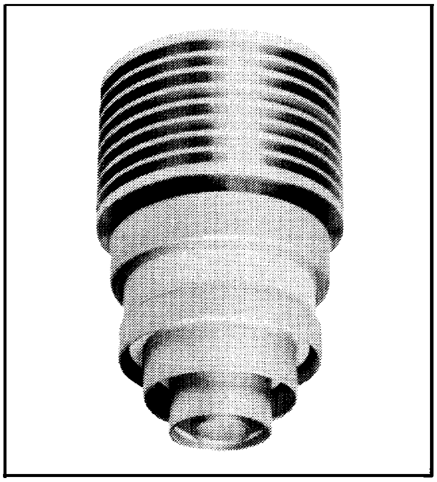
7649
Power Tube



Beam Power Tube

- CERMOLOX®
- Ruggedized
- 4.5 kW Peak Output at 1215 MHz
- Matrix-Type Cathode
- Forced-Air Cooled

BURLE 7649 is a very small, forced-air-cooled, UHF beam power tube designed for applications in which dependable performance under severe shock and vibration is essential. It is intended for use in grid-and-screen pulsed and plate-and-screen pulsed RF oscillator and amplifier service in compact airborne, mobile, and stationary equipment.

The 7649 has a maximum plate dissipation of 115 watts. It can be operated with full ratings at frequencies through the Aeronautical Radio-Navigation Band of 960 to 1215 MHz and is useful to above 2000 MHz.

When used under CCS conditions as a plate-and-screen-pulsed RF amplifier in a cathode-drive circuit at 1215 MHz with 10-microsecond pulse duration and duty factor of 0.01, the 7649 is capable of delivering about 4500 watts useful power output at peak of pulse with a drive power of 450 watts at peak of pulse.

As a grid-and-screen-pulsed RF amplifier under CCS conditions in a cathode-drive circuit at 1215 MHz with 10-microsecond pulse duration and 0.01 duty factor, the 7649, operated with peak power input of 4500 watts, can provide useful power output of about 2300 watts at peak of pulse with 460 watts drive power at peak of pulse.

Cermolox construction is featured in the design of the 7649: precision-aligned grids, ceramic-metal structure, and unitized cylindrical-electrode-and-terminal design. Precision-alignment of the grids minimizes control-grid and screen-grid currents and permits high efficiency operation with relatively low anode voltage, giving large power output with small driving power. High-alumina ceramic provides strength, close tolerances, high-temperature operation, and an excellent RF "window" to reduce RF losses within the tube. Unitized electrode-and-terminal construction adds strength, accurate assembly, and high electrical and thermal conductivity between electrode and terminal. The cylindrical terminals lend themselves to either coaxial or strip-line circuits.

Other structural features of the 7649 are sturdy heater, axial ceramic pin, and integral radiator. The axial ceramic pin rigidly holds grid No.1, grid No.2, and cathode fixed with respect to each other. The integral stacked-disc-type finned radiator offers compactness and convenient transverse forced-air cooling.

This data sheet gives application information unique to the BURLE 7649. Information contained in the following publications will help to assure longer tube life and safer operation:

TP-105 Application Guide for BURLE Power Tubes.

TP-118 Application Guide for Forced-Air Cooling of BURLE Power Tubes.

TP-122 Screen-Grid Current, Loading and Bleeder Considerations.

For copies of these publications, contact your BURLE representative or write BURLE INDUSTRIES, INC., Tube Products Division, 1000 New Holland Avenue, Lancaster, PA 17601-5688.

General Data

Electrical

Heater, for Matrix-Type, Oxide-Coated Unipotential Cathode:

Voltage (AC or DC)	6.3	±10%	V
Current	3.2		A
Minimum heating time	2		minutes

Mu-Factor, Grid No.2 to Grid No.1 for Anode Volts = 1000, Grid No.2 Volts = 500, and Anode mA = 115 18

Direct Interelectrode Capacitances:'

Grid No.1 to anode	0.16	max.	pF
Grid No.1 to cathode & heater	14		pF
Anode to cathode & heater	0.060	max.	pF
Grid No.1 to grid No.2	20		pF
Grid No.2 to anode	6.3		pF
Grid No.2 to cathode & heater	1.30	max.	pF

BURLE Electron Tubes

General Data (Cont'd)

Mechanical

Operating Position	Any
Overall Length	1.880" ± 0.050"
Greatest Diameter	1.250" ± 0.015"
Weight (Approx.)	2 oz
Socket:	
For frequencies up to 400 MHz	Erie[2] 2948-000, 9819-000 or equivalent
For higher frequencies:	See Mounting Arrangement (Figure 2)
Grid-No.2 Bypass Capacitor	Erie[2] #2929-001, or equivalent

Thermal

Anode, Grid No.2, Grid No.1, Cathode, and Heater Temperature	250 max. °C
Radiator Core Temperature	250 max. °C

See measurement points on Dimensional Outline.

Air Flow:

Through radiator - Adequate air flow to limit the radiator core temperature to 250° C should be delivered by a blower across the radiator before and during the application of anode, grid-No.2, and grid-No.1 voltages. Typical values of air flow directed across the radiator versus anode dissipation are shown in **Figures** 3 and 4.

To Anode, Grid No.2, Grid No.1, Cathode, and Heater Terminals -A sufficient quantity of air should flow across each of these terminals so that their temperature does not exceed the specified maximum value of 250° C.

During Standby Operation - Cooling air is not normally required when only heater voltage is applied to the tube.

Anode power, grid-No.2 power, heater power, and air flow may be removed simultaneously.

At sea level, cooling requirements with air flow directed across the radiator with cowling **as** shown in **Figure 5** may be met by use of the following blowers and associated motors manufactured by Rotron Mfg. Co., Inc., Woodstock, NY, or equivalent:

For 100% Anode Dissipation:

Blower Model No.	KS-2505	AS-2505	AXIMAX 1	AXIMAX 1
Motor Model No.	165AS	323JS	464YS	499JS
Phase	1	3	1	3
Frequency	60	60	400	400
Voltage	115	220	115	200

For 80% Anode Dissipation:

Blower Model No.	KS-202	AS-202	AXIMAX 1	AXIMAX 1
Motor Model No.	92AS	323JS	464YS	499JS
Phase	1	3	1	3
Frequency	60	60	400	400
Voltage	115	220	115	200

For 60% Anode Dissipation:

Blower Model No.	KS-1504	AS-1504	AXIMAX 1	AXIMAX 1
Motor Model No.	92AS	323JS	464YS	499JS
Phase	1	3	1	3
Frequency	60	60	400	400
Voltage	115	220	115	200

Grid-and-Screen-Pulsed RF Amplifier

Maximum Ratings, Absolute-Maximum Values

For maximum "on" time of 10 microseconds

	Up to 1215 MHz	
DC Anode Voltage	2250	V
Peak Positive Pulse Grid-No.2 Voltage	750	V
DC Grid-No.1 Voltage	-200	V
DC Anode Current During Pulse	3000	mA
DC Anode Current	80	mA
Grid-No.2 Input (Average)	4.5	W
Grid-No.1 Input (Average)	2	W
Anode Dissipation (Average)	115	W

Typical Operation in Class AB, Cathode-Drive Circuit with Rectangular-Wave Pulses at 1215 MHz

	Duty Factor of 0.01		
DC Anode Voltage	1350	1500	V
Peak Positive Pulse Grid-No.2 Voltage	700	700	V
DC Grid-No.1 Voltage	0	0	V
DC Anode Current During Pulse	2700	3000	mA
DC Anode Current	47	53	mA
DC Grid-No.2 Current	1.6	2	mA
DC Grid-No.1 Current	5	5	mA
Driver Power Output at Peak of Pulse (Approx.)[3]	390	460	W
Useful Power Output at Peak of Pulse (Approx.)[4]	1600	2300	W

Maximum Circuit Values

Grid-No.1 Circuit Resistance Under Any Condition . . 30,000 ohms

Anode-and-Screen-Pulsed RF Amplifier

Maximum Ratings, Absolute-Maximum Values

For maximum "on" time of 10 microseconds

	Up to 1215 MHz	
Peak Positive-Pulse Anode Voltage	3000	V
Peak Positive-Pulse Grid-No.2 Voltage	750	V
DC Grid-No.1 Voltage	-200	V
DC Anode Current During Pulse	3000	mA
DC Anode Current	50	mA
Grid-No.2 Input (Average)	4.5	W
Grid-No.1 Input (Average)	2.0	W
Anode Dissipation (Average)	115	W

Typical Operation in Class AB, Cathode-Drive Circuit with Rectangular-Wave Pulses at 1215 MHz

	Duty Factor of 0.01		
Peak Positive-Pulse Anode Voltage	2700	3000	V
Peak Positive-Pulse Grid-No.2 Voltage	700	700	V
DC Grid-No.1 Voltage	0	0	V
DC Anode Current During Pulse	2700	3000	mA
DC Anode Current	32	35	mA
DC Grid-No.2 Current	1	2	mA
DC Grid-No.1 Current	9	8	mA
Driver Power Output at Peak of Pulse (Approx.)[3]	350	450	W
Useful Power Output at Peak of Pulse (Approx.)[4]	3700	4500	W

Maximum Circuit Values

Grid-No.1 Circuit Resistance Under Any Condition . . 30,000 ohms

Characteristics Range Values

	Min.	Max.	
Heater Current[5]	2.90	3.55	A
Direct Interelectrode Capacitances:			
Grid No.1 to anode[1]	-	0.16	pF
Grid No.1 to cathode & heater[1]	11.8	15.2	pF
Anode to cathode & heater[1]	-	0.060	pF
Grid No.1 to grid No.2[1]	17.3	21.9	PF
Grid No.2 to anode[1]	5.8	6.8	pF
Grid No.2 to cathode & heater[1]	-	1.30	pF
Grid-No. 1 Voltage[5,6]	-20	-50	V
Grid-No.1 Voltage[5,10]	-6	-18	V
Reverse Grid-No.1 Current[5,10]	-	-20	uA
Grid-No.2 Current[5,6]	-5	+11	mA
Peak Emission[5,7]	-	250	peak V
Interelectrode Leakage Resistance[8]	1.0	-	Mohm
Peak Power Output[5,9]	4500		W
Grid-No.1 Cutoff Voltage[5,11]	-	-104	V

1. Measured with special shield adapter.
2. Erie Specialty Products, Inc., 645 W. 11th St., Erie, PA 16512.
3. Driver power output includes circuit losses and feed through power. It is actual power measured at input to the tube drive circuit. It will vary with frequency of operation and driver circuitry.
4. This value of useful power is measured in load of output circuit.
5. With 6.3 volts AC or DC on heater.
6. With DC anode voltage of 1000 volts, DC grid-No.2 voltage of 700 volts, and DC grid-No.1 voltage adjusted to give a DC anode current of 115 mA.
7. For conditions with grid No.1, grid No.2, and anode tied together; and pulse voltage source connected between anode and cathode. Pulse duration is 2 microseconds, pulse repetition frequency is 60 pps, and duty factor is 0.00012. The voltage-pulse amplitude is adjusted until a peak cathode current of 13 amperes is obtained. After 1 minute at this value, the voltage-pulse amplitude will not exceed 250 volts (peak).
8. Under conditions with tube at 20 to 30 °C for at least 30 minutes without any voltages applied to the tube. The minimum resistance between any two electrodes as measured with a 200-volt Megger-type ohmmeter having an internal impedance of 1 .O megohm will be 1 .O megohm.
9. In an anode-and-screen-pulsed cathode-drive cavity at 1215 MHz and for conditions with peak anode voltage of 3000 volts, peak grid-No.2 voltage of 700 volts, driver power of 560 peak watts, and grid-No.1 voltage varied for peak anode current of 3 amperes. Pulse duration is 10 microseconds and duty factor is 0.01.
10. With DC anode voltage of 1000 volts, DC grid-No.2 voltage of 300 volts, and DC grid-No.1 voltage adjusted to give a DC anode current of 115 mA.
11. With DC anode voltage of 2250 volts, DC grid-No.2 voltage of 700 volts, and DC grid-No.1 voltage adjusted to give a DC anode current of 5 mA.

Definitions

Rating System - In accordance with the Absolute Maximum rating system as defined by the Electronic Industries Association Standard RS-239A, formulated by the JEDEC Electron Tube Council.

"ON" Time - The sum of the duration of all individual pulses which occur during an indicated interval.

Pulse Duration-The time interval between the two points on the pulse at which the instantaneous value is 70% of the peak voltage value.

PeakValue-The maximum value of a smooth curve through the average of fluctuations over the top portions of the pulse.

Duty Factor - Ratio of "ON" time to indicated interval.

Special Tests and Performance Data

Resonances in the tube mountings used in the following tests can cause the specified environmental conditions to produce greatly amplified effects. Extreme care must, therefore, be used in the mountings to minimize resonance.

50 g, 11-Millisecond Shock Test

This test is performed on a sample lot of tubes to determine the ability of the tube to withstand the specified long-duration impact accelerations. Tubes are held rigid in six different positions in a Medium Impact Shock Machine and are subjected to three blows in each position.

At the end of this test, tubes will not show permanent or temporary shorts or open circuits, and are required to meet the limits for Grid-No.1 Voltage and Reverse Grid-No.1 Current under Characteristics Range Values.

52000 Hz Vibration Test

This test is performed on a sample lot of tubes to determine the ability of the tube to withstand variable frequency vibration. With heater voltage of 6.3 volts AC or DC, DC anode supply voltage of 300 volts, DC grid-No.2 voltage of 250 volts, grid-No.1 voltage adjusted to give DC anode current of 10 mA, and anode load resistor of 2000 ohms. The tube is vibrated along each of three mutually perpendicular axes over an 8-minute sweep consisting of:

a. 5-10 Hz with fixed double amplitude of 0.080 inch ± 10%.
b. 10-15 Hz at fixed acceleration of 0.42 g ± 10%.
c. 15-75 Hz with fixed double amplitude of 0.036 inch.
d. 75-2000 Hz at fixed acceleration of 10 g ± 10%.

During the above vibration tests, tubes will not show an rms output voltage in excess of 15 volts across the anode load resistor in the 5-2000 cycle range.

At the end of this test, tubes are required to meet the limits for Grid-No.1 Voltage and Reverse Grid-No.1 Current under Characteristics Range Values.

Operating Considerations

Temperature

The maximum radiator core or electrode temperature of 250° C is a tube rating and is to be observed in the same manner as other ratings. The temperature may be measured with temperature-sensitive paint, such as Tempilaq. Tempilaq is made in liquid and stick form by: Tempil Division, Big Three Industries, Inc., Hamilton Boulevard, South Plainfield, NJ 07080.

Mounting

See the preferred mounting arrangement in Figure 2. For other arrangements, cavity-type mounting for multiple-ring terminal-type tubes such as the 7649 may be constructed by using either fixed or adjustable contact rings of finger contact strips in the transverse plane.

Cooling

Forced-air cooling of the 7649 is required as indicated in Figures 3 and 4. A suitable air filter is required in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air across the socket and radiator.

The cooling system should be properly installed to insure safe operation of the 7649 under all conditions. It should be electrically interconnected with the anode power supply and the grid-No.2 power supply. Air-flow interlocks which open the power transformer primaries are desirable for protecting the tube when the air flow is insufficient.

Heater

The heater of the 7649 should be operated at constant voltage rather than constant current. The rated heater voltage of 6.3 volts should be applied for 2 minutes to allow the cathode to reach normal operating temperature before voltages are applied to other electrodes.

The life of the cathode can be conserved by operation at the lowest heater voltage which will give adequate but not excessive emission to enable the 7649 to give the desired power output. Good regulation of the heater voltage is, in general, economically advantageous from the viewpoint of tube life; in no case should the voltage fluctuations be more than 5%.

The cathode may be subjected to back bombardment as operating frequency is increased, with resultant increase in temperature. When the duty factor is small, back bombardment normally need not be considered. When high duty factors are encountered, the necessary heater voltage should be determined as follows: with all other voltages constant, the minimum heater-supply voltage conditions at this reduced value shall provide satisfactory tube performance; any further reduction will show some degradation.

Standby Operation

During long or frequent standby periods, the 7649 may be operated at decreased heater voltage to conserve life. It is recommended that the heater voltage be reduced to 80% of normal during standby periods up to 2 hours. For longer periods, the heater voltage should be turned off.

Parasitic Oscillations

The design of high-power circuits must provide for adequate suppression of parasitic oscillations to insure reliable operation of the 7649 and its associated components. These spurious oscillations not only reduce efficiency and performance by absorbing power from the circuits in which they occur, but may damage or shorten the life of the tube and other circuit components by voltage arc-over.

Grid No.2

Grid-No.2 current is composed of a positive-current component resulting from cathode emission to grid No.2 and a negative-current component resulting from secondary emission phenomena. Because it is the net result of these component currents which is read on a meter in the grid-No.2 circuit, grid-No.2 dissipation cannot be accurately determined. Operation similar to conditions given under Typical Operation in the tabulated datasection will minimize the possibility of exceeding maximum dissipation.

The grid-No.2 circuit must be capable of maintaining the proper grid-No.2 voltage in the presence of moderate negative DC current as well as normal values of average positive current. Complete protection can be achieved by the use of a well-regulated power supply, a grid-No.2-to-ground impedance that is low enough to prevent build-up of grid-No.2 voltage and/or runaway under negative current conditions, and a current overload relay to protect the grid-No.2 against positive or negative current of the order of 10 mA.

Cathode-Drive Circuits

In cathode-drive circuits, driver power output and the developed RF power output act in series to supply the load circuit. If the driving voltage and grid-No.1 current are increased, the output will always increase. In a grid-drive circuit, a saturation effect takes place, i.e., above a certain value of driving voltage and current, the output increases very slowly and may even decrease. It is important to recognize this difference and not try to saturate a cathode-drive stage because the maximum grid-No.2 input may easily be exceeded.

In tuning a cathode-drive RF amplifier, it must be remembered that variations in the load on the output stage will produce corresponding variations in the load on the driving stage. This effect will be noticed by the simultaneous increase in anode currents of both the output and driving stages.

Precautions

In beam power tubes with closely spaced electrodes, such as the 7649, extremely high voltage gradients occur even with moderate tube operating voltages. Any arc-over between electrodes may be destructive. A series impedance in the anode lead is recommended. The resultant anode impedance giving an anode voltage supply regulation of no better than 10% is usually sufficient.

Protective devices should be used to protect not only the anode but also grid No.2 against overload. In order to prevent excessive anode current flow, and resultant overheating of the tube, the common ground lead of the anode circuit should be connected in series with the coil of an instantaneous overload relay. This relay should be adjusted to remove the DC anode voltage and DC grid-No.2 voltage when the average value of anode current reaches a value slightly higher than normal anode current. A protective device in the grid-No.2 supply should remove the grid-No.2 voltage when the DC grid-No.2 current reaches a value slightly higher than normal.

The rated anode and grid-No.2 voltages of this tube are extremely dangerous. Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel can not possibly come in contact with any high-potential point in the electrical system. The interlock device should function to break the primary circuit of the high-voltage supplies when any gate or door of the protective housing is opened, and should prevent the closing of the primary circuit until the door is again locked.

Warning - Personal Safety Hazards

Electrical Shock - Operating voltages applied to this device present a shock hazard.

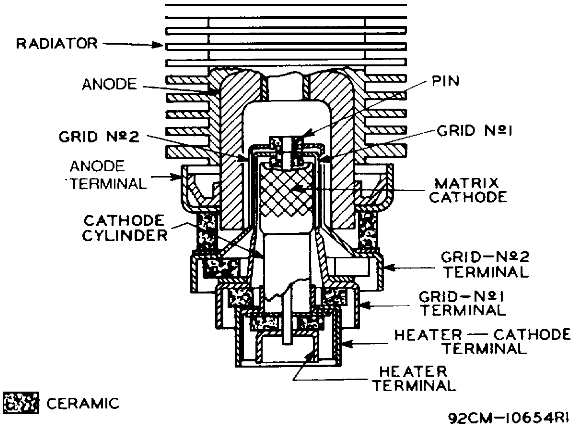
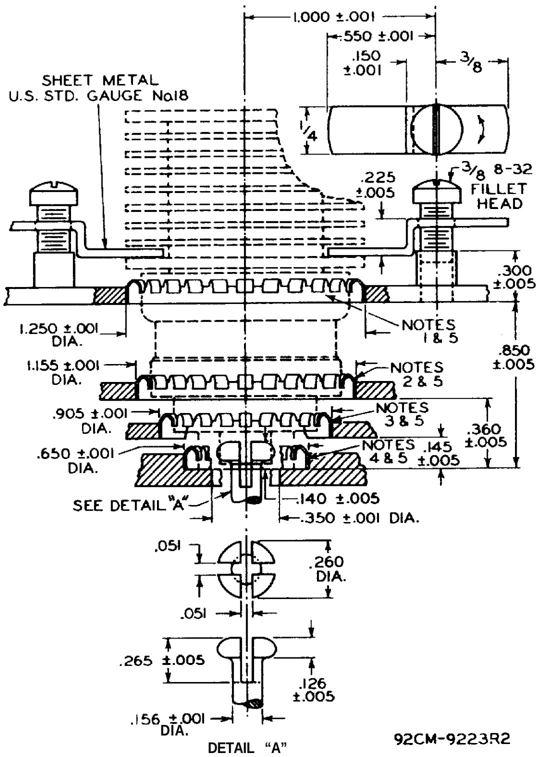


Figure 1 - Structural Arrangement



DIMENSIONS IN INCHES.

Figure 2 - Preferred Mounting Arrangement and Layout Of Associated Contacts

Note 1: Contact ring No.97-252 or finger stock No.97-380.

Note 2: Contact ring No.97-253 or finger stock No.97-380.

Note 3: Contact ring No.97-254 or finger stock No.97-380.

Note 4: Contact ring No.97-255 or finger stock No.97-380.

Note 5: Either the specified contact ring of preformed finger stock or finger stock No. 97-380 provide adequate electrical contact, but the finger stock No. 97-380 is less susceptible to breakage than the specified contact ring. Both types are made by Instrument Specialties Co., P.O. Box A, Delaware Water Gap, PA 18327.

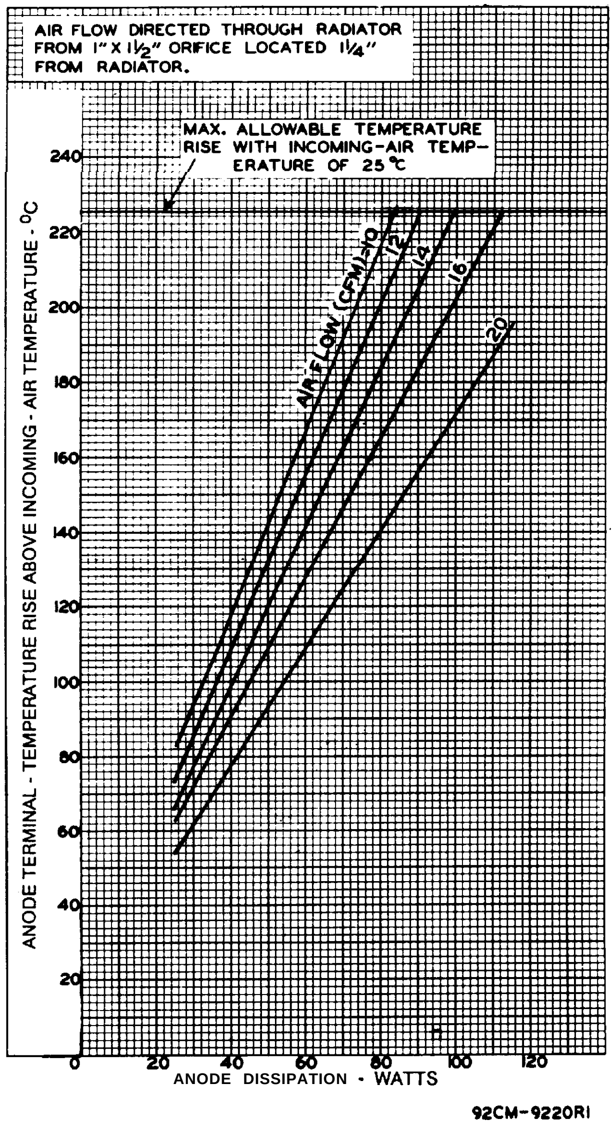


Figure 3 - Typical Cooling Requirements -With Air Flow Directed Through Radiator Without Cowling

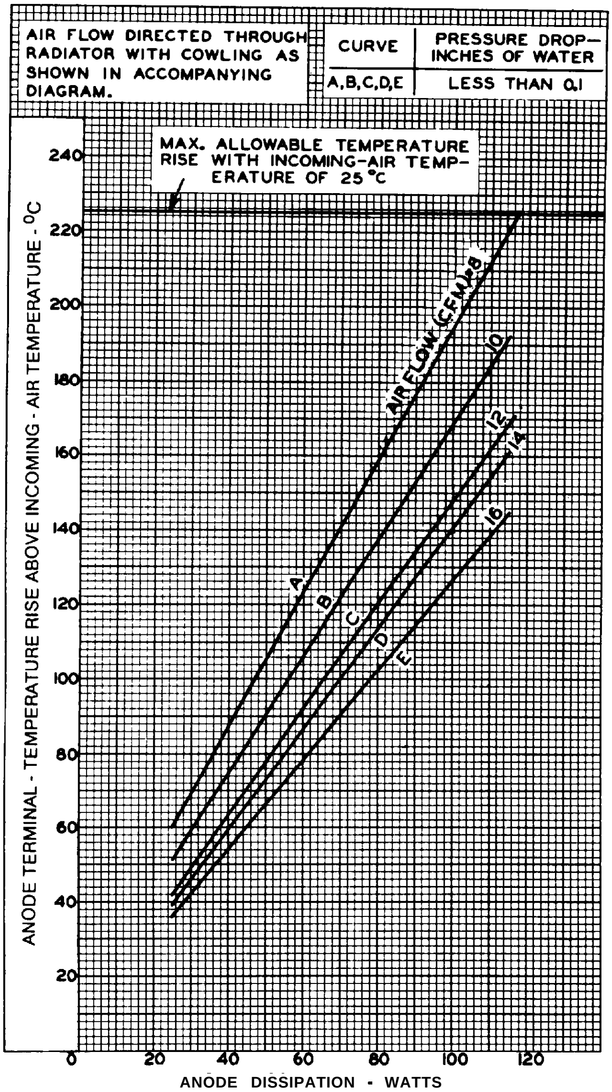


Figure 4 - Typical Cooling Requirements - With Air Flow Directed Through Radiator With Cowling

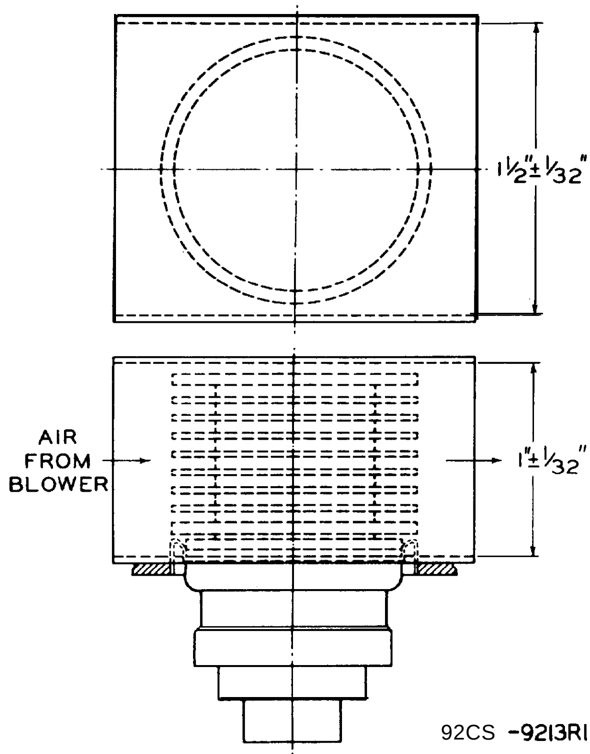


Figure 5 - Recommended Cowling For Directing Air Flow Through Radiator

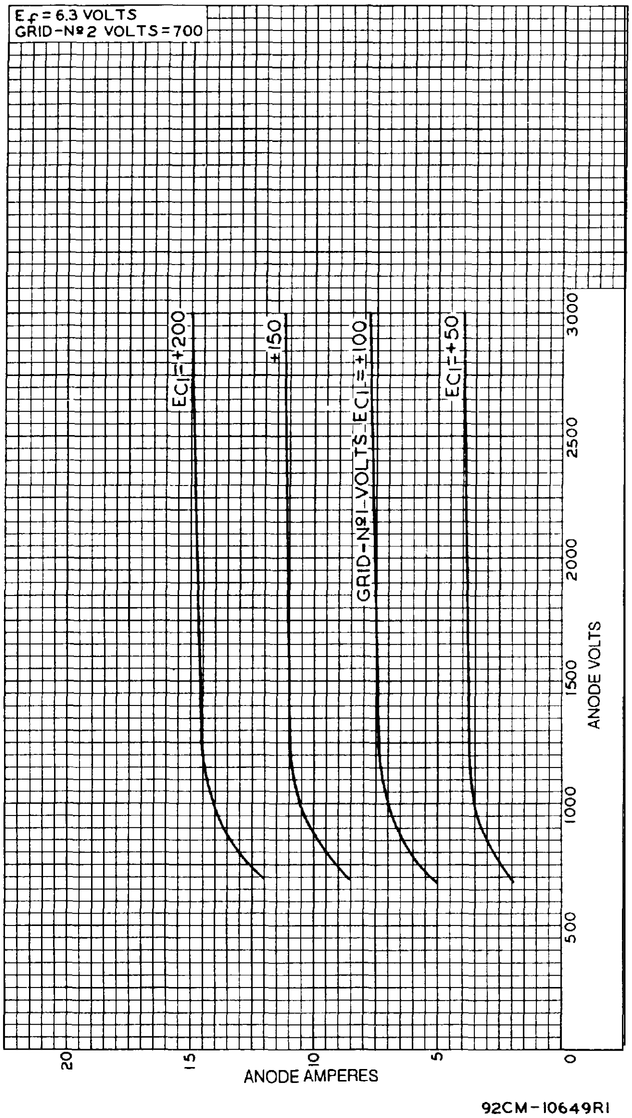


Figure 6 - Typical Anode Characteristics

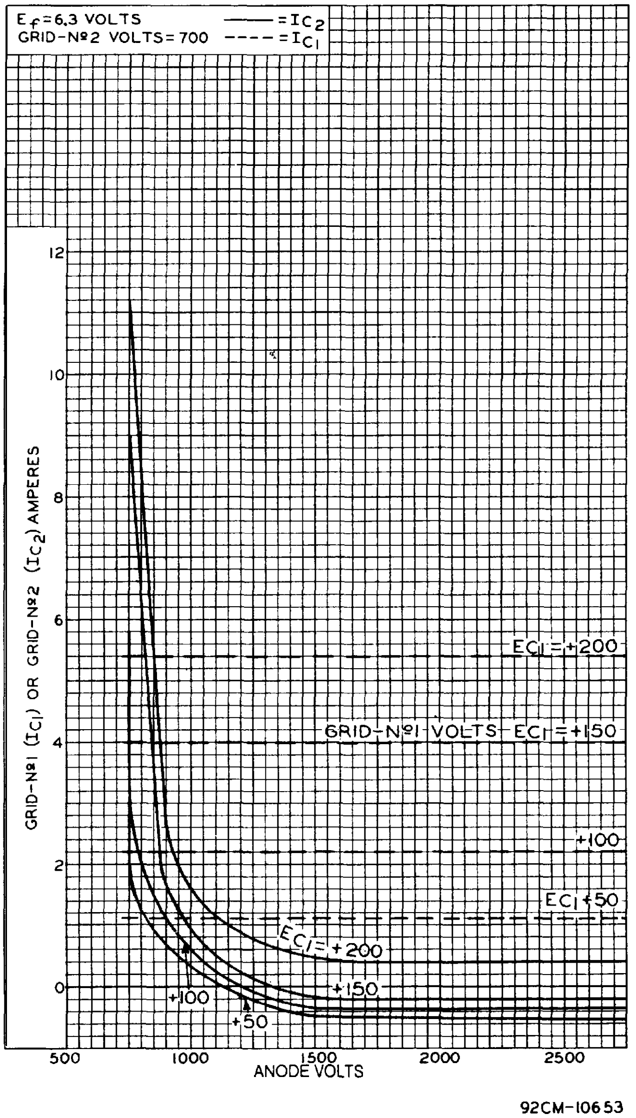


Figure 7 - Typical Characteristics

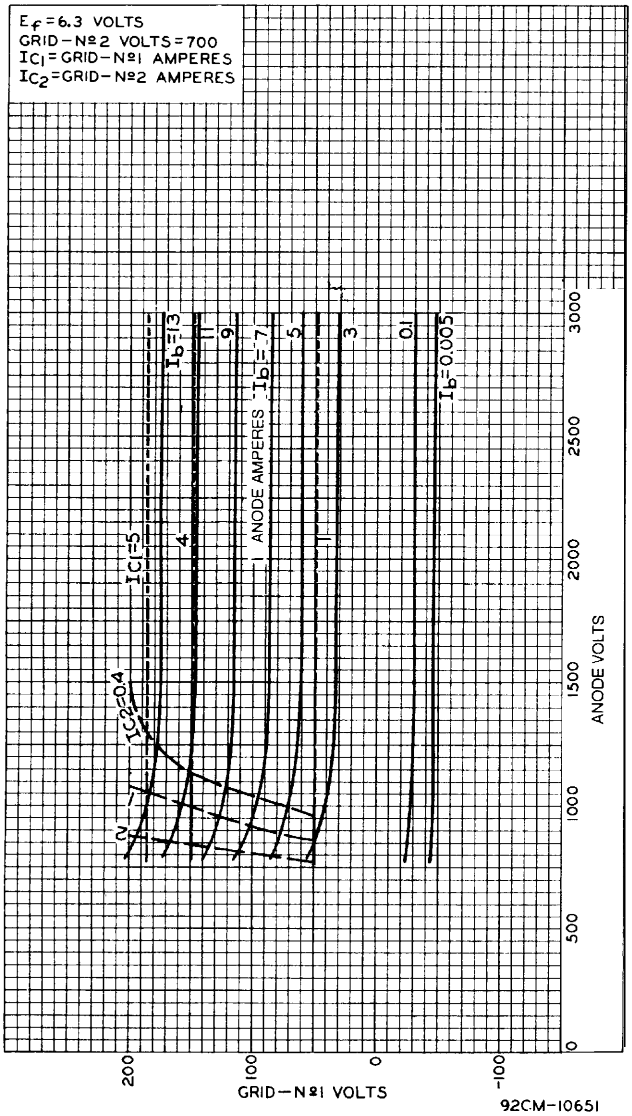


Figure 8 - Typical Constant-Current Characteristics

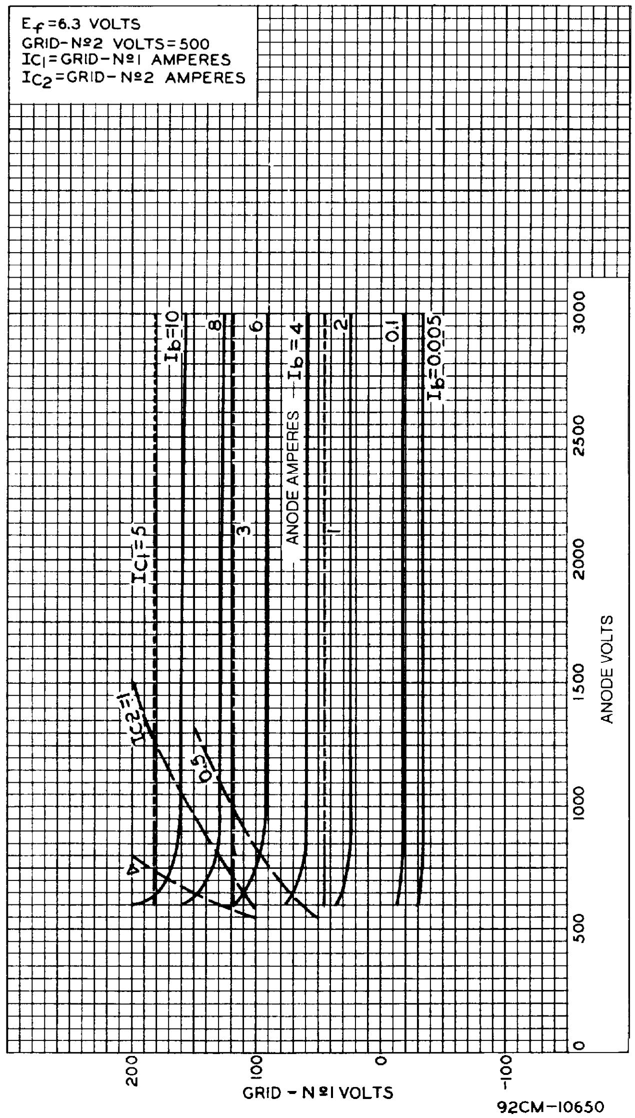


Figure 9 - Typical Constant-Current Characteristics

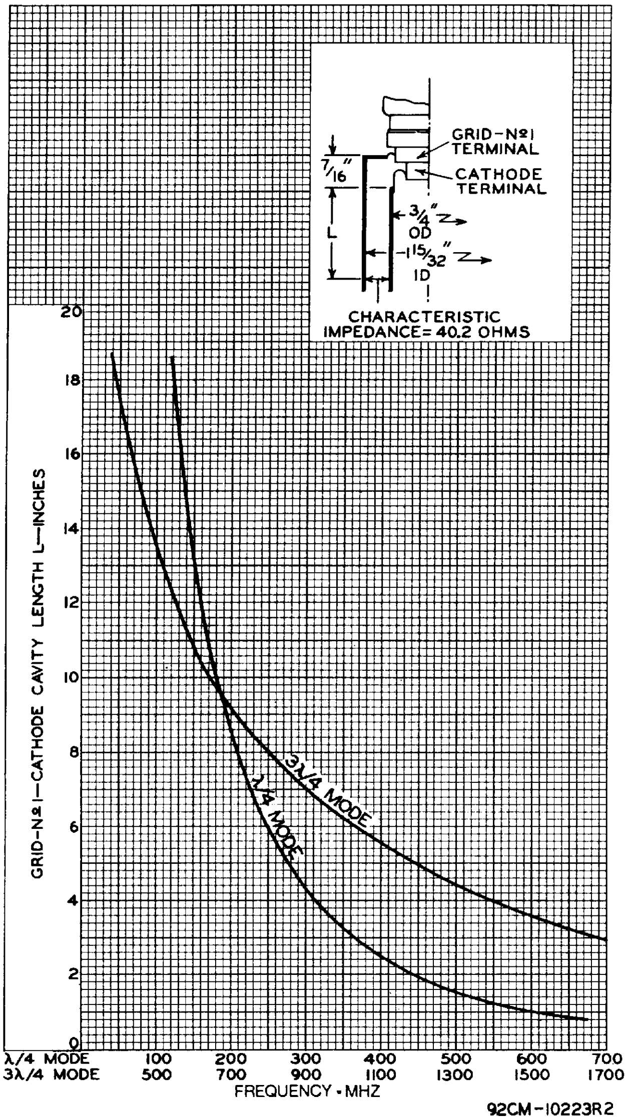


Figure 10 - Grid-No.1 Cathode Tuning Curves

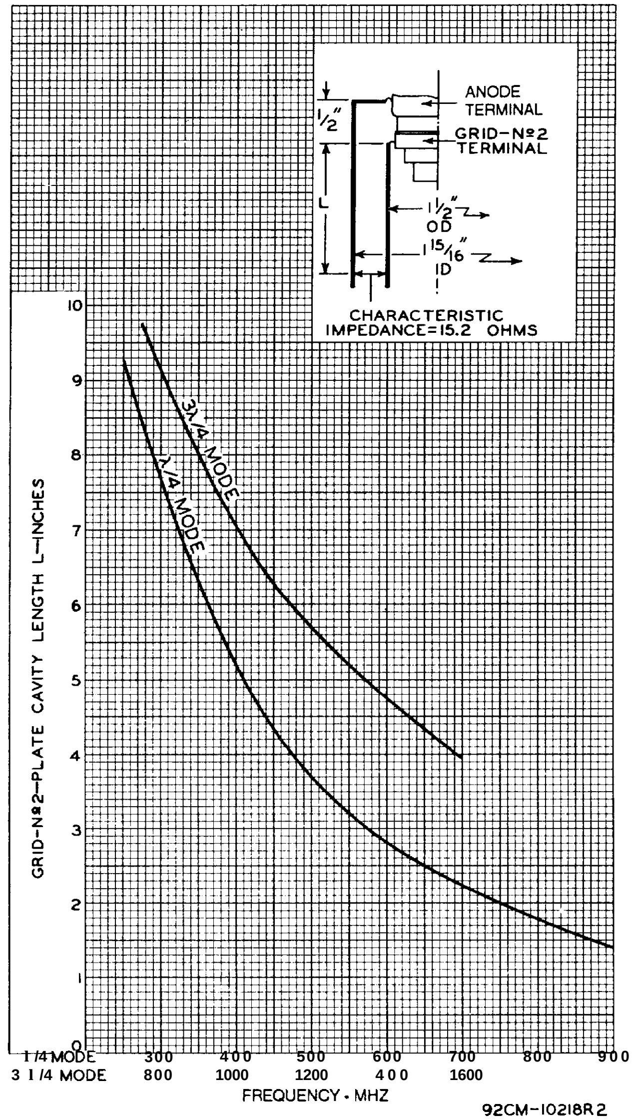


Figure 11 - Grid-No.2 Anode Tuning Curves

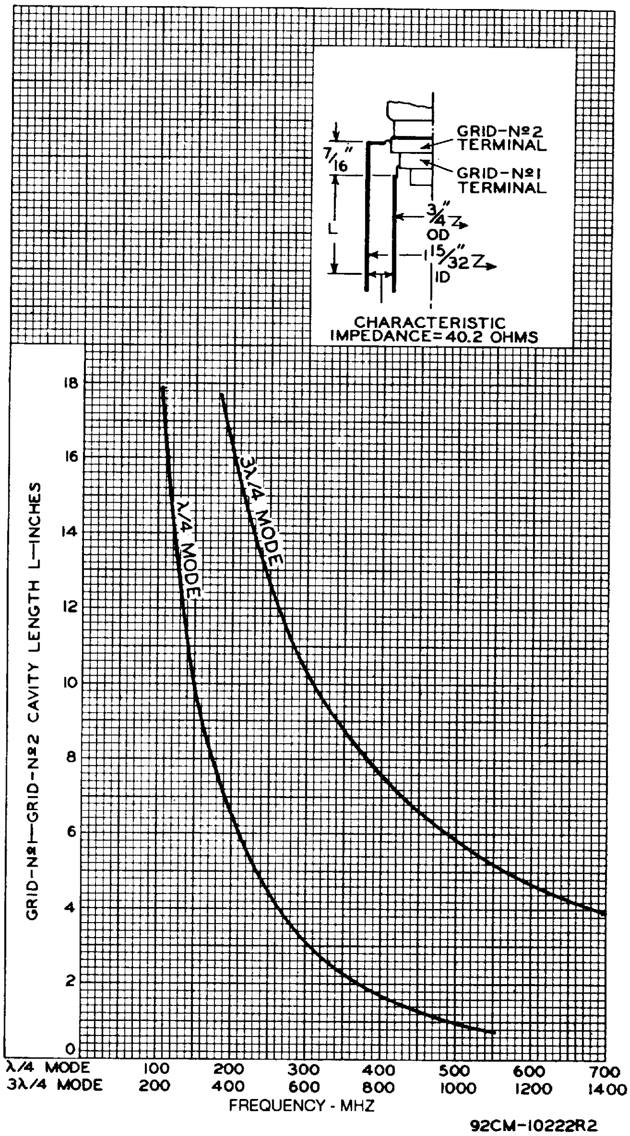


Figure 12 - Grid-No.1 and Grid-No.2 Tuning Curves

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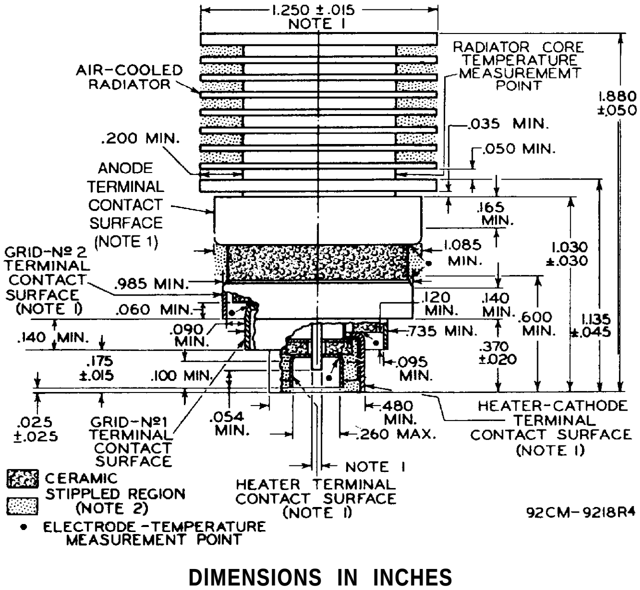

Figure 13 - Dimensional Outline

Note 1: The following diametrical space requirements accommodate the concentricity of the cylindrical surfaces of the radiator fins, axial pin, and each electrode terminal:

a. Radiator Band - 1.317"
b. Anode Terminal - 1.120"
c. Grid-No.2 Terminal - 1.020"
d. Grid-No. 1 Terminal - 0.765"
e. Heater-Cathode Terminal - 0.520"
f. Heater Terminal - 0.238"
g. Axial Pin - 0.072"

Note 2: Keep all stippled regions clear. Do not allow contacts or circuit components to protrude into these annular volumes.

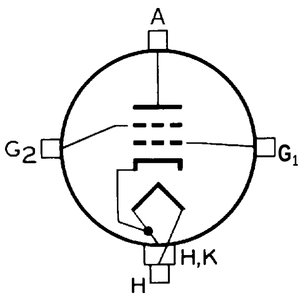

Figure 14 - Terminal Connections

G_1 - Grid-No.1 Terminal Contact Surface (Adjacent to Cathode & Heater Terminal Contact Surface)

G_2 - Grid-No.2 Terminal Contact Surface (Adjacent to Grid-No. 1 Terminal Contact Surface)

H - Heater Terminal Contact Surface (Within Cathode & Heater Terminal Contact Surface)

H,K - Cathode & Heater Terminal Contact Surface (End Opposite Air-Cooled Radiator)

A - Anode Terminal Contact Surface (Adjacent to Air-Cooled Radiator)