9C25

POWER TRIODE

Forced-Air-Cooled, Grounded-Grid Type

TENTATIVE DATA

RCA-9C25 is a forced-air-cooled power triode designed for communication and industrial service. It has a maximum rated plate dissipation of 17.5 kilowatts, and can be operated with full plate voltage, plate input, and grid current at frequencies as high as 30 megacycles. Operation at frequencies up to 100 megacycles is permissible with reduced ratings.

The flanged-header grid terminal is a design feature of particular value when the 9C25 is used in grounded-grid circuits. In such circuits, this terminal when used with a large circular connector effectively isolates the filament from the plate circuit, and provides a direct, low-inductance path to the grid. As a result, neutralization is generally unnecessary in grounded-grid service. In grounded-filament circuits, the 9C25 can be used in the conventional manner.

The design of the 9C25 also includes an effective external radiator for cooling the plate by forced air; a single-phase, multistrand, thoriated tungsten filament; and a strong, conical grid support which provides a maximum of shielding between plate and filament to give extremely low plate-filament capacitance, and also serves to reduce effectively the grid-lead inductance.

GENERAL DATA

Filament, Multistrand Thoriated Tungsten:		
Excitation	Single-Phase AC or DC	
Voltage (AC or DC)	6	Volts
Current	285	Amperes
Starting Current: The filament current must never exceed, even momentarily, a value of 425 amperes.		
Cold Resistance	0.0025	Ohms
Amplification Factor	32	
Direct Interelectrode Capacitances (Approx.):		
Grid to Plate	40	μμf
Grid to Filament	58	μμf
Plate to Filament	0.9	μμf
Maximum Overall Length	17-3/8"	
Maximum Diameter	14-1/4"	
Mounting Position	Vertical, filament end up	
Radiator	Integral part of tube	
Mounting	Special	
Air Flow:		
Through Radiator	1000 min.	cfm

The specified air flow at a pressure of 2 inches of water should be delivered by a blower vertically upward through the radiator before and during the application of any voltages, and be maintained for 2 minutes after removal of all voltages.

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Air Flow (Cont'd):		
To Filament Seals	10 ..	cfm

The specified air flow must be directed into the filament header before and during the application of any voltages in order to limit the temperature of the filament seals to the maximum value.

Output Air Temperature (From radiator)	70 max.	°C
Radiator Temperature (Measured in thermometer well)	180 max.	°C
Bulb Temperature	180 max.	°C
Seal Temperature (Filament, grid, and plate)	165 max.	°C

AF POWER AMPLIFIER & MODULATOR—Class B

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
MAX.-SIGNAL DC PLATE CURRENT *	4 max.	Amperes
MAX.-SIGNAL PLATE INPUT *	40 max.	Kw
PLATE DISSIPATION *	17.5 max.	Kw

Typical Operation:

Values are for 2 tubes

DC Plate Voltage	10500 ...	Volts
DC Grid Voltage	-250 ...	Volts
Peak AF Grid-to-Grid Voltage	1310 ...	Volts
Zero-Signal DC Plate Current	1.7 ..	Amperes
Max.-Signal DC Plate Current	7 ..	Amperes
Effective Load Resistance (Plate to plate)	3300 ...	Ohms
Max.-Signal Driving Power (Approx.)	1500 ...	Watts
Max.-Signal Power Output (Approx.)	50 ...	Kw

RF POWER AMPLIFIER—Class B Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	11500 max.	Volts
DC PLATE CURRENT	3.2 max.	Amperes
PLATE INPUT	26 max.	Kw
PLATE DISSIPATION	17.5 max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	10000 ...	Volts
DC Grid Voltage	-230 ...	Volts
Peak RF Grid Voltage	400 ...	Volts
DC Plate Current	2.5 ..	Amperes
DC Grid Current (Approx.)**	0.016 ..	Ampere
Driving Power (Approx.)** °	800 ...	Watts
Power Output (Approx.)	9.2 ...	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.):			
Carrier	800	...	Watts
Crest°	4	...	Kw
Power Output (Approx.)	10	...	Kw

PLATE-MODULATED RF POWER AMPLIFIER--Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	9000	max.	Volts
DC GRID VOLTAGE	-2000	max.	Volts
DC PLATE CURRENT	3.2	max.	Amperes
DC GRID CURRENT	0.65	max.	Ampere
PLATE INPUT	26	max.	Kw
PLATE DISSIPATION	11.5	max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	8000	...	Volts
DC Grid Voltage:			
From a fixed supply of	-650	...	Volts
From a grid resistor of	1280	...	Ohms
Peak RF Grid Voltage	1100	...	Volts
DC Plate Current	2.5	..	Amperes
DC Grid Current (Approx.)**	0.51	..	Ampere
Driving Power (Approx.)**	510	...	Watts
Power Output (Approx.)	15.8	...	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.)♦	3000	...	Watts
Power Output (Approx.)	18	...	Kw

RF POWER AMPLIFIER & OSCILLATOR--Class C Telegraphy

Key-down conditions per tube without amplitude modulation□

Maximum CCS° Ratings, Absolute Values:

DC PLATE VOLTAGE	11500	max.	Volts
DC GRID VOLTAGE	-2000	max.	Volts
DC PLATE CURRENT	4	max.	Amperes
DC GRID CURRENT	0.65	max.	Ampere
PLATE INPUT	40	max.	Kw
PLATE DISSIPATION	17.5	max.	Kw

Typical Operation in Grounded-Filament Circuit:

DC Plate Voltage	10000	11000	Volts
DC Grid Voltage:			
From a fixed supply of	-500	-540	Volts
From a grid resistor of	860	900	Ohms
From a cathode resistor of	125	130	Ohms
Peak RF Grid Voltage	1000	1050	Volts
DC Plate Current	3.5	3.6	Amperes
DC Grid Current (Approx.)**	0.58	0.61	Ampere
Driving Power (Approx.)**	515	575	Watts
Power Output (Approx.)	25	29.5	Kw

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:

Driving Power (Approx.)	3400	3750	Watts
Power Output (Approx.)	28	32.5	Kw

● CCS = Continuous Commercial Service.

* Averaged over any audio-frequency cycle of sine-wave form.

** Subject to wide variations depending on the impedance of the plate circuit. High-impedance plate circuits require more grid current and driving power to obtain the desired output. Low-impedance plate circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of supplying considerably more than the required driving power.

○ At crest of audio-frequency cycle with modulation factor of 1.0.

♁ Carrier power of driver modulated 100%.

□ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

INSTALLATION

In transportation and storage of the 9C25, care should be taken to protect the tube from rough handling that would damage the metal-to-glass seals or other parts. The 9C25 is suspended within its shipping crate so that it will not come in contact with the sides of the crate during shipment. It should be stored in the crate with the filament end up and should be protected from moisture and extreme temperature changes. Under no circumstances should crated tubes be piled one on top of another. Furthermore, while the tube is being handled, it should be kept in a vertical position with the filament end up. The weight of the 9C25 crated for shipment is approximately 295 pounds; uncrated, approximately 120 pounds.

It is recommended that the tube be tested upon receipt in the equipment in which it is to be used. Before the tube is placed in operation, any foreign material clinging to the tube should be removed. An air blast is recommended for removing any such material from the entrant metal header.

Mounting of the 9C25 requires the use of an insulating sleeve support which is usually part of the equipment. Information concerning the sleeve support can be obtained from us on request. The sleeve should support the tube in a vertical position with the filament end up. If the 9C25 is to be subjected to appreciable vibration in service, it is advisable to support the sleeve by springs. When concrete basework is provided for the equipment and when machines or other sources of vibration are not present, it is unnecessary to use a spring suspension. The installation of all wires and connections must be made so that they will not be close to or touch the bulb. This precaution is necessary to prevent almost certain puncture of the glass from corona discharge.

The 9C25 should be placed in the sleeve carefully and the radiator must be seated properly. The need for clamping the radiator is obviated by the weight of the tube, but correct seating is necessary for good electrical connection to the plate.

When the 9C25 is removed from its sleeve, first be sure that the temperature of the grid and filament is below red heat. Next remove the filament and grid connections. Then carefully remove the tube from the sleeve.

An air-cooling system, interlocked with the power supplies, is required to cool the radiator and also the entrant metal header. The air-cooling system consists of a blower capable of delivering a minimum air flow of 1000 cubic feet per minute at a pressure of 2 inches of water upward through the radiator, and an air duct of suitable cross-sectional area to convey a flow of approximately 10 cubic feet per minute downward into the header. The cooling air must not contain any water or foreign matter.

The radiator temperature measured in the thermometer well should not exceed 180°C; the temperature of the cooling air after passing through radiator should not exceed 70°C; the temperature of the bulb should not exceed 180°C at the hottest point; and the temperature of the seals (filament, grid, and plate) should be limited to 165°C.

The temperature of the bulb and seals may be measured either with a thermocouple or with temperature-sensitive paint, such as Tempilac. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York, N.Y., in the form of liquid and stick, and is stated by the manufacturer to have an accuracy of 1 per cent.

The air-cooling system should be properly installed to insure safe operation of the tube under all conditions and for this reason should be electrically interconnected with the filament and plate supplies to prevent the application of voltages to the tube without cooling. Air-pressure interlocks which open the circuit breakers of the filament- and plate-power transformers are necessary for protecting the tube when the air flow is insufficient or ceases. Precautions should be taken to insulate the air-cooling system from the tube or circuit parts which may be at high potential.

The thoriated-tungsten filament of the 9C25 may be operated from direct current or from single-phase alternating current. The filament consists of twelve strands which are brought out to two terminals sealed into the entrant metal header. The filament connectors should make firm, large-surface contact with the filament terminals in order to prevent heating by the high filament current. The filament leads should not be taut, but should allow for some movement without placing a strain on the glass bulb.

Under normal full-load conditions, the filament voltage should be maintained at the rated value within ± 5 per cent; with light loads, reduction of the filament voltage by as much as 5 per cent is permissible. In the latter case, care must be taken that the reduction of the filament voltage and, therefore, of emission is not so great that the peak-current requirements can not be met. It is recommended that in intermittent service where the standby periods are no longer than 15 minutes, the filament voltage be reduced to 80 per cent of normal during standbys; for longer periods, the filament voltage should be turned off. The filament should be operated at constant voltage rather than at constant current, and must be allowed to reach normal operating temperature before other voltages are applied to the tube. A suitable voltmeter should be permanently connected directly across the filament terminals so that the filament voltage will always be known.

When direct current is used, the polarity of the leads should be reversed every 500 hours of operation.

A filament starter should be used to raise the filament voltage gradually and to limit the high initial rush of current through the filament when the circuit is first closed. The starter may be either a system of time-delay relays cutting resistance out of the circuit, a high-reactance filament transformer, or a simple rheostat. Regardless of the method of control, it is important that the total filament current never exceed, even momentarily, a value of 425 amperes.

The <u>grid terminal</u> of the 9C25 is in the form of a flange on the entrant metal header. It is suggested that the connector for the grid lead be in the form of a flat yoke extending around perhaps half the circumference of the flange. At the higher frequencies, it is recommended that the flat-yoke connector extend completely around the circumference of the flange and that adequate connections be made to it to provide uniform rf current distribution over the flange. This yoke must be provided with holes so that it can be bolted to the flange for good electrical contact. The screws attaching the corona shield to the flange should be removed when the yoke is being bolted to the flange; they are then replaced. The yoke and grid lead should not place any strain on the header because of the possibility of damage to the glass-to-metal seal. Similarly, connections should not be soldered to the flange; and the flange should not be used to support circuit parts.

The <u>plate connection</u> for the 9C25 is provided automatically through the radiator which is connected electrically to the high-voltage supply. <u>The rated plate voltage is extremely dangerous to the user. Great care should be taken during adjustment of the circuit.</u> The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the plate supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

The plate circuit should be provided with a time-delay relay to delay the application of plate voltage until the filament has reached normal operating temperature. The plate circuit must also be provided with protective devices to prevent the tube from drawing a heavy overload. In order to prevent excessive plate-current flow and resultant overheating of the tube, the ground lead of the plate circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The time required for the operation of the relay and circuit breakers should be about 1/10 second and not more than 1/6 second. A voltage-dropping resistor should be permanently connected in series with the plate lead of each tube for protection of the tube during the time required for the relay and the circuit breaker to act. The minimum value of this resistor which will give adequate protection with minimum power loss is as follows:

SERIES RESISTOR	25	50	75	100	Ohms
MAXIMUM POWER OUTPUT OF RECTIFIER	40	100	250	640	Kw

A capacitor of high value should never be connected directly across the tube in such a manner that a disturbance within the tube will discharge appreciable energy from the capacitor.

The grid return and the plate return should be connected to the center point of the filament voltage supply when ac is used. When dc is used, the grid and the plate return should be connected to the negative filament terminal and should still be connected to the negative filament terminal whenever the filament polarity is reversed.

When a 9C25 is first placed in service, care should be taken to see that the air-cooling system is functioning properly. The tube should then be operated without plate voltage for 5 minutes at rated filament voltage. After this initial preheating schedule, the tube should be operated at approximately one-half the usual plate voltage for 15 minutes. Full plate voltage may then be applied and the tube operated under normal load conditions for a period of 1 hour or more. It is recommended that spare tubes be given the preheating and initial-operating treatment every 3 months. This procedure will insure that only good tubes are carried in stock.

When a new circuit is tried or when adjustments are made, the plate voltage should be reduced to approximately one-half the rated value to prevent damage to the tube and associated apparatus. After correct adjustment has been made with the tube operating smoothly and without excessive heating of the radiator or the glass bulb, the plate voltage may be raised in steps to the desired value. Adjustments should be made at each step for optimum operation.

Overheating of the 9C25 by severe overload may impair its vacuum. When the quantity of released gas is not too great, it is often possible to degassify the tube by operating it at reduced plate voltage. The first step in the process should be a short period of operation at a plate voltage of one-half the rated value. The plate voltage may then be increased to the normal value and the tube allowed to operate for an hour or more. In severe cases, it may be necessary to degassify the tube by increasing the plate voltage in small steps until the normal voltage is reached. At each new voltage, the tube should be allowed to operate long enough to insure the attainment of stabilized conditions. The voltage may be varied by means of a series resistor connected in the plate-supply lead.

If the release of gas has caused deactivation of the filament, the activity of the filament can often be restored by operating the filament at its normal voltage for 10 minutes or longer without plate or grid voltage. The reactivation process may be accelerated by raising the filament voltage to not higher than 120 per cent of normal value for a few minutes.

APPLICATION

The maximum ratings in the tabulated data for the 9C25 are limiting values above which the serviceability of the 9C25 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amoumt such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The 9C25 may be operated at maximum ratings in all classes of service at frequencies as high as 30 megacycles. It may be operated at higher frequencies provided the maximum values of plate voltage, plate input, and grid current are reduced as the frequency is raised. Other maximum ratings remain the same. When the 9C25 is used in grounded-grid circuits at the highest frequencies, care must be exercised to shield completely the filament-grid circuit from the grid-plate circuit.

The following table shows the highest percentage of maximum plate voltage, plate input, and grid current that can be safely used up to 100 megacycles. Special attention should be given to adequate cooling at the higher frequencies.

FREQUENCY	30	50	75	100	Mc
MAX. PERMISSIBLE PERCENTAGE OF MAX. RATED PLATE VOLTAGE, PLATE INPUT & GRID CURRENT:					
Class B Telephony	100	93	87	80	per cent
Class C Telephony	100	87	74	61	per cent
Class C Telegraphy	100	87	74	61	per cent

in the load on the driving stage. This effect will be noticed by the simultaneous increase in plate currents of both the output and driving stages.

Circuit-design considerations affecting operation of the 9C25 are given in the following paragraphs.

The grid circuit of the 9C25 when used with its filament grounded should be designed and adjusted so that no appreciable voltage can occur between grid and filament at any frequency except the fundamental. This procedure will minimize the occurrence of parasitic oscillations and be simplified if the generation of unwanted harmonic frequencies is avoided. The use of a plate tank circuit having the proper Q and the avoidance of over-excitation are helpful. Link coupling between the driving stage and the power amplifier is useful especially if the Q of the grid tank circuit is high enough to provide good voltage regulation.

Because of the relatively large high-frequency currents carried by the grid and plate terminals, heavy conductors should be used to make the circuit connections.

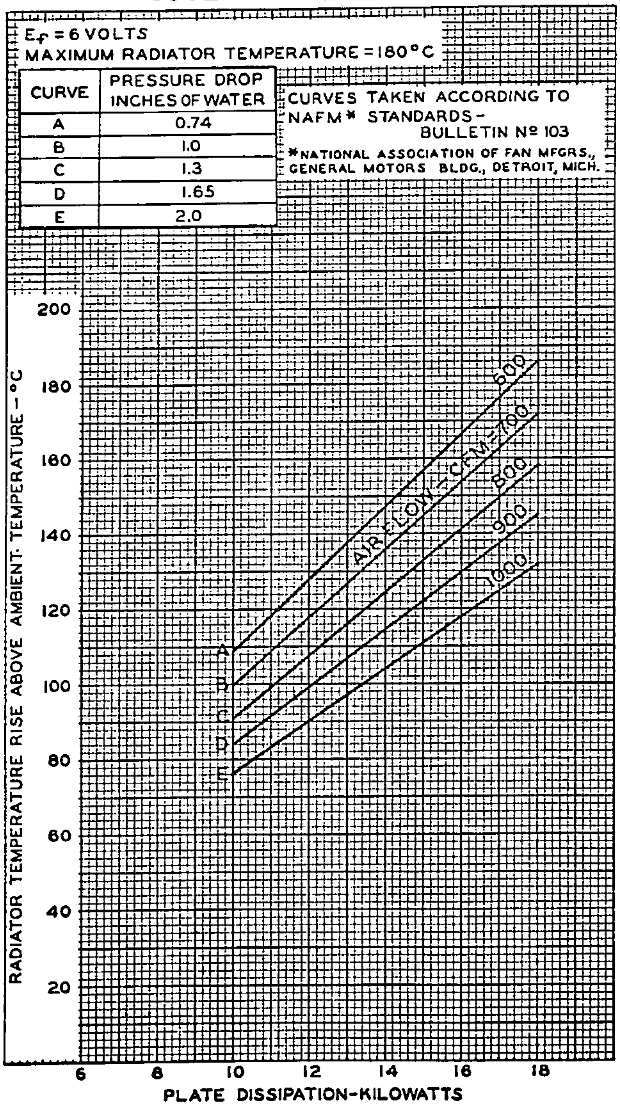
When more radio-frequency power is required than can be obtained from a single tube, push-pull or parallel circuit arrangements may be used. Two tubes in parallel or push-pull will give approximately twice the power output of one tube. The parallel connection requires no increase in exciting voltage necessary to drive the tube. With either connection, the driving power required is approximately twice that for a single tube. The push-pull arrangement has the advantage of cancelling the even-order harmonics from the output and of simplifying the balancing of high-frequency circuits.

When two or more tubes are used in the circuit, precautions should be taken so that the plate current drawn by each tube is the same.

REFERENCE

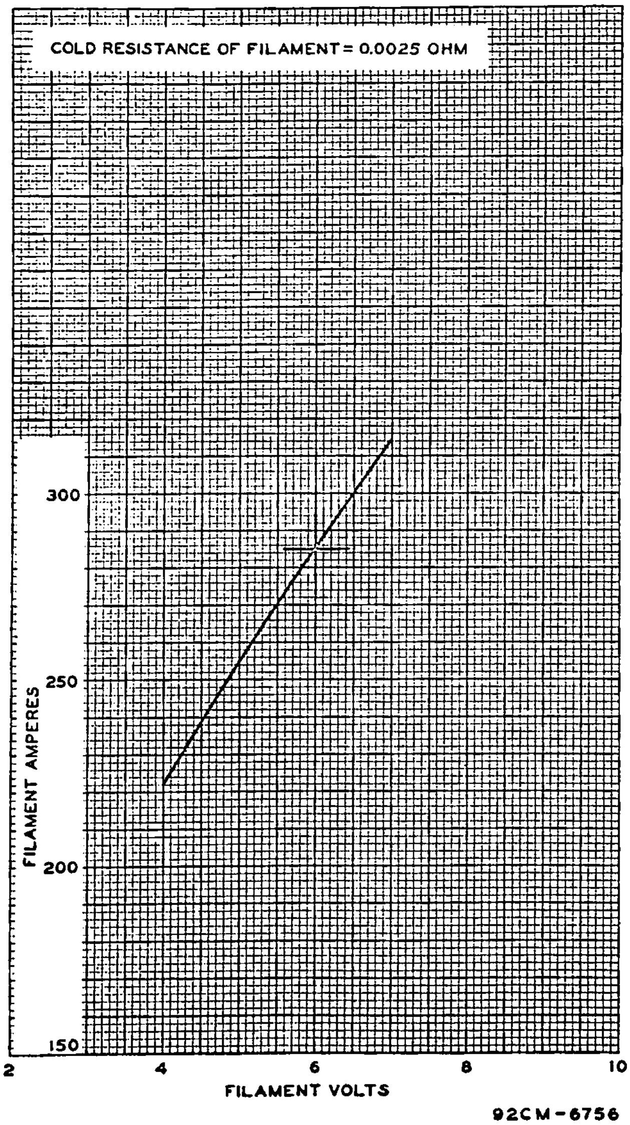
E. E. Spitzer, "Grounded-Grid Power Amplifiers," Electronics, Vol. 19, No.4, pp. 138 - 141 (April, 1946).

COOLING REQUIREMENTS

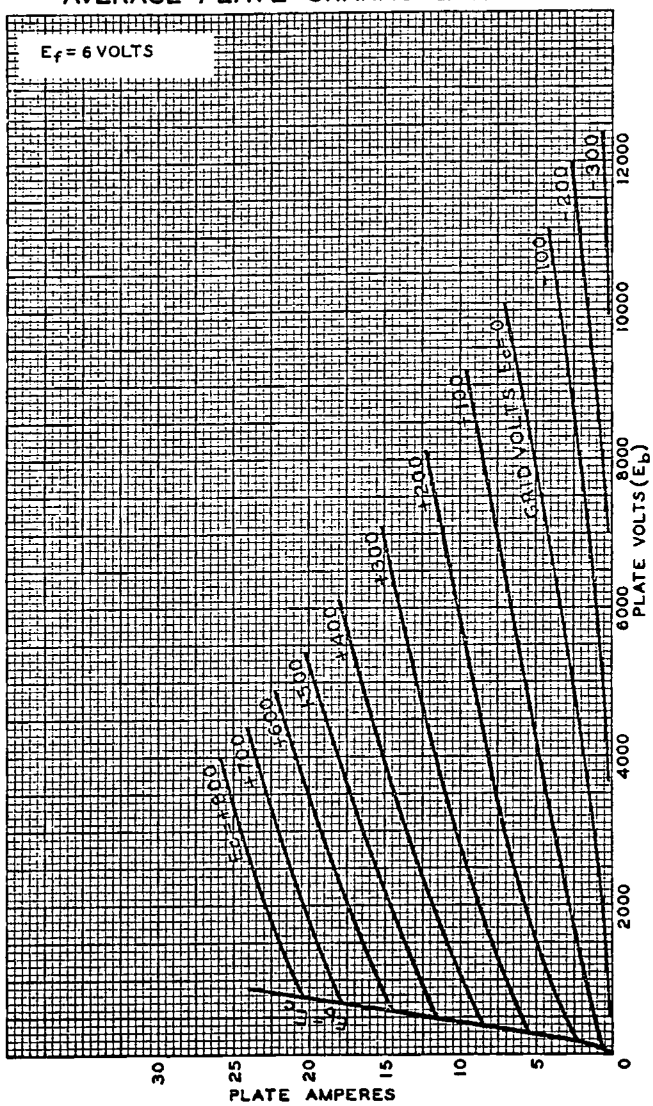


92CM-6761

AVERAGE FILAMENT CHARACTERISTIC

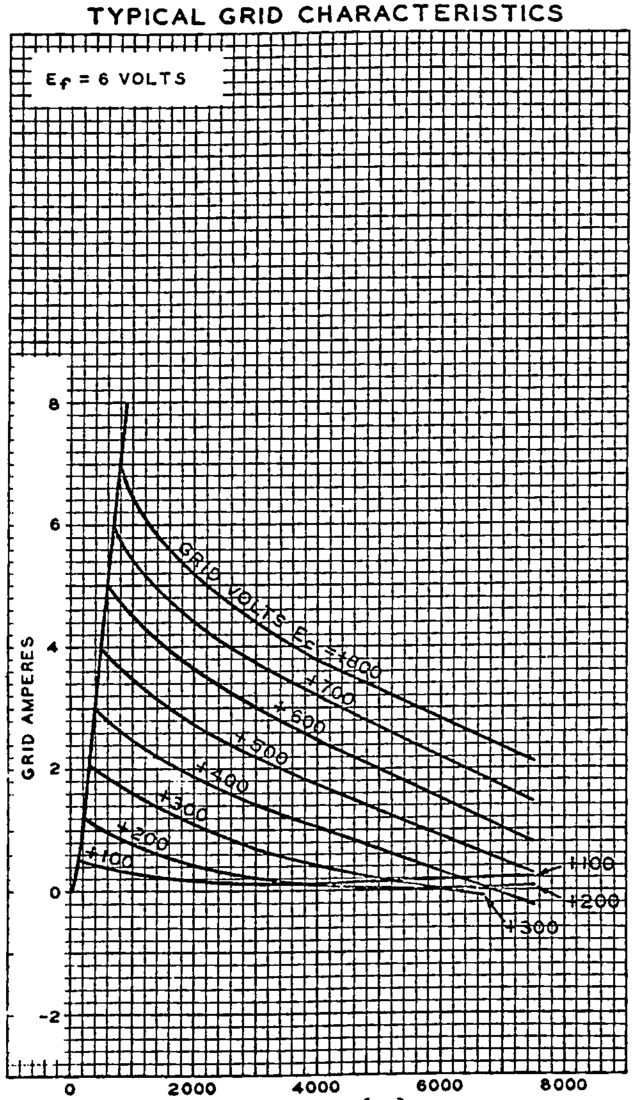


AVERAGE PLATE CHARACTERISTICS



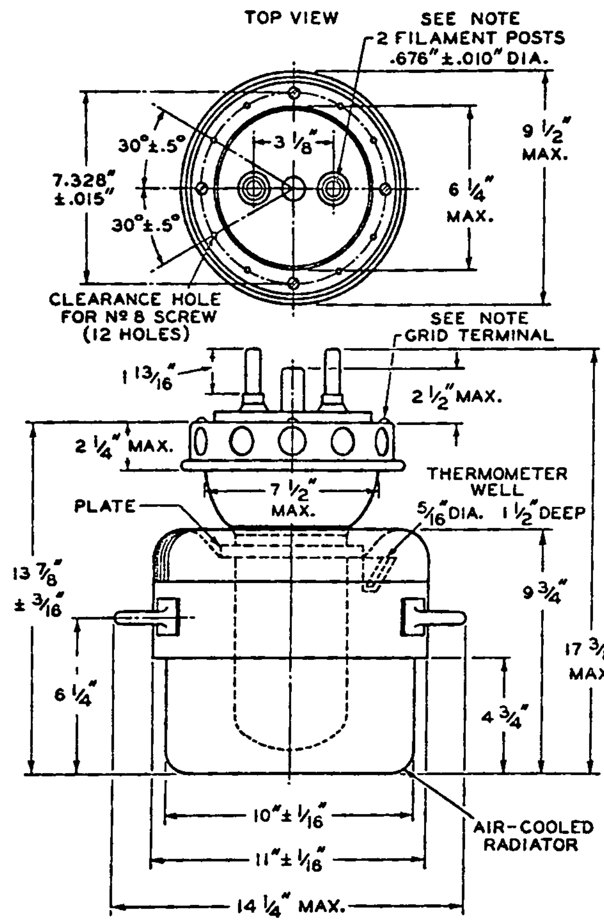
92CM-6757

TYPICAL GRID CHARACTERISTICS



92CM-6759

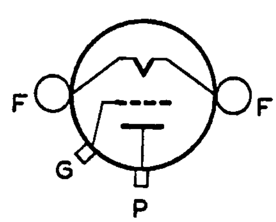
DIMENSIONAL OUTLINE



NOTE: FLEXIBLE CONNECTIONS ARE REQUIRED.

92CM-6750

TUBE SYMBOL



F: FILAMENT
G: GRID
P: PLATE