to the application. If forced-air cooling is necessary, a flow of 6 cubic feet per minute from a 1-inch nozzle directed at the zone of mercury temperature control just below the support collar ordinarily will be adequate.

Mounting — This tube has a collar at the filament end of the tube by which it is supported when mounted. It should be mounted in a vertical position only, with the filament end down. Connections to the anode and filament terminals should be flexible. Sufficient clearance should be maintained around the tube to insure free air circulation.



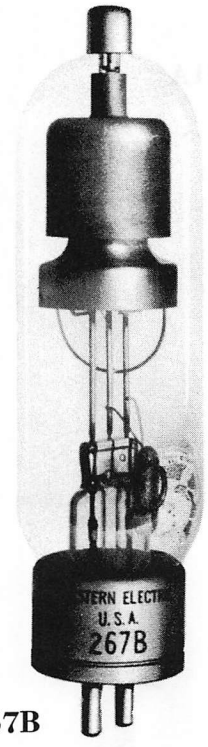

.375" ±.007"
ANODE
.953" MAX.
.812" MIN.
7/8"
21 5/8" ± 1/8"
16 9/16" ± 1/16"
7.13" MAX.
4"
1/2"
1/2"
1 1/4"
1 5/8"
5/16"
21/64"
1/4"
CONTROLLING MERCURY TEMPERATURE
1 1/2"
FLEXIBLE LEADS
.375" ± .007"
FILAMENT
1 1/16"
1/4"
5/32"
3/8"
7/8"
2"

Western Electric

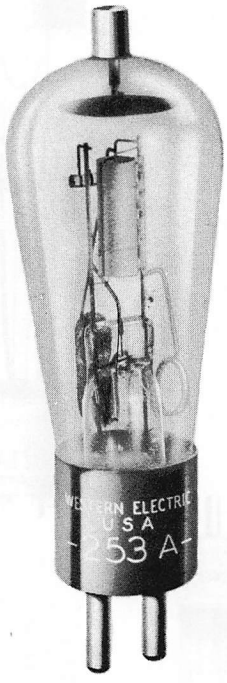
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

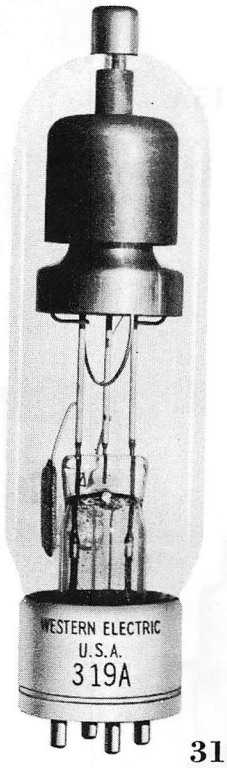
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



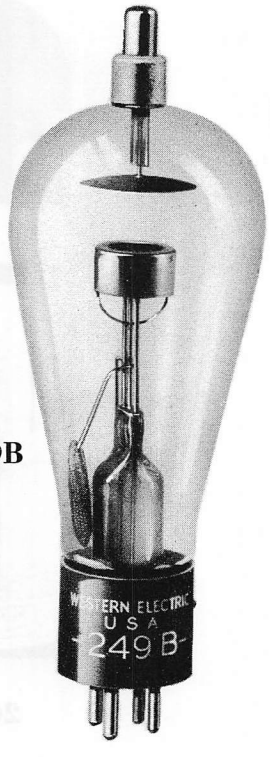
267B



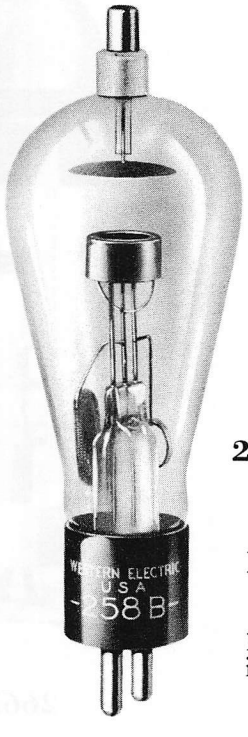
253A



319A



249B

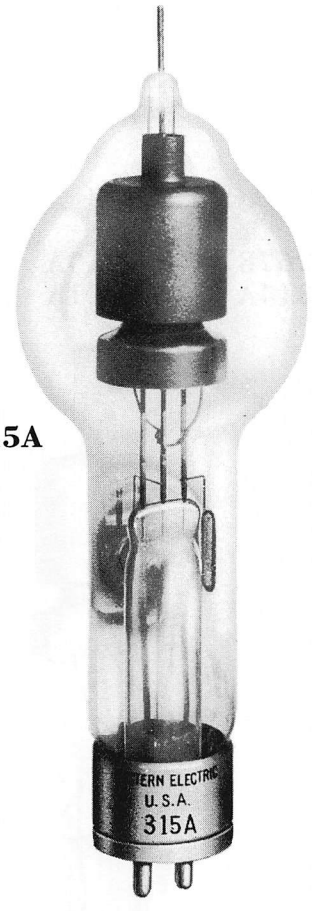


258B

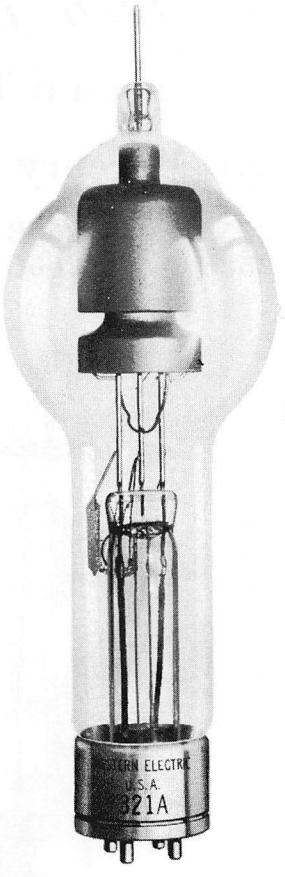
NOTE:

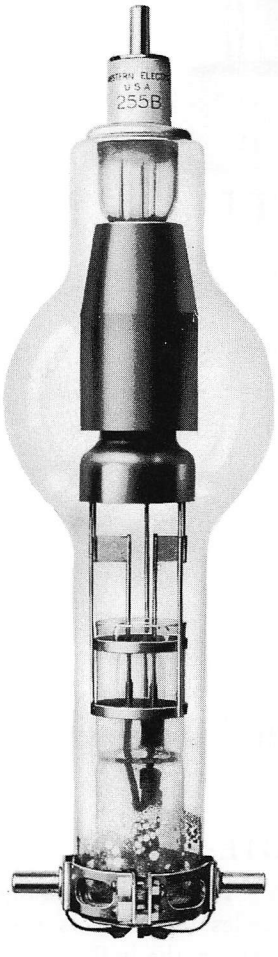
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

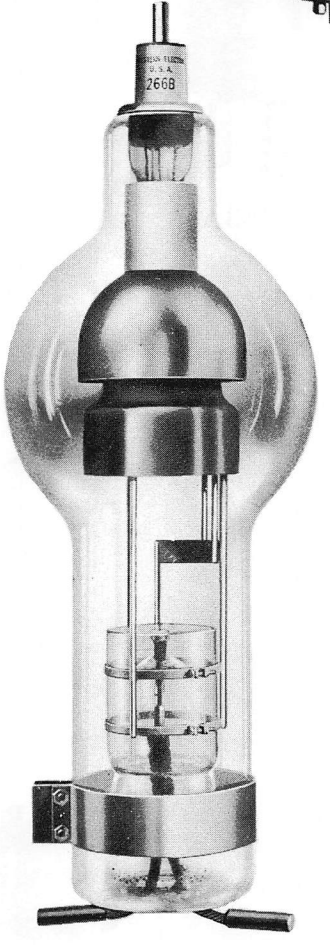


321A

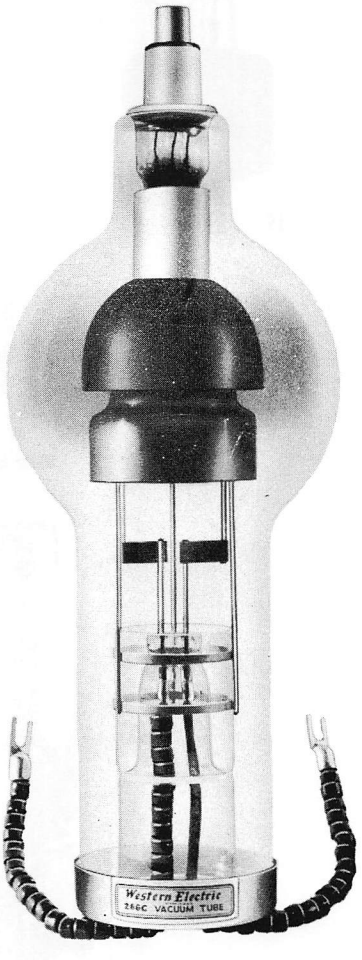




255B



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

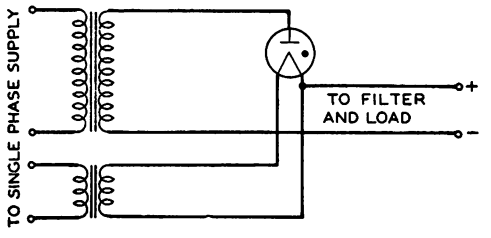
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output 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.

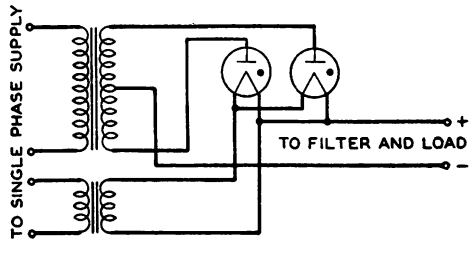
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits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

Circuits

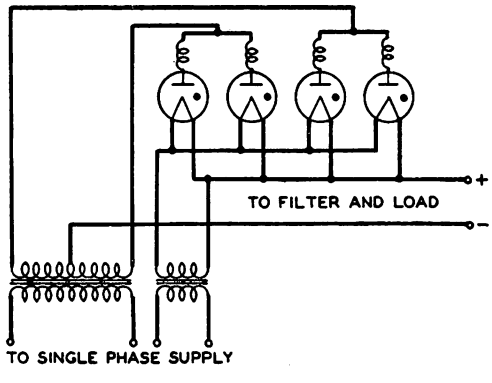
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and 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.



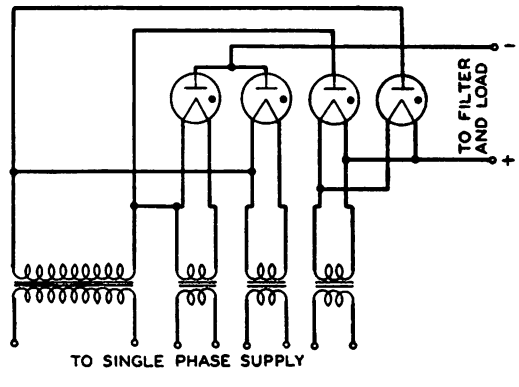
SINGLE PHASE, HALF-WAVE
CIRCUIT A



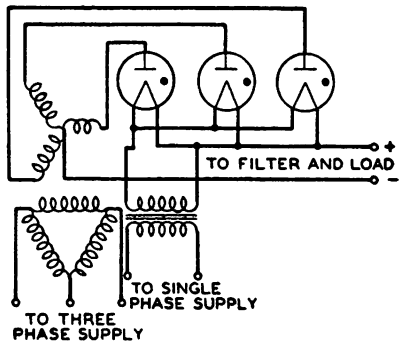
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



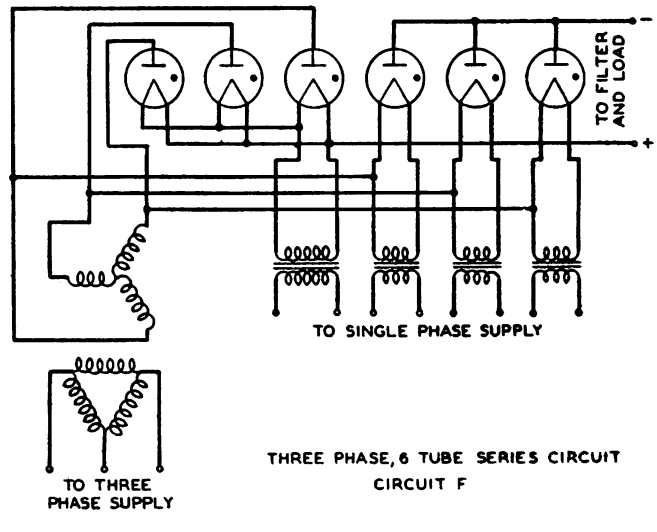
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



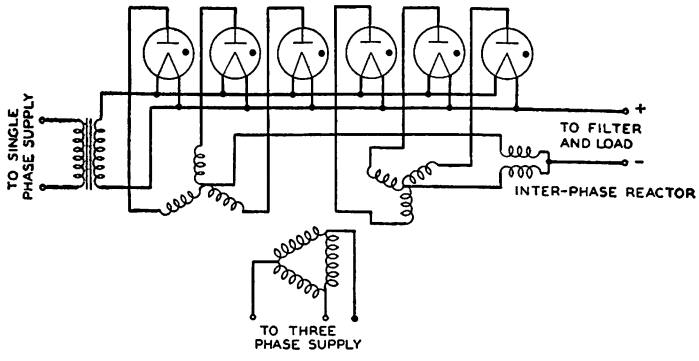
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



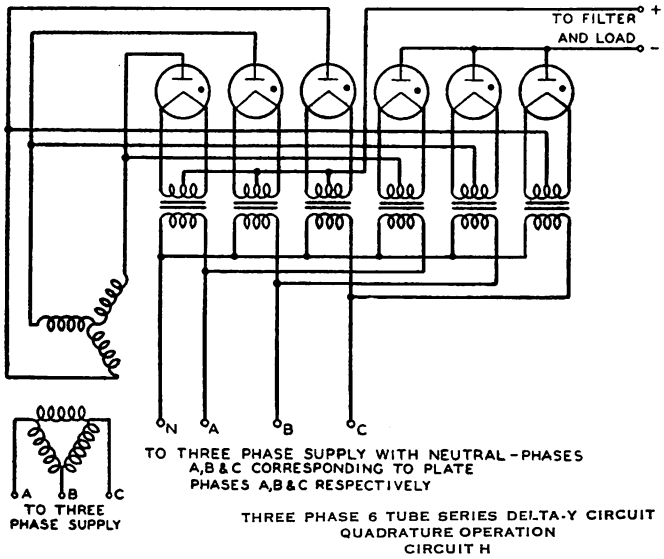
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

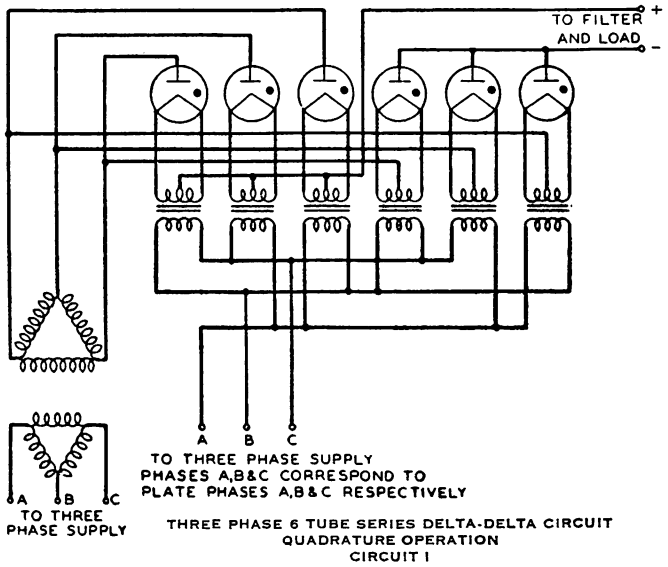


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



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

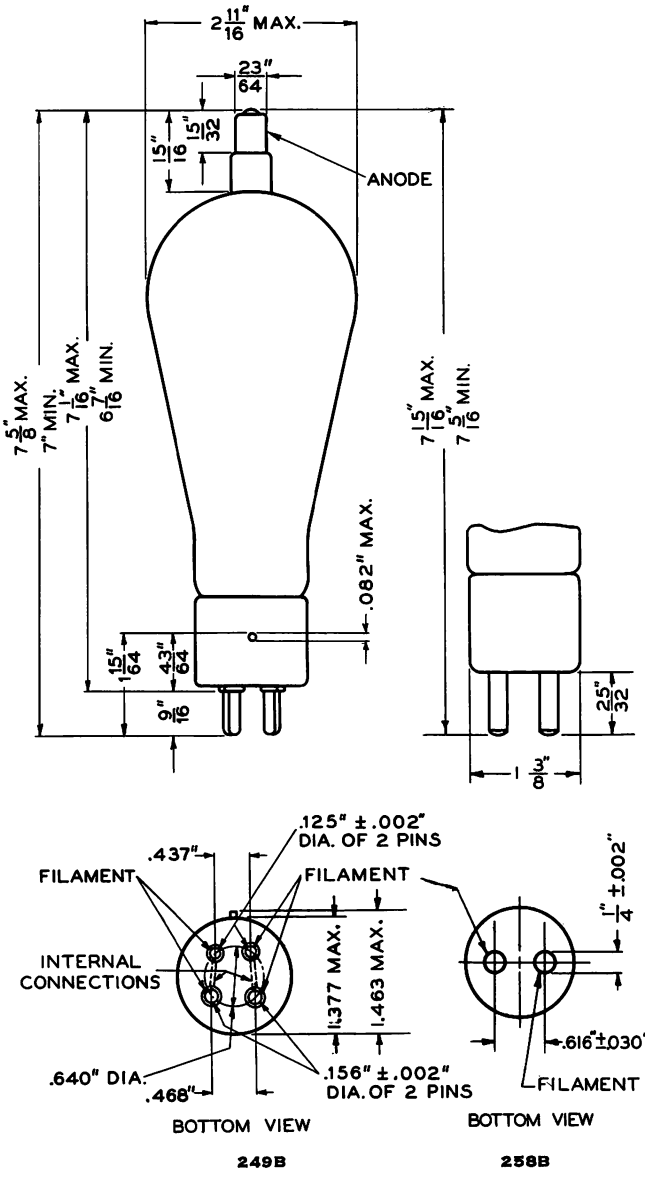
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

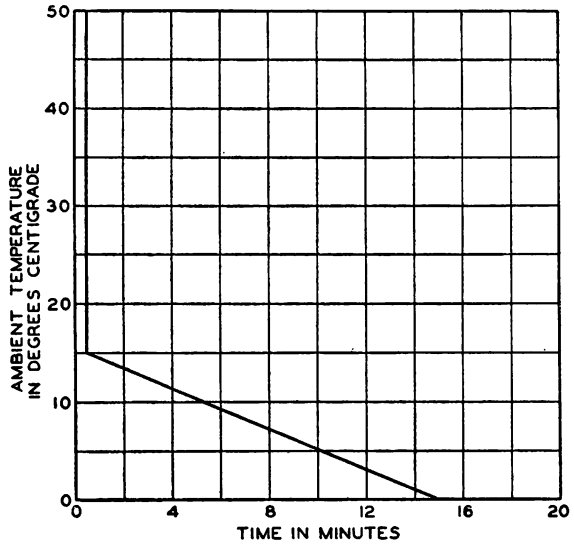


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

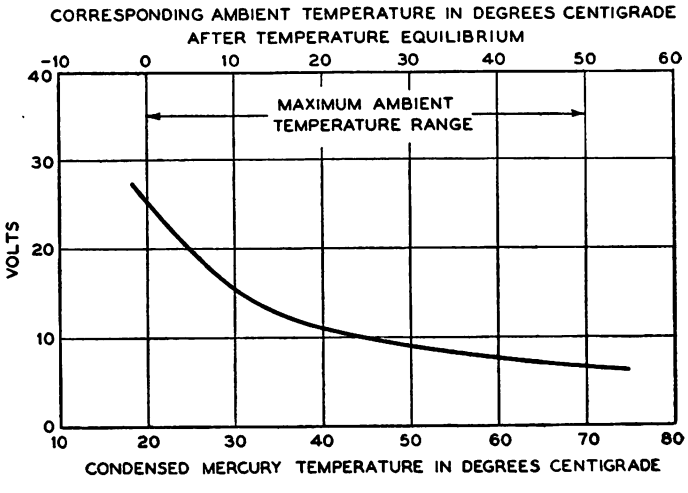
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

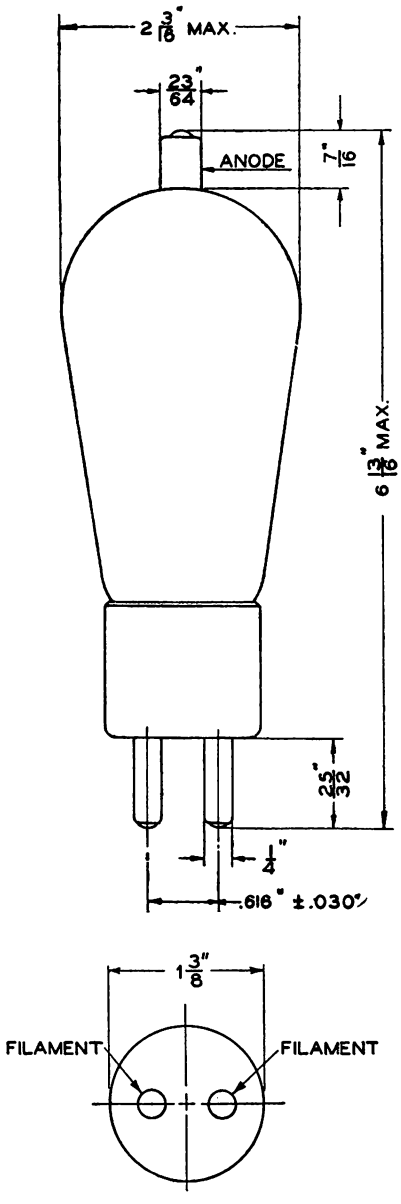
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 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.

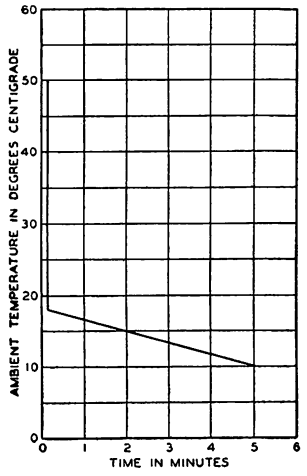
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

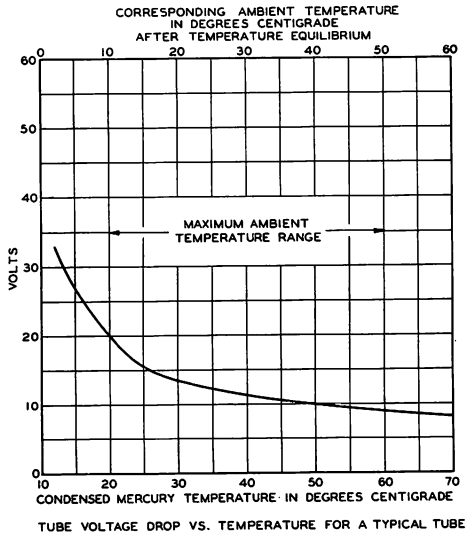
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

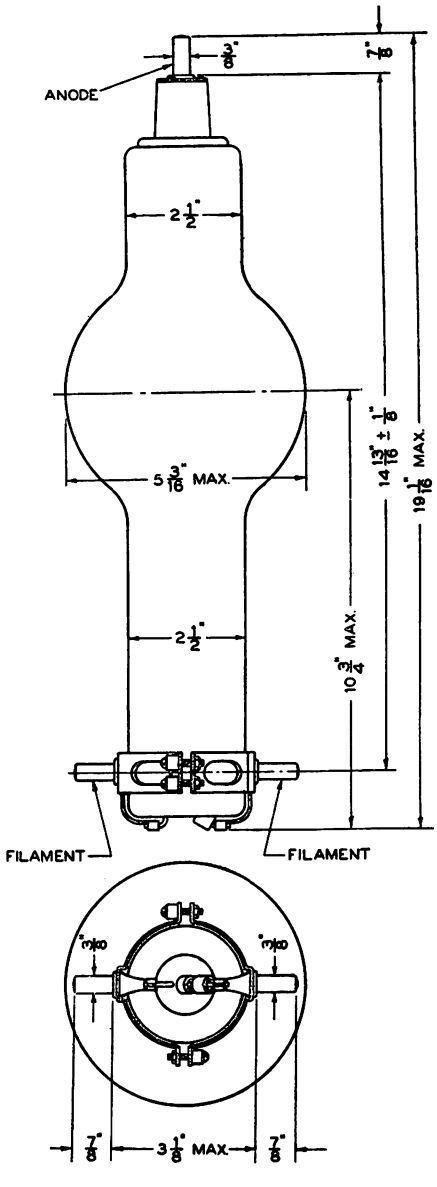
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

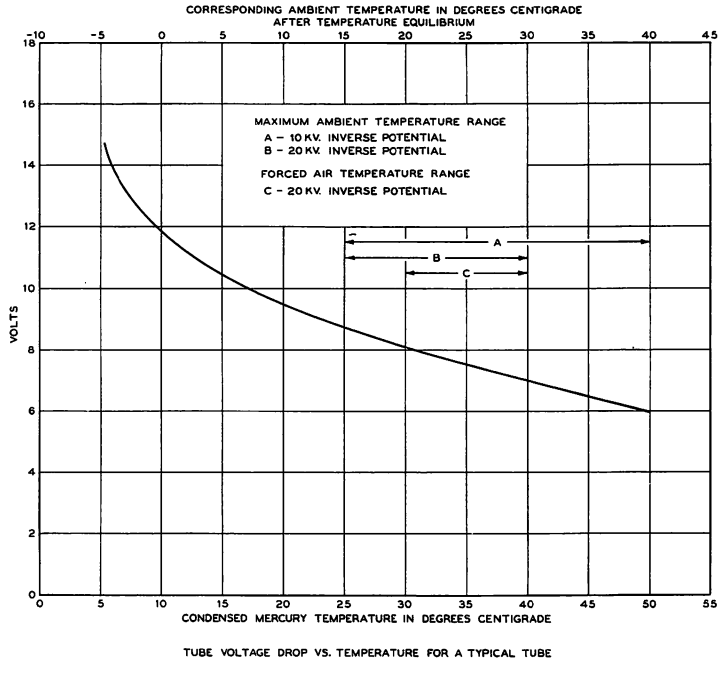
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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.

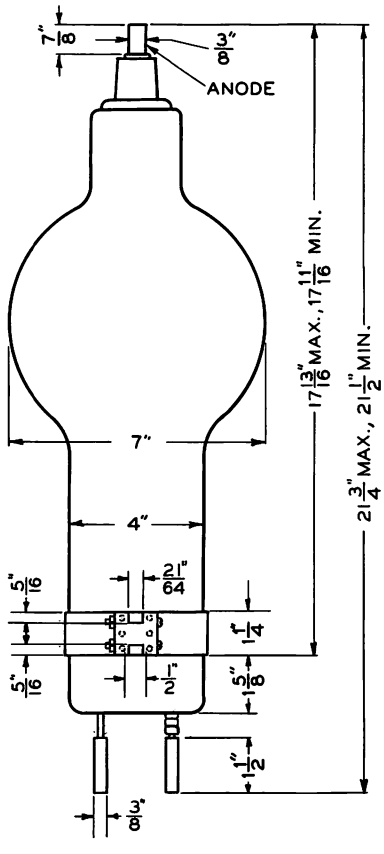
Ratings

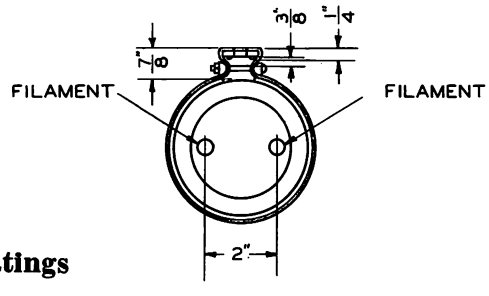
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
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

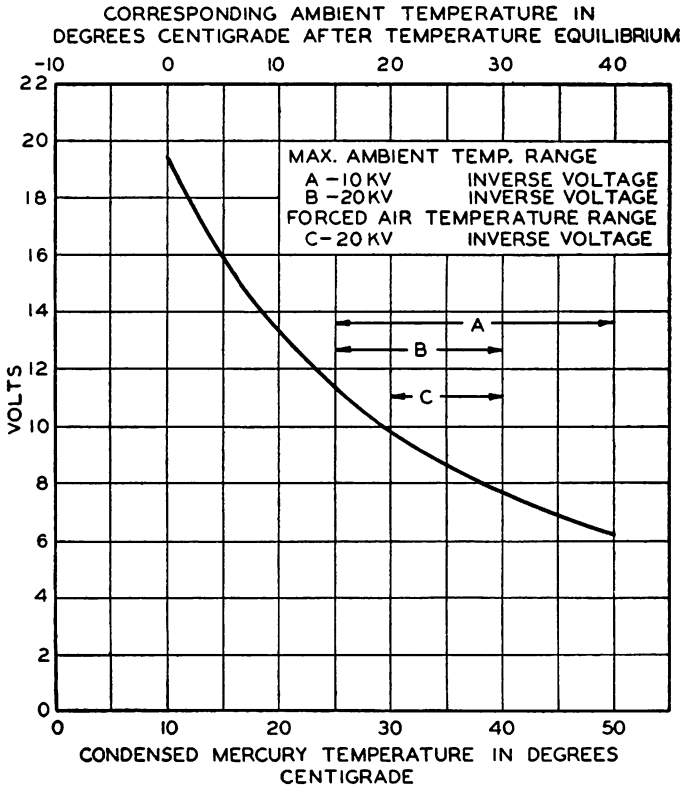
Circuit Outputs:

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

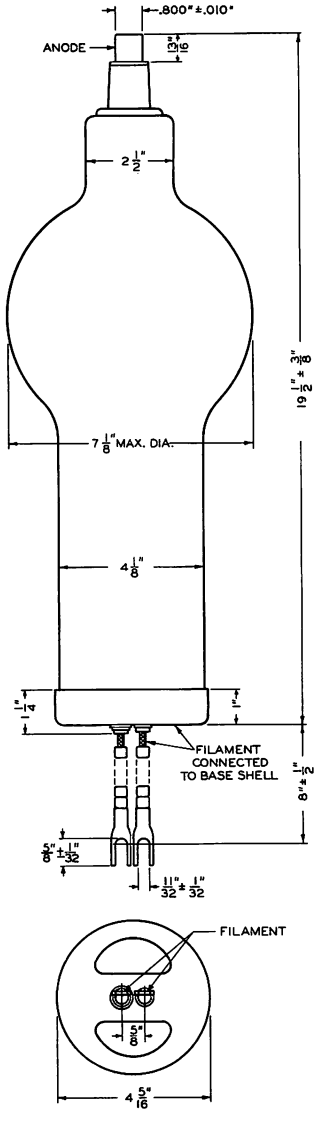
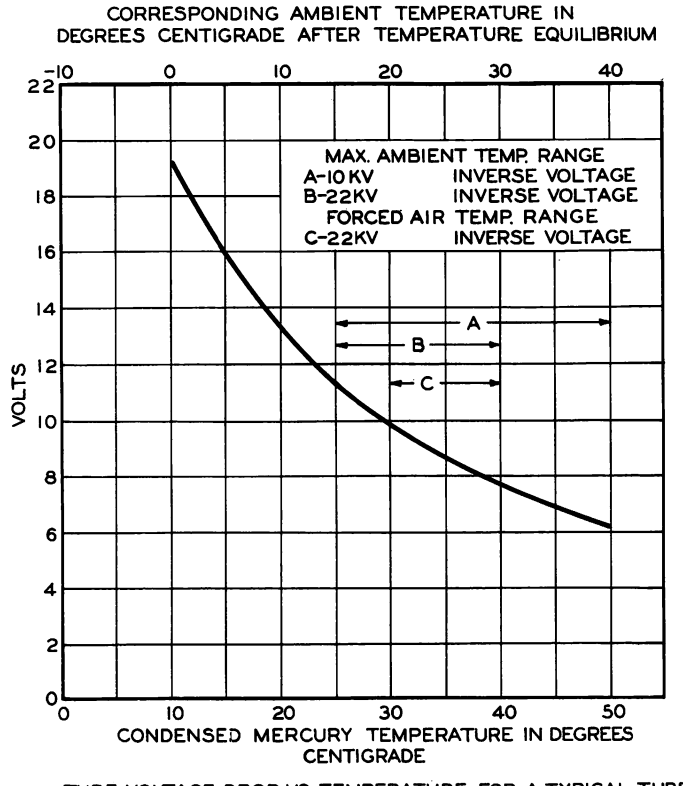


FIG. 1



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

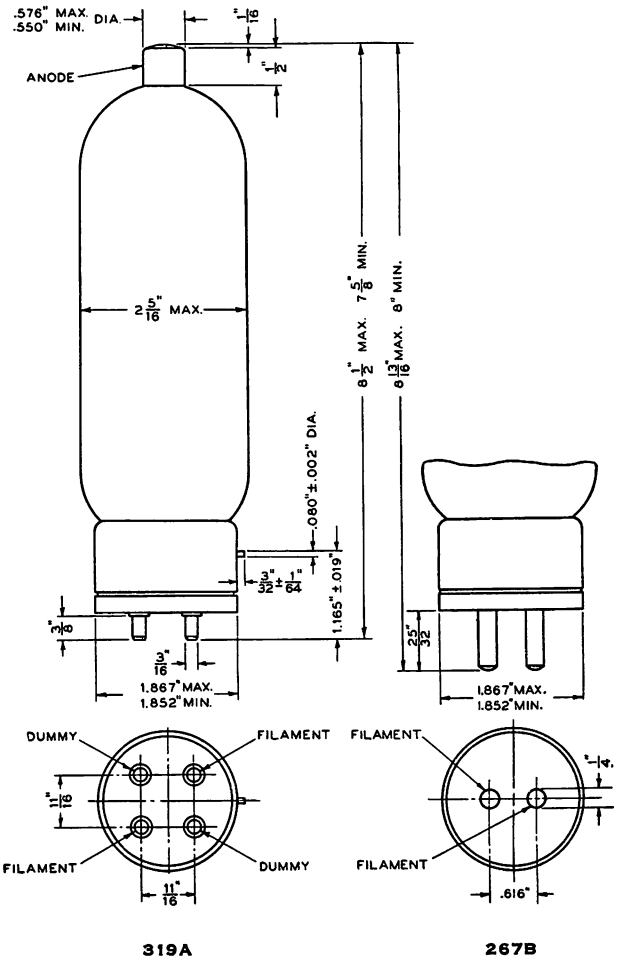
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

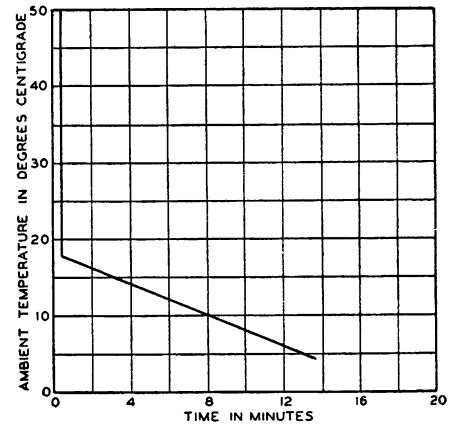
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

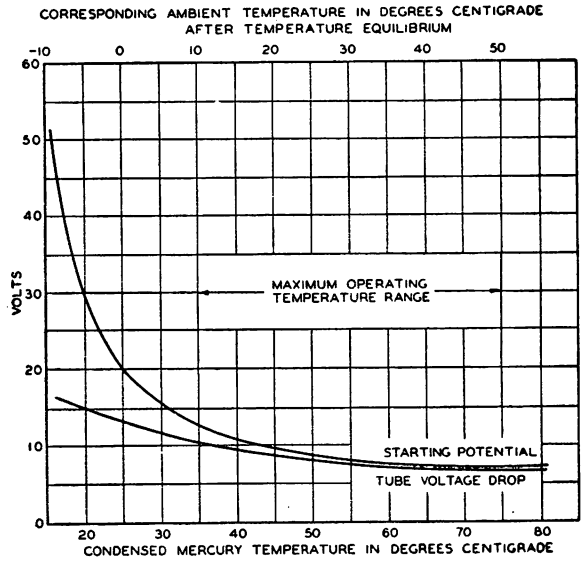
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	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

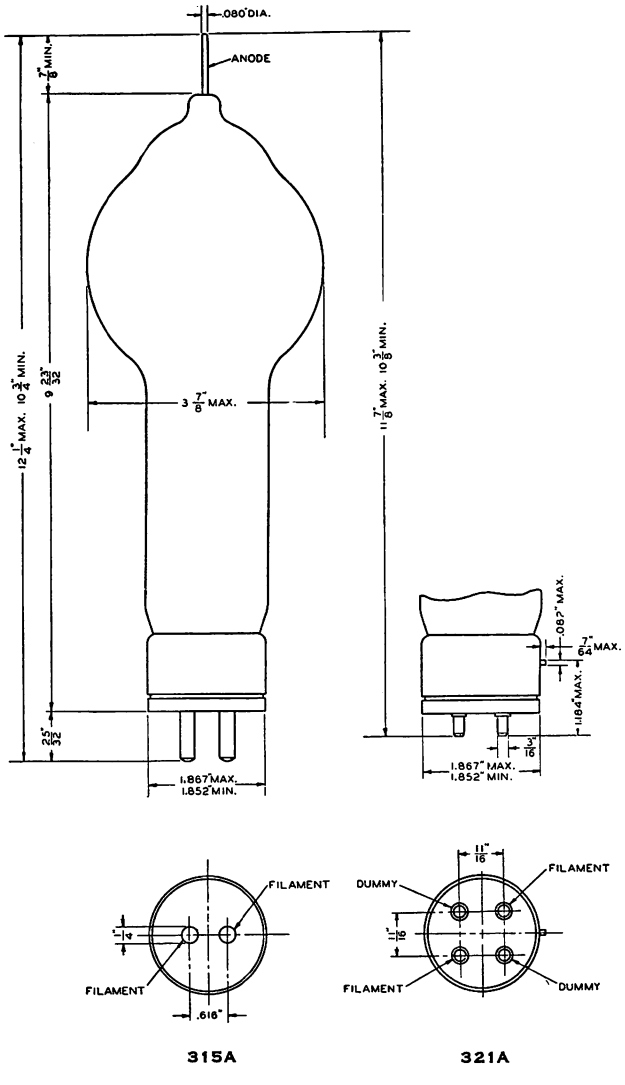
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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.

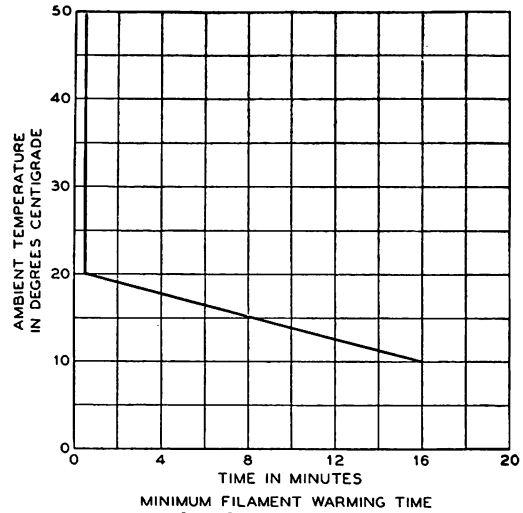
Circuit Outputs:

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

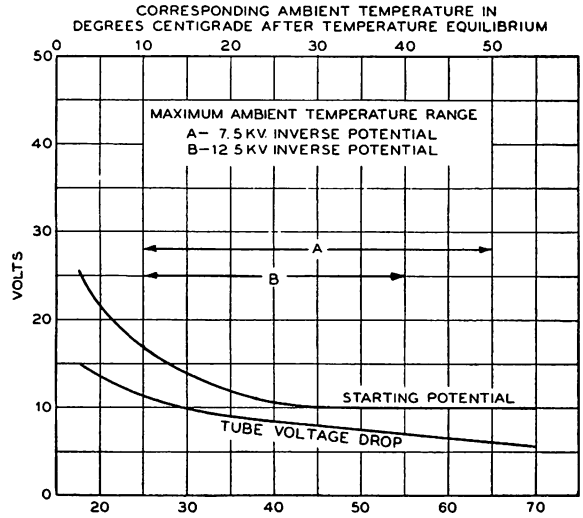
315A and 321A Vacuum Tubes



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

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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266C Vacuum Tube

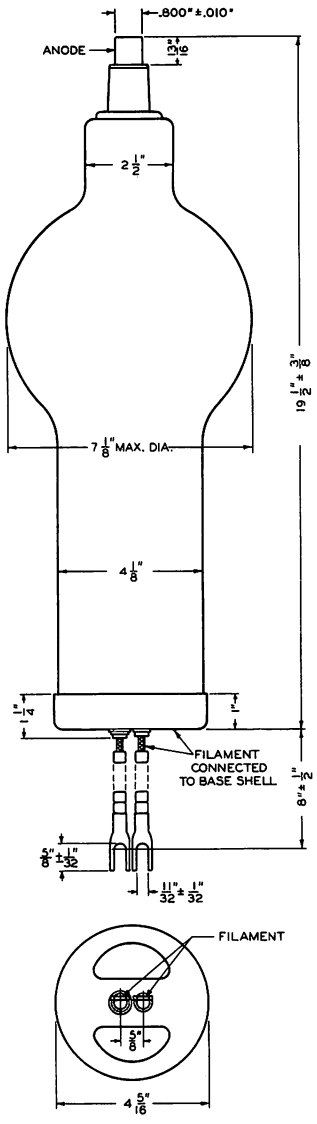
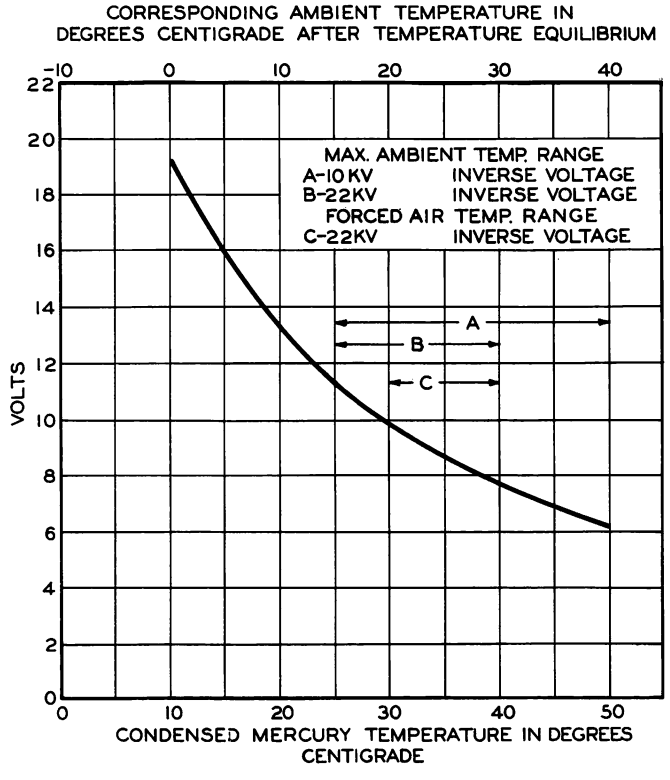


FIG. 1



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:

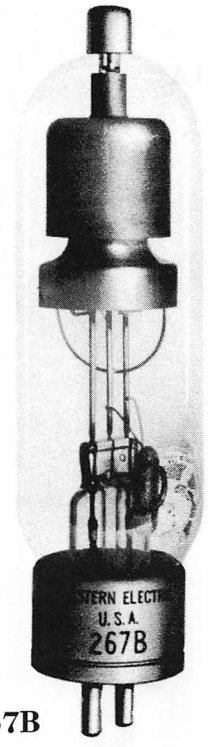
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000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

Western Electric

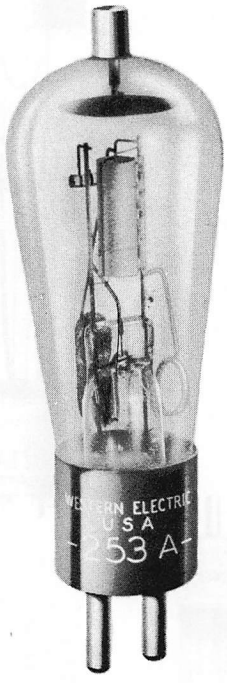
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

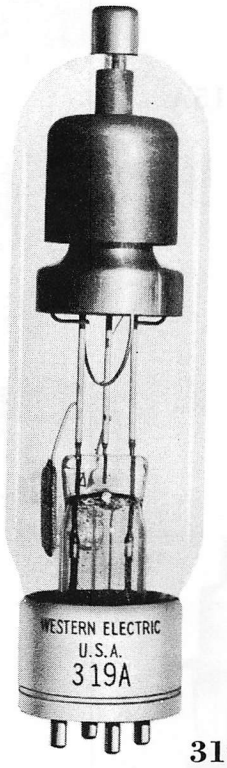
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



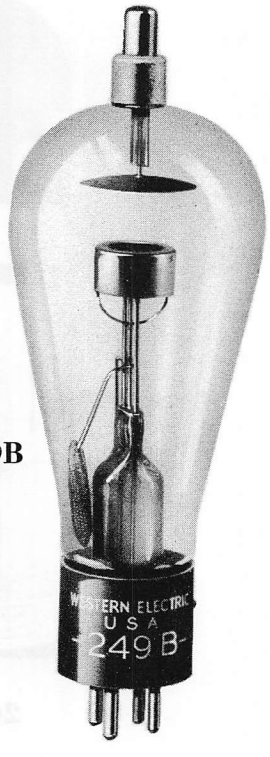
267B



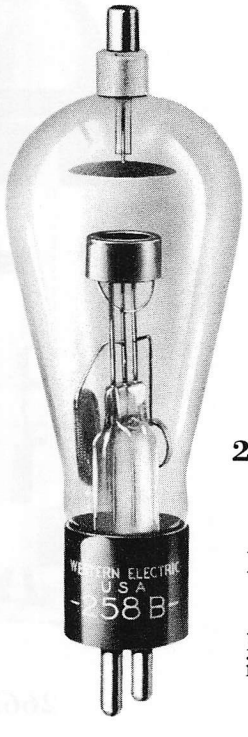
253A



319A



249B

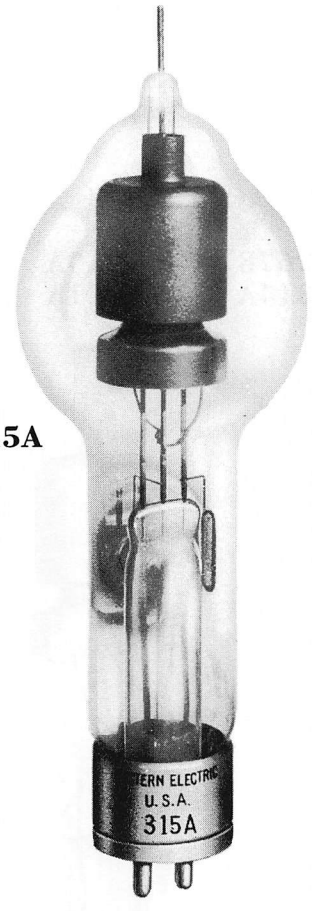


258B

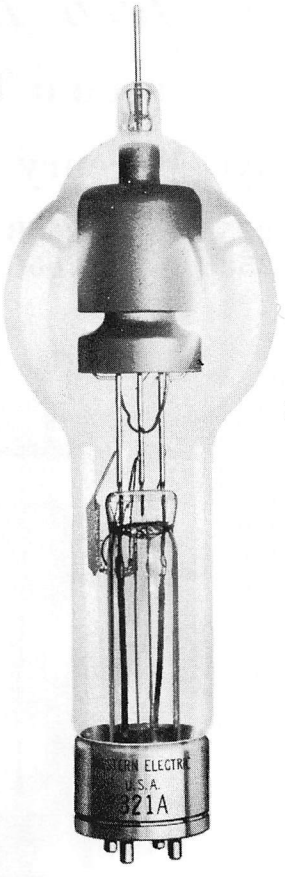
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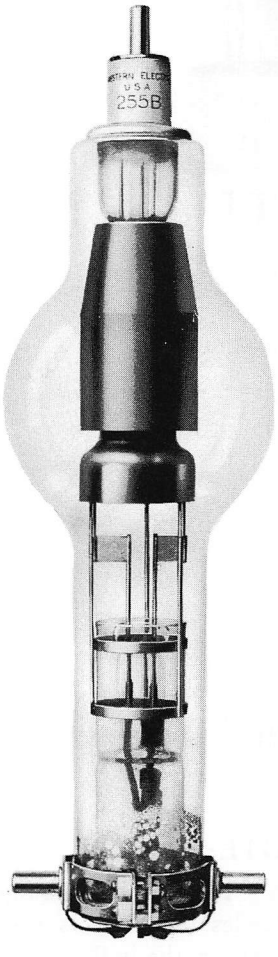
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

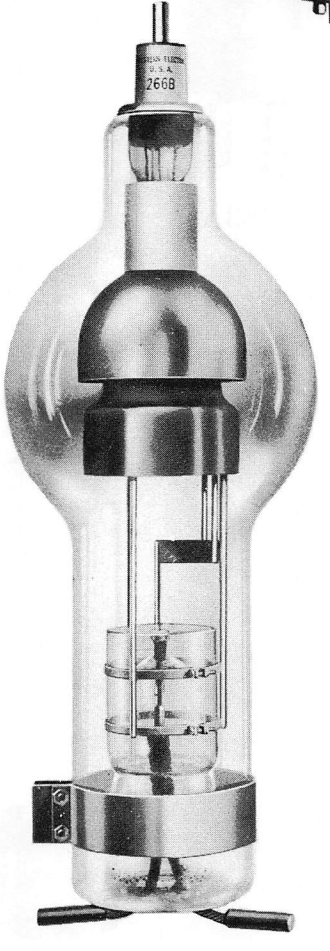


321A

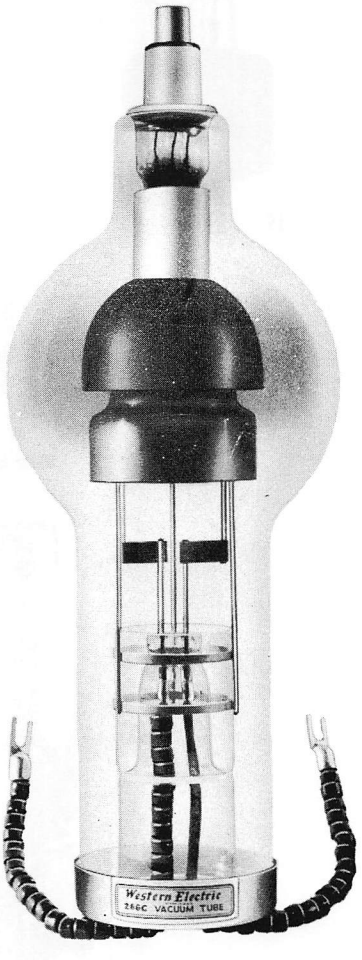




255B



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

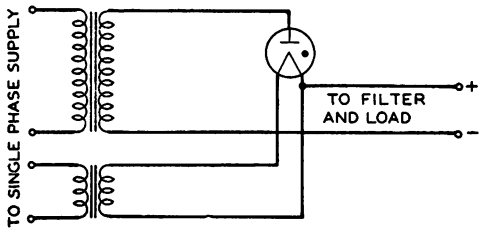
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output 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.

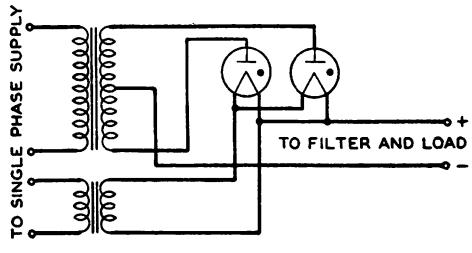
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits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

Circuits

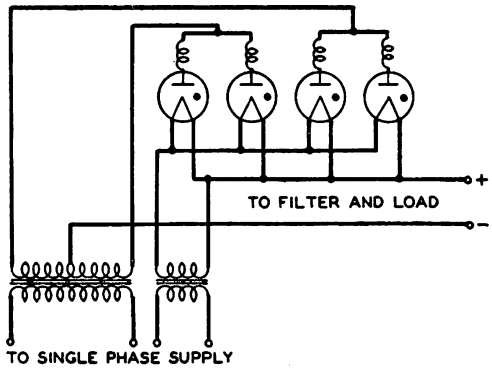
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and 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.



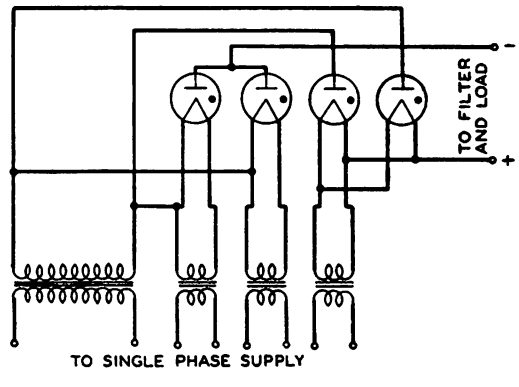
SINGLE PHASE, HALF-WAVE
CIRCUIT A



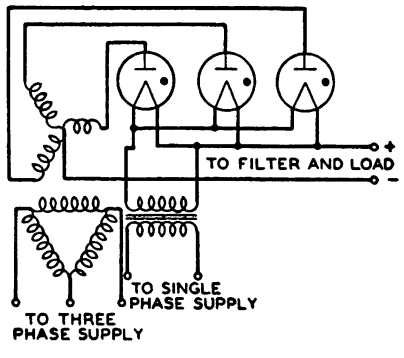
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



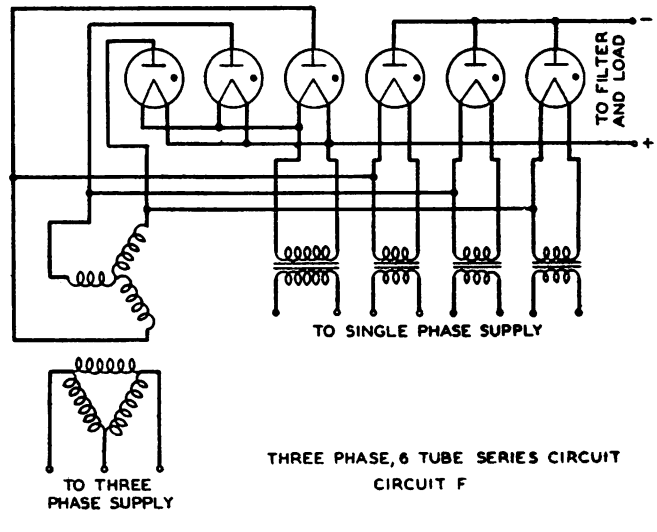
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



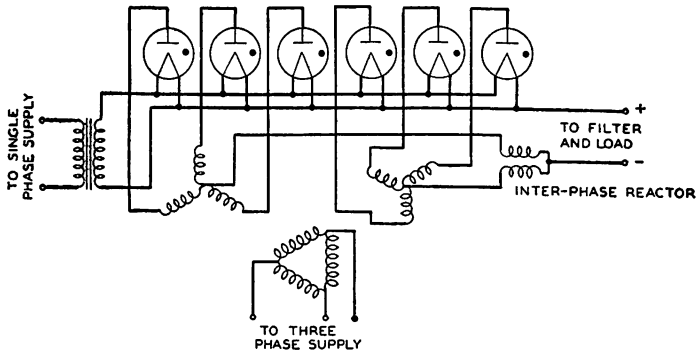
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



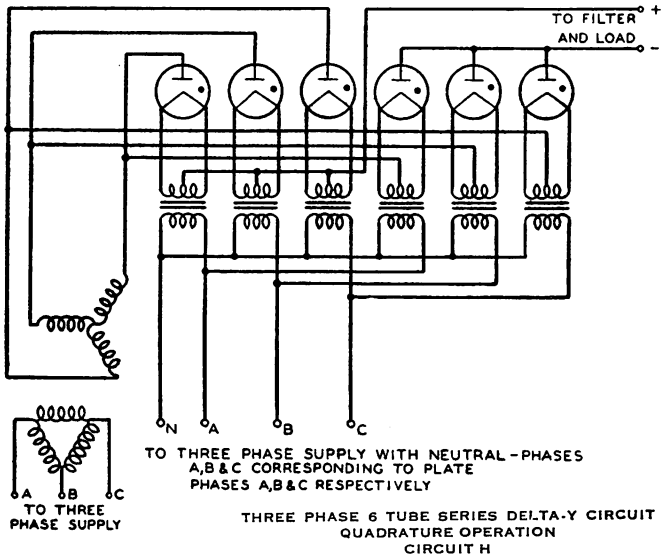
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

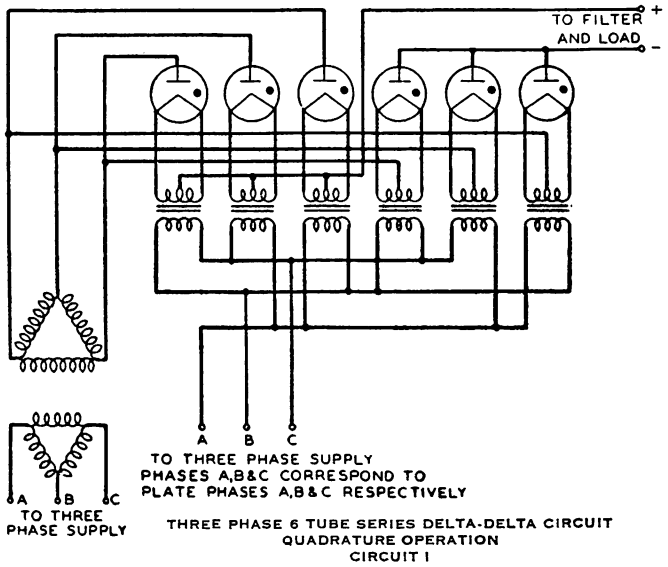


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



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

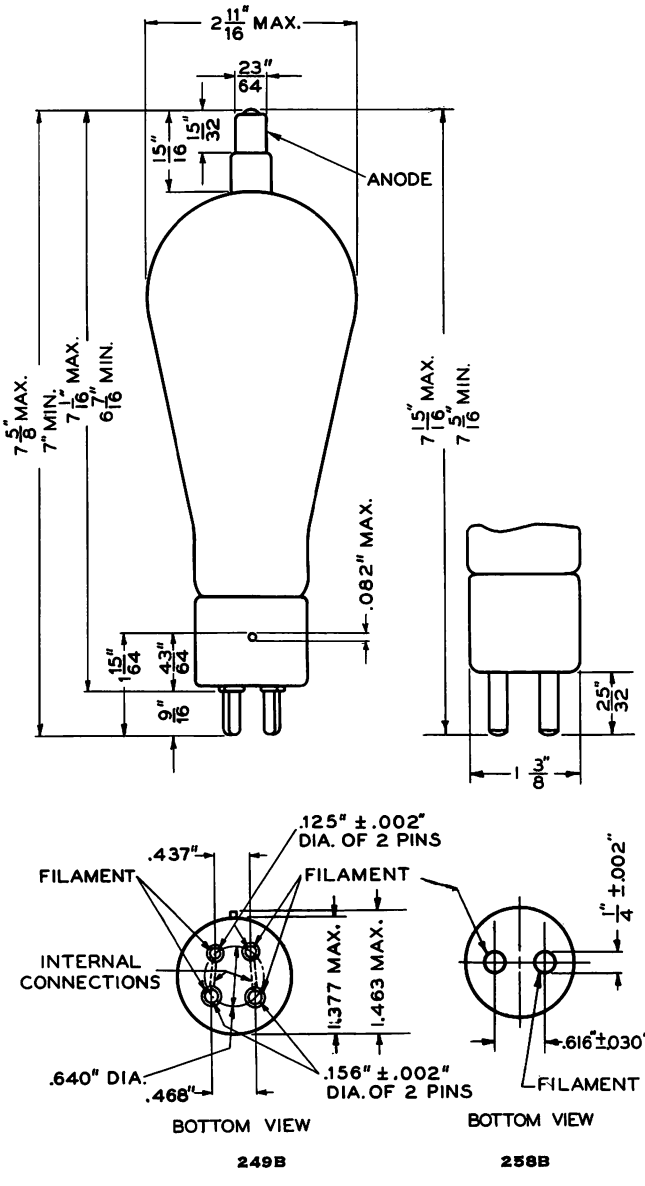
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

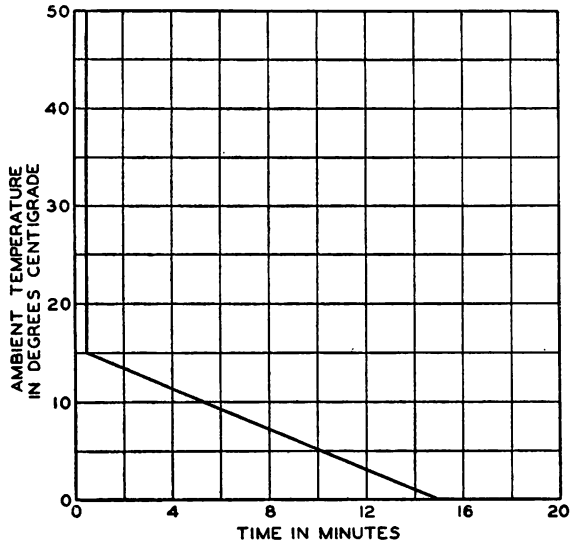


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

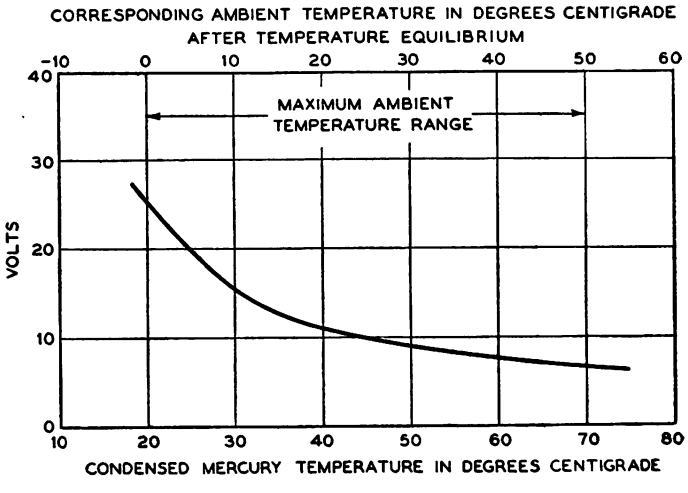
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

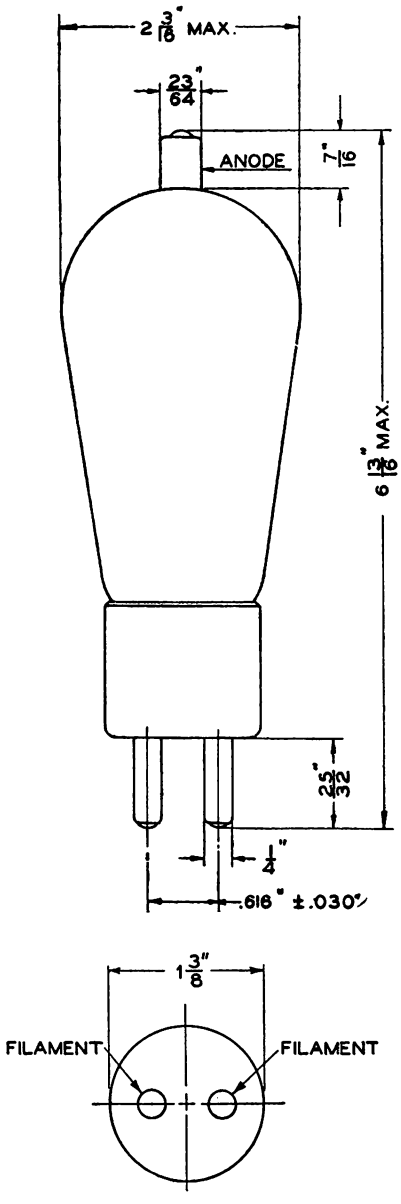
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 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.

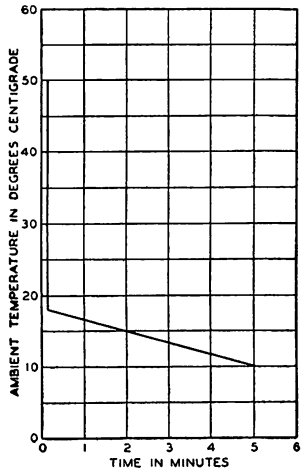
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

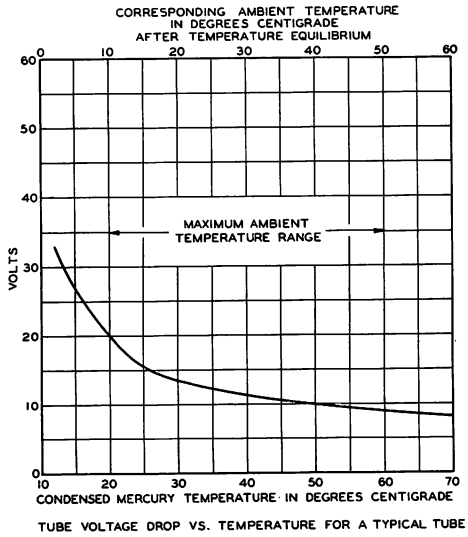
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

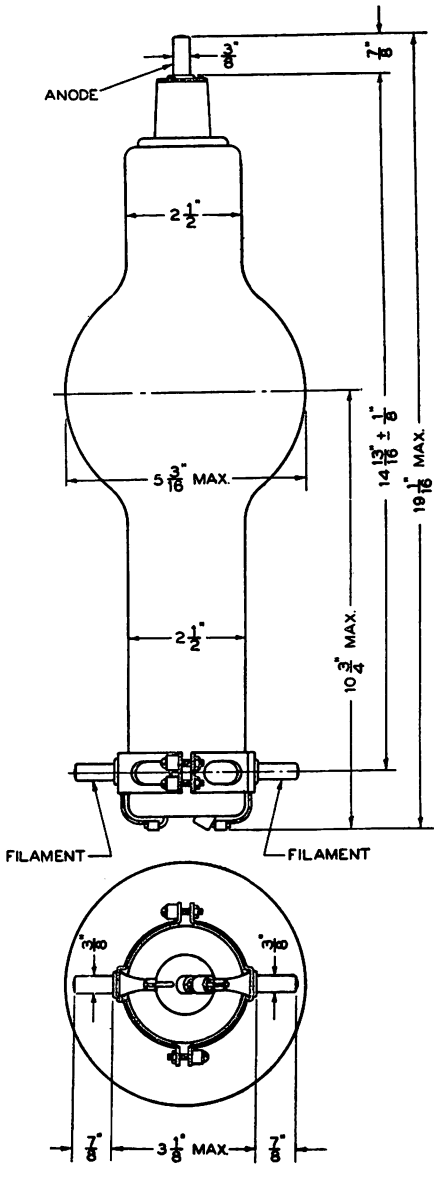
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

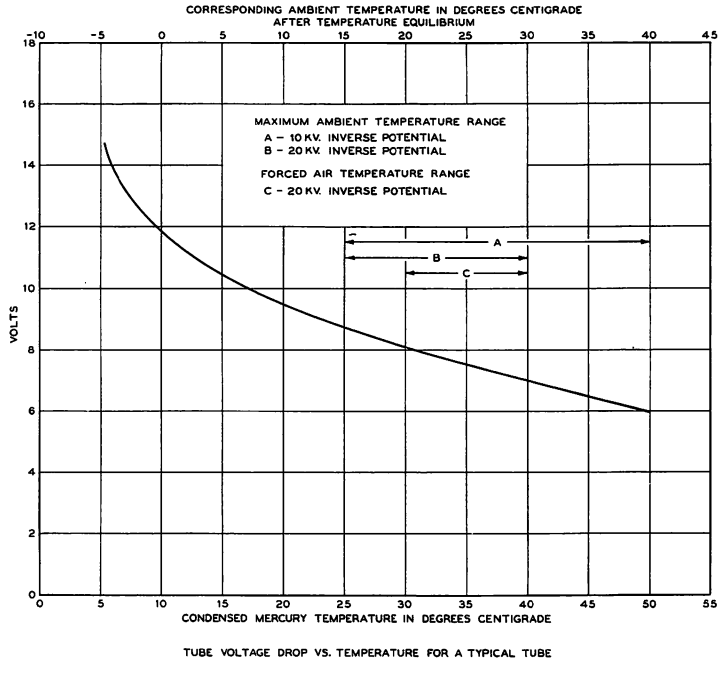
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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.

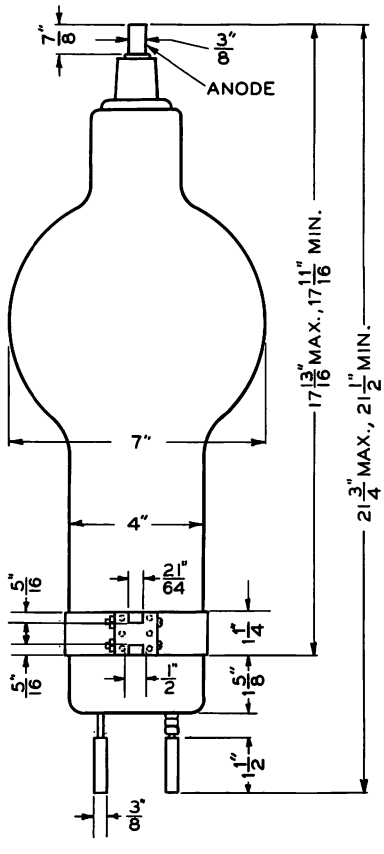
Ratings

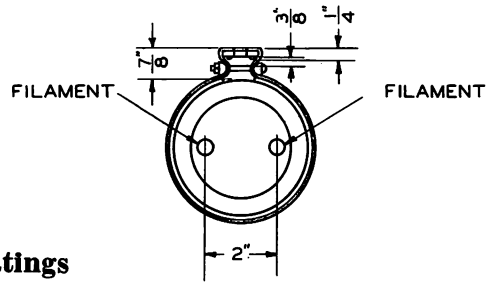
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
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

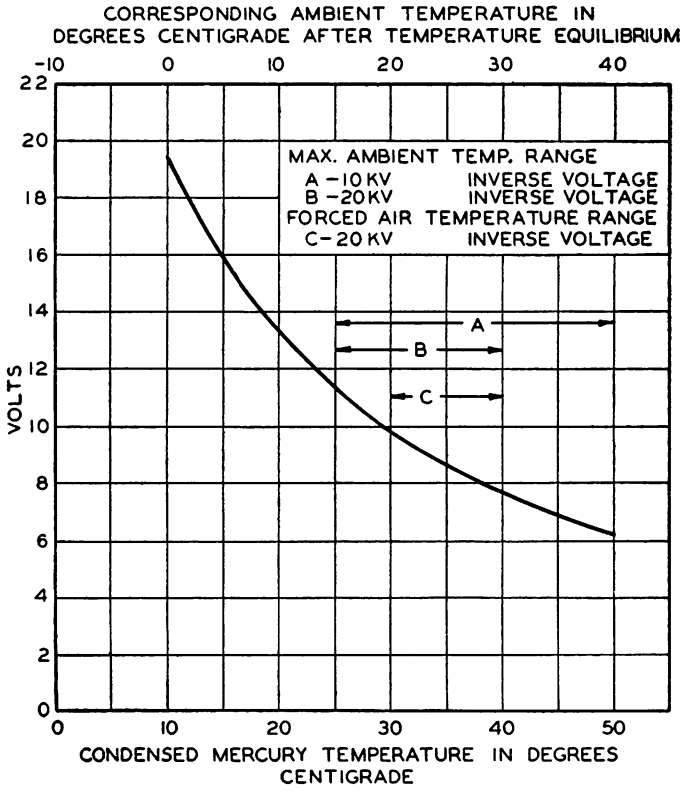
Circuit Outputs:

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

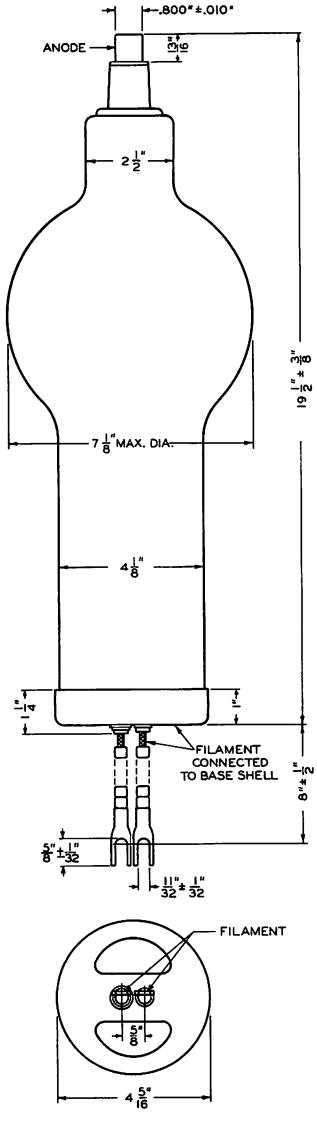
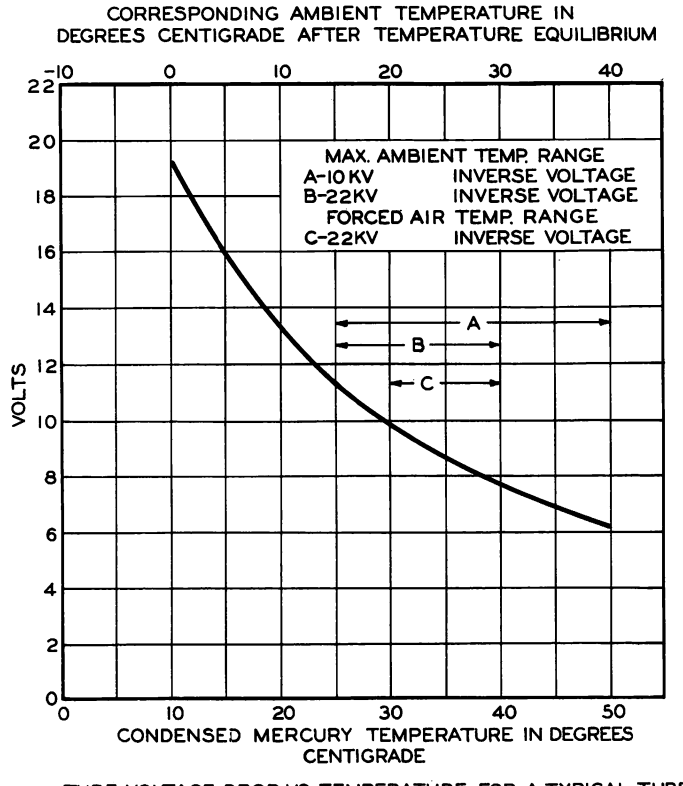


FIG. 1



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

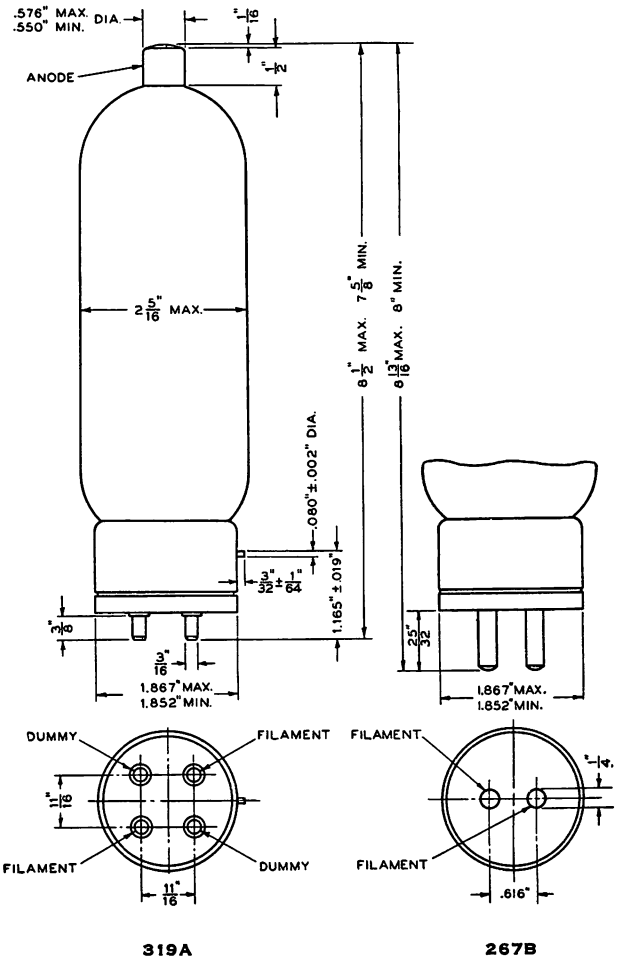
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

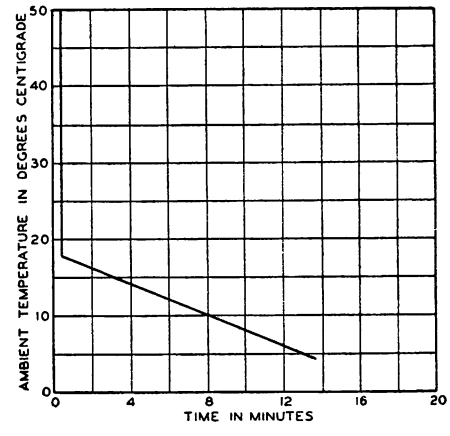
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

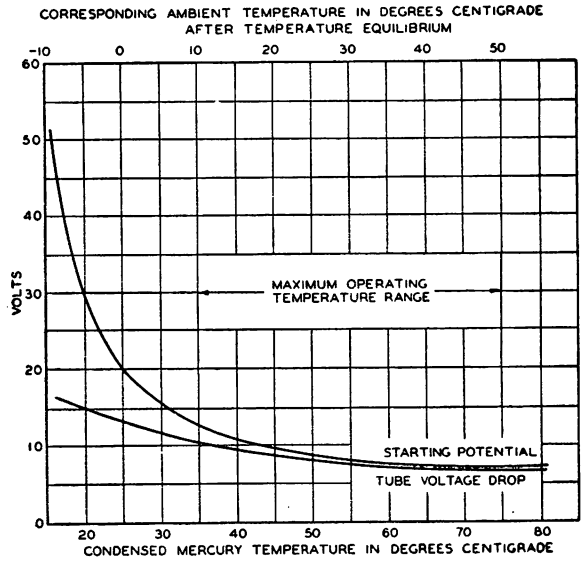
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	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

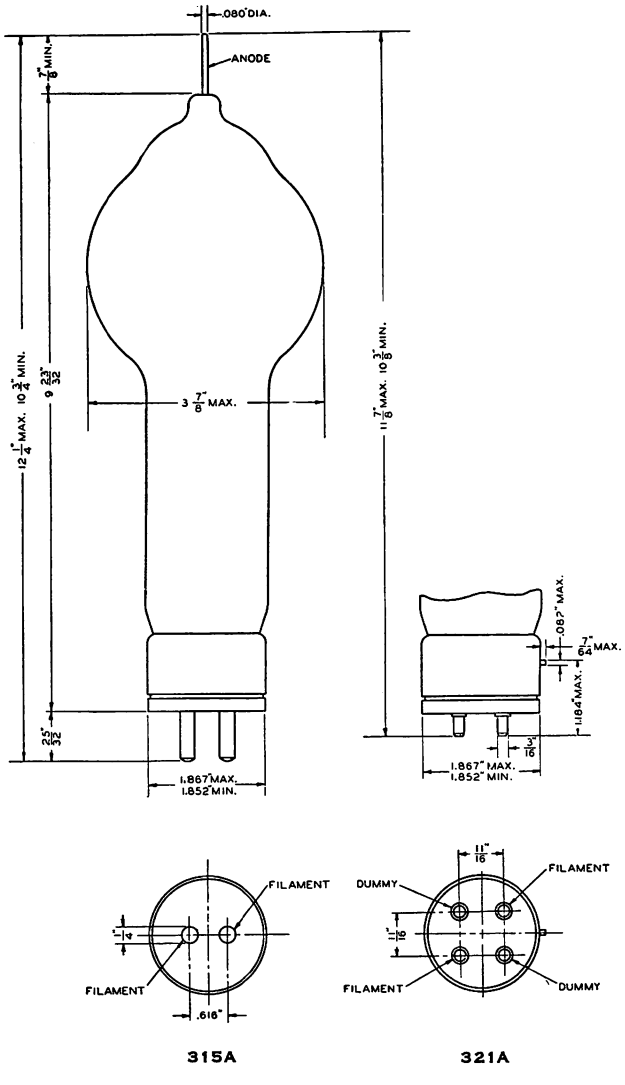
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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.

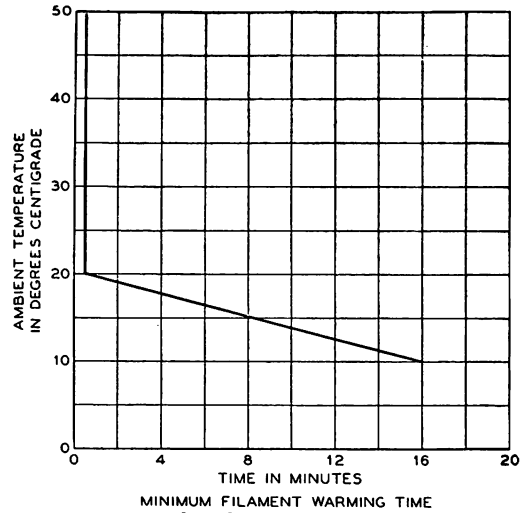
Circuit Outputs:

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

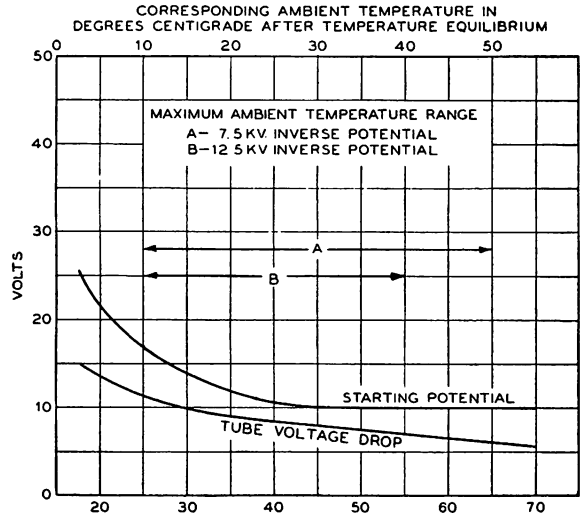
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

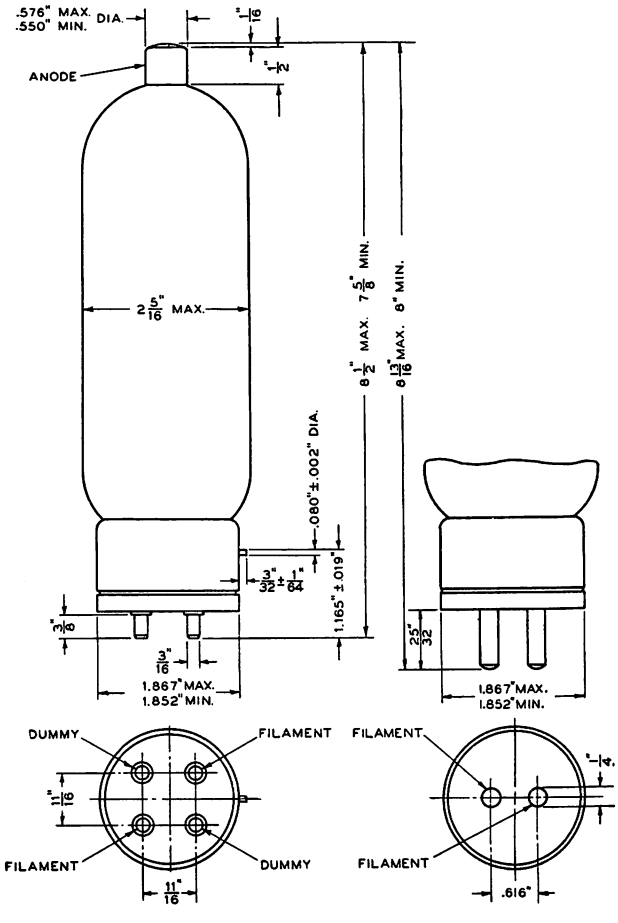
Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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

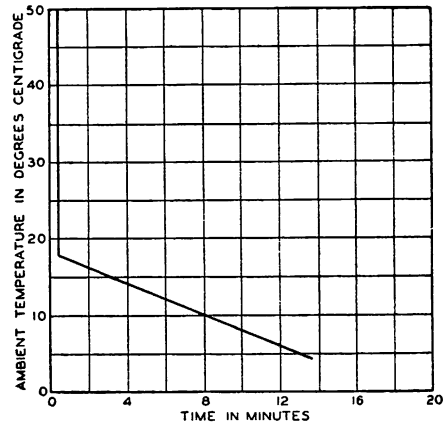
Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

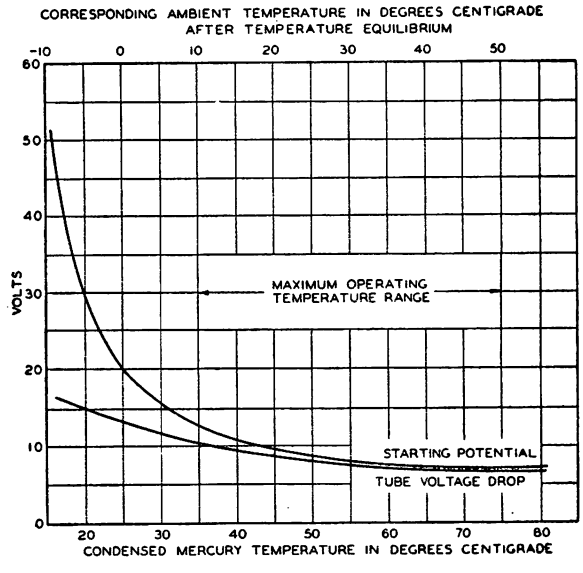
Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Output Voltage: At 12.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	3800	1	2
B	2	2300	3800	2	4
C	4	2300	3800	4	8
D	4	4600	7600	2	4
E	3	3500	5800	3	6
F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

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:

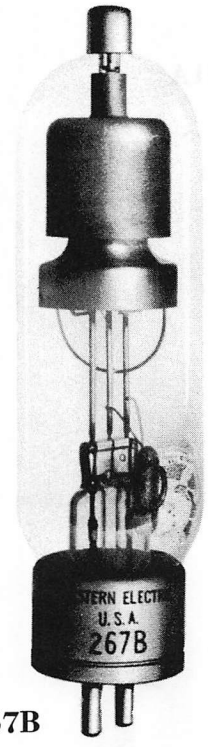
Circuit Designation	Number of Tubes	Output Voltage: At 7.5 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	2300	1	2
B	2	2300	2	4
C	4	2300	4	8
D	4	4600	2	4
E	3	3500	3	6
F	6	7000	3	—
G	6	3000	5	10
H	6	7000	—	6
I	6	7000	—	6

Western Electric

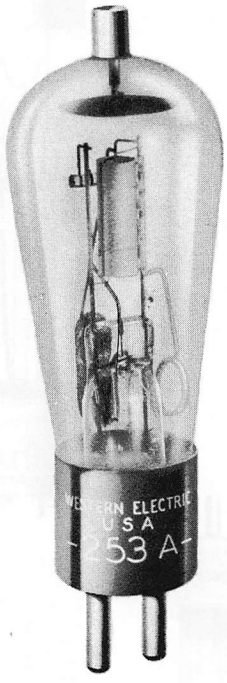
Vacuum Tubes

Half-Wave Mercury Vapor Rectifiers

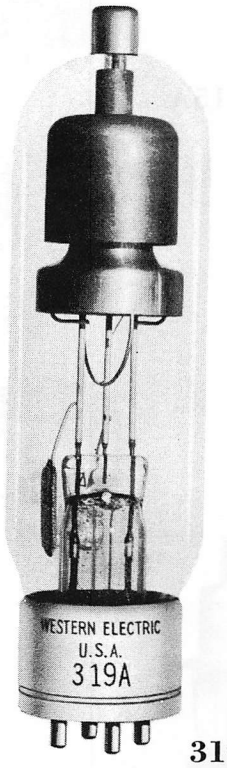
249B **255B** **266B** **267B** **319A**
253A **258B** **266C** **315A** **321A**



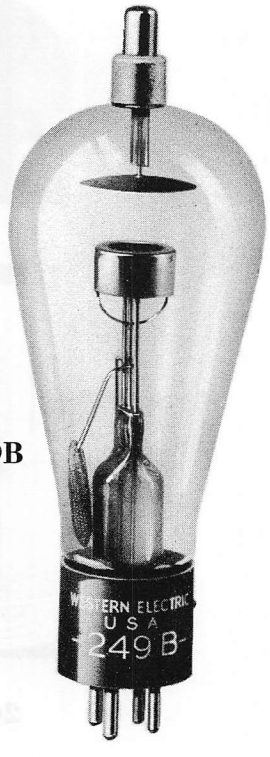
267B



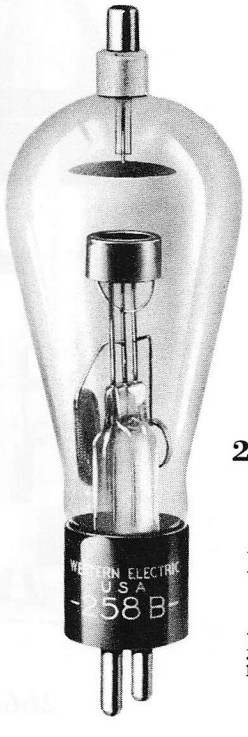
253A



319A



249B

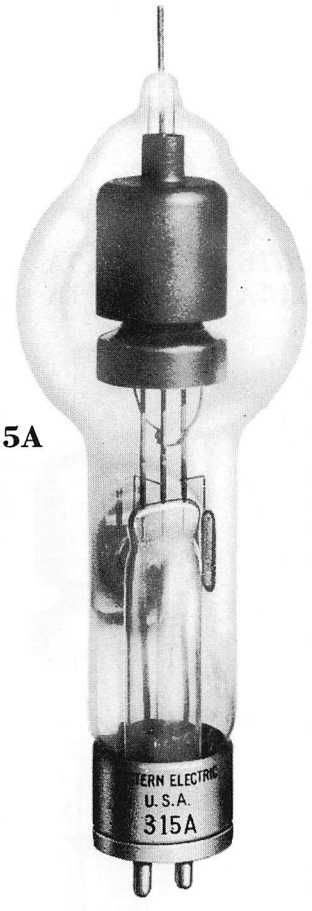


258B

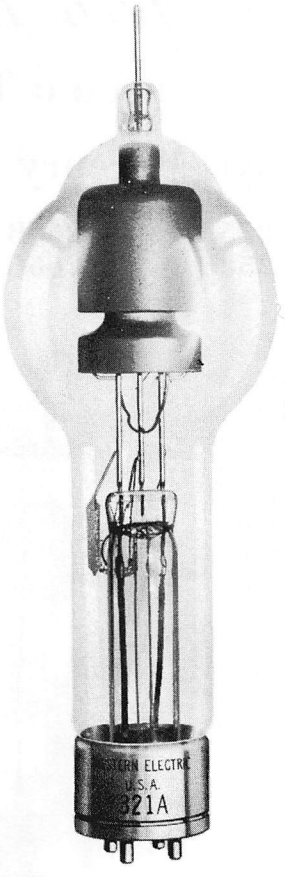
NOTE:

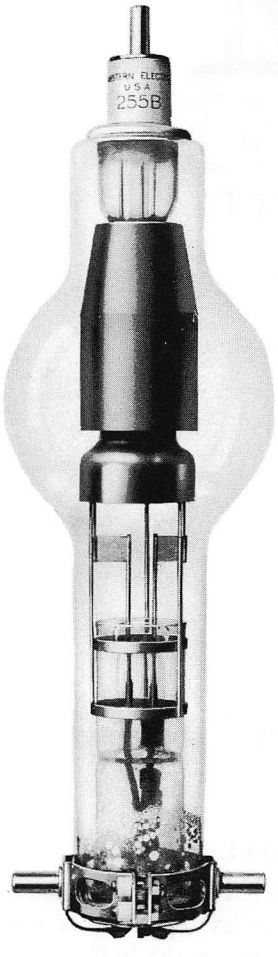
This combined bulletin supersedes data sheets previously issued for the individual tubes.

315A

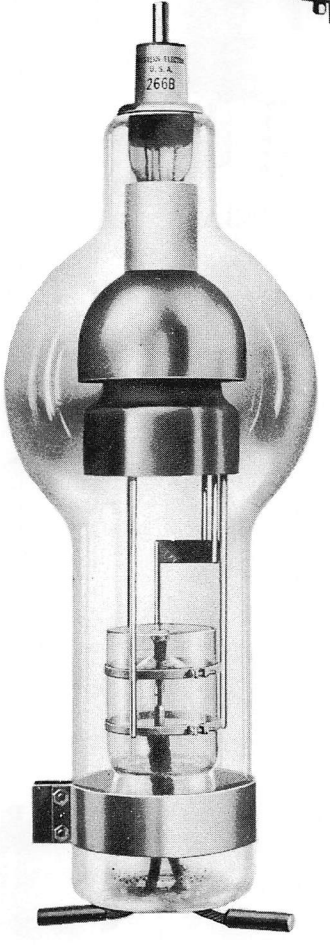


321A

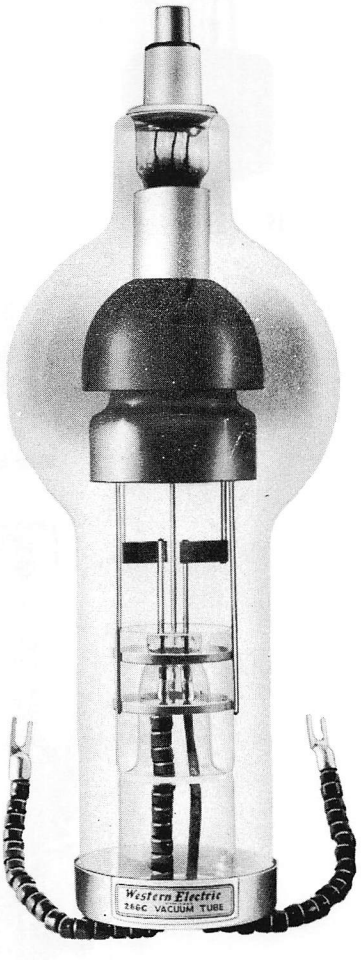




255B



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

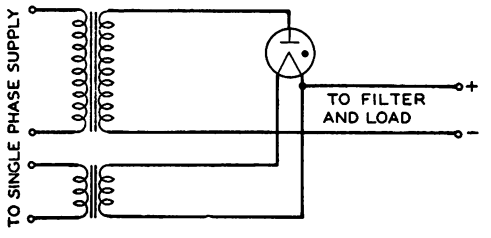
The maximum permissible peak inverse anode voltage is a limitation on the instantaneous value that the tubes can stand safely in the opposite direction to that in which they are designed to conduct. If this voltage is exceeded an arc-back may result which may injure the tubes. The maximum direct output 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.

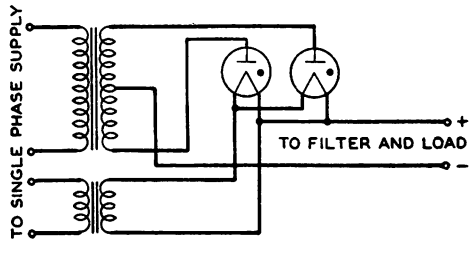
In most cases the termination of useful life of these tubes is due to the loss of filament activity which frequently results in arc-back. Failures of this kind should be safeguarded by proper overload protection to prevent injury to other tubes in the set and to auxiliary equipment. In most circuits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

Circuits

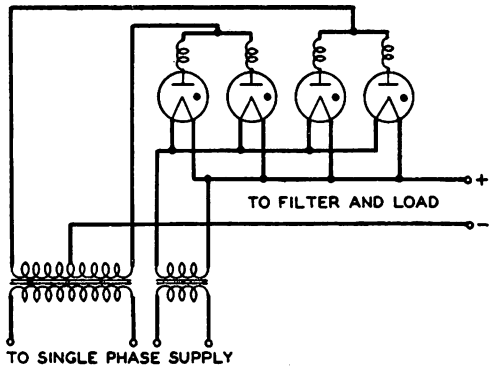
These tubes may be used in any conventional rectifier circuit subject to the current, voltage and temperature ratings. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible anode current and 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.



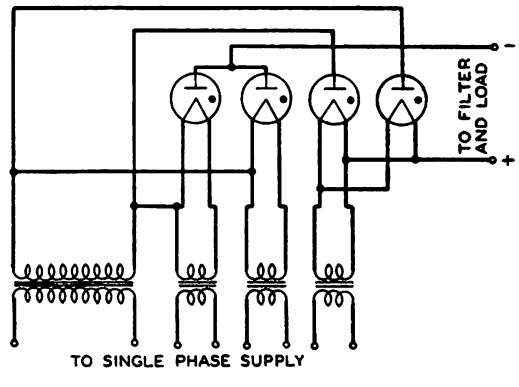
SINGLE PHASE, HALF-WAVE
CIRCUIT A



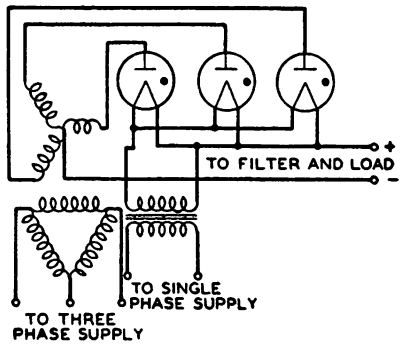
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



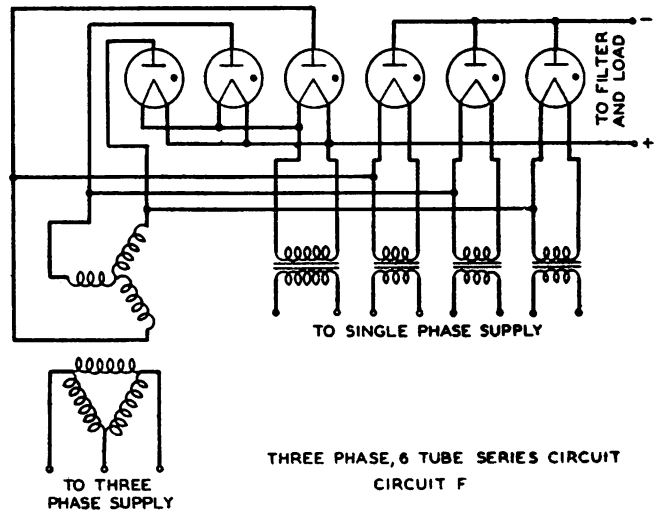
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



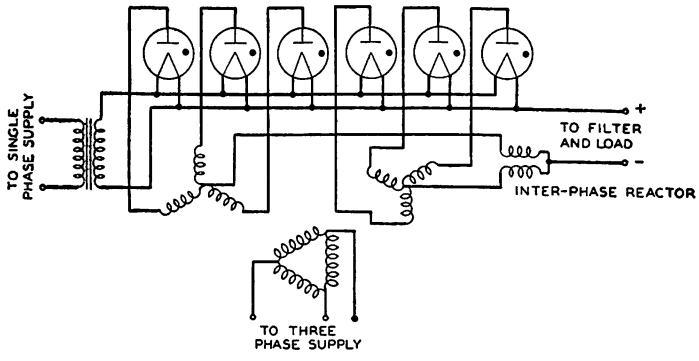
SINGLE PHASE, DOUBLE HALF-WAVE
4 TUBE SERIES CIRCUIT
CIRCUIT D



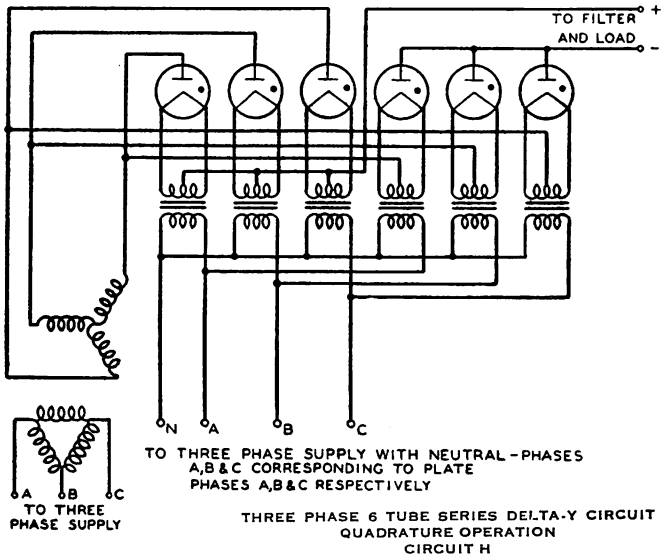
THREE PHASE 'Y' CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES CIRCUIT
CIRCUIT F

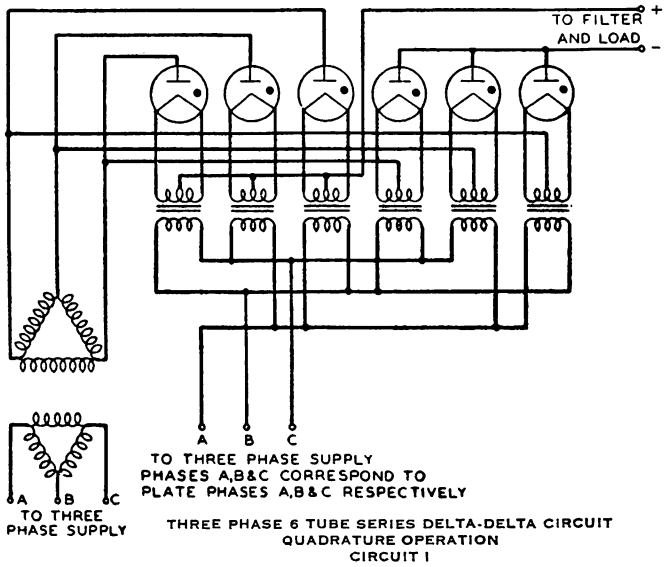


THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G



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

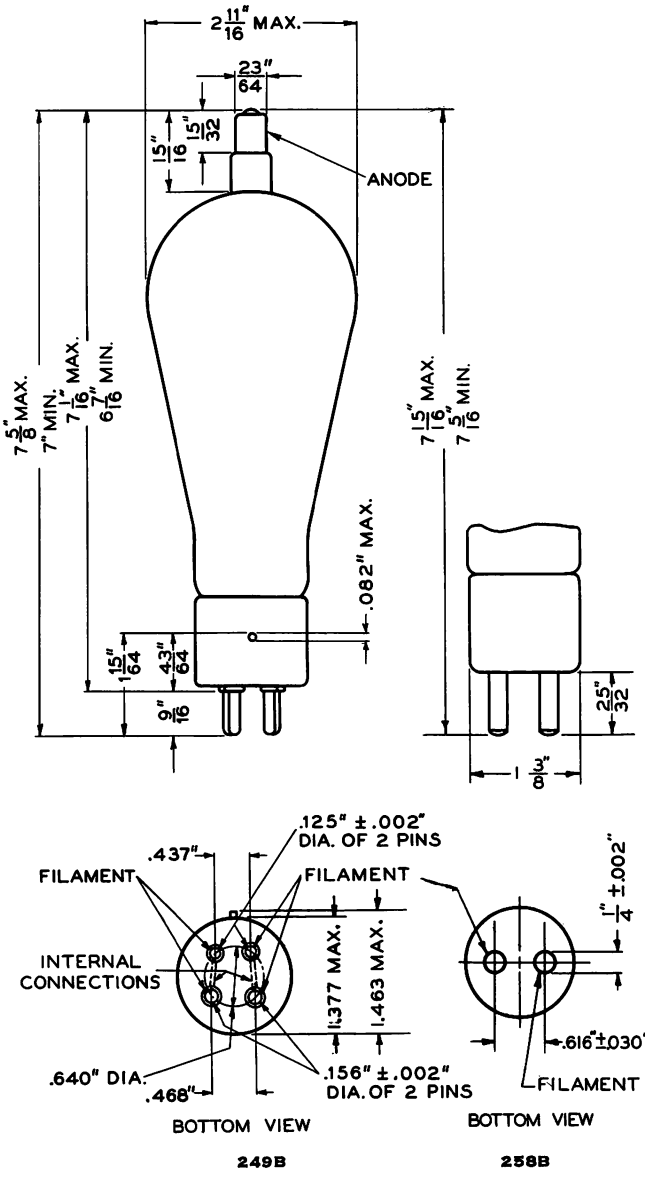
THREE PHASE 6 TUBE SERIES DELTA-Y CIRCUIT
QUADRATURE OPERATION
CIRCUIT H

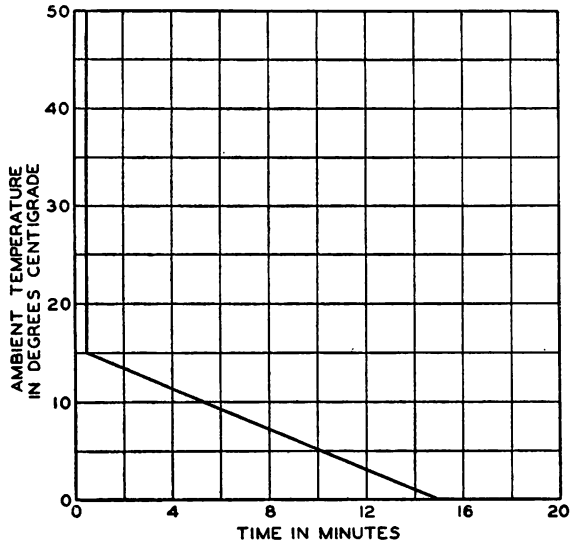


TO THREE PHASE SUPPLY
PHASES A,B&C CORRESPOND TO
PLATE PHASES A,B&C RESPECTIVELY

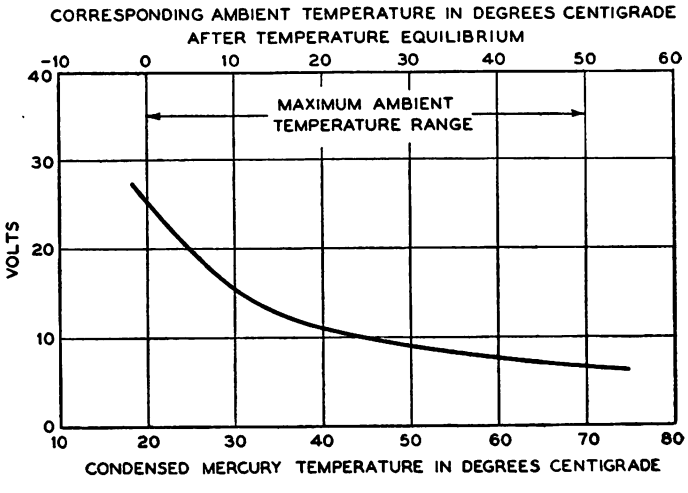
THREE PHASE 6 TUBE SERIES DELTA-DELTA CIRCUIT
QUADRATURE OPERATION
CIRCUIT I

249B and 258B Vacuum Tubes





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

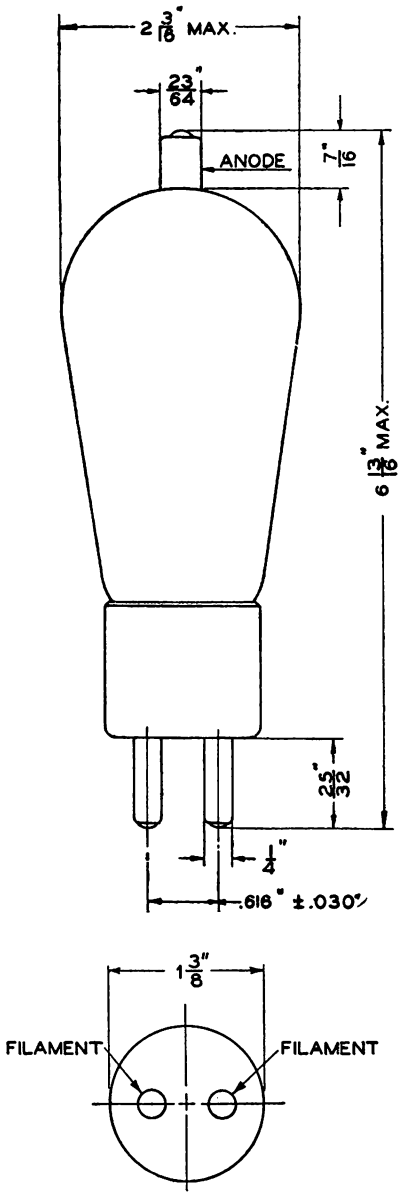
Filament	
Voltage	2.5 volts
Nominal Current	7.5 amperes
Required Heating Time	15 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	2.5 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.

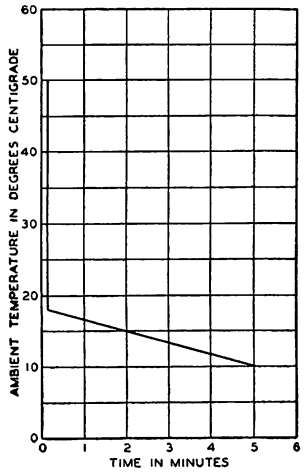
Mounting—The 249B tube requires a W. E. 143B or similar socket and the 258B a W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

Circuit Outputs:

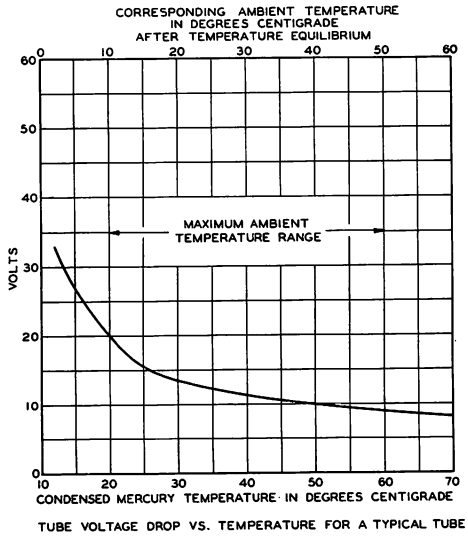
Circuit Designation	Number of Tubes	Output Voltage At 7.5 kv. Inverse Voltage	Load Current In DC Amperes
A	1	2300	0.64
B	2	2300	1.28
C	4	2300	2.56
D	4	4600	1.28
E	3	3500	1.92
F	6	7000	1.92
G	6	3000	3.2

253A Vacuum Tube





MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



TUBE VOLTAGE DROP VS. TEMPERATURE FOR A TYPICAL TUBE

Ratings

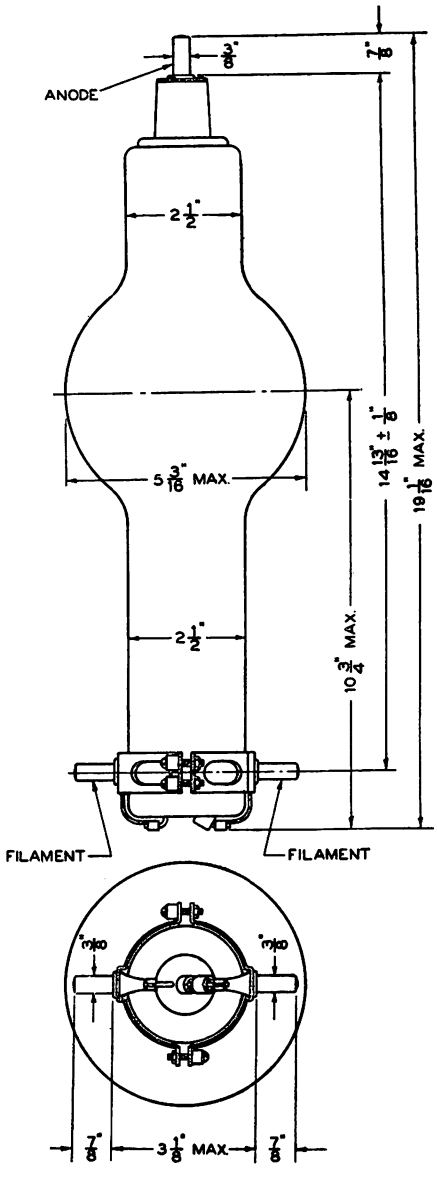
Filament	
Voltage	2.5 volts
Nominal Current	3.0 amperes
Required Heating Time	10 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	6±2 seconds
Tube Voltage Drop—Approximate	15 volts
Maximum Instantaneous Anode Current	1.0 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.

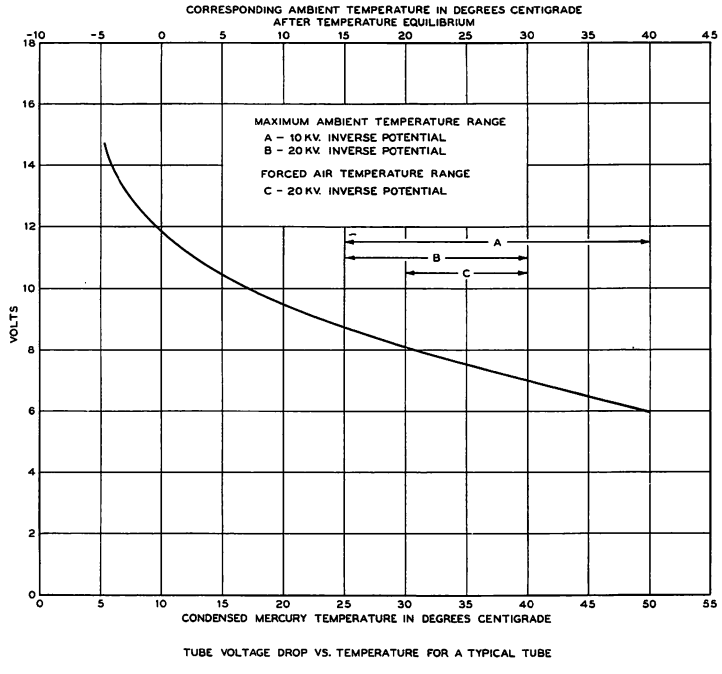
Mounting—W. E. 138B, 139A or similar socket. A spring clip anode terminal connector is required. Mount in vertical position only—base end down. A clearance of at least 1½ inches should be allowed between the bulb and any adjacent object.

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.

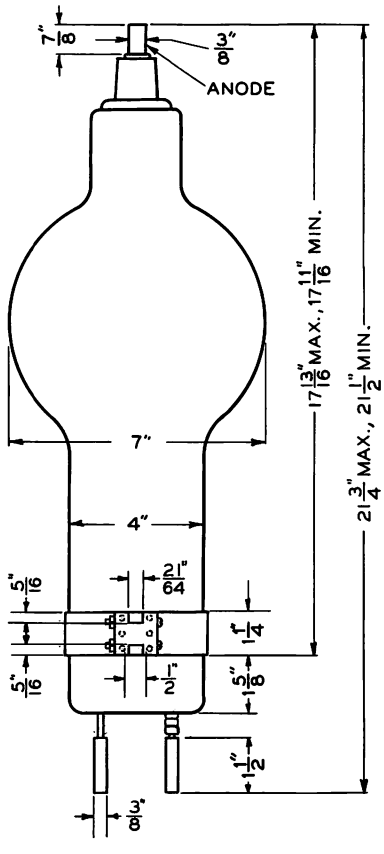
Ratings

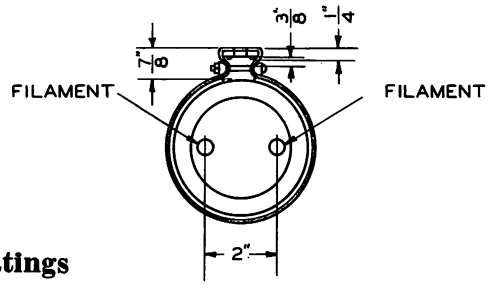
Filament	
Voltage	5.0 volts
Nominal Current	19.0 amperes
Required Heating Time	120 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	25±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
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

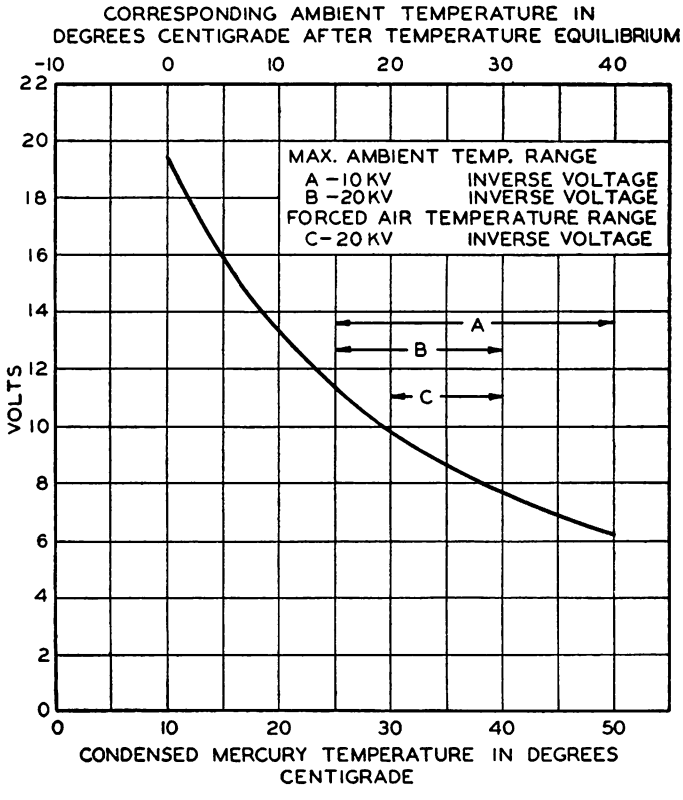
Circuit Outputs:

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

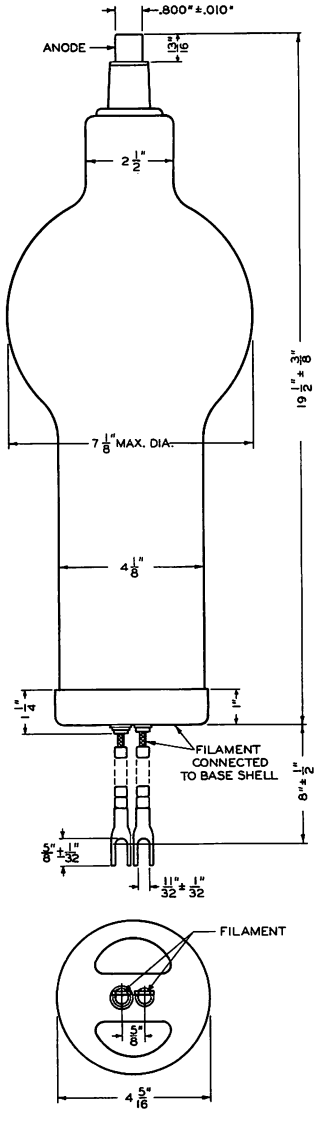
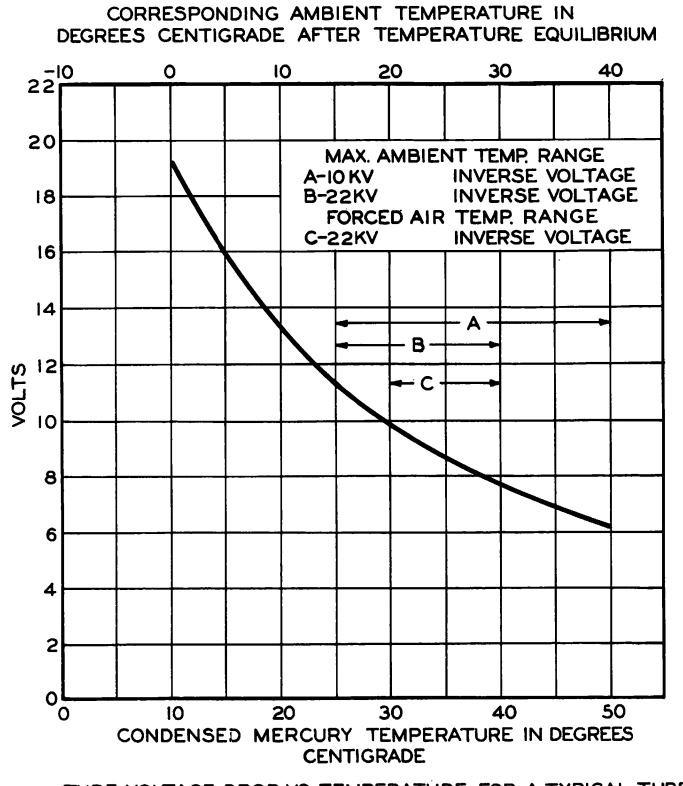


FIG. 1



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

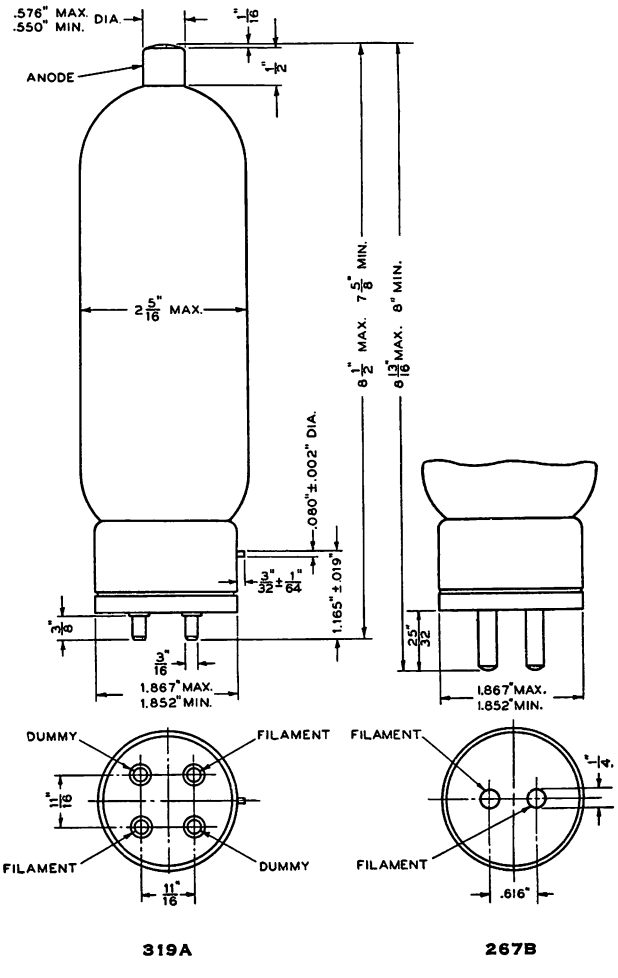
This is the temperature of the forced air applied to the bulb where the free mercury condenses. Approximately 5 cu. ft. per minute from a 1 inch nozzle and directed ½" above the filament base is recommended.

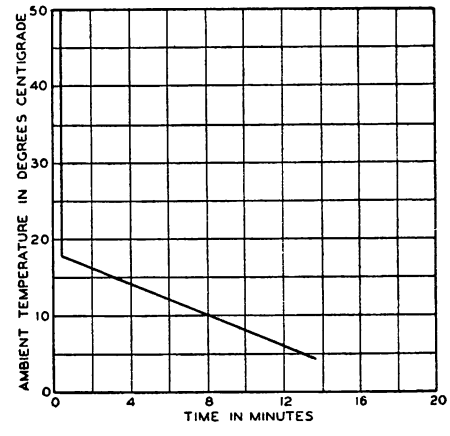
Mounting—Special mounting is required. Mount in vertical position only, filament end down. A clearance of at least 4 inches should be allowed between the bulb and any adjacent object. Connection to the anode terminal should be flexible.

Circuit Outputs:

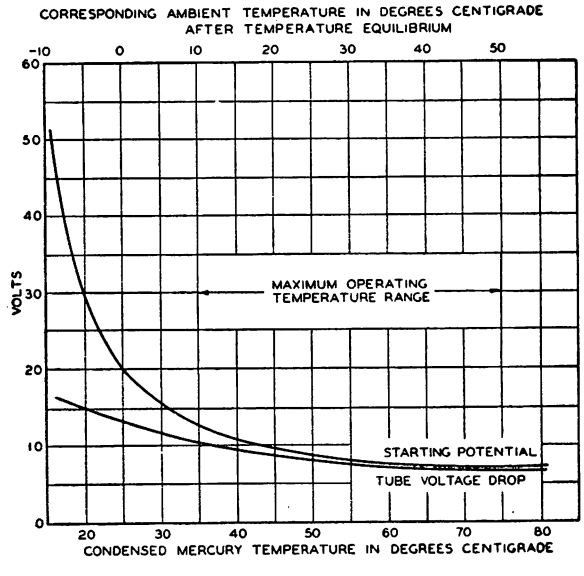
Circuit Designation	Number of Tubes	Output Voltage: At 10 kv. Inverse Voltage	Output Voltage: At 22 kv. Inverse Voltage	Load Current—DC Amps.: In-Phase Operation	Load Current—DC Amps.: Quadrature Operation
A	1	3000	6500	5	10
B	2	3000	6500	10	20
C	4	3000	6500	20	40
D	4	6000	13000	10	20
E	3	4500	10000	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

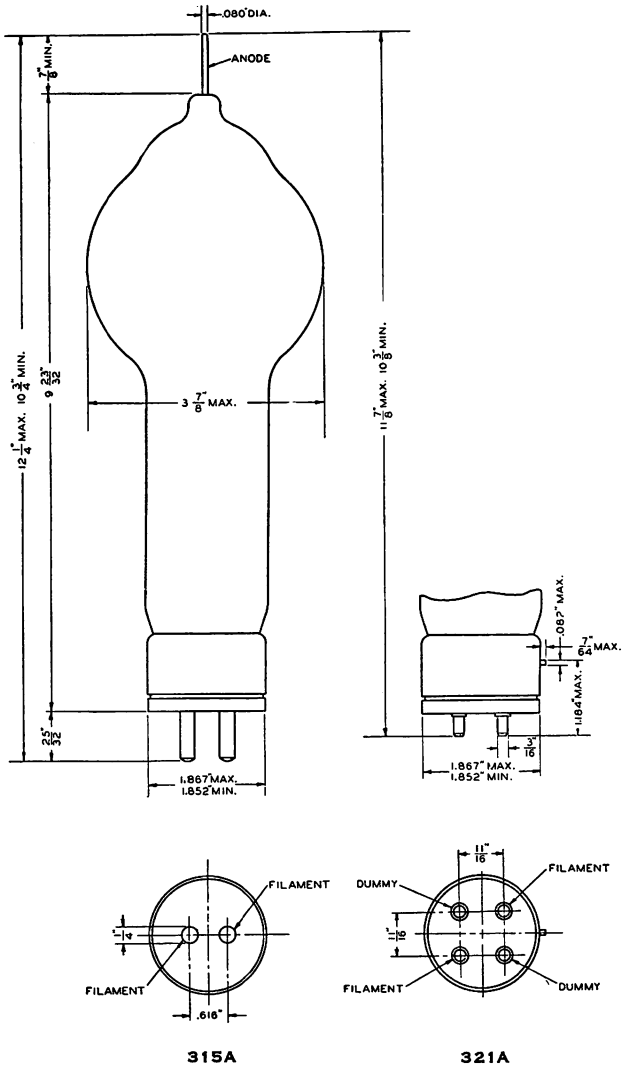
Filament	
Voltage	5.0 volts
Nominal Current	6.75 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	8±2 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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.

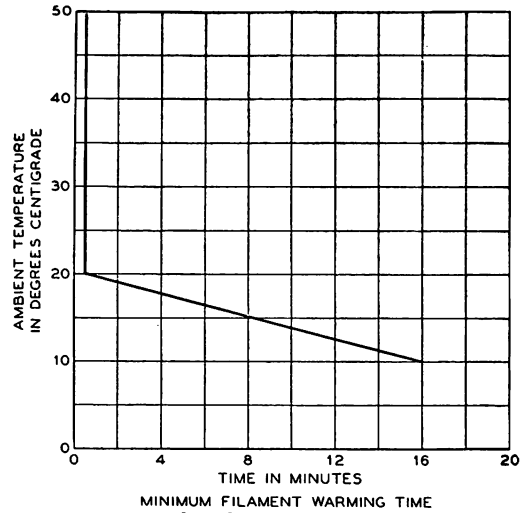
Circuit Outputs:

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

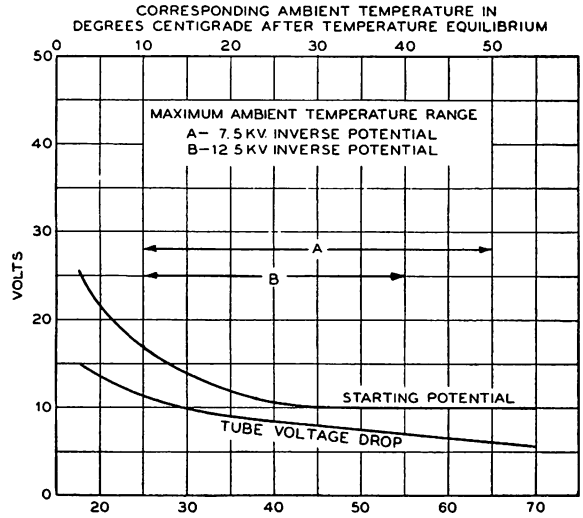
315A and 321A Vacuum Tubes



315A 321A



MINIMUM FILAMENT WARMING TIME VS. AMBIENT TEMPERATURE



OPERATING CHARACTERISTICS FOR A TYPICAL TUBE

Ratings

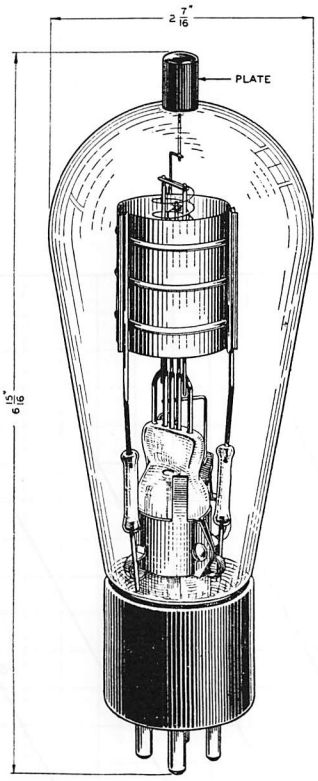
Filament	
Voltage	5.0 volts
Nominal Current	10.0 amperes
Required Heating Time	30 seconds
Accelerated Filament Heating	
Recommended open circuit over-voltage	50%
Corresponding period of over-voltage application	15±5 seconds
Tube Voltage Drop—Approximate	10 volts
Maximum Instantaneous Anode Current	
In-Phase 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

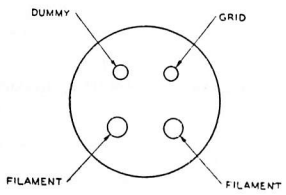
Mounting—The 315A tube requires a 138B, 139A or similar socket and the 321A a W. E. 148A or similar socket. A special anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 3 inches should be allowed between the bulb and any adjacent object.

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

268A Vacuum Tube





Classification

The 268A Vacuum Tube is a three element tube, intended for use as an oscillator, radio-frequency amplifier, or modulator at high frequency.

Base and Socket

The 268A Vacuum Tube employs a standard four prong base, suitable for use in a Western Electric 130B (rigid), 131A (cushion), or similar type socket. The arrangement of electrode connections to the base terminals is shown above. 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	5.0 Volts
Nominal Filament Current	3.25 Amperes
Maximum Plate Voltage	750 Volts
Maximum Plate Current	.060 Ampere
Maximum Plate Dissipation	25 Watts
Average Amplification Factor	5
Average Plate Resistance	5000 Ohms
Average Mutual Conductance	1000 Micromhos

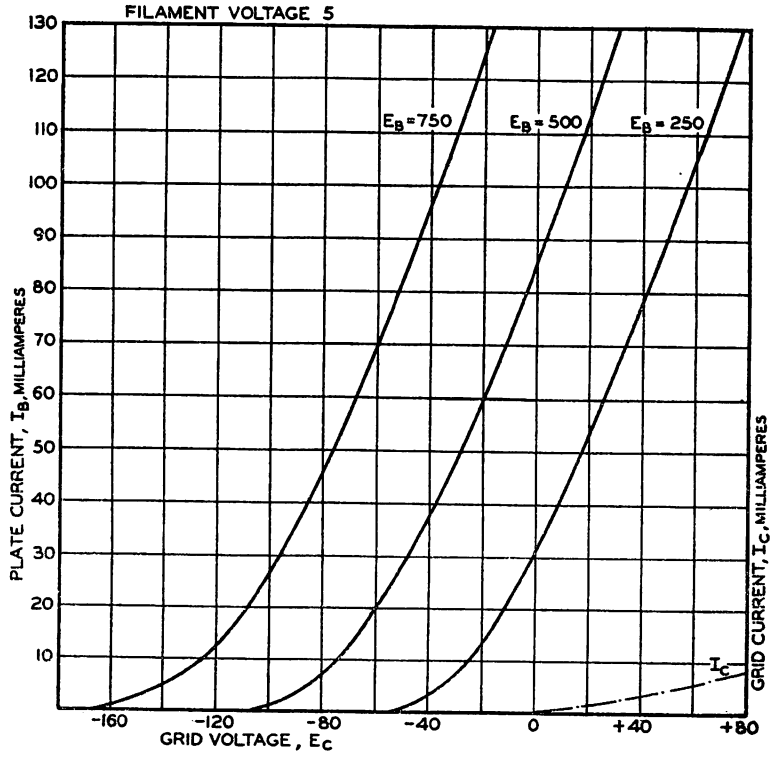
Approximate Direct Interelectrode Capacities (measured without socket)

Plate to Grid	2.3 MMF.
Plate to Filament	1.1 MMF.
Grid to Filament	5.4 MMF.

Audio-Frequency Amplifier or Modulator Rating—Peak Grid Drive Equal to or less than the Bias—Class A Service	
Maximum Plate Dissipation	20 Watts
Plate Voltage	750 Volts
Plate Current	.030 Ampere
Grid Bias Voltage	—95 Volts
Load Resistance	18,000 Ohms
Undistorted Output	4 Watts
Radio-Frequency Amplifier—Grid Bias Practically at Plate Current Cut-Off, Grid Drive Greater than the Bias—Class B Service	
Maximum Plate Voltage	750 Volts
Maximum Plate Current	.060 Ampere
Maximum Plate Dissipation	25 Watts
Grid Bias Voltage	—160 Volts
Peak Output	30 Watts
Oscillator or Radio-Frequency Amplifier—Grid Bias Below Cut-Off—Class C Service	
Maximum Modulated Plate Voltage (D.C.)	500 Volts
Maximum Non-Modulated Plate Voltage (D.C.)	750 Volts
Maximum Plate Current	.060 Ampere
Maximum Plate Dissipation	25 Watts
Maximum Radio-Frequency Charging Current in Grid and Plate Leads	3 Amperes
Approximate Grid Bias	—200 Volts
Maximum Output	30 Watts

Average Static Characteristics

The accompanying curves give the average static characteristics of the 268A Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid returns connected to the center point on the filament transformer.



General Features

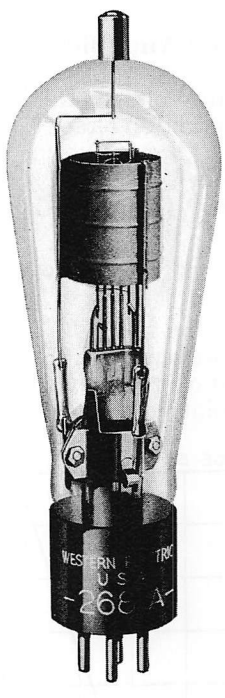
The 268A Vacuum Tube has been designed with very low interelectrode capacities which make it entirely suitable for operation over a very wide frequency range. The design of the internal structure gives rise to negligible primary emission and relatively low secondary emission thereby assuring satisfactory grid characteristics.

The thoriated tungsten filament of this tube is made in a spiral of such form as to maintain the tube internal impedance low and constant during its life. The mechanical structure has adequate strength for severe usages.

ISSUE 1
MAY 1, 1933

Western Electric

268A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

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

Maximum overall length	$6\frac{15}{16}''$
Maximum diameter	$2\frac{7}{16}''$

Mounting—Four-pin bayonet base for use in a W.E. 143B or similar socket. The anode terminal is located at the top of the bulb.

Filament—Thoriated tungsten

Filament voltage	5.0 volts, a.c. or d.c.
Nominal filament current	3.25 amperes
Average thermionic emission	0.60 ampere

Average Direct Interelectrode Capacitances

Plate to grid	2.3 μμf
Grid to filament	5.4 μμf
Plate to filament	1.1 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 and 4 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at maximum direct plate voltage and dissipation Class A (E_b = 750 volts, I_b = 25 milliamperes)

Amplification factor	5
Plate resistance	6250 ohms
Grid to plate transconductance	800 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	750 volts
Max. direct plate current	60 milliamperes
Max. plate dissipation	25 watts
Max. direct grid current	10 milliamperes
Max. r-f grid current	3 amperes
Max. frequency for the above ratings	30 megacycles
Max. plate voltage for upper frequency limit of 60 Mc	400 volts
Max. plate voltage for frequencies between 30 and 60 Mc in proportion	

Class A Audio Amplifier or Modulator

Direct plate voltage	750	500 volts
Grid bias	−100	−37 volts
Direct plate current	25	40 milliamperes
Load impedance	18000	5000 ohms
Undistorted output	4.0	1.0 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	750	500 volts
Grid bias	−120	−70 volts
Direct plate current per tube		
No drive	12	12 milliamperes
Max. drive	60	60 milliamperes
Plate dissipation	20	15 watts
Load resistance plate-to-plate	11200	7400 ohms
Load resistance per tube	2800	1850 ohms
Approximate maximum output—2 tubes	50	33 watts
Recommended power for driving stage	5	5 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	750	500 volts
Direct plate current for carrier conditions	50	60 milliamperes
Grid bias	−165	−105 volts
Approximate carrier watts for use with 100% modulation	12.5	10 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	750		500 volts
Direct plate current	60		60 milliamperes
Grid bias	−255 to −340		−165 to −220 volts
Nominal power output	30		20 watts
Plate dissipation	15		10 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	500		350 volts
Direct plate current	60		60 milliamperes
Grid bias	−220		−160 volts
Max. direct grid current	10		10 milliamperes
Nominal carrier power output for use with 100% modulation	20		14 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 75 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 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 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—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. The tube may be used at full rating up to 30 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.

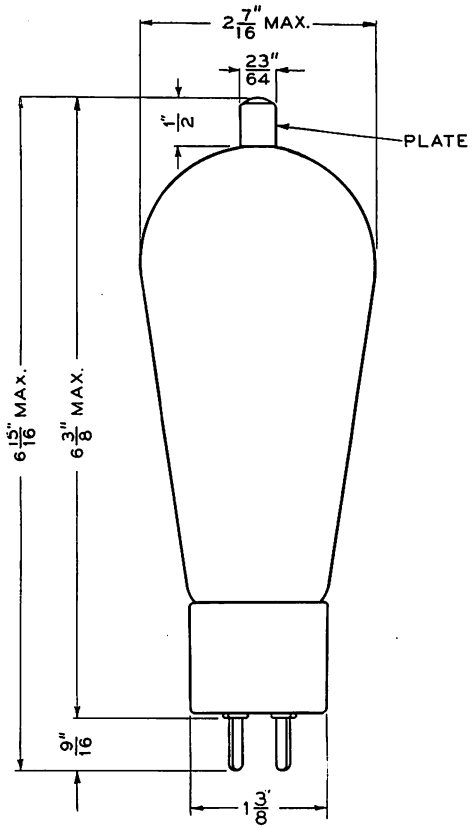

2 7/16" MAX.
23/64"
1/2"
PLATE
6 15/16" MAX.
6 3/8" MAX.
9/16"
1 3/8"

FIG. 1

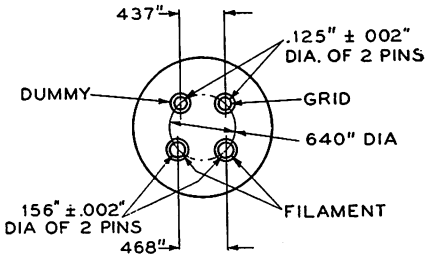

437"
.125" ± 002"
DIA. OF 2 PINS
DUMMY
GRID
640" DIA
156" ± .002"
DIA OF 2 PINS
FILAMENT
468"

FIG. 2

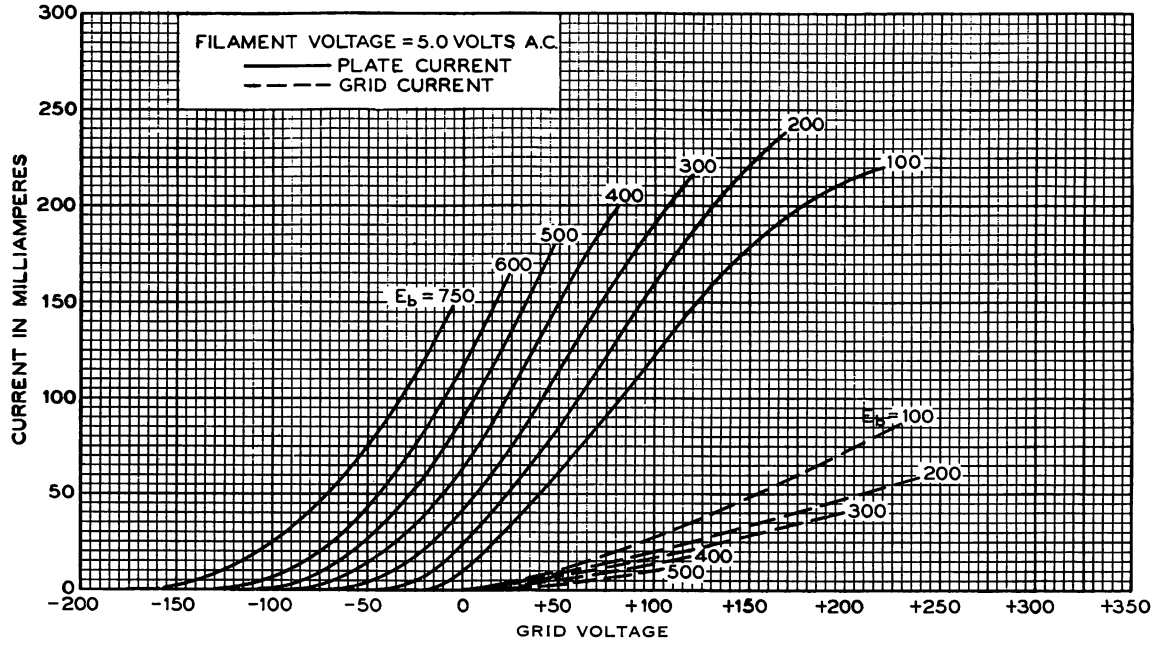

FILAMENT VOLTAGE = 5.0 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
300
250
200
150
100
50
0
-200
-150
-100
-50
0
+50
+100
+150
+200
+250
+300
+350
200
100
300
400
500
600
Eb = 750
Eb = 100
200
300
400
500

FIG. 3

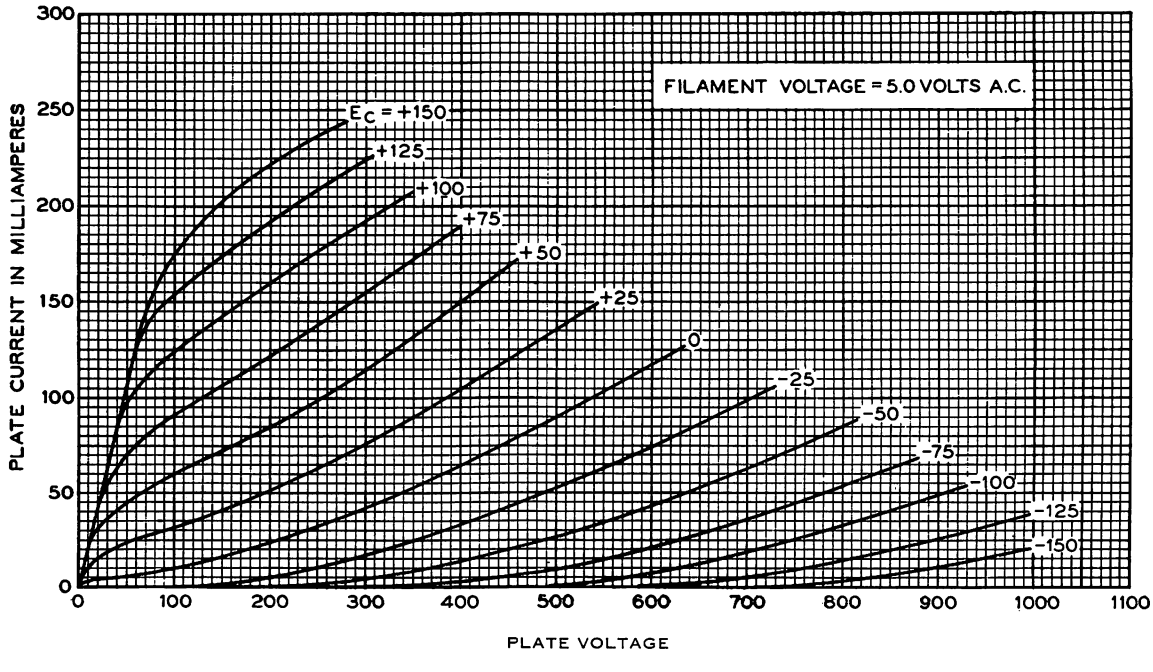
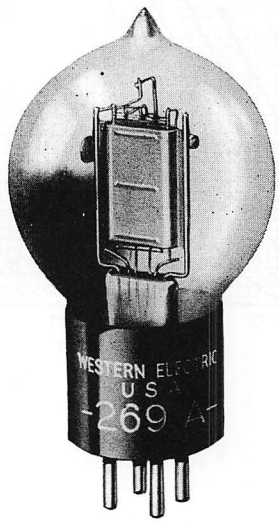

FILAMENT VOLTAGE = 5.0 VOLTS A.C.
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
300
250
200
150
100
50
0
0
100
200
300
400
500
600
700
800
900
1000
1100
EC = +150
+125
+100
+75
+50
+25
0
-25
-50
-75
-100
-125
-150

FIG. 4

Western Electric

269A Vacuum Tube



Classification—Three element, argon filled, grid-controlled rectifier with a filamentary cathode

It is primarily a rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous control-electrode 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, or as a source of sweep-voltage for a linear time axis.

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

Maximum length	4 9/16″
Diameter	2 3/8″

Mounting—The 269A vacuum tube employs a standard four-pin thrust type base suitable for use in a Western Electric 143B 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. If mounted in a horizontal position the plane of the filament, as shown in Figure 2 should be vertical.

Filament Rating

Filament voltage	2.2 volts
Nominal filament current	0.55 ampere

The filament of this tube is designed to operate on a voltage basis. The voltage should be maintained to within 5% of its rated value (2.2 volts). Operation of the filament 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 space current is drawn. If filament transformers with good regulation are used this time is 2 seconds. Failure to allow sufficient time may result in immediate failure. If the anode voltage is less than 50 volts space current may be drawn simultaneously with the application of filament voltage; but approximately 2 seconds will be required for the space current to reach its final value.

Operating Conditions

Anode-cathode potential drop	16—24 volts
Maximum instantaneous space current (sine wave)	20 milliamperes
Maximum instantaneous space current (condenser discharge)	200 milliamperes
Maximum instantaneous potential between anode and control-electrode	275 volts

The characteristics of the 269A tube are such that, for any given anode potential, there is a critical control-electrode potential. If the control-electrode is held more negative than this value and the tube is non-conducting, the space current will remain zero. If it is made less negative, the space current assumes a value determined by the applied anode potential and the resistance in the anode circuit. To extinguish the discharge and return the space current to zero, the positive anode potential must be removed. When space current is flowing, a visible discharge occurs in the tube. Under this condition, the anode-cathode potential is practically independent of the value of both the space current and the control-electrode potential. A protective resistance should always be included in the anode circuit to limit the maximum instantaneous space current to the rated values. A typical curve relating the critical control-electrode potential to the anode potential is shown in Figure 3. This characteristic 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 space 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 gas-filled tubes. 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 control-electrode 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 on it. In circuits Figures 6 and 7 alternating current may be used for the filament supply.

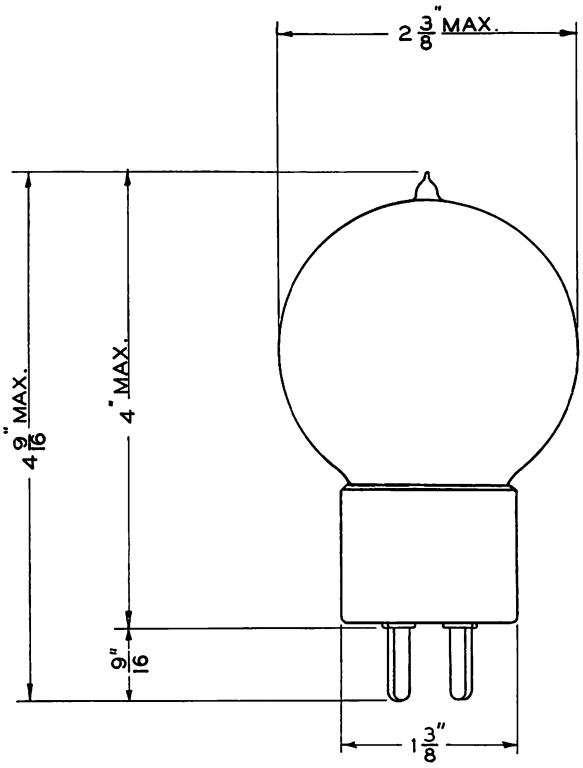


FIG. 1

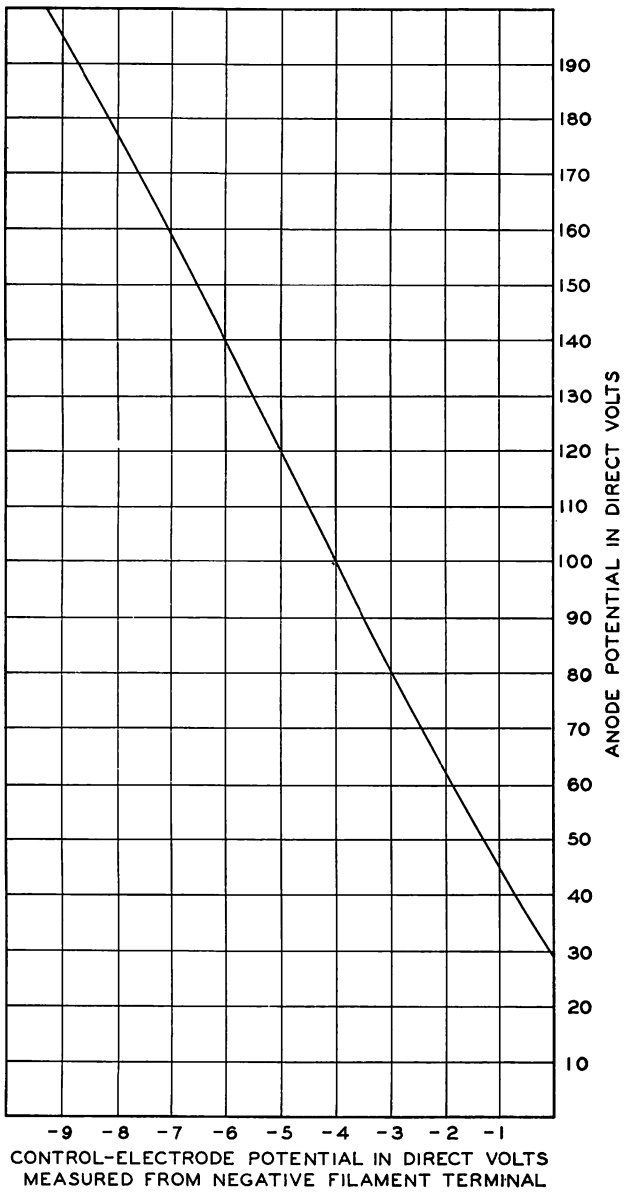


FIG. 3

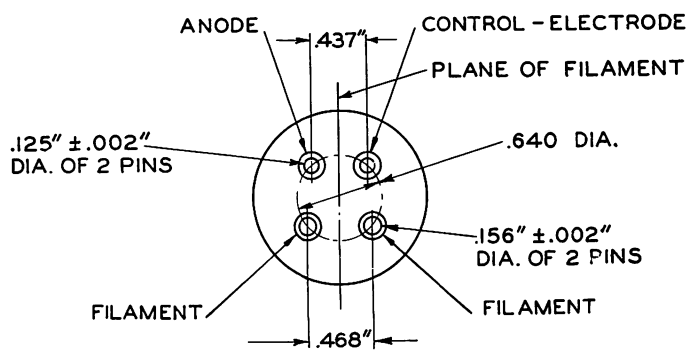


FIG. 2

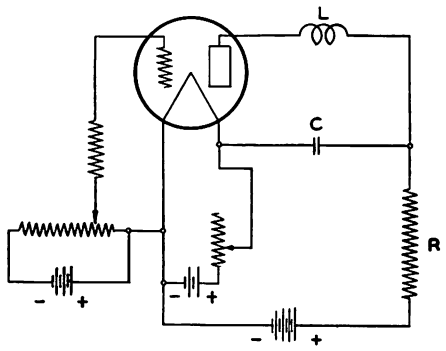


FIG. 4

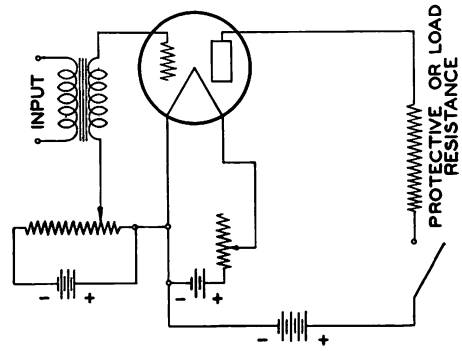


FIG. 5

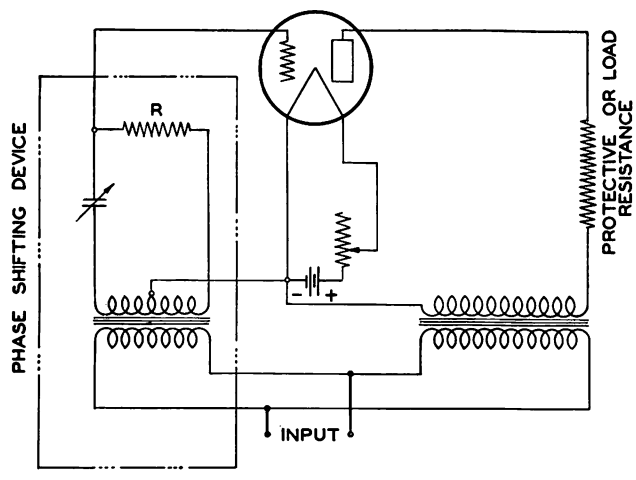


FIG. 6

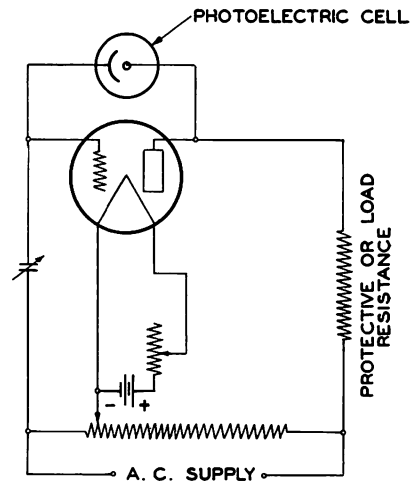
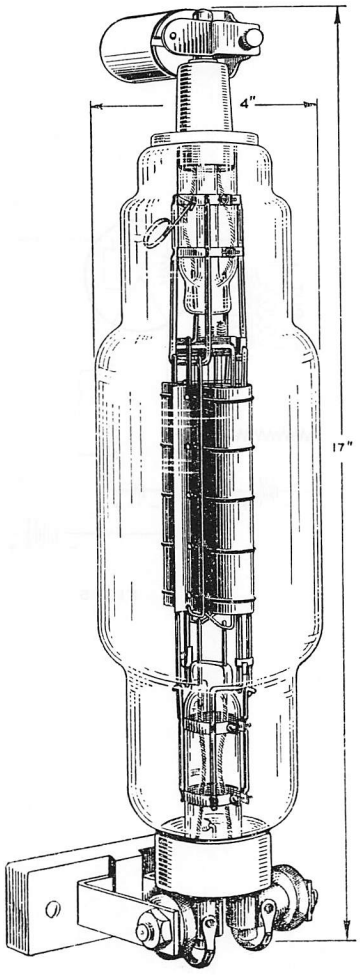
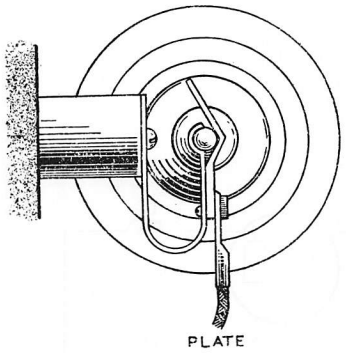
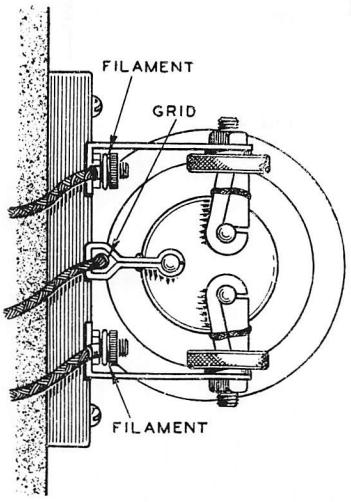


FIG. 7

270A Vacuum Tube







Classification

The 270A Vacuum Tube is a three element, air-cooled, general purpose tube. It may be used as a radio-frequency oscillator or amplifier, as a modulator, or as an audio-frequency power amplifier.

Installation

The arrangement of electrode connections to the base terminals together with the type of mounting recommended is shown above.

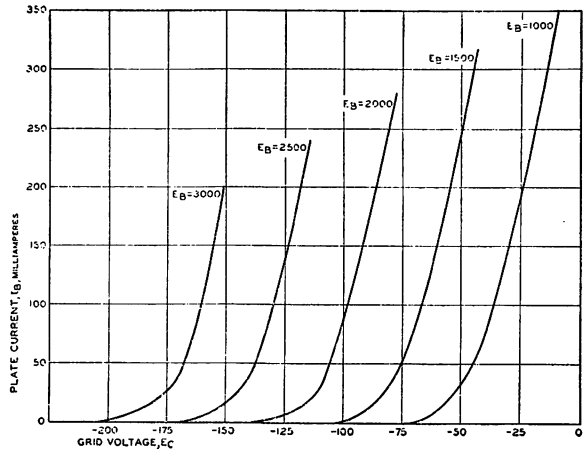
General Ratings and Information

Filament Voltage	10 Volts A.C.
Nominal Filament Current	9.75 Amperes
Maximum Plate Voltage	3000 Volts
Maximum Plate Current	.375 Ampere
Average Amplification Factor	16
Average Plate Resistance	1750 Ohms
Average Mutual Conductance	9000 Micromhos
Approximate Direct Interelectrode Capacities	
Plate to Grid	21.0 MMF.
Plate to Filament	2.0 MMF.
Grid to Filament	18.0 MMF.

Audio-Frequency Amplifier or Modulator Rating—Peak Grid Drive Equal to or less than the Bias—Class A Service	
Maximum Plate Dissipation	300 Watts
Plate Voltage	2500 Volts
Plate Current	.120 Ampere
Grid Bias Voltage	—130 Volts
Load Impedance	19,000 Ohms
Undistorted Output	90 Watts
Radio-Frequency Amplifier—Grid Bias Practically at Plate Current Cut-Off, Grid Drive Greater than the Bias—Class B Service	
Maximum Plate Voltage (D.C.)	3000 Volts
Maximum Plate Dissipation	350 Watts
Maximum Plate Current (D.C.)	.30 Ampere
Grid Bias Voltage	—200 Volts
Peak Output	500 Watts
Oscillator or Radio-Frequency Amplifier—Grid Bias Below Cut-Off—Class C Service	
Maximum Modulated Plate Voltage (D.C.)	2250 Volts
Maximum Non-Modulated Plate Voltage (D.C.)	3000 Volts
Maximum Plate Dissipation	350 Watts
Maximum Plate Current (D.C.)	.375 Ampere
Maximum Radio-Frequency Charging Current in Grid and Plate Leads	10 Amperes
Approximate Grid Bias Voltage	—300 Volts
Maximum Output	500 Watts

Average Static Characteristics

The accompanying curves give the static characteristics of an average 270A Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid circuit returns connected to a center point of the filament transformer.



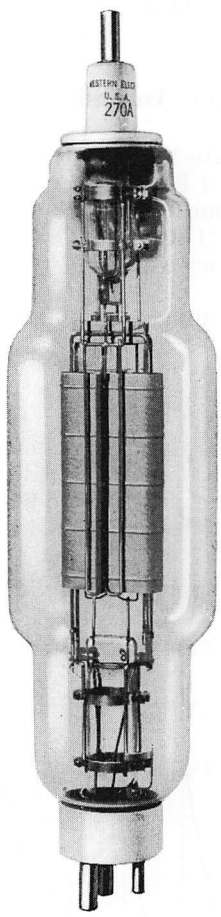
General Features

The 270A Vacuum Tube is so designed that approximately one-half of its maximum power rating can be obtained without driving the grid positive with respect to the cathode and therefore requires very little grid driving power when used in systems employing grid modulation. For other systems, increased power output can be obtained with very satisfactory grid characteristics.

The total electron emission from an adequate thoriated tungsten filament makes possible full power output over a long life. The arrangement of terminals and of the internal structure insures the maintenance of the high insulation required by the rated plate voltage.

Western Electric

270A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

Dimensions—Dimensions and outline diagrams are shown in Figure 1. The overall dimensions are

Maximum overall length	17″
Maximum diameter	4″

Mounting—The method of supporting the tube shown in Figure 1 is recommended and sufficient dimensions are given for designing a suitable mounting. The tube should preferably be mounted in an upright or vertical position.

Filament—Thoriated tungsten

Filament voltage	10 volts, a.c. or d.c.
Nominal filament current	9.75 amperes
Average thermionic emission	4.0 amperes

Average Direct Interelectrode Capacitances

Plate to grid	21.0 $\mu\mu$f.
Grid to filament	18.0 $\mu\mu$f.
Plate to filament	2.0 $\mu\mu$f.

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

Figures 2 and 3 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristic at maximum direct plate voltage and dissipation — Class A ($E_b = 2500$ volts, $I_b = 120$ milliamperes)

Amplification factor	16
Plate resistance	2800 ohms
Grid to plate transconductance	5700 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	3000 volts
Max. direct plate current	375 milliamperes
Max. plate dissipation	350 watts
Max. direct grid current	75 milliamperes
Max. r-f grid current	10 amperes
Max. frequency for the above ratings	7.5 megacycles
Max. plate voltage for upper frequency limit of 22.5 Mc	1000 volts
Max. plate voltage for frequencies between 7.5 and 22.5 Mc in proportion	

Class A Audio Amplifier or Modulator

Direct plate voltage	2500	2000 volts
Grid bias	−130	−95 volts
Direct plate current	120	150 milliamperes
Plate dissipation	300	300 watts
Load impedance	15,000	10,000 ohms
Undistorted output	90	70 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	2500	2000 volts
Grid bias	−140	−105 volts
Direct plate current per tube		
No drive	60	60 milliamperes
Max. drive	375	375 milliamperes
Load resistance, plate-to-plate	8000	6000 ohms
Load resistance, per tube	2000	1500 ohms
Plate dissipation	350	350 watts
Approx. max. output—2 tubes	1000	850 watts
Recommended power for driving stage	75	75 watts

Grid Bias Modulator

Direct plate voltage	3000 volts
Direct plate current	75 milliamperes
Grid bias	−200 volts
Load impedance	7000 ohms
Peak power output	250 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	3000	2500 volts
Direct plate current for carrier conditions	175	210 milliamperes
Grid bias	−180	−140 volts
Approximate carrier watts for use with 100% modulation	175	175 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	3000	2500 volts
Direct plate current	350	350 milliamperes
Grid bias	−315 to −420	−255 to −340 volts
Nominal power output	700	585 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	2250	1750 volts
Direct plate current	300	350 milliamperes
Grid bias	−300	−240 volts
Maximum direct grid current	80	80 milliamperes
Nominal carrier power output for use with 100% modulation	450	410 watts

Operating Precautions

Mechanical—Figure 1 shows 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 400 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 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 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 can not 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—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 on an oscillator. The tube may be used at full rating up to 7.5 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.

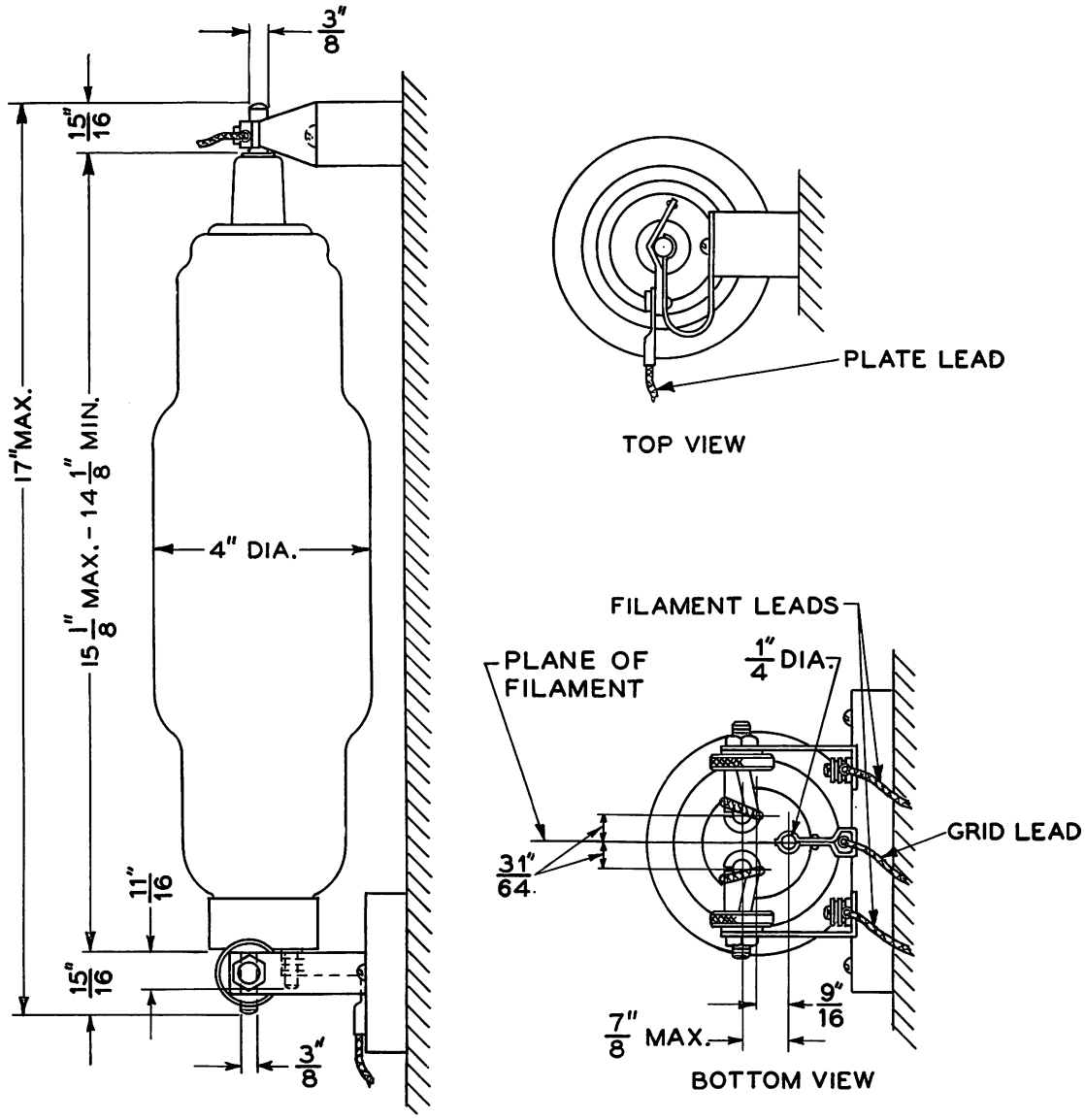

3/8"
15/16"
17" MAX.
15 1/8" MAX. - 14 1/8" MIN.
4" DIA.
11/16"
15/16"
3/8"
PLATE LEAD
TOP VIEW
FILAMENT LEADS
PLANE OF FILAMENT
1/4" DIA.
GRID LEAD
31/64"
7/8" MAX.
9/16"
BOTTOM VIEW

FIG. 1

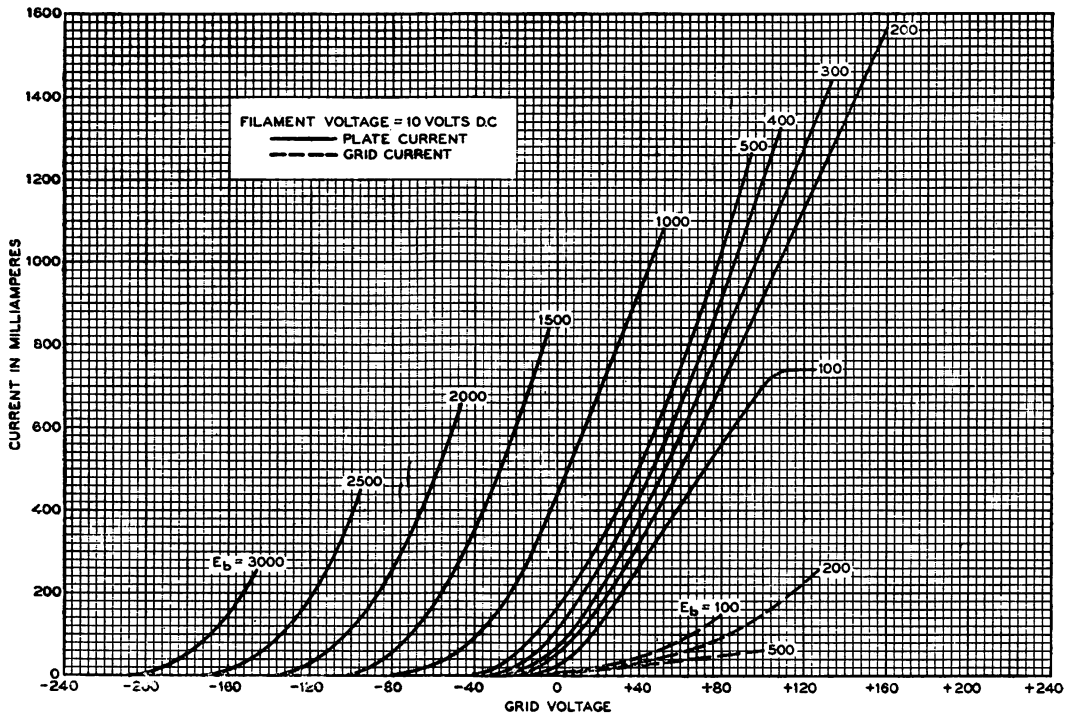

FILAMENT VOLTAGE = 10 VOLTS D.C
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
1600
1400
1200
1000
800
600
400
200
0
-240
-200
-160
-120
-80
-40
0
+40
+80
+120
+160
+200
+240
200
300
400
500
1000
1500
2000
2500
100
E_b = 3000
E_b = 100

FIG. 2

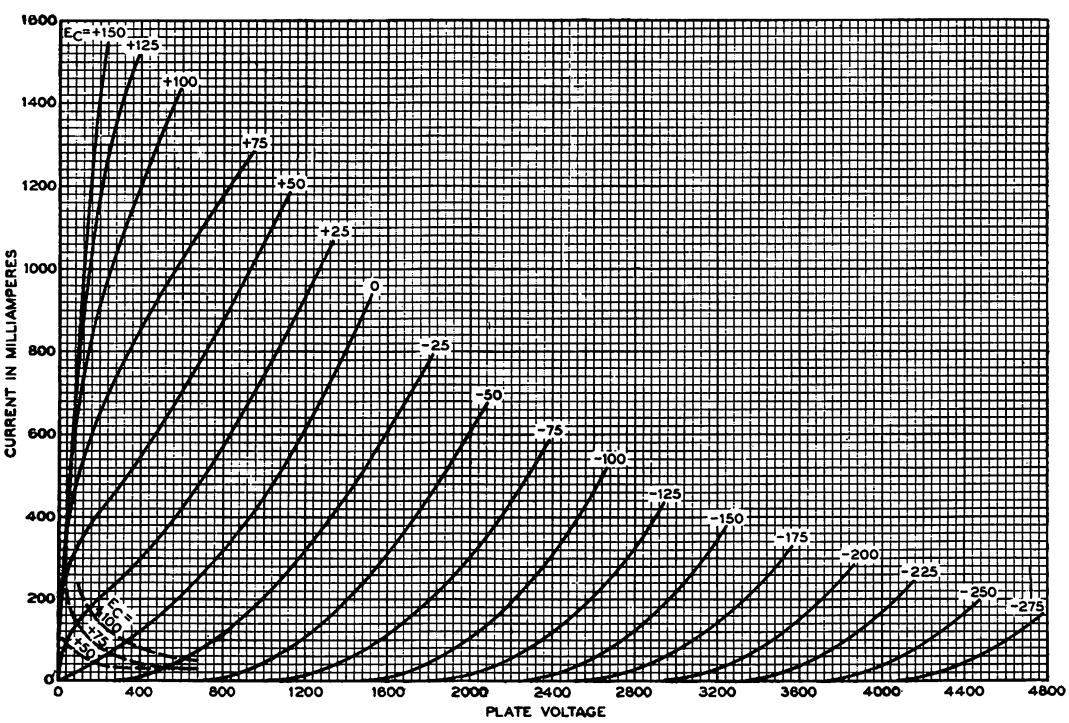
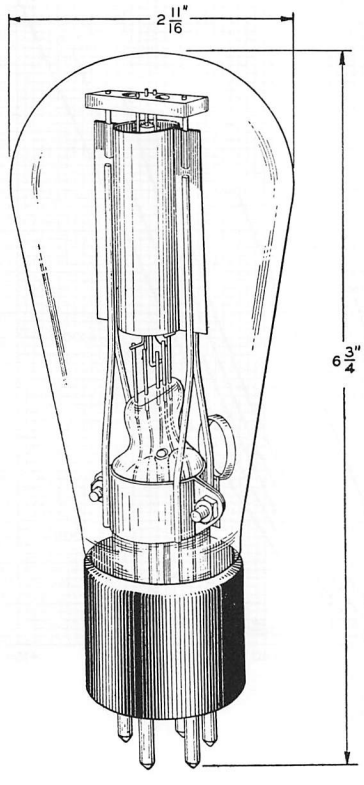
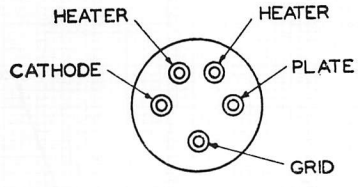

CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_C=+150
+125
+100
+75
+50
+25
0
-25
-50
-75
-100
-125
-150
-175
-200
-225
-250
-275
1600
1400
1200
1000
800
600
400
200
0
0
400
800
1200
1600
2000
2400
2800
3200
3600
4000
4400
4800

FIG. 3

No. 271A Vacuum Tube





Classification

The No. 271A Vacuum Tube is a general purpose three-element tube having an indirectly heated cathode which permits operation directly on alternating current. The tube is for use as an audio-frequency amplifier in output stages. It may also be used as a radio-frequency amplifier and, under restricted conditions, as an oscillator or modulator.

Base and Socket

The No. 271A Vacuum Tube employs a standard five-prong base suitable for use in a Western Electric No. 134A (cushion) or No. 137A (rigid) socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

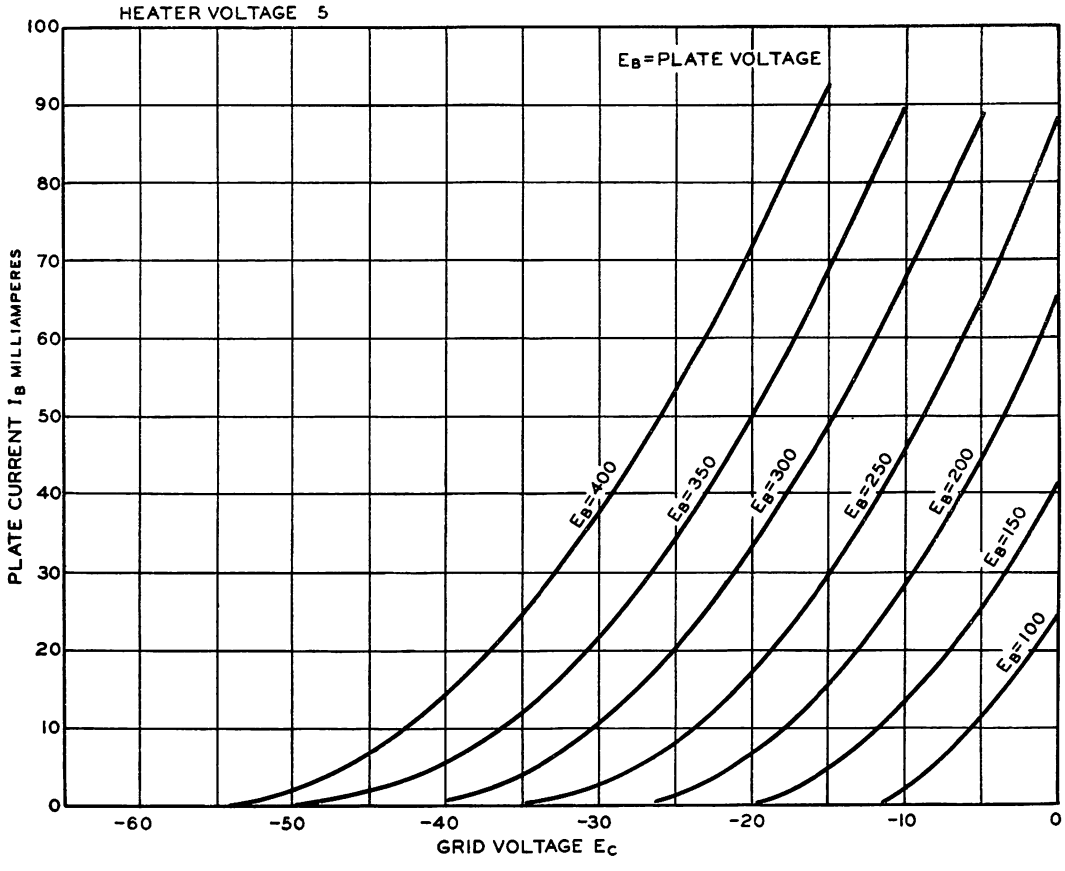
Heater Voltage		5 Volts, AC or DC
Average Heater Current		2 Amperes
Plate Voltage	350	400 Volts Maximum
Grid Voltage	—25	—30 Volts
Average Plate Current	36	39 Milliamperes
Average Plate Resistance	2900	2850 Ohms
Average Amplification Factor	8.5	8.5

Approximate Direct Interelectrode Capacities

Plate to Grid	5.3 MMF
Plate to Cathode	3.8 MMF
Grid to Cathode	6.5 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 271A Vacuum Tube.



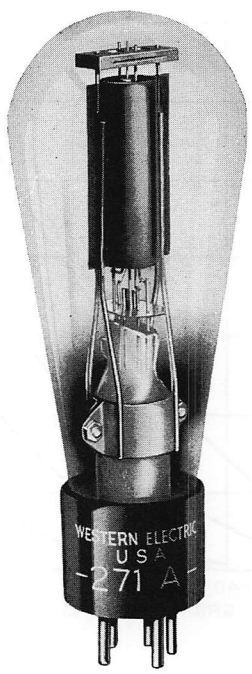
General Features

The indirectly heated cathode of the No. 271A Vacuum Tube makes it suitable for use as a power amplifier in applications requiring a low hum disturbance resulting from the use of alternating current for cathode power supply. Its hum level is approximately 30 db lower than that of filamentary type tubes of corresponding power output.

It has a large cathode area giving ample electron emission. This, together with the rugged construction, insures the maintenance of uniform electrical characteristics over a long life even when the tube is operated at its maximum rating.

Western Electric

271A Vacuum Tube



Classification—Moderate-power triode with indirectly heated cathode

Applications

Audio-frequency amplifier or modulator where outputs up to about 3 watts are required.

Radio-frequency power amplifier.

Oscillator.

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 type.

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

Mounting Positions—The 271A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Grid to plate	5.3 μμf.
Grid to heater and cathode	6.5 μμf.
Plate to heater and cathode	3.8 μμf.

Heater Rating

Heater voltage	5.0 volts, a.c. or d.c.
Nominal heater current	2.0 amperes

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—When the heater is operated on alternating current, a minimum level of hum in the tube can usually be obtained by connecting the cathode either directly to the heater at terminal 5, shown in Figure 2, or to a center tap on the secondary of the filament transformer. This minimum hum level is approximately 30 decibels lower than for a well designed filamentary tube of similar characteristics. If voltage must be applied between the heater and cathode, it should be kept as low as possible and should never exceed 90 volts.

Characteristics—Plate current characteristics of a typical 271A tube are shown in Figure 3 as functions of grid voltage for several values of plate voltage. Similar characteristics as functions of plate voltage for several values of grid voltage are shown in Figure 4. Amplification factor, plate resistance, and transconductance characteristics corresponding to the plate current characteristics of Figure 3 are given in Figures 5, 6, and 7, respectively.

Limiting Conditions for Safe Operation

Maximum plate voltage	450 volts
Maximum plate current	60 milliamperes
Maximum instantaneous grid potential on positive swing of input voltage	+20 volts

Operating Conditions and Output—Permissible operating conditions are included within the area, ABCD, in Figure 3. Amplification factor, plate resistance, transconductance, and performance data are listed in the table on page 3 for 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, P_m, in watts, and the second and third harmonic levels, F_{2m} and F_{3m}, in decibels below the fundamental for the indicated values of load resistance and input voltage. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the output and harmonic levels are given approximately by 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	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms	Micromhos	Peak Volts	Ohms	Watts	db	db
300	−25	19.5	8.2	3650	2250	25	7300	1.3	23	50
							14600	0.9	27	55
350	−30	21.5	8.1	3550	2300	30	7100	1.9	22	48
							14200	1.4	27	55
350	−25	34.5	8.4	2850	2930	25	2850	1.9	20	47
							5700	1.7	25	70
							11400	1.3	29	50
350	−20	51.0	8.6	2460	3500	20	2460	1.6	24	70
							4920	1.4	28	55
							9840	1.0	31	50
400	−35	24.5	8.1	3450	2350	35	6000	2.8	20	43
							8000	2.5	22	50
							10000	2.3	24	60
							15000	1.9	27	55
400	−30	37.5	8.3	2830	2920	30	4000	2.8	22	50
							6000	2.4	25	70
							8000	2.2	27	55
							10000	1.9	28	55
							15000	1.5	30	50
400	−25	54.0	8.5	2450	3480	25	3000	2.3	24	70
							4000	2.2	26	55
							6000	1.9	28	50
							8000	1.7	30	50
							12000	1.3	32	50
*450	−30	57.5	8.5	2450	3480	30	2450	3.4	22	50
							4900	3.1	30	60

*Maximum operating conditions.

Curves showing the variation of power output and harmonic levels with load resistance for several values of operating plate current are given in Figures 8, 9, and 10 for a plate voltage of 400 volts. The sharp minima which appear in the third harmonic curves are characteristic of the 271A tube, but their positions may be different for different tubes. For this reason, the third harmonic level in any individual tube may be widely different from the value given in the table where the operating condition under consideration is near one of these minima. Near these points, also, the expression given above for third harmonic level is not reliable.

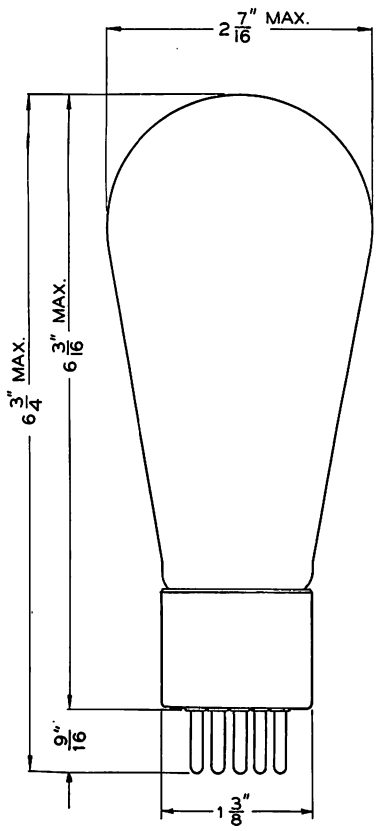


FIG. 1

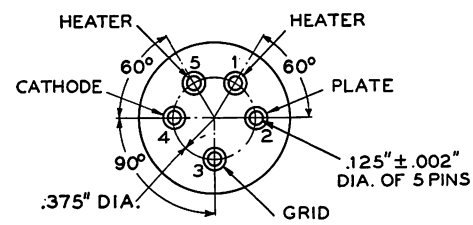


FIG. 2

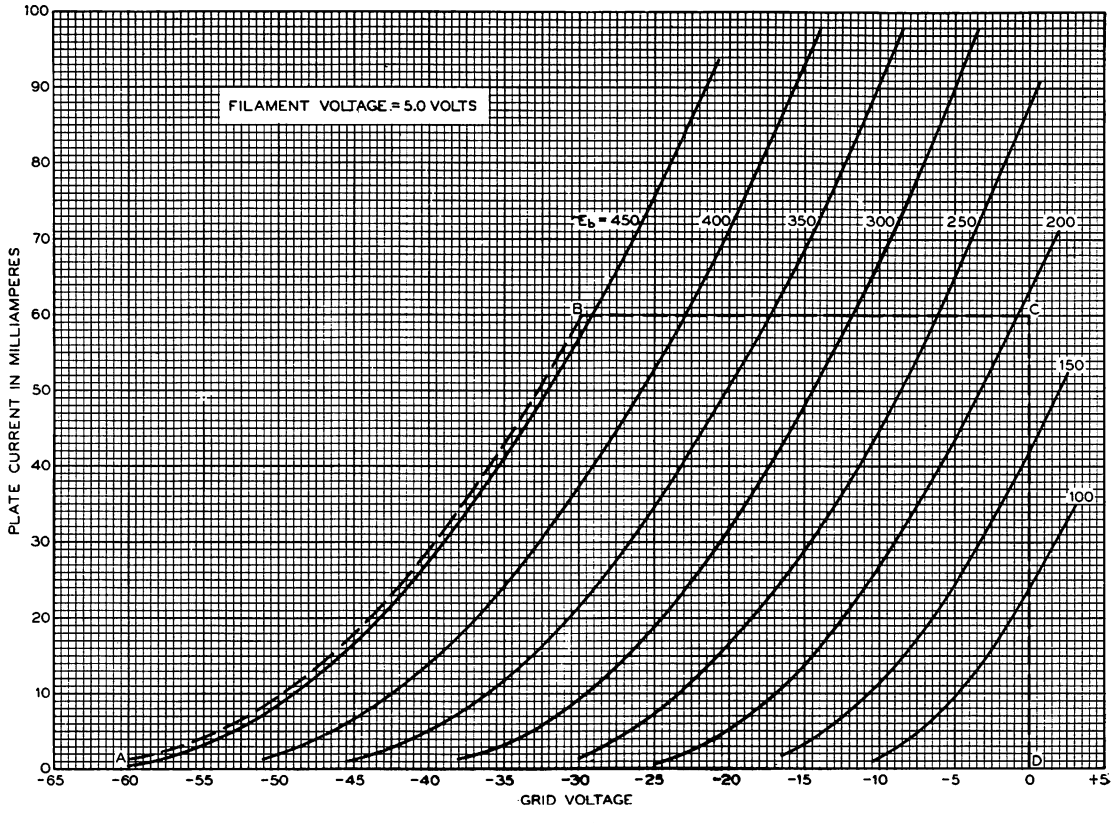

FILAMENT VOLTAGE = 5.0 VOLTS
E_b = 450
400
350
300
250
200
150
100
A
B
C
D
PLATE CURRENT IN MILLIAMPERES
GRID VOLTAGE
100
90
80
70
60
50
40
30
20
10
0
-65
-60
-55
-50
-45
-40
-35
-30
-25
-20
-15
-10
-5
0
+5

FIG. 3

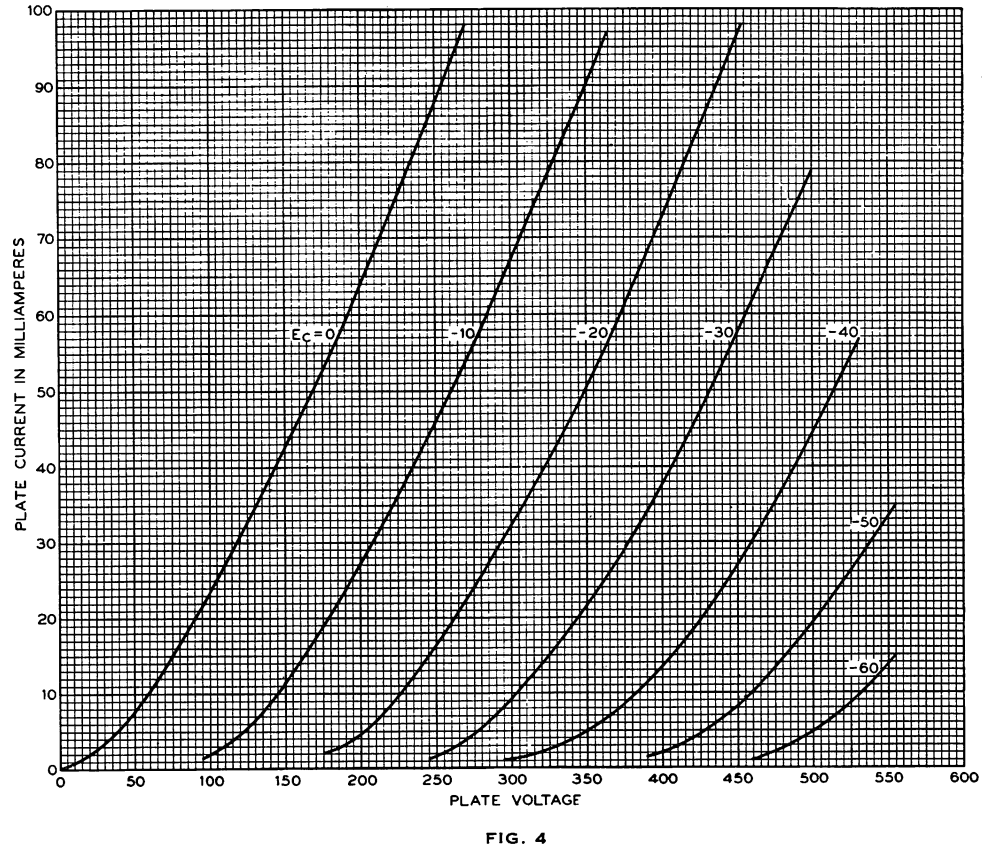

E_c = 0
-10
-20
-30
-40
-50
-60
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
100
90
80
70
60
50
40
30
20
10
0
0
50
100
150
200
250
300
350
400
450
500
550
600

FIG. 4

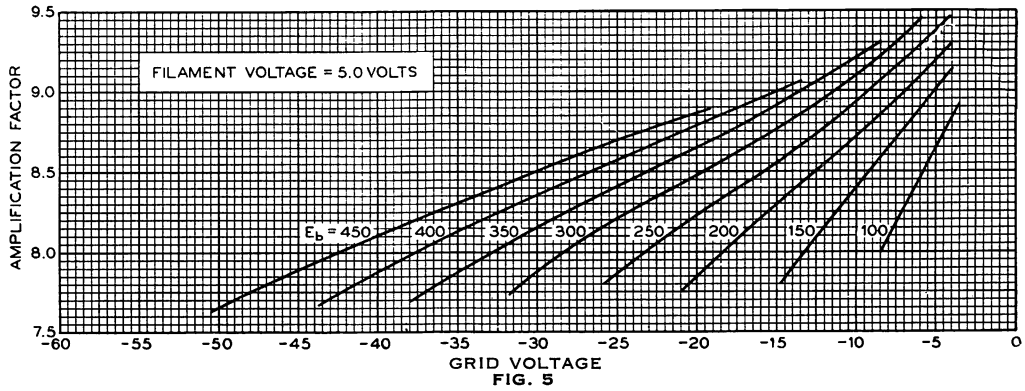


FIG. 5

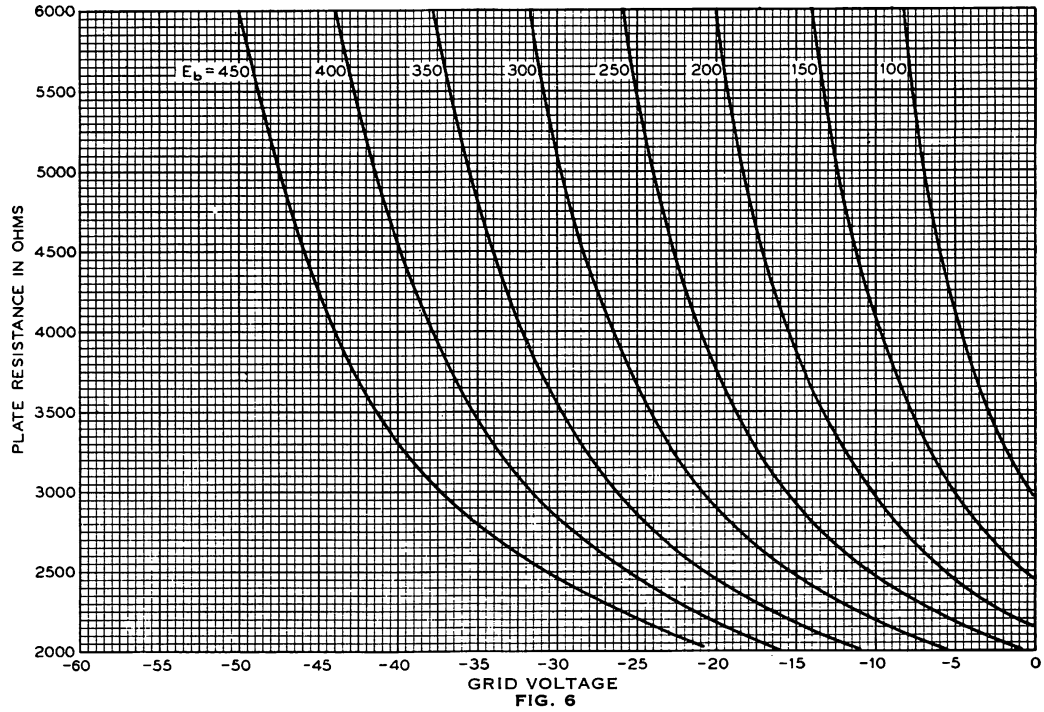


FIG. 6

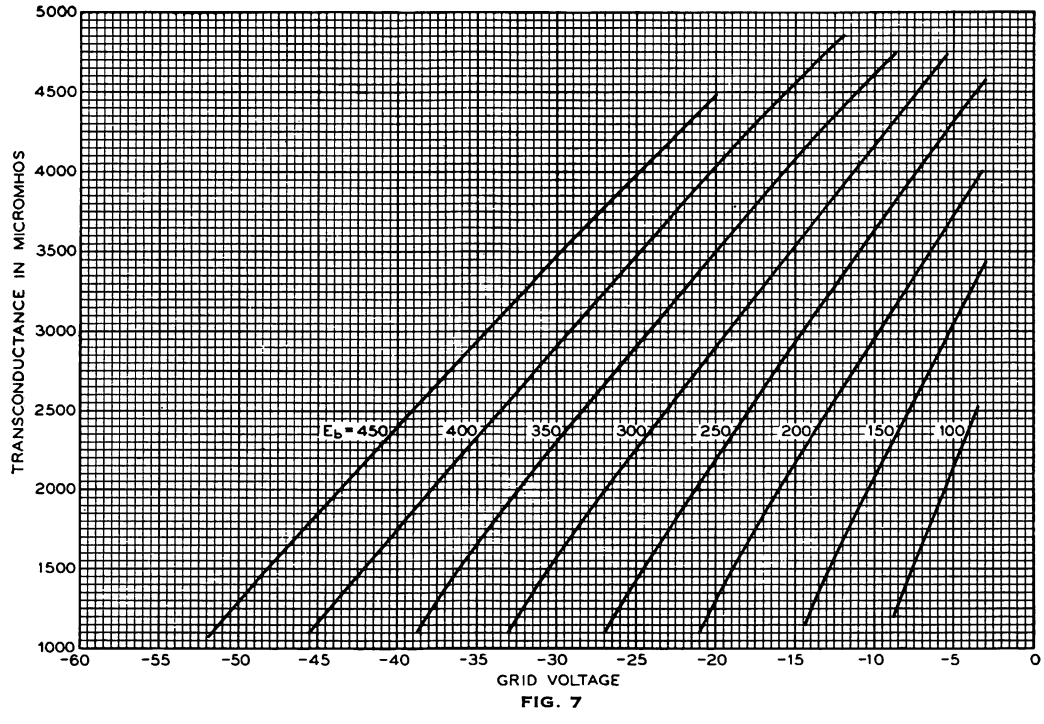


FIG. 7

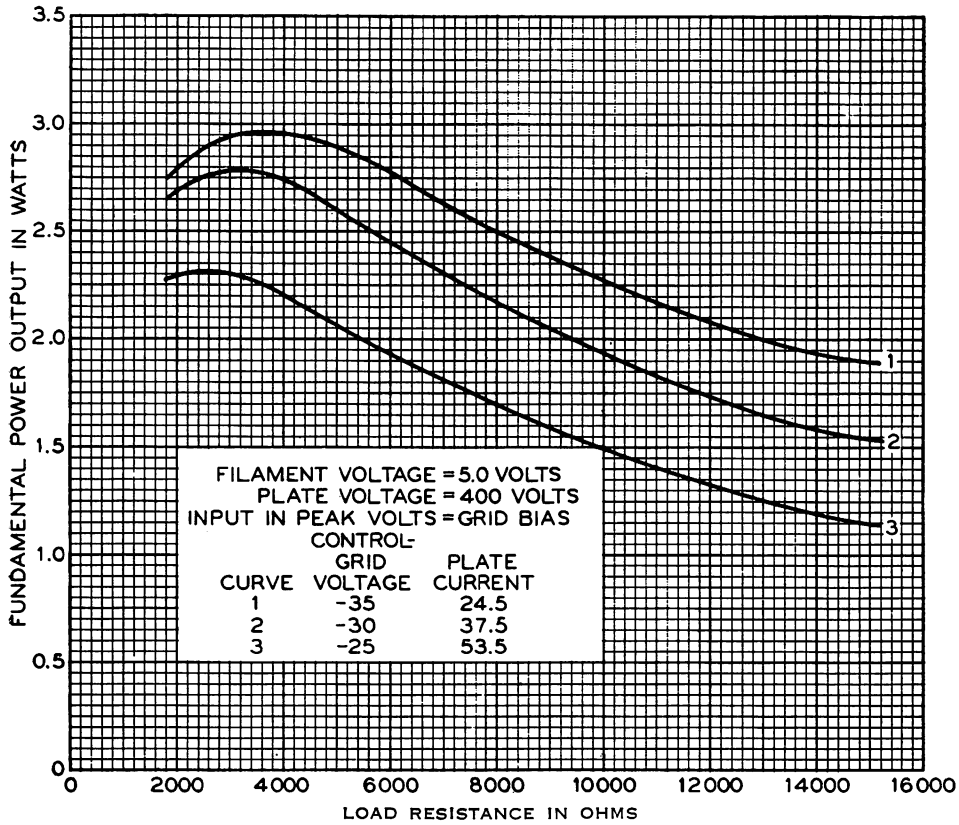

FUNDAMENTAL POWER OUTPUT IN WATTS
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0
2000
4000
6000
8000
10000
12000
14000
16000
LOAD RESISTANCE IN OHMS
FILAMENT VOLTAGE = 5.0 VOLTS
PLATE VOLTAGE = 400 VOLTS
INPUT IN PEAK VOLTS = GRID BIAS
CONTROL-GRID VOLTAGE
PLATE CURRENT
CURVE 1 -35 24.5
CURVE 2 -30 37.5
CURVE 3 -25 53.5
1
2
3

FIG. 8

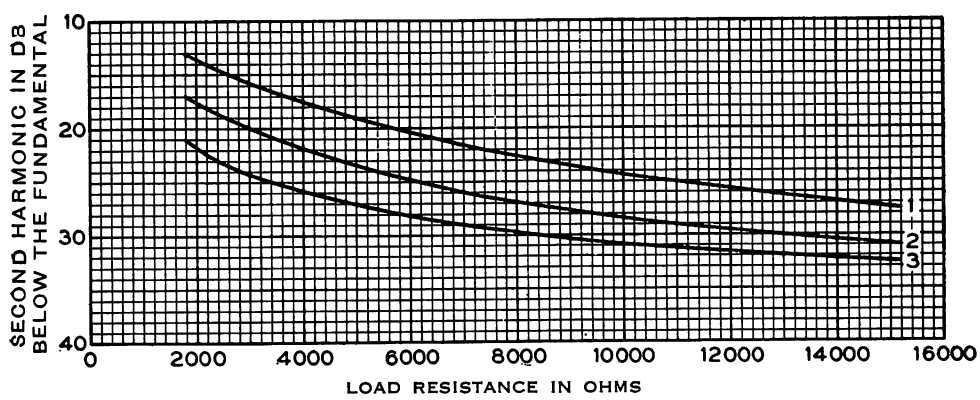

SECOND HARMONIC IN DB BELOW THE FUNDAMENTAL
10
20
30
40
0
2000
4000
6000
8000
10000
12000
14000
16000
LOAD RESISTANCE IN OHMS
1
2
3

FIG. 9

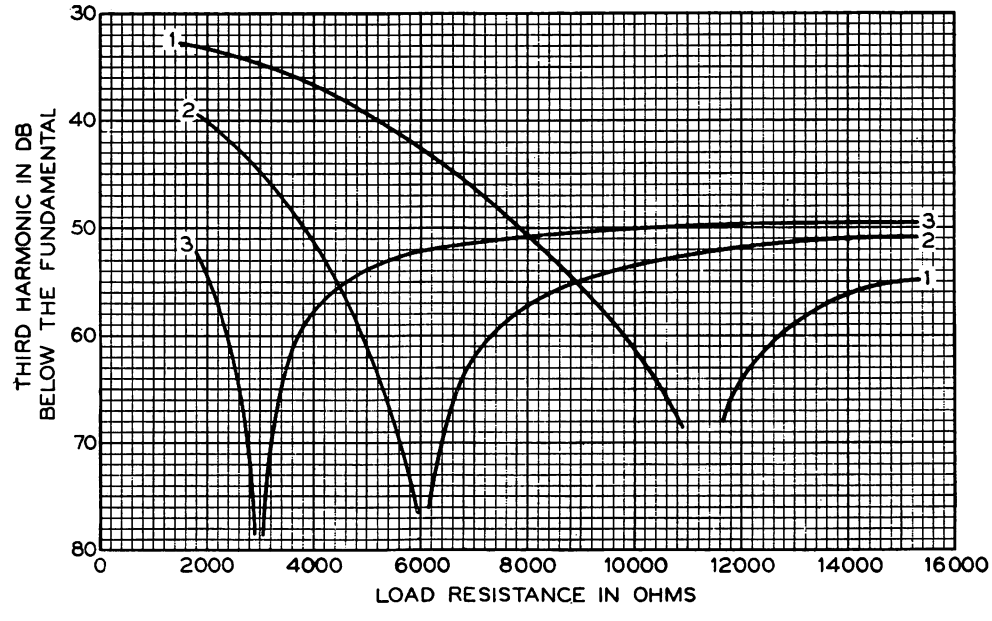
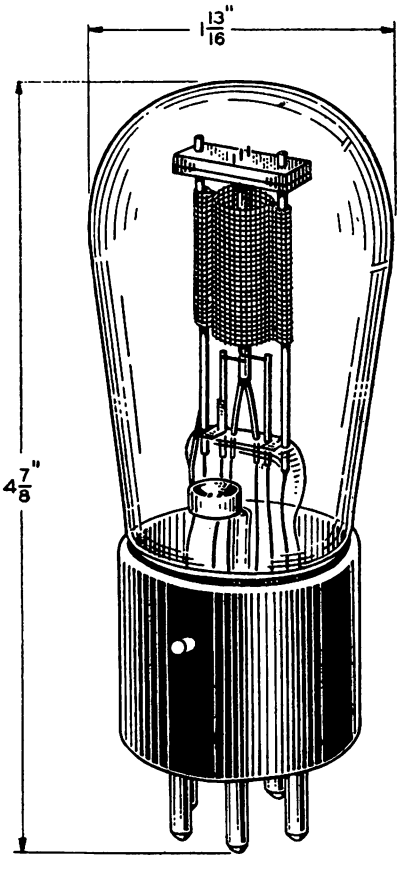
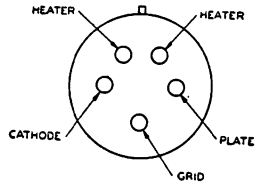

30
40
50
60
70
80
THIRD HARMONIC IN DB
BELOW THE FUNDAMENTAL
1
2
3
3
2
1
0
2000
4000
6000
8000
10000
12000
14000
16000
LOAD RESISTANCE IN OHMS

FIG. 10

272A Vacuum Tube





Classification

The No. 272A is a general purpose Vacuum Tube having an indirectly heated cathode which permits operation of the heater element directly on alternating current. It is suitable for use as a detector or power amplifier tube in applications requiring small values of output power.

Base and Socket

The No. 272A Vacuum Tube employs a standard five-prong base suitable for use in a Western Electric No. 134A (cushion), No. 137A (rigid), or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

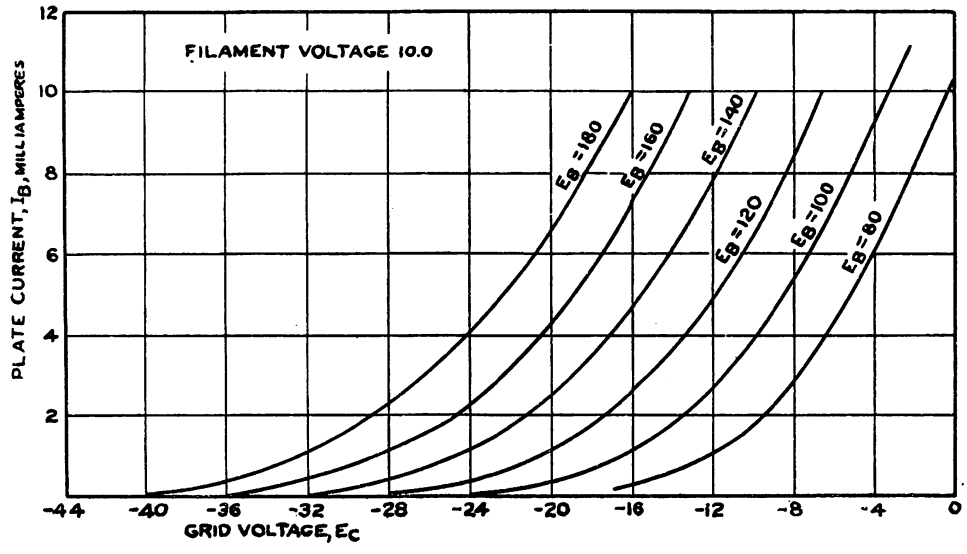
Heater Voltage	10 Volts, AC or DC	
Average Heater Current	0.32 Ampere	
Plate Voltage	140	180 Volts Max.
Grid Voltage	—15	—21
Average Plate Current	5.4	5.9 Milliamperes
Average Plate Resistance	7,200	7,200 Ohms
Average Amplification Factor	5.6	5.5

Approximate Direct Interelectrode Capacities

Plate to Grid	2.8 MMF
Plate to Cathode	2.6 MMF
Grid to Cathode	3.4 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 272A Vacuum Tube.



General Features

The No. 272A Vacuum Tube is adaptable to applications in which it is desirable to have a tube of the heater cathode type with low heater current consumption.

It is suitable for use in the final stages of amplifiers requiring somewhat greater output power than that given by the No. 262A Vacuum Tube.

Western Electric

272A Vacuum Tube



Classification—Low-power triode with indirectly heated cathode

Applications

Radio-frequency antenna-coupling amplifier.

Audio-frequency amplifier where small power outputs are required.

Detector or modulator.

Dimensions—Outline diagrams showing dimensions 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.

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

Mounting Positions—The 272A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Grid to plate	2.8 $\mu\mu$f.
Grid to heater and cathode	3.4 $\mu\mu$f.
Plate to heater and cathode	2.6 $\mu\mu$f.

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—When the heater is operated on alternating current, a reduction of hum in the tube may usually be obtained by connecting the cathode to a center tap on the secondary of the heater transformer or to the center point of a suitable resistance connected across the heater terminals. If voltage must be applied between the heater and cathode, it should be kept as low as possible and should never exceed 90 volts.

Characteristics—Plate current characteristics of a typical 272A tube are shown in Figure 3 as functions of grid voltage 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 are shown as functions of plate voltage for several values of grid voltage in Figure 7.

Operating Conditions and Output—Permissible operating conditions are included within the area, ABCD, 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. The 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 milliwatts and the second and third harmonic levels in decibels below the fundamental for values of load resistance, R, both equal to and double the plate resistance, r_p. The peak value of the sinusoidal input, E_{gm}, which gives the indicated power output, P_m, and harmonic levels, F_{2m} and F_{3m}, in each case, is numerically equal to the grid bias. For a smaller input voltage, E_g, the output and harmonic levels, except for the lowest third harmonic levels, are given approximately by the following relations:

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

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

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

The level of the third harmonic in the 272A tube is usually low and may differ widely in individual tubes. The values given in the table are for a typical tube.

Microphonic Noise—With a plate voltage of 100 volts, a grid bias of −7 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 272A tube, measured in a laboratory reference test set, is 39 decibels below 1 volt. The range of levels of individual tubes extends from 26 to 52 decibels. 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.

TABLE

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms r_p	Micromhos	Peak Volts	R	Milliwatts	db	db
80	−2	8.7	6.6	5400	1220	2	$R=r_p$	3.5	36	65
							$R=2r_p$	3	39	65
80	−5	5.4	6.1	6600	930	5	$R=r_p$	17	26	60
							$R=2r_p$	15	28	55
80	−8	2.9	5.6	8600	650	8	$R=r_p$	30	21	65
							$R=2r_p$	25	24	50
100	−7	6.6	6.0	6300	950	7	$R=r_p$	35	25	55
							$R=2r_p$	30	28	50
100	−11	3.3	5.5	8800	630	11	$R=r_p$	55	19	55
							$R=2r_p$	50	23	50
120	−10	6.7	5.8	6400	910	10	$R=r_p$	65	23	55
							$R=2r_p$	60	26	50
120	−14	3.7	5.5	8600	630	14	$R=r_p$	90	18	50
							$R=2r_p$	80	22	55
140	−15	5.4	5.6	7400	760	15	$R=r_p$	120	19	50
							$R=2r_p$	110	23	50
140	−18	3.4	5.3	9400	570	18	$R=r_p$	130	17	42
							$R=2r_p$	120	21	60
160	−20	4.5	5.4	8400	650	20	$R=r_p$	180	17	43
							$R=2r_p$	160	21	65
160	−22	3.3	5.3	10000	530	22	$R=r_p$	180	16	40
							$R=2r_p$	160	20	55
*100	−3	11.2	6.6	5000	1320	3	$R=r_p$	9	34	65
							$R=2r_p$	8	36	65
*120	−7.5	9.2	6.1	5500	1100	7.5	$R=r_p$	45	26	60
							$R=2r_p$	40	29	55
*140	−12	8.0	5.8	6100	960	12	$R=r_p$	100	23	60
							$R=2r_p$	90	26	50
*160	−17	6.6	5.6	6800	820	17	$R=r_p$	170	19	50
							$R=2r_p$	150	24	55
*180	−21	6.2	5.5	7200	760	21	$R=r_p$	230	18	46
							$R=2r_p$	210	22	60
*180	−27	2.5	5.1	11700	440	27	$R=r_p$	220	15	38
							$R=2r_p$	200	19	46

*Maximum operating conditions.

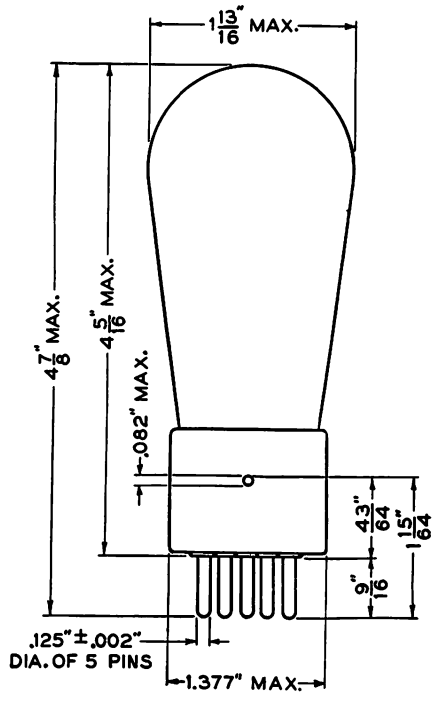


FIG. 1

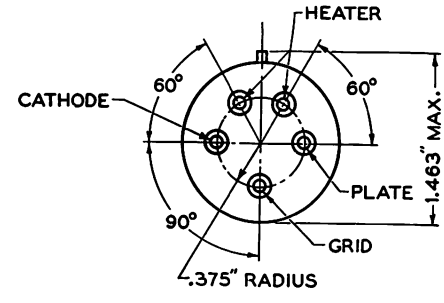


FIG. 2

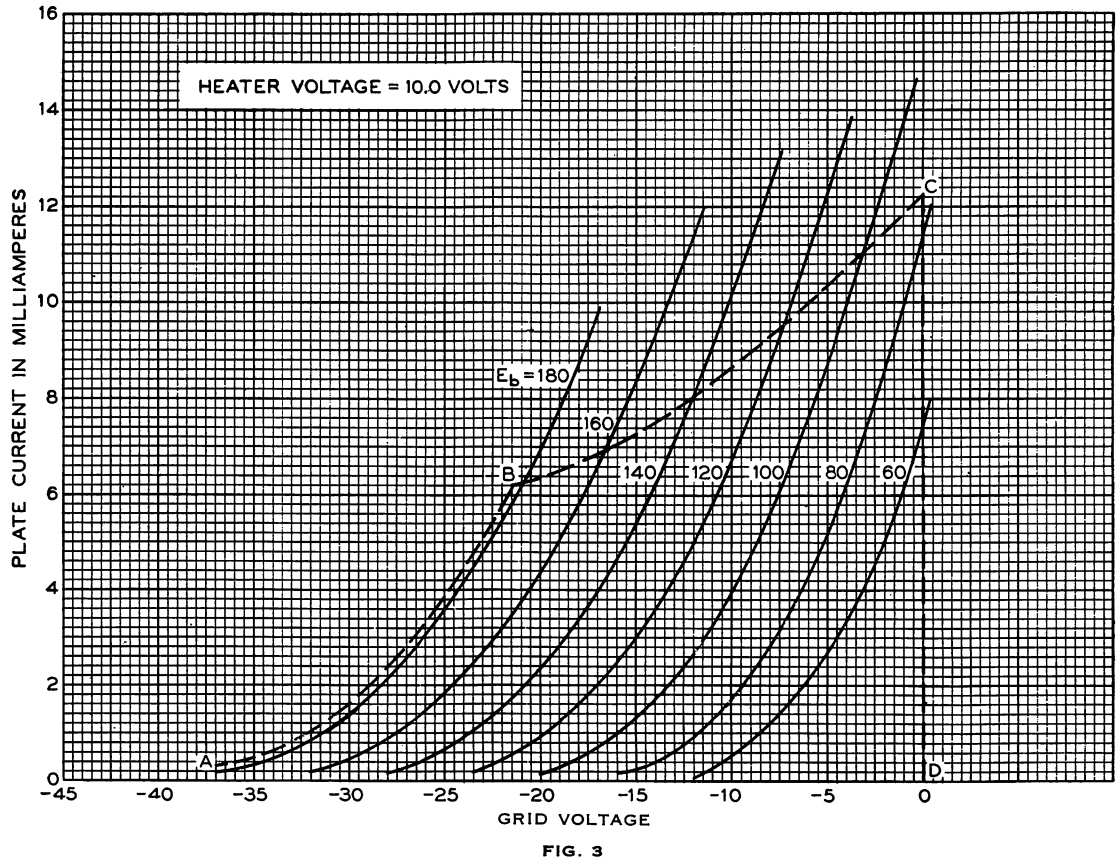


FIG. 3

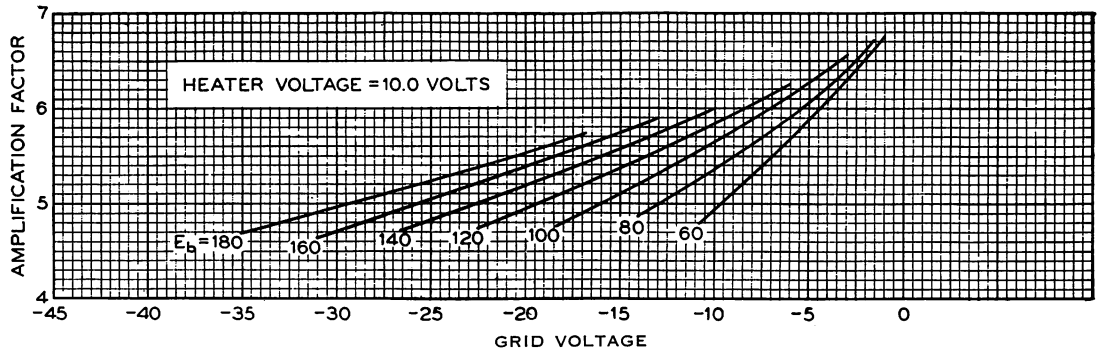


FIG. 4

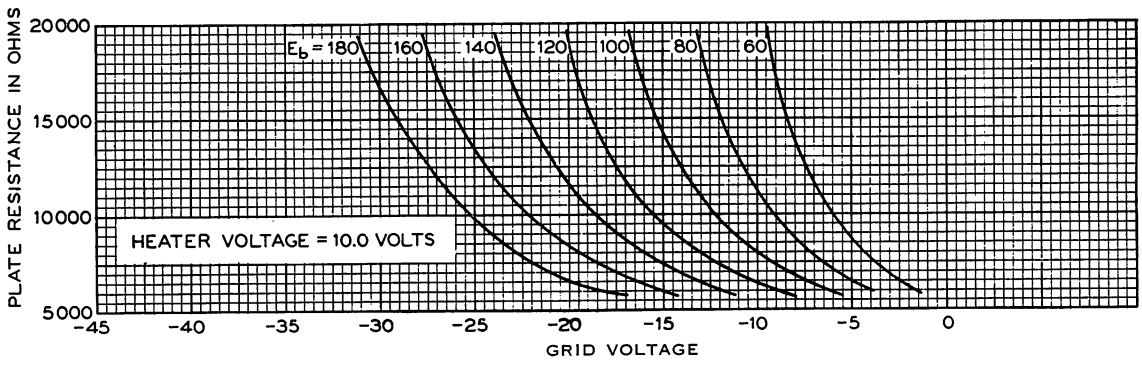


FIG. 5

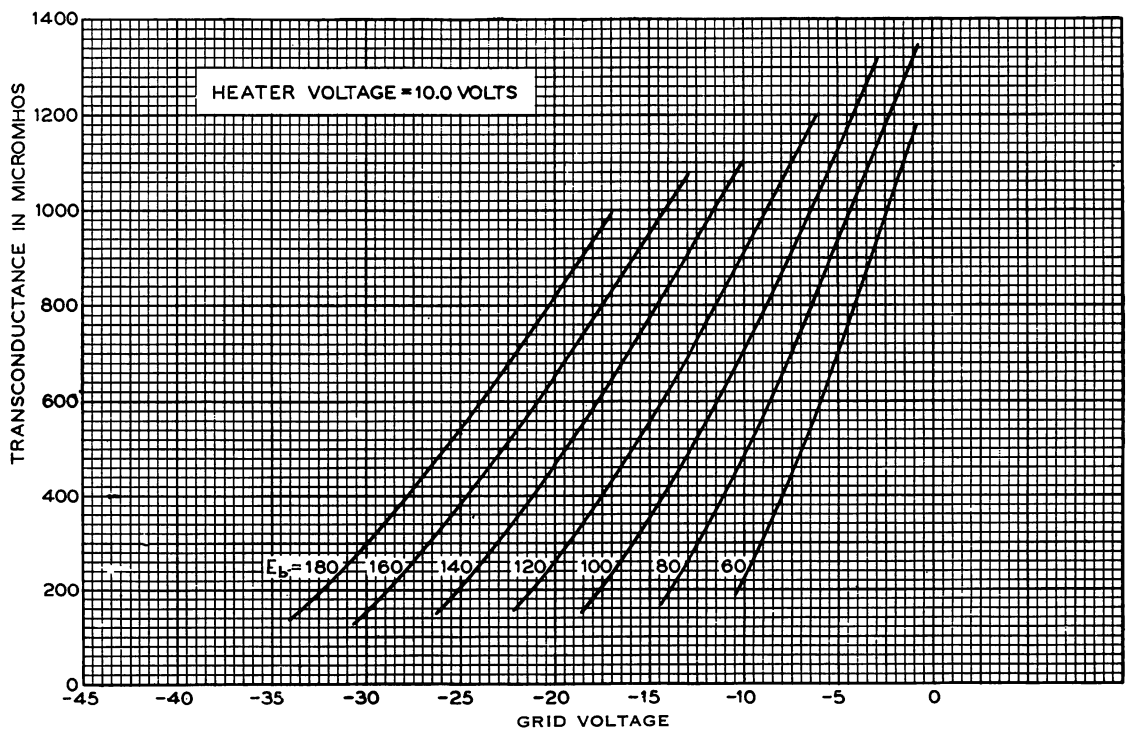


FIG. 6

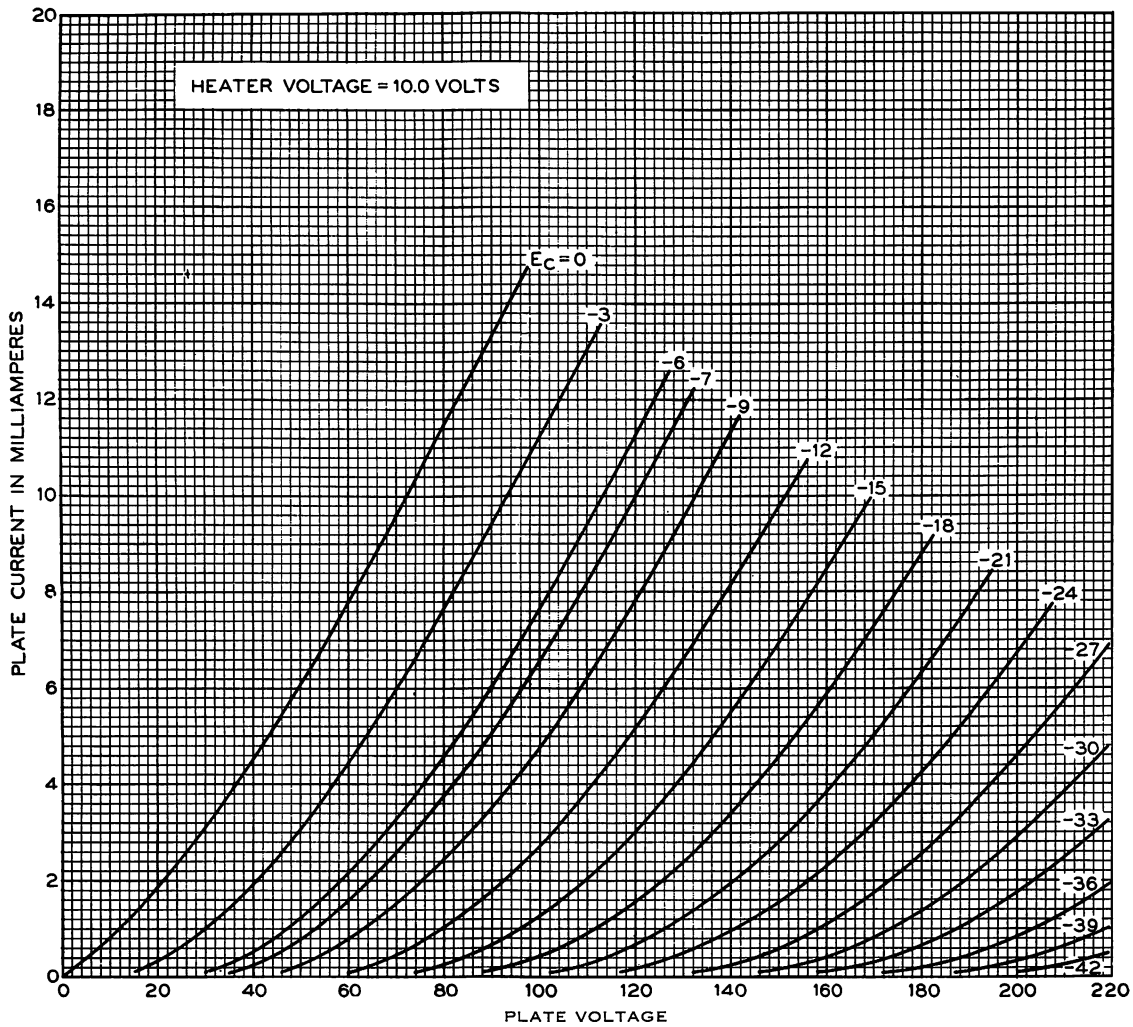
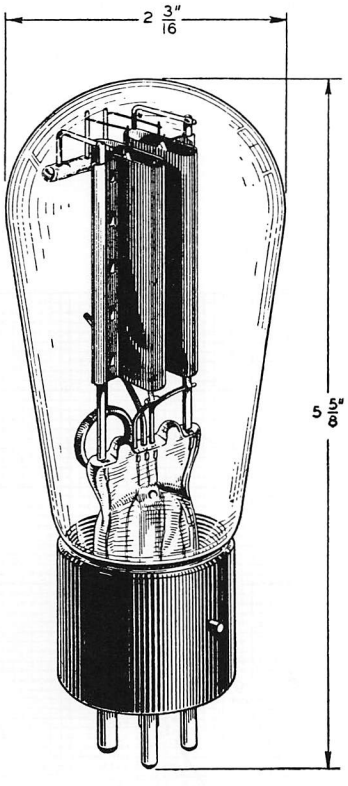
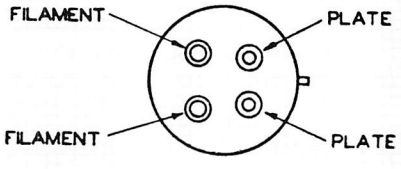

HEATER VOLTAGE = 10.0 VOLTS
$E_c = 0$
-3
-6
-7
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
-42
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
0
2
4
6
8
10
12
14
16
18
20
0
20
40
60
80
100
120
140
160
180
200
220

FIG. 7

274A Vacuum Tube





Classification

The No. 274A Vacuum Tube is a full-wave, thermionic, high-vacuum rectifier for use in circuits designed to supply direct current from an alternating current supply.

Base and Socket

The No. 274A Vacuum Tube employs a four-prong base suitable for use in a Western Electric No. 130B Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

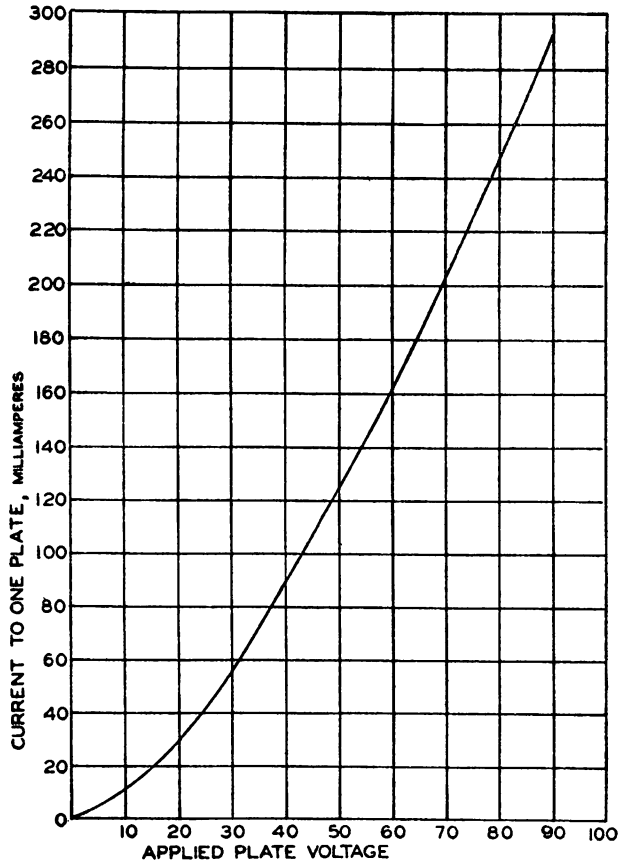
Rating and Characteristic Data

Filament Voltage	5.0 Volts
Filament Current	2.0 Amperes

	Choke Input Filter	Condenser Input Filter
Maximum A.C. Voltage per Plate	660 Volts R.M.S.	450 Volts R.M.S.
Maximum Total Rectified Current	150 Milliamperes	130 Milliamperes

Average Static Characteristics

The accompanying curves gives the average static characteristics of the No. 274A Vacuum Tube. The current for a single plate is given as a function of the voltage applied between the plate and the center taps of the filament transformer.



General Features

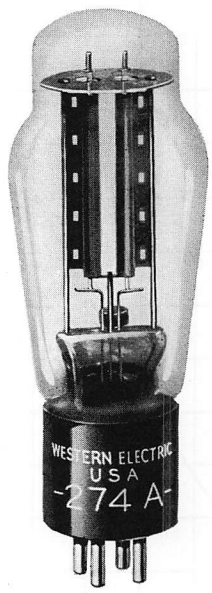
The No. 274A high vacuum rectifier tube is particularly adapted for use in applications where it is impracticable to place any limitations on the ambient temperatures and where it is necessary to apply the plate voltage simultaneously with the filament voltage.

Its large plate area results in a relatively low potential drop between the plate and filament. This makes possible better voltage regulation than is usually obtained with high vacuum thermionic rectifiers.

The large filament area gives ample electron emission to insure uniform electrical characteristics over a long life and satisfactory operation even under very severe service conditions.

Western Electric

274A Vacuum Tube



Classification—Full-wave, thermionic high vacuum rectifier

The 274A tube is designed to supply direct current up to 200 milliamperes from an alternating current source. It comprises two filament type diode units with a common filament.

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

Base—Medium, four-pin thrust type.

Socket—Standard, four-contact type such as the Western Electric 143B socket.

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

Filament Rating

Filament voltage	5.0 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.

Characteristics—The current-voltage characteristic of a single diode unit of the 274A tube is shown in Figure 3. The voltage is measured between the plate and a center tap on the filament transformer. Direct-voltage output characteristics as functions of the direct load current for a number of values of applied alternating voltage are given in Figures 4 and 5. The characteristics of Figure 4 are for a choke-input filter such as is shown in circuit A, and those of Figure 5 are for a condenser-input filter such as is shown in circuit B.

Operating Conditions

	R-M-S Alternating Voltage per Plate	Total Rectified Current
	Volts	Milliamperes
Choke-Input Filter	550	160
	*550	200
	*660	160
Condenser-Input Filter	450	140
	*450	**150

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

A less severe 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.

Double the above listed values of rectified current may be obtained from two tubes by connecting the two plates of each tube together, and using one tube in each side of the circuit.

Effect of Filter—It is evident from the regulation characteristics of Figures 4 and 5 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 normal charging and discharging of the condenser each half cycle requires the tube to supply relatively large peaks of current during each charging period. The peak current increases in value as the capacitance of the condenser is increased and may be much larger than the average rectified output current, though its duration in such cases is only a short fraction of a cycle. Since for good tube performance, the anode current must be considerably less at every part of the cycle than the total emission current from the filament, the maximum permissible output current must be limited to such a value that this condition is satisfied. The permissible output current may be larger, therefore, for a choke-input filter, in which the peak anode current is only slightly larger than the output current. The choke-input filter also gives much better regulation than the condenser-input circuit. The choke-input filter, therefore, should always be selected 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.

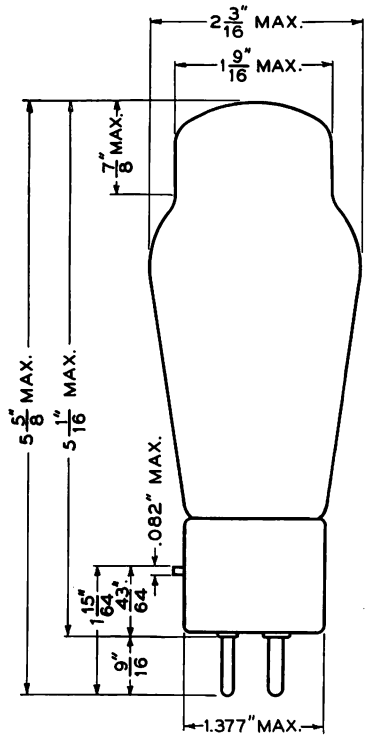


FIG. 1

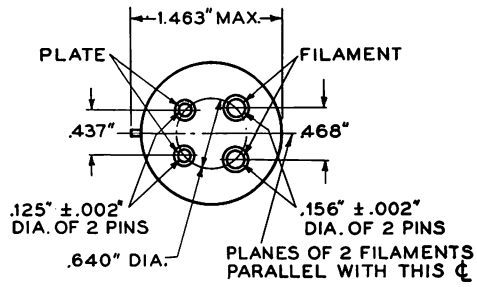


FIG. 2

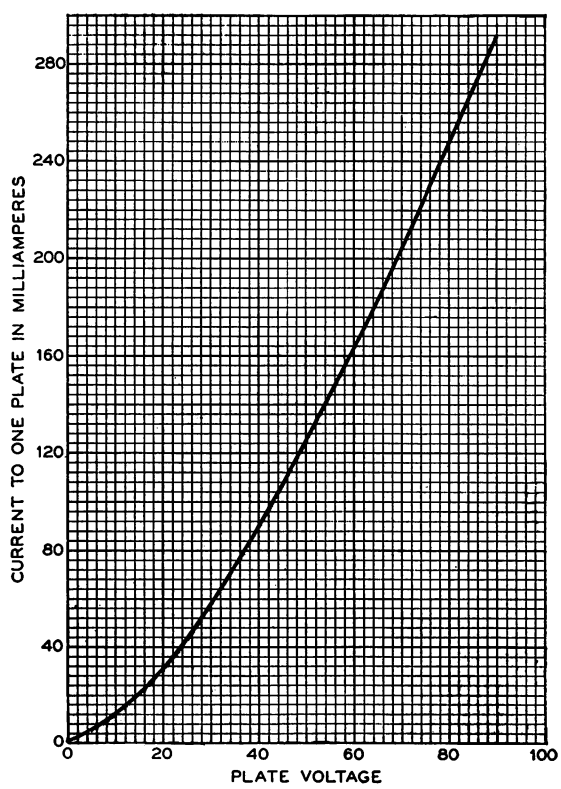


FIG. 3

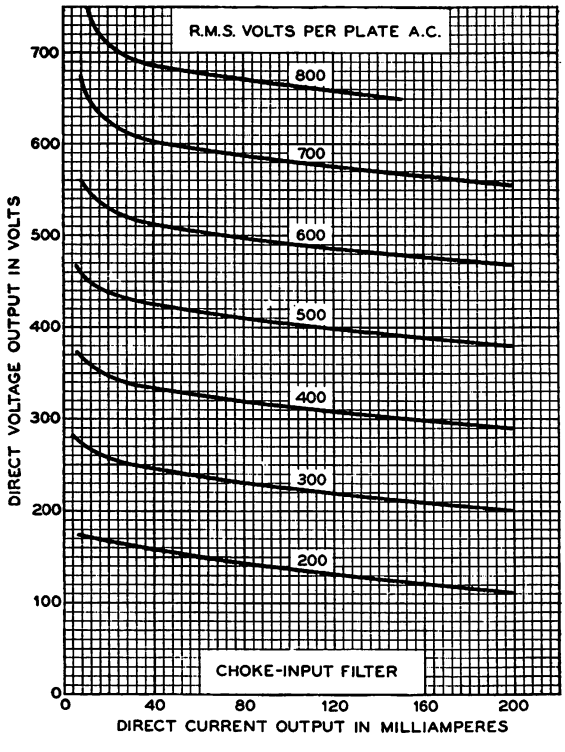


FIG. 4

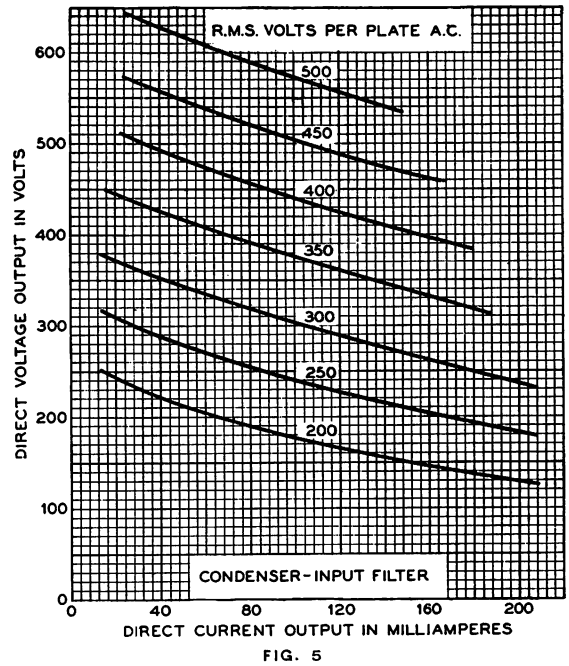
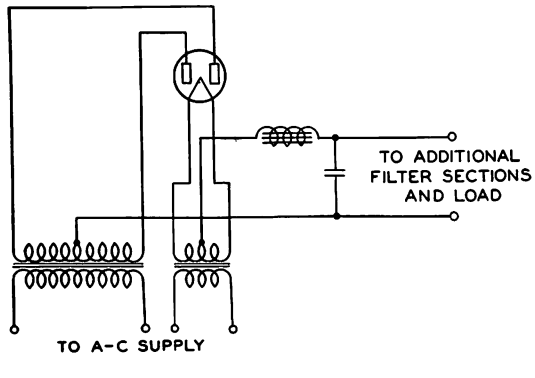
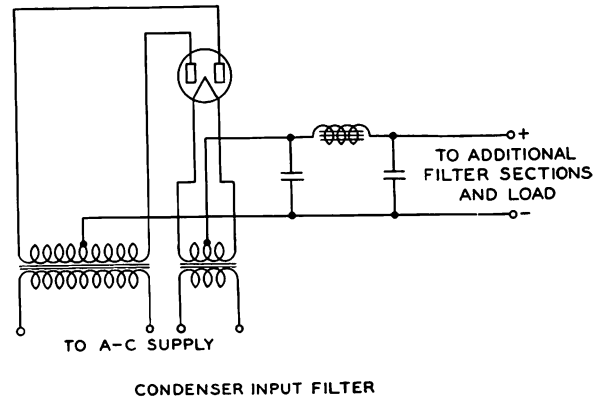


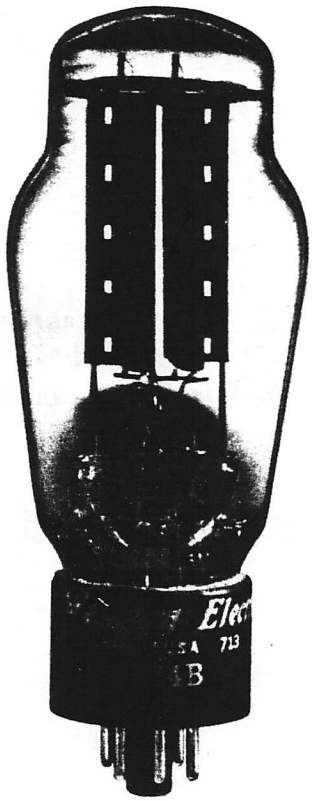
FIG. 5



CHOKE INPUT FILTER
CIRCUIT A



CONDENSER INPUT FILTER
CIRCUIT B



RECTIFIER
FULL-WAVE, HIGH VACUUM

Western Electric

DESCRIPTION

The 274B is a filamentary, octal based, full-wave rectifier designed to supply direct current from an alternating current source.

CHARACTERISTICS

Filament Voltage	5.0 volts
Maximum Plate Voltage (RMS) per Plate	660 volts
Maximum D-C Output Current	225 milliamperes

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Filament Voltage	5.0 volts
Filament Current	2.0 amperes

MECHANICAL DATA

Cathode	Coated filament
Bulb	ST16
Base	Medium 5-pin, octal
Mounting Position	Preferably vertical; if horizontal, pins #1 and #4 should be in vertical plane

Dimensions and pin connections shown in outline drawing on Page 4

MAXIMUM RATINGS, Design-Center Values

Peak Inverse Voltage	1500 volts
Peak Plate Current per Plate	675 milliamperes
Peak Transient Plate Current per Plate	2.5 amperes

With Choke-Input Filter:

A-C Plate Voltage per Plate (RMS)	660 volts
D-C Output Current	225 milliamperes
Minimum Input-Choke Inductance	3 henrys

With Condenser-Input Filter:

A-C Plate Voltage per Plate (RMS)	450 volts
D-C Output Current	160 milliamperes
Minimum Total Effective Plate-Supply Impedance per Plate	100 ohms

TYPICAL OPERATING CONDITIONS

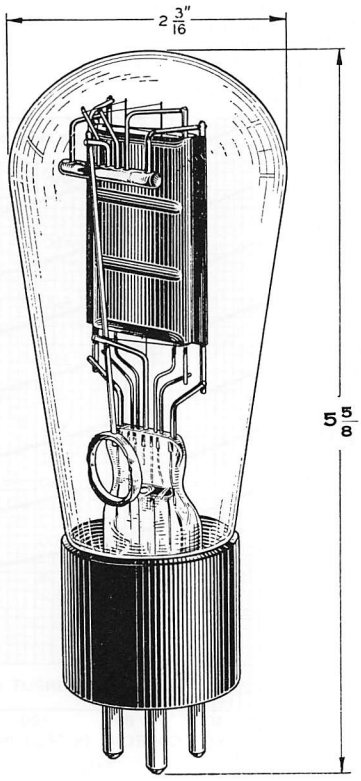
With Choke-Input Filter:

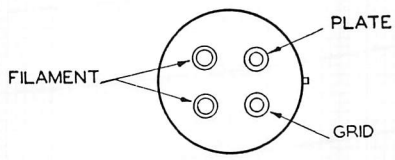
A-C Plate Voltage per Plate (RMS)	550 volts
D-C Output Current	160 milliamperes
D-C Output Voltage, Approximate, at Input to Filter	430 volts
Filter Input Choke	5 henrys

With Condenser-Input Filter:

A-C Plate Voltage per Plate (RMS)	450 volts
D-C Output Current	140 milliamperes
D-C Output Voltage, Approximate, at Input to Filter	475 volts
Total Effective Plate-Supply Impedance per Plate	180 ohms
Filter Input Condenser	4 microfarads

275A Vacuum Tube





Classification

The No. 275A Vacuum Tube is a three-element filament type tube for use as a low-voltage power tube for output stages in audio-frequency amplifiers.

Base and Socket

The No. 275A Vacuum Tube employs a standard four-prong, thrust-type base suitable for use in a Western Electric No. 130B (rigid) or No. 131A (cushion) Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

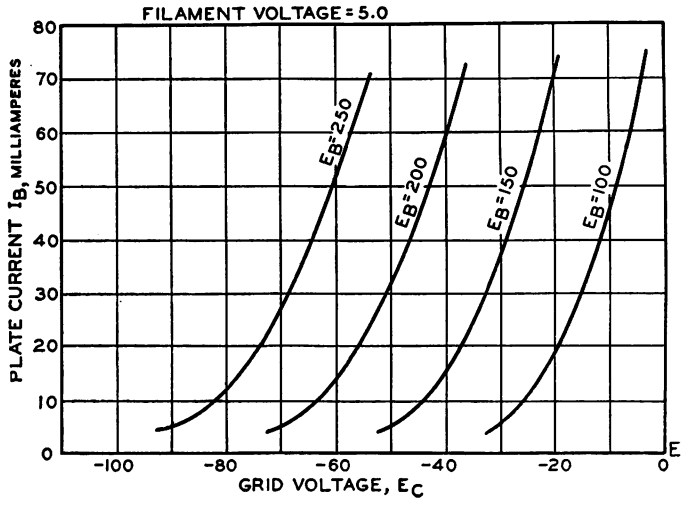
Filament Voltage		5 Volts, AC or DC
Average Filament Current		1.2 Amperes
Plate Voltage	200	250 Volts Maximum
Grid Voltage	—45	—60 Volts
Average Plate Current	45	52 Milliamperes
Average Plate Resistance	1,000	1,000 Ohms
Average Amplification Factor	2.9	2.85

Approximate Direct Interelectrode Capacities

Plate to Grid	12 MMF
Plate to Filament	3.2 MMF
Grid to Filament	6.8 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 275A Vacuum Tube.



General Features

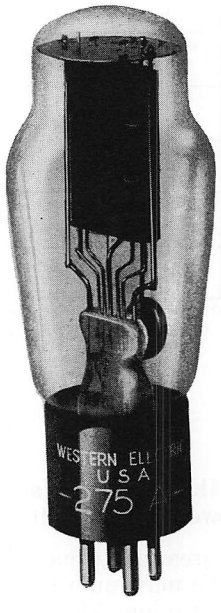
The electrical characteristics of the No. 275A Vacuum Tube make it particularly adaptable in applications requiring an output power tube operated at relatively low plate voltage.

It has an unusually large plate area for its energy dissipation. The total electron emission of the filament is large compared to the maximum space current drain. Both factors insure the delivery of full output power throughout a long life.

The rugged structure insures against breakage in shipment and in service and makes possible the maintenance of uniform electrical characteristics.

Western Electric

275A Vacuum Tube



Classification—Moderate-power, filamentary triode

The 275A tube is designed for a maximum plate voltage of 300 volts.

Application—Audio-frequency amplifier where power outputs of about 3 watts per tube are required.

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, four-pin, thrust type with bayonet pin.

Socket—Standard, four-contact type, such as the Western Electric 143B 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

Grid to plate	12.0 $\mu\mu$f.
Grid to filament	6.8 $\mu\mu$f.
Plate to filament	3.2 $\mu\mu$f.

Filament Rating

Filament voltage	5.0 volts, a.c. or d.c.
Nominal filament current	1.2 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. When the filament is heated by alternating current, the grid and plate returns should be connected to a center tap on the secondary of the filament transformer.

Characteristics—Plate current characteristics of a typical 275A tube are shown in Figure 3 as functions of grid bias for several values of plate voltage. Similar characteristics as functions of plate voltage for several values of grid bias are given in Figure 4. Amplification factor, plate resistance, and transconductance characteristics corresponding to the plate current characteristics of Figure 3 are given in Figures 5, 6 and 7, respectively. All of these characteristics are for direct-current filament supply with the grid and plate returns connected to the negative end of the filament. For alternating-current filament supply, the same characteristics are applicable if approximately 3.5 is added to the numerical value of each grid bias.

Limiting Conditions for Safe Operation

Maximum plate voltage	300 volts
Maximum plate dissipation	17 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	80 milliamperes

Operating Conditions and Output—Permissible combinations of operating plate voltage and plate current are included within the area, ABCDE, in Figure 3. Amplification factor, plate resistance, transconductance, and performance data are listed in the table below for typical operating conditions represented by selected points within this area. 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.

Where it is necessary to operate a 275A tube at or near its maximum operating plate current of 80 milliamperes or plate dissipation of 17 watts, provision should be made for adjusting the grid bias of each tube independently, so that the maximum safe plate current and dissipation will not be exceeded in any tube. Alternatively, a self-biasing circuit may be used, in which the grid bias for each tube is obtained from the voltage drop produced by the plate current 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 70 milliamperes and its plate dissipation to 15 watts so that tubes having plate currents higher than the average will not exceed the maximum ratings.

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, P_m, is given in watts and the second and third harmonic levels, F_{2m} and F_{3m}, are given in decibels below the fundamental in each case. The peak value of the sinusoidal input voltage, E_{gm}, is numerically equal to the grid bias for each operating condition. For a smaller input voltage, E_g, the output and harmonic levels are given approximately by the following relations:

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

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

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

The variations of power output and harmonic levels with load resistance for several values of operating plate current are shown in Figures 8, 9 and 10 for a plate voltage of 250 volts. The sharp minima which appear in the third harmonic curves are characteristic of the 275A tube, but their positions may be different for different tubes. For this reason, the third harmonic level in any individual tube may be widely different from the value given in the table, where the operating condition under consideration is near one of these minima. Near these points, also, the expression given above for third harmonic level is not reliable.

Table

Plate Voltage	Grid Bias	Plate Current	Amplification Factor	Plate Resistance	Transconductance	Input Voltage	Load Resistance	Power Output	Second Harmonic	Third Harmonic
Volts	Volts	Milliamperes		Ohms	Micromhos	Peak Volts	Ohms	Watts	db	db
150	−40	17	2.6	1630	1600	40	3260	0.81	19	39
							6520	0.58	23	50
150	−30	38	2.8	1065	2700	30	1065	0.86	19	40
							2130	0.77	24	50
							4260	0.56	29	65
150	−20	70	3.0	810	3700	20	810	0.55	26	55
							1620	0.49	30	80
							3240	0.36	34	60
200	−55	24	2.6	1530	1750	55	1530	2.0	15	35
							3060	1.6	19	39
							6120	1.2	23	50
200	−50	34	2.7	1230	2250	50	1230	2.0	16	35
							2460	1.8	20	41
							4920	1.3	25	55
200	−45	47	2.8	1030	2770	45	1030	1.9	18	37
							2060	1.7	22	43
							4120	1.3	27	60
200	−40	61	2.9	885	3270	40	885	1.8	20	40
							1770	1.6	25	49
							3540	1.2	29	75
250	−70	30	2.6	1400	1880	70	3000	2.8	18	39
							6000	2.0	23	50
							10000	1.4	26	70
250	−65	41	2.7	1170	2330	65	2000	3.2	19	37
							4000	2.5	23	47
							8000	1.5	28	75
250	−60	53	2.8	1000	2780	60	2000	3.1	21	41
							3000	2.6	23	47
							4000	2.3	25	55
							6000	1.7	28	80
							8000	1.4	29	60
							10000	1.2	30	60
*200	−35	78	2.9	780	3750	35	1560	1.5	27	55
							3120	1.1	31	60
*250	−55	68	2.8	870	3220	55	1000	3.3	19	38
							3000	2.4	26	55
							6000	1.6	30	60
							8000	1.2	31	55
*300	−100	18	2.4	2420	1000	100	9680	2.3	20	50
*300	−95	23	2.5	1910	1280	95	7640	2.6	21	49
*300	−90	30	2.6	1560	1630	90	6240	3.0	22	48
*300	−85	41	2.6	1300	2030	85	2600	4.7	18	38
							5200	3.3	23	49
*300	−80	51	2.7	1100	2450	80	2200	4.9	19	39
							4400	3.5	24	50

*Maximum operating conditions.

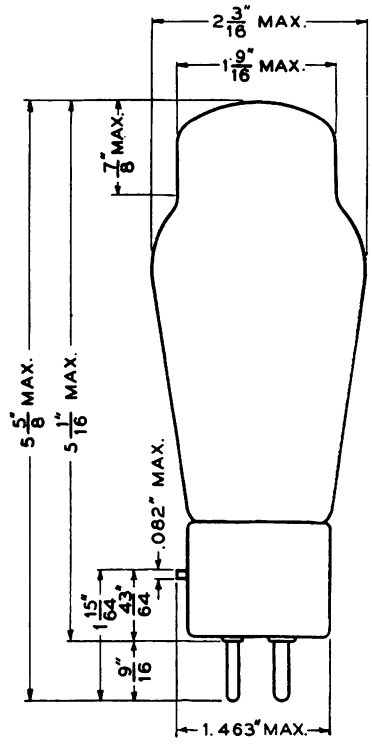

2 3/16" MAX.
1 9/16" MAX.
7/8" MAX.
5 5/8" MAX.
5 1/16" MAX.
.082" MAX.
15/64"
43/64"
9/16"
1.463" MAX.

FIG. 1

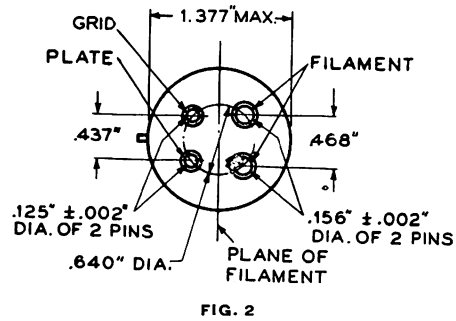

GRID
1.377" MAX.
PLATE
FILAMENT
.437"
.468"
.125" ±.002"
DIA. OF 2 PINS
.640" DIA.
PLANE OF
FILAMENT
.156" ±.002"
DIA. OF 2 PINS

FIG. 2

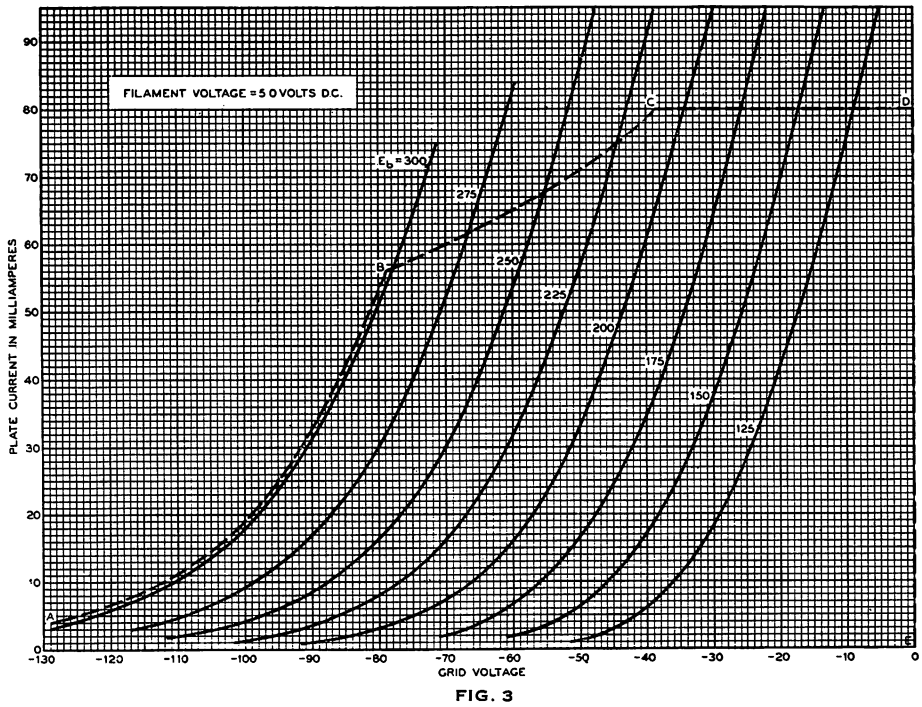

FILAMENT VOLTAGE = 5.0 VOLTS D.C.
E_b = 300
275
250
225
200
175
150
125
A
B
C
D
E
PLATE CURRENT IN MILLIAMPERES
GRID VOLTAGE
90
80
70
60
50
40
30
20
10
0
-130
-120
-110
-100
-90
-80
-70
-60
-50
-40
-30
-20
-10
0

FIG. 3

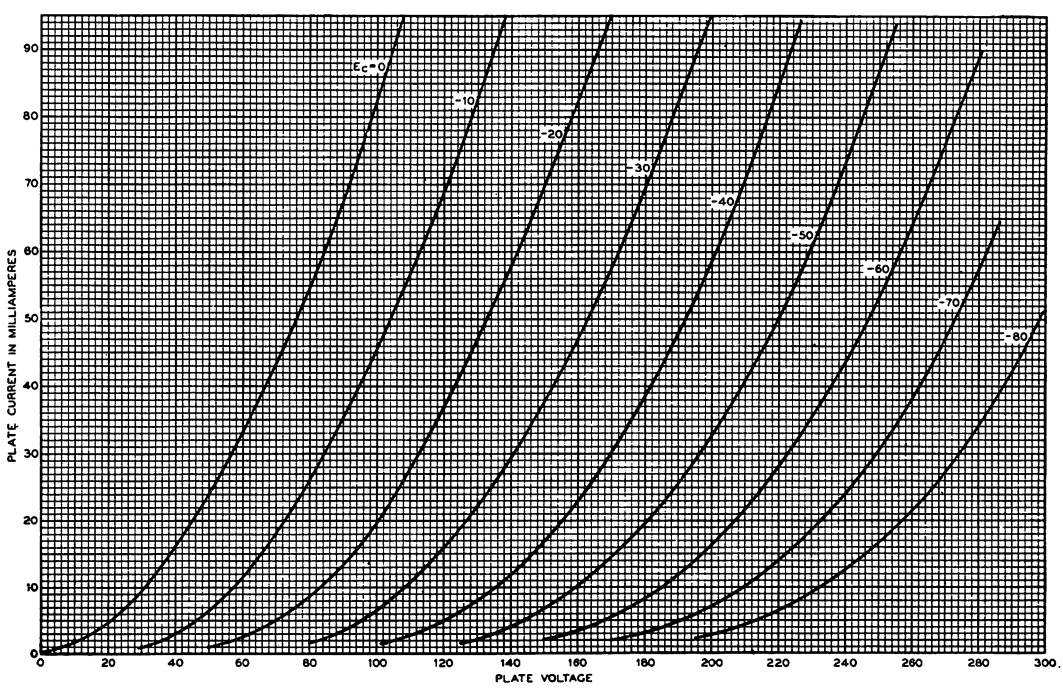

E_c = 0
-10
-20
-30
-40
-50
-60
-70
-80
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

FIG. 4

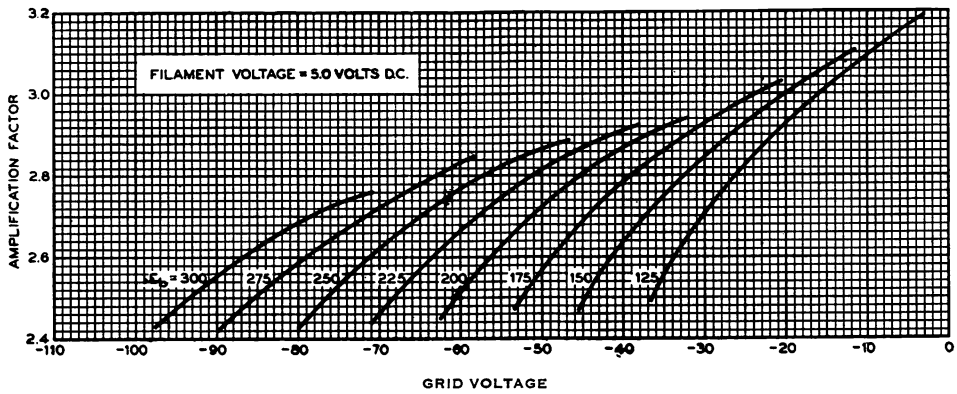


FIG. 5

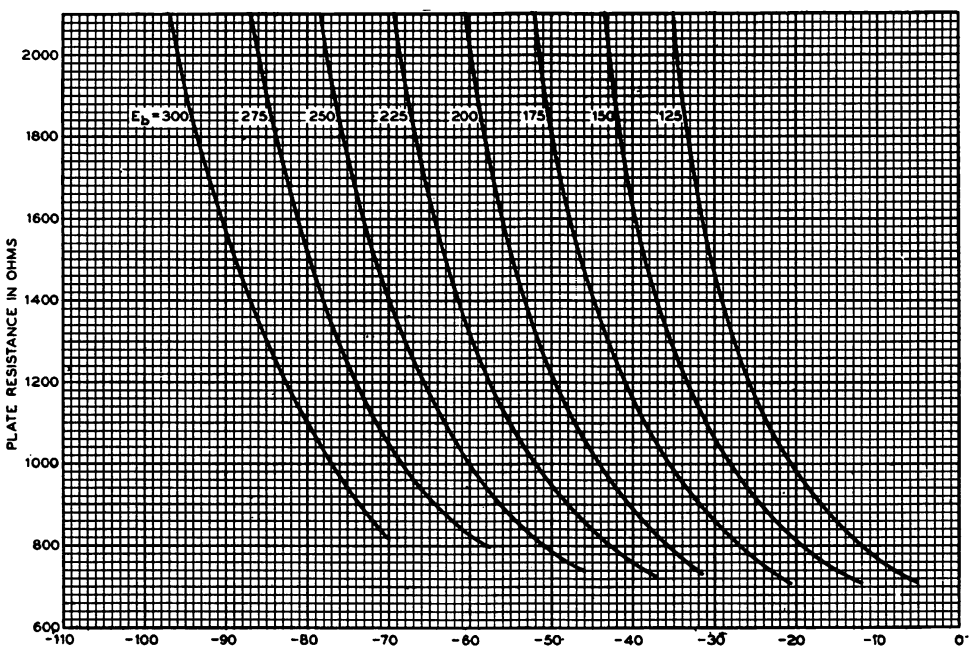


FIG. 6

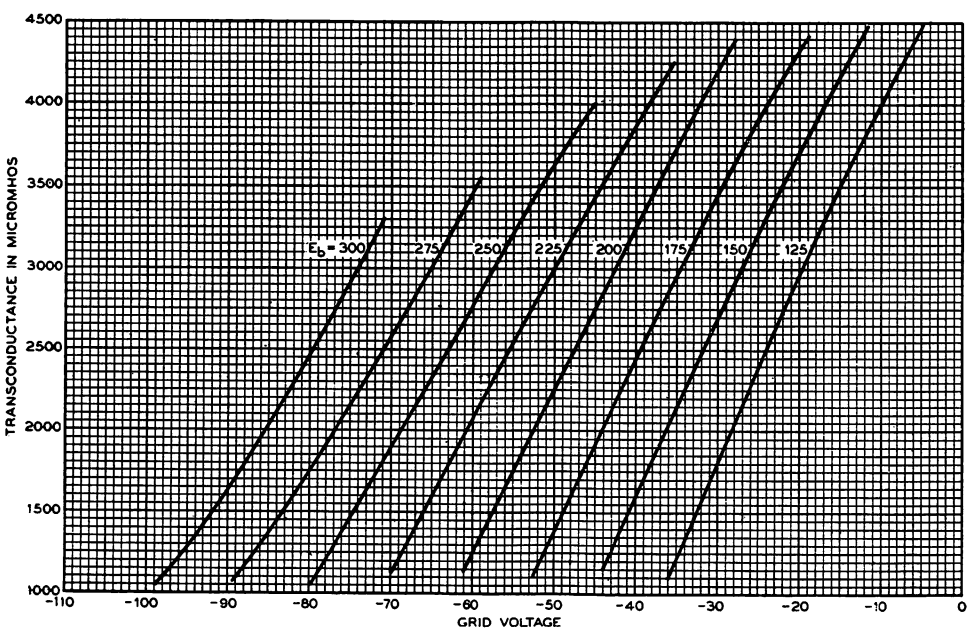


FIG. 7

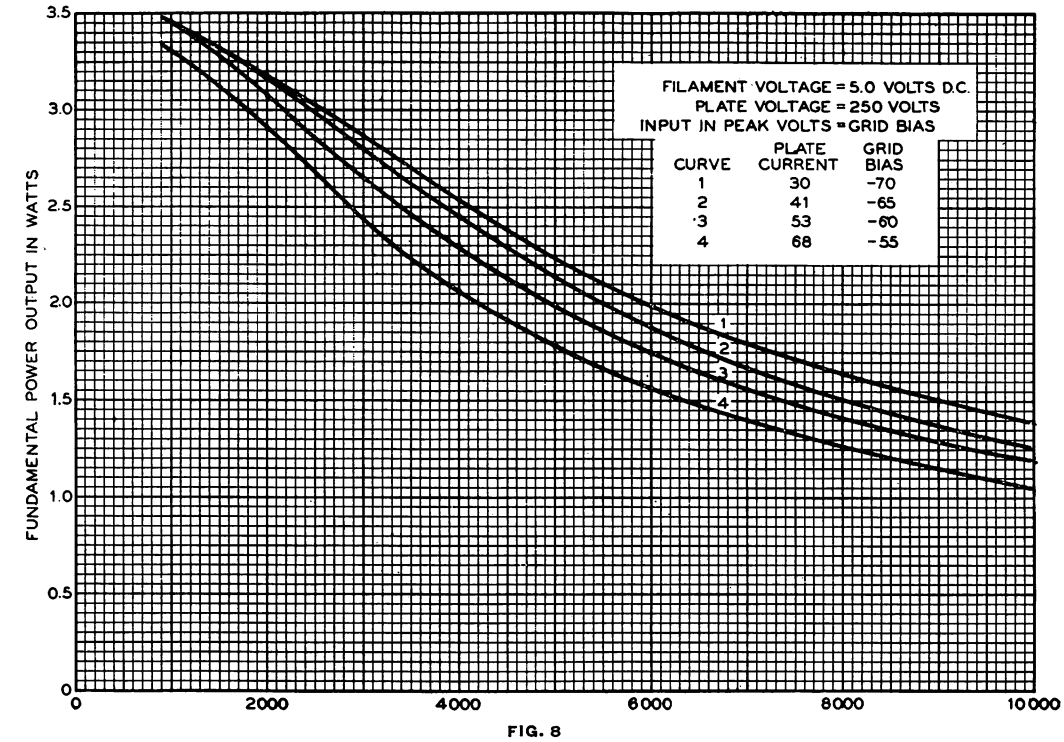


FIG. 8

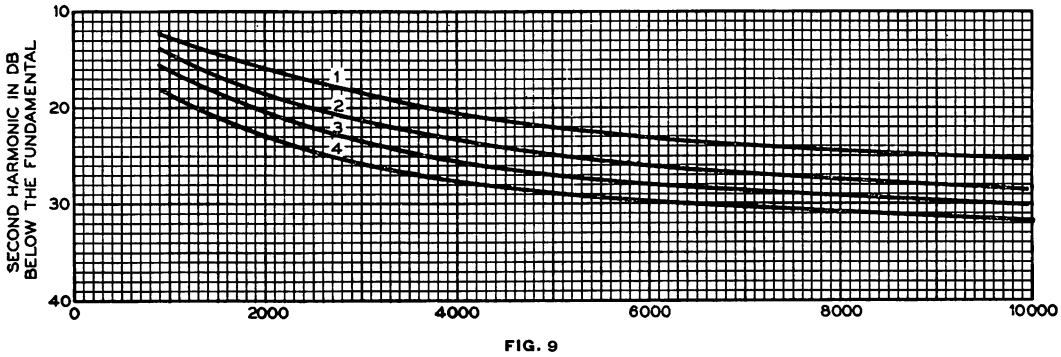


FIG. 9

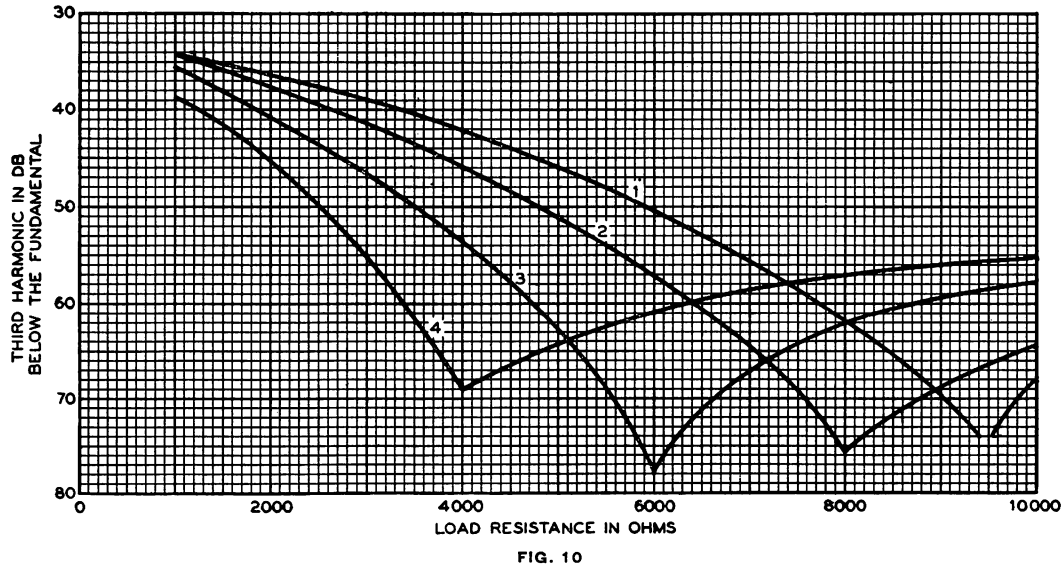


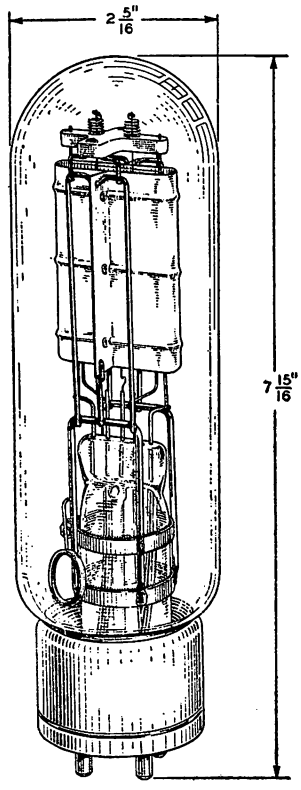
FIG. 10

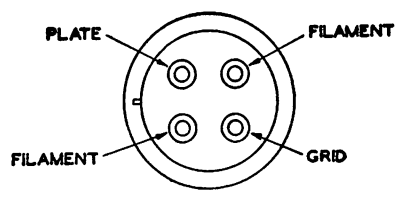
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V. T. DATA SHEET 275A
ISSUE 1

276A Vacuum Tube





Classification

The No. 276A Vacuum Tube is a three-element tube used as an oscillator, radio-frequency amplifier, modulator or audio-frequency amplifier.

Base and Socket

The No. 276A Vacuum Tube employs a standard four-prong bayonet pin type base suitable for use in a Western Electric No. 112A or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

General Ratings and Information

Filament Voltage	10 Volts, AC
Nominal Filament Current	3 Amperes
Maximum Plate Voltage	1,250 Volts
Maximum Plate Current	0.125 Ampere
Average Plate Resistance	3,500 Ohms
Average Amplification Factor	12

Approximate Direct Interelectrode Capacities

Plate to Grid	9 MMF
Plate to Filament	4 MMF
Grid to Filament	6 MMF

Audio-Amplifier or Modulator Rating—Peak Grid Drive equal to or less than the bias—Class A Service.

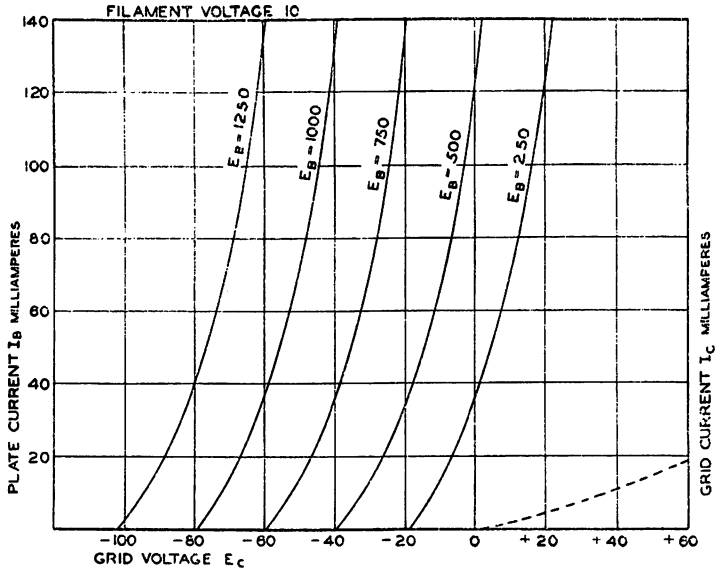
Maximum Plate Voltage	1,000
Maximum Plate Current	0.85 Ampere
Maximum Plate Dissipation	85 Watts
Grid Bias Voltage	—50 Volts
Load Impedance	7,000 Ohms
Undistorted Output	10 Watts

Radio-Frequency Amplifier—Grid Bias practically at cut-off, grid drive higher than the bias—Class B Service.

Maximum Plate Voltage	1,250
Maximum Plate Current	0.125 Ampere
Maximum Plate Dissipation	100 Watts
Grid Bias Voltage	—100 Volts
Peak Output	100 Watts

Oscillator or Radio-Frequency Amplifier—Grid Bias below Cut-Off—Class C Service.

Maximum Modulated Plate Voltage (DC)	1,000 Volts
Maximum Non-modulated Plate Voltage (DC)	1,250 Volts
Maximum Plate Current	0.125 Ampere
Maximum Plate Dissipation	100 Watts
Maximum Radio-Frequency Charging Current in Grid and Plate Leads	5 Amperes
Approximate Grid Bias	—150 Volts
Maximum Output	100 Watts



Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 276A Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid returns connected to a center point on the filament transformer.

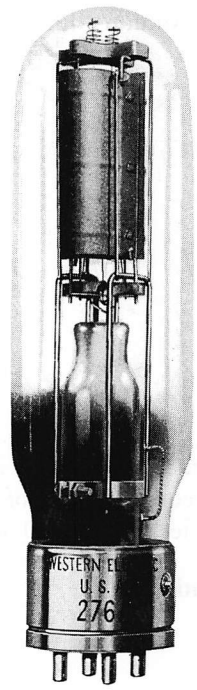
General Features

The electrical characteristics of the No. 276A Vacuum Tube are substantially the same as the No. 242A Vacuum Tube except for interelectrode capacities and filament resistance. In the design of the No. 276A Vacuum Tube, special attention has been given to obtain low interelectrode capacities. This permits of satisfactory operation over a wide frequency range. With a filament potential drop of 10 volts, the filament current range of the No. 276A Vacuum Tube is 2.8 to 3.2 amperes while for the No. 242A Vacuum Tube, the filament current range is 3.0 to 3.4 amperes. Thoriated tungsten is used for the filament in both tubes.

This Vacuum Tube has an unusually rugged type of structure which insures it against breakage in shipment and service and makes possible the maintenance of uniform electrical characteristics.

Western Electric

276A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

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

Maximum overall length	$7\frac{15}{16}$″
Maximum diameter	$2\frac{5}{16}$″

Mounting—Large four-pin bayonet base suitable for use in a W.E. 112A or similar socket for either vertical or horizontal mounting. If mounted horizontally the plane of the filament wires, which is indicated in Figure 2, should be vertical.

Filament—Thoriated tungsten

Filament voltage	10 volts, a.c.
Nominal filament current	3.0 amperes
Average thermionic emission	1.25 amperes

Average Direct Interelectrode Capacitances

Plate to grid	9.0 $\mu\mu f$
Grid to filament	6.0 $\mu\mu f$
Plate to filament	4.0 $\mu\mu f$

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 maximum direct plate voltage and dissipation—Class A (E_b = 1,250 volts, I_b = 68 milliamperes)

Amplification factor	12
Plate resistance	3000 ohms
Grid to plate transconductance	4000 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1250 volts
Max. direct plate current	125 milliamperes
Max. plate dissipation	100 watts
Max. direct grid current	50 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	30 megacycles
Max. plate voltage for upper frequency limit of 40 Mc	750 volts
Max. plate voltage for frequencies between 30 and 40 Mc in proportion	

Class A Audio Amplifier or Modulator

Direct plate voltage	1250	1000 volts
Grid bias	−75	−50 volts
Direct plate current	68	85 milliamperes
Plate dissipation	85	85 watts
Load impedance	8000	7000 ohms
Undistorted output	20	10 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	1250	1000 volts
Grid bias	−90	−67 volts
Direct plate current per tube		
No drive	20	20 milliamperes
Max. drive	125	125 milliamperes
Plate dissipation	70	65 watts
Load resistance plate-to-plate	9000	7000 ohms
Load resistance per tube	2250	1750 ohms
Approximate maximum output—2 tubes	175	135 watts
Recommended power for driving stage	25	25 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	1250	1000 volts
Grid bias	−100	−80 volts
Direct plate current for carrier conditions	125	125 milliamperes
Approximate carrier watts for use with 100% modulation	50	42 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1250	1000 volts
Grid bias	−150 to −200	−120 to −160 volts
Direct plate current	125	125 milliamperes
Nominal power output	100	85 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1000	750 volts
Grid bias	−160	−120 volts
Direct plate current	125	125 milliamperes
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	85	65 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 150 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 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 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 output can be increased or the distortion decreased by the use of degenerative feedback. 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—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. The tube may be used at full rating up to 30 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.

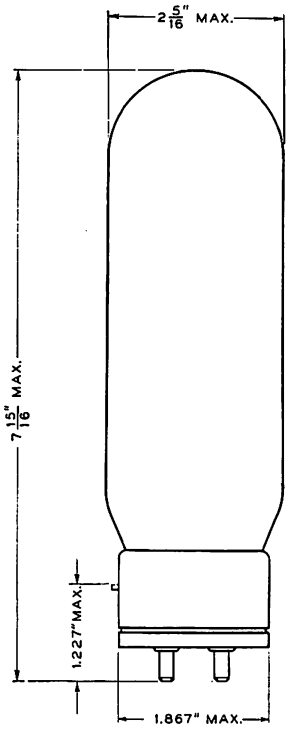

2 5/16" MAX.
7 15/16" MAX.
1.227" MAX.
1.867" MAX.

FIG. 1

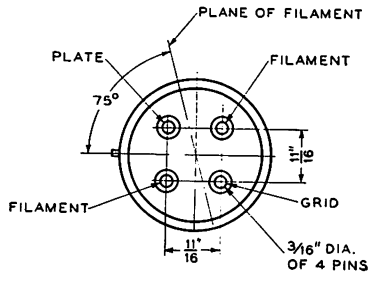

PLANE OF FILAMENT
PLATE
FILAMENT
75°
11/16"
FILAMENT
GRID
11/16"
3/16" DIA.
OF 4 PINS

FIG. 2

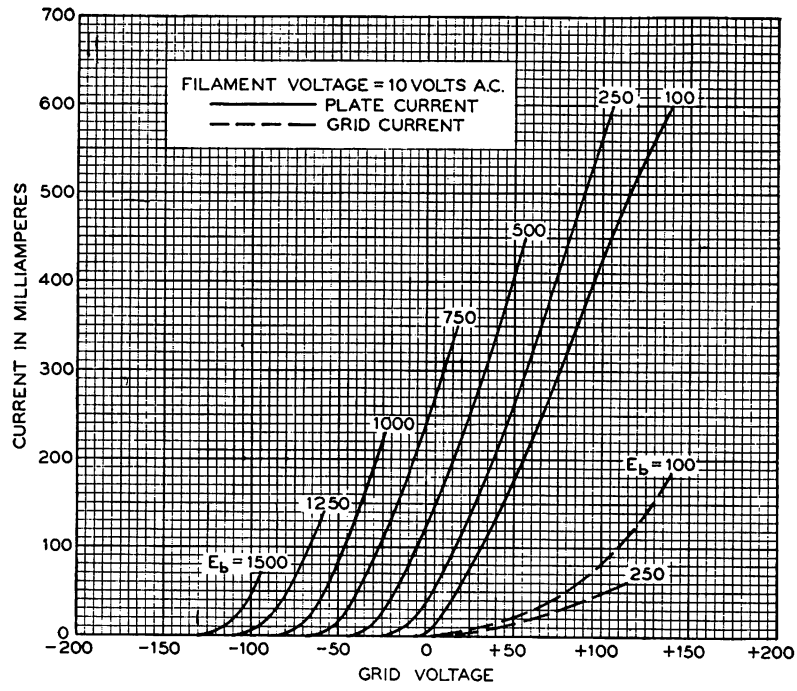

FILAMENT VOLTAGE = 10 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
700
600
500
400
300
200
100
0
-200
-150
-100
-50
0
+50
+100
+150
+200
250
100
500
750
1000
1250
E_b = 1500
E_b = 100
250

FIG. 3

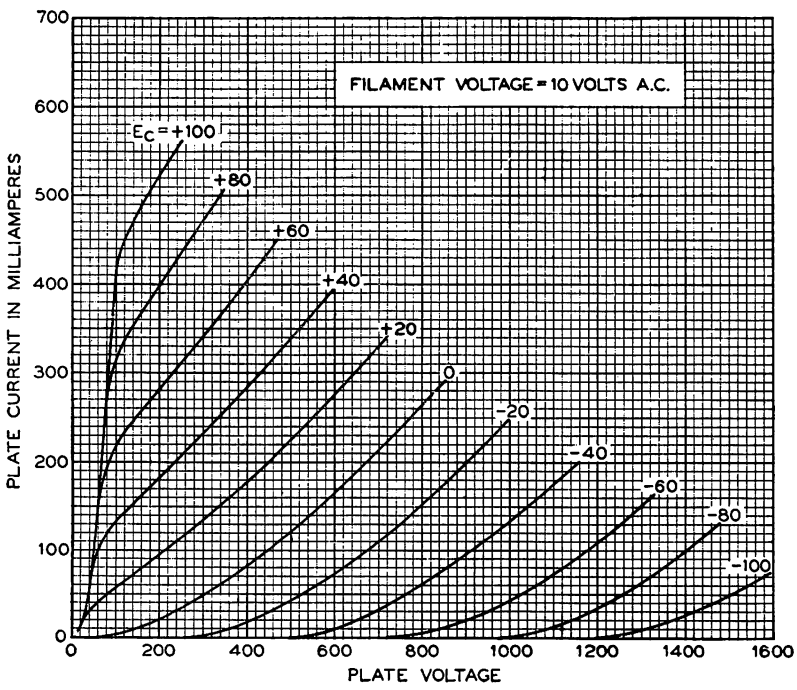
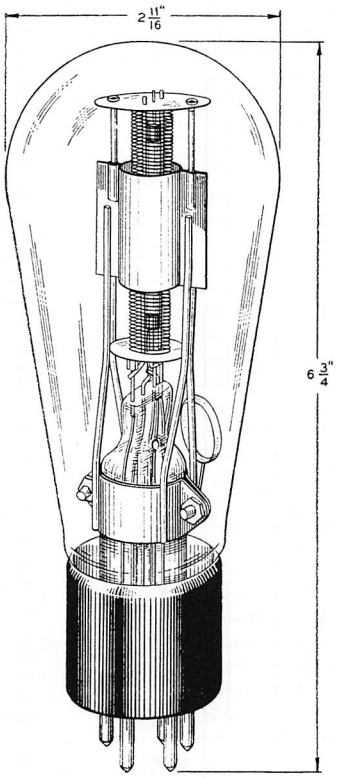
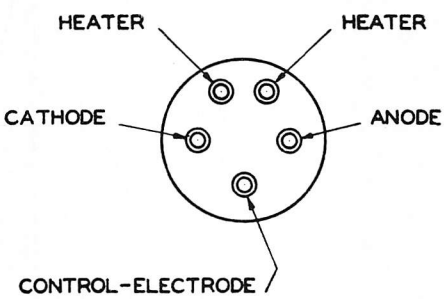

FILAMENT VOLTAGE = 10 VOLTS A.C.
PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
1400
1600
E_C = +100
+80
+60
+40
+20
0
-20
-40
-60
-80
-100

FIG. 4

277A Vacuum Tube





Classification

The No. 277A Vacuum Tube is a three-element tube which employs an indirectly heated cathode and contains argon gas at a low pressure. It is intended for use in special circuits as a relay or trigger-action device.

Base and Socket

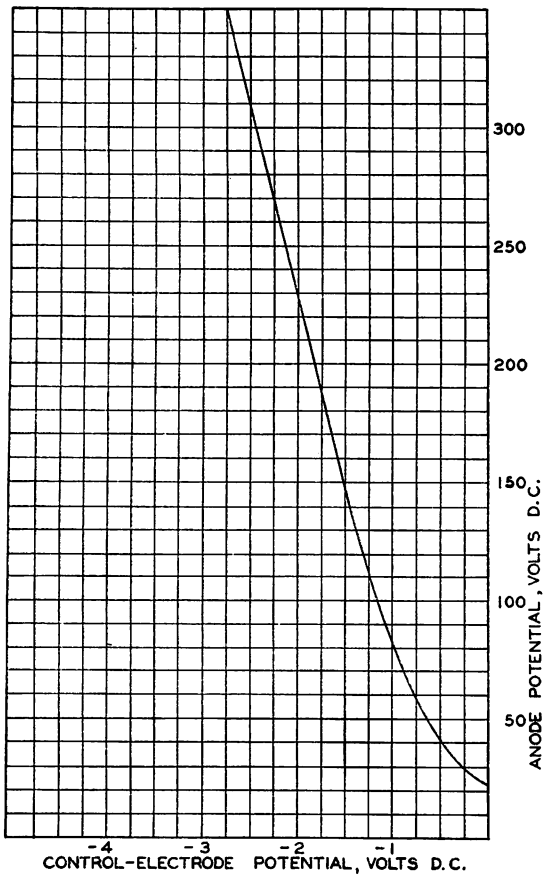
The No. 277A Vacuum Tube employs a standard five-prong, thrust-type base suitable for use in a Western Electric No. 137A Socket or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

Rating and Characteristic Data

Heater Voltage	5 Volts, AC
Nominal Heater Current	2 Amperes
Anode-Cathode Potential Drop when Conducting	10 to 20 Volts
Maximum Instantaneous Space Current	500 Milliamperes
Maximum Instantaneous Potential between Anode and Control-Electrode	350 Volts
Maximum Potential between Cathode and Heater	12 Volts

Breakdown Characteristics

A typical curve relating the critical control-electrode potential to the anode potential is given in the accompanying chart. This characteristic may vary from tube to tube and during the life of a given tube.

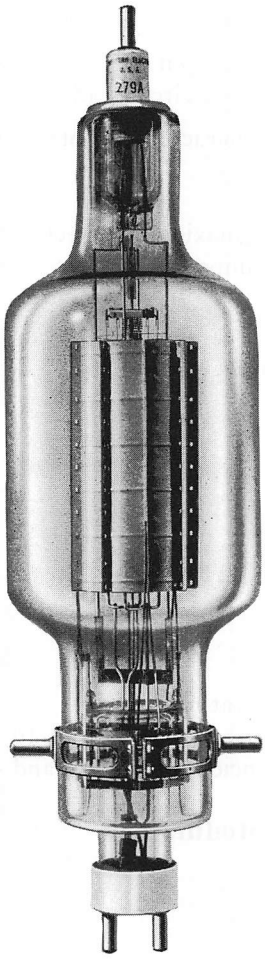


General Features

The No. 277A Vacuum Tube is primarily a rectifier of low internal impedance whose conduction cycle is determined by the relative instantaneous control-electrode and anode potentials. The special treatment of electrode elements and the use of argon gas whose pressure remains practically constant over wide temperature ranges are outstanding design features. The above qualities insure uniform and reproducible characteristics essential to various circuit applications such as: a controlled frequency oscillator giving a square wave form, a peak voltmeter or volume level-indicator and a variable voltage rectifier.

Western Electric

279A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

Dimensions—Dimensions and outline diagrams are shown in Figure 1. The overall dimensions are:

Maximum overall length	$21\frac{11}{16}$″
Maximum diameter	6″

Mounting—W.E. 142A or similar socket. See Figure 1 for mounting arrangements. The tube should be mounted in a vertical position.

Filament—Thoriated tungsten.

Filament voltage	10 volts a.c.
Nominal filament current	21.0 amperes
Average thermionic emission	8.0 amperes

Average Direct Interelectrode Capacitances

Plate to grid	18.0 $\mu\mu$f
Grid to filament	15.0 $\mu\mu$f
Plate to filament	7.0 $\mu\mu$f

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

Figures 2 and 3 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at maximum direct plate voltage and dissipation — Class A (E_b=2500 volts, I_b = 300 milliamperes.)

Amplification factor	10
Plate resistance	2000 ohms
Grid to plate transconductance	5000 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	3000 volts
Max. direct plate current	800 milliamperes
Max. plate dissipation	1200 watts
Max. direct grid current	100 milliamperes
Max. r-f grid current	15 amperes
Max. frequency for the above ratings	20 megacycles
Max. plate voltage for upper frequency limit of 40 Mc	1500 volts

Max. plate voltage for frequencies between 20 and 40 Mc in proportion.

Class A Audio Amplifier or Modulator

Direct plate voltage	2500	2000 volts
Grid bias	−170	−110 volts
Direct plate current	300	375 milliamperes
Plate dissipation	750	750 watts
Load impedance	4500	2000 ohms
Undistorted output	155	85 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	2500	2000 volts
Grid bias	−200	−150 volts
Direct plate current per tube		
No drive	150	110 milliamperes
Max. drive	800	800 milliamperes
Plate dissipation	900	720 watts
Load resistance, plate-to-plate	2800	2240 ohms
Load resistance, per tube	700	560 ohms
Approximate maximum output—2 tubes	2200	1760 watts
Recommended power for driving stage	100	100 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	3000	2500 volts
Direct plate current for carrier conditions	600	720 milliamperes
Grid bias	−325	−275 volts
Approximate carrier watts for use with 100% modulation	600	600 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	3000	2500 volts
Direct plate current	800	800 milliamperes
Grid bias	−500 to −650	−400 to −540 volts
Max. direct grid current	150	100 milliamperes
Nominal power output	1600	1300 watts
Plate dissipation	800	700 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	2250	1750 volts
Direct plate current	600	700 milliamperes
Grid bias	−450	−360 volts
Max. direct grid current	100	100 milliamperes
Nominal carrier power output for use with 100% modulation	900	830 watts

Operating Precautions

Mechanical—Figure 1 shows 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 1000 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 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 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 is 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—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. The tube may be used at full rating up to 20 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.

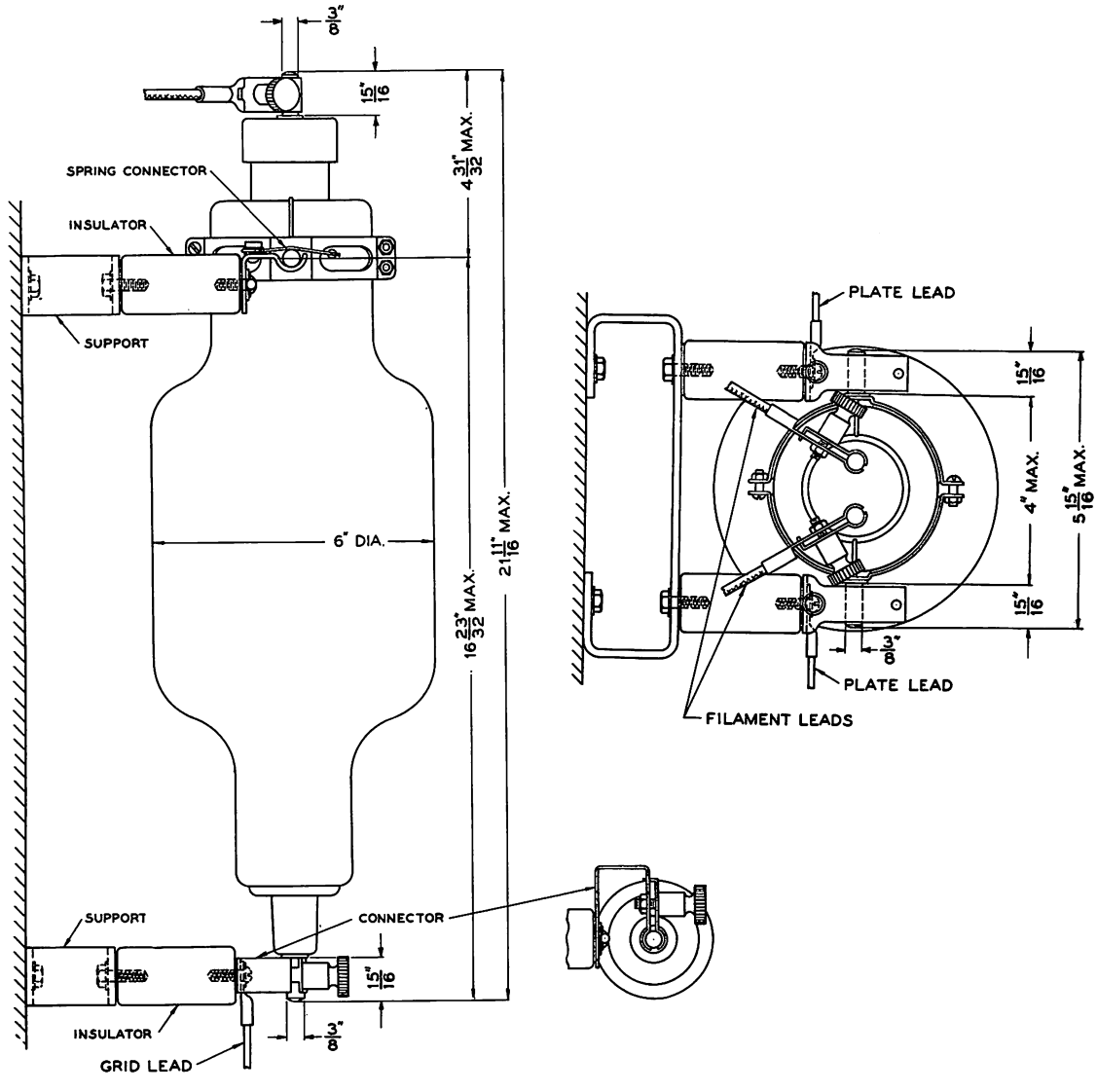


FIG. 1

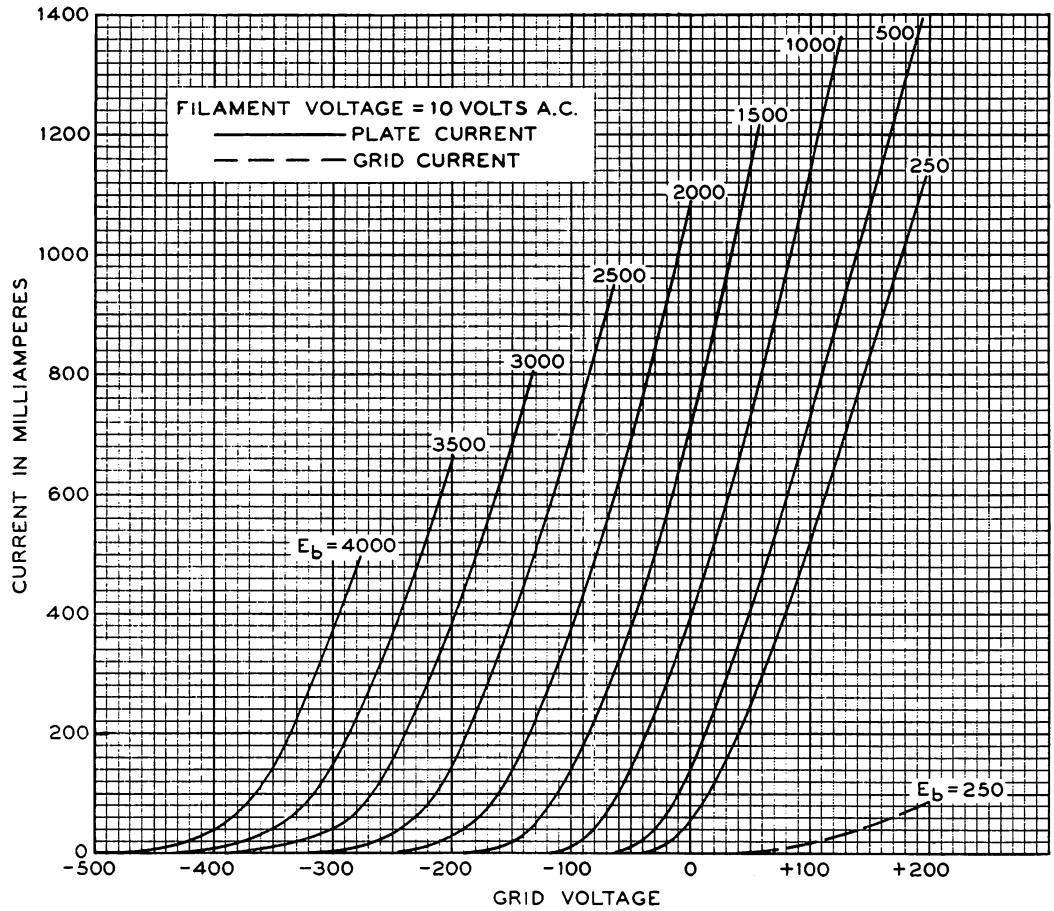


FIG. 2

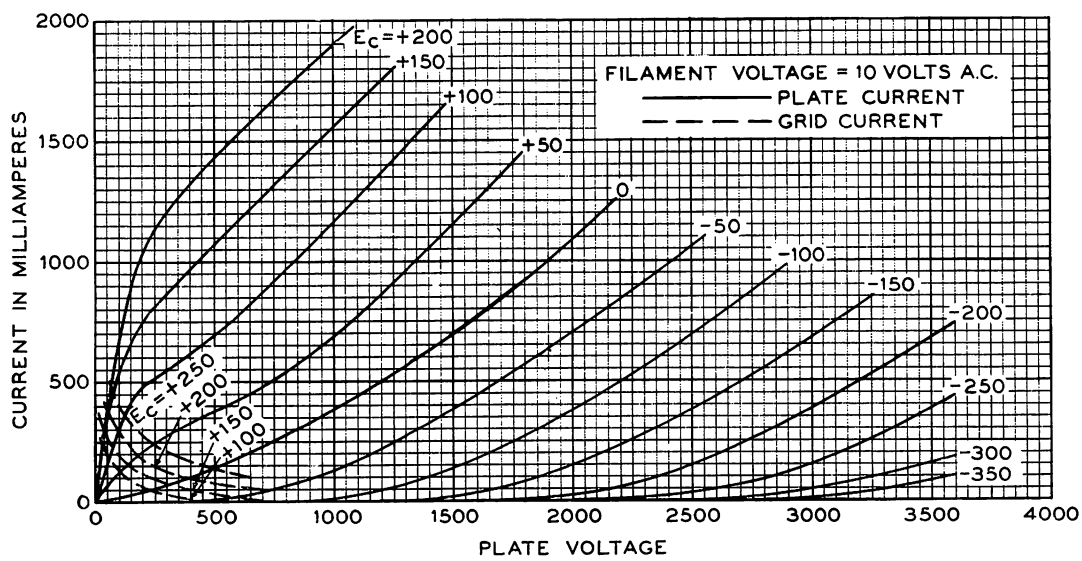


FIG. 3

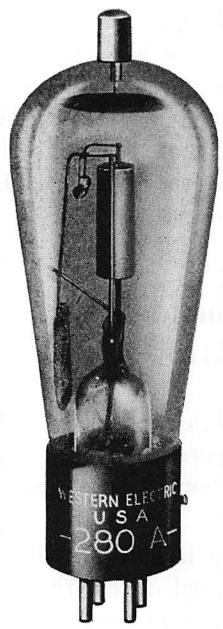
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A development of Bell Telephone Laboratories, Incorporated, the research laboratories of the American Telephone and Telegraph Company, and the Western Electric Company

V. T. DATA SHEET 279A
ISSUE 1

Western Electric

280A Vacuum Tube



Classification—Half-wave, thermionic, mercury vapor rectifier

The 280A vacuum tube is designed to supply direct current from an alternating-current supply.

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

Base—Standard medium four-pin thrust type; small metal cap anode terminal located at the top of the bulb. Base dimensions and the arrangement of electrode connections to the base terminals are shown in Figures 1 and 2.

Socket—Standard four-contact type, such as the Western Electric 143B socket. It is to be noted from the arrangement of filament terminals shown in Figure 2, that the terminals are tied together in parallel. The corresponding socket terminals should also be connected to insure the best contact connections for the filament circuit.

Mounting Position—The tube should be mounted only 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	2.5 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 (2.5 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 transformers with good regulation are used, this time is 10 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. For an ambient temperature of 15° C. the filament warming time required is 5 minutes and for an ambient temperature of 10° C., the time required is 12 minutes. A period of 5 to 10 minutes 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	15 volts
Maximum peak plate current	0.5 ampere
Maximum peak potential between electrodes	3500 volts
Maximum operating ambient temperature range	10 to 50° C.
Recommended operating ambient temperature range	15 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 potential drop as a function of the temperature is shown in Figure 3, for a typical 280A vacuum tube when passing the rated space current. The recommended operating temperature range is also shown.

The maximum permissible peak plate current (0.5 ampere) is a limitation of 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 (3500 volts) is a limitation on the instantaneous value that the tube can stand safely in the opposite direction to that in which it is designed to conduct. 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.

280A 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.

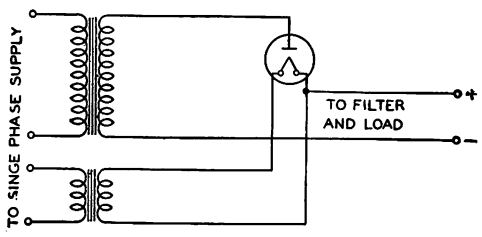
In most cases the termination of the useful life of the tube is due to the loss of filament activity. This sometimes may be predicted by an increase in the anode-cathode potential drop. If not removed such tubes may fail by arcing back under the applied inverse potential. Failures of this kind should be safeguarded by proper fuse protection to prevent injury to other tubes in the set and to the auxiliary equipment. In most circuits this requires a high-voltage, quick-acting fuse in each anode lead.

Typical Rectifier Circuits

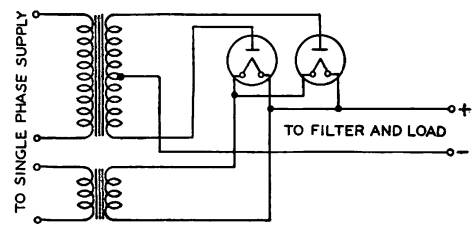
The 280A vacuum tube may be used in any standard high vacuum rectifier circuit subject to its current, voltage and temperature limitations. Typical circuits are shown below. The approximate direct output current and voltage for each type of rectifier circuit where tubes are operated at maximum permissible plate current and inverse voltage are given in Table 1. The values listed below are average values of the pulsating current and voltage for an unfiltered circuit.

Table 1

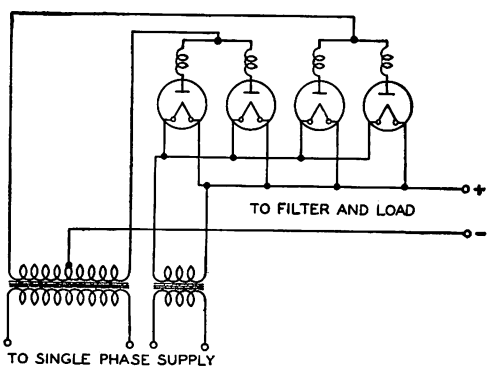
Circuit Designation	Number of Tubes	Load Potential in Volts	Load Current in Amperes
A	1	1000	0.15
B	2	1000	0.30
C	4	1000	0.60
D	4	2000	0.30
E	3	1500	0.45
F	6	3000	0.45
G	6	1500	0.90



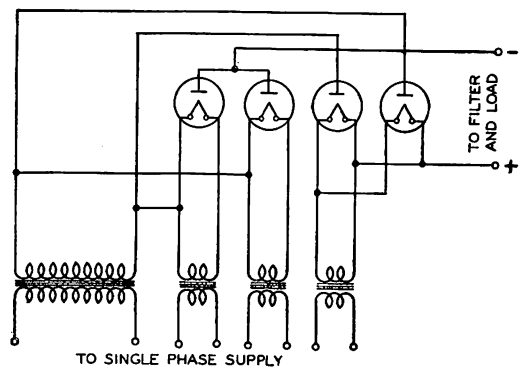
SINGLE PHASE, HALF-WAVE
CIRCUIT A



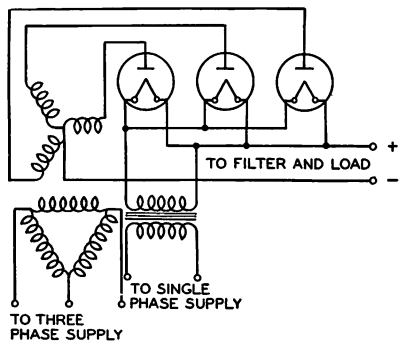
SINGLE PHASE, DOUBLE HALF-WAVE
CIRCUIT B



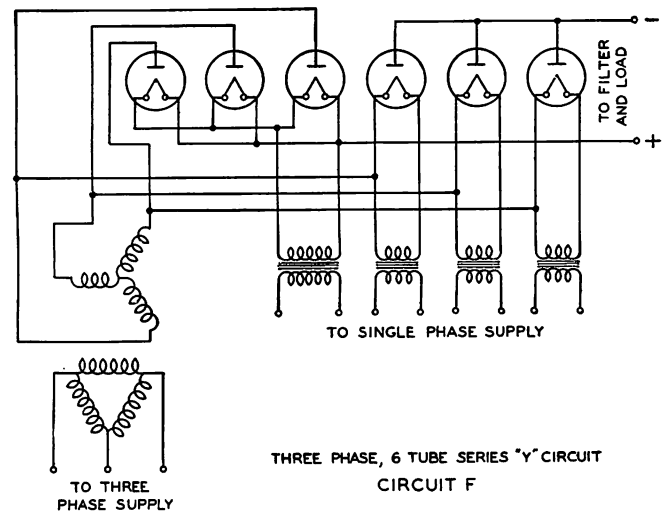
SINGLE PHASE, DOUBLE HALF-WAVE IN PARALLEL
CIRCUIT C



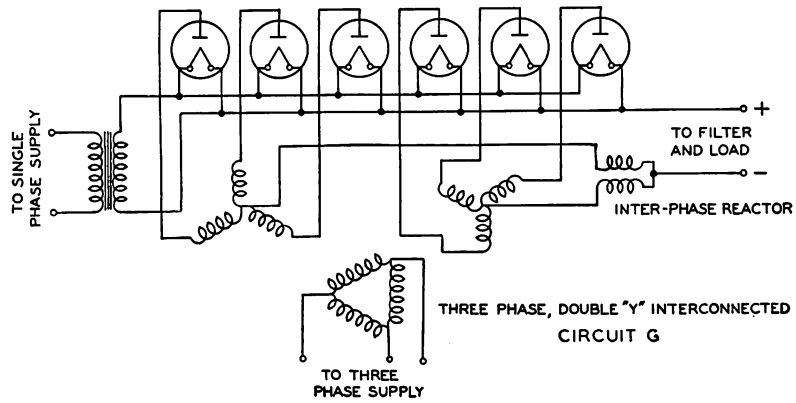
SINGLE PHASE, DOUBLE HALF-WAVE,
4 TUBE SERIES CIRCUIT
CIRCUIT D



THREE PHASE, "Y" CIRCUIT
CIRCUIT E



THREE PHASE, 6 TUBE SERIES "Y" CIRCUIT
CIRCUIT F



THREE PHASE, DOUBLE "Y" INTERCONNECTED
CIRCUIT G

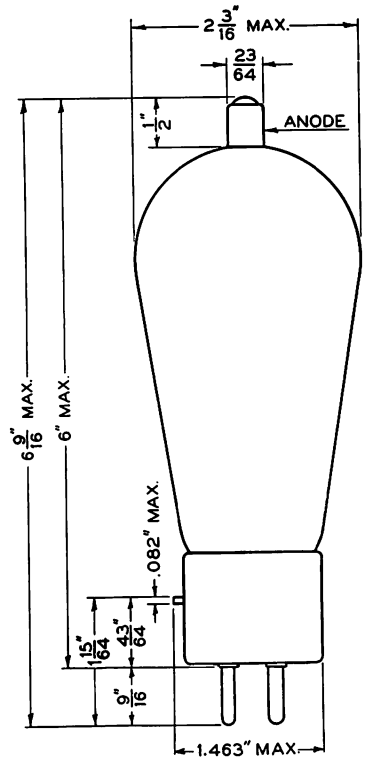


FIG. 1

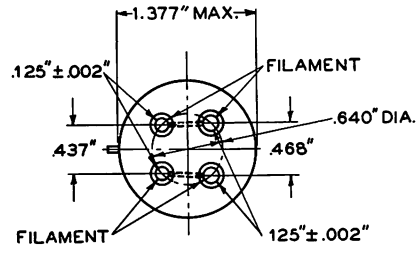


FIG. 2

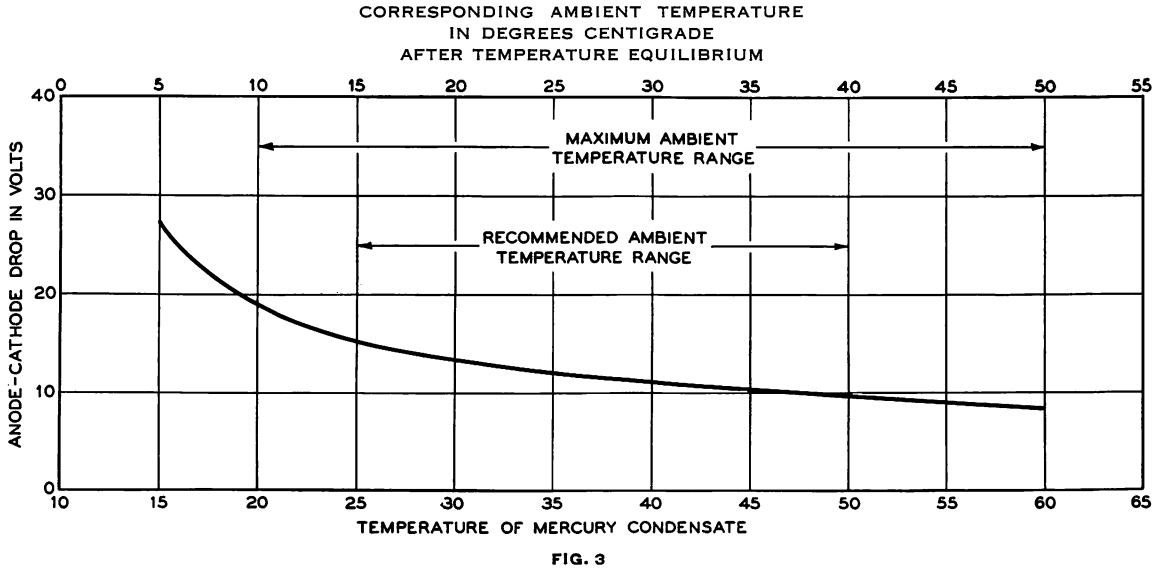
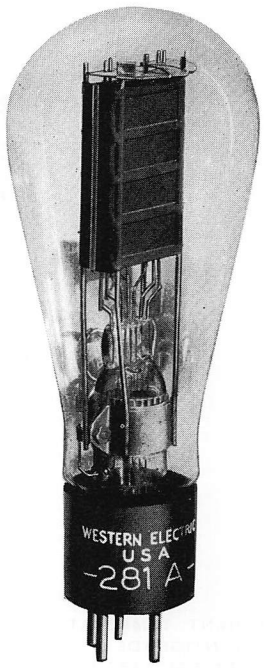


FIG. 3

Western Electric

281A Vacuum Tube



Classification—Moderate-power, filamentary, coplanar-grid tetrode

Applications

Audio-frequency amplifier where moderate power outputs are required, especially where only relatively low plate voltages are available.

High-vacuum control element in automatically controlled equipment.

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 type.

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	3.8 μμf
Control grid to filament and positive grid	18 μμf
Plate to filament and positive grid	9.4 μμf

Filament Rating

Filament voltage	5.0 volts, a.c. or d.c.
Nominal filament current	1.6 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. 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—Plate current and positive-grid current characteristics of a typical 281A tube are shown in Figure 3 as functions of control-grid voltage for a positive-grid voltage of 70 volts and several values of plate voltage. Corresponding amplification factor and plate resistance characteristics are shown in Figures 4 and 5, respectively. For any other value of positive-grid voltage, the plate current characteristics are approximately the same as those of Figure 3 except that the numerical value of each control-grid voltage must be changed by the same amount as the change made in the positive-grid voltage. For example, for a positive-grid voltage of 60 volts, the plate current characteristics of Figure 3 can be applied by subtracting 10 from the numerical value of each abscissa. The extent to which this rule is accurate is shown in Figure 6. This gives the relation between the positive-grid voltage and the control-grid voltage for constant plate current at each of three values of plate voltage. The corresponding values of positive-grid current, amplification factor, and plate resistance are shown in Figures 7, 8 and 9, respectively. The small variations in the amplification factor and plate resistance values are indicative of the small differences to be expected in the shapes of the plate current characteristics for different positive-grid voltages.

Limiting Conditions for Safe Operation

Maximum plate voltage	250 volts
Maximum plate current	45 milliamperes
Maximum potential difference between positive and control grids	150 volts
Maximum instantaneous control-grid potential on positive swing of input voltage	+10 volts

Operating Conditions and Output—Amplification factor, plate resistance, 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 may 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 no greater than the indicated values. The input voltage is given in peak volts, the power output in watts, and the harmonic levels in decibels below the fundamental.

Plate Voltage	Positive-Grid Voltage	Control-Grid Bias	Plate Current	Positive-Grid Current	Amplification Factor	Plate Resistance	Input Voltage	Load Resistance	Power Output	Second Harmonic	Third Harmonic
Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Peak Volts	Ohms	Watts	db	db
130	43	−40	25	0.2	5.1	3700	40	5000	1.1	29	30
130	63	−60	25	0.4	5.0	4000	60	3000	2.0	21	20
130	53	−40	35	0.4	5.0	3200	40	4000	1.2	33	30
130	72	−60	35	0.7	5.0	3400	60	2000	2.2	21	23
130	59	−40	45	0.9	5.1	2900	40	2800	1.4	30	30
180	55	−50	40	0.3	5.2	3400	50	5000	2.1	30	30
180	70	−65	40	0.4	5.2	3600	65	3500	3.3	26	24
*250	65	−70	45	0.2	5.2	3600	70	5000	4.2	26	29

*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 given in Figures 10, 11 and 12, respectively, for a typical operating condition. Figure 13 gives fundamental power output as a function of harmonic level for equal second and third harmonics at another typical operating condition. The corresponding values of input voltage and load resistance are shown in Figures 14 and 15, respectively.

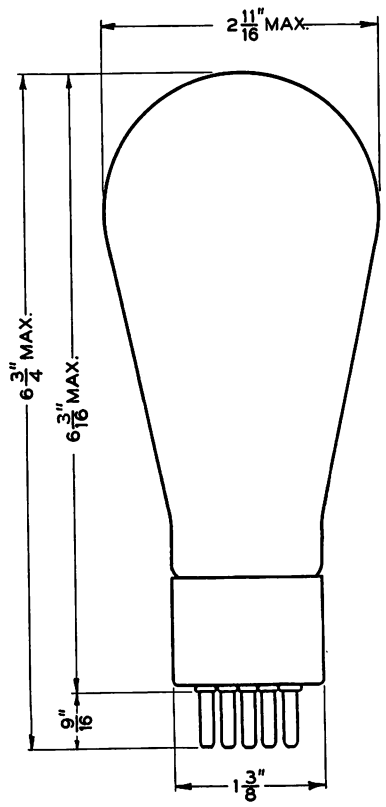


FIG. 1

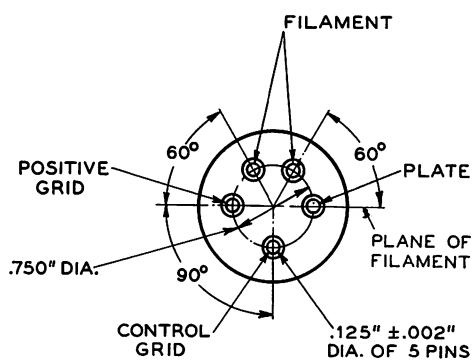


FIG. 2

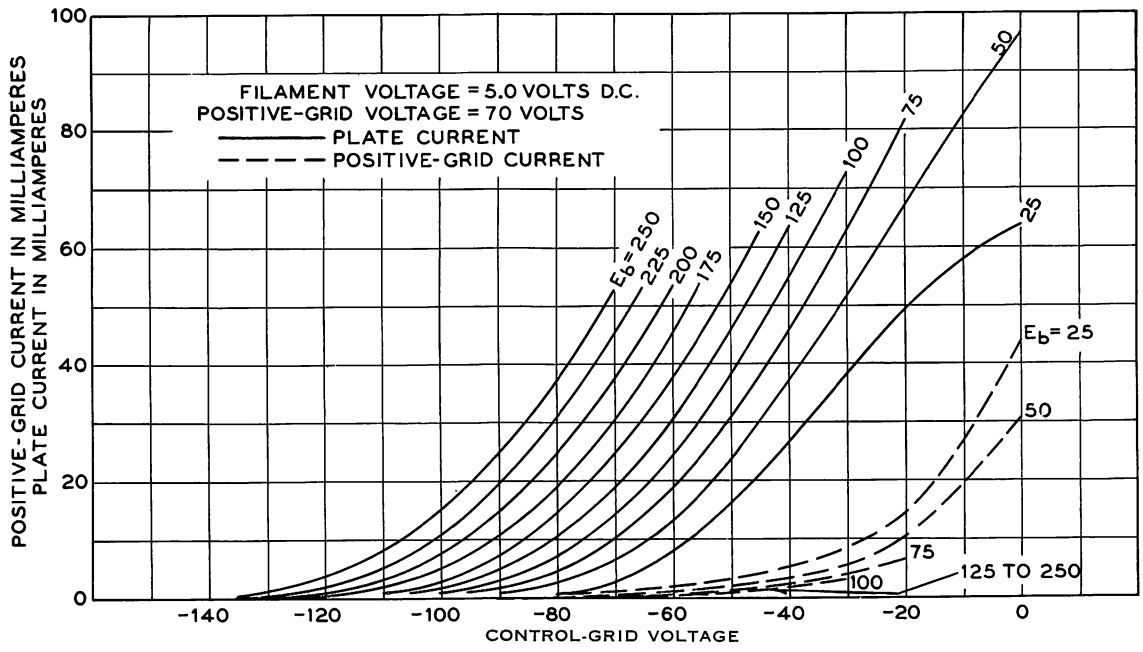


FIG. 3

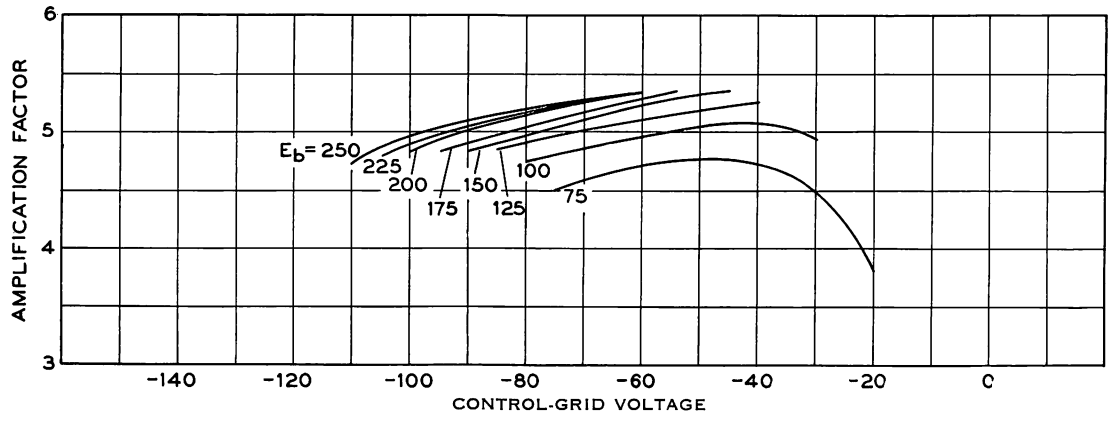


FIG. 4

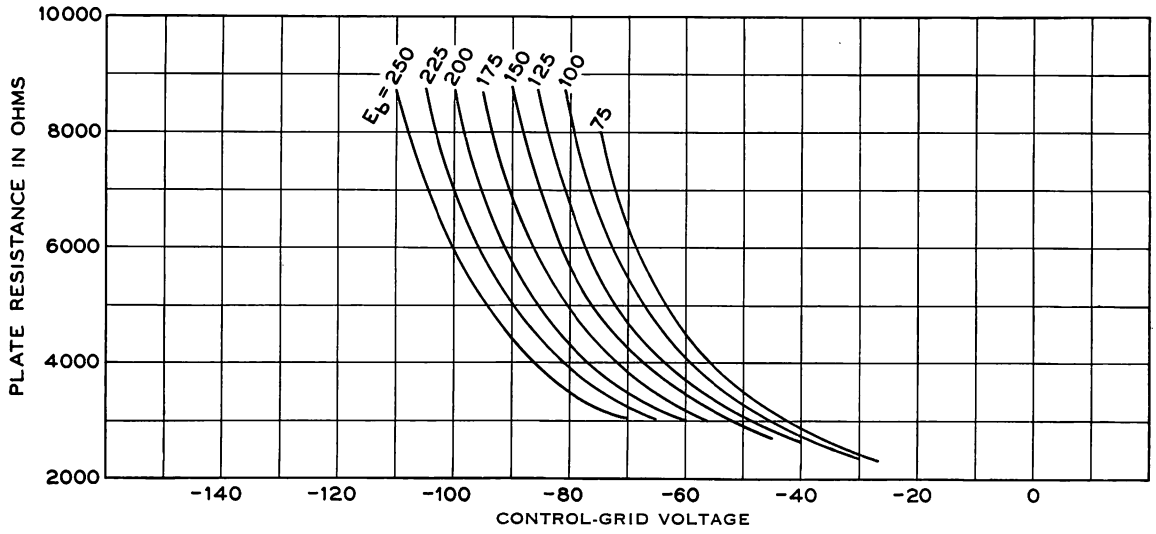


FIG. 5

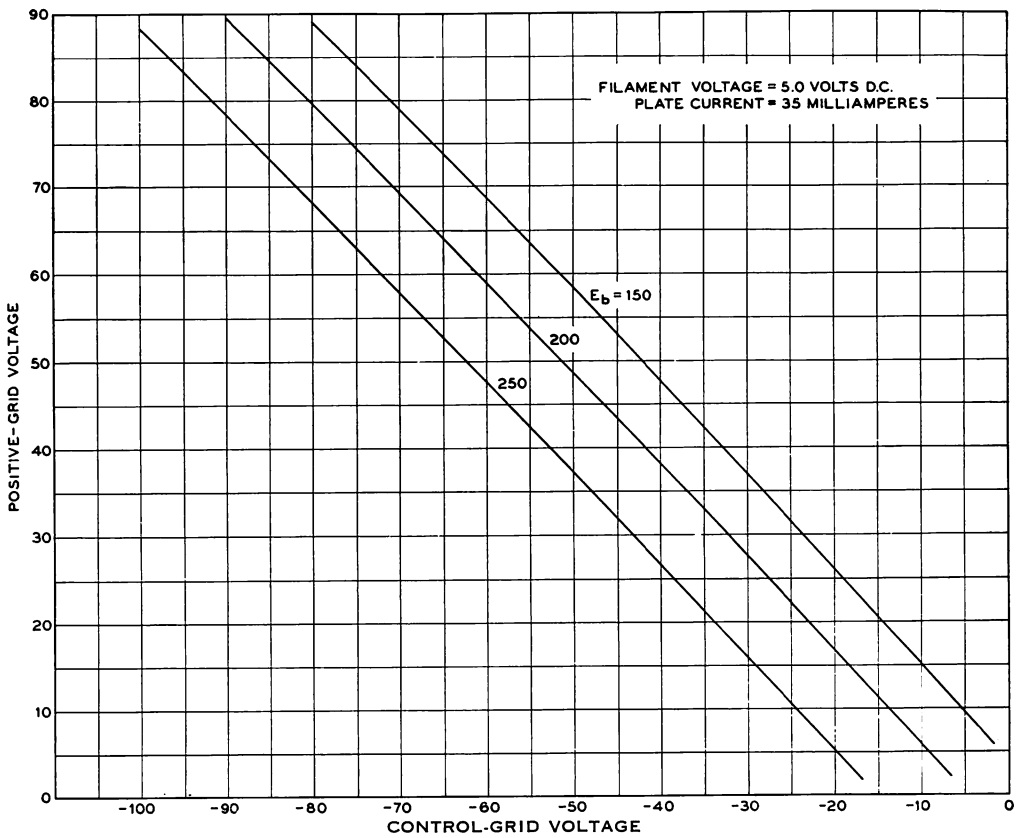


FIG. 6

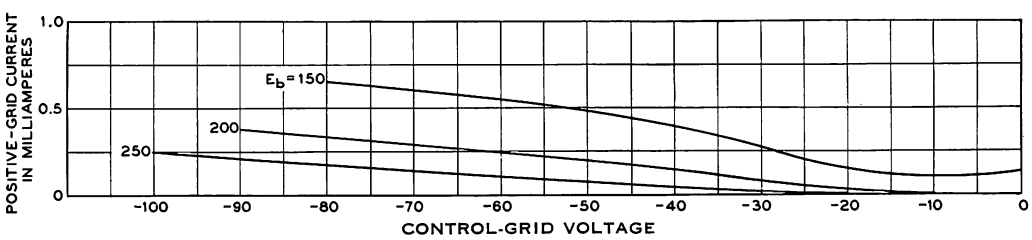


FIG. 7

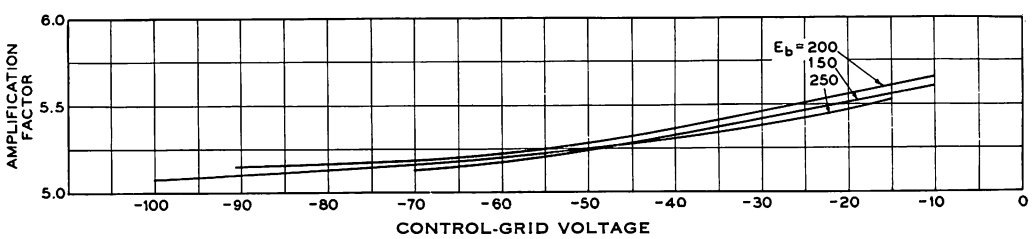


FIG. 8

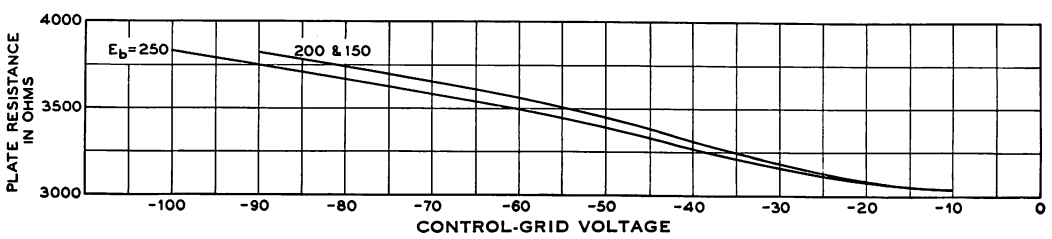


FIG. 9

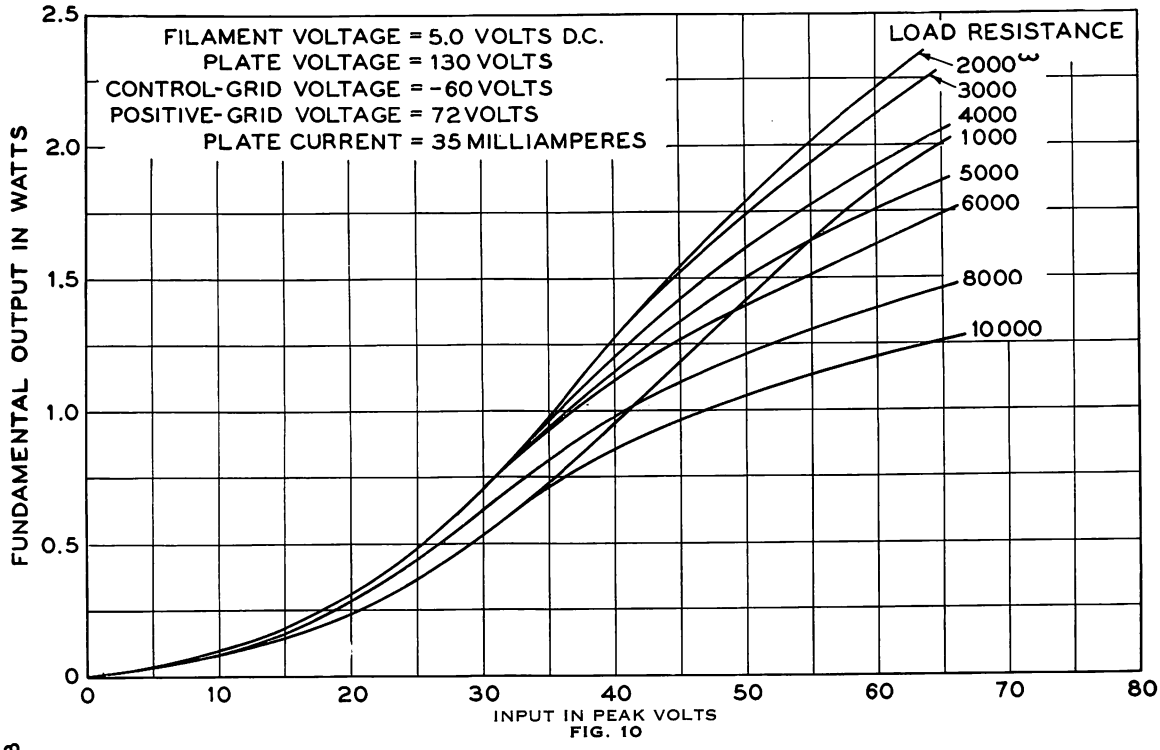


FIG. 10

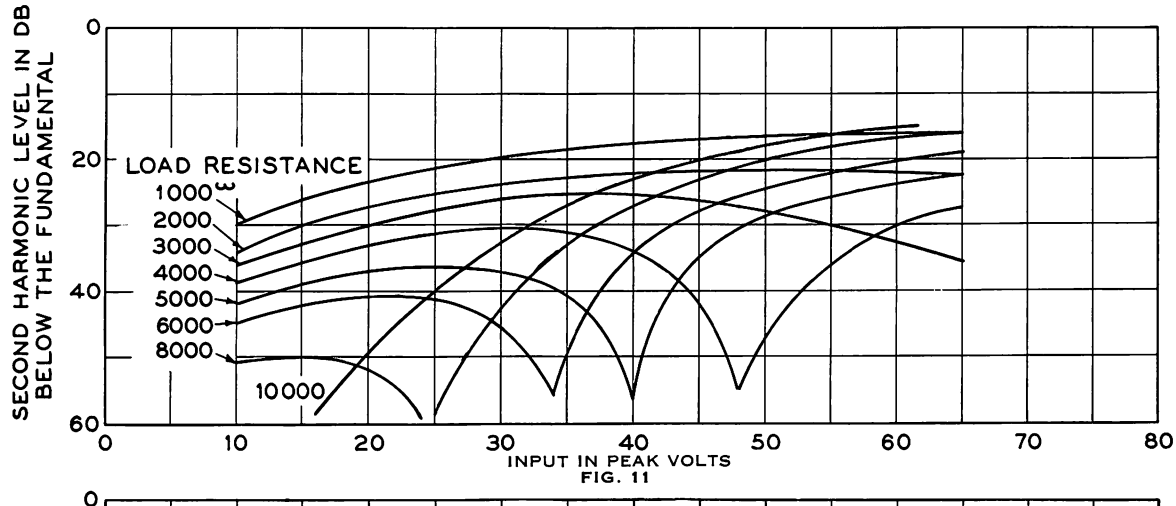


FIG. 11

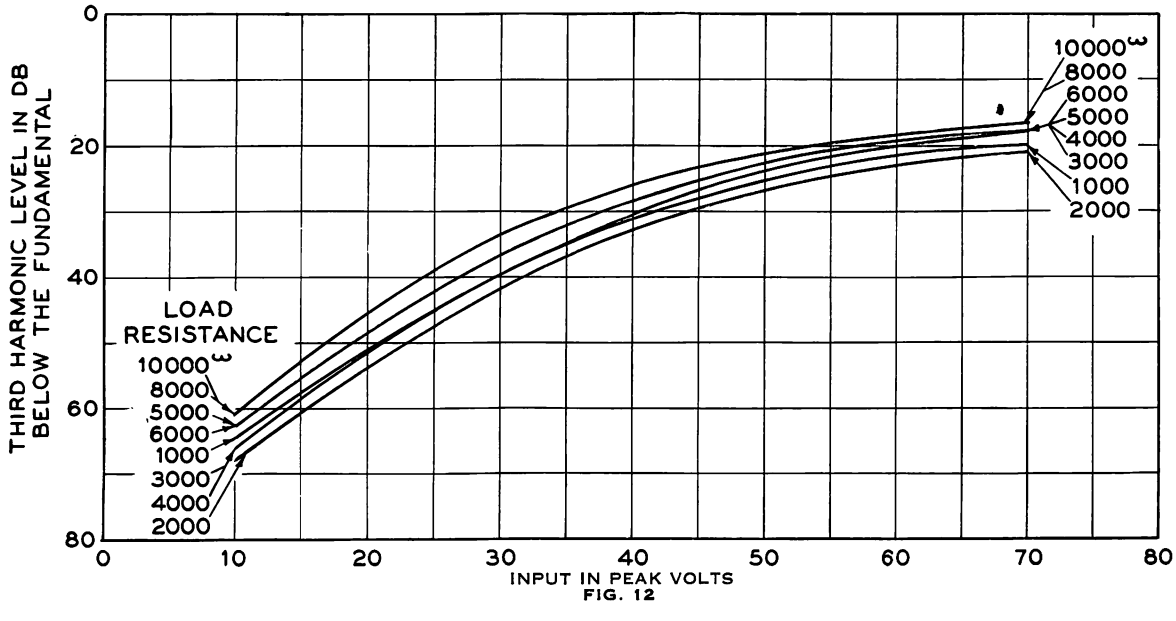


FIG. 12

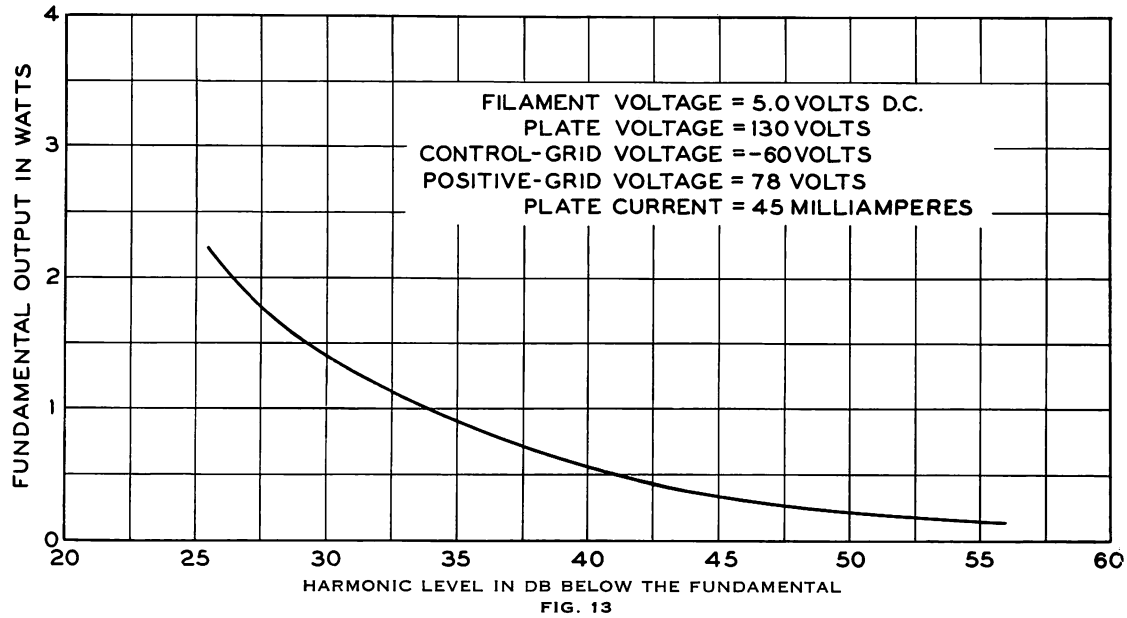


FIG. 13

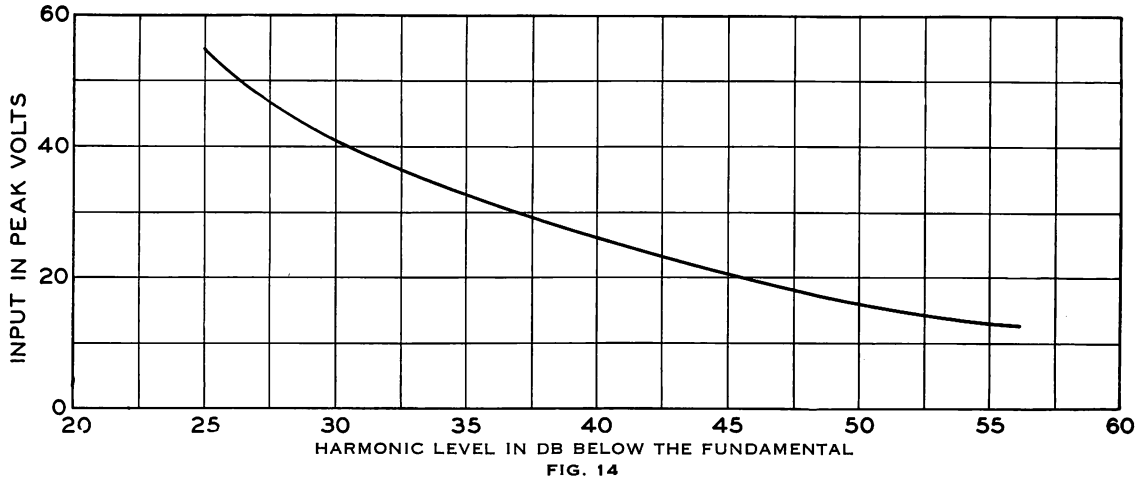


FIG. 14

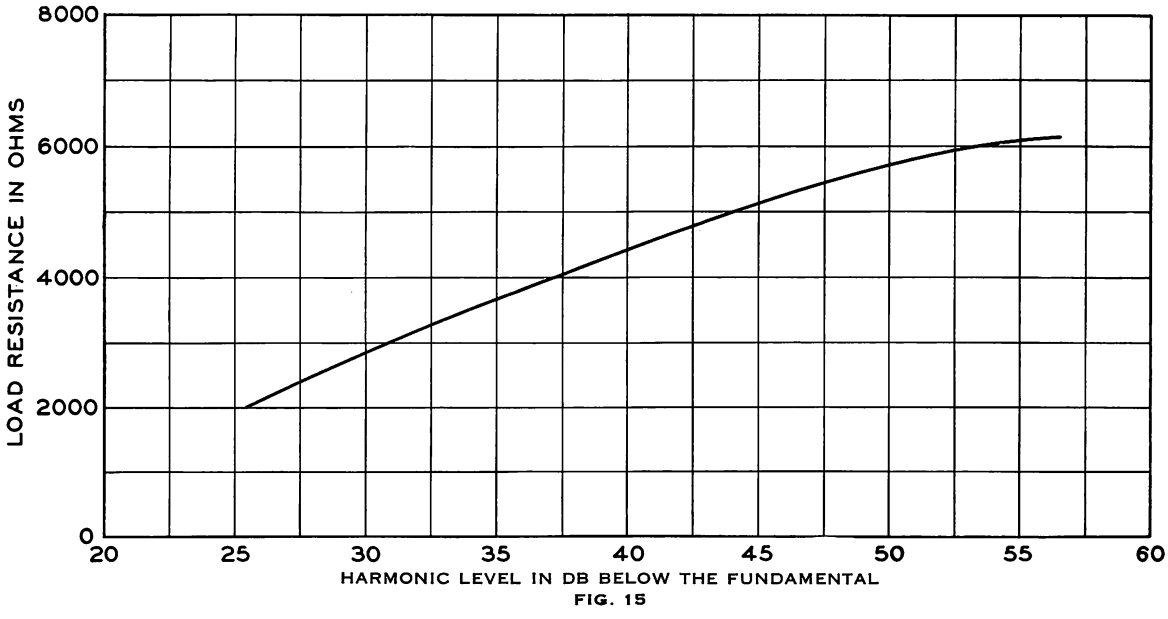
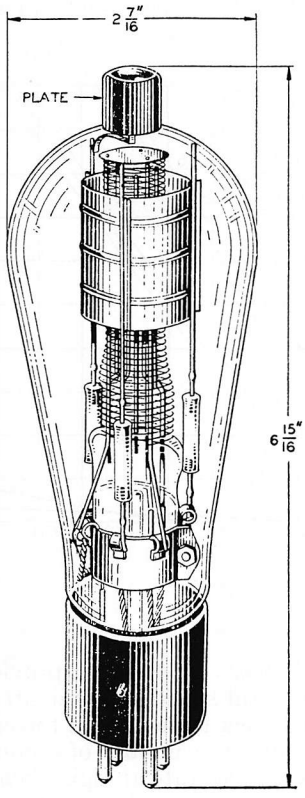
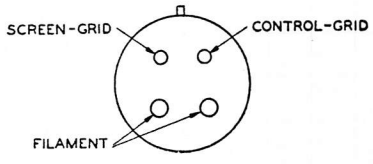


FIG. 15

282A Vacuum Tube





Classification

The No. 282A Vacuum Tube is a four-element, screen-grid tube for use as a radio-frequency power amplifier or a harmonic-generator at intermediate power levels at high frequencies. It may also be used as an oscillator at high frequencies where the reduced plate to control-grid capacity will be of advantage.

Base and Socket

The No. 282A Vacuum Tube employs a standard four-prong thrust type base suitable for use in a Western Electric 130B (rigid), 131A (cushion), or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The plate terminal is located at the top of the bulb and is arranged for a special quick release connector.

Rating and Characteristic Data

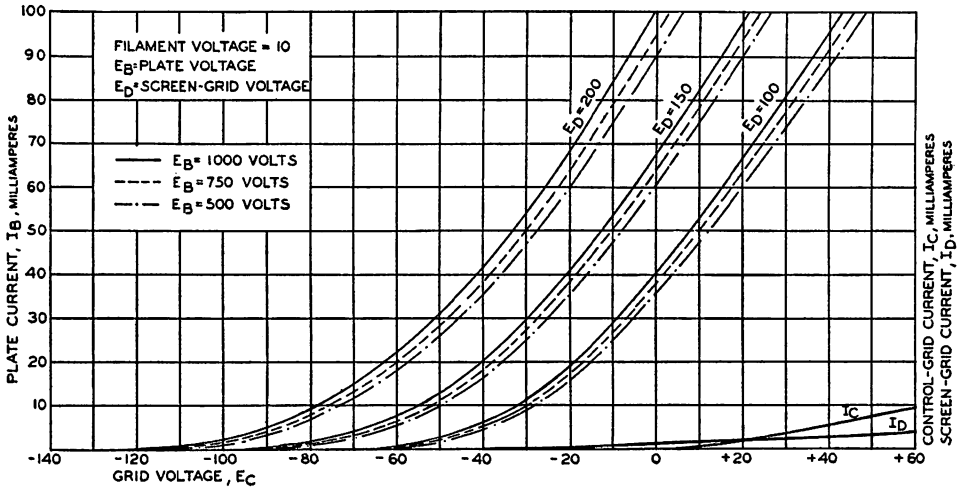
Filament Voltage	10 Volts
Nominal Filament Current	3 Amperes
Average Thermionic Emission	1.25 Amperes
Maximum Plate Voltage, DC	1000 Volts
Maximum Plate Current, DC	0.100 Ampere
Maximum Plate Dissipation	70 Watts
Maximum Screen-Grid Potential	250 Volts
Maximum Screen-Grid Dissipation	5 Watts
Average Amplification Factor	100
Average Plate Resistance	70,000 Ohms
Average Mutual Conductance	1430 Micromhos

Approximate Direct Interelectrode Capacities

Plate to Control-Grid	0.2 MMF
Plate to Filament and Screen-Grid	6.8 MMF
Control-Grid to Filament and Screen-Grid	12.2 MMF

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 282A Vacuum Tube. These curves are taken with the filament operated on alternating current and with the plate, screen and control-grid circuit returns connected to a mid-point of the filament transformer.



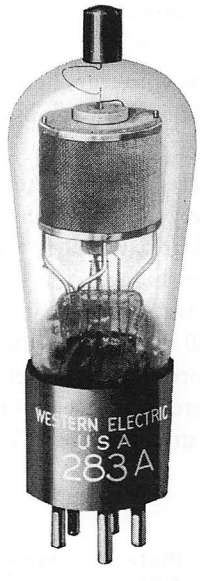
General Features

The No. 282A Vacuum Tube employs an extra grid or screen which provides an electrostatic shield between the plate and control-grid. Such internal shielding eliminates the necessity of neutralization to prevent unwanted oscillations or feed-back if the rest of the circuit elements are properly shielded. The screen has been designed to reduce the amount of current collected by it. The No. 282A bulb is made of hard glass which allows it to operate at higher temperatures and plate dissipation than the 254 type tubes.

The thoriated tungsten filament of this tube is made in a spiral of such form as to maintain the tube internal impedance low and constant during its life. The mechanical structure has adequate strength for severe usage.

Western Electric

283A Vacuum Tube



Classification—Variable-mu, voltage-amplifier, screen-grid tetrode with indirectly heated cathode

Except for the variable-mu feature, the 283A tube is similar to the 259A tube.

Applications

High-frequency voltage amplifier, especially in circuits in which the amplification is varied by varying the control-grid bias of the amplifier tubes.

Audio-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—Medium, five-pin base 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—The 283A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Control grid to plate	0.004 μμf.
Control grid to heater, cathode and screen grid	6.5 μμf.
Plate to heater, cathode and screen grid	14 μμf.

Heater Rating

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

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 heater and cathode, it should be kept as low as possible and should never exceed 90 volts.

Characteristics—Plate current and screen-grid current characteristics of a typical 283A tube are shown in Figures 3 and 4, respectively, as functions of plate voltage for a screen-grid voltage of 75 volts and several values of control-grid voltage. A typical plate current characteristic as a function of control-grid voltage is shown in Figure 5 for a plate voltage of 180 volts and a screen-grid voltage of 75 volts. The corresponding transconductance characteristic is given in Figure 6. 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 7 and 8, respectively for a screen-grid voltage of 75 volts and several values of plate voltage.

Typical Operating Conditions

Plate Voltage	Screen-Grid Voltage	Control-Grid Bias	Plate Current	Screen-Grid Current	Amplification Factor	Plate Resistance	Transconductance
Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Micromhos
135	75	−1.5	5.8	1.7	410	310000	1330
180	75	−1.5	5.9	1.6	585	430000	1360
*250	75	−1.5	6.0	1.5	980	700000	1400
**135-250	75	−19	—	—	—	—	5

*Maximum operating conditions
**Nominal cut-off

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.

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 283A tube measured in a laboratory reference test set is 18 decibels below 1 volt. The range of levels of individual tubes extends from 0 to 36 decibels. 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.

Variable-Mu Feature—The 283A tube is particularly well adapted to amplifier applications where the sensitivity is controlled by varying the grid bias. As the control grid is made more negative, the plate current and transconductance approach zero gradually, as shown in Figures 5 and 6, rather than sharply, so that distortion is relatively small at all values of grid bias.

Circuit Requirements—In order to make use of the high gain per stage of which the 283A tube is capable when used as a voltage amplifier, suitable precautions must be taken where high frequencies are involved to avoid undesired feed-back in the circuit. It is usually 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.

The screen-grid voltage should be obtained either directly from a low-resistance source or from a voltage divider. The use of a series resistance to reduce a high voltage supply to the desired value is not recommended because screen-grid currents differ widely in different tubes and vary during life in individual tubes.

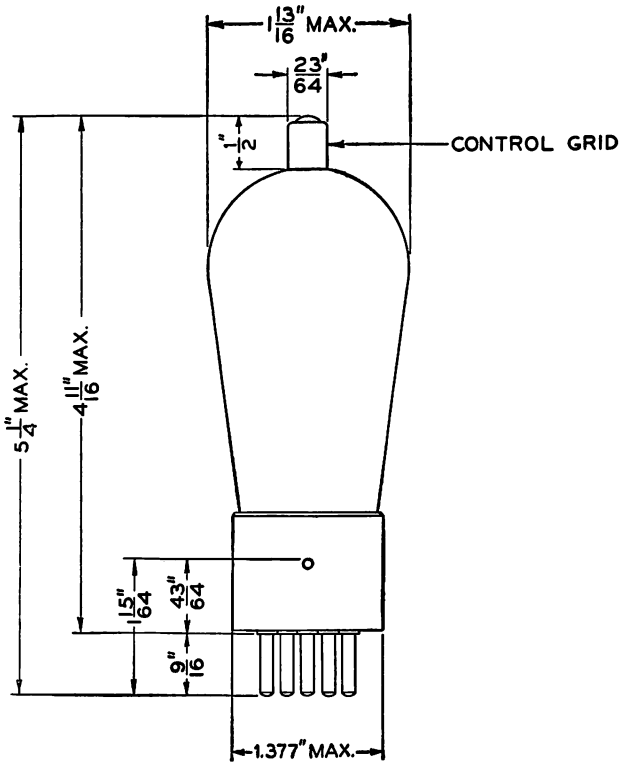


FIG. 1

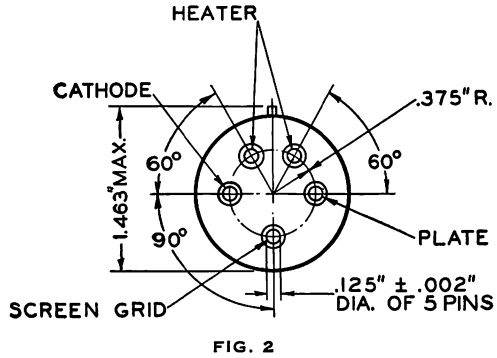


FIG. 2

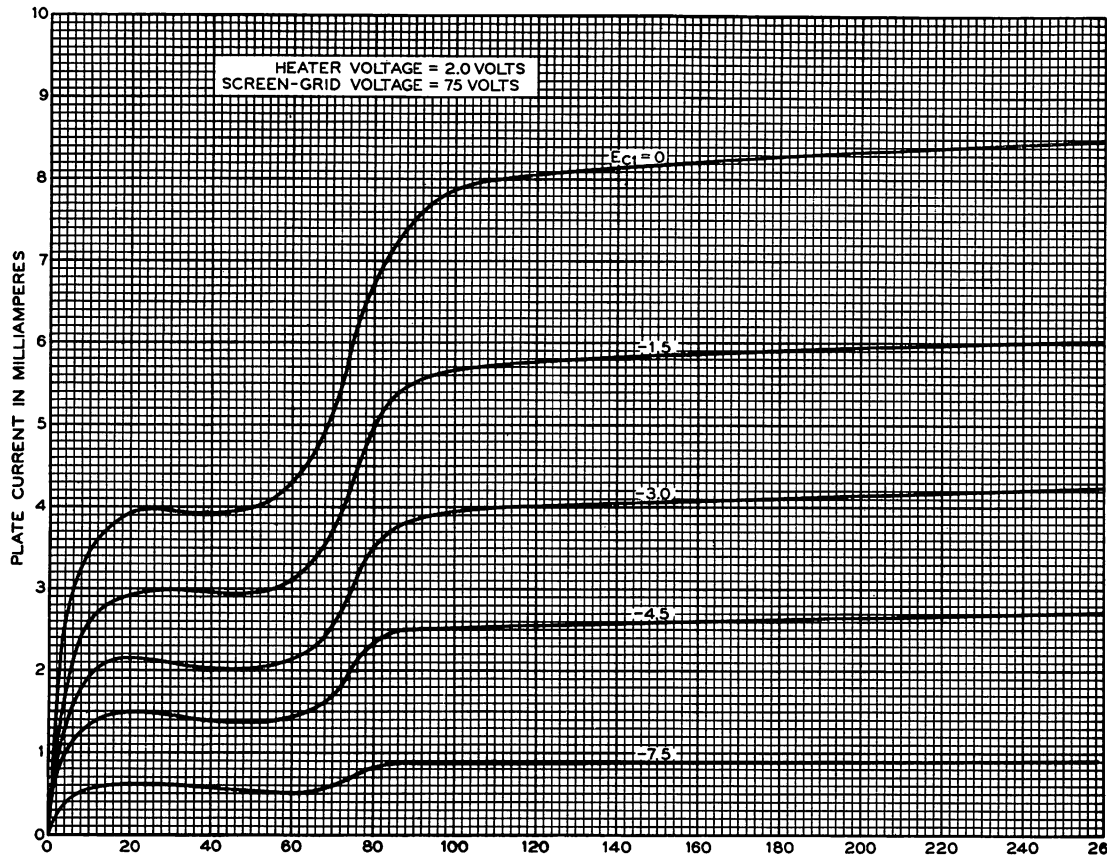

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
PLATE CURRENT IN MILLIAMPERES
E_{C1}=0
-1.5
-3.0
-4.5
-7.5
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 3

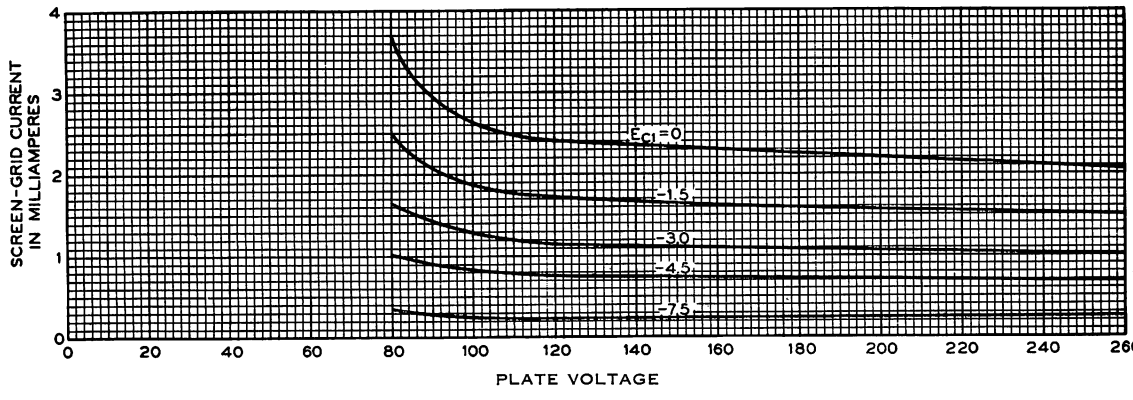

SCREEN-GRID CURRENT IN MILLIAMPERES
E_{C1}=0
-1.5
-3.0
-4.5
-7.5
0
1
2
3
4
0
20
40
60
80
100
120
140
160
180
200
220
240
260
PLATE VOLTAGE

FIG. 4

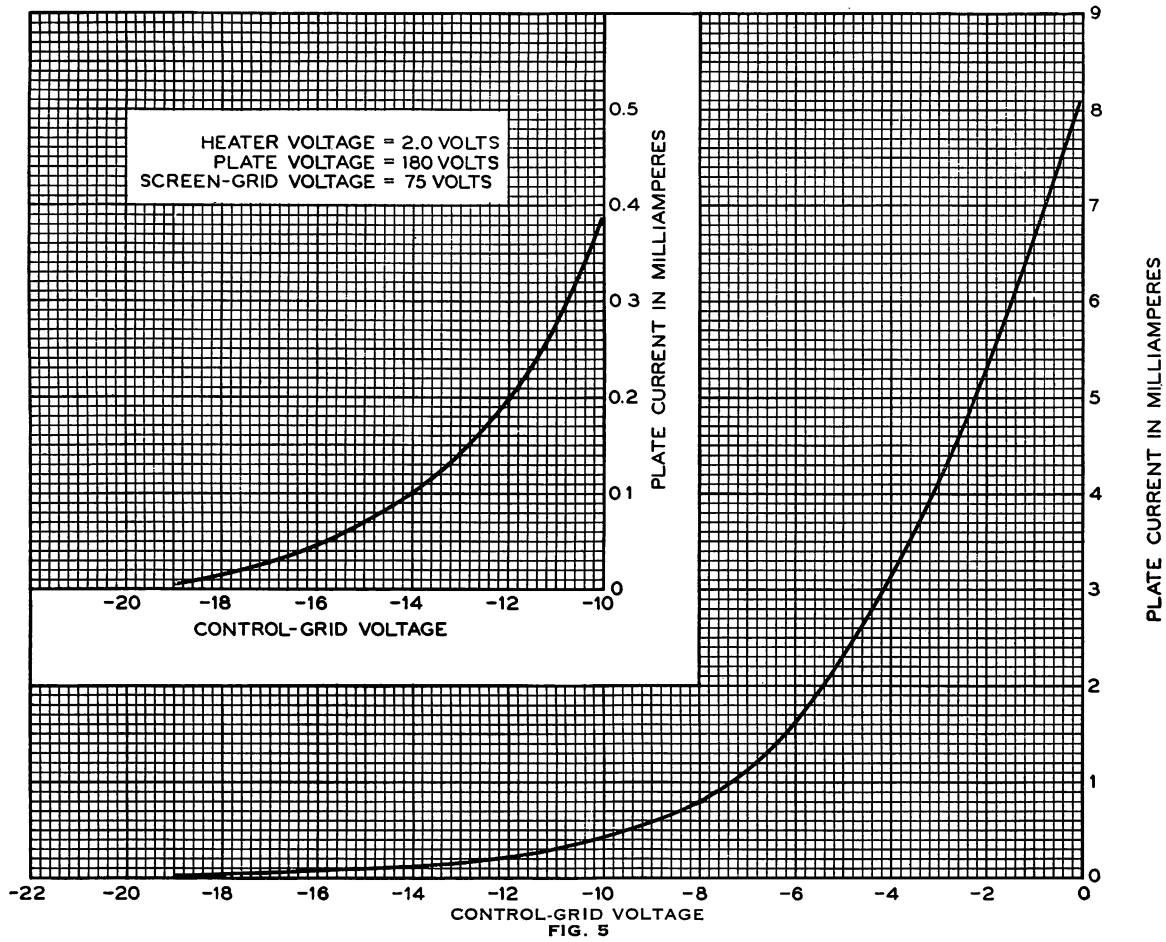

HEATER VOLTAGE = 2.0 VOLTS
PLATE VOLTAGE = 180 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
PLATE CURRENT IN MILLIAMPERES
0.5
0.4
0.3
0.2
0.1
0
-20
-18
-16
-14
-12
-10
CONTROL-GRID VOLTAGE
PLATE CURRENT IN MILLIAMPERES
9
8
7
6
5
4
3
2
1
0
-22
-20
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
CONTROL-GRID VOLTAGE

FIG. 5

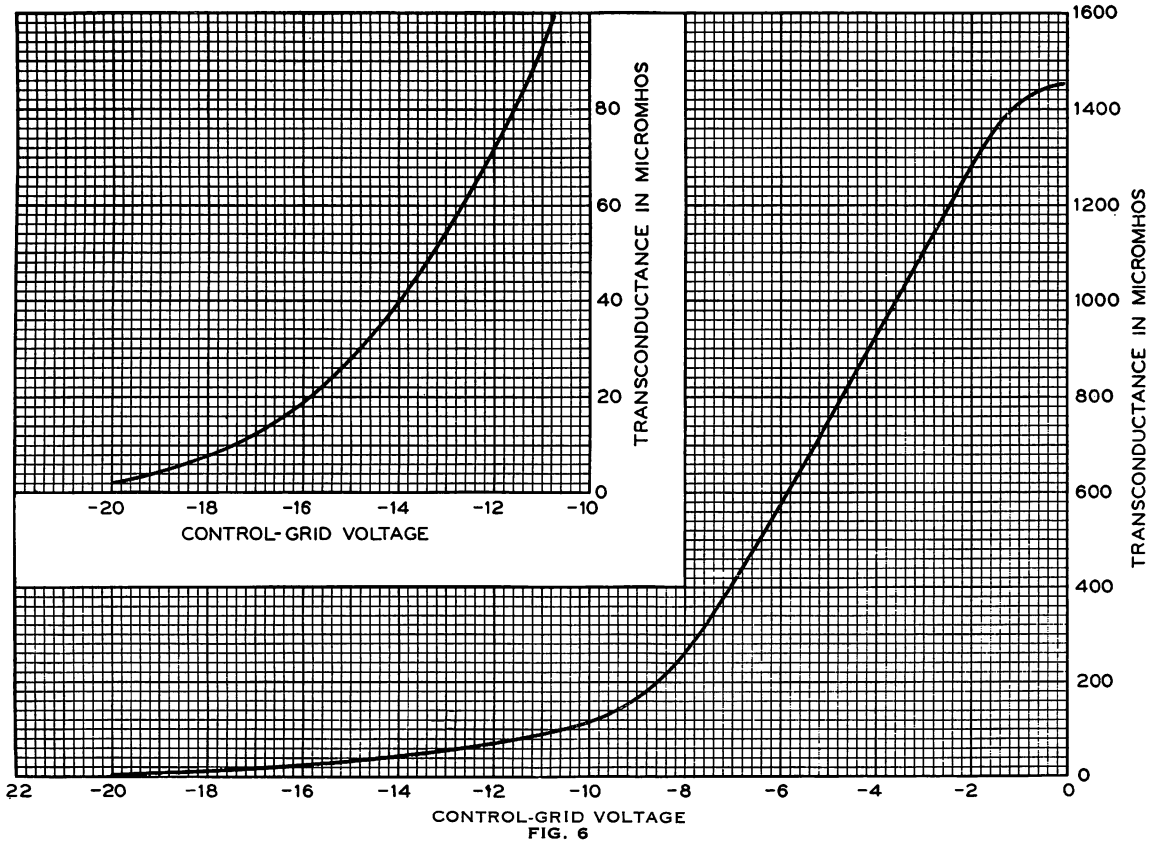

TRANSCONDUCTANCE IN MICROMHOS
80
60
40
20
0
-20
-18
-16
-14
-12
-10
CONTROL-GRID VOLTAGE
TRANSCONDUCTANCE IN MICROMHOS
1600
1400
1200
1000
800
600
400
200
0
22
-20
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
CONTROL-GRID VOLTAGE

FIG. 6

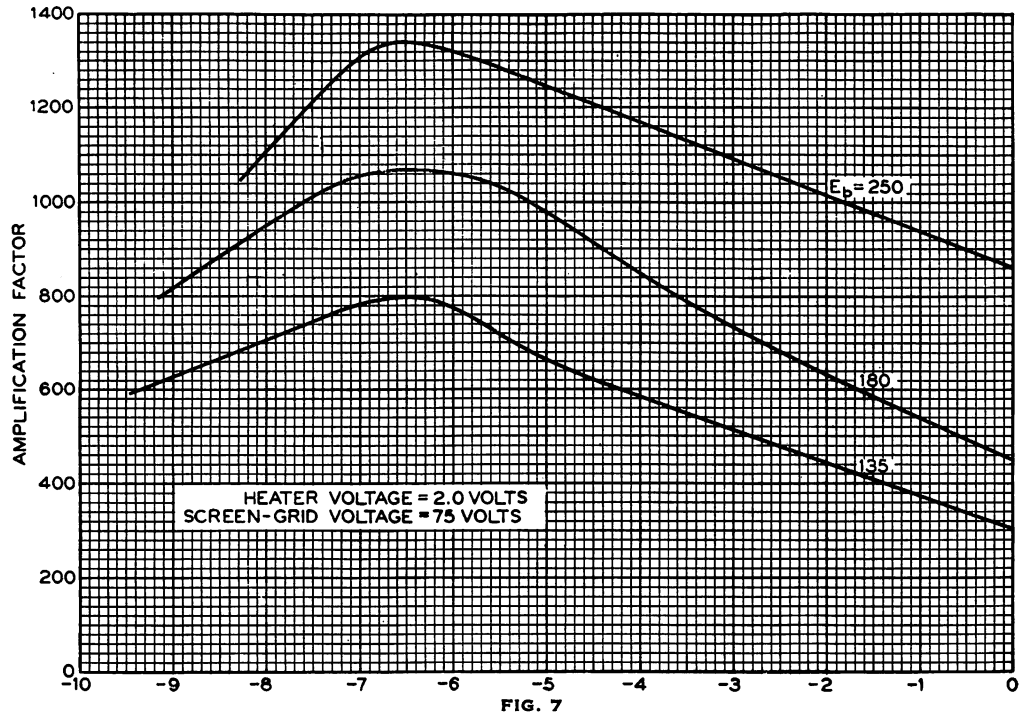

AMPLIFICATION FACTOR
1400
1200
1000
800
600
400
200
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
E_b=250
180
135
HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS

FIG. 7

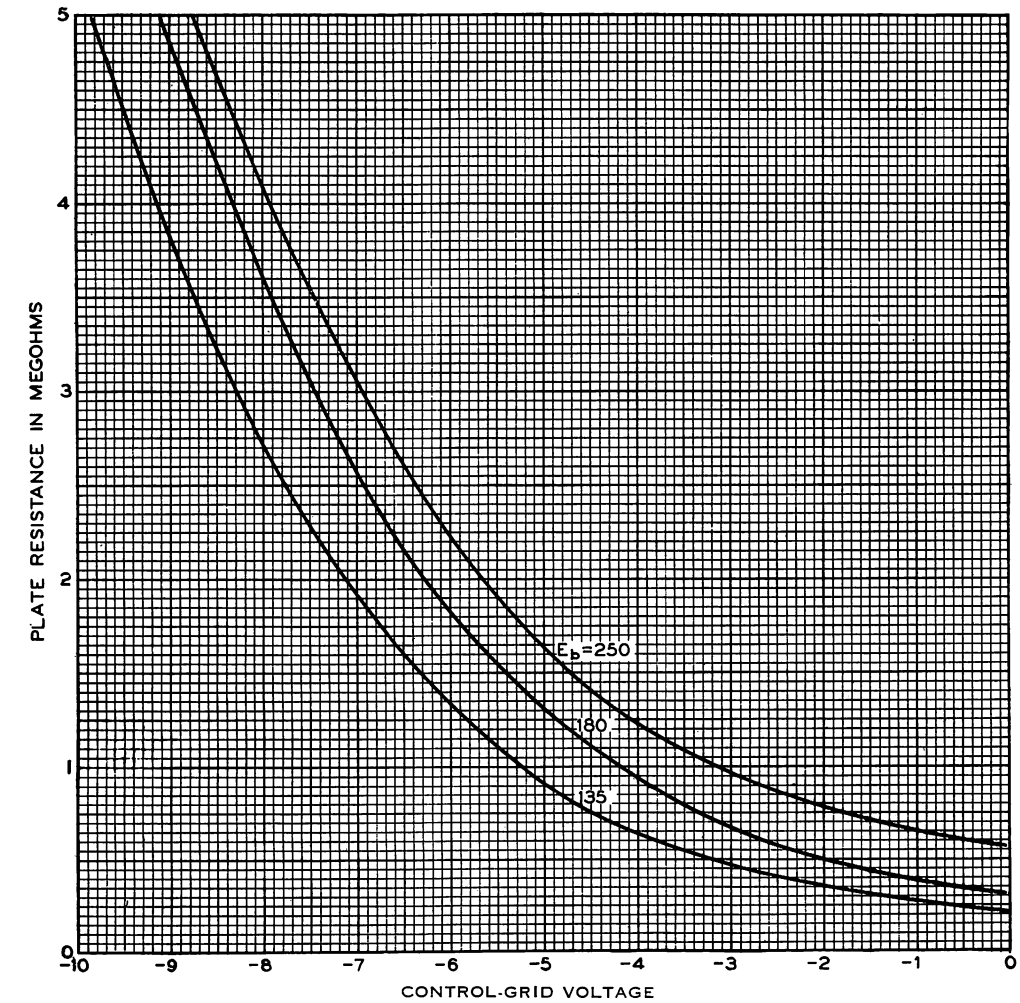
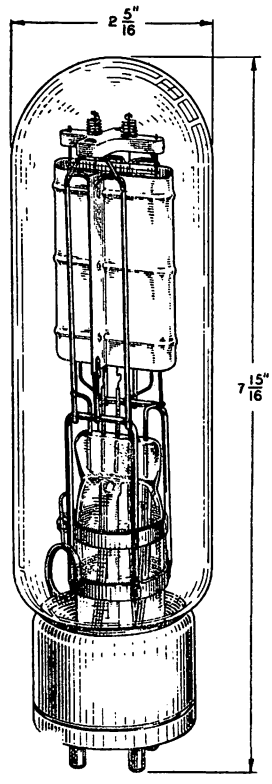
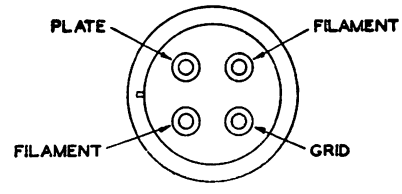

PLATE RESISTANCE IN MEGOHMS
5
4
3
2
1
0
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
E_b=250
180
135
CONTROL-GRID VOLTAGE

FIG. 8

284A Vacuum Tube





Classification

The No. 284A Vacuum Tube is a 3 element tube for use as an audio-frequency amplifier, modulator, oscillator, or radio-frequency amplifier.

Base and Socket

The No. 284A Vacuum Tube employs a standard four prong bayonet pin type base suitable for use in a Western Electric 112A or similar type socket. The arrangement of electrode connections to the base terminals is shown above.

General Ratings and Information

Filament Voltage	10 Volts AC.
Nominal Filament Current	3.25 Amperes
Maximum Plate Voltage	1250 Volts
Maximum Plate Current	0.150 Ampere
Average Plate Resistance	1900 Ohms
Average Amplification Factor	4.7
Approximate Direct Interelectrode Capacities	
Plate to Grid	8.2 MMF
Plate to Filament	7.8 MMF
Grid to Filament	7.0 MMF

Audio Amplifier or Modulator Rating—Peak Grid Drive equal to or less than the bias—Class A Service.

Maximum Plate Voltage	1000
Maximum Plate Current	0.85 Ampere
Maximum Plate Dissipation	85 Watts
Grid Bias Voltage	—165

Typical outputs obtainable within recommended operating conditions for different resistance loads, R, and for inputs on the grid equal to the grid bias:

Plate Volts	Plate Current (Milli-amperes)	Approx. Grid Volts	Approx. Plate Resist-ance, Rp, (Ohms)	R, Load Resist-ance	Funda-mental Power Output (Watts)	Second Har-monic % of Funda.	Third Har-monic % of Funda.
750	100	—106	1600	R=2Rp	16.6	4.5	.8
				R=5Rp	10.5	1.1	.03
750	75	—116	1760	R=2Rp	16.9	7.5	2.0
				R=5Rp	10.8	2.0	.16
1000	85	—165	1700	R=2Rp	33.3	10.0	3.2
				R=5Rp	22.5	2.4	.4
1000	50	—178	2100	R=5Rp	20.6	5.0	1.8
1250	60	—228	2000	R=2Rp	52.5	15.8	5.6
				R=5Rp	41.5	5.1	2.2
1250	40	—238	2440	R=5Rp	31.3	7.0	2.8

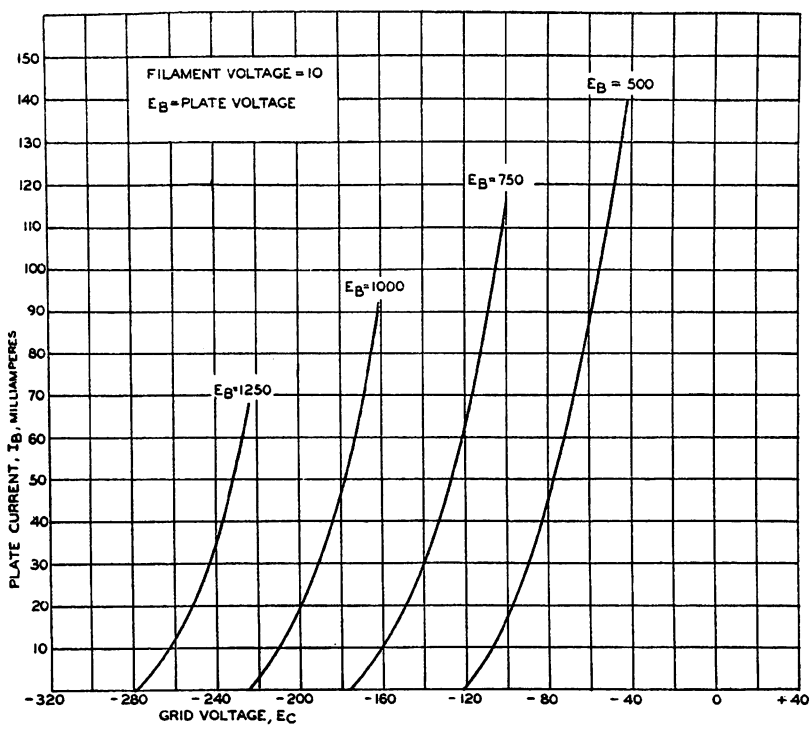
It is possible to obtain very substantial reduction in 2nd harmonic output by the use of the push-pull circuit. With resistance loads greater than twice the plate resistance of the tube, improved levels of harmonic outputs are obtained with relatively little sacrifice in the level of the fundamental power outputs.

Radio Frequency, Oscillator, or Amplifier—Grid Bias practically at or greater than cut-off, grid drive higher than the bias—Class B or C Service.

Maximum Plate Voltage	1250
Maximum Plate Current	0.150 Ampere
Maximum Plate Dissipation	100 Watts
Grid Bias Voltage	—300 Volts
Maximum R.F. Charging Current in Grid or Plate Leads	5 Amperes
Peak Output	100 Watts

Average Static Characteristics

The accompanying curves give the average static characteristics of the No. 284A Vacuum Tube. These curves are taken with the filament operating on alternating current and with the plate and grid returns connected to a center point on the filament transformer.



General Features

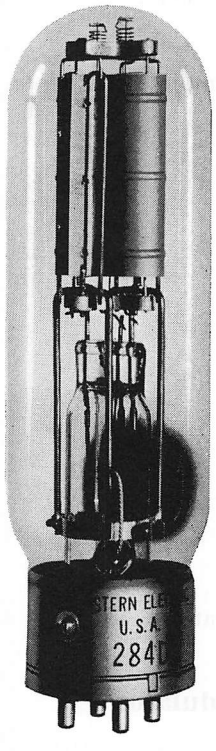
The electrical characteristics of the No. 284A Vacuum Tube make it especially suitable for audio-frequency power amplifier or modulator. In the design of the No. 284A Vacuum Tube, special attention has been given to obtain low interelectrode capacities, low plate resistance and uniform heating of the plate. Thoriated tungsten is used for the filament.

This vacuum tube has an unusually rugged type of structure which insures it against breakage in shipment and service and makes possible the maintenance of uniform electrical characteristics.

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Western Electric

284D Vacuum Tube



Classification—Filamentary air-cooled triode

The tube is designed primarily for use as an audio-frequency amplifier or modulator and may be used as a replacement for the 284A.

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

Maximum overall length	$7\frac{15}{16}$″
Maximum diameter	$2\frac{5}{16}$″

Mounting—Large four-pin bayonet type base for use in a W.E. 112A 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, ac or dc
Nominal filament current	3.25 amperes
Average thermionic emission	1.5 amperes

Average Direct Interelectrode Capacitances

Plate to grid	8.3 μμf
Grid to filament	6.0 μμf
Plate to filament	5.6 μμf

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

Figure 3 gives the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at maximum direct plate voltage and dissipation—Class A (E_b = 1250 volts, I_b = 64 milliamperes).

Amplification factor	4.8
Plate resistance	1900 ohms
Grid to plate transconductance	2500 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1250 volts
Max. direct plate current	150 milliamperes
Max. plate dissipation	85 watts
Max. direct grid current	100 milliamperes
Max. r-f grid current	5 amperes
Max. frequency for the above ratings	6 megacycles

Class A Audio Amplifier or Modulator

Direct plate voltage	1250	1000	750 volts
Grid bias	−220	−161	−104 volts
Direct plate current	64	80	100 milliamperes
Load impedance	10000	8500	8000 ohms
Undistorted output	40	22.5	10 watts
Second harmonic distortion—			
percentage of fundamental	5.0	2.4	1.1 per cent
Plate dissipation	80	80	75 watts

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

Direct plate voltage	1250	1000 volts
Grid bias	−250	−195 volts
Direct plate current per tube		
No drive	15	15 milliamperes
Max. drive	100	100 milliamperes
Plate dissipation	55	45 watts
Load resistance plate-to-plate	11200	8800 ohms
Load resistance per tube	2800	2200 ohms
Approximate maximum output—2 tubes	140	110 watts
Recommended power for driving stage	10	10 watts

Class B Radio-Frequency Amplifier (Other types of tubes are more suitable for r-f service)

Direct plate voltage	1250	1000 volts
Direct plate current for carrier conditions	100	100 milliamperes
Grid bias	−280	−225 volts
Approximate carrier watts for use with 100% modulation	42	42 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1250	1000 volts
Direct plate current	150	150 milliamperes
Grid bias	−420 to −560	−340 to −450 volts
Nominal power output	125	100 watts
Plate dissipation	62.5	50 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1000	750 volts
Direct plate current	150	150 milliamperes
Grid bias	−450	−340 volts
Max. direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	100	75 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 175 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 1,000 to 5,000 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 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 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. It is possible to obtain very substantial reduction in 2nd harmonic output by the use of the push-pull circuit. With resistance loads greater than twice the plate resistance of the tube, improved levels of harmonic outputs are obtained with relatively little sacrifice in the level of the fundamental power outputs.

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—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.

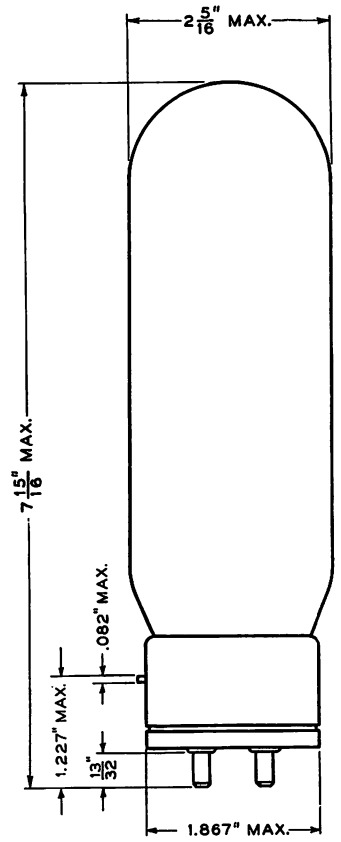


FIG. 1

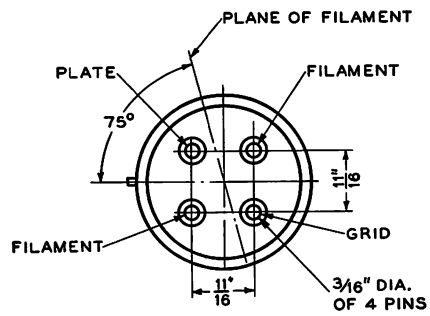


FIG. 2

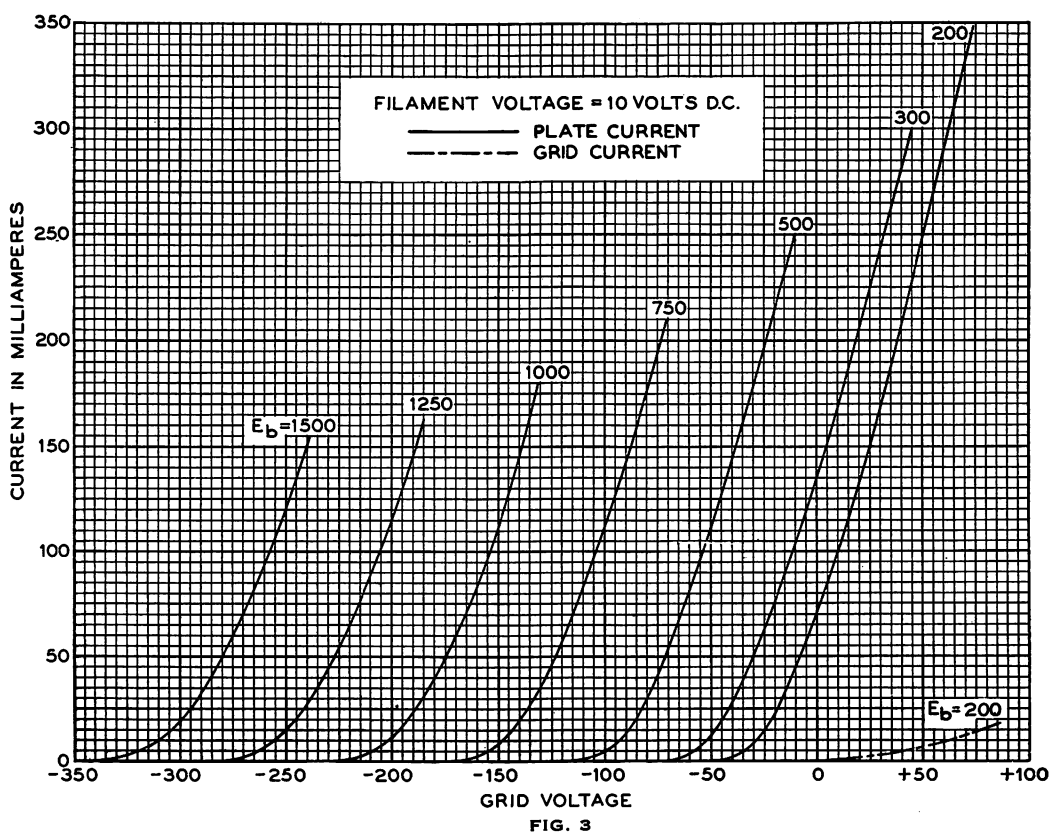
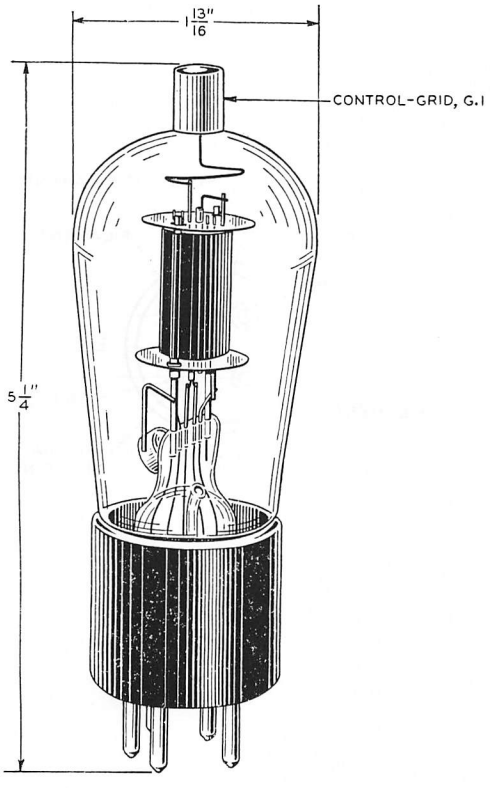
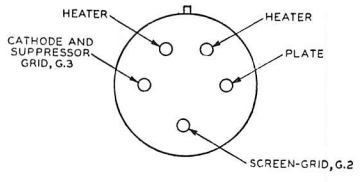


FIG. 3

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

285A Vacuum Tube





Classification

The 285A Vacuum Tube is a power-amplifier pentode having an indirectly heated cathode which permits operation of the heater element directly on alternating current. The tube is for use as an audio-frequency amplifier in output stages where moderate powers are required.

Base and Socket

The 285A Vacuum Tube employs a standard five prong base suitable for use in a Western Electric 134A (cushion), 137A (rigid), or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The control-grid terminal is located at the top of the bulb and is arranged for a special, quick-release connector.

Rating and Characteristic Data

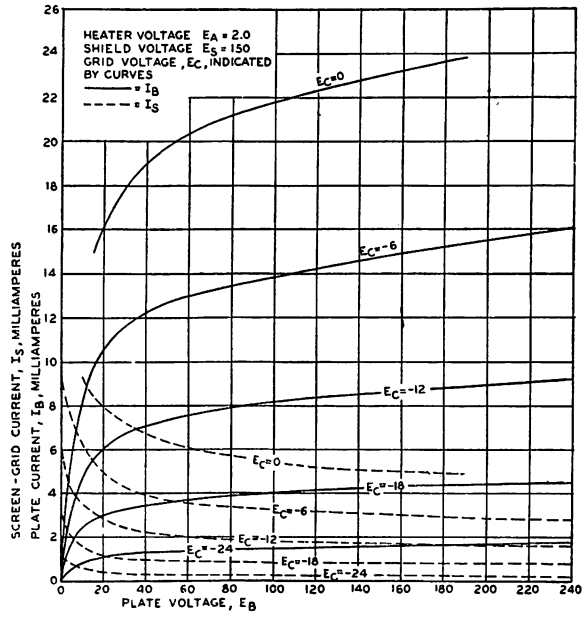
Heater Voltage (A.C. or D.C.)		2 Volts
Average Heater Current		1.6 Amperes
Plate Voltage	180	250 Max.
Screen-Grid Voltage	150	200 Max.
Control-Grid Voltage	—12	—16.5
Average Plate Current—Milliamperes	8.6	12.4
Average Plate Resistance—Ohms	147,000	137,000
Average Amplification Factor	130	140
Power Output—Milliwatts	*650	**1200
Second Harmonic—% of Fundamental Voltage	6.0	6.0
Third Harmonic—% of Fundamental Voltage	6.0	6.0
Load Resistance—Ohms	19,000	18,000

*Input = 12 peak volts.
**Input = 15 peak volts.

Approximate Direct Interelectrode Capacities (measured without socket)	
Plate to Control-Grid	0.5 MMF.
Control-Grid to Heater, Cathode, and Screen-Grid	4.2 MMF.
Plate to Heater, Cathode, and Screen-Grid	7.6 MMF.

Average Static Characteristics

The accompanying curves give the average static characteristics of the 285A Vacuum Tube.



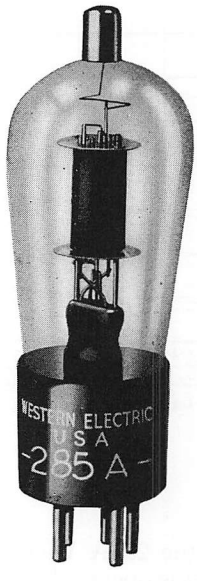
General Features

The electrical characteristics of the 285A Vacuum Tube make it particularly useful in applications requiring an output power tube operated at relatively low plate voltage and low plate current.

The cathode is designed to provide a very large electron emission compared with the space current drain. This, combined with rugged construction and careful control of manufacturing processes, assures the maintenance of uniform electrical characteristics throughout a very long life.

Western Electric

285A Vacuum Tube



Classification—Low-power, suppressor-grid pentode with indirectly heated cathode

The suppressor-grid of the 285A tube is permanently connected to the cathode within the bulb.

Application—Audio-frequency amplifier where power outputs of approximately one watt or less are required.

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 control-grid terminal at the top of the bulb.

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

Mounting Positions—The 285A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Control grid to plate	0.5 $\mu\mu$f.
Control grid to heater, cathode, screen-grid and suppressor grid	4.2 $\mu\mu$f.
Plate to heater, cathode, screen-grid and suppressor grid	7.6 $\mu\mu$f.

Heater Rating

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

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 be kept as low as possible and should never exceed 90 volts.

Characteristics—Plate-current and screen-grid current characteristics for a typical 285A tube are shown in Figures 3 and 4, respectively, as functions of control-grid voltage for a plate voltage of 180 volts and several values of 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 150 volts. Corresponding amplification-factor, plate-resistance, and transconductance characteristics are shown in Figures 7, 8 and 9, respectively.

Limiting Conditions for Safe Operation

Maximum plate voltage	250 volts
Maximum screen-grid voltage	200 volts
Maximum plate current	12.5 milliamperes
Maximum screen-grid dissipation	1 watt

Operating Conditions and Power Output—Permissible operating screen-grid and control-grid voltages are included within the area, ABCD, in Figure 3. Values of amplification factor, plate resistance, and transconductance, 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 power output in watts and the maximum level of any harmonic in db below the fundamental, for the indicated values of load resistance and input voltage. The input 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 from zero to 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	Max. Harmonic Level
	Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Micromhos	Ohms	Peak Volts	Watts	db
Recommended	135	135	−10.5	7.5	1.6	120	140000	860	16000	10.5	0.38	25.0
	180	150	−12.0	8.8	1.7	135	153000	880	19000	12.0	0.65	24.5
Maximum	250	200	−16.5	12.4	2.2	140	137000	1020	17000	16.5	1.35	23.0

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.

Microphonic Noise—With an operating plate voltage of 180 volts, a screen-grid voltage of 150 volts, a control-grid bias of −12 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 285A tube, measured in a laboratory reference test set, is 20 db below 1 volt. The range of levels of individual tubes extends from 2 to 32 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 types of tubes which have been tested in the same way.

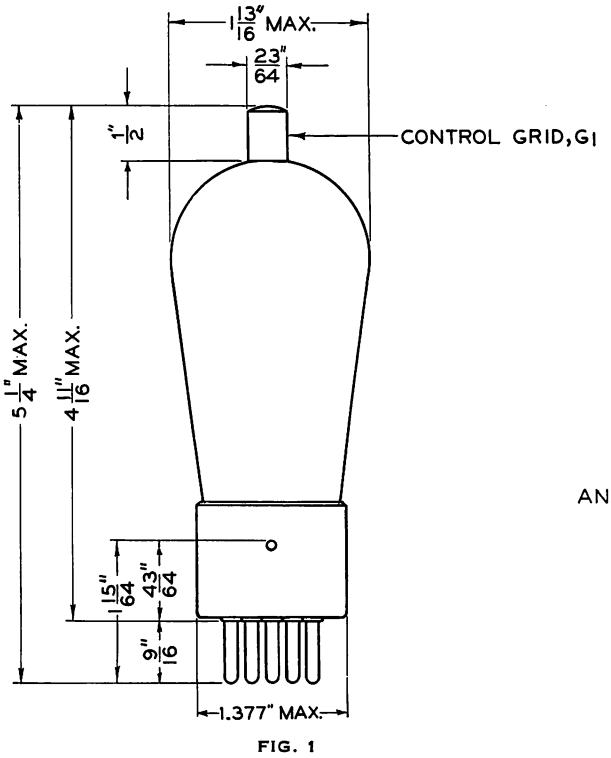


FIG. 1

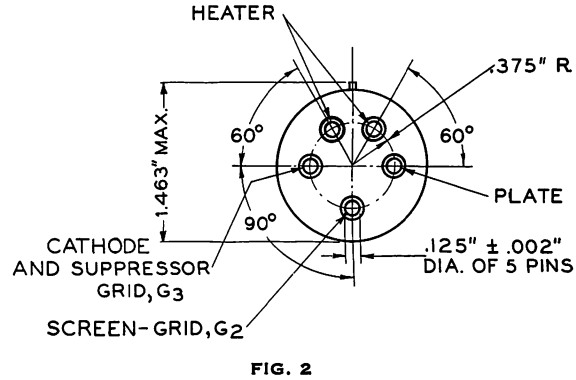


FIG. 2

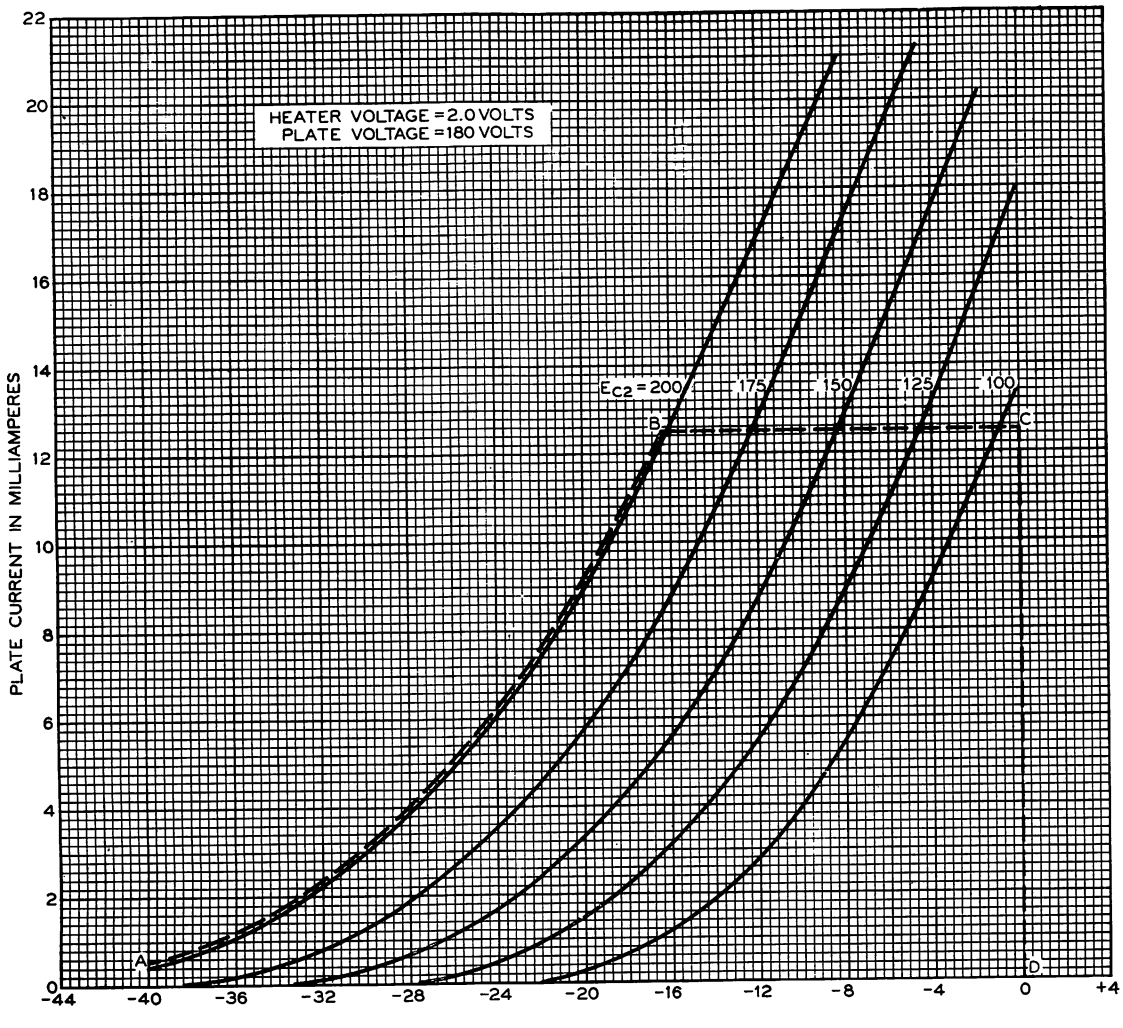

HEATER VOLTAGE = 2.0 VOLTS
PLATE VOLTAGE = 180 VOLTS
PLATE CURRENT IN MILLIAMPERES
E_{C2} = 200
175
150
125
100
A
B
C
D
22
20
18
16
14
12
10
8
6
4
2
0
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4

FIG. 3

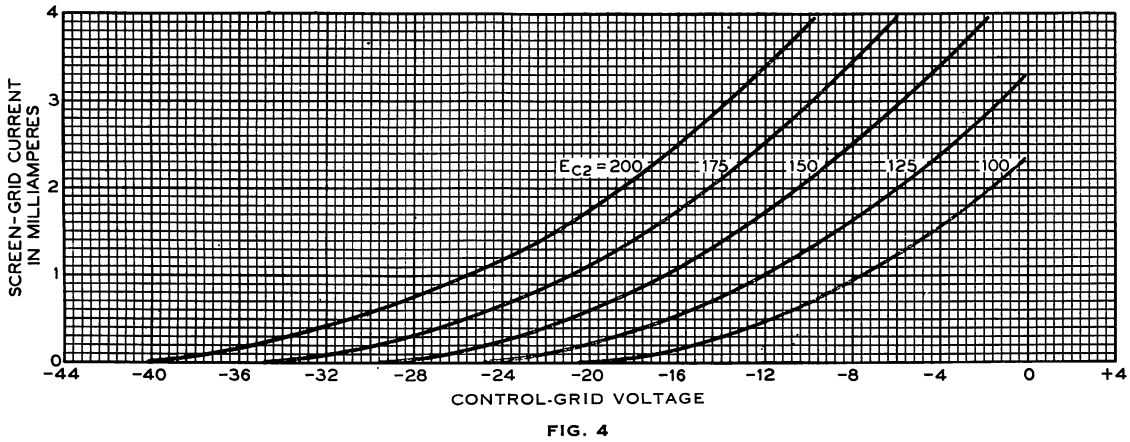

SCREEN-GRID CURRENT IN MILLIAMPERES
E_{C2} = 200
175
150
125
100
4
3
2
1
0
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
+4
CONTROL-GRID VOLTAGE

FIG. 4

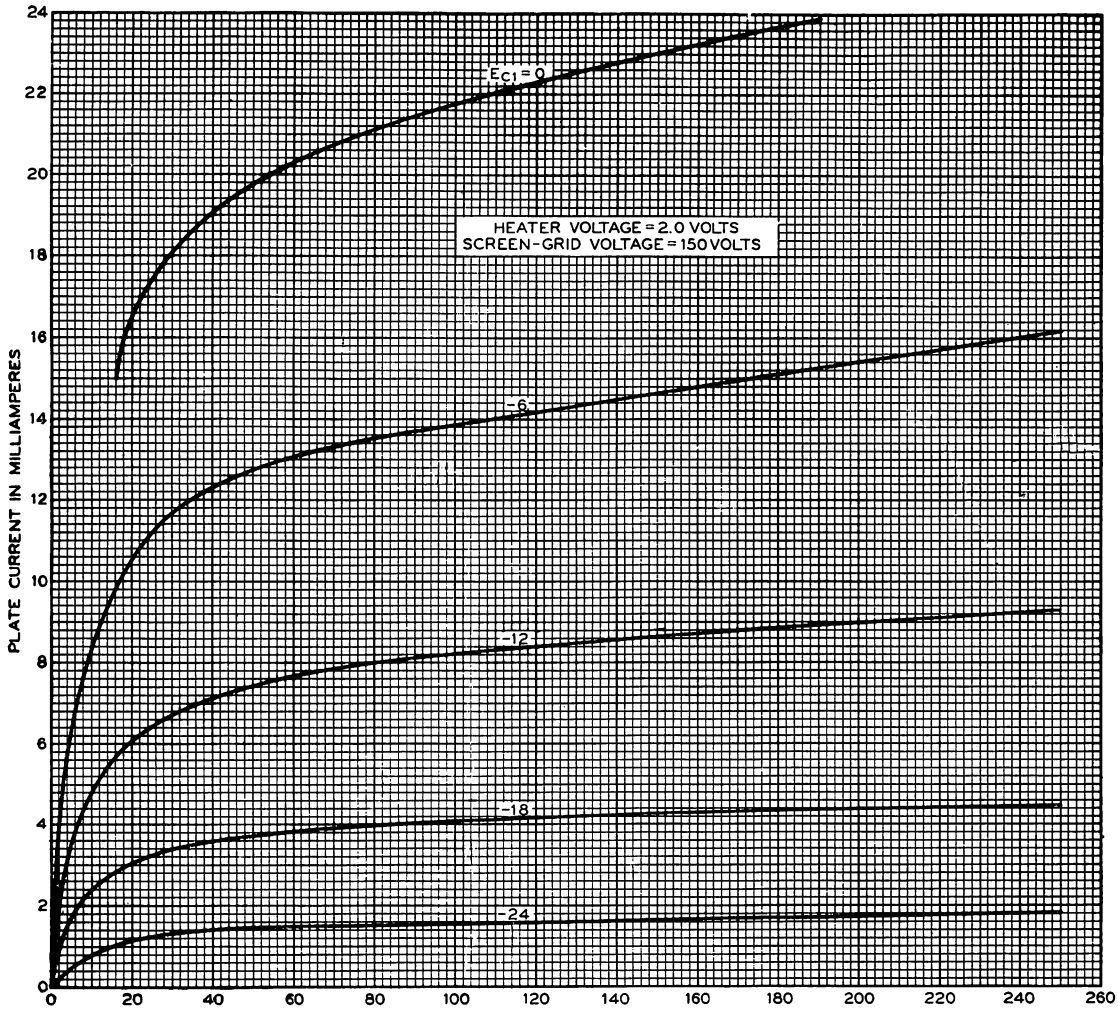

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 150 VOLTS
E_{c1} = 0
-6
-12
-18
-24
PLATE CURRENT IN MILLIAMPERES
0
2
4
6
8
10
12
14
16
18
20
22
24
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 5

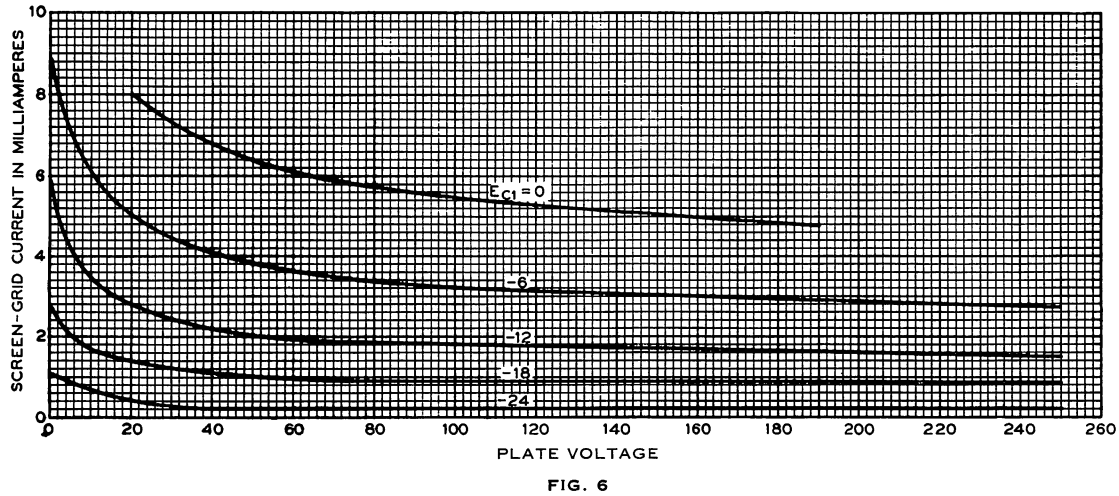

E_{c1} = 0
-6
-12
-18
-24
SCREEN-GRID CURRENT IN MILLIAMPERES
0
2
4
6
8
10
0
20
40
60
80
100
120
140
160
180
200
220
240
260
PLATE VOLTAGE

FIG. 6

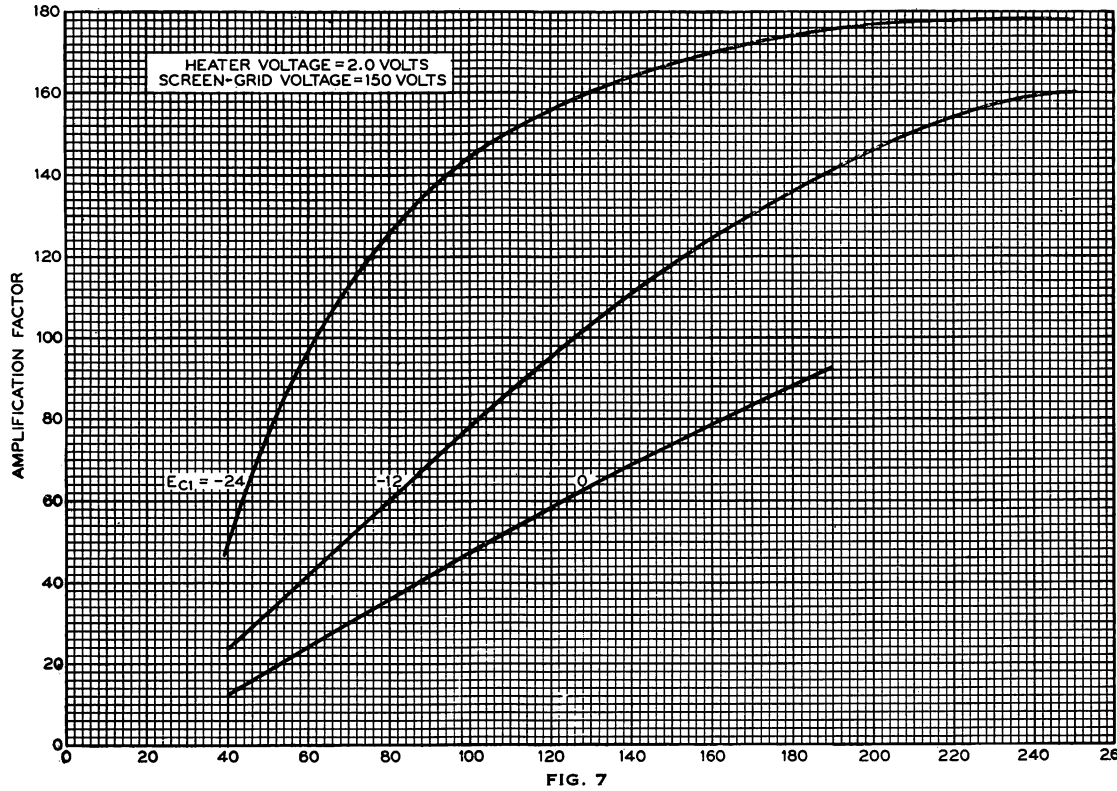


FIG. 7

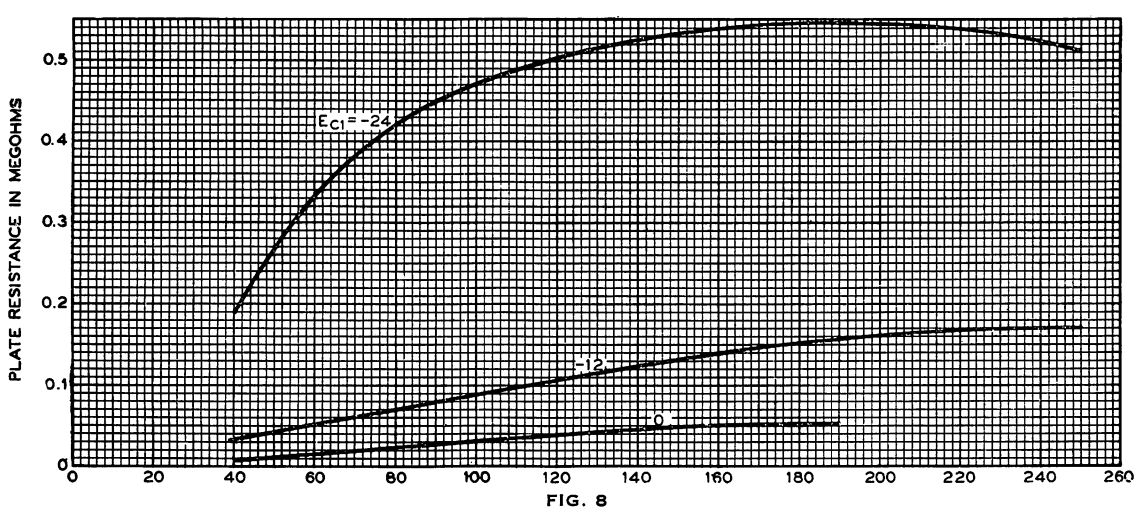


FIG. 8

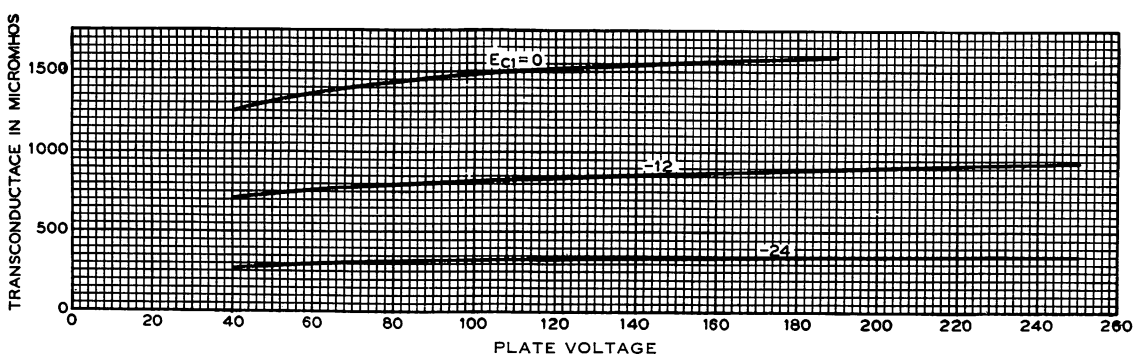


FIG. 9

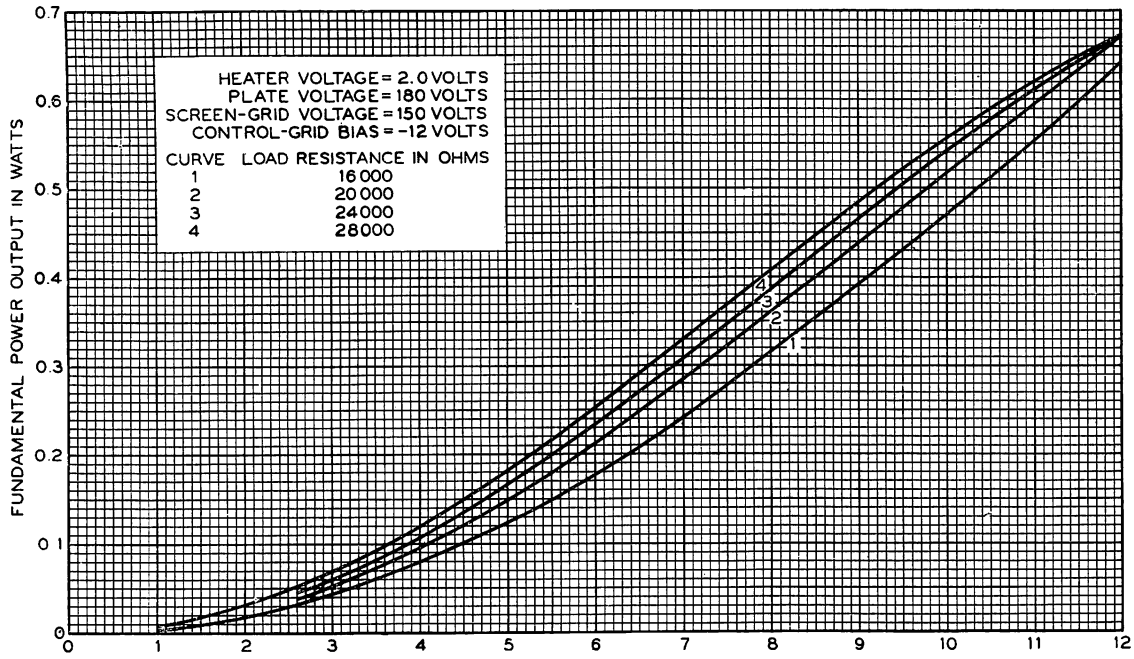


FIG. 10

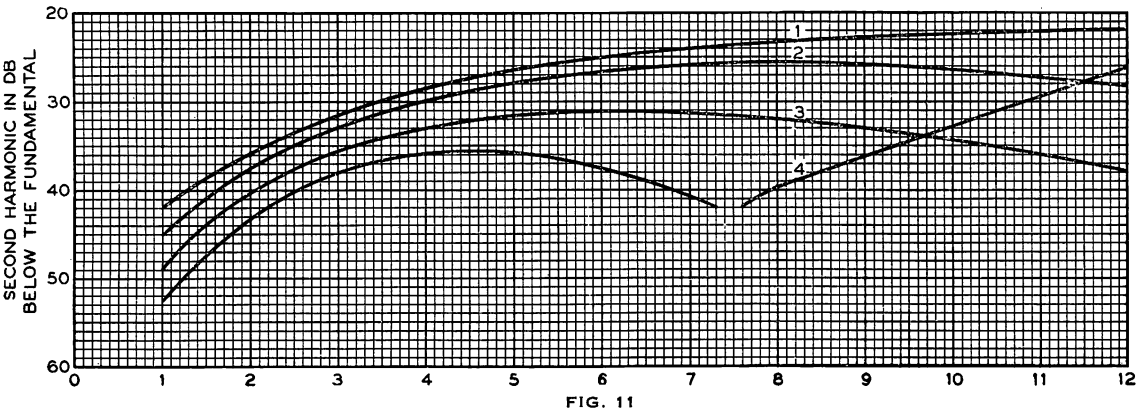


FIG. 11

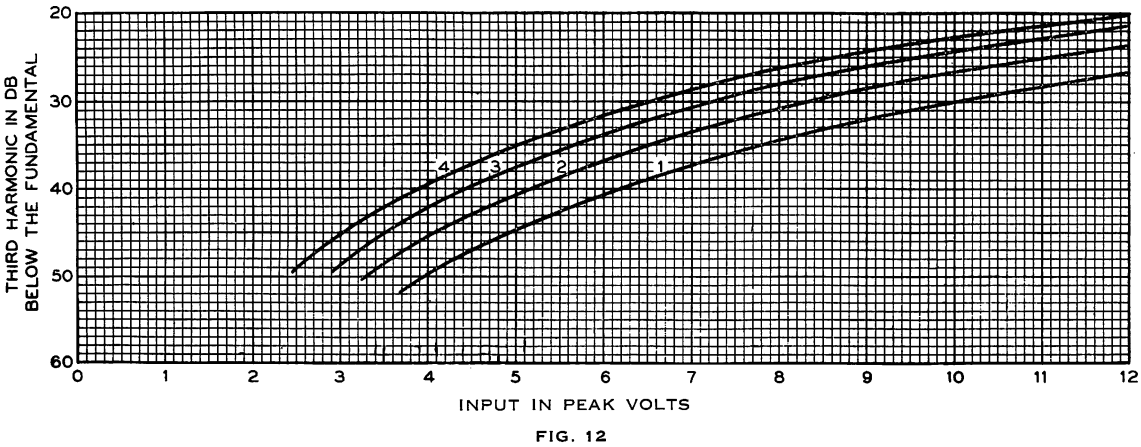


FIG. 12

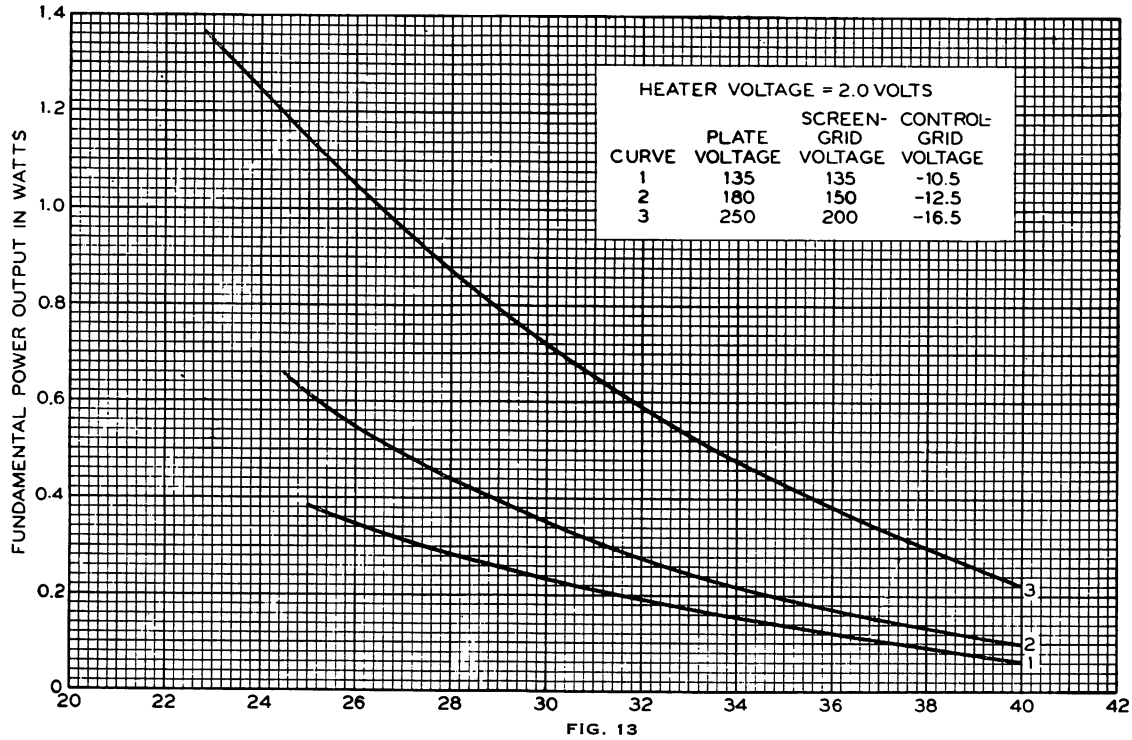


FIG. 13

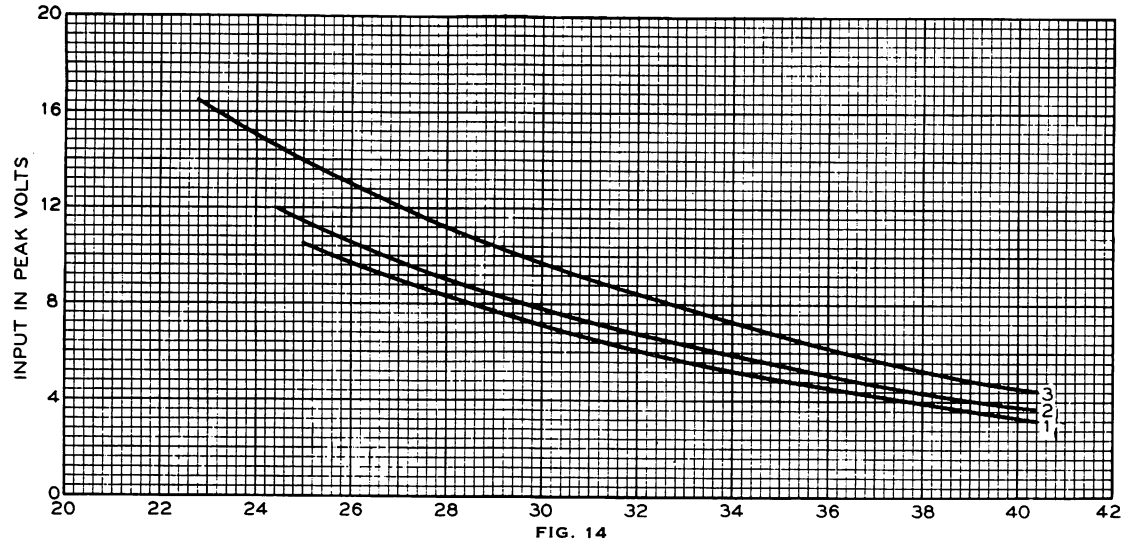


FIG. 14

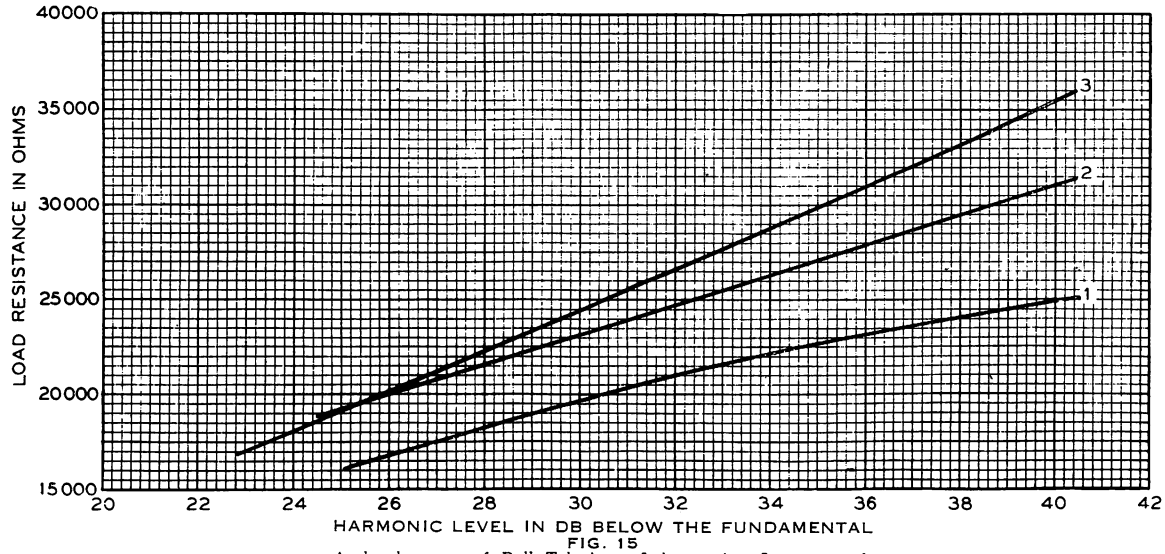
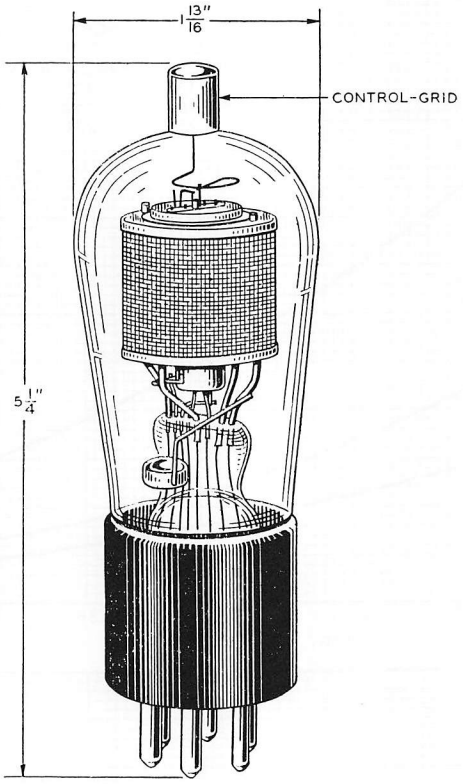
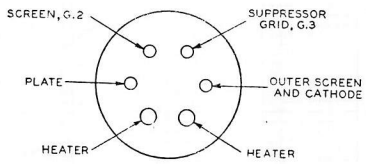


FIG. 15

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

286A Vacuum Tube





Classification

The 286A Vacuum Tube is a variable-mu, triple-grid, tube having an indirectly heated cathode which permits operation of the heater element directly on alternating current. Primarily, the tube is intended for use as a high-frequency amplifier, with the outer grid connected to the cathode and serving as a suppressor. It may also be used as an audio-frequency amplifier or as a modulator.

Base and Socket

The 286A Vacuum Tube employs a standard six prong base suitable for use in a Western Electric 144A or similar type socket. The arrangement of electrode connections to the base terminals is shown above. The control-grid terminal is located at the top of the bulb and is arranged for a special quick-release connector.

Rating and Characteristic Data

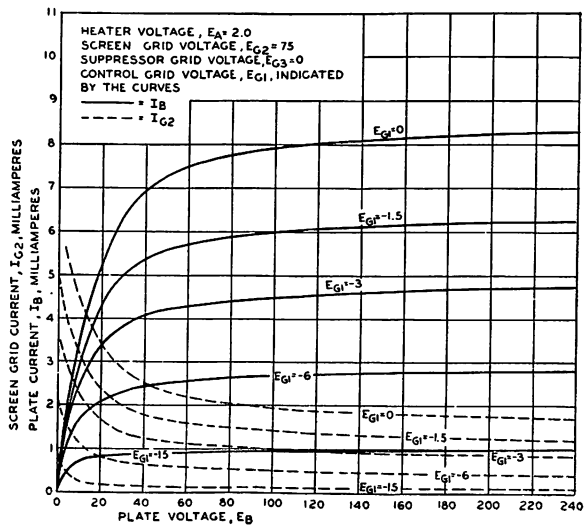
Heater Voltage (A.C. or D.C.)			2.0 Volts
Heater Current			1.6 Amperes
Plate Voltage	135	180	250 Max. Volts
Screen-Grid Voltage	75	75	75 Volts
Suppressor-Grid Voltage	0	0	0
For —1.5 Volts Control-Grid Bias			
Average Plate Current	6.1	6.2	6.3 Milliamperes
Average Plate Resistance	400,000	700,000	1,050,000 Ohms
Average Amplification Factor	475	850	1,275
Average Mutual Conductance	1,190	1,200	1,210 Micromhos
Average Control-Grid Bias for 5 Micromhos Mutual Conductance	—45	—45	—45 Volts

Approximate Direct Interelectrode Capacities (measured without socket)

Plate to Control-Grid	0.004 MMF.
Control-Grid to Heater, Cathode, Screen-Grid and Suppressor-Grid	6.0 MMF.
Plate to Heater, Cathode, Screen-Grid and Suppressor-Grid	14.0 MMF.

Average Static Characteristics

The accompanying curves give the average static characteristics of the 286A Vacuum Tube.



General Features

The low plate to control-grid capacity of this tube makes unnecessary the use of neutralization for prevention of oscillation or feed-back, provided the rest of the circuit elements are properly shielded.

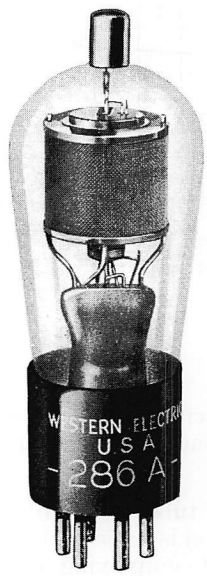
The variable-mu feature of this tube tends to prevent excessive cross-modulation and modulation-distortion as the amplification is varied by varying the control-grid bias. The tube is thus especially suitable for use in circuits employing automatic volume control.

A separate base terminal is provided for the suppressor grid making possible the use of the tube in various special circuits requiring application of either fixed or varying voltages on this element.

The cathode is designed to provide a very large electron emission compared with the current drain, thus assuring the maintenance of uniform characteristics over a long life.

Western Electric

286A Vacuum Tube



Classification—Variable-mu, voltage-amplifier, suppressor-grid pentode with indirectly heated cathode

Each of the three grids of the 286A tube is connected to a separate terminal.

Applications

High-frequency voltage amplifier, especially in circuits in which the amplification is varied by changing the control-grid bias.

Audio-frequency voltage amplifier.

Shielded modulator.

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 base. Small, metal cap control-grid terminal at the top of the bulb.

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

Mounting Positions—The 286A tube may be mounted in any position.

Average Direct Interelectrode Capacitances

Control grid to plate	0.004 μμf.
Suppressor grid to plate	1.7 μμf.
Plate to heater, cathode and screen grid	12.2 μμf.
Control grid to suppressor grid	0.06 μμf.
Control grid to heater, cathode and screen grid	6.3 μμf.
Suppressor grid to heater, cathode and screen grid	7.0 μμf.

Heater Rating

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

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 be kept as low as possible and should never exceed 90 volts.

Characteristics—Plate current and screen-grid current characteristics of a typical 286A tube are given in Figures 3 and 4, respectively, as functions of plate voltage for a screen-grid voltage of 75 volts, zero suppressor-grid voltage, and several values of control-grid voltage. A typical characteristic showing plate current as a function of control-grid voltage is given in Figure 5 for a plate voltage of 180 volts, a screen-grid voltage of 75 volts, and zero suppressor-grid voltage. The corresponding transconductance characteristic is shown in Figure 6. For other plate voltages between 135 and 250 volts, the transconductance of a typical tube for values higher than 5 micromhos does not differ by more than ± 2 per cent from its value at 180 volts. Amplification factor and plate resistance characteristics are shown in Figures 7 and 8, respectively, as functions of control-grid voltage for a screen-grid voltage of 75 volts, zero suppressor-grid voltage, and several values of plate voltage. Plate current and screen-grid current characteristics are shown in Figures 9 and 10 as functions of plate voltage for a screen-grid voltage of 75 volts, a control-grid voltage of −1.5 volts, and several values of suppressor-grid voltage. Corresponding amplification factor, plate resistance, and transconductance characteristics are given in Figures 11, 12, and 13, respectively.

Typical Operating Conditions

Plate Voltage	Screen-Grid Voltage	Suppressor-Grid Voltage	Control-Grid Bias	Plate Current	Screen-Grid Current	Amplification Factor	Plate Resistance	Transconductance
Volts	Volts	Volts	Volts	Milliamperes	Milliamperes		Ohms	Micromhos
135	75	0	−1.5	6.1	1.7	475	400,000	1190
180	75	0	−1.5	6.2	1.6	850	700,000	1200
*250	75	0	−1.5	6.3	1.5	1275	1,050,000	1210
**135-250	75	0	−45	—	—	—	—	5

*Maximum operating conditions
**Nominal cut-off

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.

Microphonic Noise—With a plate voltage of 180 volts, a screen-grid voltage of 75 volts, zero suppressor-grid voltage, a control-grid voltage of −1.5 volts, and a load resistance of 100,000 ohms, the mean microphonic noise output level of the 286A tube, measured in a laboratory reference test set, is 17 db below 1 volt. The range of levels of individual tubes extends from 0 to 34 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 types of tubes which have been tested in the same way.

Special Features—By virtue of its variable-mu characteristic, the 286A tube is particularly well adapted to amplifier or modulator applications where the sensitivity is controlled by varying the grid bias. As the control grid is made more negative, the transconductance and plate current approach zero gradually rather than sharply, so that distortion is relatively small at all values of grid bias.

In addition to its amplifier applications, the tube is also effective as a shielded modulator. Due to the low capacitance between the first and third grids, separate inputs may be applied to these elements without appreciable interaction. Both of these grids are negative for such use, so that the power required to drive them is negligible. The operating conditions suggested in the table on page 2 are appropriate except that a negative bias numerically equal to about ⅛ of the plate voltage should be applied to the suppressor grid.

Circuit Requirements—In order to make use of the high gain per stage of which the 286A 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 is usually 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. For amplifier applications, each suppressor grid should be connected directly to its corresponding cathode.

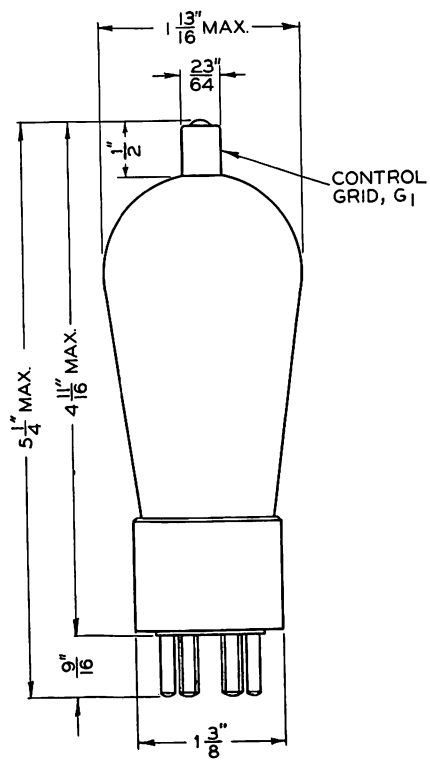


FIG. 1

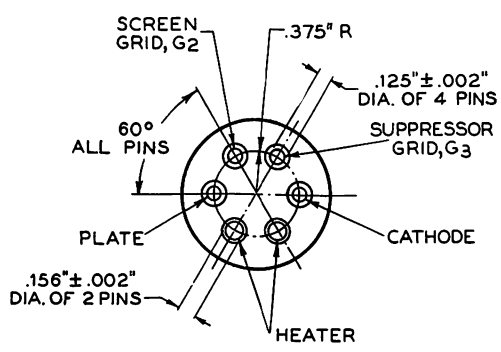


FIG. 2

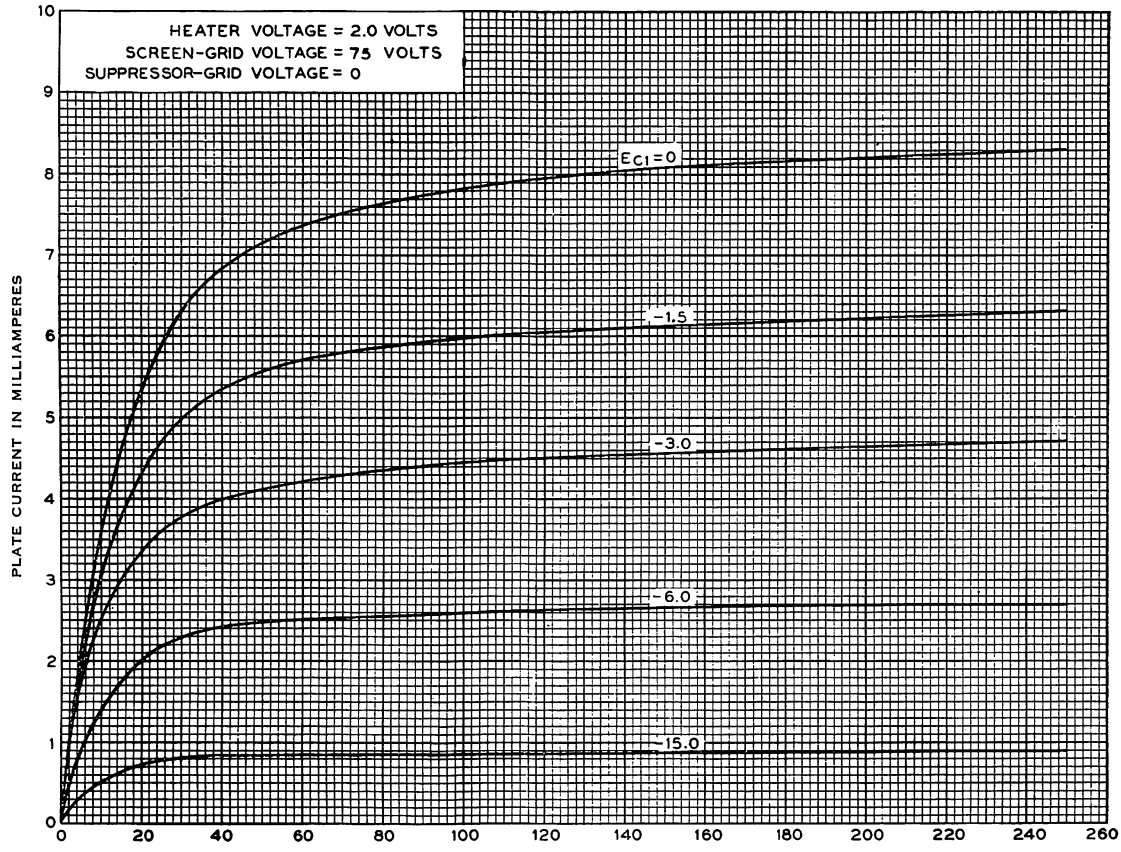

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE CURRENT IN MILLIAMPERES
E_{C1} = 0
-1.5
-3.0
-6.0
-15.0
0
1
2
3
4
5
6
7
8
9
10
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 3

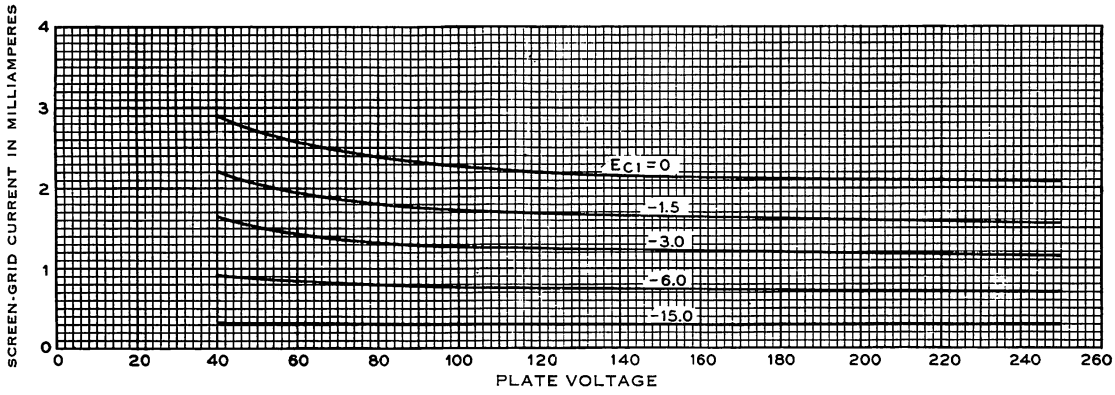

SCREEN-GRID CURRENT IN MILLIAMPERES
E_{C1} = 0
-1.5
-3.0
-6.0
-15.0
0
1
2
3
4
0
20
40
60
80
100
120
140
160
180
200
220
240
260
PLATE VOLTAGE

FIG. 4

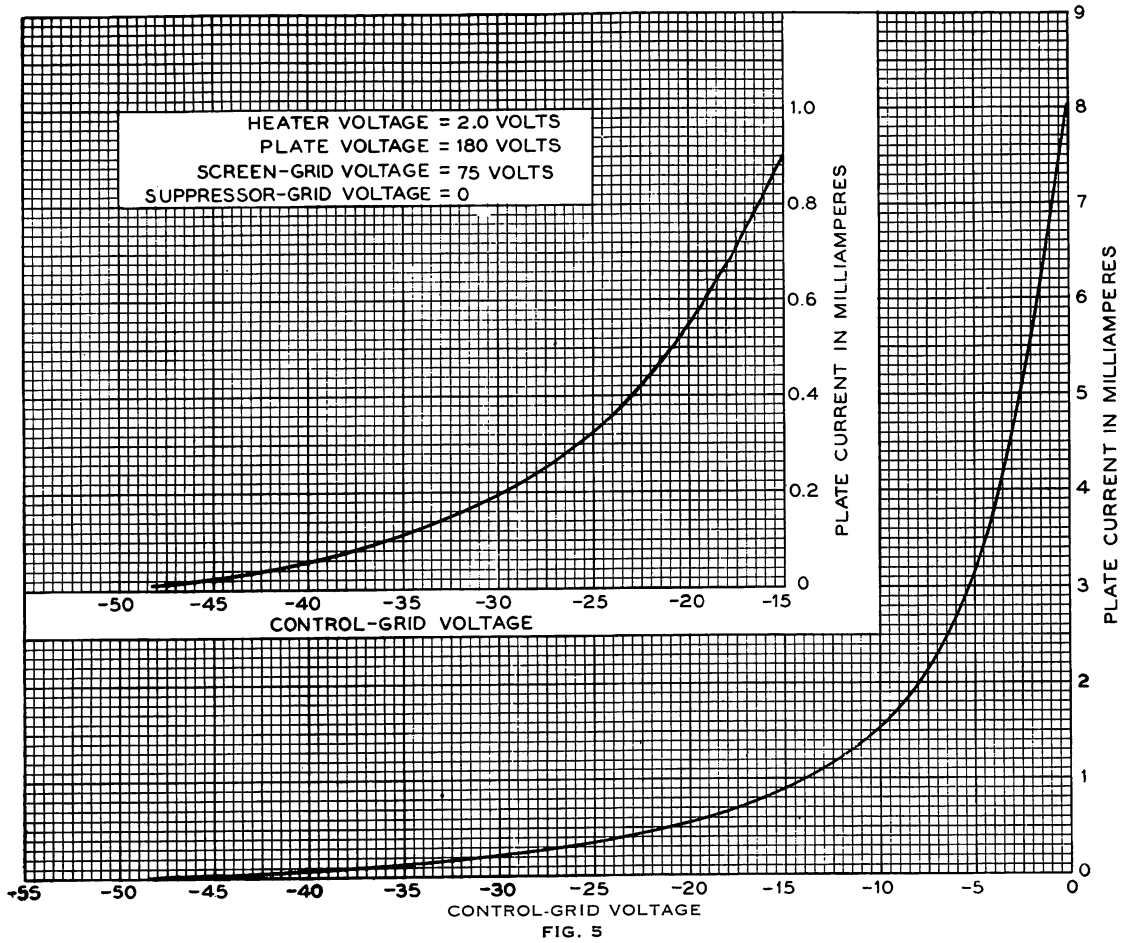

HEATER VOLTAGE = 2.0 VOLTS
PLATE VOLTAGE = 180 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
PLATE CURRENT IN MILLIAMPERES
1.0
0.8
0.6
0.4
0.2
0
-50 -45 -40 -35 -30 -25 -20 -15
CONTROL-GRID VOLTAGE
PLATE CURRENT IN MILLIAMPERES
9
8
7
6
5
4
3
2
1
0
-55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0
CONTROL-GRID VOLTAGE

FIG. 5

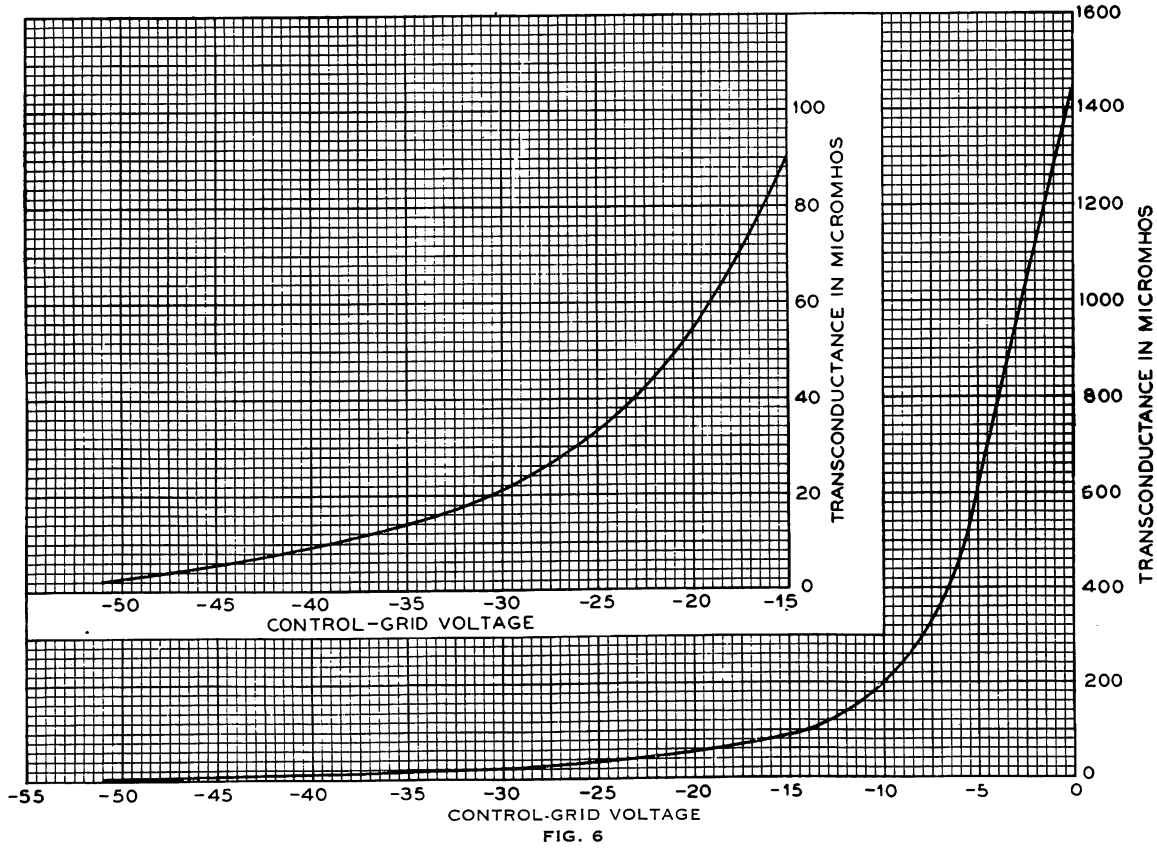

TRANSCONDUCTANCE IN MICROMHOS
100
80
60
40
20
0
-50 -45 -40 -35 -30 -25 -20 -15
CONTROL-GRID VOLTAGE
TRANSCONDUCTANCE IN MICROMHOS
1600
1400
1200
1000
800
600
400
200
0
-55 -50 -45 -40 -35 -30 -25 -20 -15 -10 -5 0
CONTROL-GRID VOLTAGE

FIG. 6

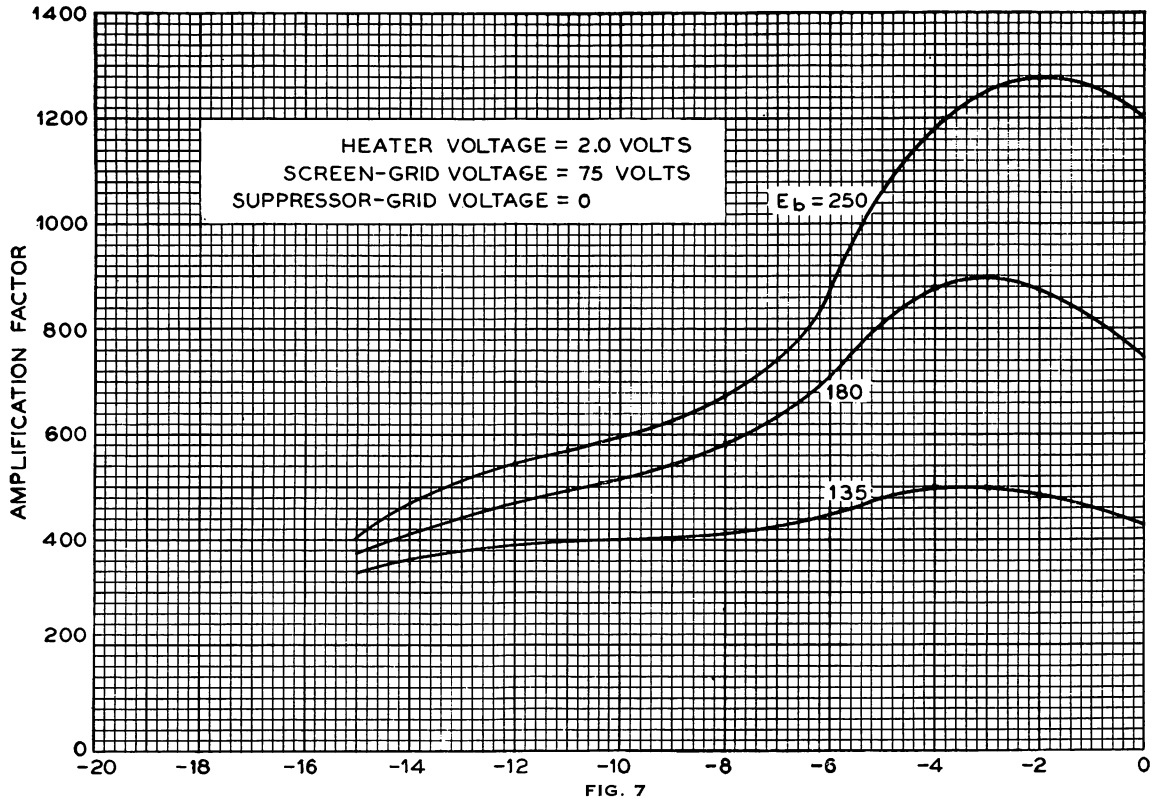

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
SUPPRESSOR-GRID VOLTAGE = 0
E_b = 250
180
135
AMPLIFICATION FACTOR
1400
1200
1000
800
600
400
200
0
-20
-18
-16
-14
-12
-10
-8
-6
-4
-2
0

FIG. 7

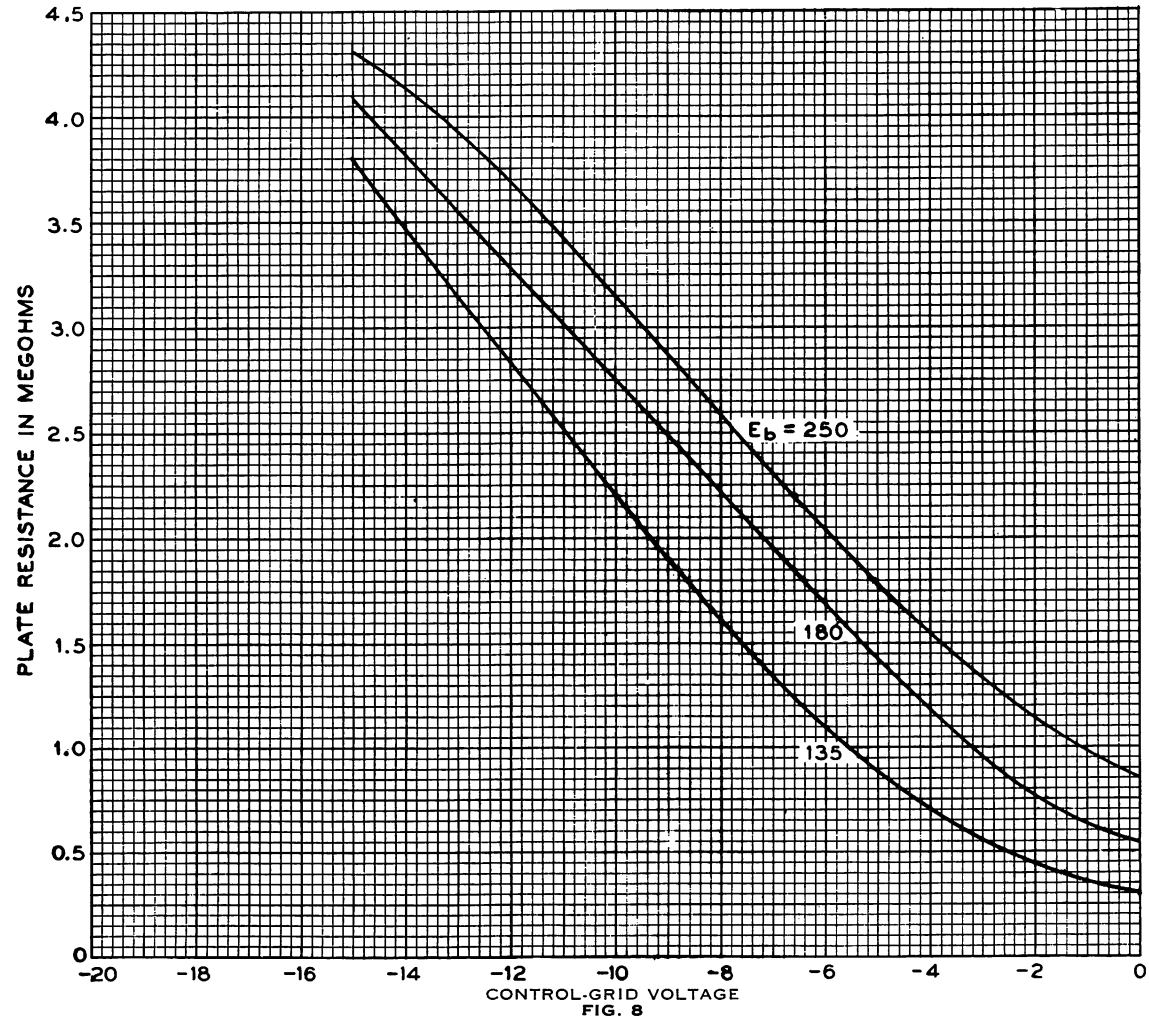

E_b = 250
180
135
PLATE RESISTANCE IN MEGOHMS
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-20
-18
-16
-14
-12
-10
-8
-6
-4
-2
0
CONTROL-GRID VOLTAGE

FIG. 8

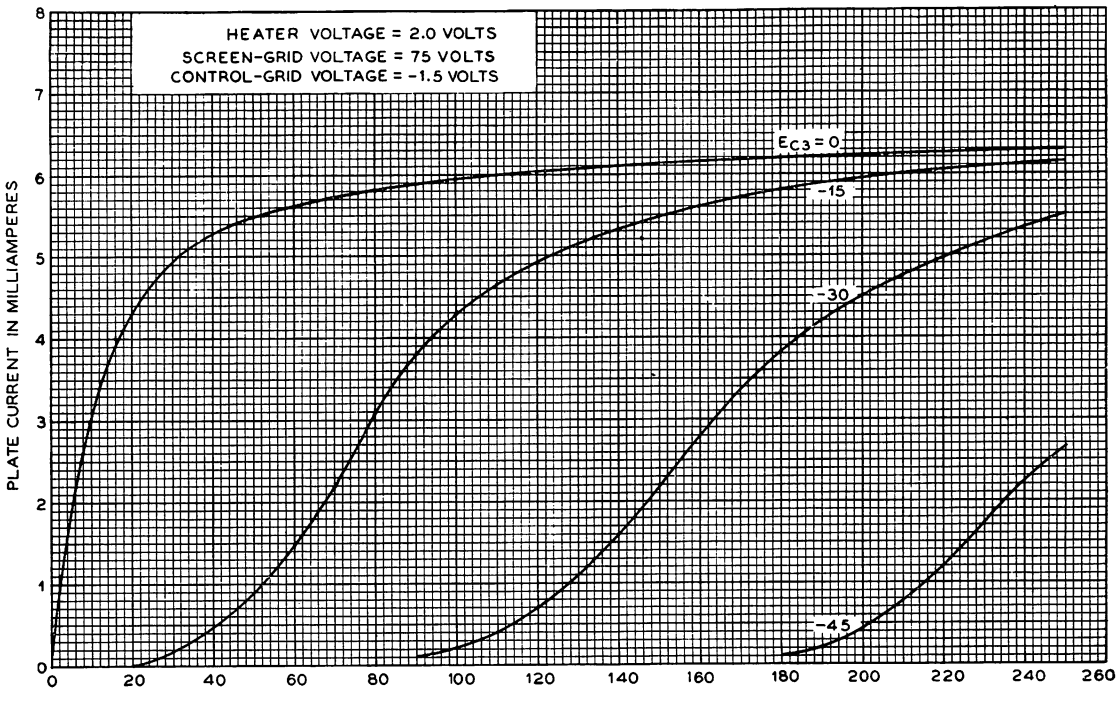

HEATER VOLTAGE = 2.0 VOLTS
SCREEN-GRID VOLTAGE = 75 VOLTS
CONTROL-GRID VOLTAGE = -1.5 VOLTS
$E_{C3} = 0$
-15
-30
-45
PLATE CURRENT IN MILLIAMPERES
0
1
2
3
4
5
6
7
8
0
20
40
60
80
100
120
140
160
180
200
220
240
260

FIG. 9

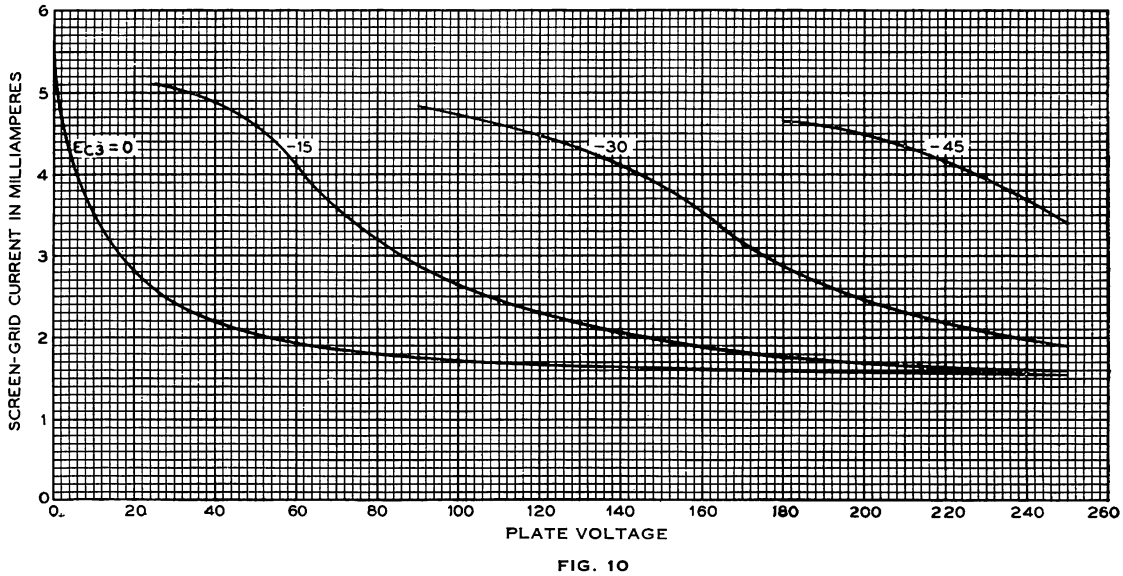

$E_{C3} = 0$
-15
-30
-45
SCREEN-GRID CURRENT IN MILLIAMPERES
0
1
2
3
4
5
6
0
20
40
60
80
100
120
140
160
180
200
220
240
260
PLATE VOLTAGE

FIG. 10

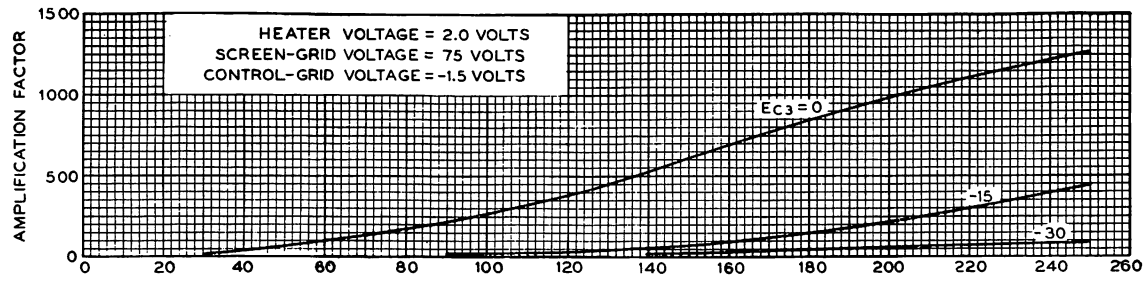


FIG. 11

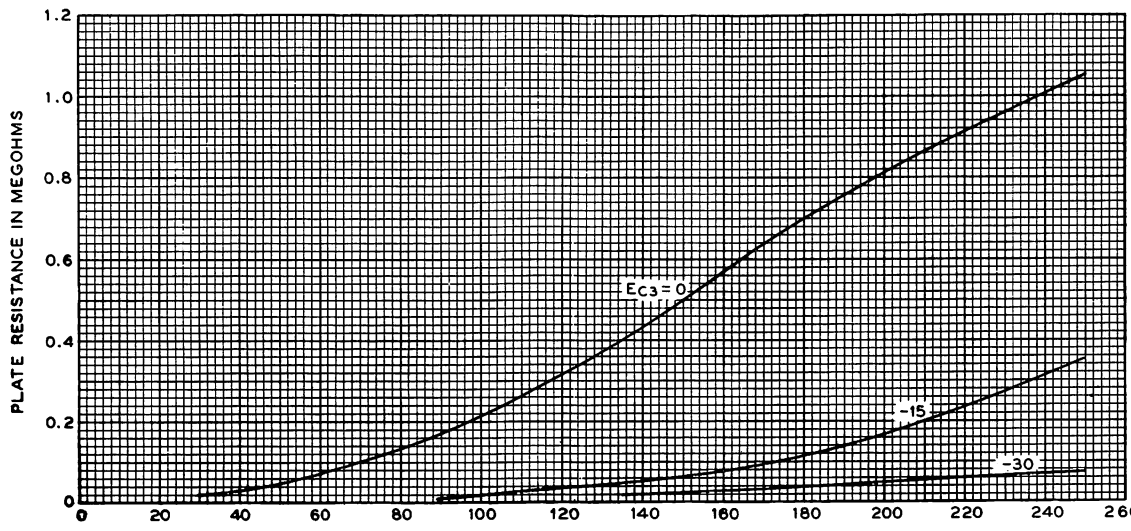


FIG. 12

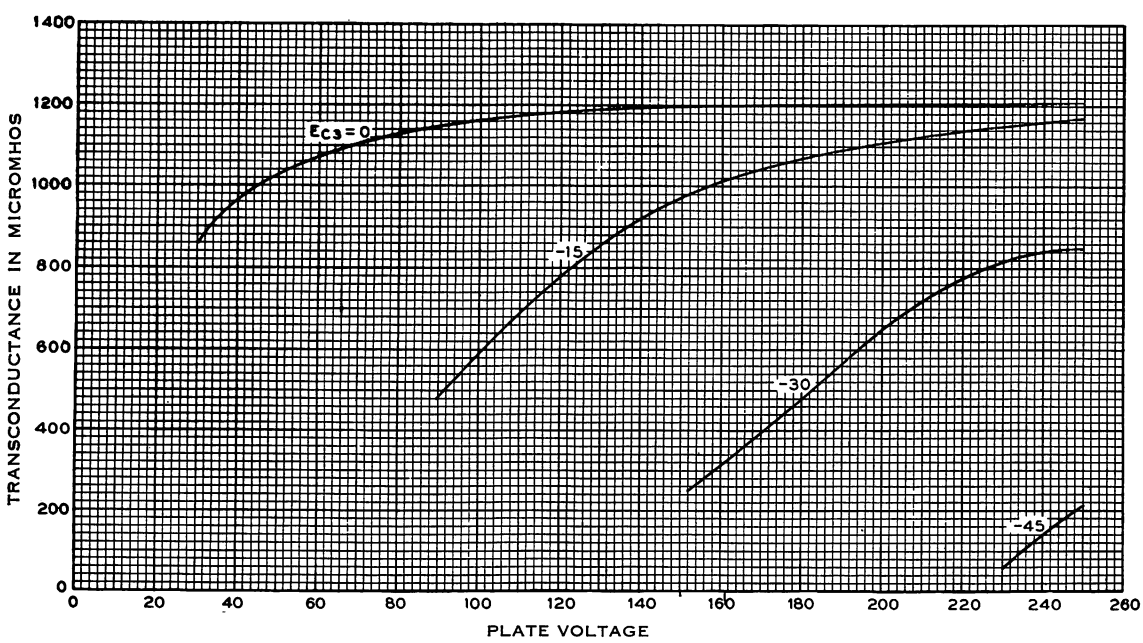


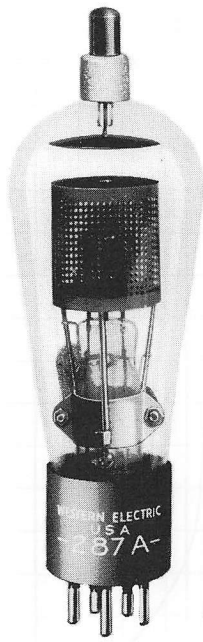
FIG. 13

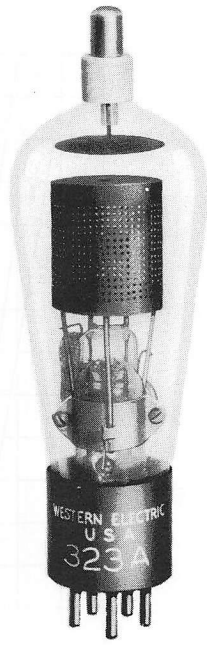
Western Electric

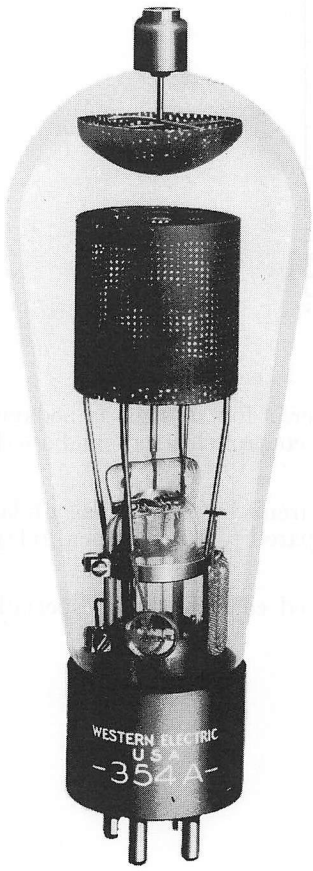
Vacuum Tubes

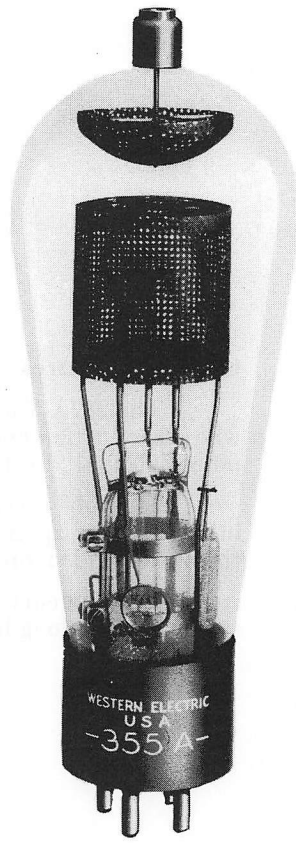
Three Element Power Thyratrons

287A 323A 354A 355A





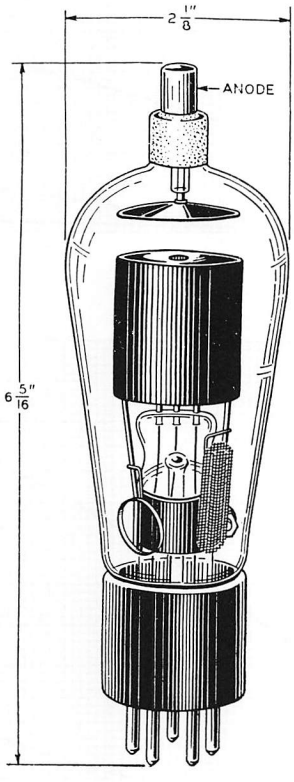


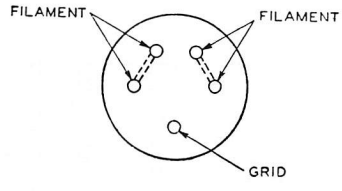


NOTE:

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.

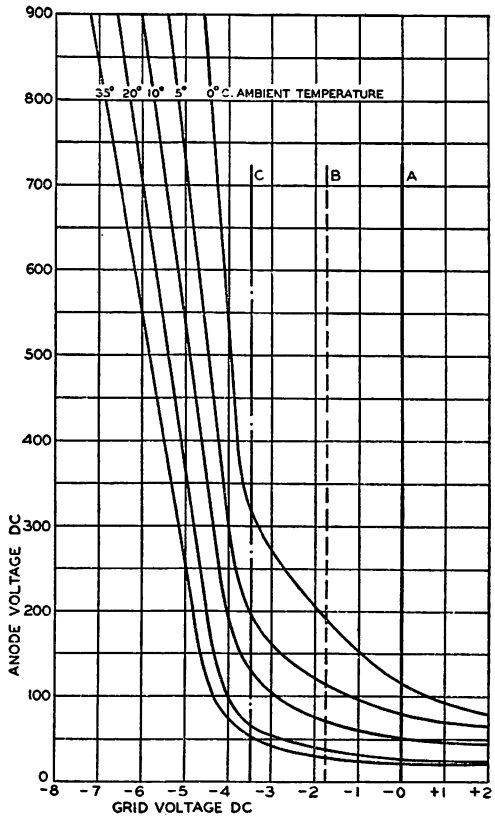
Breakdown Characteristics

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.

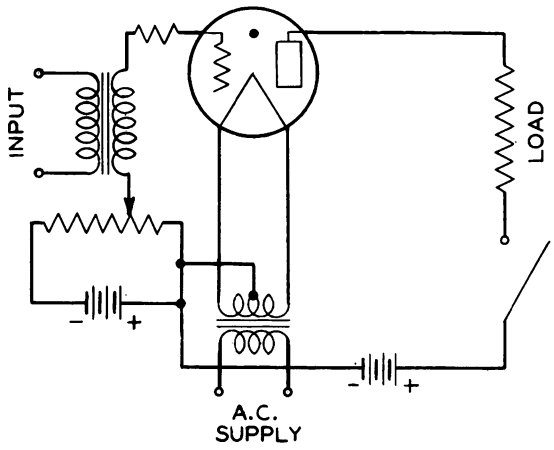


FIG. 1

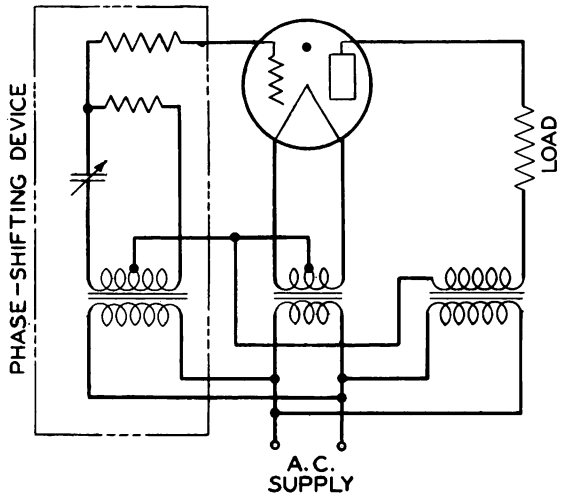


FIG. 2

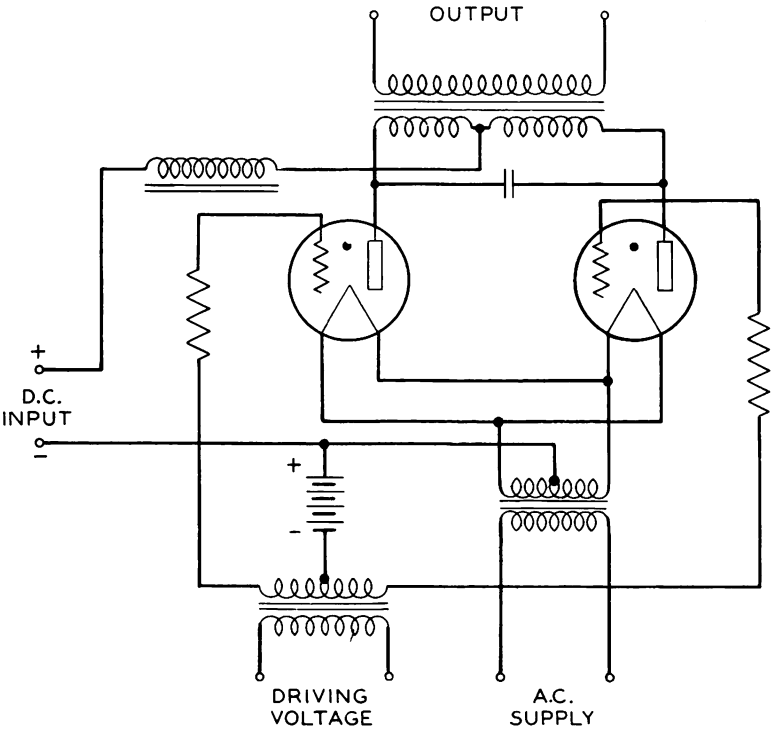


FIG. 3

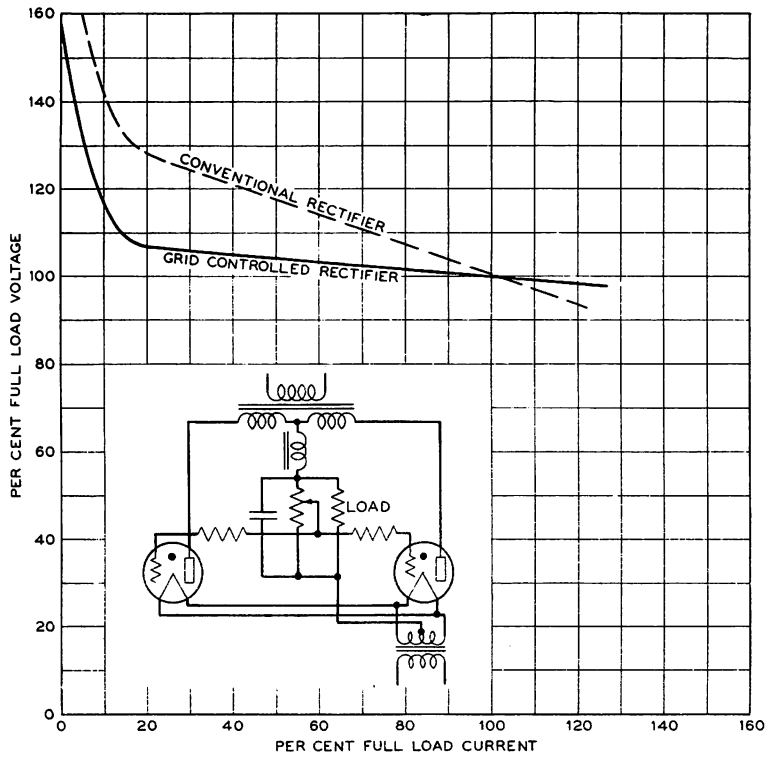

160
140
120
100
80
60
40
20
0
PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
0
20
40
60
80
100
120
140
160
PER CENT FULL LOAD CURRENT

FIG. 4

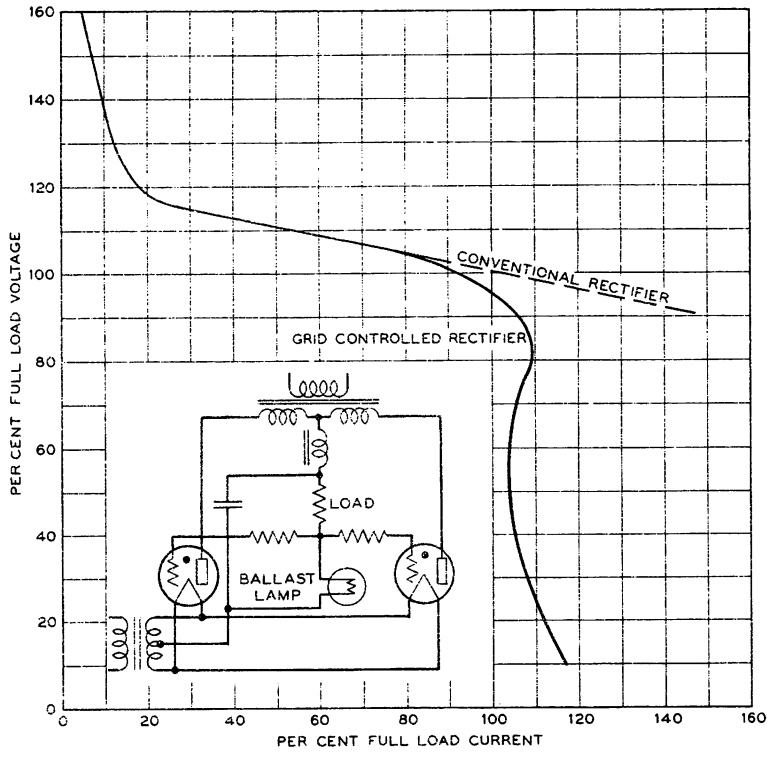
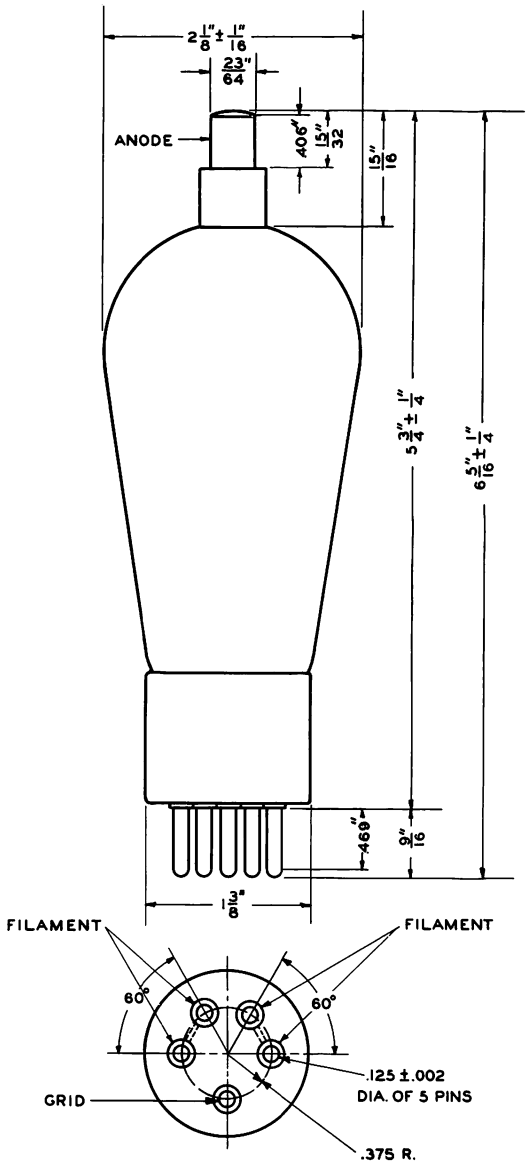
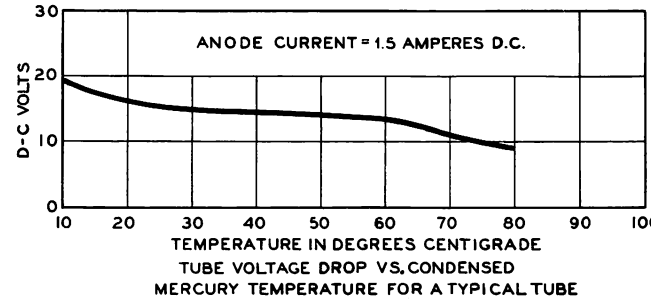

160
140
120
100
80
60
40
20
0
PER CENT FULL LOAD VOLTAGE
CONVENTIONAL RECTIFIER
GRID CONTROLLED RECTIFIER
LOAD
BALLAST LAMP
0
20
40
60
80
100
120
140
160
PER CENT FULL LOAD CURRENT

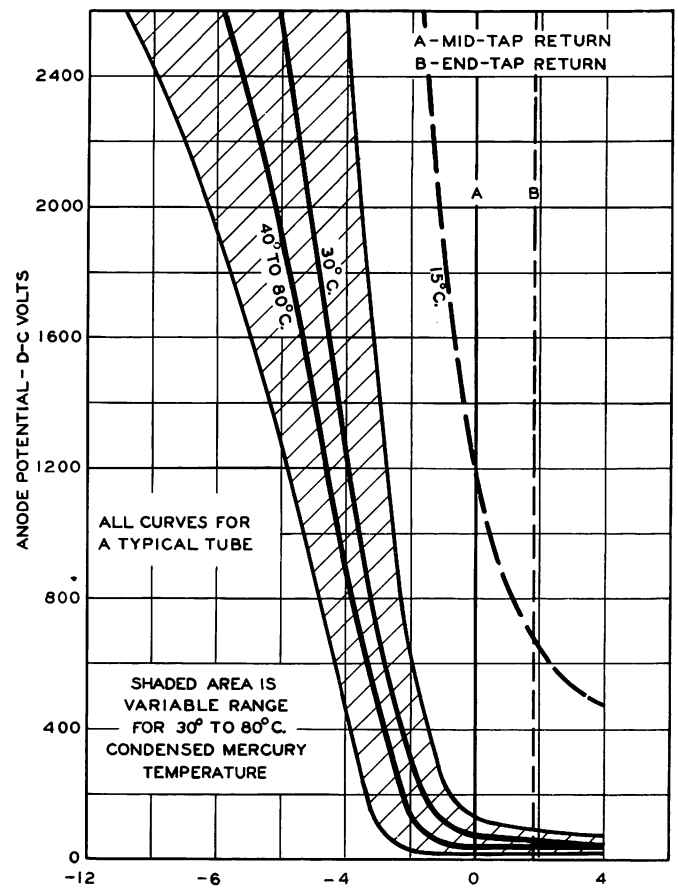
FIG. 5

287A Vacuum Tube
Mercury Vapor Filled





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



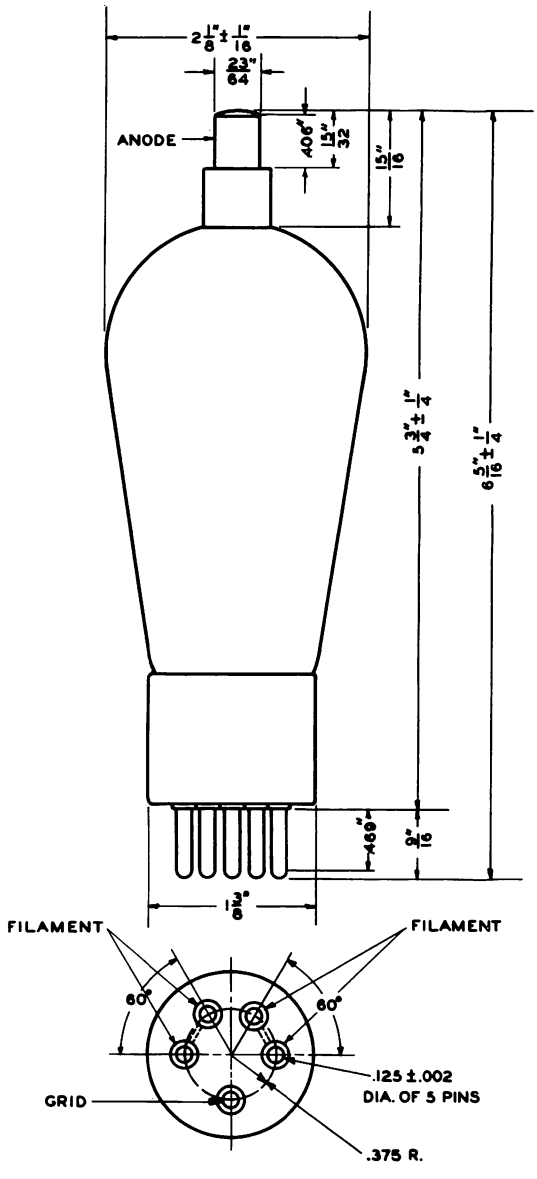
CONTROL CHARACTERISTIC

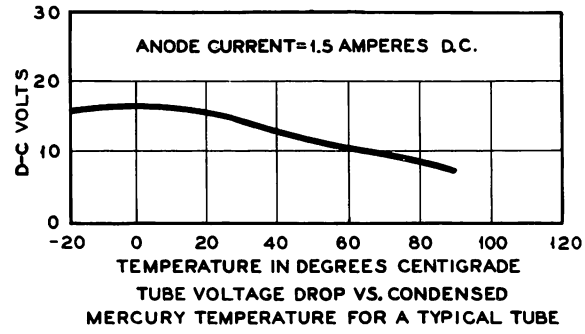
Ratings

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	

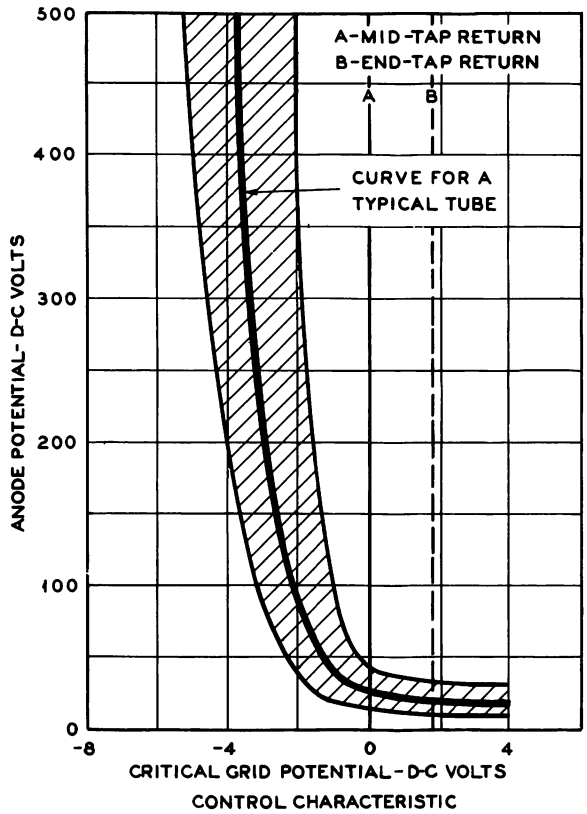
Mounting—The 287A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

323A Vacuum Tube
Mercury Vapor and Argon Filled





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



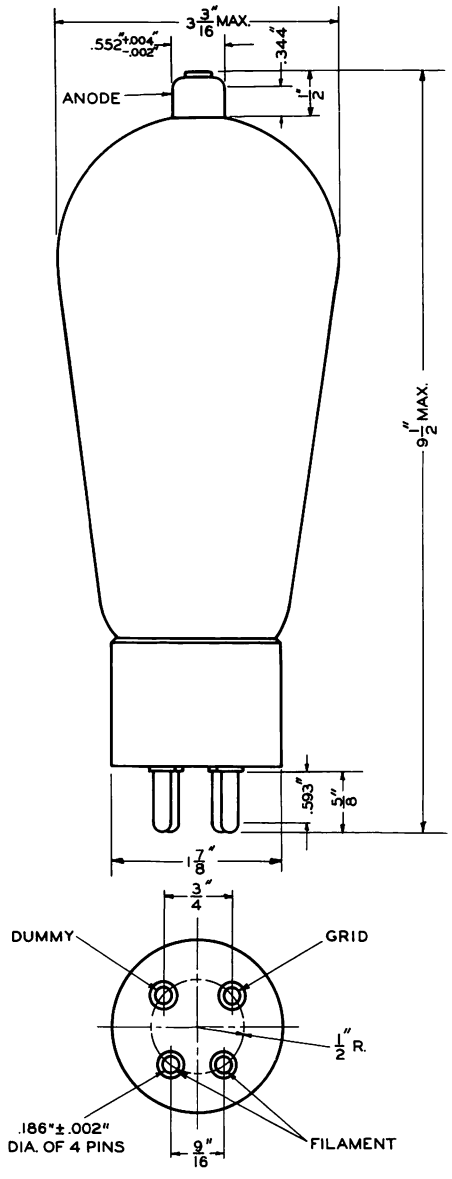
CONTROL CHARACTERISTIC

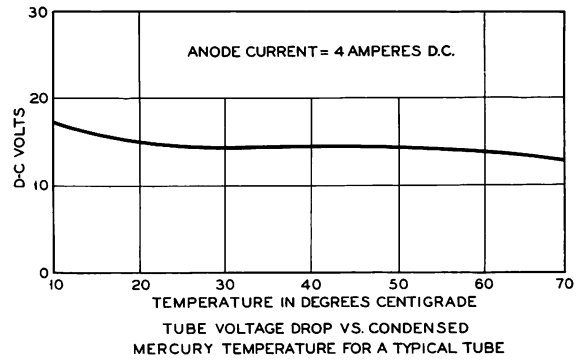
Ratings

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

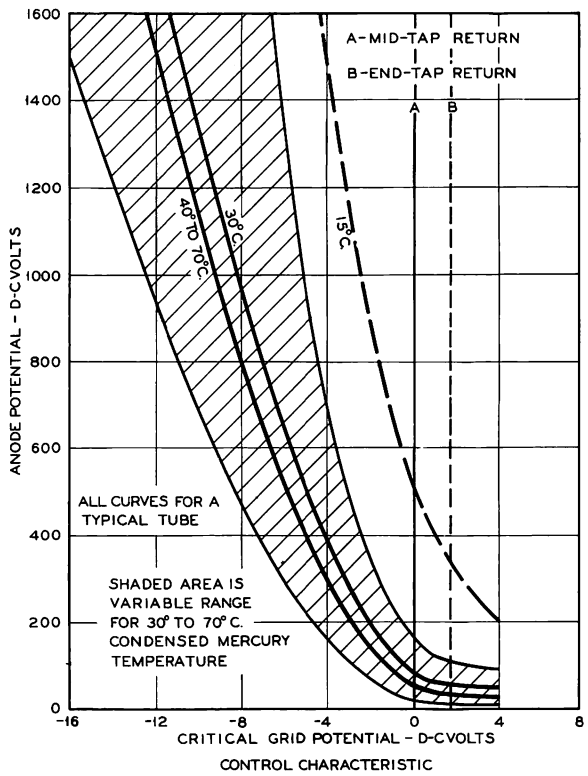
Mounting—The 323A tube requires a W. E. 141A or similar socket. A spring clip anode terminal connector is required. Mount in a vertical position only—base end down. A clearance of at least 2 inches should be allowed between the bulb and any adjacent object.

354A Vacuum Tube
Mercury Vapor Filled





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



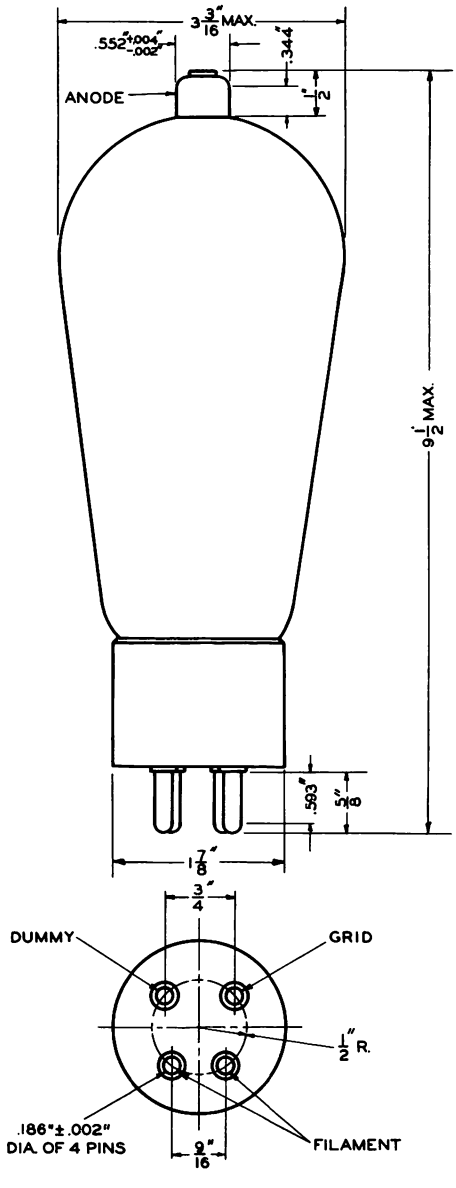
CONTROL CHARACTERISTIC

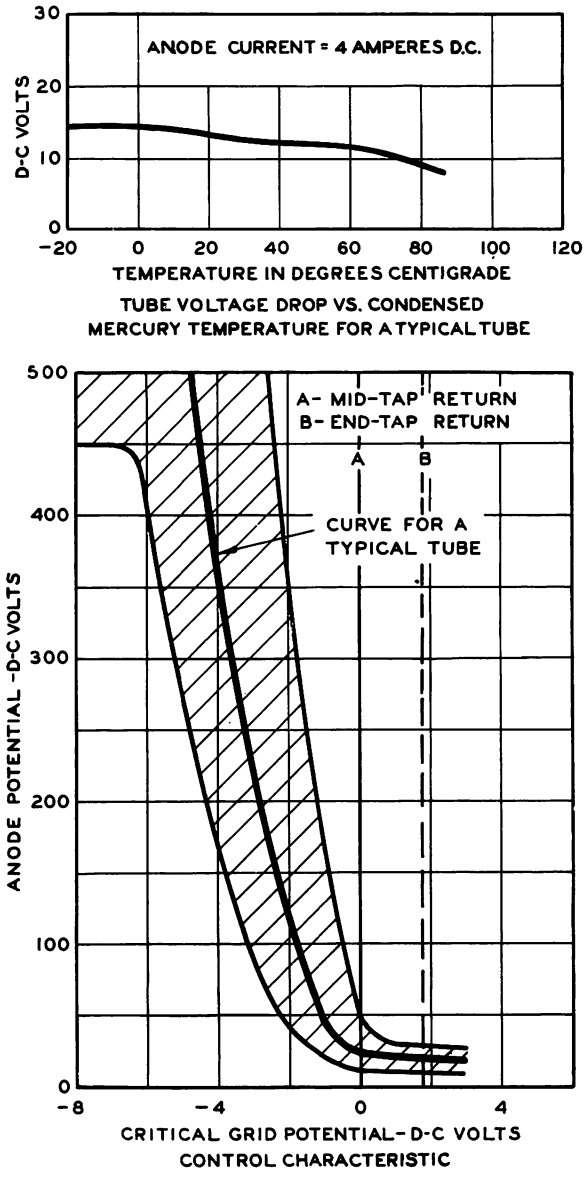
Ratings

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

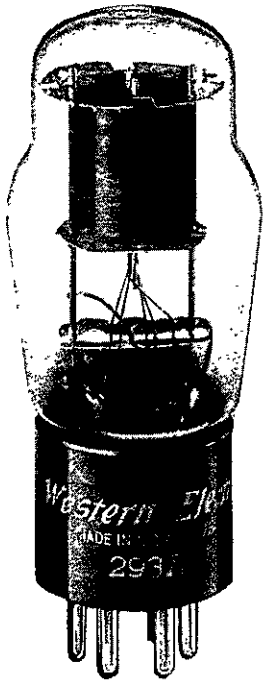




Ratings

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.



PENTODE
POWER AMPLIFIER

Western Electric

DESCRIPTION

The 293A is a suppressor grid, power pentode having an indirectly heated cathode. It is designed for use as an audio-frequency power amplifier in Class A_1 service.

CHARACTERISTICS

Heater Voltage		10.0 volts
Plate Current	$E_b = E_{c2} = 180$ volts; $E_{c1} = -18$ volts; $E_{c3} = 0$	15.8 milliamperes
Transconductance		1175 micromhos
Power Output		1.2 watts

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Heater Voltage, A-C or D-C	10.0 volts
Heater Current	320 milliamperes
Direct Interelectrode Capacitances (without external shield)	
Grid to Plate	0.66 uuf
Input	6.2 uuf
Output	6.5 uuf

MECHANICAL DATA

Cathode	Coated Unipotential
Bulb	ST14
Base	Medium 6-pin
Mounting Position	Any

Dimensions and pin connections shown in outline drawing on Page 6

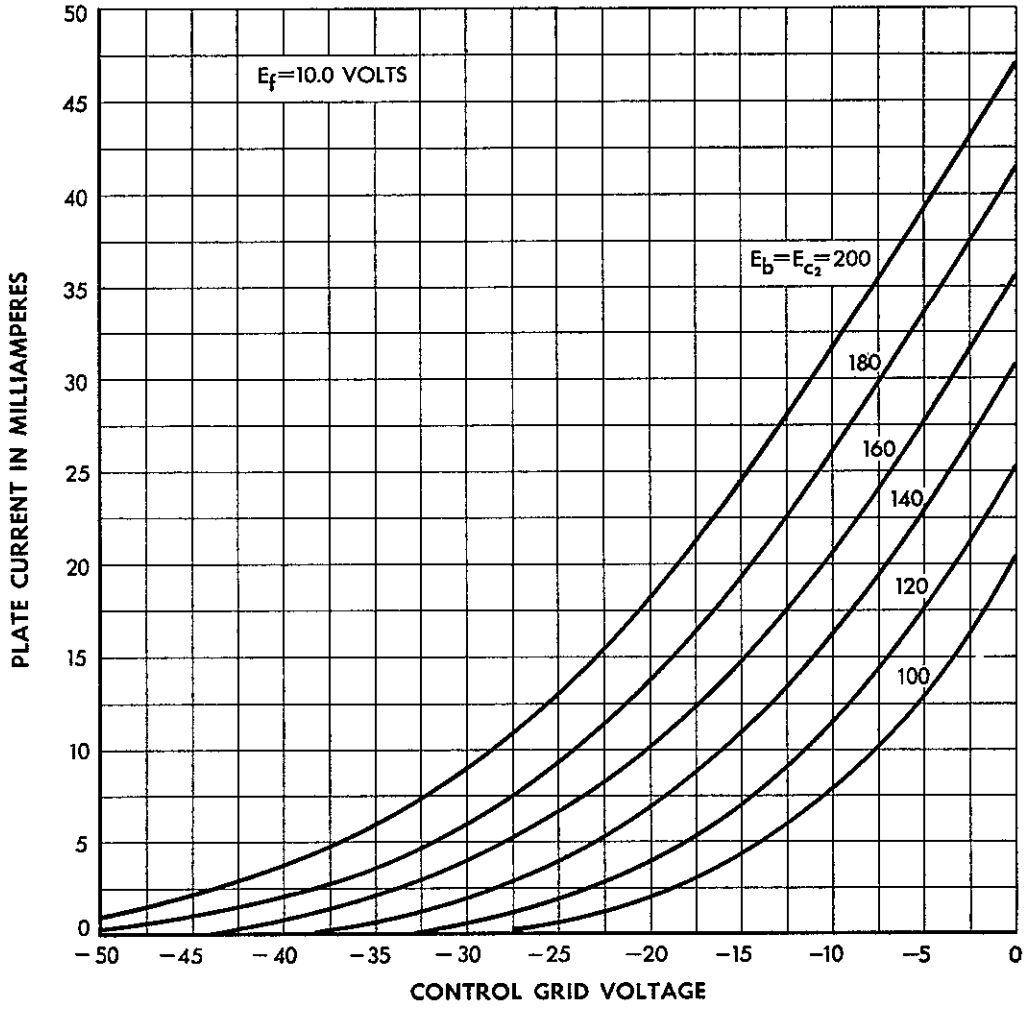
MAXIMUM RATINGS, Design-Center Values

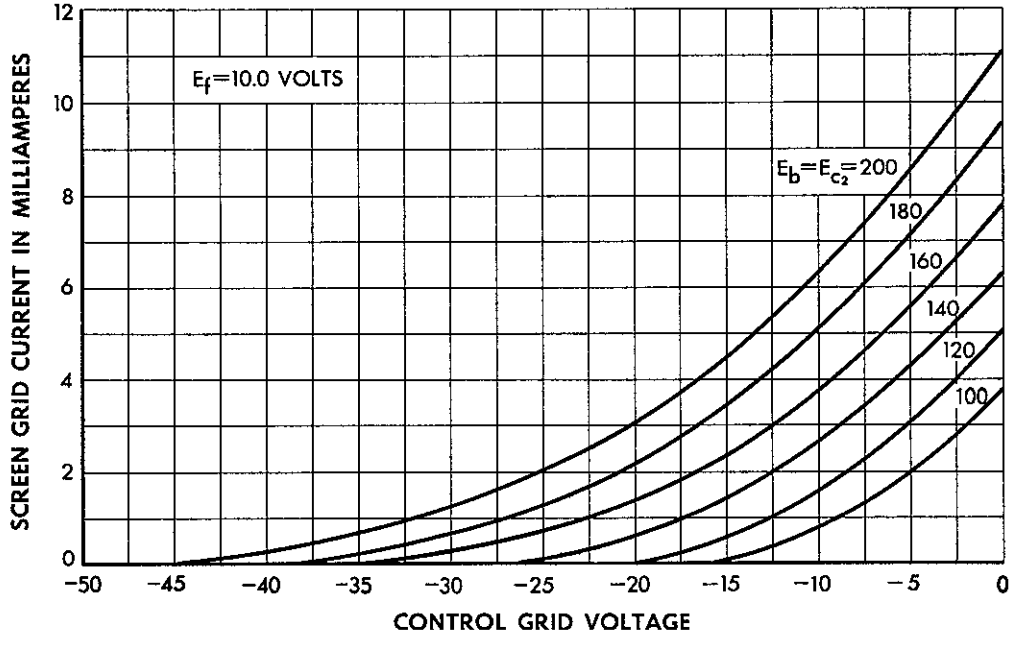
Plate Voltage	250 volts
Screen Grid Voltage	200 volts
Plate Dissipation	5 watts
Screen Grid Dissipation	1 watt
Cathode Current	30 milliamperes
Heater-Cathode Voltage	150 volts

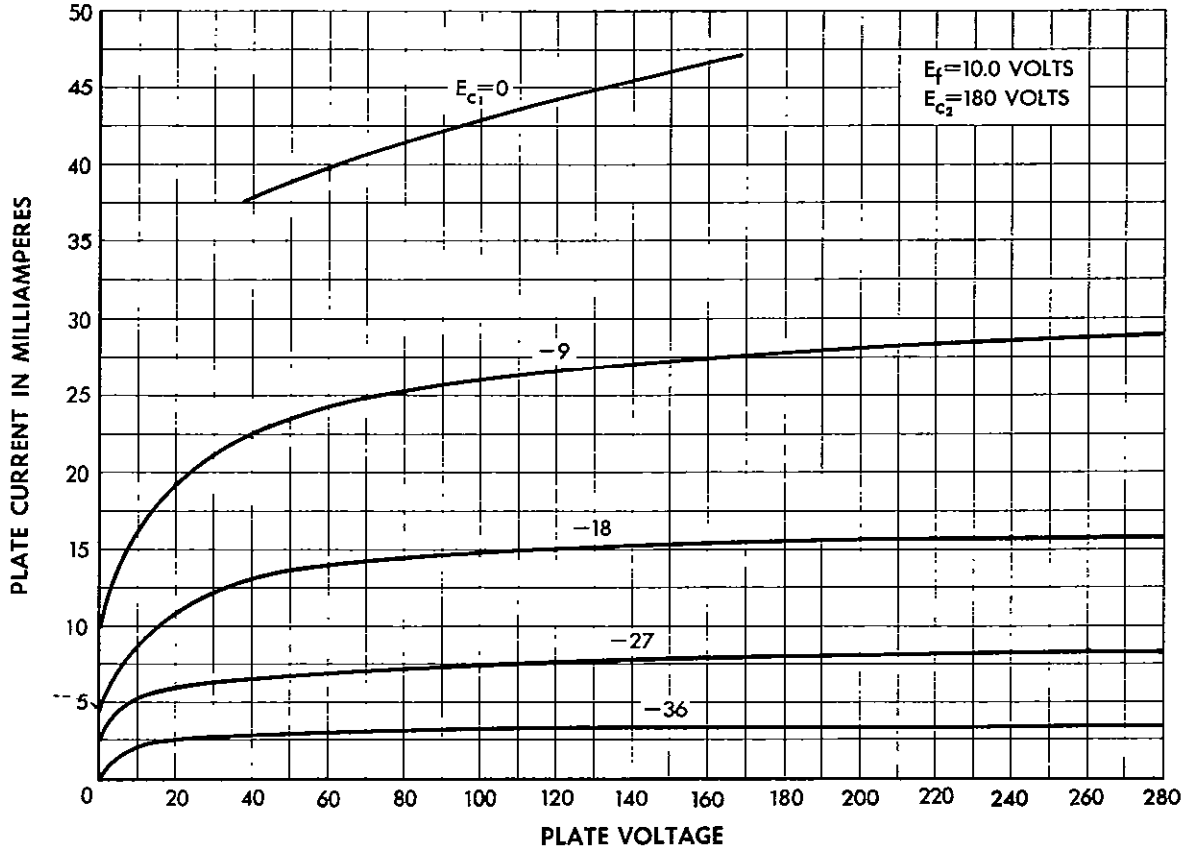
TYPICAL OPERATING CONDITIONS AND CHARACTERISTICS

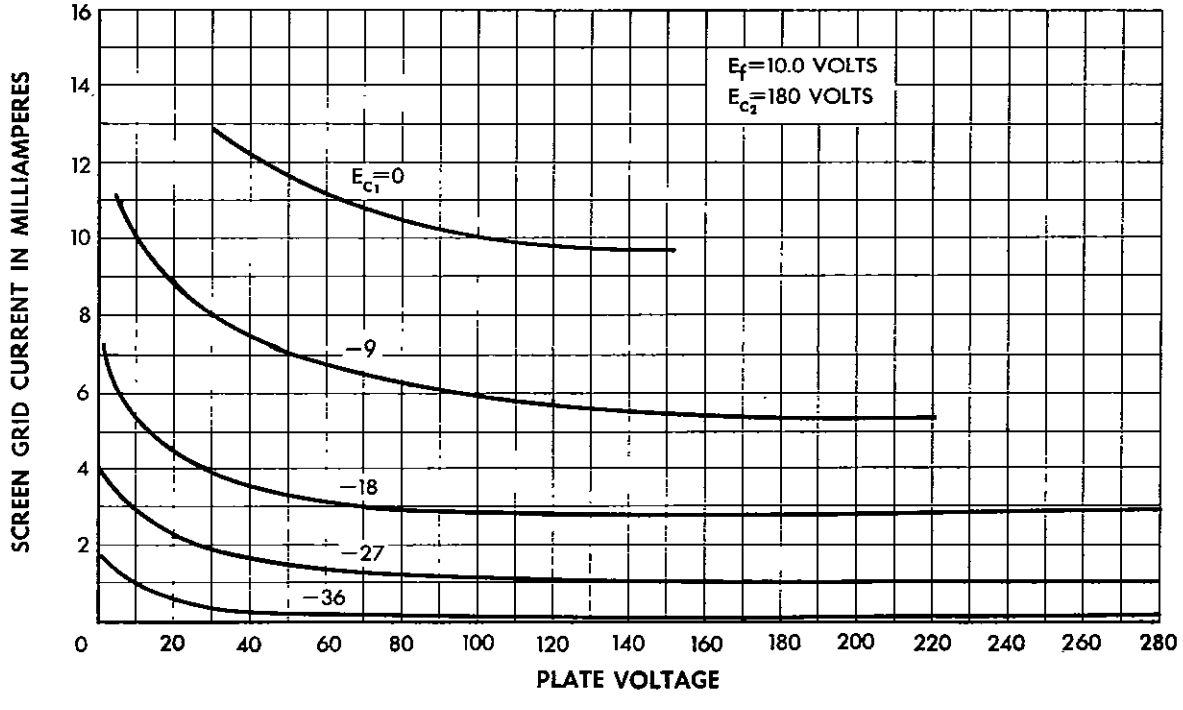
SINGLE TUBE AMPLIFIER – CLASS A_1

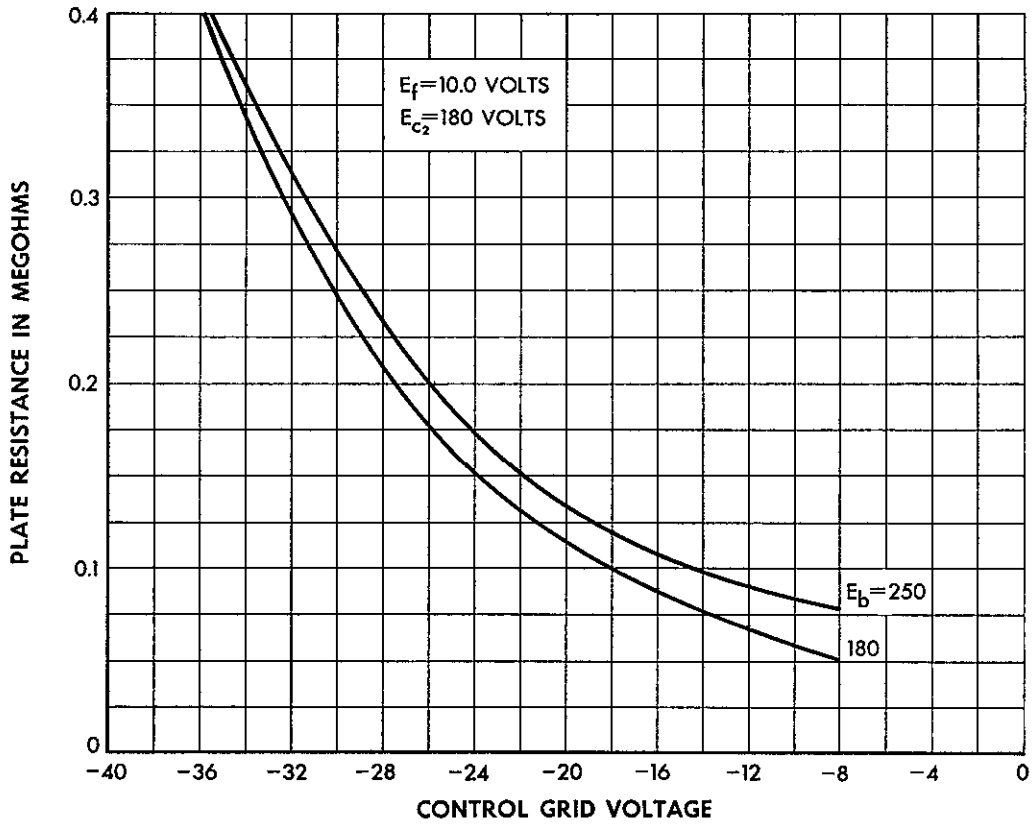
Plate Voltage	135	180	250	volts
Screen Grid Voltage	135	180	200	volts
Control Grid Voltage	−12	−18	−18	volts
Peak A-F Grid Voltage	12	18	18	volts
Zero Signal Plate Current	12.5	15.8	21.5	milliamperes
Maximum Signal Plate Current	13.5	17.0	23.5	milliamperes
Zero Signal Screen Grid Current	1.9	2.7	3.5	milliamperes
Maximum Signal Screen Grid Current	3.2	5.2	5.6	milliamperes
Transconductance	1140	1175	1340	micromhos
Plate Resistance	95000	100000	100000	ohms
Load Resistance	11000	11500	12000	ohms
Maximum Signal Power Output	0.6	1.3	2.1	watts
Total Harmonic Distortion	9.7	11	10	per cent

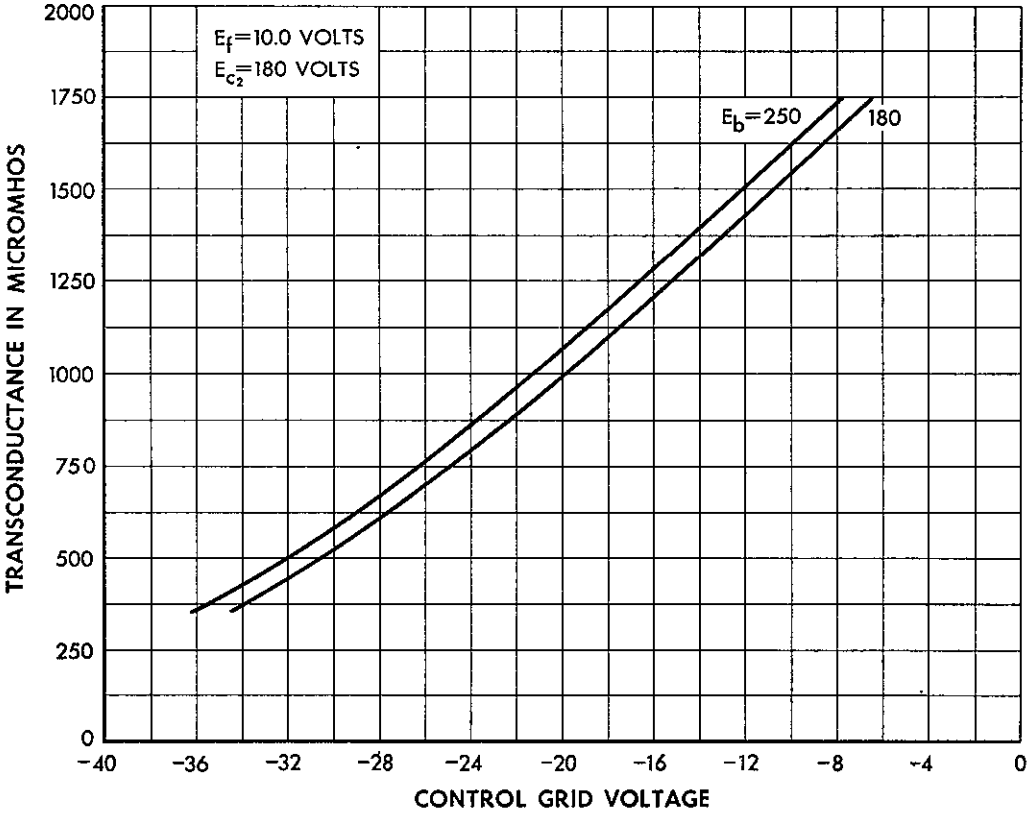

E_f=10.0 VOLTS
E_b=E_{c_2}=200
180
160
140
120
100
PLATE CURRENT IN MILLIAMPERES
CONTROL GRID VOLTAGE
50
45
40
35
30
25
20
15
10
5
0
−50
−45
−40
−35
−30
−25
−20
−15
−10
−5
0

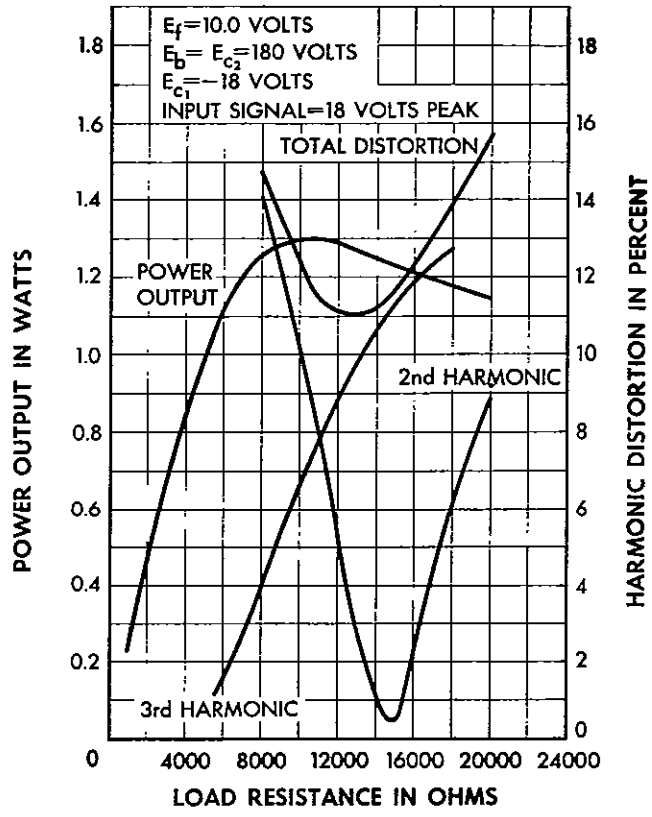

E_f=10.0 VOLTS
E_b=E_{c_2}=200
180
160
140
120
100
SCREEN GRID CURRENT IN MILLIAMPERES
CONTROL GRID VOLTAGE
12
10
8
6
4
2
0
−50
−45
−40
−35
−30
−25
−20
−15
−10
−5
0

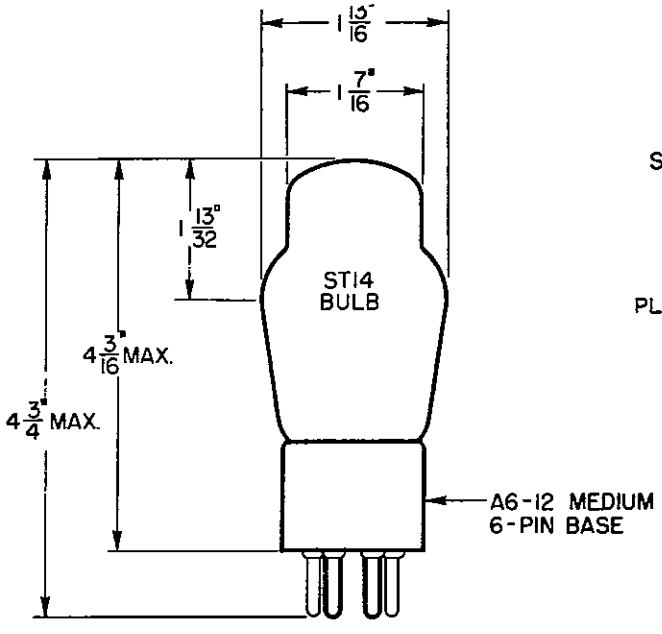

PLATE CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_f=10.0 VOLTS
E_{c_2}=180 VOLTS
E_{c_1}=0
−9
−18
−27
−36
0
5
10
15
20
25
30
35
40
45
50
20
40
60
80
100
120
140
160
180
200
220
240
260
280

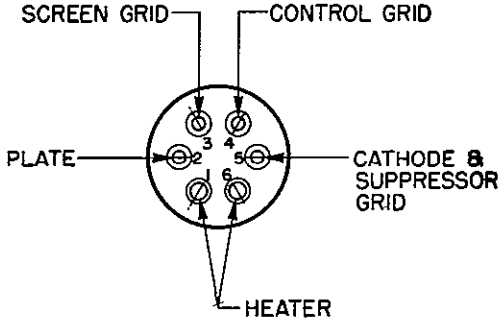

SCREEN GRID CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_f=10.0 VOLTS
E_{c_2}=180 VOLTS
E_{c_1}=0
−9
−18
−27
−36
0
2
4
6
8
10
12
14
16
20
40
60
80
100
120
140
160
180
200
220
240
260
280


0.4
0.3
0.2
0.1
0
PLATE RESISTANCE IN MEGOHMS
E_f=10.0 VOLTS
E_{c_2}=180 VOLTS
E_b=250
180
−40
−36
−32
−28
−24
−20
−16
−12
−8
−4
0
CONTROL GRID VOLTAGE


2000
1750
1500
1250
1000
750
500
250
0
TRANSCONDUCTANCE IN MICROMHOS
E_f=10.0 VOLTS
E_{c_2}=180 VOLTS
E_b=250
180
−40
−36
−32
−28
−24
−20
−16
−12
−8
−4
0
CONTROL GRID VOLTAGE





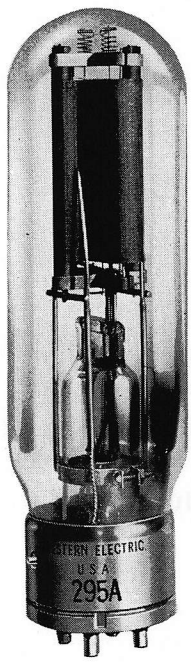


Western Electric

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

Western Electric

295A Vacuum Tube



Classification—Filamentary air-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency amplifier, modulator or oscillator.

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

Maximum overall length	$7\frac{15}{16}''$
Maximum diameter	$2\frac{5}{16}''$

Mounting—Large four-pin bayonet base for use in a W. E. 112A 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. or d.c.
Nominal filament current	3.25 amperes
Average thermionic emission	1.5 amperes

Average Direct Interelectrode Capacitances

Plate to grid	14.5 $\mu\mu$f.
Grid to filament	6.5 $\mu\mu$f.
Plate to filament	5.5 $\mu\mu$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 maximum direct plate voltage and dissipation (E_b = 1250 volts, I_b = 80 milliamperes)

Amplification factor	25
Plate resistance	6000 ohms
Grid to plate transconductance	4200 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	1250 volts
Max. direct plate current	175 milliamperes
Max. plate dissipation	100 watts
Max. direct grid current	50 milliamperes
Max. r-f grid current	7.5 amperes
Max. frequency for the above ratings	6 megacycles
Max. plate voltage for upper frequency limit of 30 Mc	600 volts
Max. plate voltage for frequencies between 6 and 30 Mc in proportion	

Class A Audio Amplifier or Modulator—The 295A tube is not recommended for Class A service. W. E. 242 or 284 types are preferable.

Class B Audio Amplifier or Modulator For Balanced 2 Tube Circuit

Direct plate voltage	1250	1000 volts
Grid bias	−40	−30 volts
Direct plate current per tube		
No drive	12	10 milliamperes
Maximum drive	160	160 milliamperes
Load resistance plate-to-plate	9000	6900 ohms
Load resistance per tube	2250	1725 ohms
Power output depends on distortion requirements:		
Approximate maximum output—2 tubes	250	200 watts
Recommended power for driving stage	20	20 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	1250	1000 volts
Direct plate current for carrier conditions	105	120 milliamperes
Grid bias	−45	−35 volts
Approximate carrier watts for use with 100% modulation	42.5	40 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	1250	1000 volts
Direct plate current	150	150 milliamperes
Grid bias	−125	−100 volts
Nominal power output	125	100 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	1000 Max.	750 volts
Direct plate current	150	150 milliamperes
Grid bias	−125	−90 volts
Maximum direct grid current	50	50 milliamperes
Nominal carrier power output for use with 100% modulation	100	70 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. The graphite anodes should not show a red color, typical for molybdenum plates, during operation as such color indicates excessive dissipation.

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 200 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 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 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—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. The tube may be used at full rating up to 6 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.

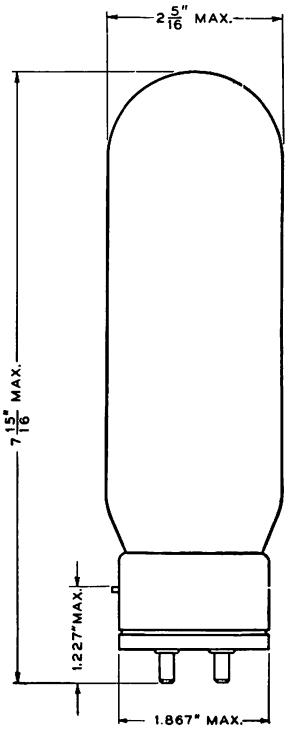


FIG. 1

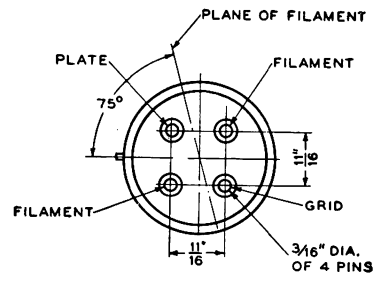
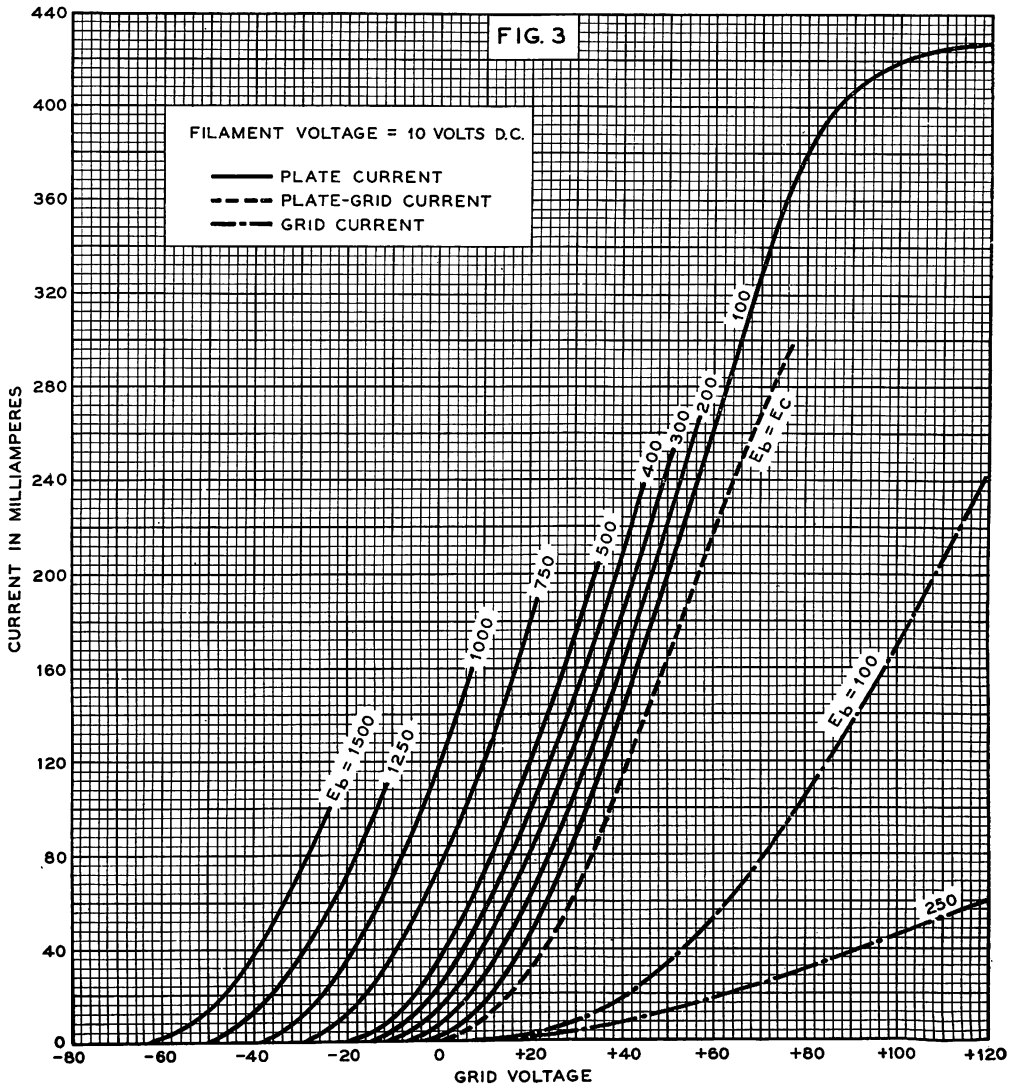
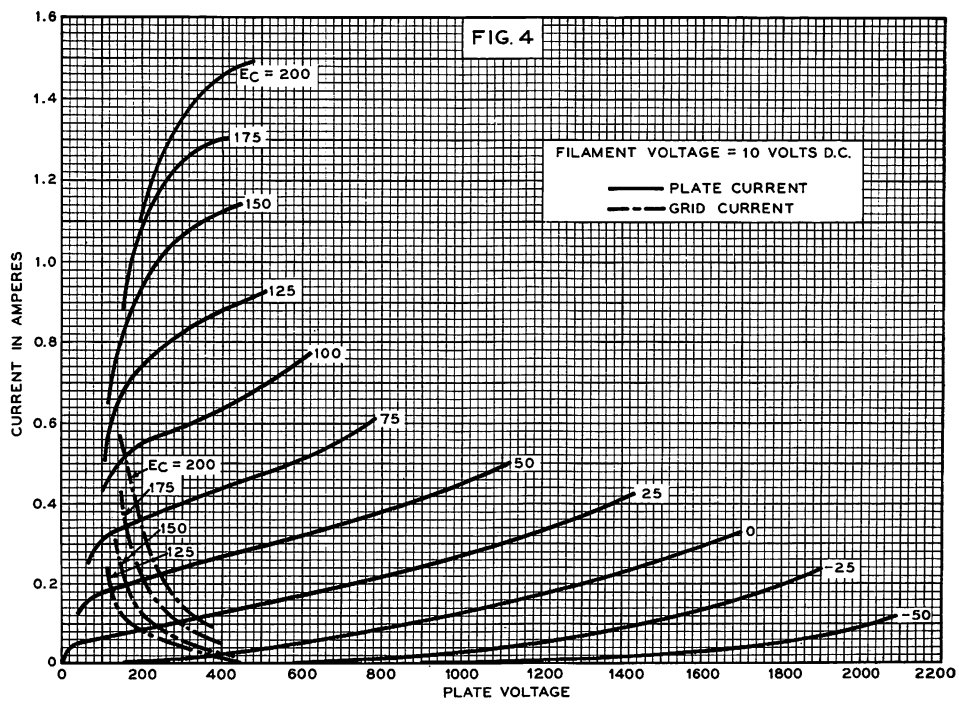


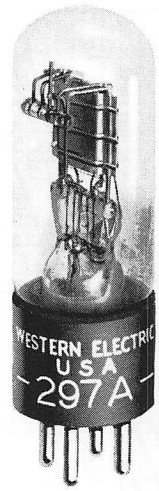
FIG. 2


FIG. 3
FILAMENT VOLTAGE = 10 VOLTS D.C.
PLATE CURRENT
PLATE-GRID CURRENT
GRID CURRENT
CURRENT IN MILLIAMPERES
GRID VOLTAGE
Eb = 1500
1250
1000
750
500
400
300
200
100
Eb = Ec
Eb = 100
250
440
400
360
320
280
240
200
160
120
80
40
0
-80
-60
-40
-20
0
+20
+40
+60
+80
+100
+120


FIG. 4
FILAMENT VOLTAGE = 10 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
CURRENT IN AMPERES
PLATE VOLTAGE
Ec = 200
175
150
125
100
75
50
25
0
-25
-50
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

Western Electric

297A Vacuum Tube



Classification—Three element, argon filled, filamentary thyratron

This tube is a rectifier of low internal impedance in which the starting of the conduction cycle may be controlled by the grid. 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, or as a source of sweep-voltage for a linear time axis.

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

Maximum length	4″
Diameter	$1\frac{3}{16}$″

Mounting—This vacuum tube employs a standard four-pin thrust type base suitable for use in a Western Electric 143B or similar socket. 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, although the vertical position is preferable. If mounted in a horizontal position the plane of the filament, which is indicated in Figure 2, should be vertical.

Filament Rating

Filament voltage	1.75 volts
Nominal filament current	0.350 ampere
Required filament heating time	2 seconds

The filament of this tube is designed to operate on a voltage basis. The voltage should be maintained to within 5% of its rated value (1.75 volts). Operation of the filament 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. If filament transformers with good regulation are used this time is 2 seconds. Failure to allow sufficient time may result in immediate failure. If instantaneous anode currents less than 10 milliamperes are desired with anode voltages less than 50 volts, anode current may be drawn simultaneously with the application of filament voltage; but approximately 2 seconds will be required for the anode current to reach its final value.

Operating Conditions

Approximate tube voltage drop	20 volts
Maximum instantaneous anode current	60 milliamperes
Maximum average anode current	10 milliamperes
Maximum time of averaging anode current	0.5 second
Maximum peak voltage between anode and grid	250 volts
Maximum instantaneous grid current	10 milliamperes
Operating ambient temperature range	−20° to +50° C.
Nominal deionization time	100 microseconds

The characteristics of the 297A tube are such 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 non-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 anode 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 anode current and the grid potential. 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 (100 microseconds).

A typical curve relating the critical grid potential to the anode potential is shown in Figure 3. This characteristic may vary from tube to tube and during the life of a given tube.

The maximum anode current is specified in terms of an instantaneous value (60 milliamperes) and an average value (10 milliamperes), with a maximum period of averaging of 0.5 second. These are maximum limitations and should not be exceeded.

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. 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. 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 on it. In circuits Figures 6 and 7 alternating current may be used for the filament supply.

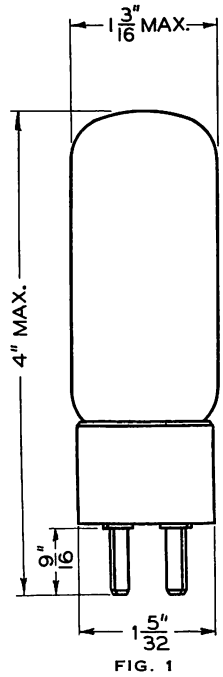


FIG. 1

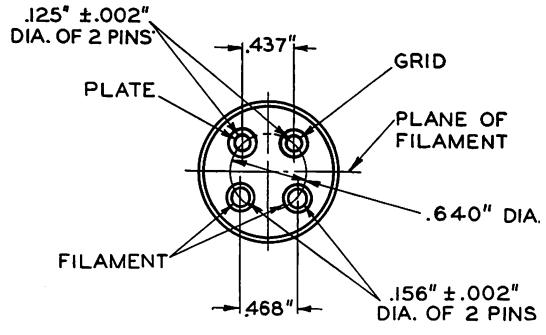


FIG. 2

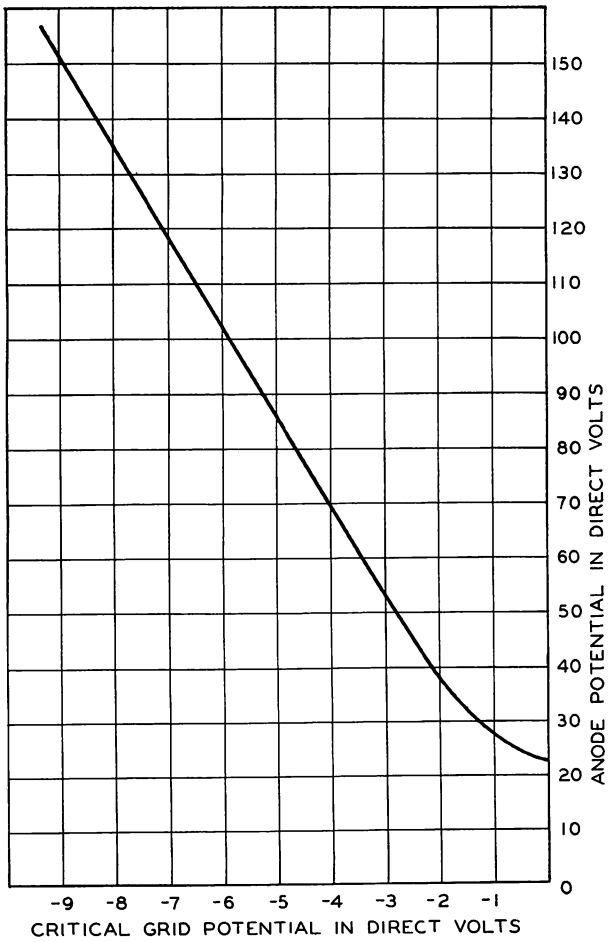


FIG. 3

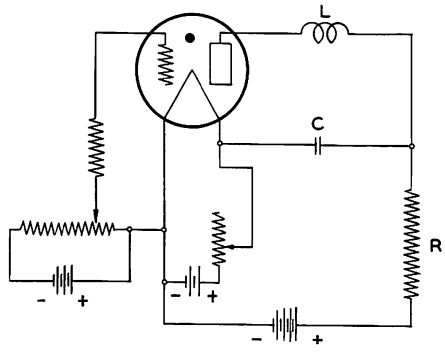


FIG. 4

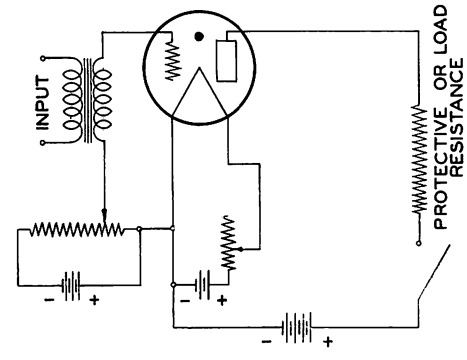


FIG. 5

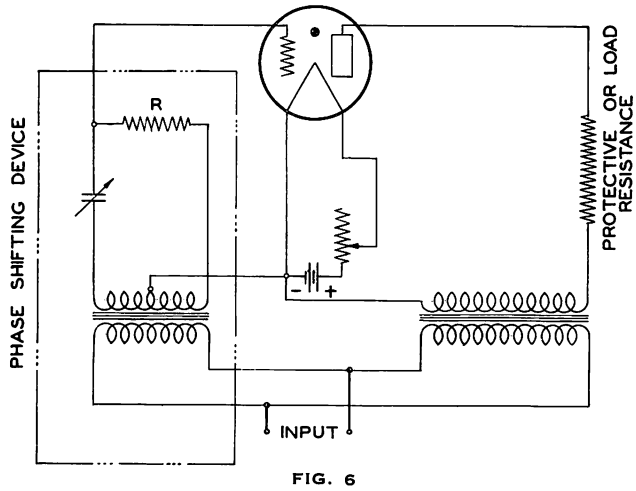


FIG. 6

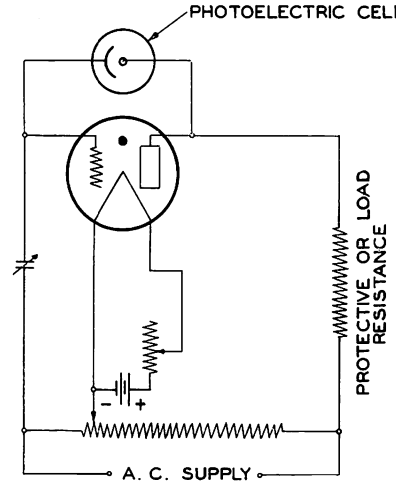


FIG. 7