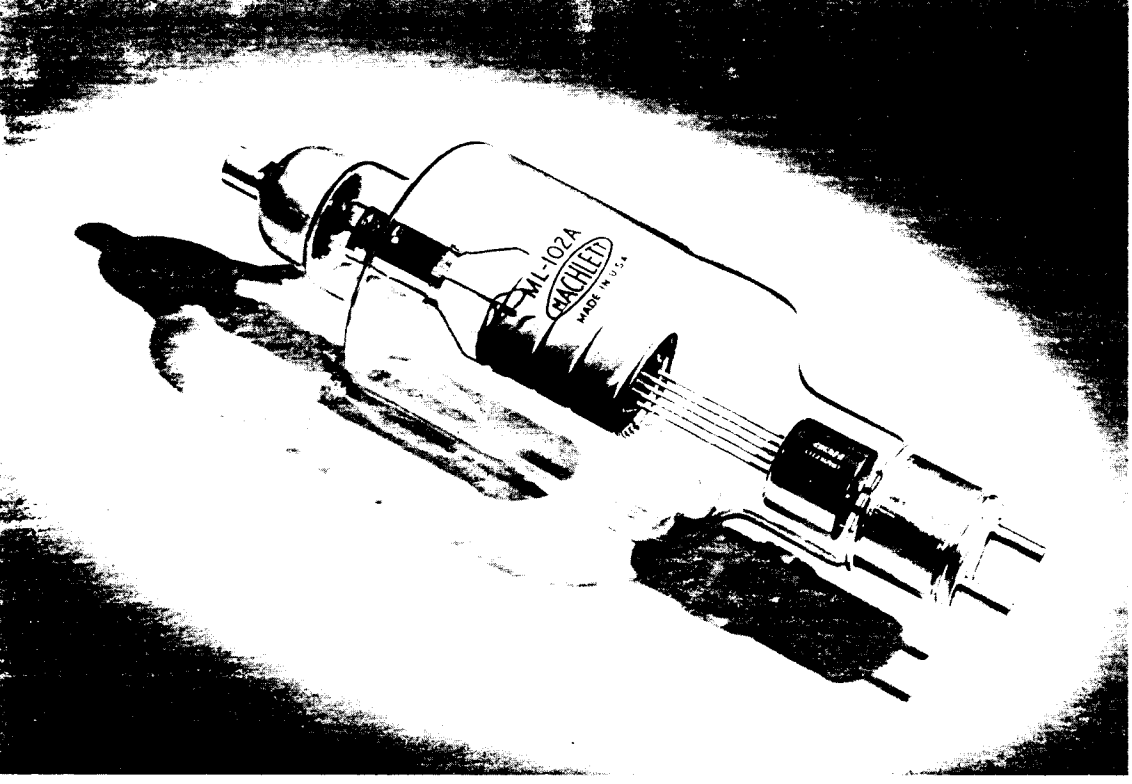


MACHLETT

ML-102A

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-102A is a high-vacuum rectifier tube having maximum ratings of 75 PKV inverse voltage and 750 MA peak anode current. It is especially adaptable to electrostatic particle precipitation service of moderately high power requirements, where its low initial cost, long life and high current capacity make it highly practical and economical to employ thermionic rectification for such service.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high-power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average load current capacity. The cathode is a pure tungsten filament of the catenary type, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The anode is a cylindrical tantalum plate treated to insure a maximum rate of heat dissipation, providing a high safety factor against accidental overload.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	20 Volts
Filament Current, approximate	19 Amps
Filament Heating Time, minimum (Before applying Plate Voltage)	30 Secs
Tube Voltage Drop, maximum (I_b—0.75 ampere)	400 Volts

MECHANICAL

Mounting Position	Optional
Type of Cooling	Radiation
Insulating Medium	Air
Net Weight, approximate	2 lbs

MAXIMUM RATINGS

Peak Inverse Anode Voltage	75000 Volts
Peak Anode Current	0.75 Amp
Plate Dissipation	750 Watts

WARNING: Operation of this tube may produce x-rays, which constitute a health hazard. Adequate rayproof shielding must therefore be provided in the equipment.

LOAD CURRENT RATINGS
(Average Direct Current Delivered To Load)

Circuit	Filament Voltage Volts	Peak Anode Current Milliamperes	Load Current Rating Unfiltered* Milliamperes	Load Current Rating Filtered** Milliamperes
Single-Phase, Two-Tube, Half Wave	20	750	240	.....
	19	450	143	.....
	18	300	95	.....
Single-Phase, Four-Tube, Full Wave	20	750	480	750
	19	450	286	450
	18	300	190	300
Three-Phase, Double-Y, Parallel	20	750	1440	1500
	19	450	860	900
	18	300	570	600
Three-Phase, Full Wave	20	750	720	750
	19	450	430	450
	18	300	285	300

* Unfiltered Load Current Ratings are based on sine-wave voltage input and resistance load without inductive or capacitive effects.
** Filtered Load Current Ratings are based on sine-wave voltage input and infinite inductance choke input filter.

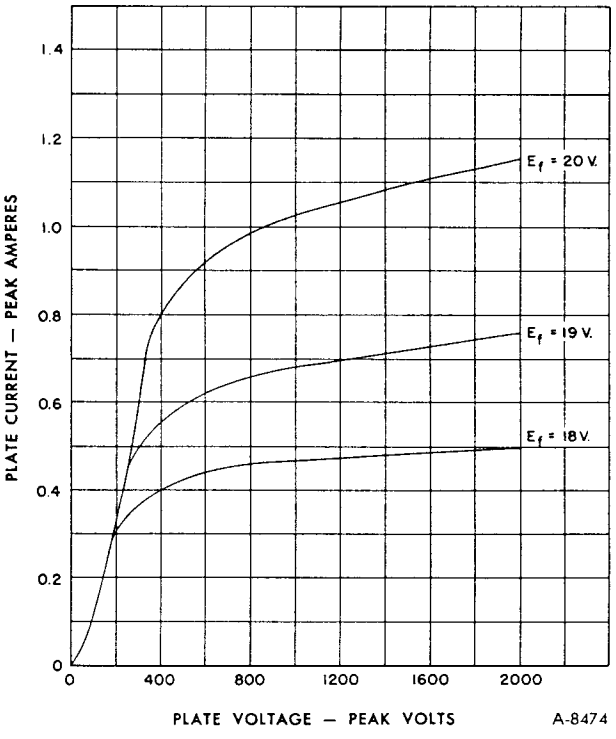
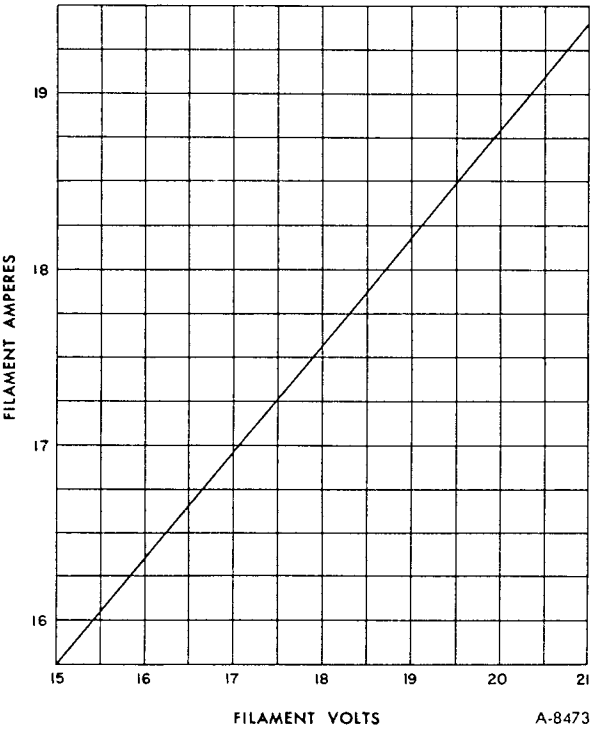
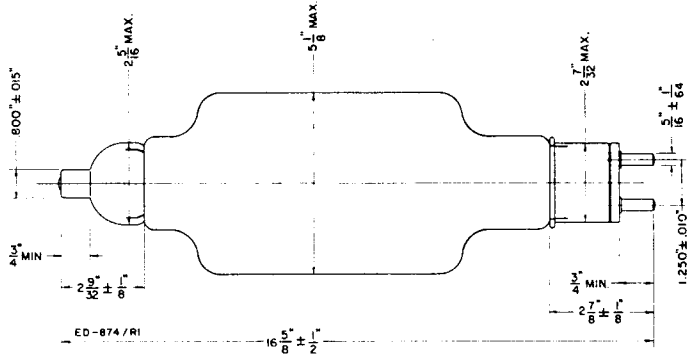


PLATE CURRENT CHARACTERISTICS



FILAMENT CHARACTERISTICS



DIMENSIONS—ML-102A

THE MACHLETT LABORATORIES, INC.

a division of Raytheon Company

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

MACHLETT

HIGH-VOLTAGE INDUSTRIAL RECTIFIER TUBES

ML-103, ML-108, ML-115, ML-120
ML-121, ML-170, ML-180

DESCRIPTION & RATINGS

DESCRIPTION

High-Voltage Industrial Rectifier Tubes, ML-103, ML-108, ML-115, ML-120, ML-121, ML-170, and ML-180, are high-vacuum diodes designed to be used in various power-supply circuits for the rectification, at high peak inverse voltages, of relatively small values of alternating current to unidirectional or direct current. Industrial applications for such tubes include high-voltage cable testing; purifying of process and exhaust atmospheres; smoke, dust, and other small-particle electrostatic precipitation; and many others which require high-voltage, low-current power.

The electron tubes listed in this data sheet are capable of withstanding peak inverse voltages of 125 to 200 kilovolts and delivering 78 to 200 milliamperes of peak anode current, depending upon the tube type. Design and process features are incorporated which insure stable and reliable operation even under wide variations in ambient temperature and the inherently severe conditions of many industrial applications. Cathodes are especially sturdy, loop-type, pure tungsten filaments permitting tubes to be mounted in any position. Anodes are of highest purity tantalum, processed to withstand the high temperatures resulting from variable loads or transient conditions.

The several types of high-voltage industrial rectifier tubes included in this series, providing a range of inverse voltage and load current ratings suitable for a variety of applications, are listed below with their characteristics and ratings.

TYPE	GENERAL CHARACTERISTICS			MAXIMUM RATINGS	
ML-	Insulating Medium*	Filament Voltage, Volts	Filament Current (Approx.), Amperes	Peak Inverse Anode Voltage, Kilovolts	Peak Anode Current, Milliamperes
103	Oil†	10	11.5	125	78
108	Oil†	13	12.5	140	200
115	Air	10	11.5	125	100
120	Air	13	12.5	140	200
121	Oil†	10	11.5	140	100
170	Air	13	12.5	200	200
180	Oil†	13	12.5	200	200

* Cooling is by oil or air convection, depending upon the tube type, and requires adequate free circulation of the medium to prevent localized overheating.

† The dielectric value of the insulating oil should not fall below 25,000 volts peak per 0.1 inch.

LOAD CURRENT RATINGS
(Average Direct Current Delivered To Load)

Type of Tube	Circuit	Filament Voltage Volts	Peak Anode Current Milliamperes	Load Current Rating Unfiltered* Milliamperes	Load Current Rating Filtered** Milliamperes
ML-103	Single-Phase, Two-Tube, Half-Wave	10.0	78	25	.....
		9.5	72	23	.....
		9.0	63	20	.....
	Single-Phase, Four-Tube, Full-Wave	10.0	78	50	50
		9.5	72	46	50
		9.0	63	40	50
	Three-Phase, Double-Y Parallel	10.0	78	150	156
		9.5	72	138	144
		9.0	63	121	126
	Three-Phase, Full-Wave	10.0	78	74	78
		9.5	72	68	72
		9.0	63	60	63
ML-108 ML-120	Single-Phase, Two-Tube, Half-Wave	13.0	200	64	.....
		12.0	157	50	.....
		11.0	100	32	.....
	Single-Phase, Four-Tube, Full-Wave	13.0	200	128	128
		12.0	157	100	128
		11.0	100	64	100
	Three-Phase, Double-Y Parallel	13.0	200	385	400
		12.0	157	302	314
		11.0	100	192	200
	Three-Phase, Full-Wave	13.0	200	191	200
		12.0	157	150	157
		11.0	100	95	100
ML-115 ML-121	Single-Phase, Two-Tube, Half-Wave	10.0	100	32	.....
		9.5	90	28	.....
		9.0	78	25	.....
	Single-Phase, Four-Tube, Full-Wave	10.0	100	64	64
		9.5	90	57	64
		9.0	78	50	64
	Three-Phase, Double-Y Parallel	10.0	100	192	200
		9.5	90	173	180
		9.0	78	150	156
	Three-Phase, Full-Wave	10.0	100	95	100
		9.5	90	86	90
		9.0	78	74	78
ML-170 ML-180	Single-Phase, Two-Tube, Half-Wave	13.0	200	64	.....
		12.0	157	50	.....
		11.0	100	32	.....
	Single-Phase, Four-Tube, Full-Wave	13.0	200	128	200
		12.0	157	100	157
		11.0	100	64	100
	Three-Phase, Double-Y Parallel	13.0	200	385	400
		12.0	157	302	314
		11.0	100	192	200
	Three-Phase, Full-Wave	13.0	200	191	200
		12.0	157	150	157
		11.0	100	95	100

* Unfiltered—Load Current Ratings are based on sine-wave voltage input and resistance load without inductive or capacitive effects.

** Filtered—Load Current Ratings are based on sine-wave voltage input and infinite inductance choke input filter.

APPLICATION NOTES

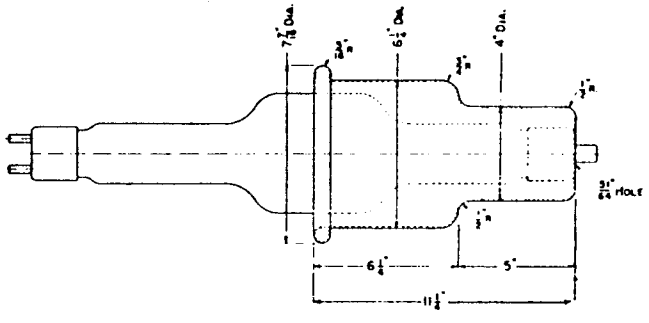
The life of tubes should be conserved as much as possible by turning on their filaments only just before the rectified power is to be used and turning them off immediately afterward. Also, when lower than rated load current values are employed, the filament voltage may be reduced somewhat, as indicated under "Load Current Ratings", to obtain extended filament life.

It is important that the circuit in which a rectifier tube is used does not subject it to inverse voltages which exceed the maximum voltage rating of the tube, as operation at higher voltages may result in tube instability, flash-over, or puncture. Types designated for oil-immersed operation cannot be used in air satisfactorily except at voltages sufficiently reduced to avoid flash-over.

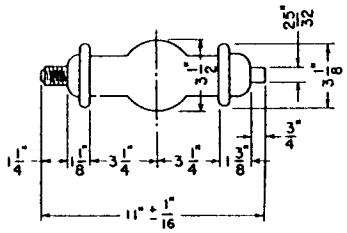
The load impedance of the rectifier circuit must be such as to limit the peak plate current to the maximum value specified. The actual value of average plate current obtainable within the peak tube current rating depends upon the current wave-form, which in turn is determined by the type of load impedance, i.e., whether it is resistive, inductive, or capacitive, and by the type of circuit employed. The foregoing tabulation of load current ratings for the various types of tubes in the various types of circuits listed represents the maximum permissible loading of the rectifier tubes, expressed in terms of average current *delivered to the load.* These load current ratings take into account the anode wattage dissipation capacity of the rectifier tube as well as the wave-form of the current through the tube under the specific circuit conditions indicated. The filtered condition assumes square current wave-form in the tubes; the unfiltered condition assumes a sine-wave or section thereof. In the case of capacitive loading or other conditions in which a more highly-peaked wave-form is obtained, the maximum peak current rating will constitute the only limitation on average load current.

The peak inverse voltage and peak plate current requirements of a tube in a particular circuit and with a particular type of filter or load must be determined and compared with the respective tube ratings before tubes of a type are installed and operated under the desired conditions. Factors such as line surges and circuit capacitance may result in inverse voltage and peak current requirements greater than calculated values so that it may be advisable in certain cases to make determinations by means of a sphere gap or oscilloscope when a tube is operated at or near maximum ratings.

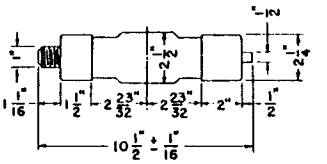
When the ML-180 is installed in an oil-filled container of minimum size and is to be subjected to inverse voltage in the order of 200 PKV, the anode end should be fitted with an external metallic shield, electrically connected to the anode terminal, to avoid the possibility of damage due to cold emission or field currents originating at the anode. A shield of the dimensions indicated in the sketch below has been found to give proper results for operation under such conditions.



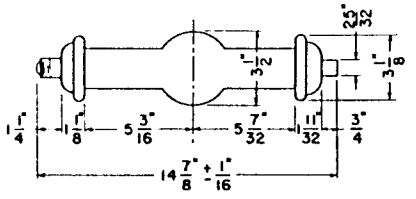
DIMENSIONS—EXTERNAL SHIELD FOR ML-180



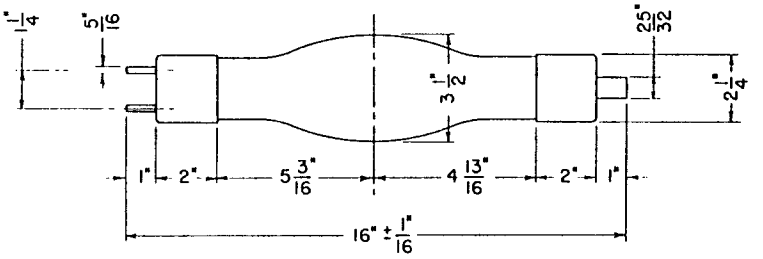
ML-121



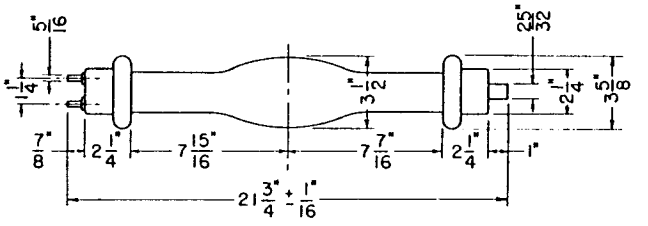
ML-103



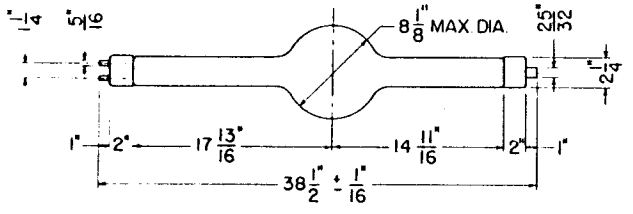
ML-108



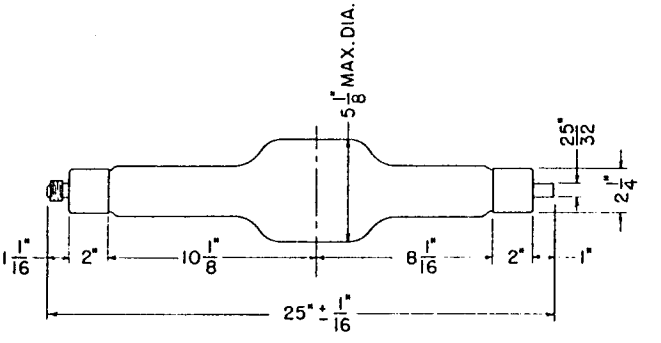
ML-115



ML-120



ML-170



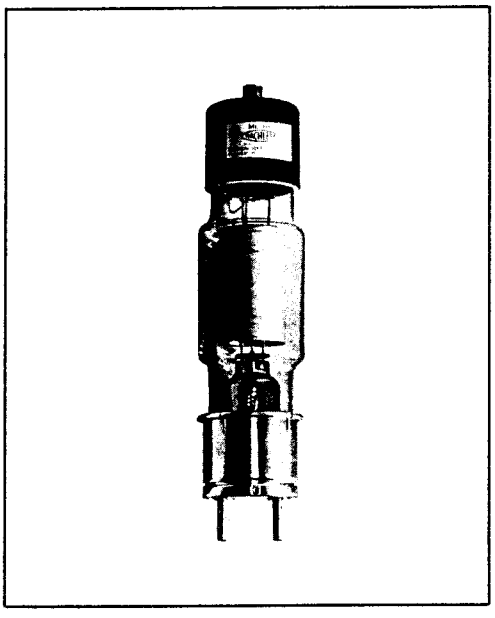
ML-180

DIMENSIONS—HIGH-VOLTAGE INDUSTRIAL RECTIFIER TUBES

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



ISSUED 12-64

ML-141

High-Voltage Rectifier

125 PKV

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-141 is a high-vacuum rectifier tube having a maximum inverse voltage rating of 125 PKV using oil insulation or 80 PKV using air insulation and a maximum peak anode current rating of 750 MA. It is especially adaptable to electrostatic particle percipitation service of moderately-high-power requirements, where its low initial cost, long life and high current capacity make it highly practical and economical to employ thermionic rectification for such service.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high-power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average-load-current capacity. The cathode is a low-wattage, thoriated-tungsten, catenary-type filament, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The cylindrical molybdenum anode provides a high rate of heat dissipation, with adequate safety factor against accidental overload.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	5.5 Volts*
Filament Current at 5.5 Volts, approximate	6.5 Amps
Filament Heating Time, minimum (Before applying anode voltage)	2 Secs
Tube Voltage Drop, maximum (I_b—0.750 Ampere)	650 Volts

* Applied filament voltage must be held within ± 5% of rated voltage. For maximum life, filament voltage should be maintained as close as possible to rated voltage under all conditions of operation.

MECHANICAL

Mounting Position	Optional
Type of Cooling	Radiation and Forced-Air**
Insulating Medium	Oil or Air
Net Weight	14½ Ounces

** A forced-air flow of 50 cfm should be directed at the bulb when the tube is operated in air.

MAXIMUM RATINGS

Peak Inverse Anode Voltage			
Oil Insulation		125,000	Volts
Air Insulation		80,000	Volts
Peak Anode Current		0.75	Amp
Anode Dissipation		100	Watts
Load Current (Average D-C)			
Circuit Application	Unfiltered†	Filtered‡	
Single-phase, two-tube, half-wave	.200	.....	Amp
Single-phase, four-tube, full-wave	.400	.470	Amp
Three-phase, double-Y parallel	1.200	1.200	Amps
Three-phase, full-wave	.600	.600	Amp

† Unfiltered Load Current Ratings are based on sine-wave input and resistance load without inductive or capacitive effects.
‡ Filtered Load Current Ratings are based on sine-wave voltage input and inductive choke input filter.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

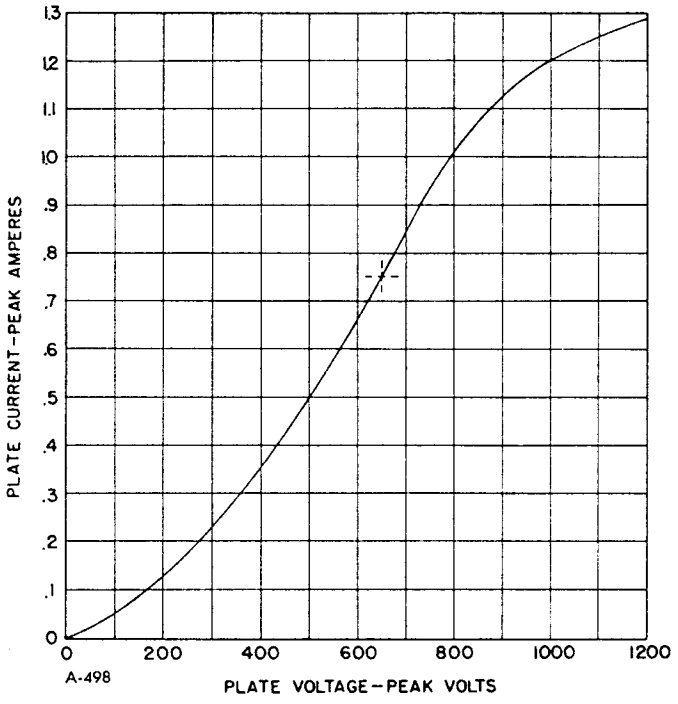
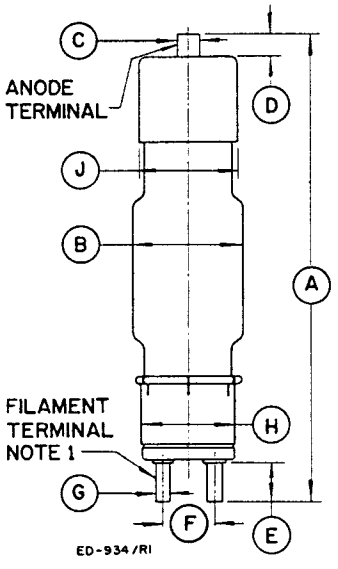


PLATE CURRENT CHARACTERISTICS

DIMENSIONS FOR OUTLINE

Ref.	INCHES		
	Minimum	Nominal	Maximum
A	10.65	10.75	10.85
B	—	—	2.75
C	.485	.500	.510
D	.44	.50	.56
E	.82	.88	.94
F	1.235	1.250	1.265
G	.292	.312	.332
H	—	2.19	—
J	—	2.25	—



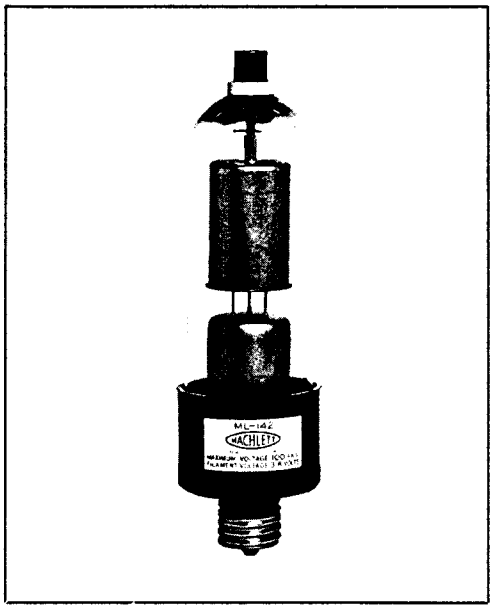
NOTE:
1. Cathode base fits Machlett mounting socket part P-8835.

DIMENSIONS — ML-141

THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT

ST-1975 5M 12-64

Printed in U.S.A.



ISSUED 6-65

ML-142

High-Voltage Rectifier

100 PKV

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-142 is a high-vacuum rectifier tube having a maximum inverse voltage rating of 100 PKV using oil insulation or 50 PKV using air insulation and a maximum peak anode current rating of 300 MA. It is especially suitable for service of moderate power requirements and affords the combination of compactness of equipment with low tube cost.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high-voltage applications. These features insure ruggedness, long life, low internal voltage drop and moderate average-load-current capacity. The cathode is a low-wattage, thoriated-tungsten, catenary-type filament, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The cylindrical molybdenum anode provides a high rate of heat dissipation, with adequate safety factor against accidental overload.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	3.8	Volts*
Filament Current at 3.8 Volts, approximate	6.6	Amps
Filament Heating Time, minimum (Before applying anode voltage)	2	Secs
Tube Voltage Drop, maximum (I_b—0.30 Ampere)	360	Volts

*Applied filament voltage must be held within ± 5% of rated voltage. For maximum life, filament voltage should be maintained as close as possible to rated voltage under all conditions of operation.

Mechanical

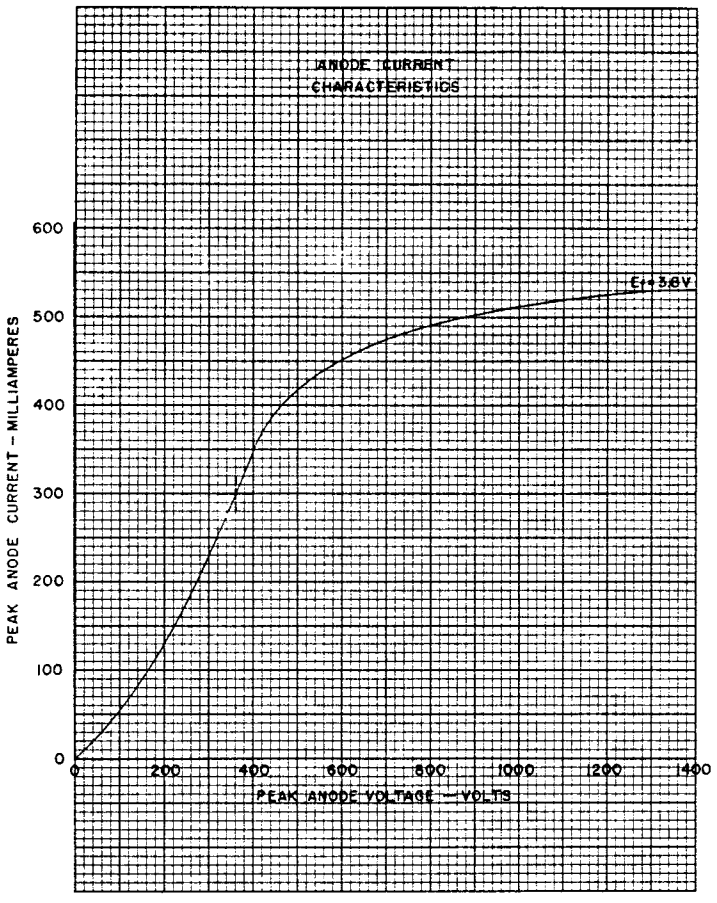
Mounting Position	Optional
Type of Cooling	Radiation
Insulating Medium	Oil or Air
Net Weight	7 Ounces

MAXIMUM RATINGS

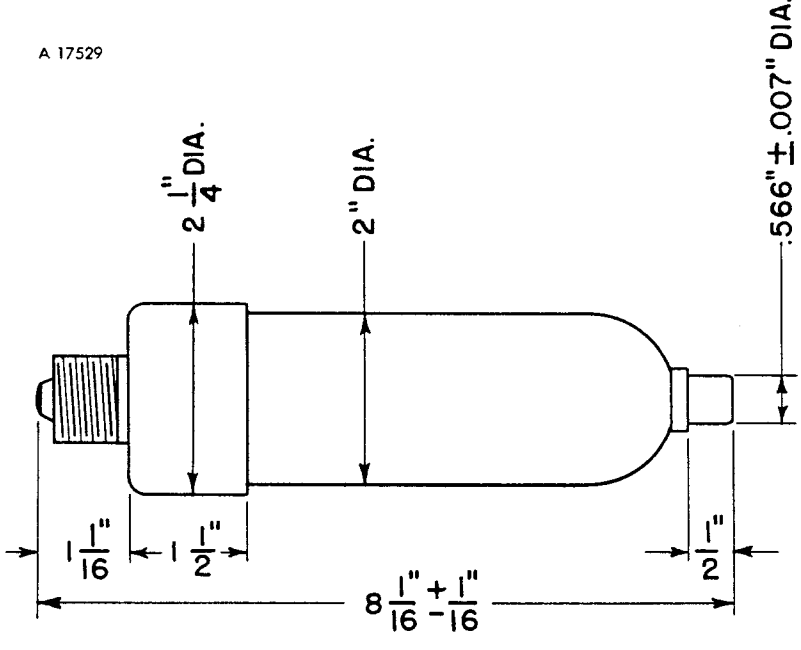
Peak Inverse Anode Voltage			
Oil Insulation		100,000	Volts
Air Insulation		50,000	Volts
Peak Anode Current		0.300	Amp
Anode Dissipation		25	Watts
Load Current (Average D-C)			
Circuit Application	Unfiltered†	Filtered‡	
Single-phase, two-tube, half-wave	.075	.....	Amp
Single-phase, four-tube, full-wave	.150	.200	Amp
Three-phase, double-Y parallel	.450	.450	Amp
Three-phase, full-wave	.225	.225	Amp

†Unfiltered Load Current Ratings are based on sine-wave input and resistance load without inductive or capacitive effects.
‡Filtered Load Current Ratings are based on sine-wave voltage input and inductive choke input filter.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.



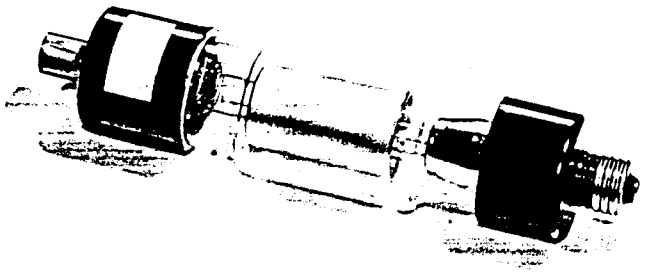
A 17529



A-937

THE MACHLETT LABORATORIES, INC.

An Affiliate of Raytheon Company



MACHLETT

ML-148

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-148 is a high-vacuum rectifier tube having a maximum inverse voltage rating of 150 PKV using oil insulation or 80 PKV using air insulation and a maximum peak anode current rating of 1.0 ampere. It is especially suitable for use in voltage multiplier circuits, energy storage capacitor circuits, and other applications where high peak power is required.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high-power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average-load-current capacity. The cathode is a low-wattage, thoriated-tungsten, catenary-type filament, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The cylindrical molybdenum anode provides a high rate of heat dissipation, with adequate safety factor against accidental overload.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	5.7	Volts*
Filament Current at 5.7 Volts, approximate	6.6	Amps
Filament Heating Time, minimum (Before applying anode voltage)	2	Secs
Tube Voltage Drop, maximum (I_b—1.0 Ampere)	800	Volts

*Applied filament voltage must be held within ± 5% of rated voltage. For maximum life, filament voltage should be maintained as close as possible to rated voltage under all conditions of operation.

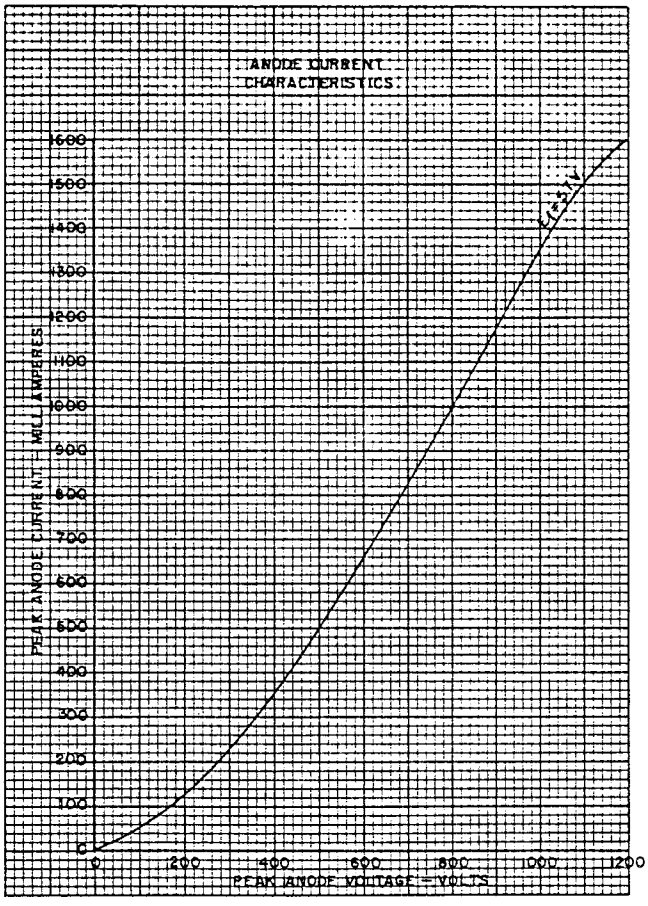
Mechanical

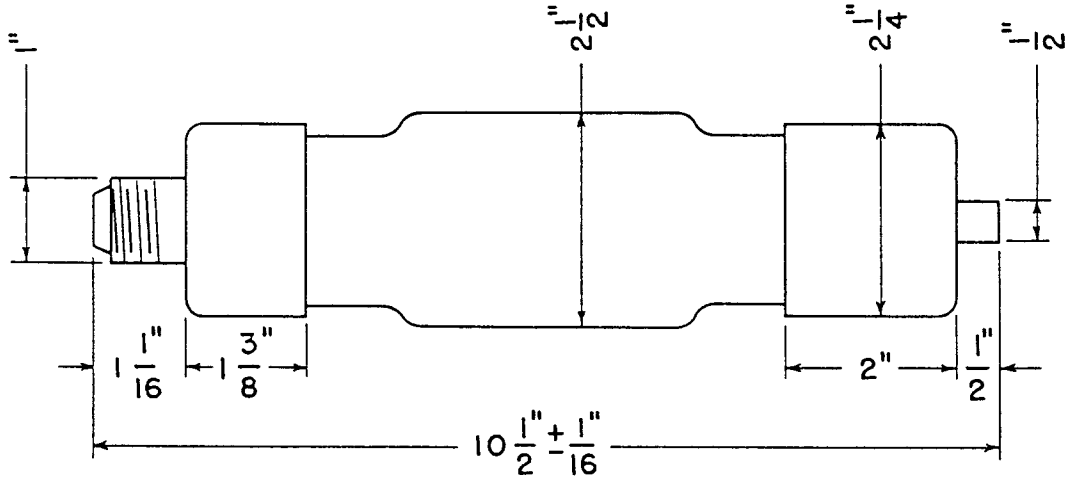
Mounting Position	Optional
Type of Cooling	Radiation
Insulating Medium	Oil or Air
Net Weight	16 Ounces

MAXIMUM RATINGS

Peak Inverse Anode Voltage			
Oil Insulation		150,000	Volts
Air Insulation		80,000	Volts
Peak Anode Current		1.0	Amp
Anode Dissipation		60	Watts
Load Current (Average D-C)			
Circuit Application	Unfiltered†	Filtered‡	
Single-phase, two-tube, half-wave	.150	.....	Amp
Single-phase, four-tube, full-wave	.300	.320	Amp
Three-phase, double-Y parallel	.900	.900	Amp
Three-phase, full-wave	.450	.450	Amp

†Unfiltered Load Current Ratings are based on sine-wave input and resistance load without inductive or capacitive effects.
‡Filtered Load Current Ratings are based on sine-wave voltage input and inductive choke input filter.

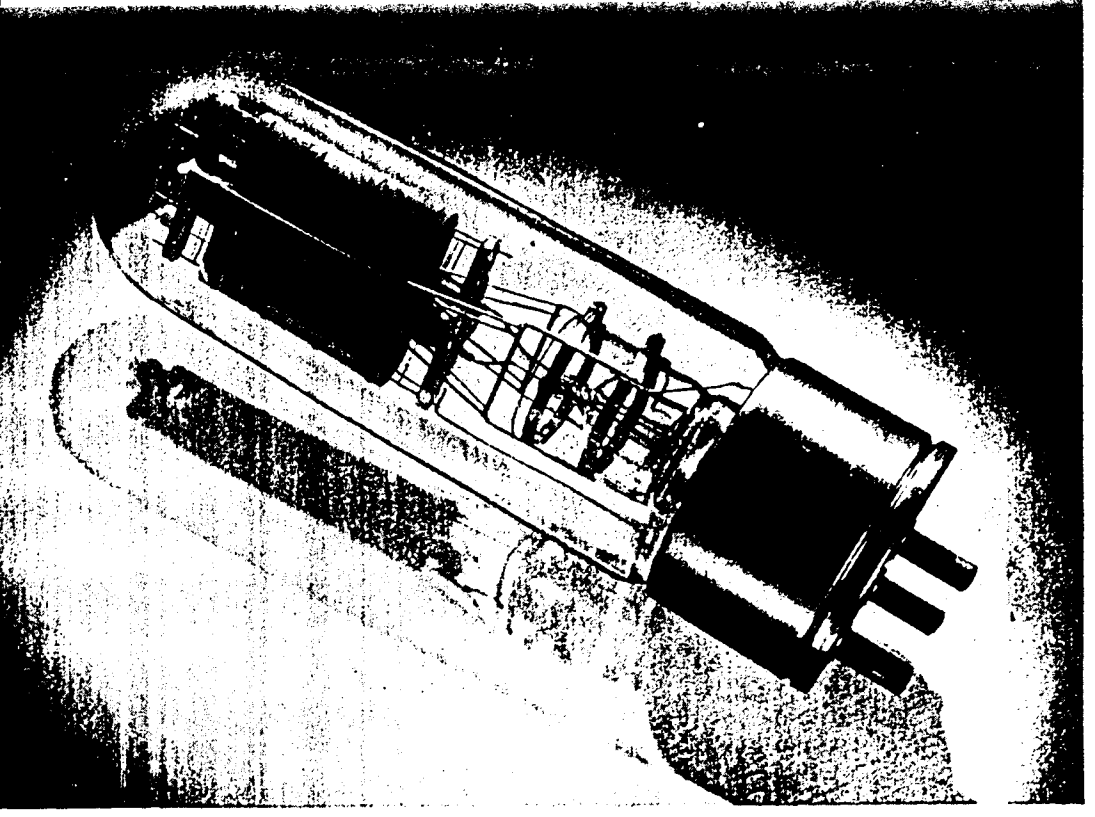




MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



MACHLETT

ML-212E

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-212E is a three-electrode tube designed for use as a modulator, amplifier, or oscillator in radio-transmitting service. The cathode is a thoriated-tungsten filament. The tube is convection cooled, the anode being capable of dissipating 275 watts. Maximum ratings of 3 kVdc and 350 milliamperes apply at frequencies up to 1.5 mc/sec; operation at 4.5 mc/sec is permissible with plate voltage reduced to 1 kVdc.

The ML-212E embodies all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent out-gassing. The tube is exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high- and super-voltage x-ray tubes.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	14 volts
Filament Current at 14 volts	6 amperes
Amplification Factor	16
Grid-Plate Transconductance	8500 uMhos
Interelectrode Capacitances	
Grid-Plate	18.8 uuf
Grid-Filament	14.9 uuf
Plate-Filament	8.6 uuf

Mechanical

Mounting Position	Vertical or Horizontal*
Type of Cooling	Convection
Base (Use with W.E. 113A socket, or equivalent)	Large 4-pin bayonet

*If mounted horizontally, the plane of the filament should be vertical.

MAXIMUM RATINGS

Direct Plate Voltage	3000 volts
Direct Plate Current	350 milliamperes
Plate Dissipation	275 watts
Direct Grid Current	75 milliamperes
R.F. Grid Current	5 amperes
Frequency	1.5 megacycles

The above are maximum ratings which do not apply simultaneously but depend on the type of service specified below.

TYPICAL OPERATING CONDITIONS

Class A Audio Amplifier or Modulator

Direct Plate Voltage	1500	1250 volts
Grid Bias	−57	−40 volts
Direct Plate Current	170	200 milliamperes
Plate Dissipation	250	250 watts
Load Impedance	5000	3000 ohms
Undistorted Output	50	40 watts

Grid Bias Modulator

Direct Plate Voltage		3000 volts
Grid Bias		−260 volts
Plate Dissipation		175 watts
Load Impedance		8000 ohms
Peak Power Output		200 watts

Class B Audio Amplifier or Modulator
(for balanced 2 tube circuit)

Direct Plate Voltage	2000	1500 volts
Grid Bias	−105	−75 volts
Direct Plate Current per tube		
No drive	40	50 milliamperes
Maximum drive	300	300 milliamperes
Plate Dissipation	250	250 watts
Load Resistance (plate-to-plate)	8000	5900 ohms
Load Resistance (per tube)	2000	1475 ohms
Approximate maximum output	650	500 watts
Recommended power for driving stage	50	50 watts

Class B Radio-Frequency Amplifier

Direct Plate Voltage	2000	1500 volts
Direct Plate Current	300	300 milliamperes
Plate Dissipation	275	275 watts
Grid Bias	−120	−90 volts
Approximate carrier watts for use with 100% modulation	200	150 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct Plate Voltage	2000	1500 volts
Direct Plate Current	300	300 milliamperes
Grid Bias	−185 to −250	−150 to −200 volts
Nominal Power Output	400	300 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct Plate Voltage	1500	1000 volts
Direct Plate Current	300	300 milliamperes
Grid Bias	−200	−125 volts
Direct Grid Current	75	75 milliamperes
Nominal Carrier Power Output for use with 100% modulation	300	200 watts

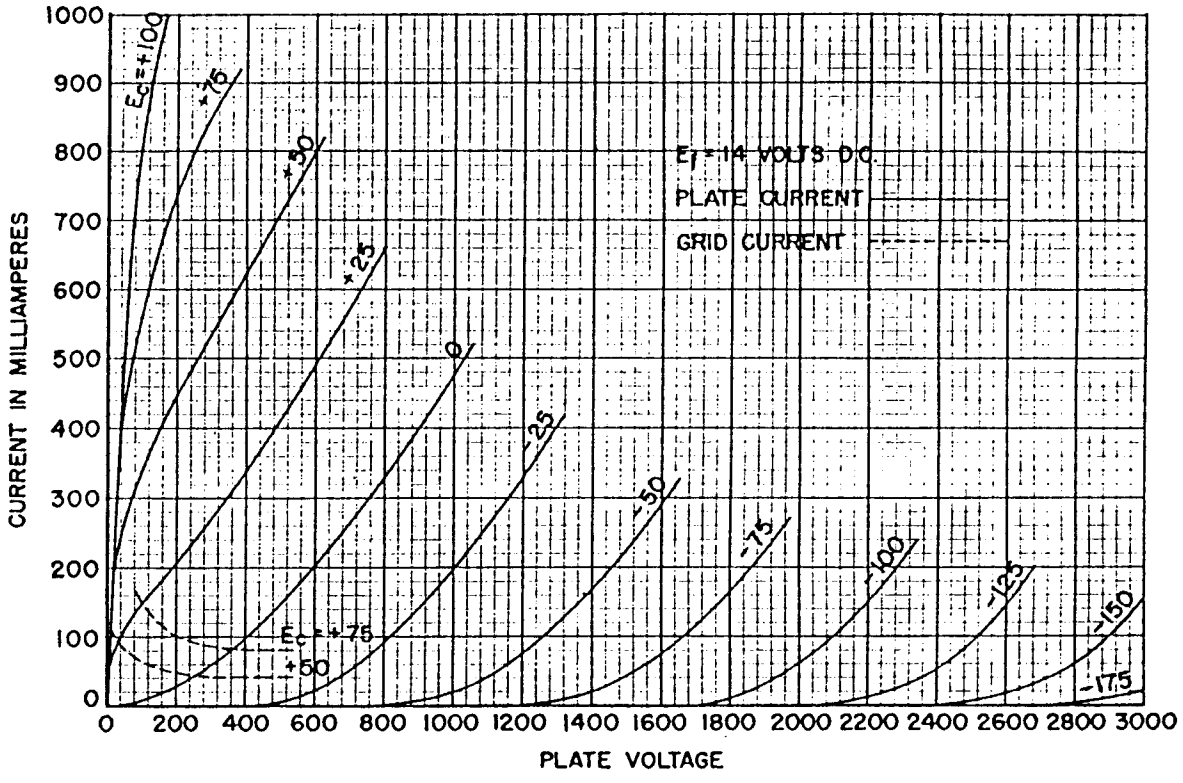
APPLICATION NOTES

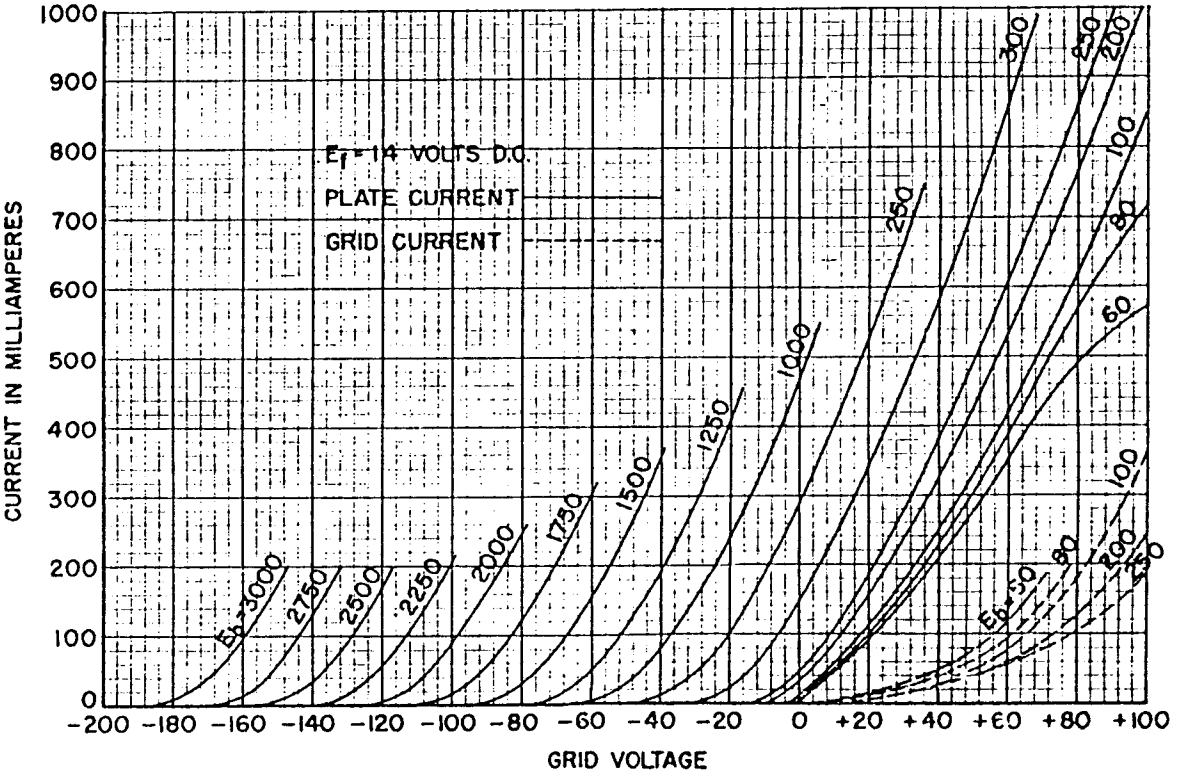
Maximum ratings apply at frequencies of 1.5 megacycles and less. The maximum plate voltage for the upper frequency limit of 4.5 megacycles is 1000 volts. The maximum plate voltage for frequencies between 1.5 and 4.5 megacycles should be proportionately reduced.

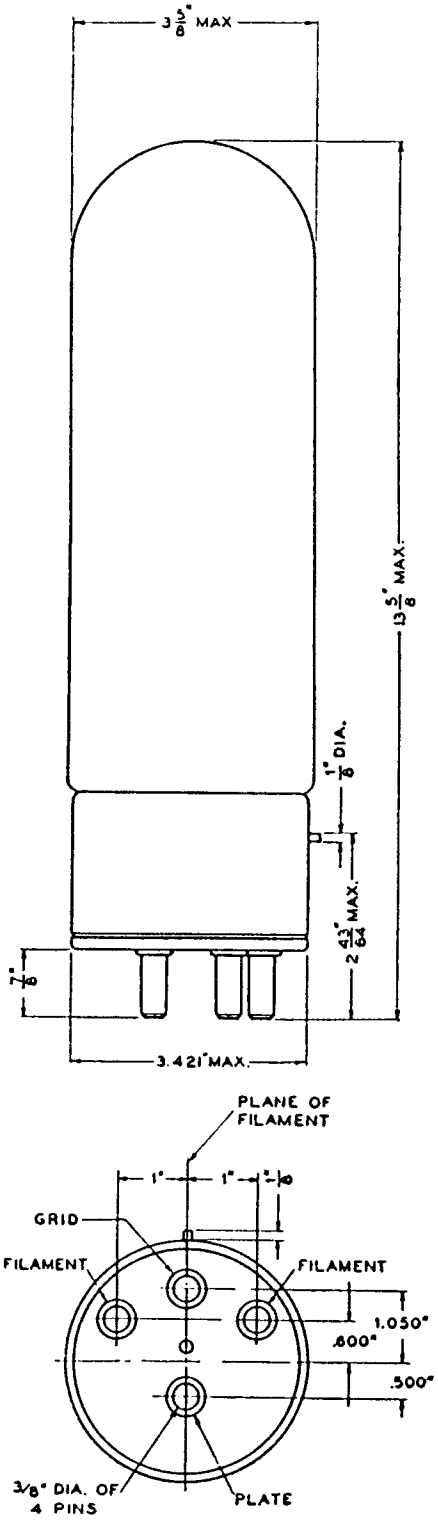
Each ML-212E vacuum tube falls within one of four impedance classes and is stamped accordingly. These classifications are #1, #2, #3 and #4, and are in no way a gradation of quality, but are to facilitate parallel operation in the ordinary system using a common grid battery. Where more than one tube is used, those of the same or adjacent classes should be employed so that the load may be evenly distributed. When only a single tube is used no one of the classes has any advantage over the other. Tubes may not be ordered according to impedance classification.

With a plate voltage of 1500 volts, a grid bias of −60 volts and a filament voltage of 14, the plate current will be as follows for each impedance class:

#1	110-129	milliamperes, inclusive
#2	130-148	" "
#3	149-167	" "
#4	168-185	" "


CURRENT IN MILLIAMPERES
PLATE VOLTAGE
E_f = 14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
E_c = +100
+75
+50
+25
0
-25
-50
-75
-100
-125
-150
-175
E_c = +75
+50


CURRENT IN MILLIAMPERES
GRID VOLTAGE
E_f = 14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
300
250
200
100
80
60
1000
1250
1500
1750
2000
2250
2500
2750
E_b = 3000
E_b = 50



DIMENSIONS—ML-212E

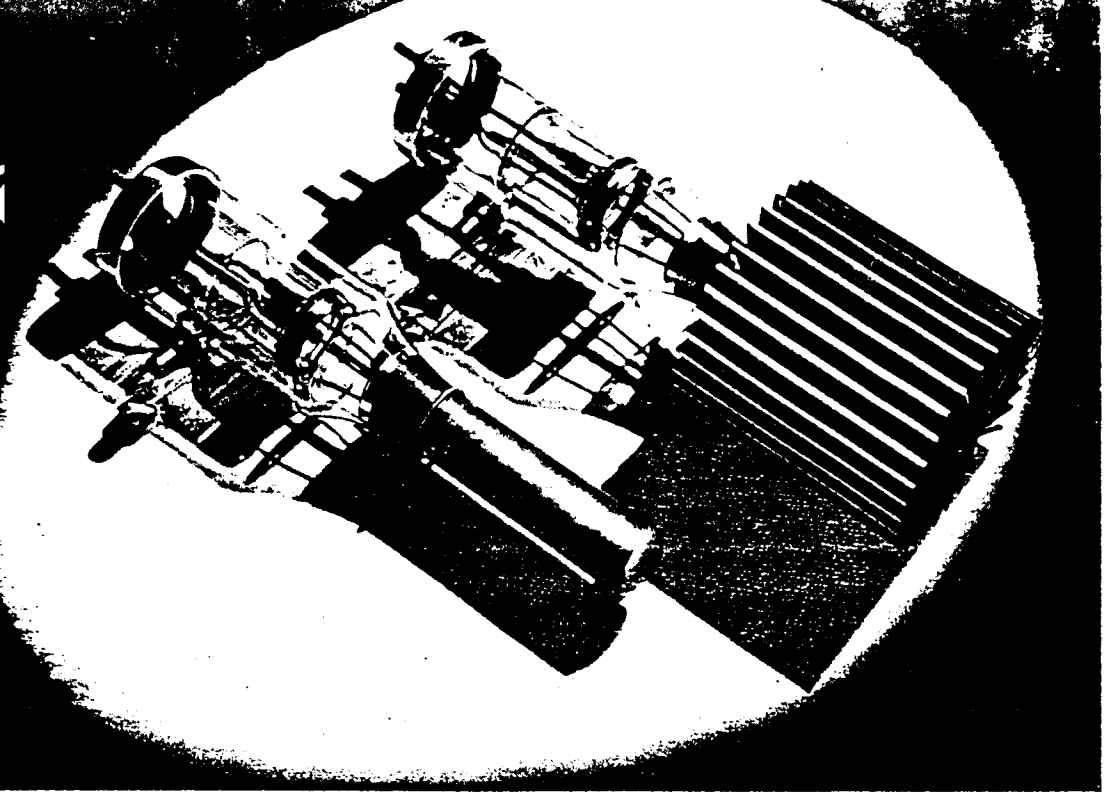
MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

ST 902-2M-WR-3 51

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MACHLETT

ML-220C
ML-220CA

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-220C and ML-220CA are three-electrode tubes designed for use as modulators, amplifiers, or oscillators in radio-transmitting service. The cathode for each type is a pure-tungsten filament. The anode of the ML-220C is water cooled and is capable of dissipating 10 kW. The anode of the ML-220CA is forced-air cooled and is capable of dissipating 5 kW. Maximum ratings of 15 kVdc and 1.5 amperes apply at frequencies up to 4 Mc; operation at 12 Mc is permissible with plate voltage reduced to 5 kVdc.

The ML-220C and ML-220CA embody all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent outgassing. The tubes are exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high- and super-voltage x-ray tubes.

GENERAL CHARACTERISTICS

Electrical

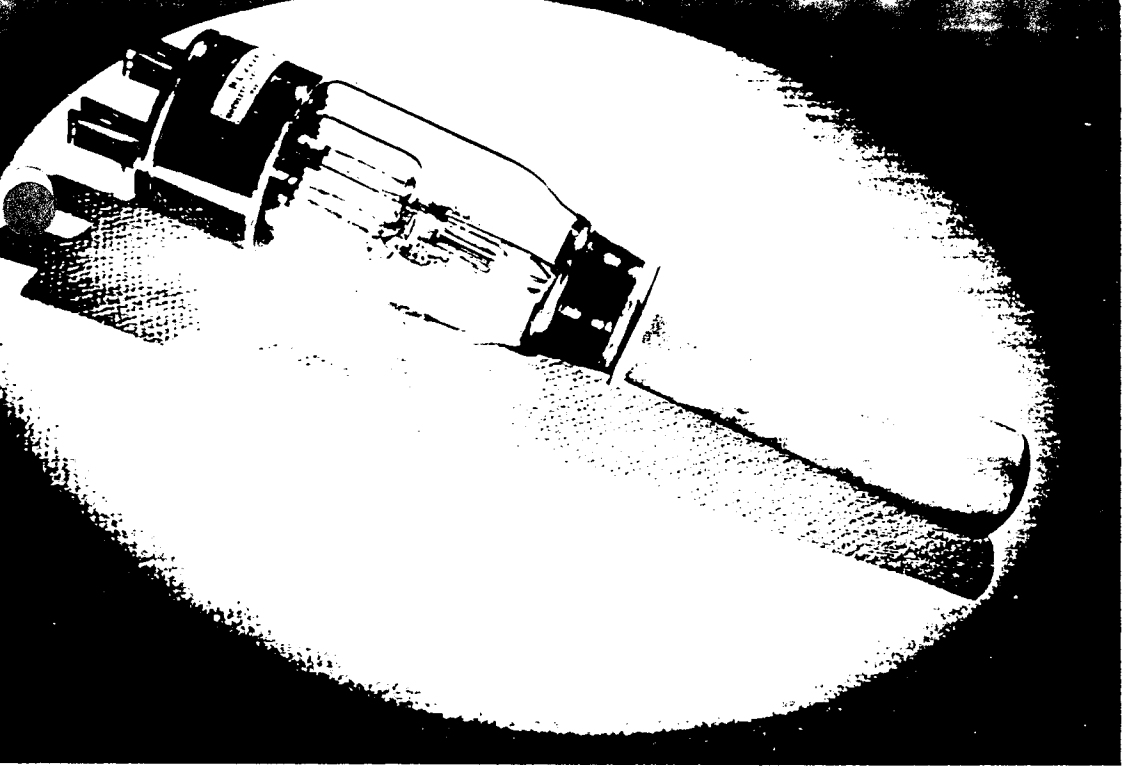
Filament Voltage	21.5	volts
Filament Current at 21.5 volts	41	amperes
Amplification Factor	40	
Grid-Plate Transconductance		
ML-220C	5000	uMhos
ML-220CA	4400	uMhos
Interelectrode Capacitances		
Grid-Plate	24	uuf
Grid-Filament	20	uuf
Plate-Filament	2.5	uuf

Mechanical

Mounting Position ..... Vertical, anode down

	ML-220C	ML-220CA
Type of Cooling	Water	Forced-air
Water Flow on Anode (minimum)	5	— gpm
Maximum Outgoing Water Temperature	75	— °C
Required Air Flow on Anode	—	600 cfm
Maximum Anode Temperature	—	120 °C

datasheet probably incomplete



MACHLETT

ML-222A

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-222A is a high-vacuum, water-cooled rectifier tube having maximum ratings of 25 PKV inverse voltage and 5 amperes peak anode current. It is designed for use as a half-wave rectifier in power supplies for radio-transmitting and radio-communication service. The cathode is a pure-tungsten filament.

The ML-222A embodies all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent outgassing. The tube is exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high-voltage x-ray rectifiers.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	21.5 volts
Filament Current, approximate	41.0 amperes
Tube Voltage Drop, approximate (I_b—5.0 amperes)	2000 volts

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Water
Water Flow on Anode, minimum	1 gpm
Maximum Outgoing Water Temperature	75 °C

MAXIMUM RATINGS

Peak Inverse Anode Voltage	25000 volts
Peak Anode Current	5.0 amperes
Load Current (Average D-C)	
Circuit Application	Unfiltered
Single-phase, double half-wave	3.0 amperes
Single-phase, double half-wave, 4 tube series circuit	3.0 amperes
Three-phase, 6-tube, series-Y circuit	5.0 amperes
Three-phase, double-Y interconnected	8.5 amperes

WARNING: Operation of this tube may produce soft x-rays, which constitute a health hazard. Adequate rayproof shielding must therefore be provided in the equipment.

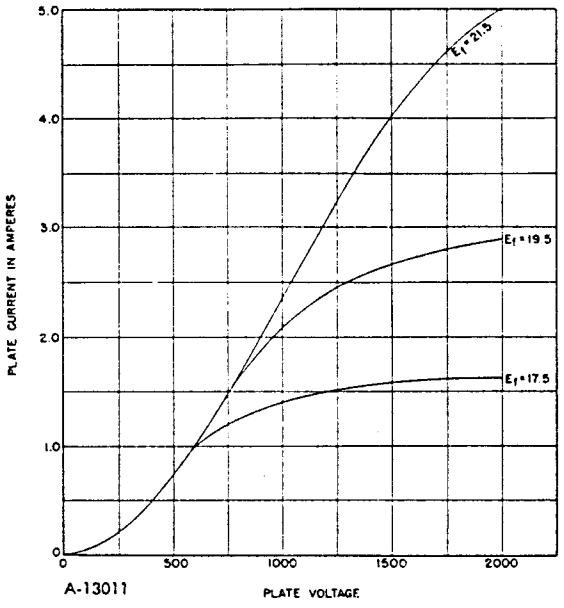
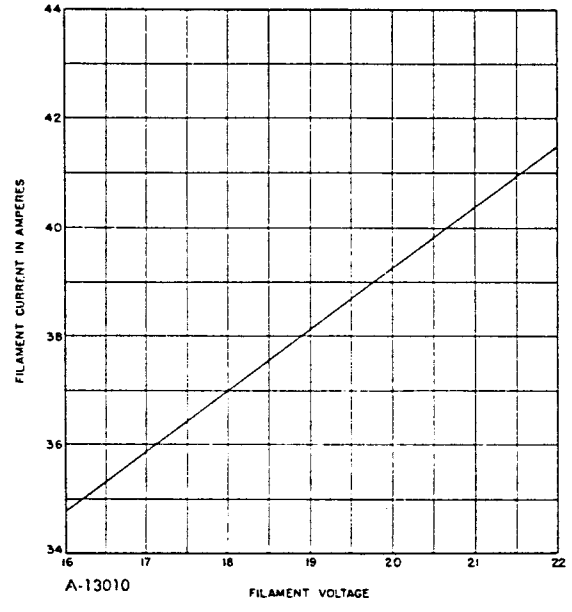
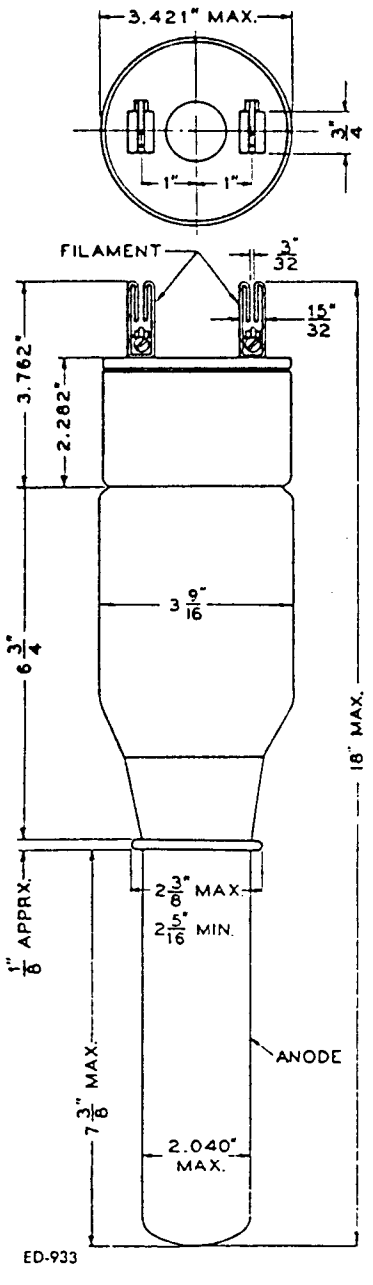


PLATE CURRENT CHARACTERISTICS



FILAMENT CHARACTERISTICS



Dimensions—ML-222A

THE MACHLETT LABORATORIES, INC.

a division of Raytheon Company

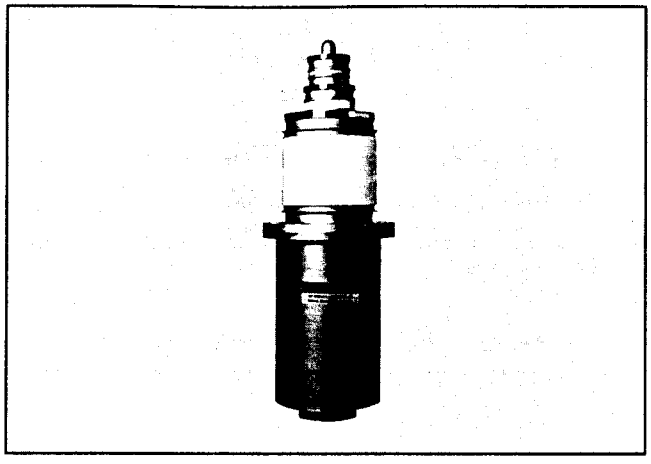
SPRINGDALE MACHLETT CONNECTICUT

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MACHLETT

PRODUCT DATA

ML-23431



APPLICATION

The ML-23431 is a general-purpose triode suitable for various rf applications. The rugged coaxial mounting structure provides high-dissipation, low-inductance rf electrode terminals. The tube is rated at 20 kVdc plate voltage (maximum) in CW operation. Maximum ratings apply at frequencies up to 30 MHz. Useful power output can be obtained at frequencies up 110 MHz with reduced ratings.

CONSTRUCTION

The cathode of this tube consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments. The water-cooled, heavy-wall anode is capable of dissipating 175 kW. Envelope construction employs low-loss ceramics.

WARNING

When operating at peak voltage in excess of 15 kV, this electron tube may give off x-rays which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 114, "Safety Standard for Non-Medical X-Ray and Sealed Gamma Ray Sources." Additional information is available in National Council on Radiation Protection and Measurements Report No. 33, "Medical X-Ray and Gamma Ray Protection for Energies up to 10 MeV." Periodic checks of shielding effectiveness are also required since x-ray radiation levels may increase with the operating life of the tube.

ORDERING NOTES

Refer to **Machlett** price list. When ordering specify:

- tube type
- accessories
  - — small filament connector F-27218
  - — large filament connector F-27219
  - — grid connector F-27220
  - — mounting socket F-12527
  - — small gasket (for mounting socket) P-12272
  - — large gasket (for mounting socket) P-13745

SPECIFICATION

ELECTRICAL CHARACTERISTICS

Filament Voltage:	14.5 volts
Filament Current:	450 amps
Filament Starting Current, maximum:	1,200 amps
Filament Cold Resistance:	0.0035 ohm
Amplification Factor:	45
Interelectrode Capacitances:	
Grid Plate:	75 pf
Grid Filament:	200 pf
Plate Filament:	4 pf

MECHANICAL CHARACTERISTICS

Mounting Position:	Vertical, anode down
Type of Cooling:	Water and forced air
Water Flow on Anode for 175 kW Dissipation, Minimum:	40 gal/min (151 L/min)
Maximum Outgoing Water Temperature:	70 °C (158 °F)
Maximum Water Pressure:	80 psi (552 kPa)
Air Flow on Insulators and Seals, approximate:	500 cfm*
Maximum Ceramic Temperature:	165 °C (329 °F)
Net Weight approximate:	110 lbs (50 kg)

*At frequencies up to 15 MHz, air flow should be directed primarily on the filament seals and main ceramic insulator; at higher frequencies or high ambient temperatures, additional air flow may be required on the grid seals. Air flow should be distributed to maintain uniform temperature, not greater than 165 °C (329 °F) around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulations

Maximum Ratings, Absolute Values	ML-23431
DC Plate Voltage	20000 V
DC Grid Voltage	−1500 V
DC Plate Current	35 A
DC Grid Current	4.0 A
Plate Dissipation	175 kW

Typical Operation	ML-23431	
DC Plate Voltage	20000 V	16000 V
DC Grid Voltage	−1000 V	−900 V
Peak RF Grid Voltage	1680 v	1550 v
Peak RF Plate Voltage	17400 v	13000 v
DC Plate Current	29 A	29.3 A
DC Grid Current	3.4 A	3.2 A
RF Load Resistance	330 ohms	2.50 ohms
Driving Power, approximate	6 kW	4.8 kW
Power Output, approximate	440 kW	340 kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 MHz except as noted. This tube may be operated at higher frequencies provided the maximum value of plate voltage is reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency in Megahertz	30	70	110
Percent Maximum Rated Plate Voltage	100	80	60

TUBE PROTECTION

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

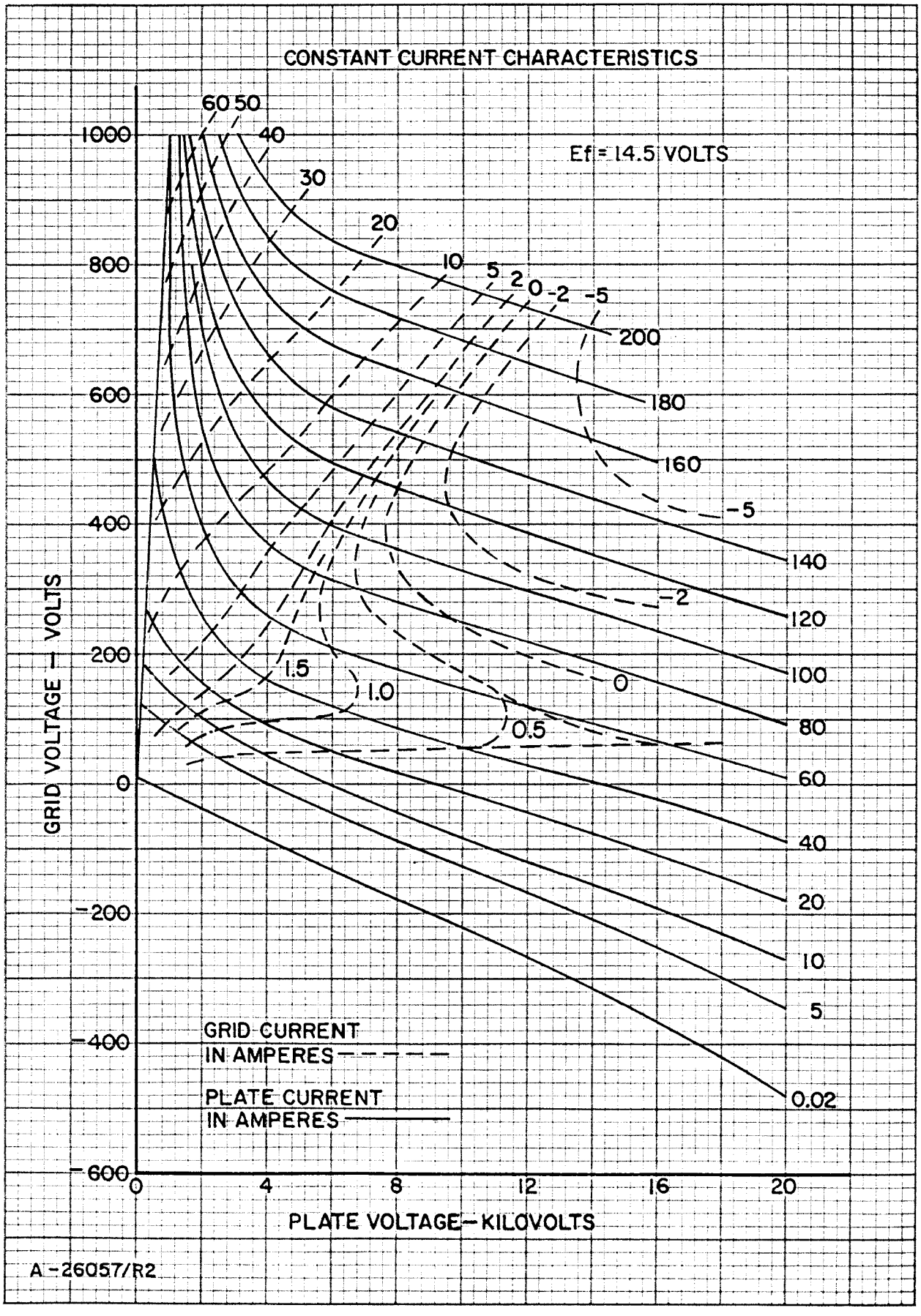
In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault," and in most cases the time interval should not be allowed to exceed approximately 10 microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as test of the effectiveness of a protection device, refer to the references listed.

A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

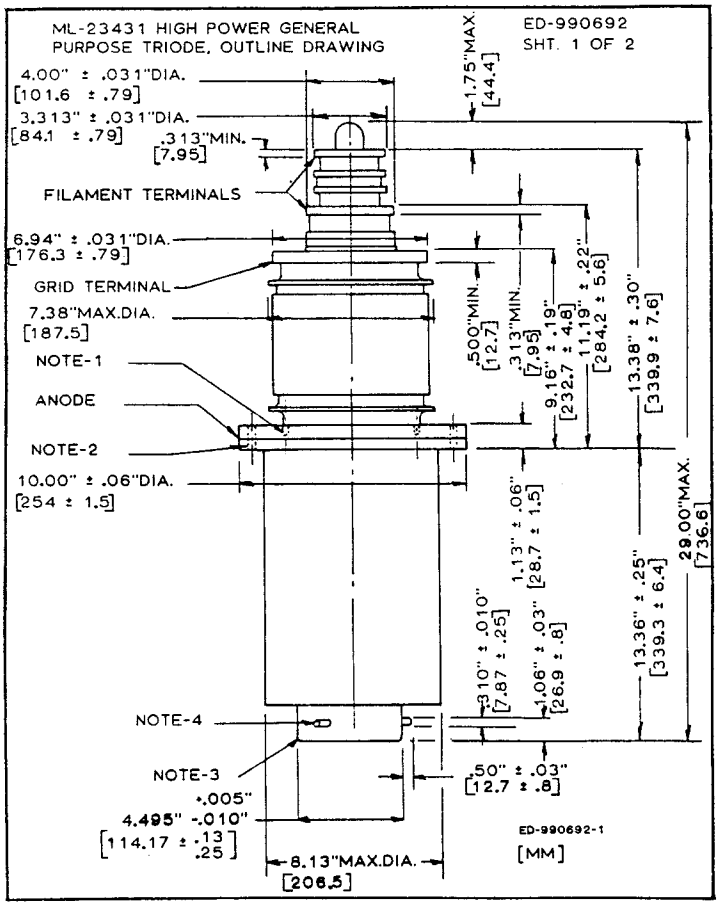
In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

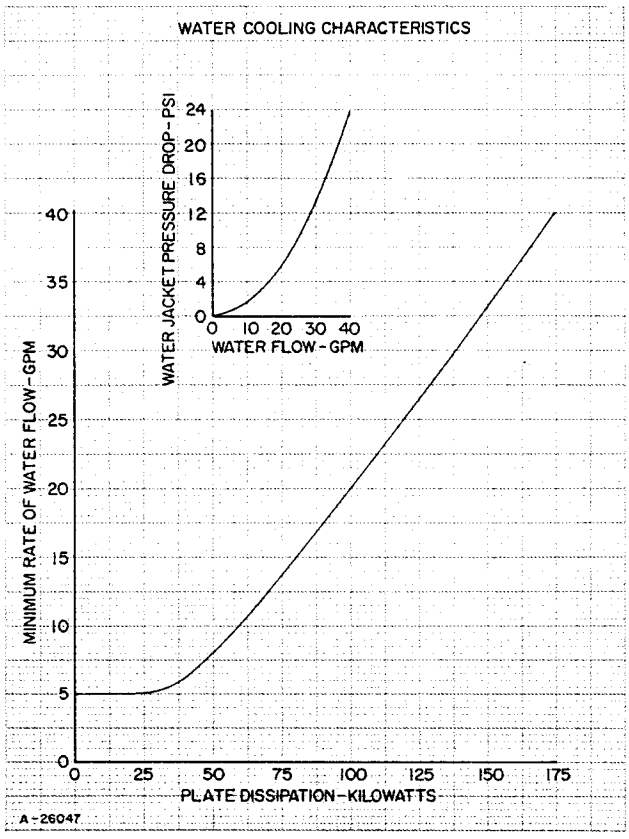
References:

1. W.N. Parker and M.V. Hoover, "Gas Tubes Protect High Power Transmitters," *Electronics, 29,* 144, January 1956.
2. H.D. Doolittle, "High Power Hydrogen Thyratrons," *Cathode Press, 1,* 6, 1954.


CONSTANT CURRENT CHARACTERISTICS
Ef = 14.5 VOLTS
60 50
40
30
20
10
5
2
0
-2
-5
200
180
160
-5
140
-2
120
100
0
80
60
40
20
10
5
0.02
1.5
1.0
0.5
1000
800
600
400
200
0
-200
-400
-600
GRID VOLTAGE — VOLTS
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
0
4
8
12
16
20
PLATE VOLTAGE—KILOVOLTS
A-26057/R2

OUTLINE DATA

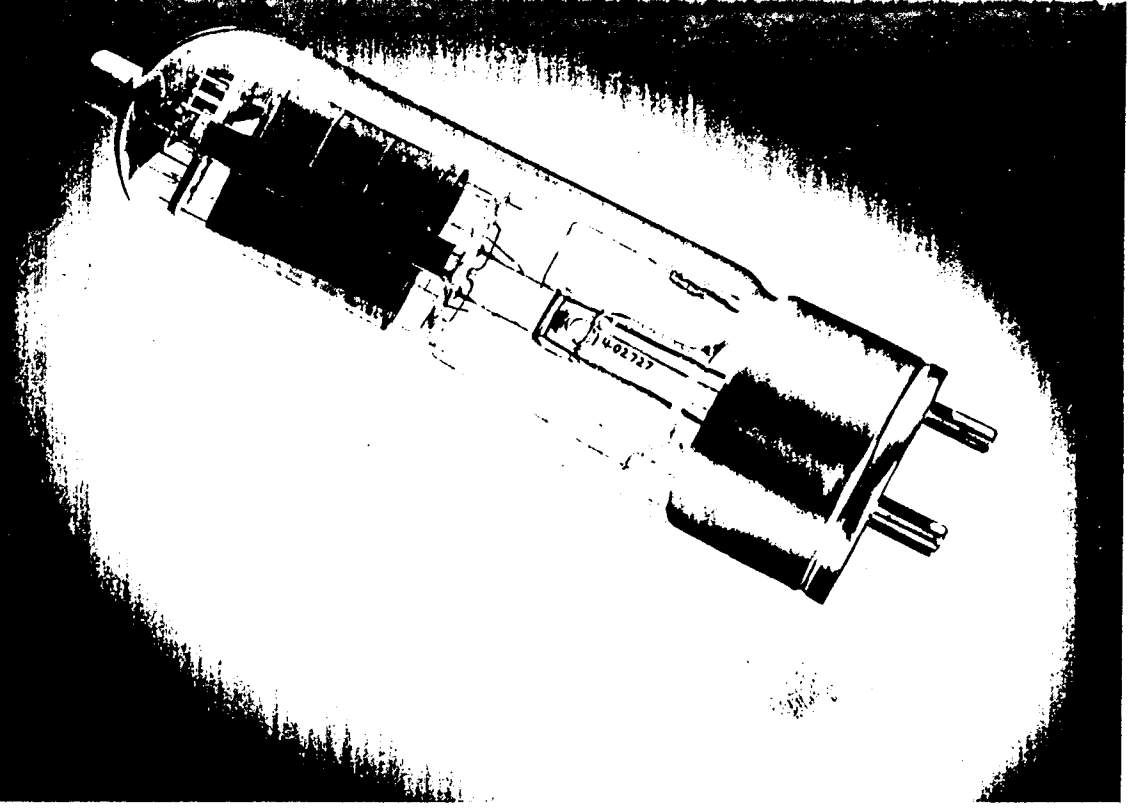




NOTES:

1. FOUR HOLES, 5/16" DEEP, 1/4"-20 TAP EQUALLY SPACED ON 8.19"±.03" B.C. FOR LIFTING.
2. FOUR THROUGH HOLES, .290" DIA. ON 9.16"±.03" B.C. FOR MOUNTING, LOCATED APPROX. 45° FROM TAPPED HOLES.
3. WATER INLET AND OUTLET.
4. 3 BAYONET PINS, 120° APART FOR SOCKET CONNECTIONS.

SPO382
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ST-3820



MACHLETT

ML-241B

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-241B is a three-electrode tube designed for use as a modulator, amplifier, or oscillator in radio-transmitting service. The cathode is a thoriated-tungsten filament. The tube is air cooled and the anode is capable of dissipating 275 watts. Maximum ratings of 3 kVdc and 350 milliamperes apply at frequencies up to 7.5 mc/sec; operation at 22.5 mc/sec is permissible with plate voltage reduced to 1 kVdc.

The ML-241B embodies all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent outgassing. The tube is exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high- and super-voltage x-ray tubes.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	14 volts
Filament Current at 14 volts	6 amperes
Amplification Factor	16
Grid-Plate Transconductance	8500 uMhos
Interelectrode Capacitances	
Grid-Plate	16.5 uuf
Grid-Filament	14.5 uuf
Plate-Filament	4.8 uuf

Mechanical

Mounting Position	Vertical or Horizontal*
Type of Cooling	Convection

* If mounted horizontally, the plane of the filament should be vertical.

MAXIMUM RATINGS

Direct Plate Voltage	3600 volts
Direct Plate Current	350 milliamperes
Plate Dissipation	275 watts
Direct Grid Current	75 milliamperes
R.F. Grid Current	5 amperes
Frequency	7.5 megacycles

The above are maximum ratings which do not apply simultaneously but depend on the type of service specified below.

TYPICAL OPERATING CONDITIONS

Class A Audio Amplifier or Modulator

Direct Plate Voltage	1500	1250 volts
Grid Bias	−58	−40 volts
Direct Plate Current	170	200 milliamperes
Plate Dissipation	250	250 watts
Load Impedance	5000	3000 ohms
Undistorted Output	50	40 watts

Grid Bias Modulator

Direct Plate Voltage	3000 volts
Grid Bias	−260 volts
Plate Dissipation	175 watts
Load Impedance	8000 ohms
Peak Power Output	200 watts

Class B Audio Amplifier or Modulator
(for balanced 2 tube circuit)

Direct Plate Voltage	2000	1500 volts
Grid Bias	−110	−75 volts
Direct Plate Current per tube		
No drive	40	50 milliamperes
Maximum drive	300	300 milliamperes
Plate Dissipation	250	200 watts
Load Resistance (plate-to-plate)	8000	5900 ohms
Load Resistance (per tube)	2000	1475 ohms
Approximate Maximum Output	650	500 watts
Recommended Power for driving stage	50	50 watts

Class B Radio-Frequency Amplifier

Direct Plate Voltage	2000	1300 volts
Direct Plate Current	300	270 milliamperes
Plate Dissipation	275	275 watts
Grid Bias	−120	−90 volts
Approximate Carrier Watts for use with 100% modulation	150	130 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

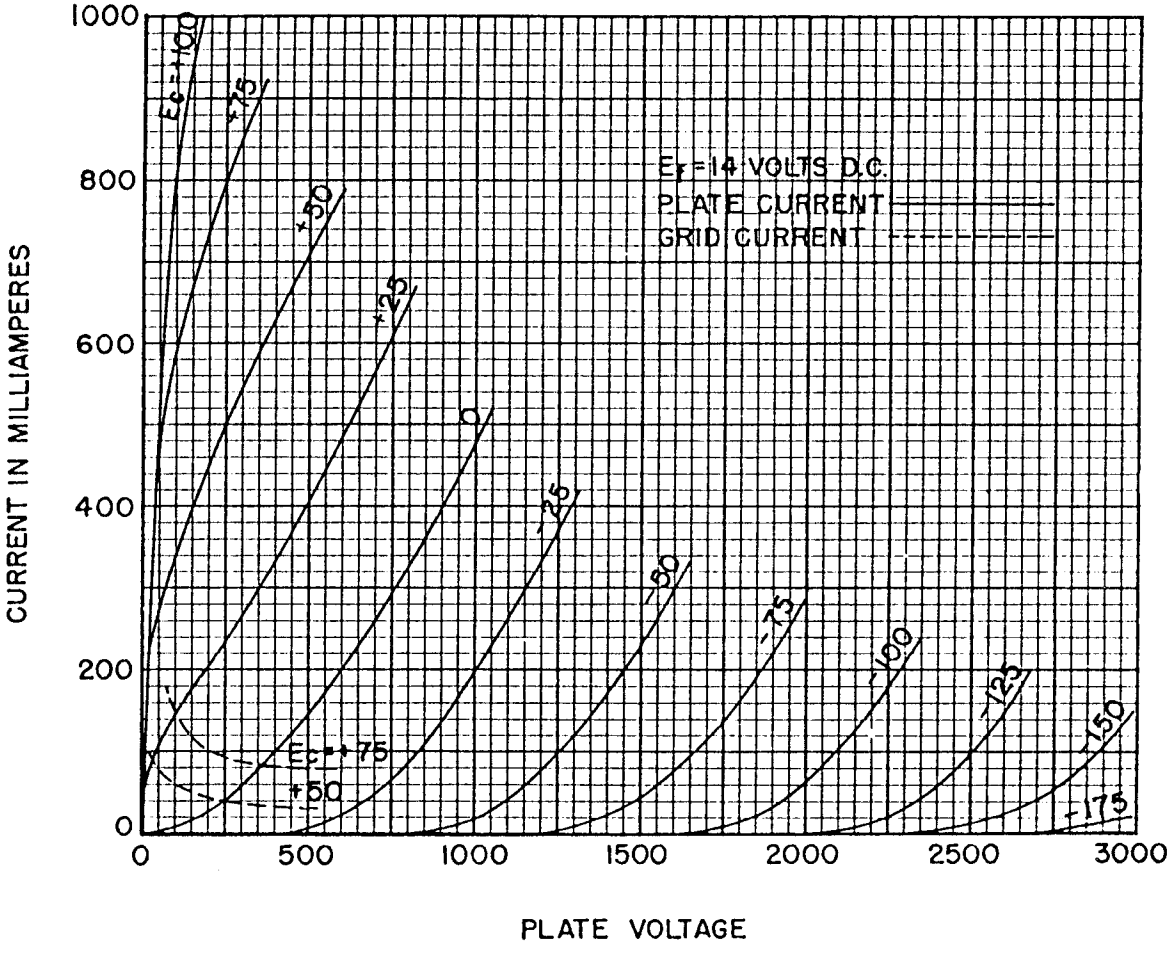
Direct Plate Voltage	2000	1500 volts
Direct Plate Current	300	300 milliamperes
Grid Bias	−185 to −250	−150 to −200 volts
Nominal Power Output	400	300 watts

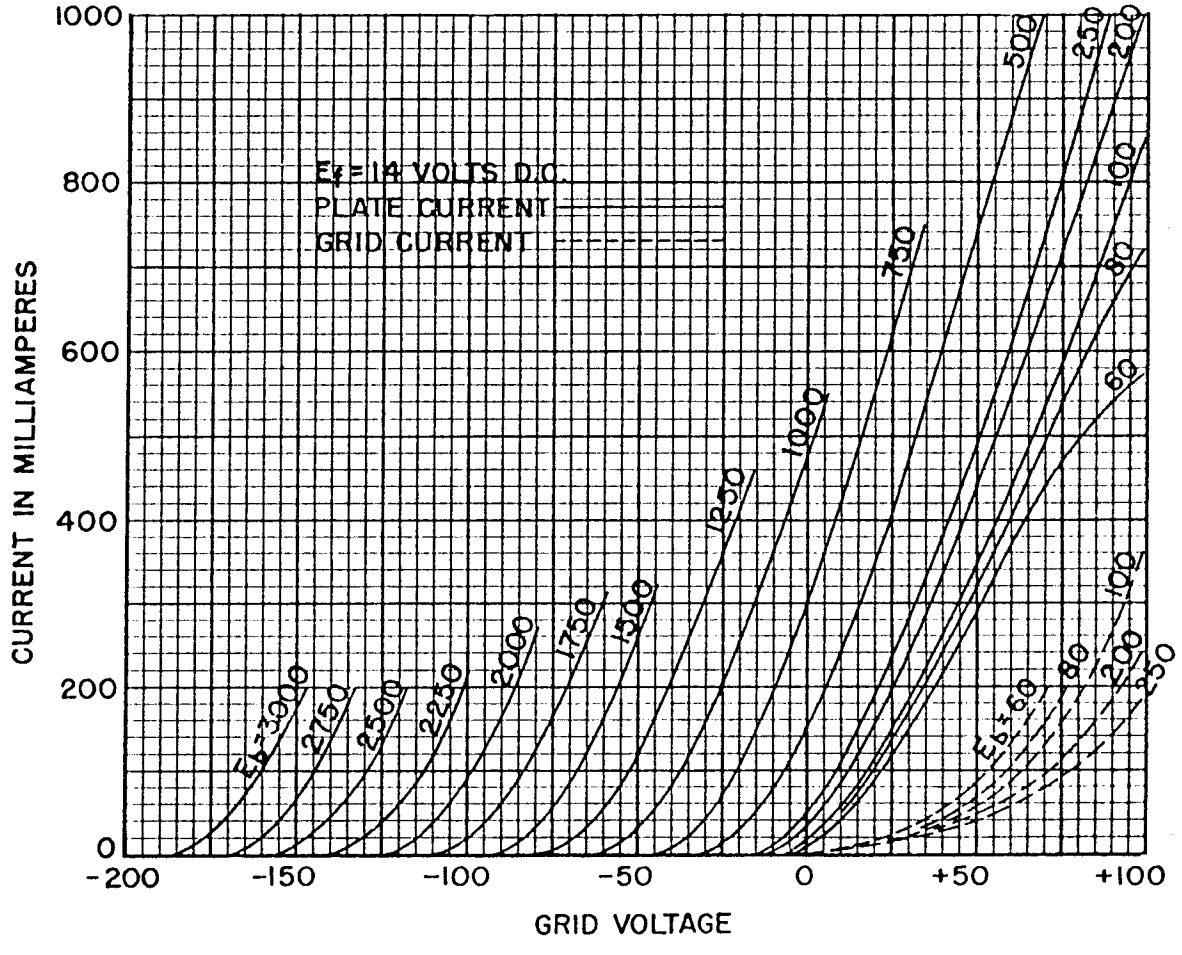
Class C Radio-Frequency Amplifier—Plate Modulated

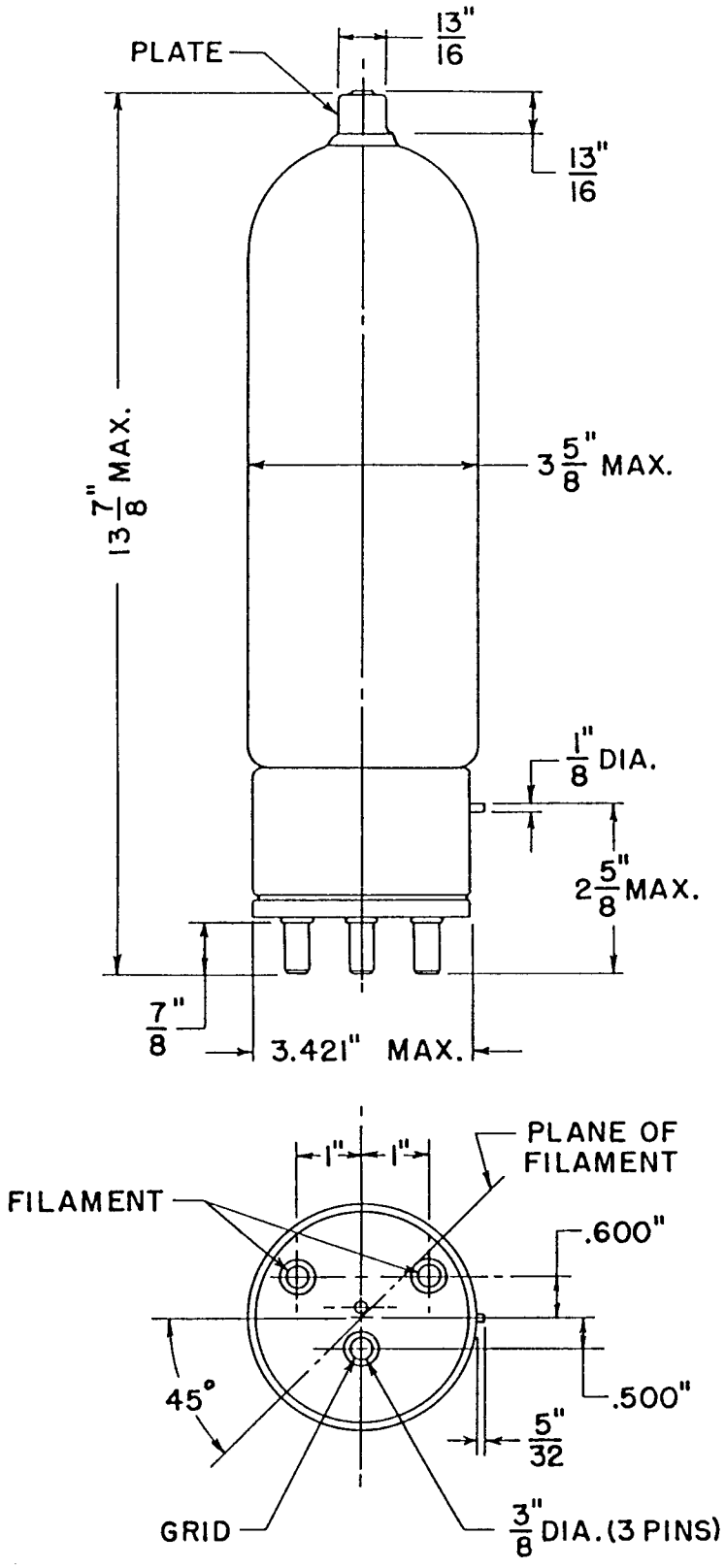
Direct Plate Voltage	1500	1000 volts
Direct Plate Current	300	300 milliamperes
Grid Bias	−200	−125 volts
Direct Grid Current	75	75 milliamperes
Nominal Carrier Power Output for use with 100% modulation	300	200 watts

APPLICATION NOTES

Maximum ratings apply at frequencies of 7.5 megacycles and less. The maximum plate voltage for the upper frequency limit of 22.5 megacycles is 1000 volts. The maximum plate voltage for frequencies between 7.5 and 22.5 megacycles should be proportionately reduced. At high frequencies special attention should be given to adequate ventilation of the bulb.


CURRENT IN MILLIAMPERES
PLATE VOLTAGE
Ef=14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
Ec=+100
+75
+50
+25
0
-25
-50
-75
-100
-125
-150
-175
Ec=+75
+50
1000
800
600
400
200
0
0
500
1000
1500
2000
2500
3000


CURRENT IN MILLIAMPERES
GRID VOLTAGE
Ef=14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
Eb=3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
200
100
80
60
Eb=60
80
100
200
250
1000
800
600
400
200
0
-200
-150
-100
-50
0
+50
+100



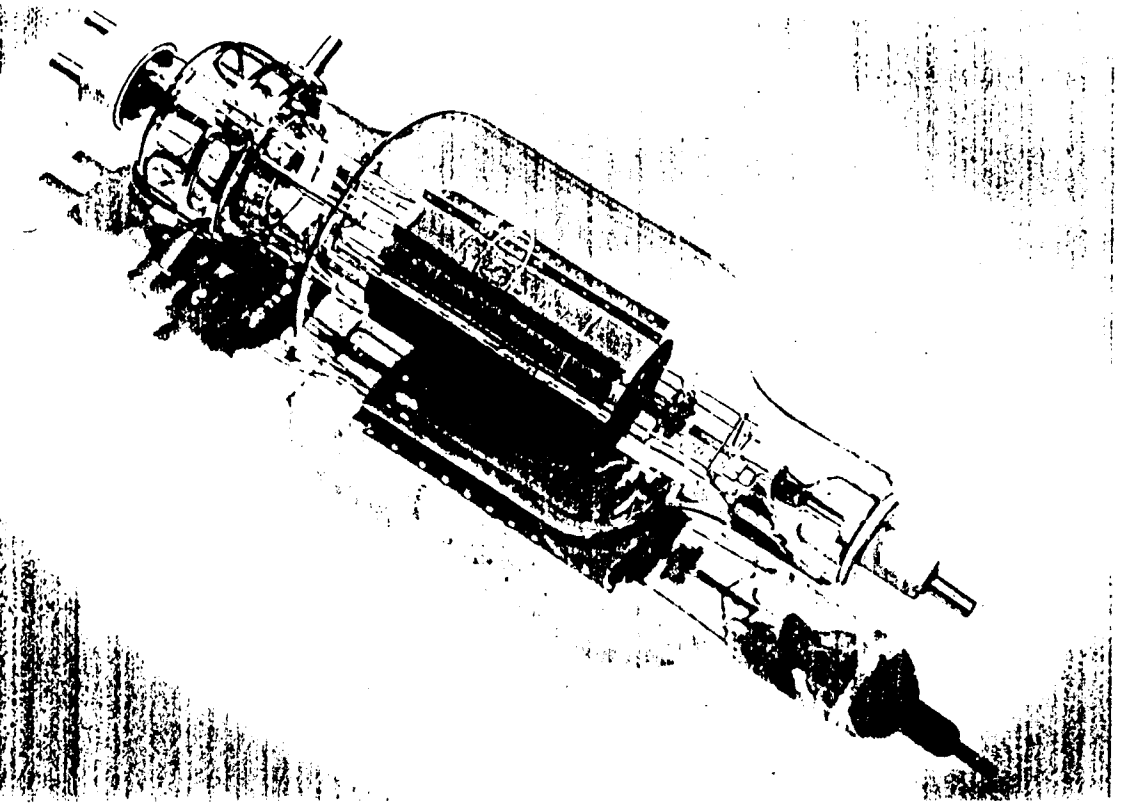
DIMENSIONS—ML-241B

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

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MACHLETT

ML-279A
ML-379A

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-279A and ML-379A are three-electrode tubes designed for use as modulators, amplifiers, or oscillators in radio-transmitting service. The cathode for each type is a thoriated-tungsten filament. Each tube is air cooled and its anode is capable of dissipating 1.2 kW. Maximum ratings of 3 kVdc and 800 milliamperes apply at frequencies up to 20 Mc; operation at 40 Mc is permissible with plate voltage reduced to 1.5 kVdc.

The ML-279A and ML-379A embody all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent outgassing. The tube is exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high- and super-voltage x-ray tubes.

GENERAL CHARACTERISTICS

Electrical	
Filament Voltage	10 volts
Filament Current at 10 Volts	21.0 amperes
Amplification Factor	10
Grid-Plate Transconductance	5000 uMhos
Interelectrode Capacitances	
Grid-Plate	18 uuf
Grid-Filament	15 uuf
Plate-Filament	7 uuf
Mechanical	
Mounting Position	Vertical
Type of Cooling	Convection

MAXIMUM RATINGS

Direct Plate Voltage	3000 volts
Direct Plate Current	800 milliamperes
Plate Dissipation	1200 watts
Direct Grid Current	100 milliamperes
R. F. Grid Current	15 amperes
Frequency	20 megacycles

The above are maximum ratings which do not apply simultaneously but depend on the type of service specified below.

TYPICAL OPERATING CONDITIONS

Class A Audio Amplifier or Modulator

Direct Plate Voltage	2500	2000 volts
Grid Bias	−170	−110 volts
Direct Plate Current	300	375 milliamperes
Plate Dissipation	750	750 watts
Load Impedance	4500	2000 ohms
Undistorted Output	155	85 watts

Class B Audio Amplifier or Modulator

(for balanced 2 tube circuit)

Direct Plate Voltage	2500	2000 volts
Grid Bias	−200	−150 volts
Direct Plate Current, per tube		
No drive	150	110 milliamperes
Maximum drive	800	800 milliamperes
Plate Dissipation	900	720 watts
Load Resistance, plate-to-plate	2800	2240 ohms
Load Resistance, per tube	700	560 ohms
Approximate Maximum Output—2 tubes	2200	1760 watts
Recommended Power for Driving Stage	100	100 watts

Class B R-F Amplifier

Direct Plate Voltage	3000	2500 volts
Direct Plate Current	600	720 milliamperes
Grid Bias	−325	−275 volts
Approximate Carrier Watts for use with 100% modulation	600	600 watts

Class C R-F Oscillator or Power Amplifier—Unmodulated

Direct Plate Voltage	3000	2500 volts
Direct Plate Current	800	800 milliamperes
Grid Bias	−500 to −650	−400 to −550 volts
Direct Grid Current	150	100 milliamperes
Nominal Power Output	1600	1300 watts
Plate Dissipation	800	700 watts

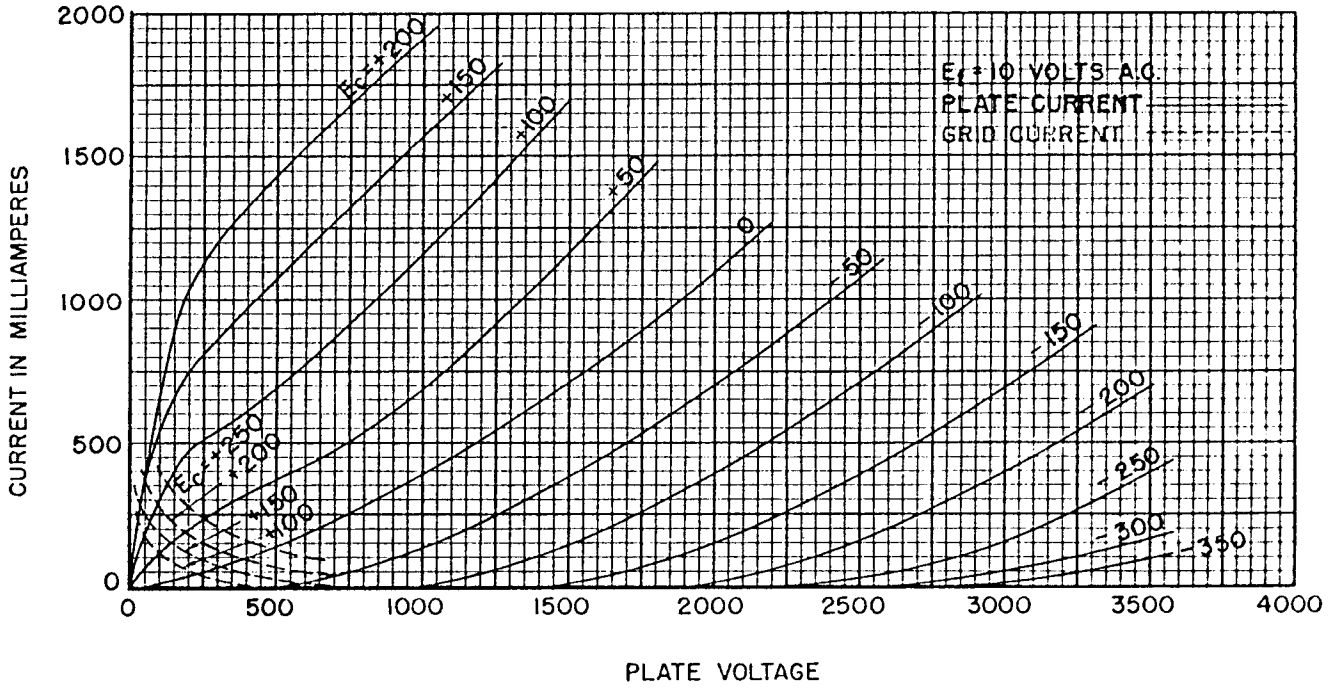
Class C R-F Amplifier—Plate Modulated

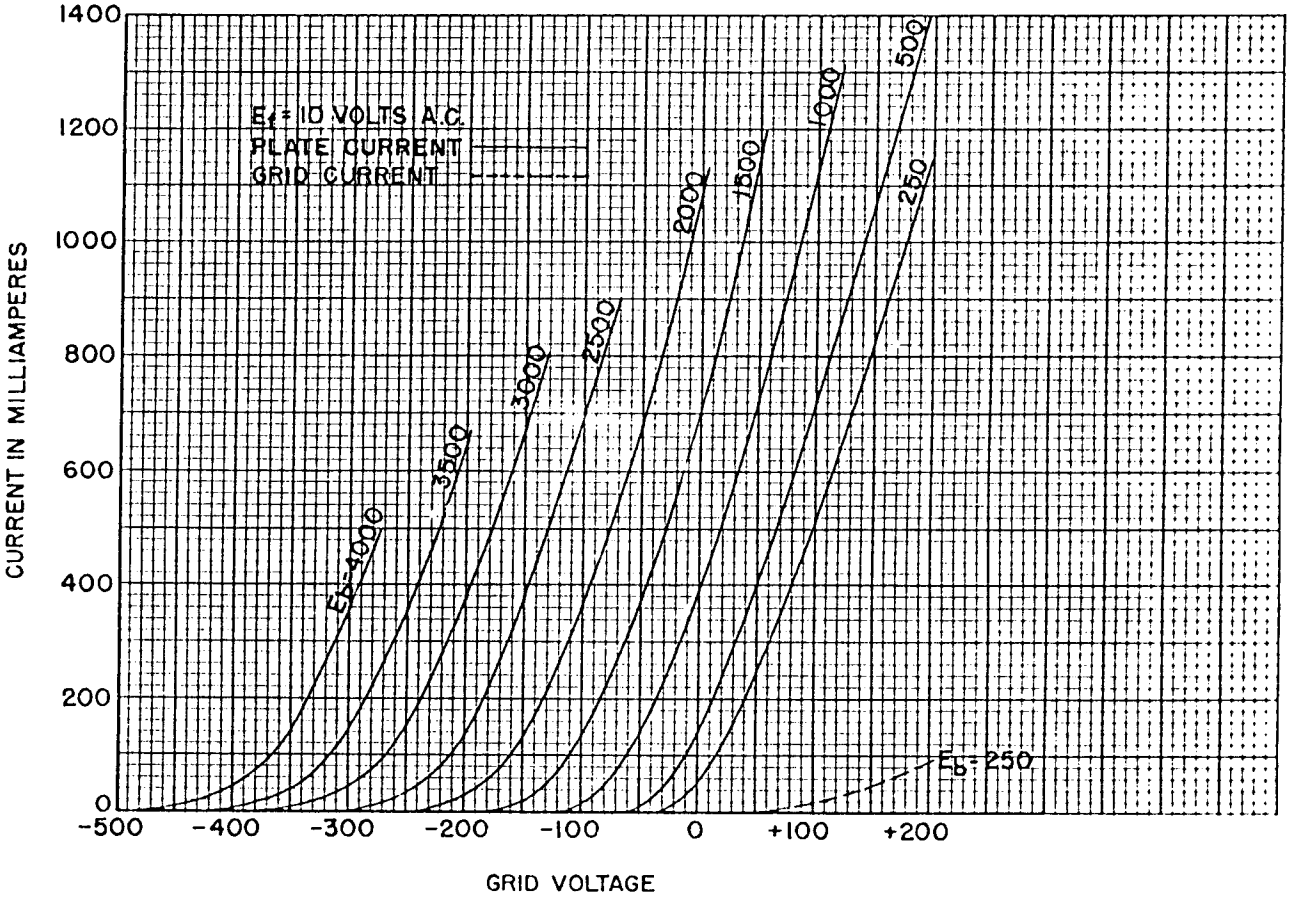
Direct Plate Voltage	2250	1750 volts
Direct Plate Current	600	700 milliamperes
Grid Bias	−450	−360 volts
Direct Grid Current	100	100 milliamperes
Nominal Carrier Power Output for use with 100% modulation	900	830 watts

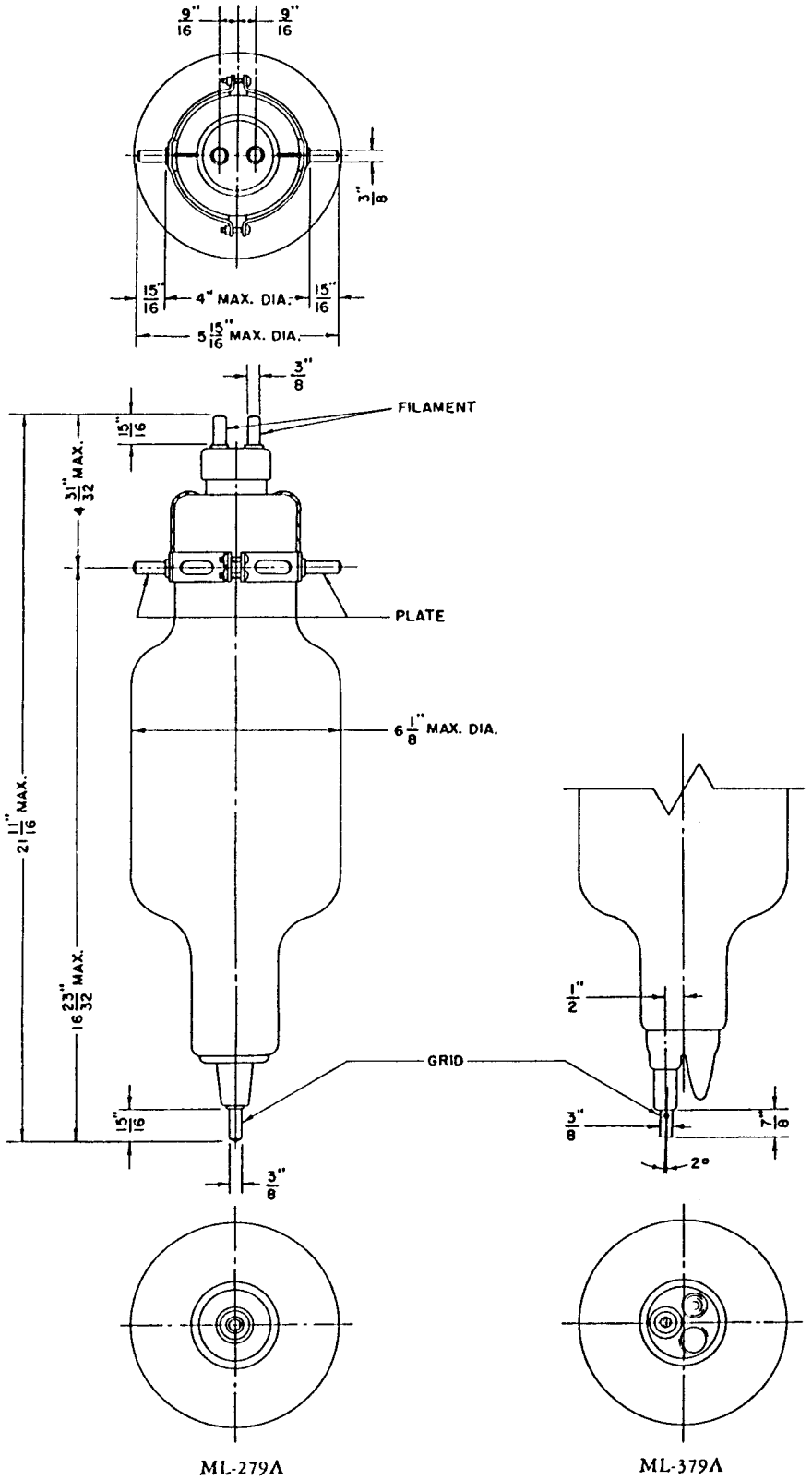
APPLICATION NOTES

Maximum ratings apply at frequencies of 20 megacycles and less. The maximum plate voltage for the upper frequency limit of 40 megacycles is 1500 volts. The maximum plate voltage for frequencies between 20 and 40 megacycles should be proportionately reduced.

A free circulation of air must be provided to insure adequate cooling of the glass during operation.


CURRENT IN MILLIAMPERES
PLATE VOLTAGE
Ef = 10 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
Ec=+200
+150
+100
+50
0
-50
-100
-150
-200
-250
-300
-350
2000
1500
1000
500
0
0
500
1000
1500
2000
2500
3000
3500
4000


CURRENT IN MILLIAMPERES
GRID VOLTAGE
Ef = 10 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
Ec=4000
3500
3000
2500
2000
1500
1000
500
250
Eb=250
1400
1200
1000
800
600
400
200
0
-500
-400
-300
-200
-100
0
+100
+200



ML-279A ML-379A

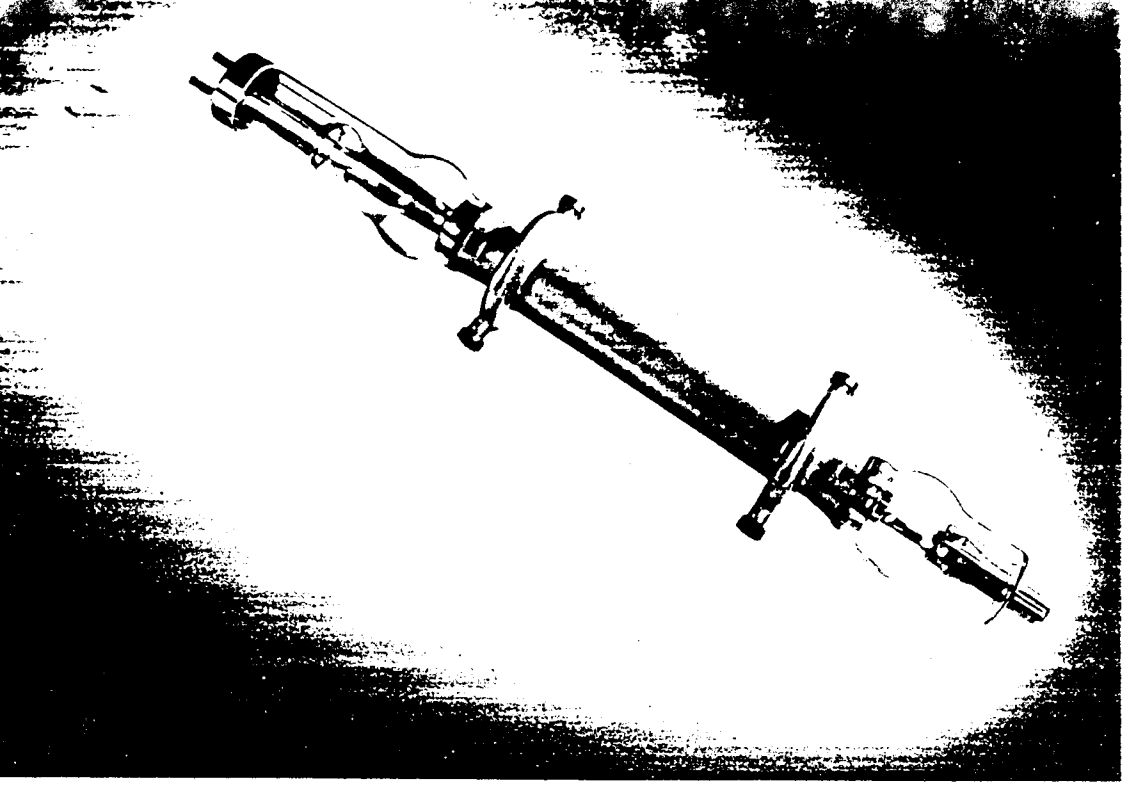
Dimensions—ML-279A and ML-379A

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MACHLETT

ML-298A
ML-298B

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-298A and ML-298B are three-electrode tubes designed for use as modulators, amplifiers, or oscillators in radio-transmitting service. The cathode for each type is a pure-tungsten filament. The anode is water cooled and is capable of dissipating 100 kilowatts. Maximum ratings of 20 kVdc and 11 amperes apply at frequencies up to 4 mc/sec; operation at 20 mc/sec is permissible with plate voltage reduced to 12 kVdc.

The ML-298A and ML-298B embody all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent outgassing. The tubes are exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high- and super-voltage x-ray tubes.

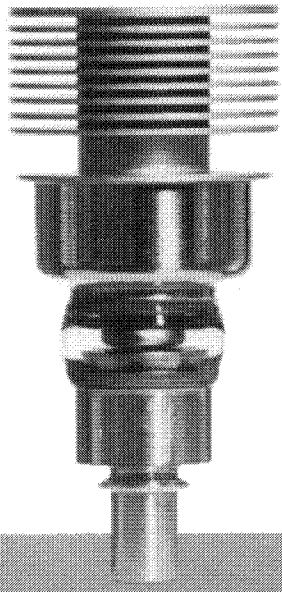
GENERAL CHARACTERISTICS

Electrical	**ML-298A**	**ML-298B**	
Filament Voltage	27	27	volts
Filament Current at 27 volts	225	225	amperes
Filament Starting Current	340	340	amperes
Filament Cold Resistance	.0096	.0096	ohms
Amplification Factor	32	57.5	
Grid-Plate Transconductance	22000	20000	uMhos
Interelectrode Capacitances			
Grid-Plate	48	50	uuf
Grid-Filament	30	31	uuf
Plate-Filament	11	11	uuf
Mechanical			
Mounting Position	Vertical, anode down		
Type of Cooling	Water		
Water Flow on Anode (minimum)	35		gpm
Maximum Outgoing Water Temperature	75		°C
Net Weight, approximate	28		lbs.

MAXIMUM RATINGS

Direct Plate Voltage	20000	volts
Direct Plate Current	11	amperes
Plate Dissipation	100000	watts
Direct Grid Dissipation	1000	watts
R.F. Grid Current	75	amperes
Frequency	4	megacycles

The above are maximum ratings which do not apply simultaneously but depend on the type of service specified below.



ML-2C39A

General purpose application.

DESCRIPTION

The **ML-2C39A** is a high-mu triode of the planar-electrode type designed specifically for use as an oscillator, frequency multiplier, or power amplifier in radio transmitting service from low frequency to above 2500 Mc. Features include low interelectrode capacitances, high transconductance, and high plate dissipation. Lead inductances and r.f. losses are minimized by a compact, rugged construction with ring type seals, making the tube ideally suited to cavity type circuits as well as for parallel line operation. The cathode is an indirectly-heated, oxide-coated disc. The anode is forced-air cooled and is capable of dissipating 100 watts.

The **ML-2C39A** embodies the highest standards of this tube type. All parts are thoroughly processed by special Machlett techniques to assure efficient operation and long life.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage	6.3	Volts†
Heater Current at 6.3 Volts	1.0	Amps
Heater Heating Time, minimum (Before Applying Plate Voltage)	60	Seconds
Amplification Factor	100	
Transconductance (I_b = 70 mA, E_b = 600 v)	24,000	umhos
Interelectrode Capacitances		
Grid-Plate	2.0	uuf
Grid-Cathode	6.60	uuf
Plate-Cathode, maximum	0.035	uuf
Mechanical		
Mounting Position	Optional	
Type of Cooling	Forced Air*	
Maximum Incoming Air Temperature	45	°C
Required Air Flow on Anode	12.5	cfm*
Maximum Anode Temperature	175	°C
Net Weight	2	oz.

†See Application Note, page 16, for optimum heater voltage.

*See Application Notes, page 16 and also air cooling curves, page 83.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

R-F Power Amplifier and Oscillator

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	1000	volts
D-C Grid Voltage	-150	volts
D-C Cathode Current	125	mA
D-C Grid Current§	50	mA
Peak Positive RF Grid Voltage	30	volts
Peak Negative RF Grid Voltage	-400	volts
Plate Dissipation† (Forced-air Cooling)	100	watts
Grid Dissipation	2	watts

Typical Operation

Power Amplifier, Grid Separation Circuit — 500 Mc

D-C Plate Voltage	900	volts
D-C Grid Voltage	-40	volts
D-C Cathode Current	115	mA
D-C Plate Current	90	mA
D-C Grid Current, Approximate	30	mA
Plate Input	64	watts
Driving Power, Approximate	6	watts
Useful Power Output	40	watts

RF Oscillator — 2500 Mc

D-C Plate Voltage	900	volts
D-C Grid Voltage (from grid-bias resistor) (approx.)	-22	volts
D-C Plate Current	90	mA
D-C Grid Current	27	mA
Useful Power Output	17	watts

Note: These conditions are for a grid-blocking oscillator and conform to the minimum power output requirements as specified in such a test by the MIL-E-1 specification for 2C39A tubes.

Plate Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage*	600	volts
D-C Grid Voltage	-150	volts
D-C Cathode Current	100	mA
D-C Grid Current§	50	mA
Peak Positive RF Grid Voltage	30	volts
Peak Negative RF Grid Voltage	-400	volts
Plate Dissipation† (Forced-air Cooling)	70	watts
Grid Dissipation	2	watts

Characteristic Range Values for Equipment Design

	Min.	Max.	
Filament Current at 6.3 volts (Note 1)	0.95	1.1	A
Plate Current (Note 2)	60	95	mAdc
Cut-off bias (Note 3)	——	-15	volts
Transconductance	20000	30000	umhos
Grid-Plate Capacitance	1.86	2.16	uuf
Grid-Cathode Capacitance (Note 4)	5.60	7.60	uuf
Plate tuning range (Note 5)	1960	2030	Mc

Note 1 — For reduced filament voltage see filament volt-ampere characteristics on page 3.

Note 2 — Measured at a plate voltage of 600 volts and a cathode-bias resistor of 30 ohms.

Note 3 — Measured at 1 mA of plate current and a plate voltage of 600 volts.

Note 4 — Capacitance measurements are with the tube cold. When the filament is heated to proper operating temperature, the grid to cathode capacitance will increase by about 1 uuf, due to thermal expansion of the cathode.

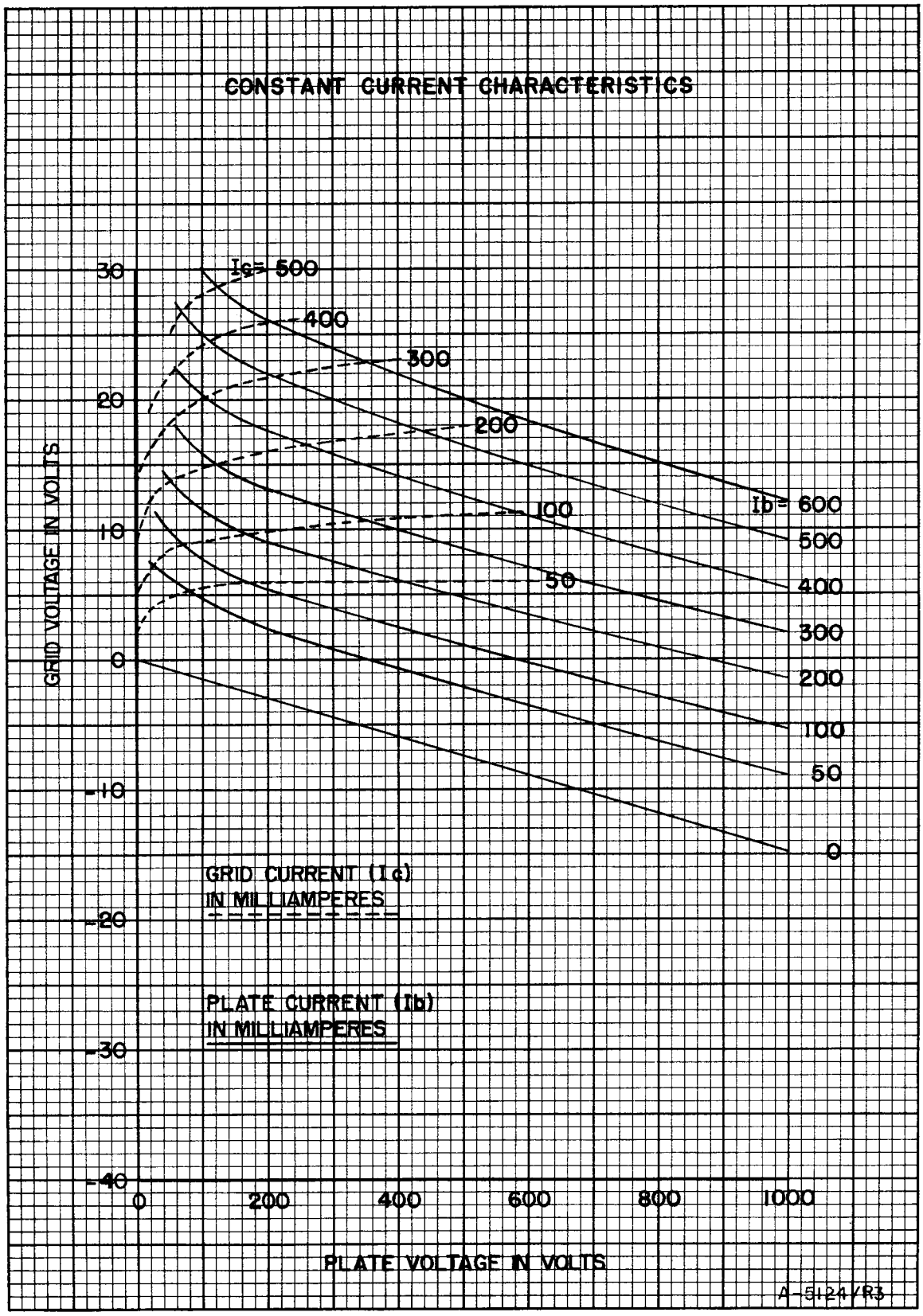
Note 5 — With a plate-grid coaxial cavity of fixed dimensions, all tubes will resonate within the specified frequency range.

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

§See Application Notes on Determination of Proper Grid Drive.

†Up to 100 watts plate dissipation allowable with forced air sufficient to limit seal temperatures to 175°C. Recommended air flow is 12.5 cubic feet per minute with cowling.

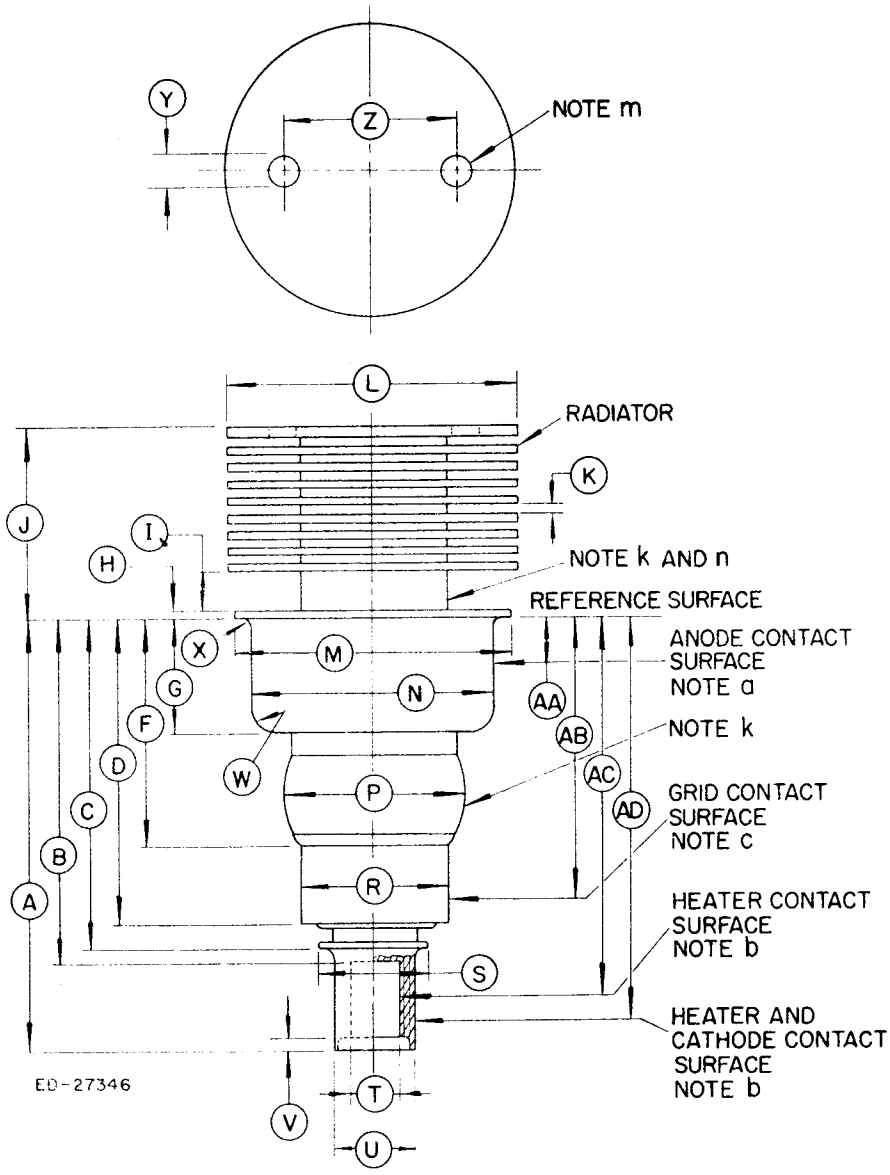
*For modulation factors less than 1.0, a higher d-c plate voltage may be used if the sum of the peak audio voltage and the d-c plate voltage does not exceed 1200 volts.


CONSTANT CURRENT CHARACTERISTICS
Ic= 500
400
300
200
100
50
Ib= 600
500
400
300
200
100
50
0
30
20
10
0
-10
-20
-30
-40
GRID VOLTAGE IN VOLTS
GRID CURRENT (Ic) IN MILLIAMPERES
PLATE CURRENT (Ib) IN MILLIAMPERES
0
200
400
600
800
1000
PLATE VOLTAGE IN VOLTS
A-5124/R3

OUTLINE AND DIMENSIONS

DIMENSIONS A ML-2C39A, ML-2C39WA, ML-2C41, ML-322, ML-7209, and ML-7210

DIMENSIONS B ML-322



DIMENSIONS FOR OUTLINE (INCHES)

	DIMENSIONS A		DIMENSIONS B	
Ref.	Min.	Max.	Min.	Max.
A	1.815	1.875	1.788	1.858
B	—	1.534	—	1.517
C	—	1.475	—	1.458
D	1.289	1.329	1.252	1.292
F	—	0.980	—	1.000
G	0.462	.477	.459	.479
H	—	.040	—	.040
I	.125	.185	.125	—
J	.766	.826	.736	.826
K	.025	.046	.015	—
L	1.234	1.264	1.235	1.265
M	1.180	1.195	1.788	1.199
N	1.025	1.035	1.021	1.039
P	—	0.812	—	.812
R	0.655	0.665	.652	.668
S	—	.545	—	.545
T	0.213	.223	.213	.223
U	.315	.325	.312	.328
V	—	.086	—	.086
W	—	.100	—	.100
X	—	.035	.105	.145
Y	.105	.145	.650	.850
Z	.650	.850		

DIMENSIONS FOR ELECTRODE CONTACT AREA (INCHES)

DIMENSIONS A

Ref.	Dimensions	Contact
AA	0.198 ± 0.163	Anode
AB	1.225 ± .040	Grid
AC	1.631 ± .097	Heater
AD	1.645 ± .170	Cathode

DIMENSIONS B

Ref.	Dimension	Contact
AA	0.195 ± .163	Anode
AB	1.210 ± .040	Cathode & Heater
AC	1.610 ± .092	Heater
AD	1.623 ± .165	Cathode & Heater

NOTES

a. The total indicated runout of the anode contact surface with respect to the cathode contact surface will not exceed 0.020 inch, except ML-322; 0.030 inch, ML-322.

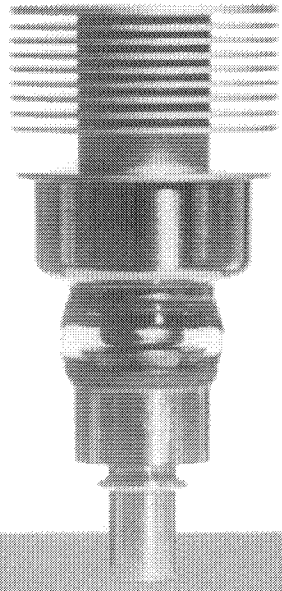
b. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed 0.012 inch, except ML-322; 0.018 inch, ML-322.

c. The total indicated runout of the grid contact surface with respect to the cathode contact surface will not exceed 0.020 inch. Does not apply to ML-322.

k. Do not clamp or locate on this surface.

m. Hole provided for tube extractor through top fin only.

n. Measure anode shank temperature here.



ML-2C39WA

Ruggedized structure. General purpose application.

DESCRIPTION

The **ML-2C39WA** is a ruggedized high-mu triode of planar-electrode type designed specifically for use as an oscillator, frequency multiplier or power amplifier in radio transmitting service at frequencies up to 2500 Mc.

The **ML-2C39WA** is interchangeable with the **ML-2C39A.** This tube retains the desirable high mu, high transconductance characteristics of the **ML-2C39A** together with its low interelectrode capacitances and compact, rugged ring-seal construction.

The **ML-2C39WA** is the result of an intensive development program with respect to the proper selection and processing of tube materials, particularly with regard to the cathode, to provide improved life, reliability and stability of operation. This tube is manufactured and tested to close tolerances to insure consistent and uniform tube performance.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.0	Volts†
Heater Current (AC or DC) at 6.0 Volts	1.0	Amp
Heater Heating Time, minimum	60	secs
Amplification Factor	100	
Transconductance (I_b = 70 mA, E_b = 600 v)	25,000	μmhos
Interelectrode Capacitances (without heater voltage)		
Grid-Plate	2.0	μμf
Grid-Cathode	6.60	μμf
Plate-Cathode, maximum	0.035	μμf
Frequency for Maximum Ratings	2500	Mc

Mechanical

Mounting Position	Optional	
Type of Cooling	Forced Air*	
Maximum Anode Temperature	200	°C
Net Weight	2.0	oz.

†See Application Note, page 16, for optimum heater voltage.

*See Application Notes, page 16 and also air cooling curves, page 83.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

R-F Power Amplifier and Oscillator

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	1000	volts
D-C Grid Voltage	−150	volts
D-C Cathode Current	125	mA
D-C Grid Current§	50	mA
Peak Positive R-F Grid-Cathode Voltage	30	volts
Peak Negative R-F Grid-Cathode Voltage	−400	volts
Plate Dissipation† (Forced-air Cooling)	100	watts
Grid Dissipation	2	watts

Typical Operation

Power Amplifier, Grid Separation Circuit — 500 Mc

D-C Plate Voltage	900	volts
D-C Grid Voltage	−40	volts
D-C Plate Current	90	mA
D-C Grid Current, Approximate	30	mA
Driving Power, Approximate	6	watts
Useful Power Output	40	watts

R-F Oscillator — 2500 Mc

D-C Plate Voltage	900	volts
D-C Grid Voltage, Approximate	−22	volts
D-C Plate Current	90	mA
D-C Grid Current	10	mA
Useful Power Output	17	watts

Plate Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage*	600	volts
D-C Grid Voltage	−150	volts
D-C Cathode Current	100	mA
D-C Grid Current§	50	mA
Peak Positive R-F Grid Voltage	30	volts
Peak Negative R-F Grid Voltage	−400	volts
Plate Dissipation† (Forced-air Cooling)	70	watts
Grid Dissipation	2	watts

Characteristic Range Values for Equipment Design

	Min.	Max.	
Filament Current at 6.0 volts	0.90	1.05	amps
Cut-off bias (Note 1)	—	−15	volts
Grid-Plate Capacitance (Note 2)	1.86	2.16	$\mu\mu f$
Grid-Cathode Capacitance (Note 2)	5.60	7.60	$\mu\mu f$

Note 1 — Measured at 1 mA of plate current and a plate voltage of 600 volts.

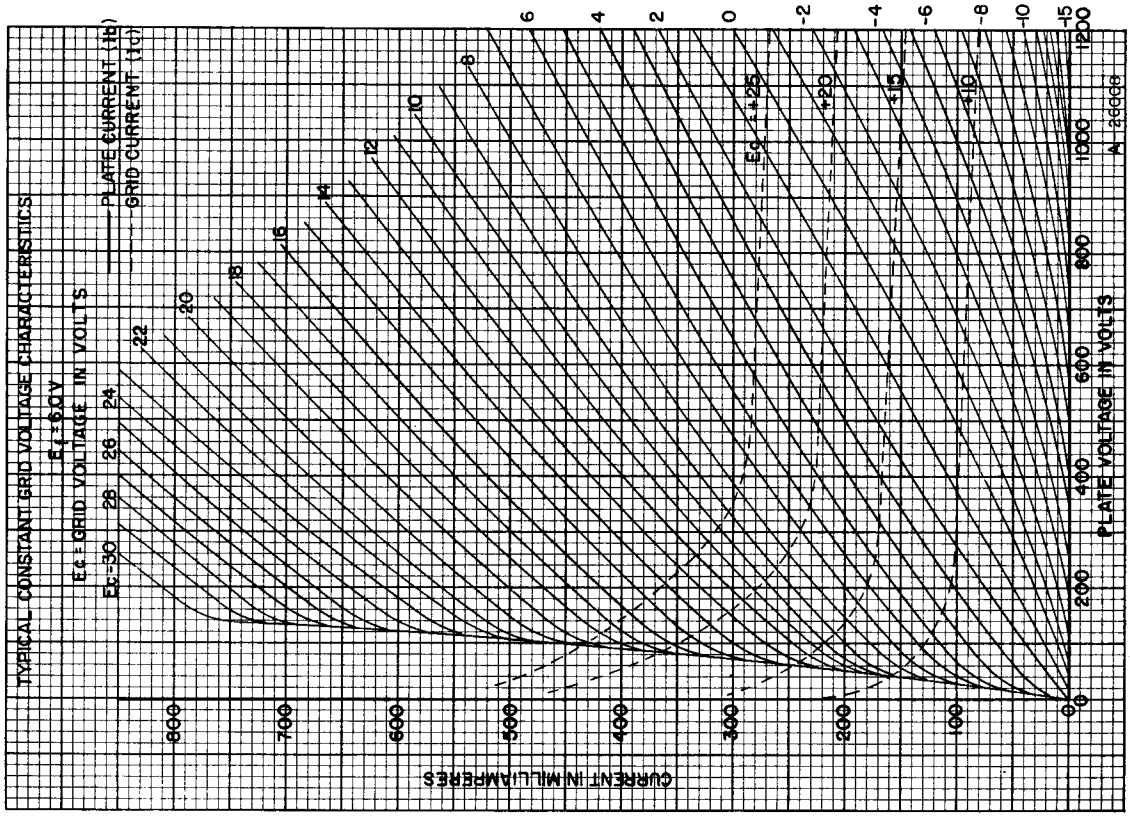
Note 2 — Capacitance measurements are with the tube cold.

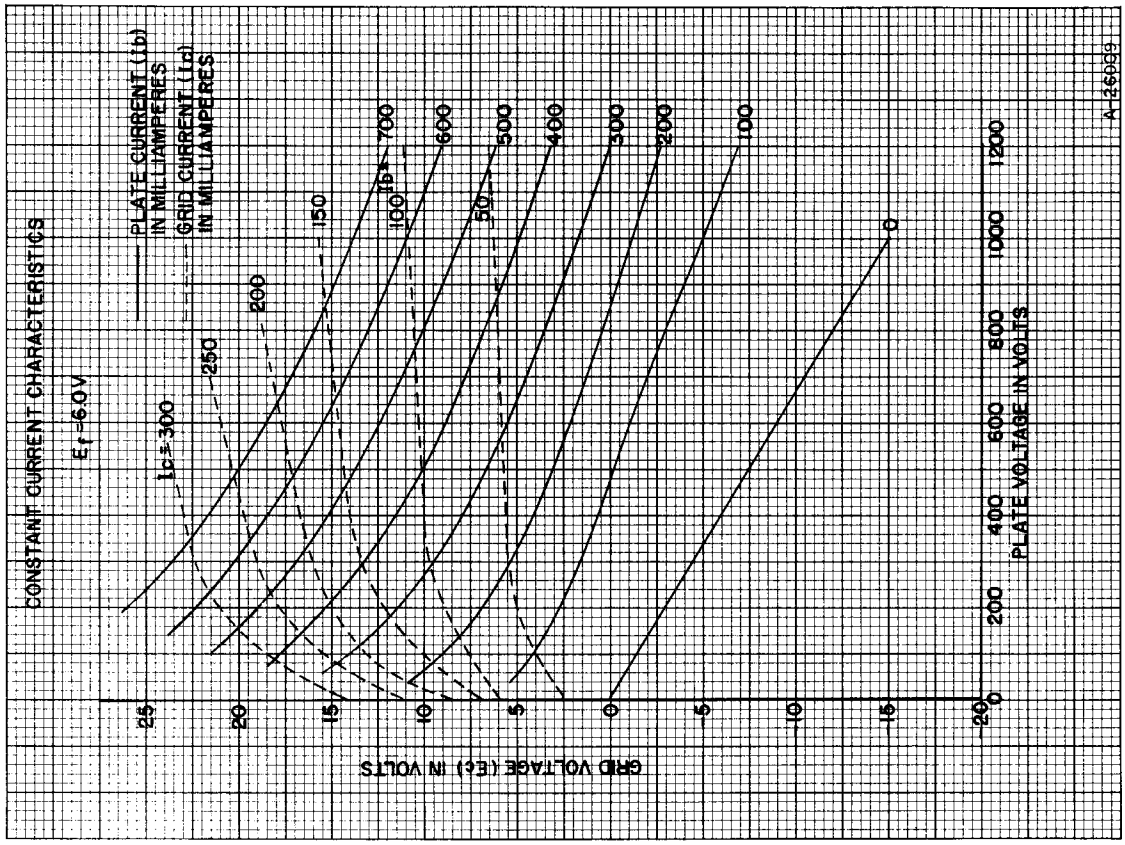
‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

§See "Application Notes" on "Determination of Proper Grid Drive".

†Refer to "Cooling" under "Application Notes".

*For modulation factors less than 1.0, a higher d-c plate voltage may be used if the sum of the peak audio voltage and the d-c plate voltage does not exceed 1200 volts.

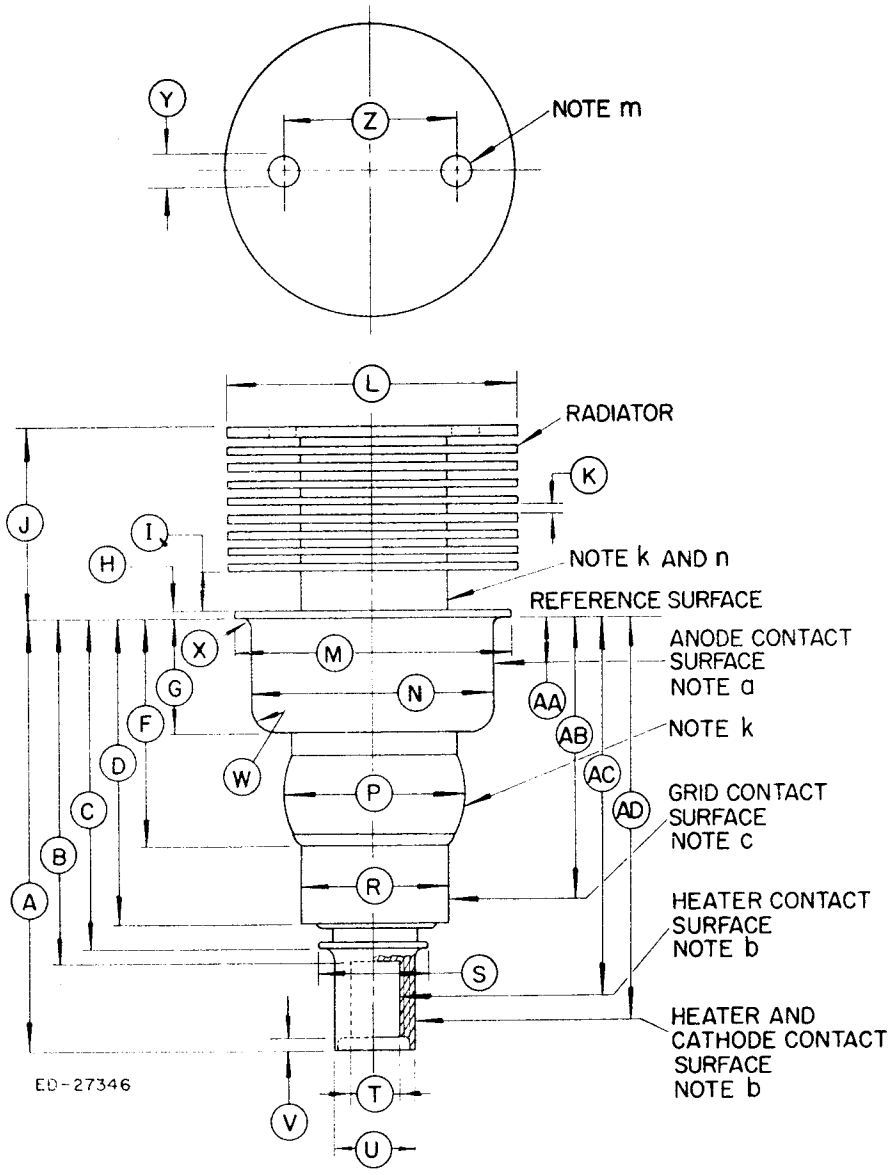

TYPICAL CONSTANT GRID VOLTAGE CHARACTERISTICS
Ef = 6.0V
Ec = GRID VOLTAGE IN VOLTS
PLATE CURRENT (Ib)
GRID CURRENT (Ic)
CURRENT IN MILLIAMPERES
PLATE VOLTAGE IN VOLTS
A-26668


CONSTANT CURRENT CHARACTERISTICS
Ef = 6.0V
PLATE CURRENT (Ib) IN MILLIAMPERES
GRID CURRENT (Ic) IN MILLIAMPERES
GRID VOLTAGE (Ec) IN VOLTS
PLATE VOLTAGE IN VOLTS
A-26669

OUTLINE AND DIMENSIONS

DIMENSIONS A ML-2C39A, ML-2C39WA, ML-2C41, ML-322, ML-7209, and ML-7210

DIMENSIONS B ML-322



DIMENSIONS FOR OUTLINE (INCHES)

	DIMENSIONS A		DIMENSIONS B	
Ref.	Min.	Max.	Min.	Max.
A	1.815	1.875	1.788	1.858
B	—	1.534	—	1.517
C	—	1.475	—	1.458
D	1.289	1.329	1.252	1.292
F	—	0.980	—	1.000
G	0.462	.477	.459	.479
H	—	.040	—	.040
I	.125	.185	.125	—
J	.766	.826	.736	.826
K	.025	.046	.015	—
L	1.234	1.264	1.235	1.265
M	1.180	1.195	1.788	1.199
N	1.025	1.035	1.021	1.039
P	—	0.812	—	.812
R	0.655	0.665	.652	.668
S	—	.545	—	.545
T	0.213	.223	.213	.223
U	.315	.325	.312	.328
V	—	.086	—	.086
W	—	.100	—	.100
X	—	.035	.105	.145
Y	.105	.145	.650	.850
Z	.650	.850		

DIMENSIONS FOR ELECTRODE CONTACT AREA (INCHES)

DIMENSIONS A

Ref.	Dimensions	Contact
AA	0.198 ± 0.163	Anode
AB	1.225 ± .040	Grid
AC	1.631 ± .097	Heater
AD	1.645 ± .170	Cathode

DIMENSIONS B

Ref.	Dimension	Contact
AA	0.195 ± .163	Anode
AB	1.210 ± .040	Cathode & Heater
AC	1.610 ± .092	Heater
AD	1.623 ± .165	Cathode & Heater

NOTES

a. The total indicated runout of the anode contact surface with respect to the cathode contact surface will not exceed 0.020 inch, except ML-322; 0.030 inch, ML-322.

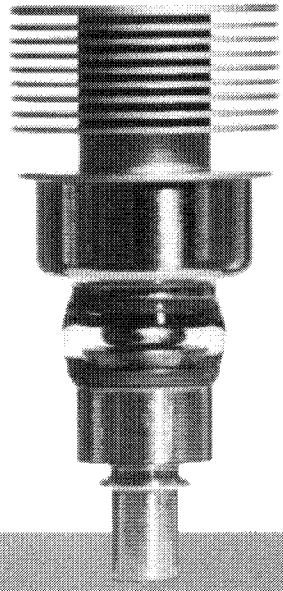
b. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed 0.012 inch, except ML-322; 0.018 inch, ML-322.

c. The total indicated runout of the grid contact surface with respect to the cathode contact surface will not exceed 0.020 inch. Does not apply to ML-322.

k. Do not clamp or locate on this surface.

m. Hole provided for tube extractor through top fin only.

n. Measure anode shank temperature here.



ML-2C41

Plate-pulsed oscillator service.

DESCRIPTION

The **ML-2C41** is a high-mu triode of the planar-electrode type designed for use as a plate-pulsed oscillator, or power amplifier in radio transmitting service from low frequency to 3000 Mc. Features include low interelectrode capacitances, high transconductance and great mechanical strength. Lead inductances and r.f. losses are minimized by a compact, rugged construction with ring-type seals, making the tube ideally suited to cavity type circuits as well as for parallel line operation. The cathode is an indirectly-heated, oxide-coated disc. The anode is forced-air cooled.

The **ML-2C41** embodies the highest standards of this tube type. All parts are thoroughly processed by special Machlett techniques to assure efficient operation and long life.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3	volts†
Heater Current at 6.3 volts	1.03	amps
Heater Heating Time, minimum	60	secs
Amplification Factor	100	
Transconductance (I_b = 70 mA, E_b = 600 v)	25000	umhos
Interelectrode Capacitances		
Grid-Plate	2.01	uuf
Grid-Cathode	6.60	uuf
Plate-Cathode	0.035	uuf max.
Duty Cycle	0.0025	
Maximum Pulse Length	3	usecs

Mechanical

Mounting Position	Optional	
Type of Cooling	Forced Air*	
Maximum Anode Temperature	175	°C
Net Weight	2¼	oz.

†See Application Note, page 16, for optimum heater voltage.

*See Application Notes, page 16 and also air cooling curves, page 83.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Plate-Pulsed Oscillator and Amplifier—Class C

Maximum Ratings, Absolute Values		
For a pulse length of *	3	usec
Duty Factor *	0.0025	
Peak Plate Pulse Supply Voltage	3500	volts
Peak Grid Bias Voltage	-150	volts
Peak Plate Current from Pulse Supply	4	amps
Average Plate Current	10	mA
Average Grid Current	6	mA
Average Plate Dissipation	35	watts
Average Grid Dissipation	2	watts
Frequency	3000	Mc
Typical Operation: 2500 Mc Oscillator		
Pulse Length	3	usec
Duty Factor	0.0025	
Peak Plate Pulse Supply Voltage	3500	volts
Peak Grid Bias Voltage	-100	volts
Peak R-F Grid Voltage	340	volts
Peak R-F Plate Voltage	2500	volts
Peak Plate Current from Pulse Supply	3	amps
Average Plate Current	7.5	mA
Average Grid Current	4.5	mA
Driving Power During Pulse, Approximate	450	watts
Useful Power Output at Peak of Pulse, Approx.	2200	watts
Pulse Recurrence Rate	825	pps

*For applications above a duty factor of 0.0025 and a pulse width of 3 μsec, contact the Machlett Engineering Department for information.

Characteristic Range Values for Equipment Design

	Min.	Max.	
Filament Current at 6.3 volts (Note 1)	0.95	1.10	A
Plate Current (Note 2)	60	95	mAdc
Cut-off Bias (Note 3)	—	-15	Vdc
Transconductance	20,000	30,000	umhos
Grid-Plate Capacitance	1.86	2.16	uuf
Grid-Cathode Capacitance (Note 4)	5.60	7.60	uuf
Plate-Cathode Capacitance	—	.035	uuf
Plate Tuning Range (Note 5)	1960	2030	Mc

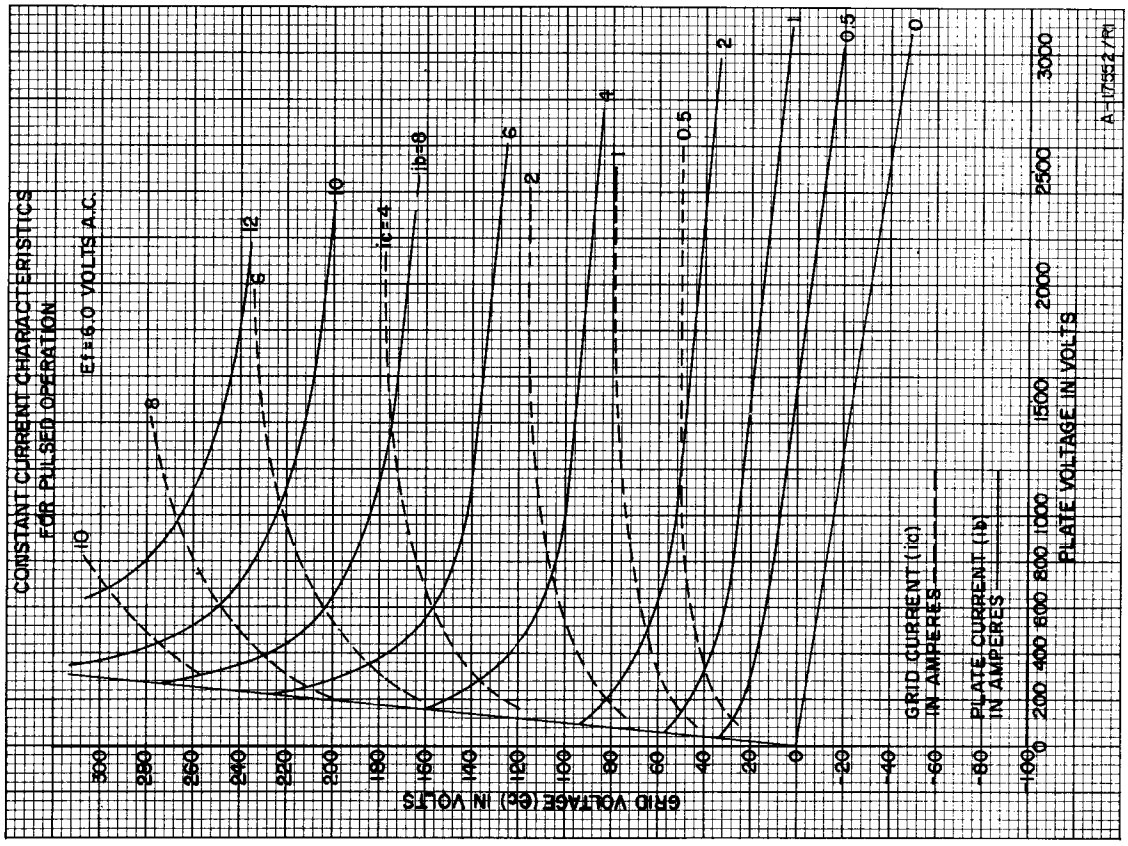
Note 1 — For reduced filament voltage see "Heater Voltage" section under "Application Notes".

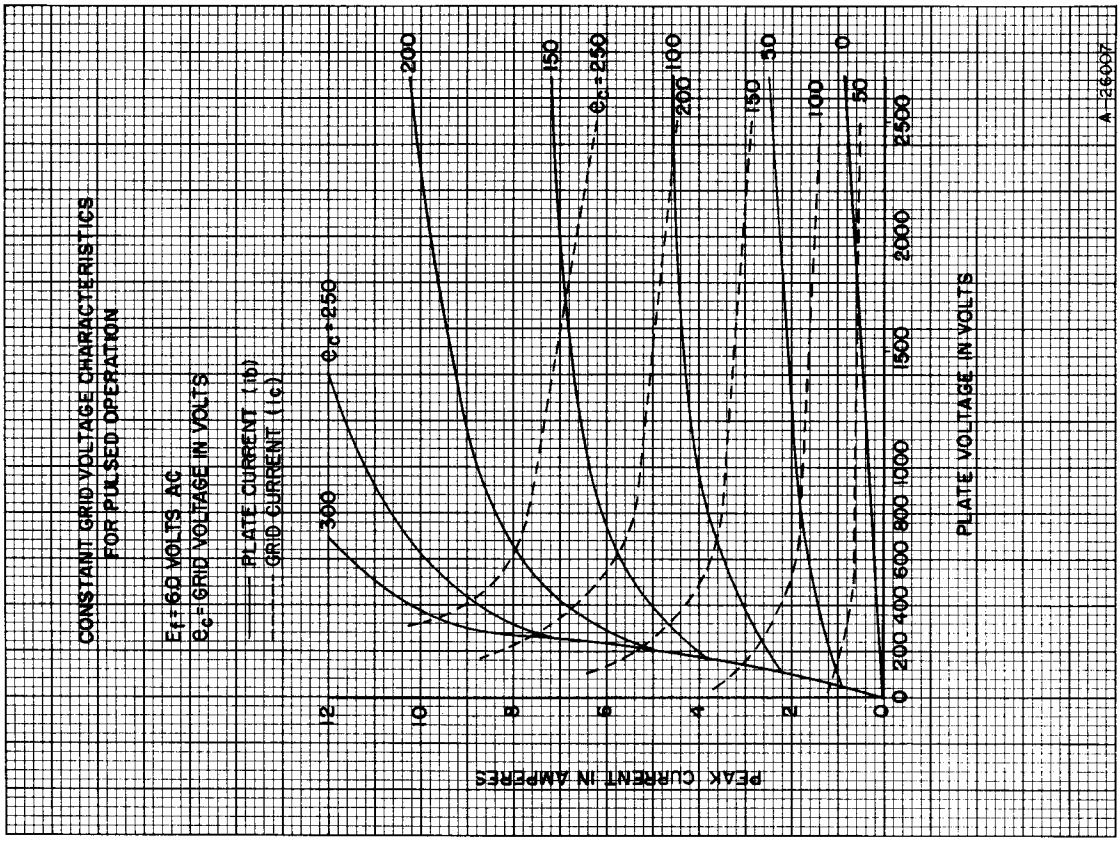
Note 2 — Measured at a plate voltage of 600 volts and a cathode-bias resistor of 30 ohms.

Note 3 — Measured at 1 mA of plate current and a plate voltage of 600 volts.

Note 4 — Capacitance measurements are with the tube cold. When the filament is heated to proper operating temperature the grid-cathode capacitance will increase by about 1 uuf due to thermal expansion of the cathode.

Note 5 — With a plate-grid coaxial cavity of fixed dimensions, all tubes will resonate within the specified frequency range.

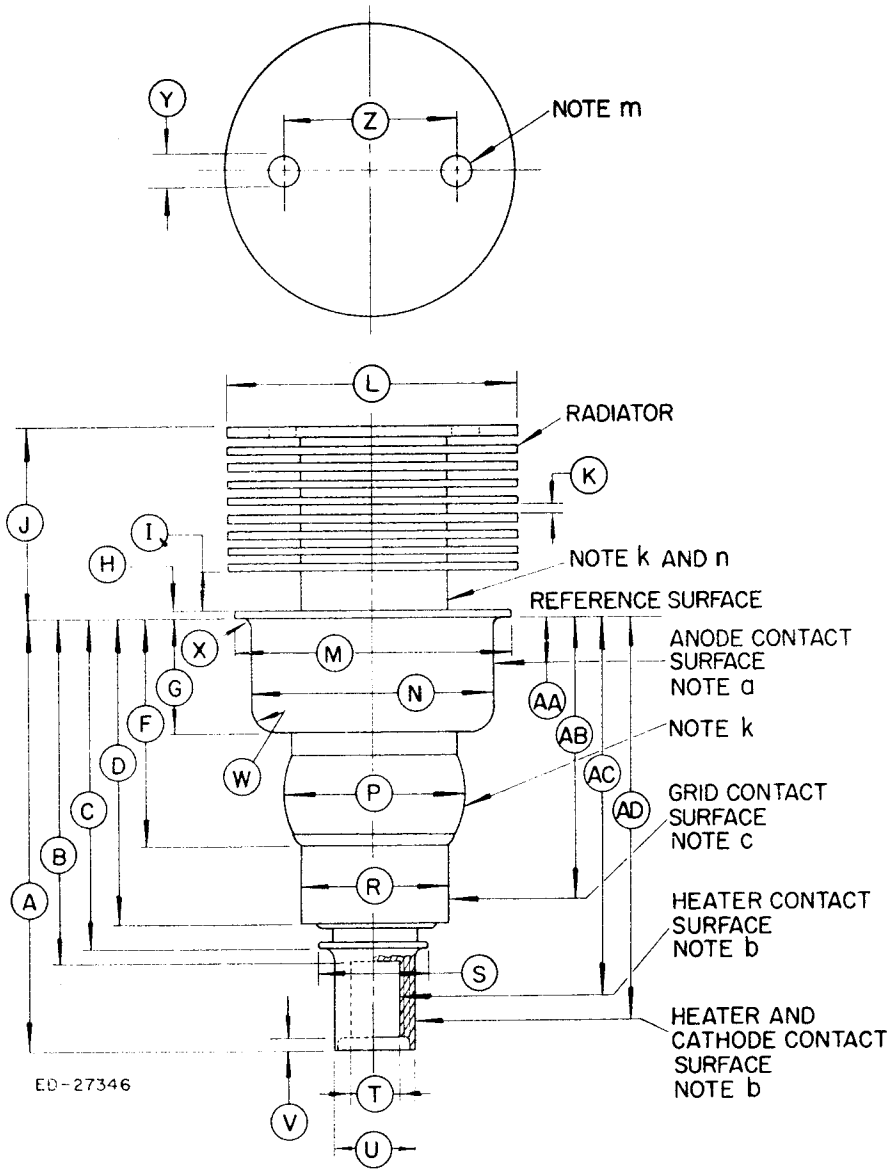

CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS A.C.
GRID VOLTAGE (Ec) IN VOLTS
PLATE VOLTAGE IN VOLTS
GRID CURRENT (Ic)
IN AMPERES
PLATE CURRENT (Ib)
IN AMPERES
A-17552 PM


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS AC
Ec = GRID VOLTAGE IN VOLTS
PLATE CURRENT (Ib)
GRID CURRENT (Ic)
PEAK CURRENT IN AMPERES
PLATE VOLTAGE IN VOLTS
A-26007

OUTLINE AND DIMENSIONS

DIMENSIONS A ML-2C39A, ML-2C39WA, ML-2C41, ML-322, ML-7209, and ML-7210

DIMENSIONS B ML-322



DIMENSIONS FOR OUTLINE (INCHES)

	DIMENSIONS A		DIMENSIONS B	
Ref.	Min.	Max.	Min.	Max.
A	1.815	1.875	1.788	1.858
B	—	1.534	—	1.517
C	—	1.475	—	1.458
D	1.289	1.329	1.252	1.292
F	—	0.980	—	1.000
G	0.462	.477	.459	.479
H	—	.040	—	.040
I	.125	.185	.125	—
J	.766	.826	.736	.826
K	.025	.046	.015	—
L	1.234	1.264	1.235	1.265
M	1.180	1.195	1.788	1.199
N	1.025	1.035	1.021	1.039
P	—	0.812	—	.812
R	0.655	0.665	.652	.668
S	—	.545	—	.545
T	0.213	.223	.213	.223
U	.315	.325	.312	.328
V	—	.086	—	.086
W	—	.100	—	.100
X	—	.035	.105	.145
Y	.105	.145	.650	.850
Z	.650	.850		

DIMENSIONS FOR ELECTRODE CONTACT AREA (INCHES)

DIMENSIONS A

Ref.	Dimensions	Contact
AA	0.198 ± 0.163	Anode
AB	1.225 ± .040	Grid
AC	1.631 ± .097	Heater
AD	1.645 ± .170	Cathode

DIMENSIONS B

Ref.	Dimension	Contact
AA	0.195 ± .163	Anode
AB	1.210 ± .040	Cathode & Heater
AC	1.610 ± .092	Heater
AD	1.623 ± .165	Cathode & Heater

NOTES

a. The total indicated runout of the anode contact surface with respect to the cathode contact surface will not exceed 0.020 inch, except ML-322; 0.030 inch, ML-322.

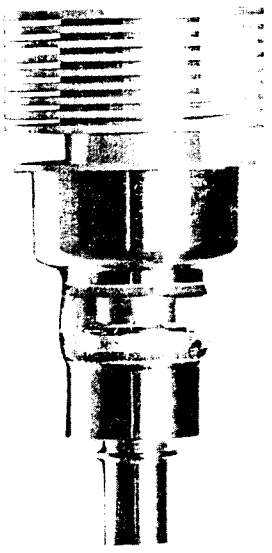
b. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed 0.012 inch, except ML-322; 0.018 inch, ML-322.

c. The total indicated runout of the grid contact surface with respect to the cathode contact surface will not exceed 0.020 inch. Does not apply to ML-322.

k. Do not clamp or locate on this surface.

m. Hole provided for tube extractor through top fin only.

n. Measure anode shank temperature here.



MACHLETT

ML-322

DESCRIPTION & RATINGS

DESCRIPTION

The ML-322 is an ultra-high-frequency diode of the planar-electrode type designed for use as a modulation clipper at frequencies up to 1500 Mc. Lead inductances and r-f losses are minimized by a compact, rugged construction with ring-type seals, making the tube ideally suited to cavity-type circuits. The electrode spacing is about 0.008". The cathode is an indirectly-heated, oxide-coated disc. The anode is convection cooled and is capable of dissipating 15 watts.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3	Volts
Heater Current at 6.3 volts, approximate	.95	Amps
Heater Heating Time, minimum (Before Applying Plate Voltage)	60	Seconds
Interelectrode Capacitance	3.5	uuf

Mechanical

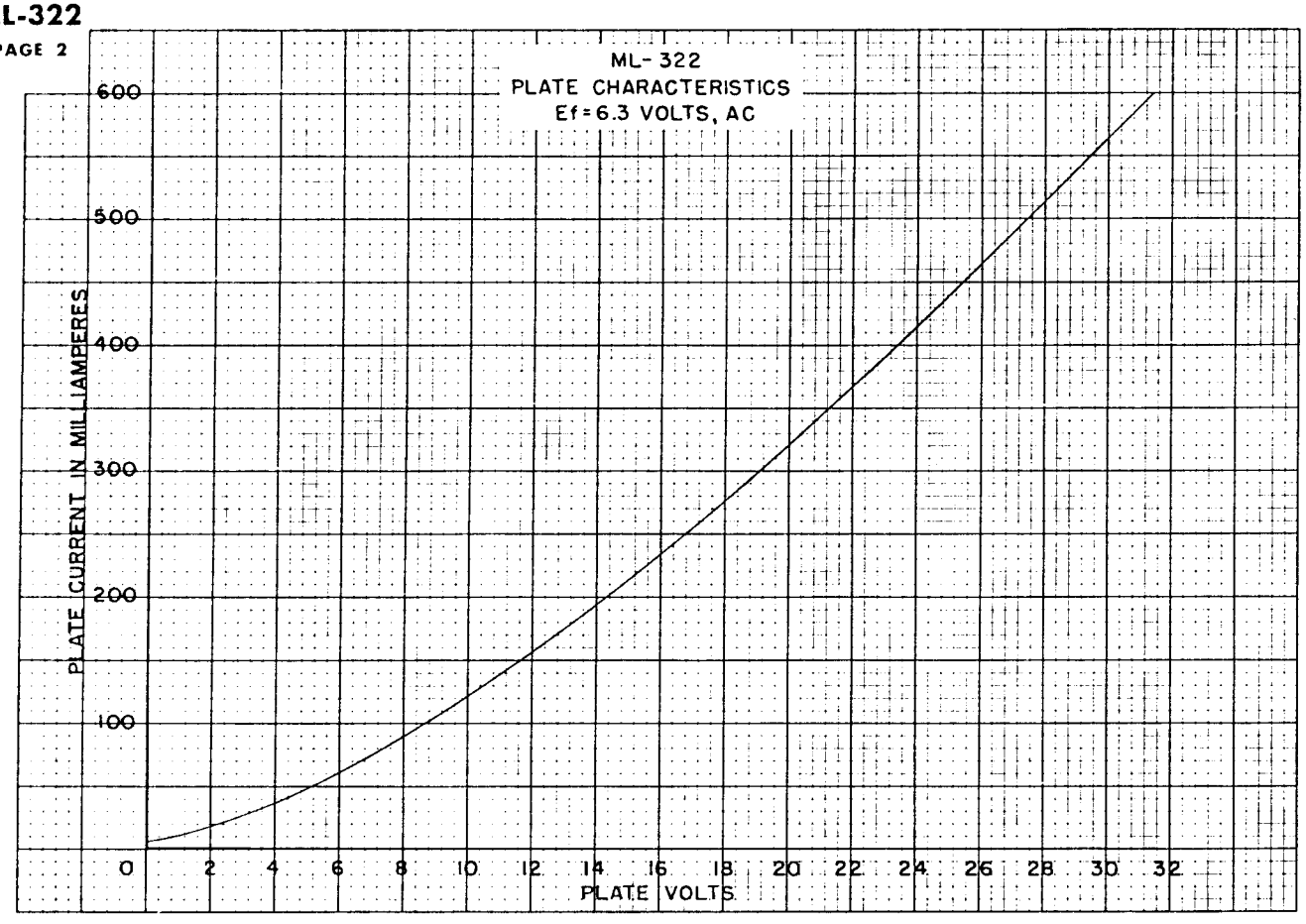
Mounting Position	Optional	
Maximum Seal Temperature	160	°C
Net Weight, approximate	0.25	lbs.

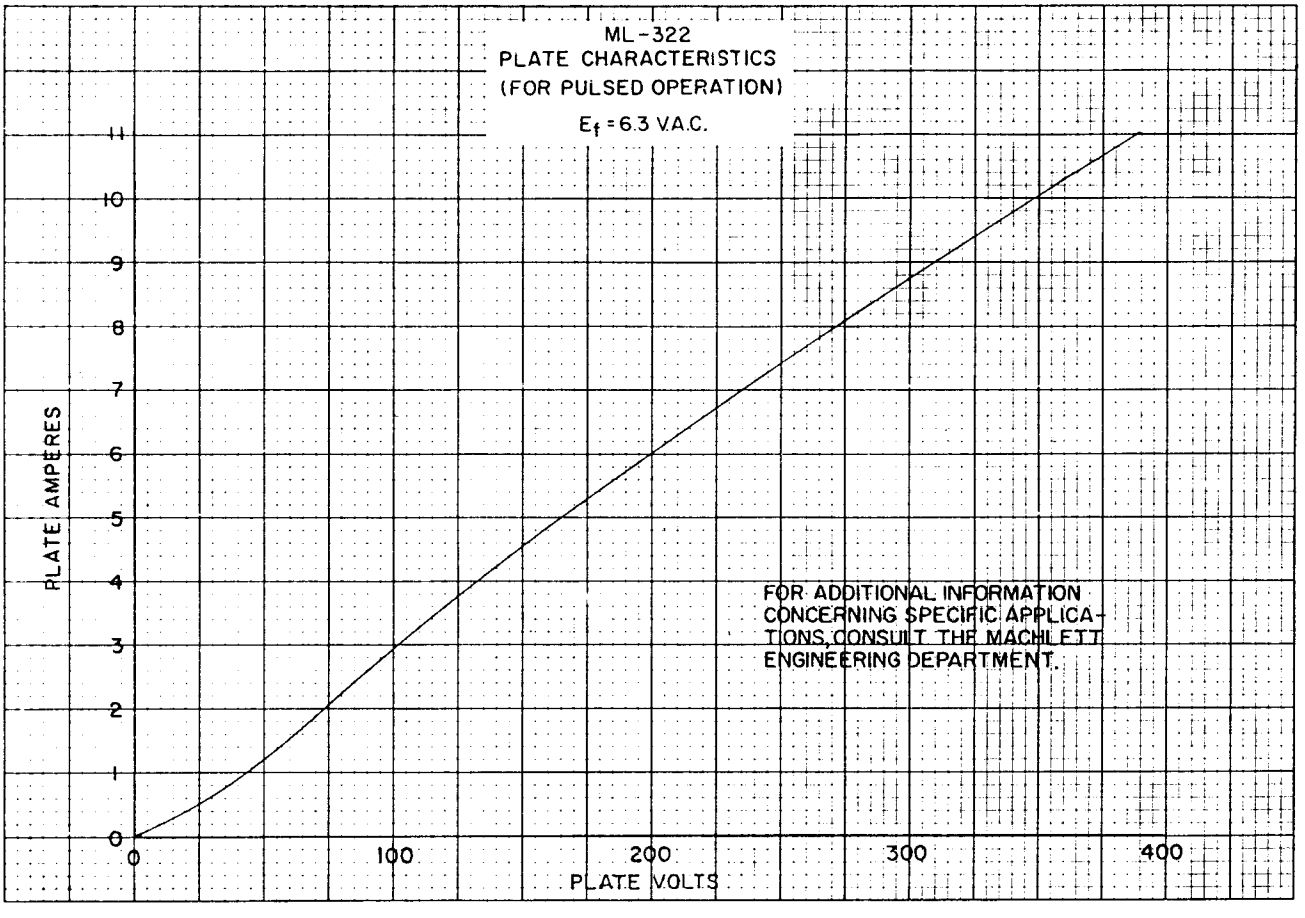
MAXIMUM RATINGS

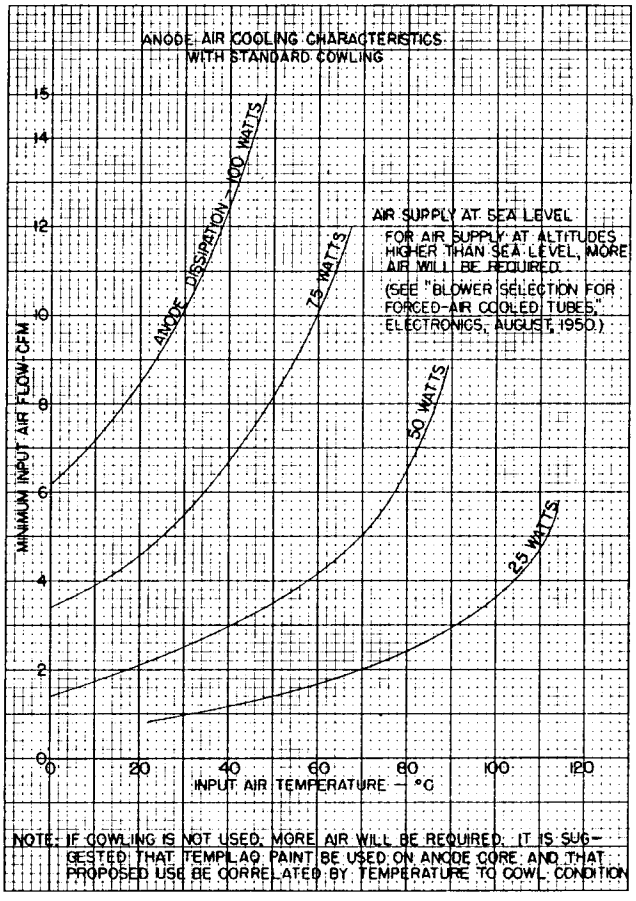
Maximum Ratings, Absolute Values

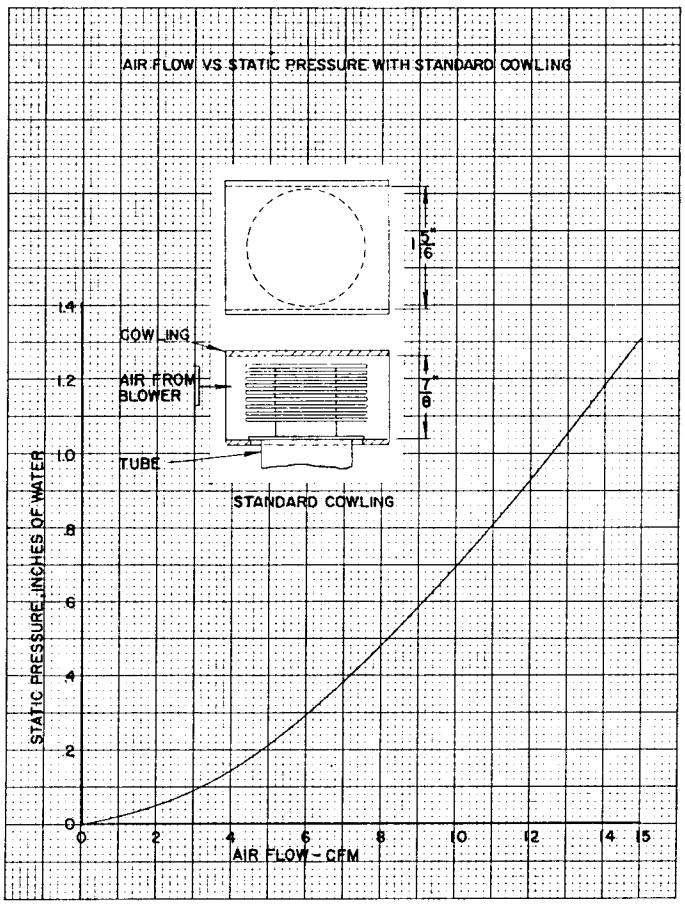
Peak Inverse Voltage	800	Volts
Peak Plate Current	600	mAdc
Average Plate Current	100	mAdc
Average Plate Dissipation	15	watts*

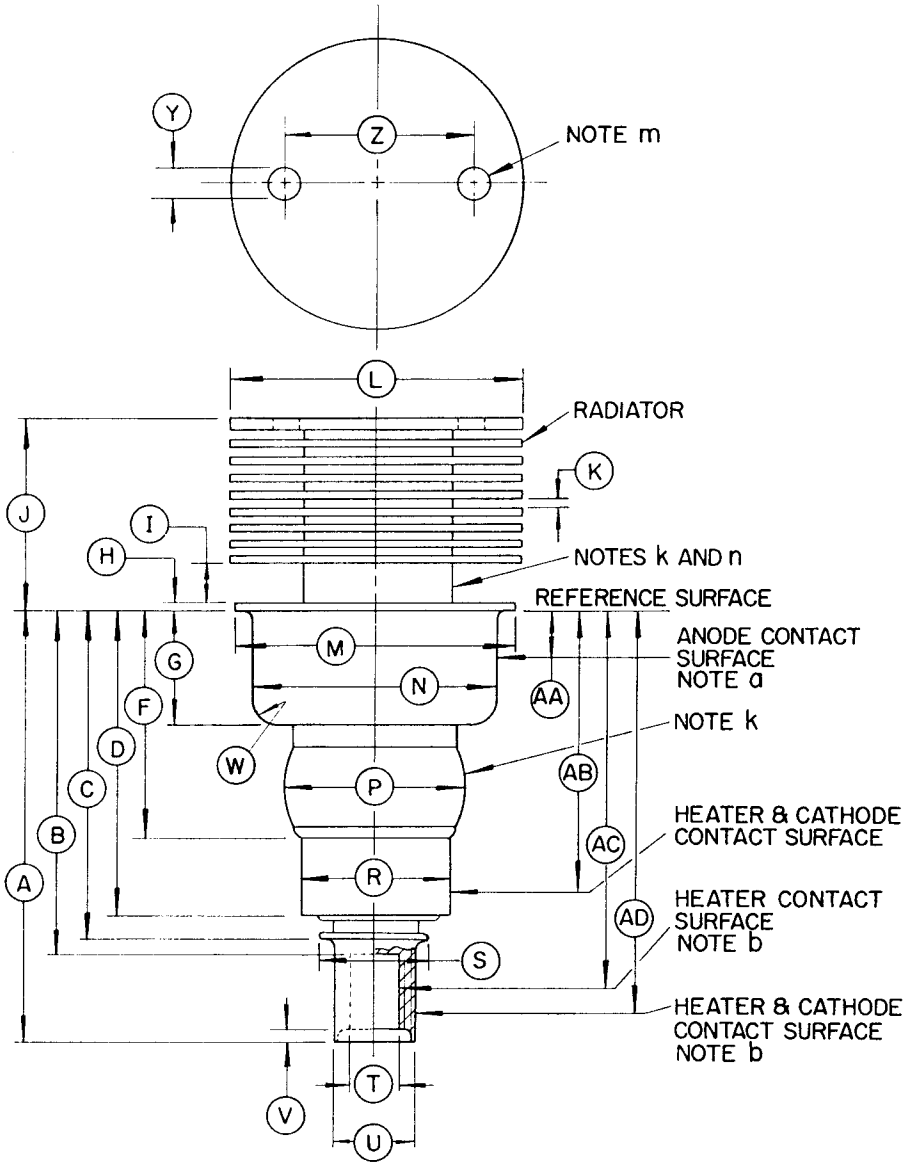
* Plate dissipation up to 100 watts may be obtained with forced-air cooling.


ML-322
PLATE CHARACTERISTICS
Ef = 6.3 VOLTS, AC
PLATE CURRENT IN MILLIAMPERES
600
500
400
300
200
100
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
PLATE VOLTS


ML-322
PLATE CHARACTERISTICS
(FOR PULSED OPERATION)
Ef = 6.3 V.A.C.
PLATE AMPERES
11
10
9
8
7
6
5
4
3
2
1
0
0
100
200
300
400
PLATE VOLTS
FOR ADDITIONAL INFORMATION CONCERNING SPECIFIC APPLICATIONS, CONSULT THE MACHLETT ENGINEERING DEPARTMENT.


ANODE AIR COOLING CHARACTERISTICS WITH STANDARD COWLING
ANODE DISSIPATION – 100 WATTS
75 WATTS
50 WATTS
25 WATTS
AIR SUPPLY AT SEA LEVEL
FOR AIR SUPPLY AT ALTITUDES HIGHER THAN SEA LEVEL, MORE AIR WILL BE REQUIRED.
(SEE "BLOWER SELECTION FOR FORCED-AIR COOLED TUBES," ELECTRONICS, AUGUST, 1950.)
MINIMUM INPUT AIR FLOW-CFM
INPUT AIR TEMPERATURE – °C
0
2
4
6
8
10
12
14
15
0
20
40
60
80
100
120
NOTE: IF COWLING IS NOT USED, MORE AIR WILL BE REQUIRED. IT IS SUGGESTED THAT TEMPILAQ PAINT BE USED ON ANODE CORE AND THAT PROPOSED USE BE CORRELATED BY TEMPERATURE TO COWL CONDITION


AIR FLOW VS STATIC PRESSURE WITH STANDARD COWLING
1 5/6"
COWLING
AIR FROM BLOWER
1"
8
TUBE
STANDARD COWLING
STATIC PRESSURE-INCHES OF WATER
AIR FLOW-CFM
0
.2
.4
.6
.8
1.0
1.2
1.4
0
2
4
6
8
10
12
14
15



DIMENSIONS FOR OUTLINE (INCHES)

Ref.	Minimum	Maximum
A	1.788	1.858
B	—	1.517
C	—	1.458
D	1.252	1.292
F	—	1.000
G	.459	.479
H	—	.040
I	.125	—
J	.736	.826
K	.015	—
L	1.235	1.265
M	1.788	1.199
N	1.021	1.039
P	—	.812
R	.652	.668
S	—	.545
T	.213	.223
U	.312	.328
V	—	.086
W	—	.100
Y	.105	.145
Z	.650	.850

NOTES

a. The total indicated runout of the anode contact surface with respect to the cathode contact surface will not exceed 0.030 inch.

b. The total indicated runout of the heater contact surface with respect to the cathode contact surface will not exceed 0.018 inch.

k. Do not clamp or locate on this surface.

m. Hole provided for tube extractor through the top fin only.

n. Measure anode shank temperature on this surface.

DIMENSIONS FOR ELECTRODE CONTACT AREA (INCHES)

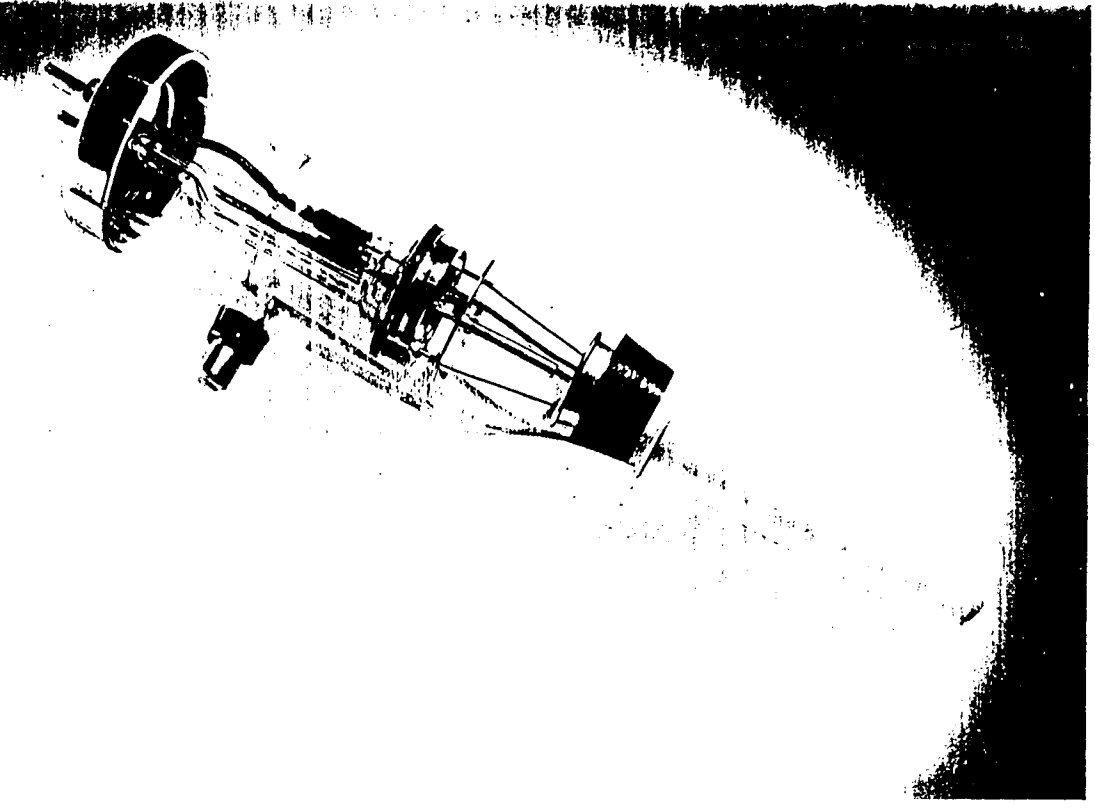
Ref.	Dimension	Contact
AA	0.195 ± .163	Anode
AB	1.210 ± .040	Cathode & Heater
AC	1.610 ± .092	Heater
AD	1.623 ± .165	Cathode & Heater

DIMENSIONS — ML-322

MACHLETT LABORATORIES, INC.

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MACHLETT

ML-342A

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-342A is a three-electrode tube designed for use as a modulator, amplifier, or oscillator in radio-transmitting service. The cathode is a pure-tungsten filament. The anode is water cooled and is capable of dissipating 25 kW. Maximum ratings of 20 kVdc and 2.5 amperes apply at frequencies up to 4 Mc; operation at 16 Mc is permissible with plate voltage reduced to 10 kVdc.

The ML-342A embodies all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent outgassing. The tube is exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high- and super-voltage x-ray tubes.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	20 volts
Filament Current at 20 volts	67 amperes
Filament Starting Current	100 amperes
Amplification Factor	40
Grid-Plate Transconductance	6820 uMhos
Interelectrode Capacitances	
Grid-Plate	27 uuf
Grid-Filament	19 uuf
Plate-Filament	2.5 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Water
Water Flow on Anode (minimum)	6 gpm
Maximum Outgoing Water Temperature	75 °C
Maximum Water Pressure	80 psi

MAXIMUM RATINGS

Direct Plate Voltage	20,000 volts
Direct Plate Current	2.5 amperes
Plate Dissipation	25,000 watts
Grid Dissipation	400 watts
R-F Grid Current	40 amperes
Frequency	4 megacycles

The above are maximum ratings which do not apply simultaneously but depend on the type of service specified below.

TYPICAL OPERATING CONDITIONS

Class B—Audio Amplifier or Modulator

(for balanced 2 tube circuit)

Direct Plate Voltage	15,000	12,500 volts
Grid Bias	−200	−160 volts
Direct Plate Current per tube		
No Drive	0.40	0.35 ampere
Maximum Drive	1.6	1.6 amperes
Plate Dissipation (per tube)	9,000	7,200 watts
Load Resistance (plate-to-plate)	9,600	7,680 ohms
Load Resistance (per tube)	2,400	1,920 ohms
Approximate Maximum Output—2 tubes	30,000	24,000 watts
Recommended Power for Driving Stage	1,000	1,000 watts

Class B—Radio-Frequency Amplifier

Direct Plate Voltage	18,000	12,500 volts
Direct Plate Current for Carrier Conditions	1.4	1.4 amperes
Grid Bias	−450	−300 volts
Approximate Carrier Watts for use with 100% modulation	8,500	5,800 watts

Class C—Radio-Frequency Oscillator or Power Amplifier—Unmodulated

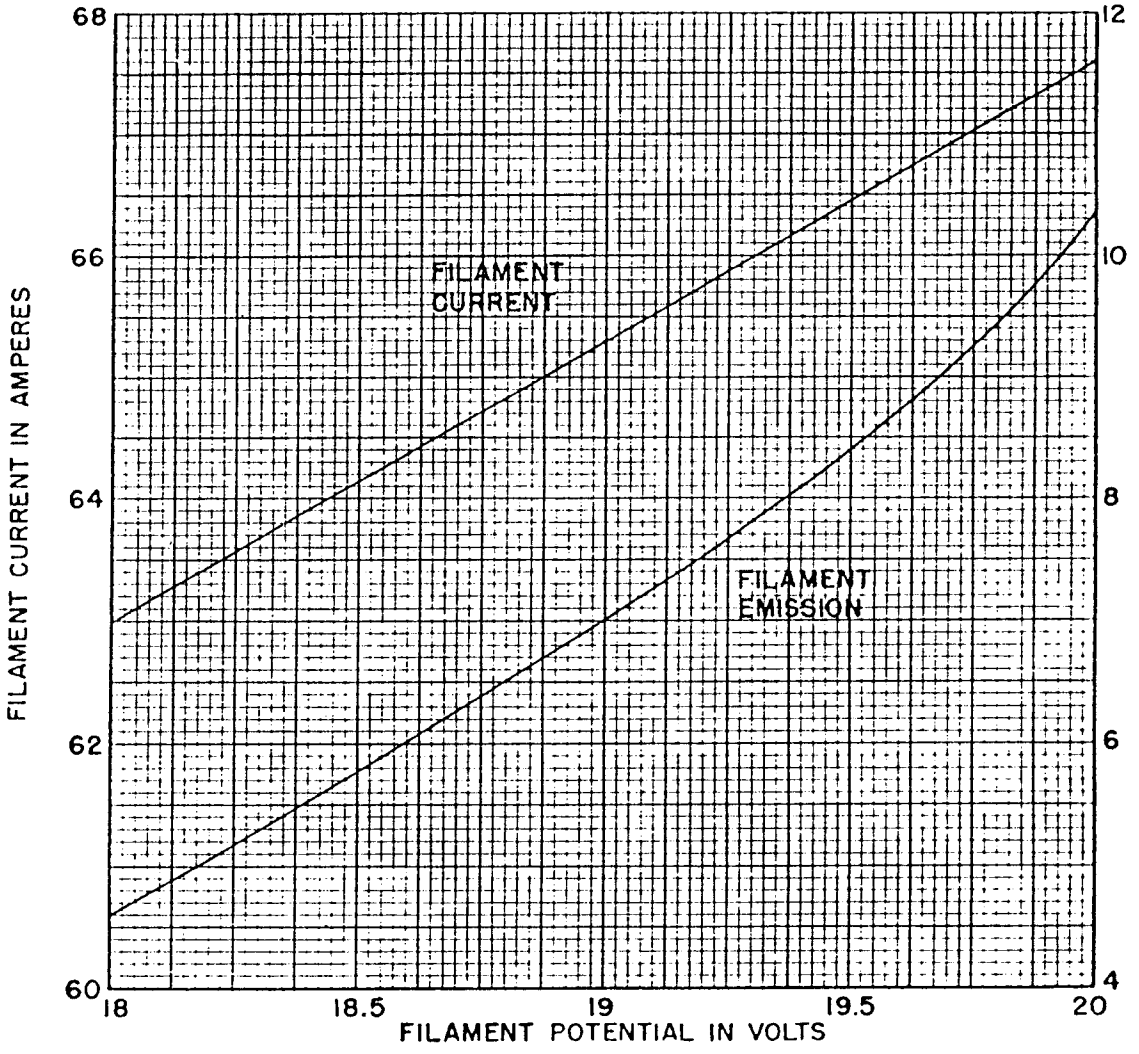
Direct Plate Voltage	18,000	15,000 volts
Direct Plate Current	2.5	2.5 amperes
Grid Bias	−675 to −900	−550 to −750 volts
Nominal Power Output	30,000	25,000 watts

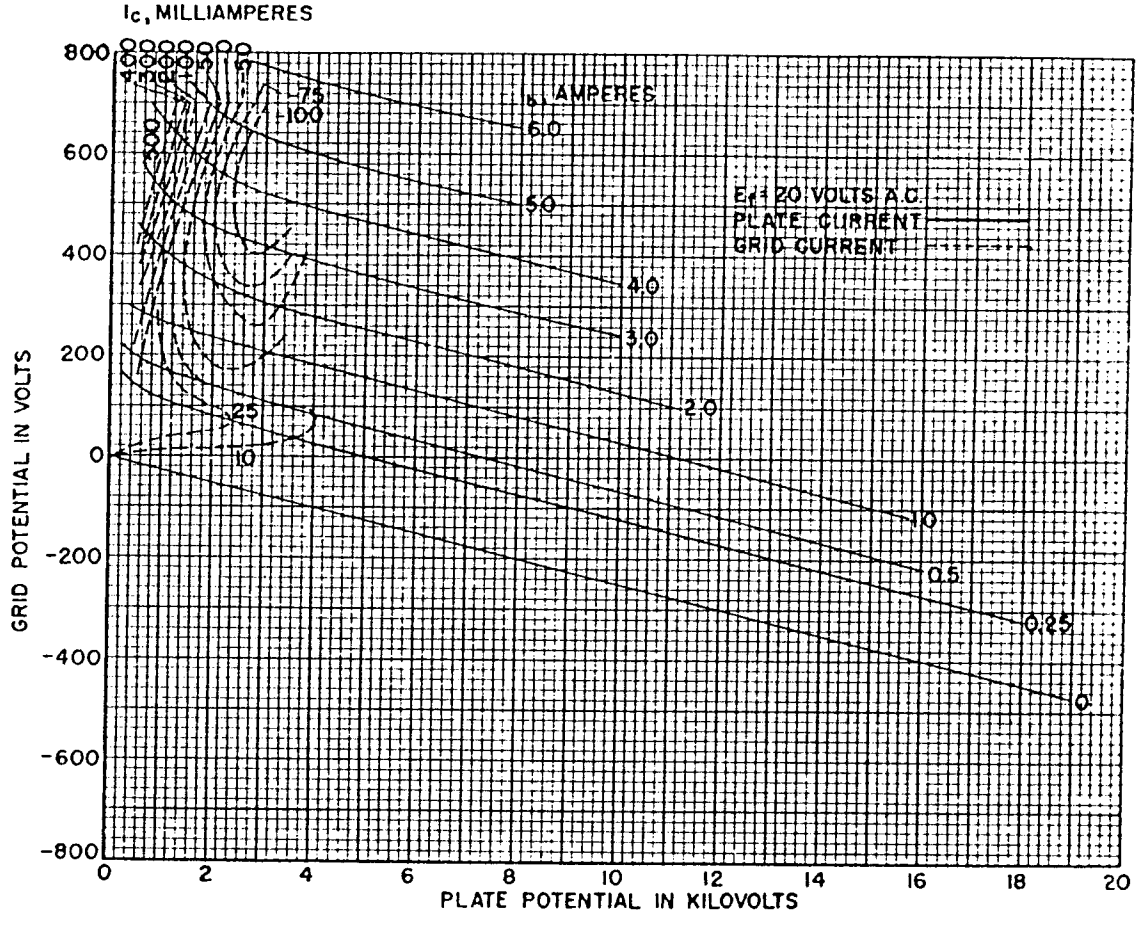
Class C—Radio-Frequency Amplifier—Plate Modulated

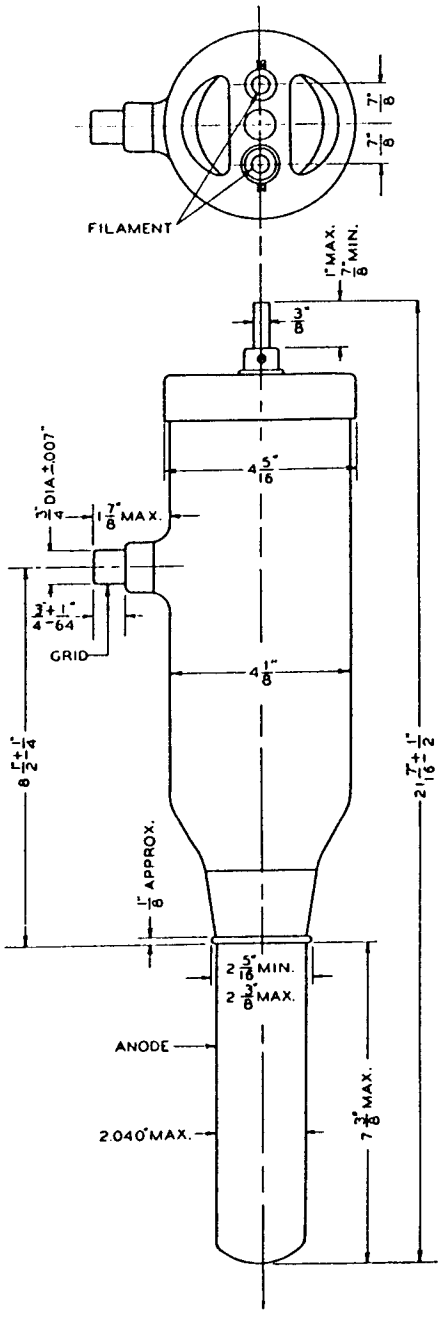
Direct Plate Voltage	12,500	10,000 volts
Direct Plate Current	1.2	1.5 amperes
Grid Bias	−600	−500 volts
Direct Grid Current	250	250 milliamperes
Nominal Carrier Power Output	10,000	10,000 watts

APPLICATION NOTES

Maximum ratings apply at frequencies of 4 megacycles and less. The maximum plate voltage for the upper frequency limit of 16 megacycles is 10,000 volts. The maximum plate voltage for frequencies between 4 and 16 megacycles should be proportionately reduced.


FILAMENT CURRENT IN AMPERES
EMISSION CURRENT IN AMPERES
FILAMENT POTENTIAL IN VOLTS
FILAMENT CURRENT
FILAMENT EMISSION
68
66
64
62
60
12
10
8
6
4
18
18.5
19
19.5
20


Ic, MILLIAMPERES
GRID POTENTIAL IN VOLTS
PLATE POTENTIAL IN KILOVOLTS
Ib, AMPERES
6.0
5.0
4.0
3.0
2.0
1.0
0.5
0.25
0
Ef = 20 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
800
600
400
200
0
-200
-400
-600
-800
0
2
4
6
8
10
12
14
16
18
20



DIMENSIONS—ML-342A

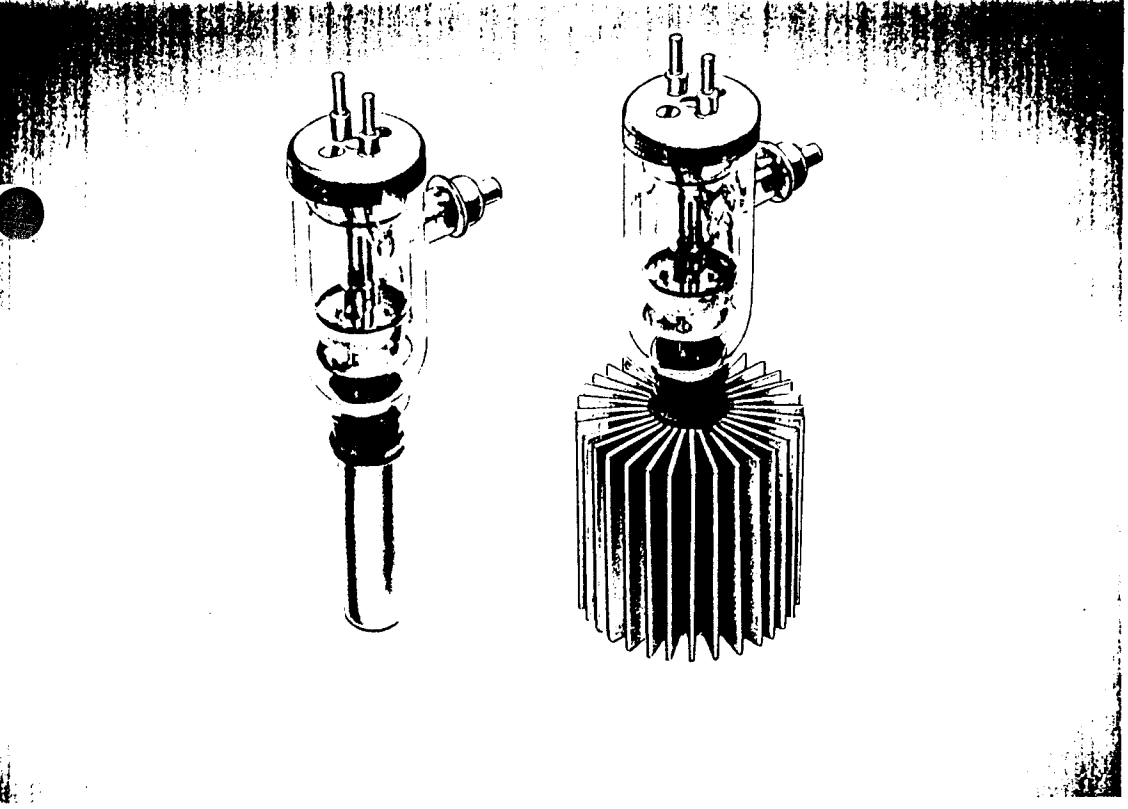
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U. S. A.

PRINTED IN U. S. A

ST-909 2.5M 7-58



MACHLETT

ML-343A
ML-343AA

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-343A and ML-343AA are three-electrode tubes designed for use as modulators, amplifiers, or oscillators in radio-transmitting service. The cathode of each type is a pure-tungsten filament. The anode of the ML-343A is water-cooled and is capable of dissipating 10 kW. The anode of the ML-343AA is air-cooled and is capable of dissipating 5 kW. The maximum rating of 18 kVdc applies at frequencies up to 4 Mc; operation at 16 Mc is permissible with plate voltage reduced to 5 kVdc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	21.5	volts
Filament Current at 21.5 volts	57.5	amperes
Filament Starting Current	90	amps
Filament Cold Resistance	.0317	ohms
Amplification Factor	40	
Grid-Plate Transconductance	6750	uMhos
Interelectrode Capacitances		
Grid-Plate	23.5	uuf
Grid-Filament	20.0	uuf
Plate-Filament	1.9	uuf

Mechanical

		ML-343A	ML-343AA
Mounting Position		Vertical anode down	
Type of Cooling		Water	Forced-air
Coolant flow on anode		3 gpm	600 cfm
Maximum outgoing water temperature		75 °C	—
Maximum Water Pressure		80 psi	—
Maximum Anode Temperature		—	120 °C
Net Weight, approximate		4.3 lbs	35 lbs

MAXIMUM RATINGS

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

	ML-343A	ML-343AA	
Direct Plate Voltage	18,000	18,000	volts
Direct Plate Current	2	1.5	amps
Plate Dissipation	10,000	5000	watts
Grid Dissipation	200	200	watts
R-F Grid Current	20	20	amps
Frequency	4	4	Mc

The above are maximum ratings which do not apply simultaneously but depend on the type of service specified below.

TYPICAL OPERATING CONDITIONS

Class A Audio Amplifier or Modulator

Direct Plate Voltage	12,500	10,000	volts
Grid Bias	—170	—130	volts
Direct Plate Current	0.40	0.30	amp
Plate Dissipation	5000	3000	watts
Load Impedance	12,000	20,000	ohms
Undistorted Output	650	400	watts

Class B Audio Amplifier or Modulator
(for balanced 2 tube circuit)

Direct Plate Voltage	12,500	10,000	volts
Grid Bias	—200	—150	volts
Direct Plate Current per tube			
No Drive	0.25	0.22	amp
Maximum Drive	1.3	1.3	amps
Plate Dissipation (per tube)	5000	5000	watts
Load Resistance (plate-to-plate)	8600	7600	ohms
Load Resistance (per tube)	2150	1900	ohms
Approximate Maximum Output—2 tubes	18,000	15,000	watts
Recommended Power for Driving Stage	750	750	watts

Class B Radio-Frequency Amplifier

Direct Plate Voltage	15,000	12,500	volts
Direct Plate Current for Carrier Conditions	0.70	0.70	amp
Grid Bias	—350	—300	volts
Approximate Carrier Watts for Use with 100% Modulation	3500	2900	watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

	ML-343A	ML-343AA		
Direct Plate Voltage	18,000	15,000	12,500	volts
Direct Plate Current	1.25	1.00	1.25	amps
Grid Bias	—600 to —800	—500 to —700	—450 to —600	watts
Nominal Power Output	15,000	10,000	10,000	watts
Plate Dissipation	10,000	5000	5600	watts

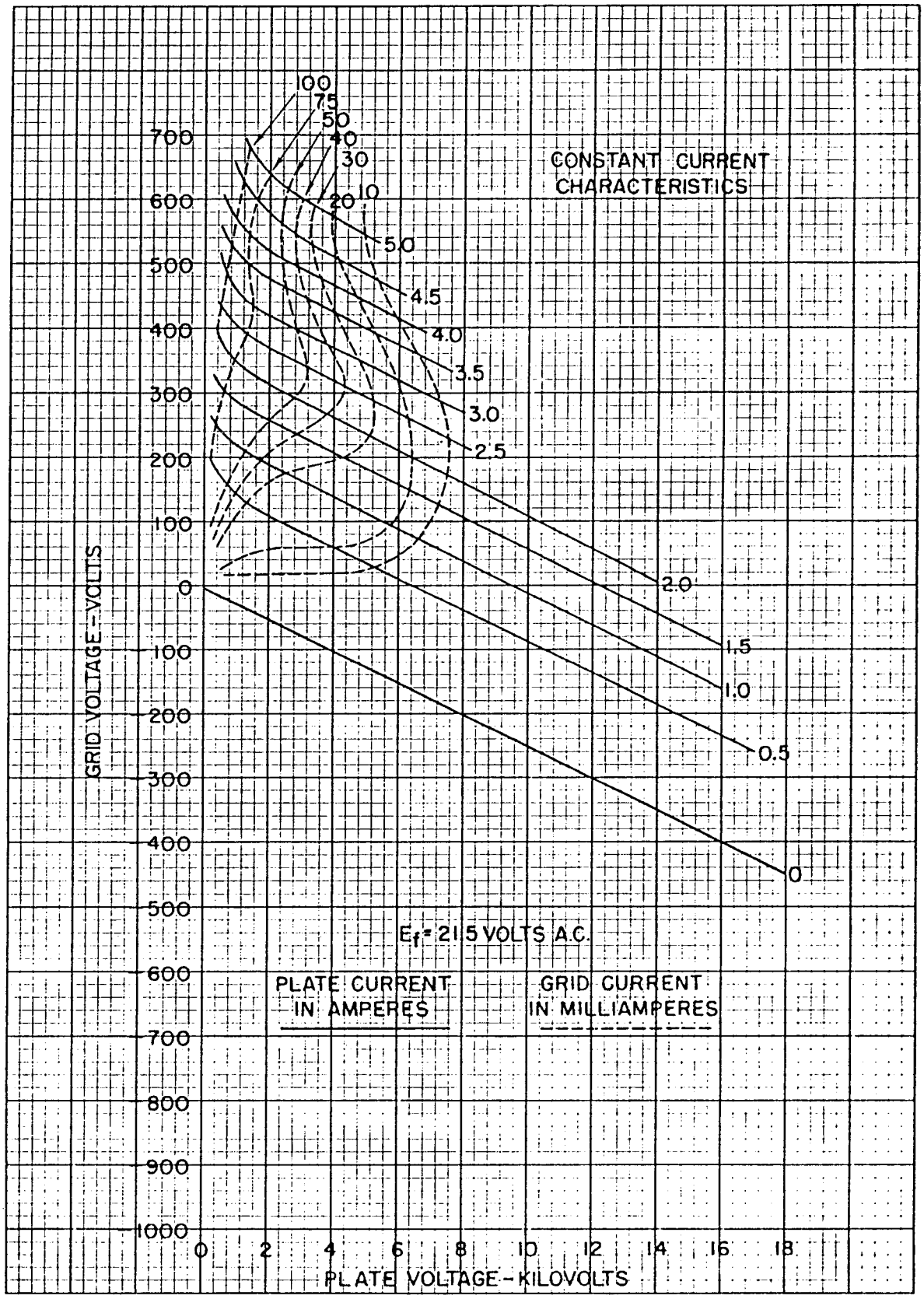
Class C Radio-Frequency Amplifier—Plate Modulated

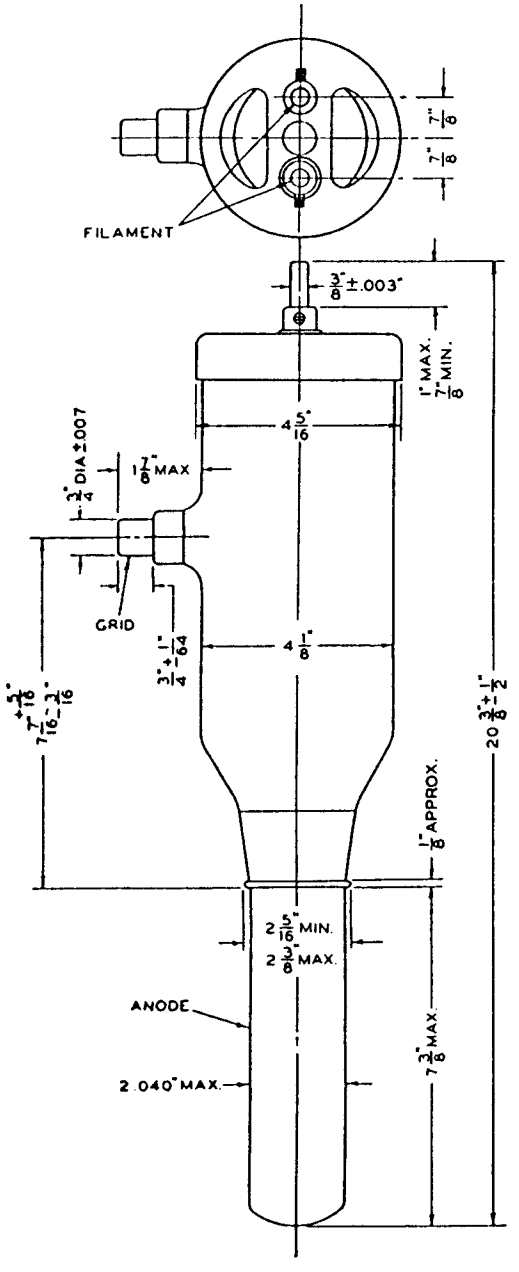
Direct Plate Voltage	7500	5000	volts
Direct Plate Current	1.0	1.0	amp
Grid Bias	—400	—300	volts
Direct Grid Current	150	150	mA
Nominal Carrier Power Output	5000	3300	watts

APPLICATION NOTES

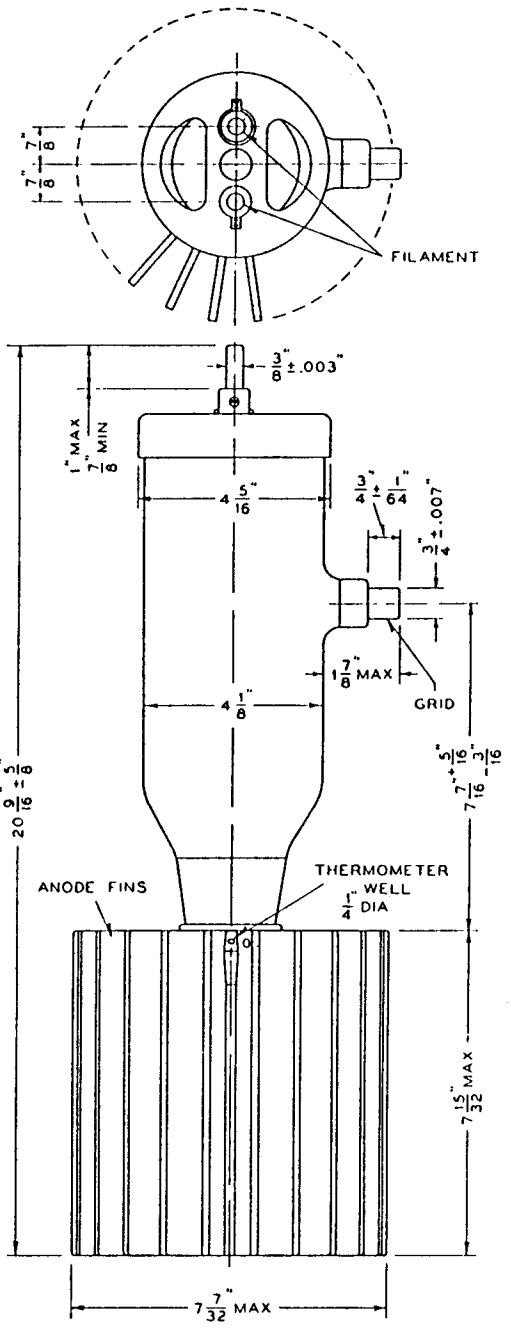
Maximum ratings apply at frequencies of 4 megacycles and less. The maximum plate voltage for the upper frequency limit of 16 megacycles is 5,000 volts. The maximum plate voltage for frequencies between 4 and 16 megacycles should be proportionately reduced.

The cooling facilities for the ML-343AA should be such that the temperature of the anode, indicated by a thermometer having a non-metallic column mounted in the tube thermometer well with the bulb protected from the air stream, is less than 120°C. The amount of air required will vary from 400 to 600 cubic feet per minute depending upon the anode dissipation and ambient temperature. An air pressure interlock is required for protecting the tube if the air flow is insufficient. The interlock should be adjusted to remove all voltages from the tube in case of failure of the forced air supply. In no case should the rate of flow be such that under prolonged operation at conditions of maximum dissipation the temperature rises above 120°C. The forced air shall be supplied at the bottom so that the air is forced upward through the anode fins.


CONSTANT CURRENT CHARACTERISTICS
100
75
50
40
30
20
10
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
GRID VOLTAGE-VOLTS
700
600
500
400
300
200
100
0
100
200
300
400
500
600
700
800
900
1000
E_f = 2.15 VOLTS A.C.
PLATE CURRENT IN AMPERES
GRID CURRENT IN MILLIAMPERES
0
2
4
6
8
10
12
14
16
18
PLATE VOLTAGE-KILOVOLTS



DIMENSIONS — ML-343A

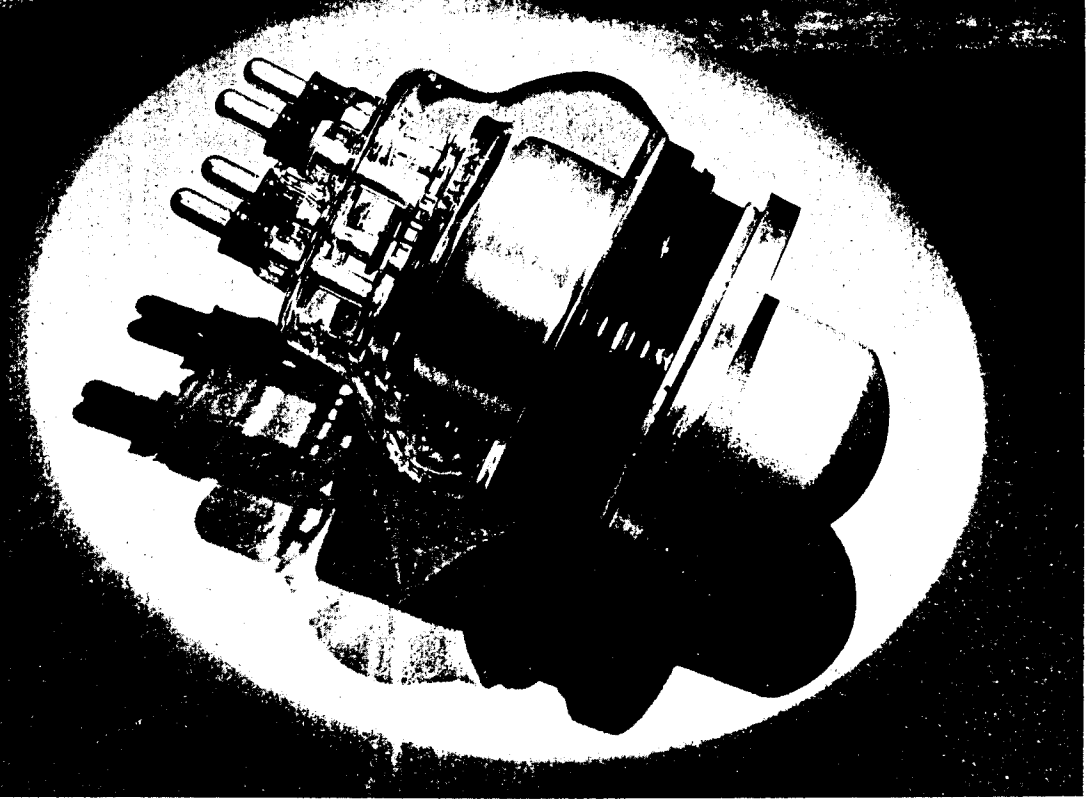


DIMENSIONS — ML-343AA

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



MACHLETT

ML-356

DESCRIPTION & RATINGS

DESCRIPTION

The ML-356 is a three-electrode tube designed specifically for use as a modulator, amplifier, or oscillator in broadcast, communication, and industrial service. The ML-356 is a direct replacement for the type 7085 tube. It is also mechanically and electrically equivalent to the type 880 tube, except that it requires less filament voltage and current; it replaces the 880 when provisions are made for the reduced filament power supply. The ML-356 is essentially equivalent to the type 5771 tube, differing only in its lower grid-cathode capacitance. It replaces the 5771 directly in industrial-oscillator equipment and also in radio-transmitting equipment. The lower grid-cathode capacitance of the ML-356 may require slight circuit adjustments at the higher frequencies.

Features include rugged kovar-glass seals and rigidly supported grid and filament assemblies capable of withstanding the electrically and mechanically rigorous and non-uniform operation inherent in industrial heating service. The anode is water cooled and is capable of dissipating 22.5 kW with a water flow of approximately 12 gpm. The cathode is a thoriated-tungsten stress-free filament employing no sliding contacts, insulators or tension springs. Maximum ratings of 12.5 kVdc plate voltage and 60 kW plate input apply at frequencies up to 25 Mc; operation at 50 Mc is permissible with the voltage and input reduced to three-quarters maximum ratings.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	7.5 Volts
Filament Current at 7.5 Volts	170 Amps
Filament Starting Current, maximum	800 Amps
Filament Cold Resistance	0.0056 Ohms
Amplification Factor	20
Interelectrode Capacitances:	
Grid-Plate	24.5 uuf
Grid-Filament	35 uuf
Plate-Filament	2.5 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Water and Forced-Air
Water flow on anode, minimum for 22.5 kW dissipation	12 gpm
Maximum outgoing water temperature	70 °C
Air flow on dish from 3" nozzle	50 cfm*
Maximum Glass Temperature	165 °C
Net Weight, approximate	7 lbs.

*At frequencies above 10 Mc special attention should be given to adequate ventilation of the dish and seals to keep the temperature at the hottest point below 165°C. Heat radiating connectors for grid and filament posts are recommended when tube operation is at frequencies greater than 10 Mc.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

A-F Power Amplifier and Modulator—Class B

Maximum Ratings, Absolute Values		
D-C Plate Voltage	12500	volts
Max. Signal D-C Plate Current*	5	amps
Max. Signal Plate Input*	45	kW
Plate Dissipation*	22.5	kW
Typical Operation (Values are for 2 tubes)		
D-C Plate Voltage	12500	volts
D-C Grid Voltage	−600	volts
Peak A-F Grid-to-Grid Voltage	1900	volts
Zero-Signal D-C Plate Current	1	amp
Max.-Signal D-C Plate Current	6.4	amps
Effective Load Resistance (Plate to Plate)	4400	ohms
Max.-Signal Driving Power, approximate	430	watts
Max.-Signal Power Output, approximate	55	kW

* Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier—Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values		
D-C Plate Voltage	12500	volts
D-C Plate Current	4	amps
Plate Input	33	kW
Plate Dissipation	22.5	kW
Typical Operation		
D-C Plate Voltage	12500	volts
D-C Grid Voltage	−625	volts
Peak R-F Grid Voltage	625	volts
D-C Plate Current	2.4	amps
D-C Grid Current	0	amp
Driving Power, approximate‡	1070	watts
Power Output, approximate	12	kW

‡ At crest of audio-frequency cycle with modulation factor of 1.0.

Plate Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values		
D-C Plate Voltage	10000	volts
D-C Grid Voltage	−2000	volts
D-C Plate Current	4	amps
D-C Grid Current	0.8	amp
Plate Input	40	kW
Plate Dissipation	15	kW
Typical Operation		
D-C Plate Voltage	10000	volts
D-C Grid Voltage	−840	volts
Peak R-F Grid Voltage	1440	volts
D-C Plate Current	3.8	amps
D-C Grid Current, approximate	0.78	amp
Driving Power, approximate	1010	watts
Power Output, approximate	29	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without modulation§

Maximum Ratings, Absolute Values					
D-C Plate Voltage		12500		15000	volts
D-C Grid Voltage		−2000		−2000	volts
D-C Plate Current		6		6	amps
D-C Grid Current		0.8		0.8	amp
Plate Input		60		67.5	kW
Plate Dissipation		22.5		22.5	kW
Frequency		25		2	Mc
Typical Operation					
D-C Plate Voltage	10000	10000	12500	15000	volts
D-C Grid Voltage	−1150	−1300	−1400	−1500	volts
Peak R-F Grid Voltage	1810	2080	2060	2130	volts
Peak R-F Plate Voltage	7900	7600	9900	12500	volts
D-C Plate Current	4.5	5.6	4.7	4.4	amps
D-C Grid Current, approximate	0.55	0.72	0.42	0.37	amp
Driving Power, approximate	960	1440	850	770	watts
Power Output, approximate	32	38	42	51	kW

§ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

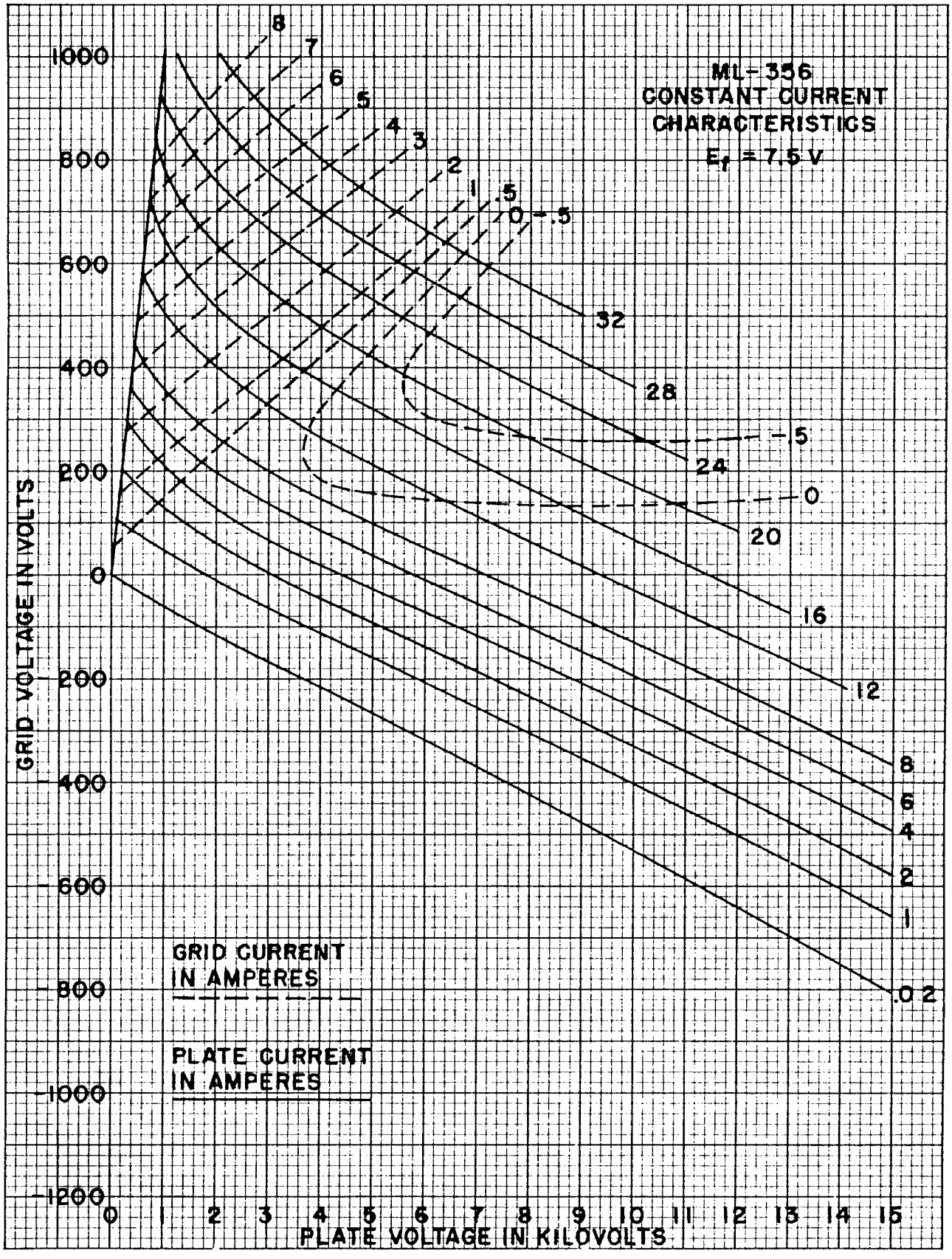
MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 25 Mc. The tube may be operated at higher frequencies provided the maximum values of plate voltage and input are reduced in accordance with the table. For Class C Telegraphy operation at frequencies below 2 Mc, the plate voltage and input may be increased by the percentage indicated in the table. (Other maximum ratings are the same as shown above.) Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	2		25		50	Mc
Percentage of Minimum Rated Plate Voltage and Input						
	Volts	Watts	Volts	Watts	Volts	Watts
Class B	—	—	100	100	80	94
Class C Telephony	—	—	100	100	75	75
Class C Telegraphy	120	112.5	100	100	75	75

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Minimum	Bogey Limits	Maximum	
Grid Voltage	e_b = 1800 volts; i_b = 28 amps;	e_c:	—	—	1100	volts
Grid Current	e_b = 1800 volts; i_b = 28 amps;	i_c:	—	—	10.0	amps
Plate Voltage	E_c = 0 Vdc; I_b = 2.0 Adc;	E_b:	2.2	3.0	3.6	kVdc
Plate Voltage	E_c = − 200 Vdc; I_b = 2.0 Adc;	E_b:	6.0	7.0	7.8	kVdc
Grid Voltage	E_b = 10 kVdc; I_b = .020 Adc	E_c:	−460	−550	−640	Vdc
Plate Power Output	E_b = 15 kVdc; I_b = 4.4 Adc; I_c = 0.37 Adc; E_c = −1500 Vdc; F = 1 Mc	P_o:	43	—	—	kW


ML-356
CONSTANT CURRENT
CHARACTERISTICS
E_f = 7.5 V
GRID VOLTAGE IN VOLTS
1000
800
600
400
200
0
200
400
600
800
1000
1200
8
7
6
5
4
3
2
1
.5
0
-.5
32
28
24
20
16
12
8
6
4
2
1
.02
-.5
0
GRID CURRENT
IN AMPERES
PLATE CURRENT
IN AMPERES
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
PLATE VOLTAGE IN KILOVOLTS

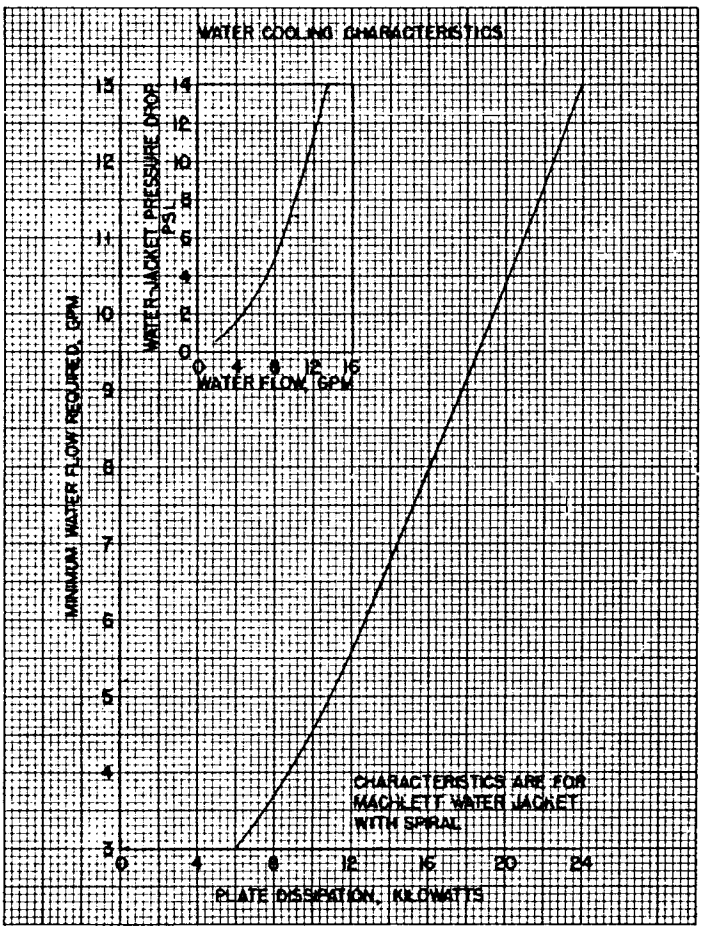
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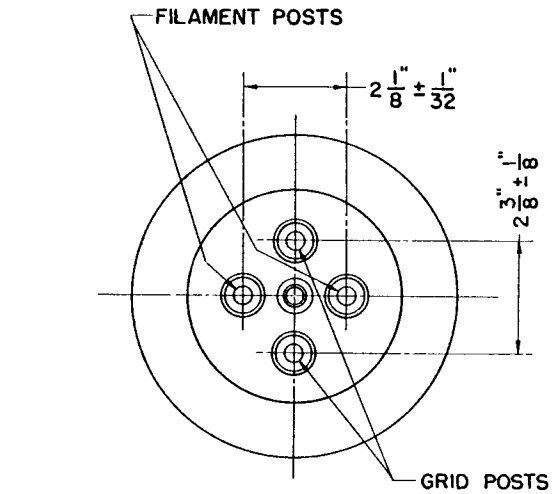
APPLICATION NOTES

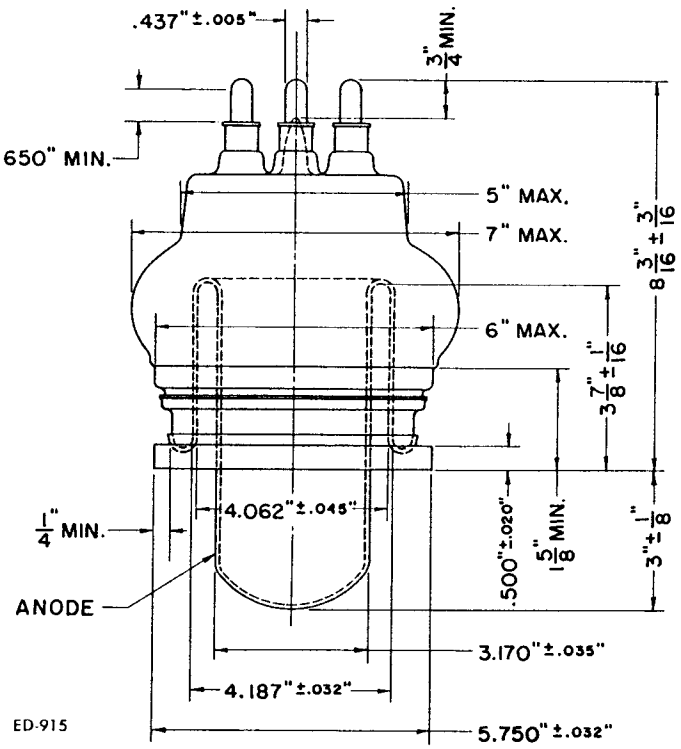
The handling of high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can severely damage the electron tube if not properly controlled. Therefore the ground leads of the plate and grid circuits should be equipped with individual quick-acting overload relays which will remove power from these circuits within 1/10 second.

Additional protection is recommended and may be obtained by connecting a resistor in series with the plate lead of each tube for protection of the tube during the time required for the plate overload relay to act. The criterion is the total energy to which the tube can be subjected. The minimum value of total resistance which will give adequate protection with reasonably low power loss is as follows:

Maximum Power Output of Rectifier	40	100	250	640	kW
Series Resistance	10	20	40	80	ohms







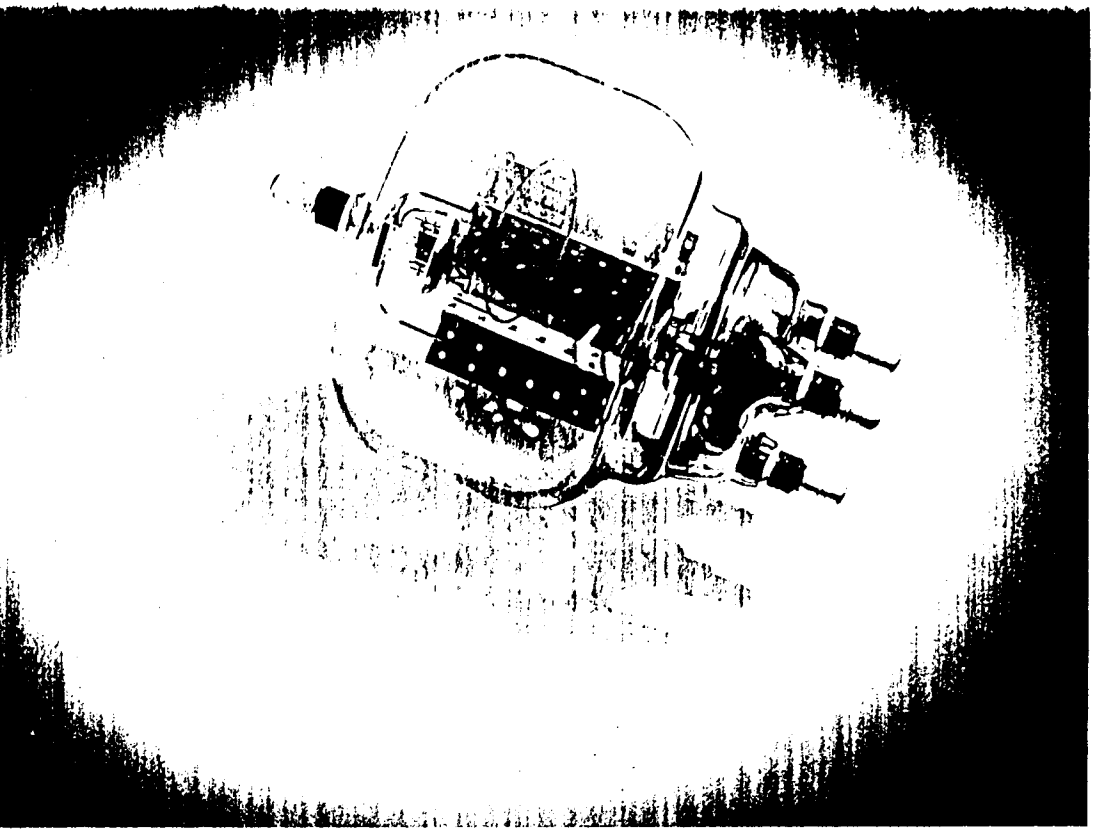
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THE MACHLETT LABORATORIES, INC.
a division of Raytheon Company

ST 995 5M 12-61

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U. S. A.

Printed in U.S.A.



MACHLETT

ML-357B

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-357B is a three-electrode tube designed for use as a modulator, amplifier, or oscillator in radio-transmitting service. The cathode is a thoriated-tungsten filament. The tube is air cooled and the anode is capable of dissipating 400 watts. Maximum ratings of 4 kVdc and 0.5 ampere apply at frequencies up to 100 Mc; operation at 150 Mc is permissible at reduced ratings.

The ML-357B embodies all the techniques and skills that have been inherently a part of Machlett Laboratories, Inc., since 1897. All parts are thoroughly processed by special Machlett techniques, which prevent contamination and assure complete and permanent outgassing. The tube is exhausted by a straight-line, high-voltage process assuring the same high standards as characterize the Machlett line of high- and super-voltage x-ray tubes.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	10 volts
Filament Current at 10 volts	10 amperes
Filament Starting Current, maximum	50 amperes
Filament Resistance, Cold	0.12 ohm
Amplification Factor (Ib = 200 mA, Eb = 2 kV)	30
Interelectrode Capacitances	
Grid-Plate	4.25 uuf
Grid-Filament	11.5 uuf
Plate-Filament	2.5 uuf
Maximum Usable Cathode Current	2.5 amperes

Mechanical

Mounting Position	Vertical, plate terminal up
Type of Cooling	Radiation or Forced-air
Required Air Flow on Envelope When Operated Above 40 Megacycles	40 cfm
Maximum Incoming Air Temperature	45 centigrade
Maximum Glass Temperature	200 centigrade
Net Weight, approximate	13 ounces

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Class B—Audio-Frequency Power Amplifier and Modulator

Maximum Ratings, Absolute Values

Direct Plate Voltage			4000 volts
Signal D-C Plate Current*			0.50 ampere
Signal Plate Input*			1100 watts
Plate Dissipation*			400 watts

Typical Operation (Unless otherwise specified, values are for 2 tubes)

D-C Plate Voltage	2000	3500	3000 volts
D-C Grid Voltage	−50	−110	−85 volts
Peak A-F Grid-to-Grid Voltage	490	520	345 volts
Zero Signal D-C Plate Current	0.160	0.120	0.120 ampere
Maximum Signal D-C Plate Current	1.00	0.72	0.43 ampere
Effective Load Resistance, Plate-to-Plate	4360	11500	14700 ohms
Maximum Signal Driving Power, approximate	50.0	35.0	13.5 watts
Maximum Signal Power Output	1400	1840	850 watts

Class B—Radio-Frequency Power Amplifier

Carrier conditions per tube for use with maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage		4000 volts
D-C Plate Current		0.275 ampere
Plate Input		550 watts
Plate Dissipation		400 watts

Typical Operation

D-C Plate Voltage	2000	3500 volts
D-C Grid Voltage	−60	−125 volts
Peak R-F Grid Voltage	135	136 volts
D-C Plate Current	0.260	0.150 ampere
D-C Grid Current, approximate	0.100	0.001 ampere
Driving Power, approximate†	25	8.5 watts
Power Output, approximate	175	190 watts

Class C Telephony—Plate Modulated Radio-Frequency Power Amplifier

Carrier conditions per tube for use with maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage		3000 volts
D-C Grid Voltage		−500 volts
D-C Plate Current		0.400 ampere
D-C Grid Current		0.100 ampere
Plate Input		1100 watts
Plate Dissipation		235 watts

Typical Operation

D-C Plate Voltage	2000	3000	3000 volts
D-C Grid Voltage	−310	−320	−270 volts
Peak R-F Grid Voltage	535	520	420 volts
D-C Plate Current	0.390	0.340	0.240 ampere
D-C Grid Current, approximate	0.070	0.065	0.035 ampere
Driving Power, approximate	35	35	20 watts
Power Output, approximate	550	780	550 watts

Class C Telegraphy—Radio-Frequency Power Amplifier and Oscillator

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage		4000 volts
D-C Grid Voltage		−500 volts
D-C Plate Current		0.500 ampere
D-C Grid Current		0.100 ampere
Plate Input		1800 watts
Plate Dissipation		400 watts

Typical Operation

D-C Plate Voltage	2000	3500 volts
D-C Grid Voltage	−200	−240 volts
Peak R-F Grid Voltage	445	460 volts
D-C Plate Current	0.500	0.450 ampere
D-C Grid Current, approximate	0.085	0.070 ampere
Driving Power, approximate	35	30 watts
Power Output, approximate	780	1200 watts

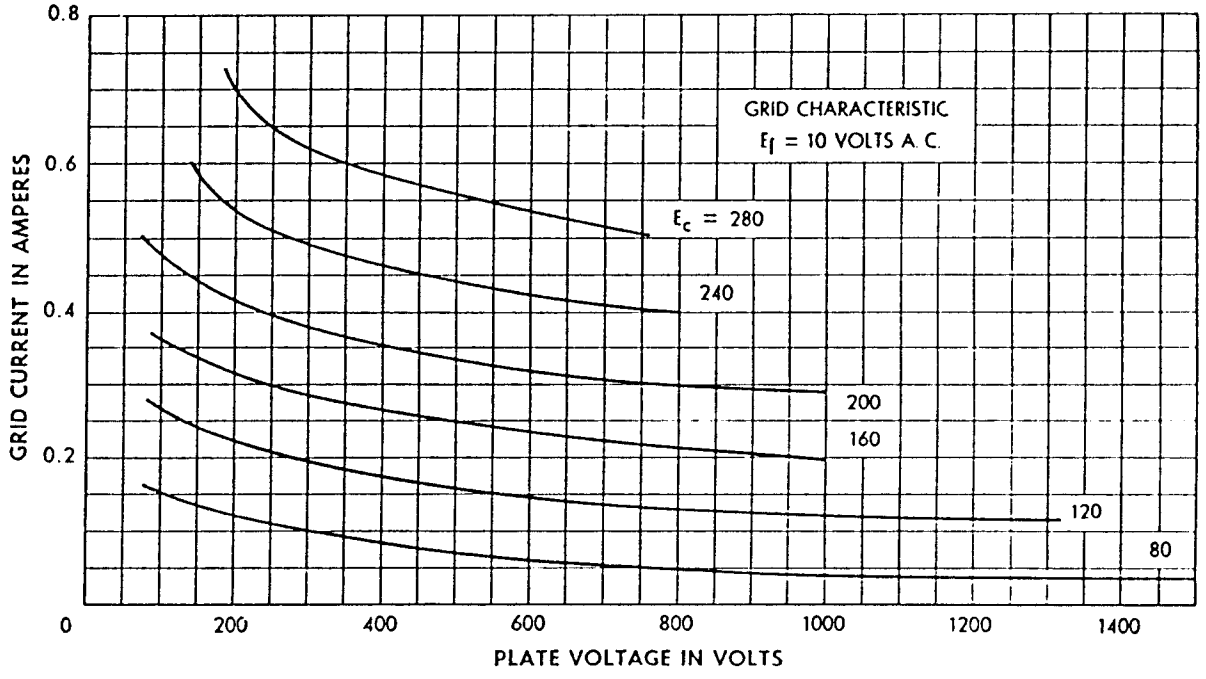
* Averaged over any audio-frequency cycle of sine wave form.
† At crest of audio-frequency cycle with modulation factor of 1.0.
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of its unmodulated value.

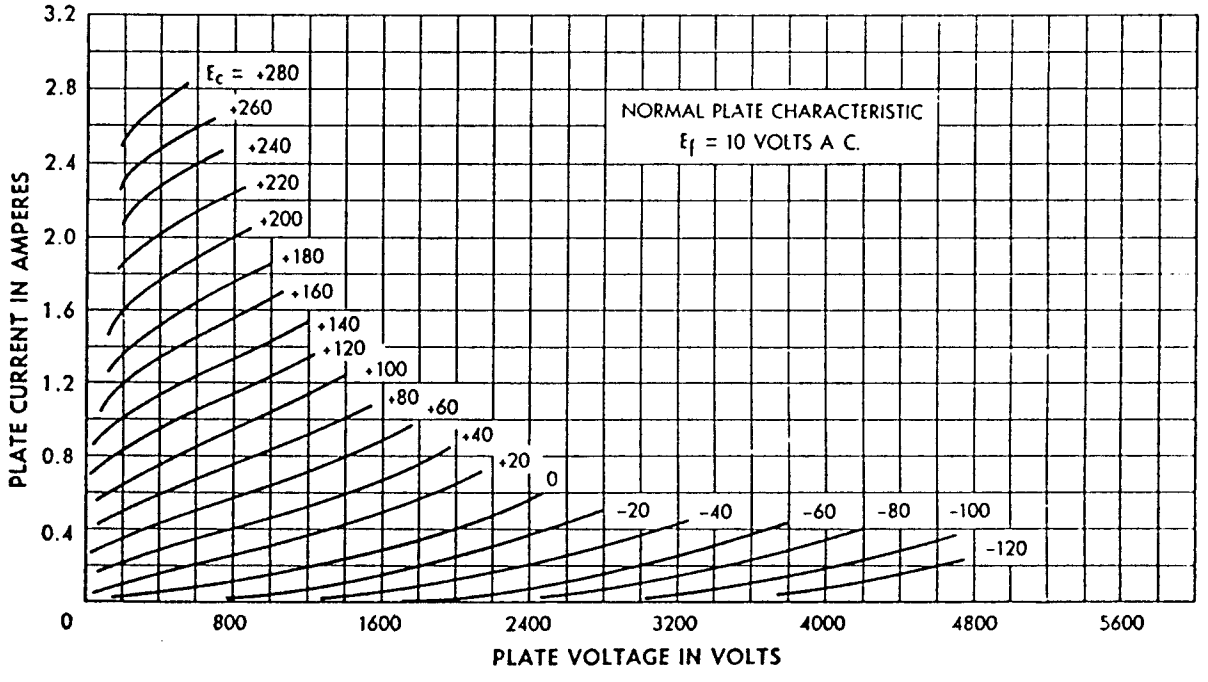
APPLICATION NOTES

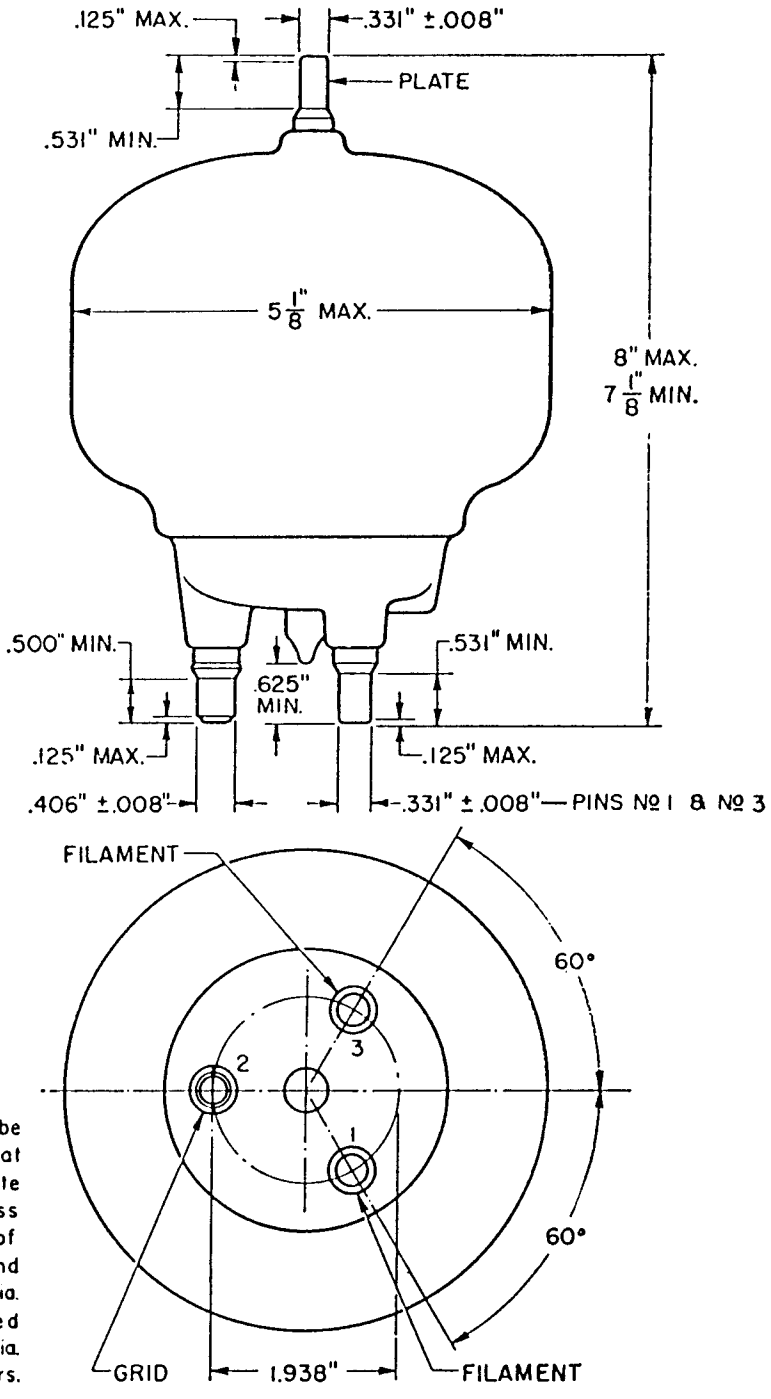
Maximum ratings apply up to 100 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below. Other maximum ratings are not affected.

Frequency	100	125	150 megacycles
Percentage of maximum rated plate voltage and plate input			
Class B	100	85	70 per cent
Class C, plate modulated	100	75	50 per cent
Class C, unmodulated	100	80	60 per cent

Radiation cooling is adequate when the tube is operated below 40 megacycles and with a free circulation of air around the tube. If operated in a confined space or at a frequency above 40 megacycles, forced-air cooling is necessary. Satisfactory air cooling will be obtained from a blower delivering approximately 40 cubic feet of air per minute from a 2-inch diameter nozzle. The nozzle outlet should be placed approximately 3 inches from the tube and directed toward the central point of the envelope, midway between the plate and grid terminal.







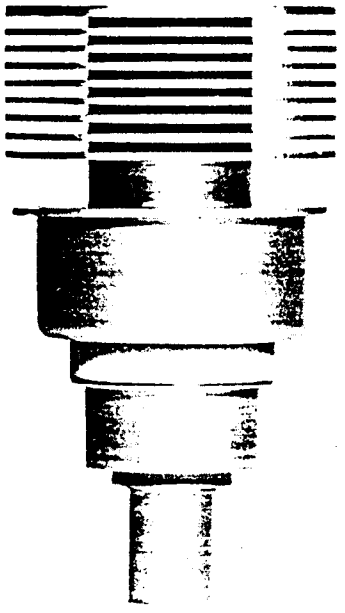
Note:
Base pin positions shall be held to tolerances such that pins will fit a flat - plate gauge having a thickness of .250" with 2 holes of .391" ± .0005" dia. and 1 hole of .469" ± .0005" dia. All holes shall be located on a 1.938" ± .0005" dia. circle at specified centers.

DIMENSIONS—ML-357B

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



MACHLETT

ML-518

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-518 is a ruggedized, high-mu planar triode of ceramic and metal construction, designed for use as an oscillator, frequency multiplier, or amplifier in radio transmitting service at frequencies up to 2500 Mc. The tube may be operated at higher frequencies with reduced ratings.

In addition to low interelectrode capacitance, high transconductance and high-mu, this tube incorporates design features which help to assure frequency stable operation even under adverse ambient temperature and varying plate dissipation conditions. The cathode is an indirectly heated oxide-coated disc. The anode is forced-air cooled. Anode adaptors for heatsink cooling can be provided upon request.

GENERAL CHARACTERISTICS

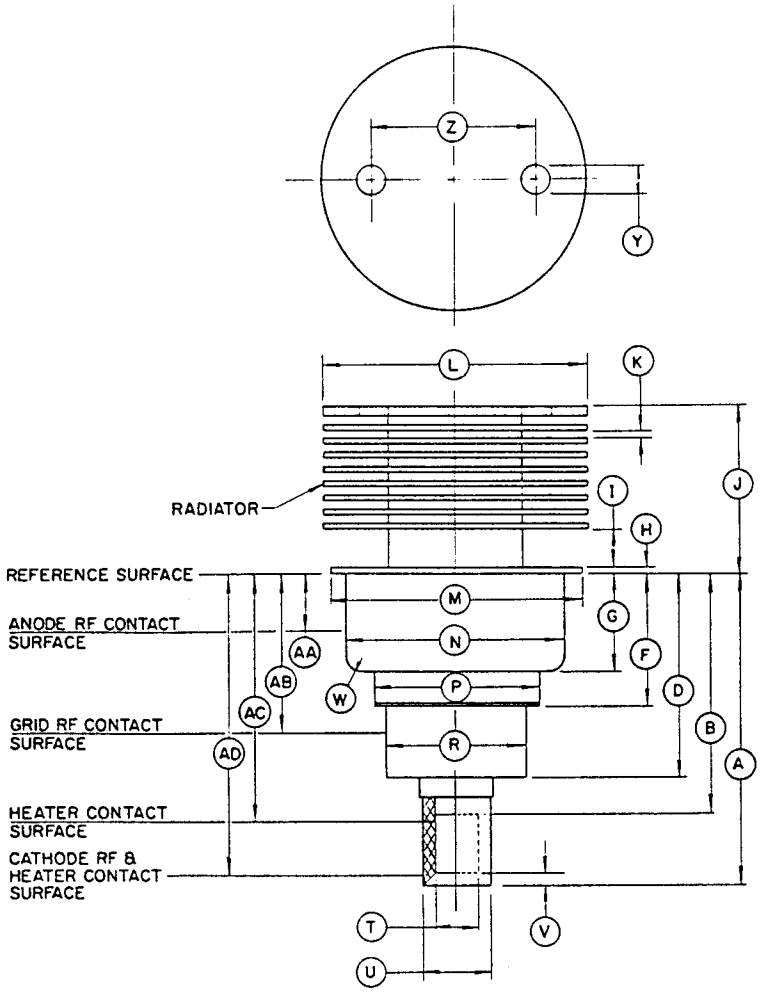
Electrical		
Heater Voltage	6.0	Volts
Heater Current (AC or DC) at 6.0 Volts	1.0	Amp
Cathode Heating Time, minimum	60	secs
Amplification Factor	100	
Transconductance (I_b=70 mA, E_b=600 V)	25,000	μmhos
Interelectrode Capacitances (without heater voltage):		
Grid-Plate	4.5	μμf
Grid-Cathode	6.60	μμf
Plate-Cathode, maximum	.06	μμf
Frequency for Maximum Ratings	2500	Mc
Mechanical		
Mounting Position	Optional	
Type of Cooling	Forced-Air	
Maximum Anode Temperature	250	°C
Net Weight, approximate	2.5	oz.

MAXIMUM RATINGS

RF Power Amplifier and Oscillator

Maximum Ratings, Absolute Values

DC Plate Voltage	600	Volts
DC Grid Voltage	−150	Volts
DC Cathode Current	125	mA
DC Grid Current	30	mA
Peak Positive RF Grid-Cathode Voltage	30	volts
Peak Negative RF Grid-Cathode Voltage	−400	volts
Plate Dissipation (Forced-air cooling or with appropriate heatsink)	100	Watts
Grid Dissipation	2	Watts



DIMENSIONS FOR OUTLINE (INCHES)

Ref.	Minimum	Maximum
A	1.447	1.507
B	—	1.166
D	0.940	0.980
F	0.605	0.645
G	0.462	0.477
H	—	0.040
I	0.125	0.185
J	0.766	0.826
K	0.025	0.046
L	1.234	1.264
M	1.180	1.195
N	1.025	1.035
P	0.752	0.792
R	0.655	0.665
T	0.213	0.223
U	0.315	0.325
V	—	0.086
W	—	0.100
Y	0.105	0.145
Z	0.650	0.850

NOTES

1. The total indicated runout of the anode and grid contact surfaces with respect to the cathode contact surface will not exceed 0.020 inch.
2. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed 0.012 inch.

DIMENSIONS FOR ELECTRODE CONTACT SURFACES (INCHES)

Ref.	Dimension	Contact
AA	0.198 ± 0.163	Anode
AB	0.876 ± 0.040	Grid
AC	1.263 ± 0.097	Heater
AD	1.277 ± 0.170	Cathode

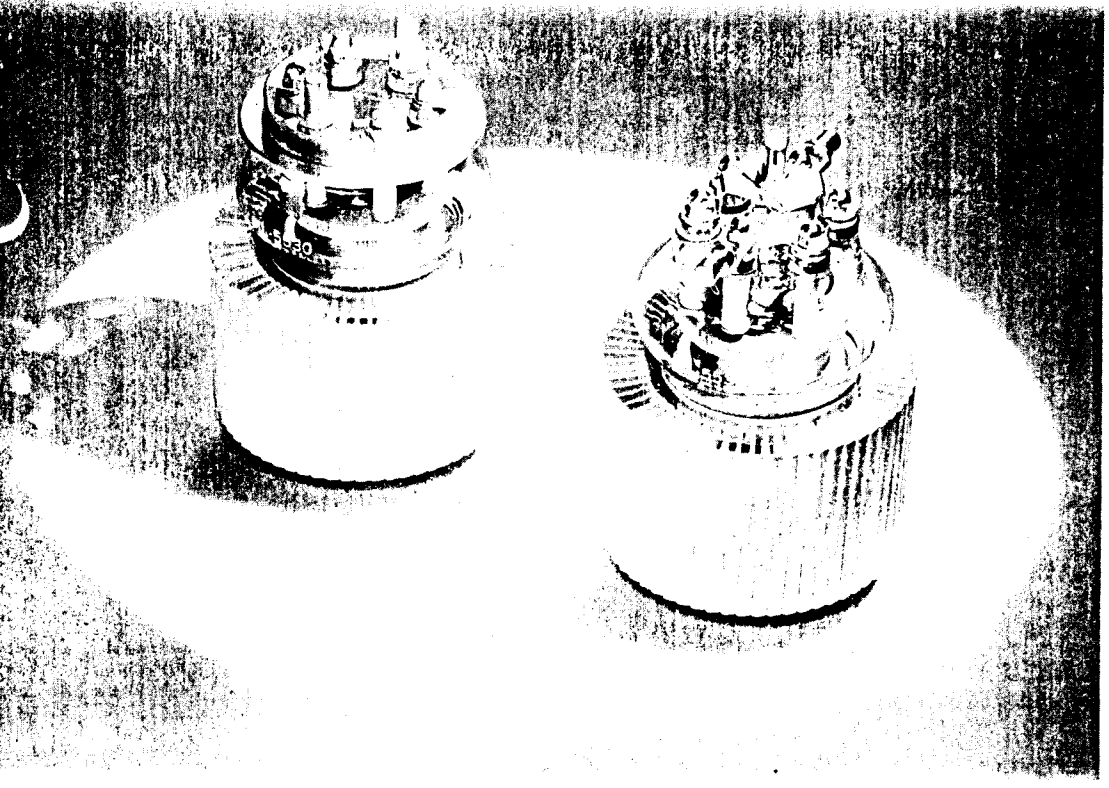
THE MACHLETT LABORATORIES, INC.
Subsidiary of Raytheon Company

ST-1762 5M 5-61

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

Printed in U.S.A.



MACHLETT

ML-5530
ML-5530-H

DESCRIPTION & RATINGS

DESCRIPTION

The ML-5530 is a three-electrode tube designed for high-frequency industrial-heating service and for AM and FM broadcasting at frequencies up to 110 megacycles. The terminal arrangement makes the tube particularly adaptable to cathode-drive applications as the filament leads are isolated from the plate by the external grid flange and internal shielding. Circuit inductance has been kept at a minimum in the grid as well as in all other internal connections. The filament is oriented with respect to the grid structure to minimize the required r-f driving power. The cathode is a thoriated-tungsten filament, whose self-supporting structure employs no sliding contacts, insulators, or tension springs. Rugged grid support rods provide great mechanical strength as well as low electrical loss. Kovar is used for the glass-to-metal seals. The anode fin structure is designed to dissipate 4 kilowatts with an air flow of 250 cfm. Maximum ratings of 5 kVdc plate voltage and 8.75 kW plate input apply at frequencies up to 110 Mc. Increased ratings of 6.5 kVdc plate voltage and 10 kW plate input are permissible at frequencies up to 70 Mc.

The ML-5530-H is a modification of the ML-5530 designed primarily for industrial service at frequencies up to 30 megacycles. Its construction is similar to the ML-5530 except for the grid terminal arrangement. Maximum ratings of 8.5 kVdc plate voltage and 10 kW plate input apply at frequencies up to 30 Mc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		5.0 Volts
Filament Current		55 Amps
Filament Starting Current, maximum		250 Amps
Filament Cold Resistance		.013 Ohm
Amplification Factor		26
Grid-Plate Transconductance at E_b = 2.0 kV; I_b = 1.5 amps		11000 μmhos
Interelectrode Capacitances:	*ML-5530	ML-5530H
Grid-Plate	23	20 μμf
Grid-Filament	20	17 μμf
Plate-Filament	0.6	1.0 μμf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Forced-air
Air flow on anode	See Cooling Characteristics
Air flow on glass and seals	See Note
Maximum incoming air temperature	45 °C
Maximum Glass Temperature	160 °C
Net Weight, approximate	9 lbs.

Note: At frequencies above 40 Mc for the ML-5530 and 15 Mc for the ML-5530-H, or at high ambient temperatures, auxiliary air flow may be required and should be distributed to maintain uniform glass temperature, not greater than 160°C. Auxiliary cooling may be obtained from separate blower or by reversing the direction of air flow through radiator (exhaust).

*Measured with 12-inch square metal shield attached to grid terminal ring.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

ML-5530

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	6500	volts
Max.-Signal D-C Plate Current*	1.5	amps
Max.-Signal Plate Input*	9	kW
Plate Dissipation*	4	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	5000	6000	6000	volts
D-C Grid Voltage	-150	-200	-180	volts
Peak A-F Grid-to-Grid Voltage	860	860	1220	volts
Peak A-F Plate-to-Plate Voltage	8000	9600	10000	volts
Zero-Signal D-C Plate Current	0.4	0.4	0.5	amp
Max.-Signal D-C Plate Current	1.7	1.45	2.6	amps
Effective Load Resistance, Plate-to-Plate	6000	8350	4800	ohms
Max-Signal Driving Power, approximate	45	30	140	watts
Max.-Signal Power Output, approximate	5.4	5.5	10.4	kW

* Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	5000	6500 volts
D-C Plate Current	0.90	0.90 amp
Plate Input	4.5	6 kW
Plate Dissipation	4	4 kW
Frequency	110	70 Mc

Typical Operation

D-C Plate Voltage	4500	6000 volts
D-C Grid Voltage	-175	-220 volts
Peak R-F Grid Voltage	390	310 volts
Peak R-F Plate Voltage	1875	2500 volts
D-C Plate Current	0.85	0.65 amp
D-C Grid Current	0.03	0 amp
R-F Load Resistance	1400	2500 ohms
Driving Power, approximate**	230	100 watts
Power Output, approximate	1.25	1.3 kW

** At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	5000	volts
D-C Grid Voltage	-1000	volts
D-C Plate Current	1.3	amps
D-C Grid Current	0.40	amp
Plate Input	8.0	kW
Plate Dissipation	2.7	kW
Frequency	70	Mc

Typical Operation

D-C Plate Voltage	4800	volts
D-C Grid Voltage	-600	volts
Peak R-F Grid Voltage	970	volts
Peak R-F Plate Voltage	3800	volts
D-C Plate Current	0.78	amp
D-C Grid Current	0.08	amp
R-F Load Resistance	2700	ohms
Driving Power, approximate	80	watts
Power Output, approximate	2.7	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	5000	6500 volts
D-C Grid Voltage	-1000	-1000 volts
D-C Plate Current	1.75	1.75 amps
D-C Grid Current	0.20	0.40 amp
Plate Input	8.75	10 kW
Plate Dissipation	4	4 kW
Frequency	110	70 Mc

Typical Operation	*Cathode drive*	*Grid drive*	
D-C Plate Voltage	4000	6300	volts
D-C Grid Voltage	-300	-650	volts
Peak R-F Grid Voltage	765	1250	volts
Peak R-F Plate Voltage	3000	5200	volts
D-C Plate Current	1.25	1.5	amps
D-C Grid Current	0.15	0.20	amp
R-F Load Resistance	1750	2000	ohms
Driving Power, approximate	950	250	watts
Power Output, approximate	4.0†	6.7	kW

‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

† Includes power transferred from driver stage.

ML-5530-H

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	8500	volts
D-C Grid Voltage	-1000	volts
D-C Plate Current	1.75	amps
D-C Grid Current	0.40	amp
Plate Input	10	kW
Plate Dissipation	4	kW

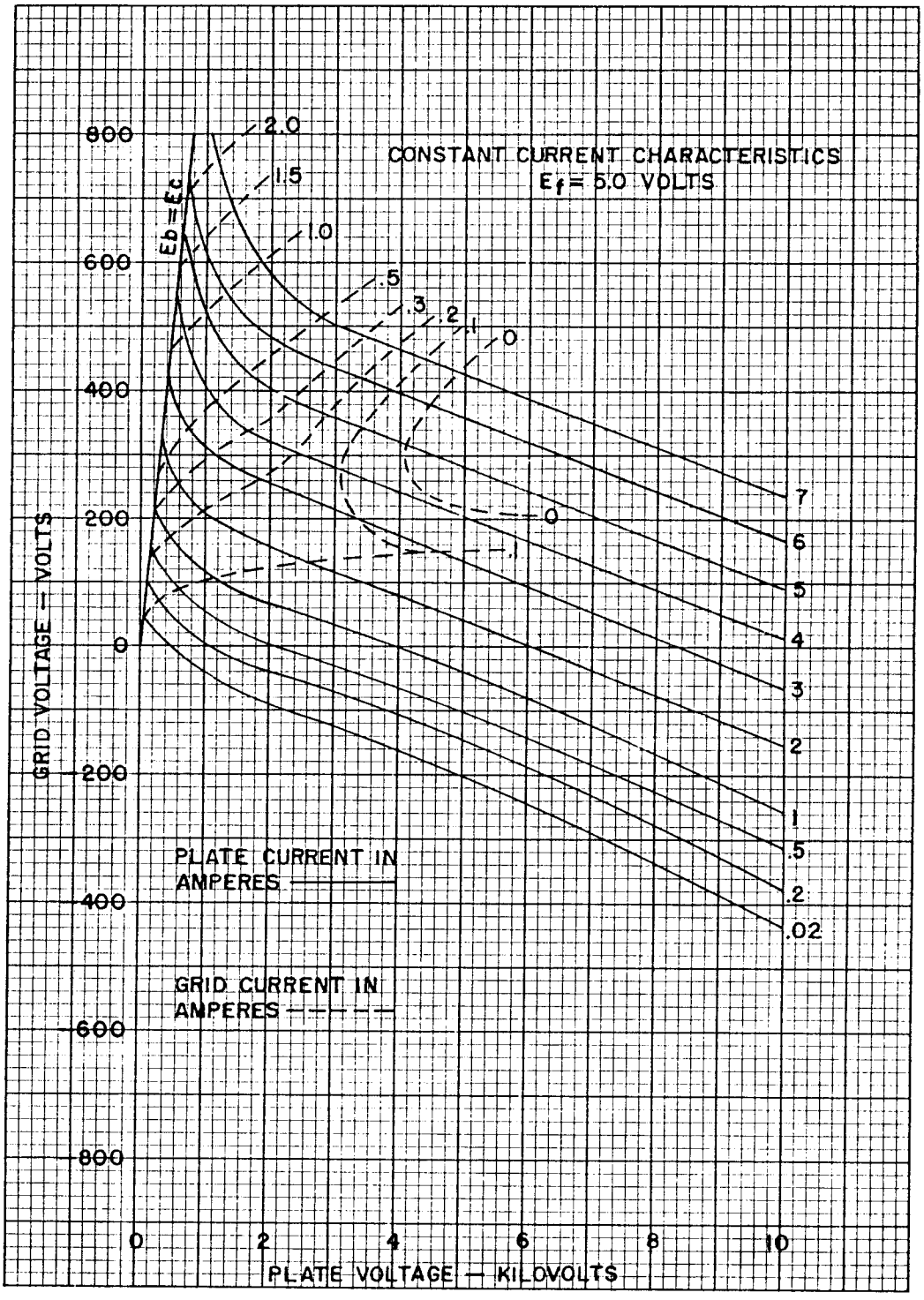
Typical Operation

D-C Plate Voltage	6300	8000	volts
D-C Grid Voltage	-650	-750	volts
Peak R-F Grid Voltage	1250	1250	volts
Peak R-F Plate Voltage	5200	6800	volts
D-C Plate Current	1.5	1.2	amps
D-C Grid Current	0.20	0.12	amp
R-F Load Resistance	2000	3200	ohms
Driving Power, approximate	250	150	watts
Power Output, approximate	6.7	7.2	kW

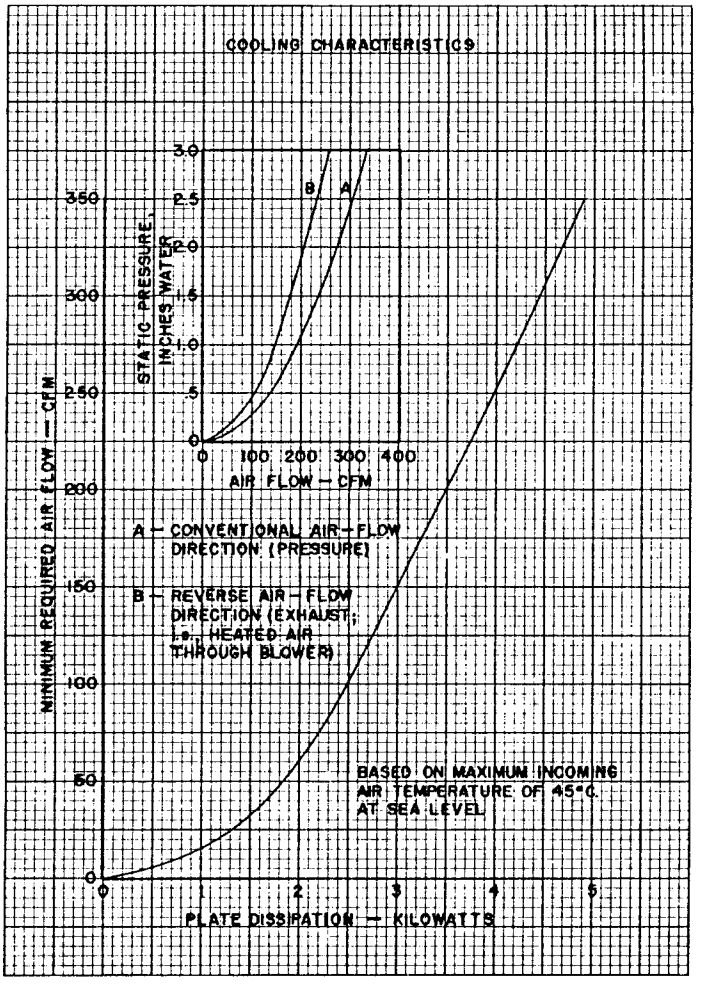
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

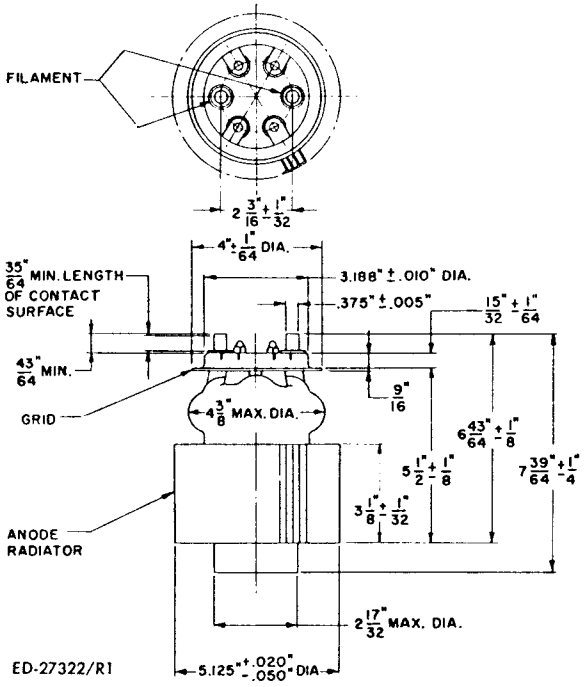
Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum
Grid Voltage	e_b = 1000 volts; i_b = 6.5 amps	e_c:	——	——	850 volts
Grid Current	e_b = 1000 volts; i_b = 6.5 amps	i_c:	——	——	2.2 amps
Plate Voltage	E_c = 0 Vdc; I_b = 0.5 Adc	E_b:	1.6	2.1	2.6 kVdc
Plate Voltage	E_c = -200 Vdc; I_b = 0.5 Adc	E_b:	6.5	7.3	8.1 kVdc
Grid Voltage	E_b = 7.0 kVdc; I_b = 0.05 Adc	E_c:	-220	-270	-320 Vdc
Plate Power Output	E_b = 6.3 kVdc; E_c = -650 Vdc I_b = 1.5 Adc; I_c = 0.20 Adc	P_o:	5.7	——	—— kW



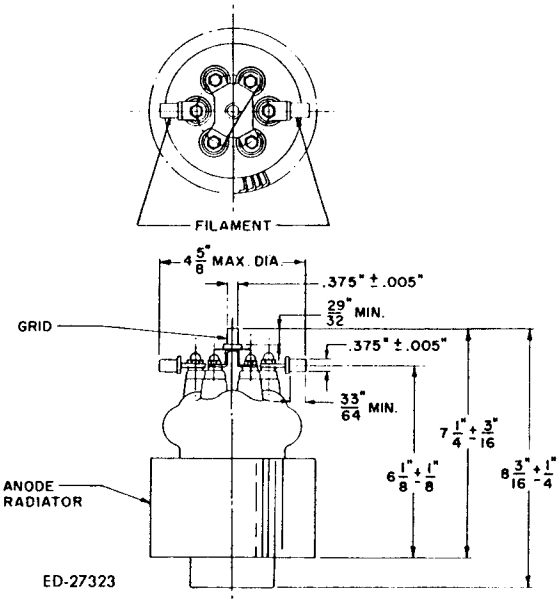
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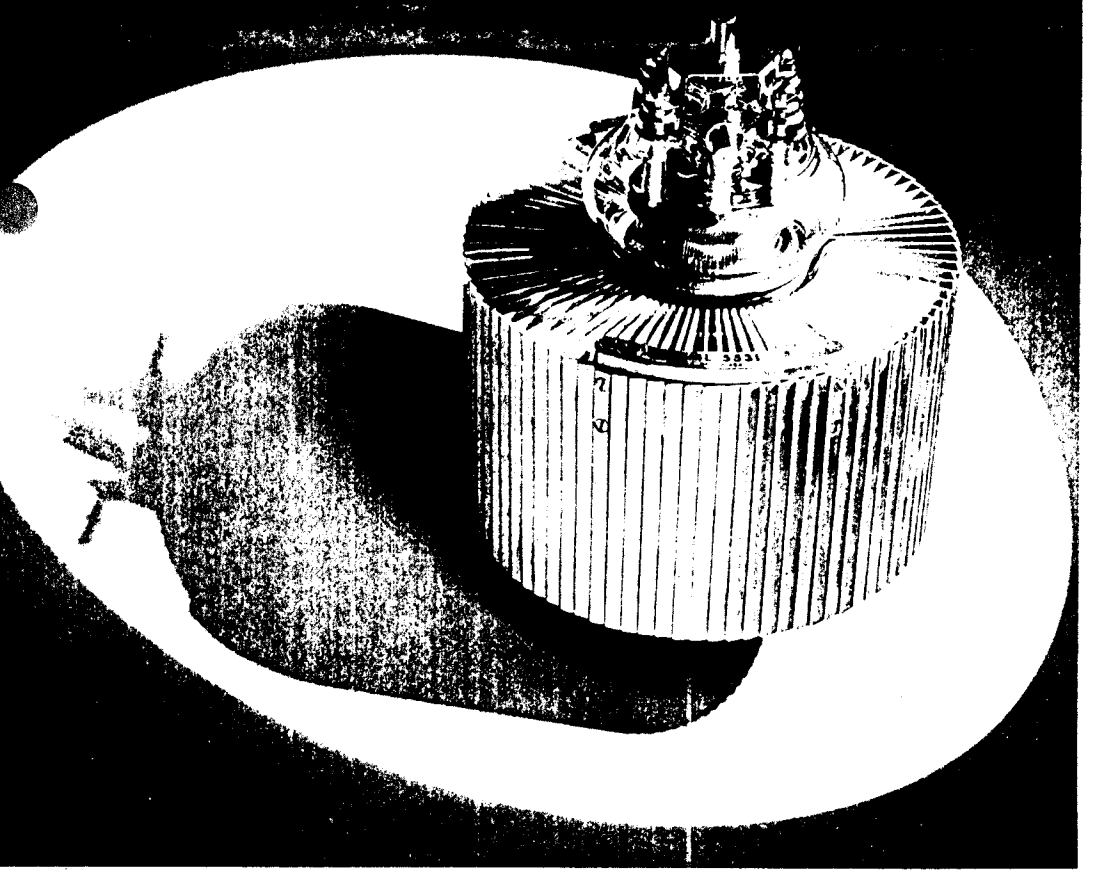


DIMENSIONS — ML-5530



DIMENSIONS — ML-5530-H

THE MACHLETT LABORATORIES, INC.
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MACHLETT

ML-5531

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-5531 is a three-electrode tube designed for industrial heating service and for AM broadcasting at frequencies up to 30 megacycles. The filament is oriented with respect to the grid structure to minimize the required r-f driving power. The cathode is a thoriated-tungsten filament, whose self-supporting structure employs no sliding contacts, insulators, or tension springs. A sturdy grid structure provides great mechanical strength as well as low electrical loss. Circuit inductance has been kept at a minimum in the grid as well as in all other internal connections. Kovar is used for the glass-to-metal seals. The plate fin structure is designed to provide 10 kilowatts dissipation with a forced-air flow of 600 cfm. Maximum ratings of 10.5 kVdc plate voltage and 30 kW plate input apply at frequencies up to 30 Mc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	6.3 Volts
Filament Current at 6.3 Volts	92 Amps
Filament Starting Current, Maximum	400 Amps
Filament Cold Resistance	.0085 Ohm
Amplification Factor	24
Grid-Plate Transconductance at E_b = 4.0 kV; I_b = 3.0 amps	22000 umhos
Interelectrode Capacitances	
Grid-Plate	26 uuf
Grid-Filament	23 uuf
Plate Filament	1.5 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Forced air
Maximum Incoming Air Temperature	45 °C
Required Air Flow on Anode	600 cfm
Static Pressure, Inches Water	0.8 inch
Maximum Bulb Temperature	160 °C
Net Weight, Approximate	30 pounds

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500 volts
Maximum Signal D-C Plate Current*	3.5 amps
Maximum Signal Plate Input*	30 kW
Plate Dissipation*	10 kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	9000 volts
D-C Grid Voltage	-350 volts
Peak A-F Grid-to-Grid Voltage	1620 volts
Peak A-F Plate-to-Plate Voltage	15400 volts
Zero Signal D-C Plate Current	1.0 amp
Maximum Signal D-C Plate Current	6.6 amps
Effective Load Resistance, plate-to-plate	2900 ohms
Maximum Signal Driving Power, approx.	490 watts
Maximum Signal Power Output, approx.	41 kW

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500 volts
D-C Plate Current	2.50 amps
Plate Input	20 kW
Plate Dissipation	10 kW

Typical Operation

D-C Plate Voltage	9000 volts
D-C Grid Voltage	-340 volts
Peak R-F Grid Voltage	430 volts
Peak R-F Plate Voltage	3800 volts
D-C Plate Current	1.8 amps
D-C Grid Current, approx.	0.030 amp
Driving Power, approx.**	330 watts
Power Output, approx.	5.5 kW

High-Efficiency Grid-Modulated Amplifier

Carrier conditions per tube, unless otherwise specified, for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

	Carrier Tube	Peak Tube	
D-C Plate Voltage	10500	10500	volts
D-C Grid Voltage	-1500	-1500	volts
D-C Plate Current	3.0	2.0†	amps
Plate Input	30	20†	kW
Plate Dissipation	10	10	kW

Typical Operation

D-C Plate Voltage	10000	10000	volts
D-C Grid Voltage	-920	-920	volts
D-C Plate Current			
Carrier	1.5	0.2	amps
Modulated†	1.5	1.1	amps
Driving Power, approx.	450	——	watts
Power Output, approx.	11.0	——	kW

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage	8000 volts
D-C Grid Voltage	-1500 volts
D-C Plate Current	3.1 amps
D-C Grid Current	0.60 amp
Plate Input	23 kW
Plate Dissipation	7.0 kW

Typical Operation

D-C Plate Voltage	7500 volts
D-C Grid Voltage	-1000 volts
Peak R-F Grid Voltage	1450 volts
Peak R-F Plate Voltage	6300 volts
D-C Plate Current	1.9 amps
D-C Grid Current	0.30 amp
Driving Power, approx.	415 watts
Power Output, approx.	11.3 kW

Radio-Frequency Power Amplifier and Oscillator Class C

Key-down conditions per tube without amplitude modulation.‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500 volts
D-C Grid Voltage	-1500 volts
D-C Plate Current	3.75 amps
D-C Grid Current	0.60 amp
Plate Input	30 kW
Plate Dissipation	10 kW

	Amplifier		Oscillator		
Typical Operation	Grounded-Grid	Grounded-Filament			
D-C Plate Voltage	8500	8500	7500	9000	volts
D-C Grid Voltage	-1000	-1000	-800	-900	volts
Peak R-F Grid Voltage	1640	1640	1320	1460	volts
Peak R-F Plate Voltage	6700	6700	5700	6800	volts
D-C Plate Current	3.4	3.4	2.8	3.2	amps
D-C Grid Current, approx.	0.44	0.44	0.31	0.30	amp
Driving Power, approx.	5660	700	——	——	watts
Power Output, approx.	25.3§	20.5	14	19	kW

* Averaged over any audio-frequency cycle of sine-wave form.

** At crest of audio-frequency cycle with modulation factor of 1.0.

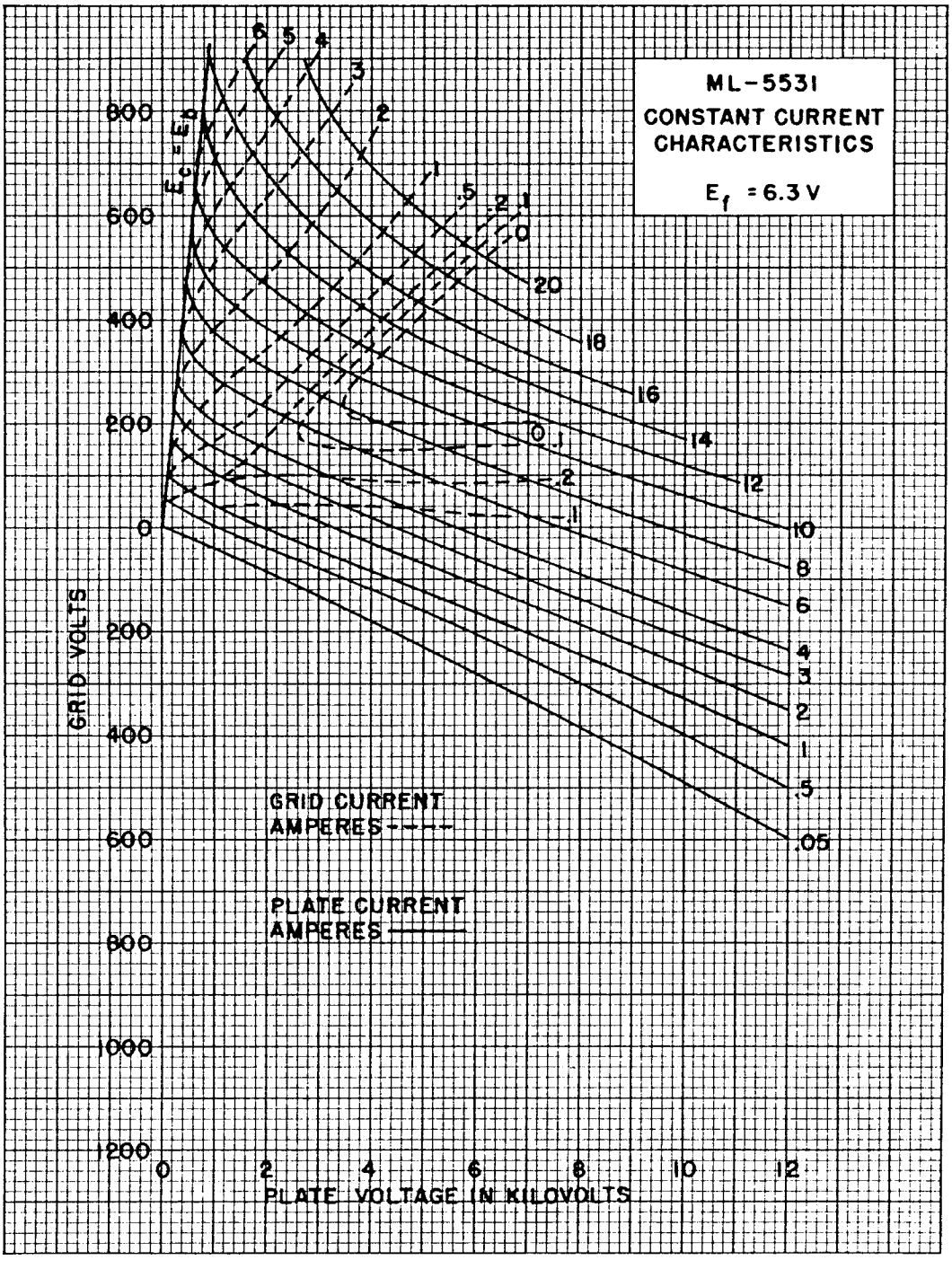
§ Includes power transferred from driver stage.

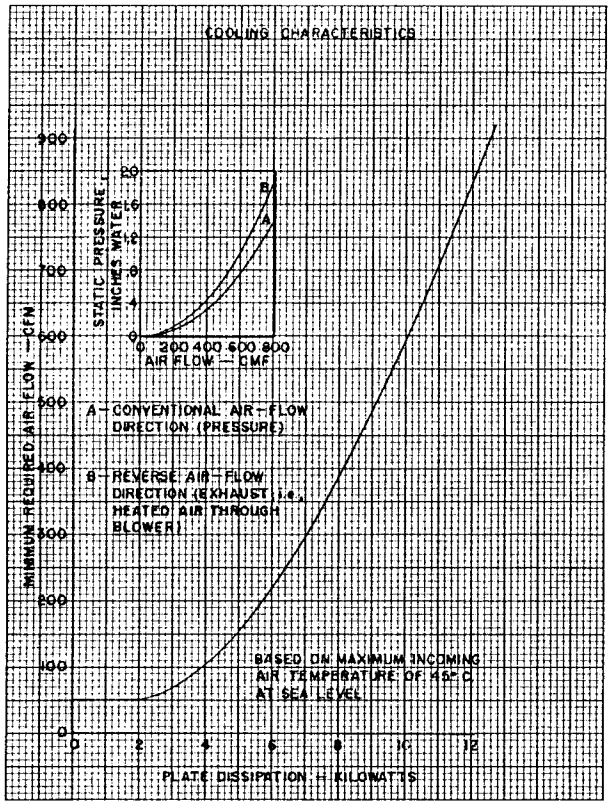
† Average value with modulation factor of 1.0.

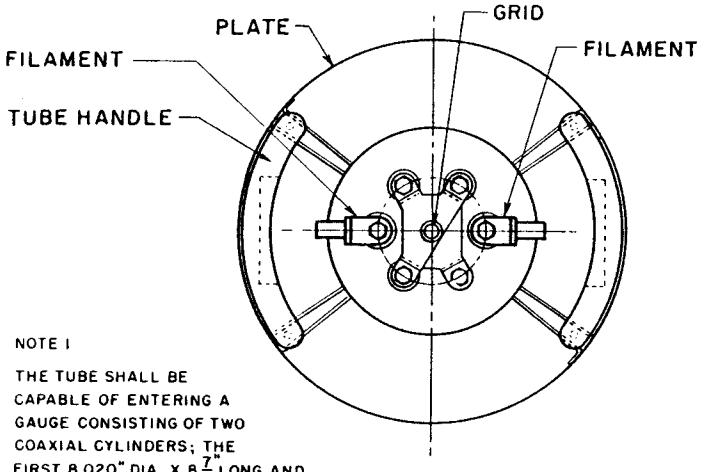
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of its unmodulated value.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Min.	Limits Bogey	Limits Max.
Grid Voltage	e_b = 1100 volts; i_b = 14 amps	e_c:	——	——	850 volts
Grid Current	e_b = 1100 volts; i_b = 14 amps	i_c:	——	——	7.0 amps
Plate Voltage	E_c = 0; I_b = 1.0 Adc	E_b:	1.7	2.2	2.7 kVdc
Plate Voltage	E_c = -100 Vdc; I_b = 1.0 Adc	E_b:	4.1	4.6	5.3 kVdc
Grid Voltage	E_b = 10 kVdc; I_b = 0.02 Adc	E_c:	-400	-490	-580 Vdc
Plate Power Output	E_b = 9.0 kVdc; E_c = -900 Vdc; I_b = 3.2 Adc; I_c = 0.30 Adc	P_o:	16	——	—— kW





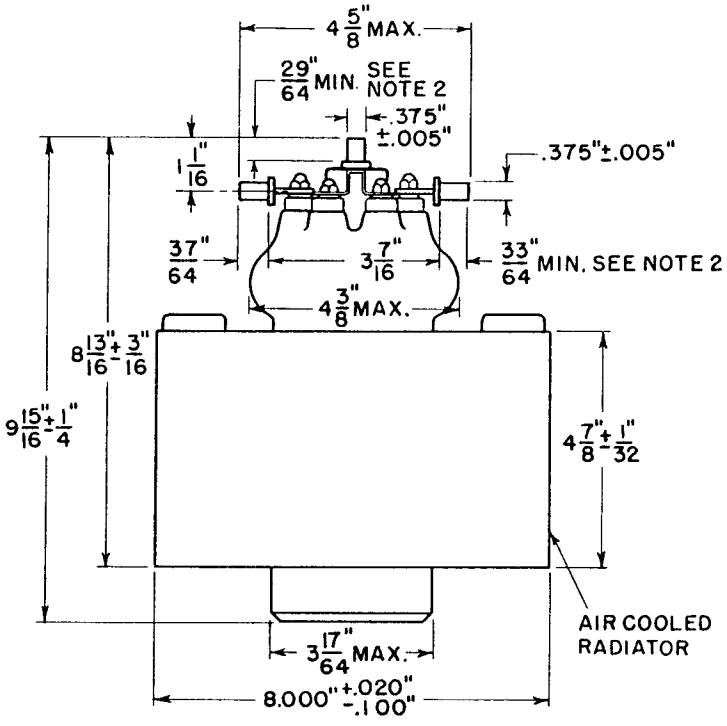


NOTE 1

THE TUBE SHALL BE CAPABLE OF ENTERING A GAUGE CONSISTING OF TWO COAXIAL CYLINDERS; THE FIRST 8.020" DIA. X $8\frac{7}{16}$" LONG AND THE SECOND .500" DIA. X $\frac{1}{2}$" LONG.

NOTE 2

LENGTH OF CONTACT SURFACE.

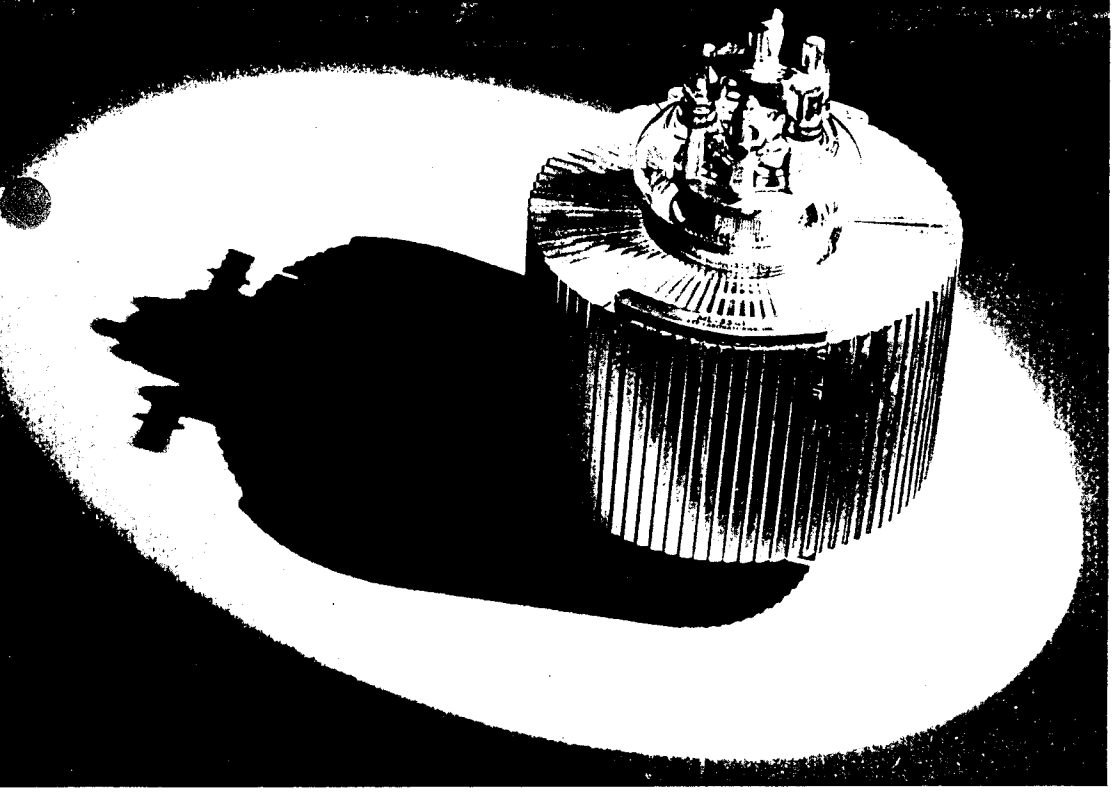


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U. S. A.



MACHLETT

ML-5541

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-5541 is a three-electrode tube designed for high-frequency dielectric-heating service, and for AM and FM broadcasting at frequencies up to 110 megacycles. The tube has been designed for grounded-plate use, but it is also suitable for grounded-grid applications. Circuit inductance has been kept at a minimum in the grid as well as in all other internal connections. The filament is oriented with respect to the grid structure to minimize the required r-f driving power. The cathode is a thoriated-tungsten filament, whose self-supporting structure employs no sliding contacts, insulators, or tension springs. Rugged grid support rods provide great mechanical strength as well as low electrical loss. Kovar is used for the glass-to-metal seals. The plate fin structure is designed to provide 10 kilowatts dissipation with a forced-air flow of 500 cfm. Maximum ratings of 8.5 kVdc plate voltage and 23 kW plate input apply at frequencies up to 110 Mc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	7.5 Volts
Filament Current at 7.5 Volts	57 Amps
Filament Starting Current, maximum	250 Amps
Filament Cold Resistance	.017 Ohms
Amplification Factor	26
Grid Plate Transconductance at E_b = 3.6 kV; I_b = 2.75 amps	21000 umhos
Interelectrode Capacitances	
Grid-Plate	25 uuf
Grid-Filament	20 uuf
Plate-Filament	1.5 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Forced-air
Air flow on anode, minimum for 10kW dissipation	500 cfm at 0.55" water
Air flow on glass and seals	See Note
Maximum incoming air temperature	45 °C
Maximum Glass Temperature	160 °C
Net Weight, approximate	30 lbs.

Note: At frequencies above 40 Mc, or at high ambient temperatures, auxiliary air flow may be required and should be distributed to maintain uniform glass temperature, not greater than 160°C. Auxiliary cooling may be obtained from separate blower or by reversing the direction of air flow through radiator (exhaust).

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	8500 volts
Maximum Signal D-C Plate Current*	2.5 amps
Maximum Signal Plate Input*	21 kW
Plate Dissipation*	10 kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	7500 volts
D-C Grid Voltage	-250 volts
Peak A-F Grid-to-Grid Voltage	1280 volts
Peak A-F Plate-to-Plate Voltage	13000 volts
Zero Signal D-C Plate Current	0.8 amp
Maximum Signal D-C Plate Current	4.2 amps
Effective Load Resistance, plate-to-plate	4000 ohms
Maximum Signal Driving Power, approx.	210 watts
Maximum Signal Power Output, approx.	21 kW

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage	8500 volts
D-C Plate Current	1.75 amps
Plate Input	15 kW
Plate Dissipation	10 kW

Typical Operation

D-C Plate Voltage	7500 volts
D-C Grid Voltage	-250 volts
Peak R-F Grid Voltage	370 volts
D-C Plate Current	1.4 amps
D-C Grid Current, approx.	0.025 amp
Driving Power, approx.**	200 watts
Power Output, approx.	3.5 kW

High-Efficiency Grid-Modulated Amplifier

Carrier conditions per tube, unless otherwise specified, for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

	Carrier Tube	Peak Tube	
D-C Plate Voltage	8500	8500	volts
D-C Grid Voltage	-1500	-1500	volts
D-C Plate Current	2.2	1.5†	amps
Plate Input	18	12†	kW
Plate Dissipation	10	10	kW

Typical Operation

D-C Plate Voltage	7500	7500	volts
D-C Grid Voltage	-920	-920	volts
D-C Plate Current			
Carrier	1.1	0.11	amps
Modulated†	1.1	0.66	amps
Driving Power, approx.	450	——	watts
Power Output, approx.	5.5	——	kW

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage	6500 volts
D-C Grid Voltage	-1500 volts
D-C Plate Current	2.3 amps
D-C Grid Current	0.30 amp
Plate Input	15 kW
Plate Dissipation	7 kW

Typical Operation

D-C Plate Voltage	6000 volts
D-C Grid Voltage	-800 volts
Peak R-F Grid Voltage	1150 volts
Peak R-F Plate Voltage	5000 volts
D-C Plate Current	1.1 amps
D-C Grid Current	0.12 amp
Driving Power, approx.	135 watts
Power Output, approx.	5.2 kW

Radio-Frequency Power Amplifier and Oscillator Class C

Key-down conditions per tube without amplitude modulation.‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	8500 volts
D-C Grid Voltage	-1500 volts
D-C Plate Current	2.75 amps
D-C Grid Current	0.30 amp
Plate Input	23 kW
Plate Dissipation	10 kW

Typical Operation

	Grounded-Grid	Grounded-Filament		
D-C Plate Voltage	7500	5000	7500	volts
D-C Grid Voltage	-650	-400	-650	volts
Peak R-F Grid Voltage	1135	825	1135	volts
Peak R-F Plate Voltage	5400	4300	5400	volts
D-C Plate Current	2.4	2.0	2.4	amps
D-C Grid Current, approx.	0.16	0.16	0.16	amp
Driving Power, approx.	2550	135	170	watts
Power Output, approx.	13.8§	6	11.5	kW

* Averaged over any audio-frequency cycle of sine-wave form.

** At crest of audio-frequency cycle with modulation factor of 1.0.

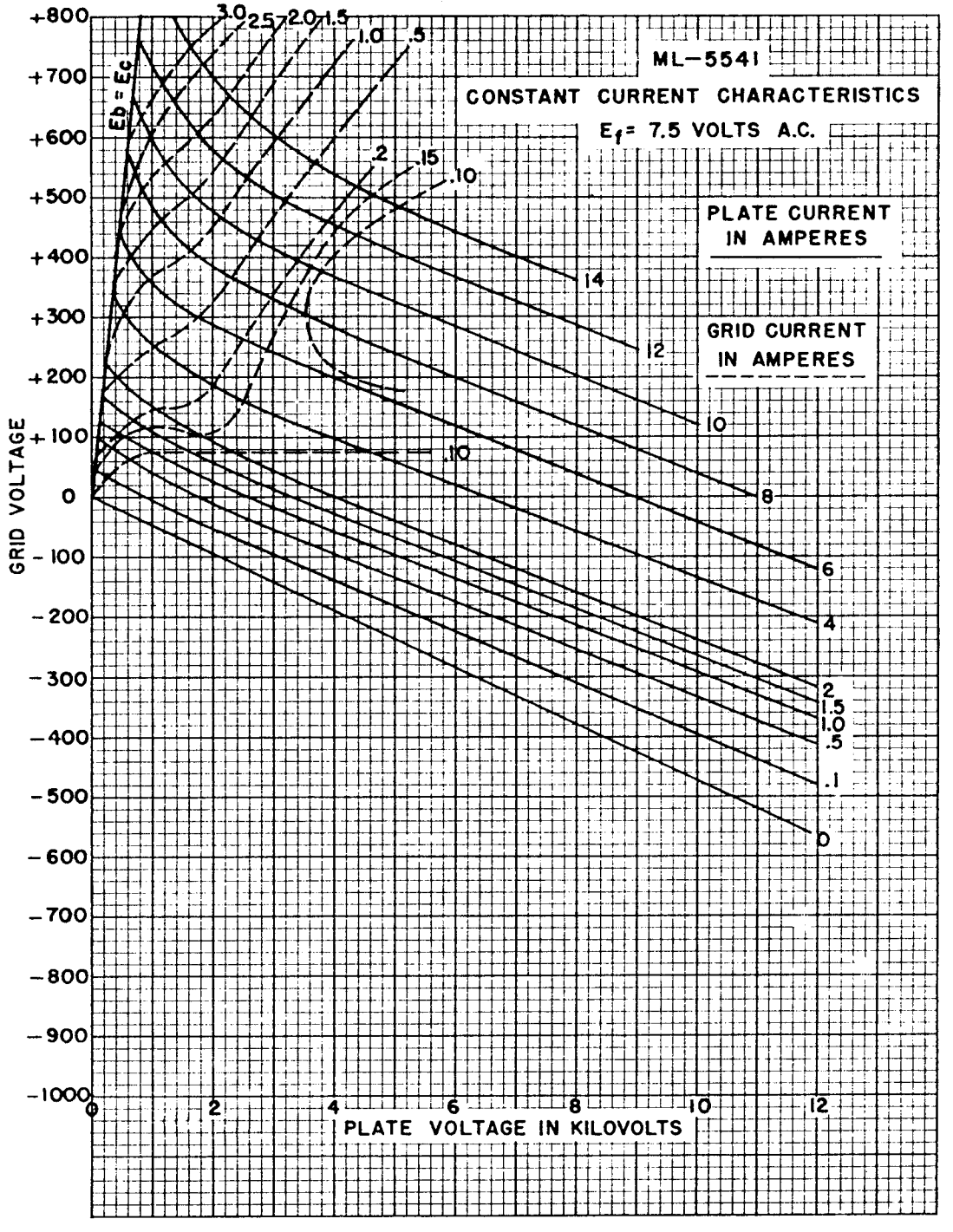
§ Includes power transferred from driver stage.

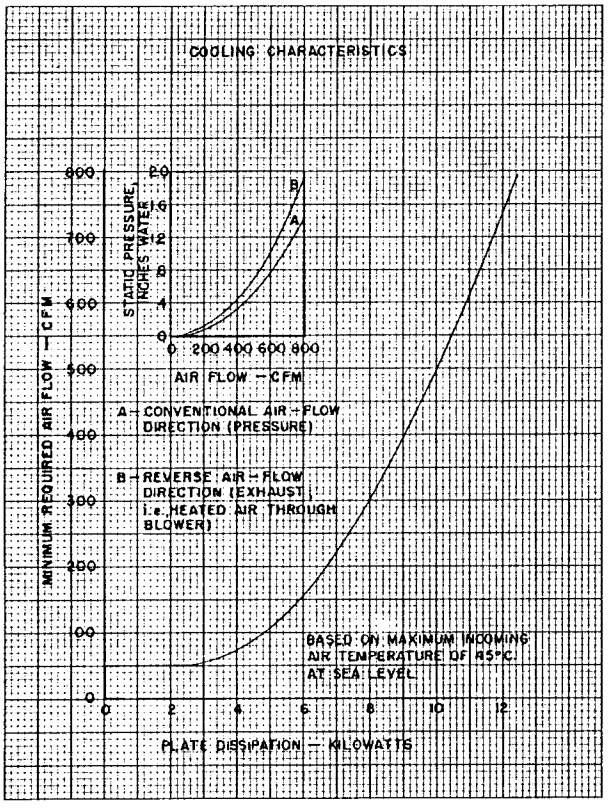
† Average value with modulation factor of 1.0.

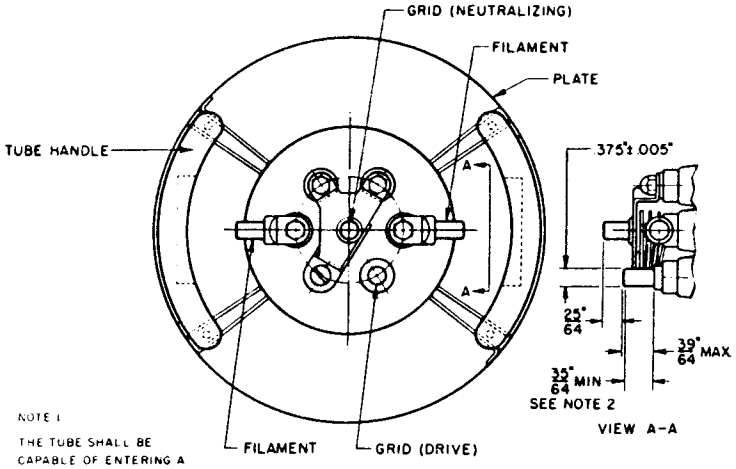
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Min.	Limits Bogey	Limits Max.
Grid Voltage	i_b = 10 amps; e_b = 1000 v	e_c:	——	——	700 volts
Grid Current	i_b = 10 amps; e_b = 1000 v	i_c:	——	——	3.5 amps
Plate Voltage	I_b = 1.0 Adc; E_c = 0	E_b:	2.2	2.5	2.8 kV
Plate Voltage	I_b = 1.0 Adc; E_c = -200 Vdc	E_b:	7.2	7.7	8.2 kV
Grid Voltage	I_b = 0.05 Adc; E_b = 8.5 kV	E_c:	-350	-400	-450 Volts
Plate Power Output	E_b = 7.5 kV; E_c = -650 Vdc; I_b = 2.4 Adc; I_c = 0.16 Adc	P_o:	9.8	——	—— kW





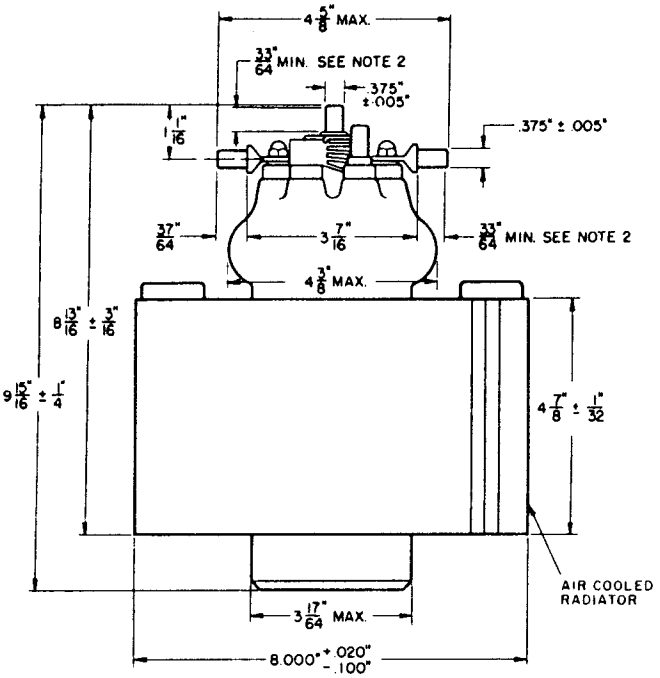


NOTE 1

THE TUBE SHALL BE CAPABLE OF ENTERING A GAUGE CONSISTING OF TWO COAXIAL CYLINDERS; THE FIRST 8.020" DIA x 8 7/16" LONG AND THE SECOND .500" DIA x 1/2" LONG

NOTE 2

LENGTH OF CONTACT SURFACE



THE MACHLETT LABORATORIES, INC.

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SPRINGDALE MACHLETT CONNECTICUT

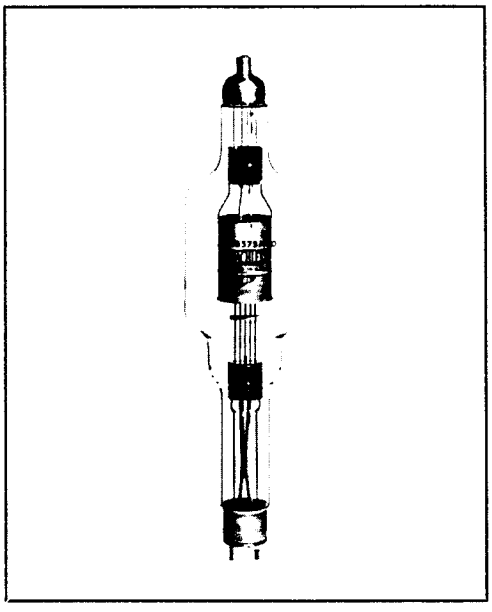
U. S. A.

ST-793 5M 3-61

Printed in U.S.A.

The Machlett Laboratories, Inc.
1063 Hope Street • Stamford, Conn. 06907
Tel. 203-348-7511 • TWX 203-327-2496

ISSUED 6-67



ML-5575/100

MACHLETT

High-Voltage Rectifier

150 PKV

DESCRIPTION

The ML-5575/100 is a high-vacuum rectifier tube having maximum ratings of 150 PKV inverse voltage and 1 ampere peak anode current. These ratings render it adaptable to a wide range of applications requiring high rectified voltages. For electrostatic particle precipitation service of extremely high power requirements, its high current capacity, low internal voltage drop, long life and ruggedness make its use particularly advantageous.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high-power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average load current capacity. The cathode is a pure tungsten filament of the catenary type, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The cylindrical tantalum anode provides an appreciable safety factor against accidental overload.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	20 V
Filament Current, approximate	24 A
Filament Heating Time, minimum (Before applying Plate Voltage)	30 Sec
Tube Voltage Drop, maximum (I_b = 1.0A, Ef = 20V)	800 V

Mechanical

Mounting Position	Optional
Mounting Socket, Machlett Part No.	P-8835
Type of Cooling	Radiation
Insulating Medium	Air
Net Weight, approximate	3 lb.

MAXIMUM RATINGS

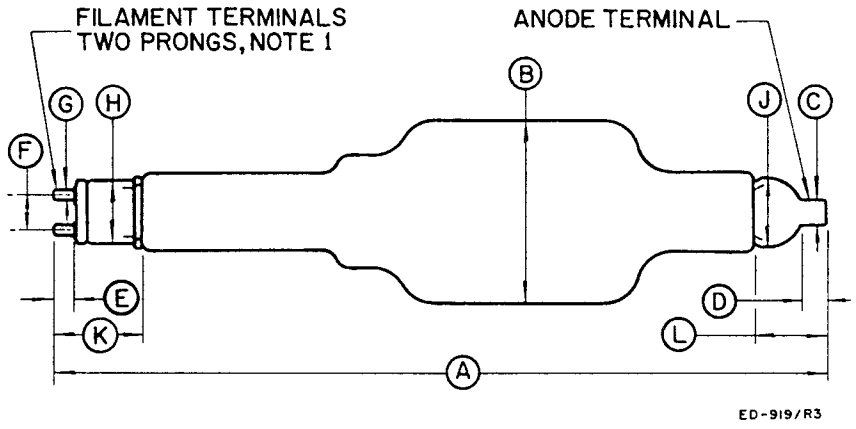
Peak Inverse Anode Voltage	150000 v
Peak Anode Current	1.0 a
Plate Dissipation	750 W

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

LOAD CURRENT RATINGS
(Average Direct Current Delivered To Load)

Circuit	Filament Voltage Volts	Peak Anode Current Milliamperes	Load Current Rating Unfiltered* Milliamperes	Load Current Rating Filtered** Milliamperes
Single-Phase, Two-Tube, Half Wave	20.0	1000	320	.....
	19.0	700	225	.....
	18.0	400	125	.....
Single-Phase, Four-Tube, Full Wave	20.0	1000	640	1000
	19.0	700	445	700
	18.0	400	255	400
Three-Phase, Double-Y, Parallel	20.0	1000	1920	2000
	19.0	700	1350	1400
	18.0	400	770	800
Three-Phase, Full Wave	20.0	1000	960	1000
	19.0	700	675	700
	18.0	400	385	400

* Unfiltered Load Current Ratings are based on sine-wave voltage input and resistance load without inductive or capacitive effects.
** Filtered Load Current Ratings are based on sine-wave voltage input and infinite inductance choke input filter.

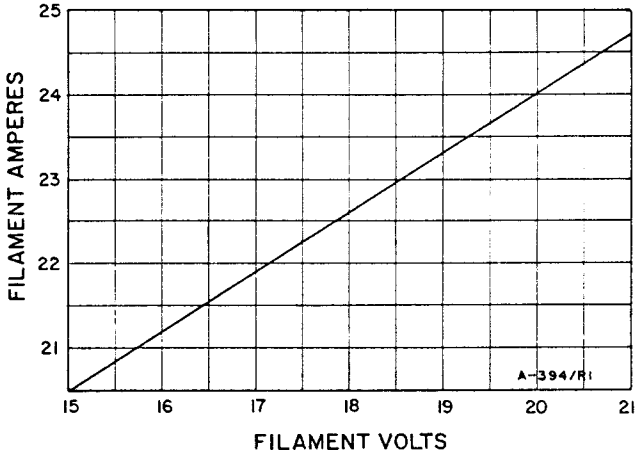


OUTLINE—ML-5575/100

DIMENSIONS FOR OUTLINE

Ref.	INCHES Minimum	Nominal	Maximum
A	24.7	25.0	25.3
B	—	—	6.2
C	.790	.800	.810
D	.75	.81	—
E	.82	.88	.94
F	1.240	1.250	1.260
G	.292	.312	.332
H	—	2.19	2.22
J	—	2.25	2.29
K	2.81	2.88	2.95
L	2.21	2.28	2.35

NOTE:
1. Cathode base fits Machlett mounting socket part P-8835.



FILAMENT CHARACTERISTICS

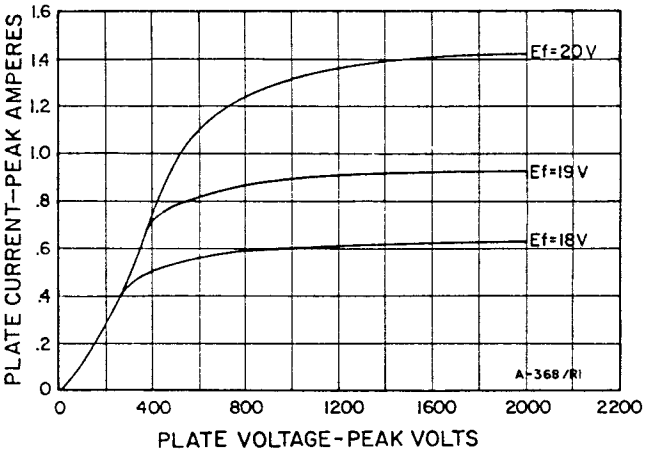
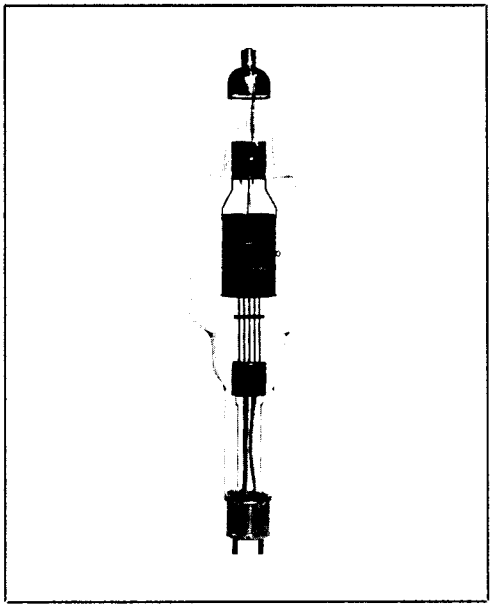


PLATE CURRENT CHARACTERISTICS

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

PRINTED IN U.S.A.
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ISSUED 6-65

ML-5576/200

MACHLETT

High-Voltage Rectifier

150 PKV

DESCRIPTION

The ML-5576/200 is a high-vacuum rectifier tube having maximum ratings of 150 PKV inverse voltage and 2.5 amperes peak anode current. It has been specially developed for use in power supply units associated with mass spectrometers for large-scale isotope separation, and also finds application in connection with various other devices requiring extremely high voltage and current capacity, such as linear accelerators and long-range radar.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high-power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average-load-current capacity. The cathode is a pure tungsten filament of the catenary type, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The anode is a cylindrical tantalum plate treated to insure a maximum rate of heat dissipation, providing a high safety factor against accidental overload.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	20	V
Filament Current, approximate	32	A
Filament Heating Time, minimum (Before applying Plate Voltage)	30	sec
Tube Voltage Drop, maximum (Ib = 2.5A, Ef = 20V)	1000	V

MECHANICAL

Mounting Position	Optional	
Mounting Socket, Machlett Part No.	P-8835	
Type of Cooling	Radiation	
Insulating Medium	Air	
Net Weight, approximate	3	lb

MAXIMUM RATINGS

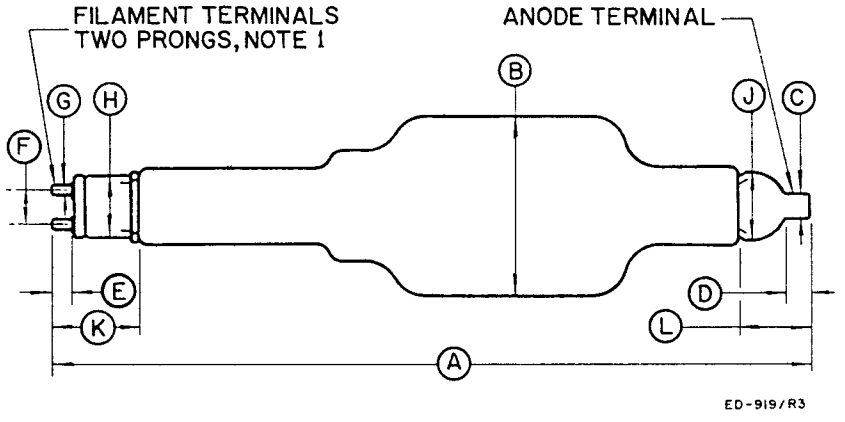
Peak Inverse Anode Voltage	150000	v
Peak Anode Current	2.5	a
Plate Dissipation	1000	W

WARNING: Operation of this tube might produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

LOAD CURRENT RATINGS
(Average Direct Current Delivered To Load)

Circuit	Filament Voltage Volts	Peak Anode Current Amperes	Load Current Rating Unfiltered* Amperes	Load Current Rating Filtered** Amperes
Single-Phase, Two-Tube, Half Wave	20.0 19.0 18.0	2.5 1.5 1.0	.80 .48 .32	....
Single-Phase, Four-Tube, Full Wave	20.0 19.0 18.0	2.5 1.5 1.0	1.59 .96 .64	2.5 1.5 1.0
Three-Phase, Double-Y, Parallel	20.0 19.0 18.0	2.5 1.5 1.0	4.80 2.90 1.93	5.0 3.0 2.0
Three-Phase, Full Wave	20.0 19.0 18.0	2.5 1.5 1.0	2.40 1.45 .96	2.5 1.5 1.0

* Unfiltered Load Current Ratings are based on sine-wave voltage input and resistance load without inductive or capacitive effects.
** Filtered Load Current Ratings are based on sine-wave voltage input and infinite inductance choke input filter.

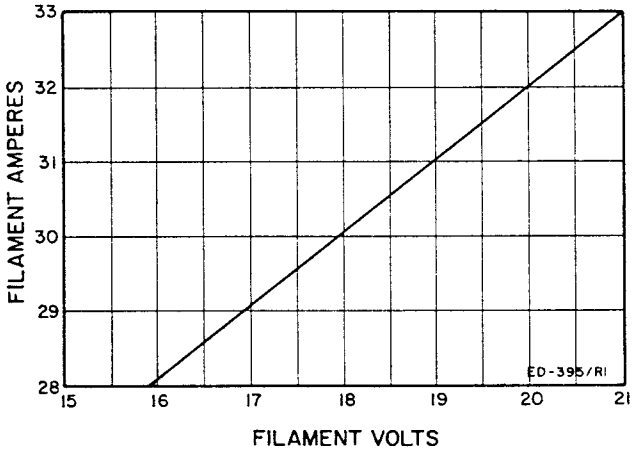


OUTLINE — ML-5576/200

DIMENSIONS FOR OUTLINE

Ref.	INCHES Minimum	Nominal	Maximum
A	—	25.0	25.3
B	—	—	6.2
C	.790	.800	.810
D	.75	.81	—
E	.82	.88	.94
F	1.240	1.250	1.260
G	.292	.312	.332
H	—	2.19	2.22
J	—	2.25	2.29
K	2.81	2.88	2.95
L	2.21	2.28	2.35

NOTE:
1. Cathode base fits Machlett mounting socket part P-8835.



FILAMENT CHARACTERISTICS

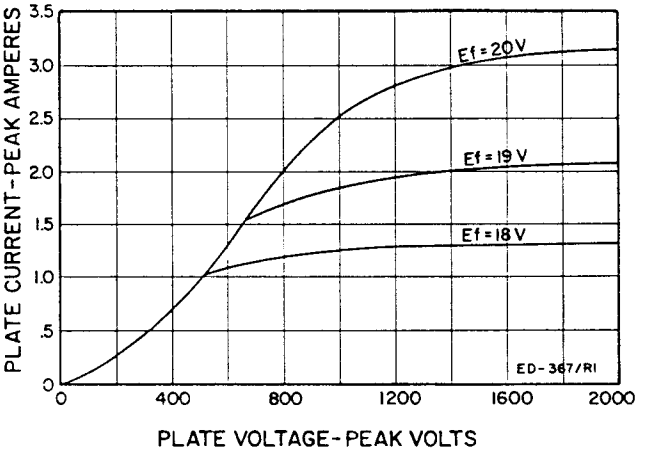


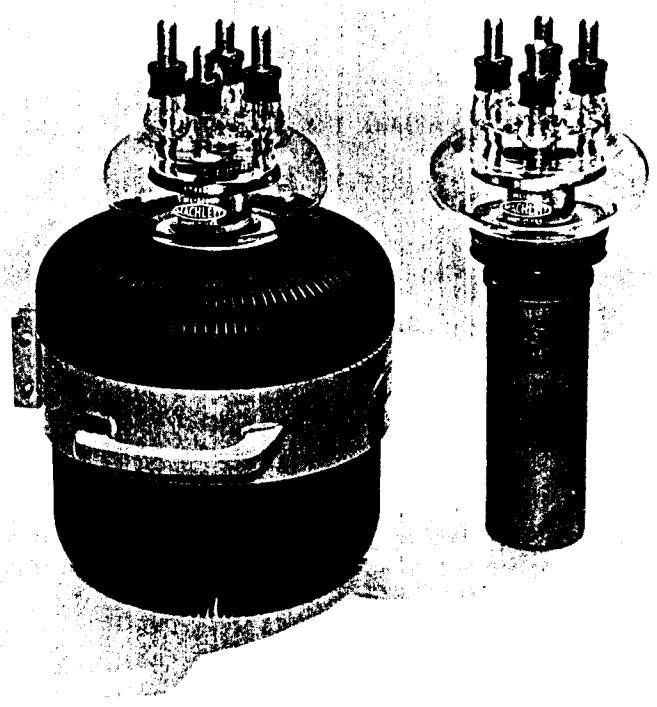
PLATE CURRENT CHARACTERISTICS

RAYTHEON

THE MACHLETT LABORATORIES, INC.

A SUBSIDIARY OF RAYTHEON COMPANY

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ST-475 2.5M 8-66



MACHLETT

ML-5604
ML-5619

DESCRIPTION & RATINGS

DESCRIPTION

The ML-5604 and ML-5619 are general purpose three electrode tubes designed specifically to meet the severe conditions of industrial heating service. Their special design also contributes to better performance when used as modulators, amplifiers, or oscillators in communications equipment. The cathode of each type is a pure-tungsten filament designed to afford long filament life. Both tubes incorporate rigidly supported grid and filament assemblies, glass surfaces completely shielded against electron bombardment and filament radiation, and rugged kovar anode, grid, and filament seals. The ML-5604 has a forced-air-cooled, heavy-wall anode capable of dissipating 10 kW with an air flow of approximately 750 cfm. The ML-5619 has a water-cooled, heavy-wall anode capable of dissipating 20 kW with a water flow of approximately 7 gpm. Maximum ratings of 12.5 kVdc plate voltage and 32.5 kW plate input apply at frequencies up to 25 Mc. These tubes are rated for service up to 50 Mc with plate voltage and plate input reduced according to the table on page 2.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		11.0	Volts
Filament Emission		12.4	Amps
Filament Current at Bogey Voltage		176	Amps
Filament Starting Current, maximum		270	Amps
Filament Cold Resistance		.0052	Ohms
Amplification Factor		20	
Interelectrode Capacitances	ML-5604	ML-5619	
Grid-Plate	24.0	23.0	$\mu\mu f$
Grid-Filament	27.0	27.0	$\mu\mu f$
Plate-Filament	1.25	1.00	$\mu\mu f$

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling — ML-5604	Forced-air	
Air flow on anode, minimum for 10 kW dissipation	750	cfm
Maximum incoming air temperature	45	°C
Type of Cooling — ML-5619	Water and forced-air	
Water flow on anode, minimum for 20 kW dissipation	7	gpm
Maximum outgoing water temperature	70	°C
Maximum Glass Temperature	160	°C
Air flow on center of dish from 3″ nozzle	50	cfm*
Net Weight, approximate		
ML-5604	45	lbs.
ML-5619	6	lbs.

*At frequencies above 15 Mc, more air flow may be necessary; special attention should be given to adequate ventilation of the dish and seals to keep the temperature at the hottest point below 160°C. Heat radiation connectors for grid and filament posts are recommended.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values	ML-5604	ML-5619	
D-C Plate Voltage	12500	12500	volts
Max.-Signal D-C Plate Current*	2.75	3.0	amps
Max.-Signal Plate Input*	32.5	32.5	kW
Plate Dissipation*	10	20	kW

Typical Operation (Values are for two tubes)				
D-C Plate Voltage	8000	10000	12000	volts
Filament Voltage	10.2	10.6	11.0	volts
D-C Grid Voltage	−370	−480	−600	volts
Peak A-F Grid-to-Grid Voltage	1620	2020	2380	volts
Zero-Signal D-C Plate Current	0.4	0.5	0.6	amp
Max.-Signal D-C Plate Current	2.6	3.7	4.5	amps
Effective Load Resistance, Plate-to-Plate	7200	6100	5900	ohms
Max.-Signal Driving Power, approximate	140	150	160	watts
Max.-Signal Power Output, approximate	14.5	25	36	kW

* Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	ML-5604	ML-5619	
D-C Plate Voltage	12500	12500	volts
D-C Plate Current	1.4	1.5	amps
Plate Input	16	16	kW
Plate Dissipation	10	16	kW

Typical Operation				
D-C Plate Voltage	8000	10000	12000	volts
Filament Voltage	9.9	10.2	10.5	volts
D-C Grid Voltage	−400	−500	−610	volts
Peak R-F Grid Voltage	410	490	590	volts
D-C Plate Current	0.6	0.8	1.0	amp
D-C Grid Current	0.00	0.00	0.00	mA
Driving Power, approximate†	75	70	65	watts
Power Output, approximate	1.7	2.8	4.4	kW

†At crest of audio-frequency cycle with modulation factor of 1.0

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	ML-5604	ML-5619	
D-C Plate Voltage	8000	10500	volts
D-C Grid Voltage	−2000	−2000	volts
D-C Plate Current	1.5	1.5	amps
D-C Grid Current	0.45	0.45	amp
Plate Input	12	15	kW
Plate Dissipation		13.3	kW

Typical Operation			ML-5619	
D-C Plate Voltage	6000	8000	10000	volts
Filament Voltage	10.4	10.7	11.0	volts
D-C Grid Voltage	−740	−1000	−1300	volts
Peak R-F Grid Voltage	1140	1540	1930	volts
D-C Plate Current	0.7	1.1	1.4	amps
D-C Grid Current	0.09	0.13	0.15	amp
Driving Power, approximate	100	200	280	watts
Power Output, approximate	3.4	7.1	11.9	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values	ML-5604	ML-5619	
D-C Plate Voltage	12500	12500	volts
D-C Grid Voltage	−2000	−2000	volts
D-C Plate Current	3.0	3.0	amps
D-C Grid Current	0.45	0.45	amp
Plate Input	32.5	32.5	kW
Plate Dissipation	10	20	kW

Typical Operation				
D-C Plate Voltage	8000	10000	12000	volts
Filament Voltage	10.5	10.7	10.9	volts
D-C Grid Voltage	−680	−870	−1170	volts
Peak R-F Grid Voltage	1300	1620	2130	volts
D-C Plate Current	1.5	2.0	2.5	amps
D-C Grid Current	0.19	0.20	0.22	amp
Driving Power, approximate	250	320	470	watts
Power Output, approximate	9.2	15	22.5	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

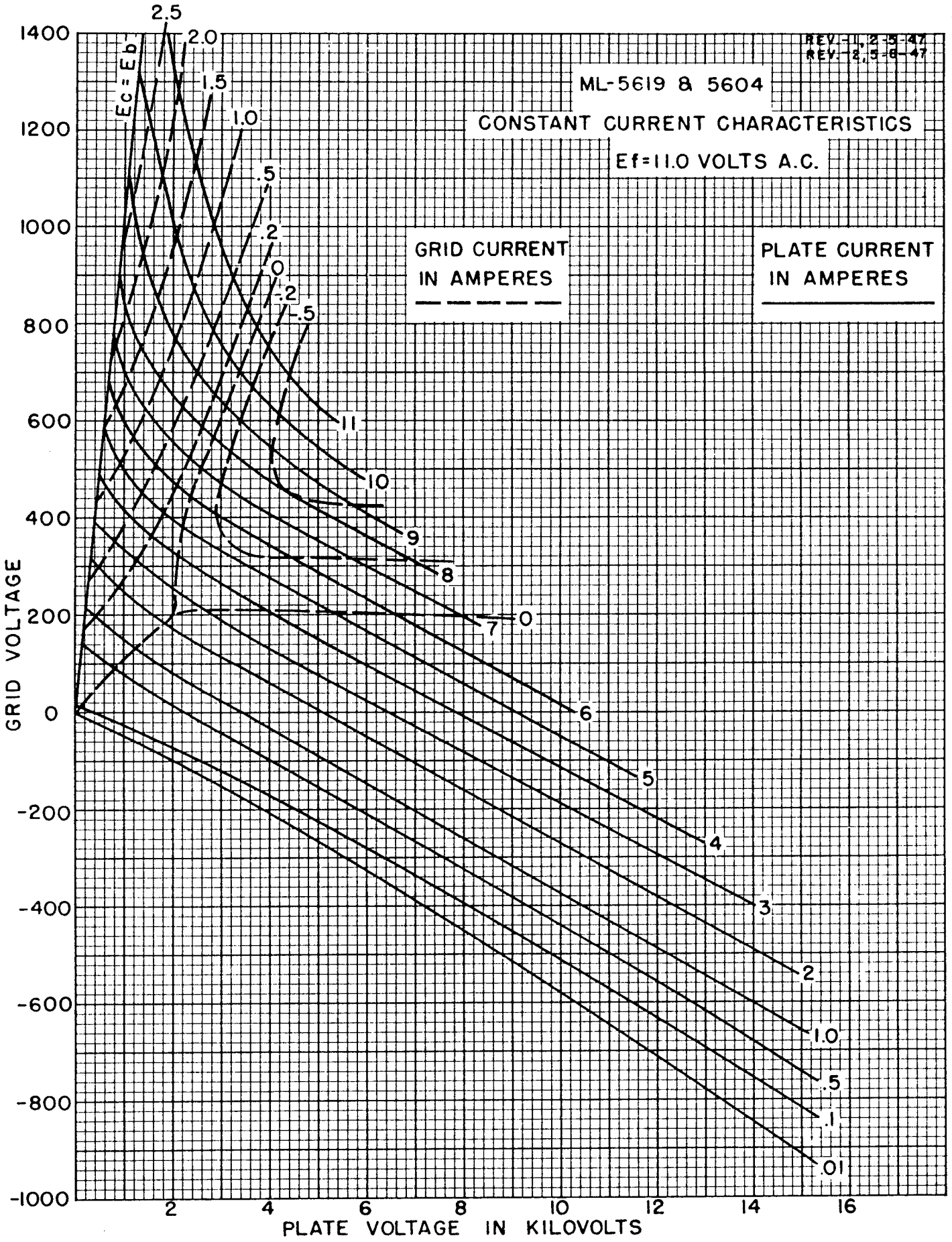
Maximum ratings apply at frequencies up to 25 Mc. These tubes may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	25	35	50 megacycles
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B	100	85	70 per cent
Class C Plate Modulated	100	80	50 per cent
Class C Unmodulated	100	80	50 per cent

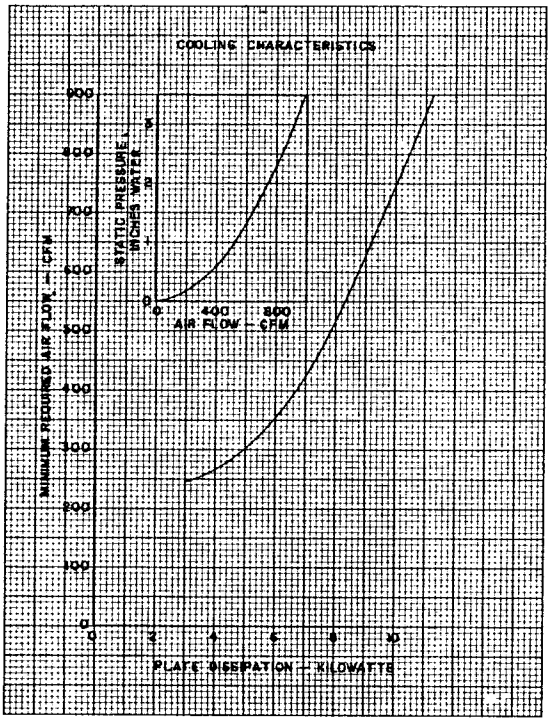
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 1500 volts; i_b = 8.0 amps	e_c:	——	——	830	volts
Grid Current	e_b = 1500 volts; i_b = 8.0 amps	i_c:	——	——	1.6	amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.25 Adc	E_b:	3.0	3.5	4.0	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 1.25 Adc	E_b:	6.7	7.5	8.3	kVdc
Grid Voltage	E_b = 10 kVdc; I_b = 0.020 Adc	E_c:	−480	−520	−600	Vdc
Peak Cathode Current (See note)		i_k:	11.5	——	——	amps
Power Output	E_b = 12.5 kVdc; I_b = 2.6 Adc; I_c = 0.225 Adc; R_g = 6000 ohms	P_o:	22.5	——	——	kW

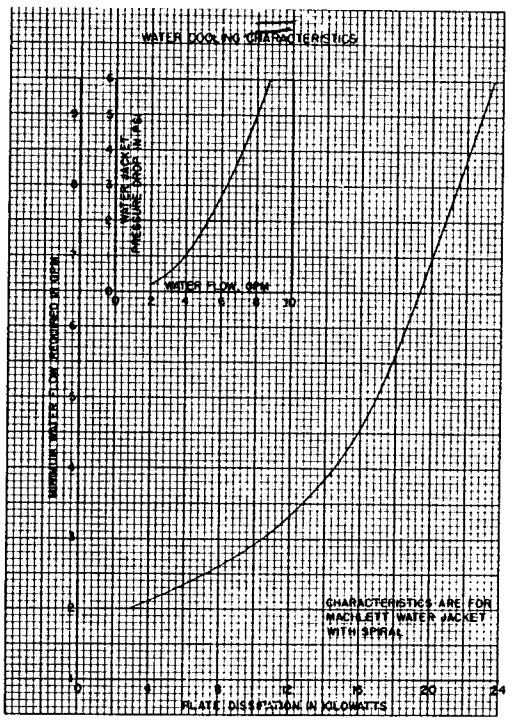
Note: Represents maximum useable plate current plus grid current for any condition of operation.

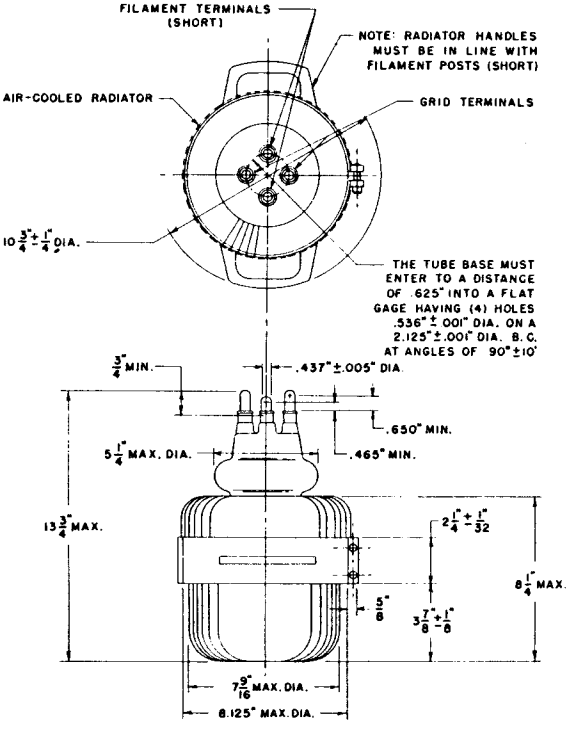

REV.-1, 2-5-47
REV.-2, 5-6-47
ML-5619 & 5604
CONSTANT CURRENT CHARACTERISTICS
Ef=11.0 VOLTS A.C.
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
Ec=Eb
2.5
2.0
1.5
1.0
.5
.2
0
-.2
-.5
11
10
9
8
7
6
5
4
3
2
1.0
.5
.1
.01
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
GRID VOLTAGE
2
4
6
8
10
12
14
16
PLATE VOLTAGE IN KILOVOLTS

ML-5604

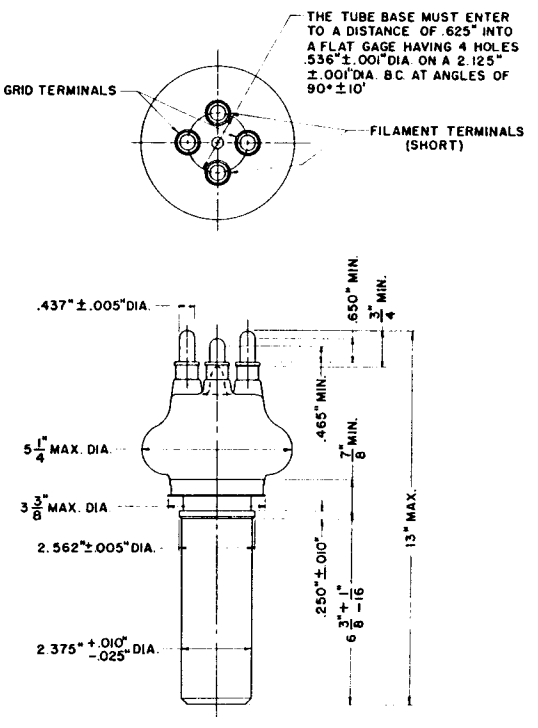


ML-5619





ML-5604



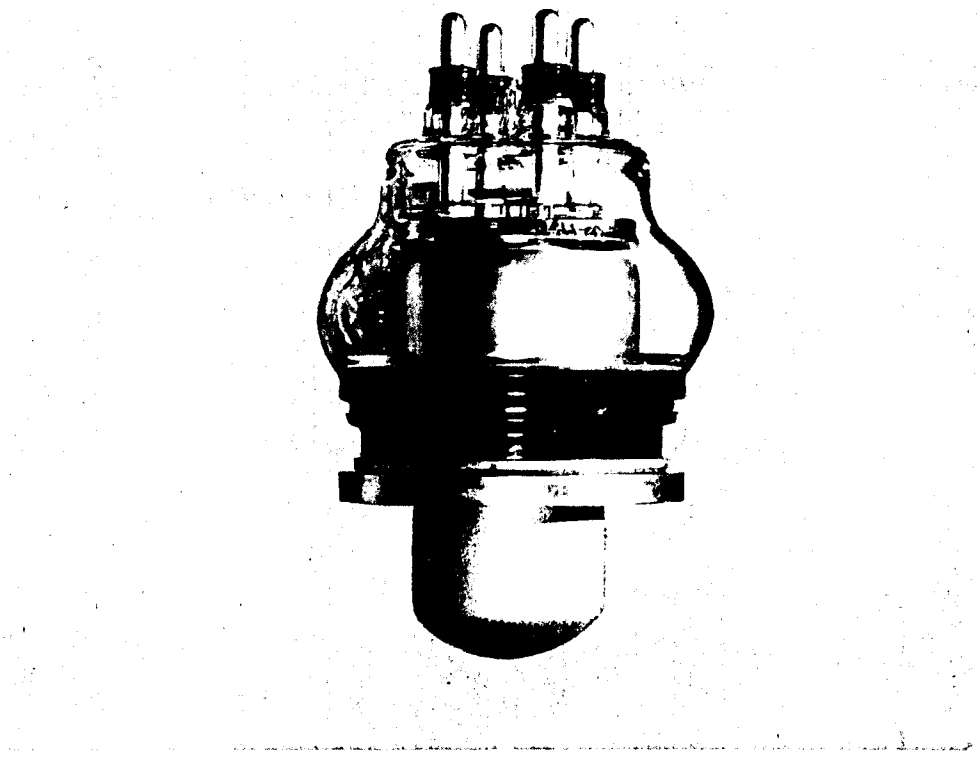
ML-5619

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

PRINTED IN U.S.A.



MACHLETT

ML-5658
ML-880

DESCRIPTION & RATINGS

DESCRIPTION

The ML-5658 is a three-electrode tube designed specifically for radio-frequency heating service, replacing the type 880 in industrial applications without equipment modification. The anode is water cooled and is capable of dissipating 20 kilowatts. The cathode is a stress-free, pure-tungsten filament. The tube incorporates rigidly supported grid and filament assemblies, glass surfaces shielded against electron bombardment and filament radiation, and sturdy kovar anode, grid, and filament seals.

The ML-880 is a three-electrode tube designed specifically for use as a modulator, amplifier, or oscillator in radio transmitting service, featuring low lead inductances and low interelectrode capacitances.

All of the structural improvements of the ML-5658 have been incorporated in the ML-880 so that these two types are now physically identical. With filament voltage at 12.6 volts, the ML-5658 is electrically identical to the ML-880 at the same filament voltage setting and will replace it directly.

Maximum ratings of 12.5 kVdc plate voltage and 60 kW plate input apply to the ML-5658 at frequencies up to 15 Mc; maximum ratings of 10.5 kVdc plate voltage and 60 kW plate input apply to both types at frequencies up to 25 Mc. Operation at higher frequencies is permissible with voltage and input reduced according to the table on p. 2.

GENERAL CHARACTERISTICS

Electrical	**ML-5658**	**ML-880**	
Filament Voltage	12.0	12.6	Volts
Filament Emission	28	35	Amps
Filament Current at Bogey Voltage	310	315	Amps
Filament Starting Current, maximum	450	450	Amps
Filament Cold Resistance	0.003	0.003	Ohms
Amplification Factor			
$I_b = 2.0$ Adc, $E_c = -100$ Vdc	20	20	
Interelectrode Capacitances			
Grid-Plate	24	24	$\mu\mu f$
Grid-Filament	35	35	$\mu\mu f$
Plate-Filament	2	2	$\mu\mu f$
Mechanical			
Mounting Position	Vertical, Anode Down		
Type of Cooling	Water and forced-air		
Water flow on anode, minimum for 20 kW dissipation	10.4		gpm
Maximum outgoing water temperature	70		°C
Air flow on dish from 3" nozzle	50		cfm*
Maximum Glass Temperature	160		°C
Net Weight, approximate	7		lbs.

*At frequencies above 10 Mc special attention should be given to adequate ventilation of the dish and seals to keep the temperature at the hottest point below 160°C. Heat radiating connectors for grid and filament posts are recommended when tube operation is at frequencies greater than 10 Mc.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

R-F C-W Oscillator (ML-5658)

Maximum Ratings, Absolute Values

D-C Plate Voltage	12500	volts
D-C Grid Voltage	−1600	volts
D-C Plate Current	5.0	amps
D-C Grid Current	0.8	amp
Plate Input	60	kW
Plate Dissipation	20	kW
Frequency	15	Mc

Typical Operation

Filament Voltage	12.0	12.0	12.0	volts
D-C Plate Voltage	8000	10000	12000	volts
Filament Voltage	11.6	11.8	12.0	volts
D-C Grid Voltage	−800	−900	−1000	volts
Peak R.F Grid Voltage	1320	1510	1680	volts
D-C Plate Current	3.1	4.0	4.5	amps
D-C Grid Current, approx.	.40	.45	.50	amp
Power Output, approx.	17	27	38	kW

A-F Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500	volts
Signal D-C Plate Current*	5.0	amps
Signal Plate Input*	40	kW
Plate Dissipation*	15	kW

Typical Operation (Values are for 2 Tubes)

Filament Voltage	12.6	12.6	volts
D-C Plate Voltage	7500	10000	volts
Zero Signal D-C Plate Current	1.0	1.0	amp
Max. Signal D-C Plate Current	6.7	7.0	amps
D-C Grid Voltage	−340	−450	volts
Peak A-F Grid-to-Grid Voltage	1450	1680	volts
Effective Load (plate to plate)	2300	3100	ohms
Max. Signal Driving Power	490	540	watts
Max. Signal Power Output	31	46	kW

*Averaged over any audio-frequency cycle of sine-wave form.

R-F Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500	volts
D-C Plate Current	4.0	amps
Plate Input	32	kW
Plate Dissipation	20	kW

Typical Operation

Filament Voltage	12.6	12.6	volts
D-C Plate Voltage	7500	10000	volts
D-C Plate Current	3.3	2.75	amps
D-C Grid Voltage	−340	−460	volts
D-C Grid Current, approximate	0.013	0.009	amp
Peak R-F Grid Voltage	570	595	volts
Driving Power†	1250	900	watts
Power Output	8	9	kW

†At crest of audio-frequency cycle with modulation factor of 1.0.

Plate Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500	volts
D-C Plate Current	3.6	amps
D-C Grid Current	0.8	amp
D-C Grid Voltage	−1200	volts
Plate Input	36	kW
Plate Dissipation	12	kW

Typical Operation

Filament Voltage	12.6	12.6	volts
D-C Plate Voltage	7500	10000	volts
D-C Plate Current	3.0	3.6	amps
D-C Grid Voltage	−1000	−1200	volts
Peak R-F Grid Voltage	1560	1840	volts
D-C Grid Current	0.57	0.64	amp
Driving Power	850	1100	watts
Power Output	16	27	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500	volts
D-C Plate Current	6.0	amps
D-C Grid Current	0.8	amp
D-C Grid Voltage	−1200	volts
Plate Input	60	kW
Plate Dissipation	20	kW

Typical Operation

Filament Voltage	12.6	12.6	12.6	volts
D-C Plate Voltage	7500	10000	10000	volts
D-C Plate Current	4.8	4.5	6.0	amps
D-C Grid Voltage	−600	−800	−1000	volts
Peak R-F Grid Voltage	1250	1460	1830	volts
D-C Grid Current	0.79	0.78	0.8	amp
Driving Power	920	1000	1500	watts
Power Output	24	33	40	kW

‡Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply at frequencies up to 25 Mc. Both types may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the table below (other maximum ratings are the same as shown on page 2). For R-F C-W Oscillator operation, the ML-5658 may be operated up to 15 Mc with the plate voltage increased to 120 per cent of the maximum rating for 25 Mc. Special attention should be given to adequate ventilation of the dish and seals at the higher frequencies.

Percentage of Maximum Rated Plate Voltage and Input

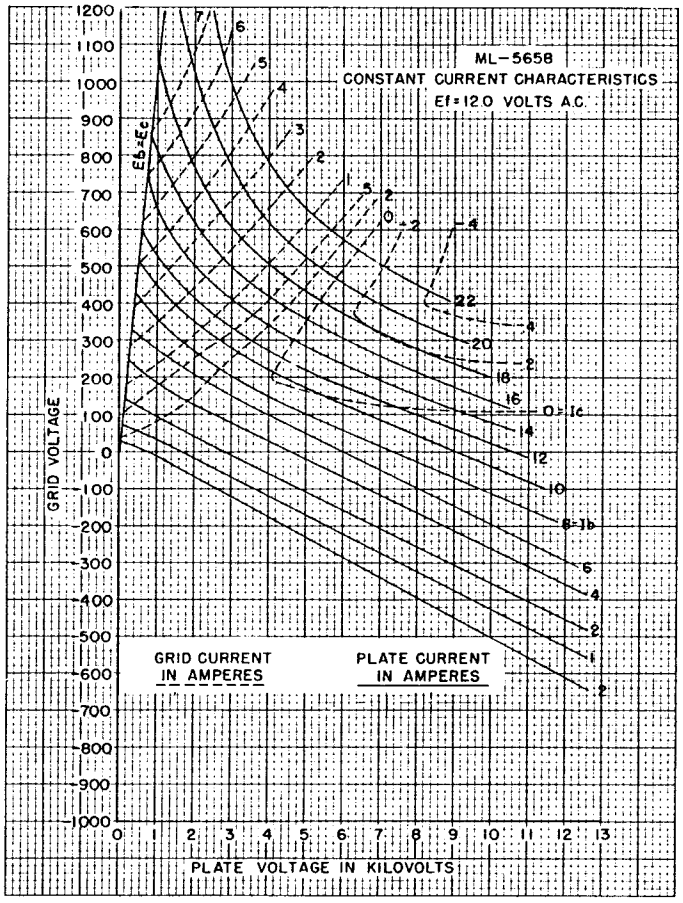
Mc	Class B		Class C Telephony	Class C Telegraphy
	Volts	Watts		
25	100	100	100	100
50	80	94	72	75
75	68	85	56	62
100	60	75	45	50

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

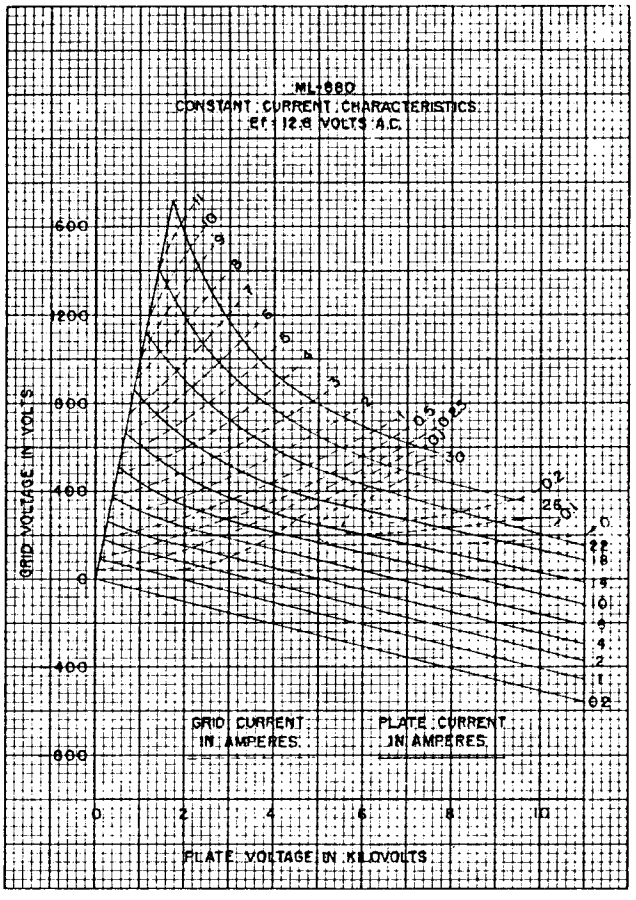
Characteristics	Conditions (E_f = 12.6 Volts)		Limits Minimum	Bogey	Maximum	
Grid Voltage	e_b = 2000 volts; i_b = 25 amps	e_c:	—	—	1300	Volts
Grid Current	e_b = 2000 volts; i_b = 25 amps	i_c:	—	—	10.0	Amps
Plate Voltage	E_c = 0 Vdc; I_b = 2.0 Adc	E_b:	2.8	3.2	3.6	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 2.0 Adc	E_b:	6.5	7.3	8.1	kVdc
Grid Voltage	E_b = 10.0 kVc; I_b = 0.02 Adc	E_c:	−460	−525	−690	Vdc
Peak Cathode Current	Note 1	i_k:	35	—	—	Amps
Power Output	E_b = 10.0 kVdc; I_b = 4.5 Adc E_c = −1000 Vdc; I_c = 0.80 Adc	P_o:	28	—	—	kW

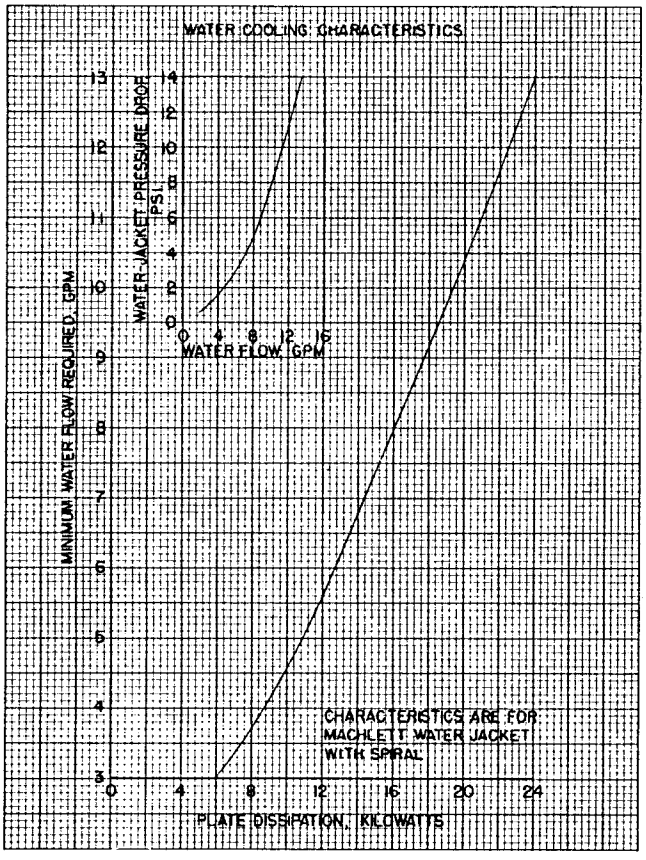
Note 1: Represents maximum plate current plus grid current for any condition of operation.

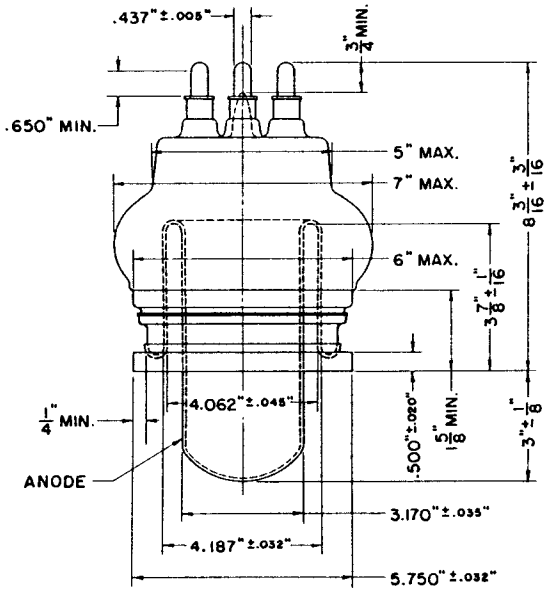
ML-5658

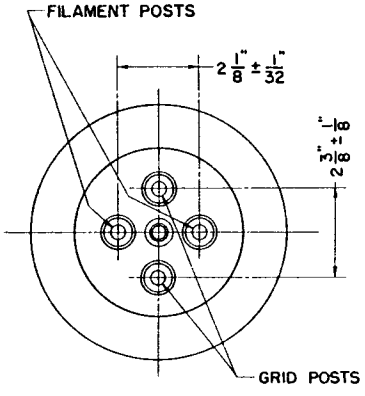


ML-880



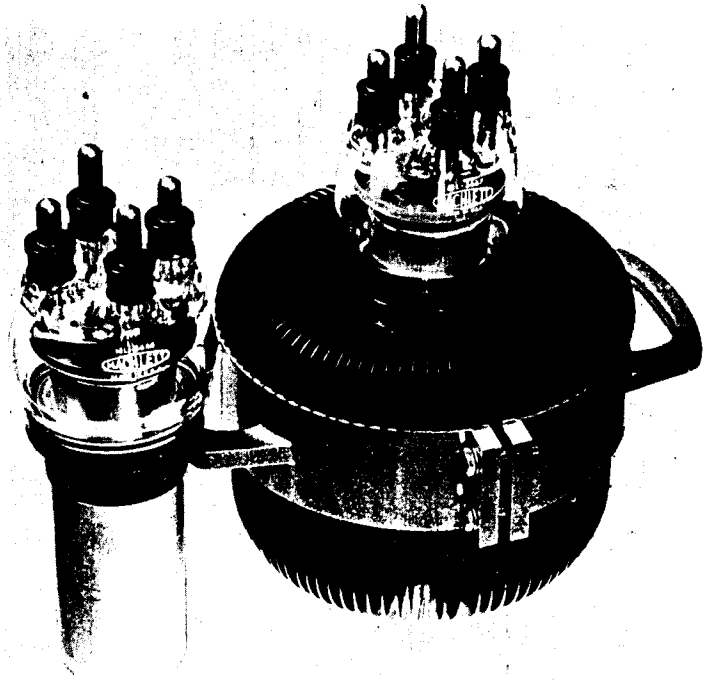






THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT
U. S. A.

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MACHLETT

ML-5666
ML-5667

DESCRIPTION & RATINGS

DESCRIPTION

The ML-5666 & ML-5667 are three electrode tubes designed specifically to meet the severe conditions of radio-frequency heating service. Their special designs also contribute to better performance when used as modulators, amplifiers or oscillators in communications equipment. The cathodes of these tubes are stress-free, pure tungsten filaments. Both tubes incorporate rigidly supported grid and filament assemblies, glass surfaces completely shielded against electron bombardment and filament radiation, and rugged Kovar anode, grid and filament seals. The ML-5666 supersedes the type 889A triode for industrial applications and will replace it with minor equipment modifications. Its heavy-wall anode is water cooled and can dissipate 12.5 kW with moderate water flow. The ML-5667 supersedes the type 889RA triode for industrial applications and will replace it without equipment modifications. Its heavy-wall anode is forced-air cooled and can dissipate 7.5 kW with an air flow of 550 cfm. Maximum ratings of 10 kVdc plate voltage and 20 kW plate input apply at frequencies up to 22.5 Mc; operation at 50 Mc is permissible with voltage input reduced according to the table on page 2.

GENERAL CHARACTERISTICS

Electrical			
Filament Voltage		11.0	Volts
Filament Current		120	Amps
Filament Starting Current, maximum		180	Amps
Filament Cold Resistance		0.0083	Ohms
Amplification Factor		21	
Interelectrode Capacitances	ML-5666	ML-5667	
Grid-Plate	17.5	18.5	$\mu\mu f$
Grid-Filament	23.3	23.3	$\mu\mu f$
Plate-Filament	2.7	3.0	$\mu\mu f$
Mechanical			
Mounting Position		Vertical, anode down	
Type of Cooling — ML-5666		Water and forced-air	
Water flow on anode, minimum for 12.5 kW dissipation		5	gpm
Maximum outgoing water temperature		70	°C
Type of Cooling — ML-5667		Forced-air	
Air flow on anode, minimum for 7.5 kW dissipation		550	cfm
Maximum incoming air temperature		45	°C
Maximum Glass Temperature		160	°C
Air flow on center of dish from 3″ nozzle		30	cfm*
Net Weight, approximate			
ML-5666		4	lbs.
ML-5667		40	lbs.

*At frequencies above 15 Mc, more air flow may be necessary; special attention should be given to adequate ventilation of the dish and seals to keep the temperature at the hottest point below 160°C. Heat radiating connectors for grid and filament posts are recommended.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

A-F Power Amplifier & Modulator Class B

Maximum Ratings, Absolute Values		
D-C Plate Voltage	10000	volts
Max.-Signal D-C Plate Current*	2	amps
Max.-Signal Plate Input*	16	kW
Plate Dissipation*		
ML-5666	12.5	kW
ML-5667	7.5	kW
Typical Operation (Values are for 2 tubes)		
D-C Plate Voltage	7500	volts
D-C Grid Voltage	−300	volts
Peak A-F Grid to Grid Voltage	1700	volts
Zero Signal D-C Plate Current	0.4	amp
Maximum Signal D-C Plate Current	3.2	amps
Effective Load Resistance (plate to plate)	5000	ohms
Maximum Signal Driving Power	150	watts
Maximum Signal Power Output	15	kW

*Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values		
D-C Plate Voltage	10000	volts
D-C Plate Current	1.0	amp
Plate Input	10	kW
Plate Dissipation		
ML-5666	12.5	kW
ML-5667	7.5	kW
Typical Operation		
D-C Plate Voltage	9000	volts
D-C Grid Voltage	−350	volts
Peak R-F Grid Voltage	450	volts
D-C Plate Current	0.8	amp
Driving Power, approx.†	110	watts
Power Output, approx.	2.5	kW

†At crest of audio-frequency cycle with modulation factor of 1.0.

Plate Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values			
D-C Plate Voltage		8000	volts
D-C Grid Voltage		−1500	volts
D-C Plate Current		1.0	amp
D-C Grid Current		0.35	amp
Plate Input		8	kW
Plate Dissipation			
ML-5666		8	kW
ML-5667		5	kW
Typical Operation			
D-C Plate Voltage	6000	7500	volts
D-C Grid Voltage	−900	−1200	volts
Peak R-F Grid Voltage	1420	1700	volts
D-C Plate Current	1.0	0.88	amp
D-C Grid Current, approx.	0.1	0.08	amp
Driving Power, approx.	140	140	watts
Power Output, approx.	4	5	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values				
D-C Plate Voltage			10000	volts
D-C Grid Voltage			−1500	volts
D-C Plate Current			2.0	amps
D-C Grid Current			0.35	amp
Plate Input			20	kW
Plate Dissipation				
ML-5666			12.5	kW
ML-5667			7.5	kW
Typical Operation				
D-C Plate Voltage	6000	7500	9000	volts
Filament Voltage	10.6	10.7	10.8	volts
D-C Grid Voltage	−500	−600	−750	volts
Peak R-F Grid Voltage	1200	1400	1700	volts
D-C Plate Current	1.6	1.8	2.0	amps
D-C Grid Current, approx.	0.19	0.20	0.21	amp
Driving Power, approx.	220	270	340	watts
Power Output, approx.	6.3	8.9	12.2	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

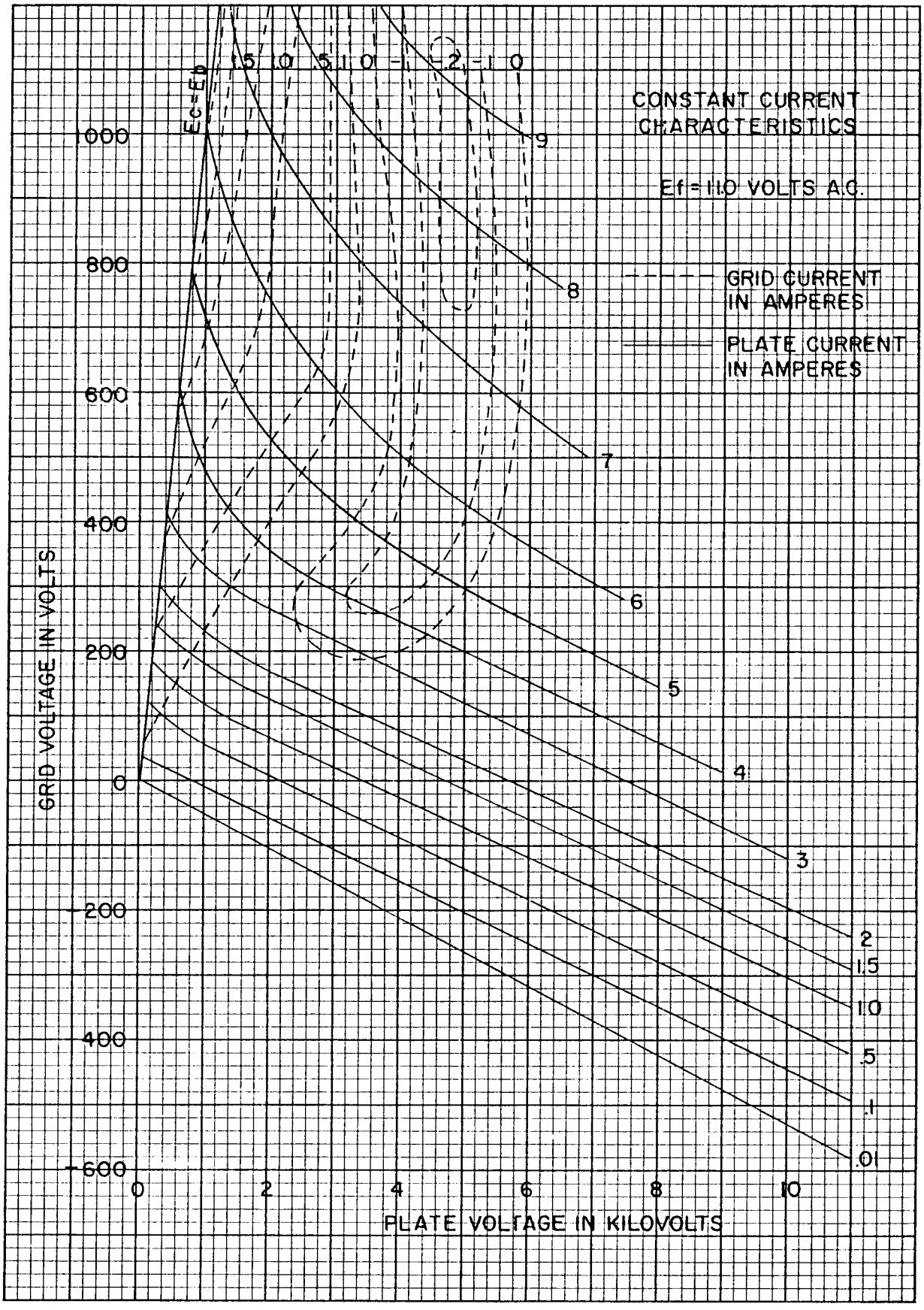
Maximum ratings apply at frequencies up to 22.5 Mc. These tubes can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with the table (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	22.5	35	50 Mc
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B	100	80	70
Class C, Plate Modulated	100	75	50
Class C, Unmodulated	100	75	50

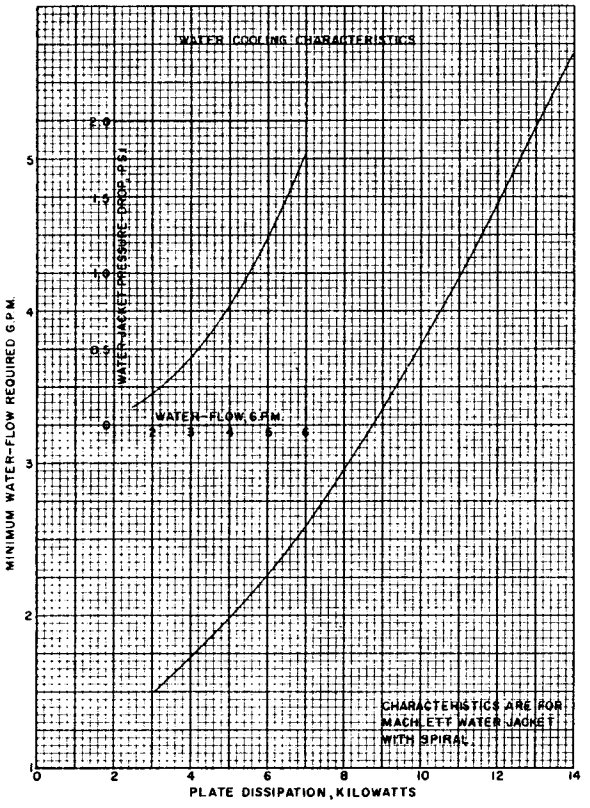
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Minimum	Limits Bogey	Maximum	
Grid Voltage	e_b = 2000 volts; i_b = 6 amps	e_c:	——	——	800	volts
Grid Current	e_b = 2000 volts; i_b = 6 amps	i_c:	——	——	1.5	amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.0 Adc	E_b:	2.8	3.3	3.8	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 1.0 Adc	E_b:	6.5	7.5	8.5	kVdc
Grid Voltage	E_b = 7.5 kVdc; I_b = 0.020 Adc	E_c:	−325	−370	−475	Vdc
Peak Cathode Current	(See Note)	i_k:	7.5	——	——	amps
Power Output	E_b = 10 kVdc; I_b = 2.0 Adc E_c = −1200 Vdc; I_c = 0.30 Adc F = 22.5 Mc	P_o:	12	——	——	kW

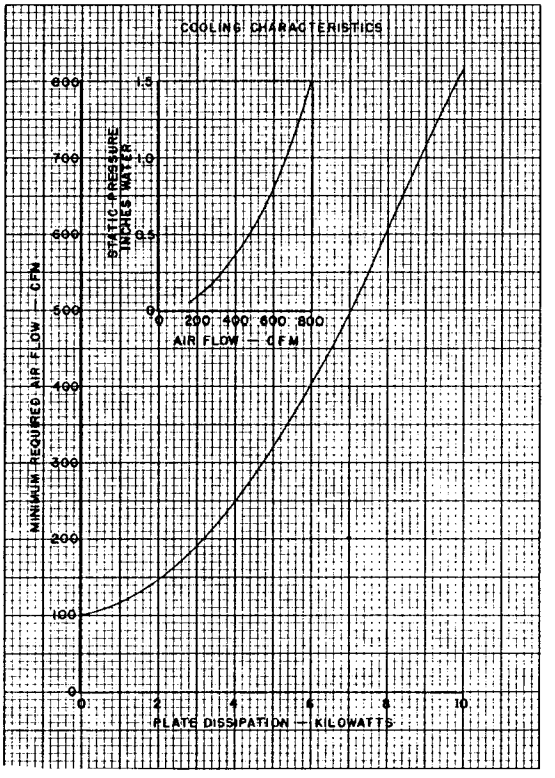
Note: Represents maximum useable plate current plus grid current for any condition of operation.

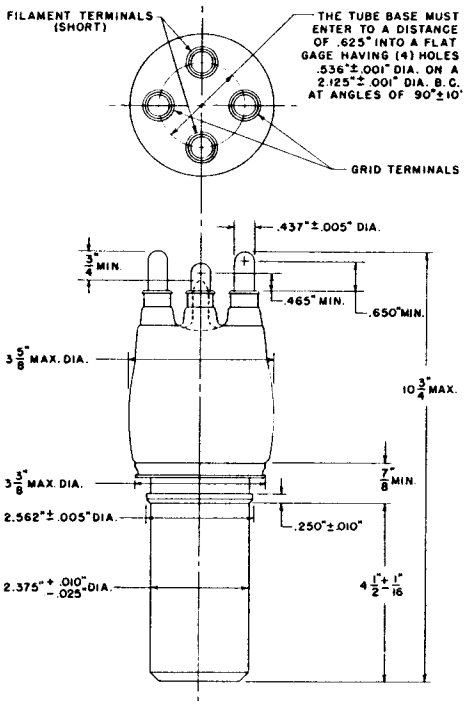

CONSTANT CURRENT CHARACTERISTICS
Ef = 110 VOLTS A.C.
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
Ec = Eb
15
10
5
1.0
-1
-2
-10
9
8
7
6
5
4
3
2
1.5
1.0
.5
.1
.01
1000
800
600
400
200
0
-200
-400
-600
GRID VOLTAGE IN VOLTS
0
2
4
6
8
10
PLATE VOLTAGE IN KILOVOLTS

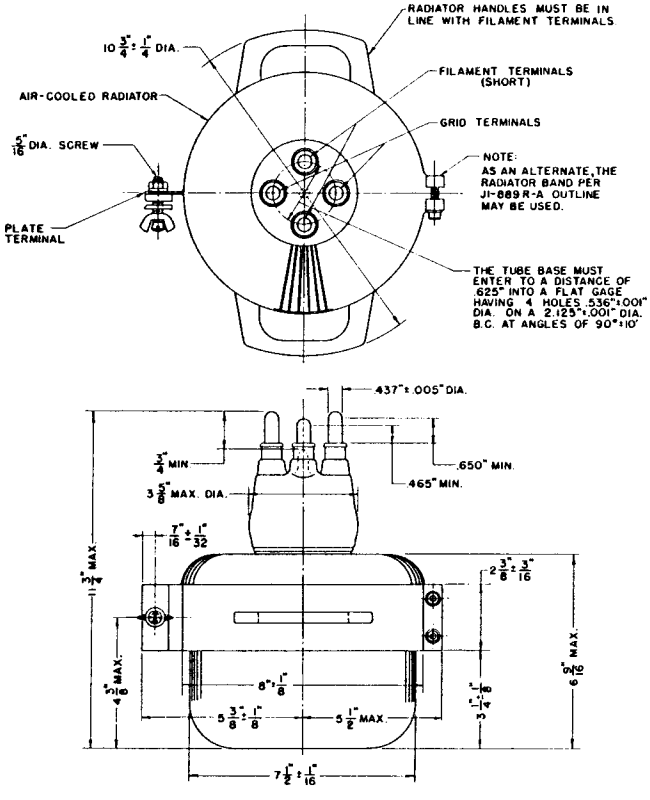
ML-5666



ML-5667







DIMENSIONS — ML-5666

DIMENSIONS — ML-5667

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SPRINGDALE MACHLETT CONNECTICUT
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ST-1664 2M 12-61



MACHLETT

ML-5668
ML-5669

DESCRIPTION & RATINGS

DESCRIPTION

The ML-5668 and ML-5669 are three-electrode tubes designed specifically to meet the severe conditions of radio-frequency heating services. The cathodes of these tubes are stress-free pure tungsten filaments. The tubes incorporate rigidly supported grid and filament assemblies, glass surfaces completely shielded against electron bombardment and filament radiation, and rugged kovar anode, grid and filament seals. Maximum ratings of 14 kVdc plate voltage and 28 kW plate input apply at frequencies up to 5 Mc; operation up to 20 Mc is permissible with voltage and input reduced to one-half maximum ratings.

The ML-5668 supersedes the type 892 triode for industrial applications and will replace it with minor equipment modifications. The heavy-wall, high-conductivity copper anode is water cooled and with moderate water flow can readily dissipate 20 kilowatts.

The ML-5669 supersedes the type 892R triode for industrial applications and will replace it without equipment modifications. The heavy-wall, high-conductivity copper anode is forced-air cooled and with nominal air flow can readily dissipate 10 kilowatts.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		22.0	Volts
Filament Current		60	Amps
Filament Starting Current, maximum		120	Amps
Filament Cold Resistance		0.031	Ohms
Amplification Factor		50	
Interelectrode Capacitances	**ML-5668**	**ML-5669**	
Grid-Plate	30	31	$\mu\mu f$
Grid-Filament	18	18	$\mu\mu f$
Plate-Filament	1.5	2.0	$\mu\mu f$

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling, ML-5668	Water and forced-air*	
Water flow on anode, minimum for 20 kW dissipation	6.5	gpm
Maximum outgoing water temperature	70	°C
Type of Cooling, ML-5669	Forced-air	
Air flow on anode, minimum for 10 kW dissipation	700	cfm
Maximum incoming air temperature	45	°C
Maximum Glass Temperature	160	°C
Air flow on center of dish from 3" diameter nozzle	35	cfm*
Net Weights		
ML-5668	10	lbs.
ML-5669	52	lbs.

*Airflow on dish may be supplied from an auxiliary blower or, in the case of the ML-5669, by deflection of air passing through the radiator. At frequencies above 3 Mc, more air flow may be necessary to keep the temperature of the hottest point on the dish and seals below 160°C. Heat radiating connectors for grid and filament posts are recommended.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

R-F Oscillator — Class C

Maximum Ratings, Absolute Values	ML-5668	ML-5669	
D-C Plate Voltage**	14000	14000	volts
D-C Grid Voltage	—1600	—1600	volts
D-C Plate Current	2.0	2.0	amps
D-C Grid Current	0.40	0.40	amp
Plate Input	28000	26000	watts
Plate Dissipation	20000	10000	watts

**D-C Plate Voltage Maximum Rating is 11000 volts when no provision is made for cooling dish at frequencies above 3 Mc.

Typical Operation				
D-C Plate Voltage	8000	10000	12000	volts
D-C Grid Voltage	—500	—600	—700	volts
Peak R-F Grid Voltage	1240	1420	1600	volts
Peak R-F Plate Voltage	6300	8100	9900	volts
D-C Plate Current	1.6	1.8	2.0	amps
D-C Grid Current	.20	.20	.20	amp
Power Output, approx.	8300	12300	17000	watts

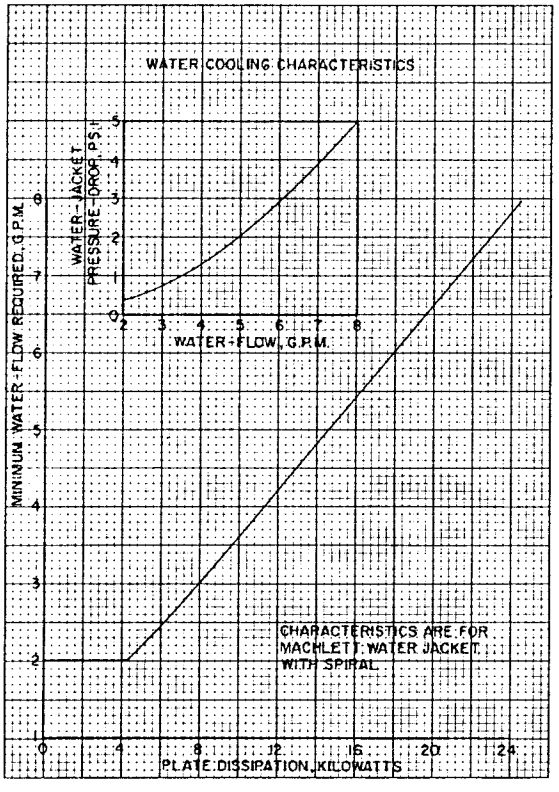
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 2000 volts; i_b = 8.0 amps	e_c:	——	——	1300	volts
Grid Current	e_b = 2000 volts; i_b = 8.0 amps	i_c:	——	——	3.5	amps
Plate Voltage	E_c = 0 Vdc; I_b = 0.5 Adc	E_b:	5.0	7.3	8.6	kVdc
Plate Voltage	E_c = —100 Vdc; I_b = 0.5 Adc	E_b:	10.0	12.3	14.8	kVdc
Grid Voltage	E_b = 15 kVdc; I_b = 0.02 Adc	E_c:	—220	—300	—420	Vdc
Power Output	E_b = 12 kVdc; E_c = —700 Vdc; I_b = 2.0 Adc; I_c = 0.20 Adc	P_o:	14.5	——	——	kW

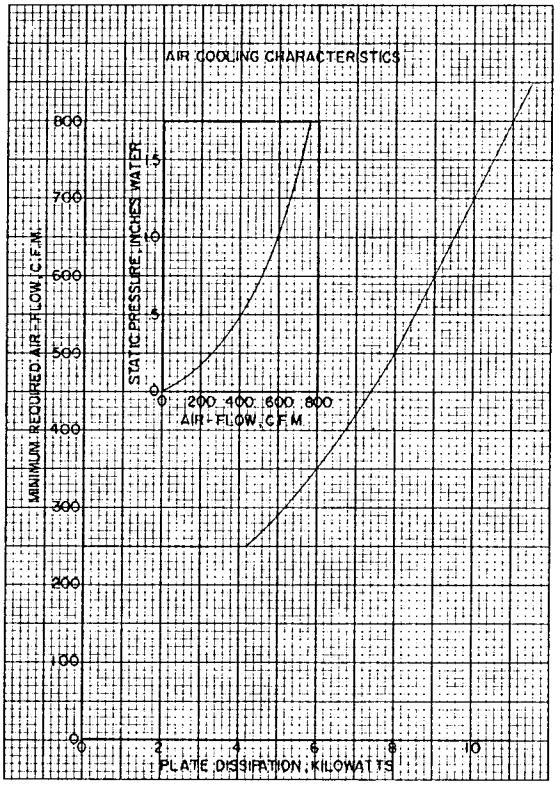
MAXIMUM FREQUENCY RATINGS

Maximum ratings apply at frequencies up to 5 Mc. These tubes can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with the table on the right. (Other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

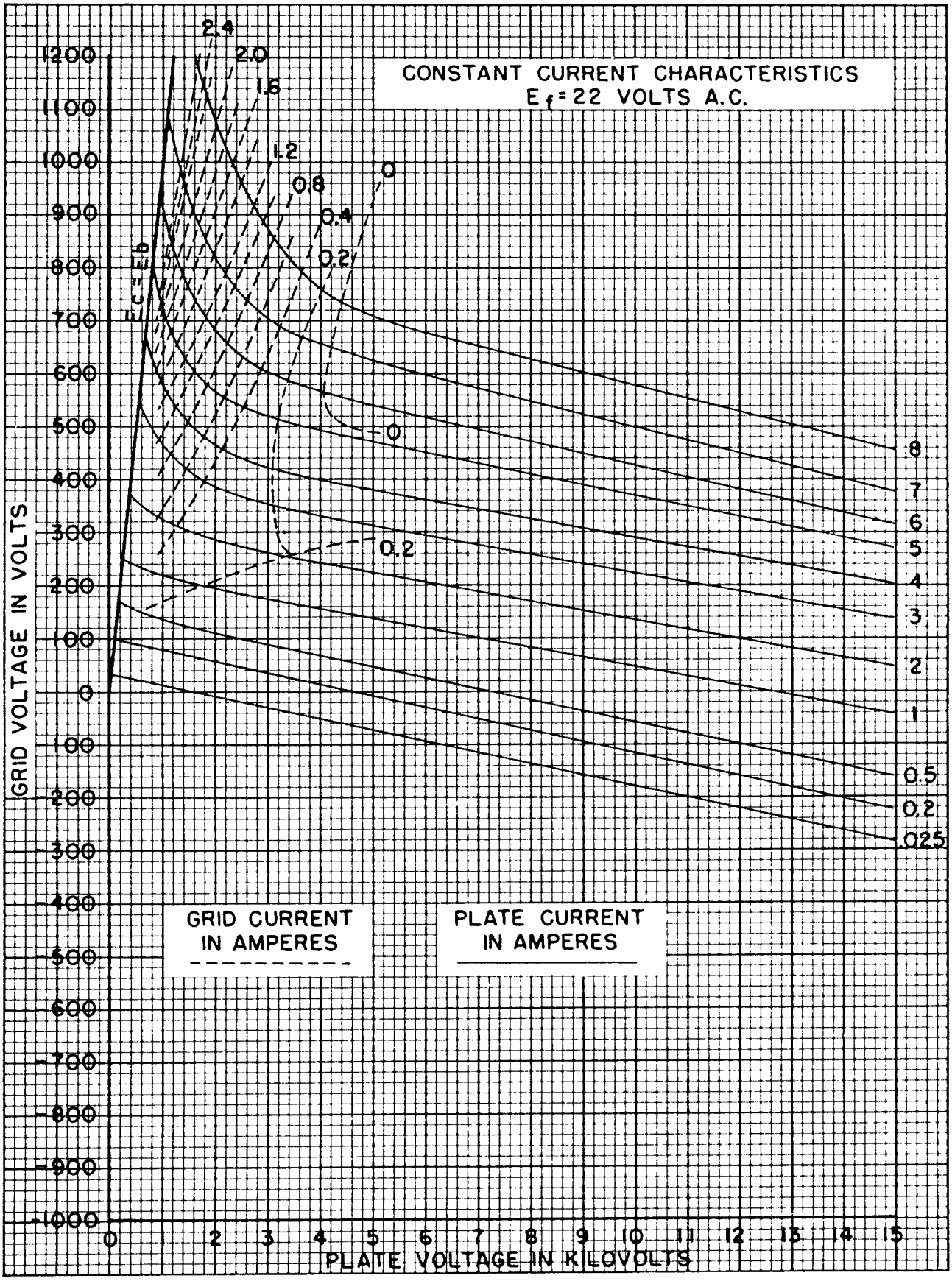
Frequency	5	12.5	20 Mc
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class C Unmodulated	100	75	50

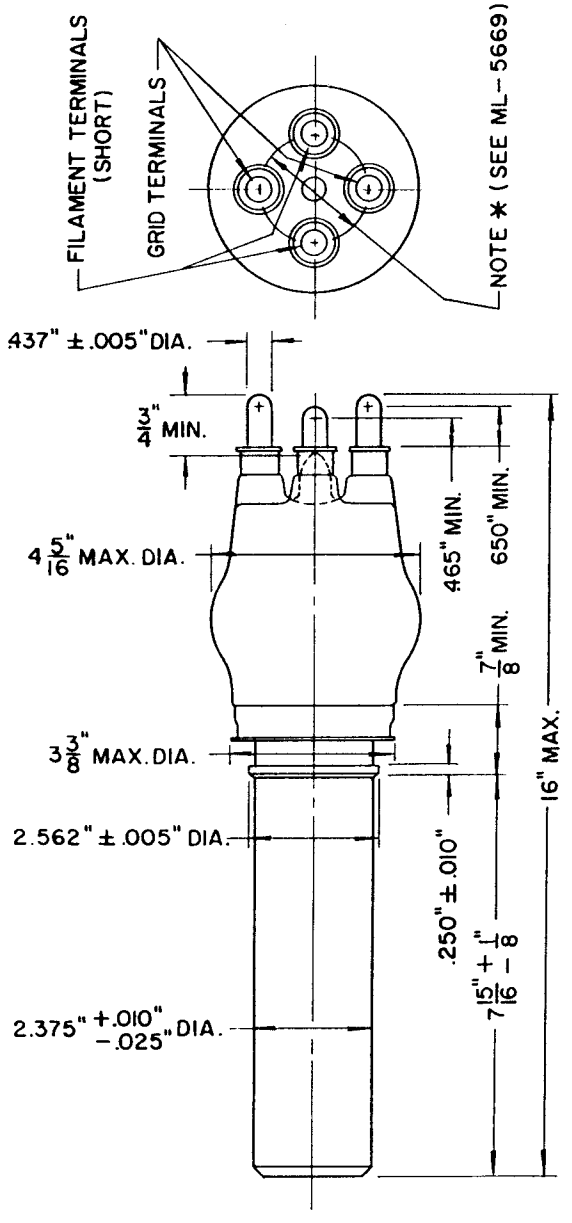


COOLING CHARACTERISTICS — ML-5668

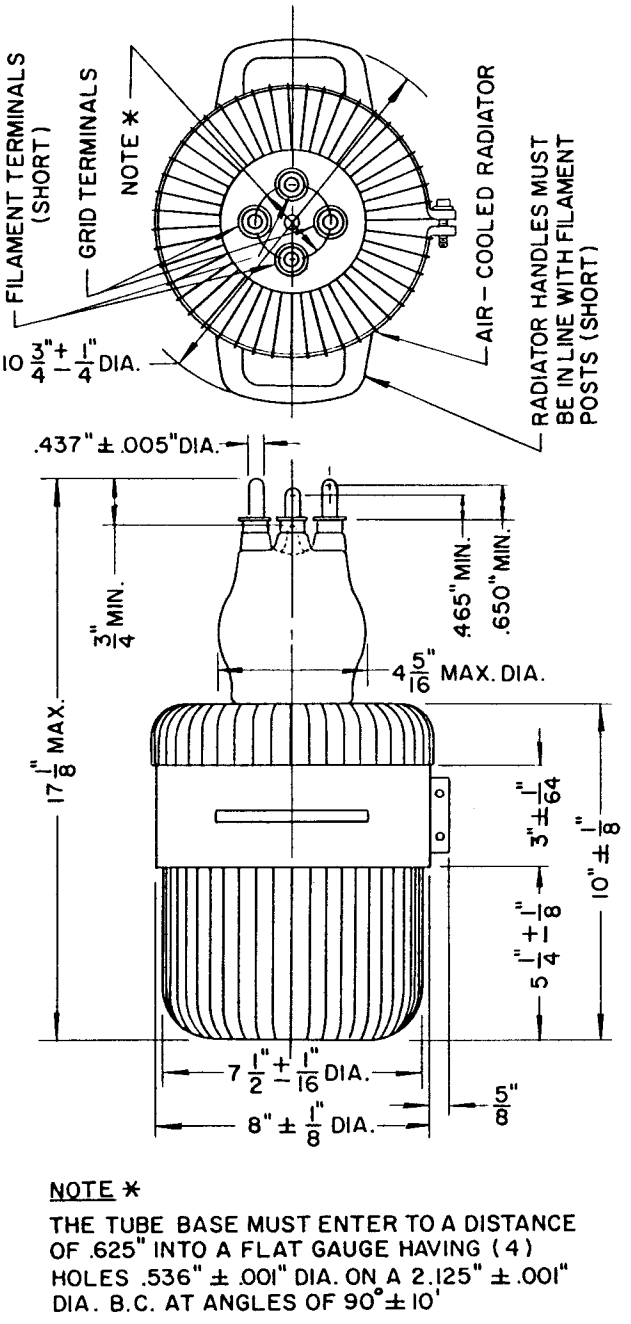


COOLING CHARACTERISTICS — ML-5669


CONSTANT CURRENT CHARACTERISTICS
E_f = 22 VOLTS A.C.
GRID VOLTAGE IN VOLTS
PLATE VOLTAGE IN KILOVOLTS
Ec = Eb
2.4
2.0
1.6
1.2
0.8
0.4
0.2
0
0
0.2
8
7
6
5
4
3
2
1
0.5
0.2
.025
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15



DIMENSIONS — ML-5668



NOTE *

THE TUBE BASE MUST ENTER TO A DISTANCE OF .625" INTO A FLAT GAUGE HAVING (4) HOLES .536" ± .001" DIA. ON A 2.125" ± .001" DIA. B.C. AT ANGLES OF 90° ± 10'

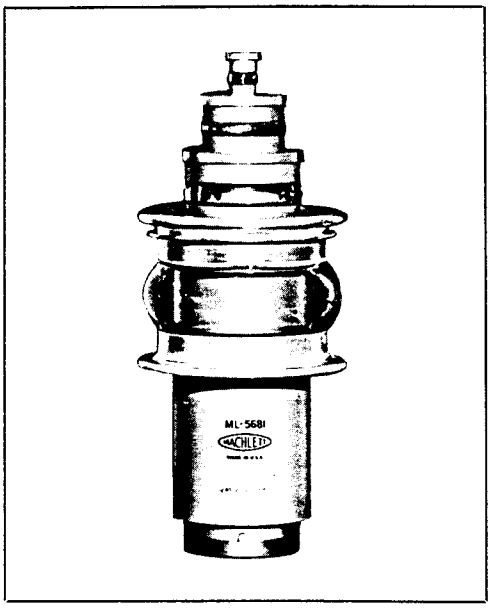
DIMENSIONS — ML-5669

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT **CONNECTICUT**

U. S. A.

The Machlett Laboratories, Inc.
1063 Hope Street • Stamford, Conn. 06907
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ISSUED 8-62

ML-5681

MACHLETT

DESCRIPTION

The ML-5681 is a compact, general-purpose, high-power electron tube designed for operation at frequencies up to 110 Mc. It is a coaxial-terminal, water- and forced-air-cooled triode capable of approximately 50 kW output at 110 Mc in cathode-drive circuitry with 10 kW driving power. Maximum ratings of 9 kVdc plate voltage and 90 kW plate input apply at frequencies up to 110 Mc; increased ratings of 15 kVdc plate voltage and 150 kW plate input are permissible at frequencies up to 30 Mc.

The ML-5681 has basic design features which make it suitable for use over a wide range of power and frequency in high-power AM, FM, and TV broadcasting, particle accelerator, and dielectric and induction heating services. This tube is ideally suited to cavity operation, and its low plate impedance makes it advantageous for broad-band service. Other features include high-conductivity glass-to-metal seals, sturdy electrodes, integral anode water jacket, quick-change water coupling, and heavy-wall copper anode designed to dissipate 75 kW. All electrodes mount directly from heavy copper rings, resulting in a structure which is electrically and mechanically superior to the conventional types of water-cooled electron tubes. The large-diameter seals provide increased strength and freedom from excessive heating. The cathode is a multistrand, thoriated-tungsten filament, completely balanced and stress free throughout life. The grid is capable of unusually high heat dissipation, contributing to maximum stability of tube performance and circuit operation.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	12.0	Volts
Filament Current at 12.0 volts	220	Amps
Filament Starting Current, maximum	550	Amps
Filament Cold Resistance	0.0062	Ohms
Amplification Factor	25	
Direct Interelectrode Capacitances		
Grid-Plate	61	uuf
Grid-Filament	76	uuf
Plate-Filament	2.0	uuf

Mechanical

Mounting Position	Vertical, Anode Down	
Type of Cooling	Water and Forced-Air	
Water Flow on Anode	See Water Cooling Characteristics	
Maximum Water Pressure	75	psi
Maximum Outlet Water Temperature	70	°C
Air Flow on Seals, approximate	250	cfm
Maximum Glass Temperature	165	°C
Net Weight, approximate	43	lbs.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	15000	volts
Max.-Signal D-C Plate Current*	11	amps
Max.-Signal Plate Input*	150	kW
Plate Dissipation*	75	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	12000	14000	volts
D-C Grid Voltage	−430	−500	volts
Peak A-F Grid-to-Grid Voltage	1950	2150	volts
Peak A-F Plate-to-Plate Voltage	21000	24000	volts
Zero-Signal D-C Plate Current	2.0	3.0	amps
Max.-Signal D-C Plate Current	18.6	21.4	amps
Effective Load Resistance, Plate-to-Plate	1450	1400	ohms
Max.-Signal Driving Power, approximate	1.4	1.4	kW
Max.-Signal Power Output, approximate	150	200	kW

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	15000	volts
D-C Plate Current	9	amps
Plate Input	110	kW
Plate Dissipation	75	kW
Frequency	40	Mc

Typical Operation

D-C Plate Voltage	10000	12000	volts
D-C Grid Voltage	−350	−430	volts
Peak R-F Grid Voltage	515	615	volts
Peak R-F Plate Voltage	4200	5000	volts
D-C Plate Current	6.0	7.5	amps
D-C Grid Current	60	50	mA
R-F Load Resistance	435	420	ohms
Driving Power, approximate**	1.3	1.8	kW
Power Output, approximate	20	30	kW

Radio Frequency Amplifier Class B — Television Service

Synchronizing level conditions per tube, unless otherwise specified, in cathode-drive circuit—88 Mc, 5 Mc bandwidth

Maximum Ratings, Absolute Values

D-C Plate Voltage	9000	volts
D-C Plate Current	12	amps
D-C Grid Current	2.0	amps
Plate Input	100	kW
Plate Dissipation	75	kW
Frequency	88	Mc

Typical Operation

D-C Plate Voltage	7500	8000	volts
D-C Grid Voltage	−300	−320	volts
Peak R-F Driving Voltage			
Synchronizing level	780	870	volts
Pedestal level	590	650	volts
Peak R-F Plate Voltage			
Synchronizing level	5700	6200	volts
Pedestal level	4300	4600	volts
D-C Plate Current			
Synchronizing level	8.0	9.7	amps
Pedestal level	6.0	7.0	amps
D-C Grid Current, approx.			
Synchronizing level	0.55	0.85	amp
Pedestal level	0.080	0.220	amp
R-F Load Resistance	500	450	ohms
Driving Power at tube, approximate			
Synchronizing level	5.3	7.5	kW
Pedestal level	2.9	3.8	kW
Power Output, approximate***			
Synchronizing level	40	55	kW
Pedestal level	23	30	kW

Doherty High-Efficiency Linear Amplifier

Carrier conditions per tube, unless otherwise specified, for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	Carrier Tube	Peak Tube	
D-C Plate Voltage	15000	15000	volts
D-C Grid Voltage	−3200	−3200	volts
D-C Plate Current	10	6†	amps
D-C Grid Current	2.0	1.0	amps
Plate Input	125	85†	kW
Plate Dissipation	75	75	kW
Frequency	30	30	Mc

Typical Operation

D-C Plate Voltage	12000	12000	volts
D-C Grid Voltage	−500	−1400	volts
Peak R-F Grid Voltage			
Carrier	900	1160	volts
Crest**	1220	2320	volts
Peak R-F Plate Voltage			
Carrier	10000	5000	volts
Crest**	10000	10000	volts
D-C Plate Current			
Carrier	6.7	0.2	amps
Modulated†	6.7	3.8	amps
D-C Grid Current			
Carrier	0.25	0	amp
Modulated†	0.45	0.24	amp
R-F Load Resistance	465	465	ohms
Driving Power, approximate**	1.5	4.0	kW
Power Output, approximate			
Carrier	54	1	kW
Modulated†	50	31	kW

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	10000	volts
D-C Grid Voltage	−3200	volts
D-C Plate Current	9	amps
D-C Grid Current	2.0	amps
Plate Input	85	kW
Plate Dissipation	50	kW
Frequency	30	Mc

Typical Operation

D-C Plate Voltage	8000	10000	volts
D-C Grid Voltage	−1000	−1200	volts
Peak R-F Grid Voltage	1590	1850	volts
Peak R-F Plate Voltage	6700	8500	volts
D-C Plate Current	6.3	7.4	amps
D C Grid Current	1.0	1.2	amps
R-F Load Resistance	590	635	ohms
Driving Power, approximate	1.5	2.1	kW
Power Output, approximate	38	57	kW

Grid-Modulated R-F Amplifier Class C Telephony

Carrier conditions per tube, unless otherwise specified, for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	15000	volts
D-C Plate Current	8	amps
D-C Grid Current	2.0	amps
Plate Input	110	kW
Plate Dissipation	75	kW
Frequency	30	Mc

Typical Operation

D-C Plate Voltage	15000	volts
D-C Grid Voltage	−1400	volts
Peak R-F Grid Voltage	1460	volts
Peak R-F Grid Voltage for maximum modulation	440	volts
Peak R-F Plate Voltage	6500	volts
D-C Plate Current	3.2	amps
D-C Grid Current, approximate	10	mA
R-F Load Resistance	1100	ohms
Driving Power, approximate	15	watts
Power Output, approximate	19	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation#

Maximum Ratings, Absolute Values

D-C Plate Voltage	9000	15000	volts
D-C Grid Voltage	−3200	−3200	volts
D-C Plate Current	12	12	amps
D-C Grid Current	2.0	2.0	amps
Plate Input	90	150	kW
Plate Dissipation	75	75	kW
Frequency	110	30	Mc

Typical Operation

Power Amplifier and Oscillator, Grid-Drive Circuit—30 Mc

D-C Plate Voltage	8000	12000	14000	volts
D-C Grid Voltage	−800	−1200	−1500	volts
Peak R-F Grid Voltage	1500	1950	2320	volts
Peak R-F Plate Voltage	6500	10000	12000	volts
D-C Plate Current	9.0	9.0	10.5	amps
D-C Grid Current	1.4	1.2	1.3	amps
R-F Load Resistance	405	560	635	ohms
Driving Power, approximate	2.0	2.2	3.0	kW
Power Output, approximate	52	90	115	kW

Power Amplifier, Cathode-Drive Circuit—110 Mc

D-C Plate Voltage	6000	9000	volts
D-C Grid Voltage	−600	−750	volts
Peak R-F Driving Voltage	1150	1350	volts
Peak R-F Plate Voltage	4700	7500	volts
D-C Plate Current	6.7	8.0	amps
D-C Grid Current	1.0	1.0	amp
R-F Load Resistance	490	635	ohms
Driving Power, approximate	8.0	10.2	kW
Power Output, approximate***	35	62	kW

* Averaged over any audio-frequency cycle of sine-wave form.

** At crest of audio-frequency cycle with modulation factor of 1.0.

*** Includes power transferred from driver stage.

† Average value with modulation factor of 1.0.

\# Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 Mc except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation below. (Other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	30	70	110	Mc
Percentage of Maximum Rated Plate Voltage and Plate Input				
Class B	100	96	60	%
Class C Plate Modulated	100	77	60	%
Class C Telegraphy	100	77	60	%

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic	Conditions		Limits Min.	Limits Bogey	Limits Max.
Grid Voltage	e_b = 1800 v; i_b = 50 a	e_c:	——	——	1100 volts
Grid Current	e_b = 1800 v; i_b = 50 a	i_c:	——	——	20 amps
Plate Voltage	E_c = 0 Vdc; I_b = 3 Adc	E_b:	2.3	2.9	3.5 kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 3 Adc	E_b:	6.9	7.9	8.9 kVdc
Grid Voltage	E_b = 15 kVdc; I_b = 0.20 Adc	E_c:	−530	−620	−730 Vdc
Plate Power Output	E_b = 14 kVdc; E_c = −1500 Vdc I_b = 10.5 Adc; I_c = 1.3 Adc F = 30 Mc	P_o:	95	——	—— kW
Plate Power Output	E_b = 9 kVdc; E_c = −750 Vdc I_b = 8.0 Adc; I_c = 1.0 Adc F = 110 Mc	P_o:	44	——	—— kW

APPLICATION NOTES

Initial Inspection and Installation

When an ML-5681 is received, it should be unpacked and inspected as soon as possible. Care should be taken to keep from jarring the tube or the inner packing box, since the thoriated-tungsten filament may become damaged. To insure against straining the glass-to-metal seals, it is recommended that the tube be handled only by the anode water jacket, anode flange, or if necessary the grid terminal flange; it should never be handled by the cathode terminals. The tube should always be stored or mounted in a vertical position with the anode down.

A careful inspection should be made for any visible damage, such as glass cracks or broken filament strands, which may have occurred in transit. The tube should then be checked with an ohmmeter between grid and cathode terminals to determine whether or not a grid-cathode short has occurred.

A complete set of rubber gaskets is shipped with each ML-5681, and the new gaskets should be inserted in the mounting socket before installing a new or spare tube. The gaskets should be wiped with a clean lint-free cloth and then coated with a thin layer of the silicone grease supplied, before insertion in the socket.

If no interelectrode short is evident, the tube should be seated securely in the mounting socket and all electrical connections made, taking care that positive contact is obtained. Rated filament voltage should be applied and the filament current checked to see if it agrees with the value marked on the anode water jacket. A reading in the order of 15 amperes below this value (or lower) indicates that one (or more) of the filament strands is open, assuming the filament voltmeter and ammeter are accurately calibrated. (The meters may be quickly checked by measuring the filament volts and amperes of some known good ML-5681's)

If there is any evidence of damage in transit, a "joint inspection" report should be prepared with the transportation company *within fifteen days*. The serial number identifying each individual tube appears on the grid terminal flange and on the outside of the packing case. It should be used in all correspondence concerning the tube.

Operation

After filament power has been on for one-half hour, apply approximately half rated plate voltage and operate the tube for an additional one-half hour. All tuning adjustments should be made during this period. Normal plate voltage may then be applied and final tune-up performed; the tube should be run at normal voltage and driving power for at least one-half hour. While the ML-5681 is operating at the desired normal output, it is suggested that the meter readings, control settings, and flow rates be recorded, especially when the tube is to be set aside as a spare. Then, in the event of an emergency tube change, the new tube can be installed and operation resumed with minimum delay.

As in the case of all large high-power vacuum tubes, no ML-5681 should remain in storage for more than three months. It should be operated in rotation with other ML-5681's, or aged every three months according to the above schedule given for newly received tubes. This procedure will keep it free from traces of gas, which may be liberated during prolonged storage, and insures that only operable tubes are carried in stock.

The glass in high-power vacuum tubes sometimes acquires a slight bluish fluorescence when subjected to high voltage. If this phenomenon is observed in an ML-5681, it should not be construed to mean that the tube is gassy. After proper aging, according to the above instructions, any fluorescence which persists is in no way detrimental to the satisfactory operation of the tube.

Tube Care

The glass insulation and other external parts of the ML-5681 should be kept free from accumulated dust to minimize sur-

face leakage and the possibility of arc-over. It is recommended that dust be wiped from the glass bulb and other external parts of the tube at least once a week. This should be done when the tube is cold, using a soft lint-free cloth moistened with alcohol.

All tube terminals and connectors must be kept bright and clean to provide good electrical contact. If they become discolored, they may be polished with fine emery cloth and then wiped clean.

When packed for shipment, the ML-5681 is sealed in a barrier bag which protects the tube from atmospheric moisture. In the case of export shipment, the barrier bag is a metalized type, which not only protects against moisture but also permits tube storage at temperatures ranging from −35°C to +55°C. Unless the barrier bag is re-heat-sealed before storing, the protection provided by the bag should be accomplished by some other means. Before placing the ML-5681 in storage, water should be completely drained from the integral water jacket to prevent freezing and corrosion in the passages. The ports should then be covered with a suitable material, such as pliofilm, to prevent the entry of foreign matter.

Filament Care

The thoriated-tungsten filament of the ML-5681 is the multistrand type and is designed for single-phase a-c operation. It provides greater electron emission with less power than conventional pure-tungsten filaments, but requires the observance of certain precautions. The filament should be operated at rated voltage ±5%. Regular operation at −5% from rated voltage, to increase tube life, is permissible when maximum power output is not used and the required peak emission does not exceed 50 amperes. Operation at lower filament voltage is not permissible. For standby periods up to two hours, however, the filament voltage may be lowered to 80% of normal; for longer periods the filament should be turned off. A suitable volt-meter should be permanently connected across the filament terminals directly at the tube so that the filament voltage will always be known.

Prolonged storage periods or overheating of the ML-5681 by severe overloads may liberate gas within the vacuum envelope which, even though minute, is sufficient to decrease the filament emission. The rectified grid current is a sensitive measure of loss of emission. The grid and plate currents should be particularly noted after an outage, as the filament may have been poisoned by the high-power surge. If these currents start to decrease, the power should be removed and the aging procedure instituted, as described in the first paragraph under "Operation".

The ML-5681 is equipped with a zirconium getter which will absorb free gas within the tube when heated with a current not to exceed 14 amperes, which may be drawn from the filament power through an appropriate dropping resistor (approximately 0.7 ohm). The getter terminals are shown on the outline drawing.

The tube (with getter connected) should be operated (a) with only filament voltage for one-half hour, (b) with half normal plate voltage for one-half hour, (c) increasing to full voltage in about one hour. The getter however is not designed for continuous operation at 14 amperes.

In some applications it may be desirable to operate the getter at reduced temperature for prolonged periods. For these applications the getter may be operated continuously at a current of 7 amperes by increasing the dropping resistor to approximately 1.0 ohms.

Should the tube become gassy due to prolonged inactivity or to flash arcing, the getter should be operated at 14 amperes for one-half hour.

The above aging period should only be considered a minimum. If behavior at rated conditions shows instability continued aging as above should be performed.

If the d-c grid and plate currents are still low, a filament reactivation cycle (with the getter disconnected) may be undertaken. This consists of operating the tube (a) with filament voltage at 20% above normal and no plate voltage for fifteen minutes, then (b) at rated filament voltage and half normal plate voltage for one-half hour. This procedure should be performed only in extreme cases.

Tube Reshipment

When packing the ML-5681 for reshipment, the water jacket should be free of water as noted above for storage. The tube and a container of desiccant must then be sealed in the same manner as in the initial shipment. It is imperative that all original packing material be installed properly so that the tube will not be subjected to undue shock or vibration during transit. The Service Report form supplied with each tube should be filled out and forwarded whenever the tube is to be returned to the factory.

EQUIPMENT DESIGN CONSIDERATIONS

Mechanical Installation

Mounting of the ML-5681 requires the Machlett mounting socket (shown on page 10) or equivalent, which has been installed to support the tube vertically, anode down. The tube should be placed in the socket and twisted clockwise, by the anode or grid flange, through approximately 60°; it is removed by the converse procedure. Suitable provision should be made to prevent water from spilling when the tube is removed. The mounted ML-5681 should not be subjected to shock or appreciable vibration.

Cooling Systems

The water cooling system generally consists of a source of anode cooling water, a feed-pipe system which carries water through flexible insulated hoses to and from the mounting socket, and provisions for interlocking the water flow with the power supplies. It is essential that the direction of water flow through the tube be upward over the anode surface (center connection), as shown on page 10. When the anode is at a high potential above ground, the feedpipe system must have sufficient insulation to reduce leakage current to a negligible value. The water system should be the closed type using distilled or deionized water to preclude the possibility of scale formation and corrosion, both of which can be expected with tap water. Scale restricts water flow and prevents proper transfer of heat from the anode to the cooling water, and corrosion may damage the elements and passages. The rates of scale formation and corrosion depend on the electrical conductivity of the water. To minimize the

formation of scale and corrosion, the use of a coolant having an initial resistance of at least 100,000 ohms per cubic centimeter is recommended. Since a very small amount of contamination can change the conductivity of distilled water, frequent measurement is desirable. The water should be changed when its resistance falls below 20,000 ohms per cubic centimeter. A filter should be placed in the water supply line to the tube to trap foreign particles likely to impair the flow. It is suggested that a filter with a 100-mesh screen (0.005" openings) be used.

The water-cooling system must function properly at all times since even a momentary failure of flow will damage the ML-5681. Without cooling water, the heat of the filament alone is sufficient to cause serious harm. It is necessary to keep the water-flow interlocks in correct adjustment and never to set them to operate below the recommended level. The flow of water and air must start before the application of any tube voltages; it is recommended that the flow of coolants continue for 5 minutes after the removal of all tube voltages. In the event of emergency or fault conditions, however, the simultaneous shut down of all power will not damage the tube. Specific water-flow data are given in the Water-Cooling Characteristics, page 9. Under no circumstances should the outlet water temperature exceed 70°C nor should the temperature of the entering water be permitted to fall below 10°C with plate potential on. Water pressure at the tube socket should never exceed 75 psi.

Forced-air cooling of the cathode terminals, the grid flange, and the glass envelope is required, and the cooling should be uniformly distributed around the circumference of the seals. Air flow of 250 cfm provides adequate cooling up to 5 Mc; at higher frequencies more air flow is required, and uniform distribution of flow over the grid-anode seals is more critical. It is important to have the air passages carefully contoured so that the highest possible velocity of air is directed on the seals to be cooled. In the equipment design stage, it is recommended that temperature measurements be made of the glass-to-metal seals, electrode contact areas, and glass envelope of the tube under maximum operating conditions. In no case should any temperatures higher than 165°C be permitted, and the difference in temperature between any two points on the periphery of a seal should not be greater than 25°C. The temperature may be measured with temperature-sensitive paint such as Tempilaq*.

Electrical Considerations

Suitable meters should be provided for monitoring filament voltage, d-c plate voltage, plate current, and grid current. A tube-life recording meter should be installed to read total hours of filament operation. If tubes are used in parallel or push-pull, individual metering of grid and plate currents is highly recommended.

Electrode contact should be made only on the surfaces designated on the outline drawing. Connecting cables and other parts of the equipment must be kept away from the electric fields between terminals and from the glass insulation. This precaution is necessary to avoid corona discharge, which may result in puncture of the glass. Connectors must be designed to carry the radio-frequency currents to the tube electrodes without excessive heating of the contact areas between connectors and terminals (165°C maximum temperature). All connecting cables and/or spring fingers must be flexible so that no strain will be transmitted to the glass envelope.

Terminal connectors, shown on page 10, are recommended for operation of the ML-5681 at low or medium frequencies in conventional lumped-constant circuitry. For operation above 10 Mc, orientation of the ML-5681 with respect to other circuit elements must be such that the distribution of radio-frequency current at the tube terminals is uniform. Otherwise, the uneven heating and consequent unequal thermal expansion may strain the seals severely. Both cathode terminals must be thoroughly by-passed to radio-frequency currents to avoid excessive heating of the filament. When cavity circuitry is used, all connectors should be the spring-pressure type, making uniformly good electrical contact around the tube circumference.

The filament transformer must limit the inrush current to a maximum of 2.5 times normal filament current. If a suitable high-reactance filament transformer is not available, step resistors in the primary will be satisfactory for the purpose of limiting the surge current.

The tube and circuitry should be housed in a protective enclosure, interlocked so that personnel cannot possibly come in contact with high voltage. The interlock devices should break the primary circuits of the plate and grid supplies when any door on the protective enclosure is opened, and should prevent the closing of the primary circuits until the door is again locked.

The plate circuit should be equipped with a time-delay relay to prevent the application of plate voltage before the filament has attained normal operating temperature.

Fault Protection

The handling of very high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can cause severe damage if not properly controlled. The ground lead of the plate circuit of each tube should be connected in series with the coil of a quick-acting overload relay, adjusted to open the circuit breakers in the primary of the rectifier transformer at slightly higher than normal plate current. The total time required for the operation of the relay and circuit breakers should be 1/10 second or less. The grid circuit should be equipped with similar overload relays which will likewise remove all grid power within 1/10 second.

To protect the tube until the relay and circuit breakers act, the installation of a device which will short circuit the plate power in the order of one-half cycle is highly recommended. For this purpose an electronic device or a railway-type line-shorting contactor may be connected to short the primary power lines to ground. Preferably, a gaseous conduction device may be connected at the output of the plate-supply filter to dissipate the filter-circuit energy as well as the rectifier output.

*Product of the Tempil Corporation, 132 West 22nd Street, New York 11, New York.

In some applications, depending on the size of the filter capacitor or speed of the relays, sufficient protection may be obtained by connecting a resistor in series with the plate lead of each tube, unless the equivalent impedance is provided by transformers or other circuit components. The criterion is the total energy to which the tube can be subjected. The minimum value of total resistance which alone will give adequate protection with reasonably low power loss is as follows:

Series Resistor	10	20	40	40-55 ohms
Maximum Power Output of Rectifier	120	280	640	1250 kW

In most cases, especially in parallel operation of tubes when power-supply impedance is low, both the electronic shorting device and the series resistor are recommended.

When such an electronic device is not installed, protective sphere gaps used in combination with the series plate resistor may be satisfactory. Appropriately designed gaps are shown in conjunction with the connectors on page 10. When the ML-5681 is used in resonant-cavity circuitry, equivalent protective gaps should be integrated within the cavity at approximately the same distances from the tube as those shown in the drawing on page 10. Gap spacings must be carefully adjusted for each individual application.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum ratings for the ML-5681 given in the tabulated data are limiting values which, if exceeded, may reduce the life and performance of the tube. When designing circuitry, therefore, it is necessary to insure that the maximum ratings will not be exceeded under any conditions, even for short periods of time. The equipment engineer must make allowances for any unusual condition of supply-voltage fluctuation or load variation, and for manufacturing tolerances in the equipment itself. (See Characteristic Range Values for Equipment Design.)

An approximate value of plate dissipation, which should not exceed the value shown under Maximum Ratings for each class of service, may be calculated from the water flow conditions by the following equation:

$$P = \frac{n\ (t_o - t_i)}{4} \text{ kilowatts}$$

where t_o and t_i are the outlet and inlet water temperatures, respectively, in degrees Centigrade measured near the tube socket, and n is the flow in gallons per minute. It should be noted, however, that n for a given plate dissipation must never be permitted to drop lower than the value shown in the Water Cooling Characteristics.

The typical operating conditions given in the tabulated data on pages 2 and 3 do not include the effects of electron transit time or circuit losses, hence, useful power output to the load will be less than that indicated, depending on the frequency of operation and circuit efficiency. At frequencies above 10 Mc, transit time effects will reduce power output to approximately the following proportions of the tabulated values: 97% at 30 Mc; 90% at 70 Mc; and 83% at 110 Mc. The useful power output can be calculated by subtracting the transit-time and circuit losses from the tube power output values shown in the tabulated data.

In the initial operation of new circuitry, or when adjustments are made, parasitic modes of oscillation may be excited, causing excessive voltages at the tube electrodes. Therefore, approximately one-half rated plate voltage should be used to avert damage to the tube and associated apparatus. Operation at reduced power is essential until all parasitic effects are eliminated or phased out. After correct adjustments have been made and the ML-5681 is operating stably within all ratings, the plate voltage may be raised in steps to the desired value.

In Class B Modulation or other audio-frequency service, the ML-5681 should be operated with grid bias obtained from a d-c voltage source of good regulation. Each grid circuit should be equipped with a separate bias adjustment to balance the grid and plate currents.

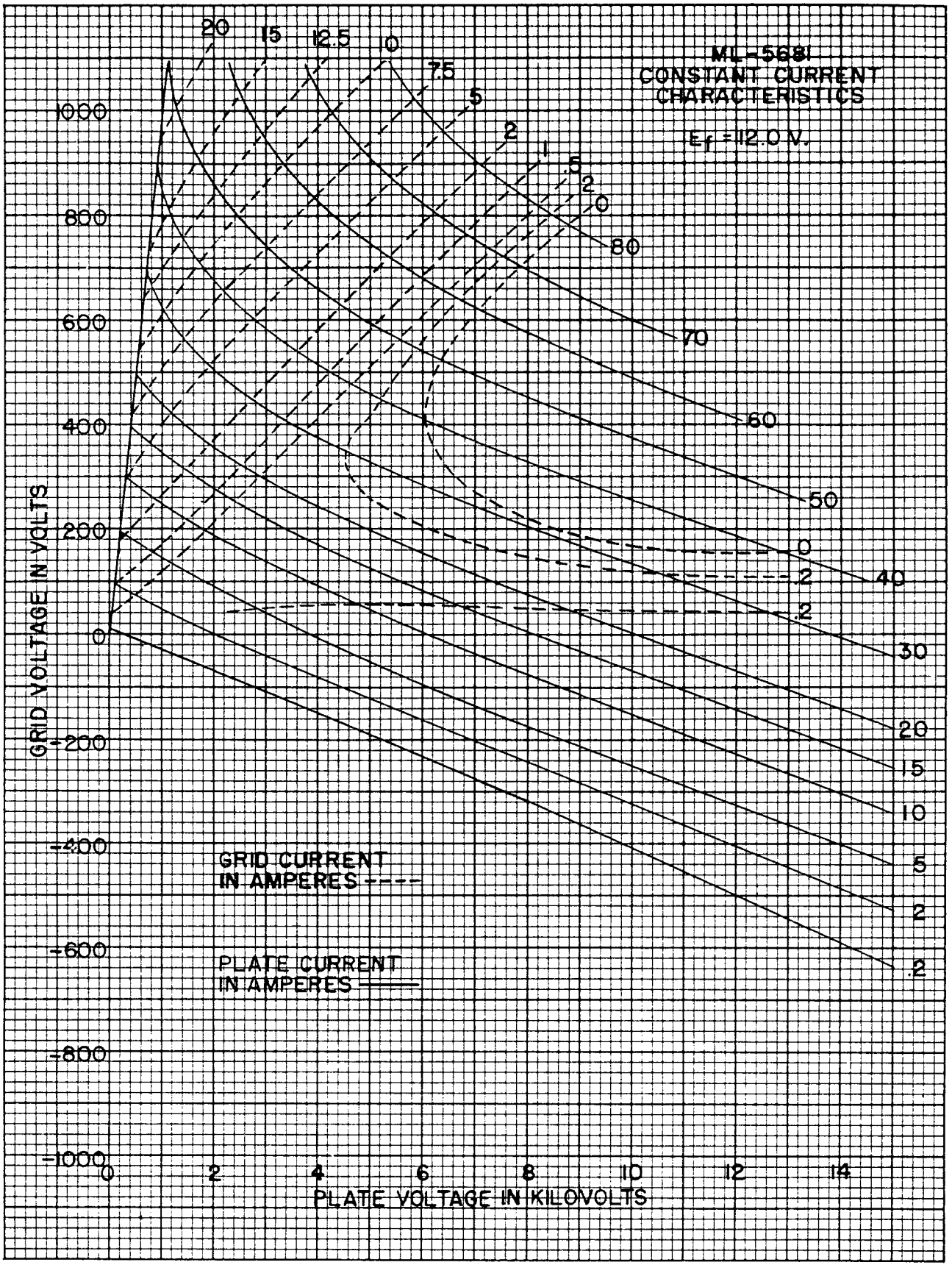
In Class C Plate-Modulated R-F Amplifier service, the ML-5681 should be supplied with bias from the grid resistor or from a suitable combination of grid resistor and fixed supply. The combination grid-resistor and fixed-supply method has the advantage of protecting the tube through loss of excitation and of minimizing distortion by bias-supply voltage compensation.

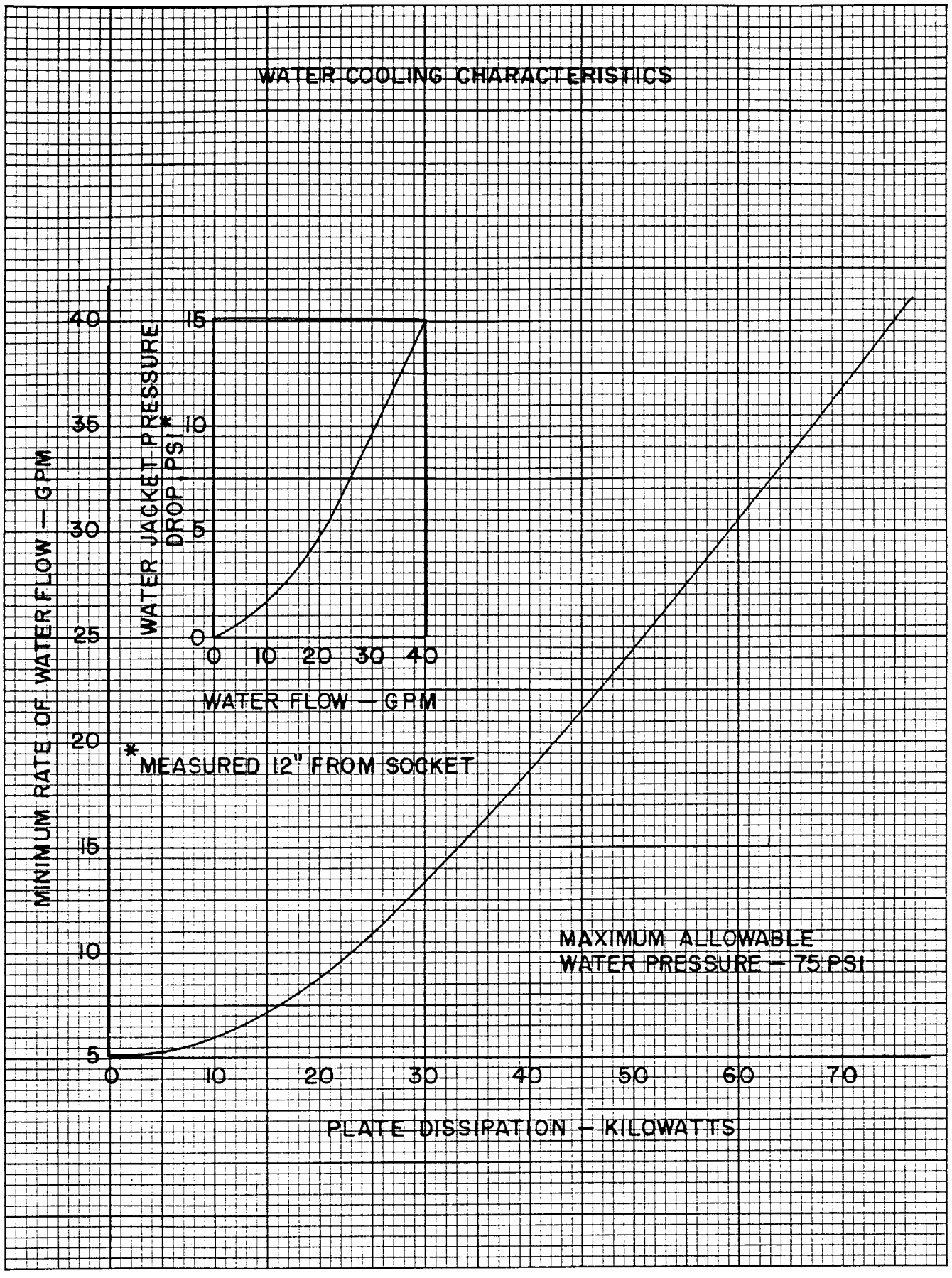
In Class C R-F Telegraphy, the ML-5681 should be supplied with bias obtained from a fixed supply for amplifier service, or from an adjustable grid resistor for oscillator service. Variation of d-c grid current between individual tubes requires provision for adjustment of the grid resistor to obtain the desired total bias for each tube.

In grid-drive circuits, the grid current and driving power for the desired power output will vary with the plate loading. If the plate-circuit resistance is low, the desired output can be obtained with relatively low grid current and driving power, but plate efficiency is sacrificed. Conversely, if the tube operates into a relatively high load resistance, higher grid current and driving power are required, and the plate-circuit efficiency will be increased. It is customary to make a compromise between these extremes; the typical operating conditions shown are designed to give good plate-circuit efficiency with reasonable driving power. The driver stage should have more output capability than shown in the tabulated data to account for circuit losses and variations in tubes as shown in the Characteristic Range Values for Equipment Design.

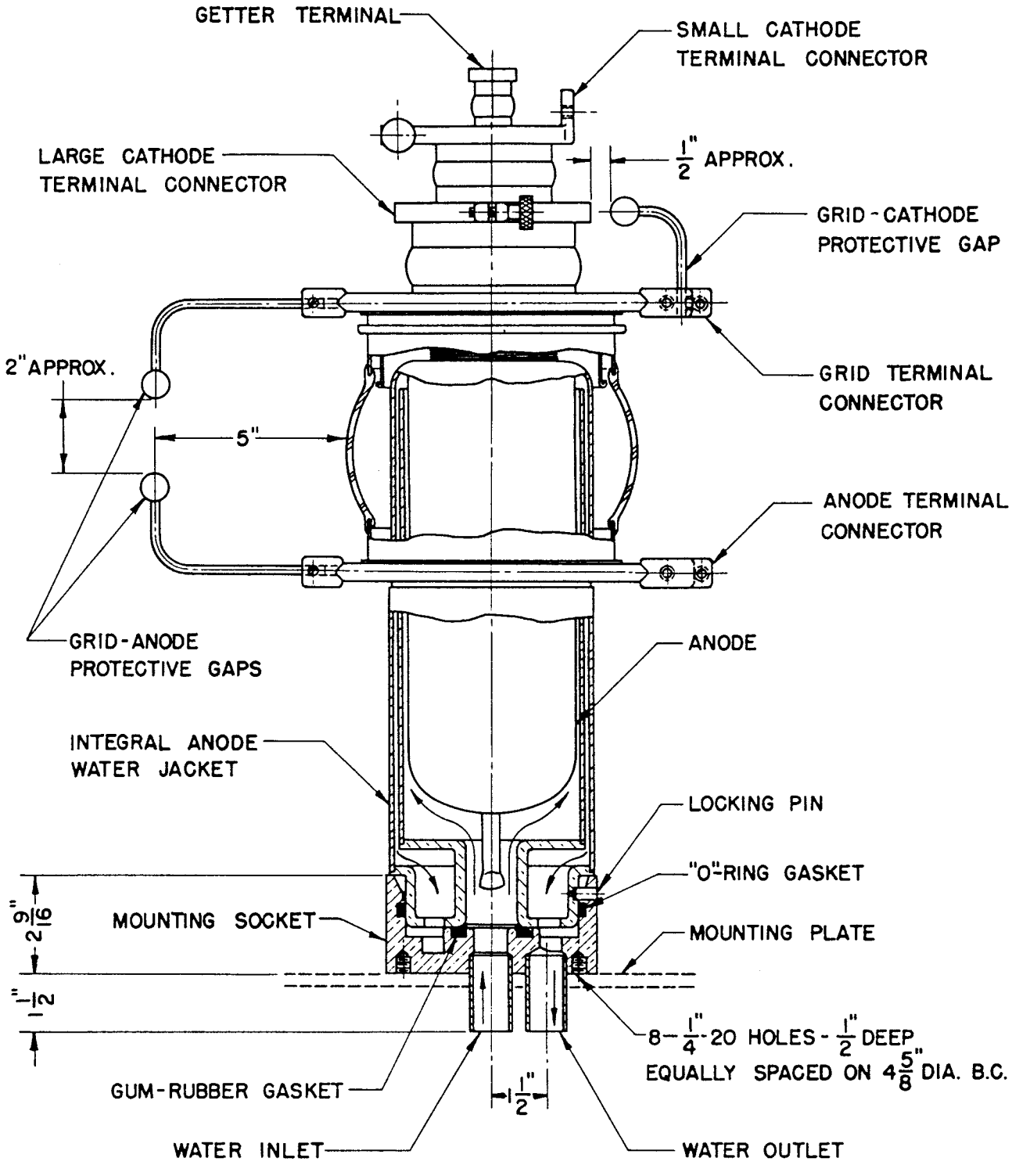
In cathode-drive circuits, the required driving power is increased since the driving voltage and the developed r-f plate voltage act in series to supply the load. This additional driving power reappears as part of the output to the load. The power output increases as the driving voltage and grid current are increased, whereas the grid-drive circuit saturates above a critical value of driving voltage and current. Saturation of a cathode-drive stage must not be attempted because the rated maximum grid current may easily be exceeded.

The above discussion presents information necessary to obtain satisfactory and economical performance of the ML-5681 under normal operating conditions. For information concerning specific tube problems or applications not covered, consult the Machlett Engineering Department.

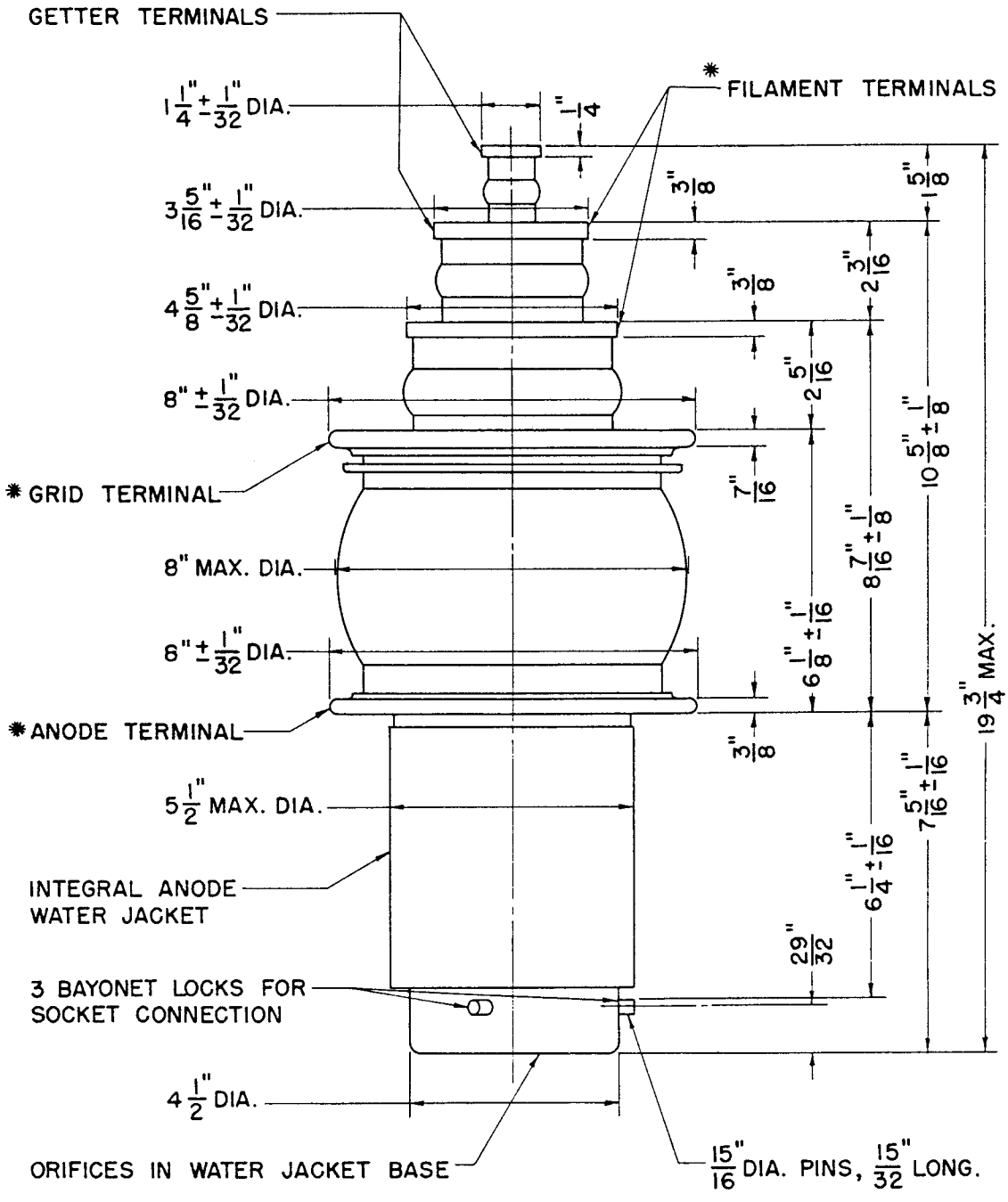

ML-5681
CONSTANT CURRENT
CHARACTERISTICS
Ef = 12.0 V.
GRID VOLTAGE IN VOLTS
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
20
15
12.5
10
7.5
5
2
1
.5
.2
0
80
70
60
50
40
30
20
15
10
5
2
.2
GRID CURRENT
IN AMPERES ----
PLATE CURRENT
IN AMPERES ——
0
2
4
6
8
10
12
14
PLATE VOLTAGE IN KILOVOLTS


WATER COOLING CHARACTERISTICS
MINIMUM RATE OF WATER FLOW — GPM
40
35
30
25
20
15
10
5
0
10
20
30
40
50
60
70
PLATE DISSIPATION — KILOWATTS
MAXIMUM ALLOWABLE
WATER PRESSURE — 75 PSI
WATER JACKET PRESSURE DROP, PSI*
15
10
5
0
0
10
20
30
40
WATER FLOW — GPM
*MEASURED 12" FROM SOCKET

ML-5681 & ML-5682
COOLING SYSTEM & PROTECTIVE GAP ARRANGEMENT



OUTLINE OF ML-5681

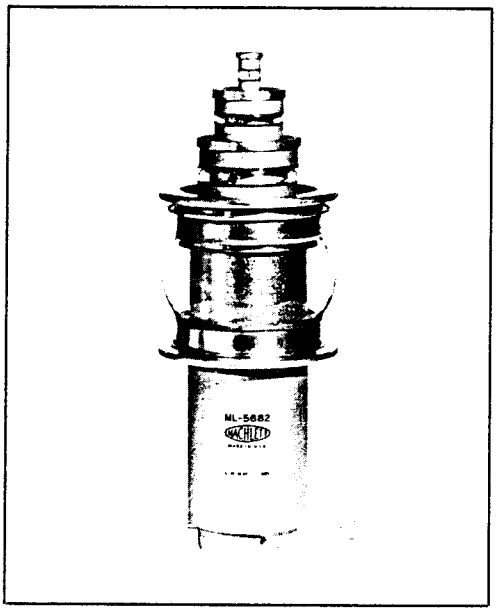


* ELECTRICAL CONTACTS TO BE MADE ON THE PERIPHERY OF THESE TERMINALS.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.
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ISSUED 6-67

ML-5682

MACHLETT

General Purpose Triode
215 kW CW
8 Mw Pulse Power

DESCRIPTION

The ML-5682 is a general-purpose high-power triode suitable for use in AM, FM and TV broadcasting, dielectric and induction heating, pulse modulation and similar applications. This tube features rugged coaxial construction with high-dissipation, low-inductance rf terminals. The cathode consists of sturdy, stress-free, thoriated-tungsten filaments. This tube is suitable for cavity operation and its low plate impedance adapts it to broad-band service.

The ML-5682 is water-cooled and accepts a quick-change water-jacket coupling. The heavy-wall anode will dissipate up to 140 kW with a water flow of 60 gpm. The maximum CW plate-voltage rating of 16 kV applies at frequencies up to 30 Mc. The tube may be operated up to 88 Mc with a reduction in ratings. In pulse service the tube is capable of switching up to 8 Mw with plate voltages up to 35 kV.

The ML-5682 is also available with envelope construction utilizing ceramic instead of glass. This version, designated as the ML-5682K, is electrically identical to the ML-5682.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	16.5	Volts
Filament Current at 16.5 volts	325	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	0.0052	Ohms
Amplification Factor	30	
Direct Interelectrode Capacitances		
Grid-Plate	85	uuf
Grid-Filament	110	uuf
Plate-Filament	2.6	uuf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling	Water and forced-air	
Water Flow on Anode	See Water Cooling Characteristics	
Maximum Water Pressure	75	psi
Maximum Outlet Water Temperature	70	°C
Air Flow on Envelope and Seals, approximate	250	cfm
Maximum Envelope Temperature	165	°C
Net Weight, approximate	50	lb.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	16000	volts
Max.-Signal D-C Plate Current*	18	amps
Max.-Signal Plate Input*	280	kW
Plate Dissipation*	140	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	12000	15000	volts
D-C Grid Voltage	-370	-450	volts
Peak A-F Grid-to-Grid Voltage	1510	1820	volts
Peak A-F Plate-to-Plate Voltage	18800	24000	volts
Zero-Signal D-C Plate Current	4.0	6.0	amps
Max.-Signal D-C Plate Current	26.7	35.0	amps
Effective Load Resistance, Plate-to-Plate	885	873	ohms
Max.-Signal Driving Power, approx.	1.3	2.1	kW
Max.-Signal Power Output, approx.	200	330	kW

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	16000	volts
D-C Plate Current	14	amps
Plate Input	150	kW
Plate Dissipation	140	kW
Frequency	30	Mc

Typical Operation

D-C Plate Voltage	10000	12000	volts
D-C Grid Voltage	-300	-380	volts
Peak R-F Grid Voltage	450	570	volts
Peak R-F Plate Voltage	4200	5000	volts
D-C Plate Current	9.0	12.0	amps
D-C Grid Current	111	93	mA
R-F Load Resistance	290	260	ohms
Driving Power, approximate**	2.2	4.2	kW
Power Output, approximate	30	48	kW

Radio-Frequency Amplifier Class B Television Service

Synchronizing level conditions per tube, unless otherwise specified, in cathode-drive circuit—88 Mc, 5 Mc bandwidth

Maximum Ratings, Absolute Values

D-C Plate Voltage	9000	volts
D-C Plate Current	20	amps
D-C Grid Current	4.0	amps
Plate Input	170	kW
Plate Dissipation	140	kW
Frequency	88	Mc

Typical Operation

D-C Plate Voltage	6000	8000	volts
D-C Grid Voltage	-200	-250	volts
Peak R-F Driving Voltage			
Synchronizing level	650	840	volts
Pedestal level	500	650	volts
Peak R-F Plate Voltage			
Synchronizing level	4600	6200	volts
Pedestal level	3600	4800	volts
D-C Plate Current			
Synchronizing level	12.2	19.0	amps
Pedestal level	9.0	14.3	amps
D-C Grid Current, approximate			
Synchronizing level	2.3	3.2	amps
Pedestal level	1.4	2.0	amps
R-F Load Resistance	265	230	ohms
Driving Power at tube, approximate			
Synchronizing level	7.8	15.1	kW
Pedestal level	4.0	8.3	kW
Power Output, approximate***			
Synchronizing level	52	107	kW
Pedestal level	30	62	kW

Doherty High-Efficiency Linear Amplifier

Carrier conditions per tube, unless otherwise specified, for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	Carrier Tube	Peak Tube	
D-C Plate Voltage	16000	16000	volts
D-C Grid Voltage	-3200	-3200	volts
D-C Plate Current	16	10†	amps
D-C Grid Current	4.0	2.0	amps
Plate Input	250	150†	kW
Plate Dissipation	140	140	kW
Frequency	30	30	Mc

Typical Operation	Carrier Tube	Peak Tube	Carrier Tube	Peak Tube	
D-C Plate Voltage	13000	13000	15000	15000	volts
D-C Grid Voltage	-450	-1300	-540	-1400	volts
Peak R-F Grid Voltage					
Carrier	850	1100	940	1160	volts
Crest**	1180	2200	1260	2320	volts
Peak R-F Plate Voltage					
Carrier	11000	5500	12500	6250	volts
Crest**	11000	11000	12500	12500	volts
D-C Plate Current					
Carrier	12.4	0.3	13.3	0.8	amps
Modulated†	12.4	7.2	13.3	7.6	amps
D-C Grid Current					
Carrier	1.0	0	0.7	0	amp
Modulated†	1.6	0.7	1.2	0.6	amps
R-F Load Resistance**	270	270	300	300	ohms
Driving Power, approximate**	4.3	9.2	3.9	9.7	kW
Power Output, approximate					
Carrier	110	2	134	4	kW
Modulated†	102	63	125	76	kW

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	10500	volts
D-C Grid Voltage	-3200	volts
D-C Plate Current	16	amps
D-C Grid Current	3.5	amps
Plate Input	185	kW
Plate Dissipation	80	kW
Frequency	30	Mc

Typical Operation

D-C Plate Voltage	10000	10000	volts
D-C Grid Voltage	-950	-1250	volts
Peak R-F Grid Voltage	1450	1850	volts
Peak R-F Plate Voltage	8700	8000	volts
D-C Plate Current	9.2	15	amps
D-C Grid Current	2.1	2.5	amps
R-F Load Resistance	525	3.75	ohms
Driving Power, approximate	2.9	5.0	kW
Power Output, approximate	72	110	kW

Grid Modulated R-F Amplifier Class C Telephony

Carrier conditions per tube, unless otherwise specified, for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	16000	volts
D-C Plate Current	10	amps
D-C Grid Current	4.0	amps
Plate Input	150	kW
Plate Dissipation	140	kW
Frequency	30	Mc

Typical Operation

D-C Plate Voltage	15000	volts
D-C Grid Voltage	-1000	volts
Peak R-F Grid Voltage	1090	volts
Peak A-F Grid Voltage for maximum modulation	380	volts
Peak R-F Plate Voltage	7000	volts
D-C Plate Current	5.0	amps
D-C Grid Current, approximate	50	mA
R-F Load Resistance	1500	ohms
Driving Power, approximate	55	watts
Power Output, approximate	30	kW

Pulse Modulator or Pulse Amplifier

Maximum Ratings

D-C Plate Voltage	35	kV
Peak Plate Voltage	40	kv
Peak Negative Grid Voltage	-7000	volts
Pulse Cathode Current	360	amps
Grid Dissipation	2.0	kW
Plate Dissipation	140	kW
Pulse Duration, approximate	1000	μsec ‡
Duty Factor	.01	‡

Typical Operation

D-C Plate Voltage	35	35	kV
D-C Grid Voltage	-2000	-2000	volts
Pulse Positive Grid Voltage	2000	2400	volts
Pulse Plate Current	200	300	amps
Pulse Grid Current	100	60	amps
Pulse Driving Power	400	300	kw
Pulse Power Output	6.6	8.4	Mw
Plate Output Voltage	33	28	kv

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation#

Maximum Ratings, Absolute Values

D-C Plate Voltage	9000	16000	volts
D-C Grid Voltage	-3200	-3200	volts
D-C Plate Current	20	20	amps
D-C Grid Current	2.5	4.0	amps
Plate Input	170	300	kW
Plate Dissipation	140	140	kW
Frequency	88	30	Mc

Typical Operation

Power Amplifier and Oscillator, Grid-Drive Circuit—30 Mc

D-C Plate Voltage	8000	12000	15000	volts
D-C Grid Voltage	-750	-1100	-1400	volts
Peak R-F Grid Voltage	1210	1750	2200	volts
Peak R-F Plate Voltage	6600	10300	12800	volts
D-C Plate Current	9.7	14.3	18.4	amps
D-C Grid Current	2.1	2.9	3.0	amps
R-F Load Resistance	380	400	380	ohms
Driving Power, approximate	2.5	4.9	7.2	kW
Power Output, approximate	58	132	215	kW

Power Amplifier, Cathode-Drive Circuit—88 Mc

D-C Plate Voltage	7000	8000	volts
D-C Grid Voltage	-550	-650	volts
Peak R-F Driving Voltage	1020	1200	volts
Peak R-F Plate Voltage	5800	6400	volts
D-C Plate Current	9.5	12.5	amps
D-C Grid Current	2.3	2.5	amps
R-F Load Resistance	400	340	ohms
Driving Power, approximate	10.6	16.2	kW
Power Output, approximate***	57	85	kW

* Averaged over any audio-frequency cycle of sine-wave form.
** At crest of audio-frequency cycle with modulation factor of 1.0.
*** Includes power transferred from driver stage.
† Average value with modulation factor of 1.0.
\# Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

‡For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 Mc except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation —— (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	30	60	88 Mc
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B	100	91	56 %
Class C Plate Modulated	100	78	56 %
Class C Telegraphy	100	78	56 %

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic	Conditions		Limits Min.	Nominal	Max.	
Grid Voltage	e_b = 1700 v; i_b = 90 a	e_c:	—	—	1050	volts
Grid Current	e_b = 1700 v; i_b = 90 a	i_c:	—	—	45	amps
Plate Voltage	E_c = 0 Vdc; I_b = 3 Adc	E_b:	1.8	2.4	3.0	kVdc
Plate Voltage	E_c = -200 Vdc; I_b = 3 Adc	E_b:	7.4	8.4	9.4	kVdc
Grid Voltage	E_b = 16 kVdc; I_b = 0.20 Adc	E_c:	-500	-620	-740	Vdc
Plate Power Output	E_b = 15 kVdc; I_b = 18.4 Adc E_c = -1400 Vdc; I_c = 3.0 Adc F = 30 Mc	P_o:	177	—	—	kW
Plate Power Output	E_b = 9 kVdc; I_b = 18.0 Adc E_c = -850 Vdc; I_c = 2.5 Adc F = 88 Mc	P_o:	81	—	—	kW

APPLICATION NOTES

Initial Inspection and Installation

When an ML-5682 is received, it should be unpacked and inspected as soon as possible. Care should be taken to keep from jarring the tube or the inner packing box, since the thoriated-tungsten filament may become damaged. To insure against straining the glass-to-metal seals, it is recommended that the tube be handled only by the anode water-jacket, anode flange, or if necessary the grid terminal flange; it should never be handled by the cathode terminals. The tube should always be stored or mounted in a vertical position with the anode down.

A careful inspection should be made for any visible damage, such as glass cracks or broken filament strands, which may have occurred in transit. The tube should then be checked with an ohmmeter between grid and cathode terminals to determine whether or not a grid-cathode short has occurred.

A complete set of rubber gaskets is shipped with each ML-5682, and the new gaskets should be inserted in the mounting socket before installing a new or spare tube. The gaskets should be wiped with a clean lint-free cloth and then coated with a thin layer of the silicone grease supplied, before insertion in the socket.

If no interelectrode short is evident, the tube should be seated securely in the mounting socket and all electrical connections made, taking care that positive contact is obtained. Rated filament voltage should be applied and the filament current checked to see if it agrees with the value marked on the anode water jacket. A reading in the order of 20 amperes below this value (or lower) indicates that one (or more) of the filament strands is open, assuming the filament voltmeter and ammeter are accurately calibrated. (The meters may be quickly checked by measuring the filament volts and amperes of some known good ML-5682's.)

If there is any evidence of damage in transit, a "joint inspection" report should be prepared with the transportation company *within fifteen days*. The serial number identifying each individual tube appears on the grid terminal flange and on the outside of the packing case. It should be used in all correspondence concerning the tube.

Operation

After filament power has been on for one-half hour, apply approximately half rated plate voltage and operate the tube for an additional one-half hour. All tuning adjustments should be made during this period. Normal plate voltage may then be applied and final tune-up performed; the tube should be run at normal voltage and driving power for at least one-half hour. While the ML-5682 is operating at the desired normal output, it is suggested that the meter readings, control settings, and flow rates be recorded, especially when the tube is to be set aside as a spare. Then, in the event of an emergency tube change, the new tube can be installed and operation resumed with minimum delay.

As in the case of all large high-power vacuum tubes, no ML-5682 should remain in storage for more than three months. It should be operated in rotation with other ML-5682's, or aged every three months according to the above schedule given for newly received tubes. This procedure will keep it free from traces of gas, which may be liberated during prolonged storage, and insures that only operable tubes are carried in stock.

The glass in high-power vacuum tubes sometimes acquires a slight bluish fluorescence when subjected to high voltage. If this phenomenon is observed in an ML-5682, it should not be construed to mean that the tube is gassy. After proper aging, according to the above instructions, any fluorescence which persists is in no way detrimental to the satisfactory operation of the tube.

Tube Care

The glass insulation and other external parts of the ML-5682 should be kept free from accumulated dust to minimize sur-

face leakage and the possibility of arc-over. It is recommended that dust be wiped from the glass bulb and other external parts of the tube at least once a week. This should be done when the tube is cold, using a soft lint-free cloth moistened with alcohol.

All tube terminals and connectors must be kept bright and clean to provide good electrical contact. If they become discolored, they may be polished with fine emery cloth and then wiped clean.

The ML-5682, when packed for shipment, is protected from atmospheric moisture and may be stored at temperatures ranging from −35°C to +55°C. Unless the inner barrier bag is re-heat-sealed before storing, however, the tube should be protected from moisture and extreme temperatures by some other means. Before placing the ML-5682 in storage, water should be completely drained from the integral water jacket to prevent freezing and corrosion in the passages. The ports should then be covered with a suitable material, such as pliofilm, to prevent the entry of foreign matter.

Filament Care

The thoriated-tungsten filament of the ML-5682 is the multistrand type and is designed for single-phase a-c operation. It provides greater electron emission with less power than conventional pure-tungsten filaments, but requires the observance of certain precautions. The filament should be operated at rated voltage ±5%. Regular operation at −5% from rated voltage, to increase tube life, is permissible when maximum power output is not used and the required peak emission does not exceed 75 amperes. Operation at lower filament voltage is not permissible. For standby periods up to two hours, however, the filament voltage may be lowered to 80% of normal; for longer periods the filament should be turned off. A suitable voltmeter should be permanently connected across the filament terminals directly at the tube so that the filament voltage will always be known.

Prolonged storage periods or overheating of the ML-5682 by severe overloads may liberate gas within the vacuum envelope which, even though minute, is sufficient to decrease the filament emission. The rectified grid current is a sensitive measure of loss of emission. The grid and plate currents should be particularly noted after an outage, as the filament may have been poisoned by the high-power surge. If these currents start to decrease, the power should be removed and the aging procedure instituted, as described in the first paragraph under "Operation".

The ML-5682 is equipped with a zirconium getter which will absorb free gas within the tube when heated with a current not to exceed 14 amperes, which may be drawn from the filament power through an appropriate dropping resistor (approximately one ohm). The getter terminals are shown on the outline drawing.

The tube (with getter connected) should be operated (a) with only filament voltage for one-half hour, (b) with half normal plate voltage for one-half hour, (c) increasing to full voltage in about one hour. The getter however is not designed for continuous operation at 14 amperes.

In some applications it may be desirable to operate the getter at reduced temperature for prolonged periods. For these applications the getter may be operated continuously at a current of 7 amperes by increasing the dropping resistor to approximately two ohms.

Should the tube become gassy due to prolonged inactivity or to flash arcing, the getter should be operated at 14 amperes for one-half hour.

The above aging period should only be considered a minimum. If behavior at rated conditions shows instability continued aging as above should be performed.

If the d-c grid and plate currents are still low, a filament reactivation cycle (with the getter disconnected) may be undertaken. This consists of operating the tube (a) with filament voltage at 20% above normal and no plate voltage for fifteen minutes, then (b) at rated filament voltage and half normal plate voltage for one-half hour. This procedure should be performed only in extreme cases.

Tube Reshipment

When packing the ML-5682 for shipment, the water jacket should be free of water as noted above for storage. The tube and a container of desiccant must then be sealed in a metallized barrier bag, as in the initial shipment. It is imperative that all original packing material be installed properly so that the tube will not be subjected to undue shock or vibration during transit. The Service Report form supplied with each tube should be filled out and forwarded whenever the tube is to be returned to the factory.

EQUIPMENT DESIGN CONSIDERATIONS

Mechanical Installation

Mounting of the ML-5682 requires the Machlett mounting socket (shown on page 11) or equivalent, which has been installed to support the tube vertically, anode down. The tube should be placed in the socket and twisted clockwise, by the anode or grid flange, through approximately 60°; it is removed by the converse procedure. Suitable provision should be made to prevent water from spilling when the tube is removed. The mounted ML-5682 should not be subjected to shock or appreciable vibration.

Cooling Systems

The water-cooling system generally consists of a source of anode cooling water, a feed-pipe system which carries water through flexible insulated hoses to and from the mounting socket, and provisions for interlocking the water flow with the power supplies. It is essential that the direction of water flow through the tube be upward over the anode surface (center connection), as shown on page 11. When the anode is at high potential above ground, the feedpipe system must have sufficient insulation to reduce leakage current to a negligible value. The water system should be the closed type using distilled or deionized water to preclude the possibility of scale formation and corrosion, both of which can be expected with tap water. Scale restricts water flow and prevents proper transfer of heat from the anode to the cooling water, and corrosion may damage the elements and passages. The rates of scale formation and corrosion depend on the electrical conductivity of the water. To minimize the formation of scale and corrosion, the use of a coolant having an initial resistance of at least 100,000 ohms per cubic centimeter is recommended. Since a very small amount of con-

tamination can change the conductivity of distilled water, frequent measurement is desirable. The water should be changed when its resistance falls below 20,000 ohms per cubic centimeter. A filter should be placed in the water supply line to the tube to trap foreign particles likely to impair the flow. It is suggested that a filter with a 100-mesh screen (0.005" openings) be used.

The water-cooling system must function properly at all times since even a momentary failure of flow will damage the ML-5682. Without cooling water, the heat of the filament alone is sufficient to cause serious harm. It is necessary to keep the water-flow interlocks in correct adjustment and never to set them to operate below the recommended level. The flow of water and air must start before the application of any tube voltages; it is recommended that the flow of coolants continue for 5 minutes after the removal of all tube voltages. In the event of emergency or fault conditions, however, the simultaneous shut down of all power will not damage the tube. Specific water-flow data are given in the Water-Cooling Characteristics, page 11. Under no circumstances should the outlet water temperature exceed 70°C nor should the temperature of the entering water be permitted to fall below 10°C with plate potential on. Water pressure at the tube socket should never exceed 75 psi.

Forced-air cooling of the cathode terminals, the grid flange, and the glass envelope is required, and the cooling should be uniformly distributed around the circumference of the seals. Air flow of 250 cfm provides adequate cooling up to 5 Mc; at higher frequencies more air flow is required, and uniform distribution of flow over the grid-anode seals is more critical. It is important to have the air passages carefully contoured so that the highest possible velocity of air is directed on the seals to be cooled. In the equipment design stage, it is recommended that temperature measurements be made of the glass-to-metal seals, electrode contact areas, and glass envelope of the tube under maximum operating conditions. In no case should any temperatures higher than 165°C be permitted, and the difference in temperature between any two points on the periphery of a seal should not be greater than 25°C. The temperature may be measured with temperature-sensitive paint such as Tempilaq*.

Electrical Considerations

Suitable meters should be provided for monitoring filament voltage, d-c plate voltage, plate current, and grid-current. A tube-life recording meter should be installed to read total hours of filament operation. If tubes are used in parallel or push-pull, individual metering of grid and plate currents is highly recommended.

Electrode contact should be made only on the surface designated on the outline drawing. Connecting cables and other parts of the equipment must be kept away from the electric fields between terminals and from the glass insulation. This precaution is necessary to avoid corona discharge, which may result in puncture of the glass. Connectors must be designed to carry the radio-frequency currents to the tube electrodes without excessive heating of the contact areas between connectors and terminals (165°C maximum temperature). All connecting cables and/or spring fingers must be flexible so that no strain will be transmitted to the glass envelope. Terminal connectors, shown on page 11, are recommended for operation of the ML-5682 at low or medium frequencies in conventional lumped-constant circuitry. For operation above 10 Mc, orientation of the ML-5682 with respect to other circuit elements must be such that the distribution of radio-frequency current at the tube terminals is uniform. Otherwise, the uneven heating and consequent unequal thermal expansion may strain the seals severely. Both cathode terminals must be thoroughly by-passed to radio-frequency currents to avoid excessive heating of the filament. When cavity circuitry is used, all connections should be the spring-pressure type, making uniformly good electrical contact around the tube circumference.

The filament transformer must limit the inrush current to a maximum of 2.5 times normal filament current. If a suitable high-reactance filament transformer is not available, step resistors in the primary will be satisfactory for the purpose of limiting the surge current.

The tube and circuitry should be housed in a protective enclosure, interlocked so that personnel cannot possibly come in contact with high voltage. The interlock devices should break the primary circuits of the plate and grid supplies when any door on the protective enclosure is opened, and should prevent the closing of the primary circuits until the door is again locked.

The plate circuit should be equipped with a time-delay relay to prevent the application of plate voltage before the filament has attained normal operating temperature.

Fault Protection

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater

* Product of the Tempil Corporation, 132 West 22nd Street, New York 11, New York

than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

Appropriately designed gaps are shown in conjunction with the connectors on Page 11. When the ML-5682 is used in resonant-cavity circuitry, equivalent protective gaps should be integrated within the cavity at approximately the same distances from the tube as those shown in the drawing on Page 11. Gap spacings must be carefully adjusted for each individual application.

References:
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics*, 29, 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press*, 1, 6, 1954.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum ratings for the ML-5682 given in the tabulated data are limiting values which, if exceeded, may reduce the life and performance of the tube. When designing circuitry, therefore, it is necessary to insure that the maximum ratings will not be exceeded under any conditions, even for short periods of time. The equipment engineer must make allowances for any unusual condition of supply-voltage fluctuation or load variation, and for manufacturing tolerances in the equipment itself. (See Characteristic Range Values for Equipment Design.)

An approximate value of plate dissipation, which should not exceed the value shown under Maximum Ratings for each class of service, may be calculated from the water flow conditions by the following equation:

$$P = \frac{n\ (t_o - t_i)}{4} \text{ kilowatts}$$

where t_o and t_i are the outlet and inlet water temperatures, respectively, in degrees Centigrade measured near the tube socket, and n is the flow in gallons per minute. It should be noted, however, that n for a given plate dissipation must never be permitted to drop lower than the value shown in the Water Cooling Characteristics.

The typical operating conditions, given in the tabulated data on pages 2 and 3, do not include the effects of electron transit time or circuit losses, hence, useful power output to the load will be less than that indicated, depending on the frequency of operation and circuit efficiency. At frequencies above 10 Mc, transit time effects will reduce power output to approximately the following proportions of the tabulated values: 97% at 30 Mc; 92% at 60 Mc; and 86% at 88 Mc. The useful power output can be calculated by subtracting the transit-time and circuit losses from the tube power output values shown in the tabulated data.

In the initial operation of new circuitry, or when adjustments are made, parasitic modes of oscillation may be excited, causing excessive voltages at the tube electrodes. Therefore, approximately one-half rated plate voltage should be used to avert damage to the tube and associated apparatus. Operation at reduced power is essential until all parasitic effects are eliminated or phased out. After correct adjustments have been made and the ML-5682 is operating stably within all ratings, the plate voltage may be raised in steps to the desired value.

In Class B Modulation or other audio-frequency service, the ML-5682 should be operated with grid bias obtained from a d-c voltage source of good regulation. The grid circuit of each tube should be equipped with a separate bias adjustment to balance the grid and plate currents.

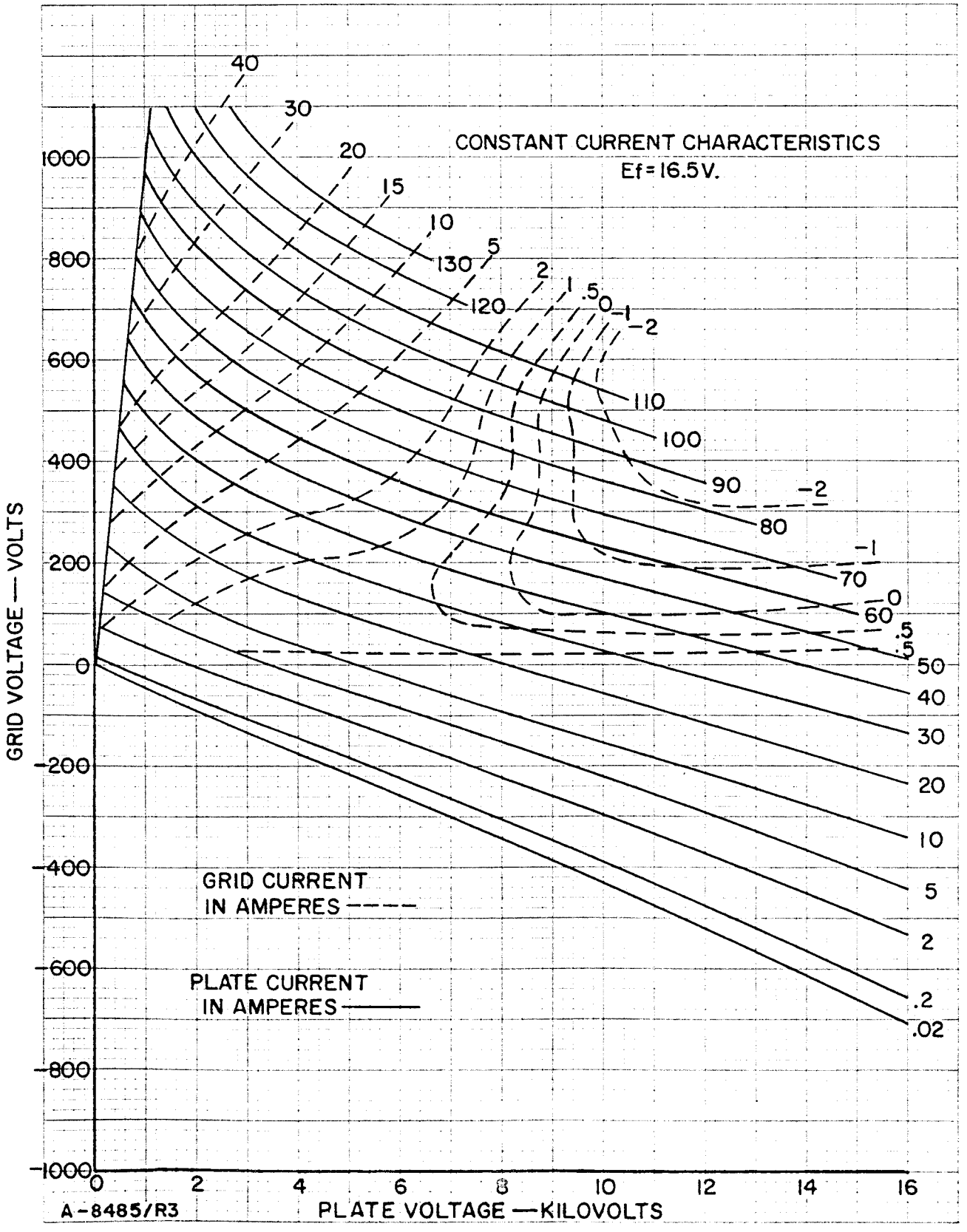
In Class C Plate-Modulated R-F Amplifier service, the ML-5682 should be supplied with bias from a grid resistor or from a suitable combination of grid resistor and fixed supply. The combination grid-resistor and fixed-supply method has the advantage of protecting the tube through loss of excitation and of minimizing distortion by bias-supply voltage compensation.

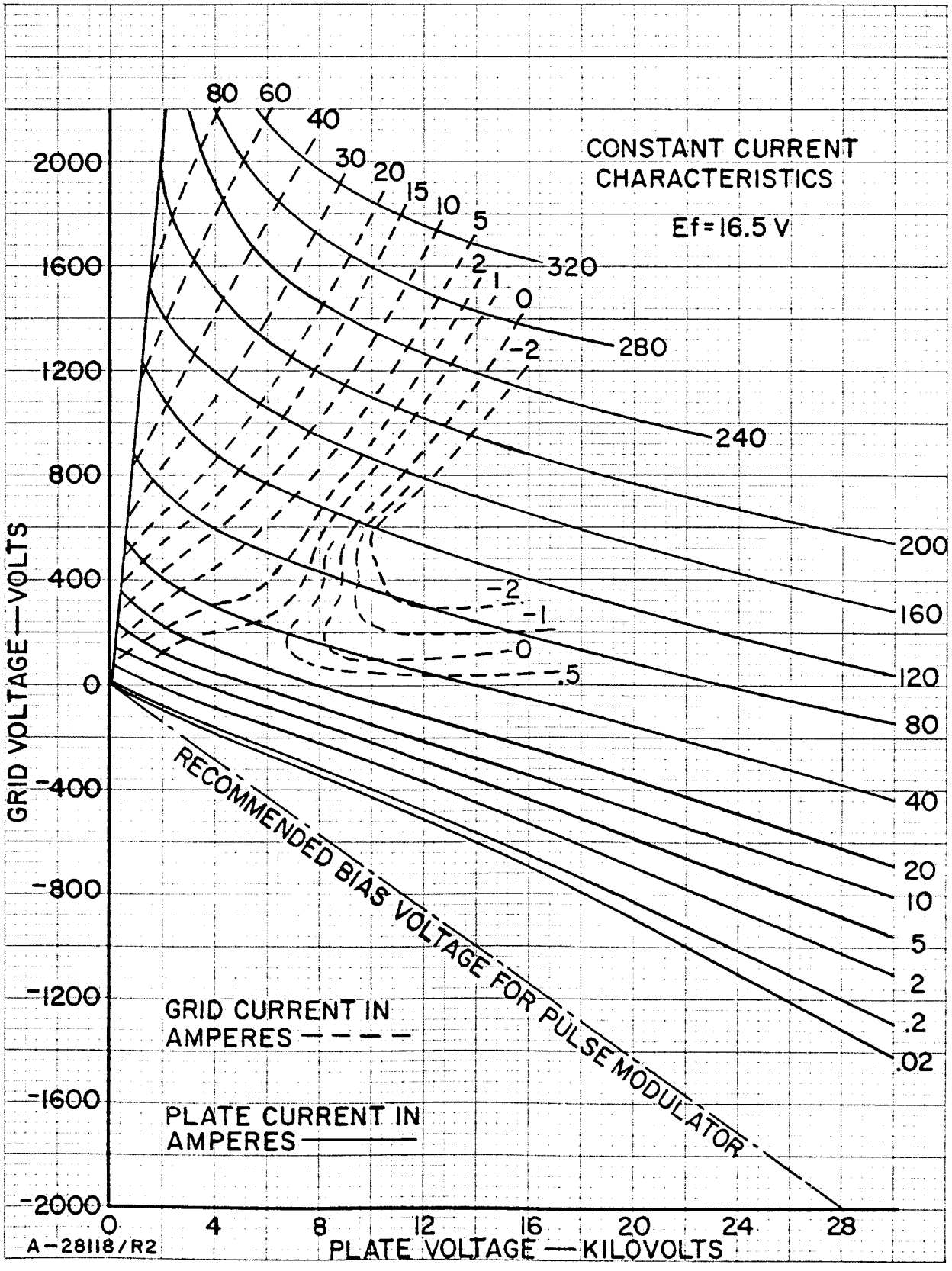
In Class C R-F Telegraphy, the ML-5682 should be supplied with bias obtained from a fixed supply for amplifier service, or from an adjustable grid resistor for oscillator service. Variation of d-c grid current between individual tubes requires provision for adjustment of the grid resistor to obtain the desired total bias for each tube.

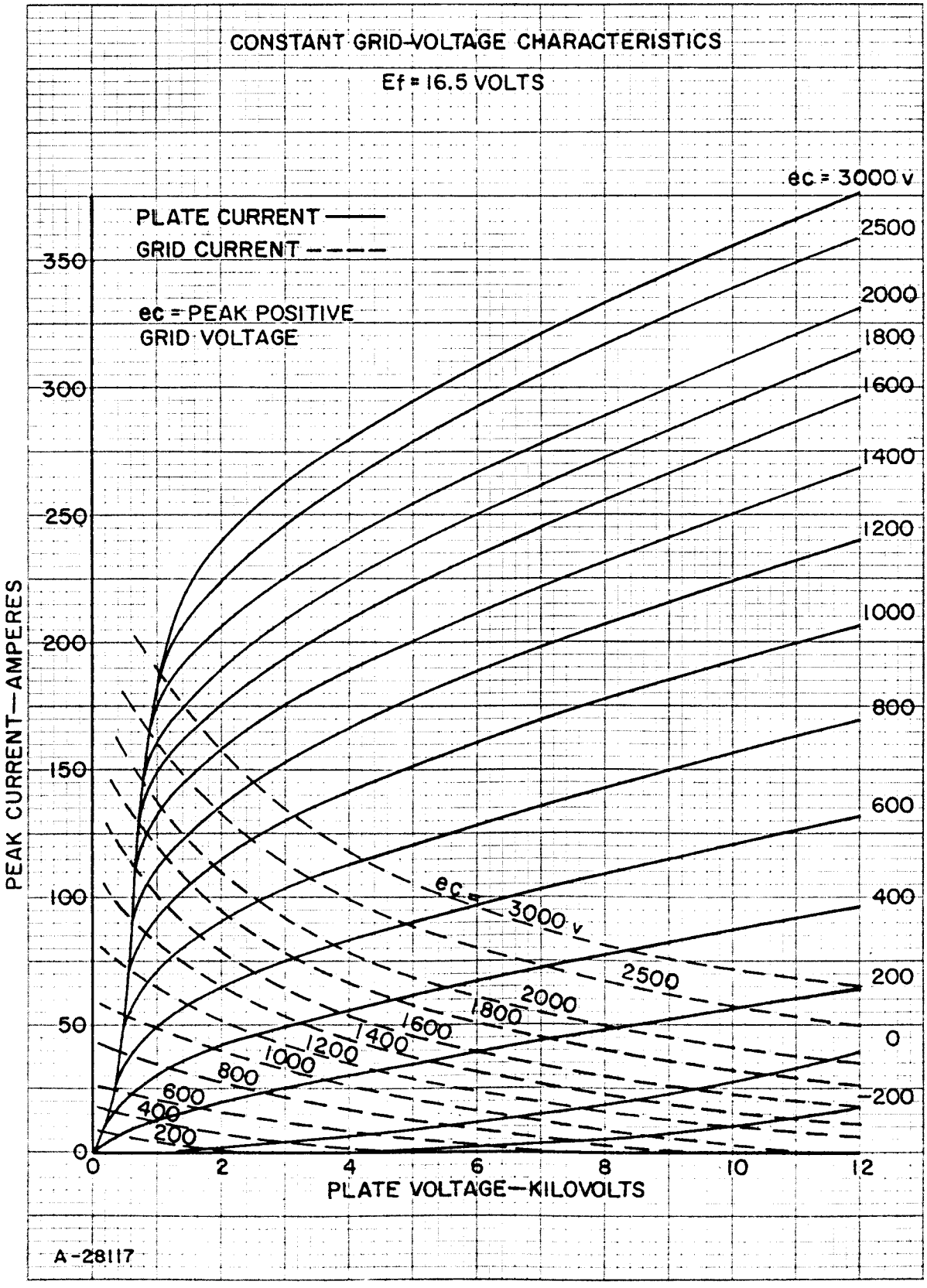
In grid-drive (grounded cathode) circuits, the grid current and driving power for the desired power output will vary with the plate loading. If the plate-circuit resistance is low, the desired output can be obtained with relatively low grid current and driving power, but plate efficiency is sacrificed. Conversely, if the tube operates into a relatively high load resistance, higher grid current and driving power are required, and the plate-circuit efficiency will be increased. It is customary to make a compromise between these extremes; the typical operating conditions shown are designed to give good plate-circuit efficiency with reasonable driving power. The driver stage should have more output capability than shown in the tabulated data to account for circuit losses and variations in tubes as shown in the Characteristics Range Values for Equipment Design.

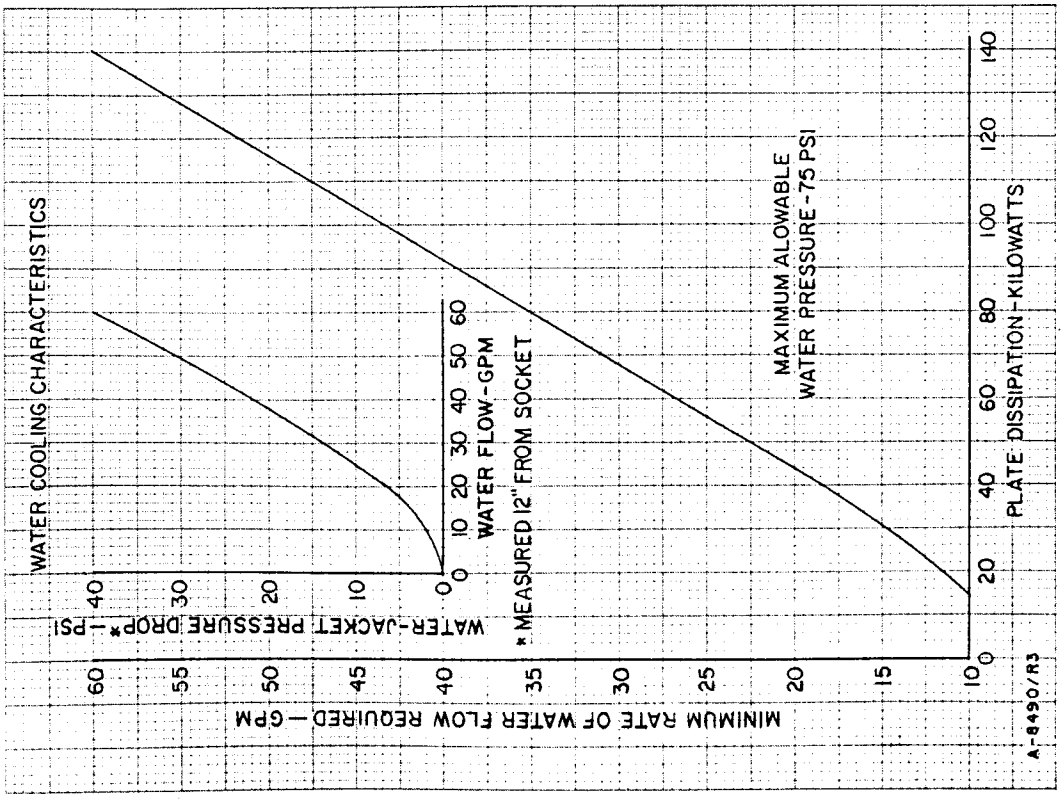
In cathode-drive (grounded-grid) circuits, the required driving power is increased since the driving voltage and the developed r-f plate voltage act in series to supply the load. This additional driving power reappears as part of the output to the load. The power output increases as the driving voltage and grid current are increased, whereas the grid-drive circuit saturates above a critical value of driving voltage and current. Saturation of a cathode-drive stage must not be attempted because the rated maximum grid current may easily be exceeded.

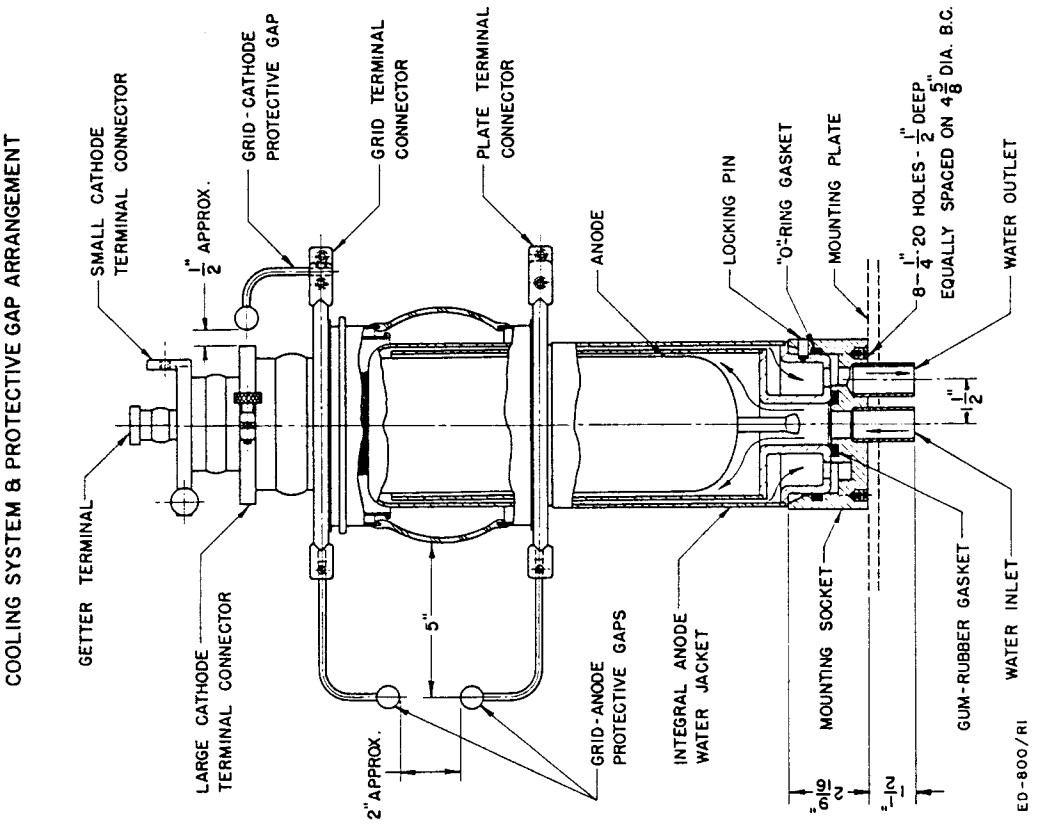
The above discussion presents information necessary to obtain satisfactory and economical performance of the ML-5682 under normal operating conditions. For information concerning specific tube problems or applications not covered, consult the Machlett Engineering Department.

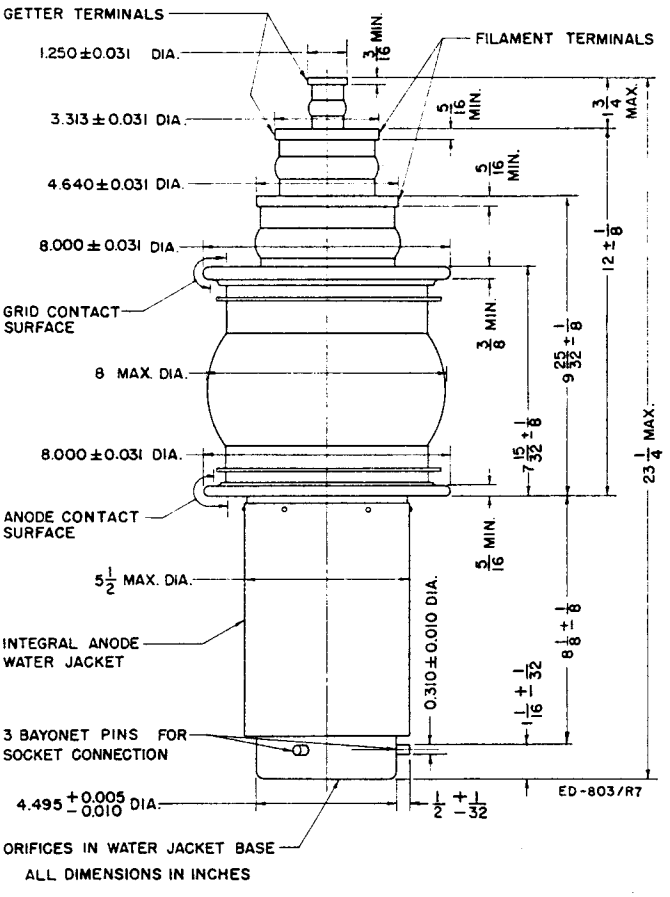

CONSTANT CURRENT CHARACTERISTICS
Ef = 16.5V.
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
A-8485/R3
40
30
20
15
10
5
2
1
.5
0
-1
-2
130
120
110
100
90
80
70
60
50
40
30
20
10
5
2
.2
.02
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
0
2
4
6
8
10
12
14
16


CONSTANT CURRENT
CHARACTERISTICS
Ef=16.5 V
80
60
40
30
20
15
10
5
2
1
0
-2
320
280
240
200
160
120
80
40
20
10
5
2
.2
.02
-2
-1
0
.5
RECOMMENDED BIAS VOLTAGE FOR PULSE MODULATOR
GRID CURRENT IN
AMPERES - - -
PLATE CURRENT IN
AMPERES ———
GRID VOLTAGE — VOLTS
2000
1600
1200
800
400
0
-400
-800
-1200
-1600
-2000
0
4
8
12
16
20
24
28
PLATE VOLTAGE — KILOVOLTS
A-28118/R2

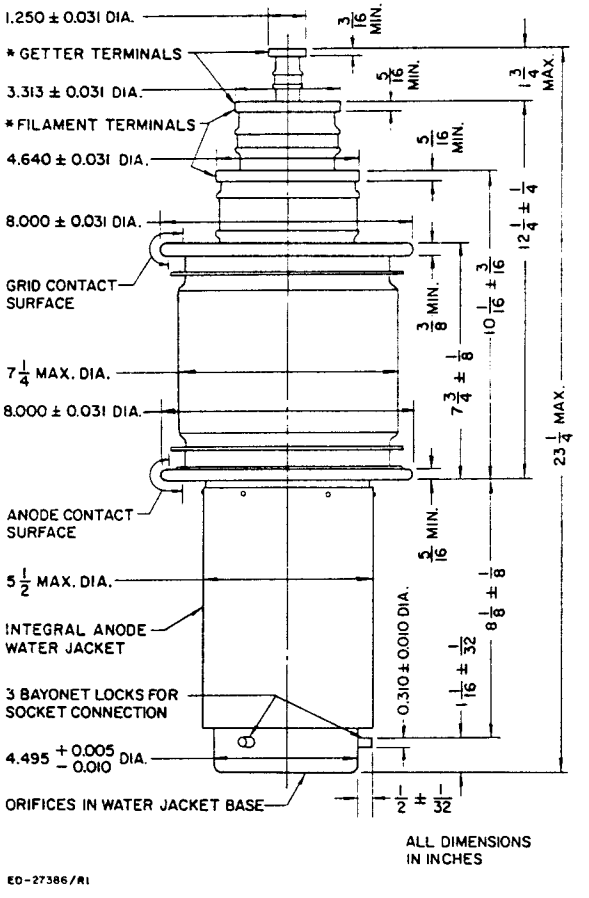

CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 16.5 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
ec = 3000 v
2500
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
PEAK CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
A-28117


WATER COOLING CHARACTERISTICS
WATER-JACKET PRESSURE DROP* - PSI
0
10
20
30
40
WATER FLOW-GPM
0
10
20
30
40
50
60
* MEASURED 12" FROM SOCKET
MINIMUM RATE OF WATER FLOW REQUIRED — GPM
10
15
20
25
30
35
40
45
50
55
60
MAXIMUM ALOWABLE
WATER PRESSURE - 75 PSI
0
20
40
60
80
100
120
140
PLATE DISSIPATION - KILOWATTS
A-8490/R3


COOLING SYSTEM & PROTECTIVE GAP ARRANGEMENT
GETTER TERMINAL
SMALL CATHODE TERMINAL CONNECTOR
1/2" APPROX.
GRID-CATHODE PROTECTIVE GAP
GRID TERMINAL CONNECTOR
PLATE TERMINAL CONNECTOR
ANODE
LOCKING PIN
"O"-RING GASKET
MOUNTING PLATE
8-1/4"-20 HOLES-1/2" DEEP EQUALLY SPACED ON 4 5/8" DIA. B.C.
WATER OUTLET
LARGE CATHODE TERMINAL CONNECTOR
5"
2" APPROX.
GRID-ANODE PROTECTIVE GAPS
INTEGRAL ANODE WATER JACKET
MOUNTING SOCKET
GUM-RUBBER GASKET
WATER INLET
1 1/2"
ED-800/R1



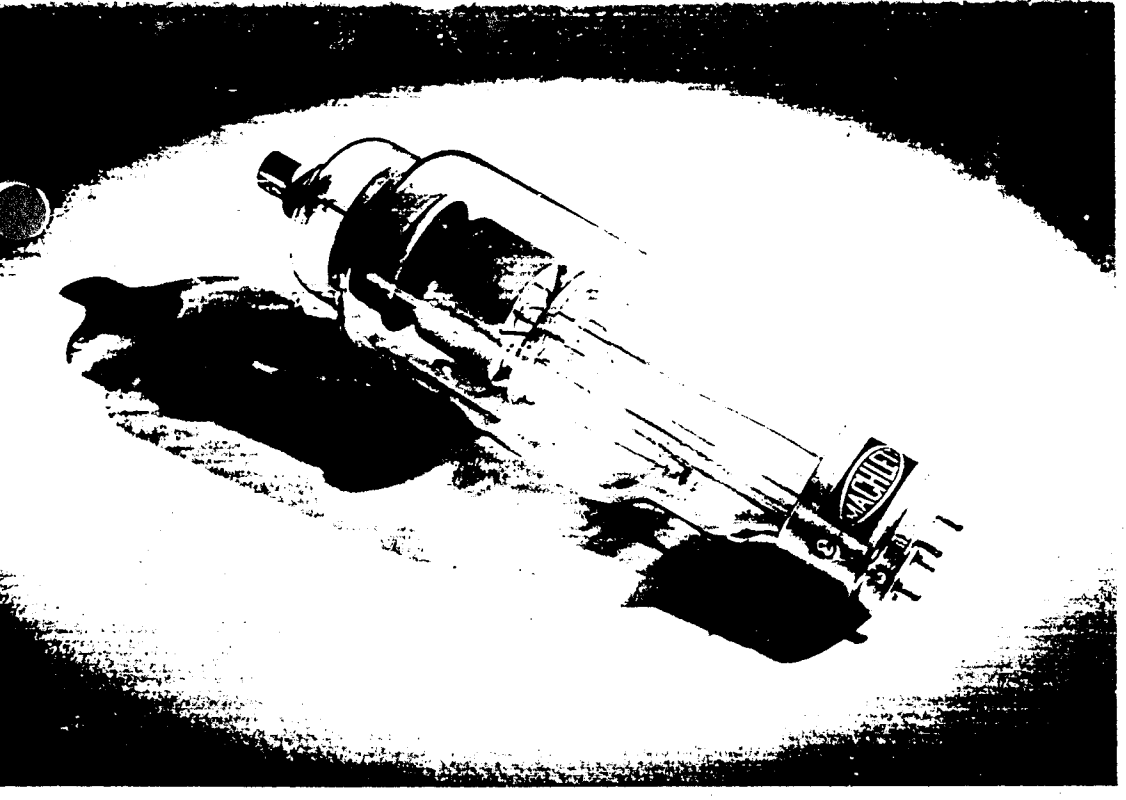
DIMENSIONS — ML-5682



DIMENSIONS — ML-5682K

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.
ST-1026 3.5M 6-67



MACHLETT

ML-575A
ML-673

DESCRIPTION & RATINGS

DESCRIPTION

The ML-575A and ML-673 are two-electrode, mercury-vapor tubes designed specifically for use as half-wave rectifiers. Rugged structure and low internal voltage drop contribute to reliability and efficient performance in radio frequency heating applications as well as in radio transmitting service. The filamentary type cathode is oxide coated and is designed to withstand the effects of sagging and vibration. The large cathode shield provides improved thermal radiation from the filament and protects the filament from extraneous electrostatic fields. Both tubes are identical with respect to characteristics, differing only in the types of bases provided. Maximum ratings of 15 PKV inverse anode voltage and 1.5 amperes average cathode current for in-phase operation apply at frequencies of 25 to 150 cycles per second.

GENERAL CHARACTERISTICS

Electrical

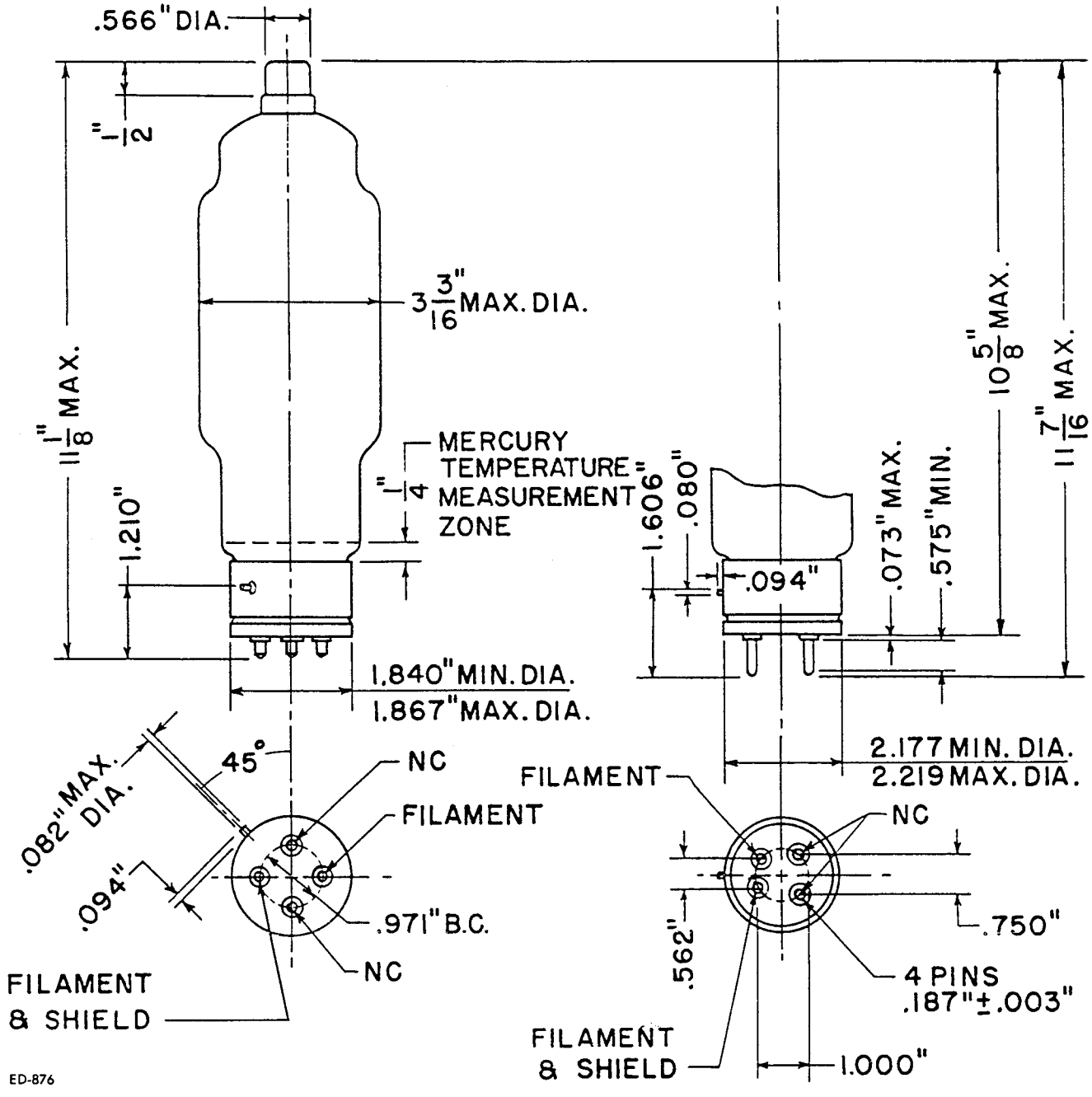
Filament Voltage	5.0	Volts
Filament Current at 5.0 Volts	10.0	Amps
Cathode Heating Time, minimum (Before applying Plate Voltage)	30	Secs
Tube Voltage Drop, approximate	10	Volts

Mechanical

Mounting Position	Vertical, Base Down	
Type of Cooling	Convection	
Condensed Mercury Temperature Rise to Equilibrium, approximate		
No Load	12	°C
Full Load	20	°C
Base, ML-575A	Jumbo, 4-Pin Bayonet, JEDEC No. A4-29	
ML-673	Super-Jumbo, 4-Pin Bayonet, JEDEC No. A4-18	
Cap	Medium Metal, JEDEC No. C1-5	
Net Weight, approximate	13	Oz.

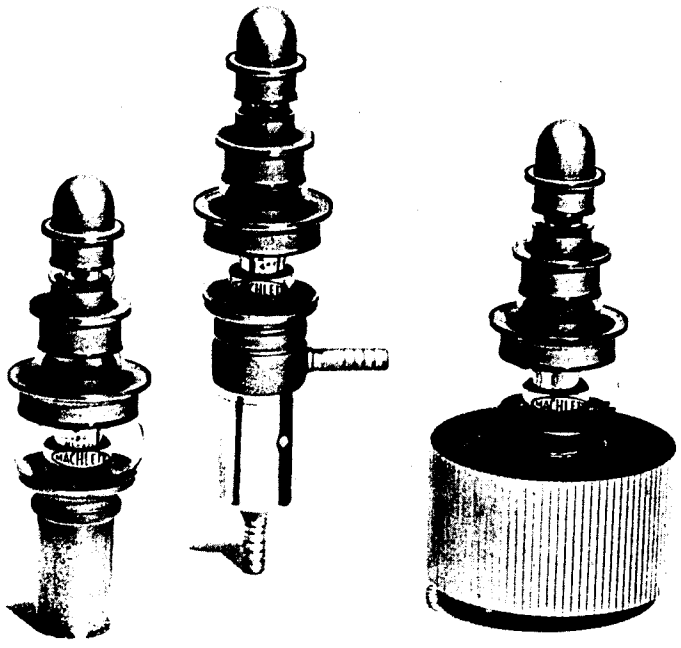
MAXIMUM RATINGS

Maximum Peak Inverse Anode Voltage			
150 cycles per second or less	10000	15000	Volts
Condensed Mercury Temperature Range	+20 to +60	+20 to +50	°C
Maximum Cathode Current			
Peak			
Quadrature Operation	10.0	10.0	Amps
In Phase Operation	7.0	6.0	Amps
Average			
Quadrature Operation	2.5	2.5	Amps
In Phase Operation	1.75	1.5	Amps
Fault (Maximum Duration 0.1 Second)	100	100	Amps
Maximum Averaging Time	20	20	Secs
Maximum Frequency	150	150	cps



ML-575A ML-673

THE MACHLETT LABORATORIES, INC.
a division of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT
U. S. A.



MACHLETT

ML-6256
ML-6257
ML-6258

DESCRIPTION & RATINGS

DESCRIPTION

The ML-6256, ML6257, and ML-6258 are three-electrode tubes designed for induction and dielectric heating and FM broadcasting service. These tubes feature coaxial-electrode structures, ideal for circuits of the coaxial-cylinder type, and provide large-area, low inductance r-f electrode terminals. They are particularly suitable for cathode-drive operation. The ML-6256 and ML-6257 have water-cooled anodes capable of dissipating 5 kW with a water flow of 3 gpm; the ML-6257 incorporates a water jacket as an integral part of the anode structure. The anode of the ML-6258 is forced-air cooled and is capable of dissipating 3 kW with an air flow of approximately 190 cfm. The cathode of each type is a thoriated-tungsten filament. Maximum ratings apply up to 40 Mc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		12.6 Volts
Filament Current		29 Amps
Filament Starting Current, maximum		120 Amps
Filament Cold Resistance		.0053 Ohm
Amplification Factor		20
Direct Interelectrode Capacitances	ML-6256 & ML-6257	ML-6258
Grid-Plate	19	20 uuf
Grid-Filament	18	18 uuf
Plate-Filament	0.6	0.7 uuf

Mechanical

Mounting Position	
ML-6256 & ML-6257	Vertical, anode down
ML-6258	Vertical, anode up or down
Type of Cooling — ML-6256 & ML-6257	Water and forced-air*
Water Flow on Anode for 5 kW Dissipation	3-5 gpm
Maximum Outgoing Water Temperature	70 °C
Type of Cooling — ML-6258	Forced-air
Air Flow on Anode for 3 kW Dissipation	190 cfm at 1.2" water
Air Flow on Glass and Seals	See Note
Maximum Incoming Air Temperature	45 °C
Maximum Glass Temperature	165 °C
Net Weight, approximate	
ML-6256	1.5 lbs.
ML-6257	1.75 lbs.
ML-6258	5.25 lbs.

*Note: At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient to cool the glass portions of the tube. At higher frequencies or high ambient temperatures, auxilary air flow in the order of 10 cfm may be required and should be distributed to maintain uniform glass temperature, not greater than 165°C, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

R-F Power Amplifier and Oscillator—Class C

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

	ML-6256 & ML-6257	ML-6258	
D-C Plate Voltage	6000	6000	volts
D-C Grid Voltage	−1500	−1500	volts
D-C Plate Current	1.5	1.5	amps
D-C Grid Current	200	200	mA
Plate Input	7	7	kW
Plate Dissipation	5	3	kW

Typical Operation (Values apply to all three tube types)

R-F Oscillator, Grid-Drive Circuit

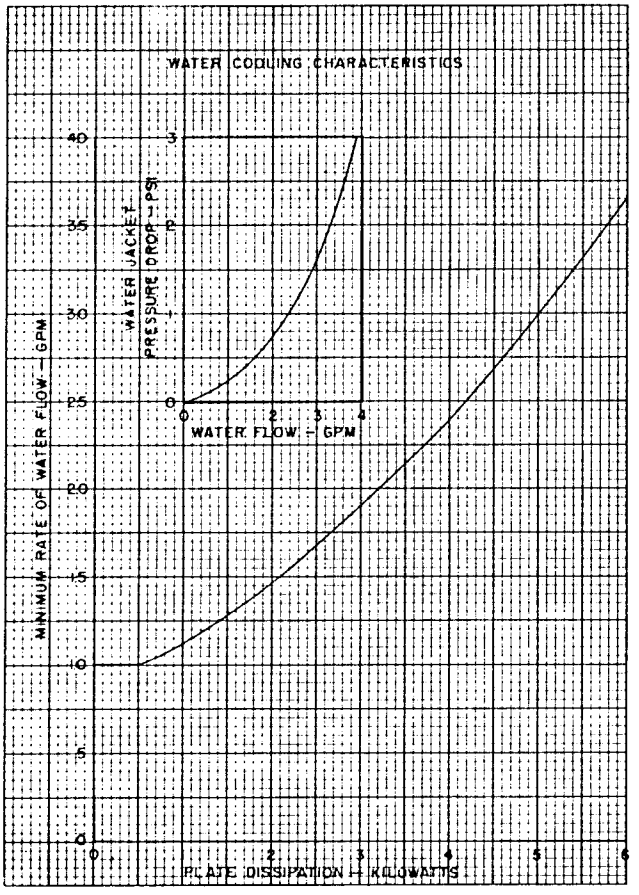
D-C Plate Voltage	4200	5300	volts
D-C Grid Voltage	-400	-500	volts
Peak R-F Grid Voltage	720	850	volts
Peak R-F Plate Voltage	3100	4000	volts
D-C Plate Current	1.1	1.3	amps
D-C Grid Current	110	110	mA
R-F Load Resistance	1600	1750	ohms
Power Output, approximate	3.0	4.5	kW

R-F Amplifier, Cathode-Drive Circuit — 110 Mc

D-C Plate Voltage		5000	volts
D-C Grid Voltage		-500	volts
Peak R-F Grid Voltage		870	volts
Peak R-F Plate Voltage		3900	volts
D-C Plate Curernt		1.3	amps
D-C Grid Current		150	mA
R-F Load Resistance		2050	ohms
Driving Power, approximate		1100	watts
Power Output, approximate*		5.5	kW

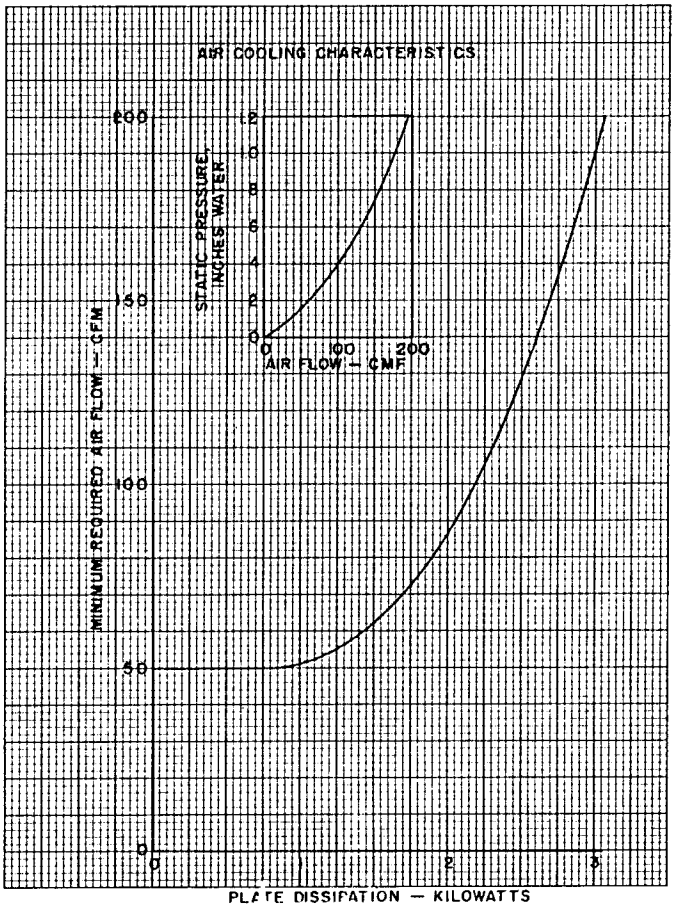
‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.
*Includes power transferred from driver stage.

ML-6256 & ML-6257



A-13042/R1

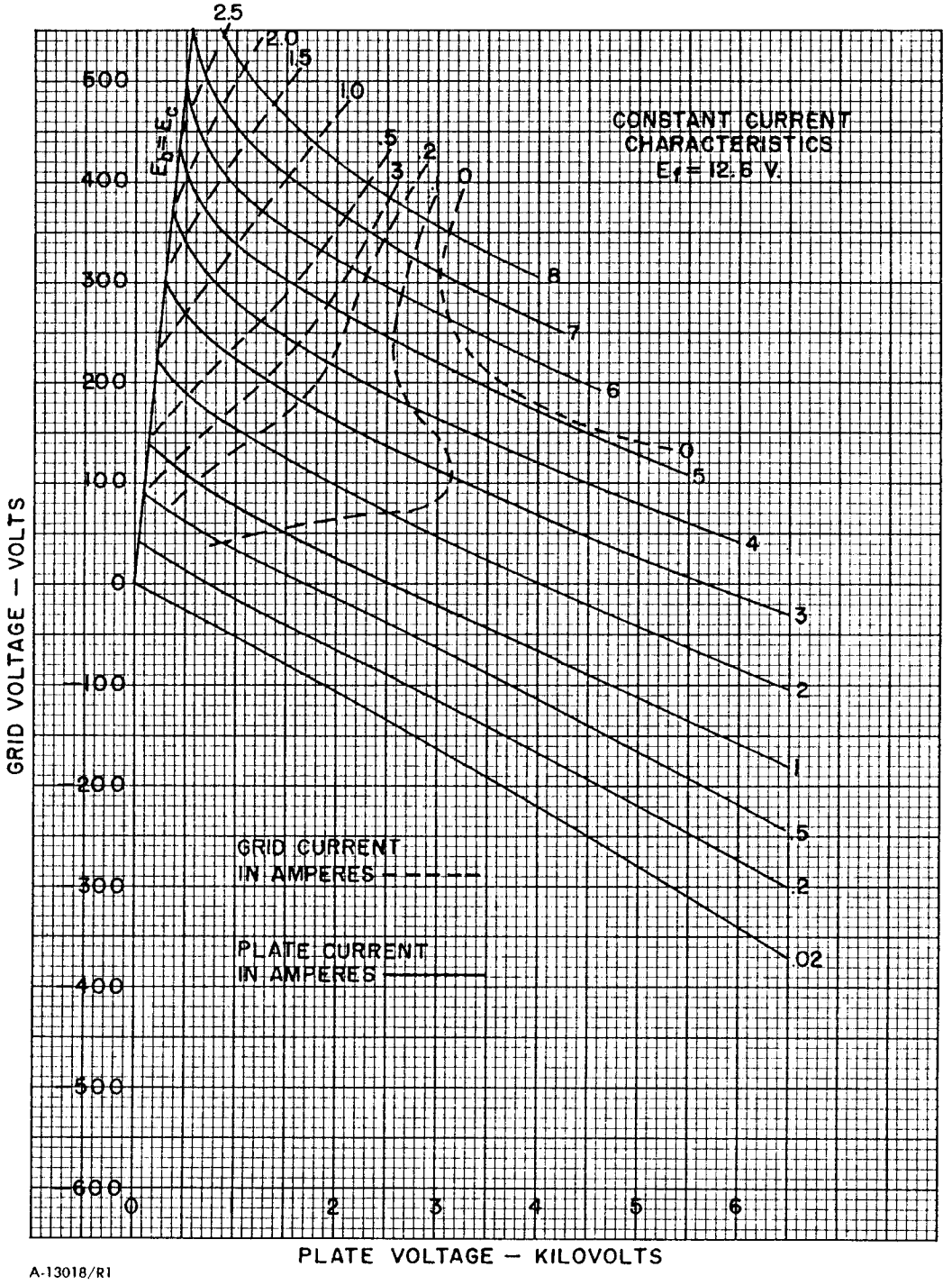
ML-6258

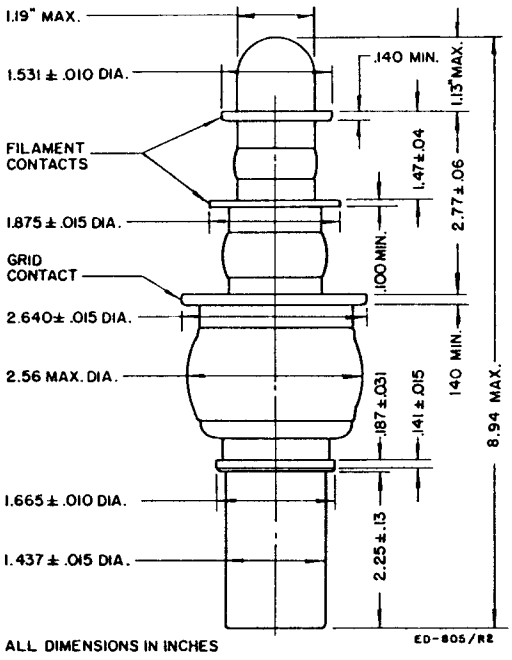


A-13038

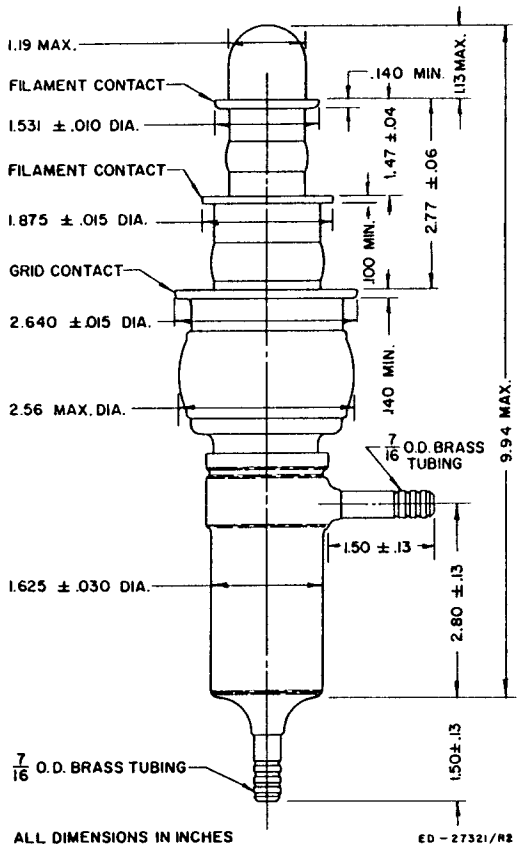
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits		
			Minimum	Bogey	Maximum
Grid Voltage	e_b = 1000 volts; i_b = 6 amps	e_c:	——	——	470 volts
Grid Current	e_b = 1000 volts; i_b = 6 amps	i_c:	——	——	1.6 amps
Plate Voltage	E_c = 0 Vdc; I_b = 0.5 Adc	E_b:	1.4	1.9	2.2 kVdc
Plate Voltage	E_c = -100 Vdc; I_b = 0.5 Adc	E_b:	3.4	3.9	4.4 kVdc
Grid Voltage	E_b = 5.0 kVdc; I_b = 0.02 Adc	E_c:	-220	-270	-320 Vdc
Plate Power Output	E_b = 5.3 kVdc; E_c = -500 Vdc I_b = 1.3 Adc; I_c = 110 mAdc	P_o:	3.9	——	—— kW

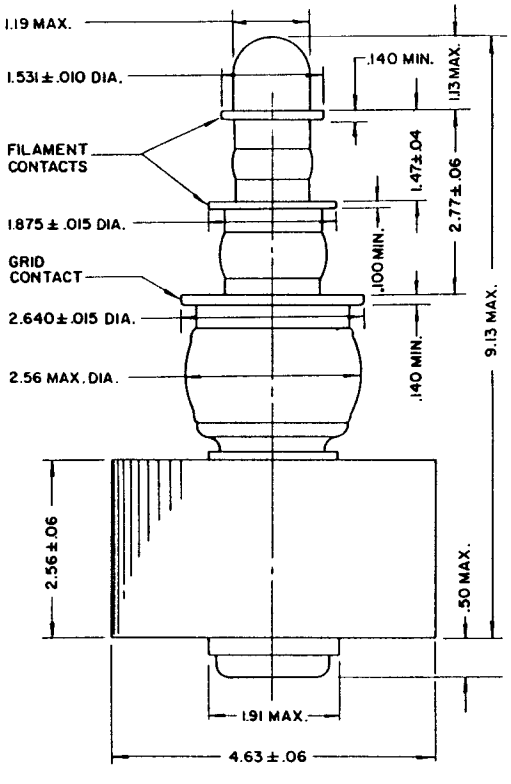




DIMENSIONS — ML-6256



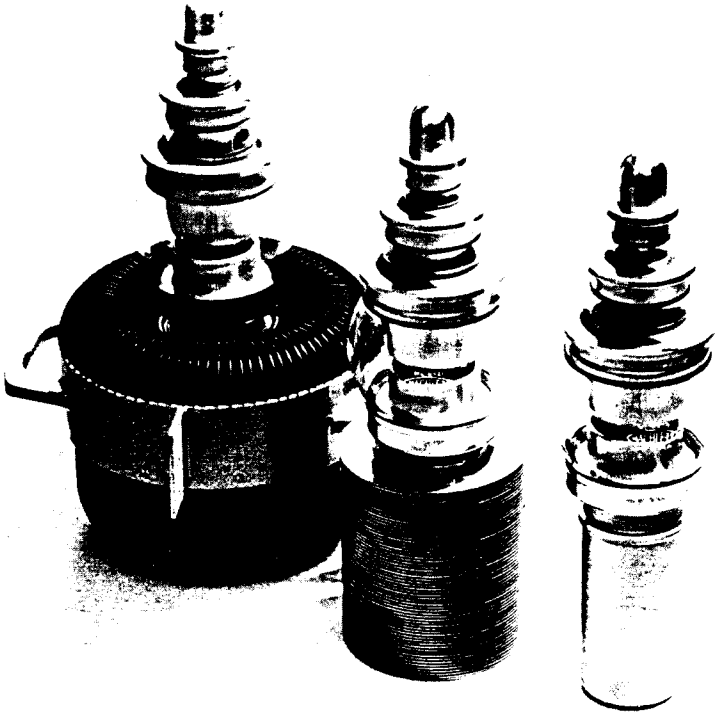
DIMENSIONS — ML-6257



DIMENSIONS — ML-6258

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MACHLETT

ML-6420
ML-6421
ML-6421-F

DESCRIPTIONS & RATINGS

DESCRIPTION

The ML-6420 and ML-6421 are general purpose three-electrode tubes designed specifically for 7.5-10 kW industrial heating service and for AM broadcasting. These tubes feature coaxial mounting structures providing high-dissipation, low-inductance r-f electrode terminals. The cathode of each type is a sturdy, self-supporting, stress-free, thoriated-tungsten filament. The ML-6420 has a water-cooled, heavy-wall anode capable of dissipating 12.5 kW with 5 gpm water flow. The ML-6421 has a forced-air-cooled, heavy-wall anode and high-efficiency aluminum disc-fin anode cooler capable of dissipating 10 kW with an air flow of approximately 475 cfm*. Maximum ratings of 10 kVdc plate voltage and 20 kW plate input apply at frequencies up to 30 Mc. These tubes are rated for service up to 70 Mc with plate voltage and plate input reduced according to the table on page 2.

The ML-6421-F includes the features of the ML-6421 except for the conventional copper fin cooler which is mechanically interchangeable with the type 5667. It is rated for 7.5 kW dissipation with an air flow of approximately 550 cfm.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		7.0 Volts
Filament Current		85 Amps
Filament Starting Current, maximum		400 Amps
Filament Cold Resistance		0.0095 Ohms
Amplification Factor		20
	ML-6420 ML-6421	**ML-6421-F**
Interelectrode Capacitances:		
Grid-Plate	20	21 uuf
Grid-Filament	30	30 uuf
Plate-Filament	1.8	2.1 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling — ML-6420	Water and forced-air†
Water flow on anode, minimum for 12.5 kW dissipation	5 gpm
Maximum outgoing water temperature	70 C
Type of Cooling — ML-6421, ML-6421-F	Forced-air
Air flow on anode	
ML-6421*, minimum for 10 kW dissipation	Pressure: 475 cfm at 3.5" water Exhaust: 550 cfm at 3.5" water
ML-6421-F, minimum for 7.5 kW dissipation	550 cfm
Maximum incoming air temperature	50 °C
Maximum Glass Temperature	165 °C†
Net Weight, approximately	
ML-6420	8 lbs.
ML-6421	11.5 lbs.
ML-6421-F	30 lbs.

*When used with Machlett ML-6421 Air Distributor, F-17796.

†At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient to cool glass portions of tube. At higher frequencies or high ambient temperatures, auxiliary air flow of 25-50 cfm may be required and should be distributed to maintain uniform glass temperature, not greater than 165°C, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO ALL THREE TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	10000 volts
Max.-Signal D-C Plate Current*	2.2 amps
Max.-Signal Plate Input*	20 kW
Plate Dissipation*	
ML-6420	12.5 kW
ML-6421	10.0 kW
ML-6421-F	7.5 kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	4500	9000 volts
D-C Grid Voltage	−220	−400 volts
Peak A-F Grid-to-Grid Voltage	1500	1750 volts
Peak A-F Plate-to-Plate Voltage	6600	15600 volts
Zero-Signal D-C Plate Current	0.05	0.4 amp
Max.-Signal D-C Plate Current	4.0	3.7 amps
Effective Load Resistance, Plate-to-Plate	2000	5400 ohms
Max.-Signal Driving Power, approximate	290	210 watts
Max.-Signal Power Output, approximate	10.8	23 kW

*Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	10000 volts
D-C Plate Current	1.8 amps
Plate Input	
ML-6420	18 kW
ML-6421	15 kW
ML-6421-F	11 kW
Plate Dissipation	
ML-6420	12.5 kW
ML-6421	10.0 kW
ML-6421-F	7.5 kW

Typical Operation

D-C Plate Voltage	9000 volts
D-C Grid Voltage	−390 volts
Peak R-F Grid Voltage	445 volts
Peak R-F Plate Voltage	3800 volts
D-C Plate Current	1.0 amp
D-C Grid Current	0 mA
R-F Load Resistance	2400 ohms
Driving Power, approximate§	100 watts
Power Output, approximate	3.0 kW

§At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	8000 volts
D-C Grid Voltage	−1600 volts
D-C Plate Current	1.8 amps
D-C Grid Current	0.40 amp
Plate Input	12 kW
Plate Dissipation	
ML-6420	8.3 kW
ML-6421	6.7 kW
ML-6421-F	5.0 kW

Typical Operation

D-C Plate Voltage	6000 volts
D-C Grid Voltage	−800 volts
Peak R-F Grid Voltage	1320 volts
Peak R-F Plate Voltage	5200 volts
D-C Plate Current	1.25 amps
D-C Grid Current	0.21 amp
R-F Load Resistance	2300 ohms
Driving Power, approximate	270 watts
Power Output, approximate	5.9 kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation†

Maximum Ratings, Absolute Values

D-C Plate Voltage	10000 volts
D-C Grid Voltage	−1600 volts
D-C Plate Current	2.2 amps
D-C Grid Current	0.42 amp
Plate Input	20 kW
Plate Dissipation	
ML-6420	12.5 kW
ML-6421	10.0 kW
ML-6421-F	7.5 kW

Typical Operation

D-C Plate Voltage	8000	8000	9000 volts
D-C Grid Voltage	−700	−700	−750 volts
Peak R-F Grid Voltage	1080	1330	1350 volts
Peak R-F Plate Voltage	7000	6500	7600 volts
D-C Plate Current	1.0	2.15	2.0 amps
D-C Grid Current	0.08	0.20	0.18 amp
R-F Load Resistance	4000	1700	2200 ohms
Driving Power, approximate	100	260	240 watts
Power Output, approximate	6.1	12.3	13.2 kW

†Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

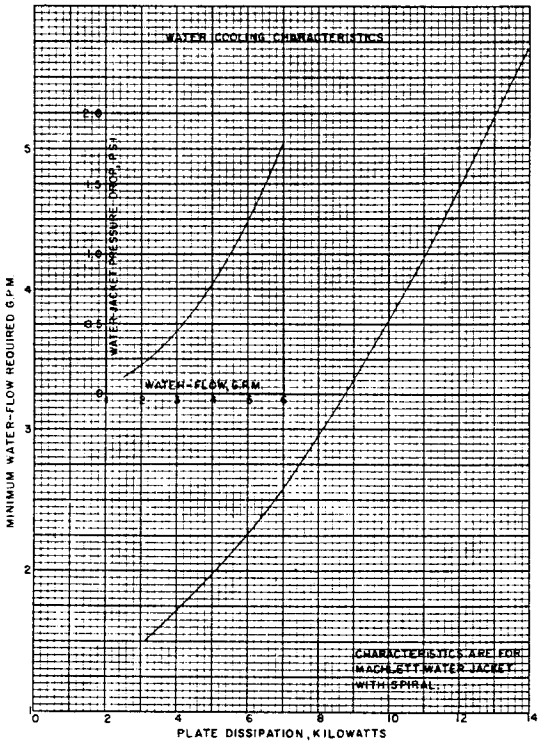
Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum
Grid Voltage	e_b = 1300 volts; i_b = 9.0 amps	e_c:	——	——	850 volts
Grid Current	e_b = 1300 volts; i_b = 9.0 amps	i_c:	——	——	3.0 amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.0 Adc	E_b:	2.5	2.9	3.3 kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 1.0 Adc	E_b:	6.2	6.9	7.6 kVdc
Grid Voltage	E_b = 10.0 kVdc; I_b = 0.02 Adc	E_c:	−470	−540	−610 Vdc
Plate Power Output	E_b = 9.0 kVdc; E_c = −750 Vdc; I_b = 2.0 Adc; I_c = 0.18 Adc	P_o:	11	——	—— kW

MAXIMUM FREQUENCY RATINGS

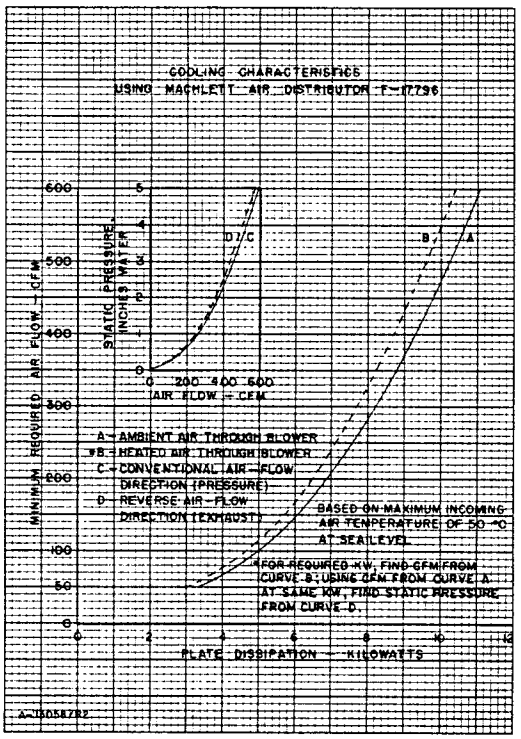
Maximum ratings apply up to 30 Mc except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation on the right (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequiencies.

Frequency	30	50	70 Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60

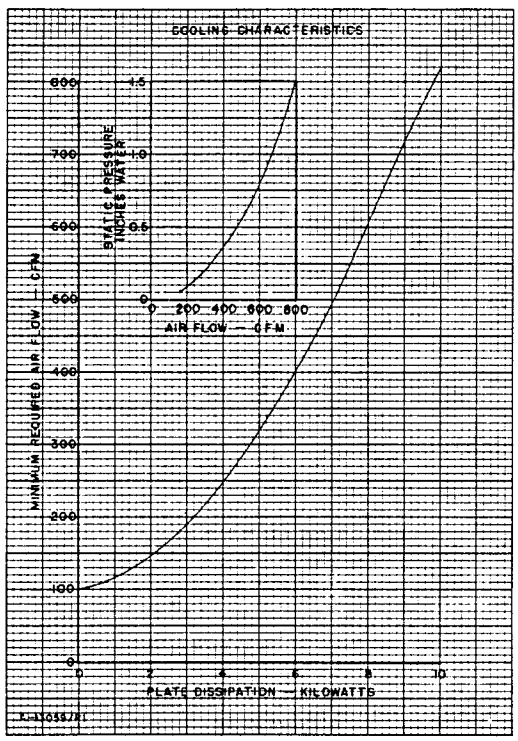
ML-6420

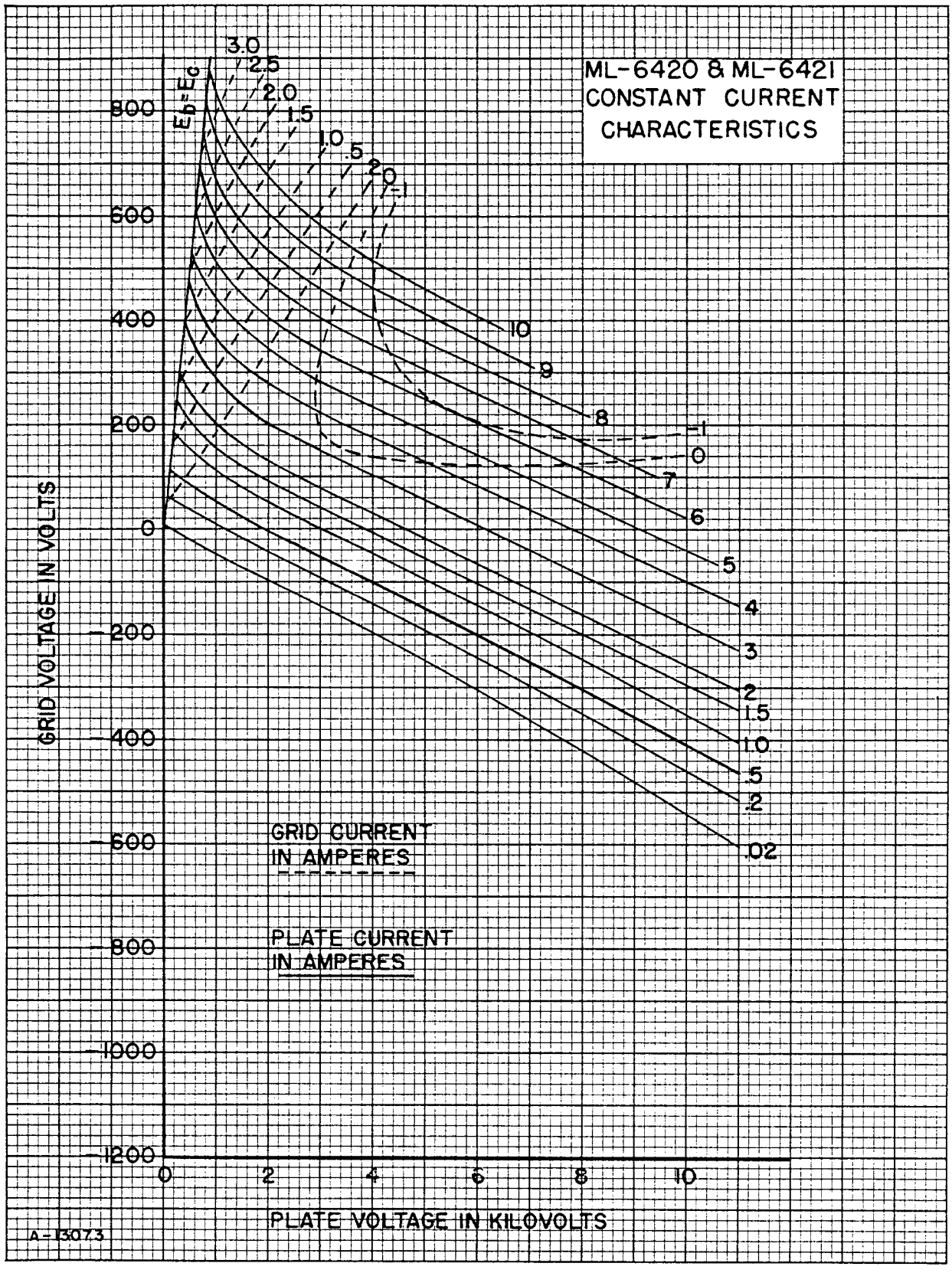


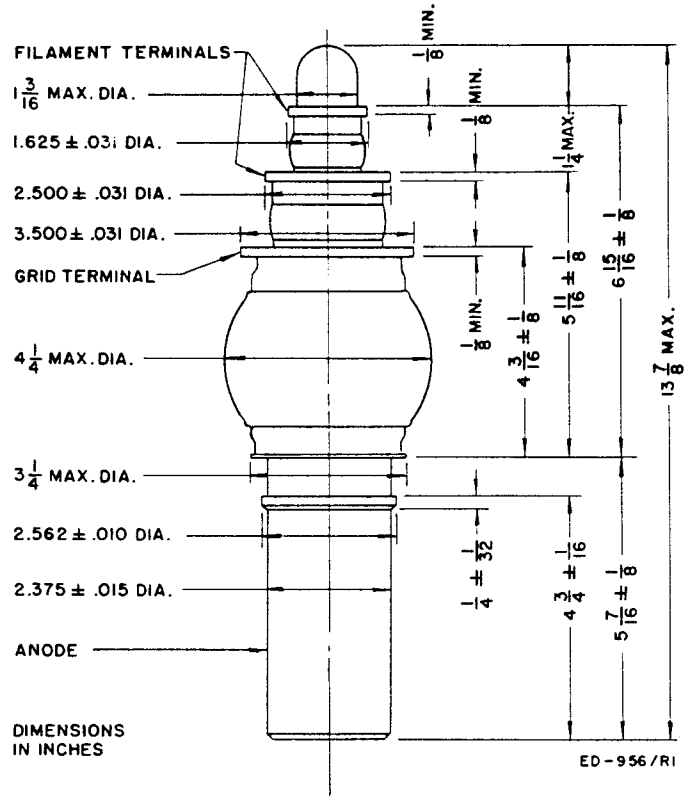
ML-6421



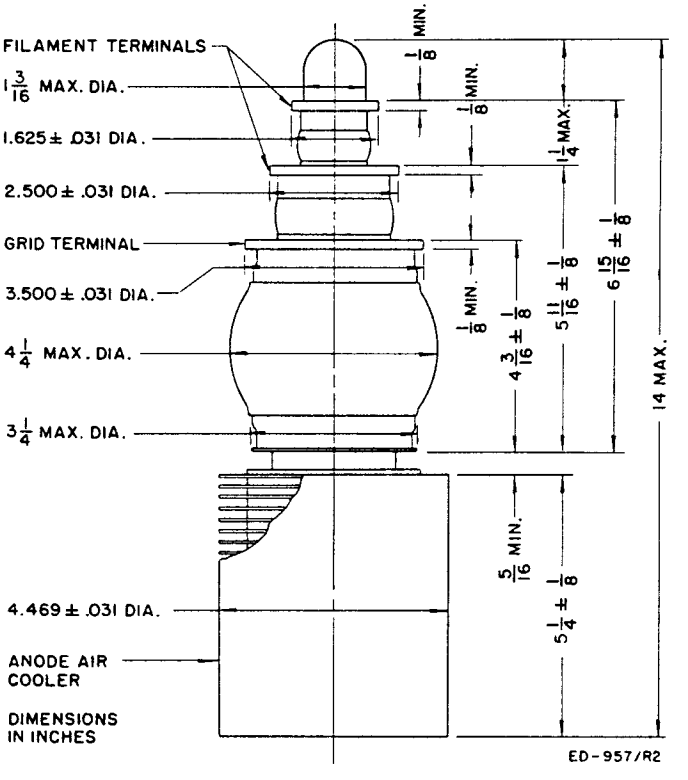
ML-6421-F



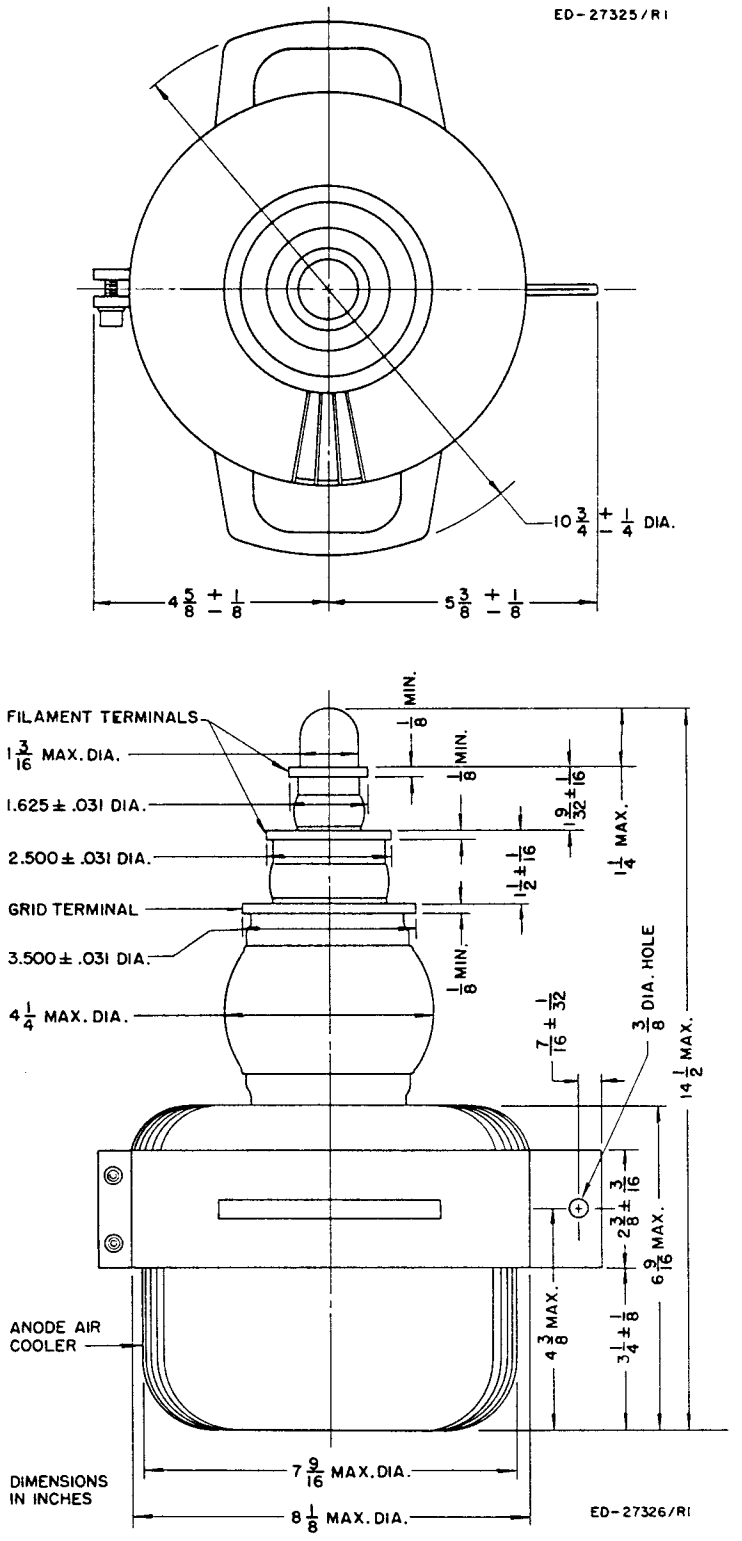

ML-6420 & ML-6421
CONSTANT CURRENT
CHARACTERISTICS
Eb=Ec
3.0
2.5
2.0
1.5
1.0
.5
.2
0
-1
10
9
8
7
6
5
4
3
2
1.5
1.0
.5
.2
.02
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
GRID VOLTAGE IN VOLTS
GRID CURRENT
IN AMPERES
PLATE CURRENT
IN AMPERES
0
2
4
6
8
10
PLATE VOLTAGE IN KILOVOLTS
A-13073



DIMENSIONS — ML-6420



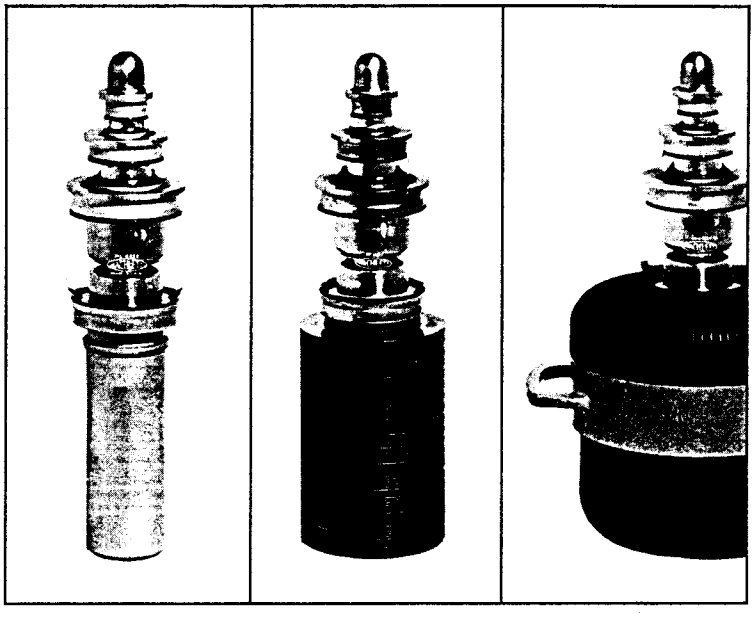
DIMENSIONS — ML-6421



DIMENSIONS — ML-6421-F

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PRINTED IN U.S.A.



ISSUED 5-64

ML-6422
ML-6423
ML-6423F

General Purpose Triodes
18 kW CW
900 kw Pulse Power

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-6422 and ML-6423 are general-purpose high-mu triodes suitable for industrial heating, AM broadcasting and pulse modulation. These tubes feature coaxial mounting structures providing high-dissipation, low-inductance rf electrode terminals. The cathode of each type consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments.

The ML-6422 has a water-cooled, heavy-wall anode capable of dissipating 20 kW. The ML-6423 has a forced-air-cooled, heavy-wall anode with high-efficiency disc fins. The ML-6423-F has an anode fin construction which fits tube supports used with types 892-R, 5699, etc.

These tubes will operate with plate voltages up to 12.5 kV in CW operation or 35 kV in pulse modulator service. Maximum ratings apply at frequencies up to 30 Mc. Useful power output can be obtained at frequencies up to 70 Mc with reduced ratings. In a typical pulse modulator application these tubes are capable of switching 900 kW.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		7.0	Volts
Filament Current		85	Amps
Filament Starting Current, maximum		400	Amps
Filament Cold Resistance		0.0095	Ohms
Amplification Factor		90	
Interelectrode Capacitances:	ML-6422 ML-6423	ML-6423-F	
Grid-Plate	25	26	$\mu\mu f$
Grid-Filament	32	32	$\mu\mu f$
Plate-Filament	1.5	1.9	$\mu\mu f$

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling — ML-6422	Water and forced-air†	
Water flow on anode, minimum for 20 kW dissipation	7	gpm
Maximum outgoing water temperature	70	°C
Type of Cooling — ML-6423, ML-6423-F	Forced-air	
Air flow on anode		
ML-6423, minimum for 12.5 kW dissipation	Pressure: 710 cfm at 4.7″ water*	
ML-6423-F, minimum for 10 kW dissipation	Exhaust: 815 cfm at 5.1″ water*	
	750	cfm
Maximum incoming air temperature	50	°C
Maximum Glass Temperature	165	°C†
Net Weight, approximately		
ML-6422	10	lbs.
ML-6423	15	lbs.
ML-6423-F	50	lbs.

*When used with Machlett ML-6423 Air Distributor F-17797.

†At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient to cool glass portion of tube. At higher frequencies or high ambient temperatures, auxiliary air flow of 25-50 cfm may be required and should be distributed to maintain uniform glass temperature, not greater than 165°C, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO ALL THREE TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values		
D-C Plate Voltage	12500	volts
Max.-Signal D-C Plate Current*	2.5	amps
Max.-Signal Plate Input*	30	kW
Plate Dissipation*		
ML-6422	20	kW
ML-6423	12.5	kW
ML-6423-F	10	kW

Typical Operation (Values are for two tubes)			
D-C Plate Voltage	9000	10000	volts
D-C Grid Voltage	−50	−50	volts
Peak A-F Grid to Grid Voltage	1040	1120	volts
Peak A-F Plate to Plate Voltage	14800	16000	volts
Zero Signal D-C Plate Current	0.4	0.4	amp
Max.-Signal D-C Plate Current	4.0	4.6	amps
Effective Load Resistance, Plate to Plate	4700	4400	ohms
Max.-Signal Driving Power, approximate	160	170	watts
Max.-Signal Power Output, approximate	23	29	kW

*Average over any audio-frequency cycle of sine wave form.

Radio Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	12500	volts
D-C Plate Current	1.8	amp
Plate Input		
ML-6422	22	kW
ML-6423	19	kW
ML-6423-F	15	kW
Plate Dissipation		
ML-6422	20	kW
ML-6423	12.5	kW
ML-6423-F	10	kW

Typical Operation		
D-C Plate Voltage	12000	volts
D-C Grid Voltage	−80	volts
Peak R-F Grid Voltage	235	volts
Peak R-F Plate Voltage	5200	volts
D-C Plate Current	0.74	amp
D-C Grid Current	0	mA
R-F Load Resistance	4500	ohms
Driving Power, approximate§	40	watts
Power Output, approximate	3.0	kW

§At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	9000	volts
D-C Grid Voltage	−1400	volts
D-C Plate Current	1.8	amps
D-C Grid Current	0.50	amp
Plate Input	16	kW
Plate Dissipation		
ML-6422	13	kW
ML-6423	8	kW
ML-6423-F	7	kW

Typical Operation		
D-C Plate Voltage	9000	volts
D-C Grid Voltage	−600	volts
Peak R-F Grid Voltage	985	volts
Peak R-F Plate Voltage	8000	volts
D-C Plate Current	0.85	amp
D-C Grid Current	0.14	amp
R-F Load Resistance	6500	ohms
Driving Power, approximate	135	watts
Power Output, approximate	6.3	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation†

Maximum Ratings, Absolute Values				
D-C Plate Voltage	12500			volts
D-C Grid Voltage	−1400			volts
D-C Plate Current	2.5			amps
D-C Grid Current	0.50			amp
Plate Input	30			kW
Plate Dissipation				
ML-6422	20			kW
ML-6423	12.5			kW
ML-6423-F	10			kW

Typical Operation				
D-C Plate Voltage	10000	10000	12000	volts
D-C Grid Voltage	−400	−400	−400	volts
Peak R-F Grid Voltage	900	1050	970	volts
Peak R-F Plate Voltage	8500	8200	10200	volts
D-C Plate Current	1.6	2.4	2.1	amps
D-C Grid Current	0.18	0.29	0.20	amp
R-F Load Resistance	3000	2000	2900	ohms
Driving Power, approximate	160	300	200	watts
Power Output, approximate	11.9	17.1	18.2	kW

†Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 1400 volts; i_b = 9.0 amps	e_c:	——	——	800	volts
Grid Current	e_b = 1400 volts; i_b = 9.0 amps	i_c:	——	——	4.0	amps
Plate Voltage	E_c = 0 Vdc; I_b = 0.50 Adc	E_b:	6.6	7.4	8.2	kVdc
Plate Voltage	E_c = −50 Vdc; I_b = 0.50 Adc	E_b:	10.7	11.9	13.1	kVdc
Grid Voltage	E_b = 12.0 kVdc; I_b = 0.02 Adc	E_c:	−100	−130	−160	Vdc
Plate Power Output	E_b = 12.0 kVdc; I_b = 2.1 Adc E_c = −400 Vdc; I_c = 0.20 Adc	P_o:	15.5	——	——	kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 Mc except as noted. These tubes may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation on the right (other maximum ratings are the same as shown above.) Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	30	50	70 Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60

Pulse Modulator or Pulse Amplifier ‡

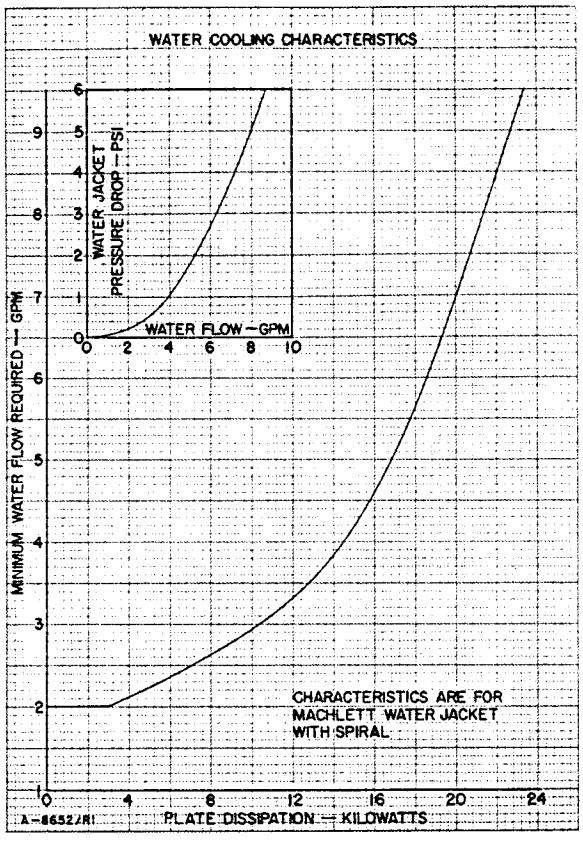
Maximum Ratings, Absolute Values		
D-C Plate Voltage	35	kV
Peak Plate Voltage	35	kv
Peak Negative Grid Voltage	−3500	volts
Pulse Cathode Current	35	amps
Grid Dissipation	300	watts
Plate Dissipation	12.5	kW
Pulse Duration, approximate*	1000	μsec
Duty Factor*	0.03	
Typical Operation		
D-C Plate Voltage	35	kV
D-C Grid Voltage	−500	volts
Pulse Positive Grid Voltage	1900	volts
Pulse Plate Current	30	amps
Pulse Grid Current	4.5	amps
Pulse Driving Power	11	kw
Pulse Power Output	900	kw
Plate Output Voltage	30	kv

‡When ordering for this application add the suffix "P" to the Machlett tube number.

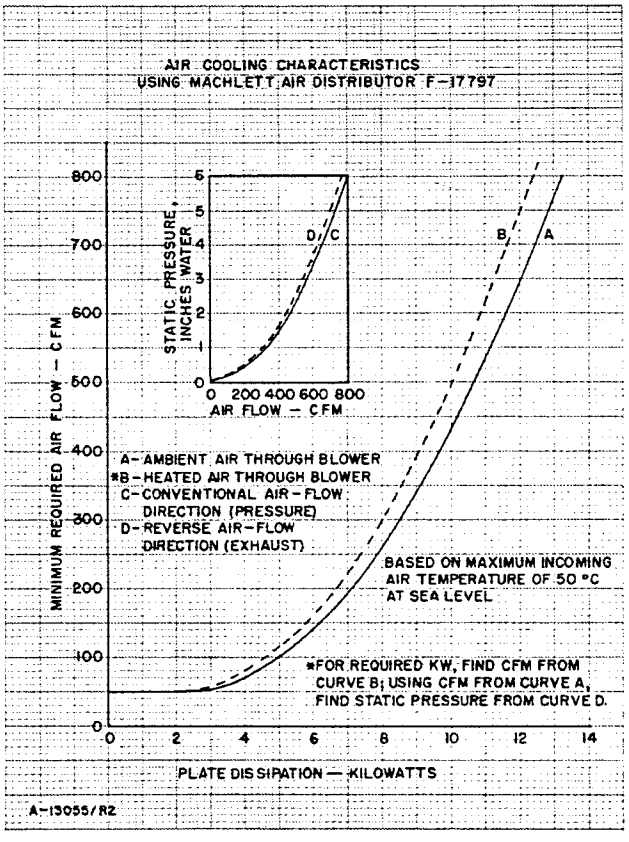
*For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

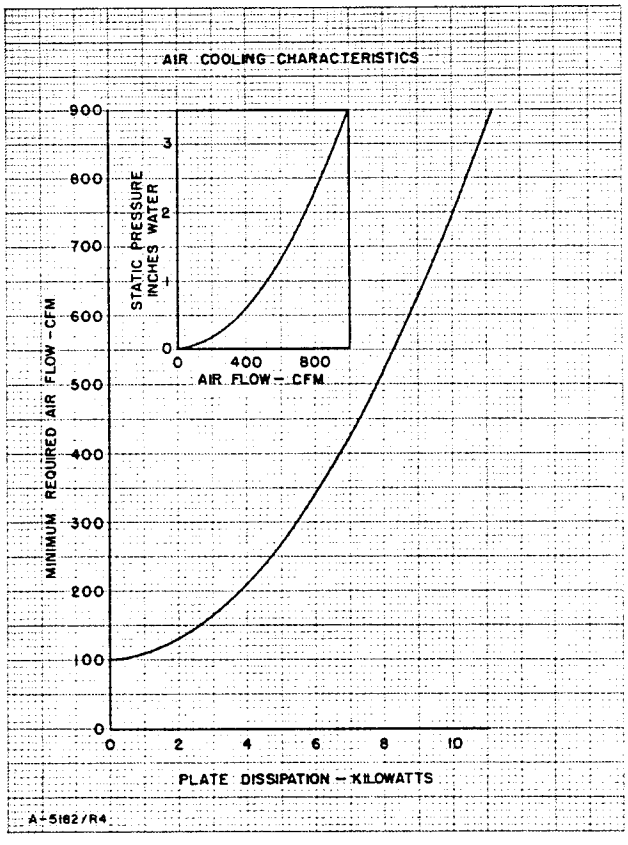
COOLING CHARACTERISTICS — ML-6422

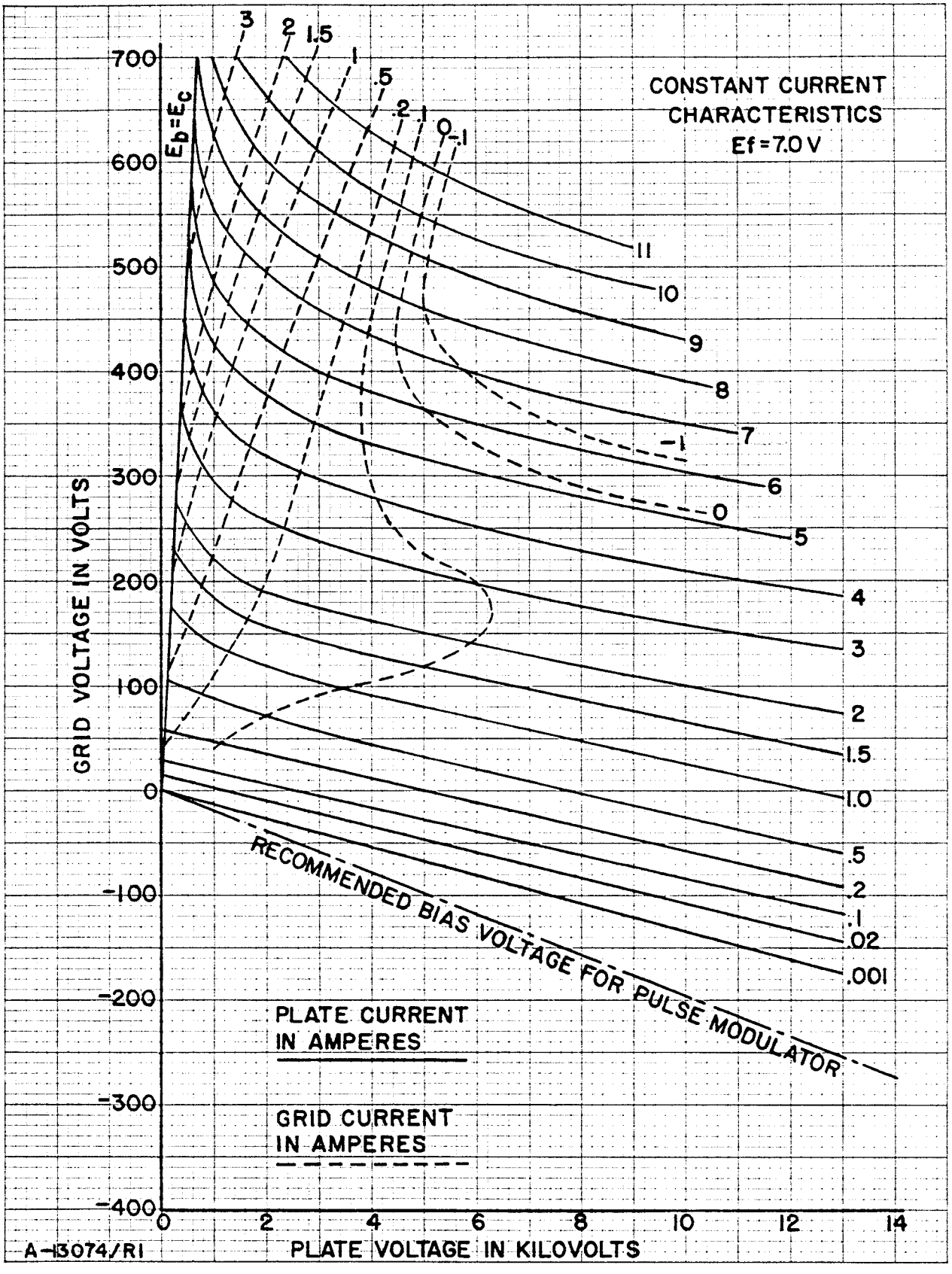


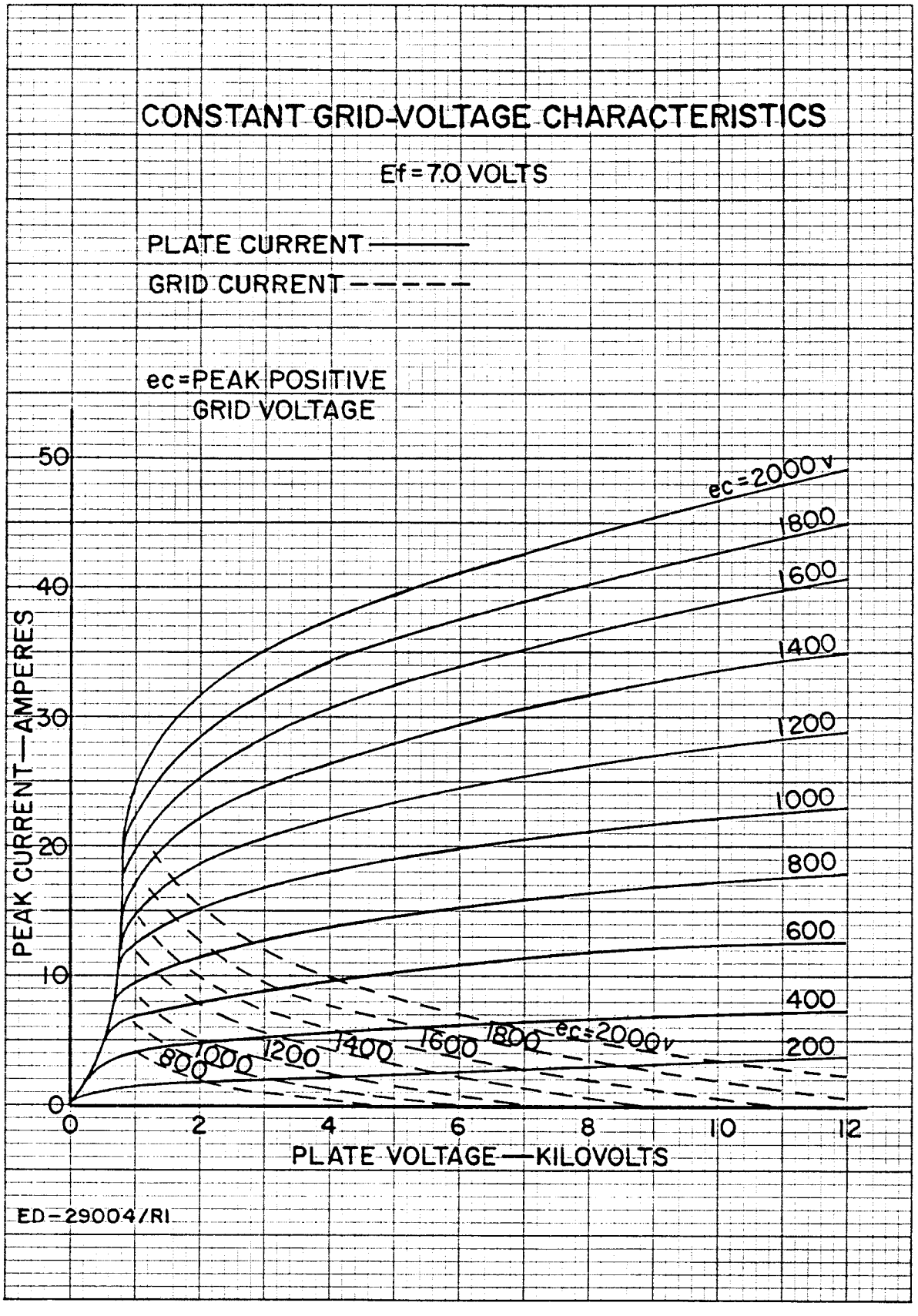
COOLING CHARACTERISTICS — ML-6423

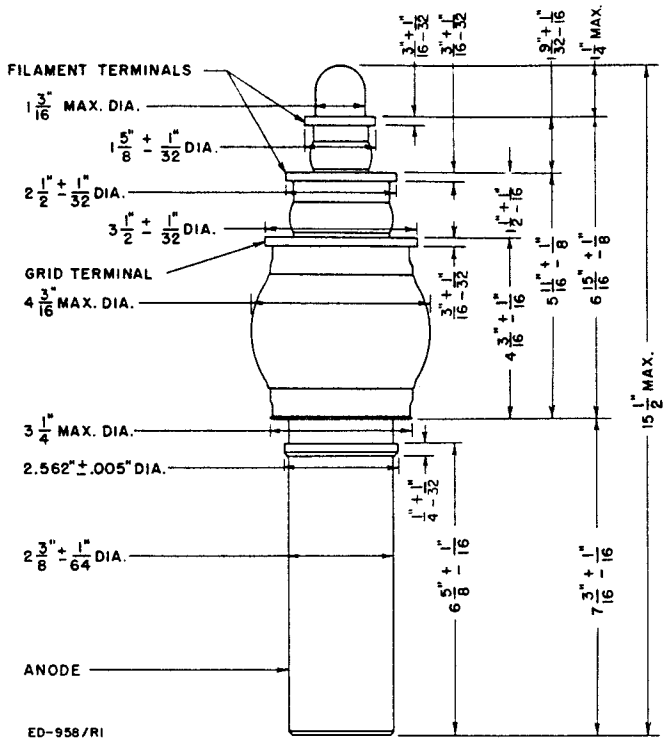


COOLING CHARACTERISTICS — ML-6423-F

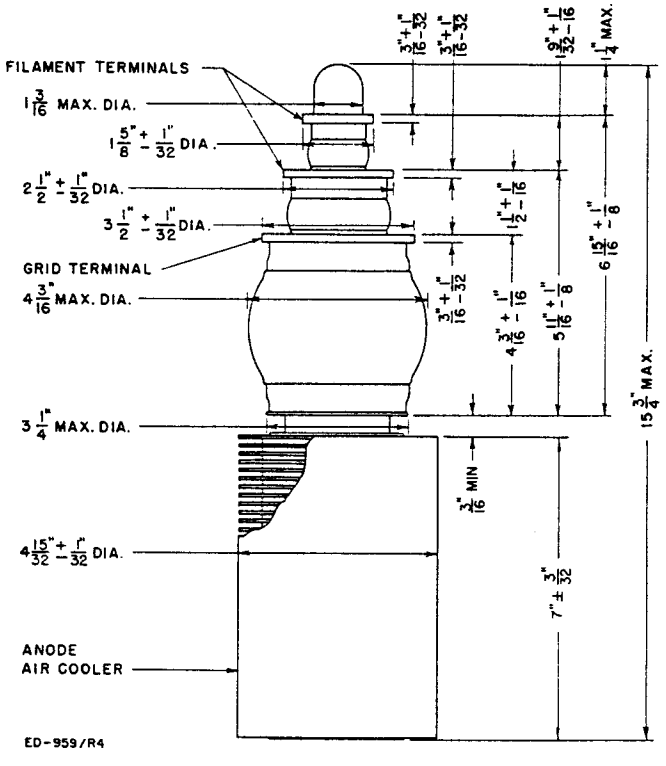



CONSTANT CURRENT
CHARACTERISTICS
Ef = 7.0 V
Eb=Ec
3
2
1.5
1
.5
.2
.1
0
-.1
11
10
9
8
7
6
5
4
3
2
1.5
1.0
.5
.2
.1
.02
.001
-1
0
RECOMMENDED BIAS VOLTAGE FOR PULSE MODULATOR
PLATE CURRENT
IN AMPERES
GRID CURRENT
IN AMPERES
GRID VOLTAGE IN VOLTS
700
600
500
400
300
200
100
0
-100
-200
-300
-400
0
2
4
6
8
10
12
14
PLATE VOLTAGE IN KILOVOLTS
A-13074/R1

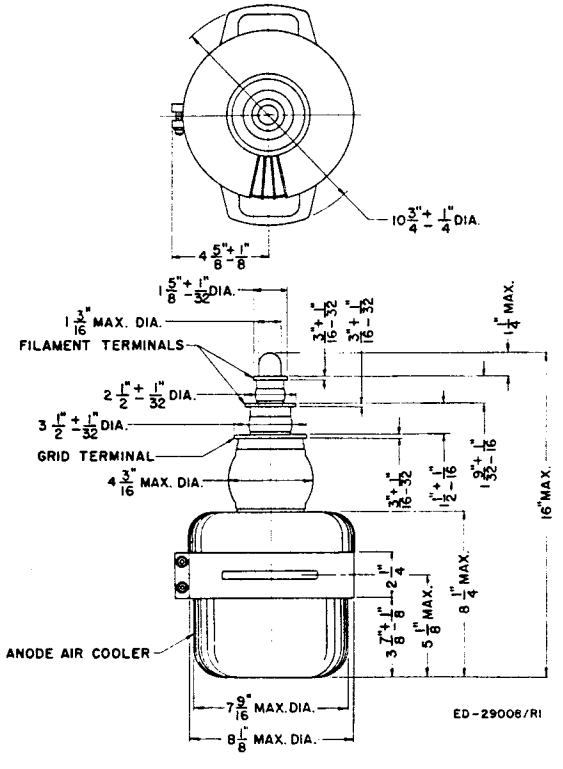

CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 7.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
PEAK CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
ec = 2000 v
1800
1600
1400
1200
1000
800
600
400
200
0
2
4
6
8
10
12
50
40
30
20
10
ED-29004/R1



DIMENSIONS — ML-6422



DIMENSIONS — ML-6423



DIMENSIONS — ML-6423-F

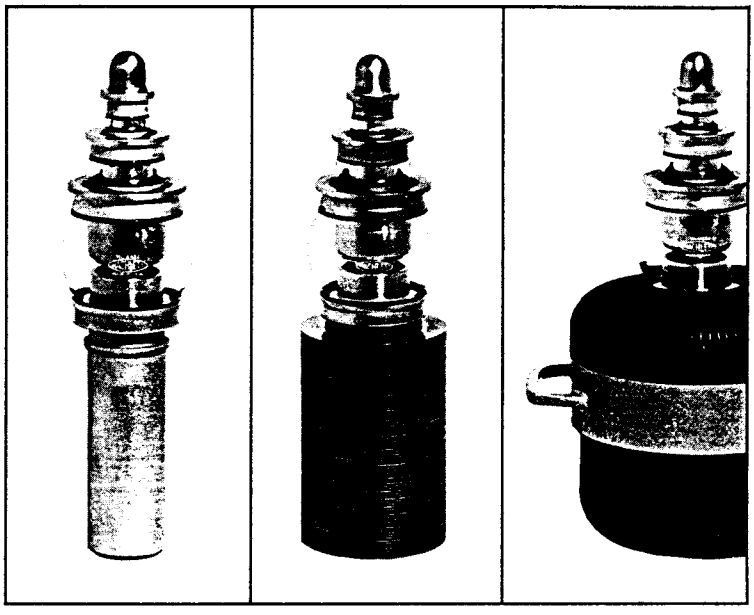
THE MACHLETT LABORATORIES, INC.

An Affiliate of Raytheon Company

SPRINGDALE MACHLETT CONNECTICUT

ST-1688 4.5M 5-64

Printed in U.S.A.



ISSUED 5-64

ML-6424
ML-6425
ML-6425F

General Purpose Triodes

30 kW CW

900 kw Pulse Power

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-6424 and ML-6425 are general-purpose triodes suitable for industrial heating, AM broadcasting and pulse modulation. These tubes feature coaxial mounting structures providing high-dissipation, low-inductance rf electrode terminals. The cathode of each type consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments.

The ML-6424 has a water-cooled, heavy-wall anode capable of dissipating 20 kW. The ML-6425. has a forced-air-cooled, heavy-wall anode with high-efficiency disc fins. The ML-6425-F has an anode fin construction which fits tube supports used with the type 5604.

These tubes will operate with plate voltages up to 12.5 kV in CW operation or 35 kV in pulse modulator service. Maximum ratings apply at frequencies up to 30 Mc. Useful power output can be obtained at frequencies up to 70 Mc with reduced ratings. In a typical pulse modulator application these tubes are capable of switching 900 kW.

GENERAL CHARACTERISTICS

Electrical			
Filament Voltage		7.0	volts
Filament Current		120	amps
Filament Starting Current, maximum		550	amps
Filament Cold Resistance		0.0070	ohms
Amplification Factor		20	
	ML-6424 ML-6425	**ML-6425-F**	
Interelectrode Capacitances			
Grid-Plate	27	28	$\mu\mu f$
Grid-Filament	34	34	$\mu\mu f$
Plate-Filament	2.0	2.2	$\mu\mu f$
Mechanical			
Mounting Position		Vertical, anode down	
Type of Cooling ML-6424		Water and forced-air†	
Water flow on anode, minimum for 20 kW dissipation		7	gpm
Maximum outgoing water temperature		70	°C
Type of Cooling ML-6425 & ML-6425-F		Forced-air	
Air flow on anode:			
ML-6425, minimum for 12.5 kW dissipation		Pressure: 710 cfm at 4.7″ water* Exhaust: 815 cfm at 5.1″ water*	
ML-6425-F, minimum for 11 kW dissipation		870	cfm
Maximum incoming air temperature		50	°C
Maximum Glass Temperature		165	°C†
Net Weight, approximately			
ML-6424		10	lbs.
ML-6425		15	lbs.
ML-6425-F		50	lbs.

*When used with Machlett ML-6425 Air Distributor F-17797.

†At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient to cool glass portion of tube. At higher frequencies or high ambient temperature, auxiliary air flow of 25-50 cfm may be required and should be distributed to maintain uniform glass temperature, not greater than 165°C, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO ALL THREE TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values		
D-C Plate Voltage	12500	volts
Max.-Signal D-C Plate Current*	3.5	amps
Max.-Signal Plate Input*	40	amps
Plate Dissipation*		
ML-6424	20	kW
ML-6425	12.5	kW
ML-6425-F	11	kW

Typical Operation (Values are for two tubes)	ML-6424		
D-C Plate Voltage	8500	12000	volts
D-C Grid Voltage	−380	−560	volts
Peak A-F Grid-to-Grid Voltage	2020	2260	volts
Peak A-F Plate-to-Plate Voltage	14000	20400	volts
Zero-Signal D-C Plate Current	0.4	0.6	amp
Max.-Signal D-C Plate Current	6.9	6.5	amps
Effective Load Resistance, Plate-to-Plate	2550	3900	ohms
Max.-Signal Driving Power, approx.	400	260	watts
Max.-Signal Power Output, approx.	38	53	kW

*Averaged over any a-f cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	12500	volts
D-C Plate Current		
ML-6424	2.8	amps
ML-6425 & ML-6425-F	2.5	amps
Plate Input		
ML-6424	30.0	kW
ML-6425	19.0	kW
ML-6425-F	16.5	kW
Plate Dissipation		
ML-6424	20	kW
ML-6425	12.5	kW
ML-6425-F	11	kW

Typical Operation	ML-6424 / ML-6425		
D-C Plate Voltage	10000	10000	volts
D-C Grid Voltage	−420	−420	volts
Peak R-F Grid Voltage	510	540	volts
Peak R-F Plate Voltage	4200	4200	volts
D-C Plate Current	1.65	1.80	amps
D-C Grid Current	0	0	mA
R-F Load Resistance	1600	1500	ohms
Driving Power, approx.§	170	200	watts
Power Output, approx.	5.5	6.0	kW

§At crest of a-f cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	9000	volts
D-C Grid Voltage	−2000	volts
D-C Plate Current	2.5	amps
D-C Grid Current	0.50	amp
Plate Input	22	kW
Plate Dissipation		
ML-6424	13	kW
ML-6425	8	kW
ML-6425-F	7.5	kW
Typical Operation		
D-C Plate Voltage	8500	volts
D-C Grid Voltage	−1400	volts
Peak R-F Grid Voltage	2000	volts
Peak R-F Plate Voltage	7300	volts
D-C Plate Current	1.8	amps
D-C Grid Current	0.17	amp
R-F Load Resistance	2200	ohms
Driving Power, approx.	330	watts
Power Output, approx.	12.1	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation.†

Maximum Ratings, Absolute Values				
D-C Plate Voltage	12500			volts
D-C Grid Voltage	−2000			volts
D-C Plate Current	3.5			amps
D-C Grid Current	0.50			amps
Plate Input	40			kW
Plate Dissipation				
ML-6424	20			kW
ML-6425	12.5			kW
ML-6425-F	11			kW
Typical Operation				
D-C Plate Voltage	10000	12000	12000	volts
D-C Grid Voltage	−1000	−1000	−1000	volts
Peak R-F Grid Voltage	1750	1620	1740	volts
Peak R-F Plate Voltage	8400	10500	10500	volts
D-C Plate Current	3.3	2.6	3.3	amps
D-C Grid Current	0.25	0.15	0.25	amp
R-F Load Resistance	1450	2300	1800	ohms
Driving Power, approx.	430	250	430	watts
Power Output, approx.	24.4	24.2	30.6	kW

†Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 1500 volts; i_b = 14 amps	e_c:	——	——	950	volts
Grid Current	e_b = 1500 volts; i_b = 14 amps	i_c:	——	——	4.0	amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.5 Adc	E_b:	2.8	3.2	3.6	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 1.5 Adc	E_b:	6.4	7.2	8.0	kVdc
Grid Voltage	E_b = 10.0 kVdc; I_b = 0.02 Adc	E_c:	−470	−560	−650	Vdc
Plate Power Output ML-6424, ML-6425	E_b = 12.0 kVdc; E_c = −1000 Vdc; I_b = 3.3 Adc; I_c = 0.25 Adc	P_o:	25	——	——	kW
Plate Power Output ML-6425-F	E_b = 12.0 kVdc; E_c = −1000 Vdc; I_b = 2.6 Adc; I_c = 0.15 Adc	P_o:	21	——	——	kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 Mc except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation on the right (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	30	50	70 Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60

Pulse Modulator or Pulse Amplifier ‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	35	kV
Peak Plate Voltage	35	kv
Peak Positive Grid Voltage	−4800	volts
Pulse Cathode Current	45	amps
Grid Dissipation	400	watts
Plate Dissipation	12.5	kW
Pulse Duration, approximate*	1000	μsec
Duty Factor*	0.03	

Typical Operation

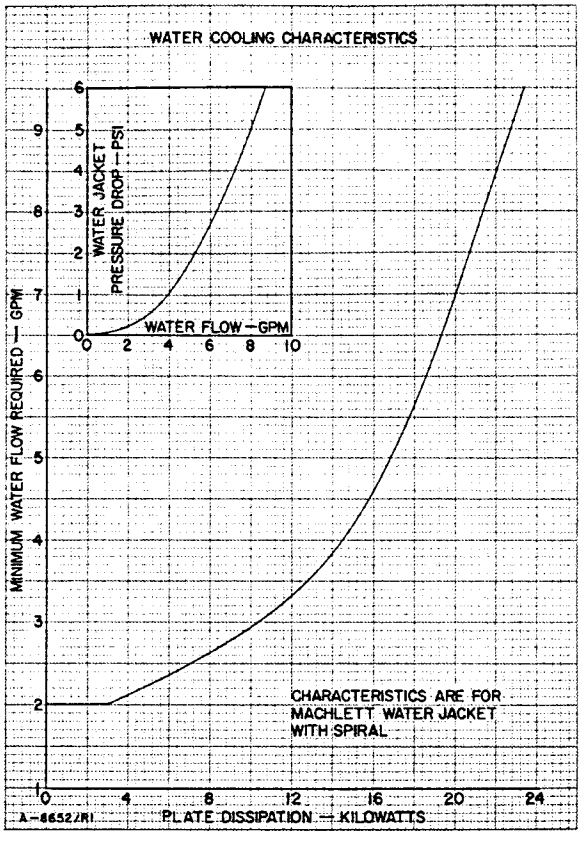
D-C Plate Voltage	30	kV
D-C Grid Voltage	−2000	volts
Pulse Positive Grid Voltage	1500	volts
Pulse Plate Current	36	amps
Pulse Grid Current	4	amps
Pulse Driving Power	16	kw
Pulse Power Output	900	kw
Plate Output Voltage	25	kv

‡When ordering for this application add the suffix "P" to the Machlett tube number.

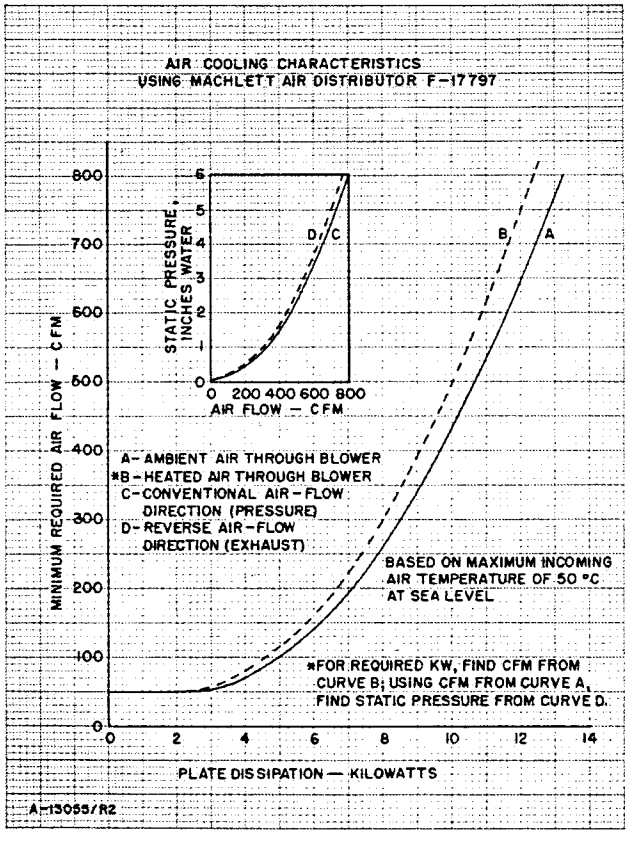
*For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

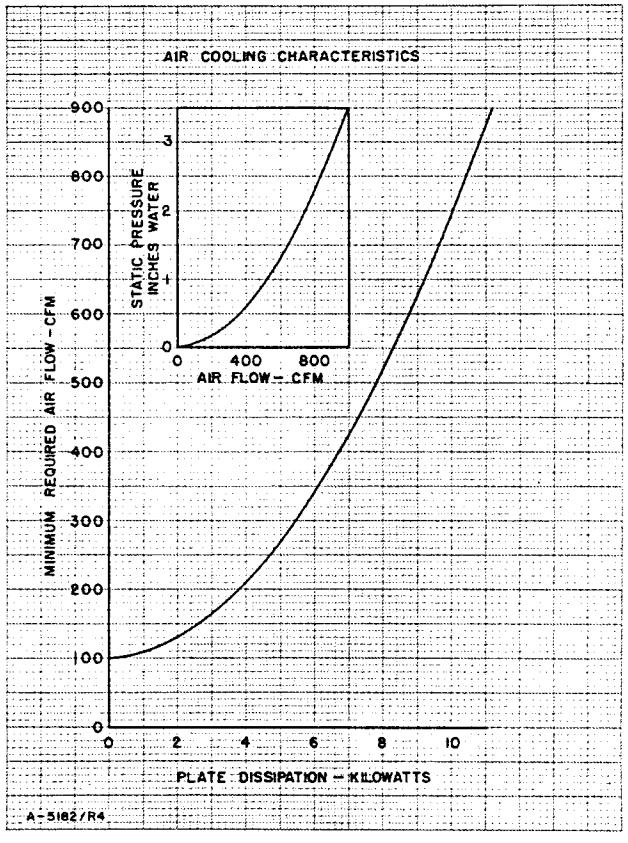
COOLING CHARACTERISTICS — ML-6424

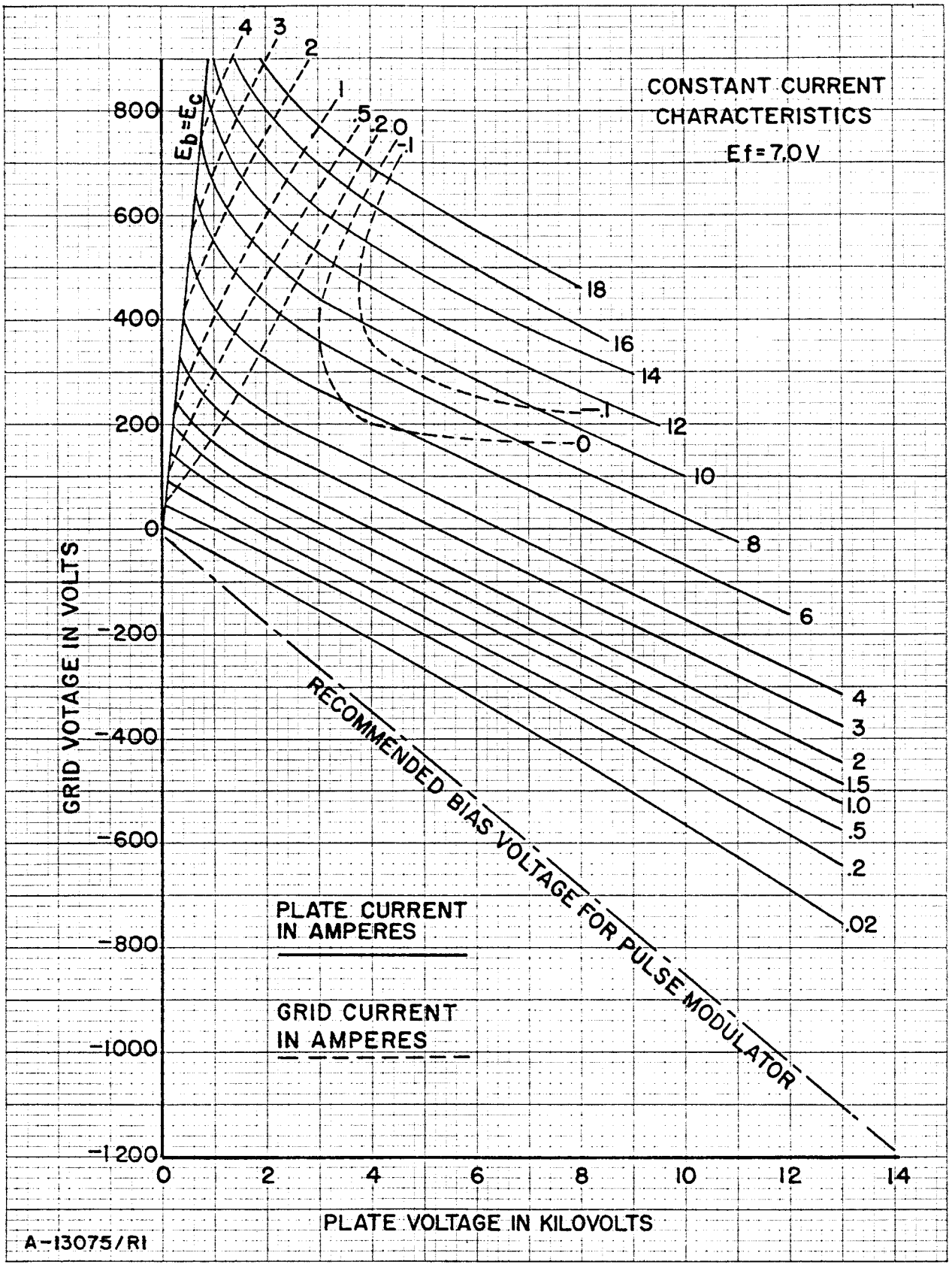


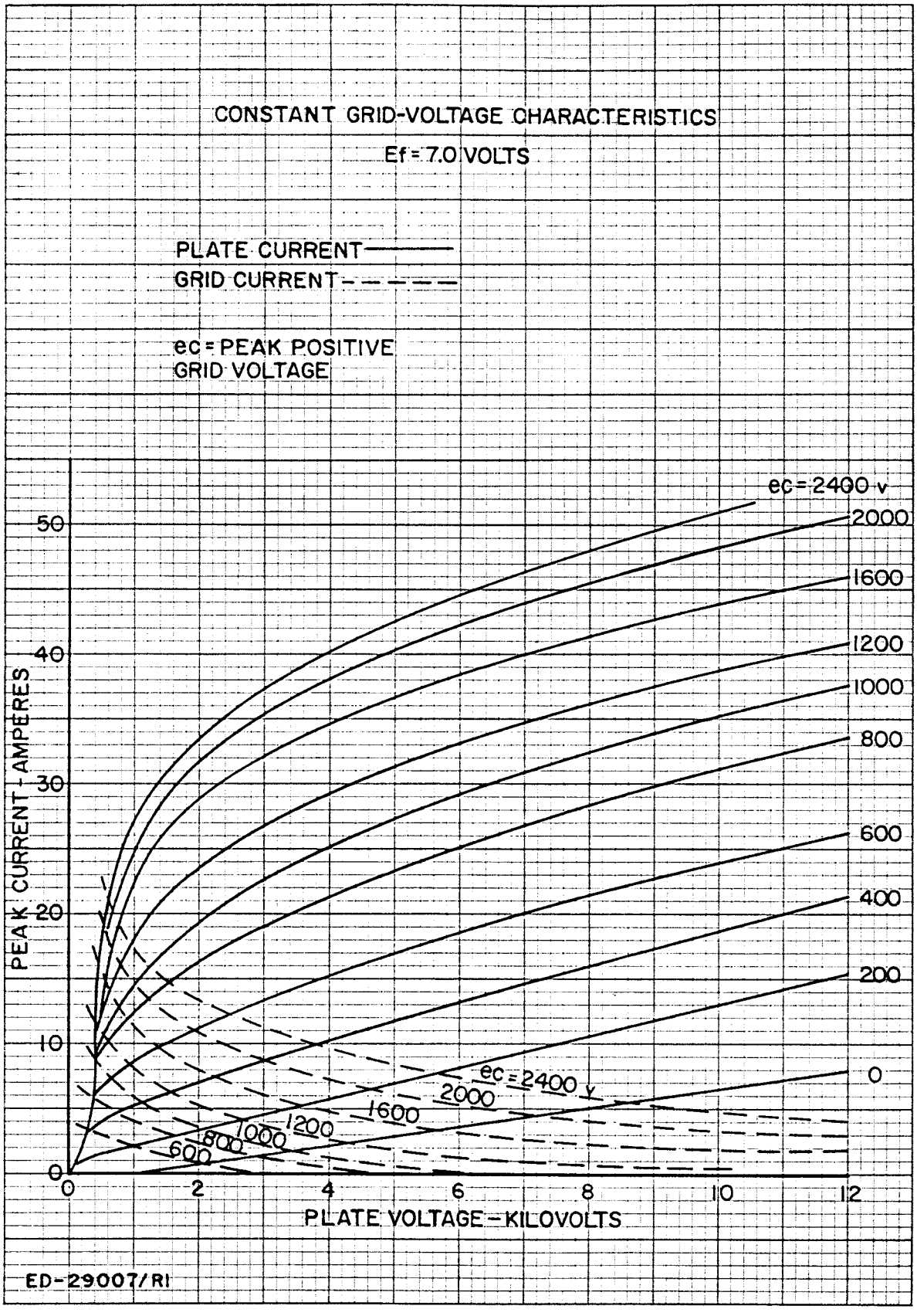
COOLING CHARACTERISTICS — ML-6425

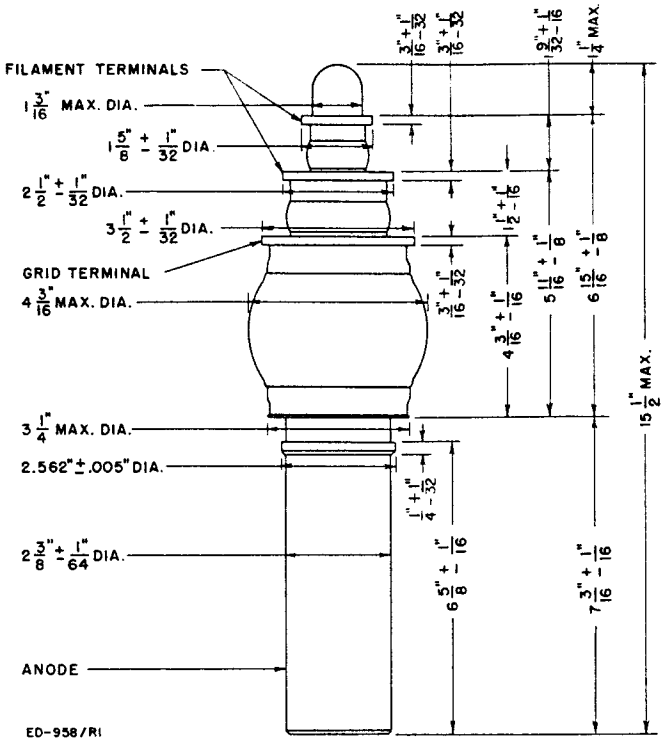


COOLING CHARACTERISTICS — ML-6425-F

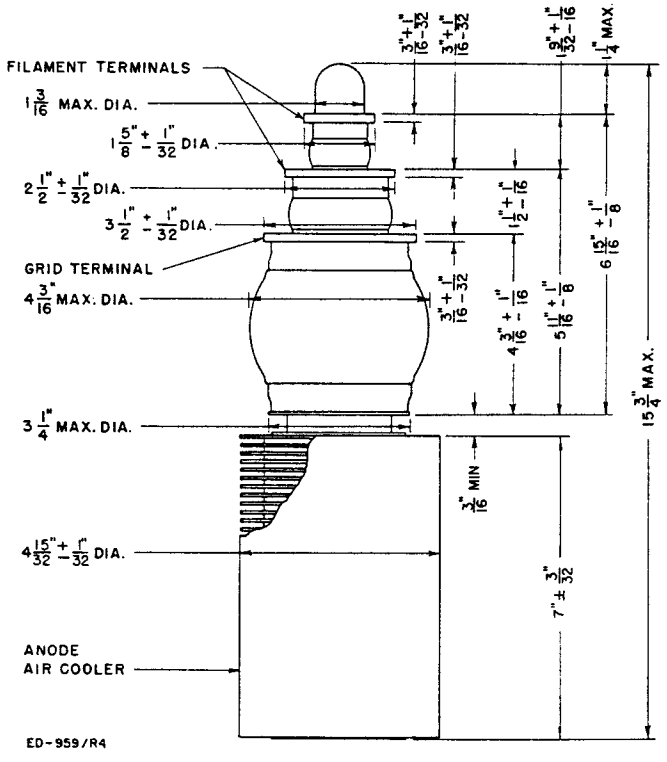



CONSTANT CURRENT CHARACTERISTICS
Ef = 7.0 V
Eb=Ec
4
3
2
1
.5
.2
0
-.1
18
16
14
12
10
8
6
4
3
2
1.5
1.0
.5
.2
.02
-.1
0
RECOMMENDED BIAS VOLTAGE FOR PULSE MODULATOR
PLATE CURRENT IN AMPERES
GRID CURRENT IN AMPERES
GRID VOTAGE IN VOLTS
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
0
2
4
6
8
10
12
14
PLATE VOLTAGE IN KILOVOLTS
A-13075/R1

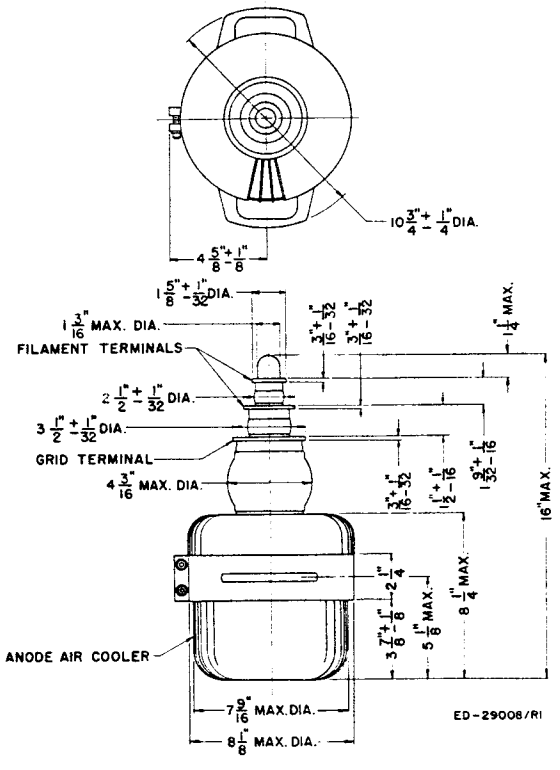

CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 7.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
PEAK CURRENT - AMPERES
PLATE VOLTAGE - KILOVOLTS
ec = 2400 v
2000
1600
1200
1000
800
600
400
200
0
0
10
20
30
40
50
0
2
4
6
8
10
12
ED-29007/R1



DIMENSIONS — ML-6424



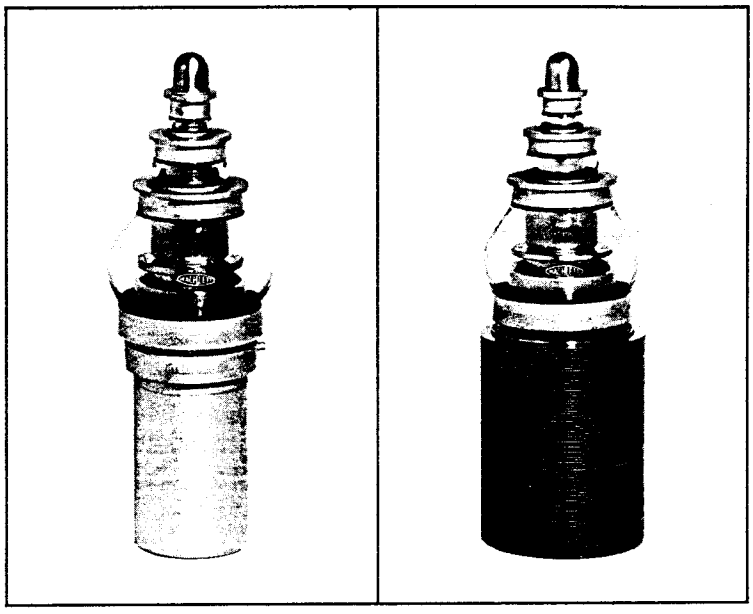
DIMENSIONS — ML-6425



DIMENSIONS — ML-6425-F

THE MACHLETT LABORATORIES, INC.
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ST-1689 4.5M 5-64
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The Machlett Laboratories, Inc. • 1063 Hope Street
Stamford, Conn. 06907 • Tel. 203-348-7511 • TWX 710-474-1744



ISSUED 3-70

ML-6426
ML-6427

MACHLETT

General Purpose Triodes
55 kW CW
2.1 Mw Pulse Power

DESCRIPTION

The ML-6426 and ML-6427 are general-purpose triodes suitable for industrial heating, AM broadcasting and pulse modulation. These tubes feature coaxial mounting structures providing high-dissipation, low-inductance rf electrode terminals. The cathode of each type consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments.

The ML-6426 has a water-cooled, heavy-wall anode capable of dissipating 40 kW. The ML-6427 has a forced-air-cooled, heavy-wall anode with high-efficiency disc fins capable of dissipating 20 kW.

These tubes will operate with plate voltages up to 12.5 kV in CW operation or 35 kV in pulse modulator service. Maximum ratings apply at frequencies up to 30 MHz. Useful power output can be obtained at frequencies up to 70 MHz with reduced ratings. In a typical pulse modulator application these tubes are capable of switching 2.1 Mw.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	8.0	Volts
Filament Current	200	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	0.0051	Ohms
Amplification Factor	20	
Interelectrode Capacitances		
Grid-Plate	38	pf
Grid-Filament	50	pf
Plate-Filament	1.8	pf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling — ML-6426	Water and forced-air†	
Water flow on anode, minimum for 40 kW dissipation	20	gpm
Maximum outgoing water temperature	70	°C
Type of Cooling — ML-6427	Forced-air	
Air flow on anode, minimum for 20 kW dissipation*	Pressure: 1000 cfm at 7.7" water Exhaust: 1150 cfm at 8.4" water	
Maximum incoming air temperature	50	°C
Maximum Envelope Temperature	165	°C†
Net Weight, approximate		
ML-6426	13	lbs.
ML-6427	30	lbs.

*When used with Machlett ML-6427 Air Distributor, F-17798.

†At frequencies up to 15 MHz, normal cabinet ventilation should be sufficient to cool glass portions of tube. At higher frequencies or high ambient temperatures, auxiliary air flow of 50-150 cfm may be required and should be distributed

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values	*ML-6426*	*ML-6427*	
D-C Plate Voltage	12500	12500	volts
Max.-Signal D-C Plate Current*	8.0	7.0	amps
Max.-Signal Plate Input*	80	60	kW
Plate Dissipation*	40	20	kW

Typical Operation (Values are for two tubes)	*ML-6426*			
D-C Plate Voltage	8500	10000	12000	volts
D-C Grid Voltage	-400	-500	-550	volts
Peak A-F Grid-to-Grid Voltage	1600	1940	2120	volts
Peak A-F Plate-to-Plate Voltage	14000	16000	19000	volts
Zero-Signal D-C Plate Current	1.3	1.2	2.4	amps
Max.-Signal D-C Plate Current	7.8	10.0	12.4	amps
Effective Load Resistance, Plate-to-Plate	2300	2000	1950	ohms
Max.-Signal Driving Power, approximate	200	200	170	watts
Max.-Signal Power Output, approximate	42	63	93	kW

*Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	*ML-6426*	*ML-6427*	
D-C Plate Voltage	12500	12500	volts
D-C Plate Current	6.0	6.0	amps
Plate Input	60	32	kW
Plate Dissipation	40	20	kW

Typical Operation	*ML-6426*			
D-C Plate Voltage	12000	10000	12000	volts
D-C Grid Voltage	-550	-450	-550	volts
Peak R-F Grid Voltage	550	580	600	volts
Peak R-F Plate Voltage	5400	4200	5300	volts
D-C Plate Current	2.6	3.6	3.2	amps
D-C Grid Current	0	0	0	mA
R-F Load Resistance	1330	730	1040	ohms
Driving Power, approximate**	350	550	480	watts
Power Output, approximate	11	12	13.5	kW

**At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	*ML-6426*	*ML-6427*	
D-C Plate Voltage	9000	9000	volts
D-C Grid Voltage	-2000	-2000	volts
D-C Plate Current	6.0	5.5	amps
D-C Grid Current	1.0	1.0	amp
Plate Input	53	53	kW
Plate Dissipation	26	13	kW

Typical operation		
D-C Plate Voltage	8500	volts
D-C Grid Voltage	-1400	volts
Peak R-F Grid Voltage	2140	volts
Peak R-F Plate Voltage	7000	volts
D-C Plate Current	4.8	amps
D-C Grid Current	0.50	amp
R-F Load Resistance	800	ohms
Driving Power, approximate	1.1	kW
Power Output, approximate	30.7	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values	*ML-6426*		*ML-6427*		
D-C Plate Voltage	7500	12500	7500	12500	volts
D-C Grid Voltage	-2000	-2000	-2000	-2000	volts
D-C Plate Current	8.0	8.0	8.0	8.0	amps
D-C Grid Current	0.8	1.0	0.8	1.0	amp
Plate Input	48	80	48	80	kW
Grid Dissipation	750	750	750	750	watts
Plate Dissipation	40	40	20	20	kW
Frequency	70	30	70	30	MHz

Typical Operation	*Cathode-Drive Circuitry*	*Grid-Drive Circuitry*			
				ML-6426	
D-C Plate Voltage	7500	10000	12000	12000	volts
D-C Grid Voltage	-850	-1100	-1200	-1200	volts
Peak R-F Grid Voltage	1500	1880	1880	1940	volts
Peak R-F Plate Voltage	5600	8000	10000	9800	volts
D-C Plate Current	5.3	6.5	5.4	6.4	amps
D-C Grid Current	0.35	0.48	0.30	0.35	amp
R-F Load Resistance	750	700	550	870	ohms
Driving Power, approx.	7500	900	550	670	watts
Power Output, approx.	33§	46.4	48.5	55.4	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

§Includes power transferred from driver stage.

Note: The Maximum Plate Input Ratings are based on operating efficiencies high enough to insure that the Maximum Plate Dissipation Ratings are not exceeded.

Pulse Modulator or Pulse Amplifier‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	35	kV
Peak Plate Voltage	40	kv
Peak Negative Grid Voltage	−5000	volts
Pulse Cathode Current	85	amps
Grid Dissipation	750	watts
Plate Dissipation	20	kW
Pulse Duration, approximate*	1000	μsec
Duty Factor*	0.03	

Typical Operation

D-C Plate Voltage	35	kV
D-C Grid Voltage	−3500	volts
Pulse Positive Grid Voltage	1300	volts
Pulse Plate Current	70	amps
Pulse Grid Current	8	amps
Pulse Driving Power	40	kw
Pulse Power Output	2.1	Mw
Plate Output Voltage	30	kv

‡When ordering for this application add the suffix "P" to the Machlett tube number.

* For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

CAUTION, X-RAYS: This device may produce x-rays when energized. Operating personnel must be protected by appropriate shielding. X-ray warning signs or labels should be permanently attached to equipment directing operating personnel never to operate this device without x-ray shielding in place.

APPLICATION NOTES

The handling of high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can severely damage the electron tube if not properly controlled. Therefore the ground leads of the plate and grid circuits should be equipped with individual quick-acting overload relays which will remove power from these circuits within 1/10 second.

Additional protection is recommended and may be obtained by connecting a resistor in series with the plate lead of each tube for protection of the tube during the time required for the plate overload relay to act. The criterion is the total energy to which the tube can be subjected. The minimum value of resistance which will give adequate protection with reasonably low power loss is as follows:

Maximum Power Output of Rectifier	80	160	320	640 kW
Series Resistor	15	25	40	60 ohms

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply at frequencies up to 30 MHz except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	30	50	70 MHz
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60

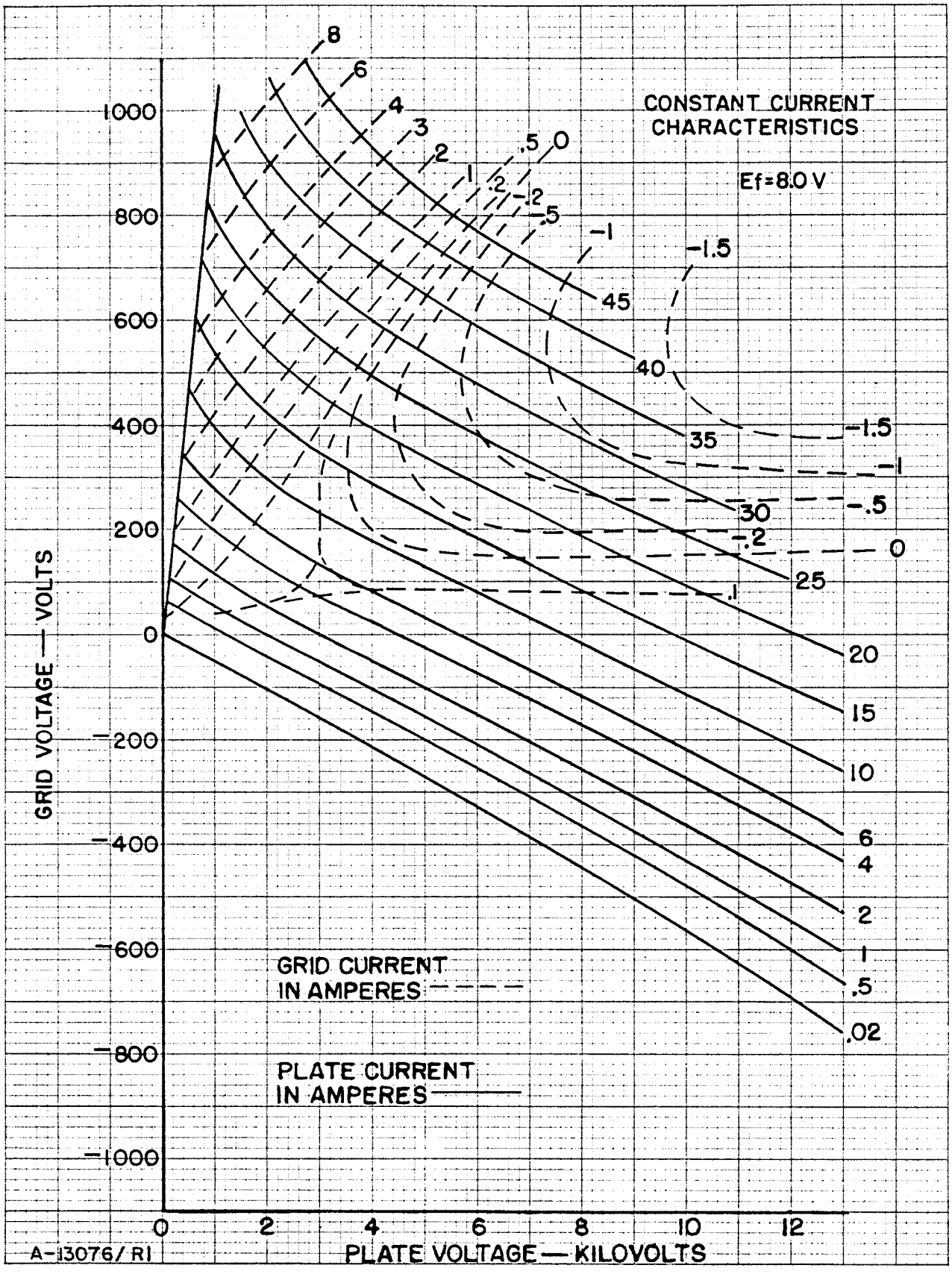
ACCESSORIES

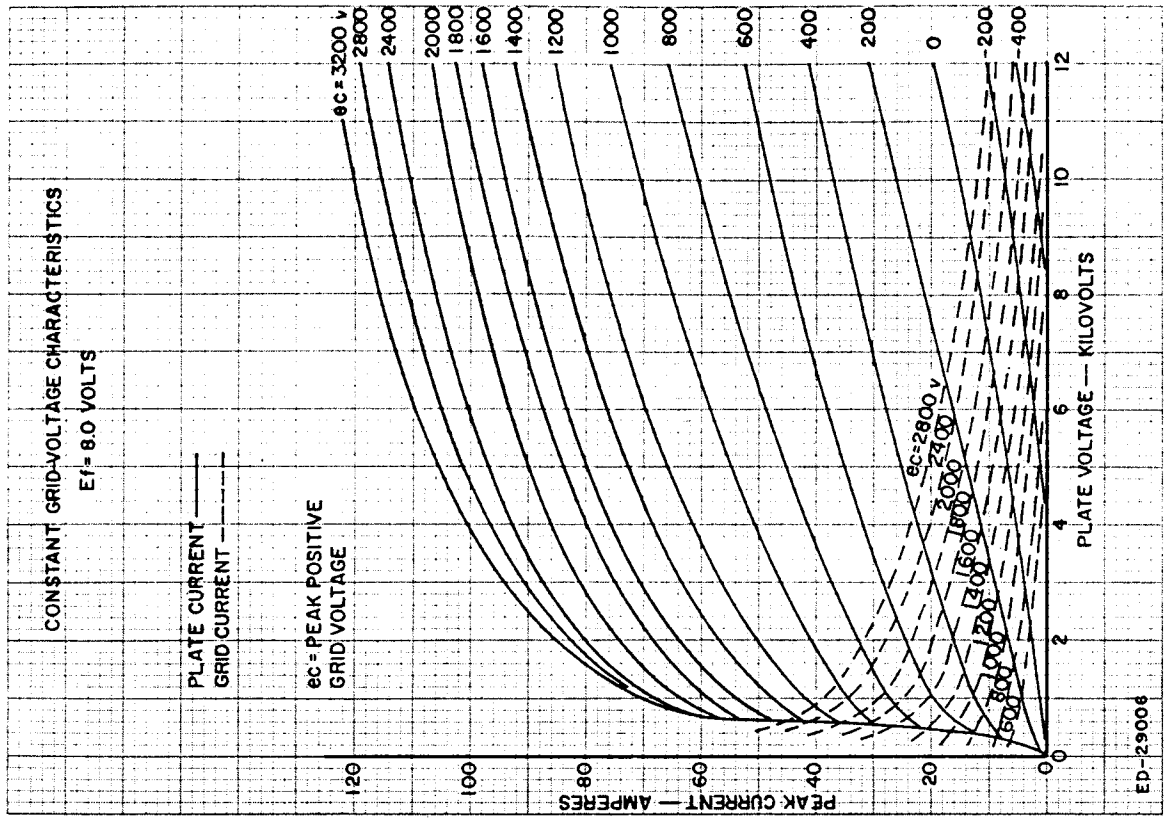
Item	Part No.
Small Filament Connector	F-17487
Large Filament Connector	F-17488
Grid Connector	F-17489
Water Jacket for ML-6426	F-17292
O-Ring Gasket for ML-6426 Water Jacket	P-17494
Mounting Clamp for ML-6426 Water Jacket	P-15198
Mounting Plate for ML-6426 Mounting Clamp	F-15196
Air Distributor for ML-6427	F-17798
Spring Clips for ML-6427 Air Distributor	P-21113
Tube Support for ML-6427	F-17795

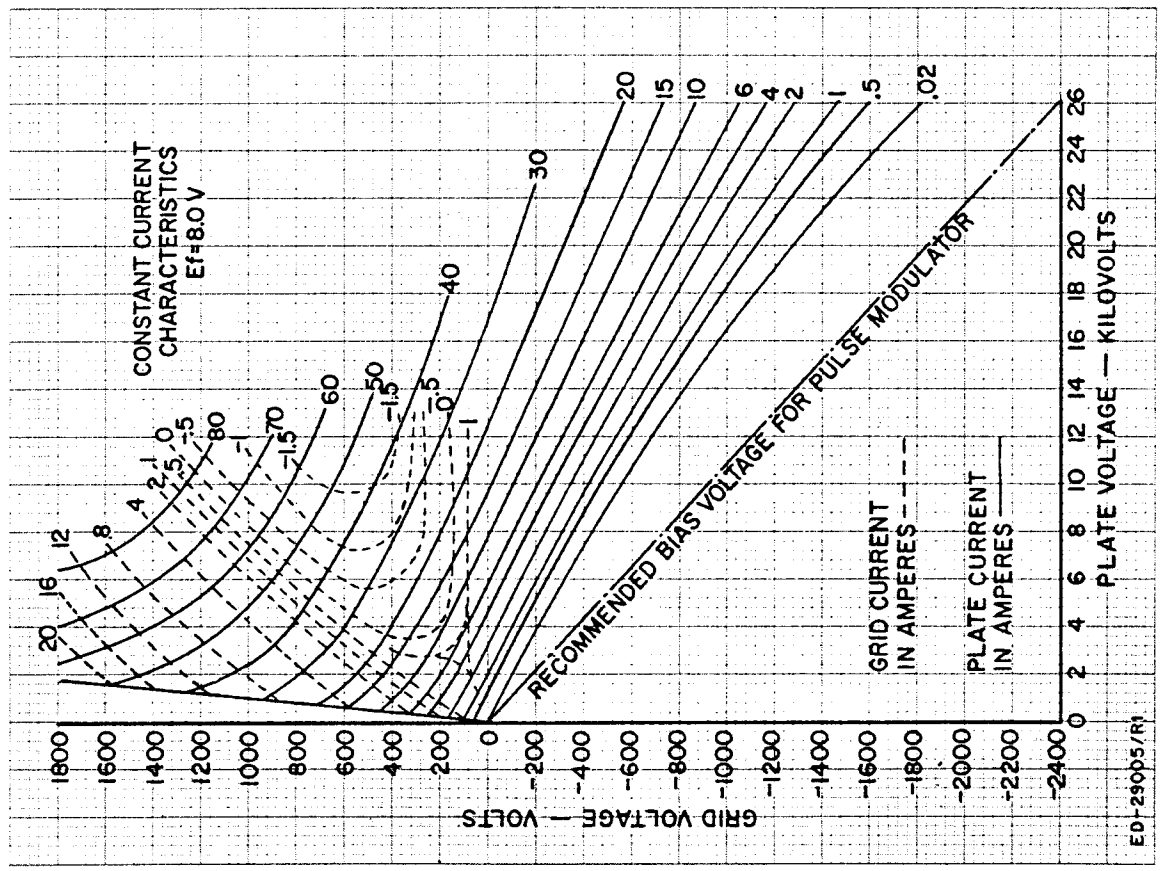
NOTE: For additional information on accessories, refer to Accessory Data Sheet No. ST-1295.

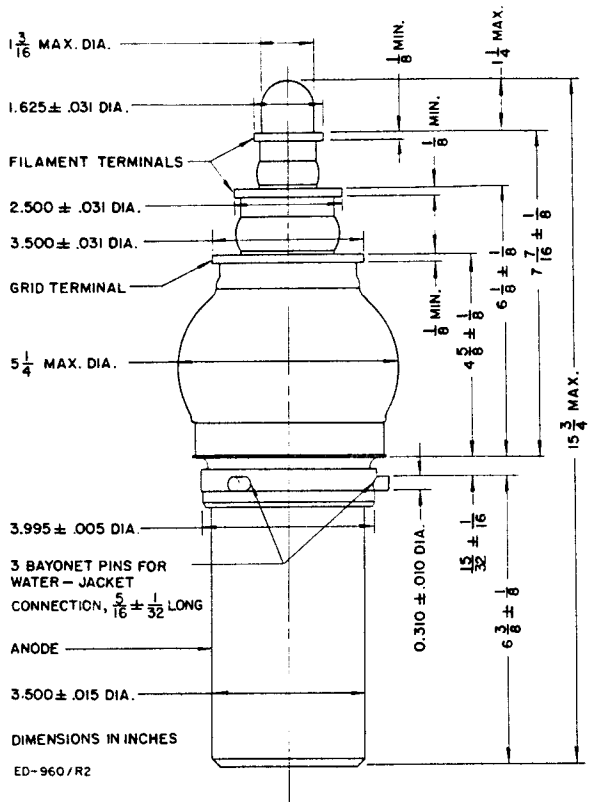
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 1500 volts; i_b = 28 amps	e_c:	———	———	1000	volts
Grid Current	e_b = 1500 volts; i_b = 28 amps	i_c:	———	———	8.5	amps
Plate Voltage	E_c = 0 Vdc; I_b = 3.0 Adc	E_b:	3.3	3.8	4.3	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 3.0 Adc	E_b:	7.2	7.8	8.4	kVdc
Grid Voltage	E_b = 12.0 kVdc; I_b = 0.02 Adc	E_c:	−570	−670	−800	Vdc
Plate Power Output	E_b = 12.0 kVdc; E_c = −1200 Vdc; I_b = 5.4 Adc; I_c = 0.30 Adc	P_o:	40	———	———	kW

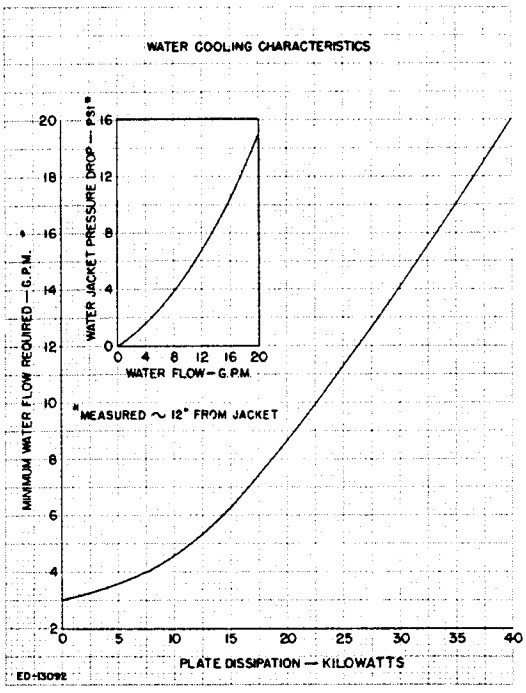

CONSTANT CURRENT CHARACTERISTICS
Ef=8.0 V
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
1000
800
600
400
200
0
−200
−400
−600
−800
−1000
0
2
4
6
8
10
12
8
6
4
3
2
1
.5
0
.2
−.2
−.5
−1
−1.5
45
40
35
30
25
20
15
10
6
4
2
1
.5
.02
−1.5
−1
−.5
−.2
0
.1
A-13076/R1

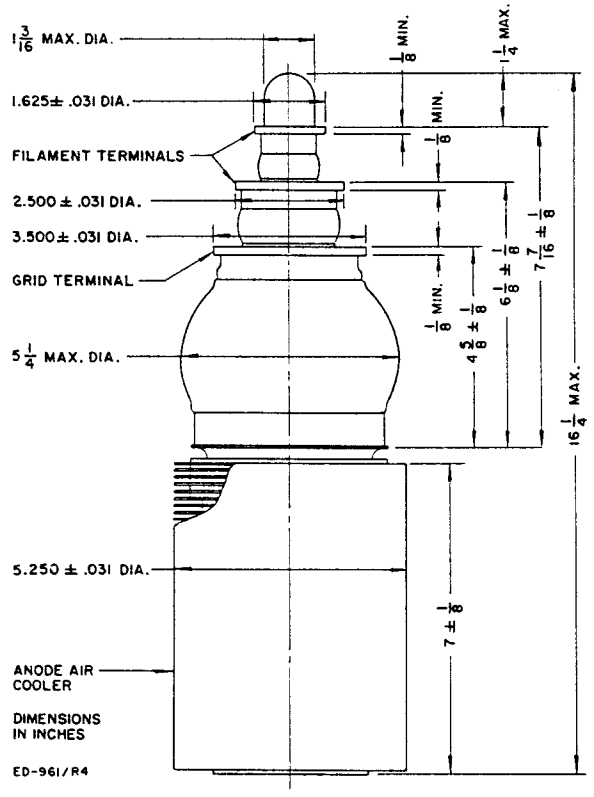

CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 8.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
ec = 3200 v
2800
2400
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-400
ec=2800 v
2400
2000
1800
1600
1400
1200
1000
800
600
400
200
PEAK CURRENT — AMPERES
PLATE VOLTAGE — KILOVOLTS
ED-29006


CONSTANT CURRENT CHARACTERISTICS
Ef=8.0 V
20
16
12
8
4
2.5
2.1
.5
0
-.5
80
-1
70
-1.5
60
50
-1.5
-.5
0
-.5
-1
40
30
20
15
10
6
4
2
1
.5
.02
RECOMMENDED BIAS VOLTAGE FOR PULSE MODULATOR
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
ED-29005/R1

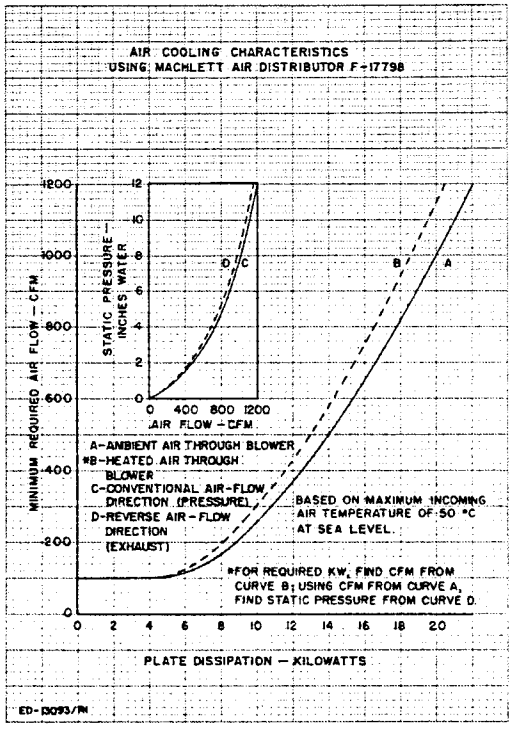


DIMENSIONS — ML-6426





DIMENSIONS — ML-6427



RAYTHEON

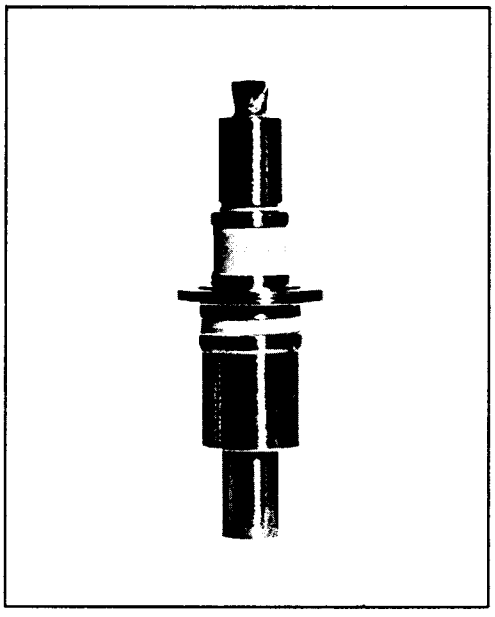
THE MACHLETT LABORATORIES, INC.

A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.

ST-1358 6M 3-70

ISSUED 11-64



ML-6442

UHF Planar Triode

Plate Pulsed or CW
to 5 Gc

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-6442 is a metal-ceramic envelope, medium-mu triode of the planar-electrode type designed specifically for use as a plate-pulsed oscillator and amplifier at frequencies up to about 5000 Mc. It can also be used as a c-w oscillator, r-f power amplifier or frequency multiplier at frequencies up to 2500 Mc. Features include short electron transit time, low inter-electrode capacitances and high transconductance. Lead inductances and r-f losses are minimized by a compact, rugged metal-ceramic construction with ring type seals, making the tube ideally suited to cavity type circuits as well as for parallel line operation. The cathode is an indirectly-heated, oxide-coated disc. The heater is insulated from the cathode permitting this tube to be used in series-string circuitry. The anode is cooled by conduction and convection and is capable of dissipating 8 watts.

GENERAL CHARACTERISTICS

Electrical

Cathode	Indirectly Heated	
Heater Voltage, Optimum, AC or DC*		
CW Operation	4.5 to 5.7	volts
Pulsed Operation	5.7 to 6.3	volts
Heater Current at 6.3 Volts	0.9	Amp
Cathode Heating Time for Pulse Operation, minimum	60	Seconds
Amplification Factor	50	
Direct Interelectrode Capacitances, approximate		
Grid-Plate	2.3	μμf
Grid-Cathode, Eh = 0	5.10	μμf
Plate-Cathode, maximum, Eh = 0	0.045	μμf

Mechanical

Mounting Position	Optional	
Type of Cooling	Conduction and convection	
Envelope Temperature, maximum	175	°C
Net Weight, approximate	1	ounce

*The optimum heater voltage is dependent upon the back-heating or transit-time effect and is a function of frequency, grid current, grid bias, plate current, duty cycle and circuit design and adjustment. However, once dynamic operation of the tube begins, the heater voltage must be maintained within ±5% of the established optimum value. Selection of heater voltage depends on stability of the supply. For specific applications above 500 Mc, consult the Machlett Engineering Department for optimum heater voltage values.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Plate-Pulsed Amplifier and Oscillator — Class C

Maximum Ratings, Absolute Values

For a Maximum Conducting Period of 5 Microseconds in any 5000 Microsecond Interval.*

The tube shall not be grid pulsed beyond the Class C Telegraphy ratings.

Peak Positive-Pulse Plate-Supply Voltage	3000	volts
Peak Negative-Pulse Grid-Bias Voltage	100	volts
Peak Plate Current from Pulse Supply†	2.5	amps
Peak Rectified Grid Current	1.25	amps
DC Plate Current	2.5	mA
DC Grid Current	1.25	mA
Plate Input	7.5	Watts
Plate Dissipation	7.5	Watts
Pulse Duration	2.0	μsec
Cathode Heating Time	60	Seconds
Peak Heater-Cathode Voltage		
Heater Negative with Respect to Cathode	90	volts
Heater Positive with Respect to Cathode	90	volts
Frequency	5000	Mc
Duty Factor*	0.001	

Typical Operation — With Rectangular Wave Shape

Plate Pulsed Self-Excited Oscillator at 3500 Mc

Duty Factor	0.001	
Peak Positive-Pulse Plate-Supply Voltage	3000	volts
Peak Negative-Pulse Grid Bias Voltage, approx.	75	volts
Grid Bias Resistor, approximate	50	ohms
Peak Current from Pulse Supply	2.5	amps
Peak Rectified Grid Current	1.25	amps
DC Plate Current	2.5	mA
DC Grid Current	1.25	mA
Useful Power Output at Peak of Pulse, approx.	2.0	kW
Pulse Duration	1.0	μsec
Pulse Repetition Rate	1000	pps
Heater Voltage	6.0	Volts

* For applications above a duty factor of 0.001, contact the Machlett Engineering Department for recommendations.

† The regulation and/or series plate supply impedance shall be such as to limit the instantaneous peak current, with the tube considered as a short circuit, to a maximum of 10 times the specified maximum current rating.

Radio-Frequency Power Amplifier and Oscillator— Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

DC Plate Voltage	275	Volts
DC Grid Voltage	−50	Volts
DC Plate Current	35	mA
DC Grid Current	15	mA
Plate Input	9.5	Watts
Plate Dissipation	6.0	Watts
Peak Heater-Cathode Voltage		
Heater Negative with Respect to Cathode	90	volts
Heater Positive with Respect to Cathode	90	volts
Frequency	2500	Mc

Radio-Frequency Power Amplifier and Oscillator— Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

DC Plate Voltage	350	Volts
DC Grid Voltage	−50	Volts
DC Plate Current	35	mA
DC Grid Current	15	mA
Plate Power Input	12	Watts
Plate Dissipation	8	Watts
Peak Heater-Cathode Voltage		
Heater Negative with Respect to Cathode	90	volts
Heater Positive with Respect to Cathode	90	volts
Frequency	2500	Mc

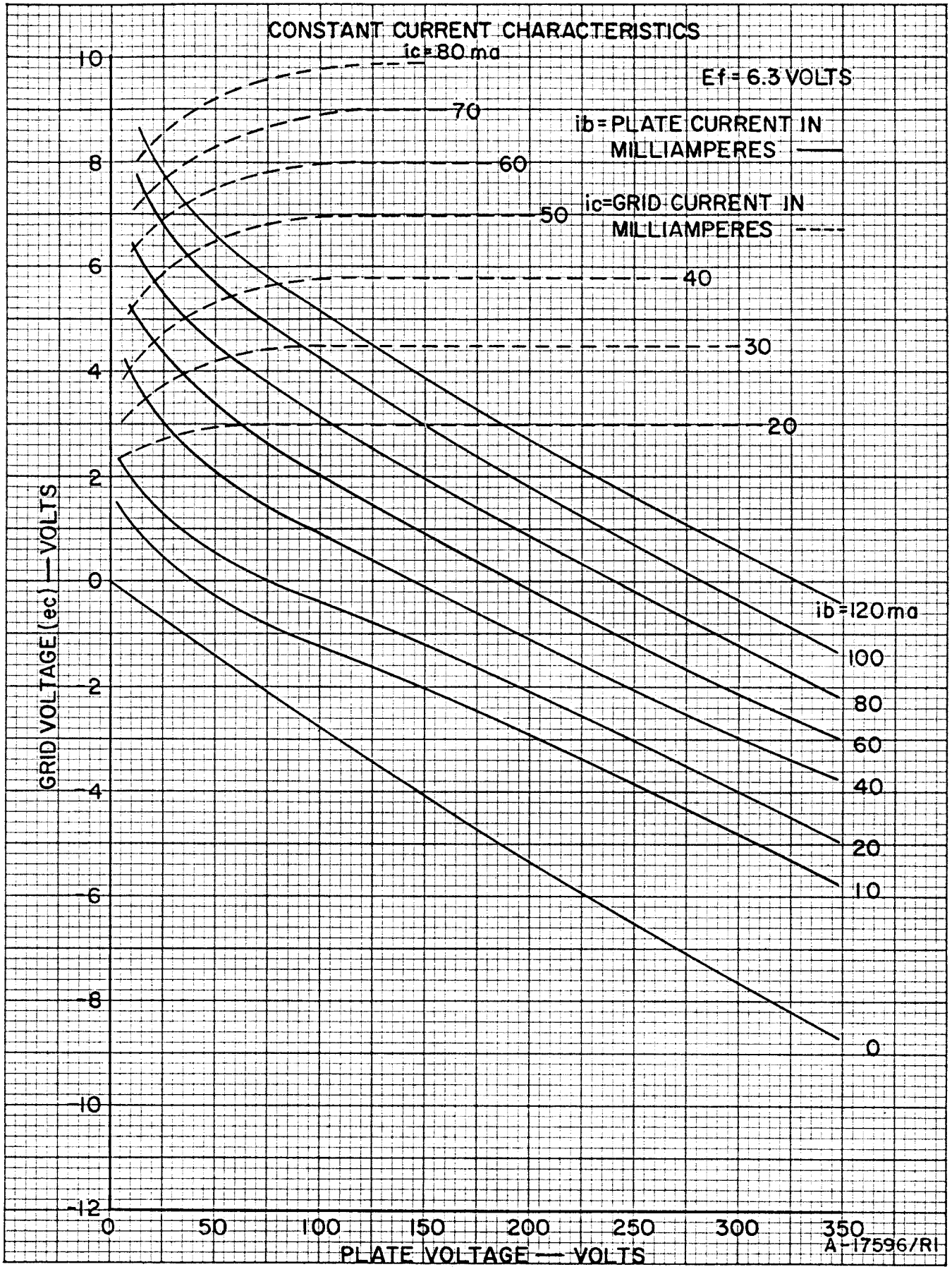
‡ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

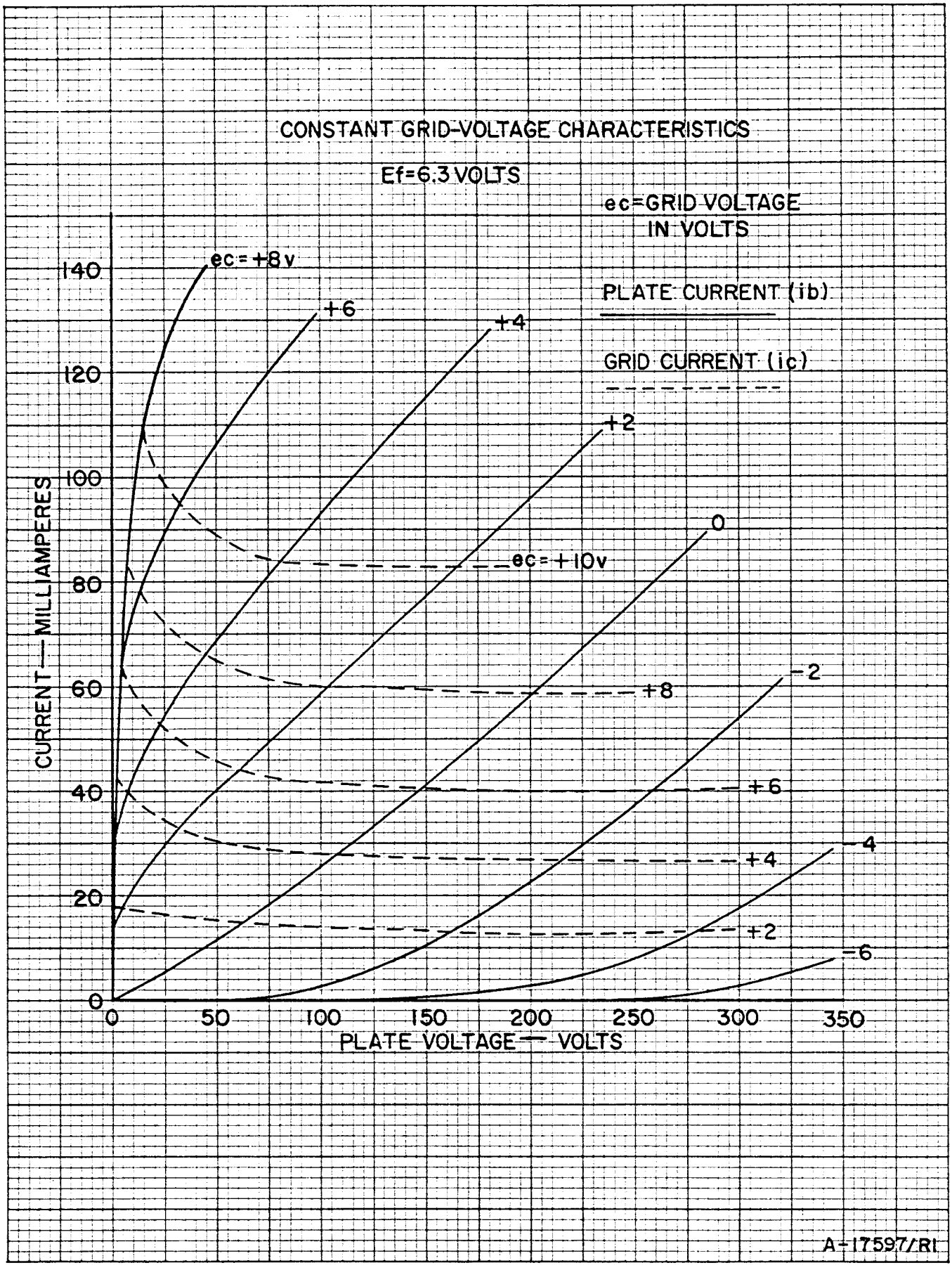
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

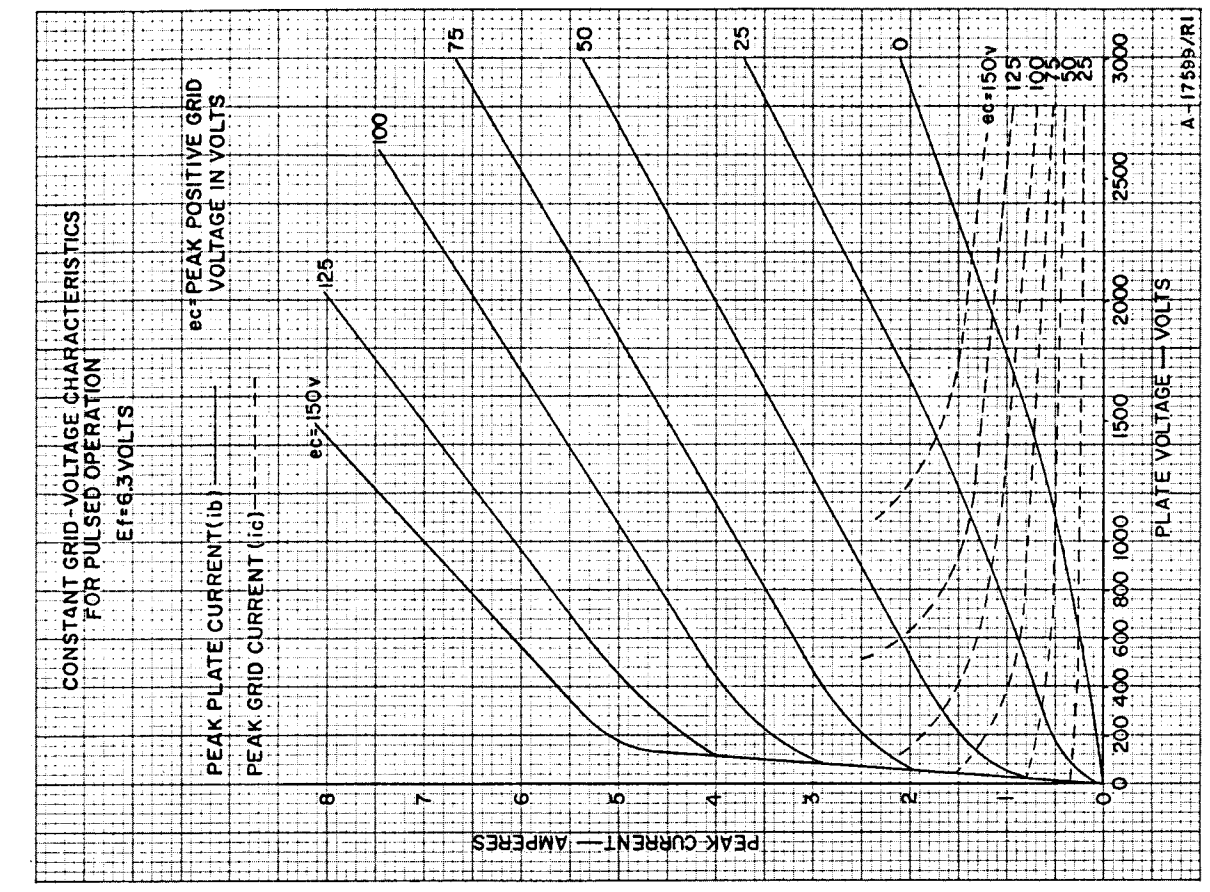
Class A_1 Amplifier	Min.	Max.	
Plate Voltage	——	350	Volts
DC Grid Bias, approximate	−2.5	−5.75	Vdc
Amplification Factor, approximate, Ec/Ib = 35 mAdc	35	65	
Transconductance	13500	19000	μmhos
Plate Current	——	35	mAdc
Grid-Plate Capacitance	2.10	2.45	μμf
Grid-Cathode Capacitance, Eh = 0	4.60	5.45	μμf
Plate-Cathode Capacitance, Eh = 0	——	0.045	μμf

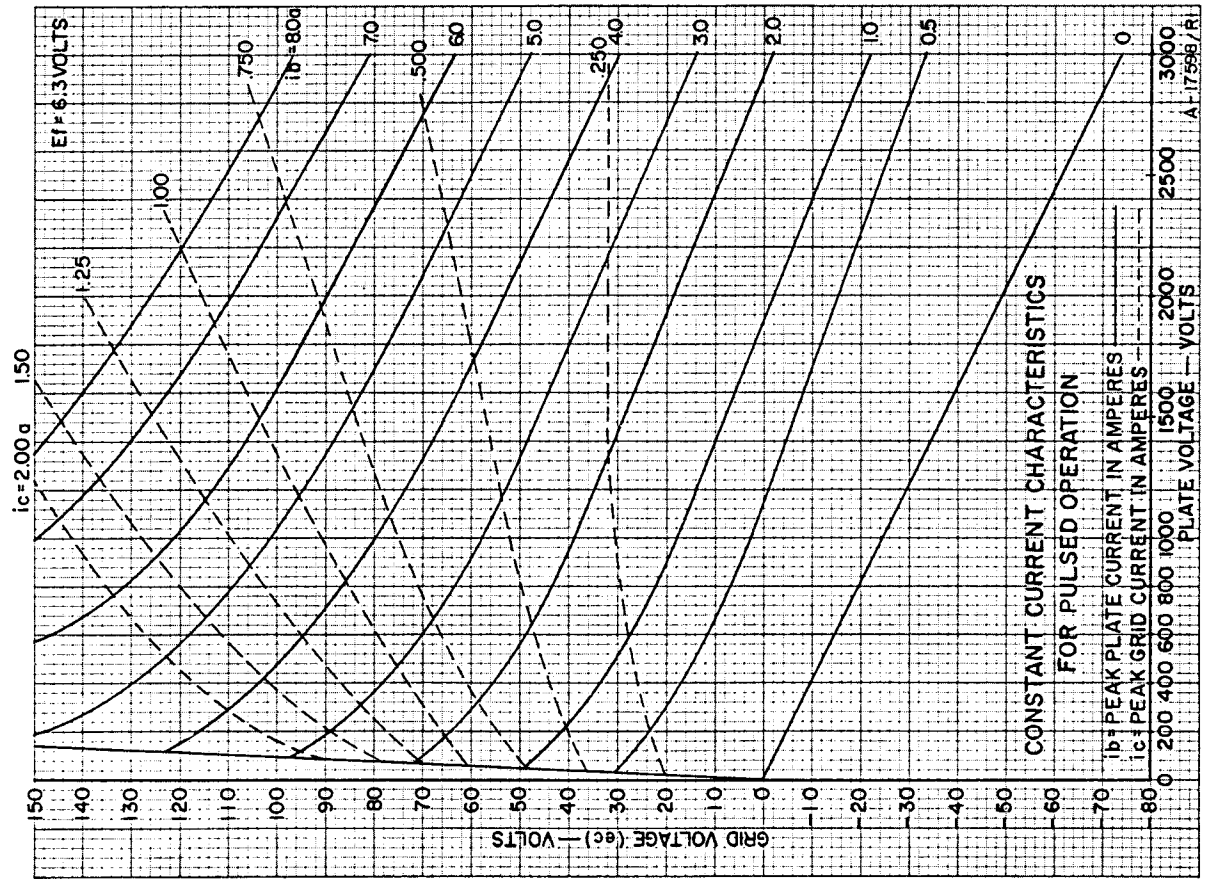
APPLICATION NOTES

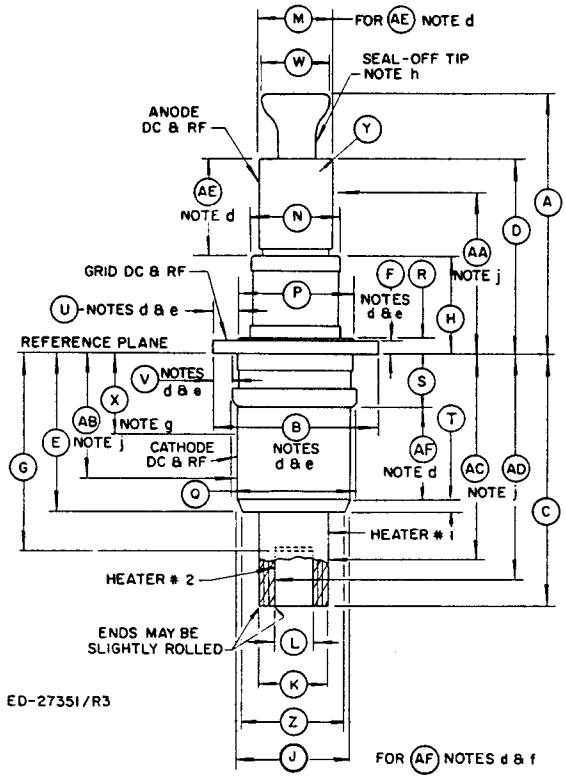
Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes — General.*


CONSTANT CURRENT CHARACTERISTICS
ic = 80 ma
70
60
50
40
30
20
Ef = 6.3 VOLTS
ib = PLATE CURRENT IN MILLIAMPERES
ic = GRID CURRENT IN MILLIAMPERES
ib = 120 ma
100
80
60
40
20
10
0
GRID VOLTAGE (ec) — VOLTS
10
8
6
4
2
0
-2
-4
-6
-8
-10
-12
0
50
100
150
200
250
300
350
PLATE VOLTAGE — VOLTS
A-17596/RI


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef=6.3 VOLTS
ec=GRID VOLTAGE IN VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
ec=+8v
+6
+4
+2
0
-2
-4
-6
ec=+10v
+8
+6
+4
+2
CURRENT — MILLIAMPERES
0
20
40
60
80
100
120
140
0
50
100
150
200
250
300
350
PLATE VOLTAGE — VOLTS
A-17597/R1


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef=6.3 VOLTS
ec=PEAK POSITIVE GRID VOLTAGE IN VOLTS
PEAK PLATE CURRENT(ib) ——
PEAK GRID CURRENT (ic) - - - -
ec=150v
125
100
75
50
25
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
A-17599/R1


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
ib= PEAK PLATE CURRENT IN AMPERES ——
ic= PEAK GRID CURRENT IN AMPERES - - - -
Ef=6.3 VOLTS
ic=2.00a
ib=80a
.750
.500
.250
125
100
75
70
60
50
40
30
20
10
05
0
GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — VOLTS
A-17598/R1



NOTES

d. Contact surfaces shall be confined to this area.

e. Only these surfaces shall be used for tube stops or clamping.

f. Maximum diameter is not increased by solder.

g. Tube marking is confined to this area.

h. Exhaust tubulation must not be subjected to any mechanical stress.

j. Eccentricity (one-half total indicated runout) is gaged at points designated and falls within the following limits:

Contact	Max. Eccentricity		Reference
	Inches	mm	
Anode	.010	.25	Grid Contact
Cathode	.010	.25	Grid Contact
Heater No. 1	.015	.38	Grid Contact
Heater No. 2	.015	.38	Grid Contact

DIMENSIONS FOR OUTLINE

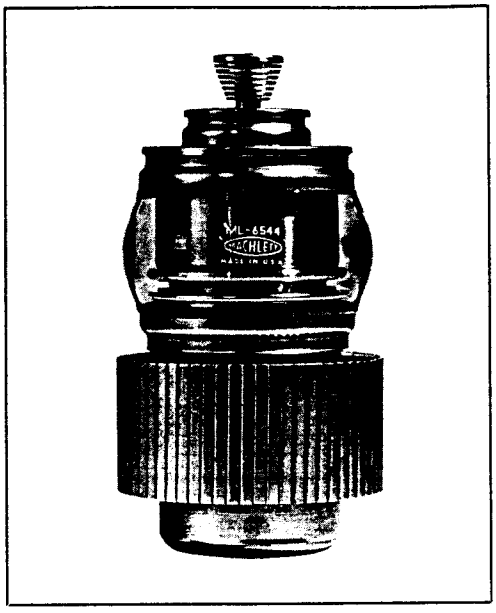
The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A			1.328			33.73	
B	.810		.818	20.57		20.77	dia.
C	1.219		1.281	30.96		32.53	
D	.953		.984	24.21		24.99	
E	.750		.813	19.05		20.65	
F	.070		.078	1.78		1.98	
G			1.016			25.80	
H			.515			13.08	
J	.539		.549	13.69		13.94	dia.
K	.318		.328	8.08		8.33	dia.
L	.180		.190	4.57		4.82	dia.
M	.365		.371	9.27		9.42	dia.
N			.453			11.50	dia.
P	.560		.570	14.22		14.47	dia.
Q			.609			15.46	dia.
R	.077		.097	1.96		2.46	
S			.266			6.75	
T	.015		.090	.38		2.28	
U		.094			2.39		
V		.094			2.39		
W			.313			7.95	
X			.375			9.52	
Y		.016			.41		rad.
Z	.490		.520	12.45		13.20	
AA		.750			19.05		
AB		.547			13.89		
AC		1.000			25.40		
AD		1.109			28.17		
AE		.438			11.13		
AF		.453			11.51		

THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE CONNECTICUT

ST-1604 5M 11-64

Printed in U.S.A.



ISSUED 5-64

ML-6544

Shielded Grid Triode

Pulse Power to 1 Mw

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-6544 is a shielded-grid triode designed primarily for use as a switch tube in hard-tube pulse modulators for radar applications. It delivers a peak pulse power output of one megawatt with less than 10 kW of driving power. The tube incorporates a beamed electrode structure to minimize driving power. This design avoids the fine-wire grids usually used in tetrodes and provides a rugged structure. The shield grid is strapped to the cathode internally and protects the cathode from transient arcs. These features provide a tube which operates much more stably at high voltages than hard-tube modulators of earlier design. The high amplification factor coupled with low grid current result in unusually low driving power requirements. Additionally, the input and output circuits are isolated so that feedback capacitance is small. The cathode is a unipotential oxide-coated type. The anode is forced-air cooled and is capable of dissipating 1 kW with an air flow of 80 cfm.

GENERAL CHARACTERISTICS

Electrical		
Filament Voltage	6.0 ±5%	Volts
Filament Current	60	Amps
Filament Starting Current, maximum	300	Amps
Cathode Warm-Up Time‡	10	Min
Amplification Factor	90	
Interelectrode Capacitances		
Grid-Plate, maximum	4	μμf
Grid-Filament	260	μμf
Plate-Filament	40	μμf
Strapped Resonant Frequency, grid to cathode, approximate	63.5	Mc
Mechanical		
Mounting Position (support tube by anode radiator only)	Any	
Type of Cooling	Forced-air†	
Air flow on anode (at 45°C and 14.7 psi ambient atmospheric pressure)	80	cfm*
Static Pressure, Inches of Water	0.2	
Air flow on grid radiator, minimum	5	cfm
Maximum incoming air temperature	75	°C
Maximum Glass Temperature	175	°C†
Net Weight, approximate	13	lbs.

‡For accelerated cathode warm-up, the filament may be energized at 7.0 volts for 5 minutes and then reduced to 6.0 volts for high-voltage operation. If a filament stand-by voltage of 5.0 volts is used, the minimum cathode warm-up time is 1 minute at 6.0 volts.

†Sufficient air cooling must be provided to keep glass seal temperatures at less than 175°C under all conditions of operation.

*For air-flow requirements at other temperatures and pressures, consult the Machlett Engineering Department.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

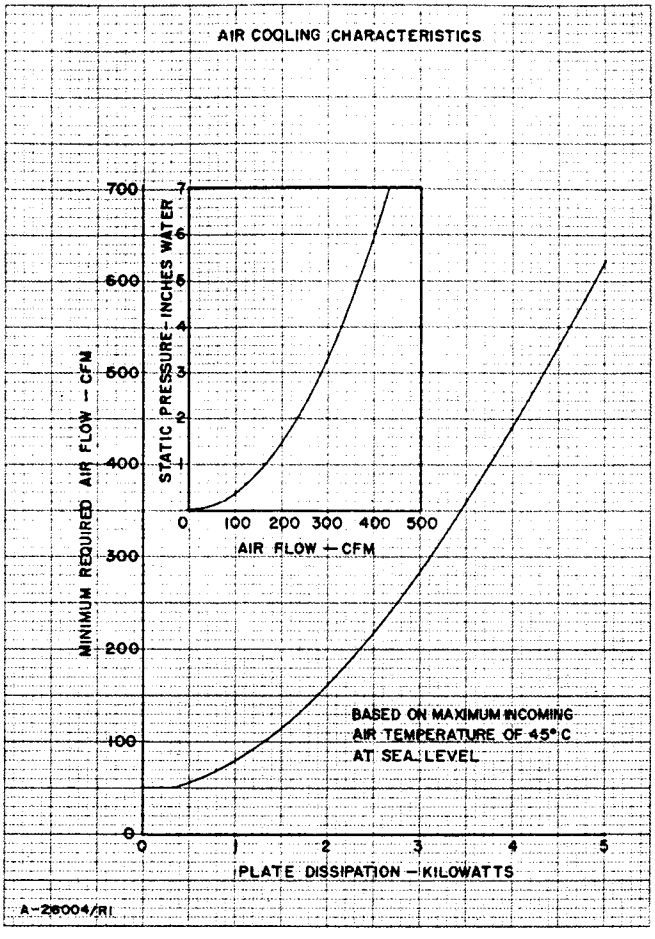
D-C Plate Voltage	20	kV
Peak Plate Voltage	25	kv
D-C Grid Voltage	−600	volts
Peak Positive Grid Voltage	1500	volts
Peak Negative Grid Voltage	−1500	volts
Pulse Cathode Current	75	amp
D-C Plate Current	250	mA
Grid Dissipation	75	watts
Plate Dissipation	1.0	kW
Pulse Duration	6	μsec*
Duty Factor	.03*	

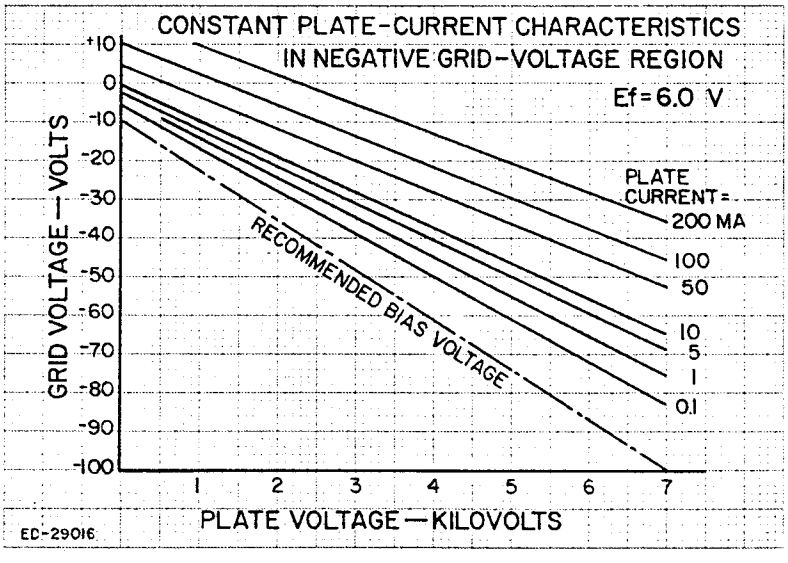
Typical Operation

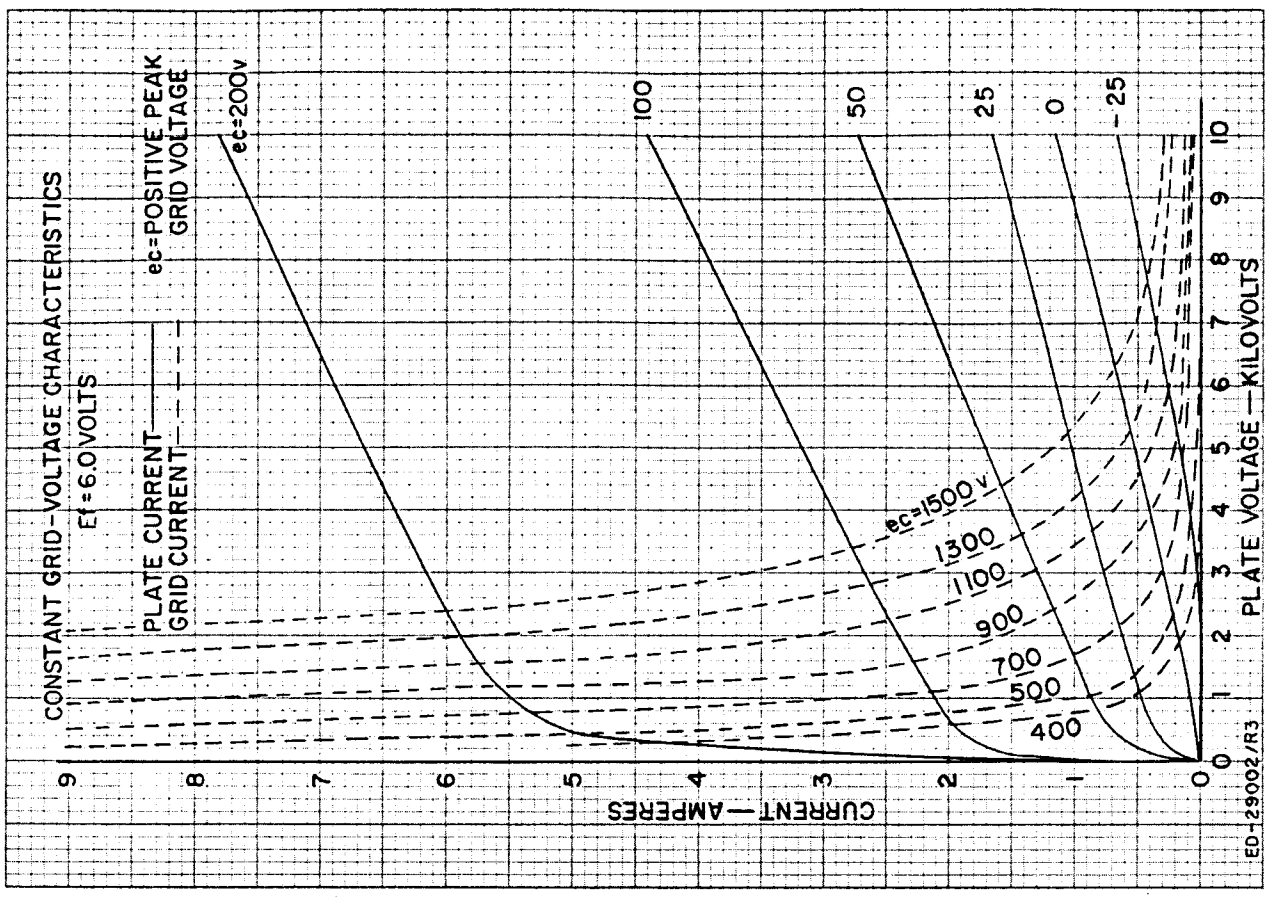
D-C Plate Voltage	18	kV
D-C Grid Voltage	−250	volts
Pulse Positive Grid Voltage	1200	volts
Pulse Plate Current	65	amp
Pulse Grid Current	7	amp
Pulse Driving Power	12	kw
Pulse Power Output	1.0	Mw
Plate Output Voltage	15.5	kv
Duty Factor	.003	

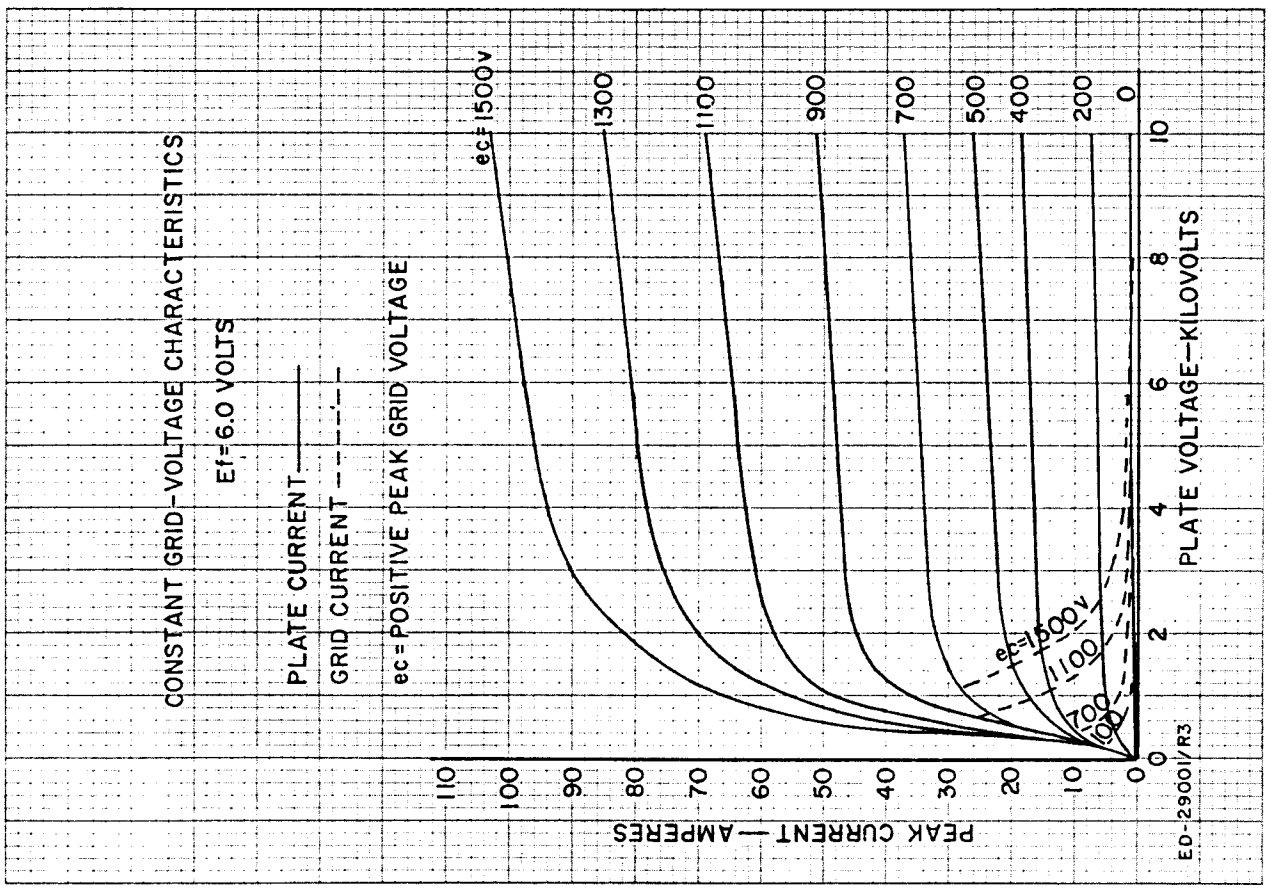
*For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

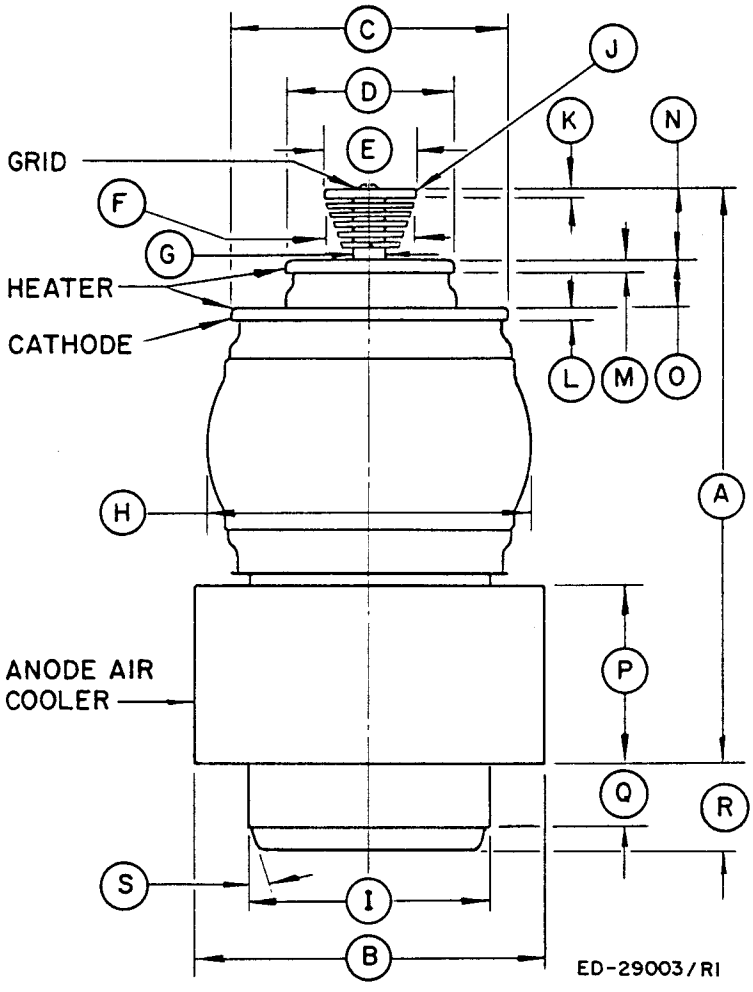
WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.






CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef=6.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec=POSITIVE PEAK GRID VOLTAGE
ec=200v
100
50
25
0
-25
ec=1500v
1300
1100
900
700
500
400
CURRENT — AMPERES
PLATE VOLTAGE — KILOVOLTS
ED-29002/R3


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef=6.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec=POSITIVE PEAK GRID VOLTAGE
ec=1500v
1300
1100
900
700
500
400
200
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE—KILOVOLTS
ED-29001/R3



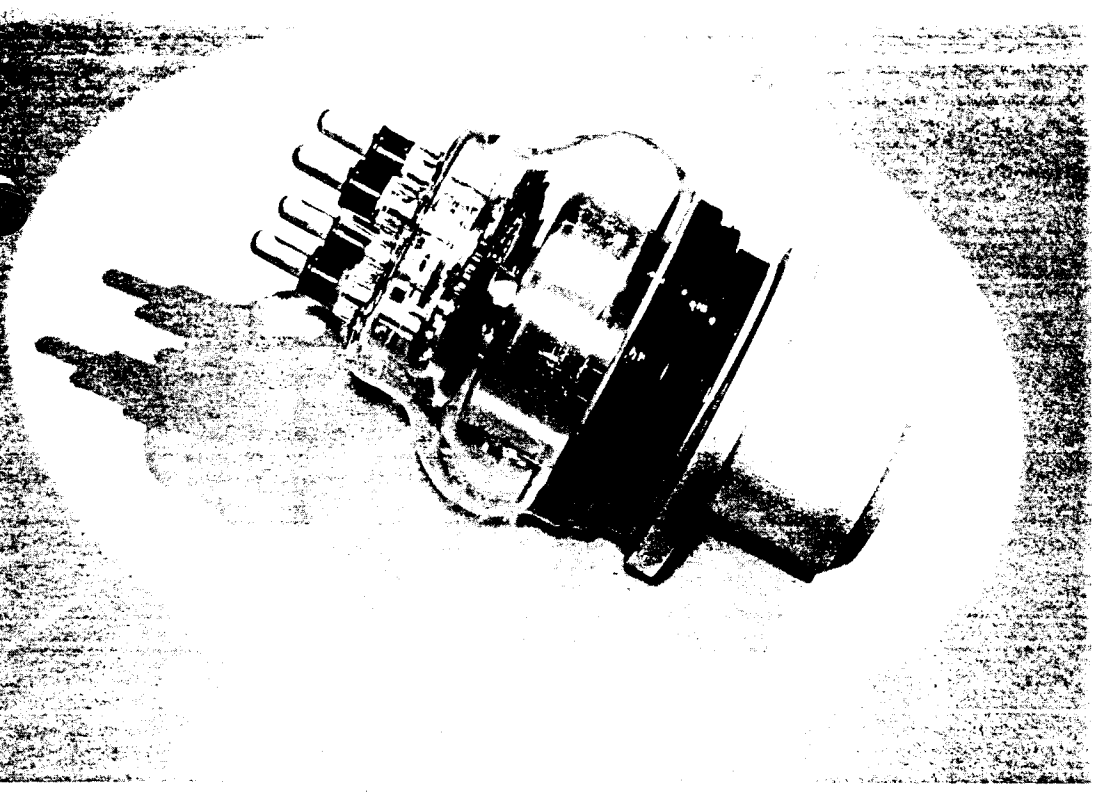
DIMENSIONS FOR OUTLINE OF ML-6544

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A			8 5/8	
B	5.075	5.125	5.135	
C	4 3/64	4 1/16	4 5/64	
D	2 27/64	2 7/16	2 29/64	
E	1.370	1.375	1.380	
F			1 5/16	
G			1 1/16	
H			4 7/8	
I			3 9/16	
J	1/32			radius
K	.135	.140	.145	
L	11/64	3/16	13/64	
M	11/64	3/16	13/64	
N	31/32	1 1/32	1 3/32	
O	5/8	11/16	3/4	
P	2 9/16	2 5/8	2 11/16	
Q			15/16	
R			1 3/4	
S	20			degrees

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SPRINGDALE MACHLETT CONNECTICUT

ST-1580 4.5M 5-64

Printed in U.S.A.



MACHLETT

ML-6576

DESCRIPTION & RATINGS

DESCRIPTION

The ML-6576 is a three-electrode tube designed specifically for use as a modulator or amplifier in broadcast and communication service, and as an R-F amplifier in single-sideband transmission systems where low distortion is of utmost importance. The ML-6576 is mechanically equivalent to the ML-356 tube; filament characteristics are also identical. Features include rugged kovar-glass seals and rigidly supported grid and filament assemblies. The anode is water cooled and is capable of dissipating 22.5 kW with a water flow of approximately 12 gpm. The cathode is a thoriated-tungsten, stress-free filament employing no sliding contacts, insulators or tension springs. Maximum ratings of 12 kVdc plate voltage and 45 kW plate input apply at frequencies up to 25 Mc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	7.5	Volts
Filament Current at 7.5 Volts	170	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	0.0056	Ohms
Amplification Factor	5.5	
Interelectrode Capacitances:		
Grid-Plate	44	uuf
Grid-Filament	33	uuf
Plate-Filament	4.0	uuf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling	Water and Forced Air	
Water Flow on anode, minimum for 22.5 kW dissipation	12	gpm*
Maximum outgoing water temperature	70	°C
Air flow on center of dish from 3" nozzle	50	cfm†
Maximum Glass Temperature	165	°C
Net Weight, approximate	14	lbs.

*This rate of water flow applies when Machlett Water Jacket F-10690 with spiral is employed.

†At frequencies above 10 Mc, more air flow may be necessary; special attention should be given to adequate ventilation of the dish and seals to keep the temperature at the hottest point below 165°C. Heat radiating connectors for grid and filament posts are recommended.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS
(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class AB

Maximum Ratings, Absolute Values

D-C Plate Voltage	12000	volts
Max.-Signal D-C Plate Current*	5.0	amps
Max.-Signal Plate Input*	45	kW
Plate Dissipation*	22.5	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	10000	12000	volts
D-C Grid Voltage	-1800	-2150	volts
Peak A-F Grid-to-Grid Voltage	3550	4250	volts
Peak A-F Plate-to-Plate Voltage	14000	19000	volts
Zero-Signal D-C Plate Current	1.8	1.8	amps
Max-Signal D-C Plate Current	7.6	5.7	amps
Effective Load Resistance, Plate-to-Plate	2300	4200	ohms
Max.-Signal Driving Power, approx.	0	0	kW
Max.-Signal Power Output, approx.	42	43	kW

Radio-Frequency Power Amplifier Class AB Single-Sideband

Two-tone test conditions per tube

Maximum Ratings, Absolute Values

D-C Plate Voltage	12000	volts
D-C Plate Current	5.0	amps
Plate Input	45	kW
Plate Dissipation	22.5	kW

Typical Operation

D-C Plate Voltage	10000	volts
D-C Grid Voltage	-1900	volts
D-C Plate Current	3.0	amps
D-C Grid Current, approximate	0	mA
Driving Power, approximate**	0	kW
Peak Envelope Power Output, approximate	36	kW

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	12000	volts
D-C Plate Current	4.0	amps
Plate Input	40	kW
Plate Dissipation	15	kW

Typical Operation

D-C Plate Voltage	12000	volts
D-C Grid Voltage	-2150	volts
Peak R-F Grid Voltage	1375	volts
Peak R-F Plate Voltage	10000	volts
D-C Plate Current	3.0	amps
D-C Grid Current	0	mA
Driving Power, approximate**	100	watts
Power Output, approximate	12	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

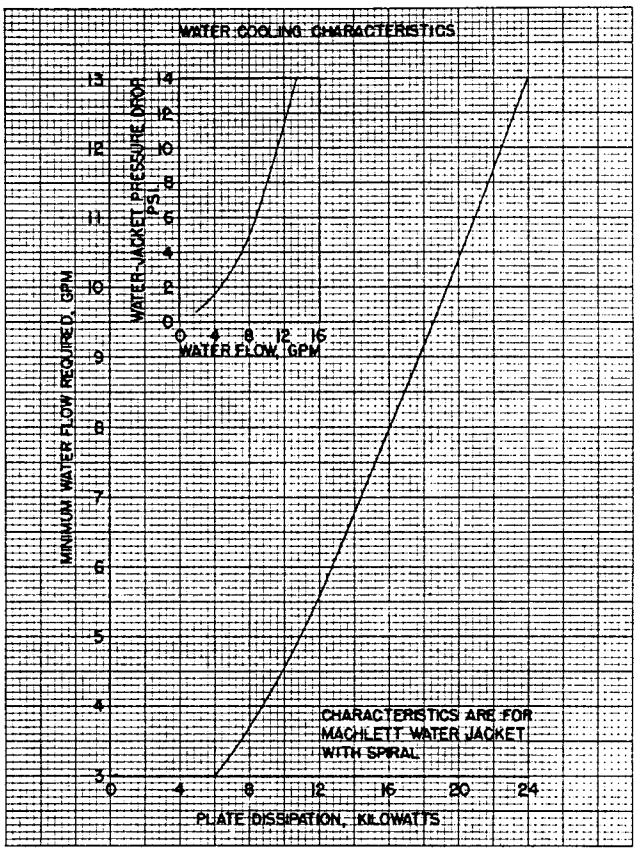
Maximum Ratings, Absolute Values

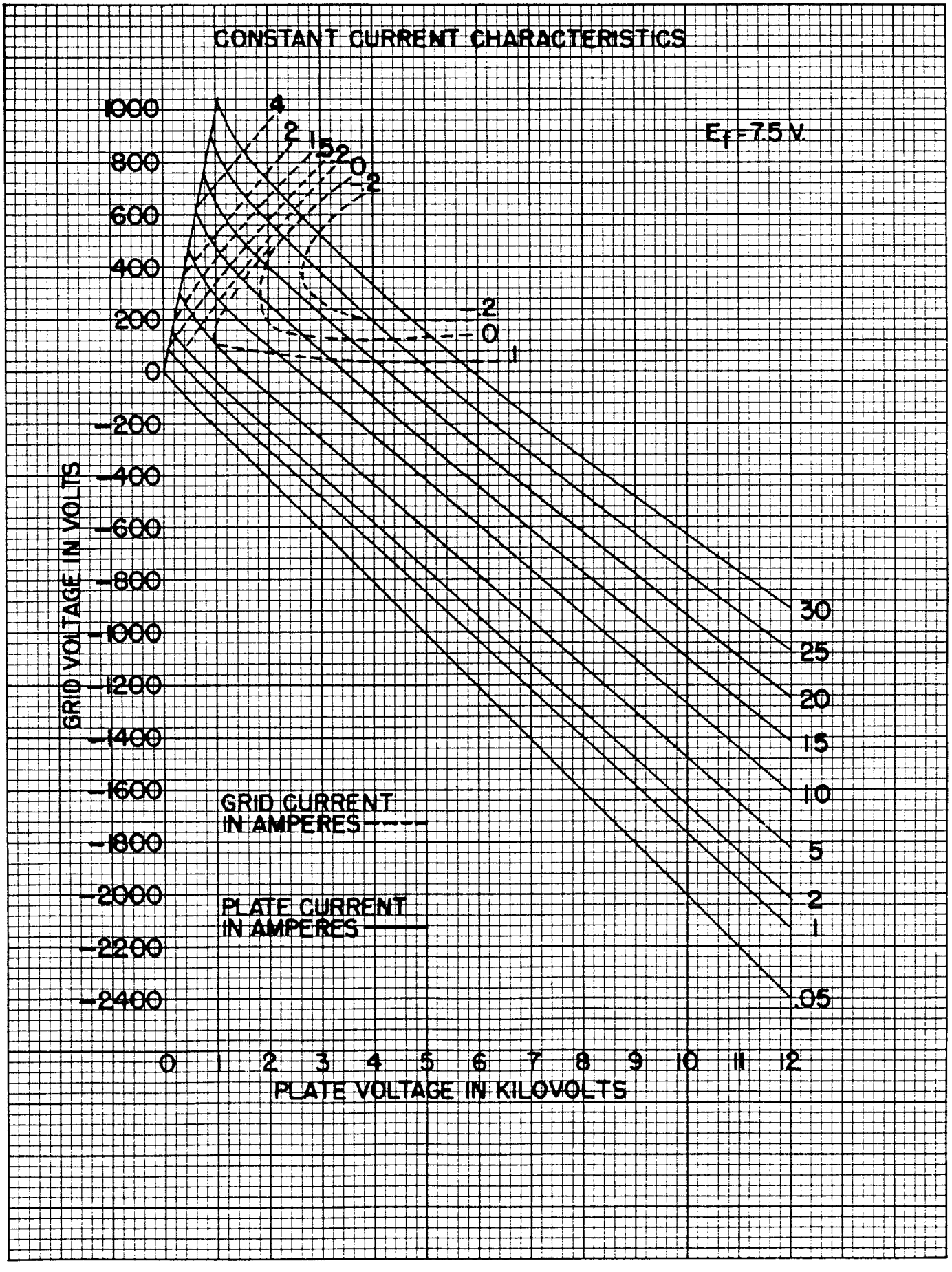
D-C Plate Voltage	10000	volts
D-C Grid Voltage	-2400	volts
D-C Plate Current	6.0	amps
D-C Grid Current	0.20	amp
Plate Input	60	kW
Plate Dissipation	22.5	kW

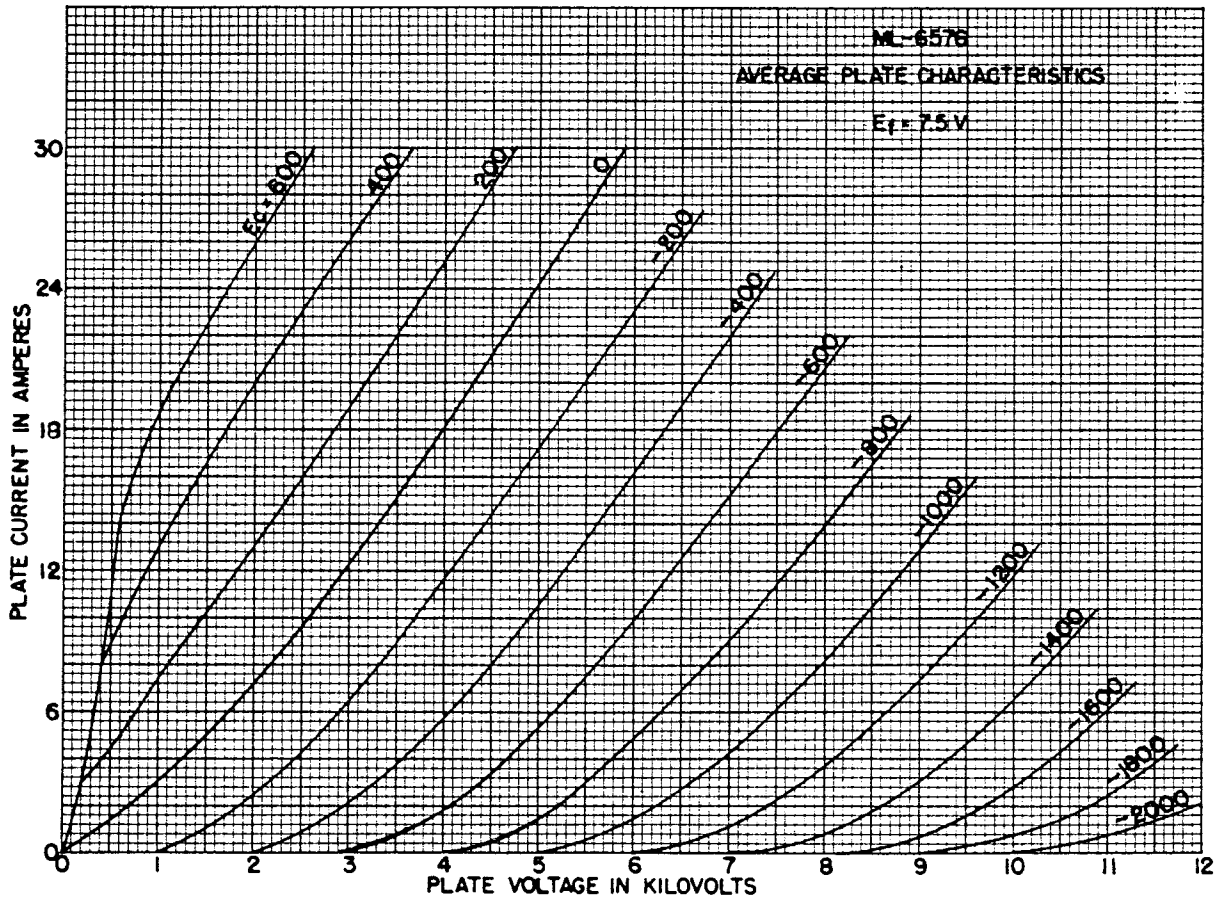
Typical Operation

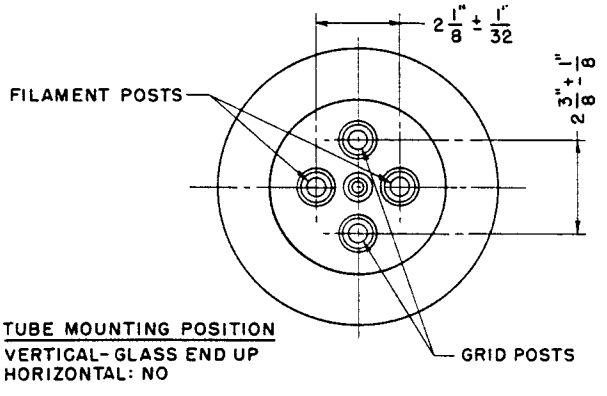
D-C Plate Voltage	8000	volts
D-C Grid Voltage	-2000	volts
Peak R-F Grid Voltage	2600	volts
Peak R-F Plate Voltage	6700	volts
D-C Plate Current	4.9	amps
D-C Grid Current, approximate	0.12	amp
Driving Power, approximate	300	watts
Power Output, approximate	29	kW

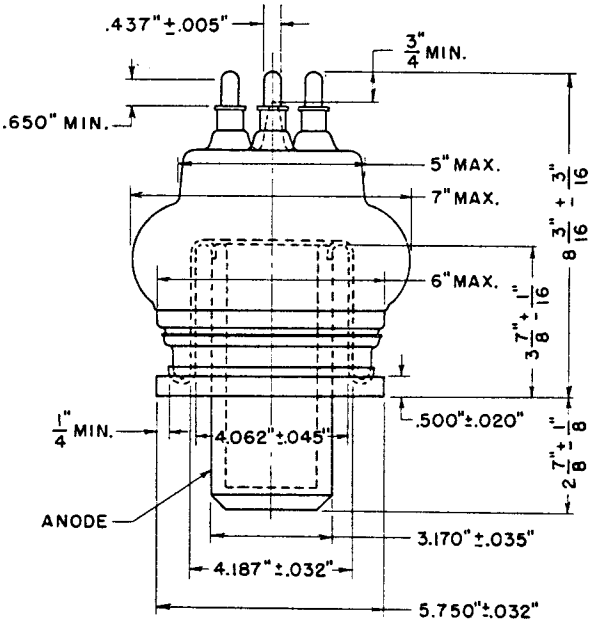
* Averaged over any audio-frequency cycle of sine-wave form.
** At crest of audio-frequency cycle with modulation factor of 1.0.
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.




CONSTANT CURRENT CHARACTERISTICS
E_f=7.5 V.
GRID VOLTAGE IN VOLTS
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
-1800
-2000
-2200
-2400
4
2
1.5
2
0
-2
-2
0
1
30
25
20
15
10
5
2
1
.05
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
0 1 2 3 4 5 6 7 8 9 10 11 12
PLATE VOLTAGE IN KILOVOLTS





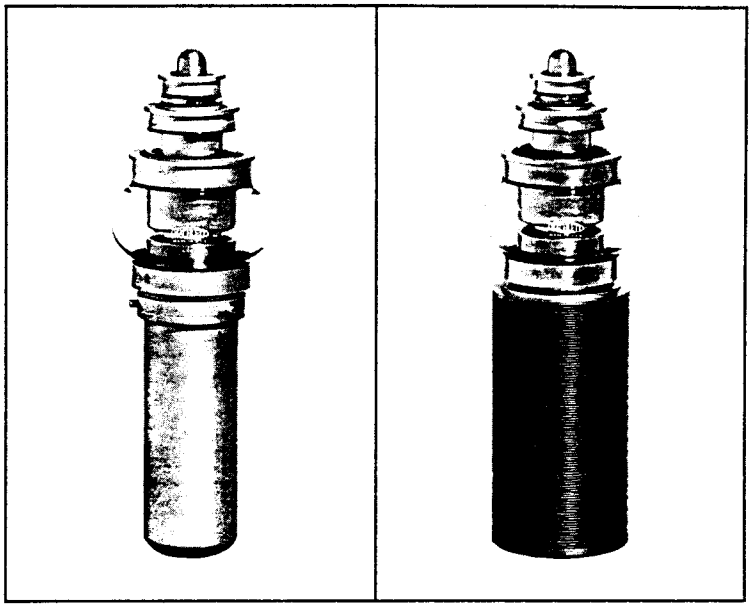


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ISSUED 9-67

ML-6696
ML-6697

General Purpose Triodes
80 kW CW

MACHLETT

DESCRIPTION

The ML-6696 and ML-6697 are general-purpose triodes suitable for industrial heating and AM broadcasting. These tubes feature rugged coaxial mounting structures providing high-dissipation, low inductance rf electrode terminals. The cathode of each type consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments.

The ML-6696 has a water-cooled, heavy-wall anode capable of dissipating 60 kW. The ML-6697 has a forced-air-cooled, heavy-wall anode with high-efficiency disc fins capable of dissipating 35 kW.

These tubes will operate with plate voltages up to 16 kV in CW operation. Maximum ratings apply at frequencies up to 30 MHz. Useful power output can be obtained at frequencies up to 70 MHz with reduced ratings.

GENERAL CHARACTERISTICS

Electrical	
Filament Voltage	13.0 Volts
Filament Current	205 Amps
Filament Starting Current, maximum	800 Amps
Filament Cold Resistance	0.0073 Ohm
Amplification Factor	20
Interelectrode Capacitances	
Grid-Plate	55 pf
Grid-Filament	76 pf
Plate-Filament	2.7 pf
Mechanical	
Mounting Position	Vertical, anode down
Type of Cooling — ML-6696	Water and forced-air†
Water flow on anode for 60 kW dissipation, approx.	18 gpm
Maximum outgoing water temperature	70 °C
Type of Cooling — ML-6697	Forced-air
Air flow on anode for 35 kW dissipation	Pressure: 1700 cfm at 7.8" water*
	Exhaust: 1970 cfm at 8.4" water*
Maximum incoming air temperature	50 °C
Maximum Envelope Temperature	165 °C†
Net Weight, approximate	
ML-6696	17 lbs.
ML-6697	43 lbs.

*When used with ML-6697 air distributor F-17759.

†Auxiliary air flow of 50-100 cfm is required and should be distributed to maintain a uniform glass temperature, not greater than 165°C, around the circumference of the seals. At high frequencies or high ambient temperature, additional air flow may be required.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values		
D-C Plate Voltage	16000	volts
Max.-Signal D-C Plate Current*	11	amps
Max.-Signal Plate Input*		
ML-6696	120	kW
ML-6697	110	kW
Plate Dissipation		
ML-6696	60	kW
ML-6697	35	kW

Typical Operation (Values are for two tubes)	ML-6696		
D-C Plate Voltage	10000	12000	volts
D-C Grid Voltage	−450	−600	volts
Peak A-F Grid-to-Grid Voltage	1750	2120	volts
Peak A-F Plate-to-Plate Voltage	16000	19200	volts
Zero Signal D-C Plate Current	3.0	2.0	amps
Max.-Signal D-C Plate Current	17.4	20.0	amps
Effective Load Resistance, Plate-to-Plate	1170	1230	ohms
Max.-Signal Driving Power, approx.	550	600	watts
Max.-Signal Power Output, approx.	110	152	kW

*Average over any audio-frequency cycle of sine-wave form.

Radio Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	16000	volts
D-C Plate Current	9	amps
Plate Input		
ML-6696	90	kW
ML-6697	55	kW
Plate Dissipation		
ML-6696	60	kW
ML-6697	35	kW

Typical Operation		ML-6696	
D-C Plate Voltage	12000	12000	volts
D-C Grid Voltage	−550	−550	volts
Peak R-F Grid Voltage	510	640	volts
Peak R-F Plate Voltage	5300	5300	volts
D-C Plate Current	4.3	6.8	amps
D-C Grid Current	0	0	mA
R-F Load Resistance	780	500	ohms
Driving Power, approx.†	450	1500	watts
Power Output, approx.	18	28	kW

†At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	10000	volts
D-C Grid Voltage	−3200	volts
D-C Plate Current	8.5	amps
D-C Grid Current	2.0	amps
Plate Input	81	kW
Plate Dissipation		
ML-6696	40	kW
ML-6697	23	kW
Typical Operation		
D-C Plate Voltage	9500	volts
D-C Grid Voltage	−1600	volts
Peak R-F Grid Voltage	2300	volts
Peak R-F Plate Voltage	7800	volts
D-C Plate Current	8.4	amps
D-C Grid Current	0.90	amp
R-F Load Resistance	510	ohms
Driving Power, approx.	2.0	kW
Power Output, approx.	60	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values			
D-C Plate Voltage	16000		volts
D-C Grid Voltage	−3200		volts
D-C Plate Current	11		amps
D-C Grid Current	2.0		amps
Plate Input	120		kW
Plate Dissipation			
ML-6696	60		kW
ML-6697	35		kW
Typical Operation			
D-C Plate Voltage	10000	15000	volts
D-C Grid Voltage	−1200	−1600	volts
Peak R-F Grid Voltage	1900	2120	volts
Peak R-F Plate Voltage	8000	12500	volts
D-C Plate Current	10.0	7.0	amps
D-C Grid Current	0.81	0.30	amp
R-F Load Resistance	440	970	ohms
Driving Power, approx.	1.5	0.60	kW
Power Output, approx.	72	80	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits			
			Minimum	Bogey	Maximum	
Grid Voltage	e_b=1500 volts; i_b=48 amps	e_c:	—	—	1000	volts
Grid Current	e_b=1500 volts; i_b=48 amps	i_c:	—	—	15	amps
Plate Voltage	E_c=0 Vdc; I_b=3.0 Adc	E_b:	1.9	2.4	2.9	kVdc
Plate Voltage	E_c=−200 Vdc; I_b=3.0 Adc	E_b:	5.6	6.4	7.2	kVdc
Grid Voltage	E_b=15.0 kVdc; I_b=0.020 Adc	E_c:	−700	−820	−940	Vdc
Plate Power Output	E_b=15.0 kVdc; I_b=7.0 Adc; E_c=−1600 Vdc; I_c=0.30 Adc	P_o:	68	—	—	kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 MHz except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation on the right. (Other maximum ratings are the same as shown above.) Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	30	50	70 MHz
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	80	55
Class C	100	75	50

Introduction

These tubes, as all high-power vacuum tubes, require some aging when they are first used in any new equipment or new environment. As the system power level increases, particularly if attended by a decrease in impedance level, it becomes increasingly important to spend enough time to acclimate the tube to the desired conditions of operation. *There is no substitute for seasoning the tube in the actual equipment in which it is to operate.* Once the procedure has been followed, however, the tube generally will be available for substantially immediate operation, unless it has been idle for an extended period of time, say three months or more.

Aging Procedure

The aging schedule will vary with the particular operating and environmental conditions. A general procedure which will serve as a starting point is to operate the tube for approximately one-half hour at each of the following steps:

(a) filament voltage only;

(b) partial plate voltage, drive and load, up to about one-half normal;

(c) full plate voltage, drive and load.

The length of time necessary for break-in to insure reliable operation can vary widely. Only experience will tell whether the above procedure can be shortened, or whether steps (b) and (c) must be extended, perhaps by a factor of two or three. The major factors affecting break-in time are the *method of applying plate voltage,* the type of *protective circuitry* available to remove power in the event of a fault, and, for a spare tube, the length of time since it had been removed from normal operation.

Plate voltage is applied preferably by continuous or stepped control. Snap-on of full plate voltage with no load may develop excessive transients which cause breakdown in the tube or other circuit components. If the voltage must be snapped on at full value, at least some load should be placed on the power transformer to limit transients to 120 percent of the d-c voltage.

Tube Protection

Fault overloads, due to tube or circuit instabilities, may result in the following conditions:

(a) liberation of gas in the tube;

(b) gross damage to internal elements, e.g. melting of grid wires;

(c) external arcing over electrodes, with damage to seals and possible puncture of envelope insulator.

A tube which becomes gassy often can be cleaned up successfully by patient reaging. The other conditions listed above are usually catastrophic.

The criteria for tube protection are the total energy which may be imparted to the tube, and the peak voltage which may appear across the electrodes. The total energy available depends on the *power source impedance,* including effect of transmission lines, and the *energy stored* in the transformer and filter components; on the *series resistance* in the circuit; and on the *duration of the discharge* or fault condition.

Primary power characteristics often are not known by the equipment designer, and the major energy-storage components usually are fixed by circuit performance requirements. Tube protection, then, is reduced to limiting surges by the design of certain components, including in the circuit at least some dissipative elements, i.e. resistance, and to sensing and removing any incipient surge as quickly as possible. The foregoing uncertainties make it difficult to specify the minimum requirements for sufficient tube protection under a given set of circumstances.

Protective Devices and Circuitry

Heretofore, it has been customary to equip plate and grid circuits with overload relays adjusted to open the circuit breakers within one-tenth of a second. In many applications, particularly where the impedance of the primary power source is low or where there is appreciable stored energy, the devices referred to above offer inadequate protection.

For high reliability and freedom from gassing and catastrophic failures, the use of an electronic shorting device or *"crowbar"* is recommended. In this case a thyratron, ignitron, or other suitable gaseous conduction device is connected to short the rectifier output to ground within 50 microseconds in the event of a fault condition. The electronic crowbar functions to divert the fault energy from the protected tube until the relay and circuit breakers act. Where multiple tubes are used with a common power supply, this type of crowbar is certainly necessary. This type of high-speed removal of fault energy has been extremely effective in reducing break-in time, and the lower the power supply impedance, the more impressive is the effect.

In some cases adequate protection can be obtained by using a vacuum switch, (a) connected as above, or (b) as a circuit breaker, replacing the usual slower acting types. These devices can divert, or remove, the fault energy in the order of one-half cycle. A vacuum-switch circuit breaker can, of course, be used to advantage in combination with the high-speed electronic shorting device. *The latter arrangement probably gives the best over-all protection to the tube and other circuit components.*

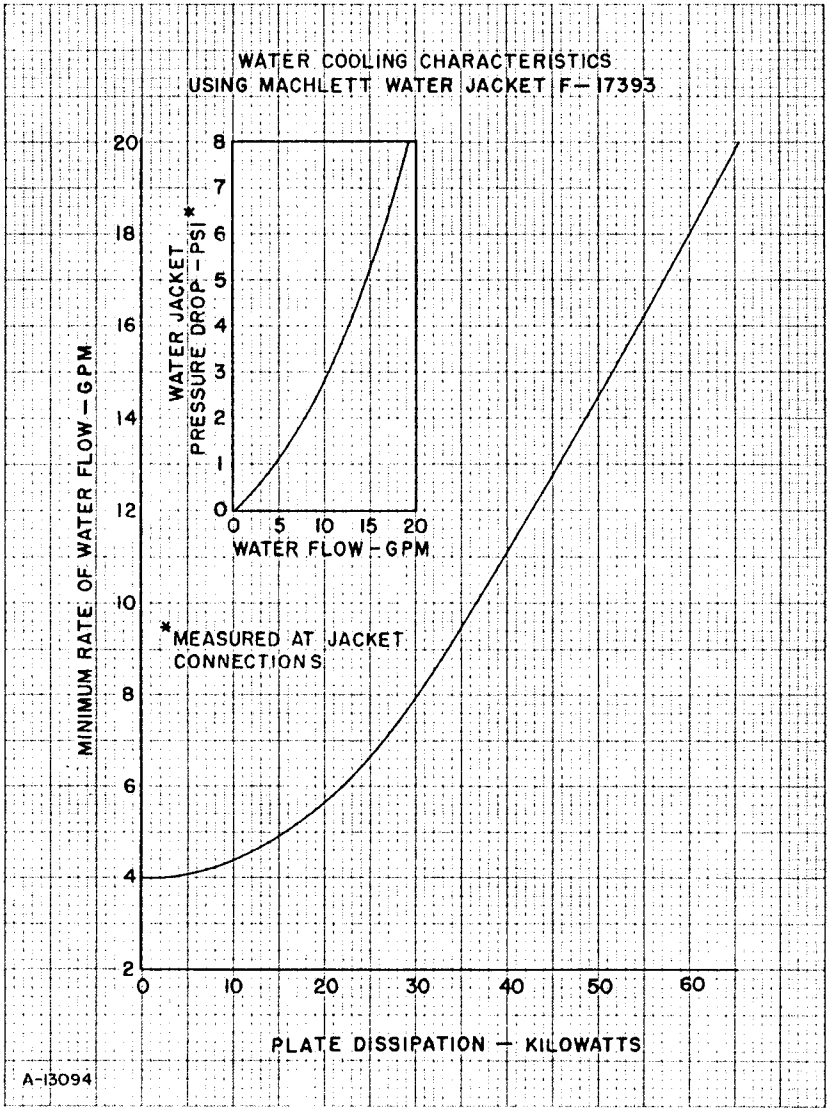
In addition, some *series resistance* should be used in the output of the power supply to limit the surge current from the transformer. Preferably, resistors may be placed in series with each rectifier lead to provide equal protection with substantially less power dissipated during normal operation. The amount of resistance will vary with circuit conditions and the speed of the protective circuitry, but the following values can be given as a guide:

Maximum Power Output of Rectifier	120	250	500	1000	kW
Series Resistor	10	20	35	50	Ohms

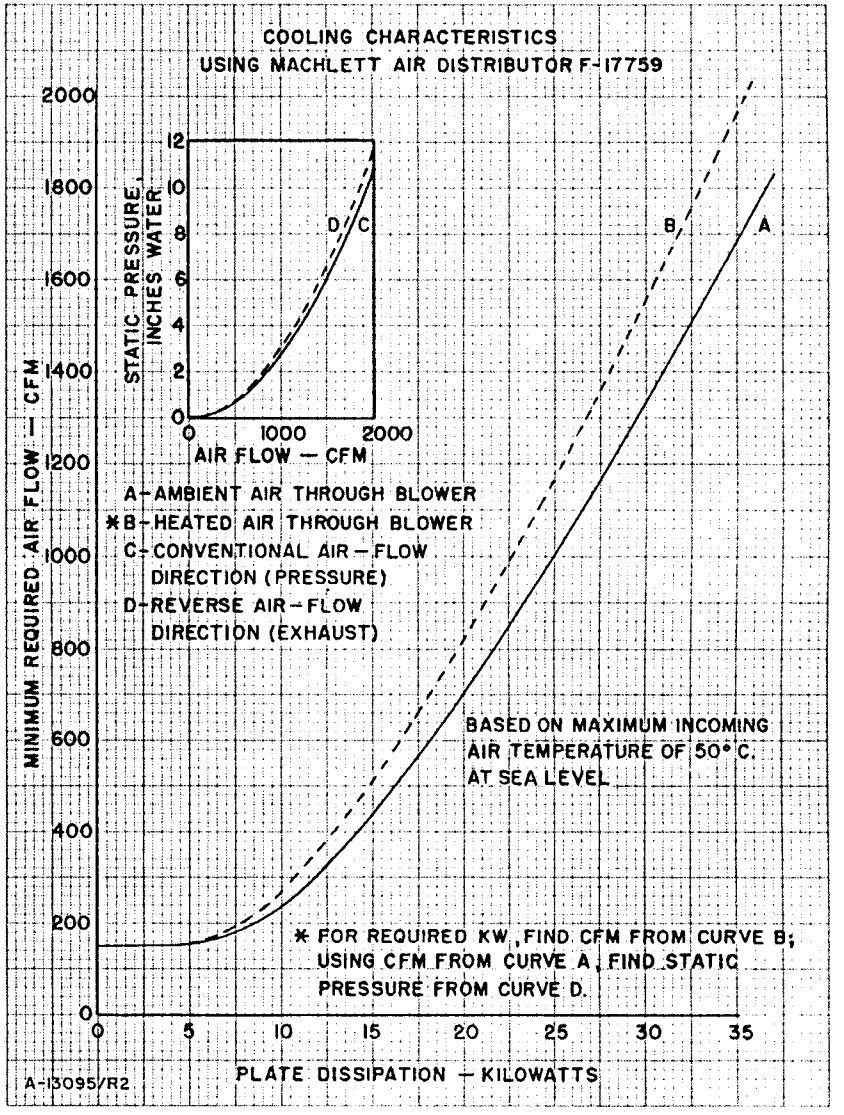
The voltage ratings of these tubes are established so that normal operation will not cause arcs to develop across the tube envelope. Any external arcing, therefore, is an indication that the rated voltages have been exceeded. To lessen the chance of permanently damaging the tube, it is helpful to attach suitable *sphere gaps,* or rings, to the electrode terminals. If the sphere gaps are properly installed, the most probable breakdown path is between the gaps rather than over the tube envelope. The gap separation must be carefully adjusted for each application. The spacing from the tube envelope to the gaps or rings, in general, should be equal to or greater than the gap separation.

Maintenance

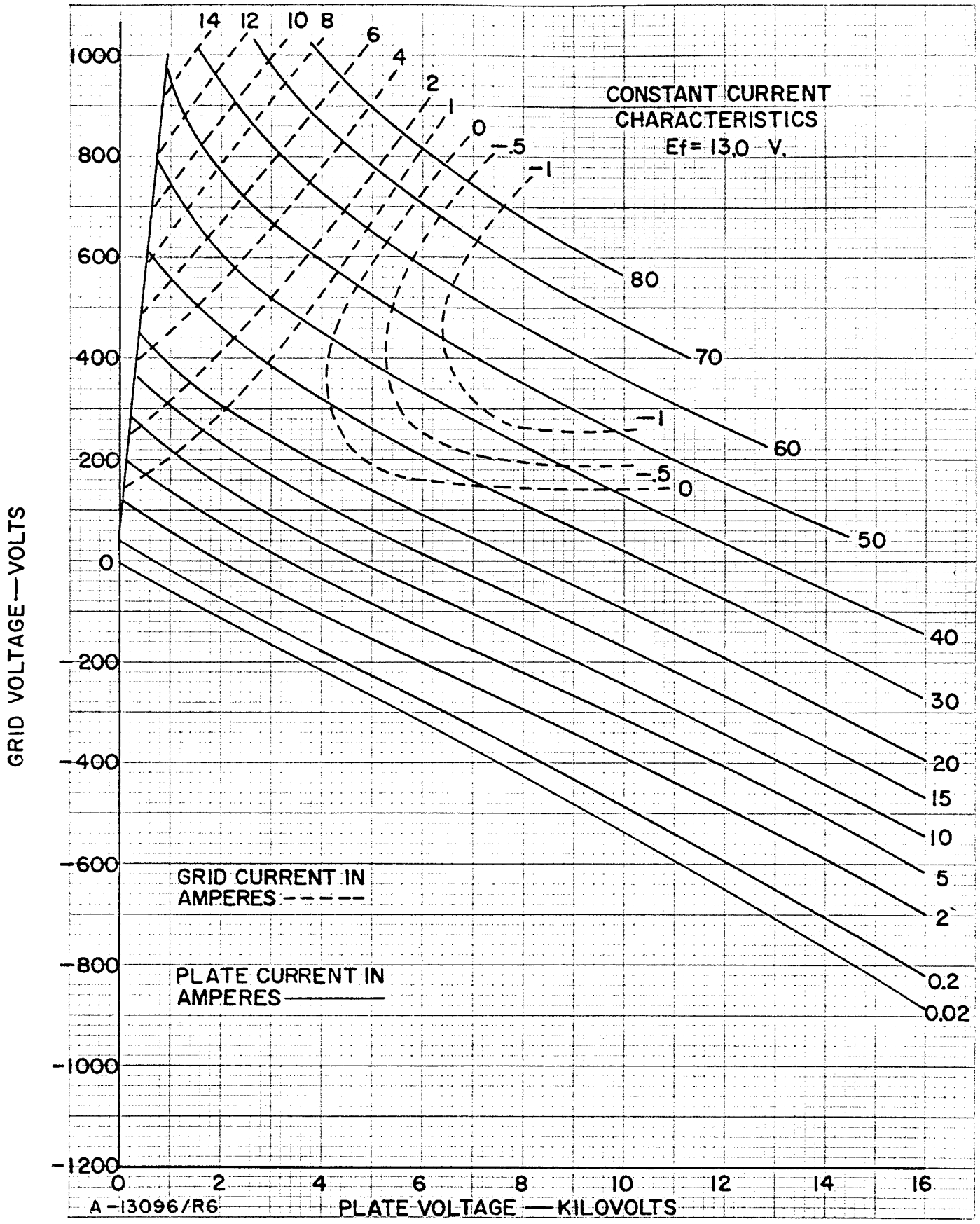
The anode cooling fins of the ML-6697 must be kept free from films of foreign materials, which will impair heat flow. To keep fins clean, it is suggested that ultrasonic cleaning or wire-brushing of the anode cooling surfaces be performed on a routine maintenance basis.

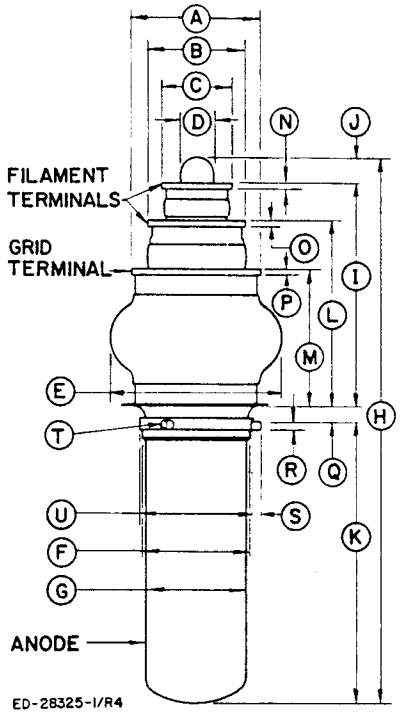


COOLING CHARACTERISTICS — ML-6696



COOLING CHARACTERISTICS — ML-6697


CONSTANT CURRENT
CHARACTERISTICS
Ef = 13.0 V.
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
GRID CURRENT IN
AMPERES - - - - -
PLATE CURRENT IN
AMPERES ———
A-13096/R6
14
12
10
8
6
4
2
1
0
-.5
-1
80
70
60
50
40
30
20
15
10
5
2
0.2
0.02
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
0
2
4
6
8
10
12
14
16

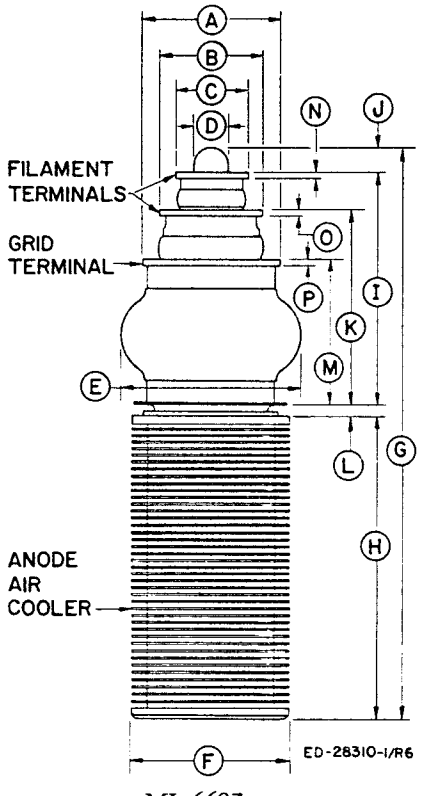


ML-6696

DIMENSIONS FOR OUTLINE OF ML-6696

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.619	4.650	4.681	
B	3.469	3.500	3.531	
C	2.469	2.500	2.531	
D	—	1.12	1.19	
E	—	5.94	6.13	
F	3.990	3.995	4.000	
G	3.485	3.500	3.515	
H	—	19.16	19.38	
I	7.75	7.88	8.00	
J	—	.94	1.00	
K	9.75	9.87	10.00	
L	6.50	6.62	6.75	
M	4.81	4.88	4.94	
N	.12	.18	—	
O	.12	.18	—	
P	.12	.18	—	
Q	.40	.44	.47	
R	.300	.310	.320	1
S	.28	.31	.35	1
T	—	120°	—	1
U	4.00	4.03	4.06	

NOTES:
1. Three bayonet pins for water jacket connection, diameter (R), length (S), nominally (T) degrees apart.



ML-6697

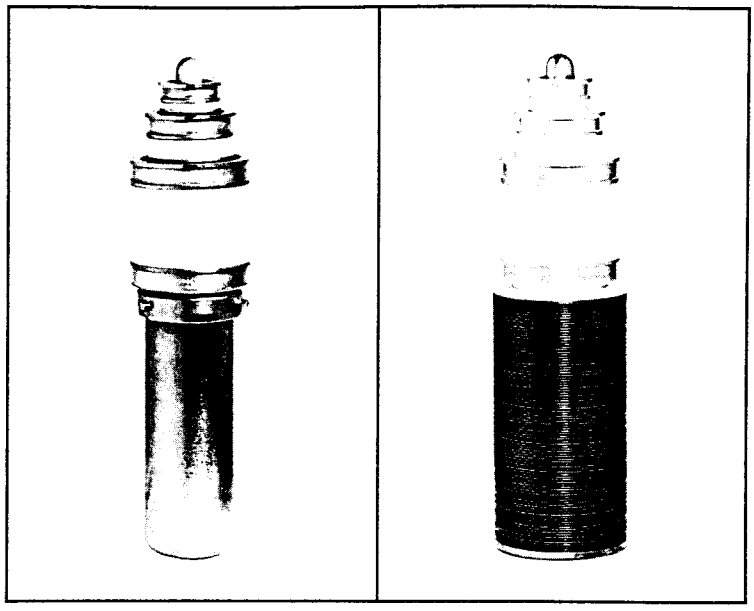
DIMENSIONS FOR OUTLINE OF ML-6697

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.619	4.650	4.681	
B	3.469	3.500	3.531	
C	2.469	2.500	2.531	
D	—	1.12	1.19	
E	—	5.94	6.13	
F	5.219	5.250	5.281	
G	—	19.36	19.88	
H	10.00	10.12	10.25	
I	7.75	7.88	8.00	
J	—	.94	1.00	
K	6.50	6.62	6.75	
L	.31	.45	—	
M	4.81	4.88	4.94	
N	.12	.18	—	
O	.12	.18	—	
P	.12	.18	—	

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ISSUED 9-67

ML-6696A
ML-6697A

General Purpose Triodes
80 kW CW

MACHLETT

DESCRIPTION

The ML-6696A and ML-6697A are general-purpose triodes suitable for industrial heating and AM broadcasting. These tubes feature rugged coaxial mounting structures providing high-dissipation, low-inductance rf electrode terminals. The envelopes employ strong, low-loss ceramic insulation. The cathode of each type consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments.

The ML-6696A has a water-cooled, heavy-wall anode capable of dissipating 60 kW. The ML-6697A has a forced air-cooled, heavy-wall anode with high-efficiency disc fins capable of dissipating 35 kW.

These tubes will operate with plate voltages up to 16 kV in CW operation. Maximum ratings apply at frequencies up to 40 MHz. Useful power output can be obtained at frequencies up to 80 MHz with reduced ratings.

GENERAL CHARACTERISTICS

Electrical	
Filament Voltage	13.0 Volts
Filament Current	205 Amps
Filament Starting Current, maximum	800 Amps
Filament Cold Resistance	0.0073 Ohm
Amplification Factor	20
Interelectrode Capacitances	
Grid-Plate	55 pf
Grid-Filament	76 pf
Plate-Filament	2.7 pf
Mechanical	
Mounting Position	Vertical, anode down
Type of Cooling — ML-6696A	Water and forced-air†
Water flow on anode for 60 kW dissipation, approx.	18 gpm
Maximum outgoing water temperature	70 °C
Type of Cooling — ML 6697A	Forced-air
Air flow on anode for 35 kW dissipation	Pressure: 1700 cfm at 7.8″ water*
	Exhaust: 1970 cfm at 8.4″ water*
Maximum incoming air temperature	50 °C
Maximum Envelope Temperature	200 °C†
Net Weight, approximate	
ML-6696A	17 lbs.
ML 6697A	43 lbs.

*When used with ML-6697A air distributor F-17759.

†Auxiliary air flow of 50-100 cfm is required and should be distributed to maintain a uniform ceramic temperature, not greater than 200°C, around the circumference of the seals. At high frequencies or high ambient temperature, additional air flow may be required.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values		
D-C Plate Voltage	16000	volts
Max.-Signal D-C Plate Current*	11	amps
Max.-Signal Plate Input*		
ML 6696A	120	kW
ML-6697A	110	kW
Plate Dissipation		
ML-6696A	60	kW
ML-6697A	35	kW

Typical Operation (Values are for two tubes)	ML-6696A		
D-C Plate Voltage	10000	12000	volts
D-C Grid Voltage	−450	−600	volts
Peak A-F Grid-to-Grid Voltage	1750	2120	volts
Peak A-F Plate-to-Plate Voltage	16000	19200	volts
Zero Signal D-C Plate Current	3.0	2.0	amps
Max.-Signal D-C Plate Current	17.4	20.0	amps
Effective Load Resistance, Plate-to-Plate	1170	1230	ohms
Max.-Signal Driving Power, approx.	550	600	watts
Max.-Signal Power Output, approx.	110	152	kW

*Average over any audio-frequency cycle of sine-wave form.

Radio Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	16000	volts
D-C Plate Current	9	amps
Plate Input		
ML-6696A	90	kW
ML-6697A	55	kW
Plate Dissipation		
ML-6696A	60	kW
ML-6697A	35	kW

Typical Operation	ML-6696A		
D-C Plate Voltage	12000	12000	volts
D-C Grid Voltage	−550	−550	volts
Peak R-F Grid Voltage	510	640	volts
Peak R-F Plate Voltage	5300	5300	volts
D-C Plate Current	4.3	6.8	amps
D-C Grid Current	0	0	mA
R-F Load Resistance	780	500	ohms
Driving Power, approx.†	450	1500	watts
Power Output, approx.	18	28	kW

†At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	10000	volts
D-C Grid Voltage	−3200	volts
D-C Plate Current	8.5	amps
D-C Grid Current	2.0	amps
Plate Input	81	kW
Plate Dissipation		
ML-6696A	40	kW
ML-6697A	23	kW
Typical Operation		
D-C Plate Voltage	9500	volts
D-C Grid Voltage	−1600	volts
Peak R-F Grid Voltage	2300	volts
Peak R-F Plate Voltage	7800	volts
D-C Plate Current	8.4	amps
D-C Grid Current	0.90	amp
R-F Load Resistance	510	ohms
Driving Power, approx.	2.0	kW
Power Output, approx.	60	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values			
D-C Plate Voltage	16000		volts
D-C Grid Voltage	−3200		volts
D-C Plate Current	11		amps
D-C Grid Current	2.0		amps
Plate Input	120		kW
Plate Dissipation			
ML-6696A	60		kW
ML-6697A	35		kW
Typical Operation			
D-C Plate Voltage	10000	15000	volts
D-C Grid Voltage	−1200	−1600	volts
Peak R-F Grid Voltage	1900	2120	volts
Peak R-F Plate Voltage	8000	12500	volts
D-C Plate Current	10.0	7.0	amps
D-C Grid Current	0.81	0.30	amp
R-F Load Resistance	440	970	ohms
Driving Power, approx.	1.5	0.60	kW
Power Output, approx.	72	80	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits			
			Minimum	Bogey	Maximum	
Grid Voltage	e_b=1500 volts; i_b=48 amps	e_c:	—	—	1000	volts
Grid Current	e_b=1500 volts; i_b=48 amps	i_c:	—	—	15	amps
Plate Voltage	E_c=0 Vdc; I_b=3.0 Adc	E_b:	1.9	2.4	2.9	kVdc
Plate Voltage	E_c=−200 Vdc; I_b=3.0 Adc	E_b:	5.6	6.4	7.2	kVdc
Grid Voltage	E_b=15.0 kVdc; I_b=0.020 Adc	E_c:	−700	−820	−940	Vdc
Plate Power Output	E_b=15.0 kVdc; I_b=7.0 Adc; E_c=−1600 Vdc; I_c=0.30 Adc	P_o:	68	—	—	kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 40 MHz except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation on the right. (Other maximum ratings are the same as shown above.) Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	40	60	80 MHz
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	80	55
Class C	100	75	50

Introduction

These tubes, as all high-power vacuum tubes, require some aging when they are first used in any new equipment or new environment. As the system power level increases, particularly if attended by a decrease in impedance level, it becomes increasingly important to spend enough time to acclimate the tube to the desired conditions of operation. *There is no substitute for seasoning the tube in the actual equipment in which it is to operate.* Once the procedure has been followed, however, the tube generally will be available for substantially immediate operation, unless it has been idle for an extended period of time, say three months or more.

Aging Procedure

The aging schedule will vary with the particular operating and environmental conditions. A general procedure which will serve as a starting point is to operate the tube for approximately one-half hour at each of the following steps:

(a) filament voltage only;

(b) partial plate voltage, drive and load, up to about one-half normal;

(c) full plate voltage, drive and load.

The length of time necessary for break-in to insure reliable operation can vary widely. Only experience will tell whether the above procedure can be shortened, or whether steps (b) and (c) must be extended, perhaps by a factor of two or three. The major factors affecting break-in time are the *method of applying plate voltage,* the type of *protective circuitry* available to remove power in the event of a fault, and, for a spare tube, the length of time since it had been removed from normal operation.

Plate voltage is applied preferably by continuous or stepped control. Snap-on of full plate voltage with no load may develop excessive transients which cause breakdown in the tube or other circuit components. If the voltage must be snapped on at full value, at least some load should be placed on the power transformer to limit transients to 120 percent of the d-c voltage.

Tube Protection

Fault overloads, due to tube or circuit instabilities, may result in the following conditions:

(a) liberation of gas in the tube;

(b) gross damage to internal elements, e.g. melting of grid wires;

(c) external arcing over electrodes, with damage to seals and possible puncture of envelope insulator.

A tube which becomes gassy often can be cleaned up successfully by patient reaging. The other conditions listed above are usually catastrophic.

The criteria for tube protection are the total energy which may be imparted to the tube, and the peak voltage which may appear across the electrodes. The total energy available depends on the *power source impedance,* including effect of transmission lines, and the *energy stored* in the transformer and filter components; on the *series resistance* in the circuit; and on the *duration of the discharge* or fault condition.

Primary power characteristics often are not known by the equipment designer, and the major energy-storage components usually are fixed by circuit performance requirements. Tube protection, then, is reduced to limiting surges by the design of certain components, including in the circuit at least some dissipative elements, i.e. resistance, and to sensing and removing any incipient surge as quickly as possible. The foregoing uncertainties make it difficult to specify the minimum requirements for sufficient tube protection under a given set of circumstances.

Protective Devices and Circuitry

Heretofore, it has been customary to equip plate and grid circuits with overload relays adjusted to open the circuit breakers within one-tenth of a second. In many applications, particularly where the impedance of the primary power source is low or where there is appreciable stored energy, the devices referred to above offer inadequate protection.

For high reliability and freedom from gassing and catastrophic failures, the use of an electronic shorting device or *"crowbar"* is recommended. In this case a thyratron, ignitron, or other suitable gaseous conduction device is connected to short the rectifier output to ground within 50 microseconds in the event of a fault condition. The electronic crowbar functions to divert the fault energy from the protected tube until the relay and circuit breakers act. Where multiple tubes are used with a common power supply, this type of crowbar is certainly necessary. This type of high-speed removal of fault energy has been extremely effective in reducing break-in time, and the lower the power supply impedance, the more impressive is the effect.

In some cases adequate protection can be obtained by using a vacuum switch, (a) connected as above, or (b) as a circuit breaker, replacing the usual slower acting types. These devices can divert, or remove, the fault energy in the order of one-half cycle. A vacuum-switch circuit breaker can, of course, be used to advantage in combination with the high-speed electronic shorting device. *The latter arrangement probably gives the best over-all protection to the tube and other circuit components.*

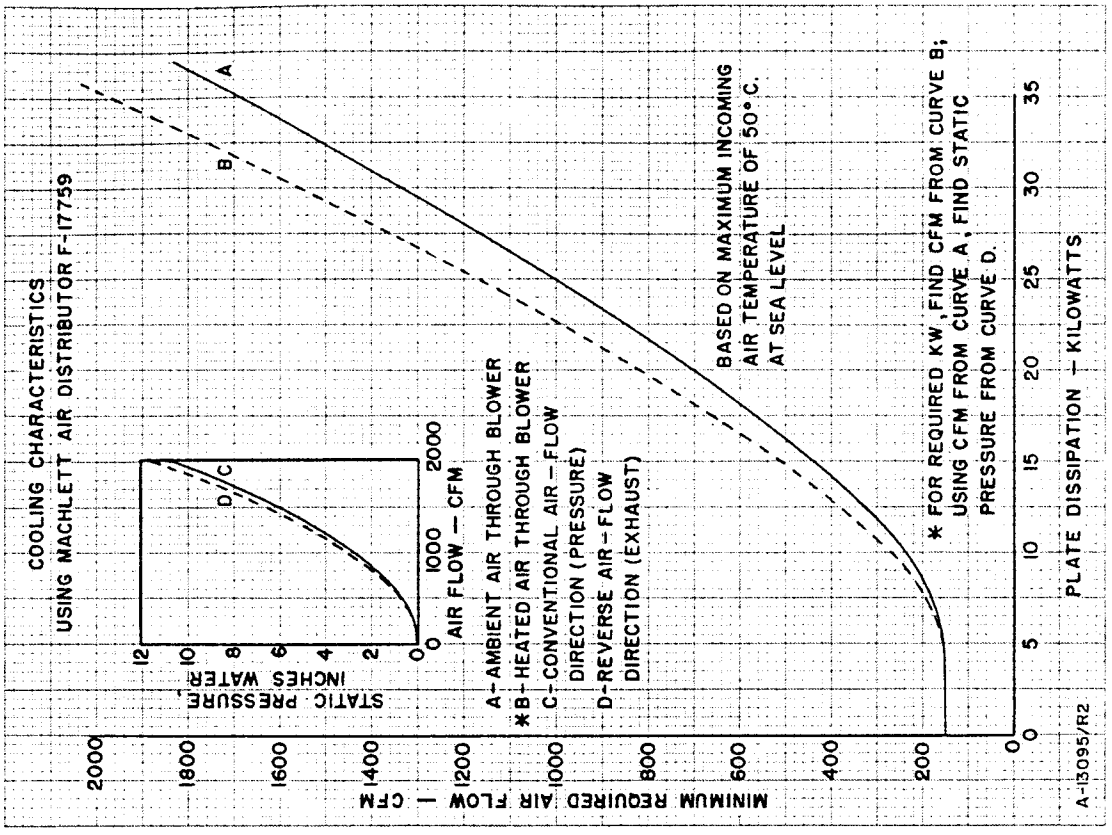
In addition, some *series resistance* should be used in the output of the power supply to limit the surge current from the transformer. Preferably, resistors may be placed in series with each rectifier lead to provide equal protection with substantially less power dissipated during normal operation. The amount of resistance will vary with circuit conditions and the speed of the protective circuitry, but the following values can be given as a guide:

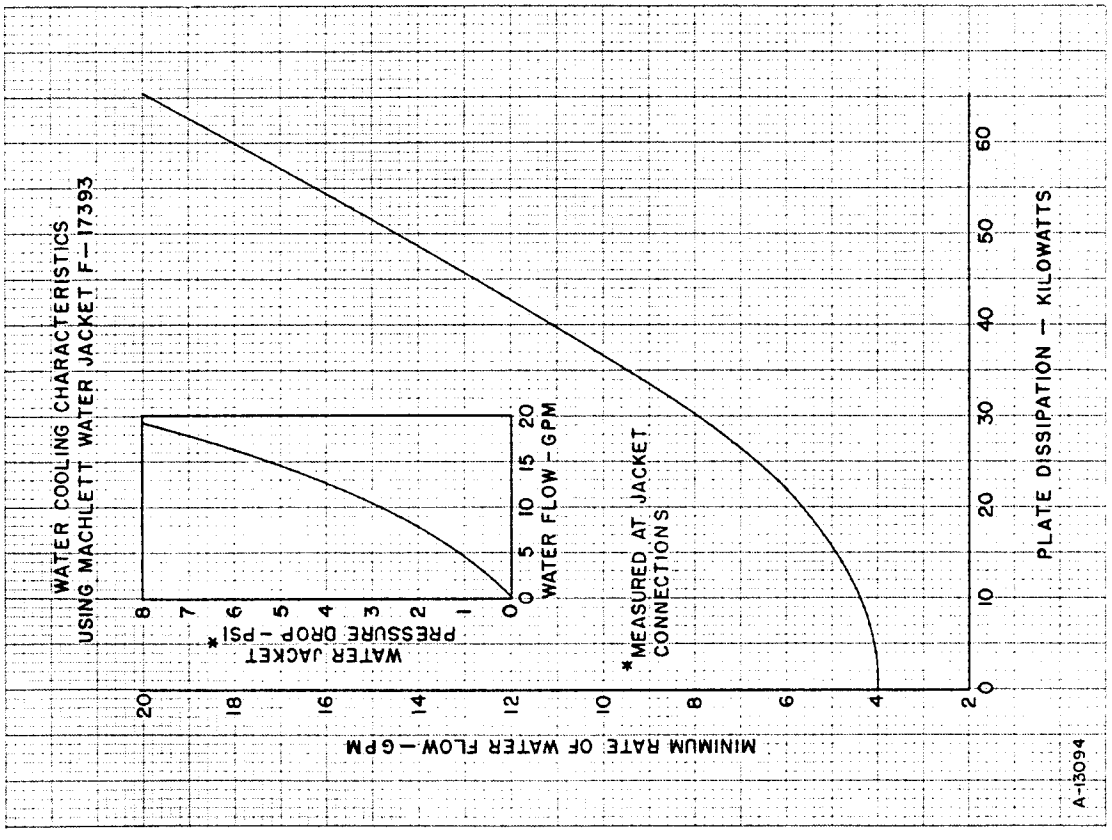
Maximum Power Output of Rectifier	120	250	500	1000	kW
Series Resistor	10	20	35	50	Ohms

The voltage ratings of these tubes are established so that normal operation will not cause arcs to develop across the tube envelope. Any external arcing, therefore, is an indication that the rated voltages have been exceeded. To lessen the chance of permanently damaging the tube, it is helpful to attach suitable *sphere gaps,* or rings, to the electrode terminals. If the sphere gaps are properly installed, the most probable breakdown path is between the gaps rather than over the tube envelope. The gap separation must be carefully adjusted for each application. The spacing from the tube envelope to the gaps or rings, in general, should be equal to or greater than the gap separation.

Maintenance

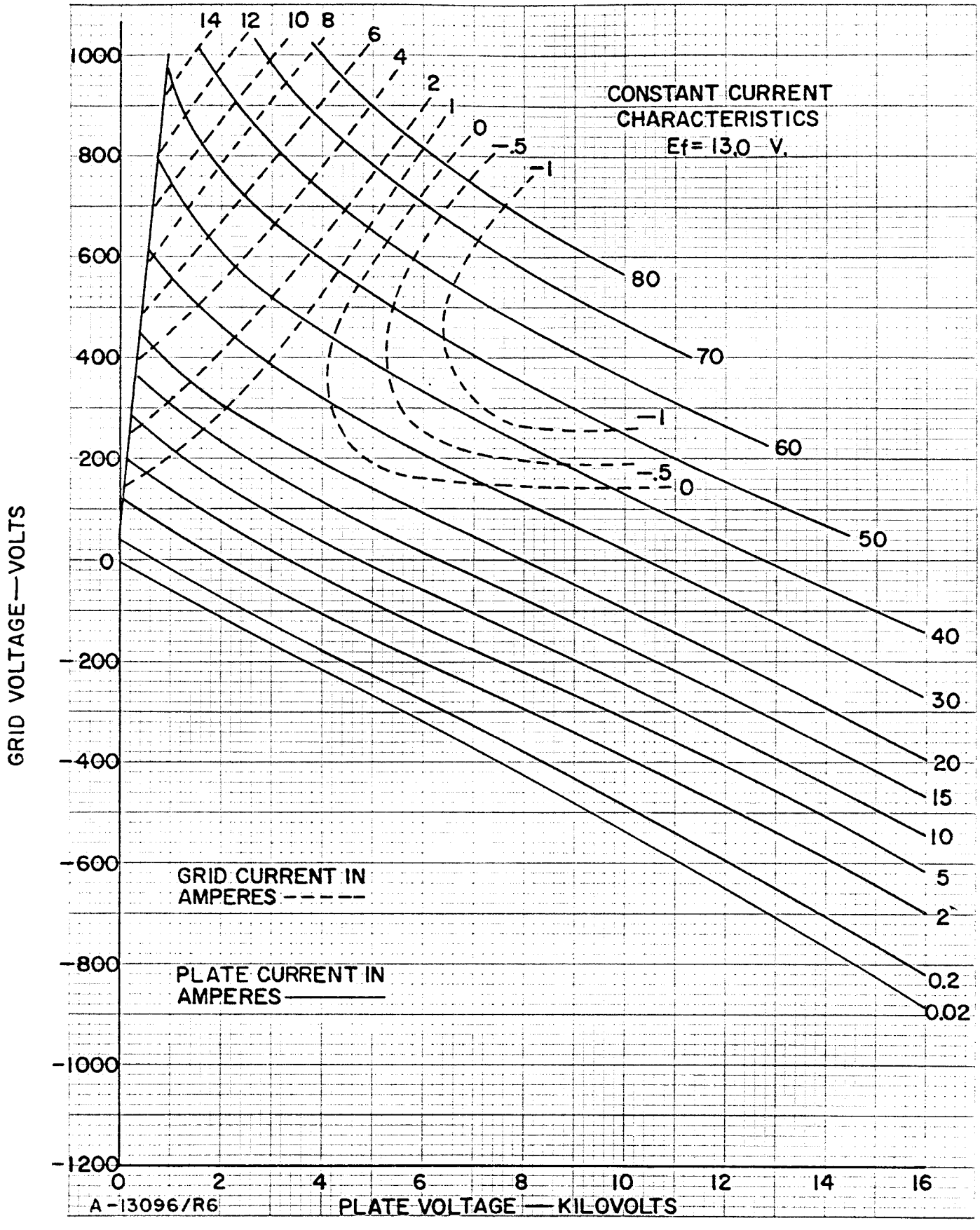
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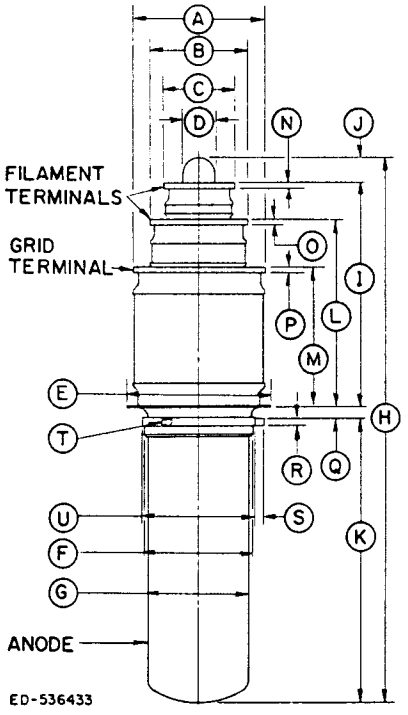




COOLING CHARACTERISTICS — ML-6697A

COOLING CHARACTERISTICS — ML-6696A


CONSTANT CURRENT
CHARACTERISTICS
Ef = 13.0 V.
14
12
10
8
6
4
2
1
0
-.5
-1
80
70
60
50
40
30
20
15
10
5
2
0.2
0.02
-1
-.5
0
GRID CURRENT IN
AMPERES - - - - -
PLATE CURRENT IN
AMPERES ———
GRID VOLTAGE—VOLTS
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
0
2
4
6
8
10
12
14
16
PLATE VOLTAGE — KILOVOLTS
A-13096/R6

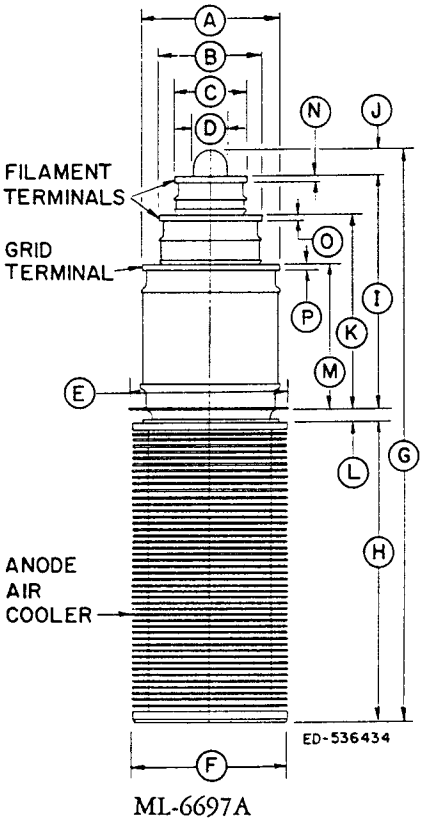


ML-6696A

DIMENSIONS FOR OUTLINE OF ML-6696A

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.619	4.650	4.681	
B	3.469	3.500	3.531	
C	2.469	2.500	2.531	
D	—	1.12	1.19	
E	—	—	5.25	
F	3.990	3.995	4.000	
G	3.485	3.500	3.515	
H	—	19.16	19.38	
I	7.75	7.88	8.00	
J	—	.94	1.00	
K	9.75	9.87	10.00	
L	6.50	6.62	6.75	
M	4.81	4.88	4.94	
N	.12	.18	—	
O	.12	.18	—	
P	.12	.18	—	
Q	.40	.44	.47	
R	.300	.310	.320	1
S	.28	.31	.35	1
T	—	120°	—	1
U	4.00	4.03	4.06	

NOTES:
1. Three bayonet pins for water jacket connection, diameter (R), length (S), nominally (T) degrees apart.



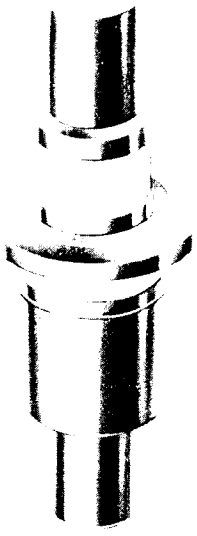
ML-6697A

DIMENSIONS FOR OUTLINE OF ML-6697A

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.619	4.650	4.681	
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C	2.469	2.500	2.531	
D	—	1.12	1.19	
E	—	—	5.25	
F	5.219	5.250	5.281	
G	—	19.36	19.88	
H	10.00	10.12	10.25	
I	7.75	7.88	8.00	
J	—	.94	1.00	
K	6.50	6.62	6.75	
L	.31	.45	—	
M	4.81	4.88	4.94	
N	.12	.18	—	
O	.12	.18	—	
P	.12	.18	—	

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MACHLETT

ML-6771

DESCRIPTION & RATINGS

DESCRIPTION

The ML-6771 is a high-mu, planar triode of ceramic-and-metal construction, particularly designed for use in grounded-grid service as a radio-frequency amplifier, oscillator, or frequency multiplier for frequencies up to 4000 Mc. The tube features low interelectrode capacitances, low electrode lead inductance, short electron transit time and rugged, compact coaxial construction. These features make the tube well suited for efficient operation in line-type and lumped-constant circuits at the lower frequencies as well as in cavity resonators at higher frequencies. The tube employs an indirectly heated, oxide-coated disc as a cathode. The heater is electrically separated from the cathode, permitting the use of comparatively simple circuits. The anode is cooled by conduction and convection.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage	6.3 Volts
Heater Current at 6.3 Volts (AC or DC)	.57 Amperes
Cathode Heating Time, minimum	60 Seconds
Amplification Factor	90
Transconductance	23,000 μmhos
Interelectrode Capacitances (without heater voltage)	
Grid-Plate	2.0 μμf
Grid-Cathode	4.05 μμf
Plate to Cathode	0.018 μμf
Frequency for Maximum Ratings	4000 Mc

Mechanical

Mounting Position	Optional
Type of Cooling	Conduction and Convection
Envelope Temperature, maximum	175 °C
Net Weight, approximate	1 Ounce

MAXIMUM RATINGS AND TYPICAL OPERATION

Radio-Frequency Amplifier — Class A

Maximum Ratings, Absolute Values	
Heater Voltage	5.7 ±5% Volts
DC Plate Voltage	300 Volts
DC Grid Voltage	−25 Volts
DC Plate Current	25 mA
Plate Dissipation	6.25 Watts
Peak Heater-Cathode Voltage	
Heater Negative	90 volts
Heater Positive	90 volts
Maximum Grid-Circuit Resistance	0.5 Megohms

Radio-Frequency Power Amplifier and Oscillator

Key-down conditions without amplitude modulation

Maximum Ratings, Absolute Values	
Heater Voltage	*
DC Plate Voltage	275 Volts
DC Plate Current	25 mA
DC Grid Voltage	−25 Volts
DC Grid Current	8 mA
Plate Power Input	7 Watts
Plate Dissipation	6.25 Watts
Peak Heater-Cathode Voltage	
Heater Negative	90 volts
Heater Positive	90 volts
Maximum Grid-Circuit Resistance	0.1 Megohms

Typical Operating Conditions	
C.W Radio-Frequency Oscillator, 4000 Mc	
Heater Voltage	5.0 Volts
DC Plate Voltage	250 Volts
DC Plate Current	25 mA
DC Grid Voltage	−1.7 Volts
DC Grid Current	0.6 mA
CW Power Input	300 Milliwatts

Radio-Frequency Power Amplifier and Oscillator Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

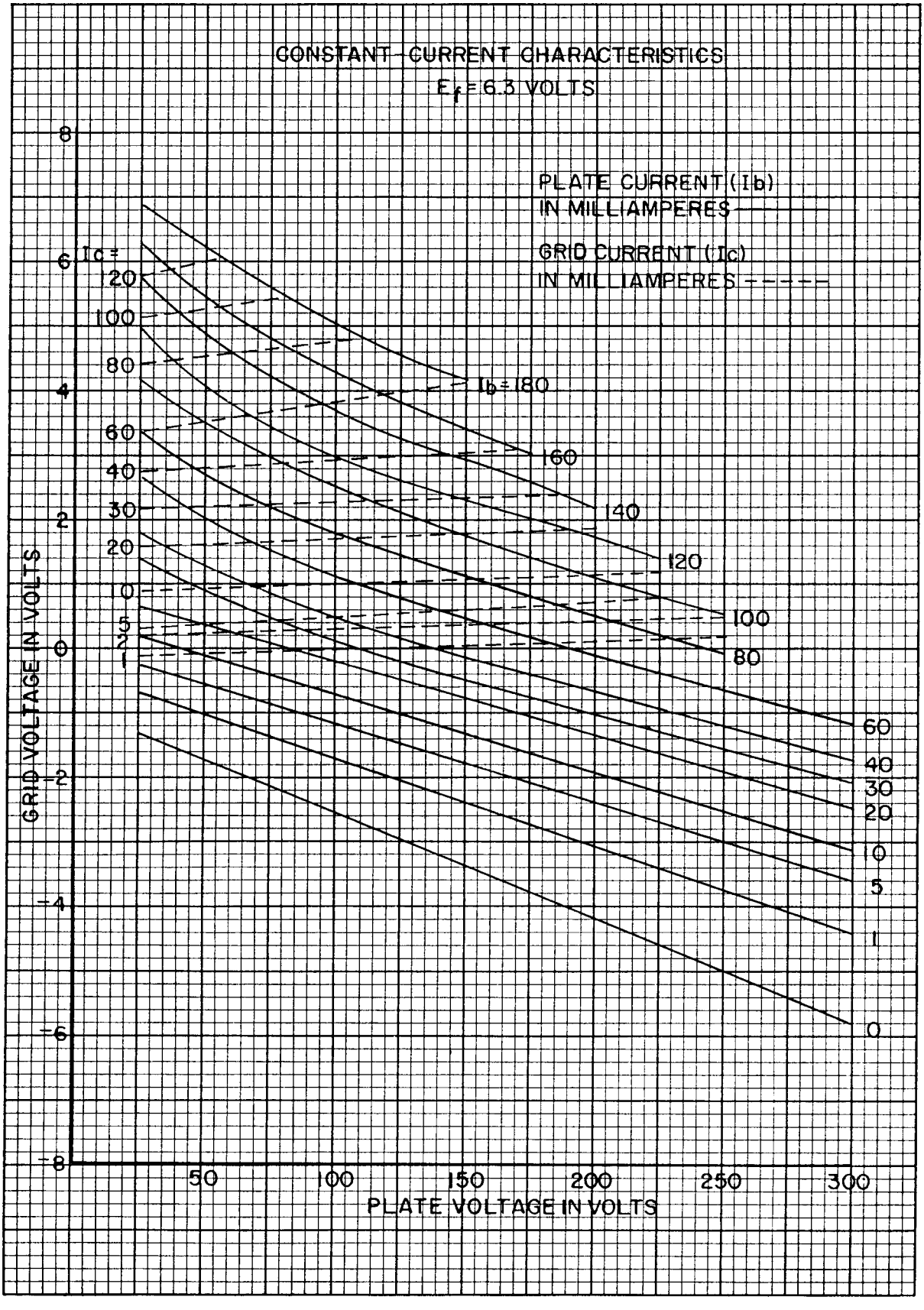
Maximum Ratings, Absolute Values	
Heater Voltage	*
DC Plate Voltage	250 Volts
DC Plate Current	22 mA
DC Grid Voltage	−25 Volts
DC Grid Current	8 mA
Plate Input	5.5 Watts
Plate Dissipation	5.0 Watts
Peak Heater-Cathode Voltage	
Heater Negative	90 volts
Heater Positive	90 volts
Maximum Grid-Circuit Resistance	0.1 Megohms

Radio-Frequency Multiplier

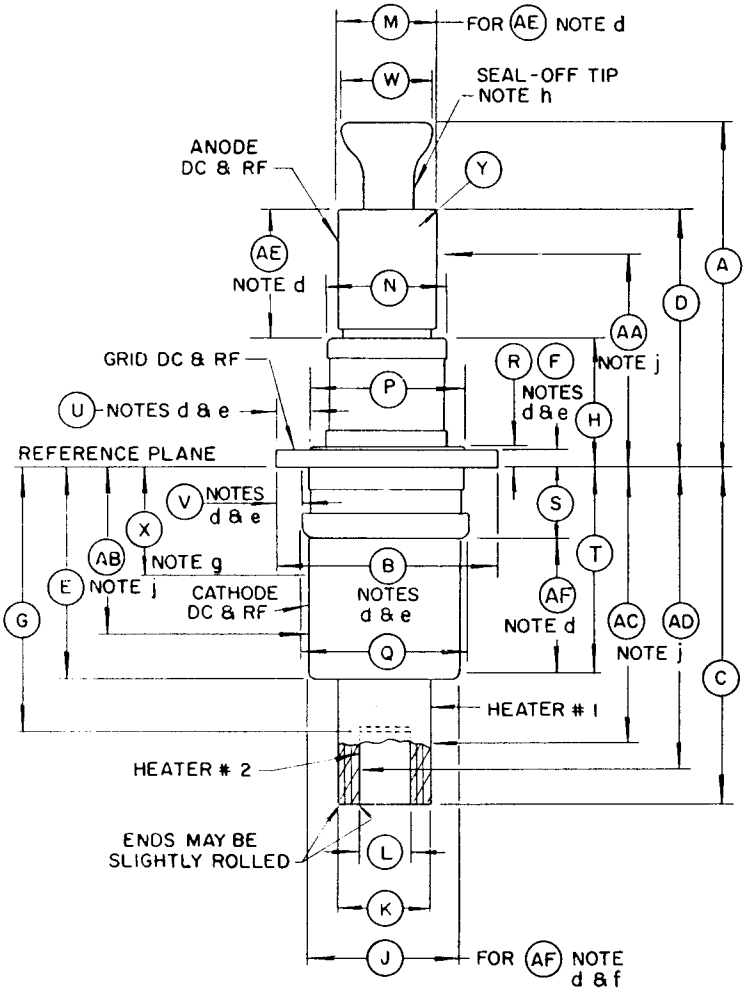
Maximum Ratings, Absolute Values	
Heater Voltage	*
DC Plate Voltage	250 Volts
DC Plate Current	20 mA
DC Grid Voltage	−50 Volts
DC Grid Current	5 mA
Plate Input	5.0 Watts
Plate Dissipation	5.0 Watts
Peak Heater-Cathode Voltage	
Heater Negative	90 volts
Heater Positive	90 volts
Maximum Grid-Circuit Resistance	0.1 Megohoms

Typical Operating Conditions	
Radio-Frequency Doubler, 500-1000 Mc	
Heater Voltage	5.7 Volts
DC Plate Voltage	250 Volts
DC Plate Current	20 mA
DC Grid Voltage	10 Volts
DC Grid Current	5 mA
RF Power Input	300 Milliwatts
RF Power Output	2.0 Watts

* The correct value of heater voltage is dependent upon the particular operating conditions and frequency. For particular applications consult the Machlett Engineering Department.



CONSTANT CURRENT CHARACTERISTICS



DIMENSIONS IN INCHES

Dim.	Limits		Nominal
	Minimum	Maximum	
A	—	1.328	—
B	0.810 dia.	0.818 dia.	—
C	1.219	1.281	—
D	0.953	0.984	—
E	0.750	0.813	—
F	0.070	0.078	—
G	—	1.016	—
H	—	0.515	—
J	0.539 dia.	0.549 dia.	—
K	0.318 dia.	0.328 dia.	—
L	0.180 dia.	0.190 dia.	—
M	0.365 dia.	0.371 dia.	—
N	—	0.453 dia.	—
P	0.560 dia.	0.570 dia.	—
Q	—	0.609 dia.	—
R	0.077	0.097	—
S	—	0.266	—
T	0.719	—	—
U	—	—	0.094
V	—	—	0.094
W	—	0.313	—
X	—	0.375	—
Y	—	—	0.016 rad.
AA	—	—	0.750
AB	—	—	0.547
AC	—	—	1.000
AD	—	—	1.109
AE	—	—	0.438
AF	—	—	0.453

NOTES

d. Contact surfaces shall be confined to this area.

e. Only these surfaces shall be used for tube stops or clamping.

f. Maximum diameter is not increased by solder.

g. Tube marking is confined to this area.

h. Exhaust tubulation must not be subjected to any mechanical stress.

j. Eccentricity is gaged at points designated and falls within the following limits:

Contact	Eccentricity*	Reference
Anode	0.010 max.	Grid Contact
Cathode	0.010 max.	Grid Contact
Heater No. 1	0.015 max.	Grid Contact
Heater No. 2	0.015 max.	Grid Contact

*Eccentricity is one-half total indicated runout.

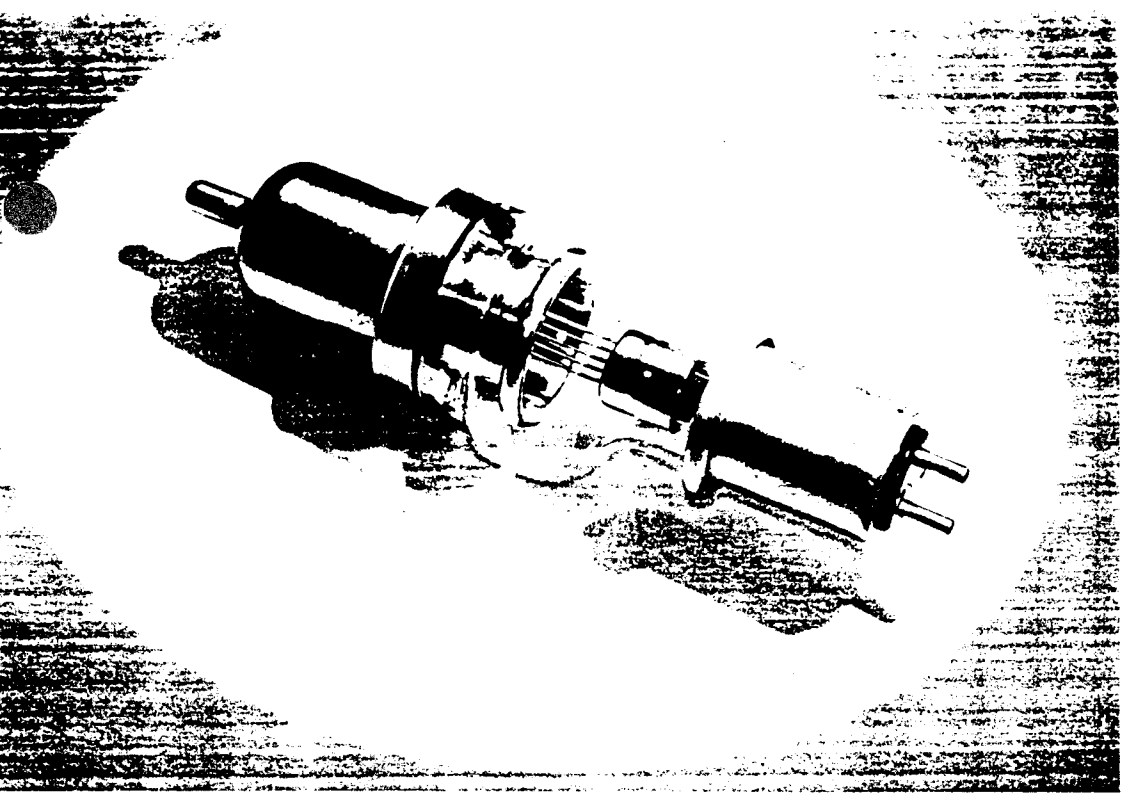
DIMENSIONS — ML-6771

THE MACHLETT LABORATORIES, INC.
Subsidiary of Raytheon Company

ST-1742 5M 3-61

SPRINGDALE MACHLETT CONNECTICUT
U. S. A.

Printed in U.S.A.



MACHLETT

ML-6908

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-6908 is an oil-immersed, high-vacuum rectifier tube having maximum ratings of 150 PKV inverse voltage and 10 amperes peak anode current. It is especially adaptable to certain pulsing circuits as a hold-off diode and to power supplies in high-power radar units, where insensitivity to low ambient temperatures and high current capacity at high voltages are essential.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average load current capacity. The cathode is a thoriated-tungsten filament of the catenary type, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The heavy-wall copper anode provides a high safety factor against accidental overload.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	12 Volts
Filament Current, approximate	23 Amps
Filament Heating Time, minimum (Before applying Plate Voltage)	30 Secs
Tube Voltage Drop, maximum (I_b—10.0 amperes)	2400 Volts

MECHANICAL

Mounting Position	Optional
Type of Cooling	Convection†
Maximum oil temperature for maximum dissipation	75 °C
Insulating Medium	Oil††
Net Weight, approximate	6¾ lbs

† When the ML-6908 is operated anode up, forced-oil cooling of the glass within the cathode base is required. An oil flow of approximately 1 quart per minute, introduced through the cathode base tubulation, is sufficient.

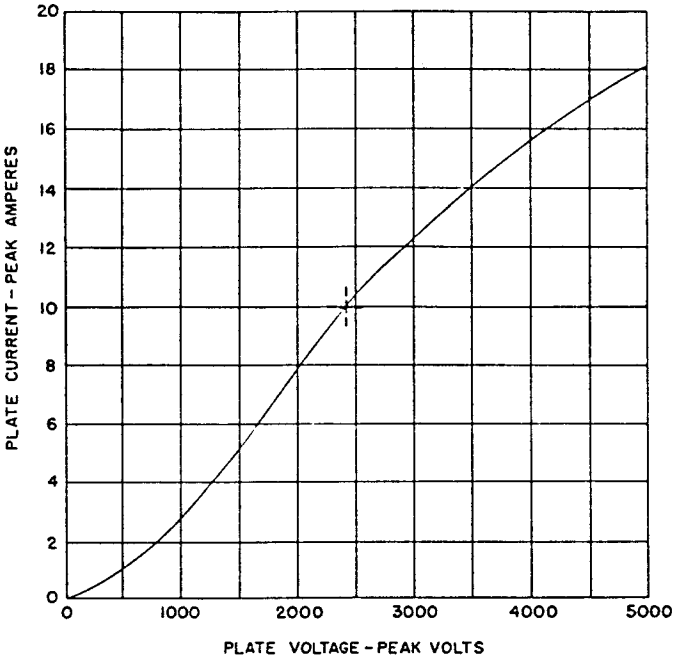
†† The dielectric value of the insulating oil should be no less than 25,000 volts peak per 0.1 inch.

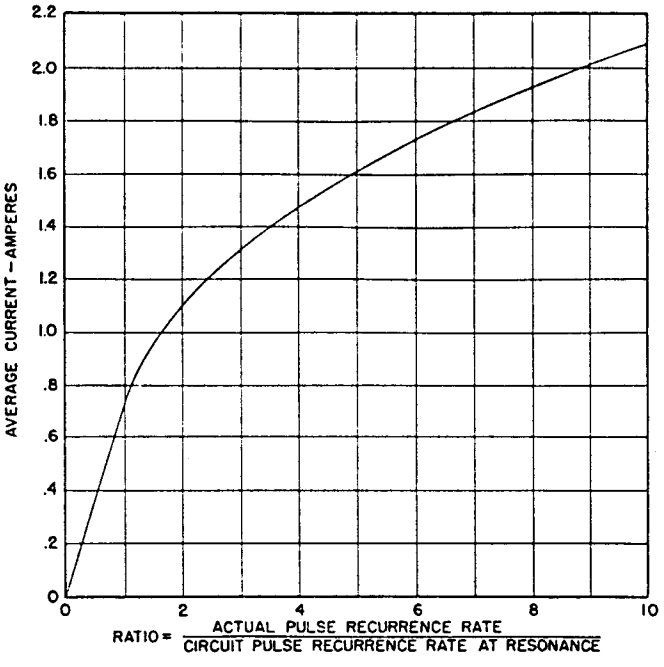
MAXIMUM RATINGS

Peak Inverse Anode Voltage		150,000 Volts
Peak Anode Current		10.0 Amps
Plate Dissipation		2000 Watts
Load Current (Average D-C)		
Circuit Application	Unfiltered*	Filtered**
Single-phase, two-tube, half-wave	1.6	..... Amps
Single-phase, four-tube, full-wave	3.2	3.5 Amps
Three-phase, double-Y parallel	8.8	9.0 Amps
Three-phase, full-wave	4.4	4.5 Amps

* Unfiltered Load Current Ratings are based on sine-wave voltage input and resistance load without inductive or capacitive effects.

** Filtered Load Current Ratings are based on sine-wave input and infinite inductance choke input filter.



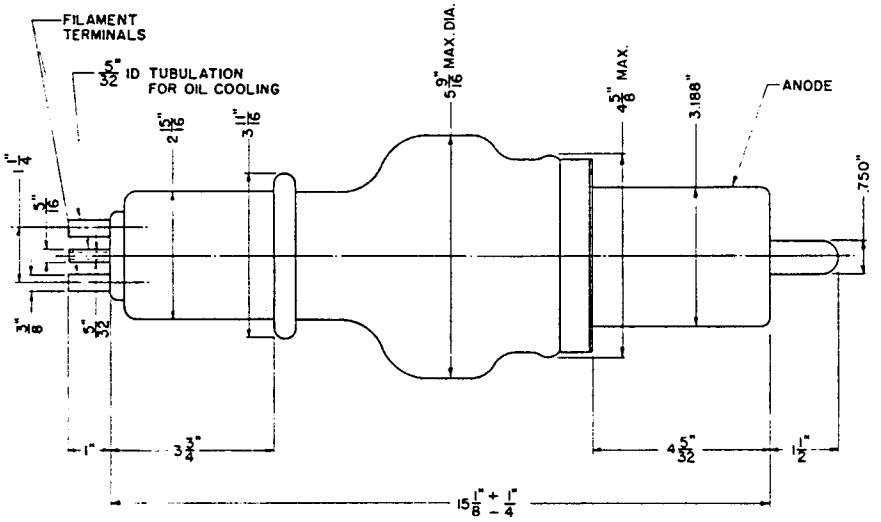


APPLICATION NOTES

When the ML-6908 is employed as a rectifier in conventional power supply circuits, the average dc load currents specified under "Maximum Ratings" apply.

Then the ML-6908 is used as a hold-off diode in connection with resonant charging of line-type pulsers, the average charging current permissible depends on the ratio of actual pulse recurrence rate to circuit pulse recurrence rate at resonance. The right-hand curve above indicates maximum permissible average currents at various values of this ratio.

When the tube is initially installed or has been inoperative for an extended period, maximum rated voltage must not be applied instantaneously. The tube should be "warmed-up" by operating at 60% of maximum rated voltage for 5 minutes, gradually increasing the voltage to 80% during the next 15 minutes and finally gradually increasing from 80% to maximum rated voltage in 20 minutes. For operating voltages less than the maximum rated voltage, the applicable part of the above procedure should be used.

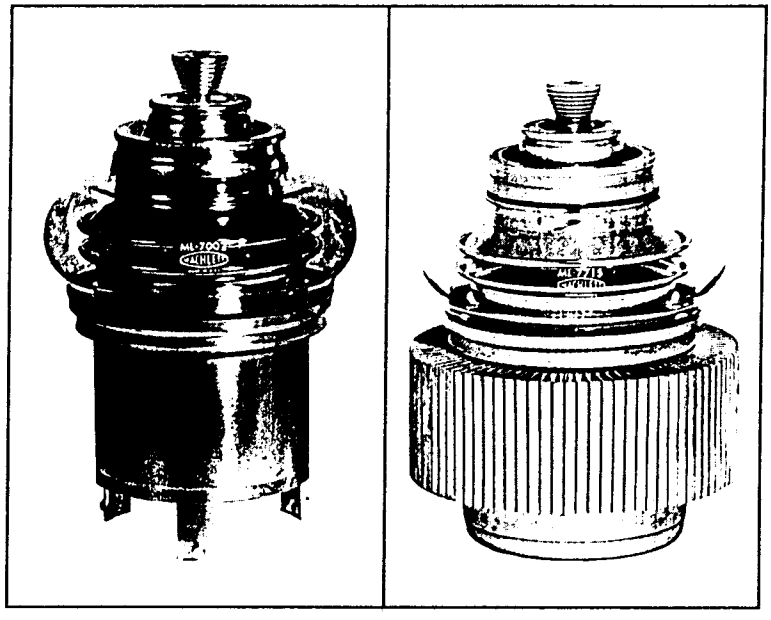


DIMENSIONS — ML-6908

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



ISSUED 5-64

ML-7002
ML-7715

Shielded
Grid Triodes
Pulse Power
to 3.5 Mw

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7002 and ML-7715 are shielded-grid triodes designed primarily to operate as switch tubes in hard-tube pulse modulators, for radar and similar applications. In this service they can deliver more than three megawatts pulse power output with less than 10 kilowatts driving power.

Each of these types has sturdy electrodes arranged to form a cylindrical array of electron-optical systems, featuring a shield electrode connected internally to the cathode by direct, low-impedance paths. This design permits operation with low grid current and it results in favorably low grid-plate capacitance. The presence of the ground-potential shield adjacent to the anode, furthermore, protects the cathode and grid from damage by transient arcs.

The cathode of each type is unipotential, oxide-coated. The anode of the ML-7002 is designed to be cooled by a forced flow of oil or other dielectric liquid.† The ML-7715 anode is cooled by forced-air or dielectric gas. When cooled by forced air the anode is capable of dissipating 3 kW with 150 cfm air flow. The maximum ratings of 65 kVdc and 70 kv peak apply when the tubes are completely immersed in a suitable dielectric fluid. This fluid is typically mineral oil for the ML-7002, and a gas such as sulfur hexafluoride for the ML-7715.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage	6.0±5%	Volts
Heater Current	60	Amps
Heater Starting Current, maximum	300	Amps
Cathode Warmup Time	10	Minutes*
Amplification Factor	400	
Interelectrode Capacitances		
Grid-Plate	2.0	μμf
Grid-Cathode	250	μμf
Plate-Cathode	25	μμf
Mehanical		
Mounting Position (support tube by anode or anode radiator only)	Any	
Type of Cooling — ML-7002	Circulating oil†	
Type of Cooling — ML-7715	Forced-air‡	
Air flow on anode, minimum for 3 kW dissipation	150 cfm at 0.3" water	
Air flow on grid	50	cfm
Maximum incoming air temperature	65	°C
Maximum Glass Temperature	175	°C‡
Net Weight, approximate		
ML-7002	18	lbs.
ML-7715	28	lbs.

†For details on cooling requirements for ML-7002, consult the Machlett Engineering Department.

*For accelerated cathode warmup, the filament may be energized at 7.0 volts for 5 minutes and then reduced to 6.0 volts for high-voltage operation. If a filament standby voltage of 5.0 volts is used, the minimum cathode warmup time is 1 minute at 6.0 volts.

‡Sufficient coolant flow must be provided to maintain glass temperatures at less than 175°C under all conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

VALUES APPLY TO BOTH TYPES

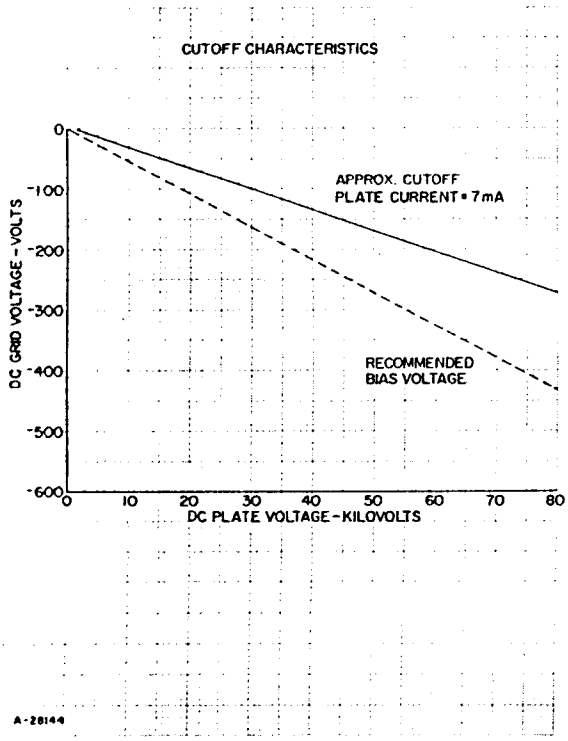
Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values			
D-C Plate Voltage		65	kV*
Peak Plate Voltage		70	kv*
D-C Grid Voltage		−600	volts
Peak Positive Grid Voltage		+1.5	kv
Peak Negative Grid Voltage		−1500	volts
Pulse Cathode Current		90	amp
D-C Plate Current		250	mA
Grid Dissipation		75	watts
Plate Dissipation		3.0	kW
Pulse Duration†		25	μsec
Duty Factor†		0.03	
Typical Operation			
D-C Plate Voltage	60	65	kV*
D-C Grid Voltage	−350	−350	volts
Pulse Positive Grid Voltage	+0.6	+1.2	kv
Pulse Plate Current	25	65	amp
Pulse Grid Current	2	4	amp
Pulse Driving Power	1.9	6.2	kw
Pulse Power Output	1.3	3.5	Mw
Plate Output Voltage	55	55	kv
Duty Factor	.01	.003	

†For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

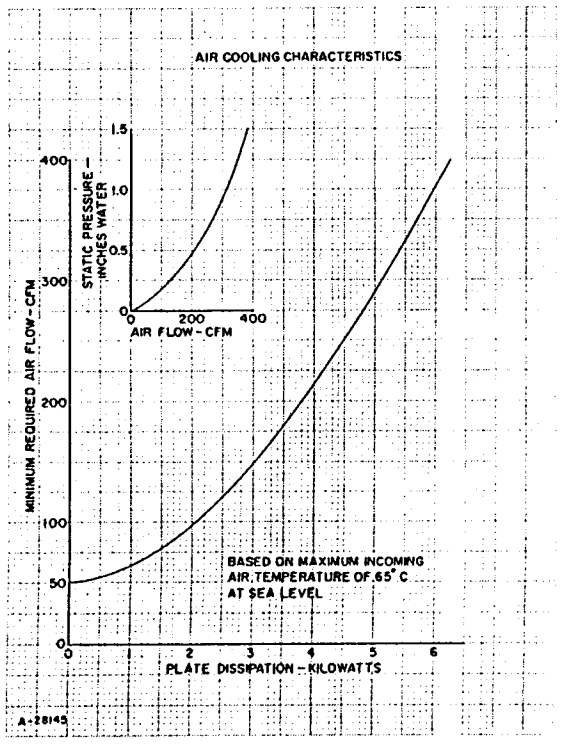
*This voltage may be applied only when the tubes are in a suitable dielectric liquid or gas. When the insulating medium is air at atmospheric pressure, the maximum plate voltage ratings are 45 kVdc and 50 kv peak.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.



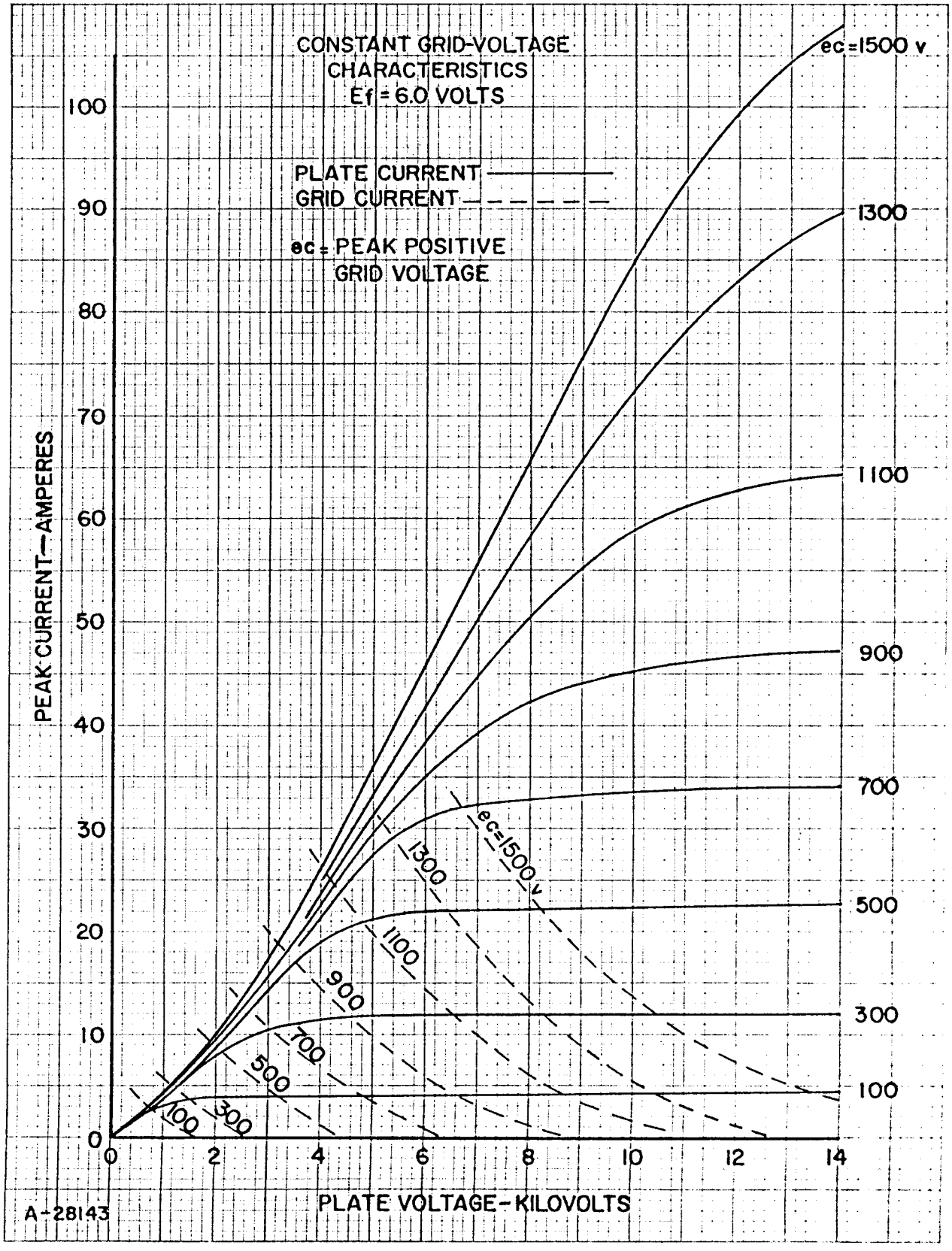
CUT-OFF CHARACTERISTICS

ML-7002 & ML-7715

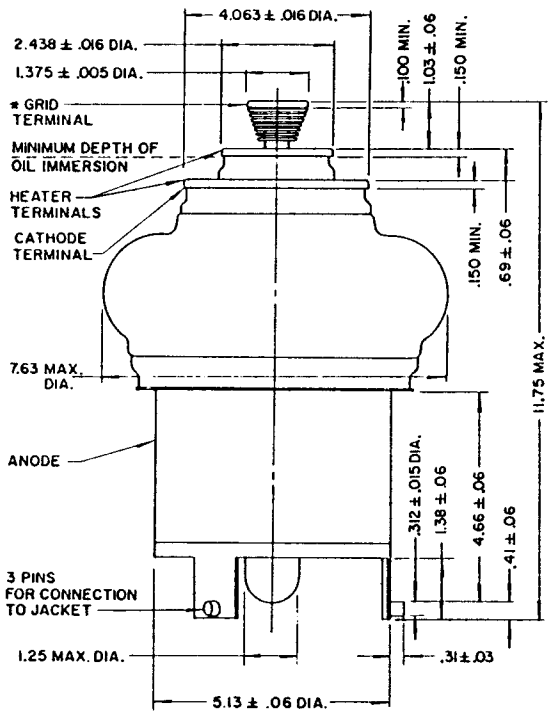


AIR COOLING CHARACTERISTICS

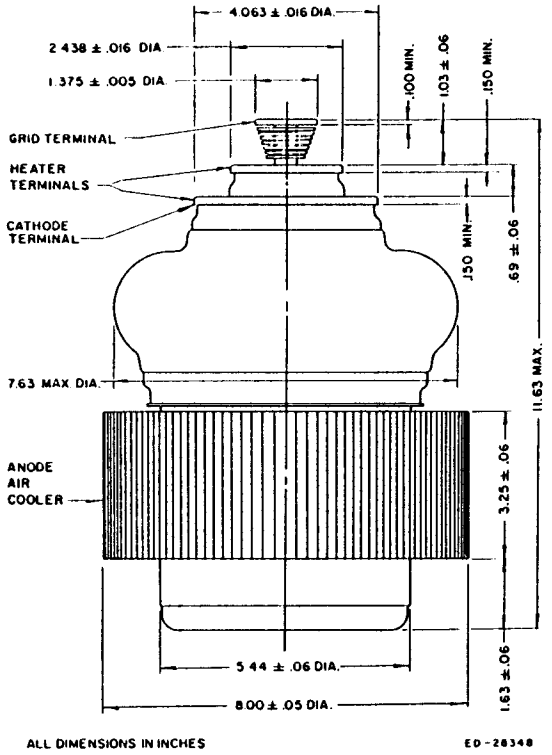
ML-7715



CONSTANT GRID VOLTAGE CHARACTERISTICS — ML-7002 & ML-7715



DIMENSIONS — ML-7002

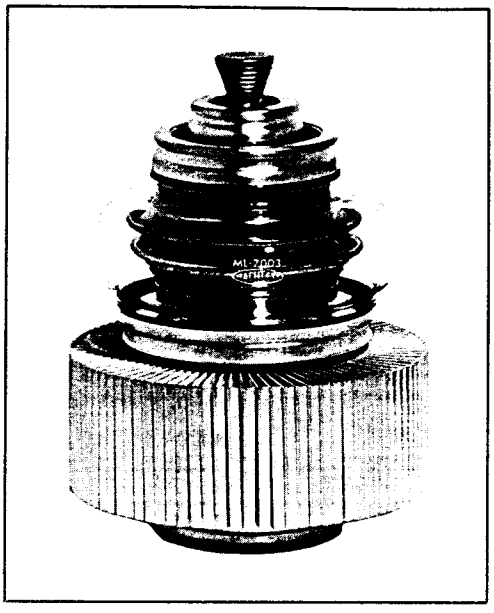


DIMENSIONS — ML-7715

THE MACHLETT LABORATORIES, INC.

An Affiliate of Raytheon Company

SPRINGDALE MACHLETT CONNECTICUT



ISSUED 5-64

ML-7003

Shielded Grid Triode

Pulse Power to 2.5 Mw

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7003 is a shielded-grid triode designed primarily to operate as a switch tube in hard-tube pulse modulators, for radar and similar applications. In this service it can deliver more than two megawatts pulse power output with less than 10 kilowatts driving power. .

The ML-7003 has sturdy electrodes arranged to form a cylindrical array of electron-optical systems, featuring a shield electrode connected internally to the cathode by direct, low-impedance paths. This design permits operation with low grid current, and it results in favorably low grid-plate capacitance. The presence of the ground-potential shield adjacent to the anode, furthermore, protects the cathode and grid from damage by transient arcs.

The cathode is a unipotential, oxide-coated type. The anode is forced-air cooled and is capable of dissipating 3kW with an air flow of 150 cfm.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage	6.0±5%	Volts
Heater Current	60	Amps
Heater Starting Current, maximum	300	Amps
Cathode Warm-up Time	10	Minutes*
Amplification Factor	200	
Interelectrode Capacitances:		
Grid Plate	2.5	pf
Input (Grid-Cathode)	250	pf
Output (Plate Cathode)	22	pf
Strapped Resonant Frequency, Grid-Cathode, approximate	63.5	Mc
Mechanical		
Mounting Position (support tube by anode radiator only)	Any	
Type of Cooling	Forced-air†	
Air flow on anode, minimum for 3kW dissipation	150 cfm at 0.2" water	
Air flow on grid	50	cfm
Maximum incoming air temperature	65	°C
Maximum Glass Temperature	175	°C†
Net Weight, approximate	25	lbs.

*For accelerated cathode warm-up, the filament may be energized at 7.0 volts for 5 minutes and then reduced to 6.0 volts for high-voltage operation. If a filament stand-by voltage of 5.0 volts is used, the minimum cathode warm-up time is 1 minute at 6.0 volts.

†Sufficient air flow must be provided to maintain glass temperatures at less than 175°C under all conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

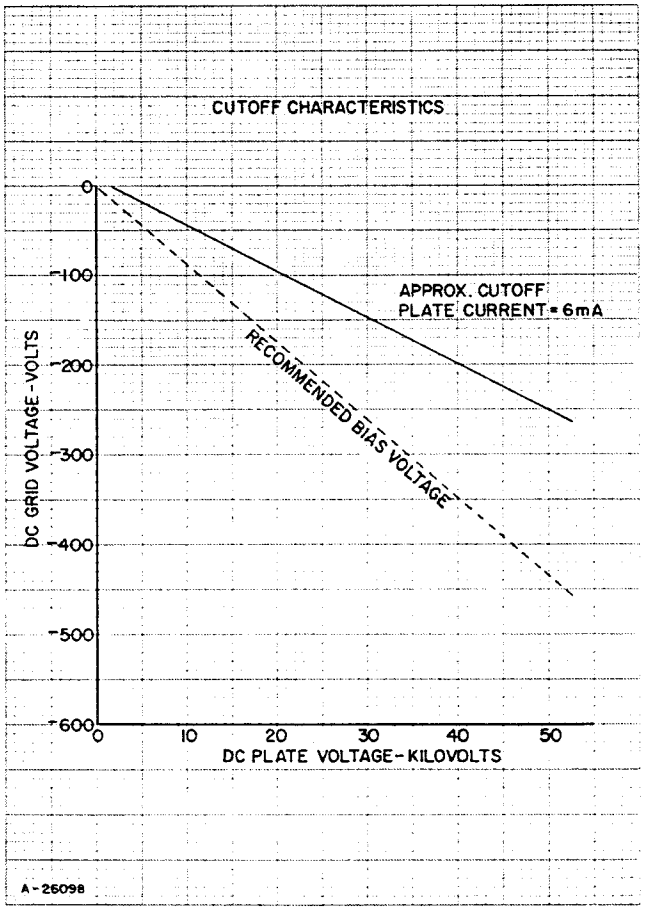
D-C Plate Voltage	45	kV
Peak Plate Voltage	50	kv
D-C Grid Voltage	−600	volts
Peak Positive Grid Voltage	+1.5	kv
Peak Negative Grid Voltage	−1500	volts
Pulse Cathode Current	90	amp
D-C Plate Current	250	mA
Grid Dissipation	75	watts
Plate Dissipation	3.0	kW
Pulse Duration*	25	μsec
Duty Factor*	0.03	

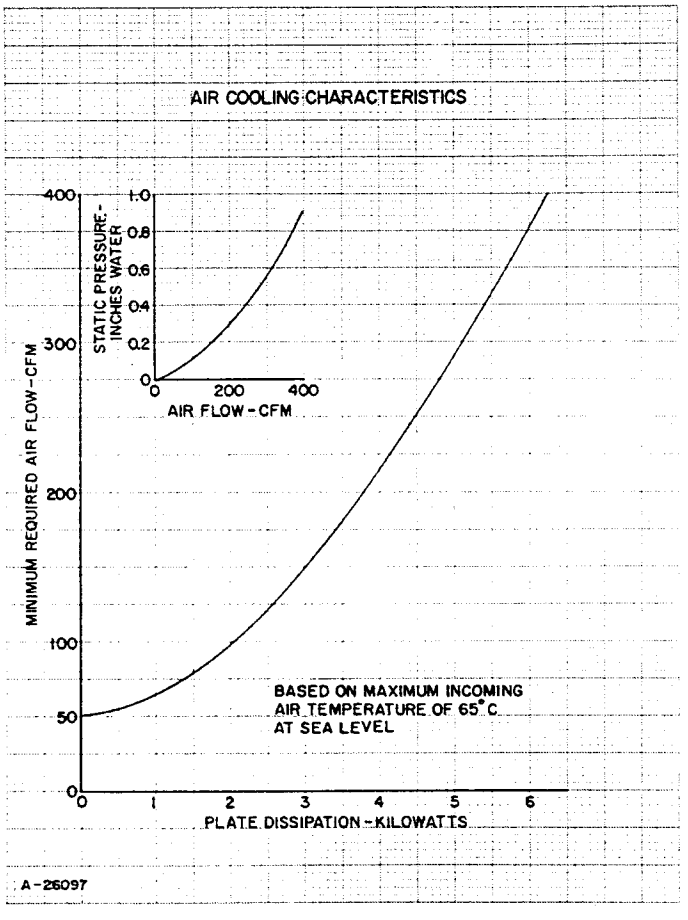
Typical Operation

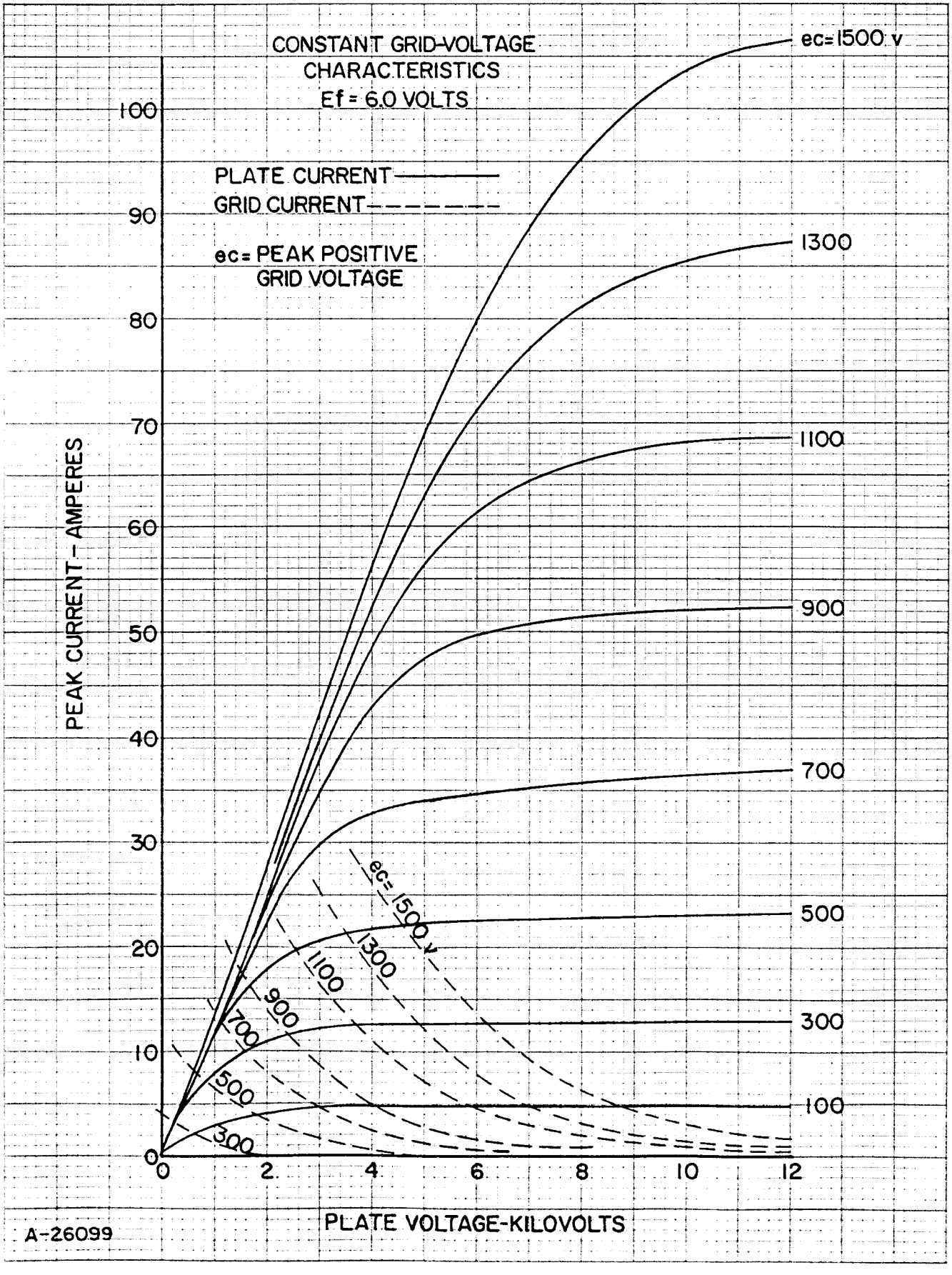
D-C Plate Voltage	35	40	kV
D-C Grid Voltage	−300	−350	volts
Pulse Positive Grid Voltage	+0.8	+1.3	kv
Pulse Plate Current	40	80	amp
Pulse Grid Current	3	4	amp
Pulse Driving Power	3.3	6.6	kw
Pulse Power Output	1.2	2.5	Mw
Plate Output Voltage	30	32	kv
Duty Factor	.006	.003	

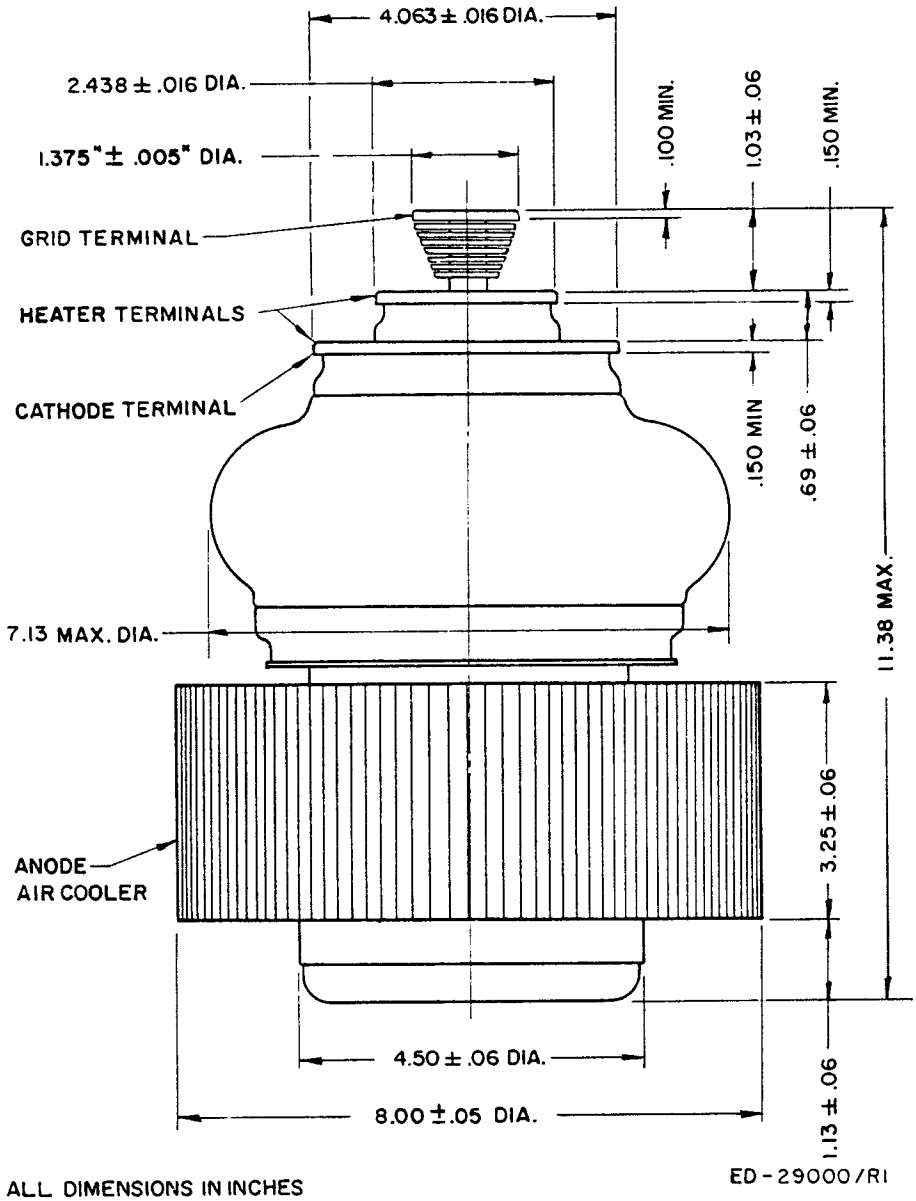
*For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.






CONSTANT GRID-VOLTAGE
CHARACTERISTICS
Ef = 6.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec= PEAK POSITIVE
GRID VOLTAGE
ec=1500 v
1300
1100
900
700
500
300
100
PEAK CURRENT - AMPERES
PLATE VOLTAGE-KILOVOLTS
0
2
4
6
8
10
12
10
20
30
40
50
60
70
80
90
100
A-26099



DIMENSIONS — ML-7003

THE MACHLETT LABORATORIES, INC.

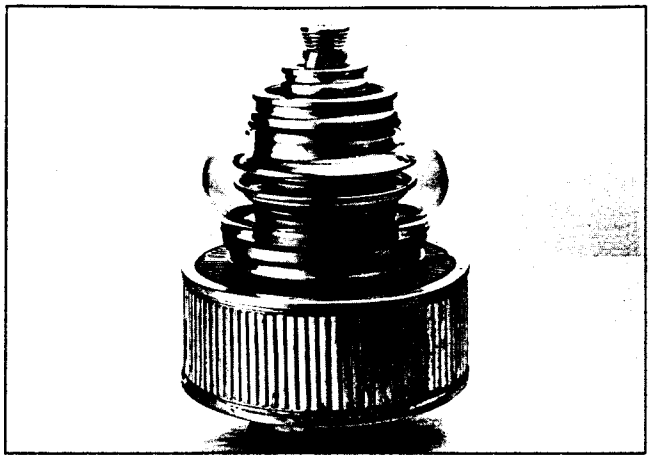
An Affiliate of Raytheon Company

SPRINGDALE MACHLETT CONNECTICUT

MACHLETT

PRODUCT DATA

ML-7003A



WARNING

When operating at peak voltage in excess of 15 kV, this electron tube may give off x-rays which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 114, "Safety Standard for Non-Medical X-Ray and Sealed Gamma Ray Sources." Additional information is available in National Council on Radiation Protection and Measurements Report No. 33, "Medical X-Ray and Gamma Ray Protection for Energies up to 10 MeV." Periodic checks of shielding effectiveness are also required since x-ray radiation levels may increase with the operating life of the tube.

APPLICATION

The ML-7003A is a ruggedized shielded-grid triode capable of withstanding severe conditions of shock and vibration, while still delivering a peak pulse power output of 2.5 megawatts in switch tube service. The tube is rated for 90 amperes peak pulse cathode current and can hold off 45 kVdc plate voltage.

CONSTRUCTION

The ML-7003A employs a beamed electrode structure to minimize driving power, utilizing the same active-area dimensions as found in the ML-7003. This design avoids the fine-wire grids usually used in tetrodes and provides a rugged structure. The shield grid is strapped to the cathode internally and protects the cathode from transient arcs. These features provide a tube which operates much more stably at high voltages than hard-tube modulators of earlier design. The high amplification factor coupled with low grid current results in unusually low driving power requirements. Additionally, the input and output circuits are isolated so that feedback capacitance is small. The cathode is a unipotential oxide-coated type. When cooled by forced air, the anode is capable of dissipating 3 kW with 200 cfm air flow.

The internal structure of the ML-7003A has been extensively reinforced and shock absorbers have been provided as an integral part of the anode radiator. The tube can withstand vibration testing from 5 to 1000 Hz (5g acceleration, 58-1000 Hz) and will tolerate shock pulses of 15g in operating (30g in non-operating) conditions without any indication of electrode shorting.

ORDERING NOTES

Refer to **Machlett** price list. When ordering specify:

- tube type
- accessories
  - — heater connector (small) F-21989
  - — cathode/heater connector (large) F-21991
  - — grid connector F-21987

SPECIFICATIONS

ELECTRICAL CHARACTERISTICS

Heater Voltage:	6.0 (+10%, −5%) V**
Heater Current:	60 A
Heater Starting Current, maximum:	300 a
Cathode Warm-up Time:	15 minutes*
Amplification Factor:	200
Interelectrode Capacitances:	
Grid Plate:	1.6 pF
Input (Grid-Cathode):	230 pF
Output (Plate-Cathode):	25 pF

MECHANICAL CHARACTERISTICS

Mounting Position (support tube by anode radiator only):	Any

Forced-Air Cooling†

Air Flow on Anode, Minimum for 3kW Dissipation:	200 cfm at 0.3" water
Air Flow on Grid:	25 cfm
Maximum Incoming Air Temperature:	75°C (167°F)

Maximum Glass Temperature: 175°C (347°F)†

Net Weight, approximate: 27 lbs. (12 kg)

*For accelerated cathode warmup, the heater may be energized at 7.5 volts for 5 minutes and then reduced to rated value for high voltage operation.

†Sufficient coolant flow must be provided to maintain glass temperatures at less than 175°C (347°F) under all conditions of operation.

**6.3 volts nominal heater voltage is recommended for new-design applications.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values*	ML-7003A
DC Plate Voltage	45 kV
Peak Plate Voltage	50 kv
DC Grid Voltage	−600 volts
Peak Positive Grid Voltage	+1.5 kv
Peak Negative Grid Voltage	−1500 volts
Pulse Cathode Current	90 a†
DC Plate Current	600 mA
Grid Dissipation	25 W
Plate Dissipation	3.0 kW
Pulse Duration*	10 μsec‡
Duty Factor*	0.03 ‡

Typical Operation	ML-7003A	
DC Plate Voltage	35 kV	40 kV
DC Grid Voltage	−300 volts	−350 volts
Pulse Positive Grid Voltage	+0.8 kv	+1.3 kv
Pulse Plate Current	40 a	80 a
Pulse Grid Current	3 a	4 a
Pulse Driving Power	3.3 kw	6.6 kw
Pulse Power Output	1.2 Mw	2.5 Mw
Plate Output Voltage	30 kv	32 kv
Duty Factor	.006	.003

*All given maximum ratings may not apply simultaneously. Due to the possibility of instantaneous overheating of electrodes during the pulse, it may be necessary to restrict some of the parameters, e.g., peak plate current, tube drop, pulse duration, duty or average dissipation, in order not to adversely affect the performance of the tube. Because of the many possible combinations of operating conditions, all restrictions cannot be delineated here, and it is suggested to review new applications with the Machlett Engineering Department.

†For pulse cathode currents above 60 amperes, minimum heater voltage for the ML-7003A is 6.3 volts.

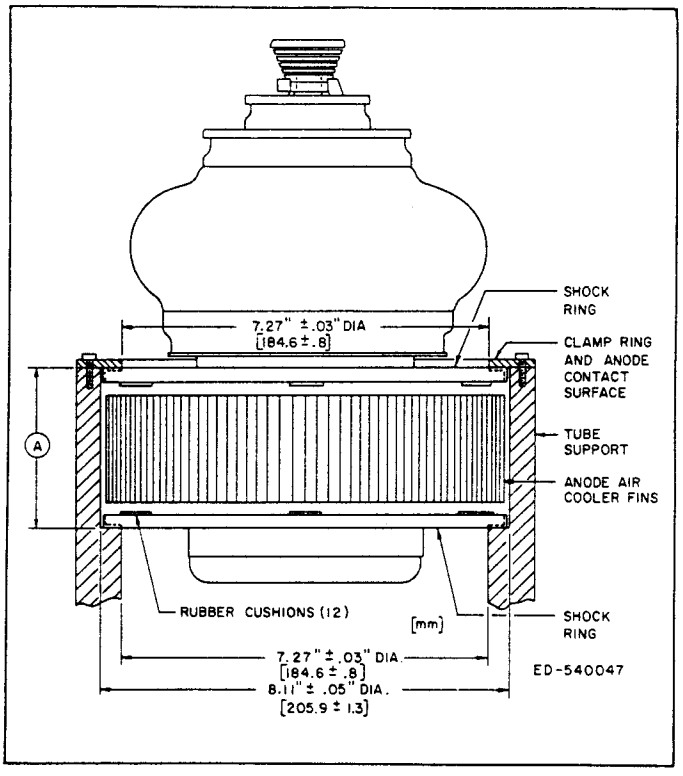
‡For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

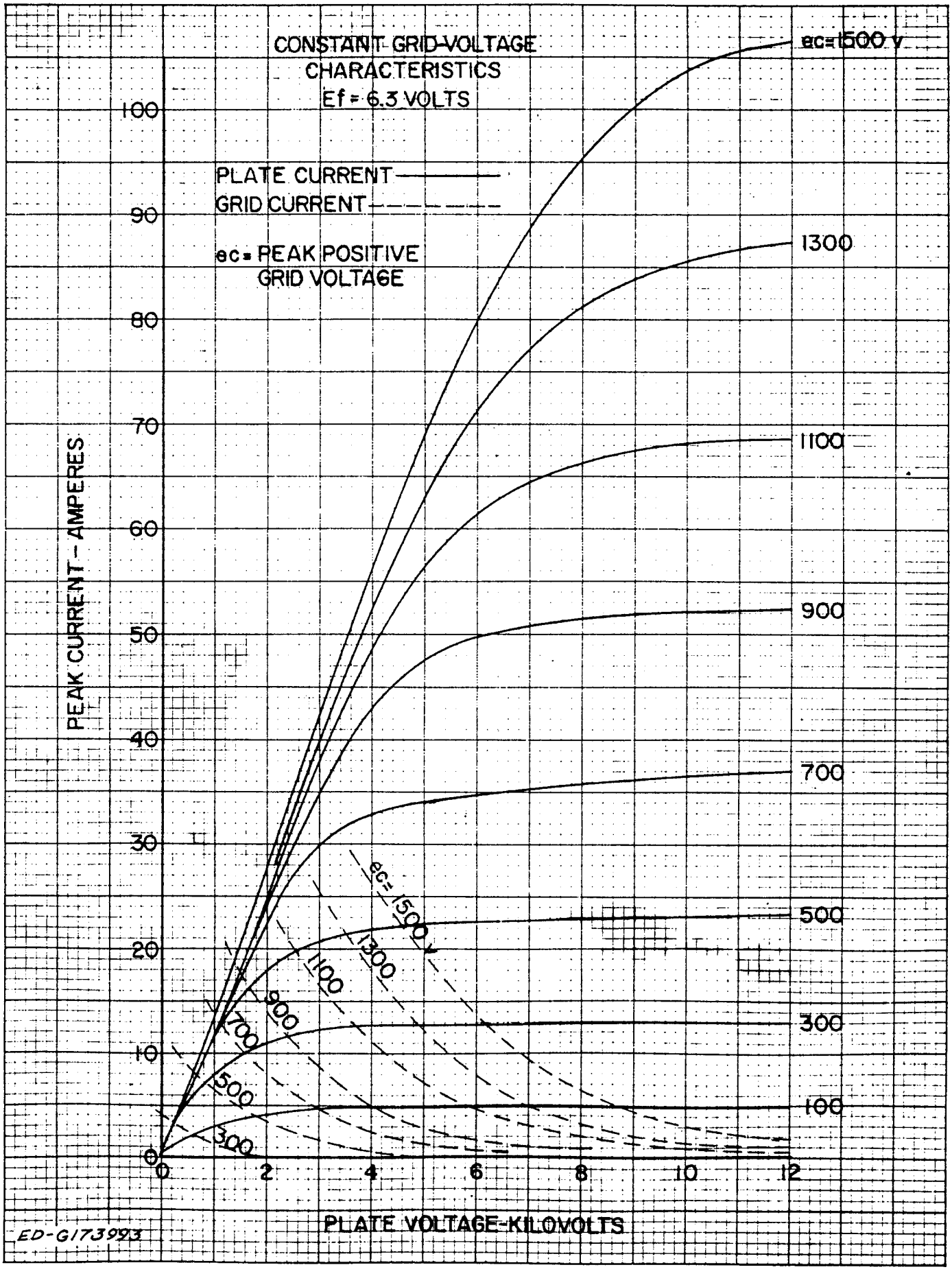
TUBE PROTECTION

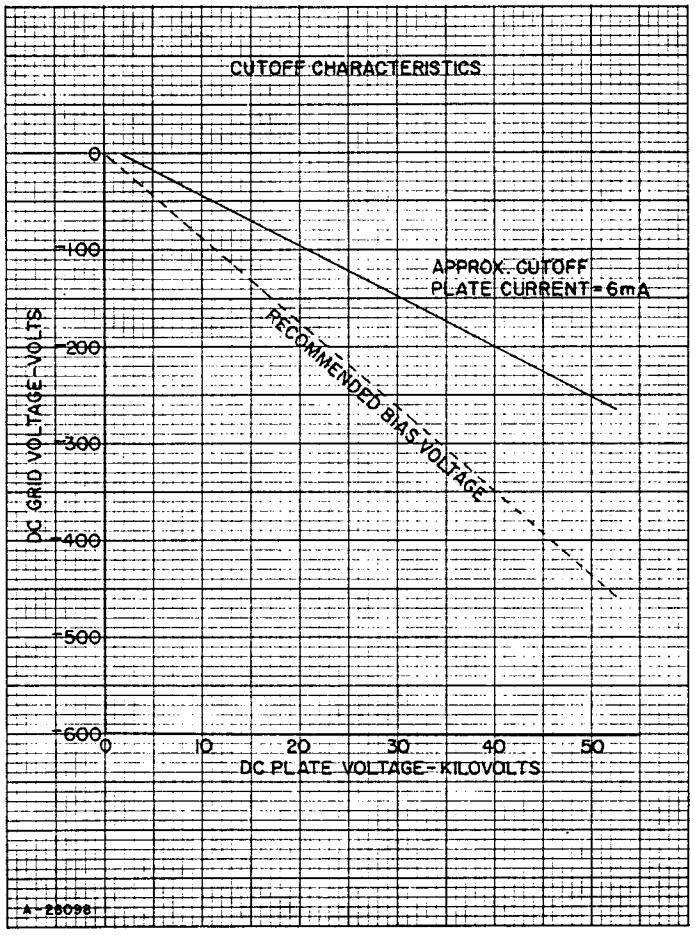
If shock and vibration protection is required, the ML-7003A should be installed in a tube support as shown. The tube should be supported by the shock rings only. Provisions must be made for the anode air cooler fins to clear the tube support. The inside diameters of the tube support and the clamp ring must be as shown.

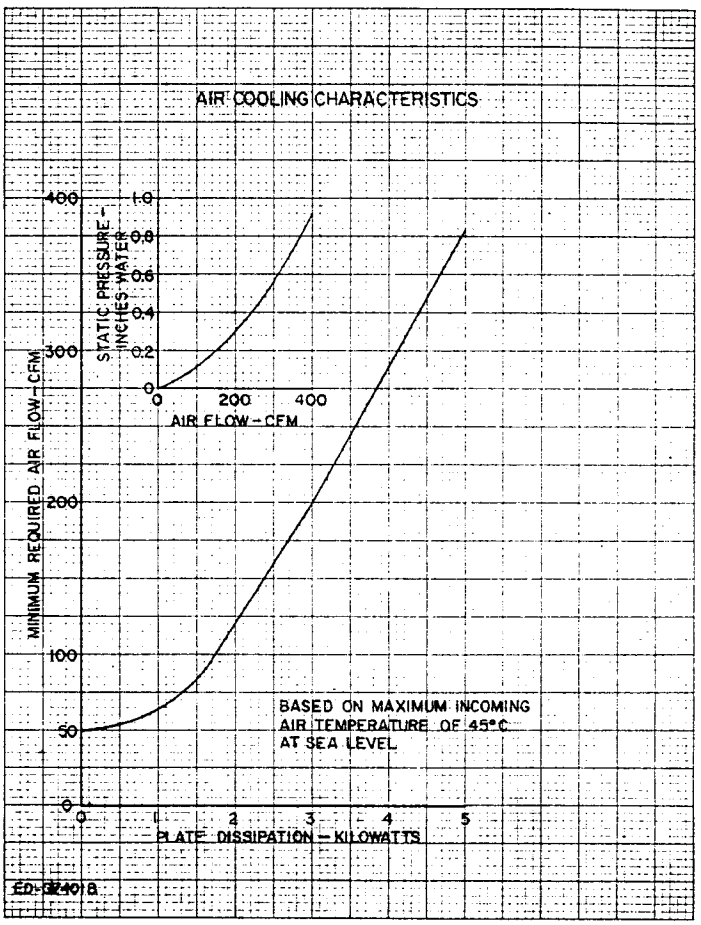
Dimension "A" must be such that total compression of the rubber cushions will be between .100" and .160". To secure this compression it might be necessary to provide shims under the clamping ring to compensate for variations from tube to tube in the dimensions of the anode air cooler.

The anode connection should be made to the clamp ring. This ring makes contact with the upper shock ring, which is connected to the anode air cooler by flexible wires located under the shock ring.

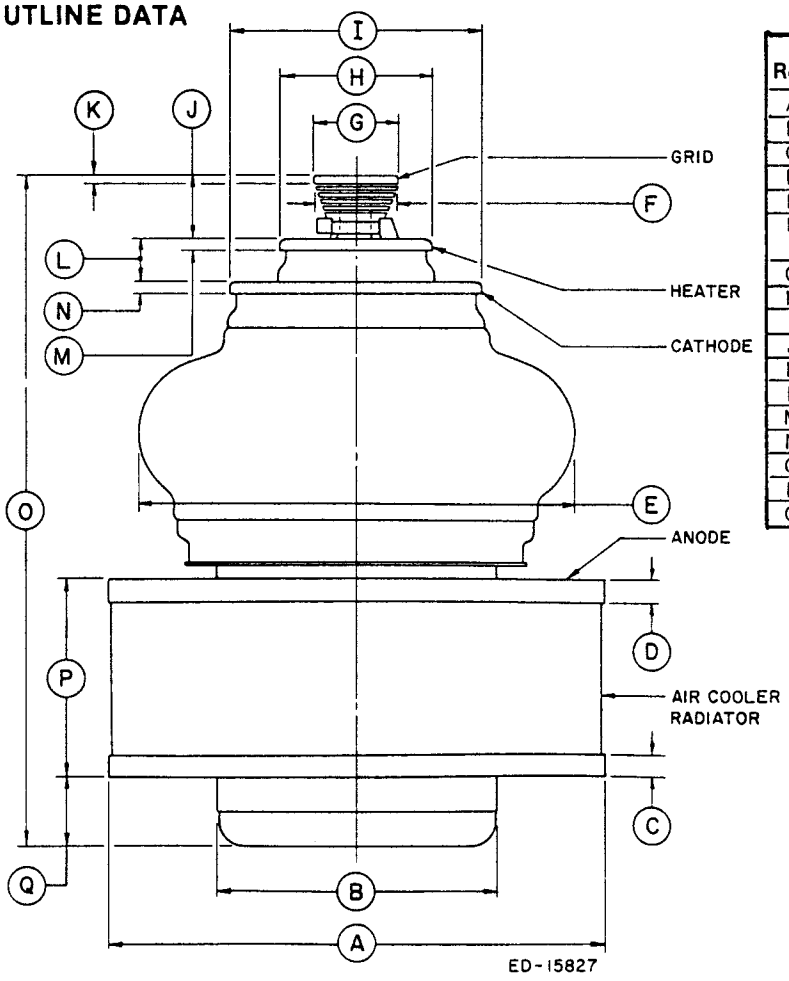



CONSTANT GRID-VOLTAGE
CHARACTERISTICS
Ef = 6.3 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE
GRID VOLTAGE
ec=1500 v
1300
1100
900
700
500
300
100
PEAK CURRENT - AMPERES
PLATE VOLTAGE-KILOVOLTS
0
2
4
6
8
10
12
100
90
80
70
60
50
40
30
20
10
0
ED-G173993





OUTLINE DATA

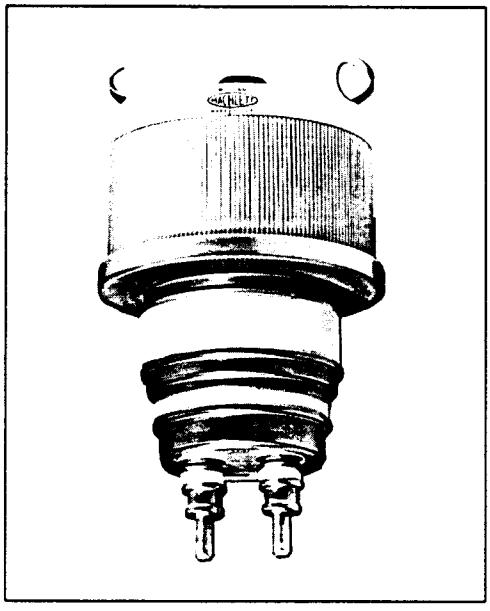


DIMENSIONS FOR OUTLINE OF ML-7003A

Ref.	(Inches) Orig. Dim.	(mm) Minimum	Nominal	Maximum
A	8.000 ± .050	201.9	203.2	204.5
B	4.5 ± .062	112	114	116
C	.36 ± .06	7.5	9.1	10.7
D	.36 ± .06	7.5	9.1	10.7
E	7.125	—	—	181
F	1.312 + 0 − .016	32.9	33.3	33.3
G	1.375 ± .005	34.80	34.93	35.06
H	2.438 ± .016	61.51	61.91	62.31
I	4.062 ± .016	102.8	103.2	103.6
J	1.031 ± .062	24.6	26.2	27.8
K	.141 ± .016	3.1	3.6	4.1
L	.688 ± .031	16.6	17.5	18.4
M	.188 ± .016	4.3	4.8	5.3
N	.188 ± .016	4.3	4.8	5.3
O	11.125 ± .25	276	283	290
P	3.25 ± .062	81.0	82.6	84.2
Q	1.125 ± .062	27.0	28.6	30.2

SPO1082
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ST-3850

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Tel. 203-348-7511 • TWX 710-474-1744



ISSUED 4-68

ML-7007

MACHLETT

High Power Tetrode
10 kW CW
800 kw Pulse Power

DESCRIPTION

The ML-7007 is a forced-air-cooled tetrode designed primarily for high-power vhf television service. It can also be used as a pulse modulator tube, and in this service is capable of switching up to 800 kW.

The envelope uses high-alumina ceramic insulation for mechanical strength and low electrical loss. Sturdy cylindrical supports for the two grids provide a smooth transition from the active tube elements to the external circuitry. With large-area coaxial terminals, they furthermore insure high heat dissipation capability. The anode is rated for 12 kW dissipation with an air flow of 550 cfm. The cathode is a sturdy, self-supporting, thoriated-tungsten filament. Maximum ratings apply at frequencies up to 220 MHz.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	5.0	Volts
Filament Current	180	Amps
Filament Cold Resistance	0.0036	Ohms
Amplification Factor, Grid No. 2 to Grid No. 1	10	
Direct Interelectrode Capacitances:		
Grid No. 1 - Plate*, maximum	0.6	pf
Grid No. 1 - Filament	43	pf
Plate - Filament*, maximum	0.08	pf
Grid No. 1 - Grid No. 2	60	pf
Grid No. 2 - Plate	21	pf
Strapped Resonant Frequency, approximate:		
Grid to Anode	510	MHz
Grid No. 1 to Grid No. 2	265	MHz
Grid No. 1 to Cathode	220	MHz

Mechanical

Mounting Position	Vertical, anode up or down	
Type of Cooling	Forced-air	
Air flow on anode, minimum for 10 kW dissipation	350 cfm at 3" water	
Air flow on seals, approximate	100	cfm†
Maximum incoming air temperature	50	°C
Maximum envelope temperature	180	°C
Net Weight, approximate	16	lbs.

*Measured with 12" square metal shield attached to Grid No. 2 terminal.

†Distributed among Grid No. 2, Grid No. 1 and Filament seals to maintain uniform temperature, not greater than 180°C, around the circumference of the seals.

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources".

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VOLTAGES ARE REFERRED TO CATHODE UNLESS OTHERWISE SPECIFIED

R-F Power Amplifier — Class B Television Service

Synchronizing-level conditions per tube unless otherwise specified.

Maximum Ratings, Absolute Values		
D-C Plate Voltage	7500	volts
D-C Grid No. 2 (Screen) Voltage	2000	volts
D-C Plate Current	4.0	amps
Plate Input	24	kW
Grid No. 2 (Screen) Input	400	watts
Plate Dissipation	12	kW
Grid No. 1 (Control Grid) Dissipation	300	watts
Typical Operation in Grid-Drive Circuit		
D-C Plate Voltage	5850	volts
D-C Grid No. 2 Voltage	1000	volts
D-C Grid No. 1 Voltage	−120	volts
Peak R-F Grid No. 1 Voltage		
Synchronizing Level	400	volts
Pedestal Level	300	volts
D-C Plate Current		
Synchronizing Level	3.2	amps
Pedestal Level	2.4	amps
D-C Grid No. 2 Current (Pedestal Level), approx.	0.110	amps
D-C Grid No. 1 Current, approx.		
Synchronizing Level	0.220	amps
Pedestal Level	0.090	amps
Driving Power, approx.		
Synchronizing Level	100	watts
Pedestal Level	30	watts
Power Output, approx.		
Synchronizing Level	12	kW
Pedestal Level	6.8	kW
Typical Operation in Cathode-Drive Circuit		
D-C Plate to Grid No. 1 Voltage	6000	volts
D-C Grid No. 2 to Grid No. 1 Voltage	700	volts
D-C Cathode to Grid No. 1 Voltage	45	volts
Peak R-F Cathode to Grid No. 1 Voltage		
Synchronizing Level	390	volts
Pedestal Level	290	volts
D-C Plate Current		
Synchronizing Level	3.8	amps
Pedestal Level	2.8	amps
D-C Grid No. 2 Current (Pedestal Level), approx.	0.140	amps
D-C Grid No. 1 Current, approx.		
Synchronizing Level	0.300	amps
Pedestal Level	0.140	amps
Driving Power, approx.		
Synchronizing Level	1200	watts
Pedestal Level	700	watts
Power Output, approx.*		
Synchronizing Level	12	kW
Pedestal Level	6.8	kW

*Includes power transferred from driver stage.

Linear RF Power Amplifier — Class AB Single-Sideband Suppressed-Carrier Service

Maximum Ratings, Absolute Values			
D-C Plate Voltage		7500	volts
D-C Grid No. 2 (Screen) Voltage		2000	volts
Maximum-Signal D-C Plate Current		2.8	amps
Maximum-Signal Plate Input		20	kW
Maximum-Signal Grid No. 2 (Screen) Input		400	watts
Plate Dissipation		12	kW
Typical Operation for Single-Tone Modulation			
D-C Plate Voltage	6500	7500	volts
D-C Grid No. 2 Voltage	1000	800	volts
D-C Grid No. 1 Voltage	−130	−100	volts
Zero Signal D-C Plate Current	0.200	0.200	amps
Zero Signal Grid No. 2 Current	0	0	amps
Maximum-Signal D-C Plate Current	2.7	2.3	amps
Maximum-Signal D-C Grid No. 2 Current, approx.	0.230	0.140	amps
Maximum-Signal D-C Grid No. 1 Current, approx.	0.140	0.160	amps
Maximum-Signal Peak RF Grid No. 1 Voltage	355	330	volts
Maximum-Signal Driving Power, approx.	40	50	watts
Maximum-Signal Plate Power Output, approx.	11	11	kW

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values		
D-C Plate Voltage	5000	volts
D-C Grid No. 2 (Screen) Voltage	2000	volts
D-C Grid No. 1 (Control Grid) Voltage	−1000	volts
D-C Plate Current	2.0	amps
D-C Grid No. 1 (Control Grid) Current	0.6	amps
Plate Input	10	kW
Plate Dissipation	8	kW
Typical Operation in Grid-Drive Circuit		
D-C Plate Voltage	4800	volts
D-C Grid No. 2 Voltage	800	volts
D-C Grid No. 1 Voltage	−300	volts
Peak R-F Grid Voltage	550	volts
D-C Plate Current	1.8	amps
D-C Grid No. 2 Current, approx.	0.160	amps
D-C Grid No. 1 Current, approx.	0.180	amps
Driving Power, approx.	100	watts
Power Output, approx.	6	kW

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
D-C Plate Voltage	25	kV
Peak Plate Voltage	30	kv
D-C Grid No. 2 (Screen) Voltage	4000	volts
D-C Grid No. 1 (Control Grid) Voltage	−1000	volts
Peak Negative Grid Voltage	−1500	volts
Pulse Cathode Current	50	amps
Grid No. 2 (Screen) Input	200	watts
Grid No. 1 (Control Grid) Dissipation	150	watts
Plate Dissipation	12	kW
Pulse Duration, approximate	1000	μsec
Duty Factor	0.01	
Typical Operation		
D-C Plate Voltage	24	kV
D-C Grid No. 2 (Screen) Voltage	3000	volts
D-C Grid No. 1 (Control Grid) Voltage	−400	volts
Pulse Positive Grid Voltage	1300	volts
Pulse Plate Current	40	amp
Pulse Grid No. 2 Current	6	amp
Pulse Grid No. 1 Current	4	amp
Pulse Driving Power	7	kw
Pulse Power Output	800	kw
Pulse Output Voltage	20	kv

R-F Power Amplifier Class C

Key-down conditions per tube without amplitude modulation

Maximum Ratings, Absolute Values			
D-C Plate Voltage	7500		volts
D-C Grid No. 2 (Screen) Voltage	2000		volts
D-C Grid No. 1 (Control Grid) Voltage	−1000		volts
D-C Plate Current	3.0		amps
D-C Grid No. 1 (Control Grid) Current	0.6		amps
Plate Input	20		kW
Grid No. 2 (Screen) Input	400		watts
Plate Dissipation	12		kW
Typical Operation in Grid-Drive Circuit			
D-C Plate Voltage	7000		volts
D-C Grid No. 2 Voltage	1000		volts
D-C Grid No. 1 Voltage	−300		volts
Peak R-F Grid No. 1 Voltage	570		volts
D-C Plate Current	2.6		amps
D-C Grid No. 2 Current, approx.	0.200		amps
D-C Grid No. 1 Current, approx.	0.150		amps
Driving Power, approx.‡†	80		watts
Power Output, approx.‡	12		kW
Typical Operation in Cathode-Drive Circuit			
D-C Plate to Grid No. 1 Voltage	7000	6000	volts
D-C Grid No. 2 to Grid No. 1 Voltage	700	700	volts
D-C Cathode to Grid No. 1 Voltage	200	140	volts
Peak R-F Cathode to Grid No. 1 Voltage	450	340	volts
D-C Plate Current	2.2	2.0	amps
D-C Grid No. 2 Current, approx.	0.150	0.125	amps
D-C Grid No. 1 Current, approx.	0.180	0.075	amps
Driving Power, approx.‡	1000	600	watts
Power Output, approx.‡*	12	6	kW

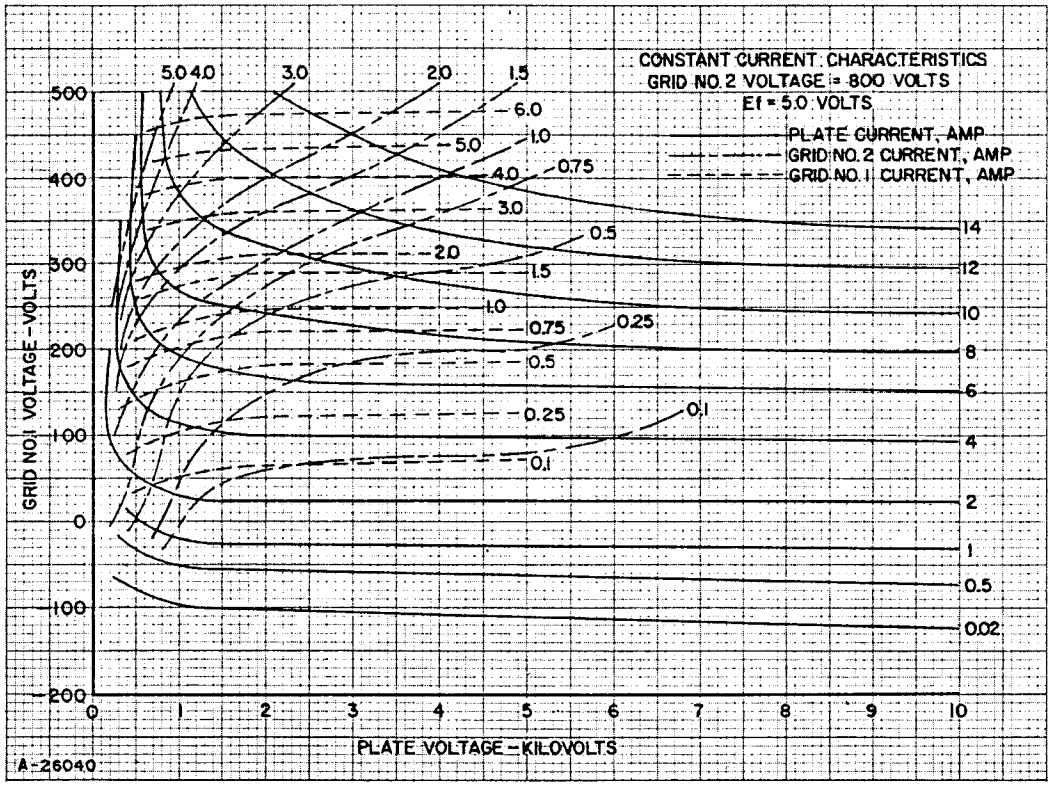
‡These calculations do not include circuit losses, since such losses are a function of frequency.

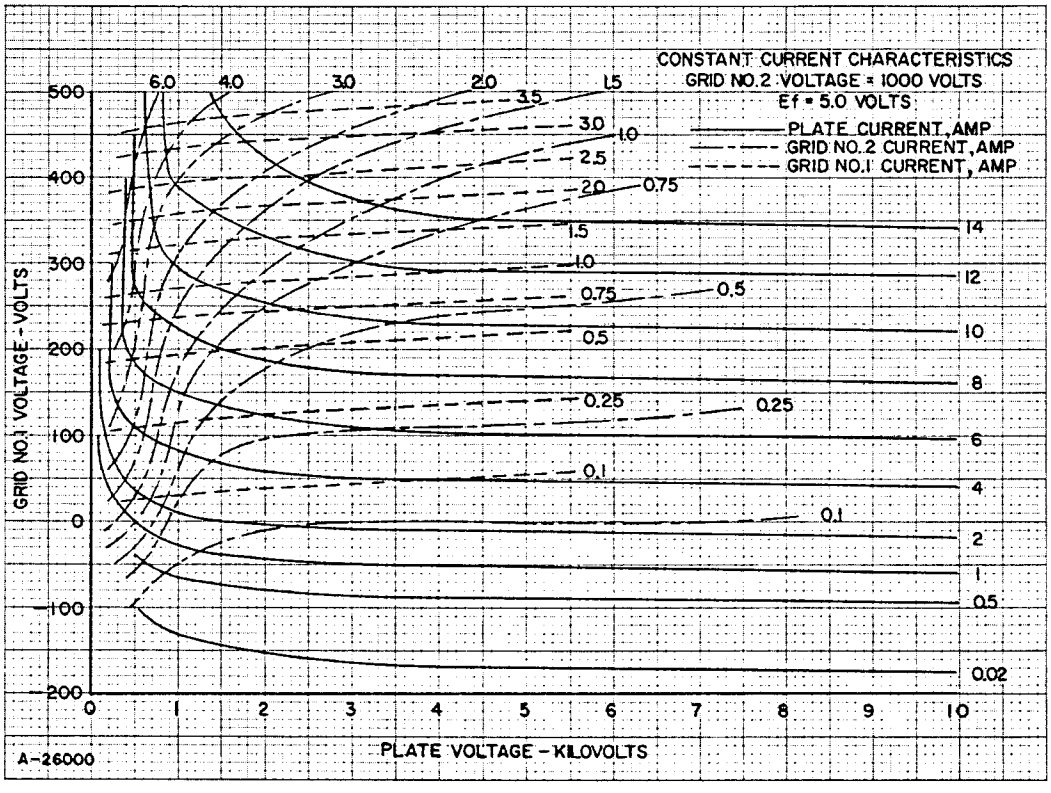
†At 220 MHz, the input losses may be as much as eight times the calculated drive power.

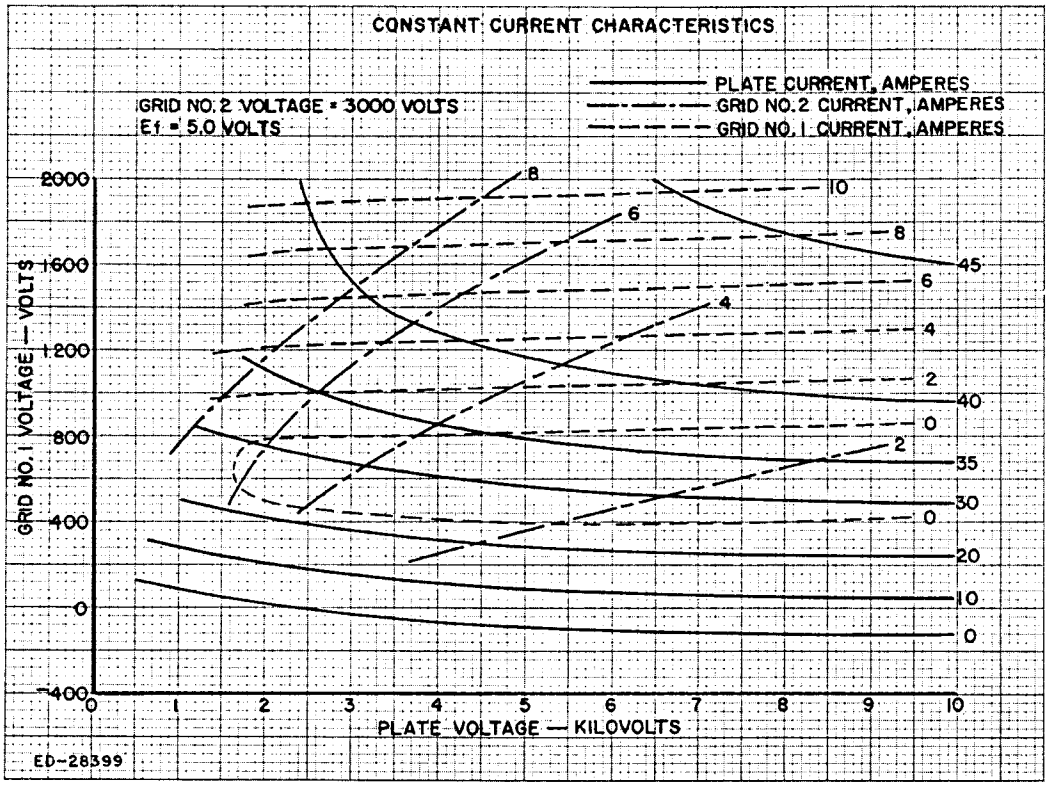
*Includes power transferred from driver stage.

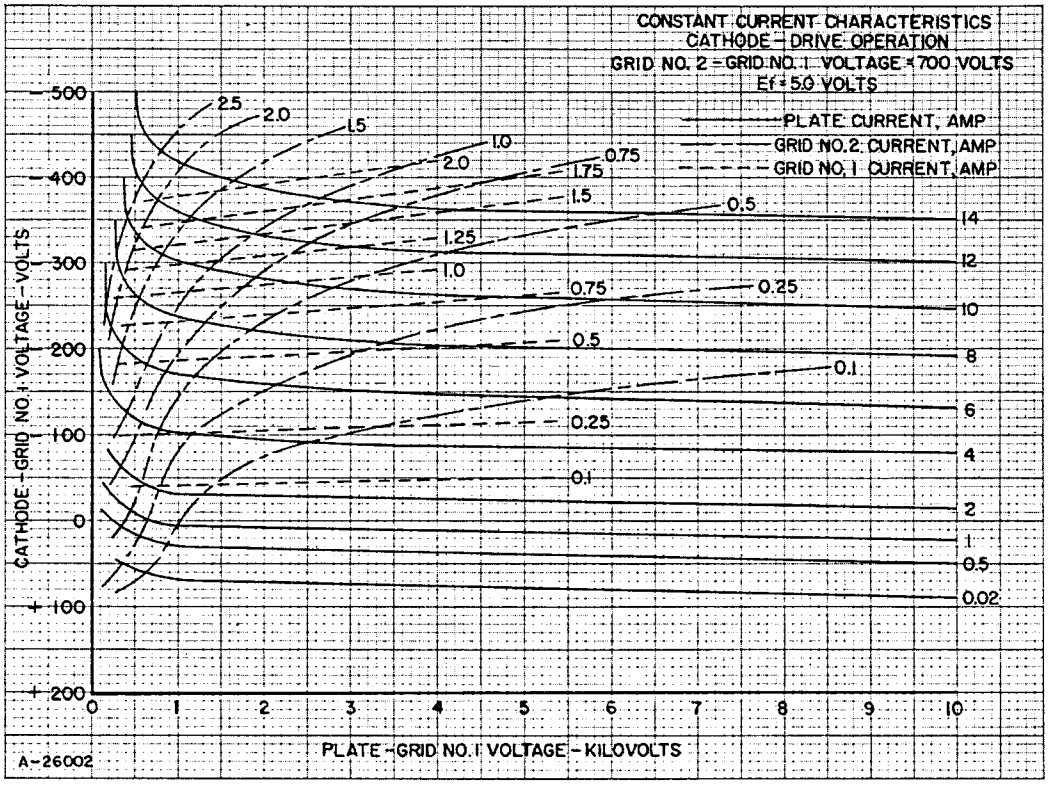
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

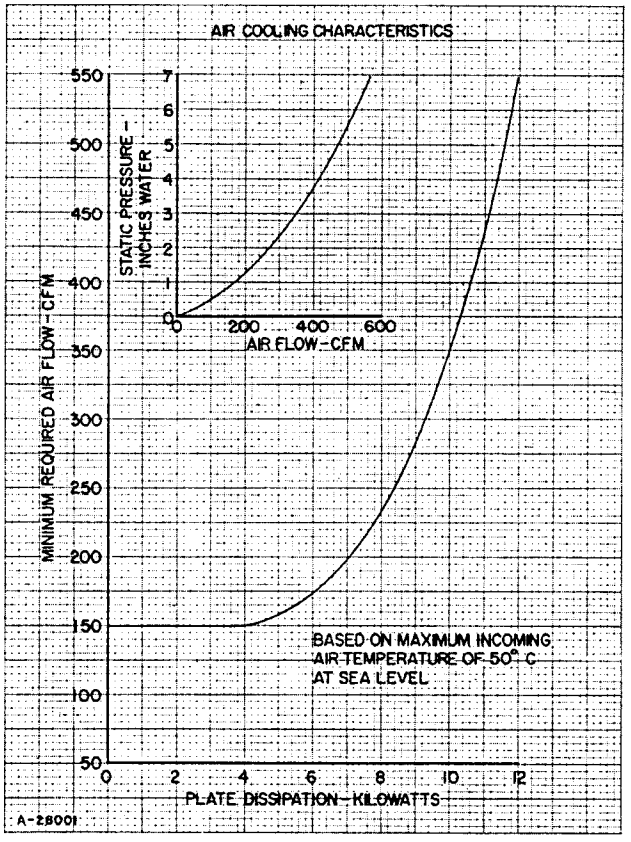
Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid No. 1 Voltage	E_b = 2000 Vdc; E_{c2} = 1000 Vdc; i_b = 8.5 amps	e_{c1}:	——	——	250	volts
Grid No. 2 Current	E_b = 2000 Vdc; E_{c2} = 1000 Vdc; i_b = 8.5 amps	i_{c2}:	——	——	0.75	amp
Grid No. 1 Current	E_b = 2000 Vdc; E_{c2} = 1000 Vdc; i_b = 8.5 amps	i_{c1}:	——	——	0.75	amp
Plate Voltage	$E_{c2} = E_b$; E_{c1} = 0 Vdc; I_b = 1.0 Adc	E_b:	0.40	0.65	0.90	kVdc
Plate Voltage	$E_{c2} = E_b$; E_{c1} = −200 Vdc; I_b = 1.0 Adc	E_b:	1.90	2.40	2.90	kVdc
Grid Voltage	E_b = 10.0 kVdc; E_{c2} = 1000 Vdc; I_b = 0.020 Adc	E_{c1}:	−110	−155	−200	Vdc


CONSTANT CURRENT CHARACTERISTICS
GRID NO.2 VOLTAGE = 800 VOLTS
Ef = 5.0 VOLTS
PLATE CURRENT, AMP
GRID NO.2 CURRENT, AMP
GRID NO.1 CURRENT, AMP
GRID NO.1 VOLTAGE - VOLTS
PLATE VOLTAGE - KILOVOLTS
A-26040

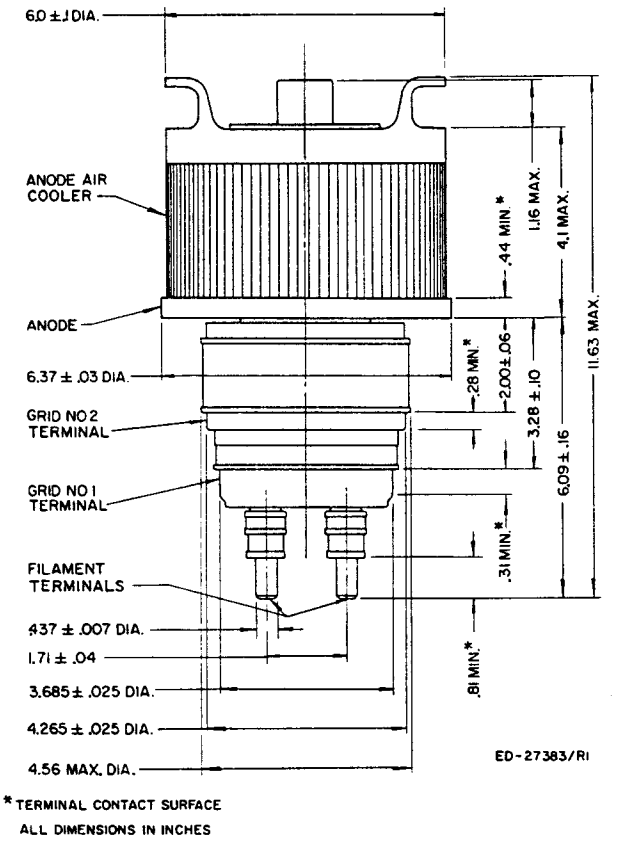

CONSTANT CURRENT CHARACTERISTICS
GRID NO.2 VOLTAGE = 1000 VOLTS
Ef = 5.0 VOLTS
PLATE CURRENT, AMP
GRID NO.2 CURRENT, AMP
GRID NO.1 CURRENT, AMP
GRID NO.1 VOLTAGE - VOLTS
PLATE VOLTAGE - KILOVOLTS
A-26000


CONSTANT CURRENT CHARACTERISTICS
GRID NO. 2 VOLTAGE = 3000 VOLTS
Ef = 5.0 VOLTS
PLATE CURRENT, AMPERES
GRID NO. 2 CURRENT, AMPERES
GRID NO. 1 CURRENT, AMPERES
GRID NO. 1 VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
ED-28399


CONSTANT CURRENT CHARACTERISTICS
CATHODE - DRIVE OPERATION
GRID NO. 2 - GRID NO. 1 VOLTAGE = 700 VOLTS
Ef = 5.0 VOLTS
PLATE CURRENT, AMP
GRID NO. 2 CURRENT, AMP
GRID NO. 1 CURRENT, AMP
CATHODE - GRID NO. 1 VOLTAGE - VOLTS
PLATE - GRID NO. 1 VOLTAGE - KILOVOLTS
A-26002



COOLING CHARACTERISTICS — ML-7007

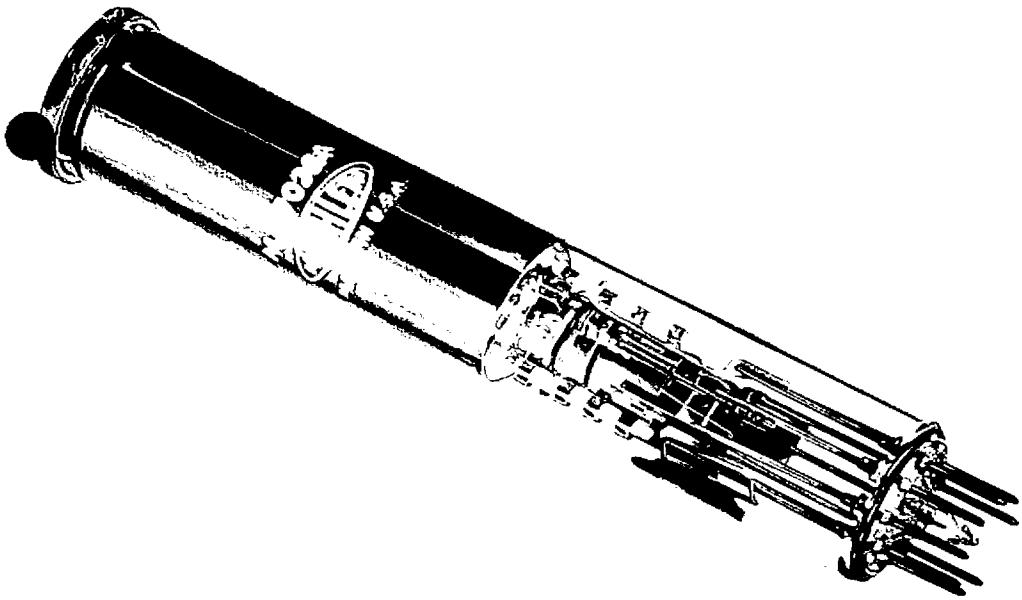


DIMENSIONS — ML-7007

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.

ST-1706 4.5M 4-68



MACHLETT

ML-7038A

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-7038A** is a small, high-quality camera tube for industrial television applications. Its resolution capability is about 600 television lines.

The **ML-7038A** utilizes a unique photoconductive surface having uniform thickness, which permits constant voltage gradient and uniform dark current across the scanned area. Because of the uniform thickness of its photoconductive surface, the **ML-7038A** can produce substantially uniform sensitivity over the entire scanned area. While dark current and sensitivity both increase with target voltage, the uniformity of the dark current makes it possible to operate the **ML-7038A** at higher values of target voltage and dark current than are permissible with previous types of vidicons. As a result, higher effective sensitivity can be obtained with the **ML-7038A.**

Featured in the design of the **ML-7038A** are an extremely flat faceplate free from optical distortion and an envelope without a side tip. The tipless envelope allows the use of a longer deflecting yoke. In addition, the tipless structure simplifies the layout of optical arrangements for light splitting in a color camera.

No alignment correction is required. The novel design of the gun gives good alignment of the beam without auxiliary alignment correcting coils or magnets. This feature also protects the beam from misalignment due to stray magnetic fields.

GENERAL CHARACTERISTICS

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 ± 10% volts
Current	0.6 amp
Direct Interelectrode Capacitance: ‡	
Target to All Other Electrodes	4.6 $\mu\mu f$
Spectral Response	S-18
Photoconductive Layer:	
Maximum Useful Diagonal of Rectangular Image (4 x 3 aspect ratio)	0.62 inch
Orientation of Quality Rectangle — Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.	
Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	6.25" ± 0.25"
Greatest Diameter	1.125" ± 0.010"
Bulb	T8
Base	Small-Button Ditetrar 8-Pin (JETEC No. E8-11)
Socket	Cinch No. 54A18088, or equivalent
Operating Position	Any
Weight (Approx.)	2 oz.

TYPICAL OPERATING CONDITIONS

Typical Operation (For scanned area of ½" x ⅜" and faceplate temperature of 30° to 35°C)		
Grid No. 4 (Decelerator) & Grid No. 3 (Beam-Focus Electrode*) Voltage	250★ to 300	volts
Grid No. 2 (Accelerator) Voltage	300	volts
Grid No. 1 Voltage for Picture Cutoff ‡‡	−45 to −100	volts
Average "Gamma" of Transfer Characteristic for signal-output current between 0.02 μa and 0.2 μa	0.65	
Visual Equivalent Signal-to-Noise Ratio (Approx.) □	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No. 1	75	volts
When applied to cathode	20	volts
Field strength at Center of focusing Coil (Approx.)	40	gausses

MAXIMUM RATINGS

Maximum Ratings, Absolute Values (For scanned area of ½" x ⅜")		
Grid No. 3 & Grid No. 4 Voltage	350	volts
Grid No. 2 Voltage	350	volts
Grid No. 1 Voltage		
Negative bias value	125	volts
Positive bias value	0	volts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	125	volts
Heater positive with respect to cathode	10	volts
Dark Current	0.25	μa
Peak Target Current	0.55	μa
Faceplate:		
Illumination	1000	ft-c
Temperature	60	°C

	For Max. Sensitivity	For Avg. Sensitivity	For Min. Lag.	
Faceplate Illumination (Highlight)	2	7	14	ft-c
Max. Target Current to Produce Specified Dark Current**	110	80	50	volts
Dark Current	0.2◀	.08	.02	μa
Target Voltage†	60 to 100	40 to 65	25 to 45	volts
Target Current (Highlight)††	0.4 to 0.5	.38 to .48	.32 to .42	μa
Signal-Output Current: #				
Peak	0.2 to 0.3	0.3 to 0.4	0.3 to 0.4	μa
Average	.08 to 0.1	0.1 to 0.2	0.1 to 0.2	μa

‡ This capacitance, which effectively is the output impedance of the ML-7038A, is increased when the tube is mounted in the deflecting-yoke and focusing-coil assembly. The resistive component of the output impedance is in the order of 100 megohms.

* Beam focus is obtained by combined effect of Grid No. 3 voltage which should be adjustable over indicated range, and a focusing coil having an average field strength of 40 gausses.

★ Definition, focus uniformity, and picture quality decrease with decreasing Grid No. 4 and Grid No. 3 voltage. In general, Grid No. 4 and Grid No. 3 should be operated above 250 volts.

‡‡ With no blanking voltage on Grid No. 1.

□ Measured with high-gain, low-noise, cascode-input-type amplifier having bandwidth of 5 Mc. Because the noise in such a system is predominately of the high-frequency type, the visual equivalent signal-to-noise ratio is taken as the ratio of highlight video-signal current to rms noise current, multiplied by a factor of 3.

** The target voltage for each ML-7038A must be adjusted to that value which gives the desired operating dark current.

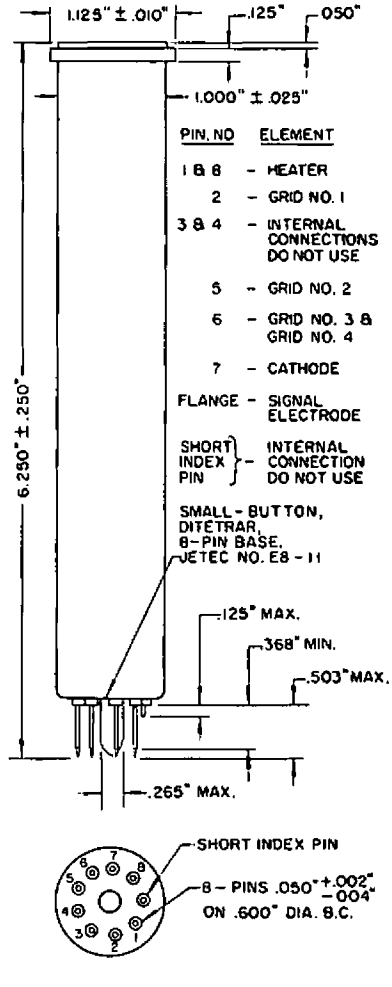
† Indicated range for each type of service serves only to illustrate the operating target-voltage range normally encountered.

◀ The deflecting circuits must provide extremely linear scanning for good black-level reproduction. Dark-current signal is proportional to the scanning velocity. Any change in scanning velocity produces a black-level error in direct proportion to the change in scanning velocity.

†† Video amplifiers must be designed properly to handle target currents of this magnitude to avoid amplifier overload or picture distortion.

Defined as the component of the target current after the dark-current component has been subtracted.

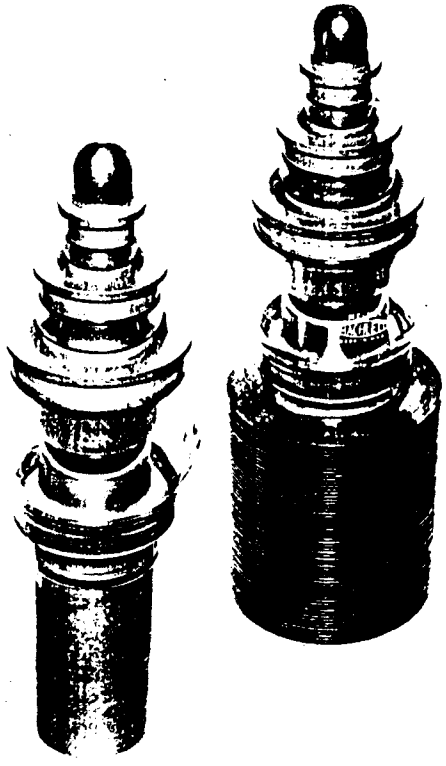
DIMENSIONS — ML-7038A



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U. S. A.



MACHLETT

ML-7120
ML-7121

DESCRIPTION & RATINGS

DESCRIPTION

The ML-7120 and ML-7121 are low-mu, three-electrode tubes designed specifically for use as Class AB1 linear amplifiers or modulators. The ML-7120 and ML-7121 are mechanically equivalent to the ML-6420 and ML-6421, respectively. The cathode of each type is a sturdy, self-supporting, stress-free, thoriated-tungsten filament. The ML-7120 has a water-cooled, heavy-wall anode capable of dissipating 12.5 kW with a water flow of approximately 5 gpm. The ML-7121 has a forced-air-cooled, heavy-wall anode capable of dissipating 10 kW with an air flow of approximately 475 cfm*. Maximum ratings of 10 kVdc plate voltage and 20 kW plate input apply at frequencies up to 30 Mc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	7.0	Volts
Filament Current	85	Amps
Filament Starting Current, maximum	400	Amps
Filament Cold Resistance	0.0095	Ohm
Amplification Factor	4.4	
Interelectrode Capacitances:		
Grid-Plate	23	$\mu\mu f$
Grid-Filament	32	$\mu\mu f$
Plate-Filament	1.7	$\mu\mu f$

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling — ML-7120	Water and Forced air†	
Water flow on anode, minimum for 12.5 kW dissipation	5	gpm
Maximum outgoing water temperature	70	°C
Type of Cooling — ML-7121	Forced-air	
Air flow on anode, minimum for 10 kW dissipation * — Pressure:	475 cfm at 3.3" water	
Air flow on anode, minimum for 10 kW dissipation * — Exhaust:	550 cfm at 3.5" water	
Maximum incoming air temperature	50	°C
Maximum Glass Temperature	165	°C†
Net Weight, approximate		
ML-7120	10	lbs.
ML-7121	13.5	lbs.

*When used with Machlett ML-7121 Air Distributor F-17796.

†At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient; at higher frequencies or high ambient temperature, auxiliary air flow of 25-50 cfm may be required and should be distributed to maintain uniform glass temperature, not greater than 165°C, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class AB1

Maximum Ratings, Absolute Values				
D-C Plate Voltage			10000	volts
Max.-Signal D-C Plate Current			2.2	amps
Max.-Signal Plate Input			20	kW
Plate Dissipation				
ML-7120			12.5	kW
ML-7121			10	kW
Typical Operation (Values are for two tubes)				
D-C Plate Voltage	6000	8500	10000	volts
D-C Grid Voltage	−1450	−2050	−2350	volts
Peak A-F Grid-to-Grid Voltage	2800	4000	4600	volts
Peak A-F Plate-to-Plate Voltage	8600	13000	12800	volts
Zero-Signal D-C Plate Current	0.2	0.4	0.6	amp
Max.-Signal D-C Plate Current	1.2	1.6	4.2	amps
Effective Load Resistance, Plate-to-Plate	9150	10400	3900	ohms
Max.-Signal Driving Power	0	0	0	watts
Max.-Signal Power Output, approximate	4.0	8.1	21	kW

Typical Operation (Values are for two tubes)			
Random Noise Drive Conditions	ML-7120		
D-C Plate Voltage	10000	10000	volts
D-C Grid Voltage	−2350	−2350	volts
Peak A-F Grid-to-Grid Voltage	4650	4650	volts
Peak A-F Plate-to-Plate Voltage	15200	15800	volts
Zero-Signal D-C Plate Current	0.6	0.6	amp
Max.-Signal D-C Plate Current	2.5	2.0	amps
Effective Load Resistance, Plate-to-Plate	7750	10000	ohms
Max.-Signal Driving Power	0	0	watts
Max.-Signal Power Output at 1.0 Power Factor	15	12.5	kVA
Load Power Factor	0-1.0	0-1.0	

Linear RF Power Amplifier — Class AB

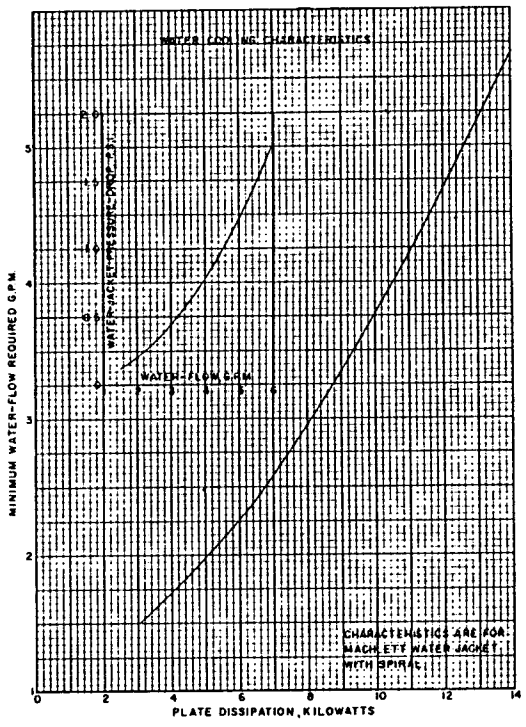
Single-Sideband Suppressed-Carrier Service

Maximum Ratings, Absolute Values		
D-C Plate Voltage	10000	volts
Max.-Signal DC Plate Current	2.2	amps
Max.-Signal Plate Input	20	kW
Max.-Signal DC Grid Current	100	mA
Plate Dissipation		
ML-7120	12.5	kW
ML-7121	10	kW
Typical Operation		
DC Plate Voltage	10000	volts
DC Grid Voltage	−2350	volts
Zero-Signal DC Plate Current	0.3	amp
Effective RF Load Resistance	3050	ohms
Single-Tone Modulation		
Max.-Signal DC Plate Current	1.5	amps
Max.-Signal DC Grid Current	0	mA
Max.-Signal Peak RF Plate Voltage	7200	volts
Max.-Signal Peak RF Grid Voltage	2325	volts
Max.-Signal Driving Power	0	watts
Max.-Signal Plate Power Output	8.5	kW
Two-Tone Modulation		
Average DC Plate Current	0.95	amp
Average DC Grid Current	0	mA
Max.-Resultant Signal Peak RF Grid Voltage	2325	volts
Average Plate Power Output	4.25	kW
Peak Envelope Plate Power Ouput	8.5	kW

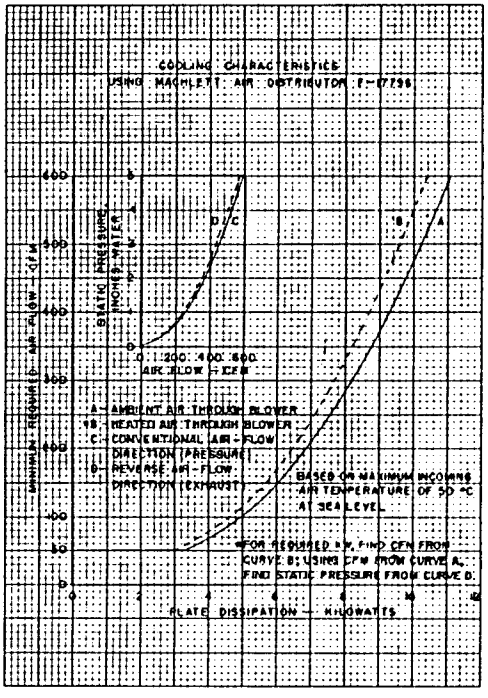
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

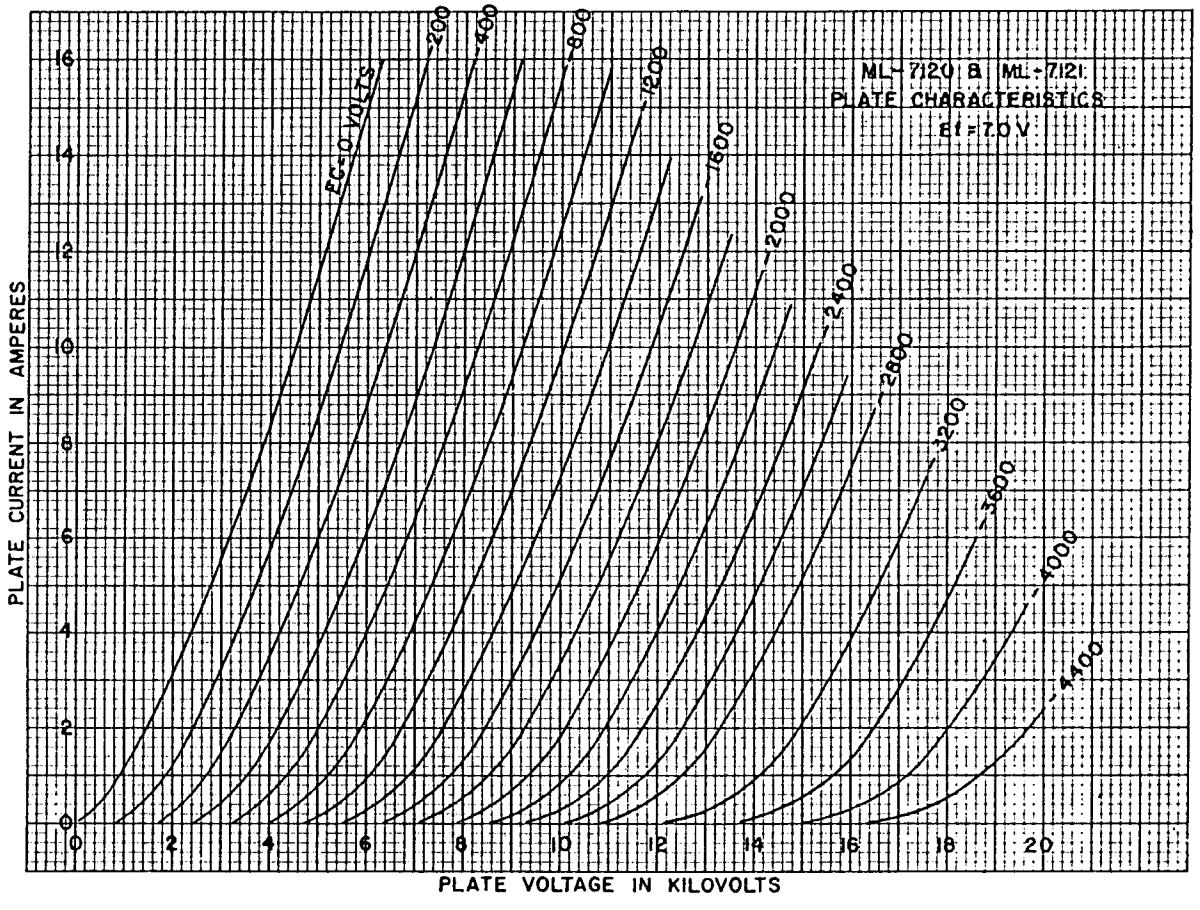
Characteristic	Conditions		Limits Minimum	Bogey	Maximum	
Plate Voltage	e_c = 0 volts; i_b = 15 amps	e_b:	——	6.0	6.4	kv
Plate Voltage	E_c = 0 Vdc; I_b = 1.0 Adc	E_b:	0.7	0.85	1.0	kVdc
Plate Voltage	E_c = −1000 Vdc; I_b = 1.0 Adc	E_b:	4.9	5.25	5.6	kVdc
Grid Voltage	E_b = 7.0 kVdc; I_b = 0.020 Adc	E_c:	−1600	−1800	−2000	Vdc
Plate Power Output	E_b = 10.0 kVdc; I_b = 1.5 Adc E_c = −2350 Vdc; I_c = 0 Adc	P_o:	7.5	8.5	——	kW

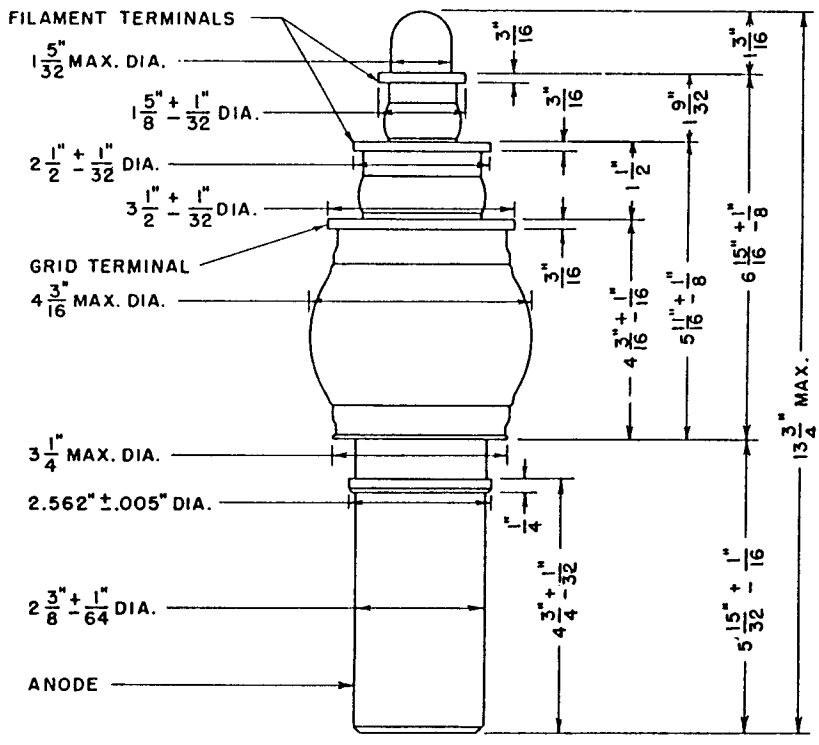
ML-7120



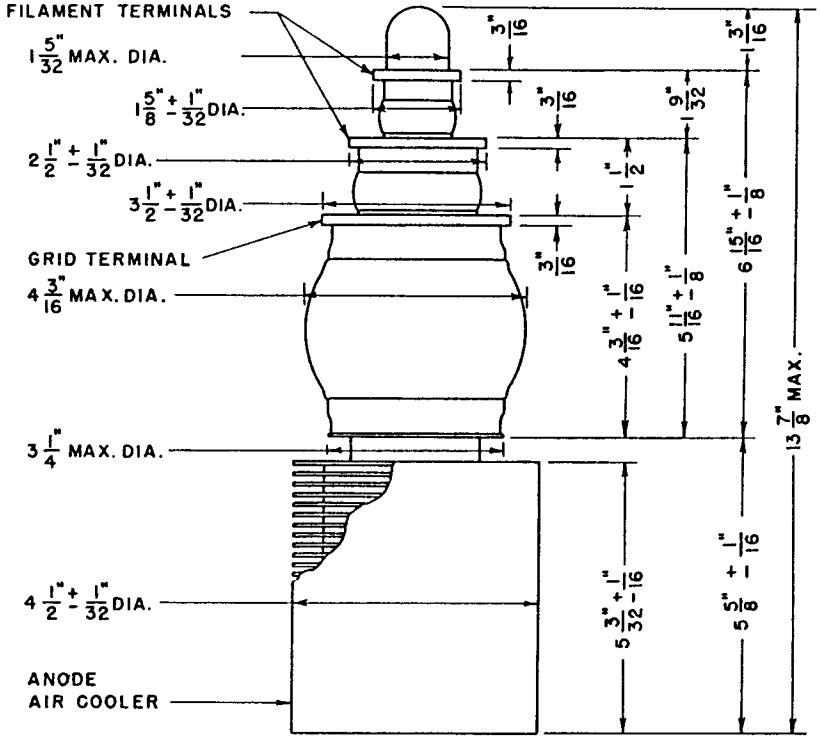
ML-7121







DIMENSIONS — ML-7120



DIMENSIONS — ML-7121

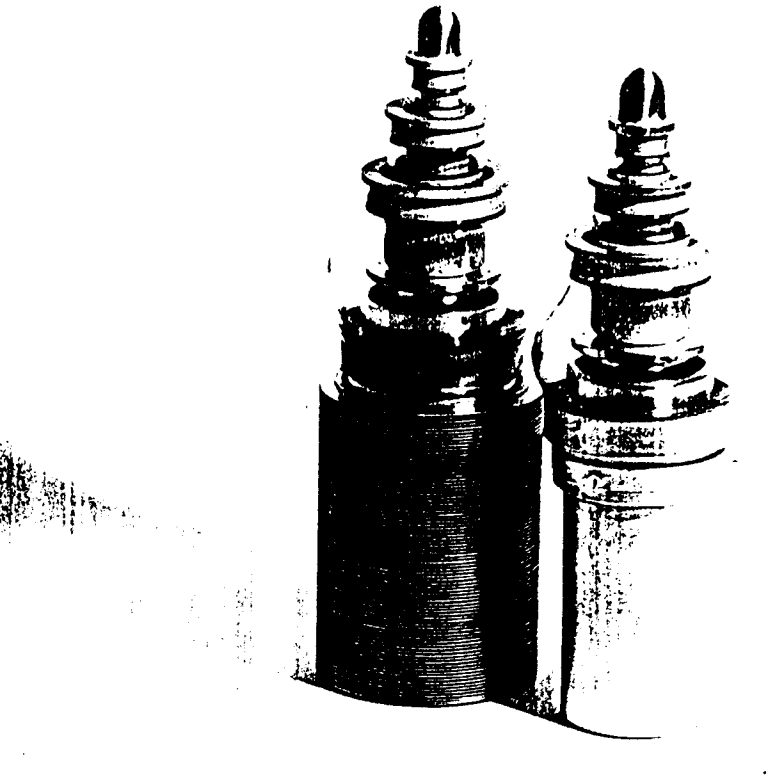
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MACHLETT

ML-7124
ML-7125

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-7124 and ML-7125 are low-mu, three-electrode tubes designed specifically for use as Class AB1 linear amplifiers or modulators. The ML-7124 has a water-cooled, heavy-wall anode capable of dissipating 40 kilowatts with a moderate rate of water flow. The ML-7125 has a forced-air-cooled, heavy-wall anode capable of dissipating 20 kW*. The cathode of each type is a sturdy, self-supporting, stress-free, thoriated-tungsten filament.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	8.0	Volts
Filament Current	200	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	0.0055	Ohms
Amplification Factor	4.5	
Interelectrode Capacitances:		
Grid-Plate	50	$\mu\mu f$
Grid-Filament	50	$\mu\mu f$
Plate-Filament	1.8	$\mu\mu f$

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling — ML-7124	Water and forced-air†	
Water flow on anode, min. for 40 kW dissipation	20	gpm
Maximum outgoing water temperature	70	°C
Type of Cooling — ML-7125	Forced-air	
Air flow on anode, min. for 20 kW dissipation*	Pressure: 1000 cfm at 7.7" water Exhaust: 1150 cfm at 8.4" water	
Maximum incoming air temperature	50	°C
Air-Flow on Bulb and Seals, approximate	100	cfm†
Maximum Glass Temperature	165	°C
Net Weight, approximate		
ML-7124	16	lbs.
ML-7125	23	lbs.

*When used with Machlett Air Distributor, F-17798.

†Auxiliary air flow of 50-150 cfm may be required and should be distributed to maintain uniform glass temperature, not greater than 165°C, around the circumference of the seals.

NOTE: Inasmuch as developmental work on the ML-7124 and ML-7125 is not complete, consult the Machlett Engineering Department before designing equipment based on these data.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class AB1

Maximum Ratings, Absolute Values	ML-7124	ML-7125	
D-C Plate Voltage	12500	12500	volts
Max.-Signal D-C Plate Current*	8.0	4.5	amps
Max.-Signal Plate Input*	80	55	kW
Plate Dissipation*	40	20	kW

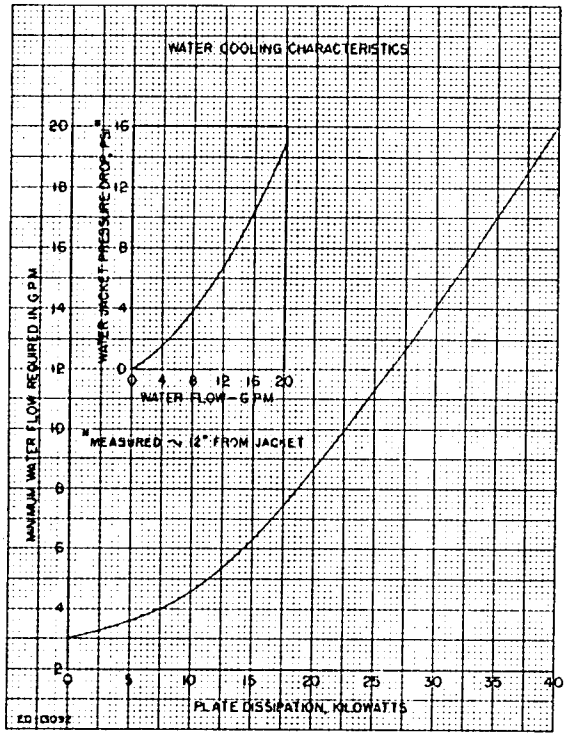
Typical Operation (Values are for two tubes)			ML-7124	
D-C Plate Voltage	9000	12000	12000	volts
D-C Grid Voltage	−1950	−2600	−2600	volts
Peak A-F Grid-to-Grid Voltage	3850	5150	5150	volts
Peak A-F Plate-to-Plate Voltage	11700	18000	16400	volts
Zero-Signal D-C Plate Current	0.4	0.4	0.4	amps
Max.-Signal D-C Plate Current	8.9	7.8	11.0	amps
Effective Load Resistance, Plate-to-Plate	1670	2950	1900	ohms
Max.-Signal Driving Power	0	0	0	watts
Max.-Signal Power Output, approximate	41	54	71	kW

Typical Operation (Values are for two tubes) Random Noise Drive Conditions	ML-7124		
D-C Plate Voltage	12000	12000	volts
D-C Grid Voltage	−2600	−2600	volts
Peak A-F Grid-to-Grid Voltage	5150	5150	volts
Peak A-F Plate-to-Plate Voltage	20600	18800	volts
Zero-Signal D-C Plate Current	0.4	0.4	amps
Max.-Signal D-C Plate Current	3.3	6.4	amps
Effective Load Resistance, Plate-to-Plate	8000	3760	ohms
Max.-Signal Driving Power	0	0	watts
Max.-Signal Power Output at 1.0 Power Factor	27	47	kVA
Load Power Factor	0-1.0	0-1.0	

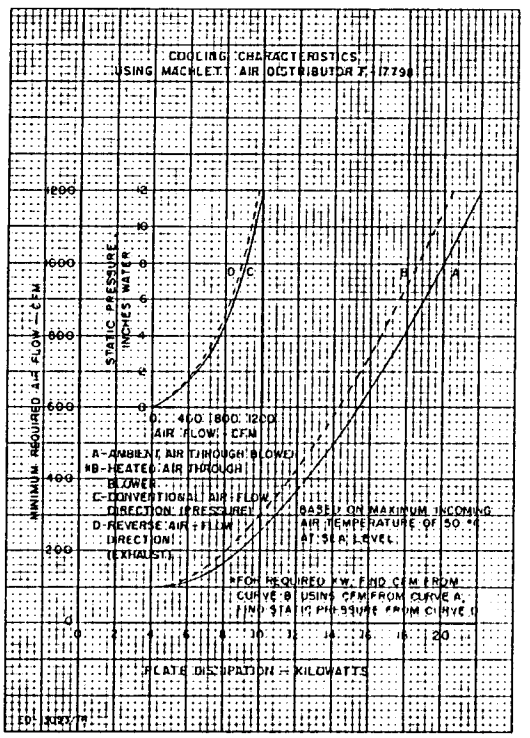
*Average over any audio-frequency cycle of sine-wave form.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

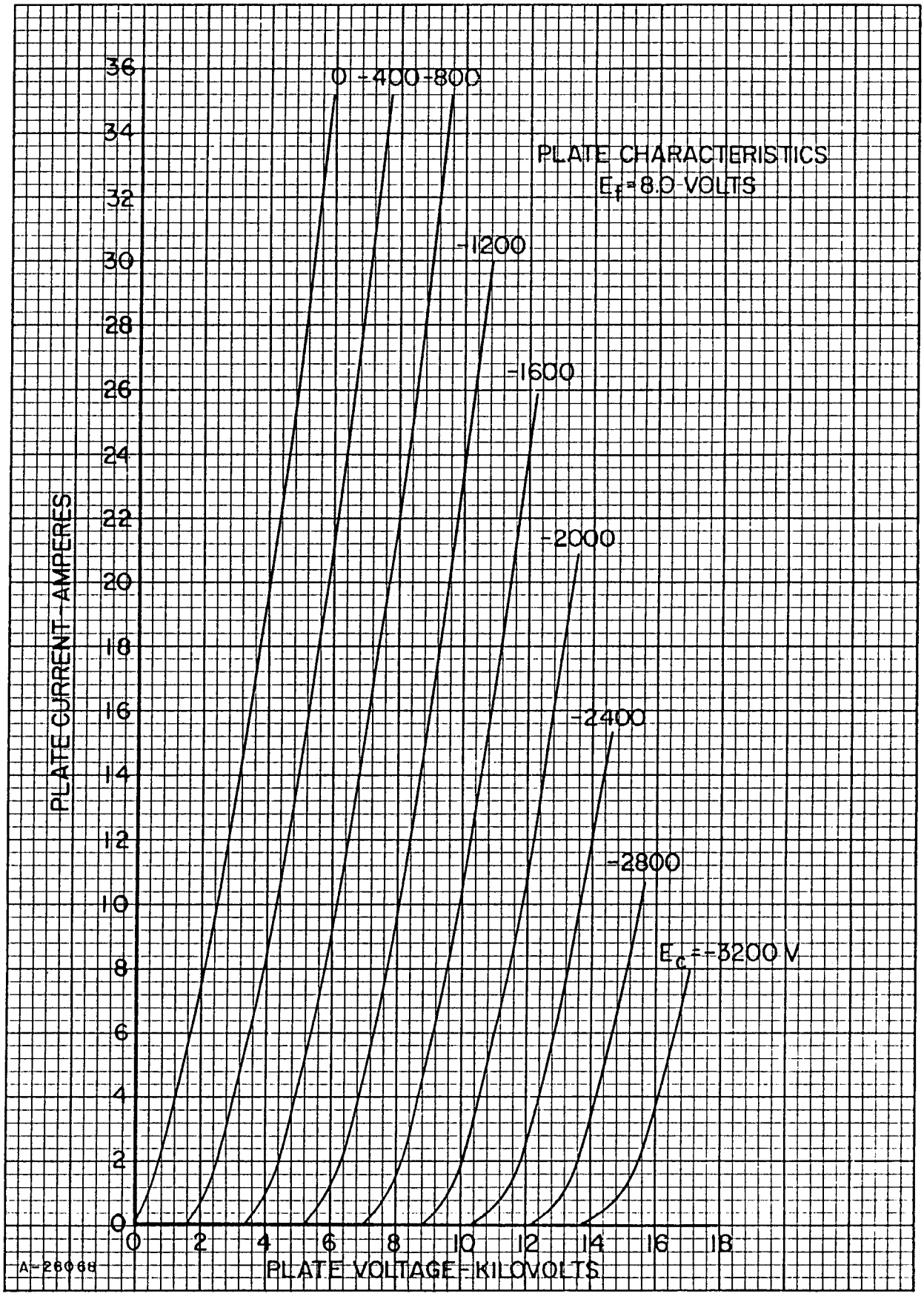
Characteristic	Conditions		Limits Minimum	Bogey	Maximum	
Plate Voltage	$e_c = 0$ volts; $i_b = 35$ amps	e_b:	——	6.0	7.0	kv
Plate Voltage	$E_c \doteq 0$ Vdc; $I_b = 3.0$ Adc	E_b:	1.0	1.1	1.3	kVdc
Plate Voltage	$E_c = -1000$ Vdc; $I_b = 3.0$ Adc	E_b:	5.0	5.6	6.3	kVdc
Grid Voltage	$E_b = 7.0$ kVdc; $I_b = 0.020$ Adc	E_c:	−1400	−1600	−2000	Vdc
Plate Power Output	$E_b = 12.0$ kVdc; $I_b = 3.7$ Adc $E_c = -2600$ Vdc; $I_c = 0$ Adc	P_o:	22	27	——	kW



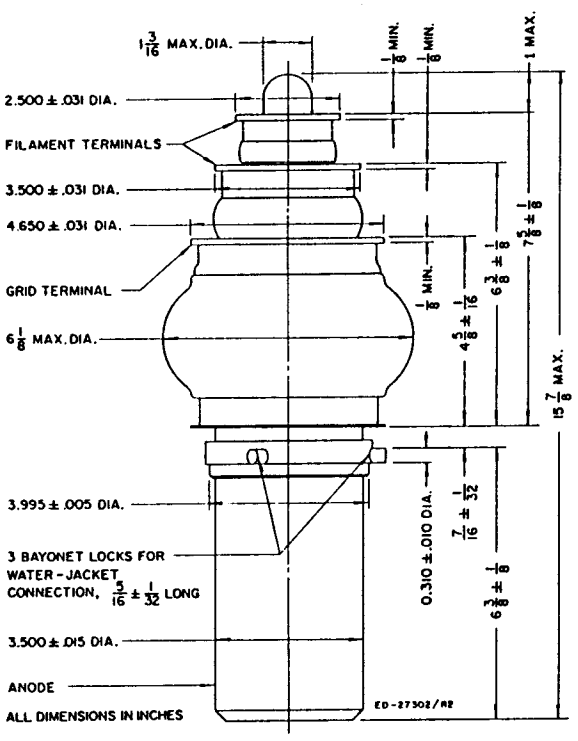
ML-7124 COOLING CHARACTERISTICS



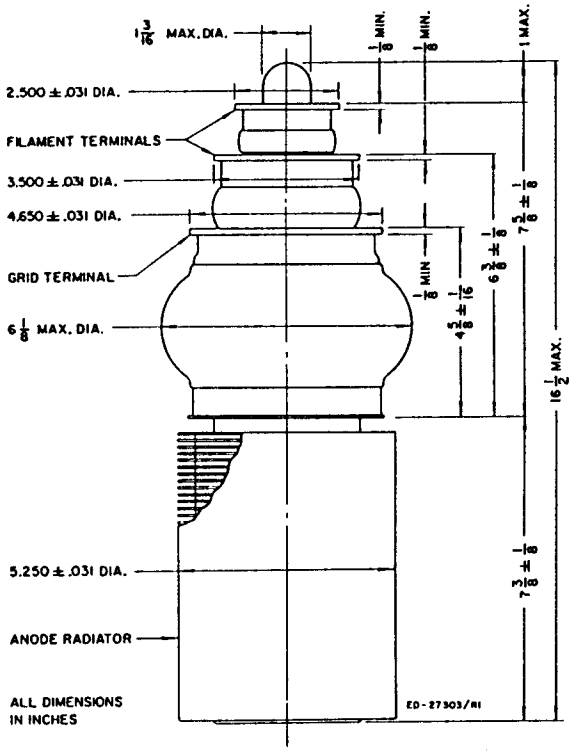
ML-7125 COOLING CHARACTERISTICS



ML-7124 AND ML-7125 PLATE CHARACTERISTICS



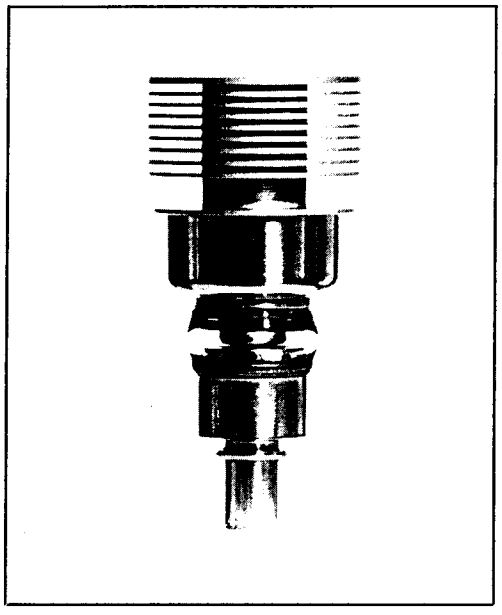
DIMENSIONS — ML-7124



DIMENSIONS — ML-7125

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ISSUED 12-64

ML-7209

UHF Planar Triode

4.5 kw Pulse Power

2.2 kw RF Pulse Power

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7209 is a high-mu triode of the planar-electrode type designed for use as a grid- or plate-pulsed oscillator, switch tube, or frequency multiplier at frequencies up to 3 Gc. Features include low interelectrode capacitances, high transconductance and great mechanical strength. Lead inductances and rf losses are minimized by a compact, rugged coaxial construction, making the tube ideally suited to cavity type circuits as well as for parallel line operation. The cathode is an indirectly-heated, oxide-coated disc. The anode is forced-air cooled. The ML-7209 is a direct replacement for the ML-381 but is constructed to withstand more severe conditions of shock and vibration.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage, AC or DC (See "Application Notes")	6.0± 5 %	V
Heater Current at 6.0 Volts	1.0	A
Heater Heating Time, minimum	60	sec
Amplification Factor, Cutoff	60	
Amplification Factor, Dynamic	100	
Transconductance (Ib=70 mA, Eb=600 V)	25000	μmhos
Interelectrode Capacitances, without Heater Voltage		
Grid-Plate	2.01	pf
Grid-Cathode	6.60	pf
Plate-Cathode, maximum	.035	pf

Mechanical

Mounting Position	Optional	
Type of Cooling	Forced-air	
Maximum Anode Temperature	200	°C
Net Weight	2¼	oz

MAXIMUM RATINGS
AND TYPICAL OPERATING CONDITIONS

Grid-Pulsed or Plate-Pulsed RF Oscillator and Amplifier — Class C

Maximum Ratings, Absolute Values		
Frequency	3	Gc
Plate Voltage		
Grid-Pulsed, DC	1.5	kV
Plate-Pulsed, Peak Pulse Supply	3.5	kv
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
Average Plate Current	10	mA
Average Grid Current	5	mA
Peak Plate Current	3	a
Average Plate Dissipation (Forced-Air Cooling)	35	W
Average Grid Dissipation	2	W
Pulse Duration	5	μs†
Duty Factor	.0033	†

Typical Operation, Plate-Pulsed RF Oscillator		
Frequency	2.5	Gc
Filament Voltage	5.8	V
Pulse Duration	5	μs
Duty Factor	.0030	
Pulse Repetition Rate	660	pps
Peak Plate Pulse Supply Voltage	3.5	kv
DC Grid Voltage	−100	V
Peak RF Plate Voltage	2.5	kv
Peak RF Grid Voltage	340	v
Peak Plate Current from Pulse Supply	3	a
Average Plate Current	9	mA
Average Grid Current	3	mA
Driving Power During Pulse, approximate	450	w
Useful Peak Power Output, approximate	2.2	kw

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	1.5	kV
Peak Plate Voltage	1.8	kv
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
DC Plate Current	100	mA
Pulse Cathode Current	4.8	a
Average Plate Dissipation (Forced-Air Cooling)	100	W
Average Grid Dissipation	1.5	W
Pulse Duration	5	μs†
Duty Factor	.0033	†

Frequency Doubler — Class C Telegraphy

Maximum Ratings, Absolute Values		
Frequency	3	Gc
Peak Plate Pulse Supply Voltage	3.5	kv
Grid Bias Voltage (from cathode resistor)	−200	v
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
Peak Cathode Current	3	a
Average Plate Current	6.5	mA
Average Grid Current	2	mA
Average Plate Input	25	W
Average Plate Dissipation (Forced-Air Cooling)	25	W
Average Grid Dissipation	1	W
Pulse Duration	5	μs†
Duty Factor	.0033	†

Typical Operation, Frequency Doubler		
Frequency	.6 to 1.2	Gc
Filament Voltage	5.5	V
Pulse Duration	3	μs
Duty Factor	.0030	
Peak Plate Pulse Supply Voltage	3.5	kv
Grid Bias Voltage (from cathode resistor)	−190	V
Cathode Resistor	160	ohms
Peak Plate Current	1.2	a
Average Plate Dissipation	9	W
Driving Power During Pulse, approximate	600	w
Useful Power Output at Peak of Pulse, approx.	1.2	kw

†For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.	
Filament Current at 6.0 volts (Note 1)	0.90	1.05	A
Plate Current (Note 2)	60	95	mAdc
Cut-off Bias (Note 3)	—	−15	Vdc
Transconductance	20,000	30,000	μmhos
Grid-Plate Capacitance (Note 4)	1.86	2.16	pf
Grid-Cathode Capacitance (Note 4)	5.60	7.00	pf
Plate-Cathode Capacitance (Note 4)	—	.035	pf
Plate Tuning Range (Note 5)	1.98	2.02	Gc

Note 1 — For reduced filament voltage see "Heater Voltage" section under "Application Notes".

Note 2 — Measure at a plate voltage of 600 volts and a cathode-bias resistor of 30 ohms.

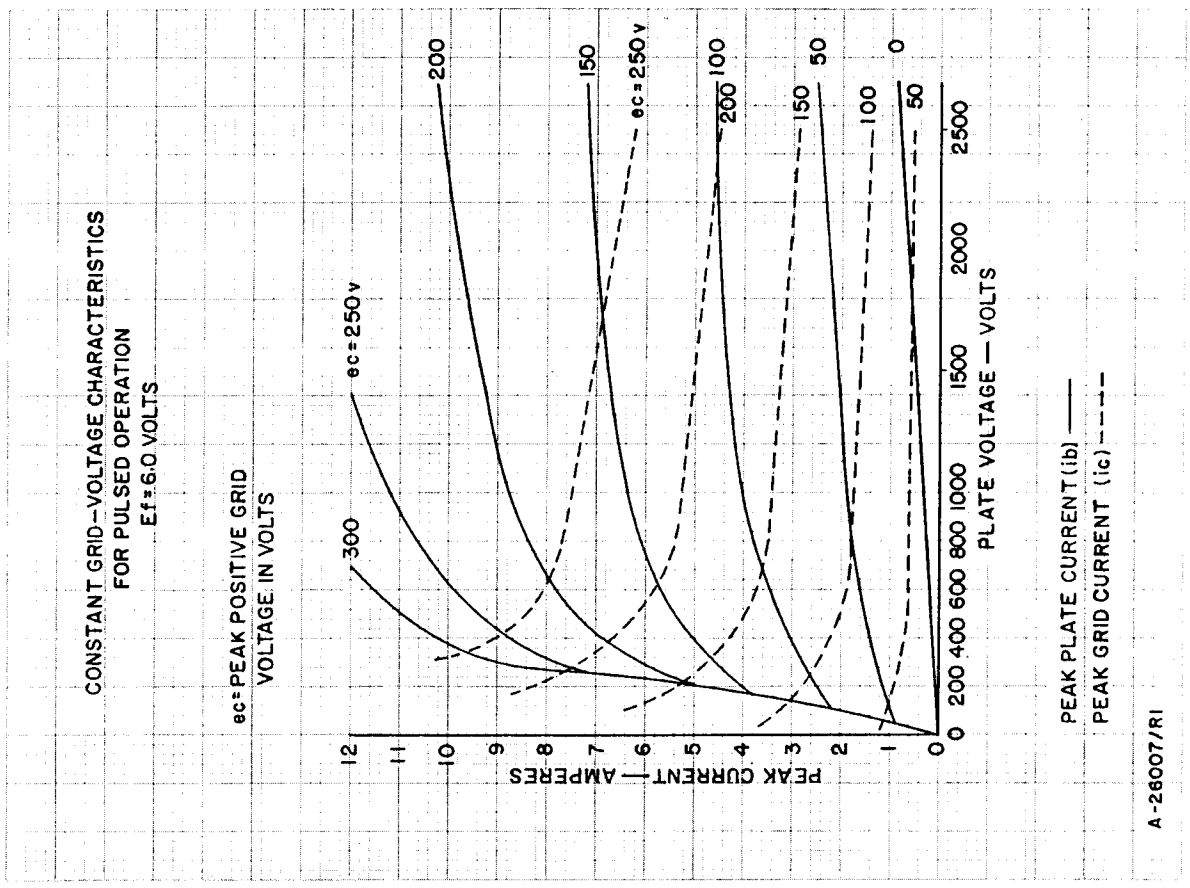
Note 3 — Measured at 1 mA of plate current and a plate voltage of 600 volts.

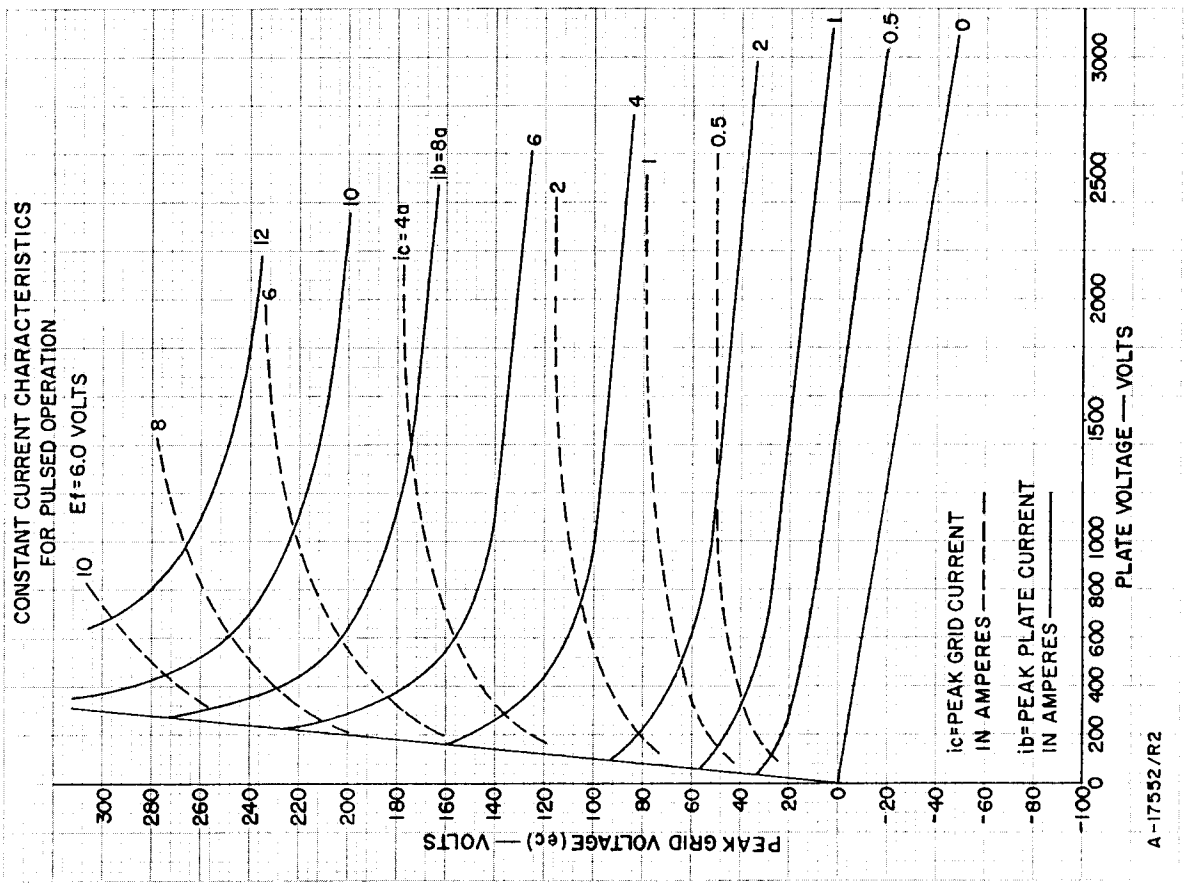
Note 4 — Capacitance measurements are with the tube cold. When the filament is heated to proper operating temperature the grid-cathode capacitance will increase by about 1 pf due to thermal expansion of the cathode.

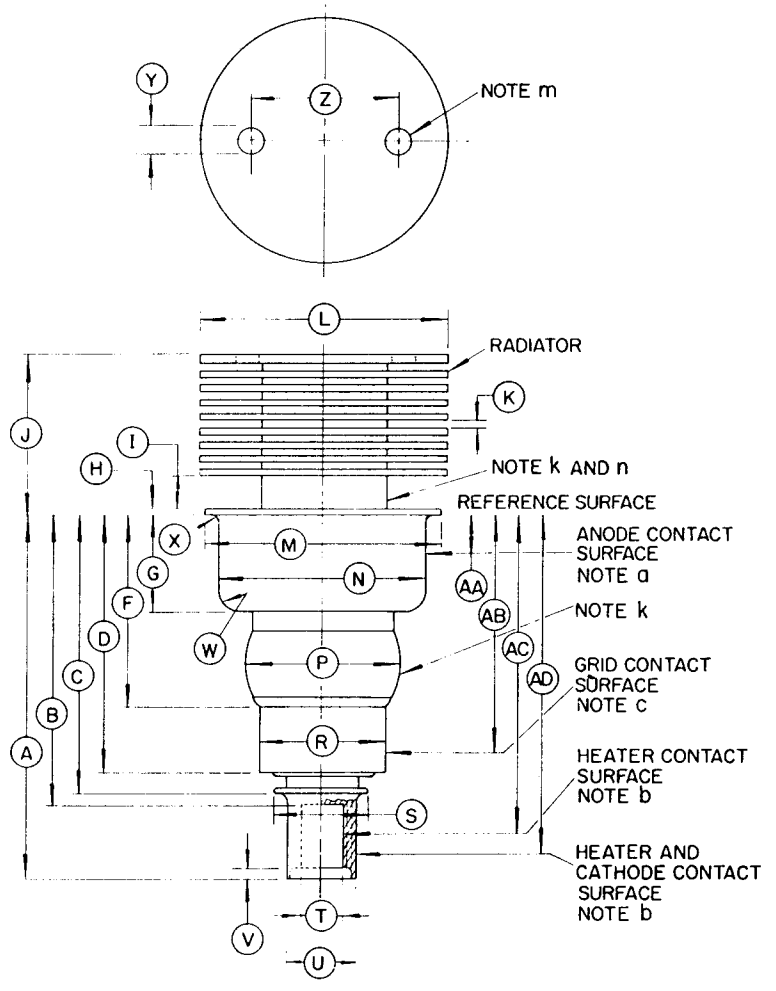
Note 5 — With a plate-grid coaxial cavity of fixed dimensions, all tubes will resonate within the specified frequency range.

APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes — General.*


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef=6.0 VOLTS
ec=PEAK POSITIVE GRID
VOLTAGE IN VOLTS
ec=250v
300
200
150
ec=250v
200
100
150
50
100
0
50
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
PEAK PLATE CURRENT (ib) ——
PEAK GRID CURRENT (ic) - - - -
A-26007/R1


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef=6.0 VOLTS
10
8
12
6
10
ic=4a
ib=8a
6
2
4
1
0.5
2
1
0.5
0
PEAK GRID VOLTAGE (ec) — VOLTS
ic=PEAK GRID CURRENT
IN AMPERES - - - - -
ib=PEAK PLATE CURRENT
IN AMPERES ——
PLATE VOLTAGE — VOLTS
A-17552/R2



DIMENSIONS FOR OUTLINE (INCHES)

Ref.	Minimum	Maximum
A	1.815	1.875
B	—	1.534
C	—	1.475
D	1.289	1.329
F	—	.980
G	.462	.477
H	—	.040
I	.125	.185
J	.766	.826
K	.025	.046
L	1.234	1.264
M	1.180	1.195
N	1.025	1.035
P	—	.812
R	.655	.665
S	—	.545
T	.213	.223
U	.315	.325
V	—	.086
W	—	.100
X	—	.035
Y	.105	.145
Z	.650	.850

NOTES

a. The total indicated runout of the anode contact surface with respect to the cathode contact surface will not exceed .020 inch.
b. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.
c. The total indicated runout of the grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
k. Do not clamp or locate on this surface.
m. Hole provided for tube extractor through top fin only.
n. Measure anode shank temperature here.

DIMENSIONS FOR ELECTRODE CONTACT AREA (INCHES)

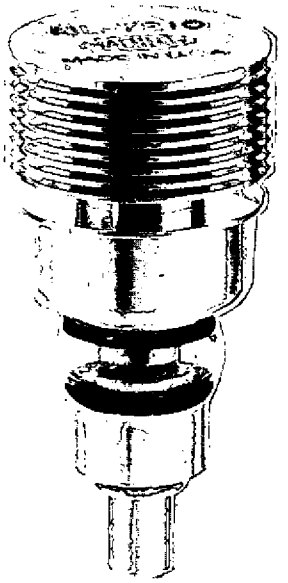
Ref.	Dimensions	Contact
AA	0.198 ± 0.163	Anode
AB	1.225 ± .040	Grid
AC	1.631 ± .097	Heater
AD	1.645 ± .170	Cathode

DIMENSIONS—ML-7209

THE MACHLETT LABORATORIES, INC.
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MACHLETT

ML-7210

DESCRIPTION & RATINGS

DESCRIPTION

The ML-7210 is a quick-heating cathode, high-mu planar triode designed for use as a plate-pulsed or CW oscillator, frequency multiplier or power amplifier in radio transmitting service from low frequency to 3000 Mc. The tube may be operated at higher frequencies with reduced ratings. Features include low interelectrode capacitances, high transconductance and great mechanical strength. Lead inductances and r-f losses are minimized by a compact, rugged construction with ring-type seals, making the tube ideally suited to cavity-type circuits as well as for parallel-line operation. The cathode is an indirectly-heated, oxide-coated disc. The anode is forced-air cooled.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage (see Application Notes)	6.3	Volts
Heater Current (AC or DC) at 6.3 Volts	0.85	Amp
Heater Heating Time, minimum	12	secs
Amplification Factor	75	
Transconductance (I_b = 70 mA, E_b = 600 v)	17,000	μmhos
Interelectrode Capacitances (without heater voltage)		
Grid-Plate	2.0	μμf
Grid-Cathode	5.0	μμf
Plate-Cathode, maximum	0.040	μμf
Duty Factor	.0025	†
Maximum Pulse Length	3	μsec†
Frequency for Maximum Ratings	3000	Mc

Mechanical

Mounting Position	Optional	
Type of Cooling	Forced Air*	
Maximum Anode Temperature	200	°C
Net Weight	2¼	oz.

†For applications requiring longer pulse lengths or higher duty factors, consult the Machlett Engineering Department.
*For cooling requirements, refer to "Cooling" under "Application Notes".

from JEDEC release #2916, Aug. 1, 1960

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

R-F Power Amplifier and Oscillator

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values		
D-C Plate Voltage	1000	volts
D-C Grid Voltage	-150	volts
D-C Cathode Current	95	mA
D-C Grid Current§	30	mA
Peak Positive RF Grid Voltage	30	volts
Peak Negative RF Grid Voltage	-400	volts
Plate Dissipation† (Forced-air Cooling)	100	watts
Grid Dissipation	1.5	watts

Plate-Pulsed Oscillator and Amplifier Class C

Maximum Ratings, Absolute Values		
Pulse Length	3	μsec
Duty Factor	0.0025	
Peak Plate Pulse Supply Voltage	3500	volts
DC Grid Bias Voltage*	-150	volts
Peak Plate Current from Pulse Supply	2.8	amps
Average Plate Current	7.0	mA
Average Grid Current	3.0	mA
Average Plate Dissipation	25	watts
Average Grid Dissipation	1.5	watts

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

§See "Application Notes" on "Determination of Proper Grid Drive".

†Refer to "Cooling" under "Application Notes".

*The maximum instantaneous peak grid-cathode voltage should be within the range of +250 to −500 volts.

Characteristic Range Values for Equipment Design

	Min.	Max.	
Filament Current at 6.3 volts	.75	.95	A
Plate Current (Note 1)	55	90	mAdc
Cut-off bias (Note 2)	—	-20	volts
Transconductance	12,000	22,000	μmhos
Grid-Plate Capacitance (Note 3)	1.84	2.16	μμf
Grid-Cathode Capacitance (Note 3)	4.00	6.00	μμf
Plate Tuning Range (Note 4)	1970	2030	Mc

Note 1 — Measured at a plate voltage of 600 volts and a cathode-bias resistor of 30 ohms.

Note 2 — Measured at 1 mA of plate current and a plate voltage of 600 volts.

Note 3 — Capacitance measurements are with the tube cold.

Note 4 — With a plate-grid coaxial cavity of fixed dimensions, all tubes will resonate within the specified frequency range.

APPLICATION NOTES

MECHANICAL

Mounting

Contacts to anode, grid, cathode and heater terminals should be made by means of spring fingers or spring collets bearing on the cylindrical surfaces within the dimensional limits specified on the tube outline. The tube when in the socket should seat against the anode flange. The tube should not be seated or stopped by any other surfaces. When the tube must be clamped in its socket to prevent loosening due to shock and vibration, clamp pressure should only be applied to the anode flange.

Cooling

Sufficient air cooling must be provided so that the maximum temperature of anode, grid and cathode seals does not exceed 200°C under any condition of operation. Improved tube life and greater reliability may be obtained if all seals are cooled well below this maximum.

Charts following these notes show the minimum air flow required to cool the anode at various rates of plate dissipation and incoming air temperature. These charts apply only to the cooling of the anode when enclosed in a standard cowling as illustrated. Since the cathode end of the tube may be well enclosed in the high-frequency tuning circuit, additional air flow, apart from that flowing through the cowling and used to cool the anode, may be required to cool seals. Tempilaq* paint is suggested for making temperature measurement at such points.

ELECTRICAL

Heater Voltage

In the frequency range where this tube is usually operated, the electron transit time is not necessarily small with respect to the period of oscillation. The transit time heating effect should be compensated by a reduction in heater voltage after dynamic operation of the tube has started. The back heating is a function of frequency, grid current, grid bias, plate current, duty cycle, and circuit design and adjustment. There is an optimum heater voltage which will maintain the cathode at the correct operating temperature for a particular set of operating conditions. A maximum variation of ±5% from optimum is permitted.

For applications above 500 Mc it is suggested that the Machlett Engineering Department be consulted for optimum heater voltages.

*Product of Tempil Corporation, New York, N. Y.

Plate Surge-Limiting Impedance

In tubes such as the ML-7210 with very closely spaced electrodes, extremely high voltage gradients occur even with moderate tube operating voltages. Any tube flash-arcing may be destructive. A series impedance in the B+ lead is recommended which limits the peak current under surge conditions to 15 amperes or less for CW operation or ten times maximum rating or less for pulsed operation. Such operation is particularly advisable where d.c. heater excitation is used and the heater voltage is used to obtain a d.c. grid bias. Under such conditions, surge currents can get to the negative plate voltage supply lead only through the heater winding and may cause shorting of the heater element unless current limiting is provided. Failure of tubes due to internal flash-arcs is much more prevalent when the circuit is not tuned to optimum conditions. Even though laboratory tests indicate no such protection is needed, poor circuit adjustment in the field may result in shortened tube life.

Provision for Circuit Tuning

With high-frequency circuits a very small motion of a tuning plunger may throw the tube out of resonance and result in high plate current and/or excessive anode dissipation. If the tube is operated at or close to maximum ratings, it is suggested that provision be made for tuneup at reduced plate voltage in any circuit where the above conditions obtain.

Self Biasing Operation

In general, for CW operation, an RC bias should be in the cathode circuit such that with normal d.c. plate voltage and no grid drive the plate current does not exceed 95 mA, i.e. the maximum rated cathode current. Both cathode and grid resistance biasing may be used. If grid resistor biasing is used, special care must be taken to protect the tube against loss of excitation; otherwise excessive plate currents may damage the cathode.

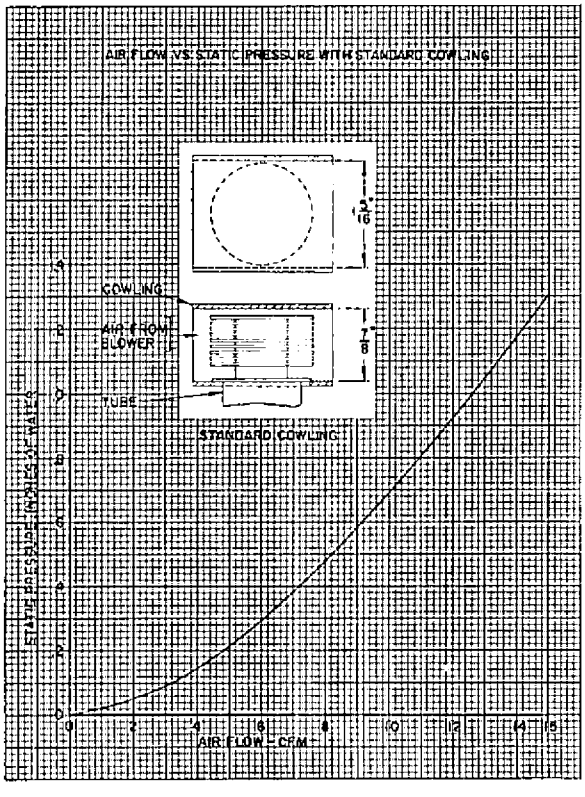
For pulsed operation, a bypassed or unbypassed grid resistor is usually satisfactory provided suitable plate surge-limiting impedance is used.

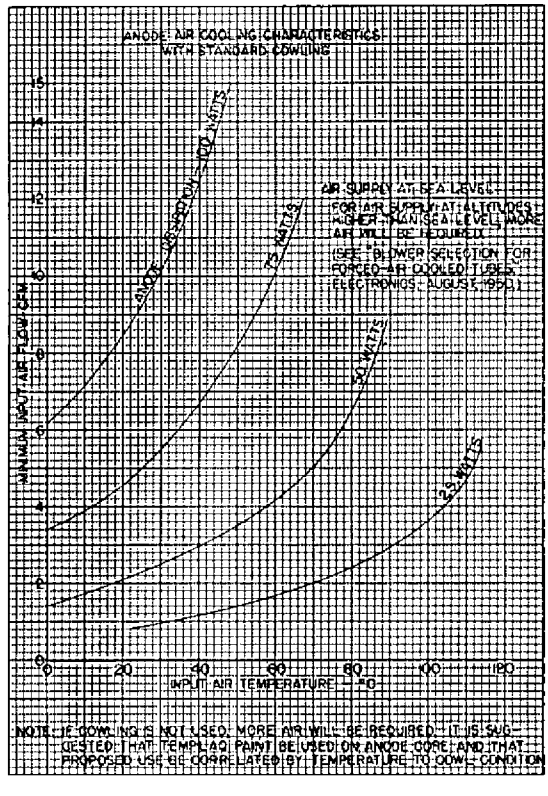
Determination of Proper Grid Drive

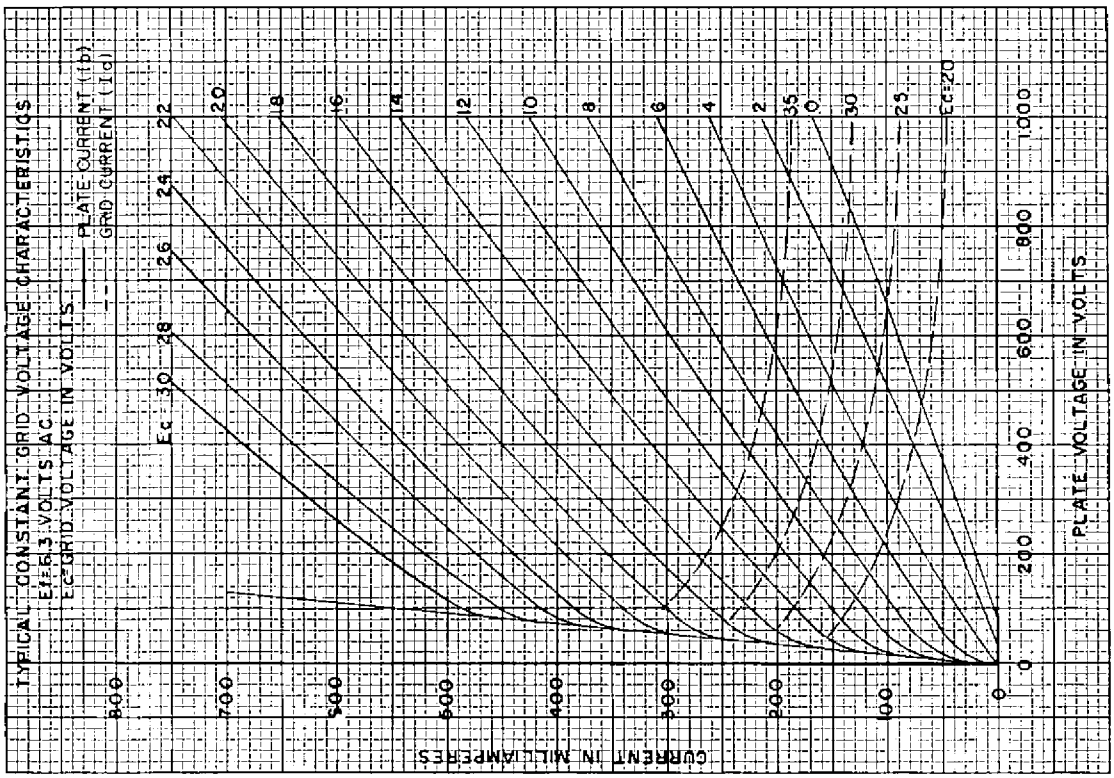
In grounded-cathode stages, the power output tends to saturate as the grid drive increases. In grid-separation circuits, increased output power is always obtainable from increased grid drive, due to the fact that a considerable portion of the grid driving power appears in the output load. Whereas high grid driving power leads to somewhat greater power output in grid-separation amplifiers, it also results in high grid current, increased back heating of the cathode and distortion of the r.f. signals due to the heavy loading of the grid signal in the positive grid region; this usually shortens the life of the tube.

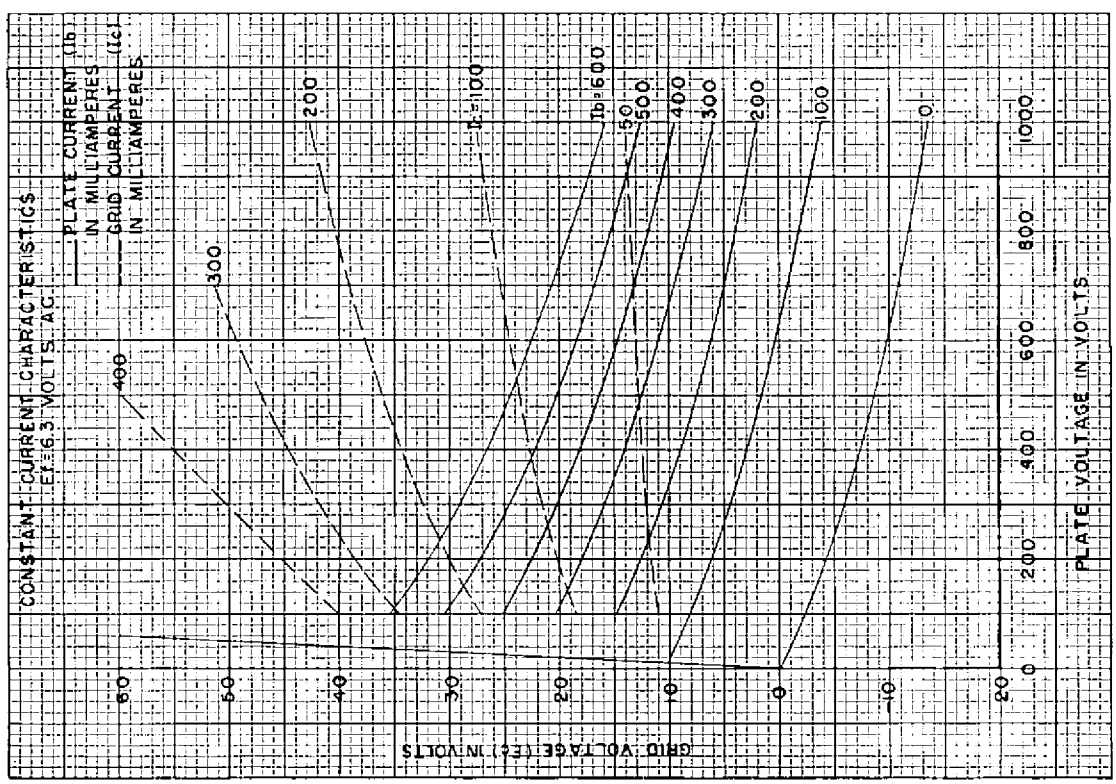
Unusual Applications

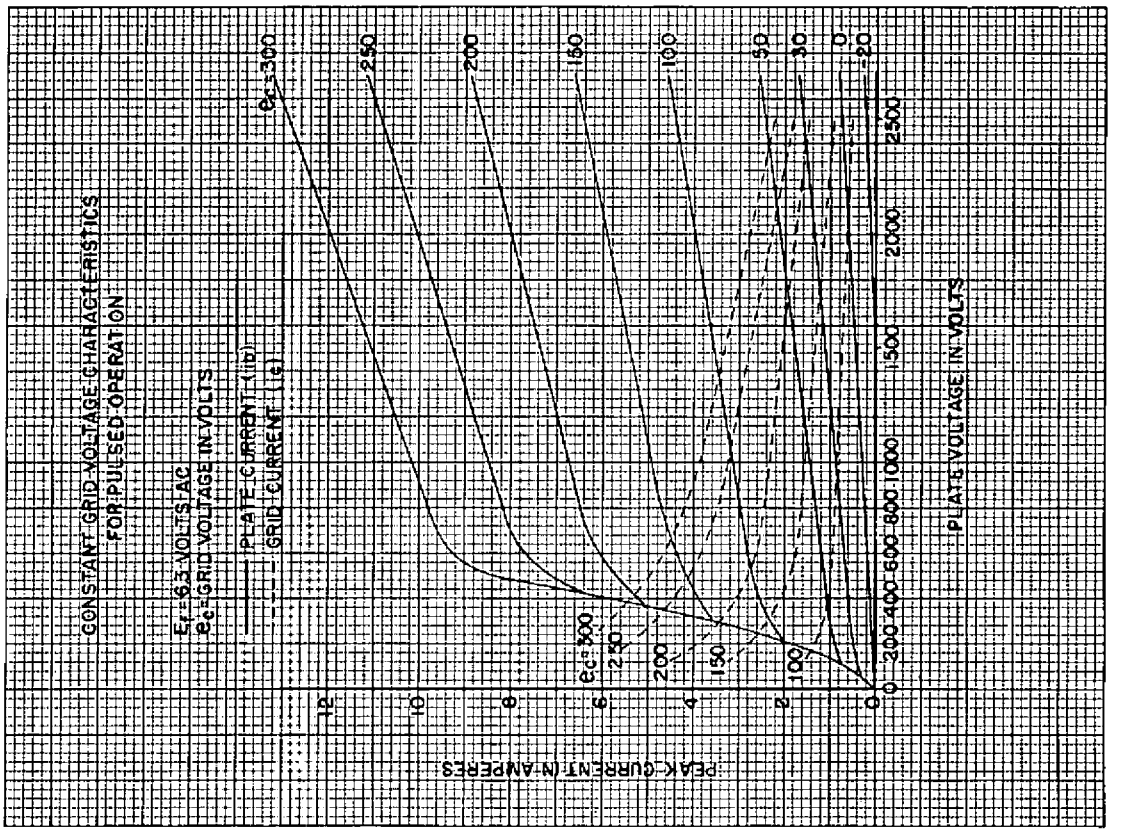
If conditions are such that the preceding ratings do not apply, additional information may be obtained from the Machlett Engineering Department.

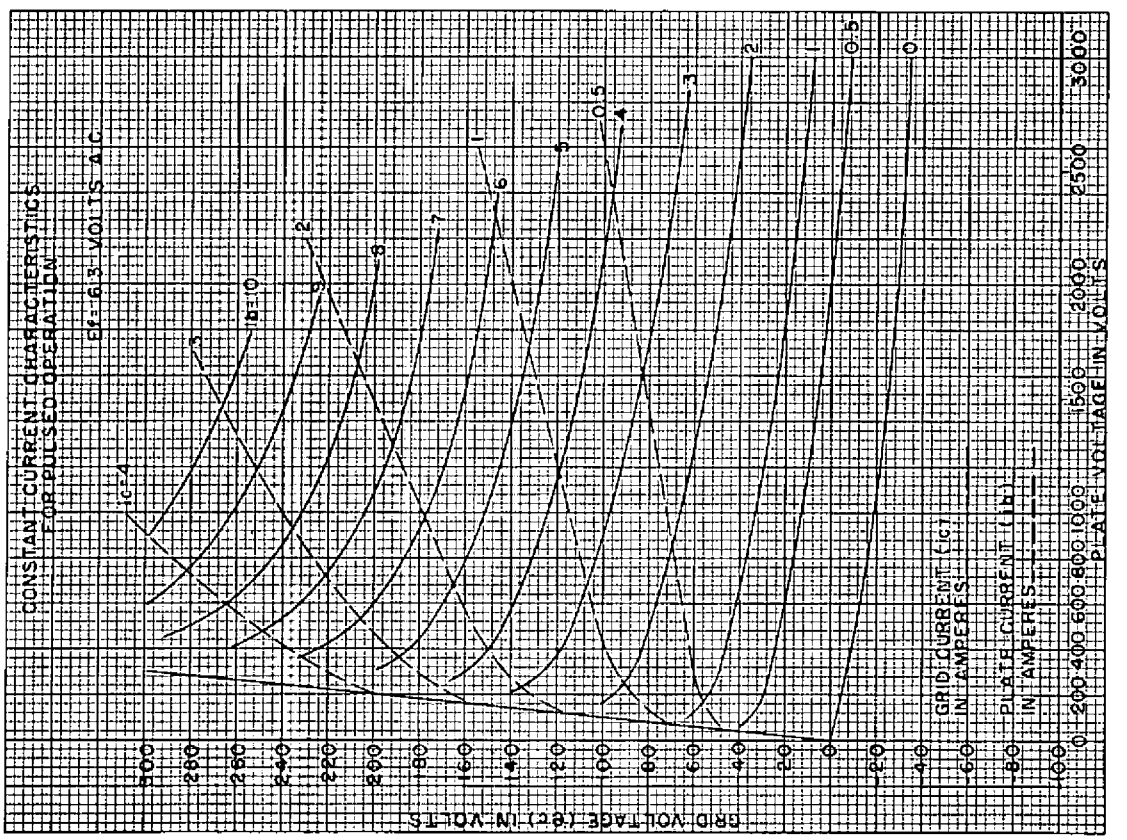


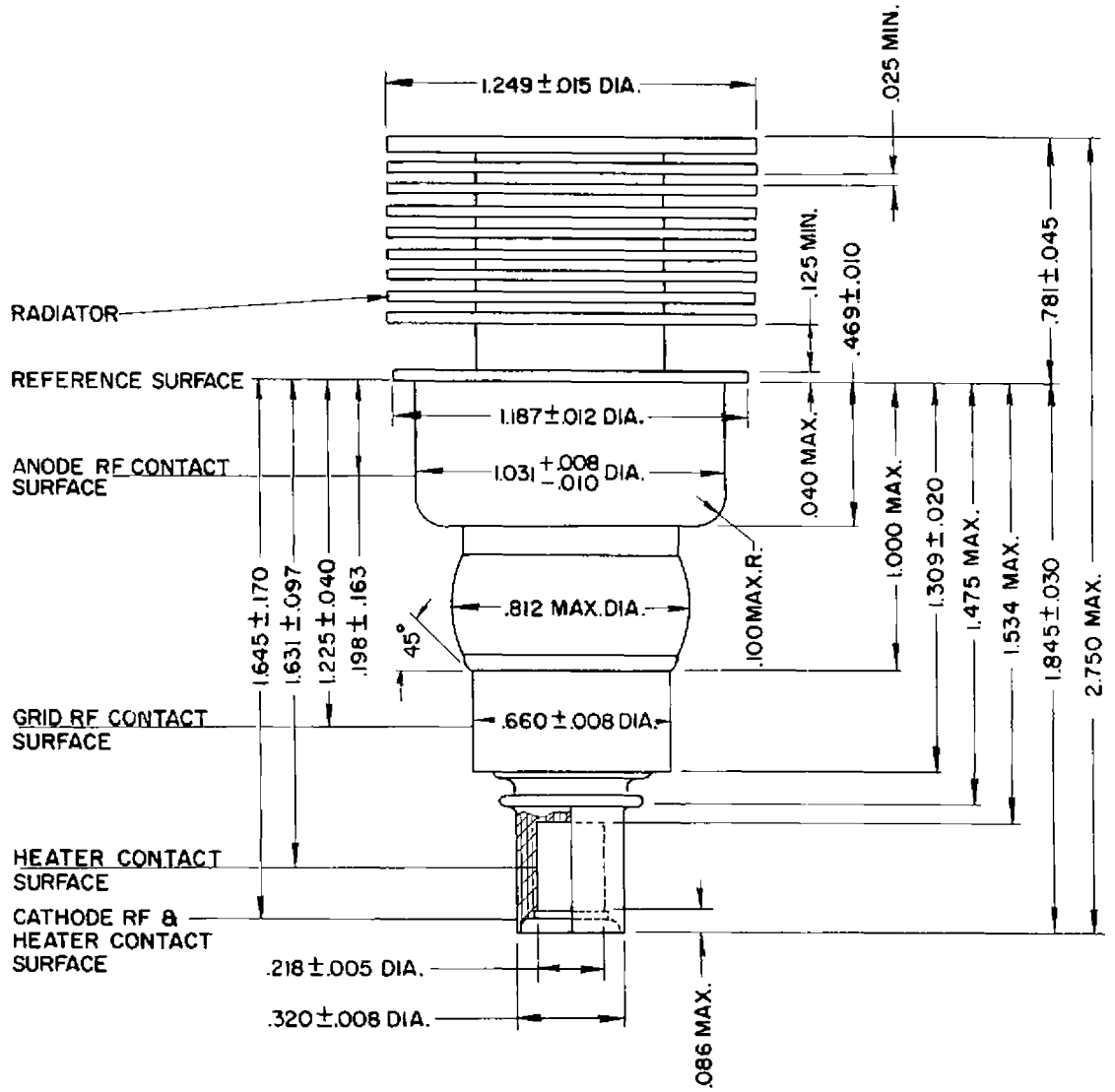



TYPICAL CONSTANT GRID VOLTAGE CHARACTERISTICS
Ef=6.3 VOLTS AC
Ec=GRID VOLTAGE IN VOLTS
PLATE CURRENT (Ib)
GRID CURRENT (Ic)
CURRENT IN MILLIAMPERES
PLATE VOLTAGE IN VOLTS


CONSTANT CURRENT CHARACTERISTICS
Ef=6.3 VOLTS AC
PLATE CURRENT (Ib) IN MILLIAMPERES
GRID CURRENT (Ic) IN MILLIAMPERES
GRID VOLTAGE (Ec) IN VOLTS
PLATE VOLTAGE IN VOLTS


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS AC
eg = GRID VOLTAGE IN VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
PEAK CURRENT IN AMPERES
PLATE VOLTAGE IN VOLTS


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS A.C.
GRID VOLTAGE (eg) IN VOLTS
GRID CURRENT (ic) IN AMPERES
PLATE CURRENT (ib) IN AMPERES
PLATE VOLTAGE IN VOLTS



NOTES:

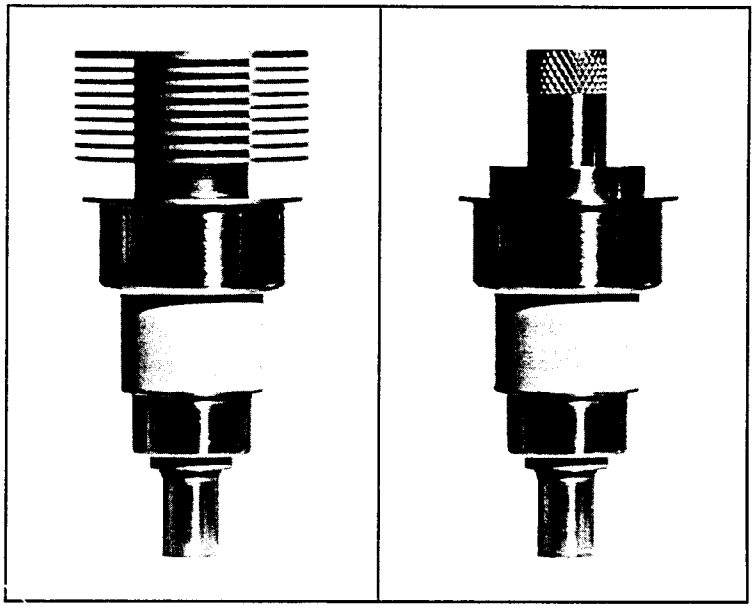
1. THE TOTAL INDICATED RUNOUT OF THE ANODE AND GRID CONTACT SURFACES WITH RESPECT TO THE CATHODE CONTACT SURFACE WILL NOT EXCEED .030
2. THE TOTAL INDICATED RUNOUT OF THE CATHODE CONTACT SURFACE WITH RESPECT TO THE HEATER CONTACT SURFACE WILL NOT EXCEED .018
3. ALL DIMENSIONS IN INCHES.

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT **CONNECTICUT**

U. S. A.

The Machlett Laboratories, Inc. • 1063 Hope Street
Stamford, Conn. 06907 • Tel. 203-348-7511 • TWX 203-327-2496



ISSUED 7-66

ML-7211
ML-7698

MACHLETT

UHF Planar Triodes
CW, Plate or Grid Pulsed
Phormat Cathode
High Cathode-Current Capability
100W CW at 1 GHz
30W CW at 2.5 GHz

DESCRIPTION

The ML-7211 and ML-7698 are ruggedized, high-mu planar triodes of ceramic-and-metal construction, designed for use as grid-pulsed, plate-pulsed or CW oscillators, frequency multipliers, or amplifiers in radio transmitting service from low frequency to 3 GHz. The ML-7698 is supplied without a radiator for conduction-convection cooling. The ML-7211 is supplied with a radiator for forced-air cooling. Except for plate-dissipation ratings, the characteristics of the two tubes are the same.*

Special features of these tubes as compared to other tubes fitting the same socket include high cathode-current capability and an extended grid-anode insulator in the tube envelope. The extended grid-anode insulator is an important feature in airborne equipment operating at high altitudes. Other features of these tubes include low interelectrode capacitance, high transconductance, and great mechanical strength. The tubes also employ a Phormat type cathode which consists of an indirectly heated disc with an oxide coating impregnated in a nickel matrix. This construction, in combination with proper plate series impedance, reduces to a minimum failures of the cathode due to voltage surges.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage (AC or DC)	6.3	V
Heater Current at 6.3 Volts	1.3	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	80	
Transconductance (Ib=100mA, Eb=600V)	30000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Grid-Plate	2.25	pf
Grid-Cathode	8.0	pf
Plate-Cathode, maximum	.06	pf

Mechanical

Mounting Position	Optional	
Type of Cooling		
With radiator (ML-7211)	Forced-Air	
Without radiator (ML-7698)	Conduction & Convection	
Maximum Anode Temperature	250	°C
Net Weight		
With radiator (ML-7211)	63	g
Without radiator (ML-7698)	51	g

***NOTE:** Data for the ML-7211 applies also to the ML-7698R, which is identical in all respects.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CW RF Power Oscillator or Amplifier — Class C

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—400	v
Grid positive to cathode	30	v
DC Plate Current	145	mA
DC Grid Current	45	mA
Plate Dissipation		
Forced-air cooling (ML-7211)	100	W
Conduction and convection (ML-7698)	10	W
Grid Dissipation	2	W
Frequency	2.5	GHz
Typical Operation, Amplifier		
Frequency	500	MHz
DC Plate Voltage	900	V
DC Grid Voltage	—30	V
DC Plate Current	140	mA
DC Grid Current, approximate	40	mA
Driving Power, approximate	9	W
Useful Power Output	65	W
Typical Operation, Oscillator		
Frequency	2.5	GHz
DC Plate Voltage	1000	V
DC Grid Voltage, approximate	—20	V
DC Plate Current	140	mA
DC Grid Current	15	mA
Useful Power Output	30	W

Grid-Pulsed or Plate-Pulsed RF Oscillator or Amplifier — Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-Pulsed, DC	2500	V
Plate-Pulsed, Peak Pulse Supply	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
Average Plate Current	16	mA
Average Grid Current	6	mA
Peak Plate Current	5	a
Average Plate Dissipation		
Forced-air cooling (ML-7211)	60	W
Conduction and convection (ML-7698)	10	W
Average Grid Dissipation	2	W
Pulse Duration	6	μs†
Duty Factor	.0033	†
Frequency	3	GHz
Typical Operation, Grid-Pulsed RF Amplifier		
Frequency	1.1	GHz
Filament Voltage	6.3	V
Pulse Duration	3.5	μs†
Duty Factor	.001	
DC Plate Voltage	2000	V
DC Grid Voltage	—70	V
Peak Plate Current from DC Supply	3	a
Peak Grid Current from Pulse Supply	1	a
Driving Power during Pulse, approximate	400	w
Useful Peak Power Output, approximate	2.5	kw
Typical Operation, Plate-Pulsed RF Oscillator		
Frequency	3	GHz
Filament Voltage	5.8	V
Pulse Duration	3	μs
Duty Factor	.0025	
Peak Plate Pulse Supply Voltage	3500	V
Peak Plate Current from Pulse Supply	4.8	a
Average Plate Current	12	mA
Average Grid Current	4	mA
Useful Peak Power Output, approximate	2.5	kw

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
Peak Plate Voltage	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	110	v
DC Plate Current	150	mA
Pulse Cathode Current	7.5	a
Average Plate Dissipation		
Forced-air cooling (ML-7211)	100	W
Conduction and convection (ML-7698)	10	W
Average Grid Dissipation	2	W
Pulse Duration	6	μs†
Duty Factor	.0033	†

†For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.	
Filament Current at 6.3 V (Note 1)	1.20	1.40	A
Cut-Off Bias (Note 2)	—	—20	Vdc
Grid-Plate Capacitance (Note 3)	2.10	2.40	pf
Grid-Cathode Capacitance (Note 3)	7.0	9.0	pf
Plate-Cathode Capacitance (Note 3)	—	.06	pf

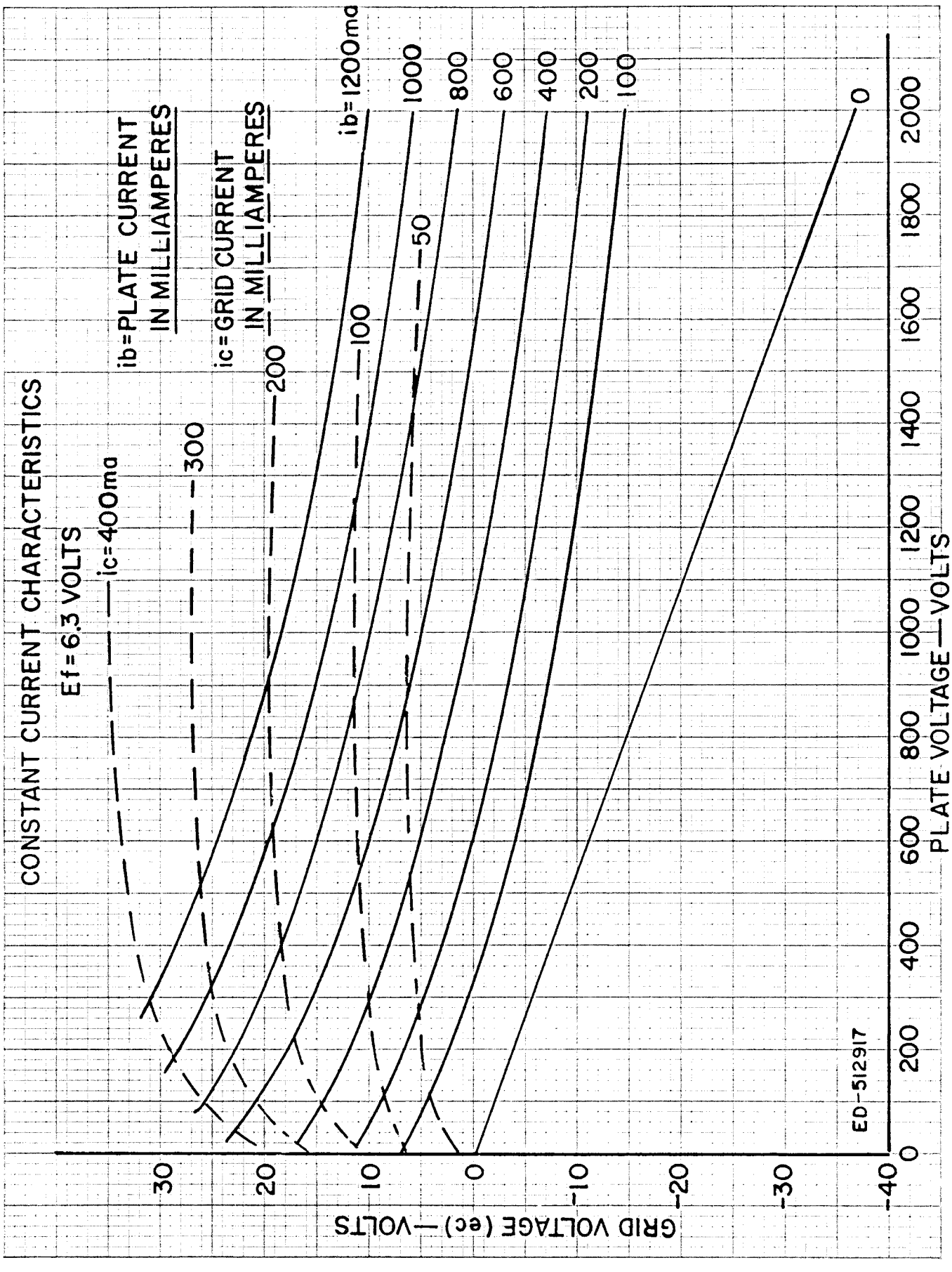
Note 1 — For operation with reduced filament voltage, see "Heater Voltage" section in *Application Notes*.

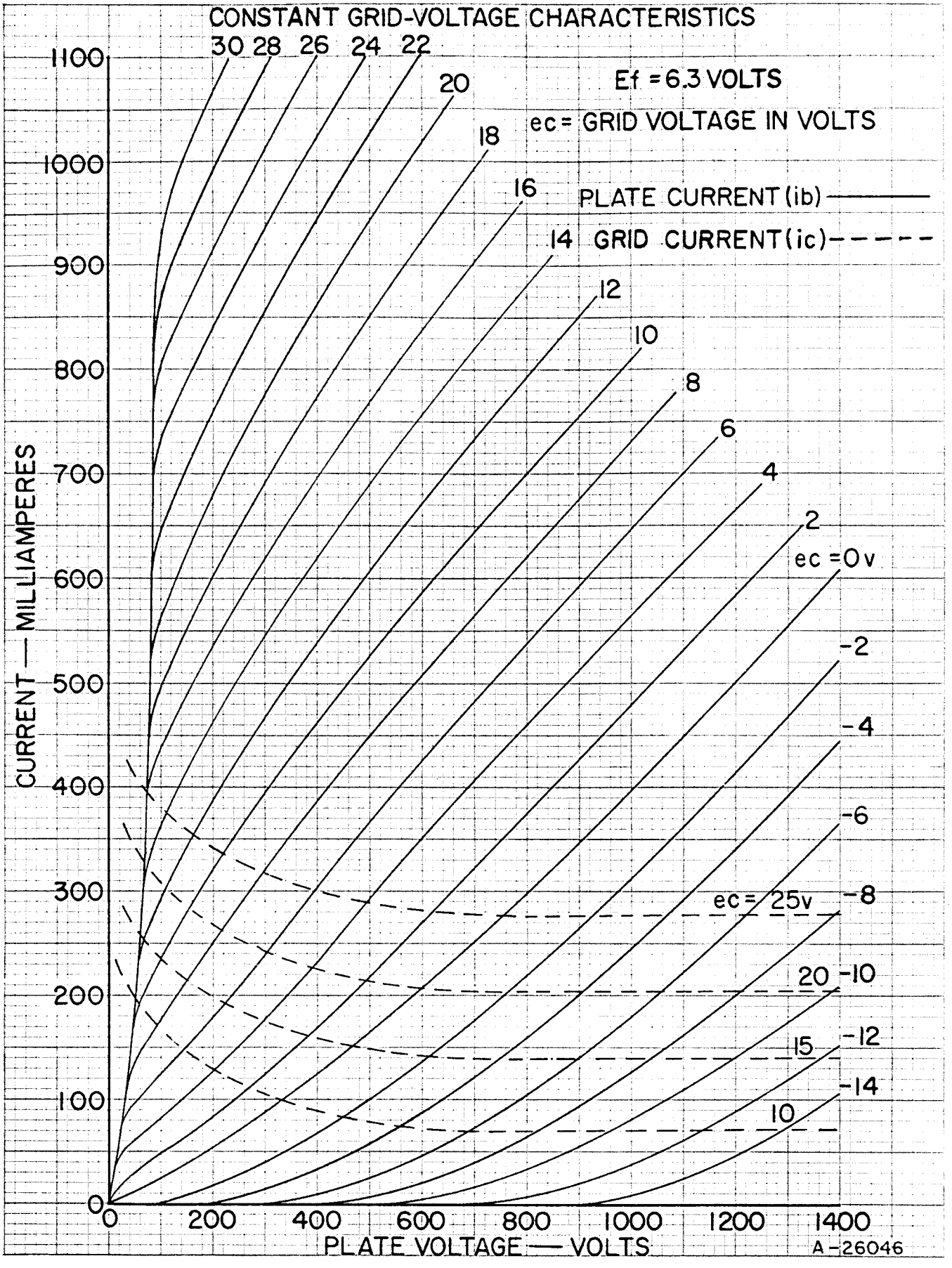
Note 2 — Measured with 1 mA plate current and a plate voltage of 600 Vdc.

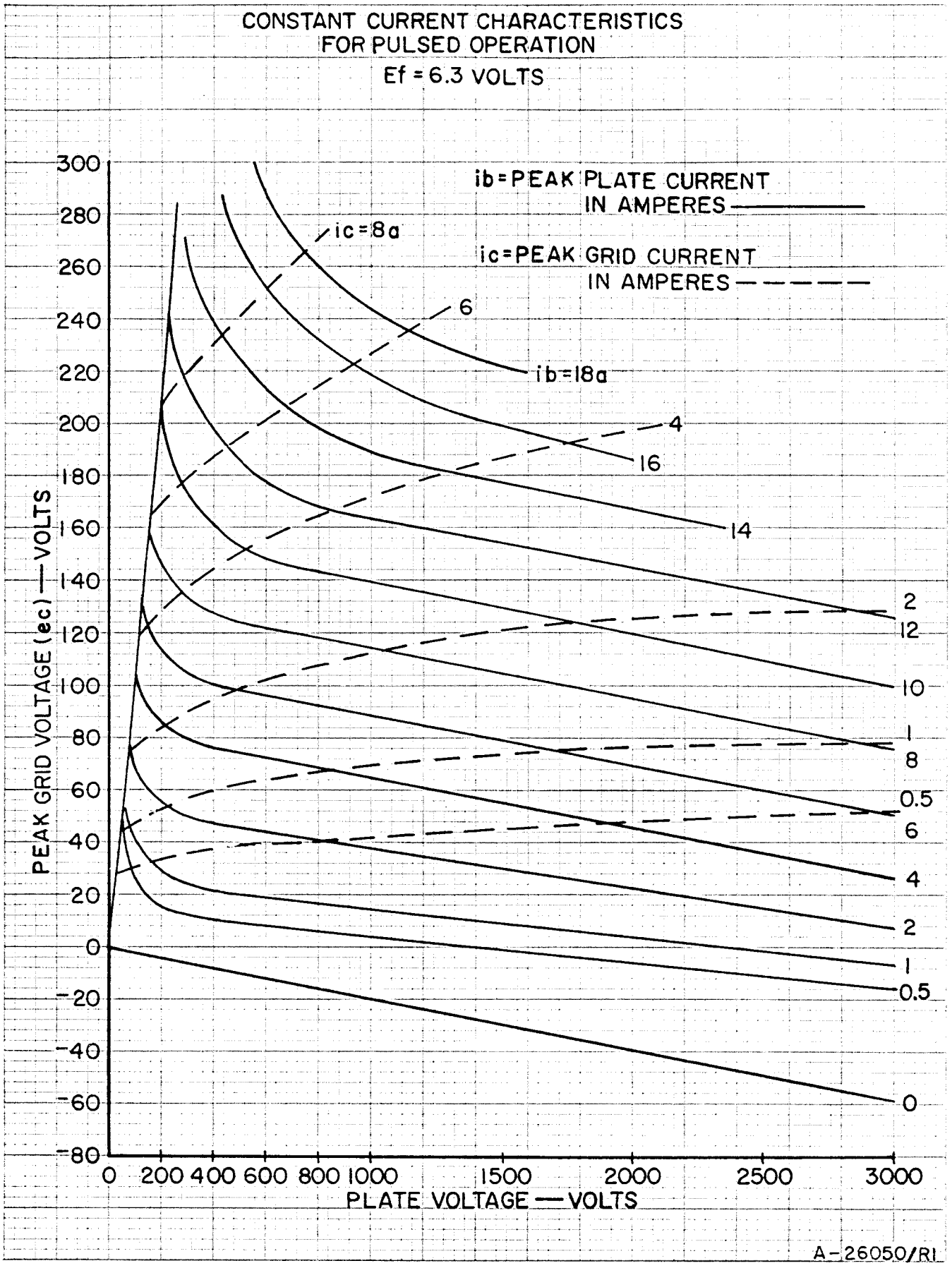
Note 3 — Capacitance values are given for a cold tube. When the filament is heated to its proper temperature, the grid-cathode capacitance will increase by approximately 1 pf due to thermal expansion of the cathode.

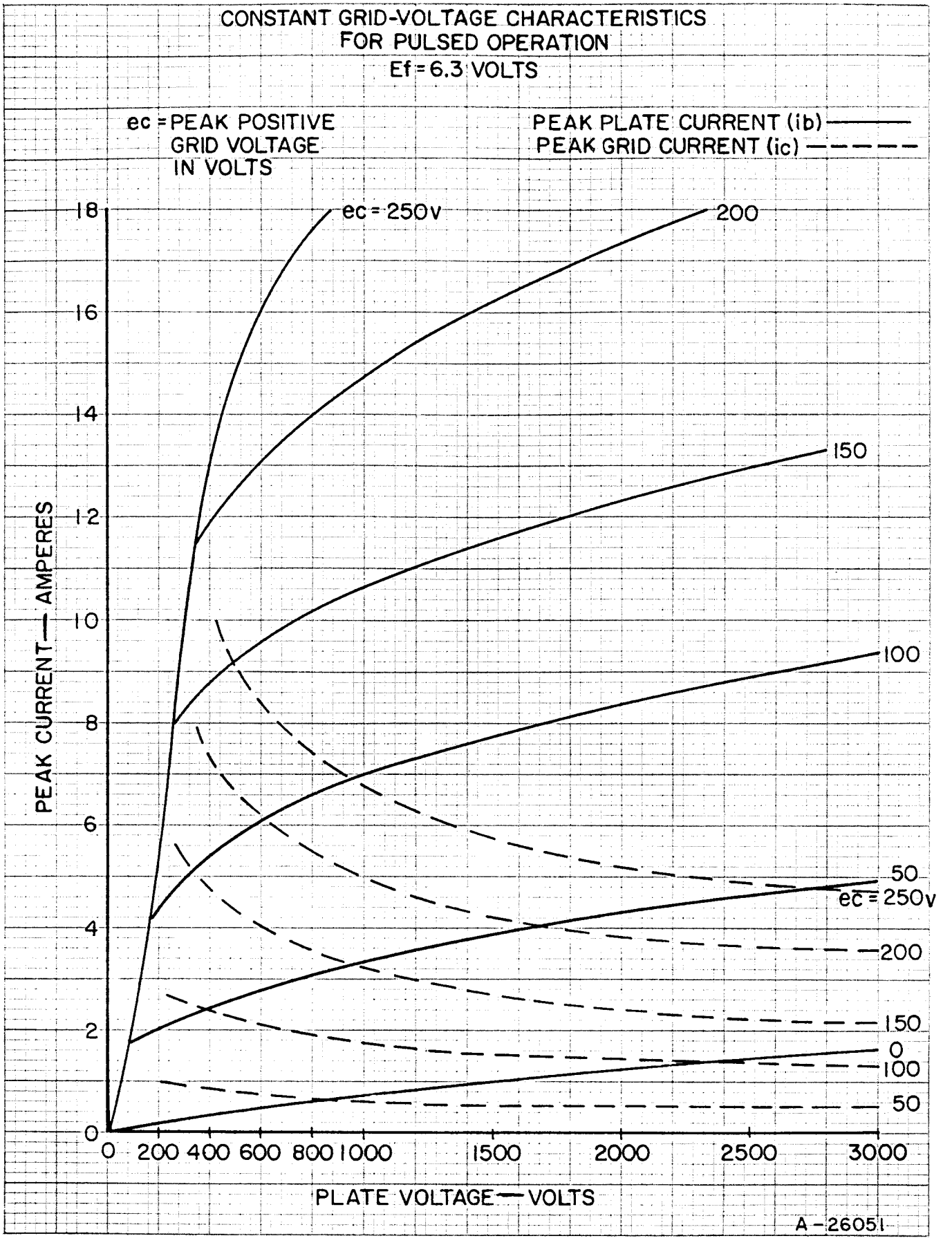
APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes — General.*


CONSTANT CURRENT CHARACTERISTICS
Ef = 6.3 VOLTS
ic = 400ma
300
200
100
50
ib = PLATE CURRENT IN MILLIAMPERES
ic = GRID CURRENT IN MILLIAMPERES
ib = 1200ma
1000
800
600
400
200
100
0
GRID VOLTAGE (ec) — VOLTS
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PLATE VOLTAGE — VOLTS
ED-512917


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 6.3 VOLTS
ec = GRID VOLTAGE IN VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
30 28 26 24 22
20
18
16
14
12
10
8
6
4
2
ec = 0v
-2
-4
-6
ec = 25v
-8
20
-10
15
-12
10
-14
CURRENT — MILLIAMPERES
0
100
200
300
400
500
600
700
800
900
1000
1100
0
200
400
600
800
1000
1200
1400
PLATE VOLTAGE — VOLTS
A-26046

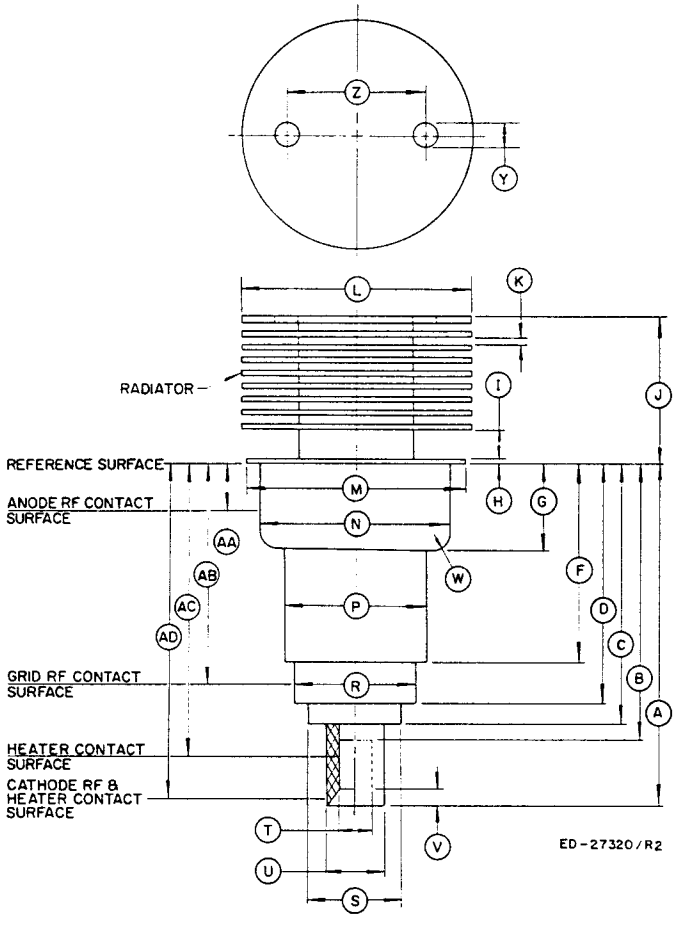

CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
ib = PEAK PLATE CURRENT IN AMPERES
ic = PEAK GRID CURRENT IN AMPERES
ic = 8a
6
4
ib = 18a
16
14
2
12
10
1
8
0.5
6
4
2
1
0.5
0
PEAK GRID VOLTAGE (ec) — VOLTS
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0
200
400
600
800
1000
1500
2000
2500
3000
PLATE VOLTAGE — VOLTS
A-26050/R1


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
ec = PEAK POSITIVE GRID VOLTAGE IN VOLTS
PEAK PLATE CURRENT (ib)
PEAK GRID CURRENT (ic)
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
ec = 250v
200
150
100
50
0
0 200 400 600 800 1000 1500 2000 2500 3000
A-26051

DIMENSIONS FOR OUTLINE OF ML-7211

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.815		1.875	46.10		47.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.185	1.225	1.265	30.10	31.12	32.13	2, 5
AC	1.534	1.631	1.728	38.96	41.43	43.89	3, 6
AD	1.475	1.645	1.815	37.46	41.78	46.10	4, 5, 6
B			1.534			38.96	
C			1.475			37.46	
D	1.289		1.329	32.74		33.76	
F	.970		1.010	24.64		25.65	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I	.125		.185	3.18		4.70	
J	.766		.826	19.46		20.98	
K	.025		.046	.64		1.17	
L	1.234		1.264	31.34		32.11	
M	1.180		1.195	29.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
S			.545			13.84	
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
Y	.105		.145	2.67		3.68	
Z	.650		.850	16.51		21.59	



OUTLINE — ML-7211

NOTES:

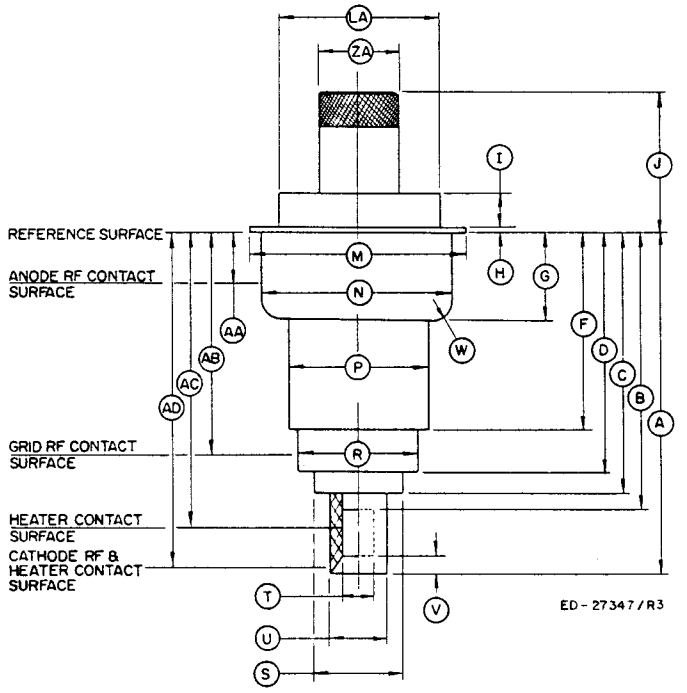
1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

DIMENSIONS FOR OUTLINE OF ML-7698

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.815		1.875	46.10		47.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.185	1.225	1.265	30.10	31.12	32.13	2, 5
AC	1.534	1.631	1.728	38.96	41.43	43.89	3, 6
AD	1.475	1.645	1.815	37.46	41.78	46.10	4, 5, 6
B			1.534			38.96	
C			1.475			37.46	
D	1.289		1.329	32.74		33.76	
F	.970		1.010	24.64		25.65	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I			.185			4.70	
J	.766		.826	19.46		20.98	
LA	.840		.860	21.34		21.84	
M	1.180		1.195	29.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
S			.545			13.84	
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
ZA	.427		.447	10.85		11.35	

OUTLINE — ML-7698

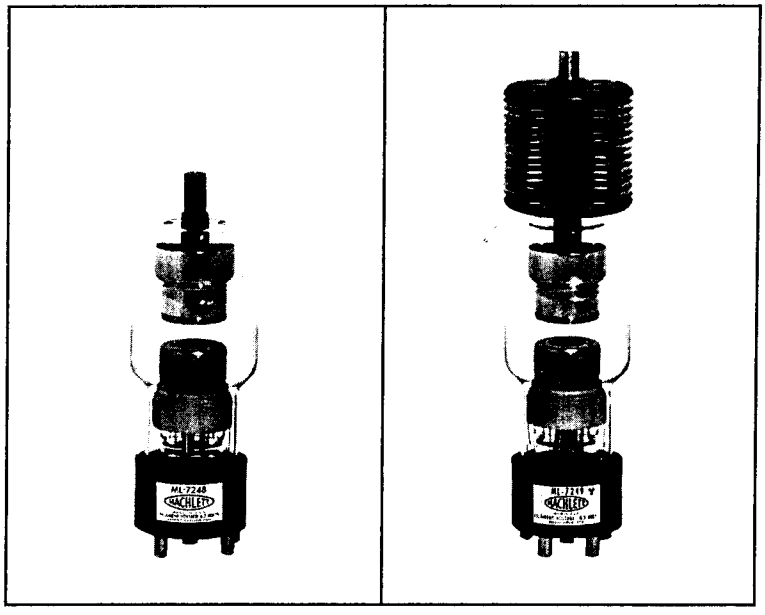


NOTES:

1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.
ST-2269 2.5M 7-66



ISSUED 5-64

ML-7248
ML-7249

High Voltage Tetrodes

Plate Voltage
to 125 kV

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7248 and ML-7249 are high-voltage tetrodes designed for use as switch tubes in hard pulse modulators for radar application and as general-purpose electronic switches in high-voltage switching and control circuits. The cathode of each type is a thoriated-tungsten filament.

The ML-7248 is designed for oil-immersed operation and has a maximum d-c plate voltage rating of 125 kV. The ML-7249, which incorporates a radiator for increased plate dissipation ratings, is designed for either air insulation or oil-immersed operation. When operated in air, the maximum d-c plate voltage rating is 65 kV; in oil, the corresponding rating is 125 kV.

GENERAL CHARACTERISTICS

Electrical	
Filament Voltage	6.3 volts
Filament Current, approximate	11.7 Amps
Direct Interelectrode Capacitances, approximate	
Cathode-control grid	6.7 $\mu\mu f$
Cathode-screen grid	3.5 $\mu\mu f$
Cathode-plate	0.08 $\mu\mu f$
Plate-control grid	0.08 $\mu\mu f$
Plate-screen grid	2.0 $\mu\mu f$
Control grid-screen grid	20.0 $\mu\mu f$
Mechanical	
Mounting Position	Horizontal or vertical cathode end down
Type of Cooling	
With oil insulation — ML-7248 & ML-7249	Convection†
Maximum oil temperature for maximum dissipation	75 °C
With air insulation — ML-7249	Forced air‡
Air flow on radiator	See Air Cooling Characteristics
Maximum incoming air temperature	50 °C
Maximum Glass Temperature	150 °C
Net Weight, approximate	
ML-7248	2.5 lbs.
ML-7249	4.3 lbs.

†When the ML-7248 or ML-7249 is mounted cathode end down in oil, a minimum oil flow of 3 pints per minute must be directed at the cathode stem during the application of filament power. Oil must be forced through the radiator of the ML-7249 in the vertical position.

‡When the ML-7249 is operated in air, a minimum air flow of 1½ cfm must be directed into the cathode stem before and during the application of filament power. (See outline drawing. This requirement applies to the ML-7248 if filament power is applied while the tube is in air.)

MAXIMUM RATINGS

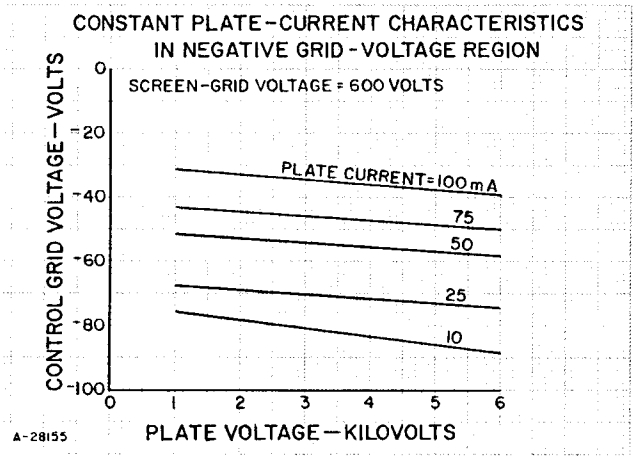
Maximum Ratings, Absolute Values	ML-7248	ML-7249	
D-C Plate Voltage — in oil	125	125	kV
in air	——	65	kV
D-C Screen-Grid Voltage	1500	1500	Volts
D-C Control-Grid Voltage	−600	−600	Volts
Peak Negative Grid Voltage	−1500	−1500	Volts
Pulse Cathode Current*	2.0	2.0	amps
Plate Dissipation — in oil	200	350†	Watts
in air	——	200‡	Watts
Screen-Grid Dissipation	20	20	Watts
Control-Grid Dissipation	10	10	Watts

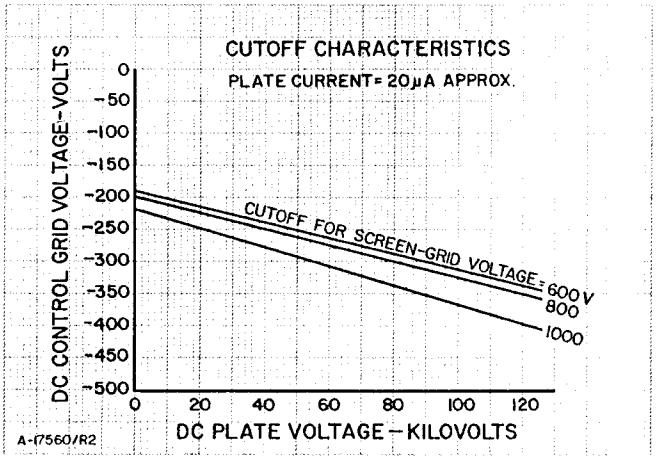
*Represents maximum usable cathode current (plate current plus current to each grid) for any conditions of operation.
†With tube horizontal only.
‡With forced-air cooling of 250 cfm minimum.

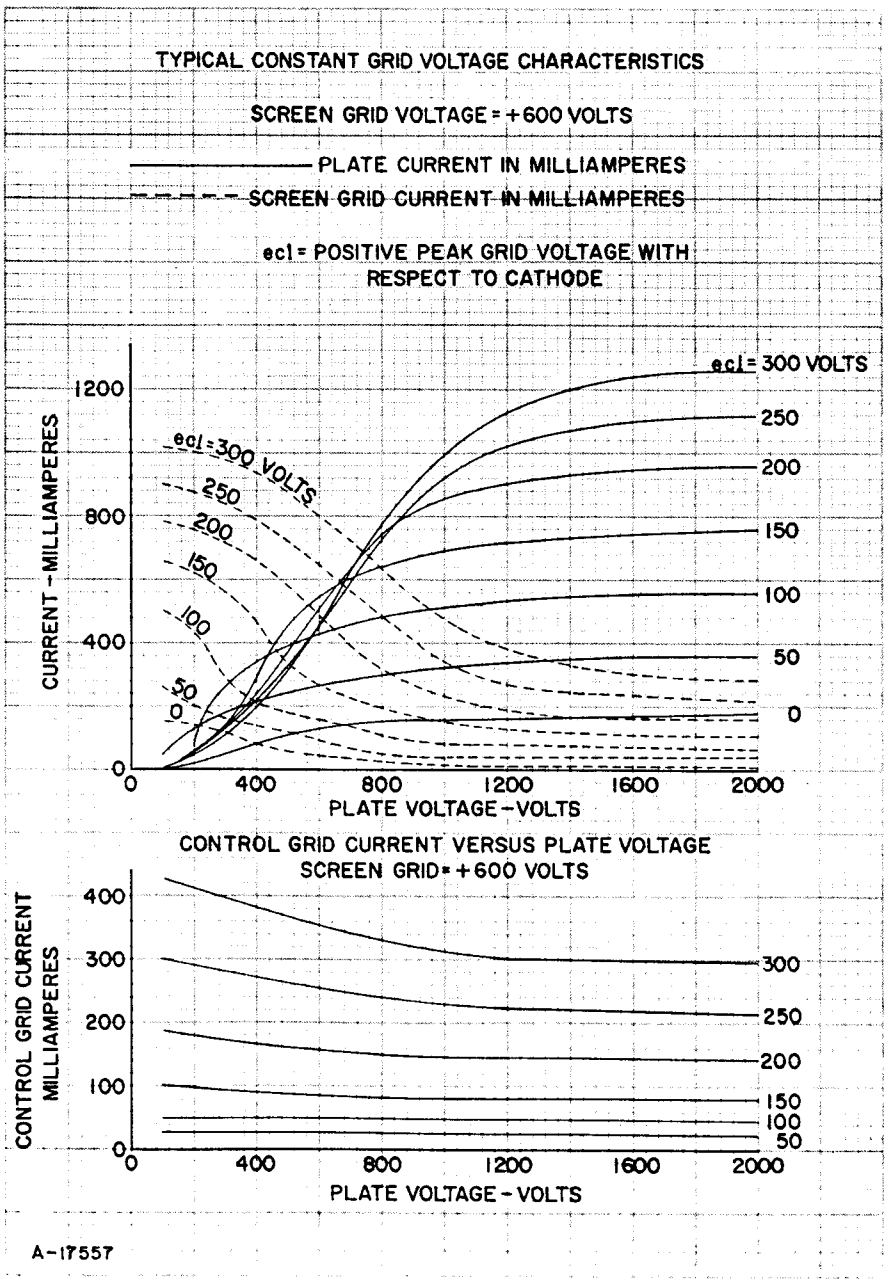
TYPICAL OPERATING CONDITIONS

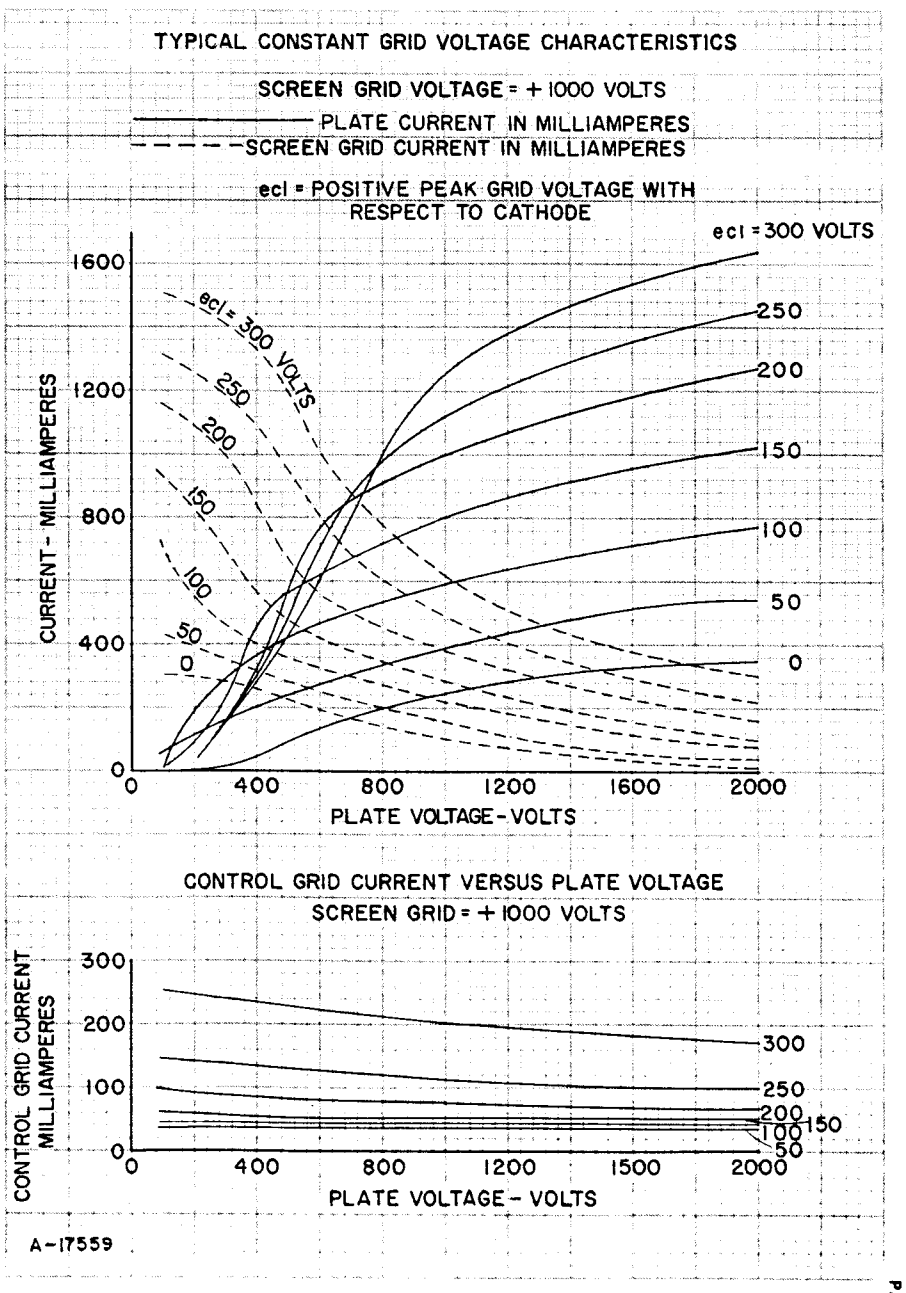
Typical Operation (in oil) — Pulse High-Voltage Switching		
D-C Plate Voltage	125	kV
D-C Screen-Grid Voltage	600	Volts
D-C Control-Grid Voltage	−360	Volts
Pulse Positive Control-Grid Voltage	250	Volts
Pulse Plate Current	1.02	amps
Pulse Screen-Grid Current	0.27	amp
Pulse Control-Grid Current	0.22	amp
Tube Drop	1200	volts
Duty, maximum for this condition of operation	12	%

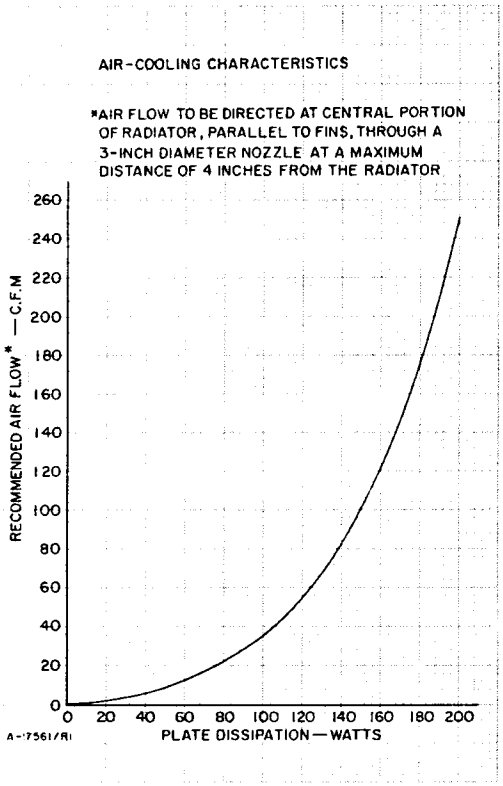
WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.



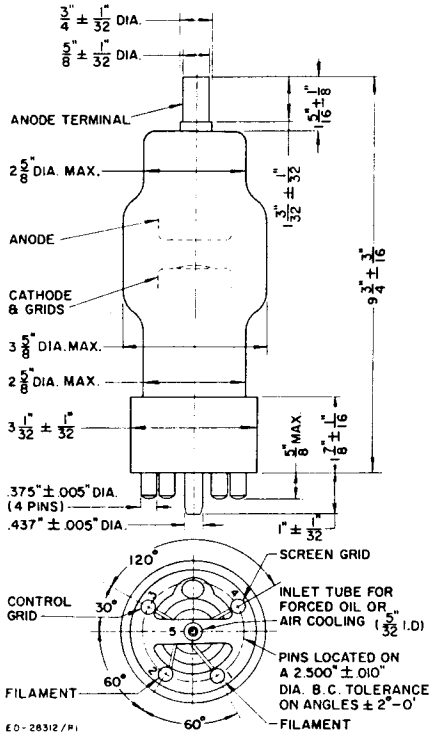



TYPICAL CONSTANT GRID VOLTAGE CHARACTERISTICS
SCREEN GRID VOLTAGE = +600 VOLTS
PLATE CURRENT IN MILLIAMPERES
SCREEN GRID CURRENT IN MILLIAMPERES
ec1 = POSITIVE PEAK GRID VOLTAGE WITH RESPECT TO CATHODE
CURRENT - MILLIAMPERES
PLATE VOLTAGE - VOLTS
ec1 = 300 VOLTS
250
200
150
100
50
0
CONTROL GRID CURRENT VERSUS PLATE VOLTAGE
SCREEN GRID = +600 VOLTS
CONTROL GRID CURRENT MILLIAMPERES
A-17557

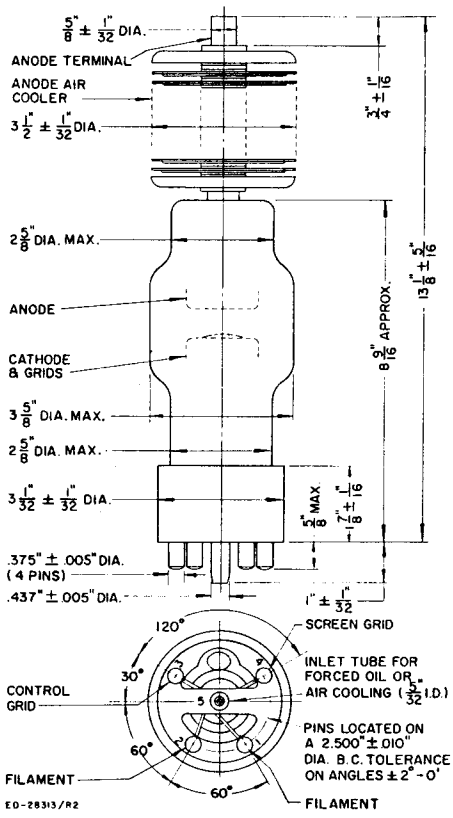

TYPICAL CONSTANT GRID VOLTAGE CHARACTERISTICS
SCREEN GRID VOLTAGE = +1000 VOLTS
PLATE CURRENT IN MILLIAMPERES
SCREEN GRID CURRENT IN MILLIAMPERES
ec1 = POSITIVE PEAK GRID VOLTAGE WITH RESPECT TO CATHODE
CURRENT - MILLIAMPERES
PLATE VOLTAGE - VOLTS
ec1 = 300 VOLTS
250
200
150
100
50
0
CONTROL GRID CURRENT VERSUS PLATE VOLTAGE
SCREEN GRID = +1000 VOLTS
CONTROL GRID CURRENT MILLIAMPERES
A-17559



ML-7249



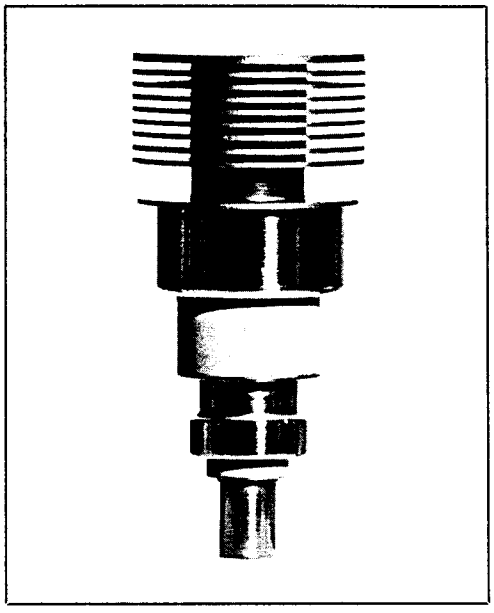
DIMENSIONS — ML-7248



DIMENSIONS — ML-7249

THE MACHLETT LABORATORIES, INC.
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SPRINGDALE CONNECTICUT
ST-1663 4.5M 5-64
Printed in U.S.A.

ISSUED 6-65



ML-7289/ 3CX100A5

UHF Planar Triode

CW or Pulsed
3 Gc

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7289 is a ruggedized, high-mu, planar triode of ceramic-and-metal construction designed specifically for use in new equipment as an oscillator, amplifier or frequency multiplier, at frequencies up to 2.5 Gc. It is well suited for pulsed operation at frequencies up to 3 Gc.

The ML-7289 can, in most cases, replace a 2C39A or 2C39WA directly without equipment modification. It retains the desirable high-mu, low interelectrode capacitance and high transconductance characteristics of its predecessors. It is manufactured to exacting dimensional tolerances to insure mechanical uniformity. Improved reliability and minimum variation in electrical characteristics are achieved through extensive and precise electrical testing. The ML-7289 is capable of sustained, reliable operation at elevated temperatures.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage, AC or DC (See Application Notes)	6.0	V
Heater Current at 6.0 Volts	1.0	A
Heater Heating Time, minimum	60	sec
Amplification Factor	100	
Transconductance (ib=70 ma, eb=600 v)	25000	μmhos
Interelectrode Capacitances, without Heater Voltage		
Grid-Plate	2.0	pf
Grid-Cathode	6.30	pf
Plate-Cathode, maximum	.035	pf

Mechanical

Mounting Position	Optional	
Type of Cooling	Forced-Air	
Maximum Anode Shank and Envelope Temperature	300	°C
Altitude Rating, CW operation	60000	ft
Net Weight	2.5	oz

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values		
DC Plate Voltage	1000	V
DC Grid Voltage	—150	V
Instantanous Peak Grid-Cathode Voltage		
Grid negative to cathode	—400	v
Grid positive to cathode	30	v
DC Cathode Current	125	mA
DC Grid Current§	50	mA
Plate Dissipation, Forced-Air Cooling†	100	W
Grid Dissipation	2	W
Frequency	2.5	Gc
Typical Operation, RF Power Amplifier, Grid Separation Circuit		
Frequency	500	Mc
DC Plate Voltage	900	V
DC Grid Voltage	—40	V
DC Plate Current	90	mA
DC Grid Current, approximate	30	mA
Driving Power, approximate	6	W
Useful Power Output	40	W
Typical Operation, RF Oscillator		
Frequency	2.5	Gc
DC Plate Voltage	900	V
DC Grid Voltage, approximate	—22	V
DC Plate Current	90	mA
DC Grid Current	10	mA
Useful Power Output	17	W

Plate-Modulated RF Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values		
DC Plate Voltage*	600	V
DC Grid Voltage	—150	V
Instantanous Peak Grid-Cathode Voltage		
Grid negative to cathode	—400	v
Grid positive to cathode	30	v
DC Cathode Current	100	mA
DC Grid Current§	50	mA
Plate Dissipation, Forced-Air Cooling†	70	W
Grid Dissipation	2	W
Frequency	2.5	Gc

Grid-Pulsed or Plate-Pulsed RF Oscillator and Amplifier — Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-Pulsed, DC	1000	V
Plate-Pulsed, Peak Pulse Supply	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
Peak Plate Current	3	a
Peak Grid Current	1.8	a
Average Plate Dissipation, Forced-Air Cooling†	100	W
Average Grid Dissipation	2	W
Pulse Duration	3	μs•
Duty Factor	.0025	•
Frequency	3	Gc
Typical Operation, Plate-Pulsed Oscillator		
Frequency	3	Gc
Filament Voltage	5.8	V
Pulse Length	3	μs
Duty Factor	.0025	
Peak Plate Pulse Supply Voltage	3500	v
Peak Plate Current from Pulse Supply	3	a
Peak Grid Current	1.8	a
Useful Peak Power Output, approximate	1600	w

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	1000	V
Peak Plate Voltage	1200	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
DC Plate Current	100	mA
Pulse Cathode Current	4.8	a
Average Plate Dissipation, Forced-Air Cooling†	100	W
Average Grid Dissipation	2	W
Pulse Duration	3	μs•
Duty Factor	.0025	•

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

§See "Application Notes" on "Determination of Proper Grid Drive".

†Refer to "Cooling" in "Application Notes".

*For modulation factors less than 1.0, a higher dc plate voltage may be used if the sum of the peak audio voltage and the dc plate voltage does not exceed 1200 volts.

•For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

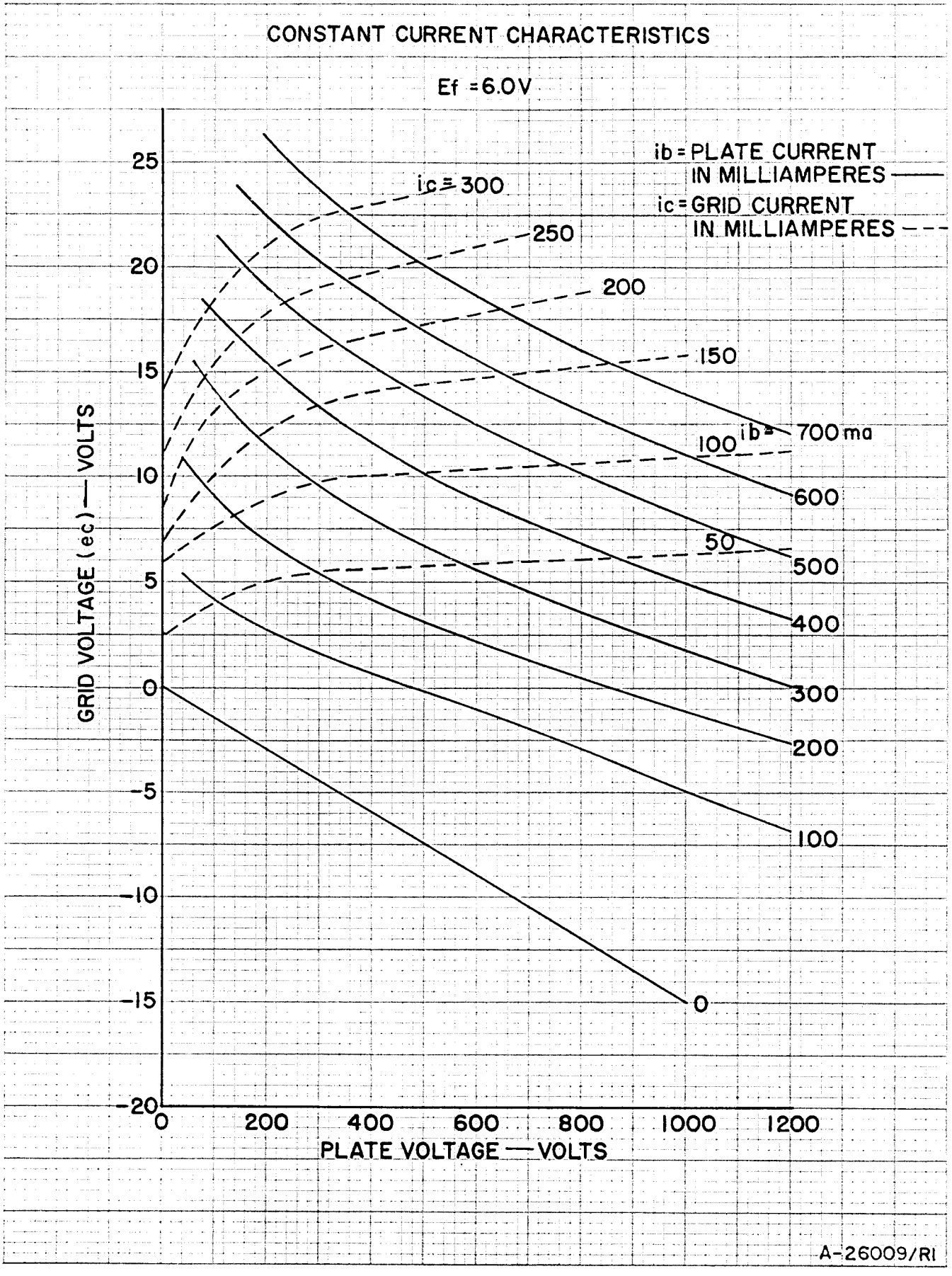
	Min.	Max.	
Filament Current at 6.0 volts	.90	1.05	A
Cut-off bias (Note 1)	—	—15	V
Grid-Plate Capacitance (Note 2)	1.95	2.15	pf
Grid-Cathode Capacitance (Note 2)	5.60	7.00	pf

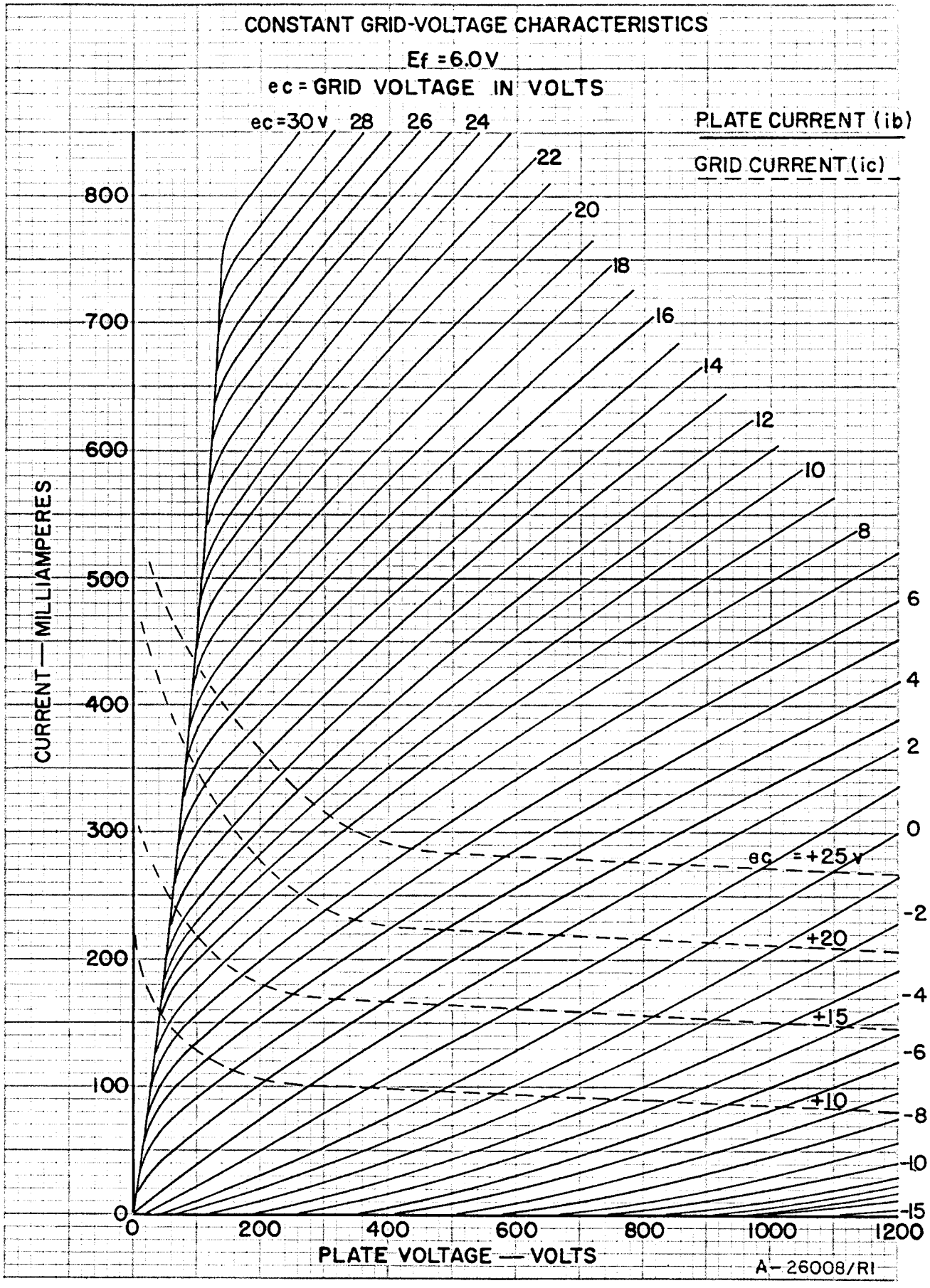
Note 1 — Measured at 1 mA of the plate current and a plate voltage of 600 volts.

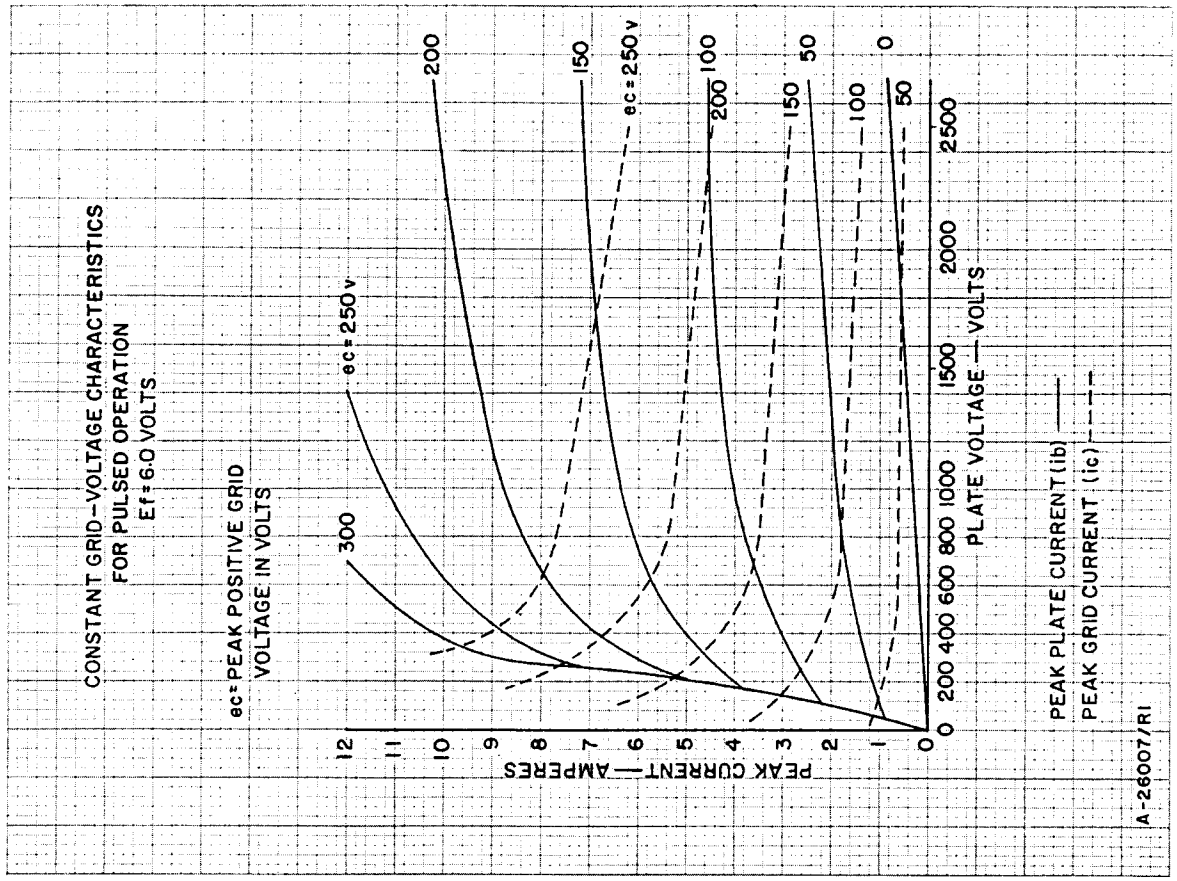
Note 2 — Capacitance measurements are with the tube cold.

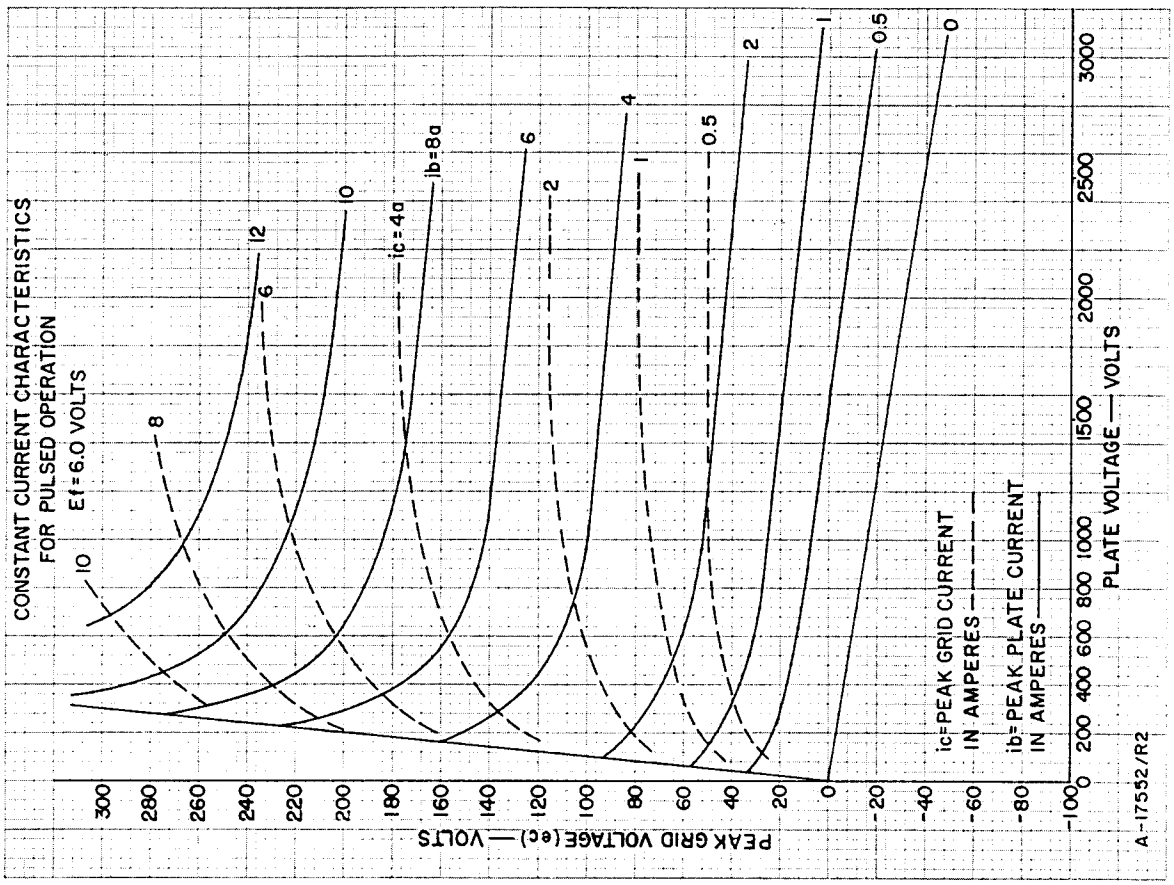
APPLICATION NOTES

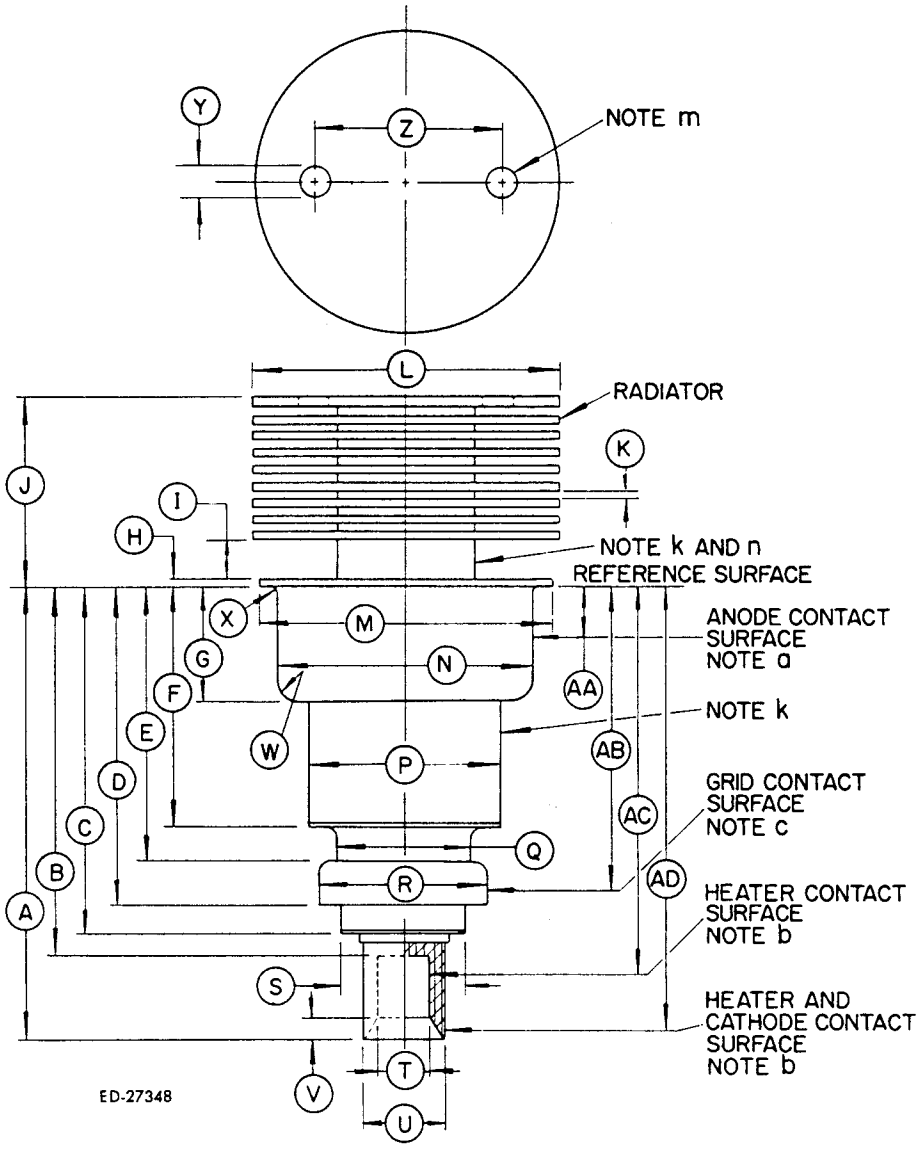
Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes — General.*


CONSTANT CURRENT CHARACTERISTICS
Ef = 6.0V
ib = PLATE CURRENT IN MILLIAMPERES
ic = GRID CURRENT IN MILLIAMPERES
ic = 300
250
200
150
100
50
ib = 700 ma
600
500
400
300
200
100
0
GRID VOLTAGE (ec) — VOLTS
25
20
15
10
5
0
-5
-10
-15
-20
0
200
400
600
800
1000
1200
PLATE VOLTAGE — VOLTS
A-26009/R1


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 6.0 V
ec = GRID VOLTAGE IN VOLTS
ec = 30 v
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
-15
PLATE CURRENT (ib)
GRID CURRENT (ic)
ec = +25 v
+20
+15
+10
CURRENT — MILLIAMPERES
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
PLATE VOLTAGE — VOLTS
A-26008/RI


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS
ec = PEAK POSITIVE GRID VOLTAGE IN VOLTS
ec = 250 v
300
200
150
ec = 250 v
100
50
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
PEAK PLATE CURRENT (ib) ——
PEAK GRID CURRENT (ic) - - - -
A-26007/R1


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS
10
8
12
6
10
ic = 4a
ib = 8a
6
2
4
1
0.5
2
1
0.5
0
PEAK GRID VOLTAGE (ec) — VOLTS
ic = PEAK GRID CURRENT IN AMPERES - - - -
ib = PEAK PLATE CURRENT IN AMPERES ——
PLATE VOLTAGE — VOLTS
A-17552/R2



DIMENSIONS FOR OUTLINE (INCHES)

Ref.	Minimum	Maximum
A	1.815	1.875
B	—	1.534
C	—	1.475
D	1.289	1.329
E	1.085	1.135
F	.880	.920
G	.462	.477
H	—	.040
I	.125	.185
J	.766	.826
K	.025	.046
L	1.234	1.264
M	1.180	1.195
N	1.025	1.035
P	.772	.792
Q	.541	.561
R	.655	.665
S	—	.545
T	.213	.223
U	.315	.325
V	—	.086
W	—	.100
X	—	.035
Y	.105	.145
Z	.650	.850

NOTES

a. The total indicated runout of the anode contact surface with respect to the cathode contact surfaces will not exceed .020 inch.

b. The total indicated runout of the cathode contact surface with respect to the heater contact surfaces will not exceed .012 inch.

c. The total indicated runout of the grid contact surface with respect to the cathode contact surface will not exceed .020 inch.

k. Do not clamp or locate on this surface.

m. Hole provided for tube extractor through the top fin only.

n Measure anode shank temperature on this surface.

DIMENSIONS FOR ELECTRODE CONTACT AREA (INCHES)

Ref.	Dimension	Contact
AA	.198 ± .163	Anode
AB	1.225 ± .040	Grid
AC	1.631 ± .097	Heater
AD	1.645 ± .170	Cathode

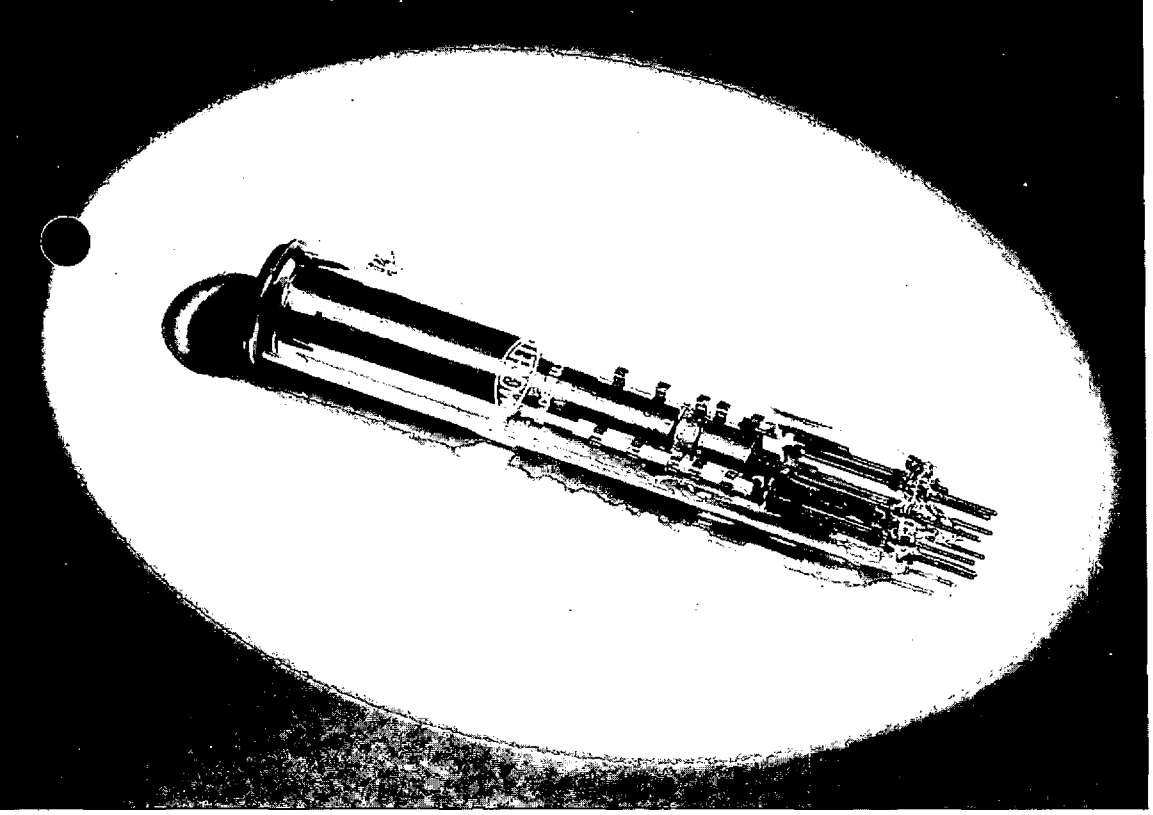
DIMENSIONS — ML-7289

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ST-2109 5M 6-65

SPRINGDALE MACHLETT CONNECTICUT

Printed in U.S.A.



MACHLETT

ML-7291 VIDICON

DESCRIPTION & RATINGS

DESCRIPTION

The ML-7291 is a small television camera tube designed primarily for use in television broadcasting for film pick-up. It will retain a minimum center resolution of 600 lines at 0.4 microamperes signal current from a standard RETMA test pattern chart. The tube will function with considerable over-beaming without picture distortion. The photoconductive layer is characterized by a spectral response approaching that of the human eye.

GENERAL CHARACTERISTICS

Heater, for Unipotential Cathode:	6.3 ± 10% volts
Voltage (AC or DC)	0.6 ampere
Current	
Direct Interelectrode Capacitance:	4.5 $\mu\mu f$
Signal Electrode to All Other Electrodes	See Curve
Spectral Response	
Photoconductive Layer:	0.62 inch
Maximum Useful Diagonal of Rectangular Image (4×3 Aspect Ratio)	
Orientation of Quality Rectangle — Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.	
Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	6¼″ ± ¼″
Greatest Diameter, excluding side tip	1.125″ ± 0.010″
Maximum Radius, including side tip	0.800″
Bulb	T-8
Operating Position	Approx. Horizontal or faceplate up

from JETEC release #2301, Oct. 27, 1958

MAXIMUM RATINGS

Maximum Ratings, Absolute Values		
Signal-Electrode Voltage	75	volts
Grid No. 4 & Grid No. 3 Voltage	350	volts
Grid No. 2 Voltage	350	volts
Grid No. 1 Voltage		
Negative bias value	125	volts
Positive bias value	0	volts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	125	volts
Heater positive with respect to cathode	10	volts
Faceplate Temperature	60	°C

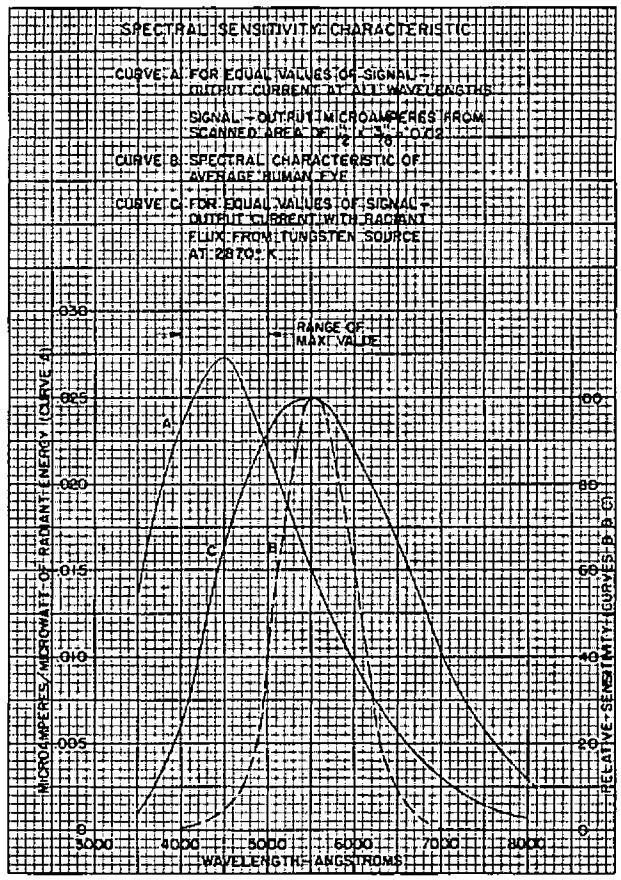
TYPICAL OPERATING CONDITIONS

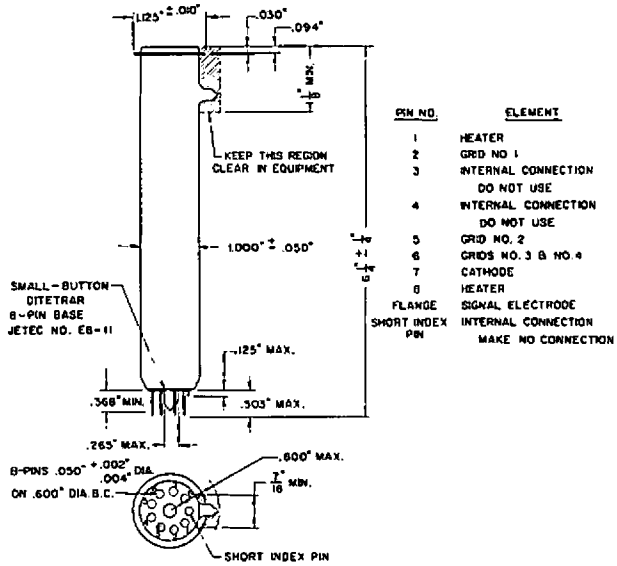
Typical Operation		
Signal-Electrode Voltage	15 to 35	volts
Grid No. 4 (Decelerator) & Grid No. 3 (Beam Focus) Voltage	200† to 300	volts
Grid No. 2 (Accelerator) Voltage	300	volts
Grid No. 1 Voltage (For picture cutoff)‡	−45 to −100	volts
Highlight Signal-Output Current	0.1 to 0.35	μamp
Maximum Dark Current	0.02	μamp
Minimum Signal Output Current with 0.6 ft-C of uniform 2870 °K illumination on tube face (at 0.02 μamp dark current)	0.05	μamp
Visual Equivalent Signal to Noise Ratio (Approx.)*	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No. 1	40	volts
When applied to cathode	10	volts
Field Strength at Center of Focusing Device	40	gausses
Field Strength of Adjustable Alignment Coil	0 to 4	gausses

†Definition, focus uniformity, and picture quality decrease with decreasing grid No. 3 and No. 4 voltage. In general, grid No. 3 and grid No. 4 should not be operated below 200 volts.

‡With no blanking voltage on grid No. 1.

*Measured with a high-gain, low-noise, cascode input amplifier having bandwidth of 5 Mc.





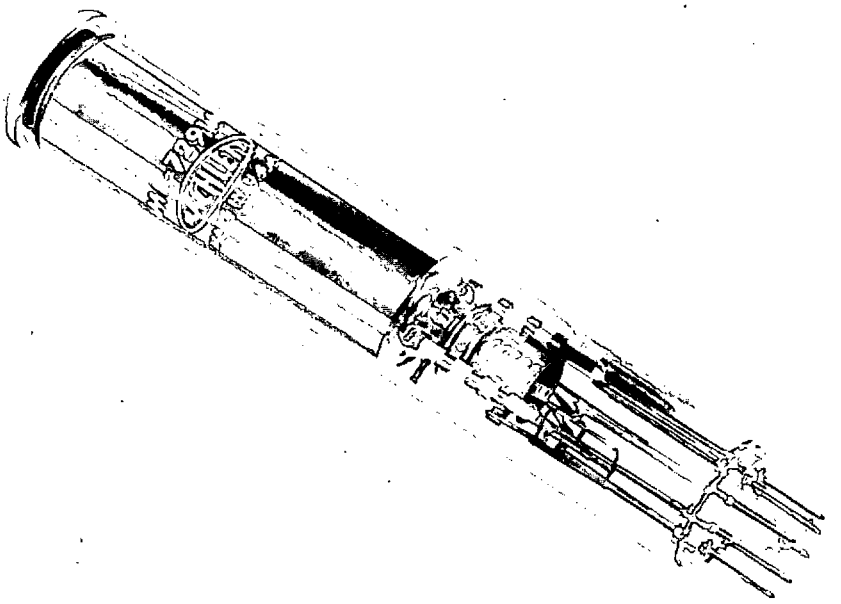
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SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

ST-1552-5M-58

PRINTED IN U.S.A.



MACHLETT

ML-7291A VIDICON

DESCRIPTION & RATINGS

DESCRIPTION

The ML-7291A is a small television camera tube designed primarily for use in television broadcasting for film pick-up. It will retain a minimum center resolution of 600 lines at 0.4 microamperes signal current from a standard RETMA test pattern chart. The photoconductive layer is characterized by a spectral response approaching that of the human eye.

Featured in the design of the ML-7291A are an extremely flat faceplate free from optical distortion and an envelope without a side tip. The tipless envelope allows the use of a longer deflecting yoke. In addition, the tipless structure simplifies the layout of optical arrangements for light splitting in a color camera.

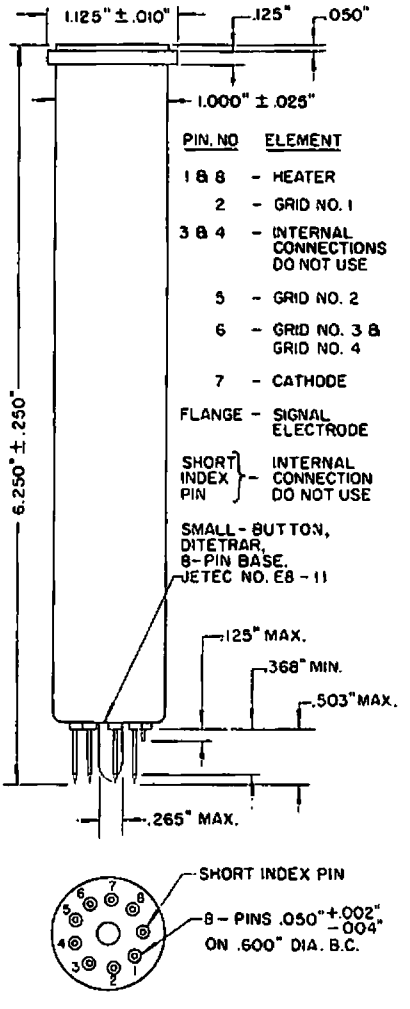
No alignment correction is required. The novel design of the gun gives good alignment of the beam without auxiliary alignment correcting coils or magnets. This feature also protects the beam from misalignment due to stray magnetic fields.

GENERAL CHARACTERISTICS

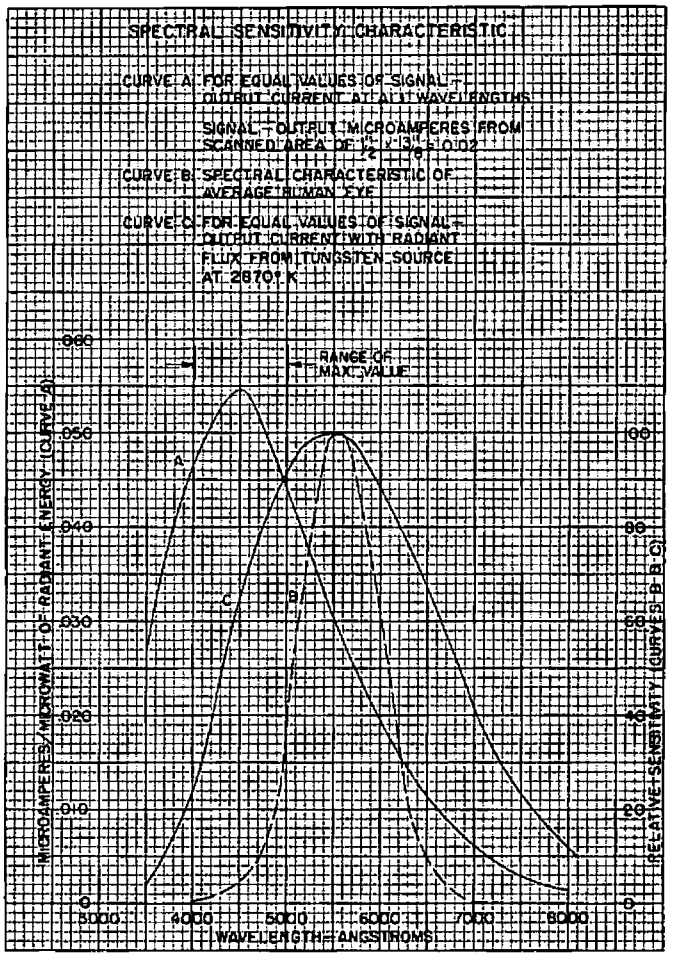
Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 ± 10% volts
Current	0.6 amp
Direct Interelectrode Capacitance:‡	
Target to All Other Electrodes	4.6 $\mu\mu f$
Spectral Response	S-18 (See Curve)
Photoconductive Layer:	
Maximum Useful Diagonal of Rectangular Image (4 x 3 aspect ratio)	0.62 inch
Orientation of Quality Rectangular — Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.	
Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	6.25″ ± 0.25″
Greatest Diameter	1.125″ ± 0.010″
Bulb	T8
Base	Small-Button Ditetrar 8-Pin (JETEC No. E8-11)
Socket	Cinch No. 54A18088, or equivalent
Operating Position	Any
Weight (Approx.)	2 oz.

MAXIMUM RATINGS

Maximum Ratings, Absolute Values		
Signal-Electrode Voltage	75	volts
Grid No. 4 & Grid No. 3 Voltage	350	volts
Grid No. 2 Voltage	350	volts
Grid No. 1 Voltage		
Negative bias value	125	volts
Positive bias value	0	volts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	125	volts
Heater positive with respect to cathode	10	volts
Dark current	0.05	μa
Target current	0.45	μa
Faceplate temperature	60	°C



DIMENSIONS — ML-7291A



TYPICAL OPERATING CONDITIONS

Typical Operation		
Signal-Electrode Voltage	15 to 35	volts
Grid No. 4 (Decelerator) & Grid No. 3 (Beam Focus) Voltage	200† to 300	volts
Grid No. 2 (Accelerator) Voltage	300	volts
Grid No. 1 Voltage (For picture cutoff)‡	−45 to −100	volts
Highlight Signal-Output Current	0.1 to 0.35	μamp
Dark Current	0.01	μamp
Average "Gamma" of Transfer Characteristic for signal-output current between 0.1 μa and 0.2 μa	0.55	
Visual Equivalent Signal to Noise Ratio (Approx.)*	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No. 1	75	volts
When applied to cathode	20	volts
Field Strength at Center of Focusing Device	40	gausses

†Definition, focus uniformity, and picture quality decrease with decreasing grid No. 3 and No. 4 voltage. In general, grid No. 3 and grid No. 4 should not be operated below 200 volts.

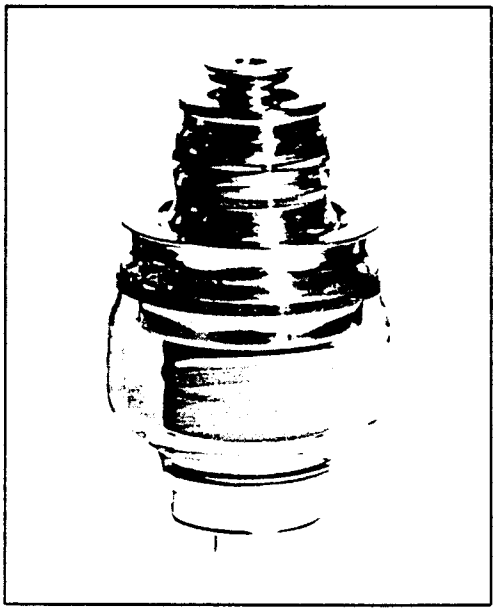
‡With no blanking voltage on grid No. 1.

*Measured with a high-gain, low-noise, cascode input amplifier having bandwidth of 5 Mc.

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



ISSUED 5-64

ML-7333

Shielded Grid Triode

Pulse Power to 300 kw

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7333 is a shielded-grid triode designed primarily to operate as a switch tube in hard-tube pulse modulators, for radar and similar applications. In this service it can deliver 300 kilowatts pulse power output with less than 2.5 kilowatts driving power. The ML-7333 will deliver this power while being vibrated at an acceleration of 10G from 50 to 2000 cps.

The ML-7333 has sturdy electrodes arranged to form a cylindrical array of electron-optical systems, featuring a shield electrode connected internally to the cathode by direct, low-impedance paths. This design permits operation with low grid current, and it results in favorably low grid-plate capacitance. The presence of the ground-potential shield adjacent to the anode, furthermore, protects the cathode and grid from damage by transient arcs.

The cathode is a unipotential, oxide-coated type. The anode is radiation cooled and is capable of dissipating 60 watts.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS AND RATINGS

Electrical		
Heater Voltage	6.0±5%	Volts
Heater Current	16	Amps
Heater Starting Current, maximum	80	Amps
Cathode Warm-Up Time	10	Minutes*
Amplification Factor	175	
Interelectrode Capacitances		
Grid-Plate	0.8	μμf
Grid-Cathode	65	μμf
Plate-Cathode	15	μμf
Mechanical		
Mounting Position		Any
Type of Cooling		Radiation†
Air Flow on Heater Terminal	2-5	cfm
Maximum Glass Temperature	175	°C†
Vibration Acceleration, maximum (Ebb=20kVdc, ib=16 a, F=50-2000 cps)	10	G
Net Weight, approximate	1	lb.

*For accelerated cathode warm-up, the filament may be energized at 7.0 volts for 5 minutes and then reduced to 6.0 volts for high-voltage operation. If a filament stand-by voltage of 5.0 volts is used, the minimum cathode warm-up time is 1 minute at 6.0 volts.

†Sufficient air flow must be provided to maintain glass temperatures at less than 175°C under all conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

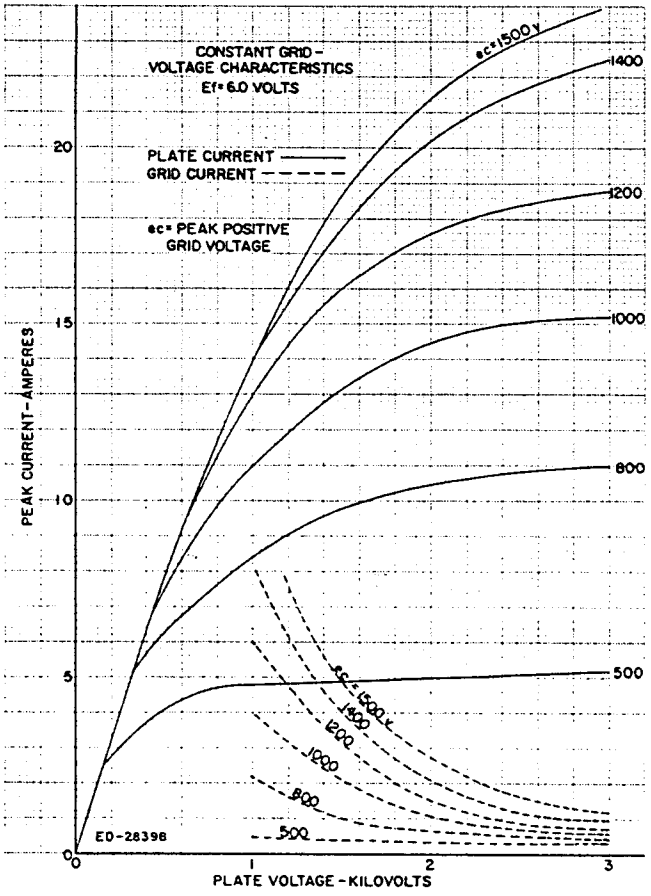
D-C Plate Voltage	20	kV
Peak Plate Voltage	25	kv
D-C Grid Voltage	−200	volts
Peak Positive Grid Voltage	1500	volts
Peak Negative Grid Voltage	−1500	volts
Pulse Cathode Current	18	amps
D-C Plate Current	20	mA
Grid-Dissipation	20	watts
Plate-Dissipation	60	watts
Pulse Duration*	25	μsec
Duty Factor*	0.001	

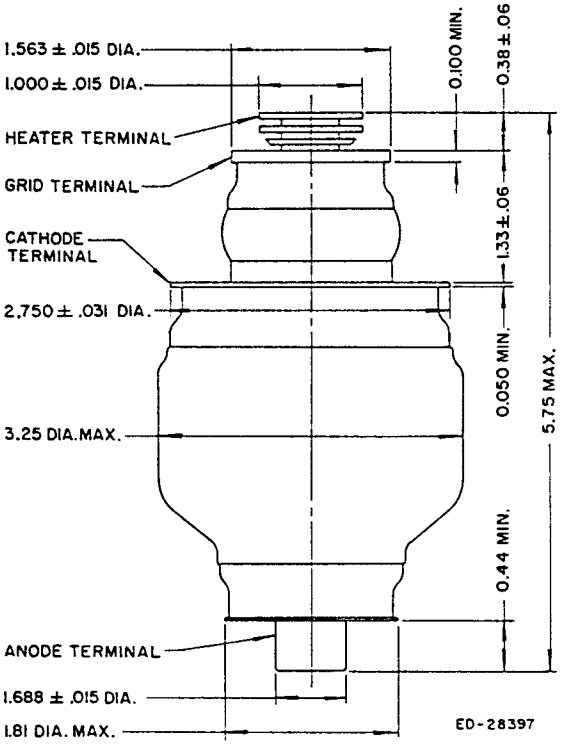
Typical Operation

D-C Plate Voltage	20	kV
D-C Grid Voltage	−150	volts
Pulse Positive Grid Voltage	1.1	kv
Pulse Plate Current	16.5	amps
Pulse Grid Current	1.8	amps
Pulse Driving Power	2.3	kw
Pulse Power Output	300	kw
Plate Output Voltage	18	kv

*For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.



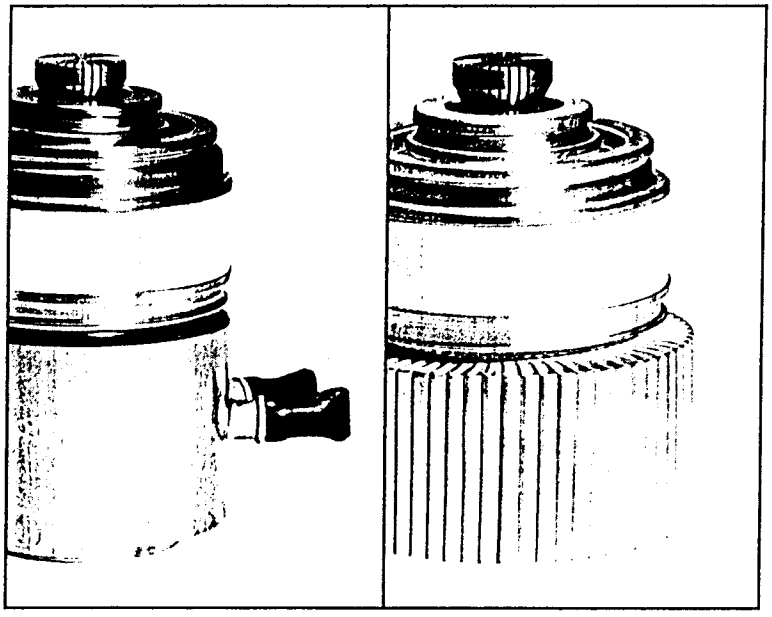


ALL DIMENSIONS IN INCHES

DIMENSIONS — ML-7333

THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT
ST-1722 4.5M 5-64
Printed in U.S.A.

ISSUED 5-64



ML-7334
ML-7335

Shielded Grid Triodes
High Duty
150 kw Pulse Power

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7334 and ML-7335 are shielded-grid triodes designed primarily to operate as switch tubes in hard-tube pulse modulators, for radar and similar applications.

The ML-7334 is designed specifically for high-duty-factor, long-pulse operation where it is capable of 150 kilowatts pulse output power. Either type may be used in this service, or in low-duty, short-pulse applications where it is capable of switching 750 kW.

Each of these types has sturdy electrodes arranged to form a cylindrical array of electron-optical systems, featuring a shield electrode connected internally to the cathode by direct, low-impedance paths. This design permits operation with low grid current and it results in favorably low grid-plate capacitance. The presence of the ground-potential shield adjacent to the anode, furthermore, protects the cathode and grid from damage by transient arcs.

The cathode of each type is unipotential oxide-coated. The anode of the ML-7334 is designed for cooling by a forced flow of water, oil, or other suitable liquid. The cooling jacket is clamped onto the anode so that tubes may be installed and removed without breaking into the cooling system.† The ML-7335 anode is forced-air cooled and is capable of dissipating 3 kW with an air flow of 280 cfm.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage	6.0±5%	Volts
Heater Current	60	Amps
Heater Starting Current, maximum	300	Amps
Cathode Warmup Time	10	Minutes*
Amplification Factor	125	
Interelectrode Capacitances		
Grid-Plate	5	$\mu\mu f$
Grid-Cathode	250	$\mu\mu f$
Plate-Cathode	50	$\mu\mu f$
Mechanical		
Mounting Position (support tube by anode or anode radiator only)	Any	
Type of Cooling—ML-7334	Forced-liquid†	
Type of Cooling—ML-7335	Forced-air‡	
Air flow on anode, minimum for 3 kW dissipation	280 cfm at 3" water	
Air flow on grid	50	cfm
Maximum incoming air temperature	65	°C
Maximum Ceramic Temperature	225	°C‡
Net Weight, approximate		
ML-7334	9	lbs.
ML-7335	12	lbs.

†For details on cooling requirements for ML-7334, consult the Machlett Engineering Department.

*For accelerated cathode warmup, the filament may be energized at 7.0 volts for 5 minutes and then reduced to 6.0 volts for high-voltage operation. If a filament standby voltage of 5.0 volts is used, the minimum cathode warmup time is 1 minute at 6.0 volts.

‡Sufficient coolant flow must be provided to maintain envelope temperatures at less than 225°C under all conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

VALUES APPLY TO BOTH TYPES

Pulse Modulator or Pulse Amplifier

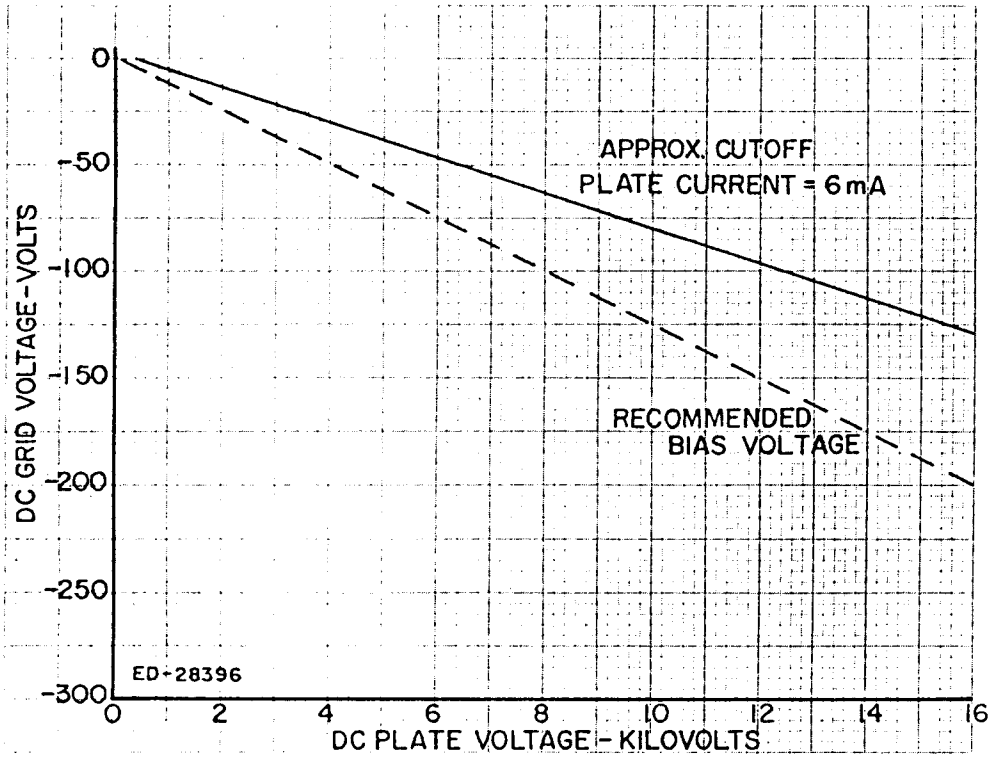
Maximum Ratings, Absolute Values

D-C Plate Voltage		16	kV
Peak Plate Voltage		20	kv
D-C Grid Voltage		−300	volts
Peak Positive Grid Voltage		1000	volts
Peak Negative Grid Voltage		−1000	volts
Pulse Cathode Current	15	75	amp
D-C Plate Current	3500	200	mA
Grid Dissipation	75	75	watts
Plate Dissipation			
ML-7334	5	5	kW
ML-7335	3	3	kW
Pulse Duration	500	25	μsec
Duty Factor	0.35	0.003	

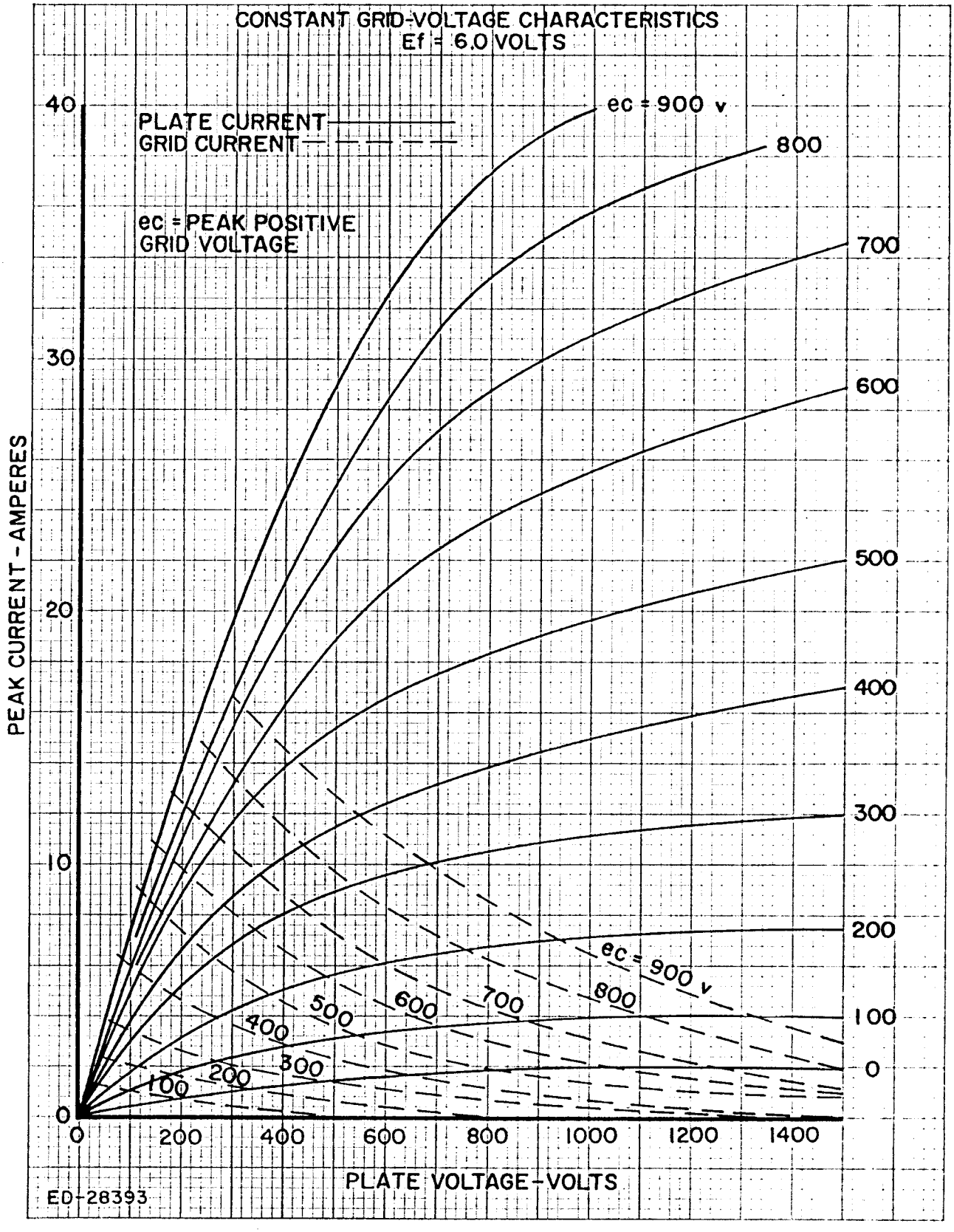
Typical Operation

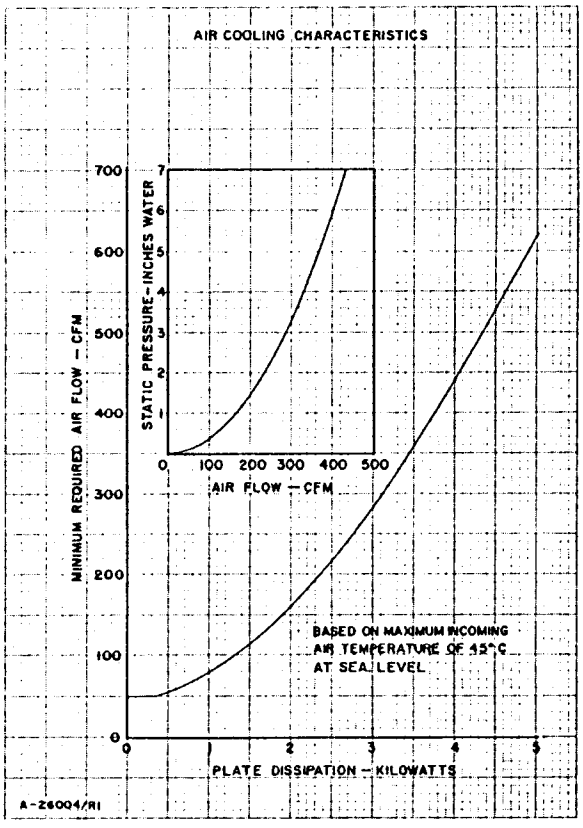
D-C Plate Voltage	8	16	kV
D-C Grid Voltage	−100	−200	volts
Pulse Positive Grid Voltage	250	1000	volts
Pulse Plate Current	10	55	amp
Pulse Grid Current	0.8	5	amp
Pulse Driving Power	0.3	6	kw
Pulse Power Output	70	770	kw
Plate Output Voltage	7	14	kv
Pulse Duration*	500	25	μsec
Duty Factor*	0.3	.003	

*For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

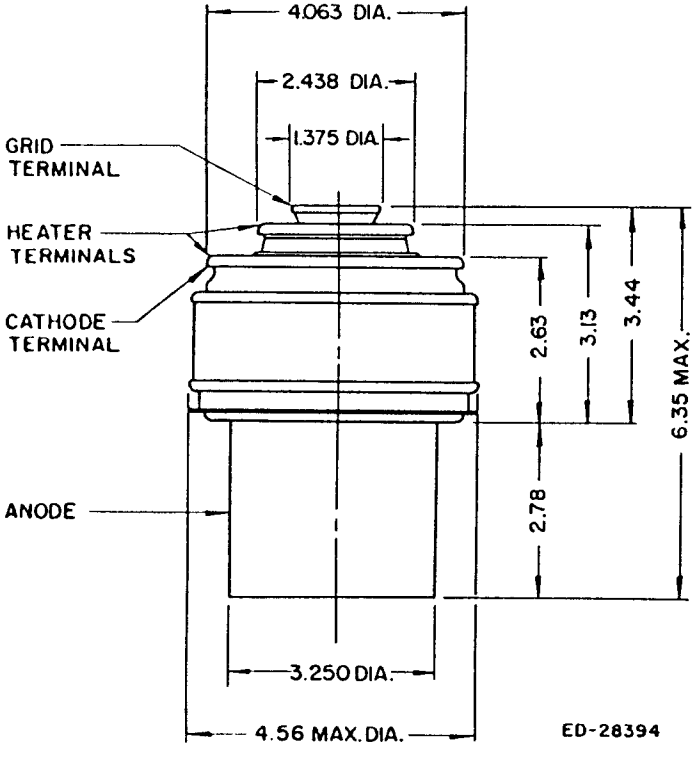


CUT-OFF CHARACTERISTICS


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 6.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE
GRID VOLTAGE
ec = 900 v
800
700
600
500
400
300
200
100
0
PEAK CURRENT - AMPERES
PLATE VOLTAGE - VOLTS
0
10
20
30
40
200
400
600
800
1000
1200
1400
ED-28393

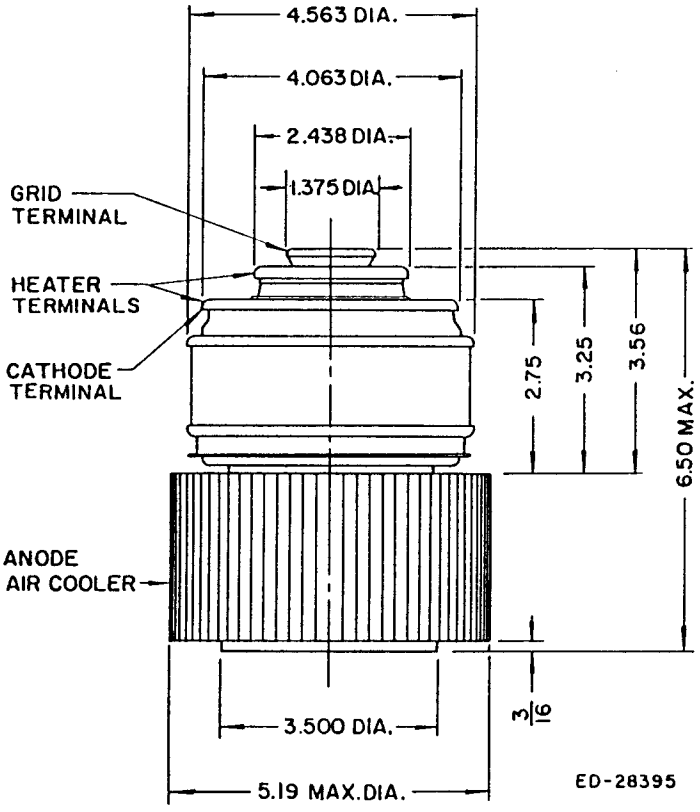


ML-7335



ALL DIMENSIONS IN INCHES
TOLERANCES TO BE DETERMINED

DIMENSIONS— ML-7334



ALL DIMENSIONS IN INCHES
TOLERANCES TO BE DETERMINED

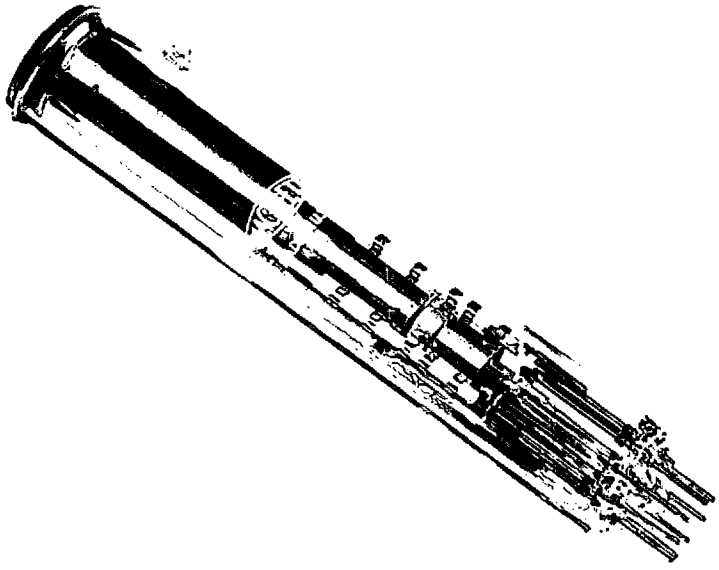
DIMENSIONS—ML-7335

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An Affiliate of Raytheon Company

ST-1793 4.5M 5-64

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Printed in U.S.A.



MACHLETT

ML-7351

DESCRIPTION & RATINGS

DESCRIPTION

The ML-7351 is a small television camera tube designed primarily for use at low light level in industrial applications with limited subject motion. Its resolution capability is about 500 lines. Using a photoconductive layer as its light sensitive element, the ML-7351 has a sensitivity which permits televising scenes with about 0.1 foot-candles illumination on the faceplate of the tube. For average scenes, this corresponds to approximately 5 foot-candles illumination on the scene when using an f/2 lens. The spectral response characteristic of the photoconductive layer exhibits a peak in the red and is somewhat dependent on dark current. The signal decay rate or lag of the ML-7351 is approximately twice that of the ML-6198.

GENERAL CHARACTERISTICS

Heater, for Unipotential Cathode:	
Voltage (AC or DC)	6.3 ± 10% volts
Current	0.6 ampere
Direct Interelectrode Capacitance:	
Signal Electrode to All Other Electrodes	4.5 $\mu\mu f$
Spectral Response	See Curve
Photoconductive Layer:	
Maximum Useful Diagonal of Rectangular Image (4 x 3 Aspect Ratio)	0.62 inch
Orientation of Quality Rectangle — Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.	
Focusing Method	Magnetic
Deflection Method	Magnetic
Overall Length	6¼″ ± ¼″
Greatest Diameter, excluding side tip	1.125″ ± 0.010″
Maximum Radius, including side tip	0.800″
Bulb	T-8

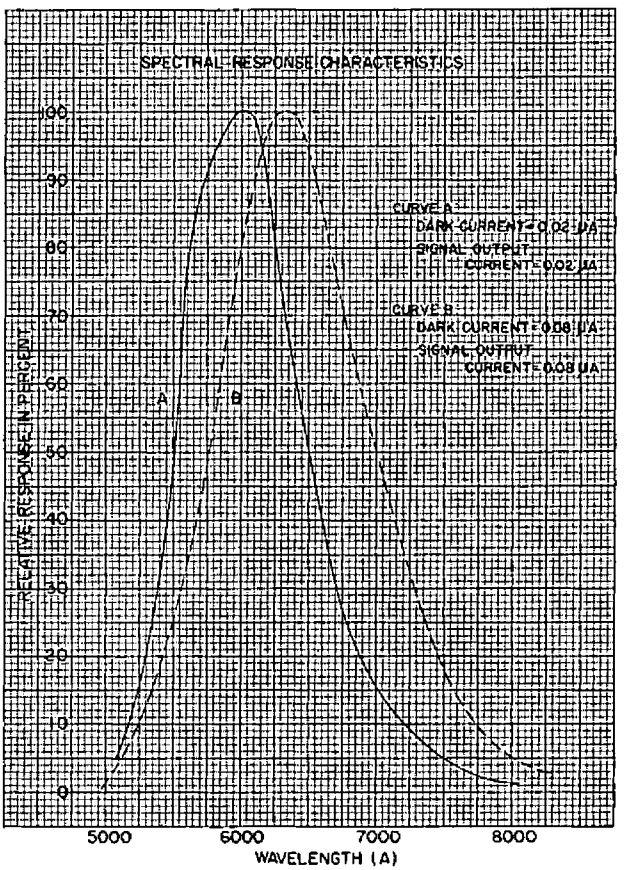
TYPICAL OPERATING CONDITIONS

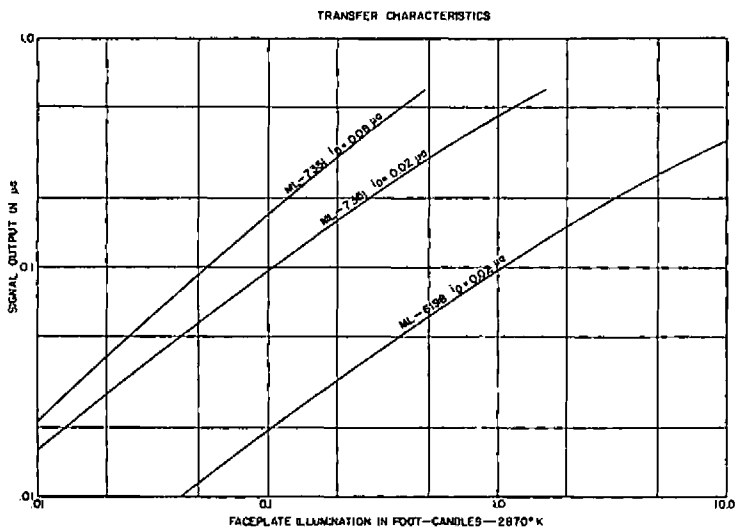
Typical Operation		
Faceplate Illumination (Highlight)	0.3 to 0.7	ft-c
Signal-Electrode Voltage	10 to 25	volts
Maximum Rating	40	volts
Grid No. 4 (Decelerator) & Grid No. 3 (Beam Focus) Voltage	250† to 300	volts
Grid No. 2 (Accelerator) Voltage	300	volts
Grid No. 1 Voltage (For picture cutoff)‡	−45 to −100	volts
Highlight Signal-Output Current	0.2 to 0.4	μamps
Maximum Dark Current	0.08	μamp
Uniform 2870°K Tungsten Illumination on Tube Face to Produce Signal-Output Current of 0.1 to 0.2 μamp	0.1 to 0.3	ft-c
"Gamma" of Transfer Characteristic	0.6 to 0.7	
Visual Equipment Signal-to-Noise Ratio (Approx.)*	300:1	
Maximum Peak-to-Peak Blanking Voltage:		
When applied to grid No. 1	40	volts
When applied to cathode	10	volts
Field Strength at Center Focusing Device	40	gausses
Field Strength of Adjustable Alignment Coil	0 to 4	gausses

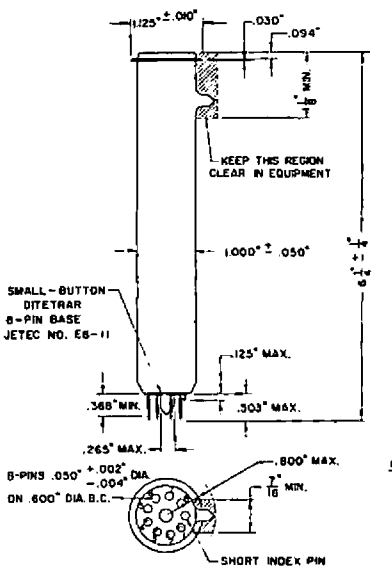
†Definition, focus uniformity, and picture quality decrease with decreasing grid No. 3 and grid No. 4 voltage. In general, grid No. 3 and grid No. 4 should not be operated below 250 volts.

‡With no blanking voltage on grid No. 1.

*Measured with a high-gain, low-noise, cascode-input amplifier having bandwidth of 5 Mc.





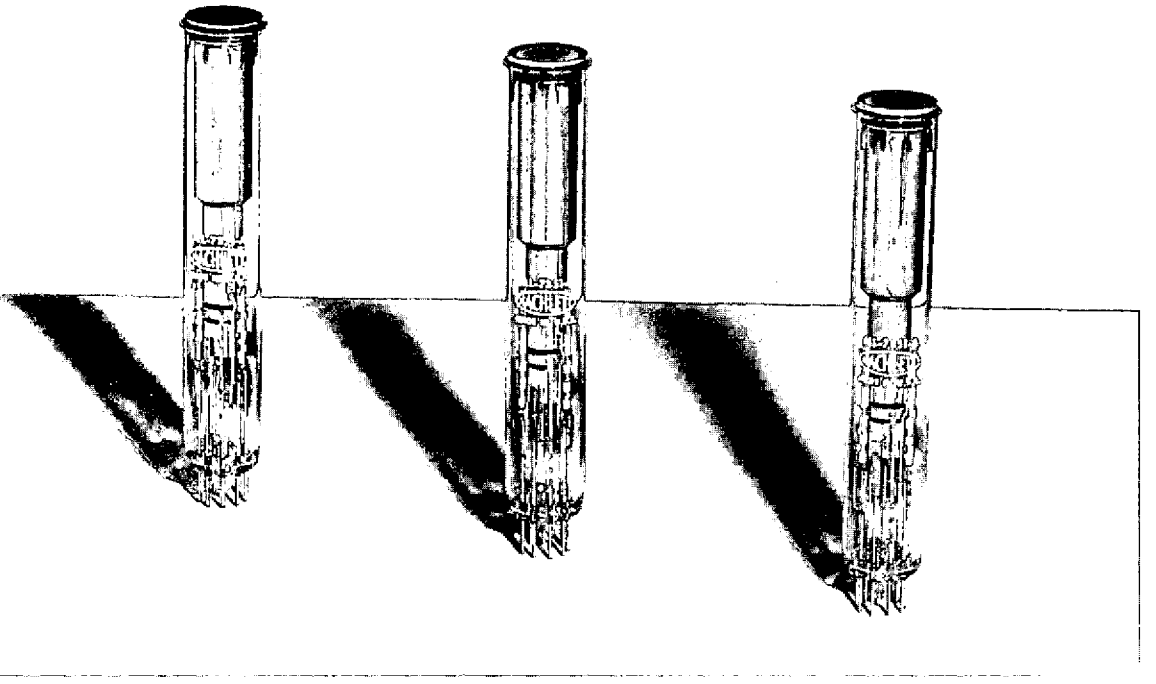


PIN NO.	ELEMENT
1	HEATER
2	GRID NO. 1
3	INTERNAL CONNECTION DO NOT USE
4	INTERNAL CONNECTION DO NOT USE
5	GRID NO. 2
6	GRIDS NO. 3 & NO. 4
7	CATHODE
8	HEATER
FLANGE	SIGNAL ELECTRODE
SHORT INDEX PIN	INTERNAL CONNECTION MAKE NO CONNECTION

MACHLETT LABORATORIES, INC.

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MACHLETT

ML-7351A VIDICON

DESCRIPTION & RATINGS

DESCRIPTION

The ML-7351A is a small television camera tube designed primarily for use at low light level in industrial applications with limited subject motion. Its target storage characteristics permit operation under slow-scan conditions. Its resolution under typical operating condition is about 500 lines. Resolution can be increased to over 800 lines with elevated focusing potentials. Using a photoconductive layer as its light sensitive element, the ML-7351A has a sensitivity which permits televising scenes with about 0.05 foot-candles illumination on the faceplate of the tube. For average scenes, this corresponds to approximately 5 foot-candles illumination on the scene when using an *f*/2 lens. The spectral response characteristic of the photoconductive layer exhibits a peak in the red and is somewhat dependent on dark current. The signal decay rate of the ML-7351A is approximately half that of a standard light-sensitive vidicon.

GENERAL CHARACTERISTICS

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3 ± 10%	volts
Current	0.6	ampere
Direct Interelectrode Capacitance:		
Signal Electrode to All Other Electrodes	4.5	$\mu\mu f$
Spectral Response	See Curve	
Photoconductive Layer:		
Maximum Useful Diagonal of Rectangular Image (4 x 3 Aspect Ratio)	0.62	inch
Orientation of Quality Rectangle — Proper orientation is obtained when the horizontal scan is essentially parallel to the plane passing through the tube axis and short index pin.		
Focusing Method	Magnetic	
Deflection Method	Magnetic	
Overall Length	6¼″ ± ¼″	
Greatest Diameter	1.125″ ± 0.010″	
Bulb	T-8	
Base	Small-Button Ditetrar 8-Pin (JEDEC No. E8-11)	
Socket	Cinch No. 54A18088, or equivalent	
Operating Position	Any	
Weight (Approx.)	2 oz.	

from JEDEC release #4174, March 4, 1963

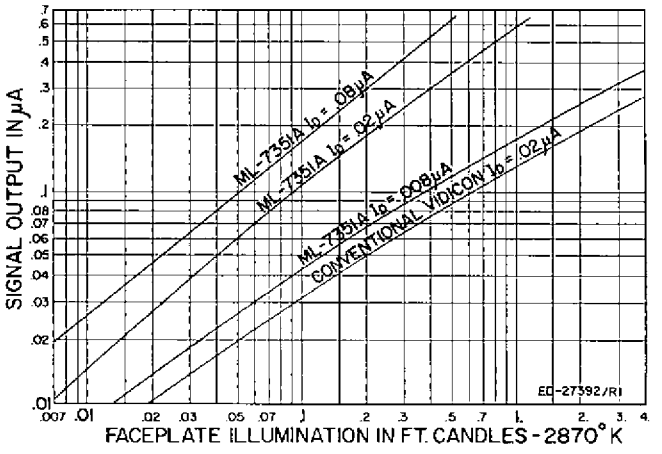
TYPICAL OPERATING CONDITIONS

Typical Operation		
Faceplate Illumination (Highlight)	0.3 to 0.7	ft-c
Signal-Electrode Voltage	10 to 25	volts
Maximum Rating	40	volts
Grid No. 4 (Decelerator) & Grid No. 3 (Beam Focus) Voltage	250† to 300	volts
Grid No. 2 (Accelerator) Voltage	300	volts
Grid No. 1 Voltage (For picture cutoff)‡	−45 to −100	volts
Highlight Signal-Output Current	0.2 to 0.4	μamps
Maximum Dark Current	0.08	μamp
Uniform 2870°K Tungsten Illumination on Tube Face to Produce Signal-Output Current of 0.1 to 0.2 μamp	0.1 to 0.3	ft-c
"Gamma" of Transfer Characteristic	0.6 to 0.7	
Visual Equivalent Signal-to-Noise Ratio (Approx.)*	300:1	
Minimum Peak-to-Peak Blanking Voltage:		
When applied to grid No. 1	40	volts
When applied to cathode	10	volts
Field Strength at Center Focusing Device	40	gausses
Field Strength of Adjustable Alignment Coil	0 to 4	gausses

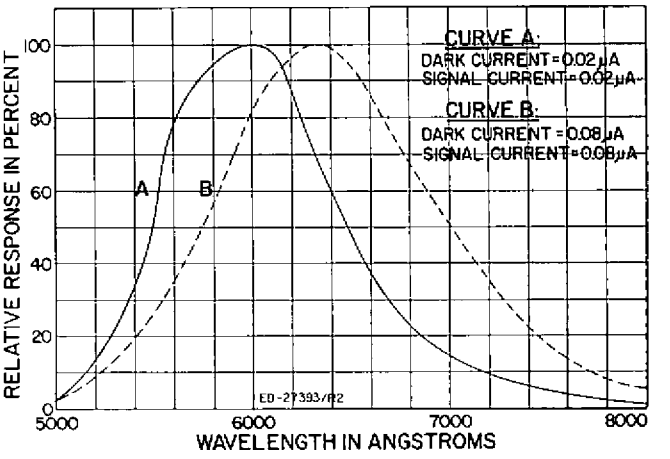
†Definition, focus uniformity, and picture quality decrease with decreasing grid No. 3 and grid No. 4 voltage. In general, grid No. 3 and grid No. 4 should not be operated below 250 volts.

‡With no blanking voltage on grid No. 1.

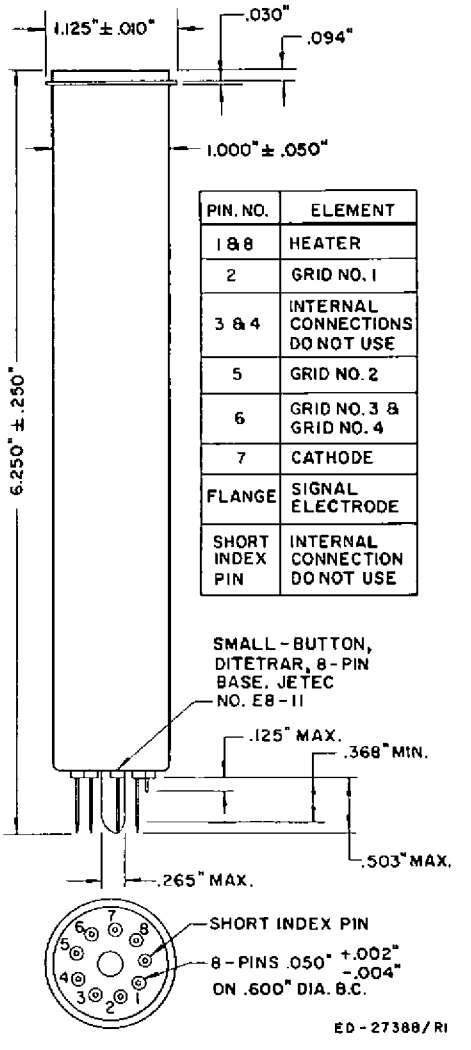
*Measured with a high-gain, low-noise, cascode-input amplifier having bandwidth of 5 Mc.



ML-7351A TRANSFER CHARACTERISTICS

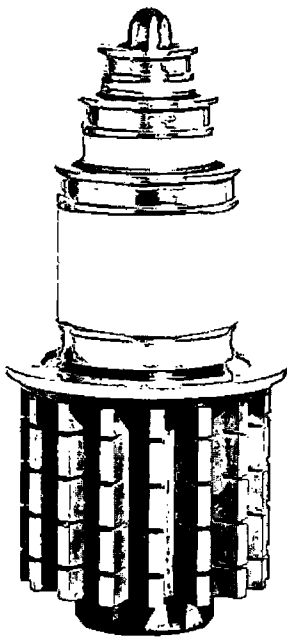


ML-7351A SPECTRAL RESPONSE CHARACTERISTICS



DIMENSIONS — ML-7351A

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U. S. A.
ST-1932 4.5M 2-63
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MACHLETT

ML-7479

DESCRIPTION & RATINGS

DESCRIPTION

The ML-7479 is a general-purpose vapor-cooled triode conservatively designed for 40-50 kW industrial heating and AM broadcast service.

The anode is designed to dissipate 50 kilowatts, and substantially higher power during momentary overloads or intermittent operation. It features greater mass than usual, with thick external ribs or protrusions. Efficient cooling is accomplished by vaporization of water in a boiler* and transport of the vapor to a secondary cooling circuit at a temperature of about 100°C. Sturdy coaxial grid and cathode mounting structures provide low-inductance, high-dissipation r-f terminals. The cathode itself is a sturdy, self-supporting, stress-free, thoriated-tungsten filament. Envelope insulation members are strong, low-loss, ceramic cylinders.

Maximum ratings of 12.5 kVdc plate voltage and 90 kW plate input apply at frequencies up to 30 Mc. Useful power output can be obtained at frequencies up to 70 Mc at reduced plate voltage and plate input.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	8.0	Volts
Filament Current	200	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	0.0051	Ohms
Amplification Factor	20	
Interelectrode Capacitances:		
Grid-Plate	38	pf
Grid-Filament	58	pf
Plate-Filament	1.8	pf

Mechanical

Mounting Position	Vertical, Anode Down	
Type of Cooling, Anode	Vaporization of water	
Air Flow on Bulb and Seals, approximate	100	cfm
Maximum Ceramic Temperature	165	°C
Net Weight, approximate	38	lb.

*For information on boiler and application details, consult the Machlett Laboratories Engineering Department.

**At frequencies up to 15 Mc, air flow should be directed primarily on filament seals and the main ceramic bulb; at higher frequencies or high ambient temperatures, additional air flow may be required on the grid seals. Air flow should be distributed to maintain uniform temperature, not greater than 165°C, around the circumference of the seals.

from JEDEC release #3954, Oct. 29, 1962

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	12500	volts
Max.-Signal D-C Plate Current*	7.0	amps
Max.-Signal Plate Input*	90	kW
Plate Dissipation*	50	kW

Typical Operation (Values are for two tubes)

D-C Grid Voltage	8500	10000	12000	volts
D-C Plate Voltage	−400	−500	−550	volts
Peak A-F Grid-to-Grid Voltage	1600	1940	2120	volts
Peak A-F Plate-to-Plate Voltage	14000	16000	19000	volts
Zero-Signal D-C Plate Current	1.3	1.2	2.4	amps
Max.-Signal D-C Plate Current	7.8	10.0	12.4	amps
Effective Load Resistance, Plate-to-Plate	2300	2000	1950	ohms
Max.-Signal Driving Power, approximate	200	200	170	watts
Max.-Signal Power Output, approximate	42	63	93	kW

*Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	12500	volts
D-C Plate Current	6.0	amps
Plate Input	75	kW
Plate Dissipation	50	kW

Typical Operation

D-C Plate Voltage	12000	10000	12000	volts
D-C Grid Voltage	−550	−450	−550	volts
Peak R-F Grid Voltage	550	580	600	volts
Peak R-F Plate Voltage	5400	4200	5300	volts
D-C Plate Current	2.6	3.6	3.2	amps
D-C Grid Current	0	0	0	mA
R-F Load Resistance	1330	730	1040	ohms
Driving Power, approximate**	350	550	480	watts
Power Output, approximate	11	12	13.5	kW

**At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	9000	volts
D-C Grid Voltage	−2000	volts
D-C Plate Current	6.0	amps
D-C Grid Current	1.0	amp
Plate Input	60	kW
Plate Dissipation	32	kW

Typical Operation

D-C Plate Voltage	8500	volts
D-C Grid Voltage	−1400	volts
Peak R-F Grid Voltage	2140	volts
Peak R-F Plate Voltage	7000	volts
D-C Plate Current	4.8	amps
D-C Grid Current	0.50	amp
R-F Load Resistance	800	ohms
Driving Power, approximate	1.1	kW
Power Output, approximate	30.7	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	7500	12500	volts
D-C Grid Voltage	−2000	−2000	volts
D-C Plate Current	8.0	8.0	amps
D-C Grid Current	0.8	1.0	amp
Plate Input	54	90	kW
Plate Dissipation	50	50	kW
Frequency	70	30	Mc

Typical Operation	Cathode-Drive Circuitry	Grid-Drive Circuitry			
D-C Plate Voltage	7500	10000	12000	12000	volts
D-C Grid Voltage	−850	−1100	−1200	−1200	volts
Peak R-F Grid Voltage	1500	1880	1880	1940	volts
Peak R-F Plate Voltage	5600	8000	10000	9800	volts
D-C Plate Current	5.3	6.5	5.4	6.4	amps
D-C Grid Current	0.35	0.48	0.30	0.35	amp
R-F Load Resistance	750	700	550	870	ohms
Driving Power, approx.	7500	900	550	670	watts
Power Output, approx.	33§	46.4	48.5	55.4	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

§Includes power transferred from driver stage.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Maximum	
Grid Voltage	e_b = 1500 volts; i_b = 28 amps	e_c:	——	——	1000	volts
Grid Current	e_b = 1500 volts; i_b = 28 amps	i_c:	——	——	8.5	amps
Plate Voltage	E_c = 0 Vdc; I_b = 3.0 Adc	E_b:	3.3	3.8	4.3	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 3.0 Adc	E_b:	7.2	7.8	8.4	kVdc
Grid Voltage	E_b = 10.0 kVdc; I_b = 0.02 Adc	E_c:	−480	−560	−640	Vdc
Plate Power Output	E_b = 12.0 Adc; E_c = −1200 Vdc I_b = 5.4 Adc; I_c = 0.30 Adc	P_o:	40	——	——	kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply at frequencies up to 30 Mc except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

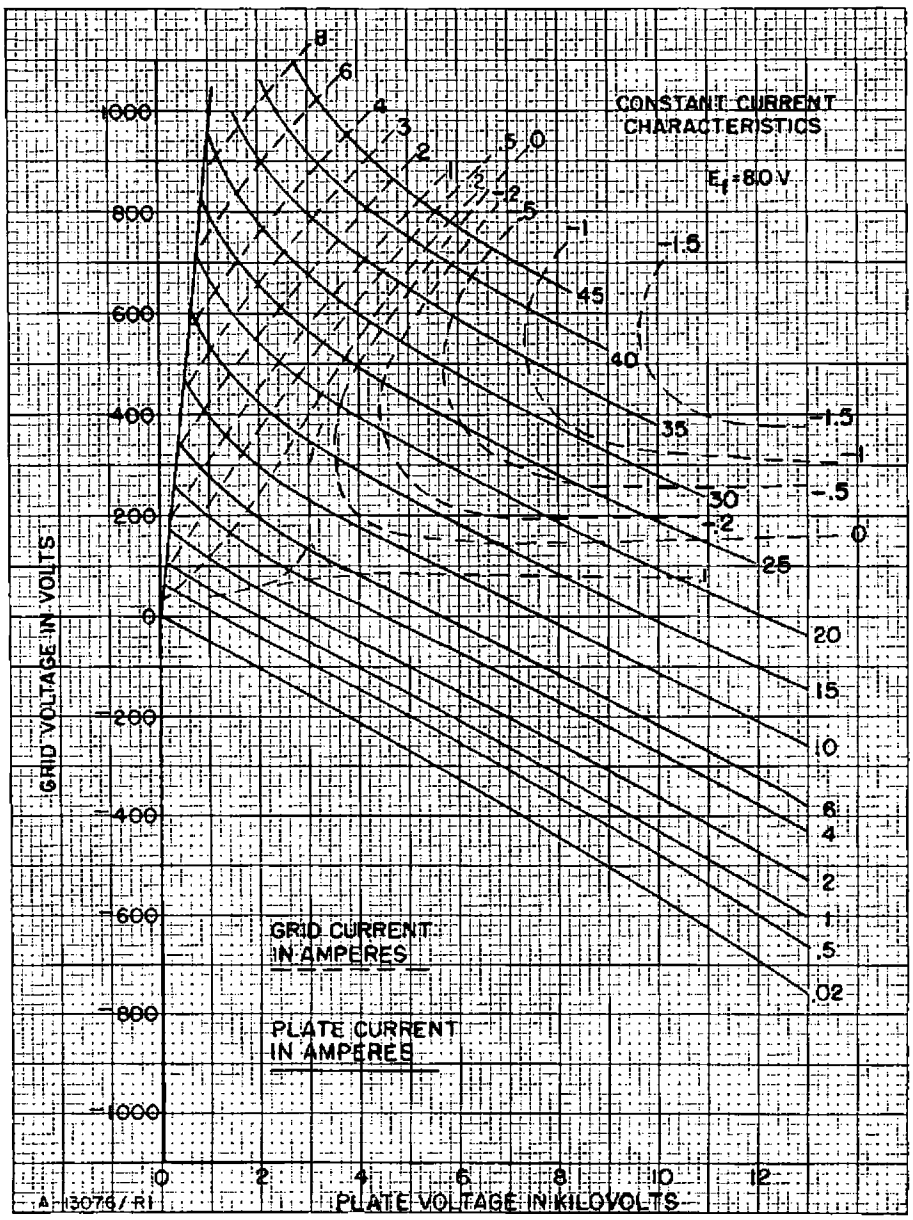
Frequency	30	50	70 Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60

APPLICATION NOTES

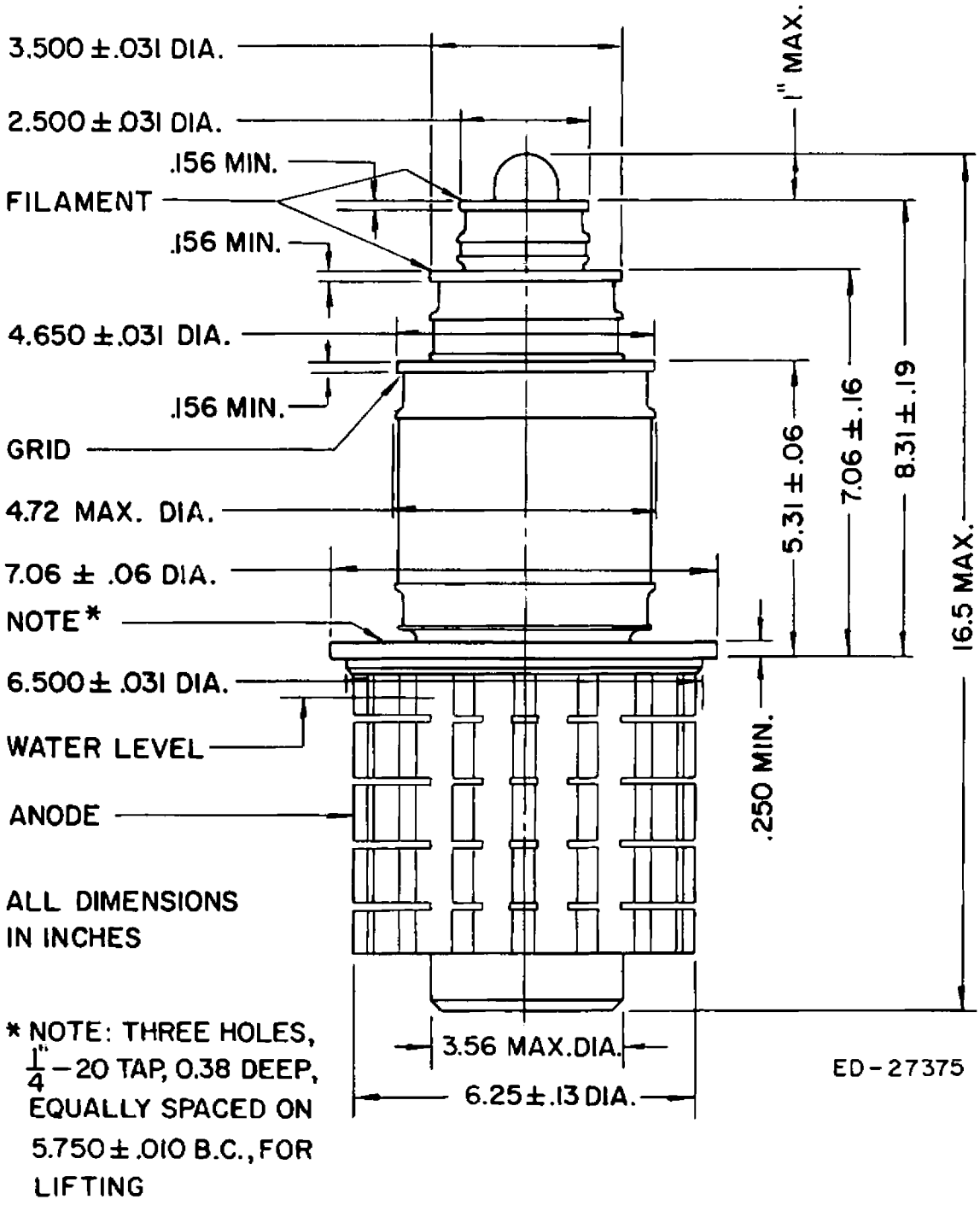
The handling of high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can severely damage the electron tube if not properly controlled. Therefore the ground leads of the plate and grid circuits should be equipped with individual quick-acting overload relays which will remove power from these circuits within 1/10 second.

Additional protection is recommended and may be obtained by connecting a resistor in series with the plate lead of each tube for protection of the tube during the time required for the plate overload relay to act. The criterion is the total energy to which the tube can be subjected. The minimum value of resistance which will give adequate protection with reasonably low power loss is as follows:

Maximum Power Output of Rectifier	80	160	320	640 kW
Series Resistor	15	25	40	60 ohms



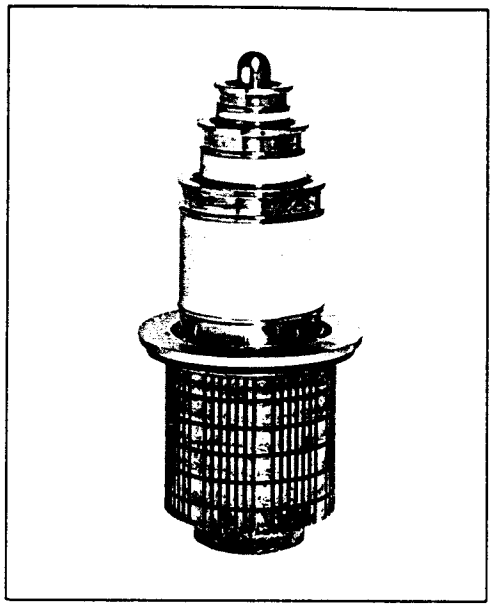
CONSTANT CURRENT CHARACTERISTICS — ML-7479



DIMENSIONS — ML-7479

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ST-1910 5M 8-62
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1063 Hope Street • Stamford, Conn. 06907
Tel. 203-348-7511 • TWX 710-474-1744



ISSUED 4-68

ML-7479A

MACHLETT

General Purpose Triode
55 kW CW

DESCRIPTION

The ML-7479A is a general-purpose vapor-cooled triode conservatively designed for 40-50 kW industrial heating and AM broadcast service.

The anode is designed to dissipate 50 kilowatts, and substantially higher power during momentary overloads or intermittent operation. Efficient cooling is accomplished by vaporization of water in a jacket and transport of the vapor to a secondary cooling circuit at a temperature of about 100°C. Sturdy coaxial grid and cathode mounting structures provide low-inductance, high-dissipation rf terminals. The cathode consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments. Envelope insulation members are strong, low-loss, ceramic cylinders.

Maximum ratings of 12.5 kVdc plate voltage and 90 kW plate input apply at frequencies up to 40 MHz. Useful power output can be obtained at frequencies up to 80 MHz at reduced plate voltage and plate input.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	8.0	Volts
Filament Current	200	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	0.0051	Ohm
Amplification Factor	20	
Interelectrode Capacitances		
Grid-Plate	38	pf
Grid-Filament	58	pf
Plate-Filament, maximum	2.5	pf

Mechanical

Mounting Position	Vertical, Anode Down	
Type of Cooling, Anode	Vaporization of water	
Air Flow on Bulb and Seals, approximate	100	cfm*
Maximum Envelope Temperature	200	°C
Net Weight, approximate	44	lb.

* At frequencies up to 15 MHz, air flow should be directed primarily on filament seals and the main ceramic bulb; at higher frequencies or high ambient temperatures, additional air flow may be required on the grid seals. Air flow should be distributed to maintain uniform temperature, not greater than 200 °C, around the circumference of the seals.

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources."

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	12500	volts
Max.-Signal D-C Plate Current*	8.0	amps
Max.-Signal Plate Input*	90	kW
Plate Dissipation*	50	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	8500	10000	12000	volts
D-C Grid Voltage	−400	−500	−550	volts
Peak A-F Grid-to-Grid Voltage	1600	1940	2120	volts
Peak A-F Plate-to-Plate Voltage	14000	16000	19000	volts
Zero-Signal D-C Plate Current	1.3	1.2	2.4	amps
Max.-Signal D-C Plate Current	7.8	10.0	12.4	amps
Effective Load Resistance, Plate-to-Plate	2300	2000	1950	ohms
Max.-Signal Driving Power, approximate	200	200	170	watts
Max.-Signal Power Output, approximate	42	63	93	kW

*Averaged over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	12500	volts
D-C Plate Current	8.0	amps
Plate Input	75	kW
Plate Dissipation	50	kW

Typical Operation

D-C Plate Voltage	12000	10000	12000	volts
D-C Grid Voltage	−550	−450	−550	volts
Peak R-F Grid Voltage	550	580	600	volts
Peak R-F Plate Voltage	5400	4200	5300	volts
D-C Plate Current	2.6	3.6	3.2	amps
D-C Grid Current	0	0	0	mA
R-F Load Resistance	1330	730	1040	ohms
Driving Power, approximate**	350	550	480	watts
Power Output, approximate	11	12	13.5	kW

**At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	9000	volts
D-C Grid Voltage	−2000	volts
D-C Plate Current	6.0	amps
D-C Grid Current	1.0	amp
Plate Input	60	kW
Plate Dissipation	32	kW

Typical Operation

D-C Plate Voltage	8500	volts
D-C Grid Voltage	−1400	volts
Peak R-F Grid Voltage	2140	volts
Peak R-F Plate Voltage	7000	volts
D-C Plate Current	4.8	amps
D-C Grid Current	0.50	amp
R-F Load Resistance	800	ohms
Driving Power, approximate	1.1	kW
Power Output, approximate	30.7	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	12500	volts
D-C Grid Voltage	−2000	volts
D-C Plate Current	8.0	amps
D-C Grid Current	1.0	amp
Plate Input	90	kW
Plate Dissipation	50	kW
Grid Dissipation	750	watts

Typical Operation	Cathode-Drive Circuitry	Grid-Drive Circuitry			
D-C Plate Voltage	7500	10000	12000	12000	volts
D-C Grid Voltage	−850	−1100	−1200	−1200	volts
Peak R-F Grid Voltage	1500	1880	1880	1940	volts
Peak R-F Plate Voltage	5600	8000	10000	9800	volts
D-C Plate Current	5.3	6.5	5.4	6.4	amps
D-C Grid Current	0.35	0.48	0.30	0.35	amp
R-F Load Resistance	750	700	550	870	ohms
Driving Power, approx.	7500	900	550	670	watts
Power Output, approx.	33§	46.4	48.5	55.4	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

§Includes power transferred from driver stage.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Maximum	
Grid Voltage	e_b = 1500 volts; i_b = 28 amps	e_c:	——	——	1000	volts
Grid Current	e_b = 1500 volts; i_b = 28 amps	i_c:	——	——	8.5	amps
Plate Voltage	E_c = 0 Vdc; I_b = 3.0 Adc	E_b:	3.3	3.8	4.3	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 3.0 Adc	E_b:	7.2	7.8	8.4	kVdc
Grid Voltage	E_b = 12.0 kVdc; I_b = 0.02 Adc	E_c:	−570	−670	−800	Vdc
Plate Power Output	E_b = 12.0 kVdc; E_c = −1200 Vdc; I_b = 5.4 Adc; I_c = 0.30 Adc	P_o:	40	——	——	kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply at frequencies up to 40 MHz except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

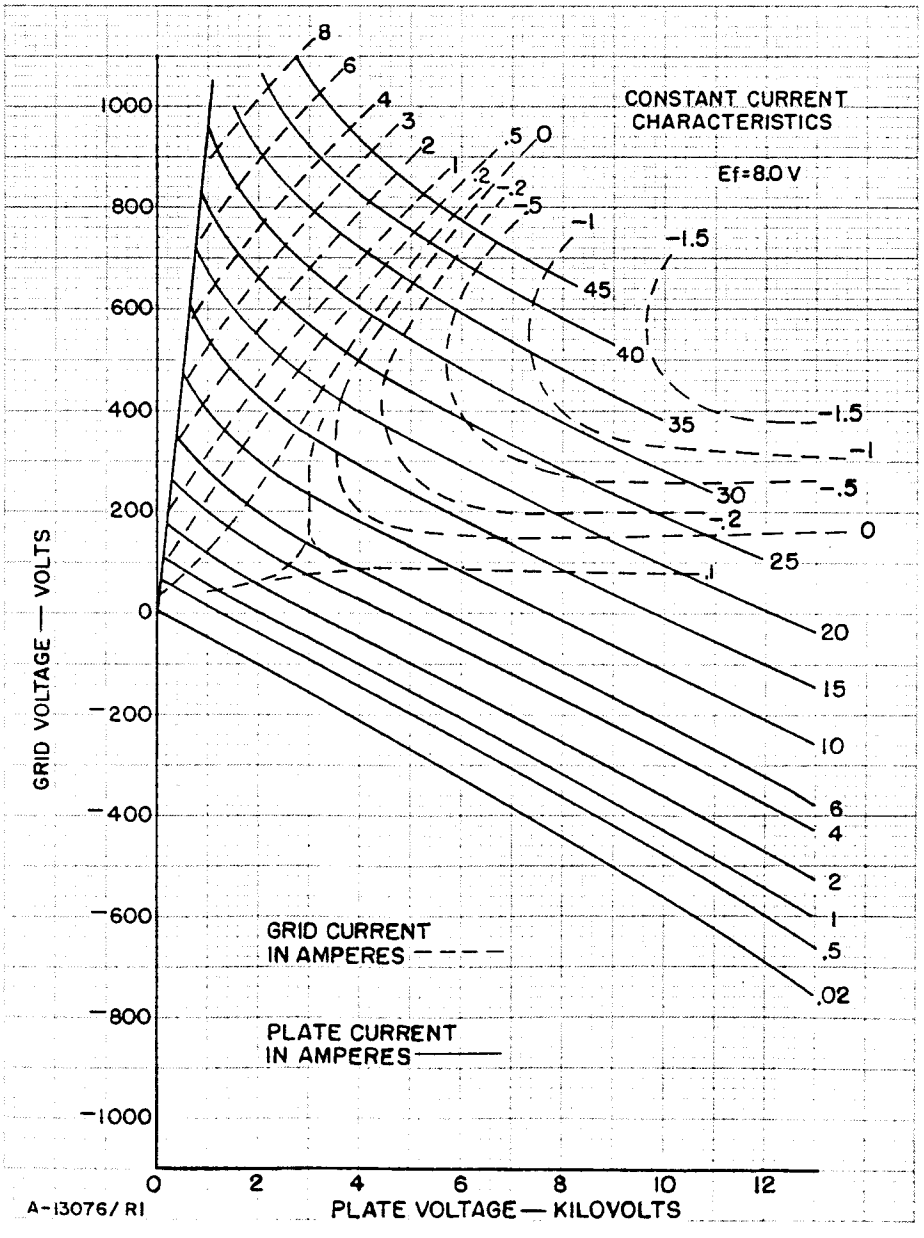
Frequency	40	60	80MHz
Percent Maximum Rated Plate Voltage and Plate Input	100	75	50%

APPLICATION NOTES

The handling of high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can severely damage the electron tube if not properly controlled. Therefore the ground leads of the plate and grid circuits should be equipped with individual quick-acting overload relays which will remove power from these circuits within 1/10 second.

Additional protection is recommended and may be obtained by connecting a resistor in series with the plate lead of each tube for protection of the tube during the time required for the plate overload relay to act. The criterion is the total energy to which the tube can be subjected. The minimum value of resistance which will give adequate protection with reasonably low power loss is as follows:

Maximum Power Output of Rectifier	80	160	320	640 kW
Series Resistor	15	25	40	60 ohms

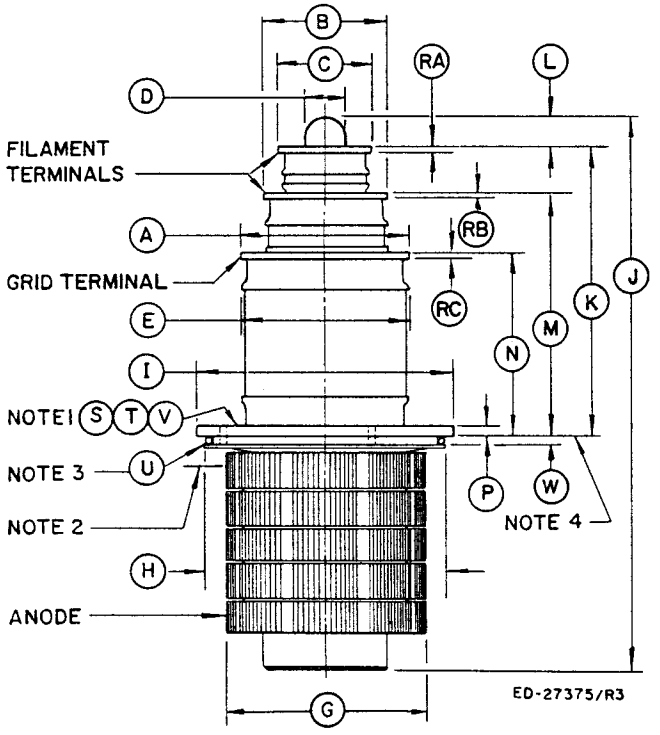


CONSTANT CURRENT CHARACTERISTICS — ML-7479A

ACCESSORIES

Item	Part. No.
Small Filament Connector	F-17488
Large Filament Connector	F-17489
Grid Connector	F-17397
O Ring	P-512126
Jacket for Vapor-Up System, 50 kW	F-27893
Jacket for Vapor-Down System, 50 kW	F-28901

NOTE: For additional information on accessories, refer to Accessory Data Sheet No. ST-2236.



DIMENSIONS FOR OUTLINE OF ML-7479A

Ref	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.62	4.65	4.68	
B	3.47	3.50	3.53	
C	2.47	2.50	2.53	
D	—	1.12	1.19	
E	—	4.63	5.38	
G	—	5.38	5.42	
H	6.47	6.50	6.53	
I	7.00	7.00	7.12	
J	—	—	16.5	
K	7.93	8.12	8.50	
L	—	—	1.00	
M	6.71	6.87	7.22	
N	5.06	5.12	5.37	
P	.25	.31	—	
RA	.15	.19	—	
RB	.15	.19	—	
RC	.15	.19	—	
S	5.74	5.75	5.76	1
T	.38	.50	—	1
U	6.559	6.562	6.565	3
V	4.96	4.98	5.00	1
W	.249	.264	.279	

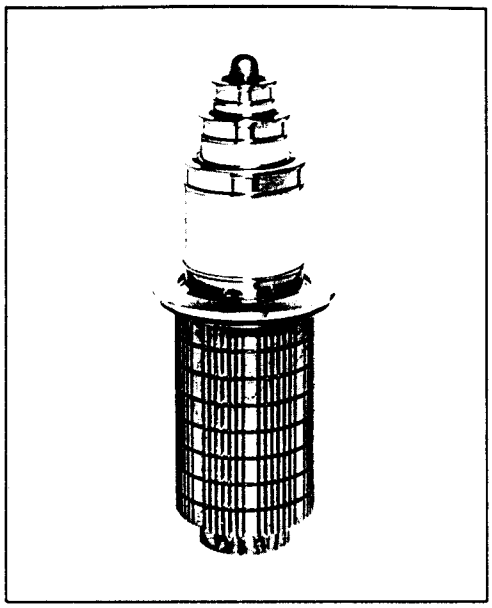
NOTES:

1. Three holes, ¼"-20 tap, (T) inches deep, on a circle of diameter (S), spaced at chordal distances (V).
2. Water level for vapor-up cooling system.
3. Hole of diameter (U) recommended for sealing tube in jacket. O-ring gasket, Machlett Part No. P-512126, supplied with tube.
4. Tube supported by this surface only.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

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ST-2261 4.5M 4-68

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ISSUED 4-68

ML-7480A

MACHLETT

General Purpose Triode
80 kW CW

DESCRIPTION

The ML-7480A is a general-purpose vapor-cooled triode conservatively designed for 50-75 kW industrial heating and AM broadcasting service.

The anode is designed to dissipate 80 kilowatts, and substantially higher power during momentary overloads or intermittent operation. Efficient cooling is accomplished by vaporization of water in a jacket and transport of the vapor to a secondary cooling circuit at a temperature of about 100°C. Sturdy coaxial grid and cathode mounting structures provide low-inductance, high-dissipation r-f terminals. The cathode consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments. Envelope insulation members are strong, low-loss, ceramic cylinders.

Maximum ratings of 16 kVdc plate voltage and 140 kW plate input apply at frequencies up to 40 MHz. Useful power output can be obtained at frequencies up to 80 MHz at reduced plate voltage and plate input.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	13.0	Volts
Filament Current	205	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	0.007	Ohm
Amplification Factor	20	
Interelectrode Capacitances		
Grid-Plate	55	pf
Grid-Filament	75	pf
Plate-Filament, maximum	3.2	pf

Mechanical

Mounting Position	Vertical, Anode Down	
Type of Cooling, Anode	Vaporization of water	
Air Flow on Bulb and Seals, approximate	100	cfm*
Maximum Envelope Temperature	200	°C
Net Weight, approximate	44	lb.

* At frequencies up to 15 MHz, air flow should be directed primarily on filament seals and the main ceramic bulb; at higher frequencies or high ambient temperatures, additional air flow may be required on the grid seals. Air flow should be distributed to maintain uniform temperature, not greater than 200 °C, around the circumference of the seals.

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources."

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	16000	volts
Max.-Signal D-C Plate Current*	11	amps
Max.-Signal Plate Input*	120	kW
Plate Dissipation	80	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	10000	12000	volts
D-C Grid Voltage	−450	−600	volts
Peak A-F Grid-to-Grid Voltage	1750	2120	volts
Peak A-F Plate-to-Plate Voltage	16000	19200	volts
Zero Signal D-C Plate Current	3.0	2.0	amps
Max.-Signal D-C Plate Current	17.4	20.0	amps
Effective Load Resistance, Plate-to-Plate	1170	1230	ohms
Max.-Signal Driving Power, approx.	550	600	watts
Max.-Signal Power Output, approx.	110	152	kW

*Average over any audio-frequency cycle of sine-wave form.

Radio-Frequency Power Amplifier Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage	16000	volts
D-C Plate Current	9	amps
Plate Input	100	kW
Plate Dissipation	80	kW

Typical Operation

D-C Plate Voltage	12000	12000	volts
D-C Grid Voltage	−550	−550	volts
Peak R-F Grid Voltage	510	640	volts
Peak R-F Plate Voltage	5300	5300	volts
D-C Plate Current	4.3	6.8	amps
D-C Grid Current	0	0	mA
R-F Load Resistance	780	500	ohms
Driving Power, approx.†	450	1500	watts
Power Output, approx.	18	28	kW

†At crest of audio-frequency cycle with modulation factor of 1.0.

Plate-Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

D-C Plate Voltage	10000	volts
D-C Grid Voltage	−3200	volts
D-C Plate Current	8.5	amps
D-C Grid Current	2.0	amps
Plate Input	85	kW
Plate Dissipation	53	kW

Typical Operation

D-C Plate Voltage	9500	volts
D-C Grid Voltage	−1600	volts
Peak R-F Grid Voltage	2300	volts
Peak R-F Plate Voltage	7800	volts
D-C Plate Current	8.4	amps
D-C Grid Current	0.90	amp
R-F Load Resistance	510	ohms
Driving Power, approx.	2.0	kW
Power Output, approx.	60	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values

D-C Plate Voltage	16000	volts
D-C Grid Voltage	−3500	volts
D-C Plate Current	11	amps
D-C Grid Current	2.0	amps
Plate Input	140	kW
Plate Dissipation	80	kW
Grid Dissipation	1000	watts

Typical Operation

D-C Plate Voltage	10000	15000	volts
D-C Grid Voltage	−1200	−1600	volts
Peak R-F Grid Voltage	1900	2120	volts
Peak R-F Plate Voltage	8000	12500	volts
D-C Plate Current	10.0	7.0	amps
D-C Grid Current	0.81	0.30	amp
R-F Load Resistance	440	970	ohms
Driving Power, approx.	1.5	0.60	kW
Power Output, approx.	72	80	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 1500 volts; i_b = 48 amps	e_c:	——	——	1000	volts
Grid Current	e_b = 1500 volts; i_b = 48 amps	i_c:	——	——	15	amps
Plate Voltage	E_c = 0 Vdc; I_b = 3.0 Adc	E_b:	1.9	2.4	2.9	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 3.0 Adc	E_b:	5.6	6.4	7.2	kVdc
Grid Voltage	E_b = 15.0 kVdc; I_b = 0.020 Adc	E_c:	−700	−820	−940	Vdc
Plate Power Output	E_b = 15.0 kVdc; I_b = 7.0 Adc E_c = −1600 Vdc; I_c = 0.30 Adc	P_o:	68	68	——	kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 40 MHz except as noted. The tube may be operated at higher frequencies provided the maximum values of plate voltage and power input are reduced according to the tabulation on the right. (Other maximum ratings are the same as shown above.) Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	40	60	80 MHz
Percent Maximum Rated Plate Voltage and Plate Input	100	75	50%

APPLICATION NOTES

Introduction

All high-power vacuum tubes require some aging when they are first used in any new equipment or new environment. As the system power level increases, particularly if attended by a decrease in impedance level, it becomes increasingly important to spend enough time to acclimate the tube to the desired conditions of operation. *There is no substitute for seasoning the tube in the actual equipment in which it is to operate.* Once the procedure has been followed, however, the tube generally will be available for substantially immediate operation, unless it has been idle for an extended period of time, say three months or more.

Aging Procedure

The aging schedule will vary with the particular operating and environmental conditions. A general procedure which will serve as a starting point is to operate the tube for approximately one-half hour at each of the following steps:

(a) filament voltage only;

(b) partial plate voltage, drive and load, up to about one-half normal;

(c) full plate voltage, drive and load.

The length of time necessary for break-in to insure reliable operation can vary widely. Only experience will tell whether the above procedure can be shortened, or whether steps (b) and (c) must be extended, perhaps by a factor of two or three. The major factors affecting break-in time are the *method of applying plate voltage,* the type of *protective circuitry* available to remove power in the event of a fault, and, for a spare tube, the length of time since it had been removed from normal operation.

Plate voltage is applied preferably by continuous or stepped control. Snap-on of full plate voltage with no load may develop excessive transients which cause breakdown in the tube or other circuit components. If the voltage must be snapped on at full value, at least some load should be placed on the power transformer to limit transients to 120 percent of the d-c voltage.

Tube Protection

Fault overloads, due to tube or circuit instabilities, may result in the following conditions:

(a) liberation of gas in the tube;

(b) gross damage to internal elements, e.g. melting of grid wires;

(c) external arcing over electrodes, with damage to seals and possible puncture of envelope insulator.

A tube which becomes gassy often can be cleaned up successfully by patient reaging. The other conditions listed above are usually catastrophic.

The criteria for tube protection are the total energy which may be imparted to the tube, and the peak voltage which may appear across the electrodes. The total energy available depends on the *power source impedance,* including effect of transmission lines, and the *energy stored* in the transformer and filter components; on the *series resistance* in the circuit; and on the *duration of the discharge* or fault condition.

Primary power characteristics often are not known by the equipment designer, and the major energy-storage components usually are fixed by circuit performance requirements. Tube protection, then, is reduced to limiting surges by the design of certain components, including in the circuit at least some dissipative elements, i.e. resistance, and to sensing and removing any incipient surge as quickly as possible. The foregoing uncertainties make it difficult to specify the minimum requirements for sufficient tube protection under a given set of circumstances.

Protective Devices and Circuitry

Heretofore, it has been customary to equip plate and grid circuits with overload relays adjusted to open the circuit breakers within one-tenth of a second. In many applications, particularly where the impedance of the primary power source is low or where there is appreciable stored energy, the devices referred to above offer inadequate protection.

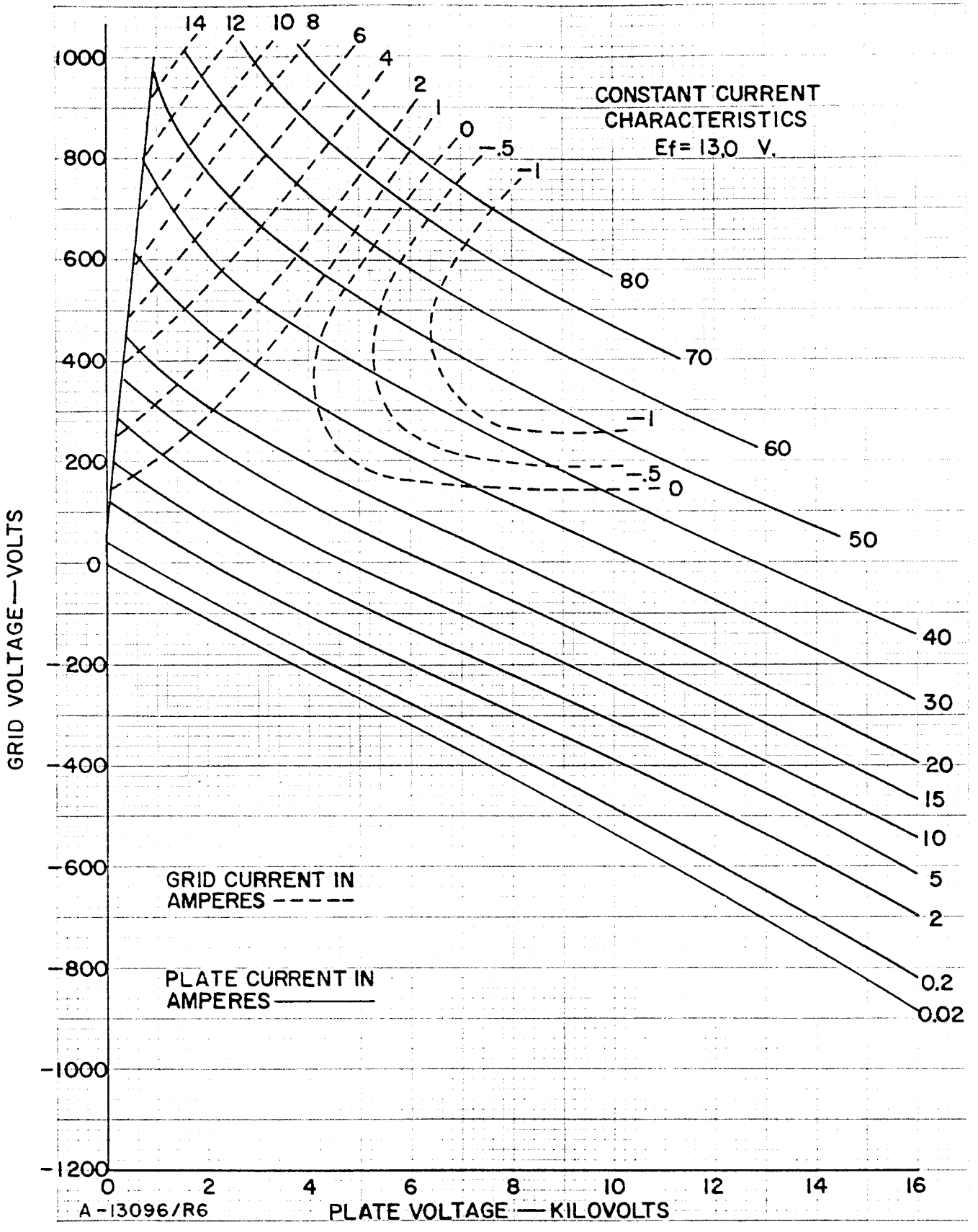
For high reliability and freedom from gassing and catastrophic failures, the use of an electronic shorting device or *"crowbar"* is recommended. In this case a thyratron, ignitron, or other suitable gaseous conduction device is connected to short the rectifier output to ground within 10 microseconds in the event of a fault condition. The electronic crowbar functions to divert the fault energy from the protected tube until the relay and circuit breakers act. Where multiple tubes are used with a common power supply, this type of crowbar is certainly necessary. This type of high-speed removal of fault energy has been extremely effective in reducing break-in time, and the lower the power supply impedance, the more impressive is the effect.

In some cases adequate protection can be obtained by using a vacuum switch, (a) connected as above, or (b) as a circuit breaker, replacing the usual slower acting types. These devices can divert, or remove, the fault energy in the order of one-half cycle. A vacuum-switch circuit breaker can, of course, be used to advantage in combination with the high-speed electronic shorting device. *The latter arrangement probably gives the best over-all protection to the tube and other circuit components.*

In addition, some *series resistance* should be used in the output of the power supply to limit the surge current from the transformer. Preferably, resistors may be placed in series with each rectifier lead to provide equal protection with substantially less power dissipated during normal operation. The amount of resistance will vary with circuit conditions and the speed of the protective circuitry, but the following values can be given as a guide:

Maximum Power Output of Rectifier	120	250	500	1000	kW
Series Resistor	10	20	35	50	Ohms

The voltage ratings are established so that normal operation will not cause arcs to develop across the tube envelope. Any external arcing, therefore, is an indication that the rated voltages have been exceeded. To lessen the chance of permanently damaging the tube, it is helpful to attach suitable *sphere gaps,* or rings, to the electrode terminals. If the sphere gaps are properly installed, the most probable breakdown path is between the gaps rather than over the tube envelope. The gap separation must be carefully adjusted for each application. The spacing from the tube envelope to the gaps or rings, in general, should be equal to or greater than the gap separation.

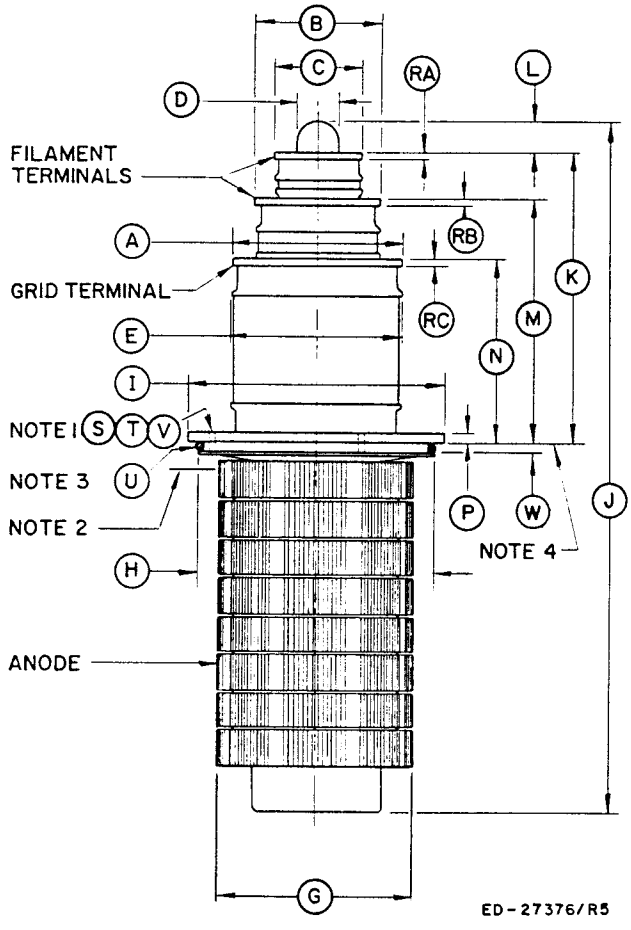


CONSTANT CURRENT CHARACTERISTICS—ML-7480A

ACCESSORIES

Item	Part. No.
Small Filament Connector	F-17488
Large Filament Connector	F-17489
Grid Connector	F-17397
O Ring	P-512126
Jacket for Vapor-Up System, 100 kW	F-27889
Jacket for Vapor-Down System, 100 kW	F-27891

NOTE: For additional information on accessories, refer to Accessory Data Sheet No. ST-2236.



DIMENSIONS FOR OUTLINE OF ML-7480A

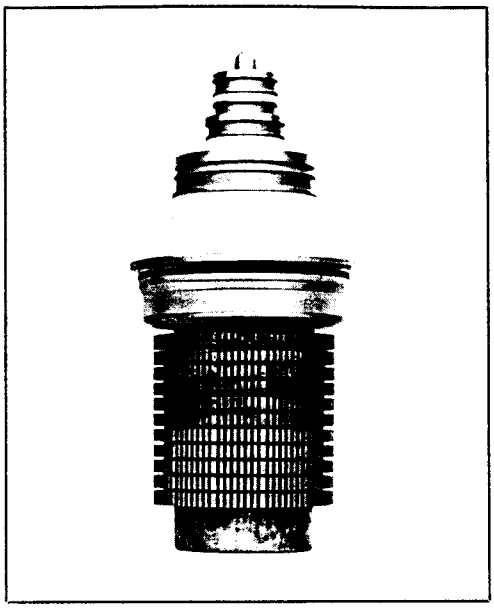
Ref	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.62	4.65	4.68	
B	3.47	3.50	3.53	
C	2.47	2.50	2.53	
D	—	1.12	1.19	
E	—	4.63	5.38	
G	—	5.38	5.42	
H	6.47	6.50	6.53	
I	7.00	7.00	7.12	
J	—	—	20.13	
K	7.93	8.12	8.50	
L	—	—	1.00	
M	6.71	6.87	7.22	
N	5.06	5.12	5.37	
P	.25	.31	—	
RA	.15	.19	—	
RB	.15	.19	—	
RC	.15	.19	—	
S	5.74	5.75	5.76	1
T	.38	.50	—	1
U	6.559	6.562	6.565	3
V	4.96	4.98	5.00	1
W	.249	.264	.279	

NOTES:

1. Three holes, ¼"-20 tap, (T) inches deep, on a circle of diameter (S), spaced at chordal distances (V).
2. Water level for vapor-up cooling system.
3. Hole of diameter (U) recommended for sealing tube in jacket. O-ring gasket, Machlett Part No. P-512126, supplied with tube.
4. Tube supported by this surface only.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

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ST-2262 4.5M 4-68



ISSUED 9-65

ML-7482

General Purpose Triode

440 kW CW

MACHLETT

ELECTRON TUBE SPECIALIST

DESRIPTION

The ML-7482 is a general-purpose vapor-cooled triode capable of 440 kilowatts continuous output as a Class C amplifier or oscillator at frequencies up to 30 Mc.

The anode is designed to dissipate 200 kilowatts, and substantially higher power during momentary overloads or intermittent operation. Efficient cooling is accomplished by vaporization of water in a boiler and transport of the vapor to a secondary cooling circuit at a temperature of about 100°C. Sturdy coaxial grid and cathode mounting structures provide low-inductance, high-dissipation rf terminals. The cathode consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments. Envelope insulation members are strong, low-loss, ceramic cylinders.

The maximum rating of 20 kVdc plate voltage applys at frequencies up to 30 Mc. Useful power output can be obtained at frequencies up to 110 Mc at reduced plate voltage.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	14.5	V*
Filament Current	450	A
Filament Starting Current, maximum	1200	A
Filament Cold Resistance	.0035	ohms
Amplification Factor	45	
Interelectrode Capacitances		
Grid-Plate	75	pf
Grid-Filament	200	pf
Plate-Filament	4	pf

Mechanical

Mounting Position	Vertical, Anode Down	
Type of Cooling, Anode	Vaporization of water	
Air Flow on Bulb and Seals, approximate	500	cfm**
Maximum Ceramic Temperature	165	°C
Net Weight, approximate	120	lb

*For older tubes with serial numbers lower than 476,000, the filament must be operated at 16.5 volts.

**At frequencies up to 15 Mc, air flow should be directed primarily on filament seals and the main ceramic bulb; at higher frequencies or high ambient temperatures, additional air flow may be required on the grid seals. Air flow should be distributed to maintain uniform temperature, not greater than 165°C, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Continuous Commercial Service

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values			
DC Plate Voltage		20000	V
Maximum-Signal DC Plate Current*		30	A
Plate Dissipation*		200	kW
Typical Operation (Values are for two tubes)			
DC Plate Voltage	12000	15000	V
DC Grid Voltage	−250	−320	V
Peak AF Grid-to-Grid Voltage	960	1740	v
Peak AF Plate-to-Plate Voltage	20400	25200	v
Zero-Signal DC Plate Current	2	2	A
Maximum-Signal DC Plate Current	20	56	A
Effective Load Resistance, Plate-to-Plate	1300	570	ohms
Max.-Signal Driving Power, approximate	.8	5	kW
Max.-Signal Power Output, approximate	160	550	kW

*Averaged over any audio-frequency cycle of sine-wave form.

Linear RF Power Amplifier — Class AB Single-Sideband Suppressed-Carrier Service

Maximum Ratings, Absolute Values			
DC Plate Voltage		20000	V
Grid Dissipation		2500	W
Plate Dissipation		200	kW
Typical Operation, Cathode-Drive	2-tone	16-tone†	
DC Plate Voltage	20000	20000	V
DC Grid Voltage	−450	−450	V
Zero-Signal DC Plate Current	1	1	A
Maximum-Signal Peak Plate Current	54	135	a
Maximum-Signal Peak RF Grid Voltage	690	1100	v
Maximum-Signal Peak Driving Power	10	40	kw
Peak Envelope Power Output ‡	230	580	kw
Average Power Output, approximate	115	58	kW

†With peak-envelope to average power ratio of approximately 10.
‡Includes power transferred from driver stage.

Plate-Modulated RF Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values			
DC Plate Voltage		15000	V
DC Grid Voltage		−1500	V
DC Plate Current		20	A
DC Grid Current		4	A
Plate Dissipation		130	kW
Typical Operation	Cathode Drive		
DC Plate Voltage	12000	14000	V
DC Grid Voltage	−800	−1000	V
Peak RF Grid Voltage	1350	1630	v
Peak RF Plate Voltage	10600	11800	v
DC Plate Current	13.5	20.5	A
DC Grid Current	3.5	3.5	A
RF Load Impedance	490	320	ohms
Driving Power, approximate	20	5.7	kW
Power Output, approximate	145§	220	kW

§Includes power transferred from driver stage.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation▲

Maximum Ratings, Absolute Values			
DC Plate Voltage		20000	V
DC Grid Voltage		−1500	V
DC Plate Current		35	A
DC Grid Current		4	A
Plate Dissipation		200	kW
Typical Operation			
DC Plate Voltage	14000	20000	V
DC Grid Voltage	−600	−1000	V
Peak RF Grid Voltage	1200	1600	v
Peak RF Plate Voltage	12000	17400	v
DC Plate Current	25	29	A
DC Grid Current	3.6	3.4	A
RF Load Impedance	250	330	ohms
Driving Power, approximate	4.5	6	kW
Power Output, approximate	260	440	kW

▲Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

TUBE PROTECTION

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

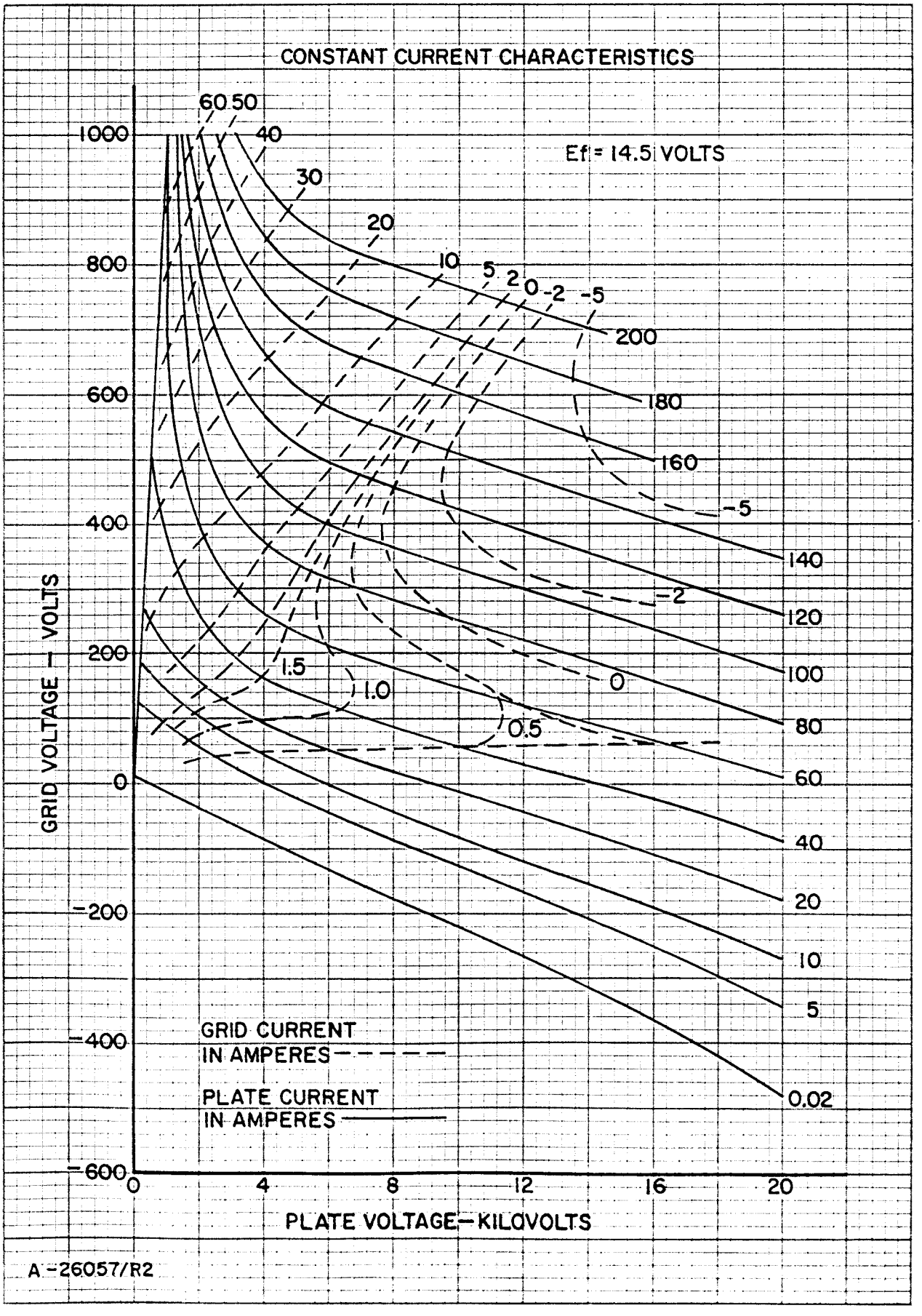
In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

References:

1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29,* 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press, 1,* 6, 1954.


CONSTANT CURRENT CHARACTERISTICS
Ef = 14.5 VOLTS
GRID VOLTAGE — VOLTS
PLATE VOLTAGE—KILOVOLTS
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
1000
800
600
400
200
0
-200
-400
-600
0
4
8
12
16
20
60
50
40
30
20
10
5
2
0
-2
-5
200
180
160
140
120
100
80
60
40
20
10
5
0.02
1.5
1.0
0.5
A-26057/R2

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 Mc except as noted. The tube may be operated at higher frequencies provided the maximum value of plate voltage is reduced according to the tabulation on the right. (Other maximum ratings are the same as shown above.) Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency	30	70	110 Mc
Percent Maximum Rated Plate Voltage	100	80	60%

ACCESSORIES

Item	Part No.
Small Filament Connector	F-27218
Small Filament Connector (Alternate)	F-28090
Large Filament Connector	F-27219
Grid Connector	F-27220
Two-Tube Dolly	S-16096
One-Tube Dolly	S-16097
O Ring	P-25946
Jacket for Vapor-Up System, 150 kW	P-27899
Jacket for Vapor-Up System, 250 kW	P-27890
Jacket for Vapor-Down System, 150 kW	P-28903
Jacket for Vapor-Down System, 200 kW	P-28905
Condenser Jacket, 200 kW	P-27870

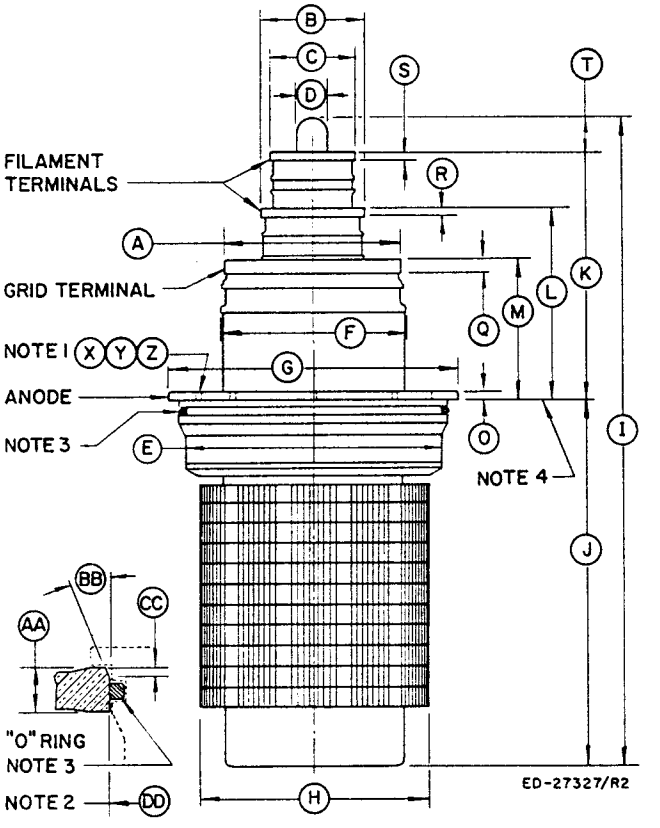
NOTE: Additional information on accessories will be supplied on request.

DIMENSIONS FOR OUTLINE OF ML-7482

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	6.907	6.938	6.969	
B	3.969	4.000	4.031	
C	3.282	3.313	3.344	
D	—	1.12	1.25	
E	—	10.00	10.13	
F	—	—	7.38	
G	11.25	11.31	11.37	
H	—	9.00	10.13	
I	—	—	26.3	
J	14.00	14.25	14.50	
K	9.45	9.75	10.05	
L	7.34	7.56	7.78	
M	5.37	5.56	5.75	
O	.344	.375	—	
Q	.500	.563	—	
R	.313	.375	—	
S	.313	.375	—	
T	—	—	1.75	
X	.44	.50	—	1
Y	9.60	9.63	9.66	1
Z	3.65	3.68	3.71	1
AA	—	.75	—	
BB	—	20°	—	degrees
CC	—	.19	—	
DD	10.498	10.503	10.508	2

NOTES:

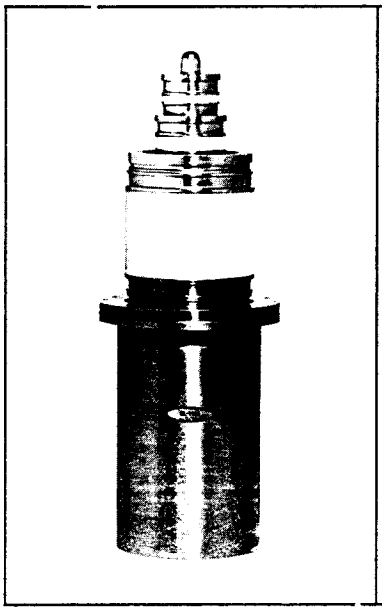
1. Eight holes, ¼-20 tap, (X) deep, on circle diameter (Y), spaced at chordal distances (Z). For lifting tube.
2. Recommended diameter of opening for tube in cooling jacket.
3. O ring, Machlett Part No. P-25946, supplied with tube.
4. Tube to be supported in equipment only by this surface.

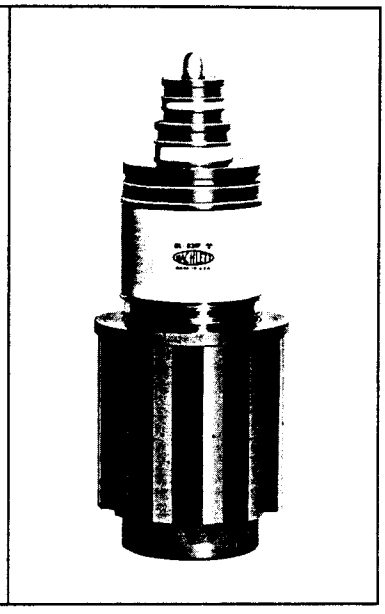


DETAIL OF RECOMMENDED OPENING IN COOLING JACKET

THE MACHLETT LABORATORIES, INC.
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ST-1806 5M 9-65
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ISSUED 5-64





ML-7560
ML-8317

General Purpose Triodes

440 kW CW

15 Mw Pulse Power

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7560 and ML-8317 are general-purpose triodes suitable for various rf and pulse applications. These tubes feature rugged coaxial mounting structures providing high-dissipation, low-inductance rf electrode terminals. The cathode of each type consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments. Envelope construction employs low-loss ceramics. The ML-7560 has a water-cooled, heavy-wall anode capable of dissipating 175 kW. The ML-8317 has a forced-air-cooled, heavy-wall anode with a high-efficiency copper fin structure capable of dissipating 60 kW. These tubes will operate with dc plate voltages up to 20 kV in CW operation or 50 kV in pulse modulator service. Maximum ratings apply at frequencies up to 30 Mc. Useful power output can be obtained at frequencies up to 110 Mc with reduced ratings.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	14.5	V*
Filament Current	450	A
Filament Starting Current, maximum	1200	A
Filament Cold Resistance	.0035	Ohms
Amplification Factor	45	
Interelectrode Capacitances		
Grid-Plate	75	pf
Grid-Filament	200	pf
Plate-Filament	4	pf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling — ML-7560	Water and forced-air	
Water flow on anode for 175 kW dissipation, minimum	40	gpm
Maximum outgoing water temperature	70	°C
Maximum water pressure	80	psi
Type of Cooling — ML-8317	Forced-air	
Air flow on anode for 60 kW dissipation, minimum	3000	cfm**
Maximum incoming air temperature	50	°C
Air Flow on Insulators and Seals, approximate	500	cfm***
Maximum Ceramic Temperature	165	°C
Net Weight, approximate		
ML-7560	110	lb
ML-8317	130	lb

*For cathode currents in excess of 350 amps, filament voltage must be 15.0 volts. For older tubes with serial numbers lower than 476,000, the filament must be operated at 16.5 volts for peak cathode currents up to 350 amps.

**When used with ML-8317 air distributor F-27836.

***At frequencies up to 15 Mc, air flow should be directed primarily on the filament seals and main ceramic insulator; at higher frequencies or high ambient temperatures, additional air flow may be required on the grid seals. Air flow should be distributed to maintain uniform temperature, not greater than 165°C, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Audio-Frequency Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values	ML-7560	ML-8317	
DC Plate Voltage	20000	20000	V
Max.-Signal DC Plate Current▲	30	20	A
Plate Dissipation▲	175	60	kW

Typical Operation (Values are for two tubes)	ML-7560		
DC Plate Voltage	15000	15000	V
DC Grid Voltage	−320	−320	V
Peak AF Grid-to-Grid Voltage	1740	1080	v
Peak AF Plate-to-Plate Voltage	25200	26000	v
Zero-Signal DC Plate Current	2	2	A
Max.-Signal DC Plate Current	56	23	A
Effective Load Resistance, Plate-to-Plate	570	1400	ohms
Max.-Signal Driving Power, approximate	5	1.1	kW
Max.-Signal Power Output, approximate	550	240	kW

Linear RF Power Amplifier — Class AB Single-Sideband Suppressed-Carrier Service

Maximum Ratings, Absolute Values	ML-7560	ML-8317	
DC Plate Voltage	20000	20000	V
Grid Dissipation	2500	2500	W
Plate Dissipation	175	60	kW

Typical Operation, Cathode-Drive, 2-tone	ML-7560		
DC Plate Voltage	20000	20000	V
DC Grid Voltage	−450	−450	V
Zero-Signal DC Plate Current	1	1	A
Maximum-Signal Peak Plate Current	54	27	a
Maximum-Signal Peak RF Grid Voltage	690	580	v
Maximum-Signal Driving Power	10	4	kW
Peak Envelope Power Output ‡	230	114	kW
Average Power Output, approximate	115	57	kW

Typical Operation Cathode-Drive, 16-tone†	
DC Plate Voltage	20000 V
DC Grid Voltage	−450 V
Zero-Signal DC Plate Current	1 A
Maximum-Signal Peak Plate Current	135 a
Maximum-Signal Peak RF Grid Voltage	1100 v
Maximum-Signal Peak Driving Power	41 kw
Peak Envelope Power Output ‡	585 kw
Average Power Output, approximate	58 kW

Plate-Modulated RF Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	ML-7560	ML-8317	
DC Plate Voltage	15000	15000	V
DC Grid Voltage	−1500	−1500	V
DC Plate Current	20	15	A
DC Grid Current	4.0	3	A
Plate Dissipation	115	40	kW

Typical Operation	ML-7560	
DC Plate Voltage	14000	V
DC Grid Voltage	−1000	V
Peak RF Grid Voltage	1630	v
Peak RF Plate Voltage	11800	v
DC Plate Current	20.5	A
DC Grid Current	3.5	A
RF Load Resistance	320	ohms
Driving Power, approximate	5.7	kW
Power Output, approximate	220	kW

Typical Operation, Cathode-Drive	ML-7560		
DC Plate Voltage	12000	12000	V
DC Grid Voltage	−800	−800	V
Peak RF Grid Voltage	1350	1200	v
Peak RF Plate Voltage	10600	10400	v
DC Plate Current	13.5	11.5	A
DC Grid Current	3.5	2	A
RF Load Resistance	490	550	ohms
Driving Power, approximate	20	15	kW
Power Output, approximate ‡	145	120	kW

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation§

Maximum Ratings, Absolute Values	ML-7560	ML-8317	
DC Plate Voltage	20000	20000	V
DC Grid Voltage	−1500	−1500	V
DC Plate Current	35	20	A
DC Grid Current	4.0	3	A
Plate Dissipation	175	60	kW

Typical Operation	ML-7560		
DC Plate Voltage	20000	20000	V
DC Grid Voltage	−1000	−1000	V
Peak RF Grid Voltage	1680	1320	v
Peak RF Plate Voltage	17400	18000	v
DC Plate Current	29	11	A
DC Grid Current	3.4	1.3	A
RF Load Resistance	330	900	ohms
Driving Power, approximate	6	2	kW
Power Output, approximate	440	175	kW

Plate-Pulsed RF Power Amplifier and Oscillator Class C

Maximum Ratings, Absolute Values	ML-7560	ML-8317	
Peak Plate Pulse Supply Voltage	40	40	kv
DC Grid Voltage	−3500	−3500	V
Peak Cathode Current	550	550	a
Grid Dissipation	3000	3000	W
Plate Dissipation	175	60	kW
Pulse Duration#	500	500	μs
Duty Factor#	.10	.05	

Typical Operation		
Peak Plate Pulse Supply Voltage	40	kv
DC Grid Voltage	—1400	V
Peak RF Grid Voltage	3000	v
Peak RF Plate Voltage	34	kv
Peak Plate Current from Pulse Supply	100	a
Peak Rectified Grid Current	16	a
RF Load Resistance	200	ohms
Driving Power during Pulse, approximate	45	kw
Power Output during Pulse, approximate	3.0	Mw

Typical Operation, Cathode-Drive		
Peak Plate Pulse Supply Voltage	40	kv
DC Grid Voltage	—1400	V
Peak RF Grid Voltage	3000	v
Peak RF Plate Voltage	34	kv
Peak Plate Current from Pulse Supply	100	a
Peak Rectified Grid Current	16	a
RF Load Resistance	210	ohms
Driving Power during Pulse, approximate	310	kw
Power Output during Pulse, approximate ‡	3.2	Mw

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values	ML-7560	ML-8317	
DC Plate Voltage	50	50	kV
Peak Plate Voltage	55	55	kv
DC Grid Voltage	—3500	—3500	V
Pulse Cathode Current	550	550	a
Grid Dissipation	3000	3000	W
Plate Dissipation	175	60	kW
Pulse Duration#	1000	1000	μs
Duty Factor#	.01	.01	

Typical Operation		
DC Plate Voltage	50	kV
DC Grid Voltage	—1800	V
Pulse Positive Grid Voltage	1600	v
Pulse Plate Current	350	a
Pulse Grid Current	80	a
Pulse Driving Power	275	kw
Pulse Power Output	15.7	Mw
Plate Output Voltage	45	kv

▲Averaged over any audio-frequency cycle of sine-wave form.

†With peak-envelope to average power ratio of approximately 10.

‡Includes power transferred from driver stage.

§Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 Mc except as noted. These tubes may be operated at higher frequencies provided the maximum value of plate voltage is reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency in Megacycles	30	70	110
Percent Maximum Rated Plate Voltage	100	80	60

TUBE PROTECTION

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic elecronic-crowbar fault-protection circuit considerations, as well as test of the effectiveness of a protection device, refer to the references listed.

A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

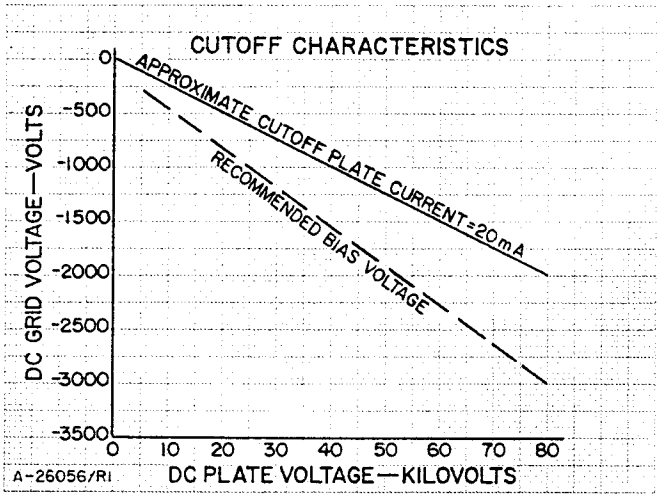
In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

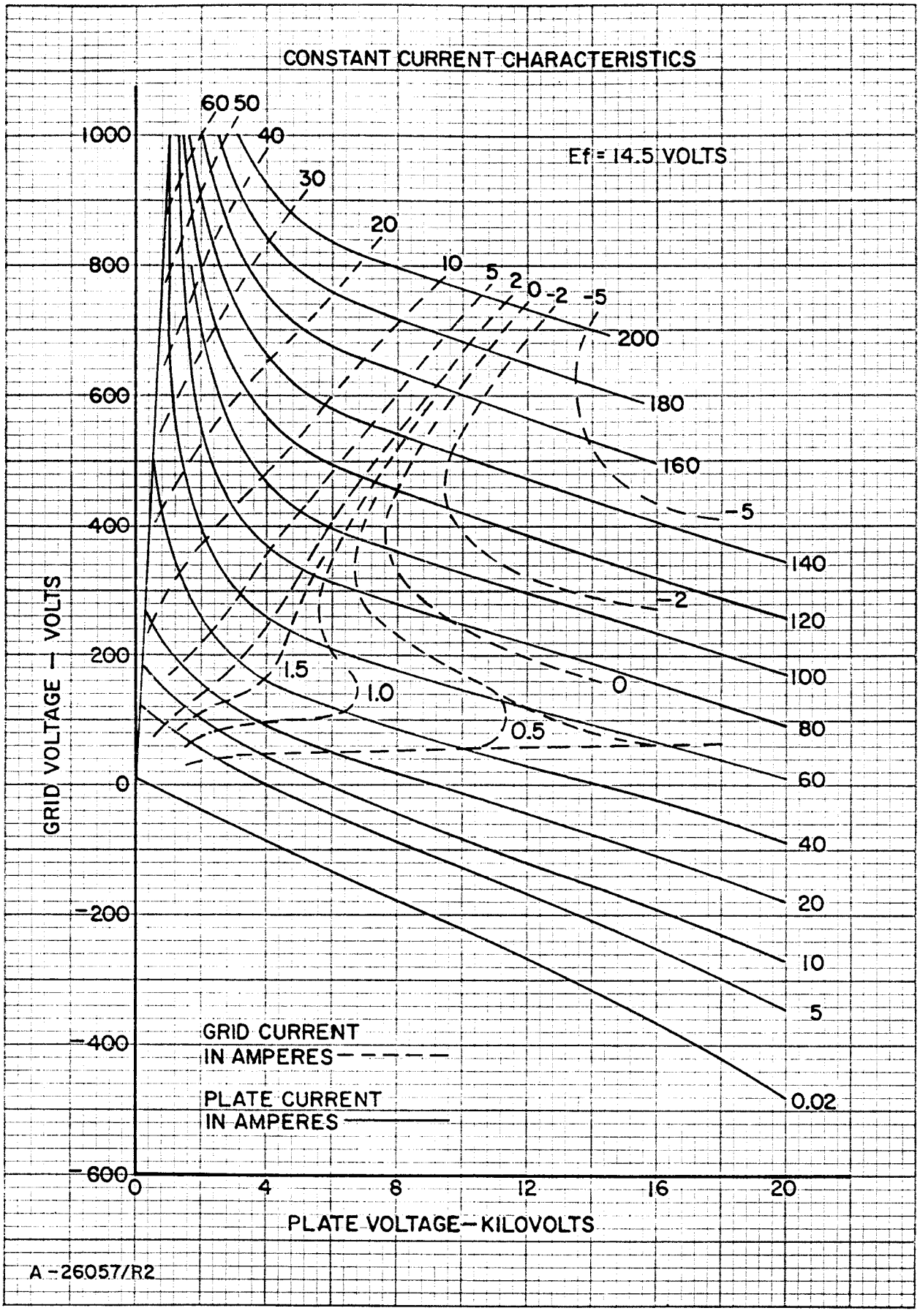
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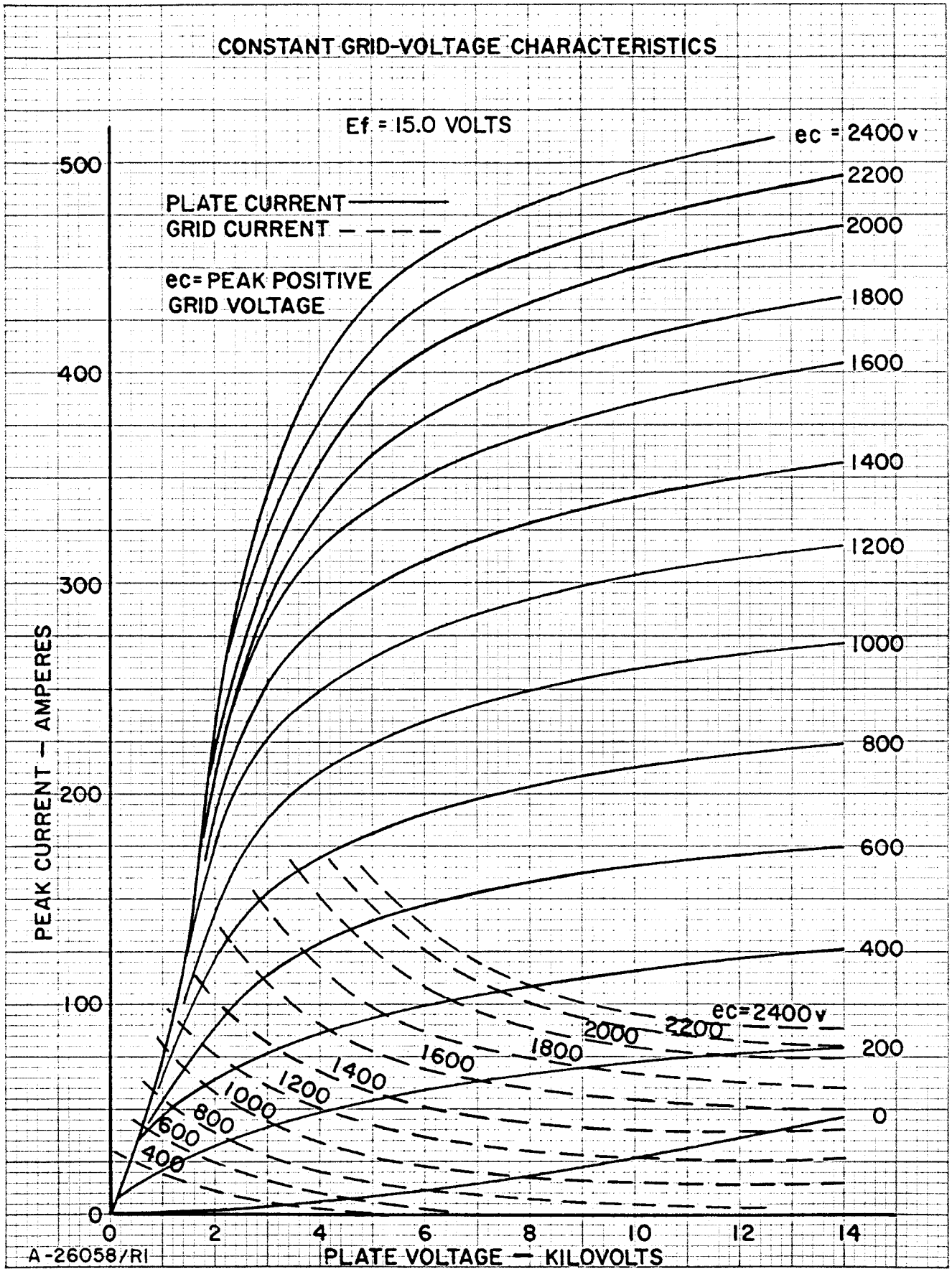
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29,* 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press, 1, 6,* 1954.

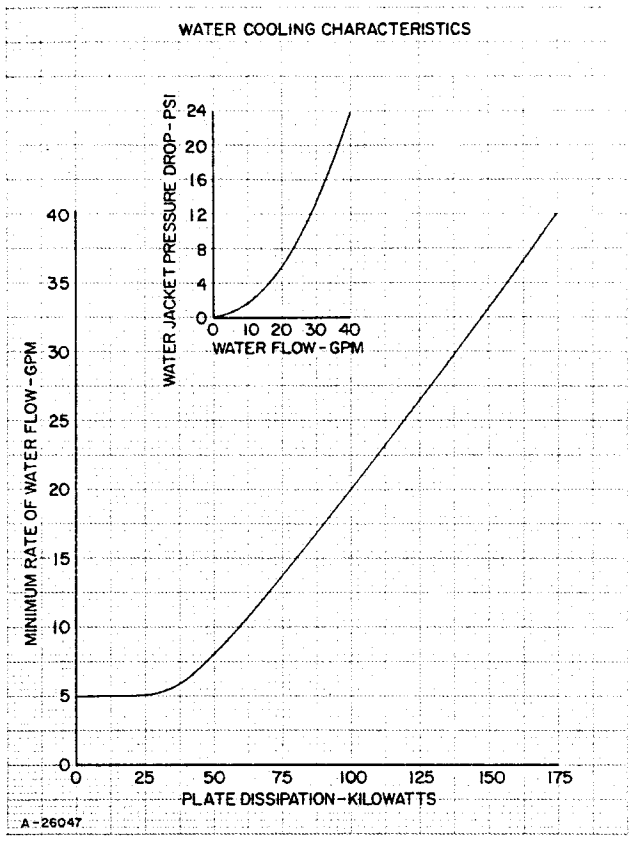
MAINTENANCE

The anode cooling fins of the ML-8317 must be kept free from films of foreign materials, which will impair heat flow. To keep fins clean, it is suggested that ultrasonic cleaning or wire-brushing of the anode cooling surfaces be performed on a routine maintenance basis.

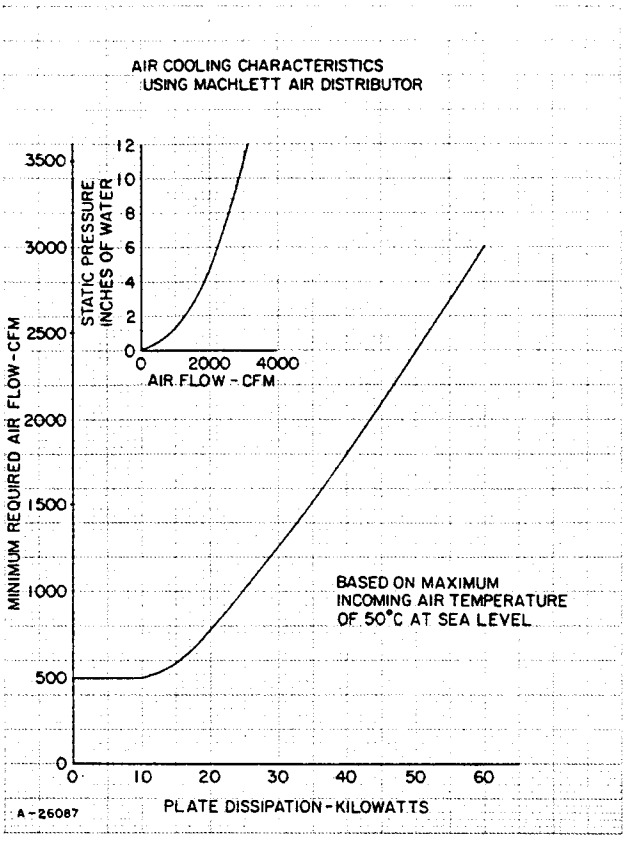



CONSTANT CURRENT CHARACTERISTICS
Ef = 14.5 VOLTS
60 50
40
30
20
10
5
2
0
-2
-5
200
180
160
-5
140
-2
120
100
0
80
1.5
1.0
0.5
60
40
20
10
5
0.02
1000
800
600
400
200
0
-200
-400
-600
GRID VOLTAGE — VOLTS
GRID CURRENT IN AMPERES - - - -
PLATE CURRENT IN AMPERES ——
0
4
8
12
16
20
PLATE VOLTAGE—KILOVOLTS
A-26057/R2

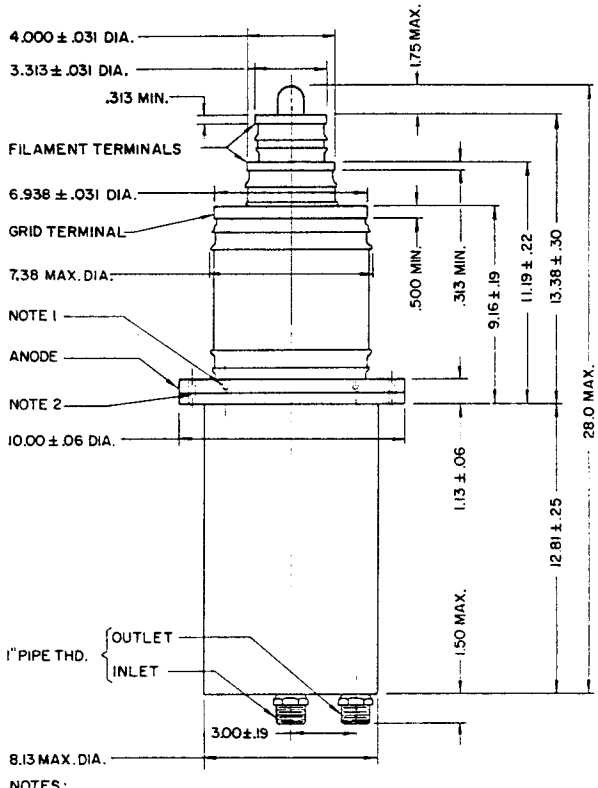

CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 15.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec= PEAK POSITIVE GRID VOLTAGE
ec = 2400 v
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE — KILOVOLTS
A-26058/RI



ML-7560



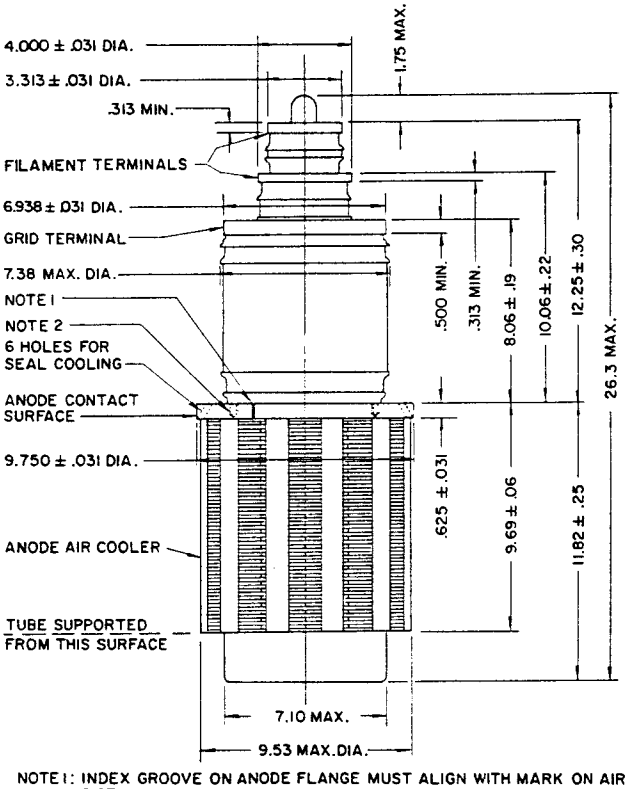
ML-8317



NOTES:
1. FOUR HOLES, $\frac{5}{16}$ DEEP, $\frac{1}{4}$ - 20 TAP, EQUALLY SPACED ON 8.19 ± .03 B.C., FOR LIFTING.
2. FOUR THROUGH HOLES .290 DIA. ON 9.16 ± .03 B.C. FOR MOUNTING, LOCATED APPROX. 45° FROM TAPPED HOLES.

ALL DIMENSIONS IN INCHES.

ED-27362/R1



NOTE 1: INDEX GROOVE ON ANODE FLANGE MUST ALIGN WITH MARK ON AIR DISTRIBUTOR TO ASSURE PROPER LOCATION OF SEAL COOLING HOLES.

NOTE 2: 4 - $\frac{1}{4}$ - 20 TAPPED HOLES EQUALLY SPACED ON A 8.19 ± .03 DIA. B.C. FOR LIFTING.

ALL DIMENSIONS IN INCHES

ED-27363/R2

THE MACHLETT LABORATORIES, INC.

An Affiliate of Raytheon Company

SPRINGDALE MACHLETT CONNECTICUT

ST-2019 4.5M 5-64

Printed in U.S.A.



ISSUED 5-64

ML-7668

High Voltage
High-Mu Triode
Plate Voltage
to 125 kV

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7668 is a high-voltage, high-mu triode designed primarily to operate as a switch tube in hard-tube pulse modulators for radar and in other electronic switching applications. In this service, the tube can deliver pulse power output up to 1.75 megawatts. It is designed for operation immersed in oil or an equivalent dielectric fluid. The cathode of the tube is a thoriated-tungsten filament. The anode is capable of dissipating up to 750 watts.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	12.6	Volts
Filament Current, approximate	29	Amperes
Grid Cutoff Voltage at 150 kV Plate Voltage, minimum	−1000	Volts
Amplification Factor	180	
Interelectrode Capacitances, approximate:		
Grid-Plate	7.5	pf
Grid-Cathode	20.0	pf
Plate-Cathode	0.2	pf

Mechanical

Mounting Position	Vertical *
Type of Cooling	Oil Convection *

* When the tube is mounted with the cathode down, forced circulation of the oil in the cathode-end re-entrant cavity will be required.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values†

D-C Plate Voltage	150	kV▲
D-C Grid Voltage	−1500	Volts
Peak Cathode Current	15	amps
Peak Positive Grid Voltage	1000	volts
Peak Negative Grid Voltage	−2000	volts
Peak Positive Plate Voltage	160	kv▲
Average Grid Dissipation	50	Watts
Average Plate Dissipation	750	Watts
Pulse Duration		‡
Duty Factor		‡

Typical Operation

D-C Plate Voltage	125	kV
D-C Grid Voltage	−1000	Volts
Pulse Positive Grid Voltage	700	volts
Pulse Plate Current	11	amps
Pulse Grid Current	2.7	amps
Pulse Driving Power	4.6	kw
Pulse Power Output	1.3	Mw
Pulse Duration	500	μsec
Duty Factor	.005	

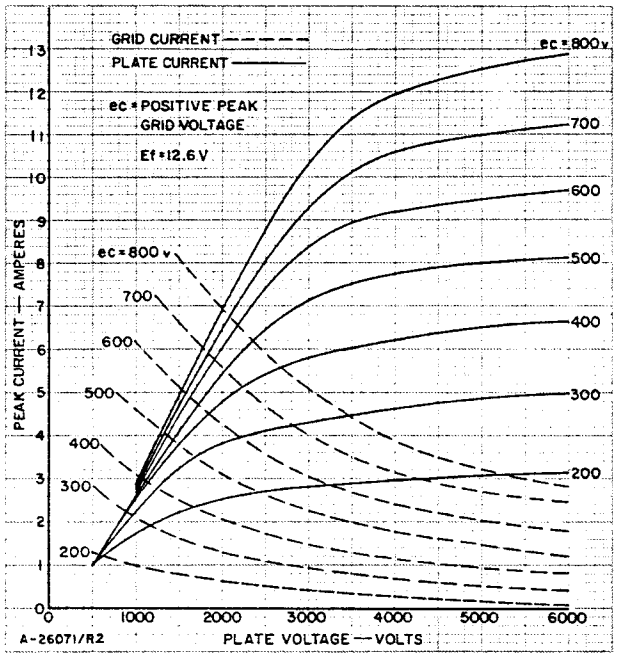
†Ratings apply only when the tube is immersed in insulating oil or an equivalent dielectric fluid.

▲For operation above 125 kV, consult the Machlett Laboratories, Engineering Department.

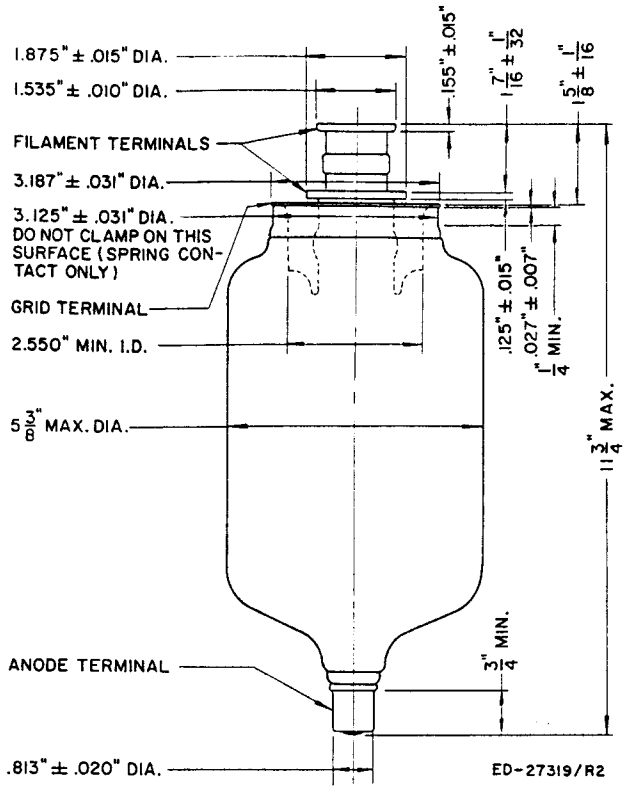
‡The duration of the pulse may be several milliseconds long. The maximum average grid and plate dissipations will determine the duty factor.

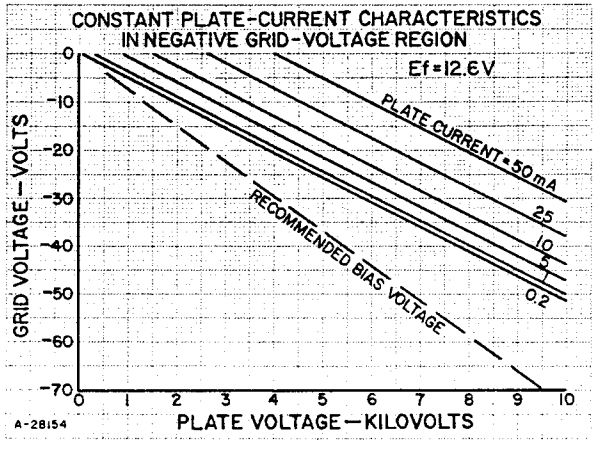
Note: For operation under conditions not covered by the above ratings, consult the Machlett Engineering Department.

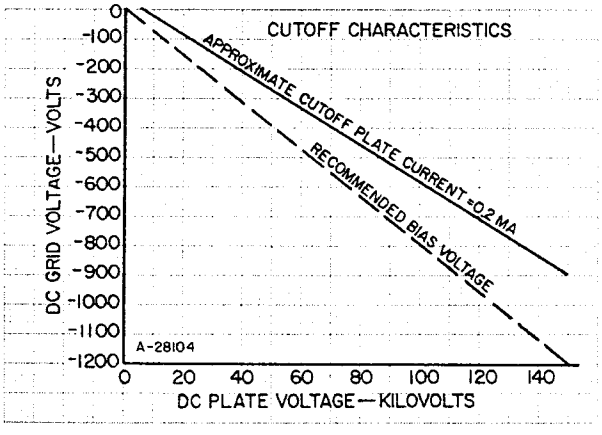
WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.



CONSTANT GRID-VOLTAGE CHARACTERISTICS



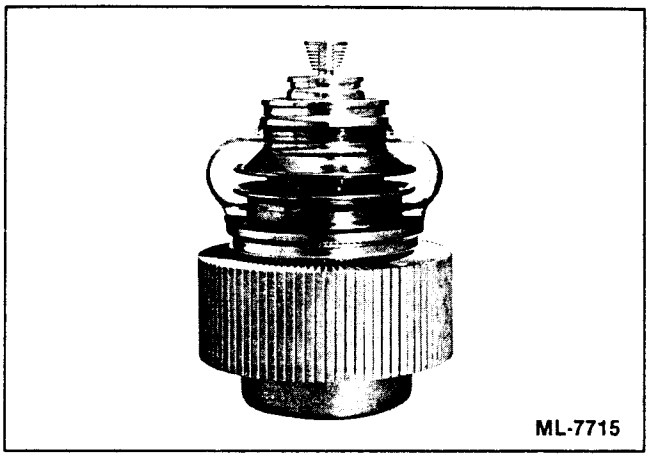




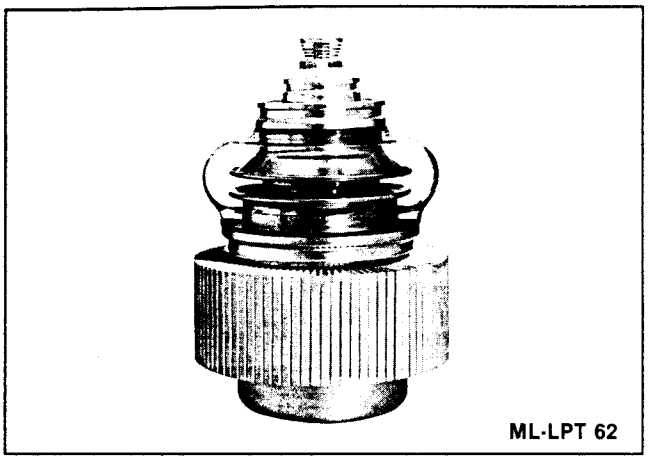
MACHLETT

PRODUCT DATA

ML-7715, ML-LPT 62



ML-7715



ML-LPT 62

APPLICATION

The ML-7715 and its ruggedized version, the ML-LPT-62, are shielded-grid triodes designed primarily for use as switch tubes in hard-tube pulse modulators for radar applications. They can deliver a peak pulse power output of 3.5 megawatts with less than 7 kilowatts driving power. The maximum ratings of 65 kVdc and 70 kV peak apply when the tube is completely immersed in a suitable dielectric fluid such as sulfur hexafluoride or a mineral oil.

CONSTRUCTION

These tubes incorporate a beamed electrode structure to minimize driving power. This design avoids the fine-wire grids usually used in tetrodes and provides a rugged structure. The shield grid is strapped to the cathode internally and protects the cathode from transient arcs. These features provide a tube which operates much more stably at high voltages than hard-tube modulators of earlier design. The high amplification factor coupled with low grid current results in unusually low driving power requirements. Additionally, the input and output circuits are isolated so that feedback capacitance is small. The cathode is a unipotential oxide-coated type. When cooled by forced air, the anode is capable of dissipating 3 kW with 200 cfm air flow. When cooled by oil forced through the radiator, the anode can dissipate 3 kW at 2 gal./min. (7.6 L/min.) oil flow.

WARNING

When operating at peak voltage in excess of 15 kV, this electron tube may give off x-rays which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 114, "Safety Standard for Non-Medical X-Ray and Sealed Gamma Ray Sources." Additional information is available in National Council on Radiation Protection and Measurements Report No. 33, "Medical X-Ray and Gamma Ray Protection for Energies up to 10 MeV." Periodic checks of shielding effectiveness are also required since x-ray radiation levels may increase with the operating life of the tube.

ORDERING NOTES

Refer to **Machlett** price list. When ordering specify:

- tube type
- accessories - (both types except as noted)
  - —heater connector (small) F-21989
  - —cathode/heater connector (large) F-21991
  - —grid connector F-21987
  - —tube support (ML-7715) P-16893

SPECIFICATION

ELECTRICAL CHARACTERISTICS

	ML-7715	ML-LPT 62
Heater Voltage:	6.0 ± 5% volts	6.3 ± 5% volts
Heater Current:	60 amps	62 amps
Heater Starting Current, maximum:	300 amps	300 amps
Cathode Warmup Time:	10 Minutes*	15 Minutes*
Amplification Factor:	400	400
Interelectrode Capacitances:		
Grid-Plate:	2.0 pf	1.2 pf
Grid-Cathode:	250 pf	275 pf
Plate-Cathode:	20 pf	20 pf

MECHANICAL CHARACTERISTICS:

	ML-7715 & ML-LPT 62
Mounting Position (support tube by anode radiator only):	Any
Forced-Air Cooling†	
Air Flow Thru Anode Radiator, Minimum for 3 kW Dissipation:	200 cfm
Air Flow on Grid Radiator, Minimum:	25 cfm
Maximum Incoming Air Temperature:	75 °C (167 °F)

Forced-Oil Cooling†	
Oil Flow Thru Anode Radiator, Minimum for 3 kW Dissipation:	2 gal./min. (7.6 L/min.)
Oil Flow on Grid Radiator:	(convection)‡
Maximum Bulk Oil Temperature:	75 °C (167 °F)
Maximum Glass Temperature:	175 °C (347 °F)
Net Weight, approximate:	28 lbs. (12.7 kg)

* For accelerated cathode warmup, the heater may be energized at 7.0 volts (7.5 volts for LPT 62) for 5 minutes and then reduced to rated value for high voltage operation. If a heater standby voltage of 5.0 volts is used (5.25 volts for LPT 62), the minimum cathode warmup time is one minute at rated voltage.

† Sufficient coolant flow must be provided to maintain glass temperatures at less than 175 °C (347 °F) under all conditions of operation.

‡ If the tube is mounted with the terminal end down, an additional oil flow of about ⅓ gpm must be directed into the grid-heater well.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values*	ML-7715 & ML-LPT 62	
DC Plate Voltage	65	kV‡
Peak Plate Voltage	70	kv‡
DC Grid Voltage	−600	volts
Peak Positive Grid Voltage	+1.5	kv
Peak Negative Grid Voltage	−1500	volts
Pulse Cathode Current	90	amp‡‡
DC Plate Current	600	mA
Grid Dissipation	25	watts
Plate Dissipation	3.0	kW
Pulse Duration	10	*μsec#*
Duty Factor	0.03	#

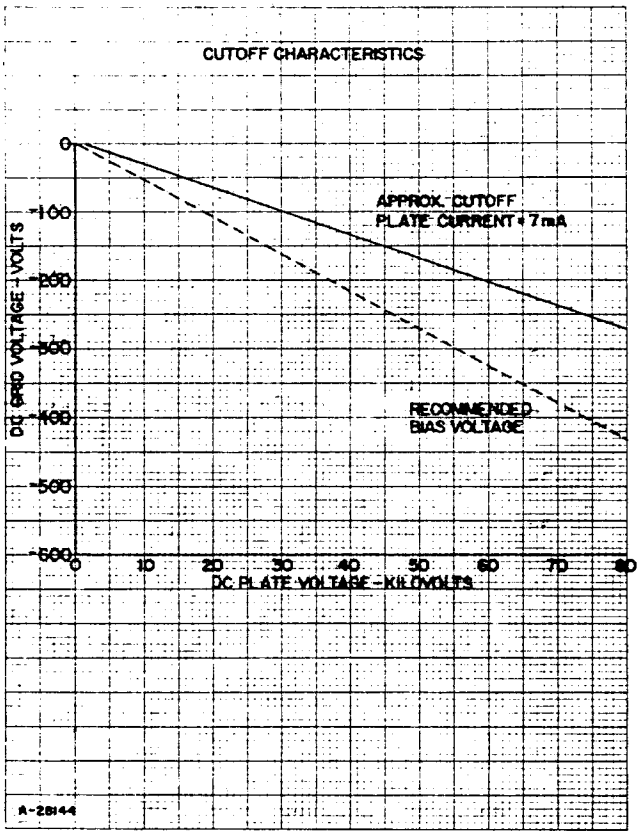
Typical Operation	ML-7715 & ML-LPT 62			
DC Plate Voltage	60	kV‡	65	kV‡
DC Grid Voltage	−350	volts	−350	volts
Pulse Positive Grid Voltage	+0.6	kv	+1.2	kv
Pulse Plate Current	25	amp	65	amp
Pulse Grid Current	2	amp	4	amp
Pulse Driving Power	1.9	kw	6.2	kw
Pulse Power Output	1.3	Mw	3.5	Mw
Plate Output Voltage	55	kv	55	kv
Duty Factor	.01		.003	

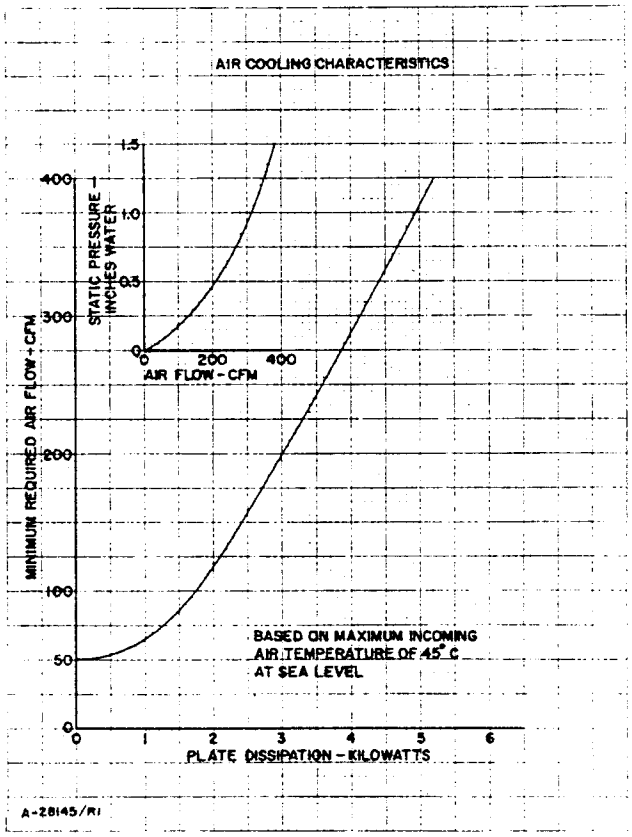
* All given maximum ratings may not apply simultaneously. Due to the possibility of instantaneous overheating of electrodes during the pulse, it may be necessary to restrict some of the parameters, e.g., peak plate current, tube drop, pulse duration, duty or average dissipation, in order not to adversely affect the performance of the tube. Because of the many possible combinations of operating conditions, all restrictions cannot be delineated here, and it is suggested to review new applications with the Machlett Engineering Department.

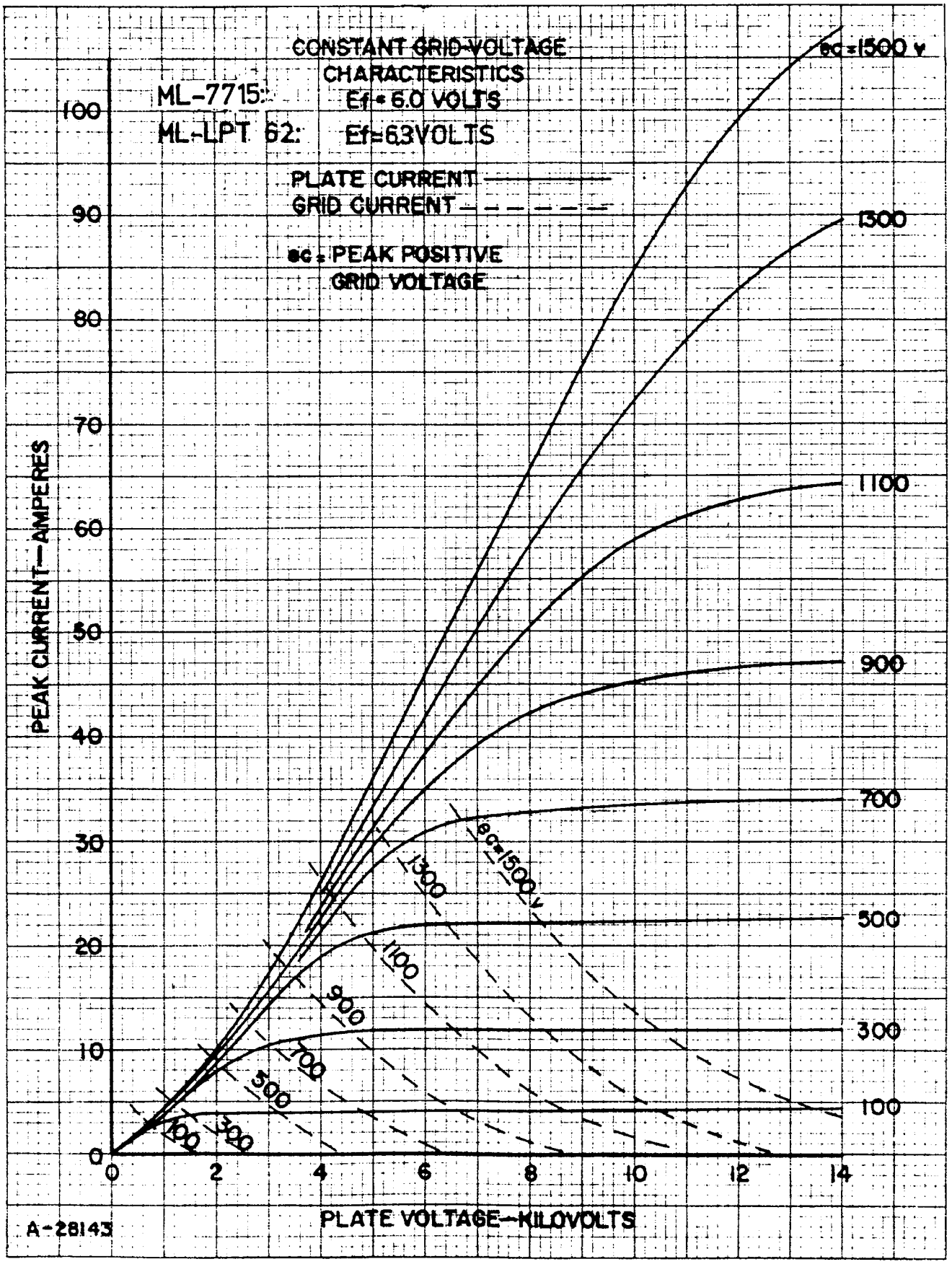
‡ This voltage may be applied only when the tubes are in a suitable dielectric liquid or gas. When the insulating medium is air at atmospheric pressure, the maximum ratings are 45 kV dc and 50 kv peak.

‡‡ For pulse cathode currents above 60 amperes, minimum heater voltage for the LPT 62 is 6.3 V.

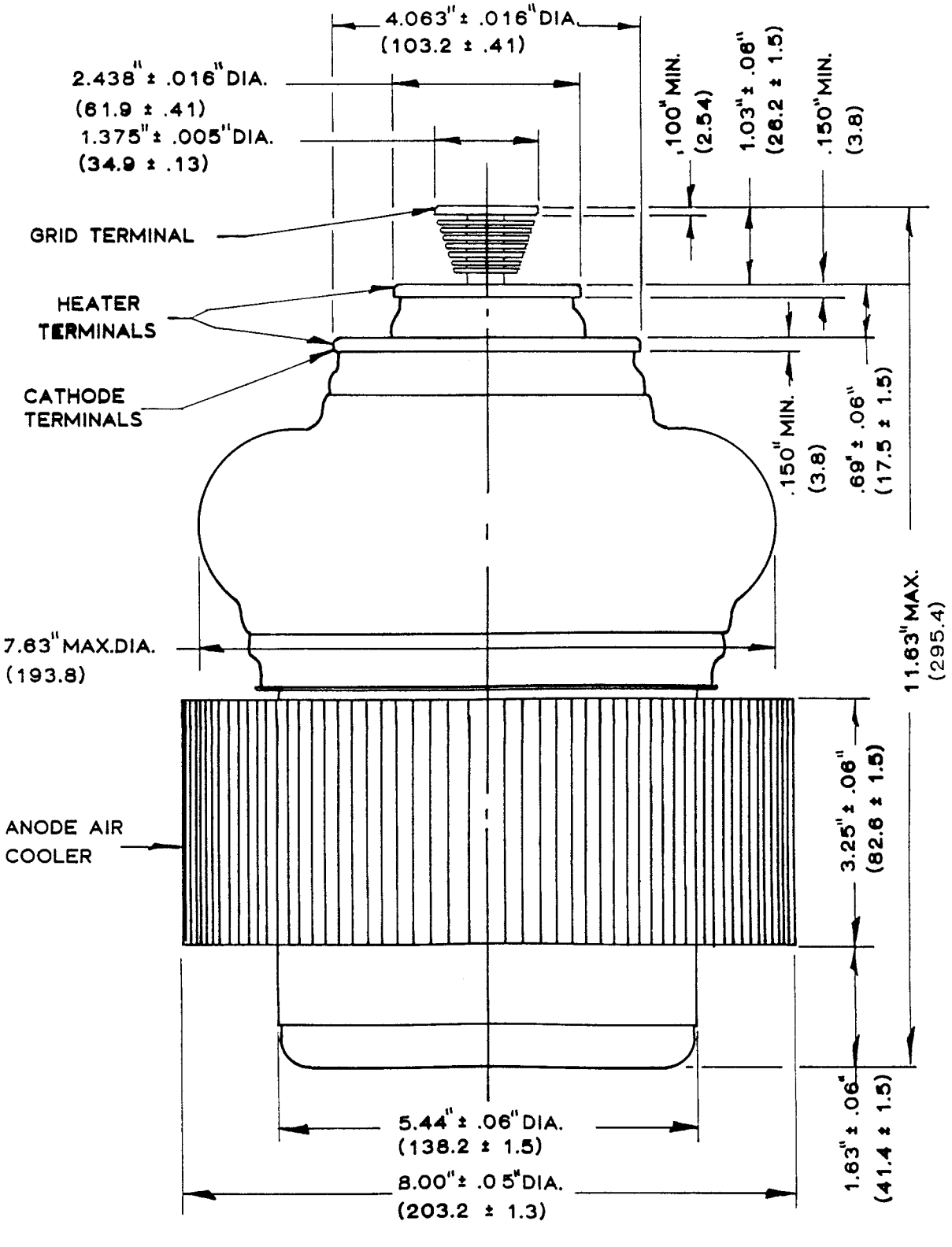
\# For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.






CONSTANT GRID-VOLTAGE CHARACTERISTICS
ML-7715: Ef = 6.0 VOLTS
ML-LPT 62: Ef=6.3VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
ec=1500 V
1300
1100
900
700
500
300
100
PEAK CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
0
2
4
6
8
10
12
14
10
20
30
40
50
60
70
80
90
100
A-28143

ML-7715 & ML-LPT 62 † OUTLINE DATA

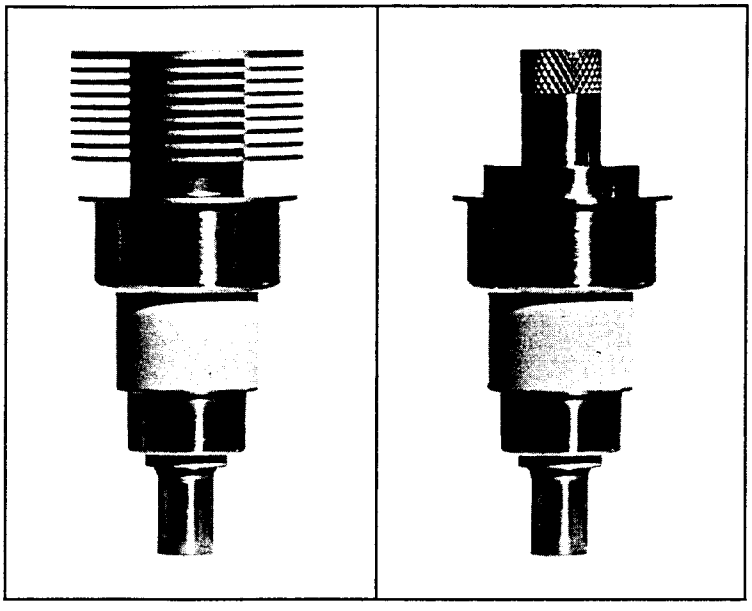


ALL DIMENSIONS IN INCHES (MM) ED-28348/R1

† The LPT 62 has a teflon re-inforcing spider mounted under the grid radiator.

SPO882
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ST-3763

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ISSUED 3-67

ML-7815/ 3CPN10A5 ML-7815R

MACHLETT

UHF Planar Triodes
CW, Plate or Grid Pulsed
Phormat Cathode
Extended Grid-Anode Insulator
3 GHz

DESCRIPTION

The ML-7815/3CPN10A5 and ML-7815R are ruggedized, high-mu planar triodes of ceramic-and-metal construction, designed for use as grid-pulsed, plate-pulsed or CW oscillators, frequency multipliers, or amplifiers in radio transmitting service from low frequency to 3 GHz. The ML-7815/3CPN10A5 is supplied without a radiator for conduction-convection cooling. The ML-7815R is supplied with a radiator for forced-air cooling. Except for plate-dissipation ratings, the characteristics of the two tubes are the same.

A special feature of these tubes as compared to other tubes fitting the same socket is an extended grid-anode insulator in the tube envelope. The extended grid-anode insulator is an important feature in airborne equipment operating at high altitudes. Other features of these tubes include low interelectrode capacitance, high transconductance, and great mechanical strength. The tubes also employ a Phormat type cathode which consists of an indirectly heated disc with an oxide coating impregnated in a nickel matrix. This construction, in combination with proper plate series impedance, reduces to a minimum failures of the cathode due to voltage surges.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage (AC or DC)	6.0	V
Heater Current at 6.0 Volts	1.0	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	100	
Transconductance (Ib = 70mA, Eb = 600V)	25000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Grid-Plate	1.98	pf
Grid-Cathode	6.30	pf
Plate-Cathode, maximum	.035	pf
Mechanical		
Mounting Position	Optional	
Type of Cooling		
Without radiator (ML-7815/3CPN10A5)	Conduction & Convection	
With radiator (ML-7815R)	Forced-Air	
Maximum Envelope Temperature	250	°C
Net Weight		
Without radiator (ML-7815/3CPN10A5)	51	g
With radiator (ML-7815R)	63	g

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Grid-Pulsed or Plate-Pulsed RF Oscillator or Amplifier — Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-Pulsed, DC	2500	V
Plate-Pulsed, Peak Pulse Supply	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
Average Plate Current	10	mA
Average Grid Current	5	mA
Peak Plate Current	3	a
Average Plate Dissipation		
Forced-air cooling (ML-7815R)	35	W
Conduction and convection (ML-7815)	10	W
Average Grid Dissipation	2	W
Pulse Duration	6	μs†
Duty Factor	.0033	†
Frequency	3	GHz
Typical Operation, Plate-Pulsed RF Oscillator		
Frequency	2.5	GHz
Filament Voltage	5.8	V
Pulse Duration	5	μs
Duty Factor	.0030	
Peak Plate Pulse Supply Voltage	3500	V
Peak Plate Current from Pulse Supply	3	a
Average Plate Current	9	mA
Average Grid Current	3	mA
Useful Peak Power Output, approximate	2.0	kw
Typical Operation, Grid-Pulsed RF Amplifier		
Frequency	1.1	GHz
Filament Voltage	6.0	V
Pulse Duration	3.5	μs
Duty Factor	.001	
DC Plate Voltage	2200	V
DC Grid Voltage	—45	V
Peak Plate Current from DC Supply	1.9	a
Peak Grid Current from Pulse Supply	1.1	a
Driving Power during Pulse, approximate	400	w
Useful Peak Power Output, approximate	2.0	kw

Pulsed Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
Peak Plate Voltage	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	150	v
DC Plate Current	100	mA
Pulse Cathode Current	4.8	a
Average Plate Dissipation		
Forced-air cooling (ML-7815R)	100	W
Conduction and convection (ML-7815)	10	W
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs†
Duty Factor	.0033	†

CW RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—400	v
Grid positive to cathode	30	v
DC Cathode Current	125	mA
DC Grid Current	50	mA
Plate Dissipation		
Forced-air cooling (ML-7815R)	100	W
Conduction and convection (ML-7815)	10	W
Grid Dissipation	2	W
Frequency	2.5	GHz
Typical Operation, RF Power Amplifier, Grid Separation Circuit		
Frequency	500	MHz
DC Plate Voltage	900	V
DC Grid Voltage	—40	V
DC Plate Current	90	mA
DC Grid Current, approximate	30	mA
Driving Power, approximate	6	W
Useful Power Output	40	W
Typical Operation, RF Oscillator		
Frequency	2.5	GHz
DC Plate Voltage	900	V
DC Grid Voltage, approximate	—22	V
DC Plate Current	90	mA
DC Grid Current	10	mA
Useful Power Output	17	W

†For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

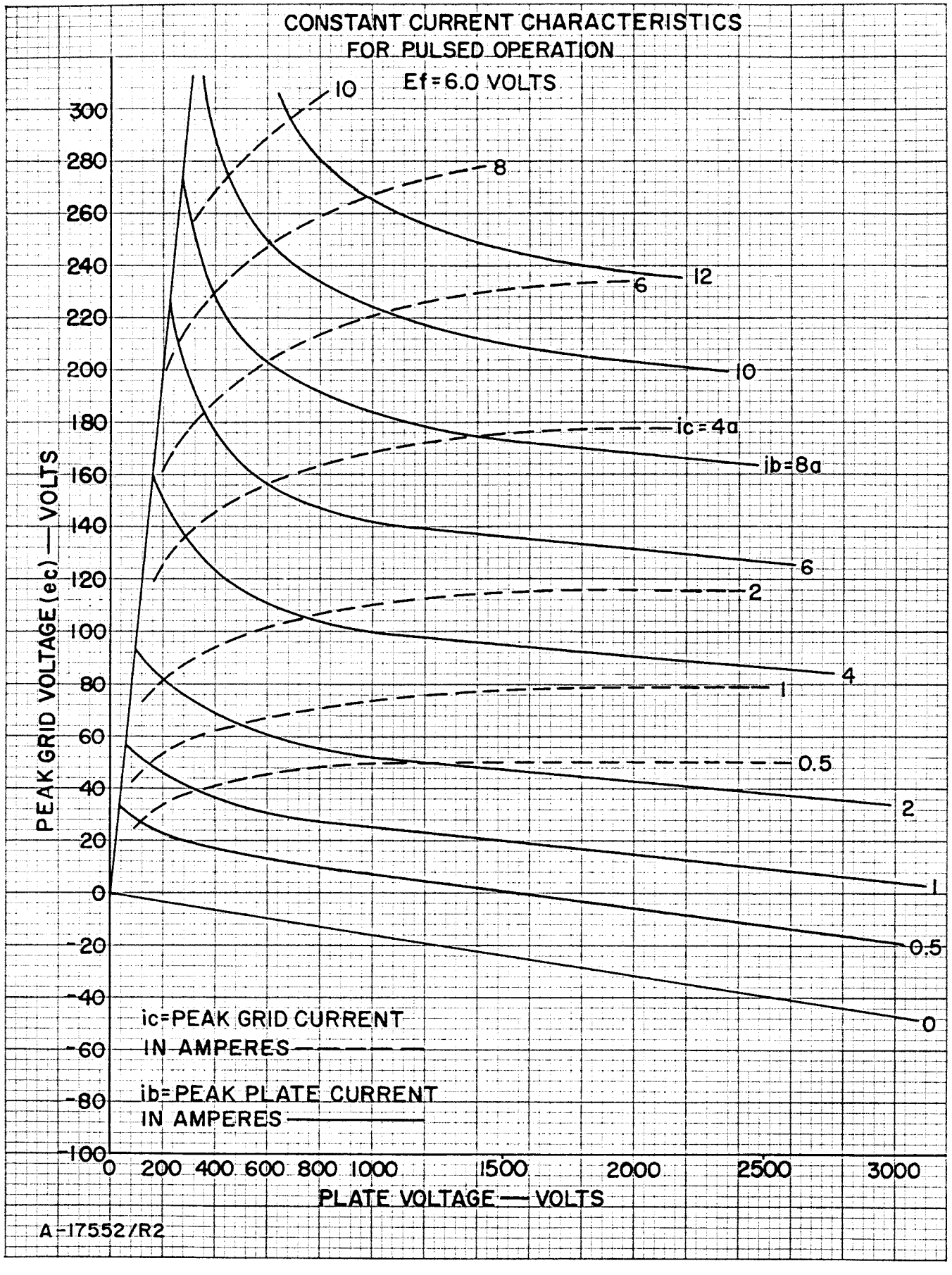
	Min.	Max.	
Filament Current at 6.0 Volts	0.90	1.05	A
Cutoff Bias (Note 1)	—	—15	V
Grid-Plate Capacitance (Note 2)	1.85	2.10	pf
Grid-Cathode Capacitance (Note 2)	5.60	7.00	pf
Plate-Cathode Capacitance (Note 2)		.035	pf

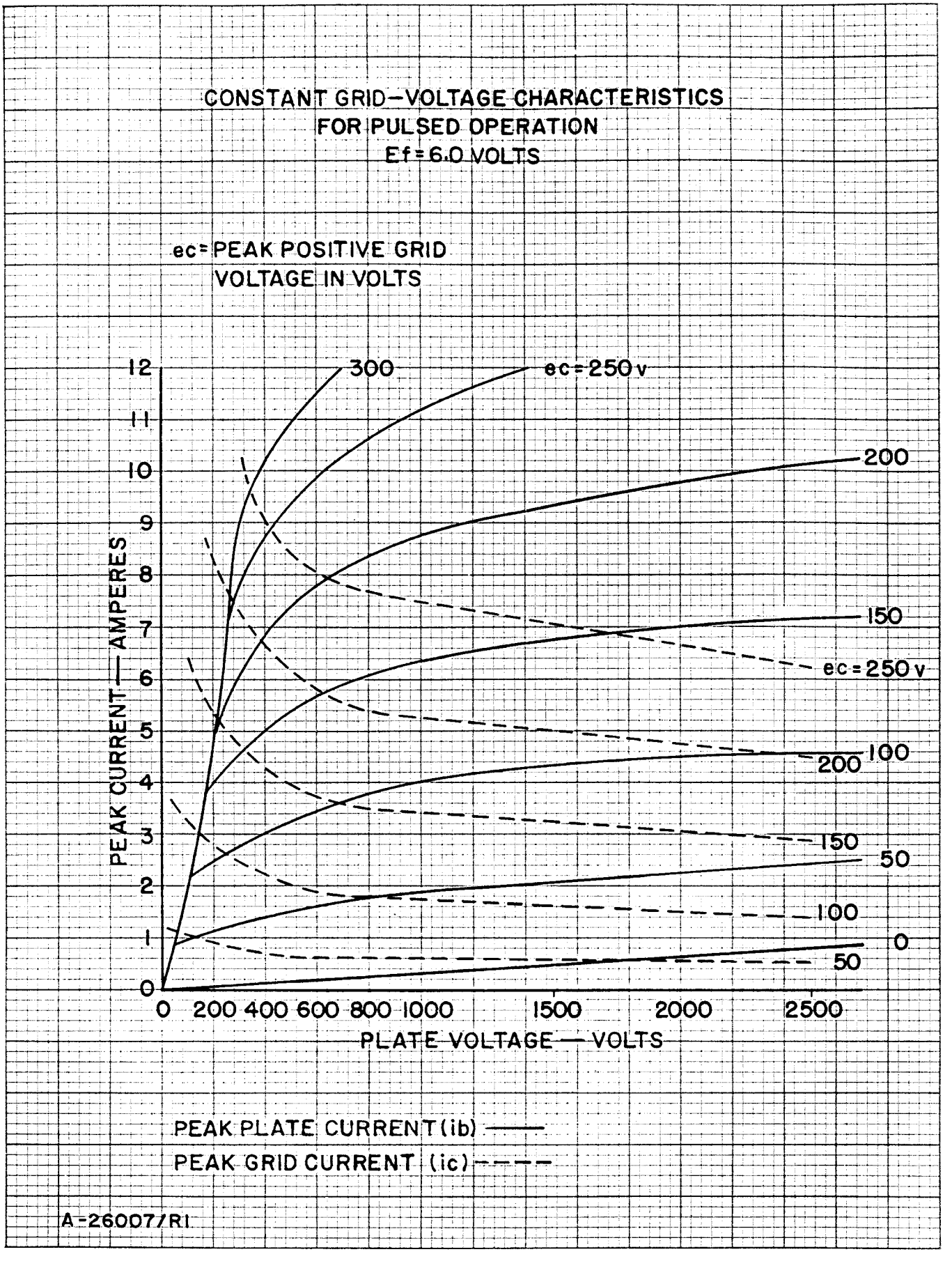
Note 1 — Measured at 1 mA of plate current and a plate voltage of 600 volts.

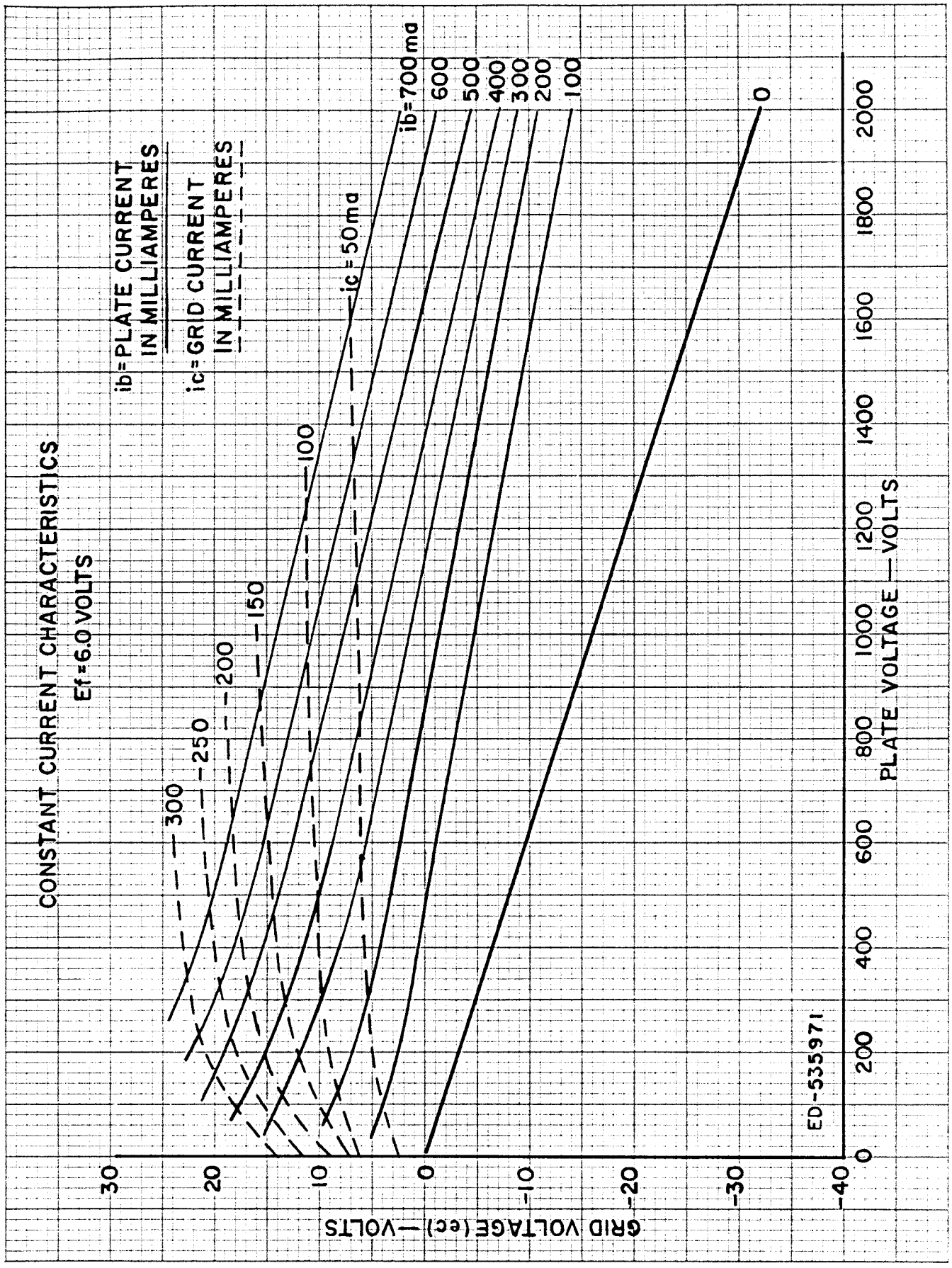
Note 2 — Capacitance measurements are made with tube cold.

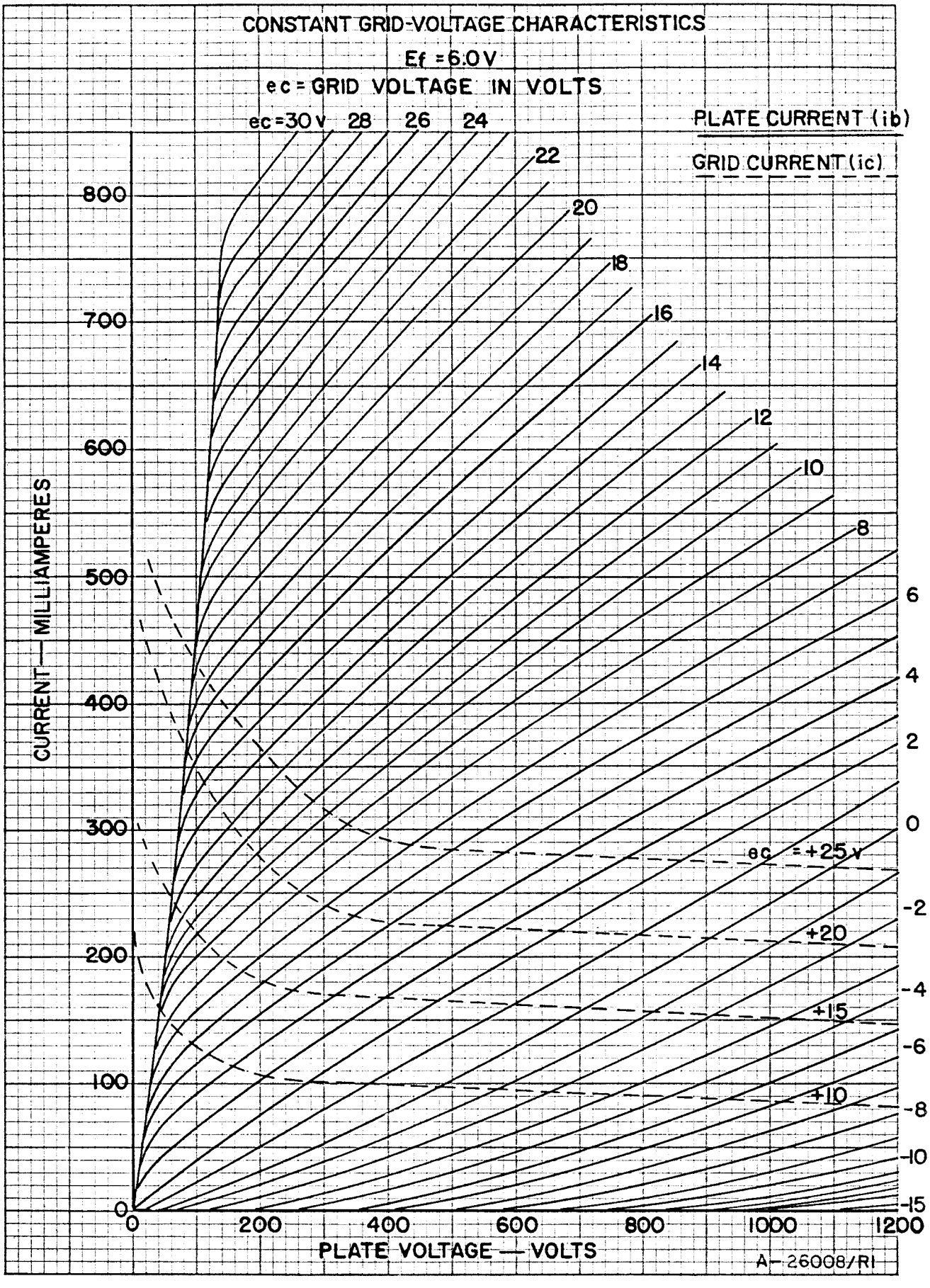
APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes — General.*


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS
PEAK GRID VOLTAGE (ec) — VOLTS
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
10
8
6
12
10
ic = 4a
ib = 8a
6
2
4
1
0.5
2
1
0.5
0
ic = PEAK GRID CURRENT
IN AMPERES
ib = PEAK PLATE CURRENT
IN AMPERES
0
200
400
600
800
1000
1500
2000
2500
3000
PLATE VOLTAGE — VOLTS
A-17552/R2


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS
ec = PEAK POSITIVE GRID
VOLTAGE IN VOLTS
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
0 200 400 600 800 1000 1500 2000 2500
0 1 2 3 4 5 6 7 8 9 10 11 12
300
ec = 250 v
200
150
ec = 250 v
200
100
150
50
100
0
50
PEAK PLATE CURRENT (ib) ——
PEAK GRID CURRENT (ic) - - - -
A-26007/R1

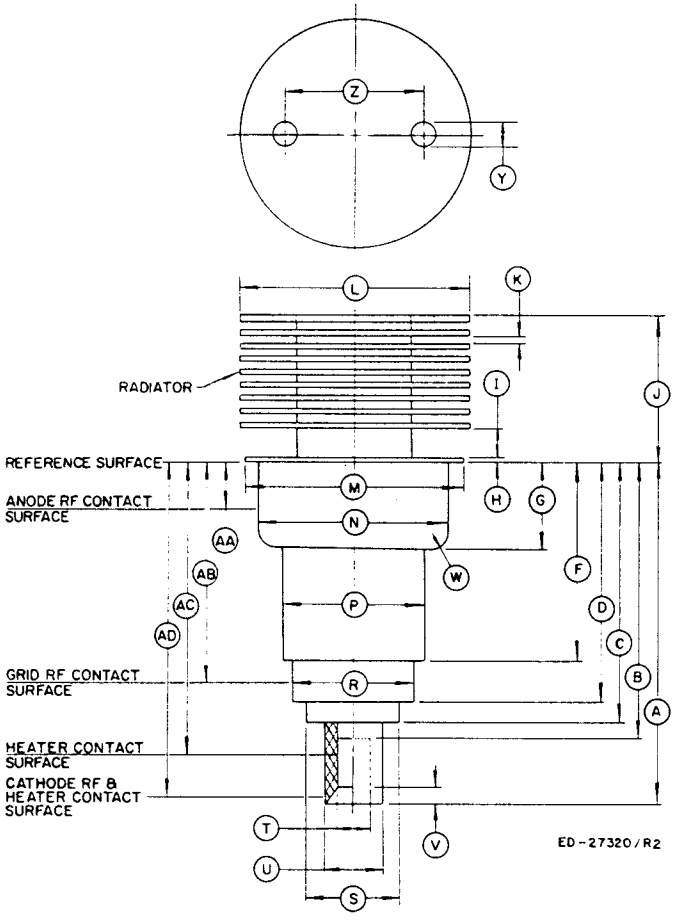

CONSTANT CURRENT CHARACTERISTICS
Ef=6.0 VOLTS
ib=PLATE CURRENT IN MILLIAMPERES
ic=GRID CURRENT IN MILLIAMPERES
ib=700ma
600
500
400
300
200
100
0
ic=50ma
100
150
200
250
300
GRID VOLTAGE (ec) — VOLTS
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PLATE VOLTAGE — VOLTS
ED-535971


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 6.0 V
ec = GRID VOLTAGE IN VOLTS
ec = 30 v 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0 -2 -4 -6 -8 -10 -15
PLATE CURRENT (ib)
GRID CURRENT (ic)
ec = +25 v
+20
+15
+10
CURRENT — MILLIAMPERES
0 100 200 300 400 500 600 700 800
0 200 400 600 800 1000 1200
PLATE VOLTAGE — VOLTS
A-26008/R1

DIMENSIONS FOR OUTLINE OF ML-7815R

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.815		1.875	46.10		47.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.185	1.225	1.265	30.10	31.12	32.13	2, 5
AC	1.534	1.631	1.728	38.96	41.43	43.89	3, 6
AD	1.475	1.645	1.815	37.46	41.78	46.10	4, 5, 6
B			1.534			38.96	
C			1.475			37.46	
D	1.289		1.329	32.74		33.76	
F	.970		1.010	24.64		25.65	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I	.125		.185	3.18		4.70	
J	.766		.826	19.46		20.98	
K	.025		.046	.64		1.17	
L	1.234		1.264	31.34		32.11	
M	1.180		1.195	29.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
S			.545			13.84	
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
Y	.105		.145	2.67		3.68	
Z	.650		.850	16.51		21.59	



OUTLINE—ML-7815R

NOTES:

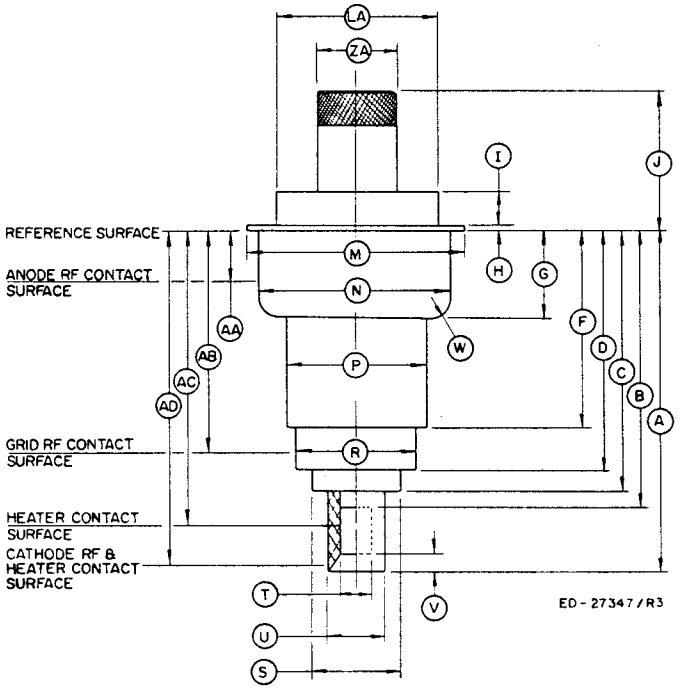
1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

DIMENSIONS FOR OUTLINE OF ML-7815/3CPN10A5

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.815		1.875	46.10		47.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.185	1.225	1.265	30.10	31.12	32.13	2, 5
AC	1.534	1.631	1.728	38.96	41.43	43.89	3, 6
AD	1.475	1.645	1.815	37.46	41.78	46.10	4, 5, 6
B			1.534			38.96	
C			1.475			37.46	
D	1.289		1.329	32.74		33.76	
F	.970		1.010	24.64		25.65	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I			.185			4.70	
J	.766		.826	19.46		20.98	
LA	.840		.860	21.34		21.84	
M	1.180		1.195	29.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
S			.545			13.84	
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
ZA	.427		.447	10.85		11.35	

OUTLINE—ML-7815/3CPN10A5



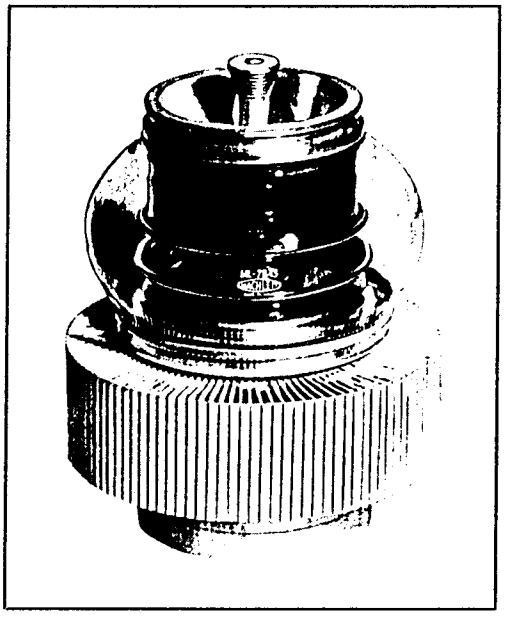
NOTES:

1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.
ST-2329 5M 3-67

ISSUED 5-64



ML-7845

Shielded Grid Triodes

Pulse Power
to 4.5 Mw

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7845 is a shielded-grid triode designed primarily to operate as a switch tube in hard-tube pulse modulators, for radar and similar applications. In this service it can deliver more than four megawatts pulse power output.

The ML-7845 has sturdy electrodes arranged to form a cylindrical array of electron-optical systems, featuring a shield electrode connected internally to the cathode by direct, low-impedance paths. This design permits operation with low grid current, and it results in favorably low grid-plate capacitance. The presence of the ground-potential shield adjacent to the anode, furthermore, protects the cathode and grid from damage by transient arcs.

The cathode is unipotential, oxide-coated. The anode is cooled by forced-air or dielectric gas. When cooled by forced air the anode is capable of dissipating 3 kW with 150 cfm air flow. The maximum ratings of 75 kVdc and 80 kv peak apply when the tube is completely immersed in a suitable dielectric gas such as sulfur hexafluoride.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage	6.0±5%	Volts
Heater Current	60	Amps
Heater Starting Current, maximum	300	Amps
Cathode Warm-up Time	10	Minutes*
Amplification Factor	500	
Interelectrode Capacitances:		
Grid-Plate	1.4	$\mu\mu f$
Grid-Cathode	250	$\mu\mu f$
Plate Cathode	18	$\mu\mu f$
Mechanical		
Mounting Position (support tube by anode radiator only)	Any	
Type of Cooling	Forced-air†	
Air flow on anode, minimum for 3kW dissipation	150 cfm at 0.2" water	
Air flow on grid	50	cfm
Maximum incoming air temperature	65	°C
Maximum Glass Temperature	175	°C†
Net Weight, approximate	40	lbs.

*For accelerated cathode warm-up, the filament may be energized at 7.0 volts for 5 minutes and then reduced to 6.0 volts for high-voltage operation. If a filament stand-by voltage of 5.0 volts is used, the minimum cathode warm-up time is 1 minute at 6.0 volts.

†Sufficient air flow must be provided to maintain glass temperatures at less than 175°C under all conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

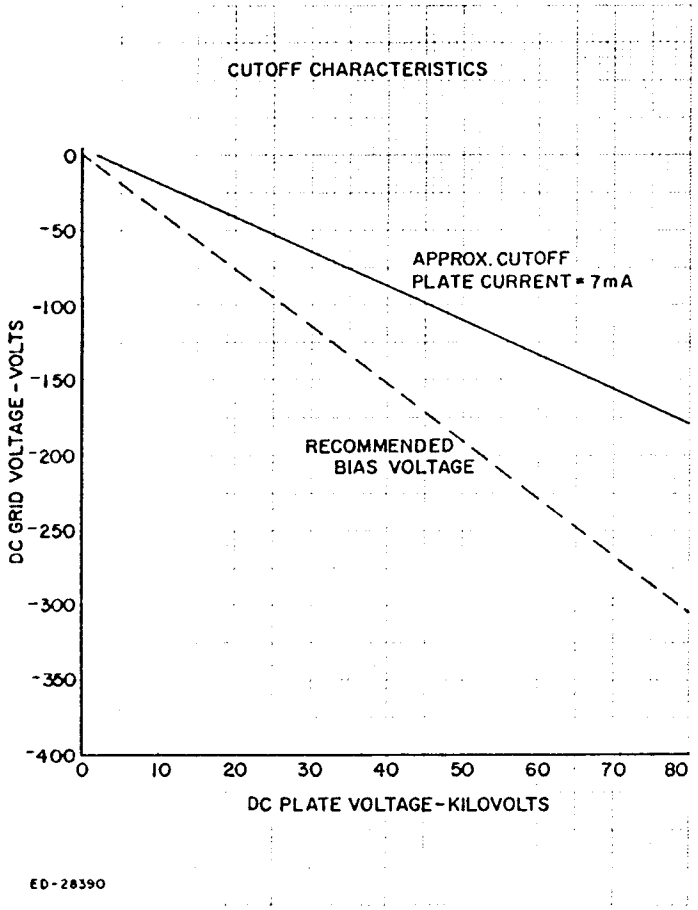
Pulse Modulator or Pulse Amplifier

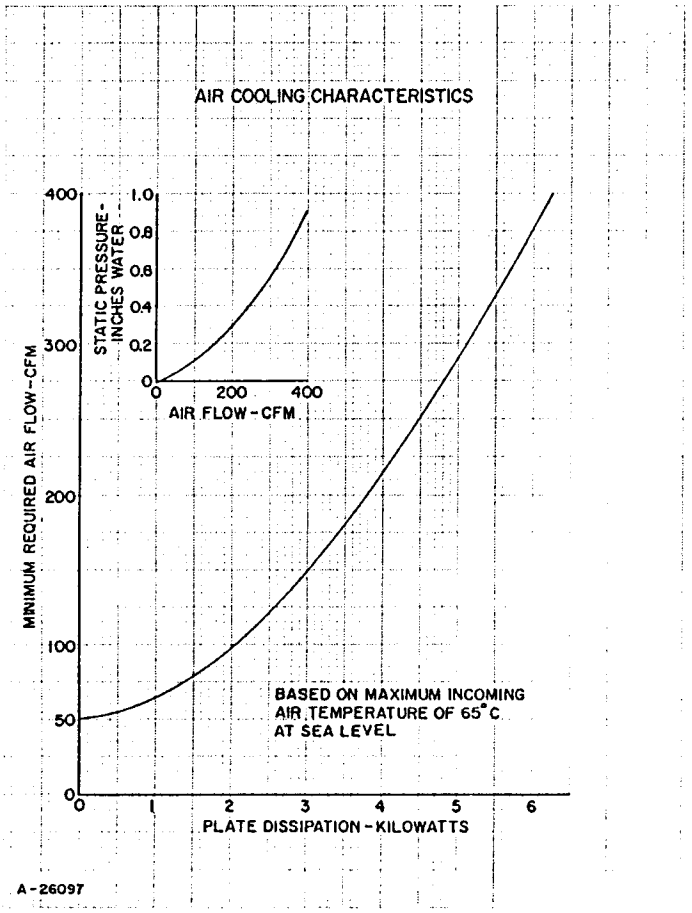
Maximum Ratings, Absolute Values			
D-C Plate Voltage		75	kV*
Peak Plate Voltage		80	kv*
D-C Grid Voltage		−600	volts
Peak Positive Grid Voltage		1500	volts
Peak Negative Grid Voltage		−1500	volts
Pulse Cathode Current		90	amp
D-C Plate Current		250	mA
Grid Dissipation		75	watts
Plate Dissipation		3.0	kW
Pulse Duration†		25	μsec
Duty Factor†		.03	
Typical Operation			
D-C Plate Voltage	75	75	kV*
D-C Grid Voltage	−300	−300	volts
Pulse Positive Grid Voltage	500	1300	volts
Pulse Plate Current	20	75	amp
Pulse Grid Current	1	10	amp
Pulse Driving Power	0.8	16	kw
Pulse Power Output	1.3	4.5	Mw
Plate Output Voltage	65	60	kv

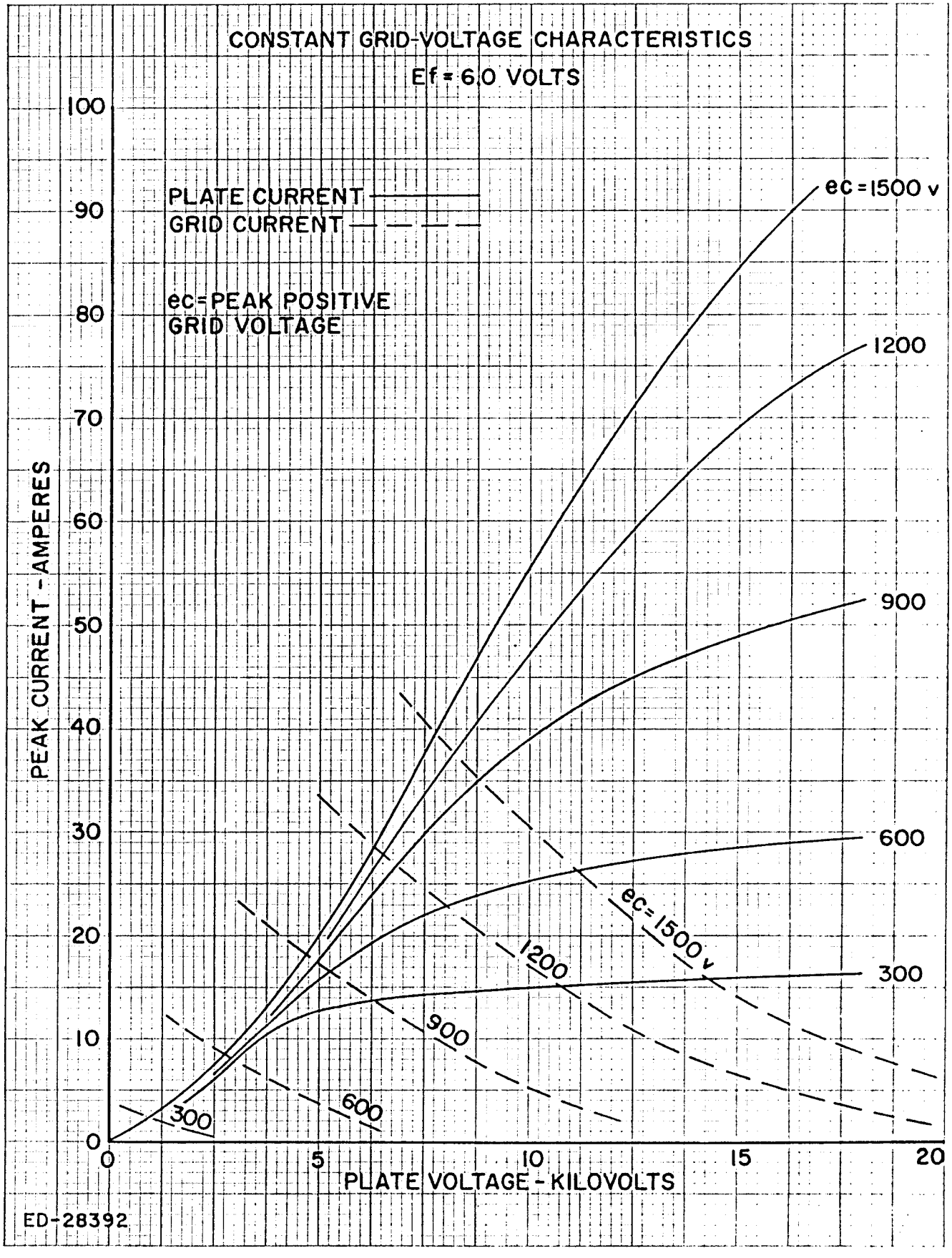
*This voltage may be applied only when the tube is in a suitable dielectric fluid.

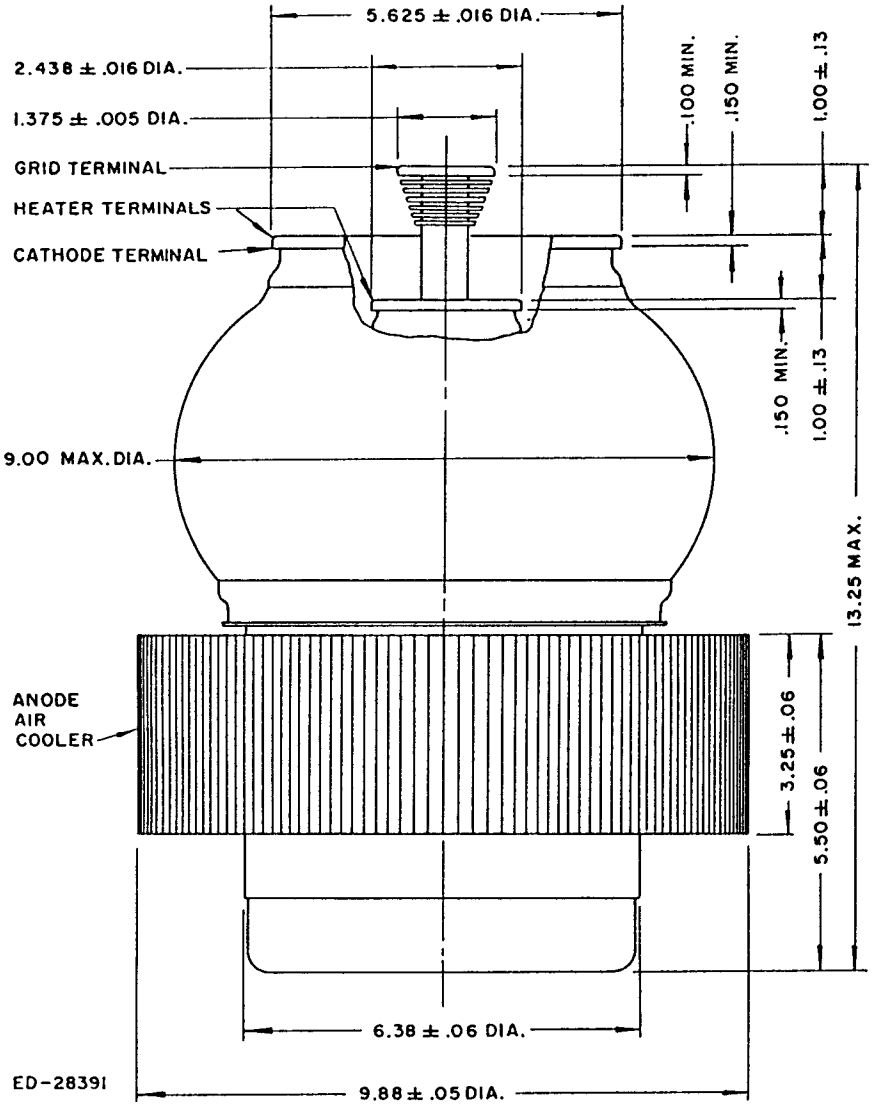
†For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.



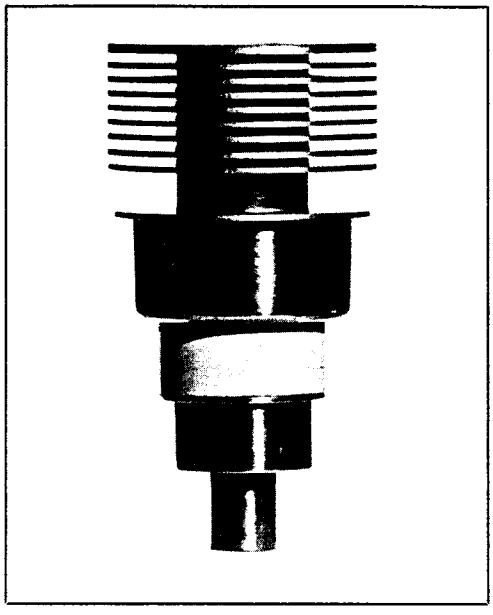



CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 6.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec=PEAK POSITIVE
GRID VOLTAGE
ec=1500 v
1200
900
600
300
ec=1500 v
1200
900
600
300
PEAK CURRENT - AMPERES
PLATE VOLTAGE - KILOVOLTS
0
10
20
30
40
50
60
70
80
90
100
0
5
10
15
20
ED-28392



DIMENSIONS — ML-7845

THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT
ST-1794 4.5M 5-64
Printed in U.S.A.



ISSUED 6-65

ML-7855

UHF Planar Triode

CW, Plate or Grid Pulsed
Frequency Stable
Phormat Cathode
17 W CW at 2.5 Gc

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-7855 is a ruggedized, high-mu planar triode of ceramic-and-metal construction, designed for use as a grid-pulsed, plate-pulsed, or CW oscillator, frequency multiplier, or amplifier in radio transmitting service from low frequency to 3 Gc.

In addition to low interelectrode capacitance, high transconductance and high mu, this tube incorporates design features which help to assure frequency-stable operation even under adverse ambient temperature and varying plate dissipation conditions. The cathode is an indirectly heated disc with an oxide coating impregnated in a nickel matrix. The unique matrix construction (in combination with proper plate series impedance) reduces to a minimum failures of the cathode due to voltage surges thereby further increasing the reliability of this tube. The anode of the ML-7855 is cooled by forced air.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage (AC or DC)	6.0	V
Heater Current at 6.0 Volts	1.00	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	80	
Transconductance	25000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Grid-Plate	2.5	pf
Grid-Cathode	6.3	pf
Plate-Cathode, maximum	.06	pf

Mechanical

Mounting Position	Optional	
Type of Cooling	Forced-air	
Maximum Anode Temperature	250	°C
Net Weight	2.5	oz

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation†

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—400	v
Grid positive to cathode	30	v
DC Plate Current	100	mA
DC Grid Current	45	mA
Plate Dissipation	100	W
Grid Dissipation	2	W
Frequency	2.5	Gc
Typical Operation, RF Power Amplifier		
Frequency	500	Mc
Filament Voltage	6.0	V
DC Plate Voltage	900	V
DC Grid Voltage	—40	V
DC Plate Current	90	mA
DC Grid Current, approximate	30	mA
Driving Power, approximate	6	W
Useful Power Output	40	W
Typical Operation, RF Oscillator		
Frequency	2.5	Gc
Filament Voltage	6.0	V
DC Plate Voltage	900	V
DC Grid Voltage, approximate	—22	V
DC Plate Current	90	mA
DC Grid Current	10	mA
Useful Power Output	17	W

Plate-Pulsed RF Oscillator and Amplifier Class C

Maximum Ratings, Absolute Values		
Peak Plate Pulse Supply Voltage	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
Peak Plate Current from Pulse Supply	3	a
Average Plate Current	10	mA
Average Grid Current	5	mA
Average Plate Dissipation	35	W
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††
Frequency	3	Gc
Typical Operation, Plate-Pulsed RF Amplifier		
Frequency	2.5	Gc
Filament Voltage	5.8	V
Pulse Duration	5	μs
Duty Factor	.0030	
Peak Plate Pulse Supply Voltage	3500	v
Peak Plate Current from Pulse Supply	3	a
Average Plate Current	9	mA
Average Grid Current	3	mA
Useful Peak Power Output, approximate	2	kw

Grid-Pulsed RF Oscillator and Amplifier Class C

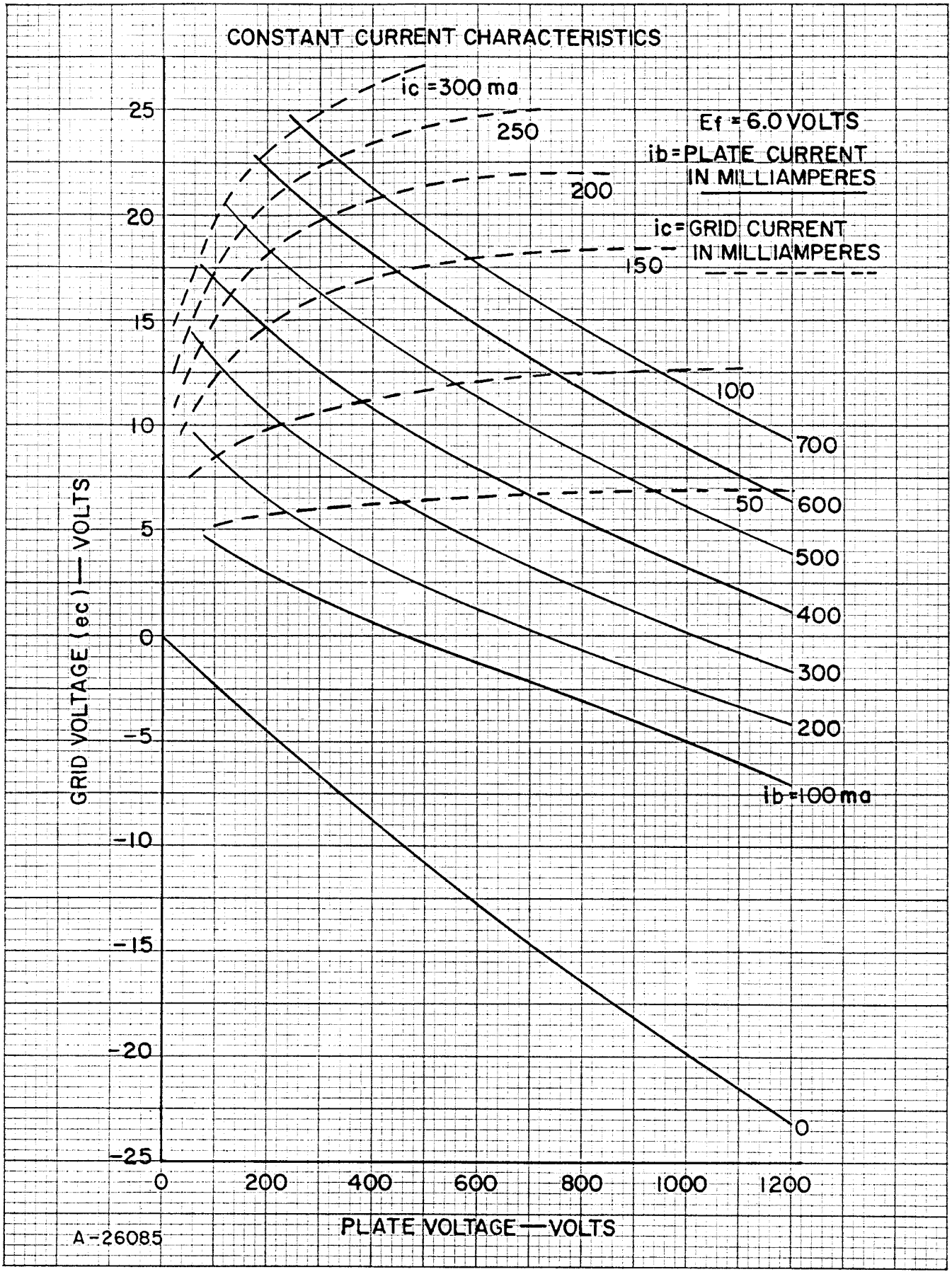
Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
Peak Plate Current from DC Supply	3	a
Average Plate Current	10	mA
Average Grid Current	5	mA
Average Plate Dissipation	20	W
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††
Frequency	3	Gc
Typical Operation, Grid-Pulsed RF Amplifier		
Frequency	1.1	Gc
Filament Voltage	6.0	V
Pulse Duration	3.5	μs
Duty Factor	.001	
DC Plate Voltage	1700	V
DC Grid Voltage	—45	V
Peak Plate Current from DC Supply	1.9	a
Peak Grid Current from Pulse Supply	1.1	a
Driving Power During Pulse, approximate	400	W
Useful Peak Power Output, approximate	1.5	kw

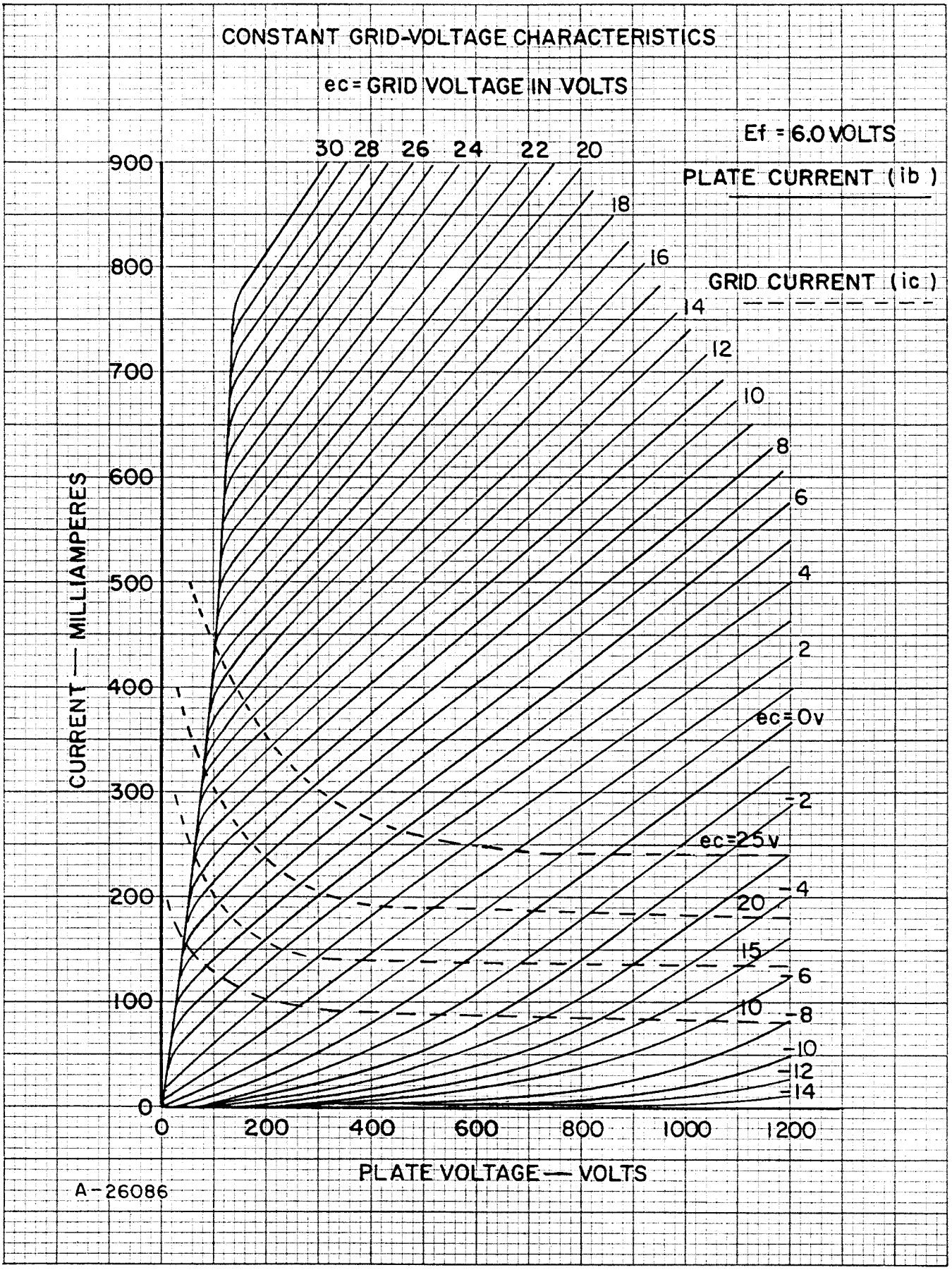
†Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

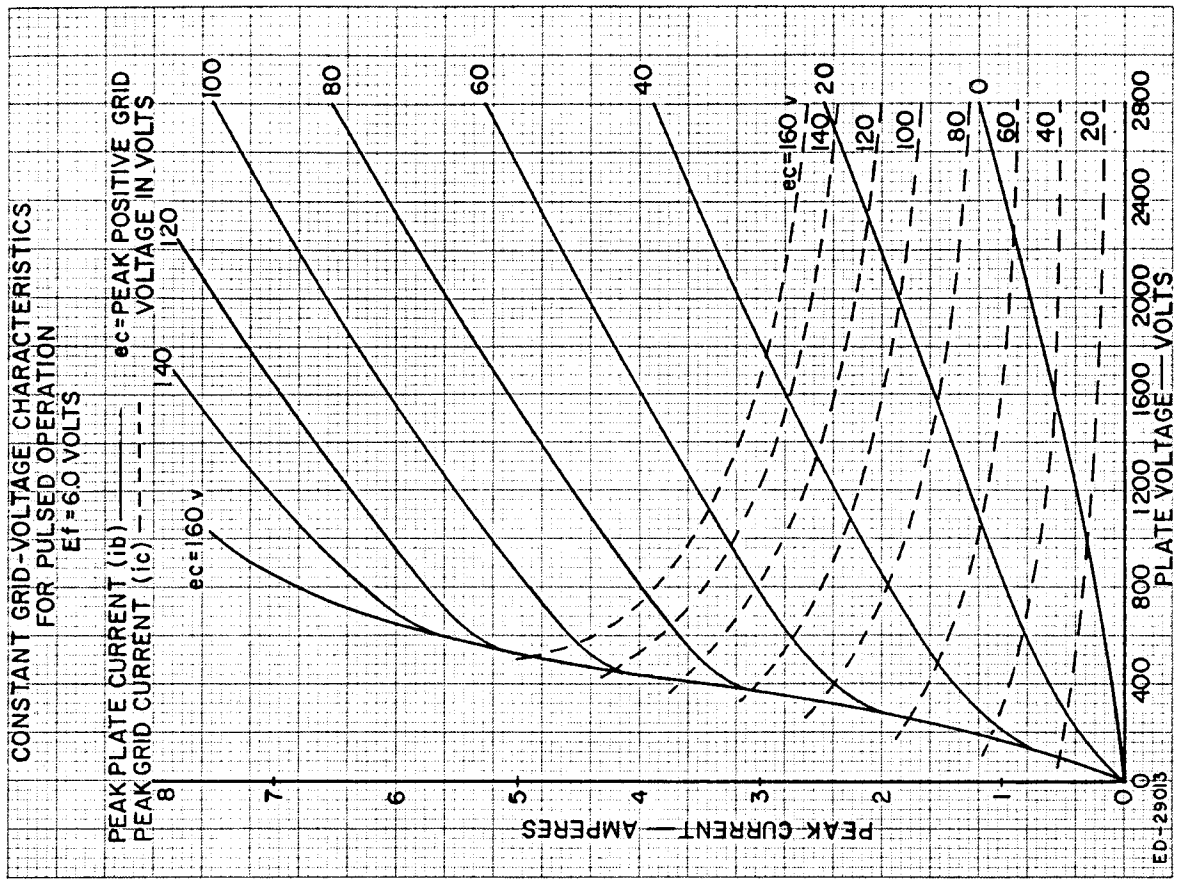
††For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

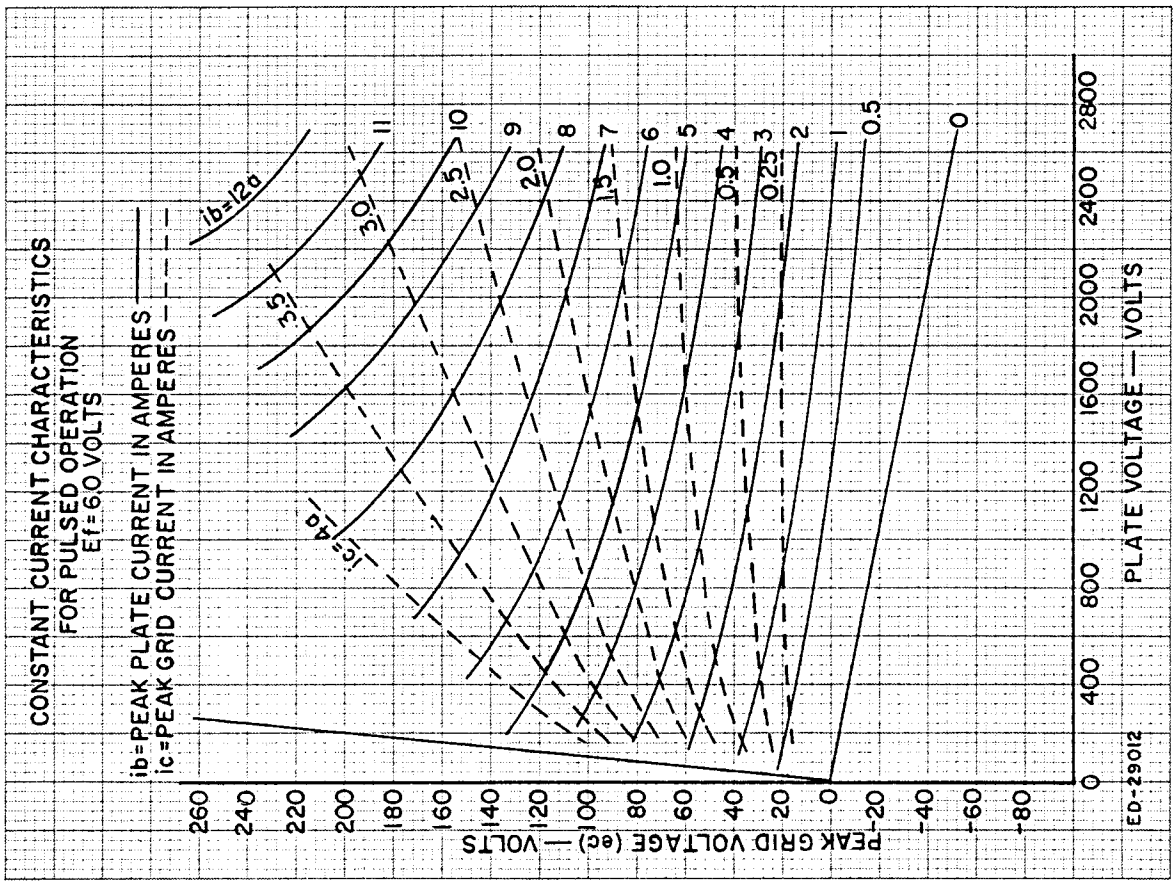
APPLICATION NOTES

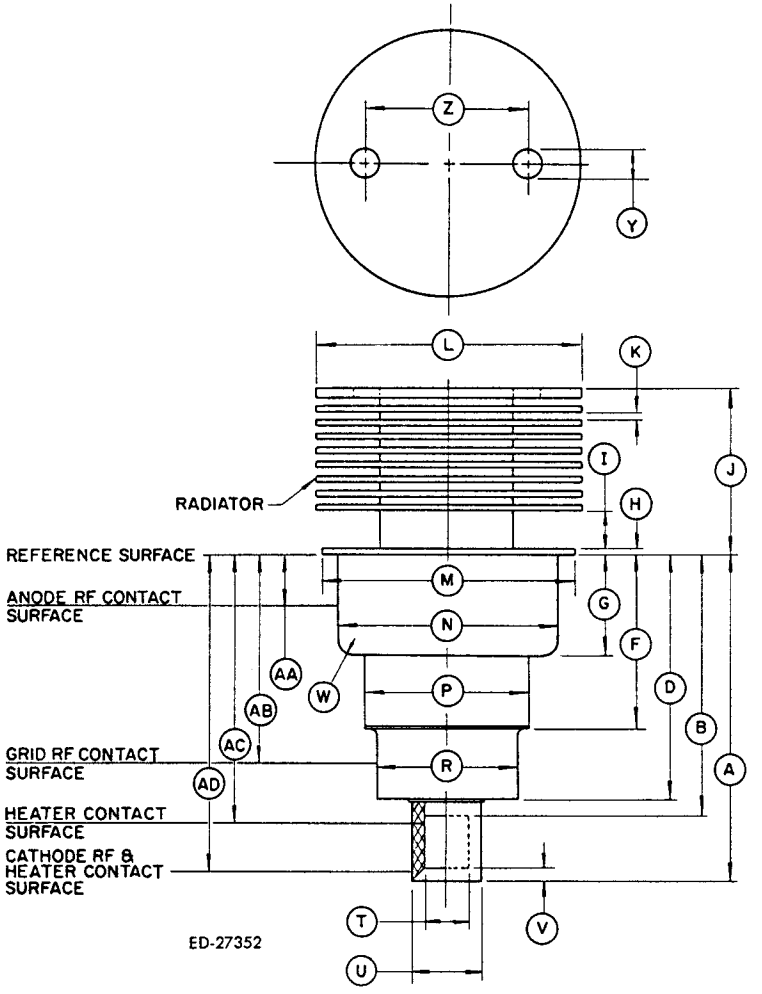
Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes — General.*


CONSTANT CURRENT CHARACTERISTICS
ic = 300 ma
250
200
150
100
50
Ef = 6.0 VOLTS
ib = PLATE CURRENT IN MILLIAMPERES
ic = GRID CURRENT IN MILLIAMPERES
700
600
500
400
300
200
ib = 100 ma
0
25
20
15
10
5
0
-5
-10
-15
-20
-25
GRID VOLTAGE (ec) — VOLTS
0
200
400
600
800
1000
1200
PLATE VOLTAGE — VOLTS
A-26085


CONSTANT GRID-VOLTAGE CHARACTERISTICS
ec = GRID VOLTAGE IN VOLTS
Ef = 6.0 VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 ec=0v -2 ec=-2.5v -4 -6 -8 -10 -12 -14
CURRENT — MILLIAMPERES
0 100 200 300 400 500 600 700 800 900
0 200 400 600 800 1000 1200
PLATE VOLTAGE — VOLTS
20 15 10
A-26086


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef=6.0 VOLTS
PEAK PLATE CURRENT (ib) ——— ec=PEAK POSITIVE GRID VOLTAGE IN VOLTS
PEAK GRID CURRENT (ic) - - - - -
ec=160 v
140
120
100
80
60
40
20
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
ED-29013


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef=6.0 VOLTS
ib=PEAK PLATE CURRENT IN AMPERES ———
ic=PEAK GRID CURRENT IN AMPERES - - - -
ib=12a
11
10
9
8
7
6
5
4
3
2
1
0.5
0
PEAK GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — VOLTS
ED-29012



DIMENSIONS FOR OUTLINE (INCHES)

Ref.	Minimum	Maximum
A	1.500	1.560
B	—	1.214
D	1.125	1.165
F	0.800	0.840
G	0.462	0.477
H	—	0.040
I	0.125	0.185
J	0.766	0.826
K	0.025	0.046
L	1.234	1.264
M	1.180	1.195
N	1.025	1.035
P	0.752	0.792
R	0.655	0.665
T	0.213	0.223
U	0.315	0.325
V	—	0.086
W	—	0.100
Y	0.105	0.145
Z	0.650	0.850

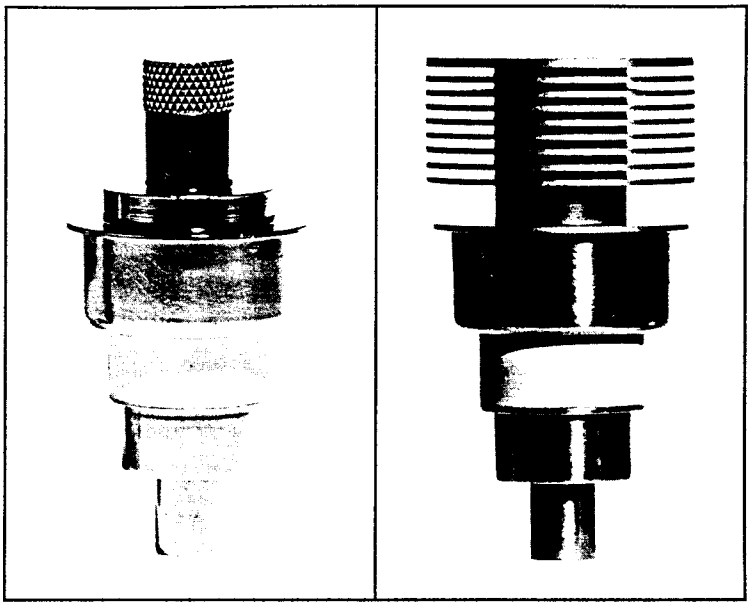
NOTES

1. The total indicated runout of the anode and grid contact surfaces with respect to the cathode contact surface will not exceed 0.020 inch.
2. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed 0.012 inch.

DIMENSIONS FOR ELECTRODE CONTACT SURFACES (INCHES)

Ref.	Dimension	Contact
AA	0.198 ± 0.163	Anode
AB	1.061 ± 0.040	Grid
AC	1.316 ± 0.097	Heater
AD	1.330 ± 0.170	Cathode

The Machlett Laboratories, Inc. • 1063 Hope Street
Stamford, Conn. 06907 • Tel. 203-348-7511 • TWX 710-474-1744



ISSUED 3-69

ML-7855K/AL
ML-7855/AL

MACHLETT

AIRLINE QUALITY
EXTENDED LIFE
UHF PLANAR TRIODES
CW, Plate or Grid Pulsed
Frequency Stable
Phormat Cathode
3 GHz

DESCRIPTION

The ML-7855K/AL and ML-7855/AL planar triodes, interchangeable mechanically and electrically with the types ML-7855K and ML-7855 respectively, are intended especially for application in airline avionics equipment, where long life and uninterrupted performance are of prime importance. These tubes are ruggedized, high-mu planar triodes of ceramic-and-metal construction, designed for use as grid-pulsed, plate-pulsed or CW oscillators, frequency multipliers or amplifiers in transmitter service to 3 GHz.

In addition to low interelectrode capacitance, high transconductance and high mu, these tubes incorporate design features which help to assure frequency stable operation even under adverse ambient temperature and varying plate dissipation conditions.

The ML-7855K/AL and ML-7855/AL employ a Phormat type cathode, which consists of an indirectly heated disk with an oxide coating impregnated in a nickel matrix. This construction, in combination with proper plate series impedance, reduces to a minimum failures of the cathode due to voltage surges.

The ML-7855K/AL is supplied without a radiator for conduction-convection cooling. The ML-7855/AL is supplied with a radiator for forced-air cooling. Except for plate-dissipation ratings, the electrical characteristics of the two tubes are the same.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage (AC or DC)	5.7	V*
Heater Current at 5.7 Volts	1.0	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	100	
Transconductance (Ib = 70mA, Eb = 600V)	25000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Grid-Plate	2.5	pf
Grid-Cathode	6.3	pf
Plate-Cathode, maximum	.06	pf
Mechanical		
Mounting Position	Optional	
Type of Cooling		
Without radiator (ML-7855K/AL)	Conduction & Convection	
With radiator (ML-7855/AL)	Forced-Air	
Maximum Envelope Temperature	250	°C
Net Weight		
Without radiator (ML-7855K/AL	1.8	oz
With radiator (ML-7855/AL)	2.2	oz

*Nominal. The heater voltage regulation should be better than ±3%.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Grid-Pulsed or Plate-Pulsed RF Oscillator or Amplifier — Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-Pulsed, DC	2500	V
Plate-Pulsed, Peak Pulse Supply	3500	v
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
Average Plate Current	10	mA
Average Grid Current	5	mA
Peak Plate Current	3	a
Average Plate Dissipation		
Forced-air cooling (ML-7855/AL)	35	W
Conduction and convection (ML-7855K/AL)	10	W
Average Grid Dissipation	2	W
Pulse Duration	6	μs†
Duty Factor	.0033	†
Frequency	3	GHz
Typical Operation, Plate-Pulsed RF Oscillator		
Frequency	2.5	GHz
Filament Voltage	5.5	V
Pulse Duration	5	μs
Duty Factor	.0030	
Peak Plate Pulse Supply Voltage	3500	V
Peak Plate Current from Pulse Supply	3	a
Average Plate Current	9	mA
Average Grid Current	3	mA
Useful Peak Power Output, approximate	2	kw
Typical Operation, Grid-Pulsed RF Amplifier		
Frequency	1.1	GHz
Filament Voltage	5.7	V
Pulse Duration	3.5	μs
Duty Factor	.001	
DC Plate Voltage	2200	V
DC Grid Voltage	−45	V
Peak Plate Current from DC Supply	1.9	a
Peak Grid Current from Pulse Supply	1.1	a
Driving Power during Pulse, approximate	400	w
Useful Peak Power Output, approximate	2	kw

CW RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−400	v
Grid positive to cathode	30	v
DC Cathode Current	125	mA
DC Grid Current	50	mA
Plate Dissipation		
Forced-air cooling (ML-7855/AL)	100	W
Conduction and convection (ML-7855K/AL)	10	W
Grid Dissipation	2	W
Frequency	2.5	GHz
Typical Operation, RF Power Amplifier, Grid Separation Circuit		
Frequency	500	MHz
DC Plate Voltage	900	V
DC Grid Voltage	−40	V
DC Plate Current	90	mA
DC Grid Current, approximate	30	mA
Driving Power, approximate	6	W
Useful Power Output	40	W
Typical Operation, RF Oscillator		
Frequency	2.5	GHz
DC Plate Voltage	900	V
DC Grid Voltage, approximate	−22	V
DC Plate Current	90	mA
DC Grid Current	10	mA
Useful Power Output	17	W

†For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

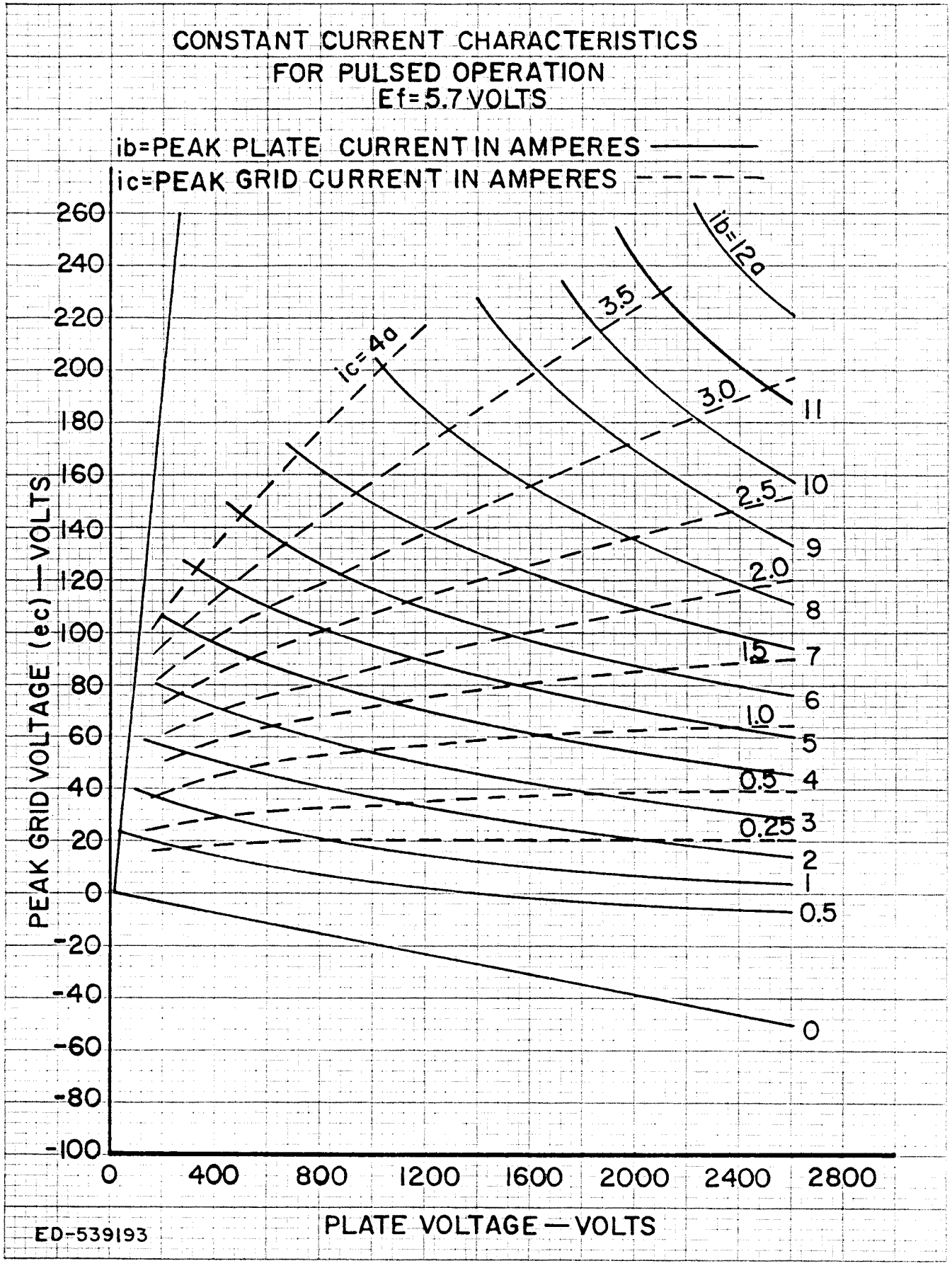
	Min.	Max.	
Filament Current at 5.7 Volts	0.90	1.05	A
Cutoff Bias (Note 1)	—	−15	V
Grid-Plate Capacitance (Note 2)	2.25	2.75	pf
Grid-Cathode Capacitance (Note 2)	5.60	7.00	pf
Plate-Cathode Capacitance (Note 2)		.040	pf

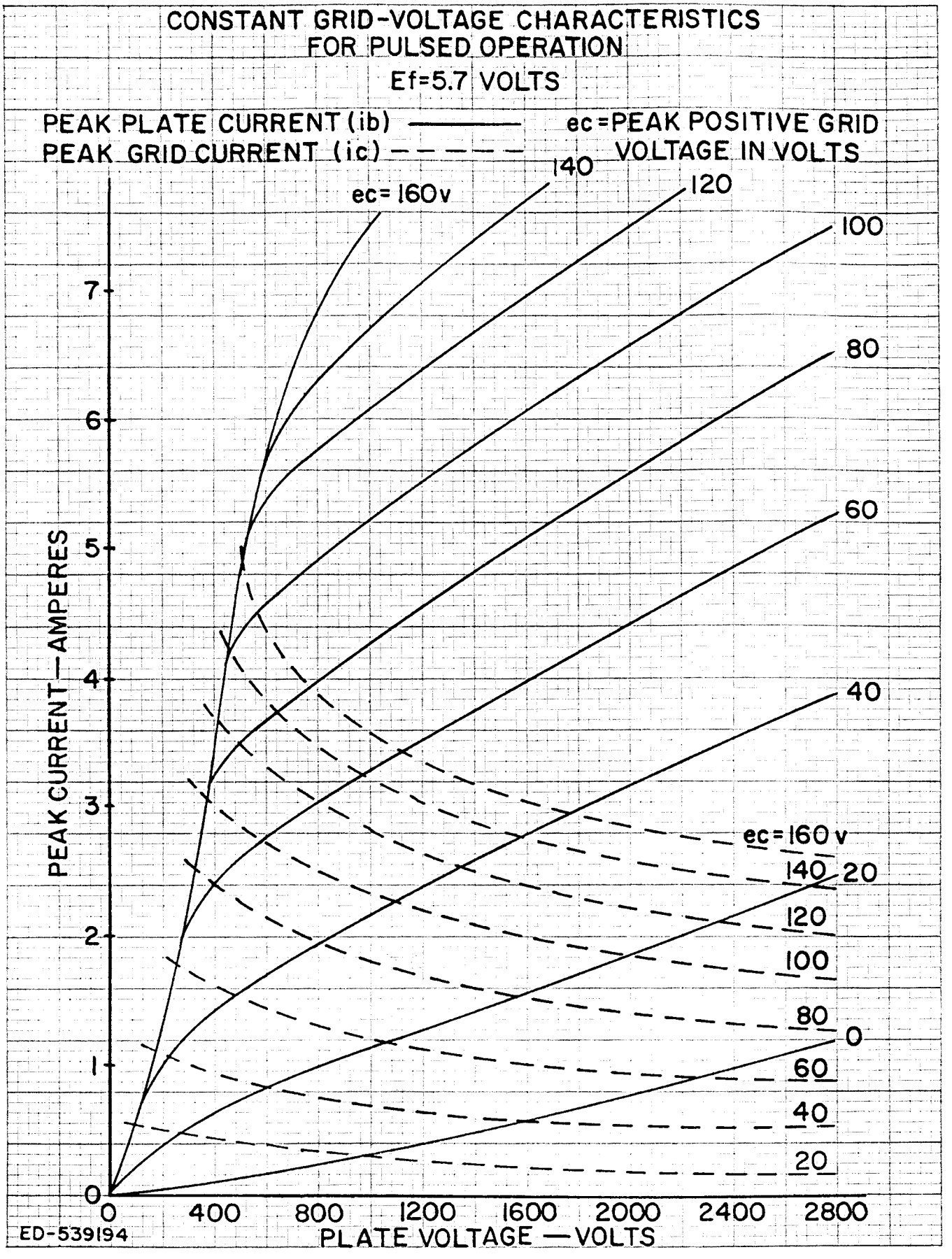
Note 1 — Measured at 1 mA of plate current and a plate voltage of 600 volts.

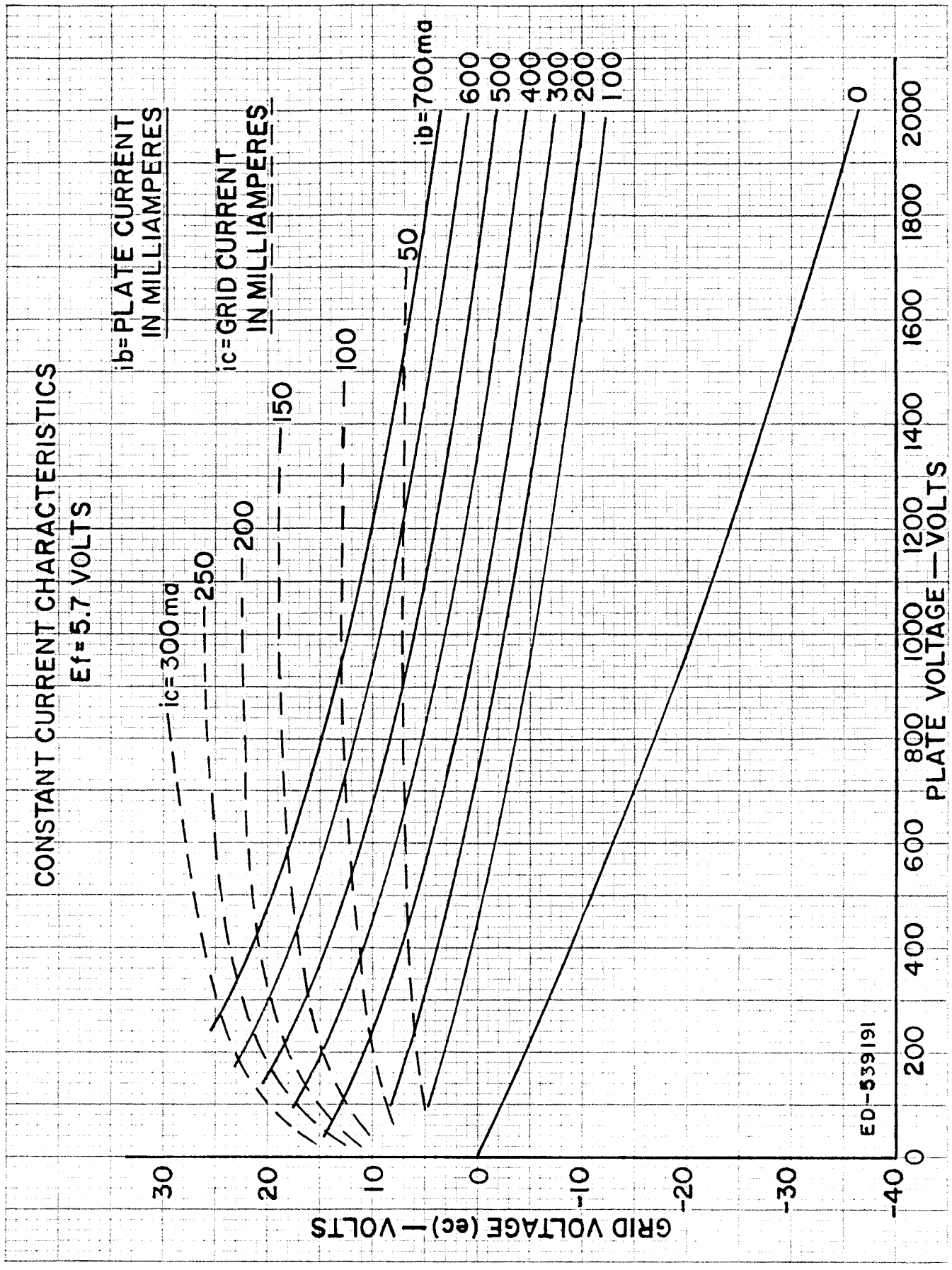
Note 2 — Capacitance measurements are made with tube cold.

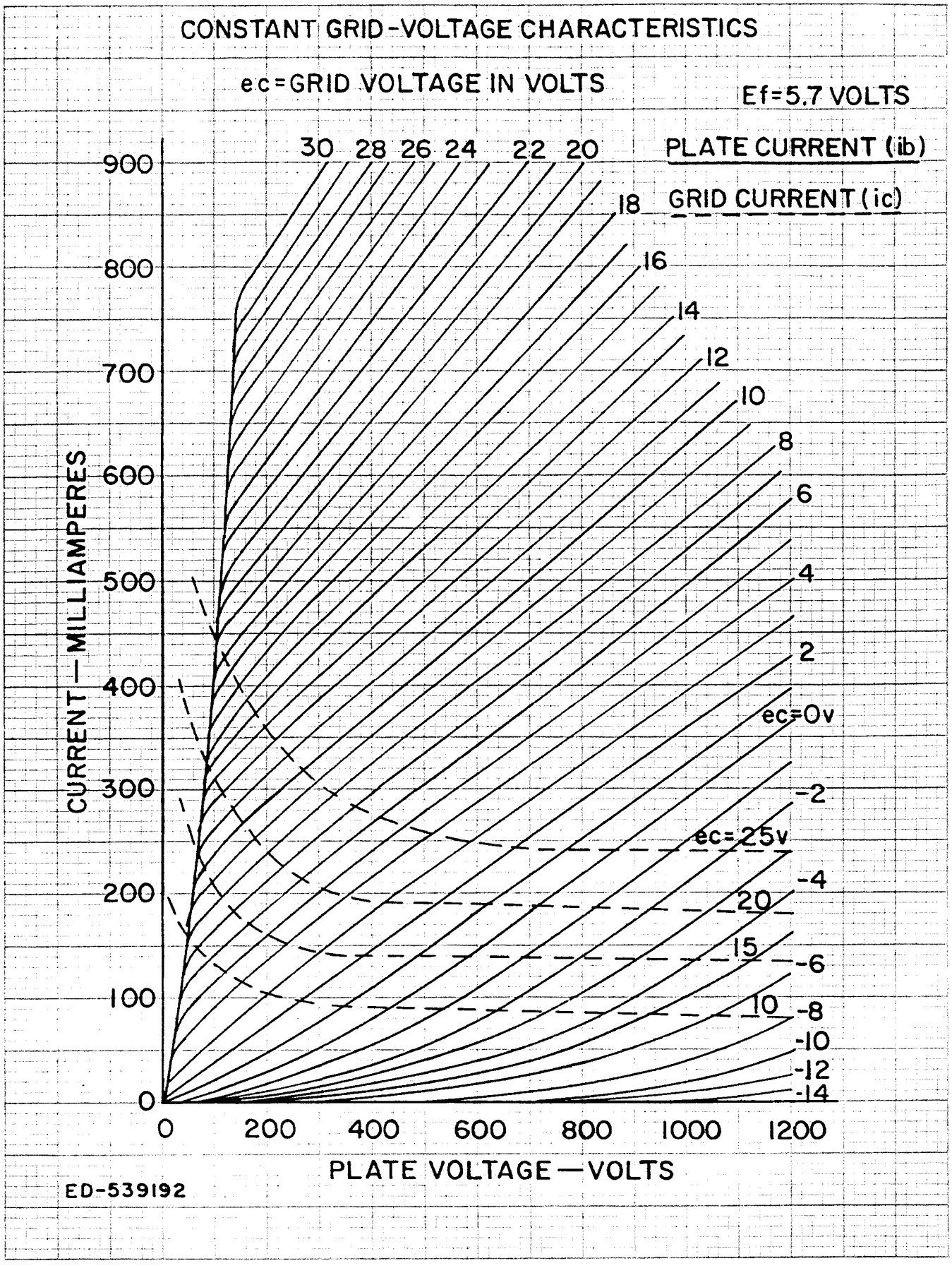
APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publications entitled *Application Notes, UHF Tubes — General* and *Application Notes, UHF Triodes. Extended Life AL Series Tubes for Airline Operation.*


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef=5.7 VOLTS
ib=PEAK PLATE CURRENT IN AMPERES
ic=PEAK GRID CURRENT IN AMPERES
PEAK GRID VOLTAGE (ec) — VOLTS
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
400
800
1200
1600
2000
2400
2800
PLATE VOLTAGE — VOLTS
ED-539193
ib=12a
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.25
ic=4a
11
10
9
8
7
6
5
4
3
2
1
0.5
0


CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef=5.7 VOLTS
PEAK PLATE CURRENT (ib) ——
PEAK GRID CURRENT (ic) - - - -
ec=PEAK POSITIVE GRID VOLTAGE IN VOLTS
ec=160v
140
120
100
80
60
40
20
0
PEAK CURRENT—AMPERES
0
1
2
3
4
5
6
7
0
400
800
1200
1600
2000
2400
2800
PLATE VOLTAGE —VOLTS
ED-539194

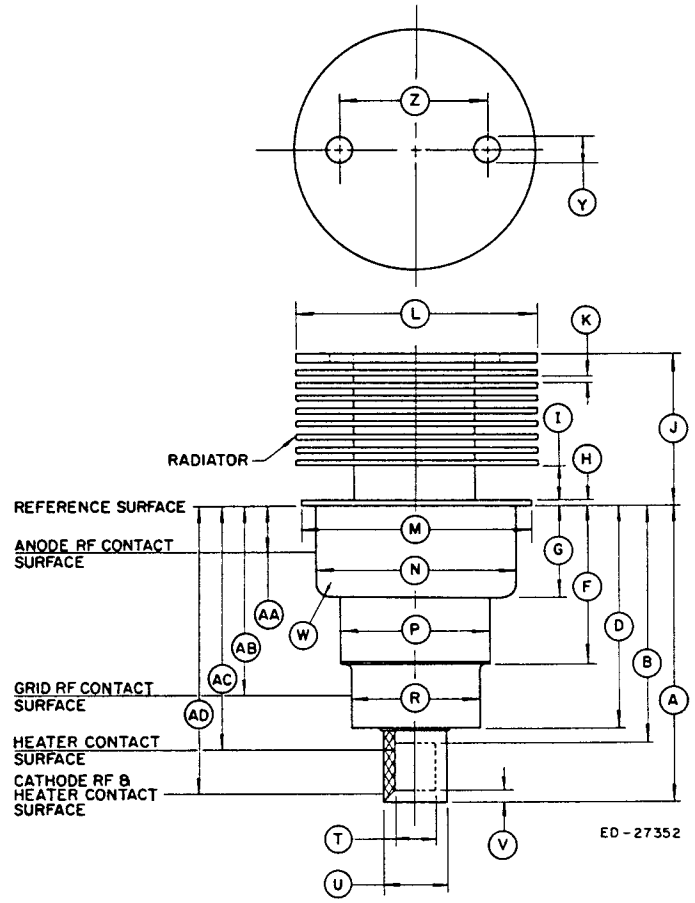

CONSTANT CURRENT CHARACTERISTICS
Ef = 5.7 VOLTS
ib = PLATE CURRENT IN MILLIAMPERES
ic = GRID CURRENT IN MILLIAMPERES
ic = 300 ma
250
200
150
100
50
ib = 700 ma
600
500
400
300
200
100
0
GRID VOLTAGE (ec) — VOLTS
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PLATE VOLTAGE — VOLTS
ED-539191


CONSTANT GRID-VOLTAGE CHARACTERISTICS
ec=GRID VOLTAGE IN VOLTS
Ef=5.7 VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
30 28 26 24 22 20
18
16
14
12
10
8
6
4
2
ec=0v
-2
ec=25v
-4
20
15
-6
10
-8
-10
-12
-14
900
800
700
600
500
400
300
200
100
0
CURRENT—MILLIAMPERES
0 200 400 600 800 1000 1200
PLATE VOLTAGE—VOLTS
ED-539192

DIMENSIONS FOR OUTLINE OF ML-7855/AL

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.500		1.560	38.10		39.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.021	1.061	1.101	25.93	26.95	27.97	2, 5
AC	1.219	1.316	1.413	80.96	33.43	35.89	3, 6
AD	1.160	1.330	1.500	29.46	33.78	38.10	4, 5, 6
B			1.214			30.84	
D	1.125		1.165	28.58		29.59	
F	.800		.840	20.32		21.34	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I	.125		.185	3.18		4.70	
J	.766		.826	19.46		20.98	
K	.025		.046	.64		1.17	
L	1.234		1.264	31.34		32.11	
M	1.180		1.195	27.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
Y	.105		.145	2.67		3.68	
Z	.650		.850	16.51		21.59	



OUTLINE — ML-7855/AL

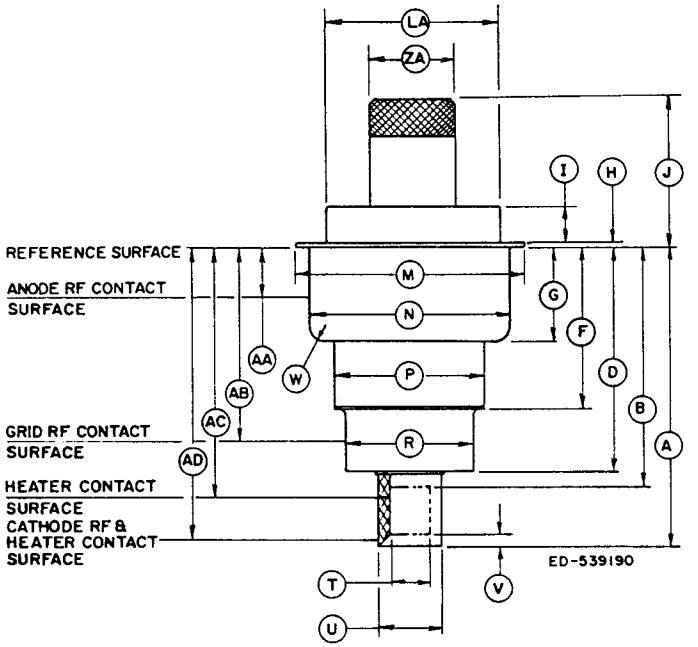
NOTES:

1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

DIMENSIONS FOR OUTLINE OF ML-7855K/AL

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.500		1.560	38.10		39.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.021	1.061	1.101	25.93	26.95	27.97	2, 5
AC	1.219	1.316	1.413	30.96	33.43	35.89	3, 6
AD	1.160	1.330	1.500	29.46	33.78	38.10	4, 5, 6
B			1.214			30.84	
D	1.125		1.165	28.58		29.59	
F	.800		.840	20.32		21.34	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I			.185			4.70	
J	.766		.826	19.46		20.98	
LA	.840		.860	21.34		21.84	
M	1.180		1.195	29.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
ZA	.427		.447	10.85		11.35	



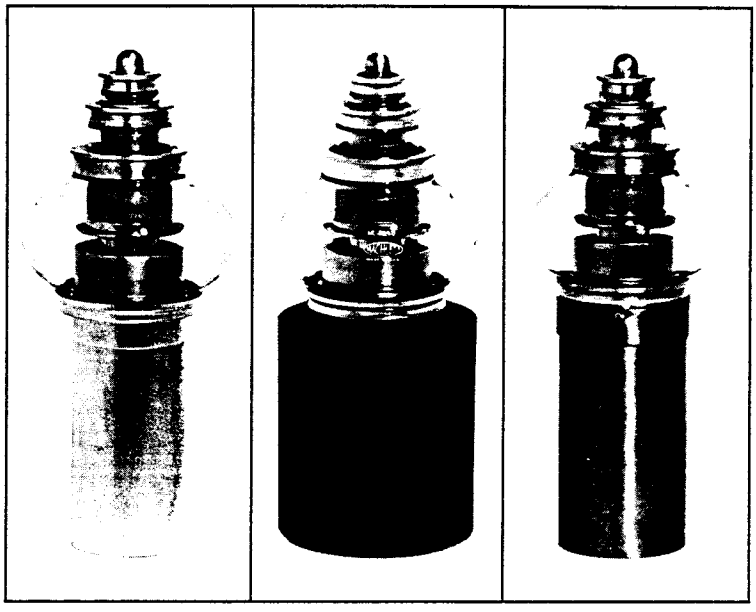
OUTLINE — ML-7855K/AL

NOTES:

1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

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ISSUED 5-64

ML-8038
ML-8040
ML-8041

High-Mu Triodes

Pulse Power

to 20 Mw

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8038, ML-8040 and ML-8041 are high-mu triodes designed primarily to operate as switch tubes in hard-tube pulse modulators, for radar and similar applications. In this service the ML-8038 can deliver pulse power output in the order of 10 to 20 megawatts. The ML-8040 and ML-8041 are capable of delivering 5 to 10 Mw.

The cathode of each type is a sturdy, self-supporting, stress-free thoriated-tungsten filament. The ML-8038 is designed for operation in oil or equivalent dielectric liquid, which is required for utilization of the maximum plate voltage rating of 125kV. Its anode is capable of dissipating 5 kilowatts when cooled by free convection of oil. The anode of the ML-8040 is forced-air-cooled, and is designed to dissipate 10kW with an air flow of approximately 800 cfm. The anode of the ML-8041 is water cooled and is capable of dissipating 60kW with a water flow of approximately 22 gpm.

GENERAL CHARACTERISTICS

Electrical	
Filament Voltage	13.0 Volts
Filament Current	205 Amps
Filament Starting Current, maximum	800 Amps
Filament Cold Resistance	0.0073 Ohms
Amplification Factor	120
Interelectrode Capacitance:	
Grid-Plate	30 $\mu\mu$f
Grid-Filament	80 $\mu\mu$f
Plate-Filament	0.8 $\mu\mu$f
Mechanical	
Mounting Position	Vertical, Anode down
Type of Cooling — ML-8038	Oil convection
Maximum bulk oil temperature	75° C*
Type of Cooling — ML-8040	Forced-air
Air flow on anode for 10kW dissipation, min.	800 cfm at 2.5" water
Air flow on bulb and filament seals	50 — 150 cfm†
Maximum incoming air temperature	50° C
Type of Cooling — ML-8041	Water and Forced-air
Water flow on anode for 60kW dissipation, min.	22 gpm
Air flow on bulb and filament seals	50 — 150 cfm†
Maximum outgoing water temperature	70° C
Maximum Glass Temperature	165° C

Net Weight, Approximate, ML-8038, 20 lb; ML-8040, 60 lb; ML-8041, 22 lb.

*It may be necessary to promote mixing of oil by agitation.

†Sufficient air cooling must be provided to keep glass seal temperatures at less than 165°C under all conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

VALUES APPLY TO ALL THREE TYPES UNLESS OTHERWISE SPECIFIED

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values	ML-8038	ML-8040	ML-8041	
D-C Plate Voltage	*125	▲60	▲60	kV
Peak Plate Voltage	*125	65	65	kv
D-C Grid Voltage	—1500	—1500	—1500	volts
Pulse Cathode Current	175	175	175	amp
Grid Dissipation	1000	1000	1000	watts
Plate Dissipation	5	10	60	kW
Pulse Duration‡	1000	1000	1000	μsec
Duty Factor‡	0.01	0.01	0.01	

*For very high reliability in circuits containing considerable stored energy, it is recommended that the plate voltage not exceed 100 kV.

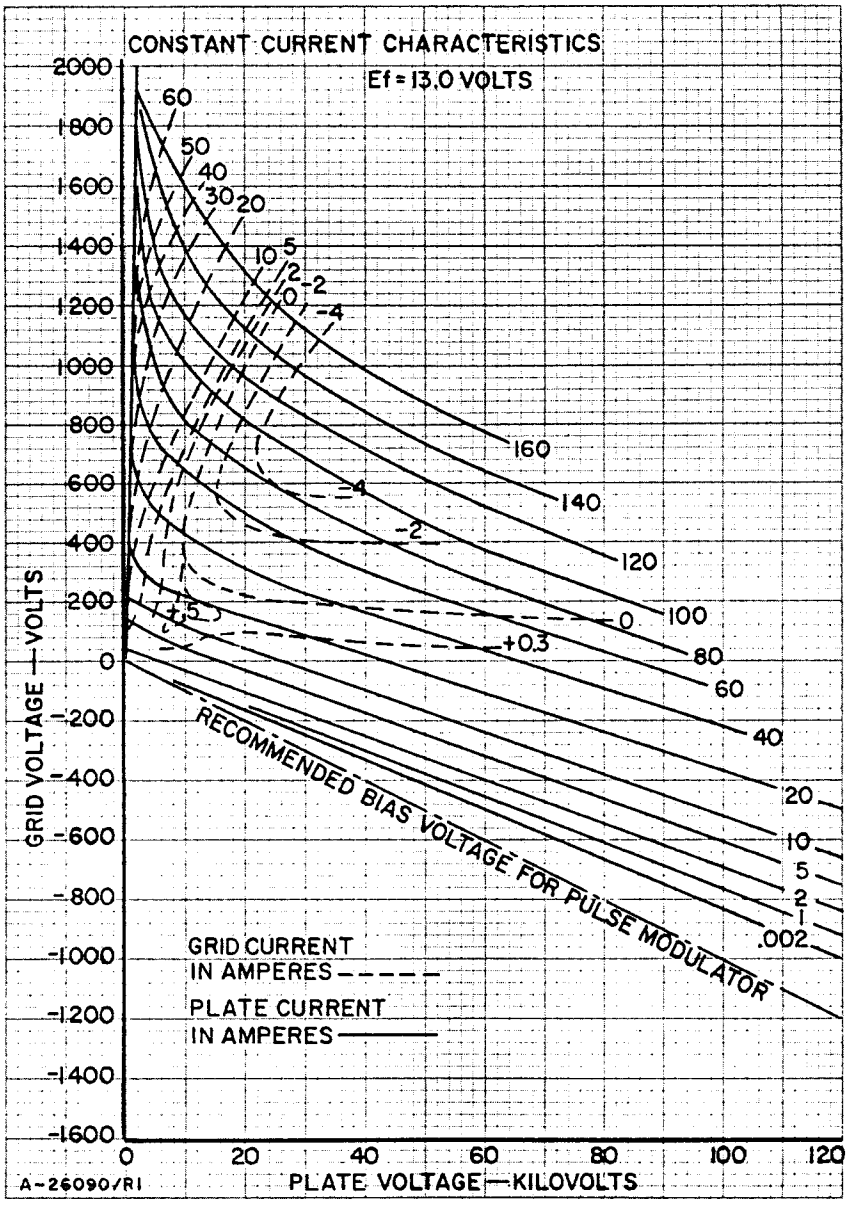
▲D-C Plate and Peak Plate voltages listed apply for operation in air. Higher voltages are possible by immersing tube in oil or other suitable dielectric fluids. For details, consult Machlett.

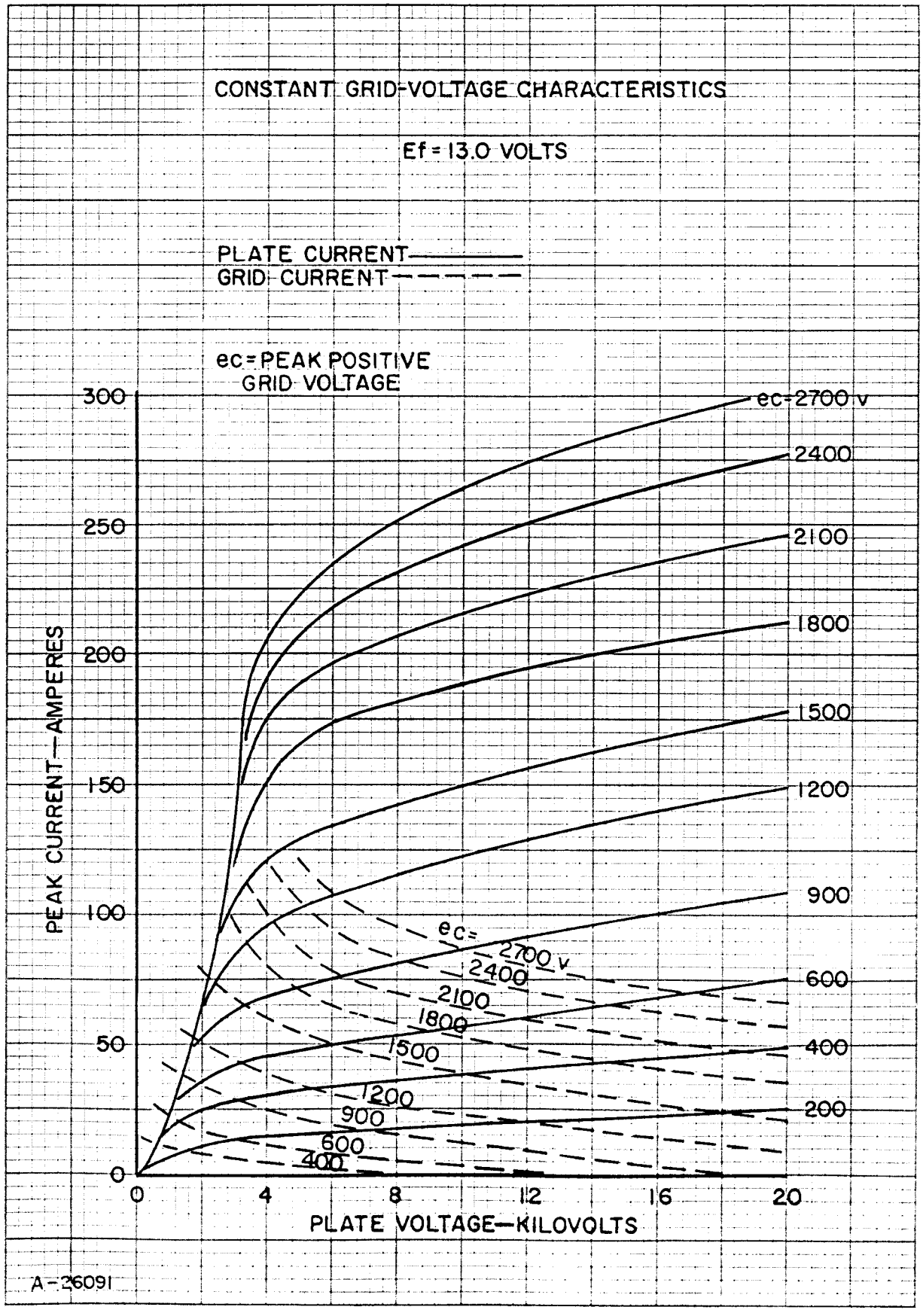
Typical Operation	ML-8038			
D-C Plate Voltage	60	100	125	kV
D-C Grid Voltage	—600	—1000	—1300	volts
Pulse Positive Grid Voltage	1350	1350	1700	volts
Pulse Plate Current	115	135	†175	amp
Pulse Grid Current	45	30	45	amp
Pulse Driving Power	9	70	135	kw
Pulse Power Output	6.3	12	20	Mw
Plate Output Voltage	55	90	115	kv
Duty Factor	.008	.003	.002	

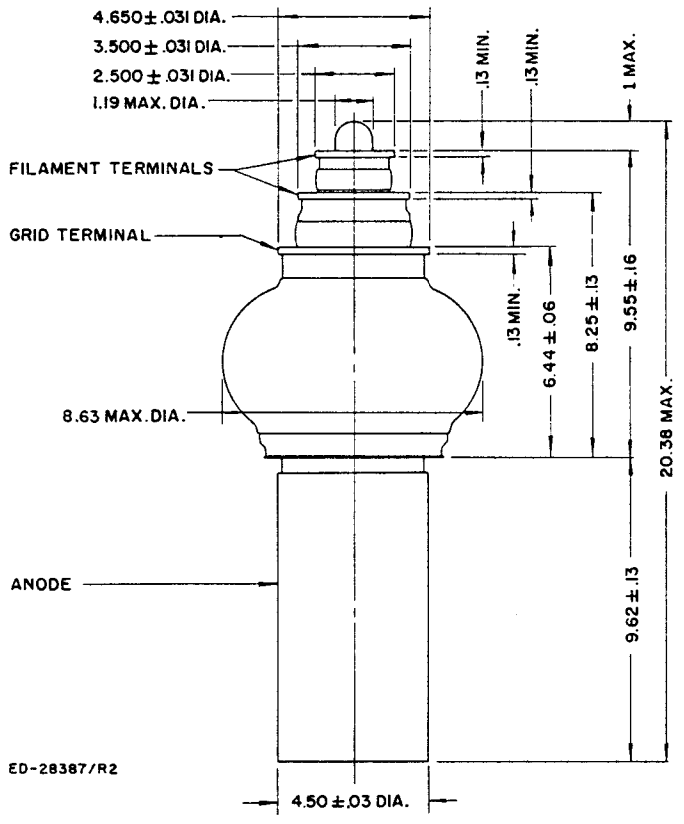
‡For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

†At filament voltage 5-10 percent above normal.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

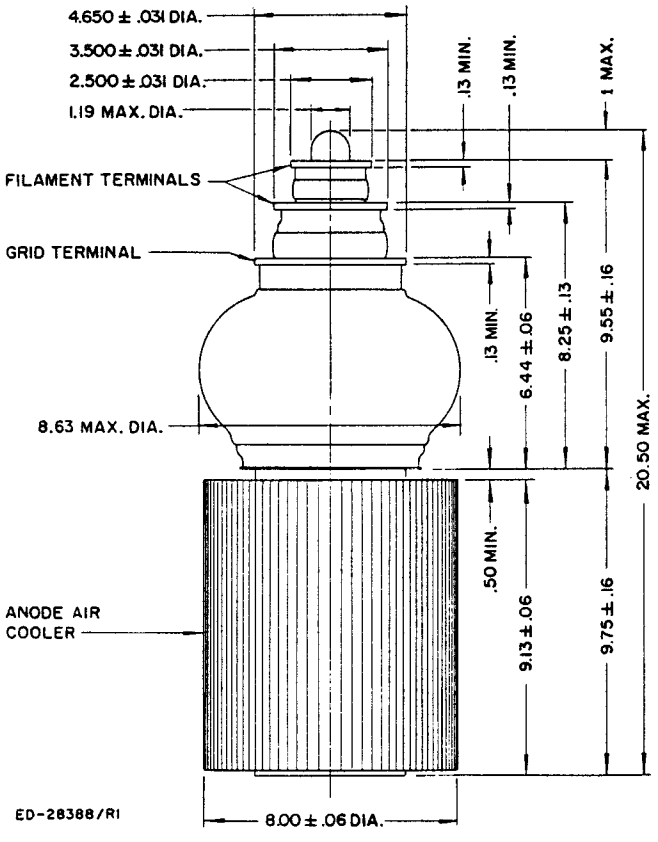



CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 13.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
PEAK CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
ec=2700 v
2400
2100
1800
1500
1200
900
600
400
200
ec=
2700 v
2400
2100
1800
1500
1200
900
600
400
0
50
100
150
200
250
300
0
4
8
12
16
20
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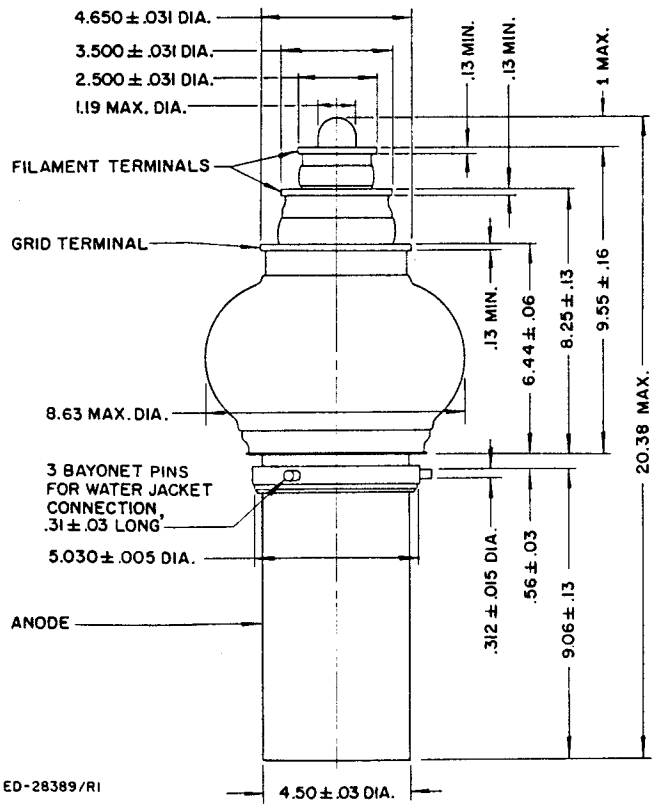
ALL DIMENSIONS IN INCHES

DIMENSIONS — ML-8038



ALL DIMENSIONS IN INCHES

DIMENSIONS — ML-8040



ALL DIMENSIONS IN INCHES

DIMENSIONS — ML-8041

THE MACHLETT LABORATORIES, INC.

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SPRINGDALE MACHLETT CONNECTICUT

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sponsor: The Machlett Laboratories

ML-8087

SCAN-CONVERSION STORAGE TUBE

DESCRIPTION:

The ML-8087 is a precisely constructed, dual-gun, electrical-signal-storage tube with a semiconductive storage medium. This tube is capable of receiving an electrical input of one scanning mode, holding or storing this information for various periods, and then generating a separate electrical output in the same or any other desired scanning mode during which time stored information is gradually erased.

Use of the ML-8087 for scan conversion or electrical-signal storage has been found to provide the following advantages:

1. High resolution (170 range rings/diameter or 680 TV lines)
2. Fast erase cycle (2 seconds maximum)
3. Gray levels or half-tones comparable to TV presentation
4. Wide storage range
5. High signal/noise ratio (15:1 to 80:1)
6. Rapid installation (mounting and adjustment accomplished in a few minutes)
7. Overall uniformity of display
8. Need for critical dynamic focusing of electron guns minimized
9. No need for spurious signal cancellation (no "crosstalk")
10. Fast writing speed (TV scanning rates or better)

Various possible applications of this tube are suggested by the following:

1. In air traffic control, use of the tube permits display of aircraft positions as a bright, flicker-free trace, with a fading trail indicating relative speed and direction.

2. The tube can be used to convert TV programs or TV video tape from one set of standards to another — for example, from British to U. S. scanning rates.

3. The storage ability and flexibility of the tube permit improved sonar displays.

4. By integrating a weak video signal over a number of scans, signal/noise ratios are improved and contrast enhanced.

5. Three scan-converter tubes can be used to store three separate colors. Color of display portions, read on a color TV tube, permits identification of an additional parameter, such as the altitude of an aircraft.

6. In signal simulation equipment, the tube permits changing analogue information on a fixed time base to a variable time base with or without a controllable delay.

7. Video or informational bandwith can be compressed by reading with a slow spiral scan, a slow TV-raster scan, or by a reduced sampling scan. Conversely, low frame-rate information can be converted into a flicker-free visual display by more rapid scanning.

The ML-8087 is an improved version of the TMA-403X, a storage tube of proven reliability. A new read gun, new storage electrode and new shading electrode permit higher resolution, faster erasing, decreased shading, and elimination of the need for spurious signal cancellation.

The tube uses only one magnetic deflection yoke and no external focus coils. This simplifies installation, since proper performance does not depend on the precise alignment of the tube with respect to external circuit elements. The deflection system of the tube is very flexible with respect to the types of scan employed. Off-centering of the write-or read-gun scan can be easily accomplished. The read gun can be scanned over only a portion of the written storage surface for partial read-out or erasure.

The writing operation in the tube utilizes bombardment-induced conductivity instead of secondary emission of the storage target. The resultant high writing speed minimizes delay after an erasure and permits inputs of very fast sweep rates.

A wide storage range (see Fig. 1) can be obtained by adjustment of a single control to vary collector electrode voltage.

This tube has been designed to meet applicable FAA specifications and sections of Military Specification MIL-E-1 pertaining to storage and cathode ray tubes.

PRINCIPLES OF OPERATION

Schematic Construction:

Figure 2 illustrates schematically the arrangement of electrodes within the tube. Symbols used to identify components are in accordance with JEDEC publication No. 33 in which the prefix "w" denotes a component in the write-gun section and the prefix "r" a component in the read-gun section. The letter "g" denotes a grid or anode, "h" a heater, "k" a cathode, and "D" a deflection plate. Table I identifies each electrode with reference to the symbol used and pin connection.

Write-Gun Section: The write gun is designed to focus a very-high-velocity electron beam on any point of the backing electrode (be). It consists of electrodes wh, wk, and wg1 to wg5.

Read-Gun Section: The read gun is designed to focus a medium-velocity electron beam on any point of the storage surface (ss). It consists of electrodes rh, rk, rg1 to rg7, and rD1 to rD4.

Storage Section: The storage section consists of electrodes ce, se, ss and be. The storage electrode consists of a very thin sheet of metal, the backing electrode (be), upon which is coated a semi-conducting material the surface of which is known as the storage surface (ss). This material has characteristics such that when struck by a medium-velocity electron beam, its secondary emission ratio is greater than one (the number of secondary electrons leaving the dielectric are greater than the number landing); any point on the storage surface (ss) can thus be positively charged with respect to backing electrode (be). When a point on the dielectric material is struck by a very-high-velocity electron beam, "charge carriers" are created within the dielectric and decrease the charge on the storage surface at that point. For the purpose of understanding operation, the storage electrode can be considered as a planar array of minute, discrete conductive areas (ss), each capacitively coupled with the backing electrode (be). The collector electrode (ce) collects electrons emitted by the storage surface. The corrector electrode, or "shading" electrode (se), corrects the field along the periphery of the storage surface to permit uniform collection of secondary electrons.

Automatic Priming Operation:

Prior to writing, the storage surface (ss) is uniformly charged to a positive potential with respect to the backing electrode. This is called "priming" and is accomplished as the backing electrode is at zero potential and the storage surface is scanned by the read-gun, operation of which will be described subsequently. The priming operation charges the storage surface to approximately the same potential as the collector electrode (ce). Erasing operations, described in later paragraphs, also prime the storage target.

Writing Operation:

Due to the high write-gun cathode potential, about -8kV, and consequent high electron velocity, the storage surface tends to be discharged at any point which is struck by the write-gun beam. The electron velocity is sufficient for electrons to penetrate the metal backing electrode and enter the semiconductive coating. The unperforated backing electrode, as compared to the mesh-type backing electrodes, does, however, minimizes the transmission of write-gun electrons through the dielectric to the storage surface, where they would otherwise be picked up as a spurious signal by the read gun. The write-gun beam density can be modulated in accordance with electrical information input to the cathode (wk) or control grid (wg1) (see Fig. 3). At the same time, the beam can be scanned across the backing electrode under control of the deflection coil. Thus, an image can be established by the write gun in the form of a pattern of varying charges on the storage surface: fully charged, most positive, surfaces corresponding to "black" unwritten points; fully discharged, near 0-volt, surfaces corresponding to "white" written points; and areas charged to intermediate, less positive, potentials corresponding to various shades of grey, or half tones. The amplitude of the charge at any point, and consequently the amplitude of any stored signal, is primarily dependent on the write-gun beam current but also dependent on more fixed factors such as electron velocity, scanning speed and pulse repetition rates.

Reading Operation

The read-gun beam can be deflected to impinge upon any point of the storage surface (ss) by means of the deflection plates (rD1, rD2, rD3, rD4). Due to the relatively lower velocity of read-gun electrons as compared to the write gun, conductivity is not induced at points struck by the beam, but the number of secondary electrons emitted from the storage surface is greater than the number landing. When the read-gun beam impinges upon a point which was previously written, and consequently negative with respect to the collector electrode (ce), the read beam tends to recharge it; electrons which are emitted from the storage surface are collected at the more positive collector electrode. This flow of electrons constitutes the output signal. When the read beam impinges upon an unwritten point, which is consequently at approximately the same potential as the collector electrode, electron flow to the collector is small and a minimum output signal is obtained.

The time necessary for recharging any storage surface point back to the potential of the collector varies inversely with read-gun beam current and directly with collector electrode voltage. The time during which an image is stored is therefore dependent upon these parameters (see Fig. 1). It will be noted that the reading gun serves also to erase the stored image.

Simultaneous Reading and Writing

Both guns are usually operated at the same time. Reading increases storage-surface potentials while writing decreases storage-surface potentials. Since, the read gun normally charges the surface at a slower rate than the write gun discharges it, written points remain visible as long as the write-gun beam impinges upon that point. When the write-gun beam moves, it will, however, leave a gradually fading trail.

Erasing Operation

Erasing of stored information is accomplished by charging all portions of the storage surface to a uniform positive potential with respect to the backing electrode. This occurs during normal scanning of the read gun as described previously. By read-gun scanning of only a portion of the storage surface, only that portion of stored information will be erased. Erasure leaves the storage surface primed, ready for another writing operation.

Since the rate at which the storage surface is charged by the read gun, and consequently the rate of erasure, is directly proportional to the read-beam current, provisions are made to increase the read-beam current to obtain faster erasure as follows:

During normal reading, the erase-focus anode (rg3) is at the same potential as accelerating anodes (rg2, rg4, rg5 and rg7) in order to obtain a beam of uniform density suitable for collimation. A large number of electrons (up to 95%) are intercepted by the collimating iris of anode (rg4), and the main-focus anode (rg6) is adjusted to obtain a very fine spot for high-resolution reading. During a fast-erase cycle, erase-focus anode (rg3) voltage is adjusted to focus electrons at the aperture of the iris of anode (rg4) so that almost all read-beam electrons pass through. This produces a somewhat larger spot at the storage surface. The

larger spot permits use of a still-higher beam current, which may be obtained, if needed, by raising the voltage of the read-gun control grid (rg1). The greater beam current recharges the negative portions of the storage surface more quickly and thus increases the rate of erasure. The maximum erase current is limited by the heat dissipating ability of the storage surface.

During the fast-erase cycle, the voltage of the backing electrode is switched in succession to +100 volts for one second, to -100 volts for one second and then to normal ground potential. Since the storage surface is capacitively coupled with the backing electrode, its potential will follow that of the backing electrode. During the cycle, additional current will flow from the storage surface to the collector. In addition, at the higher voltages , the dielectric material of the storage electrode becomes conductive. The net effect of the cycling operation is to obtain more complete erasure by bringing all points on the storage surface to a more uniform potential. This cycling procedure also increases the rate of erasure by itself, without any increase in beam current.

PERFORMANCE

Values given are for typical tubes unless otherwise specified.

Resolution with 50% Amplitude Modulation (‡1):	
Range Rings per Diameter	170
Equivalent TV Lines per Diameter	680
Storage Time:	
Read Gun Not Operating	Several days
Read Gun Operating	See Fig. 1
Fast-Erase, maximum (‡2)	2 sec
Signal/Noise Ratio (‡3)	15:1 to 80:1
Signal/Shading Ratio, minimum:	
Over 90% of storage surface	5:1
Over 100% of storage surface	3:1
Signal/Background-Shading Ratio, minimum:	
Over 90% of storage surface	10:1
Over 100% of storage surface	8:1
Grey Level Capabilities, minimum	5

‡ Notes on Performance

‡1a. If resolution were to be measured with parallel written lines orthogonal to the reading raster, instead of with PPI range rings, the resolution figure would be in the order of 820 TV lines.

‡1b. Resolution is dependent upon the read-gun focusing-anode (rg6) voltage as shown in Figure 4. In order to obtain maximum resolution in the center as well as on the edges of the target, a dynamic focusing voltage should be superimposed on the d-c voltage of the read-gun focusing anode (rg6) in accordance with Figure 5.

‡1c. To minimize gun astigmatism, the voltage of both deflecting plates of each pair should be fed symmetrically with respect to the voltage of anodes rg2, rg4, rg5 and rg7; i.e., the absolute values of deflecting plate voltages with respect to anode voltage should always be equal for each pair of plates (see Fig. 6).

‡1d. The write gun operates at very high cathode voltage and consequently does not require dynamic focusing.

‡2. Using fast-erase technique, the amplitude of the stored information can be reduced from a level of 100% to 7% in less than 2 seconds. This is the same as the noise level in a 945-line TV system. During this procedure the following conditions prevail:

Read-Beam Current, approximate	100 μA
rg3 to rk Voltage	-190 to -230 Vdc
be Voltage to Ground (in indicated order):	
For 1.0 sec	+100 Vdc
For 1.0 sec	-100 Vdc
Then return to	0 V

‡3. Due to the homogeneous structure of the storage dielectric, the disturbance level is very low.

GENERAL CHARACTERISTICS

Electrical, Write-Gun Section

Heater Voltage, AC or DC (#1)	6.3 ± 10% V
Heater Current at 6.3 Volts	0.6 ± 10% A
Focus Method	Electrostatic
Centering Method	Electromagnetic
Deflection Method	Electromagnetic
Total Deflection Angle, approximate	30 deg
Direct Interelectrode Capacitances:	
wg1 to wh	3.5 pf
wk to all other electrodes	5.0 pf
wg1 to all other electrodes	9.0 pf

Electrical, Read-Gun Storage Sections

Heater Voltage, AC or DC (#1)	6.3 ± 10% V
Heater Current at 6.3 Volts	0.6 ± 10% A
Focus Method	Electrostatic
Deflection Method	Electrostatic
Total Deflection Angle, approximate	30 deg
Deflection Sensitivity in Volts Peak-to-Peak to Sweep a Major Diameter of Target (#2):	
Plates rD1 and rD2	250 v/dia
Plates rD3 and rD4	315 v/dia

Direct Interelectrode Capacitances:

rD1 to rD2	12 pf
rD3 to rD4	12 pf
rg1 to rk	2.5 pf
rk to all other electrodes	7.0 pf
rg1 to all other electrodes	10.5 pf
ce to all other electrodes	26 pf

Mechanical

Mounting Position (#3)	Any
Dimensions	See Fig. 7
Pin Connections	See Fig. 8
Useful Storage Surface Diameter	2.0 inches
Deflection Coil Inside Diameter, minimum	2.087 inches
Bases:	
Write gun	JEDEC B12-131
Read gun	JEDEC B14-38
Recessed small ball caps	JEDEC J1-22
Shielding Required: (#4):	
Read Gun	magnetic
Storage Section	light
Weight, approximate	2.5 lbs

Notes on General Characteristics

#1. One end of the heater should be connected externally to its cathode. The heater power supply must be suitably insulated to withstand the cathode potential with respect to ground.

#2. See Note on Performance (‡1c).

#3. If it is necessary to operate the tube in vertical position, the write-gun end should be up.

#4. The read-gun end of the tube should be enclosed in triple layer mu-metal shielding approximately .60" thick which covers the read gun section and extends beyond the storage section. In addition, the same shield or a separate shield should be used to prevent light from reaching the semiconductive surface of the storage target, which is photosensitive.

RATINGS

Ratings are absolute maximums unless otherwise specified.

All voltages are referenced to ground except where indicated otherwise.

Write Gun

wk Voltage	-10000 Vdc
wg1 to wk Voltage (†1):	
Maximum	-150 Vdc
Minimum	10 Vdc
wg2, wg3, wg5 Voltage	0 v
wg4 to wk Voltage	2.5 kVdc
Peak Beam Current (†2)	2 μa

Read Gun

rk Voltage	-1500 Vdc
rg1 to rk Voltage	-150 Vdc
rg2, rg4, rg5, rg7 Voltage	-100 Vdc
rg3 Voltage:	
For normal read beam	-100 Vdc
For fast erase	-1800 Vdc
rg6 Voltage	-1500 Vdc
rD1 to rD2 Voltage, peak to peak (†3)	600 vdc
rD3 to rD4 Voltage, peak to peak (†3)	600 vdc
Peak Beam Current (†2)	250 μa

Storage Section

be Voltage:	
For normal read operation	0 V
For fast-erase operation	±100 Vdc
ce Voltage	50 Vdc
se Voltage	30 Vdc
Dynamic Output Signal Current	1.2 μA

† Notes on Ratings

†1. During initial applications of high voltage, the write-gun grid should be held at about -150 volts with respect to the write-gun cathode. A gradual rise in about 30 seconds is recommended to insure against grid decoupling effects.

†2. It will be necessary to provide an automatic means of protection against sweep or bias failure so that the beams never remain stationary on any part of the storage surface.

†3. See Note on Performance (‡1c).

TYPICAL OPERATING CONDITIONS

All voltages are referenced to ground except where indicated otherwise.

Write Gun

wk Voltage	-8000 Vdc
wg1 to wk Voltages (See Fig. 3) (*1):	
Bias Voltage	-70 to -110 Vdc
Cutoff Voltage	-80 to -110 Vdc
wg2, wg3, wg5 Voltage	0 V
wg4 Voltage (*2)	-5600 to -6400 Vdc
Peak Beam Current	0.75 μa

Read Gun

rk Voltage	-1300 Vdc
rk Current:	
For 1 μA normal read beam	110 μA
For 100 μA fast-erase beam	225 μA
rg1 to rk Voltage:	
For Cut-Off	-50 Vdc
For 1 μA normal read beam	-35 Vdc
For 100 μA fast-erase beam	-20 Vdc
rg2, rg4, rg5, rg7 Voltage	-8 Vdc
rg3 Voltage:	
For normal read beam, voltage to ground	-8 Vdc
For fast-erase beam, voltage to rk	-190 to -230 Vdc
rg6 to rk Voltage (*3)	+250 to +350 Vdc
Average Beam Current:	
For normal read operation	1 μA
For fast-erase operation	100 μA

Storage Section

be Voltage:	
For Normal read operation	0 V
For Fast-erase operation	±100 Vdc
ce Voltage	0 to 30 Vdc
se to ce Voltage (*4)	12 Vdc
Dynamic Output Signal Current	0.6 μA

* Notes on Typical Operating Conditions

*1. Input video signals must be fed to wg1 through a 10 kV capacitor.

*2. The write-gun focus anode voltage should be set at 70% to 80% of the cathode (wk) voltage.

*3. See Note on Performance (‡1).

*4. The corrector electrode (se) voltage is adjusted with respect to the collector electrode (ce) to maximize the signal/disturbance ratio. The correct voltage is one which provides maximum ratios for a wide range of storage characteristics.

TABLE I — TUBE CONNECTIONS

Symb.	Electrode	Write-Gun Base Pin	Read Gun Base Pin	Small Ball Cap
wh	write-gun heater	1	--	--
wh	write-gun heater	14	--	--
wk	write-gun cathode	12	--	--
wg1	write-gun control grid	13	--	--
wg2	write-gun accelerating anode	--	--	3
wg3	write-gun anode (conductive coating)	--	--	3
wg4	write-gun focusing anode	7	--	--
wg5	write-gun anode	--	--	3
be	backing electrode	--	--	▲
ss	storage surface	--	--	N.C.
se	corrector (shading) electrode	--	--	1
ce	collector electrode	--	--	2
rh	read-gun heater	--	8	--
rh	read-gun heater	--	9	--
rk	read-gun cathode	--	7	--
rg1	read-gun control grid	--	5	--
rg2	read-gun anode	--	14	--
rg3	read-gun erase focusing anode	--	6	--
rg4	read-gun accelerating anode	--	14	--
rg5	read-gun anode (conductive coating)	--	14	--
rg6	read-gun main focusing anode	--	10	--
rg7	read-gun anode	--	14	--
rD1	read-gun vertical deflection plate	--	1	--
rD2	read-gun vertical deflection plate	--	2	--
rD3	read-gun horizontal deflection plate	--	12	--
rD4	read-gun horizontal deflection plate	--	13	--

▲ The backing electrode is connected to the metal ring at the center of the envelope.

STORAGE CHARACTERISTICS CURVES

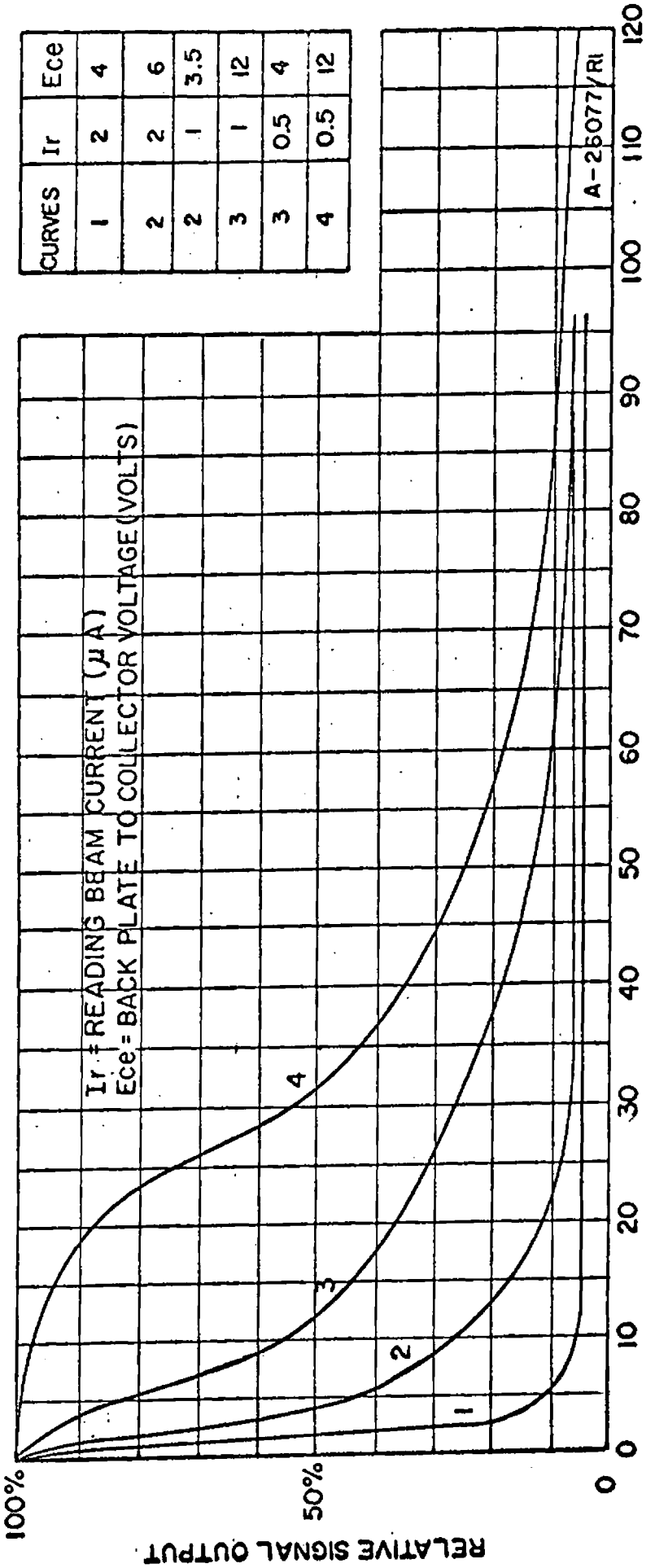


FIG. 1

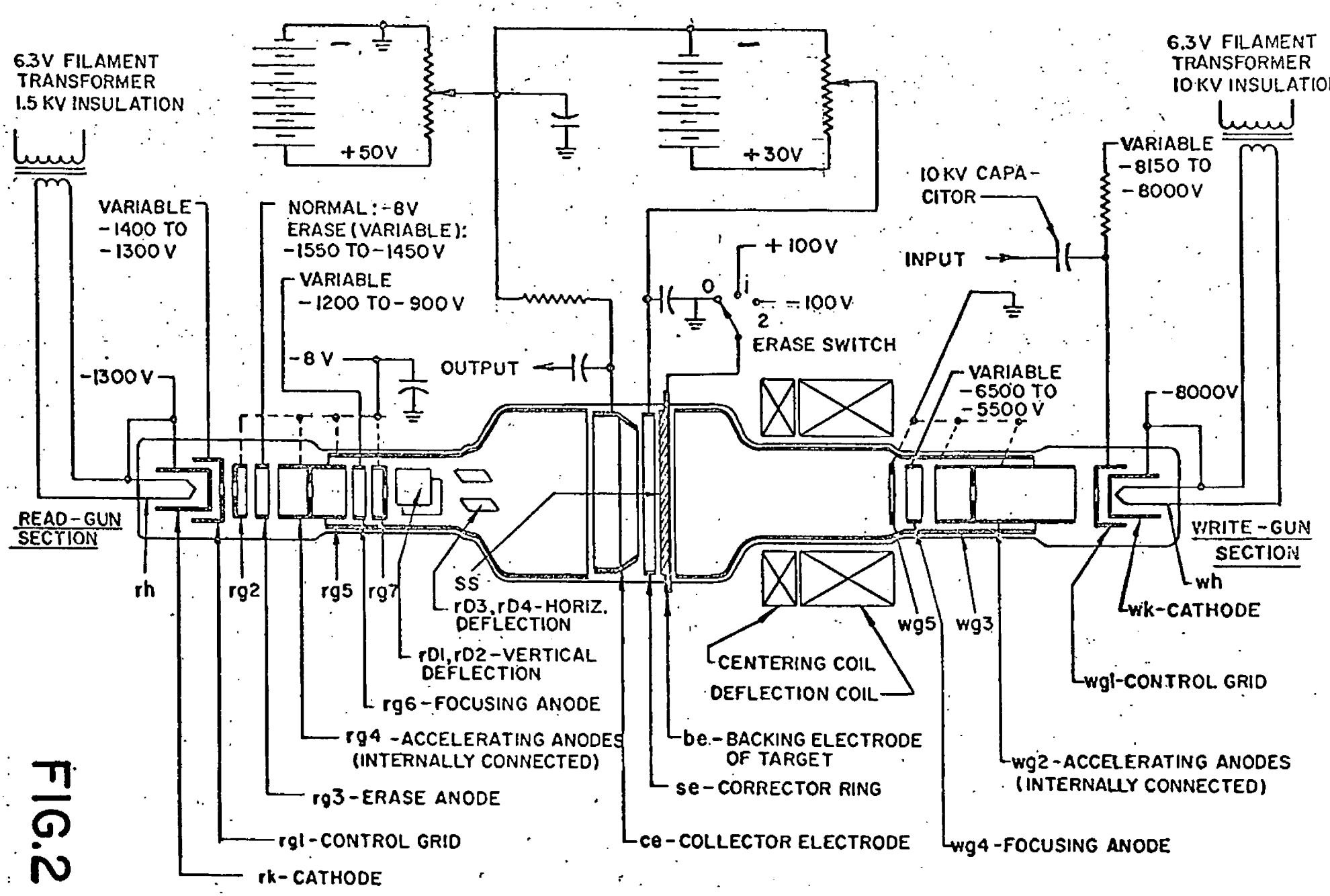


FIG.2

NOTE: VOLTAGES SHOWN ARE TYPICAL. DOTTED LINE INDICATES INTERNAL CONNECTION

ED-27330/R1

SCHEMATIC ARRANGEMENT OF ML-8087

ML-8087 TYPICAL WRITE GUN TRANSFER CHARACTERISTICS

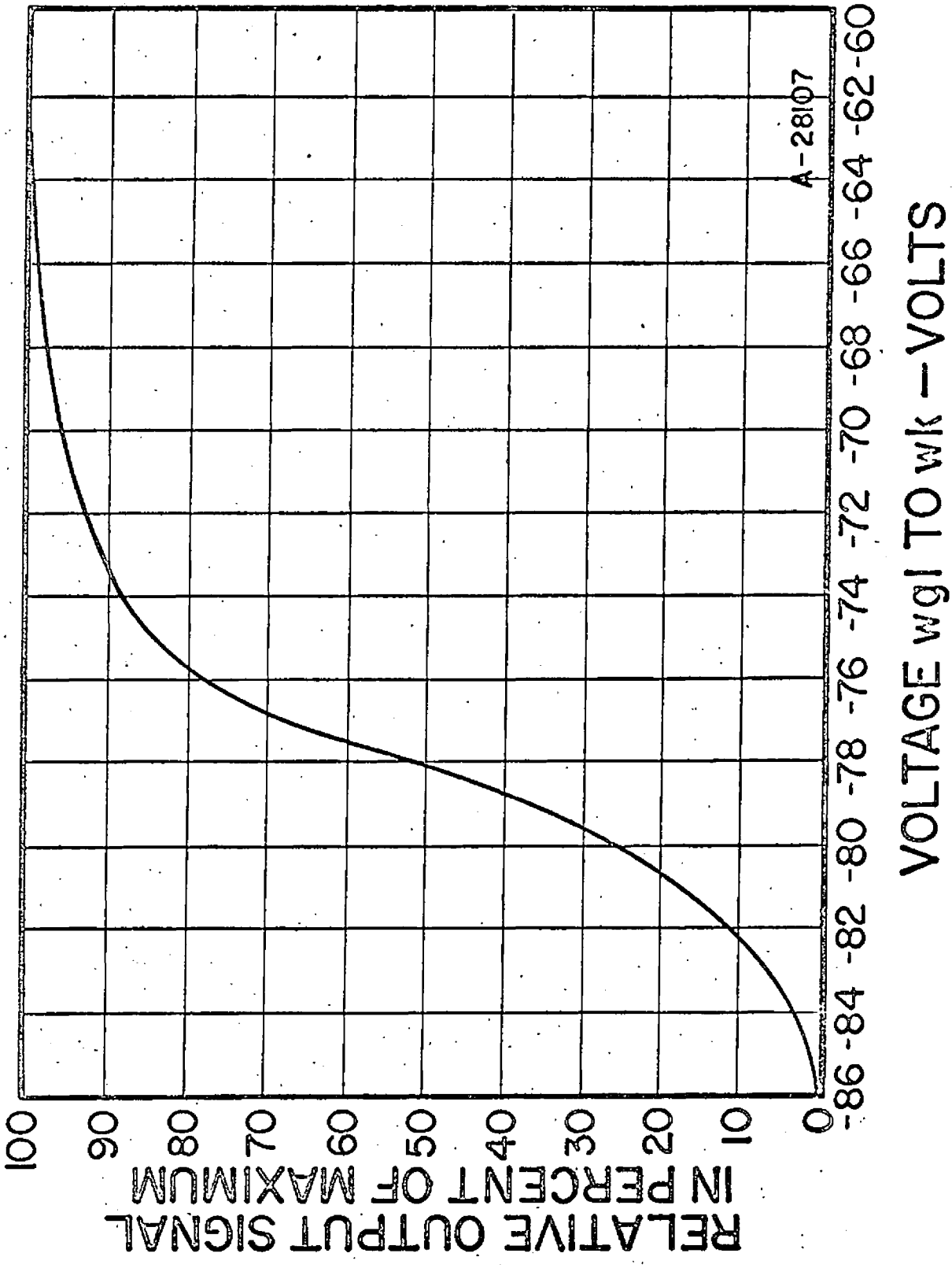


FIG. 3

ML-8087 HORIZONTAL RESOLUTION AS A FUNCTION OF DEVIATION FROM OPTIMUM FOCUS VOLTAGE OF READ GUN

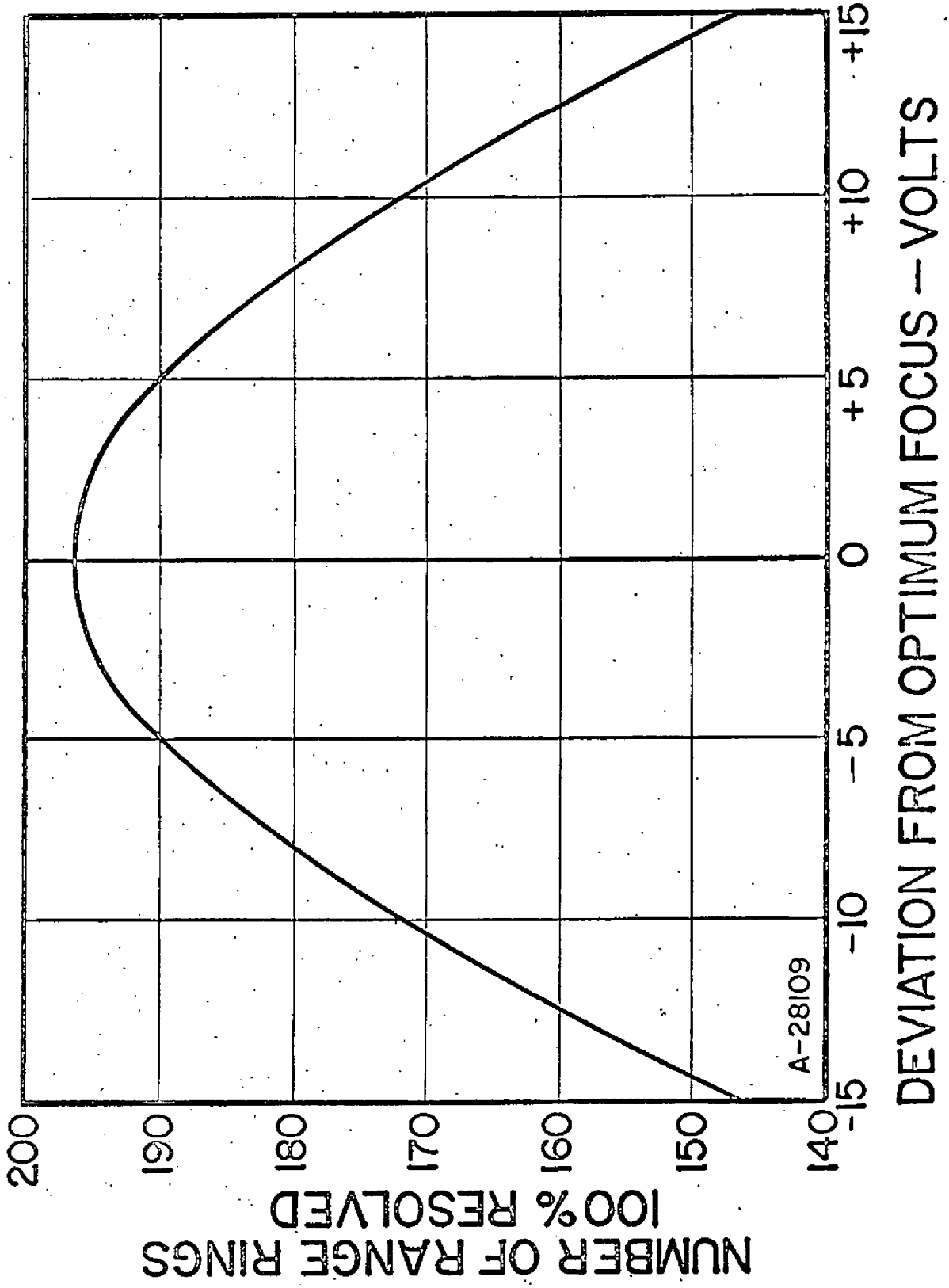


FIG. 4

ML-8087 READ GUN DYNAMIC FOCUS

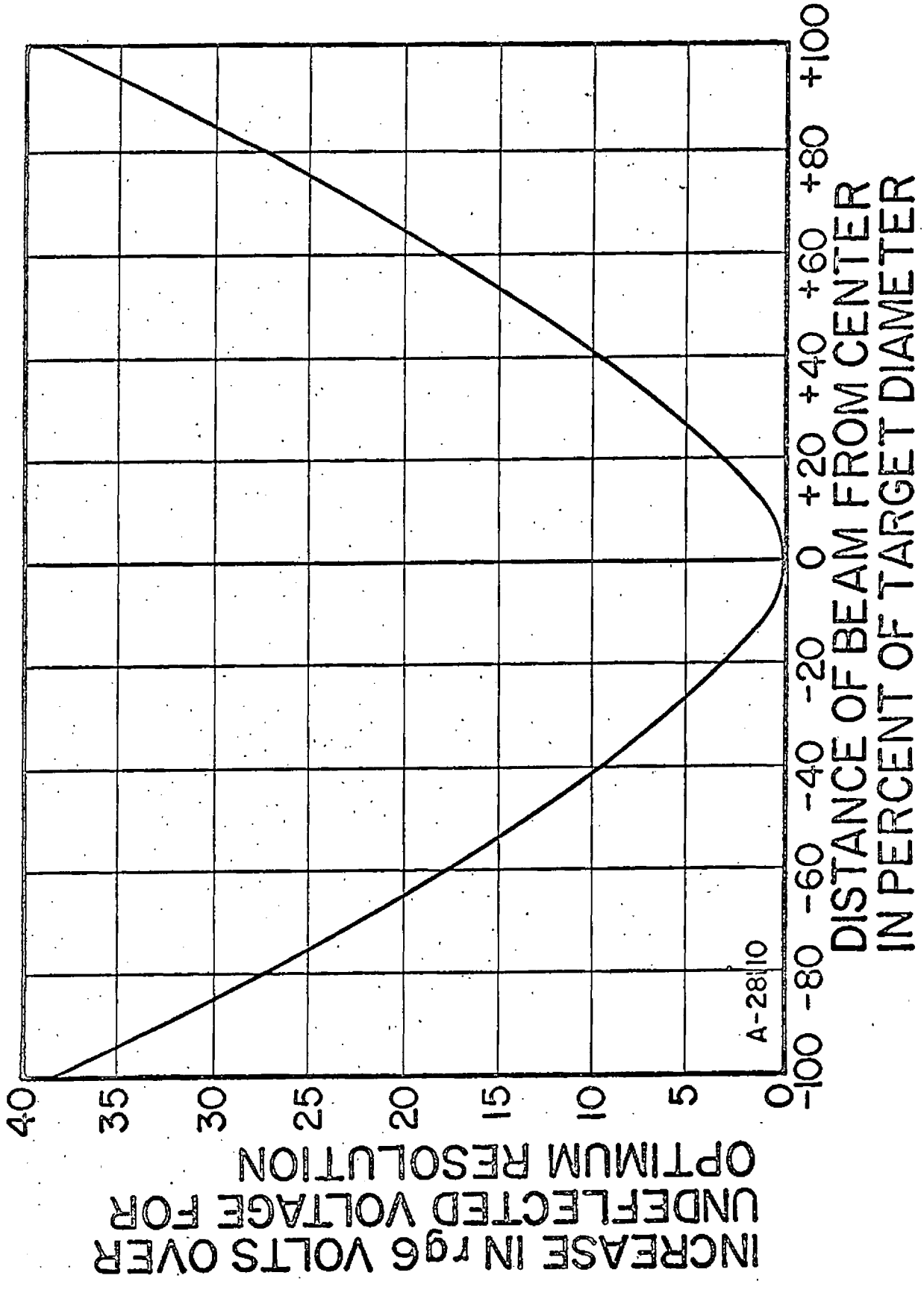


FIG. 5

ML-8087 HORIZONTAL RESOLUTION AS A FUNCTION OF DEFLECTION PLATE VOLTAGE SYMMETRY

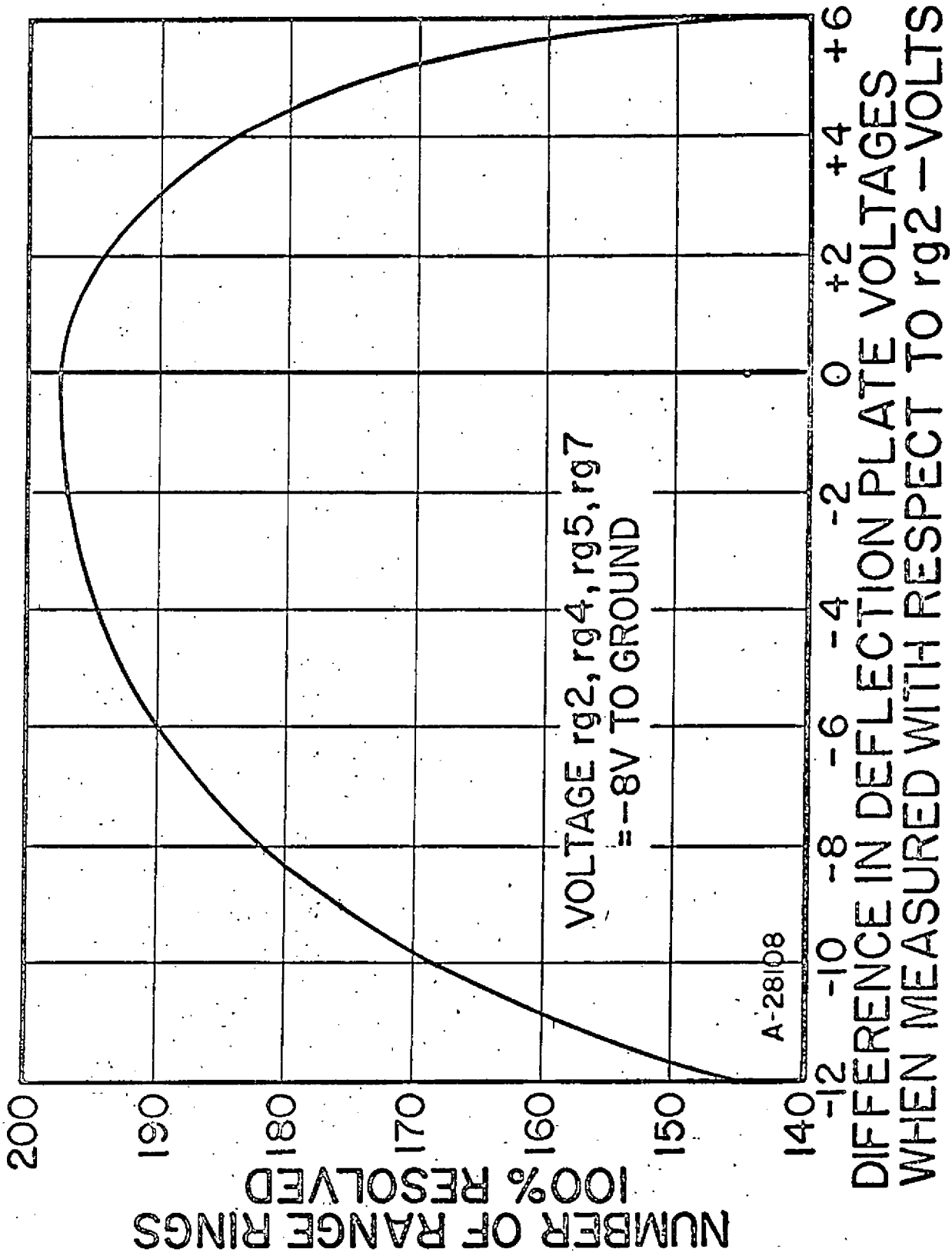


FIG.6

CATALOG OUTLINE

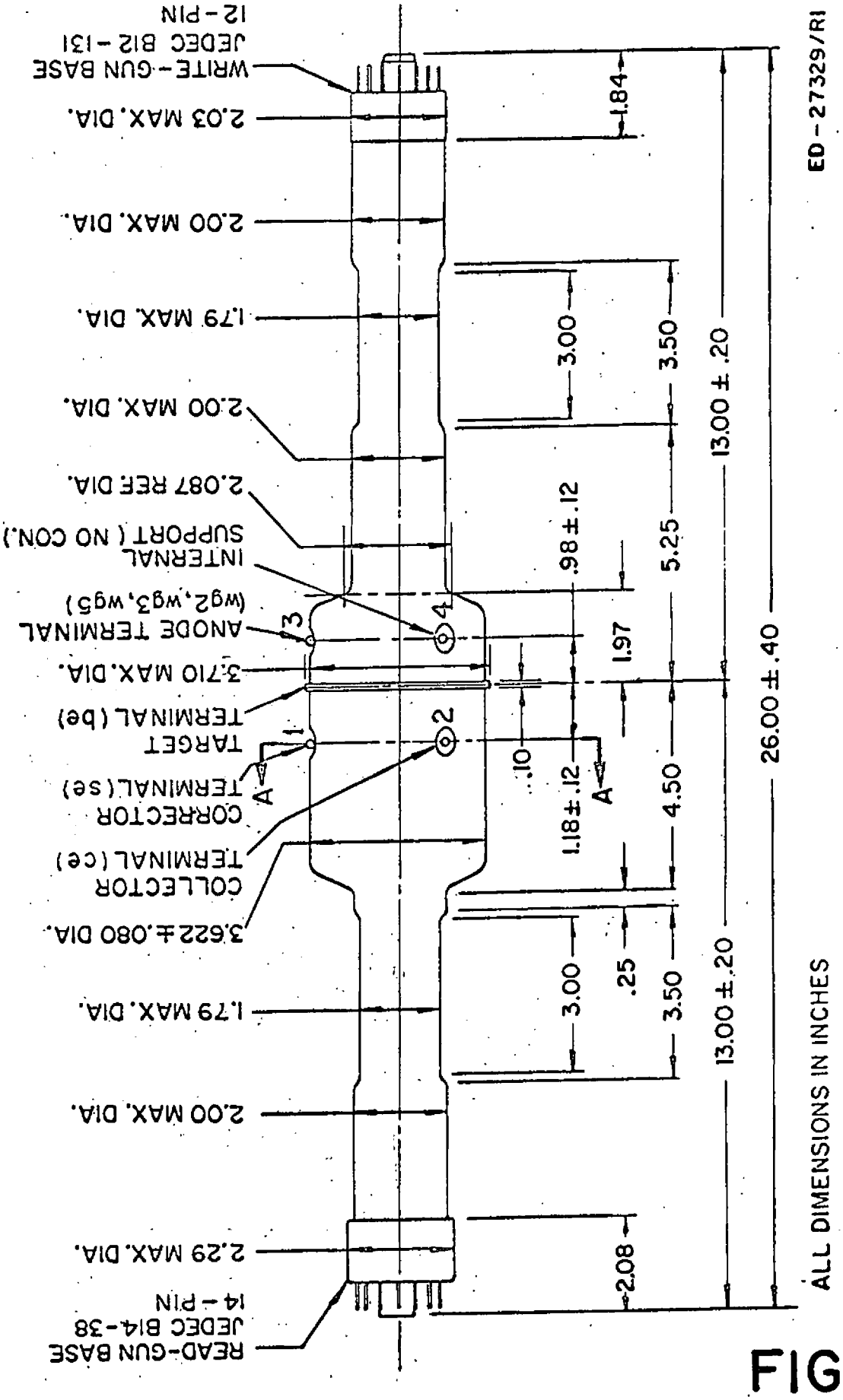
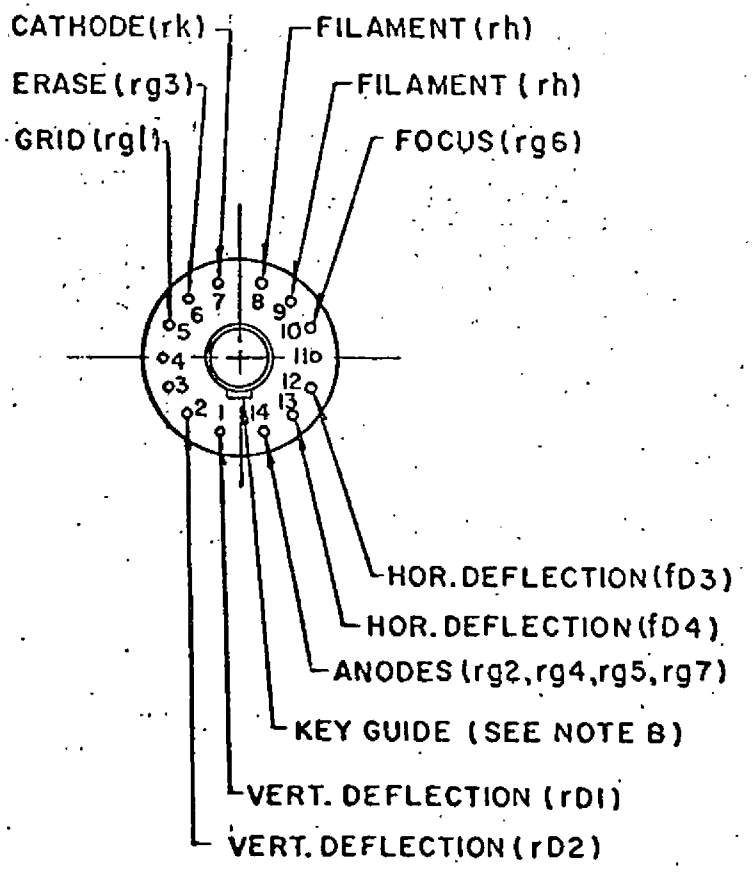


FIG. 7



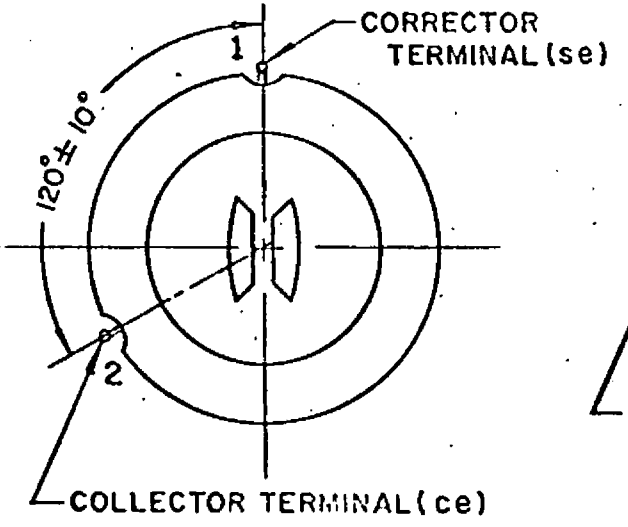
PIN CONNECTIONS
READ GUN

NOTE A:

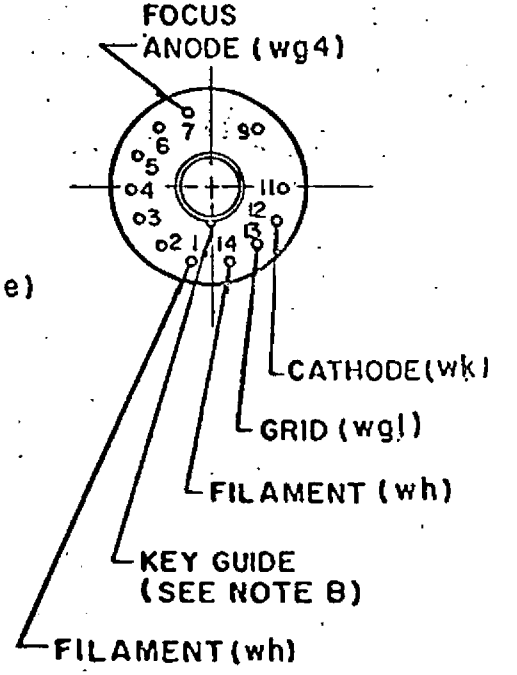
ANGULAR RELATIONSHIP OF HORIZONTAL DEFLECTION PLATES TO CORRECTOR TERMINAL NOT TO VARY MORE THAN 15°

NOTE B:

THE KEY GUIDES ON BOTH BASES ARE IN LINE WITH EACH OTHER & DIAMETRICALLY OPPOSITE TO THE CORRECTOR TERMINAL



SECTION "A-A"

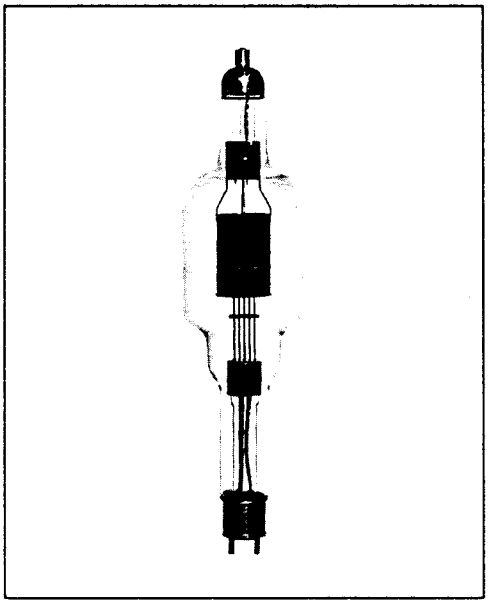


PIN CONNECTIONS
WRITE GUN

ED-27331/R1

FIG.8

The Machlett Laboratories, Inc.
1063 Hope Street • Stamford, Conn. 06907
Tel. 203-348-7511 • TWX 710-474-1744



ISSUED 12-68

ML-8094/199

MACHLETT

High-Voltage Rectifier

110 PKV

DESCRIPTION

The ML-8094/199 is a high-vacuum rectifier tube having maximum ratings of 110 PKV inverse voltage and 10 amperes peak anode current. It is especially adaptable to certain pulsing circuits as a hold-off diode and to power supplies in high-power radar units, where insensitivity to low ambient temperatures and high current capacity at high voltages are essential.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average load current capacity. The cathode is a thoriated-tungsten filament of the catenary type, allowing close anode-to-cathode spacing without distortion of the filament by electrostatic forces. The anode is a cylindrical tantalum plate treated to insure a maximum of heat dissipation, providing a high safety factor against accidental overload.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	12 Volts
Filament Current, approximate	23 Amps
Filament Heating Time, minimum (Before Applying Plate Voltage)	30 Secs
Tube Voltage Drop, maximum (I_b=10.0 amperes, E_f=12.0 volts)	2500 Volts

MECHANICAL

Mounting Position	Optional
Mounting Socket, Machlett Part No.	P-8835
Type of Cooling	Radiation†
Insulating Medium	Air
Net Weight, approximate	3 lbs

† Forced air cooling of the bulb at 125 cfm through a 6-inch diameter nozzle is required to keep the glass temperature within safe limits at maximum ratings.

MAXIMUM RATINGS

Peak Inverse Anode Voltage	110000	Volts
Peak Anode Current	10.0	Amps
Plate Dissipation	1500	Watts

Load Current (Average D-C)

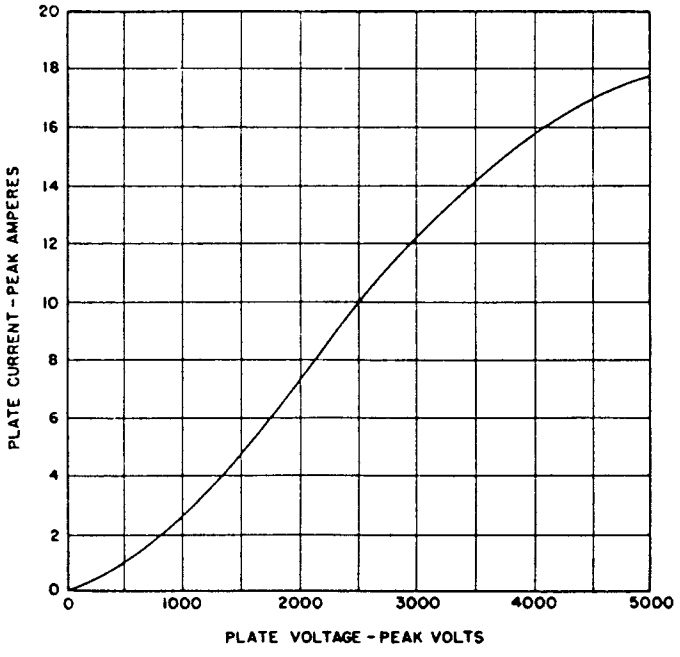
Circuit Application	Unfiltered*	Filtered**	
Single-phase, two-tube, half-wave	1.3	....	Amps
Single-phase, four-tube, full-wave	2.6	2.9	Amps
Three-phase, double-Y parallel	7.0	7.2	Amps
Three-phase, full-wave	3.5	3.6	Amps

* Unfiltered Load Current Ratings are based on sine-wave voltage input and resistance load without inductive or capacitive effects.

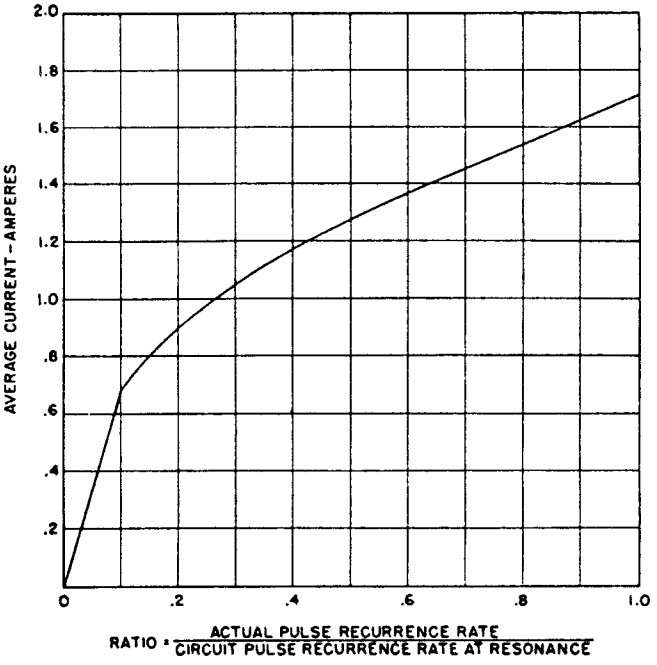
** Filtered Load Current Ratings are based on sine-wave voltage input and infinite inductance choke input filter.

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x-rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources".

A-335



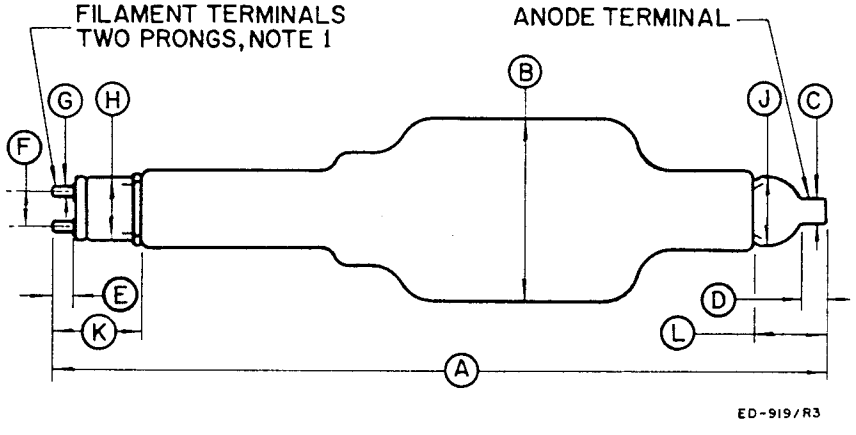
A-334



APPLICATION NOTES

When the ML-8094/199 is employed as a rectifier in conventional power supply circuits, the average dc load currents specified under "Maximum Ratings" apply.

When the ML-8094/199 is used as a hold-off diode in connection with resonant charging of line-type pulsers, the average charging current permissible depends on the ratio of actual pulse recurrence rate to circuit pulse recurrence rate at resonance. The right-hand curve above indicates maximum permissible average currents at various values of this ratio.



OUTLINE—ML-8094/199

DIMENSIONS FOR OUTLINE

	INCHES		
Ref.	Minimum	Nominal	Maximum
A	24.7	25.0	25.3
B	—	—	6.2
C	.790	.800	.810
D	.75	.81	—
E	.82	.88	.94
F	1.240	1.250	1.260
G	.292	.312	.332
H	—	2.19	2.22
J	—	2.25	2.29
K	2.81	2.88	2.95
L	2.21	2.28	2.35

NOTE:
1. Cathode base fits Machlett mounting socket part P-8835.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.
ST-830 5M 12-68

from JEDEC release #4257, May 13, 1963



MACHLETT

ML-8130
DIRECT-VIEW STORAGE TUBE

DESCRIPTION & RATINGS

DESCRIPTION

The ML-8130 is a five-inch direct-view storage tube capable of storing high-brightness, flicker-free, half-tone displays of information. Displays can be erased instantaneously or gradually. The tube is designed for operation under extreme environmental conditions and is shielded from stray magnetic fields. Typical applications are:

1. Airborne search and fire control
2. Navigational radar
3. Airport surveillance
4. Transient studies
5. Weather radar
6. Data transmission systems requiring narrow band width

The tube is provided with a P-20 aluminized screen (see Fig. 1) coated on a flat faceplate of optical quality glass. With a view-screen voltage of 10 kV, the display brightness is in the order of 2000 foot-lamberts. Minimum writing speed of the tube is 300,000 inches per second. Faster speeds may be obtained by increasing write-beam current. Displays can be stored for 30 seconds or more. The rate of erasure can be controlled by changing the width, shape or frequency of a series of pulses applied to the backing electrode. The storage ability of the tube permits integration of weak signals and prolonged observation of transients. Half-tone displays may be obtained by amplitude modulation of the write-gun input signal. Precise alignment of guns and collimating electrodes contribute to the excellent uniformity of display over the entire view screen. Focusing and deflection of the electron beams are accomplished electrostatically, eliminating need for coils and simplifying magnetic shielding.

The ML-8130 is designed for military airborne operation and is intended to meet requirements of applicable military specifications. The tube, including its electrical terminals, is potted in a resilient silicone compound and enclosed in an effective, light-weight Netic Co-Netic magnetic shield. Leads from each electrode are brought out through the potting compound in flexible cables, which are an integral part of the tube assembly. These cables may be furnished in special lengths and fitted with terminal connectors as specified by the user. This external construction combined with the rugged internal construction of this tube assure its protection against vibration, mechanical shock, variations in environmental pressure, and stray magnetic fields. The construction also greatly simplifies tube installation.

PRELIMINARY

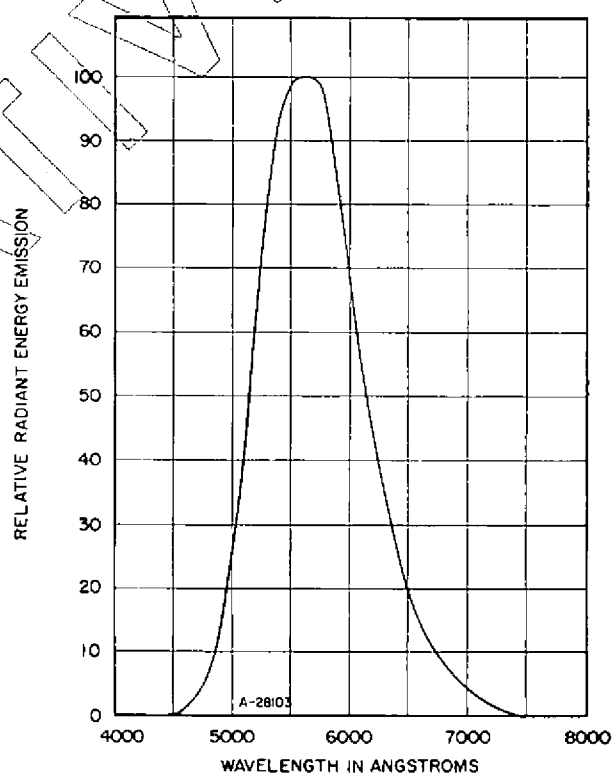


Figure 1 — P-20 Spectral Energy Emission Characteristics

PRINCIPLES OF OPERATION

Arrangement of Electrodes

Figs. 2 and 3 illustrate schematically the various internal components of the tube. Symbols used to identify electrodes are in accordance with JEDEC Publication No. 33 in which the prefix "w" denotes a component of the write-gun section and the prefix "f" denotes a component of the flood-gun section. The letter "g" denotes a grid, "h" a heater, "k" a cathode, and "D" a deflection plate.

The viewing screen (vs) is a coating of phosphor facing the electron guns. The backing electrode, or storage mesh (be), is a fine, metallic mesh, the gun-side of which is coated with a thin deposit of dielectric material, which functions as the storage surface (ss). The nature of the material used for the storage surface is such that it will maintain a pattern of charges for a considerable period of time. This surface, for analytical purposes, can be considered an array of minute, isolated storage areas each capacitively coupled with the backing electrode. The collector electrode (ce) is a high-transparency metal mesh in close proximity to the storage surface.

The remainder of the components comprise two electron-gun systems — one for viewing, the other for writing — as illustrated. Flood-gun grid fg3 is a conductive coating on the inside of the tube envelope. Flood-gun grid fg2 is a similar conductive coating electrically connected to write-gun grids wg2 and wg4.

Table A identifies each electrode with reference to the symbol used. Reference should also be made to electrode voltages given under "Typical Operating Conditions" in order to better understand the description of tube operation which follows.

TABLE A
TUBE CONNECTIONS

Symbol	Electrode	Internal Connection	Cable
fh	flood-gun heater	Pin 7	A
fh	flood-gun heater	Pin 8	A
fk	flood-gun cathode (I.C. to fh)	Pin 9	A
fg1	flood-gun control grid	Pin 6	A
fg2	flood-gun anode	Pin 10	A
fg3	flood-gun collimator	Cap 4	D
fg4	flood-gun collimator	Cap 5	D
ce	collector electrode (mesh)	Cap 3	D
ss	storage surface	N.C.	N.C.
be	backing electrode (storage mesh)	Cap 6	D
vs	view screen	Cap 1	C
wh	write-gun heater	Pin 1	B
wh	write-gun heater	Pin 14	B
wk	write-gun cathode	Pin 2	B
wg1	write-gun control grid	Pin 3	B
wg2	write-gun anode	Pin 10	A
wg3	write-gun focus electrode	Pin 13	B
wg4	write-gun anode	Pin 10	A
wD1	write-gun rear deflection plate	Pin 4	A
wD2	write-gun rear deflection plate	Pin 12	A
wD3	write-gun front deflection plate	Pin 5	A
wD4	write-gun front deflection plate	Pin 11	A
	I.C. to fg4. Do not use	Cap 2 & 7	—

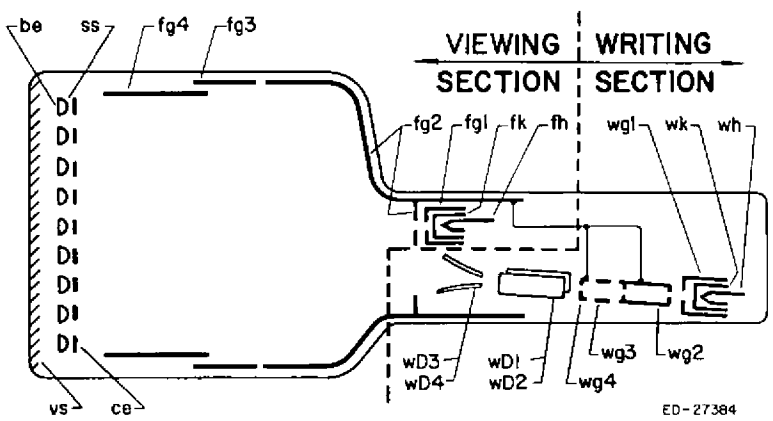
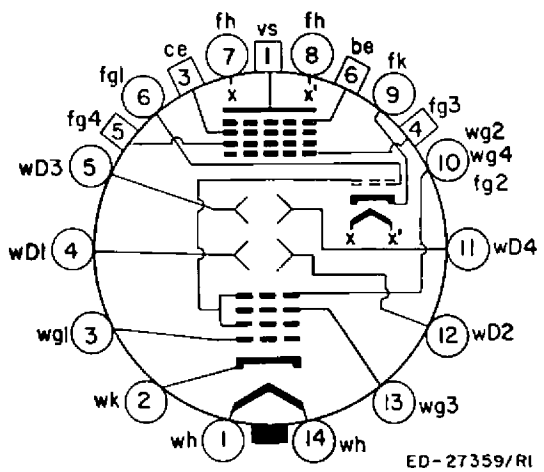


Figure 2 — Construction of Tube Shown Schematically



☐ SIGNIFIES BULB CONTACTS (NOT IN RELATIVE POSITIONS).

◯ SIGNIFIES PIN CONTACTS (IN RELATIVE POSITIONS).

NUMBERED CONTACTS ARE ENCAPSULATED IN THE MAGNETIC SHIELD OF THE ML-8130. REFER TO TABLE "A" FOR CONNECTIONS.

Figure 3 — Basing Diagram

Viewing

The flood gun produces a divergent beam of low-velocity electrons, which travel toward the storage surface. The collimating electrodes (fg3, fg4) align the electrons in a parallel path so that they continuously flood the storage surface with equal energy components. Collimation is essential so that the flood electrons will approach the storage surface in perpendicular paths, resulting in a uniform display.

The storage surface (ss), acting much in the same manner as a control grid in a triode, modulates the transmission of flood-gun electrons to the viewing screen. When the storage surface is at the same potential as the flood-gun cathode, 0 volts, all flood-gun electrons pass through openings in the storage mesh and are accelerated to the viewing screen causing it to fluoresce brightly. This condition, zero potential of the storage surface, is referred to as a condition of "saturated brightness". When the storage surface is charged to "cut-off voltage", about —8 volts, or some more negative voltage, electrons are repelled back to the collector electrode (ce) and none reach the viewing screen. The tube will then be in a "black" or "unwritten" state. With the storage surface at some intermediate voltage, some electrons reach the viewing screen and some are repelled. The screen will then fluoresce at some intermediate brightness in the "half-tone range". When a pattern of charges of different potential is applied to the storage surface, the charges ranging from cutoff voltage to zero potential, some electrons will reach the viewing screen and some will be repelled. The potential charge on any individual storage surface element determines the quantity of electrons passing through the mesh opening at that particular element. The flood electrons strike the phosphor screen at a point directly opposite this element. In this manner, the flood-gun electrons produce a visual image of the storage surface charges on the viewing screen. The overall degree of viewing brightness is determined by the view-screen voltage and the density of the flood-gun electrons. A higher view-screen voltage will produce greater acceleration of the electrons, causing them to strike the view screen with greater velocity and resulting in increased phosphor fluorescence (see Fig. 4).

When viewing-section voltages are first applied, the storage surface assumes a positive potential with respect to the flood-gun cathode due to close capacitive coupling with the backing electrode. A portion of the flood-gun electrons are intercepted by the collector mesh, but the remainder are decelerated to near zero velocity at the storage surface. Electron landing velocity is so low that the secondary emission ratio of the storage surface is less than unity; i.e., the secondary electrons lost due to collision are less than the primary electrons landing on the storage surface. The storage surface is consequently charged negatively to the same potential as the flood-gun cathode, and a condition of saturated brightness exists.

Since, in normal operation, the storage surface is always negative with respect to the flood-gun cathode, it can control transmission of flood-gun electrons but none of these electrons

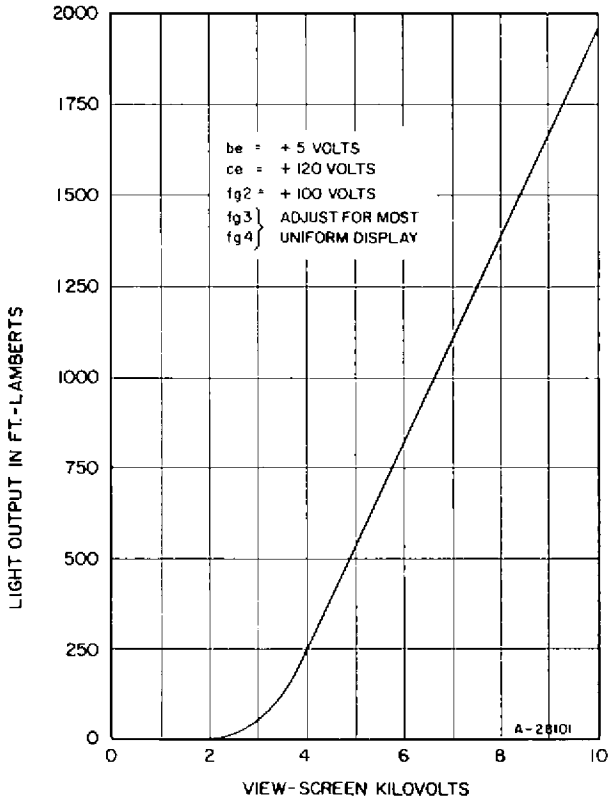


Figure 4 — Average Light Output

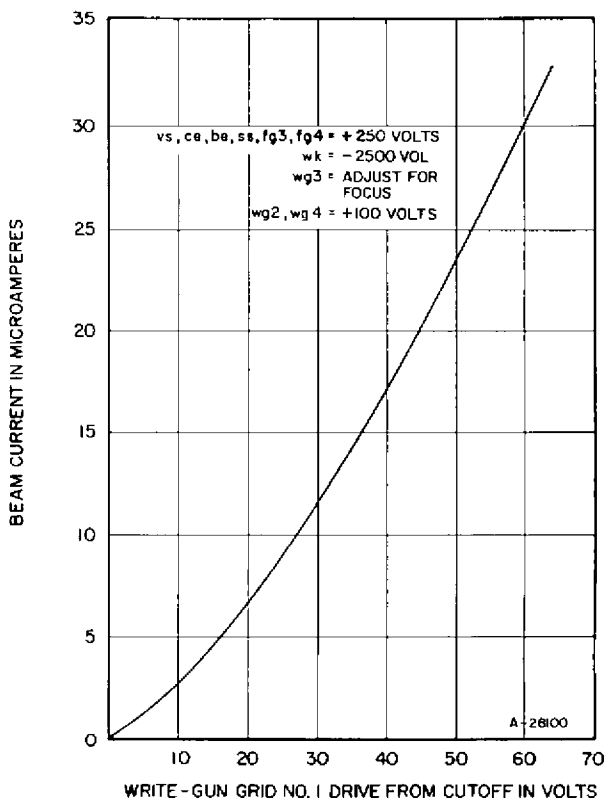


Figure 5 — Write-Gun Transfer Characteristics

will strike it and modify its charge. A negative voltage pattern on the storage surface is thus unaffected by the flood-gun emission and would exist indefinitely were it not for ion currents, which are described subsequently under "Erasing", and insulation leakage.

Writing

The writing gun is similar to electron guns used in industrial and military cathode ray tubes of the type which employ electrostatic focus and deflection. Its beam may be modulated in the same manner (see Fig. 5). It is a high-resolution-gun yielding a low-current high-velocity beam. The cathode is normally operated at a potential of —2000 volts with respect to the flood-gun cathode.

Before writing can take place, the storage surface must be at a negative, cutoff potential with respect to the backing electrode; the tube is then in a "black", unwritten state. This is accomplished by the erasing operation, which will be described subsequently.

After the writing beam is deflected, it passes through the collector mesh and strikes the dielectric coating on the backing electrode. It impinges with sufficient velocity for the dielectric to yield a secondary emission ratio greater than unity (the number of electrons emitted by the collision is greater than the number landing). With the collector at a positive potential and in close proximity to the storage mesh, complete collection of secondary electrons is possible. The net effect is to charge each individual scanned element of the storage grid in a positive direction. The amount of stored charge on each of the elements is proportional to the energy of the writing beam at the instant of impact. Thus, with the beam being modulated and scanned, a pattern of charges of different potentials is established on the storage surface. These potentials range anywhere between storage surface cut-off voltage and the zero potential of the flood-gun cathode (see Fig. 6). During the writing operation, the storage surface cannot build up any charges more positive than flood-gun cathode potential due to the nullifying action of flood-gun electrons. As described previously, under "Viewing", a voltage pattern written on the storage surface produces a visual image on the view screen due to the action of the flood-gun electrons.

Erasing

With the flood gun in operation, the amount of time a charge pattern can be stored on the storage surface is limited by ion current. Ions are produced by collisions of flood-gun electrons with residual gas molecules in the tube. Positive ions between the collector electrode and the flood gun are repelled from the storage surface by the positive-potential collector electrode. Positive ions between the collector electrode and the storage surface are attracted to the negative-potential storage surface neutralizing its charge and slowly changing the surface potential to a level of saturated brightness. Maximum image storage time is thereby limited to a period of about one minute. The loss of charge due to ion current, which is called "ion writing", also limits the time

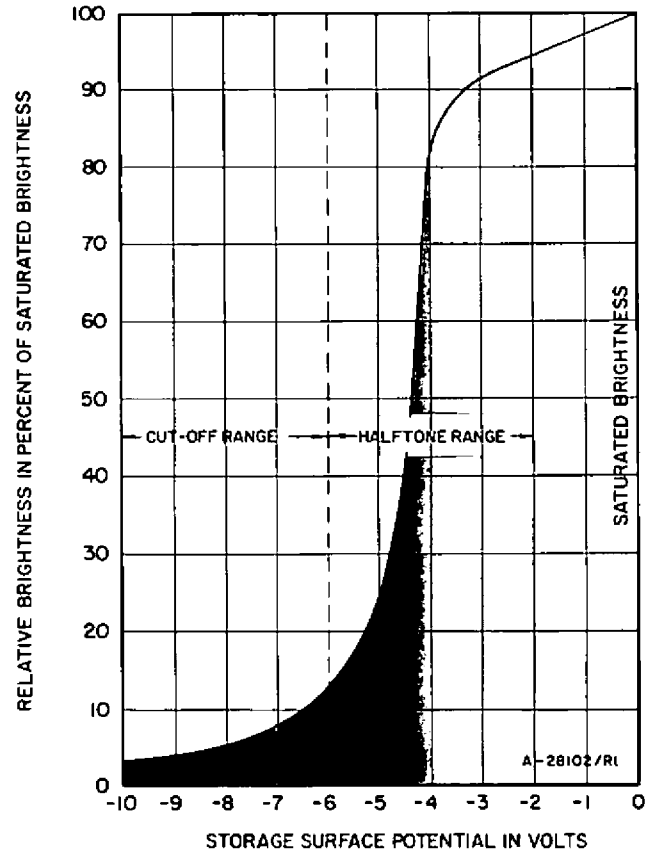


Figure 6 — Storage Characteristics

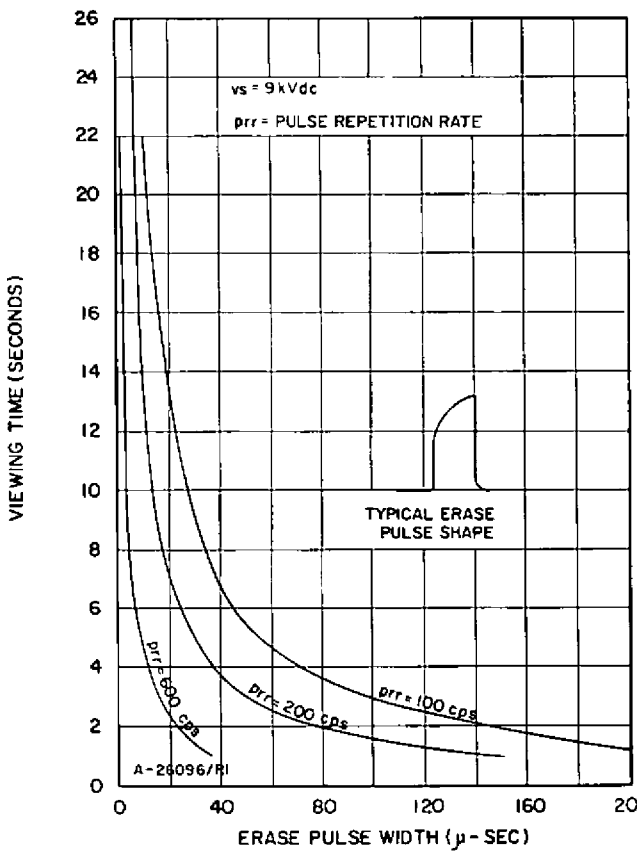


Figure 7 — Erase Characteristics

available for writing and viewing following intentional erasure to a black, unwritten state.

To erase an image intentionally, a series of positive-going pulses is applied to the backing electrode. This is termed "dynamic erasure" and permits a gradual fade-out of stored information.

When a positive-going pulse is applied to the backing electrode, the storage surface, due to capacitive coupling, will also become more positive. Electrons from the flood gun are then attracted to positive areas of the storage surface. Since flood-gun electrons are low-energy electrons, the secondary emission ratio at the storage surface is less than unity and the storage surface becomes less positive. At the end of each pulse, the backing electrode returns to its original, lower positive voltage. The voltage of each element of the storage surface will then follow the drop in backing-electrode voltage to a voltage which is more negative than before the pulse was applied. After a number of erase pulses of sufficient duration have been applied, all written areas of the storage surface will have acquired the same potential as the flood-gun cathode. At this point the storage surface potential will return to a negative value which is at or below cut-off. The tube is then in a "black", unwritten state, and the image has been erased. By limiting frequency or width of the pulses, the time required for complete erasure can be extended (see Fig. 7).

With a rectangular erasing pulse, all elements of the storage surface are discharged at the same rate; the less-positive, or low-brightness, areas will disappear first; and half-tones disappear before high-brightness areas. With a more sawtooth-shaped erase pulse (see Fig. 7), the less-negative, high-brightness areas are discharged for a longer period of time during each pulse. With proper selection of pulse shape, it is then possible to preserve low-brightness detail during the entire erase cycle.

With this tube, the amplitude of the erase pulse is not ordinarily varied to change the rate of erasure. For optimum rendition of half-tones, the proper erase-pulse amplitude is that which allows the storage surface to be charged to exact cut-off potential by the erasing operation. If the erase-pulse amplitude is less than the optimum value, all portions of the storage surface will not return to cut-off voltage after removal of the erase pulse, and complete erasure is not possible. If the erase-pulse amplitude is greater than the optimum value, the storage surface might return to a value which is more negative than cut-off voltage ("blacker than black") when erase-pulse operation is terminated. The latter condition would adversely affect the quality of subsequent writing operations.

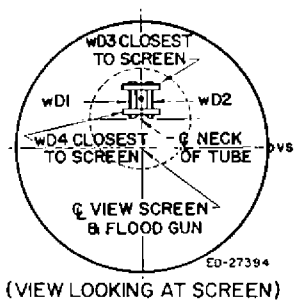


Figure 9 — Deflection Plate Orientation

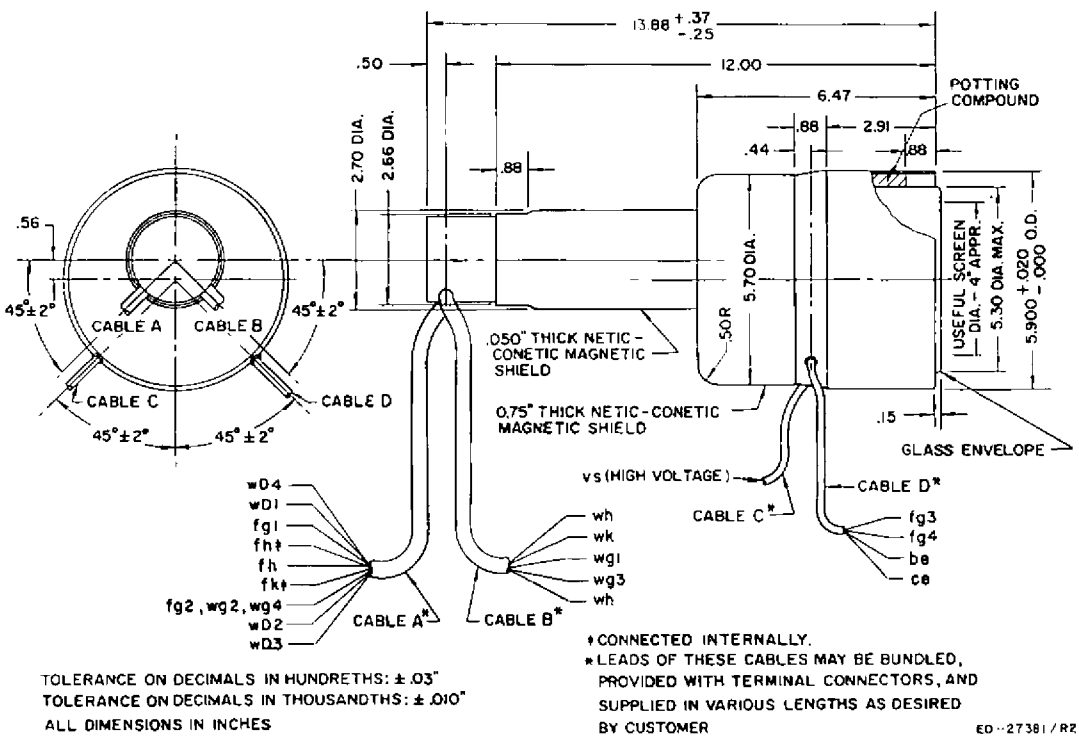


Figure 8 — Dimensions — ML-8130

PERFORMANCE

Values given are for typical tube unless otherwise specified.

Writing Speed, *minimum* (10 μA beam current)	300,000	in/sec
Light Output (vs voltage = 10 kV), *minimum*	1700	ftL
Written Resolution (10 μA beam current)	60	lines/in
Erase Time (single-pulse erasure)	50 to 250	ms
Half Tones, *minimum*	5	
Deflection Factor Uniformity	4	%

GENERAL CHARACTERISTICS

Optical

Phosphor Type	(See Fig. 1) P-20 Aluminized
Fluorescence	Green-Yellow
Phosphorescence	Green-Yellow
Faceplate	Flat, optical-quality glass

Mechanical

Overall Length	13⅞	in
Maximum Diameter	5 1/16	in
Useful Screen Diameter, *minimum*	4	in
Base (encapsulated)	See Fig. 8	
Mounting Position	Any	
Weight Less Leads, approximate	5¾	lbs

Electrical

Heater Characteristics, Flood or Write Gun:		
Heater Voltage, AC or DC	6.3 ± 10%	V
Heater Current Per Gun at 6.3 Volts	0.6 ± 10%	A
Focusing Method, Write Gun	Electrostatic	
Deflection Method, Write Gun	Electrostatic	
Deflection Orientation	See Fig. 9	
Deflection Factors:		
wD1, wD2	25 to 40	V/in/kV
wD3, wD4	25 to 40	V/in/kV
Direct Interelectrode Capacitances, approx.:		
wk to all other electrodes	10	pf
wg1 to all other electrodes	14	pf
wD1 to wD2	6	pf
wD3 to wD4	16	pf
wD1 to all other electrodes	13	pf
wD2 to all other electrodes	12	pf
wD3 to all other electrodes	13	pf
wD4 to all other electrodes	13	pf

RATINGS

Ratings given are absolute maximum values unless otherwise specified. All voltages are referenced to fk unless otherwise specified.

General

Altitude	70000	ft
Pressure, absolute	45	psi
Ambient Temperature:		
Minimum	−55	°C
Maximum	+85	°C

Viewing Section

fh Peak Voltage:		
fh negative	180	v
fh positive	180	v
fk Voltage	0	v
fg1 Voltages:		
Negative bias	125	Vdc
Positive bias	0	Vdc
Positive peak	0	v
fg1 Circuit Resistance	1.0	Meg
fg2 Voltage	150	Vdc
fg3 Voltage	200	Vdc
fg4 Voltage	300	Vdc
fg4 Circuit Resistance, *minimum*	1000	ohms
ce Voltage	300	Vdc
ce Circuit Resistance, *minimum*	1000	ohms
be Voltage	200	Vdc
be Circuit Resistance	5000	ohms
vs Voltage	11000	Vdc
vs Dissipation	10	W
vs Circuit Resistance, *minimum*	1.0	Meg

Writing Section

wh Peak Voltage:		
wh negative †	180	v
wh positive †	180	v
wk Voltage	−3000	Vdc
wg1 Voltages:		
Negative bias †	125	Vdc
Positive bias †	0	Vdc
Positive peak †	2	v
wg1 Circuit Resistance	1.0	Meg
wg2 Voltage	150	Vdc
wg3 Voltage	−2500	Vdc
wg4 Voltage	150	Vdc

TYPICAL OPERATING CONDITIONS

All voltages are referenced to fk unless otherwise specified.

Viewing Section

fk Voltage	0	Vdc
fg1 Bias Voltage	0 to −50	Vdc
fg2 Voltage	100	Vdc
fg3 Voltage	15 to 40	Vdc
fg4 Voltage	25 to 50	Vdc
ce Voltage	120	Vdc
be Voltage	2	Vdc
vs Voltage	9000	Vdc

Writing Section

wk Voltage	−2000	Vdc
wg1 Bias Voltage †	−30 to −60	Vdc
wg2 Voltage	100	Vdc
wg3 Voltage †	280 to 660	Vdc
wg4 Voltage	100	Vdc

†Voltages referenced to wk.

THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company

ST-1942 5M 3-63

SPRINGDALE MACHLETT CONNECTICUT
U. S. A.

Printed in U.S.A.

from JEDEC release #4428, Sept.23, 1963
sponsor: The Machlett Laboratories

ML-8139 Direct-View Storage Tube

DESCRIPTION

The Machlett Type ML-8139 is a 5-inch diameter direct-view storage tube that is capable of bright visual displays of half-tone images. The tube features a high-resolution electrostatically focused write gun and a flood (viewing) gun. The write beam is deflected magnetically. The useful storage time for written information is approximately one minute. The erasure of information can be gradual or can be accomplished instantaneously.

The ML-8139 incorporates a magnetic shield to minimize magnetic fields which might affect the low-velocity flood-gun electrons. The tube is potted in this shield making it suitable for high-altitude operation, as well as sea-level applications.

GENERAL CHARACTERISTICS

Optical

Phosphor Type	P20	Aluminized
Fluorescence	Green Yellow	
Phosphorescence	Green Yellow	
Faceplate	Flat, Optical Quality	

Mechanical

Overall Length	11-1/8 ± 3/8	inches
Maximum Diameter	5.670	inches
Useful Screen Diameter	4	inches
Neck Length	4-7/8	inches
Bases:		
Flood gun (Miniature 7-pin)	JEDEC	E7-1
Write gun (8-pin)	JEDEC	E8-11*
Terminals	See outline drawing	
Mounting Position	Any	

* Fits standard vidicon socket

Electrical

Flood and Write Guns:		
Heater voltage, (AC or DC)	6.3	volts
Heater current	.6 ± 10%	Amps
Write Gun:		
Focusing	Electrostatic	
Deflection	Magnetic	

MAXIMUM RATINGS

All voltages shown are with respect to flood-gun cathode, unless otherwise specified.

View-Screen Voltage	10000	volts
View-Screen Dissipation	10	watts
Storage-Mesh Voltage	0 to + 200	volts
Collector-Mesh Voltage	300	volts
Anode No. 3 (Collimating) Voltage	300	volts
Anode No. 2 Voltage (Both Guns)	200	volts
Anode No. 1, Flood Gun, Voltage	200	volts
Grid No. 1, Flood Gun, Voltage:		
Negative-bias value	125	volts
Positive-bias value	0	volts
Positive-peak value	2	volts
Grid No. 1, Write-Gun, Voltage with Respect to Write-Gun Cathode:		
Negative-bias value	125	volts
Positive-bias value	0	volts
Positive-peak value	2	volts
Peak Heater-to-Cathode, Write-Gun, Voltage with Respect to Write-Gun Cathode:		
Heater negative with respect to cathode	180	volts
Heater positive with respect to cathode	180	volts
Anode No. 1, Write-Gun, Voltage (Focus Electrode)	-3000	volts
Cathode, Write-Gun, Voltage	-3000	volts

TYPICAL OPERATING CONDITIONS

Viewing Section

Screen Voltage	8000	volts
Storage Mesh Voltage	5	volts
Collector Mesh Voltage	120	volts

Flood Gun

Cathode Voltage	0	volts
Grid No.1 (Control) Voltage	0 to -30	volts
Grid No. 2 (Anode No. 1) Voltage	80	volts
Anode No. 2 Voltage (Both Guns)	0 to 15	volts
Collimating Electrode Voltage (Anode No. 3)	20 to 40	volts

Write Gun

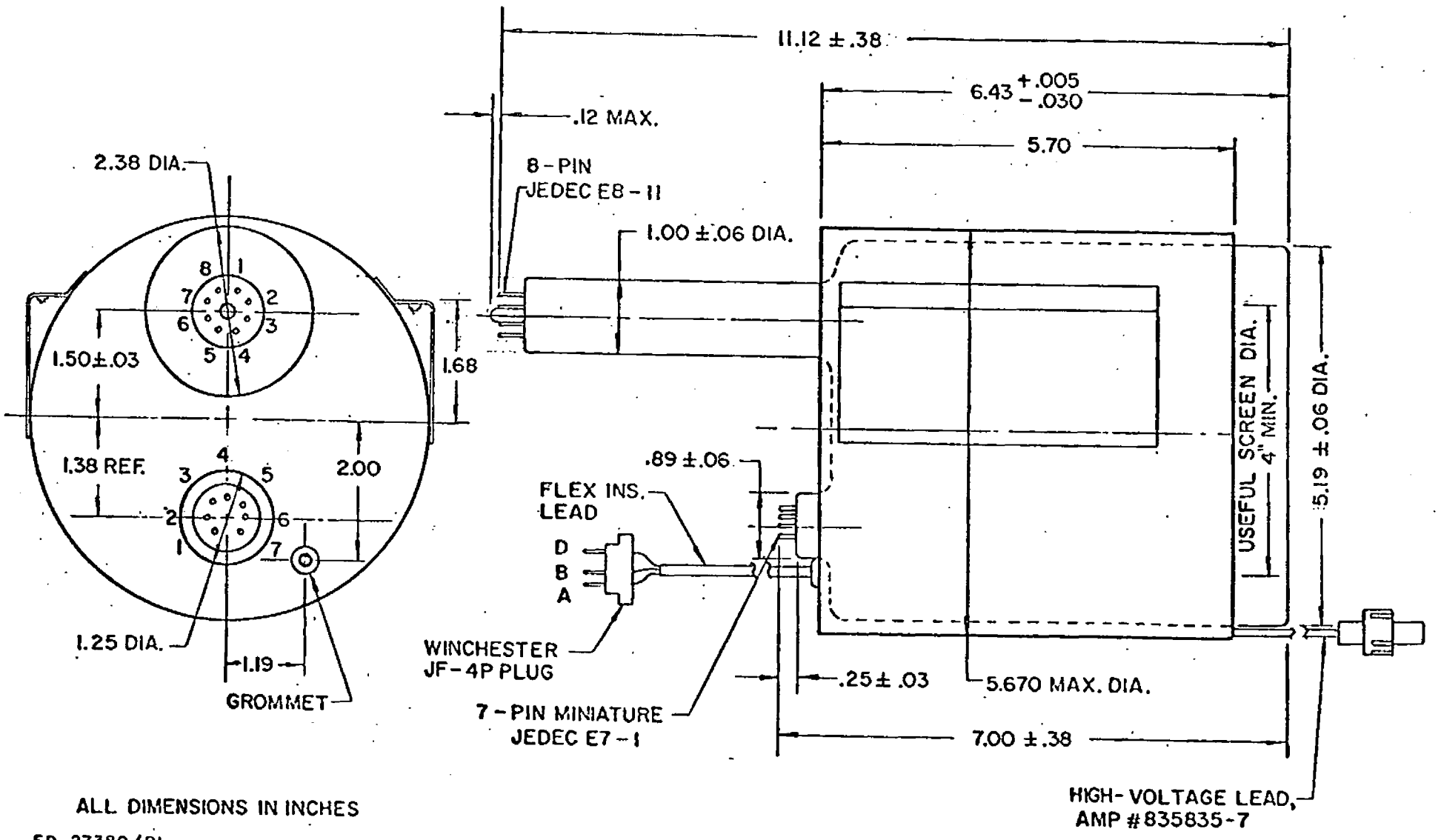
Cathode Voltage	-2500	volts
Grid No. 1 (Control-Grid) Voltage Referenced to Write-Gun Cathode	-35 to -90	volts
Anode No. 1 (Focus electrode) Voltage Referenced to Write-Gun Cathode	350 to 750	volts

Currents

Viewing Screen	0 to 500	μa
Storage Mesh	0 to 75	μa
Collector Mesh	<2	ma
Collimator (Anode No. 3)	<2	ma
Anode No. 2, Both Guns	<2	ma
Grid No. 2 (Anode No. 1), Flood Gun	<25	μa
Cathode, Flood Gun	0 to 2	ma
Anode No. 1, Write Gun (Focus)	<1	μa
Cathode, Write Gun	0 to 1500	μa

PERFORMANCE

Writing Speed (10 μa beam current)	100000	inches/sec.
Light Output at 8 kv	1600	f.l. min.
Written Resolution (10 μa beam current)	60 to 80	lines/inch
Erase Time	50 to 250	milliseconds
Half Tones	5	minimum



ALL DIMENSIONS IN INCHES

ED-27380/R1

ML-8139

OUTLINE DRAWING

ML-8139 Direct-View Storage Tube

TABLE A

PIN CONNECTIONS

Flood-Gun Socket

7-Pin JEDEC E7-1

Pin 1 -- Anode No. 1
Pin 2 -- Grid No. 1
Pin 3 -- Heater
Pin 4 -- Heater
Pin 5 -- I. C. (Do not use)
Pin 6 -- Anode No. 2 (both guns)
Pin 7 -- Cathode

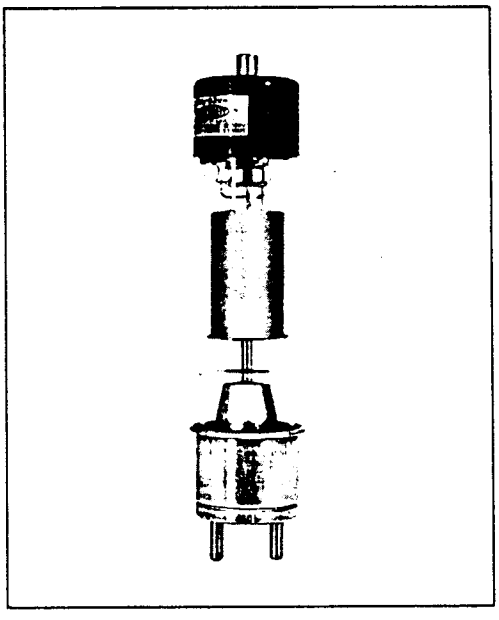
Write-Gun Socket

8-Pin JEDEC E8-11

Pin 1 -- Grid No. 1
Pin 2 -- Heater
Pin 3 -- Heater
Pin 4 -- I. C. (Do not use)
Pin 5 -- Cathode
Pin 6 -- I. C. (Do not use)
Pin 7 -- No. Connection
Pin 8 -- Anode No. 1 (focus)

Flexible Lead Connections

A Pin, Plug JF-4P -- Storage Mesh
B Pin, Plug JF-4P -- Collector Mesh
C Pin, Plug JF-4P -- Vacant
D Pin, Plug JF-4P -- Collimator
AMP Flexible Lead -- View Screen



ISSUED 1-65

ML-8224

High-Voltage Rectifier

150 PKV

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8224 is a high-vacuum rectifier tube having a maximum inverse voltage rating of 150 PKV using oil insulation or 80 PKV using air insulation and a maximum peak anode current rating of .75 ampere. It is especially suitable for use in high-voltage hold-off applications, voltage multiplier circuits, energy storage capacitor circuits, and other applications where high peak power is required.

This tube incorporates those special features of construction which characterize Machlett high-vacuum rectifiers for high-power-level applications. These features insure ruggedness, long life, low internal voltage drop and high average-load-current capacity. The cathode is a low-wattage, thoriated-tungsten filament. The cylindrical molybdenum anode provides a high rate of heat dissipation with an adequate safety factor against accidental overload.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage	5.5	V*
Filament Current at 5.5 Volts, approximate	6.5	A
Filament Heating Time, minimum (Before applying anode voltage)	2	Sec
Tube Voltage Drop (Ib = 0.750 Ampere, Ef = 5.5 Volts)	1000	V

* Applied filament voltage must be held within ±5% of rated voltage. For maximum life, filament voltage should be maintained as close as possible to rated voltage under all conditions of operation.

MECHANICAL

Mounting Position	Optional	
Mounting Socket, Machlett Part No.	P-8835	
Type of Cooling	Radiation	
Insulating Medium	Oil or Air	
Net Weight	16	Oz

MAXIMUM RATINGS

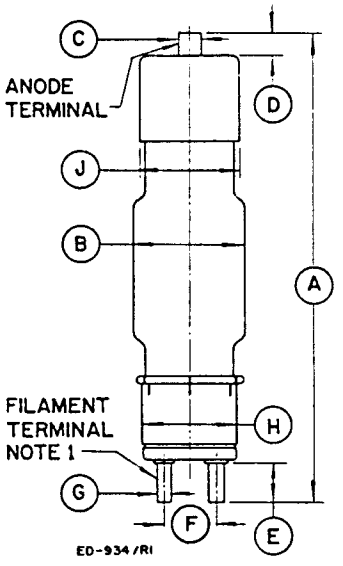
Peak Inverse Anode Voltage			
Oil Insulation		150,000	v
Air Insulation		80,000	v
Peak Anode Current		0.75	a
Anode Dissipation		60	W
Load Current (Average D-C)			
Circuit Application:	Unfiltered†	Filtered‡	
Single-phase, two-tube, half-wave	0.125	——	A
Single-phase, four-tube, full-wave	0.250	0.270	A
Three-phase, double-Y parallel	0.750	0.750	A
Three-phase, full-wave	0.375	0.375	A

† Unfiltered Load Current Ratings are based on sine-wave input and resistance load without inductive or capacitive effects.
‡ Filtered Load Current Ratings are based on sine-wave voltage input and inductive choke input filter.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

DIMENSIONS FOR OUTLINE

Ref.	INCHES		
	Minimum	Nominal	Maximum
A	10.65	10.75	10.85
B	—	—	2.75
C	.485	.500	.510
D	.44	.50	.56
E	.82	.88	.94
F	1.235	1.250	1.265
G	.292	.312	.332
H	—	2.19	—
J	—	2.25	—



NOTE:
1. Cathode base fits Machlett mounting socket part P-8835.

DIMENSIONS — ML-8224

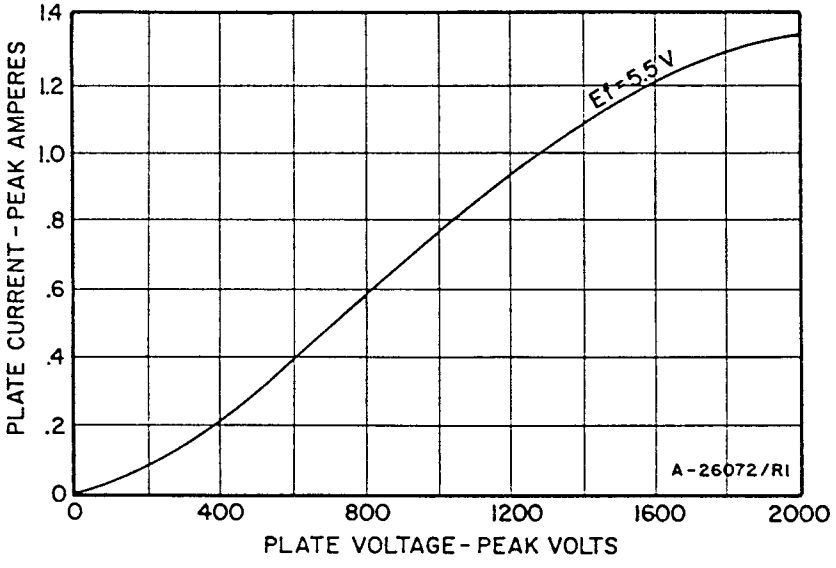


PLATE CURRENT CHARACTERISTICS

THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT

from JEDEC release #4428, Sept.23, 1963
sponsor: The Machlett Laboratories

ML-8320 Five-Inch Direct-View Half-Tone Storage Tube

DESCRIPTION

The Machlett type ML-8320 is a 5-inch diameter direct-view storage tube that is capable of bright visual displays of half-tone images. Applications include fire-control radar, airplane-cockpit radar display for weather and navigational purposes, airport surveillance, and studies of transient data.

The tube features a high resolution write gun, the beam of which is electrostatically focussed and deflected, and a flood or viewing gun. The useful storage time for written information is approximately one minute. Erasure of written information may be instantaneous or gradual. This is controlled by the application of a series of pulses to the tube's storage mesh.

The tube has a flat optical-quality face plate, a standard base filled with a suitable potting compound, and an integral, flexible high-voltage lead for high-altitude applications.

GENERAL CHARACTERISTICS

Optical

Phosphor Type	P20 Aluminized
Fluorescence	Green Yellow
Phosphorescence	Green Yellow
Faceplate	Flat, Optical Quality

Mechanical

Overall Length	14-3/4 ± 1/4 inches
Maximum Diameter	5-1/4 ± 3/32 inches
Useful Screen Diameter	4 inches
Neck Length	6-1/2 ± 1/8 inches
Base (14-pin, med. shell diheptal)	JEDEC B14-38
Bulb Contacts (Small recessed ball cap)	JEDEC J1-22
Mounting Position	Any

Electrical

Flood and Write Guns:	
Heater voltage AC or DC	6.3 volts
Heater current	.6 ± 10% Amps
Write Gun:	
Focusing	Electrostatic
Deflection	Electrostatic
Deflection Factors	
D1, D2	25 to 40 Volts/inch/kV
D3, D4	25 to 40 Volts/inch/kV

MAXIMUM RATINGS

All voltages shown are with respect to flood-gun cathode, unless otherwise specified.

View-Screen Voltage	8000	volts
View-Screen Dissipation	10	watts
Storage-Mesh Voltage	0 to + 200	volts
Collector-Mesh Voltage	300	volts
Anode No. 4 (Collimating) Voltage	300	volts
Anode No. 2 Voltage (Both Guns)	150	volts
Anode No. 3 Voltage	200	volts
Grid No. 1, Flood Gun, Voltage:		
Negative-bias value	125	volts
Positive-bias value	0	volts
Positive-peak value	0	volts
Grid No. 1, Write-Gun, Voltage with Respect to Write-Gun Cathode:		
Negative-bias value	125	volts
Positive-bias value	0	volts
Positive-peak value	2	volts
Peak Heater-to-Cathode, Write-Gun, Voltage with Respect to Write-Gun Cathode:		
Heater negative with respect to cathode	180	volts
Heater positive with respect to cathode	180	volts
Anode No. 1, Write-Gun, Voltage (Focus Electrode)	-2500	volts
Cathode, Write-Gun, Voltage	-3000	volts

TYPICAL OPERATING CONDITIONS

Viewing Section

Screen Voltage	7500	volts
Storage Mesh Voltage	2 to 5	volts
Collector Mesh Voltage	120	volts

Flood Gun

Cathode Voltage	0	volts
Grid No. 1 (Control) Voltage	0 to -45	volts
Anode No. 2 Voltage (Both Guns)	0 to 15	volts
Collimating Electrode Voltage (Anode No. 4)	0 to 50	volts
Anode No. 3	0 to 50	volts

Write Gun

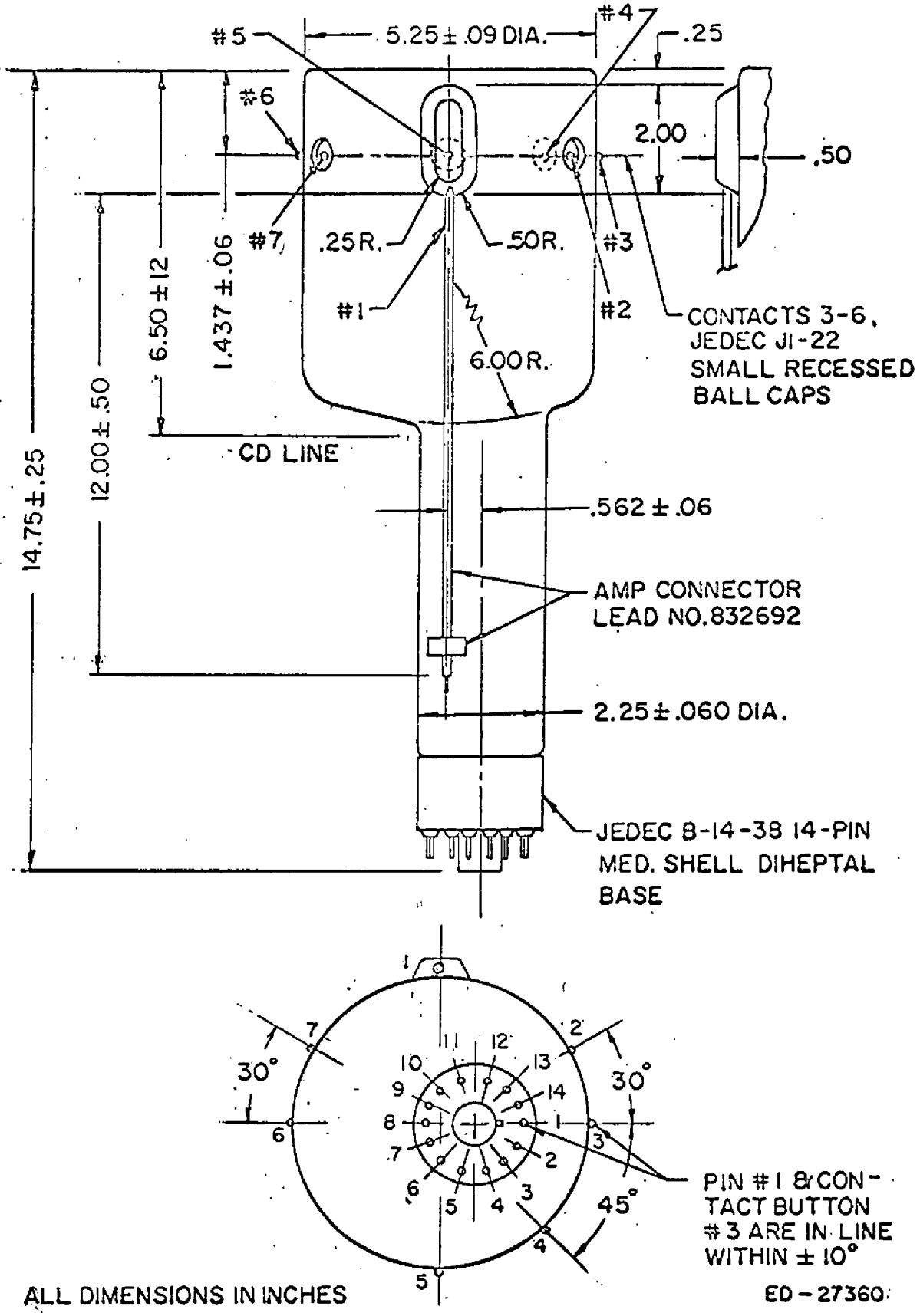
Cathode Voltage	-2000	volts
Grid No. 1 (Control-Grid) Voltage Referenced to Write-Gun Cathode	-30 to -75	volts
Anode No. 1 (Focus electrode) Voltage Referenced to Write-Gun Cathode	280 to 660	volts

PERFORMANCE

Writing Speed (10 μa beam current)	150,000	inches/sec.
Light Output at 7.5 KV	-1600	f.l. min.
Written Resolution (10 μa beam current)	60	lines/inch
Erase Time	50 to 250	milliseconds
Half Tones	5	minimum
Deflection Factor Uniformity	4	%

ML-8320

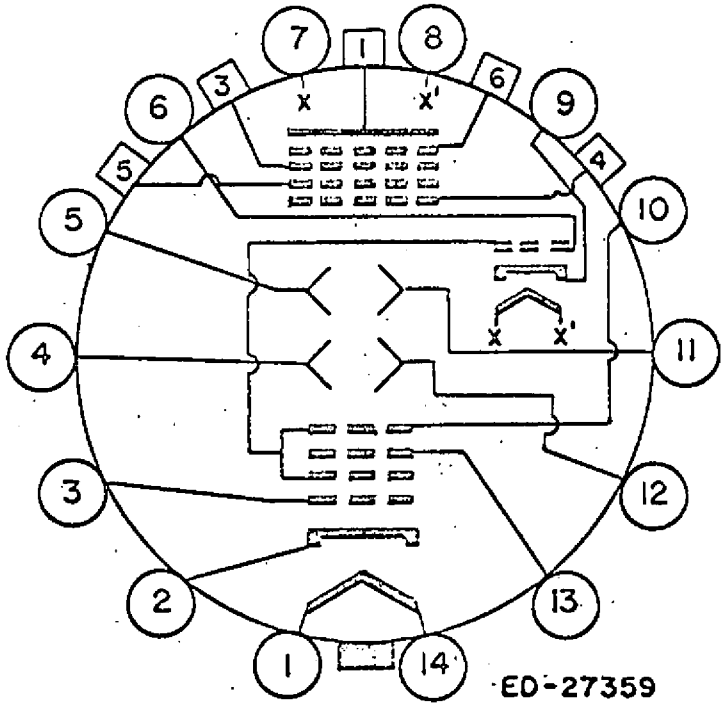
OUTLINE DRAWING



ALL DIMENSIONS IN INCHES

ED-27360

8320 PIN CONNECTION DIAGRAM



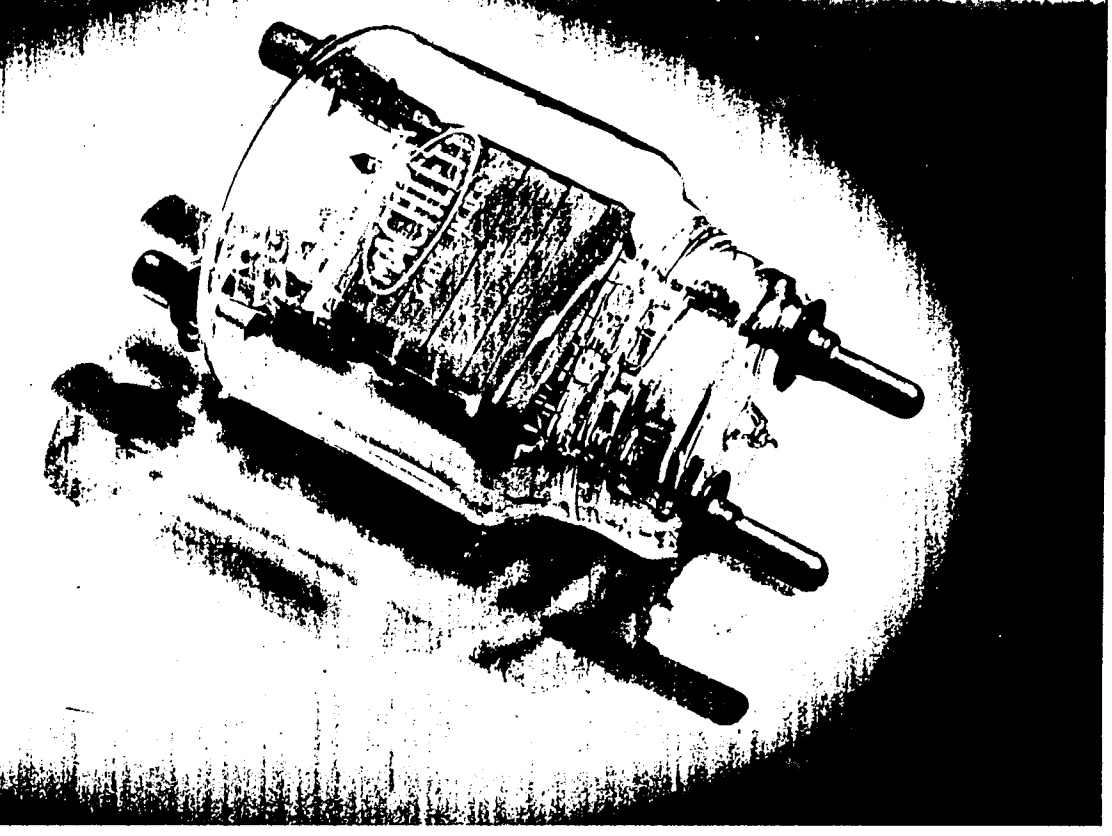
ED-27359

□

BULB CONTACT	CONNECTION
1.	VIEW SCREEN
2.	INTERNAL CONNECTION TO A4
3.	COLLECTOR ELECTRODE
4.	THIRD ANODE, A3
5.	COLLIMATOR, A4
6.	STORAGE MESH
7.	INTERNAL CONNECTION TO A4

○

PIN NO.	CONNECTION
1.	HEATER (WRITE GUN)
2.	CATHODE (WRITE GUN)
3.	CONTROL GRID (WRITE GUN)
4.	DEFLECTION PLATE, D1
5.	DEFLECTION PLATE, D3
6.	CONTROL GRID (FLOOD GUN)
7.	HEATER (FLOOD GUN)
8.	HEATER (FLOOD GUN)
9.	CATHODE (FLOOD GUN)
10.	SECOND ANODE (BOTH GUNS) A2
11.	DEFLECTION PLATE, D4
12.	DEFLECTION PLATE, D2
13.	FOCUS (WRITE GUN) A1
14.	HEATER (WRITE GUN)



MACHLETT

ML-833A

DESCRIPTION & RATINGS

DESCRIPTION

The ML-833-A is a three-electrode tube designed for use as a modulator, amplifier, or oscillator in radio transmitting service. It provides exceptional plate efficiency with low driving power due to special features which include high perveance and minimized internal lead inductance. The cathode is a thoriated tungsten filament. The tube is convection or forced-air cooled and is capable of dissipating 450 watts. Maximum ratings of 4.0 kVdc and 2.0 kW plate input with forced-air cooling apply at frequencies up to 20 mc/sec; operation at 100 mc/sec is permissible with reduced voltage and input ratings.

The ML-833-A embodies the highest standards for this tube type, all parts being thoroughly processed to assure efficient operation and long life.

GENERAL CHARACTERISTICS

Electrical	Minimum	Bogey	Maximum	
Filament Voltage		10.0		Volts
Filament Current at Bogey Voltage	9.4	10.0	10.6	Amps
Filament Starting Current	—	—	20.0	Amps
Amplification Factor: I_b = 200 mAdc, E_c = -25 volts	31.5	35.0	38.5	
Interelectrode Capacitances:				
Grid-Plate	5.5	6.3	7.1	uuf
Grid-Filament	10.1	12.3	14.5	uuf
Plate-Filament	6.4	8.5	10.6	uuf

Mechanical		
Mounting Position—Vertical, with filament terminals up or down; or horizontal, with plate in a vertical plane.		
Type of Cooling—Convection or Forced Air		
Maximum Incoming Air Temperature	45	°C
Required Air-Flow (for Forced-Air Cooling) On center of bulb between grid and plate seals from 2" diameter nozzle.	40	cfm
Maximum Glass Temperature (between grid and plate seals)	145	°C
Net Weight	1	lb.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

A-F Power Amplifier & Modulator
Class B

Maximum Ratings, Absolute Values

	Convection Cooling	Forced-Air Cooling		
	CCS	CCS	ICAS	
D-C Plate Voltage	3000	4000	4000	volts
Signal D-C Plate Current*	500	500	500	ma.
Signal Plate Input*	1125	1600	1800	watts
Plate Dissipation*	300	400	450	watts

Typical Operation

Unless otherwise specified, values are for 2 tubes

	Convection Cooling	Forced-Air Cooling		
D-C Plate Voltage	3000	4000	4000	volts
D-C Grid Voltage†	−70	−100	−100	volts
Peak A-F Grid-to-Grid Voltage	400	480	510	volts
Zero-Signal D-C Plate Current	100	100	100	ma.
Max. Signal D-C Plate Current	750	800	900	ma.
Effective Load Resistance, plate to plate	9500	12000	11000	ohms
Max.-Signal Driving Power, approx.	20	29	38	watts
Max.-Signal Power Output, approx.	1650	2400	2700	watts

* Averaged over any audio-frequency cycle of sine-wave form.
† For a-c filament supply
CCS—Continuous Commercial Service.
ICAS—Intermittent Commercial and Amateur Service.

R-F Power Amplifier—Class B Telephony

Carrier conditions per tube for use with a maximum modulating factor of 1.0.

Maximum Ratings, Absolute Values

	Convection Cooling	Forced-Air Cooling		
	CCS	CCS	ICAS	
D-C Plate Voltage	3000	4000	4000	volts
D-C Plate Current	300	300	300	ma.
Plate Input	450	600	675	watts
Plate Dissipation	300	400	450	watts

Typical Operation

	Convection Cooling	Forced-Air Cooling		
D-C Plate Voltage	3000	4000	4000	volts
D-C Grid Voltage†	−70	−120	−120	volts
Peak R-F Grid Voltage	90	120	130	volts
D-C Plate Current	150	150	150	ma.
D-C Grid Current, approx.	2	2	3	ma.
Driving Power, approx.*	10	14	21	watts
Power Output, approx.	150	225	250	watts

* At crest of a-f cycle with modulation factor of 1.0.
† For a-c filament supply.

Plate-Modulated R-F Power Amplifier
Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0.

Maximum Ratings, Absolute Values

	Convection Cooling	Forced-Air Cooling		
	CCS	CCS	ICAS	
D-C. Plate Voltage	2500	3000	4000	volts
D-C Grid Voltage	−500	−500	−500	volts
D-C Plate Current	400	450	450	ma.
D-C Grid Current	100	100	100	ma.
Plate Input	835	1250	1800	watts
Plate Dissipation	200	270	350	watts

Typical Operation

	Convection Cooling	Forced-Air Cooling		
D-C Plate Voltage	2500	3000	4000	volts
D-C Grid Voltage*	−300	−300	−325	volts
	4000	3600	3600	ohms
Peak R-F Grid Voltage	460	490	520	volts
D-C Plate Current	335	415	450	ma.
D-C Grid Current, approx.	75	85	90	ma.
Driving Power, approx.	30	37	42	watts
Power Output, approx.	635	1000	1500	watts

* Obtained by grid resistor of value shown or by partial self-bias methods.

R-F Power & Oscillator—Class C Telegraphy

Key-down conditions per tube without modulation†

Maximum Ratings, Absolute Values

	Convection Cooling	Forced-Air Cooling		
	CCS	CCS	ICAS	
D-C Plate Voltage	3000	4000	4000	volts
D-C Grid Voltage	−500	−500	−500	volts
D-C Plate Current	500	500	500	ma.
D-C Grid Current	100	100	100	ma.
Plate Input	1250	1800	2000	watts
Plate Dissipation	300	400	450	watts

Typical Operation

	Convection Cooling	Forced-Air Cooling		
D-C Plate Voltage	3000	4000	4000	volts
D-C Grid Voltage*	−200	−200	−225	volts
	3500	2650	2400	ohms
	425	380	380	ohms
Peak R-F Grid Voltage	360	375	415	volts
D-C Plate Current	415	450	500	ma.
D-C Grid Current, approx.	55	75	95	ma.
Driving Power, approx.	20	26	35	watts
Power Output, approx.	1000	1440	1600	watts

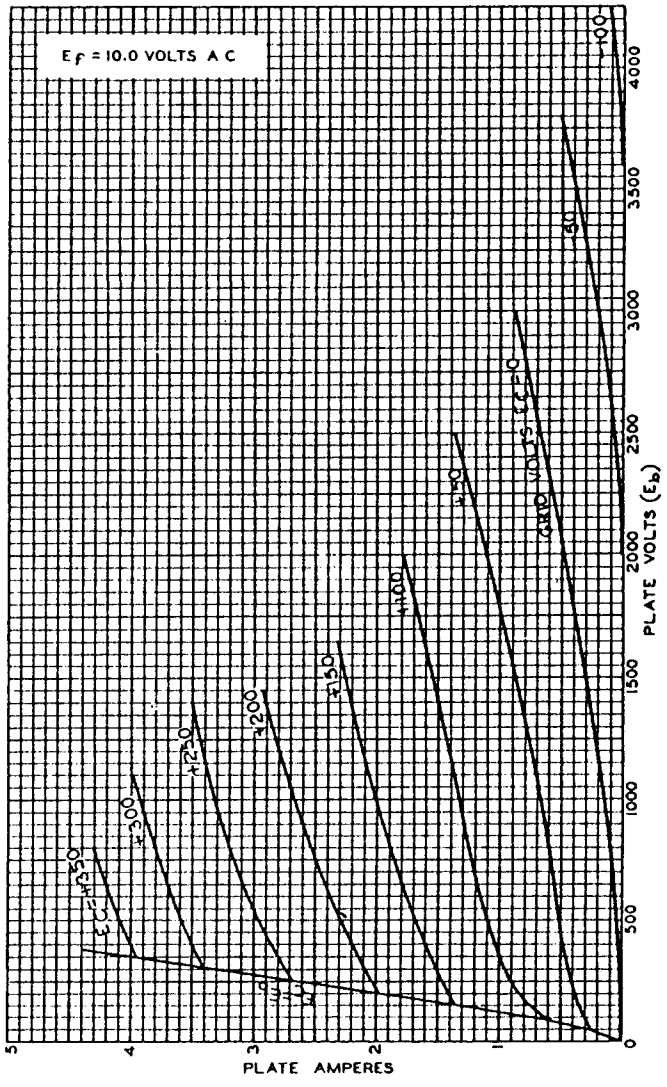
* Obtained from fixed supply, by grid resistor (3500, 2650, 2400) or by cathode resistor (425, 380, 380).

† Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

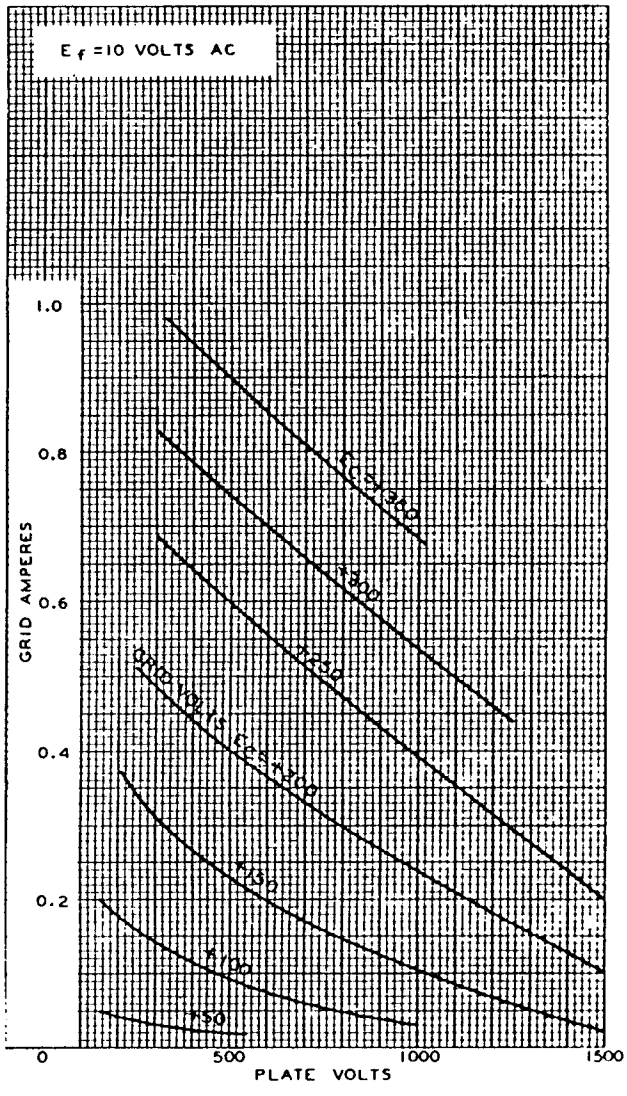
MAXIMUM FREQUENCY RATINGS

The ML-833-A can be operated at full ratings for convection cooling at frequencies up to 30 mc/sec. and full ratings for forced-air cooling at frequencies up to 20 mc/sec. Maximum values of plate voltage and power input for operation at higher frequencies are determined by the percentage factors tabulated below, other maximum ratings being the same as shown in the above section. At high frequencies special attention should be given to adequate ventilation of the bulb.

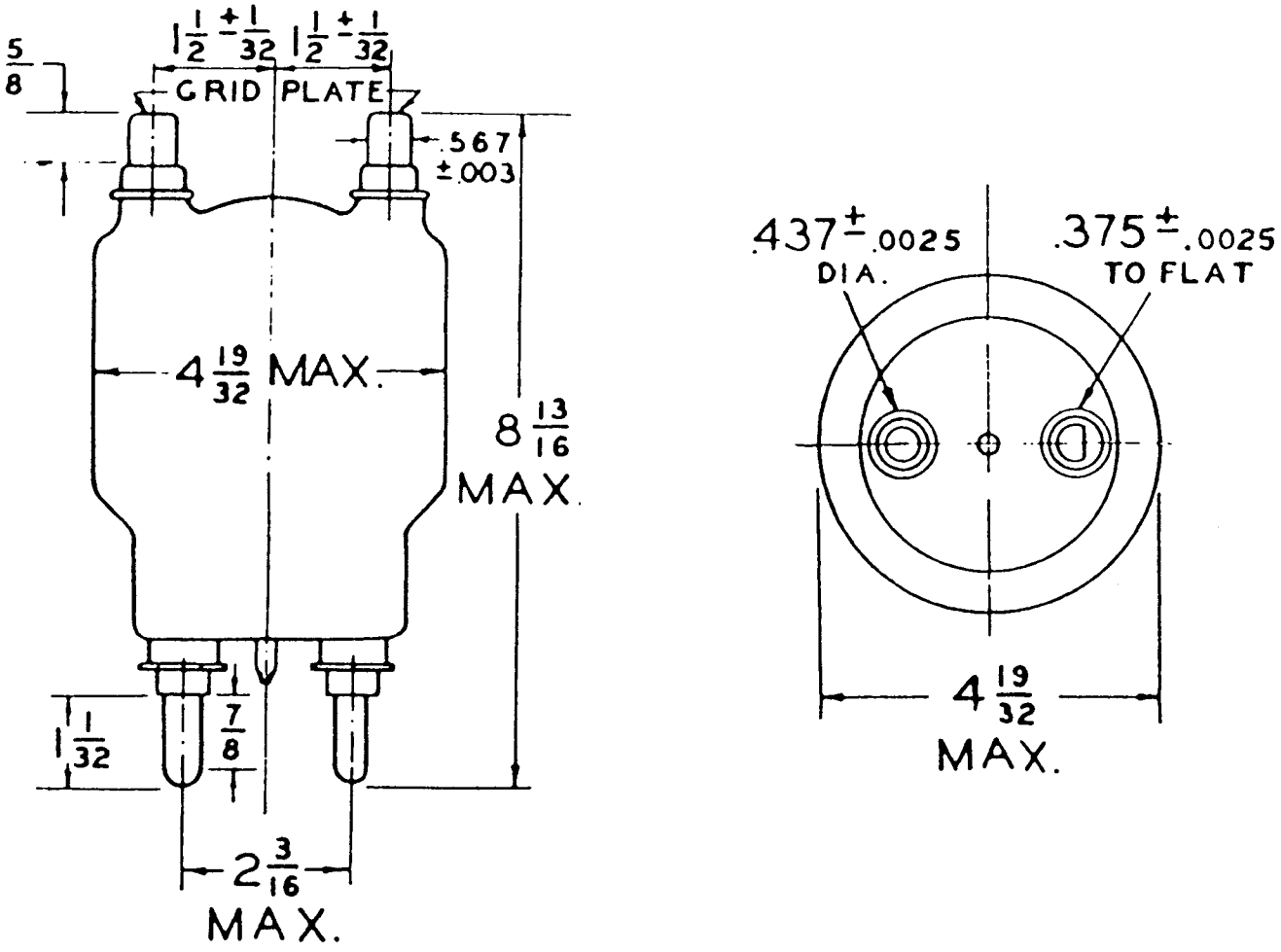
	Convection Cooling			Forced-Air Cooling			
Frequency	30	50	75	20	50	75	megacycles
Percentage of Maximum Rated Plate Voltage and Plate Input							
Class B, r-f	100	98	94	100	97	93	per cent
Class C, plate-modulated	100	90	72	100	83	65	per cent
Class C, unmodulated	100	90	72	100	83	65	per cent



AVERAGE PLATE CHARACTERISTICS



TYPICAL CHARACTERISTICS

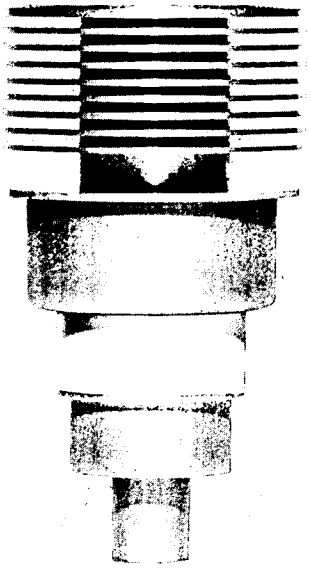


DIMENSIONS—ML-833 A

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



MACHLETT

ML-8403

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-8403 is a ruggedized, high-mu planar triode of ceramic-and-metal construction, designed for use as a grid-pulsed, plate-pulsed, or CW oscillator, frequency multipler, or amplifier in radio transmitting service from low frequency to 3 Gc.

A distinguishing characteristic of this tube is its high cathode-current capability. In addition to low interelectrode capacitance, high transconductance and high mu, this tube also incorporates design features which help to assure frequency-stable operation even under conditions of adverse ambient temperature and varying plate dissipation. The anode is forced-air cooled. The cathode is an indirectly-heated oxide-coated disc.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage (AC or DC)	6.0	V
Heater Current at 6.0 volts	1.25	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	80	
Interelectrode Capacitance:		
Grid-Plate	3.2	pf
Grid-Cathode	8.0	pf
Plate-Cathode, maximum	.065	pf
Mechanical		
Mounting Position	Optional	
Type of Cooling	Forced Air	
Maximum Anode Temperature	250	°C
Net Weight, approximately	2.5	oz

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

C-W Oscillator and Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	2000	Vdc
DC Grid Voltage	−150	Vdc
DC Cathode Current	190	mAdc
DC Grid Current	45	mAdc
Peak Positive RF Grid-Cathode Voltage	30	v
Peak Negative RF Grid-Cathode Voltage	−400	v
Plate Dissipation (forced-air cooling)	100	W
Grid Dissipation	2	W
Frequency	2.5	Gc

Plate-Pulsed Oscillator and Amplifier

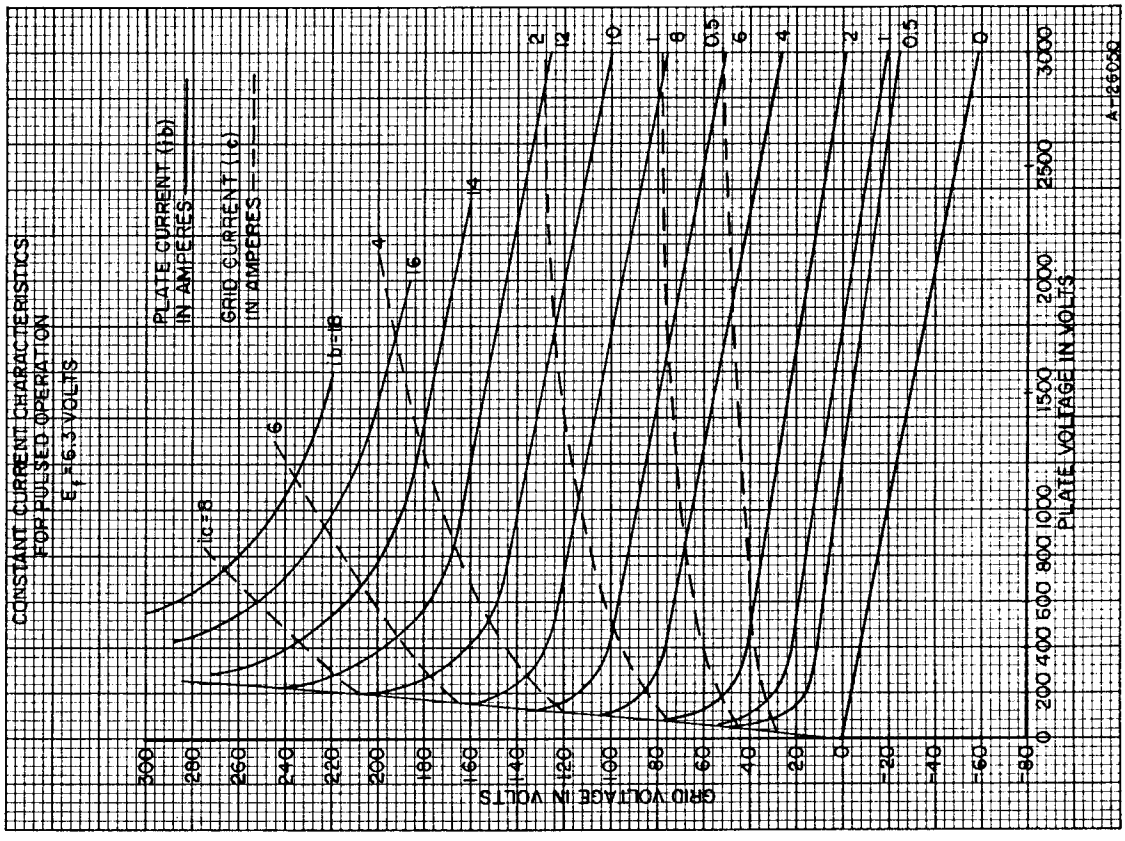
Maximum Ratings, Absolute Values		
Pulse Length	6	μs
Duty Factor	0.0033	*
Peak Plate Pulse Supply Voltage	3500	v
DC Grid Bias Voltage	−150	Vdc†
Peak Plate Current from Pulse Supply	5.0	a
Average Plate Current	13	mA
Average Grid Current	6	mA
Average Plate Dissipation	58	W
Average Grid Dissipation	2	W
Frequency	3	Gc

Grid-Pulsed Oscillator and Amplifier

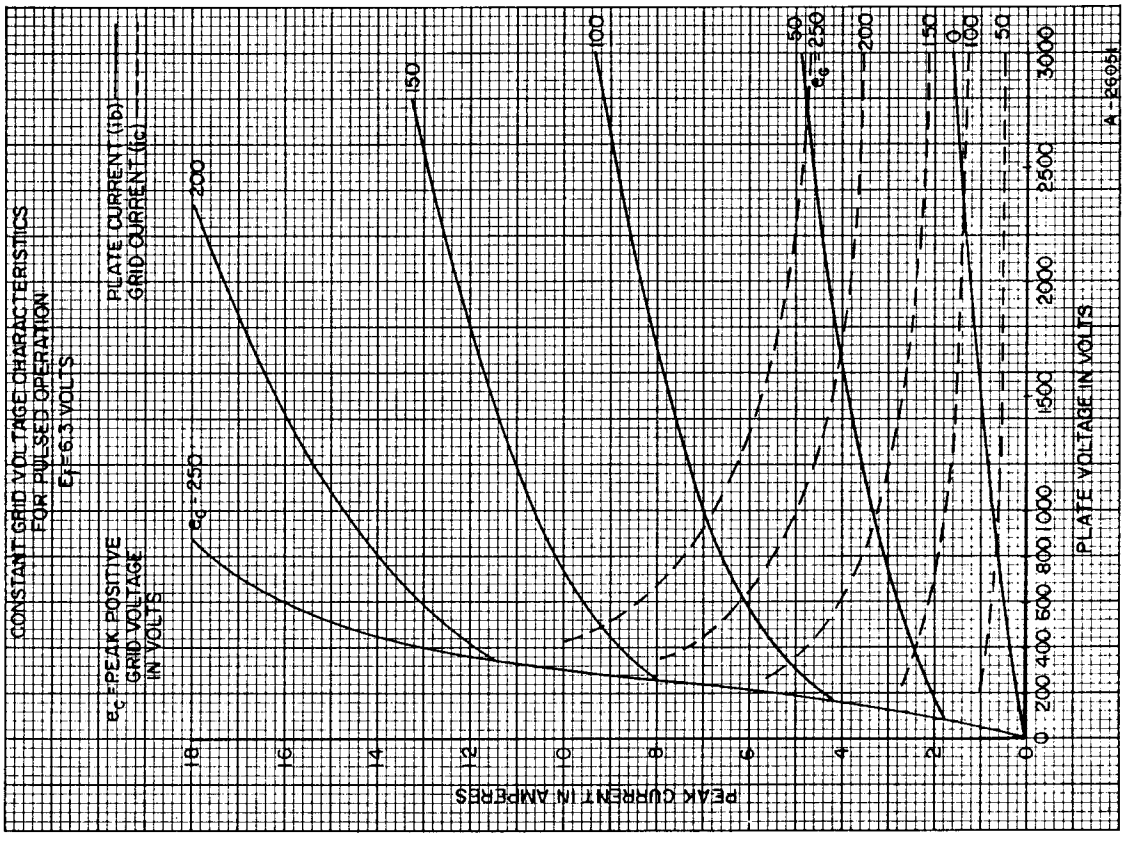
Maximum Ratings, Absolute Values		
Pulse Length	6	μs
Duty Factor	0.0033	*
DC Plate Voltage	2000	Vdc
DC Grid Bias Voltage	−150	Vdc†
Peak Plate Current from DC Supply	5.0	a
Average Plate Current	13	mA
Average Grid Current	6	mA
Average Plate Dissipation	33	W
Average Grid Dissipation	2	W
Frequency	3	Gc
Typical Operation, Oscillator		
Pulse Length	0.5	μs*
Duty Factor	0.005	*
DC Plate Voltage	2000	Vdc
DC Grid Bias Voltage	−150	Vdc
Peak Plate Current from DC Supply	4.0	a
Peak Grid Current	1.0	a
Useful Peak Power Output, approximate	1.0	kw
Frequency	1.0	Gc

*Higher duty factors are permissible at lower peak plate currents. For applications requiring longer pulse lengths or higher duty factors, consult the Machlett Engineering Department.

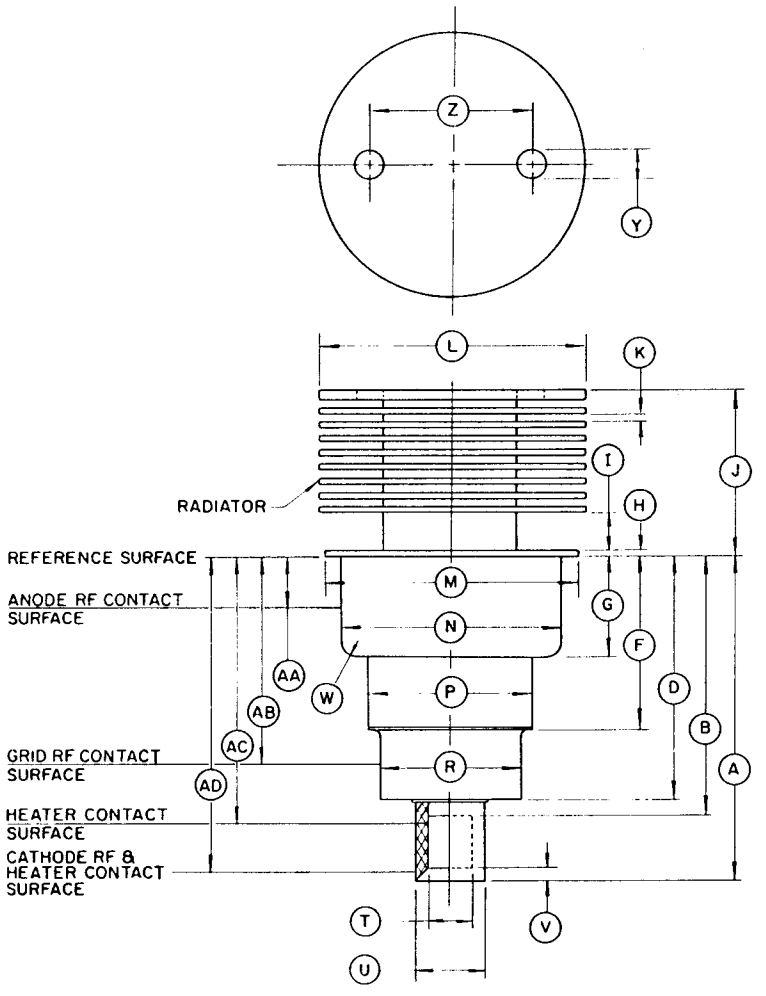
†The maximum instantaneous peak grid-cathode voltage shall be within the range of +250 to −750 volts.



CONSTANT CURRENT CHARACTERISTICS



CONSTANT GRID VOLTAGE CHARACTERISTICS



DIMENSIONS FOR OUTLINE (INCHES)

Ref.	Minimum	Maximum
A	1.500	1.560
B	—	1.214
D	1.125	1.165
F	0.800	0.840
G	0.462	0.477
H	—	0.040
I	0.125	0.185
J	0.766	0.826
K	0.025	0.046
L	1.234	1.264
M	1.180	1.195
N	1.025	1.035
P	0.752	0.792
R	0.655	0.665
T	0.213	0.223
U	0.315	0.325
V	—	0.086
W	—	0.100
Y	0.105	0.145
Z	0.650	0.850

DIMENSIONS FOR ELECTRODE CONTACT SURFACES (INCHES)

Ref.	Dimension	Contact
AA	0.198 ± 0.163	Anode
AB	1.061 ± 0.040	Grid
AC	1.316 ± 0.097	Heater
AD	1.330 ± 0.170	Cathode

NOTES

1. The total indicated runout of the anode and grid contact surfaces with respect to the cathode contact surface will not exceed 0.020 inch.
2. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed 0.012 inch.

DIMENSIONS — ML-8403

THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT
U. S. A.
ST-1977 3.5M 11-63
Printed in U.S.A.

from JEDEC release #4428, Sept.23, 1963
sponsor: The Machlett Laboratories

ML-8443

DIRECT VIEW STORAGE TUBE

DESCRIPTION

The Machlett type ML-8443 is a 5-inch-diameter, short, compact, direct-view storage tube designed primarily for airborne radar applications. It produces bright visual displays of half-tone images. The overall length is less than 8 inches and maximum diameter is held to 5-1/8 inches.

The ML-8443 design incorporates an on-axis neck with a high-resolution tetrode write gun electrostatically focussed and magnetically deflected, and an on-axis flood gun. A compact magnetic shield is available (optional), which can be made an integral part of the tube.

PERFORMANCE

Values given are for typical tube unless otherwise specified

Writing Speed	200,000	in/sec
Light Output (vs voltage = 6.5 kVdc)	1000	ftL
Written Resolution	70	lines/in
Storage Time, minimum	1	min

GENERAL CHARACTERISTICS

MECHANICAL

Outline	Per Drawing No. ED-28314
Dimensions	Per Table "B"
Pin Connections	Per Table "A"

ELECTRICAL

Flood Gun

Heater Voltage (AC or DC)	6.3	V
Heater Current	.6 ± 10%	A

Write Gun

Heater Voltage (AC or DC)	6.3	V
Heater Current	.3 ± 10%	A
Focusing Method	Electrostatic	
Deflection Method	Magnetic	

TYPICAL OPERATING CONDITIONS

All Voltages are referenced to fk unless otherwise indicated

Viewing Section

vs Voltage	6500	Vdc
be Voltage	0	V
ce Voltage	500	Vdc
fk Voltage	0	V
fg1 Voltage	0	V
fg2 Voltage	25	Vdc
fg3 Voltage	0	V
fg4 Voltage	7	Vdc

Writing Section

wk Voltage	-2500	Vdc
wg1 Voltage*	-5 to -30	Vdc
wg2 Voltage*	300	Vdc
wg3 Voltage	0	V
wg4 Voltage*	0	V
wg5 Voltage	0	V

* Referenced to wk.

TABLE A

TUBE CONNECTIONS

SYMBOL	ELECTRODE	CONNECTION
fh	flood-gun heater	Cap 5
fh	flood-gun heater	Cap 6
fk	flood-gun cathode	Cap 9
fg1	flood-gun grid	Cap 8
fg2	flood-gun grid	Cap 7
fg3	flood-gun grid†	Pin 9
fg4	flood-gun uniformity grid	Cap 2
ce	collector electrode	Cap 3
ss	storage surface	No Con.
be	backing electrode (storage mesh)	Cap 4
vs	view screen	Cap 1
wh	write-gun heater	Pin 5
wh	write-gun heater	Pin 6
wk	write-gun cathode	Pin 4
wg1	write-gun control grid	Pin 3
wg2	write-gun grid	Pin 8
wg3	write-gun grid†	Pin 9
wg4	write-gun focus electrode	Pin 1
wg5	write-gun grid†	Pin 9
--	No Connection	Pins 2 & 7

† wg3, wg5 and fg3 are internally connected.

TABLE B

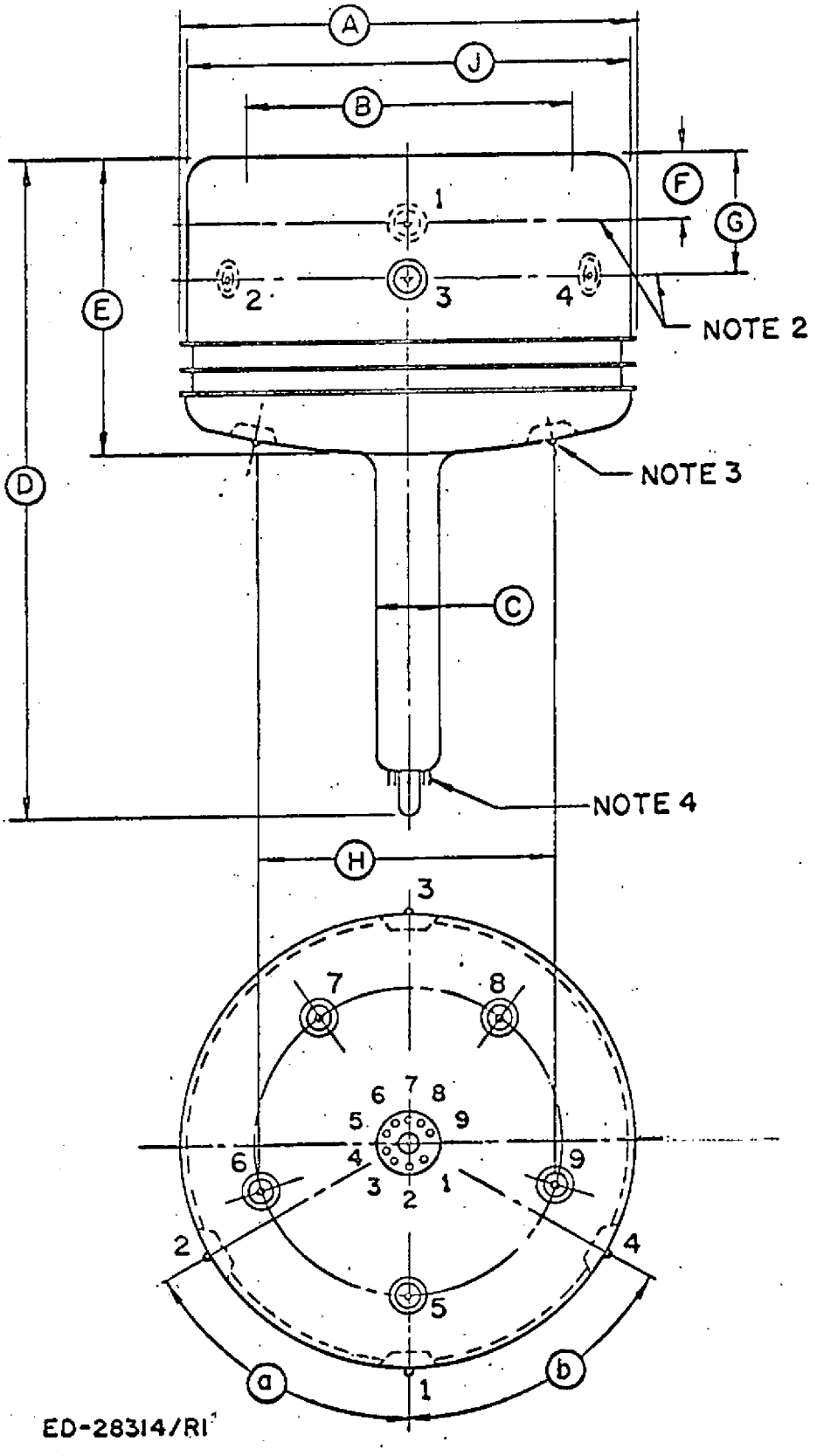
DIMENSIONS AND NOTES FOR OUTLINE DRAWING NO. ED-28314

ref.	inches (or degrees)			notes
	min.	nom.	max.	
A			5.25	
B	4.00			1
C		0.88		
D	7.75	7.88	8.00	
E		3.50		
F		0.81		
G		1.44		
H		2.75		
J		5.13		
a		60°		
b		60°		

NOTES:
1. Indicates useful screen diameter.
2. Recessed small ball caps, JEDEC J1-22 (Caps 1-4). See Table A.
3. Recessed small ball caps, JEDEC J1-25 (Caps 5-9). See Table A.
4. Base fits standard Vidicon socket. (Pins 1-9). See Table A.

ML-8443

OUTLINE DRAWING



ED-28314/RI

REFER TO TABLE "A" AND "B"

from JEDEC release #4428, Sept.23, 1963
sponsor: The Machlett Laboratories

ML-8454 Direct-View Storage Tube

DESCRIPTION

The Machlett Type ML-8454 is a 5-inch diameter direct-view storage tube that is capable of bright visual displays of half-tone images. The tube features a high-resolution electrostatically focused tetrode-type write gun and a flood (viewing) gun. The write beam is deflected magnetically. The useful storage time for written information is approximately one minute. The erasure of information can be gradual or can be accomplished instantaneously.

The ML-8454 incorporates a magnetic shield to minimize magnetic fields which might affect the low-velocity flood-gun electrons. The tube is potted in this shield making it suitable for high-altitude operation, as well as sea-level applications.

PERFORMANCE

Values given are for typical tube unless otherwise specified.

Writing Speed (10 μA beam current)	100000	in/sec.
Light Output, minimum (8 kV screen voltage)	1400	ftL
Written Resolution (10 μA beam current)	60 to 80	lines/in
Erase Time (single-pulse erasure)	50 to 250	ms
Half Tones, minimum	5	

GENERAL CHARACTERISTICS

Optical

Phosphor Type	P20 Aluminized
Fluorescence	Green-Yellow
Phosphorescence	Green-Yellow
Faceplate	Flat, Optical-Quality Glass

Mechanical

Overall Length	10-3/4	in
Maximum Diameter	5-7/8	in
Useful Screen Diameter	4	in
Neck Length	4-1/4	in
Bases:		
Flood gun (Miniature 7-pin)	JEDEC	E7-1
Write gun (8-pin)	JEDEC	B7-183
Mounting Position	Any	
Outline	See Drawing No. ED-28322	
Pin Connections	Per Table "A"	
Dimensions	Per Table "B"	

Electrical

Flood and Write Guns:		
Heater voltage, (AC or DC)	6.3	V
Heater current	.6 ± 10%	A
Write Gun:		
Focusing	Electrostatic	
Deflection	Magnetic	

RATINGS

All values are absolute maximum unless otherwise specified.

All voltages are referenced to fk unless otherwise specified.

vs Voltage	11000	Vdc
vs Dissipation	10	W
be Voltage	0 to + 200	Vdc
cc Voltage	250	Vdc
fg4 Voltage	250	Vdc
fg3, wg3 & wg5 Voltage	200	Vdc
fg2 Voltage	150	Vdc
fg1 Voltages:		
Negative-bias value	200	Vdc
Positive-bias value	0	V
Positive-peak value	2	v
wg1 Voltages:		
Negative-bias*	150	Vdc
Positive-bias*	0	V
Positive-peak*	2	v
wh Peak Voltages:		
wh negative*	125	v
wh positive*	125	v
wg4 Voltage	-3600	Vdc
wk Voltage	-3000	Vdc
wg2 Voltage	800	Vdc

TYPICAL OPERATING CONDITIONS

All voltages are referenced to fk unless otherwise specified.

Viewing Section

vs Voltage	-10000	Vdc
be Voltage	5	Vdc
ce Voltage	120	Vdc

Flood Gun

fk Voltage	0	Vdc
fg1 Voltage:		
Operating value	0 to -30	Vdc
Cut-off value	-60 to -120	Vdc
fg2 Voltage	80	Vdc
fg3, wg3 & wg5 Voltage	10 to 30	Vdc
fg4 Voltage	35 to 80	Vdc

ML-8454 Direct View Storage Tube

Write Gun

wk Voltage	-2000	Vdc
wg1 Voltage*	-20 to -50	Vdc
wg2 Voltage*	200	Vdc
wg3, wg5	(I.C. to fg3)	
wg4 Voltage*	-100 to -350	Vdc

* Referenced to wk

Currents

vs	0 to 500	μAdc
be	-15 to 75	μAdc
ce	0.6 to 0.9	mAdc
fg4	0.05 to 0.09	mAdc
fg3, wg3 & wg5	0.3 to 0.5	mAdc
fg2	0.03 to 0.2	mAdc
fk	0 to 2	mAdc
wg4	<1	μAdc
wk	0 to 1	mAdc

TABLE A

TUBE CONNECTIONS

SYMBOL	CONNECTION	BASE*	ELECTRODE
fh	Pin 3	F	flood-gun heater
fh	Pin 4	F	flood-gun heater
fk	Pin 7	F	flood-gun cathode
fg1	Pin 2	F	flood-gun control grid
fg2	Pin 1	F	flood-gun first anode
fg3	Pin 6	F	flood-gun second anode †
fg4	Lead 4	--	flood-gun third anode (collimator)
vs	Lead 1	--	view screen
be	Lead 2	--	backing electrode (storage mesh)
ce	Lead 3	--	collector electrode
ss	N. C.	N.C.	storage surface
wh	Pin 1	W	write-gun heater
wh	Pin 8	W	write-gun heater
wk	Pin 7	W	write-gun cathode
wg1	Pin 2 & 6	W	write-gun control grid
wg2	Pin 3	W	write-gun grid No. 2
wg3	Pin 6	F	write-gun second anode †
wg4	Pin 4	W	write-gun first anode (focus)
wg5	Pin 6	F	write-gun third anode †
--	Pin 5	F	I. C. Do not use.
--	Pin 5	W	vacant position

* F denotes flood-gun JEDEC E7-1 base.
W denotes write-gun JEDEC B7-183 base.

† fg3, wg3 and wg5 internally connected.

TABLE B

DIMENSIONS FOR OUTLINE DRAWING NO. ED-28322

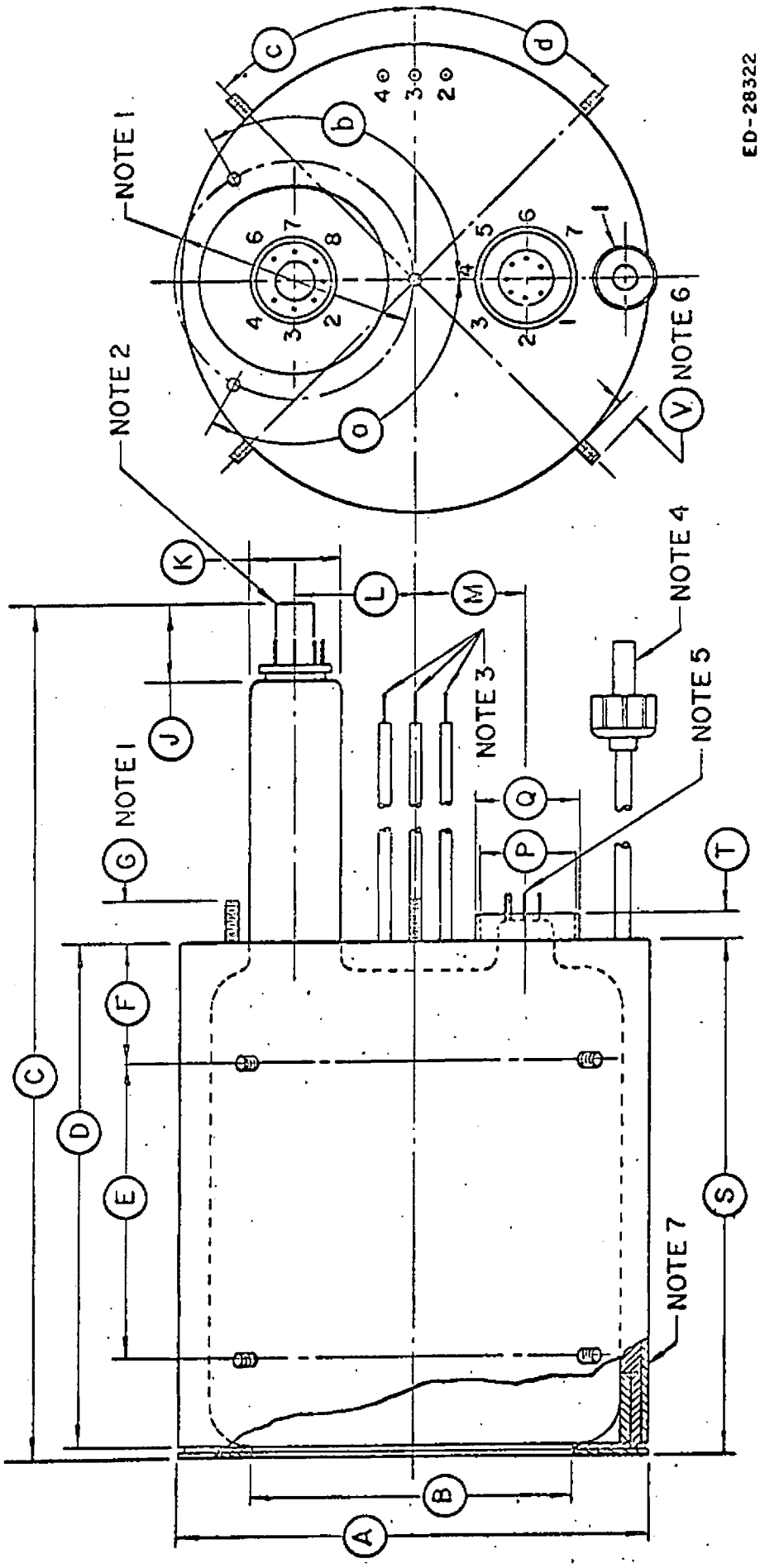
REF.	INCHES (OR DEGREES) MIN.	NOM.	MAX.	NOTES
A	—	—	5.88	
B	4.00	—	—	8
C	10.50	10.75	11.00	
D	6.28	6.31	6.34	
E	3.72	3.75	3.78	
F	1.47	1.50	1.53	
G	0.48	0.50	0.52	
J	0.943	0.948	0.948	
K	.970	1.000	1.030	
L	1.44	1.50	1.56	
M	1.32	1.38	1.44	
P	1.13	1.16	1.19	
Q	—	—	1.30	
S	6.00	6.31	6.62	
T	.282	.312	.342	
V	0.200	0.250	0.250	
a	44°	45°	46°	
b	44°	45°	46°	
c	119°	120°	121°	
d	119°	120°	121°	

NOTES FOR OUTLINE DRAWING NO. ED-28322 & TABLE B

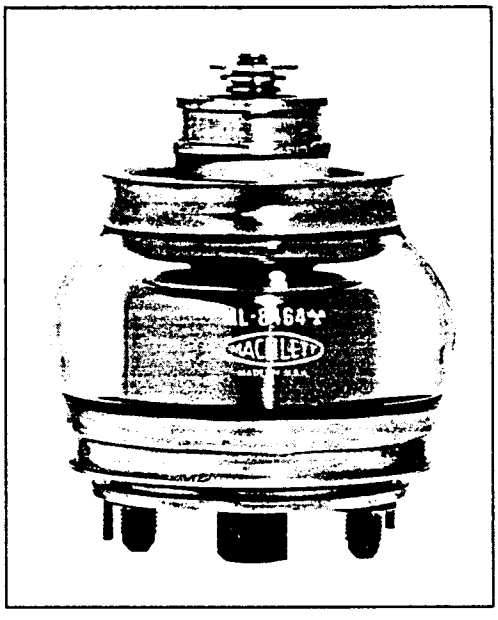
1. No. 8-32 UNC-2A threads; 3 studs.
2. Write-gun small-button eightar 7-pin base, JEDEC B7-183. (Refer to Table A for pin connections.)
3. Three flexible leads; lengths as specified by customer. (Refer to Table A for lead connections.)
4. AMP No. 835835 flexible high-voltage lead and connector; length as specified by customer.
5. Flood-gun miniature 7-pin base, JEDEC E7-1. (Refer to Table A for pin connections.)
6. No. 8-32 UNC-2A threads; 8 studs.
7. Netic Co-Netic shield.
8. Dimension represents minimum useful screen diameter.

ML-8454

OUTLINE



ISSUED 5-64



ML-8464

Ruggedized Shielded Grid Triode

Pulse Power to 500 kw

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8464 is a shielded-grid triode designed primarily to operate as a switch tube in hard-tube pulse modulators for radar and similar applications. In this service it can deliver 400 kw pulse power output with less than 2.0 kw pulse driving power.

The ML-8464 has sturdy electrodes arranged to form a cylindrical array of electron-optical systems featuring a shield electrode connected internally to the cathode by direct, low-impedance paths. This design provides a tube with extremely flat plate-current curves at constant grid-drive and very low grid-current values. The grid-plate capacitance of the tube is also very low.

The characteristics of this tube are particularly valuable when driving magnetron- and amplitron-type devices. The presence of the ground-potential shield between anode and control grid protects the cathode and control grid from damage by transient arcs. The ML-8464 will operate within ratings while being vibrated with moderately high acceleration and is suitable for applications in mobile equipment.

The cathode is a unipotential, oxide-coated type. The anode is liquid-cooled and is capable of dissipating 1500 W with a flow rate of 1.5 gpm of water.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage	5.5 ±7%	V
Heater Current	20	A
Heater Starting Current, maximum	80	A
Cathode Warm-Up Time	10	min*
Amplification Factor	200	
Interelectrode Capacitances		
Grid-Plate	1.2	pf
Grid-Cathode	78	pf
Plate-Cathode	12	pf
Mechanical		
Mounting Position	Any	
Type of Cooling	Liquid and forced-air†	
Water flow for 1.5 kW dissipation	1.5	gpm
Liquid pressure drop across tube at 1.5 gpm, approximate	15	psi
Maximum outgoing water temperature	70	°C
Air flow on heater terminal	15	cfm†
Maximum Glass Temperature	175	°C†
Net Weight, approximate	4.5	lb

*For accelerated cathode warm-up, the filament may be energized at 6.5 volts for 4 minutes and then reduced to 5.5 volts for high-voltage operation.

†Sufficient air flow must be provided to maintain glass temperature at less than 175° C under all conditions of operation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator of Pulse Amplifier

Maximum Ratings, Absolute Values

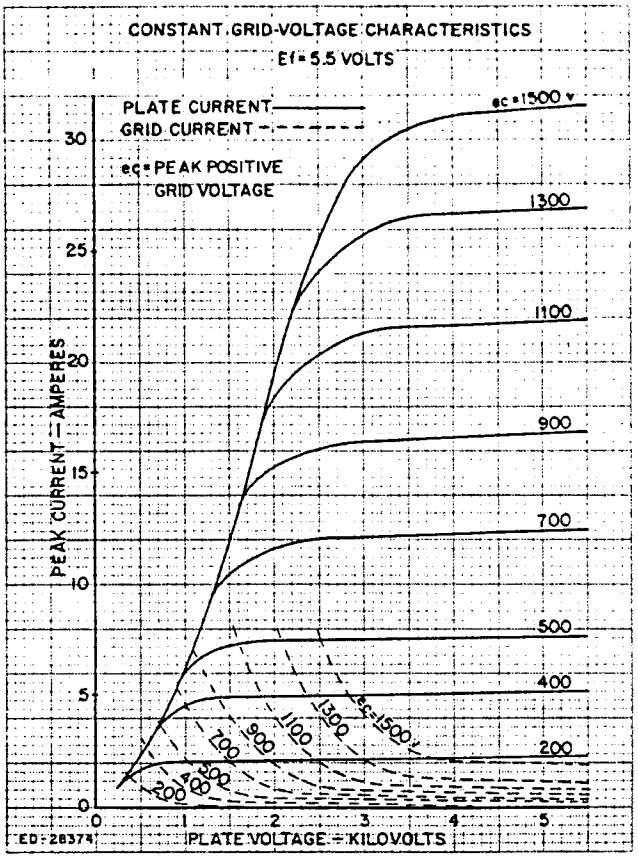
DC Plate Voltage	25	kV
Peak Plate Voltage	30	kv
DC Grid Voltage	−600	V
Peak Positive Grid Voltage	1600	v
Pulse Cathode Current	25	a
DC Plate Current	260	mA
Grid Dissipation	25	W
Plate Dissipation	1500	W
Pulse Duration	25	μs#
Duty Factor	.025	#

Typical Operation

DC Plate Voltage	23	22.5	kV
DC Grid Voltage	−250	−250	V
Pulse Positive Grid Voltage	1100	650	v
Pulse Plate Current	20	10	a
Pulse Grid Current	1.4	.5	a
Pulse Driving Power	2	.45	kw
Pulse Power Output	400	200	kw
Average Power Output	.4	5.0	kW
Pulsed Plate Output Voltage	20	20	kv
Duty Factor	.001	.025	

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube might produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

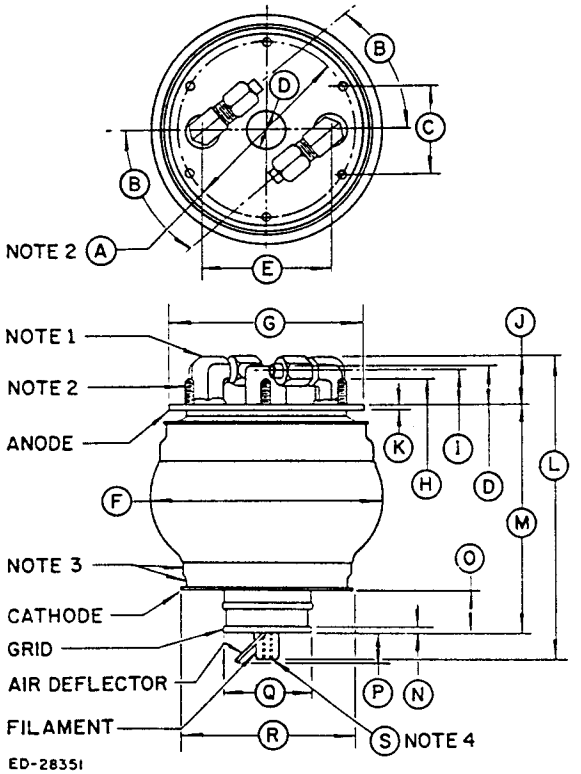


DIMENSIONS FOR OUTLINE OF ML-8464

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	—	3.442	—	2
B	37°	40°	43°	degrees
C	—	1.721	—	
D	—	.75	1.02	
E	—	2.48	—	
F	—	4.5	4.7	
G	3.70	3.75	3.80	
H	—	.50	—	
I	—	.64	—	
J	—	.95	1.02	
K	—	.12	—	
L	—	5.9	6.3	
M	4.20	4.44	4.65	
N	.08	.12	—	
O	.70	.84	.98	
P	—	.53	—	
Q	1.670	1.685	1.700	
R	3.350	3.375	3.400	
S	.43	.50	—	4

NOTES:

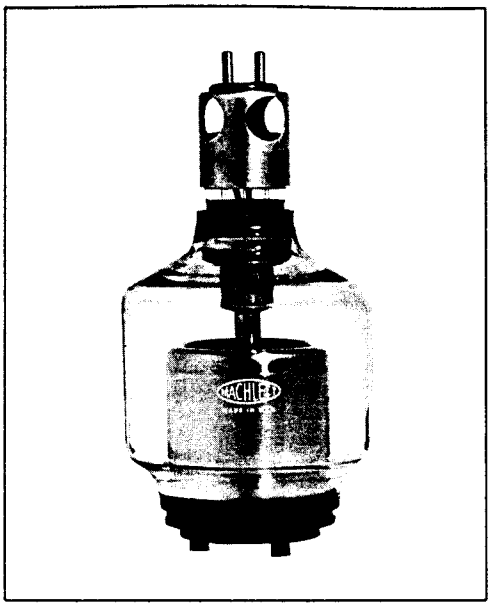
1. Water-cooling fittings for ¼" flared tubing.
2. Six mounting studs, 10-32 NF-2, on circle diameter of (A) inches.
3. Do not clamp on this surface (spring contact only).
4. Internal thread for filament connection, 10-32 NF-2, (S) inches deep.



THE MACHLETT LABORATORIES, INC.
An Affiliate of Raytheon Company
SPRINGDALE MACHLETT CONNECTICUT

Printed in U.S.A.

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ISSUED 4-68

ML-8495

MACHLETT

High-Voltage Triode
Plate Voltage to 160 kV

DESCRIPTION

The ML-8495 is a high-voltage triode designed for use as a switch tube in pulse modulators for radar and in other high-voltage switching applications. In this service the ML-8495 can deliver pulse power output in the order of 2 to 3 Mw. The cathode of this tube consists of sturdy, self-supporting, stress-free thoriated tungsten filaments. The anode, when cooled by a forced flow of oil, is capable of dissipating 2500 W. The tube is designed for operation immersed in oil or equivalent dielectric liquid, which is required for utilization of the maximum plate-voltage rating of 160 kVdc.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	12.6	V
Filament Current	29	A
Filament Starting Current, maximum	120	A
Filament Cold Resistance	.0053	Ohms
Amplification Factor	250	
Interelectrode Capacitances		
Grid-Plate	7.0	pf
Grid-Filament	30	pf
Plate-Filament	.2	pf

Mechanical

Mounting Position	Vertical, anode down	
Insulating Medium	Oil or equivalent	
Type of Cooling	Forced oil	
Oil Flow for 2500 Watts Plate Dissipation	10 to 12	gpm†
Maximum Bulk Oil Temperature	75	°C
Maximum Circulating Oil Temperature for Maximum Dissipation	75	°C
Maximum Glass Temperature	165	°C
Net Weight, with oil jacket, approximate	20	lb

†When using Machlett oil jacket part number F-27548. (Order separately.)

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources".

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

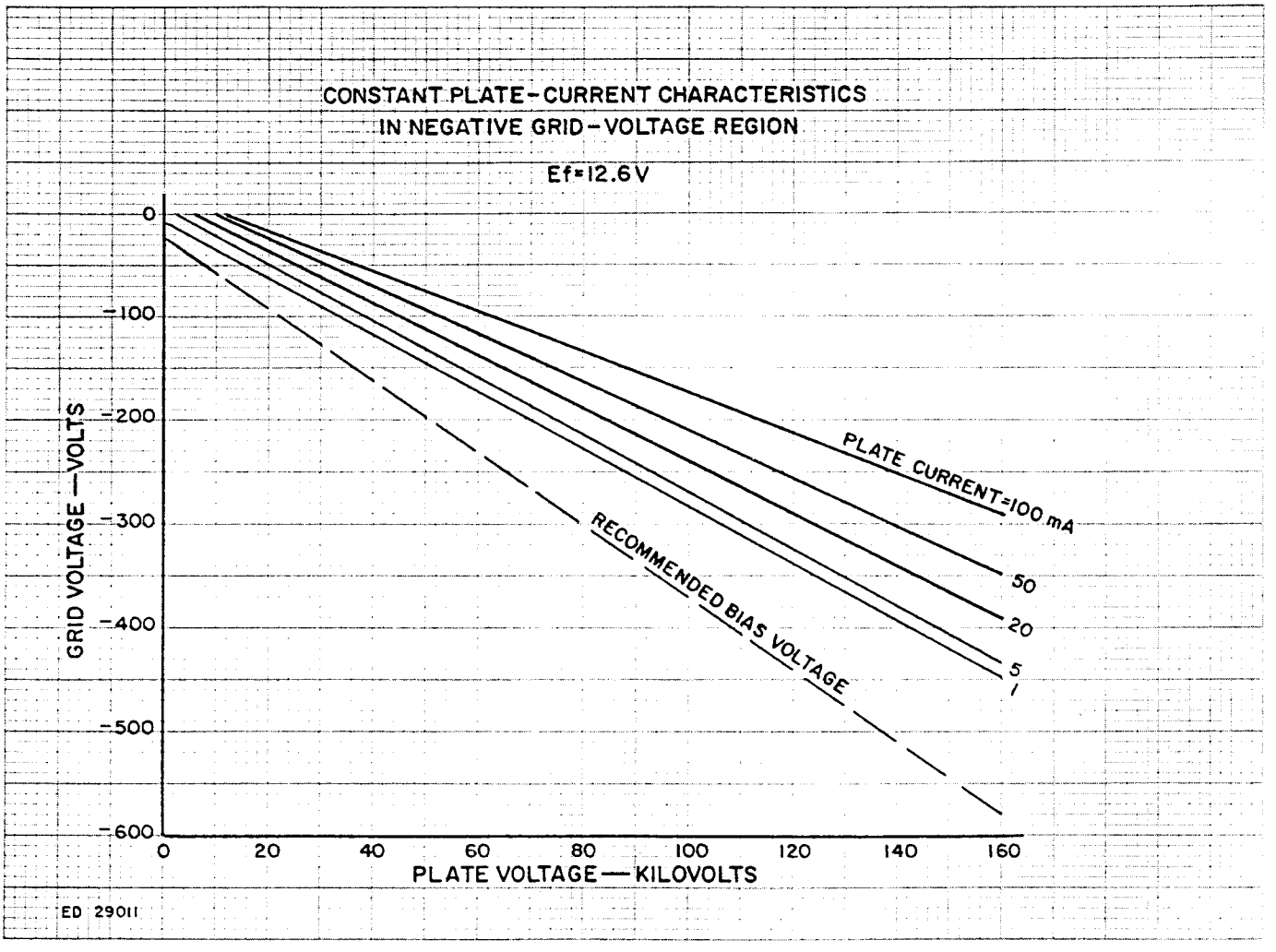
DC Plate Voltage	160	kV‡
Peak Plate Voltage	165	kv‡
DC Grid Voltage	−1000	V
Peak Negative Grid Voltage	−2500	v
Pulse Cathode Current	22	a
Grid Dissipation	50	W
Plate Dissipation	2500	W
Pulse Duration	1000	μs#
Duty Factor	.008#	

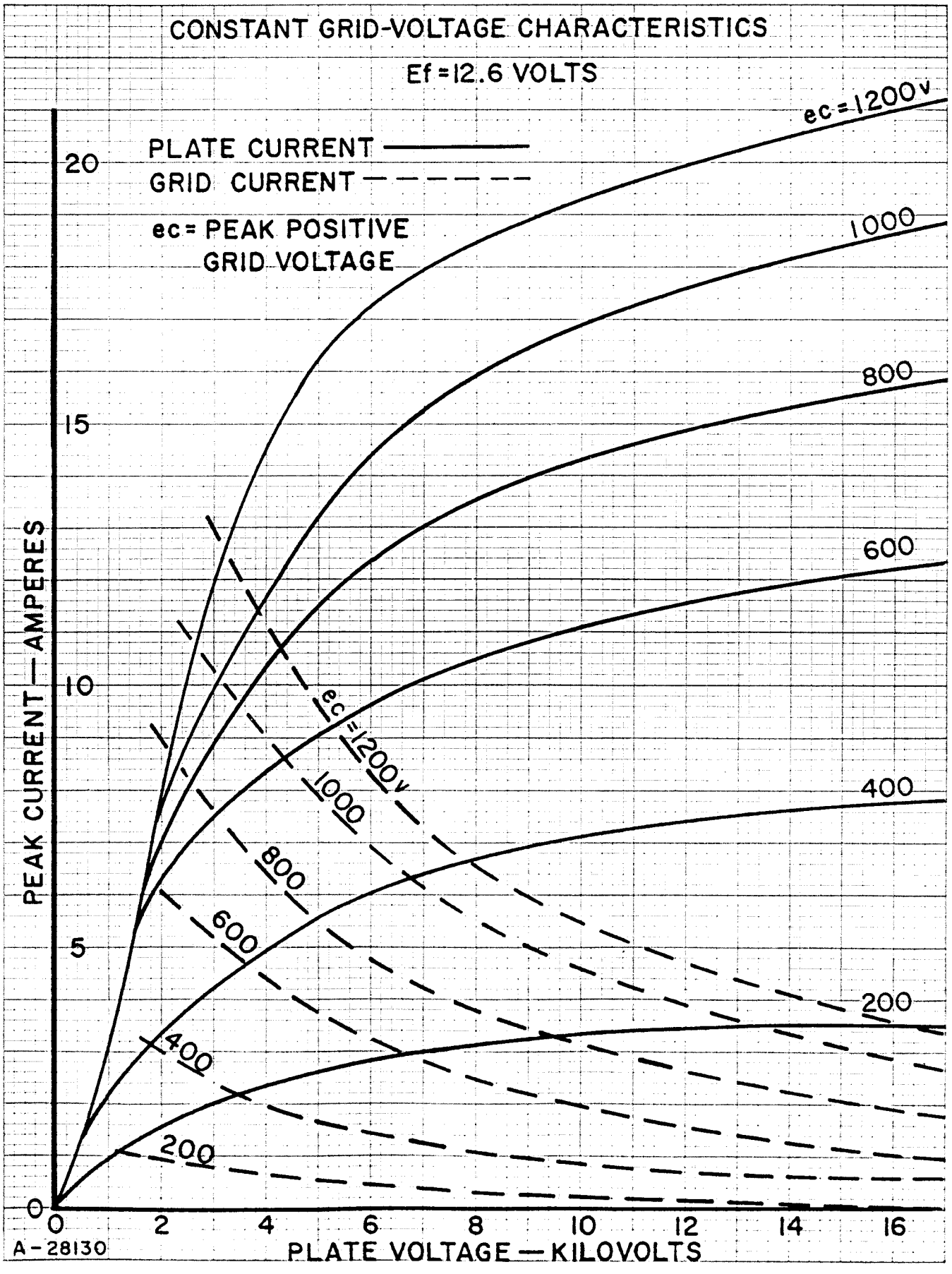
Typical Operation

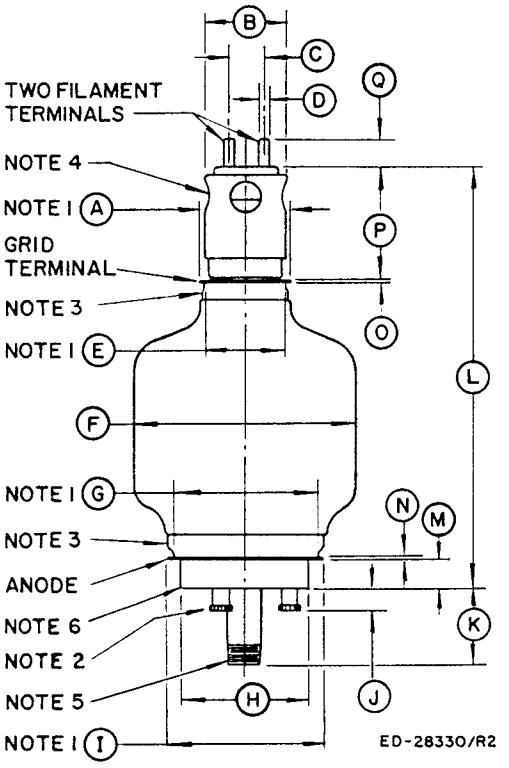
DC Plate Voltage	150	kV
DC Grid Voltage	−550	V
Pulse Positive Grid Voltage	1000	v
Pulse Plate Current	18	a
Pulse Grid Current	3	a
Pulse Driving Power	6	kw
Pulse Power Output	2.4	Mw
Pulsed Plate Output Voltage	135	kv

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

‡This voltage may be applied only when the tube is immersed in a suitable dielectric fluid.




CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 12.6 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
ec = 1200v
1000
800
600
400
200
PEAK CURRENT — AMPERES
PLATE VOLTAGE — KILOVOLTS
0
5
10
15
20
2
4
6
8
10
12
14
16
A-28130



DIMENSIONS FOR OUTLINE OF ML-8495

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	3.16	3.19	3.21	1
B		2.88	2.92	
C	1.240	1.250	1.260	
D	.368	.372	.376	
E	3.12	3.13	3.14	1, 3
F		8.00	8.18	
G	5.36	5.38	5.39	1, 3
H		4.72	4.76	
I	5.450	5.455	5.470	1
J		.75	.85	
K	2.94	3.00	3.06	
L	15.00	15.22	15.47	
M	1.01	1.19	1.38	
N	.05	.08	.12	
O	.03	.04	.05	
P	3.4	3.9	4.2	
Q		1.00	1.15	

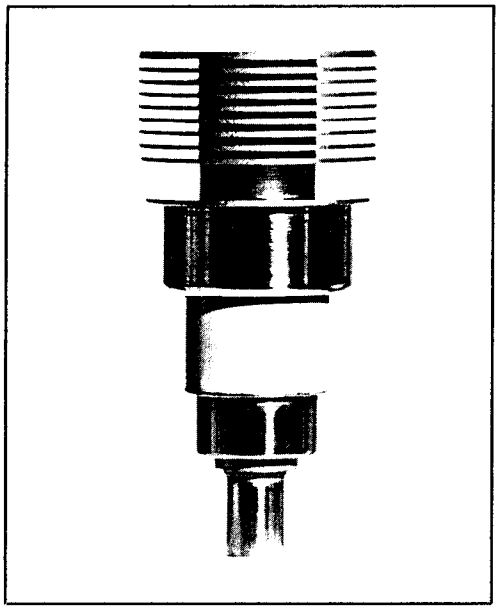
NOTES:

1. Allow additional ±.01" for out of roundness.
2. Three thumb screws for retaining oil-cooling jacket.
3. Do not clamp on this surface (spring contact only).
4. Allow clearance for circulation of oil through holes.
5. Oil inlet connection, 1" IPT. Oil discharges into enclosure.
6. Tube is shown with oil cooling jacket, which is optional item at extra cost.

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ST-2021 4.5M 4-68

ISSUED 5-64



ML-8533

UHF Planar Triode
35 kw Pulse Power
5 kw RF Pulse Power
Phormat Cathode

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8533 is a high-mu planar triode designed for use as a grid-pulsed or plate-pulsed oscillator, frequency multiplier, power amplifier or as a switch tube at high plate voltages. The tubes will deliver useful output at frequencies as high as 3 Gc. Noteworthy differences in this tube as compared to similar tube types are an extended grid-cathode insulator and a special cathode design, permitting operation with up to 8000 Vdc plate voltage. Other features include low interelectrode capacitance, high transconductance, great mechanical strength and capability for sustained, reliable operation at elevated temperatures.

Compact metal-and-ceramic coaxial construction makes the tubes well suited for operation in line-type circuits at lower frequencies as well as in cavity resonators at the higher frequencies. The cathode is an indirectly heated disc with an oxide coating impregnated in a nickel matrix. The unique matrix construction (in combination with proper plate series impedance) reduces to a minimum failures of the cathode due to voltage surges thereby further increasing the reliability of this tube. The anode of the ML-8533 is cooled by forced air.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage (AC or DC)	6.3 ±5%	V
Heater Current at 6.3 volts	1.3	A
Heater Heating Time, minimum	60	sec
Amplification Factor, Cutoff	90	
Amplification Factor, Dynamic	145	
Transconductance	30000	μmhos
Interelectrode Capacitances, without Heater Voltage		
Grid-Plate	1.65	pf
Grid-Cathode	8.0	pf
Plate-Cathode, maximum	.06	pf

Mechanical

Mounting Position	Optional	
Type of Cooling	Forced-air	
Maximum Anode Temperature	250	°C
Net Weight	2.5	oz

MAXIMUM RATINGS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

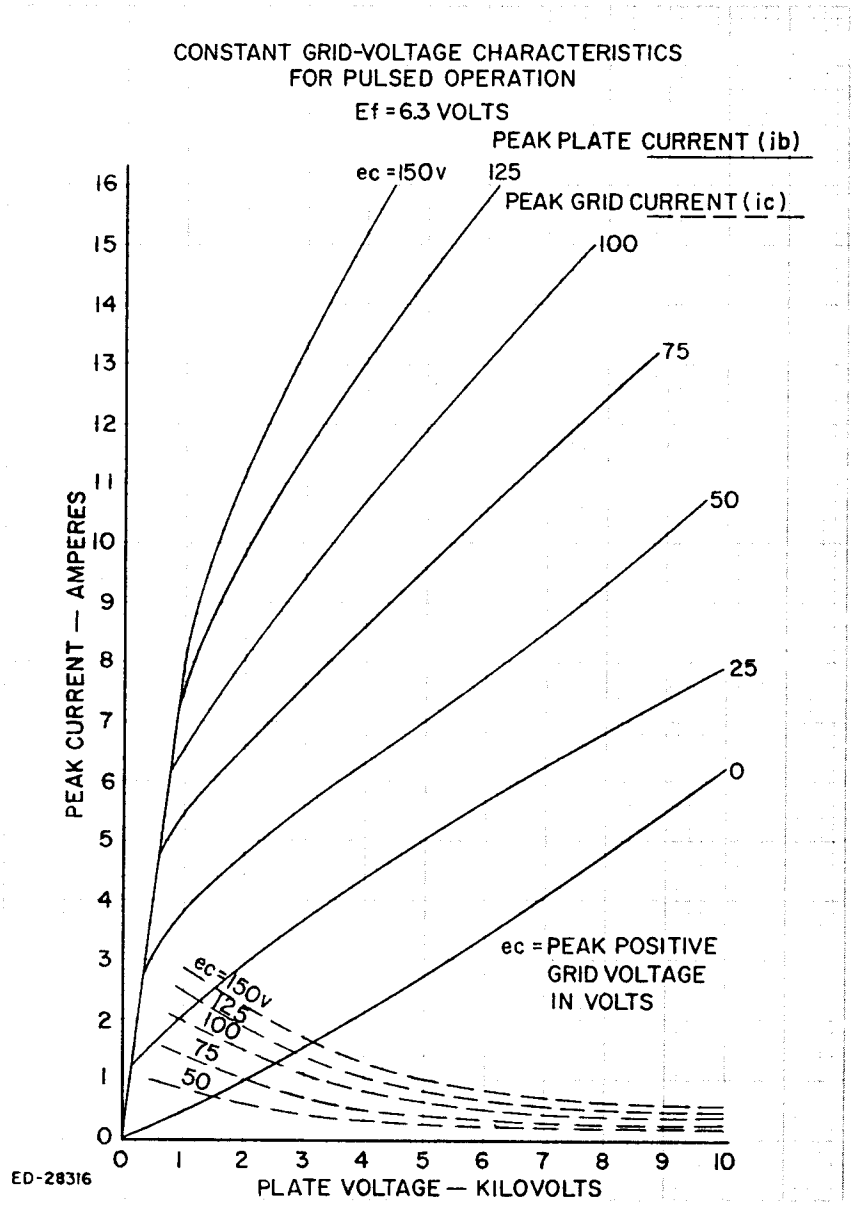
DC Plate Voltage	8	kV
Peak Plate Voltage	10	kv
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
DC Plate Current	150	mA
Peak Plate Current from Pulse Supply	5	a
Average Plate Dissipation (Forced-Air Cooling)	100	W
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs†
Duty Factor	0.0033	†

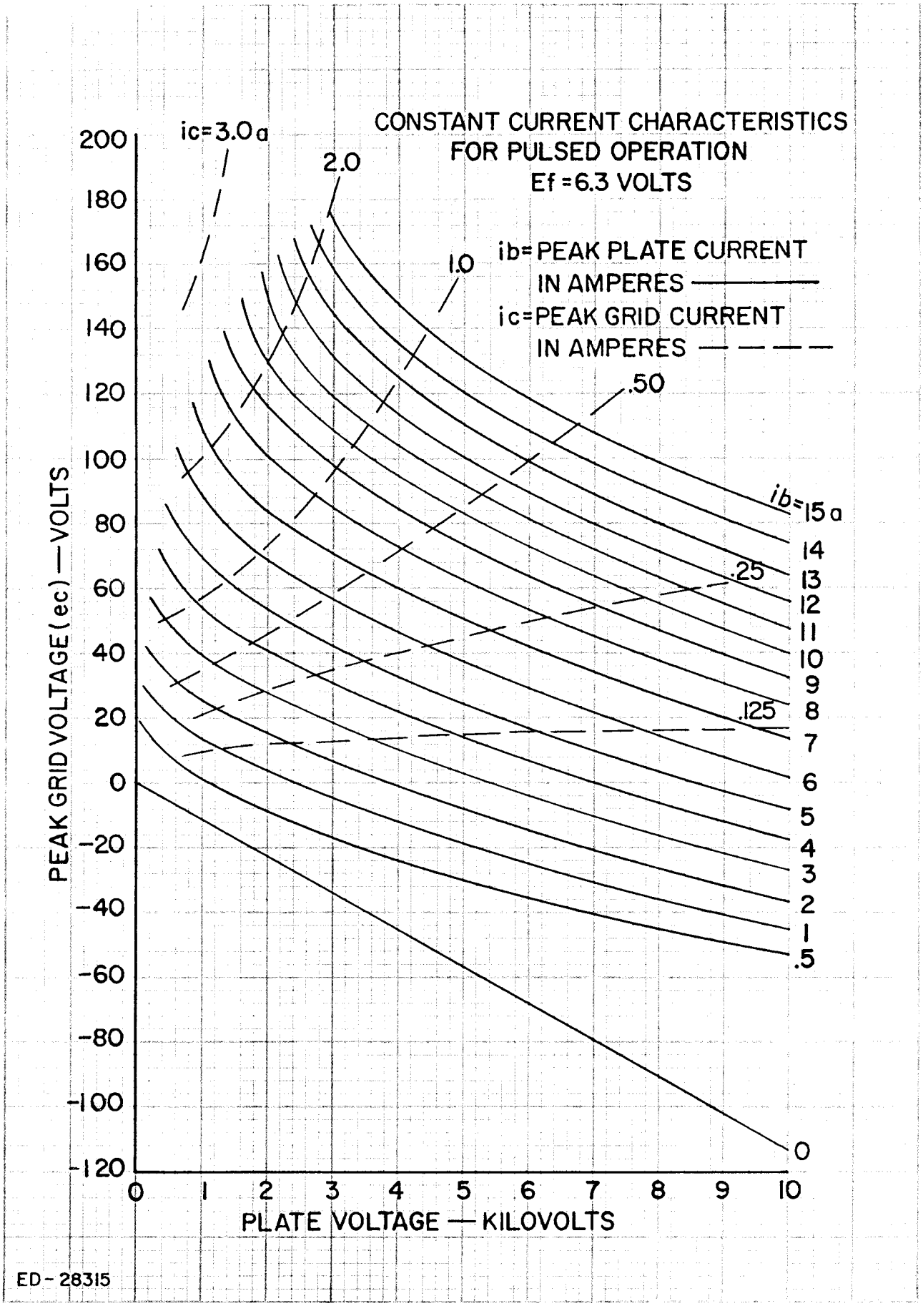
Grid-Pulsed or Plate-Pulsed RF Oscillator and Amplifier — Class C

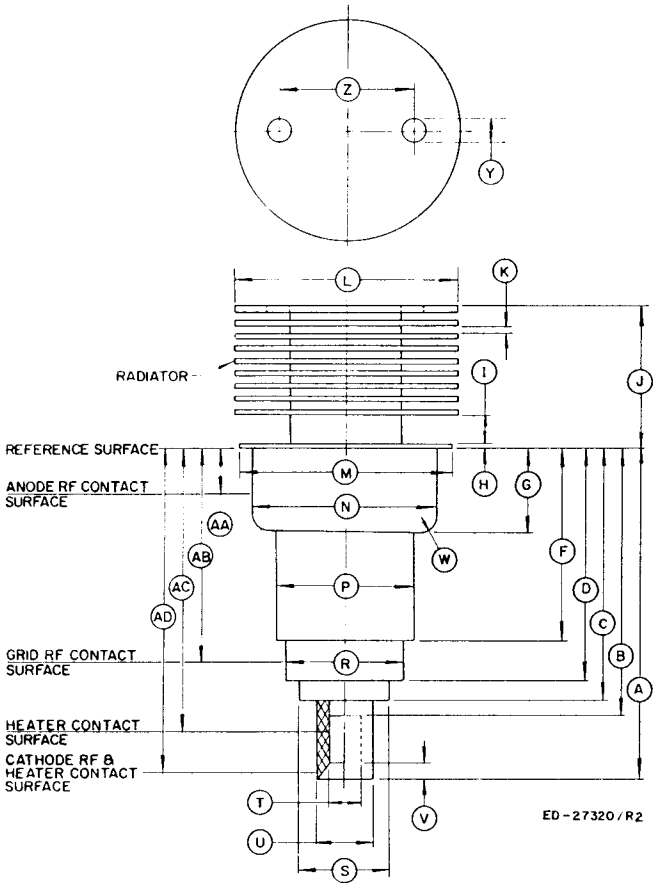
Maximum Ratings, Absolute Values

Frequency	3	Gc
DC Plate Voltage	8	kV*
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
Average Plate Current	16	mA
Average Grid Current	6	mA
Peak Plate Current from DC Supply	5	a
Average Plate Dissipation (Forced-Air Cooling)	100	W
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs†
Duty Factor	0.0033	†

†For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.
*Plate pulsed operation — peak plate voltage — to 10 kv.




CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
ib = PEAK PLATE CURRENT IN AMPERES
ic = PEAK GRID CURRENT IN AMPERES
ic=3.0 a
2.0
1.0
.50
.25
.125
ib=15 a
14
13
12
11
10
9
8
7
6
5
4
3
2
1
.5
0
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
0 1 2 3 4 5 6 7 8 9 10
PEAK GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — KILOVOLTS
ED-28315



DIMENSIONS FOR OUTLINE

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	1.815		1.875	
AA	.035	.198	.361	1, 5
AB	1.185	1.225	1.265	2, 5
AC	1.534	1.631	1.728	3, 5, 6
AD	1.475	1.645	1.815	4, 6
B	—		1.534	
C	—		1.475	
D	1.289		1.329	
F	.970		1.010	
G	.462		.477	
H	—		.040	
I	.125		.185	
J	.766		.826	
K	.025		.046	
L	1.234		1.264	
M	1.180		1.195	
N	1.025		1.035	
P	.752		.792	
R	.655		.665	
S	—		.545	
T	.213		.223	
U	.315		.325	
V	—		.086	
W	—		.100	
Y	.105		.145	
Z	.650		.850	

NOTES

1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

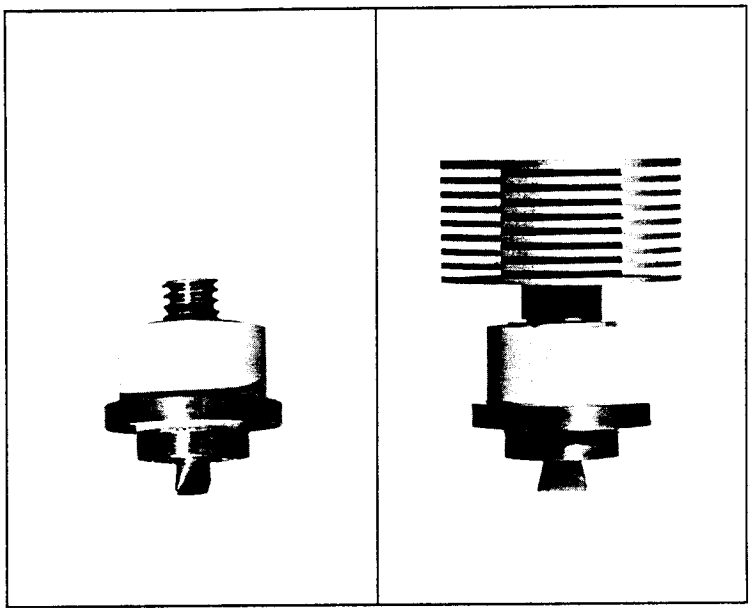
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ISSUED 3-66

ML-8534
ML-8535

MACHLETT

Miniature UHF Planar Triodes

CW, Plate or Grid Pulsed
Frequency Stable
Phormat Cathode
High Cathode-Current Capability
100W CW at 2.3 GHz

DESCRIPTION

The ML-8534 and ML-8535 are ruggedized, high-mu planar triodes of ceramic-and-metal construction, designed for use as grid-pulsed, plate-pulsed or CW oscillators, frequency multipliers, or amplifiers in radio transmitting service from low frequency to 3 GHz. The ML-8534 is supplied without a radiator for conduction-convection or heat-sink cooling. The ML-8535 is supplied with a radiator for forced-air cooling. Except for plate-dissipation ratings, the characteristics of the two tubes are the same.

Distinguishing characteristics of these tubes are their miniaturization and high cathode-current capability. In addition to low interelectrode capacitance, high transconductance and high mu, these tubes also incorporate design features which help to assure frequency-stable operation even under conditions of adverse ambient temperature and varying plate dissipation. The tubes also employ a Phormat type cathode which consists of an indirectly heated disc with an oxide coating impregnated in a nickel matrix. This construction, in combination with proper plate series impedance, reduces to a minimum failures of the cathode due to voltage surges.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage (AC or DC)	6.3	V
Heater Current at 6.3 Volts	1.30	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	80	
Transconductance (Jk=200mA/cm²)	38000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Grid-Plate	2.25	pf
Grid-Cathode	9.5	pf
Plate-Cathode, maximum	.065	pf
Mechanical		
Mounting Position	Optional	
Type of Cooling		
With radiator (ML-8535)	Forced-Air	
Without radiator (ML-8534)	Conduction & Convection	
Maximum Anode Temperature	250	°C
Net Weight		
With radiator (ML-8535)	45	g
Without radiator (ML-8534)	20	g

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CW RF Power Oscillator and Amplifier Class C

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−400	v
Grid positive to cathode	30	v
DC Plate Current	250	mA
DC Grid Current	45	mA
Plate Dissipation		
Forced-air cooling (ML-8535)	150	W
Conduction and convection (ML-8534)	10	W†
Grid Dissipation	1.5	W
Frequency	2.5	GHz
Typical Operation, Power Amplifier		
Frequency	500	MHz
Filament Voltage	6.0	V
DC Plate Voltage	900	V
DC Grid Voltage	−30	V
DC Plate Current	140	mA
DC Grid Current, approximate	40	mA
Driving Power, approximate	9	W
Useful Power Output	65	W
Typical Operation, Power Amplifier		
Frequency	2.3	GHz
Filament Voltage	5.5	V
DC Plate Voltage	1400	V
DC Plate Current	250	mA
Useful Power Output	100	W
Gain	13	db

Grid-Pulsed or Plate-Pulsed RF Oscillator or Amplifier—Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-pulsed, DC	2500	V
Plate-pulsed, peak pulse supply	3500	v
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
Average Plate Current	16	mA
Average Grid Current	6	mA
Pulse Plate Current	5	a
Average Plate Dissipation		
Forced-air cooling (ML-8535)	60	W
Conduction and convection (ML-8534)	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††
Frequency	3	GHz
Typical Operation, Grid-Pulsed RF Amplifier		
Frequency	1.1	GHz
Filament Voltage	6.3	V
Pulse Duration	3.5	μs
Duty Factor	.001	
DC Plate Voltage	2000	V
DC Grid Voltage	−70	V
Peak Plate Current from DC Supply	3.0	a
Peak Grid Current from Pulse Supply	1.0	a
Driving Power During Pulse, approximate	400	W
Useful Peak Power Output, approximate	2.5	kw

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
Peak Plate Voltage	3500	v
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	110	v
DC Plate Current	150	mA
Pulse Cathode Current	7.5	a
Average Plate Dissipation		
Forced-air cooling (ML-8535)	150	W
Conduction and convection (ML-8534)	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††

†Greater plate dissipation will be possible with the ML-8534 when the tube is used with an appropriately designed heat sink.

††For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.	
Filament Current at 6.3 V (Note 1)	1.20	1.40	A
Cut-Off Bias (Note 2)	—	−30	Vdc
Grid-Plate Capacitance (Note 3)	2.10	2.40	pf
Grid-Cathode Capacitance (Note 3)	8.50	10.50	pf
Plate-Cathode Capacitance (Note 3)	—	.065	pf

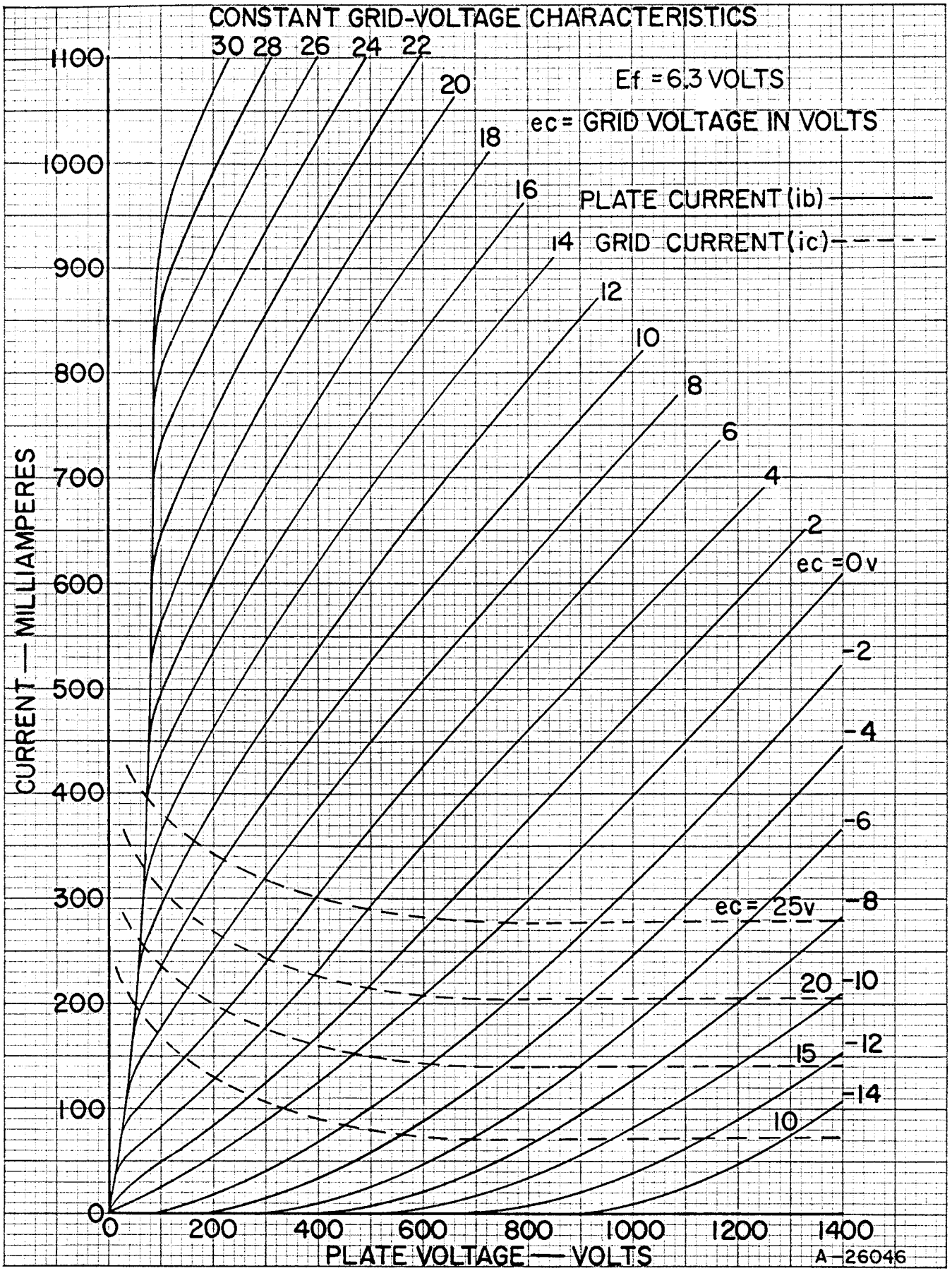
Note 1 — For reduced filament voltage see "Heater Voltage" section in *Application Notes*.

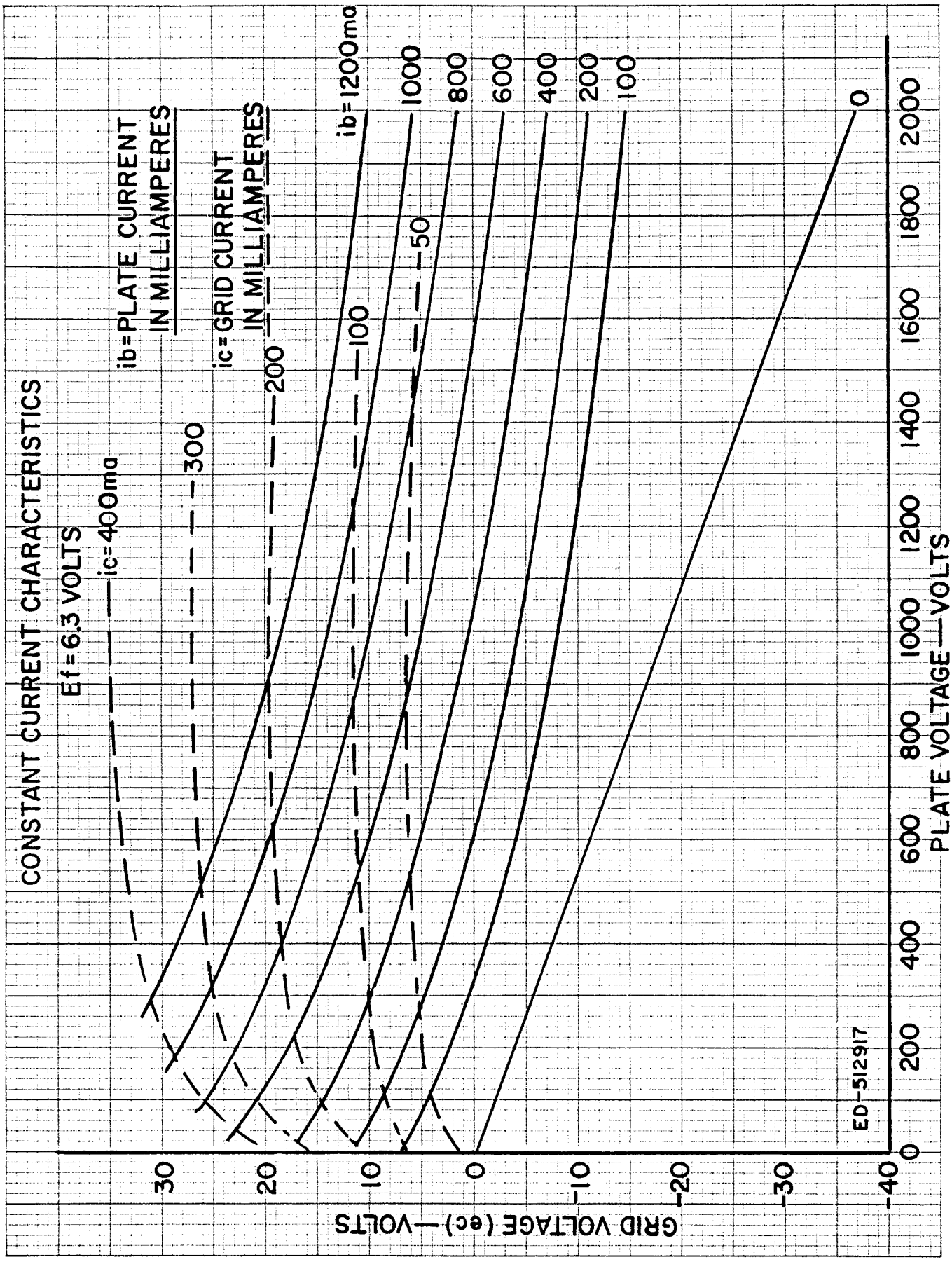
Note 2 — Measured with 1 mA plate current and a plate voltage of 1000 Vdc.

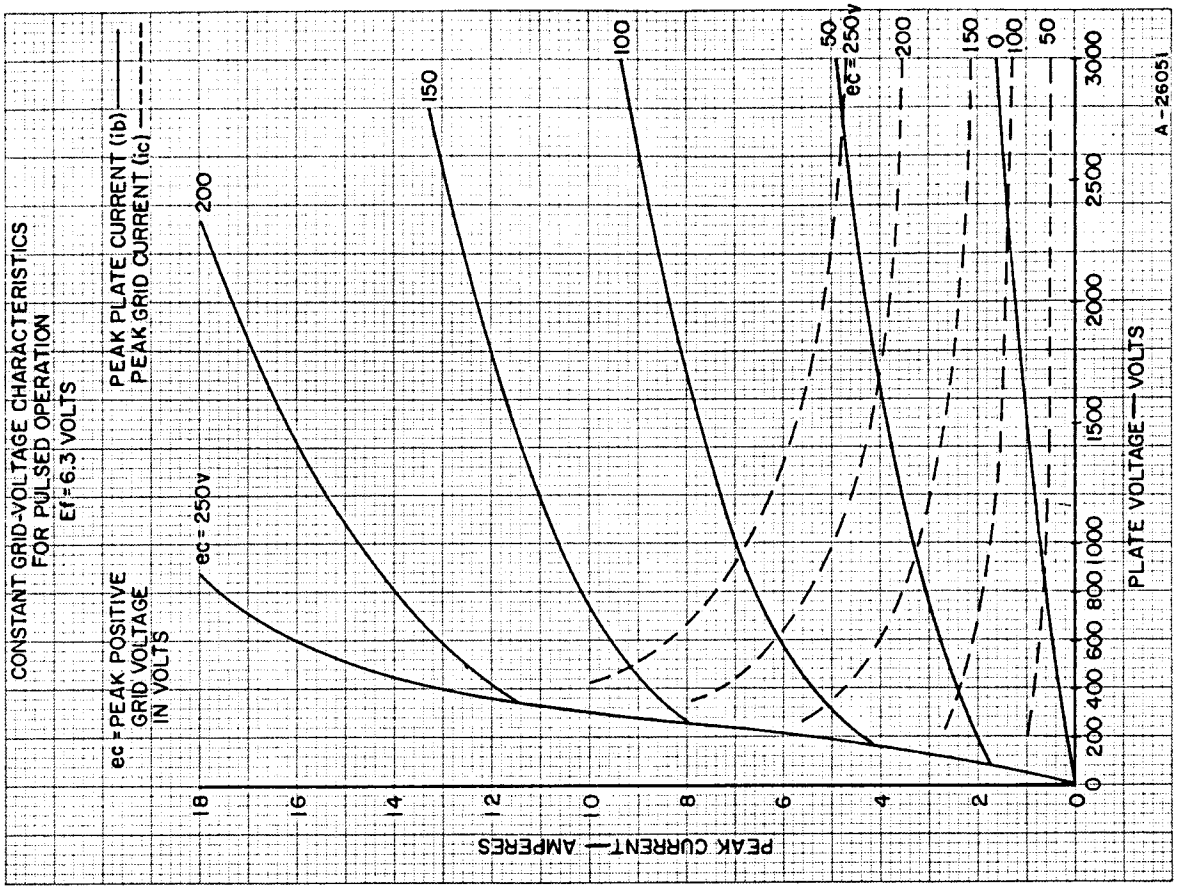
Note 3 — Capacitance values are given for a cold tube. When the filament is heated to its proper temperature, the grid-cathode capacitance will increase by approximately 1 pf due to thermal expansion of the cathode.

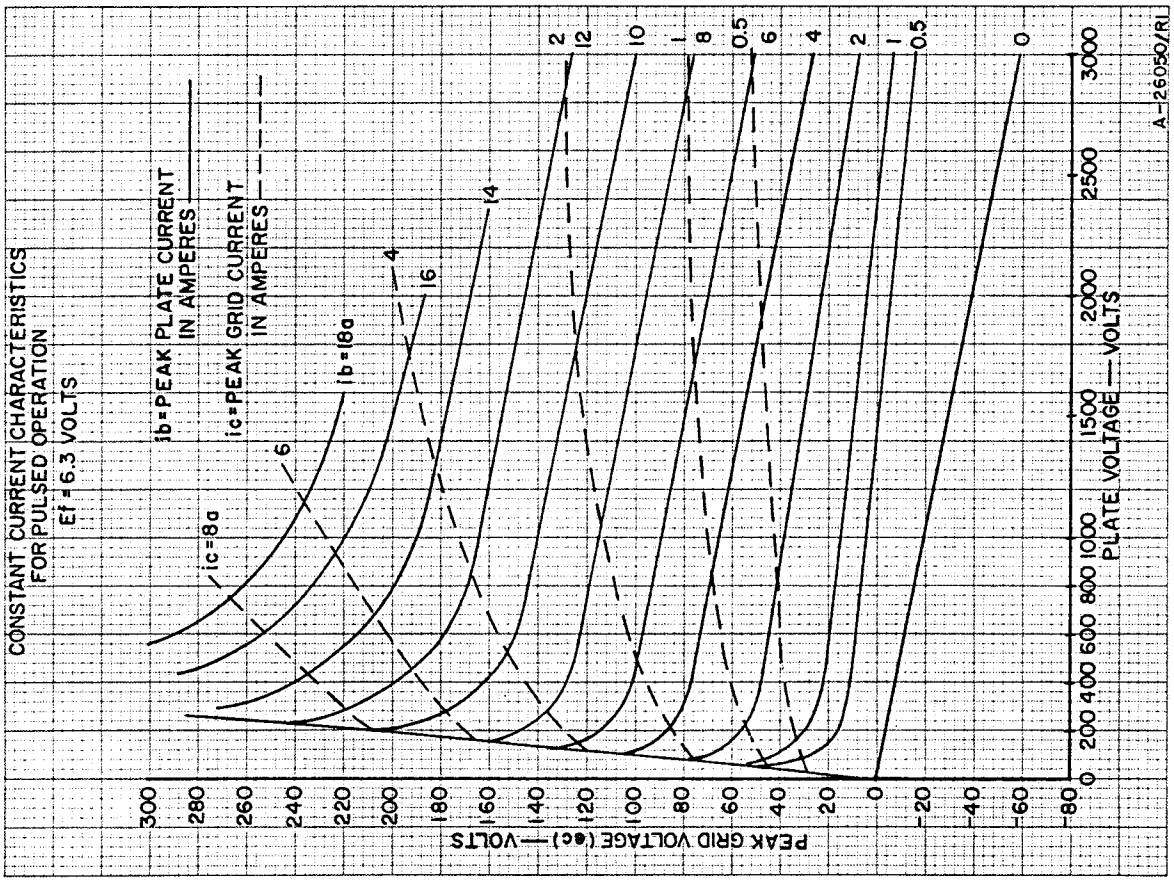
APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes —General.*


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 6.3 VOLTS
ec = GRID VOLTAGE IN VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 ec = 0v -2 -4 -6 -8 -10 -12 -14
ec = 25v
20
15
10
CURRENT — MILLIAMPERES
0 100 200 300 400 500 600 700 800 900 1000 1100
0 200 400 600 800 1000 1200 1400
PLATE VOLTAGE — VOLTS
A-26046


CONSTANT CURRENT CHARACTERISTICS
Ef=6.3 VOLTS
ic=400ma
ib=PLATE CURRENT IN MILLIAMPERES
ic=GRID CURRENT IN MILLIAMPERES
ib=1200ma
1000
800
600
400
200
100
50
100
200
300
0
GRID VOLTAGE (ec)—VOLTS
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PLATE VOLTAGE—VOLTS
ED-512917

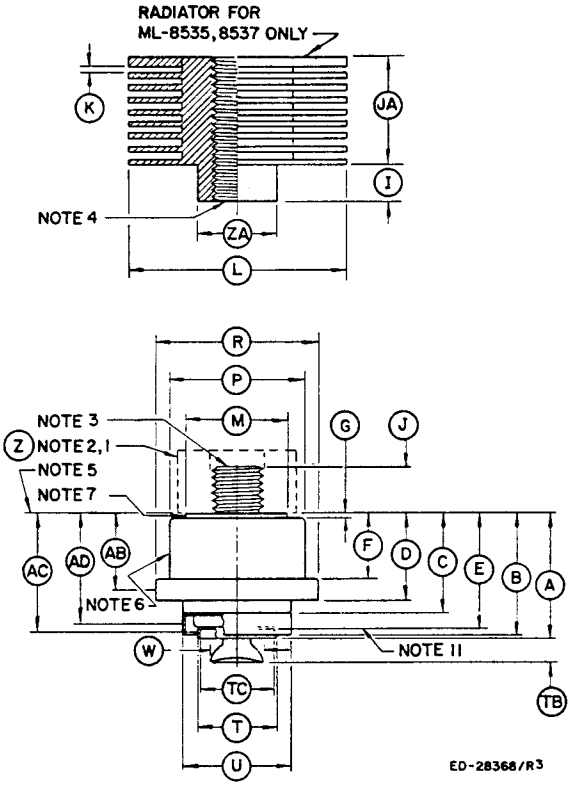

CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
PEAK PLATE CURRENT (ib) ———
PEAK GRID CURRENT (ic) - - - - -
ec = PEAK POSITIVE GRID VOLTAGE IN VOLTS
ec = 250v
200
150
100
50
ec = 250v
200
150
100
50
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
A-26051


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
ib = PEAK PLATE CURRENT IN AMPERES ———
ic = PEAK GRID CURRENT IN AMPERES - - - - -
ic = 8a
ib = 18a
6
4
16
14
2
12
10
1
8
0.5
6
4
2
1
0.5
0
PEAK GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — VOLTS
A-26050/R1

DIMENSIONS FOR OUTLINE OF ML-8534, ML-8535, ML-8536, ML-8537

The millimeter dimensions are derived from the original inch dimensions.

Ref	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	.714		.780	18.14		19.81	
AB	.437	.476	.515	11.10	12.09	13.08	1, 8
AC	.662	.682	.702	16.81	17.32	17.83	1, 10
AD	.605	.645	.685	15.37	16.38	17.40	1, 9
B	.691		.740	17.55		18.80	
C	.570		.607	14.48		15.42	
D	.520		.547	13.21		13.89	
E	.650		.705	16.51		17.91	
F	.400		.415	10.16		10.54	
G	.022		.040	.56		1.02	
I	.192		.208	4.88		5.28	
J	.240		.275	6.10		6.98	
JA	.585		.635	14.86		16.13	
K	.028		.045	.71		1.14	
L	1.235		1.265	31.37		32.13	
M	.565		.580	14.35		14.73	
P	.775		.785	19.68		19.94	
R	.935		.950	23.75		24.13	1, 8
T	.440		.460	11.18		11.68	1, 10
TB			.250			6.35	
TC	.410		.425	10.41		10.80	
U	.595		.607	15.11		15.42	1, 9
W			.313			7.95	
Z			.015			.38	1
ZA	.440		.460	11.18		11.68	



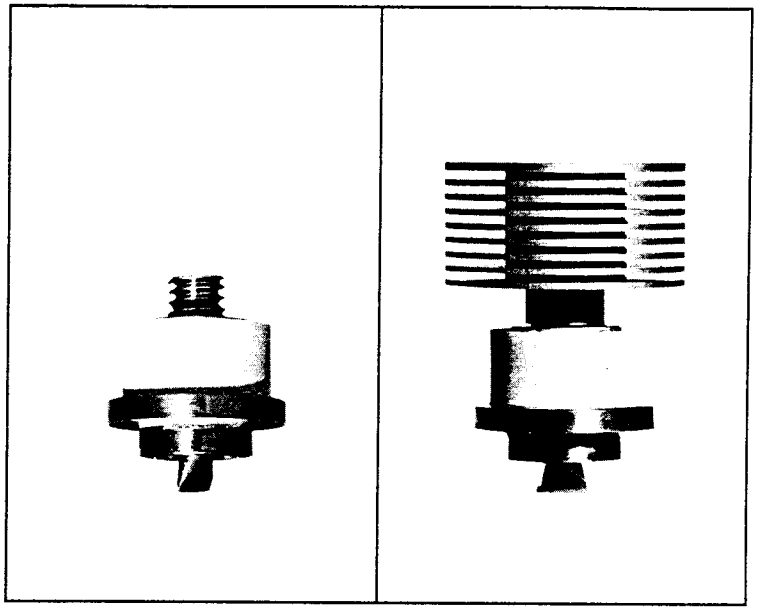
NOTES:

1. The total indicated runout of the grid-contact surface (Note 8), the cathode-contact surface (Note 9) and the heater-contact surface (Note 10) will not exceed (Z). This measurement is made with the gage (Note 2) screwed on the anode thread (Note 3) so that the face of the gage makes full contact with the reference surface (Note 5). Runout is then measured with the gage chucked on the measurement reference axis.
2. See outline. Machlett gage No. S-L5. Details will be supplied upon request.
3. See outline. Anode, 5/16 — 24 UNF-2A thread.
4. See outline. 5/16 — 24 UNF-2B thread. Use 5/16-24 bolt in this hole for tube extraction.
5. See outline. Reference surface. The tube shall be stopped only by this surface when screwed in the socket.
6. See outline. Insulating envelope. Do not clamp or locate on this surface.
7. See outline. Measure anode temperature on this surface.
8. Grid-contact surface and reference dimension for eccentricity measurement, defined by dimensions (R) and (AB).
9. Cathode- or heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (U) and (AD).
10. Heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (T) and (AC). See also Note 11.
11. See outline. Alternate heater-contact surface. Heater contact can be made to the bottom of the heater terminal-cup by means of a coil spring having a maximum coil OD of .390 inch and a minimum coil ID of .320 inch, or some similar device.

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ISSUED 3-70

ML-8536
ML-8537

MACHLETT

Miniature UHF Planar Triodes

CW, Plate or Grid Pulsed
Frequency Stable
Phormat Cathode
40W CW at 2.3 GHz

DESCRIPTION

The ML-8536 and ML-8537 are ruggedized, high-mu planar triodes of ceramic-and-metal construction, designed for use as grid-pulsed, plate-pulsed, or CW oscillators, frequency multipliers, or amplifiers in radio transmitting service from low frequency to 3 GHz. The ML-8536 is supplied without a radiator for conduction-convection or heat-sink cooling. The ML-8537 is supplied with a radiator for forced-air cooling. Except for plate dissipation ratings, the characteristics of the two tubes are the same.

A distinguishing characteristic of these tubes is their miniaturization. In addition to low interelectrode capacitance, high transconductance and high mu, these tubes also incorporate design features which help to assure frequency-stable operation even under conditions of adverse ambient temperature and varying plate dissipation. The tubes also employ a Phormat type cathode which consists of an indirectly heated disc with an oxide coating impregnated in a nickel matrix. This construction, in combination with proper plate series impedance, reduces to a minimum failures of the cathode due to voltage surges.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage (AC or DC)	6.0	V
Heater Current at 6.0 Volts	1.00	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	80	
Transconductance ($Jk=200mA/cm^2$)	30000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Grid-Plate	1.65	pf
Grid-Cathode	7.50	pf
Plate-Cathode, maximum	.040	pf

Mechanical

Mounting Position	Optional	
Type of Cooling		
With radiator (ML-8537)	Forced-air	
Without radiator (ML-8536)	Conduction and convection	
Maximum Anode Temperature	250	°C
Net Weight		
With radiator (ML-8537)	45	g
Without radiator (ML-8536)	20	g

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CW RF Power Oscillator and Amplifier Class C

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—400	v
Grid positive to cathode	30	v
DC Plate Current	150	mA
DC Grid Current	45	mA
Plate Dissipation		
Forced-air cooling (ML-8537)	150	W
Conduction and convection (ML-8536)	10	W†
Grid Dissipation	1.5	W
Frequency	2.5	GHz
Typical Operation, Power Amplifier		
Frequency	500	MHz
Filament Voltage	6.0	V
DC Plate Voltage	900	V
DC Grid Voltage	—40	V
DC Plate Current	90	mA
DC Grid Current, approximate	30	mA
Driving Power, approximate	6	W
Useful Power Output	40	W
Typical Operation, Power Amplifier		
Frequency	2.3	GHz
Filament Voltage	5.0	V
DC Plate Voltage	1000	V
DC Plate Current	150	mA
Useful Power Output	40	W
Gain	15	db

Grid-Pulsed or Plate-Pulsed RF Oscillator or Amplifier—Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-pulsed, DC	2500	V
Plate-pulsed, peak pulse supply	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
Average Plate Current	10	mA
Average Grid Current	5	mA
Pulse Plate Current	3	a
Average Plate Dissipation		
Forced-air cooling (ML-8537)	35	W
Conduction and convection (ML-8536)	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††
Frequency	3	GHz
Typical Operation, Plate-Pulsed RF Amplifier		
Frequency	2.5	GHz
Filament Voltage	5.8	V
Pulse Duration	5	μs
Duty Factor	.0030	
Peak Plate Pulse Supply Voltage	3500	v
Peak Plate Current from Pulse Supply	3.0	a
Average Plate Current	9.0	mA
Average Grid Current	3.0	mA
Useful Peak Power Output, approximate	2.0	kw
Typical Operation, Grid-Pulsed RF Amplifier		
Frequency	1.1	GHz
Filament Voltage	6.0	V
Pulse Duration	3.5	μs
Duty Factor	.001	
DC Grid Voltage	1700	V
DC Plate Voltage	—45	V
Peak Plate Current from DC Supply	1.9	a
Peak Grid Current from Pulse Supply	1.1	a
Driving Power During Pulse, approximate	400	W
Useful Peak Power Output, approximate	2	kw

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
Peak Plate Voltage	3500	v
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	100	v
DC Plate Current	100	mA
Pulse Cathode Current	5	a
Average Plate Dissipation		
Forced-air cooling (ML-8537)	150	W
Conduction and convection (ML-8536)	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††

†Greater plate dissipation will be possible with the ML-8536 when the tube is used with an appropriately designed heat sink.

††For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.	
Filament Current at 6.0V (Note 1)	.90	1.05	A
Cut-Off Bias (Note 2)	—	—25	Vdc
Grid-Plate Capacitance (Note 3)	1.50	1.80	pf
Grid-Cathode Capacitance (Note 3)	6.75	8.25	pf
Plate-Cathode Capacitance (Note 3)	—	.040	pf

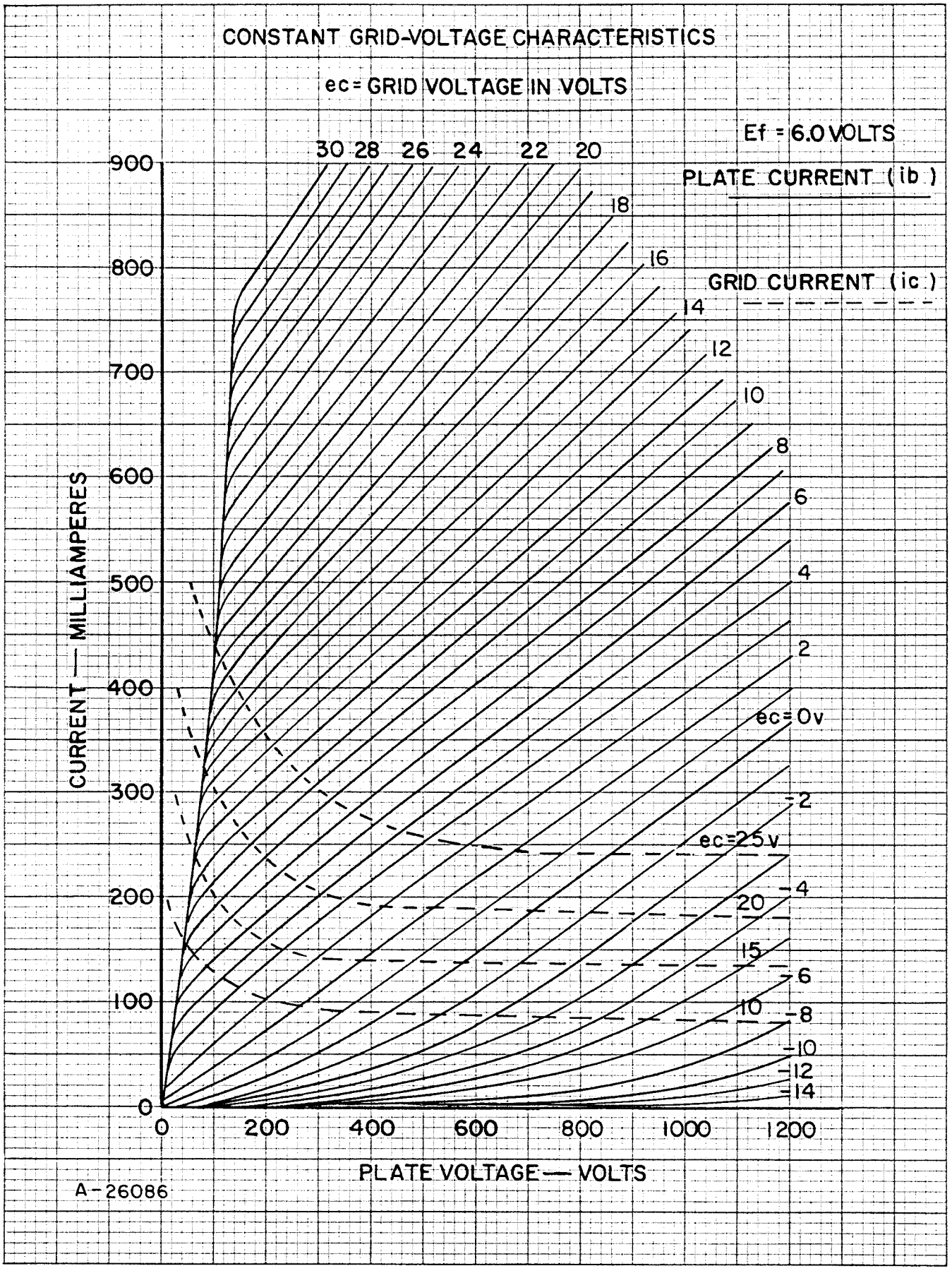
Note 1 — For reduced filament voltage see "Heater Voltage" section in *Application Notes.*

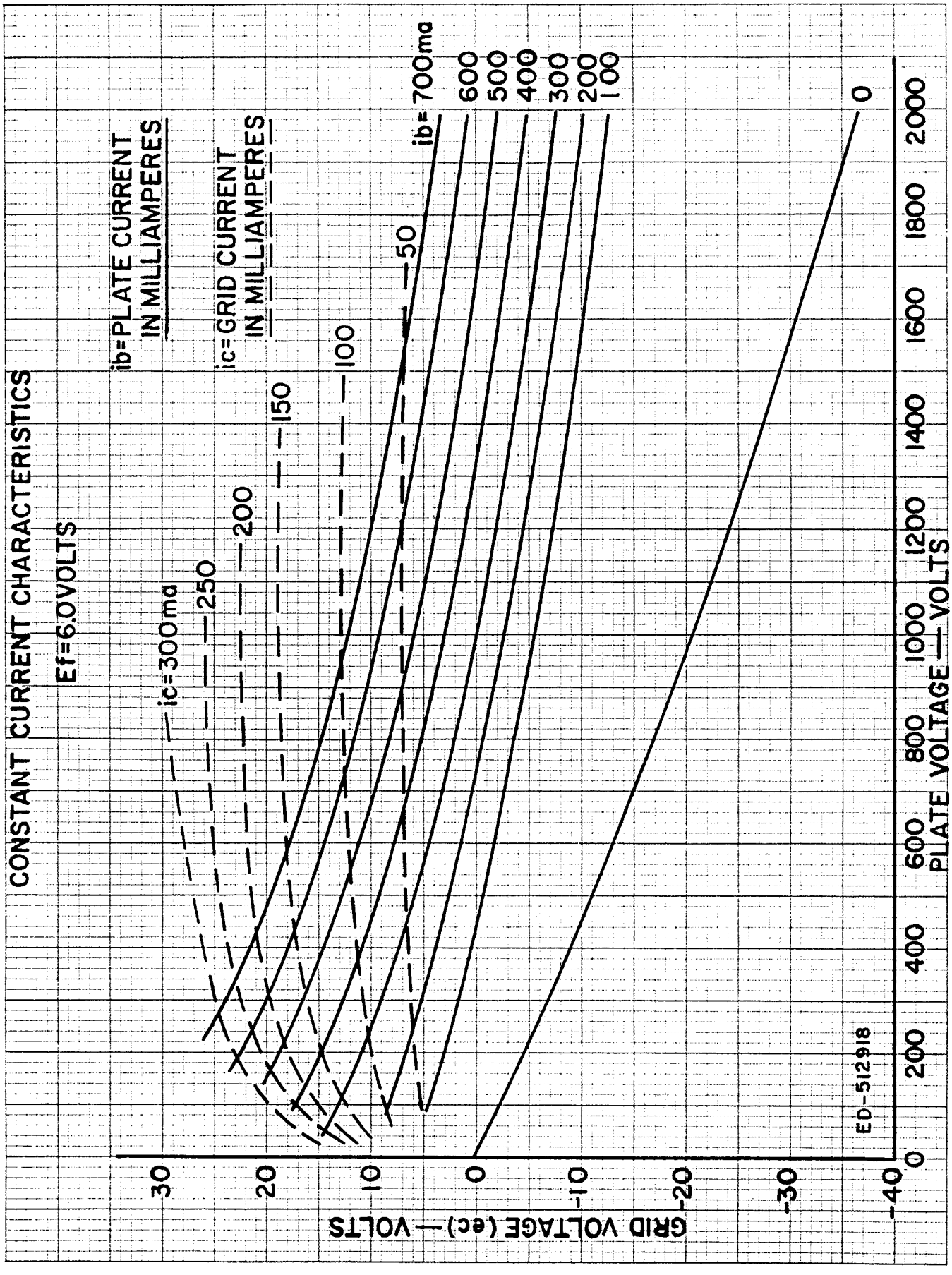
Note 2 — Measured with 1 mA plate current and a plate voltage of 1000 Vdc.

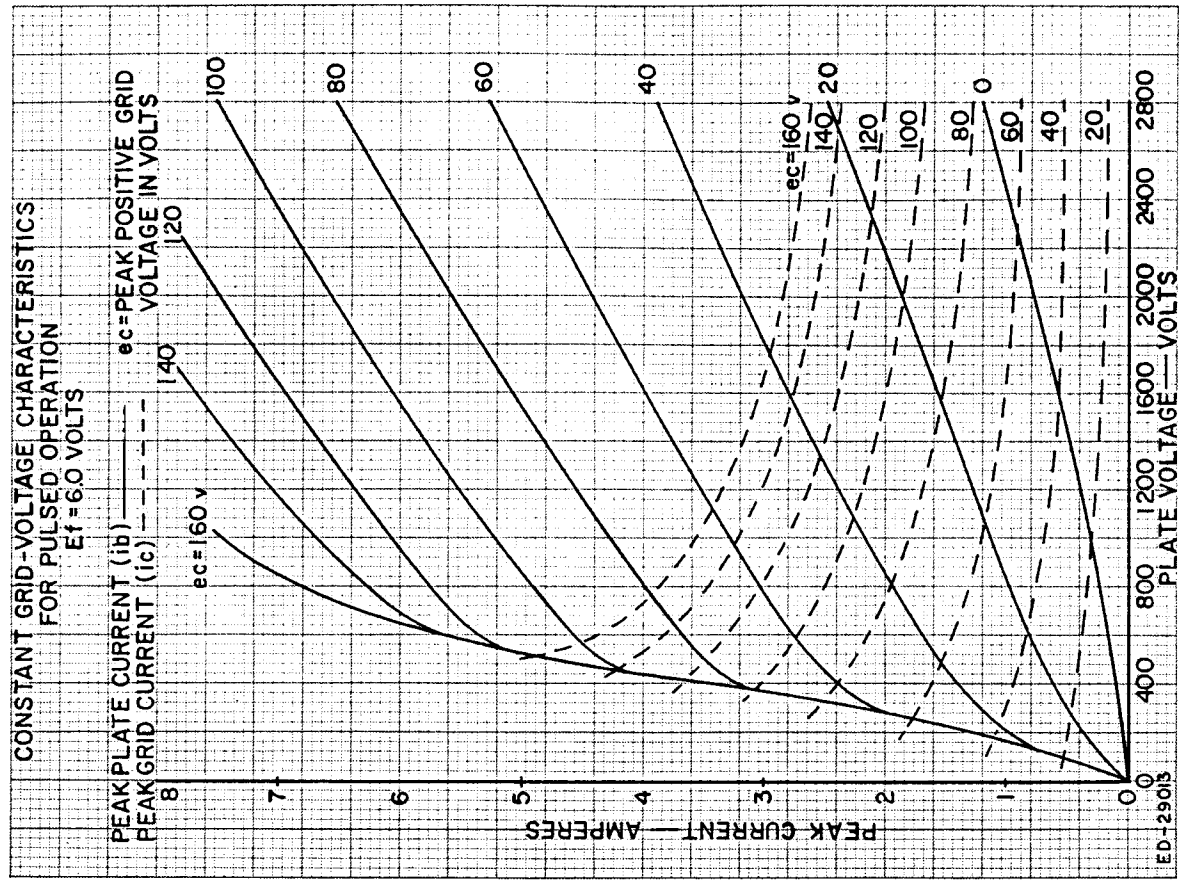
Note 3 — Capacitance values are given for a cold tube. When the filament is heated to its proper temperature, the grid-cathode capacitance will increase by approximately 1 pf due to thermal expansion of the cathode.

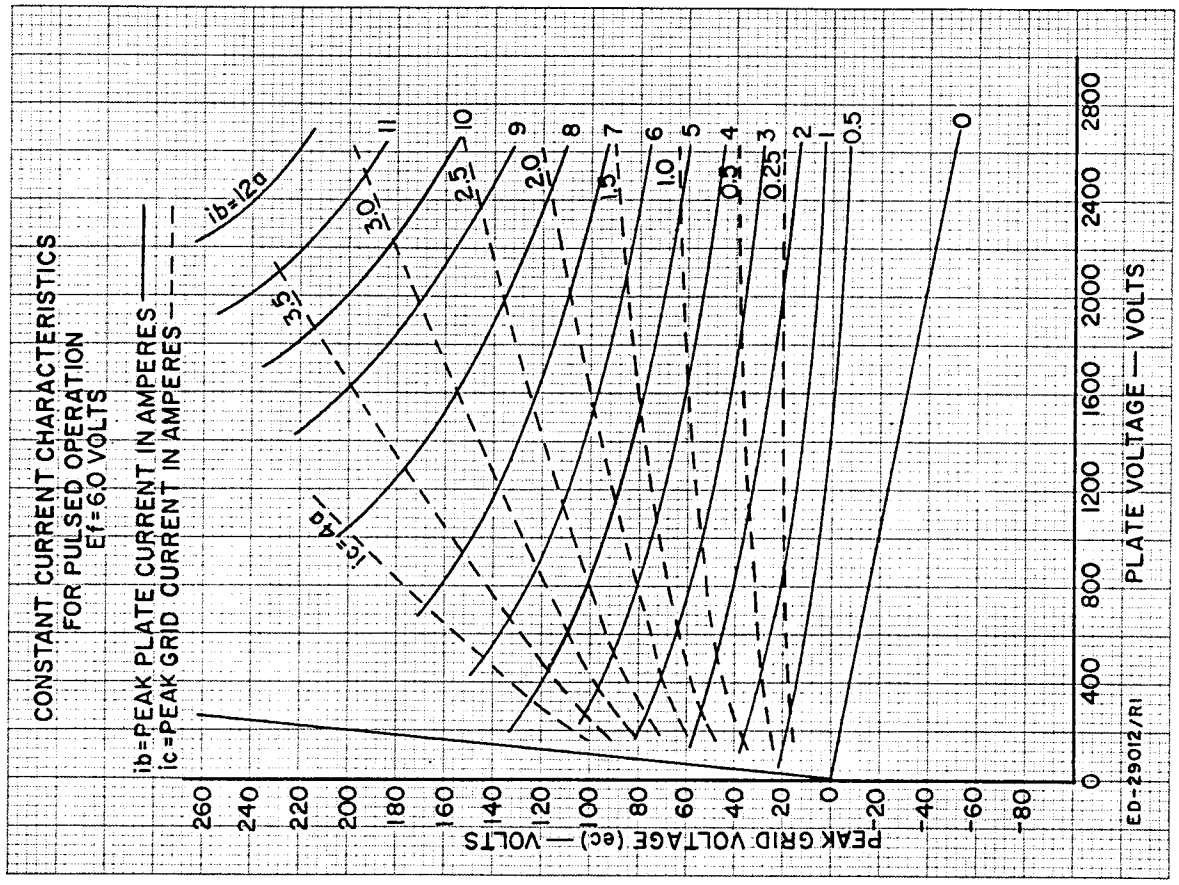
APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes —General.*


CONSTANT GRID-VOLTAGE CHARACTERISTICS
ec = GRID VOLTAGE IN VOLTS
Ef = 6.0 VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
30 28 26 24 22 20
18
16
14
12
10
8
6
4
2
ec = 0v
-2
ec = 2.5v
-4
20
15
-6
10
-8
-10
-12
-14
CURRENT — MILLIAMPERES
900
800
700
600
500
400
300
200
100
0
0
200
400
600
800
1000
1200
PLATE VOLTAGE — VOLTS
A-26086


CONSTANT CURRENT CHARACTERISTICS
Ef=6.0VOLTS
ib=PLATE CURRENT IN MILLIAMPERES
ic=GRID CURRENT IN MILLIAMPERES
ic=300ma
250
200
150
100
50
ib=700ma
600
500
400
300
200
100
0
GRID VOLTAGE (ec) — VOLTS
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PLATE VOLTAGE — VOLTS
ED-512918

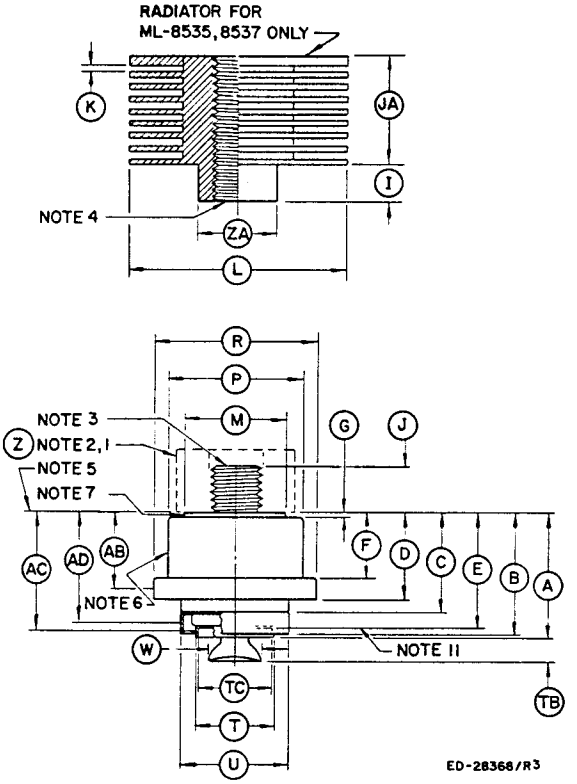

CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS
PEAK PLATE CURRENT (ib) ———
PEAK GRID CURRENT (ic) - - - - -
ec = PEAK POSITIVE GRID VOLTAGE IN VOLTS
ec = 160 v
140
120
100
80
60
40
20
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
ED-29013


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS
ib = PEAK PLATE CURRENT IN AMPERES ———
ic = PEAK GRID CURRENT IN AMPERES - - - - -
ib = 12a
11
10
9
8
7
6
5
4
3
2
1
0.5
0
PEAK GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — VOLTS
ED-29012/R1

DIMENSIONS FOR OUTLINE OF ML-8534, ML-8535, ML-8536, ML-8537

The millimeter dimensions are derived from the original inch dimensions.

Ref	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	.714		.780	18.14		19.81	
AB	.437	.476	.515	11.10	12.09	13.08	1, 8
AC	.662	.682	.702	16.81	17.32	17.83	1, 10
AD	.605	.645	.685	15.37	16.38	17.40	1, 9
B	.691		.740	17.55		18.80	
C	.570		.607	14.48		15.42	
D	.520		.547	13.21		13.89	
E	.650		.705	16.51		17.91	
F	.400		.415	10.16		10.54	
G	.022		.040	.56		1.02	
I	.192		.208	4.88		5.28	
J	.240		.275	6.10		6.98	
JA	.585		.635	14.86		16.13	
K	.028		.045	.71		1.14	
L	1.235		1.265	31.37		32.13	
M	.565		.580	14.35		14.73	
P	.775		.785	19.68		19.94	
R	.935		.950	23.75		24.13	1, 8
T	.440		.460	11.18		11.68	1, 10
TB			.250			6.35	
TC	.410		.425	10.41		10.80	
U	.595		.607	15.11		15.42	1, 9
W			.313			7.95	
Z			.015			.38	1
ZA	.440		.460	11.18		11.68	



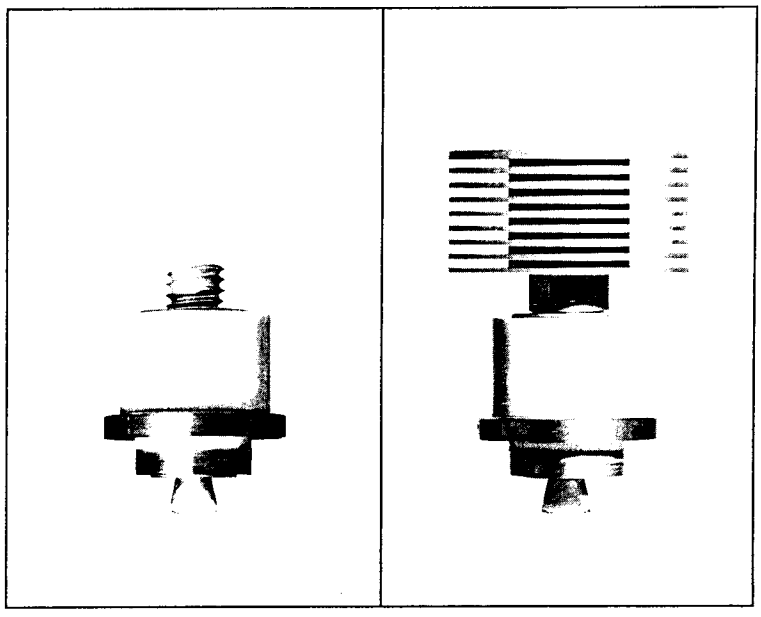
NOTES:

1. The total indicated runout of the grid-contact surface (Note 8), the cathode-contact surface (Note 9) and the heater-contact surface (Note 10) will not exceed (Z). This measurement is made with the gage (Note 2) screwed on the anode thread (Note 3) so that the face of the gage makes full contact with the reference surface (Note 5). Runout is then measured with the gage chucked on the measurement reference axis.
2. See outline. Machlett gage No. S-L5. Details will be supplied upon request.
3. See outline. Anode, $\frac{5}{16}$ — 24 UNF-2A thread.
4. See outline. $\frac{5}{16}$ — 24 UNF-2B thread. Use $\frac{5}{16}$-24 bolt in this hole for tube extraction.
5. See outline. Reference surface. The tube shall be stopped only by this surface when screwed in the socket.
6. See outline. Insulating envelope. Do not clamp or locate on this surface.
7. See outline. Measure anode temperature on this surface.
8. Grid-contact surface and reference dimension for eccentricity measurement, defined by dimensions (R) and (AB).
9. Cathode- or heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (U) and (AD).
10. Heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (T) and (AC). See also Note 11.
11. See outline. Alternate heater-contact surface. Heater contact can be made to the bottom of the heater terminal-cup by means of a coil spring having a maximum coil OD of .390 inch and a minimum coil ID of .320 inch, or some similar device.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.
ST-2041 5M 3-70

Tubes Shown Actual Size



ISSUED 5-64

ML-8538
ML-8539

Miniature
UHF Planar Triodes
35 kw Pulse Power
5 kw RF Pulse Power
Phormat Cathode

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8538 and ML-8539 are miniaturized high-mu planar triodes with high cathode-current capability for use as grid-pulsed or plate-pulsed oscillators, power amplifiers, frequency multipliers, or as switch tubes at high plate voltages. The tubes will deliver useful output at frequencies as high as 3 Gc. The ML-8538 is supplied without a radiator for conduction-convection or heat-sink cooling. The ML-8539 is supplied with a radiator for forced-air cooling. Except for plate-dissipation ratings, the characteristics of the two tubes are the same.

Noteworthy differences in these tubes as compared to similar tube types are an extended grid-cathode insulator and a special cathode design, permitting operation with up to 8000 Vdc plate voltage. Other features include low interelectrode capacitance, high transconductance, great mechanical strength and capability for sustained, reliable operation at elevated temperatures.

Compact metal-and-ceramic coaxial construction makes the tubes well suited for operation in line-type circuits at lower frequencies as well as in cavity resonators at the higher frequencies. The cathode of each type is an indirectly heated disc with an oxide coating impregnated in a nickel matrix. The unique matrix construction (in combination with proper plate series impedance) reduces to a minimum failures of the cathode due to voltage surges thereby further increasing the reliability of these tubes.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage (AC or DC)	6.3 ±5%	V
Heater Current at 6.3 volts	1.3	A
Heater Heating Time, minimum	60	sec
Amplification Factor, Cutoff	90	
Amplification Factor, Dynamic	145	
Transconductance	30000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Grid-Plate	1.6	pf
Grid-Cathode	8.0	pf
Plate-Cathode, maximum	.06	pf

Mechanical

Mounting Position	Optional	
Type of Cooling		
With radiator (ML-8539)	Forced-air	
Without radiator (ML-8538)	Conduction & Convection	
Maximum Anode Temperature	250	°C
Net Weight		
Without radiator (ML-8538)	.7	oz
With radiator (ML-8539)	1.6	oz

MAXIMUM RATINGS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

DC Plate Voltage	8	kV
Peak Plate Voltage	10	kv
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
DC Plate Current	150	mA
Peak Plate Current from Pulse Supply	5	a
Average Plate Dissipation		
Forced-air cooling (ML-8539)	100	W
Conduction & convection (ML-8538)	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††

†Dissipation of 100 W or more might be possible with the ML-8538 when the tube is used with an appropriately designed heat sink.

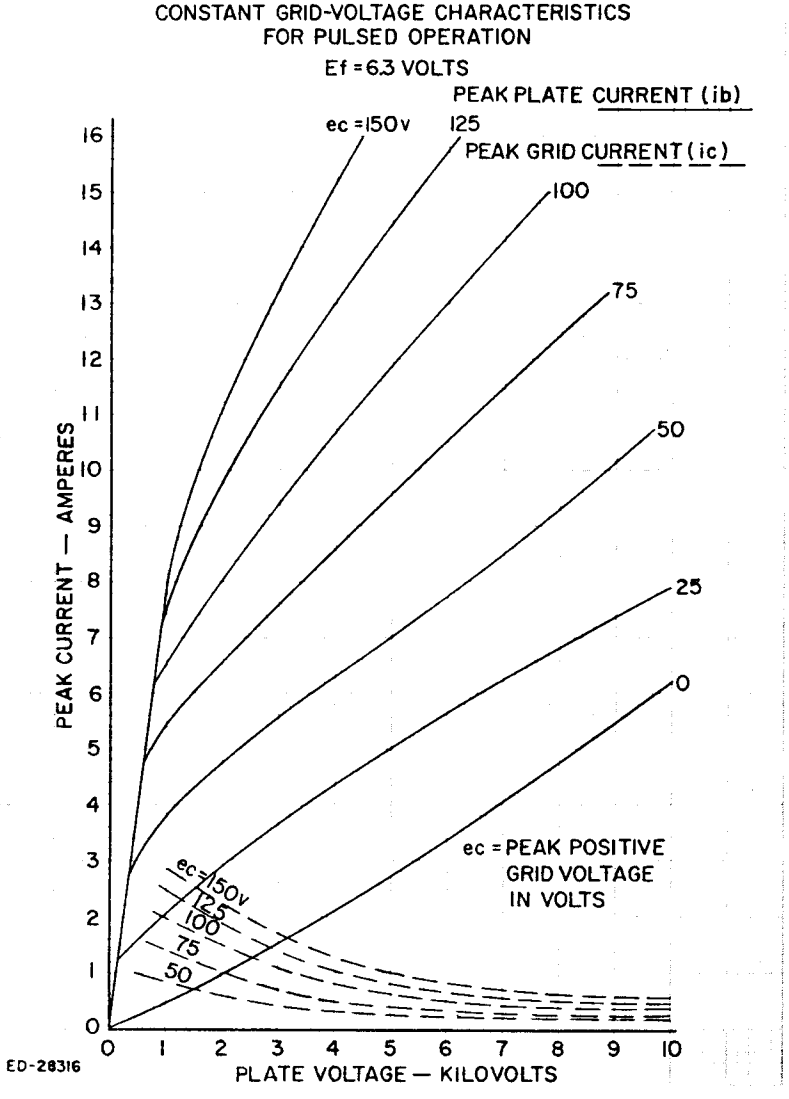
Grid-Pulsed or Plate-Pulsed RF Oscillator and Amplifier — Class C

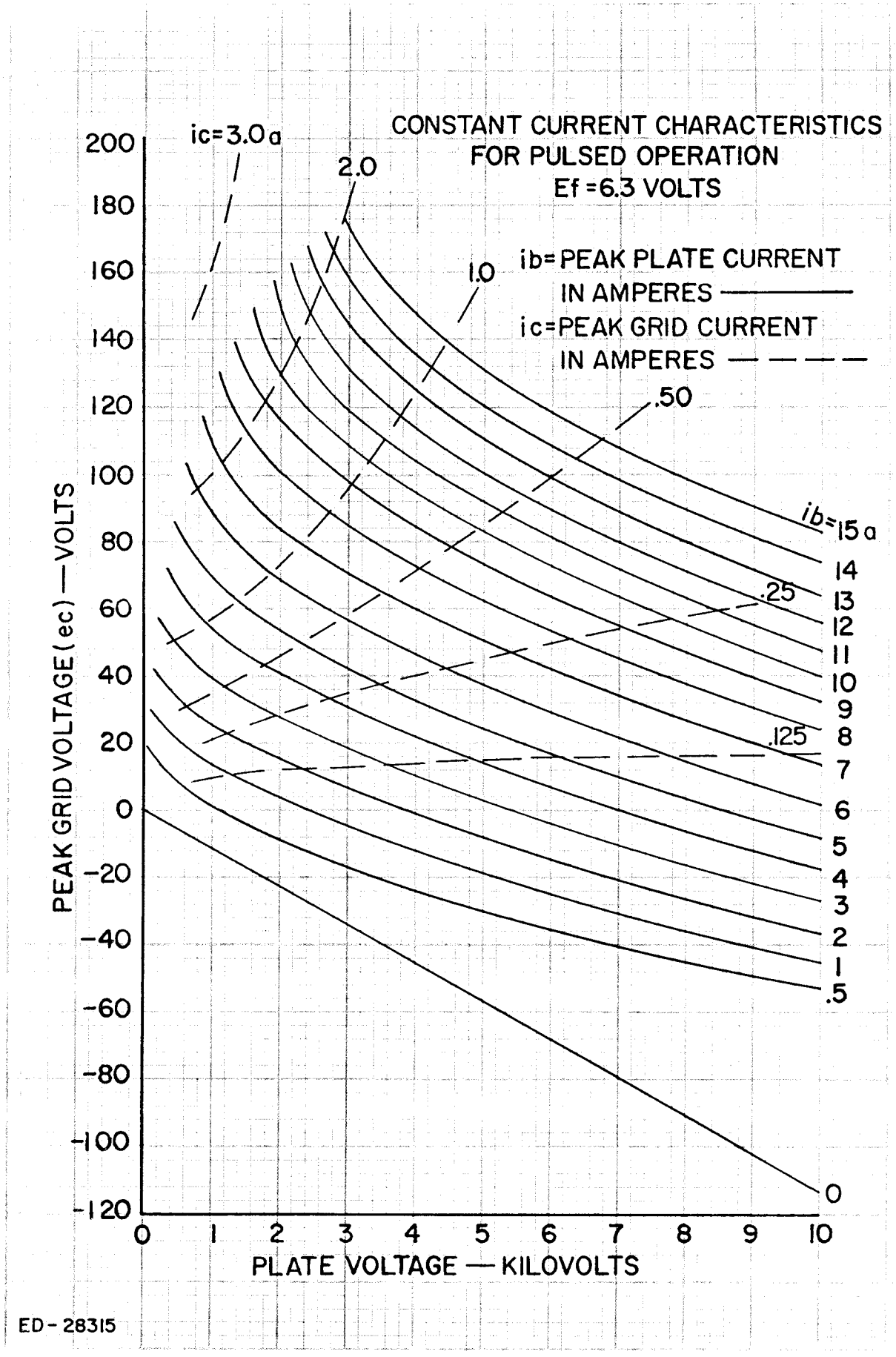
Maximum Ratings, Absolute Values

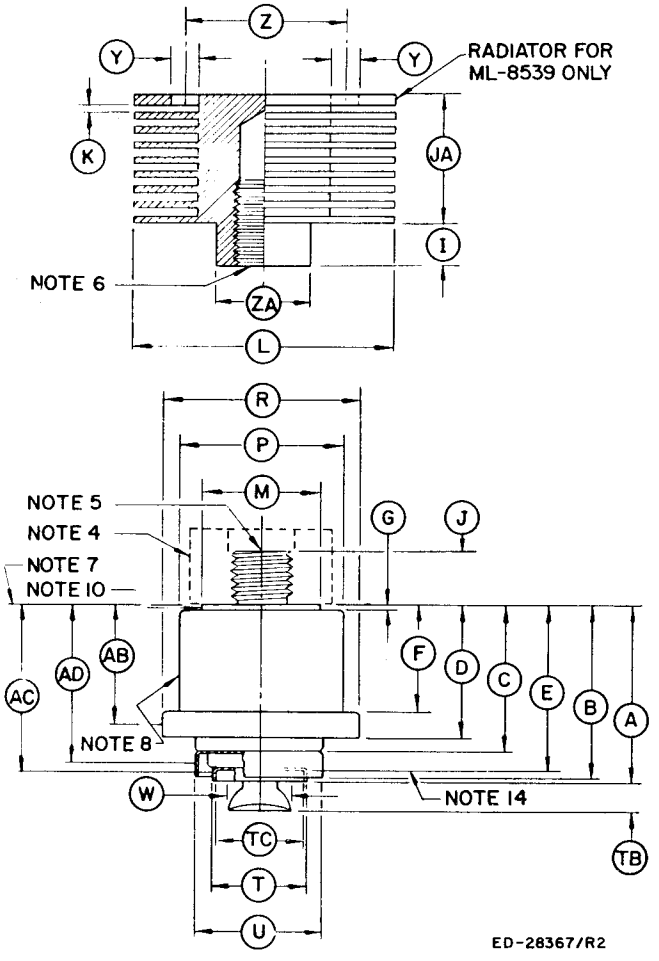
Frequency	3	Gc
DC Plate Voltage	8	kV*
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
Average Plate Current	16	mA
Average Grid Current	6	mA
Peak Plate Current from DC Supply	5	a
Average Plate Dissipation		
Forced-air cooling (ML-8539)	100	W
Conduction & convection (ML-8538)	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††

* Plate pulsed operation — peak plate voltage — to 10 kv.

††For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.




CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
ib = PEAK PLATE CURRENT IN AMPERES
ic = PEAK GRID CURRENT IN AMPERES
ic=3.0a
2.0
1.0
.50
.25
.125
ib=15a
14
13
12
11
10
9
8
7
6
5
4
3
2
1
.5
0
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
PEAK GRID VOLTAGE (ec) — VOLTS
0 1 2 3 4 5 6 7 8 9 10
PLATE VOLTAGE — KILOVOLTS
ED-28315



DIMENSIONS FOR OUTLINE

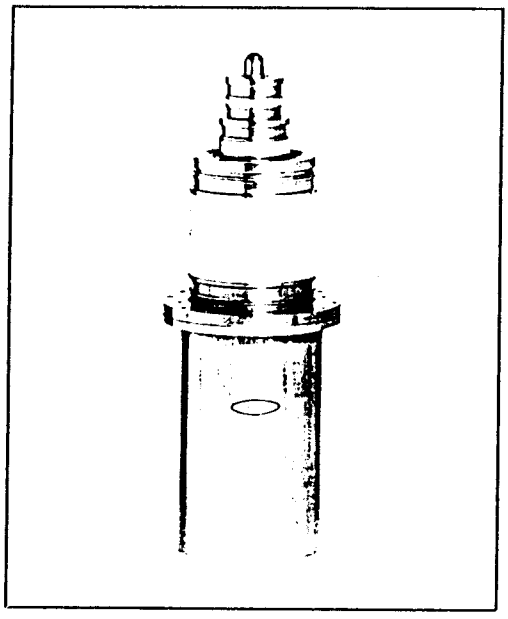
Ref.	Inches*			Notes
	Minimum	Nominal	Maximum	
A		.842		
AB	.538	.578	.618	1, 2, 11
AC	.782	.802	.822	3, 13
AD	.727	.767	.807	2, 3, 12
B		.832		
C		.702		
D		.642		
E		.782		
F		.515		
G		.025		
I		.200		
J		.260		
JA		.610		
K		.036		
L		1.250		
M		.570		1
P		.780		
R		.945		1, 2, 11
T		.450		3, 13
TB	—	—	.375	
TC		.420		
U		.600		2, 3, 12
W	—	—	.313	
Y		.125		9
Z		.770		9
ZA		.440		

*Limits to be determined.

NOTES

1. The total indicated runout of the grid-contact surface (Note 11) with respect to the anode diameter (M) will not exceed .040 inch. The gage (Note 4) must screw onto anode thread (Note 5) so that the face of the gage makes full contact with reference surface (Note 7). The eccentricity measurement is then made on the grid-contact surface with the gage chucked on the measurement reference axis.
2. The total indicated runout of the grid-contact surface (Note 11) with respect to the cathode-contact surface (Note 12) will not exceed .030 inch.
3. The total indicated runout of the cathode-contact surface (Note 12) with the heater-contact surface (Note 13) will not exceed .020 inch.
4. See outline. Machlett gage No. S-L5. Details will be supplied upon request.
5. See outline. Anode, $\frac{5}{16}$ — 24 UNF-2A thread.
6. See outline. $\frac{5}{16}$ — 24 UNF-2B thread.
7. See outline. Reference surface. The tube shall be stopped by this surface only when screwed in socket.
8. See outline. Insulating envelope. Do not clamp or locate on this surface.
9. Two holes provided for tube extractor in the top fin only, defined by dimensions (Y) and (Z).
10. See outline. Measure anode temperature on this surface.
11. Grid-contact surface and reference dimension for eccentricity measurement, defined by dimensions (R) and (AB).
12. Cathode or heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (U) and (AD).
13. Heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (T) and (AC). See also Note 14.
14. See outline. Alternate heater-contact surface. Heater contact can be made to the bottom of the heater terminal-cup by means of a coil spring having a maximum coil OD of .390 inch and a minimum coil ID of .320 inch, or some similar device.

ISSUED 5-64



ML-8547

General Purpose Triode
200 kW CW
15 Mw Pulse Power

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8547 is a general-purpose, water-cooled, high-power triode designed for applications requiring high plate currents at relatively low plate voltages. It is of particular interest for industrial heating, audio frequency power generation and pulse modulation.

The ML-8547 is capable of switching 6 Mw in a pulse modulator. As an RF generator, it can develop up to 250 kW of output power at 11 kV plate voltage. In class B push-pull circuitry, two tubes can generate approximately 300 kW audio frequency power. Maximum ratings apply up to 30 Mc. Useful power can be obtained at higher frequency with a reduction in ratings.

The anode incorporates an integral water jacket, and is designed to dissipate 175 kW. Sturdy coaxial grid and cathode mounting structures provide low-inductance, high-dissipation, RF terminals. The cathode is a sturdy, self-supporting, stress-free, thoriated-tungsten filament. Envelope insulation members are strong, low-loss ceramic cylinders.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	14.5	V†
Filament Current	450	A
Filament Starting Current, maximum	1200	A
Filament Cold Resistance	.0035	Ohm
Amplification Factor	14	
Interelectrode Capacitances		
Grid-Plate	170	pf
Grid-Cathode	200	pf
Plate-Cathode	8	pf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling	Water and forced-air	
Water flow on anode, minimum for 175 kW plate dissipation	40	gpm
Maximum outgoing water temperature	70	°C
Air flow on bulb and seals, approximate	500	cfm††
Maximum Ceramic Temperature	165	°C
Net Weight, approximate	100	lb

†For cathode currents in excess of 350 amps, filament voltage must be 15.0 volts.

††At frequencies up to 15 Mc, air flow should be directed primarily on filament seals and the main ceramic bulb; at higher frequencies or high ambient temperatures, additional air flow may be required on the grid seals. Air flow should be distributed to maintain uniform temperature, not greater than 165°, around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

AF Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values			
DC Plate Voltage		11	kV
Maximum-Signal DC Plate Current		40	A*
Maximum-Signal DC Grid Current		3.5	A*
Plate Dissipation		175	kW*
Typical Operation (Values are for two tubes)			
DC Plate Voltage	10	10	kV
DC Grid Voltage	−750	−750	V
Peak AF Grid-to-Grid Voltage	2300	2800	v
Peak AF Plate-to-Plate Voltage	16	18	kv
Zero-Signal DC Plate Current	2	2	A
Maximum-Signal DC Plate Current	48	72	A
Effective Load Resistance, Plate-to-Plate	428	318	ohms
Maximum-Signal Driving Power, approximate	400	6700	W
Maximum-Signal Power Output	300	510	kW

*Averaged over any audio-frequency cycle of sine-wave form.

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation.‡

Maximum Ratings, Absolute Values		
DC Plate Voltage	11	kV
DC Grid Voltage	−3500	V
DC Plate Current	30	A
DC Grid Current	3.5	A
Plate Dissipation	175	kW
Typical Operation		
DC Plate Voltage	10.5	kV
DC Grid Voltage	−2000	V
Peak RF Grid Voltage	2700	v
Peak RF Plate Voltage	9.5	kv
DC Plate Current	22	A
DC Grid Current	2.7	A
RF Load Resistance	238	ohms
Driving Power, approximate	7300	W
Power Output, approximate	190	kW

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of carrier conditions.

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	17	kV
Peak Plate Voltage	19	kv
DC Grid Voltage	−3500	V
Peak Negative Grid Voltage	−4500	v
Pulse Cathode Current	550	a
Grid Dissipation	2500	W
Plate Dissipation	175	kW
Pulse Duration	1000	μs#
Duty Factor	.01	#

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

Typical Operation		
DC Plate Voltage	16	kV
DC Grid Voltage	−1750	V
Pulse Positive Grid Voltage	1400	v
Pulse Plate Current	350	a
Pulse Grid Current	80	a
Pulse Driving Power	252	kw
Pulse Power Output	4.9	Mw
Plate Output Voltage	14	kv
Pulse Duration	1000	μs
Duty Factor	.01	

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 Mc except as noted. These tubes may be operated at higher frequencies provided the maximum value of plate voltage is reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency in Megacycles	30	70	110
Percent Maximum Rated Plate Voltage	100	80	60

TUBE PROTECTION

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

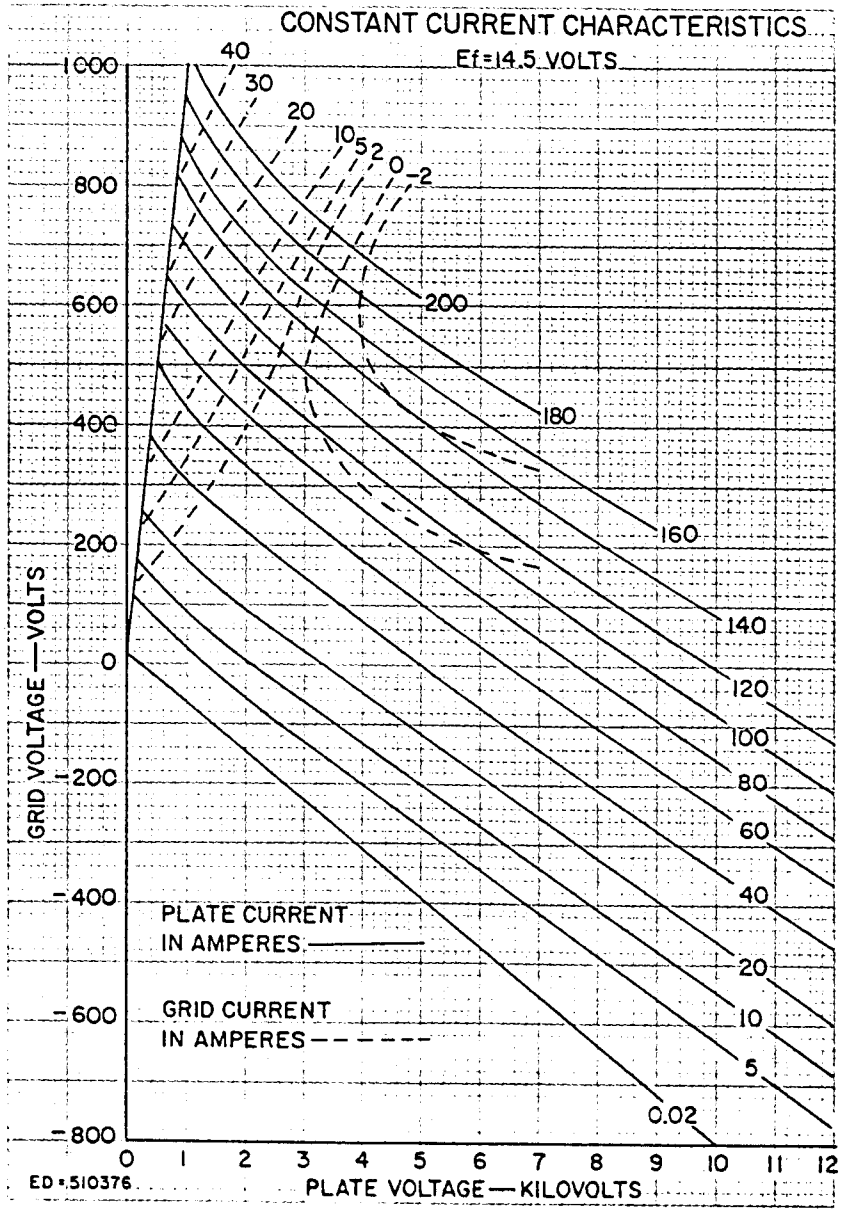
In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic elecronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

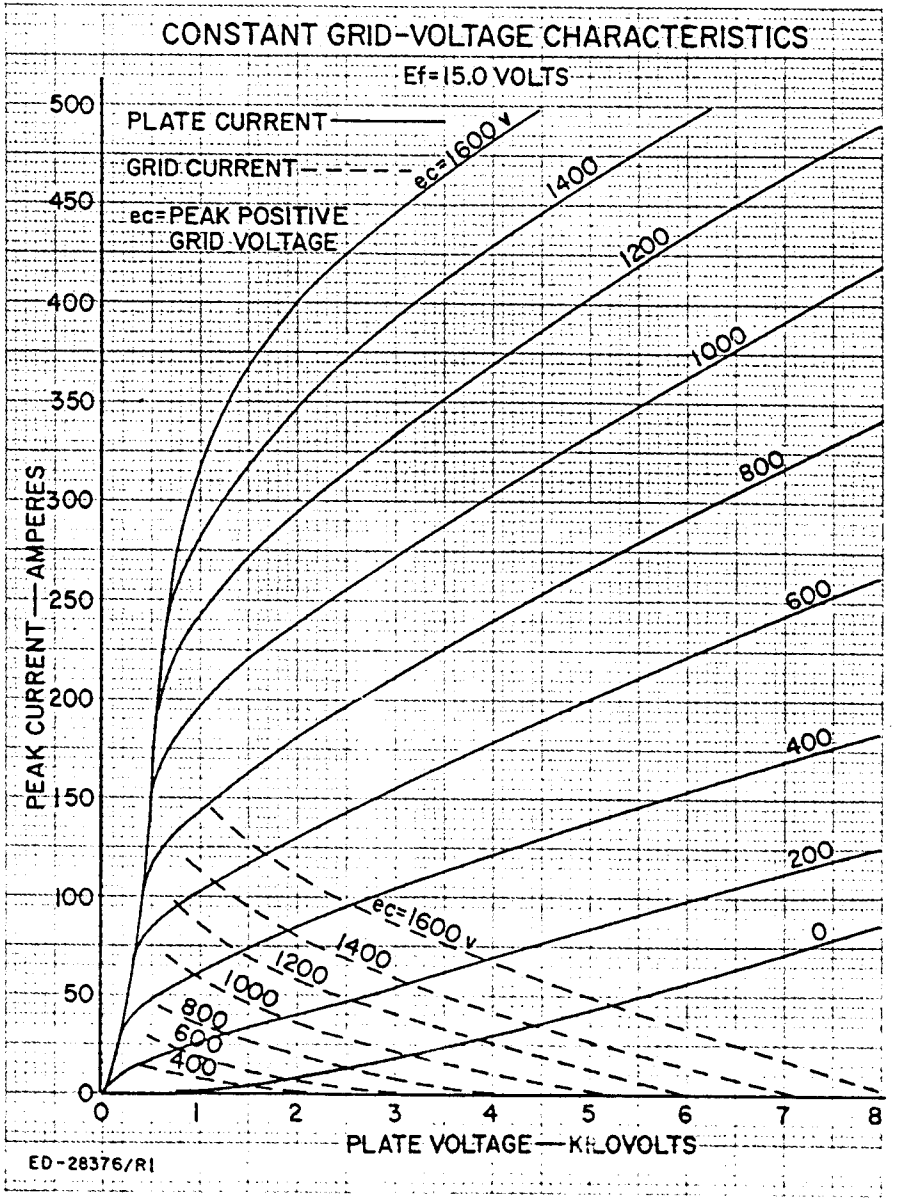
A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

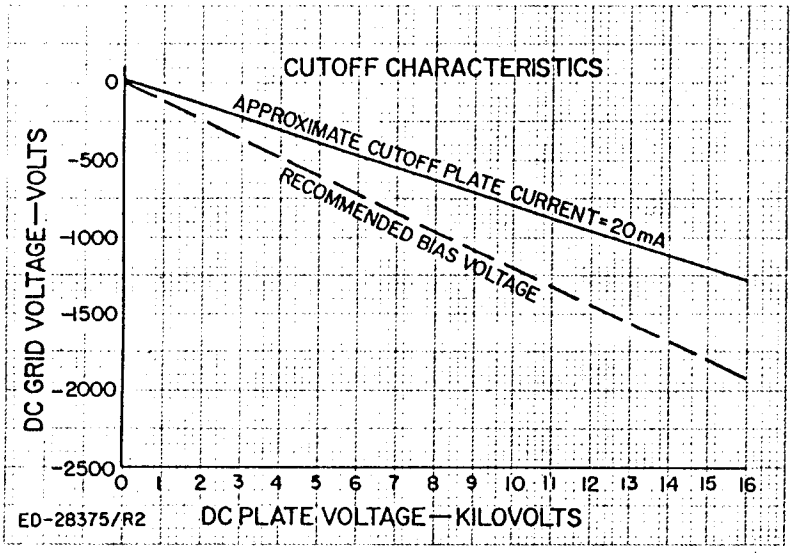
In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

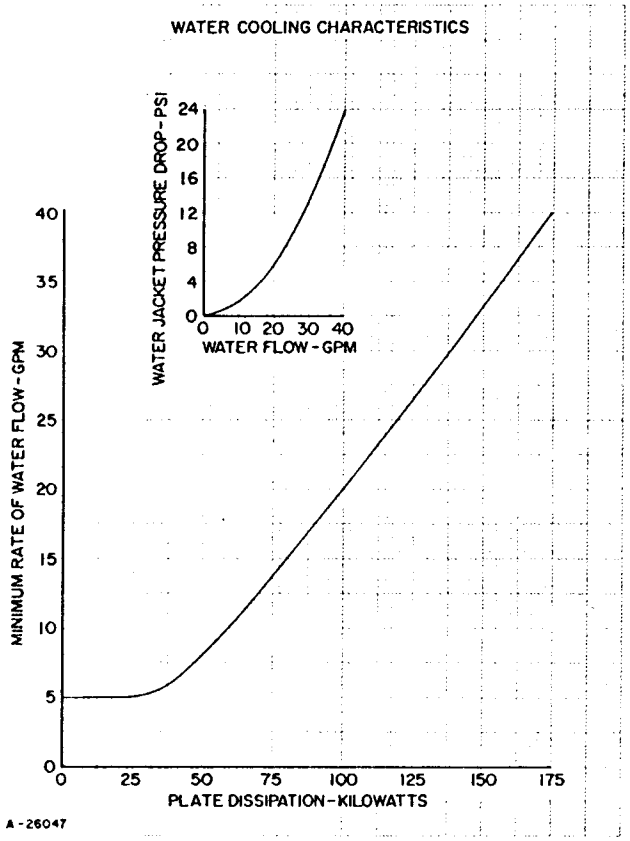
References:

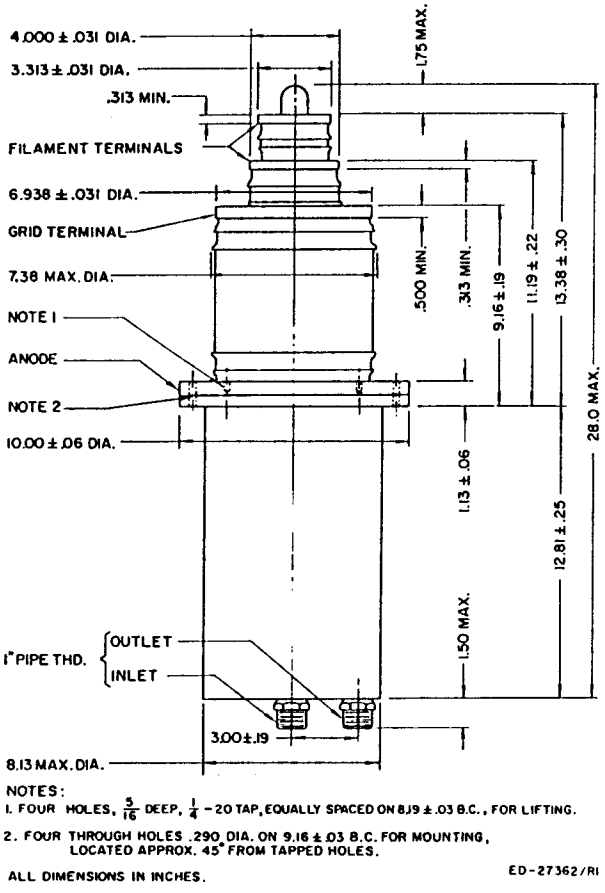
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29*, 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press, 1, 6*, 1954.


CONSTANT CURRENT CHARACTERISTICS
Ef=14.5 VOLTS
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
PLATE CURRENT IN AMPERES
GRID CURRENT IN AMPERES
ED-510376


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef=15.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec=PEAK POSITIVE GRID VOLTAGE
PEAK CURRENT — AMPERES
PLATE VOLTAGE — KILOVOLTS
ED-28376/R1

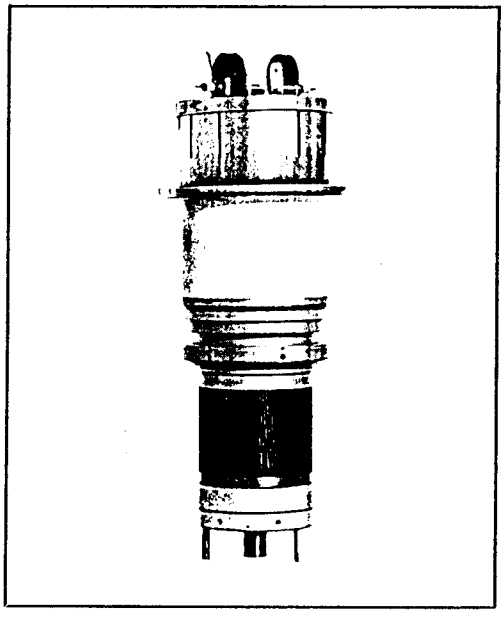






THE MACHLETT LABORATORIES, INC.
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SPRINGDALE MACHLETT CONNECTICUT
ST-2024 4.5M 5-64
Printed in U.S.A.

ISSUED 5-64



ML-8548

High-Mu Triode
Pulse Power
to 20 Mw

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8548 is a high-voltage high-mu triode designed primarily to operate as a switch tube in hard-tube pulse modulators, for radar and similar applications. In this service it can deliver pulse output in the order of 20 Mw with plate voltages up to 180 kV.

The cathode consists of sturdy, stress-free thoriated-tungsten filaments. The ML-8548 is designed for operation in oil or equivalent dielectric fluid, which is required for utilization of the maximum plate voltage rating. The anode is capable of dissipating 20 kW when cooled by a forced flow of oil.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	11.0	V
Filament Current	360	A
Filament Starting Current, maximum	1200	A
Filament Cold Resistance	.0037	ohm
Amplification Factor	500	
Interelectrode Capacitance		
Grid-Plate	30	pf
Grid-Cathode	200	pf
Plate-Cathode	50	pf

Mechanical

Mounting Position	Vertical, anode down	
Insulating Medium	Oil or equivalent	
Type of Cooling	Forced oil	
Oil flow for 20 kW dissipation	20	gpm
Maximum bulk oil temperature	75	°C
Maximum circulating oil temperature for maximum dissipation	75	°C
Maximum Ceramic Temperature	165	°C
Net Weight, approximate	140	lb

ACCESSORIES

Item	Part No.
Oil Jacket Sleeve	510267
Oil Jacket Bayonet Base	510268

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

DC Plate Voltage	180	kV†
Peak Plate Voltage	180	kv†
DC Grid Voltage	−1500	V
Peak Negative Grid Voltage	−3500	v
Pulse Cathode Current	225	a
Grid Dissipation	1000	W
Plate Dissipation	20	kW
Pulse Duration	1000	μs#
Duty Factor	.005	#

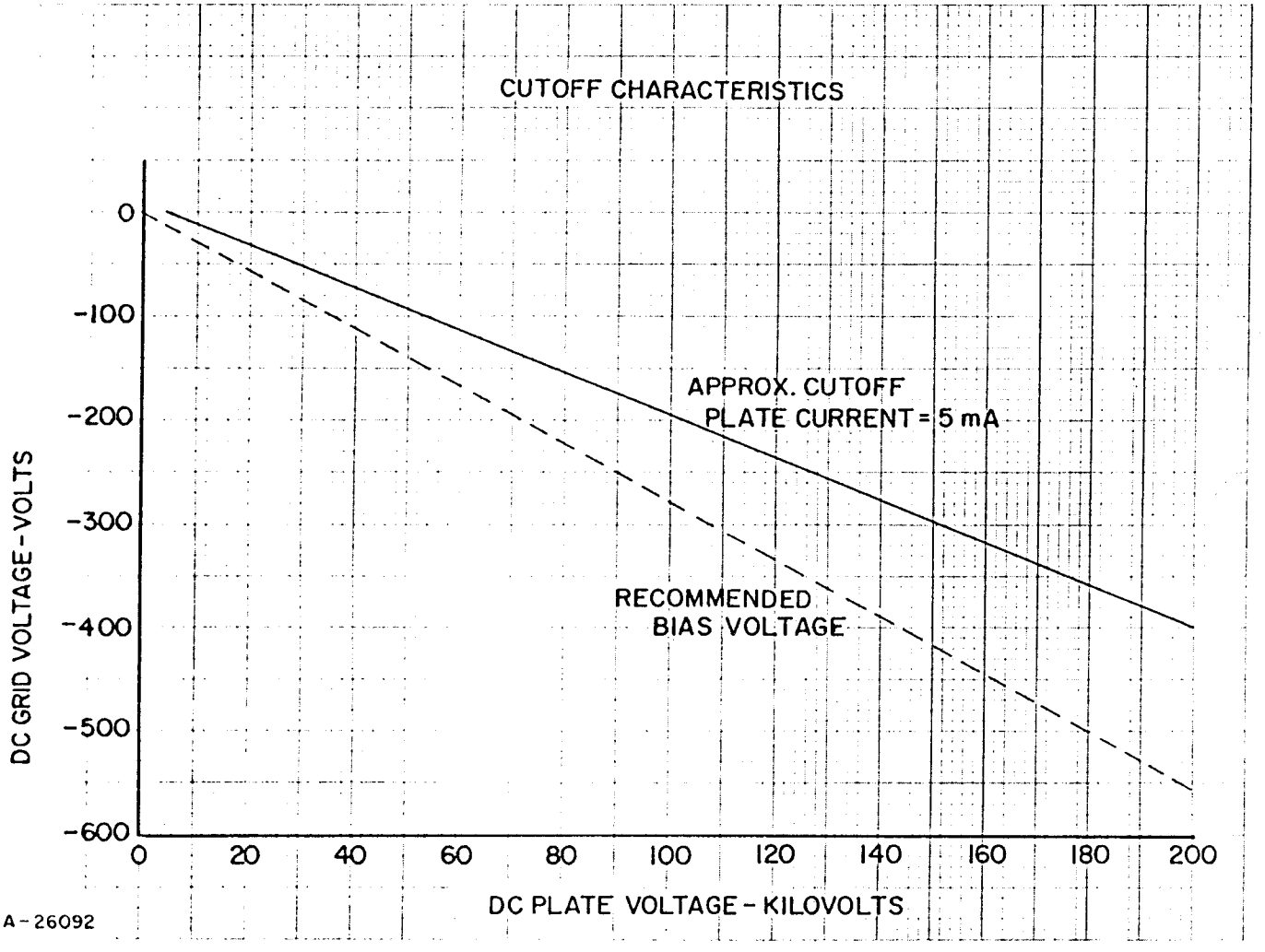
Typical Operation

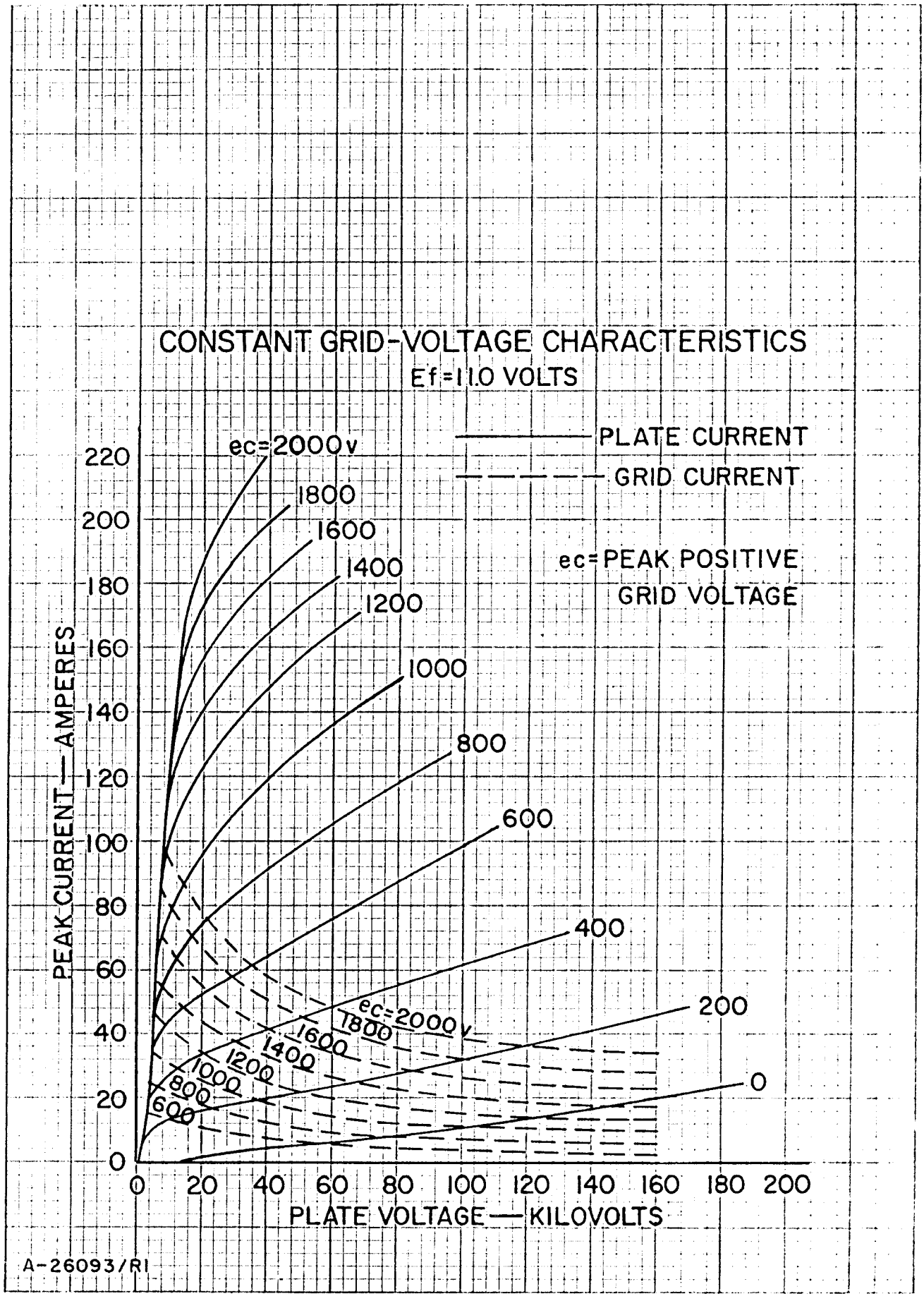
DC Plate Voltage	170	kV
DC Grid Voltage	−500	V
Pulse Positive Grid Voltage	1350	v
Pulse Plate Current	135	a
Pulse Grid Current	50	a
Pulse Driving Power	95	kw
Pulse Power Output	20	Mw
Pulsed Plate Output Voltage	150	kv

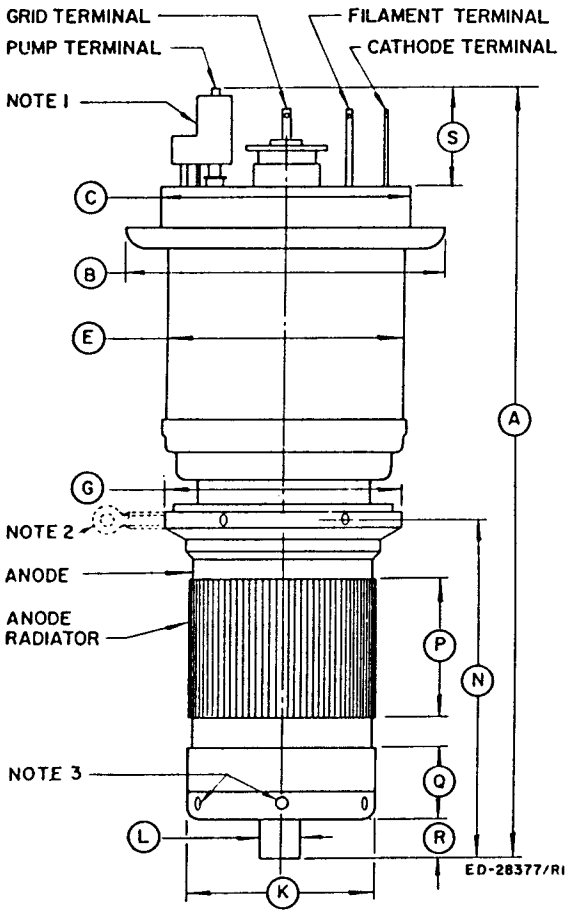
†This voltage may be applied only when the tube is immersed in a suitable dielectric fluid.

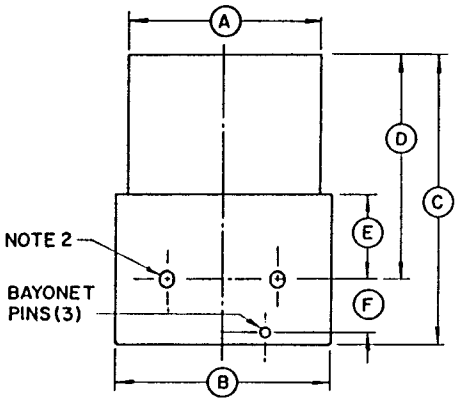
#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube might produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

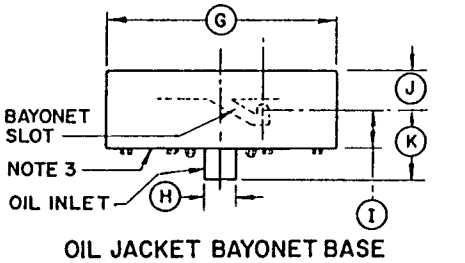



CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef=11.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec=PEAK POSITIVE GRID VOLTAGE
ec=2000v
1800
1600
1400
1200
1000
800
600
400
200
0
PEAK CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
0 20 40 60 80 100 120 140 160 180 200
0 20 40 60 80 100 120 140 160 180 200 220
A-26093/R1





OIL JACKET SLEEVE
PART NO. 510267 (NOTE 1)



OIL JACKET BAYONET BASE
PART NO. 510268 (NOTE 1)

ED-510273

DIMENSIONS FOR OUTLINE OF ML-8548

Ref.	Inches*			Notes
	Minimum	Nominal	Maximum	
A		38		
B		16.25		
C		12.75		
E		12		
G		12		
K		9.45		
L		2		
N		16.25		
P		7.06		
Q		3.75		
R		2		
S		5		

NOTES:

1. One-liter-per-second ion-type vacuum pump.
2. Three removable eyebolts supplied with tube for lifting.
3. Six holes for attaching oil jacket.

*Limits to be determined.

DIMENSIONS FOR OUTLINE OF OIL JACKET

Ref.	Inches*			Notes
	Minimum	Nominal	Maximum	
A		9.75		
B		11.01		
C		16.25		
D		11.56		
E		4.38		
F		2.75		
G		11.76		
H		1.66		
I		2.00		
J		2.00		
K		3.50		

NOTES:

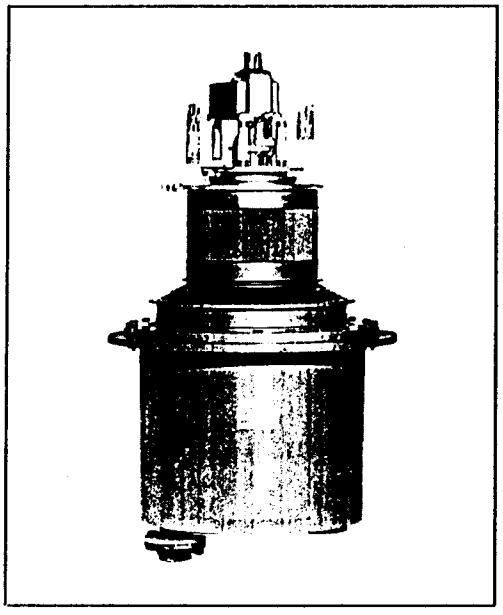
1. Oil Jacket Bayonet Base is mounted permanently in equipment. Oil Jacket Sleeve is attached to tube and assembly is locked in base by means of bayonet pins.
2. Six ½"-13 hexagon-head screws for attaching oil jacket sleeve to tube.
3. Flat annular surface, 4.0 in. ID, 9.6 in. OD, available for attaching stand-off insulators.

*Limits to be determined.

THE MACHLETT LABORATORIES, INC.
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ST-2025 4.5M 5-64 SPRINGDALE MACHLETT CONNECTICUT Printed in U.S.A.

ISSUED 5-64



ML-8549

Super Power Triode

High Duty
Pulse Power
to 60 Mw

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-8549 is a super-power general-purpose water-cooled triode featuring extremely favorable plate-grid current division which results in minimum drive-power requirements. The cathode of this tube consists of sturdy self-supporting thoriated-tungsten filaments. The coaxial terminals have low inductance and high heat-dissipation capability. Insulating members are low-loss ceramic.

When used as a switch tube in hard-tube pulse modulators for radar or similar applications, it can deliver more than 60 Mw pulse output with pulse widths up to 10,000 microseconds at a duty factor of .06. When used as a pulsed rf amplifier operating at frequencies up to 30 Mc, the ML-8549 is capable of delivering 10 Mw, also at long pulse duration and high duty factors. When used as a pulsed modulator, a maximum plate voltage of 65 kVdc applies.

When operating as a Class C amplifier or oscillator at frequencies up to 30 Mc, the ML-8549 is capable of a continuous output in excess of 2.0 MW. The maximum CW plate-voltage rating of 25 kVdc applies at frequencies up to 30 Mc. Useful power output can be obtained at higher frequencies with reduced plate voltage and input.

The water-cooled anode of the ML-8549 is capable of dissipating up to 500 kW. The tube can be operated in air at maximum plate voltage ratings. The ML-8549 is supplied with an ion pump for maintaining a high vacuum during operation. This pump is normally mounted on the cathode end of the tube but can be mounted in a concealed position within the anode water jacket on special order.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical		
Filament Voltage	7.6	V
Filament Current	1900	A
Amplification Factor	20	
Interelectrode Capacitances		
Grid-Plate	280	pf
Grid-Cathode	730	pf
Plate-Cathode	25	pf
Mechanical		
Mounting Position	Vertical	
Type of Cooling	Water and forced-air	
Water flow on anode for 500 kW dissipation	100	gpm†
Water jacket pressure for 100 gpm flow	30	psi
Maximum Ceramic Temperature	165	°C
Net Weight, approximate		
Tube	350	lb.
Water jacket and accessories	600	lb.

†Additional forced-air or forced-oil cooling of the grid and filament terminals will be required.

ACCESSORIES

Item	Part No.
Filament Connector	510269
Cathode Connector	510270
Grid Connector	510272
Water Jacket	510271
Ion Pump Connector with 14 ft. Polyethylene Cable	
With Cannon Connector	924-0022*
With unterminated supply end	924-0715*

*Part number of Varian Associates, Palo Alto, California.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	65	kV▲
Peak Plate Voltage	70	kv▲
DC Grid Voltage	—5000	V
Peak Negative Grid Voltage	—6000	v
Pulse Cathode Current	1200	a
Grid Dissipation	9	kW
Plate Dissipation	500	kW
Pulse Duration	10	ms#
Duty Factor	.06	#
Typical Operation		
DC Plate Voltage	65	kV
DC Grid Voltage	—4000	V
Pulse Positive Grid Voltage	3000	v
Pulse Plate Current	1100	a
Pulse Grid Current	10	a
Pulse Driving Power	70	kw
Pulse Power Output	65	Mw
Pulse Plate Output Voltage	59	kv

Plate-Modulated RF Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values			
DC Plate Voltage	16		kV
DC Grid Voltage	—4000		V
DC Plate Current	100		A
Plate Input	1.6		MW
Plate Dissipation	330		kW
Typical Operation	Cathode Drive	Grid Drive	
DC Plate Voltage	15	15	kV
DC Grid Voltage	—2000	—2000	V
Peak RF Plate Voltage	13	13	kv
Peak RF Grid Voltage	3500	3500	v
DC Plate Current	90	90	A
Peak RF Fundamental Plate Current	162	162	a
RF Load Resistance	102	78	ohms
Driving Power	300	4	kW
Plate Dissipation	300	300	kW
Power Output	1.3‡	1.1	MW

Plate-Pulsed RF Power Amplifier and Oscillator Class C

Maximum Ratings, Absolute Values			
Peak Plate Pulse Supply Voltage	40		kv▲
DC Grid Voltage	—4000		V
Pulse Cathode Current	1200		a
Grid Dissipation	9		kW
Plate Dissipation	500		kW
Pulse Duration	10		ms#
Duty Factor	.06		#
Typical Operation	Cathode Drive	Grid Drive	
Peak Plate Pulse Supply Voltage	38	38	kv
DC Grid Voltage	—2300	—2300	V
Peak RF Grid Voltage	5500	5500	v
Peak RF Plate Voltage	32	32	kv
Peak Plate Current from Pulse Supply	400	400	a
Peak RF Fundamental Plate Current	630	630	a
Peak Plate Dissipation	5.2	5.2	Mw
Plate Dissipation at .01 Duty	52	52	kW
Peak Driving Power	1750	33	kw
Peak Grid Dissipation	24	24	kw
RF Load Resistance	60	51	ohms
Peak Power Output	11.8‡	10	Mw

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation.†

Maximum Ratings, Absolute Values				
DC Plate Voltage	25			kV
DC Grid Voltage	—4000			V
DC Plate Current	150			A
Plate Input	3.0			MW
Plate Dissipation	500			kW
Typical Operation	Cathode Drive	Grid Drive	Grid Drive	
DC Plate Voltage	20	20	25	kV
DC Grid Voltage	—2600	—2600	—3100	V
Peak RF Grid Voltage	4400	4400	4900	v
Peak RF Plate Voltage	18000	18000	23000	v
DC Plate Current	110	110	115	A
Peak RF Fundamental Plate Current	200	200	220	a
RF Load Resistance	112	90	107	ohms
Plate Dissipation	460	460	450	kW
Grid Driving Power	450	9	10	kW
Grid Dissipation	2500	2500	2500	W
Power Output	2.3‡	1.8	2.5	MW

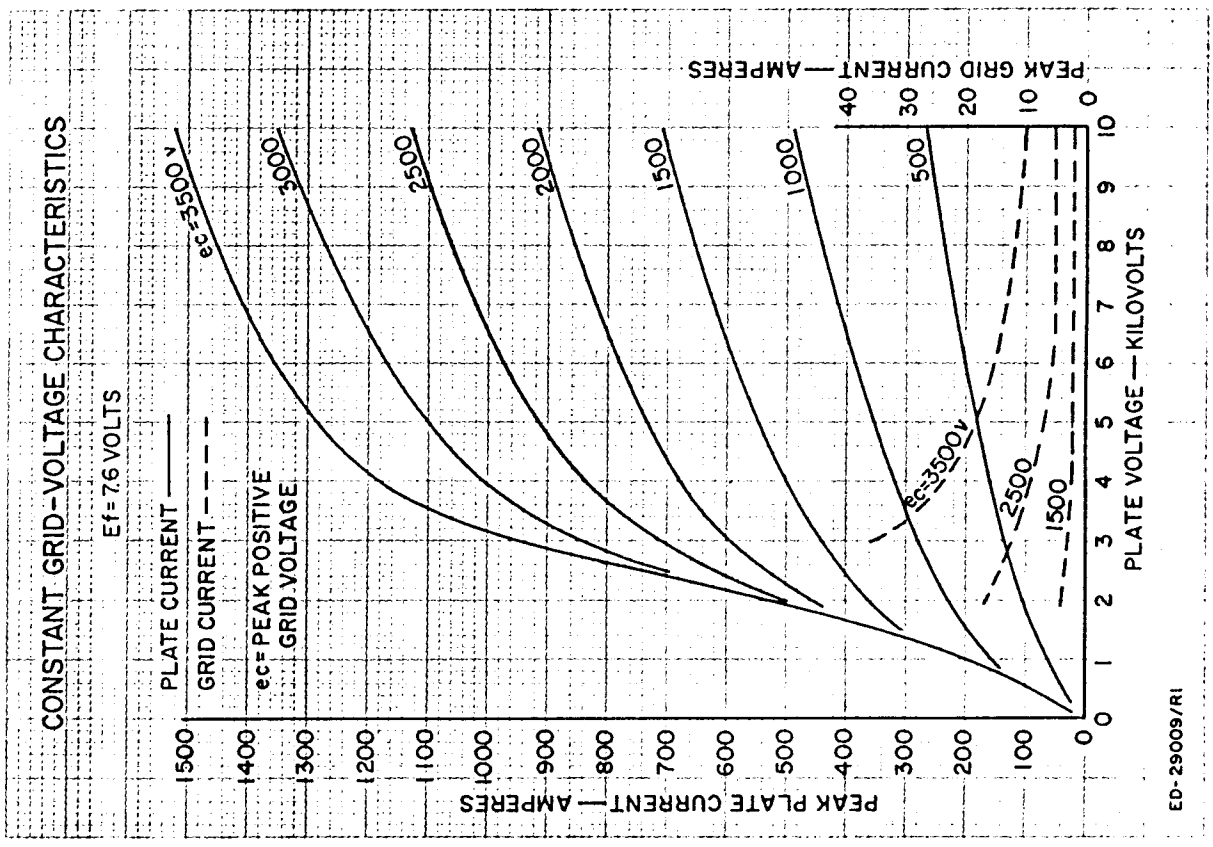
▲Maximum plate voltage ratings apply with the tube in air or immersed in oil.

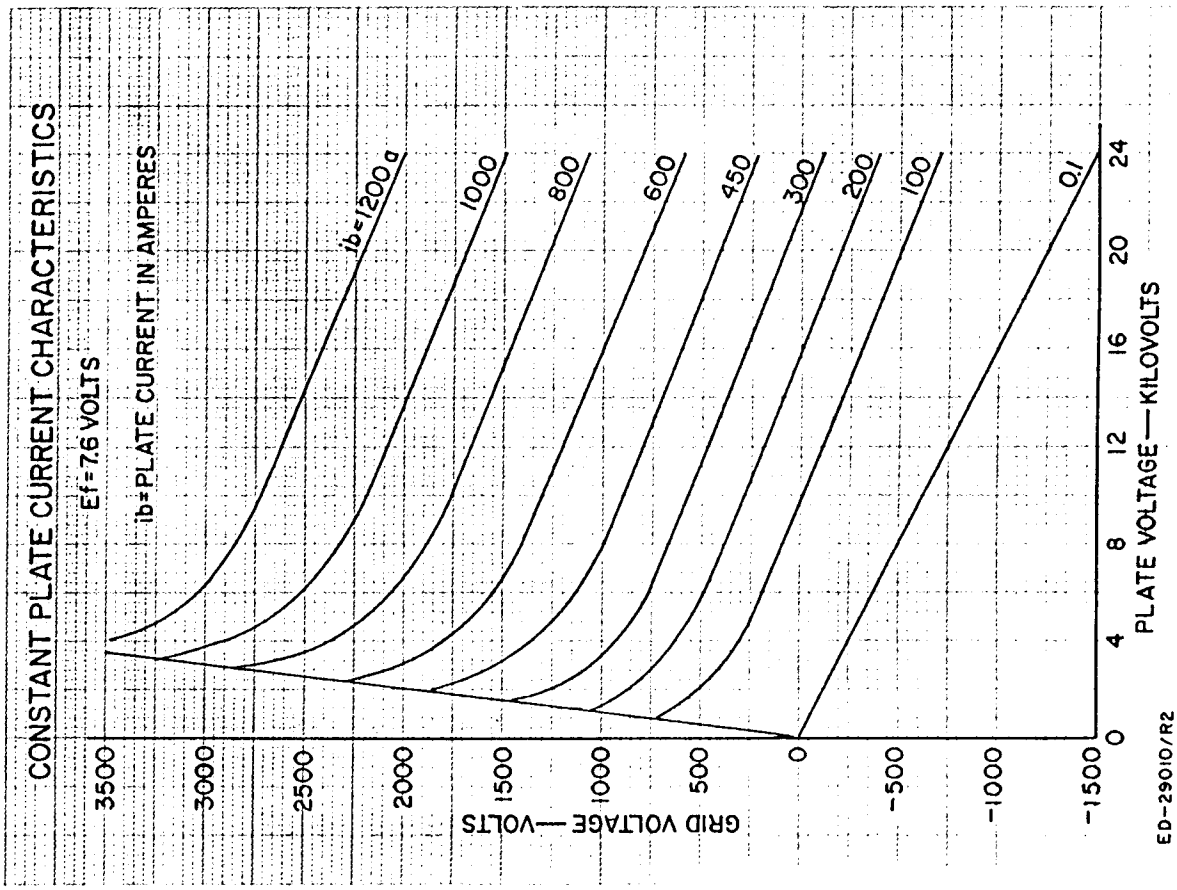
For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

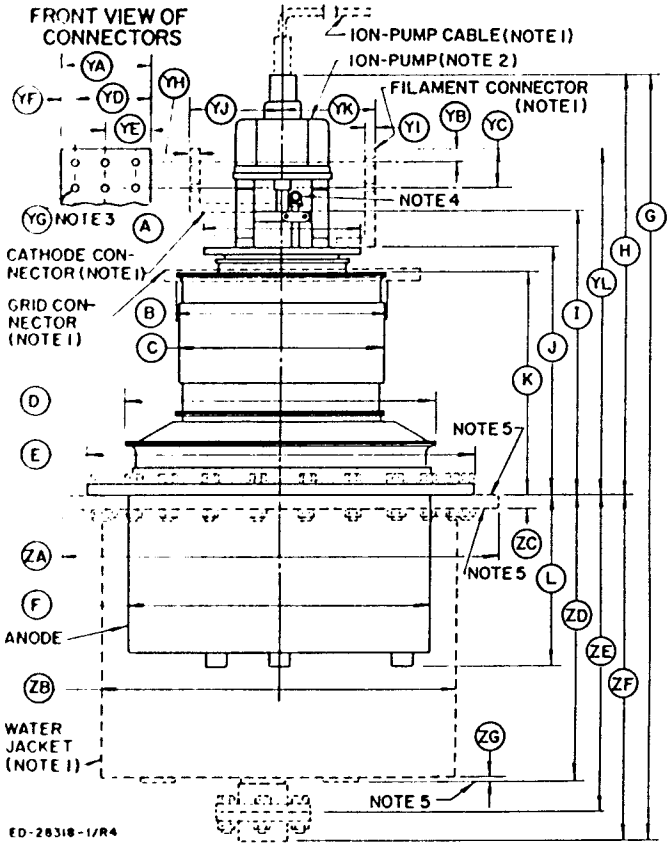
†Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

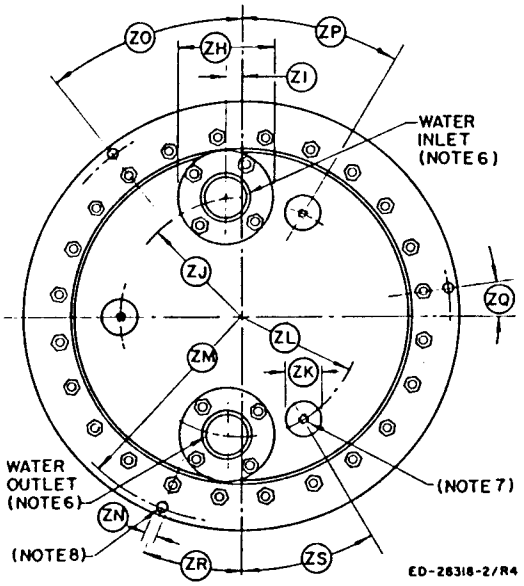
‡Includes power transferred from driver stage.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef=7.6 VOLTS
PLATE CURRENT ——
GRID CURRENT - - - -
ec=PEAK POSITIVE GRID VOLTAGE
ec=3500 v
3000
2500
2000
1500
1000
500
PEAK PLATE CURRENT — AMPERES
PEAK GRID CURRENT — AMPERES
PLATE VOLTAGE — KILOVOLTS
ED-29009/R1


CONSTANT PLATE CURRENT CHARACTERISTICS
Ef=7.6 VOLTS
ib=PLATE CURRENT IN AMPERES
ib=1200 a
1000
800
600
450
300
200
100
0.1
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
ED-29010/R2





BOTTOM VIEW OF WATER JACKET

DIMENSIONS FOR OUTLINE OF ML-8549

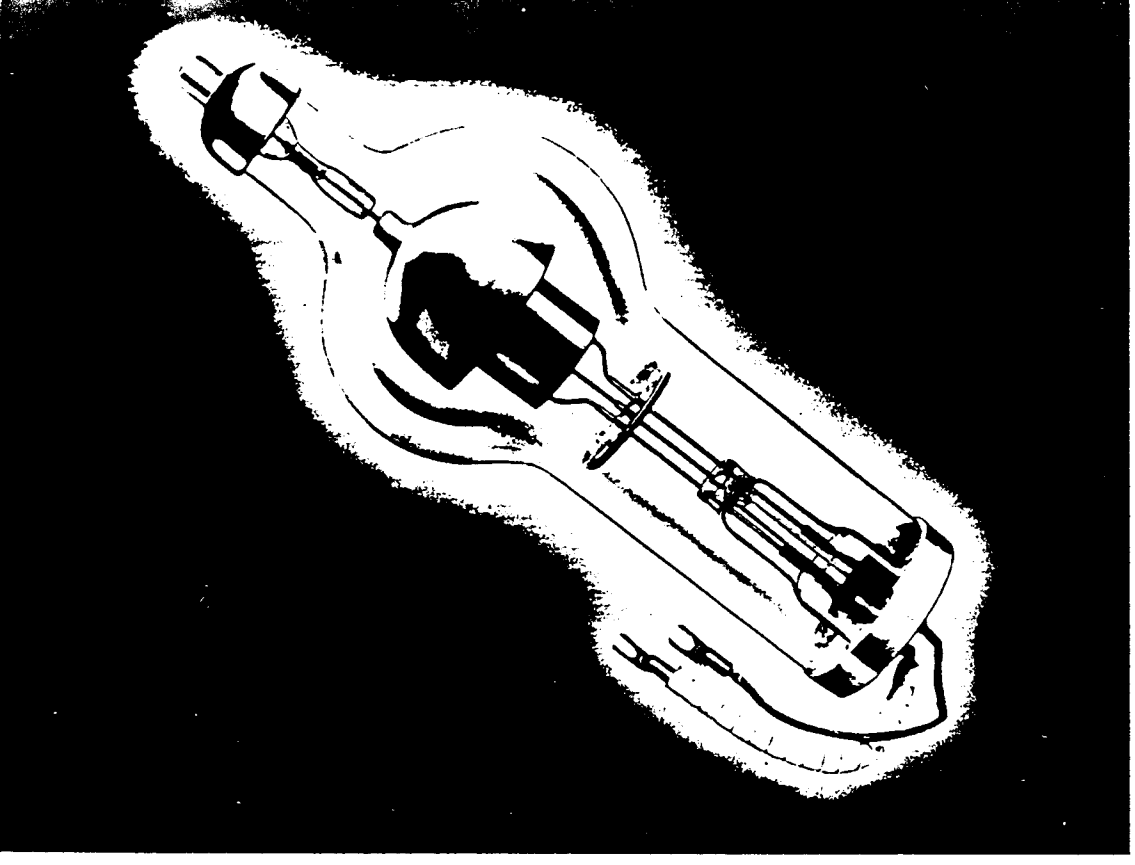
Ref.	Inches*			Notes
	Minimum	Nominal	Maximum	
A		9.63		
B		12.31		
C		12.0		
D		18.25		
E		22.88		
F		17.50		
G		45.75		
H		25.19		
I		17.03		
J		14.75		
K		13.44		
L		9.94		
YA		5.25		
YB		.88		
YC		2.38		
YD		4.38		
YE		2.63		
YF		.88		
YG		.44		3
YH		.50		
YI		.50		
YJ		5.38		
YK		5.38		
YL		20.78		
ZA		25.88		
ZB		20.25		
ZC		.75		
ZD		17.06		
ZE		18.88		
ZF		20.56		
ZG		.13		
ZH		5.56		
ZI		.94		
ZJ		7.19		6
ZK		2.00		
ZL		7.19		7
ZM		12.25		8
ZN		.81		8
ZO		37.5°		degrees
ZP		30.0°		degrees
ZQ		7.5°		degrees
ZR		22.5°		degrees
ZS		30.0°		degrees

NOTES:

1. Ion-pump cable, terminal connectors and water jacket not supplied with tube. Other terminal connectors can be designed on special order.
2. Five-liter-per-second ion pump. Ion pump can be mounted in a concealed position within the water jacket on special order.
3. Six holes, diameter (YG).
4. Connection for forced-oil or forced-air cooling of cathode re-entrant cavity, ⅜-inch male pipe thread.
5. Water jacket may be supported by upper or lower surface of flange or by three pads on bottom of jacket.
6. Water inlet and outlet are Anaconda No. 1740, 2½-inch copper tube flange unions, on circle radius (ZJ).
7. Three holes for mounting, ½"-13 ANC tap, on circle radius (ZL).
8. Three holes, diameter (ZN), on circle radius (ZM), for alternate mounting.

*Limits to be determined.

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MACHLETT

ML-857B

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-857B is a two-electrode, mercury-vapor tube designed for use as a half-wave rectifier in high-power radio-transmitting and r.f. heating equipment. Unique features, including low internal voltage drop and cathode design permitting in-phase or quadrature filament excitation, contribute to efficient and economical operation. Maximum ratings of 22 PKV inverse anode voltage and 10 amperes average anode current apply at frequencies of 25 to 150 cycles per second.

GENERAL CHARACTERISTICS

Electrical	
Filament Voltage	5 Volts
Filament Current	30 Amperes
Filament Heating Time, Minimum*	1 Minute
Tube Voltage Drop, approximate	15 Volts
Critical Anode Voltage	100 Volts
Mechanical	
Mounting Position	Vertical, Base Down
Type of Cooling	Convection or Forced-Air
Condensed Mercury Temperature Rise to Equilibrium, approximate	
No Load	11.5 °C
Full Load	15 °C
Base	JEDEC No. FO-2
Cap	JEDEC No. C1-10
Net Weight, approximate	3¾ Pounds

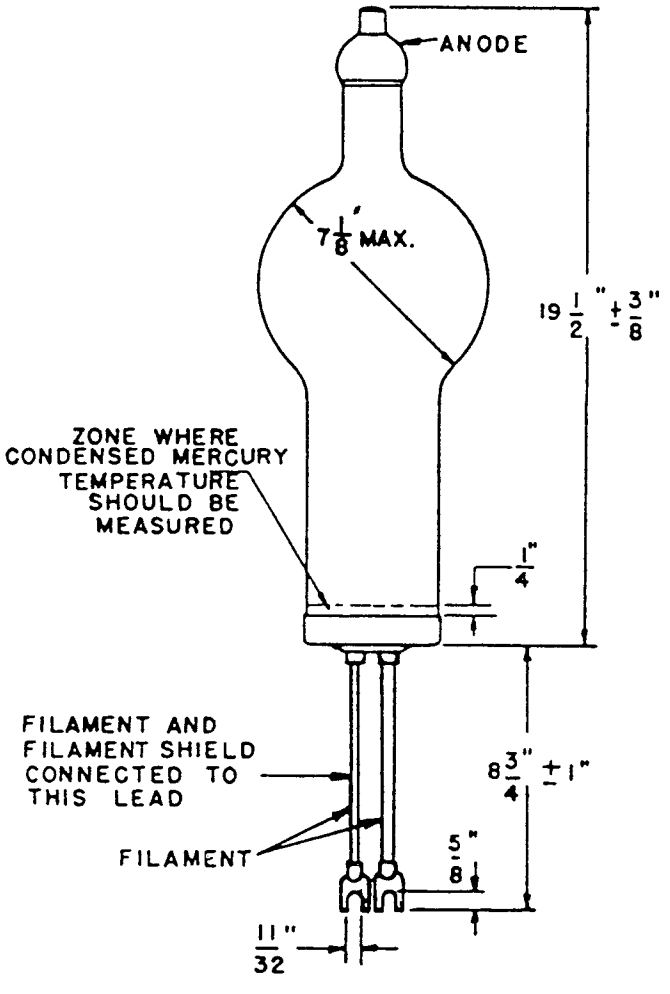
*Before applying anode voltage, sufficient time must be allowed to bring the condensed mercury temperature, measured at top edge of base, within the specified range.

MAXIMUM RATINGS

Maximum Peak Inverse Anode Voltage		
Type of Cooling	Convection	Forced-Air
150 Cycles or Less	10000	22000 Volts
Condensed Mercury Temperature Range	25-60	30-40 °C
Maximum Anode Current		
Instantaneous, 25 to 150 Cycles	40.0 Amperes	
Average, 30 Seconds Averaging Time	10.0 Amperes	
Surge, for Design Only	400.0 Amperes	
Duration of Surge Current	0.2 Second	

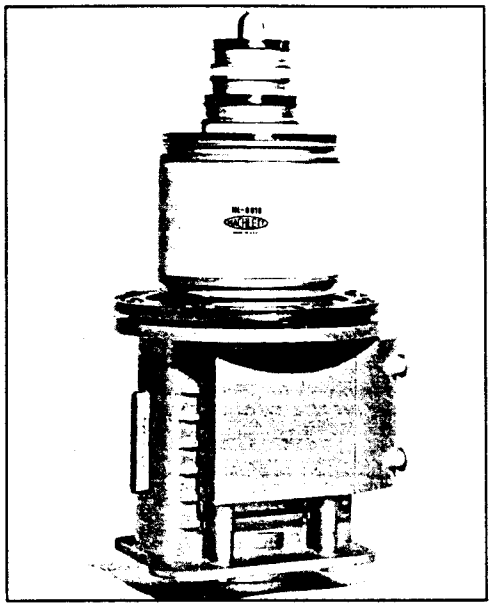
NOTE: Tube life will be increased when quadrature filament excitation (filament current 90° out of phase with anode current) is used.

WARNING: Operation of this tube at higher voltages may produce soft x-rays, which constitute a health hazard. Adequate rayproof shielding must therefore be provided in equipment.



THE MACHLETT LABORATORIES, INC.
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ISSUED 7-73



ML-8618
ML-8618V

MACHLETT

High Power-Gain Triodes
200 kW, CW
8 Mw Pulse Power

DESCRIPTION

The ML-8618 and ML-8618V are magnetically beamed, high-power, general-purpose, water-cooled triodes. Their unique design, using a magnetic field to beam electron flow, produces extremely favorable plate-grid current division, which results in minimum drive-power requirements and high overall operating efficiency. The cathode of each type consists of sturdy thoriated-tungsten filaments. Parallel plane anode construction reduces filament power requirements by utilizing both sides of the filaments. The coaxial terminals have low inductance and high heat dissipation capability. Insulating members are low-loss ceramic. The ML-8618V is identical to the ML-8618 except that it is provided with an ion getter pump.

When operated as a class C amplifier or oscillator, these tubes are capable of a continuous output of up to 200 kW with about 700 W driving power. When used as switch tubes in hard-tube pulse modulators for radar, particle accelerators, or similar applications, they can deliver 8 Mw pulse output. Since the magnetic beaming reduces the grid dissipation, the tubes are capable of operating with much longer pulses and higher duty factors than conventional tubes of similar size.

The water-cooled anodes of these tubes are capable of dissipating up to 80 kW. The tubes can be operated in air at maximum plate voltage ratings. Maximum ratings apply at frequencies up to 30 MHz. Useful power output can be obtained at higher frequencies with a reduction in plate voltage.

GENERAL CHARACTERISTICS

Electrical		
Filament Voltage (AC)	7.5	V
Filament Current	320	A
Filament Starting Current, maximum	700	A
Filament Cold Resistance	.0028	ohm
Amplification Factor	25	
Interelectrode Capacitances, approximate		
Grid-Plate	50	pf
Grid-Filament	145	pf
Plate-Filament	9	pf
Strapped Resonant Frequencies		
Grid-Plate, approximate	135	MHz
Grid-Cathode, approximate	120	MHz
Mechanical		
Mounting Position	Vertical, Anode down	
Type of Cooling	Water & Forced-Air	
Maximum water inlet pressure	30	psi†
Maximum outgoing water temperature	70	°C
Water flow on anode for 80 kW dissipation	45	gpm††
Water jacket pressure drop for 45 gpm flow	10	psi
Maximum Envelope Temperature	200	°C
Net Weight, approximate		
Tube only	56	lb
Water jacket and magnet	90	lb

†A 30 psi pressure relief valve should be connected to the water jacket.

††Additional forced-air cooling of the grid and filament terminals will be required. This should consist of an air flow of about 200 cfm uniformly distributed on the ceramic bulb and the terminal assembly.

WARNING: This electron tube may give off x-rays when operating at peak voltages in excess of 15 kv, which can be harmful unless adequately shielded by the enclosure within which it is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources".

ACCESSORIES

Item	Part No.
Small Filament Connector	F-27218*
Large Filament Connector	F-27219*
Grid Connector	F-27220*
Water Jacket and Magnet Assembly	F-535437
Water Jacket Assembly with O-Ring Gasket	F-512759
Magnet	P-511165

*For additional information on these accessories, refer to Accessory Data Sheet No. ST-2097.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values‡

DC Plate Voltage	45	kV
Peak Plate Voltage	50	kV
DC Grid Voltage	−5000	V
Pulse Cathode Current	200	a
Grid Dissipation	500	W
Plate Dissipation	80	kW
Pulse Duration	10000	μs#
Duty Factor	.06	#

Typical Operation

DC Plate Voltage	40	kV
Pulse Output Voltage	37	kv
DC Grid Voltage	−3600	V
Pulse Positive Grid Voltage	1500	v
Pulse Plate Current	150	a
Pulse Grid Current	2.5	a
Pulse Driving Power	12.8	kw
Pulse Output Power	5.5	Mw
Duty Factor	.06	

‡All given maximum ratings may not apply simultaneously. Due to the possibility of instantaneous overheating of electrodes during the pulse, it may be necessary to restrict some of the parameters, e.g., peak plate current, tube drop, pulse duration, duty or average dissipation, in order not to adversely affect the performance of the tube. Because of the many possible combinations of operating conditions, all restrictions cannot be delineated here, and it is suggested to review new applications with the Machlett Engineering Department.

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

RF Power Amplifier and Oscillator Class C Telegraphy §

Keydown conditions per tube without amplitude modulation

Maximum Ratings, Absolute Values

DC Plate Voltage	17	kV
DC Grid Voltage	−4000	V
DC Plate Current	15	A
Grid Dissipation	500	W
Plate Dissipation	80	kW

Typical Operation

DC Plate Voltage	16	kV
DC Grid Voltage	−2000	V
Peak RF Plate Voltage	14.4	kv
Peak RF Grid Voltage	3000	v
DC Plate Current	13	A
DC Grid Current, approximate	.2	A
RF Load Resistance	595	Ohms
Driving Power, approximate	600	W
Plate Dissipation	35	kW
Grid Dissipation	200	W
Power Output	175	kW
Power Gain	290	

§Consult The Machlett Laboratories Engineering Department for this application.

TUBE PROTECTION

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

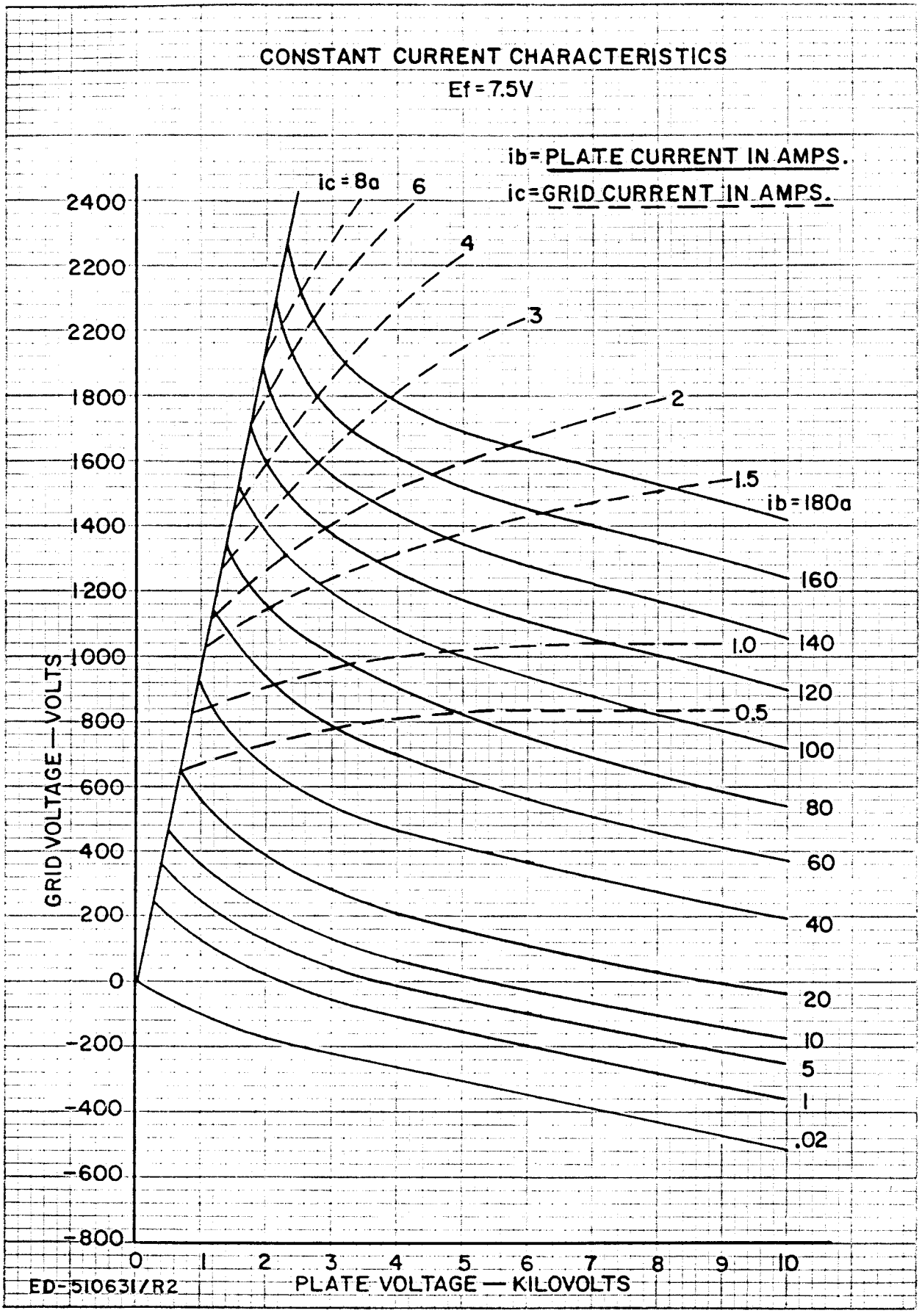
In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

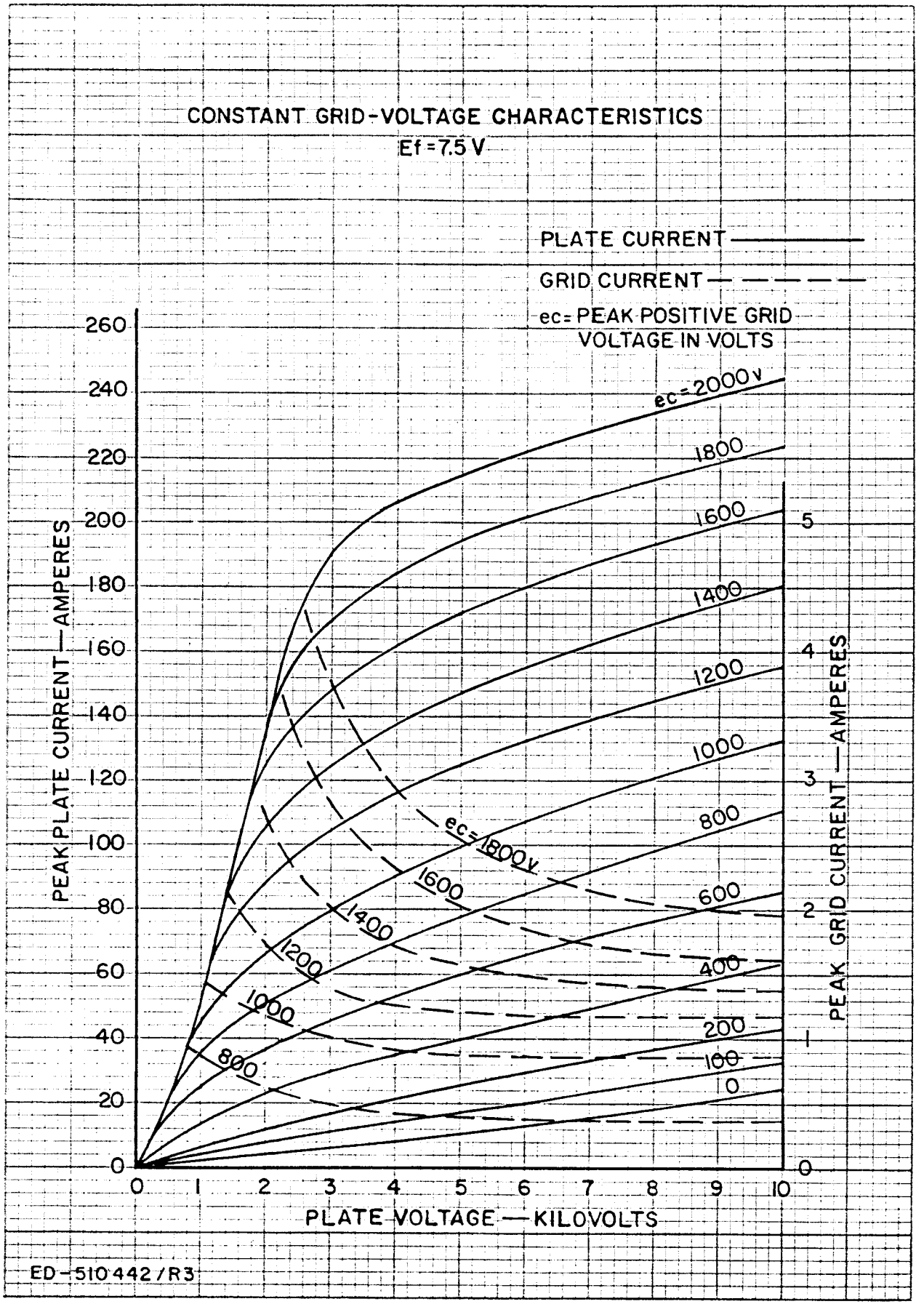
A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

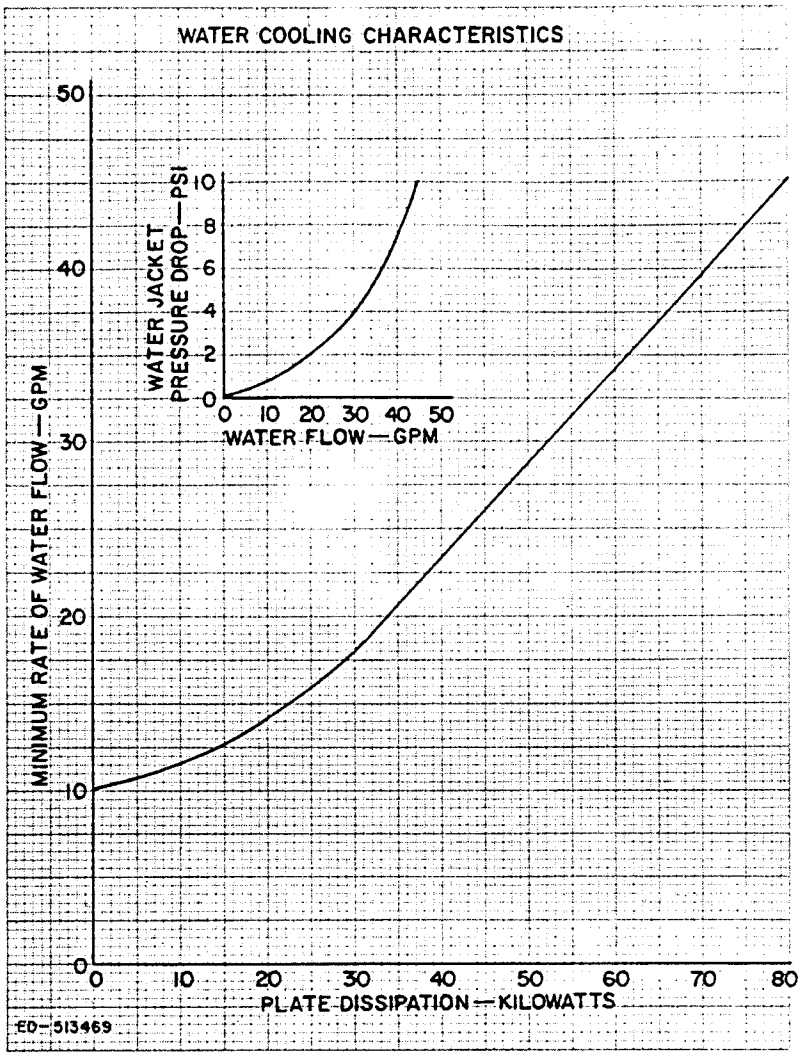
In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

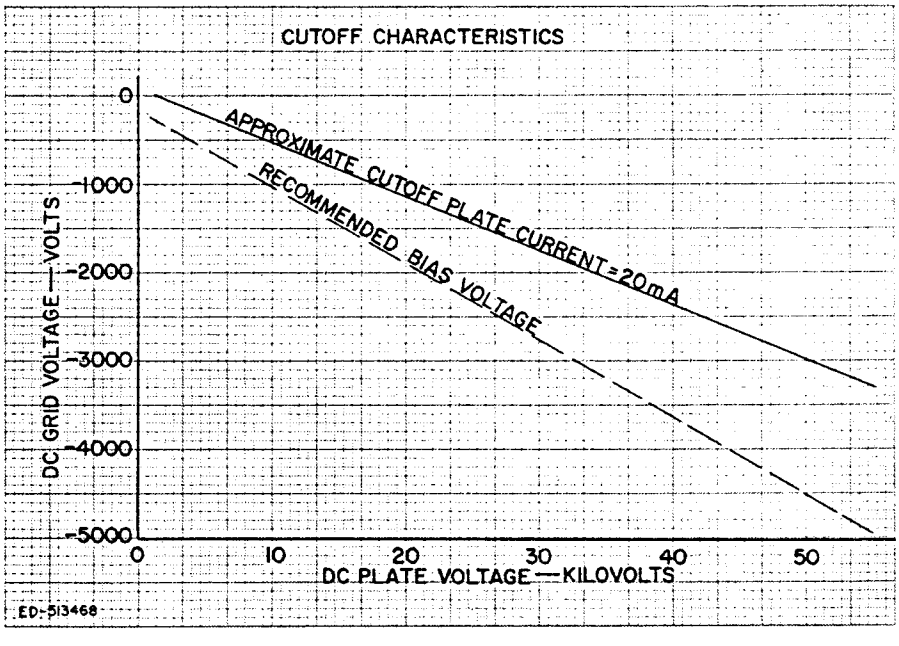
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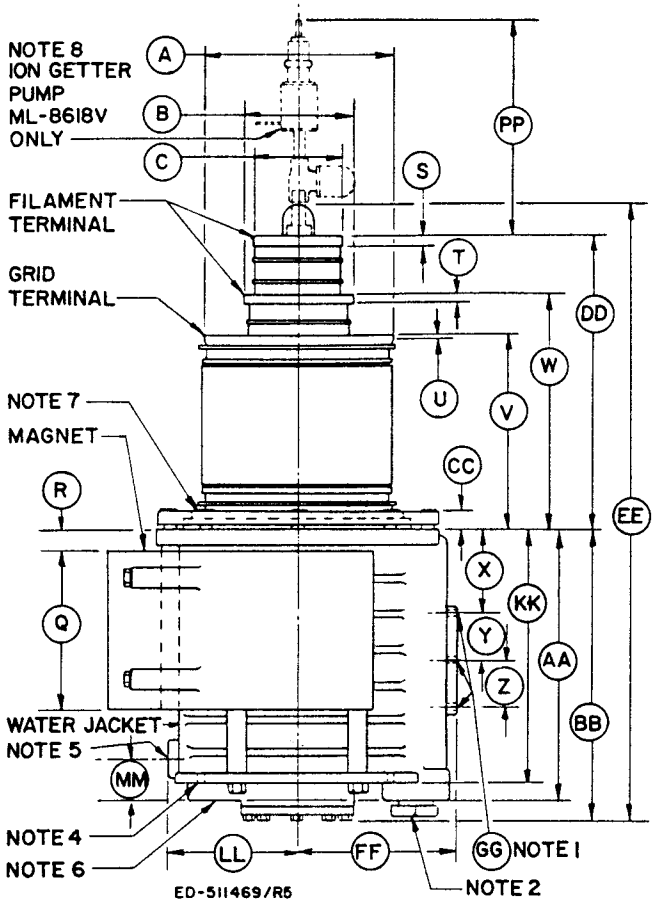
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29,* 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press, 1,* 6, 1954.

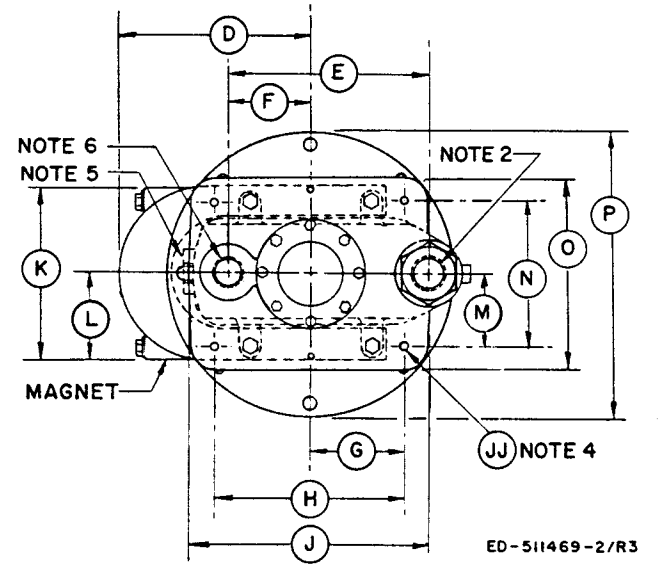

CONSTANT CURRENT CHARACTERISTICS
Ef = 7.5V
ib = PLATE CURRENT IN AMPS.
ic = GRID CURRENT IN AMPS.
ic = 8a
6
4
3
2
1.5
ib = 180a
160
140
1.0
120
0.5
100
80
60
40
20
10
5
1
.02
2400
2200
2200
1800
1600
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
GRID VOLTAGE — VOLTS
0 1 2 3 4 5 6 7 8 9 10
PLATE VOLTAGE — KILOVOLTS
ED-510631/R2


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 7.5 V
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE IN VOLTS
ec = 2000 V
1800
1600
1400
1200
1000
800
600
400
200
100
0
ec = 1800 V
1600
1400
1200
1000
800
PEAK PLATE CURRENT — AMPERES
PEAK GRID CURRENT — AMPERES
PLATE VOLTAGE — KILOVOLTS
0
20
40
60
80
100
120
140
160
180
200
220
240
260
0
1
2
3
4
5
6
7
8
9
10
ED-510442/R3


WATER COOLING CHARACTERISTICS
MINIMUM RATE OF WATER FLOW—GPM
0
10
20
30
40
50
PLATE DISSIPATION—KILOWATTS
0
10
20
30
40
50
60
70
80
WATER JACKET PRESSURE DROP—PSI
0
2
4
6
8
10
WATER FLOW—GPM
0
10
20
30
40
50
ED-513469


CUTOFF CHARACTERISTICS
DC GRID VOLTAGE—VOLTS
0
-1000
-2000
-3000
-4000
-5000
APPROXIMATE CUTOFF PLATE CURRENT=20mA
RECOMMENDED BIAS VOLTAGE
0
10
20
30
40
50
DC PLATE VOLTAGE—KILOVOLTS
ED-513468





DIMENSIONS FOR OUTLINE OF ML-8618 AND ML-8618V

Ref	Inches			Notes
	Minimum	Nominal	Maximum	
A	6.917	6.937	6.957	3
B	3.985	4.005	4.025	3
C	3.298	3.318	3.338	3
D	—	7.00	7.50	
E	7.28	7.34	7.40	
F	2.94	3.00	3.06	
G	3.47	3.50	3.53	
H	6.97	7.00	7.03	
J	—	8.88	9.10	
K	—	6.75	6.95	
L	—	3.38	3.48	
M	2.66	2.69	2.72	
N	5.35	5.38	5.41	
O	—	7.00	7.20	
P	—	10.56	10.80	
Q	—	6.00	6.20	
R	.62	.82	1.02	
S	.31	.38	—	
T	.31	.38	—	
U	.10	.13	—	
V	7.17	7.27	7.37	
W	8.61	8.76	8.91	
X	2.75	2.95	3.15	
Y	1.66	1.69	1.72	
Z	1.66	1.69	1.72	
AA	9.90	10.10	10.30	
BB	10.53	10.73	10.93	
CC	.64	.69	.74	
DD	10.74	10.94	11.14	
EE	—	22.86	23.20	
FF	5.72	5.92	6.12	
GG	.30	.38	—	1
JJ	.302	.312	.322	4
KK	9.40	9.60	9.80	
LL	4.49	4.69	4.89	
MM	1.21	1.41	1.61	
PP	—	8.25	8.75	

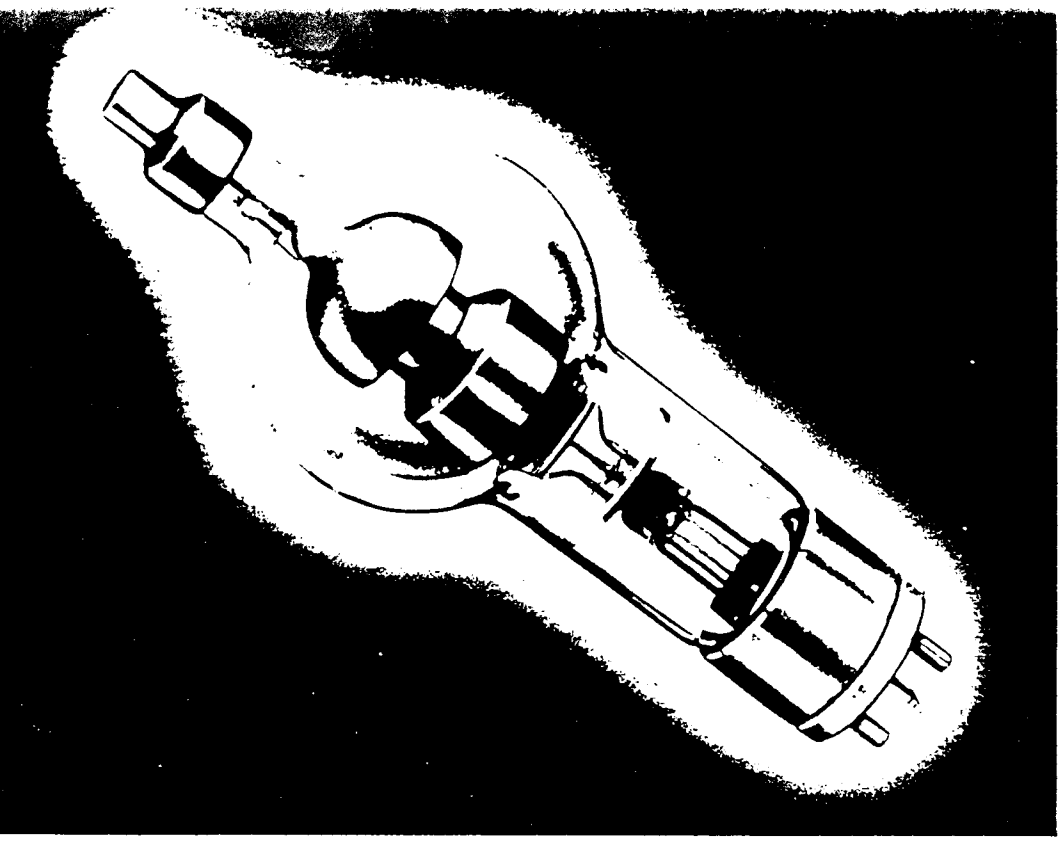
NOTES:

1. Three holes, ¼-20 tap, (GG) inches deep, for plate connection.
2. Water outlet, 1″ NPT tap.
3. Add ± .01″ to maximum and minimum for out-of-roundness.
4. Four through holes diameter (JJ) for stand-off insulator mounting.
5. Connection for pressure relief valve, ½″ NPT tap.
6. Water inlet, 1″ NPT tap.
7. Hold-down ring holds tube in water jacket. Fastened by eight screws.
8. Vac Ion pump, Varian No. 913-0035 (modified) or equivalent and magnet, Varian No. 913-0011 supplied with ML-8618V tube only.

OUTLINE OF ML-8618 AND ML-8618 V

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ST-2609 5M 7-73



MACHLETT

ML-869B

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-869B is a two-electrode, mercury-vapor tube designed for use as a half-wave rectifier in radio transmitting and r.f. heating equipment. Unique features, including low internal voltage drop and cathode design permitting in-phase or quadrature filament excitation, contribute to efficient and economical operation. Maximum ratings of 20 PKV inverse anode voltage and 2.5 amperes average anode current apply at frequencies of 25 to 150 cycles per second.

GENERAL CHARACTERISTICS

Electrical	
Filament Voltage	5 Volts
Filament Current	19 Amperes
Filament Heating Time, Minimum*	1 Minute
Tube Voltage Drop, approximate	15 Volts
Critical Anode Voltage	100 Volts
Mechanical	
Mounting Position	Vertical, Base Down
Type of Cooling	Convection or Forced-Air
Base	3-Pin Jumbo, RMA No. A3-20
Cap	Skirted Large, RMA No. C1-9
Net Weight, approximate	1½ Pounds

* Before applying anode voltage, sufficient time must be allowed to bring the condensed mercury temperature, measured at top edge of base, within the specified range.

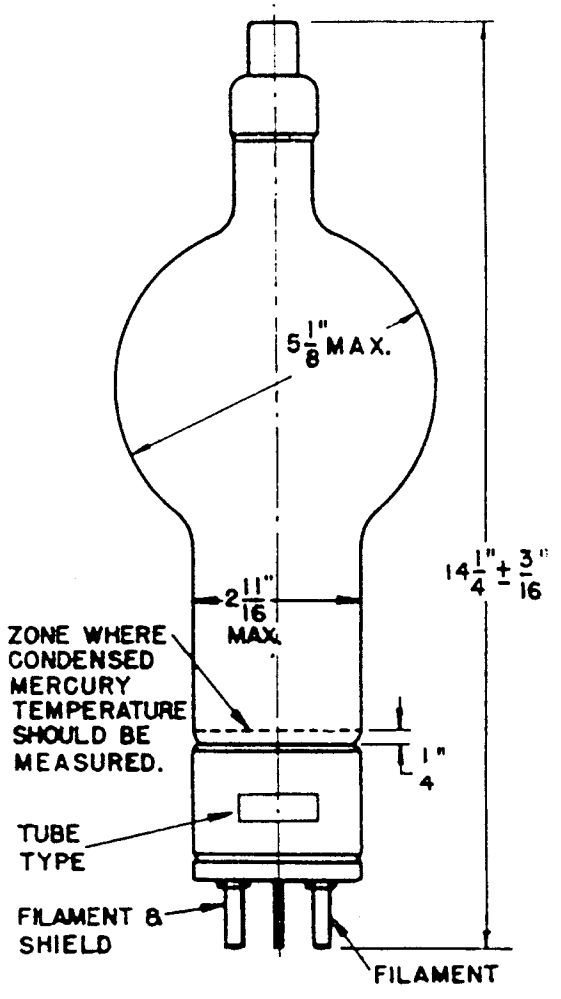
MAXIMUM RATINGS

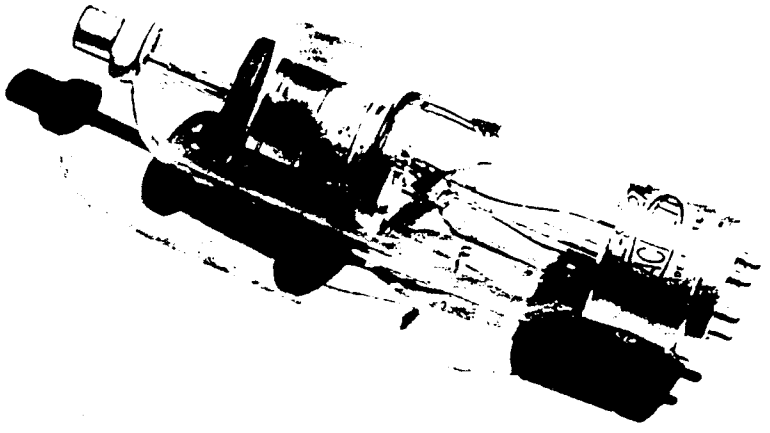
In-Phase Filament Excitation		
Maximum Peak Inverse Anode Voltage		
Type of Cooling	Convection	Forced-Air
150 Cycles or Less	10000	20000 Volts
Condensed Mercury Temperature Range	30-60	30-40 °C
Maximum Anode Current		
Instantaneous, 25 to 150 Cycles	10.0 Amperes	
Average, 30 Seconds Averaging Time	2.5 Amperes	
Surge, for Design Only	100.0 Amperes	
Duration of Surge Current	0.1 Second	

Quadrature Filament Excitation**

Maximum Peak Inverse Anode Voltage	
Type of Cooling	Forced-Air
150 Cycles or Less	15000 Volts
Condensed Mercury Temperature Range	30-40 °C
Maximum Anode Current	
Instantaneous, 25 to 150 Cycles	20.0 Amperes
Average, 30 Seconds Averaging Time	5.0 Amperes
Surge, for Design Only	100.0 Amperes
Duration of Surge Current	0.1 Second

**Filament current 90° ± 30° out of phase with anode current.





MACHLETT

ML-872A
ML-8008

DESCRIPTION & RATINGS

DESCRIPTION

The ML-872A and ML-8008 are two-electrode mercury-vapor tubes designed for use as half-wave rectifiers in radio-transmitting and r.f. heating equipment. Low internal voltage drop, permitting the tube to conduct at relatively low applied voltages, contributes to efficient operation. Both tubes are identical with respect to characteristics, differing only in the types of bases provided. Maximum ratings of 10 PKV inverse anode voltage and 1.25 amperes average anode current apply at frequencies of 25 to 150 cycles per second.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	5	Volts
Filament Current	7.5	Amperes
Filament Heating Time, Minimum*	30	Seconds
Tube Voltage Drop, approximate	10	Volts

Mechanical

Mounting Position	Vertical, Base Down
Type of Cooling	Convection
Base, ML-872A	Super-Jumbo, 4-Pin Bayonet, RMA No. A4-29
ML-8008	Super-Jumbo, 4-Pin Bayonet, RMA No. A4-18
Cap	Medium Metal, RMA No. C1-5
Net Weight, approximate	½ Pound

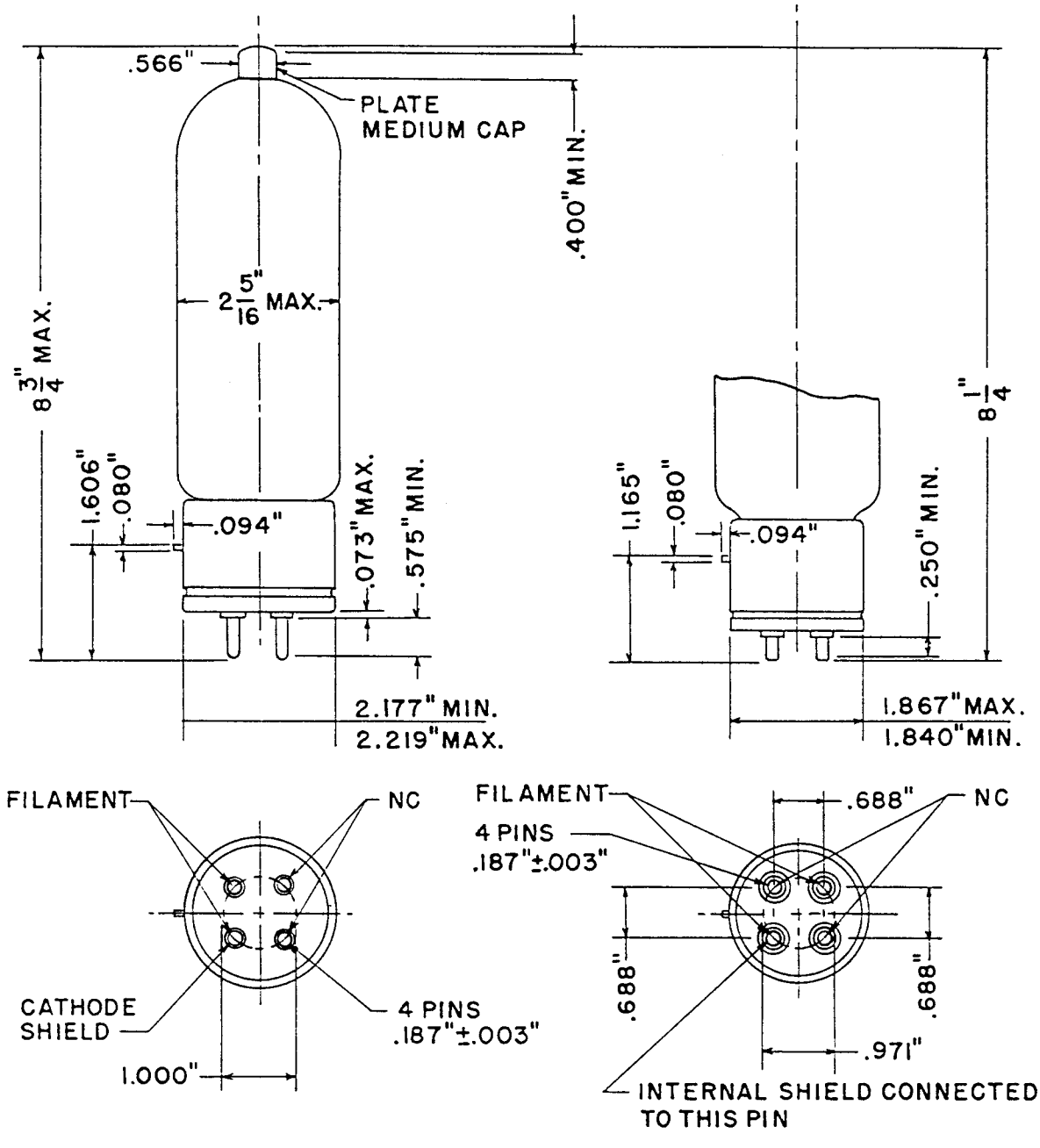
* Before applying anode voltage, sufficient time must be allowed to bring the condensed mercury temperature, measured at the top edge of the base, within the specified range.

MAXIMUM RATINGS

Maximum Peak Inverse Anode Voltage			
150 Cycles or Less	5000	10000	Volts
Condensed Mercury Temperature Range	20-70	20-60	°C
Maximum Anode Current			
Instantaneous, 25 to 150 Cycles	5.0	Amperes	
Average, 15 Seconds Averaging Time	1.25	Amperes	
Surge, for Design Only	50.0	Amperes	
Duration of Surge Current	0.3	Second	

APPLICATION NOTES

Shielding and r.f. filter circuits should be isolated from the transmitter or r.f. heating equipment as much as possible in order to avoid the detrimental effects of magnetic and electro-static fields. These fields tend to produce breakdown in the mercury vapor, are detrimental to tube life, and make filtering difficult. External shielding should be used when the tubes are in proximity to these external fields. R-f filtering should be used when the tubes are affected by r-f voltages. When shields are used, special attention must be given to adequate ventilation and to maintenance of normal condensed-mercury temperature.



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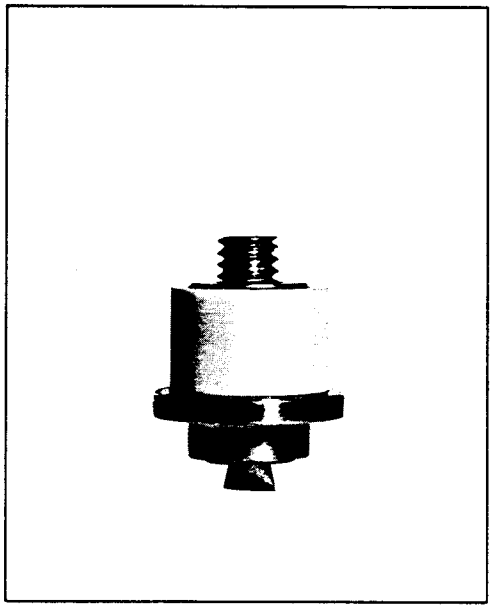
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ISSUED 9-66

ML-8741

MACHLETT

Miniature UHF Planar Triodes

CW, Plate or Grid Pulsed
Low Grid-Plate Capacitance
Phormat Cathode
High Cathode-Current Capability

DESCRIPTION

The ML-8741 is a ruggedized, high-mu planar triode of ceramic-and-metal construction, designed for use as a grid-pulsed, plate-pulsed or CW oscillator, frequency multiplier, or amplifier in radio transmitting service from low frequency to 3 GHz. With its low grid-plate capacitance, the tube is especially suitable for use in wide-band amplifiers.

Distinguishing characteristics of this tube are its miniaturization, high cathode-current capability, high transconductance and high mu. Also, the tube employs a Phormat type cathode, which consists of an indirectly heated disc with an oxide coating impregnated in a nickel matrix. This construction, in combination with proper plate series impedance, reduces to a minimum failures of the cathode due to voltage surges.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical

Heater Voltage (AC or DC)	6.3	V
Heater Current at 6.3 Volts	1.30	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	80	
Transconductance (I_k=200mA/cm²)	38000	μmhos
Interelectrode Capacitance, without Heater Voltage		
Gride-Plate	1.7	pf
Gride-Cathode	9.5	pf
Plate-Cathode, maximum	.065	pf

Mechanical

Mounting Position	Optional	
Type of Cooling		
With radiator	Forced Air	
Without radiator	Conduction & Convection	
Envelope Temperature, maximum	250	°C
Net Weight		
With radiator	45	g
Without radiator	20	g

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CW RF Power Oscillator and Amplifier Class C

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−400	v
Grid positive to cathode	30	v
DC Plate Current	250	mA
DC Grid Current	45	mA
Plate Dissipation		
Forced-air cooling with radiator	150	W
Conduction and convection	10	W†
Grid Dissipation	1.5	W
Frequency	2.5	GHz
Typical Operation, Power Amplifier		
Frequency	500	MHz
Filament Voltage	6.0	V
DC Plate Voltage	900	V
DC Grid Voltage	−30	V
DC Plate Current	140	mA
DC Grid Current, approximate	40	mA
Driving power, approximate	9	W
Useful Power Output	65	W

Grid-Pulsed or Plate-Pulsed RF Oscillator or Amplifier — Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-pulsed, DC	2500	V
Plate-pulsed, peak pulse supply	3500	v
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	250	v
Average Plate Current	16	mA
Average Grid Current	6	mA
Pulse Plate Current	5	a
Average Plate Dissipation		
Forced-air cooling with radiator	60	W
Conduction and convection	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††
Frequency	3	GHz
Typical Operation, Grid-Pulsed RF Amplifier		
Frequency	1.1	GHz
Filament Voltage	6.3	V
Pulse Duration	3.5	μs
Duty Factor	.001	
DC Plate Voltage	2000	V
DC Grid Voltage	−70	V
Peak Plate Current from DC Supply	3.0	a
Peak Grid Current from Pulse Supply	1.0	a
Driving Power During Pulse, approximate	400	W
Useful Peak Power Output, approximate	2.5	kw

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	3500	V
Peak Plate Voltage	5000	v
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	110	v
DC Plate Current	150	mA
Pulse Cathode Current	7.5	a
Average Plate Dissipation		
Forced-air cooling with radiator	150	W
Conduction and convection	10	W†
Average Grid Dissipation	1.5	W
Pulse Duration	6	μs††
Duty Factor	.0033	††

†Greater plate dissipation will be possible with the ML-8741 when the tube is used with an appropriately designed heat sink.

††For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Filament Current at 6.3 V (Note 1)	1.20	1.40	A
Cut-Off Bias (Note 2)	—	−30	Vdc
Grid-Plate Capacitance (Note 3)	1.55	1.85	pf
Grid-Cathode Capacitance (Note 3)	8.50	10.50	pf
Plate-Cathode Capacitance (Note 3)	—	.065	pf

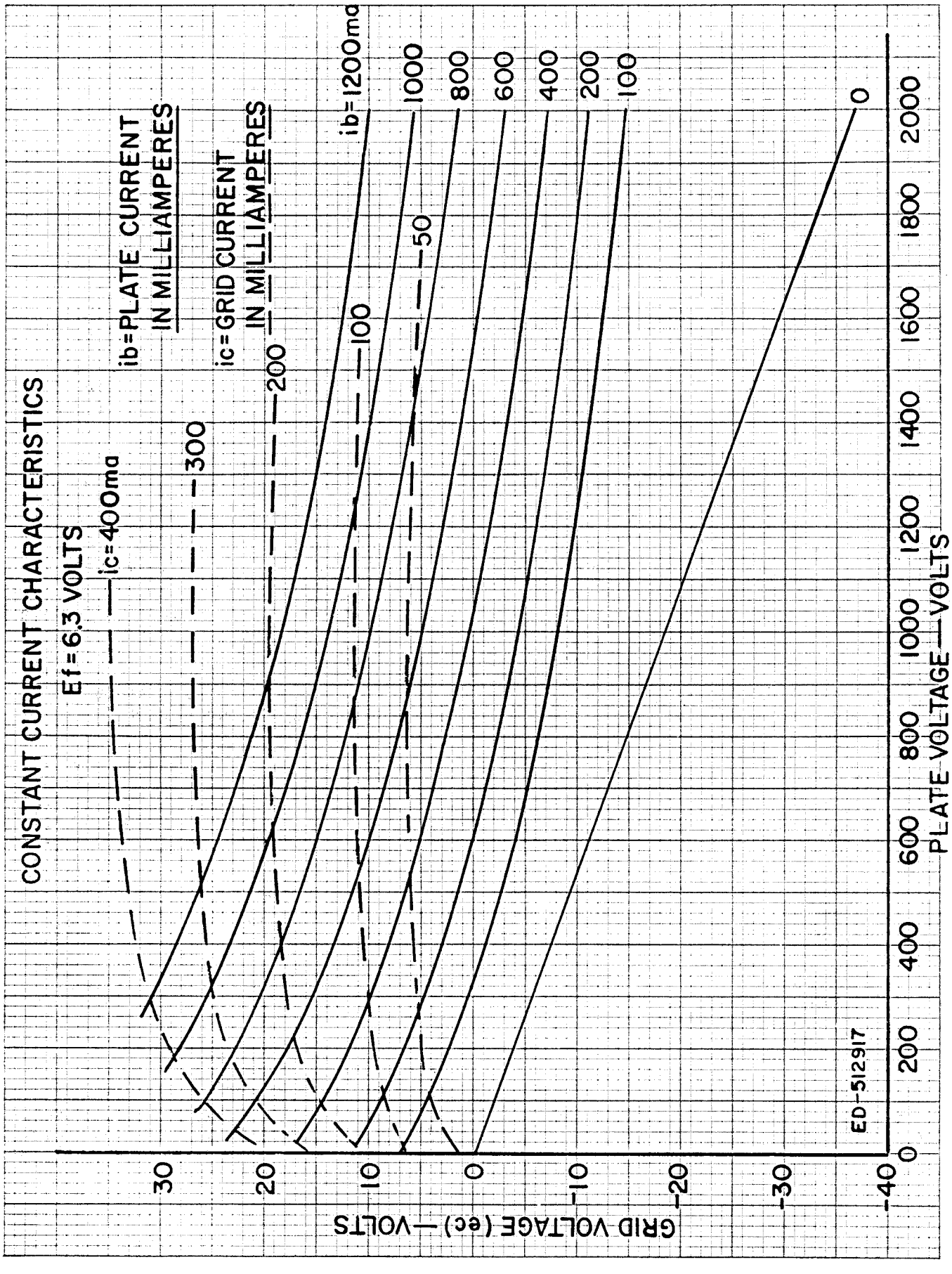
Note 1 — For reduced filament voltage see "Heater Voltage" section in *Application Notes.*

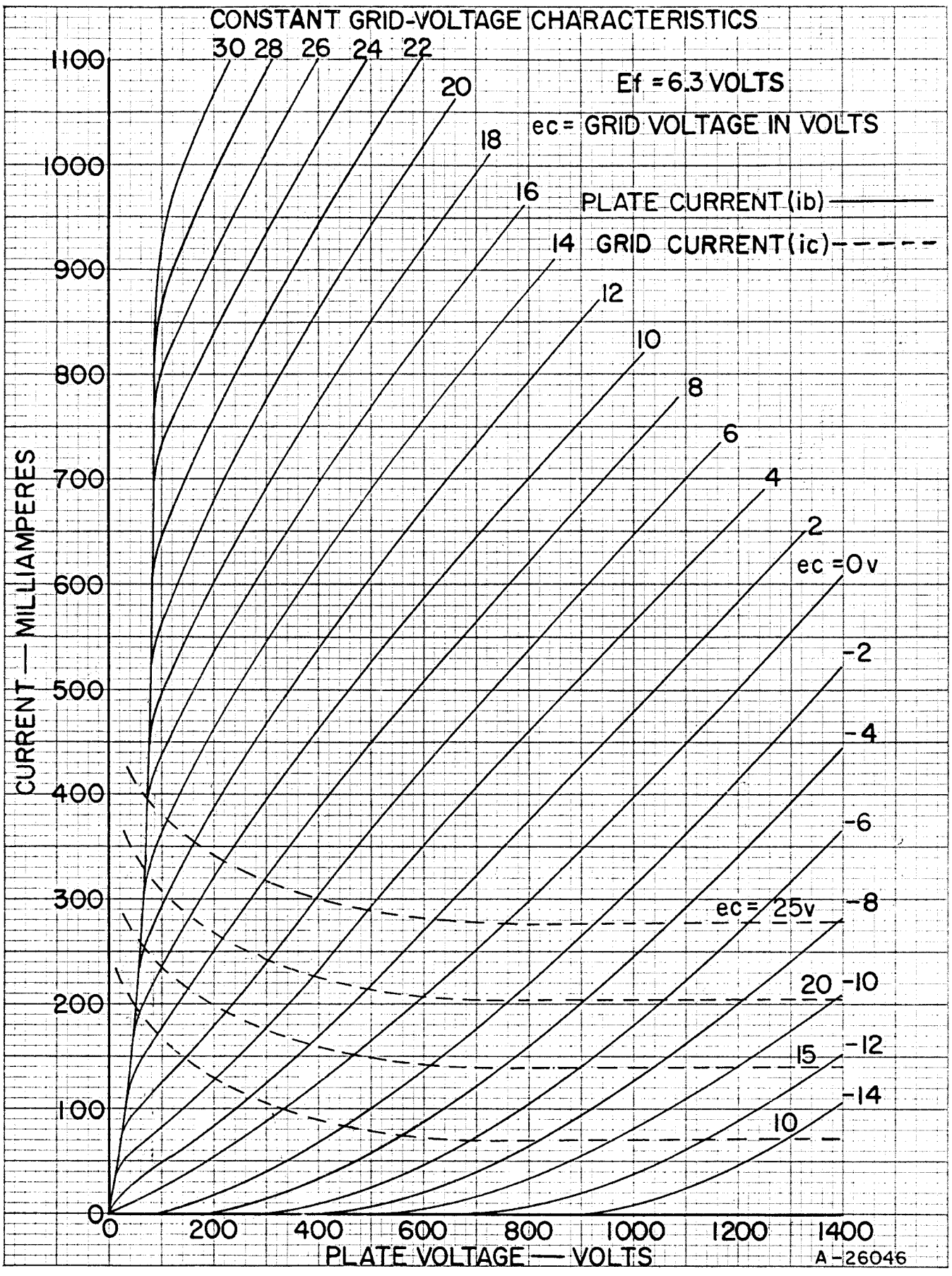
Note 2 — Measured with 1 mA plate current and a plate voltage of 1000 Vdc.

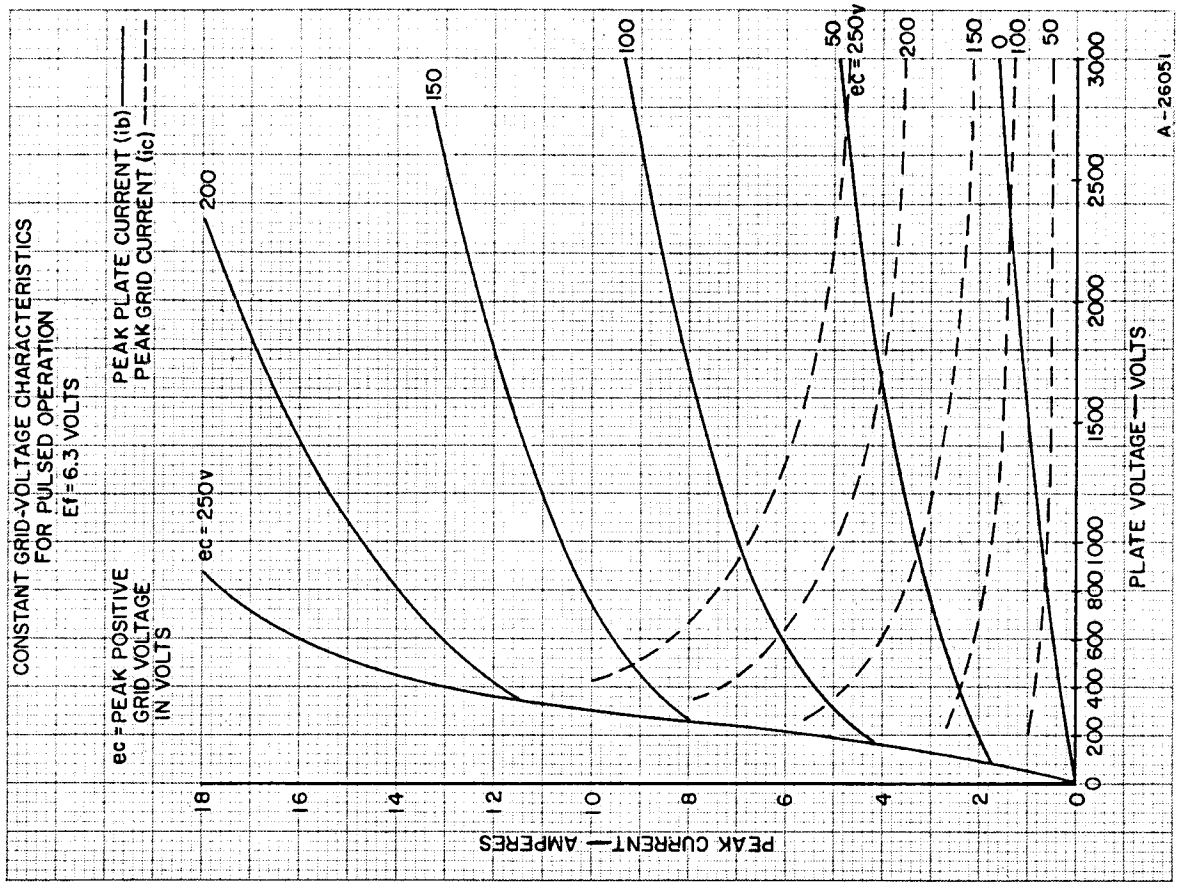
Note 3 — Capacitance values are given for a cold tube. When the filament is heated to its proper temperature, the grid-cathode capacitance will increase by approximately 1 pf due to thermal expansion of the cathode.

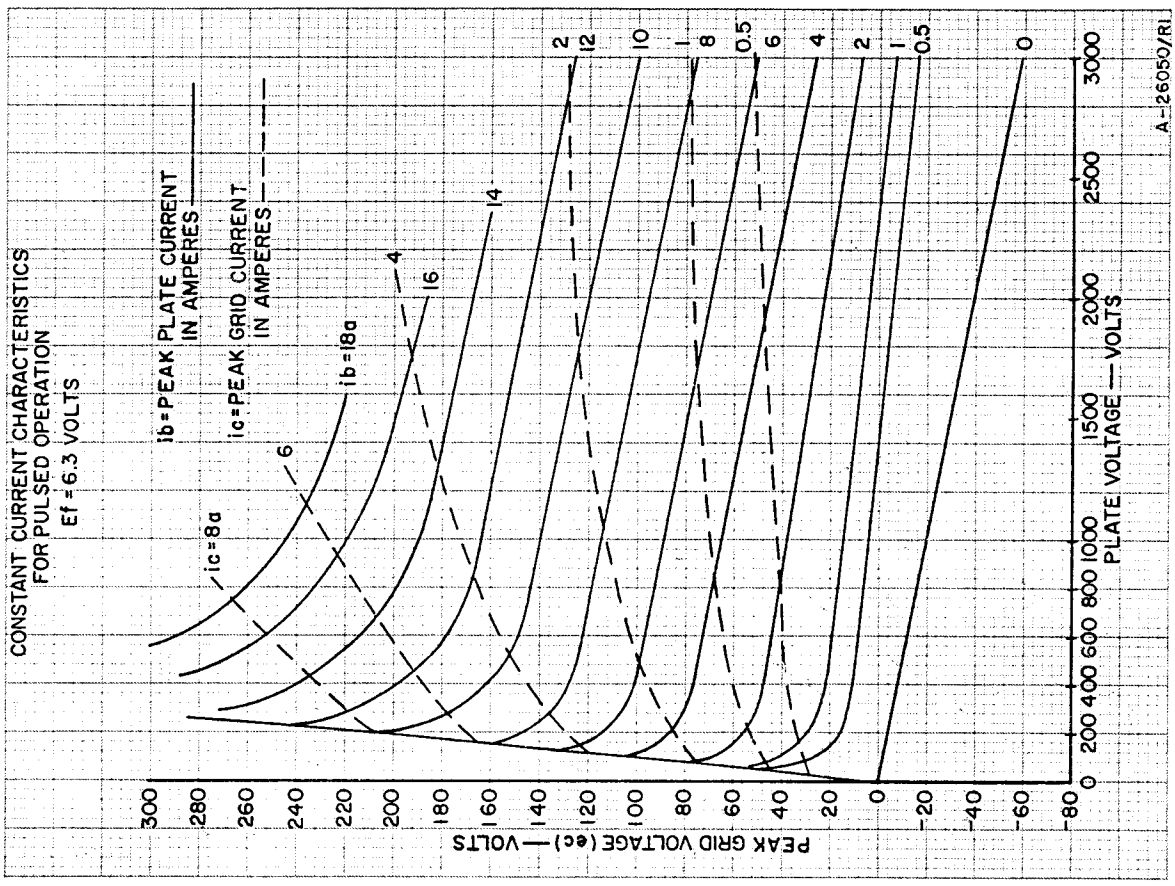
APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes —General.*


CONSTANT CURRENT CHARACTERISTICS
Ef = 6.3 VOLTS
ic = 400ma
300
200
100
50
ib = PLATE CURRENT IN MILLIAMPERES
ic = GRID CURRENT IN MILLIAMPERES
ib = 1200ma
1000
800
600
400
200
100
0
GRID VOLTAGE (ec) — VOLTS
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PLATE VOLTAGE — VOLTS
ED-512917


CONSTANT GRID-VOLTAGE CHARACTERISTICS
30 28 26 24 22
20
18
16
14
12
10
8
6
4
2
ec = 0v
-2
-4
-6
-8
-10
-12
-14
Ef = 6.3 VOLTS
ec = GRID VOLTAGE IN VOLTS
PLATE CURRENT (ib)
GRID CURRENT (ic)
ec = 25v
20
15
10
CURRENT — MILLIAMPERES
0
100
200
300
400
500
600
700
800
900
1000
1100
0
200
400
600
800
1000
1200
1400
PLATE VOLTAGE — VOLTS
A-26046

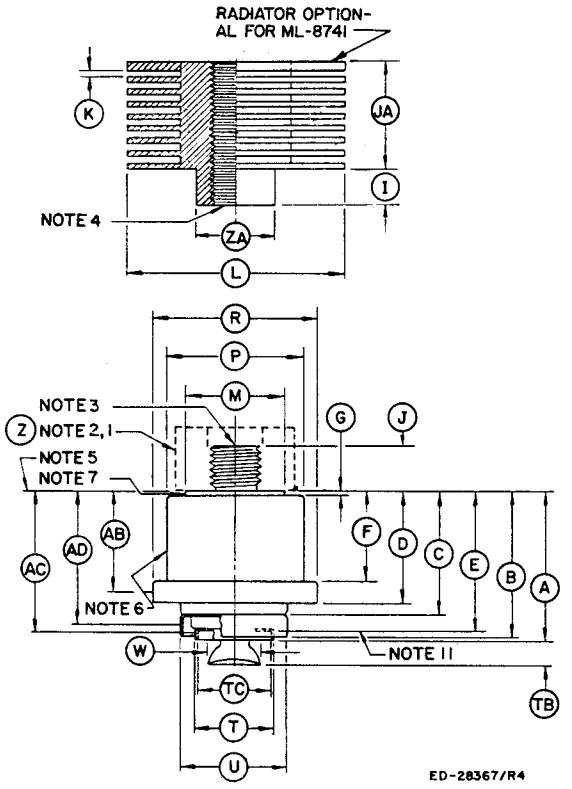

CONSTANT GRID-VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
ec = PEAK POSITIVE GRID VOLTAGE IN VOLTS
PEAK PLATE CURRENT (ib) ——
PEAK GRID CURRENT (ic) — — —
ec = 250v
200
150
100
50
ec = 25v
200
150
100
50
0
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
A-26051


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.3 VOLTS
ib = PEAK PLATE CURRENT IN AMPERES ——
ic = PEAK GRID CURRENT IN AMPERES — — —
ic = 8a
6
ib = 18a
4
16
14
2
12
10
1
8
0.5
6
4
2
1
0.5
0
PEAK GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — VOLTS
A-26050/R1

DIMENSIONS FOR OUTLINE OF ML-8741

The millimeter dimensions are derived from the original inch dimensions.

Ref	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	.845		.909	21.46		23.09	
AB	.559	.598	.637	14.20	15.19	16.18	1, 8
AC	.795	.815	.835	20.19	20.70	21.21	1, 10
AD	.738	.778	.818	18.75	19.76	20.78	1, 9
B	.825		.875	20.96		22.22	
C	.702		.740	17.83		18.80	
D	.640		.669	16.26		16.99	
E	.782		.837	19.86		21.26	
F	.520		.537	13.21		13.64	
G	.022		.040	.56		1.02	
I	.192		.208	4.88		5.28	
J	.240		.275	6.10		6.98	
JA	.585		.635	14.86		16.13	
K	.028		.045	.71		1.14	
L	1.235		1.265	31.37		32.13	
M	.565		.580	14.35		14.73	
P	.775		.785	19.68		19.94	
R	.935		.950	23.75		24.13	1, 8
T	.440		.460	11.18		11.68	1, 10
TB			.250			6.35	
TC	.410		.425	10.41		10.80	
U	.595		.607	15.11		15.42	1, 9
W			.313			7.95	
Z			.015			.38	1
ZA	.440		.460	11.18		11.68	



NOTES:

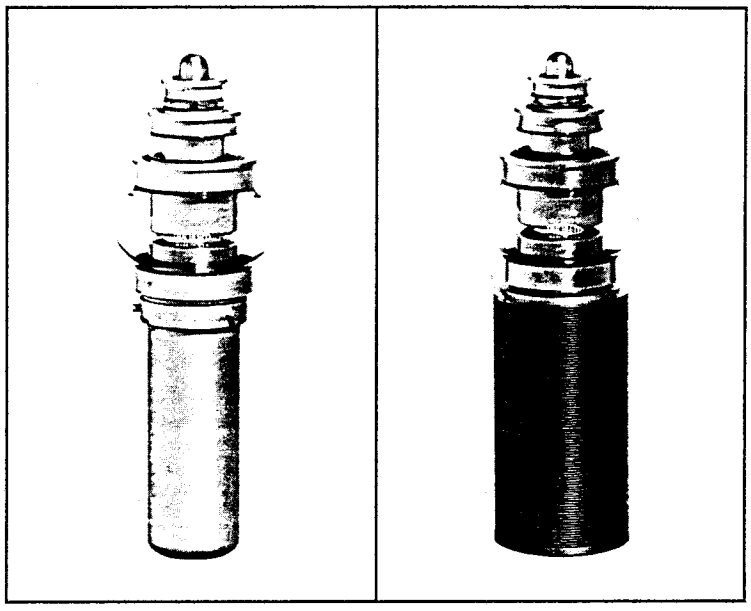
1. The total indicated runout of the grid-contact surface (Note 8), the cathode-contact surface (Note 9) and the heater-contact surface (Note 10) will not exceed (Z). This measurement is made with the gage (Note 2) screwed on the anode thread (Note 3) so that the face of the gage makes full contact with the reference surface (Note 5). Runout is then measured with the gage chucked on the measurement reference axis.
2. See outline. Machlett gage No. S-L5. Details will be supplied upon request.
3. See outline. Anode, 5/16 — 24 UNF-2A thread.
4. See outline. 5/16 — 24 UNF-2B thread. Use 5/16-24 bolt in this hole for tube extraction.
5. See outline. Reference surface. The tube shall be stopped only by this surface when screwed in the socket.
6. See outline. Insulating envelope. Do not clamp or locate on this surface.
7. See outline. Measure anode temperature on this surface.
8. Grid-contact surface and reference dimension for eccentricity measurement, defined by dimensions (R) and (AB).
9. Cathode- or heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (U) and (AD).
10. Heater-contact surface and reference dimension for eccentricity measurement, defined by dimensions (T) and (AC). See also Note 11.
11. See outline. Alternate heater-contact surface. Heater contact can be made to the bottom of the heater terminal-cup by means of a coil spring having a maximum coil OD of .390 inch and a minimum coil ID of .320 inch, or some similar device.

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ISSUED 4-68



ML-8772
ML-8773

MACHLETT

Pulse Modulating Triodes

4.5 Mw Pulse Power

DESCRIPTION

The ML-8772 and ML-8773 are triodes which are rated to operate as switch tubes in hard-tube pulse modulators for radar and similar applications. These tubes feature rugged coaxial mounting structures providing high-dissipation, low-inductance electrode terminals. The cathode of each type consists of sturdy, self-supporting, stress-free, thoriated-tungsten filaments.

The ML-8772 has a water-cooled, heavy-wall anode capable of dissipating 60 kW. The ML-8773 has a forced-air-cooled, heavy-wall anode with high-effciency disc fins capable of dissipating 35 kW.

These tubes will operate with plate voltages up to 40 kV in pulse modulator service. In a typical application these tubes are capable of switching 4.5 Mw.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	13.0 V
Filament Current	205 A
Filament Starting Current, maximum	800 A
Filament Cold Resistance	.0073 Ohm
Amplification Factor	20
Interelectrode Capacitances	
Grid-Plate	55 pf
Grid-Filament	76 pf
Plate-Filament	2.7 pf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling — ML-8772	Water and forced-air†
Water flow on anode for 60 kW dissipation, approx.	18 gpm
Maximum outgoing water temperature	70 °C
Type of Cooling — ML-8773	Forced-air
Air flow on anode for 35 kW dissipation — Pressure:	1700 cfm at 7.8" water*
Exhaust:	1970 cfm at 8.4" water*
Maximum incoming air temperature	50 °C
Maximum Envelope Temperature	165 °C†
Net Weight, approximate	
ML-8772	17 lb
ML-8773	43 lb

*When used with ML-8773 air distributor F-17759.

†Auxiliary air flow of 50-100 cfm is required and should be distributed to maintain a uniform glass temperature, not greater than 165°C, around the circumference of the seals. At high ambient temperature, additional air flow may be required.

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray sources."

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values‡		
DC Plate Voltage	40	kV
Peak Plate Voltage	45	kv
Peak Negative Grid Voltage	−7500	v
Pulse Cathode Current	175	a
Grid Dissipation	1000	W
Plate Dissipation		
ML-8772	60	kW
ML-8773	35	kW
Pulse Duration, approximate	1000	μs#
Duty Factor	.01	#
Typical Operation		
DC Plate Voltage	35	kV
DC Grid Voltage	−2700	V
Pulse Positive Grid Voltage	1500	v
Pulse Plate Current	150	a
Pulse Grid Current	25	a
Pulse Driving Power	105	kw
Pulse Power Output	4.5	Mw
Plate Output Voltage	30	kv

‡All given maximum ratings may not apply simultaneously. Due to the possibility of instantaneous overheating of electrodes during the pulse, it may be necessary to restrict some of the parameters, e.g., peak plate current, tube drop, pulse duration, duty or average dissipation, in order not to adversely affect the performance of the tube. Because of the many possible combinations of operating conditions, all restrictions cannot be delineated here, and it is suggested to review new applications with the Machlett Engineering Department.

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

ACCESSORIES

Item	Part No.
Small Filament Connector	F-17489
Large Filament Connector	F-17488
Grid Connector	F-17397
Water Jacket for ML-8772	F-17393
O-Ring Gasket for ML-8772 Water Jacket	P-17494
Mounting Clamp for ML-8772 Water Jacket	P-15198
Mounting Plate for ML-8772 Water Jacket	F-15196
Air Distributor for ML-8773	F-17759
Tube Support for ML-8773	F-17795
Tube Lifting Handle	F-27776

NOTE: For additional information on accessories, refer to Accessory Data Sheet No. ST-1295

TUBE PROTECTION

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

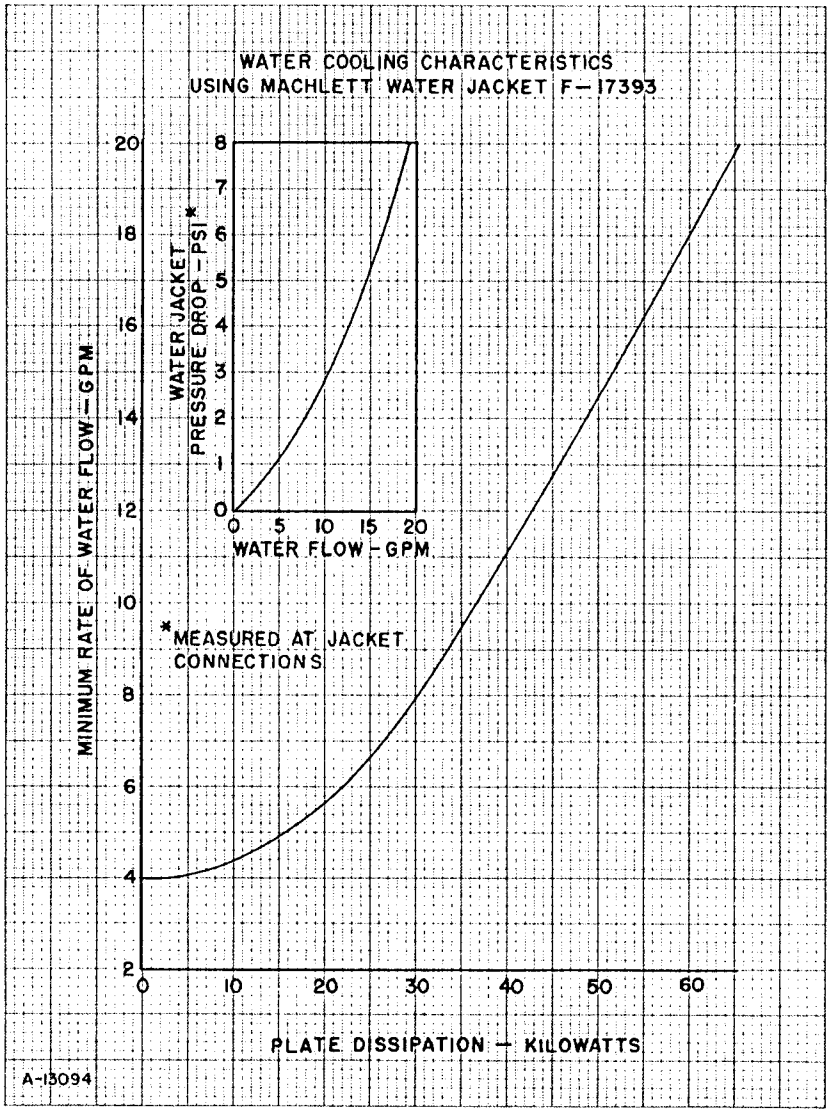
In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

References:

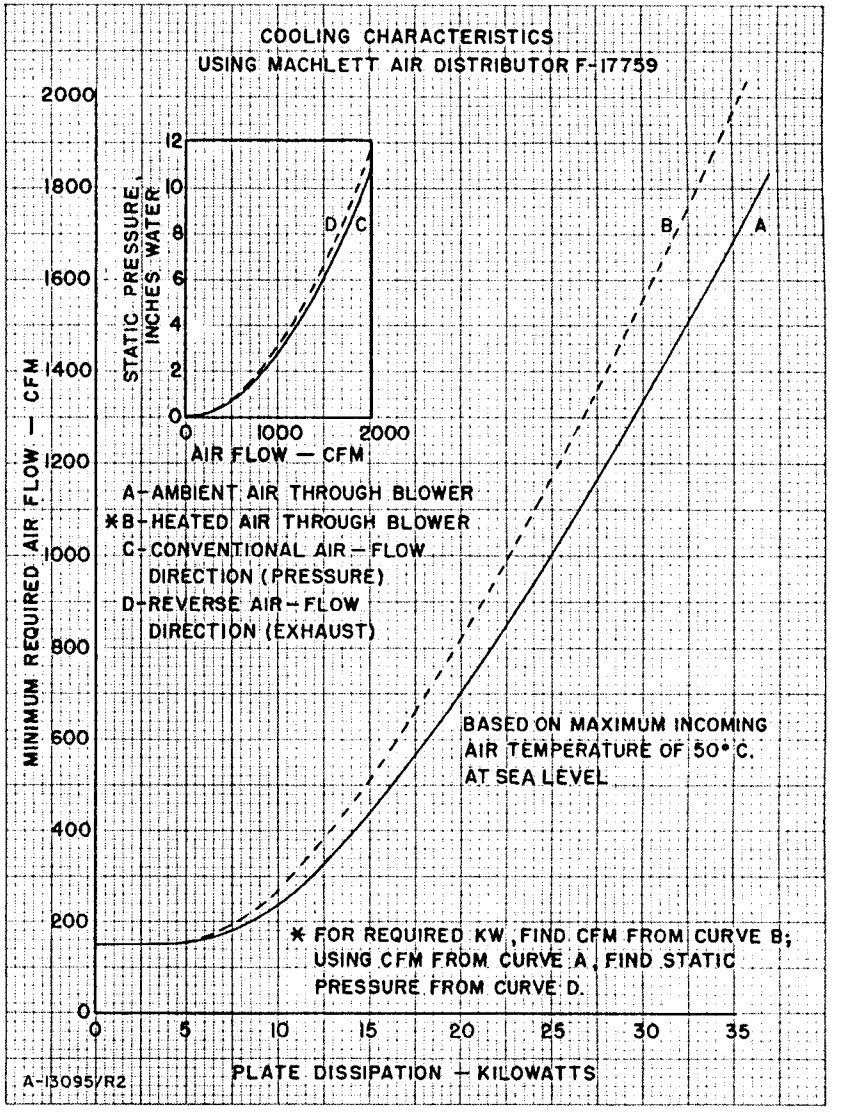
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29,* 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press, 1, 6,* 1954.

MAINTENANCE

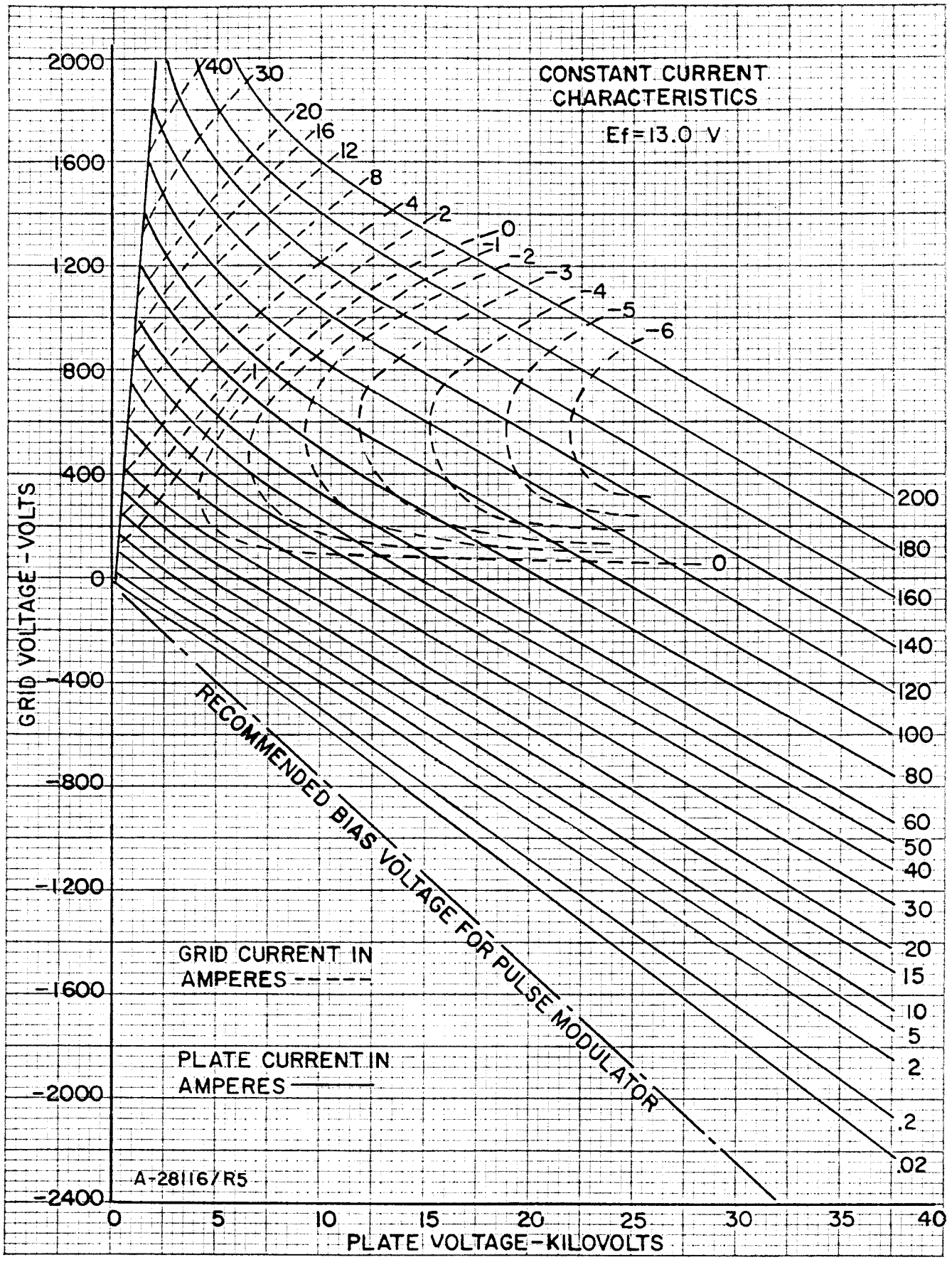
The anode cooling fins of the ML-8773 must be kept free from films of foreign materials, which will impair heat flow. To keep fins clean, it is suggested that ultrasonic cleaning or wire-brushing of the anode cooling surfaces be performed on a routine maintenance basis.

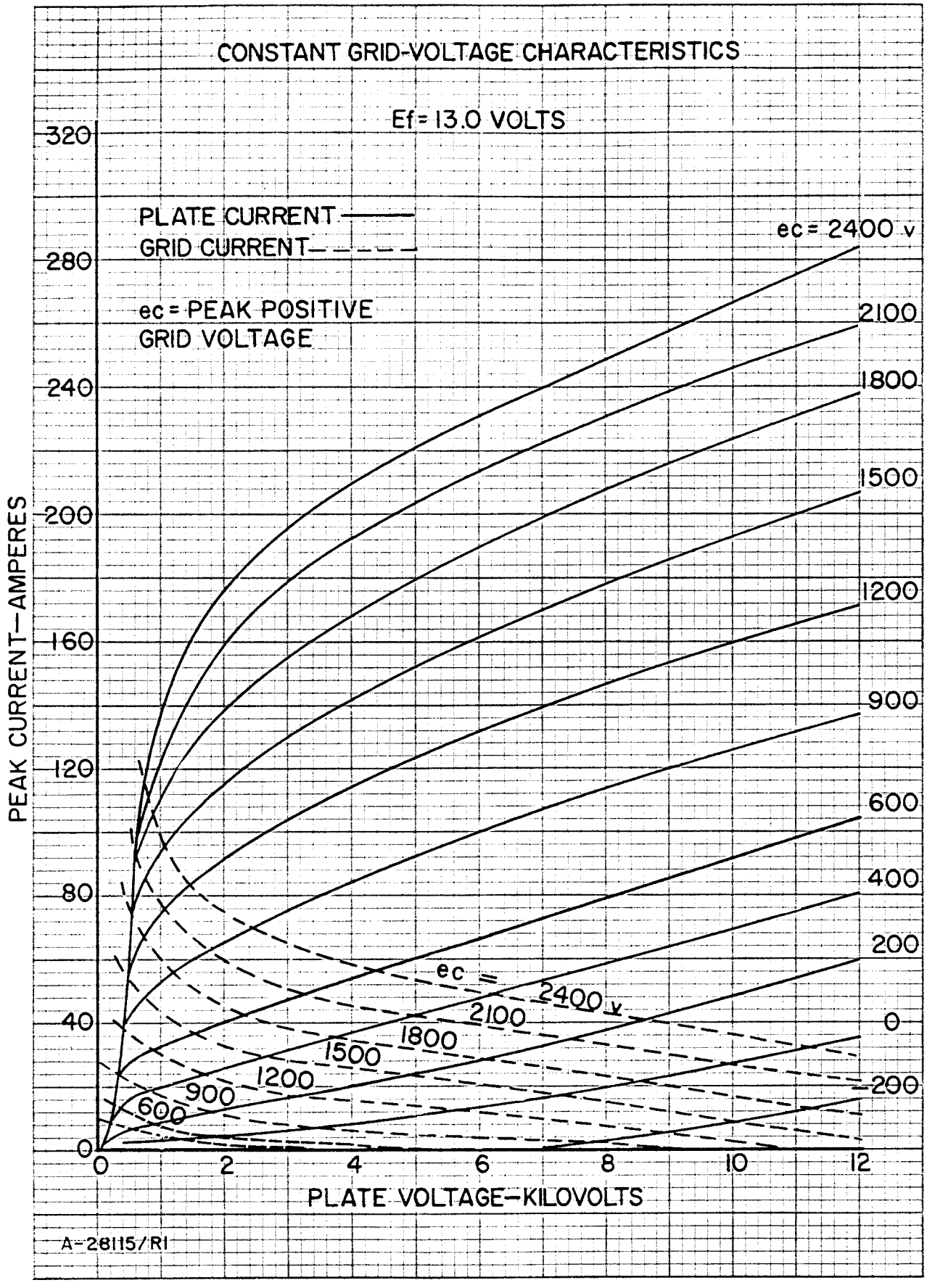


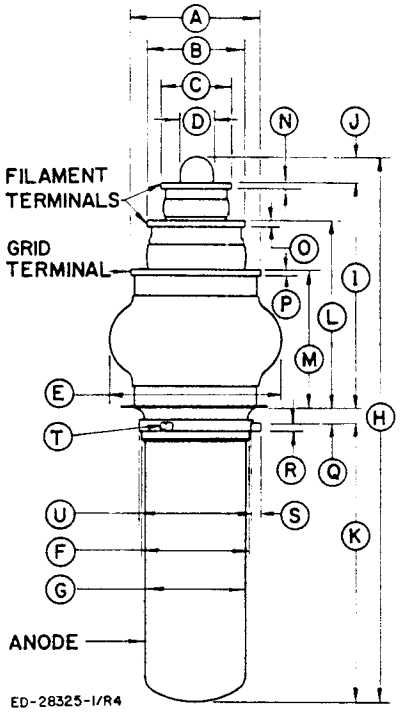
COOLING CHARACTERISTICS — ML-8772



COOLING CHARACTERISTICS — ML-8773


CONSTANT CURRENT CHARACTERISTICS
Ef=13.0 V
GRID VOLTAGE - VOLTS
PLATE VOLTAGE - KILOVOLTS
2000
1600
1200
800
400
0
-400
-800
-1200
-1600
-2000
-2400
0
5
10
15
20
25
30
35
40
40
30
20
16
12
8
4
2
0
-1
-2
-3
-4
-5
-6
200
180
160
140
120
100
80
60
50
40
30
20
15
10
5
2
.2
.02
RECOMMENDED BIAS VOLTAGE FOR PULSE MODULATOR
GRID CURRENT IN AMPERES - - - -
PLATE CURRENT IN AMPERES ——
A-28116/R5


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 13.0 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
PEAK CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
ec = 2400 v
2100
1800
1500
1200
900
600
400
200
0
-200
320
280
240
200
160
120
80
40
0
2
4
6
8
10
12
A-28115/R1

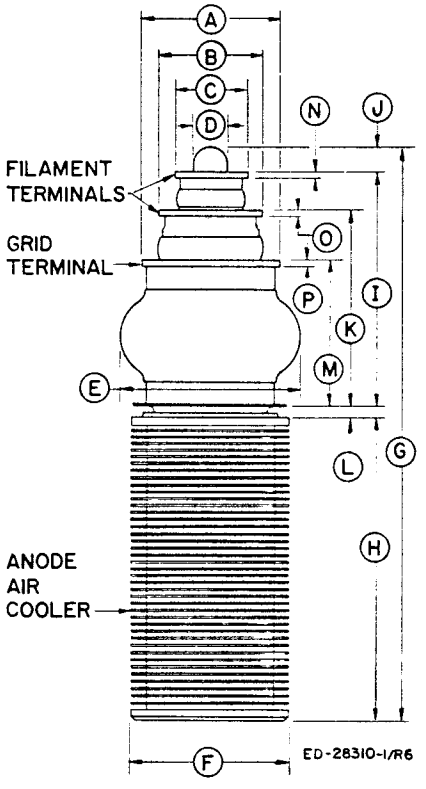


ML-8772

DIMENSIONS FOR OUTLINE OF ML-8772

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.619	4.650	4.681	
B	3.469	3.500	3.531	
C	2.469	2.500	2.531	
D	—	1.12	1.19	
E	—	5.94	6.13	
F	3.990	3.995	4.000	
G	3.485	3.500	3.515	
H	—	19.16	19.38	
I	7.75	7.88	8.00	
J	—	.94	1.00	
K	9.75	9.87	10.00	
L	6.50	6.62	6.75	
M	4.81	4.88	4.94	
N	.12	.18	—	
O	.12	.18	—	
P	.12	.18	—	
Q	.40	.44	.47	
R	.300	.310	.320	1
S	.28	.31	.35	1
T	—	120°	—	1
U	4.00	4.03	4.06	

NOTES:
1. Three bayonet pins for water jacket connection, diameter (R), length (S), nominally (T) degrees apart.



ML-8773

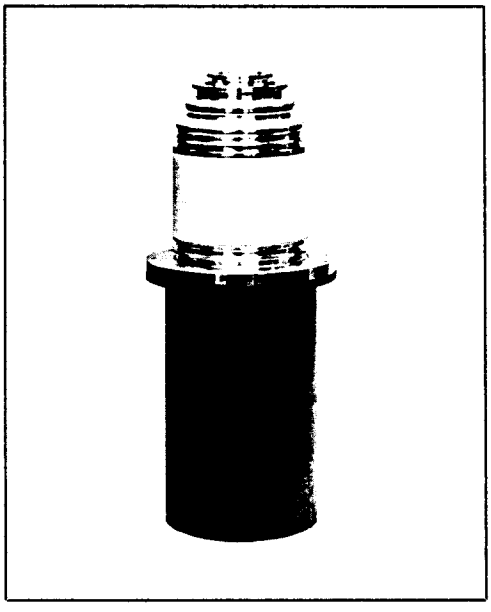
DIMENSIONS FOR OUTLINE OF ML-8773

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	4.619	4.650	4.681	
B	3.469	3.500	3.531	
C	2.469	2.500	2.531	
D	—	1.12	1.19	
E	—	5.94	6.13	
F	5.219	5.250	5.281	
G	—	19.36	19.88	
H	10.00	10.12	10.25	
I	7.75	7.88	8.00	
J	—	.94	1.00	
K	6.50	6.62	6.75	
L	.31	.45	—	
M	4.81	4.88	4.94	
N	.12	.18	—	
O	.12	.18	—	
P	.12	.18	—	

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ISSUED 4-71

ML-8785
ML-8786

MACHLETT

General Purpose Tetrodes
350 kW CW
12.0 Mw Pulsed

DESCRIPTION

The ML-8785 and ML-8786 are general purpose tetrodes capable of 350 kW continuous output as a Class C amplifier or oscillator. The ML-8785 is provided with a vapor-cooled anode; the ML-8786 is water-cooled.

The anodes of both tubes are designed to dissipate 175 kW during continuous operation and substantially higher power during momentary overloads or intermittent operation. Coaxial grid and cathode mounting structures provide low-inductance, high-dissipation rf terminals. The cathode consists of sturdy thoriated-tungsten filaments. Low-loss alumina ceramics are used for all insulation members.

Maximum ratings apply at frequencies up to 30 MHz. Useful power output can be obtained at higher frequencies with an appropriate reduction in ratings.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	15.0	V†
Filament Current	400	A
Filament Starting Current, maximum	1000	A
Filament Cold Resistance	.0043	ohm
Amplification Factor, Control Grid to Screen Grid, approx.	5	
Direct Interelectrode Capacitances		
Control Grid to Plate	6.5	pf
Control Grid to Cathode	240	pf
Control Grid to Screen Grid	390	pf
Plate to Cathode	2	pf
Screen Grid to Plate	130	pf
Screen Grid to Cathode	40	pf
Strapped Resonant Frequencies, approx.		
Screen Grid to Plate	125	MHz
Screen Grid to Control Grid	92	MHz
Control Grid to Cathode	96	MHz

Mechanical

Mounting Position	Anode down	
Type of Anode Cooling, ML-8785	Vaporization of water	
Type of Anode Cooling, ML-8786	Water	
Water flow on anode for 175 kW dissipation, min.	46	gpm*
Maximum outgoing water temperature	70	°C
Maximum water pressure	80	psi
Maximum Envelope Temperature	200	°C
Air Flow on Insulators and Seals, approx.	500	cfm**
Net Weight, approximate		
ML-8785	130	lb
ML-8786	115	lb

†For peak cathode currents in excess of 375 A, filament voltage must be 15.5 V.

*The given water cooling characteristics apply for typical RF and AF operation as given in this data sheet. In specialized applications involving relatively high plate voltages and low plate currents, electron beaming may occur requiring increased water flow rates for cooling. Consult the Machlett Laboratories Engineering Department regarding further cooling information for special applications.

**Air flow should be distributed to maintain a uniform temperature, not greater than 200°C, on the ceramic insulators and the circumference of the seals. At frequencies above 15 MHz, special attention should be given to cooling the seals. At frequencies above 30 MHz, additional air flow may be required to maintain seal temperature below the specified maximum.

WARNING: This electron tube when operated at peak voltages in excess of 15 kv may give off x-rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma Ray Sources".

ACCESSORIES

Item	Part No.
Small Filament Connector	P-510187
Large Filament Connector	P-510188
Control-Grid Connector	P-510206
Screen-Grid Connector	F-27220
Vapor-Cooling Jacket, Vapor-Up System (ML-8785)	P-27899
Vapor-Cooling Jacket, Vapor-Down System (ML-8785)	P-28903
O Ring (ML-8785)	P-25946
One-Tube Dolly	S-16097
Two-Tube Dolly	S-16096

NOTE: Additional information on accessories will be supplied on request.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

RF Power Amplifier or Oscillator Class C Telegraphy

Key-down condition per tube without amplitude modulation.§

Maximum Ratings, Absolute Values			
DC Plate Voltage		18	kV
DC Screen-Grid Voltage		2500	V
DC Control-Grid Voltage		−1200	V
Screen-Grid Dissipation		3000	W
Control-Grid Dissipation		1000	W
Plate Dissipation		175	kW
Typical Operation			
DC Plate Voltage	16	18	kV
Peak RF Plate Voltage	13.5	15.5	kv
DC Screen-Grid Voltage	1500	1500	V
DC Control-Grid Voltage	−900	−1000	V
Peak RF Control-Grid Voltage	1170	1300	v
DC Plate Current	25	25	A
DC Screen-Grid Current	2.0	2.0	A
DC Control-Grid Current	.38	.42	A
Peak Fundamental RF Plate Current	43	45	a
Load Impedance	314	345	ohms
Driving Power, approximate	420	510	W
Plate Dissipation	110	100	kW
Plate Output Power	290	350	kW

Plate-Modulated RF Power Amplifier Class C Telephony

Carrier condition except where noted for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values			
DC Plate Voltage		13	kV
DC Screen-Grid Voltage		2000	V
DC Control-Grid Voltage		−1200	V
Screen-Grid Dissipation		3000	W
Control-Grid Dissipation		1000	W
Plate Dissipation		117	kW
Typical Operation			
DC Plate Voltage	11	13	kV
Peak RF Plate Voltage	9	11	kv
DC Screen-Grid Voltage	750	750	V
DC Control-Grid Voltage	−600	−600	V
Peak AF Screen-Grid Voltage for 100% Modulation	750	750	v
Peak RF Control-Grid Voltage	910	910	v
DC Plate Current	20.8	19.0	A
DC Screen-Grid Current	2.7	2.7	A
DC Control-Grid Current	1.7	1.7	A
Peak Fundamental RF Plate Current	34	34	a
Load Impedance	265	323	ohms
Driving Power, approximate	1430	1430	W
Plate Output Power	153	187	kW
Plate Dissipation	55	60	kW

AF Power Amplifier or Modulator

Class AB

Maximum Ratings, Absolute Values (per tube)			
DC Plate Voltage		18	kV
DC Screen-Grid Voltage		2500	V
DC Control-Grid Voltage		−1200	V
Screen-Grid Dissipation‡		3000	W
Control-Grid Dissipation‡		1000	W
Plate Dissipation‡		175	kW
Typical Operation (Values are for two tubes, sinusoidal wave)			
DC Plate Voltage	16	16	kV
DC Screen-Grid Voltage	1500	1500	V
DC Control-Grid Voltage	−400	−400	V
Peak AF Driving Voltage, per tube	400	575	v
Zero-Signal DC Plate Current	5	6	A
Maximum-Signal DC Plate Current	32	62	A
Maximum-Signal DC Screen-Grid Current	2.0	4.2	A
Maximum-Signal DC Control-Grid Current	0	.31	A
Driving Power	0	167	W
Load Resistance, plate-to-plate	1080	630	ohms
Plate Dissipation, per tube	92	170	kW
Maximum-Signal Plate Output Power	338	658	kW

Linear RF Power Amplifier Class AB Single-Sideband, Suppressed-Carrier Service

Maximum Ratings				
DC Plate Voltage			18	kV
DC Screen-Grid Voltage			2750	V
DC Control-Grid Voltage			−1200	V
Screen-Grid Dissipation			3000	W
Control-Grid Dissipation			1000	W
Plate Dissipation			175	kW
Typical Operation for Single-Tone Modulation				
DC Plate Voltage	18	18	18	kV
DC Screen-Grid Voltage	820	1500	2000	V
DC Control-Grid Voltage	−260	−400	−550	V
Maximum-Signal DC Plate Current	9.5	14.4	22	A
Zero Signal DC Plate Current	2	5	7	A
Maximum-Signal DC Screen-Grid Current	.5	1.0	1.5	A
Peak RF Control-Grid Voltage	260	400	550	v
Driving Power	0	0	0	W
Peak Fundamental RF Plate Current	15.0	22.5	34.5	a
Load Impedance	1070	710	435	ohms
Plate Dissipation	51	80	136	kW
Plate Output Power	120	180	260	kW

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values*		
DC Plate Voltage	40	kV
Peak Plate Voltage	50	kv
DC Screen-Grid Voltage	2750	V
DC Control-Grid Voltage	−3000	V
Peak Negative Control-Grid Voltage	−5000	v
Pulse Cathode Current		
With 15.0 V filament voltage	375	a
With 15.5 V filament voltage	500	a
Control-Grid Dissipation	1000	W
Screen-Grid Dissipation	3000	W
Plate Dissipation	175	kW
Pulse Duration	1000	μs**
Duty Factor	.01	**

Typical Operation		
DC Plate Voltage	40	kV
DC Screen-Grid Voltage	2750	V
DC Control-Grid Voltage	−2000	V
Pulse Positive Control-Grid Voltage	750	V
Pulse Plate Current	300	a
Pulse Screen-Grid Current	45	a
Pulse Control-Grid Current	17	a
Pulse Driving Power	47	kw
Pulse Output Power	10.5	Mw
Pulse Output Voltage	35	kv
Duty Factor	.01	

Plate-Pulsed RF Power Amplifier or Oscillator Class C

Maximum Ratings, Absolute Values*		
Peak Plate Pulse Supply Voltage	30	kv
Peak Screen-Grid Pulse Supply Voltage	2750	v
DC Control-Grid Voltage	−3000	V
Peak Cathode Current		
With 15.0 V filament voltage	375	a
With 15.5 V filament voltage	500	a
Control-Grid Dissipation	1000	W
Screen-Grid Dissipation	3000	W
Plate Dissipation	175	kW
Pulse Duration	500	μs**
Duty Factor	.1	**

Typical Operation		
Peak Plate Pulse Supply Voltage	30	kv
Peak Screen-Grid Pulse Supply Voltage	2750	v
DC Control-Grid Voltage	−2000	V
Peak RF Plate Voltage	26	kv
Peak RF Control-Grid Voltage	2750	v
Peak Plate Current from Pulse Supply	62	a
Peak Screen-Grid Current from Pulse Supply	7	a
Peak Rectified Control-Grid Current	2	a
RF Load Impedance	210	ohms
Driving Power during Pulse	5.1	kw
Power Output during Pulse	1.5	Mw
Duty Factor	.1	

§Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

‡Averaged over any audio-frequency cycle of sine-wave form.

*All given maximum ratings may not apply simultaneously. Due to the possibility of instantaneous overheating of electrodes during the pulse, it may be necessary to restrict some of the parameters, e.g., peak plate current, tube drop, pulse duration, duty or average dissipation, in order not to adversely affect the performance of the tube. Because of the many possible combinations of operating conditions, all restrictions cannot be delineated here, and it is suggested to review new applications with the Machlett Engineering Department.

**For application requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

TUBE PROTECTION

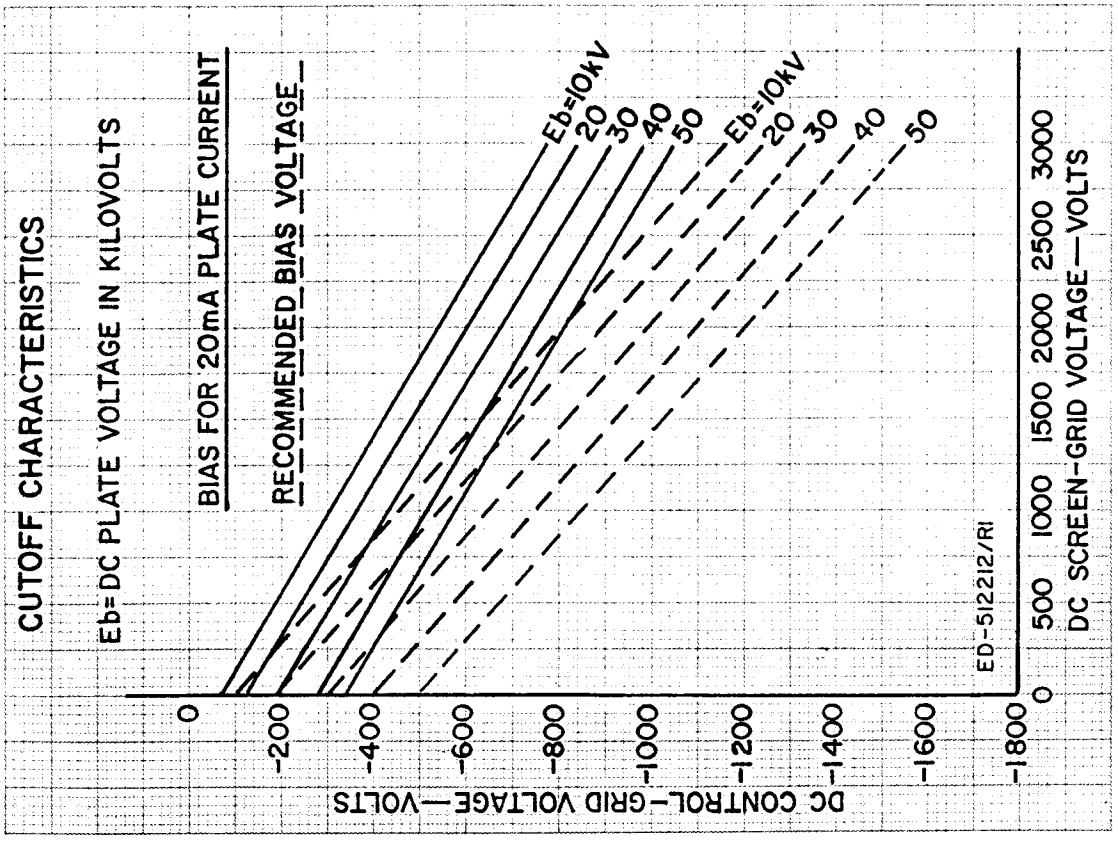
The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

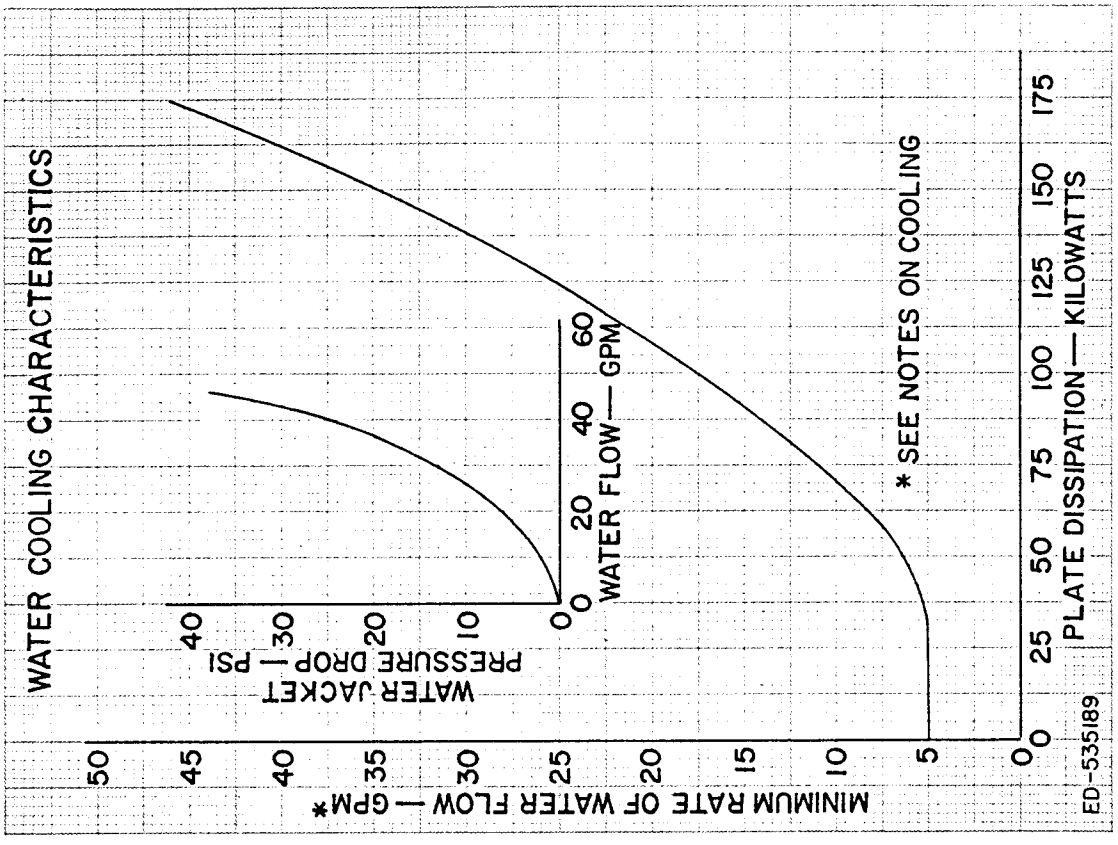
A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

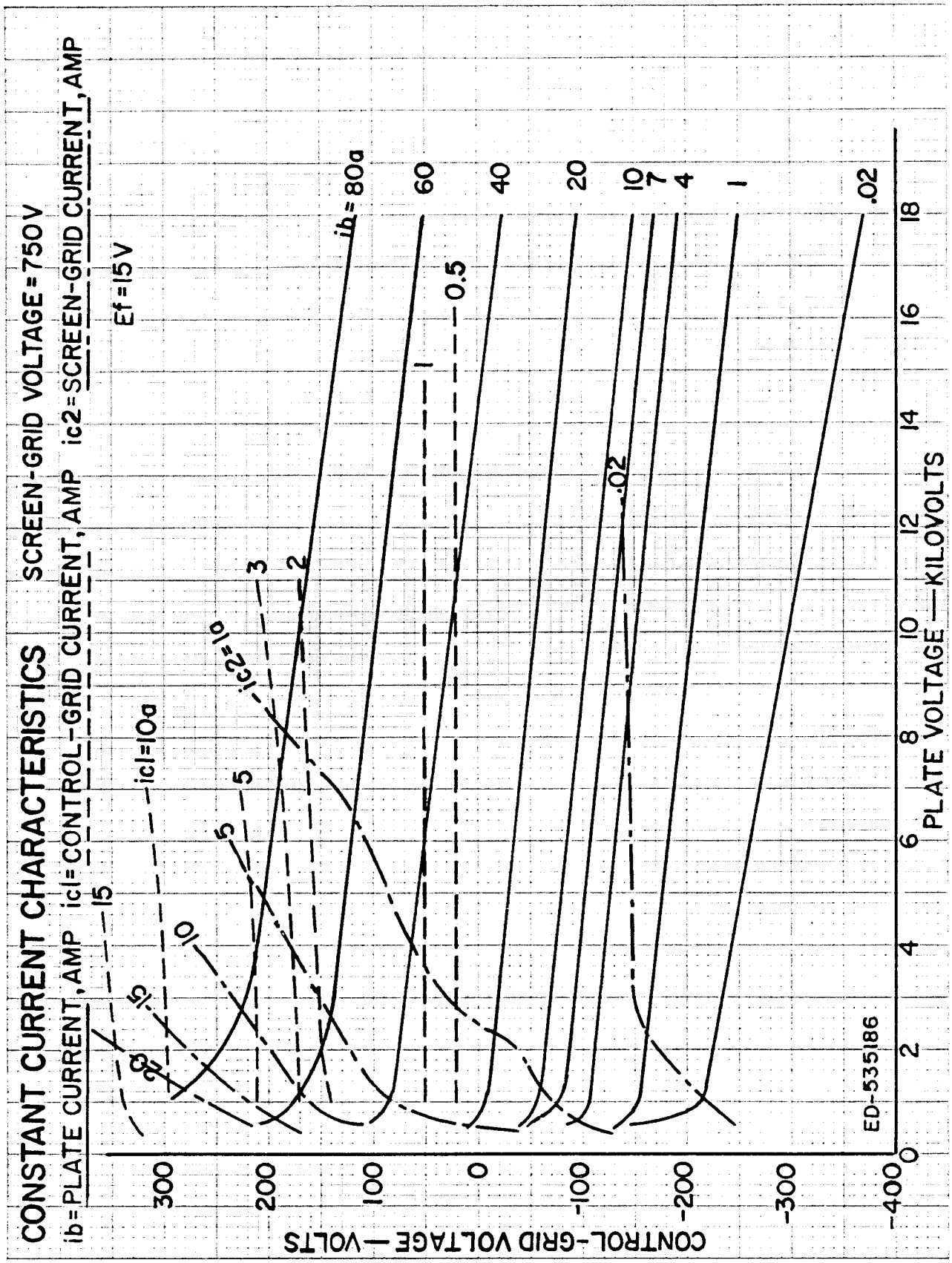
References:
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29*, 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press 1, 6*, 1954.

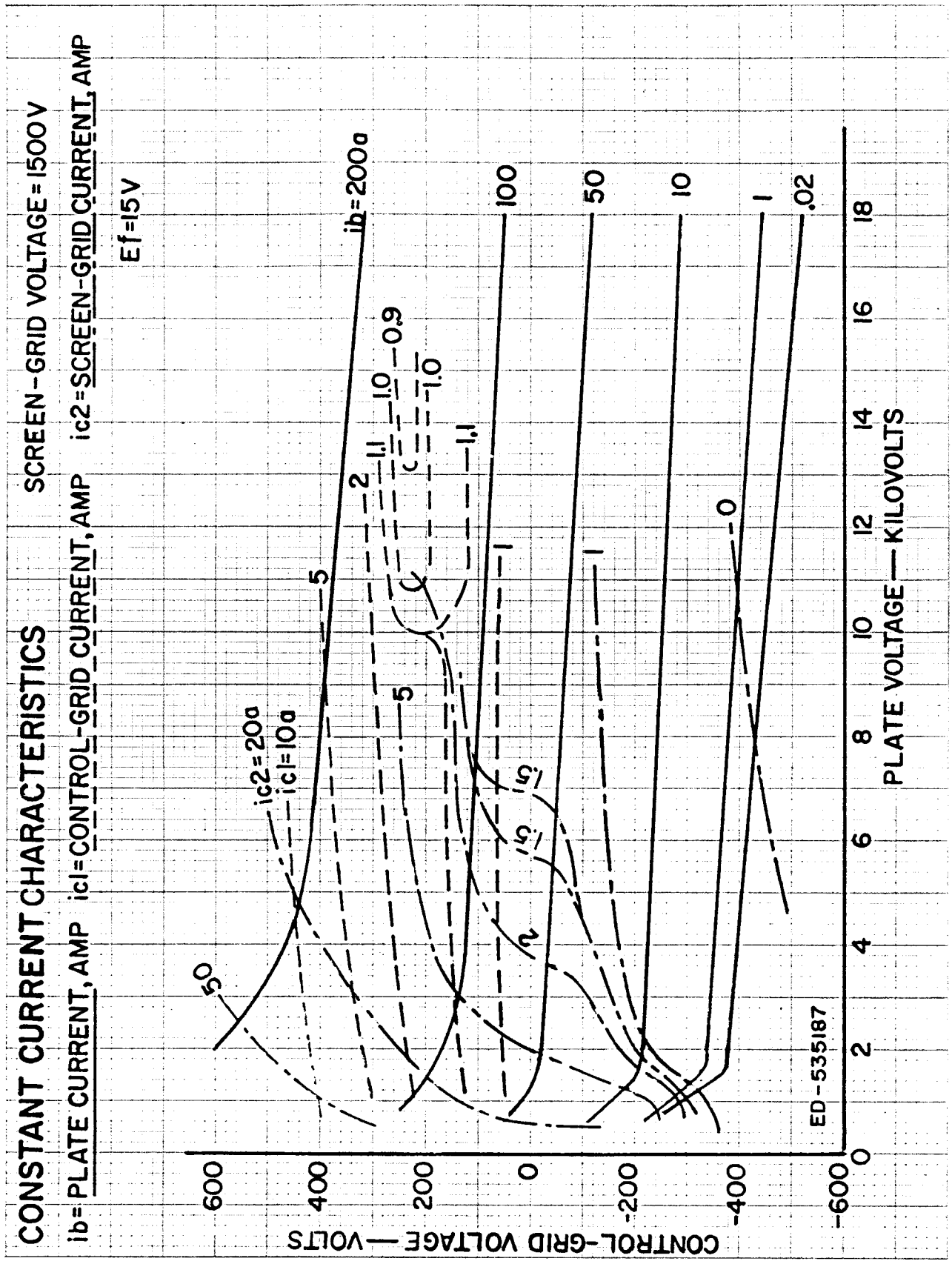


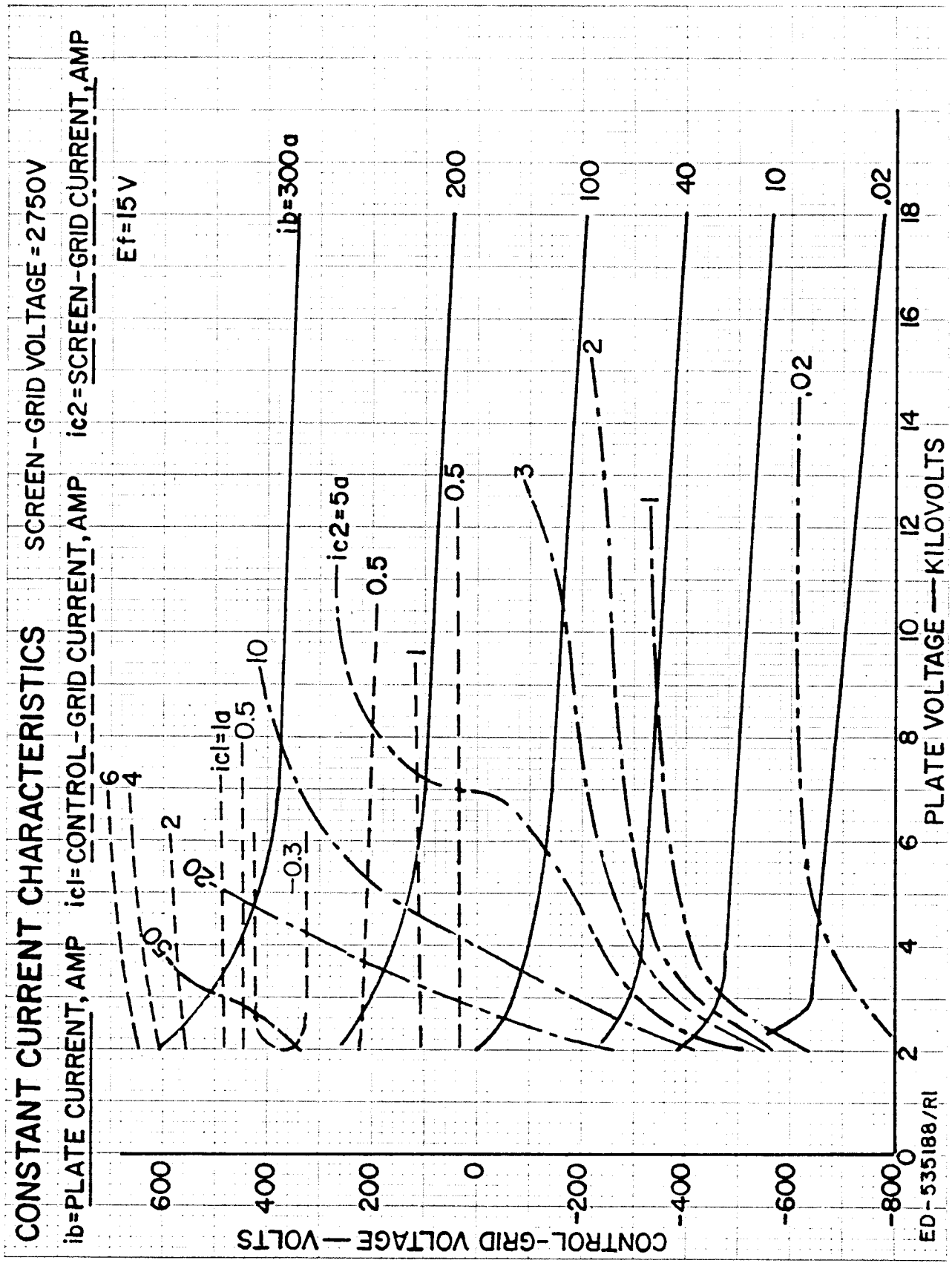
CUTOFF CHARACTERISTICS
ML-8785, ML-8786

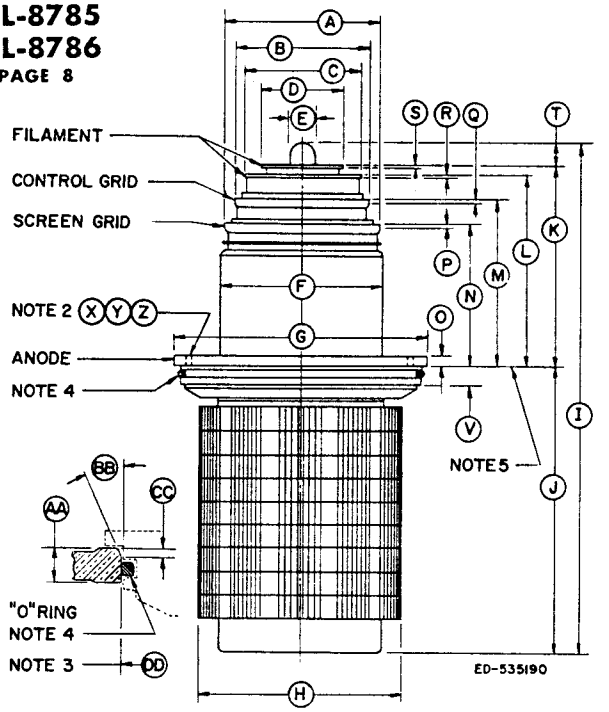


WATER COOLING CHARACTERISTICS
ML-8786


CONSTANT CURRENT CHARACTERISTICS
SCREEN-GRID VOLTAGE = 750 V
ib = PLATE CURRENT, AMP ic1 = CONTROL-GRID CURRENT, AMP ic2 = SCREEN-GRID CURRENT, AMP
Ef = 15 V
ib = 80a
60
40
20
10
7
4
1
0.5
.02
ic1 = 10a
15
10
8
6
5
3
2
1
ic2 = 10
5
3
2
1
.02
CONTROL-GRID VOLTAGE — VOLTS
300
200
100
0
-100
-200
-300
-400
0
2
4
6
8
10
12
14
16
18
PLATE VOLTAGE — KILOVOLTS
ED-535186


CONSTANT CURRENT CHARACTERISTICS
SCREEN-GRID VOLTAGE = 1500 V
ib = PLATE CURRENT, AMP ic1 = CONTROL-GRID CURRENT, AMP ic2 = SCREEN-GRID CURRENT, AMP
Ef = 15 V
ic2 = 20a
ic1 = 10a
ib = 200a
100
50
10
1
.02
0
CONTROL-GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
ED-535187


CONSTANT CURRENT CHARACTERISTICS
SCREEN-GRID VOLTAGE = 2750V
ib=PLATE CURRENT, AMP ic1=CONTROL-GRID CURRENT, AMP ic2=SCREEN-GRID CURRENT, AMP
Ef=15 V
ib=300a
200
100
40
10
.02
ic2=5a
0.5
1
3
2
.02
ic1=1a
0.5
10
-0.3
6
4
2
0
-2
-5
CONTROL-GRID VOLTAGE — VOLTS
600
400
200
0
-200
-400
-600
-800
0
2
4
6
8
10
12
14
16
18
PLATE VOLTAGE — KILOVOLTS
ED-535188/RI



DETAIL OF RECOMMENDED
OPENING IN COOLING JACKET

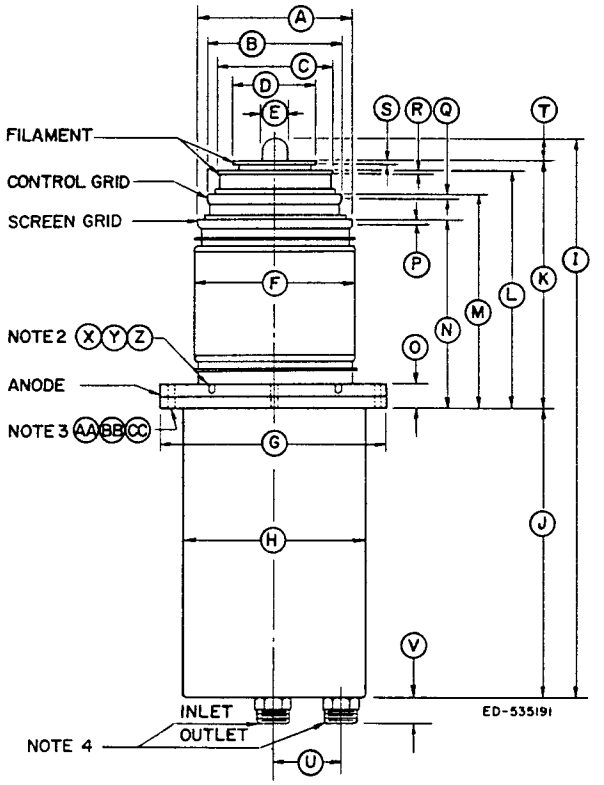
OUTLINE OF ML-8785

DIMENSIONS FOR OUTLINE OF ML-8785

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	6.87	6.94	6.97	1
B	5.87	5.94	5.97	1
C	5.17	5.19	5.21	1
D	3.60	3.62	3.64	1
E	—	1.12	1.19	
F	—	7.19	7.40	
G	11.26	11.31	11.35	
H	—	9.00	9.05	
I	—	—	23.07	
J	—	12.72	12.85	
K	8.40	8.78	9.09	
L	7.92	8.24	8.46	
M	7.06	7.24	7.42	
N	6.01	6.13	6.25	
O	.34	.37	.40	
P	.22	.25	—	
Q	.22	.25	—	
R	.23	.25	—	
S	.23	.25	—	
T	—	1.06	1.17	
V	.92	.94	.96	
X	.44	.50	—	2
Y	9.610	9.625	9.640	2
Z	3.680	3.686	3.692	2
AA	—	.75	—	
BB	—	20°	—	degrees
CC	—	.19	—	
DD	10.498	10.503	10.508	3

NOTES:

1. Includes out-of-roundness.
2. Eight ¼"-20 tapped holes, (X) deep, on circle diameter (Y), spaced at chordal distances (Z). For lifting tube.
3. Recommended diameter of opening for tube in cooling jacket.
4. O ring, Machlett Part No. P-25946, supplied with tube.
5. Tube to be supported in equipment only by this surface.



OUTLINE OF ML-8786

DIMENSIONS FOR OUTLINE OF ML-8786

Ref.	Inches			Notes
	Minimum	Nominal	Maximum	
A	6.87	6.94	6.97	1
B	5.87	5.94	5.97	1
C	5.17	5.19	5.21	1
D	3.60	3.62	3.64	1
E	—	1.12	1.19	
F	—	7.19	7.40	
G	9.94	10.00	10.06	
H	—	8.00	8.13	
I	—	—	25.17	
J	12.56	12.81	13.06	
K	10.53	10.84	11.15	
L	10.09	10.30	10.51	
M	9.12	9.30	9.48	
N	8.07	8.19	8.31	
O	1.06	1.12	1.18	
P	.22	.25	—	
Q	.22	.25	—	
R	.23	.25	—	
S	.23	.25	—	
T	—	1.06	1.17	
U	2.81	3.00	3.19	
V	—	1.12	1.50	
X	.33	.39	—	2
Y	8.16	8.19	8.22	2
Z	5.77	5.79	5.81	2
AA	9.13	9.16	9.19	3
BB	6.46	6.48	6.50	3
CC	.286	.290	.298	3

NOTES:

1. Includes out-of-roundness.
2. Four ¼"-20 tapped holes, (X) deep, on circle diameter (Y), spaced at chordal distances (Z). For lifting tube.
3. Four thru holes, diameter (CC), on circle diameter (AA), spaced at chordal distances (BB). For mounting and plate-circuit connections.
4. Water-cooling connections, one-inch pipe thread (NPT).

MACHLETT

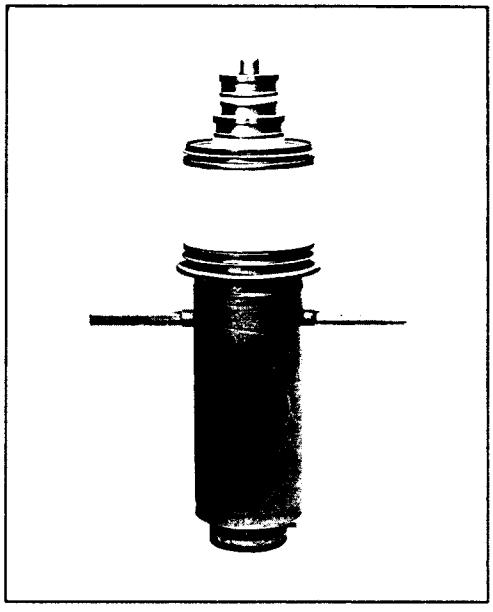
THE MACHLETT LABORATORIES, INC.

1063 Hope Street • Stamford, Conn. 06907 • Printed in U.S.A. A Raytheon Company

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ST-2611 4ML 4-71

The Machlett Laboratories, Inc.
1063 Hope Street • Stamford, Conn. 06907
Tel. 203-348-7511 • TWX 710-474-1744



ISSUED 2-71

ML-8795
ML-8796

MACHLETT

General Purpose Triodes
240 kW CW

DESCRIPTION

The ML-8795 and ML-8796 are high-power, general-purpose triodes. The ML-8795 is water cooled and the ML-8796 is vapor cooled. Electrical characteristics of the tubes are the same. The cathodes of these tubes consist of sturdy thoriated-tungsten filaments. The coaxial terminals have low inductance and high heat dissipation capability. Low-loss alumina ceramics are used for all envelope insulation members.

When operated as class C amplifiers or oscillators, these tubes will produce a continuous output of up to 240 kW. The anodes are capable of dissipating up to 140 kW. The tubes can be operated in air at maximum plate voltage ratings. Maximum ratings apply at frequencies up to 30 MHz; useful power output can be obtained at higher frequencies with a reduction in plate voltage.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage (AC)	16.5	V
Filament Current	325	A
Filament Starting Current, maximum	800	A
Filament Cold Resistance	.0052	ohm
Amplification Factor	40	
Interelectrode Capacitances, approximate		
Grid-Plate	58	pf
Grid-Filament	149	pf
Plate-Filament	1.8	pf

Mechanical

Mounting Position	Vertical, Anode Down	
Type of Cooling, ML-8795	Water & Forced-Air†	
Maximum water inlet pressure	80	psi
Maximum outgoing water temperature	70	°C
Water flow on anode for 140 kW dissipation	40	gpm
Water jacket pressure drop for 40 gpm flow	25	psi
Type of Cooling, ML-8796	Vaporization of Water & Forced-Air†	
Maximum Envelope Temperature	200	°C
Net Weight		
ML-8795	75	lb
ML-8796	85	lb

†Additional forced-air cooling of the grid and filament terminals will require an air flow of about 200 cfm uniformly distributed on the ceramic bulb and terminal assembly.

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray sources."

ACCESSORIES

Item	Part No.
Small Filament Connector	F-27218
Large Filament Connector	F-27219
Grid Connector	F-27220
Mounting Socket, ML-8795	F-12527

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES

RF Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation.

Maximum Ratings, Absolute Values		
DC Plate Voltage	20	kV
DC Grid Voltage	−3200	V
DC Plate Current	20	A
Grid Dissipation	2500	W
Plate Dissipation	140	kW

Typical Operation		
DC Plate Voltage	17	kV
DC Grid Voltage	−1200	V
Peak RF Plate Voltage	14	kv
Peak RF Grid Voltage	1900	v
DC Plate Current	19	A
DC Grid Current, approximate	3.5	A
RF Load Resistance	410	ohms
Driving Power, approximate	6500	W
Plate Dissipation	83	kW
Grid Dissipation	2100	W
Power Output	240	kW
Power Gain	37	

TUBE PROTECTION

The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

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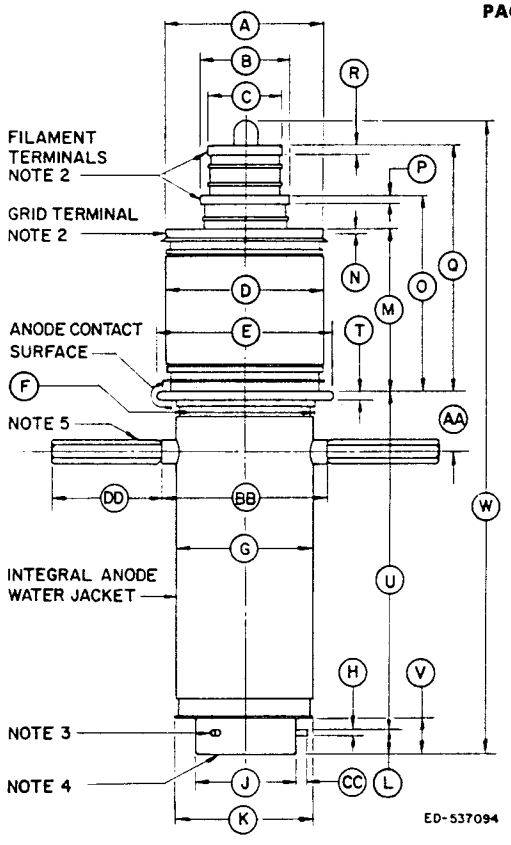
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2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press, 1, 6,* 1954.

DIMENSIONS FOR OUTLINE OF ML-8795

Ref	Inches			Notes
	Minimum	Nominal	Maximum	
A	6.917	6.937	6.957	1,2
B	3.985	4.005	4.025	1,2
C	3.298	3.318	3.338	1,2
D		7.19	7.30	
E	8.00	8.00	8.03	
F		6.19	6.21	
G		6.12	6.15	
H	.305	.315	.320	3
J	4.486	4.496	4.501	
K	6.02	6.06	6.10	
L	1.02	1.06	1.10	3
M		7.27		
N	.10	.18		
O		8.76		
P	.31	.38		
Q		10.94		
R	.31	.38		
T	.36	.38	.40	
U		15.12		
V	1.64	1.68		
W		28.30		
AA		2.68		
BB		7.38	7.44	
CC	.47	.50	.53	3
DD		5.00	5.06	

NOTES:

1. Add ± .010" to limits for out of roundness.
2. Electrical connections to be made only on periphery of these terminals.
3. Three bayonet pins 120 degrees apart to fit Machlett mounting socket, part no. F-12527.
4. Water inlet and outlet orifices in anode water jacket base to fit part no. F-12527 mounting socket.
5. Two handles (DD) inches long screw into bosses on water jacket for lifting tube.



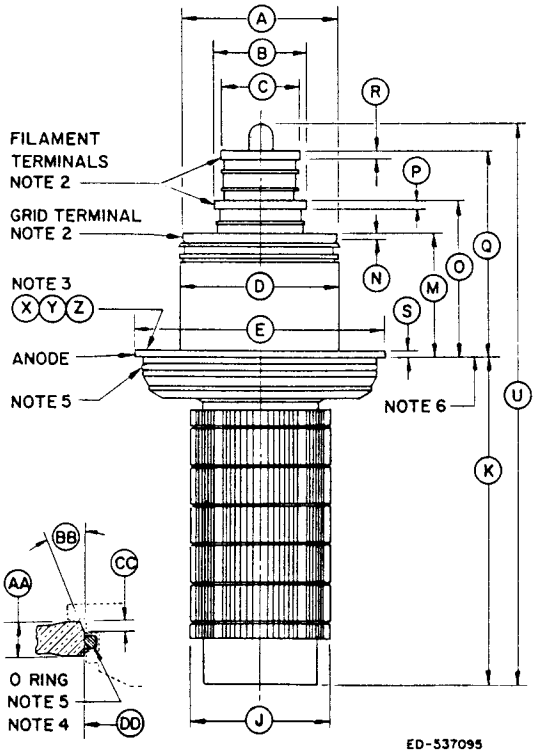
OUTLINE OF ML-8795

DIMENSIONS FOR OUTLINE OF ML-8796

Ref	Inches			Notes
	Minimum	Nominal	Maximum	
A	6.917	6.937	6.957	1,2
B	3.985	4.005	4.025	1,2
C	3.298	3.318	3.338	1,2
D		7.19	7.40	
E	11.240	11.250	11.260	
J		6.63	6.69	
K		14.50		
M		6.02		
N	.10	.18		
O		7.51		
P	.31	.38		
Q		9.69		
R	.31	.38		
S	.34	.38		
U		25.38		
X	.44	.50		3
Y	9.610	9.625	9.640	3
Z	3.66	3.68	3.70	3
AA		.75		
BB		20°		degrees
CC		.19		
DD	10.498	10.503	10.508	4

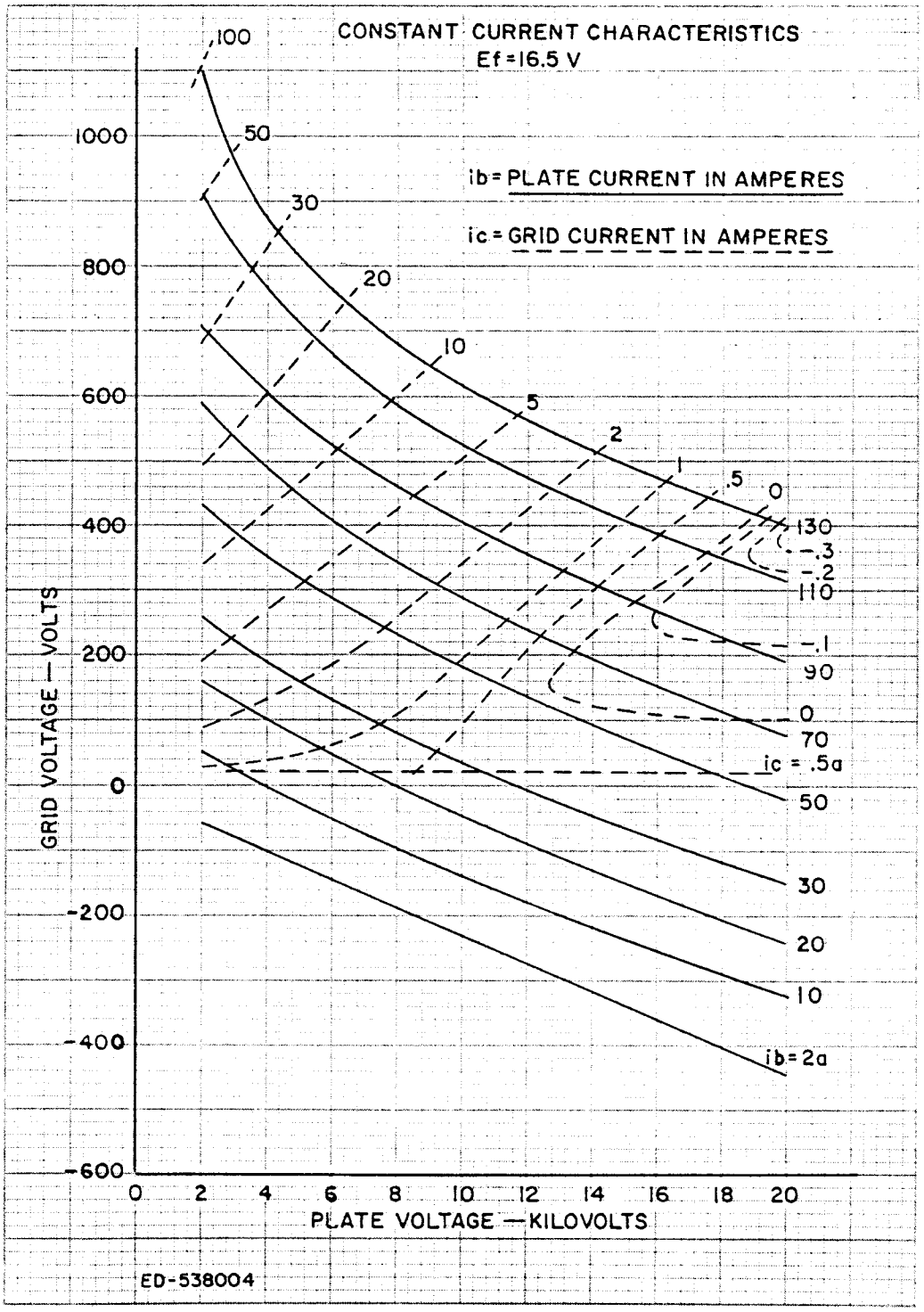
NOTES:

1. Add ± .010" to limits for out of roundness.
2. Electrical connections to be made only on periphery of these terminals.
3. Eight ¼"-20 tapped holes, (X) deep, on circle diameter (Y), spaced at chordal distances (Z). For lifting tube.
4. Recommended diameter of opening for tube in cooling jacket.
5. O-ring gasket, Machlett part P-25946, supplied with tube.
6. Tube to be supported in equipment only by this surface.



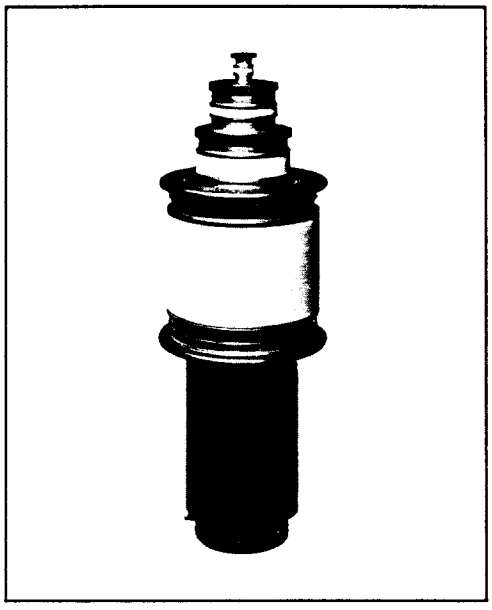
DETAIL OF RECOMMENDED OPENING IN COOLING JACKET

OUTLINE OF ML-8796



Printed in U.S.A.
ST-2610 3.5M 2-71

The Machlett Laboratories, Inc.
1063 Hope Street • Stamford, Conn. 06907
Tel. 203-348-7511 • TWX 710-474-1744



ISSUED 1-70

ML-8846

MACHLETT

General Purpose Triode
215 kW CW
8 Mw Pulse Power

DESCRIPTION

The ML-8846 is a general-purpose high-power triode suitable for use in dielectric and induction heating, pulse modulation and similar applications. This tube features rugged, ceramic-and-metal, coaxial construction with high-dissipation, low-inductance rf terminals. The cathode consists of sturdy, stress-free, thoriated-tungsten filaments. This tube is suitable for cavity operation and its low plate impedance adapts it to broad-band service.

The ML-8846 is water-cooled and accepts a quick-change water-jacket coupling. The heavy-wall anode will dissipate up to 140 kW with a water flow of 60 gpm. The maximum CW plate-voltage rating of 16 kV applies at frequencies up to 30 MHz. The tube may be operated up to 88 MHz with a reduction in ratings. In pulse service the tube is capable of switching up to 8 Mw with plate voltages up to 35 kV.

Except for minor dimensional differences, the ML-8846 can be used to replace the ML-5682.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	16.5	V
Filament Current at 16.5 volts	325	A
Filament Starting Current, maximum	800	A
Filament Cold Resistance	0.0052	ohm
Amplification Factor	30	
Direct Interelectrode Capacitances		
Grid-Plate	85	pf
Grid-Filament	110	pf
Plate-Filament	2.6	pf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling	Water and forced-air	
Water Flow on Anode	See Water Cooling Characteristics	
Maximum Water Pressure	75	psi
Maximum Outlet Water Temperature	70	°C
Air Flow on Envelope and Seals, approximate	250	cfm
Maximum Envelope Temperature	200	°C
Net Weight, approximate	50	lb.

WARNING: This electron tube when operating at peak voltages in excess of 15 kv may give off x-rays, which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standards for Non-Medical X-Ray and Sealed Gamma-Ray Sources".

ACCESSORIES

Item	Part No.
Small Filament Connector	F-12589
Large Filament Connector	F-12590
Grid or Anode Connector	F-12591
Grid-Cathode Protective Gap	F-12506
Grid or Anode Protective Gap	F-12507
Mounting Socket	F-12527
Large Gasket for Mounting Socket	P-13745
Small Gasket for Mounting Socket	P-12272

NOTE: For additional information on accessories, refer to Accessory Data Sheet No. ST-1006.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

R F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation#

Maximum Ratings, Absolute Values

Frequency	88	30	MHz
D C Plate Voltage	9000	16000	V
D C Grid Voltage	−3200	−3200	V
D C Plate Current	20	20	A
D C Grid Current	2.5	4.0	A
Plate Input	170	300	kW
Plate Dissipation	140	140	kW

Typical Operation

Power Amplifier and Oscillator, Grid-Drive Circuit — 30 MHz

D C Plate Voltage	8000	12000	15000	V
D C Grid Voltage	−750	−1100	−1400	V
Peak R F Grid Voltage	1210	1750	2200	v
Peak R F Plate Voltage	6600	10300	12800	v
D C Plate Current	9.7	14.3	18.4	A
D C Grid Current	2.1	2.9	3.0	A
R F Load Resistance	380	400	380	ohms
Driving Power, approximate	2.5	4.9	7.2	kW
Power Output, approximate	58	132	215	kW

Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

Pulse Modulator or Pulse Amplifier

Maximum Ratings

D C Plate Voltage	35	kV
Peak Plate Voltage	40	kv
Peak Negative Grid Voltage	−7000	v
Pulse Cathode Current	360	a
Grid Dissipation	2.5	kW
Plate Dissipation	140	kW
Pulse Duration, approximate	1000	μs‡
Duty Factor	.01	‡

Typical Operation

D C Plate Voltage	35	35	kV
D C Grid Voltage	−2000	−2000	V
Pulse Positive Grid Voltage	2000	2400	v
Pulse Plate Current	200	300	a
Pulse Grid Current	100	60	a
Pulse Driving Power	400	300	kw
Pulse Power Output	6.6	8.4	Mw
Plate Output Voltage	33	28	kv

‡For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply up to 30 MHz except as noted. These tubes may be operated at higher frequencies provided the maximum value of plate voltage and plate input are reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

Frequency in Megahertzes	30	60	88
Percent Maximum Rated Plate Voltage and Plate Input	100	78	56

TUBE PROTECTION

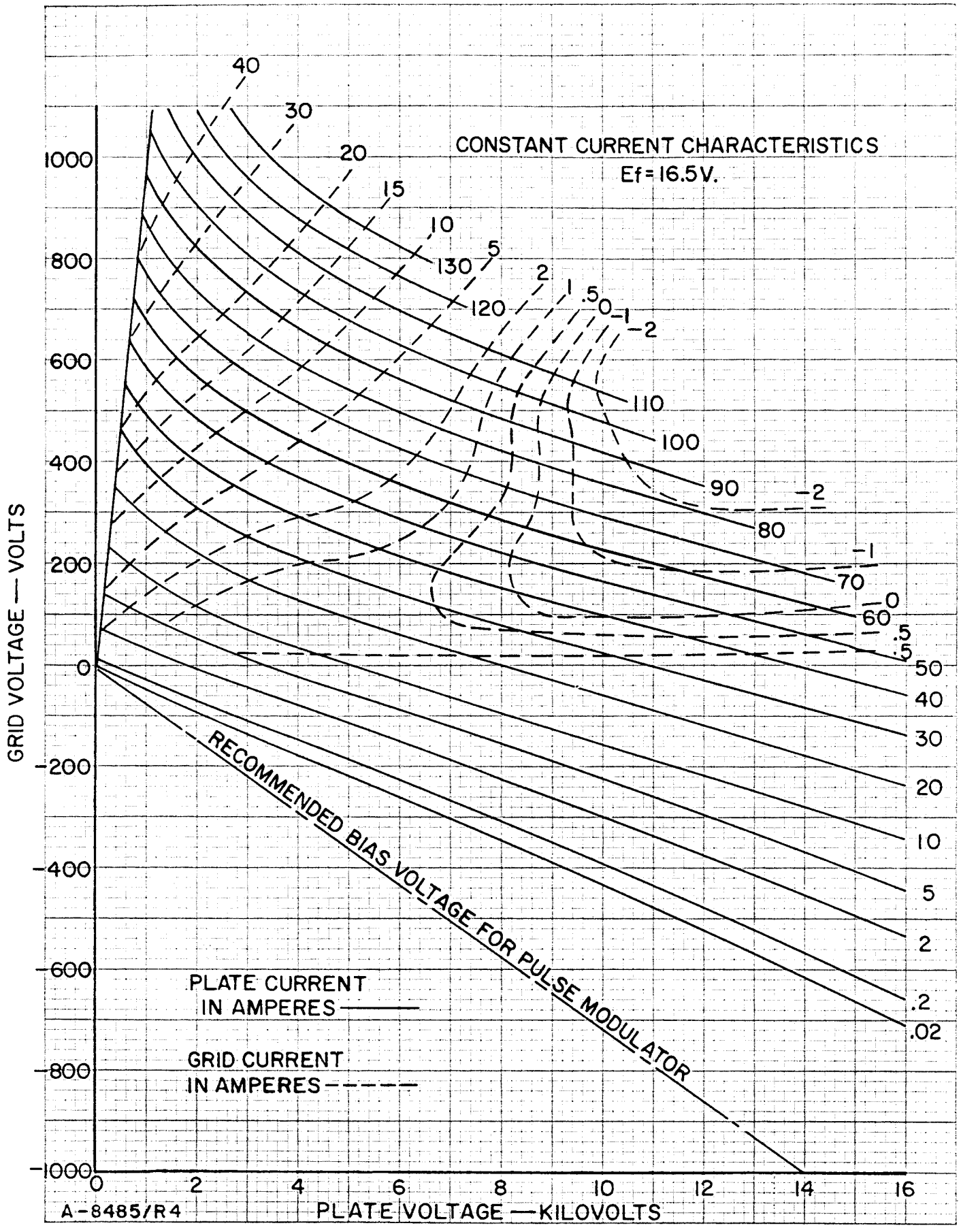
The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by limiting the time elapsed from inception of a fault condition to diverting the energy from the tube, as well as the amount of energy expended in the tube during this interval.

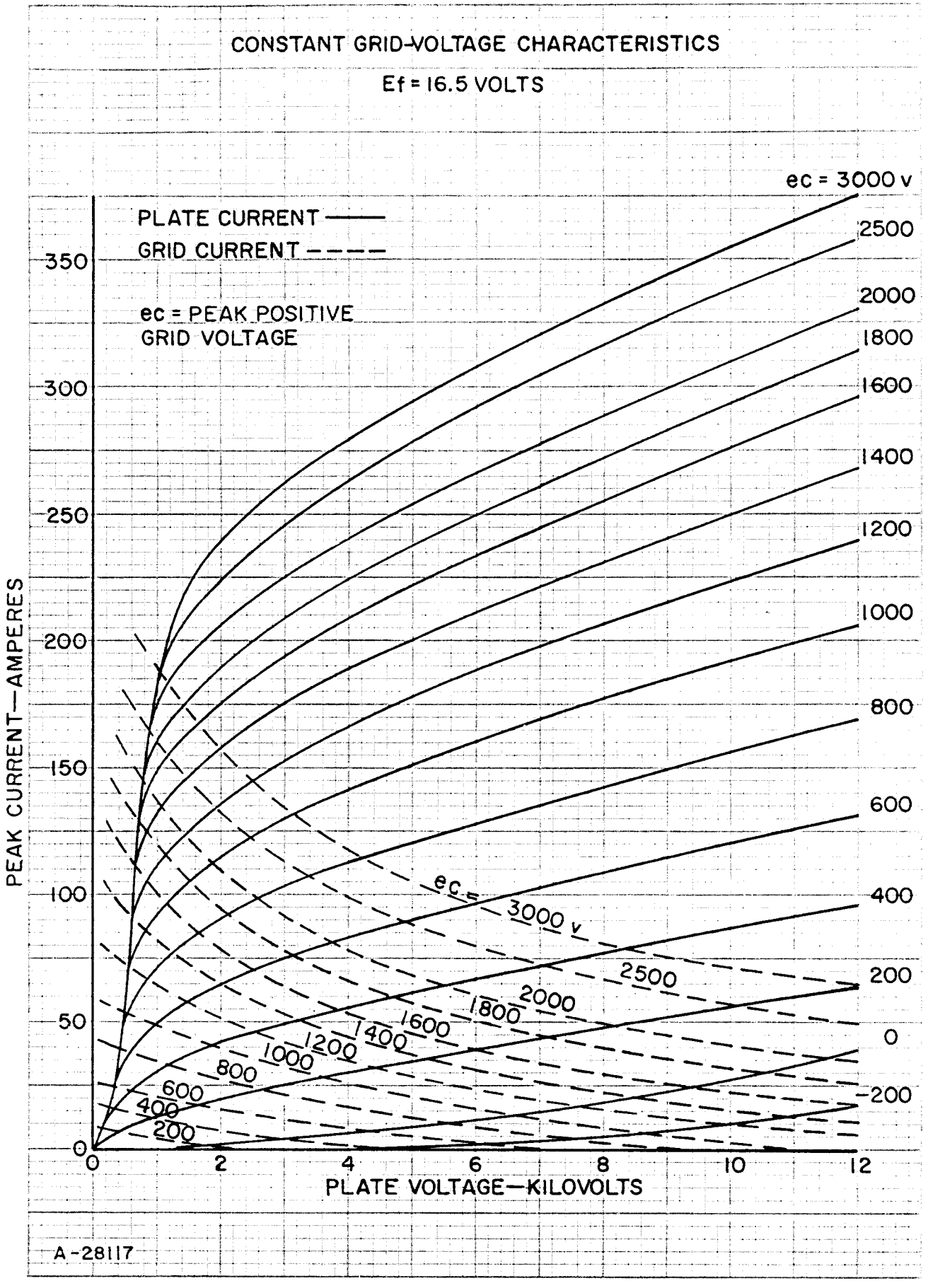
In addition to the normal circuit breakers and overload relays, it is necessary that a fast-acting electronic protective device (crowbar) or equivalent be used. This device will in most cases be a triggered gaseous device connected across the output of the plate supply filter, if used, to dissipate the filter-circuit energy as well as the rectifier output. The complete energy source must be shorted out as quickly as possible after the inception of a "fault", and in most cases the time interval should not be allowed to exceed approximately ten microseconds. For some basic electronic-crowbar fault-protection circuit considerations, as well as tests of the effectiveness of a protection device, refer to the references listed.

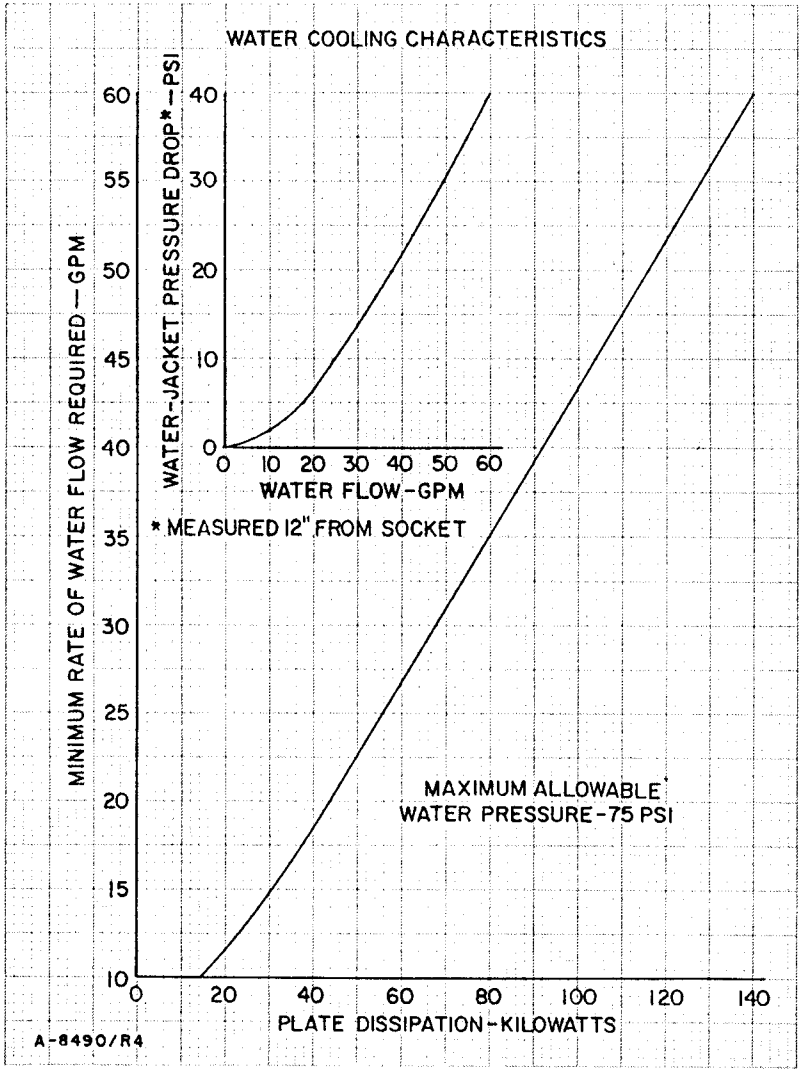
A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge circuit. It is also recommended that a minimum of five to ten ohms resistance be connected in series with each rectifier tube in order to limit surge currents.

In circuits where high transient voltages may be developed due to a shorted load or other fault, special precautions are necessary to keep these excessive voltages from appearing at the tube electrodes.

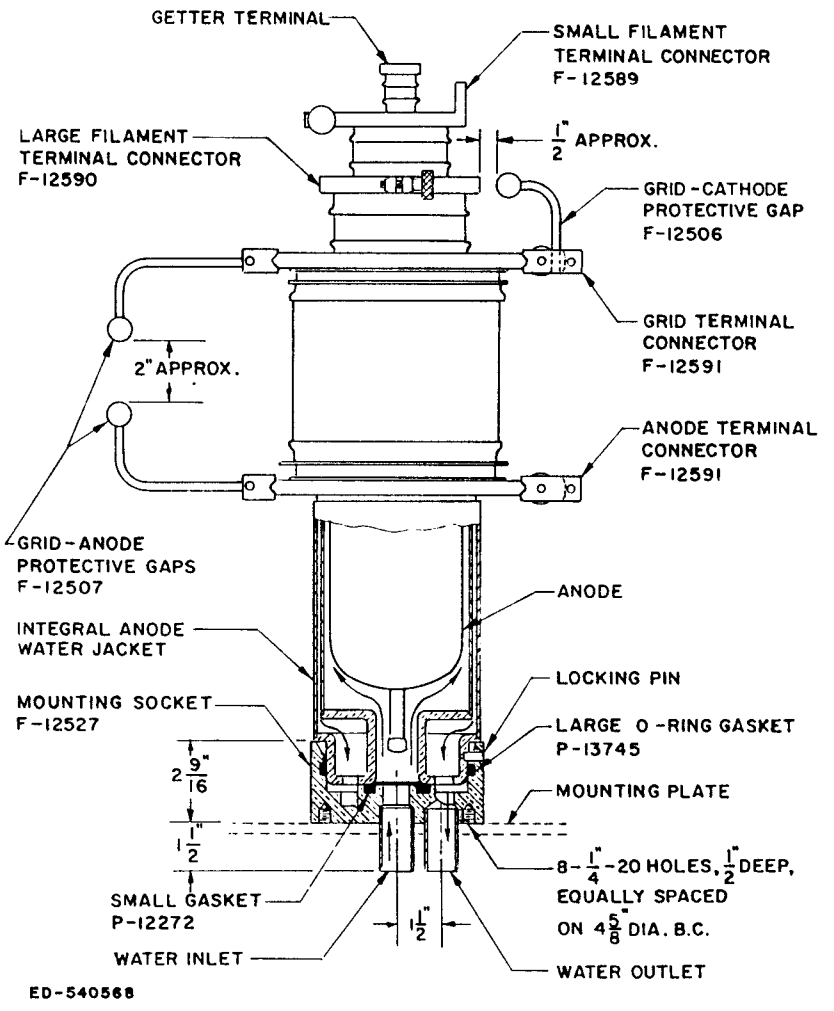
References:
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29*, 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press, 1, 6*, 1954.

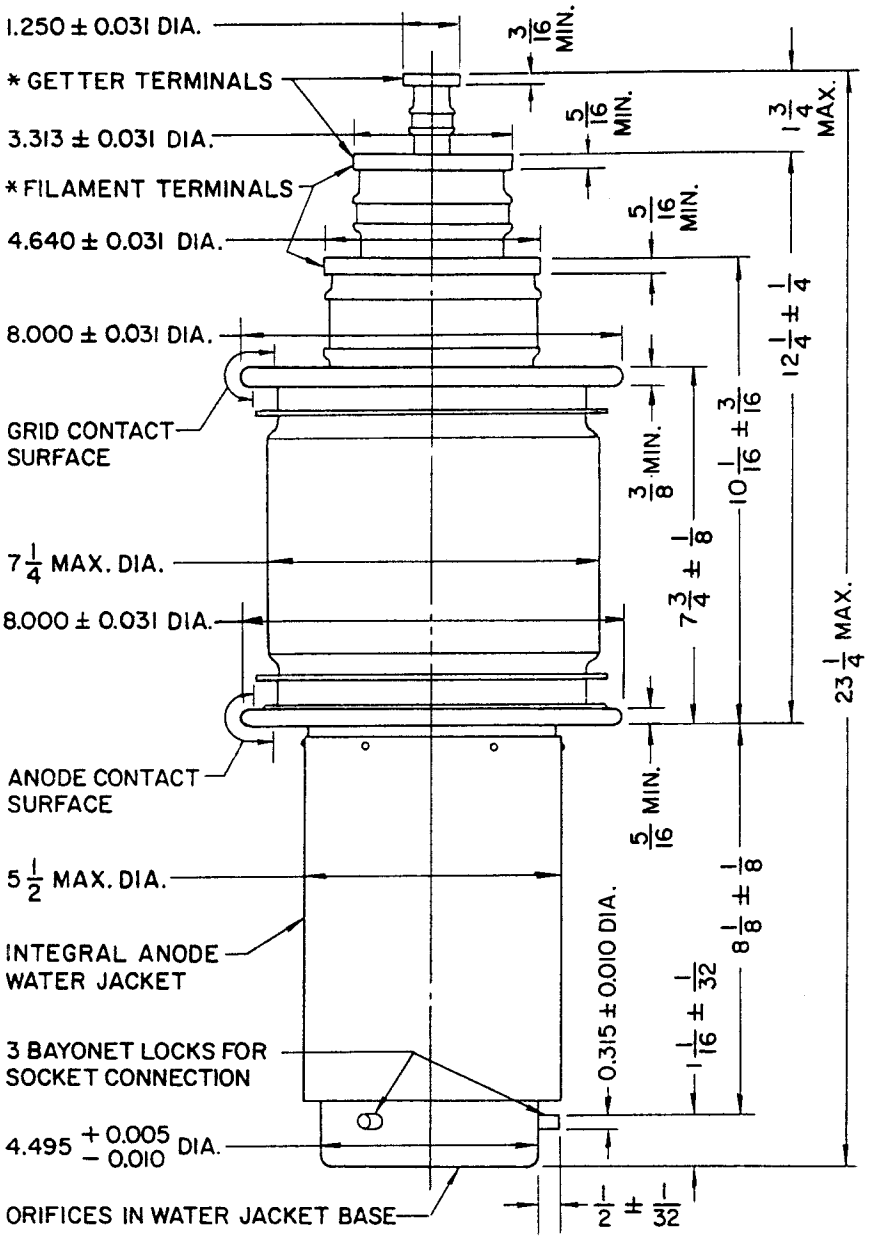

CONSTANT CURRENT CHARACTERISTICS
Ef = 16.5V.
40
30
20
15
10
5
2
1
.5
0
-1
-2
130
120
110
100
90
80
70
60
50
40
30
20
10
5
2
.2
.02
.5
.5
-2
-1
0
RECOMMENDED BIAS VOLTAGE FOR PULSE MODULATOR
PLATE CURRENT IN AMPERES
GRID CURRENT IN AMPERES
GRID VOLTAGE — VOLTS
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
0
2
4
6
8
10
12
14
16
PLATE VOLTAGE — KILOVOLTS
A-8485/R4


CONSTANT GRID-VOLTAGE CHARACTERISTICS
Ef = 16.5 VOLTS
PLATE CURRENT
GRID CURRENT
ec = PEAK POSITIVE GRID VOLTAGE
ec = 3000 v
2500
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-200
PEAK CURRENT—AMPERES
PLATE VOLTAGE—KILOVOLTS
0
50
100
150
200
250
300
350
2
4
6
8
10
12
A-28117



COOLING SYSTEM & PROTECTIVE GAP ARRANGEMENT





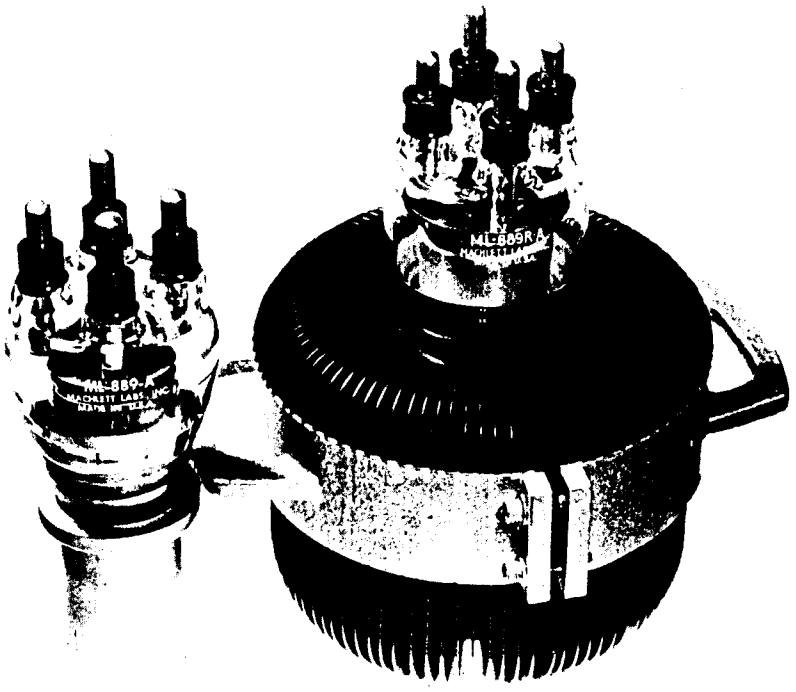
* ELECTRICAL CONTACTS TO BE MADE ON THE PERIPHERY OF THESE TERMINALS.

ALL DIMENSIONS IN INCHES

ED-27386/R2

DIMENSIONS — ML-8846

Printed in U.S.A.
ST-2592 5M 1-70



MACHLETT

ML-889A
ML-889RA

DESCRIPTION & RATINGS

DESCRIPTION

The ML-889A and ML-889RA are three electrode tubes designed specifically for use as modulators, amplifiers or oscillators in radio transmitting service. The cathode of each type is a pure-tungsten filament. The ML-889A has a water-cooled anode capable of dissipating 5 kW with 6 gpm water flow. The ML-889RA has a forced-air-cooled anode capable of dissipating 5 kW with an air flow of 500 cfm. Maximum ratings of 8.5 kVdc plate voltage and 16 kW plate input apply at frequencies up to 50 Mc for the ML-889A and 40 Mc for the ML-889RA. These tubes are rated for service up to 150 Mc and 100 Mc, respectively, with plate voltage and plate input reduced according to the table on page 2.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage		11.0	Volts
Filament Current at 11.0 volts		120	Amps
Filament Starting Current, maximum		180	Amps
Filament Cold Resistance		.008	Ohms
Amplification Factor		21	
Interelectrode Capacitances	ML-889A	ML-889RA	
Grid-Plate	17.5	18.5	$\mu\mu f$
Grid-Filament	23.3	23.3	$\mu\mu f$
Plate-Filament	2.7	3.0	$\mu\mu f$

Mechanical

Mounting Position		Vertical, anode down
Type of Cooling — ML-889A		Water and forced-air*
Water flow on anode, minimum for 5 kW dissipation		6 gpm
Maximum outgoing water temperature		70 °C
Type of Cooling — ML-889RA		Forced-air
Air flow on anode, minimum for 5 kW dissipation	500	cfm at 0.7" Water*
Maximum incoming air temperature		45 °C
Maximum Anode Temperature, ML-889RA		230 °C
Maximum Glass Temperature		160 °C*
Net Weight, approximate		
ML-889A		2 lbs.
ML-889RA		35 lbs.

*Auxiliary air flow of 30 cfm should be directed through a 3" diameter nozzle at the top of the glass envelope to maintain a uniform glass temperature of not more than 160°C around the circumference of the seals.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

VALUES APPLY TO BOTH TYPES

A-F Power Amplifier and Modulator Class B

Maximum Ratings, Absolute Values				
D-C Plate Voltage			8500	volts
Max.-Signal D-C Plate Current*			2.0	amps
Max.-Signal Plate Input*			12000	watts
Plate Dissipation*			5000	watts
Typical Operation (Values are for 2 tubes)				
D-C Plate Voltage	5000	6000	7500	volts
D-C Grid Voltage	−180	−230	−300	volts
Peak A-F Grid-to-Grid Voltage	1460	1680	1700	volts
Zero Signal D-C Plate Current	0.4	0.4	0.4	amp
Max.-Signal D-C Plate Current	3.2	3.6	3.2	amps
Effective Load Resistance (plate-to-plate)	2520	3680	5000	ohms
Max.-Signal Driving Power, approximate	170	180	150	watts
Max.-Signal Power Output, approximate	8800	12000	15000	watts

*Average over any audio-frequency cycle of sine-wave form.

R-F Power Amplifier Class B Telephony

Carrier conditions per tube with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values			
D-C Plate Voltage		8500	volts
D-C Plate Current		1.0	amps
Plate Input		7500	watts
Plate Dissipation		5000	watts
Typical Operation			
D-C Plate Voltage	6000	7500	volts
D-C Grid Voltage	−250	−300	volts
Peak R-F Grid Voltage	460	500	volts
D-C Plate Current	0.9	0.9	amp
Driving Power, approx.†	95	80	watts
Power Output, approx.	1500	2000	watts

†At crest of a-f cycle with modulation factor of 1.0.

Plate Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values				
D-C Plate Voltage			6000	volts
D-C Grid Voltage			−1000	volts
D-C Plate Current			1.0	amp
D-C Grid Current			0.25	amp
Plate Input			6000	watts
Plate Dissipation			3000	watts
Typical Operation				
D-C Plate Voltage	5000	6000		volts
D-C Grid Voltage	−800	−900		volts
Peak R-F Grid Voltage	1300	1420		volts
D-C Plate Current	0.9	1.0		amp
D-C Grid Current, approx.	0.12	0.10		amp
Driving Power, approx.	155	140		watts
Power Output, approx.	2750	4000		watts

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation‡

Maximum Ratings, Absolute Values				
D-C Plate Voltage			8500	volts
D-C Grid Voltage			−1000	volts
D-C Plate Current			2.0	amps
D-C Grid Current			0.25	amp
Plate Input			16000	watts
Plate Dissipation			5000	watts
Typical Operation				
D-C Plate Voltage	5000	6000	7500	volts
D-C Grid Voltage	−500	−600	−800	volts
Peak R-F Grid Voltage	1200	1460	1830	volts
D-C Plate Current	1.5	1.8	2.0	amps
D-C Grid Current, approx.	0.19	0.21	0.24	amp
Driving Power, approx.	220	290	400	watts
Power Output, approx.	5000	7000	10000	watts

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of carrier conditions.

MAXIMUM FREQUENCY RATINGS

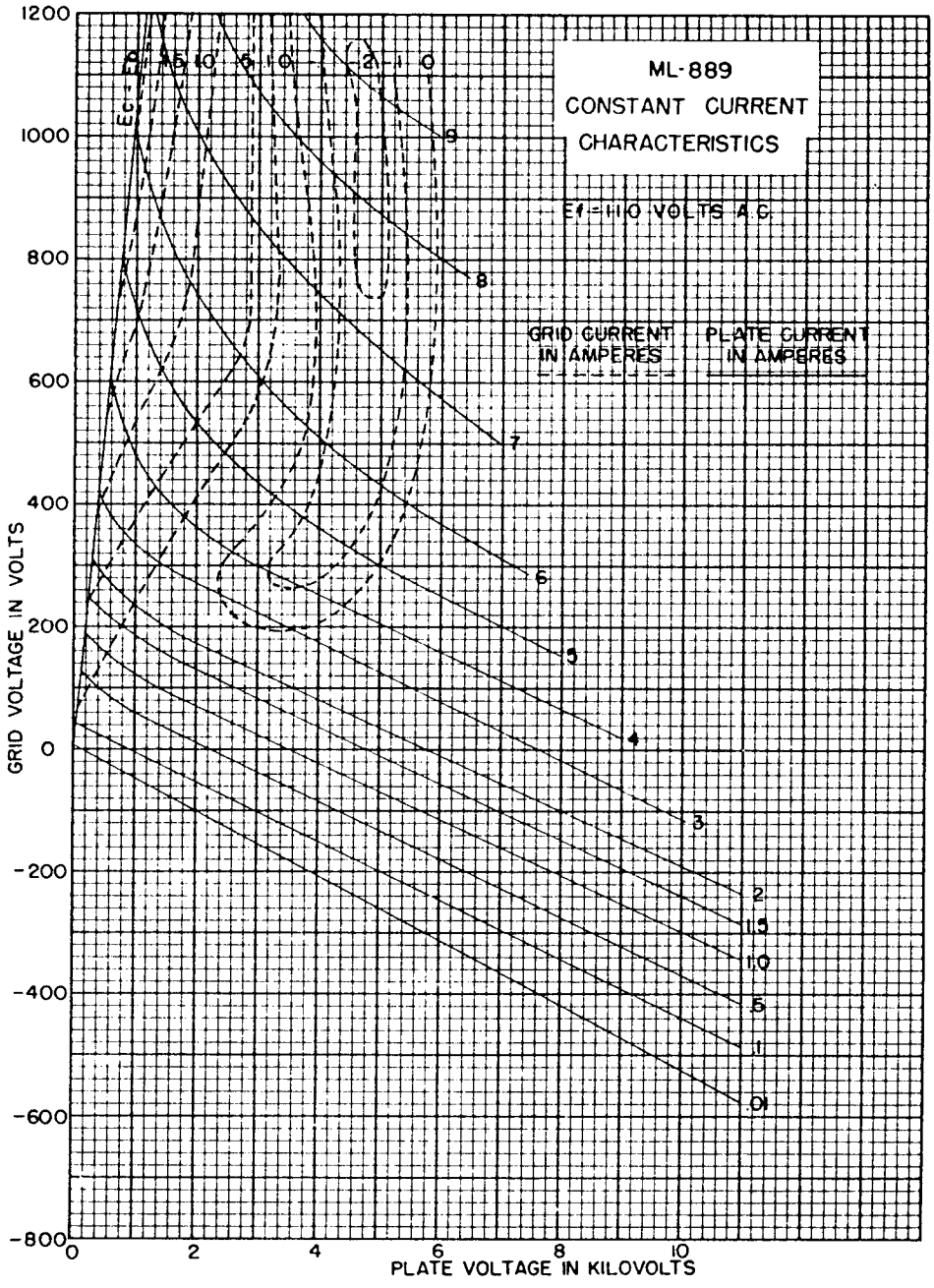
Maximum ratings apply at frequencies up to 50 Mc for the ML-889A or up to 40 Mc for the ML-889RA. The tubes can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with the table on the right (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

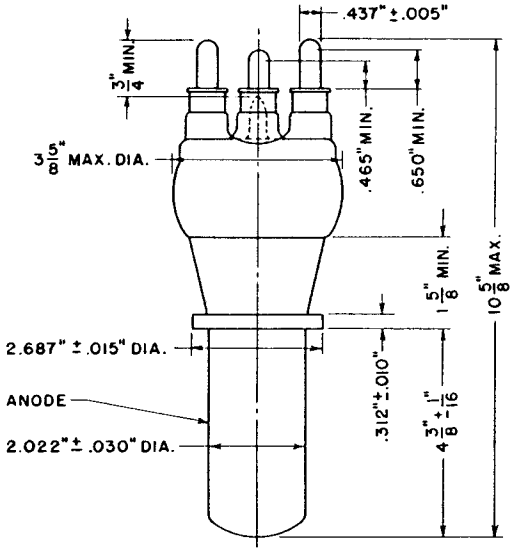
	ML-889A			ML-889RA		
Frequencies	50	100	150 Mc	40	65	100 Mc
Percentage of Maximum Rated Plate Voltage and Plate Input						
Class B	100	83	72	100	85	72
Class C Plate Modulated	100	75	60	100	78	60
Class C Telegraphy, Plate Voltage	100	78	65	100	87	65
Class C Telegraphy, Plate Input	100	70	50	100	73	50

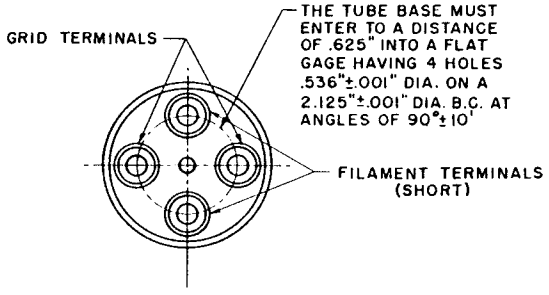
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 200 volts; i_b = 6 amps	e_c:	——	——	800	volts
Grid Current	e_b = 200 volts; i_b = 6 amps	i_c:	——	——	1.5	amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.0 Adc	E_b:	2.8	3.3	3.8	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 1.0 Adc	E_b:	6.5	7.5	8.5	kVdc
Grid Voltage	E_b = 7.5 kVdc; I_b = 0.020 Adc	E_c:	−325	−370	−475	Vdc
Peak Cathode Current*		i_k:	7.5	——	——	amps
Power Output	E_b = 8 kVdc; I_b = 1.75 Adc E_c = −750 Vdc; I_c = .23 Adc	P_o:	9.0	——	——	kW

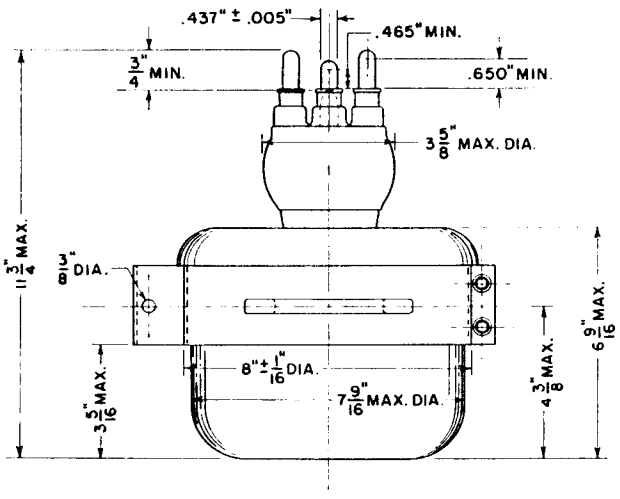
*Represents maximum useable plate current plus grid current for any conditions of operation.

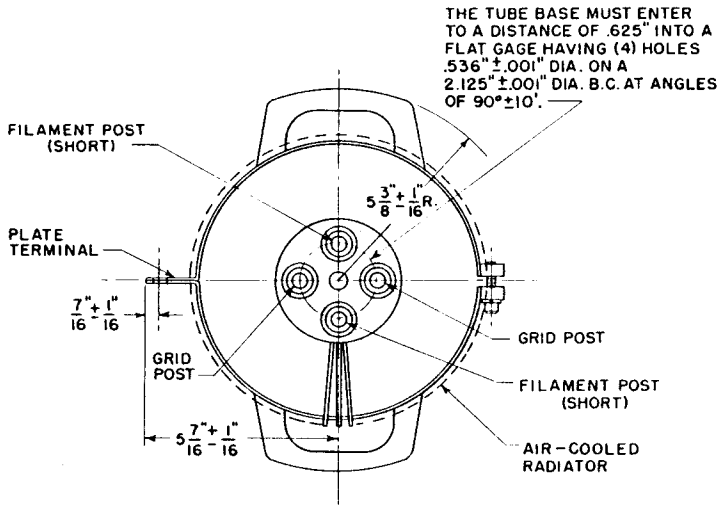






DIMENSIONS — ML-889A





DIMENSIONS — ML-889RA

MACHLETT LABORATORIES, INC.

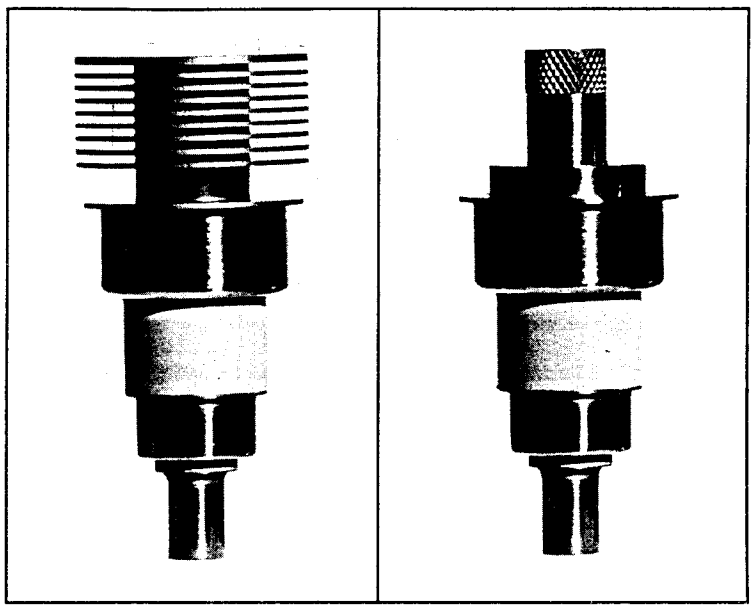
SPRINGDALE MACHLETT **CONNECTICUT**

U. S. A.

ST-1624 5M 7-59

Printed in U.S.A.

The Machlett Laboratories, Inc. • 1063 Hope Street
Stamford, Conn. 06907 • Tel. 203-348-7511 • TWX 203-327-2496



ISSUED 7-73

ML-8906
ML-8907
ML-8906/AL

MACHLETT

UHF Planar Triodes

CW, Plate or Grid Pulsed
Phormat Cathode
High Cathode Current Capability
Extended Grid-Anode Insulator
3 GHz

DESCRIPTION

The ML-8906, ML-8907 and ML-8906/AL are ruggedized, high-mu planar triodes of ceramic-and-metal construction designed for use as grid-pulsed, plate-pulsed or CW oscillators, amplifiers or frequency multipliers in transmitting service at frequencies up to 3 GHz. They may also be used as pulse modulators, pulse amplifiers or voltage regulators. The ML-8907 is fitted with a radiator for forced-air cooling. The ML-8906 and ML-8906/AL are intended for conduction and convection cooling. The ML-8906/AL is specially processed and tested for application in airline avionics service where long life and uninterrupted service are of prime importance.

These tubes are provided with an extended grid-anode insulator in the tube envelope making them suitable for high-altitude operation. They employ a Phormat type cathode, which consists of an indirectly heated disc with an oxide coating impregnated in a nickel matrix. This construction, in combination with proper plate series impedance, reduces to a minimum failures of the cathode due to voltage surges. The ceramic insulators of these tubes are provided with spew shields to minimize changes in grid-plate capacitance with life. Other features of these tubes include high cathode current capability, low interelectrode capacitance, high transconductance and great mechanical strength.

The envelopes of these tubes are dimensionally equivalent to the ML-7211, ML-7698, ML-7815, ML-7815R, ML-7815/AL and ML-7815R/AL. The ML-8906, ML-8907 and ML-8906/AL have a larger cathode surface than the ML-7815, ML-7815R, ML-7815/AL and ML-7815R/AL. The tubes can be used to replace the ML-7211 and ML-7698 with a reduction in heater power requirements.

GENERAL CHARACTERISTICS

Electrical		
Heater Voltage (AC or DC)		
ML-8906, ML-8907	6.0±.3	V
ML-8906/AL	5.7±2%	V
Heater Current		
ML-8906, ML-8907 (at 6.0 V)	1.00	A
ML-8906/AL (at 5.7 V)	.95	A
Cathode Heating Time, minimum	60	sec
Amplification Factor	80	
Transconductance (Ib=100 mA, Eb=600 V)	30000	μmhos
Interelectrode Capacitance, without heater voltage		
Grid-Plate	1.98	pf
Grid-Cathode	8.00	pf
Plate-Cathode, maximum	.06	pf
Mechanical and Environmental		
Mounting Position	Optional	
Type of Cooling		
With radiator (ML-8907)	Forced-Air	§
Without radiator (ML-8906, ML-8906/AL)	Conduction & Convection	§
Maximum Envelope or Anode Temperature	250	°C
Non-Operating Shock, 11 millisecond	60	G
Vibration, All Axis, Operating, 55 to 500 Hertz	10	G
Altitude, maximum	70000	ft
Net Weight		
ML-8906, ML-8906/AL	51	g
ML-8907	63	g

§ For cooling data refer to *Machlett Application Notes, UHF Tubes — General*

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

CW RF Power Oscillator or Amplifier — Class C

Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−400	v
Grid positive to cathode	30	v
DC Plate Current	150	mA
DC Grid Current	45	mA
Plate Dissipation		
Forced-air cooling (ML-8907)	100	W
Conduction and convection (ML-8906, ML-8906/AL)	10	W
Grid Dissipation	1.5	W
Frequency	2.5	GHz
Typical Operation, Cathode Drive Amplifier		
Frequency	.7	GHz
DC Plate Voltage	630	V
DC Grid Voltage, approximate	−5	V
DC Cathode Current	140	mA
DC Grid Current	25	mA
Driving Power, approximate	4	W
Useful Power Output	45	W
Typical Operation, Cathode Drive Oscillator		
Frequency	2.5	GHz
Heater Voltage	5.0	V*
DC Plate Voltage	1000	V
DC Grid Voltage, approximate	−20	V
DC Plate Current	140	mA
DC Grid Current, approximate	30	mA
Useful Power Output	30	W

*The heater voltage is reduced approximately 15% in this application due to back heating of the cathode.

Grid-Pulsed or Plate-Pulsed RF Oscillator or Amplifier — Class C

Maximum Ratings, Absolute Values		
Plate Voltage		
Grid-Pulsed, DC	3500	V
Plate-Pulsed, Peak Pulse Supply	4500	v
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode		
ML-8906, ML-8907	−700	v
ML-8906/AL	−750	v
Grid positive to cathode		
ML-8906, ML-8907	200	v
ML-8906/AL	250	v
Pulse Plate Current	5	a
Pulse Grid Current	2.5	a
Average Plate Dissipation		
Forced-air cooling (ML-8907)	100	W
Conduction and convection (ML-8906, ML-8906/AL)	10	W
Average Grid Dissipation		
ML-8906, ML-8907	1.5	W
ML-8906/AL	2	W
Pulse Duration	6	μs**
Duty Factor	0.0033	**
Frequency	3	GHz

**For applications requiring longer pulse duration or higher duty factor, consult the Machlett Engineering Department.

Typical Operation, Grid-Pulsed RF Amplifier, ML-8906, ML-8907		
Frequency	1.1	GHz
Heater Voltage	6.0	V
Pulse Duration	3	μs
Duty Factor	0.002	
DC Plate Voltage	2200	V
DC Grid Voltage	−50	V
Peak Video Plate Current	2.5	a
Peak Video Grid Current	1	a
Driving Power during Pulse	400	W
Useful Peak Power Output, approximate	2.5	kw
Typical Operation, Grid-Pulsed RF Oscillator, ML-8906/AL		
Frequency	1.1	GHz
Heater Voltage	5.7	V
Pulse Duration	.5	μs
Duty Factor	0.001	
DC Plate Voltage	2000	V
DC Grid Voltage	−75	V
Peak Video Plate Current	1.1	a
Peak Video Grid Current	.8	a
Useful Peak Power Output, approximate	850	w
Typical Operation, Plate-Pulsed RF Amplifier, ML-8906/AL		
Frequency	1.1	GHz
Heater Voltage	5.7	V
Pulse Duration	3.5	μs
Duty Factor	0.001	
Peak Plate Pulse Supply Voltage	2000	v
DC Grid Voltage	−45	V
Peak Video Plate Current	2	a
Peak Video Grid Current	1	a
Driving Power	300	W
Useful Peak Power Output, approximate	2	kw
Typical Operation, Plate-Pulsed RF Oscillator, ML-8906, ML-8907		
Frequency	3	GHz
Heater Voltage	5.8	V
Pulse Duration	3	μs
Duty Factor	0.0025	
Peak Plate Pulse Supply Voltage	3500	v
Peak Video Plate Current	4.8	a
Peak Video Grid Current	1.5	a
Useful Peak Power Output, approximate	3	kw

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values		
DC Plate Voltage	3500	V
Peak Plate Voltage	4500	v
DC Grid Voltage	−150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	−750	v
Grid positive to cathode	150	v
DC Plate Current	150	mA
Pulse Cathode Current	7.5	a
Average Plate Dissipation		
Forced-air cooling (ML-8907)	100	W
Conduction and convection (ML-8906, ML 8906/AL)	10	W
Average Grid Dissipation	1.5	W
Cutoff Amplification Factor	60	
Pulse Duration	6	μs**
Duty Factor	0.0033	**

**For applications requiring longer pulse duration or higher duty factor, consult the Machlett Engineering Department

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

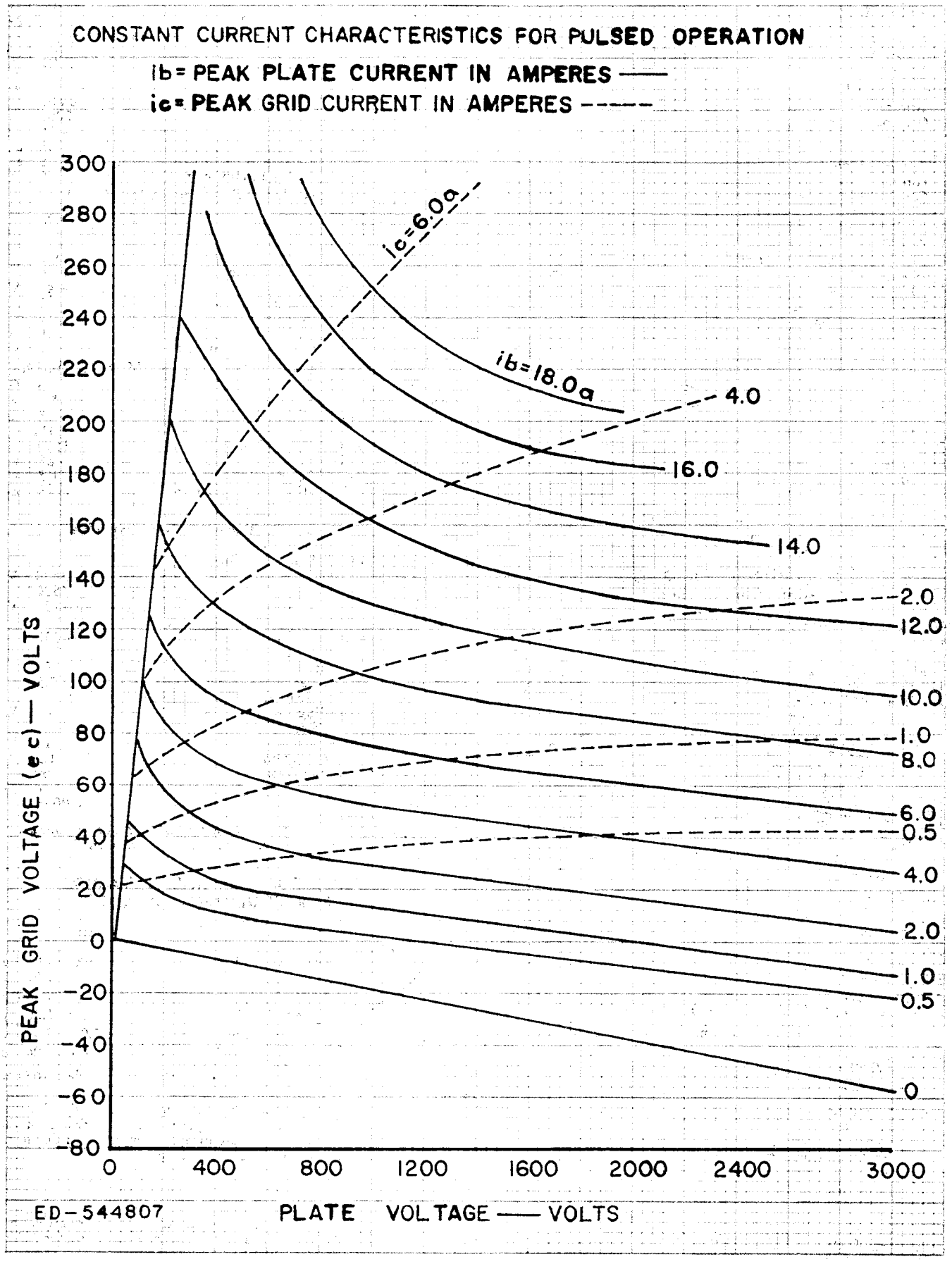
	Min	Max	
Filament Current			
ML-8906, ML-8907 (at 6.0 V)	.90	1.05	A
ML-8906/AL (at 5.7 V)	.87	1.02	A
Cut-Off Bias (Note 1)	—	−30	V
Grid-Plate Capacitance (Note 2)	1.85	1.20	pf
Grid-Cathode Capacitance (Note 2)	7.0	9.0	pf
Plate-Cathode Capacitance (Note 2)	—	.06	pf

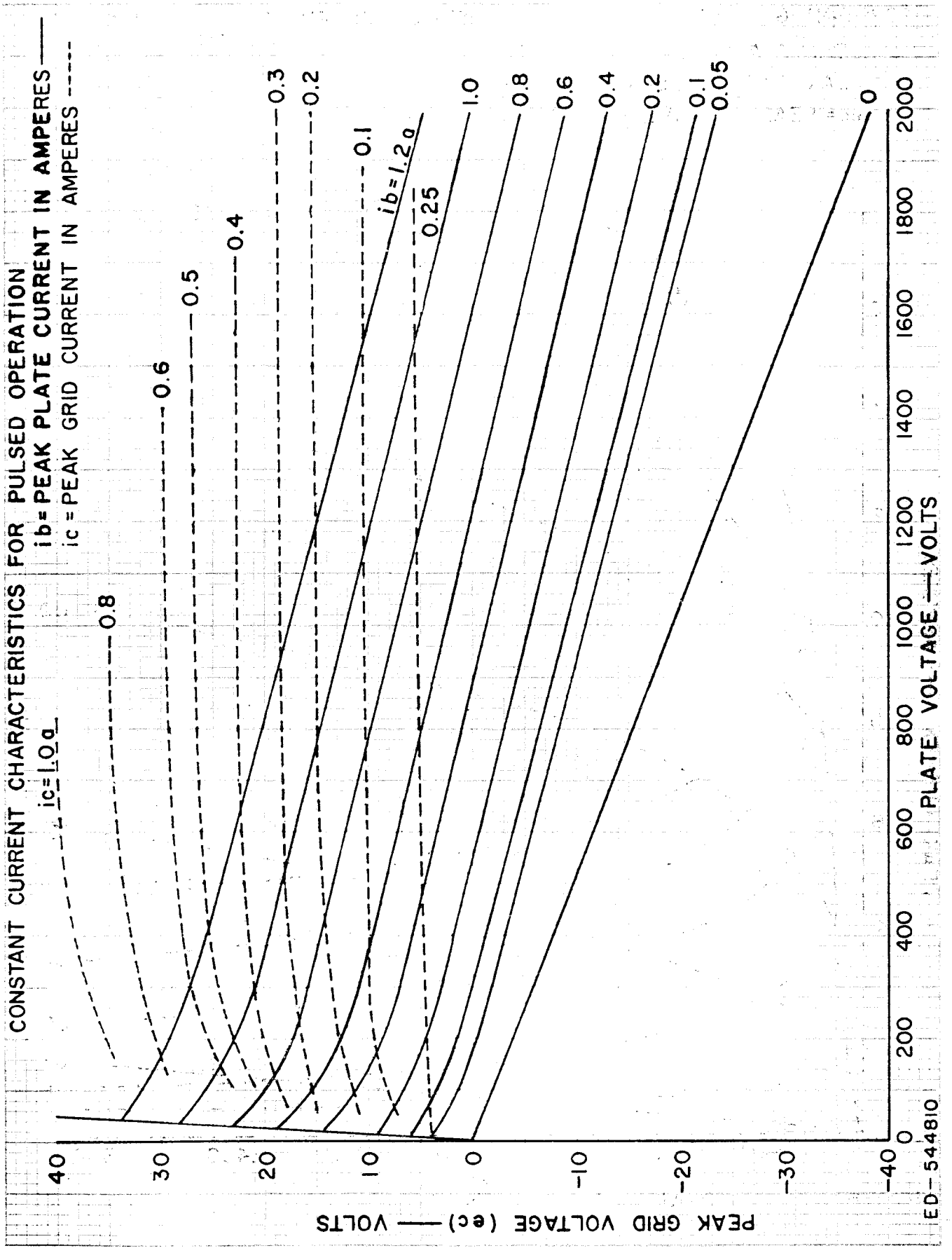
Note 1 — Measured at 1 mA of plate current and a plate voltage of 1000 Vdc.

Note 2 — Capacitance values are given for a cold tube. When the cathode is heated to its proper temperature, the grid-cathode capacitance will increase by approximately 1 pf due to thermal expansion of the cathode support structure.

APPLICATION NOTES

Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publications entitled *Application Notes, UHF Tubes — General* and *Application Notes, UHF Triodes, Extended Life AL Series Tubes for Airline Operation.*


CONSTANT CURRENT CHARACTERISTICS FOR PULSED OPERATION
ib = PEAK PLATE CURRENT IN AMPERES ——
ic = PEAK GRID CURRENT IN AMPERES - - - - -
ic=6.0a
ib=18.0a
4.0
16.0
14.0
2.0
12.0
10.0
1.0
8.0
6.0
0.5
4.0
2.0
1.0
0.5
0
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
0
400
800
1200
1600
2000
2400
3000
PEAK GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — VOLTS
ED-544807

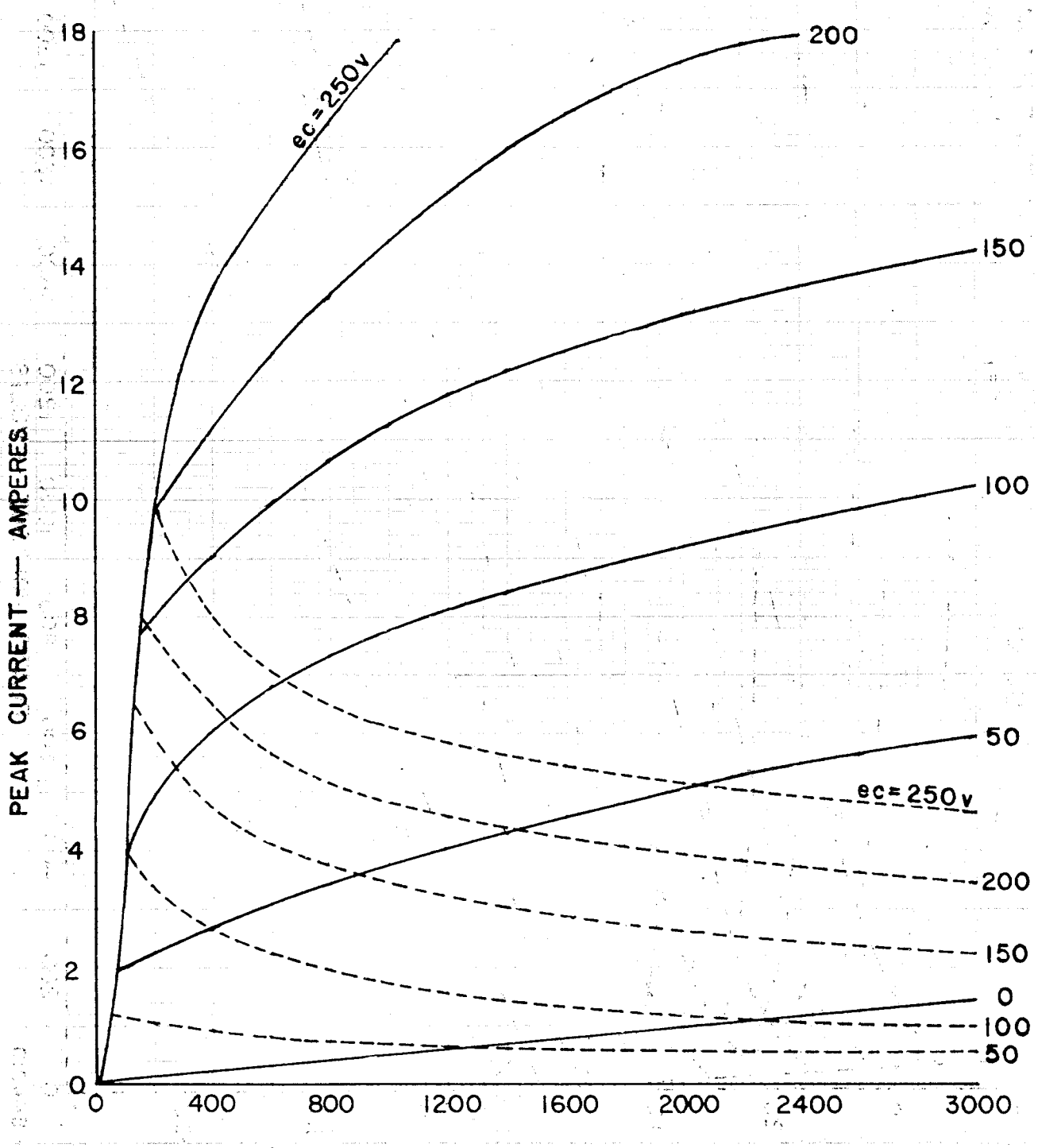

CONSTANT CURRENT CHARACTERISTICS FOR PULSED OPERATION
ib = PEAK PLATE CURRENT IN AMPERES ——
ic = PEAK GRID CURRENT IN AMPERES - - - -
ic = 1.0 a
0.8
0.6
0.5
0.4
0.3
0.2
0.1
ib = 1.2 a
0.25
1.0
0.8
0.6
0.4
0.2
0.1
0.05
0
PEAK GRID VOLTAGE (ec) —— VOLTS
40
30
20
10
0
-10
-20
-30
-40
0
200
400
600
800
1000
1200
1400
1600
1800
2000
PLATE VOLTAGE — VOLTS
ED-544810

CONSTANT GRID-VOLTAGE CHARACTERISTICS FOR PULSED OPERATION

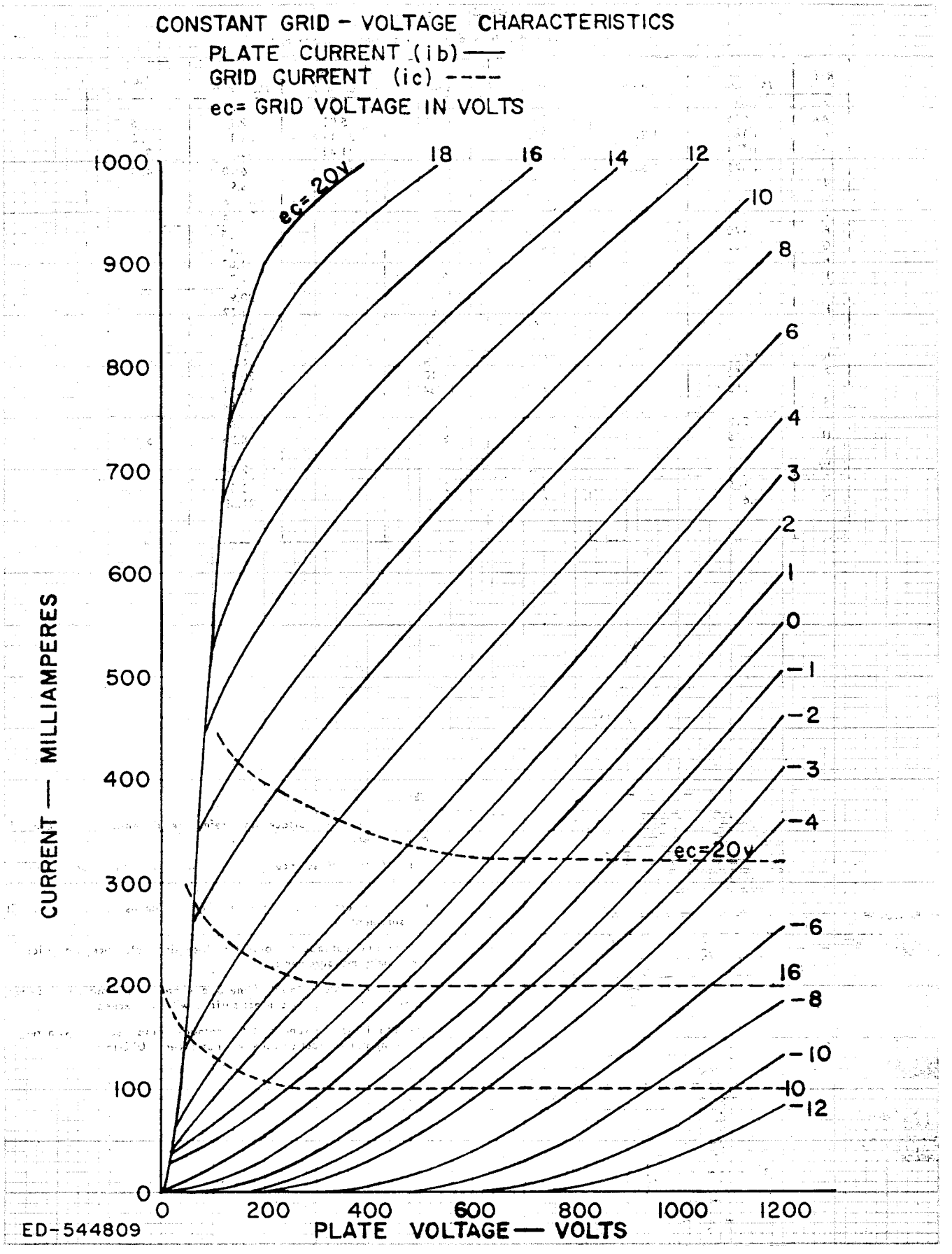
PEAK PLATE CURRENT (ib)——

PEAK GRID CURRENT (ic)-----

ec= PEAK POSITIVE GRID VOLTAGE IN VOLTS



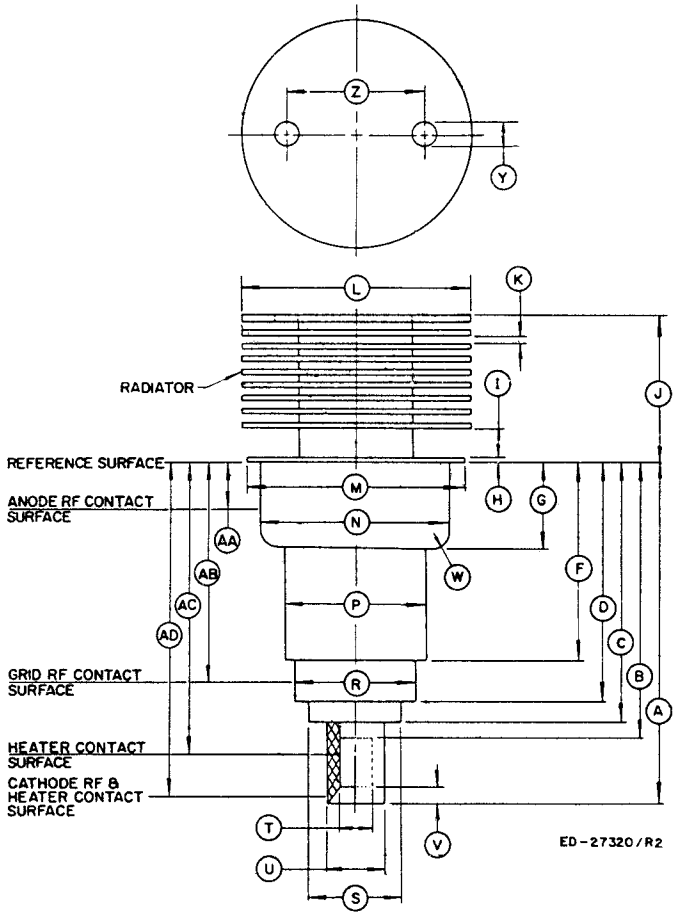
ED-544808


CONSTANT GRID - VOLTAGE CHARACTERISTICS
PLATE CURRENT (ib) ——
GRID CURRENT (ic) ----
ec= GRID VOLTAGE IN VOLTS
CURRENT — MILLIAMPERES
PLATE VOLTAGE — VOLTS
ED-544809
ec= 20v
ec=20v
18
16
14
12
10
8
6
4
3
2
1
0
-1
-2
-3
-4
-6
16
-8
-10
10
-12
0
100
200
300
400
500
600
700
800
900
1000
0
200
400
600
800
1000
1200

DIMENSIONS FOR OUTLINE OF ML-8907

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.815		1.875	46.10		47.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.185	1.225	1.265	30.10	31.12	32.13	2, 5
AC	1.534	1.631	1.728	38.96	41.43	43.89	3, 6
AD	1.475	1.645	1.815	37.46	41.78	46.10	4, 5, 6
B			1.534			38.96	
C			1.475			37.46	
D	1.289		1.329	32.74		33.76	
F	.970		1.010	24.64		25.65	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I	.125		.185	3.18		4.70	
J	.766		.826	19.46		20.98	
K	.025		.046	.64		1.17	
L	1.234		1.264	31.34		32.11	
M	1.180		1.195	29.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
S			.545			13.84	
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
Y	.105		.145	2.67		3.63	
Z	.650		.850	16.51		21.59	



OUTLINE — ML-8907

NOTES:

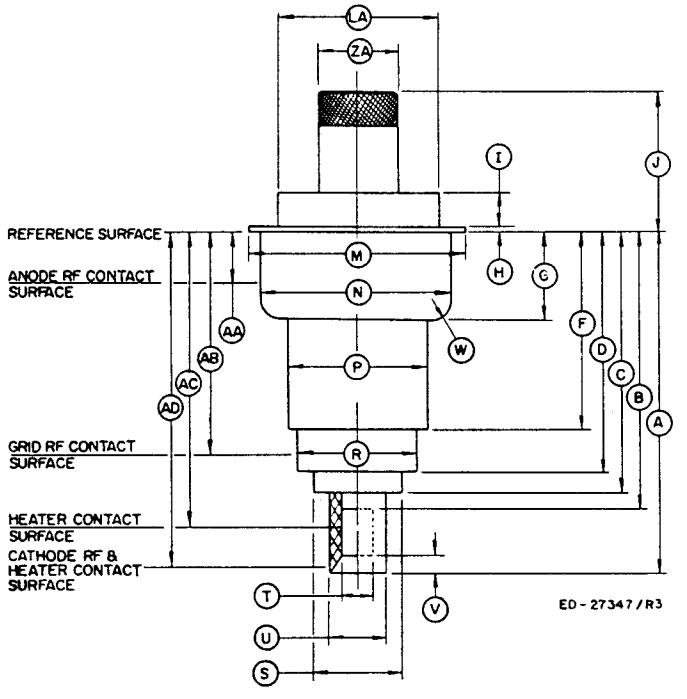
1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

DIMENSIONS FOR OUTLINE OF ML-8906 and ML-8906/AL

The millimeter dimensions are derived from the original inch dimensions.

Ref.	Inches			Millimeters			Notes
	Minimum	Nominal	Maximum	Minimum	Nominal	Maximum	
A	1.815		1.875	46.10		47.62	
AA	.035	.198	.361	.89	5.03	9.17	1, 5
AB	1.185	1.225	1.265	30.10	31.12	32.13	2, 5
AC	1.534	1.631	1.728	38.96	41.43	43.89	3, 6
AD	1.475	1.645	1.815	37.46	41.78	46.10	4, 5, 6
B			1.534			38.96	
C			1.475			37.46	
D	1.289		1.329	32.74		33.76	
F	.970		1.010	24.64		25.65	
G	.462		.477	11.73		12.12	
H			.040			1.02	
I			.185			4.70	
J	.766		.826	19.46		20.98	
LA	.840		.860	21.34		21.84	
M	1.180		1.195	29.97		30.35	
N	1.025		1.035	26.04		26.29	5
P	.752		.792	19.10		20.12	
R	.655		.665	16.64		16.89	5
S			.545			13.84	
T	.213		.223	5.41		5.66	6
U	.315		.325	8.00		8.26	5, 6
V			.086			2.18	
W			.100			2.54	
ZA	.427		.447	10.85		11.35	

OUTLINE — ML-8906 & ML-8906/AL

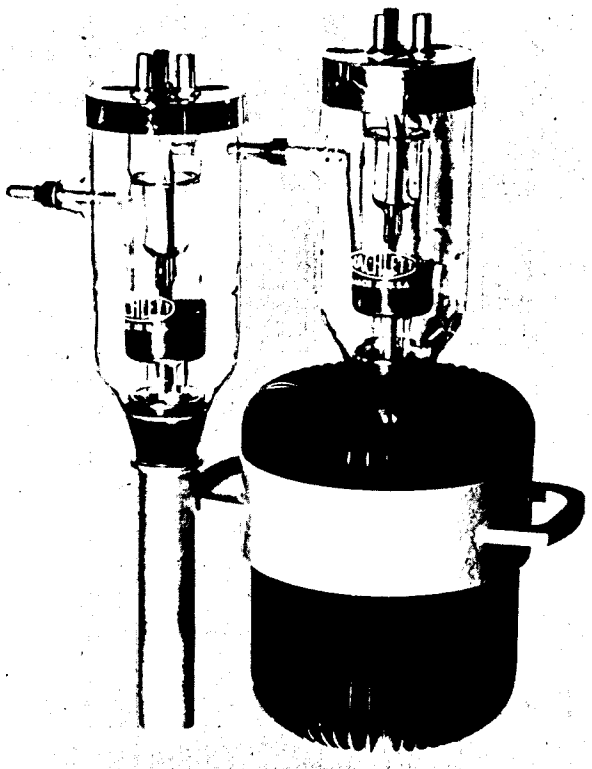


NOTES:

1. Anode rf contact surface and reference dimension for eccentricity measurements.
2. Grid rf contact surface and reference dimension for eccentricity measurements.
3. Heater contact surface and reference dimension for eccentricity measurements.
4. Heater and cathode rf contact surface and reference dimension for eccentricity measurements.
5. The total indicated runout of the anode and grid contact surface with respect to the cathode contact surface will not exceed .020 inch.
6. The total indicated runout of the cathode contact surface with respect to the heater contact surface will not exceed .012 inch.

RAYTHEON
THE MACHLETT LABORATORIES, INC.
A SUBSIDIARY OF RAYTHEON COMPANY

ST-2744 8M 7-73
Printed in U.S.A.



MACHLETT

ML-891
ML-891R

DESCRIPTION & RATINGS

DESCRIPTION

The ML-891 and ML-891R are three electrode tubes designed specifically for use as modulators, amplifiers or oscillators in radio transmitting service. The cathode of each type is a pure-tungsten filament. The ML-891 has a water-cooled anode capable of dissipating 6 kW with moderate water flow. The ML-891R has a forced-air-cooled anode capable of dissipating 4 kW with an air flow of approximately 450 cfm. Maximum ratings of 12 kVdc plate voltage and 18 kW plate input for the ML-891 and 10 kVdc plate voltage and 15 kW plate input for the ML-891R apply at frequencies up to 1.6 Mc. Operation at 20 Mc is permissible with plate voltage and plate input reduced according to the table on page 2.

GENERAL CHARACTERISTICS

Electrical			
Filament Voltage		22	Volts
Filament Current		60	Amps
Filament Starting Current, maximum		120	Amps
Filament Cold Resistance		0.031	Ohms
Amplification Factor		8.5	
Interelectrode Capacitances:	ML-891	ML-891R	
Grid-Plate	27	28	$\mu\mu f$
Grid-Filament	19	19	$\mu\mu f$
Plate-Filament	2	2.5	$\mu\mu f$
Mechanical			
Mounting Position		Vertical, anode down	
Type of Cooling — ML-891		Water	
Water flow on anode		3-8	gpm
Maximum water pressure		80	psi
Maximum outgoing water temperature		70	°C
Type of Cooling — ML-891R		Forced-air	
Air flow on anode, minimum for 4 kW dissipation	450	cfm at 0.5" Water	
Maximum incoming air temperature		45	°C
Maximum Glass Temperature		160	°C
Net Weight, approximate			
ML-891		3.5	lbs
ML-891R		45	lbs

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Services)
VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

A-F Power Amplifier & Modulator Class B

Maximum Ratings, Absolute Values	ML-891	ML-891R	
D-C Plate Voltage	15000	10000	volts
Max.-Signal D-C Plate Current*	2.0	2.0	amps
Max.-Signal Plate Input*	20000	10500	watts
Plate Dissipation*	5000	3500	watts
Typical Operation (Values are for 2 tubes)		**ML-891**	
D-C Plate Voltage	8000	12500	volts
D-C Grid Voltage	−860	−1450	volts
Peak A-F Grid to Grid Voltage	2260	3760	volts
Zero Signal D-C Plate Current	0.5	0.4	amp
Max.-Signal D-C Plate Current	2.1	2.5	amps
Eff. Load Resistance, Plate to Plate	8000	12000	ohms
Max.-Signal Driving Power, approx.	50	245	watts
Max.-Signal Power Output, approx.	10000	22000	watts

*Averaged over any audio-frequency cycle of sine wave form.

R-F Power Amplifier — Class B Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	ML-891	ML-891R	
D-C Plate Voltage	15000	10000	volts
D-C Plate Current	1.0	1.0	amp
Plate Input	10000	5500	watts
Plate Dissipation	6000	3500	watts
Typical Operation		**ML-891**	
D-C Plate Voltage	8000	14000	volts
D-C Grid Voltage	−820	−1600	volts
Peak R-F Grid Voltage	700	1000	volts
D-C Plate Current	0.6	0.56	amp
Driving Power, approx.§	0	0	watts
Power Output, approx.	1300	2300	watts

§At crest of a-f cycle with modulation factor of 1.0.

Plate Modulated R-F Power Amplifier Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	ML-891	ML-891R	
D-C Plate Voltage	8000	8000	volts
D-C Grid Voltage	−3000	−3000	volts
D-C Plate Current	1.0	1.0	amps
D-C Grid Current	0.15	0.15	amp
Plate Input	8000	8000	watts
Plate Dissipation	4000	2500	watts
Typical Operation			
D-C Plate Voltage	6000	8000	volts
D-C Grid Voltage	−2000	−2400	volts
Peak R-F Grid Voltage	2650	3100	volts
D-C Plate Current	0.75	0.78	amp
D-C Grid Current, approx.	0.1	0.08	amp
Driving Power, approx.	260	260	watts
Power Output, approx.	3500	5000	watts

R-F Power Amplifier Oscillator Class C Telegraphy

Key-down conditions per tube without modulation‡

Maximum Ratings, Absolute Values	ML-891	ML-891R	
D-C Plate Voltage	12000	10000	volts
D-C Grid Voltage	−3000	−3000	volts
D-C Plate Current	2.0	2.0	amps
D-C Grid Current	0.15	0.15	amp
Plate Input	18000	15000	watts
Plate Dissipation	6000	4000	watts
Typical Operation			
D-C Plate Voltage	8000	10000	volts
D-C Grid Voltage	−1800	−2000	volts
Peak R-F Grid Voltage	2400	2700	volts
D-C Plate Current	1.1	1.4	amps
D-C Grid Current, approx.	0.09	0.14	amp
Driving Power, approx.	215	375	watts
Power Output, approx.	6500	10000	watts

‡Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

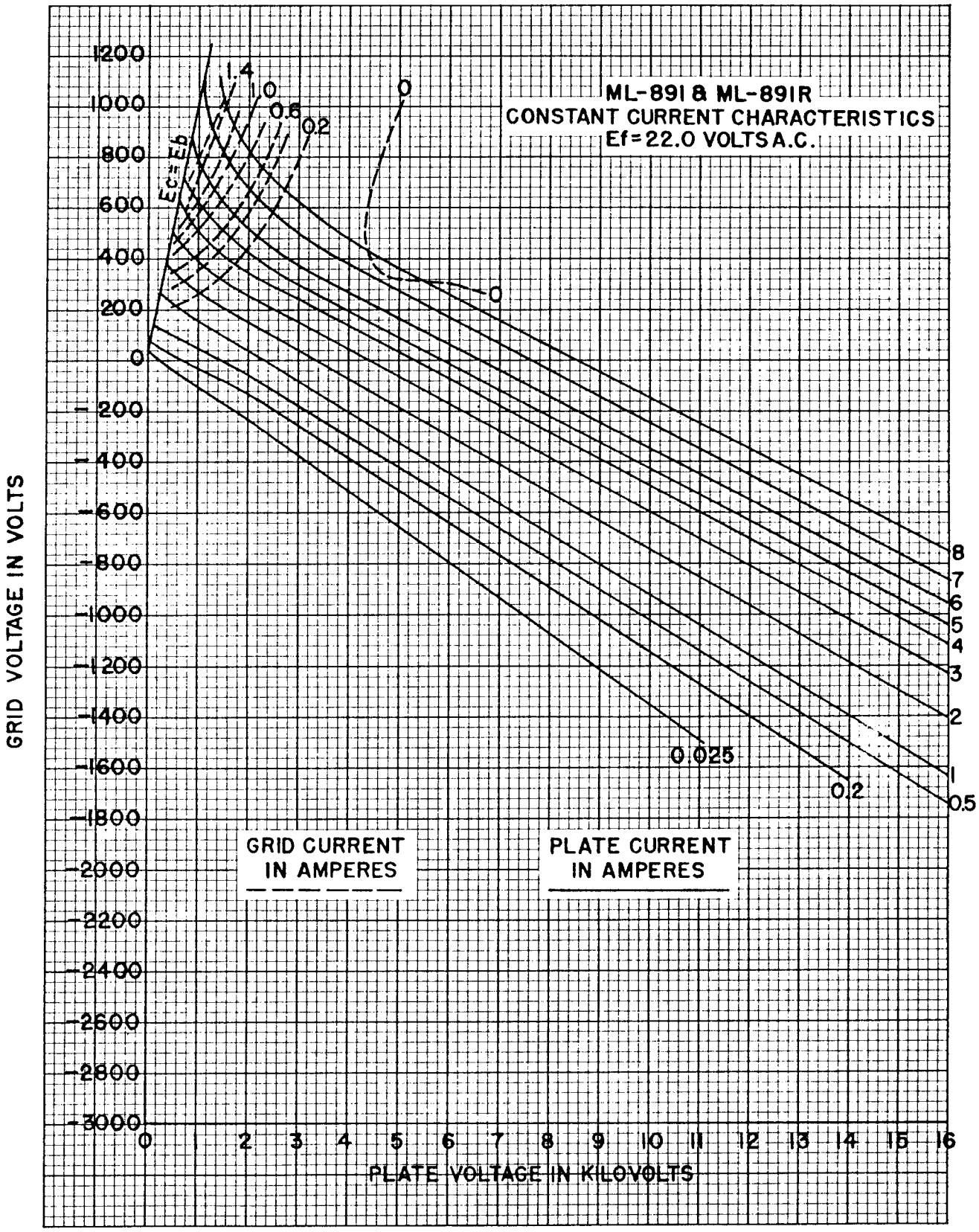
Maximum ratings apply at frequencies up to 1.6 Mc. These tubes may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with the table on the right (other maximum ratings are the same as shown above.)

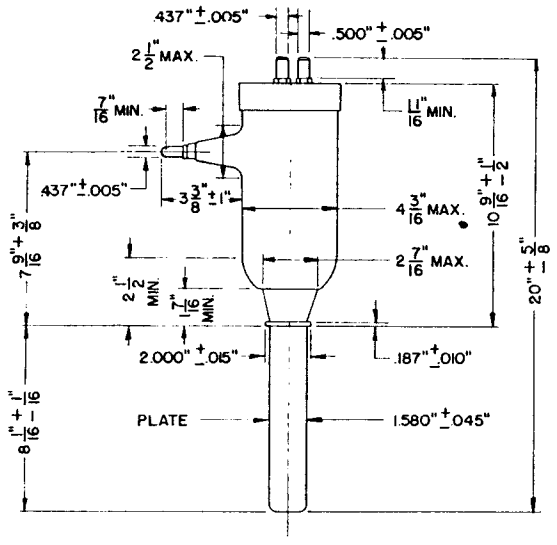
Frequency	1.6	7.5	20 Mc
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B	100	82	72
Class C Plate Modulated	100	75	65
Class C Unmodulated	100	75	50

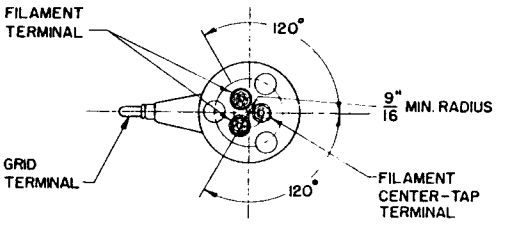
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 1500 volts; I_b = 6.0 amps	e_c:	——	——	875	volts
Grid Current	e_b = 1500 volts; I_b = 6.0 amps	i_c:	——	——	1.5	amps
Plate Voltage	E_c = 0Vdc; I_b = 0.45 Adc	E_b:	1.2	1.475	1.75	kVdc
Plate Voltage	E_c = −1000 Vdc; I_b = 0.45 Adc	E_b:	8.8	9.8	10.8	kVdc
Grid Voltage	E_b = 12 kVdc; I_b = 0.020 Adc	E_c:	−1.5	−1.675	−1.85	kVdc
Peak Cathode Current*		i_k:	9.0	——	——	amps
Power Output (ML-891)	E_b = 12 kVdc; I_b = 1.5 Adc; I_c = 0.100 Adc; R_g = 19000 ohms	P_o:	12.0	——	——	kW
Power Output (ML-891R)	E_b = 10 kVdc; I_b = 1.4 Adc; I_c = 0.100 Adc; R_g = 19000 ohms	P_o:	10.0	——	——	kW

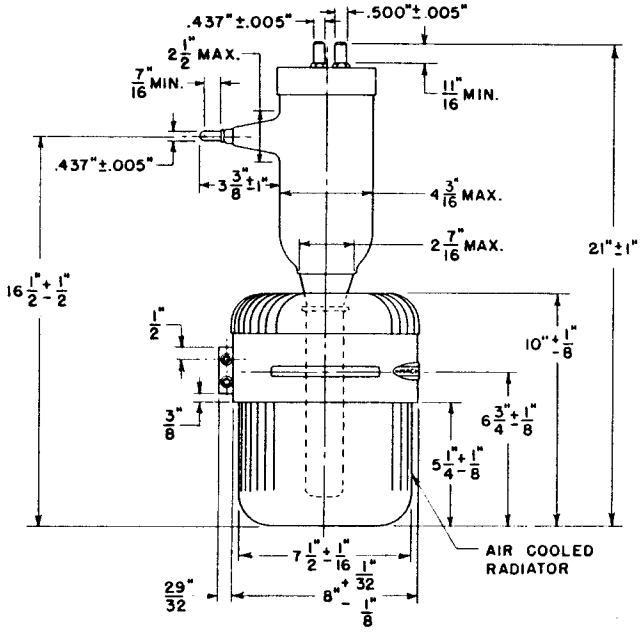
*Represents maximum useable plate current plus grid current for any condition of operation.

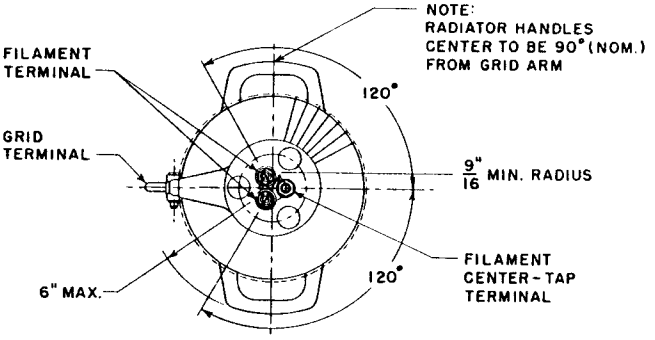

ML-891 & ML-891R
CONSTANT CURRENT CHARACTERISTICS
Ef = 22.0 VOLTS A.C.
Ec = Eb
1.4
1.0
0.6
0.2
0
0
0.025
0.2
0.5
1
2
3
4
5
6
7
8
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
GRID VOLTAGE IN VOLTS
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
-1400
-1600
-1800
-2000
-2200
-2400
-2600
-2800
-3000
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
PLATE VOLTAGE IN KILOVOLTS





DIMENSIONS — ML-891



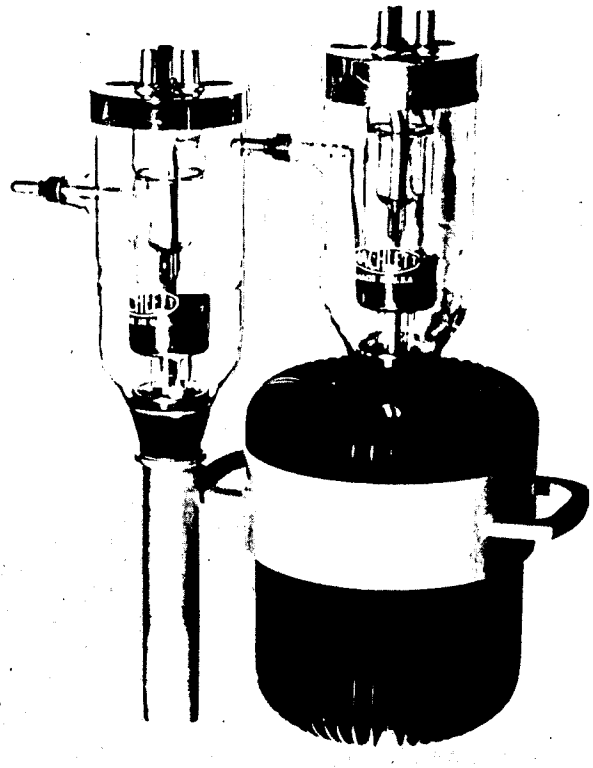


DIMENSIONS — ML-891R

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT **CONNECTICUT**

U. S. A.



MACHLETT

ML-892
ML-892R

DESCRIPTION & RATINGS

DESCRIPTION

The ML-892 and ML-892R are three-electrode tubes designed specifically for use as modulators, amplifiers, or oscillators in radio transmitting service. The cathode of each type is a pure-tungsten filament. The ML-892 has a water-cooled anode capable of dissipating 10 kW with a moderate water flow. The ML-892R has a forced-air-cooled anode capable of dissipating 4 kW with an air flow of approximately 450 cfm. Maximum ratings of 15 kVdc plate voltage and 30 kW plate input for the ML-892 and 12.5 kVdc plate voltage and 18 kW plate input for the ML-892R apply at frequencies up to 1.6 Mc. These tubes are rated for service up to 20 Mc with plate voltage and plate input reduced according to the table on page 2.

GENERAL CHARACTERISTICS

Electrical			
Filament Voltage		22	Volts
Filament Current		60	Amps
Filament Starting Current, maximum		120	Amps
Filament Cold Resistance		0.031	Ohms
Amplification Factor		50	
Interelectrode Capacitances:	ML-892	ML-892R	
Grid-Plate	30	31	$\mu\mu f$
Grid-Filament	20	20	$\mu\mu f$
Plate-Filament	1.5	2.0	$\mu\mu f$
Mechanical			
Mounting Position		Vertical, anode down	
Type of Cooling — ML-892		Water	
Water flow on anode		3-8	gpm
Maximum outgoing water temperature		70	°C
Type of Cooling — ML-892R		Forced-air	
Air flow on anode, minimum for 4 kW dissipation	450	cfm at 0.5" Water	
Maximum incoming air temperature		45	°C
Maximum Glass Temperature		160	°C
Net Weight, approximate			
ML-892		3.5	lbs.
ML-892R		45	lbs.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)
VALUES APPLY TO BOTH TYPES UNLESS OTHERWISE SPECIFIED

A-F Power Amplifier & Modulator
Class B

Maximum Ratings, Absolute Values	ML-892	ML-892R	
D-C Plate Voltage	15000	12500	volts
Max-Signal D-C Plate Current*	2.0	2.0	amps
Max-Signal Plate Input*	20000	12000	watts
Plate Dissipation*	7500	4000	watts

Typical Operation (Values are for two tubes)	ML-892				
D-C Plate Voltage	6000	8000	10000	12500	volts
D-C Grid Voltage	0	−60	−90	−170	volts
Peak A-F Grid-to-Grid Voltage	1000	1000	1380	1370	volts
Zero-Signal D-C Plate Current	0.5	0.5	0.5	0.4	amp
Max.-Signal D-C Plate Current	2.6	2.3	3.3	2.8	amps
Effective Load Resistance (plate to plate)	4200	6800	6400	10000	ohms
Max.-Signal Driving Power, approx.	135	84	240	160	watts
Max.-Signal Power Output, approx.	8000	10500	20000	22000	watts

*Averaged over any audio-frequency cycle of sine-wave form.

R-F Power Amplifier
Class B Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	ML-892	ML-892R	
D-C Plate Voltage	15000	12500	volts
D-C Plate Current	1.0	1.0	amp
Plate Input	15000	6000	watts
Plate Dissipation	10000	4000	watts

Typical Operation	ML-892				
D-C Plate Voltage	6000	8000	10000	14000	volts
D-C Grid Voltage	0	−60	−100	−190	volts
Peak R-F Grid Voltage	230	320	370	440	volts
D-C Plate Current	0.64	0.67	0.77	0.82	amp
Driving Power, approx.†	77	150	133	106	watts
Power Output, approx.	1000	1800	2500	4000	watts

†At crest of a-f cycle with modulation factor of 1.0.

Plate Modulated R-F Power Amplifier
Class C Telephony

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values	ML-892	ML-892R	
D-C Plate Voltage	1000	1000	volts
D-C Grid Voltage	−3000	−3000	volts
D-C Plate Current	1.0	1.0	amps
D-C Grid Current	0.30	0.30	amp
Plate Input	10000	10000	watts
Plate Dissipation	6600	2500	watts

Typical Operation	ML-892			
D-C Plate Voltage	6000	8000	10000	volts
D-C Grid Voltage	−1000	−1300	−1600	volts
Peak R-F Grid Voltage	1650	1950	2250	volts
D-C Plate Current	0.83	0.82	0.78	amp
D-C Grid Current, approx.	0.28	0.24	0.23	amp
Driving Power, approx.	420	430	460	watts
Power Output, approx.	3500	5000	6000	watts

R-F Power Amplifier & Oscillator
Class C Telegraphy

Key-down conditions per tube without modulation§

Maximum Ratings, Absolute Values	ML-892	ML-892R	
D-C Plate Voltage	15000	12500	volts
D-C Grid Voltage	−3000	−3000	volts
D-C Plate Current	2.0	2.0	amps
D-C Grid Current	0.40	0.40	amp
Plate Input	30000	18000	watts
Plate Dissipation	10000	4000	watts

Typical Operation	ML-892			
D-C Plate Voltage	8000	10000	12000	volts
D-C Grid Voltage	−1000	−1300	−1600	volts
Peak R-F Grid Voltage	1700	2150	2550	volts
D-C Plate Current	1.17	1.4	1.55	amps
D-C Grid Current, approx.	0.22	0.24	0.23	amp
Driving Power, approx.	330	495	565	watts
Power Output, approx.	6500	10000	14000	watts

§Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

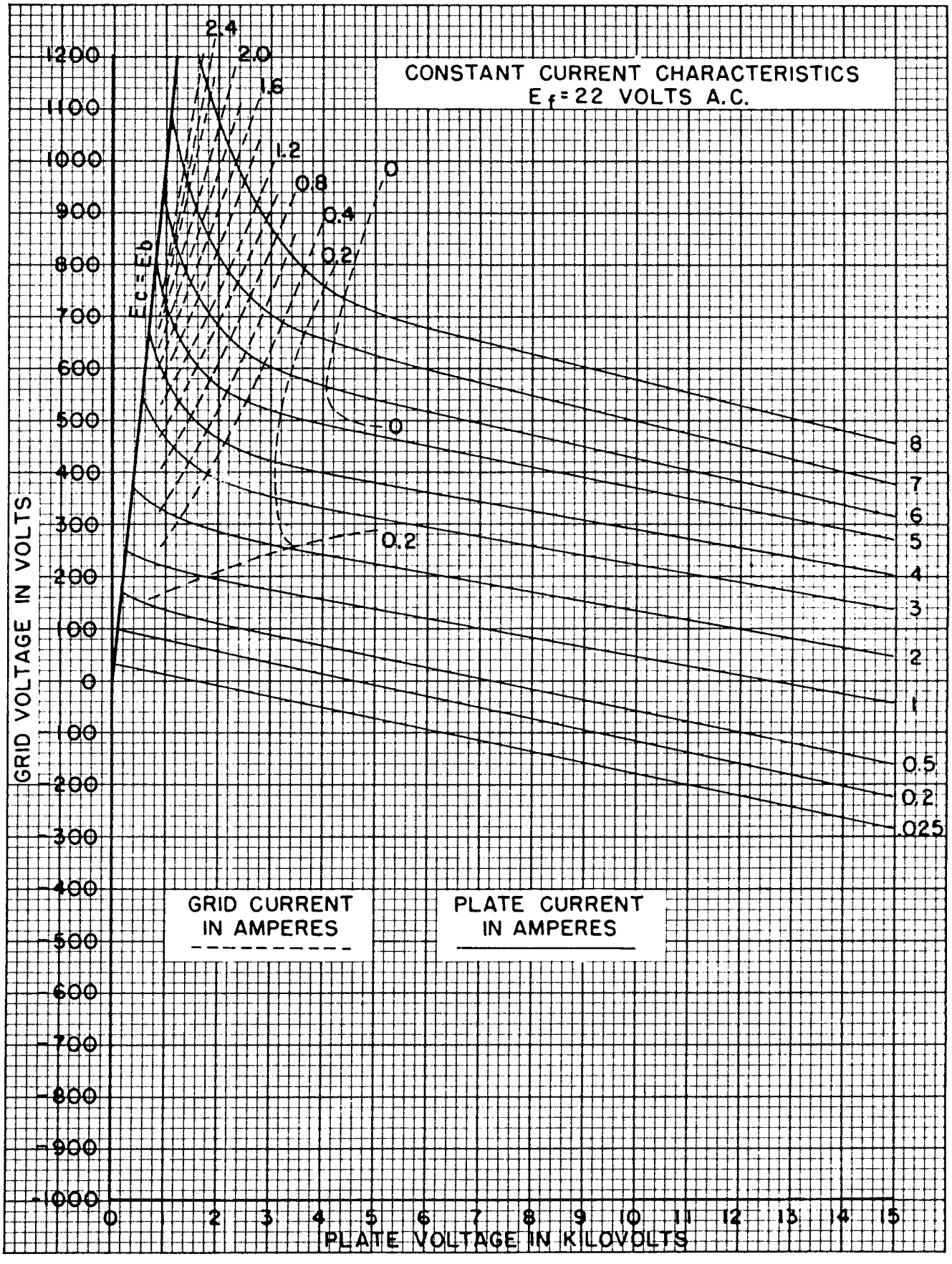
Maximum ratings apply at frequencies up to 1.6 Mc. These tubes can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with the table on the right. (Other maximum ratings are the same as shown above.)

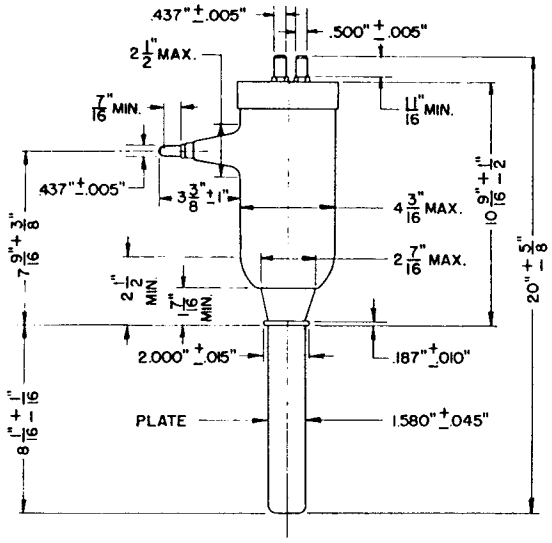
Frequency	1.6	7.5	20 Mc
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class B	100	85	76
Class C Plate Modulated (ML-892)	100	85	75
Class C Plate Modulated (ML-892R)	100	75	50
Class C Unmodulated	100	75	50

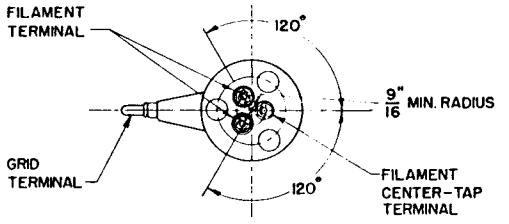
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
Grid Voltage	e_b = 1500 volts; i_b = 6 amps	e_c:	——	——	925	volts
Grid Current	e_b = 1500 volts; i_b = 6 amps	i_c:	——	——	1.75	amps
Plate Voltage	E_c = 0 Vdc; I_b = 0.42 Adc	E_b:	5.0	6.2	7.4	kVdc
Plate Voltage	E_c = −100 Vdc; I_b = 0.42 Adc	E_b:	9.2	11.2	13.2	kVdc
Grid Voltage	E_b = 15 kVdc; I_b = 0.020 Adc	E_c:	−240	−320	−400	Vdc
Peak Cathode Current*		i_k:	9.0	——	——	amps
Power Output (ML-892)	E_b = 15 kVdc; I_b = 2.0 Adc; I_c = .250 Adc; R_g = 5000 ohms	P_o:	20	——	——	kW
Power Output (ML-892R)	E_b = 10 kVdc; I_b = 1.4 Adc; I_c = .250 Adc; R_g = 5000 ohms	P_o:	10	——	——	kW

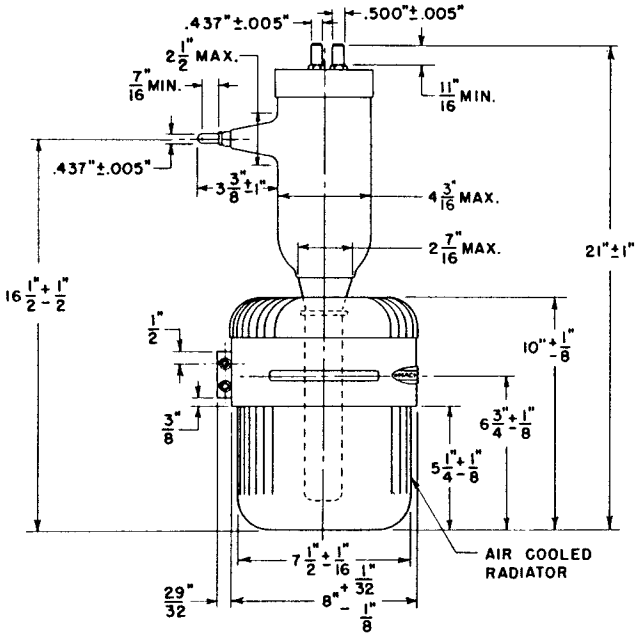
*Represents maximum useable plate current plus grid current for any condition of operation.

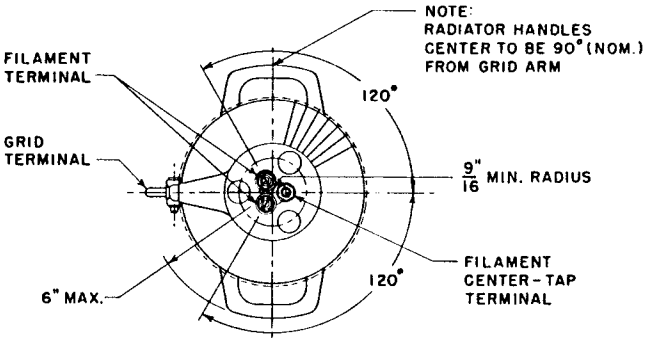

CONSTANT CURRENT CHARACTERISTICS
Ef = 22 VOLTS A.C.
GRID VOLTAGE IN VOLTS
PLATE VOLTAGE IN KILOVOLTS
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
Ec = Eb
2.4
2.0
1.6
1.2
0.8
0.4
0.2
0
0
0.2
8
7
6
5
4
3
2
1
0.5
0.2
.025
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
0
2
3
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9
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11
12
13
14
15





DIMENSIONS — ML-892





DIMENSIONS — ML-892R

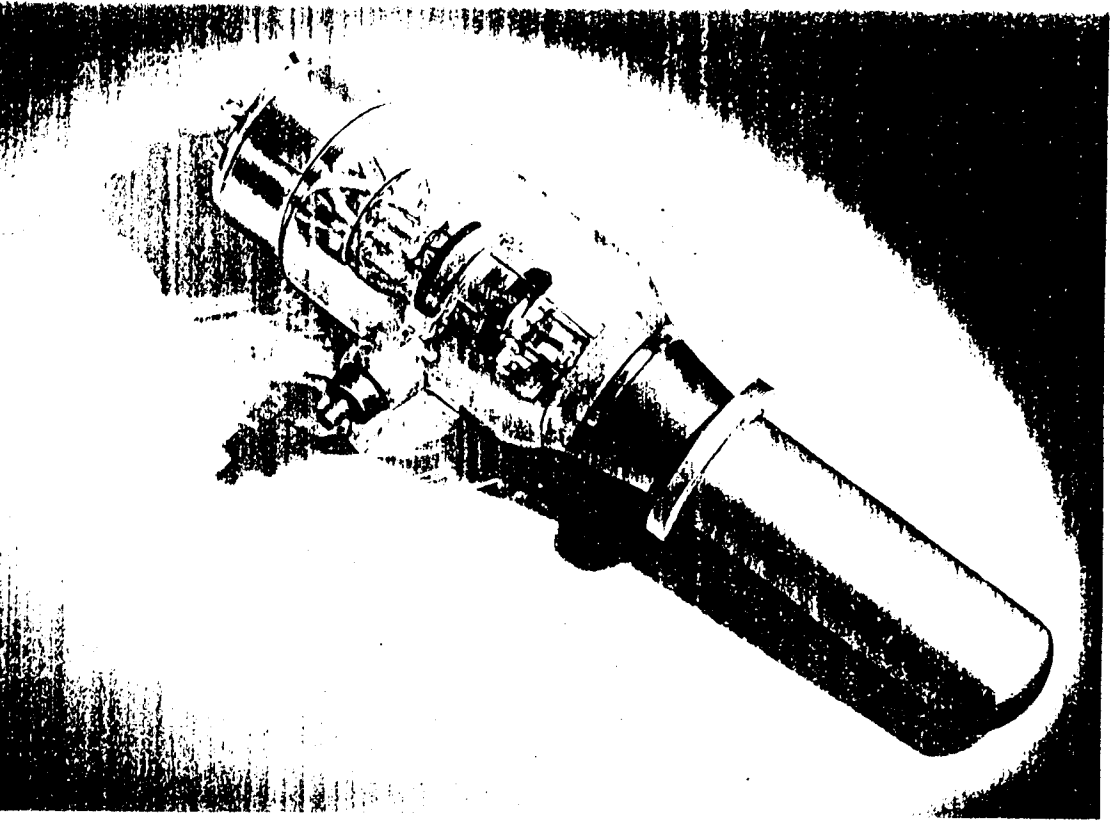
MACHLETT LABORATORIES, INC.

SPRINGDALE CONNECTICUT

U. S. A.

ST-1640 5M 11-59

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MACHLETT

ML-893A

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-893A is a three-electrode tube designed specifically for use as a modulator, amplifier, or oscillator in radio transmitting service. The cathode is a pure-tungsten filament and can be operated from single, three, or six-phase power supply; it has been designed for maximum strength to minimize the possibility of grid to filament shorts. The anode is water-cooled and is capable of dissipating 20 kilowatts. Maximum ratings of 20 kVdc plate voltage and 70 kW plate input apply at frequencies up to 5 mc/sec; operation at 40 mc/sec is permissible with voltage and input reduced to one-half maximum ratings.

The ML-893A embodies the highest standards for this tube type. All types are thoroughly processed by special Machlett techniques to assure efficient operation and long life.

GENERAL CHARACTERISTICS

Electrical	Minimum	Bogey	Maximum	
Filament Voltage (Notes 1 and 2)	—	20	—	Volts
Filament Emission at Bogey Voltage	—	25.3	—	Amps
Filament Current at Bogey Voltage (Notes 1 and 2)	175	183	190	Amps
Filament Starting Current (Note 1)	—	—	275	Amps
Filament Cold Resistance	—	.0093	—	Ohms
Amplification Factor $I_b = 1.0$ Adc, $E_c = -100$ Vdc	28	34.5	41	
Interelectrode Capacitances				
Grid-Plate	28.5	33	37.5	uuf
Grid-Filament	39.5	48	56.5	uuf
Plate-Filament	2.0	3	4.0	uuf

Mechanical		
Mounting Position — Vertical, Anode Down		
Type of Cooling — Water and Forced Air		
Water Flow on Anode	15	gpm
Maximum Outgoing Water Temperature	70	°C
Air Flow to Stem (Note 3)	2	cfm
Maximum Glass Temperature	150	°C
Net Weight, approximate	12	lbs.

Note 1: Single-Phase Excitation.
Note 2: See Diagrams of Filament Connections and Excitation Circuits.
Note 3: Air flow to be directed into stem through tubing in center of base.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

A-F Power Amplifier and Modulator — Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	20000 volts
Max. Signal D-C Plate Current※	4.0 amps
Max. Signal Plate Input※	60000 watts
Plate Dissipation※	20000 watts

Typical Operation*

D-C Plate Voltage	12000	15000	18000 volts
Zero Signal D-C Plate Current	0.8	0.8	0.8 amps
Max. Signal D-C Plate Current	7	6	5.5 amps
D-C Grid Voltage	-260	-350	-450 volts
Peak A-F Grid-to-Grid Voltage	1480	1560	1720 volts
Effective Load Resistance (plate to plate)	4000	6000	8000 ohms
Max. Signal Driving Power	220	190	140 watts
Max. Signal Power Output, approximate	52000	60000	70000 watts

Plate-Modulated R-F Power Amplifier — Class C

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	12000 volts
D-C Plate Current	2 amps
D-C Grid Voltage	-3000 volts
D-C Grid Current	0.4 amps
Plate Input	24000 watts
Plate Dissipation	12000 watts

Typical Operation

D-C Plate Voltage	10000	10000	12000 volts
D-C Plate Current	1.5	2	2 amps
D-C Grid Voltage	-800	-800	-1000 volts
Peak R-F Grid Voltage	1200	1280	1500 volts
D-C Grid Current	0.1	0.16	0.14 amps
Driving Power	120	210	210 watts
Power Output	11000	15000	18000 watts

R-F Power Amplifier — Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	20000 volts
D-C Plate Current	2.0 amps
Plate Input	32000 watts
Plate Dissipation	20000 watts

Typical Operation

D-C Plate Voltage	12000	15000	15000 volts
D-C Plate Current	1.5	1.5	2.0 amps
D-C Grid Voltage	-250	-340	-340 volts
D-C Grid Current, approximate	35	30	50 ma
Peak R-F Grid Voltage	350	395	450 volts
Driving Power	130	150	200 watts
Power Output	6000	7500	10000 watts

R-F Power Amplifier and Oscillator — Class C

Key-down conditions per tube without modulation**

Maximum Ratings, Absolute Values

D-C Plate Voltage	20000 volts
D-C Plate Current	4 amps
D-C Grid Voltage	-3000 volts
D-C Grid Current	0.4 amps
Plate Input	70000 watts
Plate Dissipation	20000 watts

Typical Operation

D-C Plate Voltage	12000	15000	18000 volts
D-C Plate Current	3.5	3.6	3.6 amps
D-C Grid Voltage	-800	-900	-1000 volts
Peak R-F Grid Voltage	1430	1520	1630 volts
D-C Grid Current	0.26	0.25	0.21 amps
Driving Power	360	370	340 watts
Power Output	30000	40000	50000 watts

※ Averaged over any audio-frequency cycle of sine-wave form.
* Unless otherwise specified, values are for 2 tubes.
** Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

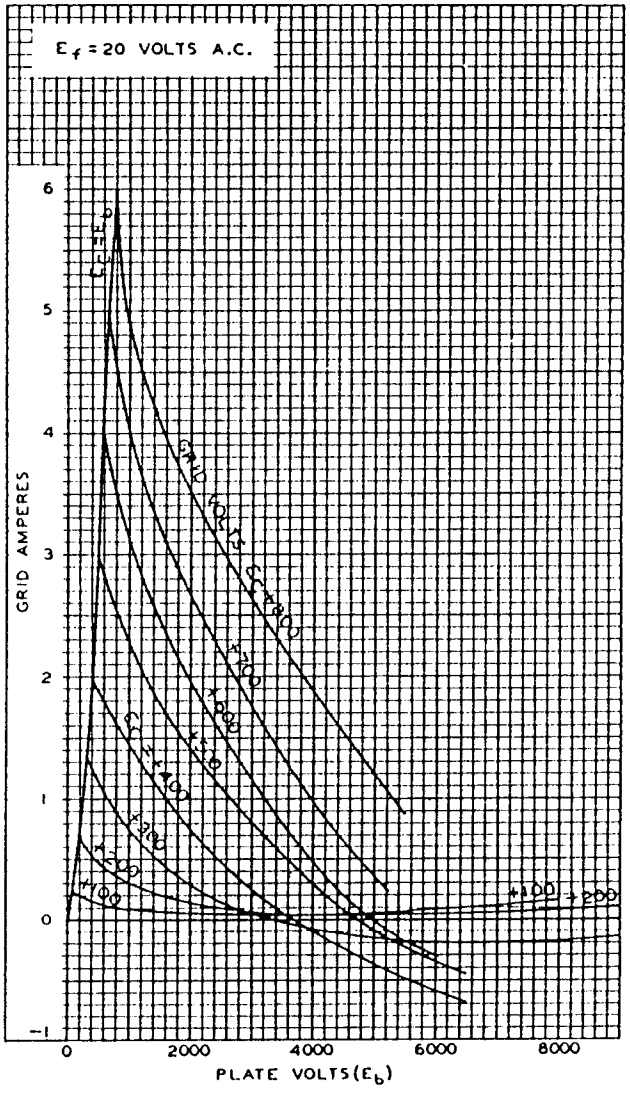
The ML-893A can be operated at full power at frequencies as high as 5 megacycles. It can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with table which shows the maximum permissible percentage of rated plate voltage and plate input for various frequencies above 5 megacycles.

Mc	Class B		Class C Plate Modulated		Class C	
	Volts	Watts	Volts	Watts	Volts	Watts
5	100%	100%	100%	100%	100%	100%
20	85%	82%	80%	75%	80%	66%
40	65%	73%	64%	64%	60%	50%

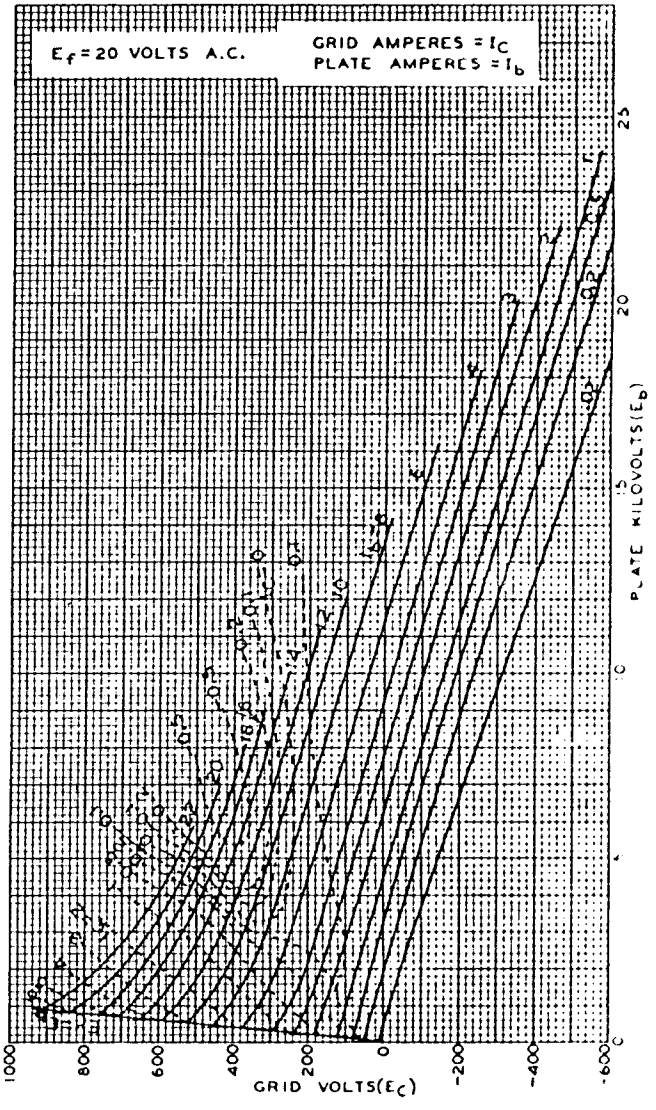
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic	Conditions		Limits Min.	Bogey	Max.
Grid Voltage	i_b = 15.0 amps; e_b = 1500 volts	e_c:	—	—	800 Volts
Grid Current	i_b = 15.0 amps; e_b = 1500 volts	i_c:	—	—	4.5 Amps
Plate Voltage	I_b = 1.0 Adc; E_c = 0	E_b:	3.0	4.0	5.0 kVdc
Plate Voltage	I_b = 1.0 Adc; E_c = −200 Vdc	E_b:	9.2	11.2	13.2 kVdc
Grid Voltage	E_b = 20 kVdc; I_b = 0.020 Adc	E_c:	−530	600	770 Vdc
Peak Cathode Current	Note 1	i_k:	20	—	— Amps
Power Output	E_b = 18.0 kVdc; I_b = 3.6 Adc I_c = 0.36 Adc; E_c = −1800Vdc	P_o:	45	—	— kW

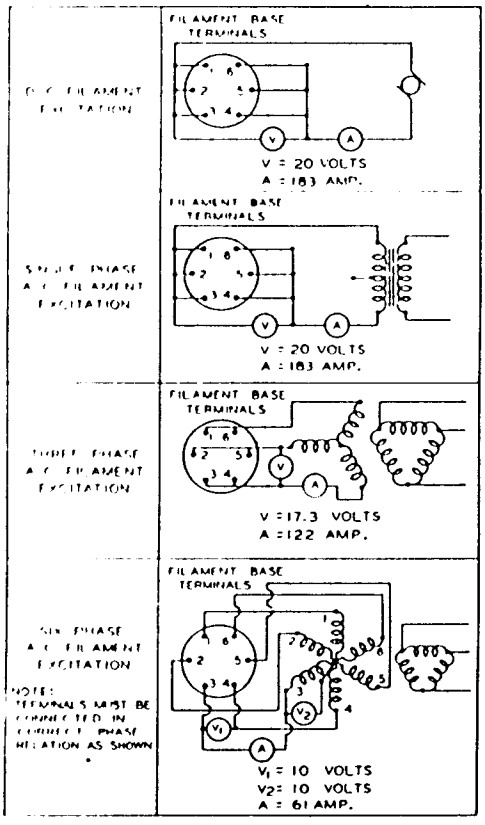
Note 1: Represents maximum usable cathode current for tube as plate current plus grid current for any condition of operation.



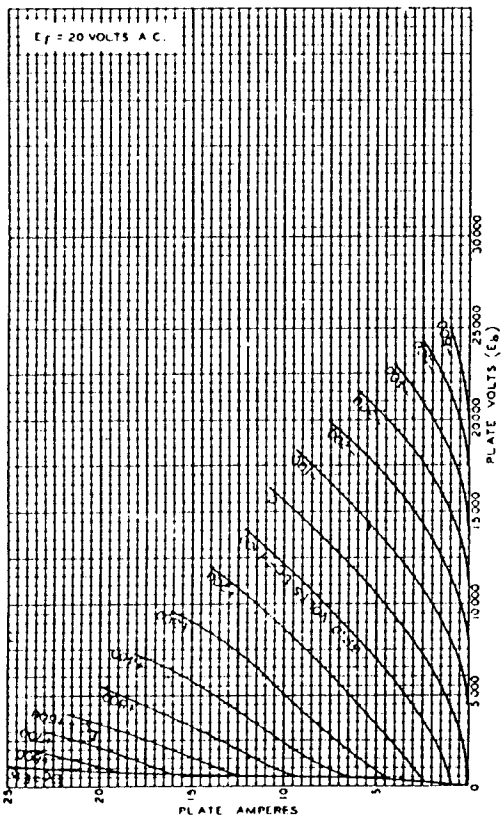
GRID-PLATE TRANSFER CHARACTERISTICS



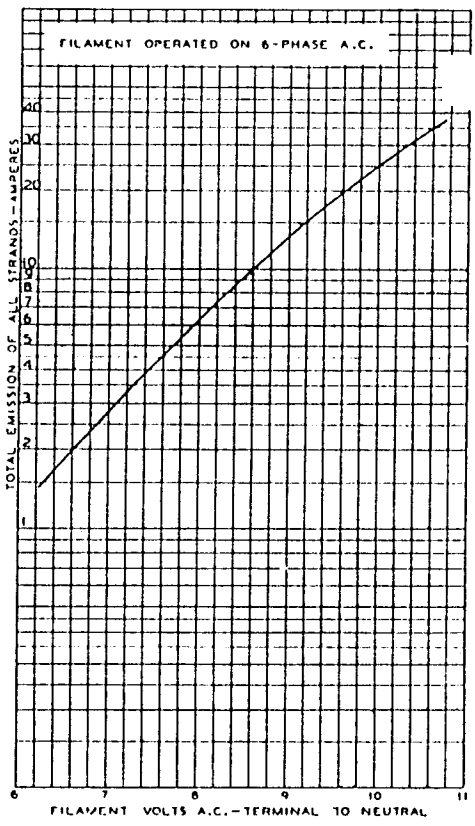
AVERAGE CONSTANT-CURRENT CHARACTERISTICS



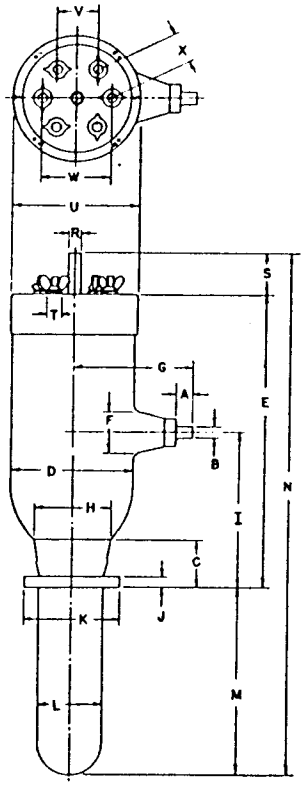
FILAMENT CONNECTIONS AND EXCITATION CIRCUITS



AVERAGE PLATE CHARACTERISTICS



AVERAGE FILAMENT-EMISSION CHARACTERISTIC



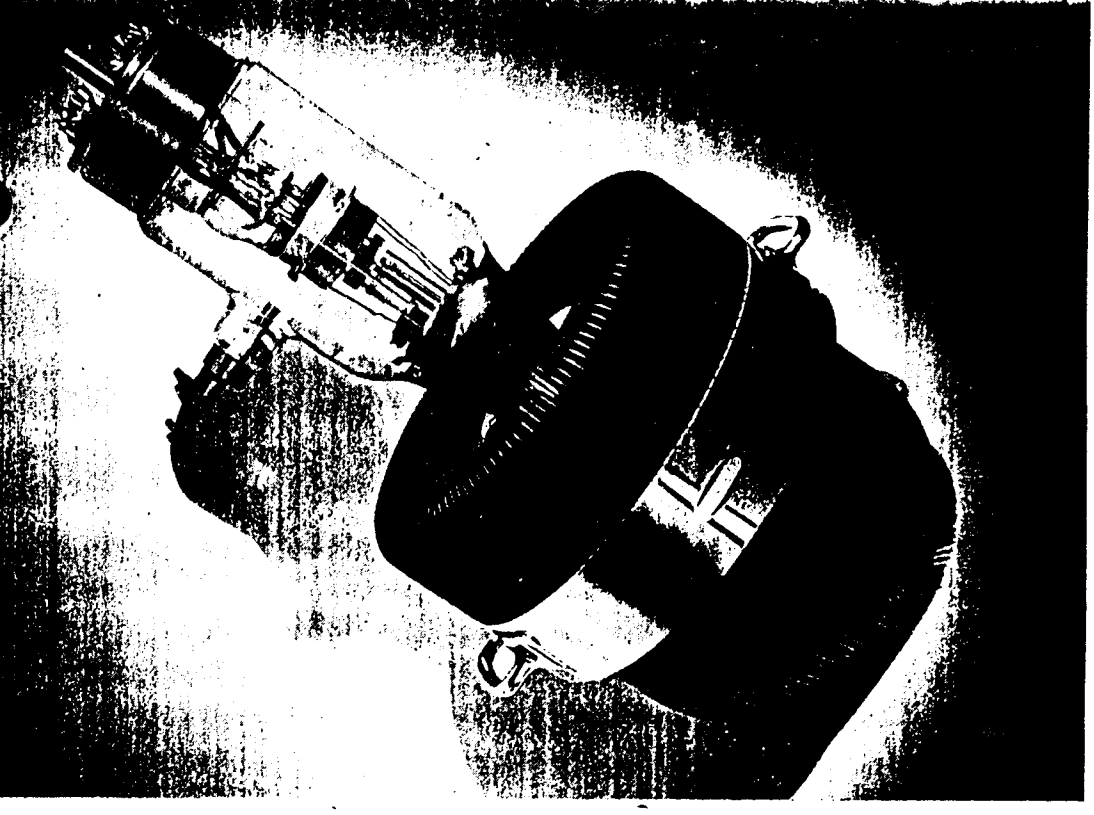
DIMENSIONS IN INCHES

	Min.	Max.
A—	0.687	0.812
B—	0.561	0.571
C—	2.00	2.75
D—	5.87	6.13
E—	14.00	15.00
F—	1.50	3.06
G—	5.00	6.50
H—	3.81	4.312
I—	7.375	8.125
J—	0.480	0.520
K—	4.667	4.707
L—	3.125	3.250
M—	9.00	9.50
N—	24.50	26.75
R—	0.590	0.660
S—	1.875	2.250
T—	0.215	0.285
U—	6.250	6.375
V—	1.965	2.035
W—	3.310	3.375
X—	1.465	1.535

MACHLETT LABORATORIES, INC.

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MACHLETT

ML-893A-R

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-893A-R is a three-electrode tube designed specifically for use as a modulator, amplifier, or oscillator in radio transmitting service. The cathode is a pure-tungsten filament and can be operated from single, three, or six-phase power supply; it has been designed for maximum strength to minimize the possibility of grid to filament shorts. The anode is forced-air cooled and is capable of dissipating 20 kilowatts. Maximum ratings of 20 kVdc plate voltage and 70 kW plate input apply at frequencies up to 5 mc/sec; operation at 25 mc/sec is permissible with voltage and input reduced to one-half maximum ratings.

The ML-893A-R embodies the highest standards for this tube type. All types are thoroughly processed by special Machlett techniques to assure efficient operation and long life.

GENERAL CHARACTERISTICS

	Minimum	Bogey	Maximum	
Electrical				
Filament Voltage (Notes 1 and 2)		20		Volts
Filament Emission at 20 Volts		25.3		Amps
Filament Current at 20 Volts (Notes 1 and 2)	175	183	190	Amps
Filament Starting Current (Note 1)	—	—	275	Amps
Filament Cold Resistance	—	.0093	—	Ohms
Amplification Factor $I_b = 1.0$ Adc, $E_c = -100$ Vdc	28	34.5	41	
Interelectrode Capacitances				
Grid-Plate	29.8	34.0	38.8	uuf
Grid-Filament	39.5	48.0	56.5	uuf
Plate-Filament	2.6	3.5	4.4	uuf
Mechanical				
Mounting Position - - Vertical, Anode Down				
Type of Cooling — Forced Air				
Maximum Incoming Air Temperature			45	°C
Required Air-Flow on Anode				
Plate Dissipation — Per Cent of Rating	100	80	65	
Air Flow — Cubic Feet per Minute	1800	1250	1000	
Static Pressure — Inches Water	1.05	0.56	0.38	
Required Air Flow to Stem			2	cfm
Maximum Anode Temperature			230	°C
Maximum Glass Temperature			150	°C
Net Weight, approximate			230	lbs.

Note 1: Single-Phase Excitation.
Note 2: See Diagrams of Filament Connections and Excitation Circuits.
Note 3: Air flow to be directed into stem through tubing in center of base.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

A-F Power Amplifier and Modulator—Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	20000 volts
Max. Signal D-C Plate Current§	4.0 amps
Max. Signal Plate Input§	60000 watts
Plate Dissipation§	20000 watts

Typical Operation*

D-C Plate Voltage	12000	15000	18000 volts
Zero Signal D-C Plate Current	0.8	0.8	0.8 amps
Max. Signal D-C Plate Current	7	6	5.5 amps
D-C Grid Voltage	−260	−350	−450 volts
Peak A-F Grid-to-Grid Voltage	1480	1560	1720 volts
Effective Load Resistance (plate to plate)	4000	6000	8000 ohms
Max. Signal Driving Power	220	190	140 watts
Max. Signal Power Output, approximate	52000	60000	70000 watts

Plate-Modulated R-F Power Amplifier—Class C

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	12000 volts
D-C Plate Current	2 amps
D-C Grid Voltage	−3000 volts
D-C Grid Current	0.4 amps
Plate Input	24000 watts
Plate Dissipation	12000 watts

Typical Operation

D-C Plate Voltage	10000	10000	12000 volts
D-C Plate Current	1.5	2	2 amps
D-C Grid Voltage	−800	−800	−1000 volts
Peak R-F Grid Voltage	1200	1280	1500 volts
D-C Grid Current, approximate	0.10	0.16	0.14 amps
Driving Power, approximate	120	210	210 watts
Power Output, approximate	11000	15000	18000 watts

R-F Power Amplifier—Class B

Carrier conditions per tube for use with a maximum modulation factor of 1.0

Maximum Ratings, Absolute Values

D-C Plate Voltage	20000 volts
D-C Plate Current	2.0 amps
Plate Input	32000 watts
Plate Dissipation	20000 watts

Typical Operation

D-C Plate Voltage	12000	15000	15000 volts
D-C Plate Current	1.5	1.5	2.0 amps
D-C Grid Voltage	−250	−340	−340 volts
D-C Grid Current, approximate	35	30	50 ma
Peak R-F Grid Voltage	350	395	450 volts
Driving Power, approximate†	130	150	200 watts
Power Output, approximate	6000	7500	10000 watts

R-F Power Amplifier and Oscillator—Class C

Key-down conditions per tube without modulation**

Maximum Ratings, Absolute Values

D-C Plate Voltage	20000 volts
D-C Plate Current	4 amps
D-C Grid Voltage	−3000 volts
D-C Grid Current	0.4 amps
Plate Input	70000 watts
Plate Dissipation	20000 watts

Typical Operation

D-C Plate Voltage	12000	15000	18000 volts
D-C Plate Current	3.5	3.6	3.6 amps
D-C Grid Voltage	−800	−900	−1000 volts
Peak R-F Grid Voltage	1430	1520	1630 volts
D-C Grid Current, approximate	0.26	0.25	0.21 amps
Driving Power, approximate	360	370	340 watts
Power Output, approximate	30000	40000	50000 watts

§ Averaged over any audio-frequency cycle of sine-wave form.
† At crest of audio-frequency cycle with modulation factor of 1.0.
* Unless otherwise specified, values are for 2 tubes.
** Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

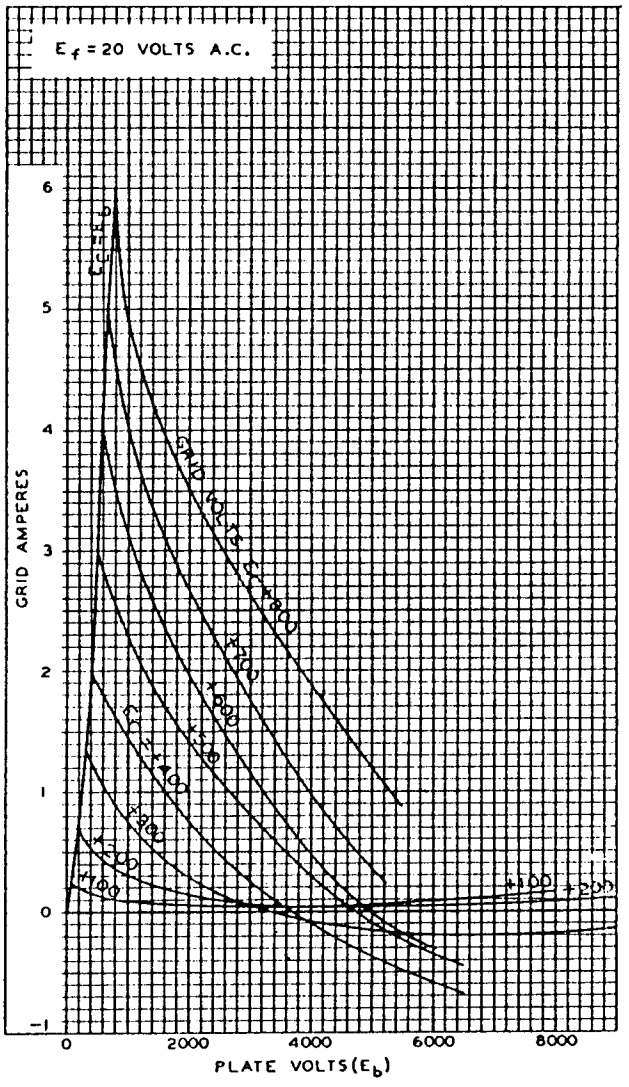
The ML-893A-R can be operated at full power at frequencies as high as 5 megacycles. It can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with table which shows the maximum permissible percentage of rated plate voltage and plate input for various frequencies above 5 megacycles.

Mc	Class B		Class C Plate Modulated		Class C	
	Volts	Watts	Volts	Watts	Volts	Watts
5	100%	100%	100%	100%	100%	100%
12	86%	86%	81%	81%	81%	75%
25	74%	74%	65%	65%	65%	50%

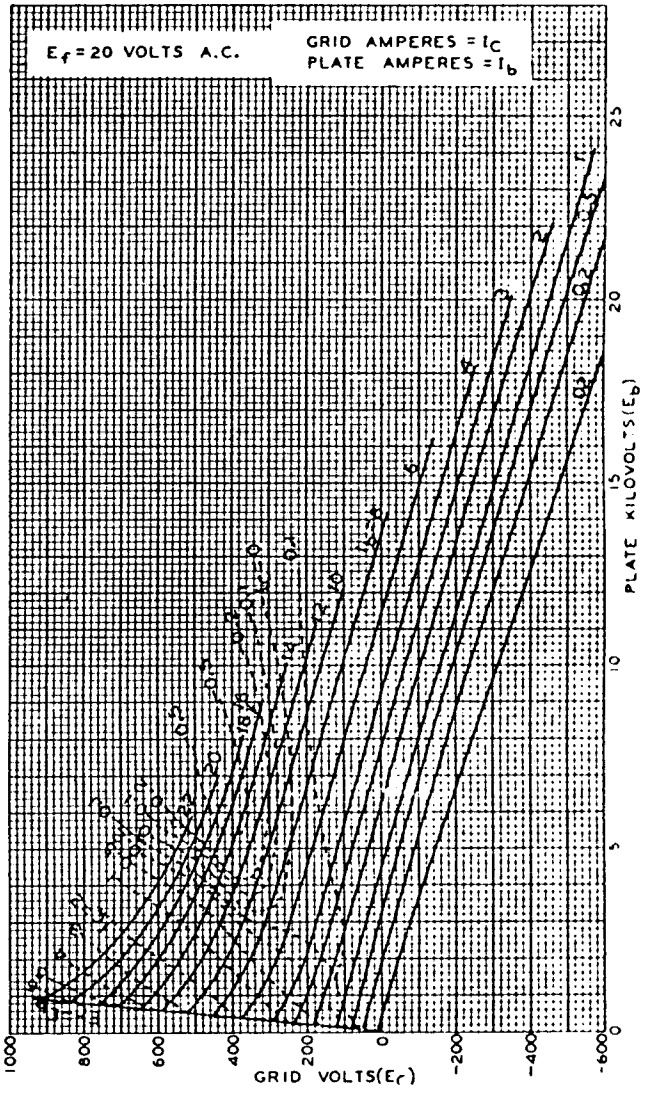
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic	Conditions		Limits Min.	Bogey	Max.	
Grid Voltage	i_b = 15.0 amps; e_b = 1500 volts	e_c:	—	—	-800	Volts
Grid Current	i_b = 15.0 amps; e_b = 1500 volts	i_c:	—	—	1.5	Amps
Plate Voltage	I_b = 1.0 Adc; E_c = 0	E_b:	3.0	4.0	5.0	kVdc
Plate Voltage	I_b = 1.0 Adc; E_c = −200 Vdc	E_b:	9.2	11.2	13.2	kVdc
Grid Voltage	E_b = 20 kVdc; I_b = 0.020 Adc	E_c:	-530	600	770	Vdc
Peak Cathode Current	Note 1	i_k:	20	—		Amps
Power Output	E_b = 18.0 kVdc; I_b = 3.6 Adc I_c = 0.36 Adc; E_c = −1800Vdc	P_o:	45	—		kW

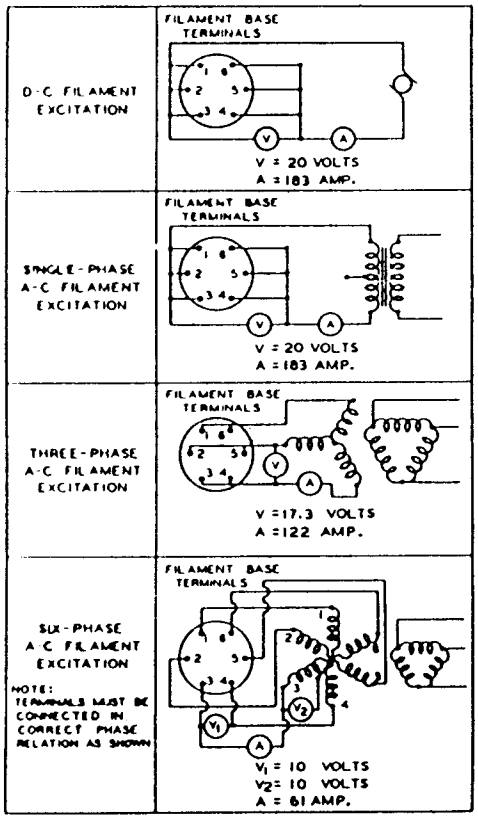
Note 1: Represents maximum usable cathode current for tube as plate current plus grid current for any condition of operation



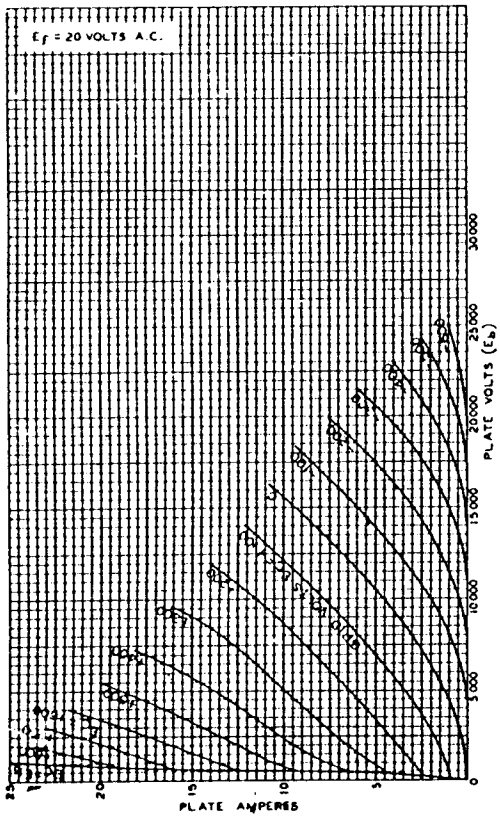
GRID-PLATE TRANSFER CHARACTERISTICS



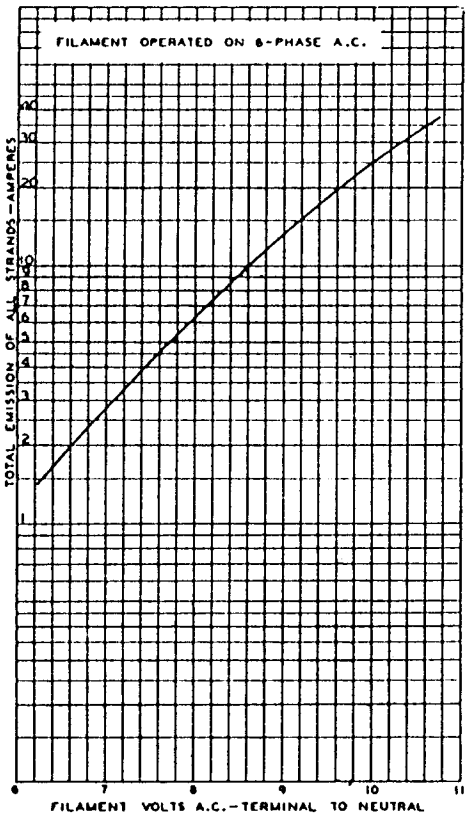
CONSTANT-CURRENT CHARACTERISTICS



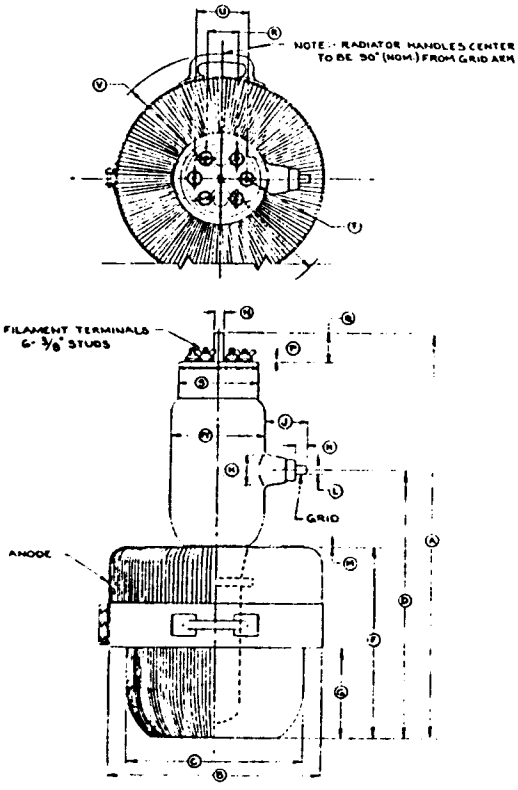
FILAMENT CONNECTIONS AND EXCITATION CIRCUITS



AVERAGE PLATE CHARACTERISTICS



AVERAGE FILAMENT-EMISSION CHARACTERISTICS



DIMENSIONS IN INCHES

	Min.	Max.
A—	25.750	28.000
B—	13.625	14.125
C—		12.000
D—		18.750
F—	12.812	
G—	5.937	6.063
H—		3.060
J—	2.625	3.375
K—	0.687	0.812
L—	0.559	0.573
M—		0.312
N—	0.590	0.660
P—	0.215	0.285
Q—	1.870	2.250
R—	1.965	2.035
S—	5.187	5.312
T—	1.465	1.535
U—	3.310	3.380
V—	16.500	17.000
W—	5.870	6.130

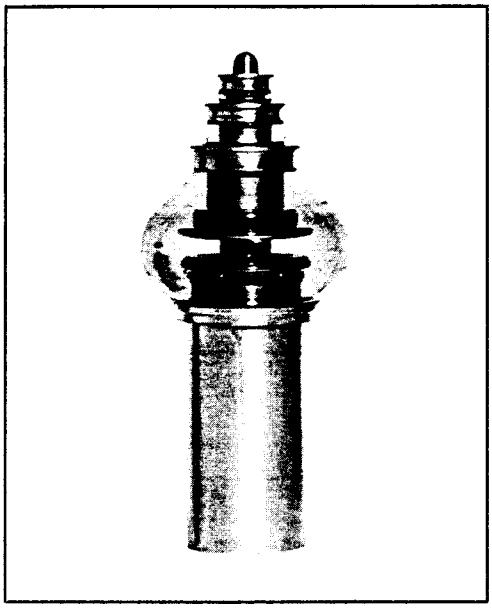
MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

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The Machlett Laboratories, Inc.
1063 Hope Street • Stamford, Conn. 06907
Tel. 203-348-7511 • TWX 203-327-2496



ISSUED 5-64

ML-DP15

MACHLETT

High-Mu Triode
Pulse Power
to 20 Mw

DESCRIPTION

The ML-DP15 is a high-mu triode designed primarily to operate as a switch tube in hard-tube pulse modulators, for radar and similar applications. In this service it can deliver pulse output in the order of 15 to 20 Mw, depending on circuitry and performance requirements.

The ML-DP15 is designed for operation in oil or equivalent dielectric fluid, which is required for utilization of the maximum plate voltage ratings. For applications with a resistive load and low energy storage, the tube is tentatively rated at 150 kVdc plate voltage. Where the tube is to be used in series with the rf load tube, where high stored energy is involved, or where the frequency of kick-outs must be extremely low, the dc plate voltage should be limited to 125 kV.

The cathode of this tube consists of sturdy, stress-free thoriated-tungsten filaments. The anode is capable of dissipating 6 kW when cooled by free convection of oil. Several modifications of the anode are feasible for higher dissipation, in the order of 9 to 20 kW. In this case a forced flow of the dielectric liquid would be required, in the order of 10 to 20 gpm when the liquid is mineral oil.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	13.0	V
Filament Current	210	A
Amplification Factor	135	
Interelectrode Capacitances		
Grid-Plate	25	pf
Grid-Filament	80	pf
Plate-Filament	.7	pf

Mechanical

Mounting Position (tube to be supported by anode only)	Vertical, anode down	
Type of Cooling	Oil convection	
Maximum bulk oil temperature	75	C†
Maximum Glass Temperature	165	°C
Net Weight, approximate	35	lb

†It might be necessary to promote mixing of oil by agitation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings

DC Plate Voltage	150	kV‡
Peak Plate Voltage	150	kv‡
DC Grid Voltage	−1500	V
Peak Negative Grid Voltage	−6000	v
Pulse Cathode Current	175	a
Grid Dissipation	1000	W
Plate Dissipation	6	kW‡‡
Pulse Duration	1000	μs#
Duty Factor	.01	#

Typical Operation

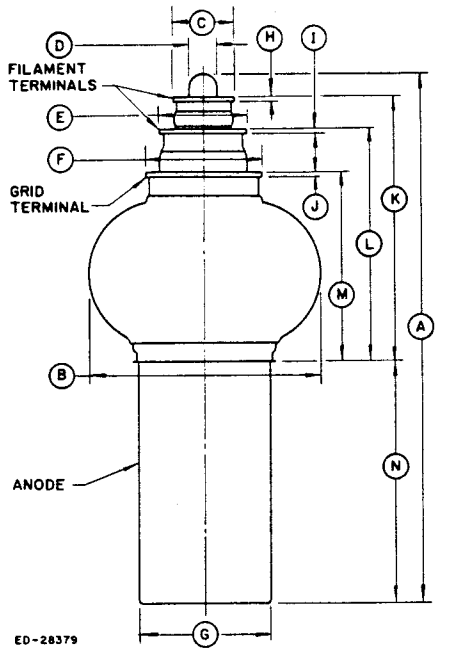
DC Plate Voltage	125	kV
DC Grid Voltage	−1200	V
Pulse Positive Grid Voltage	1300	v
Pulse Plate Current	130	a
Pulse Grid Current	35	a
Pulse Driving Power	90	kw
Pulse Power Output	15	Mw
Pulsed Plate Output Voltage	115	kv
Duty Factor	.004	

‡Consult the Machlett Laboratories for operation above 125 kV. This voltage may be applied only when the tube is immersed in a suitable dielectric fluid.

‡‡With tube immersed in oil and cooled by natural convection. Higher plate dissipation is possible with forced-liquid cooling.

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

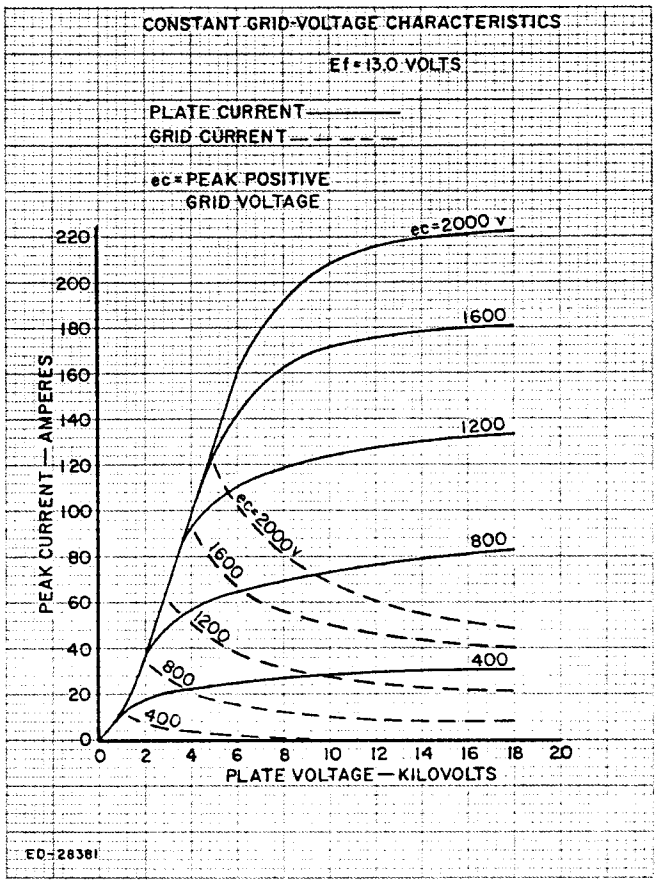
WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

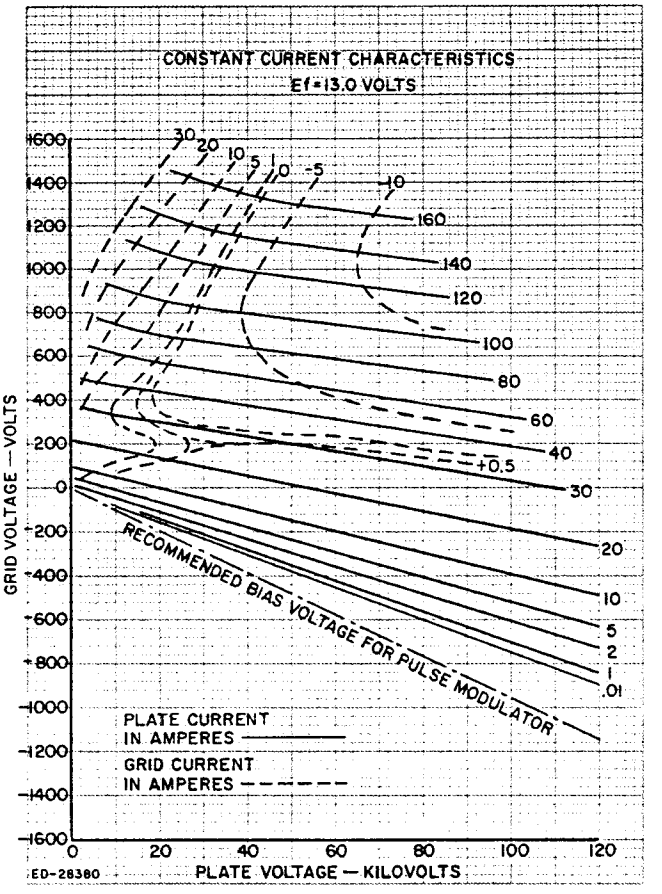


DIMENSIONS FOR OUTLINE OF ML-DP15

Ref.	Inches* Nominal	Ref.	Inches* Nominal	Ref.	Inches* Nominal	Ref.	Inches* Nominal
A	21	E	3.50	I	.19	M	7.38
B	9	F	4.63	J	.19	N	9.50
C	2.50	G	5.13	K	10.38		
D	1.13	H	.19	L	9.13		

*Limits to be determined.





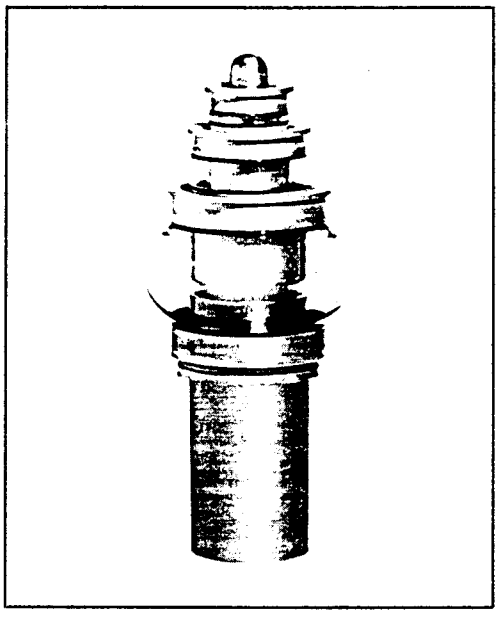
RAYTHEON

THE MACHLETT LABORATORIES, INC.

A SUBSIDIARY OF RAYTHEON COMPANY

Printed in U.S.A.

ST-2027 4.5M 5-64



ISSUED 5-64

ML-DP20

High-Mu Triode
Pulse Power
to 2 Mw

MACHLETT
ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-DP20 is a high-mu triode designed primarily to operate as a switch tube in hard-tube pulse modulators, for radar and similar applications. In this service the tube can deliver pulse power output in the order of 2 Mw.

The cathode of this tube consists of sturdy, self-supporting, stress-free thoriated-tungsten filaments. The tube is designed for operation in oil or equivalent dielectric liquid, which is required for utilization of the maximum plate voltage rating of 90 kV. The anode is capable of dissipating 1.6 kW when cooled by free convection of oil.

Note: Data contained herein are based on initial design and test criteria. Before using these data in final equipment designs, consult Machlett for possible revisions.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	7.0	V
Filament Current	85	A
Filament Starting Current	400	A
Filament Cold Resistance	.0095	Ohm
Amplification Factor	180	
Interelectrode Capacitance, approximate		
Grid-Plate	14	pf
Grid-Cathode	32	pf
Plate-Cathode	1	pf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling	Oil convection	
Maximum bulk oil temperature	75	°C†
Maximum Glass Temperature	165	°C
Net Weight, approximate	15	lb

†It might be necessary to promote mixing of oil by agitation.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings, Absolute Values

DC Plate Voltage	90	kV§
Peak Plate Voltage	100	kv§
DC Grid Voltage	−1500	V
Peak Negative Grid Voltage	−2500	v
Pulse Cathode Current	35	a
Grid Dissipation	300	W
Plate Dissipation	1.6	kW‡
Pulse Duration, approximate	1000	μs#
Duty Factor	.03	#

Typical Operation

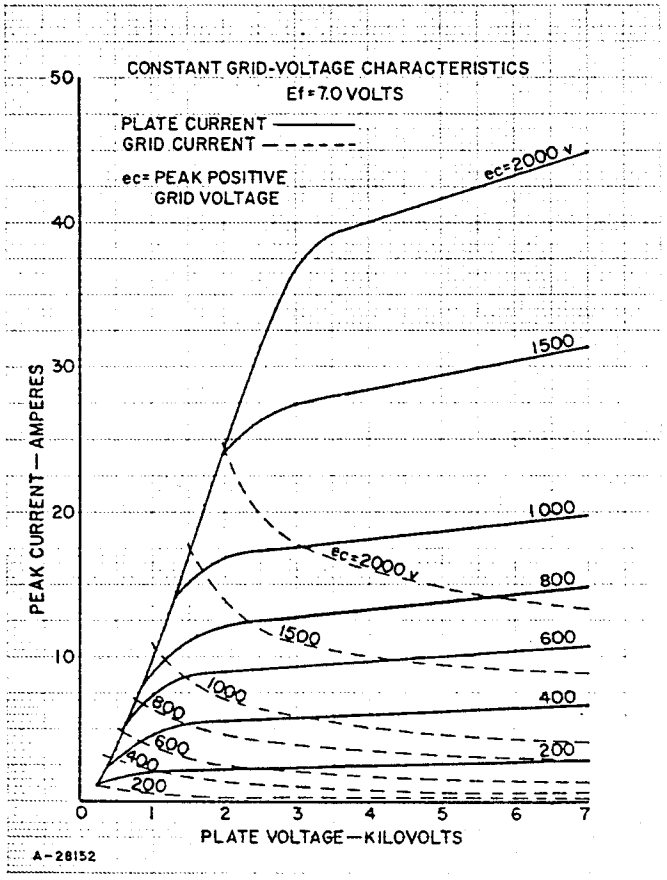
DC Plate Voltage	80	kV
DC Grid Voltage	−600	V
Peak Positive Grid Voltage	1600	v
Pulse Plate Current	30	a
Pulse Grid Current	10	a
Pulse Driving Power	21	kw
Pulse Power Output	2.2	Mw
Pulsed Plate Output Voltage	76	kv
Duty Factor	.01	

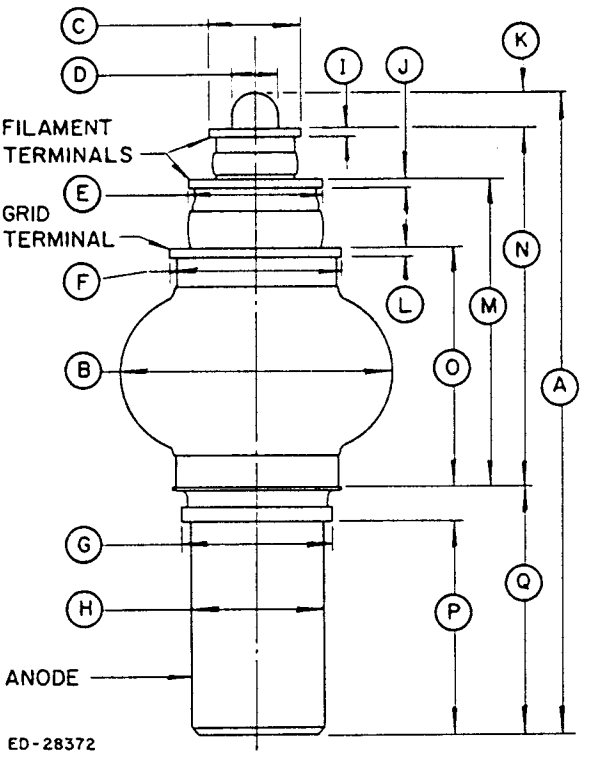
§This voltage may be applied only when the tube is immersed in a suitable dielectric fluid.

‡With tube immersed in oil and cooled by natural convection. Higher plate dissipation is possible with forced-liquid cooling.

#For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

WARNING: Operation of this tube might produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

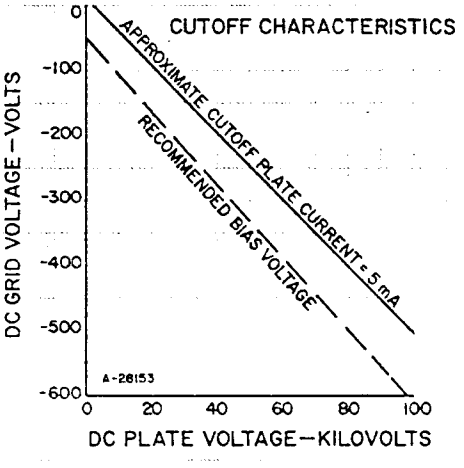




DIMENSIONS FOR OUTLINE OF ML-DP20

Ref.	Inches*			Notes
	Minimum	Nominal	Maximum	
A		16.4		
B		7.0		
C		2.50		
D		1.16		
E		3.50		
F		4.63		
G		4.00		
H		3.50		
I		.19		
J		.19		
K		.94		
L		.19		
M		8.00		
N		9.25		
O		6.31		
P		5.50		
Q		6.19		

*Limits to be determined.



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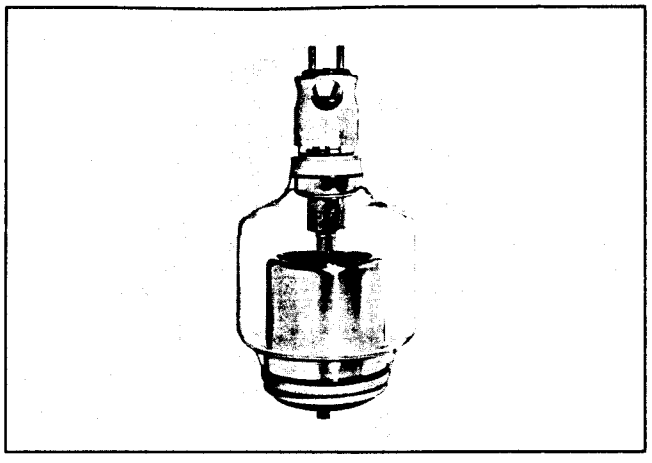
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SPRINGDALE CONNECTICUT

MACHLETT

PRODUCT DATA

ML-LPT 44



APPLICATION

The ML-LPT 44 is a high voltage, high mu triode designed primarily to operate as a switch tube in hard-tube pulse modulators for radar and similar applications. In this service it can deliver pulse output in the order of 1-2 Mw, depending on circuitry and performance requirements.

The ML-LPT 44 is designed for operation in oil or equivalent dielectric fluid, which is required for utilization of the maximum plate voltage ratings. For applications with a resistive load and low energy storage, the tube is rated at 120 kVdc plate voltage. Where the tube is to be used in series with the rf load tube, where high stored energy is involved, or where the frequency of kick-outs must be extremely low, the dc plate voltage should be limited to 100 kV.

CONSTRUCTION

The cathode of this tube is a double helix of carburized thoriated-tungsten filament wire, supported at both ends. The re-entrant copper anode is capable of dissipating 2,500 W when cooled by forced oil.

WARNING

When operating at peak voltage in excess of 15 kV, this electron tube may give off x-rays which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standard for Non-Medical X-Ray and Sealed Gamma Ray Sources." Additional information is available in National Council on Radiation Protection and Measurements Report No. 33, "Medical X-Ray and Gamma Ray Protection for Energies up to 10 MeV." Periodic checks of shielding effectiveness are also required since x-ray radiation levels may increase with the operating life of the tube.

ORDERING NOTES

Refer to **Machlett** price list. When ordering specify

- tube type
- accessories - oil jacket assembly (optional) F-27548

SPECIFICATION

ELECTRICAL CHARACTERISTICS

Filament Voltage:	12.6 volts
Filament Current:	29 amps
Filament Starting Current, maximum:	120 amps
Filament Cold Resistance:	0.0053 ohm
Amplification Factor:	350
Interelectrode Capacitances:	
Grid Plate:	7.0 pf
Grid Filament:	30 pf
Plate Filament:	0.2 pf

MECHANICAL CHARACTERISTICS

Mounting Position:	Vertical, anode down
Insulating Medium:	Oil or equivalent
Type of Cooling:	Forced oil
Oil Flow for 2,500 W Plate Dissipation:	10-12 gal/min (38-45 l/min.) †
Maximum Bulk Oil Temperature:	75 °C (167 °F)
Maximum Circulating Oil Temp. for Maximum Dissipation:	75 °C (167 °F)
Maximum Glass Temperature:	165 °C (329 °F)
Net Weight, approximate:	20 lbs. (9.1 kg)

†When using Machlett oil jacket part number F-27548 (order separately)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

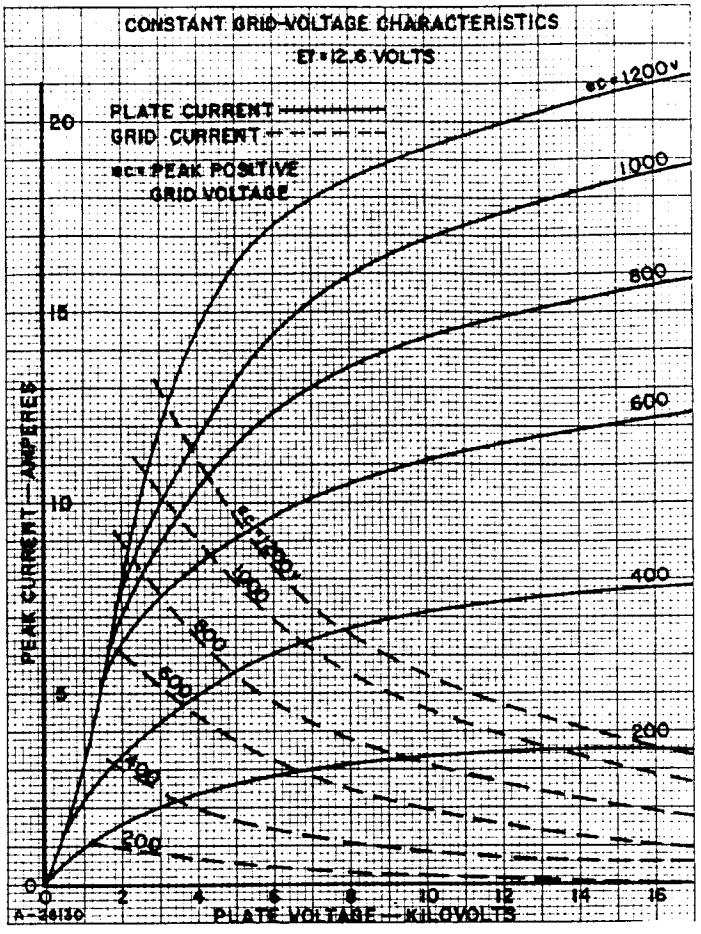
Pulse Modulator or Pulse Amplifier

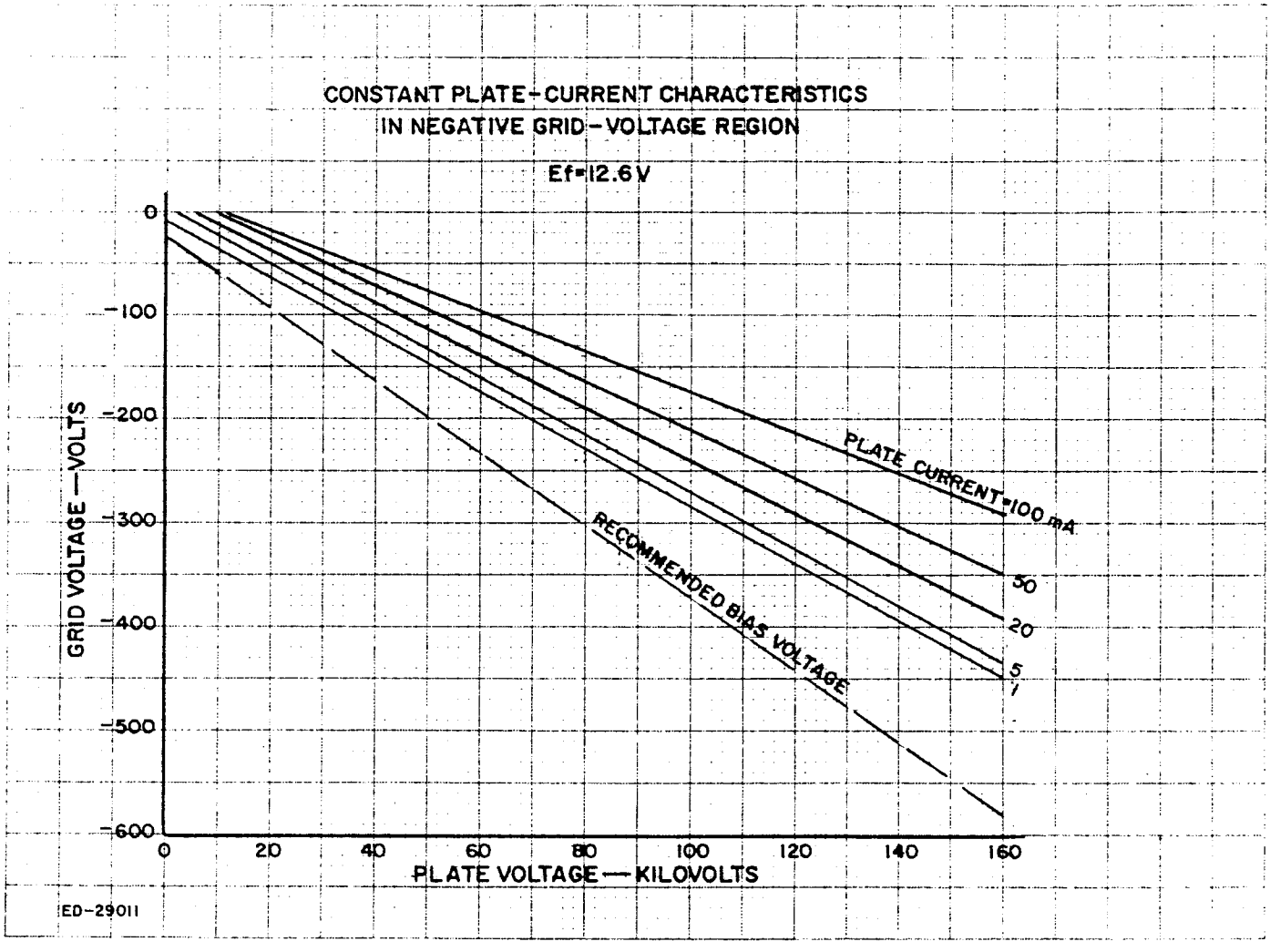
Maximum Ratings		
DC Plate Voltage	120	kV‡
Peak Plate Voltage	125	kv‡
DC Grid Voltage	−1000	V
Peak Negative Grid Voltage	−2500	v
Pulse Cathode Current	22	a
Grid Dissipation	50	W
Plate Dissipation	2500	W
Pulse Duration	1000	μs#
Duty Factor	.01	#
Typical Operation		
DC Plate Voltage	100	kV
DC Grid Voltage	−400	V
Pulse Positive Grid Voltage	800	v
Pulse Plate Current	15	a
Pulse Grid Current	2.6	a
Pulse Driving Power	3.1	kw
Pulse Power Output	1.3	Mw
Pulsed Plate Output Voltage	88	kv
Duty Factor	.005	

‡ This voltage may be applied only when the tube is immersed in a suitable dielectric fluid.

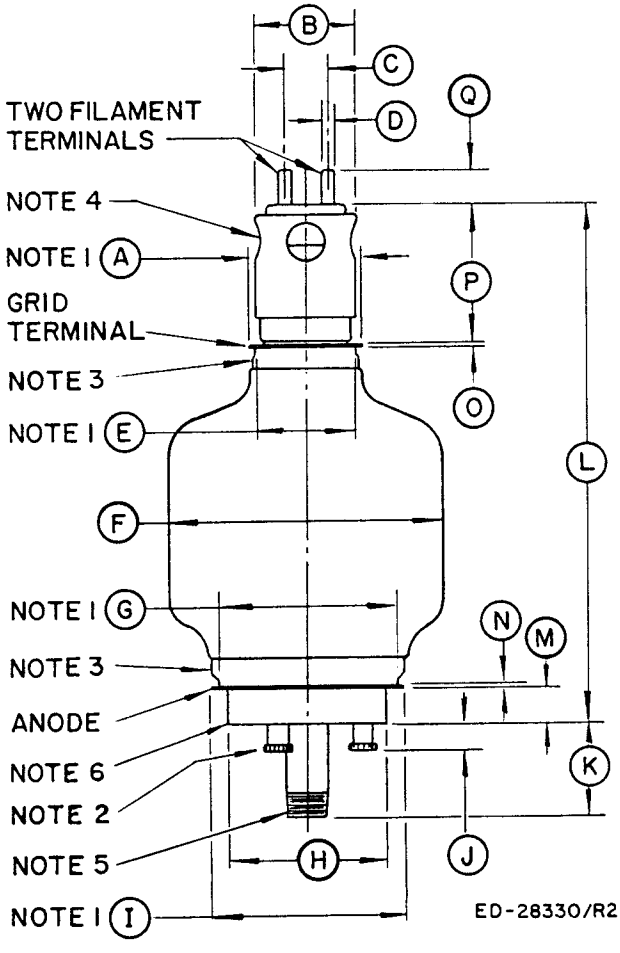
‡‡ With tube immersed in oil and cooled by 10-12 gal/min (38-45 l/min.) oil flow in ML oil jacket F-27548

\# For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.





OUTLINE DATA



DIMENSIONS FOR OUTLINE OF ML-LPT 44

Ref	Inches (mm) Minimum	Nominal	Maximum	Notes
A	3.16 (80.3)	3.19 (81.0)	3.21 (81.5)	1
B	—	2.88 (73.2)	2.92 (74.2)	
C	1.240 (31.50)	1.250 (31.8)	1.260 (32.0)	
D	.368 (9.35)	.372 (9.45)	.376 (9.55)	
E	3.12 (79.2)	3.13 (79.5)	3.14 (79.8)	1, 3
F	—	8.00 (203.2)	8.18 (207.8)	
G	5.36 (136.1)	5.38 (136.7)	5.39 (136.9)	1, 3
H		4.72 (119.9)	4.76 (120.9)	
I	5.450 (138.43)	5.455 (138.56)	5.470 (138.94)	1
J	—	.75 (19.1)	.85 (21.6)	
K	2.94 (74.7)	3.00 (76.2)	3.06 (77.7)	
L	15.00 (38.1)	15.22 (386.6)	15.47 (392.9)	
M	1.01 (25.7)	1.19 (30.2)	1.38 (35.1)	
N	.05 (1.3)	.08 (2.0)	.12 (3.0)	
O	.03 (0.8)	.04 (1.0)	.05 (1.3)	
P	3.4 (86.4)	3.9 (99.1)	4.2 (106.7)	
Q	—	1.00 (25.4)	1.15 (29.2)	

NOTES:

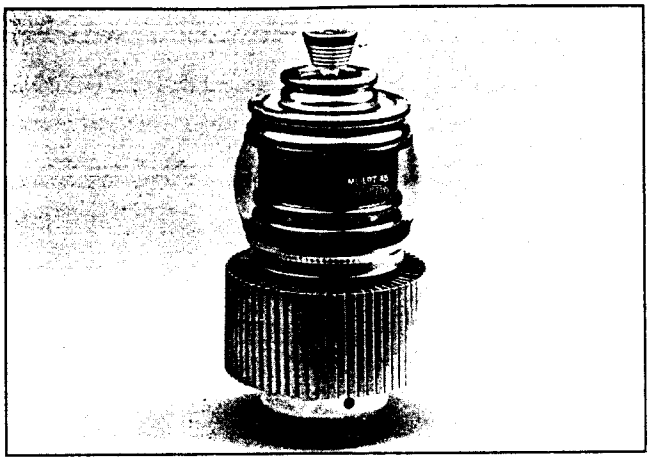
1. Allow additional ±.01" for out of roundness.
2. Three thumb screws for retaining oil-cooling jacket.
3. Do not clamp on this surface (spring contact only).
4. Allow clearance for circulation of oil through holes.
5. Oil inlet connection 1" IPT. Oil discharges into enclosure.
6. Tube is shown with oil cooling jacket which is optional — refer to ORDERING NOTES.

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Specifications subject to change without notice

Machlett
A **Raytheon** Company

PRODUCT DATA

ML-LPT 45
ML-LPT 45H



APPLICATION
The ML-LPT 45 and LPT 45H are shielded grid triodes designed primarily for use as switch tubes in hard-tube pulse modulators for radar applications. They can deliver a peak pulse power output of 1.5 megawatts with less than 5 kilowatts driving power.

CONSTRUCTION
These tubes incorporate a beamed electrode structure to minimize driving power. This design avoids the fine-wire grids usually used in tetrodes and provides a rugged structure. The shield grid is strapped to the cathode internally and protects the cathode from transient arcs. These features provide a tube which operates much more stably at high voltages than hard-tube modulators of earlier design. The high amplification factor coupled with low grid current results in unusually low driving power requirements. Additionally, the input and output circuits are isolated so that feedback capacitance is small. The cathode is a unipotential oxide-coated type. The anode is forced-air cooled and is capable of dissipating 1 kW with 80 cfm air flow.

WARNING
When operating at peak voltage in excess of 15 kV, this electron tube may give off x-rays which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 114, "Safety Standard for Non-Medical X-Ray and Sealed Gamma Ray Sources." Additional information is available in National Council on Radiation Protection and Measurements Report No. 33, "Medical X-Ray and Gamma Ray Protection for Energies up to 10 MeV." Periodic checks of shielding effectiveness are also required since x-ray radiation levels may increase with the operating life of the tube.

ORDERING NOTES
Refer to **Machlett** price list. When ordering specify
- tube type
- accessories
  - small filament connector F-21989
  - large filament connector F-21991
  - grid connector F-21987
  - tube support P-16981

SPECIFICATION

ELECTRICAL CHARACTERISTICS

Filament Voltage:	6.0 ± 5% volts
Filament Current:	60 amps
Filament Starting Current, maximum:	300 amps
Cathode Warmup Time:	10 minutes*
Amplification Factor:	130
Interelectrode Capacitances:	
Grid-Plate, maximum:	3 pf
Grid-Cathode:	260 pf
Plate-Cathode:	35 pf
Strapped Resonant Frequency (grid to cathode), approx.:	63.5 MHz

MECHANICAL CHARACTERISTICS

Mounting Position (support tube by anode radiator only):	any
Type of Cooling:	Forced-air†
Air Flow on Anode [at 45°C (113°F) and 14.7 psi (101 kPa) ambient atmospheric pressure]:	80 cfm‡
Static Pressure:	0.3" of water
Air Flow on Grid Radiator, minimum:	5 cfm
Maximum Incoming Air Temperature:	75°C (167°F)
Maximum Glass Temperature:	175°C (347°F)
Net Weight approximate:	13 lbs. (5.9 kg)

* For accelerated cathode warmup, the heater may be energized at 7.0 volts for 5 minutes and then reduced to rated value for high voltage operation. If a heater standby voltage of 5.0 volts is used, the minimum cathode warmup time is 1 minute at rated voltage.

† Sufficient air cooling must be provided to maintain glass temperatures at less than 175 °C (347 °F) under all conditions of operation.

‡ For air-flow requirements at other temperatures and pressures, consult the Machlett Engineering Department.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

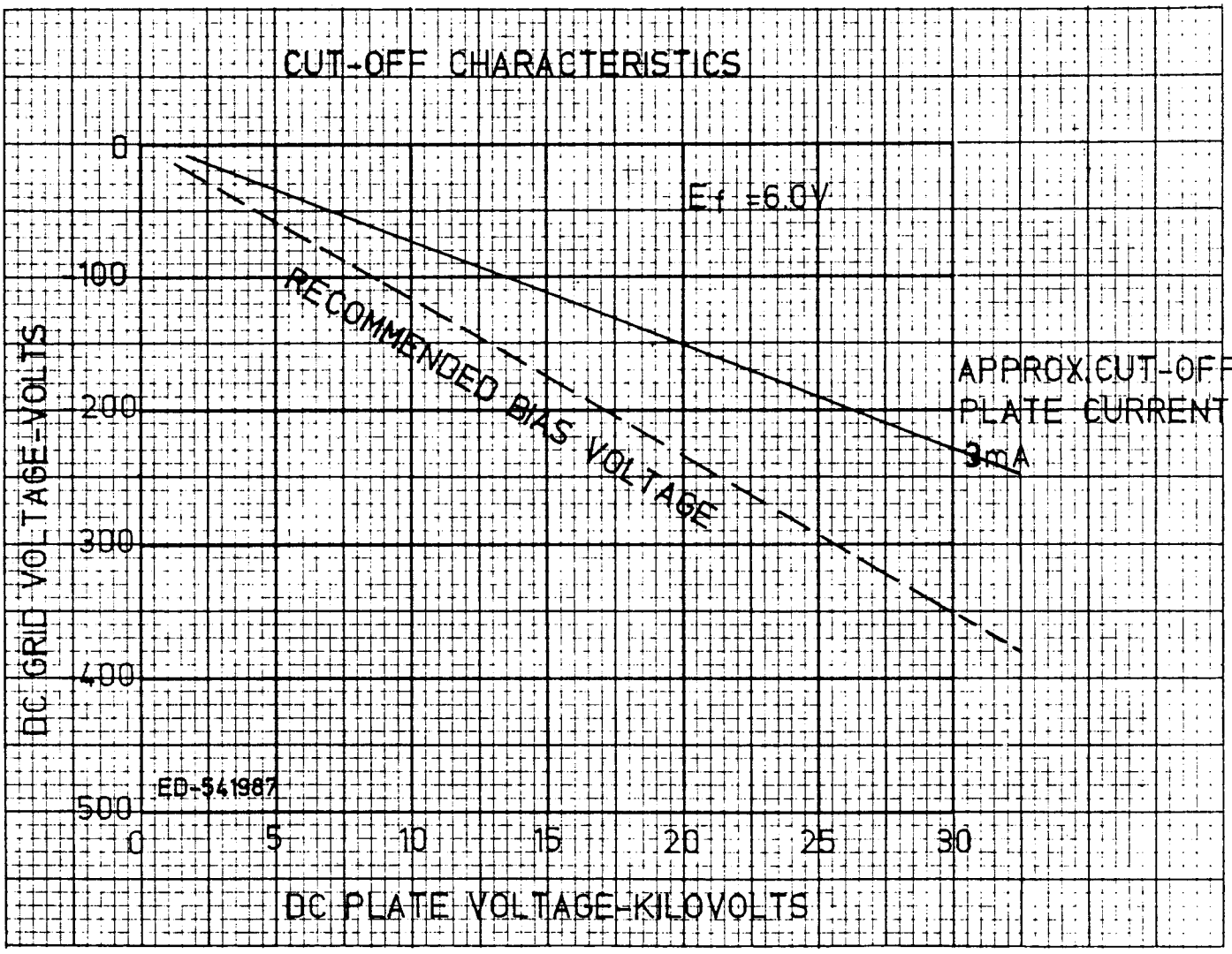
Pulse Modulator or Pulse Amplifier

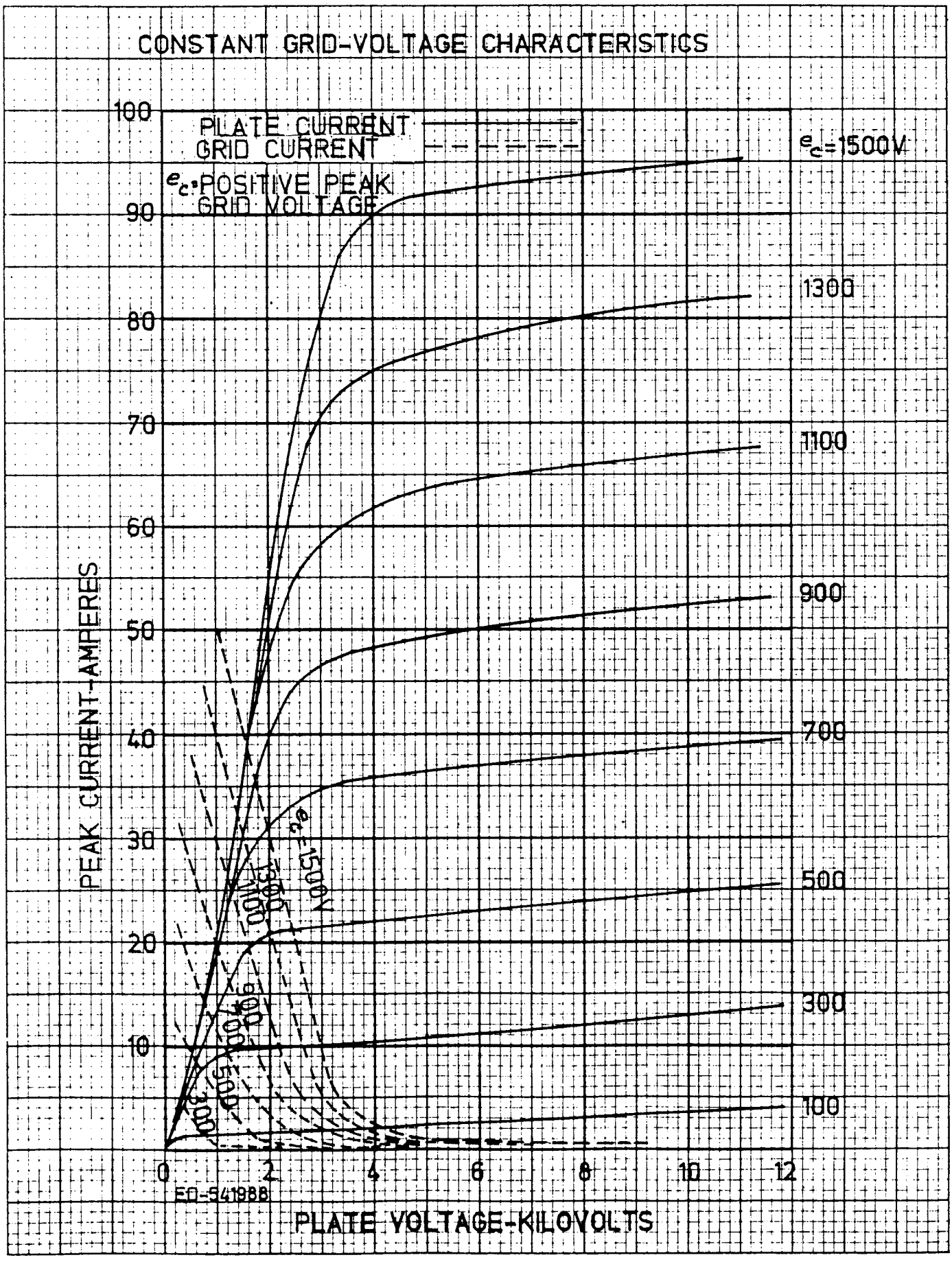
Maximum Ratings, Absolute Values*	LPT 45	LPT 45H
DC Plate Voltage	27 kV	32 kV
Peak Plate Voltage	32 kv	34 kv
DC Grid Voltage	−600 v	−600 v
Peak Positive Grid Voltage	1500 v	1500 v
Peak Negative Grid Voltage	−1500 v	−1500 v
Pulse Cathode Current	90 a	90 a
DC Plate Current	600 mA	600 mA
Grid Dissipation	25 W	25 W
Plate Dissipation	1.0 kW	1.0 kW
Pulse Duration	10 μsec#	10 μsec#
Duty Factor	0.03 #	0.03 #

Typical Operation*	LPT 45	LPT 45H	LPT 45H
DC Plate Voltage	17 kV	25 kV	31 kV
DC Grid Voltage	−200 v	−200 v	−360 v
Pulse Positive Grid Voltage	600 v	1200 v	680 v
Pulse Plate Current	25 a	65 a	30 a
Pulse Grid Current	1 a	3 a	3 a
Pusle Driving Power	0.8 kw	4.5 kw	3.1 kw
Pulse Power Output	0.35 Mw	1.35 Mw	0.87 Mw
Plate Output Voltage	14 kv	21 kv	29 kv
Duty Factor	.01	.003	.01

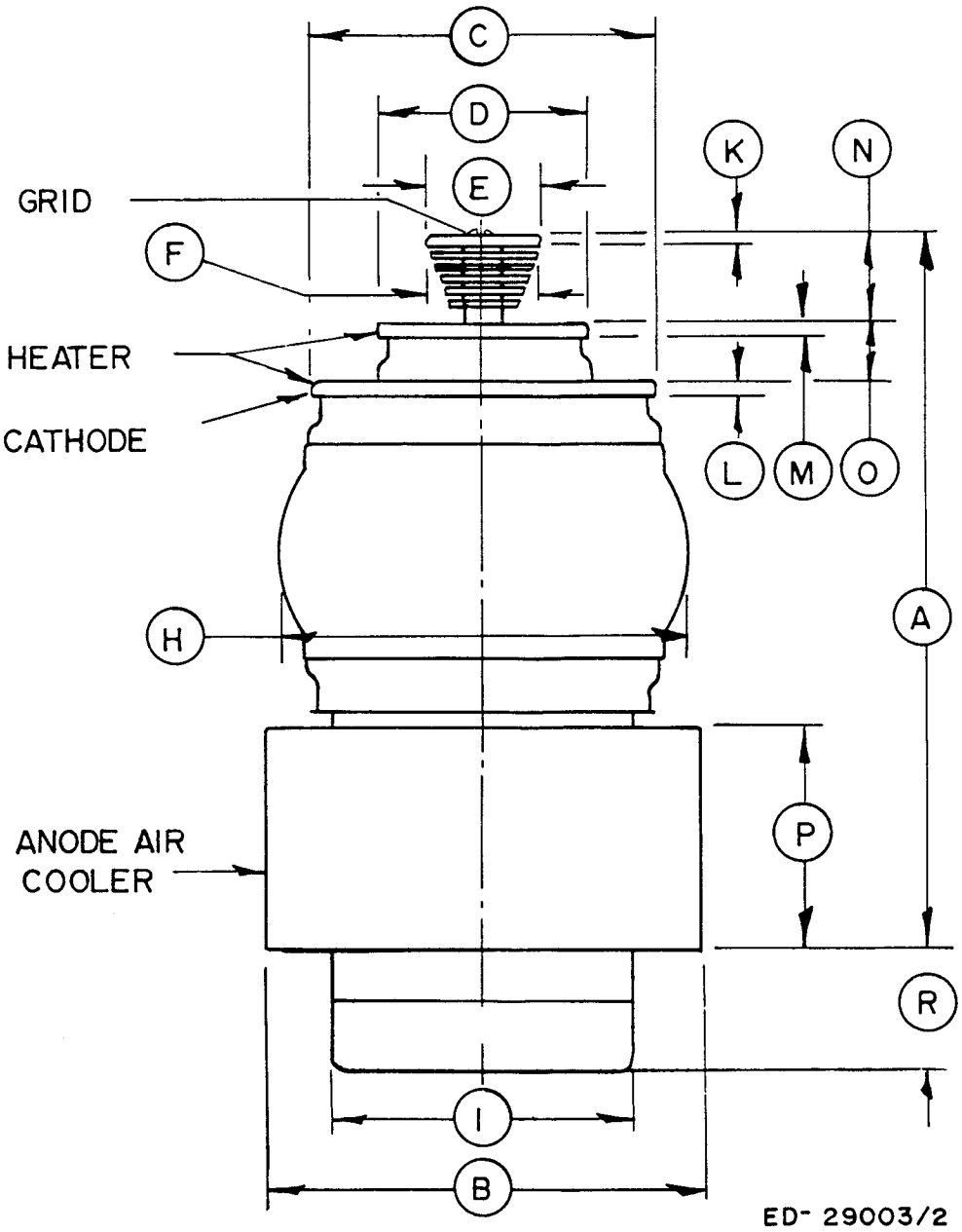
* All given maximum ratings may not apply simultaneously. Due to the possibility of instantaneous overheating of electrodes during the pulse, it may be necessary to restrict some of the parameters, e.g., peak plate current, tube drop, pulse duration, duty or average dissipation, in order not to adversely affect the performance of the tube. Because of the many possible combinations of operating conditions, all restrictions cannot be delineated here, and it is suggested to review new applications with the Machlett Engineering Department.

For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.




CONSTANT GRID-VOLTAGE CHARACTERISTICS
PLATE CURRENT
GRID CURRENT
e_c=POSITIVE PEAK GRID VOLTAGE
e_c=1500V
1300
1100
900
700
500
300
100
PEAK CURRENT-AMPERES
100
90
80
70
60
50
40
30
20
10
0
2
4
6
8
10
12
EO-S41988
PLATE VOLTAGE-KILOVOLTS

OUTLINE DATA



DIMENSIONS FOR OUTLINE OF ML-LPT 45 AND LPT 45H

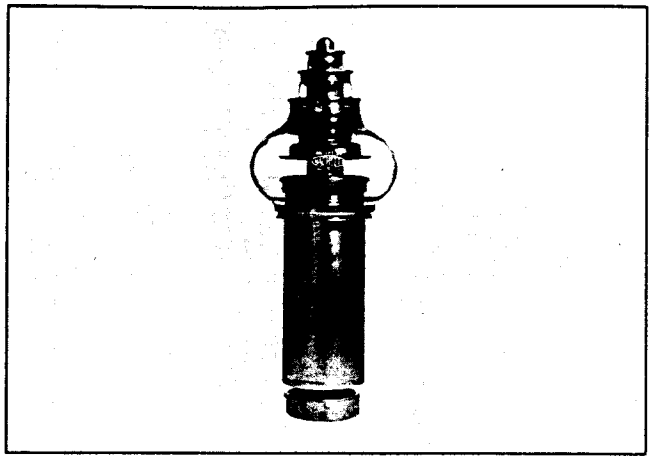
Ref	Inches (mm) Minimum	Nominal	Maximum
A	—	—	8.625 (219.08)
B	5.075 (128.9)	5.125 (130.18)	5.135 (130.43)
C	4.047 (102.79)	4.062 (103.17)	4.078 (103.58)
D	2.422 (61.52)	2.438 (61.93)	2.453 (62.31)
E	1.370 (34.80)	1.375 (34.92)	1.380 (35.05)
F	—	—	1.312 (33.32)
H	—	—	5.375 (136.53)
I	—	—	3.562 (90.47)
K	0.135 (3.43)	0.140 (3.56)	0.145 (3.68)
L	0.172 (4.37)	0.188 (4.78)	0.203 (5.16)
M	0.172 (4.37)	0.188 (4.78)	0.203 (5.16)
N	0.969 (24.61)	1.031 (26.19)	1.094 (27.79)
O	0.625 (15.88)	0.688 (17.48)	0.75 (19.05)
P	2.562 (65.07)	2.625 (66.68	2.688 (68.28)
R	—	—	1.75 (44.45)

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MACHLETT

PRODUCT DATA

ML-LPT 50



APPLICATION

The ML-LPT 50 is a high voltage, high mu triode designed primarily to operate as a switch tube in hard-tube pulse modulators for radar and similar applications. In this service it can deliver pulse output in the order of 10 Mw, depending on circuitry and performance requirements.

The ML-LPT 50 is designed for operation in oil or equivalent dielectric fluid, which is required for utilization of the maximum plate voltage ratings. For applications with a resistive load and low energy storage, the tube is rated at 125 kVdc plate voltage. Where the tube is to be used in series with the rf load tube, where high stored energy is involved, or where the frequency of kick-outs must be extremely low, the dc plate voltage should be limited to 100 kV.

CONSTRUCTION

The cathode of this tube consists of stress-free, carburized thoriated tungsten filaments. The control grid includes encapsulated zirconium getter bands for improved high voltage stability. The anode is capable of dissipating 10 kW when cooled by forced oil.

WARNING

When operating at peak voltage in excess of 15 kV, this electron tube may give off x-rays which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standard for Non-Medical X-Ray and Sealed Gamma Ray Sources." Additional information is available in National Council on Radiation Protection and Measurements Report No. 33, "Medical X-Ray and Gamma Ray Protection for Energies up to 10 MeV." Periodic checks of shielding effectiveness are also required since x-ray radiation levels may increase with the operating life of the tube.

ORDERING NOTES

Refer to **Machlett** price list. When ordering specify

- tube type
- accessories - small filament connector
  F-17488
  large filament connector
  F-17489
  grid connector
  F-17397
  oil jacket assembly
  F-543919

SPECIFICATION

ELECTRICAL CHARACTERISTICS

Filament Voltage:	13.0 volts
Filament Current:	205 amps
Filament Starting Current, maximum:	800 amps
Filament Cold Resistance:	0.0075 ohm
Amplification Factor:	135
Interelectrode Capacitances:	
Grid-Plate:	25 pf
Grid-Filament:	80 pf
Plate-Filament:	0.7 pf

MECHANICAL CHARACTERISTICS

Mounting Position:	Vertical, anode down
Insulating Medium:	Oil or equivalent
Type of Cooling:	Forced oil
Oil Flow for 10 kW Plate Dissipation:	30 gal/min (114 l/min.) †
Maximum Bulk Oil Temperature:	75 °C (167 °F)
Maximum Circulating Oil Temp. for Maximum Dissipation:	75 °C (167 °F)
Maximum Glass Temperature:	165 °C (329 °F)
Net Weight, approximate:	35 lbs. (15.9 kg)

†When using Machlett oil jacket part number F-543919 (order separately)

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Pulse Modulator or Pulse Amplifier

Maximum Ratings

DC Plate Voltage	125	kV‡
Peak Plate Voltage	125	kv‡
DC Grid Voltage	−1500	V
Peak Negative Grid Voltage	−6000	v
Pulse Cathode Current	175	a
Grid Dissipation	1000	W
Plate Dissipation	10	kW‡‡
Pulse Duration	1000	μs#
Duty Factor	.01	#

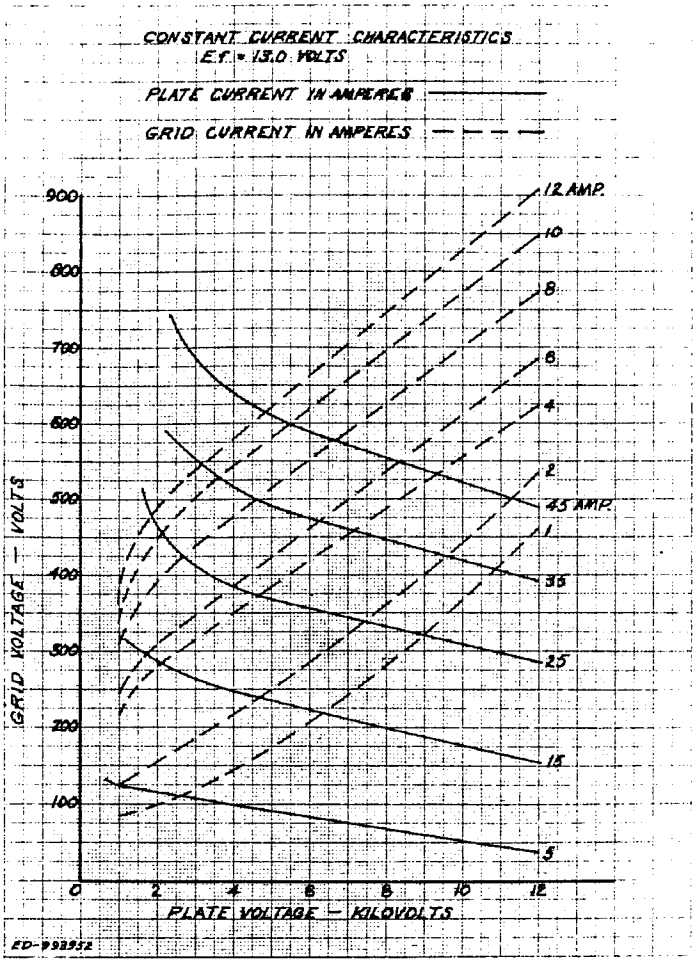
Typical Operation

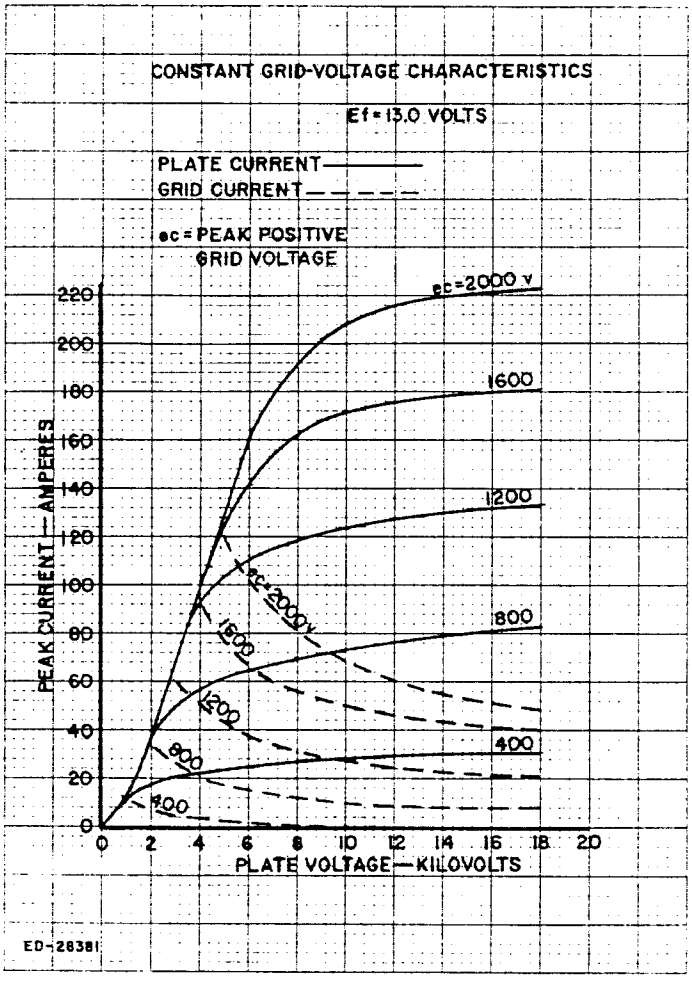
DC Plate Voltage	110	kV
DC Grid Voltage	−1000	V
Pulse Positive Grid Voltage	1000	v
Pulse Plate Current	100	a
Pulse Grid Current	20	a
Pulse Driving Power	40	kw
Pulse Power Output	10	Mw
Pulsed Plate Output Voltage	100	kv
Duty Factor	.001	

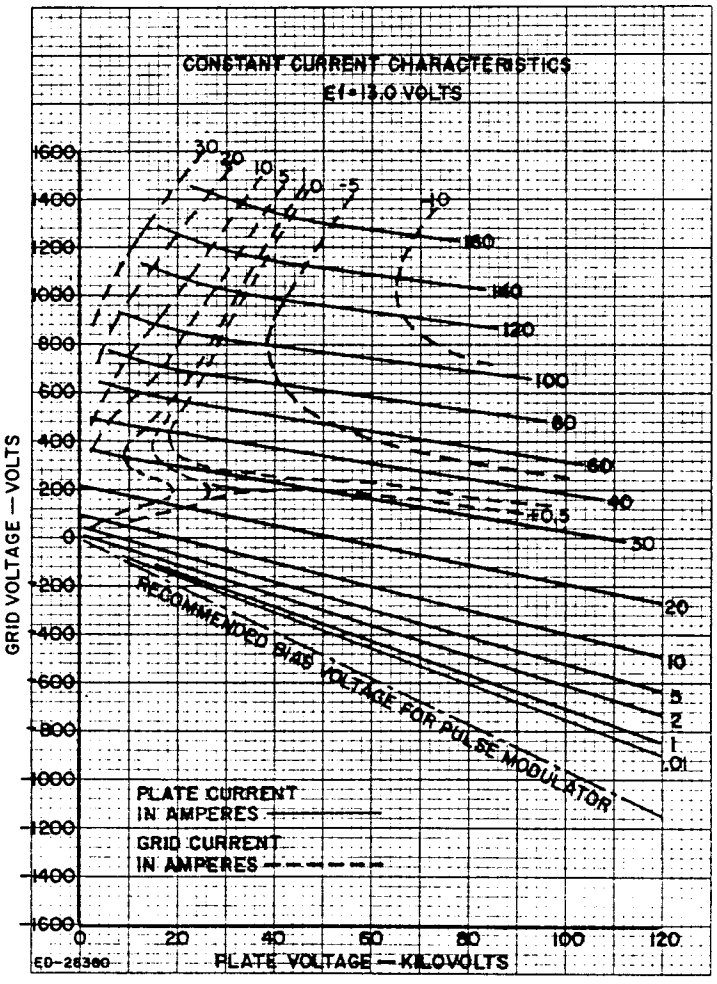
‡ This voltage may be applied only when the tube is immersed in a suitable dielectric fluid.

‡‡ With tube immersed in oil and cooled by 30 gal/min (114 l/min.) oil flow in ML oil jacket F-543919

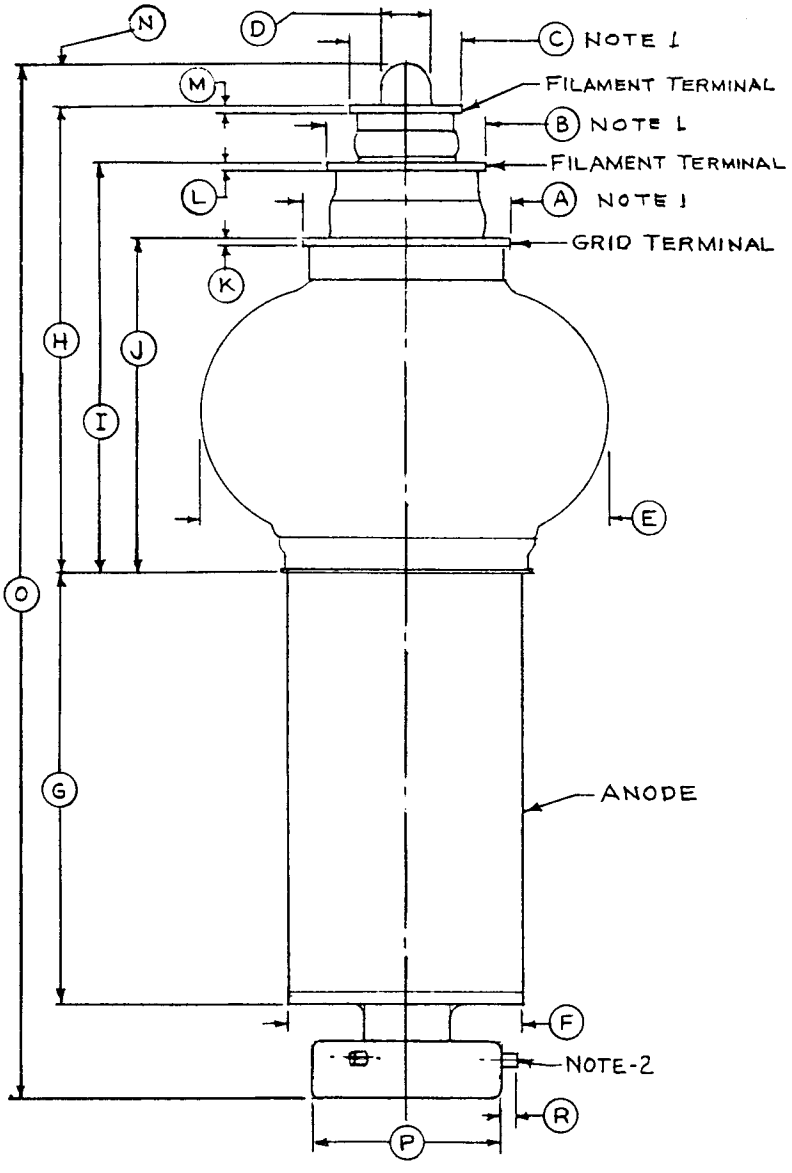
\# For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.







OUTLINE DATA



DIMENSIONS FOR OUTLINE OF ML-LPT 50

Ref	Inches (mm) Minimum	Nominal	Maximum	Notes
A	4.60 (116.8)	4.63 (117.6)	4.66 (118.4)	1
B	3.48 (88.4)	3.51 (89.2)	3.54 (89.9)	1
C	2.48 (63.0)	2.51 (63.8)	2.54 (64.5)	1
D	—	1.13 (28.7)	1.19 (30.2)	
E	8.81 (223.8)	9.00 (228.6)	9.25 (235.0)	
F	5.09 (129.3)	5.12 (130.0)	5.15 (130.8)	
G	9.91 (251.5)	10.04 (255.0)	10.17 (258.3)	
H	10.25 (260.4)	10.45 (265.4)	10.65 (270.5)	
I	9.08 (230.6)	9.20 (233.7)	9.32 (236.7)	
J	7.39 (187.7)	7.45 (189.2)	7.51 (190.8)	
K	.16 (4.1)	.19 (4.8)	.22 (5.6)	
L	.16 (4.1)	.19 (4.8)	.22 (5.6)	
M	.16 (4.1)	.19 (4.8)	.22 (5.6)	
N	—	.94 (23.9)	1.00 (25.4)	
O	—	—	23.5 (597.0)	
P	4.486 (113.9)	4.496 (114.2)	4.506 (114.5)	
R	.29 (7.4)	.31 (7.9)	.33 (8.4)	2

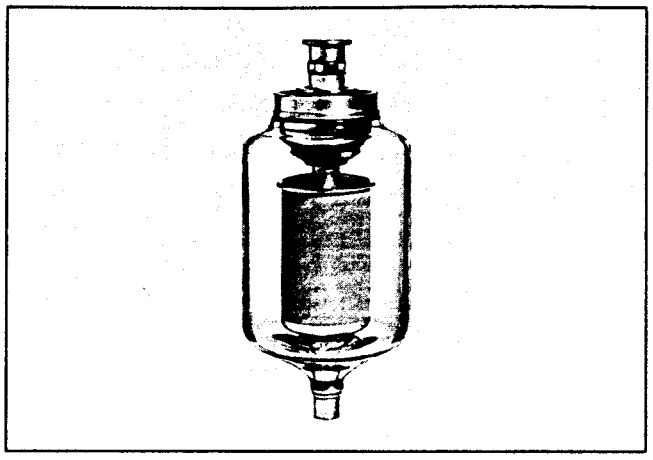
NOTES: 1. Allow ± .01" for out of roundness to min. and max.
2. Bayonet pins 120° apart for oil jacket connections.

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MACHLETT

PRODUCT DATA

ML-LPT 60



APPLICATION

The ML-LPT 60 is a high voltage, high mu triode designed primarily to operate as a switch tube in hard-tube pulse modulators for radar and similar applications. In this service it can deliver pulse output in the order of 1.0 Mw, depending on circuitry and performance requirements.

The ML-LPT 60 is designed for operation in oil or equivalent dielectric fluid, which is required for utilization of the maximum plate voltage ratings.

CONSTRUCTION

The cathode of this tube is a double helix of carburized thoriated-tungsten filament wire, supported at both ends. The molybdenum anode is radiation-cooled and is capable of dissipating 750 W.

WARNING

When operating at peak voltage in excess of 15 kV, this electron tube may give off x-rays which can be harmful unless adequately shielded by the enclosure within which the tube is used. Instructions for protective installation are given in National Bureau of Standards Handbook 93, "Safety Standard for Non-Medical X-Ray and Sealed Gamma Ray Sources." Additional information is available in National Council on Radiation Protection and Measurements Report No. 33, "Medical X-Ray and Gamma Ray Protection for Energies up to 10 MeV." Periodic checks of shielding effectiveness are also required since x-ray radiation levels may increase with the operating life of the tube.

ORDERING NOTES

Refer to **Machlett** price list when ordering.

SPECIFICATION

ELECTRICAL CHARACTERISTICS

Filament Voltage:	12.6 volts
Filament Current:	29 amps
Filament Starting Current, maximum:	120 amps
Filament Cold Resistance:	0.0053 ohm
Grid Cutoff Voltage at 100 kV Plate Voltage, minimum:	−700 volts
Amplification Factor:	180
Interelectrode Capacitances:	
Grid-Plate:	7.5 pf
Grid-Filament:	20.0 pf
Plate-Filament:	0.2 pf

MECHANICAL CHARACTERISTICS

Mounting Position:	Vertical*
Insulating Medium:	Oil or equivalent
Type of Cooling:	Oil convection
Maximum Glass Temperature:	165 °C (329 °F)
Net Weight, approximate:	3 lbs. (1.4 kg)

* When the tube is mounted with the cathode down, forced circulation of the oil in the cathode-end re-entrant cavity will be required.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

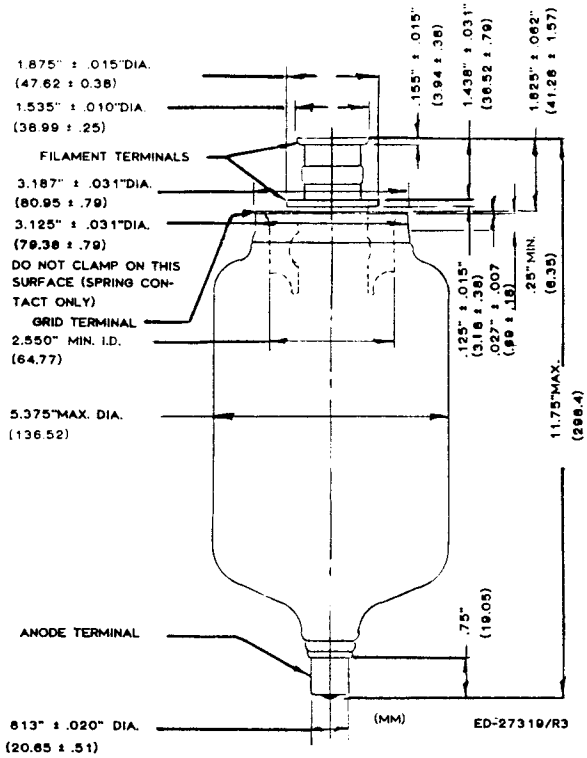
Pulse Modulator or Pulse Amplifier

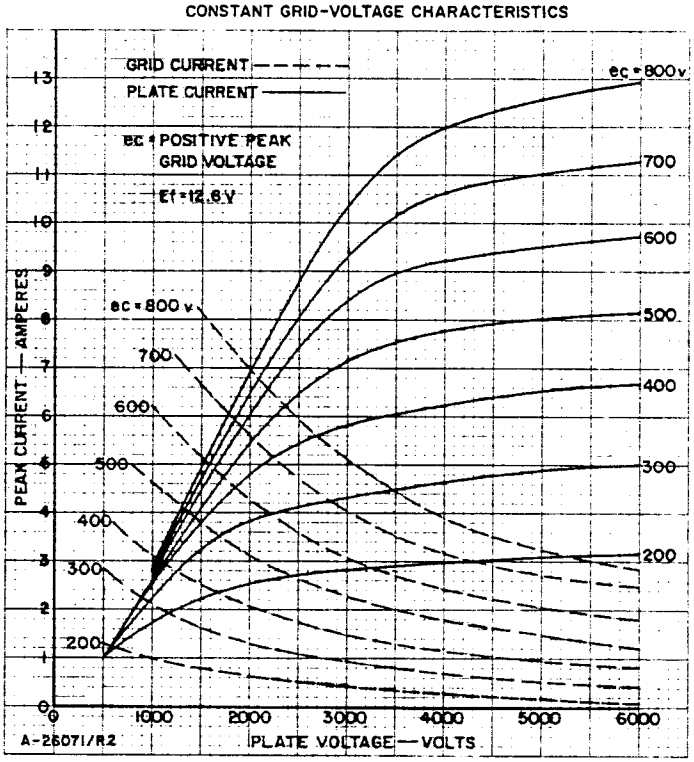
Maximum Ratings		
DC Plate Voltage	100	kV▲
Peak Positive Plate Voltage	105	kv‡
DC Grid Voltage	−1500	V
Peak Positive Grid Voltage	1000	v
Peak Negative Grid Voltage	−2000	v
Peak Cathode Current	15	a
Grid Dissipation	50	W
Plate Dissipation	750	W
Pulse Duration	‡	
Duty Factor	‡	
Typical Operation		
DC Plate Voltage	80	kV
DC Grid Voltage	−700	V
Pulse Positive Grid Voltage	700	v
Pulse Plate Current	11	a
Pulse Grid Current	2.7	a
Pulse Driving Power	3.8	kw
Pulse Power Output	830	kw
Pulsed Plate Output Voltage	75	kv
Pulse Duration	500	μ sec
Duty Factor	.005	

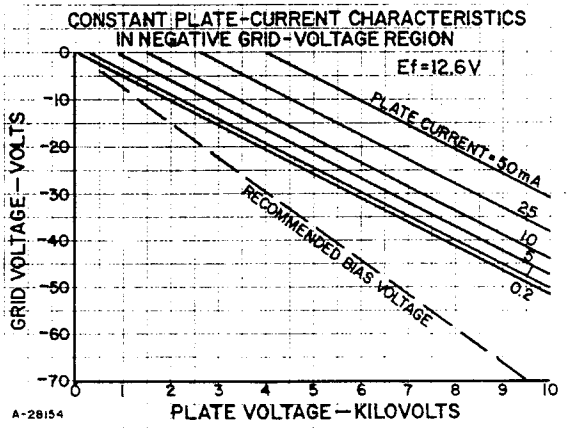
Ratings apply only when the tube is immersed in insulating oil or an equivalent dielectric fluid.

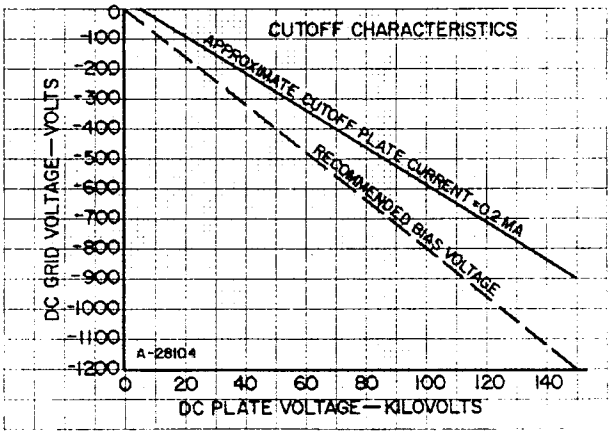
‡ The duration of the pulse may be several milliseconds long. The maximum average grid and plate dissipations will determine the duty factor.

Note: For operation under conditions not covered by the above ratings, consult the Machlett Engineering Department.

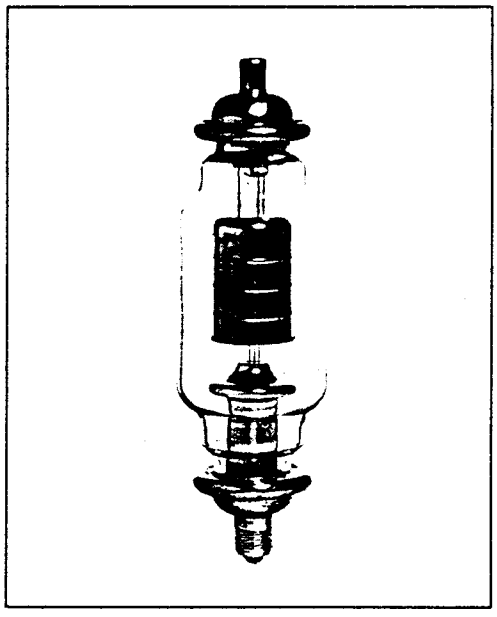








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ST-3731



ISSUED 12-64

ML-XRT-1

High-Voltage Rectifier

165 PKV

MACHLETT

ELECTRON TUBE SPECIALIST

DESCRIPTION

The ML-XRT-1 is a high-vacuum rectifier having a maximum inverse voltage rating of 165 PKV when insulated with oil. The tube may be operated with peak anode currents as high as 1.00 ampere. The cathode is a low-wattage thoriated-tungsten filament. The anode is a pure tantalum cylinder. Tube construction insures long life, low internal voltage drop, high average-load-current capacity and an adequate safety factor against accidental overload.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament Voltage		
For peak anode currents of 0 to .75a	5.7	V*
For peak anode currents of .75 to 1.00a	6.0	V*
Filament Current at 6.0 V, approximate	6.8	A
Filament Heating Time (Before applying anode voltage)	2	sec
Tube Voltage Drop		
For Ef = 5.7 V, ib = .75a	1400	v
For Ef = 6.0 V, ib = 1.00a	1600	v

*Applied filament voltage should be held to within ±5% of specified voltage.

MECHANICAL

Mounting Position	Any	
Type of Cooling	Radiation	
Insulating Medium	Oil	
Net Weight	2.2	lb

MAXIMUM RATINGS

Peak Inverse Anode Voltage		165,000	v §
Peak Anode Current			
With filament voltage of 5.7 V		.75	a
With filament voltage of 6.0 V		1.00	a
Anode Dissipation		150	W
Load Current (Average DC)			
Circuit Application	Unfiltered†	Filtered‡	
Single-phase, two-tube, half-wave	.18	—	A
Single-phase, four-tube, full-wave	.36	.39	A
Three-phase, double-Y, parallel	1.10	1.10	A
Three-phase, full-wave	.54	.54	A

§In some circuits the tube may be operated at higher peak inverse voltages. Consult the Machlett Laboratories Engineering Department.
†Unfiltered Load Current Ratings are based on sine-wave input and resistance load without inductive or capacitive effects.
‡Filtered Load Current Ratings are based on sine-wave voltage input and inductive choke input filter.

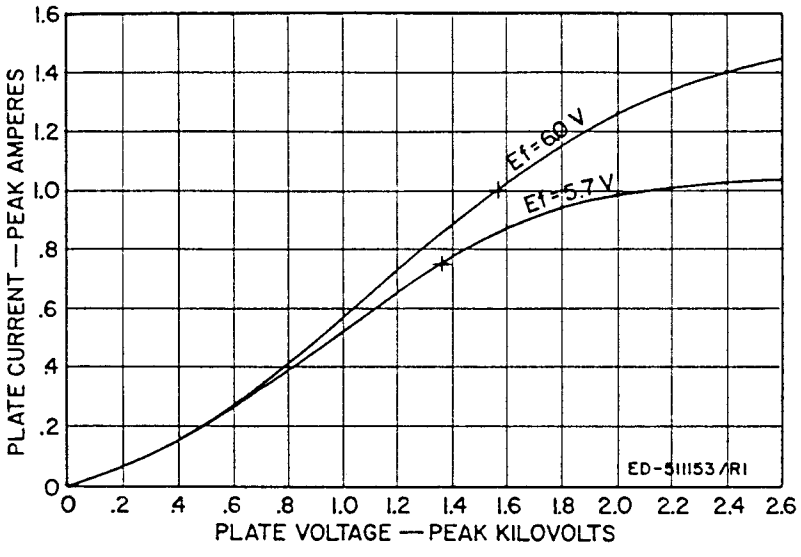
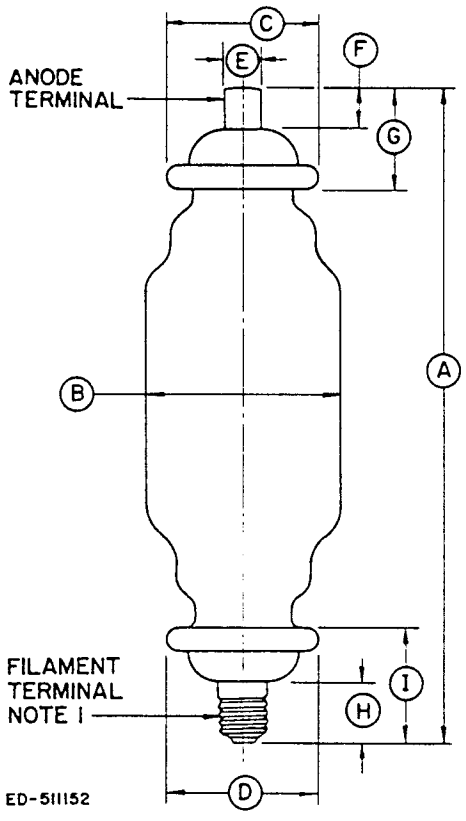


PLATE CURRENT CHARACTERISTICS



OUTLINE — ML-XRT-1

APPLICATION NOTES

It is recommended that a minimum resistance of 1/10 ohm per volt of peak inverse voltage be placed in series with the tube when it is subjected to inverse voltages in excess of 150 PKV, to insure that the magnitude of any fault currents are minimized. Failure to do so may result in permanent damage to the tube caused by an excessive amount of energy being dissipated in the tube during circuit instabilities or momentary tube instabilities.

WARNING: Operation of this tube may produce x-rays. Adequate rayproof shielding must therefore be provided in the equipment.

DIMENSIONS FOR OUTLINE

Ref	Inches		
	Minimum	Nominal	Maximum
A	—	—	13.50
B	—	—	4.15
C	—	3.13	3.25
D	—	3.13	3.25
E	.76	.78	.80
F	.67	.75	—
G	—	2.09	—
H	1.17	1.25	—
I	—	2.38	—

NOTE:
1. Filament terminal fits medium lamp socket.

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