Springdale, Connecticut

MACHLETT

Electron Tubes

This catalog is registered in the name of

HAROLD W. ULMER

A compilation of technical data and important user information covering Machlett electron tubes.

As changes, additions or deletions are made in the line, corrective notices or specification sheets will be automatically forwarded to the holder.

Please notify us immediately upon any change of address.

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

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MACHLETT LABORATORIES

INCORPORATED

SPRINGDALE, CONNECTICUT

STAMFORD, FIRESIDE 8-7511

September 22, 1959

NOTICE OF REVISED EQUIPMENT MANUFACTURER PRICES
MACHLETT ELECTRON TUBES

The attached price list of Machlett electron tubes becomes effective October 1, 1959.

Tube prices in general are the same as those listed in price sheets dated February 15, 1959. A few types, including ML-242C, 833A, 889A, 857B, 866A, 869B, 872A and 8008, have incurred slight cost and price increase. However, a few other types, including ML-6544, 7002, 7003, 7248, 7249 and 6908, have been reduced in price as a result of increasing usage and lower manufacturing costs.

Note that the equipment manufacturer prices of certain types are indicated with symbols referring to "Minimum Ordering Quantity". The equipment manufacturer prices listed for these certain types are the prices applicable when quantities ordered for individual shipments equal or exceed the minimum ordering quantities shown. Orders calling for individual shipments of less than the minimum quantity for a type will be billed at the Suggested User Price less 10 percent.

The minimum direct order billing is $10.00. Individual direct orders having a price list value of less than $10.00 will be billed at the minimum of $10.00.

New listings include:

ML-3CX100A5, UHF planar triode with ceramic envelope
ML-7333, forced-air-cooled, shielded grid triode for hard tube modulators
ML-7335, ceramic beam power triode for 5 KW average power modulator service

Deletions from the price list include types:

ML-207
ML-228A
ML-240B

The attached prices and conditions of sale will supersede those given in Machlett electron tube price lists dated February 15, 1959. These new prices become effective with orders booked on and after October 1, 1959.

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Springdale, Connecticut

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ELECTRONIC EQUIPMENT MANUFACTURERS PRICE LIST
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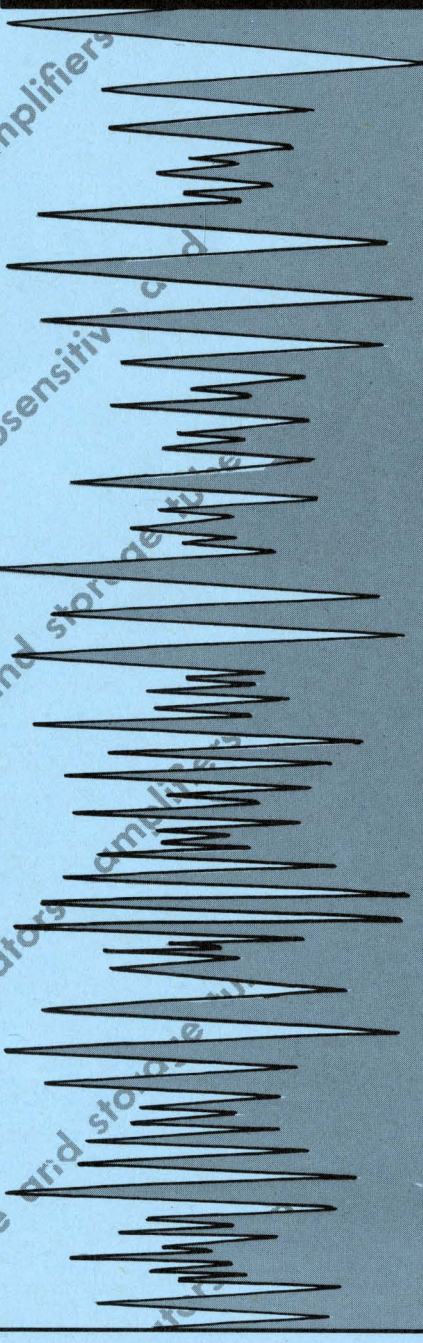

Electron Tube Price List

Effective Date
October 1, 1959

MACHLETT LABORATORIES INCORPORATED
Springdale, Connecticut

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MODULATORS—AMPLIFIERS—OSCILLATORS

Tube Type		Class	Shipping Weight-Lbs.	Suggested Users Net	Mfrs. Net
ML-2C39A	▲	UHF TRI	1*	$ 22.50	$ 14.50 ††
ML-2C39WA	▲	UHF TRI	1*	30.00	20.00 ††
ML-2C41	▲	UHF TRI	1*	26.50	19.50 ††
ML-3CX100A5	▲	UHF TRI	1*	32.15	22.50 ††
ML-212E		RC TRI	10	210.00	170.00
ML-220C		WC TRI	49	449.00	360.00
ML-220CA		FAC TRI	85	550.00	435.00
ML-232B		WC TRI	49	670.00	545.00
ML-241B		RC TRI	10	210.00	170.00
ML-242C	▲	RC TRI	3	30.00	22.00 †
ML-279A		RC TRI	15	415.00	325.00
ML-298A		WC TRI	121	1485.00	1310.00
ML-342A		WC TRI	48	670.00	545.00
ML-342AA		FAC TRI	84	775.00	632.00
ML-343A		WC TRI	49	449.00	360.00
ML-343AA		FAC TRI	84	550.00	435.00
ML-354		WC TRI	123	1750.00	1475.00
ML-356/5771		WC TRI	18	635.00	480.00
ML-357B		RC TRI	10	170.00	138.00
ML-379A		RC TRI	15	440.00	365.00
ML-833A	▲	RC TRI	6	55.00	40.00
ML-880		WC TRI	18	595.00	475.00
ML-889A		WC TRI	15	235.00	195.00
ML-889RA		FAC TRI	72	370.00	275.00
ML-891		WC TRI	16	295.00	230.00
ML-891R		FAC TRI	60	460.00	370.00
ML-892		WC TRI	16	290.00	225.00
ML-892R		FAC TRI	60	455.00	365.00
ML-893A		WC TRI	24	800.00	635.00
ML-893AR		FAC TRI	400	1340.00	1065.00
ML-5530		FAC TRI	49	330.00	245.00
ML-5530H		FAC TRI	49	330.00	245.00
ML-5531		FAC TRI	76	630.00	470.00
ML-5541		FAC TRI	76	500.00	385.00
ML-5604		FAC TRI	93	600.00	450.00
ML-5606		WC TRI	12	288.00	223.00
ML-5619		WC TRI	18	443.00	335.00
ML-5658		WC TRI	18	595.00	475.00
ML-5666		WC TRI	12	280.00	230.00
ML-5667		FAC TRI	72	370.00	275.00
ML-5668		WC TRI	20	$330.00	$250.00
ML-5669		FAC TRI	100	490.00	383.00
ML-5681		WC TRI	123	1875.00	1575.00
ML-5682		WC TRI	328	2625.00	2100.00
ML-5736		FAC TRI	15	190.00	150.00
ML-6256		WC TRI	10	240.00	180.00
ML-6257		WC TRI	11	252.00	190.00
ML-6258		FAC TRI	22	280.00	210.00
ML-6420		WC TRI	15	360.00	265.00
ML-6421		FAC TRI	30	425.00	315.00
ML-6421F		FAC TRI	72	440.00	325.00
ML-6422		WC TRI	35	385.00	290.00
ML-6423		FAC TRI	50	495.00	370.00
ML-6423F		FAC TRI	93	510.00	385.00
ML-6424		WC TRI	35	455.00	340.00
ML-6425		FAC TRI	50	580.00	425.00
ML-6425F		FAC TRI	93	600.00	440.00
ML-6426		WC TRI	45	675.00	510.00
ML-6427		FAC TRI	55	830.00	640.00
ML-6442	▲	UHF TRI	1*	39.25	30.00 ††
ML-6544	▲	PM TRI	33	1200.00	950.00
ML-6576		WC TRI	22	680.00	540.00
ML-6623		FAC TRI	17	205.00	160.00
ML-6696		WC TRI	60	1090.00	825.00
ML-6697		FAC TRI	80	1310.00	1010.00
ML-7002	▲	PM TRI	33	2500.00	2000.00
ML-7003	▲	FAC PM TRI	44	2500.00	2000.00
ML-7007		FAC TET	28	1120.00	860.00
ML-7120		WC TRI	15	425.00	315.00
ML-7121		FAC TRI	30	495.00	375.00
ML-7124		WC TRI	35	760.00	575.00
ML-7125		FAC TRI	50	920.00	710.00
ML-7209	▲	UHF TRI	1	30.25	22.00 ††
ML-7210	▲	UHF TRI	1	65.00	45.00 ††
ML-7211	▲	UHF TRI	1	**	**
ML-7248	▲	SW TET	10	1075.00	800.00
ML-7249	▲	SW TET	10	1150.00	850.00
ML-7333	▲	PM TRI	2	1050.00	800.00
ML-7335	▲	PM TRI	10	1550.00	1200.00

PHOTOSENSITIVE AND STORAGE TUBES

Tube Type		Class	Shipping Weight-Lbs.	Suggested Users Net	Mfrs. Net
ML-5820	●	I.O.	4	$1200.00	$990.00
ML-6198	●	VID	2	230.00	165.00
ML-6577	●	S.D.	12	2250.00	1800.00
ML-7038	●	VID	2	265.00	195.00
ML-7291	●	VID	2	$ 375.00	$ 290.00
ML-7351	●	VID	2	415.00	300.00
ML-C19K	●	D	73	2125.00	1700.00

** Please refer to Machlett Laboratories for prices.

† Minimum ordering quantity = 4

†† Minimum ordering quantity = 10

★ Shipping weights in lots of 36 domestic packing = 12 lbs.
Shipping weights in lots of 72 export packing = 55 lbs.

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RECTIFIERS

Tube Type		Class	Shipping Weight-Lbs.	Suggested Users Net	Mfrs. Net
ML-102A		H VAC	6	$176.00	$137.00
ML-141		H VAC	6	110.00	79.00
ML-142		H VAC	6	74.00	53.00
ML-148		H VAC	6	152.00	110.00
ML-199		H VAC	11	350.00	280.00
ML-222A		WC VAC	14	365.00	280.00
ML-322	▲	UHF DIODE	1*	25.25	18.75 ††
ML-575A	▲	HG VAP	6	21.00	15.00 †
ML-673	▲	HG VAP	6	21.00	15.00 †
ML-857B		HG VAP	16	$ 245.00	$210.00
ML-866A	▲	HG VAP	5	3.00	2.10 ††
ML-869B		HG VAP	6	165.00	140.00
ML-872A	▲	HG VAP	5	11.00	7.50 †
ML-5575/100		H VAC	10	237.00	190.00
ML-5576/200		H VAC	10	266.00	215.00
ML-6908		OCHV	15	790.00	600.00
ML-8008	▲	HG VAP	5	11.00	7.50 †

Class Symbols

Tri	:	Triode	OC	:	Oil Cooled	Hg Vap	: Mercury Vapor
Tet	:	Tetrode	SW	:	Switch	IO	: Image Orthicon
Pent	:	Pentode	RC	:	Radiation Cooled	Vid	: Vidicon
PM	:	Pulse Modulator (Shielded Grid)	WC	:	Water Cooled	SD	: Storage Display
			FAC	:	Forced Air Cooled	D	: Display
UHF	:	Ultra High Frequency	Vac	:	Vacuum		

Price indicated is the price when quantities ordered for individual shipment equal or exceed the minimum ordering quantity shown. Orders calling for individual shipments of less than minimum quantity for a type will be billed at user price less ten percent.

RENEWAL PRICES ON RADIATOR AND INTEGRAL WATER JACKET TYPES OF TUBES

TYPE	NET CREDIT	SUGGESTED USERS NET	MFRS. NET
ML-220CA	$40.00	$510.00	$395.00
ML-342AA	40.00	735.00	592.00
ML-343AA	40.00	510.00	395.00
ML-354	150.00	1600.00	1325.00
ML-889RA	20.00	350.00	255.00
ML-891R	30.00	430.00	340.00
ML-892R	30.00	425.00	335.00
ML-893AR	100.00	1240.00	965.00
ML-5530	15.00	315.00	230.00
ML-5530H	15.00	315.00	230.00
ML-5531	20.00	610.00	450.00
ML-5541	20.00	480.00	365.00
ML-5604	45.00	555.00	405.00
ML-5667	$20.00	$350.00	255.00
ML-5669	30.00	460.00	353.00
ML-5681	150.00	1725.00	1425.00
ML-5682	200.00	2425.00	1900.00
ML-6421	20.00	405.00	295.00
ML-6421F	20.00	420.00	305.00
ML-6423	30.00	465.00	340.00
ML-6423F	30.00	480.00	355.00
ML-6425	30.00	550.00	395.00
ML-6425F	45.00	555.00	395.00
ML-6427	40.00	790.00	600.00
ML-6697	50.00	1260.00	960.00

These prices currently apply when a new tube is purchased and a tube and shipping container are returned prepaid in good physical condition with a replacement order.

FLAT GASKETS FOR WATER JACKETS

TYPE	REQUIRED QUANTITY AND PART NUMBER		SUGGESTED USERS NET		MFRS. NET	
ML-220C	1	P-9569	F	.30	F	.18
	1	P-9709				
ML-222A	1	P-9569	F	.30	F	.18
	1	P-9709				
ML-232B	1	P-9569	F	.30	F	.18
	1	P-9709				
ML-298A	4	P-9675	F	.30	F	.18
ML-342A	1	P-9569	F	.30	F	.18
	1	P-9709				
ML-343A	1	P-9569	F	.30	F	.18
	1	P-9709				
ML-880	1	P-4619		1.18		.74
ML-889A	1	P-6083		.42		.26
ML-891	1	P-4599		.20		.12
ML-892	1	P-4599		.20		.12
ML-893A	1	P-5962		.96		.60
ML-5606	1	P-4599		.20		.12
ML-5658	1	P-4619		1.18		.74

F — Price is per set required.

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POWER TUBE ACCESSORIES

DESCRIPTION	NO. REQUIRED	PART NO.	USED WITH TUBE TYPES	USER	MFRS. NET
Filament Connector with Straps	2	F-12167	356, 880, 889A, 889RA, 5604, 5606, 5619, 5658, 5666, 5667, 5668, 5669	$ 8.50	$ 6.30
Filament Connector without Straps	2	F-13220		4.75	3.65
Grid Connector with Jumper and Straps	1	F-8540		11.00	8.50
Grid Connector with Jumper without Straps	1	F-13221		10.25	7.75
Water Jacket with "O" Ring Gasket	1	F-10690	356, 880, 5658, 6576	96.00	76.75
"O" Ring Gasket for Water Jacket	1	F-8645		2.10	1.55
Water Jacket with "O" Ring Gasket	1	F-7963	5619, 6422, 6424	76.50	61.50
Water Jacket with "O" Ring Gasket	1	F-8529	5666, 6420	76.50	61.50
Water Jacket with "O" Ring Gasket	1	F-8528	5668	76.50	61.50
"O" Ring Gasket for Water Jacket	1	P-7976	5619, 5666, 5668, 6420, 6422, 6424	.85	.65
Mounting Clamp for Water Jacket	1	F-8768		15.25	12.35
Mounting Plate for Water Jacket	1	F-8772		12.85	9.50
Standoff Insulator with Mounting Clamp	1	F-8775	5619, 5666, 6420, 6422, 6424	44.75	35.75
Filament Connector (small)	1	F-12589	5681, 5682, 354	22.55	17.85
Filament Connector (large)	1	F-12590		29.50	23.00
Grid or Anode Connector	2 { 1, grid 1, anode	F-12591		34.85	27.55
Sphere Gap for Grid or Anode	2	F-12507		3.25	2.70
Sphere Gap for Grid to Filament	1	F-12506		3.00	2.55
Mounting Socket	1	F-12527		110.25	82.75
"O" Ring Gasket for Mounting Socket	1	P-13745		1.35	.85
Inner Gasket for Mounting Socket	1	P-12272		1.95	1.35
Filament Connector (small)	1	F-14383	6256, 6257, 6258	3.15	2.45
Filament Connector (large)	1	F-14382		3.35	2.70
Grid Connector	1	F-14381		3.40	2.70
Water Jacket	1	F-14157	6256	28.50	22.00
"O" Ring Gasket for Water Jacket	1	F-14384		.85	.65
Glass Insulated Tube Support	1	P-21186	6258	39.00	28.50
Steatite Insulated Tube Support	1	or P-17468		65.00	48.50
Tube Support	1	P-17822	889RA, 5667, 5604, 5669, 891R, 892R, 6421F, 6423F, 6425F	97.00	74.50
Tube Support	1	P-16891	5530, 553OH	78.25	62.00
Tube Support	1	P-16893	5531, 5541	59.25	43.00
Filament or Grid Connector	3 { 2, fil. 1, grid	P-14988	5530, 5530H, 5531, 5541	4.50	3.30
Filament Connector (small)	1	F-17487	7120, 7121, 7124, 6420, 6421, 6421F, 6422, 6423, 6423F, 6424, 6425, 6425F, 6426, 6427, 7125	8.70	5.75
Filament Connector (large)	1	F-17488		8.70	5.75
Grid Connector	1	F-17489		9.00	6.25
Tube Support	1	F-17794	6421, 6423, 6425	38.50	27.50
Air Distributor (including 3 P-21113 clips)	1	F-17796	6421	70.75	49.50
Air Distributor (including 3 P-21113 clips)	1	F-17797	6423, 6425	84.80	60.50
Water Jacket with "O" Ring Gasket	1	F-17292	6426	122.00	93.50
"O" Ring Gasket for Water Jacket	1	P-17494	6426, 6696	1.35	.85
Mounting Clamp for Water Jacket (1 required if mounted on plate) (2 required if mounted from side with horizontal insulators)	1 or 2	F-15198	6426, 6696	29.75	24.00
Mounting Plate	1	F-15196	6426, 6696	23.25	18.75
Tube Support	1	F-17795	6427, 6697	54.00	38.50
Air Distributor (including 3 P-21113 clips)	1	F-17798	6427	95.75	71.50
Filament Connector (small)	1	F-17488	6696, 6697	8.75	5.75
Filament Connector (large)	1	F-17489		9.25	6.25
Grid Connector	1	F-17397		14.50	10.50
Water Jacket with "O" Ring Gasket	1	F-17393	6696	137.50	105.00
Air Distributor (including 3 P-21113 clips)	1	F-17759	6697	110.50	83.00
Mounting Socket	1	P-8835	102A, 141, 199, 5575, 5576	8.00	5.50
Grid Connector	1	F-21987	6544, 7002, 7003	10.50	8.00
Heater Connector	1	F-21989		9.75	7.00
Cathode Connector	1	F-21991		14.00	10.00
½ oz. Tube Grease		RM-6388	"O" Ring Gasket	.85	.65
Spring Locking Clips	3	P-21113	Air Distributor	.50	.35

PRICES

Prices are F.O.B. point of shipment and subject to change without notice. Minimum direct order billing: $10.00; individual direct orders having a price list value less than $10.00 will be billed at the minimum of $10.00.

TERMS

Terms are net 30 days from date of invoice.

DELIVERY POLICY

All direct orders for factory shipment are F.O.B. point of shipment with full transportation allowed, via railway express, within Continental U.S.A. on domestic orders authorizing individual shipments having a billing value of $250.00 or more. All other orders are F.O.B. point of shipment. If buyer requests delivery via more expensive means than Railway Express, the additional costs will be billed to the buyer.

FEDERAL GOVERNMENT OR ITS AGENCIES

For any quotation involving government specifications and/or government inspection refer to factory for special quotation.

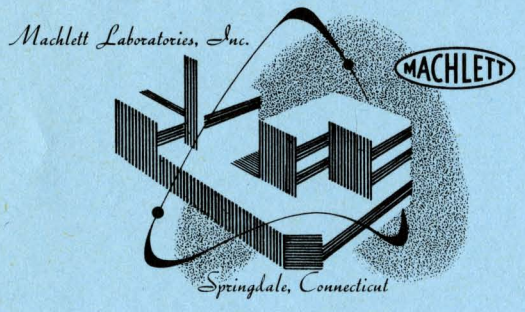
WARRANTY POLICY

Tubes, all except those identified by ● and ▲, are warranted to be free from defects in design, material, and workmanship, and no other warranty may be implied. If such defects appear within 50 hours service, the tube will be subect to full adjustment or proportional adjustment for the difference between elapsed life and 1000 hours for failures up to 1000 hours service, provided operation has been within published ratings. No adjustments will be made if the tube life exceeds either 1000 hours or one year.

Tubes identified by ● are warranted to be free from defects in design, material and workmanship, and no other warranty may be implied. If such defects appear within 50 hours service, the tube will be subject to full adjustment or proportional adjustment for difference between elapsed life and 500 hours for failures up to 500 hours service, provided operation has been within published ratings. No adjustments will be made if tube life exceeds either 500 hours or one year.

Tubes identified by ▲ are warranted to be free from defects in design, material and workmanship, and no other warranty may be implied. If such defects appear within 50 hours service, the tube will be subject to full adjustment.

For users the warranty period extends for 12 months after receipt of tube. For manufacturer this warranty period extends 18 months after receipt of tube.



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Broadcasting and Communication Power Tubes

Electron tubes designed for use as modulators, amplifiers, and oscillators in broadcasting and communication equipment are high-power, precision devices requiring in their manufacture top level engineering and the most advanced techniques. In addition to these requirements is the quality of materials and processing, both of which must be closely controlled in order to insure consistently efficient, reliable, and economical tube performance.

Machlett Laboratories, in the course of its more than half a century of electron tube production, has developed many original techniques which result in superior quality power tubes. The many important factors, such as the use of highest purity materials, special processing of internal parts, clean air-conditioned assembly rooms, and outgassing at high plate voltages in final exhaust, which have made Machlett x-ray tubes known throughout the world for their superior quality, are also incorporated in the production of electron power tubes for broadcasting and communication. In many cases existing tube types have been materially improved and strengthened by redesign of filament and grid structures and by the use of kovar for glass to metal seals. In other cases, where gaps existed in the power "spectrum" or where the desirability of new tube types for specific applications was indicated, Machlett has provided — and will continue to develop—new electron tube types for special applications. Continued research and engineering effort which contribute so much to its progress and leadership in the x-ray tube industry, provide assurance of the best in quality and performance in Machlett broadcasting and communication power tubes.

The Machlett line of radio transmitting tubes includes a wide range of types and power levels. Descriptive information on each is set forth in individual data sheets which follow, including general electrical and mechanical characteristics, maximum ratings and typical operating conditions, charted tube characteristics, and dimensional data.

The purpose of this article is to develop in a broad and non-technical manner an understanding of the basis for various types of ratings applied to broadcasting and communication power tubes and to present general instructions and recommendations with respect to their installation and operation. The headings below correspond with and follow in general those which appear on individual tube data sheets; it is suggested that reference be made to one of the data sheets, such as that for the ML-5619, during the reading of this material.

GENERAL CHARACTERISTICS

Most items listed under "General Characteristics" are self-explanatory and need no elaboration. Even though in some cases minimum and maximum limits are shown, the actual tube values are made as close to the bogey value as is feasible to permit interchangeability or replacement of tubes with little or no circuit adjustments.

Cathodes

Cathodes in electron tubes with power ratings above a few hundred watts are filamentary in design and are of two types, pure-tungsten and thoriated-tungsten. The former has the advantages of being sturdier, is not readily poisoned as a result of tube overloading and gassiness.

and can be operated at reduced or increased voltage to obtain, respectively, longer life or greater emission. Thoriated-tungsten filaments have higher emission efficiency with consequent decrease in filament heating requirements. The rated voltage for a pure-tungsten filament is that at which the user can get satisfactory service and long useful life. Variation from this voltage rating has a direct bearing on filament life and is discussed further under "Operation". In the case of a thoriated-tungsten filament, the rated voltage is that required for proper filament operating temperature and must be maintained as closely as possible for satisfactory service and long useful life.

Cooling

The required water-flow for water-cooled tubes and air-flow for forced-air-cooled tubes are also specified in the tube data to guide the user in providing the required amount of coolant for the heat which must be dissipated. Where one value of required water-flow is listed, it is adequate for the rated heat dissipation. In some cases, data sheets also present charts of water or air-flow versus plate dissipation, giving values of required cooling for intermediate values of dissipation. Temperature limits specified (such as 70°C maximum outgoing water temperature for water-cooled tubes, 230°C maximum anode temperature for forced-air-cooled tubes, 160°C maximum glass and seal temperature) are in general absolute, and operation appreciably beyond these values will jeopardize tube life and may cause immediate failure.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Maximum ratings for tube operation are the safe limits, based on test data and general experience, under which the user can get reliable performance and economical life. Whereas operation outside the limits specified may be satisfactory, life testing of several tubes under conditions which are beyond established limits is necessary before good life can be assured. It is therefore practically essential that tube operation be within the ratings specified. However, Machlett Laboratories is always interested in new tube applications and will assist in performing tests required to determine the feasibility of using a particular type of tube under any special conditions which may be proposed.

Operation under conditions which exceed maximum ratings may result in premature failure. The bulb may crack or puncture and the glass at the electrode seals may electrolyze due to high temperatures as a result of excessive voltage, operating frequency, plate input and dissipation. The anode and the grid may also fail at very high temperatures with too great a plate dissipation and excessive electron current to and r.f. current within the plate and grid, respectively. A continuous or starting current in the filament which is appreciably greater than that recommended is certain to shorten filament life and may result in its immediate failure. The foregoing constitute only a few of the possible causes of tube failure and emphasize the importance of tube operation within established ratings so as to assure satisfactory service and long useful life.

Maximum ratings for the various classes or service are generally based on ratings determined experimentally for the tube operating as an r.f. amplifier or oscillator, class C telegraphy. In establishing ratings on a new type, tubes are tested under conditions sufficiently beyond the proposed ratings of frequency, voltage, current and dissipation to assure satis factory life and service for all tubes of the type concerned. Ratings for other classes of service are readily derived from those determined to be the most useful and yet economical for the tube operating as a class C amplifier or oscillator.

Generally, the ratings given are for CCS (Continuous Commercial Service), assuring reliable operation continuously to end of filament life. In some instances ratings for ICAS

(Intermittent Commercial and Amateur Service) are also provided; ratings for intermittent service are somewhat higher than those for continuous service and are authorized for operating periods which are no longer than five minutes, with at least an equal off period.

Plate Voltage Rating

The d.c. plate voltage rating for any class of service is related to the highest instantaneous voltage which may be safely impressed between the plate and other elements of the tube. It depends upon a number of considerations, some of which are tube geometry, voltage gradients within and outside the tube, the operating frequency, and the class of service for which the tube is intended. The plate voltage rating for class C telegraphy is determined experimentally, as indicated above. The plate voltage ratings for class B modulator and for class B r.f. amplifier telephone service are usually the same as for class C telegraphy; the modulator rating may be higher due to the absence of r.f. voltages. Ratings for television service are based on synchronizing level conditions; plate voltage ratings for class B r.f. power amplifier and class C grid-modulated r.f. power amplifier are generally the same as in telegraphy. In modulated class C operation, the instantaneous applied crest plate voltage is greater than the d.c. plate voltage under carrier conditions. When 100% modulation is applied, the r.f. losses are equal to 1.225 times those produced by the unmodulated supply voltage; the plate voltage rating for class C telephony is given for carrier conditions with a modulation factor of 1.0 and must therefore be limited to approximately 80% of the class C telegraph rating.

Plate Current Rating

The primary limitation on the value of plate current which may be provided by a tube is the amount of emission available from the filament. Pure-tungsten filaments may be operated at saturation or emission limited, and therefore the total filament emission is available for tube currents, both plate and grid, the crests of which, incidentally, are drawn simultaneously. Due to the fact that thoriated-tungsten filaments are more sensitive to positive ion bombardment than are pure-tungsten filaments, the emission available for tube currents is generally taken as not more than one-half the total filament emission.

When the peak emission, in the case of a pure-tungsten filament, has been determined for a filament voltage designed for long life, a maximum plate current rating for class C unmodulated operation can be established. The direct current may be 28% or more of the peak emission current, but to draw such a value of plate current requires the relatively wide angle of plate current flow of approximately 160 electrical degrees. Normally the rating is taken as 25 to 20% of the peak emission, which value could be achieved at a narrower angle of current flow and consequently higher plate power efficiency. More complete information on direct to peak current ratios versus angles of plate current flow and the allied subject of voltage, current, and power relations for triodes in class C telegraphy is available on pp. 444-448 of F. E. Terman's *Radio Engineer's Handbook.*

In class B audio service maximum plate current ratings can be the same as in telegraphy; however, due to requirements of linearity for quality in sound reproduction, a lower value, such as 80 to 85% of the telegraph current rating, is often chosen. The conditions at synchronizing level for television service are similar to those for telegraphy, and so the television plate current ratings may be set the same as for telegraphy. Since fully modulated crest conditions for class C and class B amplifiers for telephone service require peak emission values which are twice those of carrier conditions, plate current ratings for carrier conditions with a modulation factor of 1.0 can be no more than one-half the values given for class C oscillator and class B modulator service, respectively, provided, of course, that the oscillator and

modulator ratings were limited only by the peak emission available. With thoriated-tungsten filaments, the total emission is considerably higher than actual tube current demands, so that current ratings may be determined by power input and dissipation limits rather than by the above considerations.

Grid Voltage and Current Ratings

Ratings which are placed on the grid with respect to voltage and direct current are primarily for the purpose of avoiding excessive grid temperatures. A grid which is overdriven may become overheated to the extent that it becomes an emitter of electrons causing unstable operation and possible destruction of the grid. Since it is not practical for the user to measure grid dissipation in terms of watts, limits are established for class C telegraphy in terms of bias voltage and direct grid current. These values must also insure that the a.c. grid voltage swing with operation at maximum plate voltage and current ratings is not so great as to cause tube flash-arcs internally or externally. The direct grid voltage and current ratings which are established for class C telegraph service are also applied to class C telephone and class C television services. For class B operation these ratings are not listed, since bias values for satisfactory operation are at or near plate current cutoff and other factors are limitations to the amount of grid heating.

Plate Input and Dissipation Ratings

In most cases the plate input is limited by the heat dissipation capability of the anode. Since the actual plate dissipation required of a high-power electron tube is dependent upon the plate efficiency obtainable under any class and conditions of operation, limits must be set upon anode input and dissipation for the several classes of service so as to preclude its failure due to excessive temperatures. There are important considerations such as extreme purity of materials and highest degree of parts cleaning and tube evacuation which permit momentary or intermittent overloads, but maximum plate input and dissipation ratings are determined as operating limits within which no tube of a given type will fail due to excessive temperatures during any extended period of continuous operation, provided, of course, that other ratings are not exceeded.

For class C telegraphy and oscillator service and also class B audio amplifier and modulator service the plate input ratings may be the product of the rated d.c. plate voltage and current. However, due to limitations imposed by frequencies of operation for which the tube is designed and the plate dissipation which can be achieved with reasonable anode water or forced-air cooling, the plate input may be limited to a value somewhat less. Generally, for class C telegraph and class B audio services, the plate dissipation ratings are the same, and plate efficiencies can be achieved to warrant plate input ratings which are 3 to $3\frac{1}{2}$ times the established limit on plate dissipation.

The plate dissipation limit for class B r.f. amplifier telephone service is the same as for class C telegraphy, but, since there are periods of operation in this class of service during which there is no modulation, the plate input rating must be established for carrier conditions, allowing for a modulation factor of 1.0 Generally, without modulation the plate dissipation is of the order of 2/3 the plate input, so that the carrier plate input must be limited to 1.5 times the rated plate dissipation. In the case of the class B r.f. power amplifier and class C grid-modulated r.f. power amplifier for television service, the plate dissipation has the same rating as in telegraphy; the allowable plate input depends upon the efficiency obtainable and is generally rated at a value lower than that for telegraphy.

For fully modulated class C operation, as in telephony, the plate loss is 1.5 times its value

without modulation, so that the rated plate dissipation, which is given for carrier conditions, can be no greater than 2/3 the rating for class C telegraphy. Also, the plate input rating for this class of service may be as great as 2/3 the rated telegraphy input but is usually taken as the product of the rated d.c. plate voltage and current.

Frequency Ratings

Maximum ratings for any particular tube type are dependent upon the class of service and frequency of operation for which the tube is designed. Maximum ratings as set forth apply at the frequency specified and at any lower frequency. Since the amount of heat generated in tube leads and glass-to-metal seals is proportional to the 5/2 power of the frequency and the square of the maximum instantaneous potential difference between plate and grid, frequencies of operation greater than that specified as the limit for full plate voltage and input are allowable only with reduced voltage and consequently reduced input. A parameter for determining at what frequency a certain plate voltage is allowable is the temperature of glass-to-metal seals. Such temperatures which are appreciably greater than 160°C for extended periods of time will result in electrolysis and softening of the glass followed by gassiness within the tube. Special attention to adequate cooling of the tube is necessary at relatively high frequencies. Also, it is extremely important at high frequencies that both or all grid terminals of tubes provided with two or more such terminals be used and that the currents be split equally so as to minimize grid seal heating due to r.f. currents. Generally, individual data sheets tabulate percentages of plate voltage and input which are permissible at frequencies greater than that specified for maximum ratings and stated air-flow to bulb and seals.

Typical Operating Conditions

Typical operation data are set up for the various classes of service which are applicable to broadcasting and communication. These data do not necessarily represent optimum conditions of operation for any particular case, but they are examples of those in practice and may be used to serve as guides for design purposes. For methods of analysis and calculation of operating conditions for class B and class C amplifiers, see pp. 571-578 of *Applied Electronics* by the E. E. Staff of M.I.T.

INSTALLATION

Broadcasting and communication tubes should be handled with care and without shock so as to preclude possible breakage of the filament, other internal parts, glass-to-metal seals, and tube envelope. Upon receipt, tubes should be inspected and then tested in the equipments in which they are to be used, so as to insure that tubes which may have been damaged in shipment are not carried in stock as useable spares.

It is generally desirable to secure the tube in its mount, air jacket or water jacket, as the case may be, before electrical connections are made. The filament and grid leads should be flexible so as not to impart stresses to terminal seals. The terminal connectors must be clamped tightly in order to minimize contact resistance; I^2R losses at the terminals, caused by improperly mounted connectors, can jeopardize tube life by raising seal temperatures to a dangerous level. Also, precautions should be taken that there is sufficient clearance between connector leads and bulb of the tube so that there is no possibility of corona discharge, which may result in puncture of the glass.

In order to monitor tube service, provisions should be made for determining filament voltage, d.c. plate voltage and current, and running total hours of filament operation. The equipment should also include overload relays in case of excessive plate current or breakdown in

blocking condensers for tube and equipment protection, and interlock devices for the safety of operating personnel. These are generally connected to the primary circuit of the power supply transformer. The filament transformer should be the high-reactance type, or the filament circuit should include provisions for shorting series resistors automatically, so that the filament starting current is never greater, even momentarily, than 1½-2 times the filament current at rated voltage, as specified on individual data sheets.

Sufficient coolant flow must be provided to limit the out-going water temperature in the case of water-cooled tubes to 70°C., or the anode temperature in the case of forced-air-cooled tubes to 230°C. The minimum required water and/or air-flows are indicated in data sheets for each tube type. It is advisable to include interlocks or coolant flow switches which will open the plate and filament power supply circuits if the cooling becomes inadequate or ceases entirely. Unless otherwise specified in individual tube data sheets, a delay in removal of cooling with shut down of power is not required; however, where there is a tendency for any tube temperatures to rise after removal of filament and plate power, as in types 893A and 893AR, cooling should continue for a short period, in the order of 5 minutes, after removal of filament and plate power. This may be accomplished automatically by the use of a time delay relay. The water system, in the case of water-cooled tubes, should be kept free of accumulation of foreign matter. Water which shows a hardness greater than 10 grains per gallon in carbonates, sulphates, or other minerals or a specific resistance less than 4000 ohms per inch cube should not be used; distilled or rain water is generally most satisfactory. Forced-air for tubes requiring such cooling should be filtered to insure that dust is not blown through the tube air jacket. Any accumulation of foreign material on radiator fins will act as a thermal insulator and thereby reduce the cooling efficiency of the tube radiator.

OPERATION

Cooling must be provided for any high power transmitting tube before the application of filament and/or plate voltages. Even momentary operation without coolant flow will result in destruction of the tube.

When a new tube has been installed in the transmitting equipment for the first time, it should be operated at rated filament voltage but without plate voltage for a minimum period of five minutes. The equipment may then be operated with low d.c. plate voltage, in the order of one-half tube rating. After approximately 15 minutes of operation at reduced input, load conditions within maximum ratings may be assumed continuously. Tubes which have been shelved as spares should every three months undergo the above schedule, with operation under normal load conditions for one-half hour so as to minimize the possibility of their becoming gassy. Tubes in which the vacuum has been impaired as a result of overload conditions, causing instability of operation at high voltage, can be electrically cleaned up, in many cases, by operation as a class C amplifier or oscillator at one-half rated voltage for approximately a one-half hour period. Plate voltage and input should then be increased in two or three steps for short periods and the tube operated for one hour or as long as is necessary to insure stable operation.

Due to the fact that a pure-tungsten filament may be operated at saturation, or within limits of distortion, filament voltage and temperature may be reduced when the tube is operated at relatively low current. Since the activity or the emission-hours of a pure-tungsten filament is not impaired by its operation at reduced voltage, appreciable tube economy will result from operation of the filament at a voltage no greater than that necessary to produce the required emission. End of filament life can be expected when the diameter of a filament wire

has been reduced, due to evaporation of the tungsten, to approximately 90% of its original value. Life expectancy is nearly doubled when the filament is operated 5% less than rated voltage and is quadrupled when the filament voltage is decreased 10%. On the other hand, if the filament is operated with an overvoltage of 5%, the evaporation rate of the tungsten is doubled, and it can be expected that the life of the filament will be one-half its design value.

Since the source of emission in a thoriated-tungsten filament is a layer of thorium on the filament surface, the evaporated thorium being constantly replenished from within the filament wire, the operating temperature of the thoriated-tungsten must be kept within narrow limits. For maximum thoriated-tungsten filament efficiency and life, its operating voltage should not vary more than ±5% from rated filament voltage, and the total emission provided is about twice that required for any condition of operation. If a tube with such a filament has been overloaded, with resultant overheating, any gas liberated may contaminate the filament and reduce its emissivity. Prior to attempting electrical cleanup of the tube, it may be possible to restore the activity of the filament by operating it at 70% above normal operating voltage for five minutes and then at 20% overvoltage for 15 minutes without plate voltage. It may be necessary to vary somewhat and repeat this procedure to obtain the required activation. Electrical cleanup of the tube may then be attempted, with operation under class C conditions at one-half rated plate voltage for a half hour and further operation at increased plate voltage and input power until stability under normal operating conditions is assured.

It is desirable to maintain voltage on the filament when the tube is at standby conditions for periods not in excess of two hours. In the case of a pure-tungsten filament its voltage under standby conditions should be reduced to a value which is approximately 80% of rated voltage. A thoriated-tungsten filament of a tube under standby conditions must be maintained at its rated voltage.

In all cases of tube operation, the limit with respect to plate input depends upon the plate efficiency obtainable under the specific class and conditions of service and the maximum plate dissipation allowable with a certain rate of cooling water or air-flow. It is extremely important that adequate coolant be provided so as to preclude tube failure by anode melting and puncture or alloying of internal parts. There should be no operation of water-cooled tubes at plate dissipation levels which cause hissing sounds from within the water jacket. This may be caused by water boiling at the anode due to inadequate water-flow, or it may be the result of absorbed air being expelled from the water; the effect of such conditions will be localized heating and possible puncture of the anode. Although individual data sheets indicate rates of flow, water or forced-air, required for rated plate dissipation, limiting conditions are the maximum outgoing water temperature of 70°C and the maximum anode temperature of 230°C, for the water-cooled and forced-air-cooled types, respectively. Certain tube data sheets include charts of water-jacket or radiator characteristics, which indicate values of required coolant flow for values of actual plate dissipation.

In the case of a water-cooled tube, the approximate amount of heat, including that due to plate losses, filament power, and internal grid losses, being dissipated by the anode may be determined from

$$P = N \frac{(T_2 - T_1)}{4}$$

where P = dissipation in kilowatts
N = water-flow in gallons per minute
T_2 = outgoing water temperature in degrees C.
T_1 = input water temperature in degrees C.

In the development of new circuitry, plate voltage and input to the tube should be limited initially to one-half ratings until it is assured that correct adjustments have been made

and the tube and associated apparatus are without jeopardy with respect to temperature, voltages, etc. Plate voltage and input may then be increased gradually to normal values with further adjustments made to assure optimum conditions of operation.

ACCESSORIES

While extreme care may be exercised with respect to tube installation and operation, its service and life may be jeopardized by the use of improperly designed accessories. Terminal connectors which do not fit filament and grid posts exactly provide poor electrical contact and cause excessive terminal and seal heating. Connectors must also provide a relatively large outside surface area for the radiation of heat generated by r. f. currents. Machlett Laboratories provides for several types of broadcast and communication power tubes filament and grid connectors designed to insure maximum tube life and convenience of tube installation. These connectors not only make minimum I^2R loss connections to the electrodes but provide adequate finned cooling area to keep terminal and seal temperatures within reasonable limits. The connectors are furnished with silver-plated flexible copper straps for high electrical conductivity and stress-free connection to the tube. The grid connectors for tubes with two terminal posts are joined to a single strap by means of a jumper in such a manner that r.f. grid currents will be split evenly between the two terminals.

Water jackets which are of inferior design can also affect tube service and life. The required rate of water-flow and degree of turbulence at the surface of the anode may not be achieved in the case of inefficient water jackets; even though the outgoing water is within the temperature limit, boiling may occur at the surface of the anode with resultant hot spotting and possible puncture. Also, water jackets which require pressure sealed gaskets and screw thread clamps are subject to leakage and often make the installation or removal of tubes a very difficult and time consuming task. Machlett water jackets, which are available for several tube types, are of an improved design incorporating an O-ring gasket for the water seal and a snap ring to lock the tube flange in place. The special circular cross-section gasket makes a tight positive seal contact with the tube flange and cylindrical wall of the water jacket as a result of hydrostatic pressure caused by water-flow through the jacket. Certain Machlett water jackets include a helical guide to increase turbulence and cooling efficiency, thereby permitting an appreciable decrease in the required water-flow. Tube installation in a Machlett water jacket is the simple procedure of inserting the tube and rotating the lock ring 15 degrees counter-clockwise. For tube removal the reverse procedure is followed. No tools of any kind are necessary for the installation or removal of a tube.

The accessories discussed in the foregoing are designed to assist the user in obtaining maximum tube reliability, service, and life. Other accessories, such as water jacket mounting plates and clamps, standoff insulators and clamps, which may in special cases be required for the installation of certain heavy-walled anode tubes, are also available. These and others to be developed, as required, are representative of the Machlett policy of assisting equipment manufacturers and tube users in obtaining suitable accessories for the most practical installation and optimum operation of radio transmitting tubes.

Although in a short discussion of so general a nature as the foregoing and in the technical information set forth in individual data sheets one can not anticipate and answer all problems in connection with tube application, an effort has been made to present all the information and data necessary to the satisfactory and economical operation of power tubes in broadcasting and communication equipment. For information in connection with specific tube problems or applications, consult the Machlett Engineering Department.

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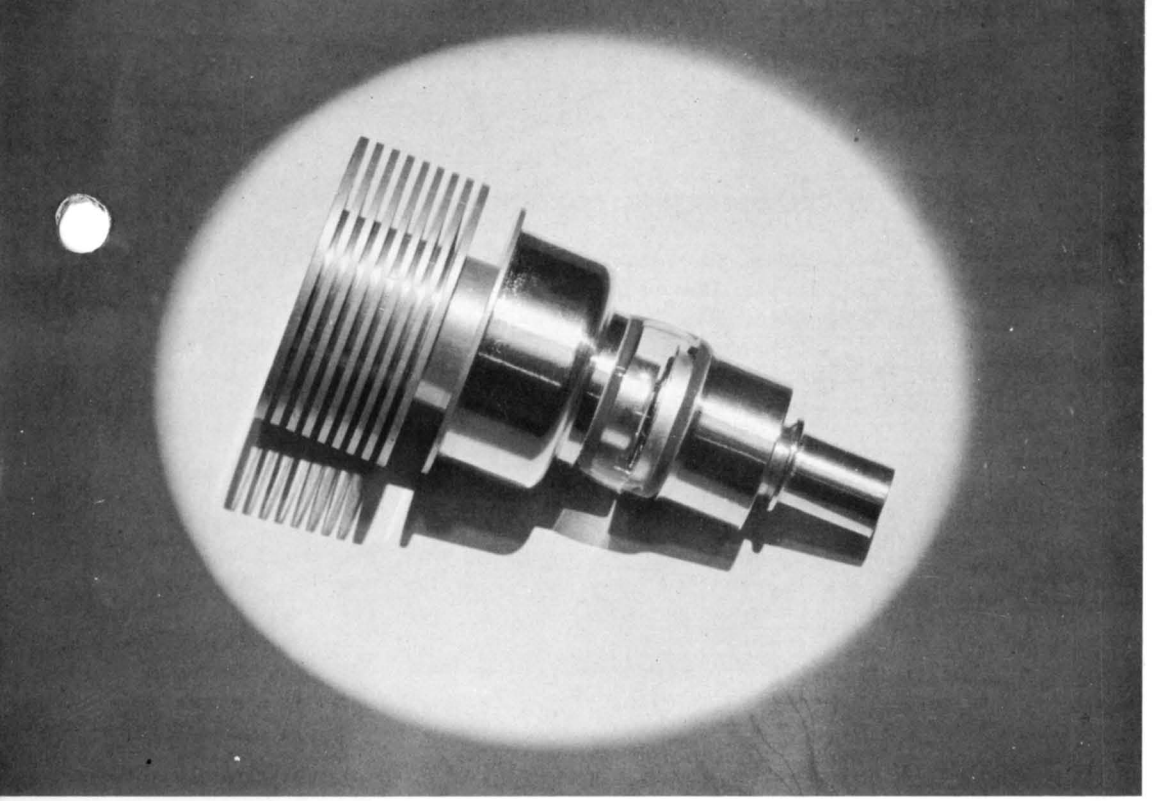


MACHLETT

ML-2C39A

DESCRIPTION & RATINGS

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 (see Application Notes)	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.

* For maximum plate dissipation of 100 watts, required air flow is 12.5 cubic feet per minute through radiator with cowling described on page 5. This air flow is specified for air at 25°C and at a pressure of 14.7 lb/in^2. Cooling must be sufficient to limit anode seal temperatures to 175°C. Cavity should be ventilated and an air flow provided to limit grid-seal and cathode-seal temperatures to 175°C maximum (see Application Notes).

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

‡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.

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.

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.

Cooling

The maximum temperature of plate, grid and cathode seals under any operating conditions is 175°C. In most applications, forced-air cooling of all three seals is required. Improved tube life usually results if all seals are cooled well below the maximum limit. The cathode and heater seals are ordinarily well enclosed in coaxial circuits and require careful attention for proper cooling. Tempilaq* paint is suggested for making temperature measurements.

*Product of Tempil Corporation, New York, N. Y.

ELECTRICAL

Heater Voltage

V.H.F. and U.H.F. tubes operate at frequencies where the transit time (i.e. the time for an electron to traverse the space between grid and cathode) is not necessarily small compared with the period of oscillation. Under such conditions, electron bombardment of the cathode occurs due to returned out of phase electrons and the cathode temperature may be raised excessively. The "back heating" is a function of frequency, grid current, grid bias and circuit design. The optimum heater voltage cannot be accurately specified because of the dependence on circuitry. For most applications where liberal seal cooling is provided, the following chart of heater voltages vs. frequency should be satisfactory.

Frequency	Ef
Up to 300 Mc	6.3 volts
300 to 1000 Mc	6.0 volts
1000 to 1500 Mc	5.5 volts
1500 to 2000 Mc	5.0 volts
2000 and over	4.5 volts

Permitted tolerances on filament voltage are ± 10% of the values given above. For long tube life, however, a maximum variation in filament voltage of ± 5% is advised. If such improved regulation is provided, Ef can advantageously be lowered 5% below the values given in the table. For circuits requiring maximum grid bias, longer life may be achieved with lower filament ratings even at frequencies below 300 Mc. In cases where unusual conditions present difficulties, it is suggested that the Machlett Engineering Department be consulted.

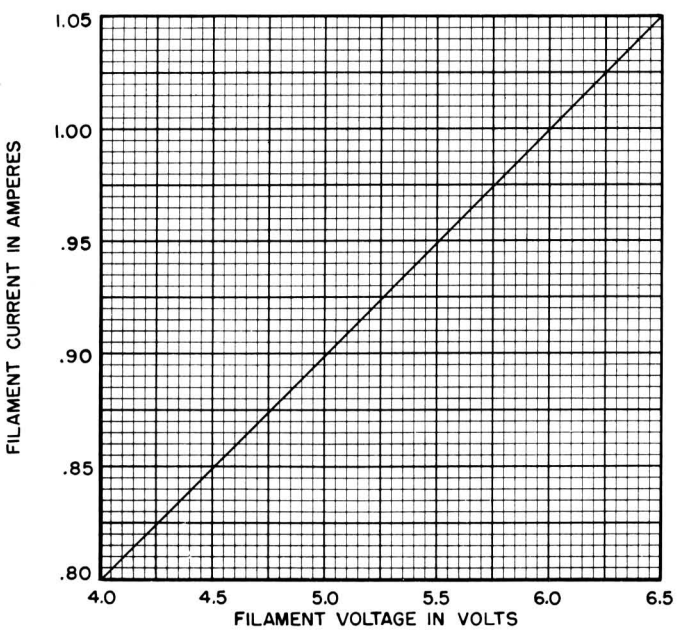


Plate Surge-Limiting Impedance

In tubes such as the ML-2C39A 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 which limits the peak current under surge conditions to 15 amperes or less is recommended. 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

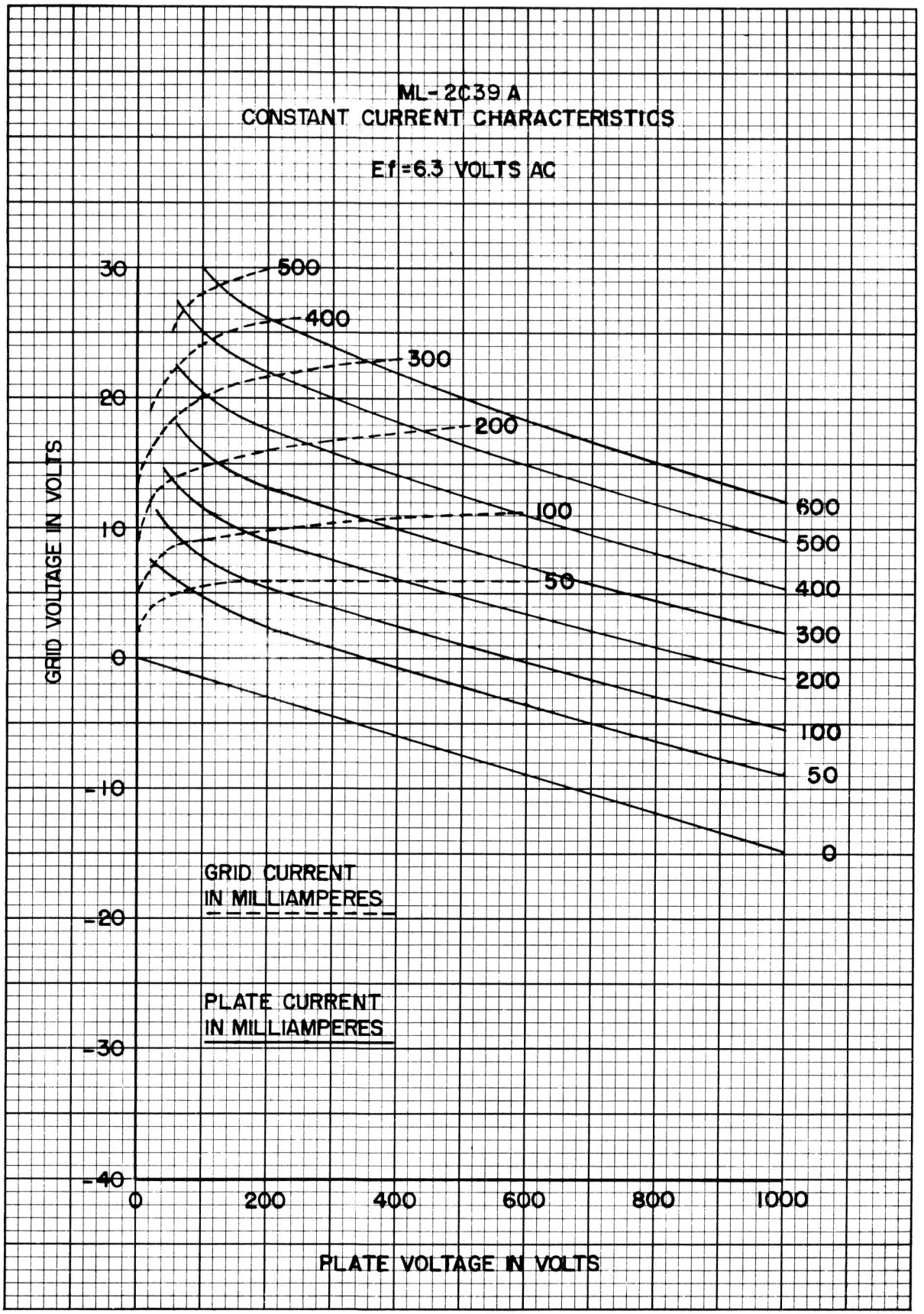
With high-frequency circuits a very small motion of a tuning plunger may throw the tube out of resonance and result in high plate current and/or excessive anode dissipation. It is recommended that provision be made for tuneup at reduced plate voltages in any circuit where the above conditions obtain.

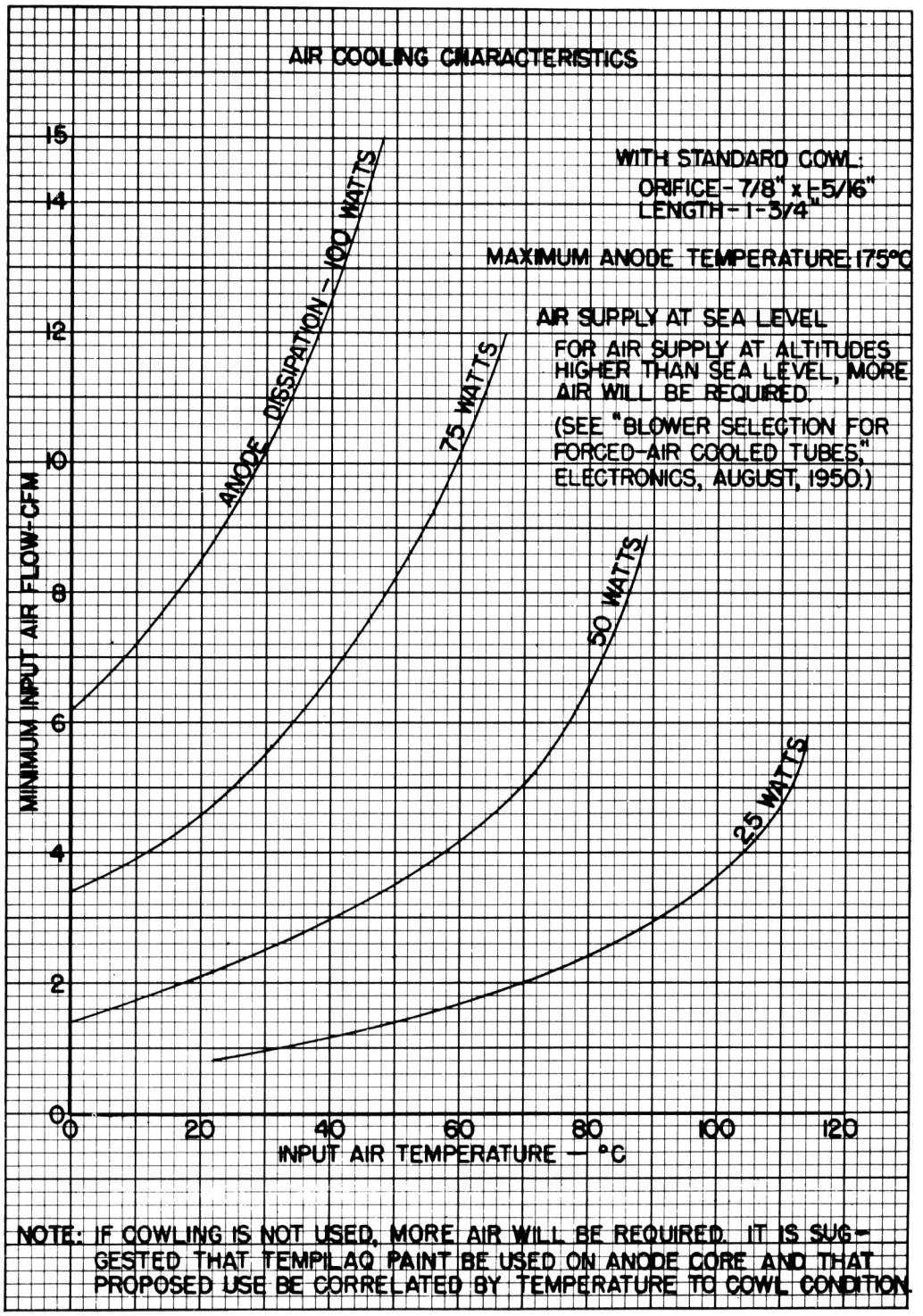
Self Biasing Operation

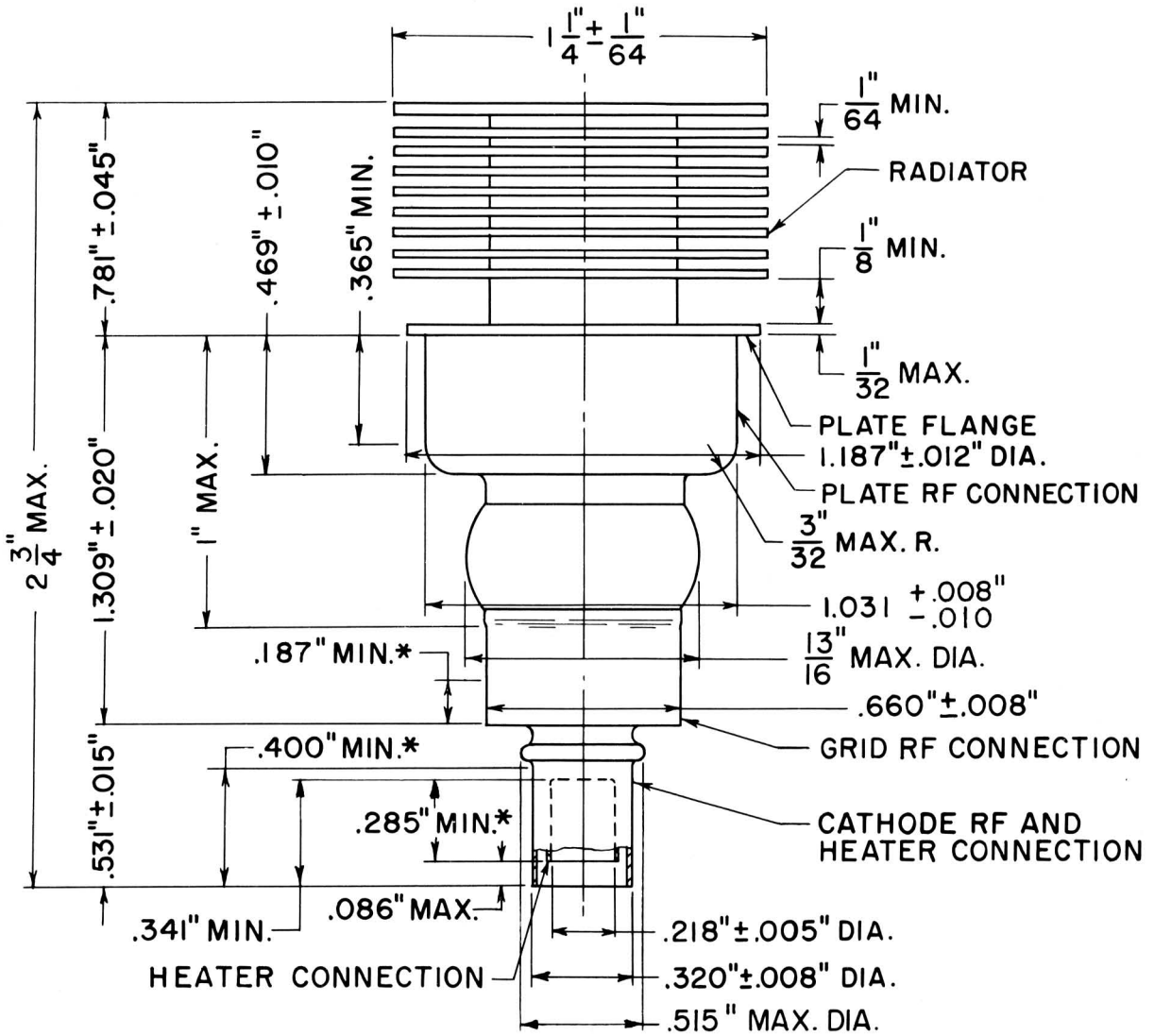
In general, an RC bias should be in the cathode circuit such that with normal d.c. plate voltage and no grid drive the plate current does not exceed 125 mA, i.e. the maximum rated cathode current. Both cathode and grid resistance biasing may be used. If grid resistor biasing is used, special care must be taken to protect the tube against loss of excitation; otherwise excessive plate currents may damage the cathode.

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. For normal operation the average grid current should not exceed 30% of the average plate current. The tube should never be operated without a suitable plate load.


ML-2C39A
CONSTANT CURRENT CHARACTERISTICS
Ef=6.3 VOLTS AC
GRID VOLTAGE IN VOLTS
30
20
10
0
-10
-20
-30
-40
500
400
300
200
100
50
600
500
400
300
200
100
50
0
GRID CURRENT
IN MILLIAMPERES
PLATE CURRENT
IN MILLIAMPERES
0
200
400
600
800
1000
PLATE VOLTAGE IN VOLTS


AIR COOLING CHARACTERISTICS
WITH STANDARD COWL:
ORIFICE - 7/8" x 1-5/16"
LENGTH - 1-3/4"
MAXIMUM ANODE TEMPERATURE: 175°C
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.)
ANODE DISSIPATION - 100 WATTS
75 WATTS
50 WATTS
25 WATTS
MINIMUM INPUT AIR FLOW-CFM
0
2
4
6
8
10
12
14
15
0
20
40
60
80
100
120
INPUT AIR TEMPERATURE — °C
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.



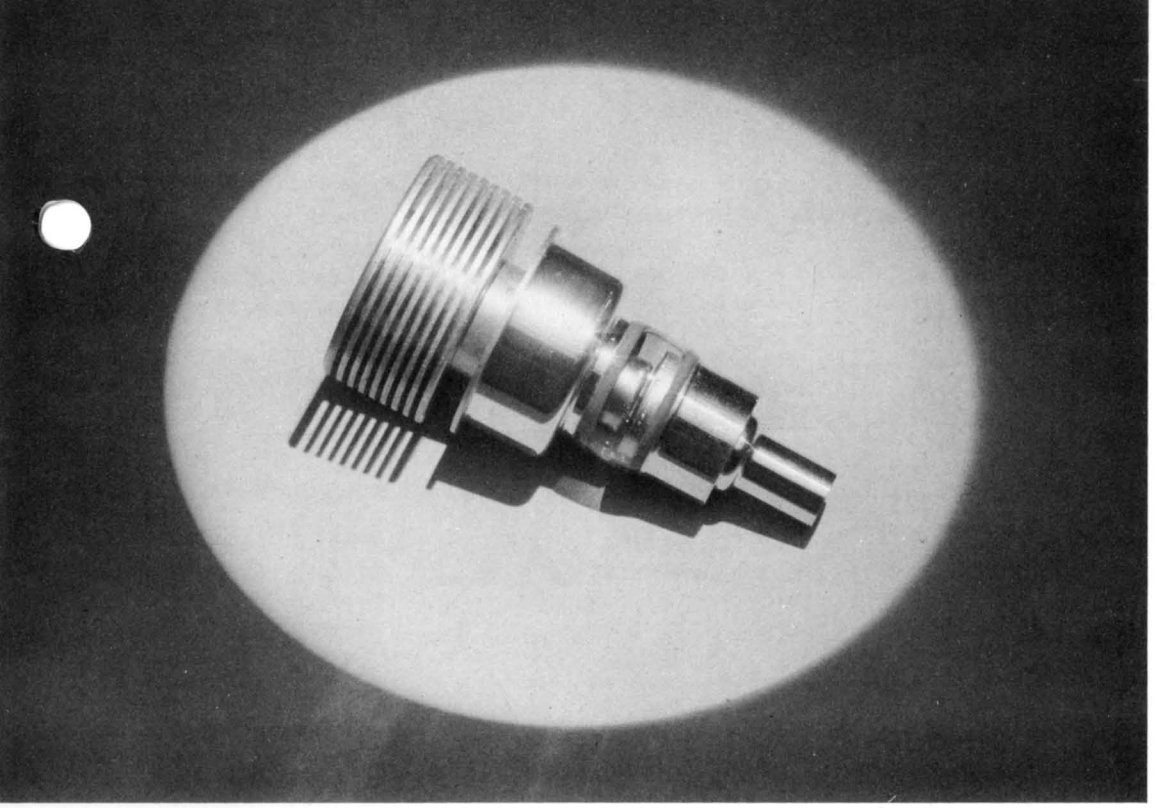
*Represents maximum straight portion available for contact area.

DIMENSIONS— ML-2C39A

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT **CONNECTICUT**

U. S. A.



MACHLETT

ML-2C39WA

DESCRIPTION & RATINGS

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 (see Application Notes)	5.8	Volts ±5%
Heater Current at 5.8 Volts	1.0	Amps
Heater Heating Time, minimum	60	secs
Amplification Factor	100	
Transconductance (I_b = 70 mA, E_b = 600 v)	22,000	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.

* For maximum plate dissipation of 100 watts, required air flow is 12.5 cubic feet per minute through radiator with cowling described on page 5. This air flow is specified for air at 25°C and at a pressure of 14.7 lb/in². Cooling must be sufficient to limit anode seal temperatures to 175°C. Cavity should be ventilated and an air flow provided to limit grid-seal and cathode-seal temperatures to 175°C maximum (see Application Notes).

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 2C39WA 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

‡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.

Characteristic Range Values for Equipment Design

	Min.	Max.	
Filament Current at 5.8 volts (Note 1)	0.87	1.03	A
Plate Current (Note 2)	60	95	mAdc
Cut-off bias (Note 3)	——	-15	volts
Transconductance	18000	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)	1980	2020	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.

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.

Cooling

The maximum temperature of plate, grid and cathode seals under any operating conditions is 175°C. In most applications, forced-air cooling of all three seals is required. Improved tube life usually results if all seals are cooled well below the maximum limit. The cathode and heater seals are ordinarily well enclosed in coaxial circuits and require careful attention for proper cooling. Tempilaq* paint is suggested for making temperature measurements.

*Product of Tempil Corporation, New York, N. Y.

ELECTRICAL

Heater Voltage

V.H.F. and U.H.F. tubes operate at frequencies where the transit time (i.e. the time for an electron to traverse the space between grid and cathode) is not necessarily small compared with the period of oscillation. Under such conditions, electron bombardment of the cathode occurs due to returned out of phase electrons and the cathode temperature may be raised excessively. The "back heating" is a function of frequency, grid current, grid bias and circuit design. The optimum heater voltage cannot be accurately specified because of the dependence on circuitry. For most applications where liberal seal cooling is provided, the following chart of heater voltages vs. frequency should be satisfactory.

Frequency	Ef
Up to 1000 Mc	5.8 volts
1000 to 2000 Mc	5.4 volts
2000 and over	5.2 volts

Permitted tolerances on filament voltage are ± 5% of the values given above. When variations of ± 10% are necessary, the filament voltage should be increased 0.2 volts over the values specified above. However, operation at this increased voltage will result in a reduced filament life expectancy of approximately 50%. For circuits requiring maximum grid bias, longer life may be achieved with lower filament ratings even at frequencies below 300 Mc. In cases where unusual conditions present difficulties, it is suggested that the Machlett Engineering Department be consulted.

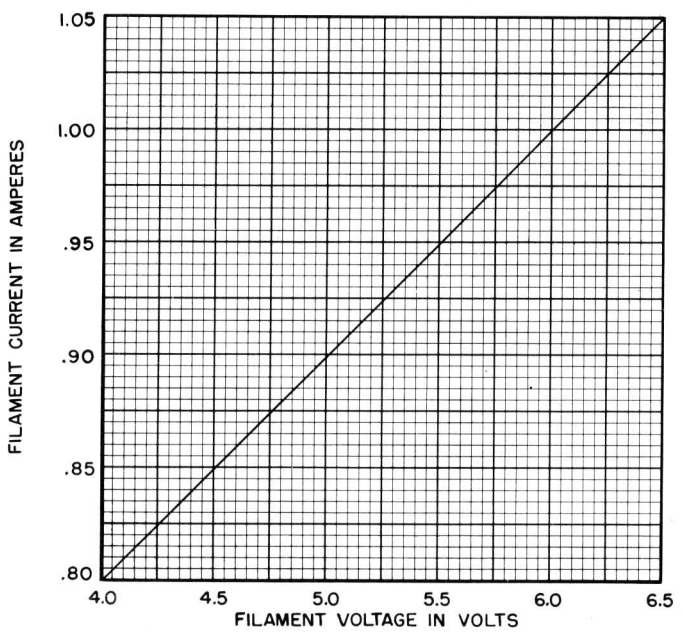


Plate Surge-Limiting Impedance

In tubes such as the ML-2C39WA 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 which limits the peak current under surge conditions to 15 amperes or less is recommended. 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

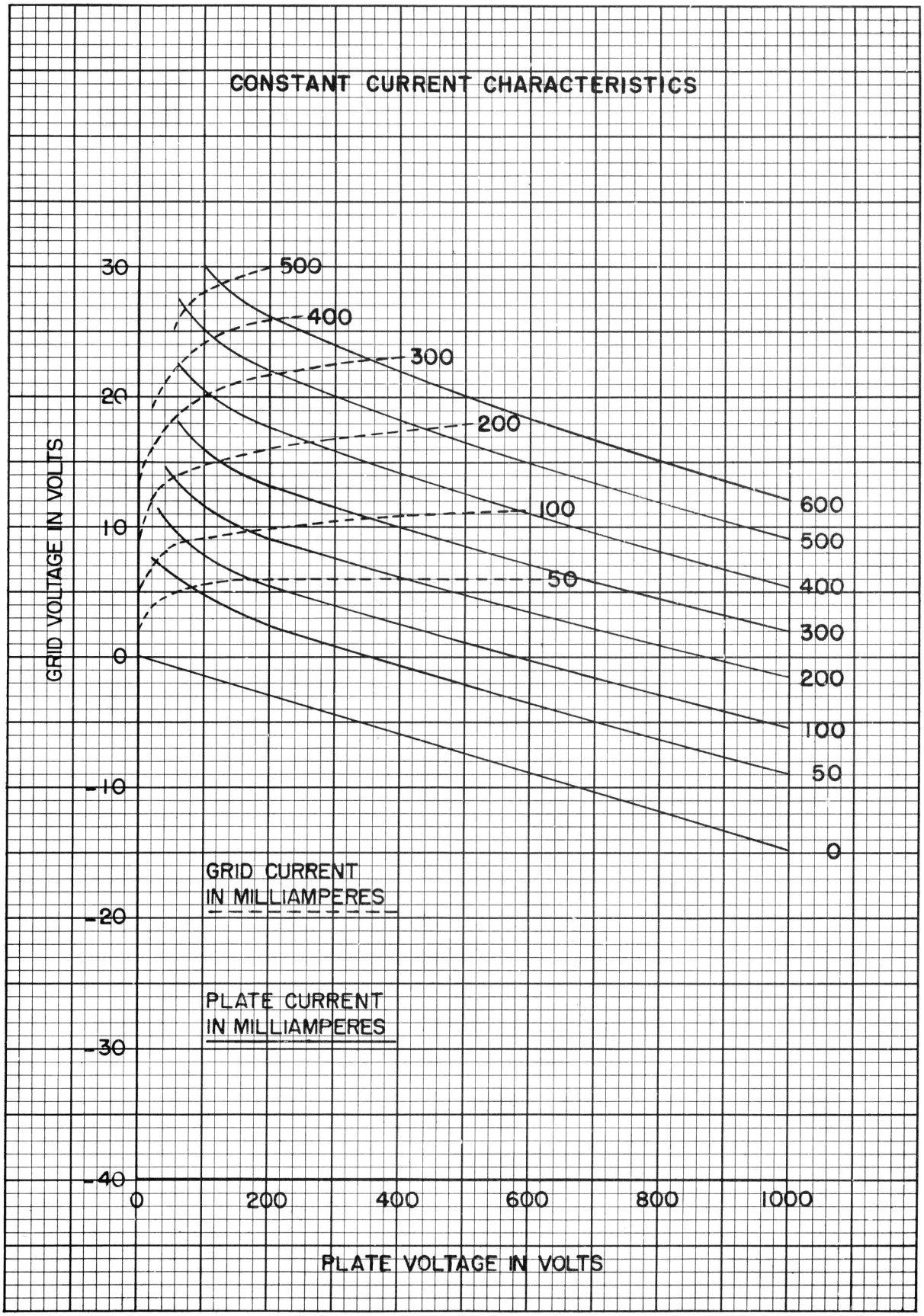
With high-frequency circuits a very small motion of a tuning plunger may throw the tube out of resonance and result in high plate current and/or excessive anode dissipation. It is recommended that provision be made for tuneup at reduced plate voltages in any circuit where the above conditions obtain.

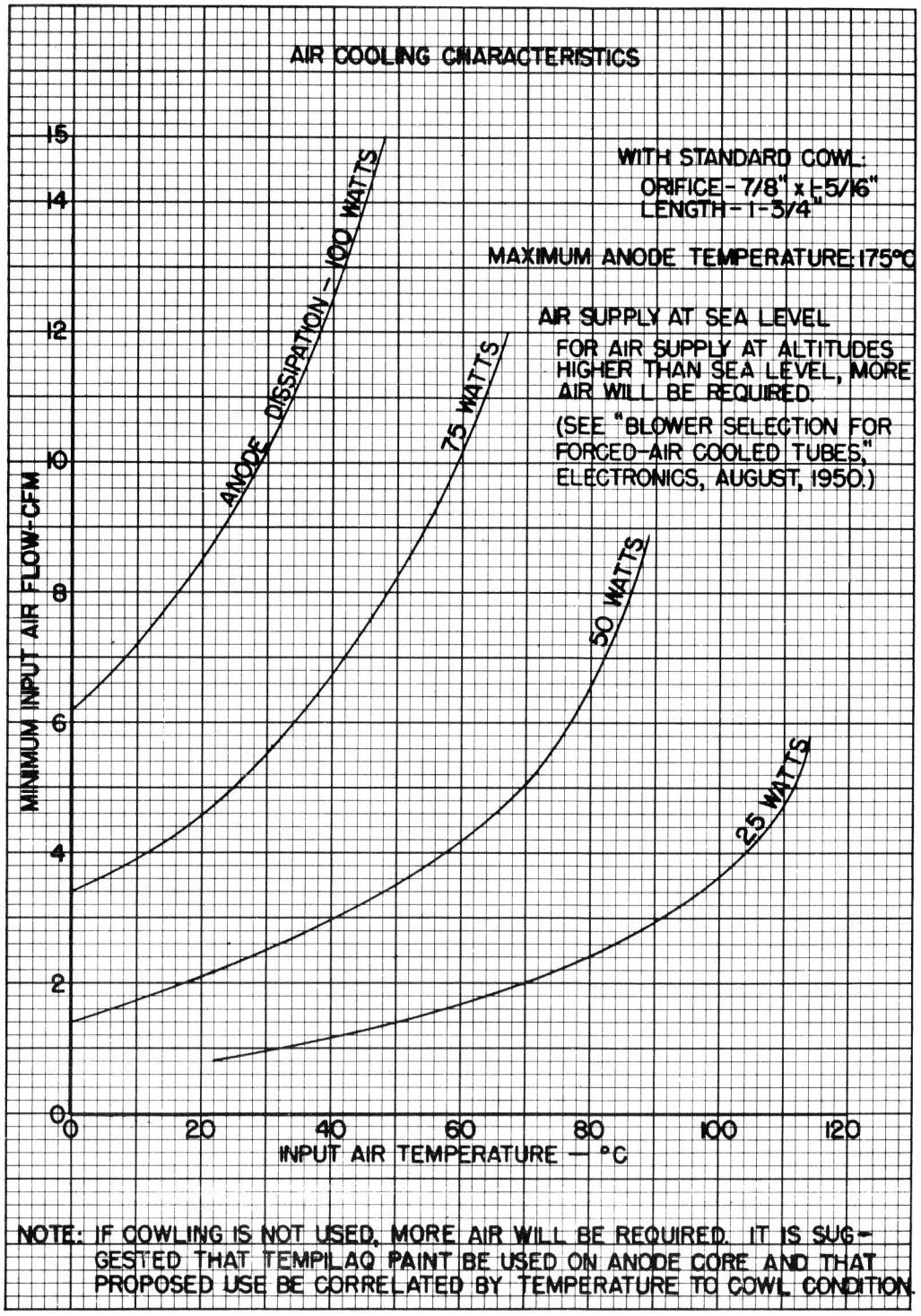
Self Biasing Operation

In general, 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 125 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.

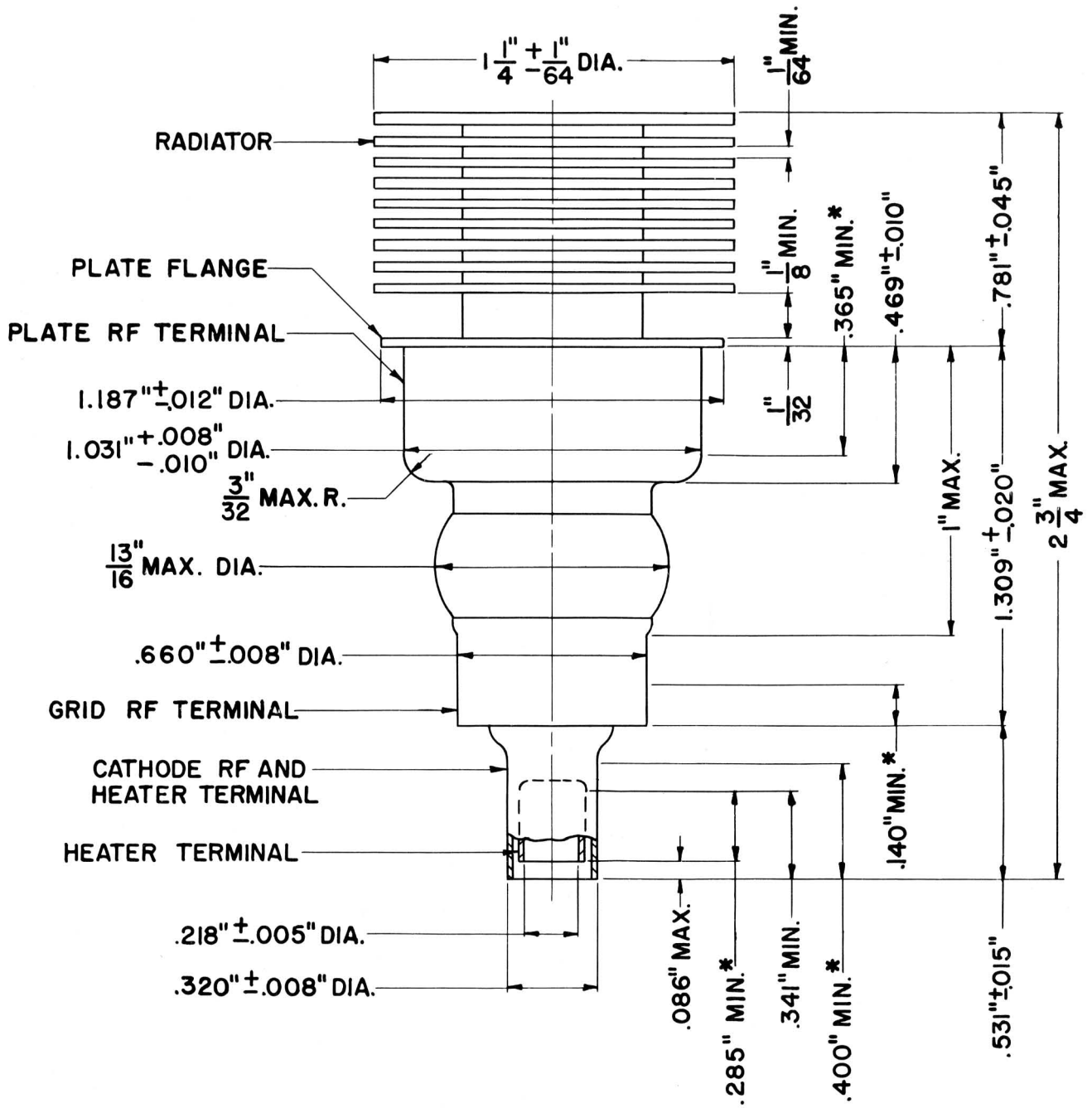
Determination of Proper Grid Drive

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. For normal operation the average grid current should not exceed 30% of the average plate current. The tube should never be operated without a suitable plate load.


CONSTANT CURRENT CHARACTERISTICS
GRID VOLTAGE IN VOLTS
30
20
10
0
-10
-20
-30
-40
500
400
300
200
100
50
600
500
400
300
200
100
50
0
GRID CURRENT
IN MILLIAMPERES
PLATE CURRENT
IN MILLIAMPERES
0
200
400
600
800
1000
PLATE VOLTAGE IN VOLTS



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.



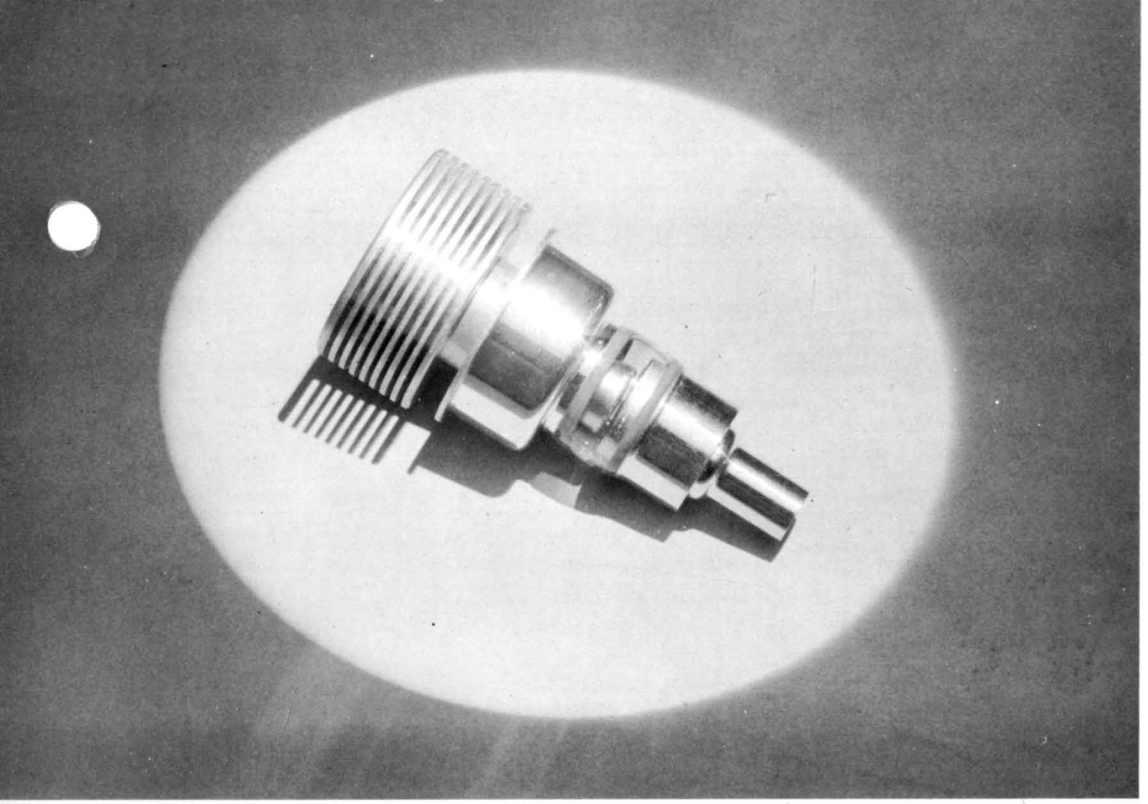
*Represents maximum straight portion available for contact area.

DIMENSIONS — ML-2C39WA

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.



MACHLETT

ML-2C41

DESCRIPTION & RATINGS

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 (See Application Notes)	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.

*For cooling requirements, refer to "Cooling" under "Application Notes".

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

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.

APPLICATION NOTES

MECHANICAL

Mounting

Contact 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 and tolerances specified on the tube outline drawing. The tube when in the socket should seat against the anode flange. The tube should not be seated or stopped by any other surfaces.

Cooling

Sufficient air cooling must be provided to maintain the maximum temperature of the grid, cathode and anode seals and the anode radiator shank at 175°C or less. In most cases, forced-air cooling of all three electrode surfaces is required. The following chart shows air flow in cfm at sea level versus input air temperature in °C for several values of plate dissipation. These data indicate the minimum air-flow requirements and cowl dimensions necessary to maintain the radiator temperature at or below 175°C. Improved tube life may be obtained if all seals are cooled well below the maximum limit of 175°C and by lowering the anode radiator shank temperature by providing more than the minimum air flow indicated on this chart. The cathode and heater seals are ordinarily well enclosed in coaxial circuits and require careful attention to insure proper cooling. Tempilaq* paint is suggested for making temperature measurements.

*Product of Tempil Corporation, New York, N. Y.

ELECTRICAL

Heater Voltage

V.H.F. and U.H.F. tubes operate at frequencies where the transit time (i.e. the time for an electron to traverse the space between grid and cathode) is not small compared with the period of oscillation. Under such conditions, electron bombardment of the cathode occurs due to returned out of phase electrons and the cathode temperature may be raised excessively. The "back heating" is a function of frequency, peak r-f grid voltage, grid current, grid bias and circuit design. The optimum heater voltage cannot be accurately specified because of the dependence on circuitry. For most applications where liberal seal cooling is provided, the following table of heater voltage vs. frequency should be satisfactory. For Service applications, we suggest that recommendations be obtained through the Service Laboratories regarding the heater voltage to be used.

Frequency	Ef
Up to 400 Mc	6.3 volts
400 to 1000 Mc	6.1 volts
1000 and over	5.8 volts

Permitted tolerances on filament voltage are + 5% and — 10% of the values given above. For long tube life, however, a maximum variation in filament voltage of ± 5% is advised. If such improved regulation is provided, Ef can advantageously be lowered 5% below the values given in the table.

Plate Surge-Limiting Impedance

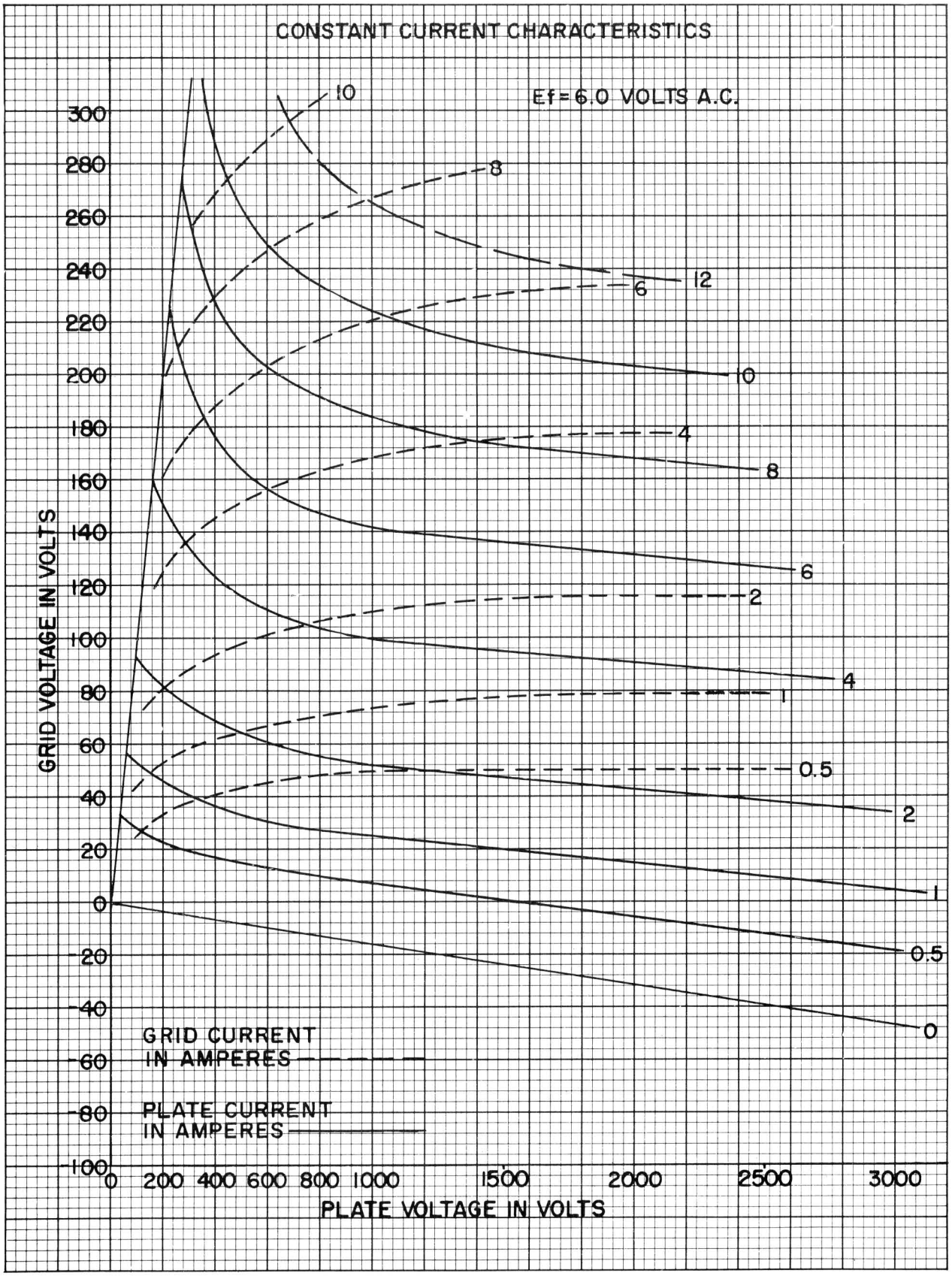
In tubes such as the **ML-2C41**, which have very closely spaced electrodes, extremely high voltage gradients occur even with moderate tube operating voltages. Any tube flash-arcing may be destructive. A series impedance in the B+ lead is recommended to limit the peak current under surge conditions to 10 times maximum rating or less. 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 cathode heater winding, and may cause shorting of the heater element unless current limiting is provided. Failure of tubes due to internal flash-arcs are 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.

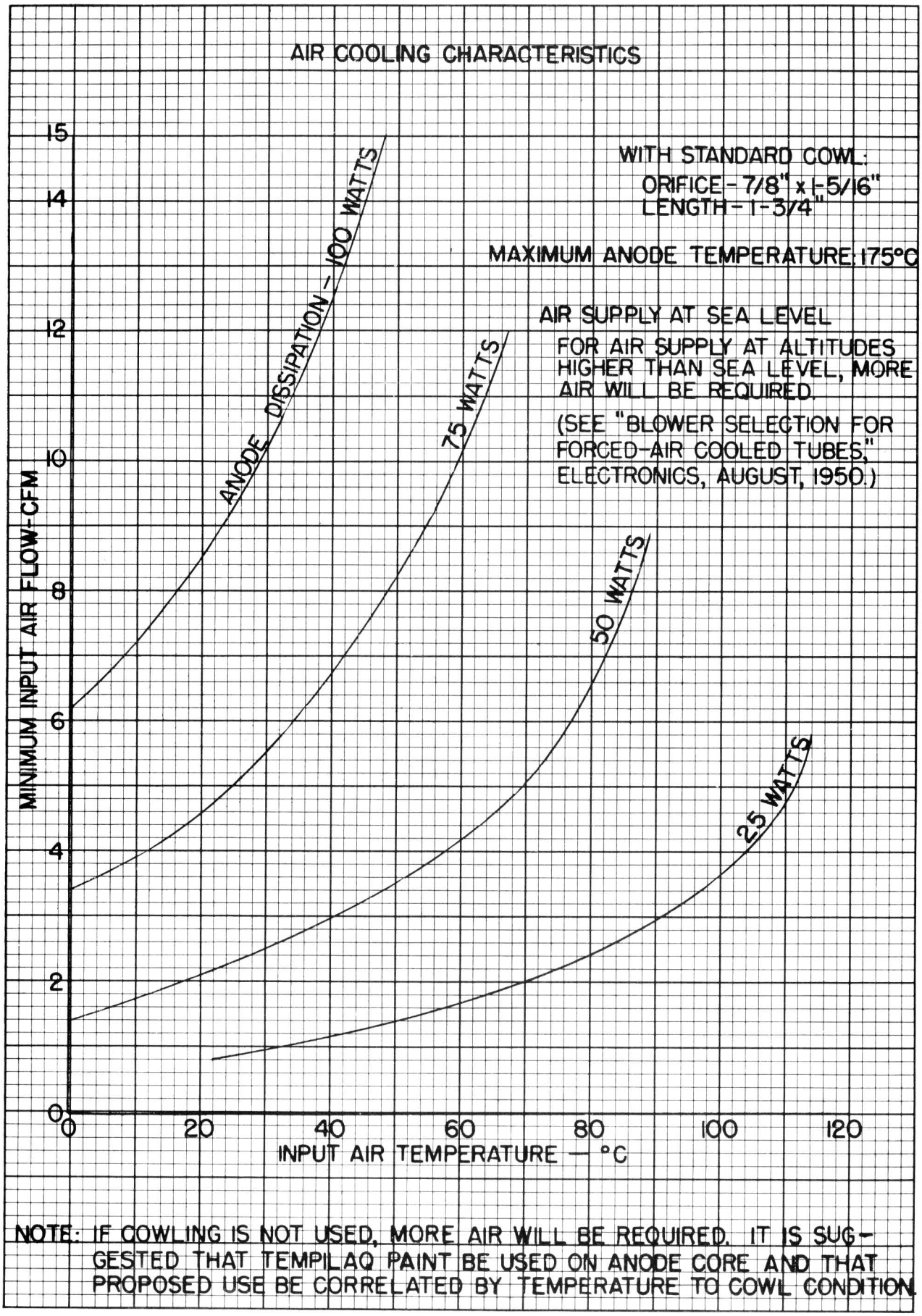
Provision for Circuit Tuning

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. It is required that provision be made for tuneup at a plate voltage which is approximately 70% of normal, i.e. half power.

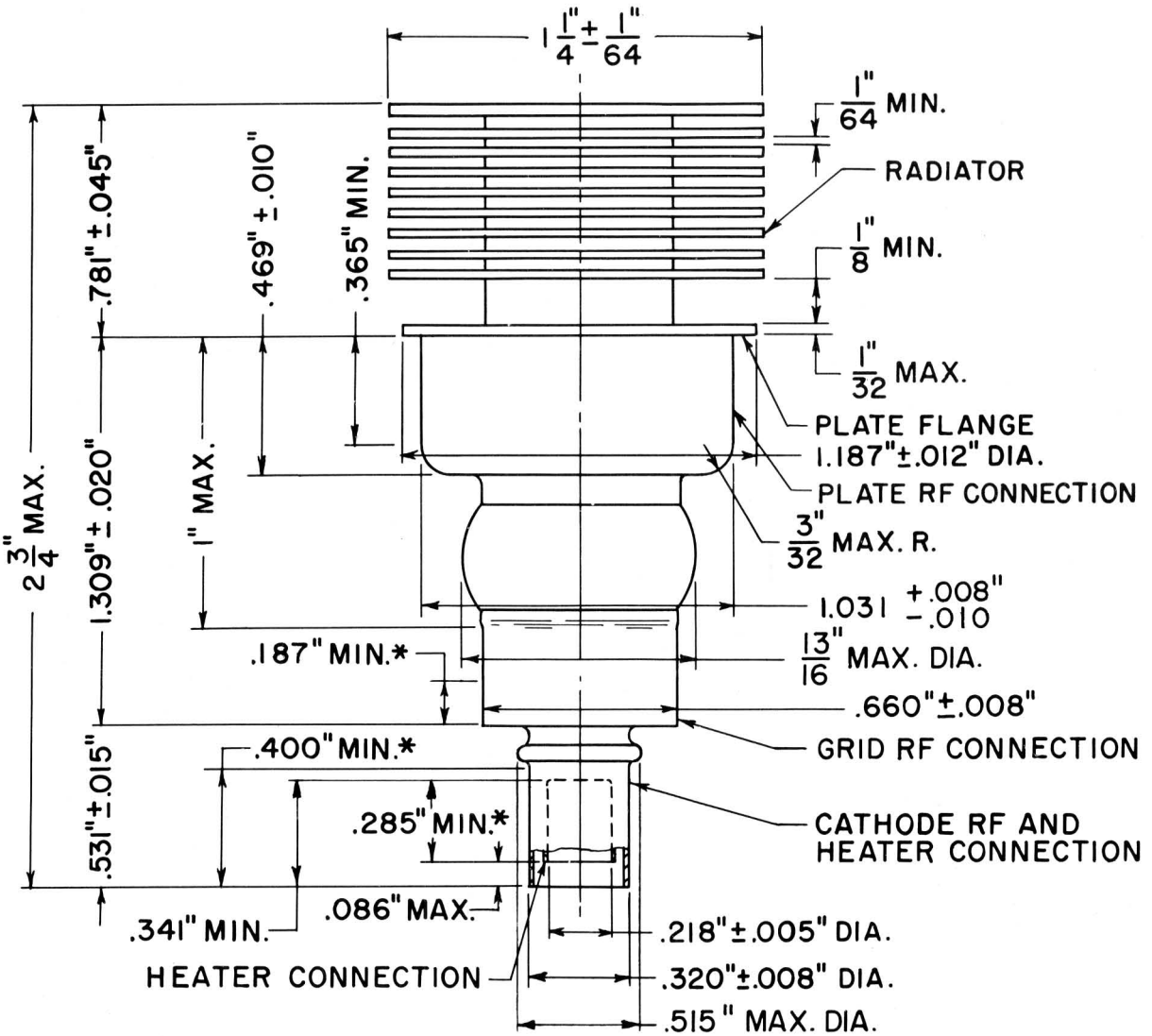
Determination of Proper Grid Drive

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 shorter tube life.


CONSTANT CURRENT CHARACTERISTICS
Ef = 6.0 VOLTS A.C.
GRID VOLTAGE IN 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
4
8
6
2
4
1
0.5
2
1
0.5
0
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
0
200
400
600
800
1000
1500
2000
2500
3000
PLATE VOLTAGE IN VOLTS



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.



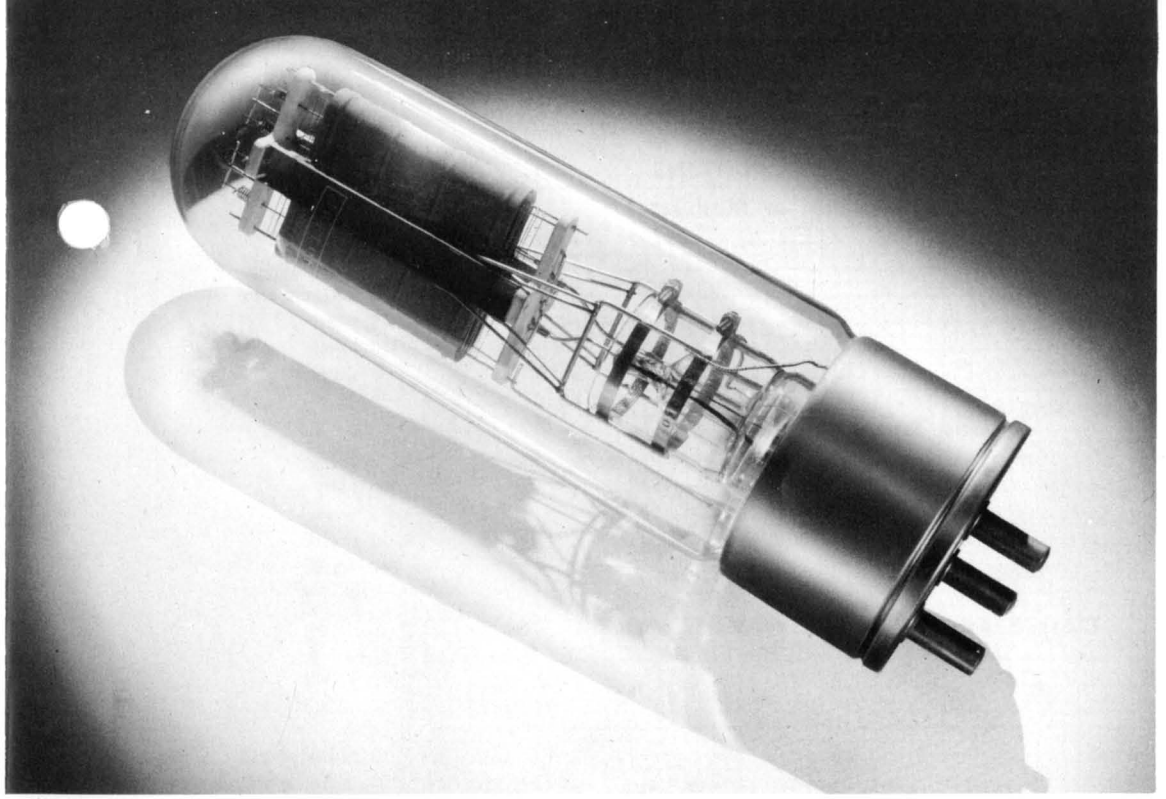
*Represents maximum straight portion available for contact area.

DIMENSIONS—ML-2C41

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

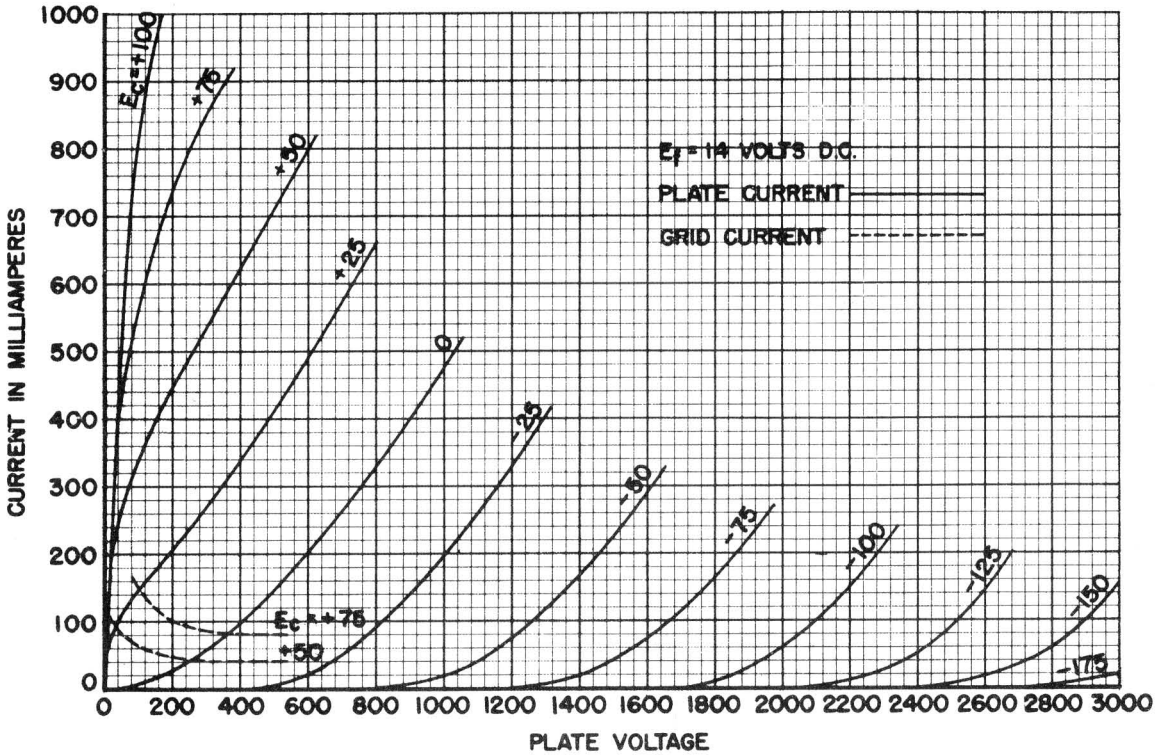
APPLICATION NOTES

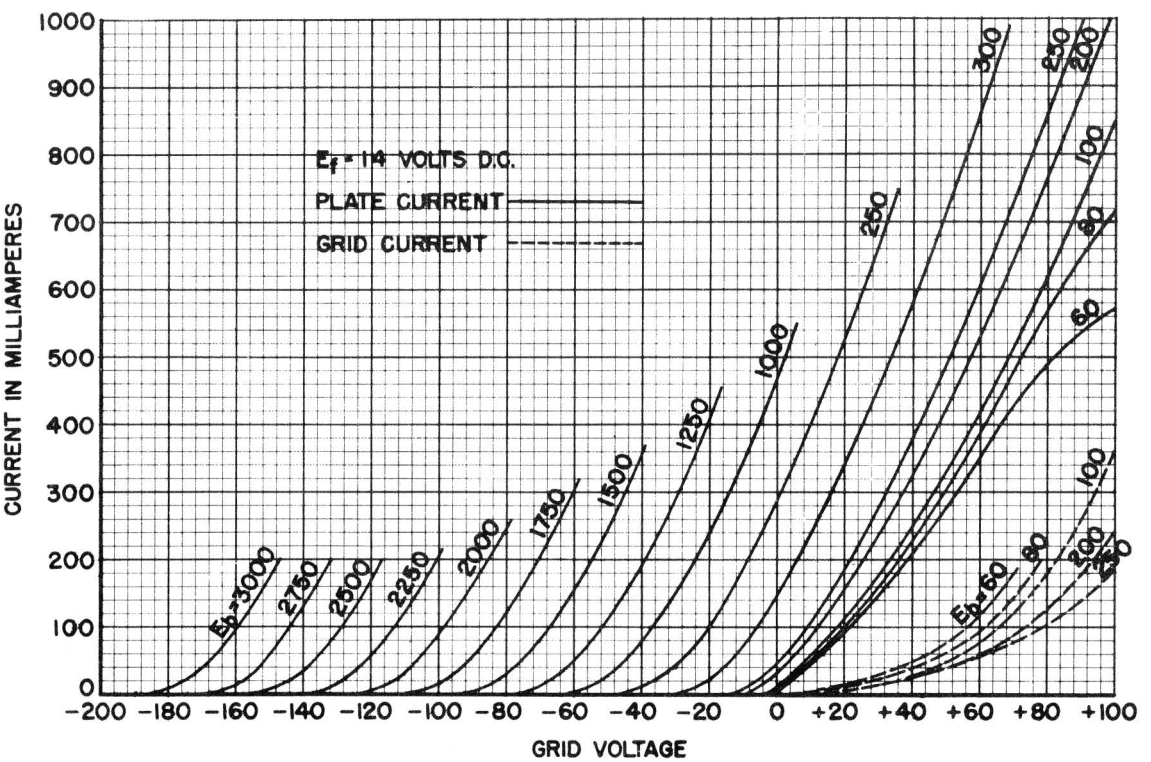
Maximum ratings apply at frequencies of 1.5 megacycles and less. The maximum plate voltage for the upper frequency limit of 4.5 megacycles is 1000 volts. The maximum plate voltage for frequencies between 1.5 and 4.5 megacycles should be proportionately reduced.

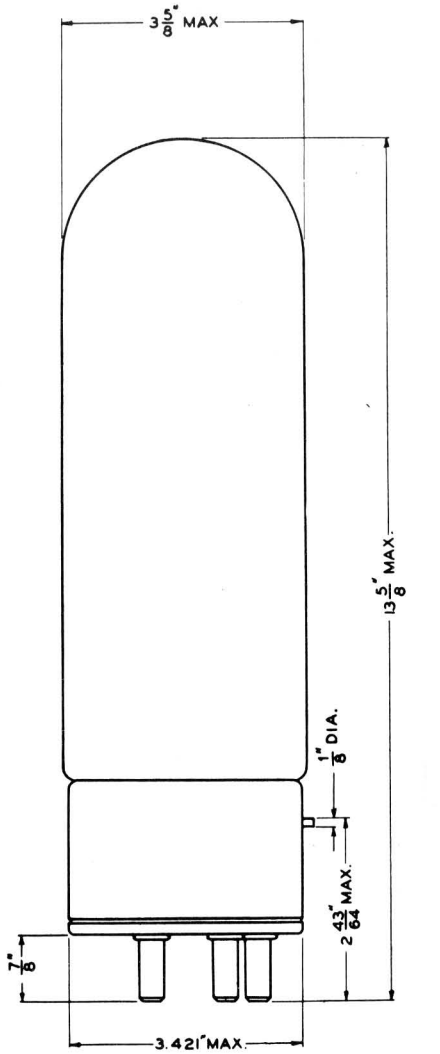
Each **ML-212E** vacuum tube falls within one of four impedance classes and is stamped accordingly. These classifications are #1, #2, #3 and #4, and are in no way a gradation of quality, but are to facilitate parallel operation in the ordinary system using a common grid battery. Where more than one tube 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.

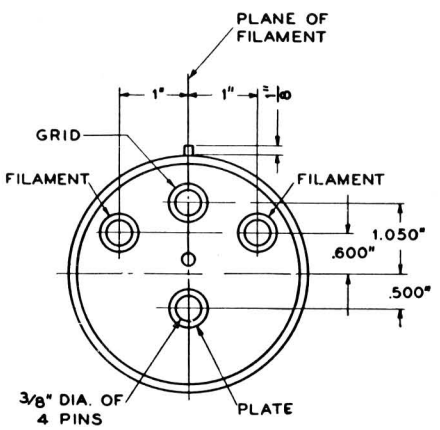
With a plate voltage of 1500 volts, a grid bias of −60 volts and a filament voltage of 14, the plate current will be as follows for each impedance class:

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


CURRENT IN MILLIAMPERES
PLATE VOLTAGE
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
0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000
0 100 200 300 400 500 600 700 800 900 1000


CURRENT IN MILLIAMPERES
GRID VOLTAGE
Ef = 14 VOLTS D.C.
PLATE CURRENT
GRID CURRENT
Eb=3000
2750
2500
2250
2000
1750
1500
1250
1000
250
300
250
200
100
80
60
Eb=50
80
100
200
250
-200 -180 -160 -140 -120 -100 -80 -60 -40 -20 0 +20 +40 +60 +80 +100
0 100 200 300 400 500 600 700 800 900 1000





DIMENSIONS—ML-212E

MACHLETT LABORATORIES, INC.

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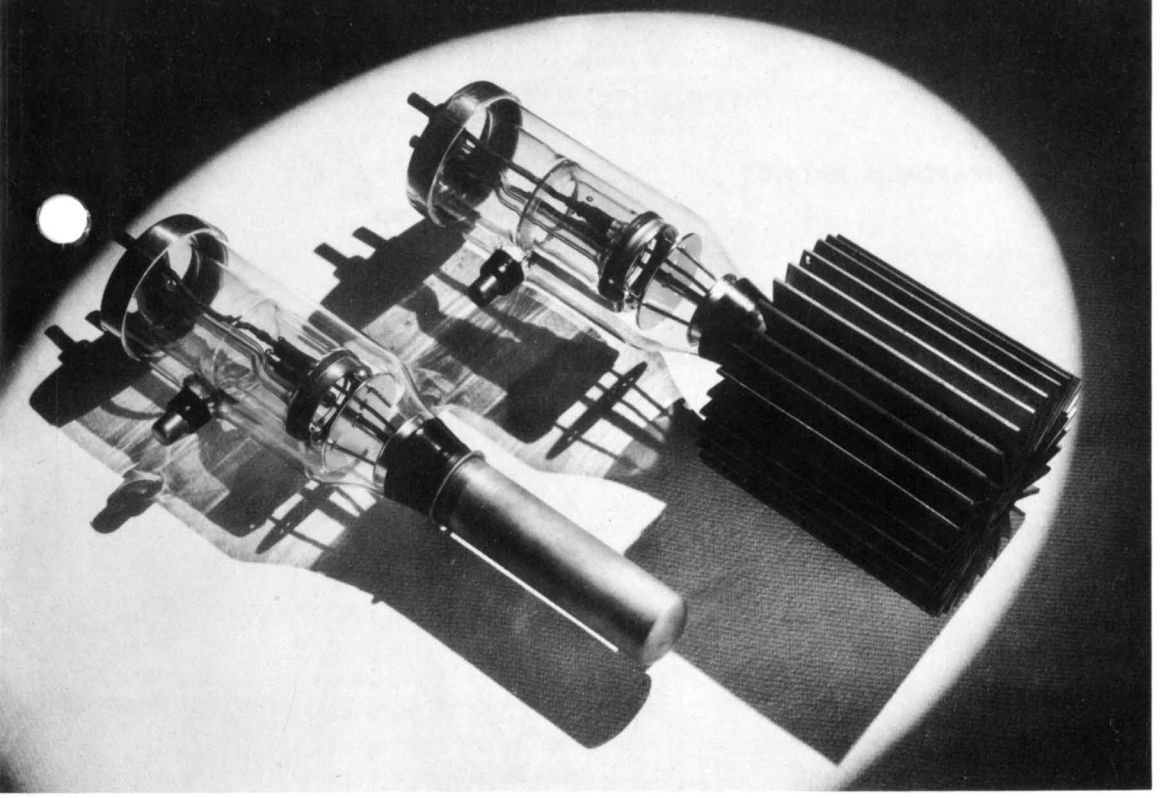


MACHLETT

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
Filament Cold Resistance	65	amperes
Filament Starting Current	.0433	ohms
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)	3	—	gpm
Maximum Water Pressure	—	80	psi
Maximum Outgoing Water Temperature	75	—	°C
Required Air Flow on Anode	—	600	cfm
Maximum Anode Temperature	—	120	°C

MAXIMUM RATINGS

	ML-220C	ML-220CA	
Direct Plate Voltage	15000	15000	volts
Direct Plate Current	1.5	1.5	amperes
Plate Dissipation	10000	5000	watts
Direct Grid Dissipation	200	200	watts
R.F. Grid Current	20	20	amperes
Frequency	4	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 A Audio Amplifier or Modulator

Direct Plate Voltage	12500	10000	volts
Grid Bias	−150	−130	volts
Direct Plate Current	0.40	0.25	ampere
Plate Dissipation	5000	2500	watts
Load Impedance	28000	35000	ohms
Undistorted Output	760	460	watts

Class-B Audio Amplifier or Modulator

(for balanced 2 tube circuit)

Direct Plate Voltage	10000	7500	volts
Grid Bias	−150	−100	volts
Direct Plate Current Per Tube			
No drive	0.20	0.15	ampere
Maximum drive	1.1	1.1	amperes
Load resistance, plate-to-plate	9200	6000	ohms
Load resistance, per tube	2300	1500	ohms
Approximate maximum output—2 tubes	14000	9000	watts
Recommended power for driving stage	1500	1500	watts

Class B Radio-Frequency Amplifier

Direct Plate Voltage	11000	7500	volts
Direct Plate Current for Carrier Conditions	0.75	1.0	ampere
Grid Bias	−250	−150	volts
Approximate carrier watts for use with 100% modulation	2750	2500	watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct Plate Voltage	10000	7500	volts
Direct Plate Current	1.5	1.0	amperes
Grid Bias	−375 to −500	−175 to −300	volts
Nominal Power Output	10000	5000	volts
Plate Dissipation	5000	2500	watts

Class C Radio-Frequency Amplifier—Plate Modulated

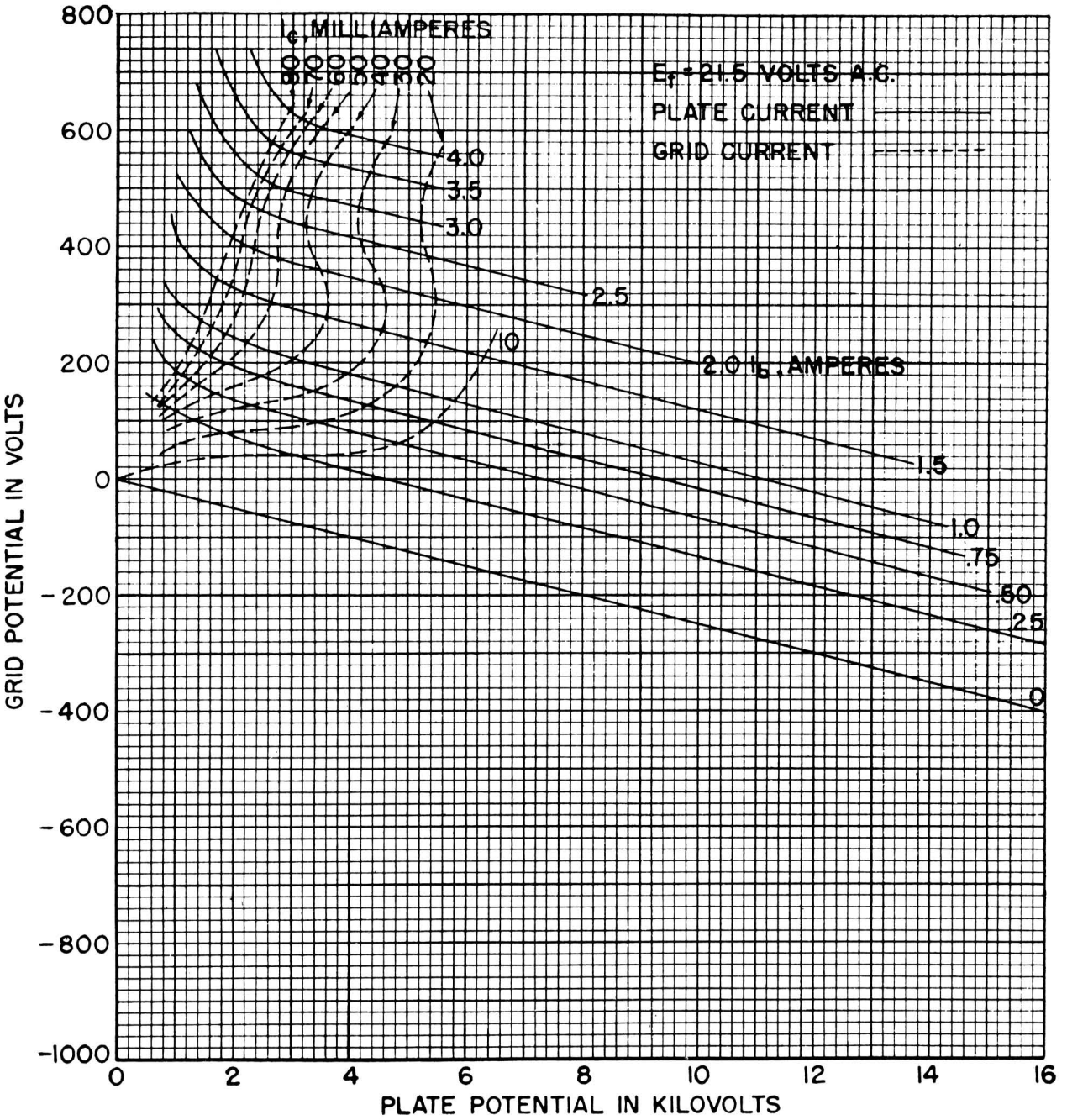
Direct Plate Voltage	7500	5000	volts
Direct Plate Current	1.1	1.1	amperes
Grid Bias	−300	−200	volts
Maximum Direct Grid Current	150	150	milliamperes
Nominal Carrier Power Output	5500	3650	watts

APPLICATION NOTES

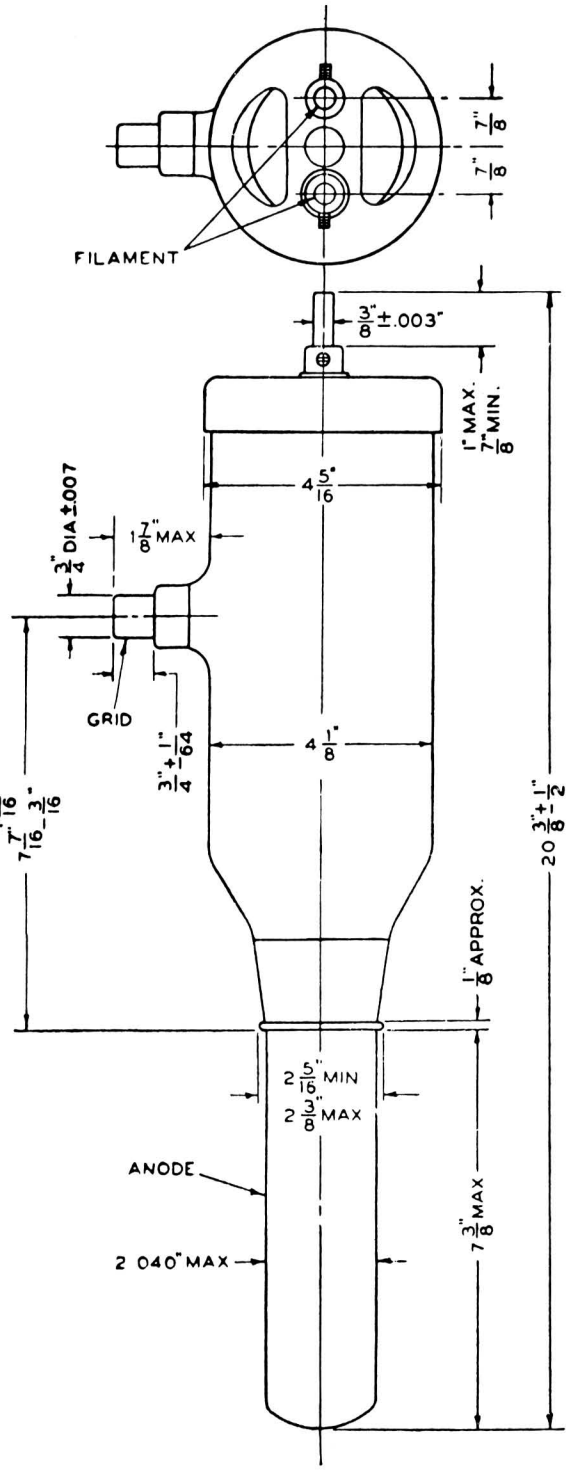
Maximum ratings apply at frequencies of 4 megacycles and less. The maximum plate voltage for the upper frequency limit of 12 megacycles is 5,000 volts. The maximum plate voltage for frequencies between 4 and 12 megacycles should be proportionately reduced.

The cooling facilities for the **ML-220C** should be such that the temperature of the water and rate of flow prevent boiling of the cooling water, as indicated by a hissing sound, under maximum dissipation. In general, the outlet water temperature should not exceed 75°C and the rate of flow should be not less than 3 gallons per minute.

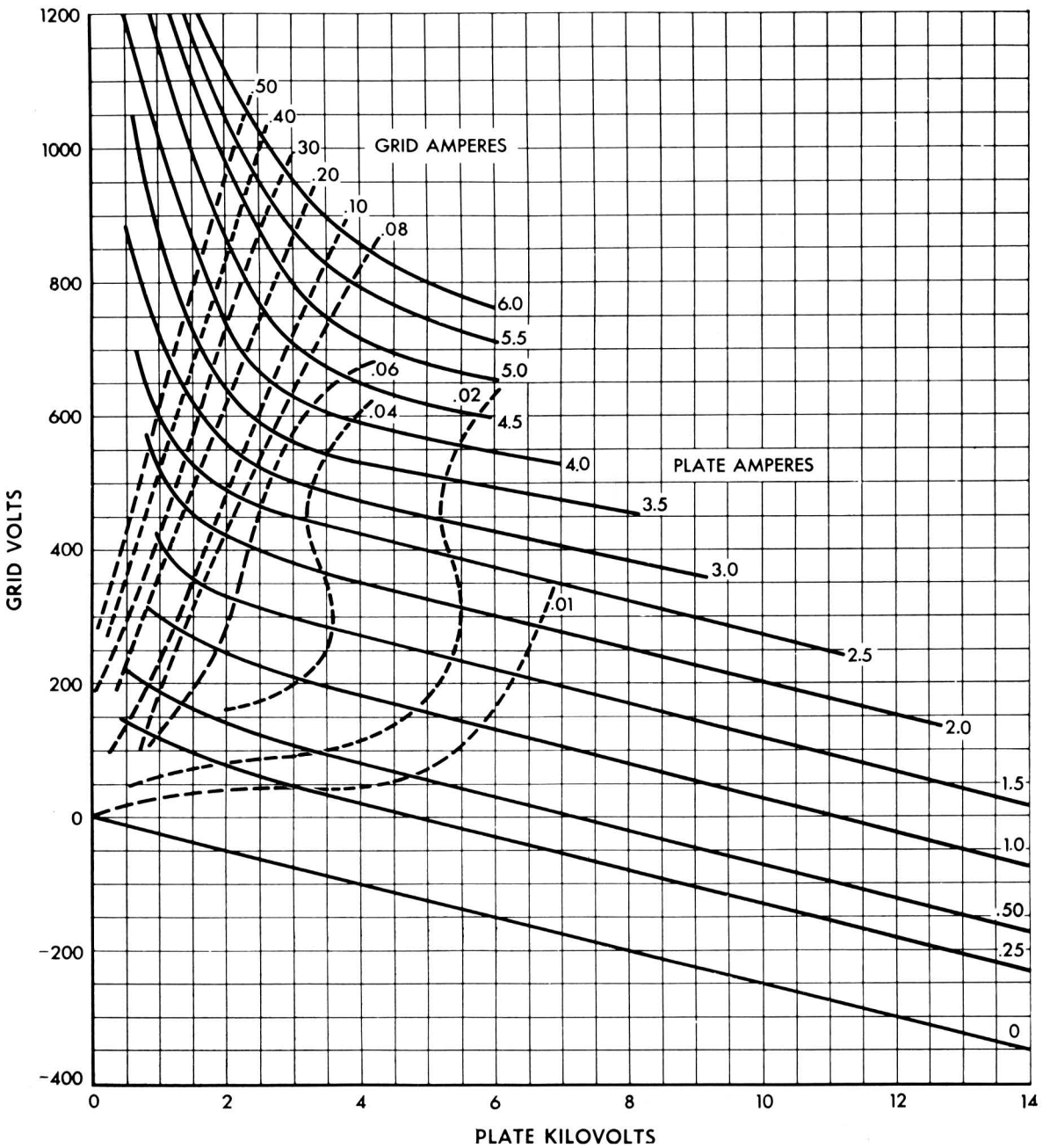
The cooling facilities for the **ML-220CA** should be such that the temperature of the anode, indicated by a thermometer having a nonmetallic column mounted in the tube thermometer well with the bulb protected from the air stream, is less than 120°C. The amount of air required will vary from 400 to 600 cu. 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.



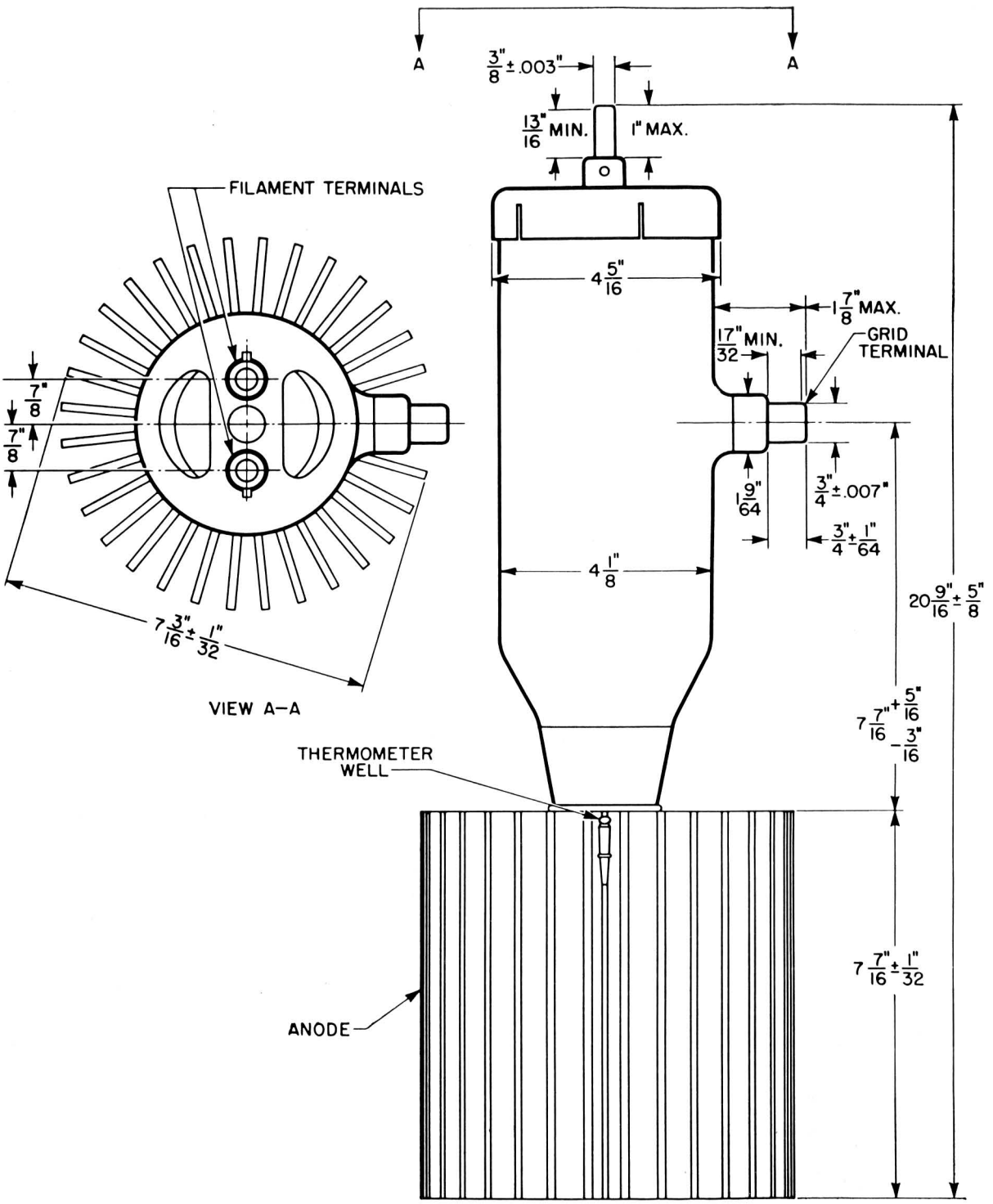
ML-220C CONSTANT CURRENT CHARACTERISTICS



DIMENSIONS—ML-220C



ML-220CA CONSTANT CURRENT CHARACTERISTICS



DIMENSIONS—ML-220CA

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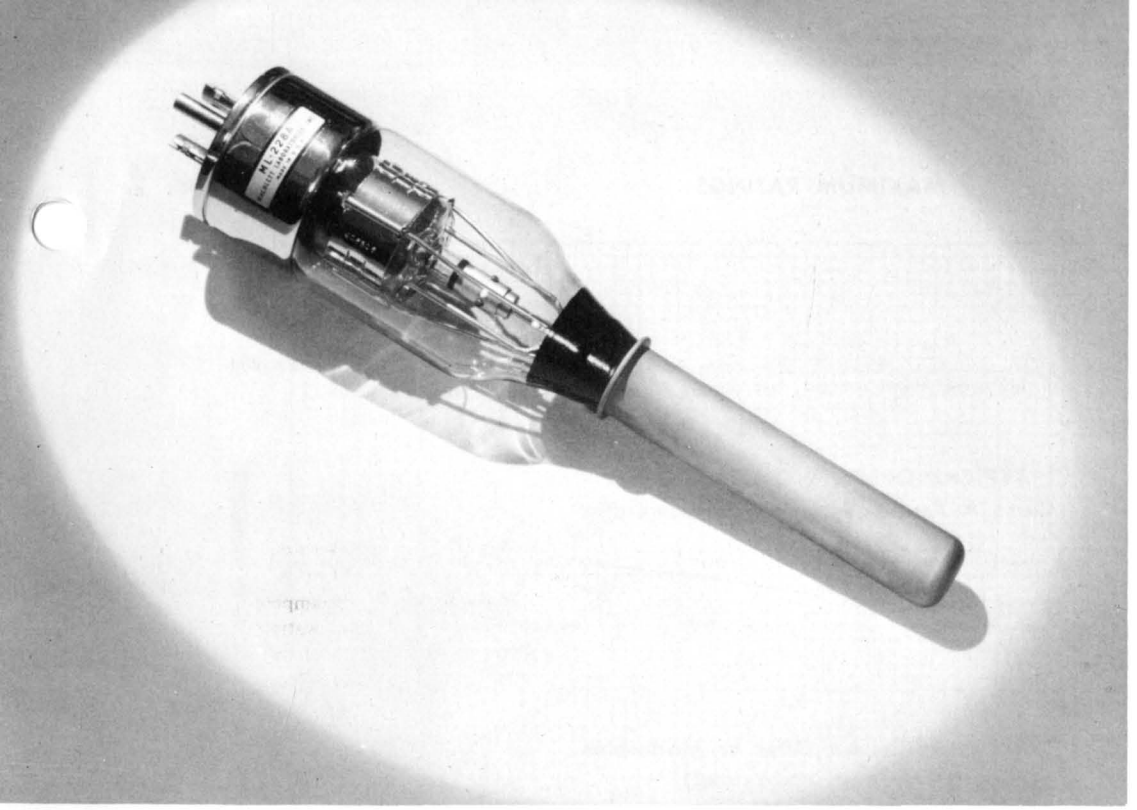


MACHLETT

ML-228A

DESCRIPTION AND RATINGS

DESCRIPTION

The **ML-228A** 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 5 kilowatts. Maximum ratings of 6 kVdc and 1.5 amperes apply at frequencies up to 3 mc/sec; operation at 6 mc/sec is permissible with plate voltage reduced to 3 kVdc.

The **ML-228A** 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	21.5 volts
Filament Current at 21.5 volts	41.0 amperes
Filament Starting Current	65 amperes
Amplification Factor	16
Grid-Plate Transconductance	6500 uMhos
Interelectrode Capacitances	
Grid-Plate	23.8 uuf
Grid-Filament	25.9 uuf
Plate-Filament	3.1 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Water
Water Flow on Anode	7-15 gpm
Maximum Water Pressure	80 psi
Maximum Outgoing Water Temperature	75 °C

MAXIMUM RATINGS

Direct Plate Voltage	6000 volts
Direct Plate Current	1.5 amperes
Plate Dissipation	5000 watts
Grid Dissipation	100 watts
R.F. Grid Current	20 amperes
Frequency	3 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	5000	6000 volts
Grid Bias	−100	−170 volts
Direct Plate Current	.85	.80 ampere
Plate Dissipation	4250	4800 watts
Load Impedance	5000	7500 ohms
Undistorted Output	125	285 watts

Class B Audio Amplifier or Modulator

(for balanced 2 tube circuit)

Direct Plate Voltage	5000	4000 volts
Grid Bias	−265	−200 volts
Direct Plate Current per tube		
No drive	0.15	0.15 ampere
Maximum drive	0.60	0.70 ampere
Plate Dissipation	1125	1300 watts
Load Resistance (plate-to-plate)	8400	5000 ohms
Load Resistance (per tube)	2100	1250 ohms
Approximate maximum output—2 tubes	3750	3000 watts
Recommended power for driving stage	200	200 watts

Class B Radio-Frequency Amplifier

Direct Plate Voltage	5000	4000 volts
Direct Plate Current for Carrier Conditions	0.65	0.65 ampere
Grid Bias	−325	−275 volts
Approximate Carrier Watts for use with 100% modulation	1100	900 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct Plate Voltage	6000	4000 volts
Direct Plate Current	1.25	1.25 amperes
Grid Bias	−600 to −800	−450 to −530 volts
Nominal Power Output	5000	3300 watts
Plate Dissipation	2500	1700 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct Plate Voltage	4000	3000 volts
Direct Plate Current	1.25	1.3 amperes
Grid Bias	−500	−300 volts
Direct Grid Current	150	150 milliamperes
Nominal Carrier Power Output	2500	2000 watts

APPLICATION NOTES

Maximum ratings apply at frequencies of 3 megacycles and less. The maximum plate voltage for the upper frequency limit of 6 megacycles is 3000 volts. The maximum plate voltage for frequencies between 3 and 6 megacycles should be proportionately reduced. At high frequencies special attention should be given to adequate ventilation of the bulb.

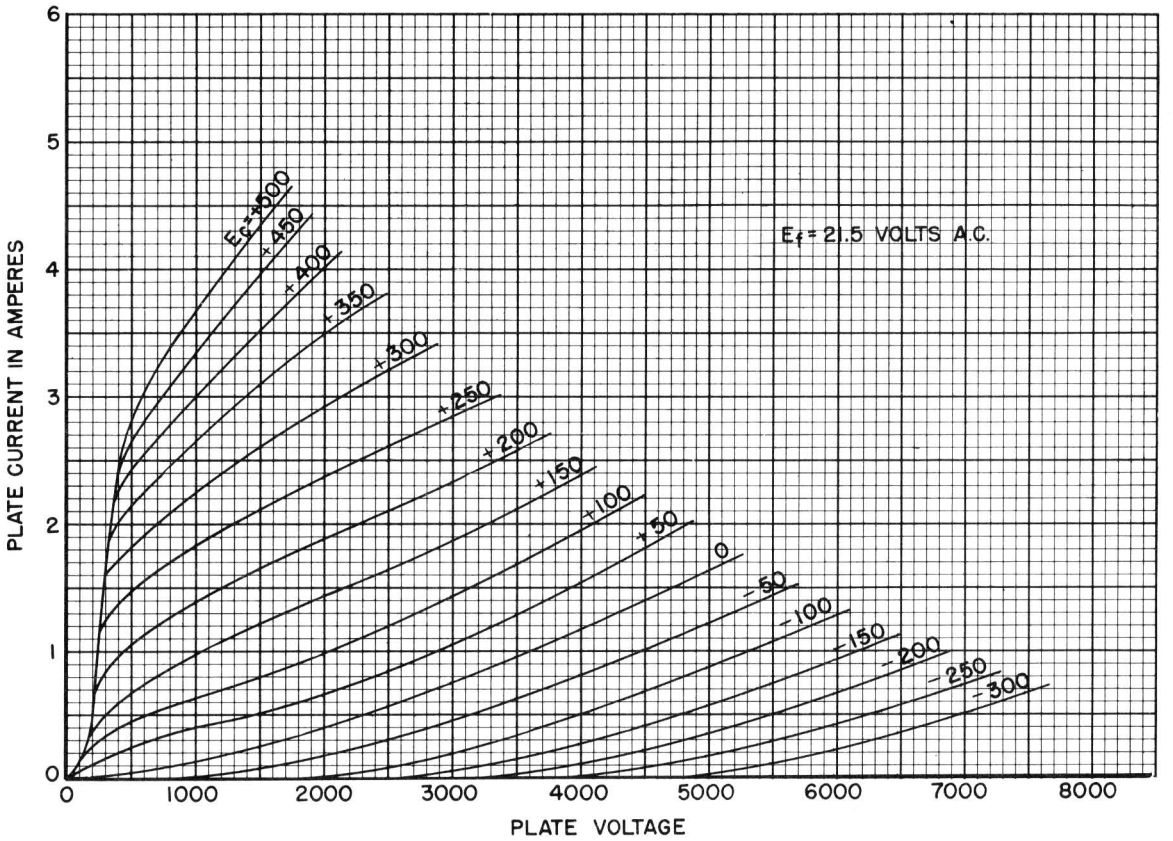


PLATE CURRENT IN AMPERES
PLATE VOLTAGE
E_f = 21.5 VOLTS A.C.
E_c = +500
+450
+400
+350
+300
+250
+200
+150
+100
+50
0
-50
-100
-150
-200
-250
-300
0
1000
2000
3000
4000
5000
6000
7000
8000
0
1
2
3
4
5
6

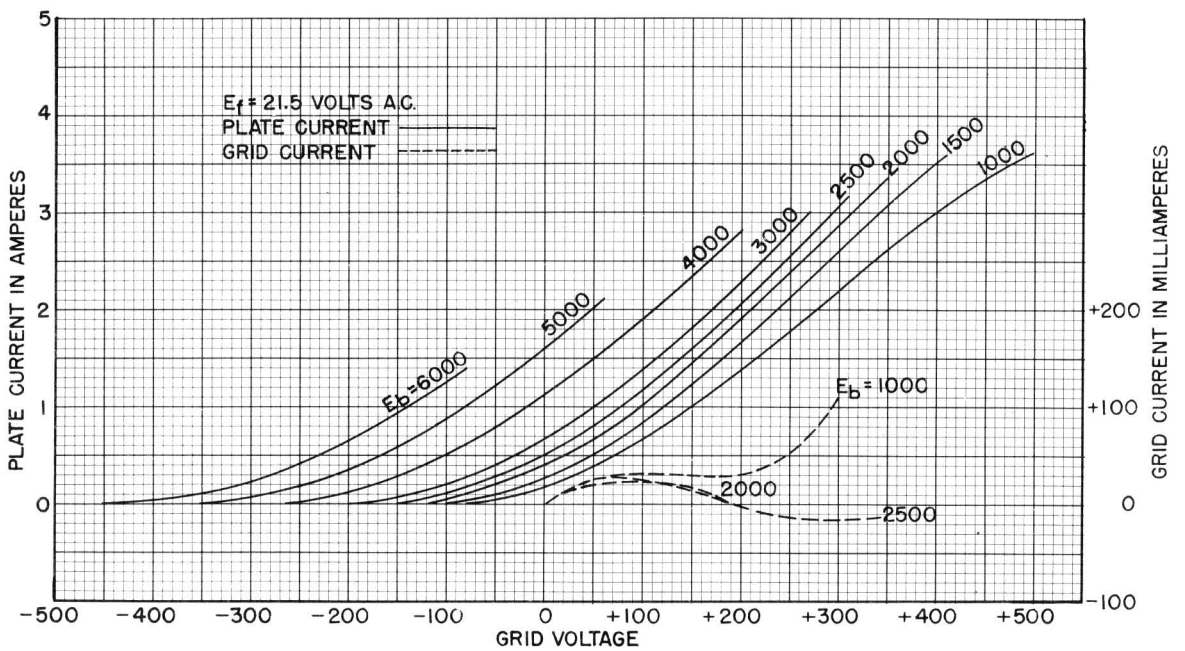
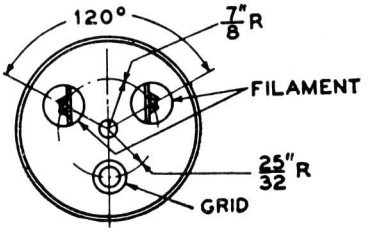
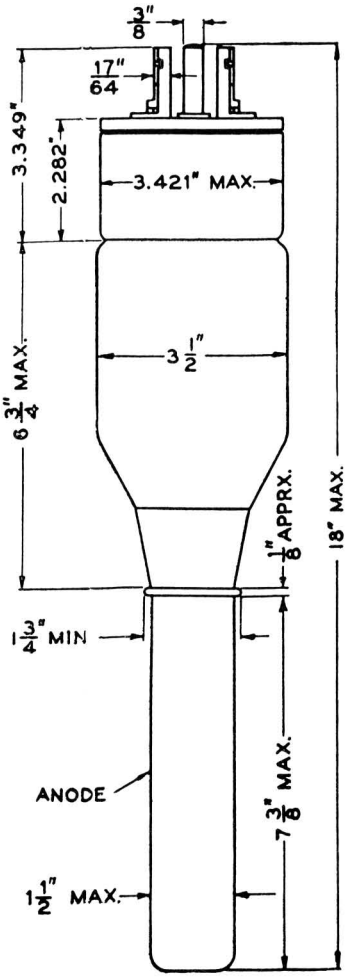


PLATE CURRENT IN AMPERES
GRID CURRENT IN MILLIAMPERES
GRID VOLTAGE
E_f = 21.5 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
E_b = 6000
5000
4000
3000
2500
2000
1500
1000
E_b = 1000
2000
2500
-500
-400
-300
-200
-100
0
+100
+200
+300
+400
+500
+200
+100
0
-100
0
1
2
3
4
5





DIMENSIONS—ML-228A

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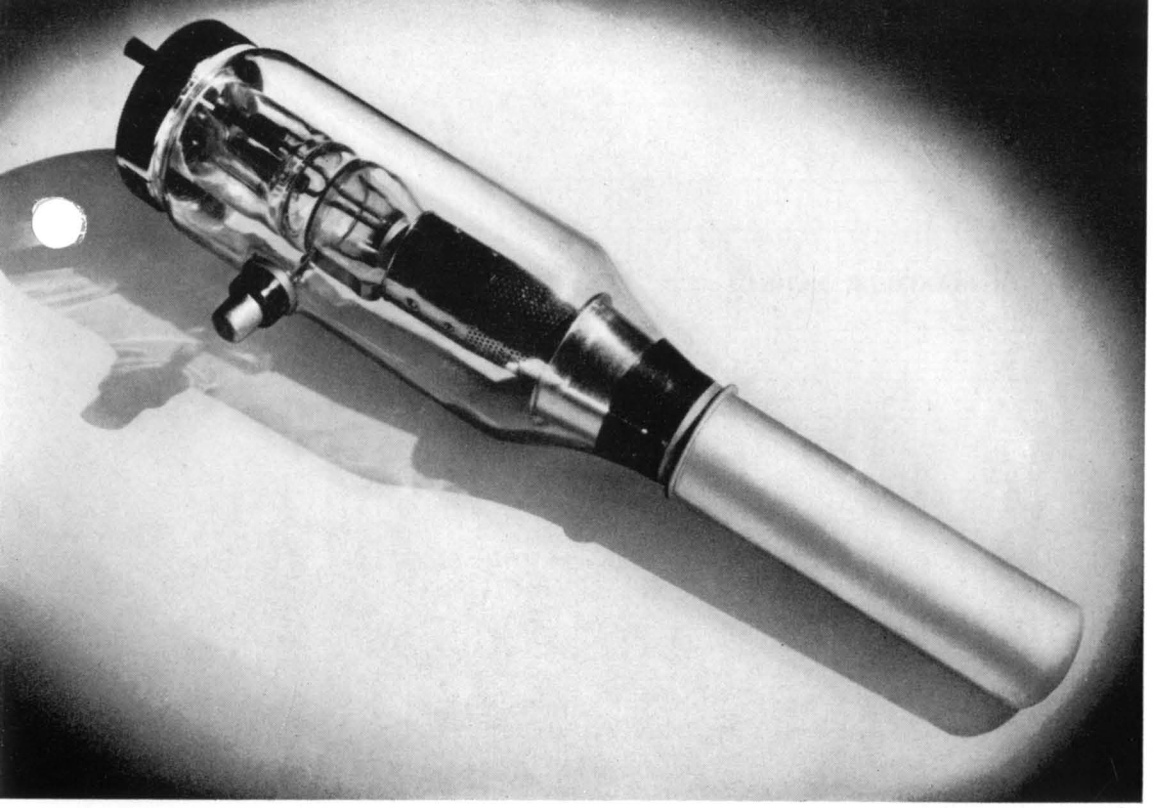

MACHLETT

ML-232B

DESCRIPTION AND RATINGS

DESCRIPTION

The **ML-232B** 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 kilowatts. Maximum ratings of 20 kVdc and 3 amperes apply at frequencies up to 3 mc/sec; operation at 12 mc/sec is permissible with plate voltage reduced to 10 kVdc.

The **ML-232B** 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	60 amperes
Amplification Factor	40
Grid-Plate Transconductance	6500 uMhos
Interelectrode Capacitances	
Grid-Plate	29.1 uuf
Grid-Filament	19.9 uuf
Plate-Filament	0.6 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Water
Water Flow on Anode	7-15 gpm
Maximum Outgoing Water Temperature	75 °C

MAXIMUM RATINGS

Direct Plate Voltage	20000 volts
Direct Plate Current	3.0 amperes
Plate Dissipation	25000 watts
Grid Dissipation	400 watts
R.F. Grid Current	40 amperes
Frequency	3 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 Radio-Frequency Amplifier

Direct Plate Voltage	17500	12500 volts
Direct Plate Current for Carrier Conditions	1.5	2.2 amperes
Grid Bias	–500	–350 volts
Approximate carrier watts for use with 100% modulation	9000	9000 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct Plate Voltage	15000	10000 volts
Direct Plate Current	2.5	2.6 amperes
Grid Bias	–600 to –800	–450 to –600 volts
Nominal Power Output	25000	17500 watts
Plate Dissipation	12500	8500 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct Plate Voltage	12500	7500 volts
Direct Plate Current	1.50	1.50 amperes
Grid Bias	–700	–450 volts
Direct Grid Current	250	250 milliamperes
Nominal Carrier Power Output	12500	7500 watts

APPLICATION NOTES

Maximum ratings apply at frequencies of 3 megacycles and less. The maximum plate voltage for the upper frequency limit of 12 megacycles is 10,000 volts. The maximum plate voltage for frequencies between 3 and 12 megacycles should be proportionately reduced.

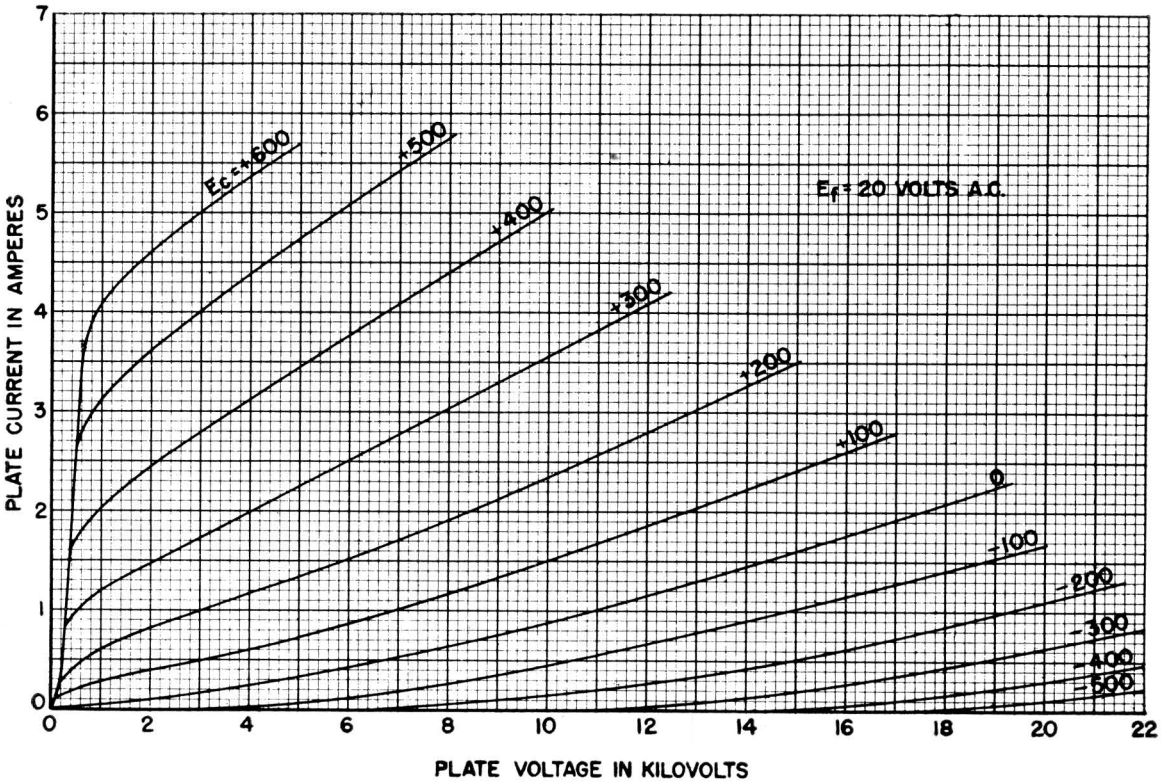
PLATE CURRENT IN AMPERES
PLATE VOLTAGE IN KILOVOLTS
E_f = 20 VOLTS A.C.
E_c = +600
+500
+400
+300
+200
+100
0
-100
-200
-300
-400
-500
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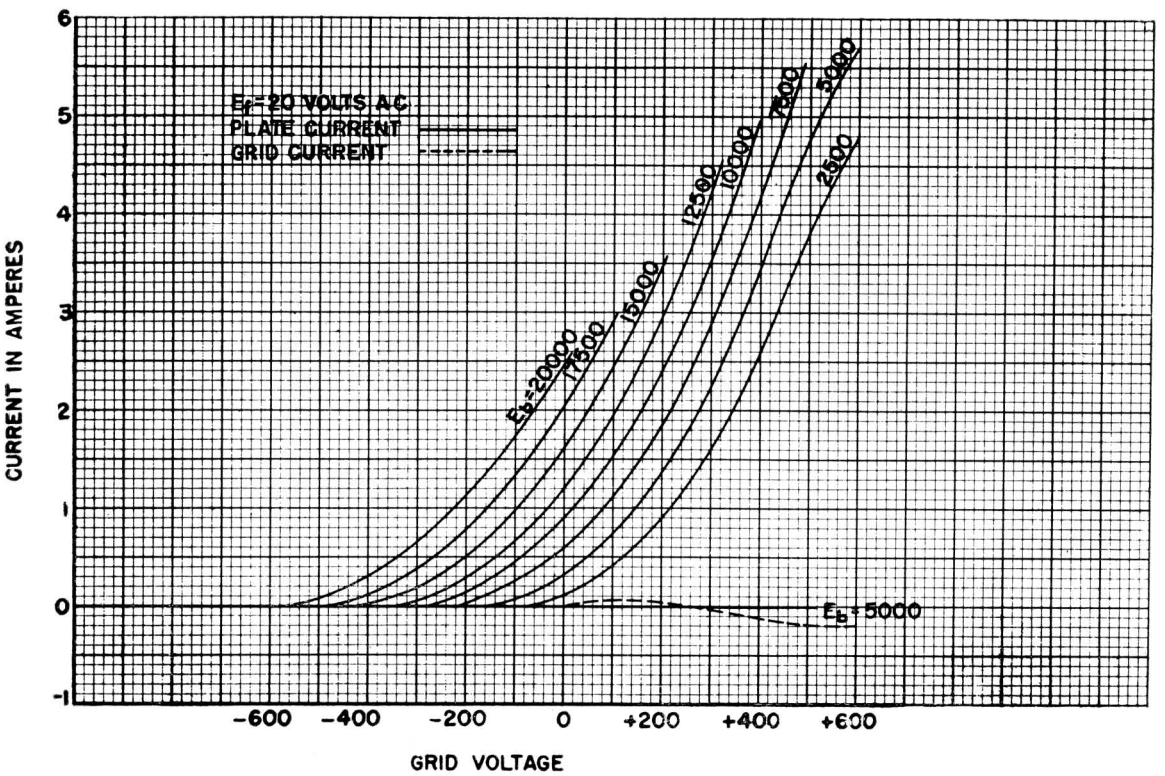
CURRENT IN AMPERES
GRID VOLTAGE
E_f = 20 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
E_b = 20000
17500
15000
12500
10000
7500
5000
2500
E_b = 5000
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0
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2
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4
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6
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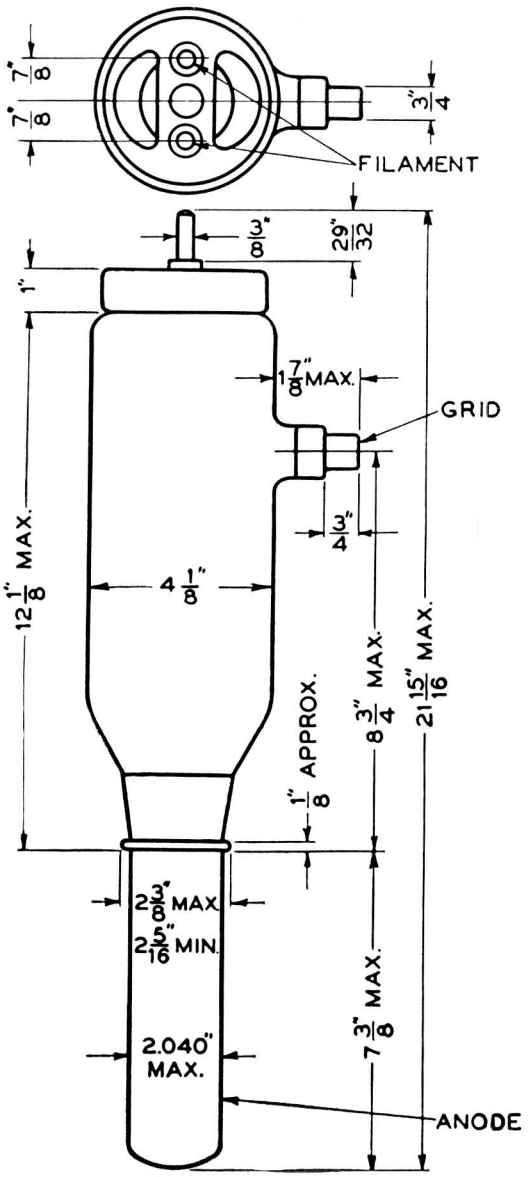
-400
-200
0
+200
+400
+600



DIMENSIONS—ML-232B

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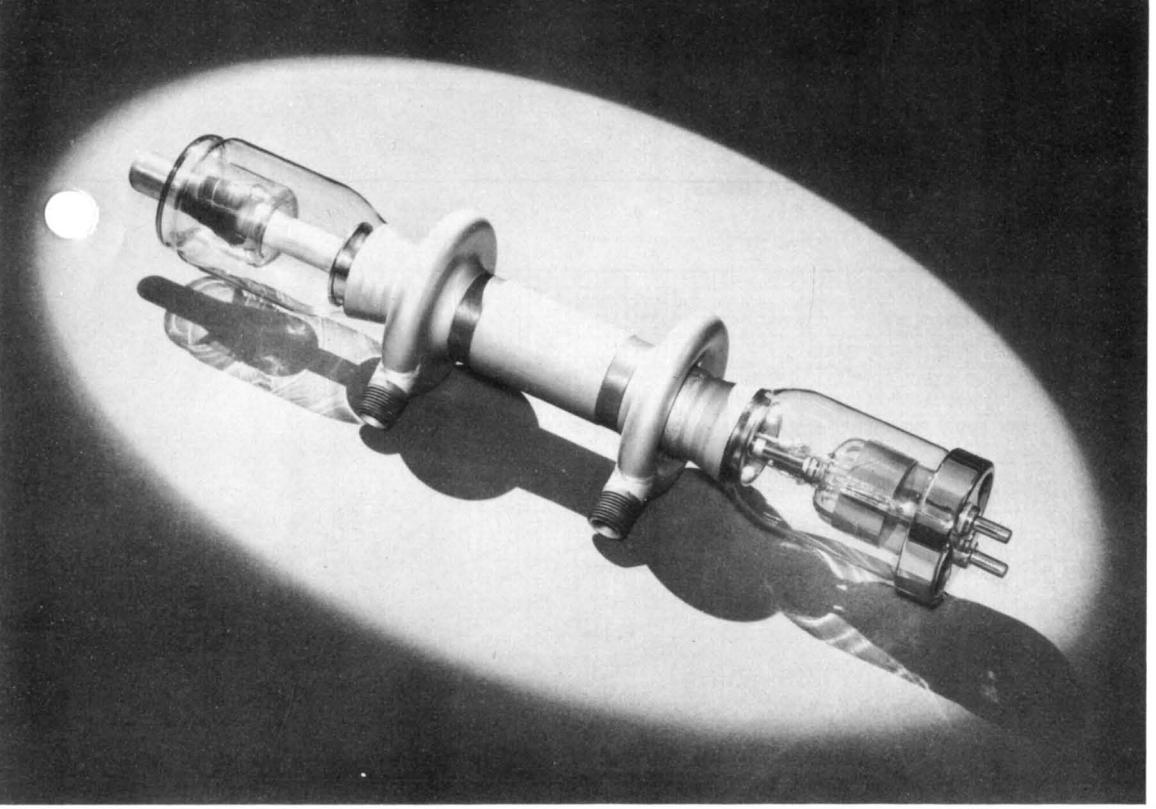


MACHLETT

ML-240B

DESCRIPTION AND RATINGS

DESCRIPTION

The **ML-240B** 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 10 kilowatts. Maximum ratings of 12 kVdc and 1.7 amperes apply at frequencies up to 20 mc/sec; operation at 40 mc/sec is permissible with plate voltage reduced to 6 kVdc.

The **ML-240B** 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	21.5 volts
Filament Current at 21.5 volts	41.0 amperes
Filament Starting Current	65 amperes
Filament Cold Resistance	.0391 ohms
Amplification Factor	40
Grid-Plate Transconductance	5000 uMhos
Interelectrode Capacitances	
Grid-Plate	28 uuf
Grid-Filament	12 uuf
Plate-Filament	5.8 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Water
Water Flow on Anode	3-8 gpm
Maximum Outgoing Water Temperature	75 °C

MAXIMUM RATINGS

Direct Plate Voltage	12000 volts
Direct Plate Current	1.7 amperes
Plate Dissipation	10000 watts
Direct Grid Dissipation	300 watts
R.F. Grid Current	60 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 B Audio Amplifier or Modulator

(for balanced 2 tube circuit)

Direct Plate Voltage	12000	10000 volts
Grid Bias	−225	−170 volts
Direct Plate Current per tube		
No drive	0.15	0.15 ampere
Maximum drive	1.20	1.20 amperes
Plate Dissipation	5650	5250 watts
Load Resistance (plate-to-plate)	10200	7920 ohms
Load Resistance (per tube)	2550	1980 ohms
Approximate Maximum Output—2 tubes	17500	13500 watts
Recommended Power for driving stage	750	750 watts

Class B Radio-Frequency Amplifier

Direct Plate Voltage	12000	10000 volts
Direct Plate Current for Carrier Conditions	1.25	1.20 amperes
Grid Bias	−250	−200 volts
Approximate Carrier Watts for use with 100% modulation	5000	4000 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct Plate Voltage	12000	10000 volts
Direct Plate Current	1.50	1.50 amperes
Grid Bias	−450 to −600	−335 to −450 volts
Nominal Power Output	12000	10000 watts
Plate Dissipation	6000	5000 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct Plate Voltage	9000	7500 volts
Direct Plate Current	1.40	1.40 amperes
Grid Bias	−450	−400 volts
Direct Grid Current	150	150 milliamperes
Nominal Carrier Power Output	8500	7000 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 6,000 volts. The maximum plate voltage for frequencies between 20 and 40 megacycles should be proportionately reduced. At high frequencies special attention should be given to adequate ventilation of the bulb.

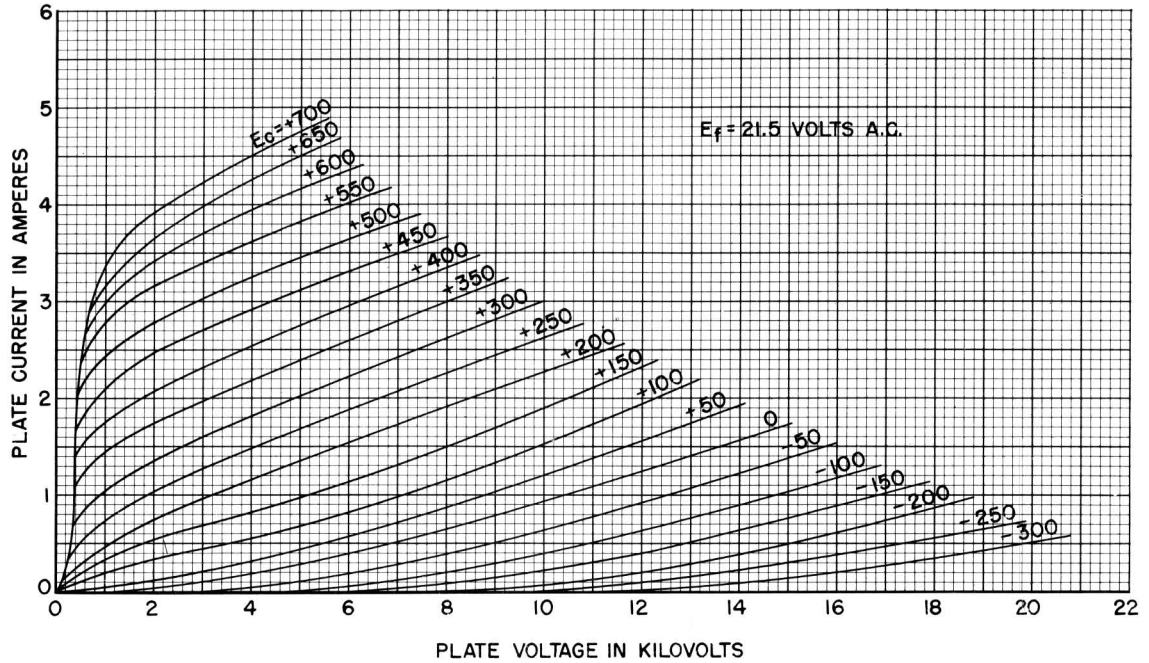
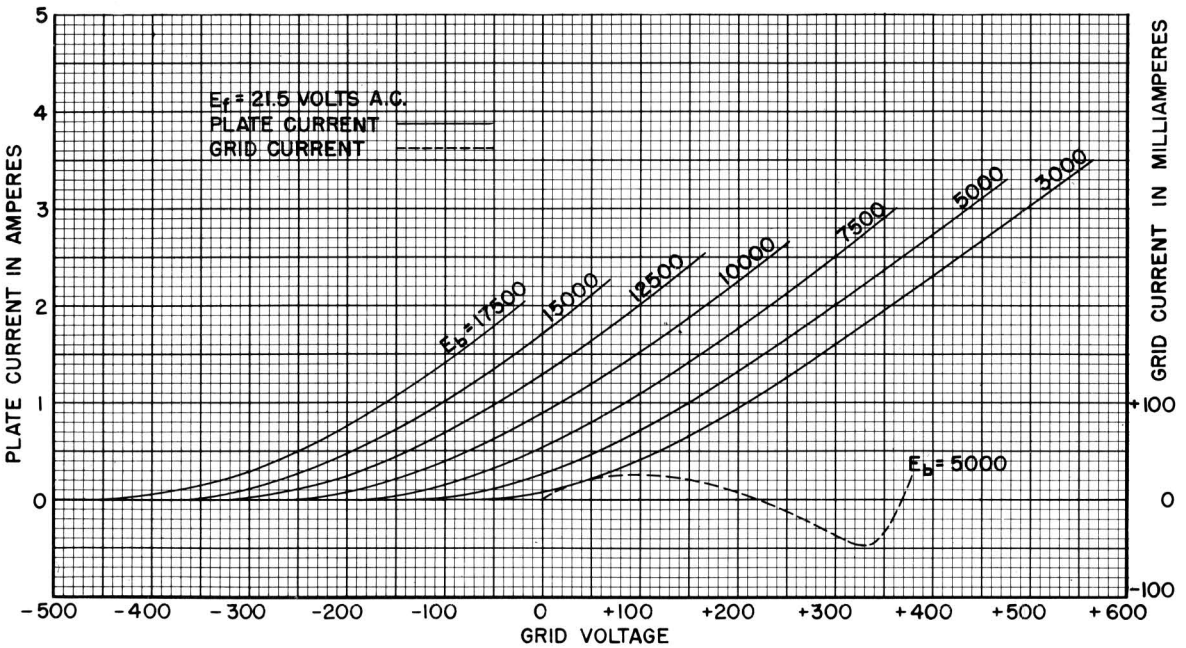
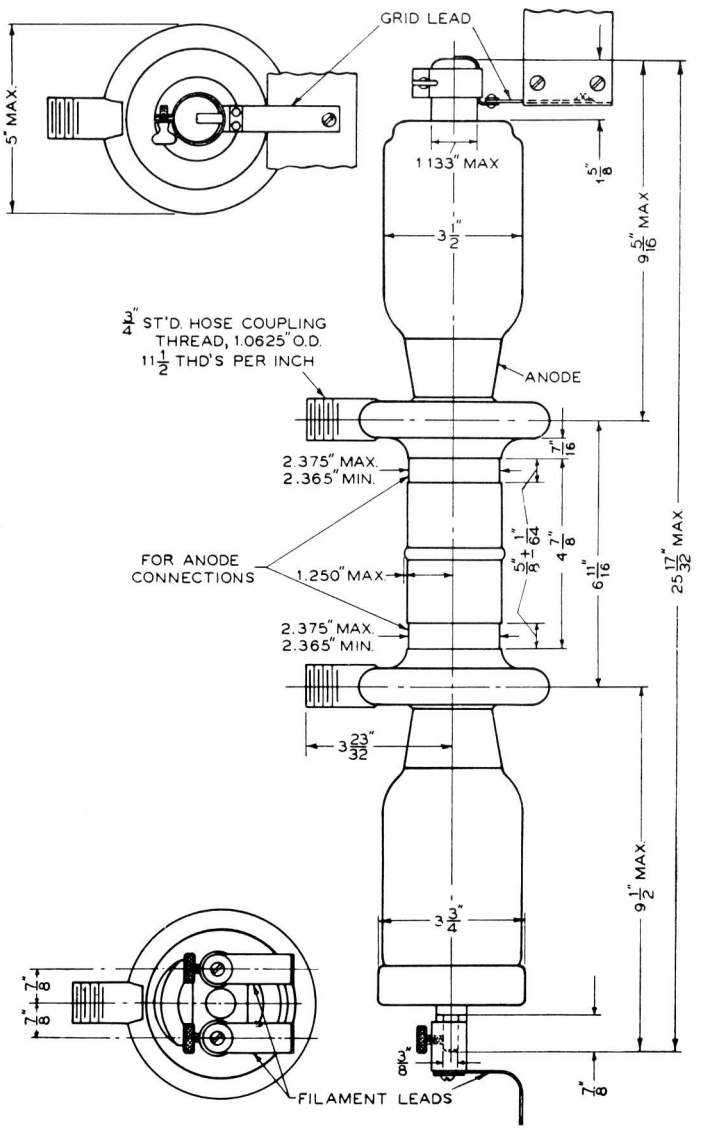


PLATE CURRENT IN AMPERES
PLATE VOLTAGE IN KILOVOLTS
E_f = 21.5 VOLTS A.C.
E_c = +700
+650
+600
+550
+500
+450
+400
+350
+300
+250
+200
+150
+100
+50
0
-50
-100
-150
-200
-250
-300
0
1
2
3
4
5
6
0
2
4
6
8
10
12
14
16
18
20
22


E_f = 21.5 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
PLATE CURRENT IN AMPERES
GRID CURRENT IN MILLIAMPERES
GRID VOLTAGE
E_b = 17500
15000
12500
10000
7500
5000
3000
E_b = 5000
-500
-400
-300
-200
-100
0
+100
+200
+300
+400
+500
+600
-100
0
+100



DIMENSIONS—ML-240B

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

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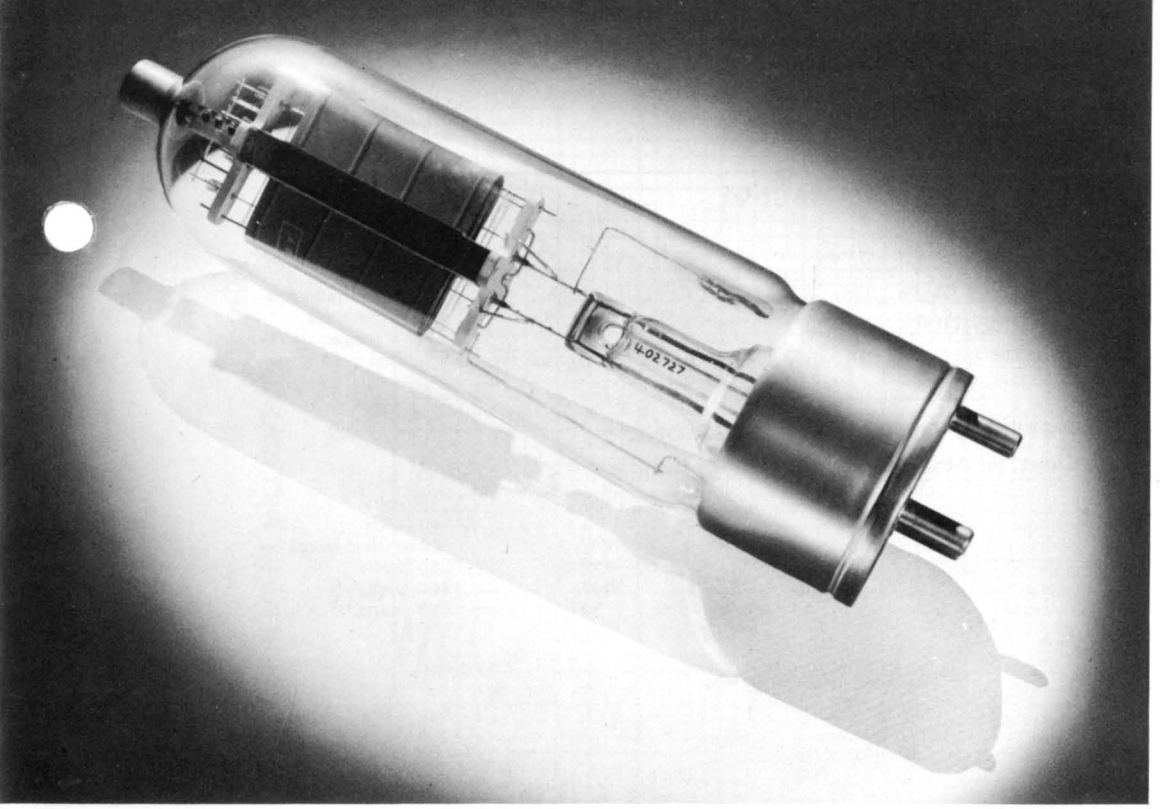


MACHLETT

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	3000 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

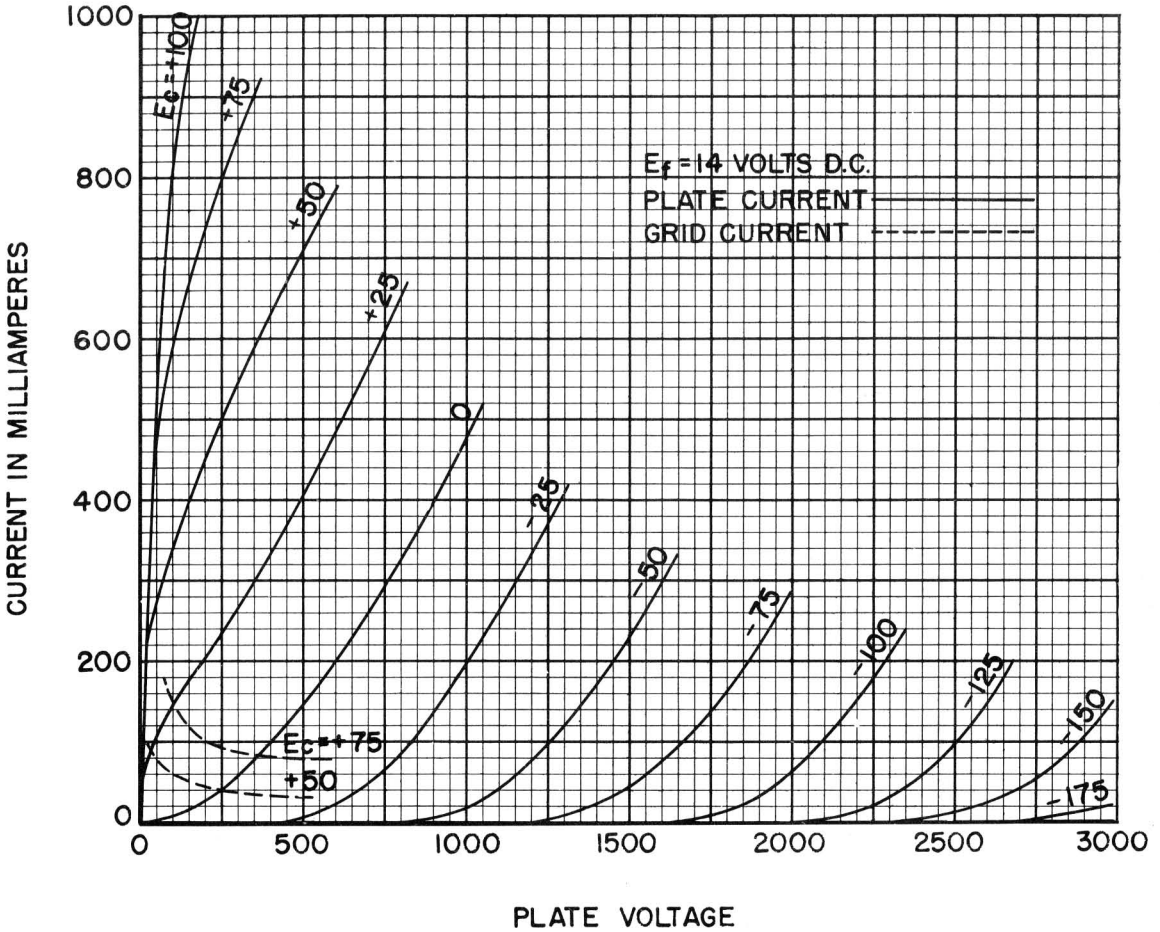
Direct Plate Voltage	2000	1500 volts
Direct Plate Current	300	300 milliamperes
Grid Bias	−185 to −250	−150 to −200 volts
Nominal Power Output	400	300 watts

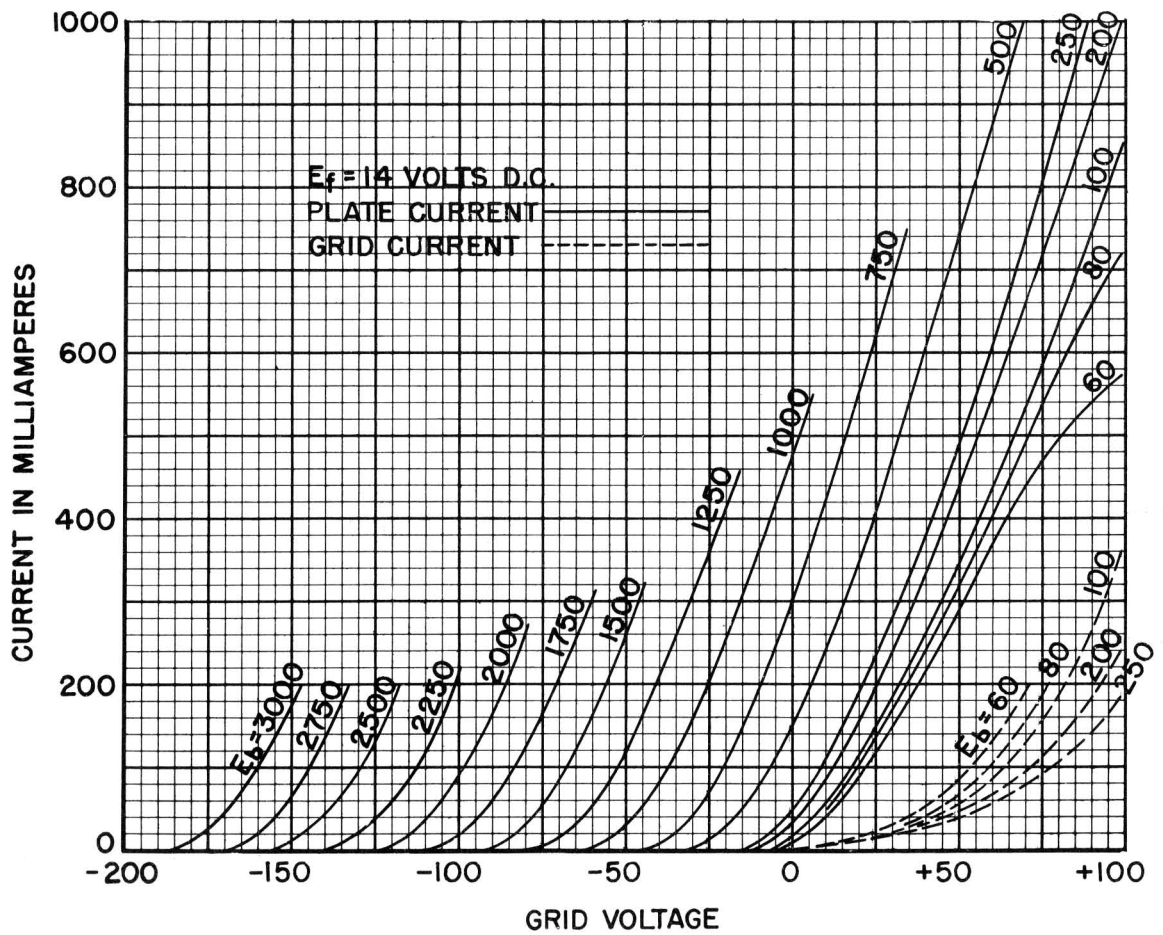
Class C Radio-Frequency Amplifier—Plate Modulated

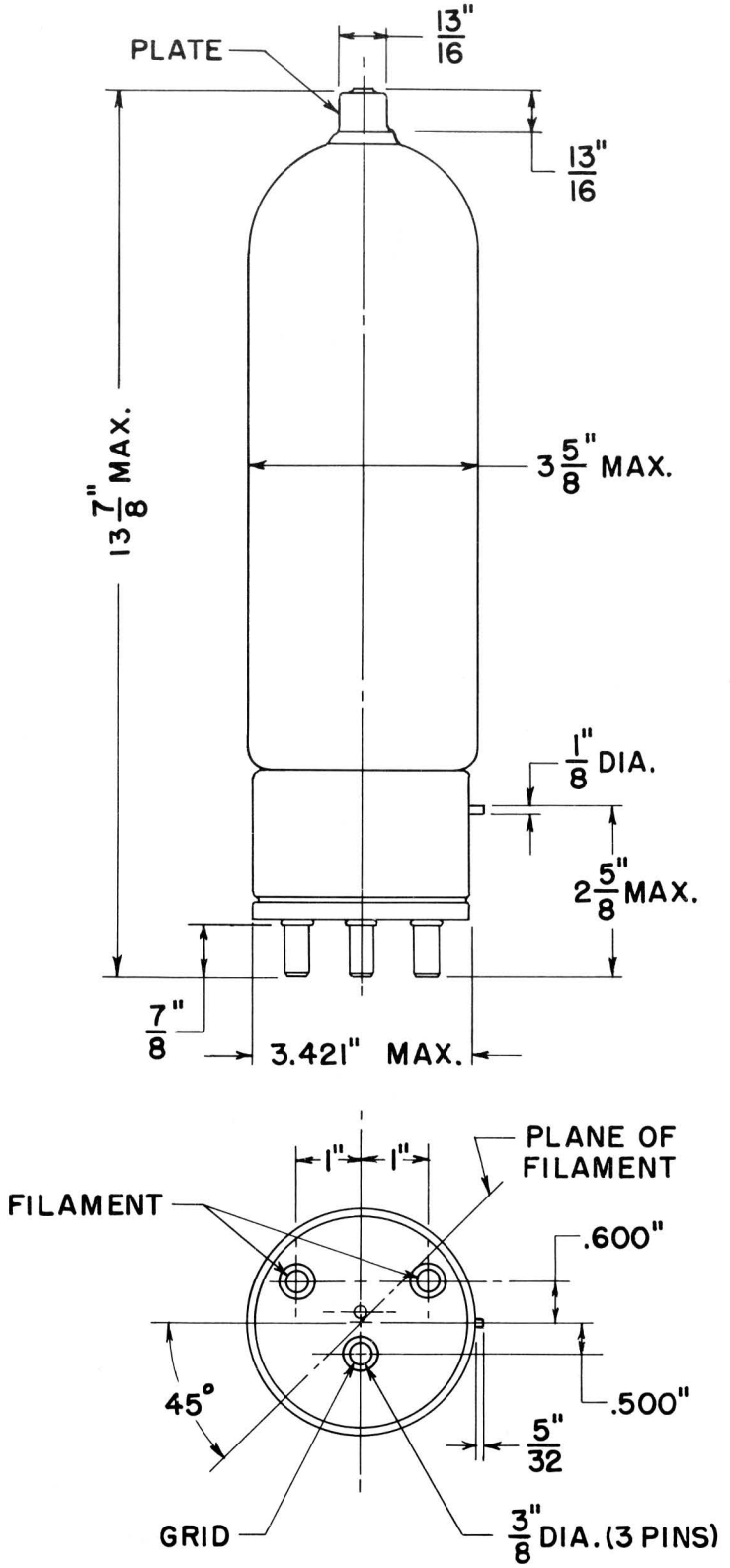
Direct Plate Voltage	1500	1000 volts
Direct Plate Current	300	300 milliamperes
Grid Bias	−200	−125 volts
Direct Grid Current	75	75 milliamperes
Nominal Carrier Power Output for use with 100% modulation	300	200 watts

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
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
0
200
400
600
800
1000
0
500
1000
1500
2000
2500
3000


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



DIMENSIONS—ML-241B

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SPRINGDALE MACHLETT CONNECTICUT

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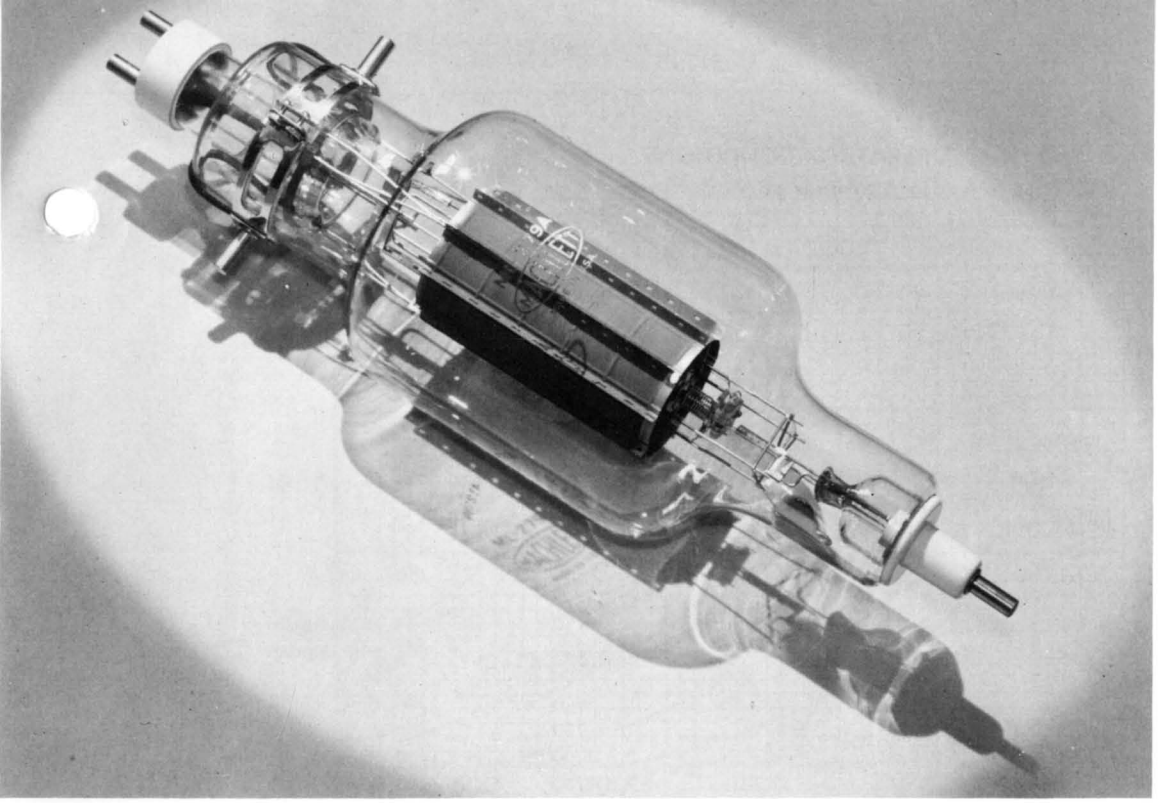


MACHLETT

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

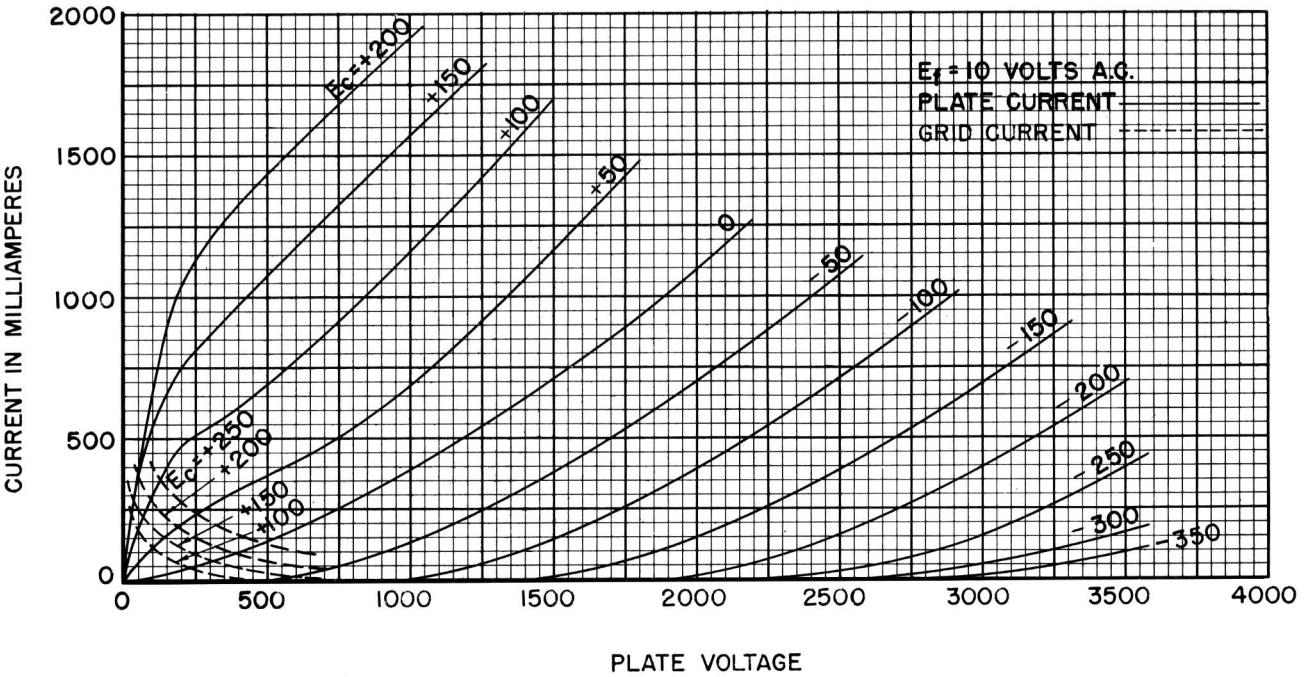
Class C R-F Amplifier—Plate Modulated

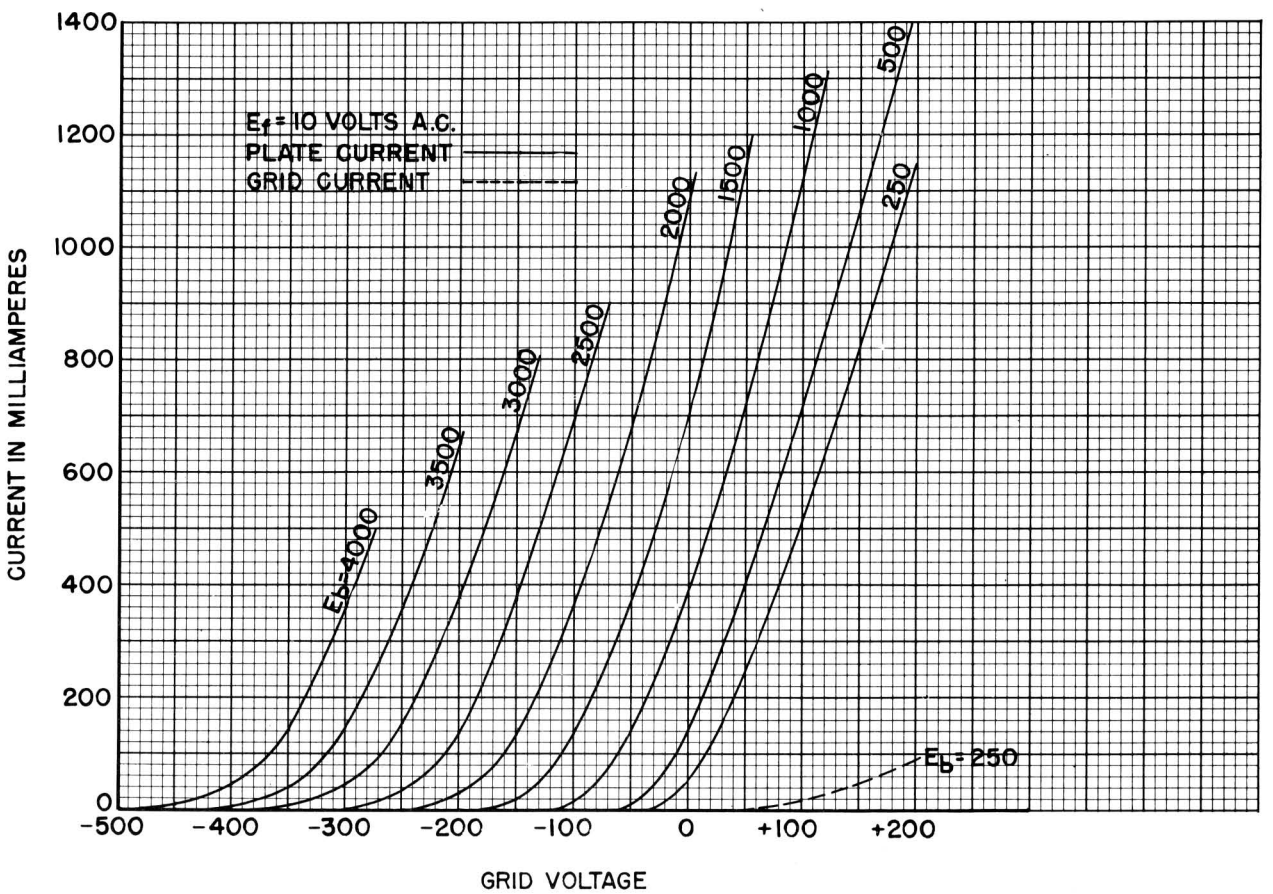
Direct Plate Voltage	2250	1750 volts
Direct Plate Current	600	700 milliamperes
Grid Bias	−450	−360 volts
Direct Grid Current	100	100 milliamperes
Nominal Carrier Power Output for use with 100% modulation	900	830 watts

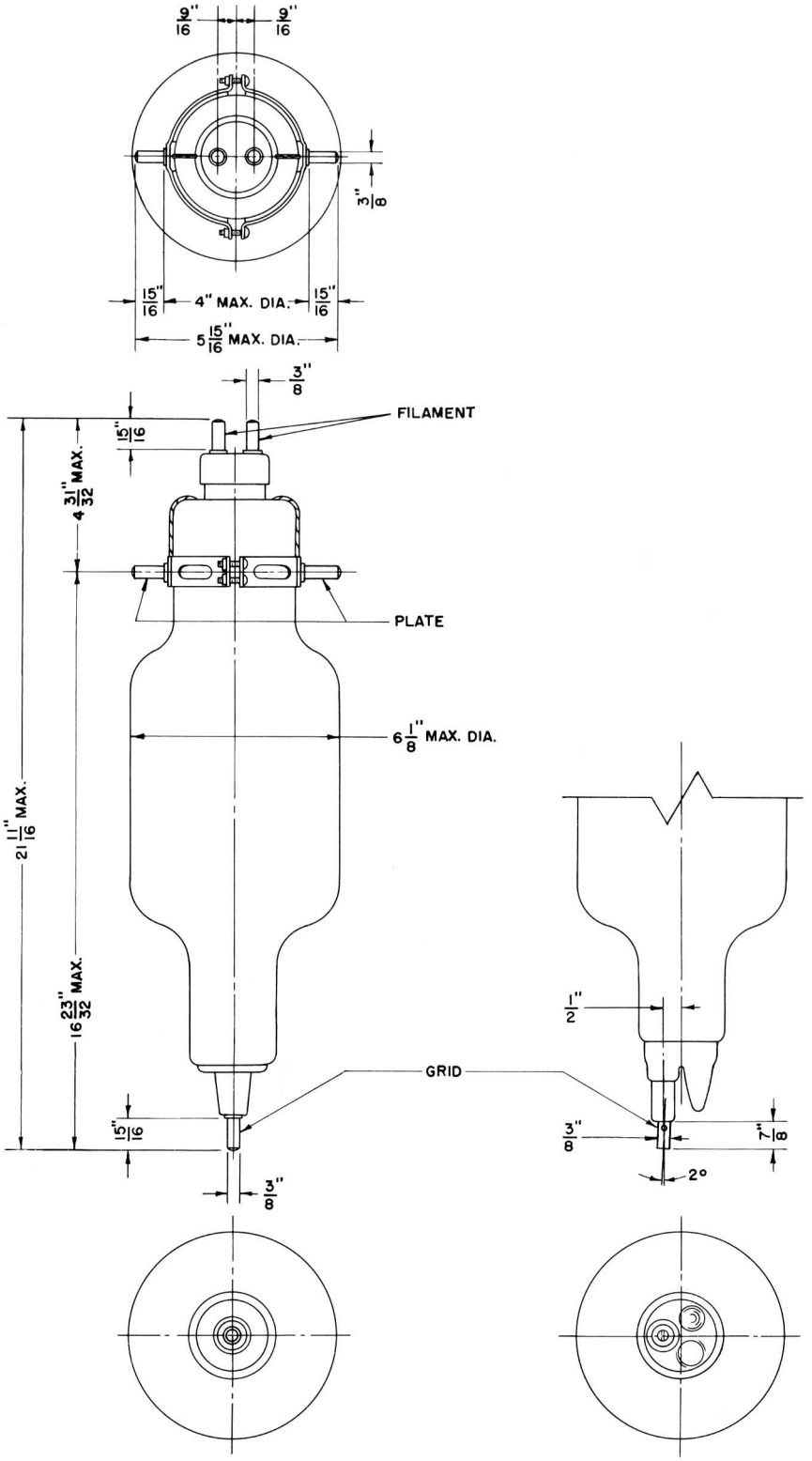
APPLICATION NOTES

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


CURRENT IN MILLIAMPERES
GRID VOLTAGE
E_f = 10 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
Eb=4000
3500
3000
2500
2000
1500
1000
500
250
E_b = 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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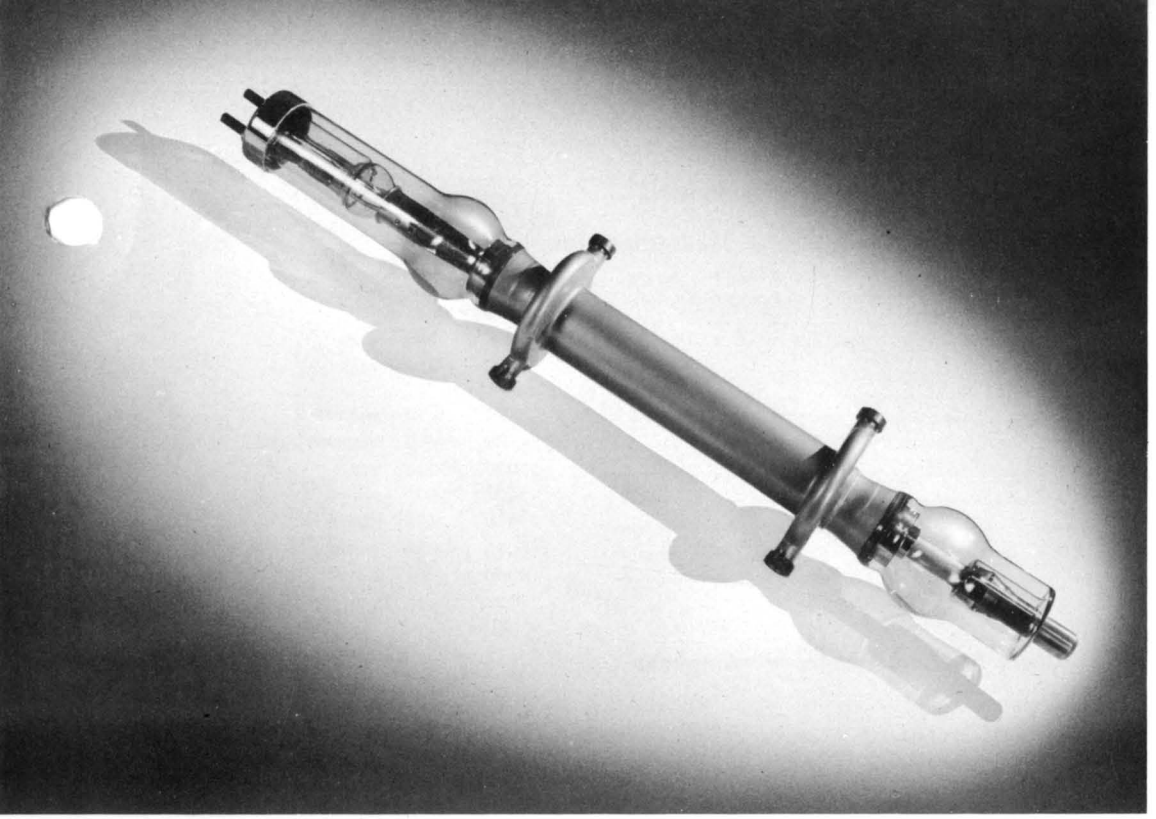


MACHLETT

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

	ML-298A	ML-298B	
Electrical			
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.

TYPICAL OPERATING CONDITIONS

Class B—Audio Amplifier or Modulator

(for balanced 2 tube circuit)

	ML-298A		
Direct Plate Voltage	15000	12000	volts
Grid Bias	−350	−250	volts
Direct Plate Current per tube			
No drive	0.70	0.70	ampere
Maximum drive	7.0	7.0	amperes
Plate Dissipation	35000	28000	watts
Load Resistance (plate-to-plate)	2200	1600	ohms
Load Resistance (per tube)	550	400	ohms
Approximate Maximum Output—2 tubes	140000	112000	watts
Recommended Power for driving stage	1000	800	watts

Class B Radio-Frequency Amplifier

	ML-298A		ML-298B		
Direct Plate Voltage	18000	15000	18000	15000	volts
Direct Plate Current for Carrier Conditions	4.2	4.2	4.2	4.2	amperes
Grid Bias	−500	−400	−250	−200	volts
Approximate Carrier Watts for use with 100% Modulation	25000	21000	25000	21000	watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

	ML-298A			ML-298B		
Direct Plate Voltage	18000	15000	10000	18000	15000	volts
Direct Plate Current	6.7	8.0	8.0	9.0	8.0	amperes
Grid Bias	−750 to −1000	−600 −800	−525 −700	−500 −750	−400 −600	volts
Nominal Power Output	80000	80000	53000	100000	80000	watts
Plate Current with Zero Bias				3.5	2.5	amperes

Class C Radio-Frequency Amplifier—Plate Modulated

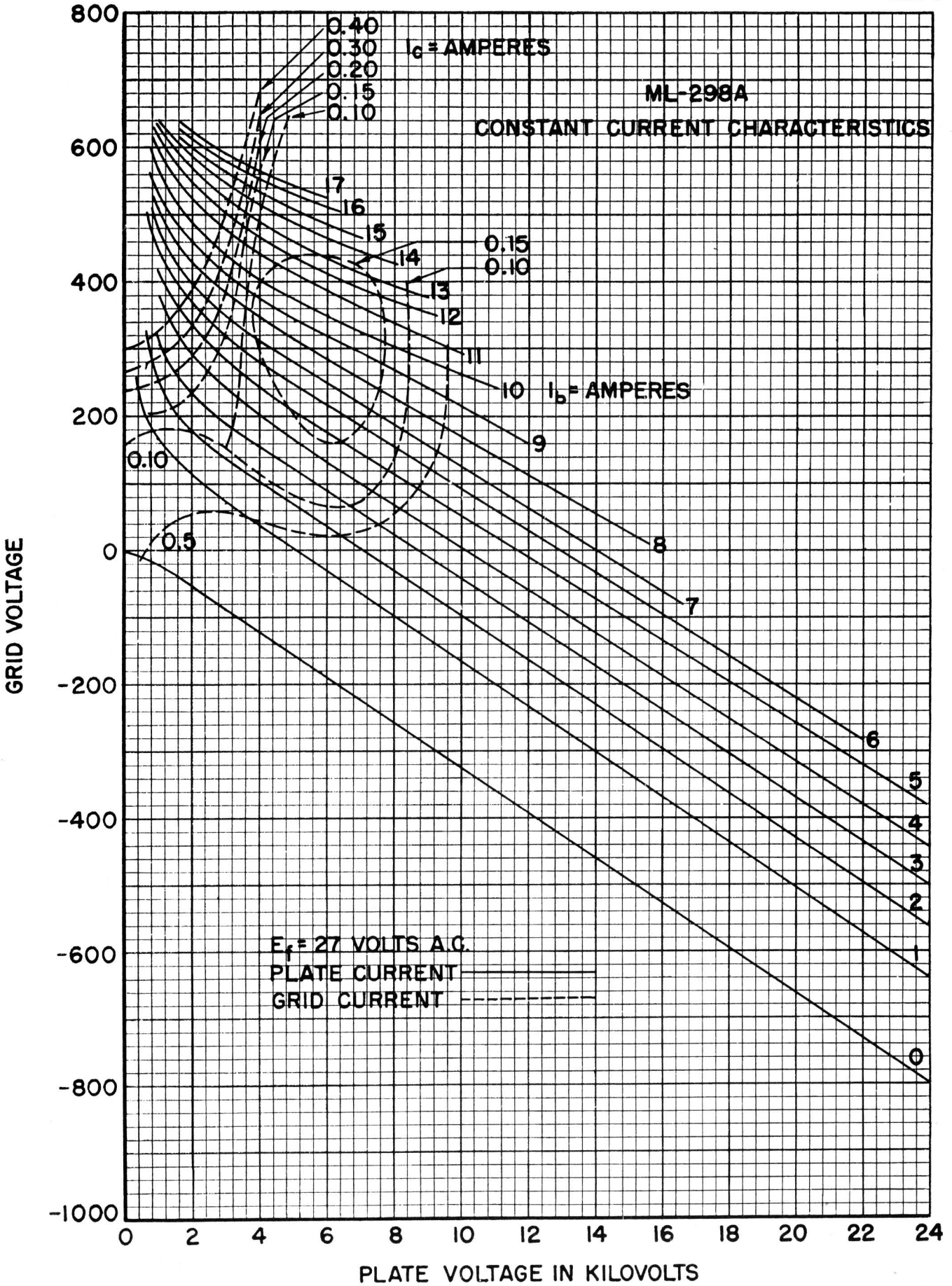
	ML-298A		ML-298B	
Direct Plate Voltage	12000	10000	12000	volts
Direct Plate Current	5.0	6.0	5.5	amperes
Grid Bias	*	*	*	
Maximum Direct Grid Current	500	500	1000	milliamperes
Nominal Carrier Power Output	40000	40000	45000	watts

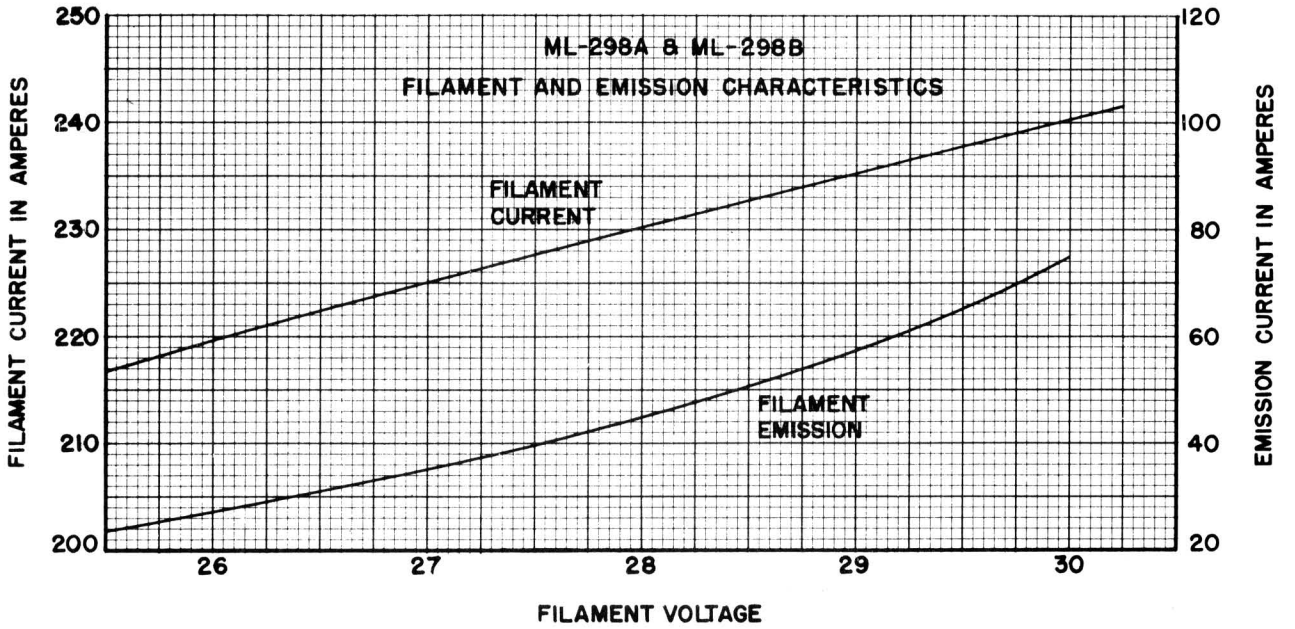
* It is recommended that the grid circuit for high level modulation be arranged to receive its operating bias from the flow of grid current through a resistance of from 5,000 to 10,000 ohms. An additional steady state bias voltage of sufficient magnitude to limit the plate dissipation to a safe value with no r-f driving voltage applied to the grid, should be incorporated in the circuit.

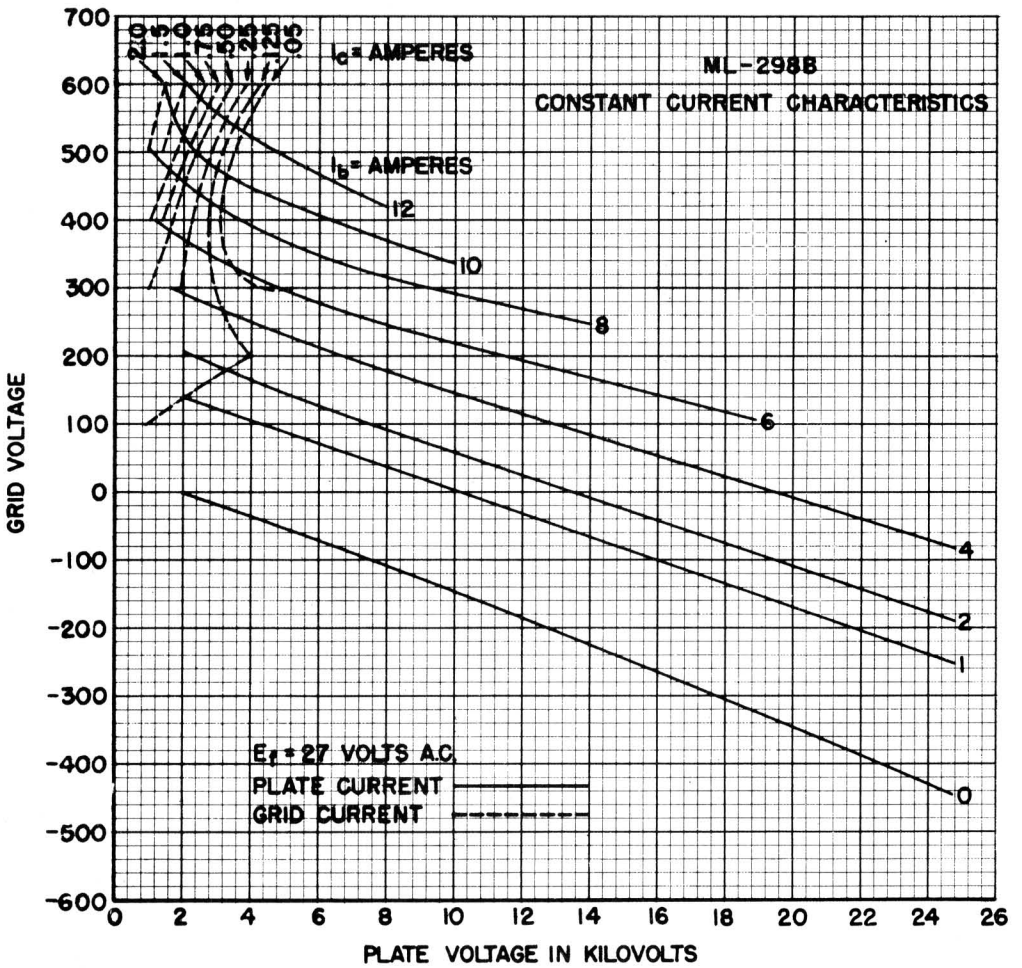
APPLICATION NOTES

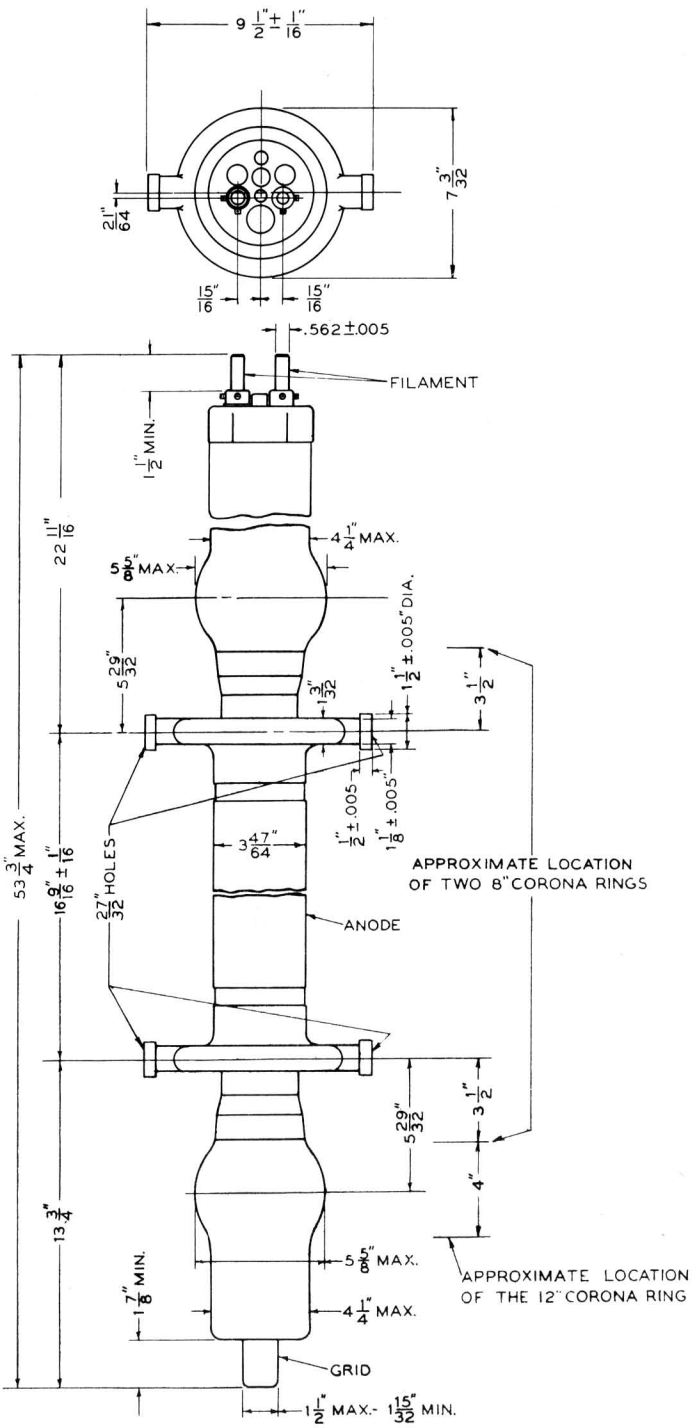
Maximum ratings apply at frequencies of 4 megacycles and less. The maximum plate voltage for the upper frequency limit of 20 megacycles is 12,000 volts. The maximum plate voltage for frequencies between 20 and 40 megacycles should be proportionately reduced.

To protect the glass and copper to glass anode seals from being damaged by flashovers external to the tube, corona rings furnished with the W.E. socket are mounted at each end of the anode and at the grid terminal. The approximate locations of these rings are indicated in the dimensional outline. These rings are 8″ and 12″ in diameter of ½″ tubing. The 8″ rings are hinged so that they encircle the glass bulb just outside the anode seals when closed. The 12″ ring circles the glass bulb adjacent to the grid terminal to which it is directly attached. Old gaskets should be replaced by the new ones supplied with each tube. This tube should not be subjected to unnecessary shock or vibration. No object should touch the bulb and there should be a free circulation of air around the tube.


ML-298A
CONSTANT CURRENT CHARACTERISTICS
I_c = AMPERES
0.40
0.30
0.20
0.15
0.10
I_b = AMPERES
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.15
0.10
0.10
0.5
E_f = 27 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
GRID VOLTAGE
800
600
400
200
0
-200
-400
-600
-800
-1000
0
2
4
6
8
10
12
14
16
18
20
22
24
PLATE VOLTAGE IN KILOVOLTS


ML-298A & ML-298B
FILAMENT AND EMISSION CHARACTERISTICS
FILAMENT CURRENT IN AMPERES
EMISSION CURRENT IN AMPERES
FILAMENT VOLTAGE
FILAMENT CURRENT
FILAMENT EMISSION
250
240
230
220
210
200
120
100
80
60
40
20
26
27
28
29
30


ML-298B
CONSTANT CURRENT CHARACTERISTICS
GRID VOLTAGE
PLATE VOLTAGE IN KILOVOLTS
I_c = AMPERES
I_b = AMPERES
12
10
8
6
4
2
1
0
E_f = 27 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
0
2
4
6
8
10
12
14
16
18
20
22
24
26



DIMENSIONS—ML-298A & ML-298B

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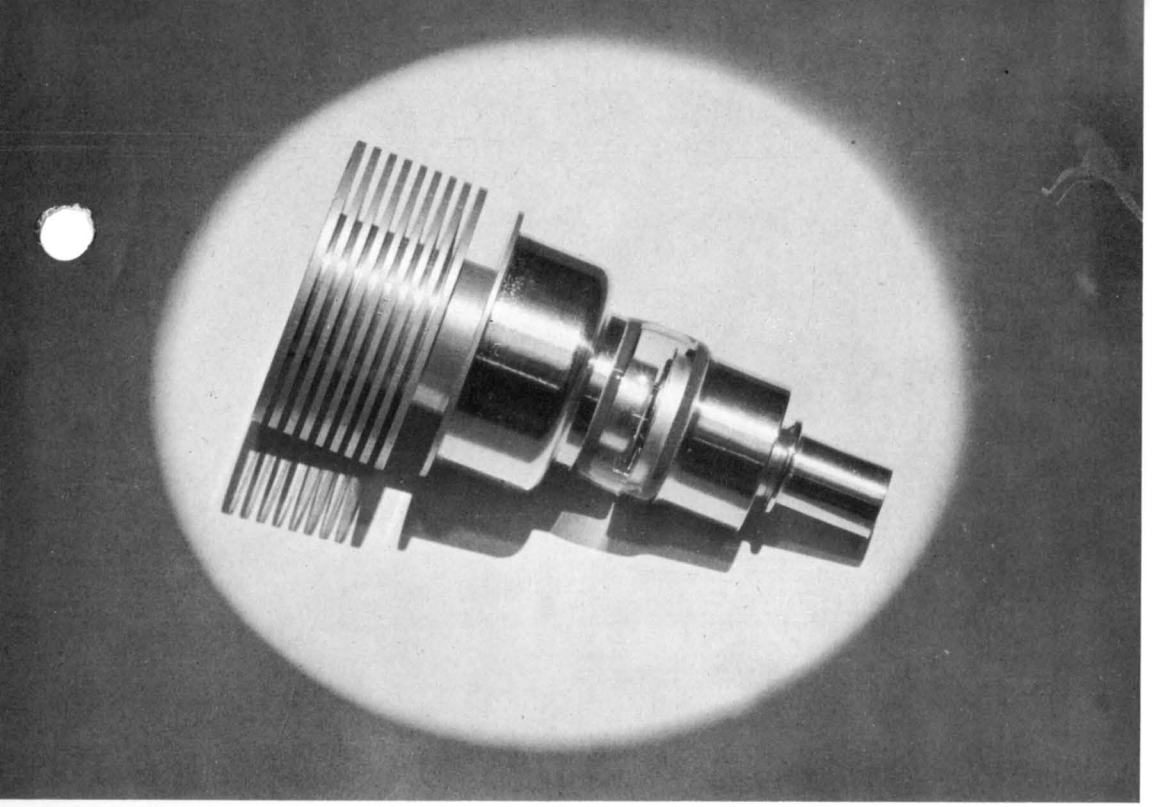


MACHLETT

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

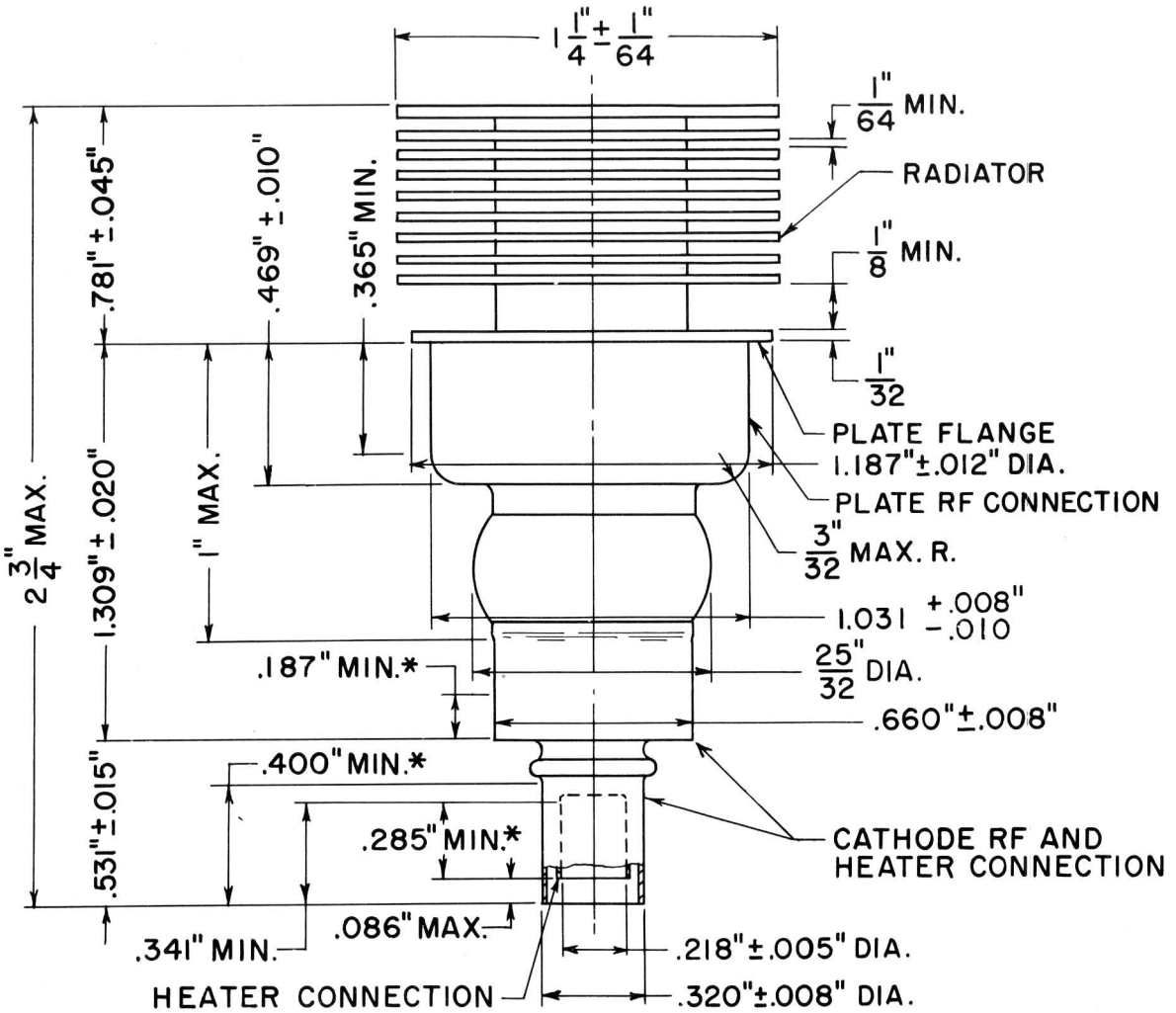
Mechanical

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



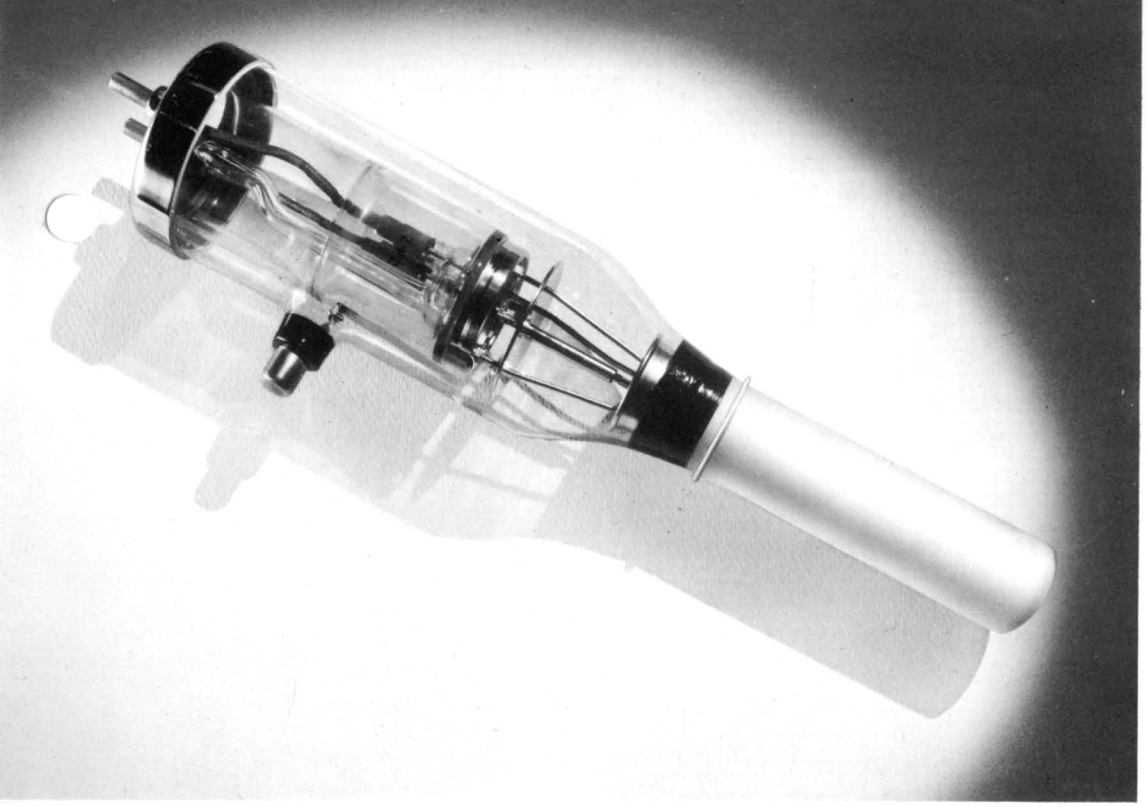
*Represents maximum straight portion available for contact area.

DIMENSIONS — ML-322

MACHLETT LABORATORIES, INC.

SPRINGDALE CONNECTICUT

U. S. A.



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

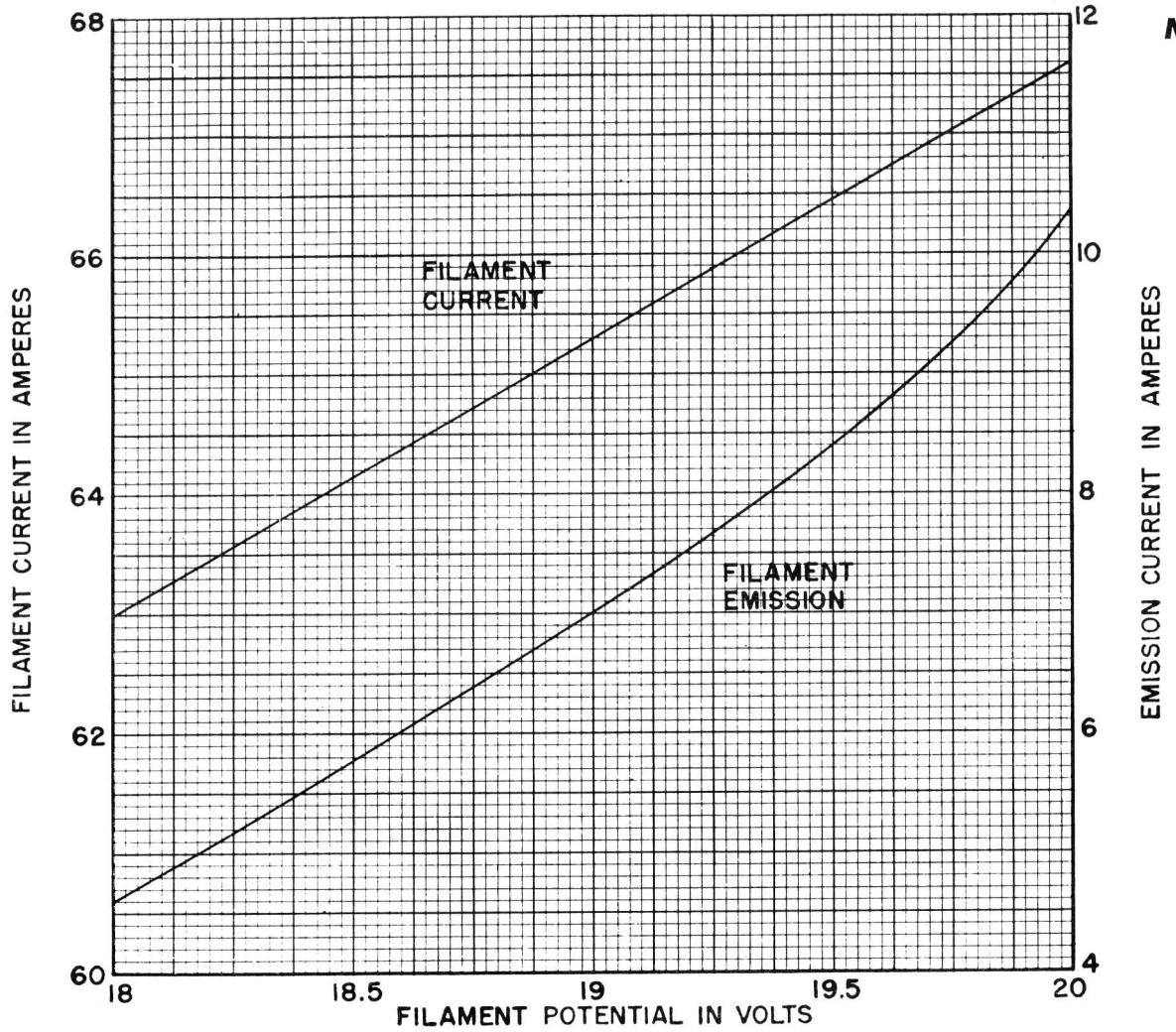
Direct Plate Voltage	18,000	15,000 volts
Direct Plate Current	2.5	2.5 amperes
Grid Bias	−675 to −900	−550 to −750 volts
Nominal Power Output	30,000	25,000 watts

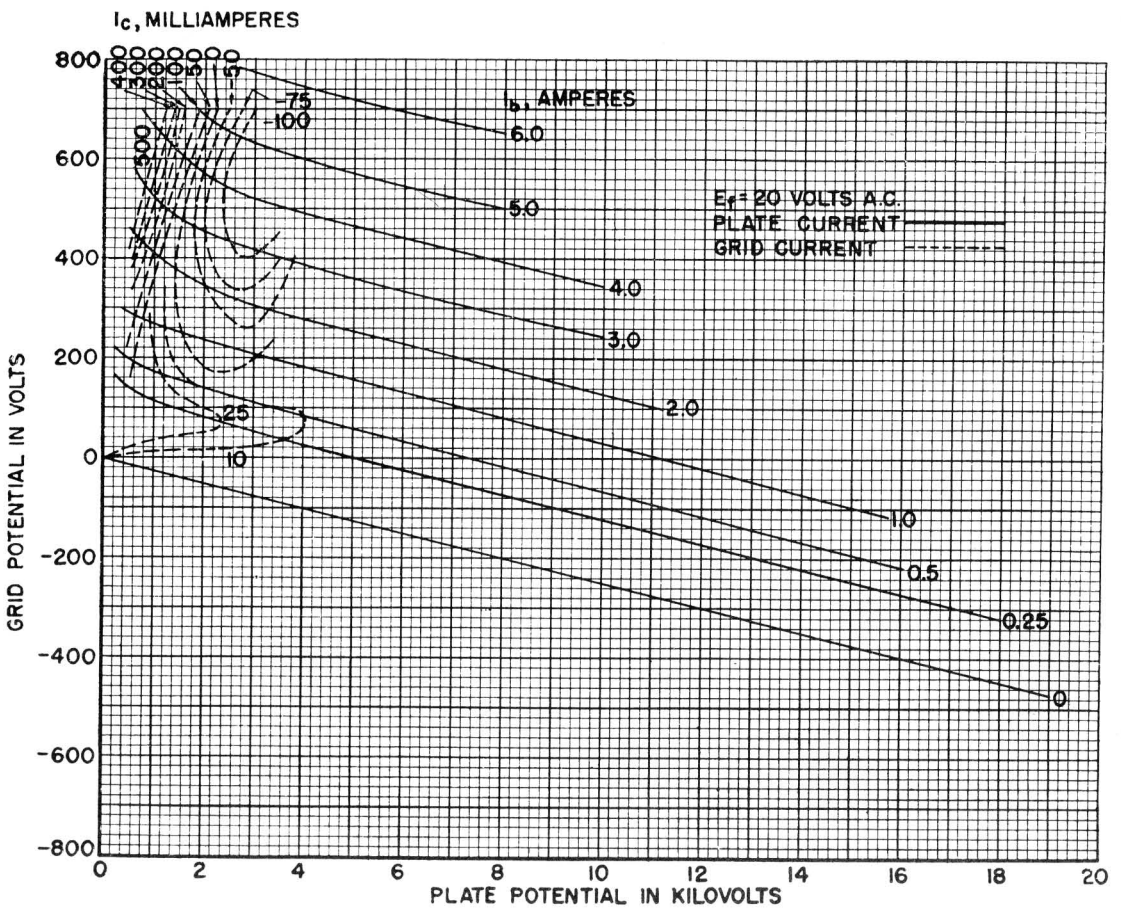
Class C—Radio-Frequency Amplifier—Plate Modulated

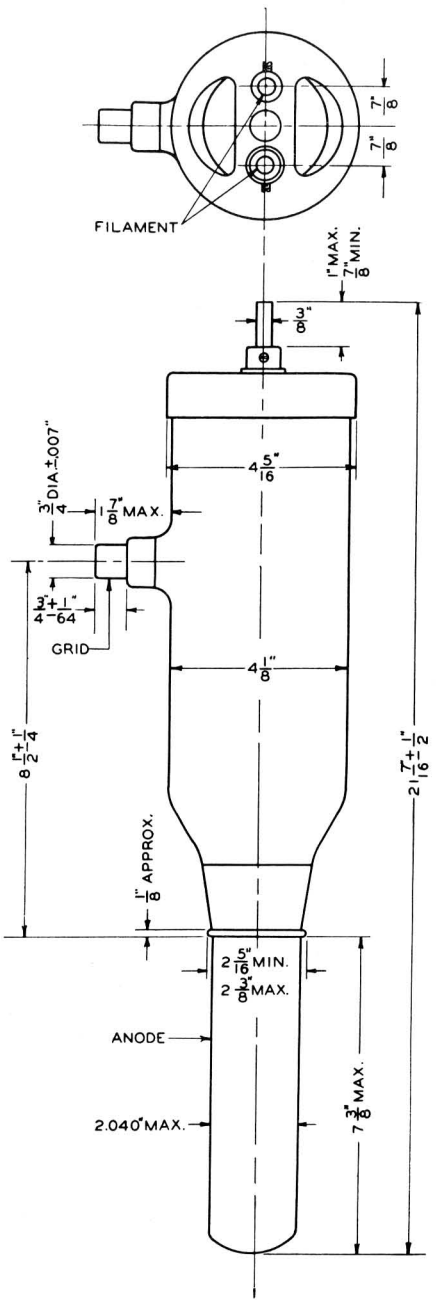
Direct Plate Voltage	12,500	10,000 volts
Direct Plate Current	1.2	1.5 amperes
Grid Bias	−600	−500 volts
Direct Grid Current	250	250 milliamperes
Nominal Carrier Power Output	10,000	10,000 watts

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


Ic, MILLIAMPERES
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
-75
-100
-25
10
GRID POTENTIAL IN VOLTS
PLATE POTENTIAL IN KILOVOLTS
800
600
400
200
0
-200
-400
-600
-800
0
2
4
6
8
10
12
14
16
18
20



DIMENSIONS—ML-342A

MACHLETT LABORATORIES, INC.

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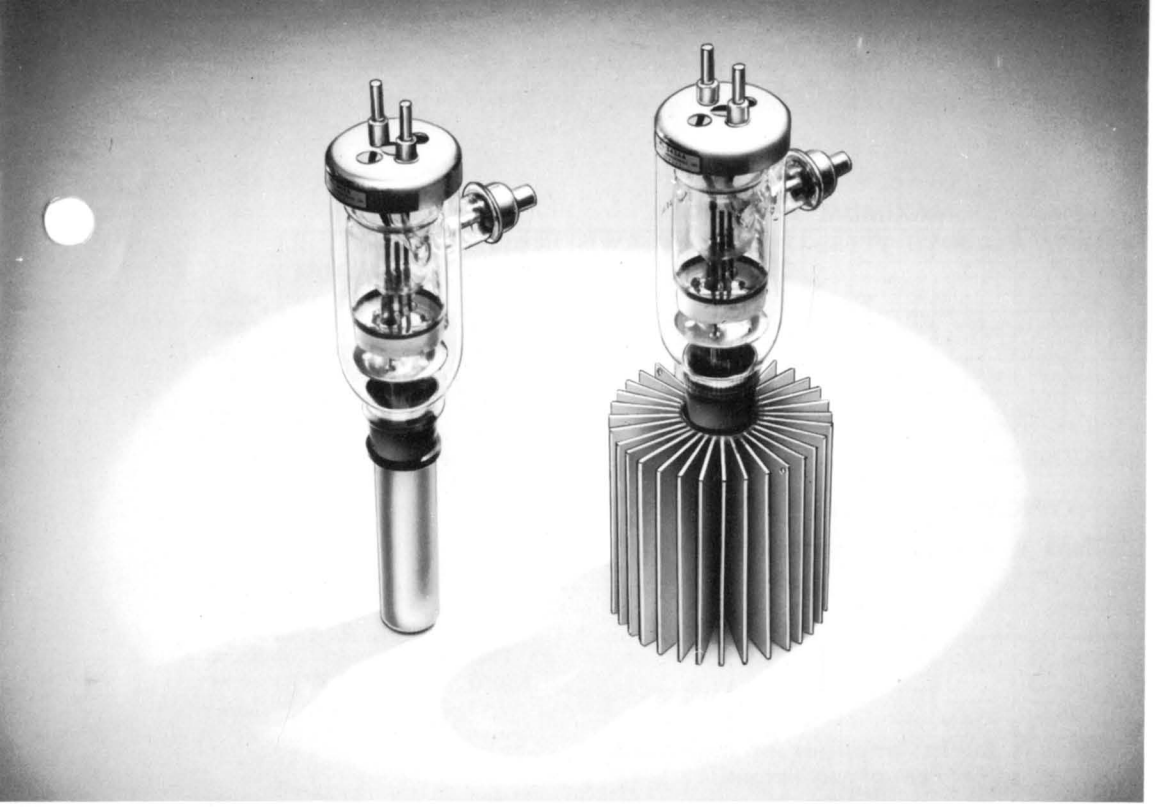


MACHLETT

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

Mounting Position	Vertical anode down	
	ML-343A	**ML-343AA**
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

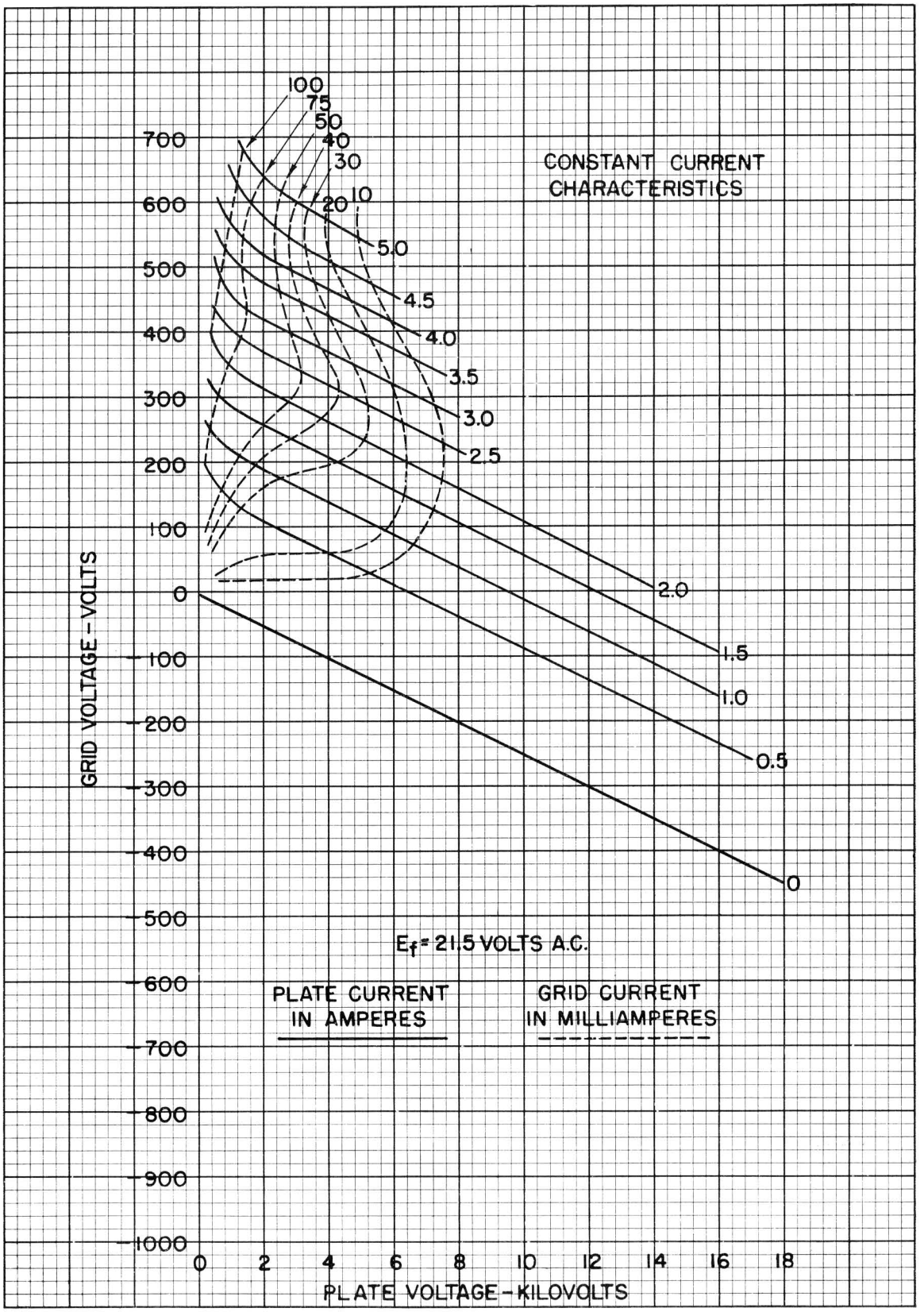
Class C Radio-Frequency Amplifier—Plate Modulated

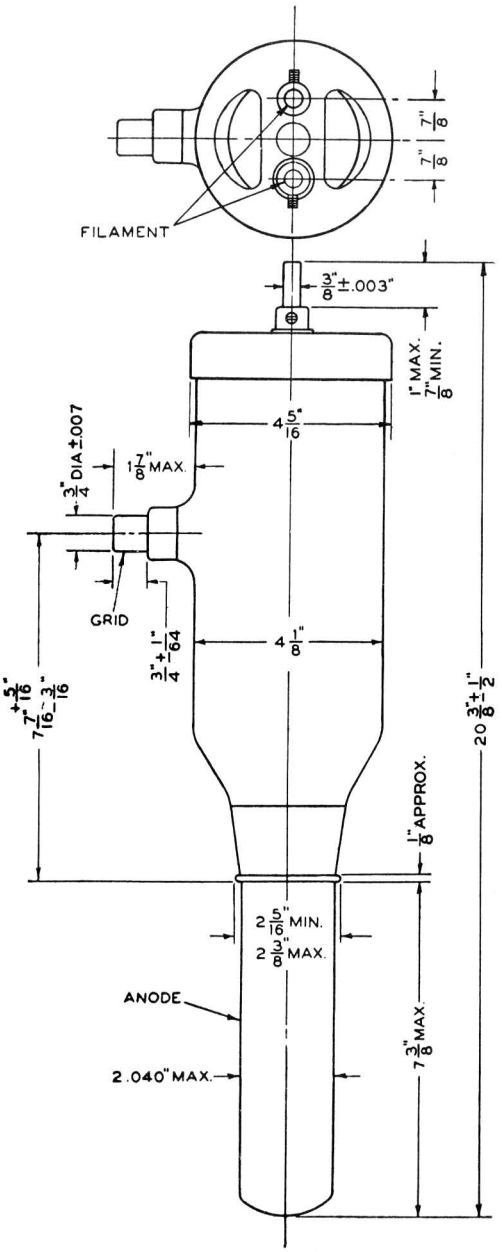
Direct Plate Voltage	7500	5000	volts
Direct Plate Current	1.0	1.0	amp
Grid Bias	—400	—300	volts
Direct Grid Current	150	150	mA
Nominal Carrier Power Output	5000	3300	watts

APPLICATION NOTES

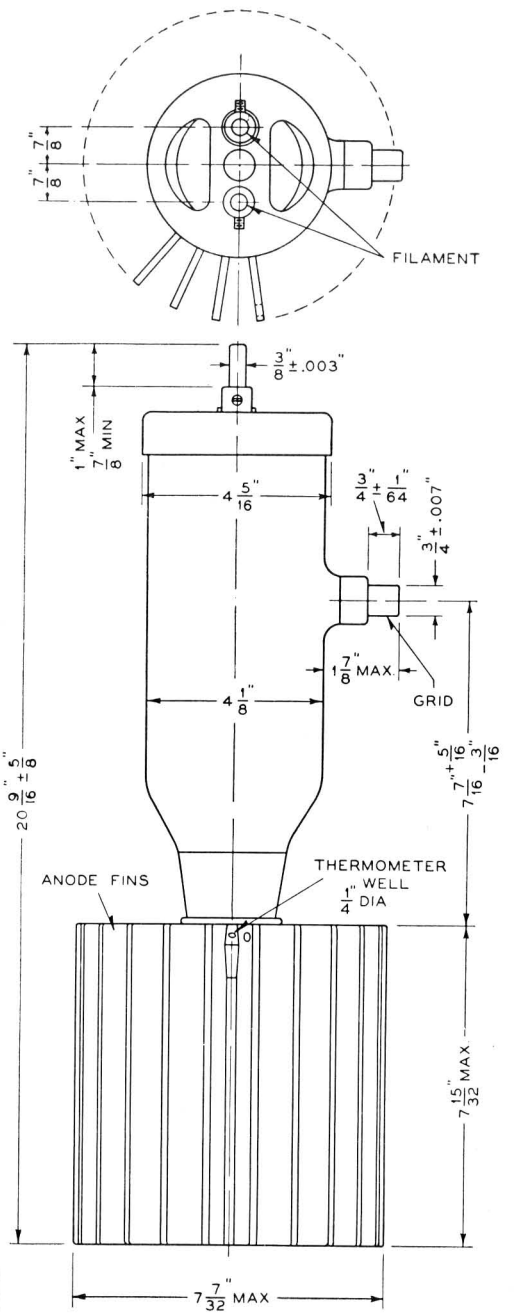
Maximum ratings apply at frequencies of 4 megacycles and less. The maximum plate voltage for the upper frequency limit of 16 megacycles is 5,000 volts. The maximum plate voltage for frequencies between 4 and 16 megacycles should be proportionately reduced.

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
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
-900
-1000
GRID VOLTAGE - VOLTS
E_f = 21.5 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

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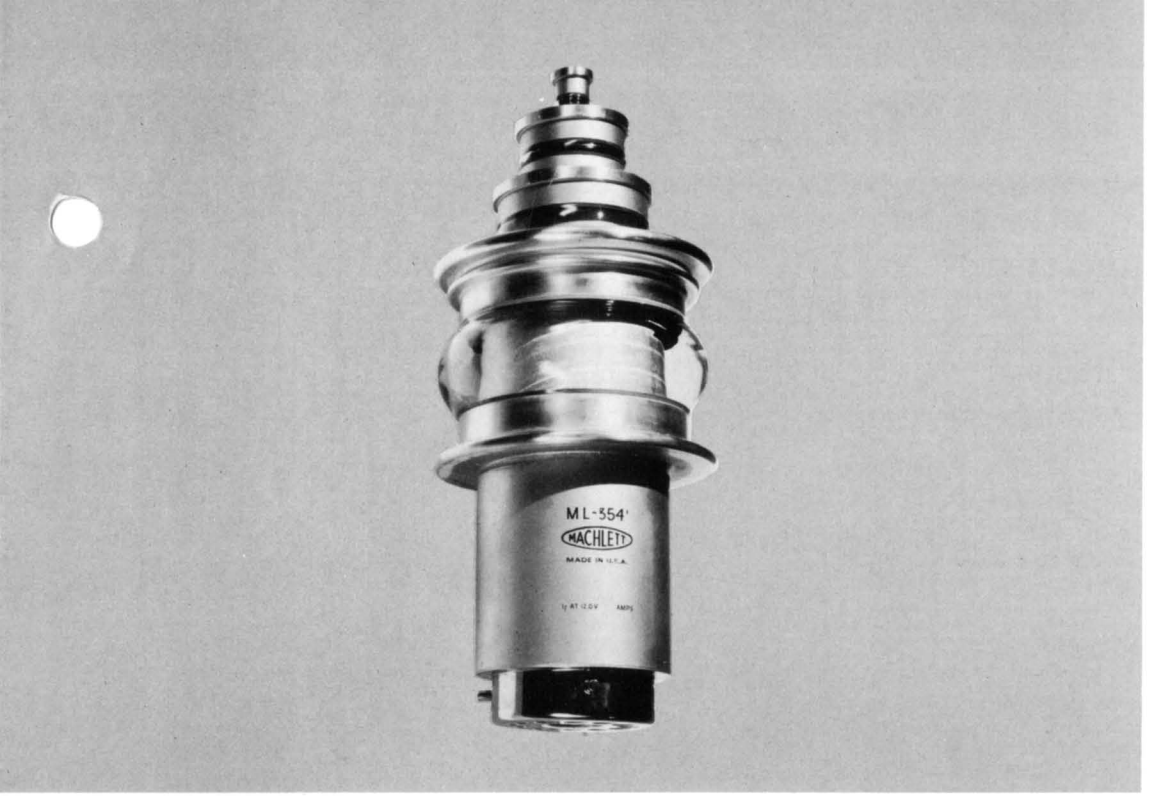


MACHLETT

ML-354

DESCRIPTION AND RATINGS

DESCRIPTION

The **ML-354** is a compact, high-power electron tube designed primarily for industrial heating service at frequencies up to 20 MC. It is a coaxial-terminal, water- and forced-air-cooled triode with maximum ratings of 15 kVdc plate voltage and 150 kW plate input.

Design features of the **ML-354** 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 $\mu\mu$f
Grid-Filament	76 $\mu\mu$f
Plate-Filament	2.0 $\mu\mu$f

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
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	15000 volts
D-C Grid Voltage	−3200 volts
D-C Plate Current	12 amps
D-C Grid Current	2.0 amps
Plate Input	150 kW
Plate Dissipation	75 kW

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

Typical Operation				
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
Driving Power, approximate	2.0	2.2	3.0	kW
Power Output, approximate	52	90	115	kW

APPLICATION NOTES

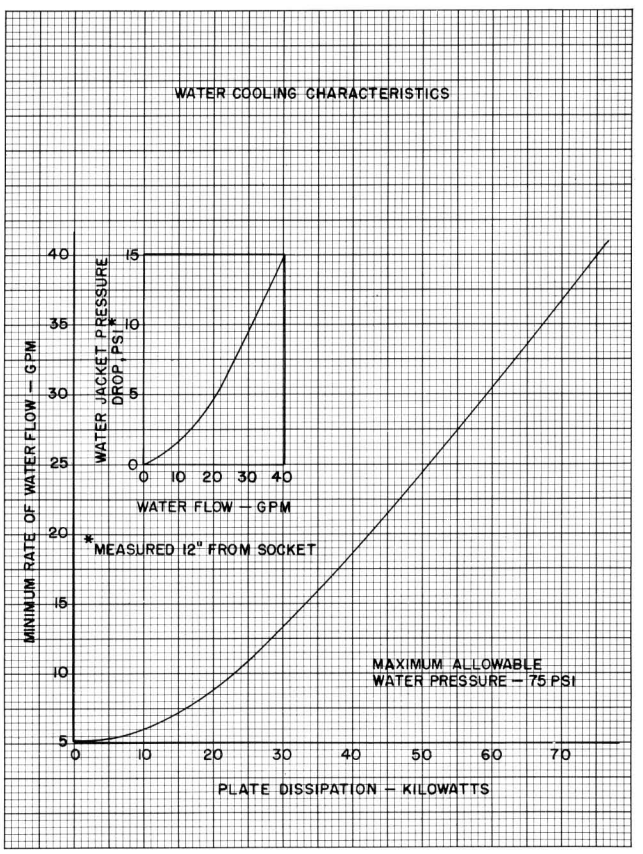
The handling of very high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can cause severe damage if not properly controlled. The ground lead of the plate circuit of each tube should be connected in series with the coil of 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 of a railway-type line-power 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, if used, to dissipate the filter-circuit energy as well as the rectifier output. 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 will give adequate protection with reasonably low power loss is as follows:

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

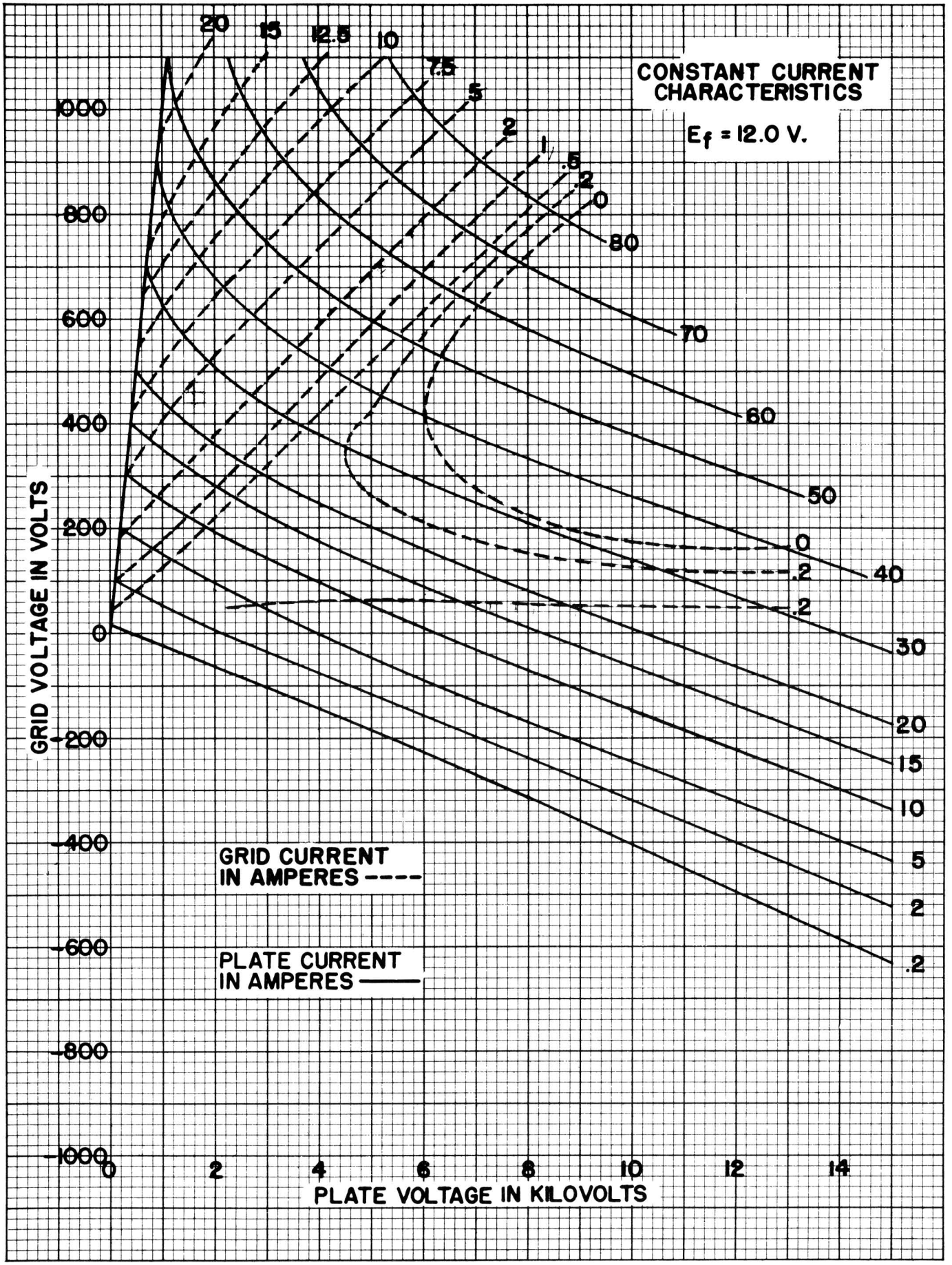
In most cases, especially in parallel operation of tubes when power-supply impedance is low, both the electronic shorting device and the series resistor are recommended.

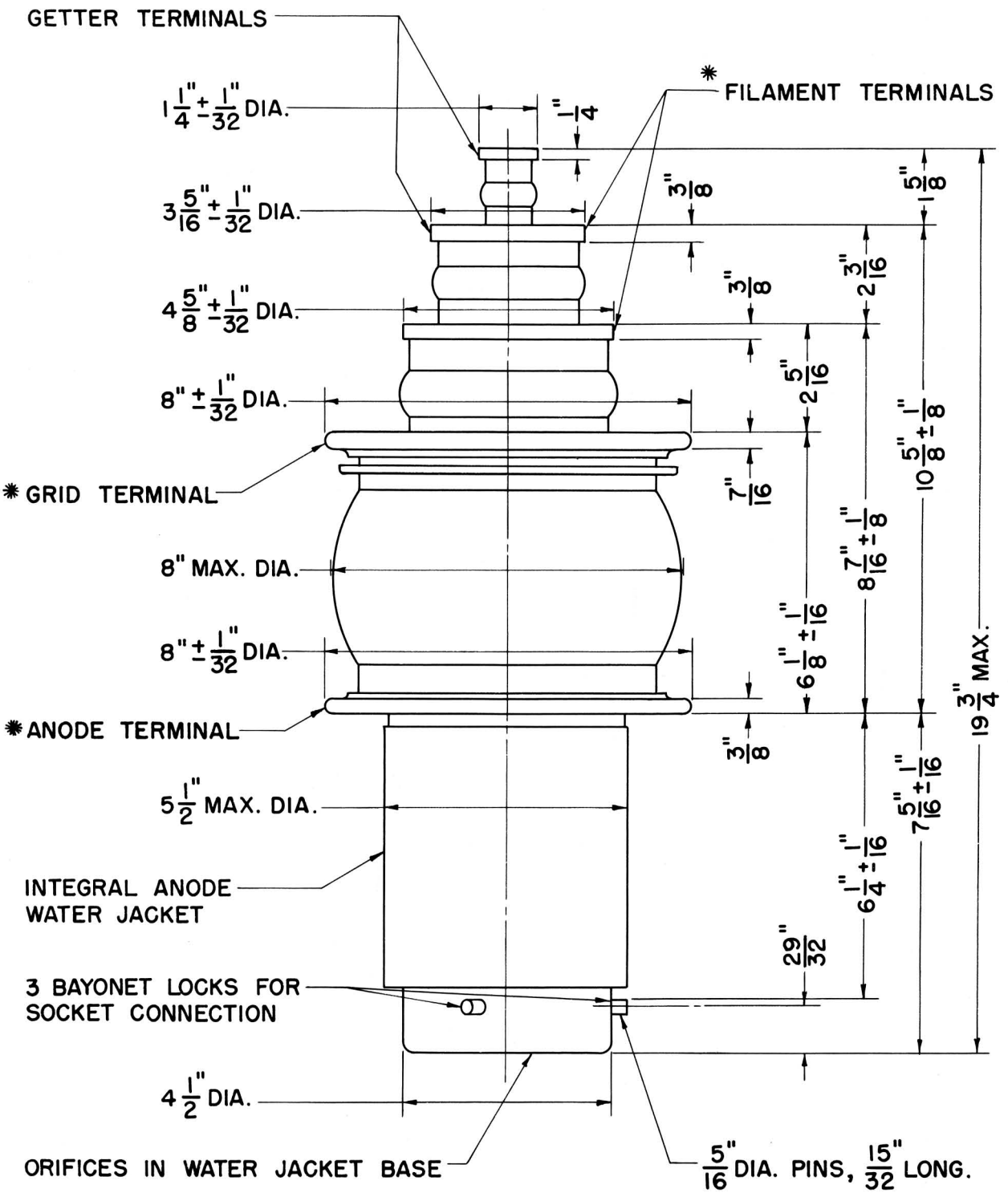
When such an electronic device is not installed, protective sphere gaps used in combination with the series plate resistor may be satisfactory. Gap spacings must be carefully adjusted for each individual application.



CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic	Conditions		Limits Minimum	Limits Bogey	Limits Maximum	
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:	2.1	2.8	3.5	kVdc
Plate Voltage	E_c = −300 Vdc; I_b = 3 Adc	E_b:	8.7	10.3	11.9	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;	P_o:	95	——	——	kW


CONSTANT CURRENT CHARACTERISTICS
E_f = 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
0
.2
.2
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



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

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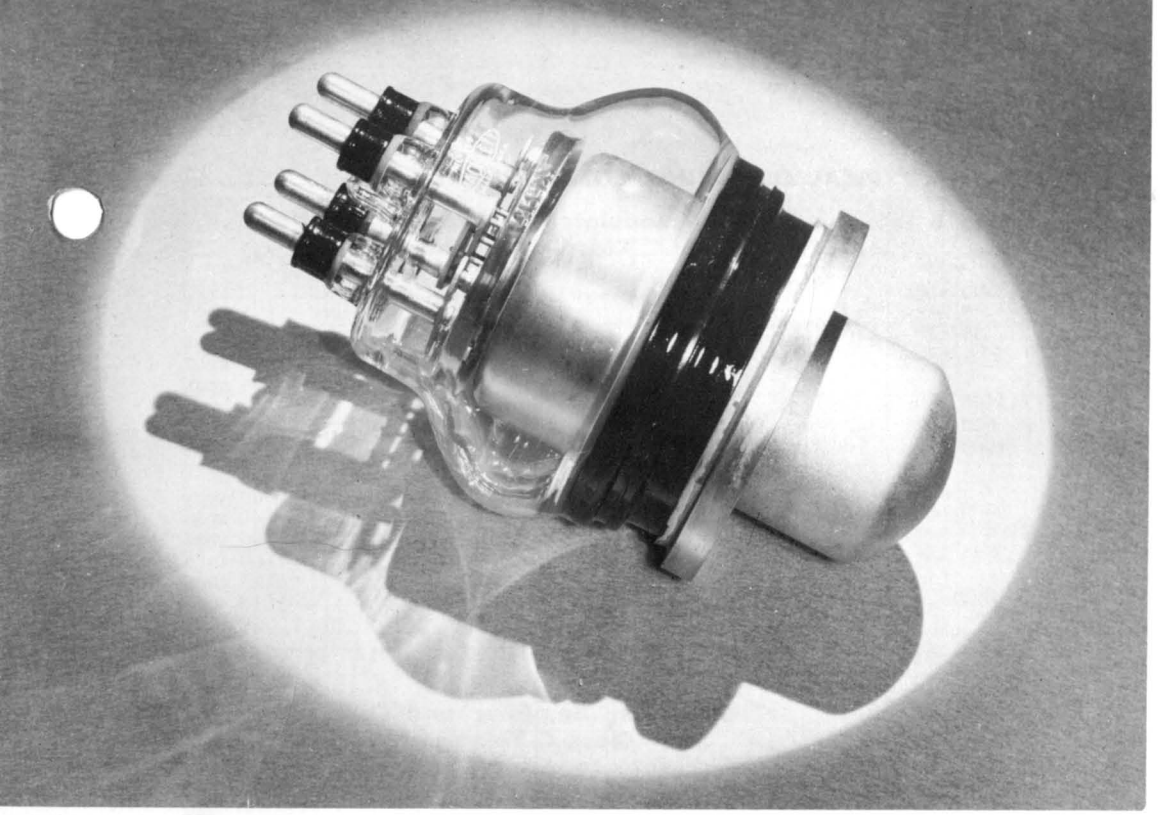


MACHLETT

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.

† The driving stage should have good regulation and should be capable of supplying considerably more than the specified driving power.

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

** Subject to wide variations depending on the impedance of the load circuit. High-impedance load circuits require more grid current, and driving power to obtain the desired output. Low-impedance circuits require less grid current and driving power but sacrifice plate-circuit efficiency. The driving stage should have a tank circuit with good regulation and should be capable of supplying considerably more than the required driving power.

‡ 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

‖ Obtained by grid resistor of 1075 ohms or by partial self-bias methods.

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.

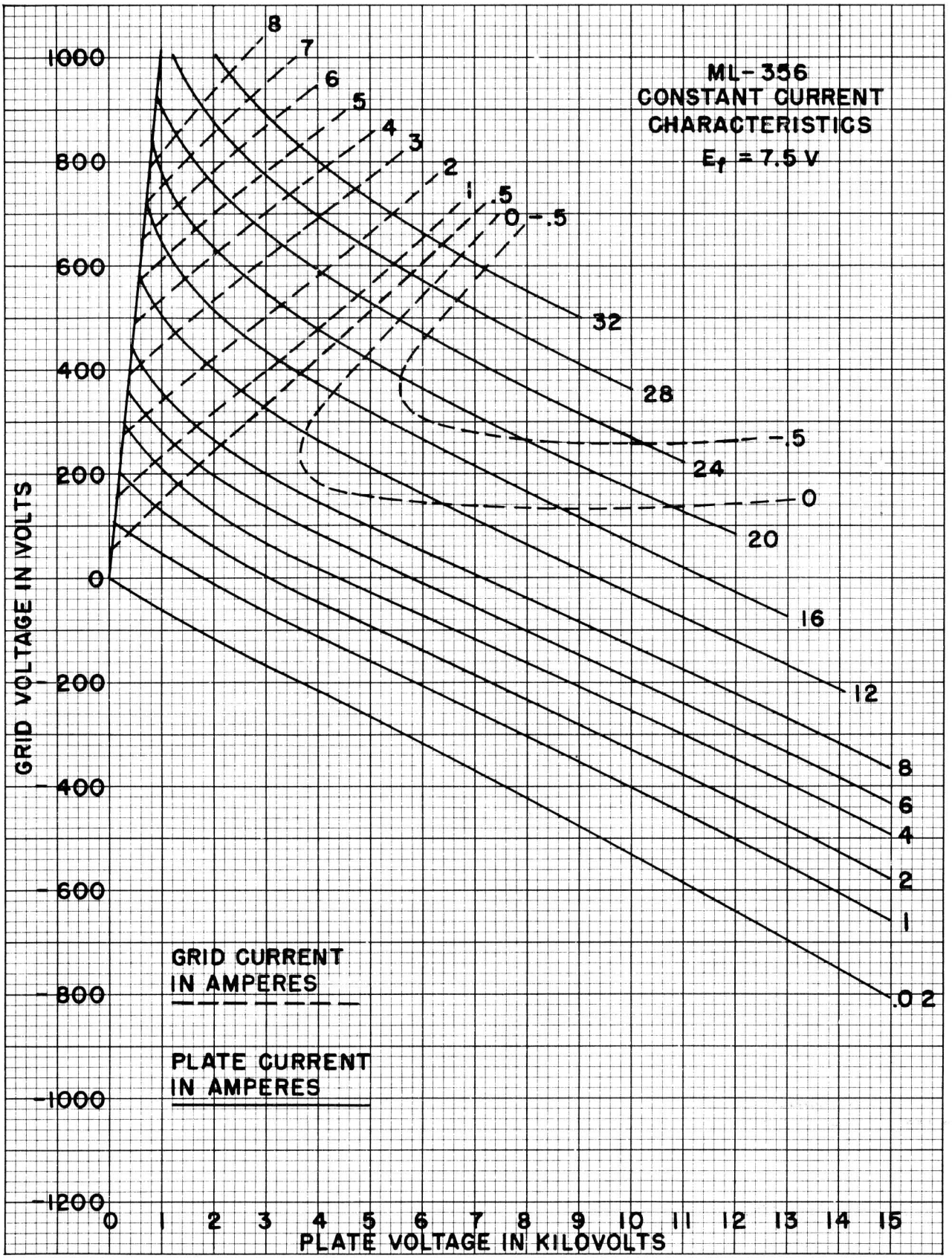
MAXIMUM FREQUENCY RATINGS

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		Limits Minimum	Limits 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:	2.5	3.2	3.6 kVdc
Plate Voltage	E_c = —200 Vdc; I_b = 2.0 kVdc;	E_b:	6.2	7.2	8.2 kVdc
Grid Voltage	E_b = 10 kVdc; I_b = .020 Adc	E_c:	—460	—530	—600 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

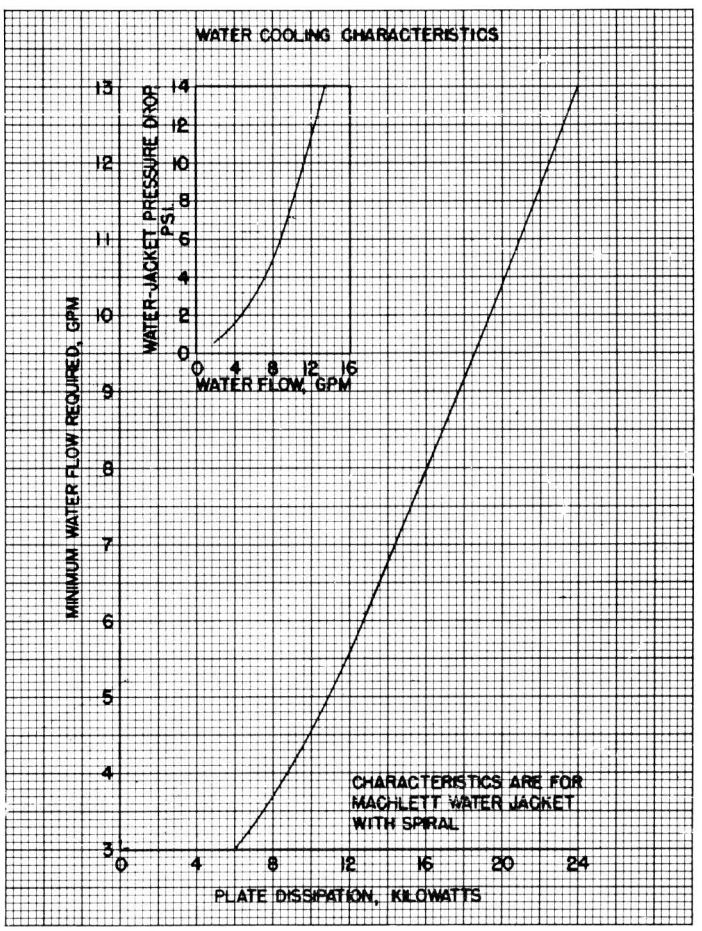

ML-356
CONSTANT CURRENT
CHARACTERISTICS
E_f = 7.5 V
8
7
6
5
4
3
2
1
.5
0
-.5
32
28
24
20
16
12
8
6
4
2
1
.02
-.5
0
GRID VOLTAGE IN VOLTS
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
GRID CURRENT
IN AMPERES
PLATE CURRENT
IN AMPERES
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
PLATE VOLTAGE IN KILOVOLTS

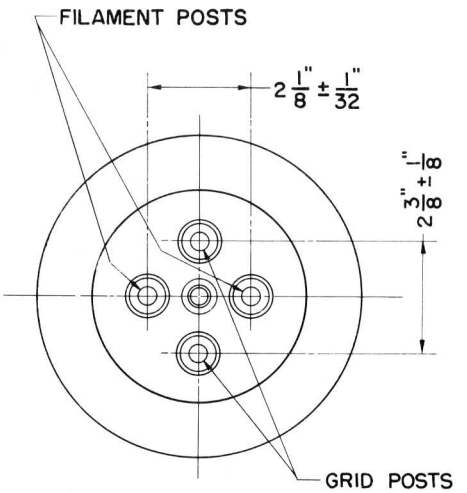
APPLICATION NOTES

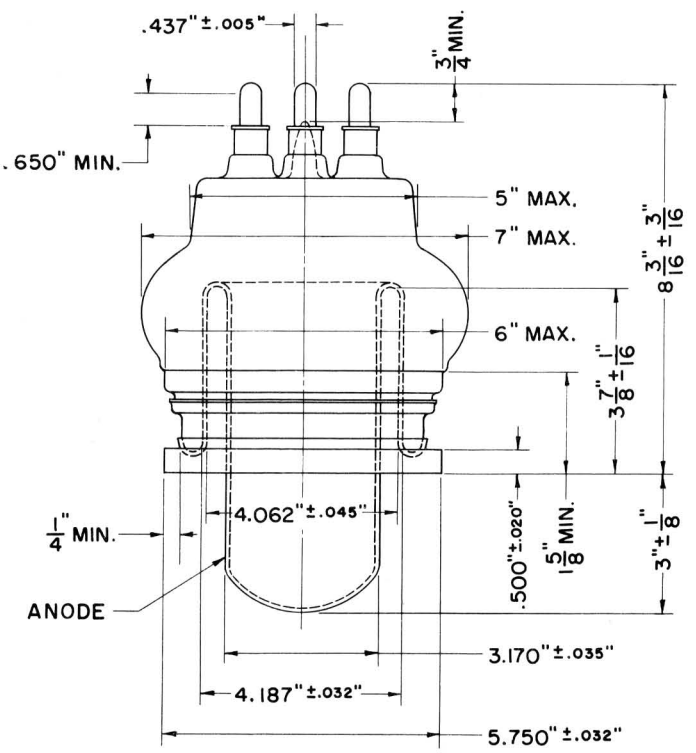
The handling of high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can severely damage the electron tube if not properly controlled. Therefore the ground leads of the plate and grid circuits should be equipped with individual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

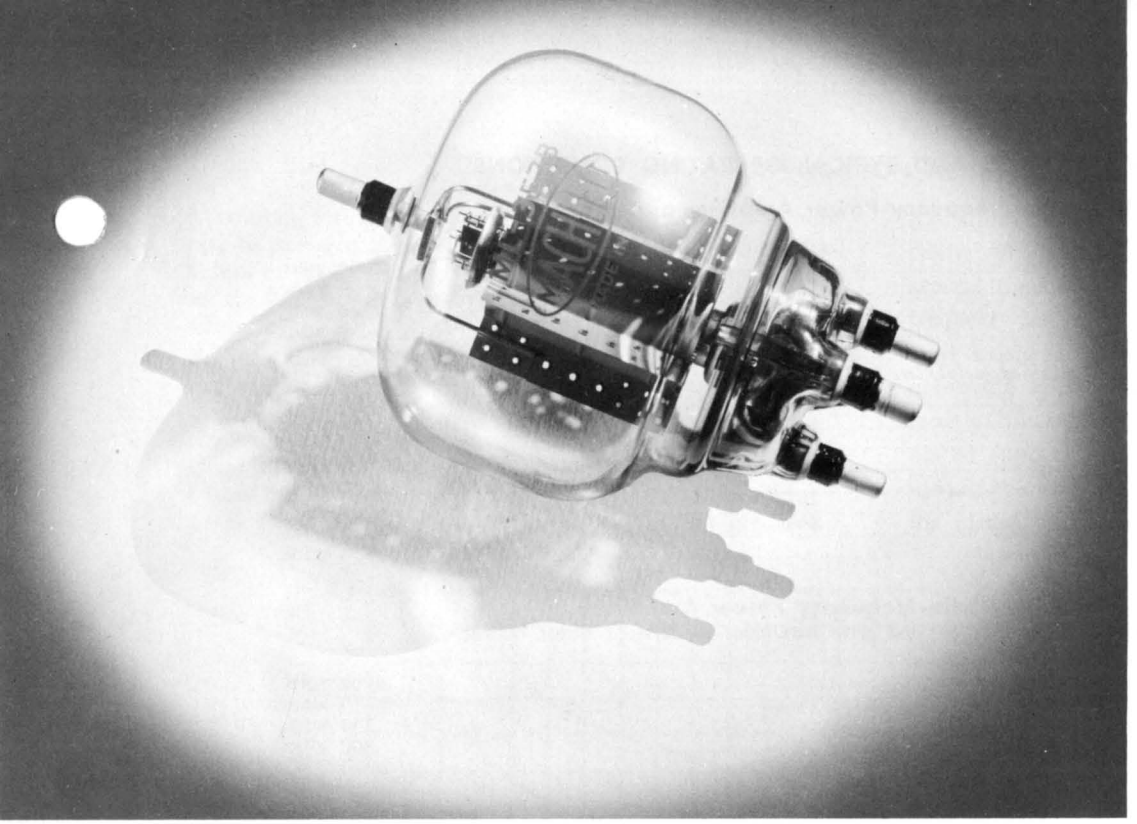
Additional protection is recommended and may be obtained by connecting a resistor in series with the plate lead of each tube for protection of the tube during the time required for the plate overload relay to act. The criterion is the total energy to which the tube can be subjected. The minimum value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

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









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

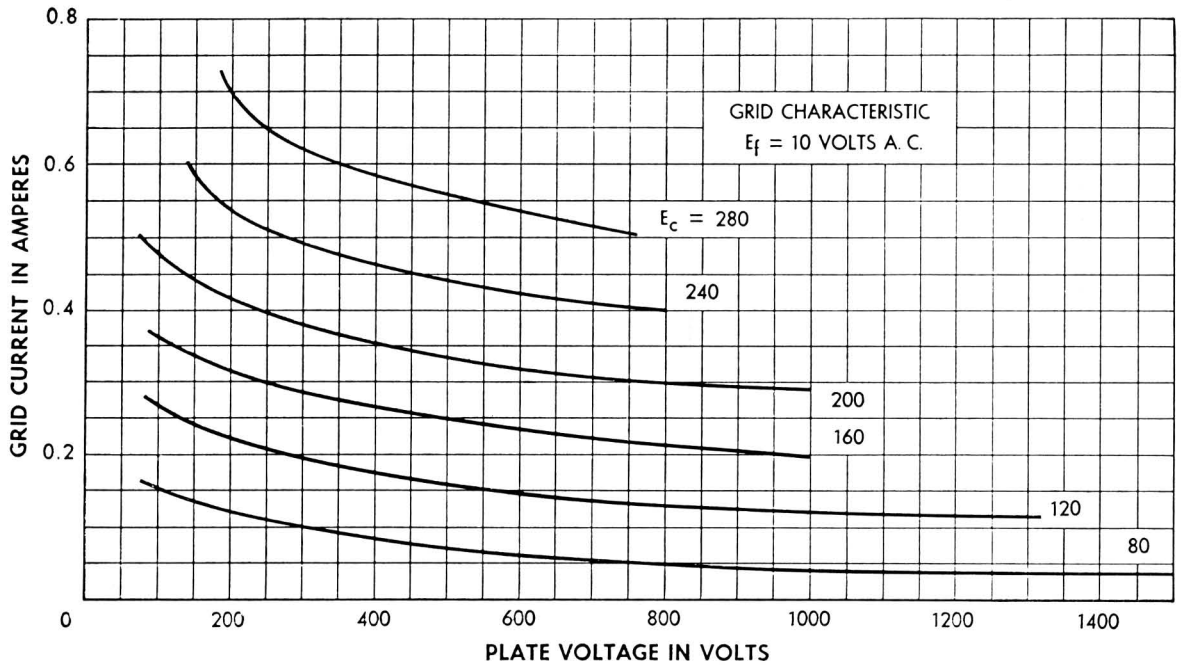
* Averaged over any audio-frequency cycle of sine wave form.
† At crest of audio-frequency cycle with modulation factor of 1.0.
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of its unmodulated value.

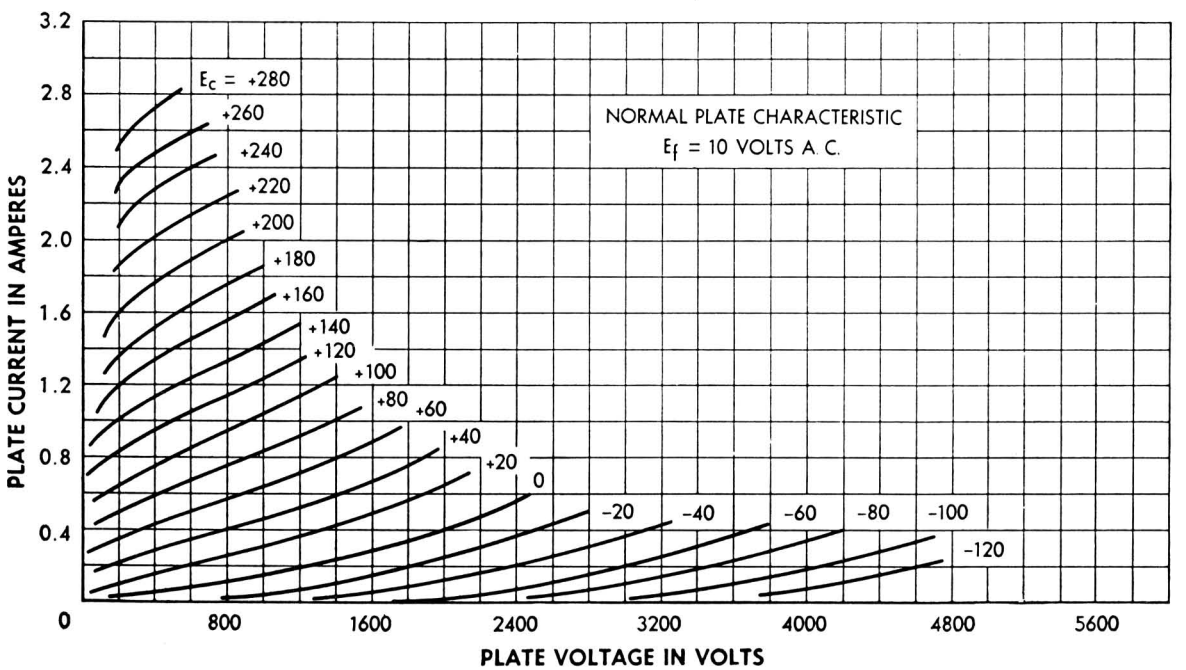
APPLICATION NOTES

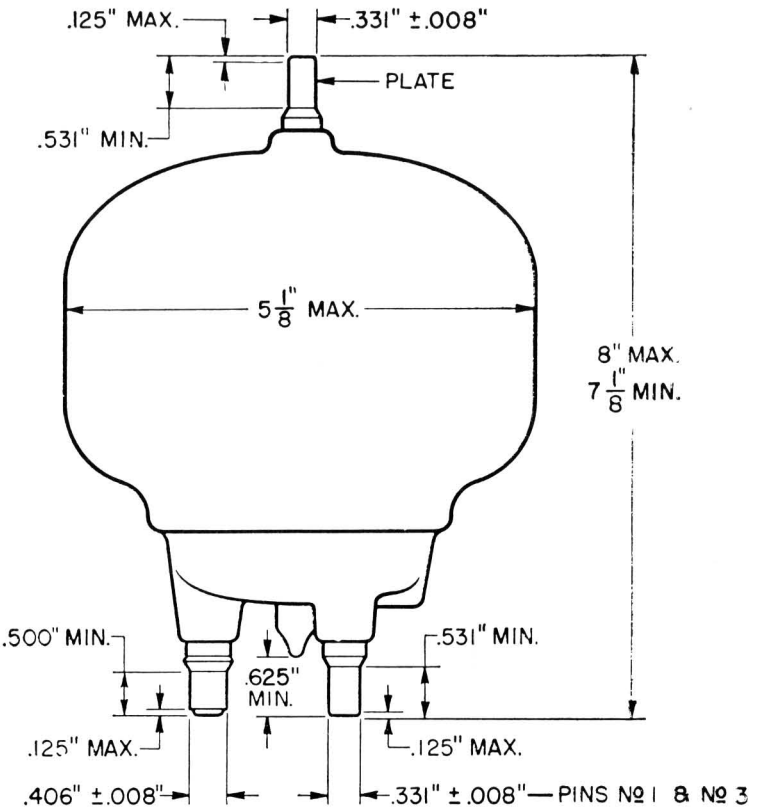
Maximum ratings apply up to 100 megacycles. The tube may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below. Other maximum ratings are not affected.

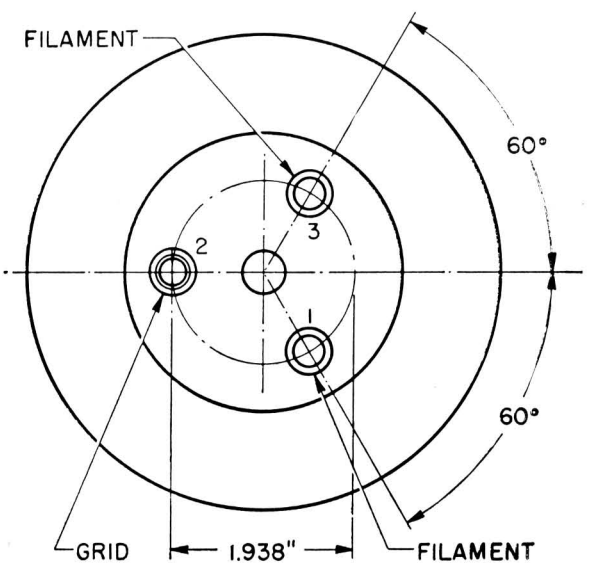
Frequency	100	125	150 megacycles
Percentage of maximum rated plate voltage and plate input			
Class B	100	85	70 per cent
Class C, plate modulated	100	75	50 per cent
Class C, unmodulated	100	80	60 per cent

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.

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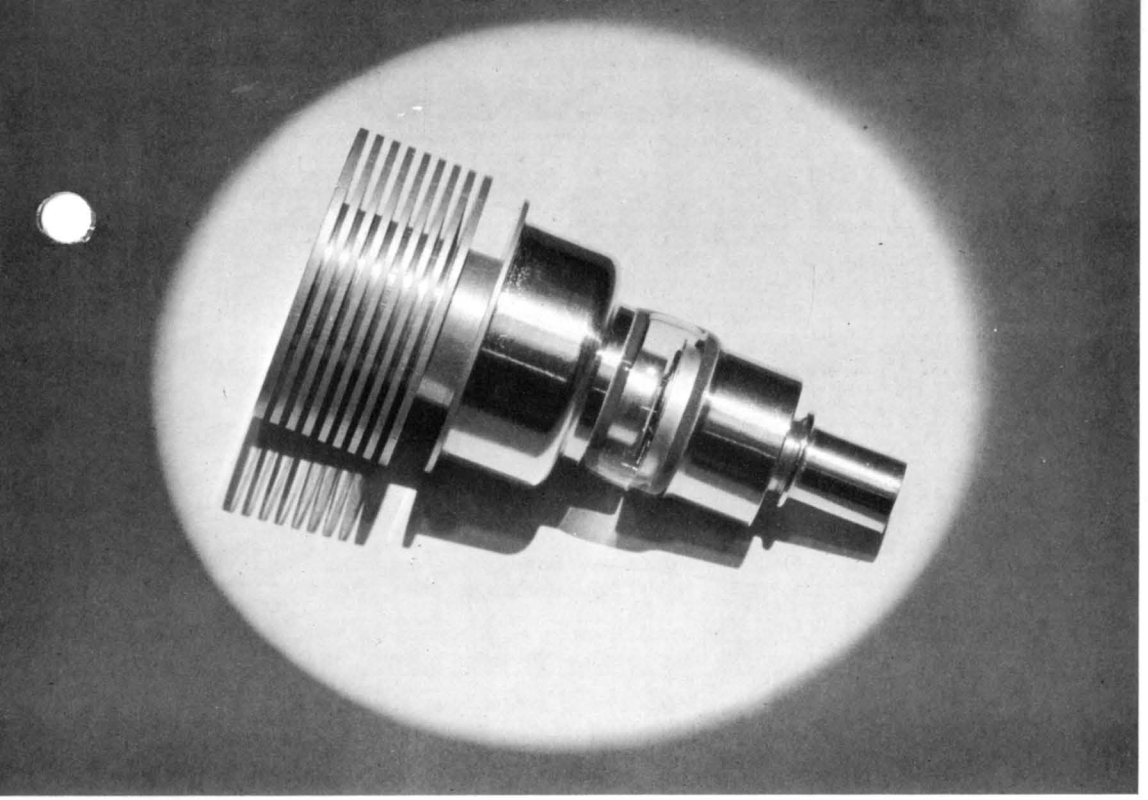


MACHLETT

ML-381

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-381** is a high-mu triode of the planar-electrode type designed for use as a plate-pulsed oscillator, frequency multiplier, 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-381** 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 (see Application Notes)	6.0	Volts ±5%
Heater Current at 6.0 Volts	1.0	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	See Duty Cycle Chart	
Maximum Pulse Length	5	usecs
Mechanical		
Mounting Position	Optional	
Type of Cooling	Forced Air*	
Maximum Anode Temperature	175	°C
Net Weight	2¼	oz.

*For cooling requirements, refer to "Cooling" under "Application Notes".

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Plate-Pulsed Oscillator and Amplifier—Class C

Maximum Ratings, Absolute Values

For a pulse length of	5	usec
Duty Factor	3.3×10^{-3}	
Peak Plate Pulse Supply Voltage	3500	volts
Peak Grid Bias Voltage	-150	volts
Peak Plate Current from Pulse Supply	3	amps
Average Plate Current	10	mA
Average Grid Current	5	mA
Average Plate Dissipation	35	watts
Average Grid Dissipation	2	watts
Frequency	3000	Mc

Typical Operation: 2500 Mc Oscillator

Pulse Length	5	usec
Duty Factor	3.0×10^{-3}	
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	9	mA
Average Grid Current	3	mA
Driving Power During Pulse, Approximate	450	watts
Useful Power Output at Peak of Pulse, Approx.	2200	watts
Pulse Recurrence Rate	660	pps

Frequency Doubler—Class C Telegraphy

Maximum Ratings, Absolute Values

For a pulse length of	5	usec
Duty Factor	3.3×10^{-3}	
Peak Plate Pulse Supply Voltage	3500	volts
Peak Grid Bias Voltage (from cathode resistor)	-200	volts
Peak Cathode Current	3	amps
Average Plate Current	6.5	mA
Average Grid Current	2.0	mA
Average Plate Input	25	watts
Average Plate Dissipation	25	watts
Average Grid Dissipation	1.0	watt

Typical Operation — Doubler 600 to 1200 Mc

Pulse Length	3	usec
Duty Factor	3.0×10^{-3}	
Filament Voltage (See Application Notes)	5.5	volts
Peak Plate Pulse Supply Voltage	3500	volts
Peak Grid Bias Voltage (from cathode resistor)	-190	volts
Cathode Resistor	160	ohms
Peak Plate Current	1.2	amps
Driving Power During Pulse, Approximate	600	watts
Useful Power Output at Peak of Pulse, Approx.	1200	watts
Average Plate Dissipation	9	watts

Characteristic Range Values for Equipment Design

	Min.	Max.	
Filament Current at 6.0 volts (Note 1)	0.92	1.08	A
Plate Current (Note 2)	60	95	mAdc
Cut-off Bias (Note 3)	—	-15	Vdc
Transconductance	20,000	30,000	
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.

APPLICATION NOTES

MECHANICAL

Mounting

Contact 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 and tolerances specified on the tube outline drawing. The tube when in the socket should seat against the anode flange. The tube should not be seated or stopped by any other surfaces.

Cooling

Sufficient air cooling must be provided to maintain the maximum temperature of the grid, cathode and anode seals and the anode radiator shank at 175°C or less. In most cases, forced-air cooling of all three electrode surfaces is required. The following chart shows air flow in cfm at sea level versus input air temperature in °C for several values of plate dissipation. These data indicate the minimum air-flow requirements and cowl dimensions necessary to maintain the radiator temperature at or below 175°C. Improved tube life may be obtained if all seals are cooled well below the maximum limit of 175°C and by lowering the anode radiator shank tempera-

ture by providing more than the minimum air flow indicated on this chart. The cathode and heater seals are ordinarily well enclosed in coaxial circuits and require careful attention to insure proper cooling. Templiaq* paint is suggested for making temperature measurements.

* Product of Tempil Corporation, New York, N. Y.

ELECTRICAL

Heater Voltage

V.H.F. and U.H.F. tubes operate at frequencies where the transit time (i.e. the time for an electron to traverse the space between grid and cathode) is not small compared with the period of oscillation. Under such conditions, electron bombardment of the cathode occurs due to returned out of phase electrons and the cathode temperature may be raised excessively. The "back heating" is a function of frequency, peak r-f grid voltage, grid current, grid bias and circuit design. The optimum heater voltage cannot be accurately specified because of the dependence on circuitry. For most applications where liberal seal cooling is provided, the following table of heater voltages vs. frequency should be satisfactory for plate voltages above 3 KV and peak cathode current of 2.5 amps. At lower plate voltages and currents, back heating will increase requiring lower filament voltages.

Frequency	Ef
Up to 400 Mc	6.0 volts
400 to 1000 Mc	5.8 volts
1000 and over	5.5 volts

Permitted tolerances on filament voltage are ± 10% of the values given above. For long tube life, however, a maximum variation in filament voltage of ± 5% is advised. If such improved regulation is provided, Ef can advantageously be lowered 5% below the values given in the table.

Plate Surge-Limiting Impedance

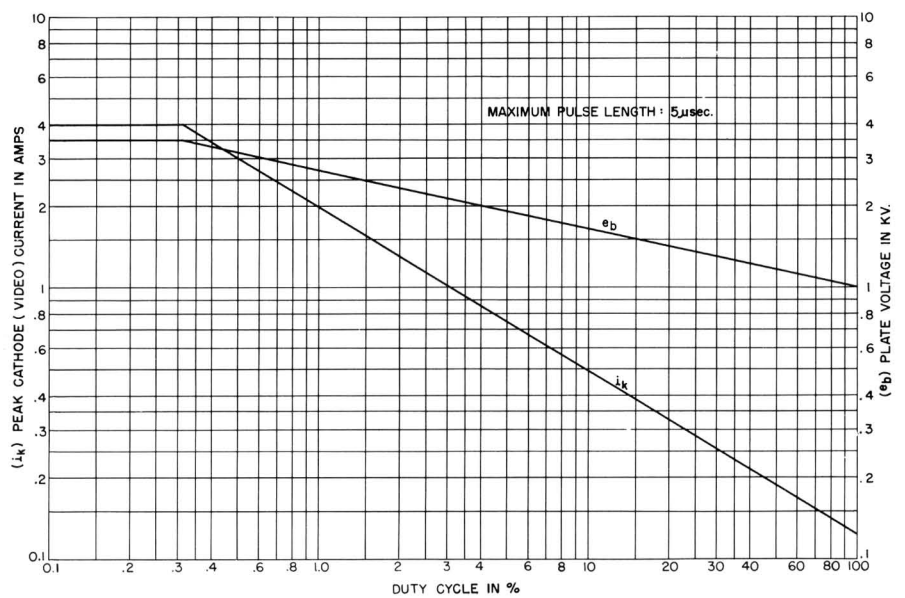
In tubes such as the ML-381, which have very closely spaced electrodes, extremely high voltage gradients occur even with moderate tube operating voltages. Any tube flash-arcing may be destructive. A series impedance in the B+ lead is recommended to limit the peak current under surge conditions to 10 times maximum rating or less. 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 cathode heater winding, and may cause shorting of the heater element unless current limiting is provided. Failure of tubes due to internal flash-arcs are 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.

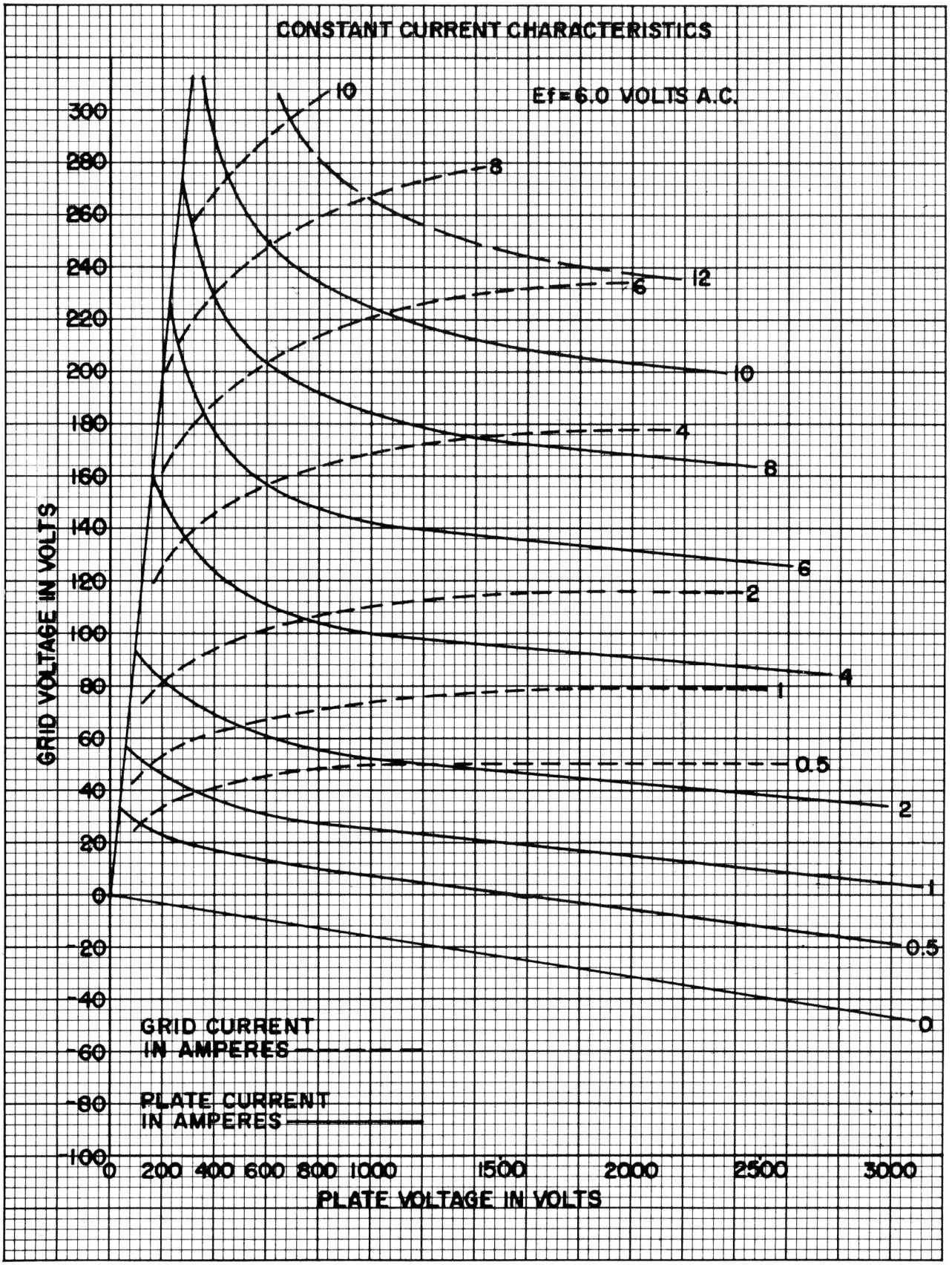
Provision for Circuit Tuning

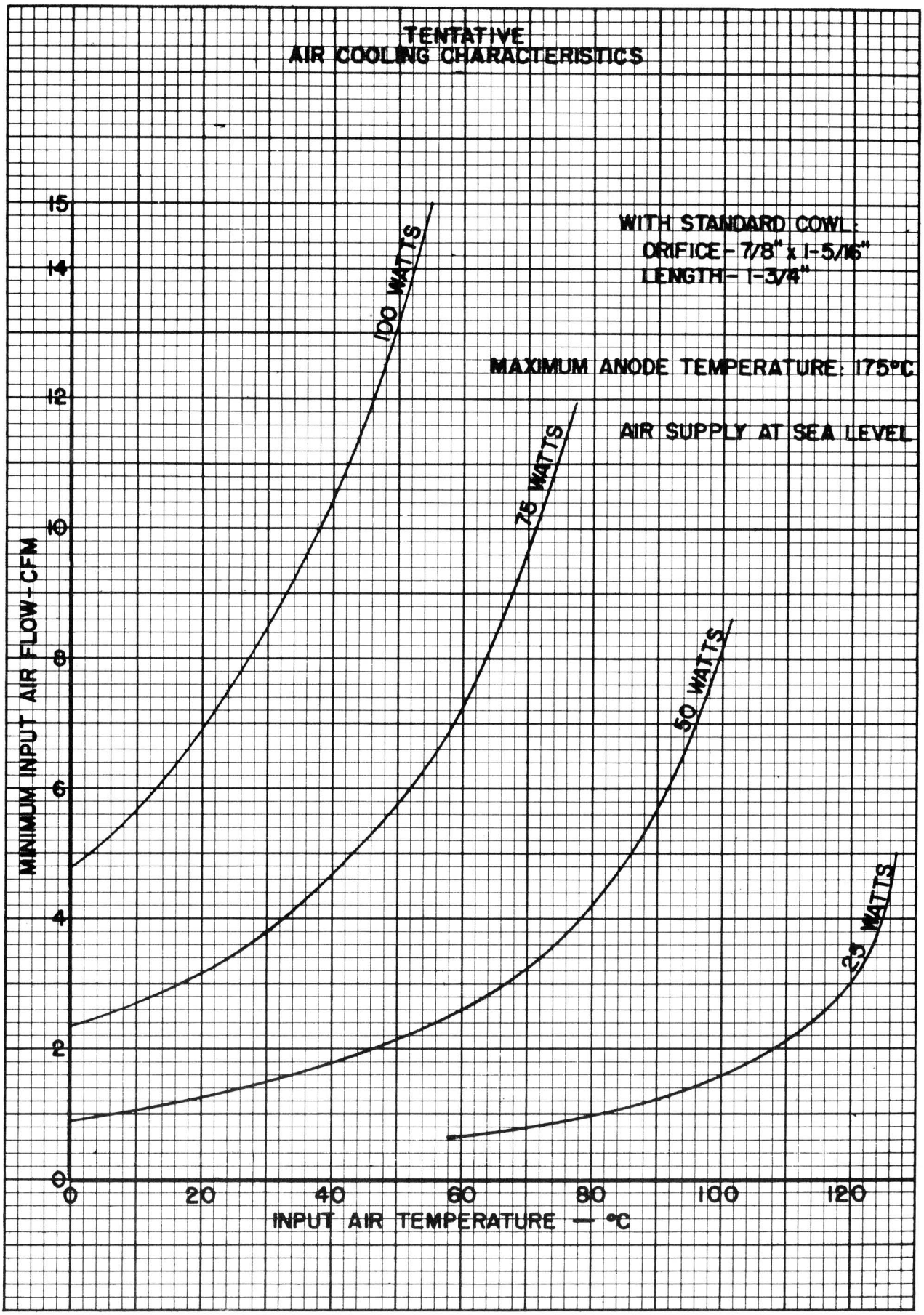
With high-frequency circuits, a very small motion of a tuning plunger may throw the tube out of resonance and result in high plate current and/or excessive anode dissipation. It is required that provision be made for tuneup at a plate voltage which is approximately 70% of normal, i.e. half power.

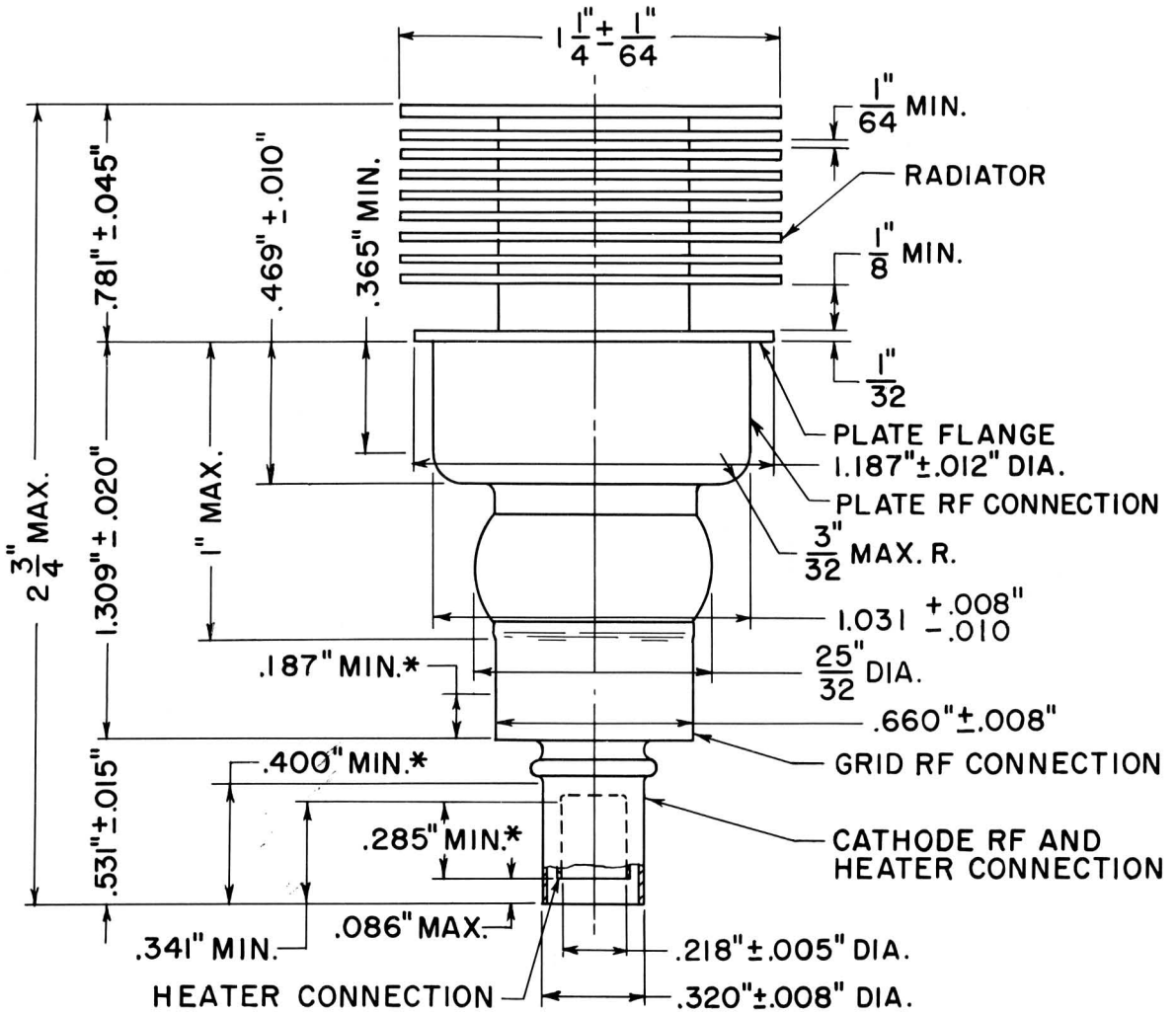
Determination of Proper Grid Drive

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 shorter tube life.




CONSTANT CURRENT CHARACTERISTICS
Ef=6.0 VOLTS A.C.
GRID VOLTAGE IN VOLTS
PLATE VOLTAGE IN VOLTS
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
0
200
400
600
800
1000
1500
2000
2500
3000
10
8
6
4
2
1
0.5
0
12
10
8
6
4
2
1
0.5
0


TENTATIVE
AIR COOLING CHARACTERISTICS
WITH STANDARD COWL:
ORIFICE - 7/8" x 1-5/16"
LENGTH - 1-3/4"
MAXIMUM ANODE TEMPERATURE: 175°C
AIR SUPPLY AT SEA LEVEL
100 WATTS
75 WATTS
50 WATTS
25 WATTS
MINIMUM INPUT AIR FLOW-CFM
0
2
4
6
8
10
12
14
15
0
20
40
60
80
100
120
INPUT AIR TEMPERATURE — °C



*Represents maximum straight portion available for contact area.

DIMENSIONS—ML-381

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

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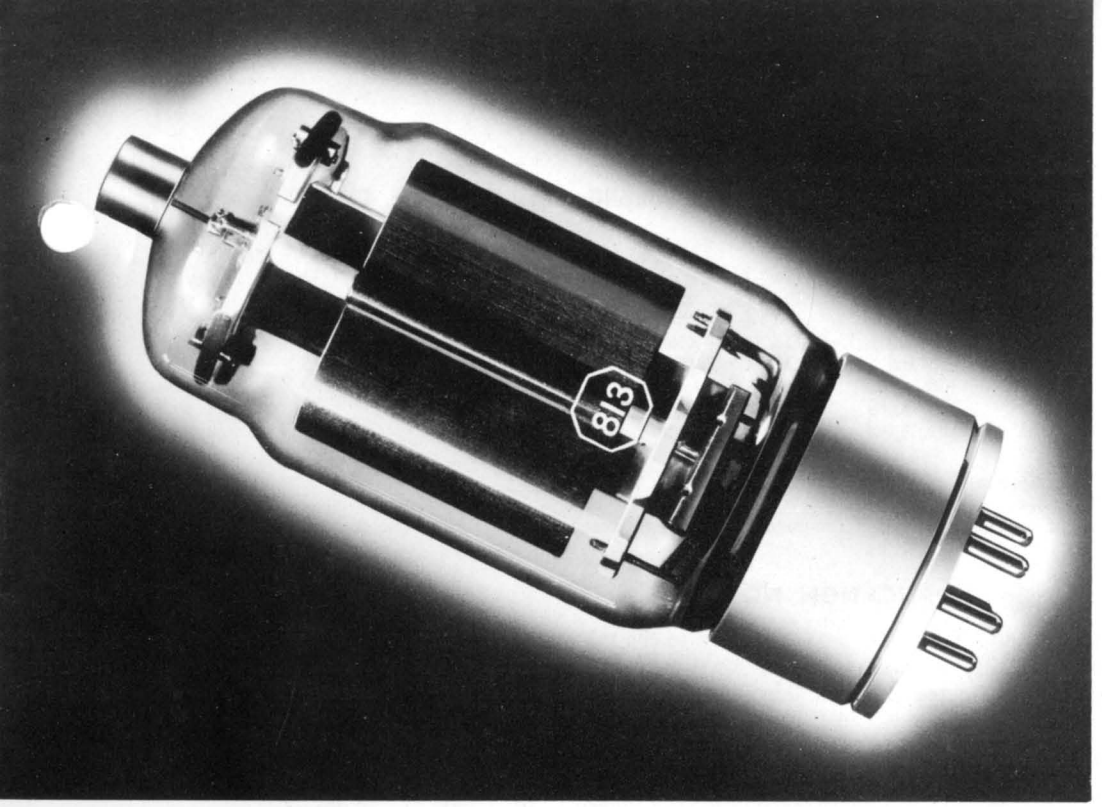


MACHLETT

ML-813

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-813** is a five-electrode beam power tube designed for use as a modulator, amplifier, and oscillator in radio-transmitting service. Features include minimum drive requirement for full power output, frequency changing without neutralization adjustments, and high-power sensitivity for frequency multiplier service. The cathode is a thoriated-tungtsen filament. The anode is radiation cooled and is capable of dissipating 100 watts. Maximum ratings for continuous operation of 2000 volts plate voltage and 360 watts plate input apply at frequencies up to 30 mc/sec; operation at 120 mc/sec is permissible with plate voltage and input reduced to one-half maximum ratings.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	10 volts
Filament Current	5 amperes
Amplification Factor, G1-G2 $E_b = 2000$ Vdc, $I_b = 50$ ma	8.5
Transconductance $I_b = 50$ ma	3750 uMhos
Interelectrode Capacitances	
Grid #1-Plate, max.	0.25 uuf
Input	16.3 uuf
Output	14.0 uuf

Mechanical

Mounting Position	Vertical, Base Up or Down; Horizontal, Plate on Vertical Plane
Type of Cooling	Convection
Base	Giant, 7-Pin Bayonet, JETEC No. A7-17
Cap	Medium, JETEC No. C1-5
Net Weight, approximate	½ Pound

MAXIMUM RATINGS

A-F Power Amplifier and Modulator, Class AB_1

	CCS*	IACS**	
D-C Plate Voltage	2250	2500	volts
D-C Grid #2 Voltage	1100	1100	volts
Max. Signal D-C Plate Current†	180	225	ma
Max. Signal Plate Input†	360	450	watts
Max. Signal Grid #2 Input†	22	22	watts
Plate Dissipation	100	125	watts

R-F Power Amplifier, Class B Telephony

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

	CCS*	IACS**	
D-C Plate Voltage	2000	2250	volts
D-C Grid #2 Voltage	400	400	volts
D-C Plate Current	100	125	ma
Plate Input	150	200	watts
Grid #2 Input	15	20	watts
Plate Dissipation	100	125	watts

Plate-Modulated R-F Power Amplifier, Class C Telephony

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

	CCS*	ICAS**	
D-C Plate Voltage	1600	2000	volts
D-C Grid #2 Voltage	400	400	volts
D-C Grid #1 Voltage	−300	−300	volts
D-C Plate Current	150	200	ma
D-C Grid #1 Current	25	30	ma
Plate Input	240	400	watts
Grid #2 Input	15	20	watts
Plate Dissipation	67	100	watts

Grid-Modulated R-F Power Amplifier, Class C Telephony

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

	CCS*	ICAS**	
D-C Plate Voltage	2000	2250	volts
D-C Grid #2 Voltage	400	400	volts
D-C Grid #1 Voltage	−200	−200	volts
D-C Plate Current	100	125	ma
Plate Input	150	200	watts
Grid #2 Input	15	20	watts
Plate Dissipation	100	125	watts

R-F Power Amplifier and Oscillator, Class C Telegraphy

	CCS*	ICAS**	
D-C Plate Voltage	2000	2250	volts
D-C Grid #2 Voltage	400	400	volts
D-C Grid #1 Voltage	−300	−300	volts
D-C Plate Current	180	225	ma
D-C Grid #1 Current	25	30	ma
Plate Input	360	500	watts
Grid #2 Input	22	22	watts
Plate Dissipation	100	125	watts

* CCS—Continuous Commercial Service.
** ICAS—Intermittent Commercial and Amateur Service.
† Averaged over any audio-frequency cycle of sine-wave form.
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

APPLICATION NOTES

Maximum ratings apply up to 30 megacycles. 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 these frequencies.

Frequency	30	45	60	120	Megacycles
Percentage of Maximum Rated Plate Voltage and Plate Input					
Class B	100	93	88	76	Percent
Class C Grid Modulated	100	93	88	76	Percent
Class C Plate Modulated	100	87	75	50	Percent
Class C Unmodulated	100	87	75	50	Percent

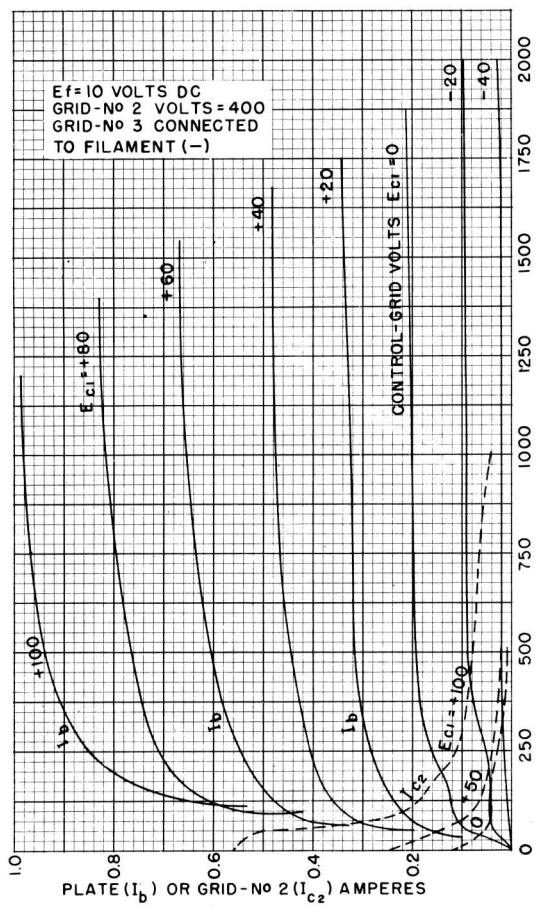
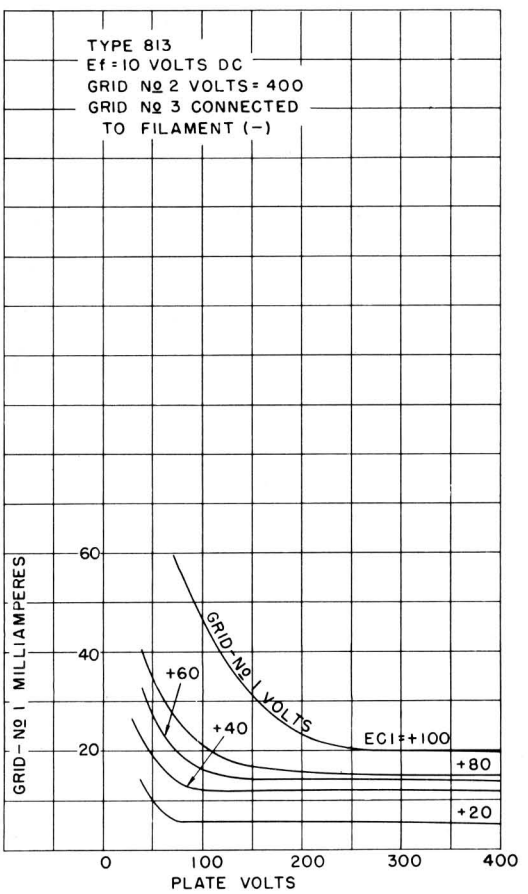
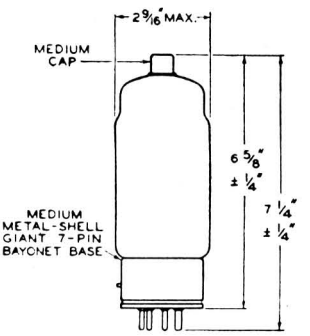
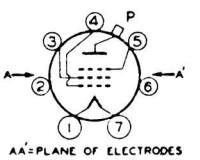


PLATE CHARACTERISTICS



TRANSFER CHARACTERISTICS





Pin 1—Filament
Pin 2—No Connection
Pin 3—Grid No. 2
Pin 4—Grid No. 1
Pin 5—Grid No. 3, Int. Shield
Pin 6—No Connection
Pin 7—Filament
Cap—Plate

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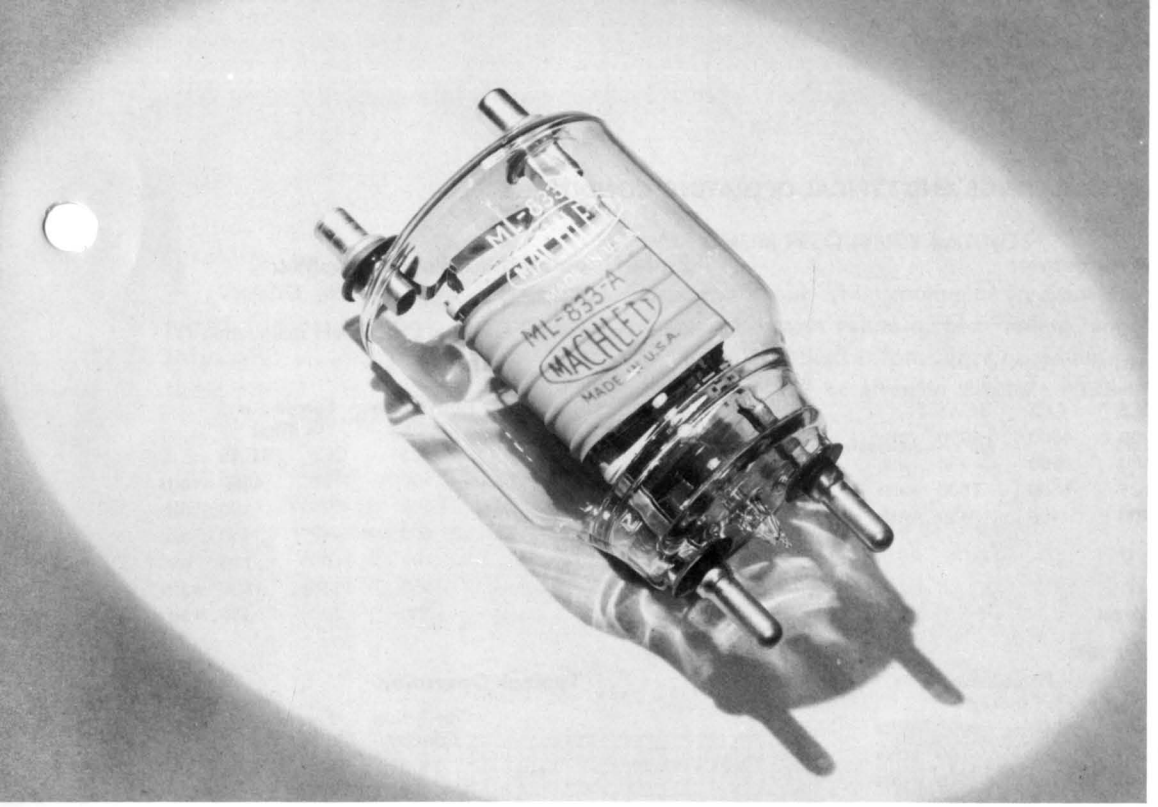


MACHLETT

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

Filament Voltage	10.0	Volts
Filament Current at Bogey Voltage	10.0	Amps
Filament Starting Current	—	Amps
Amplification Factor:		
I_b = 200 mAdc, E_c = -10 volts	35.0	
Interelectrode Capacitances:		
Grid-Plate	6.3	uuf
Grid-Filament	12.3	uuf
Plate-Filament	8.5	uuf

Mechanical

Mounting Position—Vertical, with filament terminals up or down; or horizontal, with all terminals in same vertical plane.		
Type of Cooling—Convection or Forced Air		
Maximum Incoming Air Temperature	45	°C
Required Air-Flow (for Forced-Air Cooling)	40	cfm
On center of bulb between grid and plate seals from 2" diameter nozzle.		
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

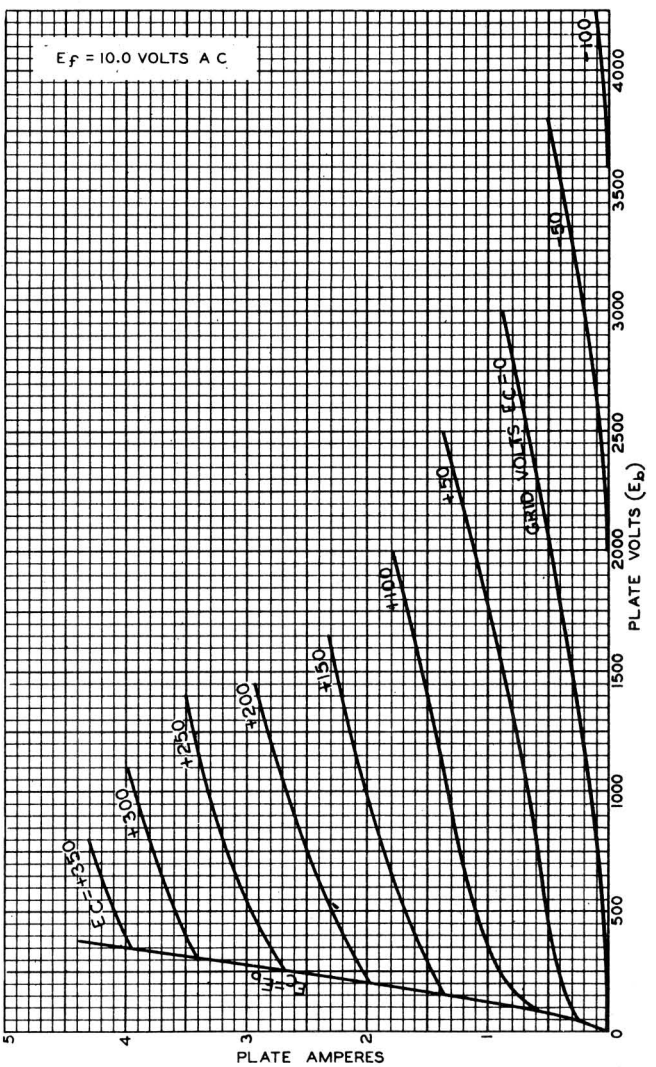
* Obtained from fixed supply, by grid resistor (3500, 2650, 2400) or by cathode resistor (425, 380, 380).

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

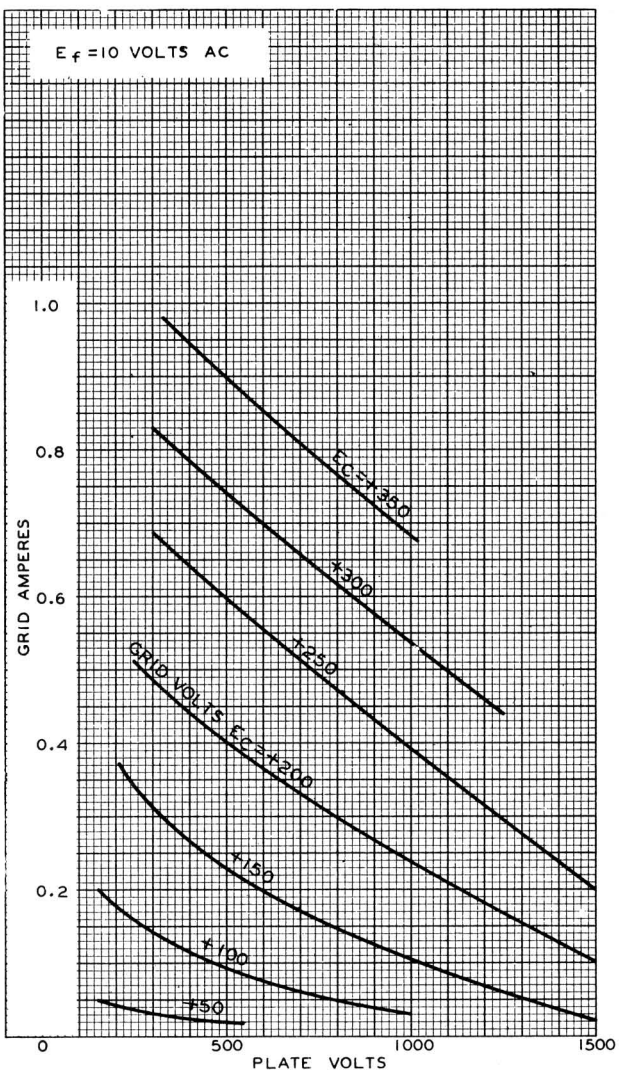
MAXIMUM FREQUENCY RATINGS

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.

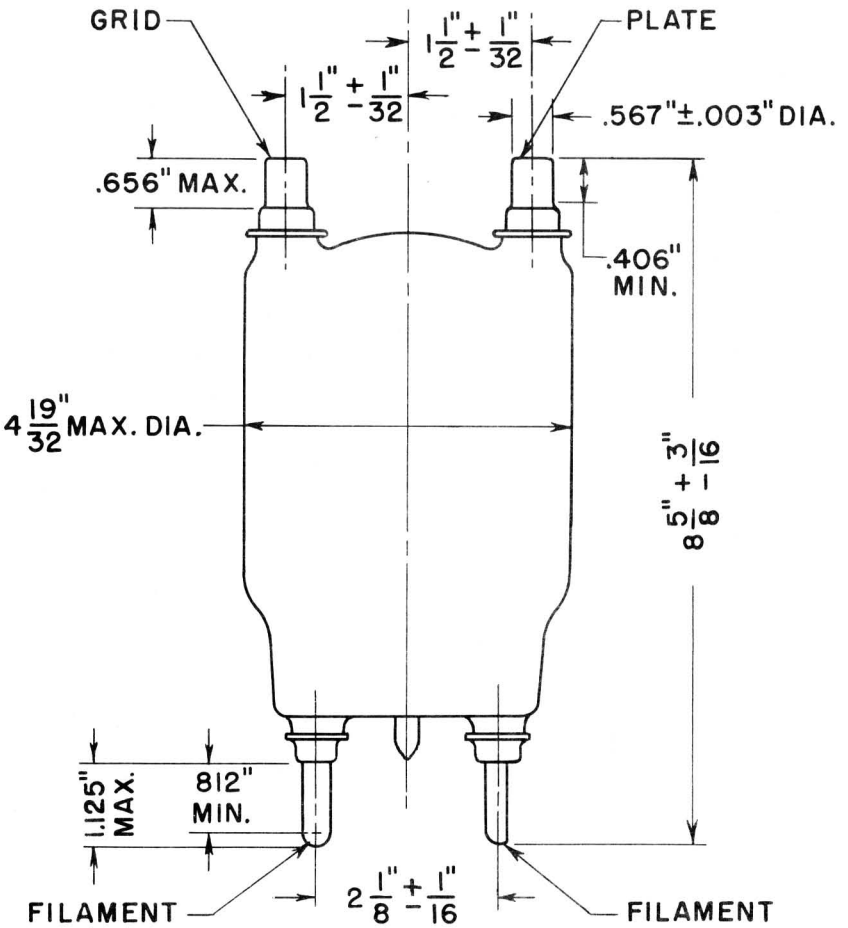
	Convection Cooling			Forced-Air Cooling			
Frequency	30	50	75	20	50	75	megacycles
Percentage of Maximum Rated Plate Voltage and Plate Input							
Class B, r-f	100	98	94	100	97	93	per cent
Class C, plate-modulated	100	90	72	100	83	65	per cent
Class C, unmodulated	100	90	72	100	83	65	per cent

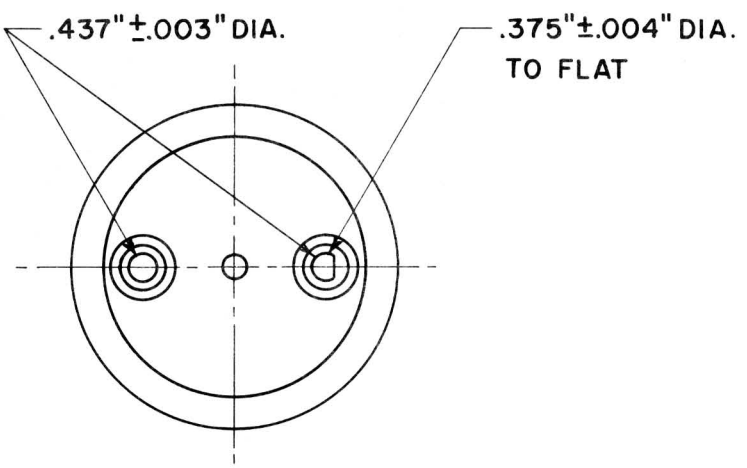


AVERAGE PLATE CHARACTERISTICS



TYPICAL CHARACTERISTICS





DIMENSIONS—ML-833 A

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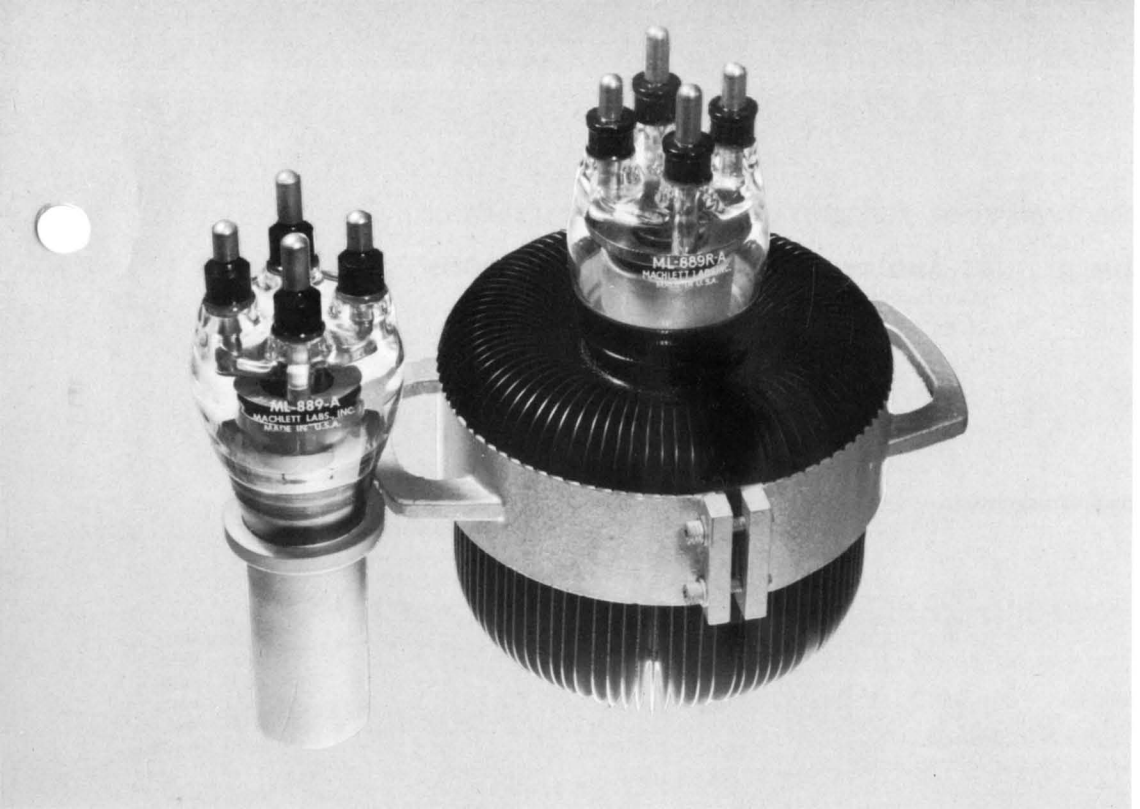


MACHLETT

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

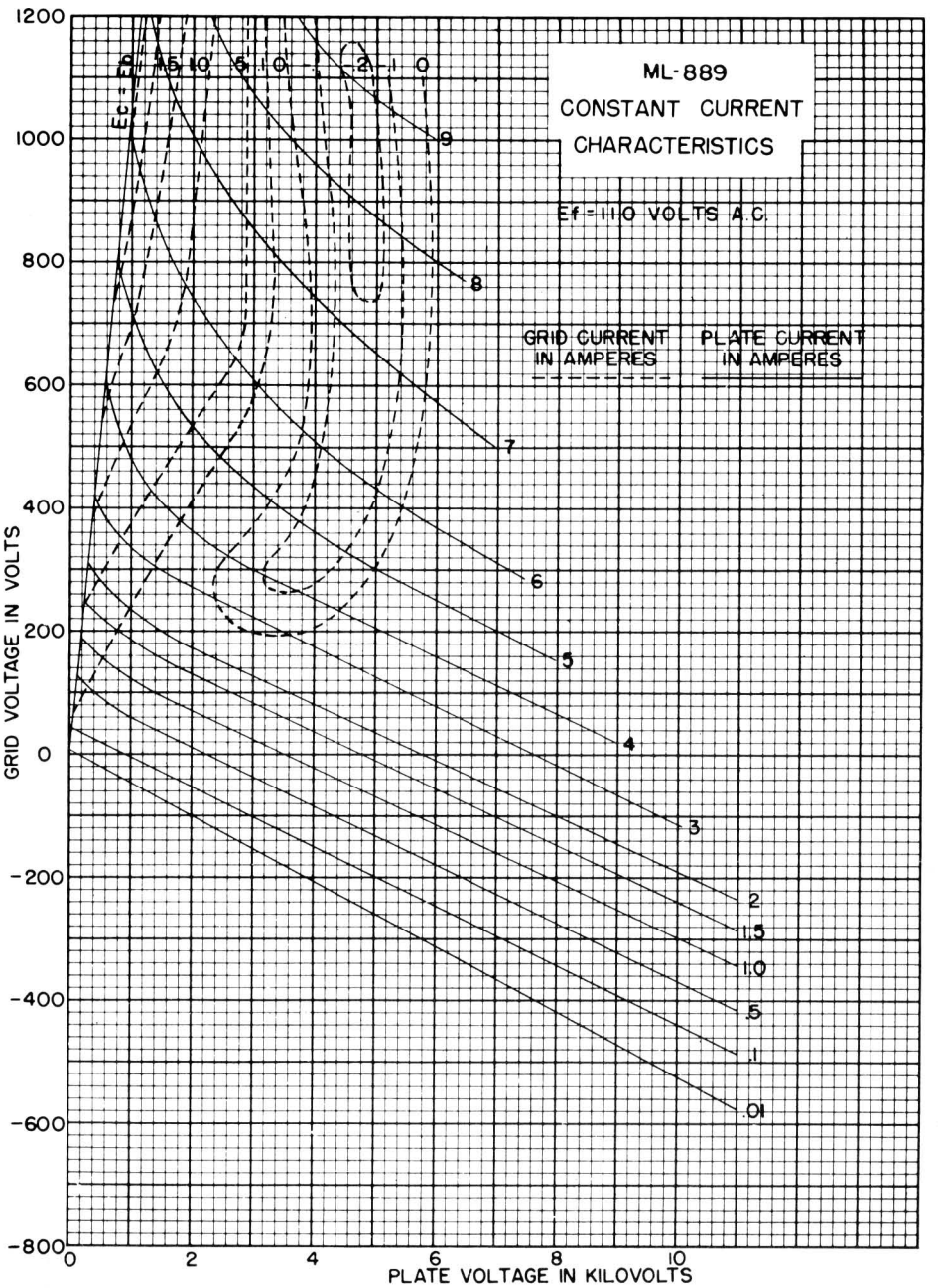
Maximum ratings apply at frequencies up to 50 Mc for the **ML-889A** or up to 40 Mc for the **ML-889RA**. The tubes can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with the table on the right (other maximum ratings are the same as shown above). Special attention should be given to adequate ventilation of the bulb at the higher frequencies.

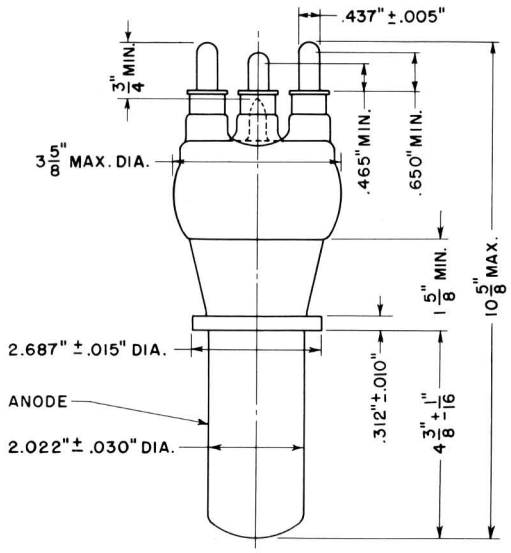
	ML-889A			ML-889RA		
Frequencies	50	100	150 Mc	40	65	100 Mc
Percentage of Maximum Rated Plate Voltage and Plate Input						
Class B	100	83	72	100	85	72
Class C Plate Modulated	100	75	60	100	78	60
Class C Telegraphy, Plate Voltage	100	78	65	100	87	65
Class C Telegraphy, Plate Input	100	70	50	100	73	50

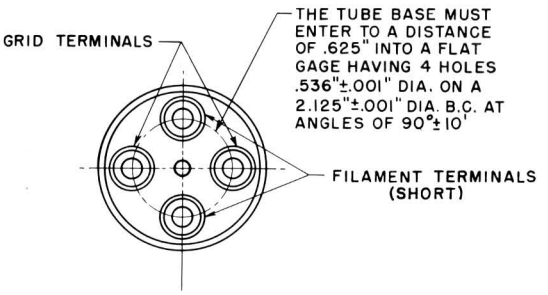
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

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

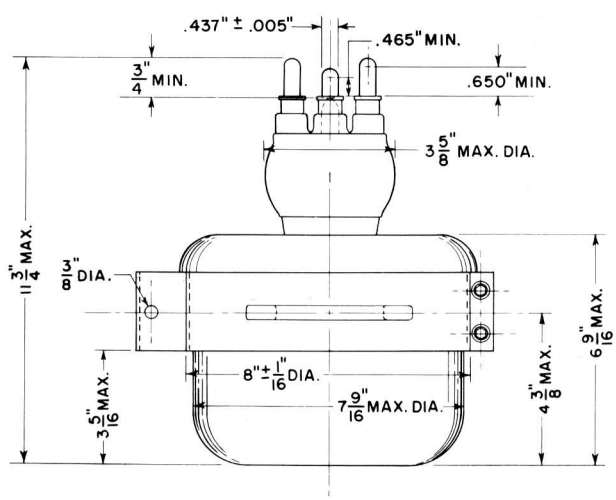
*Represents maximum useable plate current plus grid current for any conditions of operation.

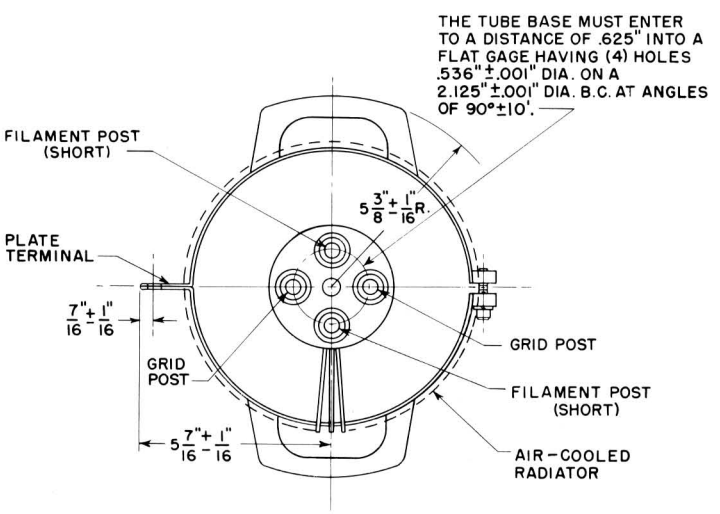






DIMENSIONS — ML-889A





DIMENSIONS — ML-889RA

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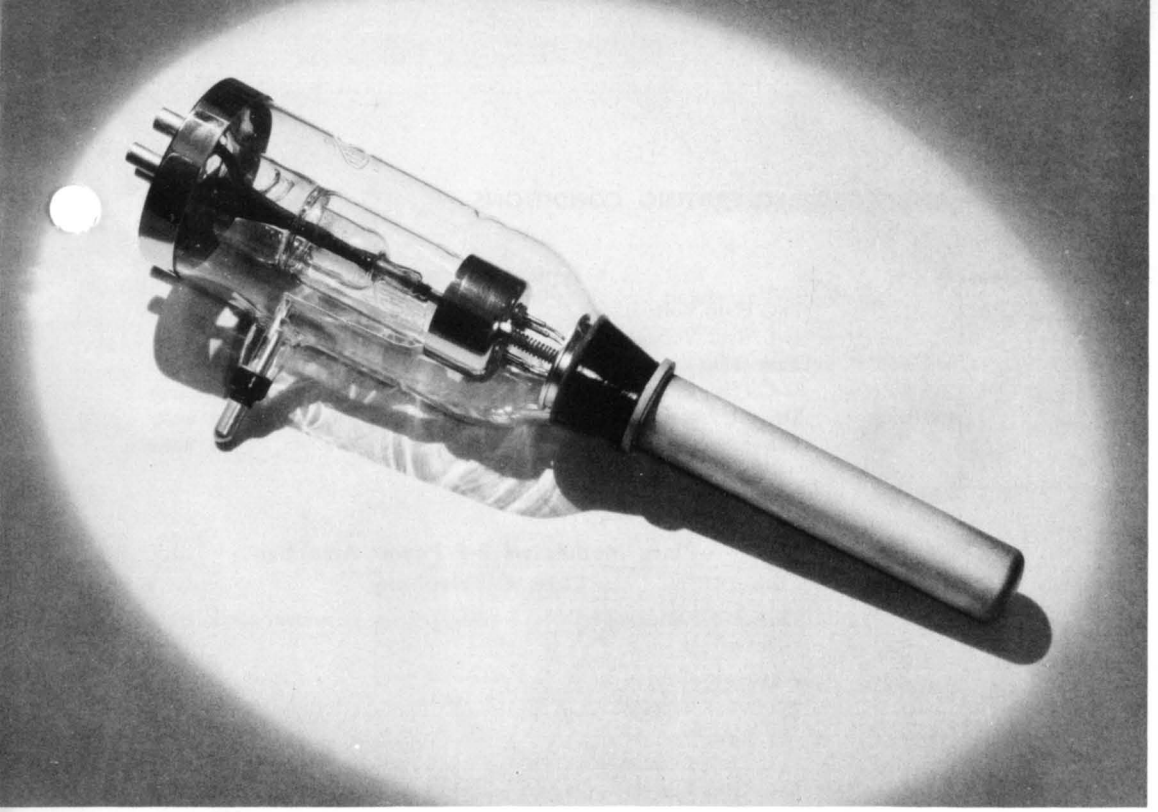


MACHLETT

ML-891

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-891** is a three-electrode tube designed specifically for use as a modulator, amplifier, or oscillator in radio transmitting service. Its rugged design, incorporating heavy sections of Kovar to provide maximum strength at the grid and plate seals, also contributes to better performance when used for radio-frequency heating applications. The cathode is a pure-tungsten filament. The anode is water-cooled and is capable of dissipating 6 kilowatts. Maximum ratings of 12 kVdc plate voltage and 18 kW plate input apply at frequencies up to 1.6 mc/sec; operation at 20 mc/sec is permissible with voltage and input reduced to one-half maximum ratings.

The **ML-891** embodies the highest standards available in tubes of this type. All parts are thoroughly processed by special Machlett techniques to assure efficient operation and long life.

GENERAL CHARACTERISTICS

Electrical	Minimum	Bogey	Maximum	
Filament Voltage		22		Volts
Filament Emission at Bogey Voltage		9.4		Amps
Filament Current at Bogey Voltage	57	60	62	Amps
Filament Starting Current	—	—	120	Amps
Filament Cold Resistance	—	0.031	—	Ohms
Amplification Factor I_b = 0.75 amp, E_c = -500 volts	7.6	8.5	9.4	
Interelectrode Capacitances				
Grid-Plate	24	27	31	uuf
Grid-Filament	15	19	23	uuf
Plate-Filament	1	2	3	uuf

Mechanical				
Mounting Position—Vertical, Anode Down				
Type of Cooling—Water				
Water Flow on Anode			3-8	gpm
Maximum Water Pressure			80	psi
Maximum Outgoing Water Temperature			70	°C
Maximum Glass Temperature			160	°C
Net Weight, approximate			3.5	lbs.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

A-F Power Amplifier & Modulator—Class A

Maximum Ratings, Absolute Values

D-C Plate Voltage	12000 volts
Plate Input	7500 watts
Plate Dissipation	7500 watts

Typical Operation

D-C Plate Voltage	8000 volts
D-C Grid Voltage†	−630 volts
Peak A-F Grid Voltage	700 volts
D-C Plate Current	0.9 amps
Load Resistance	5200 ohms
U.P.O. (5% second harmonic)	2000 watts

A-F Power Amplifier & Modulator—Class B

Maximum Ratings, Absolute Values

D-C Plate Voltage	15000 volts
Max. Signal D-C Plate Current*	2.0 amps
Max. Signal Plate Input*	20000 watts
Plate Dissipation*	5000 watts

Typical Operation

Unless otherwise specified, values are for 2 tubes

D-C Plate Voltage	6000	10000	12500	volts
D-C Grid Voltage	−630	−1100	−1450	volts
Peak A-F Grid-to-Grid Voltage	2060	3060	3760	volts
Zero-Signal D-C Plate Current	0.5	0.5	0.4	amp
Max.-Signal D-C Plate Current	2.5	2.4	2.5	amps
Effective Load resistance (plate to plate)	5000	10000	12000	ohms
Max. Signal Driving Power, approx.	110	225	245	watts
Max. Signal Power Output, approx.	8000	16000	22000	watts

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

D-C Plate Voltage	15000 volts
D-C Plate Current	1.0 amp
Plate Input	10000 watts
Plate Dissipation	6000 watts

Typical Operation

D-C Plate Voltage	6000	10000	14000	volts
D-C Grid Voltage	−600	−1130	−1600	volts
Peak R-F Grid Voltage	600	830	1000	volts
D-C Plate Current	0.7	0.8	0.56	amp
Driving Power, approx.§	82	0	0	watts
Power Output, approx.	1000	2000	2300	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	8000 volts
D-C Grid Voltage	−3000 volts
D-C Plate Current	1.0 amp
D-C Grid Current	0.15 amp
Plate Input	8000 watts
Plate Dissipation	4000 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

D-C Plate Voltage	12000 volts
D-C Grid Voltage	−3000 volts
D-C Plate Current	2.0 amps
D-C Grid Current	0.15 amp
Plate Input	18000 watts
Plate Dissipation	6000 watts

Typical Operation

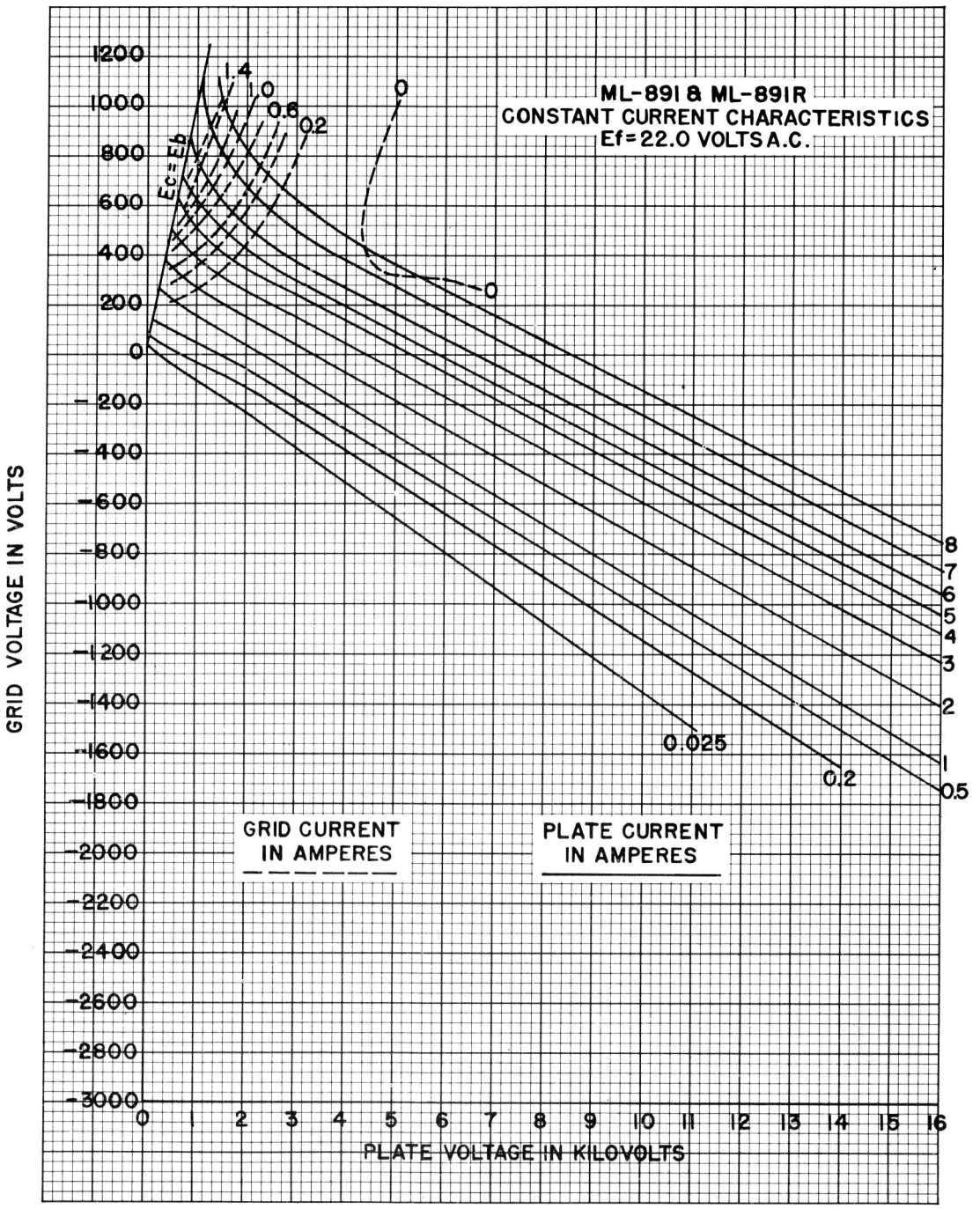
D-C Plate Voltage	8000	10000	volts
D-C Grid Voltage	−1800	−2000	volts
Peak R-F Grid Voltage	2400	2700	volts
D-C Plate Current	1.15	1.33	amps
D-C Grid Current, approx.	0.09	0.14	amp
Driving Power, approx.	215	375	watts
Power Output, approx.	6500	10000	watts

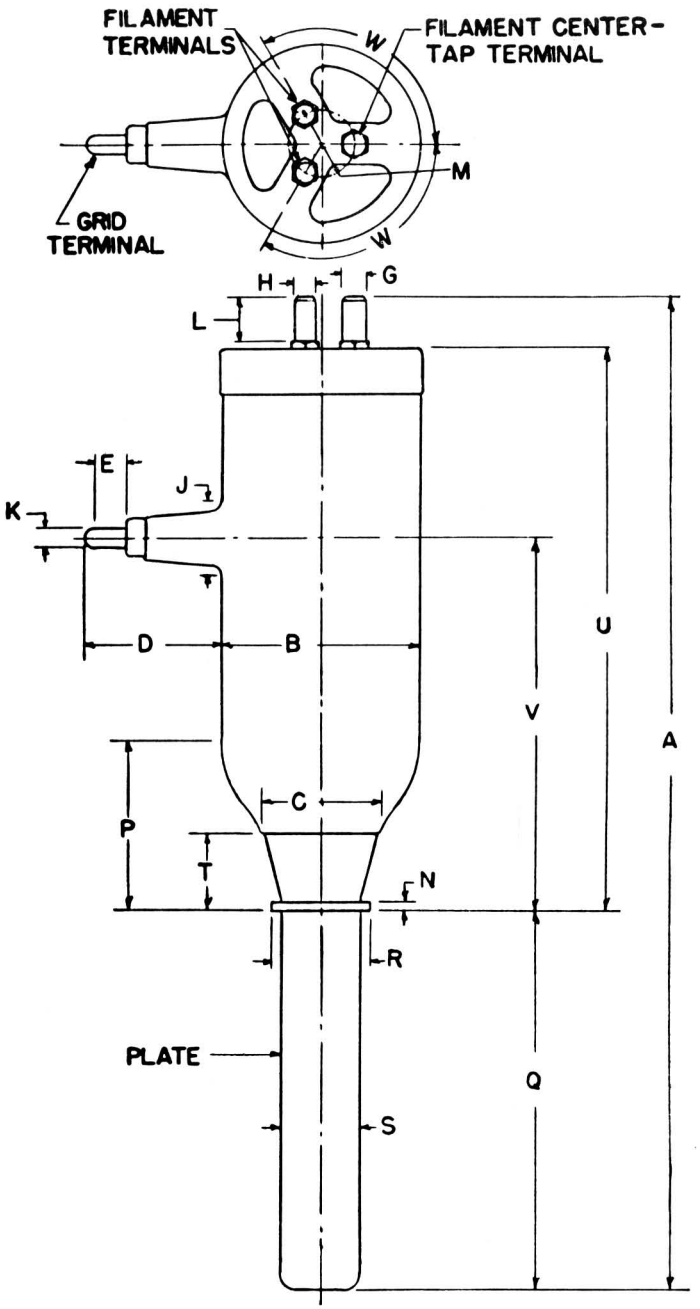
† The d-c resistance in the grid circuit should not exceed 100000 ohms when cathode bias is used, or 50000 ohms with fixed bias.
* Averaged over any audio-frequency cycle of sine-wave form.
§ At crest of a-f cycle with modulation factor of 1.0.
‡ Modulation essentially negative may be used if the positive peak of audio-frequency envelope does not exceed 115% of the carrier conditions.

MAXIMUM FREQUENCY RATINGS

The ML-891 can be operated at full power at frequencies as high as 1.6 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.

Mc	Class B		Class C Plate Modulated		Class C	
	Volts	Watts	Volts	Watts	Volts	Watts
1.6	100%	100%	100%	100%	100%	100%
7.5	82%	82%	75%	75%	75%	75%
20	72%	72%	65%	65%	50%	50%





DIMENSIONS IN INCHES

	Min.	Max.		Min.	Max.
A—	19.375	20.875	M—	0.563	—
B—	—	4.125	N—	0.177	0.197
C—	—	2.437	P—	2.50	—
D—	2.375	4.375	Q—	7.938	8.187
E—	0.500	—	R—	1.985	2.015
G—	0.495	0.505	S—	1.535	1.625
H—	0.432	0.442	T—	1.438	—
J—	—	2.50	U—	10.063	11.063
K—	0.432	0.442	V—	7.188	7.937
L—	0.687	—	W—	120°	Nom.

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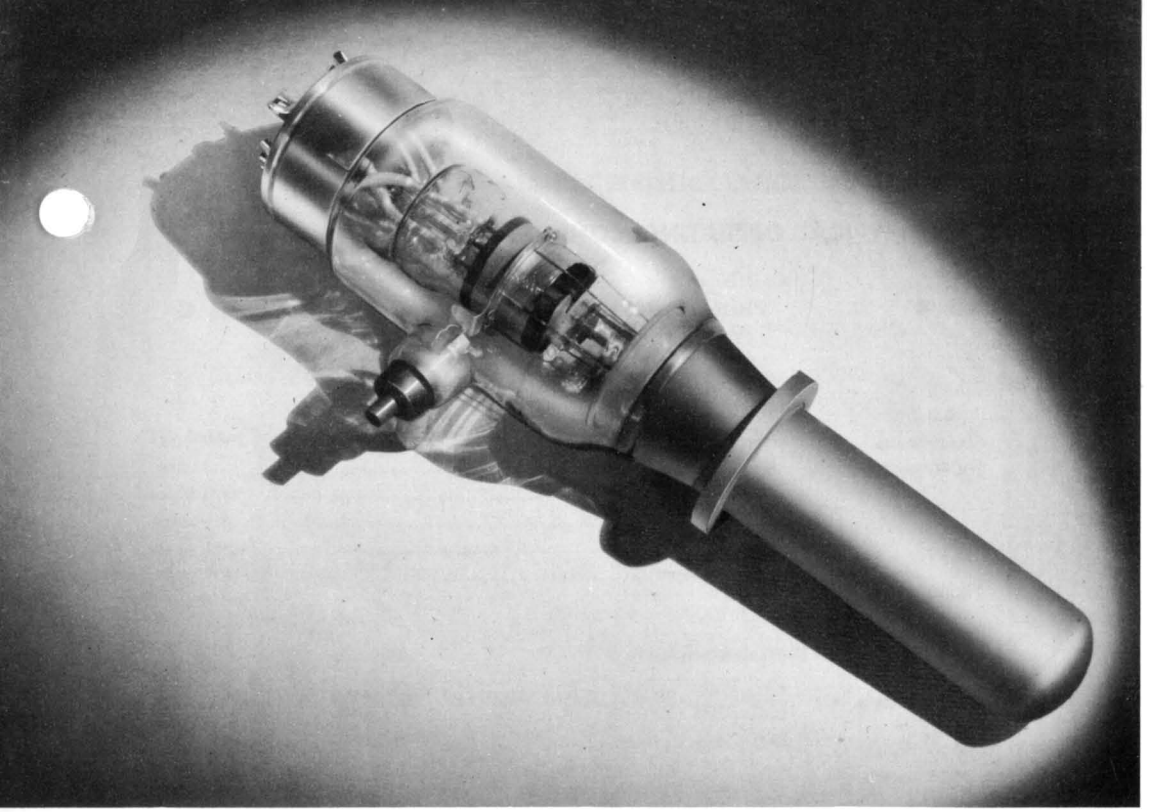


MACHLETT

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	7	°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

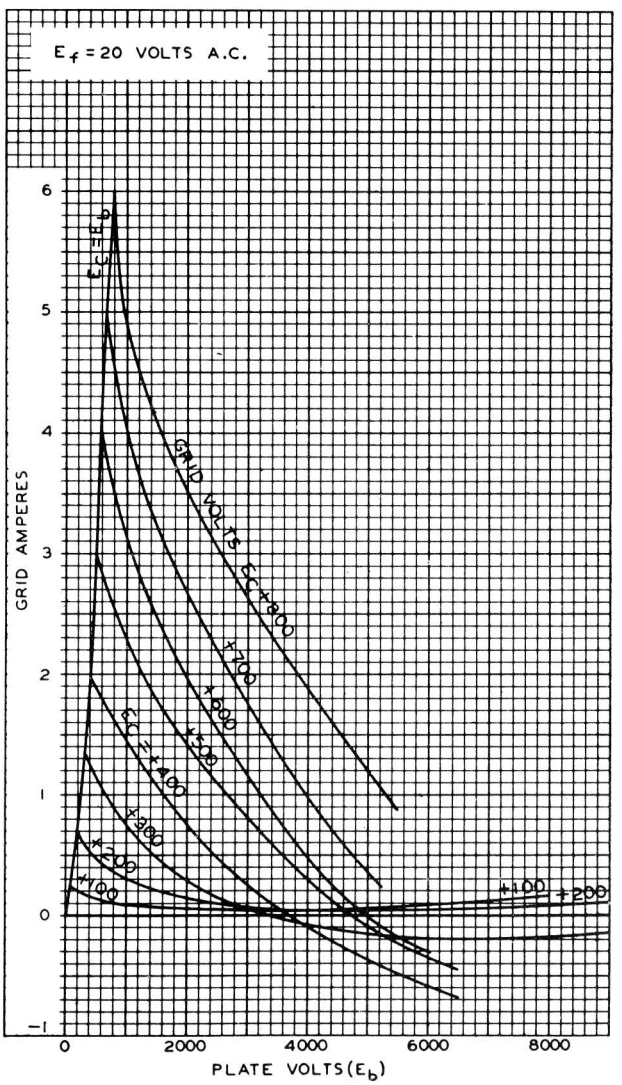
The ML-893A can be operated at full power at frequencies as high as 5 megacycles. It can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with table which shows the maximum permissible percentage of rated plate voltage and plate 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%

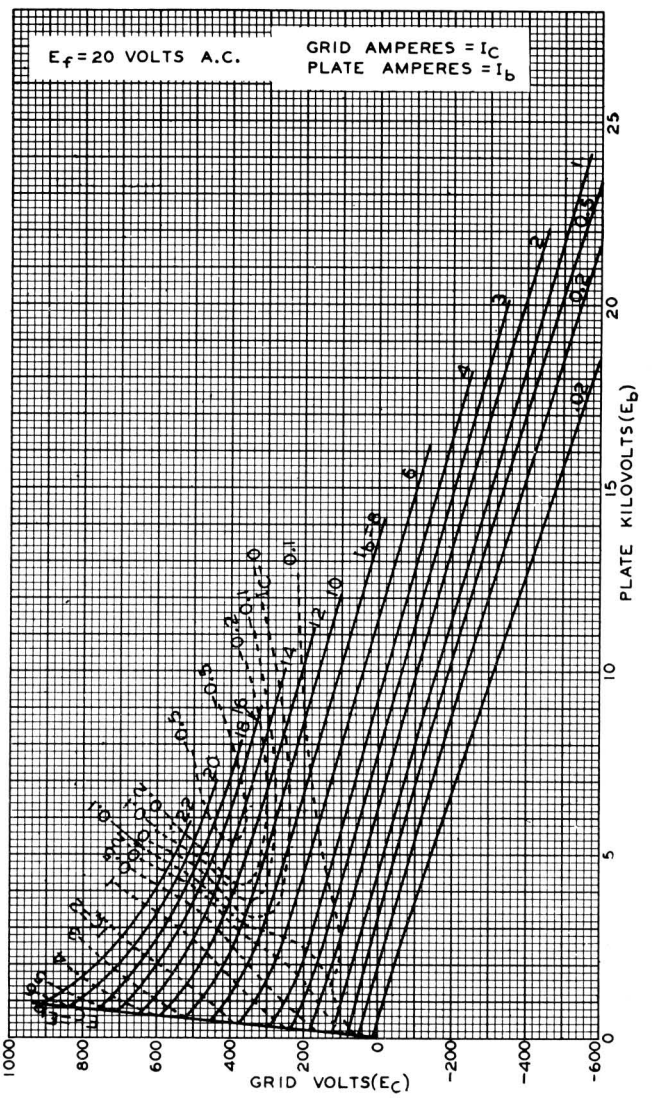
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

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

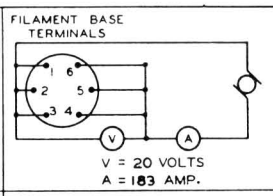
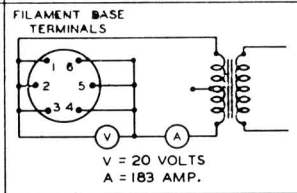
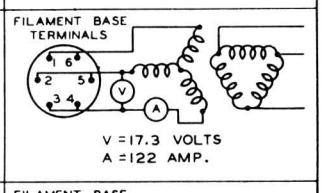
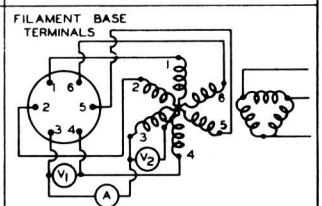
Note 1: Represents maximum usable cathode current for tube as plate current plus grid current for any condition of operation.



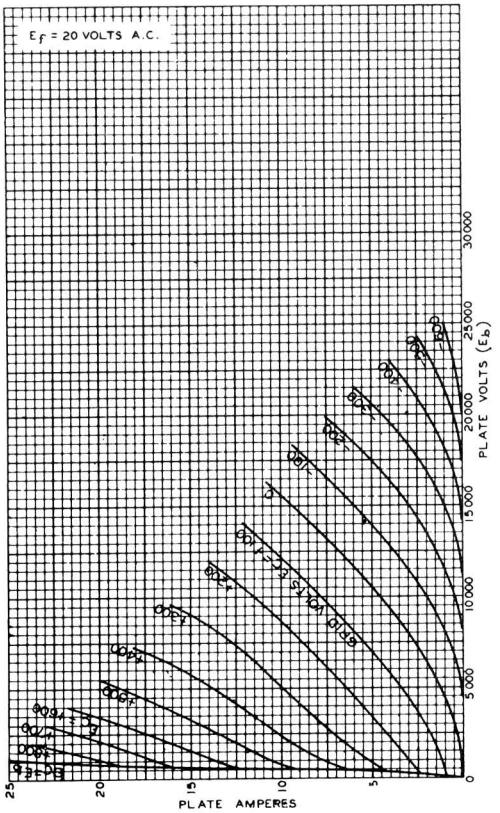
GRID-PLATE TRANSFER CHARACTERISTICS



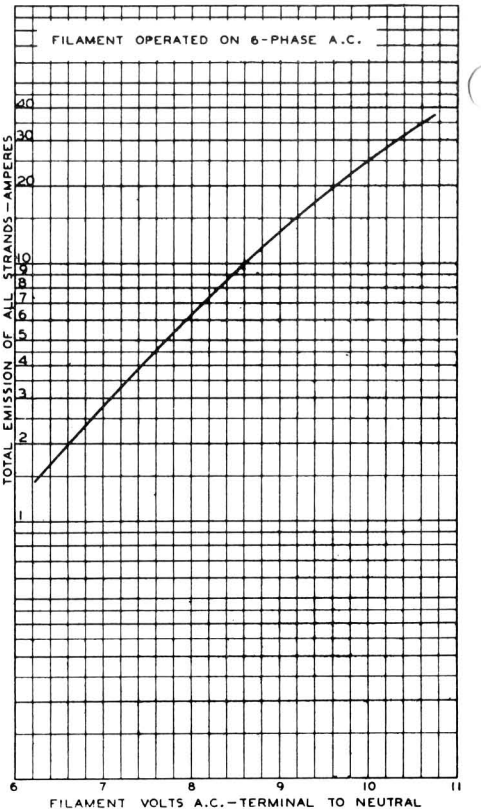
AVERAGE CONSTANT-CURRENT CHARACTERISTICS

D-C FILAMENT EXCITATION	 V = 20 VOLTS A = 183 AMP.
SINGLE-PHASE A-C FILAMENT EXCITATION	 V = 20 VOLTS A = 183 AMP.
THREE-PHASE A-C FILAMENT EXCITATION	 V = 17.3 VOLTS A = 122 AMP.
SIX-PHASE A-C FILAMENT EXCITATION NOTE: TERMINALS MUST BE CONNECTED IN CORRECT PHASE RELATION AS SHOWN	 V1 = 10 VOLTS V2 = 10 VOLTS A = 61 AMP.

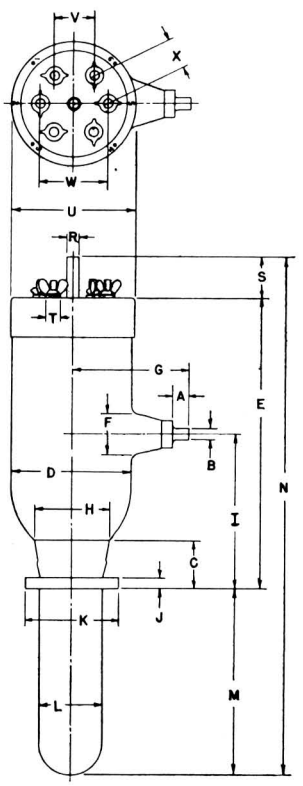
FILAMENT CONNECTIONS AND EXCITATION CIRCUITS



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

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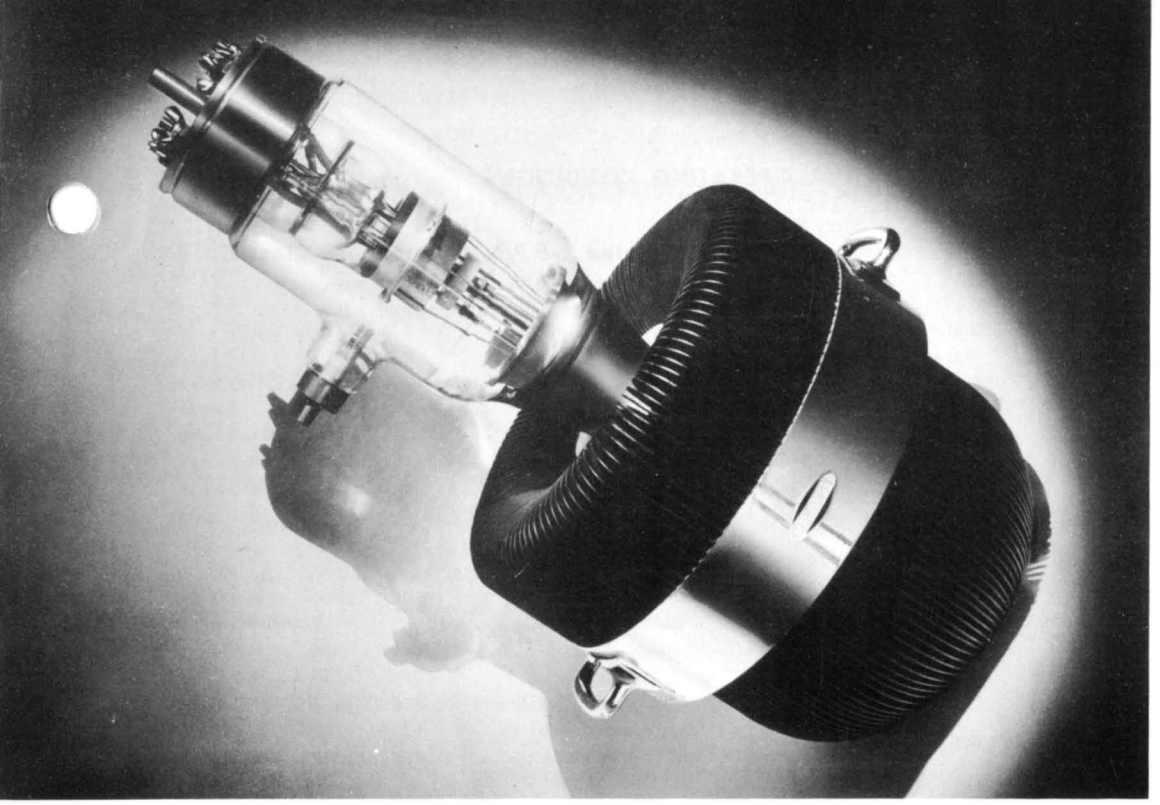


MACHLETT

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

Electrical	Minimum	Bogey	Maximum	
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

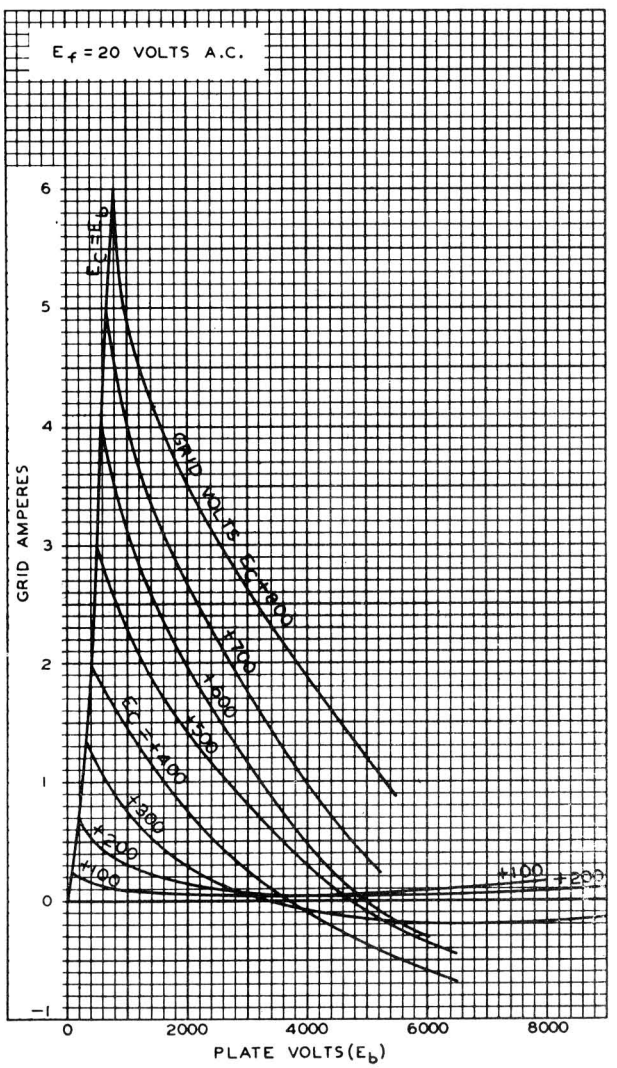
The ML-893A-R can be operated at full power at frequencies as high as 5 megacycles. It can be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced in accordance with table which shows the maximum permissible percentage of rated plate voltage and plate 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%

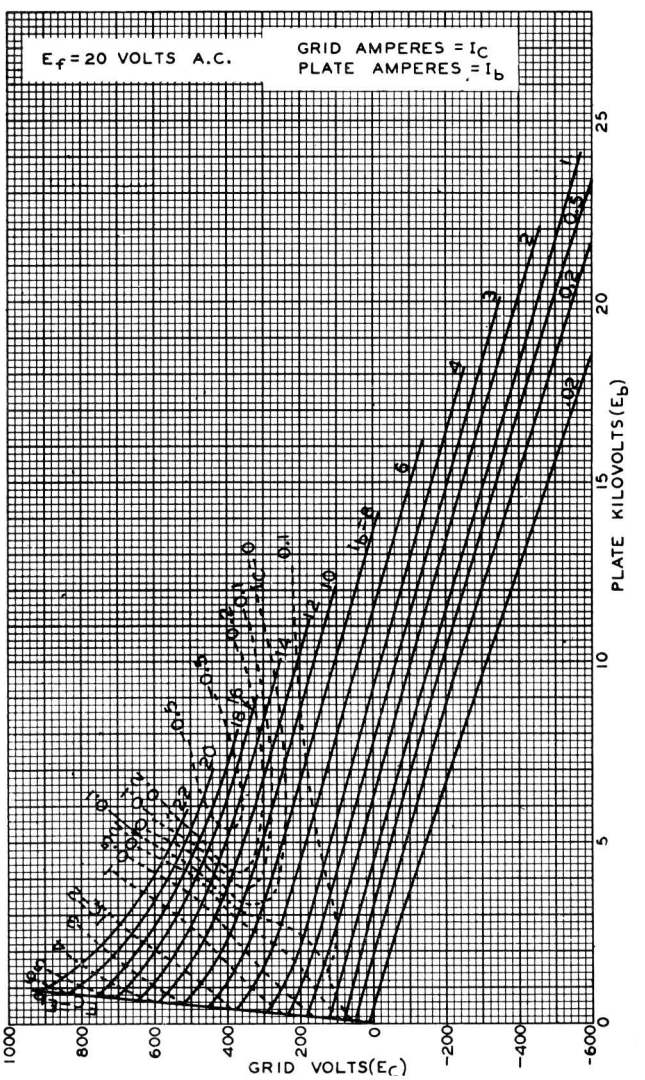
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

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:	—	—	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

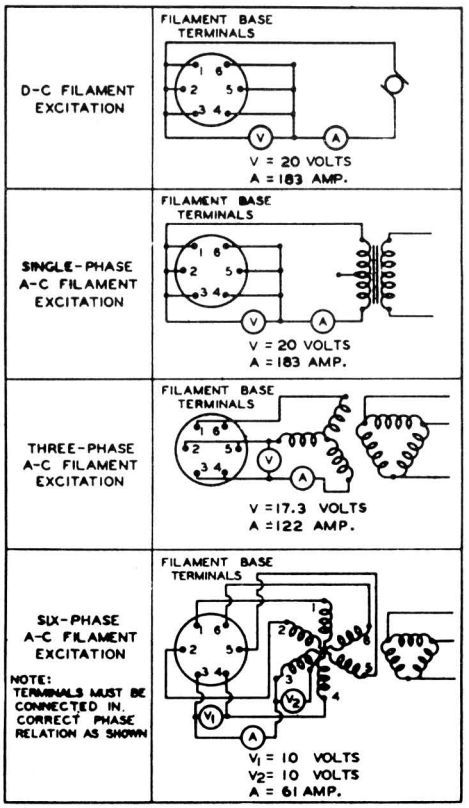
Note 1: Represents maximum usable cathode current for tube as plate current plus grid current for any condition of operation.



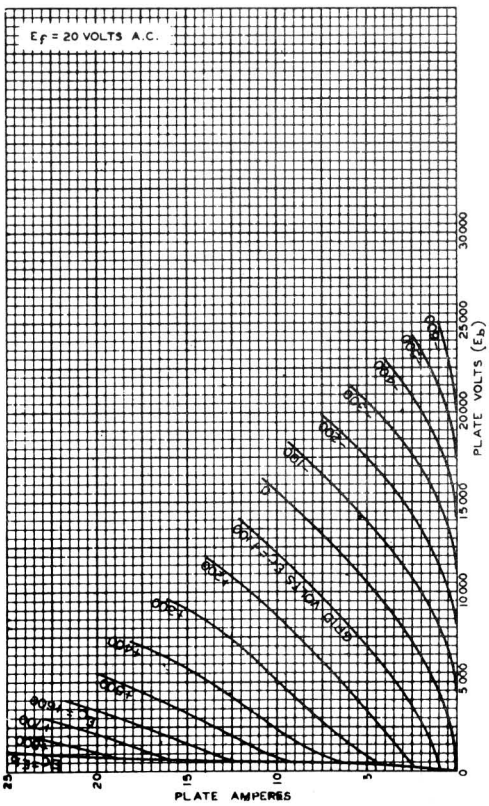
GRID-PLATE TRANSFER CHARACTERISTICS



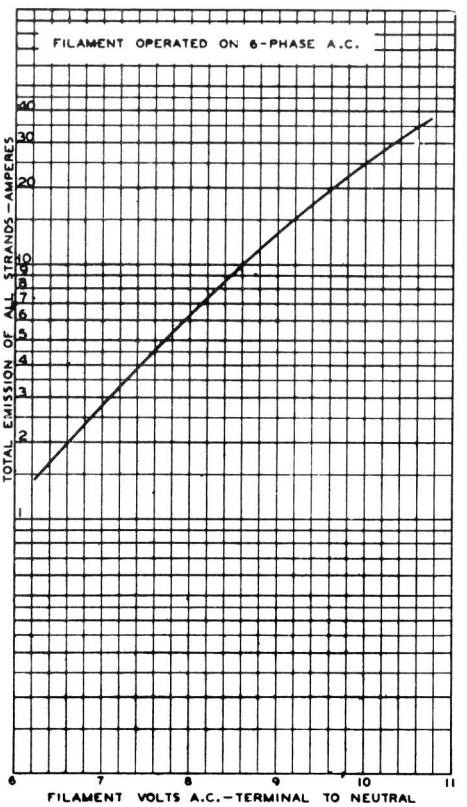
CONSTANT-CURRENT CHARACTERISTICS



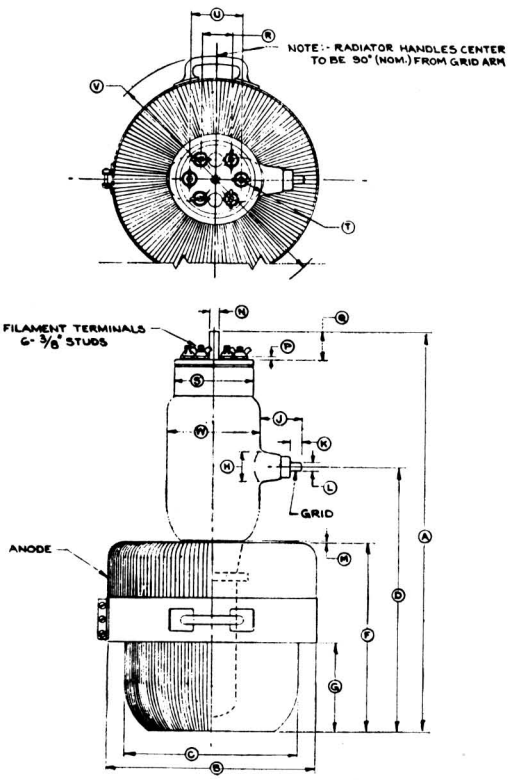
FILAMENT CONNECTIONS AND EXCITATION CIRCUITS



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

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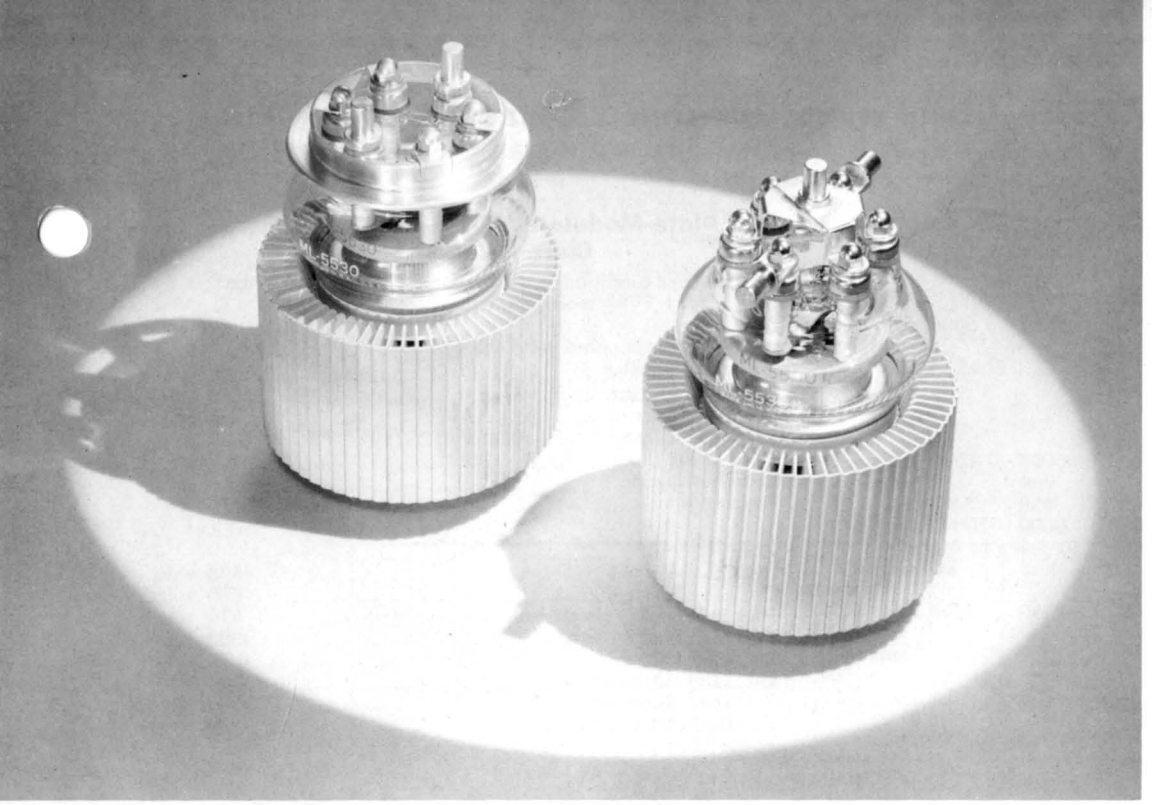


MACHLETT

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 umhos
Interelectrode Capacitances:	
Grid-Plate	23 uuf
Grid-Filament	20 uuf
Plate-Filament	0.6 uuf

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).

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

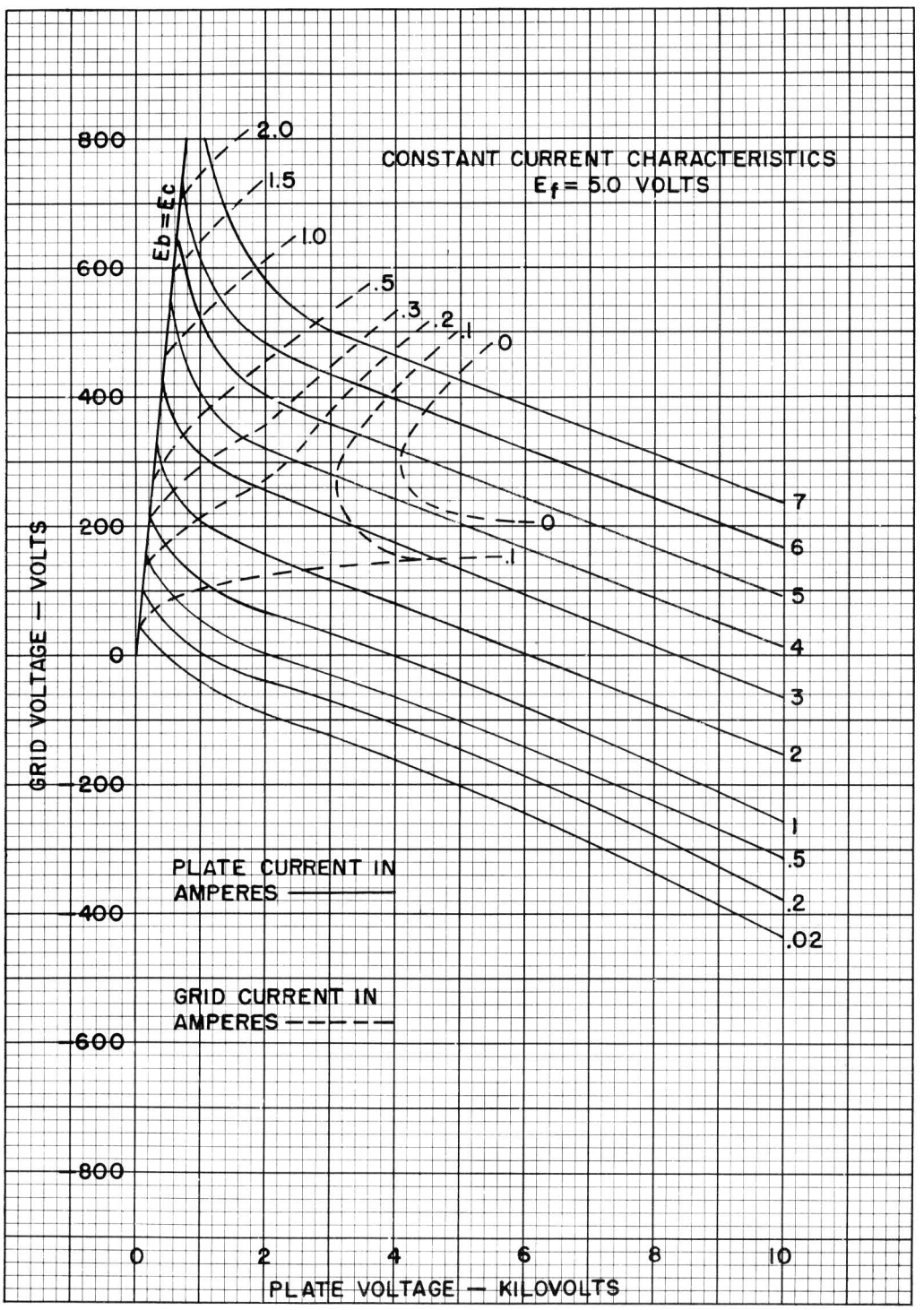
Typical Operation

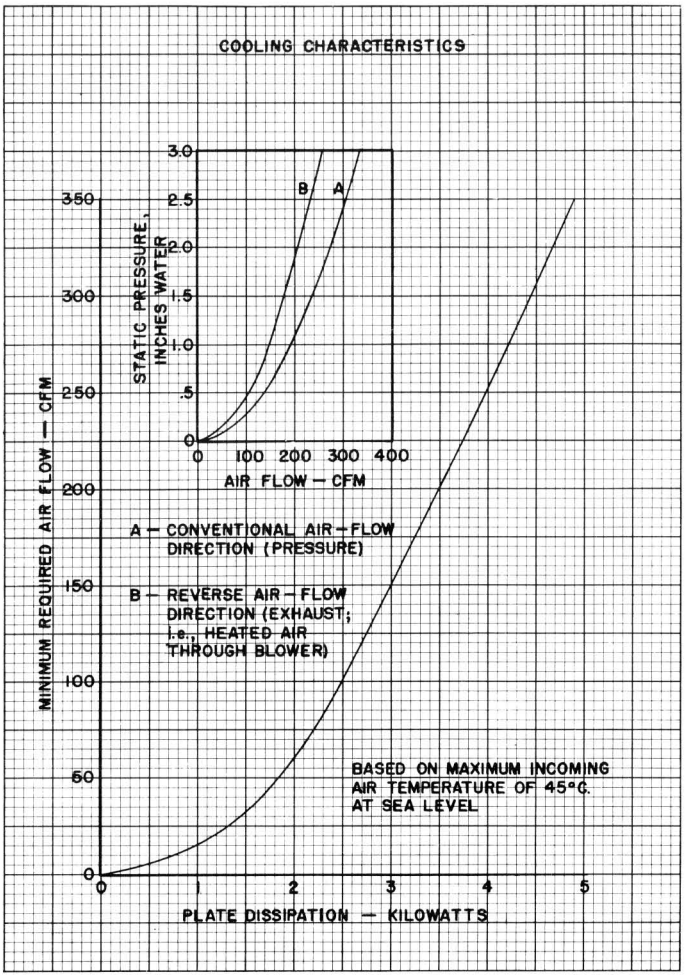
D-C Plate Voltage	6300	8000	volts
D-C Grid Voltage	-650	-750	volts
Peak R-F Grid Voltage	1250	1250	volts
Peak R-F Plate Voltage	5200	6800	volts
D-C Plate Current	1.5	1.2	amps
D-C Grid Current	0.20	0.12	amp
R-F Load Resistance	2000	3200	ohms
Driving Power, approximate	250	150	watts
Power Output, approximate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

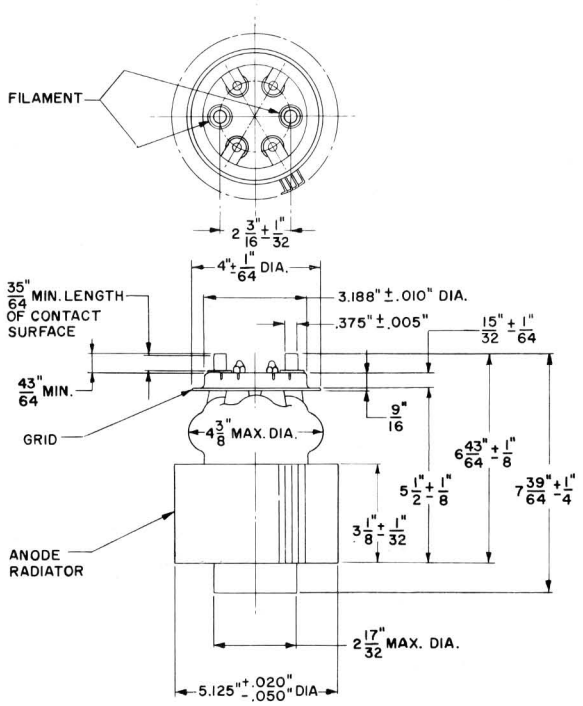
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

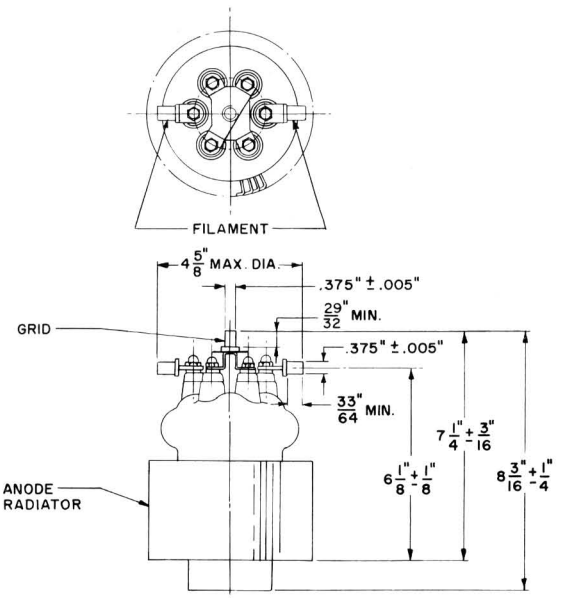
Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum
Grid Voltage	e_b = 1000 volts; i_b = 6.5 amps	e_c:	——	——	850 volts
Grid Current	e_b = 1000 volts; i_b = 6.5 amps	i_c:	——	——	2.2 amps
Plate Voltage	E_c = 0 Vdc; I_b = 0.5 Adc	E_b:	1.6	2.1	2.6 kVdc
Plate Voltage	E_c = -200 Vdc; I_b = 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







DIMENSIONS — ML-5530



DIMENSIONS — ML-5530-H

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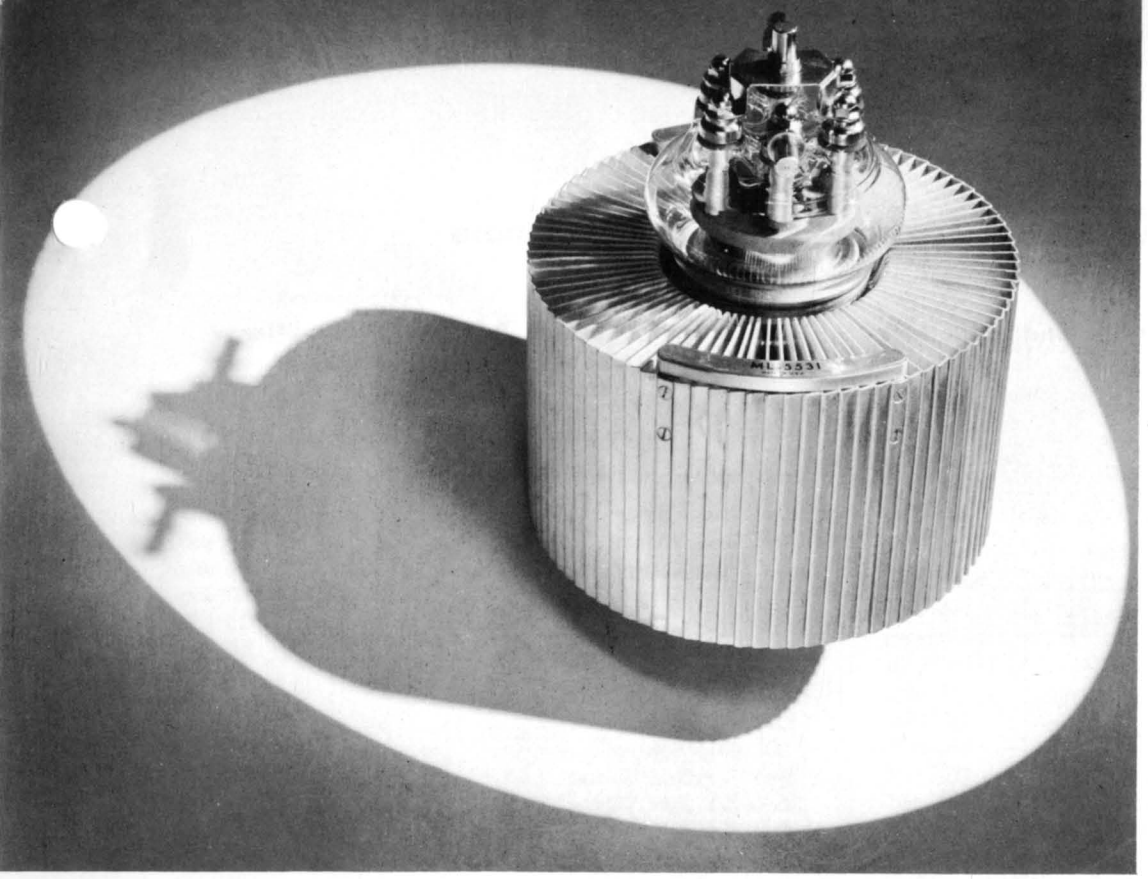


MACHLETT

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 Peak Driving Power, approx.***	1940 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.

*** Peak driving power is defined as the product of peak a-f grid voltage and peak grid current.

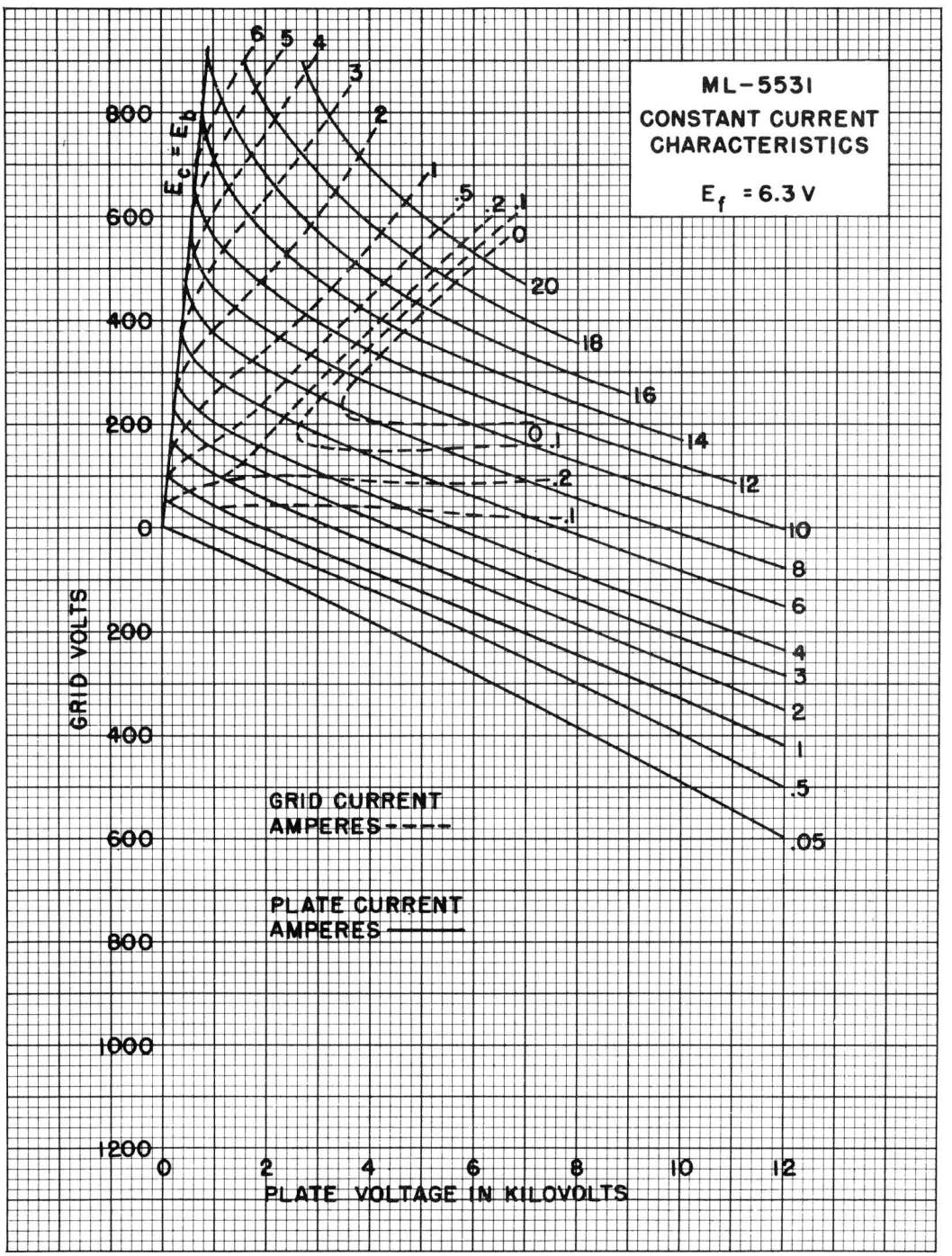
§ Includes power transferred from driver stage.

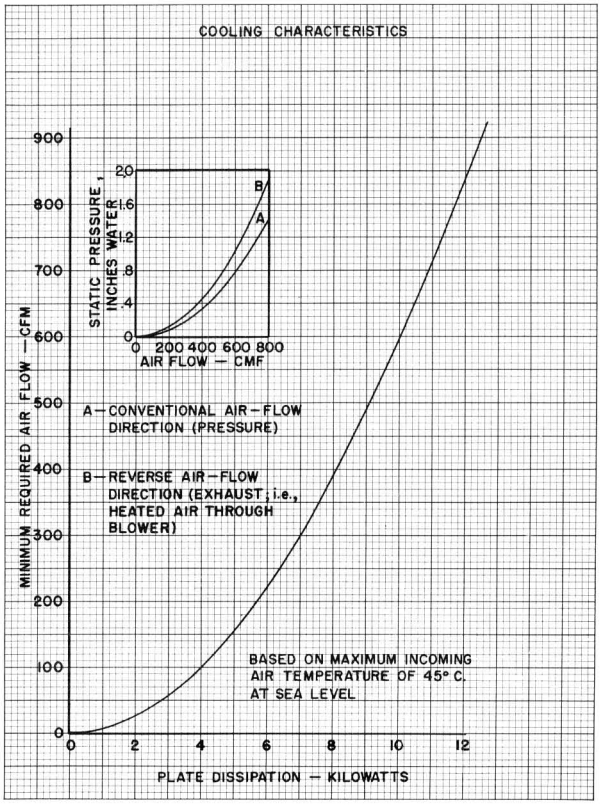
† Average value with modulation factor of 1.0.

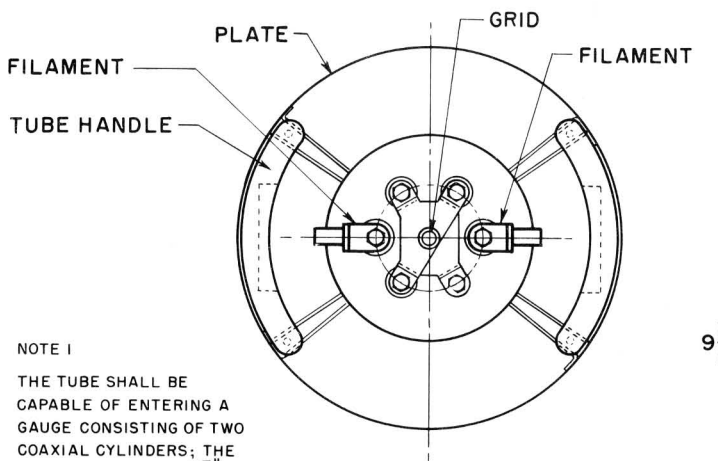
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of its unmodulated value.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Min.	Limits Bogey	Limits Max.
Grid Voltage	i_b = 14 amps; e_b = 1100 v	e_c:	——	——	850 volts
Grid Current	i_b = 14 amps; e_b = 1100 v	i_c:	——	——	7.0 amps
Plate Voltage	I_b = 1.0 Adc; E_c = 0	E_b:	1.5	1.9	2.3 kV
Plate Voltage	I_b = 1.0 Adc; E_c = -200 Vdc	E_b:	6.2	6.7	7.2 kV
Grid Voltage	I_b = 0.05 Adc; E_b = 10 kV	E_c:	-430	-490	-550 Volts
Plate Power Output	E_b = 9.0 kV; E_c = -900 Vdc; I_b = 3.2 Adc; I_c = 0.30 Adc	P_o:	16	——	—— kW





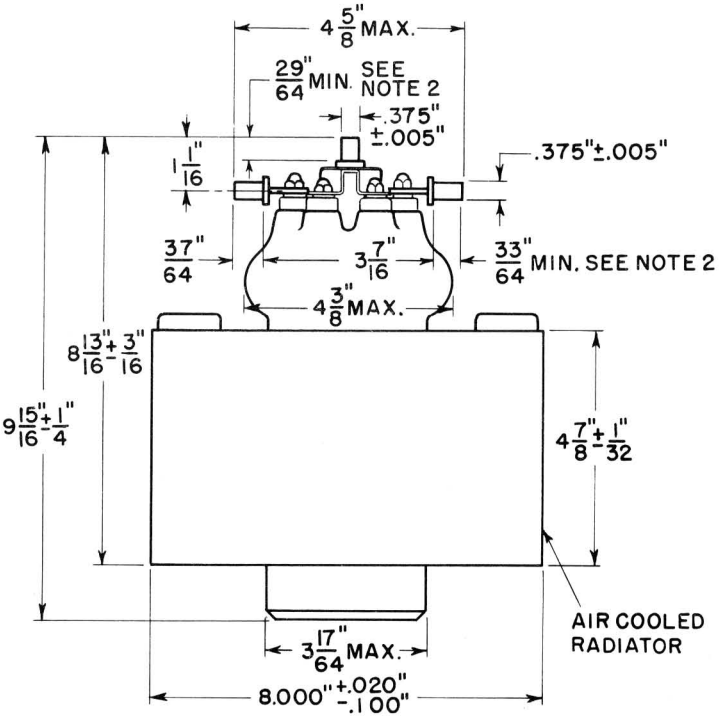


NOTE 1

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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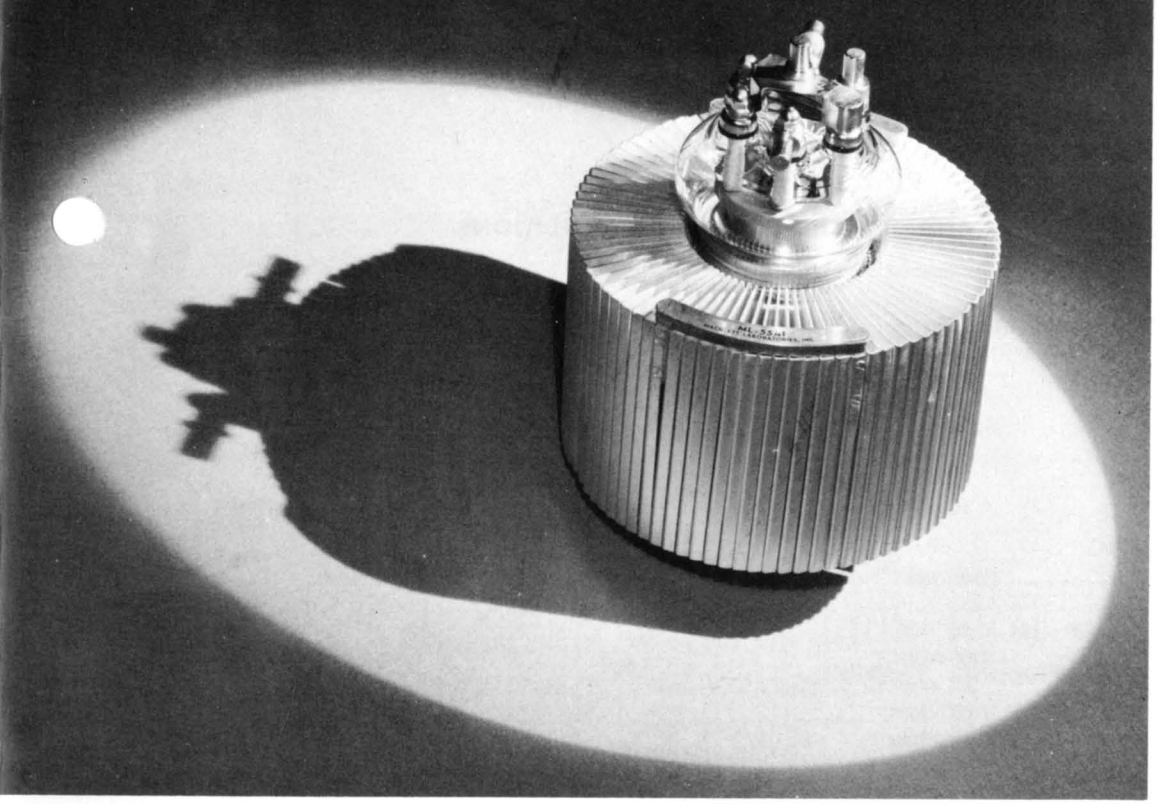


MACHLETT

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
Maximum Incoming Air Temperature	45 °C
Required Air Flow on Anode	500 cfm
Static Pressure, Inches Water	0.55 inch
Maximum Glass Temperature*	160 °C
Net Weight, approximate	30 pounds

* To insure adequate cooling of the glass at frequencies above 40 Mc, it may be necessary either to provide additional air flow or to reverse the direction of air flow through the radiator.

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.

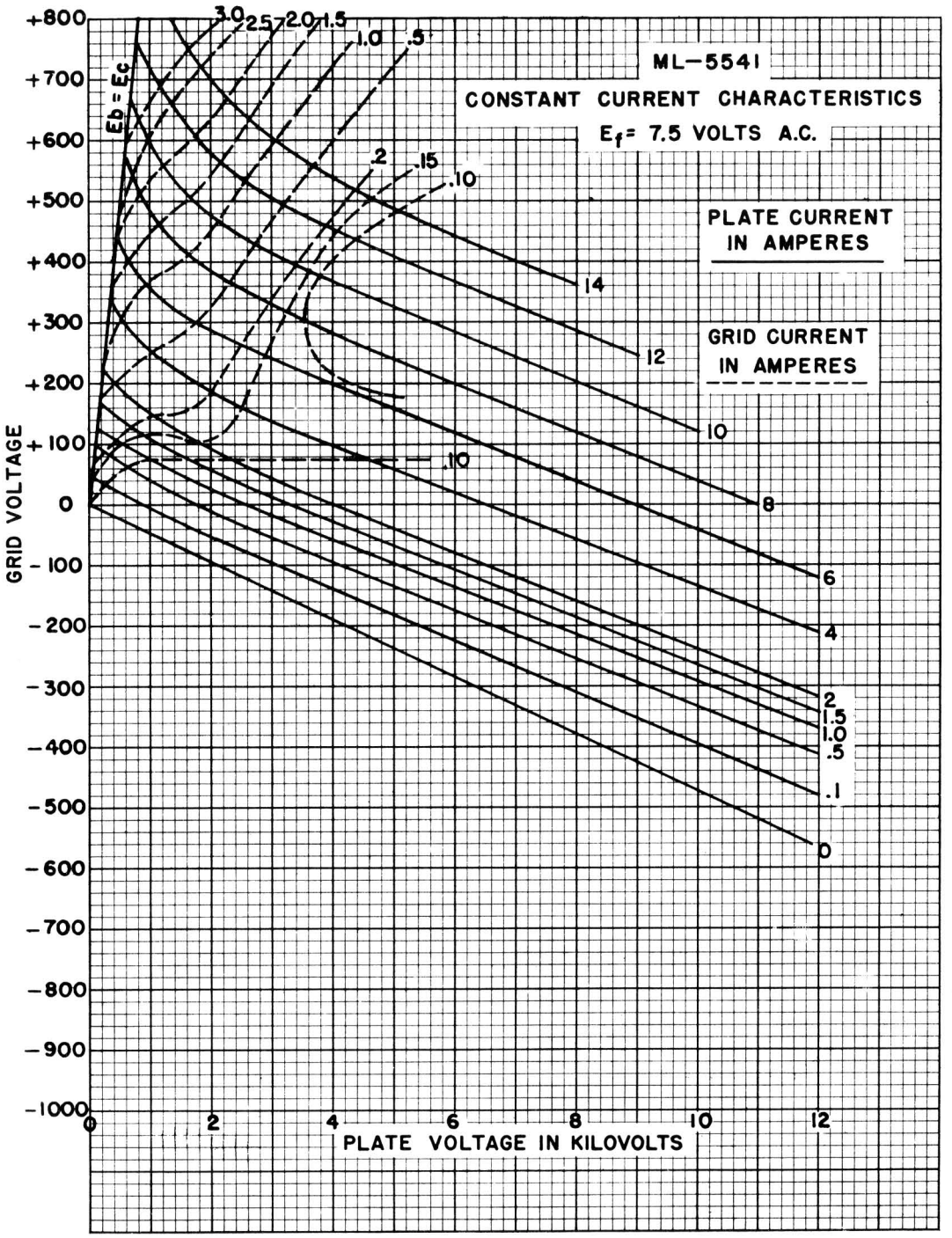
§ Includes power transferred from driver stage.

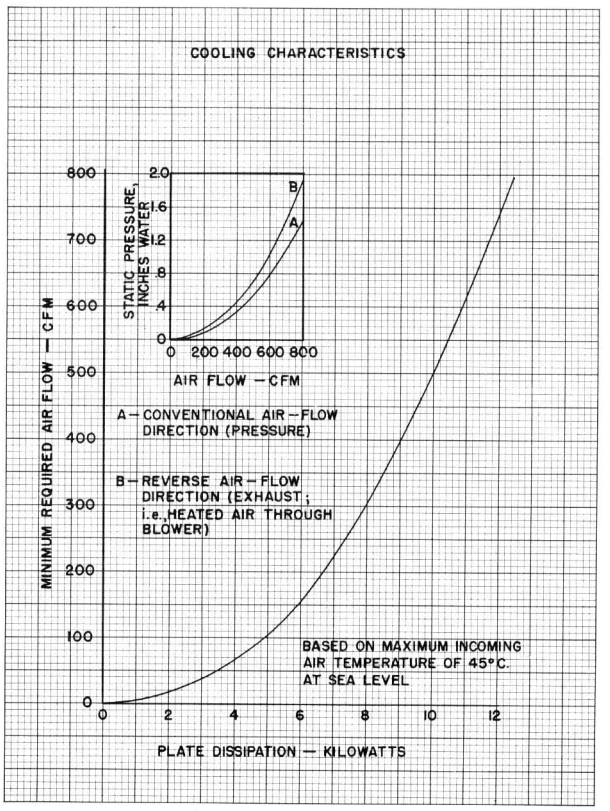
† Average value with modulation factor of 1.0.

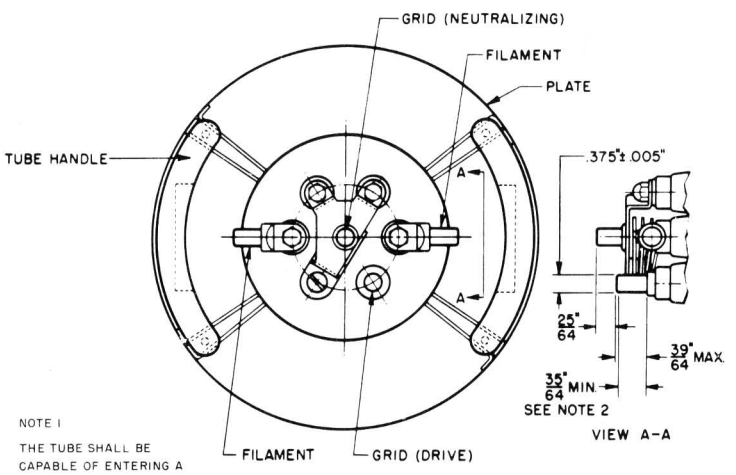
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115 per cent of the carrier conditions.

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





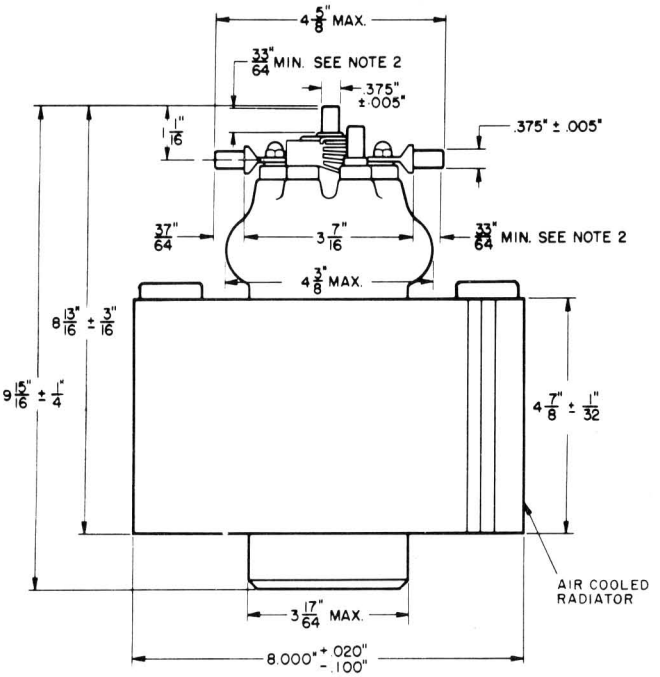


NOTE 1

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.



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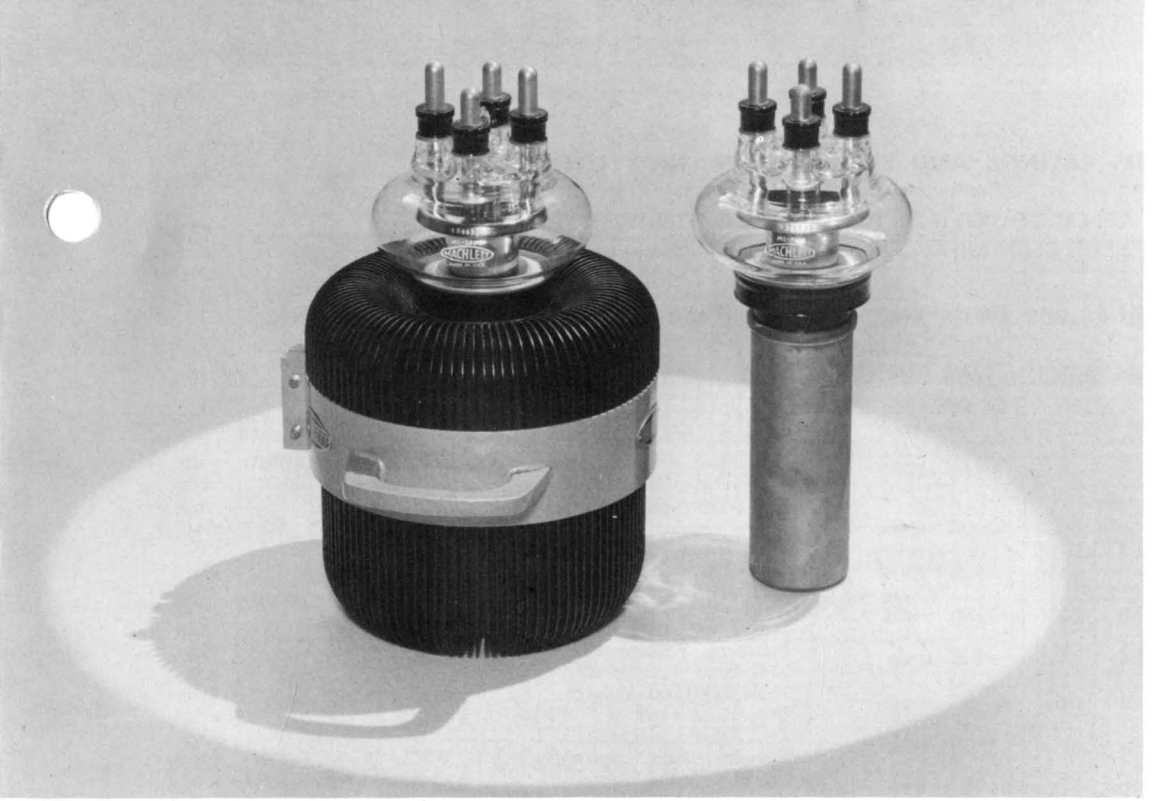


MACHLETT

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	6	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

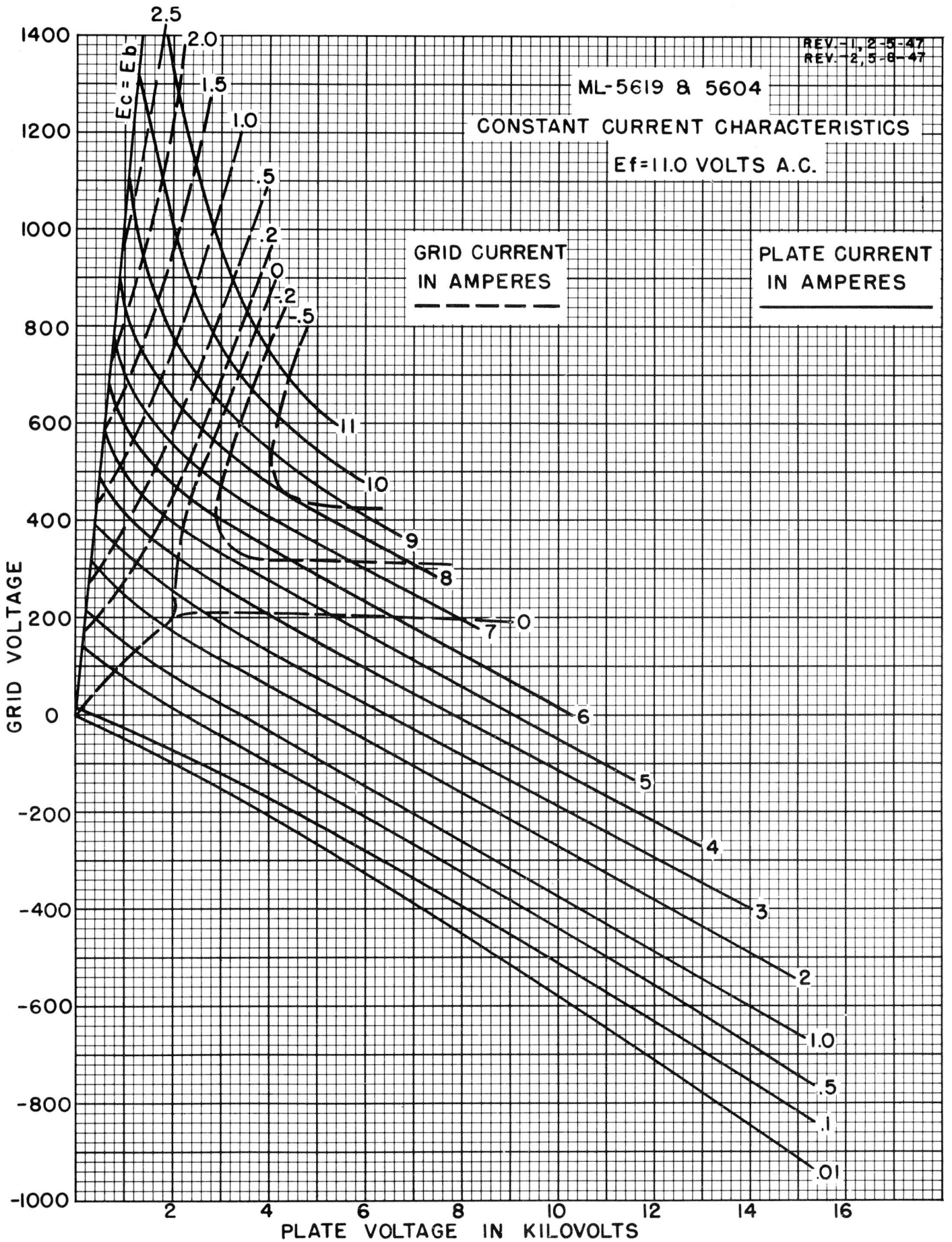
Maximum ratings apply at frequencies up to 25 Mc. These tubes may be operated at higher frequencies provided the maximum values of plate voltage and plate input are reduced according to the tabulation below (other maximum ratings are the same as shown above). Special attention should be given to adequate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

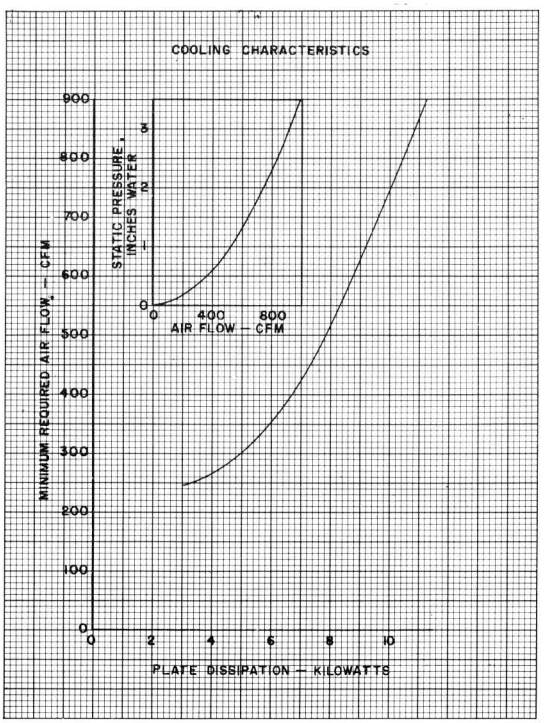
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

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

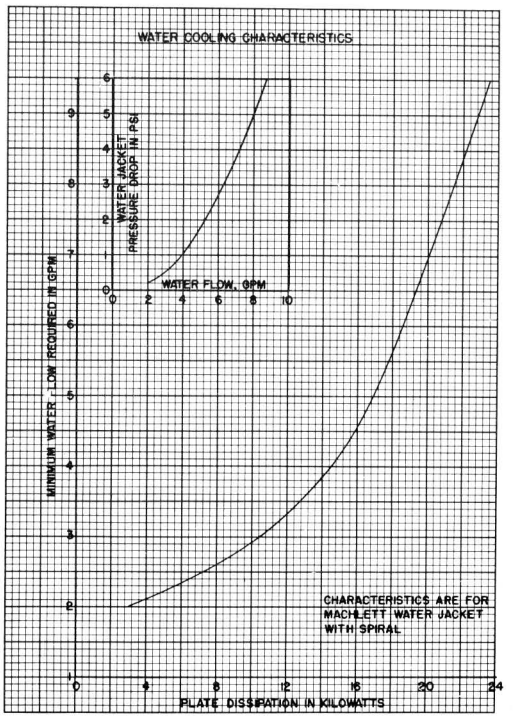
Note: Represents maximum useable plate current plus grid current for any condition of operation.

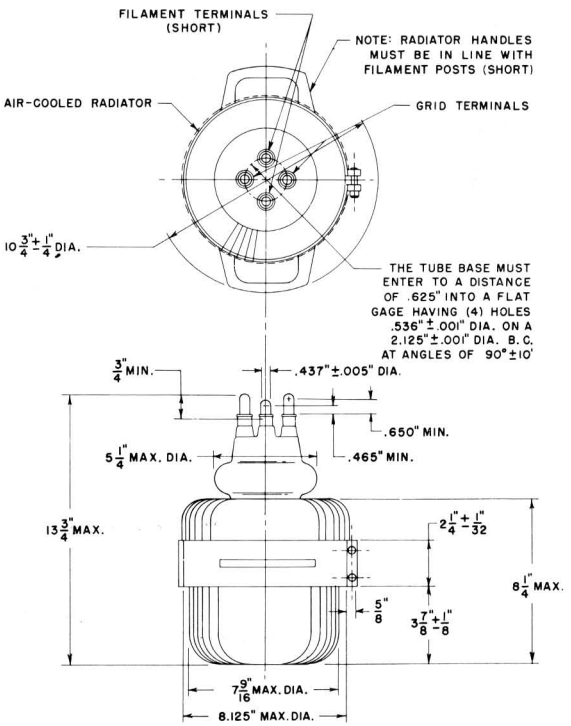

REV.-1, 2-5-47
REV.-2, 5-8-47
ML-5619 & 5604
CONSTANT CURRENT CHARACTERISTICS
Ef=11.0 VOLTS A.C.
GRID CURRENT IN AMPERES
PLATE CURRENT IN AMPERES
Ec=Eb
2.5
2.0
1.5
1.0
.5
.2
0
-.2
-.5
11
10
9
8
7
6
5
4
3
2
1.0
.5
.1
.01
1400
1200
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
GRID VOLTAGE
2
4
6
8
10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

ML-5604

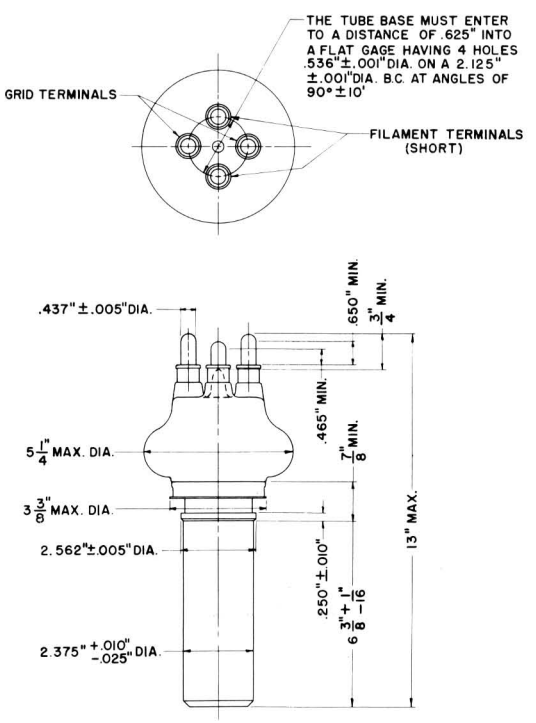


ML-5619





ML-5604



ML-5619

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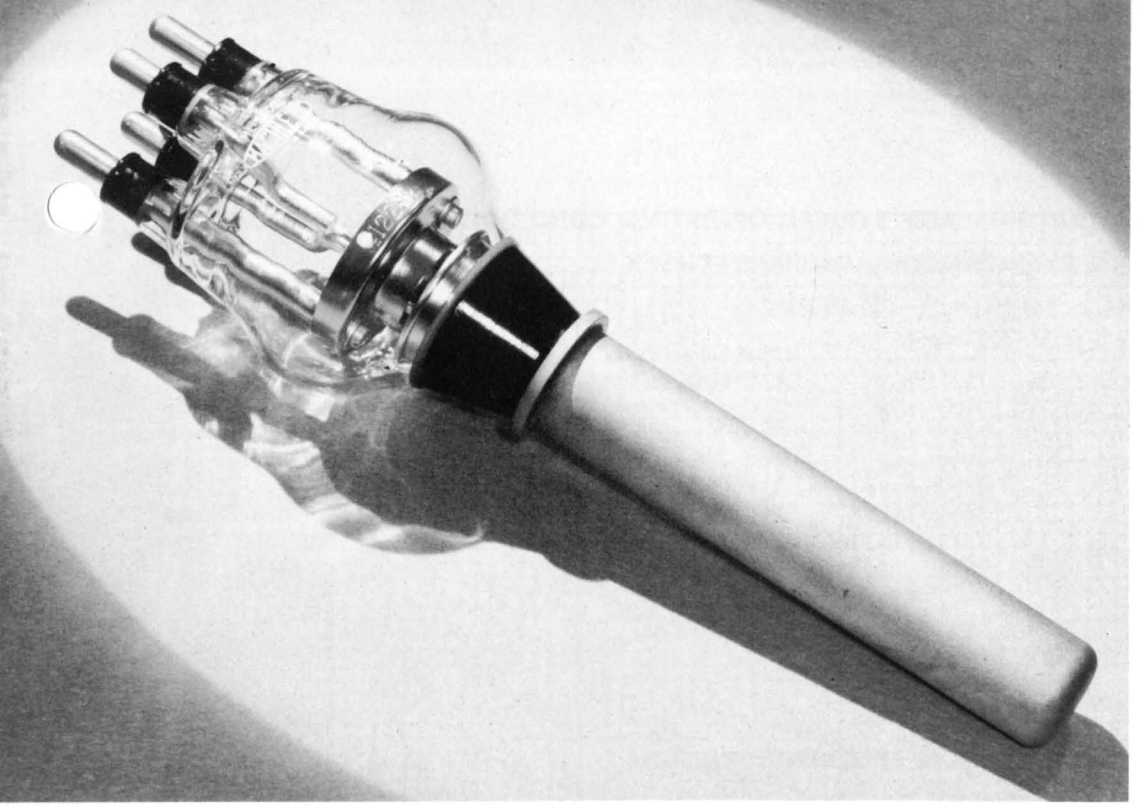


MACHLETT

ML-5606

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-5606** is a three-electrode tube designed to meet the severe conditions of induction heating service. For industrial applications, it supersedes the Type 892 triode and will replace it without equipment modifications. The anode, which is designed for use in existing standard 892 sockets, is water-cooled and with moderate water flow can readily dissipate 10 kW. The cathode is a pure-tungsten stress-free filament. Additional features incorporated include rigidly supported grid and filament assemblies, glass surfaces completely shielded from electron bombardment and filament radiation, and rugged Kovar anode, grid and filament seals. Maximum ratings of 14 kVdc plate voltage and 25 kW plate input apply at frequencies up to 1.6 Mc; operation at 20 Mc is permissible with voltage and input reduced to one-half maximum ratings.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	22 Volts
Filament Current at 22 Volts	60 Amps
Filament Starting Current, maximum	120 Amps
Filament Cold Resistance	0.031 Ohms
Amplification Factor	50
Interelectrode Capacitances	
Grid-Plate	30 uuf
Grid-Filament	16 uuf
Plate-Filament	1.5 uuf

Mechanical

Mounting Position	Vertical, Anode Down
Type of Cooling	Water
Water Flow on Anode	3-8 gpm
Maximum Outgoing Water Temperature	70 °C
Maximum Glass Temperature	160 °C
Net Weight, approximate	3.5 lbs.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

Radio-Frequency Oscillator—Class C*

Maximum Ratings, Absolute Values	
D-C Plate Voltage	14000 volts
D-C Grid Voltage	-1600 volts
D-C Plate Current	2.0 amps
D-C Grid Current	0.40 amp
Plate Input	25000 watts
Plate Dissipation	10000 watts

* For other classes of operation, see ML-892 data.

Typical Operation			
D-C Plate Voltage	8000	10000	12000 volts
D-C Grid Voltage	-700	-900	-1100 volts
Peak R-F Grid Voltage	1440	1730	2040 volts
Peak R-F Plate Voltage	6400	8100	9900 volts
D-C Plate Current	1.4	1.6	1.8 amps
D-C Grid Current, approx.	0.20	0.20	0.20 amp
Power Output, approx.	7800	11300	15500 watts

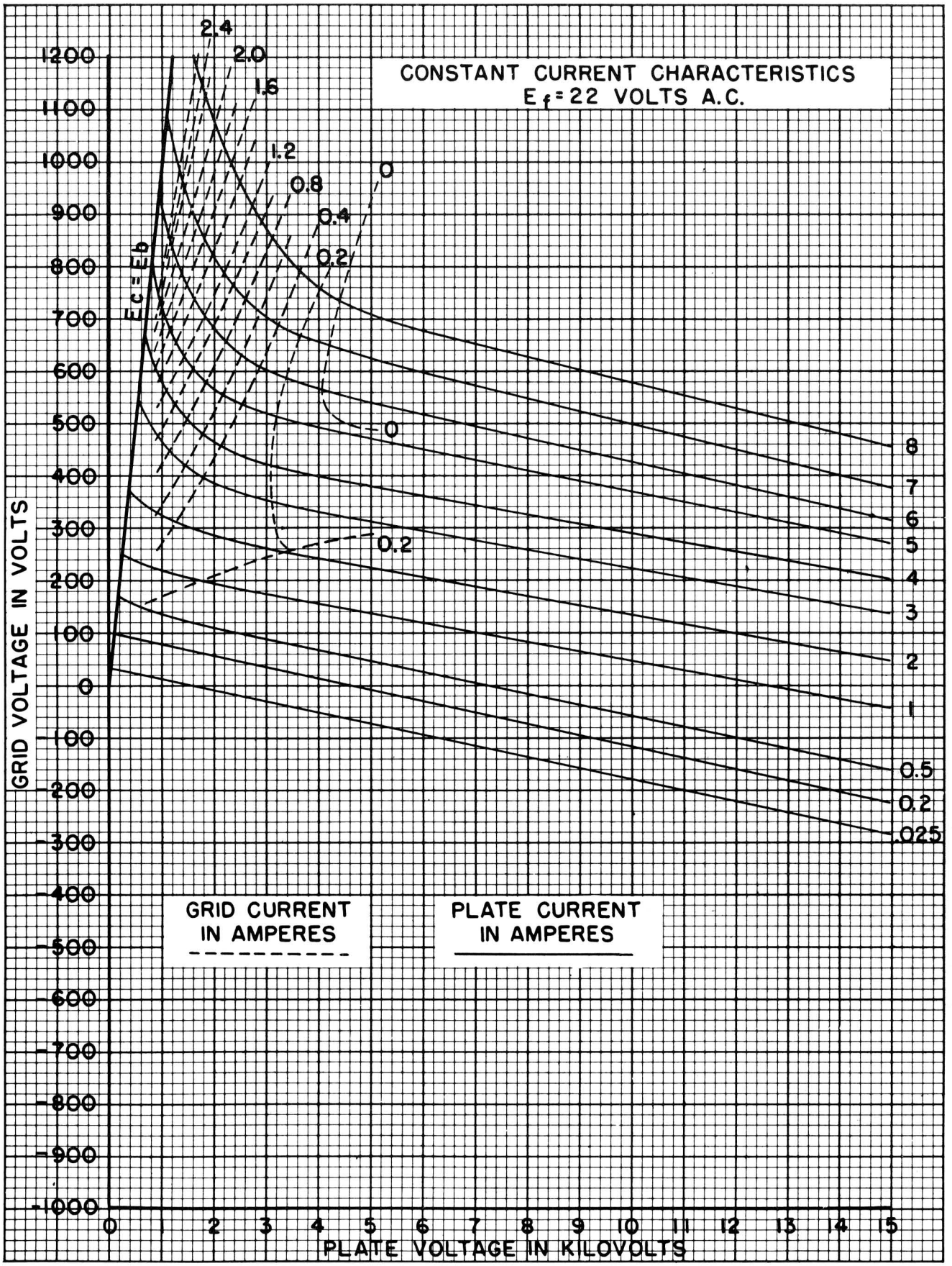
MAXIMUM FREQUENCY RATINGS

Maximum ratings apply at frequencies of 1.6 megacycles and less. 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.

Frequency	1.6	7.5	20 megacycles
Percentage of Maximum Rated Plate Voltage and Plate Input			
Class C Unmodulated	100	75	50 per cent

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 = -1100 Vdc; I_b = 1.8 Adc; I_c = 0.20 Adc.	P_o:	13.0	——	—— kW


CONSTANT CURRENT CHARACTERISTICS
Ef = 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
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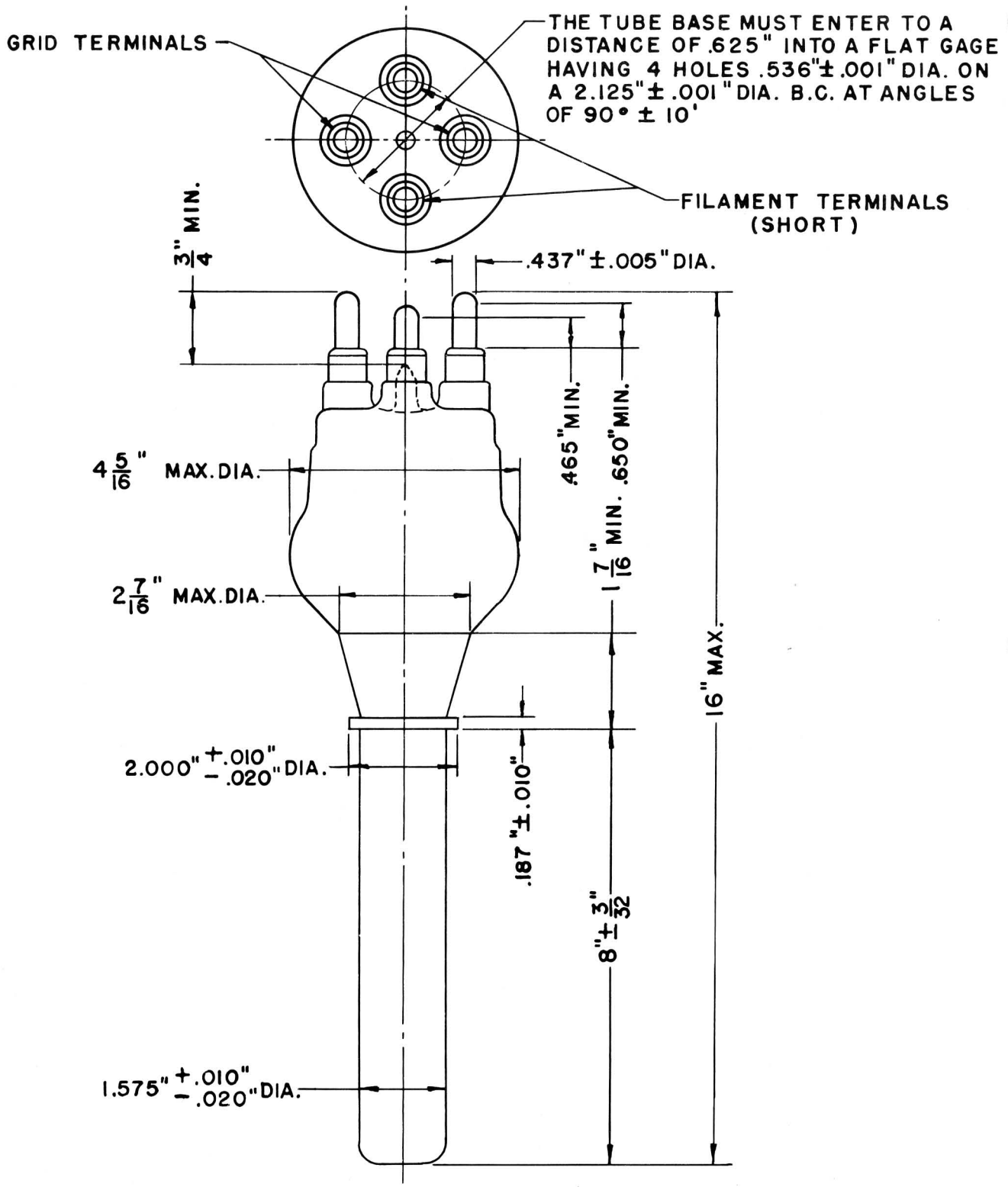

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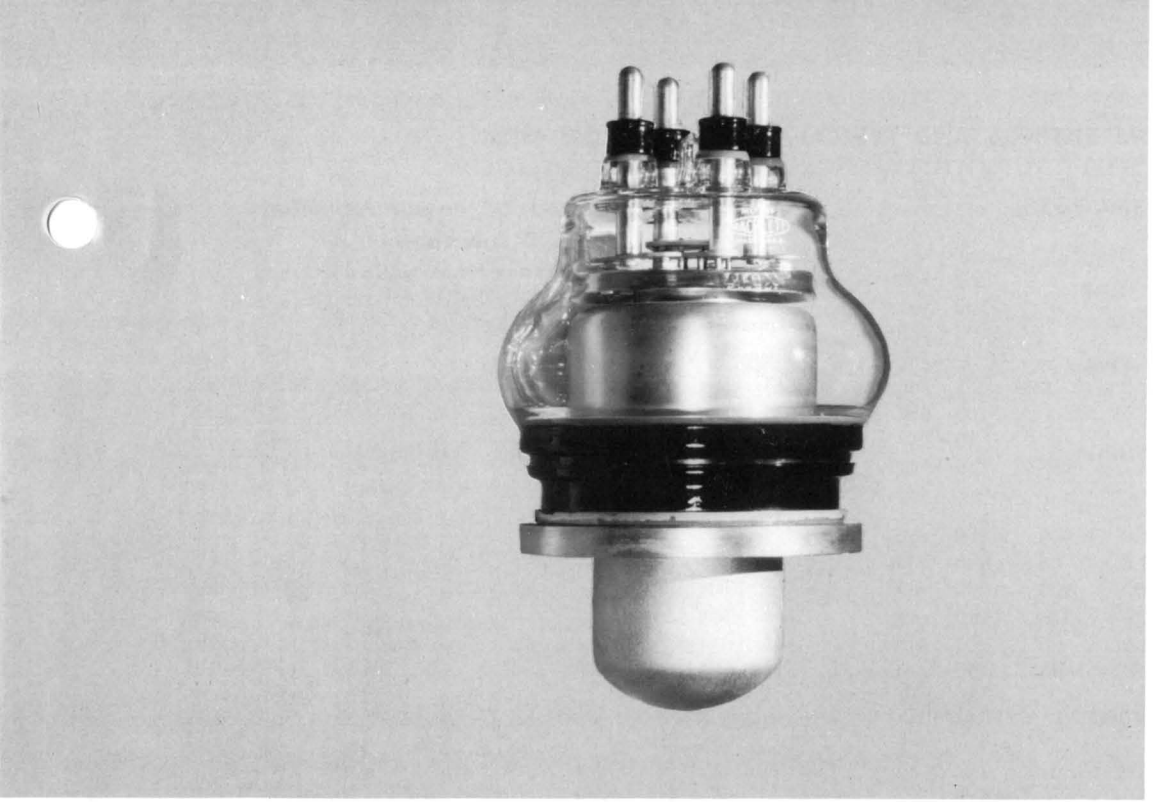


MACHLETT

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

Filament Voltage	12.0	volts
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

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

Filament Voltage	12.6	volts
D-C Plate Voltage	10500	volts
Signal D-C Plate Current*	5.0	amps
Signal Plate Input*	40	kW
Plate Dissipation*	15	kW

Values are for 2 Tubes

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

Filament Voltage	12.6	volts
D-C Plate Voltage	10500	volts
D-C Plate Current	4.0	amps
Plate Input	32	kW
Plate Dissipation	20	kW

Typical Operation

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

Filament Voltage	12.6	volts
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

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

Filament Voltage	12.6	volts
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

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

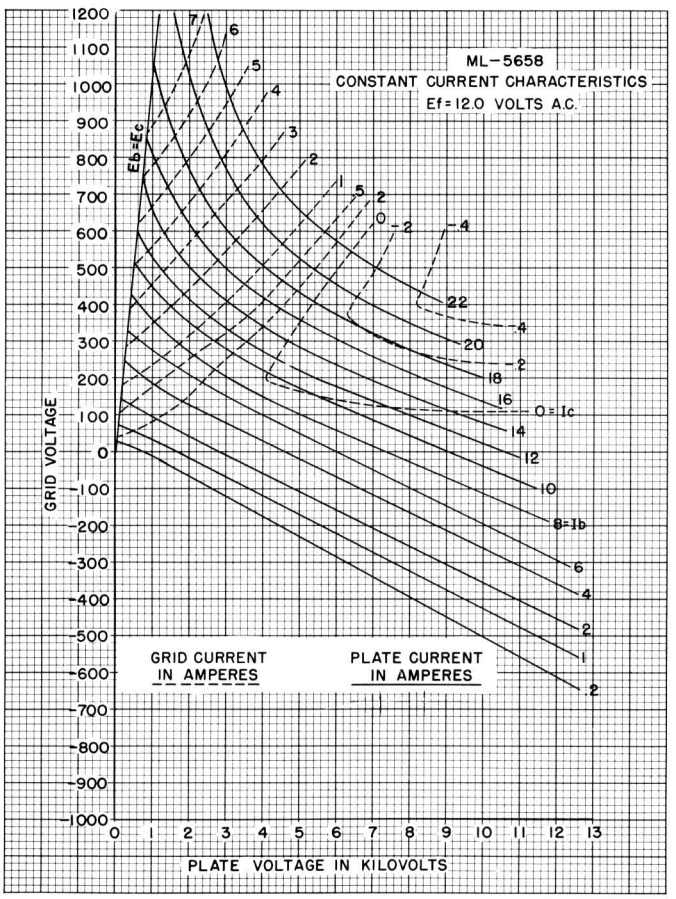
Mc	Class B		Class C Telephony	Class C Telegraphy
	Volts	Watts		
25	100	100	100	100
50	80	94	72	75
75	68	85	56	62
100	60	75	45	50

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

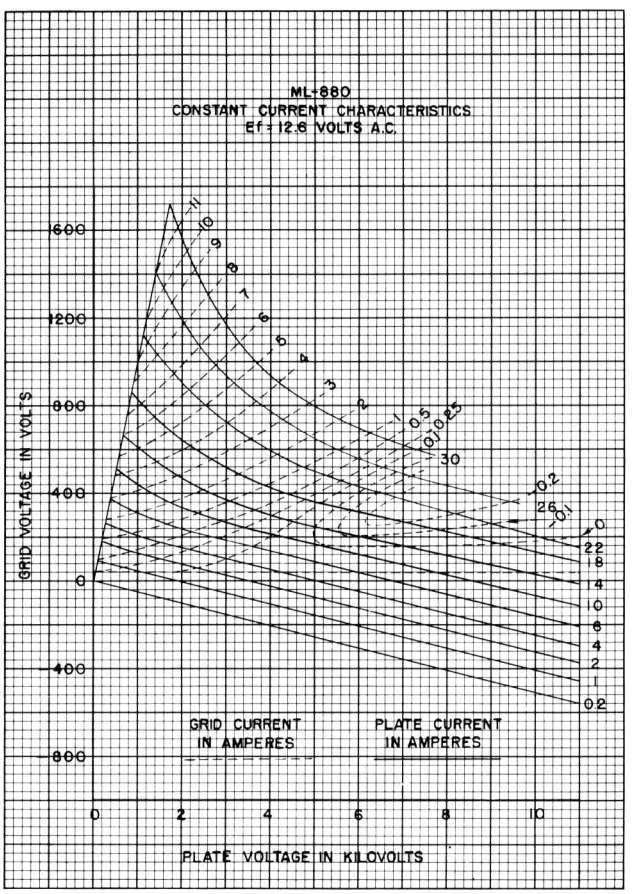
Characteristics	Conditions (E_f = 12.6 Volts)		Limits Minimum	Bogey	Maximum	
Grid Voltage	e_b = 2000 volts; i_b = 25 amps	e_c:	—	—	1300	Volts
Grid Current	e_b = 2000 volts; i_b = 25 amps	i_c:	—	—	10.0	Amps
Plate Voltage	E_c = 0 Vdc; I_b = 2.0 Adc	E_b:	2.8	3.2	3.6	kVdc
Plate Voltage	E_c = −200 Vdc; I_b = 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

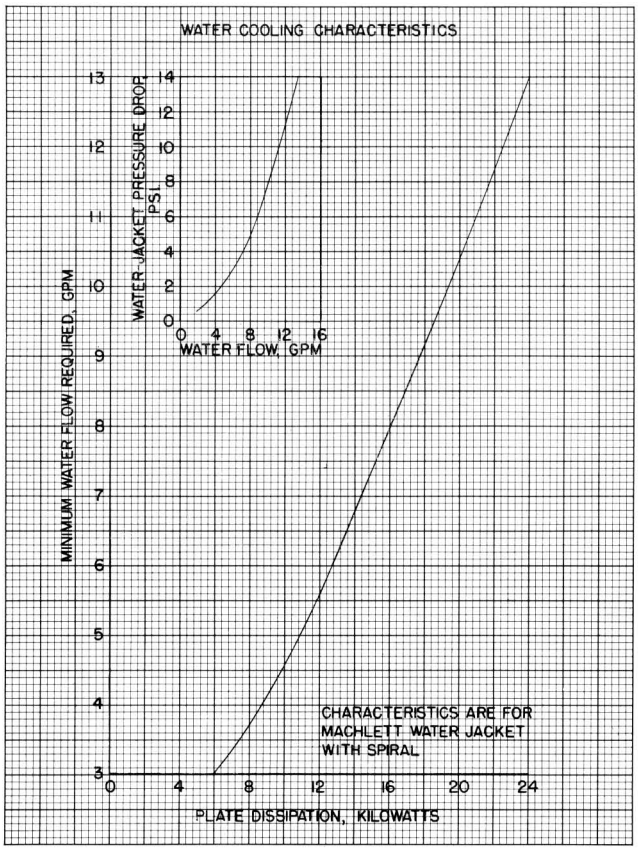
Note 1: Represents maximum plate current plus grid current for any condition of operation.

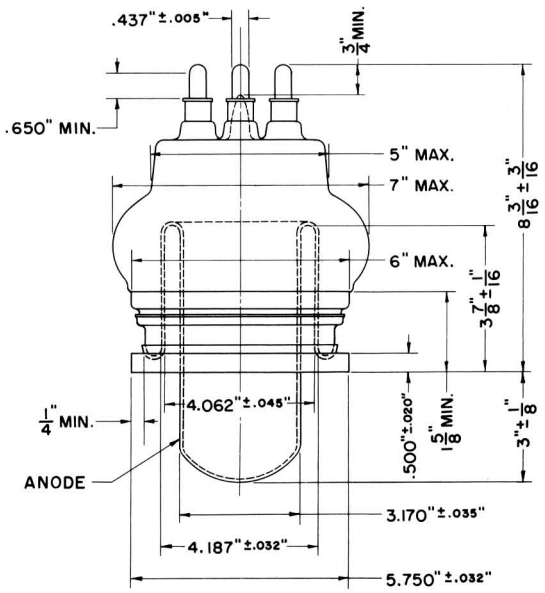
ML-5658

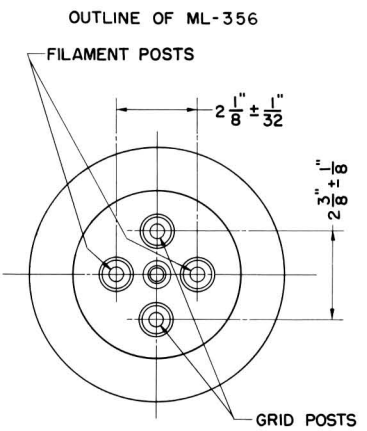


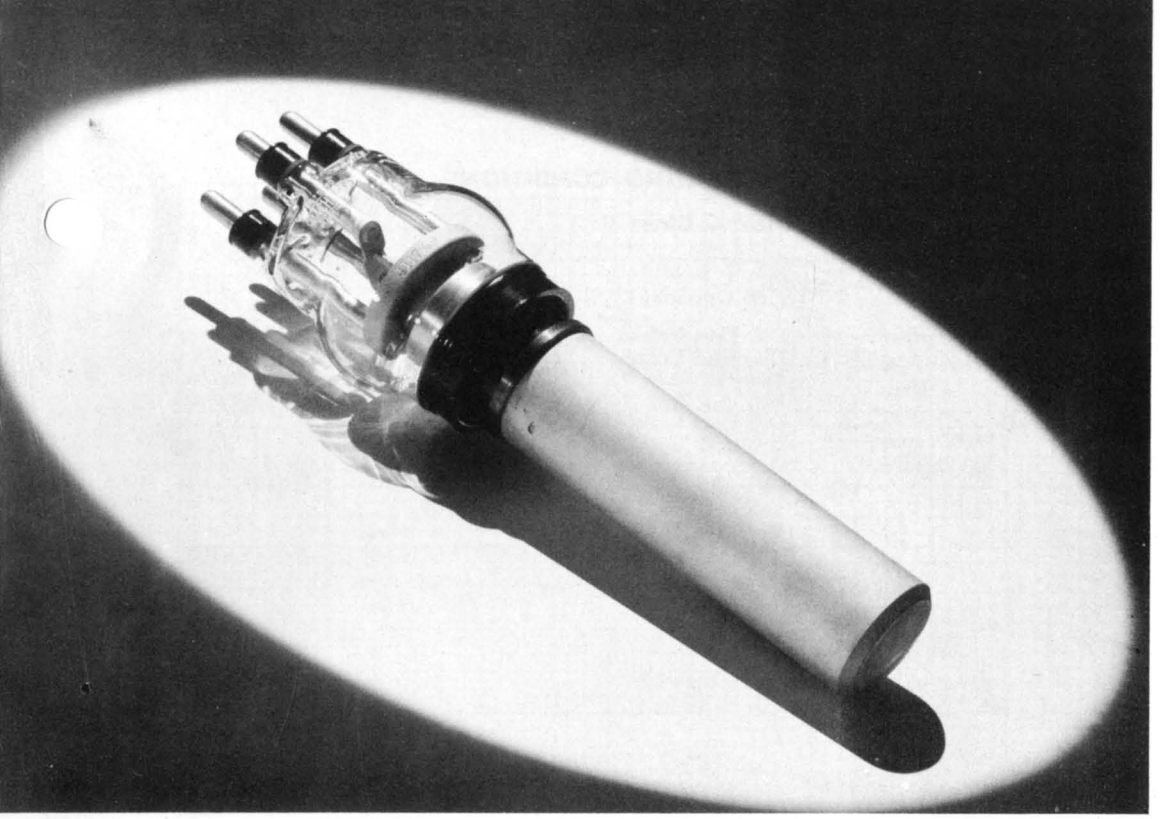
ML-880




WATER COOLING CHARACTERISTICS
MINIMUM WATER FLOW REQUIRED, GPM
WATER-JACKET PRESSURE DROP PSI
WATER FLOW, GPM
CHARACTERISTICS ARE FOR MACHLETT WATER JACKET WITH SPIRAL
PLATE DISSIPATION, KILOWATTS


.437" ±.005"
3/4" MIN.
.650" MIN.
5" MAX.
7" MAX.
6" MAX.
8 3/16" ± 3/16"
3 7/8" ± 1/16"
1/4" MIN.
4.062" ±.045"
.500" ±.020"
5/8" MIN.
3" ± 1/8"
ANODE
3.170" ±.035"
4.187" ±.032"
5.750" ±.032"


OUTLINE OF ML-356
FILAMENT POSTS
2 1/8" ± 1/32"
2 3/8" ± 1/8"
GRID POSTS



MACHLETT

ML-5668

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-5668** is a three-electrode tube designed specifically to meet the severe conditions of radio-frequency heating service. For industrial heating service, it supersedes the Type 892 triode 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 cathode is a pure-tungsten stress-free filament designed to afford longer filament life. The tube incorporates rigidly supported grid and filament assemblies, glass surfaces completely shielded against electron bombardment and filament radiation, and rugged kovar anode, grid, and filament seals to withstand the rigorous mechanical and electrical operation inherent in industrial applications. Maximum ratings of 14 kVdc plate voltage and 28 kW plate input apply at frequencies up to 5 Mc; operation at 20 Mc is permissible with voltage and input reduced to one-half maximum ratings.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	22.0 Volts
Filament Emission	9.4 Amps
Filament Current at 22.0 volts	60 Amps
Filament Starting Current, maximum	120 Amps
Filament Cold Resistance	.031 Ohms
Amplification Factor	50
Interelectrode Capacitances	
Grid-Plate	30 uuf
Grid-Filament	18 uuf
Plate-Filament	1.5 uuf

Mechanical

Mounting Position	Vertical, anode down
Type of Cooling	Water and forced-air
Water flow on anode	See Water Cooling Characteristics on page 2
Maximum outgoing water temperature	70 °C
Air flow on center of dish from 3" nozzle	35 cfm*
Maximum Glass Temperature	160 °C
Net Weight, approximate	10 lbs.

* At frequencies above 3 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

Radio-Frequency Oscillator — Class C

Maximum Ratings, Absolute Values

D-C Plate Voltage	14000 volts
D-C Grid Voltage	-1600 volts
D-C Plate Current	2.0 amps
D-C Grid Current	0.40 amp
Plate Input	28000 watts
Plate Dissipation	20000 watts

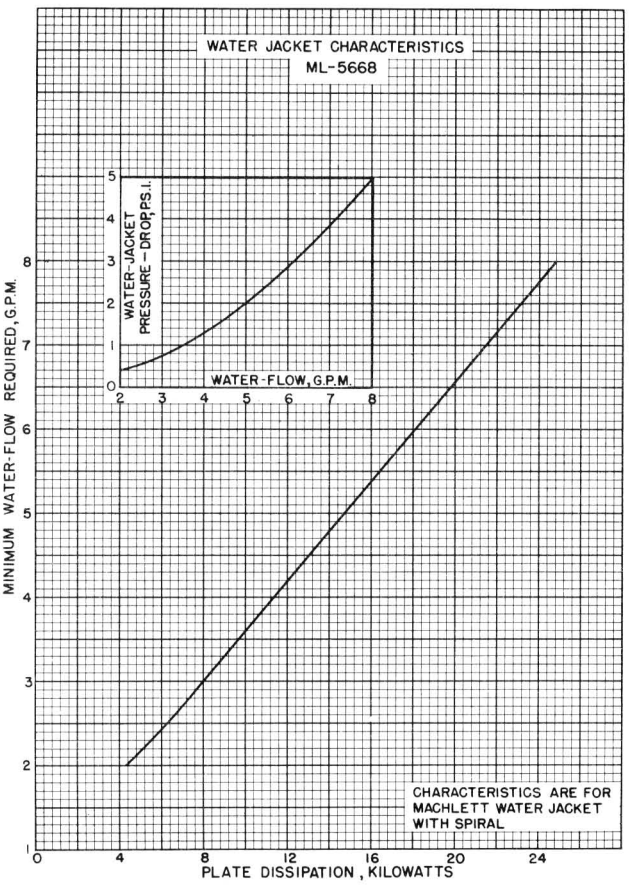
Typical Operation

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

MAXIMUM FREQUENCY RATINGS

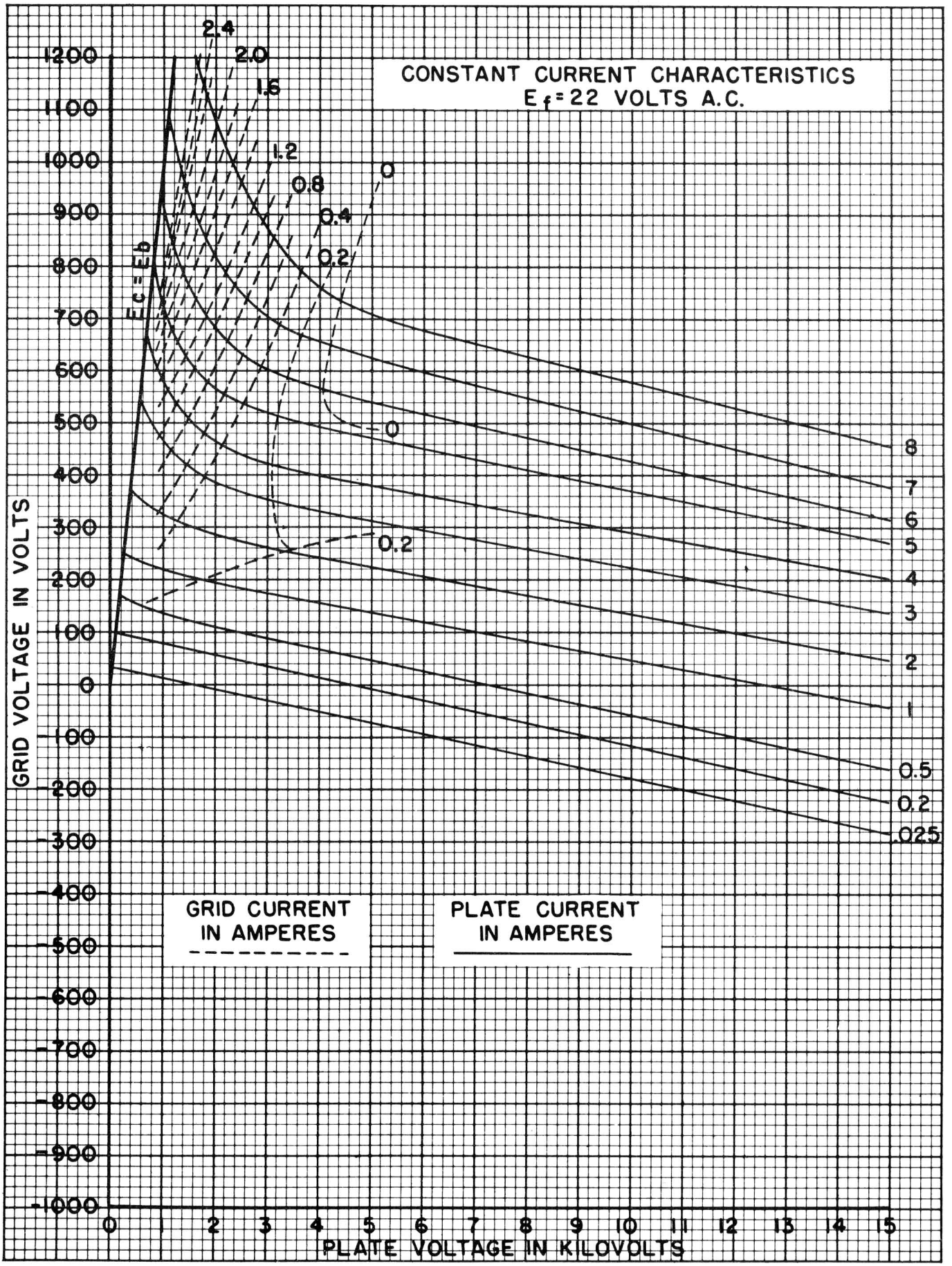
Maximum ratings apply at frequencies of 5 megacycles and less. Maximum values of plate voltage and power input for operation at higher frequencies are determined by the percentage factors tabulated below, other maximum ratings being the same as shown in the above section. At high frequencies special attention should be given to adequate ventilation of the bulb.

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



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


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
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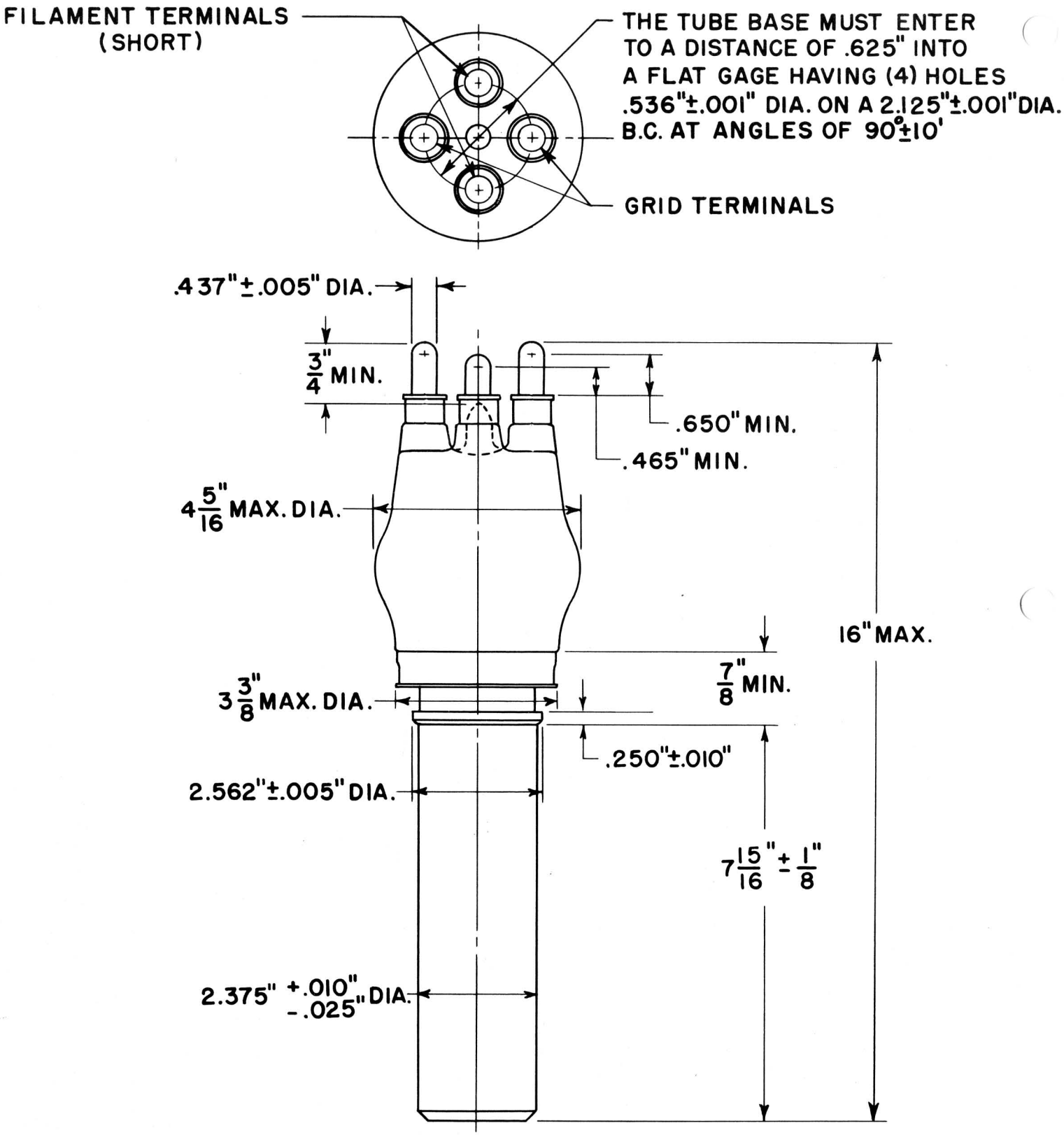


MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

MACHLETT

ML-5681

DESCRIPTION AND RATINGS

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.			
Sychronizing 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 Curent	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.	Bogey	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".

If the tube still fails to operate satisfactorily, it is sometimes possible to getter this gas. The **ML-5681** is equipped with a zirconium getter which will absorb free gas within the tube when heated by a current of 8.5 amperes (at about two volts) which may be drawn from the filament power through an appropriate dropping resistor (approximately 1.5 ohms). 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, then (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.

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 insulating 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.

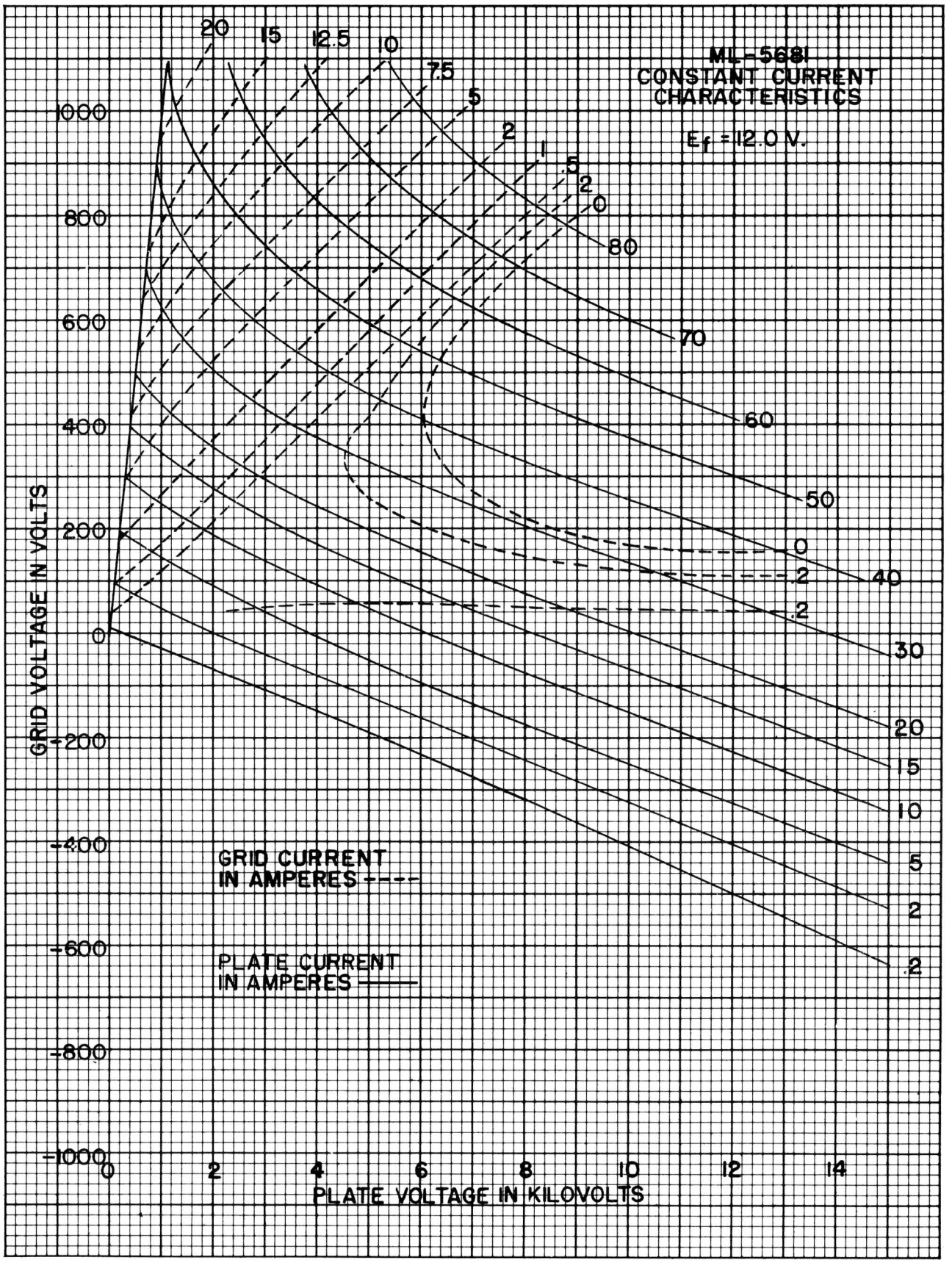
In Class C Plate-Modulated R-F Amplifier service, the **ML-5681** should be supplied with bias from the grid resistor or from a suitable combination of grid resistor and fixed supply. The combination grid-resistor and fixed-supply method has the advantage of protecting the tube through loss of excitation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

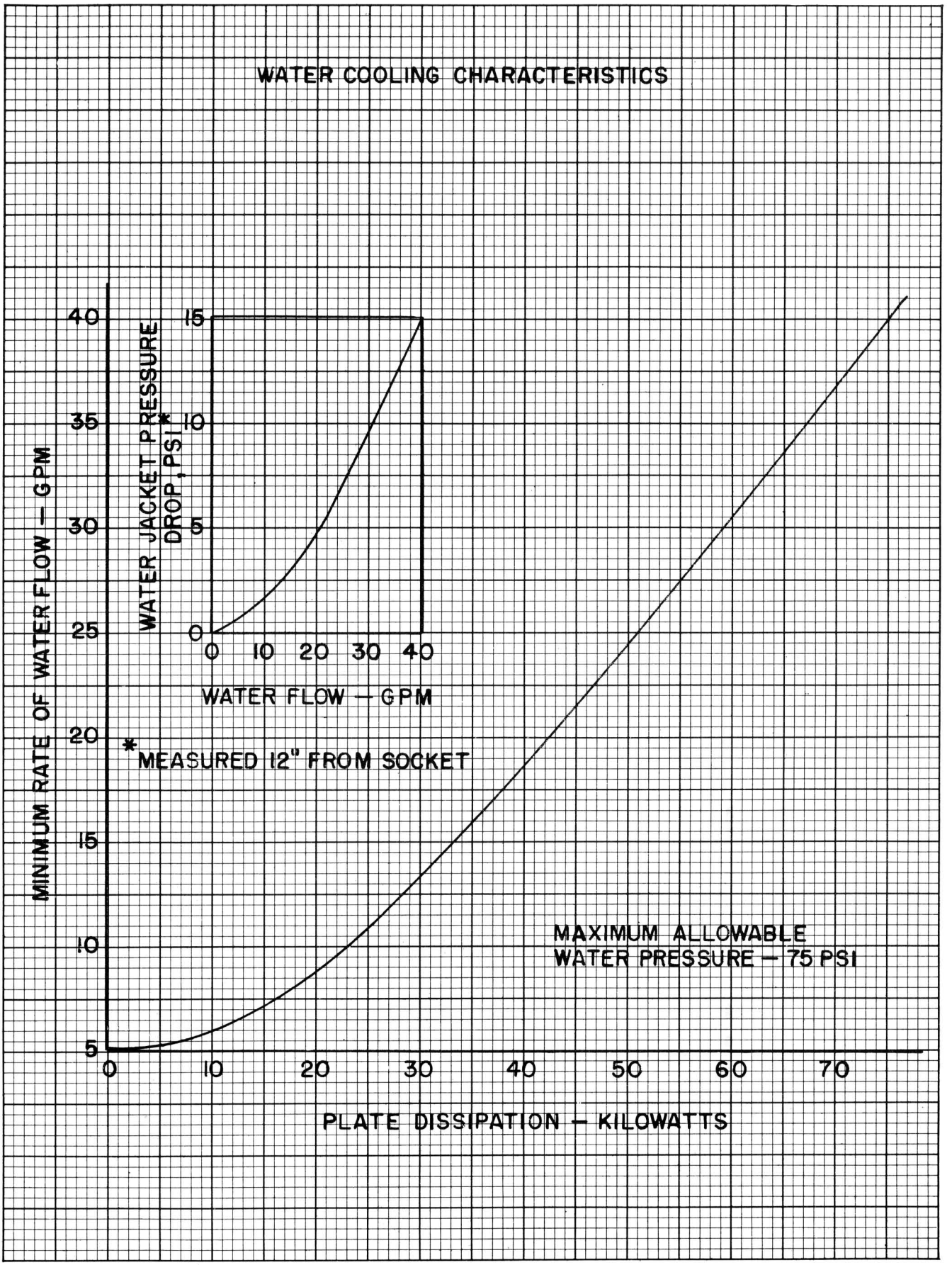
In Class C R-F Telegraphy, the **ML-5681** should be supplied with bias obtained from a fixed supply for amplifier service, or from an adjustable grid resistor for oscillator service. Variation of d-c grid current between individual tubes requires provision for adjustment of the grid resistor to obtain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

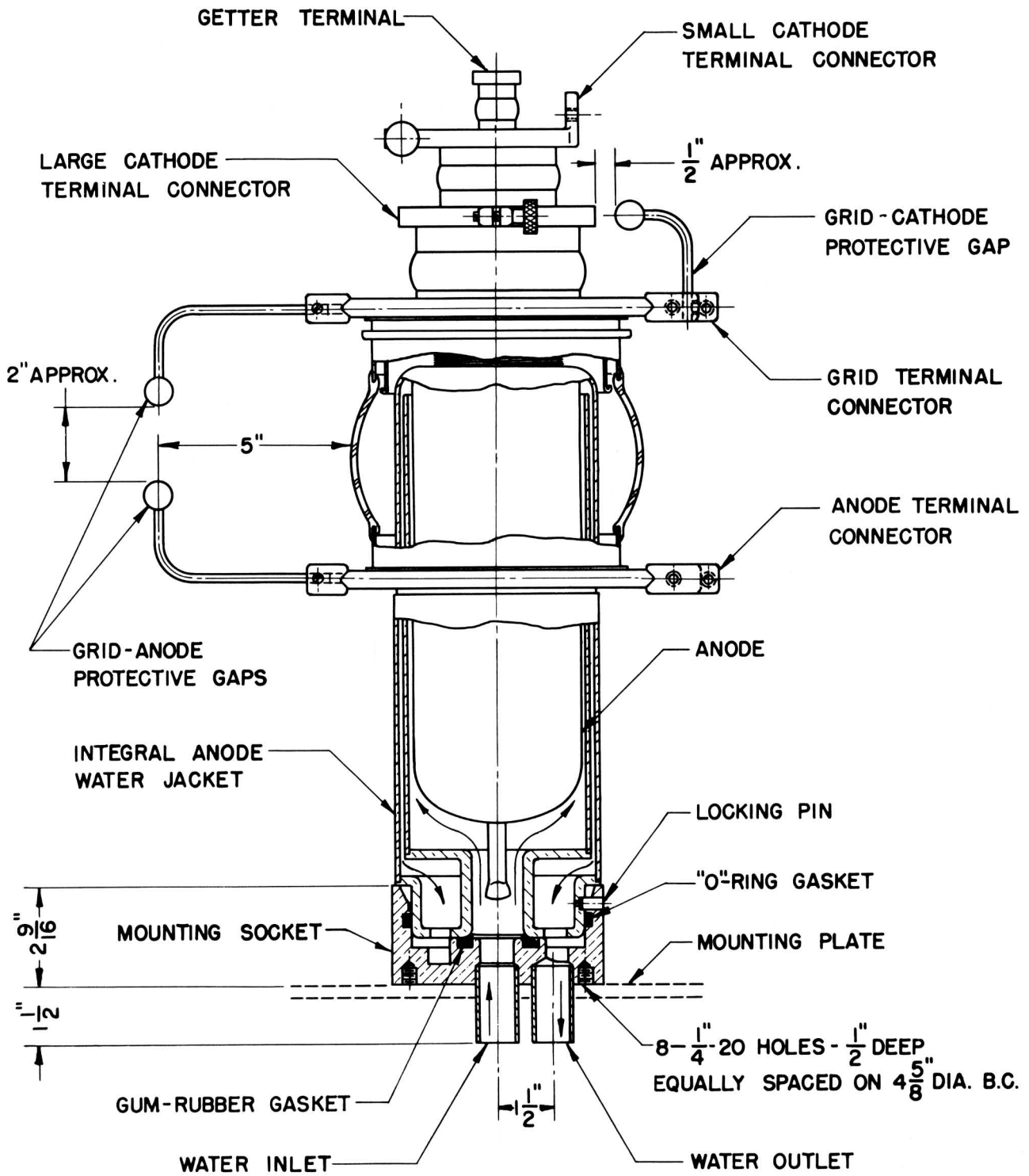
In cathode-drive circuits, the required driving power is increased since the driving voltage and the developed r-f plate voltage act in series to supply the load. This additional driving power reappears as part of the output to the load. The power output increases as the driving voltage and grid current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

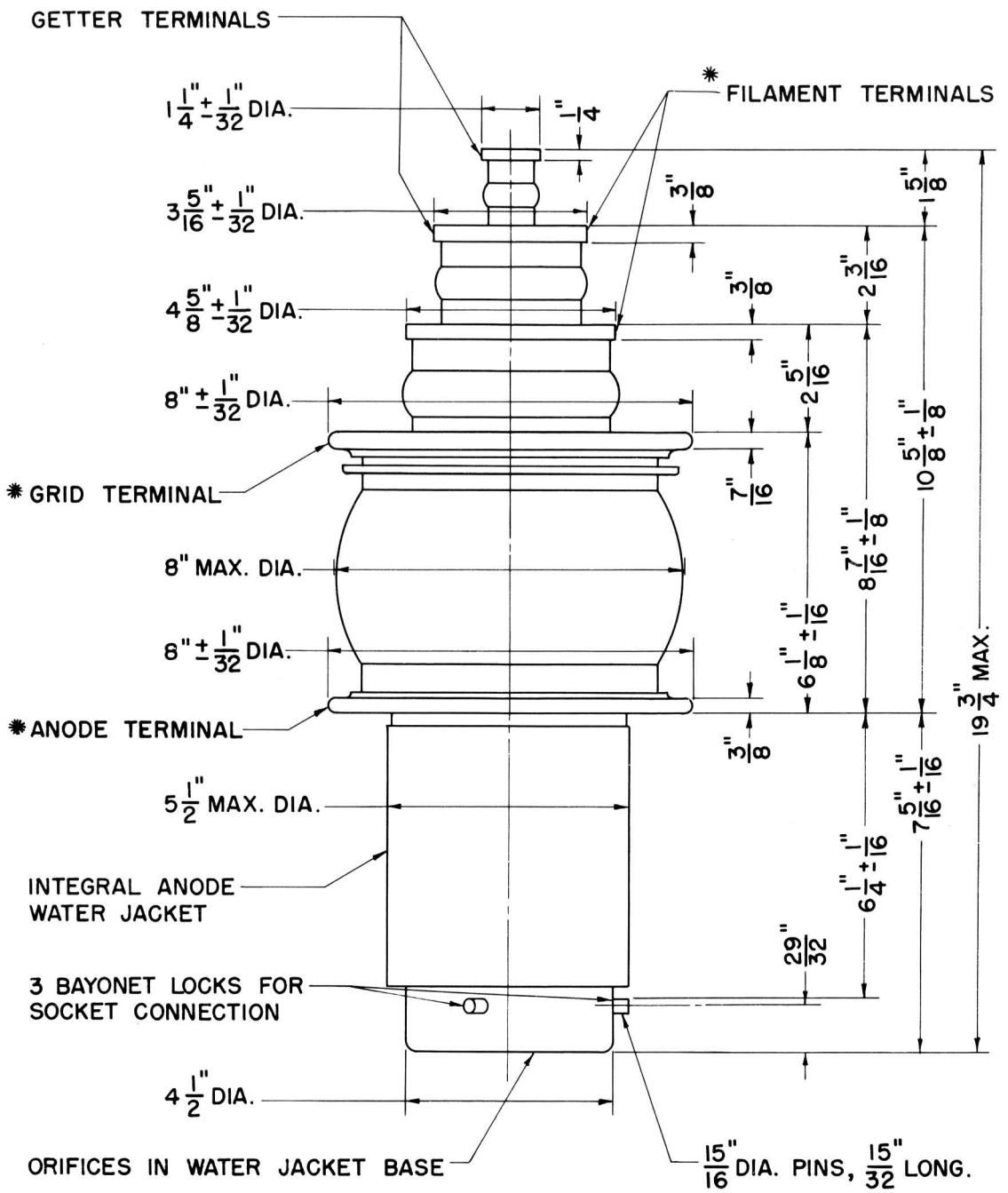

ML-5681
CONSTANT CURRENT
CHARACTERISTICS
E_f = 12.0 V.
20
15
12.5
10
7.5
5
2
1
.5
.2
0
80
70
60
50
40
30
20
15
10
5
2
.2
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
GRID VOLTAGE IN VOLTS
GRID CURRENT
IN AMPERES ----
PLATE CURRENT
IN AMPERES ——
0
2
4
6
8
10
12
14
PLATE VOLTAGE IN KILOVOLTS


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.

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

PRINTED IN U.S.A.

MACHLETT

ML-5682

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-5682** is a compact, general purpose, high-power electron tube designed for operation at frequencies up to 88 Mc. It is a coaxial-terminal, water- and forced-air-cooled triode capable of approximately 75 kW output at 88 Mc in cathode-drive circuitry with 15 kW driving power. Maximum ratings of 9 kVdc plate voltage and 170 kW plate input apply at frequencies up to 88 Mc; increased ratings of 16 kVdc plate voltage and 300 kW plate input are permissible at frequencies up to 30 Mc.

The **ML-5682** 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 120 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	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 Seals, approximate	250	cfm
Maximum Glass 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*	120	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	120	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	120	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	120	120	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	14000	volts
D-C Grid Voltage	-3200	volts
D-C Plate Current	14	amps
D-C Grid Current	4.0	amps
Plate Input	185	kW
Plate Dissipation	80	kW
Frequency	30	Mc

Typical Operation

D-C Plate Voltage	10000	14000	volts
D-C Grid Voltage	-950	-1270	volts
Peak R-F Grid Voltage	1450	1810	volts
Peak R-F Plate Voltage	8700	12300	volts
D-C Plate Current	9.2	10.3	amps
D-C Grid Current	2.1	2.0	amps
R-F Load Resistance	525	640	ohms
Driving Power, approximate	2.9	3.4	kW
Power Output, approximate	72	118	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	120	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

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	120	120	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.

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	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".

If the tube still fails to operate satisfactorily, it is sometimes possible to getter this gas. The **ML-5682** is equipped with a zirconium getter which will absorb free gas within the tube when heated by a current of 8.5 amperes (at about two volts) which may be drawn from the filament power through an appropriate dropping resistor (approximately 2 ohms). 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, then (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.

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 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 a metalized 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 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-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 10. 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 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 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 10, 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 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 conductive device may be connected at the output of the plate-supply filter to dissipate the filter-circuit energy as well as the rectifier output.

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. The criterion is the total energy to which the tube can be subjected. The minimum values of resistance

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

which alone will give adequate protection with reasonably low power loss is as follows:

Series Resistor	10	20	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-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 10. Gap spacings must be carefully adjusted for each individual application.

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 tabluated 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 tabluated 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.

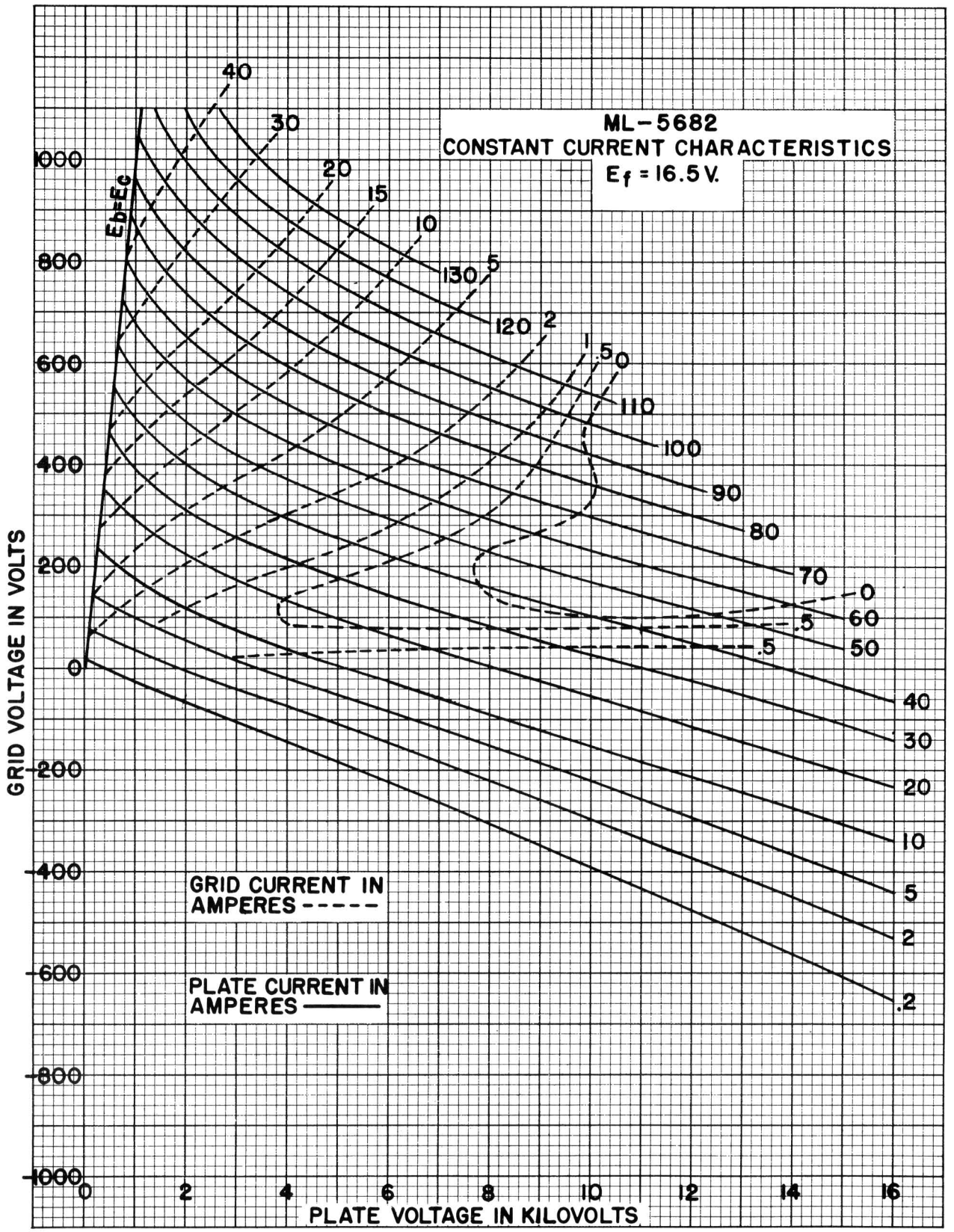
In Class C Plate-Modulated R-F Amplifier service, the **ML-5682** should be supplied with bias from a grid resistor or from a suitable combination of grid resistor and fixed supply. The combination grid-resistor and fixed-supply method has the advantage of protecting the tube through loss of excitation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

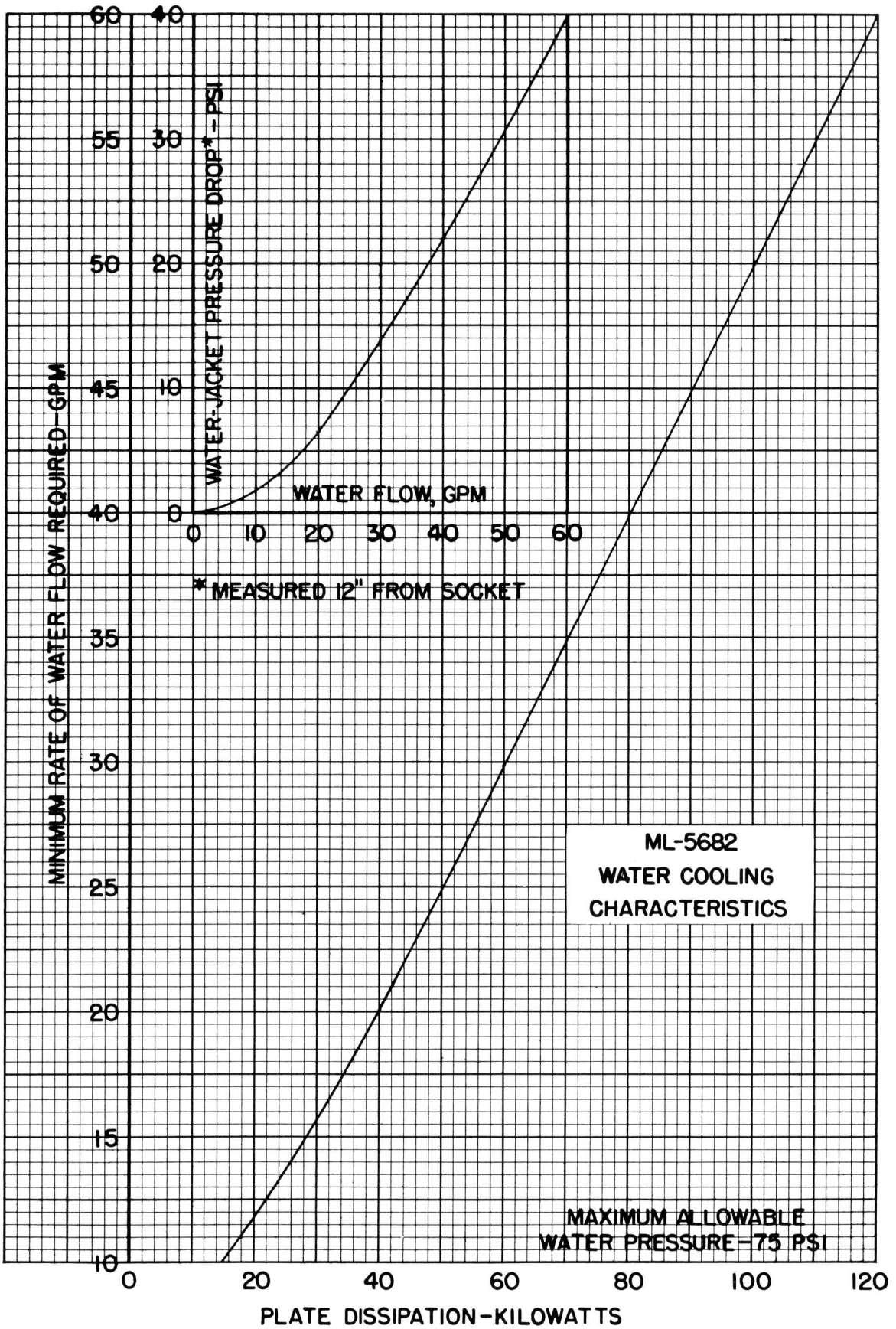
In Class C R-F Telegraphy, the **ML-5682** should be supplied with bias obtained from a fixed supply for amplifier service, or from an adjustable grid resistor for oscillator service. Variation of d-c grid currrent between individual tubes requires provision for adjustment of the grid resistor to obtain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

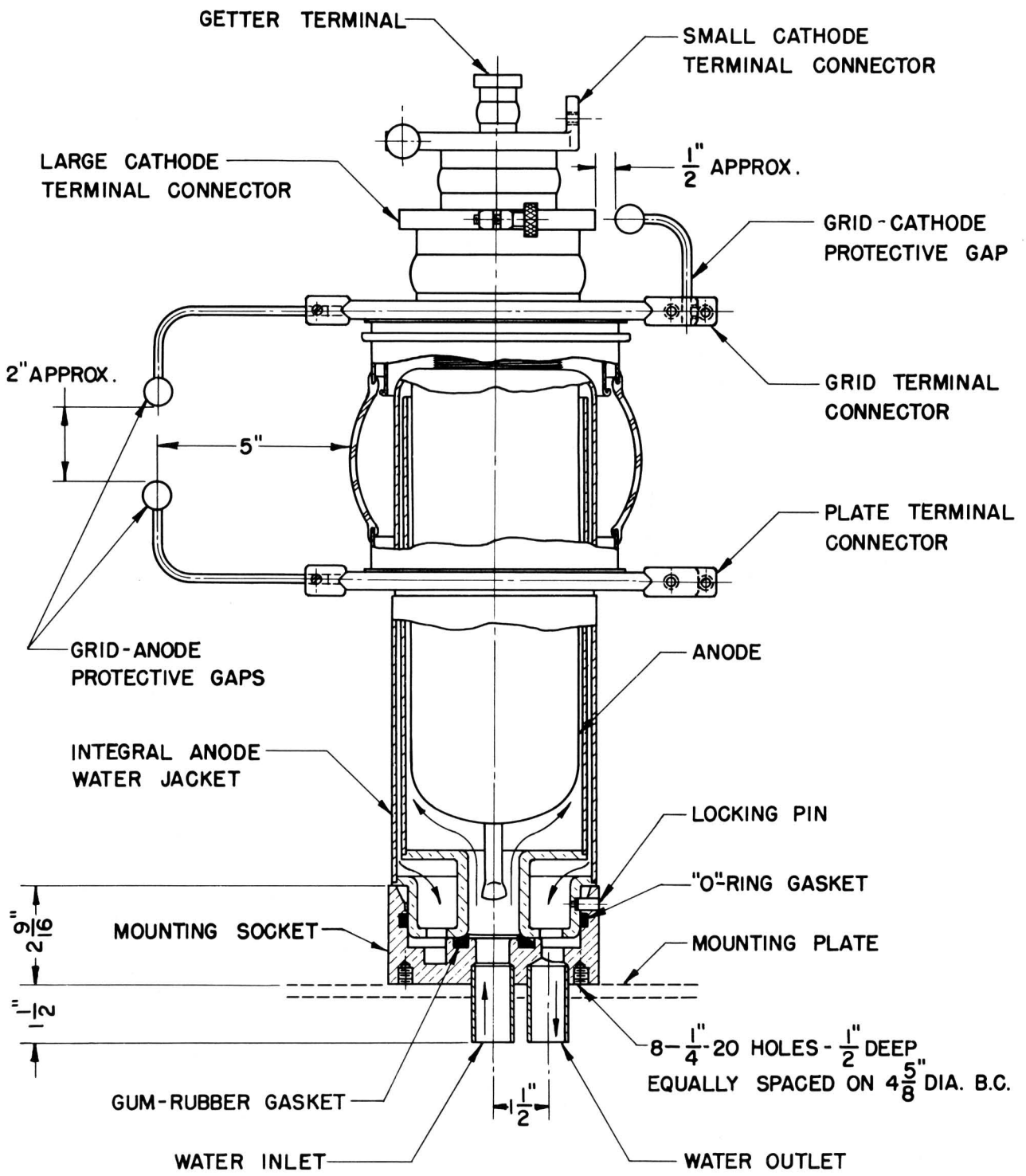
In grid-drive (grounded cathode) circuits, the grid current and driving power for the desired power output will vary with the plate loading. If the plate-circuit resistance is low, the desired output can be obtained with relatively low grid current and driving power, but plate efficiency is sacrificed.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

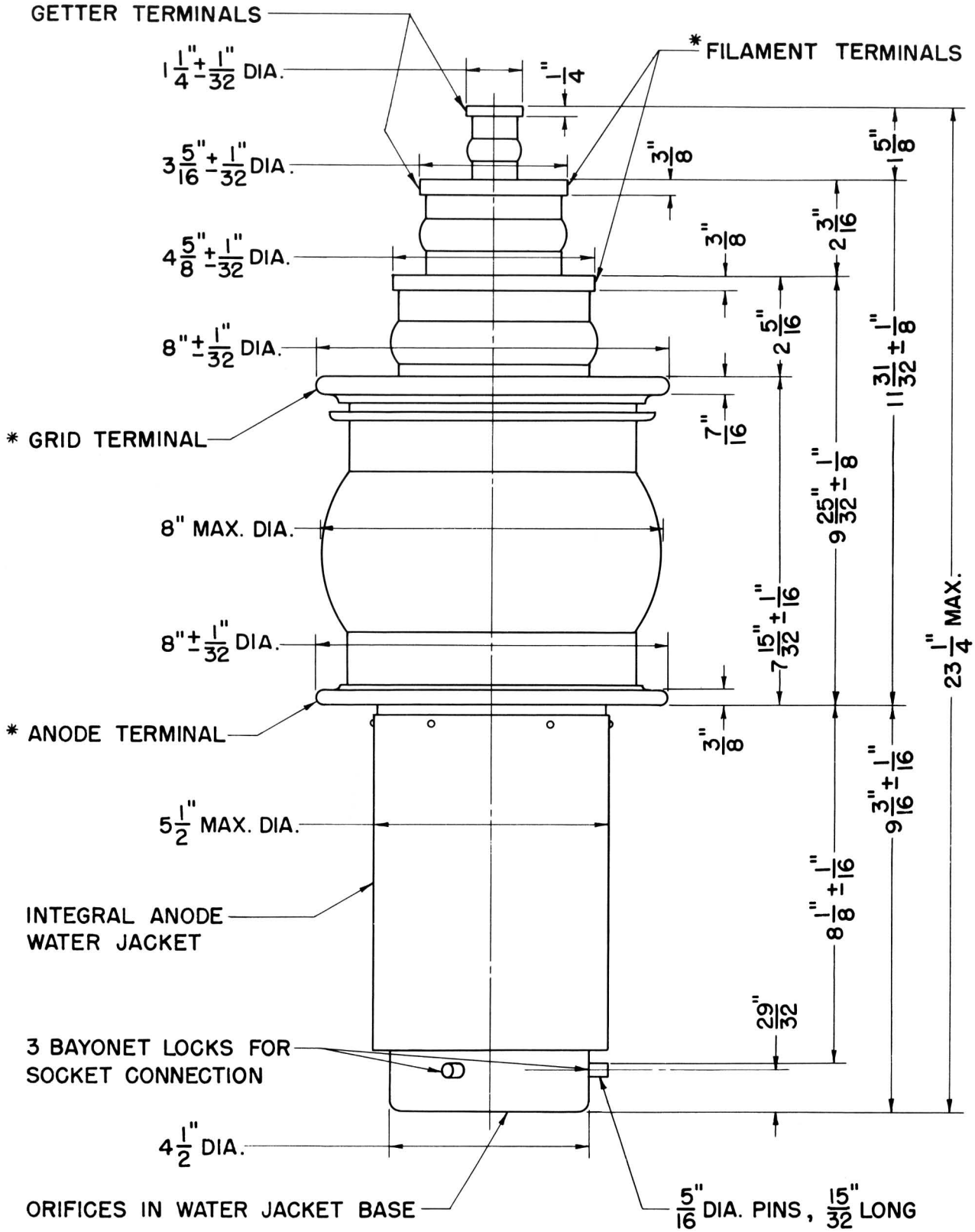

ML-5682
CONSTANT CURRENT CHARACTERISTICS
E_f = 16.5 V.
Eb=Ec
40
30
20
15
10
5
2
1
.5
0
130
120
110
100
90
80
70
60
50
40
30
20
10
5
2
.2
.5
0
GRID VOLTAGE IN VOLTS
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
GRID CURRENT IN AMPERES - - - - -
PLATE CURRENT IN AMPERES ———
0
2
4
6
8
10
12
14
16
PLATE VOLTAGE IN KILOVOLTS


MINIMUM RATE OF WATER FLOW REQUIRED-GPM
60
55
50
45
40
35
30
25
20
15
10
WATER-JACKET PRESSURE DROP*-PSI
40
30
20
10
0
WATER FLOW, GPM
0 10 20 30 40 50 60
* MEASURED 12" FROM SOCKET
ML-5682
WATER COOLING
CHARACTERISTICS
MAXIMUM ALLOWABLE
WATER PRESSURE-75 PSI
0 20 40 60 80 100 120
PLATE DISSIPATION-KILOWATTS



ML-5682
COOLING SYSTEM AND PROTECTIVE GAP ARRANGEMENT

OUTLINE OF ML-5682



*Electrical contacts to be made on the periphery of these terminals

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SPRINGDALE CONNECTICUT

U. S. A.

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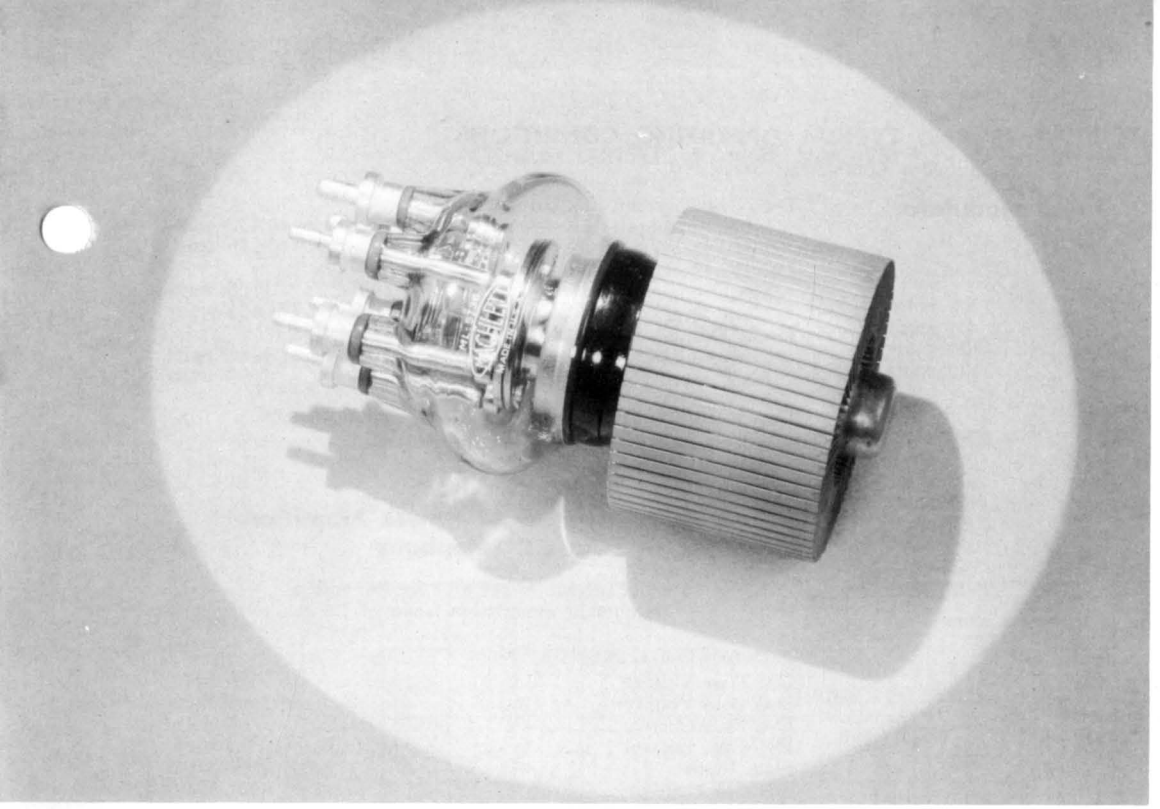


MACHLETT

ML-5736

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-5736 is a three-electrode tube designed for use as a modulator, amplifier or oscillator in AM, FM and TV broadcasting service, high-frequency communications systems, and induction and dielectric heating equipments. Four grid terminals provide a low-inductance connection to the grid making the tube suited especially to cathode-drive operation. The cathode is a thoriated-tungsten filament connected for single-phase operation. The anode is forced-air cooled and can readily dissipate 2.5 kW with a moderate rate of air flow. Special features include: precise and stable alignment of electrodes, to prevent grid-cathode shorts and to assure reliability and uniform operation; brazed radiator construction, to eliminate hot-spotting and its detrimental effects; and quick r-f heated final seal-in, to provide a non-poisoned-cathode, contaminent-free, stress-free tube. Maximum ratings of 5.0 kVdc plate voltage and 5.0 kW plate input apply at frequencies up to 60 Mc; operation at 100 Mc is permissible with plate voltage and input reduced to 80 per cent of maximum ratings.

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Filament Voltage	6.0 Volts
Filiament Current at 6.0 Volts	60 Amps
Filament Starting Current, maximum	300 Amps
Filament Cold Resistance	0.016 Ohms
Amplification Factor	22
Interelectrode Capacitances:	
Grid-Plate	16 uuf
Grid-Filament	19 uuf
Plate-Filament	0.8 uuf

MECHANICAL

Mounting Position	Vertical, anode up or down
Type of Cooling	Forced air
Air-flow on anode	150 cfm at 2.8″ water*
Air-flow on dish	See Note
Maximum incoming air temperature	45 °C
Maximum Glass Temperature	160 °C
Net Weight, approximate	3 lbs

* Except television service which requires 180 cfm at 4 inches of water static pressure.

Note: Cooling of dish and bulb may be provided by deflection of anode cooling air or by blower delivering 10 cfm air through a 1″ diameter nozzle.

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	3000 volts
Maximum Signal D-C Plate Current*	1.4 amps
Maximum Signal Plate Input*	4200 watts
Plate Dissipation*	2500 watts
Typical Operation (Values are for two tubes)	
D-C Plate Voltage	3000 volts
D-C Grid Voltage	-160 volts
Peak A-F Grid-to-Grid Voltage	820 volts
Zero Signal D-C Plate Voltage	0.66 amp
Maximum Signal D-C Plate Current	2.80 amps
Effective Load Resistance, plate-to-plate	3060 ohms
Maximum Signal Driving Power, approx.	140 watts
Maximum Signal Power Output, approx.	4350 watts

* 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	3500 volts
D-C Plate Current	1.75 amps
Plate Input	3500 watts
Plate Dissipation	2500 watts
Typical Operation	
D-C Plate Voltage	3000 volts
D-C Grid Voltage	-160 volts
Peak R-F Grid Voltage	280 volts
D-C Plate Current	1.1 amps
D-C Grid Current, approx.	0.050 amp
Driving Power, approx.‡	175 watts
Power Output, approx.	800 watts

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

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	3500 volts
D-C Plate Current	1.75 amps
Plate Input	4000 watts
Plate Dissipation†	2800 watts
Typical Operation	
D-C Plate Voltage	2600 volts
D-C Grid Voltage	-160 volts
Peak R-F Driving Voltage:	
Synchronizing level	535 volts
Black level	400 volts
D-C Plate Current:	
Synchronizing level	2.32 amps
Black level	1.47 amps
D-C Grid Current, approximate	
Synchronizing level	0.430 amp
Black level	0.136 amp
Driving Power, approximate	
Synchronizing level	1160 watts
Black level	535 watts
Power Output, approximate§	
Synchronizing level	3680 watts
Black level	1690 watts

† Requires 180 cfm cooling air at 4 inches static pressure.

§ Includes power transferred from driver stage.

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	3500 volts
D-C Grid Voltage	-1000 volts
D-C Plate Current	1.4 amps
D-C Grid Current	0.5 amp
Plate Input	4000 watts
Plate Dissipation	1650 watts
Typical Operation	
D-C Plate Voltage	3500 volts
D-C Grid Voltage	-600 volts
Peak R-F Grid Voltage	950 volts
D-C Plate Current	1.14 amps
D-C Grid Current, approx.	0.28 amp
Driving Power, approx.	270 watts
Power Output, approx.	3200 watts

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation#

	60 Mc	110 Mc	
Maximum Ratings, Absolute Values			
D-C Plate Voltage	5000	3500	volts
D-C Grid Voltage	-1000	-700	volts
D-C Plate Current	1.4	1.4	amps
D-C Grid Current	0.5	0.5	amp
Plate Input	5000	3500	watts
Plate Dissipation	2500	2500	watts

	60 Mc	110 Mc		
Typical Operation				
D-C Plate Voltage	5000	3500	3500	volts
D-C Grid Voltage	-850	-600	-300	volts
Peak R-F Grid Voltage	1200	940	555	volts
D-C Plate Current	1.0	1.0	1.0	amps
D-C Grid Current, approx.	0.210	0.250	0.155	amp
Driving Power, approx.	250	235	85	watts
Power Output, approx.	4100	2800	2550	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 up to 60 megacycles. The tube may be operated at higher frequencies provided the maximum values of the plate voltage and plate input are reduced according to the tabulation below. All other maximum ratings remain as shown above. Special attention should be given to adequate ventilation of the bulb at the higher frequencies. See special television service ratings.

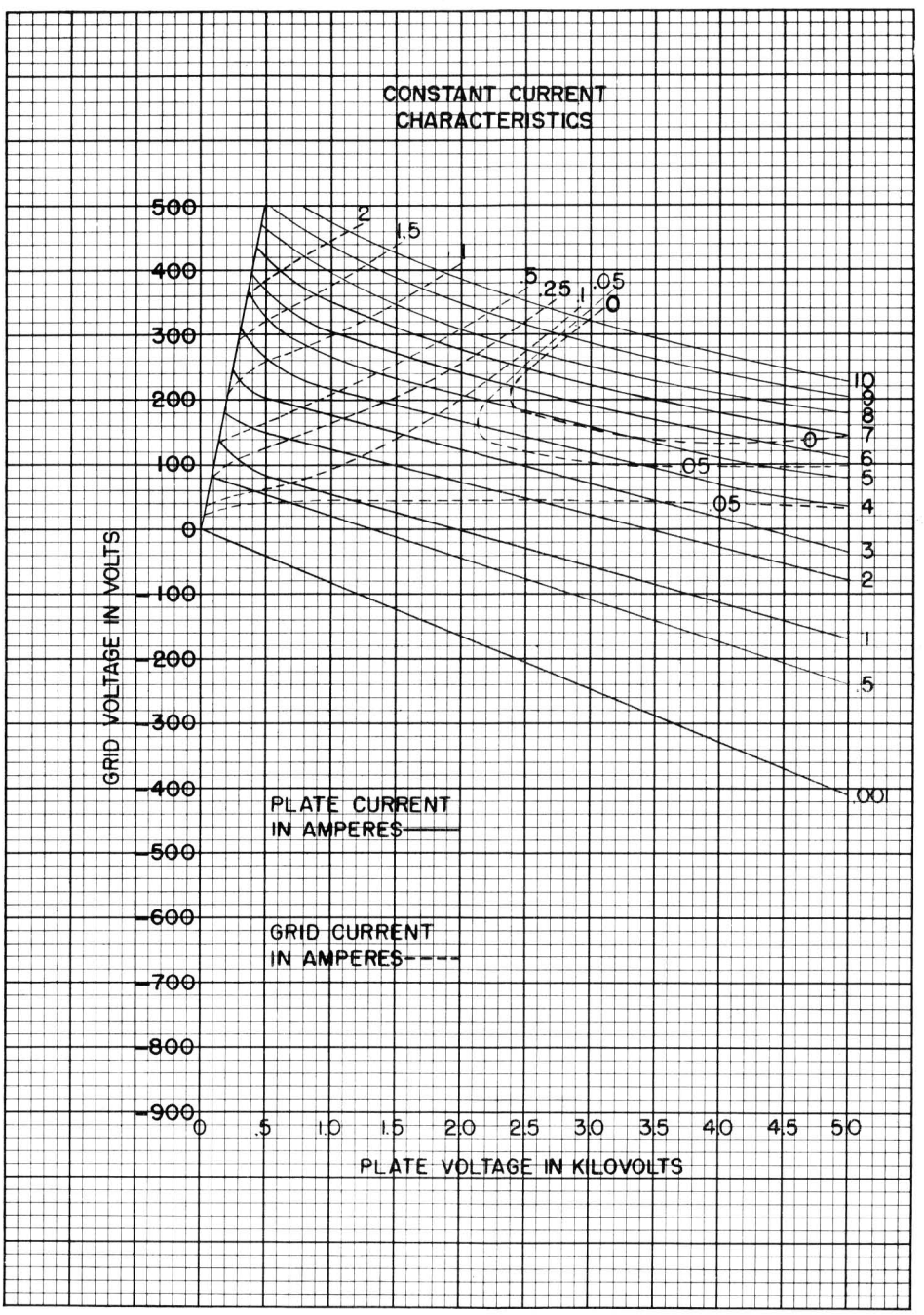
Percentage of Maximum Rated Plate Voltage and Plate Input:

Frequency	60	100	200 Mc
Class B	100	85	60
Class C Plate Modulated	100	80	50
Class C Unmodulated	100	80	50

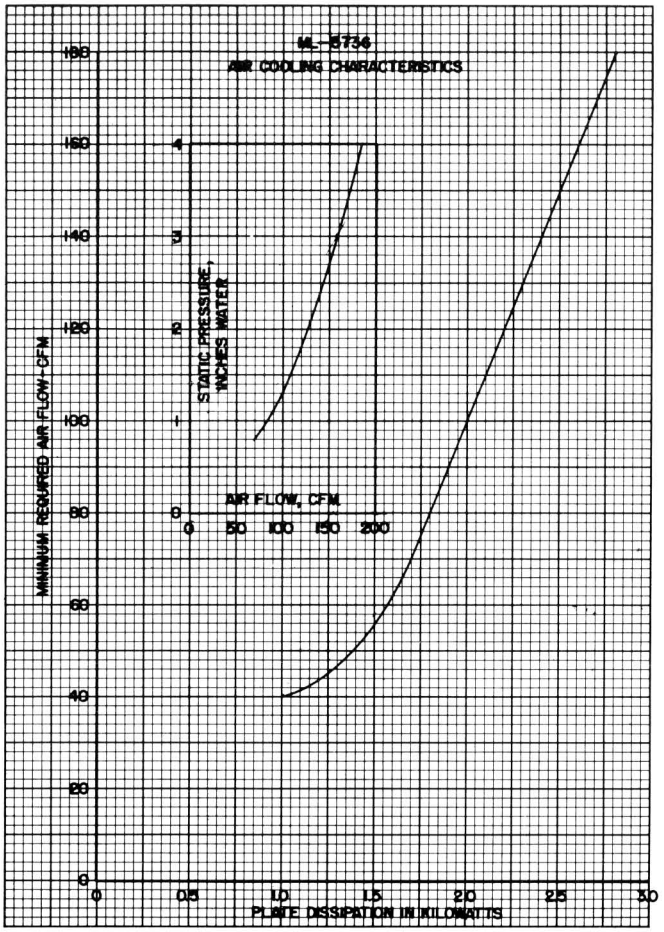
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

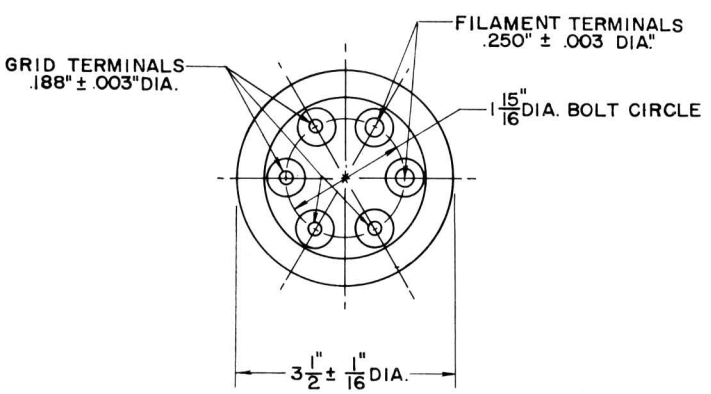
Characteristic:	Conditions:		Limits Minimum	Bogey	Maximum
Grid Voltage	e_b = 1000 volts; i_b = 6 amps	e_c:	——	——	360 volts
Grid Current	e_b = 1000 volts; i_b = 6 amps	i_c:	——	——	2.2 amps
Plate Voltage	E_c = -20 Vdc; I_b = 0.40 Adc	E_b:	1150	1400	1650 Vdc
Plate Voltage	E_c = -30 Vdc; I_b = 0.40 Adc	E_b:	1370	1620	1870 Vdc
Grid Voltage	E_b = 4000 Vdc; I_b = 0.020 Adc	E_c:	-180	-215	-250 Vdc
Peak Cathode Current*		i_k:	10	——	—— amps
Power Output	E_b = 5000 Vdc; E_c = -850 Vdc I_b = 1.0 Adc; I_c = 0.3 Adc f = 60 megacycles	P_o:	3500	——	—— watts

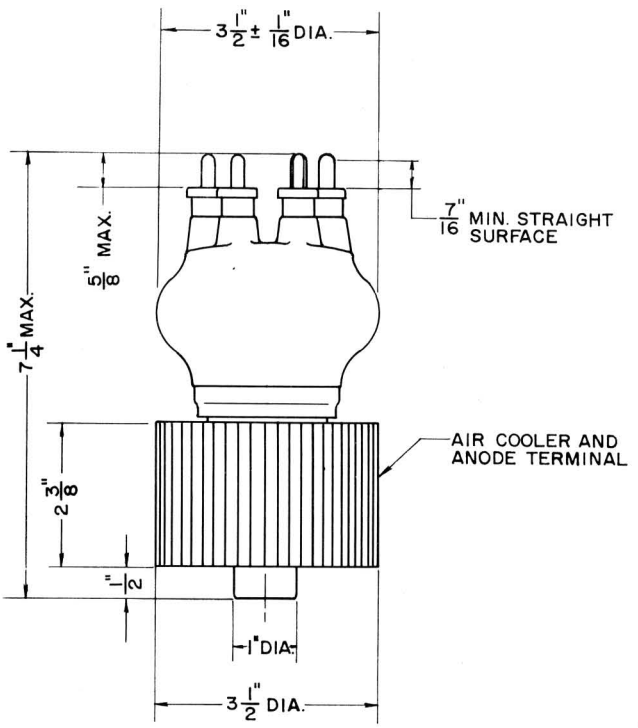
* Represents maximum usable plate current plus grid current for any condition of operation.



CONSTANT CURRENT CHARACTERISTICS



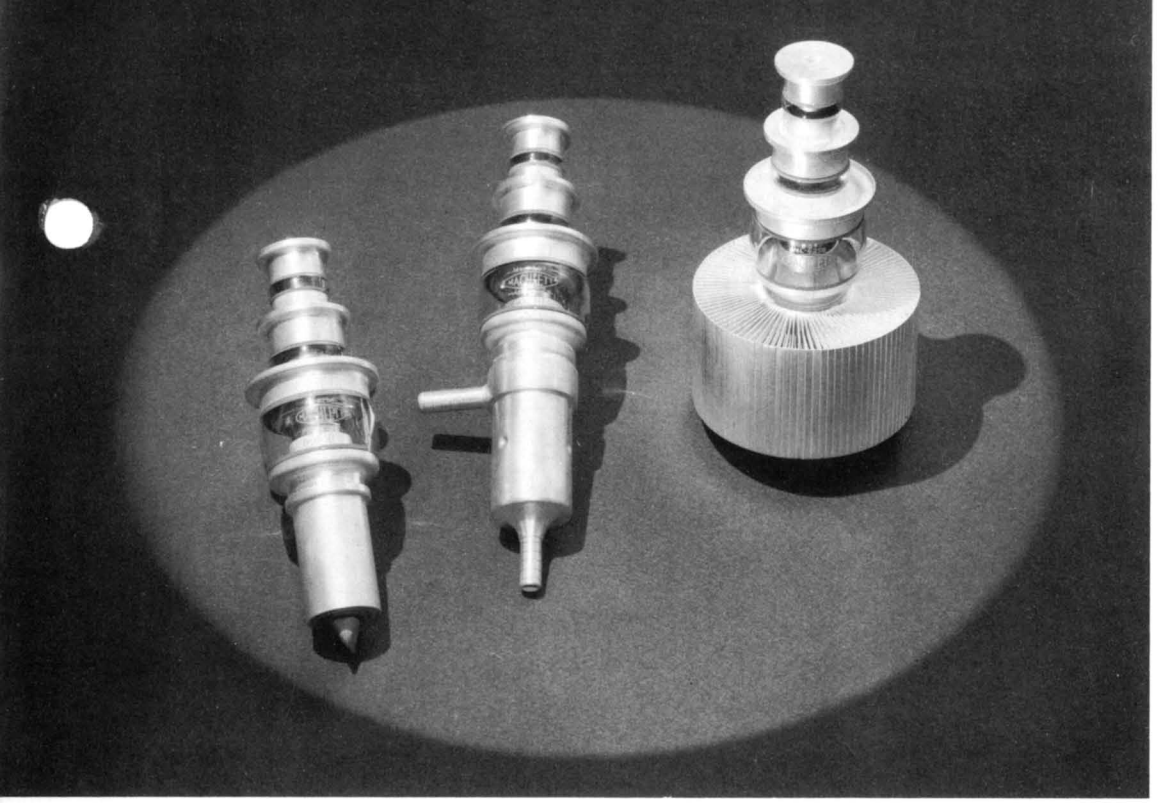




MACHLETT LABORATORIES, INC.

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 110 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 30 Mc, normal cabinet ventilation should be sufficient. 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	5500	5500	volts
D-C Grid Voltage	-1500	-1500	volts
D-C Plate Current	1.5	1.5	amps
D-C Grid Current	.22	.22	amp
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

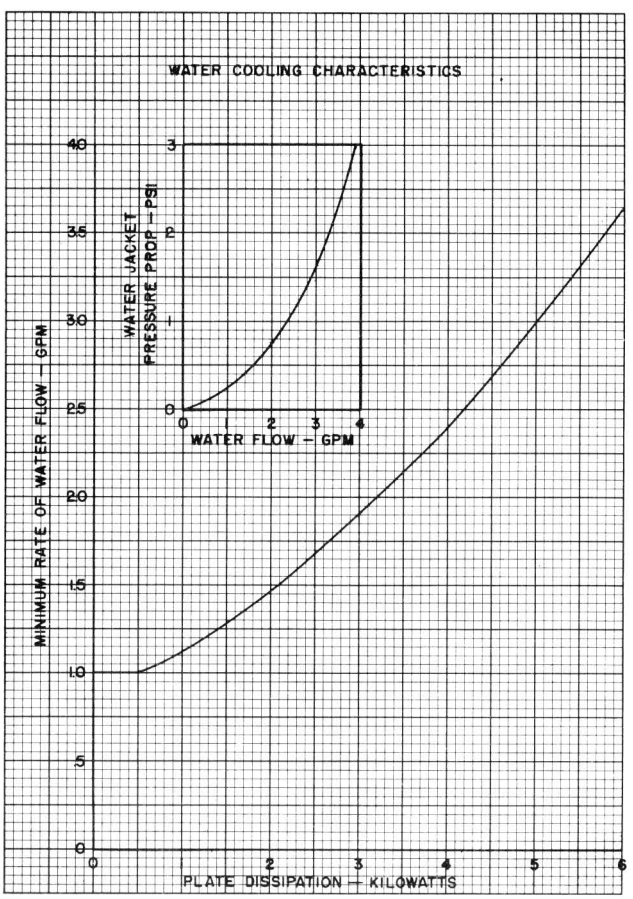
D-C Plate Voltage	4200	5300	volts
D-C Grid Voltage	-400	-500	volts
Peak R-F Grid Voltage	720	850	volts
Peak R-F Plate Voltage	3100	4000	volts
D-C Plate Current	1.1	1.3	amps
D-C Grid Current	110	110	mA
R-F Load Resistance	1600	1750	ohms
Power Output, approximate	3.0	4.5	kW

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

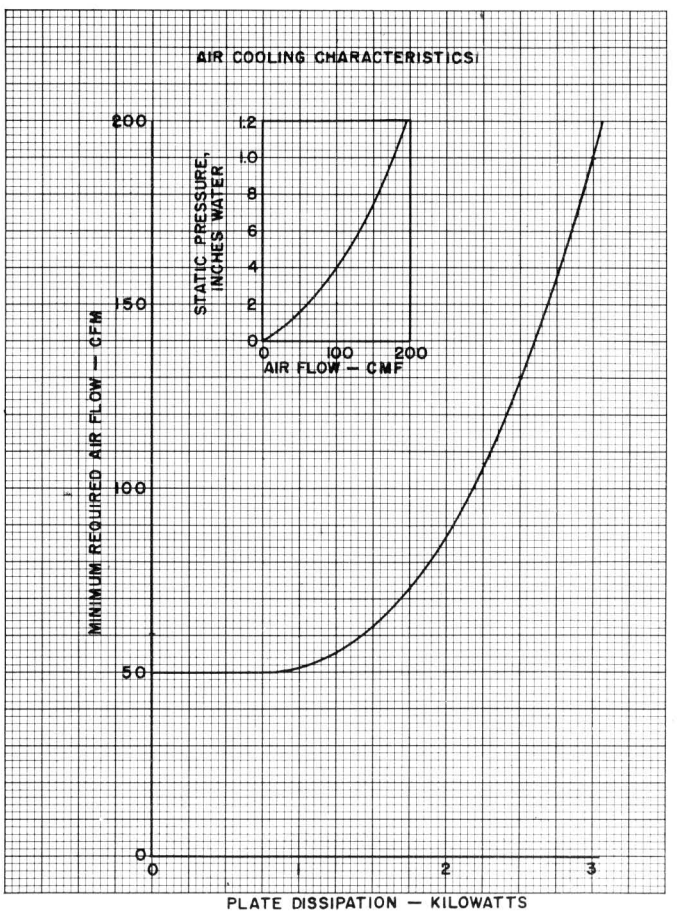
D-C Plate Voltage	5000	volts
D-C Grid Voltage	-500	volts
Peak R-F Grid Voltage	870	volts
Peak R-F Plate Voltage	3900	volts
D-C Plate Curernt	1.3	amps
D-C Grid Current	150	amps
R-F Load Resistance	2050	ohms
Driving Power, approximate	1100	watts
Power Output, approximate*	5.5	kW

‡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

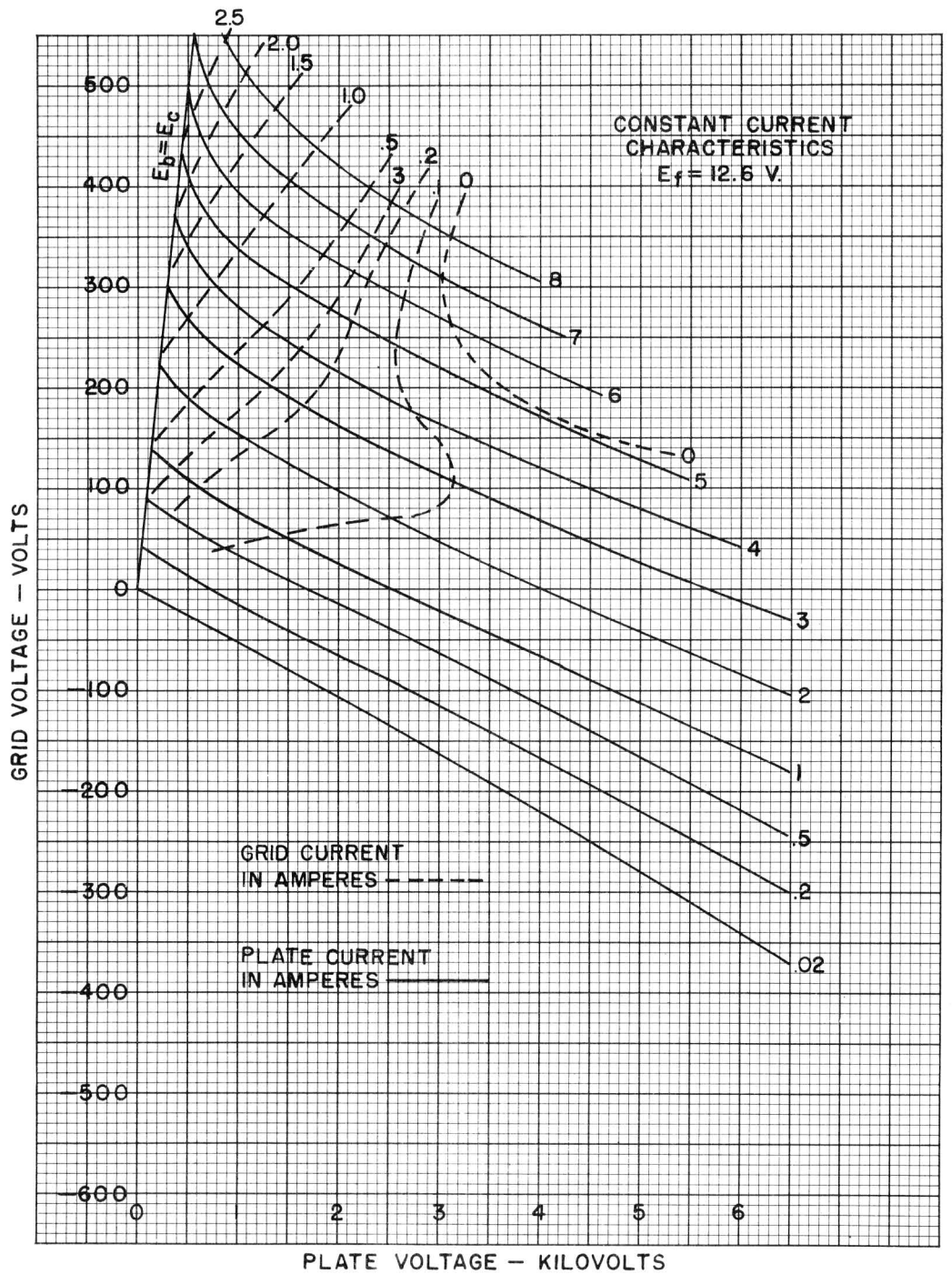


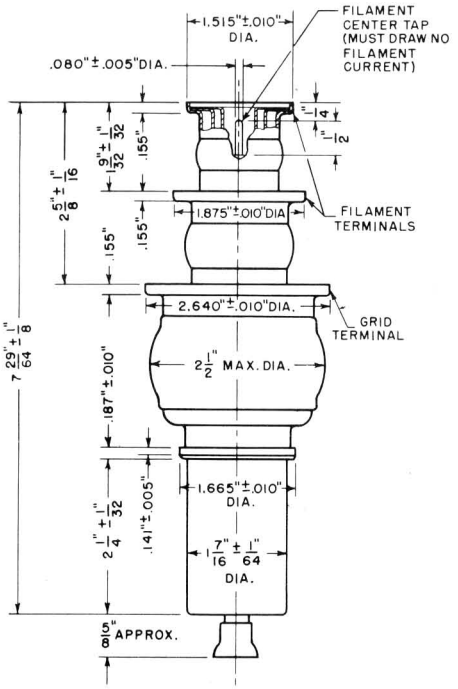
ML-6258



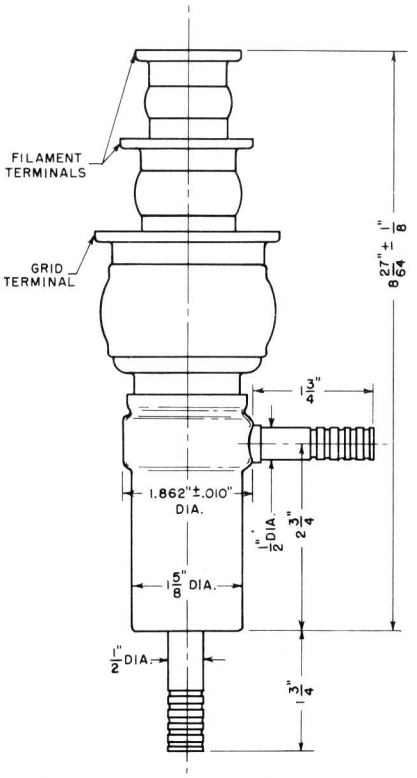
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits 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	1.7	2.0 kVdc
Plate Voltage	E_c = -100 Vdc; I_b = 0.5 Adc	E_b:	3.3	3.7	4.1 kVdc
Grid Voltage	E_b = 5.0 kVdc; I_b = 0.02 Adc	E_c:	-230	-285	-340 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

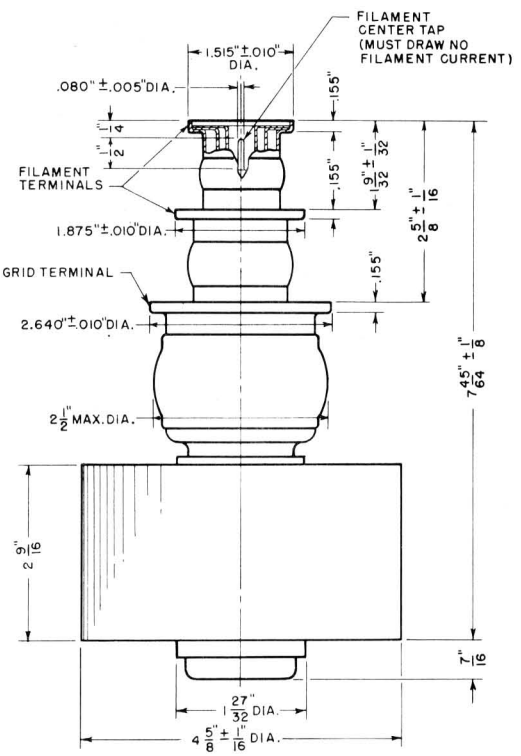




ML-6256



ML-6257



ML-6258

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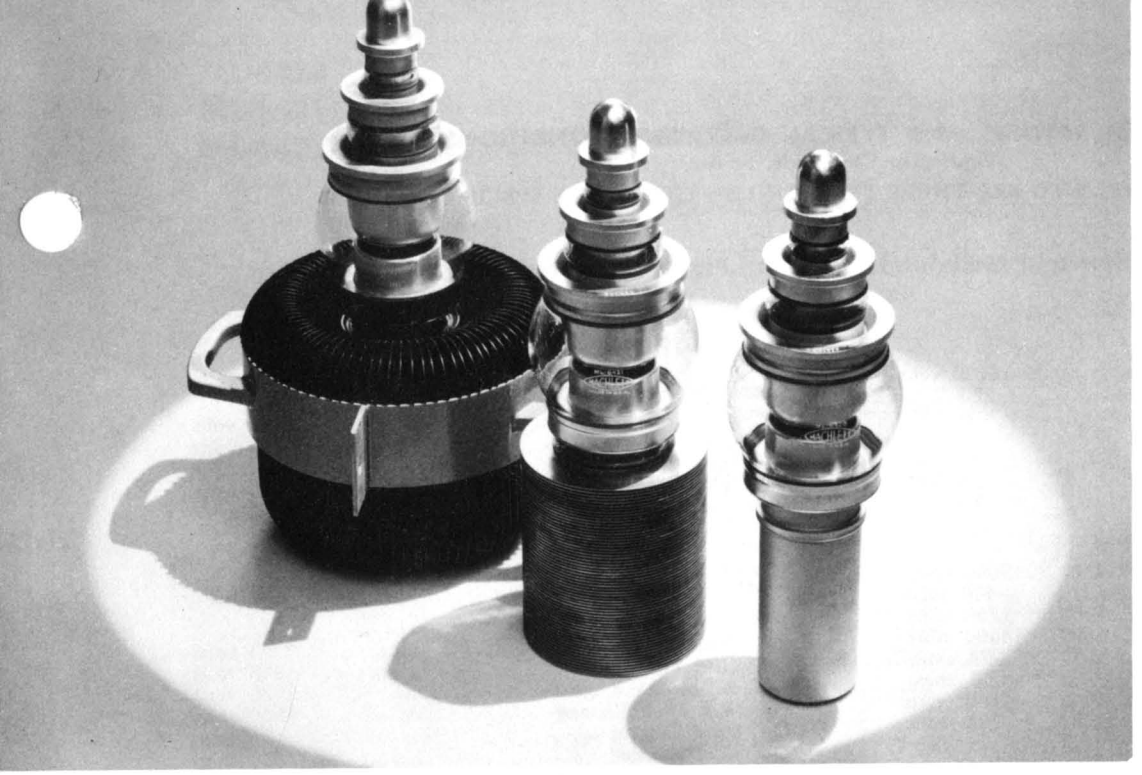


MACHLETT

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 3.3″ 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

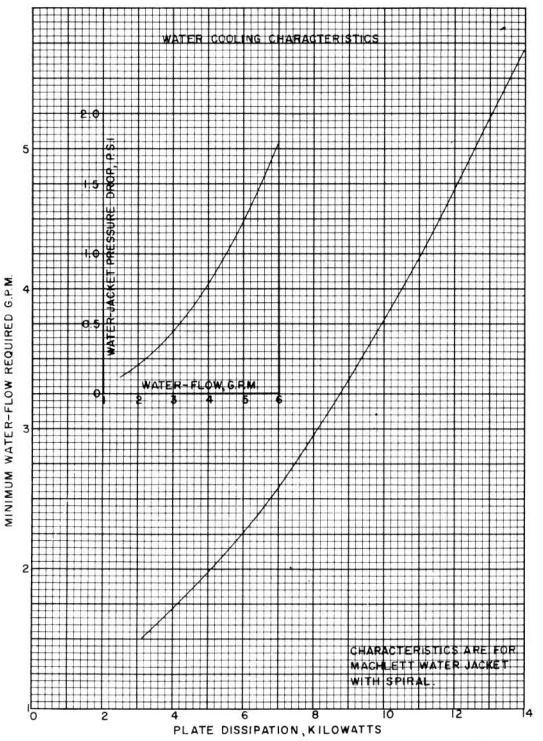
Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum
Grid Voltage	e_b = 1300 volts; i_b = 9.0 amps	e_c:	——	——	850 volts
Grid Current	e_b = 1300 volts; i_b = 9.0 amps	i_c:	——	——	3.0 amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.0 Adc	E_b:	2.5	2.9	3.3 kVdc
Plate Voltage	E_c = —200 Vdc; I_b = 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



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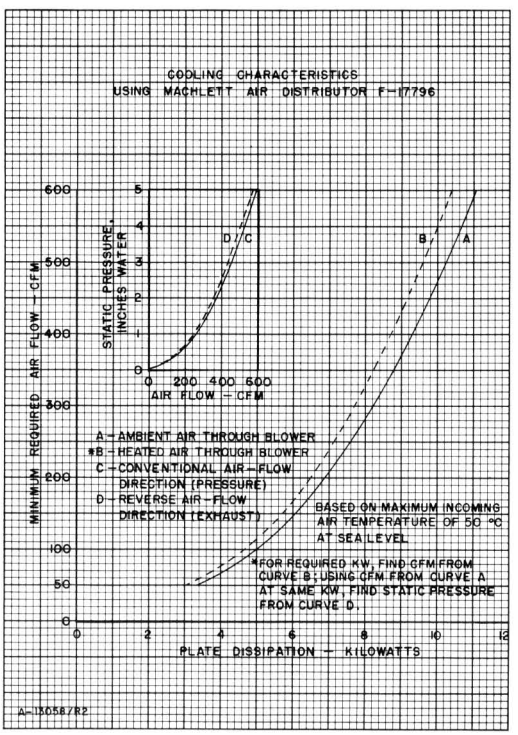
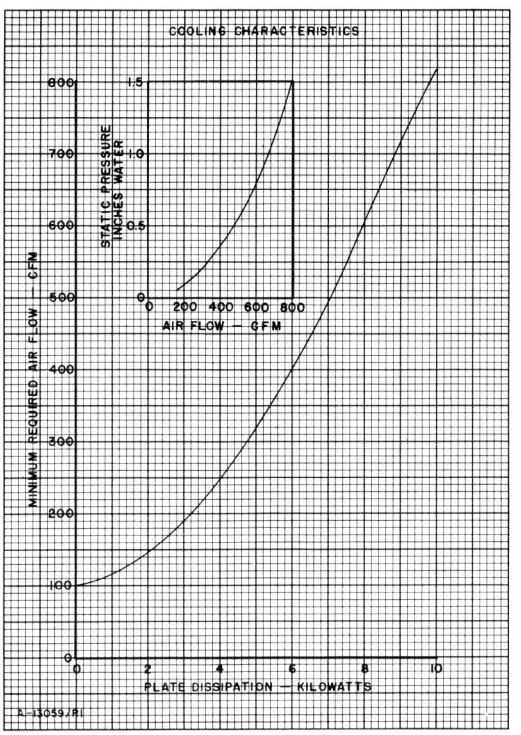
ML-6421

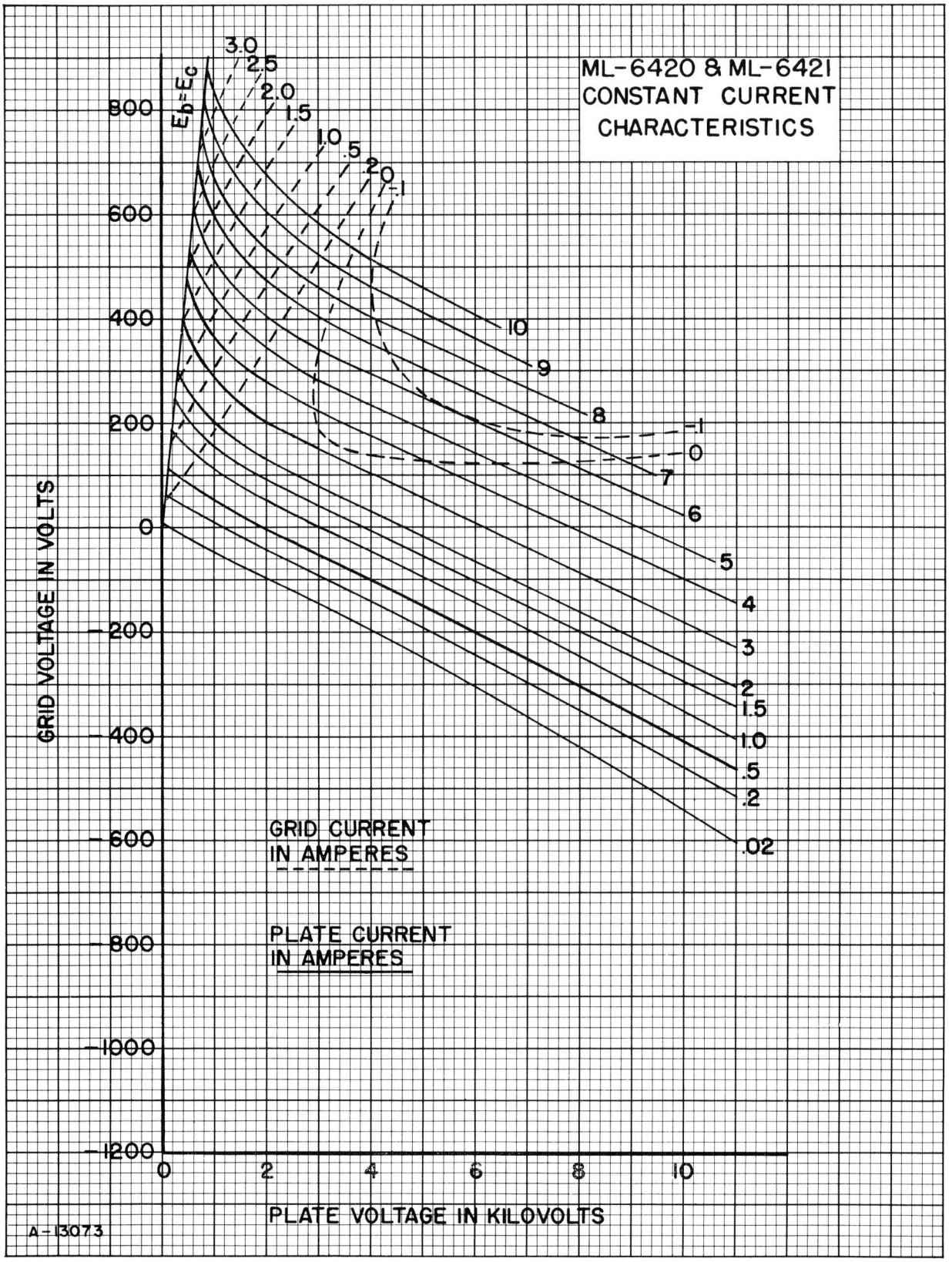


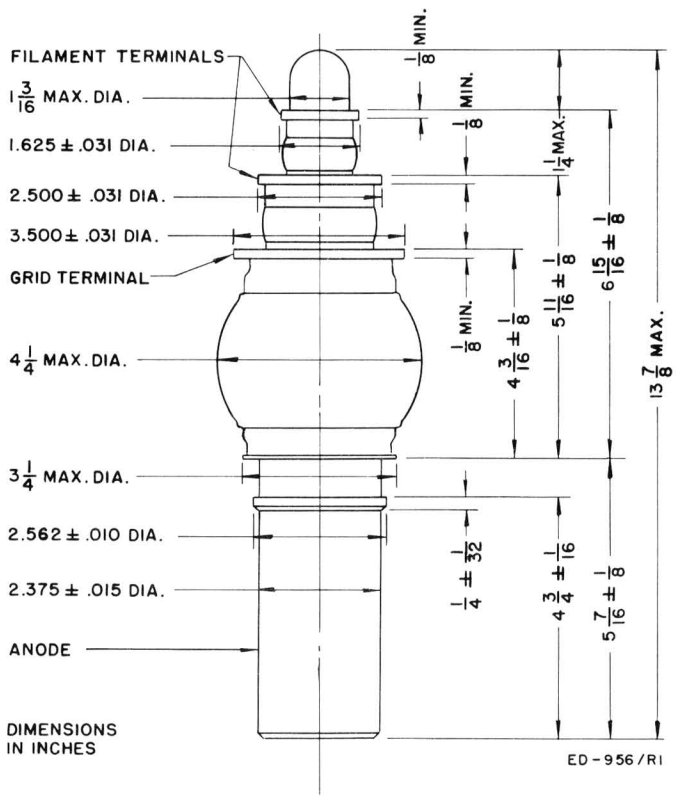
A-13058/R2

ML-6421-F

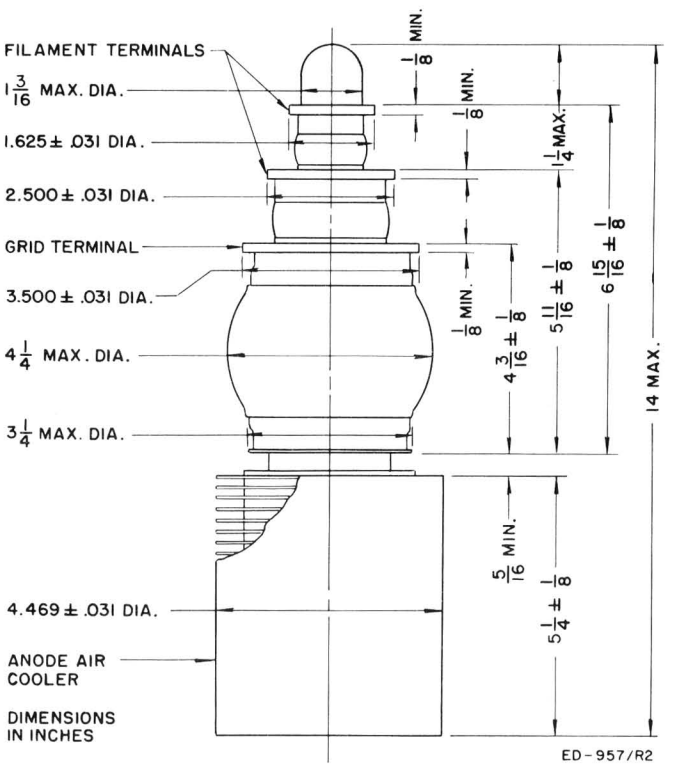


A-13059/R1


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
-1
0
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



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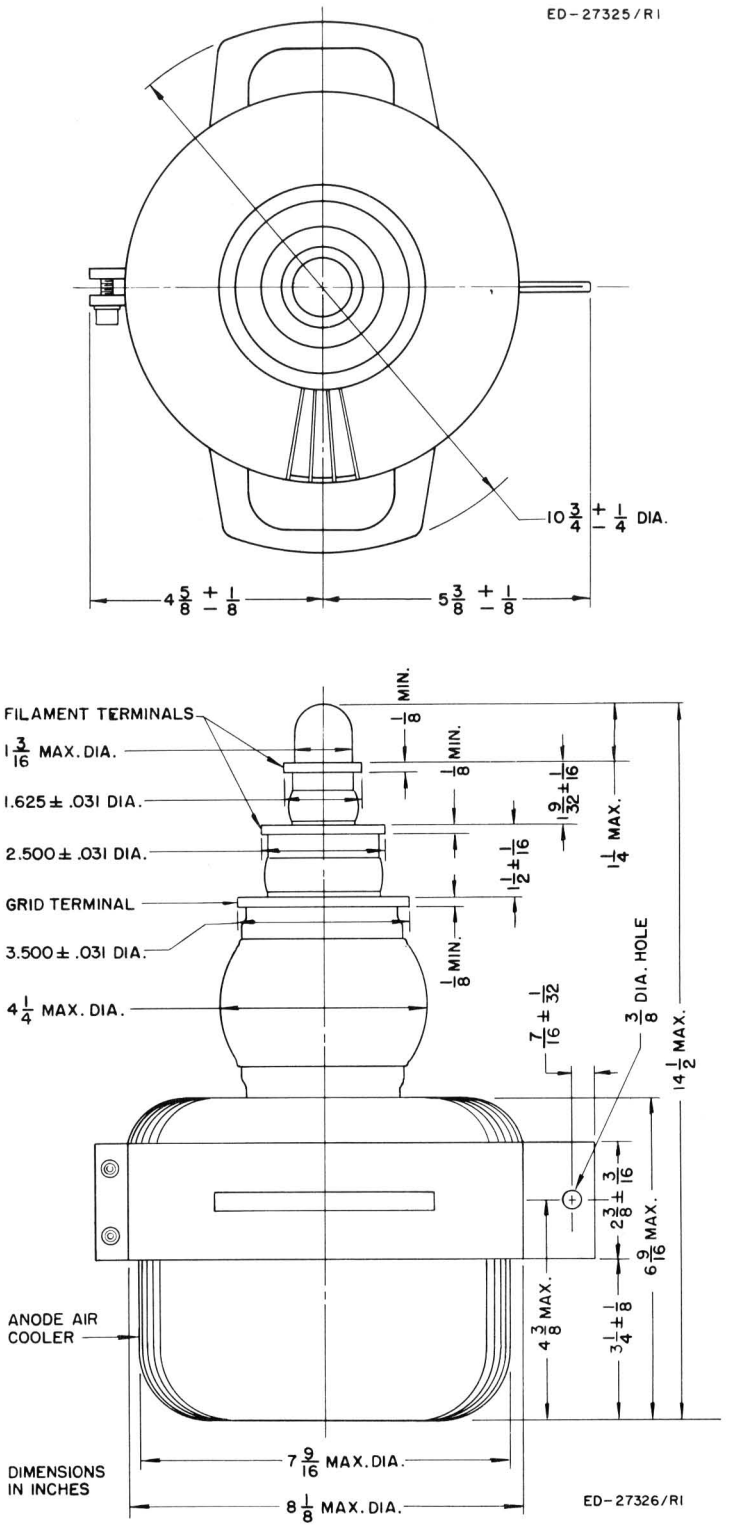

DIMENSIONS — ML-6421-F

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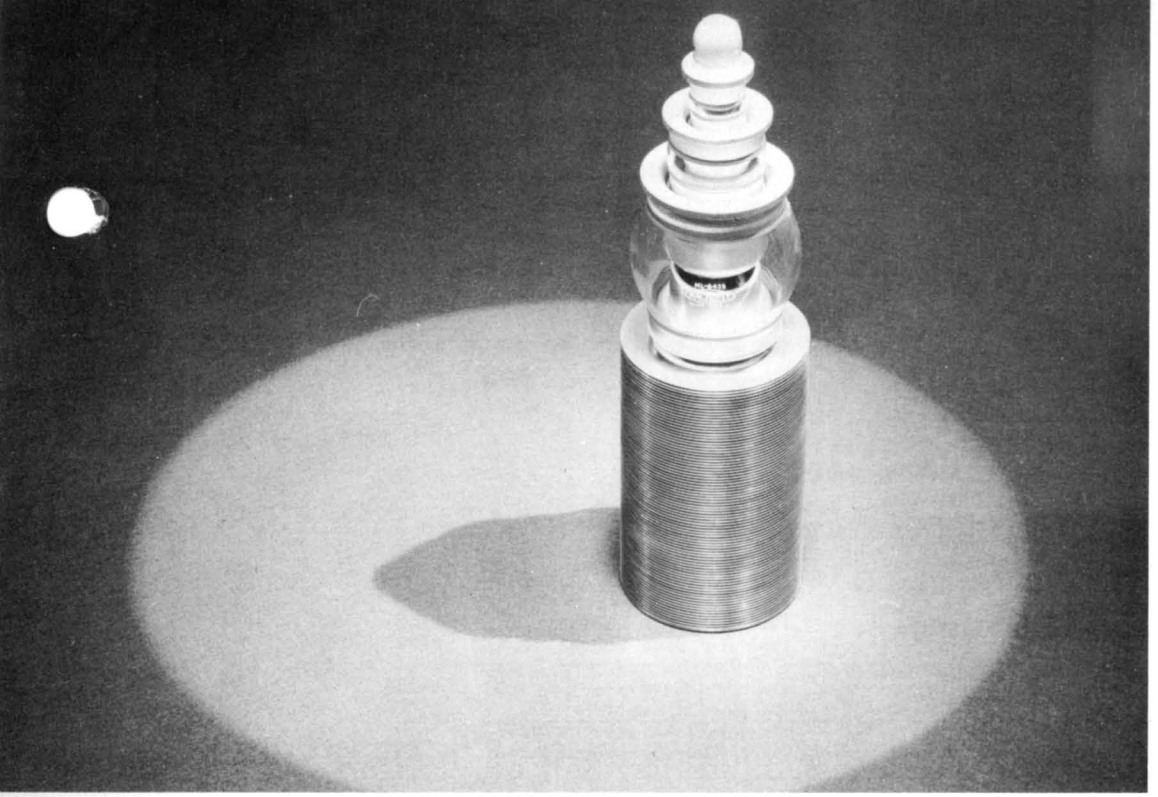


MACHLETT

ML-6425

DESCRIPTION & RATINGS

DESCRIPTION

The ML-6425 is a general purpose forced-air-cooled three-electrode tube designed specifically for 15-25 kW industrial heating service and for AM broadcasting. The tube features rugged coaxial mounting structures providing high-dissipation, low-inductance r-f electrode terminals. The heavy-wall anode is capable of dissipating 12.5 kilowatts with an air flow of approximately 710 cfm*. The cathode is a sturdy, self-supporting stress-free thoriated-tungsten filament. Maximum ratings of 12.5 kVdc plate voltage and 40 kW plate input apply at frequencies up to 30 Mc. Useful power output can be obtained at frequencies up to 110 Mc with plate voltage and plate input reduced according to the table on Page 3.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	7.0	Volts
Filament Current	120	Amps
Filament Starting Current, maximum	550	Amps
Filament Cold Resistance	.0070	Ohms
Amplification Factor	20	
Interelectrode Capacitances:		
Grid-Plate	27	uuf
Grid-Filament	34	uuf
Plate-Filament	2.0	uuf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling	Forced-air	
Air flow on anode, minimum for 12.5 kW dissipation	Pressure: 710 cfm at 4.7" water Exhaust: 815 cfm at 5.1" water	
Air flow on glass and seals	See Note	
Maximum incoming air temperature	50	°C
Maximum Glass Temperature	165	°C
Net Weight, approximate	15	lbs.

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

Note: At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient; 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)

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	kW
Plate Dissipation*	12.5	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	8500	12000	volts
D-C Grid Voltage	-380	-560	volts
Peak A-F Grid-to-Grid Voltage	2020	2080	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	5.6	amps
Effective Load Resistance, Plate-to-Plate	2550	4650	ohms
Max.-Signal Driving Power, approximate	400	100	watts
Max.-Signal Peak Driving Power, approx.#	3800	1400	watts
Max.-Signal Power Output, approximate	38	45	kW

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

#Peak driving power defined as product of peak audio-frequency grid voltage and peak grid current.

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	2.5	amps
Plate Input	19	kW
Plate Dissipation	12.5	kW

Typical Operation

D-C Plate Voltage	10000	volts
D-C Grid Voltage	-420	volts
Peak R-F Grid Voltage	540	volts
Peak R-F Plate Voltage	4200	volts
D-C Plate Current	1.8	amps
D-C Grid Current	0	mA
R-F Load Resistance	1500	ohms
Driving Power, approximate*	200	watts
Power Output, approximate	6.0	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	-2000	volts
D-C Plate Current	2.5	amps
D-C Grid Current	0.50	amp
Plate Input	22	kW
Plate Dissipation	8	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, approximate	330	watts
Power Output, approximate	12.1	kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation†

Maximum Ratings, Absolute Values

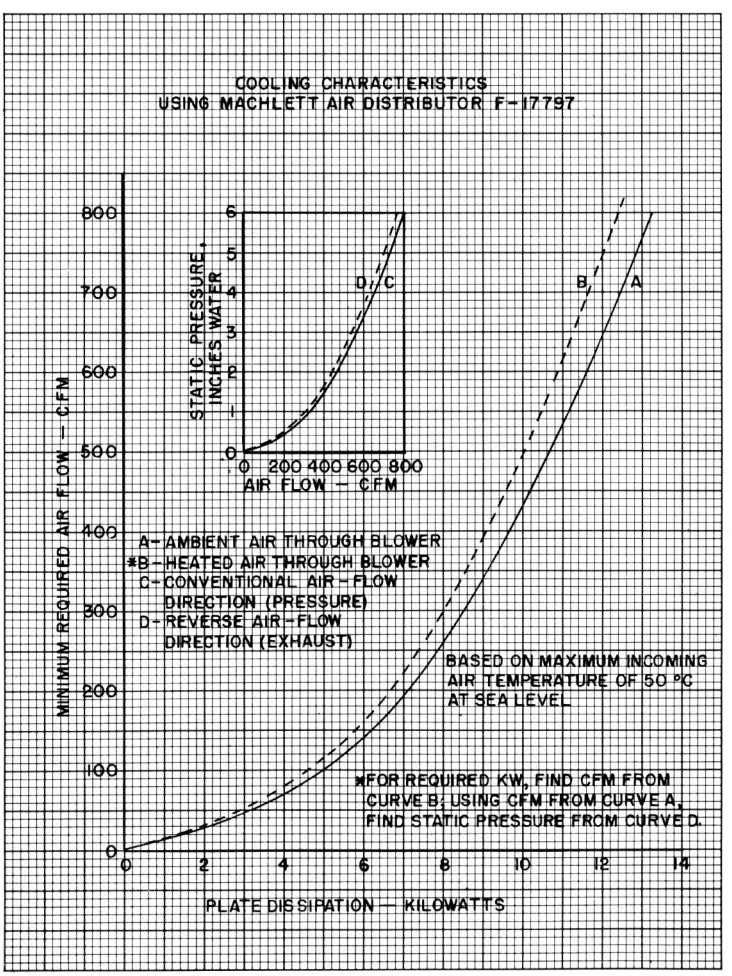
D-C Plate Voltage	12500	volts
D-C Grid Voltage	-2000	volts
D-C Plate Current	3.5	amps
D-C Grid Current	0.50	amp
Plate Input	40	kW
Plate Dissipation	12.5	kW

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, approximate	430	250	430	watts
Power Output, approximate	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.

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



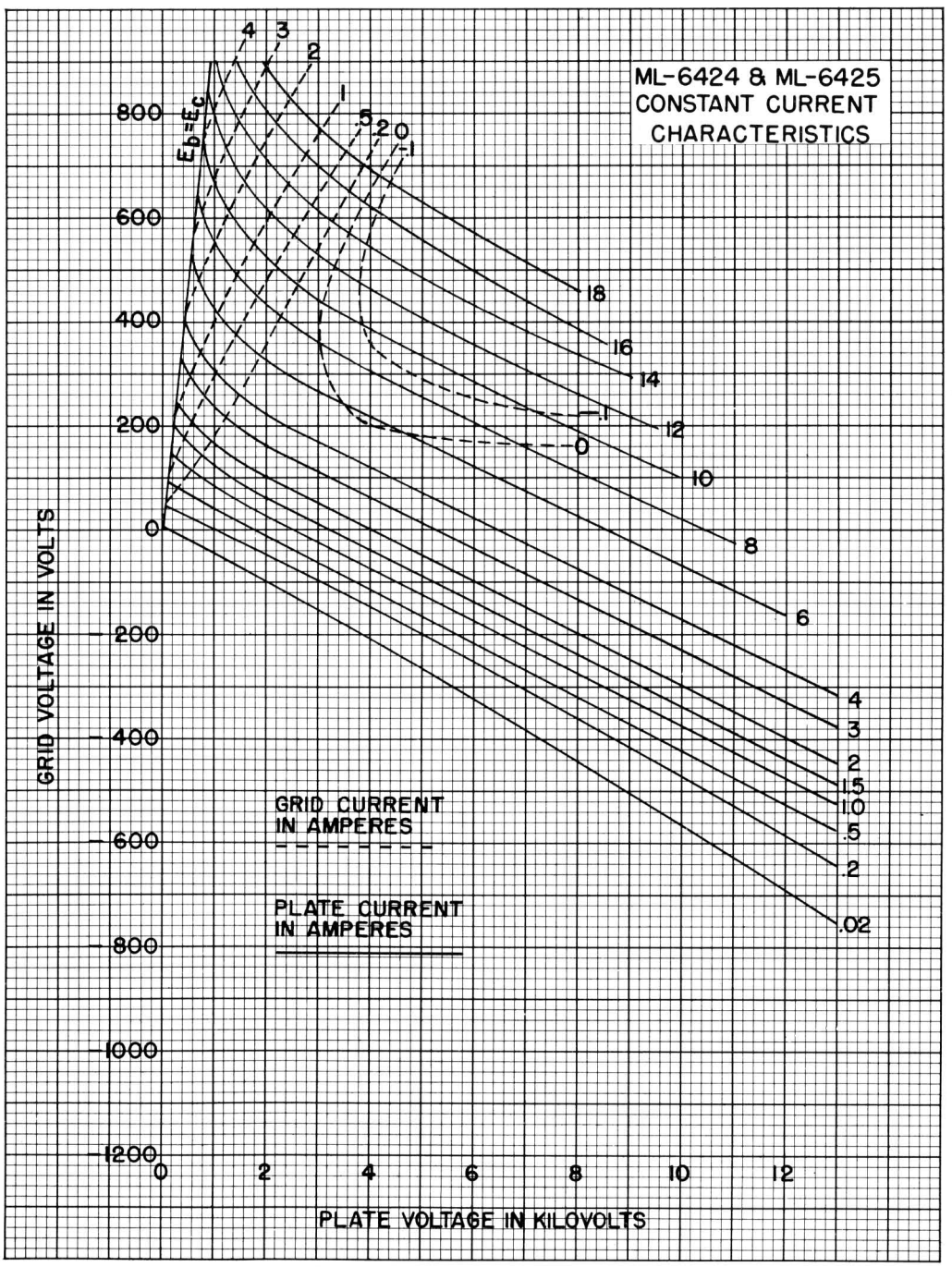
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

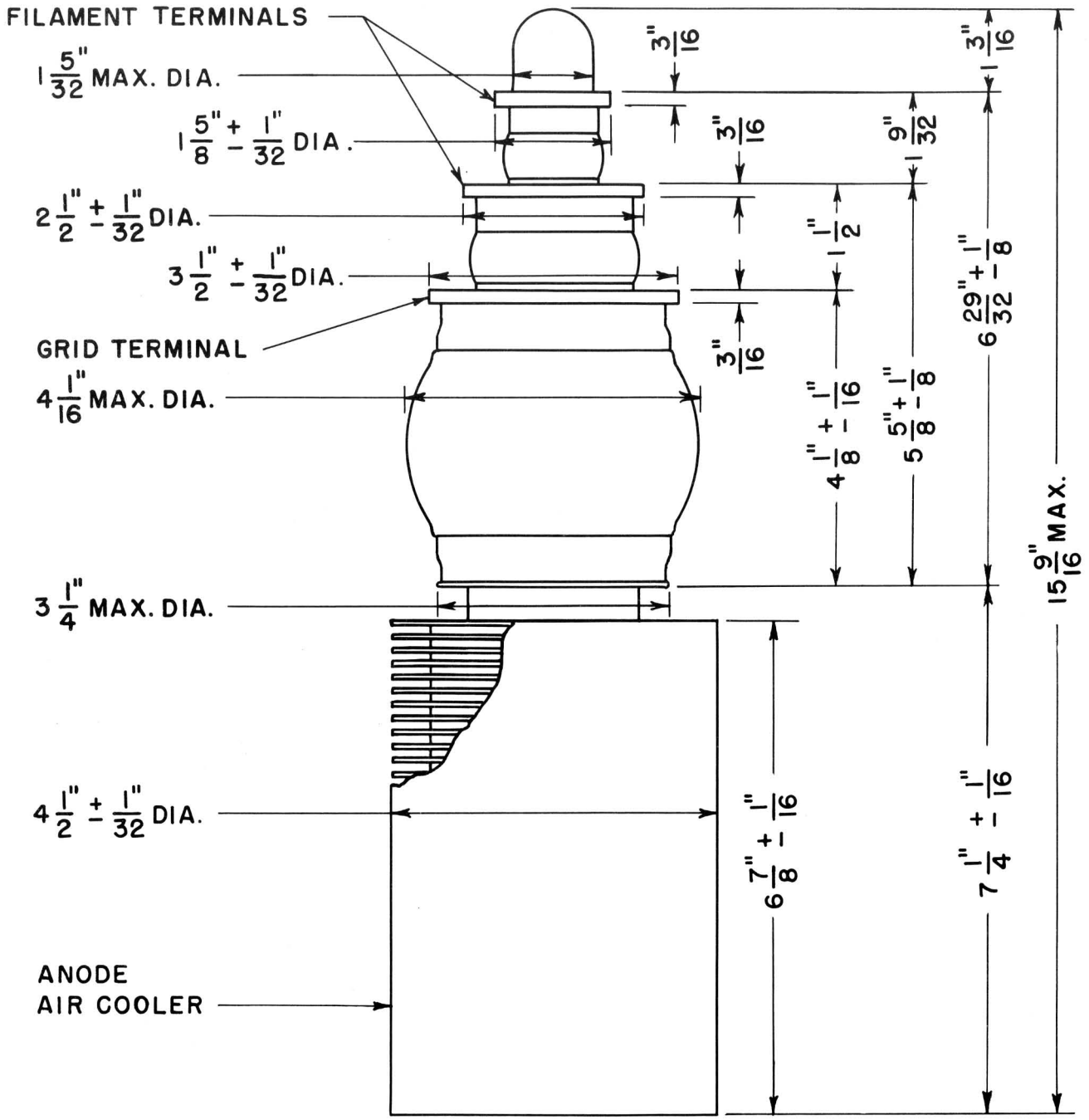
Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum
Grid Voltage	e_b = 1500 volts; i_b = 14 amps	e_c:	——	——	950 volts
Grid Current	e_b = 1500 volts; i_b = 14 amps	i_c:	——	——	4.0 amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.5 Adc	E_b:	2.6	3.1	3.6 kVdc
Plate Voltage	E_c = -400 Vdc; I_b = 1.5 Adc	E_b:	10.0	11.1	12.2 kVdc
Grid Voltage	E_b = 10.0 kVdc; I_b = 0.02 Adc	E_c:	-470	-560	-650 Vdc
Plate Power Output	E_b = 12.0 kVdc; E_c = -1000 Vdc; I_b = 3.3 Adc; I_c = 0.25 Adc	P_o:	25	——	—— 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 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	110Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60





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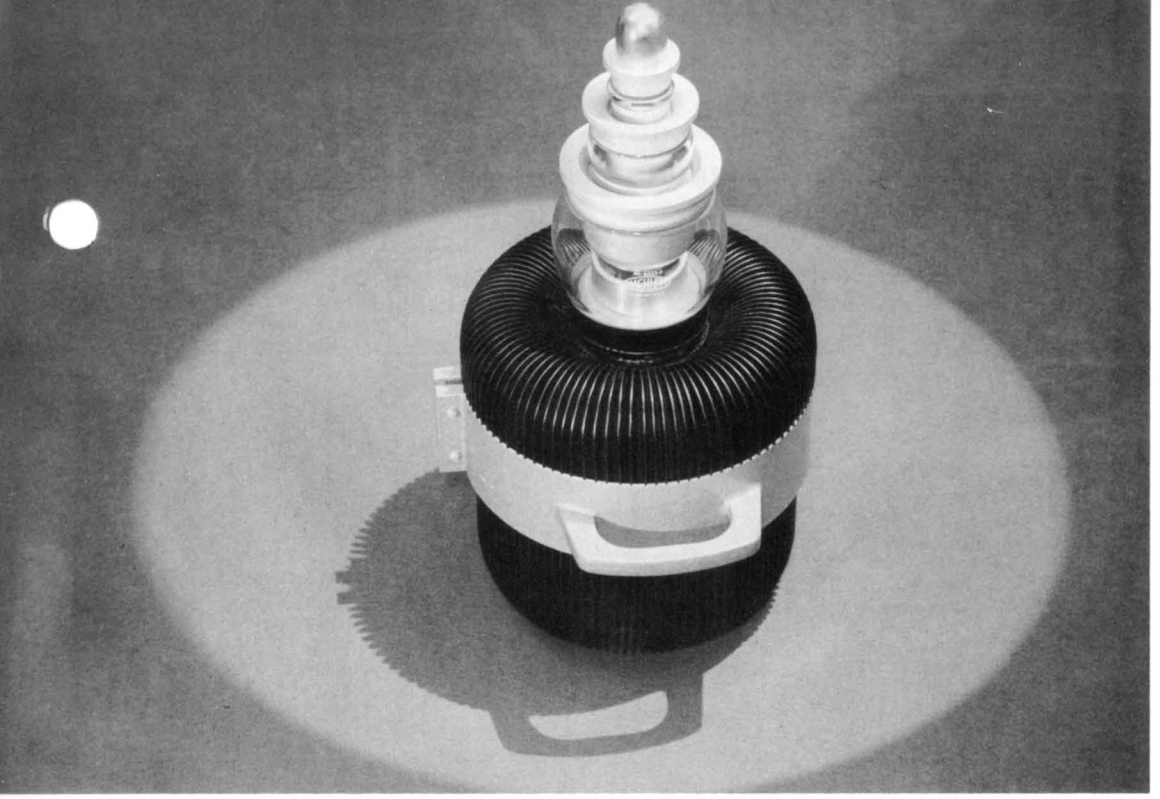


MACHLETT

ML-6425-F

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-6425-F** is a general purpose forced-air-cooled three-electrode tube designed primarily for replacement of older tube types in 15-25 kW industrial heating service and for AM broadcasting. The tube features rugged coaxial mounting structures providing high-dissipation, low-inductance r-f electrode terminals. The heavy-wall anode is capable of dissipating 11 kilowatts with an air flow of approximately 870 cfm. The cathode is a sturdy, self-supporting stress-free thoriated-tungsten filament. Maximum ratings of 12.5 kVdc plate voltage and 40 kW plate input apply at frequencies up to 30 Mc. Useful power output can be obtained at frequencies up to 110 Mc with plate voltage and plate input reduced according to the table on Page 3.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	7.0 Volts
Filament Current	120 Amps
Filament Starting Current, maximum	550 Amps
Filament Cold Resistance	.0070 Ohms
Amplification Factor	20
Interelectrode Capacitances:	
Grid-Plate	28 uuf
Grid-Filament	34 uuf
Plate-Filament	2.2 uuf

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	50 °C
Maximum Glass Temperature	165 °C
Net Weight, approximate	50 lbs.

Note: At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient; 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. Auxiliary air flow may be obtained from separate blower or from deflection of anode cooling air.

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*	3.5 amps
Max.-Signal Plate Input*	40 kW
Plate Dissipation*	11 kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	12000 volts
D-C Grid Voltage	-560 volts
Peak A-F Grid-to-Grid Voltage	2080 volts
Peak A-F Plate-to-Plate Voltage	20400 volts
Zero-Signal D-C Plate Current	0.6 amp
Max.-Signal D-C Plate Current	5.6 amps
Effective Load Resistance, Plate-to-Plate	4650 ohms
Max.-Signal Driving Power, approximate	100 watts
Max.-Signal Power Output, approximate	45 kW

*Averaged over any audio-frequency 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	2.5 amps
Plate Input	16.5 kW
Plate Dissipation	11 kW

Typical Operation

D-C Plate Voltage	10000 volts
D-C Grid Voltage	-420 volts
Peak R-F Grid Voltage	510 volts
Peak R-F Plate Voltage	4200 volts
D-C Plate Current	1.65 amps
D-C Grid Current	0 mA
R-F Load Resistance	1600 ohms
Driving Power, approximate*	170 watts
Power Output, approximate	5.5 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 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	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, approximate	330 watts
Power Output, approximate	12.1 kW

R-F Power Amplifier and Oscillator Class C Telegraphy

Key-down conditions per tube without amplitude modulation†

Maximum Ratings, Absolute Values

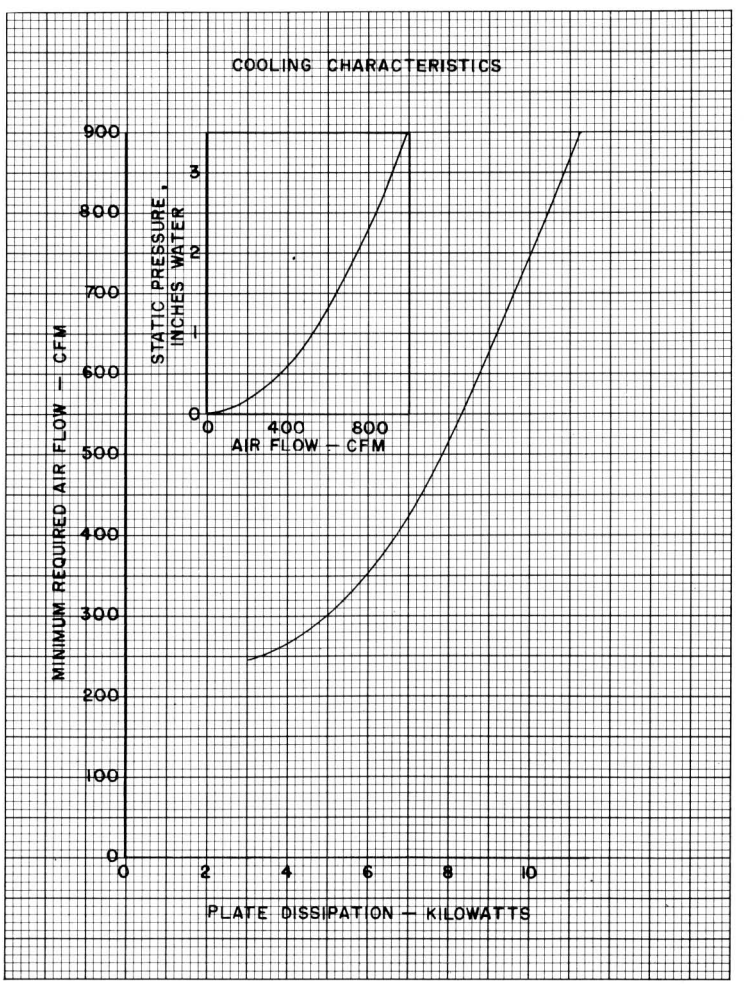
D-C Plate Voltage	12500 volts
D-C Grid Voltage	-2000 volts
D-C Plate Current	3.5 amps
D-C Grid Current	0.50 amp
Plate Input	40 kW
Plate Dissipation	11 kW

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, approximate	430	250	430 watts
Power Output, approximate	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.

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



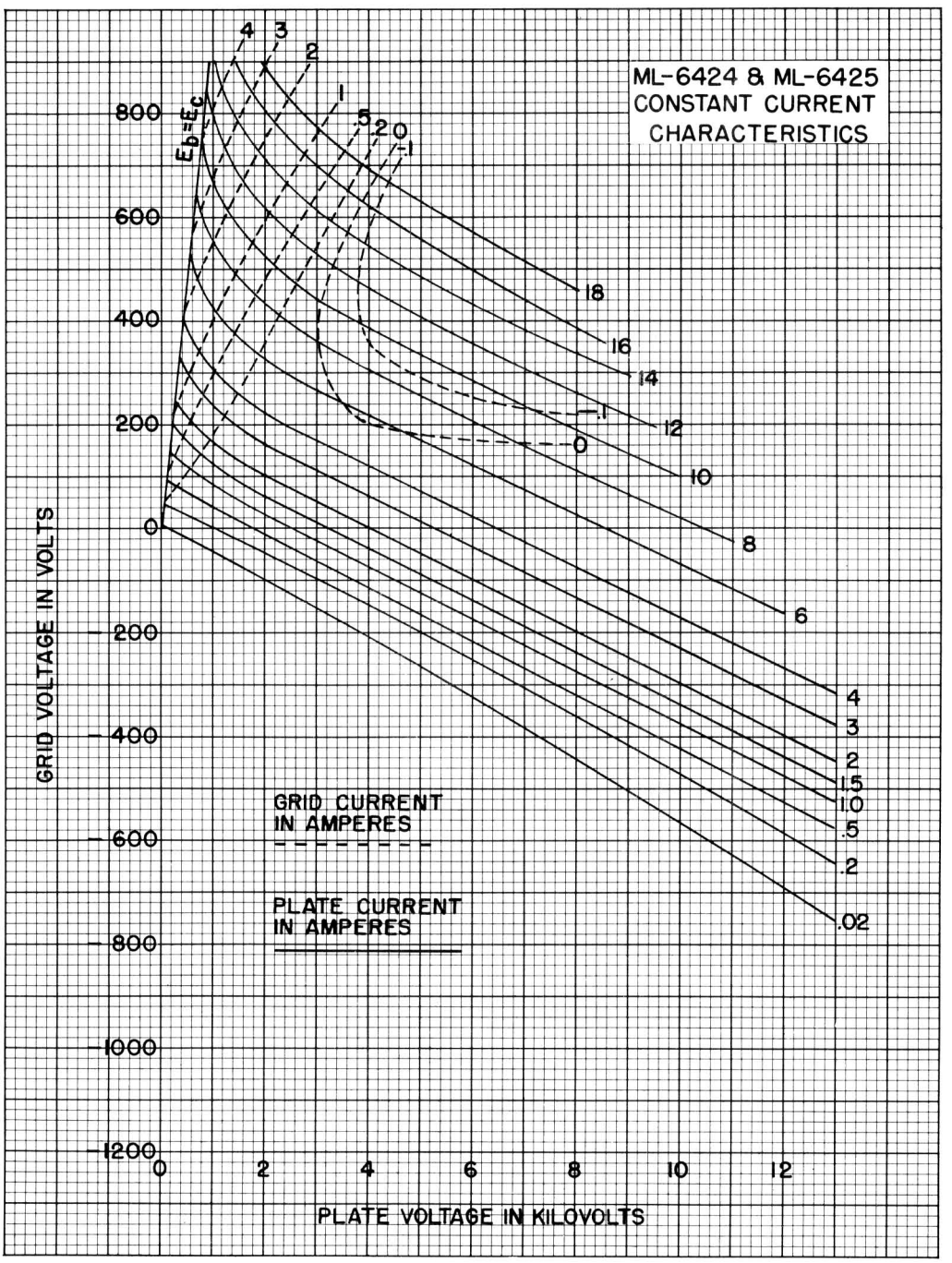
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

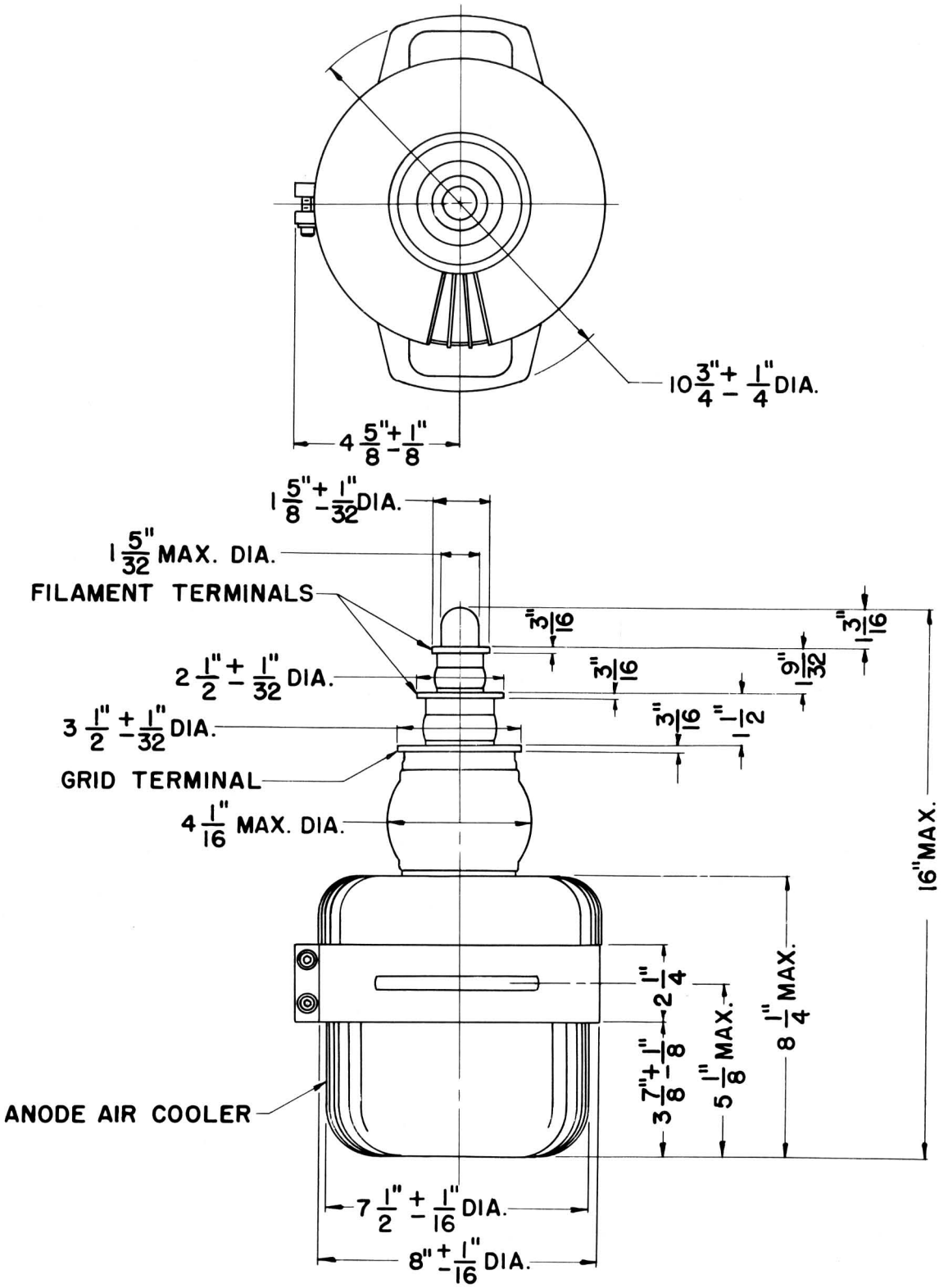
Characteristics	Conditions		Limits Minimum	Limits Bogey	Limits Maximum
Grid Voltage	e_b = 1500 volts; i_b = 14 amps	e_c:	——	——	950 volts
Grid Current	e_b = 1500 volts; i_b = 14 amps	i_c:	——	——	4.0 amps
Plate Voltage	E_c = 0 Vdc; I_b = 1.5 Adc	E_b:	2.6	3.1	3.6 kVdc
Plate Voltage	E_c = -400 Vdc; I_b = 1.5 Adc	E_b:	10.0	11.1	12.2 kVdc
Grid Voltage	E_b = 10.0 kVdc; I_b = 0.02 Adc	E_c:	-470	-560	-650 Vdc
Plate Power Output	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 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	110Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60





MACHLETT LABORATORIES, INC.

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MACHLETT

ML-6426
ML-6427

DESCRIPTIONS & RATINGS

DESCRIPTION:

The **ML-6426** and **ML-6427** are general purpose three-electrode tubes designed specifically for 40-50 kW and 25-30 kW industrial heating service respectively, 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-6426** has a water-cooled, heavy-wall anode capable of dissipating 40 kW with 20 gpm water flow. The **ML-6427** has a forced-air-cooled, heavy-wall anode capable of dissipating 20 kW with an air flow of approximately 1000 cfm*. Maximum ratings of 12.5 kVdc plate voltage and 80 kW plate input apply at frequencies up to 30 Mc. These tubes are rated for service up to 110 Mc with plate voltage and plate input reduced according to the table on page 3.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	8.0 Volts
Filament Current	200 Amps
Filament Starting Current, maximum	800 Amps
Filament Cold Resistance	.0051 Ohms
Amplification Factor	20
Interelectrode Capacitances:	
Grid-Plate	38 uuf
Grid-Filament	50 uuf
Plate-Filament	1.8 uuf

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 Glass Temperature	165 °C†
Net Weight, approximate	
ML-6426	13 lbs.
ML-6427	20 lbs.

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

†At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient; at higher frequencies or high ambient temperatures, 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.

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
Plate Dissipation	40	40	20	20	kW
Frequency	110	30	110	30	Mc

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.

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:	3.1	3.5	3.9 kVdc
Plate Voltage	E_c = -200 Vdc; I_b = 3.0 Adc	E_b:	6.9	7.5	8.1 kVdc
Grid Voltage	E_b = 10.0 kVdc; I_b = 0.02 Adc	E_c:	-490	-570	-650 Vdc
Plate Power Output	E_b = 12.0 Adc; E_c = -1200 Vdc I_b = 5.0 Adc; I_c = 0.30 Adc	P_o:	40	——	—— kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply 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	70	110Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	90	70
Class C	100	75	60

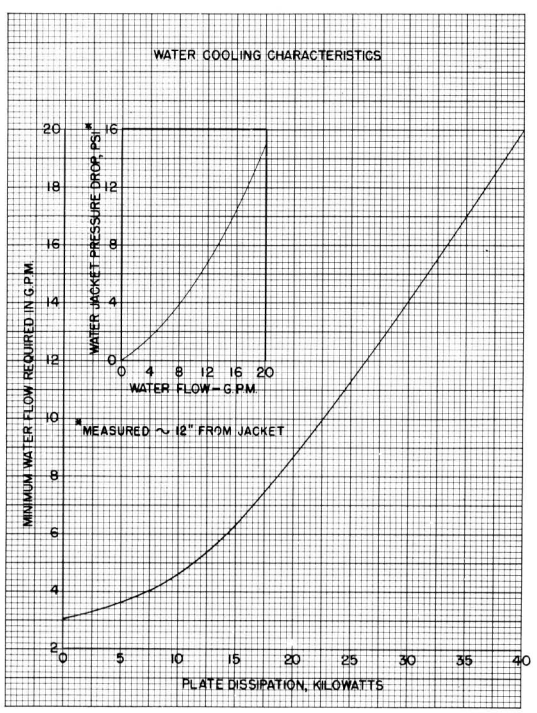
APPLICATION NOTES

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.

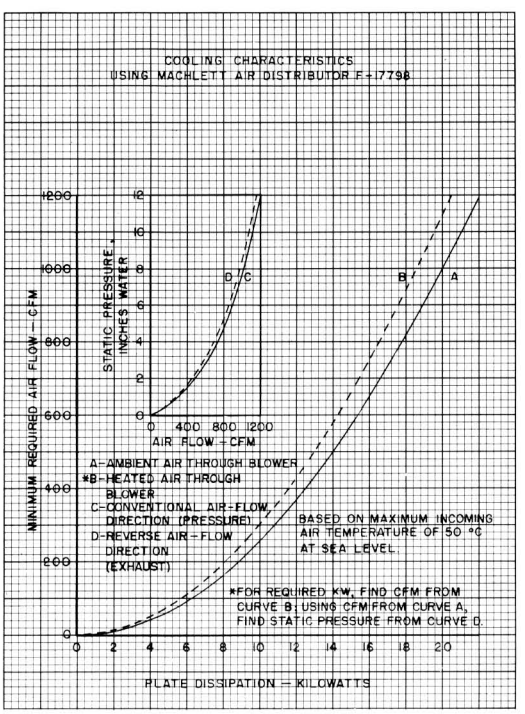
Additional protection is recommended and may be obtained by connecting a resistor in series with the plate lead of each tube for protection of the tube during the time required for the plate overload relay to act. A suitable resistor should be added unless the equivalent impedance is provided by transformers or other circuit components. The criterion is the total energy to which the tube can be subjected. The minimum value of total resistance which will give adequate protection with reasonably low power loss is as follows:

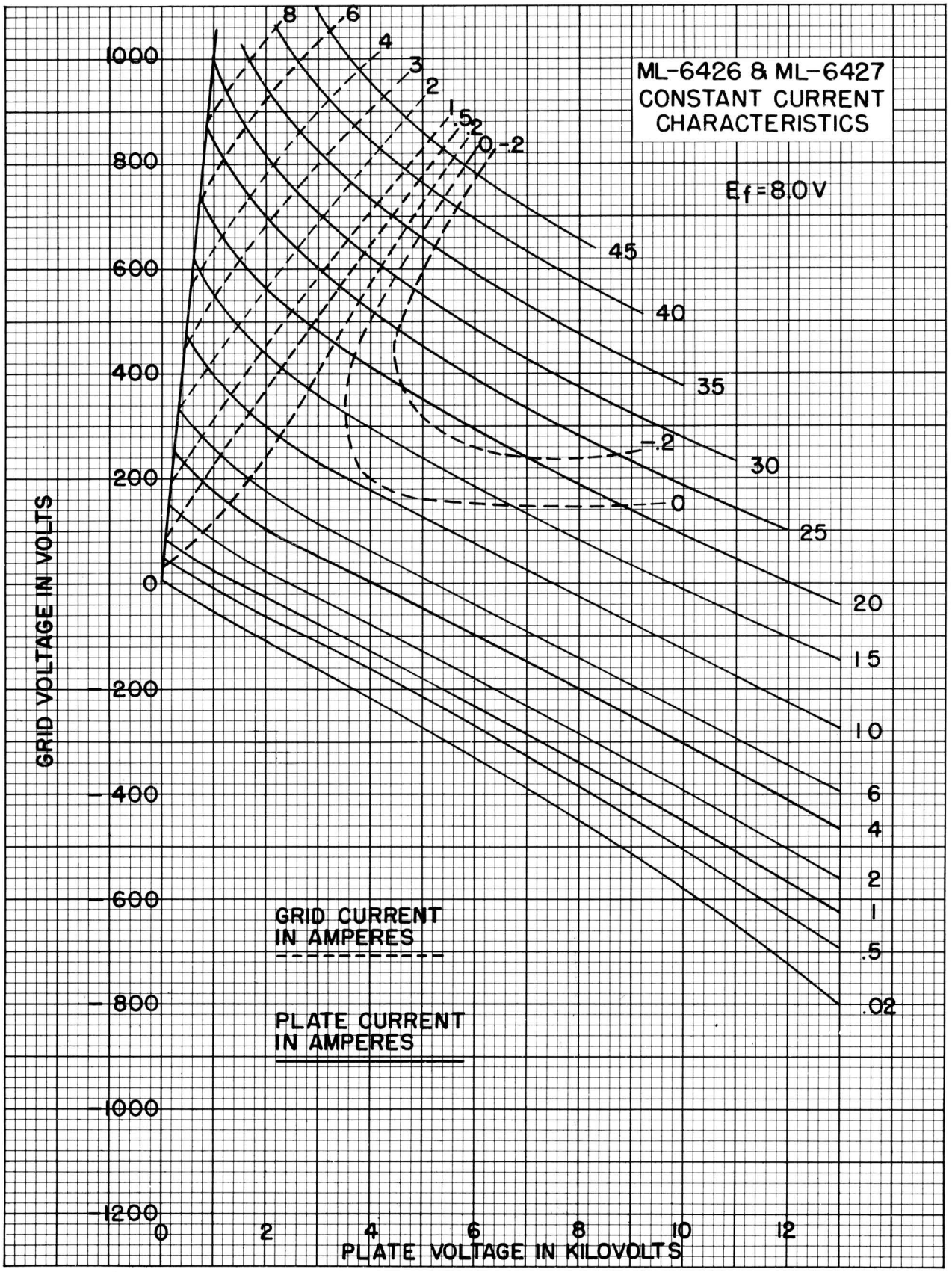
Series Resistor	15	25	40	60 ohms
Maximum Power Output of Rectifier	80	160	320	640 kW

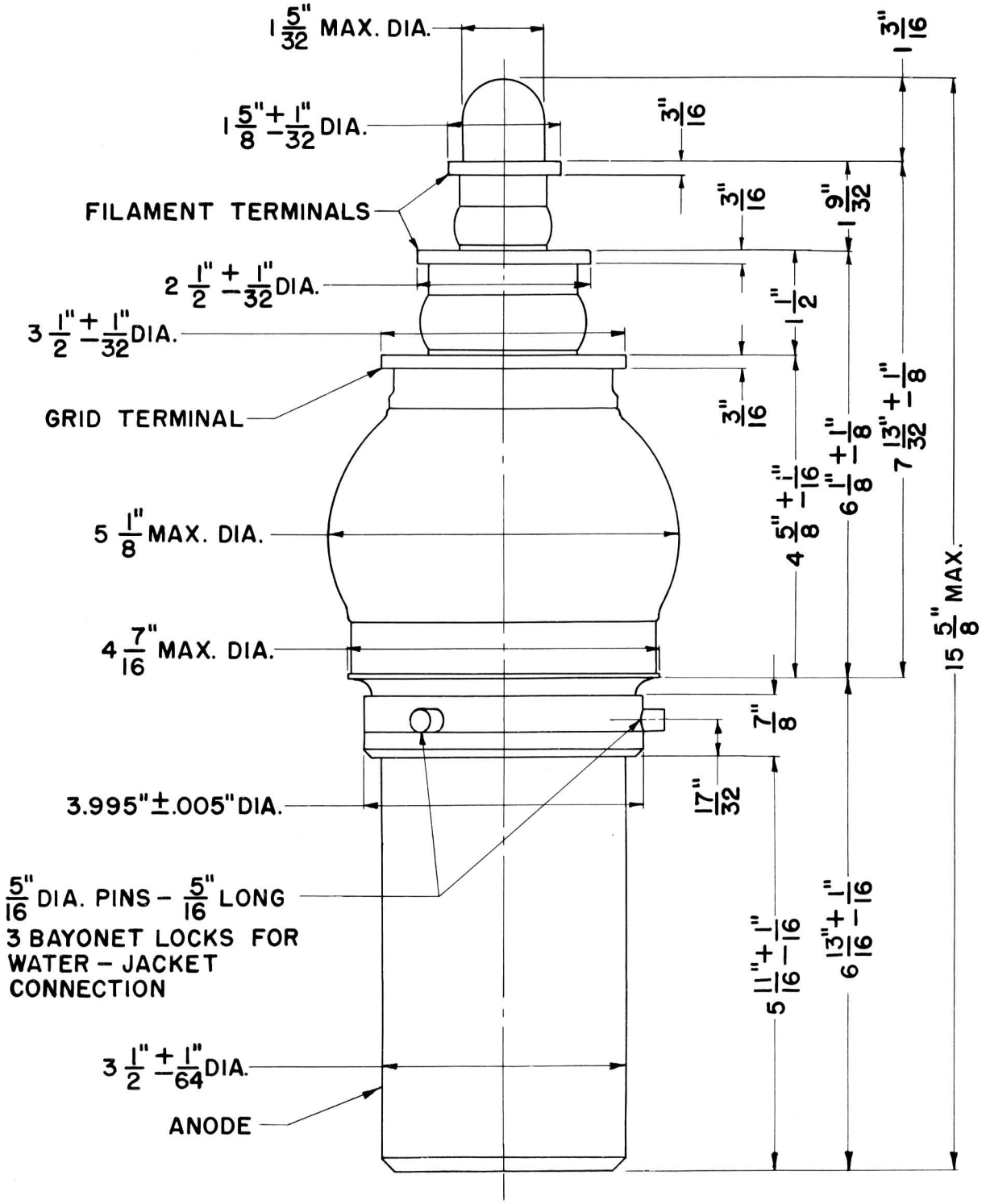
ML-6426



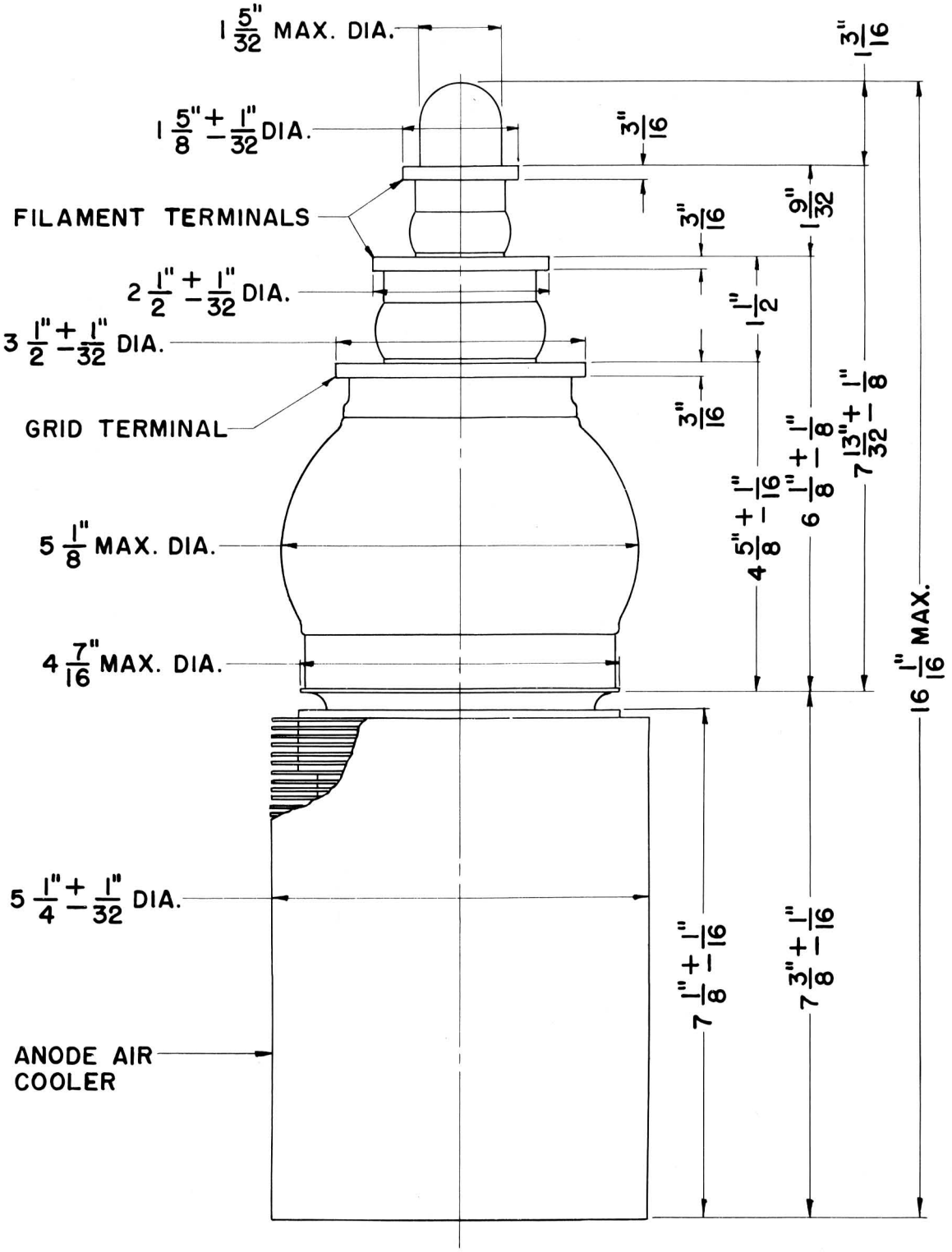
ML-6427




ML-6426 & ML-6427
CONSTANT CURRENT
CHARACTERISTICS
Ef = 8.0V
GRID VOLTAGE IN VOLTS
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
-1200
8
6
4
3
2
1.5
1
0
-2
45
40
35
30
25
20
15
10
6
4
2
1
.5
.02
-.2
0
GRID CURRENT
IN AMPERES
PLATE CURRENT
IN AMPERES
0
2
4
6
8
10
12
PLATE VOLTAGE IN KILOVOLTS


1 5/32" MAX. DIA.
1 5/8" +1/32 -1/32 DIA.
FILAMENT TERMINALS
2 1/2" +1/32 -1/32 DIA.
3 1/2" +1/32 -1/32 DIA.
GRID TERMINAL
5 1/8" MAX. DIA.
4 7/16" MAX. DIA.
3.995" ±.005" DIA.
5/16" DIA. PINS - 5/16" LONG
3 BAYONET LOCKS FOR WATER - JACKET CONNECTION
3 1/2" +1/64 -1/64 DIA.
ANODE
3/16"
3/16"
3/16"
9/32"
1/2"
3/16"
7/8"
17/32"
3/16"
1 3/32" +1/8 -1/8
6 1/8" +1/8 -1/8
4 5/8" +1/16 -1/16
5 11/16" +1/16 -1/16
6 13/16" +1/16 -1/16
15 5/8" MAX.

ML-6426



ML-6427

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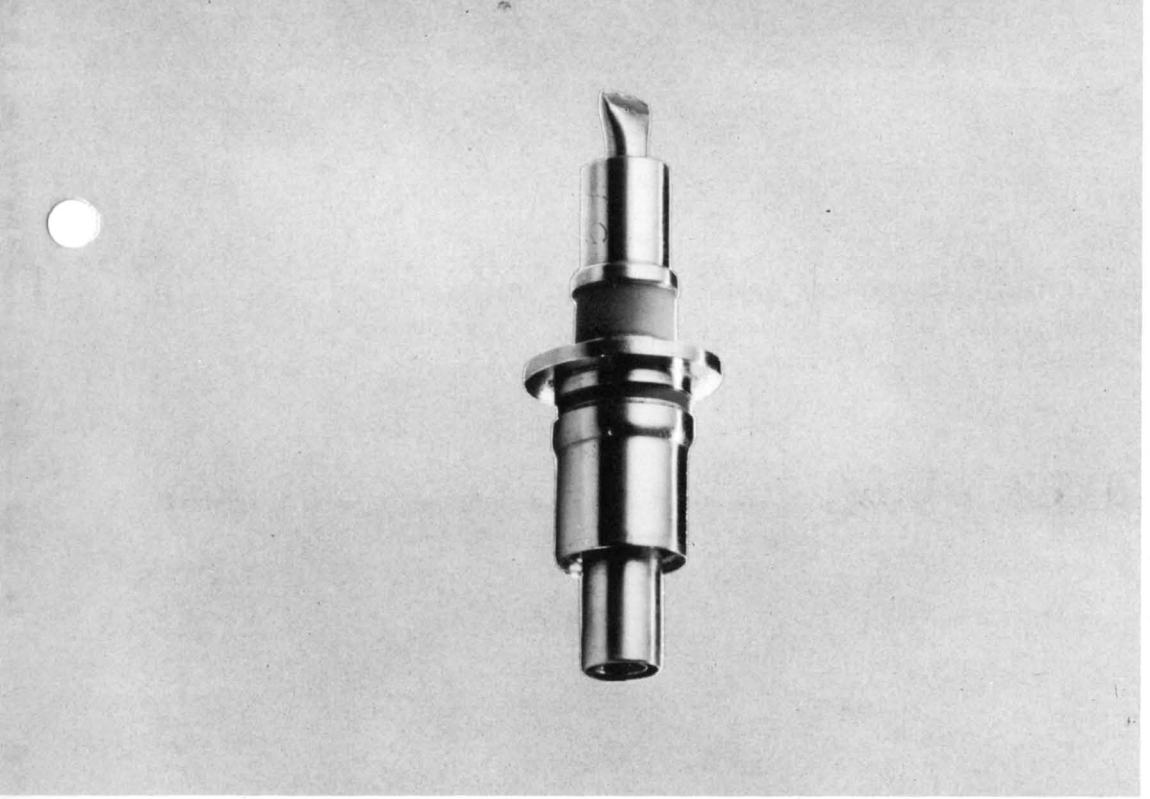
U. S. A.



MACHLETT

ML-6442

DESCRIPTION AND RATINGS

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 at frequencies up to about 4000 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 transist time, low interelectrode 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*	6.3 $^{-10\%}_{+5\%}$	Volts
Heater Current, AC or DC	0.9	Amp
Cathode Heating Time for Pulse Operation, minimum	60	Seconds
Amplification Factor	50	
Direct Interelectrode Capacitances, approximate		
Grid-Plate	2.3	$\mu\mu$f
Grid-Cathode, Eh = 0	5.10	$\mu\mu$f
Plate-Cathode, maximum, Eh = 0	0.045	$\mu\mu$f

Mechanical

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

* The transit time heating effect of the cathode shall 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 plus or minus 5 percent from optimum is permitted. For applications above 500 Mc, contact 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	4000	Mc

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‡

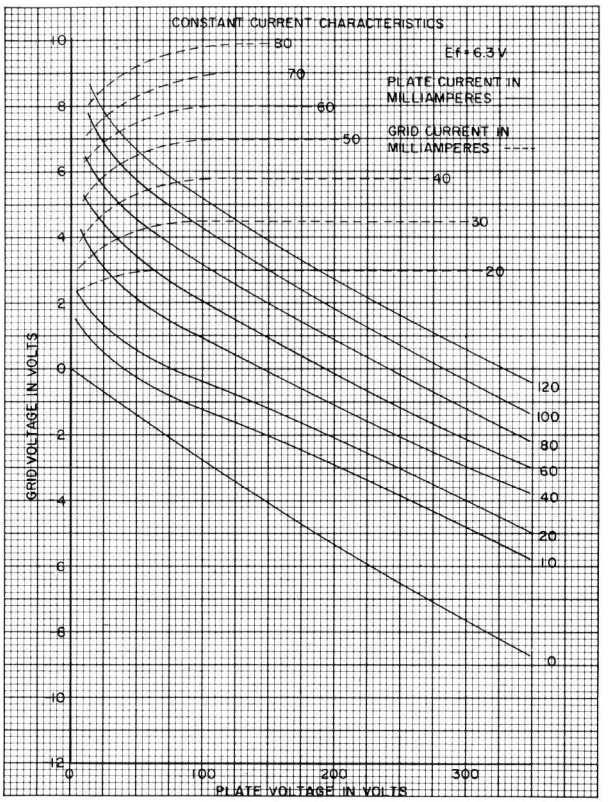
Maximum Ratings, Absolute Values

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

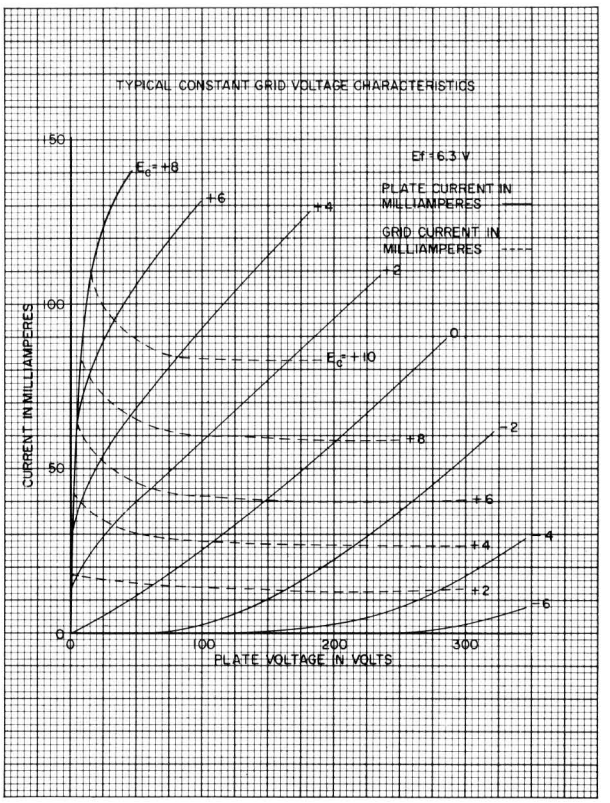
‡ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 percent of the carrier conditions.

CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

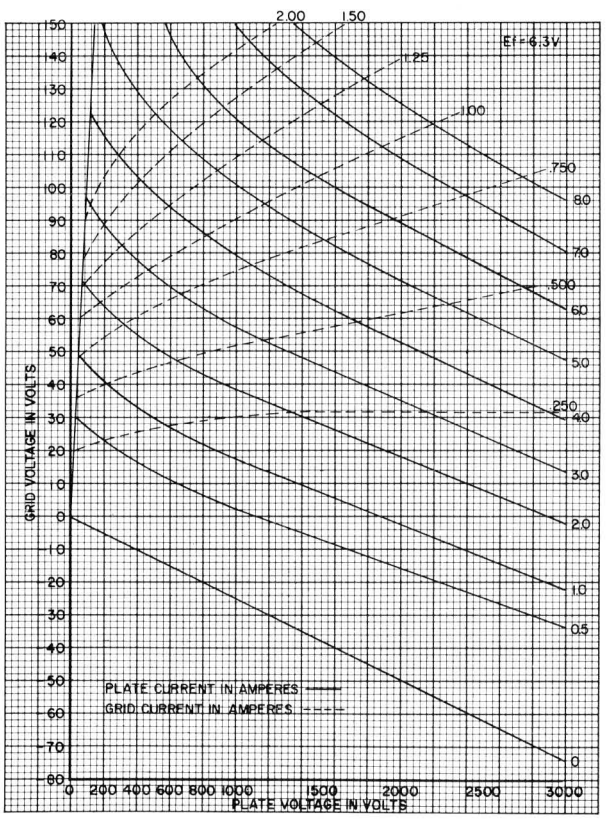
Class A_1 Amplifier	Min.	Max.	
Plate Voltage	——	350	Volts
DC Grid Bias, approximate	−2.5	−5.75	Vdc
Amplification Factor, approximate, Ec/Ib = 35 mAdc	35	65	
Transconductance	13500	19000	μmhos
Plate Current	——	35	mAdc
Grid-Plate Capacitance	2.10	2.45	μμf
Grid-Cathode Capacitance, Eh = 0	4.60	5.45	μμf
Plate-Cathode Capacitance, Eh = 0	——	0.045	μμf



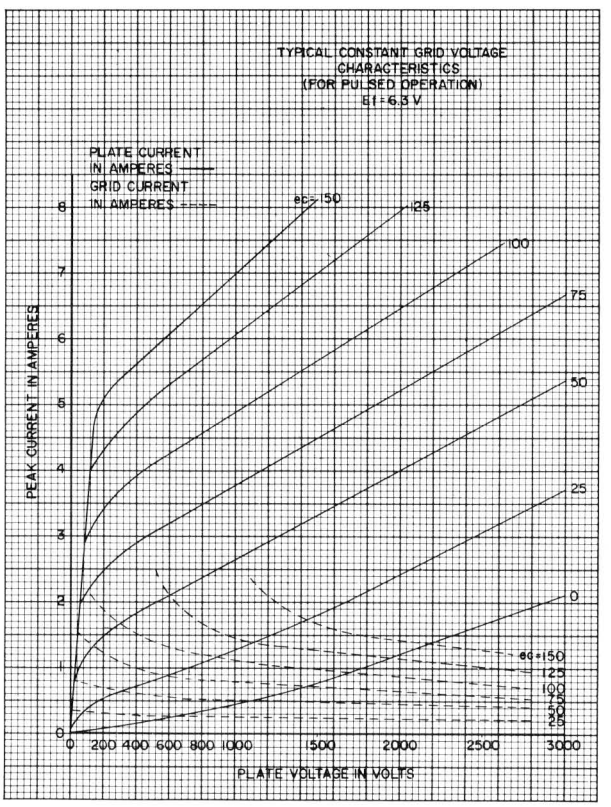
CONSTANT CURRENT CHARACTERISTICS



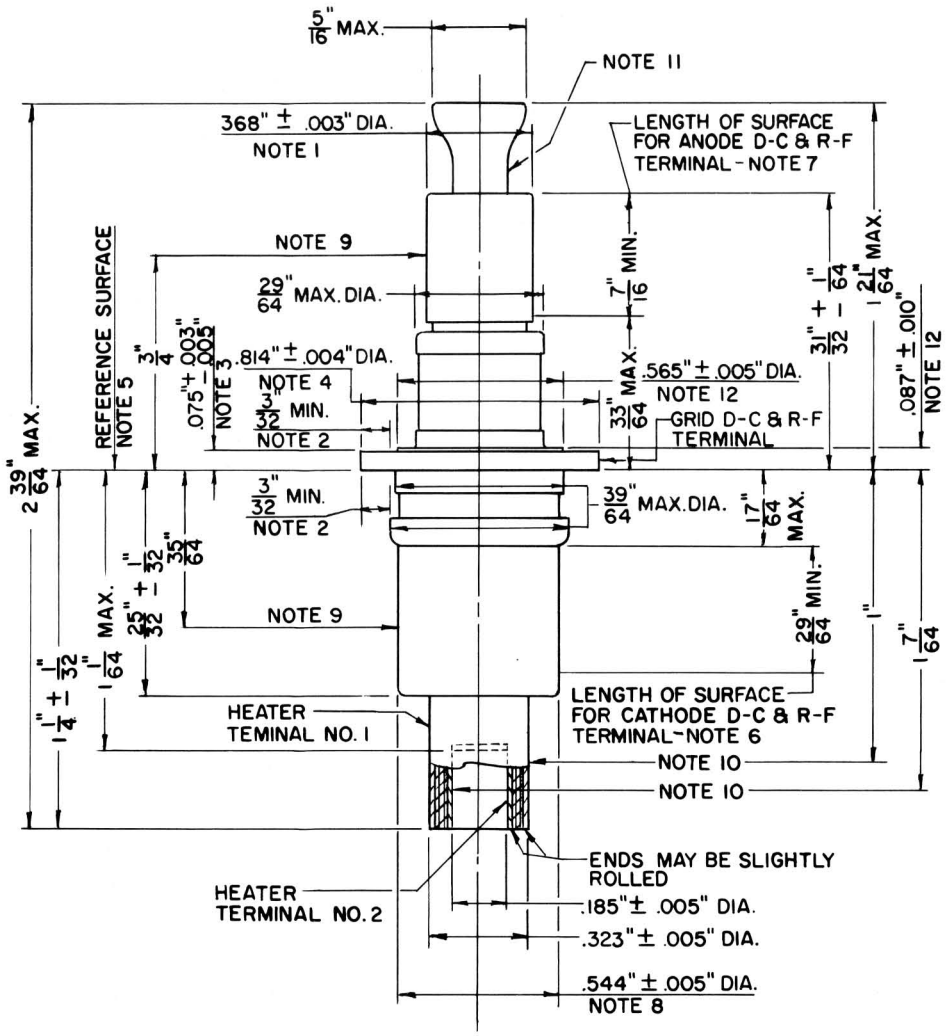
TYPICAL CONSTANT GRID VOLTAGE CHARACTERISTICS



CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION



TYPICAL CONSTANT GRID VOLTAGE CHARACTERISTICS
FOR PULSED OPERATION



Note 1. Applies to minimum surface for anode d-c and r-f terminal only. Other surfaces must not be used for these terminal purposes.

Note 2. Applies to minimum surface for grid d-c and r-f terminal only. Other surfaces, except for Notes 3 and 4, must not be used for terminal purposes.

Note 3. Applies to minimum surfaces for grid d-c and r-f terminal only.

Note 4. The cylindrical surface of this diameter may be used for grid d-c and r-f terminal purposes.

Note 5. The surfaces defined by Notes 2, 3 and 4 must be the only surfaces used for tube stops and clamping purposes.

Note 6. Other surfaces must not be used for cathode d-c and r-f terminal purposes.

Note 7. Other surfaces must not be used for anode d-c and r-f terminal purposes.

Note 8. Applies to surface designated for cathode d-c and r-f terminal.

Note 9. The maximum eccentricity of the anode and cathode with respect to the grid terminal in a prescribed jig is 0.010 (or maximum total runout of 0.020) and is measured by indicators at the points designated.

Note 10. The maximum eccentricity of heater-terminal No. 1 and heater-terminal No. 2 with respect to the grid terminal in a prescribed jig is 0.015 (or maximum total runout of 0.030) and is measured by indicators at the points designated.

Note 11. Exhaust tubulation must not be subjected to any mechanical stress.

Note 12. For reference only. Dimension does not include any possible solder fillet.

DIMENSIONS — ML-6442

MACHLETT

ML-6544

DESCRIPTION & RATINGS

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 AND RATINGS

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	$\mu\mu f$
Grid-Filament	260	$\mu\mu f$
Plate-Filament	40	$\mu\mu f$
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.

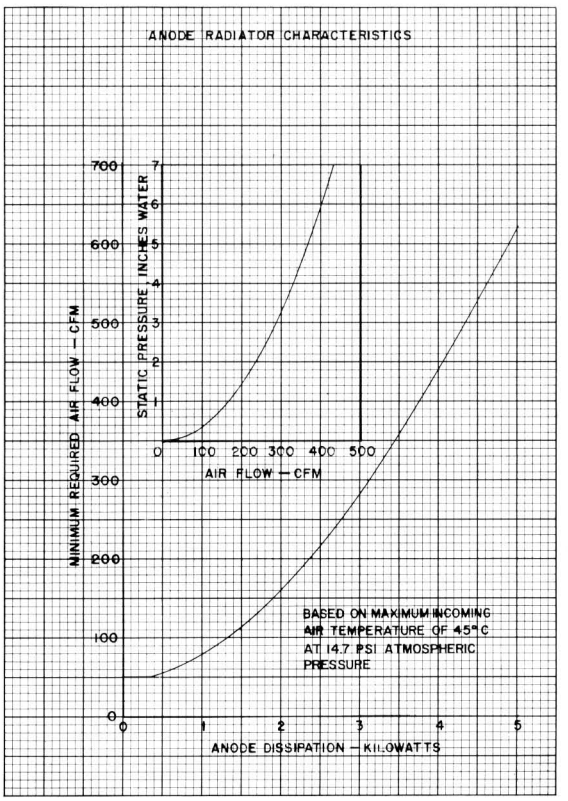
*For air-flow requirements at other temperatures and pressures, consult the Machlett Engineering Department.

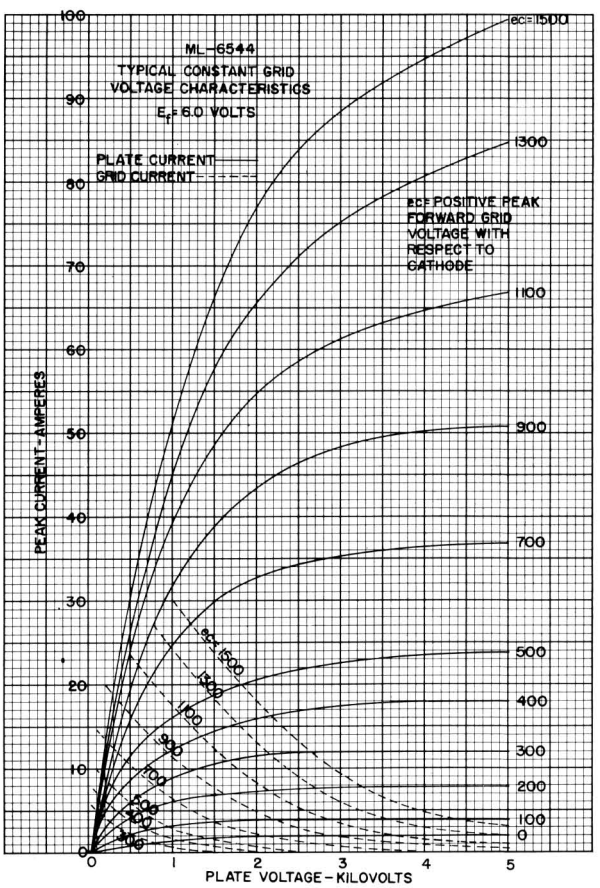
MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

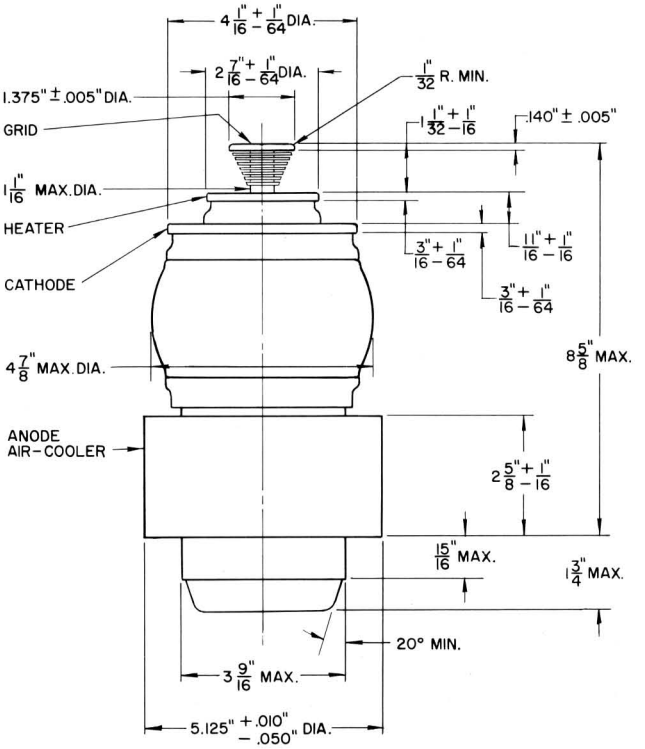
Maximum Ratings, Absolute Values		
Pulse Width*§	6	μsec
Duty Factor	.03	
Peak Plate Voltage	25	kv
D-C Plate Voltage	20	kV
D-C Grid Voltage	−600	Volts
Peak Positive Grid Voltage	1500	volts
Peak Cathode Current	75	amps
D-C Plate Current	250	mA
Grid Dissipation	75	watts
Plate Dissipation (80 cfm @ 0.2″ water)	1000	watts
Typical Operation: Pulse Modulator or Amplifier — Class C§		
D-C Plate Voltage	18	kV
D-C Grid Voltage	−500	Volts
Pulse Positive Grid Voltage	1200	volts
Pulse Plate Current	65	amps
Pulse Grid Current	7	amps
Load Resistance	225	ohms
Duty Factor	.0015	
Pulse Power Input	12.0	kw
Pulse Power Output	1000	kw

*Under certain conditions of operation, longer pulses may be possible.

§For information concerning specific tube problems or applications not covered, consult the Machlett Engineering Department.







DIMENSIONS — ML 6544

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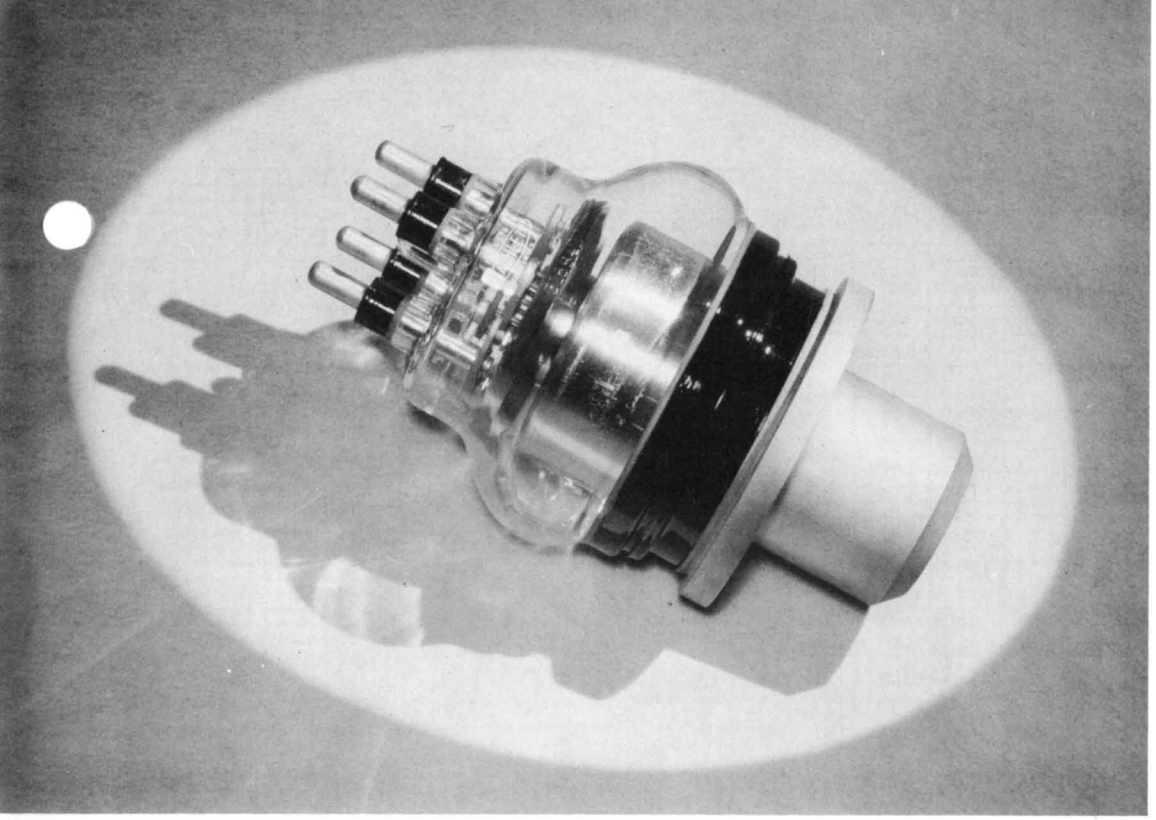


MACHLETT

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‡

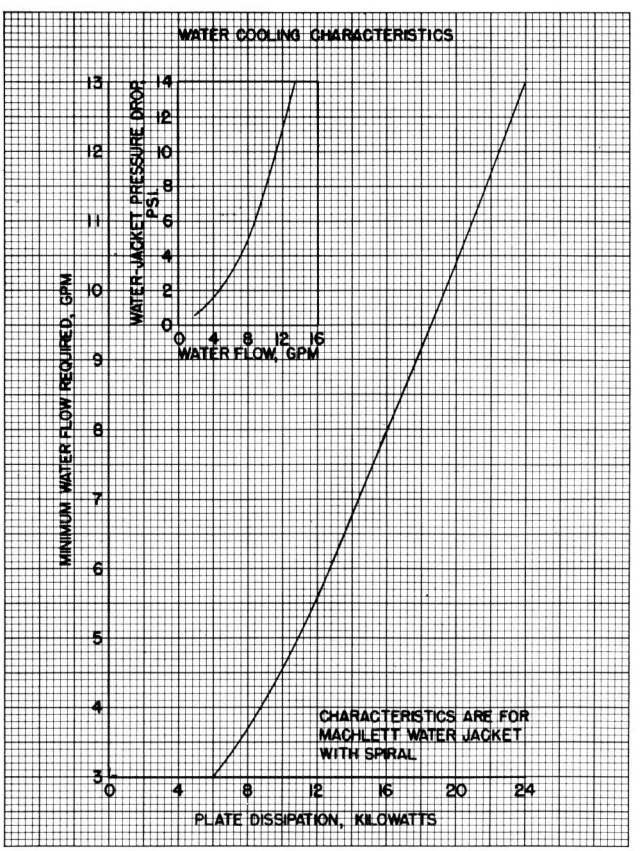
Maximum Ratings, Absolute Values

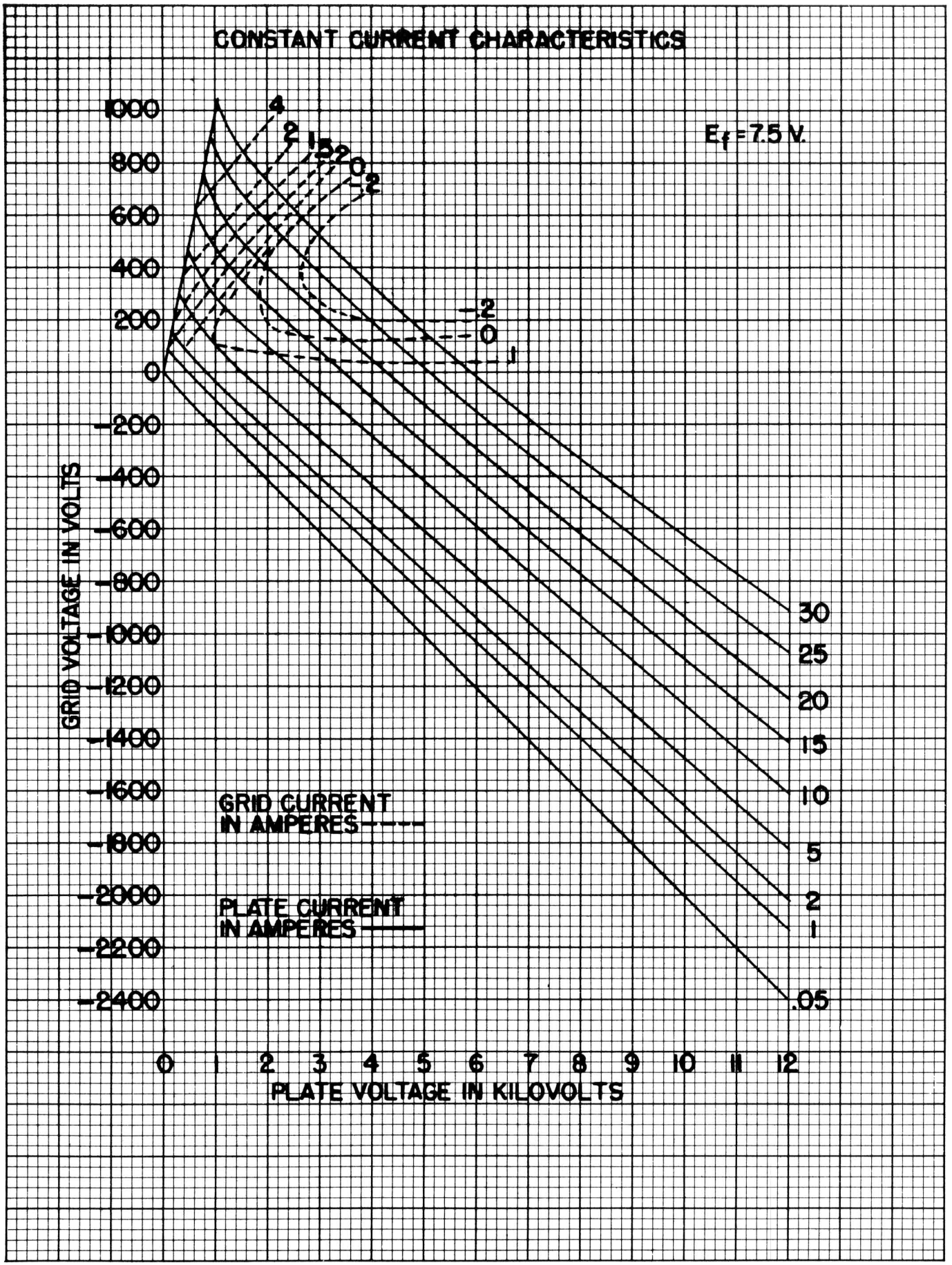
D-C Plate Voltage	10000	volts
D-C Grid Voltage	-2400	volts
D-C Plate Current	6.0	amps
D-C Grid Current	0.20	amp
Plate Input	60	kW
Plate Dissipation	22.5	kW

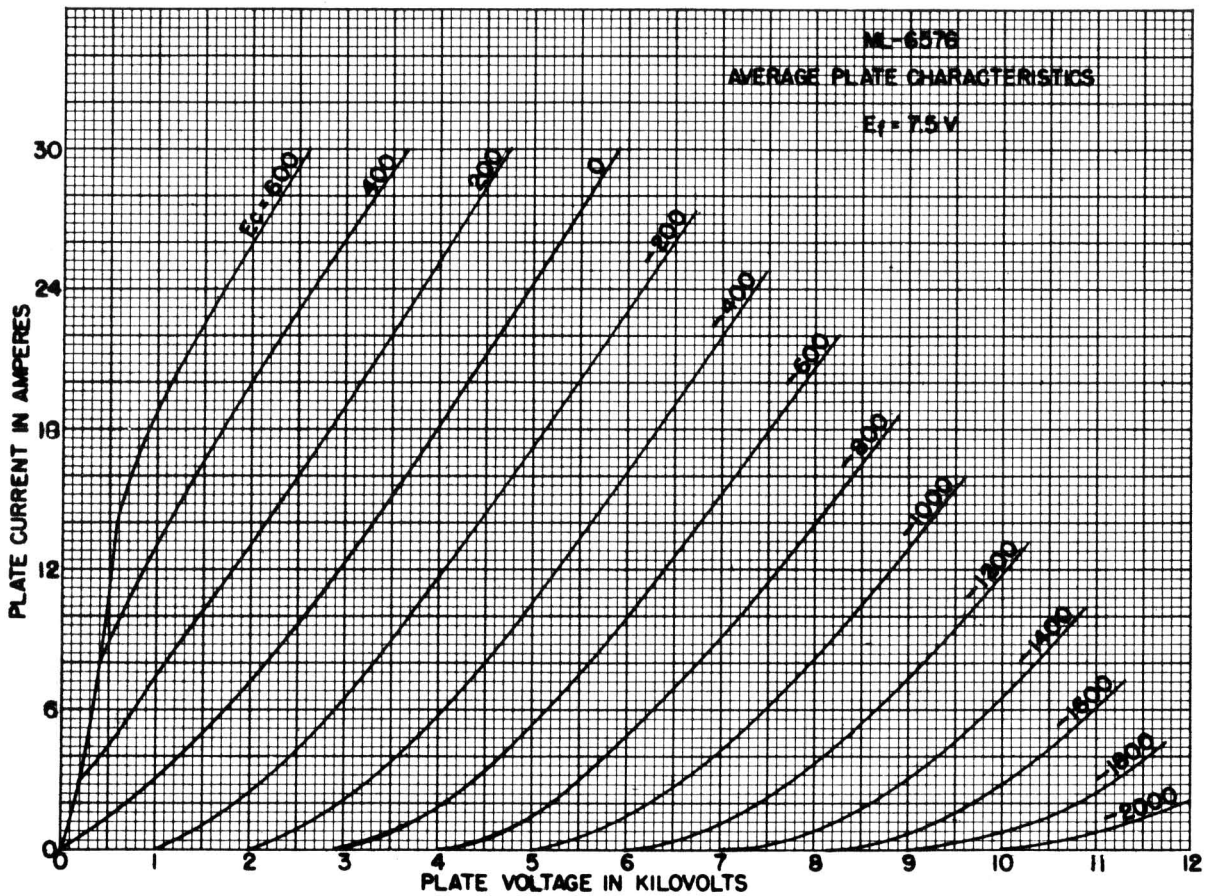
Typical Operation

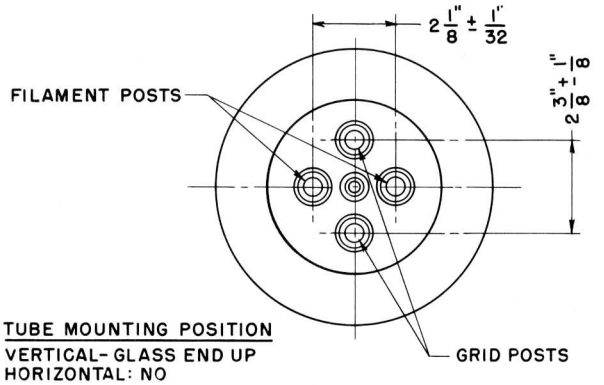
D-C Plate Voltage	8000	volts
D-C Grid Voltage	-2000	volts
Peak R-F Grid Voltage	2600	volts
Peak R-F Plate Voltage	6700	volts
D-C Plate Current	4.9	amps
D-C Grid Current, approximate	0.12	amp
Driving Power, approximate	300	watts
Power Output, approximate	29	kW

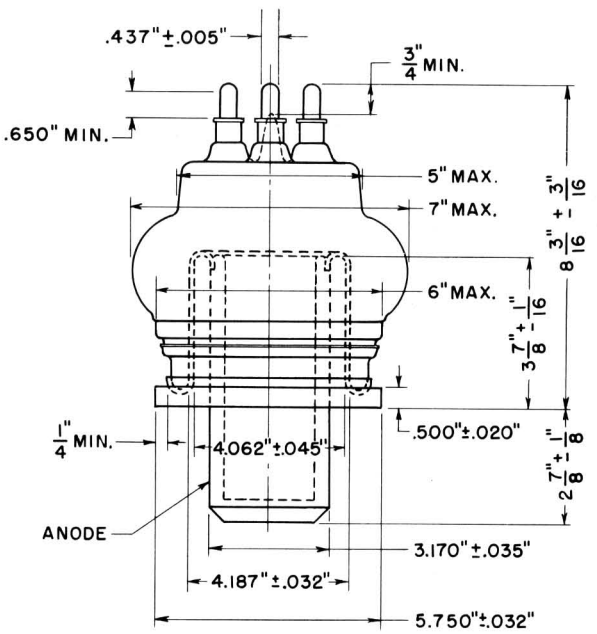
* Averaged over any audio-frequency cycle of sine-wave form.
** At crest of audio-frequency cycle with modulation factor of 1.0.
‡ Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.




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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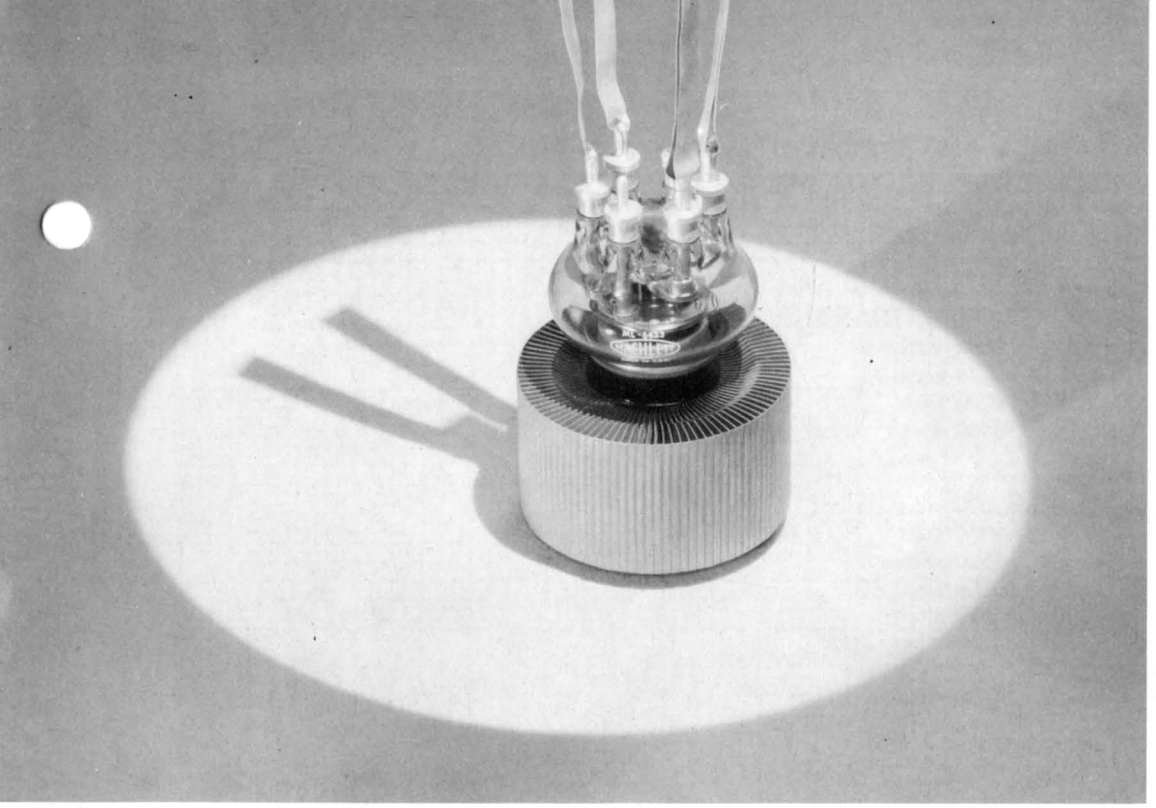


MACHLETT

ML-6623

DESCRIPTION AND RATINGS

DESCRIPTION

The **ML-6623** is a forced-air-cooled three-electrode tube designed for industrial heating service and for AM broadcasting. The grid and filament terminals are equipped with permanently attached flexible straps to facilitate circuit connections. The cathode is a thoriated-tungsten filament. The anode is forced-air cooled and can readily dissipate 2.5 kW with a moderate rate of air flow at low static pressure. Special features include: precise and stable alignment of electrodes, to prevent grid-cathode shorts and to assure reliability and uniform operation; brazed radiator construction, to eliminate hot-spotting and its detrimental effects; and quick r-f heated final seal-in, to provide a non-poisoned-cathode, contaminant-free, stress-free tube. Maximum ratings of 5.0 kVdc plate voltage and 5.0 kW plate input apply at frequencies up to 30 Mc.

GENERAL CHARACTERISTICS

ELECTRICAL DATA

Filament Voltage	6.0	Volts
Filament Current at 6.0 Volts	60	Amps
Filament Starting Current, maximum	300	Amps
Filament Cold Resistance	0.016	Ohms
Amplification Factor	22	
Interelectrode Capacitances:		
Grid-Plate	16	uuf
Grid-Filament	19	uuf
Plate-Filament	1.0	uuf

MECHANICAL

Mounting Position	Vertical, anode up or down	
Type of Cooling	Forced air	
Air-flow on anode	150 cfm at 0.9″ water	
Air-flow on dish	See Note	
Maximum incoming air temperature	45	°C
Maximum Glass Temperature	160	°C
Net Weight, approximate	4	lbs

Note: Cooling of dish and bulb may be provided by deflection of anode cooling air or by blower delivering 10 cfm air through a 1″ diameter nozzle.

MAXIMUM RATINGS AND TYPICAL OPERATING CONDITIONS

(Continuous Commercial Service)

Audio-Frequency Power Amplifier and Modulator Class B

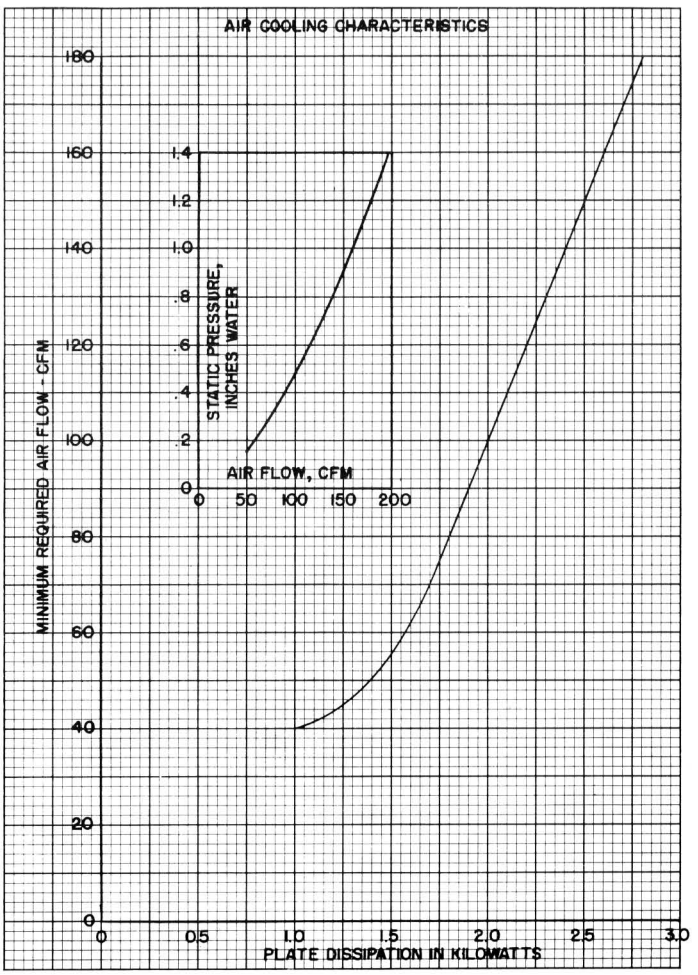
Maximum Ratings, Absolute Values

D-C Plate Voltage	3000 volts
Maximum Signal D-C Plate Current*	1.75 amps
Maximum Signal Plate Input*	4200 watts
Plate Dissipation*	2500 watts

Typical Operation (Values are for two tubes)

D-C Plate Voltage	3000 volts
D-C Grid Voltage	-160 volts
Peak A-F Grid-to-Grid Voltage	820 volts
Zero Signal D-C Plate Voltage	0.66 amp
Maximum Signal D-C Plate Current	2.80 amps
Effective Load Resistance, plate-to-plate	3060 ohms
Maximum Signal Driving Power, approx.	140 watts
Maximum Signal Power Output, approx.	4350 watts

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



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 volts
D-C Grid Voltage	-1000 volts
D-C Plate Current	1.4 amps
D-C Grid Current	0.5 amp
Plate Input	5000 watts
Plate Dissipation	2500 watts

Typical Operation

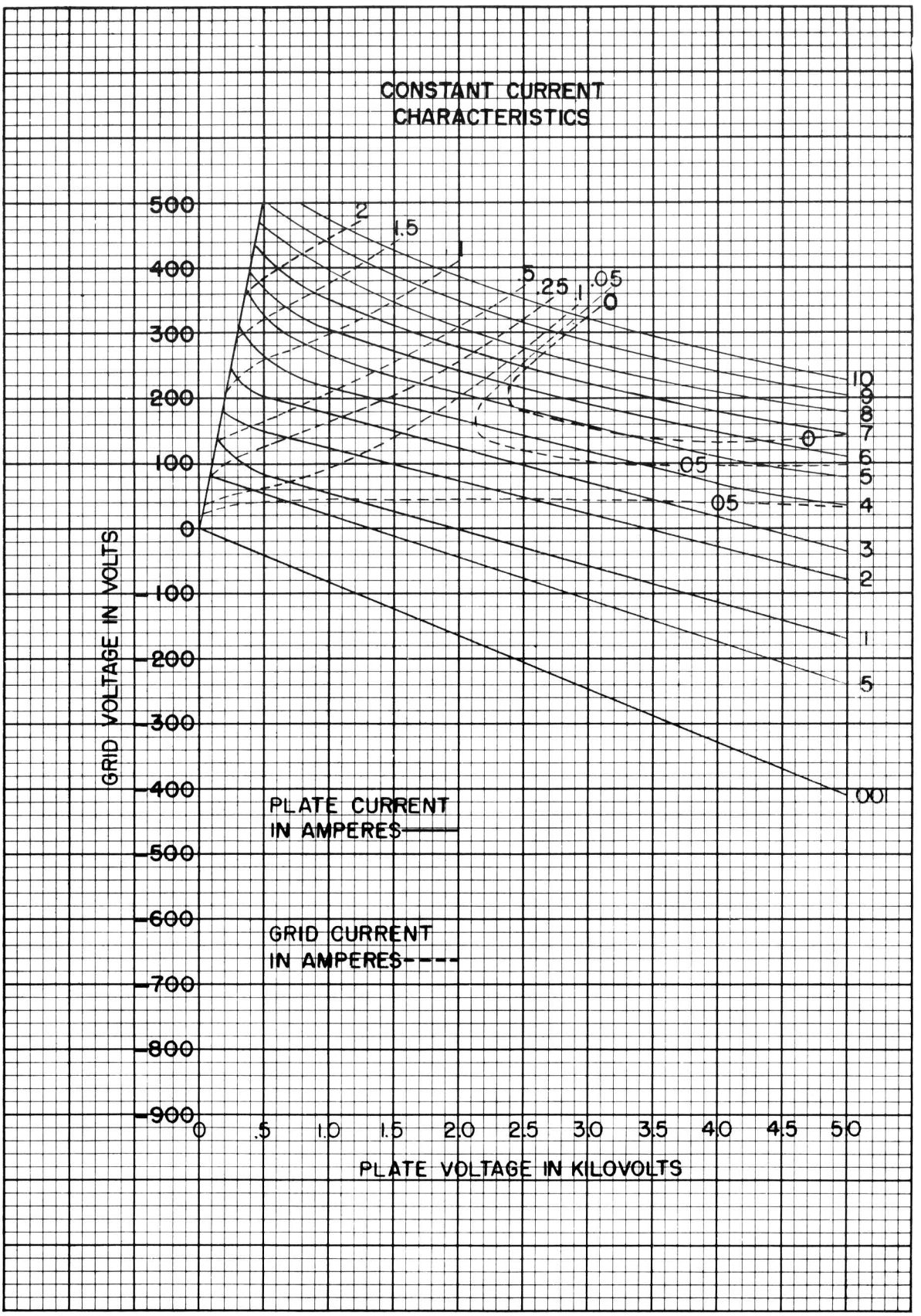
D-C Plate Voltage	5000 volts
D-C Grid Voltage	-850 volts
Peak R-F Grid Voltage	1200 volts
D-C Plate Current	1.0 amp
D-C Grid Current, approx.	0.210 amp
Driving Power, approx.	250 watts
Power Output, approx.	4100 watts

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

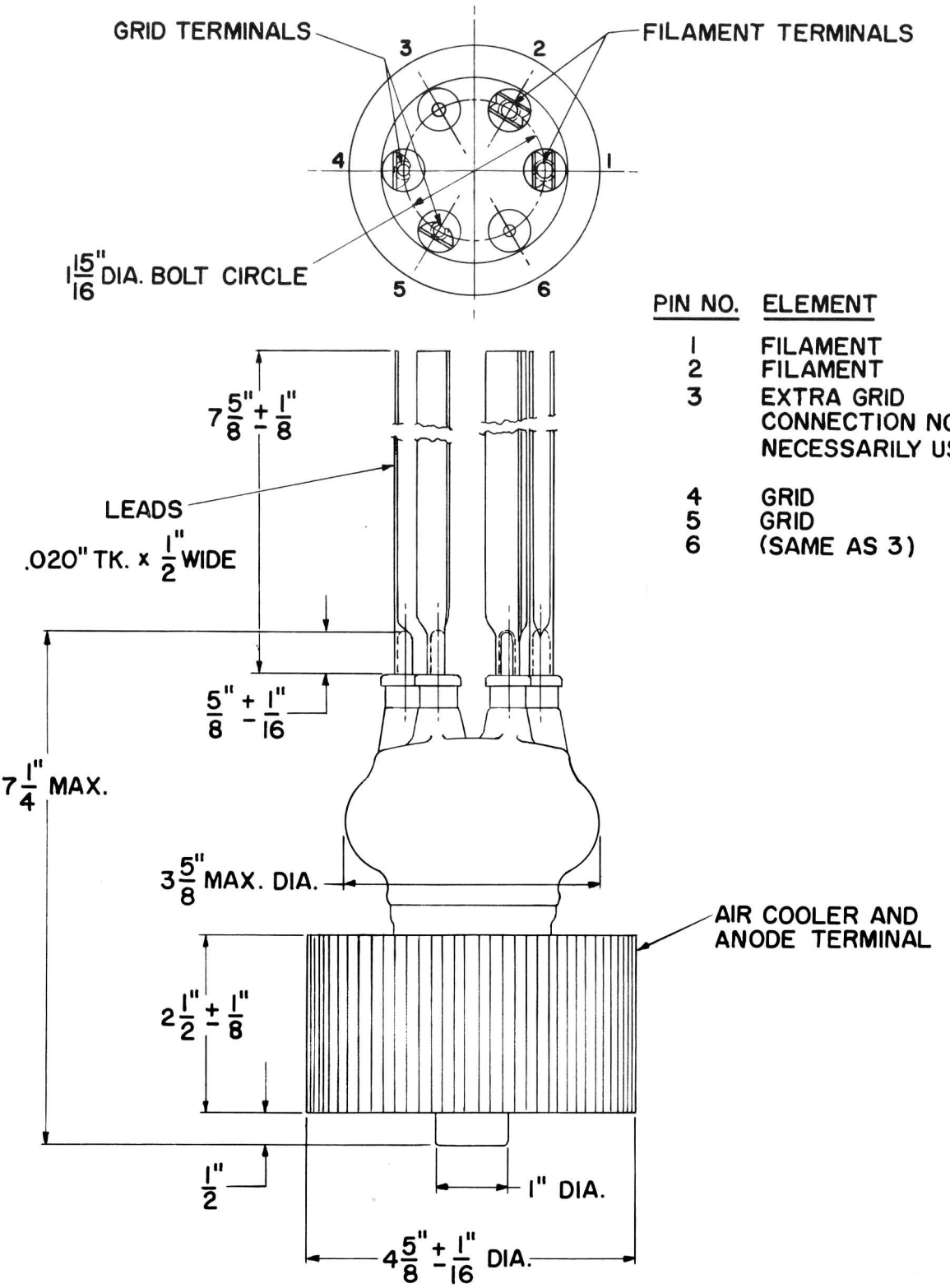
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

Characteristic:	Conditions:		Limits Minimum	Limits Bogey	Limits Maximum
Grid Voltage	e_b = 1000 volts; i_b = 6 amps	e_c:	——	——	360 volts
Grid Current	e_b = 1000 volts; i_b = 6 amps	i_c:	——	——	2.2 amps
Plate Voltage	E_c = -20 Vdc; I_b = 0.40 Adc	E_b:	1150	1400	1650 Vdc
Plate Voltage	E_c = -30 Vdc; I_b = 0.40 Adc	E_b:	1370	1620	1870 Vdc
Grid Voltage	E_b = 4000 Vdc; I_b = 0.020 Adc	E_c:	-180	-215	-250 Vdc
Peak Cathode Current*		i_k:	10	——	—— amps
Power Output	E_b = 5000 Vdc; E_c = -850 Vdc; I_b = 1.0 Adc; I_c = 0.3 Adc	P_o:	3800	——	—— watts

* Represents maximum usable plate current plus grid current for any condition of operation.



CONSTANT CURRENT CHARACTERISTICS



PIN NO.	ELEMENT
1	FILAMENT
2	FILAMENT
3	EXTRA GRID CONNECTION NOT NECESSARILY USED
4	GRID
5	GRID
6	(SAME AS 3)

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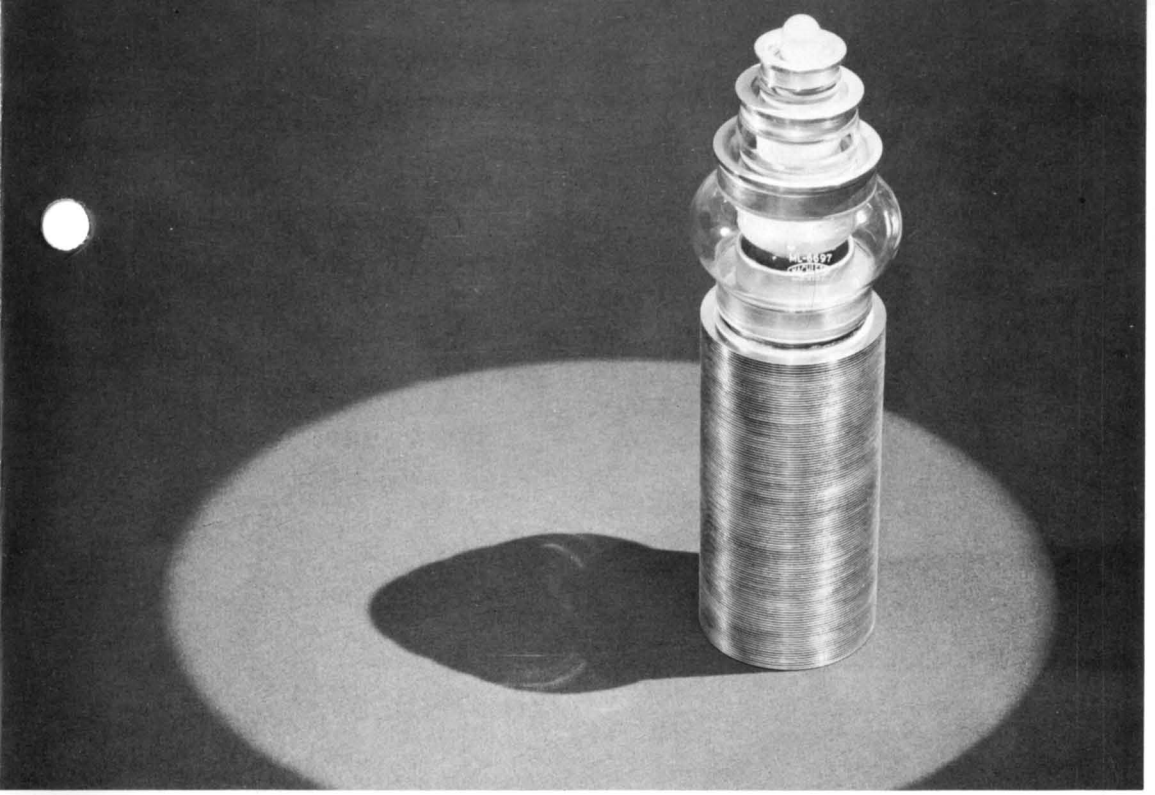


MACHLETT

ML-6697

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-6697** is a general purpose forced-air-cooled three-electrode tube designed specifically for 40-60 kW industrial heating and AM broadcasting service. The tube features rugged coaxial mounting structures providing high-dissipation, low-inductance r-f electrode terminals. The heavy-wall anode is capable of dissipating 35 kW with an air flow of approximately 1700 cfm.* The cathode is a sturdy, self-supporting, stress-free, thoriated-tungsten filament. Maximum ratings of 16 kVdc plate voltage and 120 kW plate input apply at frequencies up to 30 Mc. Full input can be utilized from about 10 kVdc and 11 Adc to 15.5 kV and 7 Adc, offering the equipment designer a wide latitude in choice of load impedance. Useful power output can be obtained at frequencies up to 90 Mc with plate voltage and plate input reduced according to the table on Page 3.

GENERAL CHARACTERISTICS

Electrical

Filament Voltage	13.0	Volts
Filament Current	205	Amps
Filament Starting Current, maximum	800	Amps
Filament Cold Resistance	.0073	Ohms
Amplification Factor	20	
Interelectrode Capacitances:		
Grid Plate	55	uuf
Grid-Filament	76	uuf
Plate-Filament	2.7	uuf

Mechanical

Mounting Position	Vertical, anode down	
Type of Cooling	Forced-air	
Air flow on anode for 35 kW dissipation*	Pressure: 1700 cfm at 7.8" Water Exhaust: 1970 cfm at 8.4" Water	
Air flow on glass and seals	See Note	
Maximum incoming air temperature	50	°C
Maximum Glass Temperature	165	°C
Net Weight, approximate		
Tube only	29	lbs.
Tube with air distributor	41	lbs.

*When used with Machlett Air Distributor F-17759.

Note: At frequencies up to 15 Mc, normal cabinet ventilation should be sufficient; at higher frequencies or high ambient temperatures, 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.

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*	110	kW
Plate Dissipation*	35	kW

Typical Operation (Values are for two tubes)

D-C Plate Voltage	10000	volts
D-C Grid Voltage	-450	volts
Peak A-F Grid-to-Grid Voltage	1750	volts
Peak A-F Plate-to-Plate Voltage	16000	volts
Zero-Signal D-C Plate Current	3.0	amps
Max.-Signal D-C Plate Current	17.4	amps
Effective Load Resistance, Plate-to-Plate	1170	ohms
Max.-Signal Driving Power, approximate	450	watts
Max.-Signal Power Output, approximate	110	kW

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

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	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	amps
R-F Load Resistance	510	ohms
Driving Power, approximate	2.0	kW
Power Output, approximate	60	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	9	amps
Plate Input	55	kW
Plate Dissipation	35	kW

Typical Operation

D-C Plate Voltage	12000	volts
D-C Grid Voltage	-550	volts
Peak R-F Grid Voltage	510	volts
Peak R-F Plate Voltage	5300	volts
D-C Plate Current	4.3	amps
D-C Grid Current	0	mA
R-F Load Resistance	780	ohms
Driving Power, approximate**	450	watts
Power Output, approximate	18	kW

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

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	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	amps
R-F Load Resistance	440	970	ohms
Driving Power, approximate	1.5	0.60	kW
Power Output, approximate	72	80	kW

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

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

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:	1.8	2.3	2.8 kVdc
Plate Voltage	E_c = -400 Vdc; I_b = 3.0 Adc	E_b:	9.2	10.3	11.4 kVdc
Grid Voltage	E_b = 15.0 kVdc; I_b = 0.20 Adc	E_c:	-730	-850	-970 Vdc
Plate Power Output	E_b = 15.0 kVdc; E_c = -1600 Vdc; I_b = 7.0 Adc; I_c = 0.30 Adc	P_o:	68	——	—— kW

MAXIMUM FREQUENCY RATINGS

Maximum ratings apply 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	60	90Mc
Percent Maximum Rated Plate Voltage and Plate Input			
Class B	100	80	55
Class C	100	75	50

APPLICATION NOTES

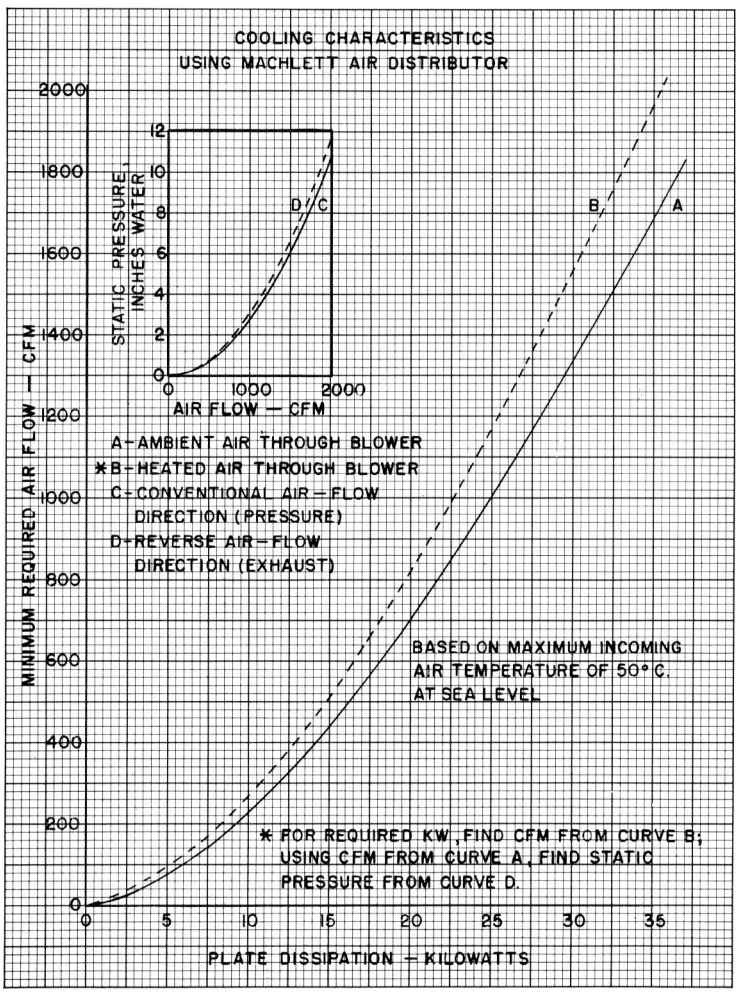
The handling of very high power requires particular attention to the removal of power under fault conditions, since the large amount of energy involved can cause severe damage if not properly controlled. The ground lead of the plate circuit of each tube should be connected in series with the coil of 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.

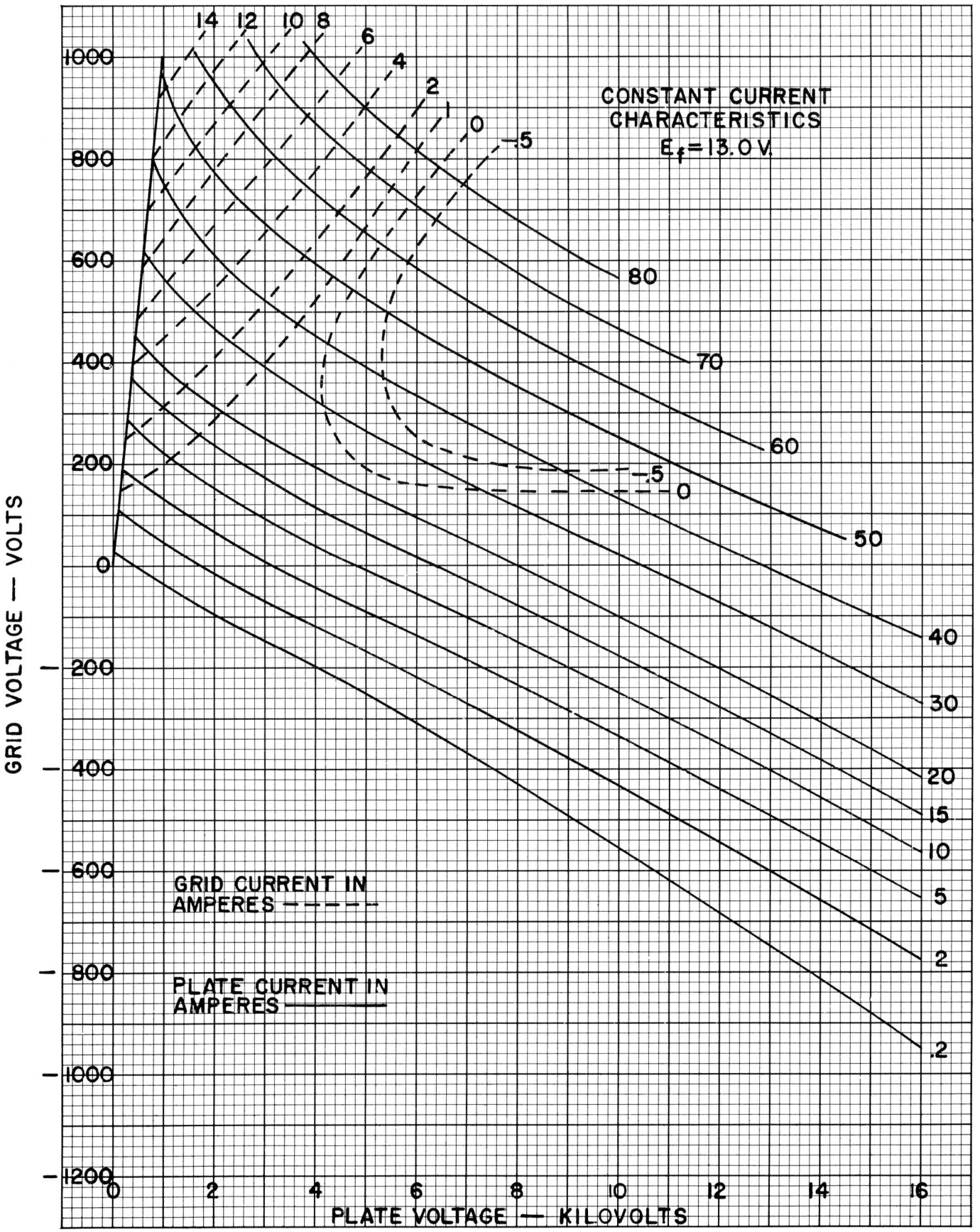
To protect the tube until the relay and circuit breakers act, the installation of a device which will short circuit the plate power in the order of one-half cycle is highly recommended. For this purpose an electronic device or a railway-type line-power contactor may be connected to short the primary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

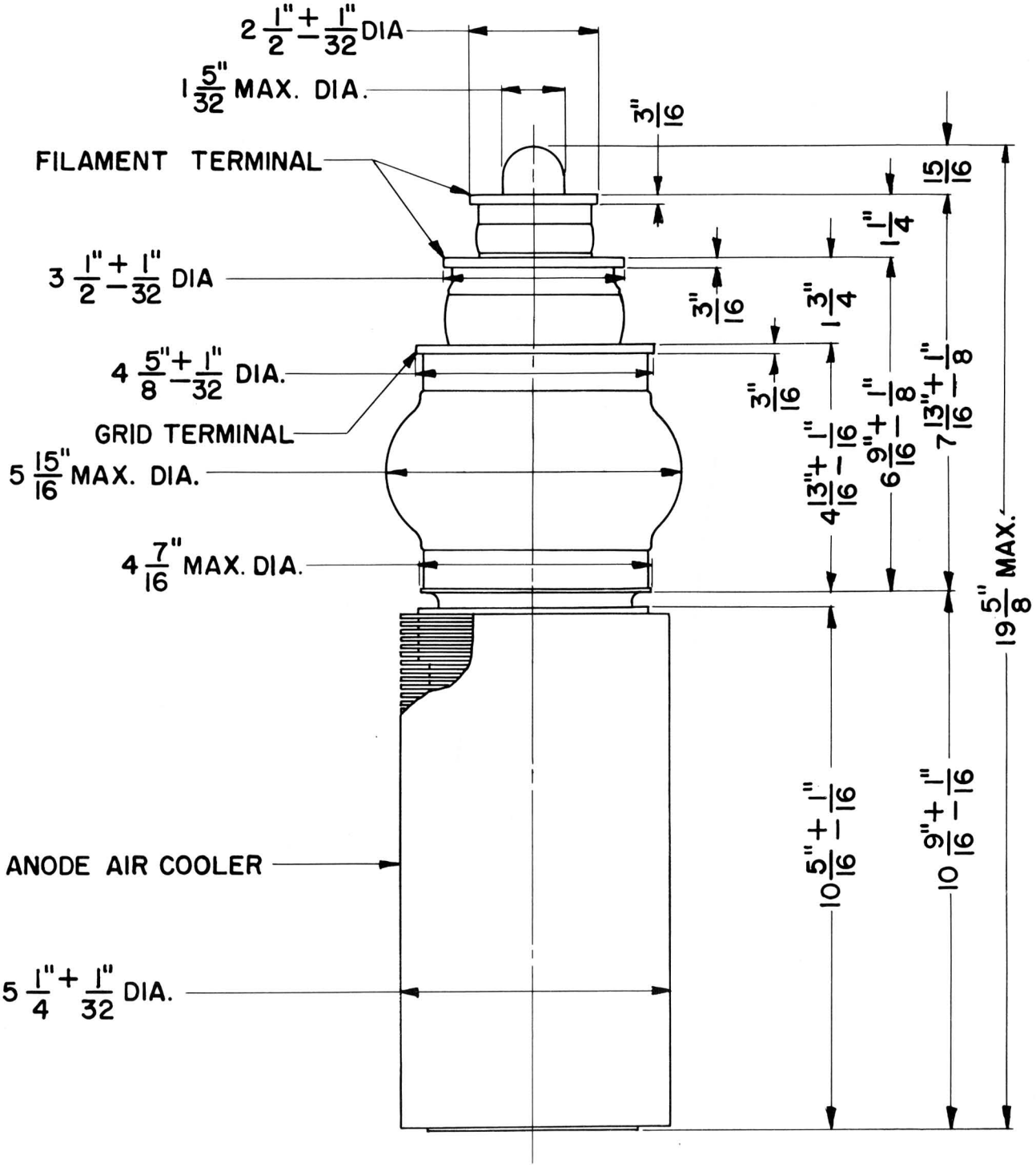
Series Resistor	10	20	35	50	ohms
Maximum Power Output of Rectifier	120	250	500	1000	kW

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. Gap spacings must be carefully adjusted for each individual application.




CONSTANT CURRENT
CHARACTERISTICS
E_f = 13.0 V.
14
12
10
8
6
4
2
1
0
-.5
80
70
60
50
40
30
20
15
10
5
2
.2
-.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


2 1/2 +1" -1/32 DIA
1 5/32" MAX. DIA.
FILAMENT TERMINAL
3 1/2 +1" -1/32 DIA
4 5/8 +1" -1/32 DIA.
GRID TERMINAL
5 15/16" MAX. DIA.
4 7/16" MAX. DIA.
ANODE AIR COOLER
5 1/4 +1" -1/32 DIA.
3" 16
3" 16
3" 16
1" 4
3" 4
1" 8
15" 16
13" 16 +1" -1/8
9" 16 +1" -1/16
13" 16 +1" -1/16
5" 16 +1" -1/16
9" 16 +1" -1/16
19 5/8" MAX.

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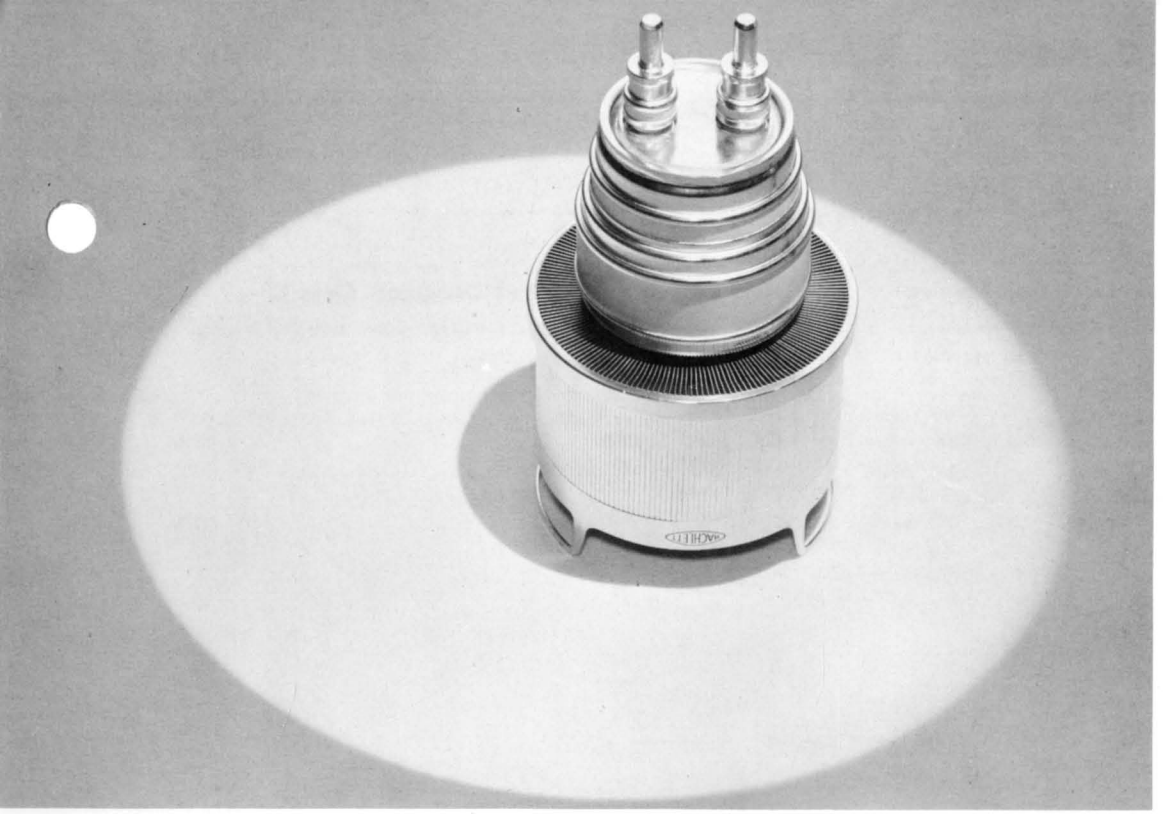


MACHLETT

ML-7007

DESCRIPTION & RATINGS

DESCRIPTION

The **ML-7007** is a forced-air-cooled tetrode designed primarily for high power vhf television service. The envelope uses high-alumina ceramic insulation for mechanical strength and low electrical loss. Sturdy cylindrical supports for the two grids and large-area coaxial terminals provide low lead inductance and high heat dissipation capability. The anode is rated for 10 kW dissipation with an air flow of 350 cfm. The cathode is a sturdy, self-supporting, thoriated-tungsten filament. Maximum ratings apply at frequencies up to 220 Mc.

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	uuf
Grid No. 1 - Filament	43	uuf
Plate - Filament*, maximum	0.08	uuf
Grid No. 1 - Grid No. 2	60	uuf
Grid No. 2 - Plate	21	uuf

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.

MAXIMUM RATINGS

R-F Power Amplifier, Class B Television Service

Synchronizing-level conditions unless otherwise specified.
(Voltages are referred to cathode unless otherwise specified.)

Maximum Ratings, Absolute Values

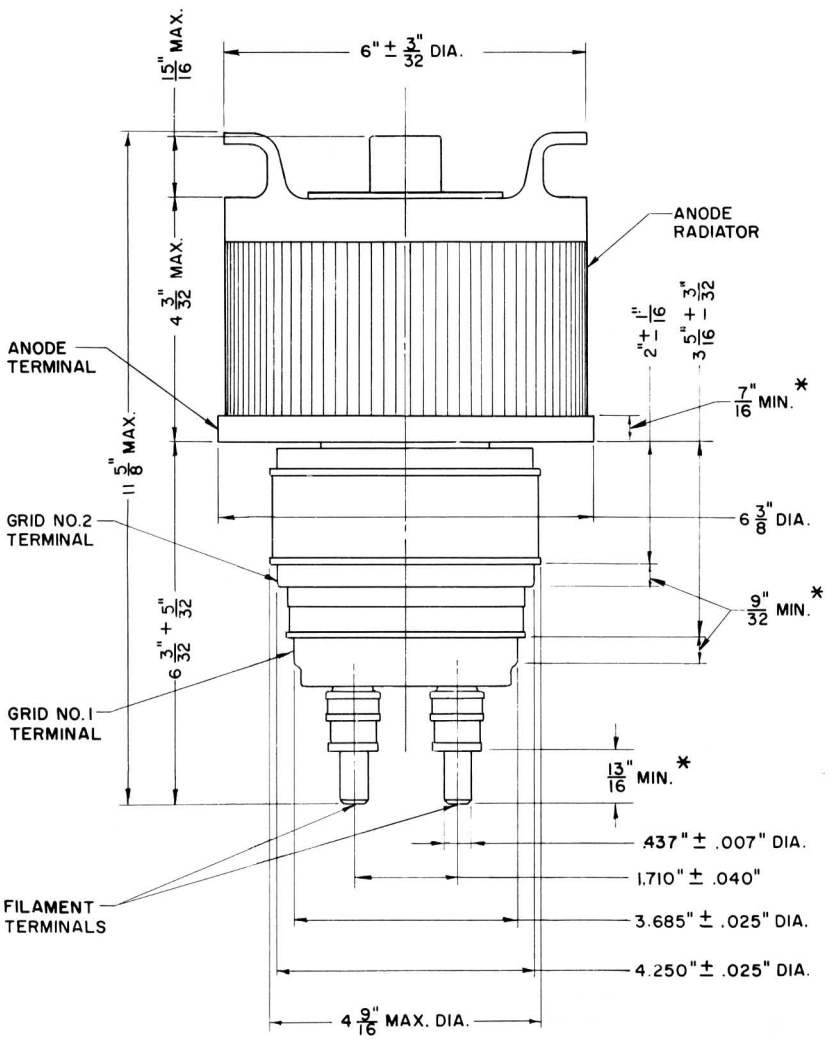
D-C Plate Voltage	6500 volts
D-C Grid No. 2 Voltage	2000 volts
D-C Plate Current	4 amps
Plate Input	24 kW
Grid No. 2 Input	400 watts
Plate Dissipation	10 kW
Grid No. 1 Dissipation	300 watts

R-F Amplifier and Oscillator, Class C

Key-down conditions per tube without amplitude modulation.

Maximum Ratings, Absolute Values

D-C Plate Voltage	7000 volts
D-C Grid No. 2 Voltage	2000 volts
D-C Plate Current	2.75 amps
D-C Grid No. 1 Current	0.6 amp
Plate Input	20 kW
Grid No. 2 Input	400 watts
Plate Dissipation	10 kW



* REPRESENTS MAXIMUM STRAIGHT PORTION AVAILABLE FOR CONTACT.

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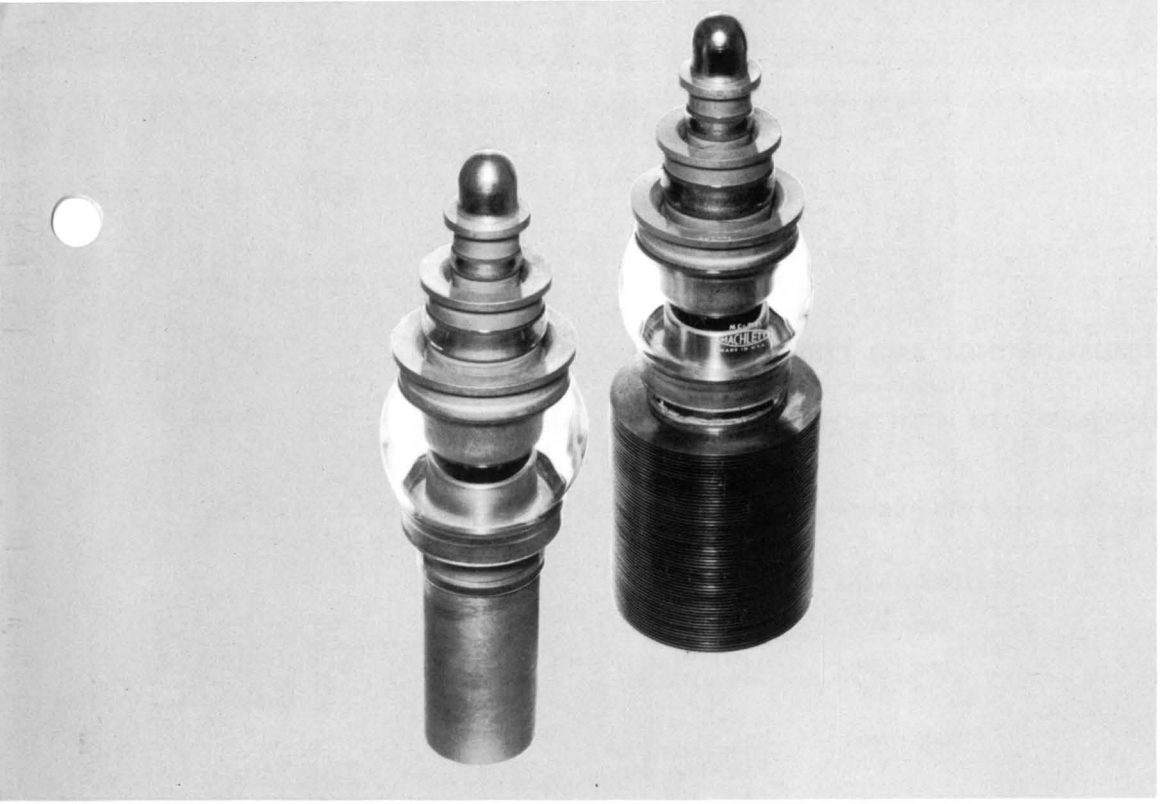


MACHLETT

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

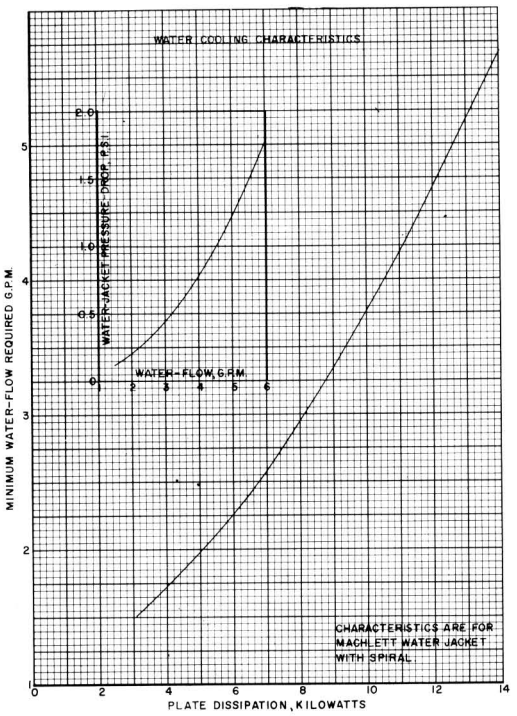
Single-Sideband Suppressed-Carrier Service

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

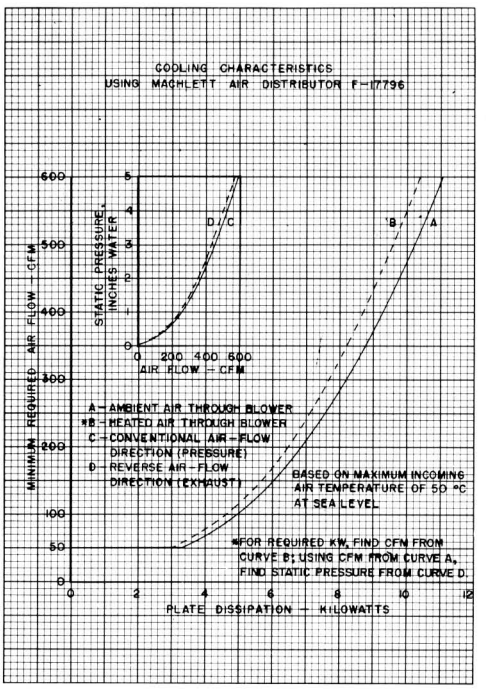
CHARACTERISTIC RANGE VALUES FOR EQUIPMENT DESIGN

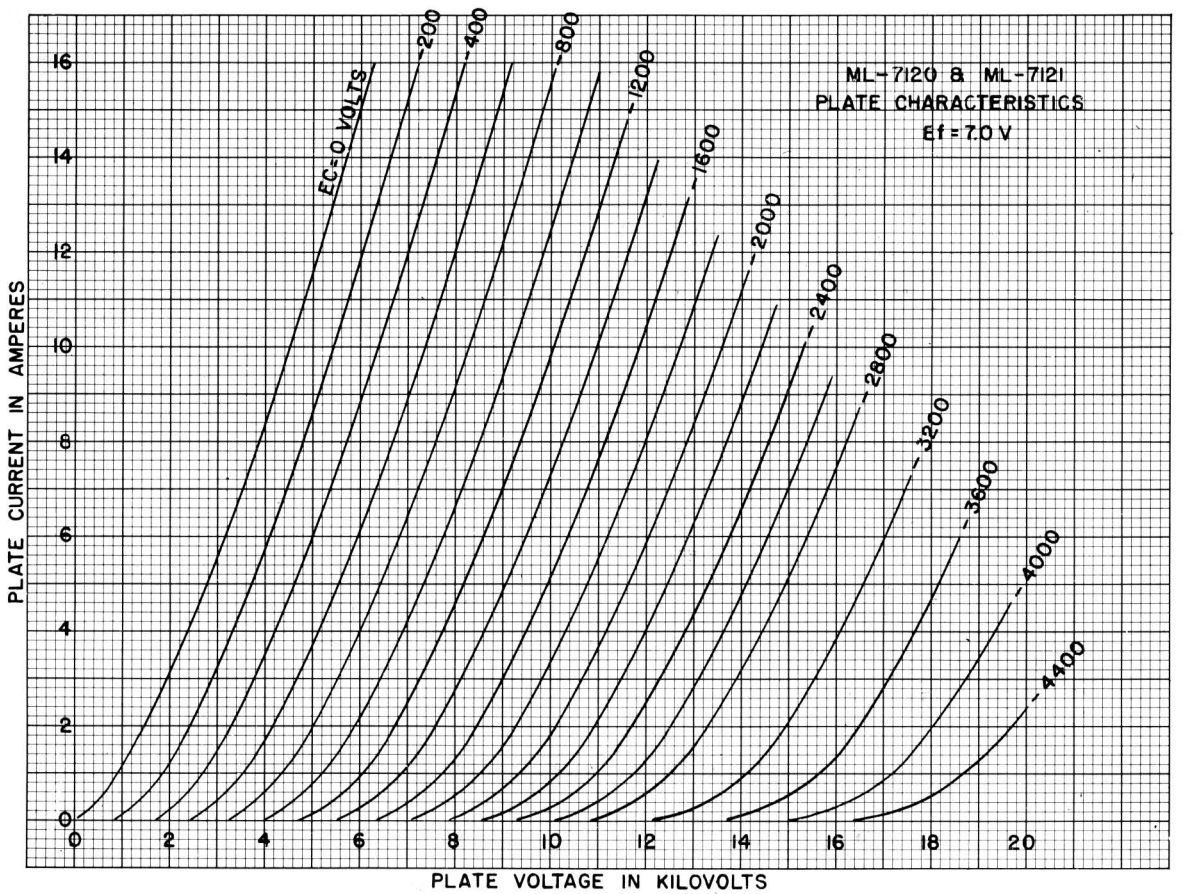
Characteristic	Conditions		Limits Minimum	Bogey	Maximum	
Plate Voltage	e_c = 0 volts; i_b = 15 amps	e_b:	——	6.0	6.4	kv
Plate Voltage	E_c = 0 Vdc; I_b = 1.0 Adc	E_b:	0.7	0.85	1.0	kVdc
Plate Voltage	E_c = −1000 Vdc; I_b = 1.0 Adc	E_b:	4.9	5.25	5.6	kVdc
Grid Voltage	E_b = 7.0 kVdc; I_b = 0.020 Adc	E_c:	−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

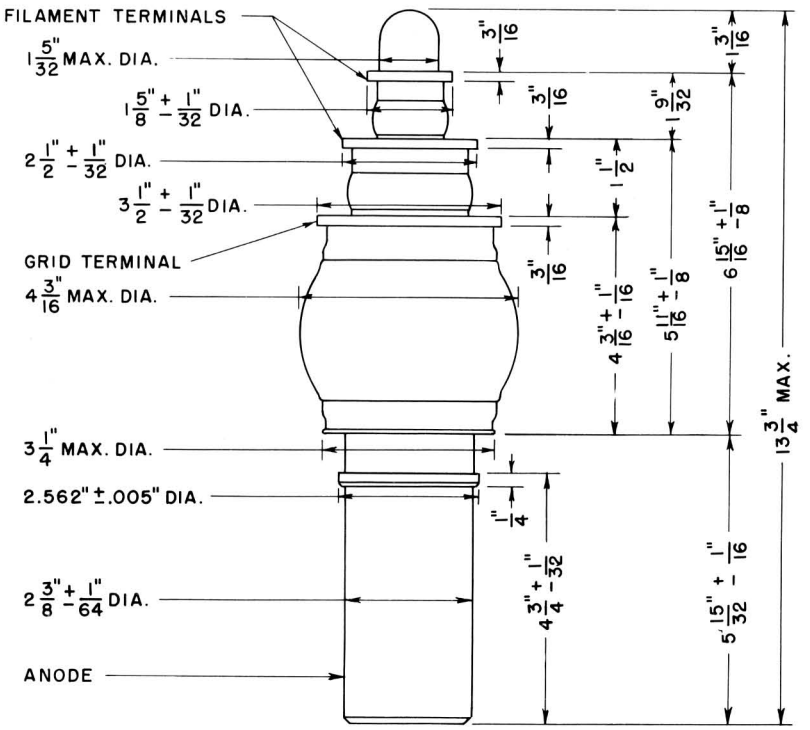
ML-7120



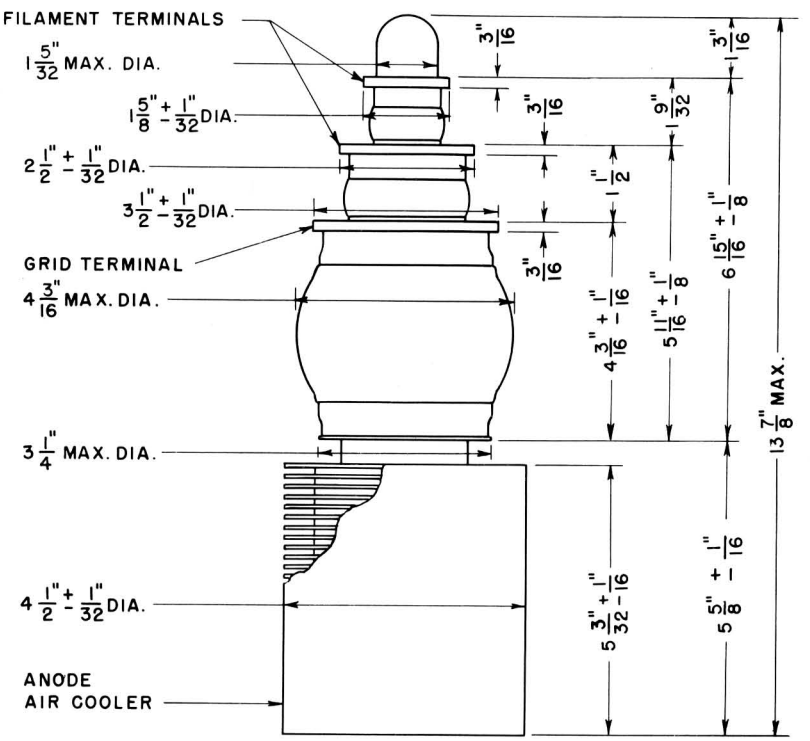
ML-7121







DIMENSIONS — ML-7120



DIMENSIONS — ML-7121

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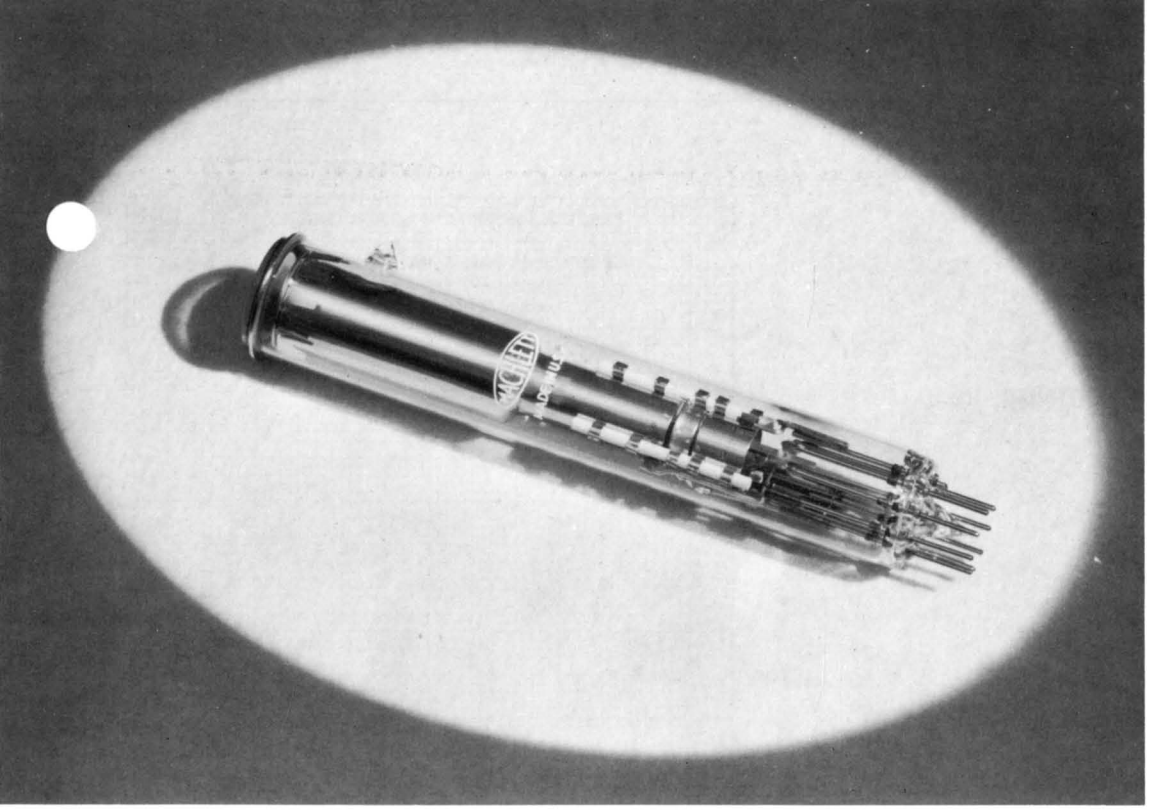


MACHLETT

ML-7291 VIDICON

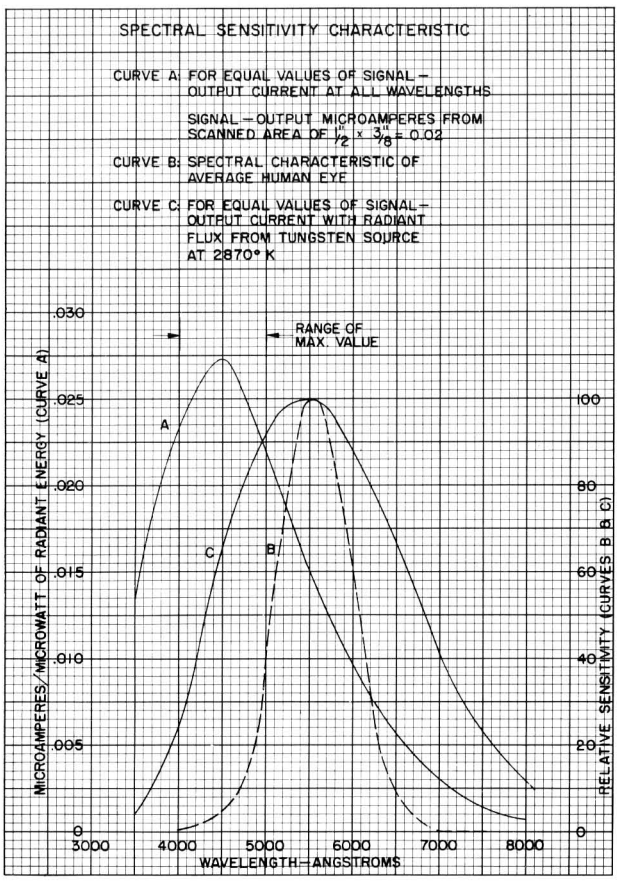
DESCRIPTION & RATINGS

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:	
Maximum Useful Diagonal of Rectangular Image (4×3 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
Operating Position	Approx. Horizontal or faceplate up



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

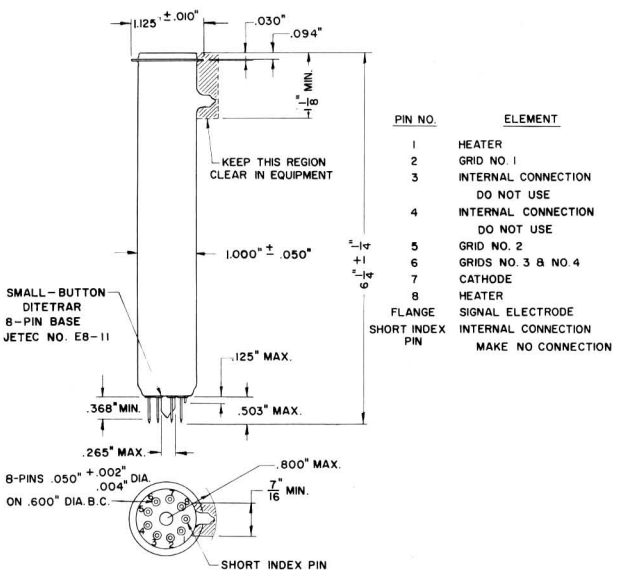
TYPICAL OPERATING CONDITIONS

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**

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ST-1552-5M-58

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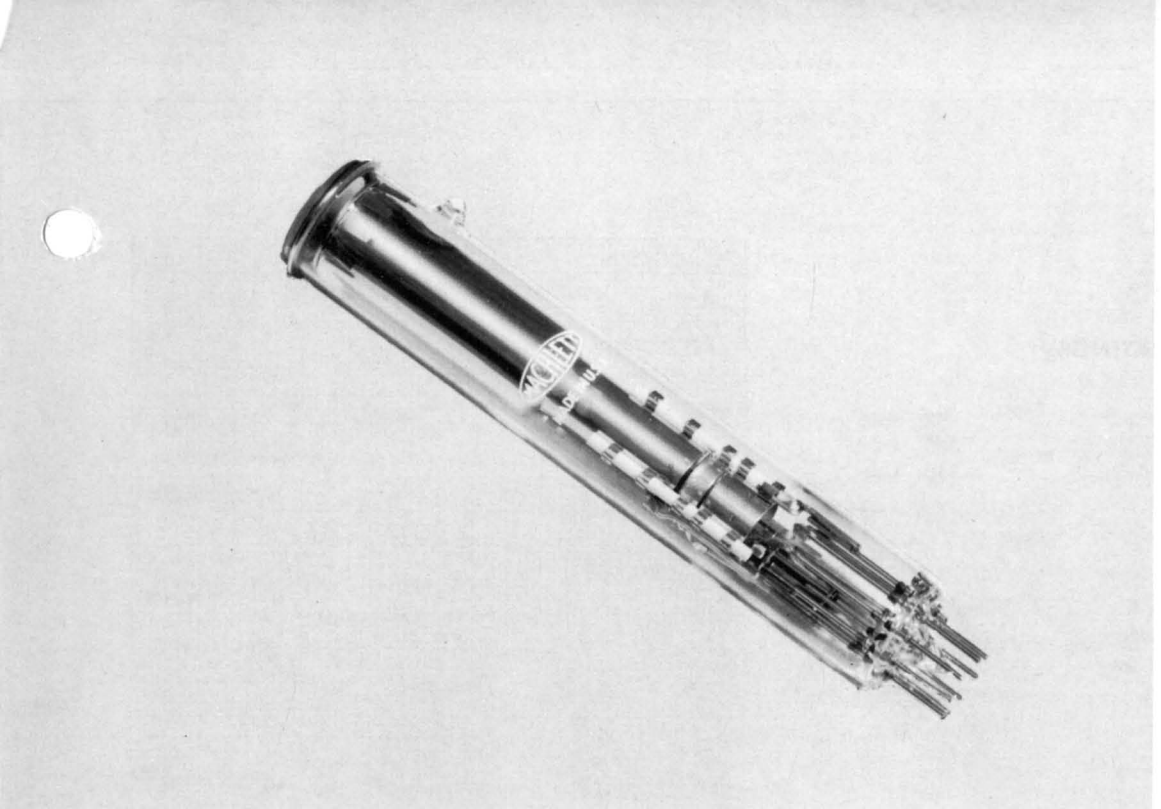


MACHLETT

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

MAXIMUM RATINGS

Maximum Ratings, Absolute Values		
Signal-Electrode Voltage	40	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:		
Illumination	100	ft-c

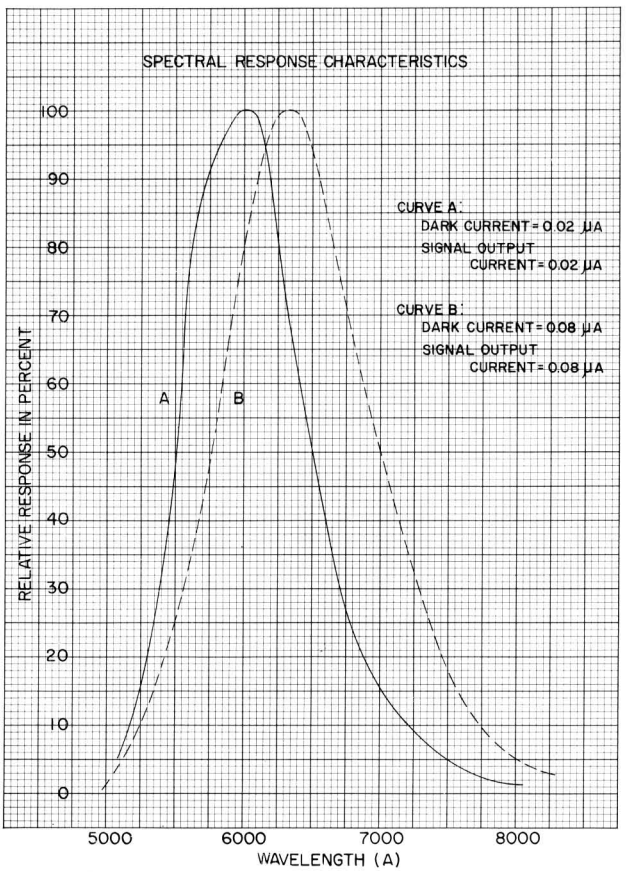
TYPICAL OPERATING CONDITIONS

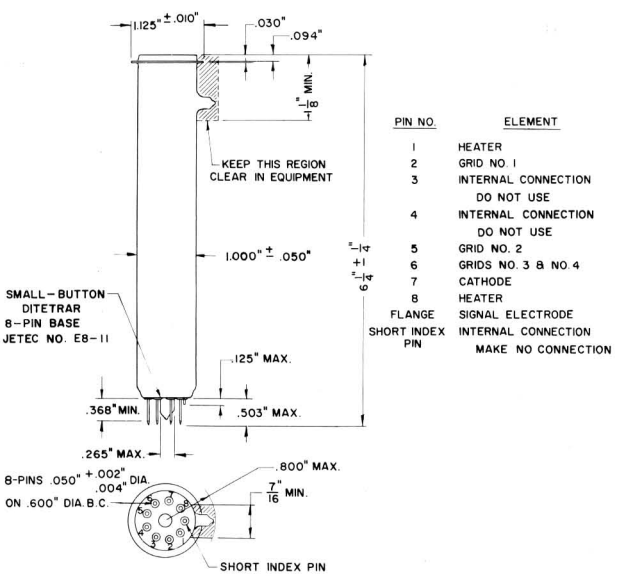
Typical Operation		
Faceplate Illumination (Highlight)	0.3 to 0.7	ft-c
Signal-Electrode Voltage	10 to 25	volts
Grid No. 4 (Decelerator) & Grid No. 3 (Beam Focus) Voltage	250† to 300	volts
Grid No. 2 (Accelerator) Voltage	300	volts
Grid No. 1 Voltage (For picture cutoff)‡	−45 to −100	volts
Highlight Signal-Output 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	gauss
Field Strength of Adjustable Alignment Coil	0 to 4	gauss

†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.



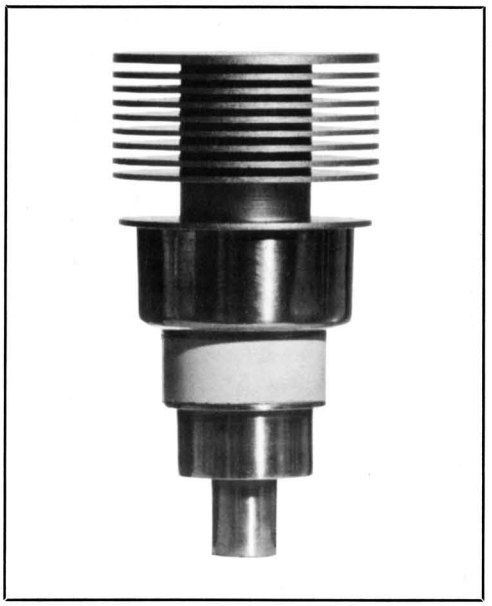


MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT **CONNECTICUT**

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

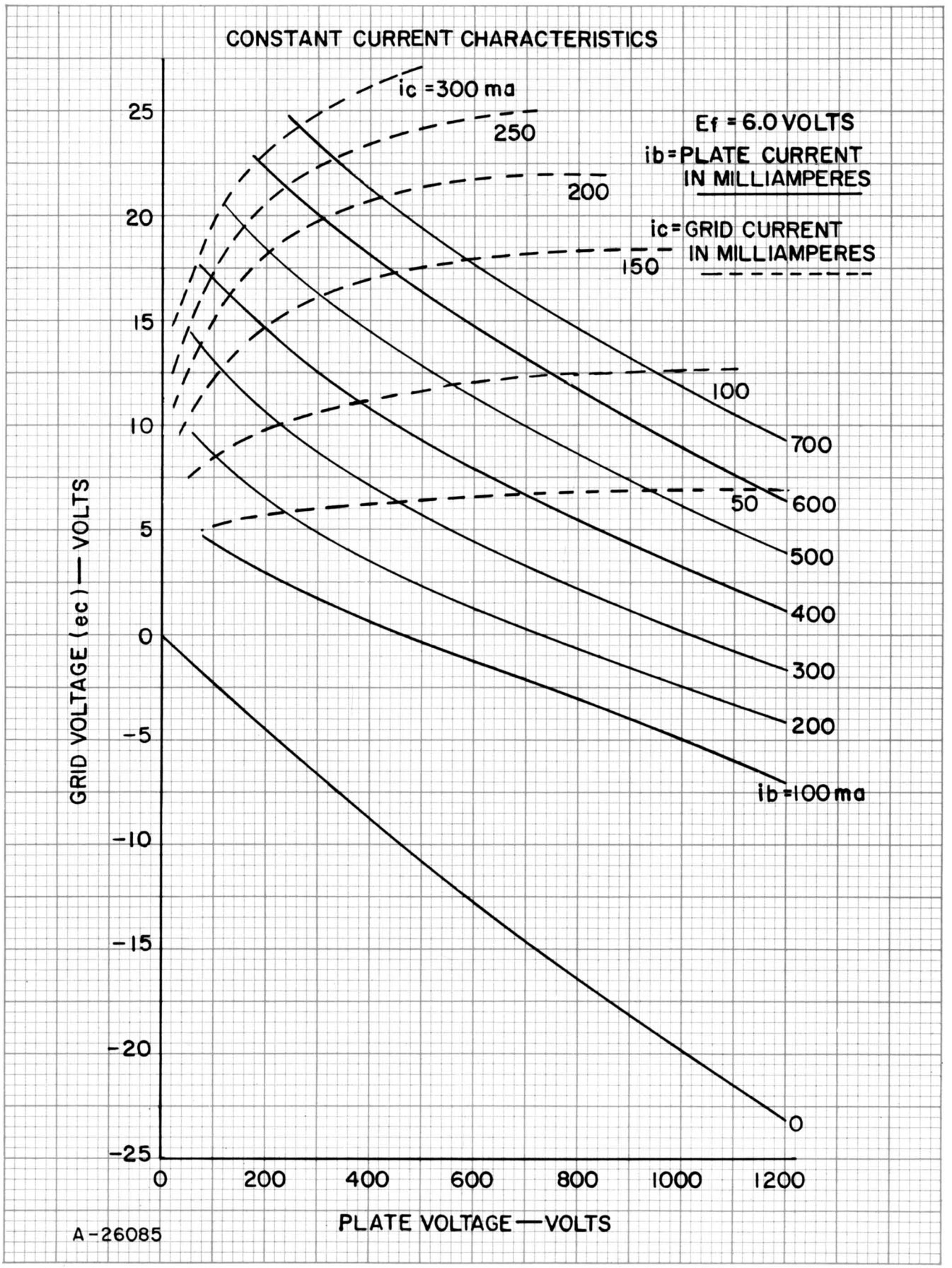
Maximum Ratings, Absolute Values		
DC Plate Voltage	2500	V
DC Grid Voltage	—150	V
Instantaneous Peak Grid-Cathode Voltage		
Grid negative to cathode	—750	v
Grid positive to cathode	250	v
Peak Plate Current from DC Supply	3	a
Average Plate Current	10	mA
Average Grid Current	5	mA
Average Plate Dissipation	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

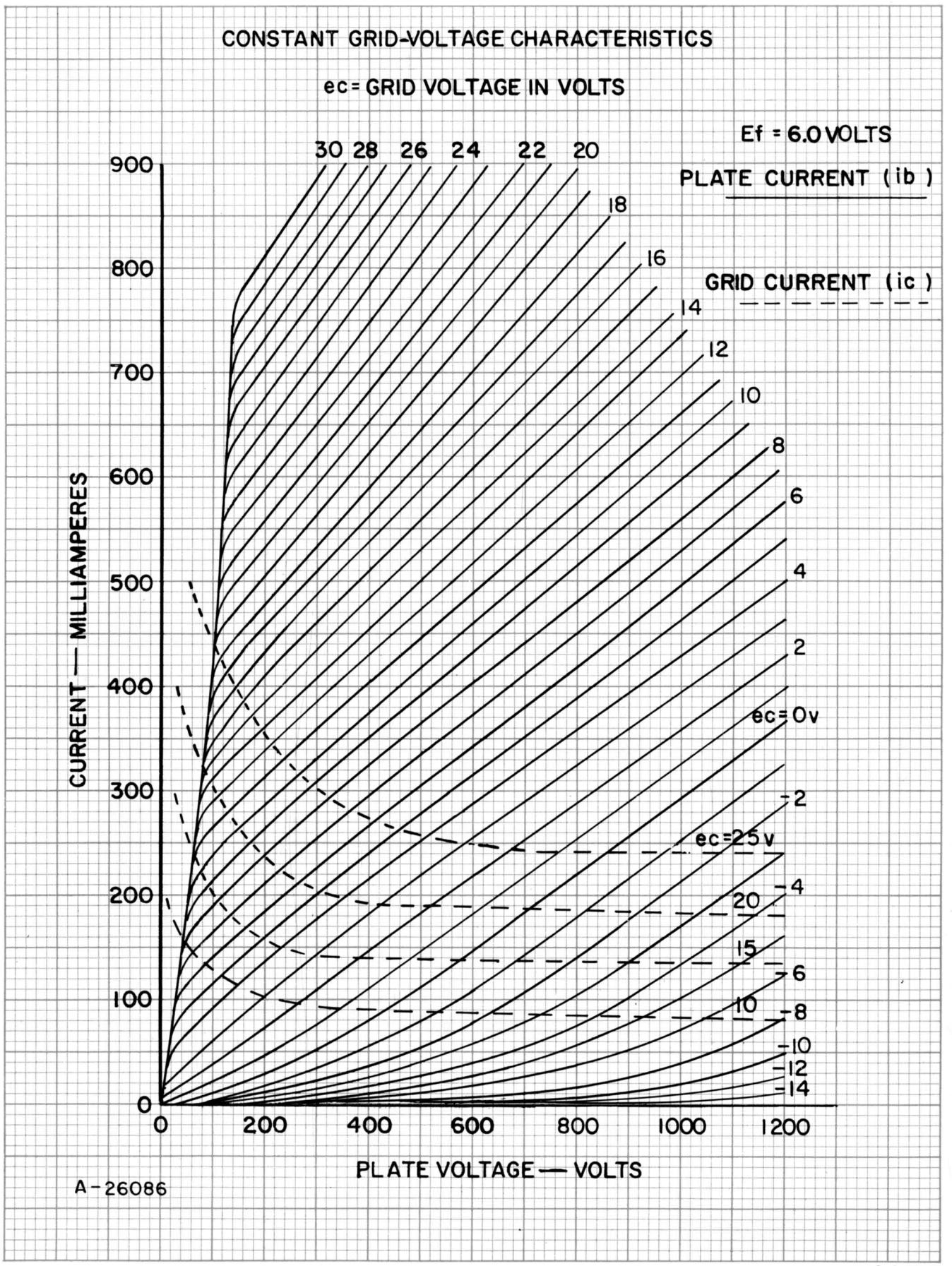
†Modulation essentially negative may be used if the positive peak of the envelope does not exceed 115% of the carrier conditions.

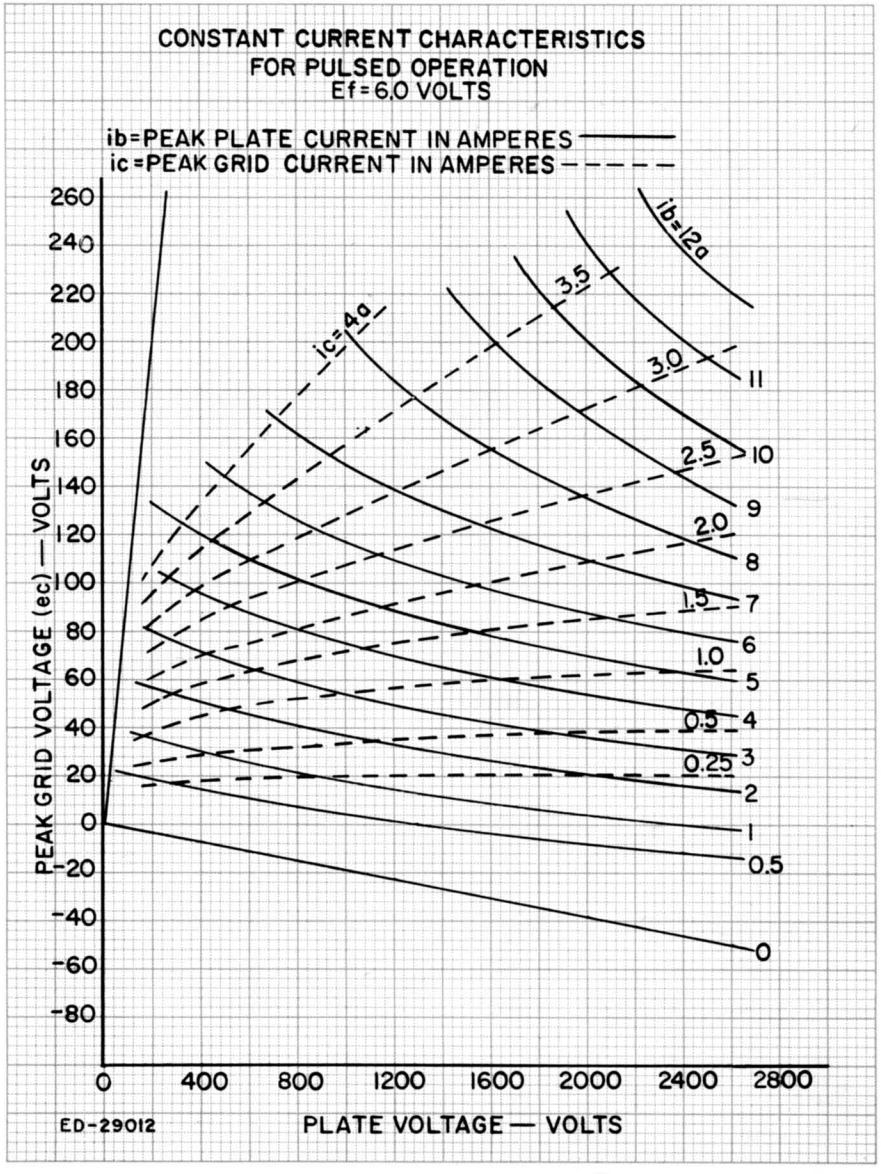
††For applications requiring longer pulse duration or higher duty factors, consult the Machlett Engineering Department.

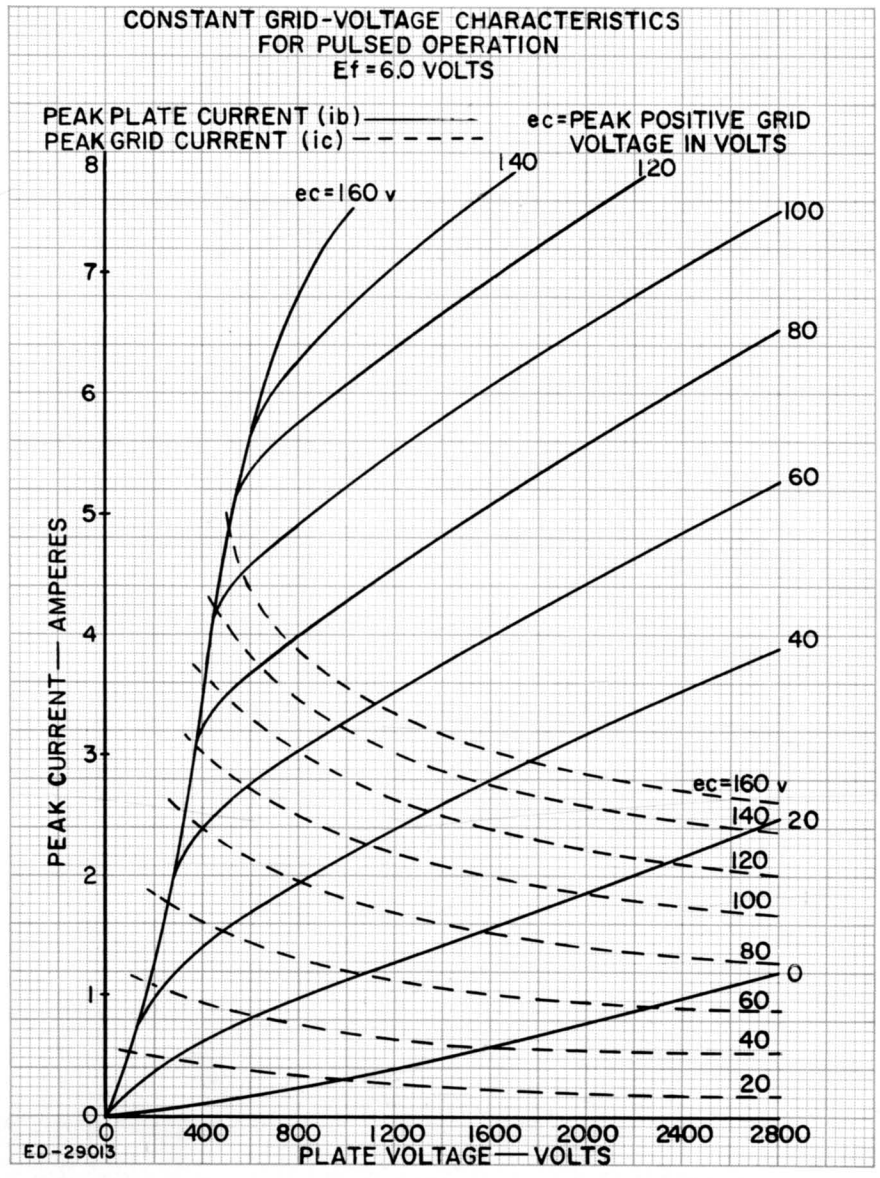
APPLICATION NOTES

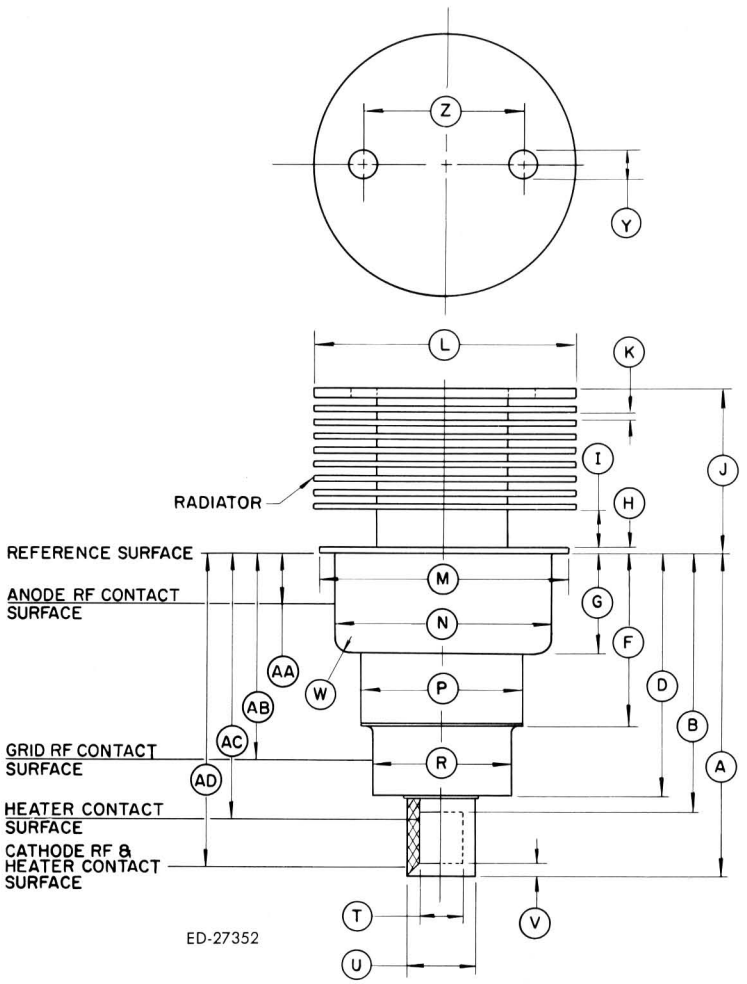
Before designing equipment for use with these tubes and before installing tubes in equipment, refer to the general information given in the Machlett publication entitled *Application Notes, UHF Tubes — General.*


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
GRID VOLTAGE (ec) — VOLTS
25
20
15
10
5
0
-5
-10
-15
-20
-25
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
A-26086


CONSTANT CURRENT CHARACTERISTICS
FOR PULSED OPERATION
Ef = 6.0 VOLTS
ib=PEAK PLATE CURRENT IN AMPERES
ic=PEAK GRID CURRENT IN AMPERES
PEAK GRID VOLTAGE (ec) — VOLTS
PLATE VOLTAGE — VOLTS
ED-29012
ib=12a
ic=4a
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.25
11
10
9
8
7
6
5
4
3
2
1
0.5
0


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
PEAK CURRENT — AMPERES
PLATE VOLTAGE — VOLTS
ED-29013
ec=160 v
140
120
100
80
60
40
20
0



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

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ST-1759 5M 6-65
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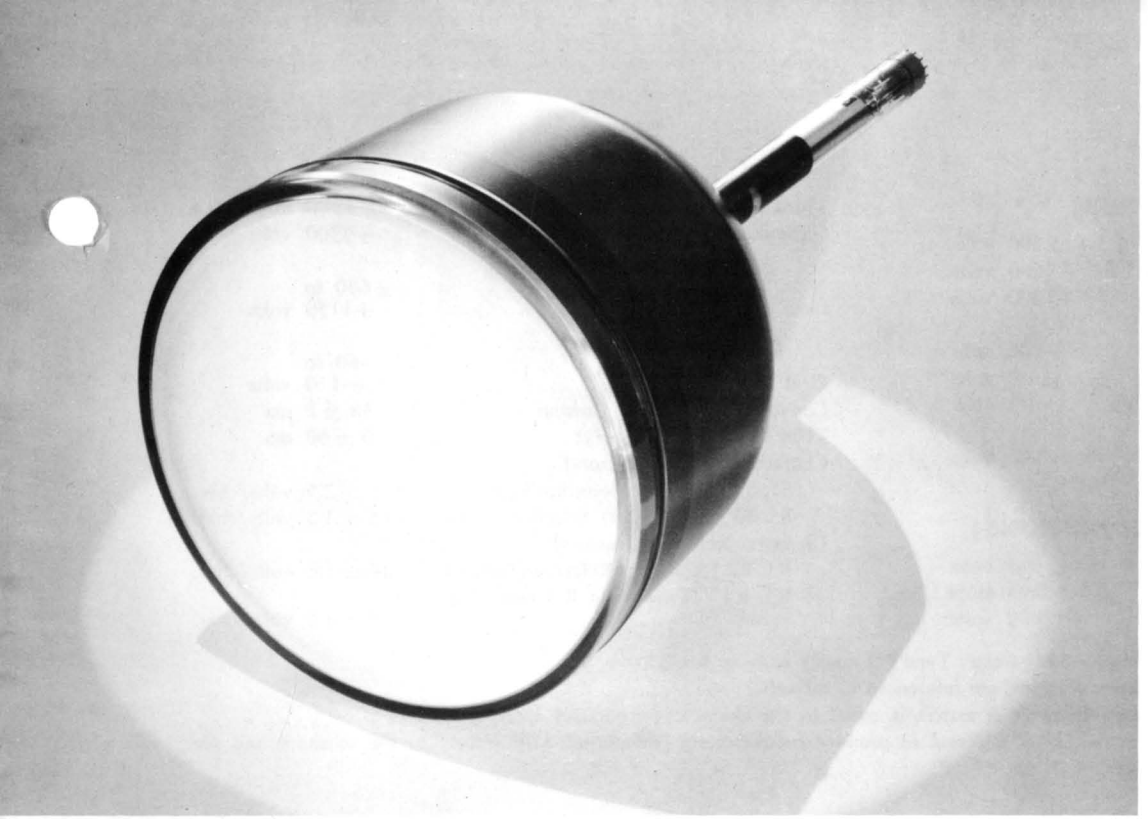


MACHLETT

ML-C19K SCRIPTRON® SHAPED BEAM TUBE

DESCRIPTIONS & RATINGS

DESCRIPTION:

The SCRIPTRON Shaped Beam Tube of the C19K type is a 19-inch round cathode-ray tube designed primarily for use as a large screen visual display device. It is capable of displaying alphanumeric and special characters in combination with analog data on the viewing screen of the tube at a speed greater than 20,000 characters per second, which is over five times faster than functionally similar mechanical devices now available. The tube is especially useful in applications where simultaneous identification of radar targets is desired, together with normal plan position indication.

The generation of characters with a beam having cross sections formed into shapes of predetermined characters provides excellent display quality and inherent letter component registry.

The SCRIPTRON Shaped Beam Tube requires the use of a deflection yoke, convergence coil, and mount assembly manufactured by Stromberg-Carlson, or their equivalent.

GENERAL CHARACTERISTICS

Electrical	
Selection Method	Electrostatic
Reference Method	Electrostatic
Deflection Method	Electromagnetic
Convergence Method	Electromagnetic
Optical	
Phosphor Number	P 14*
Fluorescent Color	Blue
Phosphorescent Color	Orange
Persistence	Medium Long
Faceplate	Round Clear
Mechanical	
Minimum Useful Screen Diameter	17 inches
Neck Length	$21\frac{11}{16}$ Inches
Display orientation**	By index mark
Matrix	64 character position Type FD
Height of displayed character†	0.115 ± 0.015 inch
Yoke	Stromberg-Carlson Type Y17-25C
Convergence Coil	Stromberg-Carlson Type C18-9C
Mount Assembly	Stromberg-Carlson Type S22A

*Other phosphors may be supplied upon request.

**Correct screen orientation is indicated by the index mark on periphery of tube panel which denotes the 12 o'clock position on the panel.

†These are typical values based on the use of a 64-character Type FD matrix with an 8 x 8 array.

MAXIMUM RATINGS‡

Third Anode Voltage	+15,000 volts
Second Anode & Matrix Voltage	+3600 volts
First Anode Voltage	+1300 volts
Grid Voltage	
Negative Bias Value	−200 volts
Positive Bias Value	0 volts
Positive Peak Value	+2 volts
Peak Voltage Between Second Anode and Matrix and any Selection or Reference Plate	500 volts

TYPICAL OPERATING CONDITIONS‡‡

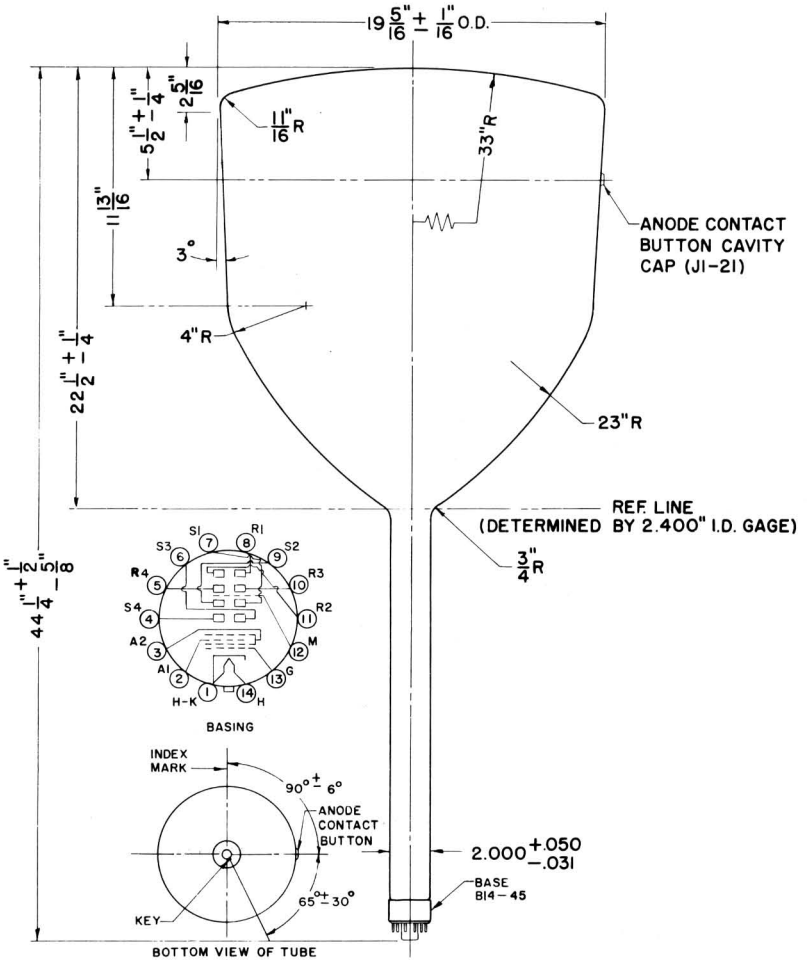
Heater Voltage	6.3 volts
Heater Current	0.6 ± 0.06 amps
Third Anode Voltage	+12000 volts
Third Anode Current (Max.)	300 microamps
Second Anode & Matrix Voltage	+3300 volts
First Anode Voltage††	+650 to +1150 volts
Grid Cutoff	−60 to −110 volts
Convergence-Winding Current	38 ± 2 ma
Trim-Winding Currents‡‡	0 ± 30 ma
Character-Selection Factors†	
S1, S2 (Vertical) Selection Factor	25.5 ± 2.5 volts/char.
S3, S4 (Horizontal) Selection Factor	14.5 ± 1.5 volts/char.
Character-Reference Factors†	
R1, R2 (Vertical) Reference Factor	16 ± 1.6 volts/char.
R3, R4 (Horizontal) Reference Factor	16 ± 1.6 volts/char.

†These are typical values based on the use of a 64-character Type FD matrix with an 8 x 8 array.

‡All voltages, except selection and reference voltages, are referenced to cathode.

††First anode voltage adjusted so that beam diameter at matrix is equal to the character-to-character spacing.

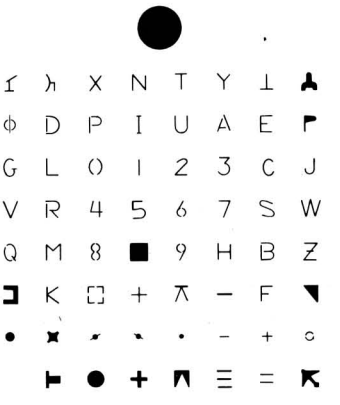
‡‡Currents in selection and reference trim windings adjusted to produce correct beam orientation with respect to the selection and reference plates.



BASING

PIN	ELEMENT
1	HEATER-CATHODE (H-K)
2	FIRST ANODE (A1)
3	SECOND ANODE (A2)
4	HORIZ. SEL. PLATE (S4)
5	HORIZ. REF. PLATE (R4)
6	HORIZ. SEL. PLATE (S3)
7	VERT. SEL. PLATE (S1)
8	VERT. REF. PLATE (R1)
9	VERT. SEL. PLATE (S2)
10	HORIZ. REF. PLATE (R3)
11	VERT. REF. PLATE (R2)
12	MATRIX (M)
13	CONTROL GRID (G)
14	HEATER (H)

MATRIX



MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT **CONNECTICUT**

U. S. A.

High-Voltage Industrial Rectifier Tubes

High-voltage power supplies used in particle precipitation, high-voltage cable testing, and various other industrial services employ any one of a large number of types of two-electrode, high-vacuum tubes for the rectification of alternating to unidirectional or direct current. Included among the electrostatic precipitation applications for such high-voltage industrial rectifier tubes are paint spraying and detearing, reclamation of valuable chemical and metallurgical materials in gases of industrial processes, purifying of exhaust and process atmospheres in various industries, and many others, which have proved to be practical, efficient, and economical.

Electron tubes designed for use in the rectifier circuits of these applications are capable of withstanding peak inverse voltages of 125 to 200 kilovolts and delivering 100 milliamperes to 10 amperes of peak anode current, depending upon the tube type. For such high inverse voltage ratings, tubes must be of the high-vacuum type, which can be made to insulate about 10 times the maximum operating voltage between electrodes as compared with vapor-filled types of similar sizes.

Machlett Laboratories provides for high-power industrial services a wide range of rectifier tube types, designed to be especially sturdy and to insure stable and reliable operation even under wide variations in ambient temperature and the inherently severe conditions of many industrial applications. Such important factors as the use of highest purity materials, special processing of internal parts, clean air-conditioned assembly rooms, and out-gassing at high plate voltages in final exhaust, which have made Machlett Electron Tubes known throughout the world for their superior quality, are incorporated in the production of Machlett high-voltage industrial rectifier tubes. Individual data sheets for each type of tube, which follow in this section of the catalog, set forth descriptive information, general electrical and mechanical characteristics, maximum ratings, dimensional data, and, in some cases, load current ratings. The purpose of this article is to develop an understanding of the basis for the various ratings and to present general instructions, and recommendations with respect to tube installation and operation. The headings below correspond with and follow, in general, those which appear on individual tube data sheets.

GENERAL CHARACTERISTICS

Most items listed under "General Characteristics" are self-explanatory and need little or no elaboration.

Cathodes

Cathodes in high-voltage industrial rectifier tubes are filamentary in design and are of two types, pure-tungsten, and thoriated-tungsten. The former has the advantages of being sturdier, is not readily poisoned as a result of tube overloading and gassiness, and can be operated at

reduced or increased voltage to obtain, respectively, longer life or greater emission. Thoriated-tungsten filaments have higher emission efficiency with consequent decrease in filament heating requirements.

The rated filament voltage for a pure-tungsten filament is that at which the user can get satisfactory service and long useful life, the design value at rated voltage being in the order of 3000 to 10000 hours, depending upon the tube type. Tubes may fail for reasons other than end of filament life, so that expected tube life may not in every case be achieved. Variation from rated voltage has a direct bearing on tube life, and on tube voltage drop and consequent plate dissipation; this is discussed further under "Operation". In the case of a thoriated-tungsten filament, the rated voltage is that required for proper filament operating temperature and must be maintained as closely as possible for satisfactory service and long useful life. Design life values for thoriated-tungsten filaments are less susceptible to accurate calculation, but 4000 to 8000 hours operation may be expected, with some thoriated-tungsten filament tubes providing greater than 10000 hours of service.

Data sheets in most cases specify a minimum filament heating time before the application of anode voltage. The filament heating time specified is sufficient to bring the filament to operating temperature to assure adequate emission for the required plate current and minimum volt age drop.

MAXIMUM RATINGS

Maximum ratings for rectifier tube operation are the safe limits, based on test data and general experience, under which the user can get reliable performance and economical life. Tubes are tested under conditions more severe than at established ratings to assure satisfactory life and service for all tubes of the type concerned.

Peak Inverse Voltage Rating

The peak inverse voltage rating is the highest instantaneous voltage which may be safely impressed between the electrodes of the tube during the inverse or non-conducting half cycle of the applied a.c. supply voltage. It depends upon a number of considerations, including tube geometry and voltage gradients within and outside the tube. 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. Rectifier tubes designed for oil-immersed operation cannot be used in air satisfactorily except at voltages sufficiently reduced to avoid flash-over. Some common types of rectifier circuits, with a tabulation of inverse, r.m.s., and average voltage relationships, are presented in a later section on "Circuit Conditions".

Peak Plate Current Rating

The primary limitation on the peak plate current which may be provided by a rectifier tube is the amount of emission available from the filament operating at a voltage consistent with long, serviceable life. The load impedance of the rectifier circuit must be such as to limit the peak plate current to the maximum value specified. The maximum peak current permissible must be such that the tube is operated well below the knee of the Ep-Ip curve corresponding to the filament setting chosen. If this caution were not observed, normal variations

of line voltage, differences between individual tubes and changes in tube characteristics with age would allow the tube to operate beyond the knee of the curve, greatly increasing the tube voltage drop and power to be dissipated by the anode.

The peak plate currents permissible with various reduced values of filament voltage are listed in the table of Load Current Ratings, and are also indicated on the Plate Current Characteristics curve, given in the data sheets on pure-tungsten filament tube types. The actual value of average plate current obtainable with a given circuit, within a 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. A tabulation of the relationships of peak tube to average load current for choke input filters and resistive loads is included with the diagrams of rectifier circuits set forth in a following section on "Circuit Conditions".

Plate Dissipation Rating

Plate dissipation ratings as specified on tube data sheets indicate the average power which can be dissipated by the anode at its maximum safe temperature. The instantaneous plate power is the product of the plate current and voltage drop at any instant, and the average power is the average of these instantaneous values integrated on a continuous basis. Hence, the plate dissipation requirement in any given case depends on both the tube characteristics and the current wave-form through the tube, as determined by the kind of circuit and load.

The tube data sheet usually gives a curve of plate current *vs.* voltage drop. This curve can be utilized, if the current wave form through the tube is known, to calculate the average plate power to be dissipated by means of a graphical procedure as illustrated in Figure 1. This method is applicable to any complex wave-form, whether obtained by mathematical analysis of the circuit or by means of an oscillograph; it consists of noting the instantaneous current values at a number of points throughout a complete cycle on the time axis, ascertaining the corresponding values of plate voltage from the characteristic curve, multiplying these current and voltage values together to obtain the corresponding values of instantaneous plate power, plotting them on the same time base, and finally measuring the area under the power curve and averaging it over the complete cycle.

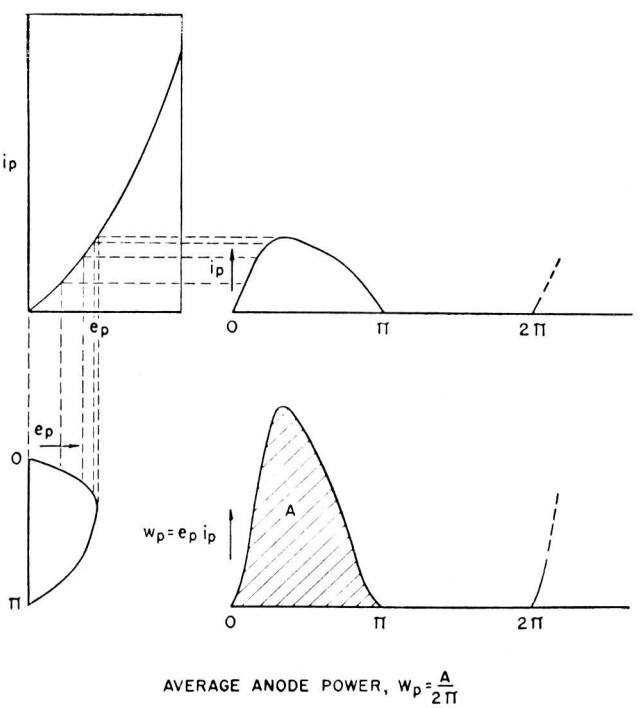


Figure 1

Frequently, the current wave is of such a form that a simple arithmetical computation is sufficient to calculate the plate dissipation requirement. If the output of the rectifier unit is filtered by an inductance input filter, the current through each tube is in the form of an approximately square wave having a duration of one-half cycle in the case of single-phase supply and one-third cycle with three-phase. The average plate power in such a case is the product of the peak current and the corresponding plate voltage drop, divided by 2 (for single-phase) or 3 (for three-phase) as the case may be. If the current through each tube has the form of a half sine-wave, as in the case of a single-phase rectifier unit feeding a pure resistance load, the average plate power can be shown to be equal to $\frac{.27}{k^{2/3}} I_{peak}^{5/3}$, where I_{peak} is the peak value of the current wave and k is the constant in the equation of the current *vs.* voltage characteristic curve of the tube, having the form $i_p = ke_p^{3/2}$.

Load Current Ratings

The tables of load current ratings usually given in the tube data sheets are for the convenience of circuit and application engineers, enabling them to ascertain readily the maximum load current that may be drawn from any of the more common types of rectifier circuits, equipped with the type of tube in question. The load current values given represent *average* current, as read with a d.c. meter, delivered to the load, not the average current per tube.

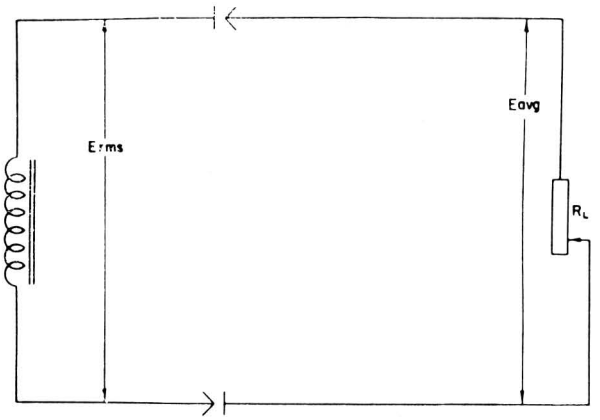
These values represent the maximum load currents which can be supplied under the stated conditions without exceeding either the peak anode current or plate dissipation limits. In some cases, values for reduced filament voltages are also given, for guidance in utilizing the possibilities of increased filament life when load requirements permit, as discussed in greater detail below under "Operation".

Two sets of values are given; one is for the condition where no filtering is employed and the load is a pure resistance, and the other is for the condition where a filter with choke input (commonly designated as "infinite inductance input") is employed. For other conditions, such as capacitive loads, condenser input filters, or other complex wave-form conditions, it is necessary to analyze the situation for compliance with peak current and plate dissipation limits as discussed above.

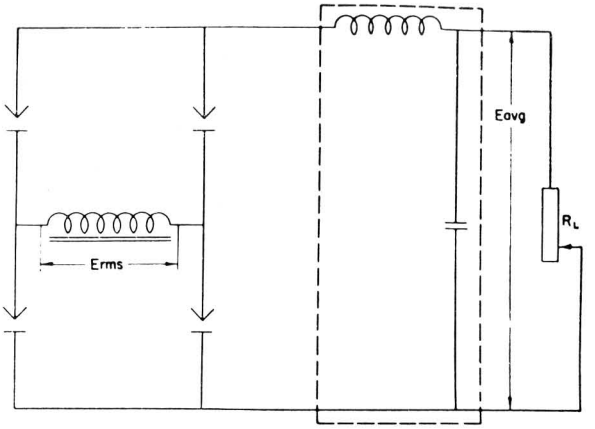
Circuit Conditions

Rectifier tubes may be used in a number of different circuit arrangements and for various applications. The peak plate current and peak inverse voltage requirements imposed on rectifier tubes for any particular values of average output voltage and current which may be desired in the load are quite different in some of these circuits as compared with others and must be determined to assure proper tube selection and safe operation. Rectifier circuit arrangements commonly employed in industrial applications are shown schematically by the diagrams on page 5. The accompanying tabulation gives peak inverse voltage relationships in terms of circuit output and transformer secondary voltages, and peak tube current relationships in terms of circuit output currents. The values presented are for square and sine wave-forms, such as would be obtained with an infinite inductance filter and a purely resistive load, respectively, and neglect voltage drops through the tubes in a forward direction. Capacitive input filters and other types of loads will result in voltage and current wave-forms which may have peaked or shal-

Rectifier Circuits For Industrial Applications



SINGLE-PHASE, TWO-TUBE, HALF-WAVE

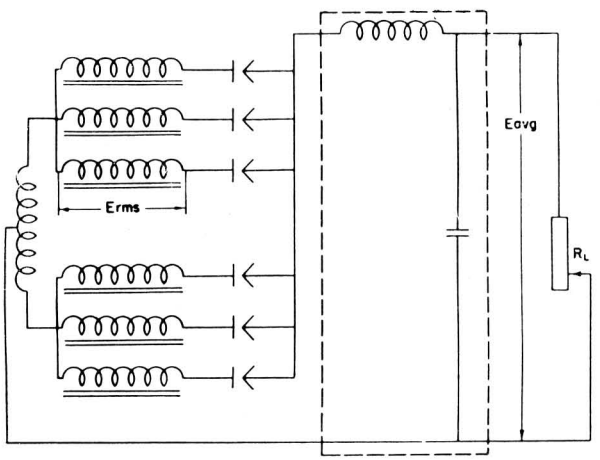


SINGLE-PHASE, FOUR-TUBE, FULL-WAVE

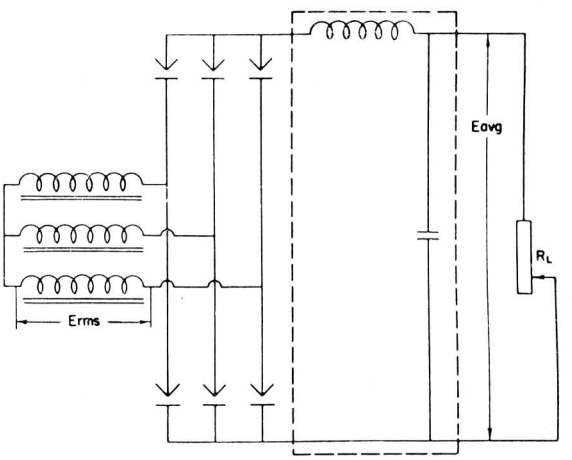
VOLTAGE AND CURRENT RELATIONSHIPS

	Peak Inverse Voltage	Peak Plate Current
RESISTIVE LOAD *	1.57 Eavg, 0.71 Erms	3.14 Iavg

	Peak Inverse Voltage	Peak Plate Current
CHOKE INPUT FILTER**	1.57 Eavg, 1.41 Erms	1.0 Iavg
RESISTIVE LOAD *	1.57 Eavg, 1.41 Erms	1.57 Iavg



THREE-PHASE, DOUBLE-Y PARALLEL



THREE-PHASE, FULL-WAVE

VOLTAGE AND CURRENT RELATIONSHIPS

	Peak Inverse Voltage	Peak Plate Current
CHOKE INPUT FILTER**	2.42 Eavg, 2.83 Erms	0.5 Iavg
RESISTIVE LOAD *	2.09 Eavg, 2.45 Erms	0.52 Iavg

	Peak Inverse Voltage	Peak Plate Current
CHOKE INPUT FILTER**	1.05 Eavg, 2.45 Erms	1.0 Iavg
RESISTIVE LOAD *	1.05 Eavg, 2.45 Erms	1.05 Iavg

* FACTORS ARE BASED ON SINE-WAVE VOLTAGE INPUT, RESISTANCE LOAD WITHOUT INDUCTIVE OR CAPACITIVE EFFECTS, AND NO RECTIFIER LOSSES.

** FACTORS ARE BASED ON SINE-WAVE VOLTAGE INPUT, INFINITE INDUCTANCE CHOKE INPUT FILTER, AND NO RECTIFIER LOSSES.

Eavg: AVERAGE OUTPUT VOLTAGE OF FILTER OR CIRCUIT.

Erms: TRANSFORMER SECONDARY VOLTAGE (RMS), PHASE TO PHASE OR PER LEG.

Iavg: AVERAGE OUTPUT CURRENT OF FILTER OR CIRCUIT.

low crests, so that the relationships presented are not valid but will have to be determined for each individual application.

As an example, consider the requirement of supplying an average voltage of 90 KV and an average current flow of 1.5 Adc to a resistive load. Using four type ML-5576/200 tubes in a single-phase full-wave circuit, unfiltered, the peak current would be 1.57 x 1.5 amperes, or 2.34 amperes, and the peak inverse voltage would be 1.57 x 90 KV, or 141 KV peak. These are within the maximum ratings as quoted for the ML-5576/200. A calculation for the average power dissipated in each tube anode on the basis of space charge limiting, sine wave of voltage and current, gives 560 watts per tube, still well within the 1000 watts rated maximum.

Voltage and current requirements for tubes in other types of systems can be determined as in the foregoing from the corresponding factors presented in the above tabulation. In the case of filters or loads which are neither infinite-inductive nor pure-resistive, the wave-forms and relationships must be ascertained and applied for each installation. A more complete discussion of rectifier circuits with inductive and capacitive systems is available in F. E. Terman's *Radio Engineer's Handbook,* pp. 589-612.

INSTALLATION

Rectifier tubes should be handled with reasonable care and without shock to avoid possible breakage of the filament, other internal parts, glass to metal seals, and tube envelope. Upon receipt, tubes should be inspected and then tested in the equipments in which they are to be used, to insure that tubes which may have been damaged in shipment are not carried in stock as useable spares.

Before mounting a tube in its socket, reference should be made to the appropriate data sheet to determine permissible mounting positions. For most high vacuum type rectifier tubes the mounting position is optional. The sockets or electrical connections must not impart stresses to the glass envelope; however, the contacts and leads should have minimum resistance and sufficient current carrying capacity to preclude excessive I^2R losses and temperatures. Precautions should also be taken that there is sufficient clearance between connector leads and bulb of the tube so that there is no possibility of corona discharge or sparkover which may result in puncture of the glass.

In order to monitor tube service, provisions should be made for determining filament voltage and load d.c. voltage and current. The filament transformer should be of the high reactance type to impede the flow of inrush current when voltage is first applied to the filament. The equipment should also include an overload relay for both equipment and tube protection in case of excessive load current and corresponding excessive peak tube current. In the case of particle precipitation equipment, in which frequent sparking is apt to occur, it is recommended that a resistor be included in the primary circuit of the high-voltage transformer to reduce the input voltage during current surges for the protection of rectifier tubes and transformer. Interlock devices for the safety of operating personnel are also recommended. Harmful x-radiation may be generated as a result of operation at high voltages; adequate protection of personnel should be provided in such cases in accordance with the "Safety Code for the Industrial Use of X-rays", published by the American Standards Association.

Cooling of high-vacuum type rectifier tube anodes is generally by radiation through the glass envelopes, the latter being cooled by convection air or oil. In some cases, forced circulation of air may be required, as indicated by the individual data sheets. Free circulation of air or oil, as the case may be, should be maintained to prevent localized overheating. Oil should be kept free from impurities, such as moisture or dirt, and its dielectric quality must be at least 25,000 volts peak per 0.1 inch.

OPERATION

When a new tube has been installed in the rectifier equipment for the first time, it should be operated at rated filament voltage but without plate voltage for a minimum period of 30 seconds, or as long as necessary to insure that the filament is at operating temperature. The equipment may then be operated with relatively low peak inverse voltage on the plate of the tube, in the order of one-half maximum rating. After approximately 15 minutes of operation during which the plate input power is gradually increased, load conditions within maximum tube ratings may be assumed continuously. High-vacuum type tubes in which the vacuum has been impaired as a result of overload conditions, causing instability of operation at high voltage, can be electrically cleaned up, in many cases, by operation at one-half rated peak inverse voltage and peak plate current for approximately a one-half hour period. Plate voltage and current should then be increased in two or three steps for short periods and the tube operated at normal operating conditions for one hour or as long as is necessary to insure stable operation.

Due to the fact that a pure-tungsten filament of a rectifier tube need only provide electron emission adequate for the peak value of plate current required by the load, filament voltage and temperature may be reduced when the tube is operated at relatively low current. Since the life of a pure-tungsten filament is increased by its operation at reduced voltage, appreciable tube economy will result from operation at a filament voltage no greater than that necessary to produce the required emission. Life expectancy is nearly doubled when the filament is operated at 5% less than rated voltage and quadrupled when the filament voltage is decreased 10%. On the other hand, if the filament is operated with an overvoltage of 5%, the evaporation rate of the tungsten is doubled, and it can be expected that the life of the filament will be one-half its design value. Normal line voltage fluctuations, however, will

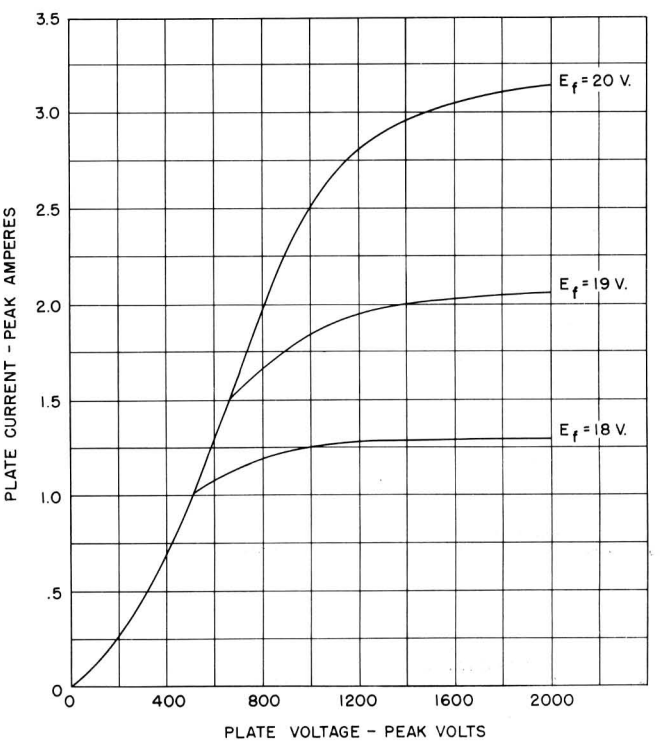


Plate Current Characteristics for Type ML-5576/200 Rectifier Tube

in most cases vary the operating filament voltage. The average value of the filament voltage should be so set that the minimum value occurring when the line voltage fluctuates is the voltage necessary to produce the required emission with safety.

Proper filament voltage settings for a pure-tungsten filament type of high-vacuum rectifier are determined by the peak plate current requirements of the circuit and service. The filament emission must be adequate to provide the desired current flow without permitting departure from the space-charge region of the plate current characteristic. Assume that it is desired to determine the filament voltage setting required for ML-5576/200 high-voltage industrial rectifier tubes in a three-phase full-wave circuit providing 2.0 Adc output current. If the load is such that the current wave-form through each tube is square, as with a choke-input filter or inductive load with infinite inductance, the current requirement per tube is 2.0 amperes peak. The proper filament voltage setting for this value of peak plate current would be 19.5 volts, and the tube voltage drop would be approximately 800 volts, as indicated by the plate current characteristics for the ML-5576/200 tube. Since the current wave-form is assumed to be square, the average plate dissipation would be 1/3 x 2.0 amperes x 800 volts = 533 watts. For other waveforms with the same load current, the plate dissipation would be a value somewhat greater, being the average of the instantaneous wattages for the complete alternating current cycle. The average anode power can be calculated from the e_p-i_p curve as discussed above, provided the waveform and average or peak current through the tube are known.

Since the source of emission in a thoriated-tungsten filament is a layer of thorium on the filament surface, the evaporated thorium being constantly replenished from within the filament wire, the operating temperature of the thoriated-tungsten must be kept within narrow limits. For maximum efficiency and life, the filament temperature must be such as to obtain an equilibrium between evaporation of thorium from the wire surface and diffusion of thorium to the surface from within the wire, and to maintain this condition, the operating voltage should not vary more than ± 5% from rated filament voltage. If a tube with such a filament has been overloaded, with resultant overheating, any gas liberated may contaminate the filament and reduce its emissivity. Prior to attempting electrical cleanup of the tube, it may be possible to restore the activity of the filament by operating it at 70% above normal operating voltage for five minutes and then at 20% over-voltage for 15 minutes without plate voltage. It may be necessary to vary somewhat and repeat this procedure to obtain the required activation. Electrical cleanup of the tube may then be attempted, with operation at one-half rated plate voltage and power for a half hour and further operation at increased plate voltage and power until stability under normal operating conditions is assured.

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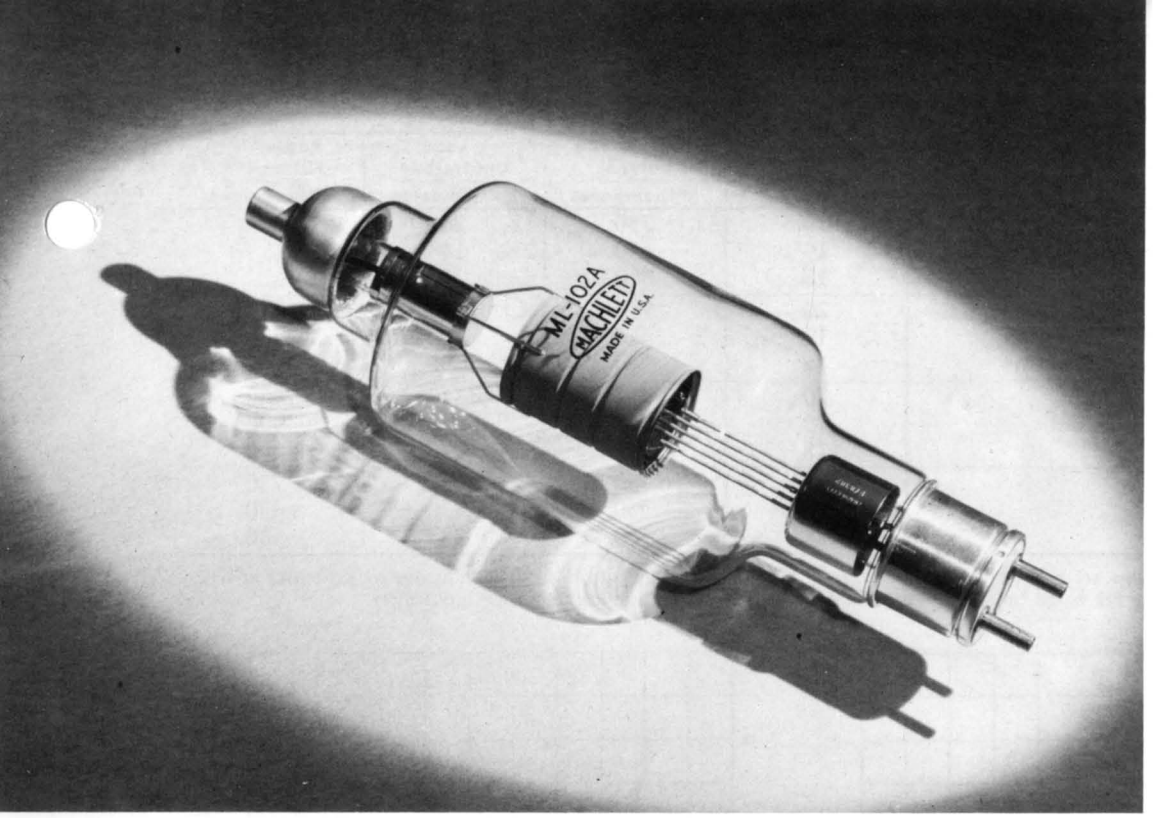


MACHLETT

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

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.

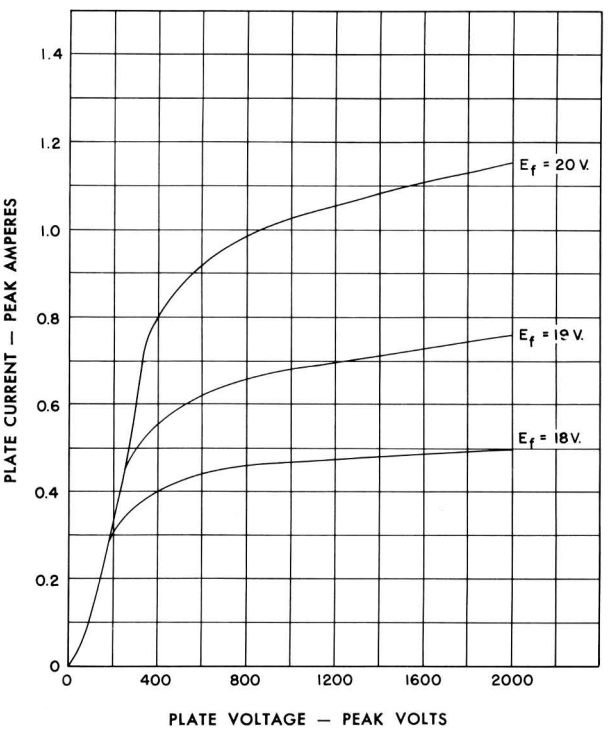
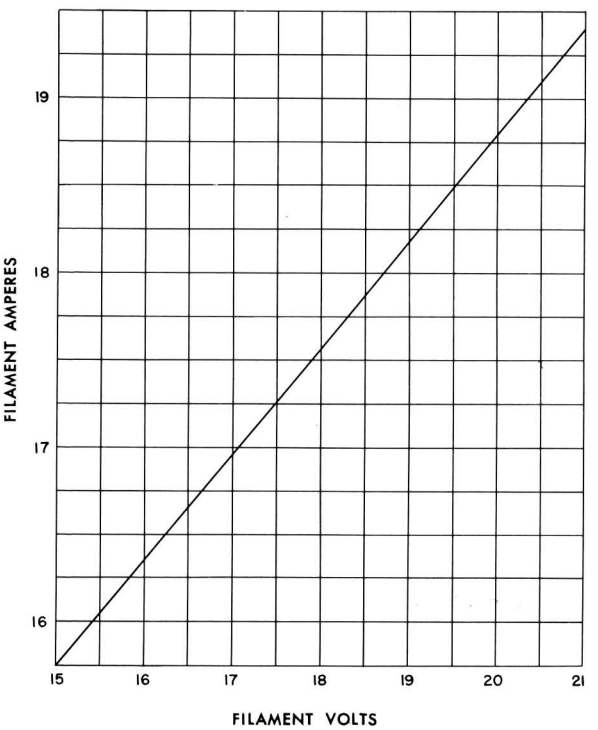
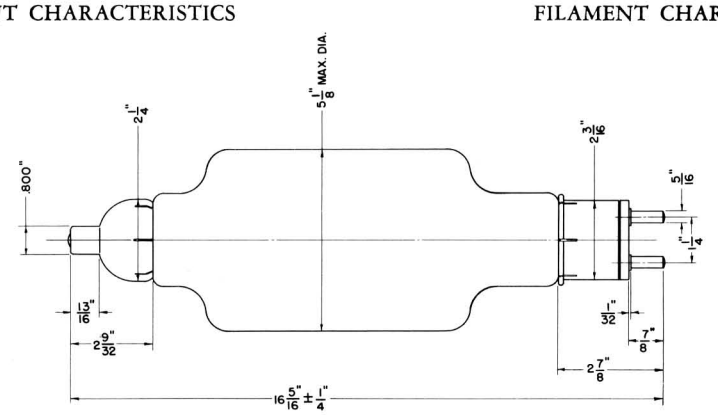


PLATE CURRENT CHARACTERISTICS



FILAMENT CHARACTERISTICS



DIMENSIONS—ML-102A

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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

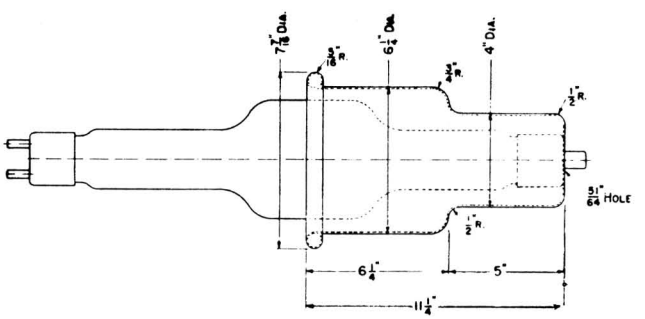
The life of tubes should be conserved as much as possible by turning on their filaments only just before the rectified power is to be used and turning them off immediately afterward. Also, when lower than rated load current values are employed, the filament voltage may be reduced somewhat, as indicated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

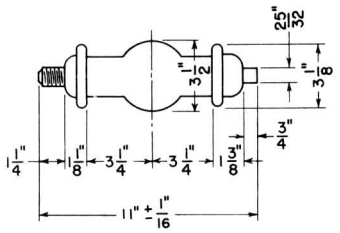
The load impedance of the rectifier circuit must be such as to limit the peak plate current to the maximum value specified. The actual value of average plate current obtainable within the peak tube current rating depends upon the current wave-form, which in turn is determined by the type of load impedance, 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.

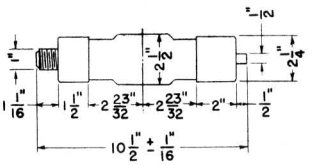
When the ML-180 is installed in an oil-filled container of minimum size and is to be subjected to inverse voltage in the order of 200 PKV, the anode end should be fitted with an external metallic shield, electrically connected to the anode terminal, to avoid the possibility of damage due to cold emission 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



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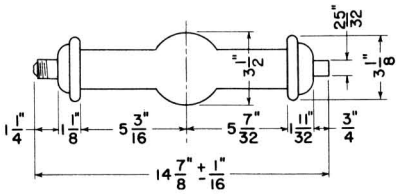
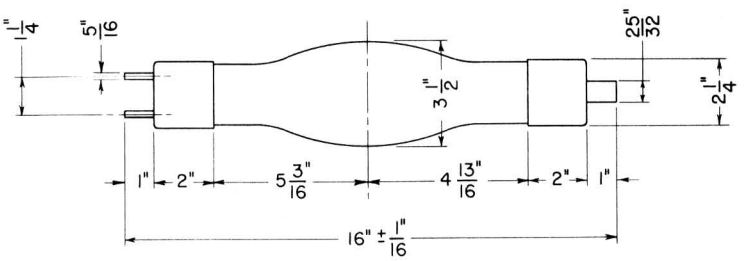


ML-108



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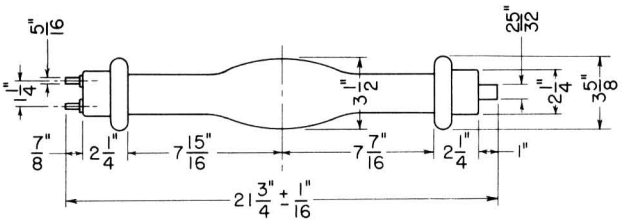

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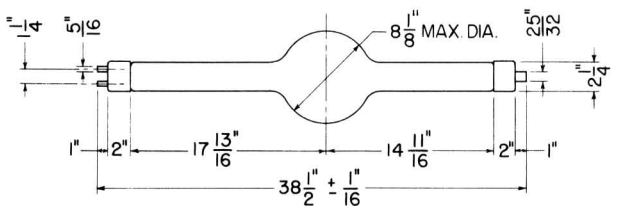
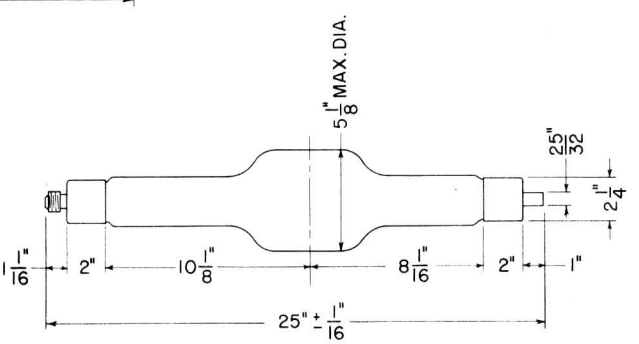


ML-170



ML-180

DIMENSIONS—HIGH-VOLTAGE INDUSTRIAL RECTIFIER TUBES

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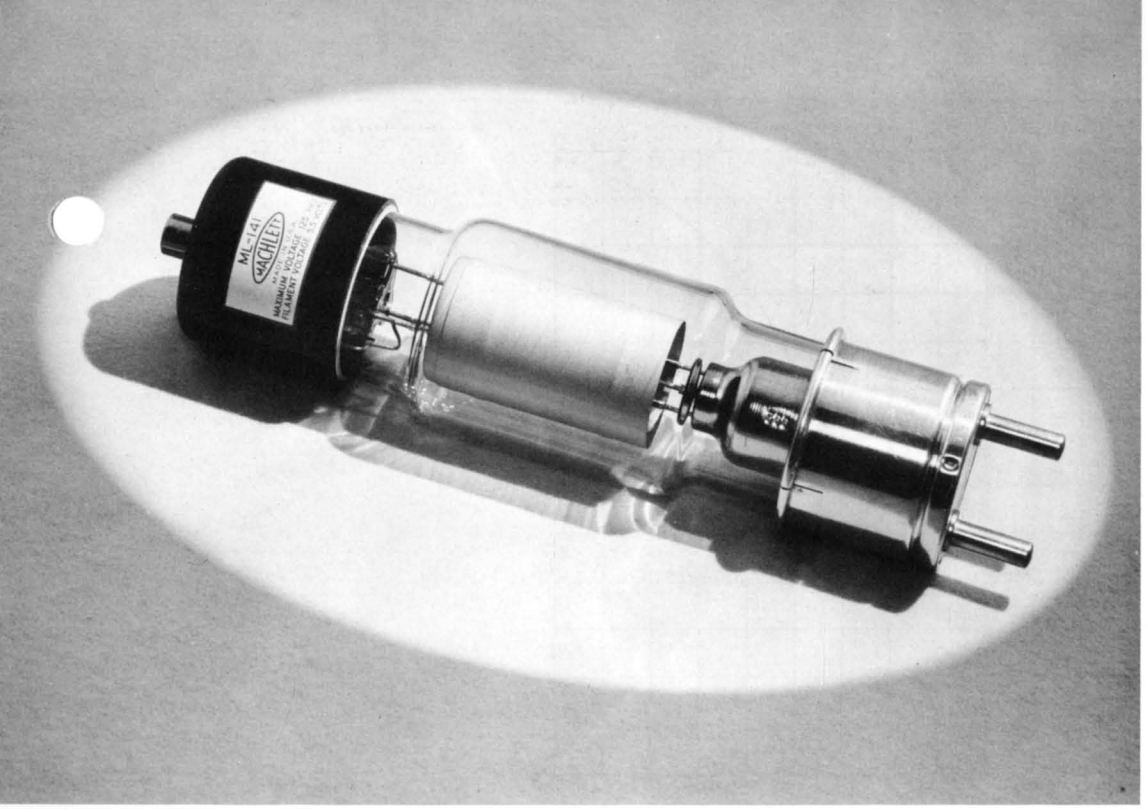


MACHLETT

ML-141

DESCRIPTION AND RATINGS

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.

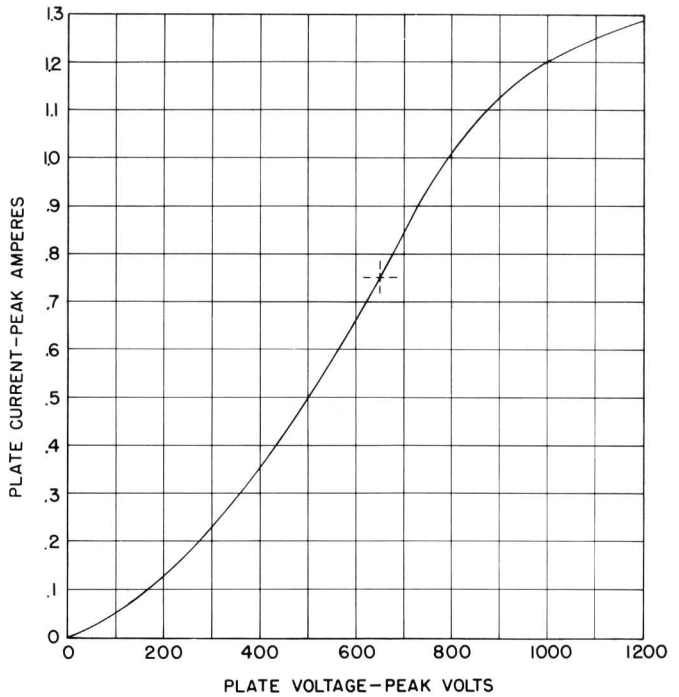
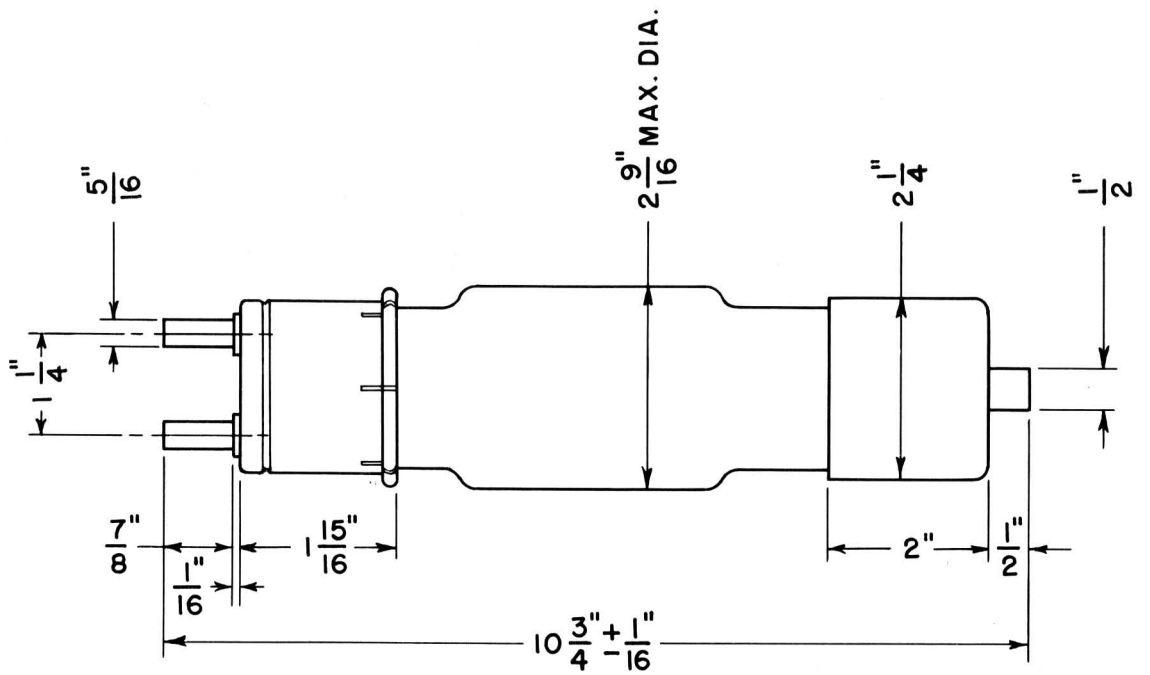


PLATE CURRENT CHARACTERISTICS



DIMENSIONS ML-141

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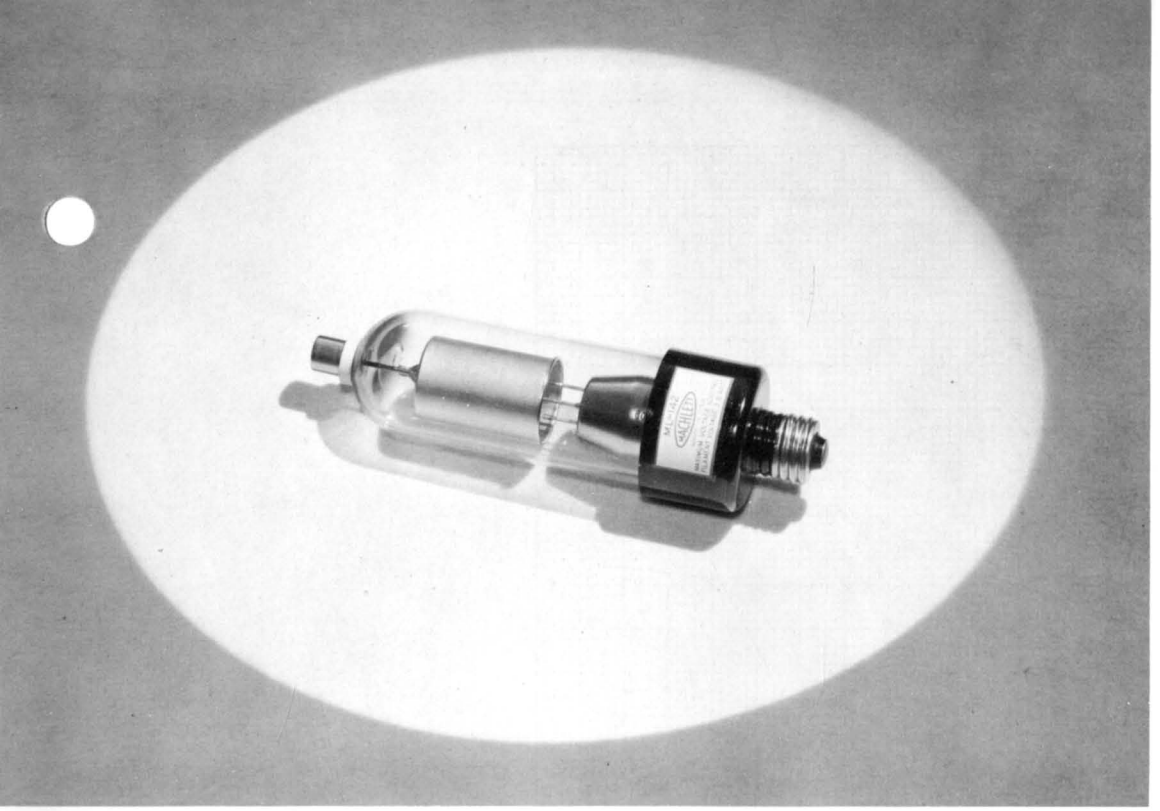


MACHLETT

ML-142

DESCRIPTION AND RATINGS

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.

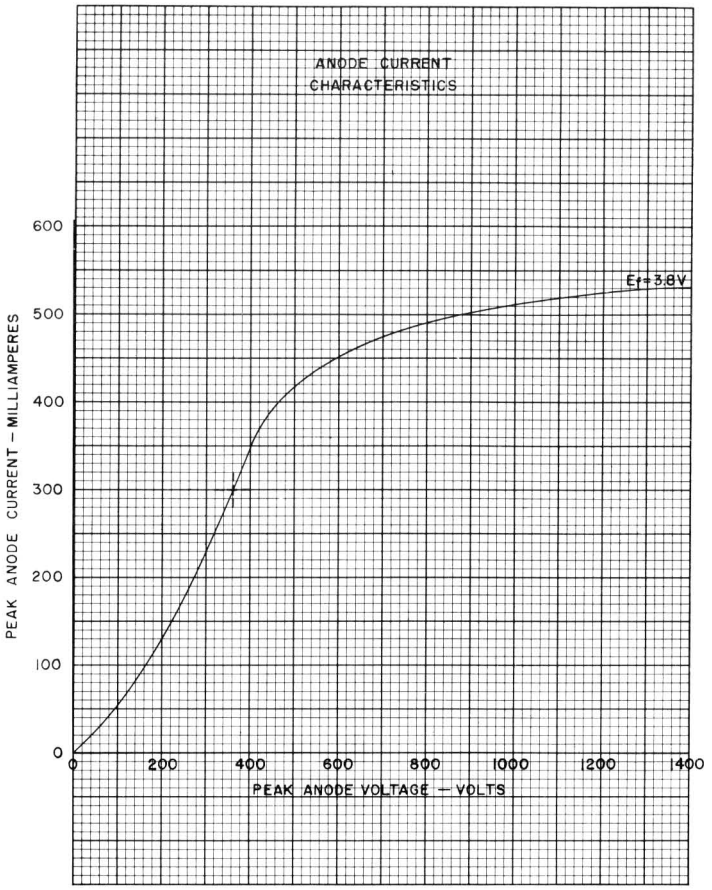
Mechanical

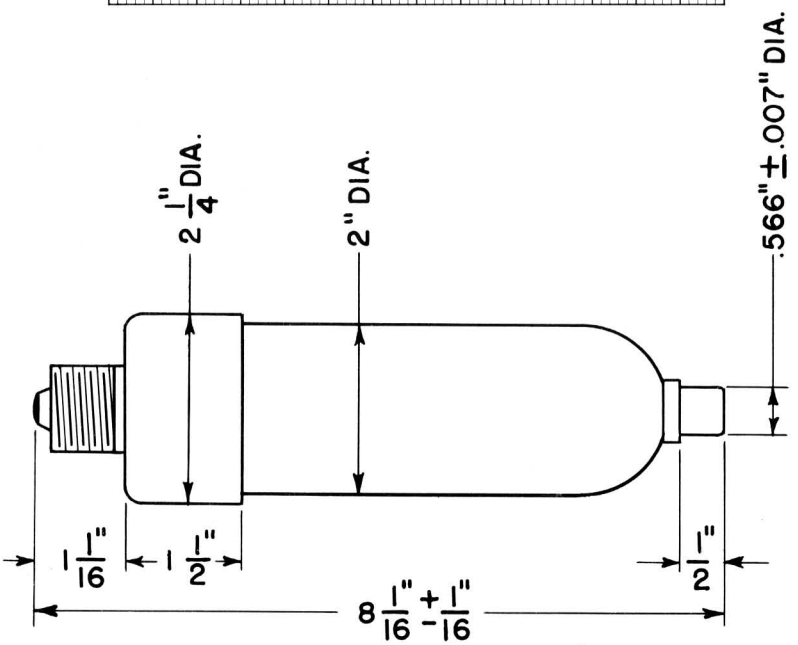
Mounting Position	Optional
Type of Cooling	Radiation
Insulating Medium	Oil or Air
Net Weight	14½ Ounces

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.





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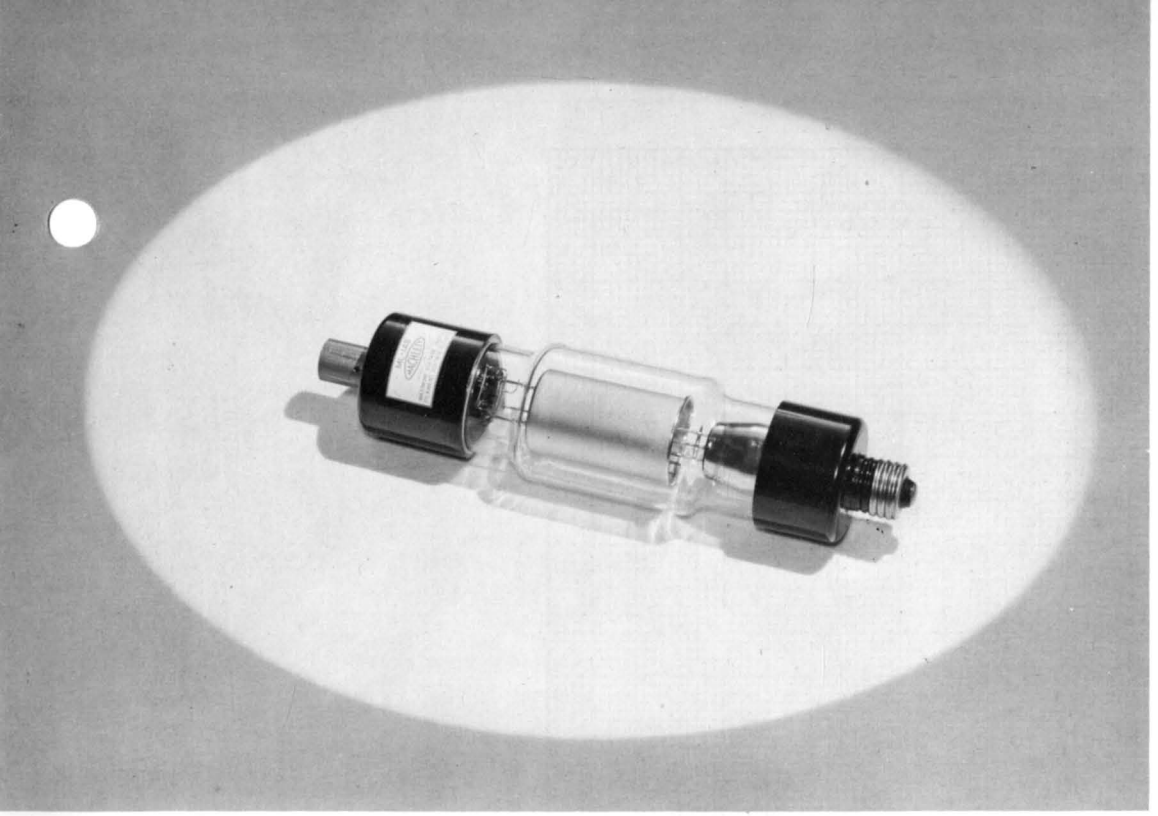


MACHLETT

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.

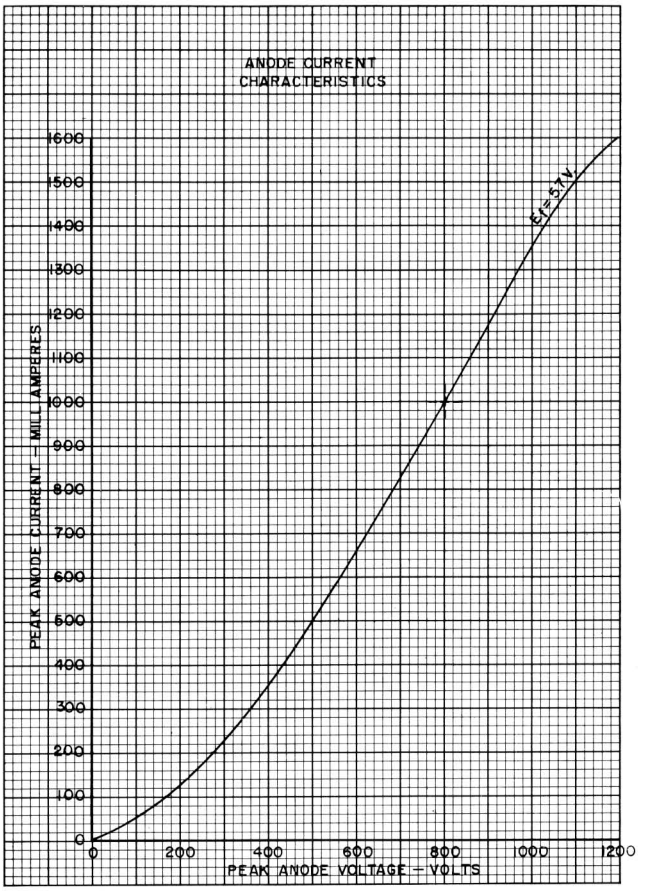
Mechanical

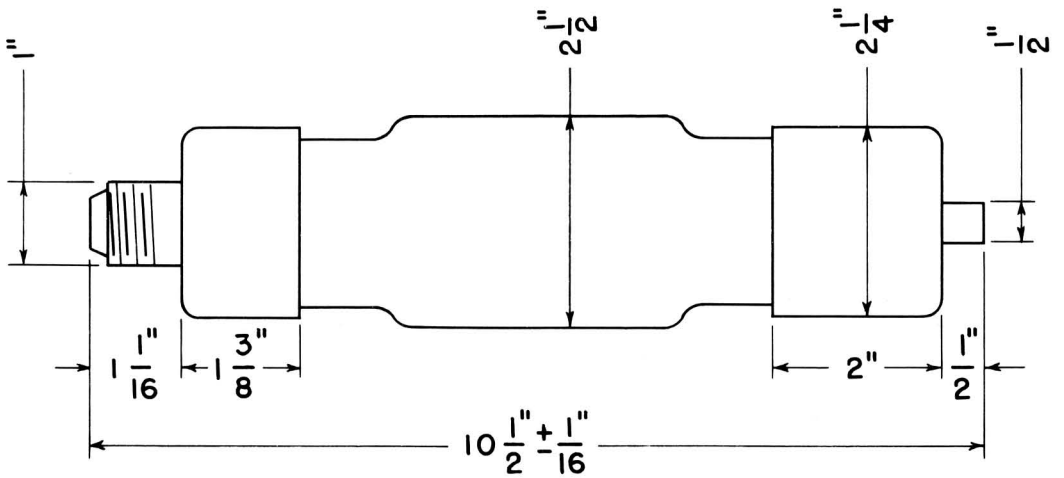
Mounting Position	Optional
Type of Cooling	Radiation
Insulating Medium	Oil or Air
Net Weight	16 Ounces

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.





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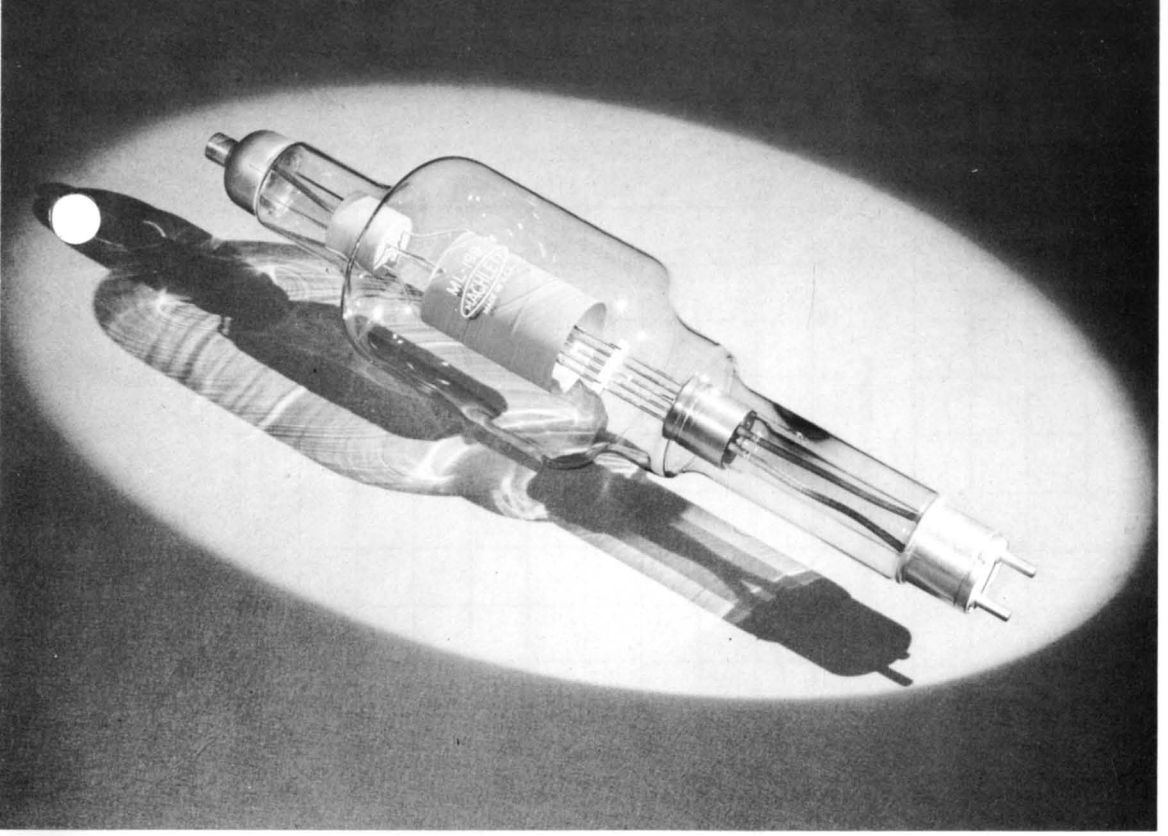


MACHLETT

ML-199

DESCRIPTION AND RATINGS

DESCRIPTION

The ML-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 molybdenum 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)	2500	Volts

MECHANICAL

Mounting Position	Optional	
Type of Cooling	Radiation†	
Insulating Medium	Air	
Net Weight, approximate	3	lbs

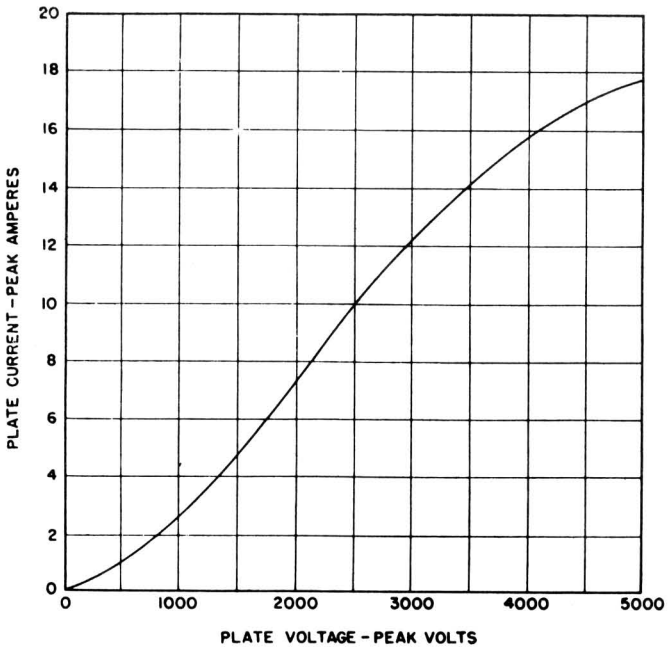
† Forced air cooling of the bulb at 125 cfm through a 6-inch diameter nozzle is required to keep the glass temperature within safe limits at maximum ratings.

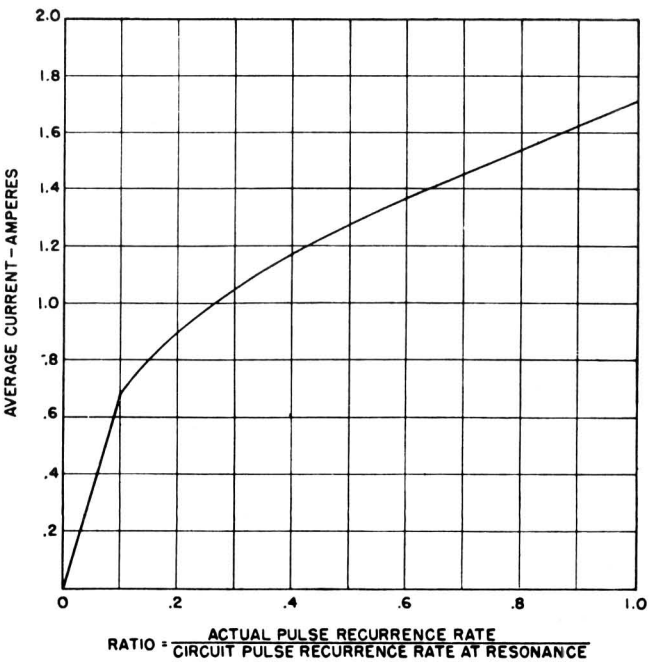
MAXIMUM RATINGS

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.

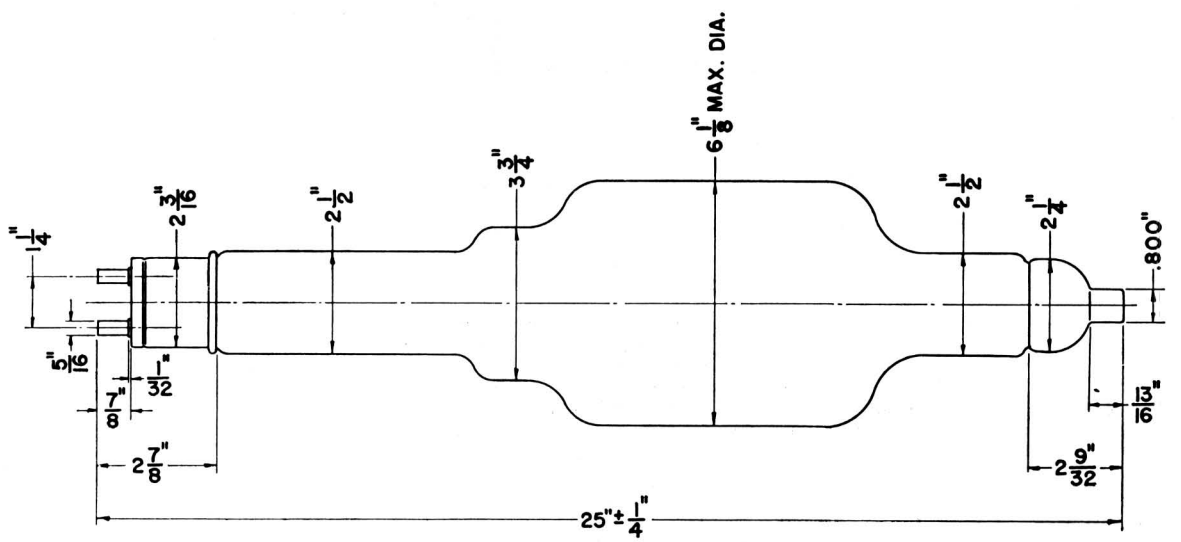




APPLICATION NOTES

When the ML-199 is employed as a rectifier in conventional power supply circuits, the average dc load currents specified under "Maximum Ratings" apply.

When the ML-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.



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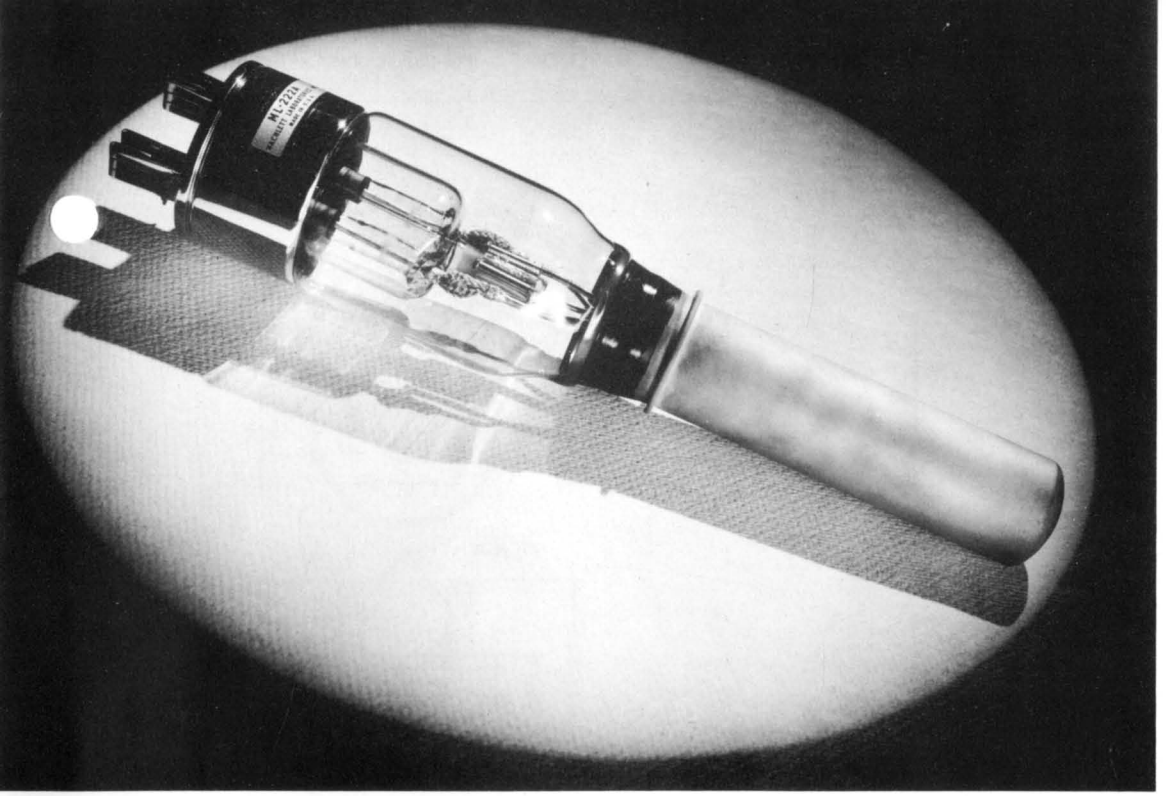


MACHLETT

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

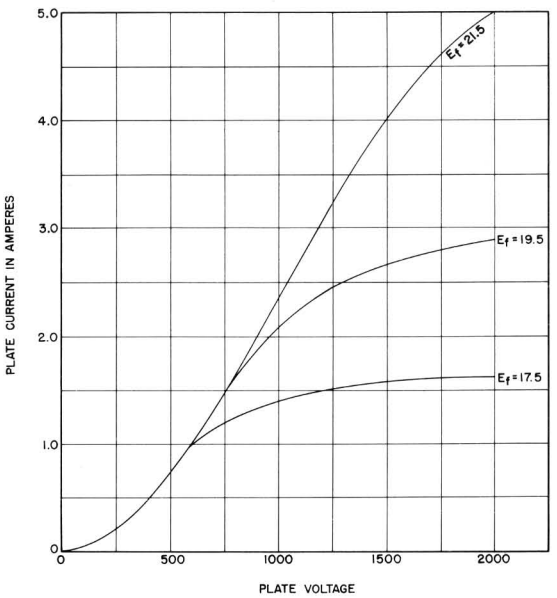
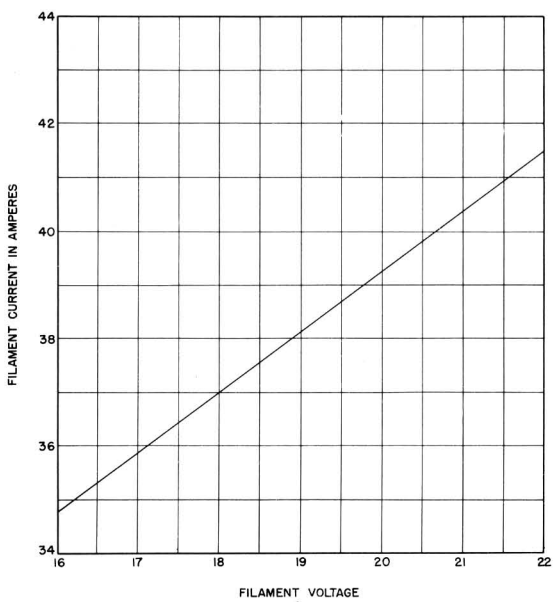
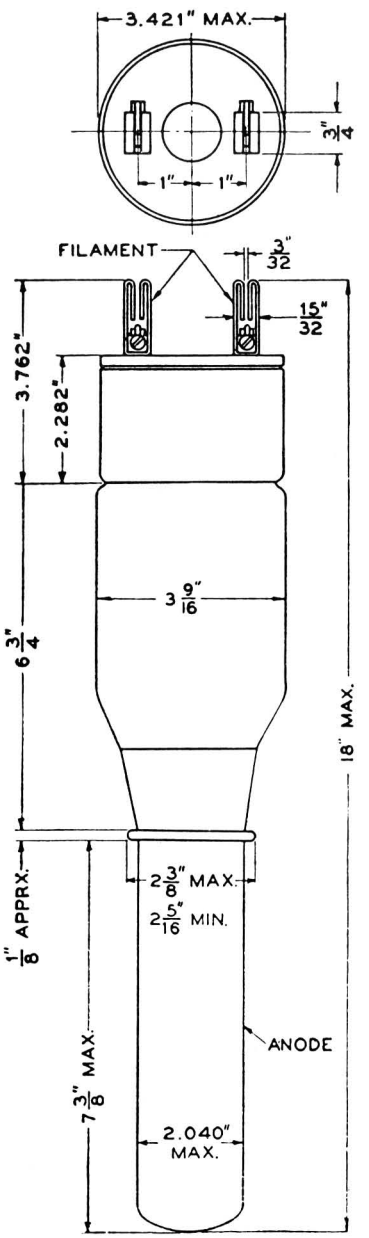


PLATE CURRENT CHARACTERISTICS



FILAMENT CHARACTERISTICS



Dimensions—ML-222A

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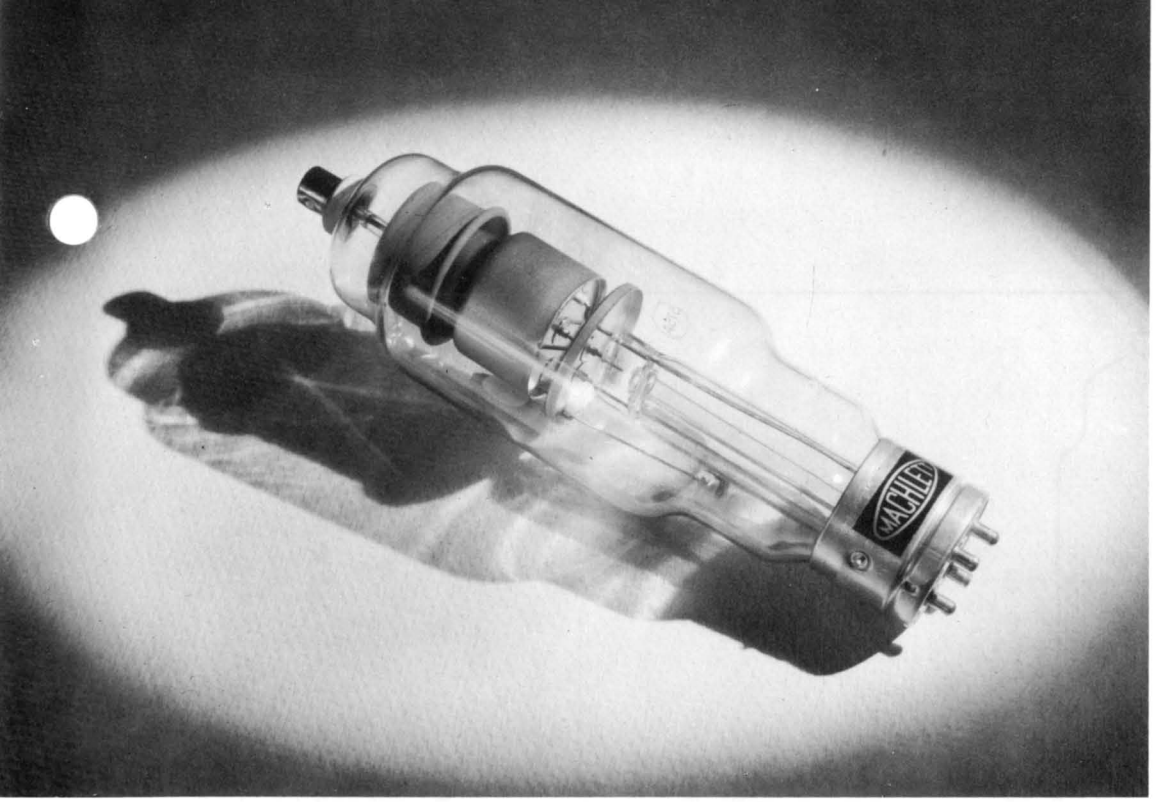


MACHLETT

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

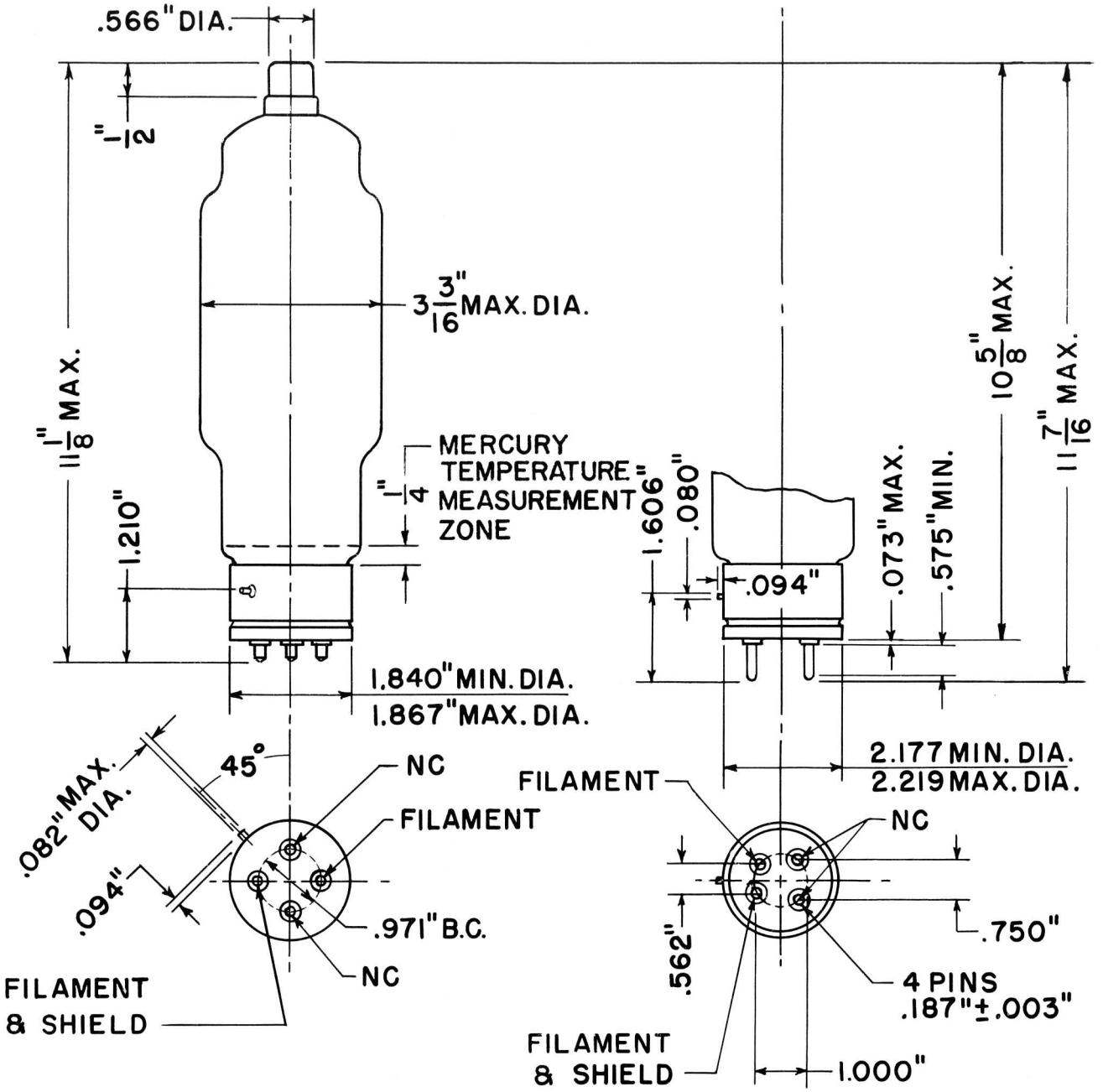
Filament Voltage	5.0	Volts
Filament Current at 5.0 Volts	10.0	Amps
Cathode Heating Time, minimum (Before applying Plate Voltage)	30	Secs
Tube Voltage Drop, approximate	10	Volts

Mechanical

Mounting Position	Vertical, Base Down	
Type of Cooling	Convection	
Base, ML-575A	Super-Jumbo, 4-Pin Bayonet, RMA No. A4-29	
ML-673	Super-Jumbo, 4-Pin Bayonet, RMA No. A4-18	
Cap	Medium Metal, RMA 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

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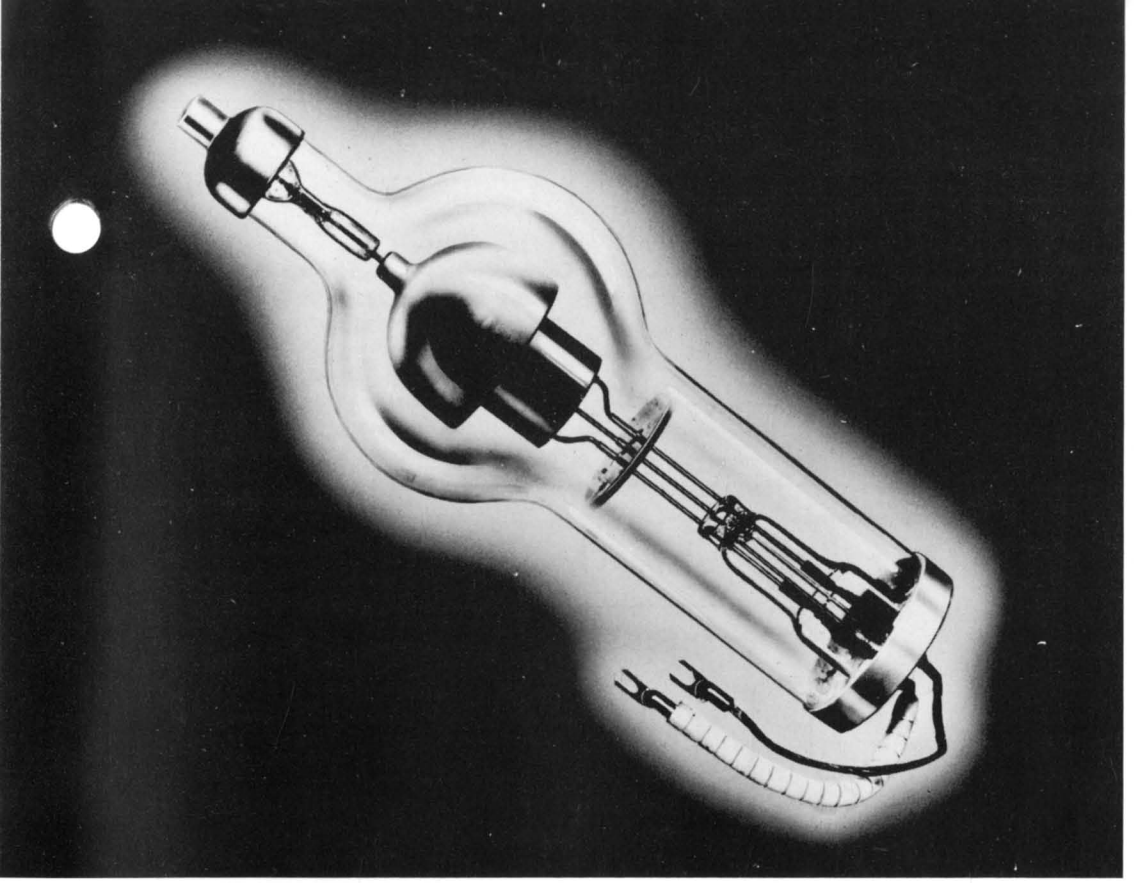


MACHLETT

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
Base	RMA No. FO-2
Cap	RMA 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

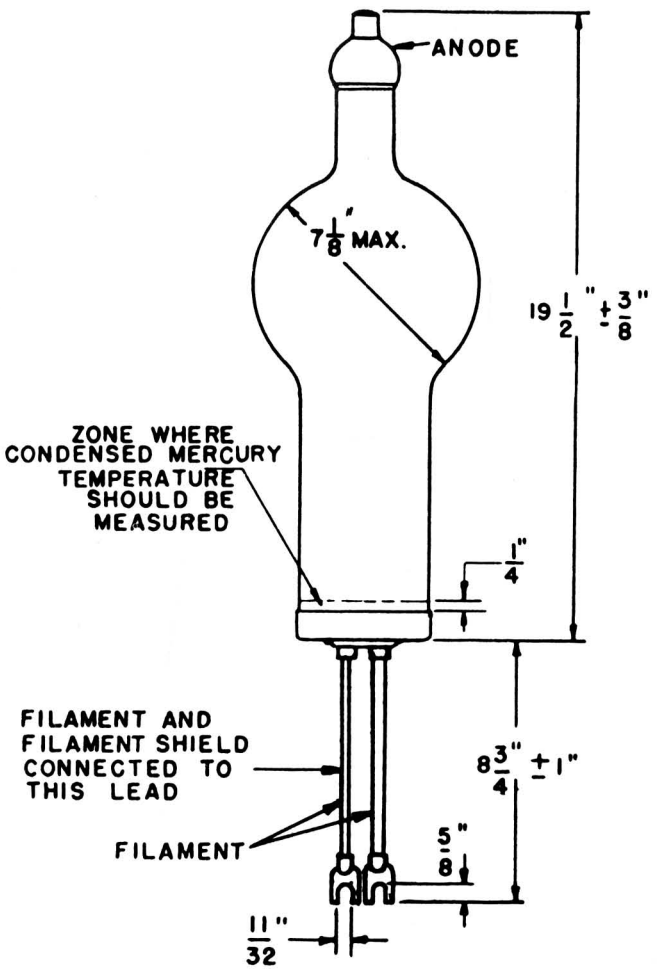
In-Phase Filament Excitation

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	20.0 Amperes	
Average, 30 Seconds Averaging Time	5.0 Amperes	
Surge, for Design Only	400.0 Amperes	
Duration of Surge Current	0.2 Second	

Quadrature Filament Excitation**

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	

**Filament current 90° ± 30° out of phase with anode current.



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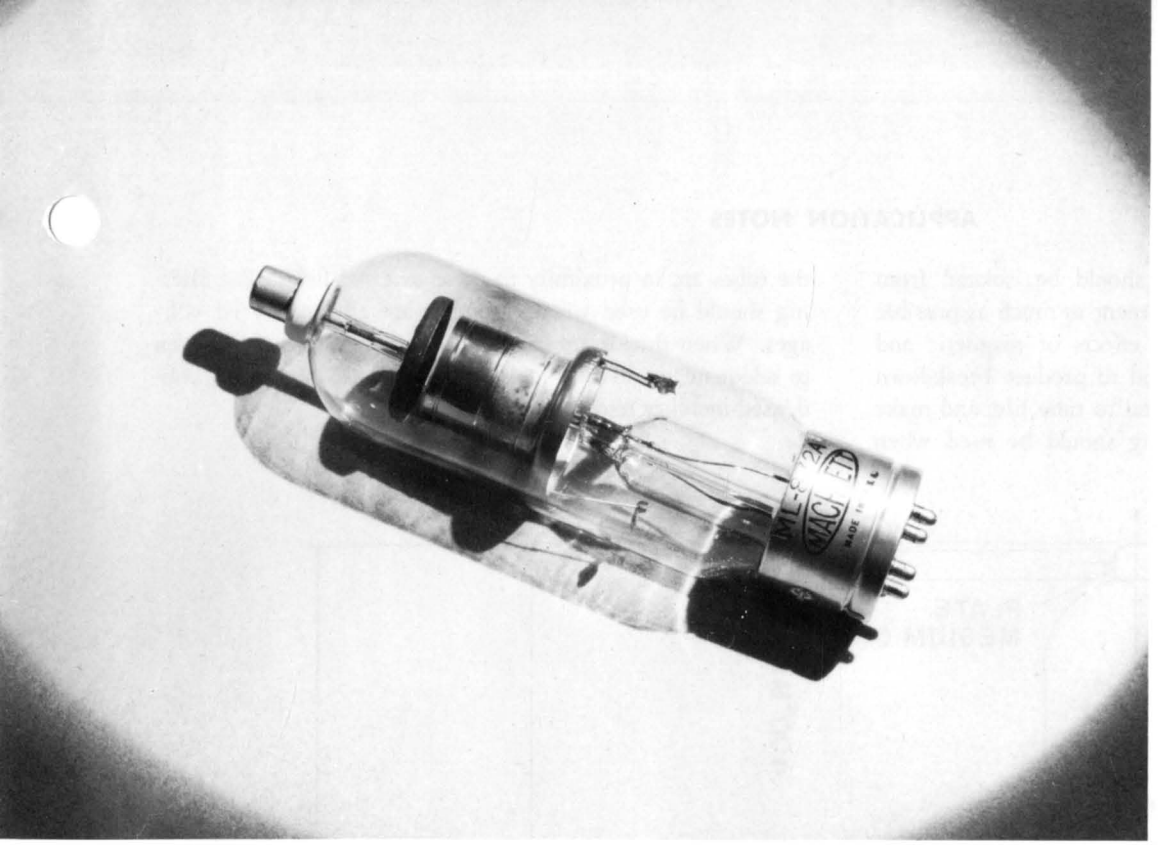


MACHLETT

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

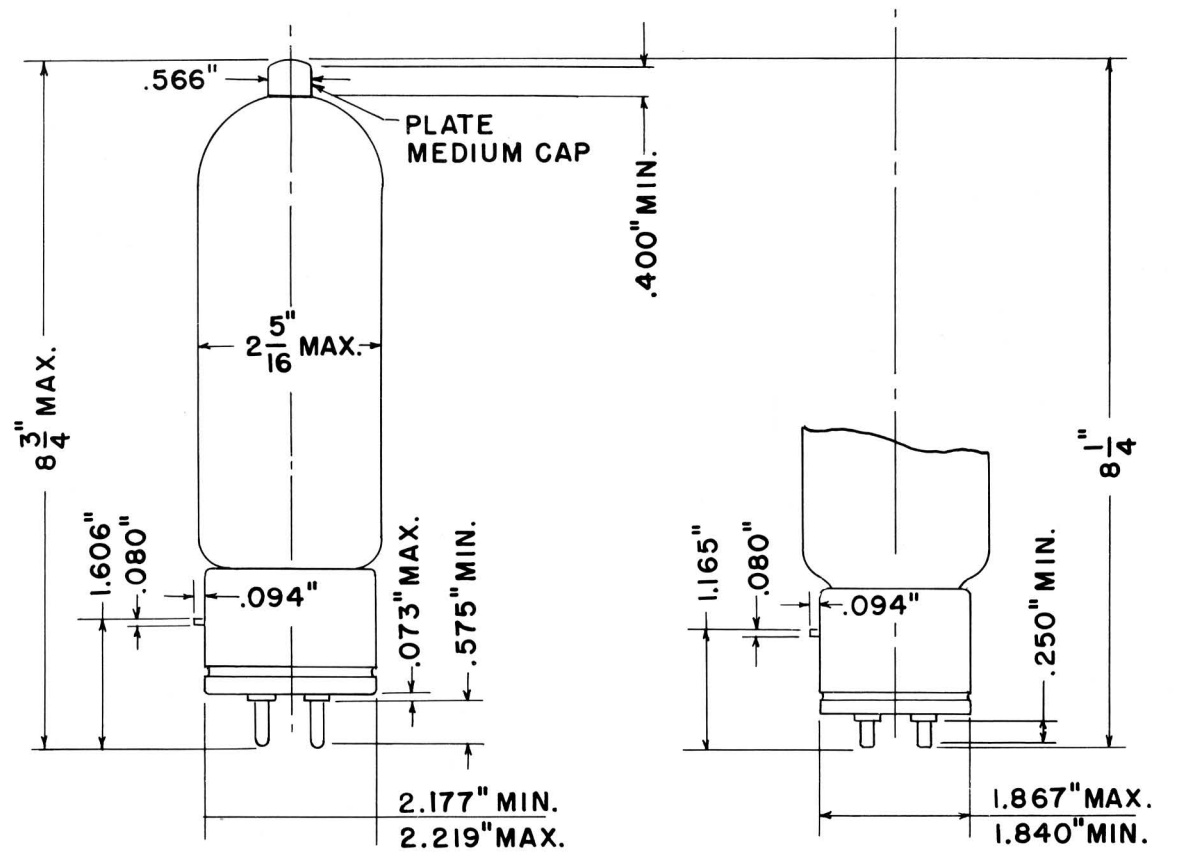
* Before applying anode voltage, sufficient time must be allowed to bring the condensed mercury temperature, measured at the top edge of the base, within the specified range.

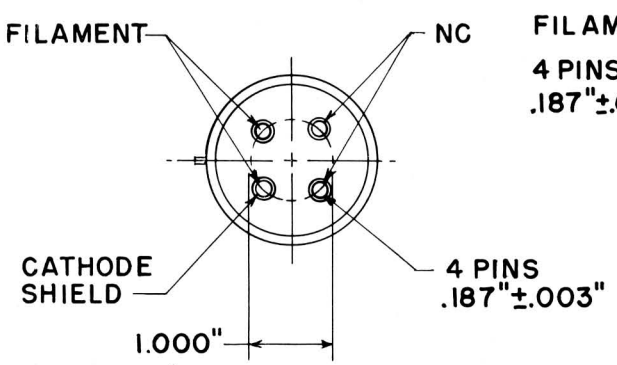
MAXIMUM RATINGS

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

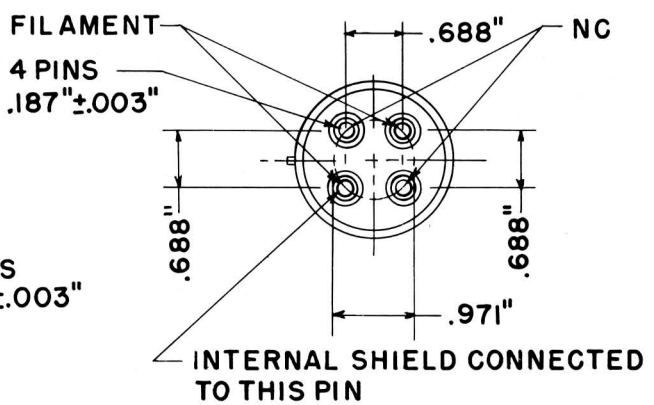
APPLICATION NOTES

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.





ML-8008



ML-872A

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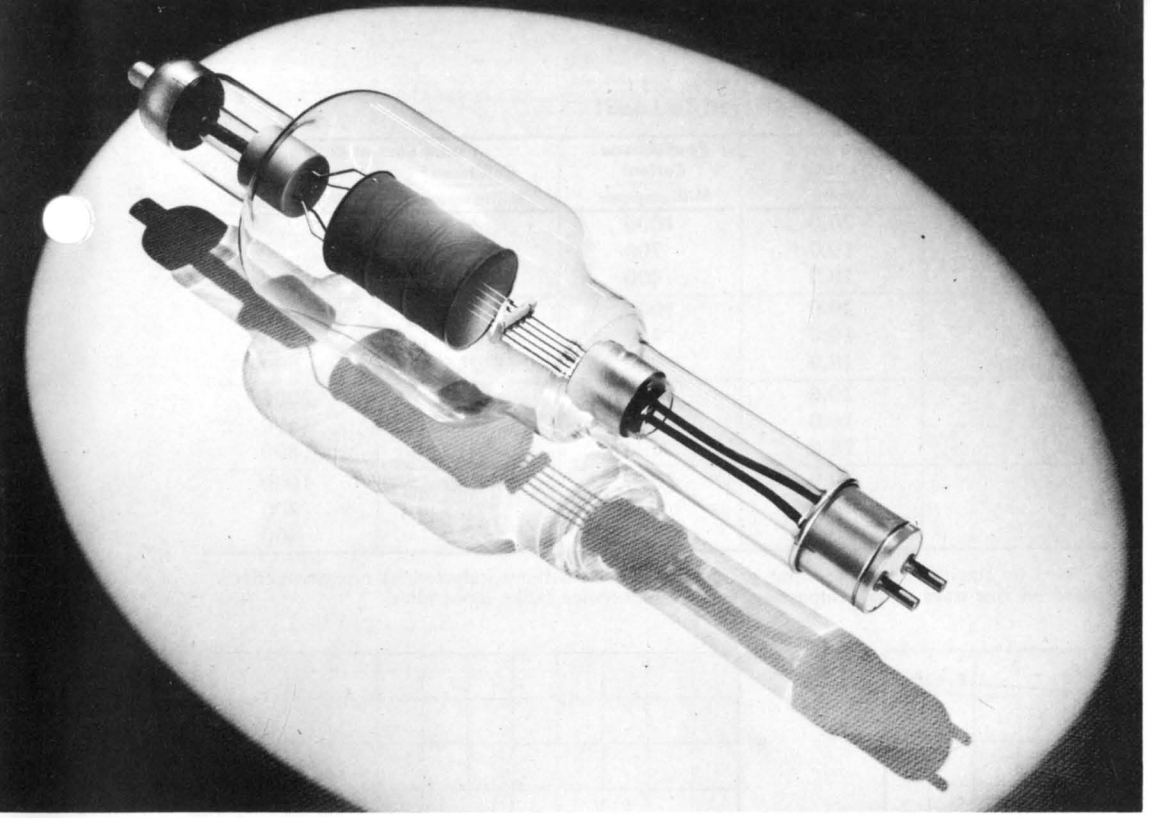


MACHLETT

ML-5575/100

DESCRIPTION AND RATINGS

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 Volts
Filament Current, approximate	24 Amps
Filament Heating Time, minimum (Before applying Plate Voltage)	30 Secs
Tube Voltage Drop, maximum (I_b—1.0 ampere)	800 Volts

Mechanical

Mounting Position	Optional
Type of Cooling	Radiation
Insulating Medium	Air
Net Weight, approximate	3 lbs

MAXIMUM RATINGS

Peak Inverse Anode Voltage	150000 Volts
Peak Anode Current	1.0 Amp
Plate Dissipation	750 Watts

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.

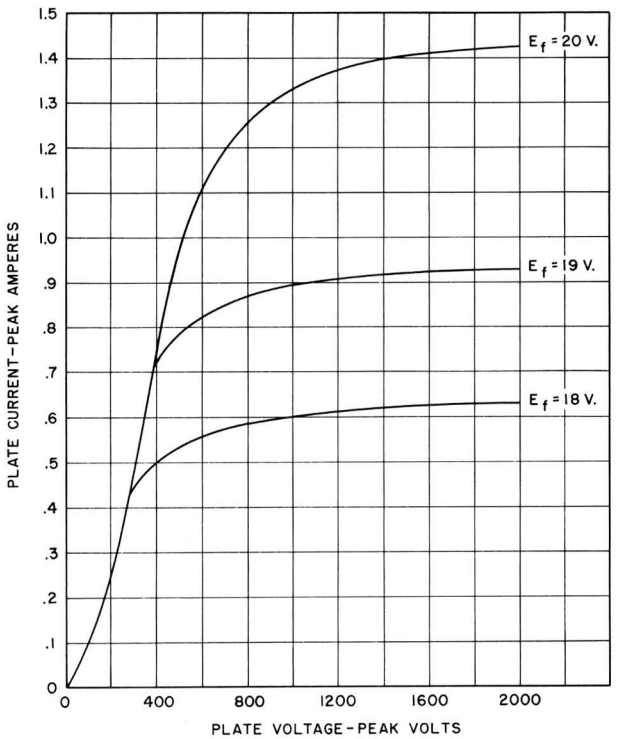
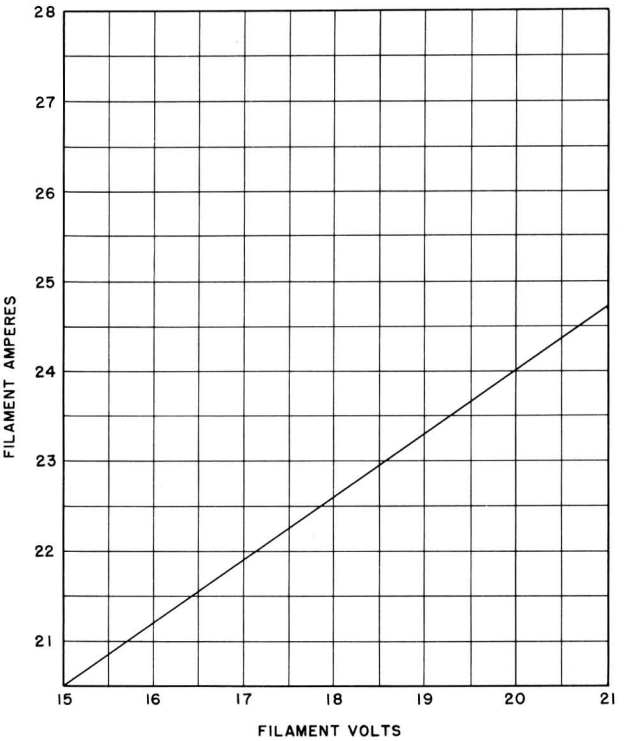
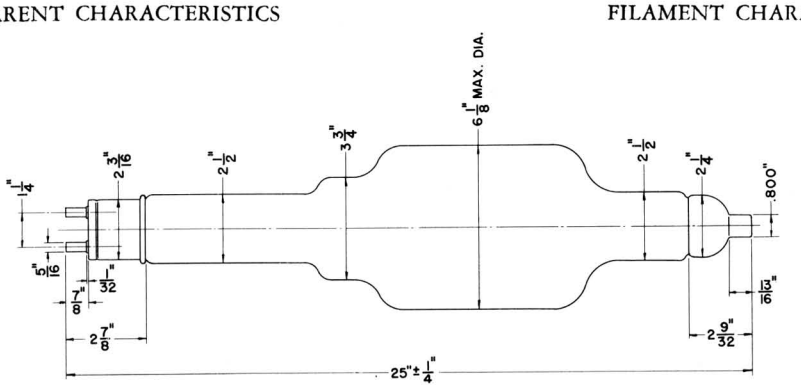


PLATE CURRENT CHARACTERISTICS



FILAMENT CHARACTERISTICS



DIMENSIONS—ML-5575/100

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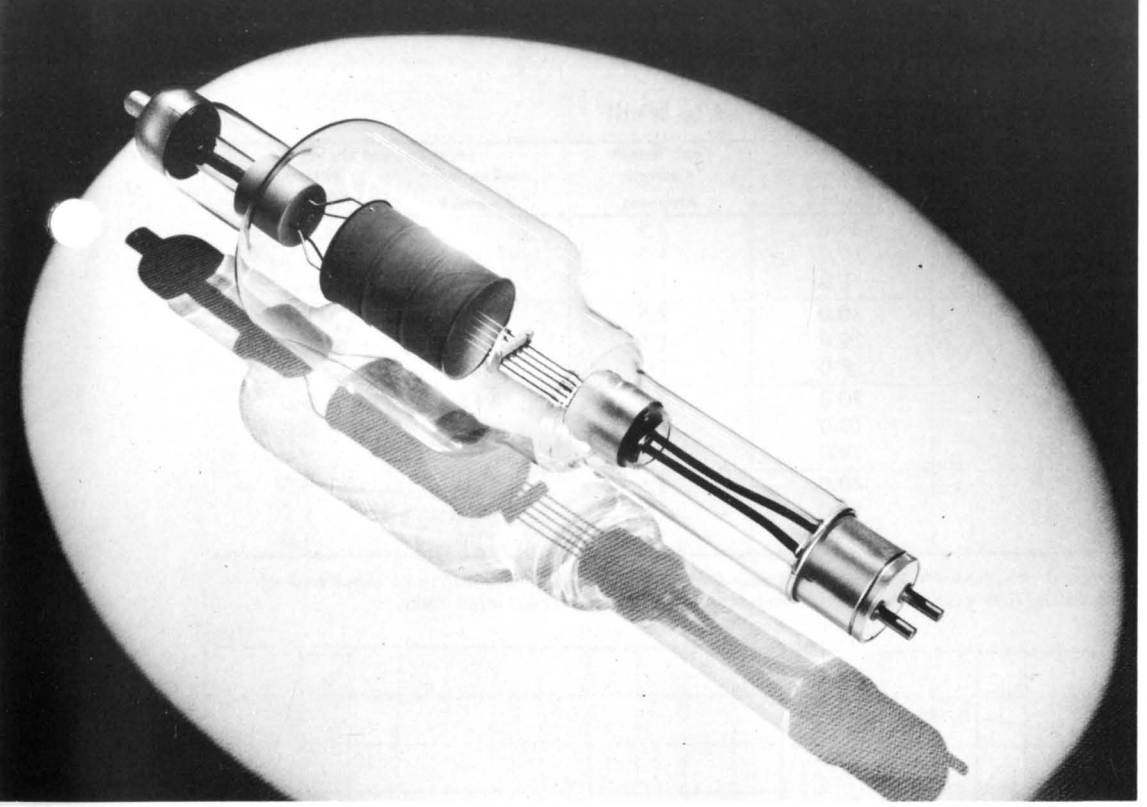


MACHLETT

ML-5576/200

DESCRIPTION AND RATINGS

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 Volts
Filament Current, approximate	32 Amps
Filament Heating Time, minimum (Before applying Plate Voltage)	30 Secs
Tube Voltage Drop, maximum (I_b—2.5 amperes)	1000 Volts

Mechanical

Mounting Position	Optional
Type of Cooling	Radiation
Insulating Medium	Air
Net Weight, approximate	3 lbs

MAXIMUM RATINGS

Peak Inverse Anode Voltage	150000 Volts
Peak Anode Current	2.5 Amps
Plate Dissipation	1000 Watts

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	2.5	.80	.....
	19.0	1.5	.48	.....
	18.0	1.0	.32	.....
Single-Phase, Four-Tube, Full Wave	20.0	2.5	1.59	2.5
	19.0	1.5	.96	1.5
	18.0	1.0	.64	1.0
Three-Phase, Double-Y, Parallel	20.0	2.5	4.80	5.0
	19.0	1.5	2.90	3.0
	18.0	1.0	1.93	2.0
Three-Phase, Full Wave	20.0	2.5	2.40	2.5
	19.0	1.5	1.45	1.5
	18.0	1.0	.96	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.

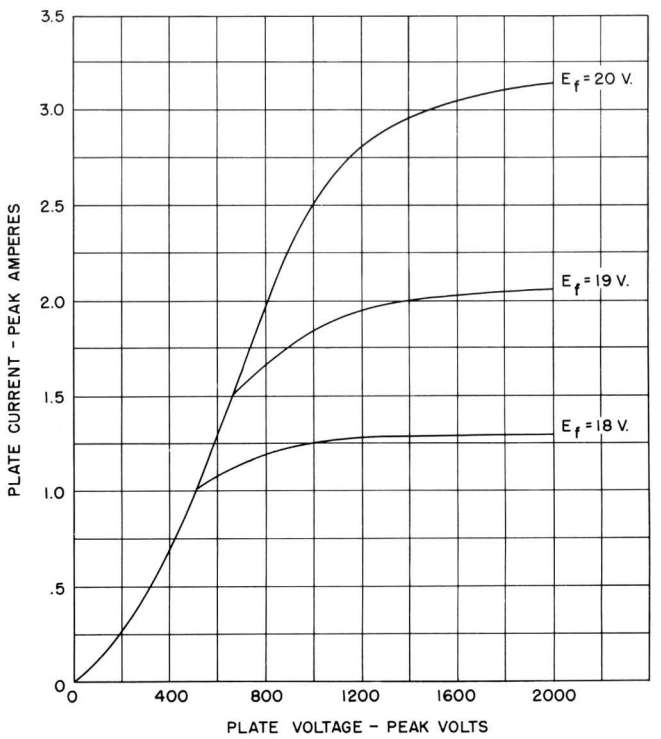
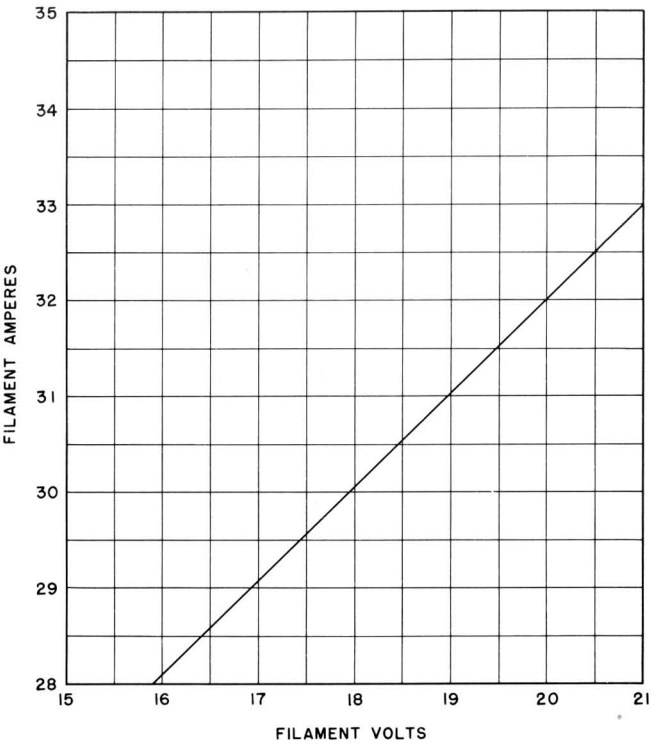
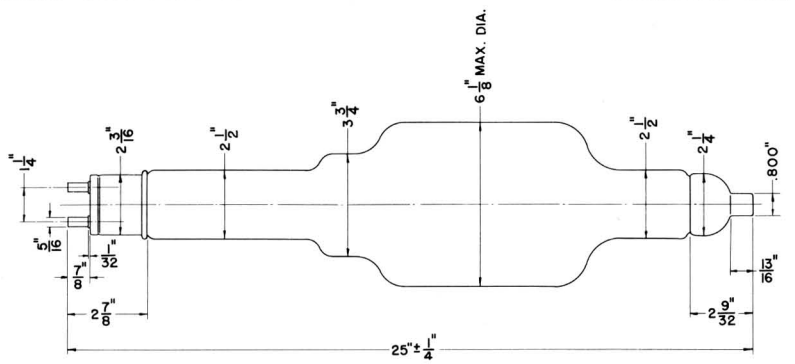


PLATE CURRENT CHARACTERISTICS



FILAMENT CHARACTERISTICS



DIMENSIONS—ML-5576/200

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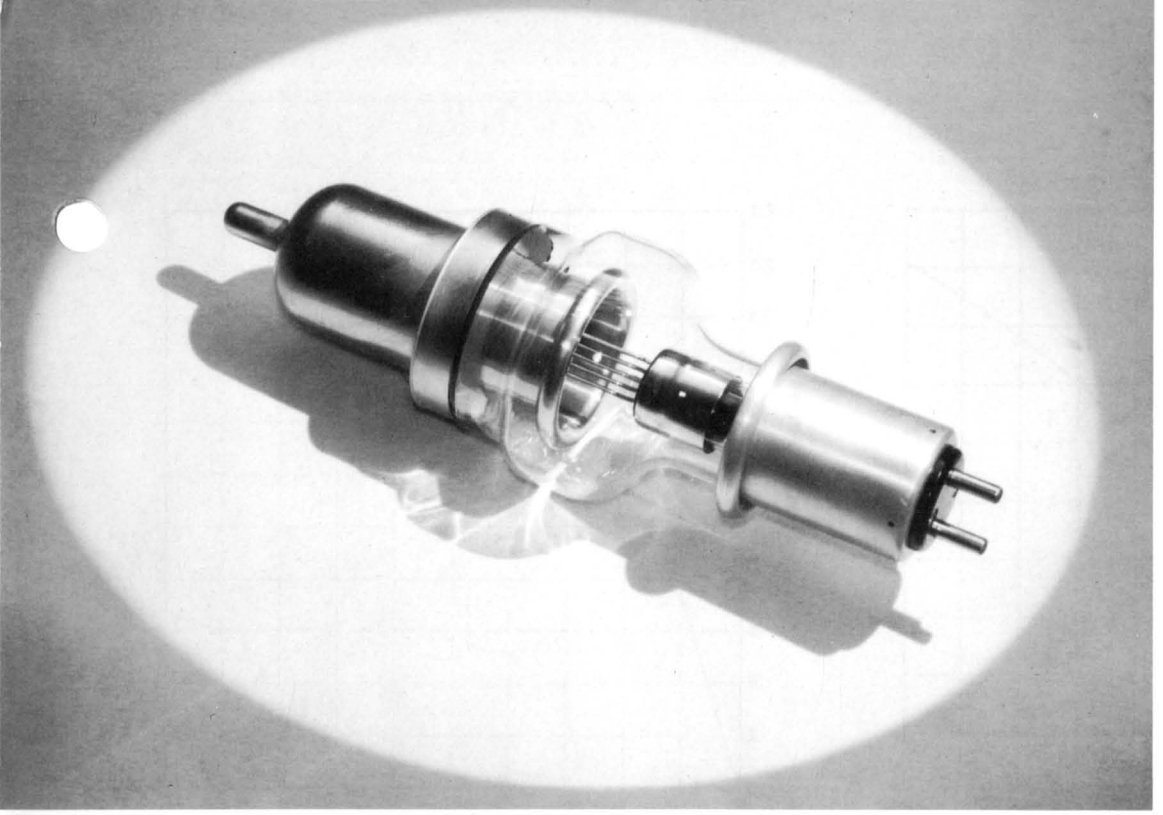


MACHLETT

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.

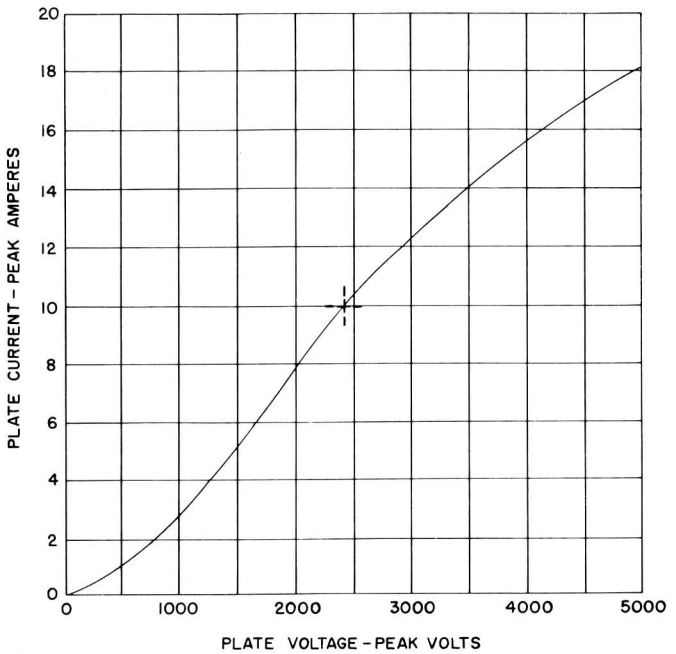
†† The dielectric value of the insulating oil should be no less than 25,000 volts peak per 0.1 inch.

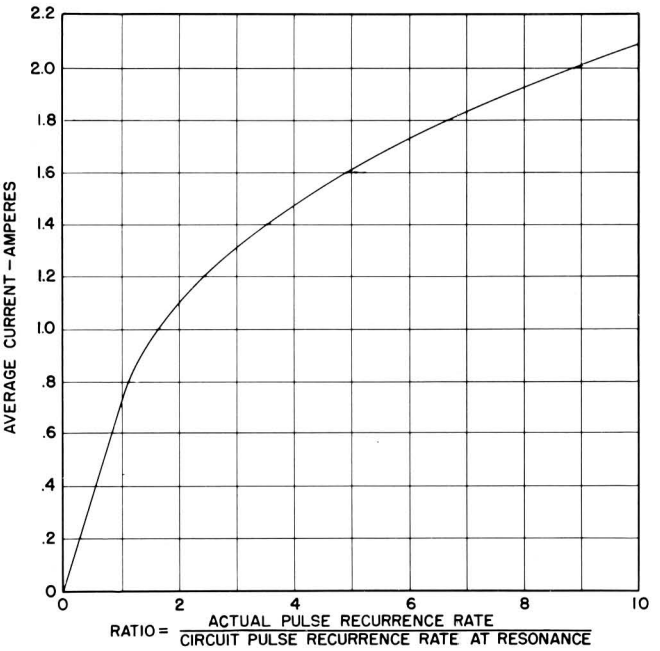
MAXIMUM RATINGS

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.



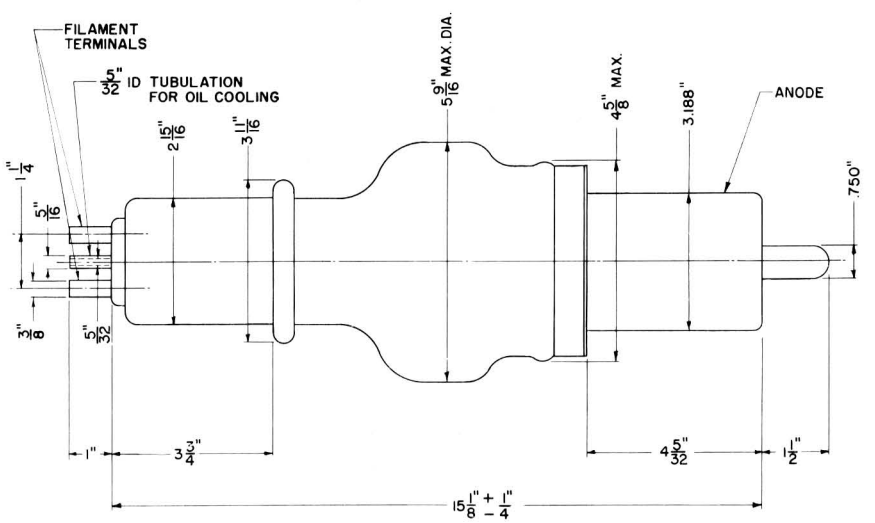


APPLICATION NOTES

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

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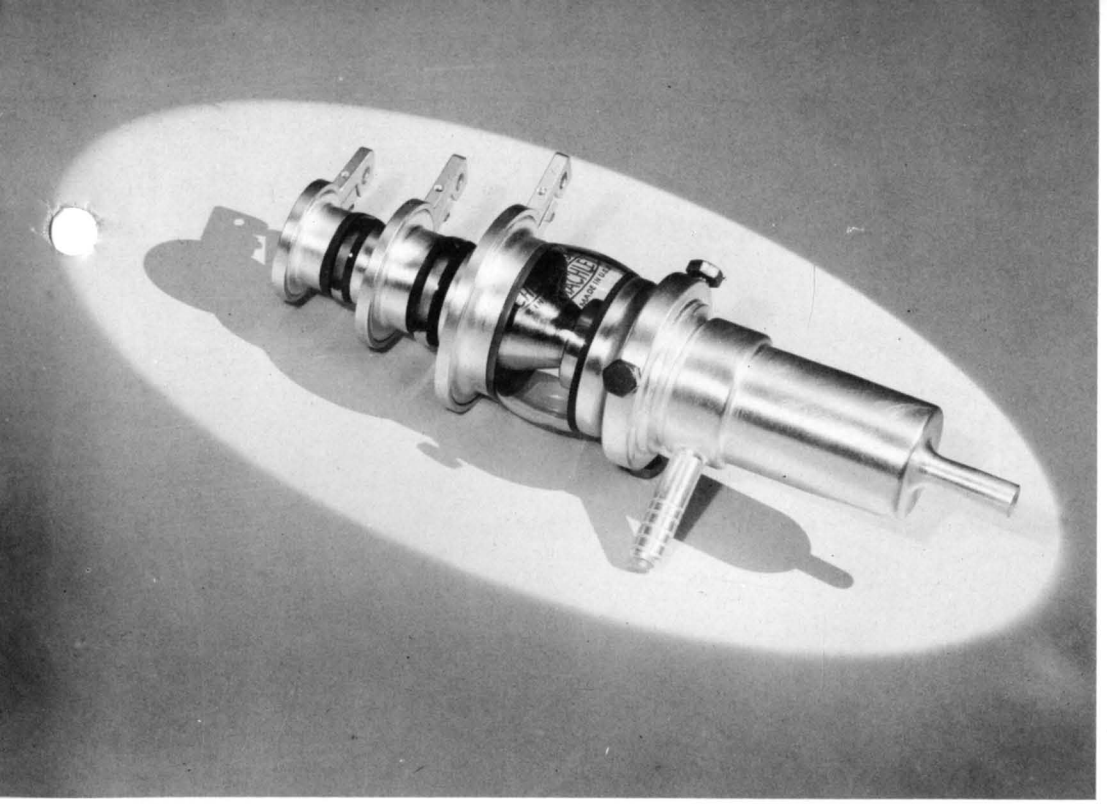


MACHLETT

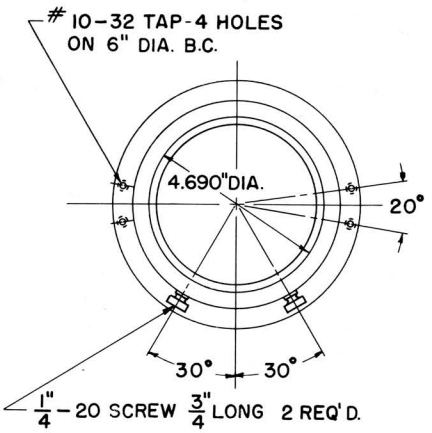
ACCESSORIES
FOR

ML-6256

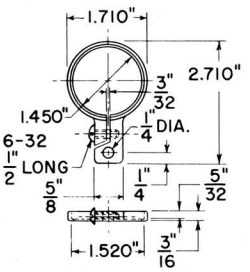
ML-6257

ML-6258

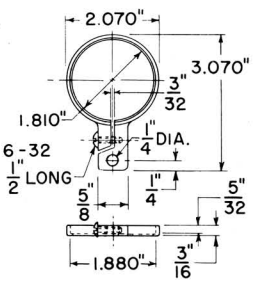
AIR JACKET
P-21186



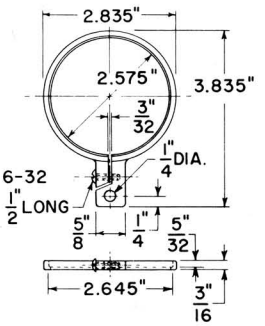
SMALL FILAMENT CONNECTOR
F-14383



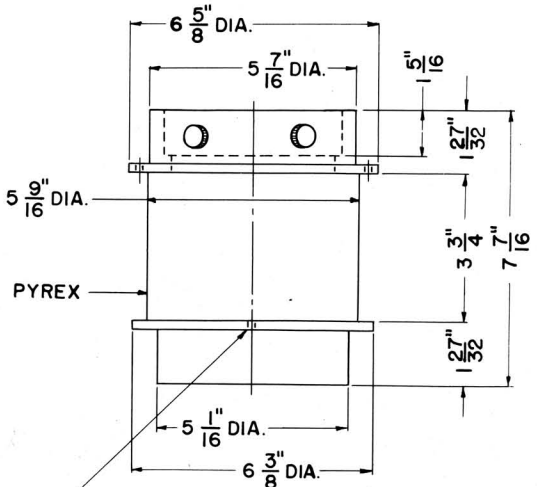
LARGE FILAMENT CONNECTOR
F-14382

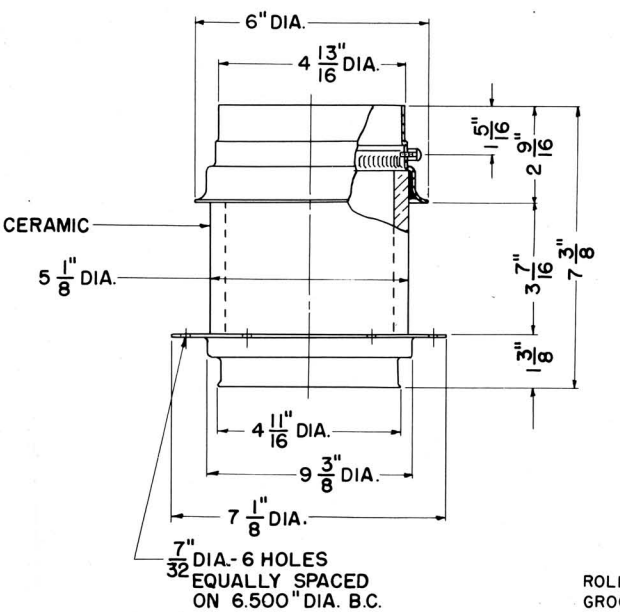


GRID CONNECTOR
F-14381

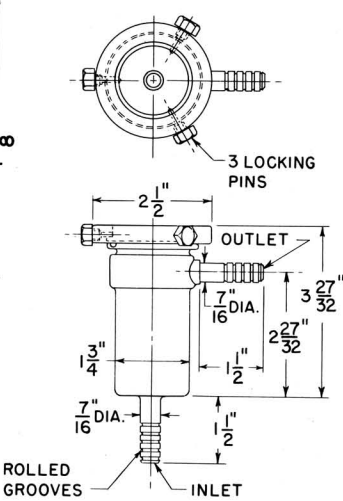


AIR JACKET
P-17468





WATER JACKET
F-14157



ACCESSORIES FOR ML-6256, ML-6257 & ML-6258

ITEM	ORDER NUMBER
Small Filament Connector	F-14383
Large Filament Connector	F-14382
Grid Connector	F-14381
Air Jacket	P-21186
Air Jacket	P-17468
Bracelet	P-14387
Water Jacket	F-14157
O-Ring Gasket for Water Jacket	P-14384

MACHLETT LABORATORIES, INC.

SPRINGDALE MACHLETT CONNECTICUT

U. S. A.

ST-1043

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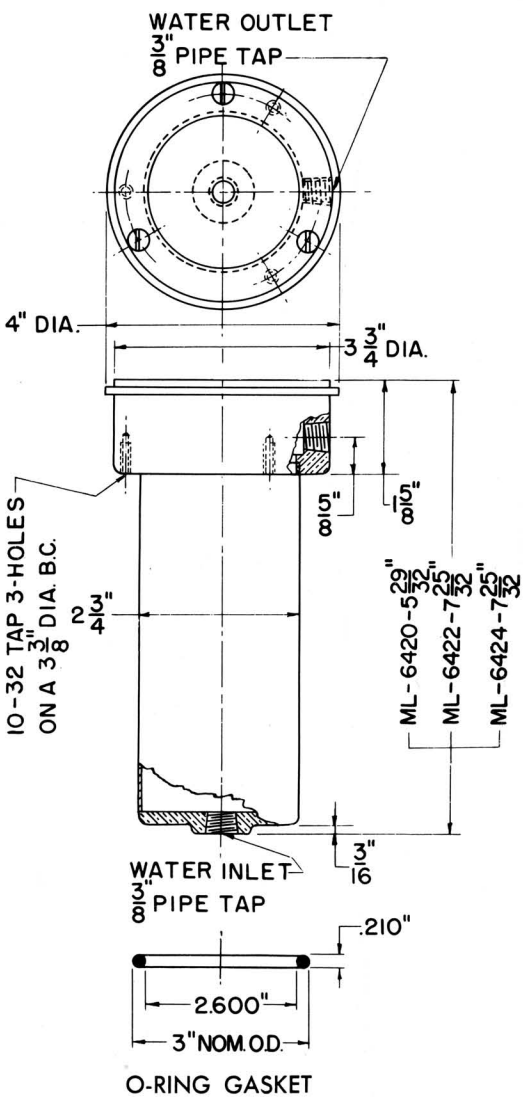
ACCESSORIES
FOR

ML-6420 ML-6421
ML-6422 ML-6423
ML-6424 ML-6425
ML-6426 ML-6427
ML-6696 ML-6697

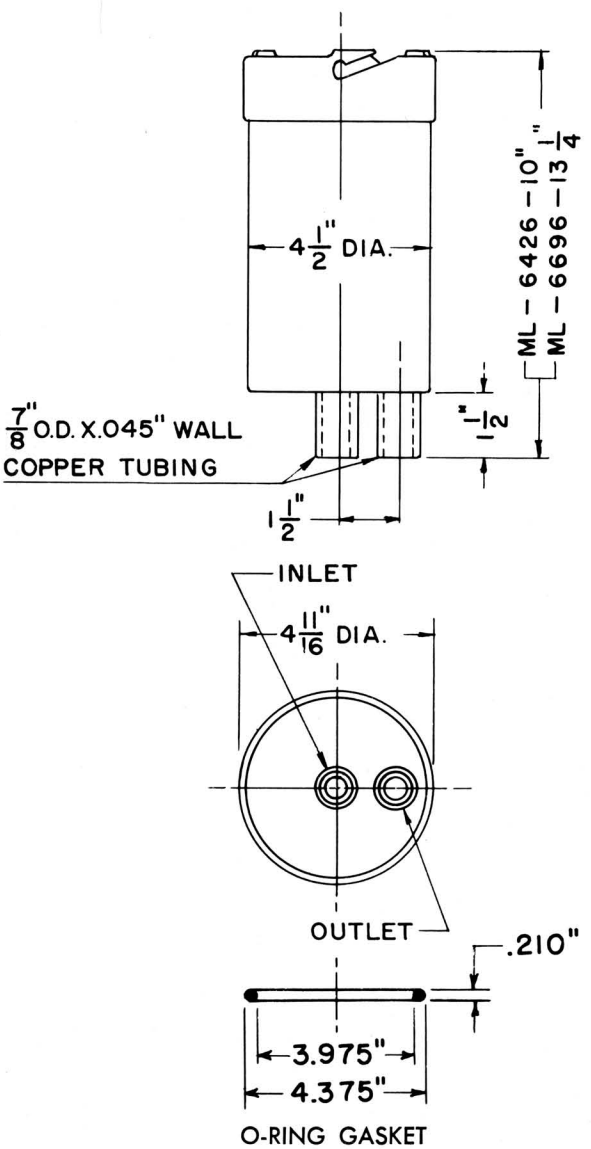
WATER JACKETS

ML-6420 - F-8529
ML-6422 - F-7963
ML-6424 - F-7963



O-RING GASKET
P-7976

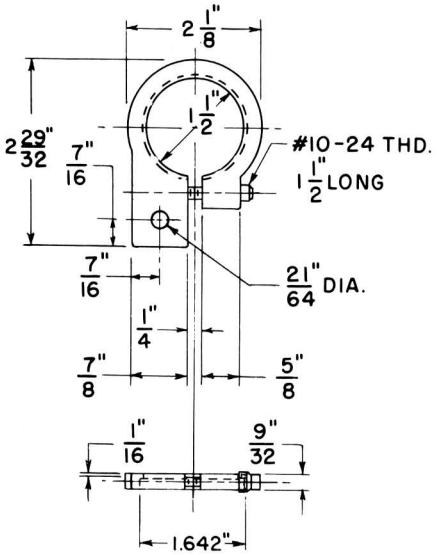
ML-6426 - F-17292
ML-6696 - F-17393



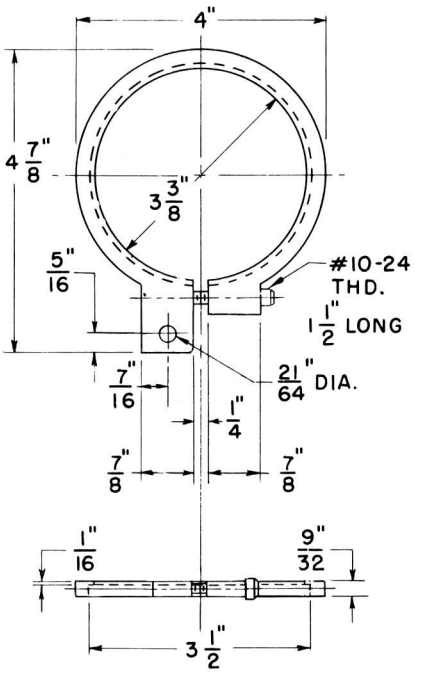
O-RING GASKET
P-17494

CONNECTORS

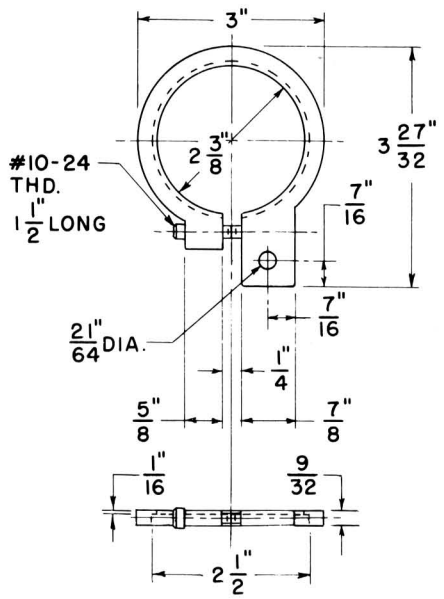
FOR ML-6420 through ML-6427 & ML-6696, ML-6697



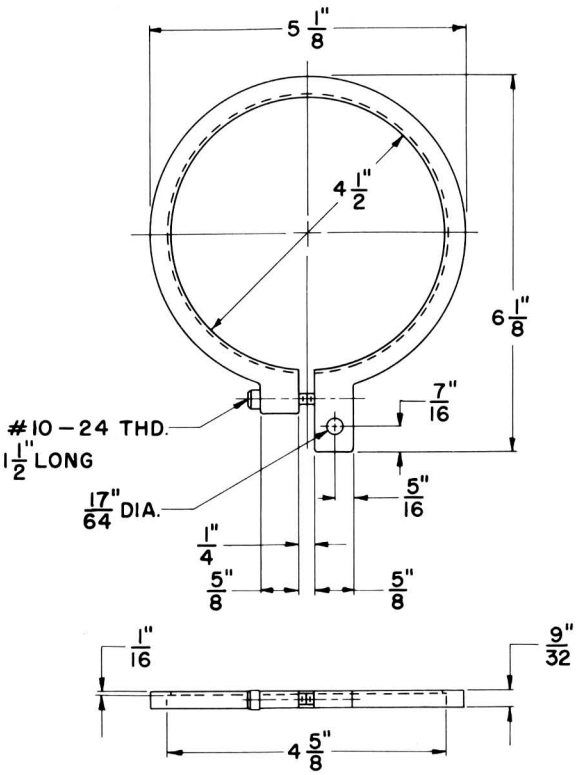
FILAMENT CONNECTOR
F-17487



FILAMENT OR GRID CONNECTOR
F-17489



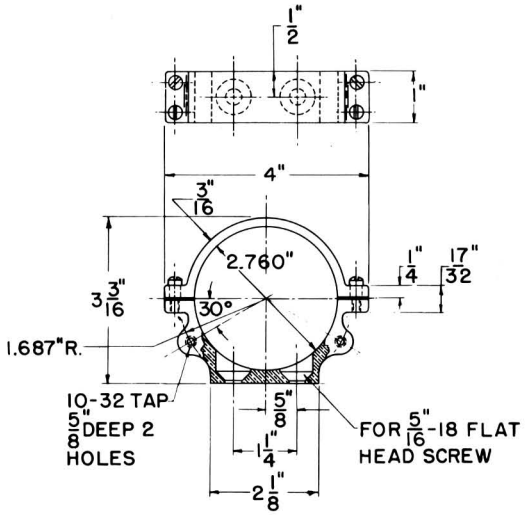
FILAMENT CONNECTOR
F-17488



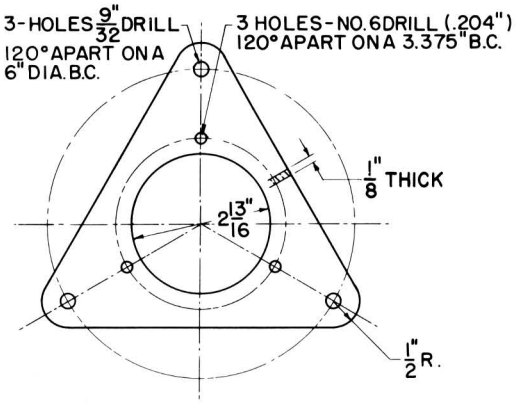
GRID CONNECTOR
F-17397

MOUNTING PLATE AND CLAMP

FOR
WATER JACKETS FOR
ML-6420, ML-6422, ML-6424



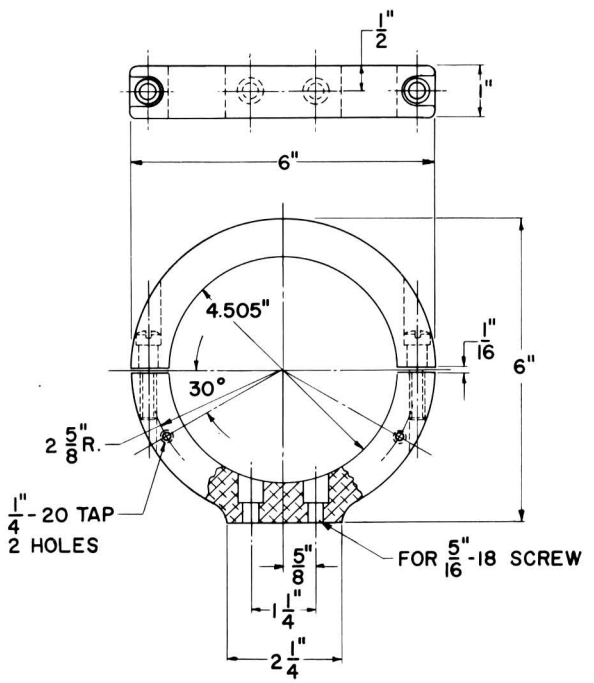
MOUNTING CLAMP
F-8768



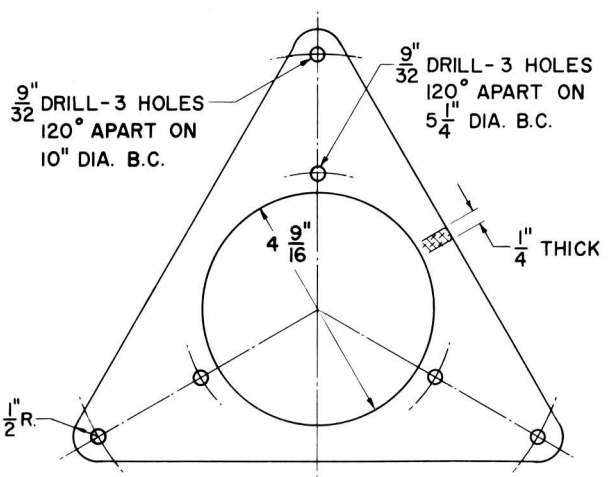
MOUNTING PLATE
F-8772

MOUNTING PLATE AND CLAMP

FOR
WATER JACKETS FOR
ML-6426, ML-6696



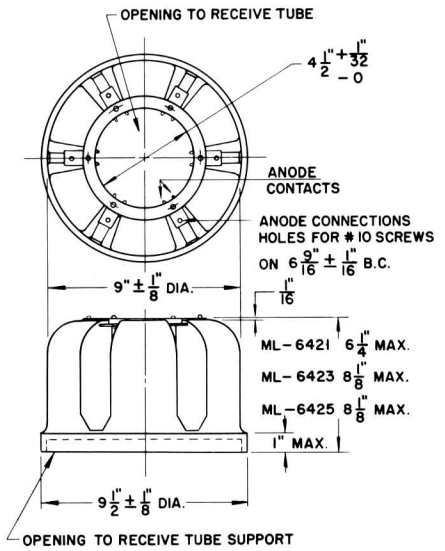
MOUNTING CLAMP
F-15198



MOUNTING PLATE
F-15196

AIR DISTRIBUTOR AND TUBE SUPPORT

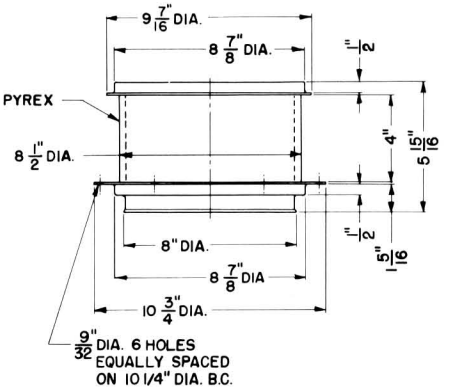
FOR ML-6421, ML-6423, ML-6425



AIR DISTRIBUTOR

Air Distributor for ML-6421 .... F-17796

Air Distributor for ML-6423, ML-6425 ..... F-17797

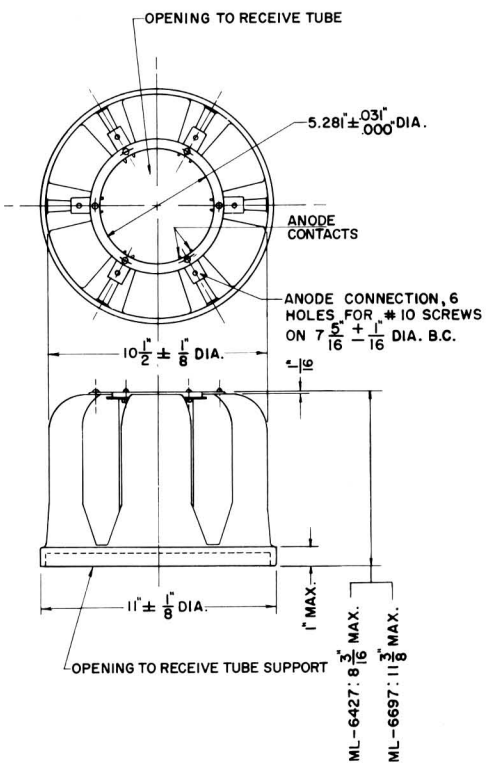


TUBE SUPPORT

Tube Support for ML-6421, ML-6423, ML-6425 .... F-17794

AIR DISTRIBUTOR AND TUBE SUPPORT

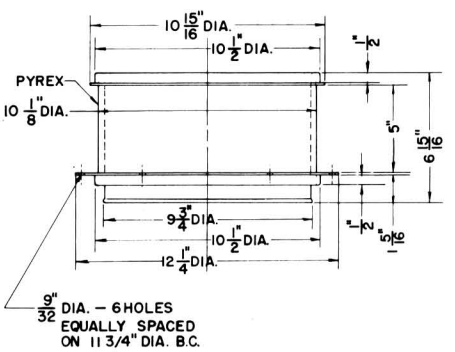
FOR ML-6427, ML-6697



AIR DISTRIBUTOR

Air Distributor for ML-6427 .... F-17798

Air Distributor for ML-6697 .... F-17759

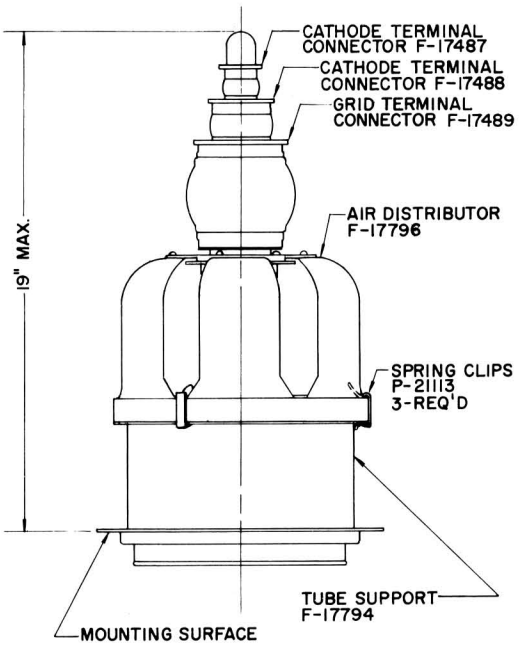


TUBE SUPPORT

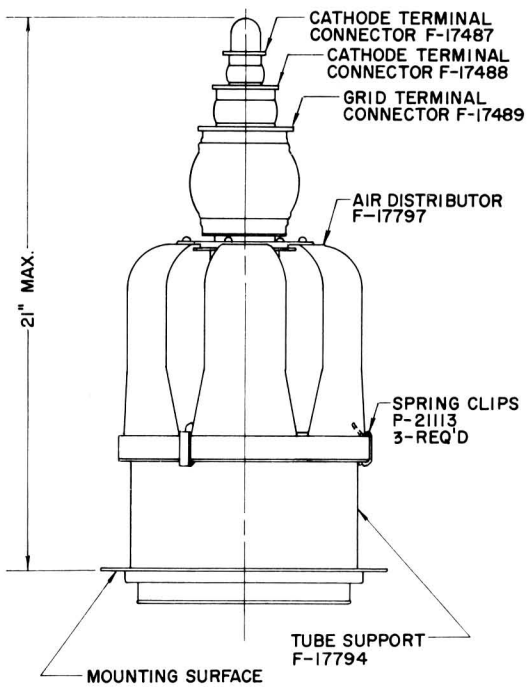
Tube Support for ML-6427, ML-6697 .... F-17795

ASSEMBLY OUTLINES

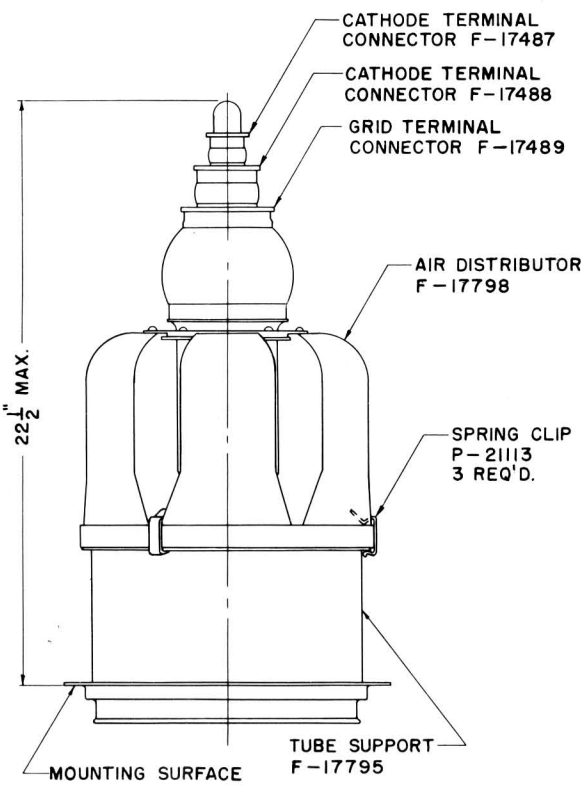
FOR ML-6421, ML-6423, ML-6425, ML-6427 & ML-6697



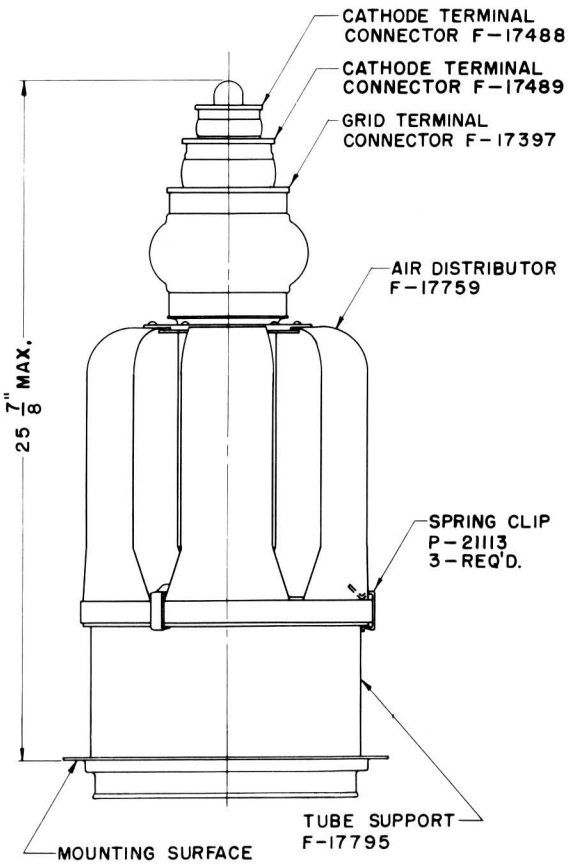
ML-6421



ML-6423 & ML-6425



ML-6427



ML-6697

ACCESSORIES FOR ML-6420, ML-6421, ML-6422, ML-6423, ML-6424, ML-6425, ML-6426, ML-6427, ML-6696 & ML-6697

ITEM	ORDER NUMBER
Filament Connector	F-17487
Filament Connector	F-17488
Filament Connector (ML-6696 & ML-6697) or Grid Connector (ML-6420 through ML-6427)	F-17489
Grid Connector (ML-6696 & ML-6697)	F-17397
Water Jacket	
For ML-6420	F-8529
For ML-6422	F-7963
For ML-6424	F-7963
O-Ring Gasket for above Jackets	P-7976
Mounting Clamp for above Jackets	F-8768†
Mounting Plate for any above Clamp and Jacket	F-8772
Water Jacket	
For ML-6426	F-17292
For ML-6696	F-17393
O-Ring Gasket for above Jackets	P-17494
Mounting Clamp for above Jackets	F-15198†
Mounting Plate for above Clamp or Jacket	F-15196‡
Air Distributor	
For ML-6421	F-17796
For ML-6423	F-17797
For ML-6425	F-17797
For ML-6427	F-17798
For ML-6697	F-17759
Spring Clips for above Air Distributors	P-21113
Tube Support for ML-6421, ML-6423 or ML-6425	F-17794
Tube Support for ML-6427 & ML-6697	F-17795

†For cantilever mounting, two mounting clamps and two standoff insulators should be employed.

‡Mounting Plate F-15196 requires use of Mounting Clamp F-15198.

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