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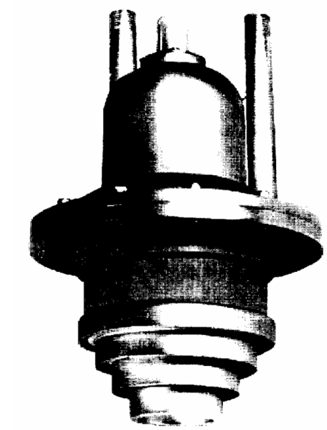
S93419E
Power Tetrode

VHF Linear Beam Power Tetrode

- **Full Input to 300 MHz Liquid Cooled Anode**
- **125 kW CW Power Output**
  16dB Gain
  75% Efficiency


Shown with Anode Coolant Separator

The BURLE S93419E is designed specifically for use in high-gain, high efficiency, high linearity VHF CW service.

Rated for full input to 300 MHz, the tube is easily circuited to this frequency. The terminals are coaxial for operation in the TEM mode and the anode cooler location avoids restricting the resonant cavity circuits in VHF operation. The type is also well suited to other applications such as single sideband, pulsed RF or modulator service.

Its sturdy, coaxial Cermolox® construction and thoriated-tungsten mesh filament minimize tube inductances and feed-thru capacitances. They make possible the use of simple, economical circuit techniques in amplifier operation.

To minimize tube and spares inventory costs, the Anode Coolant Separator, J15654, which must be used with the tube is not supplied with each tube. It should be ordered separately as required. This separator, which surrounds the tube anode and includes the coolant connector pipes, is easily assembled to the tube prior to tube use. It may be exchanged from one tube to another.

Additional information of a general nature applicable to tubes of this type is given in the following publications:

TP-105 Application Guide for BURLE Power Tubes

TP-122 Screen-Grid Current, Loading and Bleeder

TP-117 Handling and Operating Considerations

TP-118 Application Guide for Forced Air Cooling

Close attention to the instructions contained in these publications will assure longer tube life, safer operation, less equipment downtime and fewer tube handling accidents.

General Data

Electrical

Filamentary Cathode, Thoriated-Tungsten Mesh Type:			
Voltage[1] (AC or DC)	12.5	typ.	V
	13.5	max.	V
Current:[2]			
Typical	155		A
Instantaneous peak value during startups[15]	350	max.	A
Cold resistance	0.01		Ω
Minimum heating time		See Note 3	
Mu-Factor[4] (Grid No.2 to Grid No.1)	15		
Direct interelectrode Capacitances:			
Grid No.1 to anode[5]	0.7		pF
Grid No.1 to filament	200		pF
Anode to filament[5]	0.5		pF
Grid No.1 to grid No.2	250		pF
Grid No.2 to anode	30		pF
Grid No.2 to filament[5]	5		pF

Mechanical

Operating Attitude	Vertical, anode up	
Overall Length (Max.)	13.0	in
Greatest Diameter (Max.)	8.5	in
Weight (Approx.)		
Tube only	18	lbs
Anode coolant separator	6	lbs

ISO 9001

BURLE

Thermal

Storage Temperature[11]	-65	min.	°C
Seal Temperature[6]	250	max.	°C

(Grid-No.2, Grid-No.1 Cathode-Filament, and Filament)

Anode Cooling:[14]

Liquid cooling of the anode using the J15654 Anode Coolant Separator or equivalent is required. When the environmental temperature permits, the coolant may be water. In this case, the use of distilled or filtered deionized water is essential. The liquid flow must start before application of any voltages, including filament voltage, and preferably should continue for several seconds after removal of all voltage. Interlocking of the liquid flow through the anode with all power supplies is recommended to prevent tube damage in the event of inadequate liquid flow.

See **Figure 2-** Anode Cooling Characteristics.

Liquid pressure at any inlet, maximum gauge	100 lbs/in^2 (7.0 kg/cm^2)
Resistivity of water @ 25° C, minimum	1.0 megohm-cm
Water temperature from any outlet, maximum	70°C

Grid-No.2, Grid-No.1, Cathode-Filament and Filament Cooling[16]

Cooling airflow is essential to limit these terminal-seal temperatures to values that will assure long, reliable tube life. A sufficient quantity of air should be directed past each of these terminals to assure that its temperature does not approach the absolute-maximum limit of 250°C. A safety factor of 25° to 50° C is recommended to compensate for all probable system and component variations throughout life. The air flow must start before application of any voltages, including filament voltage, and should be continued for a minimum of three minutes after all voltages have been removed. Interlocking of the air flow with all power supplies is recommended to prevent tube damage in the event of inadequate air flow.

RF Power Amplifier & Osc. - Class AB Telegraphy and RF Power Amplifier - Class AB FM Telephony[7]

Maximum CCS Ratings, Absolute-Maximum Values

	Up to 300 MHz
DC Anode Voltage[8]	20,000 max. V
DC Grid-No.2 Voltage[9]	2000 max. V
DC Grid-No.1 Voltage[13]	6.00 max. V
DC Anode Current	12 max. A
Grid-No.1 Input	300 max. W
Grid-No.2 Input	500 max. W
Anode Dissipation[10]	100,000 max. W

Maximum Circuit Values

Grid-No.1 Circuit Resistance Under Any Conditions:

With fixed bias	1000 max. Ω
With cathode bias	Not recommended

Typical CCS Operation

In a Cathode Drive Circuit at 50 to 110 MHz

DC Anode Voltage	16,000 V
DC Grid-No.2 Voltage	1500 V
DC Grid-No.1 Voltage	-250 V
DC Anode Current	10.5 A
DC Grid-No.2 Current	0.24 A
DC Grid-No.1 Current	0.63 A
Driver Power Output (Approx.)[12]	2700 W
Useful Power Output	125,000 W

Notes

1. Measured at the tube terminals. For accurate data the ac filament voltage should be measured using an accurate RMS type meter such as an iron-vane or the thermocouple type meter. The dc voltage should be measured using a high input impedance type meter.

   For high-current, low voltage filaments such as are used in this tube, it is recommended that the filament current be monitored since very small changes in resistance can produce misleading changes in voltage. For maximum life, the filament power should be regulated at the lowest value that will give stable performance. For those applications where hum is a critical consideration, dc filament or hum bucking circuits are recommended. See also Application Note TP-117.

2. It is recommended that additional current be available to allow for both product variation and the normal reduction of filament resistance with life. Thus the filament supply adjustment should be designed for capability of 205 amperes at 14.0 volts. A minimum setting is 11.0 volts.

3. Recommended starting procedure for maximum stability and longest life.
   1. Standard: Filament heating time of 120 seconds followed by grid-No.1, anode, grid-No.2, and RF drive.
   2. Emergency 1: (Power Interruption of 15 seconds or less). The tube may be brought back on the air two seconds after power restoration. Precautions must be taken so that neither the filament surge current limit nor the maximum filament voltage rating is exceeded. The sequence of voltage application after filament warm-up is as follows: gird-No.1, anode, grid-No.2, and RF drive.
   3. Emergency 2: (Power interruption of greater than 15 seconds). After power restoration the tube may be brought back on the air following 30 seconds of full filament voltage operation. Precautions must be taken so that neither the filament surge current limit nor the maximum filament voltage rating is exceeded. In order to insure that the tube does not operate in excess of typical conditions, control of the RF drive level will be required until tube temperature stability is achieved and special consideration must be given to the design of grid-No.1 circuitry. Application Engineering assistance is available from BURLE INDUSTRIES, INC. The sequence

of voltage application after filament warm up is as follows: grid-No.1, anode, grid-No.2, and RF drive.

4 For anode voltage 2000 V, grid-No.2 voltage = 1250 V, and anode current = 15 A.

5 No external shield.

6. See Dimensional Outline for Temperature Measurement Points. For good contact-finger life, a maximum temperature of 180° C at the terminal is recommended when using commercially available beryllium-copper socket contacts.

7 See TP-105. At the 3 dB points, the maximum recommended Q is 30.

8 See TP-105.

The maximum voltage ratings must be modified for operation at altitudes higher than sea level and for temperatures in excess of 20° C in accordance with the curves of Figure 1. For altitude derating of the anode voltage, use the voltage difference between anode and grid-No.2. The maximum fault energy that can be dissipated within the tube is approximately 100 joules. The filament can be damaged with as little as 3 joules of fault energy. Therefore, the energy available for a high voltage arc or fault must be limited by means of current limiting resistors or fault-protection circuitry such as spark gaps and electronic "crow bars". This is especially important where high, stored energy and large capacitors are used. For additional information, see TP-105, "Application Guide for BURLE Power Tubes".

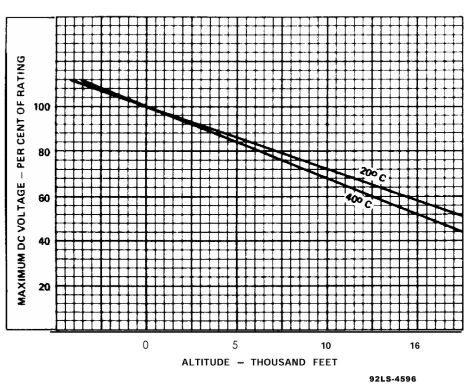


Figure 1 -**Maximum DC Voltage with Respect to Altitude**

9 See TP-105 and TP-122. Protection devices such as spark gaps should be used.

10 Permitted anode dissipation is a function of cooling. For specific ratings see **Figure 2** - Anode Cooling Characteristics.

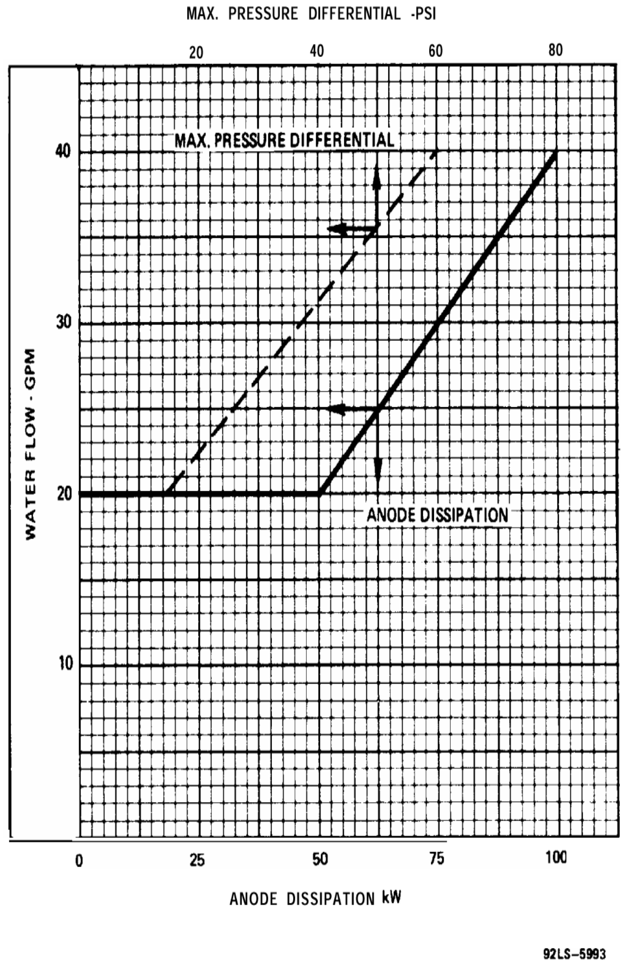


Figure 2 - Anode Cooling Characteristics

11 The tube coolant ducts must be free of water before storage or shipment of the tube to prevent damage from freezing.

12 Driver power output represents circuit losses in the driver output and the grid input circuit in addition to the power necessary to drive the tube.

13 See TP-105. Protection devices such as spark gaps or positive clamping should be used.

14 For additional information on liquid cooling, see the "Application Guide for BURLE Power Tubes" TP-105.

15 Use an oscilloscope in system checkout. Systems such as auto transformers, step transformers, shortable limiting resistors, saturable reactors, or combinations thereof must be used.

16 For further information on forced air cooling, see TP-105 and TP-118 , "Application Guide for Forced Air Cooling".

Operating Considerations

Safety Precautions

Protection circuits serve a threefold purpose: safety of personnel, protection of the tube in the event of abnormal circuit operation, and protection of the tube circuits in the event of abnormal tube operation.

Warning - Personal Safety Hazards
Electrical Shock - Operating voltages applied to this device present a shock hazard.
X-Ray Warning - This device in operation produces X-rays which can constitute health hazard unless the **device is adequately shielded for radiation.**
RF Radiation - This device in operation produced RF radiation which may be harmful to personnel.

Power tubes require mechanical protective devices such as interlocks, relays, and circuit breakers. Circuit breakers alone may not provide adequate protection in certain power-tube circuits when the power-supply filter, modulator, or pulse-forming network stores much energy. Additional protection may be achieved by the use of high-speed electronic circuits to bypass the fault current until mechanical circuit breakers are opened. These circuits may employ a control gas tube, such as a thyratron or ignitron, depending on the amount of energy to be handled.

Great care should be taken during the adjustment of circuits. The tub and its associated apparatus, especially all pats 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 cannot possible come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies and discharge high-voltage capacitors 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 screen circuit requires special attention because the heating power of the current and voltage of this electrode is not the algebraic product of the current and voltage elements as observed at the terminal. For analysis of the circuit, review TP-122.

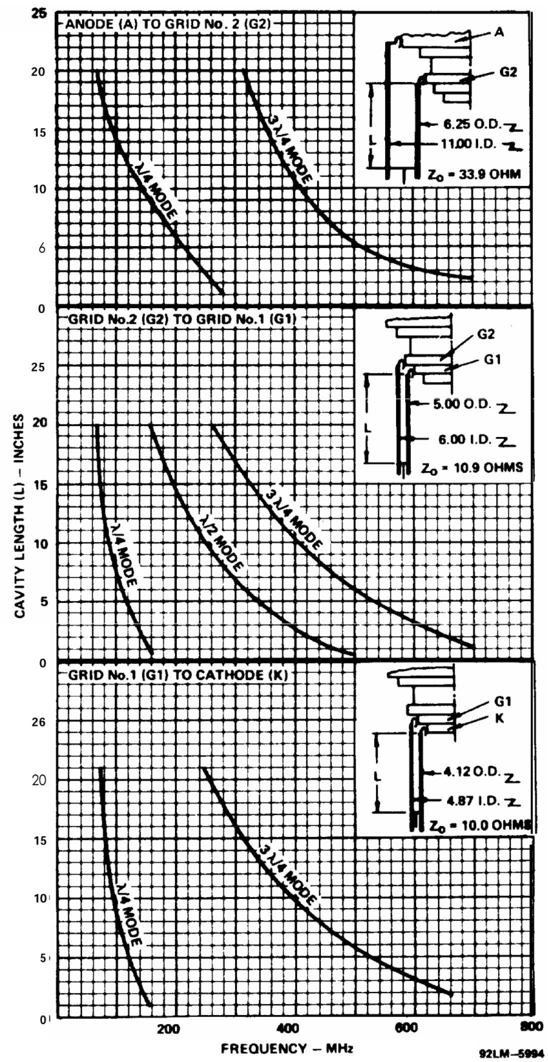
A time-delay relay must be provided in the grid-No.1 supply circuit to delay application of this voltage until the filament has reached normal operating temperature.

An interlocking relay system should be provided to prevent application of anode voltage prior to the application of sufficient bias voltage otherwise, with insufficient bias, the resultant high anode current may cause excessive anode dissipation with consequent damage to the tube. RF load shorts or other causes of high output VSWR may also cause high dissipations, excessive voltage gradients, or insulator flash-over. The load VSWR should be monitored and the detected signal used to actuate the interlock system to remove the anode voltage in less than 10 milliseconds after the fault occurs.

Assembly of Separator and Tube

The Anode Coolant Separator, J15654, is a necessary accessory for the S93419E tube and should be ordered as a separate item unless already available. The tube will be delivered without a separator. Separators may be reused or exchanged from one tube to another. The following procedure should be used for installation of the separator:

1. Visually inspect the separator and tube anode liquid course to assure that they are clean and free of particles. DO NOT clean the anode coolant fins mechanically. See TP-105 for instructions on “Inspection of Coolant Courses*' and for instructions of “Cleaning Coolant Courses”.
2. Invert the separator (inlet and outlet pipes down) and place the larger “O” ring, Uniform Size No.1 22, supplied, clean and lubricant-free in the moat on the separator flange. (A ringstand or similar type support for the separator is helpful at this stage.)
3. Carefully lower the tube, anode down, into the separator. Avoid damaging the coolant fins on the side of the anode. Center the tube in the separator and rotate, if necessary, to align the tapped holes in the anode flange with the clearance holes in the separator flange.
4. Holding the assembly firmly in this position, invert it to place the separator on top.
5. Secure the separator in place with the twelve 1/4-20 NC x 3/4” stainless steel, socket head screws provided.
6. Place the smaller “0” ring, Uniform Size No.261, supplied, clean and lubricant-free, in the moat on the top separator flange.
7. Place the small Clamp Plate over the “O” ring and secure in place with the four 8-32 x 1/4” stainless steel socket head screws provided.



Maximum rated frequency is 300 MHz. However, the tube is capable of amplication to beyond 2 GHz and care must be taken by the circuit designer to prevent parasitic oscillations as high frequencies. Tuning curves above 300 MHz are provided for circuit design assistance to prevent oscillation in the TE_{11} mode.

Figure 3 - Electrode Cavity Tuning Characteristics

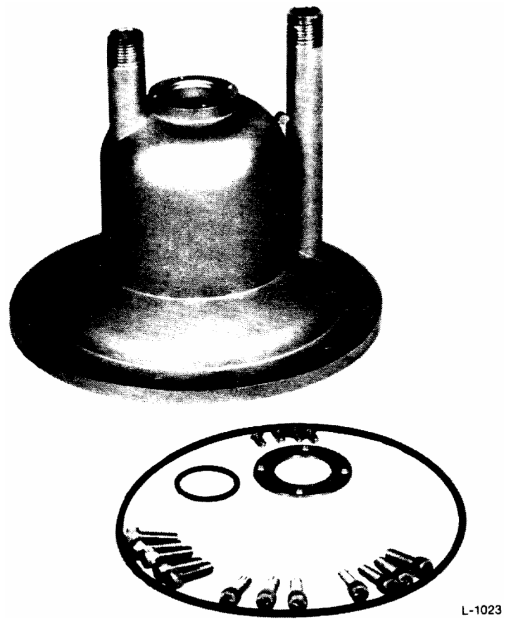


Figure 4 - **J15654 Anode Coolant Separator and Accessories**

Tube/Separator Installation and Removal

No mechanical aids should be required in well designed sockets. However, extreme care should be exercised to assure that contact fingers in the socket are not broken or damaged.

Place the tube gently over the socket and move the base slightly until the contacts are aligned and the tube partially enters the assembly. A firm push on the anode should then seat the tube against a stop which assures correct contact alignment.

Connect flexible coolant lines to the two 1/2" threaded pipes on the anode coolant separator. The longer pipe should be used as the inlet and the shorter as the outlet.

To remove the tube from a socket, first remove the coolant lines. Gently rock the tube back and forth while exerting an upward force on the coolant pipes until it is free of the finger contacts. Then lift the tube straight out avoiding further contact.

Filament-Voltage Adjustment

The life of the filament can be conserved by adjusting to the lowest filament supply voltage that will give the desired performance. Follow the filament voltage adjustment procedure below.

1. Before the application of any other voltages to a new tube, the filament voltage should be adjusted to 14.2 volts at the tube socket. A true RMS voltmeter should be used for accurate measurement. It may be more convenient to make the measurement at other contacts in the equipment, but the value will be higher because of increased impedance such as wire loss or contact resistance.
2. Apply voltages and adjust tuning controls as necessary for proper operation as described in the appropriate instruction manual.
3. Reduce the filament voltage in 0.1-volt increments - repeating the procedures in Steps 1 and 2 - until performance degradation such as a decrease in anode current or power output is noted. Then increase the filament voltage 0.2 volt above this point. Typically depending upon the application, this voltage will be in the range of 13.8 to 14.2 volts.

During life when evidence is observed that a tube is becoming emission limited, increasing the filament voltage may extend the useful life of the tube. However, never increase filament voltage to compensate for a decrease in other circuit parameters such as RF drive voltage!

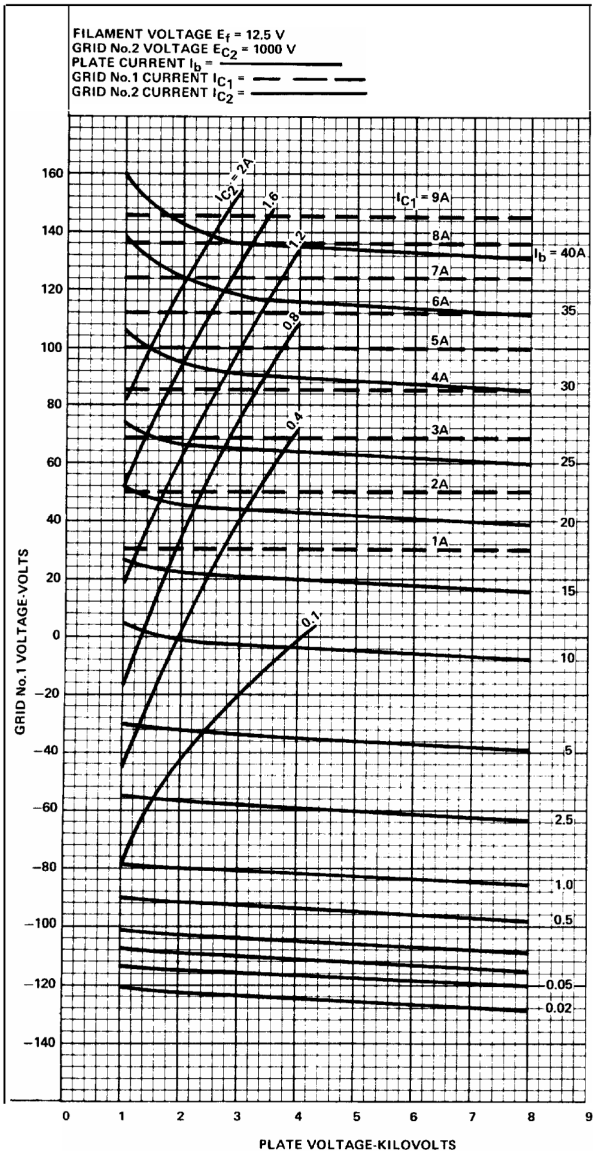


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Figure 5 - **Typical Constant Current Characteristics**

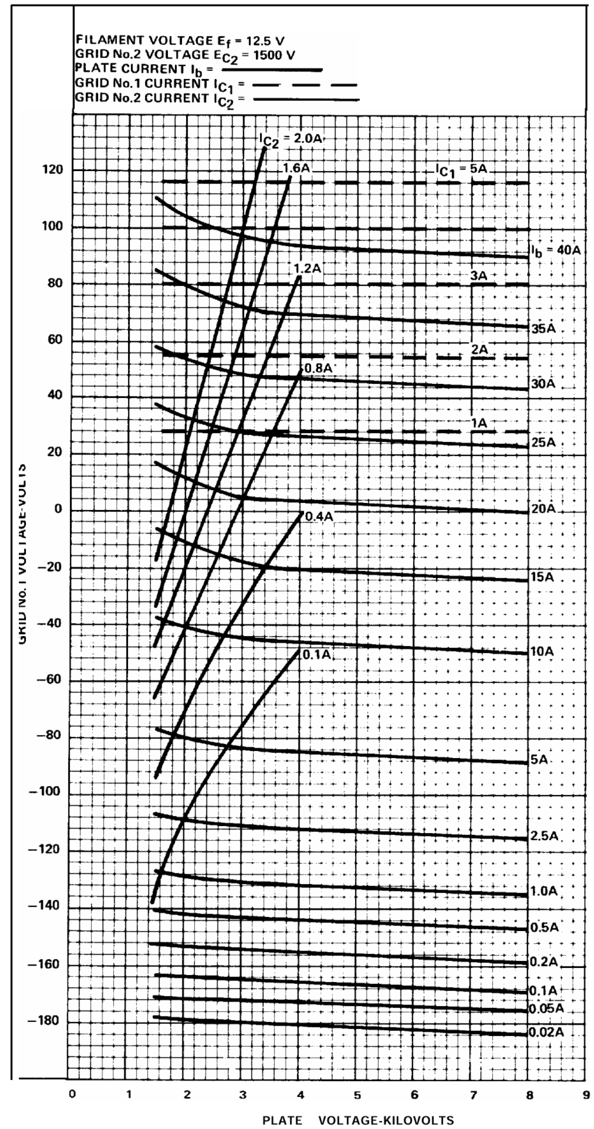

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Figure 6 - **Typical Constant Current Characteristics**

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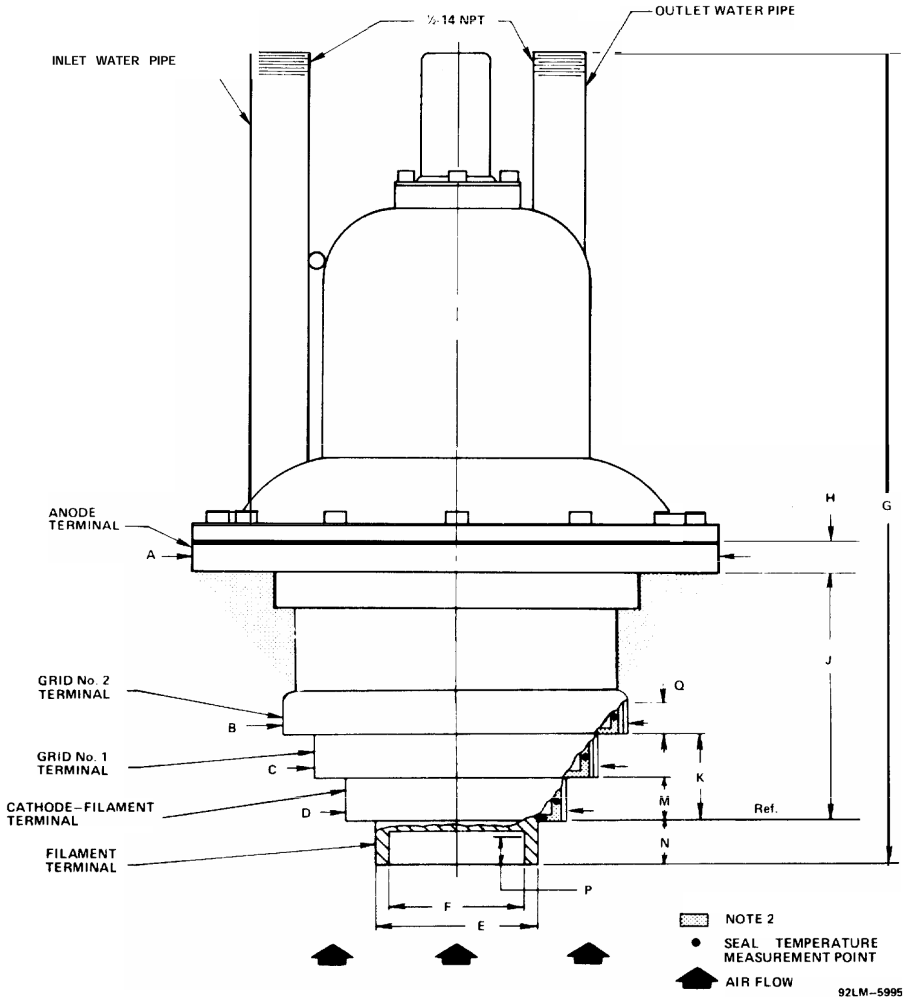

Tabulated Dimensions

Dim.	Inches	Millimeters	Notes
A Dia.	8.500 ± .010	215.90 ± .25	1,3
B Dia.	5.590 ± .020	141.97 ± .51	1,3
C Dia.	4.590 ± .020	116.59 ± .51	1,3
D Dia.	3.590 ± .020	91.19 ± .51	1,3
E Dia.	2.600 ± .010	66.04 ± .25	1,3
F Dia.	2.100 ± .010	53.34 ± .25	1,3
G	13.000 max	330.20 max	
H	0.400 ± 010	10.16 ± 25	
J	4.075 ± .100	103.51 ± 2.5	
K	1.430 ± .060	36.32 ± 1.52	
M	0.750 ± 060	19.05 ± 1.52	
N	0.710 ± 030	18.03 ± 76	
P	0.500 min.	12.70 min.	
Q	0.400 min.	10.16 min.	

Note 1 -The diameter of each terminal is maintained only over the indicated minimum length of its contact surface.

Note 2 -Keep all stippled regions clear. In general do not allow contacts to protrude into these annular regions. If special connectors are required which may intrude on these regions, contact BURLE Power Tube Application Engineering, Lancaster, PA 17601,

Note 3 -With the anode terminal and the cathode-filament terminal used as reference, the other terminals will measure less than 0.060 (1.52 mm) total indicator run-out (TIR).

Dimensions are in inches unless otherwise stated. Metric dimensions are derived from the basic inch dimensions (one inch - 25.4 millimeters).

Figure 7 - **Dimensional Outline (Shown With Anode Coolant Separator Attached)**