* 8973

WATER-COOLED POWER TETRODE

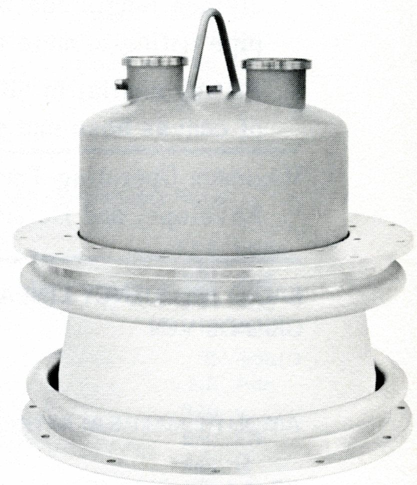
* Previous designation was X-2170

TECHNICAL DATA

The EIMAC 8973 is a ceramic/metal, water-cooled power tetrode designed for very-high-powered medium-frequency or high-frequency broadcast service and very-low-frequency communication in the half-megawatt power range.

The 8973 has a thoriated-tungsten mesh filament mounted on water-cooled supports. The maximum anode dissipation rating is 650 kilowatts steady state.

Large-diameter coaxial terminals are used for the control grid and the rf filament terminals. Filament power and filament support cooling-water connections are made through special couplings.



GENERAL CHARACTERISTICS[1]

ELECTRICAL

Filament: Thoriated-tungsten Mesh

Voltage	18.5 ± 0.9 V
Current at 18.5 V	650 A
Amplification Factor (Average), Grid to Screen	4.5

Direct Interelectrode Capacitance (grounded cathode):[2]

Cin	1000 pF
Cout	165 pF
Cgp	5 pF

Frequency of Operation: useful to 100 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 shown are nominal, measured with no special shielding.

MECHANICAL

Maximum Overall Dimensions:

Length	18.75 in; 47.62 cm
Diameter	17.03 in; 43.26 cm
Net Weight	153 lbs; 69.5 kg
Operating Position	Vertical, base down
Cooling	Water and Forced Air
Base Terminals	Special

(Effective 7-1-78) Printed in U.S.A.

Recommended Filament Connectors (not supplied with tube):

Filament Power/Water Connector (2 required)	EIMAC SK-2310
Filament rf Connector (1 required)	EIMAC SK-2315

Recommended Anode Cooling Water Connectors (not supplied with tube):

Note: 2 SK-2320 or SK-2321 connectors are required per tube.

Complete fitting, with knurled nut, replaceable electrolytic target, 20-inch length canvas hose, corona shield, and 2-1/2-inch female pipe fitting to mate to rigid pipe	EIMAC SK-2320
Fitting similar to SK-2320 but does not include the 20-inch length of canvas hose and pipe fitting	EIMAC SK-2321

Maximum Operating Temperature:

Envelope, and Ceramic/Metal Seals	200 °C

RADIO FREQUENCY LINEAR AMPLIFIER GRID DRIVEN
Class AB

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	22.5	KILOVOLTS
DC SCREEN VOLTAGE	2.5	KILOVOLTS
DC PLATE CURRENT	65	AMPERES
PLATE DISSIPATION	650	KILOWATTS
SCREEN DISSIPATION	7.5	KILOWATTS
GRID DISSIPATION	2.0	KILOWATTS

TYPICAL OPERATION (Frequencies to 30 MHz)
Class AB_1, Peak Envelope Conditions

Plate Voltage	20.0	kVdc
Screen Voltage	1500	Vdc
Grid Voltage [1]	-360	Vdc
Zero Signal Plate Current	10	Adc
Single Tone Plate Current	45	Adc
Single Tone Screen Current [2]	2.0	Adc
Peak rf Grid Voltage [2]	360	v
Plate Dissipation	250	kW
Plate Load Resistance	264	Ω
Plate Power Output	610	kW

1. Adjust to specified zero-signal plate current.
2. Approximate value.

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

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	22.5	KILOVOLTS
DC SCREEN VOLTAGE	2.5	KILOVOLTS
DC PLATE CURRENT	65	AMPERES
PLATE DISSIPATION	650	KILOWATTS
SCREEN DISSIPATION	7.5	KILOWATTS
GRID DISSIPATION	2.0	KILOWATTS

TYPICAL OPERATION (Frequencies to 30 MHz)

Plate Voltage	21.0	kVdc
Screen Voltage	2.5	Vdc
Grid Voltage	-600	Vdc
Plate Current	63	Adc
Screen Current [1]	9	Adc
Grid Current [1]	3.5	Adc
Calculated Driving Power	3.5	kW
Plate Dissipation [1]	273	kW
Plate Load Resistance	166	Ω
Plate Power Output	1050	kW

1. Approximate value.

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

ABSOLUTE MAXIMUM RATINGS

DC PLATE VOLTAGE	17.5	KILOVOLTS
DC SCREEN VOLTAGE	2.0	KILOVOLTS
DC PLATE CURRENT	50	AMPERES
PLATE DISSIPATION	400	KILOWATTS
SCREEN DISSIPATION	7.5	KILOWATTS
GRID DISSIPATION	2.0	KILOWATTS

TYPICAL OPERATION (Frequencies to 30 MHz)

Plate Voltage	17.5	kVdc
Screen Voltage	800	Vdc
Grid Voltage	-800	Vdc
Plate Current	50	Adc
Screen Current [1]	4	Adc
Grid Current [1]	2.2	Adc
Pk. Screen Voltage (100% Mod)	800	v
Pk. rf Grid Voltage	1060	v
Calculated Driving Power	2400	W
Plate Dissipation	175	kW
Plate Load Resistance	165	Ω
Plate Output Power	700	kW

1. Approximate value.

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR
Class AB

ABSOLUTE MAXIMUM RATINGS (per tube):

DC PLATE VOLTAGE	22.5	KILOVOLTS
DC SCREEN VOLTAGE	2.5	KILOVOLTS
DC PLATE CURRENT	65	AMPERES
PLATE DISSIPATION	650	KILOWATTS
SCREEN DISSIPATION	7.5	KILOWATTS
GRID DISSIPATION	2.0	KILOWATTS

1. Adjust for stated zero-signal plate current.
2. Approximate value.

TYPICAL OPERATION Two Tubes - Sinusoidal Wave

Plate Voltage	17.5	kVdc
Screen Voltage	1500	Vdc
Grid Voltage [1]	-400	Vdc
Zero Signal Plate Current	5	Adc
Max. Signal Plate Current	78	Adc
Max Signal Screen Current [2]	2.8	Adc
Pk. Audio Freq. Grid Voltage [3]	370	v
Max. Signal Plate Dissipation [3]	550	kW
Plate-Plate Load Resistance	444	Ω
Plate Output Power [4]	950	kW

3. Per Tube.
4. Suitable to modulate a carrier power of 1.25 Megawatts.

NOTE: TYPICAL OPERATION data are obtained by calculation from the published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, screen, and plate voltages is assumed. If this procedure is followed, there will be little variation in output power then the tube is changed, even though there may be some variation in grid and screen current. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current.

APPLICATION

MECHANICAL

MOUNTING - The 8973 must be mounted vertically, base down. The full weight of the tube should rest on the main screen-grid contact flange at the base of the tube, and all lifting of the tube should be done with the lifting eye which is attached to the top of the anode cooling jacket.

COOLING - 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. System pressure should not exceed 100 psi. 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 (at 25°C) or better for long-term operation. EIMAC Application Bulletin #16 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.

Anode Dissipation (kW)	Water Flow (gpm)	Apprx. Jacket Press. Drop (psi)
250	120	20
450	165	30
650	200	40

The tube base requires air cooling, with a minimum of 50 cfm of air at 50° C maximum at sea level, directed toward the base seal areas from a general purpose fan.

Water cooling of the filament and screen grid supports is also required, with inlet water temperature not to exceed 50° C. Each of the 2 filament connectors includes both an inlet and outlet line, with the proper section for the inlet water shown on the outline drawing. Minimum flow for the F1 connector is 2.0 gpm, at an approximate pressure drop of 12 psi. Minimum flow for the F2 connector is 4.0 gpm, at an approximate pressure drop of 50 psi. The screen grid cooling water is fed by means of 1/4-18 NPT tapped holes shown on the outline drawing, with a minimum flow of 2.0 gpm required, at an approximate pressure drop of 12 psi.

All cooling must be applied before or simultaneously with the application of electrode voltages, including the filament, and should be maintained for at least two minutes after all voltages are removed to allow for tube cooldown.

As regards base air cooling, temperatures of the ceramic/metal seals and the lower envelope areas are the controlling and final limiting factor. Temperature-sensitive paints are available for use in checking temperatures in these areas before equipment design and air-cooling arrangements are finalized.

ELECTRICAL

FILAMENT OPERATION - Filament turn-on and turn-off should be programmed in accordance with a special procedure. Filament voltage should be smoothly increased from zero to the operating level over a period of two minutes, and a motor-driven VARIAC or POWERSTAT is suggested. Inrush current must never be allowed to exceed twice the normal operating current. Turnoff procedure should be a smooth decrease from the operating voltage to zero over a period of two minutes, such as would be provided by a motor-driven VARIAC, POWERSTAT or solid-state regulator circuit.

Filament voltage should be measured at the tube base with an accurate meter. When operating at the nominal voltage, variations of ±5% are tolerable and should have little effect on the electrical performance of the tube. When very long life and consistent performance are factors, the filament voltage can often be reduced to a lower value than the nominal, but should be regulated and held to ±1% when this is done. To achieve a regulated voltage and still have it adjustable a typical procedure would involve a one-to-one regulating transformer feeding a variable-ratio transformer, which in turn feeds the filament transformer. The equipment is first operated with nominal filament voltage, and when stable operation is achieved the voltage is then reduced in small steps, until a point is reached where performance of the tube is clearly affected. The voltage is then raised a few tenths of a volt above this level for operation. Periodically the procedure should be repeated and the operating value of filament voltage readjusted if necessary. This value is normally 16.5 to 17.0 volts rms (initially).

Where hum is an important system consideration it may be necessary to operate the filaments with dc rather than ac power, or provide suitable hum-bucking circuits.

Care should be exercised to keep any rf power out of the filament of the tube, as this can cause excessive operating temperatures. A HEWLETT-PACKARD Vector Impedance meter is useful in detecting the presence of impedance that will support rf buildups in the filament "backcavity" circuit.

VACION PUMP OPERATION - The tube is supplied with an ion pump and magnet, mounted inside the filament structure at the base (stem). A power supply (Varian Part #921-0015) and 8-foot cable (Varian Part #924-0020) are required for operation.

It is reommended that the VACION pump be operated continuously if possible; otherwise it should be operated at least once a year until the indicator meter shows 1.0 μA or less of current.

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, load variation, or manufacturing variations in the equipment itself. It does not necessarily follow that combinations of absolute maximum ratings can be attained simultaneously.

GRID OPERATION - The 8973 control grid is rated at 2000 watts of dissipation. Protective measures should be included in the circuitry to insure that this rating is not exceeded. Control grid dissipation is the approximate product of the dc grid current and peak positive grid voltage.

SCREEN GRID OPERATION - Base cooling (air and water) must be on and at the correct level before tube operation is started. The power applied to the screen grid must not exceed 7500 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 voltage, plate load, or grid bias voltage must never be removed while filament and screen voltages are present since the screen dissipation rating will be exceeded. Suitable protective circuitry must be provided to remove screen power in case of such a fault condition. Tetrode tubes may exhibit reversed screen current to a greater or lesser degree depending on individual tube design and operating conditions. The screen supply voltage must be maintained constant for any values of negative or positive screen currents that may be encountered. Dangerously high plate currents may flow if the screen power supply exhibits a rising voltage characteristic with negative screen current. Stabilization may be accomplished by use of a shunt regulator circuit in the screen voltage supply, bleeder resistors, or other suitable techniques.

PLATE OPERATION - The maximum dissipation rating of the 8973 is 650 kilowatts with water cooling. When used as a plate-modulated rf amplifier, plate dissipation under carrier conditions is limited to 400 kilowatts.

Specified anode dissipation ratings assume 10 kilovolts maximum anode voltage during conduction. If full rated dissipation at a tube drop greater than this value for periods greater than 200 milliseconds is desired, contact EIMAC's Power Grid Tube Application Engineering Office.

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 of 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, which should be approximately inches long. 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 should 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.

HIGH VOLTAGE - Normal operating voltages used with the 8973 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 supplies 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.

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.

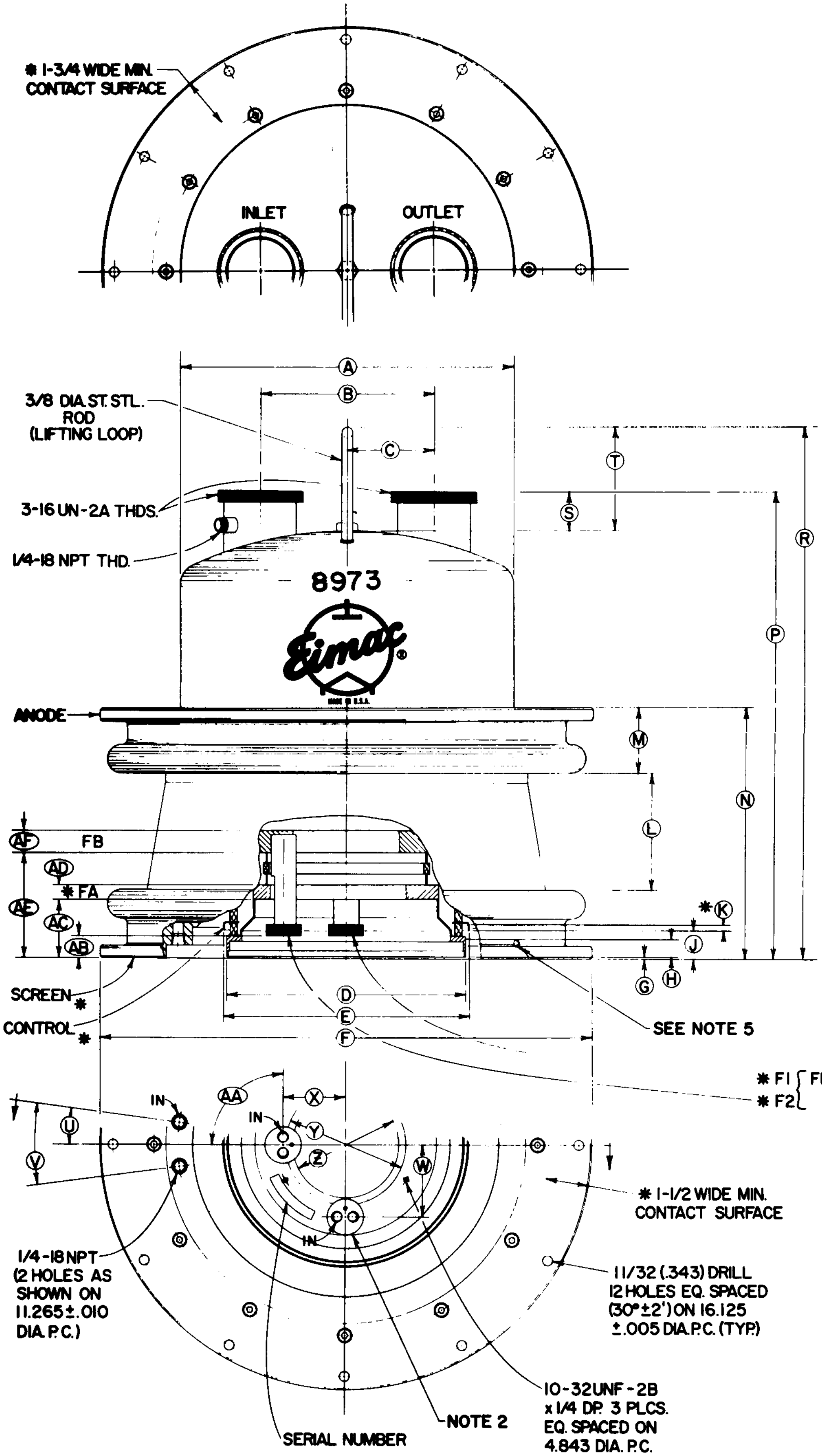
X-RADIATION - High-vacuum tubes operating at voltages in excess of 15 kilovolts produce progressively more dangerous X-Radiation as the voltage is increased. The 8973, operating at its rated voltages and currents, is a potential X-Ray hazard. Only limited shielding is afforded by the tube envelope. Moreover, the X-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-Radiation 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-Radiation, is available for viewing windows. If there is any doubt as to the requirements for or the adequacy of shielding, an expert in this field should be contacted to perform an X-Radiation 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-Radiation exposure.

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 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.

ELECTRODE RF TUNING CHARACTERISTICS - Typical electrode tuning characteristics may be obtained by contacting the EIMAC Power Grid Tube Application Engineering Office.

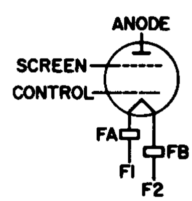
SPECIAL APPLICATIONS - Where it is desired to operate this tube under conditions widely different from those listed here, write to: Product Line Manager, High Power Tubes, Varian EIMAC Division, 301 Industrial Way, San Carlos, CA 94070.



DIMENSIONAL DATA						
DIM	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	11.440	11.560	- -	290.6	293.6	- -
B	- -	- -	6.000	- -	- -	152.4
C	- -	- -	3.000	- -	- -	76.2
D	8.235	8.265	- -	209.2	209.9	- -
E	8.485	8.525	- -	215.5	216.5	- -
F	16.970	17.030	- -	431.0	432.6	- -
G	- -	- -	0.025	- -	- -	0.63
H	0.310	- -	- -	7.9	- -	- -
J	0.900	1.000	- -	22.9	25.4	- -
K	0.180	- -	- -	4.6	- -	- -
L	- -	- -	4.093	- -	- -	104.0
M	- -	- -	2.375	- -	- -	60.3
N	8.700	8.900	- -	221.0	226.0	- -
P	16.250	16.500	- -	412.7	419.1	- -
R	18.500	18.750	- -	469.9	476.2	- -
S	- -	- -	1.375	- -	- -	34.9
T	- -	- -	3.575	- -	- -	90.8
U	- -	- -	7-1/2°	- -	- -	7-1/2°
V	- -	- -	15°	- -	- -	15°
W	- -	- -	2.500	- -	- -	63.5
X	- -	- -	2.156	- -	- -	54.8
Y	4.113	4.137	- -	104.5	105.1	- -
Z	3.675	3.699	- -	93.3	93.9	- -
AA	- -	- -	90°	- -	- -	90°
AB	- -	- -	0.720	- -	- -	18.3
AC	1.950	2.100	- -	49.5	53.3	- -
AD	0.450	- -	- -	11.4	- -	- -
AE	3.560	3.680	- -	90.4	93.5	- -
AF	0.725	- -	- -	18.4	- -	- -

NOTES:

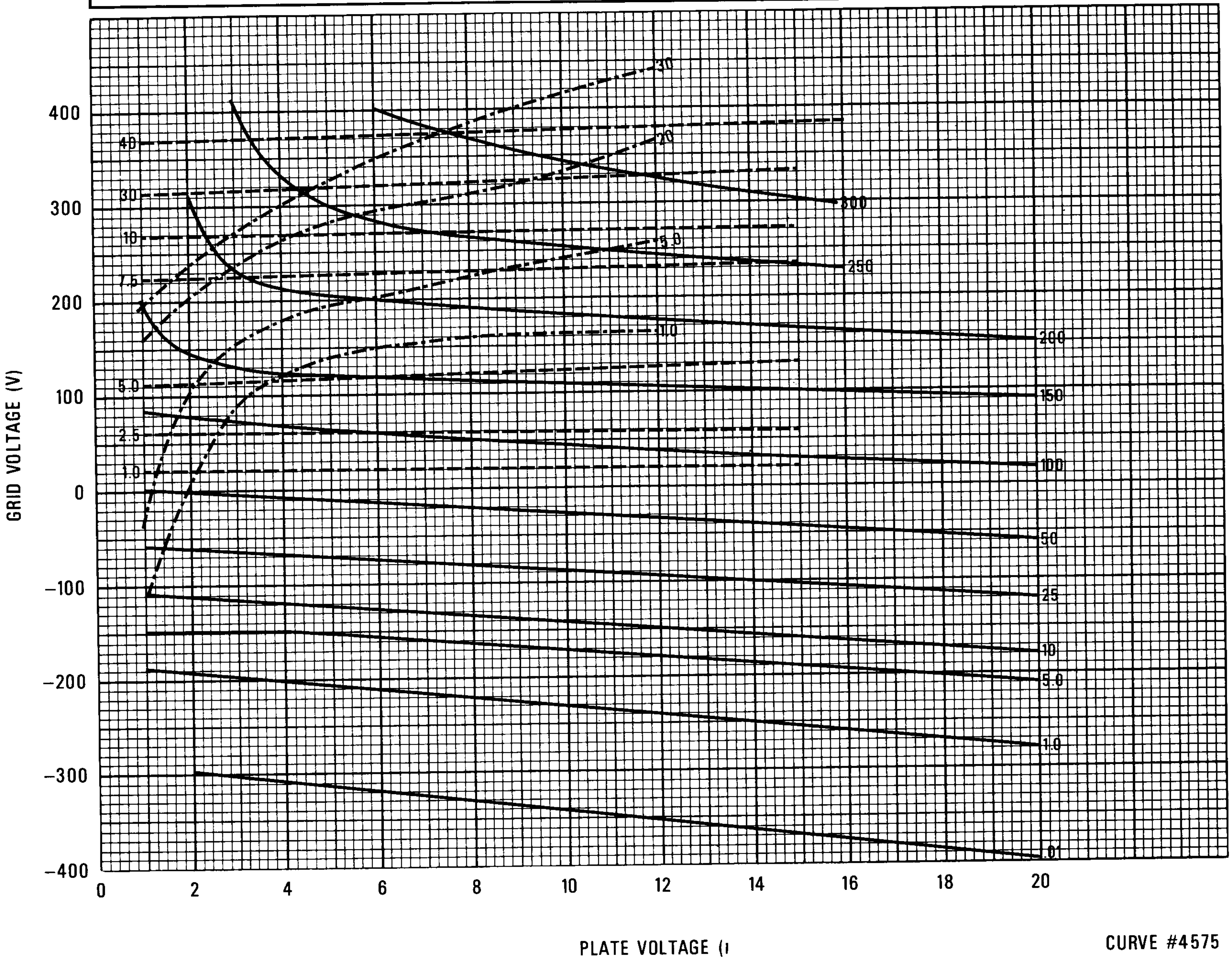
1. CIRCUIT RETURN MAY BE MADE TO FA BY SK-2315 CONNECTOR.
2. MATE WITH EIMAC CONNECTOR SK-2310 (2 Reqd.).
3. REF. DIMENSIONS ARE FOR INFO. ONLY AND ARE NOT REQUIRED FOR INSPECTION PURPOSES.
4. (*) CONTACT SURFACES.
5. 1/4 DIA. WATER DRAIN HOLES - 3 PLACES.



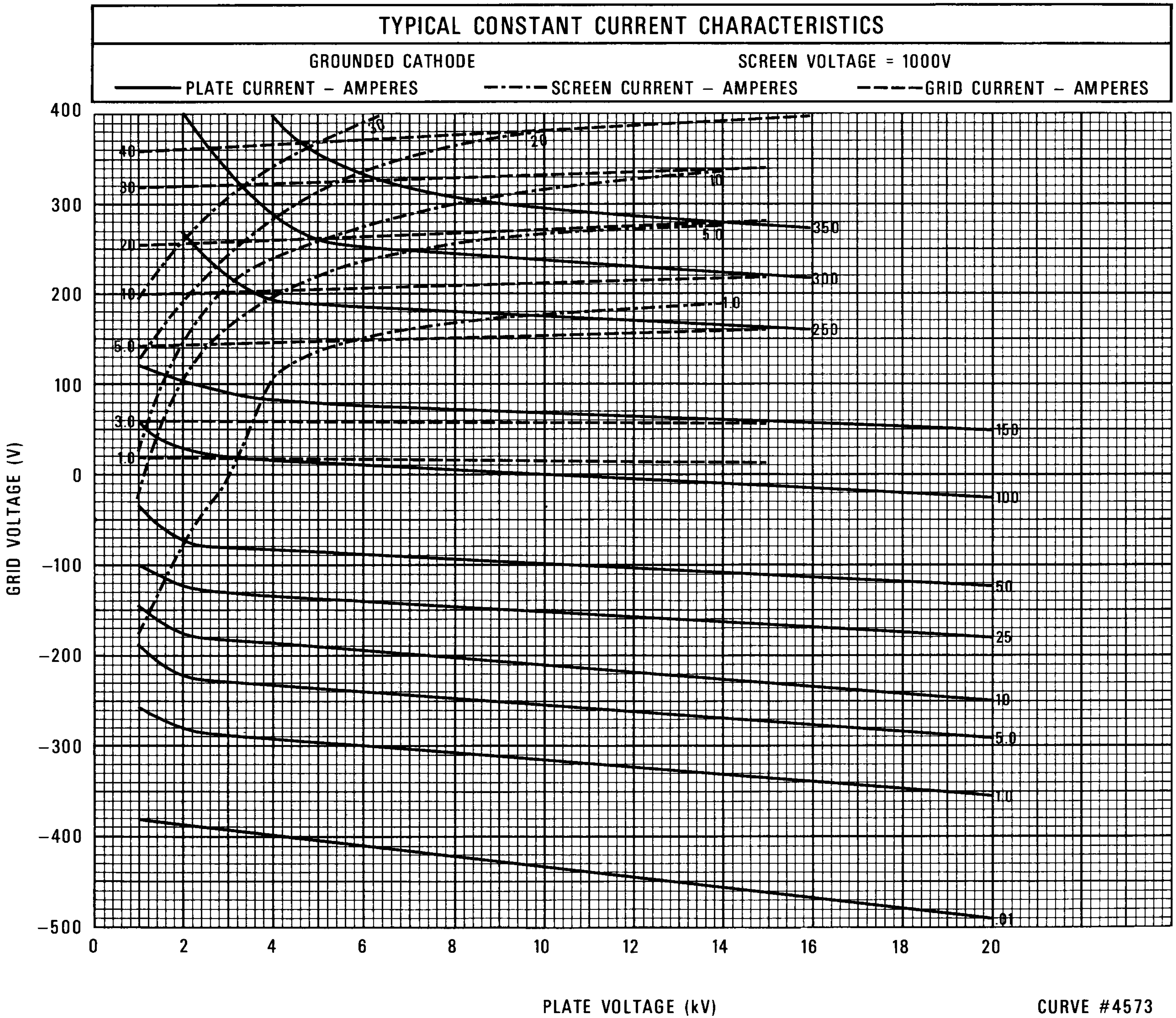
TYPICAL CONSTANT CURRENT CHARACTERISTICS

GROUNDED CATHODE   SCREEN VOLTAGE = 750V

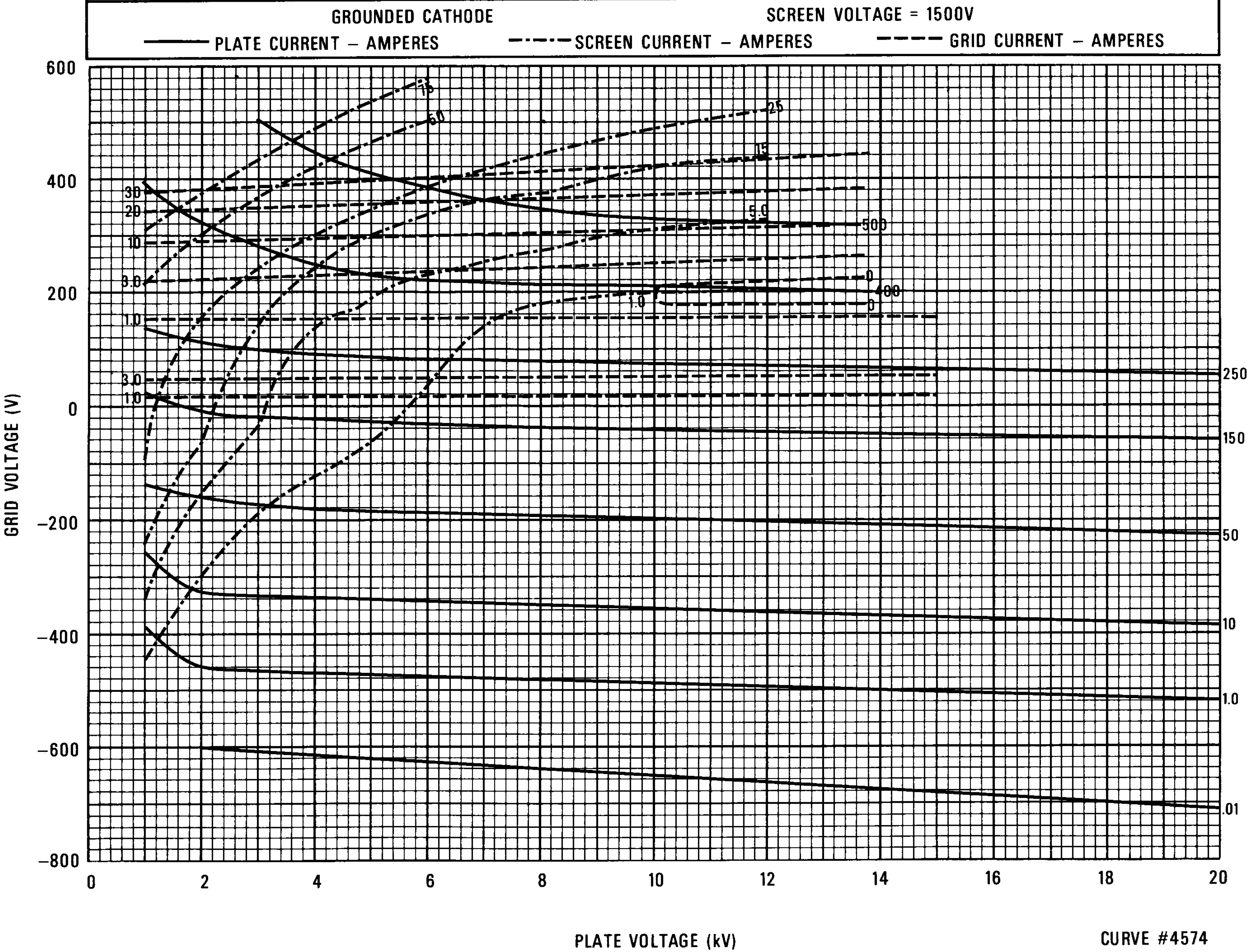
——— PLATE CURRENT – AMPERES   —·—·— SCREEN CURRENT – AMPERES   – – – – GRID CURRENT – AMPERES



CURVE #4575


TYPICAL CONSTANT CURRENT CHARACTERISTICS
GROUNDED CATHODE
SCREEN VOLTAGE = 1000V
PLATE CURRENT – AMPERES
SCREEN CURRENT – AMPERES
GRID CURRENT – AMPERES
GRID VOLTAGE (V)
400
300
200
100
0
–100
–200
–300
–400
–500
PLATE VOLTAGE (kV)
0
2
4
6
8
10
12
14
16
18
20
350
300
250
150
100
50
25
10
5.0
1.0
.01
40
30
20
10
5.0
3.0
1.0
CURVE #4573

TYPICAL CONSTANT CURRENT CHARACTERISTICS

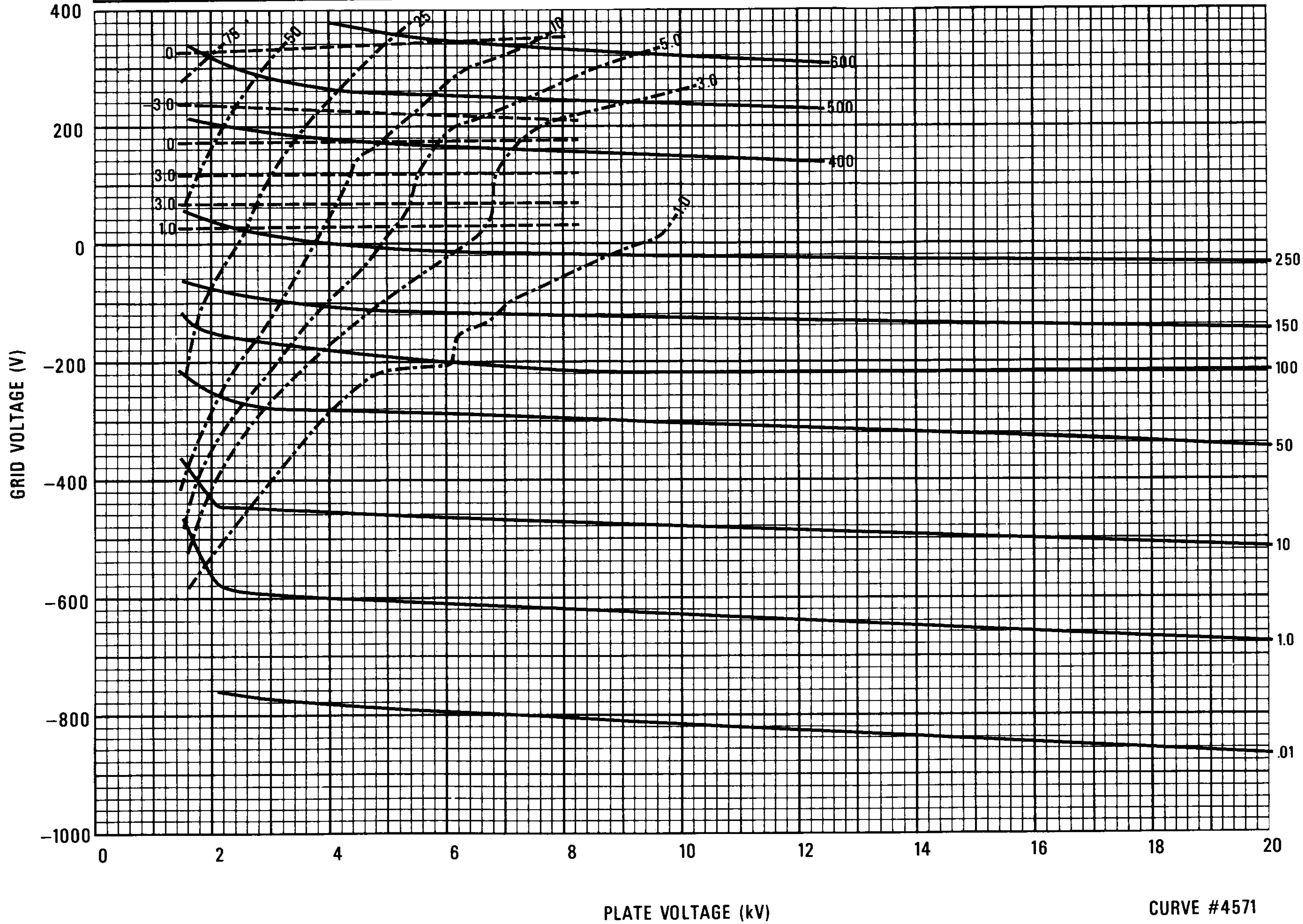


TYPICAL CONSTANT CURRENT CHARACTERISTICS

GROUNDED CATHODE

SCREEN VOLTAGE = 2000V

——— PLATE CURRENT – AMPERES —·—·— SCREEN CURRENT – AMPERES – – – – GRID CURRENT – AMPERES



CURVE #4571