



8988 Power Tube

Linear Beam Power Tube

- CERMOLOX[®] Tube
- High Gain-Bandwidth Product
- Full Input to 400 MHz
- 7000 W Peak Sync. Output Through VHF-TV Band with 16 dB Gain

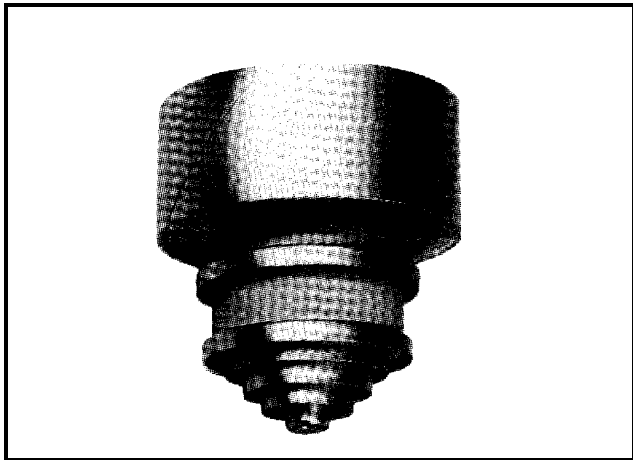
The BURLE 8988 is designed specifically to meet the high linearity, high gain requirements of modern, reliable, VHF-TV and UHF linear amplifier equipments.

In VHF-TV service at 220 MHz, the 8988 will deliver a full 7.0 kW peak sync. output with 6.3 MHz bandwidth and 16 dB gain. At 220 MHz it can supply the 5 kW aural power output required for a 25 kW TV transmitter.

Rated for full input for the VHF-TV band and for other service to 400 MHz, the 8988 can be readily circuited for these frequencies. The 8988 and available variants are also well suited for other applications such as SSB, CW, pulsed RF, or modulator service.

Its sturdy, CERMOLOX construction and thoriated tungsten, mesh filament minimize tube inductances and feedthru capacitances.

This data sheet gives application information unique to the BURLE 8988. It is to be used in conjunction with the publication, "Application Guide for BURLE Power Tubes", TP-105, for general application information for tubes of this type.



Its coaxial, forced-air-cooled radiator reduces noise to a minimum and insures against spurious outputs. These features make possible the use of simple, economical, broadband circuit techniques in VHF and UHF operation.

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. For copies of publications, specific information or application assistance, contact your nearest BURLE Representative or write BURLE INDUSTRIES, INC., 1000 New Holland Ave., Lancaster, PA 17601-5688.



General Data

Electrical:

Filamentary Cathode:.....	Thoriated-Tungsten Mesh		
Type.....	5.7	typ.	V
Voltage ^a (ac or dc).....	6.0	max.	V
Current:			
Typical value at 5.7 volts ^b	115		A
Maximum value for starting even momentarily.....	300		A
Cold resistance.....	0.005		ohm
Minimum heating time ^c	15		s
Mu-Factor: ^d			
(Grid No. 2 to grid No. 1).....	20		
Direct Interelectrode Capacitances:			
Grid No 1 to plate ^e	0.20	max.	pF
Grid No. 1 to filament.....	76		pF
Plate to filament ^{e,f}	0.02	max.	pF
Grid No. 1 to grid No.2.....	86		pF
Grid No. 2 to plate.....	12		pF
Grid No. 2 to filament ^f	1.5	max.	pF

Mechanical

Operating Attitude.....	Vertical, either end up		
Overall Length.....	(136.6mm)	5.38 max.	in
Greatest Diameter.....	(116.1 mm)	4.57 max.	in
Terminal Connections.....	See Dimensional Outline		
Radiator.....	Integral part of tube		
Weight (Approx.).....	(2.7 kg)6.0 lbs		

Thermal

Seal Temperature ^h (Plate, grid No. 2, grid No. 1, filament-cathode and filament).....	250	max.	°C
Plate-Core Temperature ^h	250	max.	°C

RF Power Amplifier - Class AB2 Television Service^j

Synchronized-level conditions per tube unless otherwise specified

Maximum CCS Ratings, Absolute-Maximum Values:

DC Plate Voltage ^{k,m}	8000	V
DC Grid-No. 2 Voltage ⁿ	1650	V
DC Grid-No. 1 Voltage ^p	-450	V
DC Plate Current.....	5	A
Plate Dissipation.....	5000	A
Grid-No. 2 Input.....	150	W
Grid-No. 1 Input.....	50	W

Typical CCS Operation:

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

DC Plate Voltage.....	3000	4100	V
DC Grid-No.2 Voltage.....	1000	1000	V
DC Grid-No. 1 Voltage.....	-40 ^s	-28 ^t	V
Zero Signal DC Plate Current.....	0.4	0.8	A
DC Plate Current:			
Synchronizing level.....	1.3	2.3	A
Blanking level.....	1.0	1.8	A
DC Grid-No.2 Current:			
Synchronizing level.....	-	100	mA
Blanking level.....	20	50	mA
DC Grid No. 1 Current:			
Synchronizing level.....	-	240	mA
Blanking level.....	2.0	110	MA
Driver Power Output:			
Synchronizing level.....	55	138	W
Blanking level.....	31	77	W

Plate Dissipation:

Blanking level.....	-	4410	W
Output Circuit Efficiency.....	95	95	%
Useful Power Output:			
Synchronizing level.....	1700	5000	W
Blanking level.....	950	2820	W

RF Power Amplifier or Oscillator - Class B Telegraphy or FM Telephony^j

Maximum CCS Ratings, Absolute-Maximum Value

	Up to 400 MHz		
DC Plate Voltage ^{k,m}	8000	V	
DC Grid-No. 2 Voltage ⁿ	1650	V	
DC Grid-No. 1 Voltage ^p	-450	V	
DC Plate Current.....	4.0	A	
DC Grid-No. 1 Current.....	500	mA	
Grid-No. 1 Input.....	50	W	
Grid-No. 2 Input.....	150	W	
Plate Dissipation.....	5000	W	

Maximum Circuit Values:

Grid-No.1 Circuit Resistance Under Any Conditions:

With fixed bias.....	5000 max.	ohms
With cathode bias.....	Not recommended	
Grid-No.2 Circuit Impedance.....	See note n	
Plate Circuit Impedance.....	See note k	

- a 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 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.
- b The characteristic range of current at 5.7 volts is from 106 to 126 amperes. It is recommended that an additional six amperes be available to allow for the normal reduction of filament resistance with life Thus, the filament supply should be designed for a mean value of 132 amperes at 5.7 volts.
- c Sequence for applying voltage is as follows: Filament, Bias, Plate, Screen and RF Drive
- d For plate voltage = 2000 V, grid-No. 2 voltage = 1375 V, and plate current = 6.0 A.
- e With external flat metal shield 8" (200 mm) in diameter having a center hole 3" (76 mm) in diameter. Shield is located in plane of the grid-No. 2 terminal, perpendicular to the tube axis, and is connected to grid No. 2.
- f With external flat metal shield 8" (200 mm) in diameter having center hole 2-3/8" (60 mm) in diameter Shield is located in plane of the grid-No. 1 terminal, perpendicular to the tube axis, and is connected to grid No. 1.
- g As manufactured by Jettron Products Inc., 56 Route Ten, Hanover, NJ 07936

- h See Dimensional Outline for Temperature Measurement points.
- j See TP-105.
- k See TP-105.
- m 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. This is especially important in pulse service where high, stored energy and large capacitors are used. For typical 5000 watt TV transmitters, series resistor values are:
 - Plate = 10 ohms
 - Screen = 30 to 50 ohms
 - Grid = 50 ohms
 For additional information see TP-105 "Application Guide for BURLE Power Tubes".
- n See TP-105.
- p See TP-105.
- r The bandwidth of 6.3 MHz is calculated at the -0.72 dB power points of a double 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 3**.
- s Adjusted for $I_{bo} = 0.4$ A.
- t Adjusted for $I_{bb} = 0.8$ A.

Protection Circuits

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.

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 thyatron or ignitron, depending on the amount of energy to be handled.

The voltages applied to power tubes 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 cannot 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.

A time-delay relay should be provided in the plate-supply circuit to delay application of plate 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

Air Flow:

Through radiator Adequate air flow to limit the plate-core temperature to 250 °C should be delivered by a blower through the radiator before and during the application of filament, plate, grid-No. 2 and grid-No. 1 voltage.

For a plate dissipation of 5000 watts and an incoming air temperature of 50 °C, and air flow of 105 cfm is required in accordance with the Typical Cooling Characteristics as shown in **Figure 4**.

To Plate, Grid-No. 2 and Grid-No.1 Terminals A sufficient quantity of air should be allowed to flow past each of these terminals so that its temperature does not exceed the specified maximum value of 250 °C.

To Cathode-Filament and Filament Terminals A sufficient quantity of air should be blown directly at these terminals so that their temperature does not exceed the specified limit of 250 °C. A value of at least 40 cfm is recommended.

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

During Shutdown Operation Air flow should continue for a few minutes after all electrode power is removed.

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

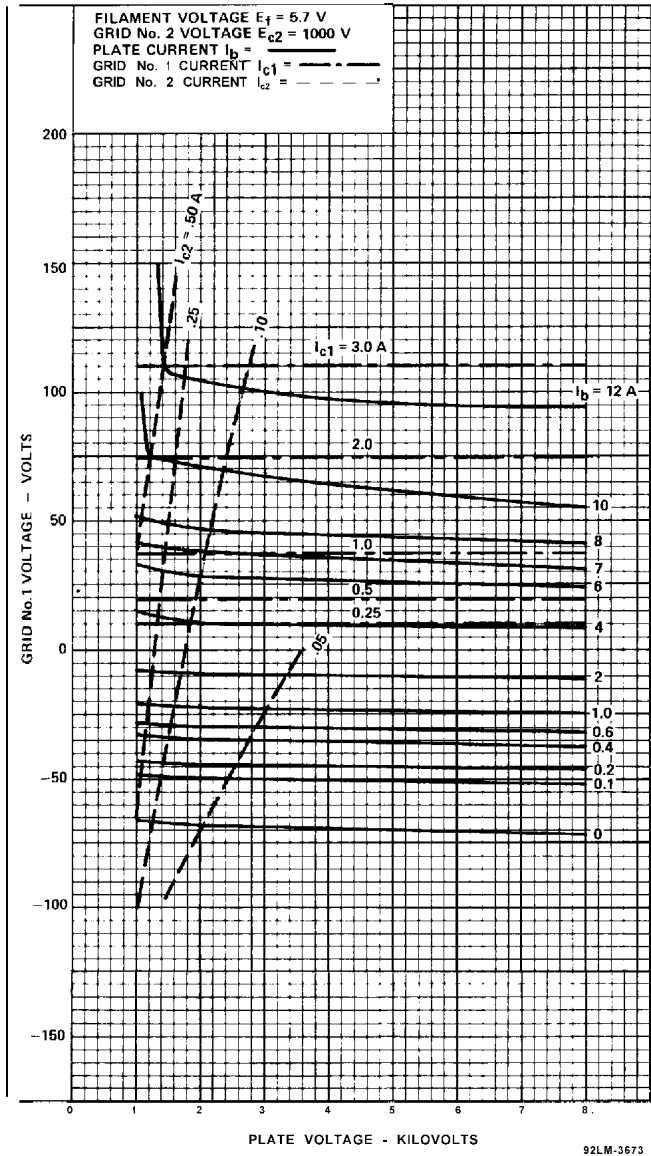


Figure 1 - Typical Constant Current Characteristics

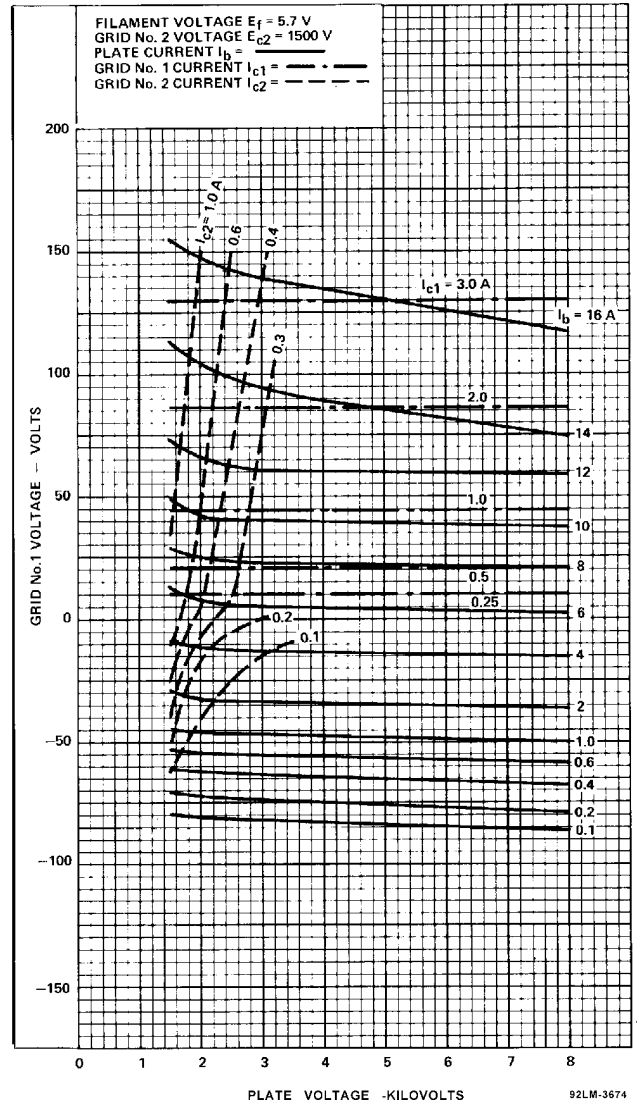


Figure 2 - Typical Constant Current Characteristics

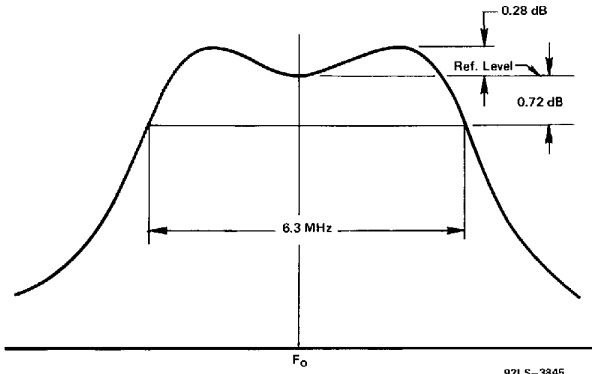
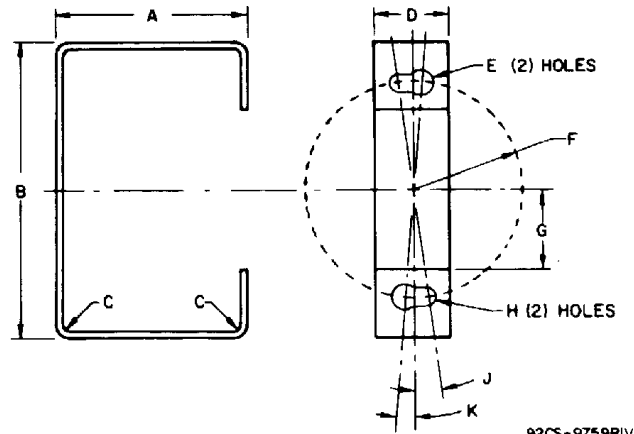


Figure 3 - Bandwidth Calculation

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92CS-9759RIV

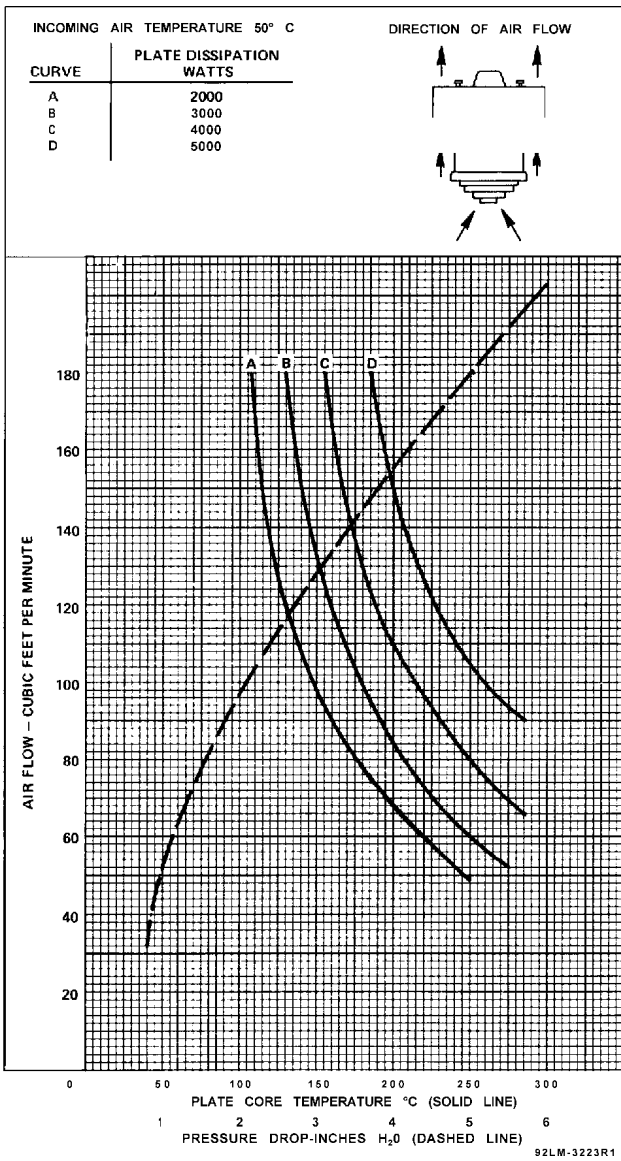


Figure 4 - Typical Cooling Characteristics

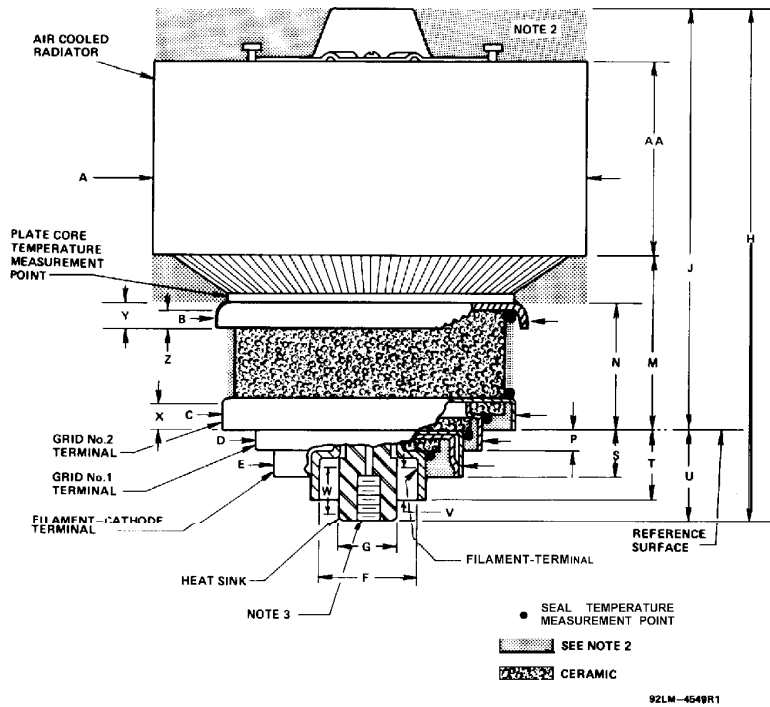
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Tabulated Dimensions

Dim.	Inches	Millimeters
A	1.8	46
B	3.1	79
C	0.06	1.5
D	0.7	18
E Dia.	0.250	6.35
F Radius	1.175	29.85
G	0.9	23
H Dia.	0.140	3.56
J	8.3°	
K	4.5°	

Notes: Material 1/16" CRS. Slot between holes. Round all edges.

Figure 5 - Tube Extractor



- 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. Do not allow contacts or circuit components to intrude into these annular volumes.
- Note 3** - Tapped 1/4-20 NC x 0.5 inch (12.7 mm) deep.

Figure 6 - Dimensional Outline

Tabulated Dimensions

Dim.	Inches	Millimeters
A Dia.1	4.510 ± .060	114.6 ± 1.5
B Dia.1	3.250 ± .015	82.55 ± 0.38
C Dia.1	3.028 ± .014	76.91 ± 0.36
D Dia.1	2.319 ± .012	58.90 ± 0.30
E Dia.1	1.850 ± 0.10	46.99 ± 0.25
F Dia. 1	1.200 ± .010	30.48 ± 0.25
G Dia.1	0.617 ± .003	15.67 ± 0.08
H	5.300 ± .080	134.6 ± 2.0
J	4.345 ± .045	110.4 ± 1.1
M	1.790 ± .040	45.5 ± 1.0
N	1.330 ± .030	33.8 ± 0.8
P	0.200 ± .025	5.1 ± 0.6
S	0.475 ± .030	12.1 ± 0.8
T	0.725 ± .040	18.4 ± 1.0
U	0.955 ref.	24.3 ref.
V	0.250 min.	6.35 min.
W	0.375 min.	9.53 min.
X	0.220 min.	5.59 min.
Y	0.325 ref.	8.26 ref.
Z	0.160 min.	4.06 min.
AA	1.945 ref.	49.40 ref.