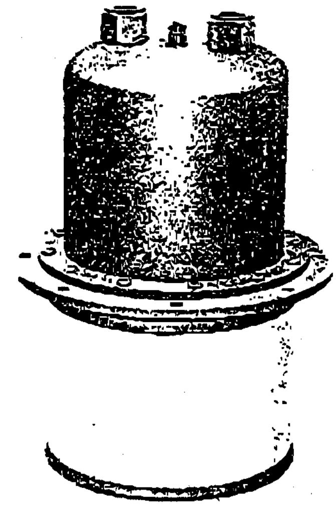
TECHNICAL DATA



The EIMAC 4CW150,000E is a ceramic/metal, high power tetrode for applications requiring tube outputs from 100 to 300 kilowatts. It is ideal for use as a Class C rf amplifier or oscillator, a Class AB rf linear amplifier, or a class AB push-pull audio frequency amplifier or modulator as well as as a plate-and-screen-modulated Class C rf amplifier.

In pulse-modulator service it can deliver a peak output of 4 megawatts.

The tube is characterized by low input and feedback capacitances and low internal lead inductances. Its rugged mesh thoriated-tungsten filament provides ample emission for long operating life. The water-cooled anode is rated for 150 kilowatts of dissipation.

GENERAL CHARACTERISTICS[1]

ELECTRICAL

Filament: Thoriated-tungsten Mesh	
Voltage	15.5 ± 0.75 V
Current @ 15.5 volts	215 A
Direct Interelectrode Capacitances (grounded cathode)	
Cin	370 pF
Cout	60 pF
Cgp	1.0 pF
Direct Interelectrode Capacitances (grounded grid)	
Cin	175 pF
Cout	60 pF
Cpk	0.35 pF
Frequency of Maximum Rating, CW	108 MHz 250 MHz [MAX. USE

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. Varian EIMAC should be consulted before using this information for final equipment design.

MECHANICAL

Maximum Overall Dimensions:	
Height	14.25 in; 36.20 cm
Diameter (anode mounting flange)	9.53 in; 24.21 cm
Net Weight	47.0 lb; 21.4 kg
Operating Position	Vertical, base up or down
Anode Cooling	Water
Base Cooling	Forced Air

392650 (Effective 25 May 1983)
VA4592

Printed in U.S.A.

Maximum Operating Temperature:	
Ceramic/Metal Seals and Envelope	250°C
Base	Special
Recommended Air-System Socket	EIMAC SK-2011A

TYPICAL OPERATION values are obtained 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. 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.

RADIO FREQUENCY LINEAR AMPLIFIER
Class AB

ABSOLUTE MAXIMUM RATINGS:

PLATE VOLTAGE	22	KILOVOLTS
SCREEN VOLTAGE	2.5	KILOVOLTS
GRID VOLTAGE	-1.5	KILOVOLTS
PLATE CURRENT	20	AMPERES
PLATE DISSIPATION	150	KILOWATTS
SCREEN DISSIPATION	1750	WATTS
GRID DISSIPATION	500	WATTS

TYPICAL OPERATION, Class AB1
GRID DRIVEN
Peak Envelope or Modulation Crest Conditions

Plate Voltage	18	kVdc
Screen Voltage	1.5	kVdc
Grid Voltage #	-320	Vdc
Zero-Signal Plate Current	4.0	Adc
Single-Tone Plate Current	13.5	Adc
Peak rf Grid Voltage *	300	v
Plate Dissipation *	75	kW
Plate Output Power *	168	kW
Resonant Load Impedance	697	Ohms

* Approximate
# Adjust to give specified zero-signal plate current

RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR
Class C Telegraphy or FM
(Key-Down Conditions)

ABSOLUTE MAXIMUM RATINGS:

PLATE VOLTAGE	22	KILOVOLTS
SCREEN VOLTAGE	2.5	KILOVOLTS
GRID VOLTAGE	-1.5	KILOVOLTS
PLATE CURRENT	20	AMPERES
PLATE DISSIPATION	150	KILOWATTS
SCREEN DISSIPATION	1750	WATTS
GRID DISSIPATION	500	WATTS

TYPICAL OPERATION

Plate Voltage	20	kVdc
Screen Voltage	1.5	kVdc
Grid Voltage	-800	Vdc
Plate Current	15.2	Adc
Screen Current *	567	mAdc
Grid Current *	125	mAdc
Peak rf Grid Voltage *	900	v
Calculated Driving Power *	120	W
Plate Dissipation *	54	kW
Plate Output Power *	220	kW
Resonant Load Impedance	575	Ohms

* Approximate

PLATE MODULATED RADIO FREQUENCY AMPLIFIER
GRID DRIVEN
Class C Telephony (Carrier Conditions)

ABSOLUTE MAXIMUM RATINGS:

PLATE VOLTAGE **	17.5	KILOVOLTS
SCREEN VOLTAGE	2.0	KILOVOLTS
GRID VOLTAGE	-1.5	KILOVOLTS
PLATE CURRENT	20	AMPERES
PLATE DISSIPATION #	100	KILOWATTS
SCREEN DISSIPATION ##	1750	WATTS
GRID DISSIPATION ##	500	WATTS

TYPICAL OPERATION

Plate Voltage	15	kVdc
Screen Voltage	750	Vdc
Grid Voltage	-600	Vdc
Screen Current *	875	mAdc
Grid Current *	660	mAdc
Peak Audio Screen Voltage, 100% mod. *	750	v
Peak rf Grid Voltage *	800	v
Calculated Driving Power *	530	W
Plate Dissipation *	35	kW
Plate Output Power	140	kW
Resonant Load Impedance	620	Ohms

* Approximate value
** 100% modulation
\# Corresponds to 150 kW at 100% sine-wave modulation
\## Average value, with or without modulation

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR, GRID DRIVEN
Class AB1 (Sinusoidal Wave)

ABSOLUTE MAXIMUM RATINGS:

PLATE VOLTAGE	22	KILOVOLTS
SCREEN VOLTAGE	2.5	KILOVOLTS
GRID VOLTAGE	-1.5	KILOVOLTS
PLATE CURRENT	20	AMPERES
PLATE DISSIPATION	150	KILOWATTS
SCREEN DISSIPATION	1750	WATTS
GRID DISSIPATION	500	WATTS

TYPICAL OPERATION (Two Tubes)

Plate Voltage	15	kVdc
Screen Voltage	1.5	kVdc
Grid Voltage #	-345	Vdc
Zero-Signal Plate Current	6.0	Adc
Maximum-Signal Plate Current	19.5	Adc
Maximum-Signal Screen Current *	830	mAdc
Peak Audio Grid Voltage (per tube) *	275	v
Max.Signal Plate Dissipation (per tube) *	46	kW
Plate Output Power *	200	kW
Load Resistance (plate/plate)	1825	Ohms

* Approximate value
\# Adjust to give specified zero-signal plate current

PULSE MODULATOR SERVICE

ABSOLUTE MAXIMUM RATINGS:

PLATE VOLTAGE	40	KILOVOLTS
SCREEN VOLTAGE	2.5	KILOVOLTS
GRID VOLTAGE	-2.0	KILOVOLTS
PEAK CATHODE CURRENT	200	AMPERES
PLATE DISSIPATION #	1.0	MEGAWATT
PLATE DISSIPATION ##	150	KILOWATTS
SCREEN DISSIPATION ##	1750	WATTS
GRID DISSIPATION ##	500	WATTS
PULSE LENGTH	10	MILLISEC

TYPICAL OPERATION

Plate Voltage	40	kVdc
Pulse Plate Current	110	a
Screen Voltage	2.5	kVdc
Pulse Screen Current *	12	a
Grid Voltage	-1.2	kVdc
Pulse Grid Current *	400	ma
Duty	6	%
Pulse Output Voltage	37	kv
Pulse Input Power	4.4	Mw
Pulse Output Power	4.1	Mw.
Pulse Cathode Current *	122	a

* Approximate value
\# During the pulse; power dissipated during rise and fall time neglected
\## Average

RANGE VALUES FOR EQUIPMENT DESIGN:

	Min.	Max.	
Filament Current @ 15.5 volts	200	230	A
Cutoff Bias, at Eb = 25 kVdc, Ec2 = 1500 Vdc, Ib = 10 mAdc	---	-625	Vdc
Interelectrode Capacitances (grounded cathode)			
Cin	350	390	pF
Cout	55	65	pF
Cgp	---	1.2	pF
Interelectrode Capacitances (grounded grid)			
Cin	160	190	pF
Cout	55	65	pF
Cpk	---	0.5	pF

APPLICATION

MECHANICAL

MOUNTING - The 4CW150,000E must be mounted with its major axis vertical. The tube base may be up or down, at the discretion of the designer.

SOCKETING - The EIMAC SK-2011A, or equivalent, is recommended to assure good contact and allow for forced-air cooling of the tube base.

COOLING - Anode cooling is accomplished by circulating water through the water jacket. Insufficient water flow will cause anode temperature to rise to levels which will shorten tube life. Also, if the coolant lines become clogged, enough steam pressure may be generated to rupture the water jacket and destroy the tube.

High velocity water flow is required to maintain high thermal efficiency. Cooling water must be well filtered (with effectiveness the equivalent of a 100-mesh screen) to eliminate any solid materials, to avoid the possibility of blockage of any cooling passages, as this would immediately affect cooling efficiency and could produce localized anode overheating and failure of the tube.

Tube life can be seriously compromised by the cooling water condition. If it becomes contaminated, deposits will form on the inside of the water jacket, causing localized anode heating and eventual tube failure. To insure minimum electrolysis and power loss, the water resistance at 25 °C should always be one megohm per cubic centimeter or higher. The relative water resistance can be continuously monitored in the reservoir by readily available instruments.

EIMAC Application Bulletin #16, WATER PURITY REQUIREMENTS IN LIQUID COOLING SYSTEMS, is available on request, and contains considerable detail on purity requirements and maintenance systems.

The table lists the minimum cooling water requirements at various dissipation levels with a maximum inlet water temperature of 50°C. The pressure drop values shown should be considered approximate and system pressure should be limited to 80 psi.

Anode Diss. (kW)	Water Flow (gpm)	Press. Drop (psi)
20	5.0	2.8
40	9.0	5.6
60	12.5	9.3
80	16.5	14.2
100	20.0	19.2
125	23.5	27.5
150	26.0	36.0

Auxiliary forced-air cooling of the tube base is required to maintain filament and grid seal temperatures at safe operation levels. An air flow of approximately 100 cfm at 50°C maximum at sea level should be directed through the EIMAC SK-2011A series socket, toward the filament and grid seal areas.

Both anode and base cooling should be applied before or simultaneously with the application of electrode voltages, including the tube filament. Cooling should normally continue for about three minutes after removal of electrode voltages to allow the tube to cool down properly.

ELECTRICAL

ABSOLUTE MAXIMUM RATINGS - The values shown for each type of service are based on the "absolute system" and are not to be exceeded under any service conditions. These ratings are limiting values outside which the serviceability of the tube may be impaired. In order not to exceed absolute ratings the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by a safety factor so that the absolute values will never be exceeded under any usual conditions of supply voltage variation in the equipment itself. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

FILAMENT OPERATION - During turn-on the filament inrush current should be limited to 450 amperes. At rated (nominal) filament voltage the peak emission capability of the tube is many times that needed for communication service. A reduction in filament voltage will lower the filament temperature, which will substantially increase life expectancy. The correct value of filament voltage should be determined for the particular application. It is recommended the tube be operated at full nominal voltage for an initial stabilization period of 100 to 200 hours before any action is taken to operate at reduced voltage. The voltage should gradually be reduced until there is a slight degradation in performance (such as power output or distortion). The filament voltage should then be increased a few tenths of a volt above the value where performance degradation was noted for operation. The operating point should be rechecked after 24 hours. Filament voltage should be closely regulated when voltage is to be reduced below nominal in this manner, to avoid any adverse influence by normal line voltage variations.

Filament voltage should be measured at the tube base or socket, using an accurate rms-responding meter. Periodically throughout the life of the tube the procedure outlined above for reduction of voltage should be repeated, with voltage reset as required, to assure best tube life.

GRID OPERATION - The maximum control grid dissipation is 500 watts, determined approximately by the product of the dc grid current and the peak positive grid voltage. A protective spark-gap device should be connected between control grid and cathode to guard against excessive voltage.

Under some operating conditions the control grid may exhibit a negative resistance characteristic. This may occur when, with high screen voltage, increasing the drive voltage decreases the grid current. As a result, large values of instantaneous negative grid current can be produced, causing the amplifier to become regenerative. Because this may happen, the driver stage must be designed to tolerate this condition. One technique is to swamp the driver so that the change in load, due to secondary grid emission, is a small percentage of the total driver load.

SCREEN OPERATION - The maximum screen grid dissipation is 1750 watts. With no ac applied to the screen grid, dissipation is simply the product of dc screen voltage and the dc screen current. With screen modulation, 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. A protective spark-gap device should be connected between the screen grid and the cathode to guard against excessive voltage.

The tube may exhibit reverse screen current to a greater or lessser degree depending on operating conditions. The screen power supply should be designed with this characteristic in mind, so that the correct operating voltage will be maintained on the screen under all conditions. Dangerously high plate current may flow if the screen power supply exhibits a rising voltage characteristic with negative screen current. A current path from the screen to cathode must be provided by a bleeder resistor. A series regulated power supply can be used only when an adequate bleeder resistor is provided.

PLATE DISSIPATION - The rated plate dissipation of 150 kilowatts, attainable with water cooling, provides a margin of safety in most applications. This rating may be exceeded briefly during tuning. When the tube is used as a plate-modulated rf amplifier plate dissipation under carrier conditions should be limited to 100 kilowatts.

FAULT PROTECTION - In addition to the normal plate over-current interlock, screen current interlock, and coolant interlock, the tube must be protected from internal damage caused by an internal plate arc which may occur at high plate voltage. A protective resistance should always be connected in series with each tube anode, to help absorb power supply stored energy if an internal arc should occur. An electronic crowbar, which will discharge power supply capacitors in a few microseconds after the start of an arc, is recommended. The protection criteria for each electrode supply is to short each electrode to ground, one at a time, through a vacuum relay switch and a 6-inch length of #30 AWG copper wire. The wire will remain intact if the criteria is met.

EIMAC Application Bulletin #17 titled FAULT PROTECTION contains considerable detail, and is available on request.

X-RADIATION HAZARD - High-vacuum tubes operating at voltages higher than 15 kilovolts produce progressively more dangerous X-ray radiation as the voltage is increased. This tube, operating at its rated voltages and currents, is a potential X-ray source. Only limited shielding is afforded by the tube envelope. Moreover, the X-radiation level may increase significantly with tube aging and gradual deterioration, due to leakage paths or emission characteristics as they are effected by the high voltage. X-ray shielding may be required on all sides of tubes operating at these voltages to provide adequate protection throughout the life of the tube. Periodic checks on the X-ray level should be made, and the tube should never be operated without required shielding in place. If there is any question as to the need for or the adequacy of shielding, an expert in this field should be contacted to perform an equipment X-ray survey.

In cases where shielding has been found to be required operation of high voltage equipment with interlock switches "cheated" and cabinet doors open in order to be better able to locate an equipment malfunction can result in serious X-ray exposure.

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.

RADIO-FREQUENCY RADIATION - Avoid exposure to strong rf fields even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. Under 300 MHz most of the energy will pass completely through the human body with little attenuation or heating affect. Public health agencies are concerned with the hazard even at these frequencies. OSHA (Occupational Safety and Health Administration) recommends that prolonged exposure to rf radiation should be limited to 10 milliwatts per square centimeter.

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. Testing is performed on a cold tube. The capacitance values shown in the technical data are taken with no special shielding.

The equipment designer is therefore cautioned to make allowance for the actual capacitence values which will exist in the appliction. Measurements should be taken with the mounting which represents approximate final layout if capacitance values are highly significant in the design.

SPECIAL APPLICATIONS - When it is desired to operate this tube under conditions widely different from those listed here, write to Varian EIMAC; attn: Applications Engineering; 301 Industrial Way; San Carlos, CA 94070 U.S.A.

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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 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:

a. HIGH VOLTAGE - Normal operating voltages can be deadly.

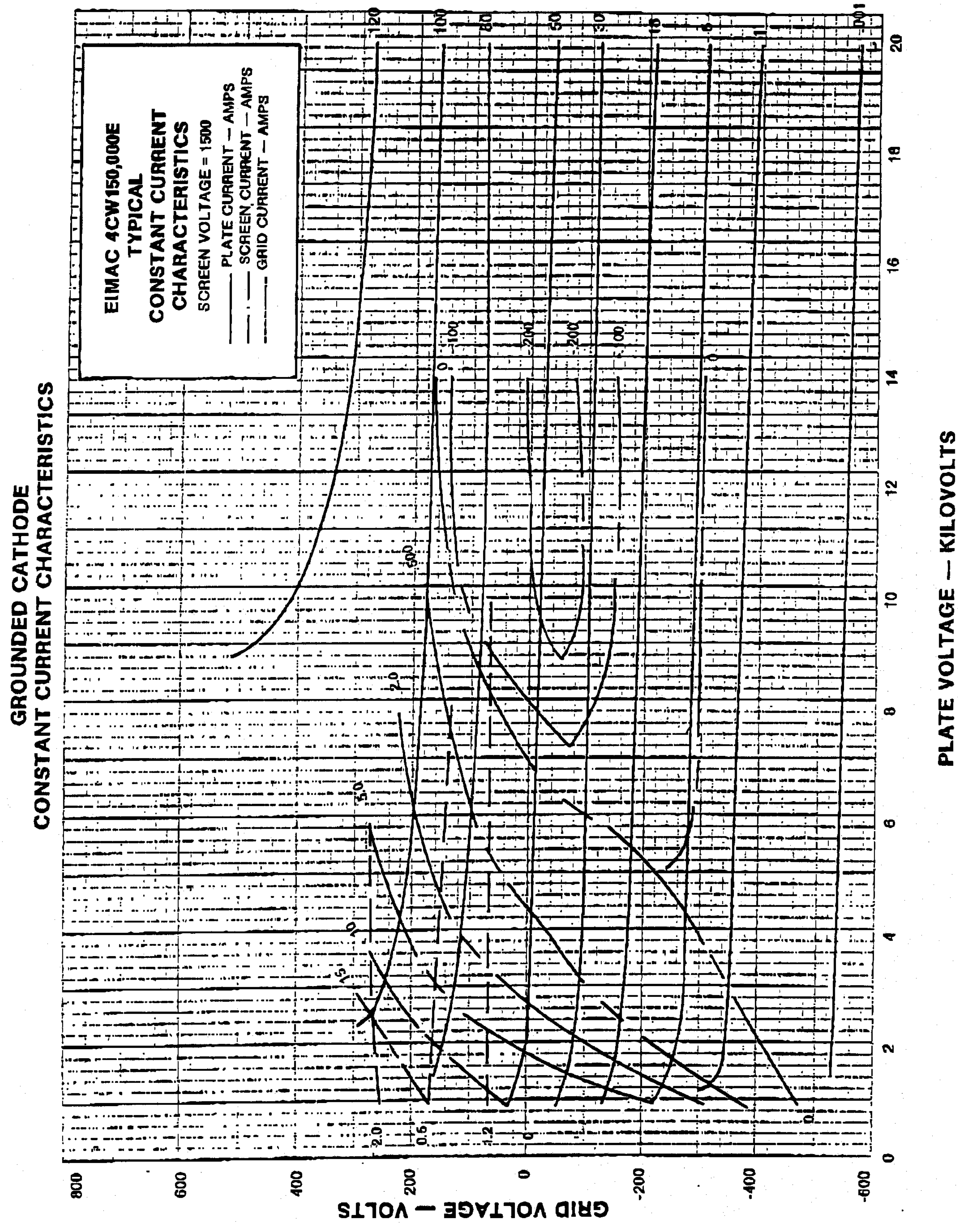
b. RF RADIATION - Exposure to strong rf fields should be avoided, even at low and medium frequencies. CARDIAC PACEMAKERS MAY BE EFFECTED.

c. X-RAY RADIATION - High voltage tubes can produce dangerous and possibly fatal X-Rays.

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

f. HOT SURFACES - Surfaces of air-cooled radiators and other parts of tubes can reach temperatures of several hundred Degrees C and cause serious burns if touched for several minutes after all power is removed.

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



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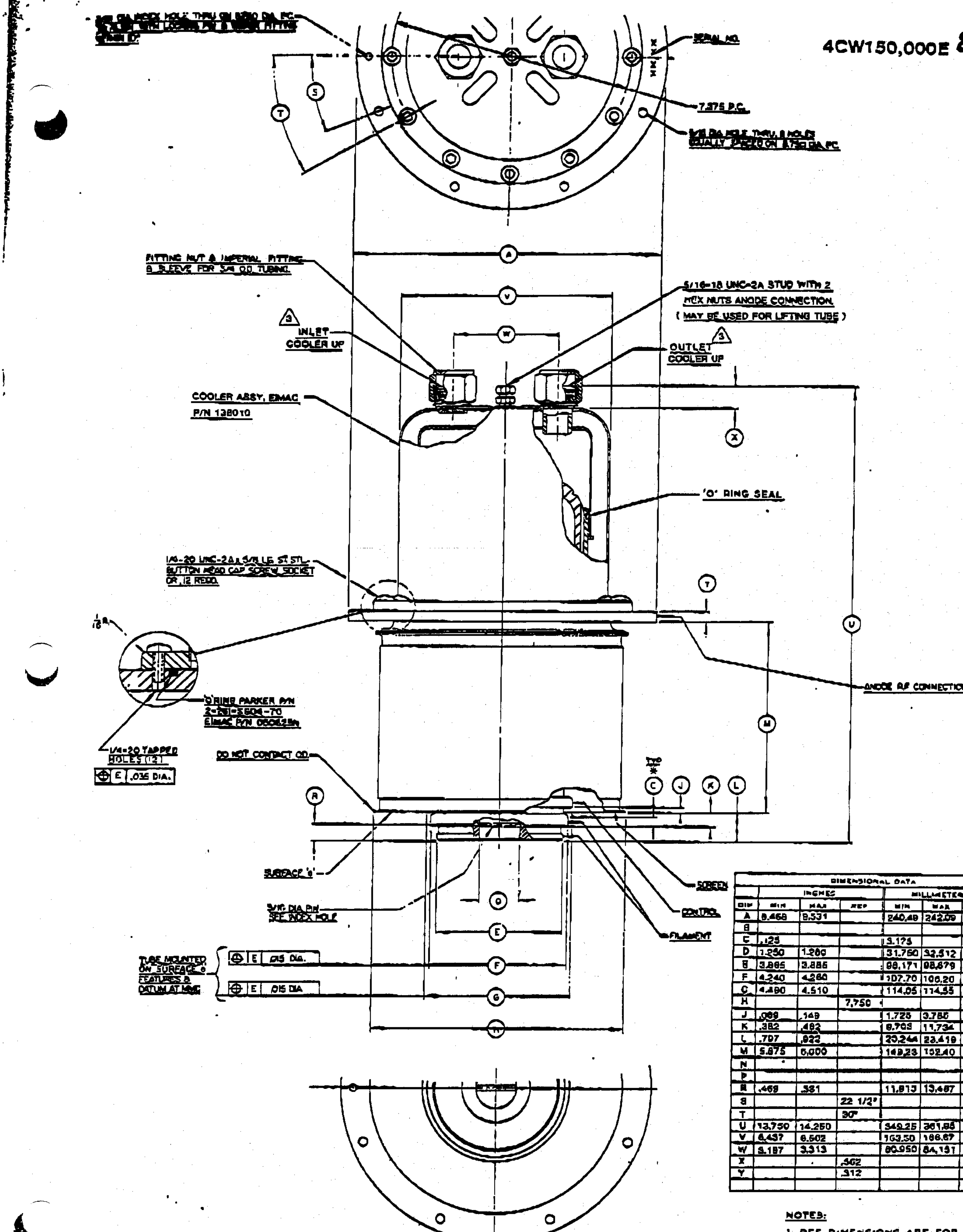
4CW150,000E



DIMENSIONAL DATA						
	INCHES			MILLIMETERS		
DIM	MIN	MAX	REF	MIN	MAX	REF
A	9.468	9.531		240.48	242.09	
B						
C	.125			3.175		
D	1.250	1.280		31.750	32.512	
E	3.865	3.885		98.171	98.679	
F	4.240	4.260		107.70	108.20	
G	4.490	4.510		114.05	114.55	
H			7.750			196.85
J	.069	.149		1.725	3.785	
K	.382	.482		9.703	11.734	
L	.797	.922		20.244	23.419	
M	5.875	6.000		149.23	152.40	
N						
P						
R	.469	.531		11.913	13.487	
S			22 1/2°			
T			30°			
U	13.750	14.250		349.25	361.95	
V	6.437	6.562		163.50	166.67	
W	3.187	3.313		80.950	84.151	
X			.562			14.275
Y			.312			7.925

NOTES:

1. REF DIMENSIONS ARE FOR INFO ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. (R) MIN. CONTACT SURFACE
3. IF TUBE IS OPERATED COOLER DOWN THE WATER INLET & OUTLET ARE REVERSED.