

# Multi-Phase Cooled Power Tetrode 4CM300,000GA

The Eimac 4CM300,000GA is a ceramic/metal, multiphase-cooled (water/vapor) power tetrode designed to be used as an exact replacement for the Thomson TH537. This tube has a thoriated tungsten mesh filament and pyrolytic graphite grids which provide high dissipation combined with low secondary emission characteristics.

Base coaxial contact rings are provided for the filament, grid, and screen terminals, and these terminals are cooled with forced air. The maximum anode dissipation rating is 300 kilowatts steady state, with multiphase cooling.

### GENERAL CHARACTERISTICS<sup>1</sup>

#### ELECTRICAL

Filament: Thoriated Tungsten	
Voltage (DC or AC) .....	18.0 Volts
Current at 18.0 volts nominal .....	430 Amperes
Peak Maximum Filament Inrush	
Current at Turn-on .....	860 Amperes
Amplification Factor, average	
Grid to Screen .....	4.3
Maximum Frequency of CW Ratings <sup>1</sup> .....	50 MHz
Highest Useful Frequency With	
Reduced Ratings <sup>1</sup> .....	110 MHz
Direct Interelectrode Capacitance (nominal values) <sup>2</sup>	
C <sub>g1k</sub> .....	310 pF
C <sub>g2k</sub> .....	26 pF
C <sub>pk</sub> .....	0.8 pF
C <sub>g1g2</sub> .....	510 pF
C <sub>g1p</sub> .....	4.5 pF
C <sub>g2p</sub> .....	75 pF

#### MECHANICAL

Maximum Overall Dimensions:	
Length .....	22.0 in; 56.0 cm
Diameter .....	12.3 in; 31.1 cm
Net Weight (approximate) .....	125 lbs; 57 kg
Operating Position .....	Vertical, base down
Cooling .....	Water & Forced Air
Maximum Operating Temperature:	
Envelope and Ceramic/Metal Seals .....	200° C

<sup>1</sup>Characteristics and operating values are based on performance tests. These figures may change without notice as the result of additional data or product refinement. CPI Eimac should be consulted before using this information for final equipment design.

<sup>2</sup>Capacitance values are nominal, measured with no special shielding but otherwise in accordance with Electronics Industries Association Standard RS-191.





**PLATE MODULATED RADIO FREQUENCY  
POWER AMPLIFIER:**

Class C Telephony  
Control & Screen Grids also modulated

**Absolute Maximum Ratings:**

DC Plate Voltage .....	13.0 Kilovolts
DC Screen Voltage .....	1200 Volts
DC Grid Voltage .....	-800 Volts
Peak Cathode Current .....	325 Amperes
Plate Dissipation .....	300 Kilowatts
Screen Dissipation .....	5 Kilowatts
Grid Dissipation .....	2 Kilowatts

**TYPICAL OPERATION:**

Frequencies to 30 MHz  
Carrier Conditions

DC Plate Voltage.....	11.0 Kilovolts
DC Screen Voltage.....	1000 Volts
DC Grid Voltage.....	-550 Volts
Peak RF Drive Voltage <sup>3</sup> .....	700 Volts
DC Plate Current.....	36 Amperes
DC Screen Current <sup>3</sup> .....	1.3 Amperes
DC Grid Current <sup>3</sup> .....	2.0 Amperes
Plate Input Power.....	400 Kilowatts
Driving Power <sup>3</sup> .....	2.4 Kilowatts
Plate Dissipation.....	90 Kilowatts
Screen Dissipation <sup>3</sup> .....	4.0 Kilowatts
Grid Dissipation.....	600 Watts
Plate Output Power <sup>4</sup> .....	300 Kilowatts

**AUDIO FREQUENCY POWER AMPLIFIER  
OR MODULATOR:**

Class AB

**Absolute Maximum Ratings (per tube):**

DC Plate Voltage .....	15.0 Kilovolts
DC Screen Voltage .....	1.5 Kilovolts
DC Grid Voltage .....	-800 Volts
Peak Cathode Current .....	325 Amperes
Plate Dissipation .....	300 Kilowatts
Screen Dissipation .....	5 Kilowatts
Grid Dissipation .....	2 Kilowatts

**TYPICAL OPERATION:**

Two Tubes - Sinusoidal Wave

DC Plate Voltage.....	11.0 Kilovolts
DC Screen Voltage.....	1250 Volts
DC Grid Voltage.....	-300 Volts
DC Plate Current.....	54 Amperes
DC Screen Current <sup>3</sup> .....	1.6 Amperes
DC Grid Current <sup>3</sup> .....	0 Amperes
Plate Dissipation.....	190 Kilowatts
Output Power <sup>4</sup> .....	400 Kilowatts

<sup>3</sup>Approximate value.

<sup>4</sup>Circuit losses not taken into account.

Typical operation values are obtained by measurement or by calculation from published characteristic curves. To obtain the specified plate current at the specified bias, screen, and plate voltages, adjustment of the rf grid voltage is assumed. Following this procedure, there will be little variation in output power when the tube is replaced, even though there may be variation in grid and screen currents. The grid and screen currents which occur when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no performance degradation if the circuit maintains the correct voltage.

**APPLICATION**

**MECHANICAL**

**MOUNTING AND HANDLING** - The 4CM300,000GA must be mounted vertically and with the base down. When mounted, the weight of the tube must be supported by its anode flange, which is at the level of the reference plane shown on the outline drawing.

Because the tube filament structure is made of thoriated-tungsten wire, which is quite brittle when cold, the tube should be left in its original shipping container until ready for use. Upon arrival, the tube should be inspected for shipping damage, but once removed from its protective pack, the tube should be handled with considerable care.

**ANODE COOLING** - The anode is cooled with water circulating through the structure. Multi-phase cooling provides efficient anode heat removal and allows extra capac-

ity for temporary overloads. The inlet and outlet connections are clearly marked on top of the jacket and it is important they be used as indicated.

Tube life can be seriously compromised by water conditions. With contaminated water, deposits will form on the anode, causing localized anode heating and eventual tube failure. To minimize electrolysis and power loss, water resistance at 25°C should always be 0.5 megohm per cubic centimeter or higher. Relative water resistance can be continuously monitored in the reservoir using readily available instruments. Suitable water flow, temperature, and pressure protection devices must be used.

For the full-rated anode dissipation of 300 kW and with inlet water at 60°C maximum, a flow of 40 gallons (150 liters) of water per minute must be passed through the anode cooler jacket. At this flow rate the pressure drop across the cooler

jacket (does not include connector pressure drop) will be approximately 8.7 psi (60 kPa). Maximum outlet water temperature is 100°C. System pressure should be limited to 75 psi (520 kPa).

Cooling water must be well filtered, with the equivalent of a 100-mesh screen, to eliminate any solid material and avoid the possibility of cooling passage blockage. Reduced cooling could produce localized anode overheating and tube failure.

For more detailed information, Application Bulletin #16, "Water Purity Requirements in Liquid-Cooling Systems," is available upon request.

**BASE COOLING** - In a typical transmitter, the tube base requires air cooling. A minimum of 53 cfm (1.5 m<sup>3</sup>/min) of air at 25°C maximum at sea level is forced through the socket from a high-pressure blower. Maximum air inlet temperature is 45°C, and the blower must be able to supply this flow rate at a back pressure of 158 mm of water. Temperatures of the ceramic/metal seals and the lower envelope areas are the controlling and final limiting factor, and the maximum allowable temperature is 200°C. Temperature-sensitive paints are available for use in checking temperatures in these areas before equipment design and air-cooling arrangements are finalized. Well filtered air must be used and suitable flow and temperature interlocks provided.

For more detailed information, Application Bulletin #20, "Temperature Measurements with Eimac Power Tubes," is available upon request.

All cooling must be applied before or simultaneously with the electrode voltages, including the filament, and should be maintained for at least three minutes after all voltages are removed to allow for tube cool-down.

## ELECTRICAL

**ABSOLUTE MAXIMUM RATINGS** - Values shown for each type of service are based on the "absolute system" and are not to be exceeded under any service condition. In order not to exceed these ratings, the equipment designer's responsibility is to determine an average design value for each rating by a safety factor so that the absolute values will never be exceeded under usual conditions of supply voltage variation, load variation, or manufacturing variation in the equipment itself. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

**HIGH VOLTAGE** - Normal operating voltages used with this tube are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open primary circuits of the power

supply and to discharge high-voltage capacitors whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that high voltage can kill.

**FILAMENT MANAGEMENT PROGRAM** - A properly executed filament management program extends tube life. The program addresses two filament life issues: 1. how to extend filament electron emission life by optimizing the filament heating power. 2. how to reduce filament distortion by minimizing the filament thermal cycling. For more detailed information, Application Bulletin #18, "Extended Transmitter Tube Life" is available upon request.

**Operating Procedures** - The theoretical filament operating voltage is 18.0 Volts RMS. Actual practice dictates the operating voltage can be less than 18.0 Volts. The control and screen grid power dissipations produce an additive heat source to the filament resulting in a higher than desired filament operating temperature. The control and screen operating conditions should be conveyed to CPI Eimac's Application Engineering Department to determine an optimum operating filament voltage.

Excessive filament thermal cycling can cause filament mechanical distortion and result in degradation of the tube's electrical performance. For optimum life, the average filament on/off cycle rate should not exceed 1 cycle per day. Following CPI Eimac's standby mode procedure (see below) does not constitute an on/off cycle each time the filament is reduced to the recommended standby voltage.

A new tube must have the filament voltage maintained at 18.0 volts for 30 minutes minimum prior to the application of any other tube voltages. Filament voltage must be measured at the tube socket with an accurate rms responding ammeter.

**Standby Mode Procedure** - To improve tube life, reduce the installed tube's filament voltage to 15 Volts whenever the tube is not in active duty.

Forced air cooling must be maintained on the tube stem to ensure the ceramic/metal seal temperature does not exceed 200° C while the tube is operated in the standby mode. In addition, the anode cooling water flow must be maintained at a level which ensures the outlet water temperature never exceeds 100°C.

**Voltage Ramp Up/Down Procedures** - To raise the filament voltage to the operational voltage, gradually increase the voltage over a minimum period of 90 seconds. Conversely, lowering the filament voltage gradually over a minimum period of 90 seconds is recommended.

In case of a fault condition which removes filament voltage for a period less than 30 seconds, full filament voltage can be applied immediately. If the failure time exceeds 30 seconds, follow the linear programmed schedule of 90 seconds.

The heater surge current should not exceed 860 Amps peak during the first cycle after voltage is applied to the filament.

**PLATE OPERATION** - The 300 kW plate dissipation maximum rating may be exceeded for very brief periods during setup or tuning. When used as a plate-modulated rf amplifier under carrier conditions, anode dissipation is limited to 200 kilowatts.

**GRID OPERATION** - The maximum grid dissipation is 2000 Watts, and protective measures should be taken to ensure that this rating is not exceeded. Grid dissipation is approximately equal to the product of dc grid current and peak positive grid voltage. A protective spark gap might be connected between the control grid and the cathode to guard against excessive voltage.

**SCREEN OPERATION** - The maximum screen grid dissipation is 5000 Watts. With no ac applied to the screen grid, dissipation is simply the product of dc screen voltage and dc screen current. With screen modulation and/or cathode drive, dissipation is dependent on rms screen voltage and rms screen current. Plate voltage, plate loading, or bias voltage must never be removed while filament and screen voltages are present, since screen dissipation ratings will be exceeded. Suitable protective circuitry must be provided to remove the screen power in case of a fault condition. A protective spark-gap should be connected between the screen grid and the cathode to guard against excessive voltage. The spark-gap setting should be 5 kV or less, as specified by the transmitter manufacturer.

**FAULT PROTECTION** - In addition to the normal plate over-current, screen current, and coolant interlocks, the tube must be protected from damage caused by an internal arc which may occur at high plate voltage. No more than 50 joules of energy may be dissipated in the tube structure.

## OPERATING HAZARDS

Proper use and safe operating practices of power tubes are the responsibility of equipment manufacturers and users of such tubes. All persons who work with or are exposed to power tubes or equipment which utilizes such tubes must take precautions to protect themselves against possible serious bodily injury. Do not be careless around such products.

The operation of this tube may involve the following hazards, any one of which, in the absence of safe operating practices and precautions, could result in serious harm to personnel. Please review the following hazards as well as the detailed operating hazards sheet enclosed with each tube, or request a copy from Eimac.

**HIGH VOLTAGE** - Normal operating voltages can be deadly. Remember that **high voltage can kill**.

A protective resistance of 10 - 50 ohms should be connected in series with the tube anode (in the B+ lines) to absorb power supply stored energy if an internal arc occurs. If the power supply stored energy is high, an electronic crowbar in the circuitry design is recommended. This type circuit will discharge power supply capacitors in a few microseconds after the start of an arc.

To conduct a protection test for each electrode supply, short circuit each HV power supply to ground through a vacuum switch or other suitable high-speed, high-voltage switch and a 6 inch (15.24 cm) length of #30 AWG (0.255 mm) soft copper wire. If the total energy delivered is less than 50 joules, the wire will remain intact, verifying adequate tube protection.

For more detailed information, Application Bulletin #17, "Fault Protection," is available upon request.

**INTERELECTRODE CAPACITANCE** - In most applications, the internal interelectrode capacitance of a tube is influenced by many variables, such as stray capacitance to the chassis from the tube terminals and associated wiring. To control capacitance values with the tube, as the key component involved, the industry and military services use a standard test described in Electronic Industries Association Standard RS-191. The test is performed on a cold tube, and in the case of the 4CM300,000GA, with no shielding. Other factors being equal, controlling internal tube capacitance in this way usually assures interchangeability of tubes over a period of time.

**SPECIAL APPLICATIONS** - To operate this tube under conditions different from those listed here, contact CPI Eimac Marketing Department in San Carlos, CA at 650/592-1221 or fax 650/592-9988.

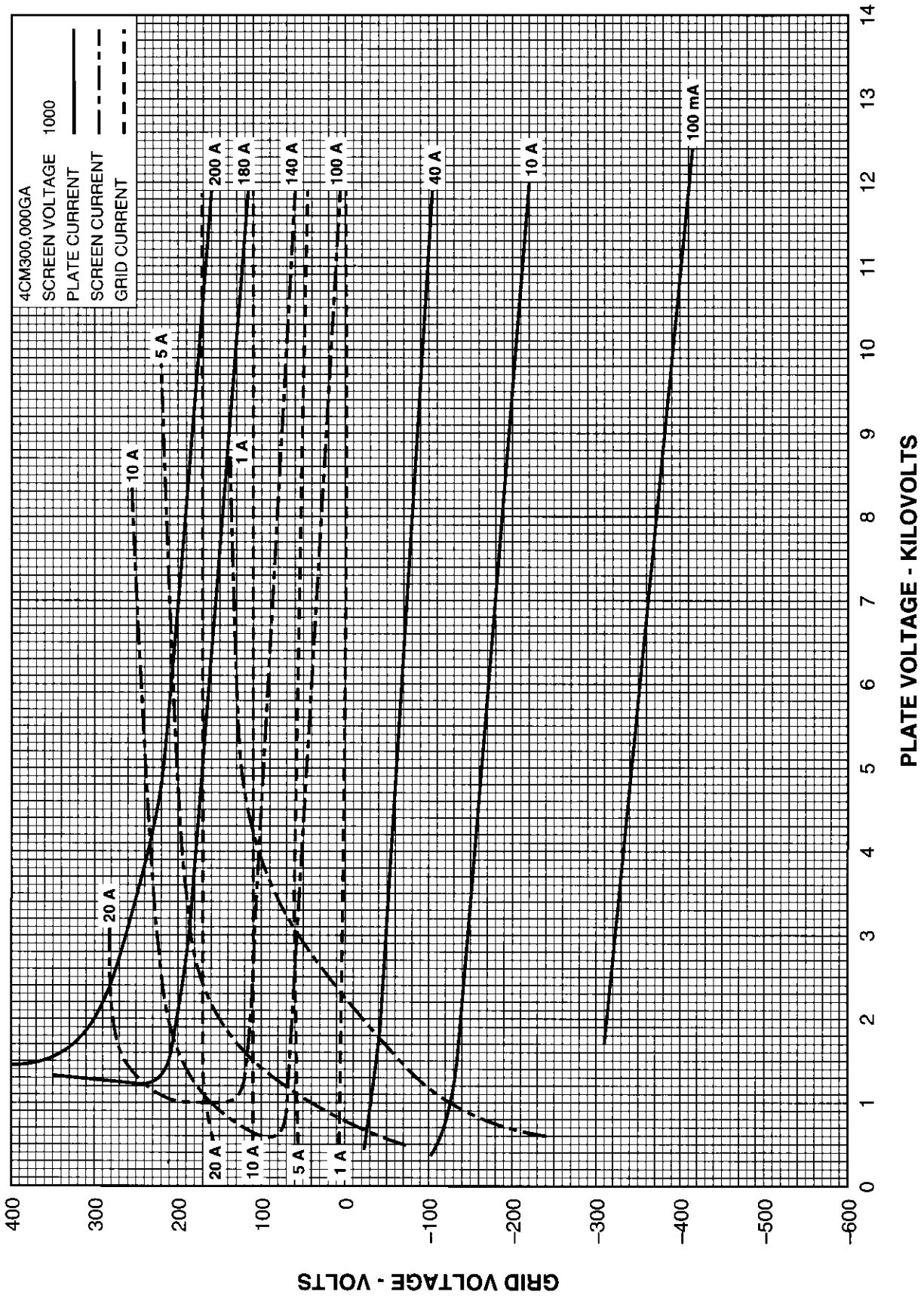
**LOW VOLTAGE, HIGH-CURRENT CIRCUITS** - Jewelry should not be worn when working with filament contacts or connectors as a short circuit can produce very high current and melting, resulting in severe burns.

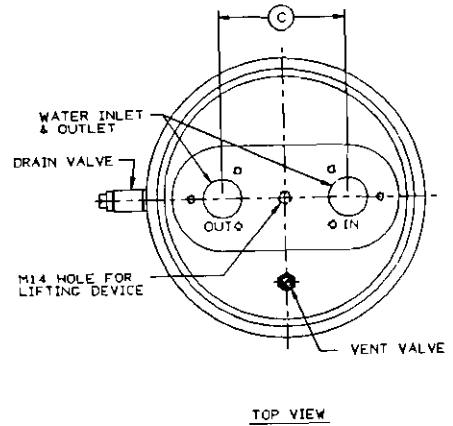
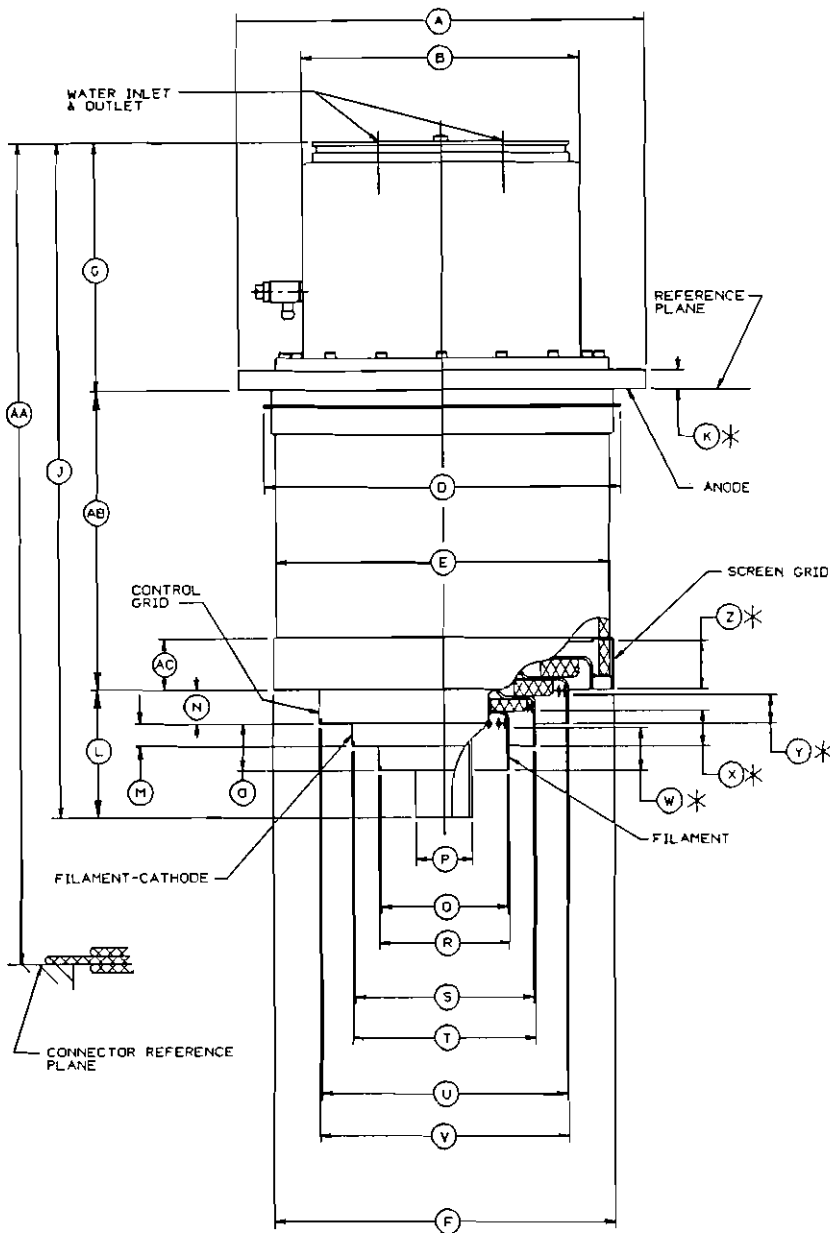
**RF RADIATION** - Exposure to strong rf fields should be avoided, even at relatively low frequencies. The dangers of rf radiation are more severe at UHF and microwave frequencies and can cause serious bodily and eye injuries. **Cardiac pacemakers may be affected.**

**HOT WATER** - Water used to cool tubes may reach scalding temperatures. Touching the cooling system or rupture of the cooling system can cause serious burns.

**HOT SURFACES** - Surfaces of tubes can reach and maintain temperatures of several hundred °C even several minutes after all power is removed.

**GROUNDING CATHODE  
CONSTANT CURRENT CHARACTERISTICS**





DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	12.165	12.244		309	311	
B			8.307			211
C	3.728	3.752		94.7	95.3	
D		10.670			271	
E	9.960	10.039		253	255	
F	10.197	10.276		259	261	
G		7.874			200	
H						
J		22.047			560	
K	.581	.591		14.76	15.01	
L		5.315			135	
M	.646	.724		16.4	18.4	
N	.905	1.142		23	29	
O	1.331	1.488		33.8	37.8	
P		2.362			60	
Q	3.768	3.791		95.7	96.3	
R	3.925	3.949		99.7	100.3	
S	5.362	5.386		136.2	136.8	
T	5.500	5.524		139.7	140.3	
U	7.350	7.374		186.7	187.3	
V	7.469	7.492		189.7	190.3	
W	1.161	1.200		29.5	30.5	
X	.886	.925		22.5	23.5	
Y	.728	.768		18.5	19.5	
Z	1.260	1.457		32	37	
AA	12.362	12.402		314	315	
AB	8.740	8.976		222	228	
AC	1.417	1.614		36	41	

1. Reference dimensions are for info only and are not required for inspection purposes.
2. (\*) Contact surface.



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