TECHNICAL DATA

8963

HIGH-MU VHF TRANSMITTING TRIODE

The EIMAC 8963 is a ceramic/metal high-mu triode designed especially for use in the VHF spectrum as a cathode-driven Class AB rf amplifier or Class C power amplifier and for pulsed rf amplifier or modulator service.

The 8963 makes use of beam-forming cathode and control grid geometry to produce high gain, low grid interception, and zero-bias operation capability in linear-amplifier service. In a typical VHF television amplifier application 25 kW of useful output (Sync level) is obtained with a bandwidth (1 dB) of 6 MHz with a stage gain of 15 dB.

The 8963 has coaxial terminals for which contact collets are available from EIMAC. The tube is forced-air cooled with an anode dissipation rating of 20,000 watts.

GENERAL CHARACTERISTICS[1]

ELECTRICAL

Cathode: Oxide-Coated, Unipotential		
Heater Voltage	16.0 ± 0.8	V
Heater Current, at 16.0 volts	13.0	A
Amplification Factor (Average)	260	
Transconductance, average (I_b = 2.0 Adc)	90,000	μmhos
Direct Interelectrode Capacitances (grid grounded) [2]		
Cin	79	pF
Cout	21	pF
Cpk	0.1	pF
Frequency of Maximum Rating:		
CW	260	MHz
Pulsed	500	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 in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

MECHANICAL

Overall Dimensions:		
Length	6.700 In; 170	mm
Diameter	9.175 In; 233	mm
Net Weight	21.5 lb; 9.7	kg

Printed in U.S.A.

Operating Position	Any
Maximum Operating Temperature: Base seals & envelope	250°C
Anode Core	275°C
Cooling	Forced Air
Base	Special Coaxial

Recommended Contact Collets:

Tube Element	EIMAC Part No.
Heater	154373
Heater-Cathode	154374
Grid	154375
Anode	154376

RADIO FREQUENCY LINEAR AMPLIFIER CATHODE DRIVEN

Class AB

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	10,000 VOLTS
DC PLATE CURRENT	5.0 AMPERES
PLATE DISSIPATION	20,000 WATTS
GRID DISSIPATION	100 WATTS

1. Approximate value.
2. Adjust to obtain specified value.

TYPICAL OPERATION (Frequencies to 260 MHz)
Class

Plate Voltage	8000 Vdc
Grid Voltage	0 Vdc
Zero-Signal Plate Current[1]	1.8 Adc
Single-Tone Plate Current[2]	5.0 Adc
Single-Tone Grid Current[1]	36 mAdc
Driving Power[1]	498 W
Plate Dissipation	14.0 kW
Single-Tone Plate Output Power	26.0 kW
Resonant Load Impedance	850 Ω
Drive Impedance (Resistive component)	15.9 Ω

RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR GRID DRIVEN

Class C Telegraphy or FM

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	10,000 VOLTS
DC GRID VOLTAGE	-300 VOLTS
DC PLATE CURRENT	5.0 AMPERES
PLATE DISSIPATION	20,000 WATTS
GRID DISSIPATION	100 WATTS

1. Approximate value.
2. Adjust to obtain specified value.

TYPICAL OPERATION

Plate Voltage	9000 Vdc
Grid Voltage	-100 Vdc
Plate Current[2]	4.9 Adc
Grid Current[1]	290 mAdc
Peak rf Grid Voltage[1]	260 v
Calculated Driving Power[1]	77 W
Plate Input Power	43.9 kW
Plate Dissipation[1]	10.5 kW
Plate Output Power[1]	33.4 kW
Resonant Load Impedance	933 Ω

RADIO FREQUENCY POWER AMPLIFIER CATHODE DRIVEN

Class C-Telegraphy or FM

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	10,000 VOLTS
DC GRID VOLTAGE	-300 VOLTS
DC PLATE CURRENT	5.0 AMPERES
PLATE DISSIPATION	20,000 WATTS
GRID DISSIPATION	100 WATTS

1. Approximate value.

TYPICAL OPERATION

Plate Voltage	7500 Vdc
Grid-to-Cathode Voltage	-80 Vdc
Plate Current	4.7 Adc
Grid Current[1]	425 mAdc
Peak rf Cathode Voltage	240 v
Cathode Driving Power[1]	1070 W
Plate Dissipation[1]	7.78 kW
Plate Load Resistance	830 Ω
Plate Output Power[1]	27.5 kW

RADIO FREQUENCY POWER AMPLIFIER
CATHODE DRIVEN Class B Television Service

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	10,000 VOLTS
DC PLATE CURRENT	5.0 AMPERES
PLATE DISSIPATION	20,000 WATTS
GRID DISSIPATION	100 WATTS

1. Approximate value.

TYPICAL OPERATION (Frequencies to 260 MHz)
Class B

Plate Voltage	7500 Vdc
Grid Voltage	0 Vdc
Zero-Signal Plate Current[1]	1.8 Adc
Effective rf Load Resistance	670 Ω
Plate Current: Blanking Level	4.43 Adc
Sync. Peak Level	5.75 Adc
Grid Current: Blanking Level[1]	17 mAdc
Sync. Peak Level[1]	30 mAdc
rf Cathode Voltage Peak: Blanking Level[1]	130 v
Sync. Peak Level[1]	150 v
Driving Power: Blanking Level[1]	398 w
Sync. Peak Level[1]	687 w
Plate Power Output: Blanking Level	16.5 kw
Sync. Peak Level	27.5 kw

SWITCH TUBE OR PULSED REGULATOR SERVICE
GRID DRIVEN

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	18,000 VOLTS
DC GRID VOLTAGE	-300 VOLTS
PEAK PLATE CURRENT[2]	100 AMPERES
PLATE DISSIPATION[1]	20,000 WATTS
GRID DISSIPATION[1]	100 WATTS
PULSE LENGTH	See Note 2
DUTY FACTOR	See Note 2

1. Dissipation values shown are average.
2. Pulse length, peak current, and duty are inter-related. See PULSE DERATING CHART.

PULSED RADIO FREQUENCY POWER AMPLIFIER
Class C - **CATHODE DRIVEN**

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	10,000 VOLTS
DC GRID VOLTAGE	-300 VOLTS
PLATE CURRENT[2]	50 AMPERES
PLATE DISSIPATION[1]	20,000 WATTS
GRID DISSIPATION[1]	100 WATTS
PULSE LENGTH	See Note 2
DUTY FACTOR	See Note 2

1. Dissipation values shown are average.
2. Pulse length, peak current, and duty are inter-related. See PULSE DERATING CHART. The anode current values shown are average during the pulse.

NOTE: TYPICAL OPERATION data are obtained by calculation from published characteristic curves or actual measurement. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid current. The grid current which the desired plate current is obtained is incidental and varies 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.

RANGE VALUES FOR EQUIPMENT DESIGN	Min.	Max.	
Heater Current, at 16.0 volts	12.0	14.0	A
Cathode Warmup Time	3.0	---	Min.
Interelectrode Capacitances (grid grounded)[1]			
Cin	75.0	84.0	pF
Cout	19.0	23.0	pF
Cpk	---	0.15	pF

1. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

APPLICATION

MOUNTING & SOCKETING - Part numbers of available EIMAC collets are listed under MECHANICAL. These collets may be soft-soldered to appropriate VHF line or cavity elements. The collets provide low-inductance connections between tube and circuitry and serve to draw off a portion of the heat released during normal operation. The tube may be mounted in any position, at the convenience of the equipment designer.

HEATER-CATHODE OPERATION - The nominal heater voltage for the 8963 is 16.0 volts and should normally be held within plus or minus five percent of this value for good life and stable performance. Regulation to a tolerance better than ±5% normally will be beneficial as regards life expectancy, and if variation can be held to ±1% then the voltage can be reduced to as low as 15.2 volts, for greatest life expectancy. When this is done, however, voltage should be set and monitored with a (true rms-responding type) voltmeter of high accuracy.

For pulse service, the full nominal value of 16.0 volts should be used on the heater.

The oxide coated unipotential cathode must be protected against excessively high emission current. The maximum rated dc input current (anode) is 5.0 Adc for all types of operation except pulse. Rated heater voltage should be applied for a minimum of 3 minutes before other operating voltages are applied. If reduced heater voltage is being used, with close voltage regulation, a warmup time of longer than 3 minutes should be allowed.

INTERLOCKS - An interlock device should be provided to insure that cooling air flow is established before application of electrical power, including the heater. The circuit should be so arranged that rf drive cannot be applied in the absence of normal plate voltage.

COOLING - The maximum temperature rating for the base seals and envelope of the 8963 is 250°C, and for the anode core 275°C. Sufficient forced-air cooling must be provided so these ratings are not exceeded. Minimum air flow requirements, for 35°C inlet air, at sea level and at 10,000 feet elevation, are shown in the table, for air flowing in a base-to-anode direction. The pressure drop values shown are for the anode cooler only and do not include any losses which may occur with any specific chimney or socketing arrangement. In cases where the tube base is not directly in the anode cooling air stream, special provision must be made for separate base cooling.

Air cooling should be applied before or simultaneously with the application of heater voltage and should normally be maintained for a short period of time after all voltages are removed to allow for tube cool-down. Where long life and consistent performance are factors, cooling in excess of minimum requirements is normally beneficial.

SEA LEVEL		
Dissipation Anode kW	Air Flow CFM	Approx. Press. Drop, In. H_2O
12.0	250	0.45
14.0	365	1.0
16.0	505	1.8
18.0	650	2.8
20.0	820	4.1
10,000 FEET ALT.		
12.0	365	0.66
14.0	533	1.5
16.0	740	2.6
18.0	950	4.1
20.0	1200	6.0

INPUT CIRCUIT - When the 8963 is operated as a grounded-grid rf amplifier, the use of a matching network in the cathode circuit is recommended. For best results with a single-ended amplifier, and depending on the application, it is suggested the network have a "Q" of at least 2, and higher if possible.

X-RADIATION HAZARD - High-vacuum tubes operating at voltages higher than 10 kilovolts produce progressively more dangerous X-radiation as the voltage is increased. The 8963, operating at the voltage and current levels for which it is rated as a switch tube or pulsed regulator, 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 effected by the high voltage. X-ray shielding may be required on all sides of the tube to provide protection throughout its life, and periodic checks on the X-ray level should be made. 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. If it has been determined that shielding is normally required, the equipment should never be operated with interlock switches "cheated" and cabinet doors open in order to be better able to locate an equipment malfunction as X-ray exposure may result.

FAULT PROTECTION - In addition to normal cooling airflow interlock and plate over-current interlock it is good practice to protect the tube from internal damage which could result from occasional plate arcing at high plate voltage.

In all cases some protective resistance, at least 10 ohms, should be used in series with the tube anode to absorb power supply stored energy in case a plate arc should occur. In pulse service, where stored energy is high, it is recommended that some form of electronic crowbar be used which will discharge power supply capacitors in as short a time as possible following indication of start of a plate arc.

HIGH VOLTAGE - Normal operating voltages used with the 8963 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.

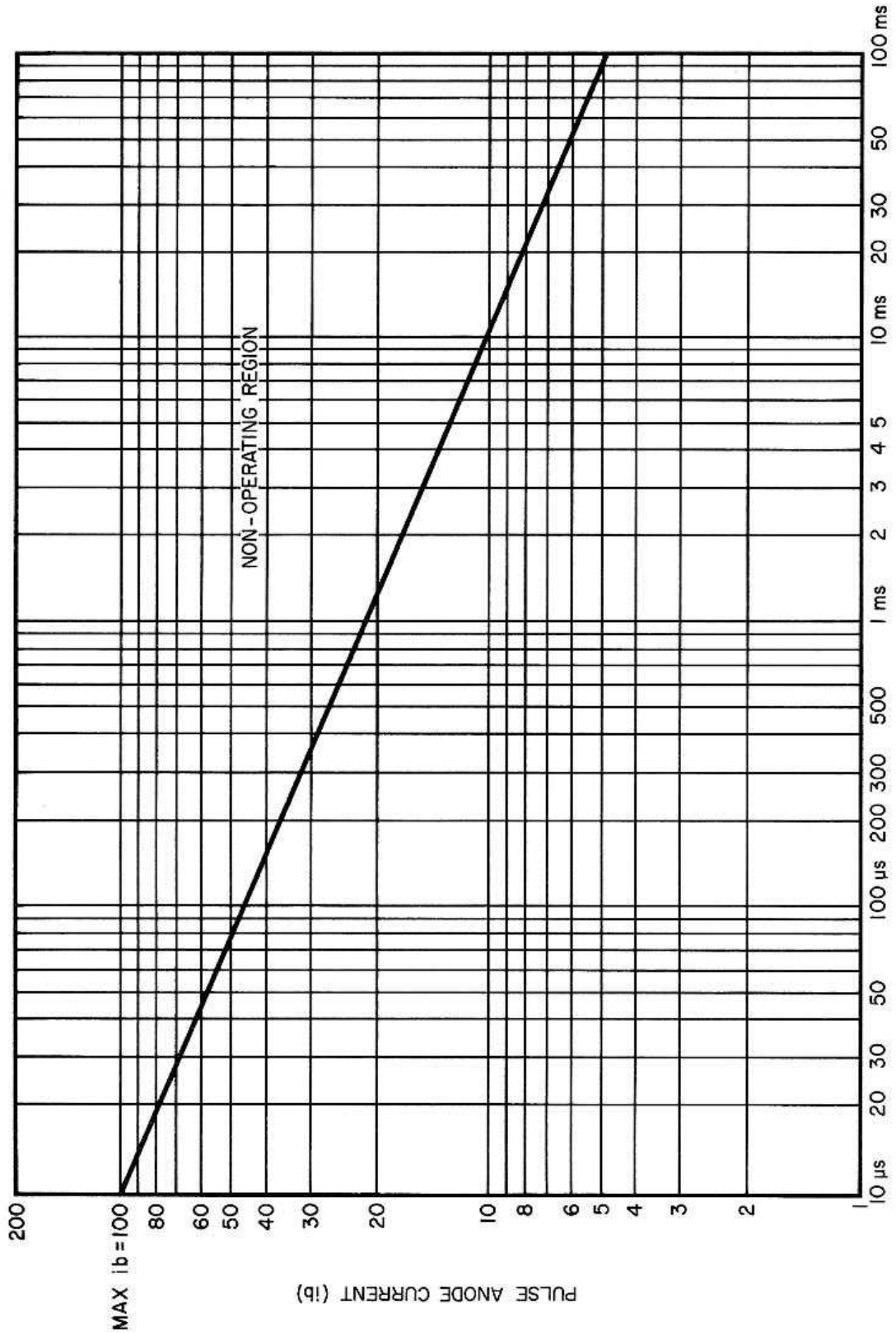
INTERELECTRODE CAPACITANCE - The actual internal interelectrode capacitance of a tube is influenced by many variables in most applications, such as stray capacitance to the chassis, capacitance added by the socket used, stray capacitance between tube terminals, and wiring effects. To control the actual capacitance values within the tube, as the key component involved, the industry and the 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 eliminates 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.

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.

Many EIMAC power tubes, such as the 8963, are specifically designed to generate or amplify radio frequency power. There may be a relatively strong rf field in the general proximity of the power tube and its associated circuitry--- the more power involved, the stronger the rf field. Proper enclosure design and efficient coupling of rf energy to the load will minimize the rf field in the vicinity of the power amplifier unit itself.

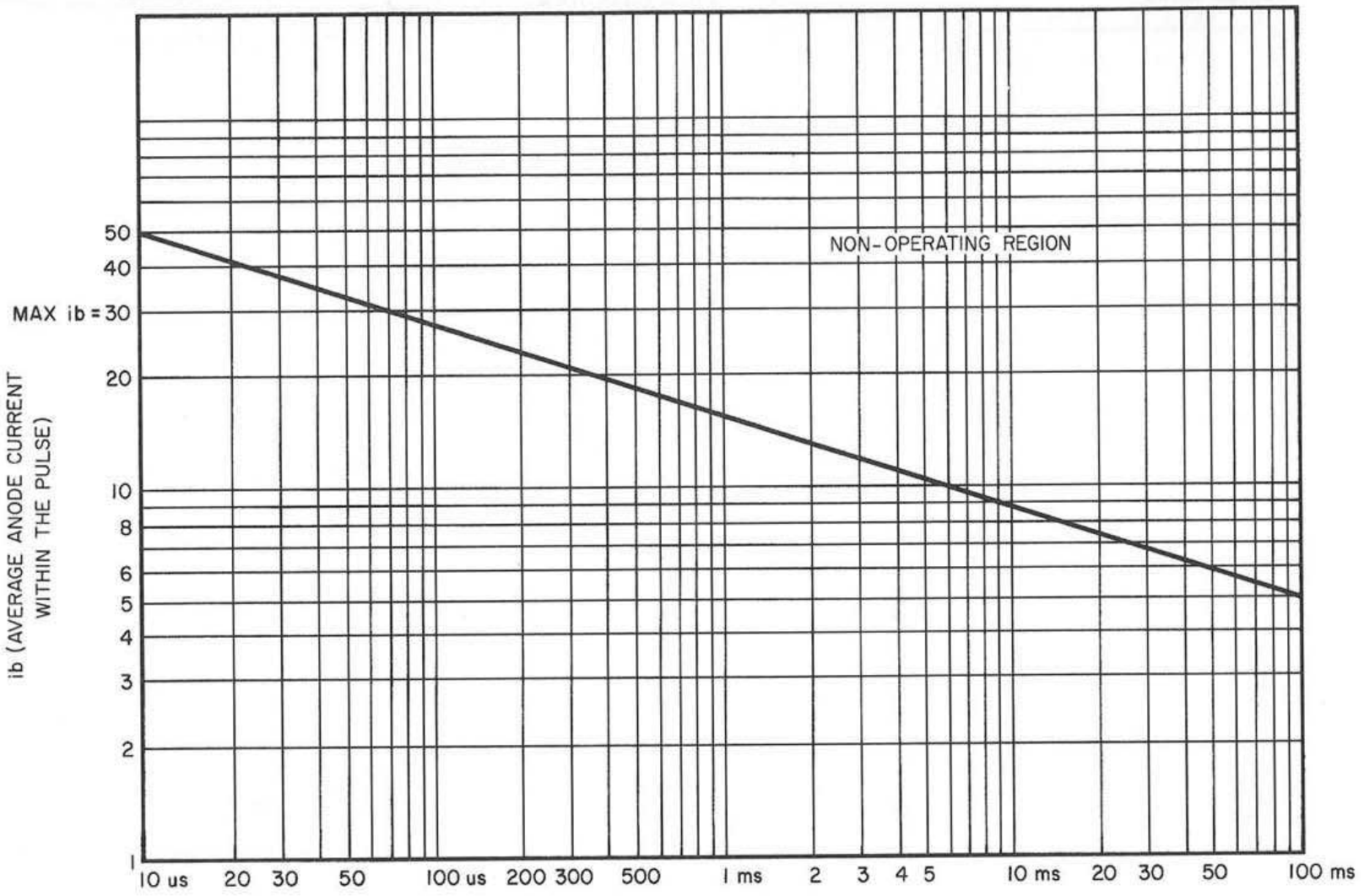
SPECIAL APPLICATIONS - For information on complete UHF-TV cavity amplifier assemblies, or if it is desired to operate this tube under conditions widely different from those given here, write to the Application Engineering Dept., Power Grid Tube Division, EIMAC, Division of Varian, 301 Industrial Way, San Carlos, California, 94070 for recommendations.



Note: Pulse Anode Current (ib) capability is dependent on pulse length (tp) and Duty Factor (Du). Maximum ib for any given tp is shown; maximum Du may then be derived from:

$$5.0 = ib\sqrt{Du}$$

PULSE DERATING CHART, TYPE 8963 - SWITCH TUBE OR PULSE MODULATOR SERVICE



Note: Pulse Anode Current (ib) capability is dependent on pulse length (tp) and Duty Factor (Du). Maximum ib for any given tp is shown; maximum Du may then be derived from:

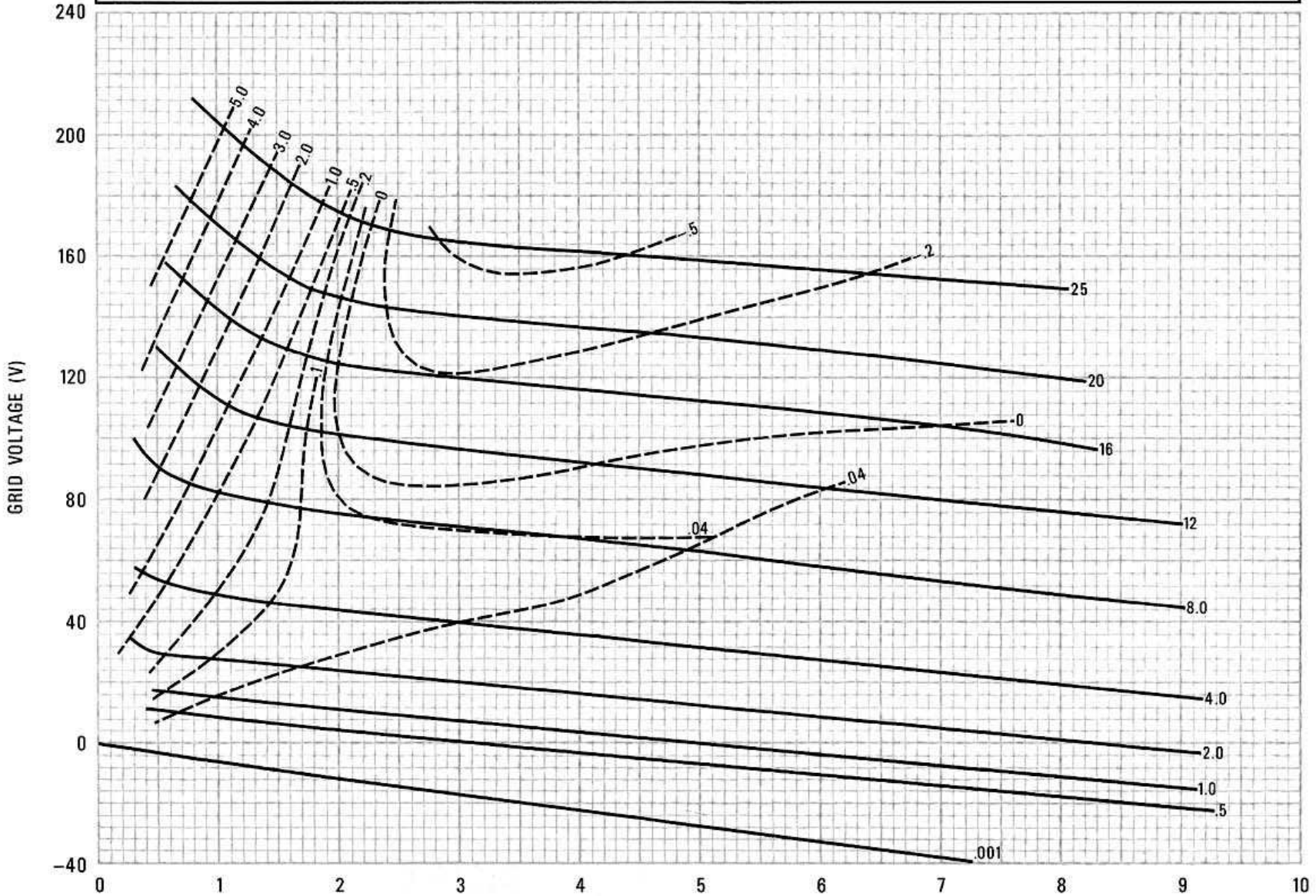
$$5.0 = ib\sqrt{Du}$$

PULSE DERATING CHART, TYPE 8963 - PULSED RF AMPLIFIER SERVICE

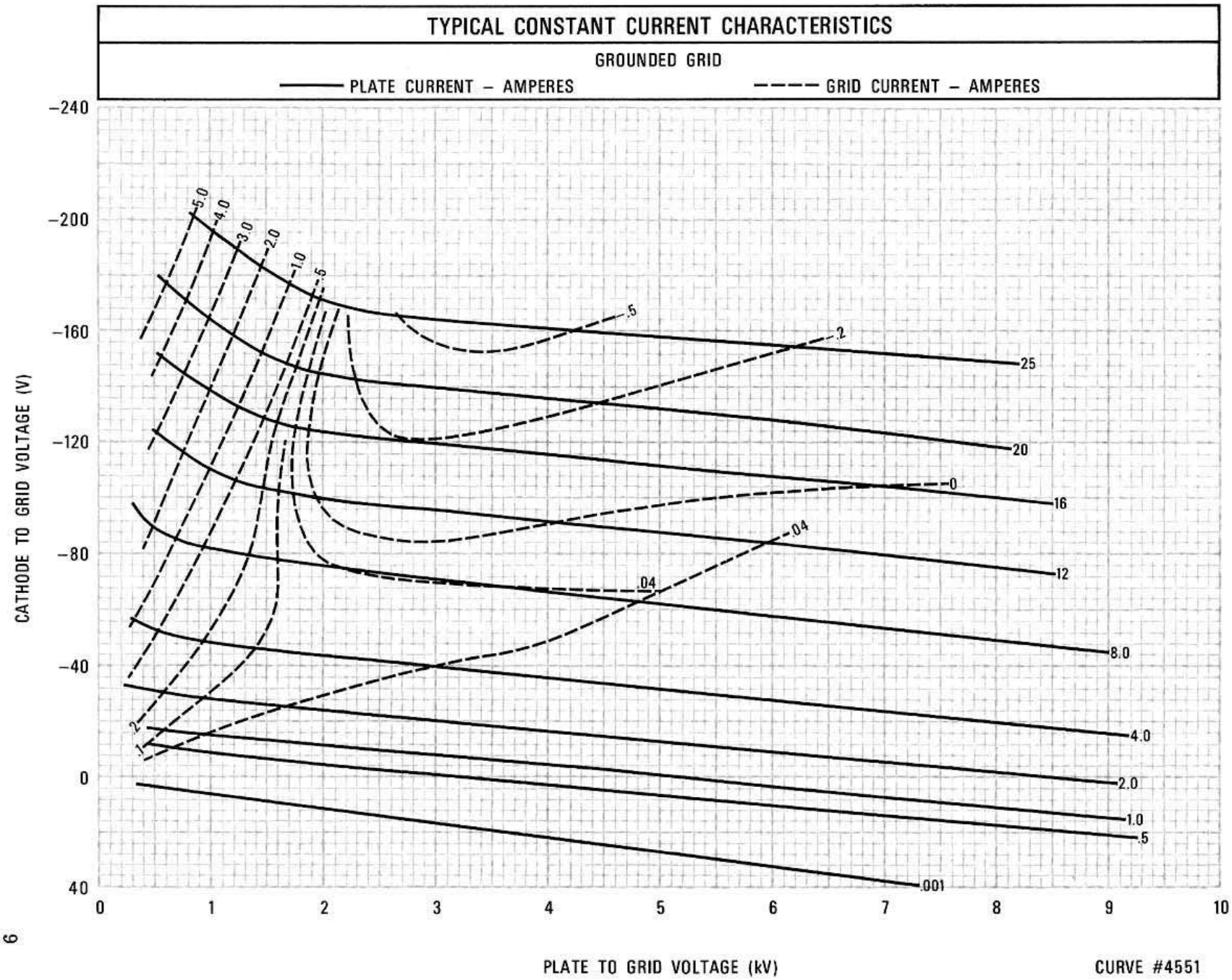
TYPICAL CONSTANT CURRENT CHARACTERISTICS

GROUNDED CATHODE

——— PLATE CURRENT – AMPERES – – – – GRID CURRENT – AMPERES



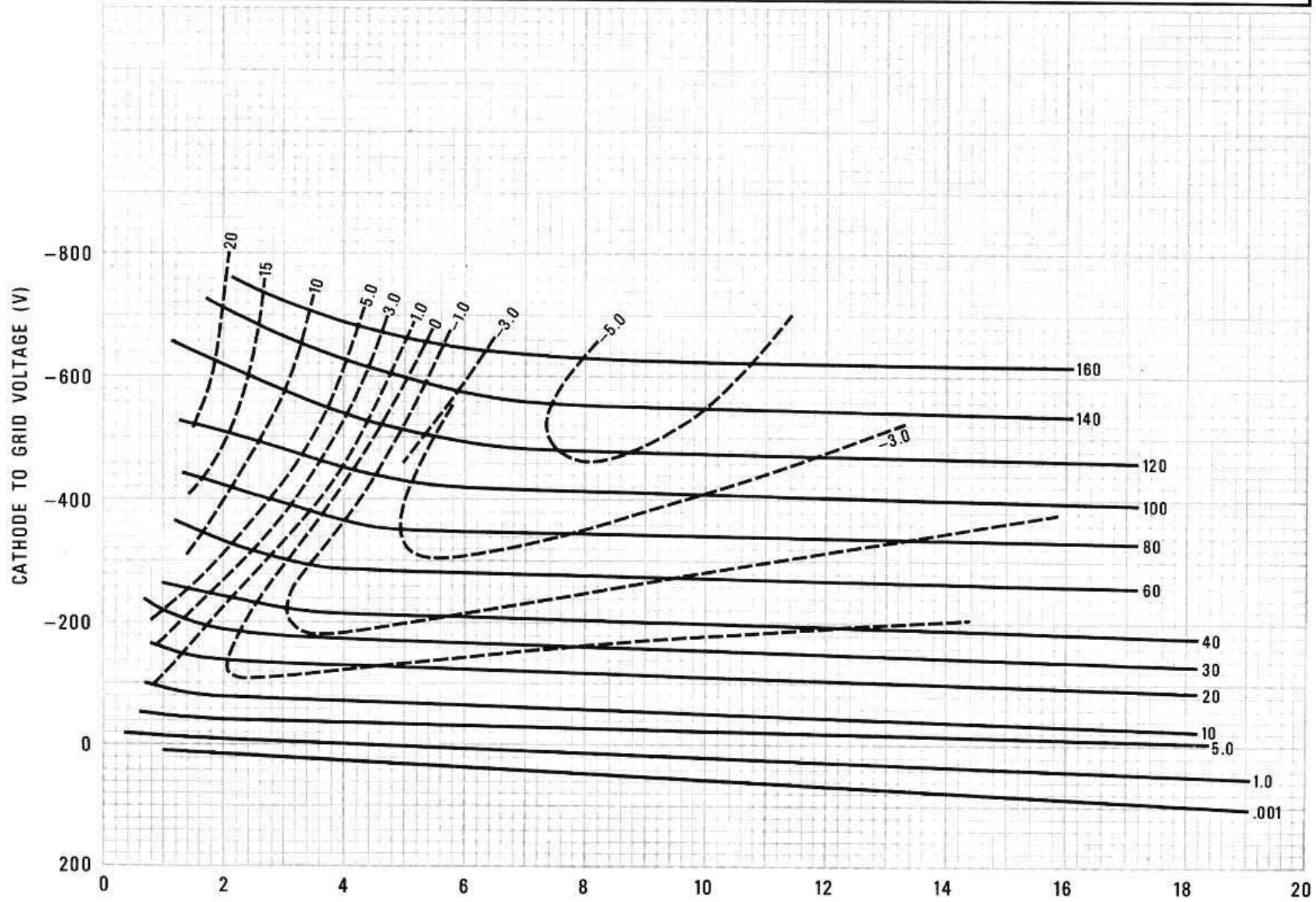
CURVE #4550


TYPICAL CONSTANT CURRENT CHARACTERISTICS
GROUNDED GRID
PLATE CURRENT – AMPERES
GRID CURRENT – AMPERES
CATHODE TO GRID VOLTAGE (V)
PLATE TO GRID VOLTAGE (kV)
CURVE #4551
-240
-200
-160
-120
-80
-40
0
40
0
1
2
3
4
5
6
7
8
9
10
5.0
4.0
3.0
2.0
1.0
.5
.5
2
25
20
0
16
.04
12
8.0
4.0
2.0
1.0
.5
.001
.04
.2
.1

TYPICAL CONSTANT CURRENT CHARACTERISTICS

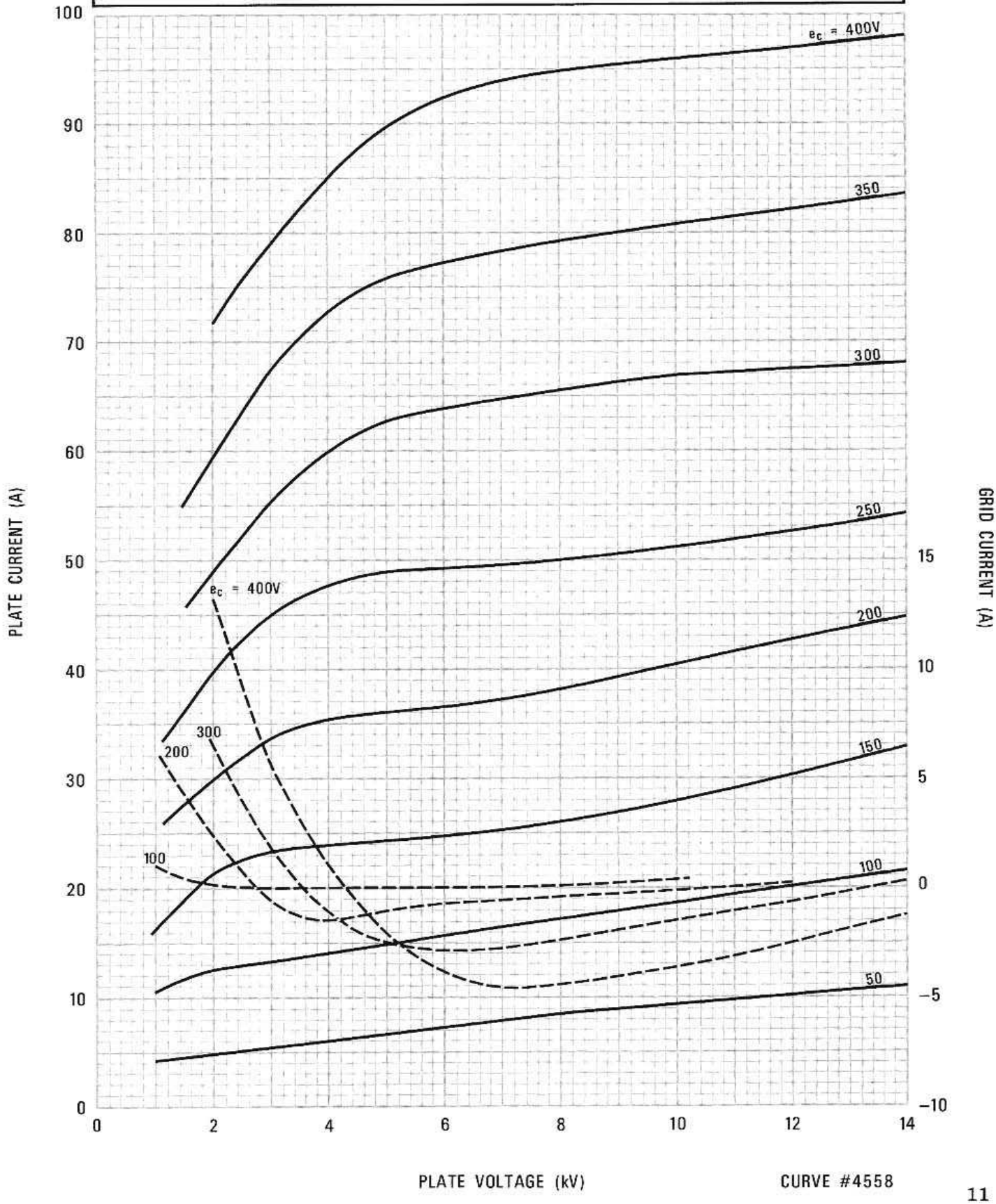
GROUNDED GRID

——— PLATE CURRENT – AMPERES – – – – GRID CURRENT – AMPERES



CURVE #4556

TYPICAL CONSTANT GRID VOLTAGE CHARACTERISTICS



CURVE #4558

DIM	DIMENSIONAL DATA					
	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	- -	6.700	- -	- -	170.18	- -
B	9.175	9.225	- -	233.08	234.32	- -
C	2.090	2.110	- -	53.09	53.59	- -
D	3.690	2.720	- -	68.33	69.09	- -
E	3.275	3.310	- -	83.19	84.07	- -
F	4.230	4.250	- -	107.44	107.96	- -
G	0.265	- -	- -	6.73	- -	- -
H	0.265	- -	- -	6.73	- -	- -
J	2.000	- -	- -	50.80	- -	- -
K	0.340	0.385	- -	8.64	9.78	- -
L	0.660	0.705	- -	16.76	17.91	- -
M	0.265	- -	- -	6.73	- -	- -
N	1.965	1.985	- -	49.92	50.42	- -
P	0.200	- -	- -	5.08	- -	- -
R	1.680	1.740	- -	42.67	44.20	- -
S	2.580	2.670	- -	65.53	67.82	- -
T	5.800	5.950	- -	147.32	151.13	- -
U	0.380	0.430	- -	9.65	10.92	- -
V	1.985	2.015	- -	50.42	51.18	- -
W	0.190	0.210	- -	4.83	5.33	- -
Y	0.045	0.075	- -	1.14	1.91	- -
AA	0.200	0.245	- -	5.08	6.22	- -