4CV250,000B
VAPOR COOLED

4CW250,000B
WATER COOLED

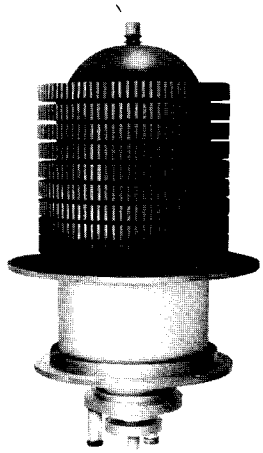
POWER TETRODES

TECHNICAL DATA

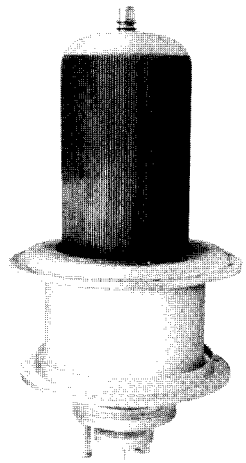
The EIMAC 4CV250,000B and 4CW250,000 are ceramic/metal (vapor cooled and water cooled, respectively) power tetrodes intended for use at the 250 to 500 kilowatt output power level. They are recommended for use as a Class C amplifier or oscillator, Class AB rf linear amplifier, Class AB push-pull af amplifier or modulator, plate or screen modulated Class C rf amplifier, or for pulse modulator or regulator service.

The 4CV250,000B is operated in the accessory boiler BR-620 (not supplied with the tube); the 4CW250,000B is operated with the accessory water jacket SK-1720 (not supplied with the tube), and both tubes are rated for 250 kilowatts maximum anode dissipation.

4CV250,000B



4CW250,000B



GENERAL CHARACTERISTICS[1]

ELECTRICAL

Filament: Thoriated Tungsten		
Voltage	12.0 ± 0.6	V
Current @ 12.0 V	660	A
Amplification Factor (average), grid to screen	4.5	
Direct Interelectrode Capacitance (grounded cathode)[2]		
Cin	760	pF
Cout	124	pF
Cgp	6.0	pF
Frequency of Maximum Rating, CW	50	MHz

1. Characteristics and operating values are based upon 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 without any special shielded fixture.

MECHANICAL

Maximum Overall Dimensions:

Length (4CV250,000B)	26.895 In; 68.31 cm
(4CW250,000B)	26.525 In; 67.37 cm
Diameter (4CV250,000B)	15.062 In; 38.26 cm
(4CW250,000B)	13.062 In; 33.18 cm

4177 (Effective 7-15-79) Printed in U.S.A.

Base (both types)	Special
Recommended Base Connectors (both types):	
Filament Connector (2 required)	EIMAC SK-1710
Control Grid Connector (1 required)	EIMAC SK-1712
Recommended Accessories For Anode Cooling (not supplied with tube):	
4CV250,000B	EIMAC Boiler BR-620
4CW250,000B	EIMAC Jacket SK-1720
Operating Position: 4CV250,000B	Vertical, Anode Up
4CW250,000B	Vertical, Base Up or Down
Maximum Ceramic/Metal Seal or Envelope Temperature	200°C
Cooling: 4CV250,000B	Vapor and Water
4CW250,000B	Water
Net Weight: 4CV250,000B (w/o boiler)	180 Lb; 81.8 kg
4CW250,000B (w/o jacket)	98 Lb; 44.5 kg

RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR
Class C Telegraphy or FM
(Key-down Condition)

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	20,000 VOLTS
DC SCREEN VOLTAGE	2,500 VOLTS
DC PLATE CURRENT	40 AMPERES
PLATE DISSIPATION	250,000 WATTS
SCREEN DISSIPATION	3,500 WATTS
GRID DISSIPATION	1,500 WATTS

TYPICAL OPERATION (Frequencies below 30 MHz)

DC Plate Voltage	16	19 kV
DC Screen Voltage	800	800 V
DC Grid Voltage	-800	-800 V
DC Plate Current	23.5	32.5 A
DC Screen Current	2.4	3.5 A
DC Grid Current	1.15	2.5 A
Driving Power[1]	2.24	3.0 kW
Plate Output Power	275	460 kW
Plate Dissipation	100	155 kW
RF Load Impedance	300	275 Ω

1. Calculated Driving Power neglects input conductance and rf circuit loss.

PLATE MODULATED RADIO FREQUENCY POWER AMPLIFIER
Class C Telephony
(Carrier conditions except where noted)

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	17,500 VOLTS
DC SCREEN VOLTAGE	2,000 VOLTS
DC PLATE CURRENT	30 AMPERES
PLATE DISSIPATION[1]	167,000 WATTS
SCREEN DISSIPATION	3,500 WATTS
GRID DISSIPATION	1,500 WATTS

1. Corresponds to 250,000 watts at 100 per cent sine wave modulation.
2. Approximate Value.

TYPICAL OPERATION (Frequencies below 30 MHz)

DC Plate Voltage	15 kV
DC Screen Voltage	800 V
Peak af Screen Voltage (for 100% Mod.)[2]	800 v
DC Grid Voltage	-800 V
DC Plate Current	22.8 A
DC Screen Current	4.1 A
DC Grid Current	1.46 A
Peak rf Grid Voltage	1110 v
Grid Driving Power[3]	1630 W
Plate Output Power	280 kW
RF Load Impedance	323 Ω
Plate Dissipation	63 kW

3. Calculated Driving Power neglects input conductance and rf circuit loss.

AUDIO FREQUENCY AMPLIFIER OR MODULATOR
Class AB

ABSOLUTE MAXIMUM RATINGS: (Per Tube)

DC PLATE VOLTAGE	20,000 VOLTS
DC SCREEN VOLTAGE	2,500 VOLTS
DC PLATE CURRENT	40 AMPERES
PLATE DISSIPATION	250,000 WATTS
SCREEN DISSIPATION	3,500 WATTS
GRID DISSIPATION	1,500 WATTS

1. Approximate Value.
2. Per Tube

TYPICAL OPERATION (Two Tubes)
Class AB 1

DC Plate Voltage	15	20 kV
DC Screen Voltage	1.8	1.8 kV
DC Grid Voltage	-500	-500 V
Max-Signal Plate Current	40	46 A
Zero Signal Plate Current[2]	0.2	0.2 A
Max-Signal Screen Current[1]	1.1	1.2 A
Peak af Driving Voltage[2]	500	500 v
Driving Power	0	0 W
Load Impedance (plate to plate)	650	870 Ω
Plate Dissipation	160	260 kW
Max-Signal Output Power	440	660 kW

RADIO FREQUENCY LINEAR AMPLIFIER
Class AB

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	20,000 VOLTS
DC SCREEN VOLTAGE	2,500 VOLTS
DC PLATE CURRENT	40 AMPERES
PLATE DISSIPATION	250,000 WATTS
SCREEN DISSIPATION	3,500 WATTS
GRID DISSIPATION	1,500 WATTS

1. Approximate Value.
2. Calculated Driving Power neglects input conductance and rf circuit loss.

TYPICAL OPERATION (Frequencies below 30 MHz)
Class AB 1, Peak-Envelope or Modulation Crest Conditions

DC Plate Voltage	15	20 kV
DC Screen Voltage	1.8	1.8 kV
DC Grid Voltage	-500	-500 V
Plate Current	20	23 A
Zero Signal Plate Current	0.2	0.2 A
Max-Signal Screen Current[1]	1.1	1.2 A
Peak rf Grid Voltage	500	500 v
Driving Power[2]	0	0 W
Plate Dissipation	80	130 kW
Resonant Load Impedance	325	435 Ω
Plate Output Power	220	330 kW

PULSE MODULATOR OR REGULATOR

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	40,000 VOLTS
DC SCREEN VOLTAGE	2,500 VOLTS
PEAK CATHODE CURRENT	350 AMPERES
PLATE DISSIPATION	250,000 WATTS
SCREEN DISSIPATION	3,500 WATTS
GRID DISSIPATION	1,500 WATTS

APPLICATION

MECHANICAL

MOUNTING (4CV250,000B) - The tube must be mounted vertically, anode up. The tube may be supported by the anode flange or the screen flange.

Care must be exercised to insure that the axis of the tube/boiler combination is vertical and that the water in the boiler is at the correct level. The anode flange on the tube must seal securely against the "O" ring, forming a vapor-tight seal between the tube and boiler.

MOUNTING (4CW250,000B) - The tube must be mounted vertically, anode up or down. The tube may be supported by the anode flange or the screen flange.

ANODE COOLING (4CV250,000B) - Cooling is accomplished by immersing the anode of the 4CV250,000B in a "Boiler" filled with distilled water. Energy dissipated by the anode causes the water to boil at the anode surfaces, be converted into steam and be carried away to an external condenser. The condensate is then returned to the boiler, completing the cycle.

This boiling action maintains the anode surfaces at a fairly constant temperature near 100°C. The vapor-cooled tube has good overload capabilities; excess dissipation for moderate periods only causes more water to boil.

Since the tube anode and boiler are usually at high potential to ground, water and steam connections to the boiler are made through insulated tubing.

ANODE COOLING (4CW250,000B) - Minimum cooling water requirements for the anode are shown in the table for an outlet water temperature not to exceed 70°C and an inlet water temperature of 50°C. High-purity water must be used to minimize power loss, corrosion of metal fittings, and loss of anode dissipation capability. Water resistivity must be maintained at 1 megohm/cm^3 or better for long term operation.

Anode Dissipation (kW)	Water Flow (gpm)	Approx. Jacket Press. Drop (psi)
150	37.5	3.5
200	50.0	9.0
250	60.0	10.0

EIMAC Application Bulletin #16 titled, "WATER PURITY REQUIREMENTS IN LIQUID COOLING SYSTEMS" is available on request, and should be consulted for details on maintenance of water quality standards and use of a water purification loop in the installation. Since the anode is normally at high potential to

ground, water connections to the anode are made through insulating tubing, with long enough sections that column resistance is above 4 megohms per 1000 plate supply volts, or 10 megohms total, whichever is less.

BASE COOLING (Both Types) - The filament supports of both tubes are water cooled. Approximately .5 GPM should circulate through each of the filament connectors with a pressure drop of 20 PSI. Filament connector assemblies, SK-1710, provide electrical and water connections. Two sets of SK-1710 are required.

It is recommended that the water cooled control grid connector, SK-1712, be used. Water flow of approximately .5 GPM should circulate through the grid connector. The pressure drop across the grid connector is low. A convenient way to make water connection is to series connect the grid cooling water with the outer filament cooling water path.

The outer filament water path has a lower pressure drop than the inner filament water path making this connection practical.

ALL COOLING MUST BE APPLIED BEFORE OR SIMULTANEOUSLY WITH THE APPLICATION OF ELECTRODE VOLTAGES, INCLUDING FILAMENT, AND SHOULD NORMALLY BE MAINTAINED FOR SEVERAL MINUTES AFTER ALL VOLTAGES ARE REMOVED TO ALLOW FOR TUBE COOLDOWN.

ELECTRICAL

FILAMENT OPERATION - The peak emission at rated filament voltage is normally many times the peak emission required for communication service. A small decrease in filament temperature due to reduction of filament voltage can increase life by a substantial percentage. It is good practice to determine the nominal filament voltage for a particular application that will not affect the operation of the equipment. This is done by measuring some important parameter of performance such as plate current, power output, or an increase in distortion. Operation may be at a filament voltage slightly higher than that point at which performance appeared to deteriorate. This voltage should be measured at the socket with a 1% meter and periodically checked.

Filament starting current must be limited to a maximum of 1800 amperes.

CONTROL GRID OPERATION - The control grid is rated at 1,500 watts of dissipation and protective measures should be included in circuitry to insure that this rating is not exceeded. Grid dissipation is the approximate product of dc grid current and peak positive grid voltage.

SCREEN DISSIPATION - The power applied to the screen grid must not exceed 3,500 watts. Where no ac is applied to the screen, dissipation is the product of dc screen voltage and dc screen current. With screen modulation the dissipation is the product of RMS screen current and RMS screen voltage.

PLATE DISSIPATION - The plate dissipation of 250 kilowatts provides a large margin of safety in most applications. The rating may be exceeded for brief periods during tuning. When used as a plate-modulated rf amplifier, plate dissipation under carrier conditions is limited to 167,000 watts.

LOAD VSWR - The load VSWR should be monitored and the detected signal used to operate the interlock system to remove the plate voltage within 20 milliseconds after a fault occurs. In the case of high stored energy in the load system, care must be taken to avoid excessive return energy from damaging the tube and associated circuit components.

FAULT PROTECTION - To assure nondestruction of tube elements from high-energy power supplies, during a fault condition, all supplies must be checked for proper operation of their protective circuits. An approved method to meet the tube protection criteria would be the use foil, solder wire, or small diameter wire to produce a controlled short on the power supply. The simplest technique is to short the plate to cathode, screen grid to cathode, control grid to cathode, and screen grid to anode (individually, one at a time) using

a vacuum relay through a section of #30 AWG copper wire. The wire will remain intact if the power supply protective circuitry is operating properly. An electronic crowbar will be required on the anode supply, and may be required on the other electrode supplies if the test outlined above is not passed. See EIMAC Application Bulletin #17 for further details.

Properly rated spark gaps must also be located between the screen grid and cathode and between the control grid and cathode to meet over-voltage protection criteria. A series resistance of 10 to 50 ohms is recommended in the screen and control grid power supply leads.

X-RADIATION - High-vacuum tubes operating at voltages higher than 15 kilovolts produce progressively more dangerous X-ray radiation as the voltage is increased. These tubes, operating at rated voltages and currents, are a potential X-ray hazard. Only limited shielding is afforded by the tube envelope. Moreover, the X-ray radiation level can increase significantly with aging and gradual deterioration, due to leakage paths or emission characteristics as they are affected by the high voltage. X-ray shielding must be provided on all sides of tubes operating at these voltages to provide adequate protection throughout the tube's life. Periodic checks on the X-ray level should be made, and the tube should never be operated without adequate shielding in place when voltages above 15 kilovolts are in use. Lead glass, which attenuates X-rays, is available for viewing windows. If there is any doubt as to the requirement for or the adequacy of shielding, an expert in this field should be contacted to perform an X-ray survey of the equipment.

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 these tubes 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 condensers 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 30 MHz, most of the energy will pass completely through the human body with little attenuation or heating effect. Public health agencies are concerned with the hazard, however, even at these frequencies, and it is worth noting that some commercial dielectric heating units actually operate at frequencies as low as the 13 and 27 MHz bands.

SPECIAL APPLICATION - If it is desired to operate this tube under conditions widely different from those listed here, write to Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California, 94070, For information and 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.

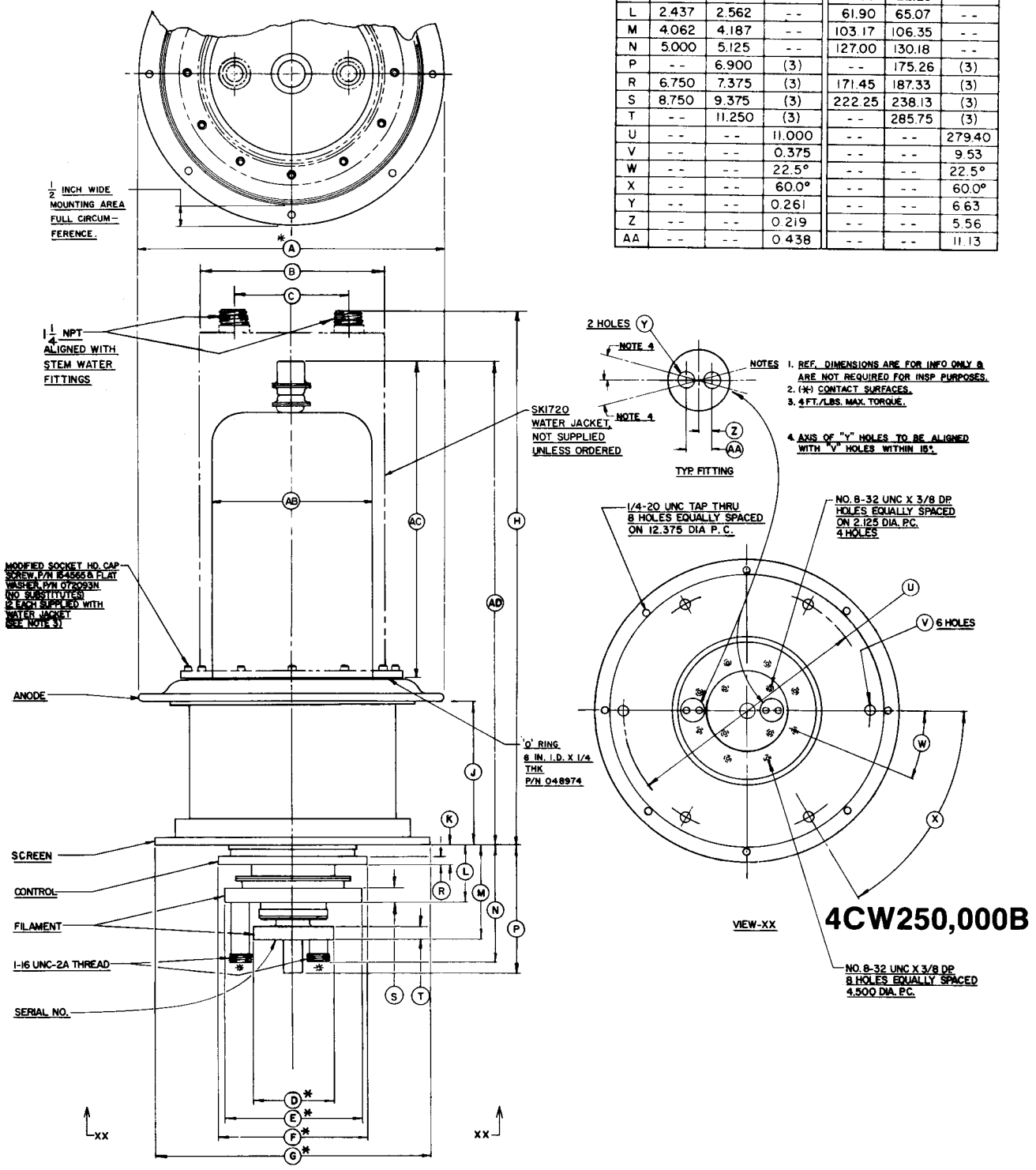
f. *HOT WATER* - Water used to cool tubes may reach scalding temperatures. Touching or rupture of the cooling system can cause serious burns.

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.

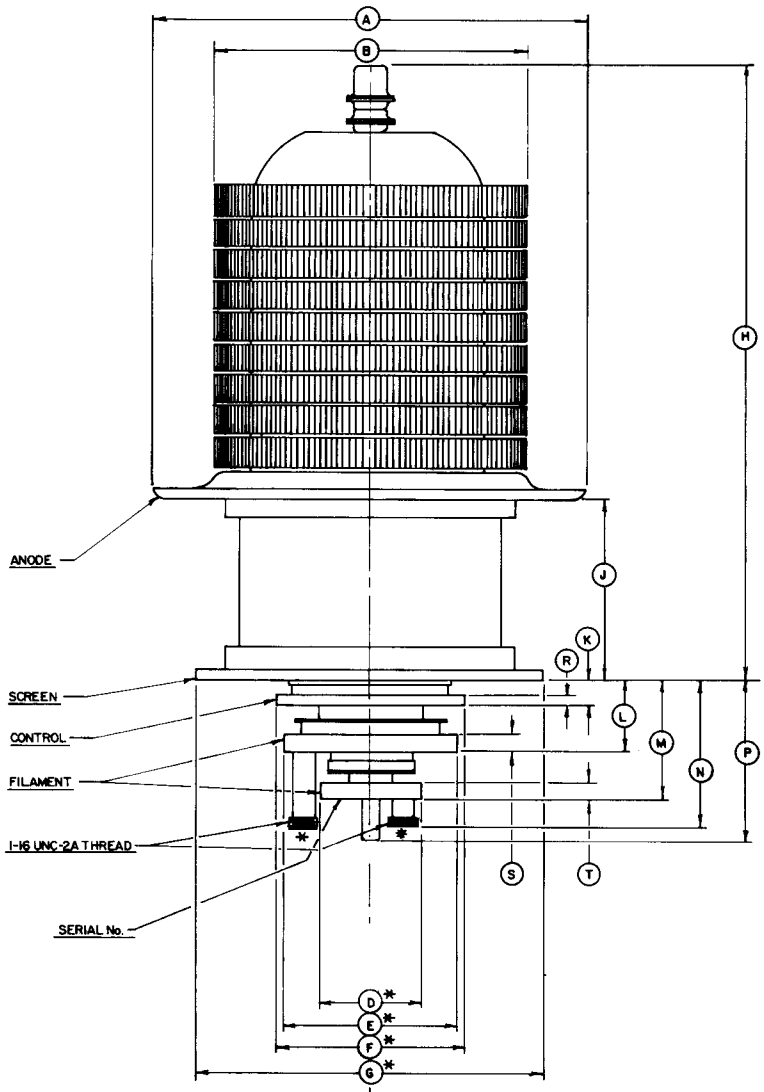
Please review the detailed operating hazards sheet enclosed with each tube or request a copy from the address shown below: Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070.

DIMENSIONAL DATA

DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	12.937	13.062	--	328.60	331.77	--
B	7.937	8.062	--	201.60	204.77	--
C	4.437	4.562	--	112.70	115.87	--
D	3.437	3.562	--	87.30	90.47	--
E	5.937	6.062	--	150.80	153.97	--
F	6.437	6.562	--	163.50	166.67	--
G	11.937	12.062	--	303.20	306.37	--
H	23.437	23.562	--	595.30	598.47	--
J	6.250	6.375	--	158.75	161.93	--
K	0.750	0.875	--	19.05	22.23	--
L	2.437	2.562	--	61.90	65.07	--
M	4.062	4.187	--	103.17	106.35	--
N	5.000	5.125	--	127.00	130.18	--
P	--	6.900	(3)	--	175.26	(3)
R	6.750	7.375	(3)	171.45	187.33	(3)
S	8.750	9.375	(3)	222.25	238.13	(3)
T	--	11.250	(3)	--	285.75	(3)
U	--	--	11.000	--	--	279.40
V	--	--	0.375	--	--	9.53
W	--	--	22.5°	--	--	22.5°
X	--	--	60.0°	--	--	60.0°
Y	--	--	0.261	--	--	6.63
Z	--	--	0.219	--	--	5.56
AA	--	--	0.438	--	--	11.13



4CW250,000B

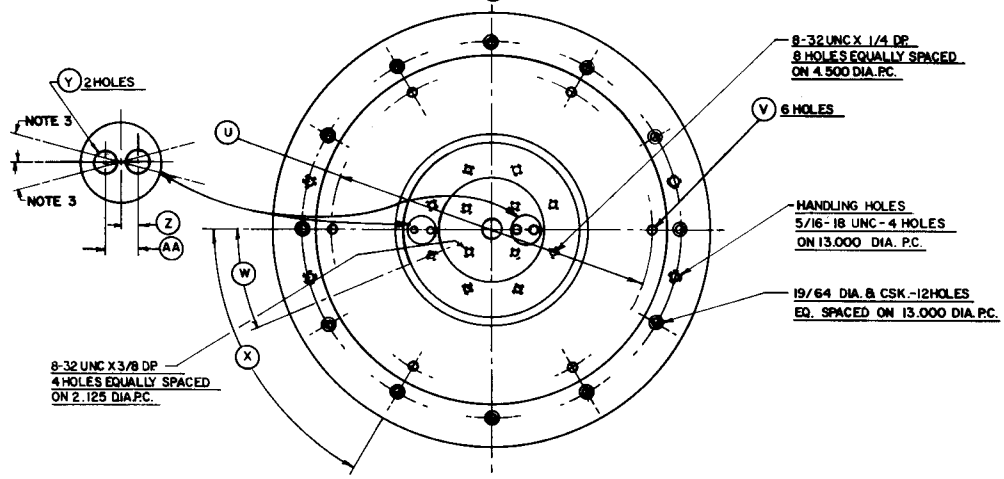


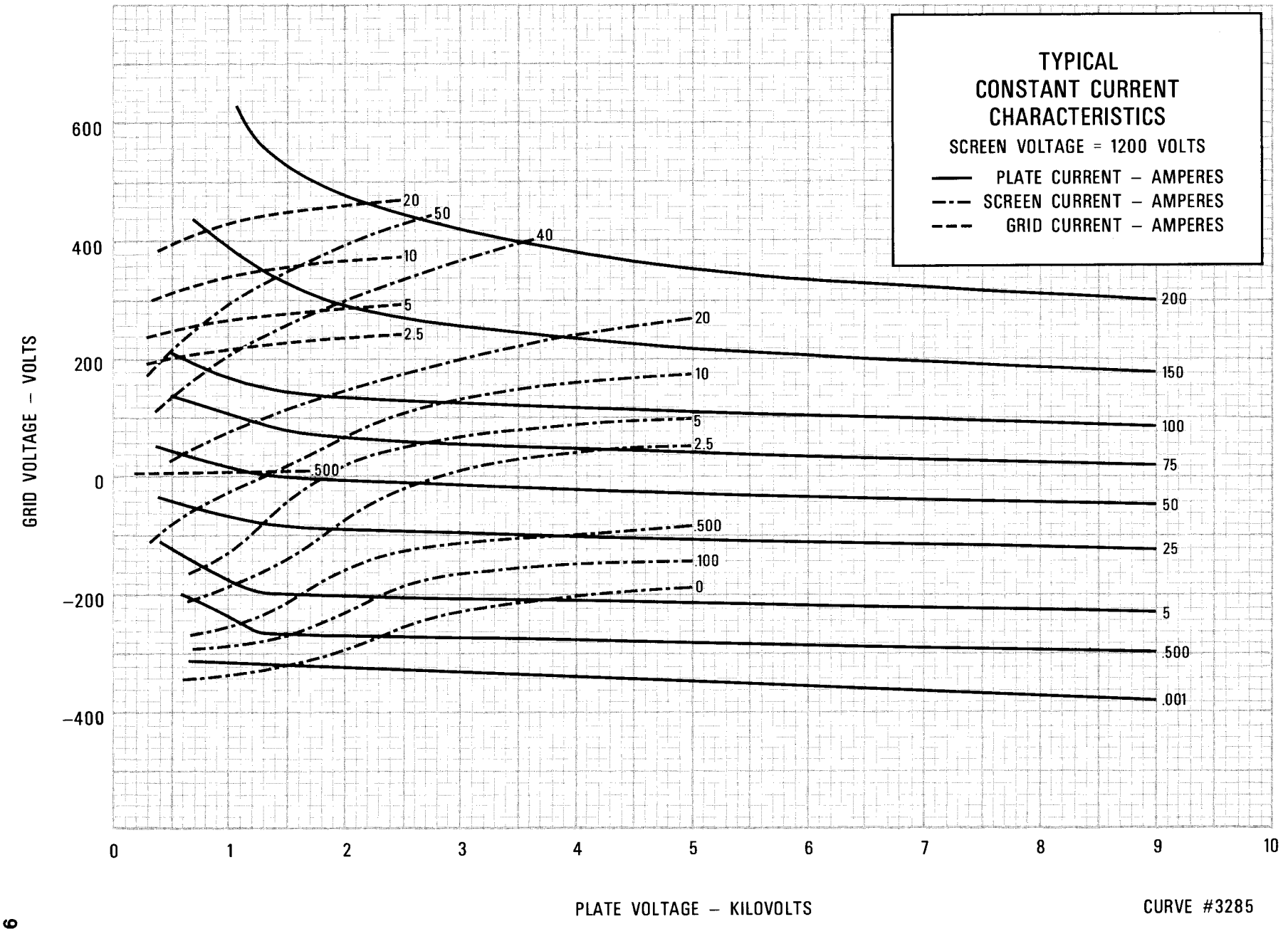
DIMENSIONAL DATA

DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF	MIN.	MAX.	REF
A	14.937	15.062	- -	379.40	382.57	- -
B	11.125	11.375	- -	282.57	288.92	- -
D	3.437	3.562	- -	87.30	90.47	- -
E	5.937	6.062	- -	150.80	153.97	- -
F	6.437	6.562	- -	163.50	166.67	- -
G	11.937	12.062	- -	303.20	306.37	- -
H	20.400	21.120	- -	518.16	536.45	- -
J	6.250	6.375	- -	158.75	161.92	- -
K	0.750	0.875	- -	19.05	22.22	- -
L	2.437	2.562	- -	61.90	65.07	- -
M	4.062	4.187	- -	103.17	106.35	- -
N	5.000	5.125	- -	127.00	130.17	- -
U	- -	- -	11.000	- -	- -	279.40
V	- -	- -	0.375	- -	- -	9.52
W	- -	- -	22-1/2°	- -	- -	22-1/2°
X	- -	- -	60°	- -	- -	60°
Y	- -	- -	0.261	- -	- -	6.63
Z	- -	- -	0.219	- -	- -	5.56
AA	- -	- -	0.438	- -	- -	11.12

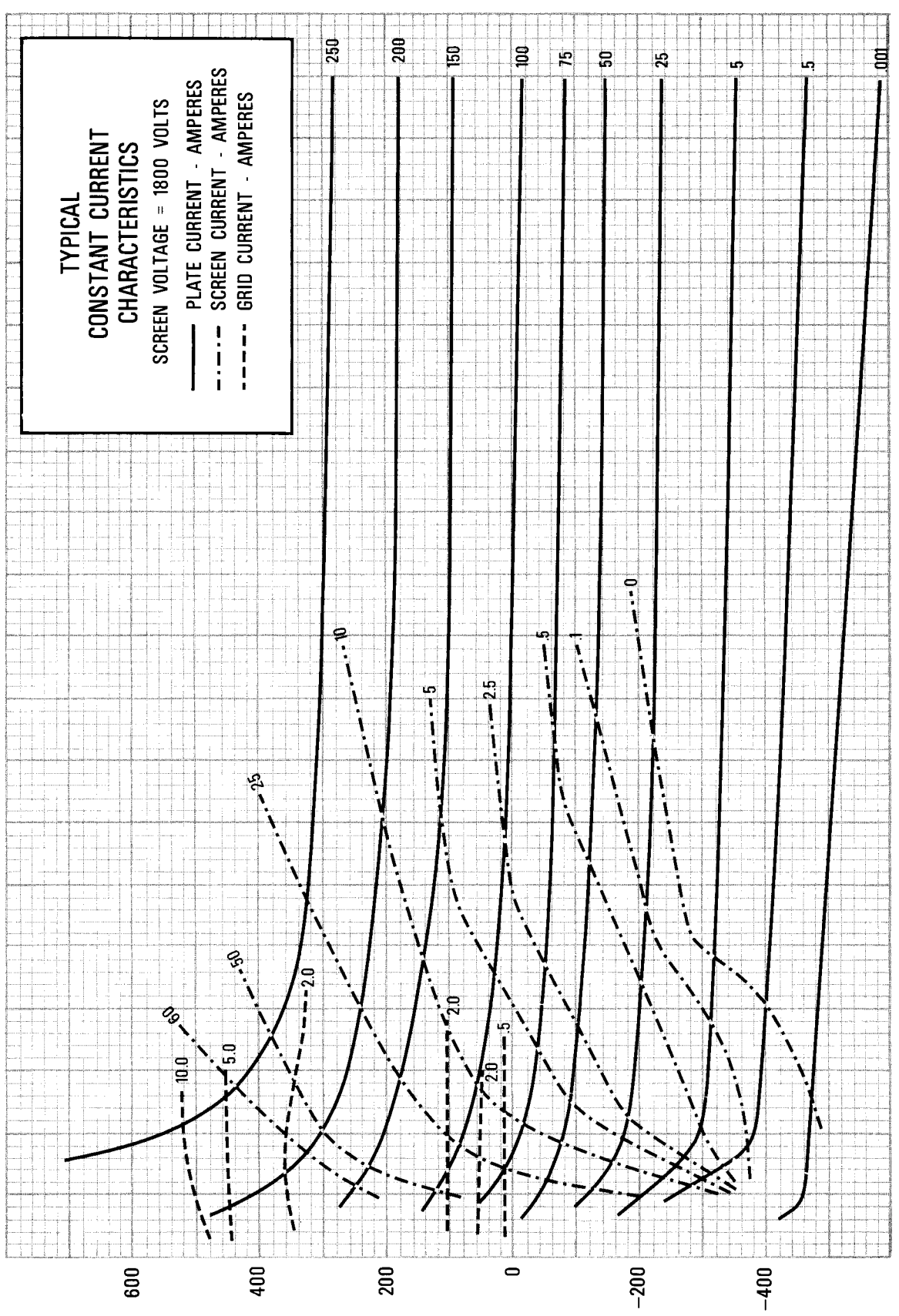
NOTES:
1. REF DIMENSIONS ARE FOR INFO. ONLY & ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. (*) CONTACT SURFACES.
3. AXIS OF "Y" HOLES TO BE ALIGNED WITH "V" HOLES WITHIN 15°
4. 'O'-RING, P/N 049172 N, 12 I.D. x 3/16 WALL, SUPPLIED WITH TUBE.

4CV250,000B

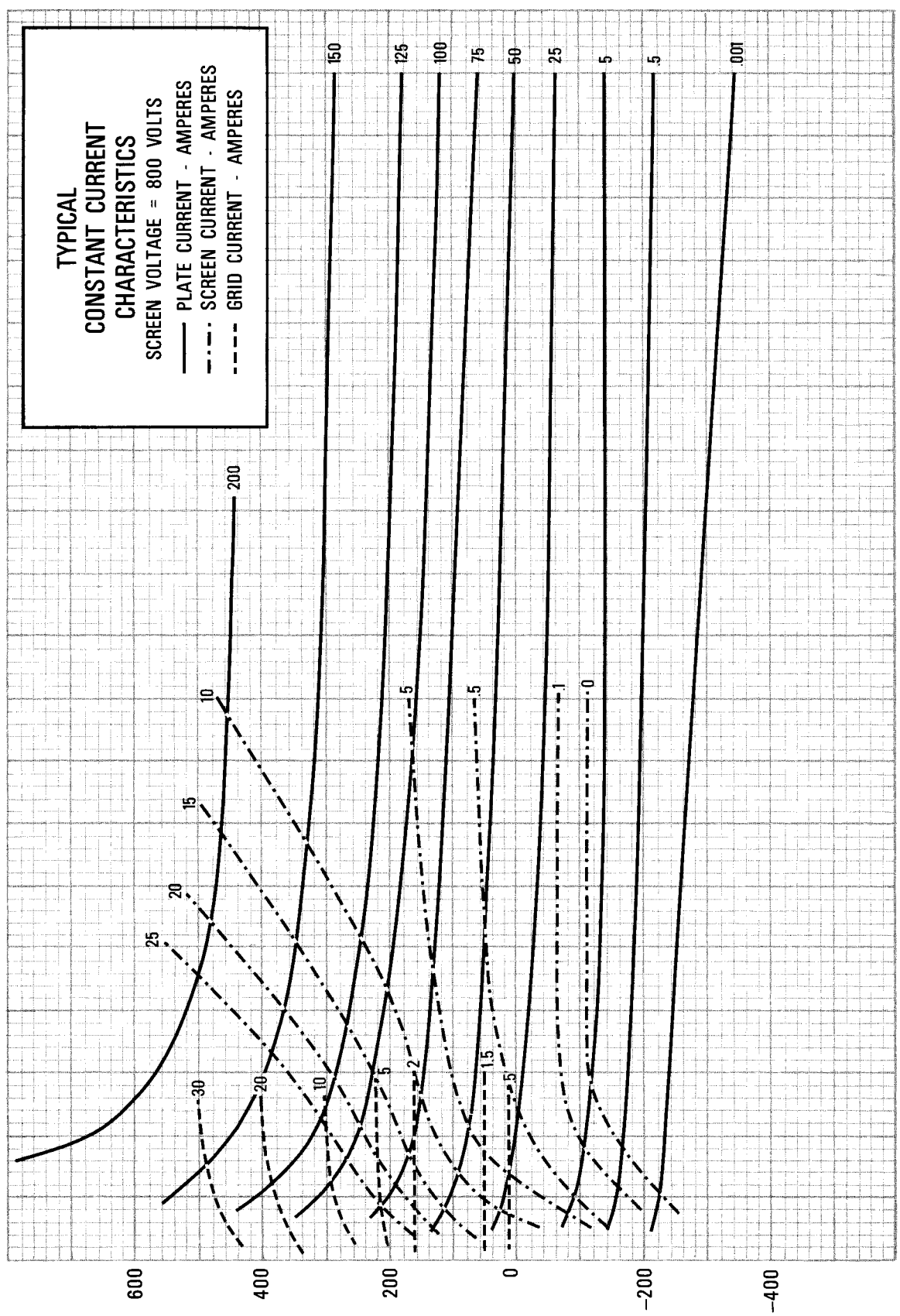



TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 1200 VOLTS
PLATE CURRENT – AMPERES
SCREEN CURRENT – AMPERES
GRID CURRENT – AMPERES
GRID VOLTAGE – VOLTS
600
400
200
0
–200
–400
0
1
2
3
4
5
6
7
8
9
10
PLATE VOLTAGE – KILOVOLTS
20
50
40
10
5
2.5
.500
200
150
100
75
50
25
5
.500
.001
20
10
5
2.5
.500
.100
0

CURVE #3285


TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 1800 VOLTS
PLATE CURRENT - AMPERES
SCREEN CURRENT - AMPERES
GRID CURRENT - AMPERES
250
200
150
100
75
50
25
5
.5
.001
10.0
5.0
2.0
.5
2.5
.1
0
GRID VOLTAGE - VOLTS
600
400
200
0
-200
-400
0
2
4
6
8
10
12
14
16
18
20
PLATE VOLTAGE - KILOVOLTS

CURVE #3464


TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 800 VOLTS
PLATE CURRENT - AMPERES
SCREEN CURRENT - AMPERES
GRID CURRENT - AMPERES
150
125
100
75
50
25
5
.5
.001
200
10
15
20
25
30
20
10
5
2
1.5
5
5
5
1
0
GRID VOLTAGE - VOLTS
600
400
200
0
-200
-400
0
2
4
6
8
10
12
14
16
18
20
PLATE VOLTAGE - KILOVOLTS
CURVE #3465