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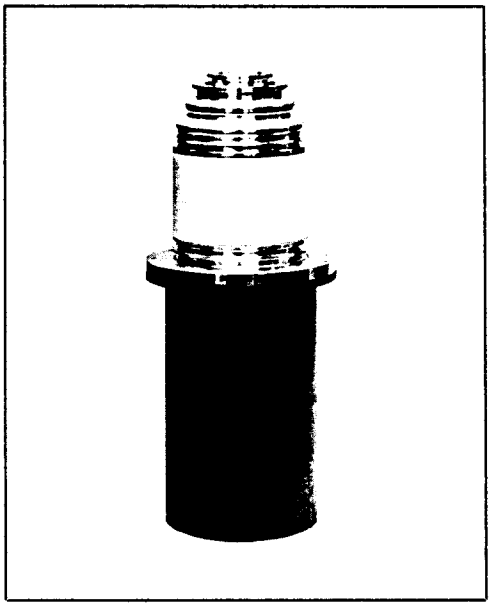


ISSUED 4-71

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

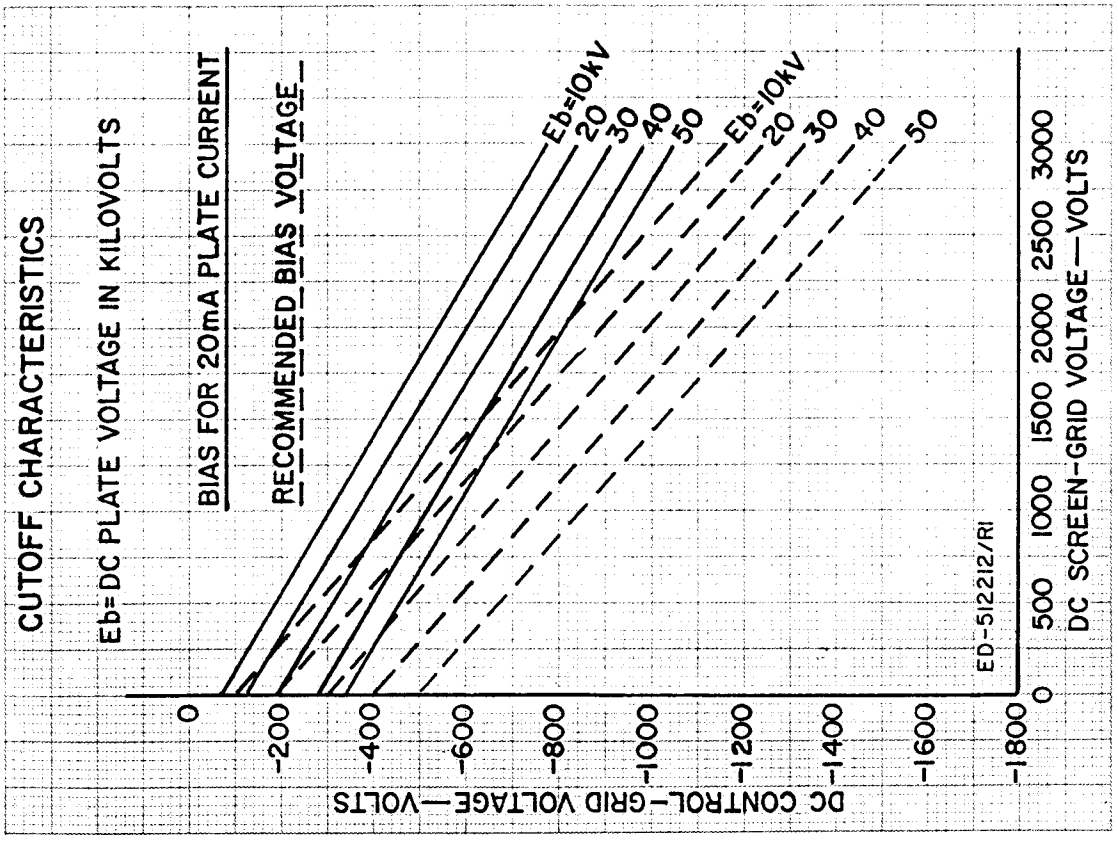
The handling of very high power requires particular attention to the removal of power from tubes during fault conditions (initiated by tube or circuit instabilities) since the larger amount of energy involved can cause tube damage if not properly controlled. The tube must, therefore, be protected by 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.

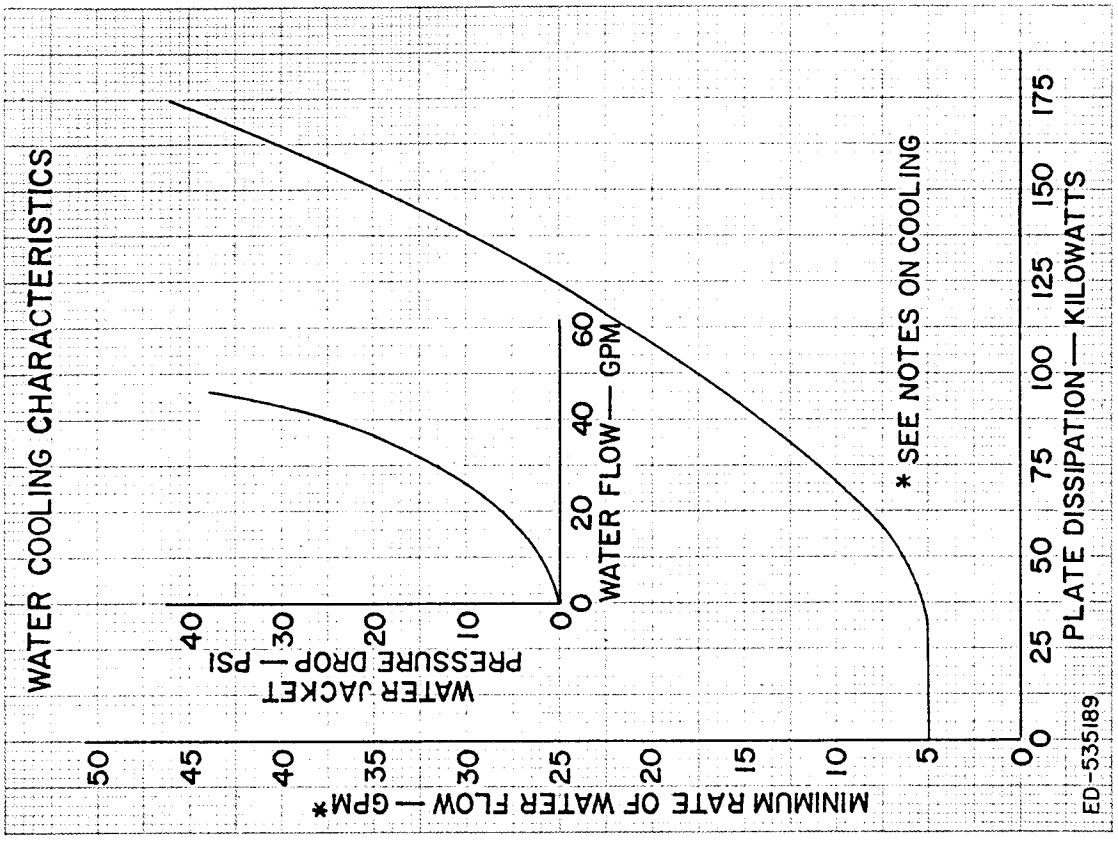
A nominal value of resistance must be placed in the plate lead of the tube being protected in order to be assured that the impedance of this tube under a flash arc condition is greater than that of the crowbar device when the latter is triggered. Critical damping is required for the crowbar discharge 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.

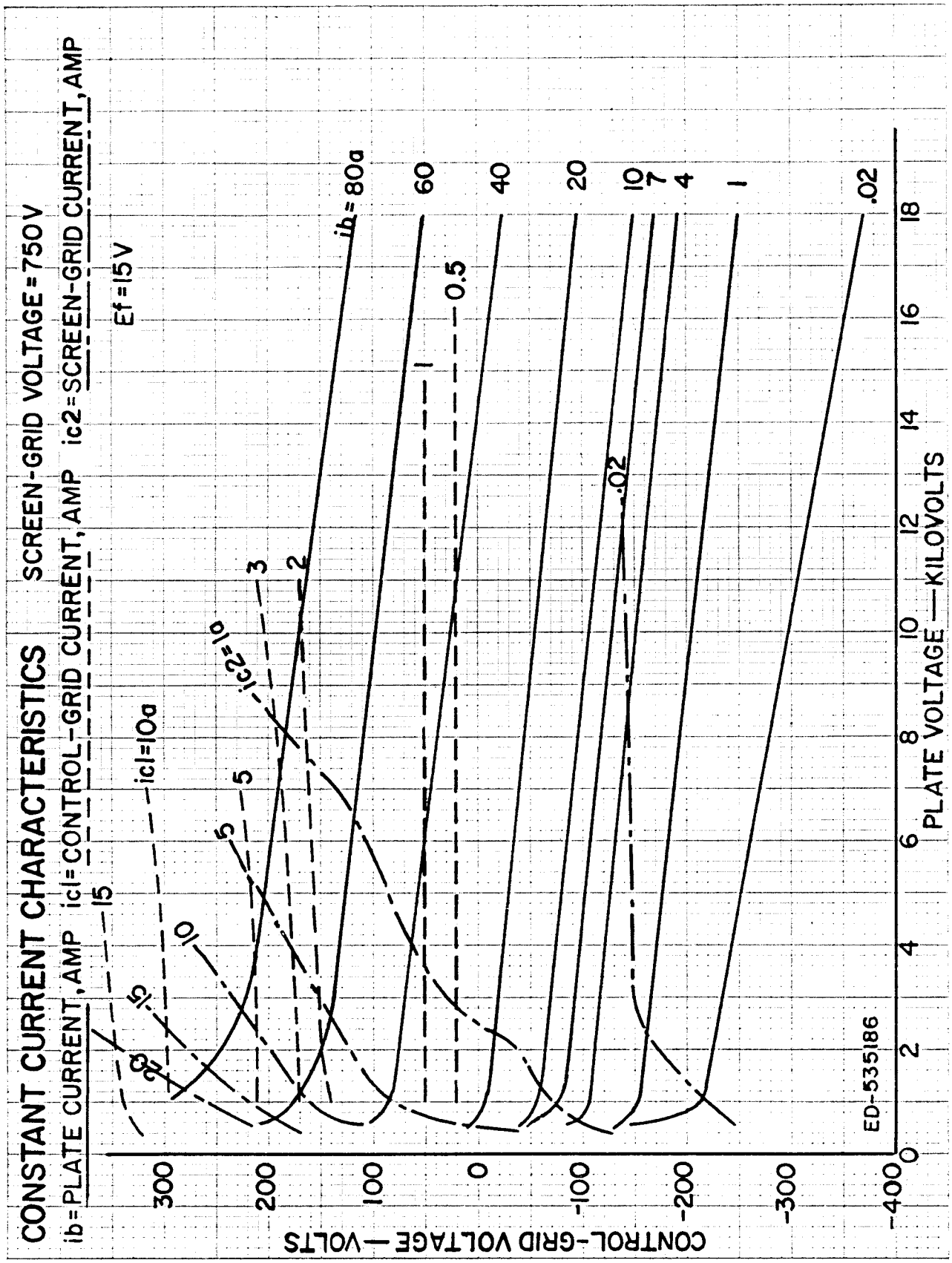
References:
1. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High Power Transmitters", *Electronics, 29*, 144, January 1956.
2. H. D. Doolittle, "High Power Hydrogen Thyratrons", *Cathode Press 1, 6*, 1954.

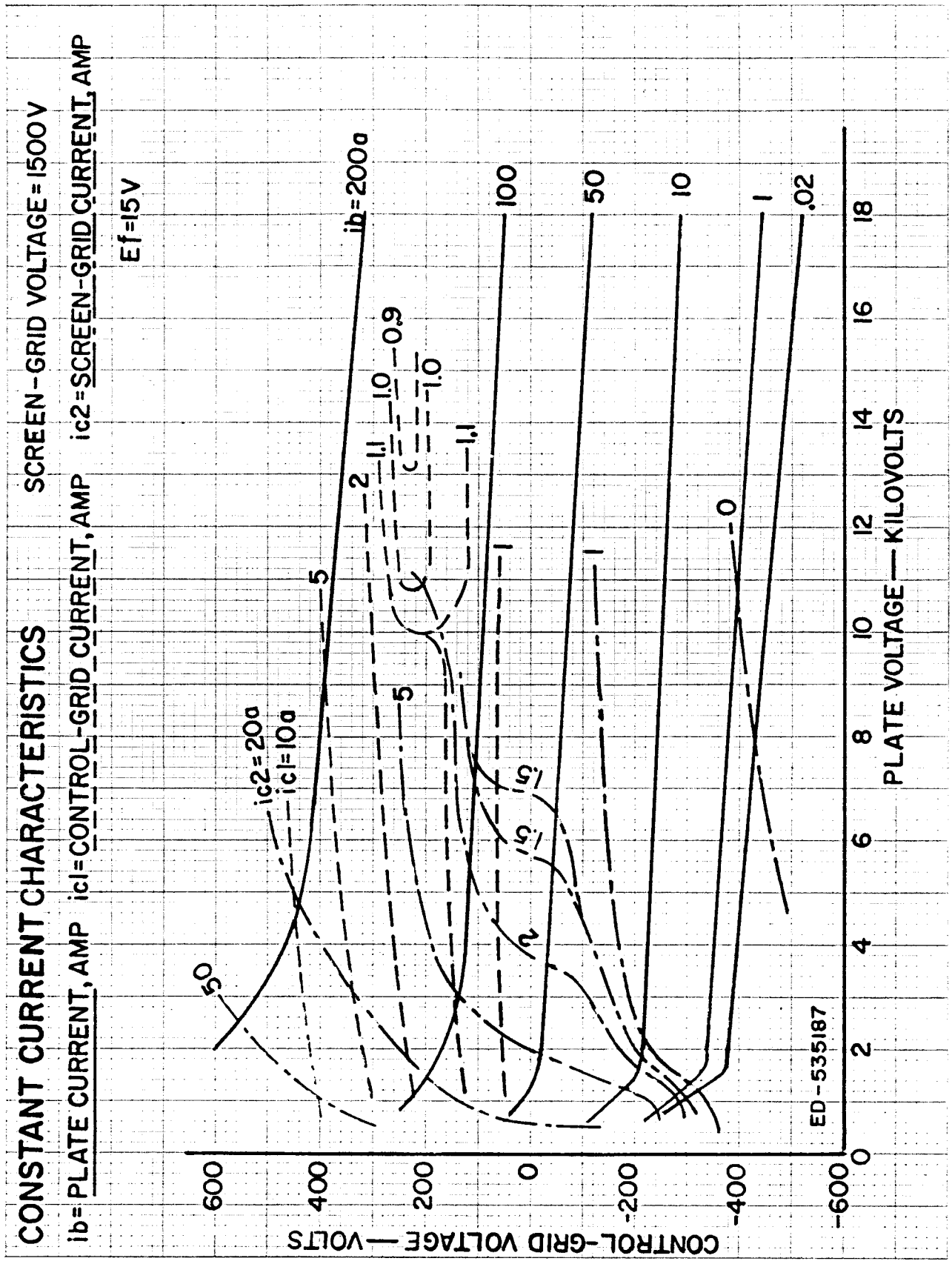


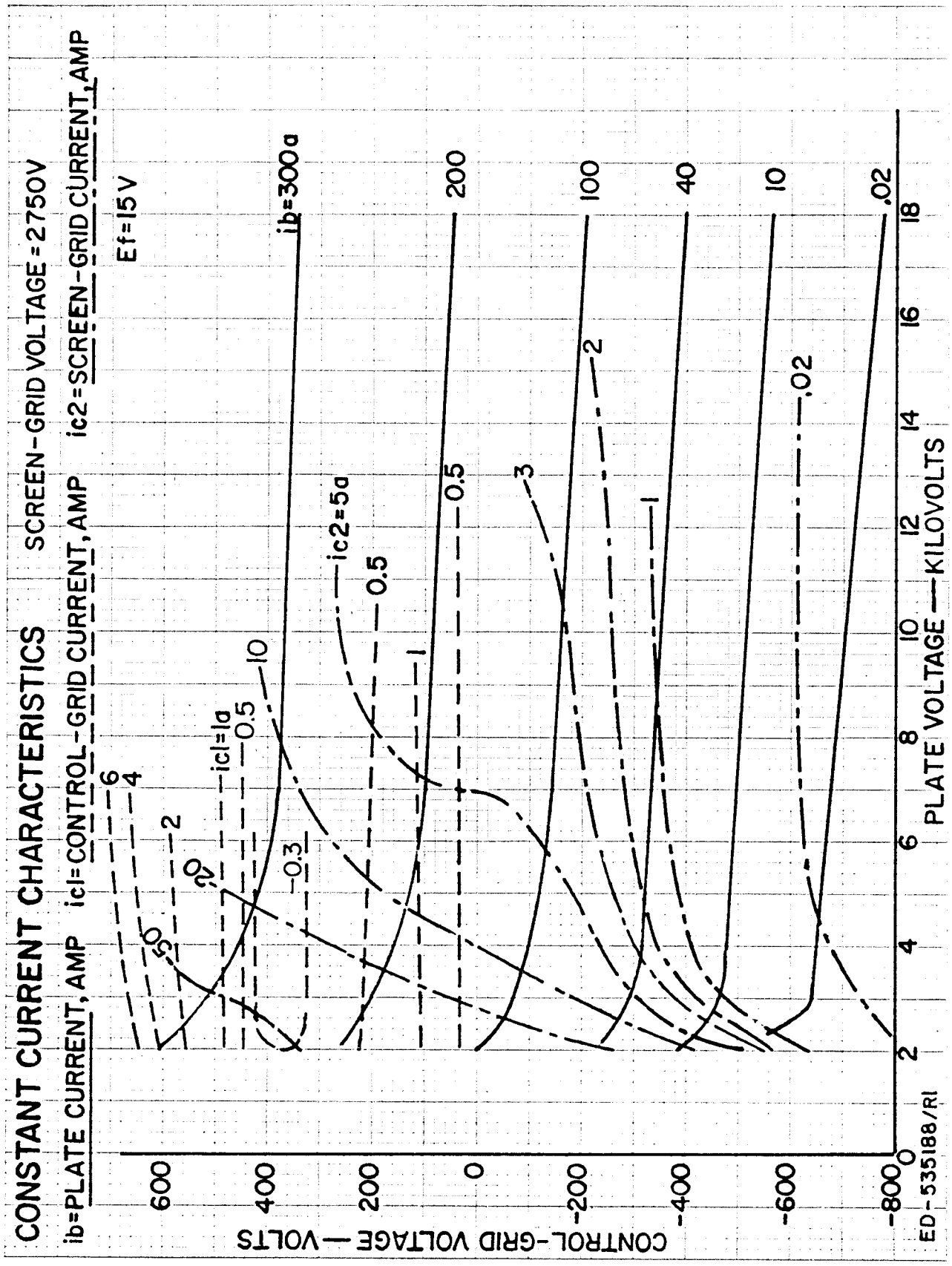
CUTOFF CHARACTERISTICS
ML-8785, ML-8786

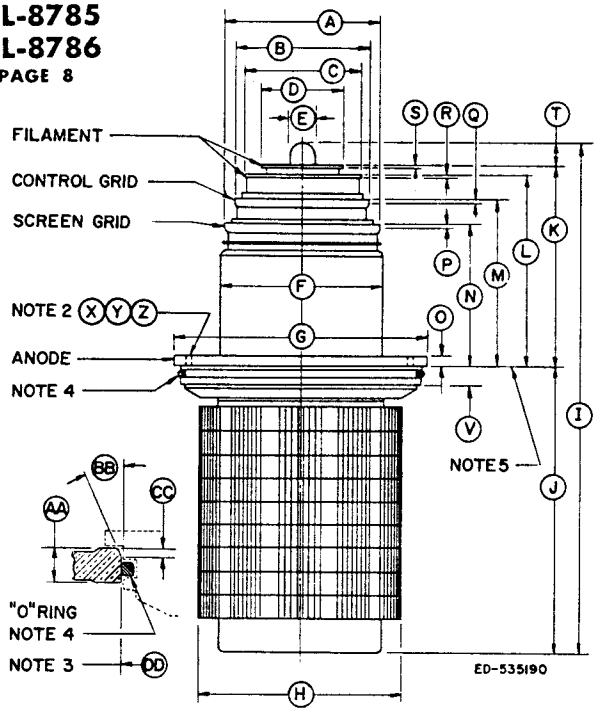


WATER COOLING CHARACTERISTICS
ML-8786


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

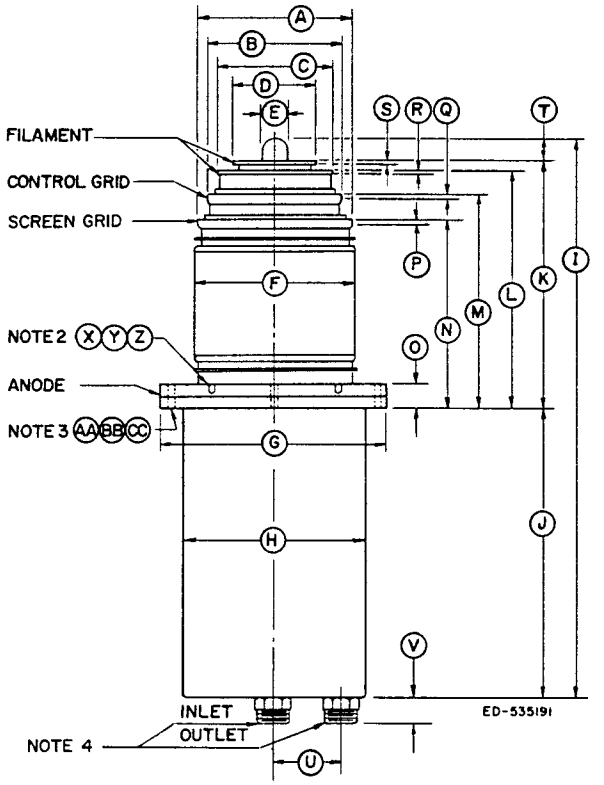
OUTLINE OF ML-8785

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

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