



TECHNICAL DATA

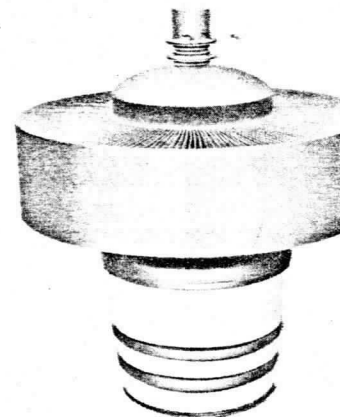
8990
4CX20,000A
8990A

VHF
RADIAL BEAM
POWER TETRODE

The EIMAC 8990/4CX20,000A is a ceramic/metal power tetrode intended for use in audio or radio-frequency applications. It features a type of internal mechanical structure which results in high rf operating efficiency. Low rf losses in this structure permit operation at full ratings up to 110 MHz.

The 8990/4CX20,000A has a gain of over 18 dB in FM broadcast service, and is also recommended for radio-frequency linear power amplifier service, and for VHF television linear amplifier service. The anode is rated for 20 kW of dissipation with forced-air cooling and incorporates a highly efficient cooler of new design.

The 8990A is recommended for high-level, plate modulated amplifier service.



GENERAL CHARACTERISTICS¹

ELECTRICAL

Filament: Thoriated Tungsten

Voltage: 10.0 ± 0.5 V

Current, at 10.0 volts. 140 A

Amplification Factor, average

Grid to Screen. 6.7

Direct Interelectrode Capacitances (cathode grounded):²

Cin. 190 pF

Cout 23.5 pF

Cgp 1.5 pF

Direct Interelectrode Capacitances (grid and screen grounded):²

Cin. 83 pF

Cout 24.5 pF

Cpk 0.2 pF

Frequency of Maximum Ratings (CW) 110 MHz

1. Characteristics and operating values are based on performance tests. These figures may change without notice as the result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.
2. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

MECHANICAL

Maximum Overall Dimensions:

Length 9.840 in; 24.99 cm

Diameter 8.800 in; 22.35 cm

Net Weight (Approximate) 14.0 lbs; 6.35 kg

Operating Position Axis vertical, base up or down

Cooling Forced air

Operating Temperature, maximum

Ceramic/Metal Seals and Anode Core 250°C

Base Special, concentric

Recommended Air System Socket SK-320

Recommended Air Chimney SK-326

RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class C Telephony or FM
(Key-Down Conditions)

ABSOLUTE MAXIMUM RATINGS

DC PLATE VOLTAGE.....	10,000	VOLTS
DC SCREEN VOLTAGE.....	2,000	VOLTS
DC PLATE CURRENT.....	5.0	AMPERES
PLATE DISSIPATION.....	20,000	WATTS
SCREEN DISSIPATION.....	450	WATTS
GRID DISSIPATION.....	200	WATTS

TYPICAL OPERATION (frequencies to 30 MHz)

Plate Voltage.....	7.5	9.0	kVdc
Screen Voltage.....	750	900	Vdc
Grid Voltage.....	-200	-250	Vdc
Plate Current.....	3.68	4.01	Adc
Screen Current ¹	208	222	mAdc
Grid Current ¹	91	88	mAdc
Peak rf Grid Voltage ¹	265	300	v
Calculated Drive Power.....	24.1	26.4	W
Plate Dissipation ¹	5.84	7.93	kW
Plate Output Power ¹	21.8	28.2	kW
Load Impedance.....	1062	1136	Ω

¹ Approximate value

TYPICAL OPERATION, COMMERCIAL FM SERVICE (measured values at frequency shown, in EIMAC CV-2200 cavity amplifier)

Frequency of Operation.....	88.3	107.7	MHz
Plate Voltage.....	9.0	9.0	kVdc
Screen Voltage.....	800	800	Vdc
Grid Voltage.....	-400	-300	Vdc
Plate Current.....	4.08	4.15	Adc
Screen Current.....	200	200	mAdc
Grid Current.....	40	38	mAdc
Drive Power.....	325	360	W
Useful Power Output ¹	28.75	28.9	kW
Efficiency.....	80.5	77.4	%
Gain.....	19.5	19.0	dB

¹ Delivered to the load

PLATE MODULATED RADIO FREQUENCY POWER AMPLIFIER 8990A RECOMMENDED

GRID DRIVEN Class C Telephony
(Carrier Conditions)

ABSOLUTE MAXIMUM RATINGS

DC PLATE VOLTAGE.....	8,000	VOLTS
DC SCREEN VOLTAGE.....	2,000	VOLTS
DC GRID VOLTAGE.....	-1,000	VOLTS
DC PLATE CURRENT.....	5	AMPERES
PLATE DISSIPATION.....	13.5	KILOWATTS
SCREEN DISSIPATION.....	450	WATTS
GRID DISSIPATION.....	200	WATTS

TYPICAL OPERATION

Plate Voltage.....	7,800	Vdc
Screen Voltage.....	750	Vdc
Grid Voltage.....	-300	Vdc
Peak af screen voltage (100% modulation).....	750	v
Plate Current.....	4.6	Adc
Screen Current ¹	220	mAdc
Grid Current ¹	108	mAdc
Calculated Driving Power.....	35	W
Plate Impedance.....	845	Ω
Plate Output Power.....	29	kW
Plate Dissipation.....	6880	W

¹ Approximate

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR

GRID DRIVEN, Class AB1
(sinusoidal wave)

ABSOLUTE MAXIMUM RATINGS (per tube)

DC PLATE VOLTAGE.....	10,000	VOLTS
DC SCREEN VOLTAGE.....	2,500	VOLTS
DC PLATE CURRENT.....	6	AMPERES
PLATE DISSIPATION.....	20	KILOWATTS
SCREEN DISSIPATION.....	450	WATTS
GRID DISSIPATION.....	200	WATTS

TYPICAL OPERATION (2 tubes)

Plate Voltage.....	7,800	7,800	7,800	Vdc
Screen Voltage.....	500	750	1500	Vdc
Grid Voltage ¹	-70	-125	-250	Vdc
Zero Signal Plate Current.....	0.75	0.75	1.0	Adc
Max. Signal Plate Current.....	3.4	5.2	9.2	Adc
Max. Signal Screen Current ²	90	220	600	mAdc
Peak Grid Voltage ²	65	115	200	v
Max. Signal Plate Dissipation ³	6	7	13.5	kW
Plate Output Power.....	14.5	26	44	kW
Load Impedance p/p.....	6,300	3,500	1600	Ω

¹ Adjust for specified zero-signal plate current.

² Approximate value

³ Per tube

TYPICAL OPERATION values are obtained by calculations 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. If this procedure is followed, there will be little variation in output power when the tube is replaced, even though there may be some 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 providing the circuit maintains the correct voltage in the presence of the current variations. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to produce the required bias voltage when the correct rf grid voltage is applied.

APPLICATION

MOUNTING – The 8990 must be operated with its axis vertical. The base of the tube may be up or down at the convenience of the circuit designer.

SOCKET & CHIMNEY – The EIMAC air-system socket SK-320 and air chimney SK-326 are designed especially for use with the 8990. The use of the recommended air flow through this socket provides effective forced-air cooling of the base, with air then guided through the anode cooling fins by the air chimney.

COOLING – The maximum temperature rating for the external surfaces of the tube is 250°C, and sufficient forced-air cooling must be used in all applications to keep the temperature of the anode (at the base of the cooling fins) and the temperature of the ceramic/metal seals comfortably below the rated maximum.

The cooling characteristics of the anode are shown in the attached graph, for power levels from 7.5 kW to 20 kW dissipation. The designer is cautioned to keep in mind that is ABSOLUTE data, with pure dc power, with no safety factors added, and the pressure drop figures make no allowance for losses in filters, ducting, and the like.

It is considered good engineering practice to design for a maximum anode core temperature of 225°C, and temperature sensitive paints are available for checking base and seal temperatures before any design is finalized. It is also considered good practice to add a 15% safety factor to the indicated airflow, and allow for variables such as dirty air filters, rf seal heating at VHF, and the fact that the anode cooling fins may not be clean if the tube has been in service for some length of time. Special attention is required in cooling the center of the stem (base), by means of special directors or some other provision. An air interlock system should be incorporated into the design to automatically remove all voltages from the tube in case of even partial failure of the tube cooling air.

Air flow must be applied before or simultaneously with the application of power, including the tube filament, and should normally be maintained for a short period of time after all power is removed to allowed for tube cooldown.

FILAMENT OPERATION – The rated nominal filament voltage for the 8990 is 10.0 volts, as measured at the socket or tube base. Variation in voltage should be maintained within plus or minus five percent. During application of filament voltage the inrush current should be limited to no more than twice normal current.

The peak emission capability at nominal filament voltage is normally more than that required for communication service. A small decrease in filament temperature due to reduction in filament voltage can increase tube life by a substantial percentage. It is good practice to determine the nominal filament voltage for a particular application that will not adversely affect equipment operation. This is done by measuring some important parameter of performance (such as plate current, power output, or distortion) while filament voltage is reduced. At some point in filament voltage there will be a noticeable change in the operating parameter being monitored, and the operating filament voltage must be slightly higher than the level at which deterioration was noted. When filament voltage is to be reduced in this manner it should be regulated and held to plus or minus one percent, and the actual operating value should be checked periodically to maintain proper operation.

ELECTRODE DISSIPATION RATINGS – The maximum dissipation ratings for the 8990 must be respected to avoid damage to the tube. An exception is the plate dissipation which may be permitted to rise above the rated maximum during brief periods (10 seconds maximum) such as may occur during tuning.

GRID OPERATION – The 8990 control grid has a maximum dissipation rating of 200 watts. Precautions should be observed to avoid exceeding this rating. The grid bias and driving power should normally be kept near the values shown in the TYPICAL OPERATION section of the data sheet whenever possible.

SCREEN OPERATION – The power dissipated by the screen of the 8990 must not exceed 450 watts. Screen dissipation, in cases where there is no ac applied to the screen, is the simple product of the screen voltage and the screen current. If the screen voltage is modulated, the screen dissipation will depend upon loading, driving power, and carrier screen voltage.

Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage, or plate load are removed with the filament and screen voltages applied. Suitable protective means must be provided to limit the screen dissipation to 450 watts in the event of circuit failure. Energy limiting circuitry (which will activate if there is a fault condition) and spark gap over-voltage protection are recommended as good engineering practice.

The 8990 may exhibit reversed (negative) screen current under some operating conditions.

The screen supply voltage must be maintained constant for any values of negative and positive screen current which may be encountered. Dangerously high plate current may flow if the screen power supply exhibits a rising voltage characteristic with negative screen current. Stabilization may be accomplished with a bleeder resistor connected from screen to cathode, to assure that net screen supply current is always positive. This is absolutely essential if a series electronic regulator is employed.

FAULT PROTECTION – In addition to normal plate overcurrent interlock and screen current interlock it is good practice to protect the tube from internal damage which could result from a plate arc at high voltage. In all cases some protective resistance, 10 to 50 ohms, should be used in series with the tube anode to absorb power supply stored energy in case a tube arc should occur. If power supply stored energy is high some form of electronic crowbar which will discharge power supply capacitors in a few microseconds following indication of start of a tube arc is recommended.

HIGH VOLTAGE – Normal operating voltages used with the 8990 are deadly and the equipment must be designed properly and operating precautions must be followed. All equipment must be designed so that no one can come into 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.

INTERELECTRODE CAPACITANCE – The actual internal interelectrode capacitance of a tube is influenced by many variables in most applications, such as stray capacitance to the chassis, capacitance added by the socket used, stray capacitance between tube terminals, and wiring effects. To control the actual capacitance values within the tube, as the key component involved, the industry and Military Services use a standard test procedure as described in Electronic Industries Association Standard RS-191. This requires the use of specially constructed test fixtures which effectively shield all external tube leads from each other and eliminate any capacitance reading to "ground". The test is performed on a cold tube. Other factors being equal, controlling internal tube capacitance in this way normally assures good interchangeability of tubes over a period of time, even when the tube may be made by different manufacturers. The capacitance values shown in the manufacturer's technical data, or test specifications, normally are taken in accordance with Standard RS-191.

The equipment designer is therefore cautioned to make allowance for the actual capacitance values which will exist in any normal application. Measurements should be taken with the socket and mounting which represent approximate final layout if capacitance values are highly significant in the design.

SPECIAL APPLICATIONS – If it is desired to operate this tube under conditions widely different from those listed here, write to Application Engineering, Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, CA 94070 for recommendations.

OPERATING HAZARDS

PROPER USE AND SAFE OPERATING PRACTICES WITH RESPECT TO 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 power tubes involves one or more of the following hazards, any one of which, in the absence of safe operating practices and precautions, could result in serious harm to personnel:

- a. **HIGH VOLTAGE** – Normal operating voltages can be deadly.
- b. **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.

- c. **X-RAY RADIATION** – High voltage tubes can produce dangerous and possibly fatal x-rays.
- d. **BERYLLIUM OXIDE POISONING** – Dust or fumes from BeO ceramics used as thermal links with some conduction-cooled power tubes are highly toxic and can cause serious injury or death.
- e. **GLASS EXPLOSION** – Many electron tubes have glass envelopes. Breaking the glass can cause an implosion, which will result in an explosive scattering of glass particles. Handle glass tubes carefully.
- f. **HOT WATER** – Water used to cool tubes may reach scalding temperatures. Touching or rupture of the cooling system can cause serious burns.
- g. **HOT SURFACES** – Surfaces of air-cooled radiators and other parts of tubes can reach temperatures of several hundred degrees centigrade and cause serious burns if touched.

Please review the detailed operating hazards sheet enclosed with each tube or request a copy from the address shown below: Power Grid Tube Division, Varian, EIMAC division, 301 Industrial Way, San Carlos, California 94070.

**EIMAC 8990
COOLING CHARACTERISTICS
BASE TO ANODE AIRFLOW
ALTITUDE - SEA LEVEL**

AIRFLOW—CUBIC FEET PER MINUTES

1300

1200

1100

1000

900

800

700

600

500

400

300

120

140

160

180

200

240

260

ANODE CORE TEMPERATURE °C

0

1.0

2.0

3.0

4.0

5.0

6.0

7.0

PRESSURE DROP—INCHES OF WATER (FOR SOCKET/TUBE CHIMNEY)

ANODE DISSIPATION = 20 kW

17.5 kW

15 kW

12.5 kW

10 kW

PRESSURE DROP

MAXIMUM ANODE CORE TEMPERATURE = 250 °C



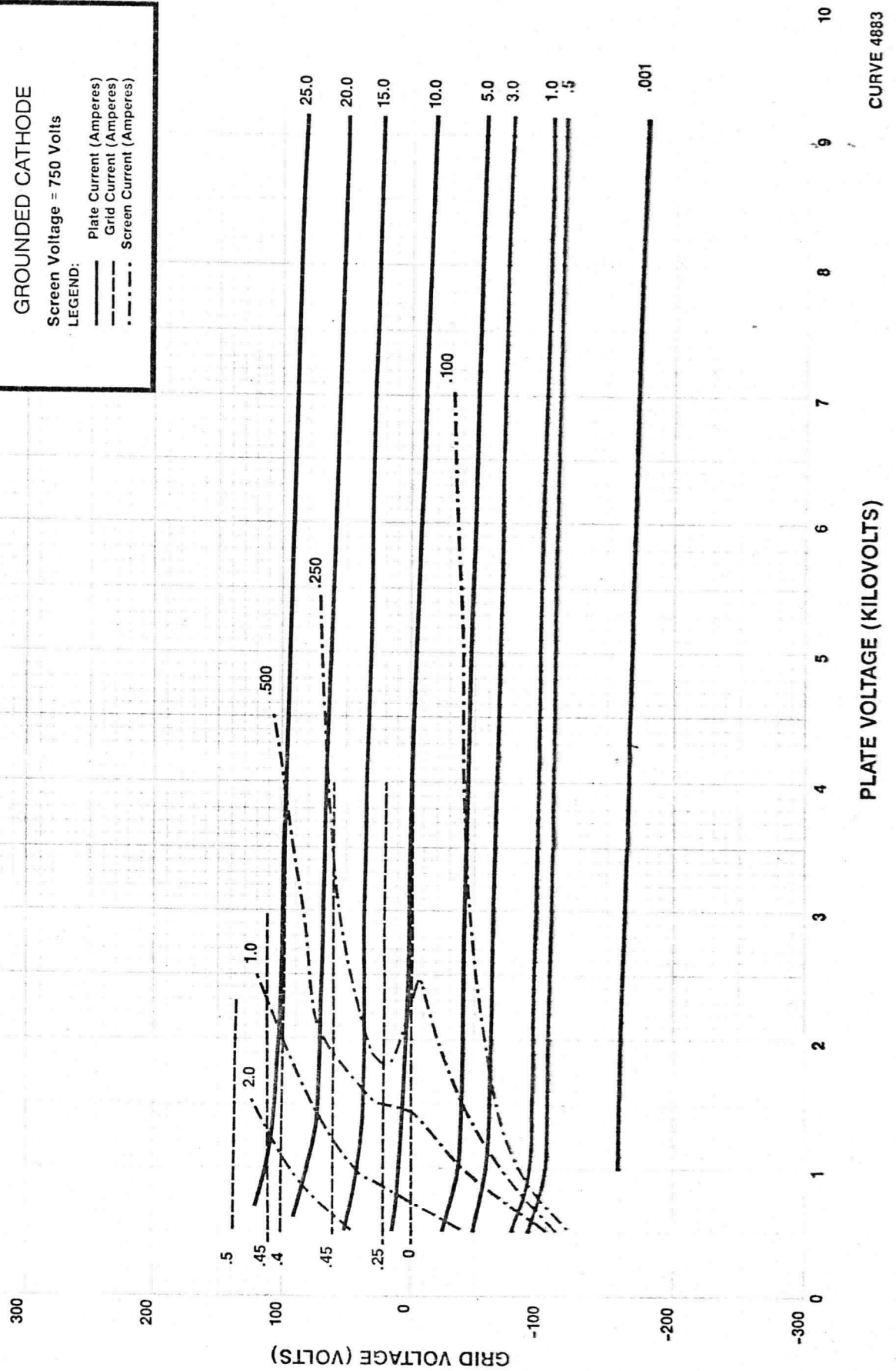
8990/4CX20,000A,8990A

**EIMAC 8990
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED CATHODE**

Screen Voltage = 750 Volts

LEGEND:

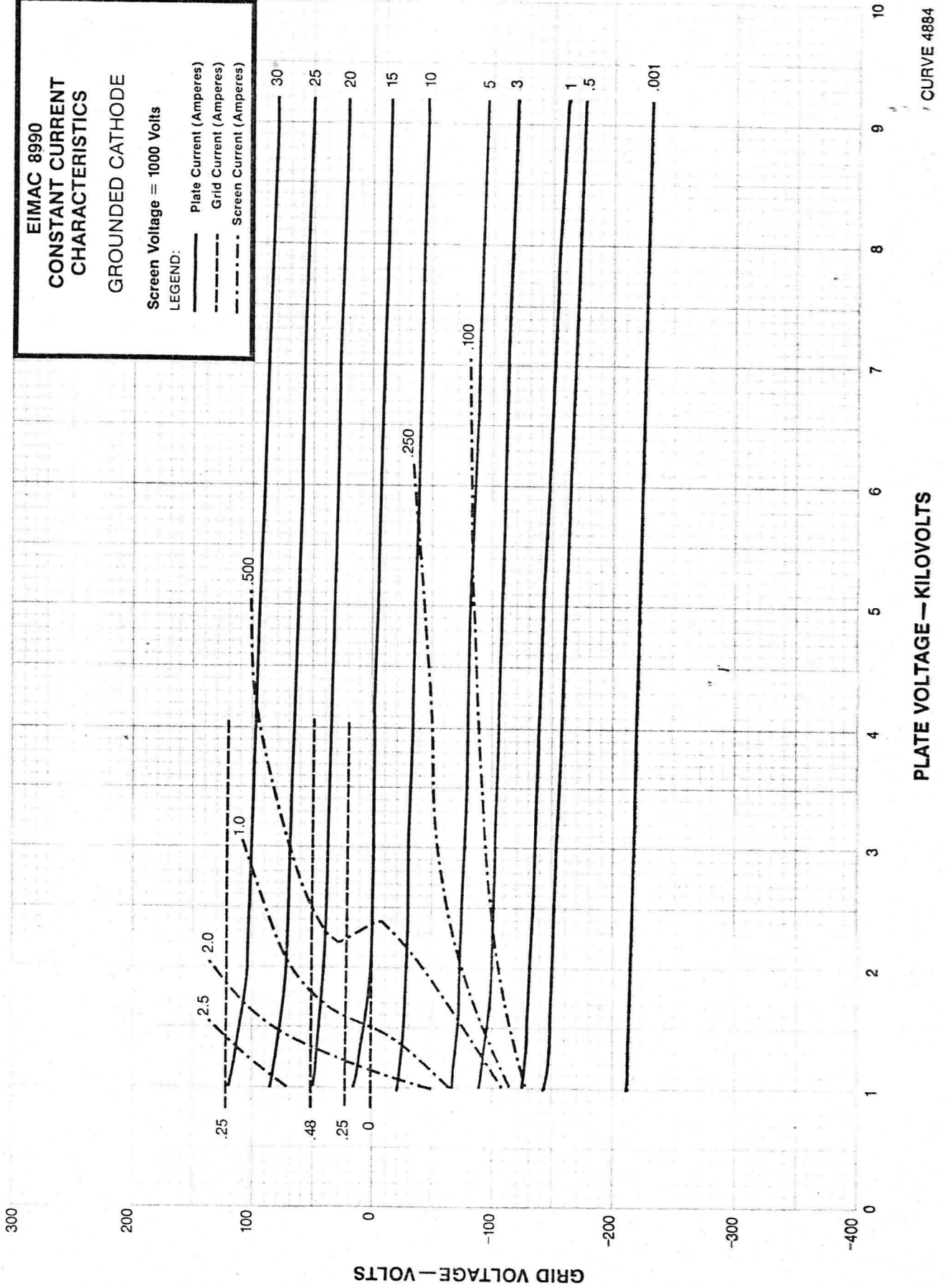
- Plate Current (Amperes)
- - - Grid Current (Amperes)
- . - . Screen Current (Amperes)



**EIMAC 8990
CONSTANT CURRENT
CHARACTERISTICS
GROUNDED CATHODE**

Screen Voltage = 1000 Volts

LEGEND:
 — Plate Current (Amperes)
 - - - Grid Current (Amperes)
 - · - · Screen Current (Amperes)





GROUNDING CATHODE

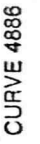
Screen Voltage = 1500 Volts

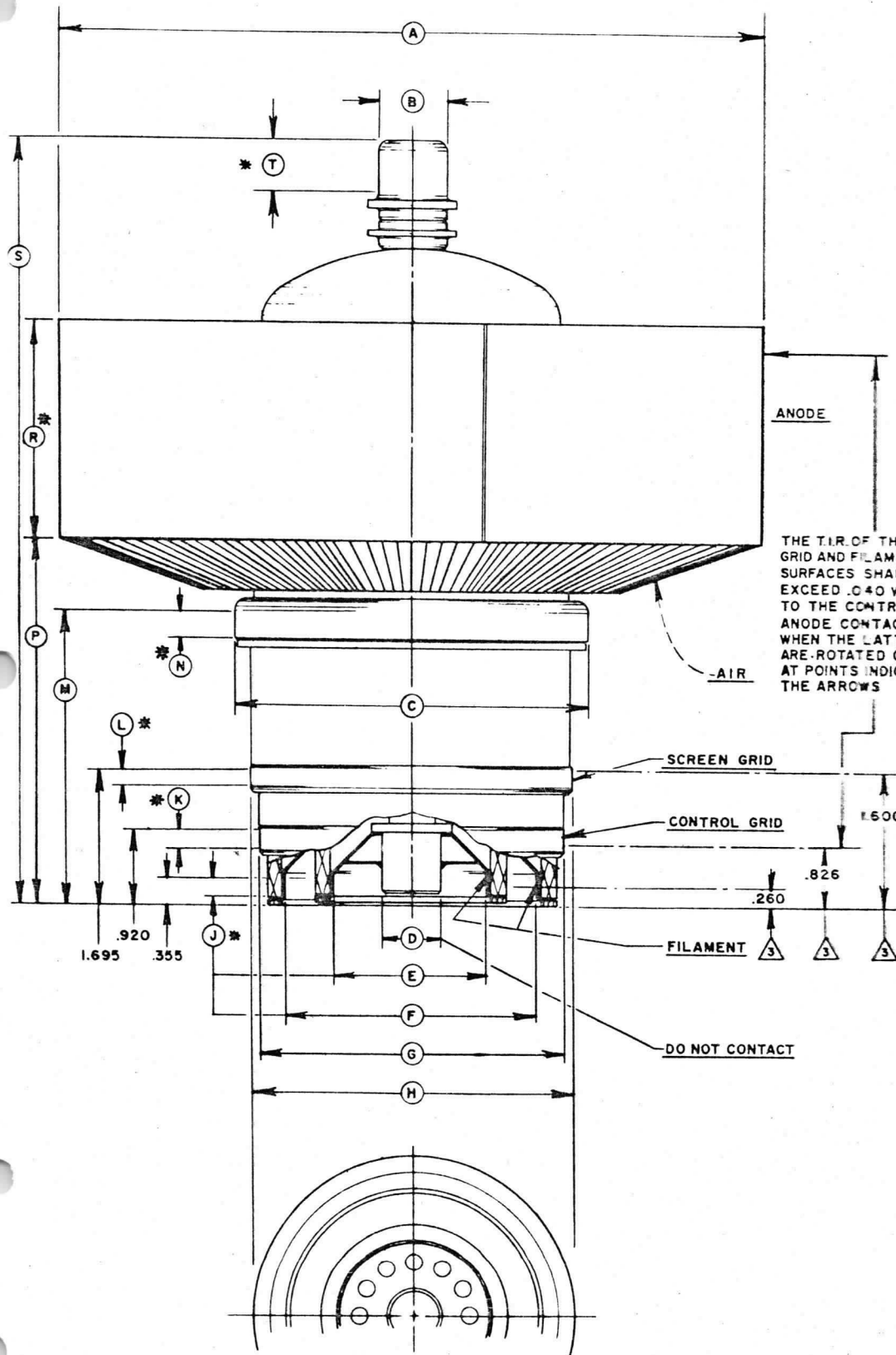
LEGEND:

Plate Current (Amperes)

Grid Current (Amperes)

Screen Current (Amperes)





DIM	INCHES			MILLIMETERS		
	MIN	MAX	REF	MIN	MAX	REF
A	8.670	8.800		220.22	223.52	
B	855	895		21.72	22.73	
C	4.425	4.468		111.91	113.49	
D	600	760		15.24	19.30	
E	1.896	1.936		48.16	49.17	
F	3.133	3.173		79.58	80.59	
G	3.792	3.832		96.32	97.33	
H	3.980	4.020		101.09	102.11	
J	188			4.78		
K	188			4.78		
L	188			4.78		
M	3.718	3.781		94.44	96.04	
N	219			5.56		
P	4.593	4.656		116.66	118.26	
R	2.705	2.825		68.71	71.76	
S	9.465	9.840		240.41	249.94	
T	500			12.70		

NOTES:

1. REF DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. * CONTACT SURFACE.
3. OPTIMUM FILAMENT & GRID CONNECTOR HEIGHTS FOR SOCKET DESIGN PURPOSES.

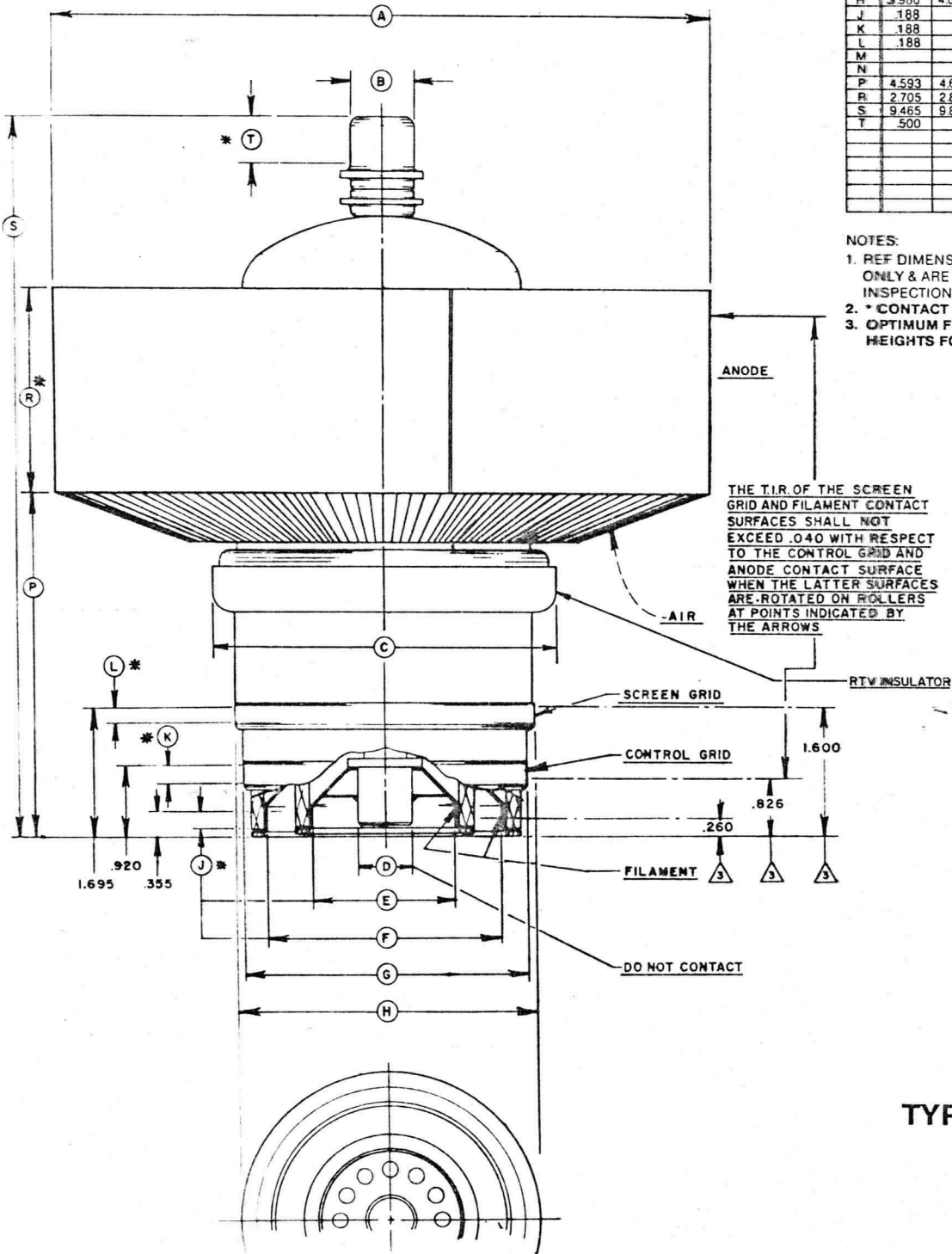
THE T.I.R. OF THE SCREEN GRID AND FILAMENT CONTACT SURFACES SHALL NOT EXCEED .040 WITH RESPECT TO THE CONTROL GRID AND ANODE CONTACT SURFACE WHEN THE LATTER SURFACES ARE ROTATED ON ROLLERS AT POINTS INDICATED BY THE ARROWS

TYPE 8990

DIM	INCHES			MILLIMETERS		
	MIN	MAX	REF	MIN	MAX	REF
A	8.670	8.800		220.22	223.52	
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TYPE 8990A