

ML-6696  
 ML-6697

**General Purpose Triodes**  
 80 kW CW



**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 capa-

ble 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	2.9 kVdc
Plate Voltage	$E_c=-200$ Vdc; $I_b=3.0$ Adc	$E_b$ :	5.6	7.2 kVdc
Grid Voltage	$E_b=15.0$ kVdc; $I_b=0.020$ Adc	$E_c$ :	-700	-940 Vdc
Plate Power Output	$E_b=15.0$ kVdc; $I_b=7.0$ Adc;	$P_o$ :	68	— kW
	$E_c=-1600$ Vdc; $I_c=0.30$ Adc			

**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

## APPLICATION NOTES

**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 thyatron, 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.*

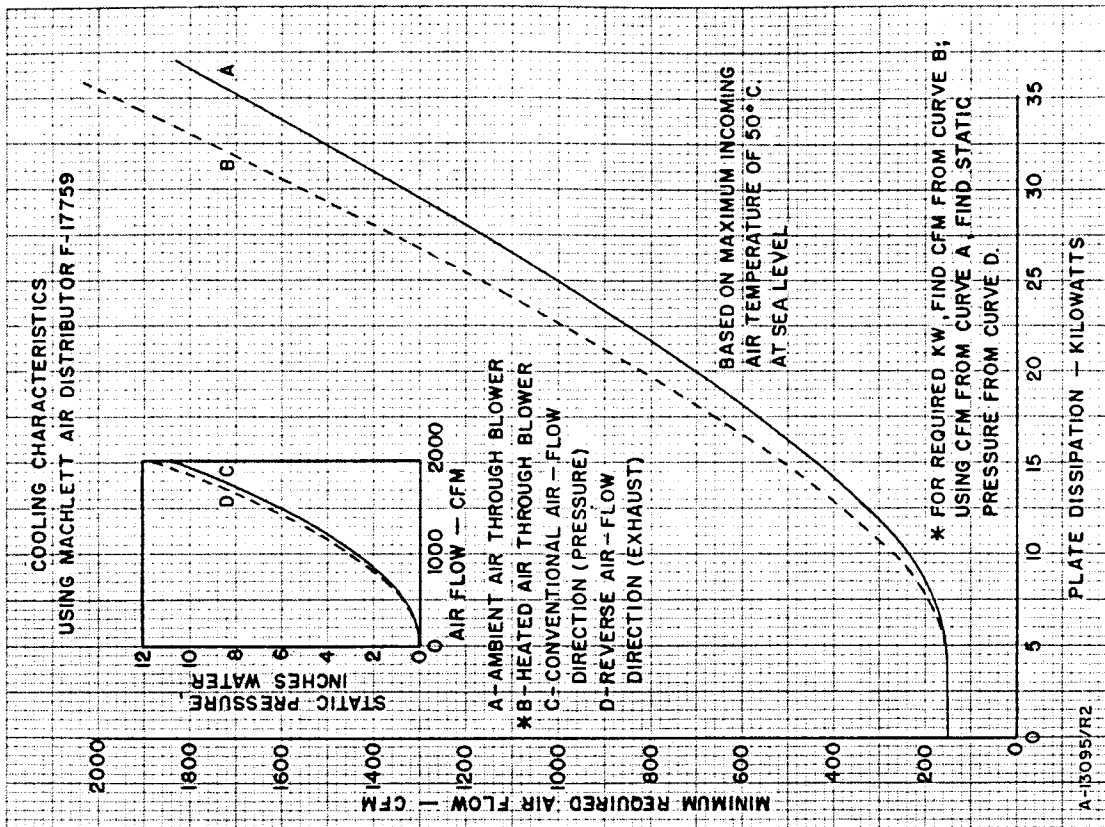
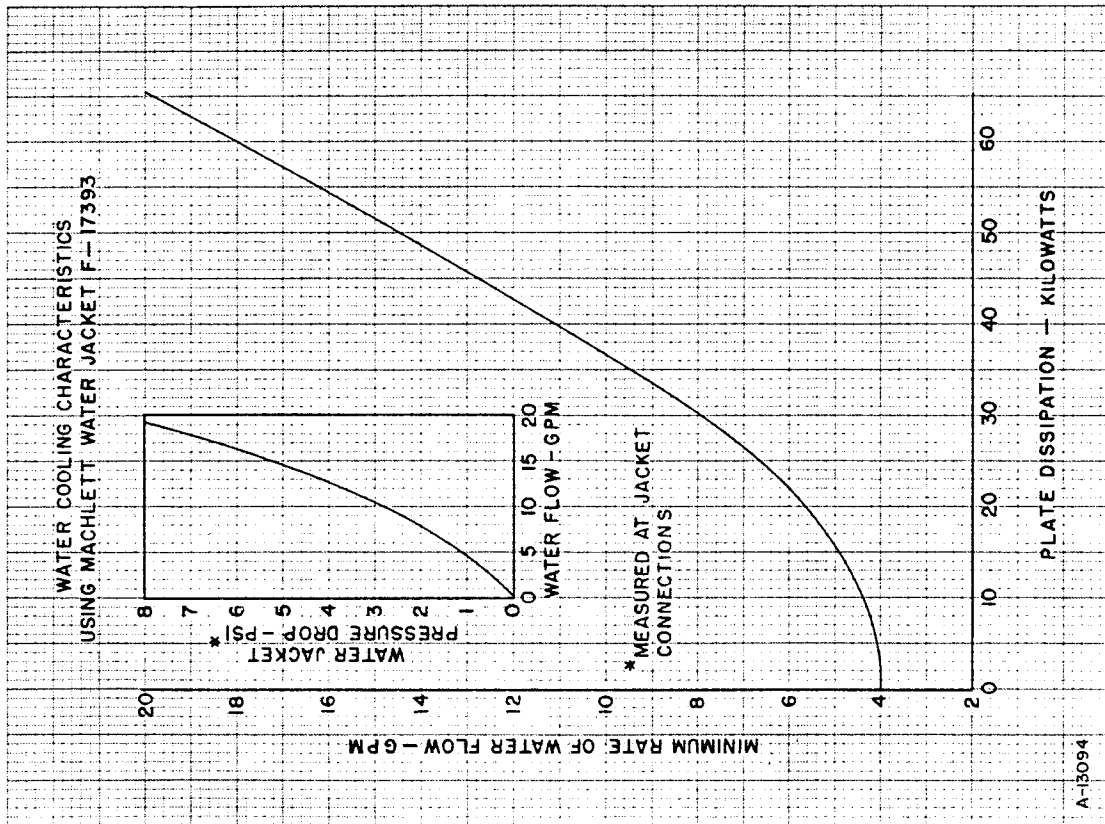
In addition, some *series resistance* should be used in the output of the power supply to limit the surge current from the transformer. Preferably, resistors may be placed in series with each rectifier lead to provide equal protection with substantially less power dissipated during normal operation. 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:

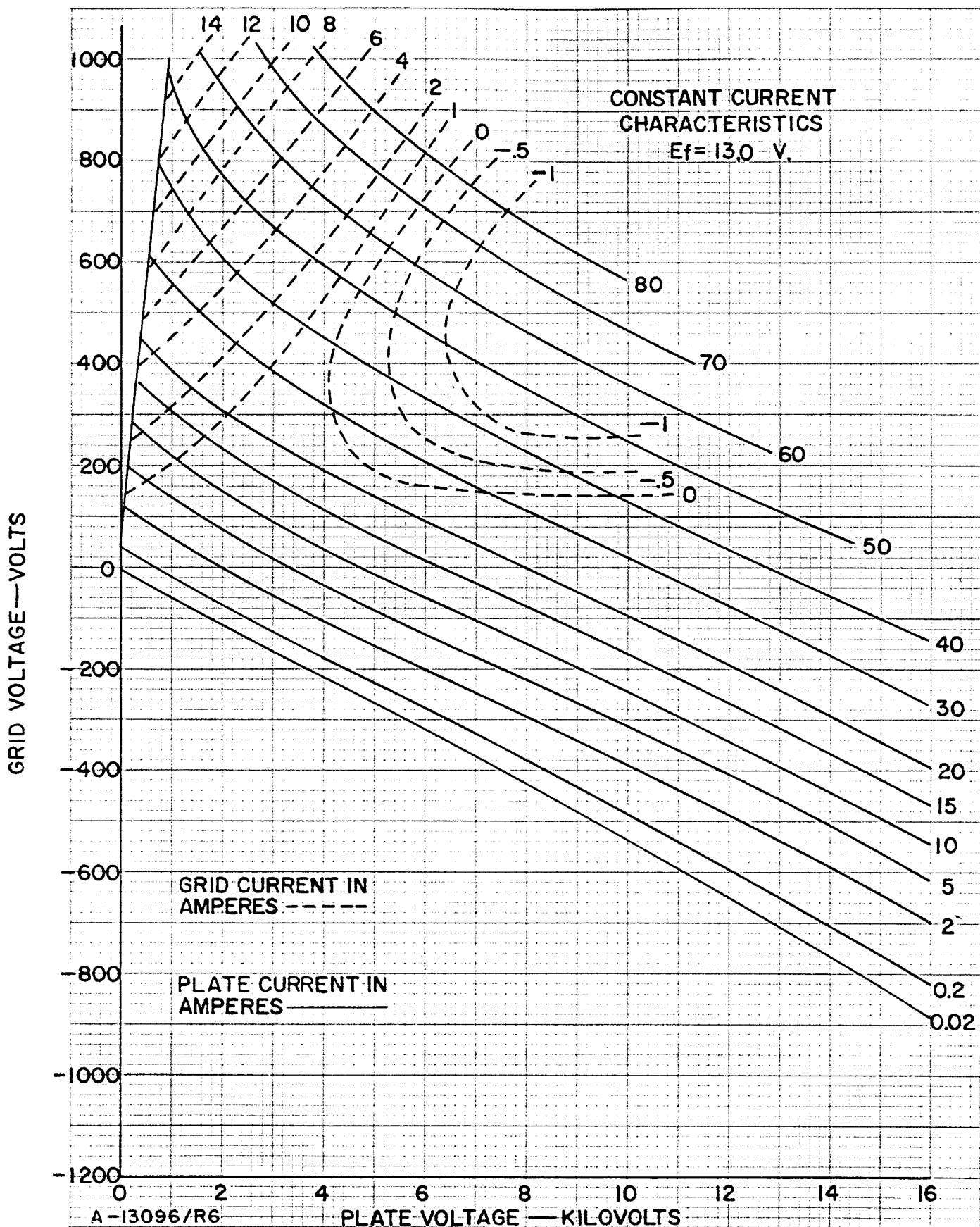
Maximum Power Output of Rectifier	120	250	500	1000	kW
Series Resistor	10	20	35	50	Ohms

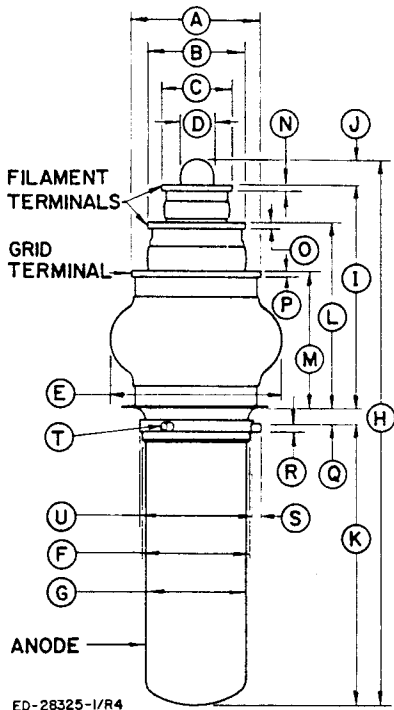
The voltage ratings of these tubes are established so that normal operation will not cause arcs to develop across the tube envelope. Any external arcing, therefore, is an indication that the rated voltages have been exceeded. To lessen the chance of permanently damaging the tube, it is helpful to attach 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.







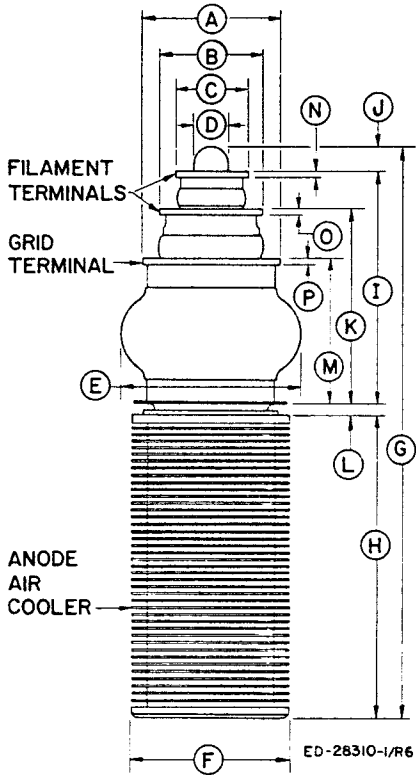
ML-6696

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:

- Three bayonet pins for water jacket connection, diameter (R), length (S), nominally (T) degrees apart.



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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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