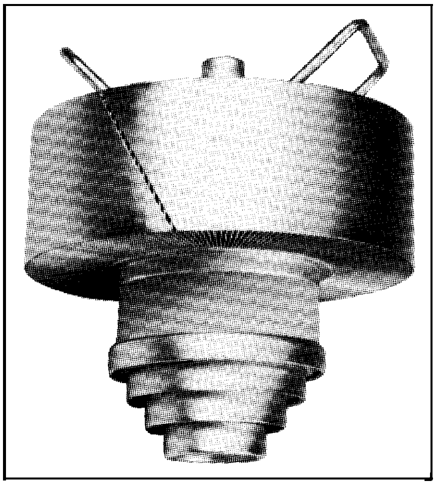
8984
Power Tube



VHF Linear Beam Power Tube

- Full Input to 300 MHz
  Forced-Air Cooled
- 55 kW Peak Sync. Output
  VHF-TV Band
  16 dB Gain
- FM Broadcast Service
  55 kW Output
  16 dB Gain

The BURLE 8984 is designed specifically for use in high-gain, high-linearity equipments for VHF-TV and FM 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 radiator location avoids restricting the resonant cavity circuits in VHF operation. This assures high gain-bandwidth products for the full VHF-TV band. In addition, it is well suited for other applications such as single sideband, CW or pulsed RF, modulator service, and translator 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, broadband circuit techniques in VHF operation. Additional information of a general nature applicable to tubes of this type is given in the following publications:

TP-105	Application Guide for 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 (AC or DC)	See Note a		
Current:[b]			
Typical	155		A
Instantaneous peak value during startups[s]	350	max	A
Cold resistance	0.01		ohms
Minimum heating time	See Note c		
Mu-Factor[d] (Grid No.2 to Grid No.1)	15		
Direct Interelectrode Capacitances:			
Grid No.1 to plate[e]	0.7		pF
Grid No.1 to filament	200		pF
Plate to filament[e]	0.5		pF
Grid No.1 to grid No.2	250		pF
Grid No. 2 to plate	30		pF
Grid No.2 to filament[e]	5		pF

BURLE Electron Tubes

Mechanical:

Operating Attitude	Vertical, anode up	
Overall Length (Max.)	11.3	in
Greatest Diameter (Max.)	10.3	in
Radiator	Integral part of tube	
Weight (Approx.)	60	lbs

Thermal:

Seal Temperature[f] ...... 250 max. °C
(Plate, Grid-No.2, Grid-No. 1, Cathode-Filament, and Filament)
Average Plate-Core Temperature[g] ...... 250 max. °C

RF Power Amplifier-Class B Television Service[h]

Synchronizing-level conditions per tube unless otherwise specified.

Maximum CCS Ratings, Absolute-Maximum Values:

DC Plate Voltage)	15,000	max.	V
DC Grid-No.2 Voltage[k]	2000	max.	V
DC Grid-No. 1 Voltage[q]	-600	max.	V
DC Plate Current	12	max.	A
Plate Dissipation[m]	40,000	max.	W
Grid-No.2 Input	500	max.	W
Grid-No.1 Input	300	max.	W

Typical CCS Operation:

In a cathode-drive circuit at 216 MHz and bandwidth of 6.3 MHz[r]

DC Plate Voltage	10,500	V
DC Grid-No.2 Voltage	1200	V
DC Grid-No. 1 Voltage[n]	-75	V
Zero-Signal DC Plate Current	1.5	A
DC Plate Current:		
Synchronizing level	8.4	A
Blanking level..	6.4	A
DC Grid-No.2 Current:		
Synchronizing level	0.3	A
Blanking level..	0.1	A
DC Grid-No.1 Current:		
Synchronizing level	0.25	A
Blanking level	0.12	A
Driver Power Output:[p]		
Synchronizing level	1250	W
Blanking level..	700	W
Useful Power Output:		
Synchronizing level	55,000	W
Blanking level	30,800	W
Power Gain, including Circuit Losses	16.4	dB

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

Maximum CCS Ratings, Absolute-Maximum Values:

	Up to 300 MHz		
DC Plate Voltage[j]..	15,000	max.	V
DC Grid-No.2 Voltage[k]	2000	max.	V
DC Grid-No.1 Voltage[q]	-600	max.	V
DC Plate Current	12	max.	A
Grid-No.1 Input	300	max.	W
Grid-No.2 Input	500	max.	W
Plate Dissipation[m]	40,000	max.	W

Maximum Circuit Values:

Grid-No, l-Circuit Resistance Under Any Conditions:

With fixed bias	1000 max	Ohms
With cathode bias	Not recommended	

Typical, Grid Driven, Class B, CCS Operation:

		At 7.0 MHz
DC Plate Voltage	10,000	V
DC Grid-No. 2 Voltage	1250	V
DC Grid-No, 1 Voltage[n]	-125	V
Zero-Signal DC Plate Current	0.5	A
DC Plate Current	7.5	A
DC Grid-No. 2 Current	0.3	A
DC Grid-No. 1 Current	0.4	A
Driver Power Output (Approx.)[P]	150	W
Grid Loading Resistance	750	Ohms
Useful Power Output	50,000	W

Typical CCS Operation:

In a Grid-Drive Circuit at 100 MHz

DC Plate Voltage	10,800	V
DC Grid-No. 2 Voltage	1300	V
DC Grid-No.1 Voltage	-250	V
DC Plate Current	6.5	A
DC Grid-No. 2 Current	0.28	A
DC Grid-No. 1 Current	0.01	A
Driver Power Output (Approx.)[P]	1400	W
Useful Power Output	55,000	W

Notes

a The typical filament voltage is 12.5 volts, ac or dc. The maximum filament voltage, measured at the tube terminals, is 13.5 volts. For maximum life, the filament power should be regulated at the lowest value that will give satisfactory performance.

For accurate data, ac filament voltage should be measured using an RMS type meter such as an iron-vane or thermocouple type. DC voltage should be measured using a high input impedance type meter.

For those applications where hum is a critical consideration, dc filament voltage of hum-bucking circuits are recommended.

See Application Note, TP-117, for further information.

b 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 200 amperes at 13.5 volts.

c Recommended starting procedure for maximum stability and longest life.

1. Standard: Filament heating time of 120 seconds followed by grid-No.1, plate, 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: grid-No.1, plate, 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 isavailable from BURLE. The sequence of voltage application after filament warm-up is as follows: grid-No.1, plate grid-No. 2, and rf drive.

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

e No external shield.

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.

g The value of 250° C is the average of 4 readings taken 90° apart around the anode core. No one reading may exceed 275° C.

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

j 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 plate voltage, use the voltage difference between plate and grid No. 2.

The maximum fault energy that can be dissipated within the tube is approximately 100 joules. Therefore, the energy available for a high-voltage arc or fault must be limited to this value 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. In typical 55 kW TV transmitters, the series resistors used are:

Plate -Thirty ohm minimum is required in high capacitance power supplies for video service.

Grid No. 2 - Fifty ohms minimum.

Grid No.1 - Fifty ohms.

For additional information see TP-105, "Application Guide for Power Tubes."

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

m Permitted plate dissipation is a function of cooling. For specific ratings see Forced Air Cooling information in this data sheet.

n Adjusted for specified zero-signal dc plate current.

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

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

The bandwidth of 6.3 MHz is calculated at the -0.72 dB power points of a doubled-tuned output circuit using two times the tube output capacity and a damping factor of the square root of 1.5 as shown in **Figure 2.**

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

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 a health hazard unless the device is adequately shielded for radiation.**
>
> **RF Radiation - This device in operation produces rf radia-** tion **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 controlled 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 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 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 on 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 plate voltage prior to the application of sufficient bias voltage otherwise, with insufficient bias, the resultant high plate current may cause excessive plate 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 flashover. The load VSWR

should be monitored and the detected signal used to actuate the interlock system to remove the plate voltage in less than 10 milliseconds after the fault occurs.

Forced Air Cooling

Cooling air flow is necessary to limit the anode-core and terminal-seal temperatures to values that will assure long reliable life. A sufficient quantity of air should be directed past each of these terminals so that its temperature does not approach the absolute-maximum limit. The absolute-maximum temperature rating for this tube is 275°C with a maximum average temperature around the anode of 250°C. It is recommended that a safety factor of 25° to 50° be applied, to compensate for all probable system and component variations throughout life.

The cooling air must be delivered by the blower through the radiator and at the terminal seals during the application of power and for a minimum of three minutes after the power has been removed.

To Cathode-Filament and Filament Terminals--A sufficient quantity of air should be blown directly at these terminals so that their temperature does not approach the absolute-maximum limit of 250° C. A value of at least 100 cfm is recommended.

The Cooling Characteristic Curve indicates the airflow and pressure requirements of a system sufficient to limit the core temperature to specific values for various levels of plate dissipation.

Incoming air is at Standard Temperature and Pressure (STP) (22.5°C and 760 mm Hg). Pressure drop values are for the anode only and do not include any losses which may occur with specific sockets or cavities. When the tube base is not directly in the anode cooling air stream, special provisions must be made for separate base cooling.

Because the cooling capacity of air varies with its density, factors must be applied to the air flow to compensate for operation at altitude or in high temperature environments.

During Standby Operation-Cooling air is requiredwhen only the filament voltage is applied to the tube.

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

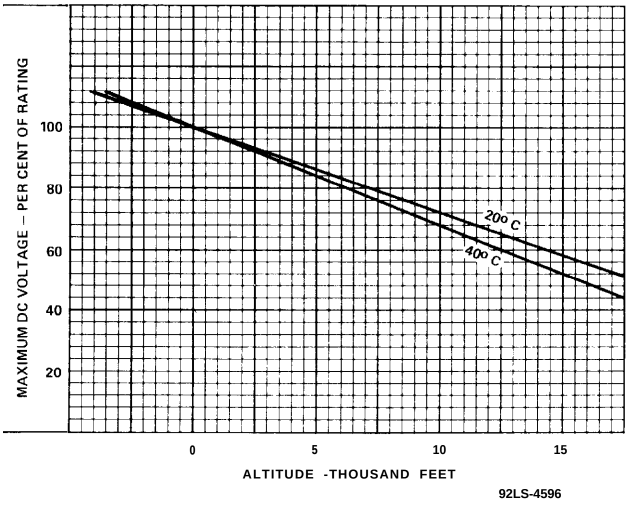


Figure 1 - Maximum DC Voltage with Respect to Altitude

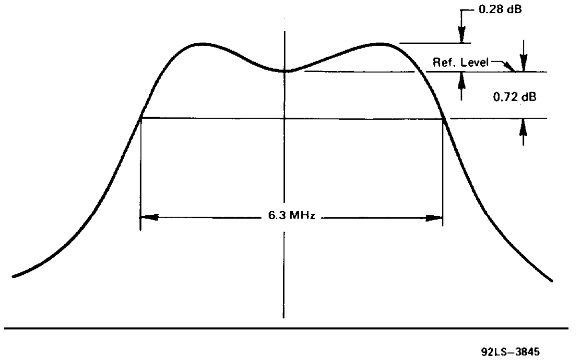


Figure 2 - Bandwidth Characteristics

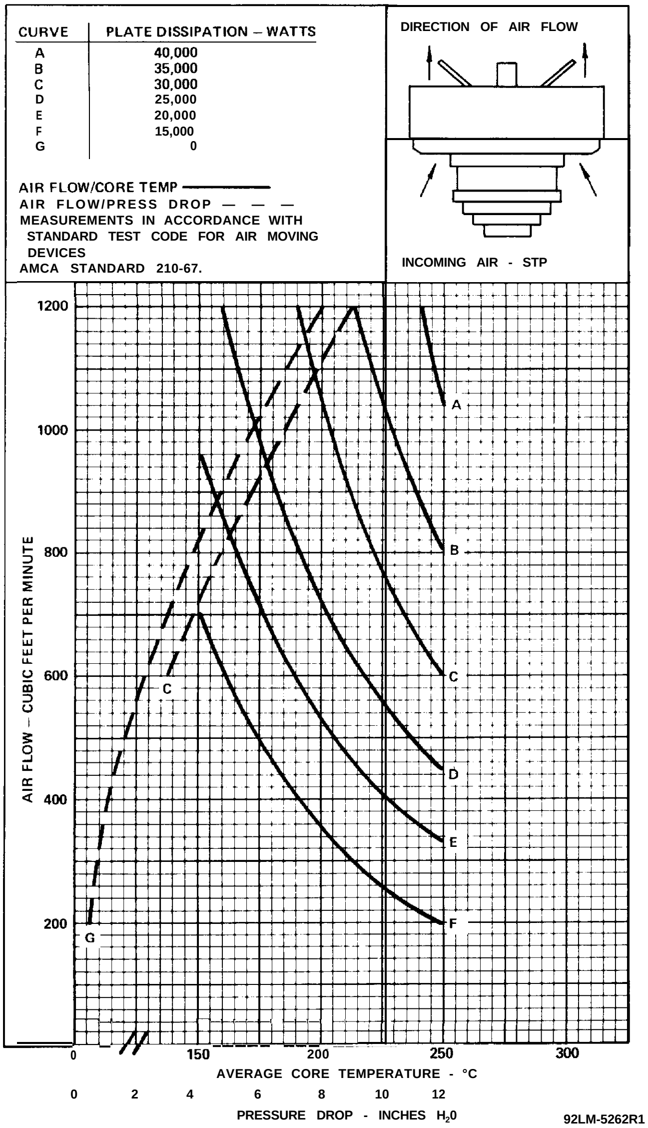


Figure 3 - Typical Cooling Characteristics

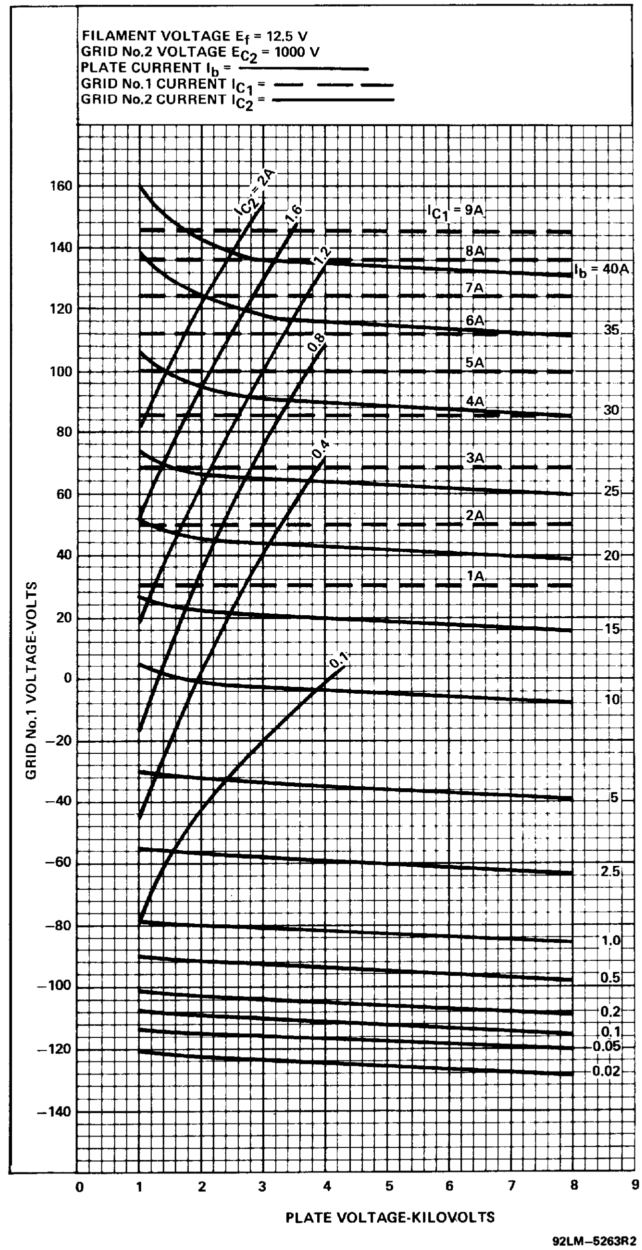


Figure 4 - Typical Constant Current Characteristics

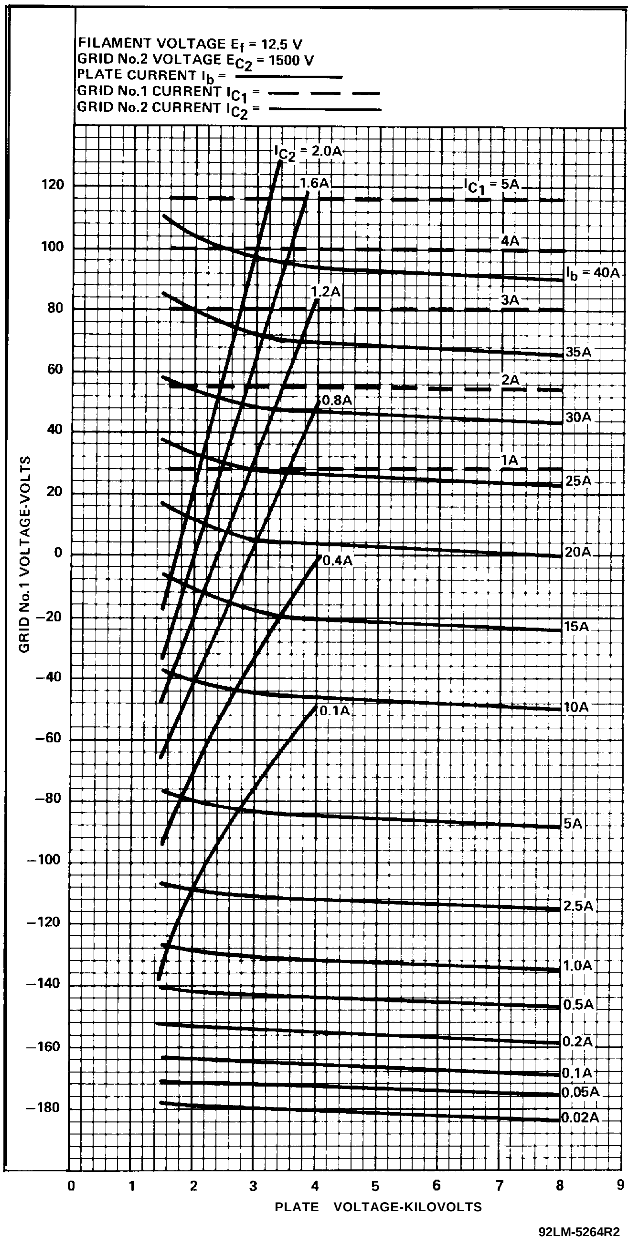
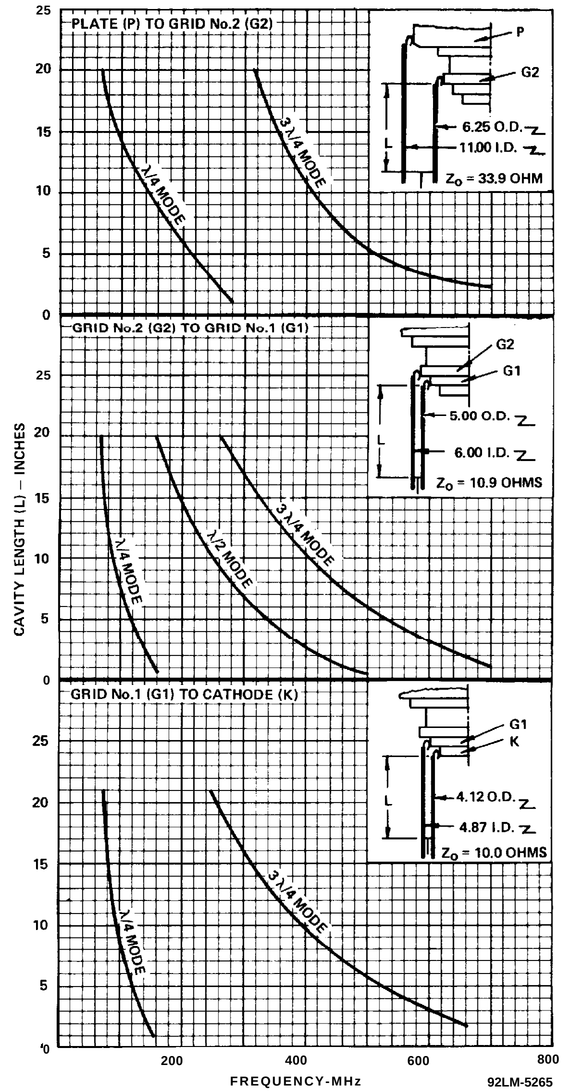
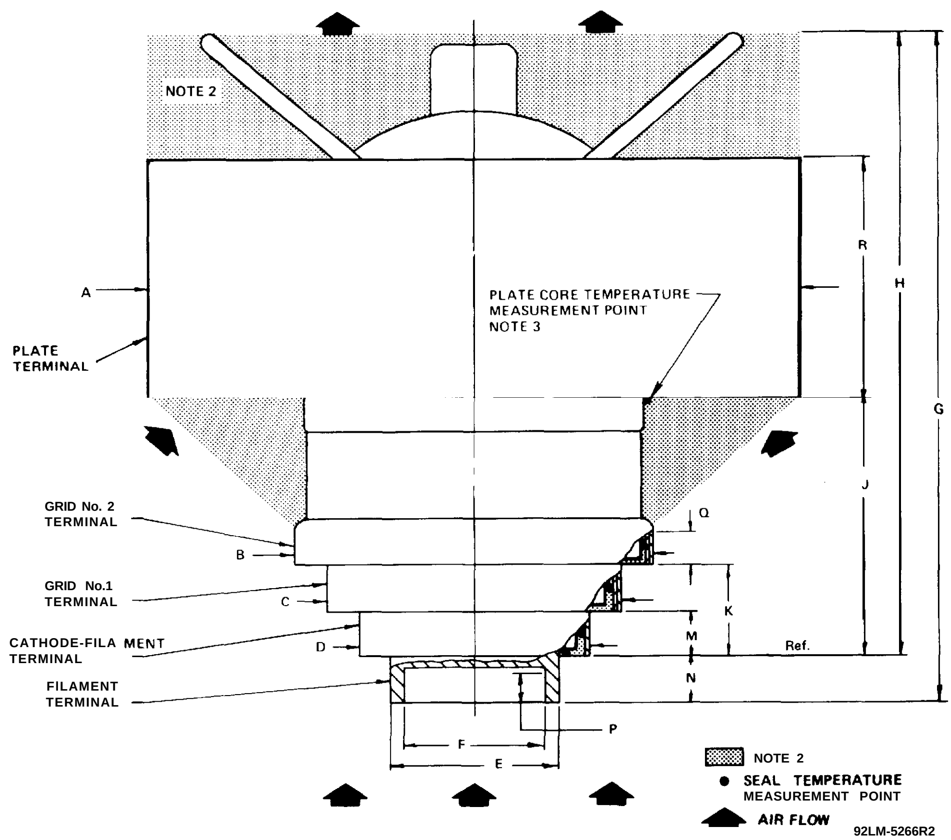


Figure 5 - Typical Constant Current Characteristics



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

Figure 6 - Electrode Cavity Tuning Characteristics



Tabulated Dimensions

Dim.	Inches	Millimeters	Notes
A Dia.	10.175 ± .040	258.44 ± 1.02	1,4
B Dia.	5.590 ± .020	141.97 ± .51	1,4
C Dia.	4.590 ± .020	116.59 ± .51	1,4
D Dia.	3.590 ± .020	91.19 ± .51	1,4
E Dia.	2.600 ± .010	66.04 ± .25	1,4
F Dia.	2.100 ± .010	53.34 ± .25	1,4
G	11.300 max	287.02 max.	
H	10.500 max.	266.70 max.	
J	4.075 ± .100	103.51 ± 2.54	
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.	
R	3.650 ref.	92.71 ref.	

Figure 7 - Dimensional Outline

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 17601-5688.

Note 3 - Plate core temperature measurement point is located on the plate itself and not at the fins.

Note 4 - With the plate 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).