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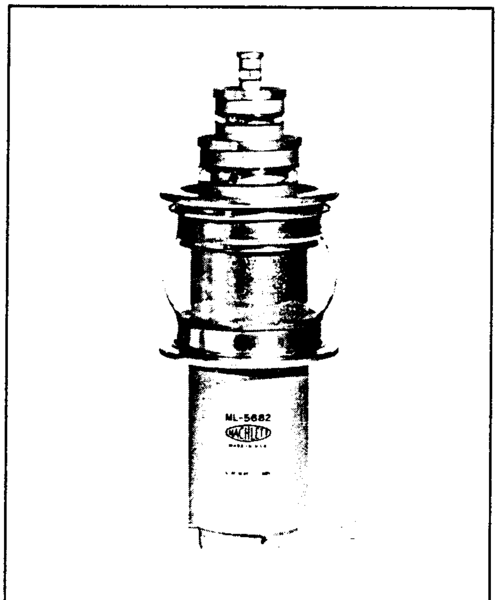


ISSUED 6-67

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 surface 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 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-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.

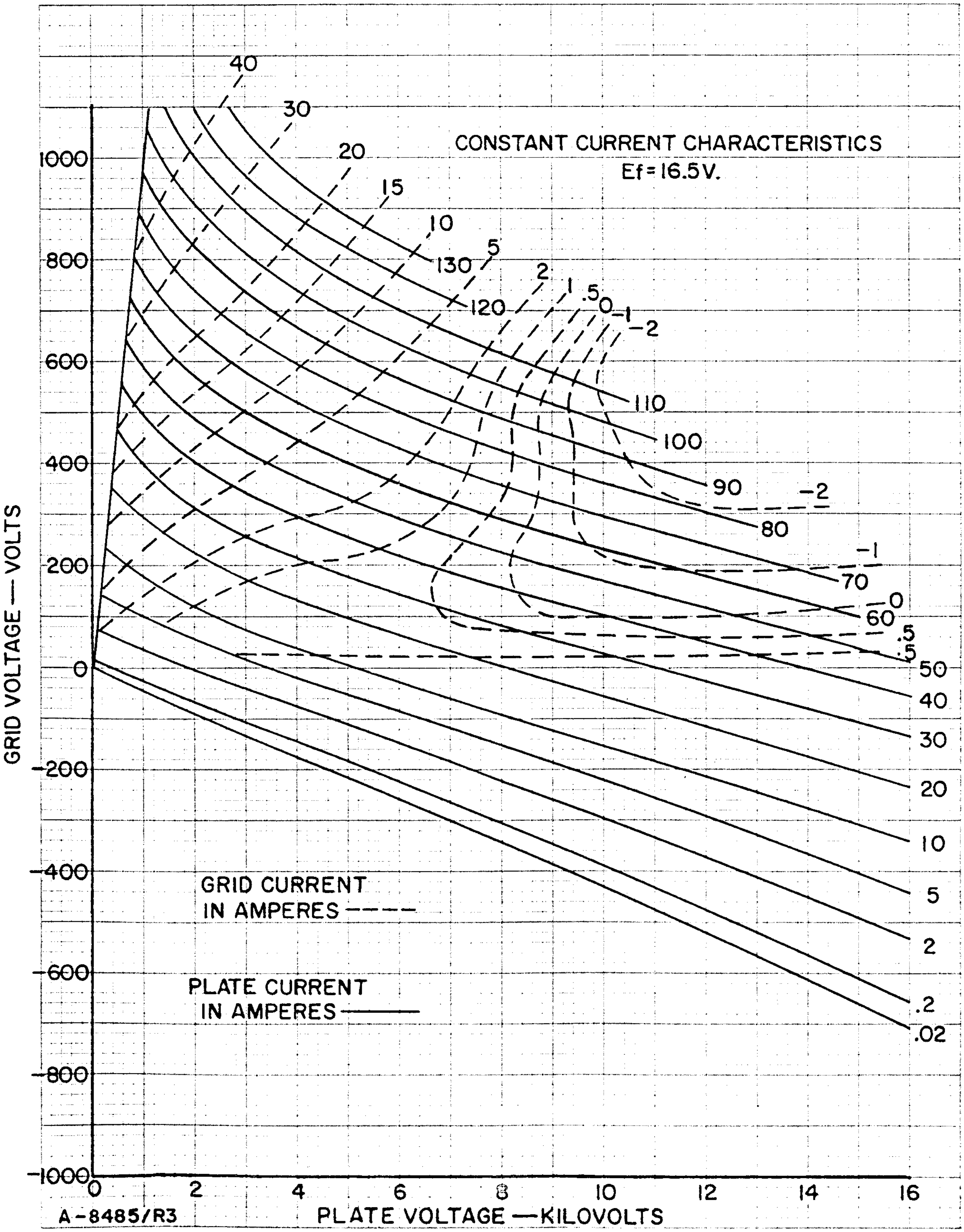
In Class C Plate-Modulated R-F Amplifier service, the ML-5682 should be supplied with bias from a grid resistor or from a suitable combination of grid resistor and fixed supply. The combination grid-resistor and fixed-supply method has the advantage of protecting the tube through loss of excitation and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

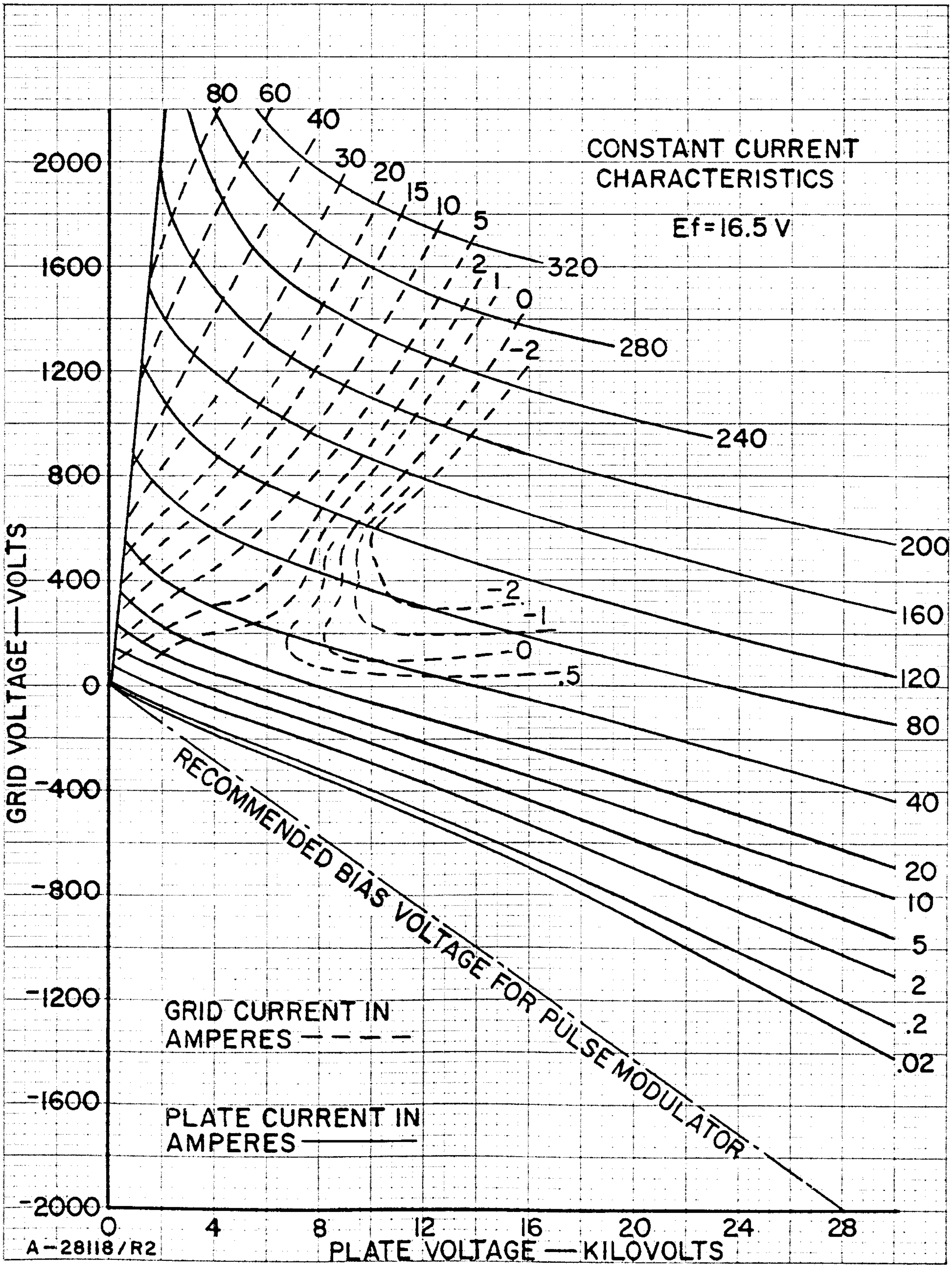
In Class C R-F Telegraphy, the ML-5682 should be supplied with bias obtained from a fixed supply for amplifier service, or from an adjustable grid resistor for oscillator service. Variation of d-c grid current between individual tubes requires provision for adjustment of the grid resistor to obtain the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

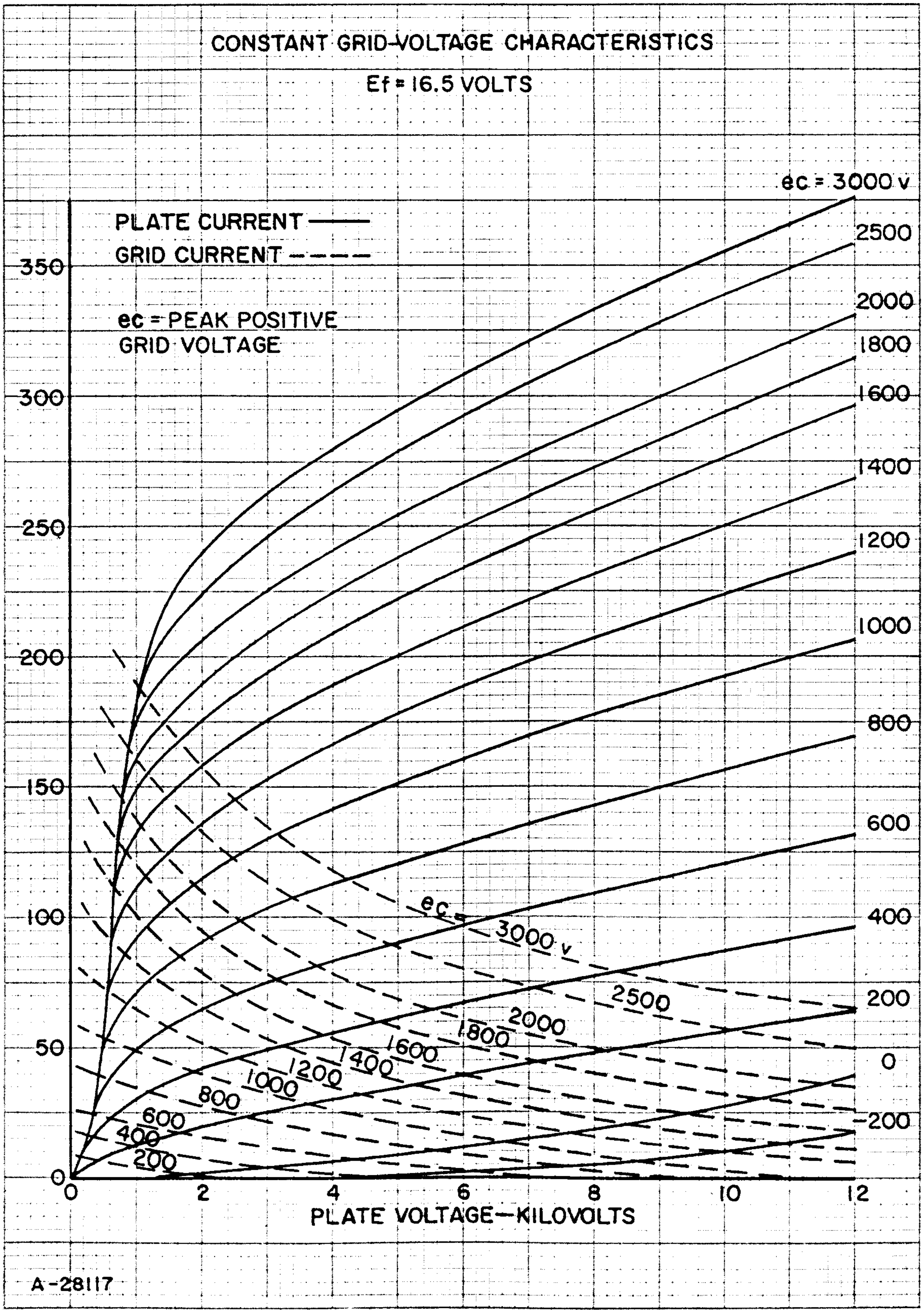
In grid-drive (grounded cathode) circuits, the grid current and driving power for the desired power output will vary with the plate loading. If the plate-circuit resistance is low, the desired output can be obtained with relatively low grid current and driving power, but plate efficiency is sacrificed. 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.

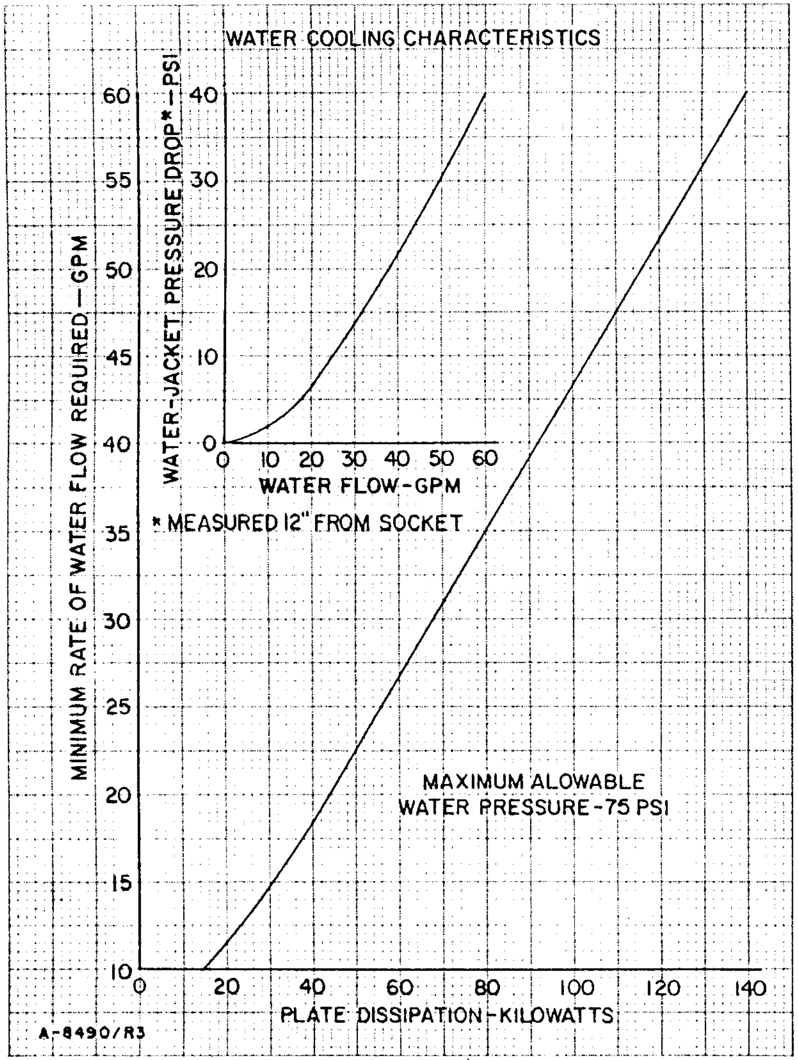
In cathode-drive (grounded-grid) circuits, the required driving power is increased since the driving voltage and the developed r-f plate voltage act in series to supply the load. This additional driving power reappears as part of the output to the load. The power output increases as the driving voltage 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.

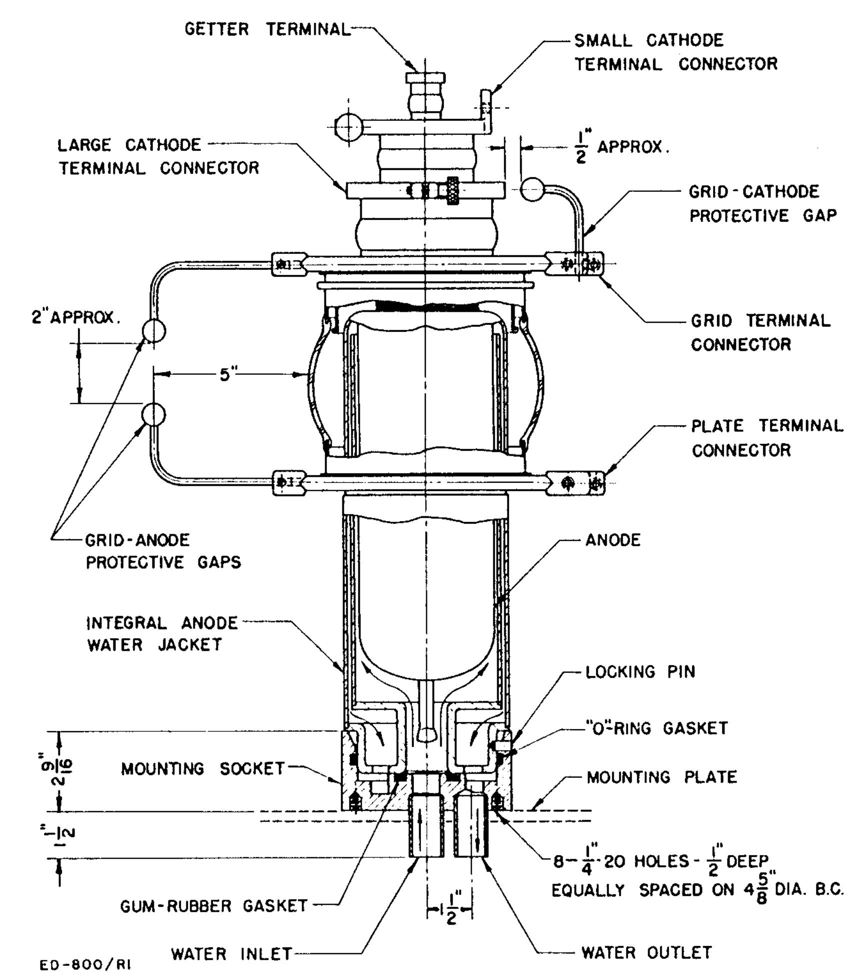

CONSTANT CURRENT CHARACTERISTICS
Ef=16.5V.
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
GRID CURRENT IN AMPERES ----
PLATE CURRENT IN AMPERES ——
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
0
2
4
6
8
10
12
14
16
40
30
20
15
10
5
2
1
.5
0
-1
-2
130
120
110
100
90
80
70
60
50
40
30
20
10
5
2
.2
.02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

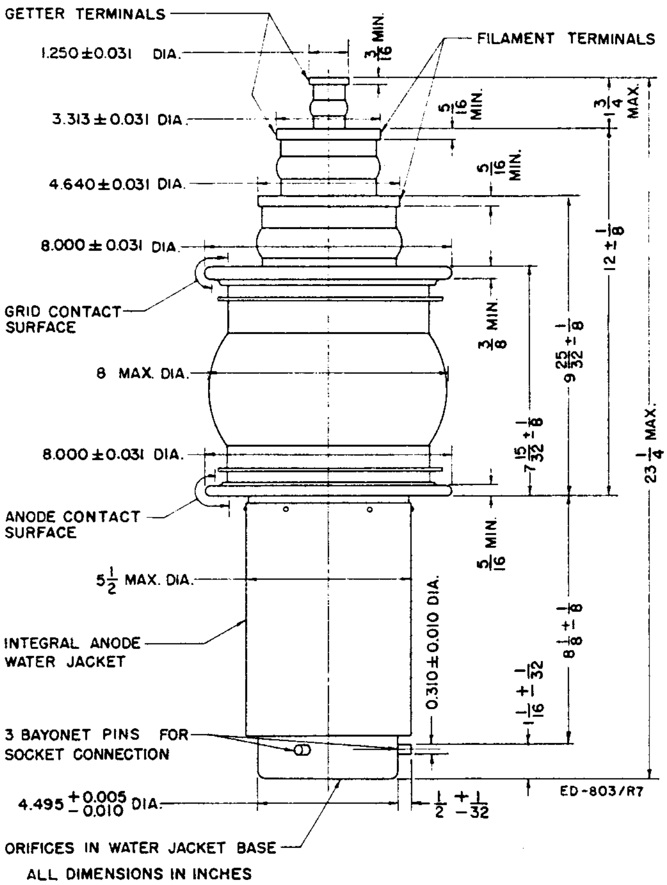

CONSTANT CURRENT
CHARACTERISTICS
Ef=16.5 V
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — KILOVOLTS
0
4
8
12
16
20
24
28
2000
1600
1200
800
400
0
-400
-800
-1200
-1600
-2000
80
60
40
30
20
15
10
5
2
1
0
-2
320
280
240
200
160
120
80
40
20
10
5
2
.2
.02
-2
-1
0
.5
RECOMMENDED BIAS VOLTAGE FOR PULSE MODULATOR
GRID CURRENT IN
AMPERES
PLATE CURRENT IN
AMPERES
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
ec = 3000 v
2500
2000
1800
1600
1400
1200
1000
800
600
400
200
PEAK CURRENT—AMPERES
350
300
250
200
150
100
50
0
0
2
4
6
8
10
12
PLATE VOLTAGE—KILOVOLTS
A-28117

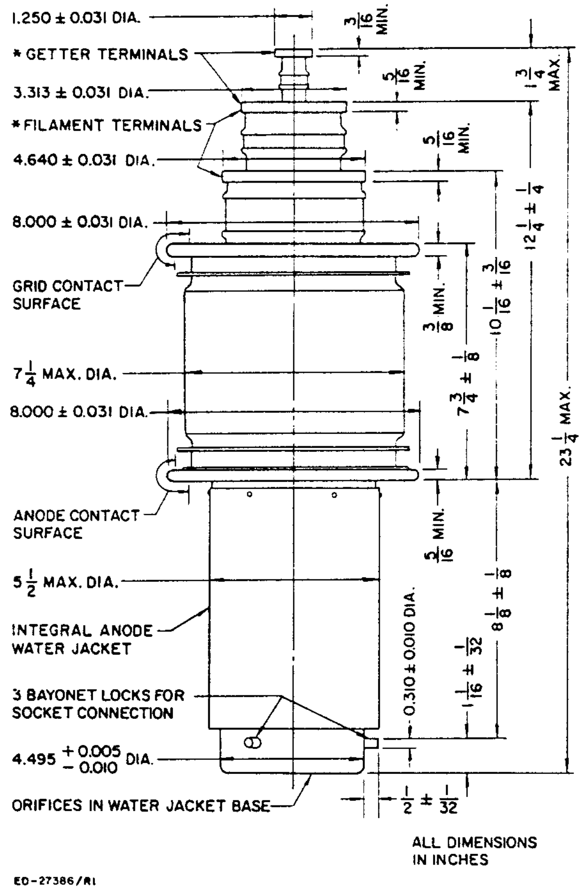


COOLING SYSTEM & PROTECTIVE GAP ARRANGEMENT





DIMENSIONS — ML-5682



DIMENSIONS — ML-5682K

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