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general

A QUICK GUIDE TO EIMAC PRODUCTS AND SERVICES OFFERED IN THIS CATALOG

GENERAL SECTION

This section contains general information applying to all Eimac products. It includes a Quick Reference Catalog, Price Lists, Eimac Tube Numbering System Chart, Tube Replacement Chart, Field Engineer and Distributor lists.

DIODES • RECTIFIERS PULSE MODULATORS TRIODES • TETRODES KLYSTRONS

Each of these sections include data sheets on current Eimac tube types, listing mechanical and electrical characteristics, typical operation data, and important application information.

OTHER PRODUCTS

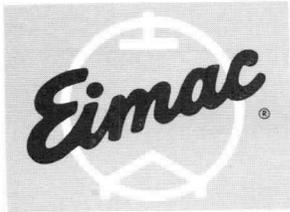
Data on all other Eimac products are found in this section. It includes information on Vacuum Capacitors, Air System Sockets and Chimneys, Contact Finger Stock, Heat Dissipating Connectors, Vacuum Pump and other products.

APPLICATION BULLETINS

Technical guides giving detailed information on the operation of Eimac products in specific applications are found in this section. This includes: Tube Performance Computer, Single Sideband, and other timely bulletins.

Application Engineering. The Eimac Application Engineering Department is available at all times for consultation. New tube operating techniques are continually being explored, tested and proved by Eimac engineers, whose combined knowledge and experience are at your service. Additional contributions by this Eimac department are its Application Bulletins, a service which you receive without obligation.

Field Engineering. Serving as an extension of the Application Engineering Department outside the Eimac plant, Eimac Field Engineers cover the United States, operating out of offices in major cities. They will help you personally with experimental work, problems of technique, etc. Engineers from Eitel-McCullough, Inc. are available, too, for field consultation throughout the country. As Eimac tubes are world renowned, the same services extend to various countries overseas through the Eimac Export Department.



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

Eimac Tube Type Numbering System

Since 1945 all new tube types developed by Eitel-McCullough, Inc. have been given a type number chosen according to a coded number system. This system is designed to convey descriptive information about the tube.

In general, the type numbers consist of: a numeral indicating the number of electrodes, one or more letters denoting special characteristics, a numeral representing the plate dissipation, and a final letter to distin-

guish the tube from others bearing similar preceding letters and numerals. Triode types carry an additional number to indicate their approximate amplification factor.

To illustrate the method of coding and the information the type number conveys, a 100-watt, ceramic, external-anode, forced-air cooled Eimac triode, type number 3CX100A5, is broken down as follows:

3CX100A5

Number of Electrodes

- 2—Diode
- 3—Triode
- 4—Tetrode
- 5—Pentode

Plate Dissipation (Watts)

Amplification Factor

- 1—0 to 10
- 2—11 to 20
- 3—21 to 30
- 4—31 to 50
- 5—51 to 100
- 6—101 to 200
- 7—201 to 500
- 8—501 to 1000

Description

- C—Ceramic Envelope (No Glass)
- L—External Anode, Liquid Convection Cooling
- N—External Anode, Natural Convection Air Cooling
- P—Primarily for Pulse Applications
- °R—Internal Anode, Radiation Cooled
- W—External Anode, Water Cooled
- X—External Anode, Forced-Air Cooled

°In older types, the dash, as in the case of the 4-250A, carries the meaning of "R" given above.

Version

Distinguishes tubes which, although alike as to number of electrodes and plate dissipation, are not necessarily interchangeable physically or electrically.



Eimac Tube-Type Numbering System for Power Klystrons

In general, Eimac power klystrons are described by a coded numbering system similar to that used to identify negative-grid tubes.

The type numbers contain: a numeral indicating the number of cavities along the beam, one or more letters denoting the type of tube and special characteristics if any, a numeral designating the collector

dissipation, and a pair of letters, the first describing the frequency band in which the tube operates and the second describing the sub-band in which it operates.

As an example, the type number describing an Eimac four-cavity klystron with modulating anode and 50,000-watt collector, designed for use in the "L" band is broken down as follows:

4KM50,000LR

Number of Cavities

Collector Dissipation

In klystron catalog numbers assigned prior to May 1, 1961 this was expressed in watts. In those assigned since that date it is expressed in kilowatts.

Sub-Band

Describes useful frequency sub-band. Since no standard sub-band assignment system exists Eimac has evolved its own.

Description

- K—Klystron
- M—Utilizes Eimac Modulating Anode
- P—Primarily for Pulse Applications

Frequency Band (Megacycles)

- P—225 to 390
- L—390 to 1550
- S—1550 to 3900
- C—3900 to 6200
- X—6200 to 10,900
- K—10,900 to 36,000
- Q—36,000 to 46,000
- V—46,000 to 56,000



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

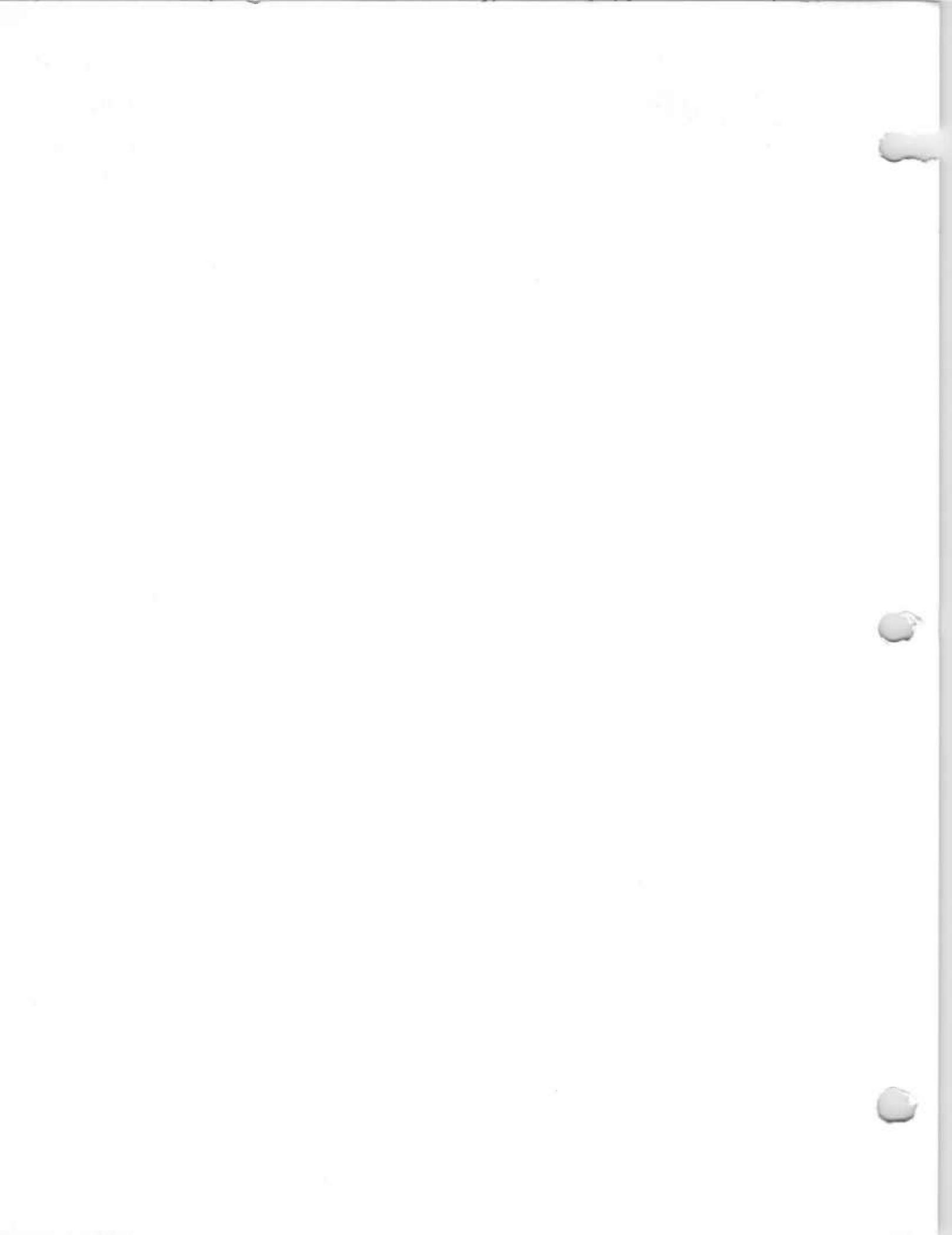
EIMAC and EIA

TUBE NUMBER

CROSS REFERENCE
SHEET

May, 1965

Eimac No.	EIA No.	EIA No.	Eimac No.
3-200A3.....	592	4D21.....	4-125A
3-400Z.....	8163	4E27A.....	5-125B
3-1000Z.....	8164	5D22.....	4-250A
3CPN10A5.....	7815	592.....	3-200A3
3CPX100A5.....	7815R	7034.....	4X150A
3CX100A5.....	7289	7035.....	4X150D
3CX100F5.....	8250	7203.....	4CX250B
3CX1000A7.....	8283	7204.....	4CX250F
3CX10,000A1.....	8158	7289.....	3CX100A5
3CX10,000A3.....	8159	7580W.....	4CX250R
3CX10,000A7.....	8160	7815.....	3CPN10A5
3W5000A1.....	8240	7815R.....	3CPX100A5
3W5000F1.....	8241	8158.....	3CX10,000A1
3W5000A3.....	8242	8159.....	3CX10,000A3
3W5000F3.....	8243	8160.....	3CX10,000A7
3X2500A3.....	8161	8161.....	3X2500A3
3X2500F3.....	8251	8162.....	3X3000F7
3X3000A1.....	8238	8163.....	3-400Z
3X3000F1.....	8239	8164.....	3-1000Z
3X3000F7.....	8162	8165.....	4-65A
4-65A.....	8165	8166.....	4-1000A
4-125A.....	4D21	8167.....	4CX300A
4-250A.....	5D22	8168.....	4CX1000A
4-400A.....	8438	8169.....	4CX3000A
4-1000A.....	8166	8170.....	4CX5000A
4CPX250K.....	8590	8170W.....	4CX5000R
4CV100,000C.....	8351	8171.....	4CX10,000D
4CW2000A.....	8244	8172.....	4X150G
4CW50,000C.....	8350	8173.....	4W20,000A
4CX250B.....	7203	8187.....	4PR65A
4CX250F.....	7204	8188.....	4PR400A
4CX250K.....	8245	8189.....	4PR1000A
4CX250M.....	8246	8238.....	3X3000A1
4CX250R.....	7580W	8239.....	3X3000F1
4CX300A.....	8167	8240.....	3W5000A1
4CX300Y.....	8561	8241.....	3W5000F1
4CX350A.....	8321	8242.....	3W5000A3
4CX350F.....	8322	8243.....	3W5000F3
4CX1000A.....	8168	8244.....	4CW2000A
4CX1000K.....	8352	8245.....	4CX250K
4CX3000A.....	8169	8246.....	4CX250M
4CX5000A.....	8170	8247.....	4PR125A
4CX5000R.....	8170W	8248.....	4PR250C
4CX10,000D.....	8171	8249.....	4W300B
4CX15,000A.....	8281	8250.....	3CX100F5
4CX35,000C.....	8349	8251.....	3X2500F3
4PR60B.....	8252	8252.....	4PR60B
4PR65A.....	8187	8281.....	4CX15,000A
4PR125A.....	8247	8283.....	3CX1000A7
4PR250C.....	8248	8296.....	4X150R
4PR400A.....	8188	8297.....	4X150S
4PR1000A.....	8189	8321.....	4CX350A
4W300B.....	8249	8322.....	4CX350F
4W20,000A.....	8173	8349.....	4CX35,000C
4X150A.....	7034	8350.....	4CW50,000C
4X150D.....	7035	8351.....	4CV100,000C
4X150G.....	8172	8352.....	4CX1000K
4X150R.....	8296	8438.....	4-400A
4X150S.....	8297	8561.....	4CX300Y
5-125B.....	4E27A	8590.....	4CPX250K





EIMAC

A Division of Varian Associates
S A N C A R L O S , C A L I F O R N I A

EIMAC and EIA
POWER GRID TUBE NUMBER
CROSS-REFERENCE LIST

EIMAC EIA POWER GRID TUBE

EIMAC to EIA

<i>Eimac No.</i>	<i>EIA No.</i>	<i>Eimac No.</i>	<i>EIA No.</i>	<i>Eimac No.</i>	<i>EIA No.</i>
KY21A.....	---	3X3000A7.....	---	4PR65A.....	8187
RX21A.....	---	3X3000F1.....	8239	4PR125A.....	8247
2-01C.....	---	3X3000F7.....	8162	4PR250C.....	8248
2-25A.....	---	4-65A.....	8165	4PR400A.....	8188
2-50A.....	---	4-125A.....	4D21	4PR1000A.....	8189
2-150D.....	---	4-250A.....	5D22	4PR1000B.....	---
2-240A.....	---	4-400A.....	8438	4W300B.....	8249
2-450A.....	---	4-1000A.....	8166	4W20,000A.....	8173
2-2000A.....	---	4CPX250K.....	8590	4X150A.....	7034
2C39A.....	2C39A	4CS250H.....	---	4X150D.....	7035
2C39WA.....	2C39WA	4CV8000A.....	---	4X150G.....	8172
2X1000A.....	---	4CV20,000A.....	---	4X150R.....	8296
2X3000F.....	---	4CV35,000A.....	---	4X150S.....	8297
322.....	---	4CV100,000C.....	8351	4X500A.....	---
3C24.....	3C24	4CW800A.....	---	5-125B.....	4E27A
3-200A3.....	592	4CW2000A.....	8244	5-500A.....	---
3-400Z.....	8163	4CW10,000A.....	---	5CX1500A.....	---
3-1000Z.....	8164	4CW25,000A.....	---	5CX3000A.....	---
3CPN10A5.....	7815	4CW50,000C.....	8350	6C21.....	6C21
3CPX100A5.....	7815R	4CW100,000D.....	---	25T.....	25T
3CV30,000A1.....	---	4CX125C.....	---	35T.....	35T
3CV30,000A3.....	---	4CX125F.....	---	35TG.....	35TG
3CW20,000A1.....	---	4CX250B.....	7203	75TH.....	75TH
3CW20,000A3.....	---	4CX250F.....	7204	75TL.....	75TL
3CW20,000A7.....	---	4CX250K.....	8245	100R.....	8020
3CW20,000H3.....	---	4CX250M.....	8246	100TH.....	100TH
3CW25,000A3.....	---	4CX250R.....	7580W	100TL.....	100TL
3CW30,000H3.....	---	4CX300A.....	8167	152TH.....	152TH
3CX100A5.....	7289	4CX300Y.....	8561	152TL.....	152TL
3CX100F5.....	8250	4CX350A.....	8321	250R.....	---
3CX1000A7.....	8283	4CX350F.....	8322	250TH.....	250TH
3CX2500A3.....	8161	4CX600A.....	---	250TL.....	250TL
3CX2500F3.....	8251	4CX1000A.....	8168	253.....	253
3CX10,000A1.....	8158	4CX1000K.....	8352	304TH.....	304TH
3CX10,000A3.....	8159	4CX1500B.....	8660	304TL.....	304TL
3CX10,000A7.....	8160	4CX3000A.....	8169	450TH.....	450TH
3CX15,000A3.....	---	4CX5000A.....	8170	450TL.....	450TL
3W5000A1.....	8240	4CX5000R.....	8170W	750TL.....	750TL
3W5000F1.....	8241	4CX10,000D.....	8171	1000T.....	1000T
3W5000A3.....	8242	4CX15,000A.....	8281	1500T.....	1500T
3W5000F3.....	8243	4CX35,000C.....	8349	2000T.....	2000T
3X3000A1.....	8238	4PR60B.....	8252		

NUMBER CROSS-REFERENCE LIST

EIA to EIMAC

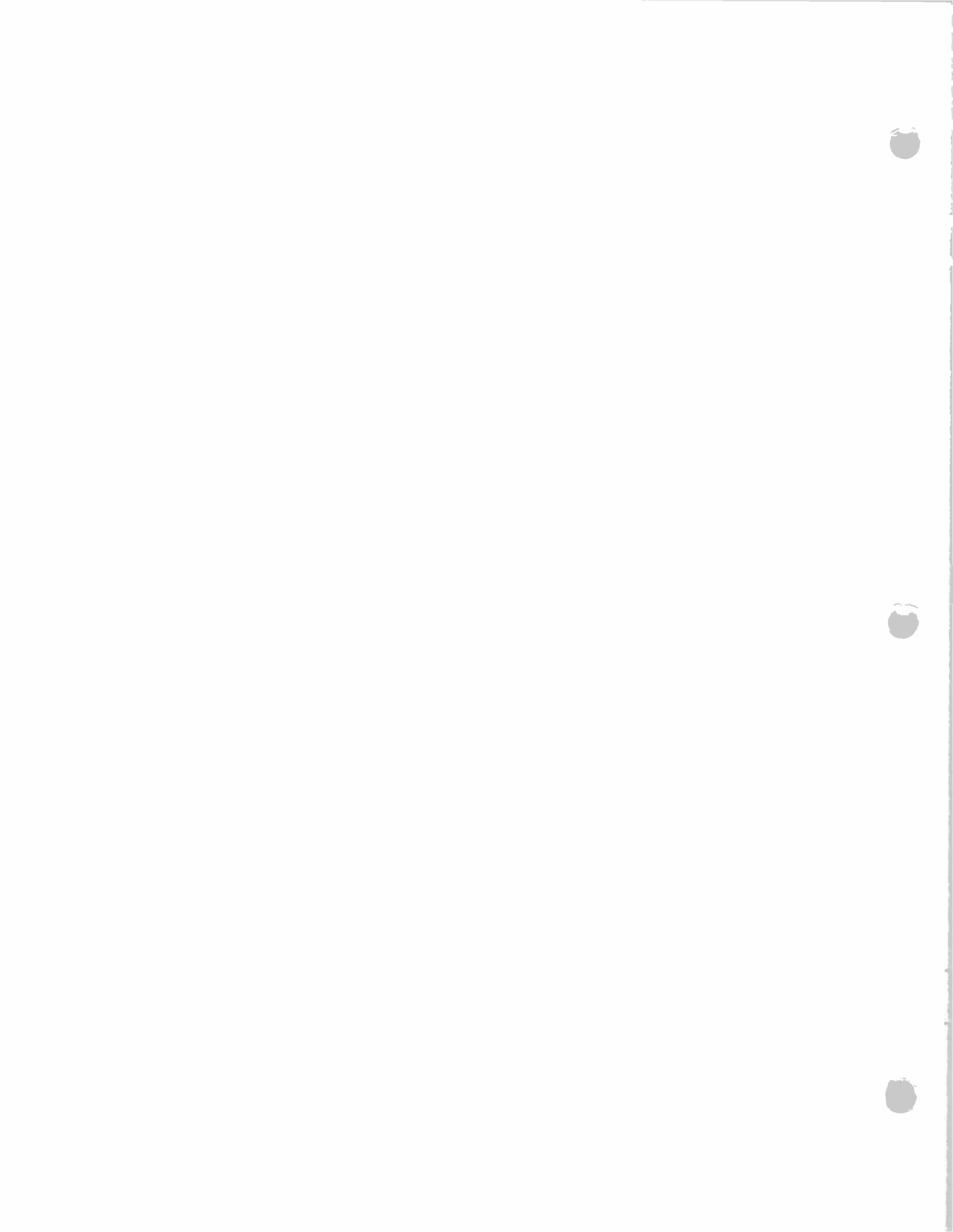
<i>EIA No.</i>	<i>Eimac No.</i>	<i>EIA No.</i>	<i>Eimac No.</i>	<i>EIA No.</i>	<i>Eimac No.</i>
2C39A.....	2C39A	6697A.....	—	8173.....	4W20,0000A
2C39WA.....	2C39WA	6884.....	—	8187.....	4PR65A
4D21.....	4-125A	6894.....	—	8188.....	4PR400A
4E27A.....	5-125B	6895.....	—	8189.....	4PR1000A
5D22.....	4-250A	7034.....	4X150A	8238.....	3X3000A1
6C21.....	6C21	7035.....	4X150D	8239.....	3X3000F1
25T.....	25T	7203.....	4CX250B	8240.....	3W5000A1
35T.....	35T	7204.....	4CX250F	8241.....	3W5000F1
35TG.....	35TG	7211.....	—	8242.....	3W5000A3
75TH.....	75TH	7289.....	3CX100A5	8243.....	3W5000F3
75TL.....	75TL	7480.....	—	8244.....	4CW2000A
100TH.....	100TH	7580W.....	4CX250R	8245.....	4CX250K
100TL.....	100TL	7698.....	—	8246.....	4CX250M
152TH.....	152TH	7815.....	3CPN10A5	8247.....	4PR125A
152TL.....	152TL	7815R.....	3CPX100A5	8248.....	4PR250C
250TH.....	250TH	7843.....	—	8249.....	4W300B
250TL.....	250TL	8020.....	100R	8250.....	3CX100F5
253.....	253	8158.....	3CX10,000A1	8251.....	3CX2500F3
304TH.....	304TH	8159.....	3CX10,000A3	8252.....	4PR60B
304TL.....	304TL	8160.....	3CX10,000A7	8281.....	4CX15,000A
450TH.....	450TH	8161.....	3CX2500A3	8283.....	3CX1000A7
450TL.....	450TL	8162.....	3X3000F7	8296.....	4X150R
575A.....	—	8163.....	3-400Z	8297.....	4X150S
592.....	3-200A3	8164.....	3-1000Z	8321.....	4CX350A
673.....	—	8165.....	4-65A	8322.....	4CX350F
750TL.....	750TL	8166.....	4-1000A	8349.....	4CX35,000C
869B.....	—	8167.....	4CX300A	8350.....	4CW50,000C
869B/L.....	—	8168.....	4CX1000A	8351.....	4CV100,000C
1000T.....	1000T	8169.....	4CX3000A	8352.....	4CX1000K
1500T.....	1500T	8170.....	4CX5000A	8438.....	4-400A
2000T.....	2000T	8170W.....	4CX5000R	8561.....	4CX300Y
5867A.....	—	8171.....	4CX10,000D	8590.....	4CPX250K
6696A.....	—	8172.....	4X150G	8660.....	4CX1500B





Varian EIMAC
301 Industrial Way
San Carlos, California
94070

POWER GRID TUBE SELECTION GUIDE



POWER GRID TUBE SELECTION GUIDE

The EIMAC Power Grid Tube Selection Guide is arranged for ease in making type selections by use rather than tube type. The Guide is applications-oriented.

Tube types are listed according to the principal modes of service for which they are rated. Under each mode of service, EIMAC tube types suitable for the application are tabulated in descending order of the most significant tube parameter in the left hand column. For example, in the POWER AMPLIFIER tabulation tube types are listed in descending order of typical

power output; PULSE REGULATOR tubes are listed in descending order of peak current capability. This format places emphasis on tube application and facilitates comparison in terms of the significant ratings of the EIMAC types available for a given application.

After preliminary selection of a tube type (or types) from the Guide, the final choice should be based upon the complete ratings from the EIMAC data sheet for the tube in question and consultation with the EIMAC Application Engineering Department.

RADIO FREQUENCY POWER AMPLIFIER

Linear Service

Peak Env. Power† Typical (kW—W)	Rated Plate Diss. (kW—W)	Frequency* F1/ Upper Useful (MHz)	Inter-Mod. Distortion Typical†		Cooling	EIMAC Type Number	Tube Type
			3rd (dB)	5th (dB)			
1180 kW	1250 kW	30/50	—	—	water	8974/X-2159	Tetrode
600 kW	650 kW	50/100	—	—	water	8973/X-2170	Tetrode
230 kW	250 kW	30/50	-31	-43	vapor	4CV250,000B	Tetrode
230 kW	250 kW	30/50	-31	-43	water	4CW250,000B	Tetrode
168 kW	100 kW	108/150	—	—	water	4CW100,000E	Tetrode
123 kW	100 kW	30/50	-26	-40	vapor	4CV100,000C	Tetrode
55 kW	35 kW	30/50	-30	-40	air	4CX35,000C	Tetrode
45 kW	50 kW	110/200	-46	-60	vapor	4CV50,000J	Tetrode
45 kW	50 kW	110/200	-46	-60	water	4CW50,000J	Tetrode
27.5 kW	20 kW	110/220	—	—	air	3CX20,000A7	Triode ²
17 kW	15 kW	110/220	-40	-39	air	3CX15,000A7	Triode ¹
17 kW	20 kW	140/220	-40	-39	water	3CW20,000A7	Triode ¹
17 kW	10 kW	140/220	-40	-39	air	3CX10,000A7	Triode ¹
12 kW	15 kW	110/220	-41	-41	air	4CX15,000J	Tetrode
10.5 kW	10 kW	100/220	-35	-40	air	4CX10,000J	Tetrode
10 kW	10 kW	250/—	—	—	air	3CX10,000U7	Triode ^{1, 2}
10 kW	5 kW	100/220	-30	-38	air	4CX5000R	Tetrode
5.8 kW	3 kW	150/220	-40	-43	air	5CX3000A	Pentode
5.5 kW	3 kW	110/—	-51	-45	air	3CX3000A7	Triode ¹
5.3 kW	3 kW	150/220	-32	-36	air	4CX3000A	Tetrode
3.3 kW	5 kW	100/220	-41	-44	air	4CX5000J	Tetrode
2060 W	1 kW	220/400	-31	-39	air	3CX1000A7	Triode ¹
2050 W	1500 W	220/400	-38	-44	air	3CX1500A7/8877	Triode ¹
2030 W	1500 W	500/—	-44	-44	air	8938	Triode ¹
1785 W	1500 W	110/220	-33	-42	air	5CX1500A	Pentode
1160 W	1000 W	110/220	-43	-47	air	4CX1500B	Tetrode
1080 W	1000 W	110/—	-29	-37	air	3-1000Z	Triode ¹
740 W	500 W	110/—	-40	-45	air	3-500Z	Triode ¹
645 W	500 W	110/—	-33	-41	air	5-500A	Pentode
590 W	200 W	500/900	-35	-36	conduction	8873	Triode ¹
590 W	400 W	500/900	-35	-36	air	8874	Triode ¹
590 W	300 W	500/900	-35	-36	air	8875	Triode ¹
590 W	400 W	110/—	-28	-35	air	3-400Z	Triode ¹
580 W	600 W	30/—	-43	-43	air	4CX600J	Tetrode
495 W	400 W	110/—	—	—	air	4-400C	Tetrode
350 W	350 W	500/—	-27	-50	air	8930	Tetrode
295 W	250 W	500/—	-25	-30	air	4CX250R	Tetrode
295 W	250 W	500/—	-25	-30	conduction	4CS250R	Tetrode
263 W	350 W	30/220	-30	-35	air	4CX350A	Tetrode
263 W	350 W	30/220	-30	-35	air	4CX350F	Tetrode
263 W	350 W	30/220	-40	-45	air	4CX350FJ	Tetrode

‡Plate power output, calculated or measured at low frequency.

*F1 is the maximum frequency at which maximum ratings apply. Operation at the upper useful frequency normally involves operation at reduced plate voltage and reduced plate input power.

†Calculated or measured by two-tone method at 2.0 MHz.

1. Cathode driven. 2. VHF TV

RF POWER AMPLIFIER

Class C, CW or FM Service

Plate Pwr. Output Typical* (kW—W)	Rated Plate Diss. (kW—W)	Frequency [†] F1/ Upper Useful (MHz)	Power Gain*	Cooling	EIMAC Type Number	Tube Type
1650 kW	1250 kW	30/50	x200	water	8974/X-2159	Tetrode
1050 kW	650 kW	50/100	x300	water	8973/X-2170	Tetrode
460 kW	250 kW	30/50	x150	vapor	4CV250,000B	Tetrode
460 kW	250 kW	30/50	x150	water	4CW250,000B	Tetrode
220 kW	100 kW	108/150	x1800	water	4CW100,000E	Tetrode
168 kW	100 kW	30/50	x1350	vapor	4CV100,000C	Tetrode
165 kW	100 kW	30/50	x140	water	4CW100,000D	Tetrode
137 kW	50 kW	110/220	x900	vapor	4CV50,000E	Tetrode
137 kW	50 kW	110/220	x900	water	4CW50,000E	Tetrode
110 kW	35 kW	30/50	x425	air	4CX35,000C	Tetrode
64 kW	20 kW	90/150	x66	air	3CX20,000A3/H3	Triode
42 kW	25 kW	100/150	x37	water	3CW25,000A3	Triode
38 kW	20 kW	110/220	x170	air	4CX20,000A/8990	Tetrode
36.5 kW	15 kW	110/225	x166	air	4CX15,000A	Tetrode
30 kW	15 kW	100/150	x45	air	3CX15,000A3	Triode
25 kW	15 kW	110/160	x50	air	3CX15,000A7	Triode
24.5 kW	10 kW	140/200	x6	air	3CX10,000A3	Triode ¹
24.5 kW	20 kW	140/200	x6	water	3CW20,000A3	Triode ¹
22.5 kW	10 kW	160/—	x15	air	3CX10,000A7	Triode
20 kW	15 kW	220/—	x850	air	8989	Tetrode
16 kW	5 kW	100/220	x1050	air	4CX5000A	Tetrode
16 kW	10 kW	100/220	x1050	air	4CX10,000D	Tetrode
16 kW	10 kW	100/220	x1050	water	4CW10,000A	Tetrode
16 kW	5000 W	100/220	x1050	air	4CX5000R	Tetrode
11 kW	3000 W	30/100	x260	air	4CX3000A	Tetrode
10 kW	4000 W	75/150	x73	air	3CX2500A3/F3	Triode
10 kW	5000 W	75/150	x73	water	3CW5000A3/F3	Triode
8500 W	3000 W	150/220	x160	air	5CX3000A	Pentode
3400 W	1000 W	110/—	x225	air	4-1000A	Tetrode
3200 W	1500 W	110/220	x350	air	4CX1500A	Tetrode
3180 W	1500 W	110/220	x350	air	5CX1500A	Pentode
2600 W§	1500 W	250/—	x33	air	3CX1500A7/8877	Triode ¹
1500 W§§	1500 W	500/—	x30	air	8938	Triode ¹
1265 W	500 W	110/—	x140	air	4-500A	Pentode
1100 W	400 W	110/—	x190	air	4-400C	Tetrode
1000 W	250 W	110/—	x190	air	4-250A	Tetrode
840 W	350 W	100/150	x31	air	5867A	Triode
805 W	500 W	110/—	x67	air	4-500A	Tetrode
600 W	300 W	110/220	x158	air	4CX300Y	Tetrode
500 W	300 W	500/—	x177	air	4CX300A	Tetrode
450 W	350 W	500/—	x190	air	8930	Tetrode
380 W	250 W	500/—	x190	conduction	4CS250R	Tetrode
380 W	250 W	500/—	x130	air	4CX250B/FG	Tetrode
380 W	250 W	500/1500	x130	air	4CX250K/M	Tetrode
380 W	250 W	500/—	x190	air	4CX250R	Tetrode
380 W	250 W	150/500	x130	air	4X150A/7609	Tetrode
375 W	125 W	120/—	x150	air	4-125A	Tetrode
320 W	200 W	500/—	x35	conduction	8873	Triode
320 W	400 W	500/—	x35	air	8874	Triode
320 W	300 W	500/—	x35	air	8875	Triode
300 W	600 W	1000/—	x31.5	air	3CX600U7	Triode
270 W	65 W	150/—	x160	convection	4-65A	Tetrode
216 W	400 W	1000/—	x11.5	air	3CX400U7	Triode ²

*Power output and power gain are calculated or measured at low frequency.

†F1 is the maximum frequency at which maximum ratings apply. Operation at the upper useful frequency normally involves operation at reduced anode voltage and reduced plate input power.

§Power output shown is measured useful, delivered to load, at 104 MHz.

§§Useful power output, measured at 430 MHz.

1. Cathode driven. 2. 900 MHz.

R F POWER AMPLIFIER

Class C—Plate Modulated Service

Carrier Pwr. Output Typical* (kW—W)	Plate Diss. at Typical Conditions (kW—W)	Frequency† F1/ Upper Useful (MHz)	Power Gain*	Cooling	EIMAC Type Number	Tube Type
1375 kW	300 kW	30/50	x200	water	8974/X-2159	Tetrode
700 kW	160 kW	50/100	x290	water	8973/X-2170	Tetrode
285 kW	119 kW	30/50	x120	vapor	4CV250,000B	Tetrode
285 kW	119 kW	30/50	x120	water	4CW250,000B	Tetrode
140 kW	47 kW	30/50	x110	vapor	4CV100,000C	Tetrode
140 kW	35 kW	108/150	x260	water	4CW100,000E	Tetrode
138 kW	22 kW	30/50	x160	water	4CW100,000D	Tetrode
110 kW	22 kW	110/220	x160	water	4CW50,000E	Tetrode
110 kW	22 kW	110/220	x160	vapor	4CV50,000E	Tetrode
55 kW	13 kW	30/50	x440	air	4CX35,000C	Tetrode
29 kW	7 kW	30/—	x800	air	8990A	Tetrode
27.5 kW	7.5 kW	90/150	x18	air	3CX20,000A3	Triode
27.5 kW	7.5 kW	90/150	x18	air	3CX20,000H3	Triode
23.5 kW	5.8 kW	110/225	x155	air	4CX15,000A	Tetrode
23.5 kW	5.8 kW	110/225	x155	vapor	4CV35,000A	Tetrode
18.0 kW	5.4 kW	100/150	x37	air	3CX15,000A3	Triode
12.4 kW	2.6 kW	140/200	x24	air	3CX10,000A3	Triode
8.5 kW	3.5 kW	100/220	x230	air	4CX10,000D	Tetrode
8.5 kW	3.5 kW	100/220	x230	air	4CX5000A	Tetrode
8.5 kW	3.5 kW	100/220	x230	air	4CX5000R	Tetrode
5.75 kW	1.25 kW	150/220	x190	air	4CX3000A	Tetrode
5300 W	950 W	75/150	x45	air	3CX2500A3/F3	Triode
2630 W	670 W	110/—	x290	air	4-1000A	Tetrode
2320 W	780 W	110/220	x230	air	4CX1500A	Tetrode
1960 W	575 W	110/220	x195	air	5CX1500A	Pentode
1765 W	485 W	110/—	x50	air	3-1000Z	Triode
830 W	245 W	110/—	x140	air	4-500A	Tetrode
785 W	280 W	110/—	x110	air	5-500A	Pentode
640 W	185 W	110/—	x25	air	3-500Z	Triode
630 W	195 W	110/—	x190	air	4-400C	Tetrode
510 W	165 W	110/—	x160	air	4-250A	Tetrode
300 W	80 W	120/—	x90	air	4-125A	Tetrode
300 W	200 W	110/220	x175	air	4CX300Y	Tetrode
270 W	280 W	500/—	x160	air	8930	Tetrode
235 W	65 W	500/—	x160	conduction	4CS250R	Tetrode
235 W	65 W	500/—	x135	air	4CX250B	Tetrode
235 W	65 W	500/—	x135	air	4CX250FG	Tetrode
235 W	65 W	500/1500	x135	air	4CX250K	Tetrode
235 W	65 W	500/1500	x135	air	4CX250M	Tetrode
235 W	65 W	500/—	x160	air	4CX250R	Tetrode
235 W	65 W	500/—	x135	air	4CX300A	Tetrode
235 W	65 W	150/500	x135	air	4X150A	Tetrode
235 W	65 W	150/500	x135	air	7609	Tetrode
210 W	45 W	150/—	x65	convection	4-65A	Tetrode

*Power output and power gain are calculated or measured at low frequency.

†F1 is the maximum frequency at which maximum ratings apply. Operating at the upper useful frequency normally involves operation at reduced plate voltage and reduced plate input power.

Class C—Oscillator or Amplifier

Plate Pwr. Output Typical* (kW—W)	Rated Plate Diss. (kW—W)	Filament Heating Power (Watts)	Frequency† F1/ Upper Useful (MHz)	Cooling	EIMAC Type Number	Tube Type
1600 kW	1000 kW	26640	30/60	water	8972/X-2176	Triode
750 kW	500 kW	13320	30/60	water	8971/X-2177	Triode
70 kW	40 kW	1600	90/—	water	3CW40,000H3	Triode
60 kW	20 kW	1600	90/—	air	3CX20,000H3	Triode
42 kW	30 kW	1020	90/—	water	3CW30,000H3	Triode
42 kW	30 kW	1020	100/—	vapor	3CV30,000H3	Triode
41.2 kW	15 kW	1020	90/—	air	3CX15,000H3	Triode
29 kW	10 kW	742	90/—	air	3CX10,000H3	Triode
28 kW	20 kW	742	90/—	water	3CW20,000H3	Triode
20.6 kW	10 kW	566	90/—	water	3CW10,000H3	Triode
18.6 kW	5 kW	566	90/—	air	3CX5000H3	Triode
10 kW	5 kW	379	75/150	water	3CW5000H3	Triode
8.3 kW	4.5 kW	550	75/—	air	3CX4500A3/H3	Triode
5 kW	2.5 kW	379	75/150	air	3CX2500A3/F3/H3	Triode
2.0 kW	1.0 kW	150	100/—	air	3-1000H	Triode
1.2 kW	300 W	125	40/80	air	304TL	Triode
680 W	350 W	70	100/—	air	5867A	Triode

*Plate power output, calculated or measured at low frequency.

†F1 is the maximum frequency at which maximum ratings apply. Operation at the upper useful frequency normally involves operation at reduced plate voltage and reduced plate input power.

REGULATOR SERVICE

Voltage or Current

Maximum Pass Current (A dc)	Maximum Hold-off Voltage* (kVdc)	Minimum Tube Drop (Vdc)	Rated Plate Diss. (kW—W)	Cooling	EIMAC Type Number	Tube Type
300	40 kV	3000	1250 kW	water	8974/X-2159	Tetrode
150	40 kV	2500	650 kW	water	8973/X-2170	Tetrode
90	130 kV	2000	1000 kW	water	9009/X-2062K	Tetrode
90	100 kV	2000	300 kW	water	9008/X-2062J	Tetrode
50	40 kV	4400	250 kW	water	4CW250,000B	Tetrode
35	40 kV	2700	100 kW	water	4CW100,000E	Tetrode
30	40 kV	3300	100 kW	water	4CW100,000D	Tetrode
15	35 kV	3000	50 kW	water	4CW50,000E	Tetrode
15	40 kV	2200	35 kW	air	4CX35,000C	Tetrode
7.5	10 kV	1500	20 kW	water	3CW20,000A1	Triode
7.5	20 kV	1200	20 kW	water	3CW20,000A7	Triode
7	10 kV	1300	12 kW	air	3CX10,000A1	Triode
6	20 kV	800	25 kW	water	4CW25,000A	Tetrode
4	20 kV	500	15 kW	air	3CX15,000A7	Triode
4	15 kV	2000	10 kW	water	4CW10,000A	Tetrode
3	12 kV	1300	5000 W	water	3CW5000A1	Triode
2	12 kV	1000	3000 W	air	3CX3000F1	Triode
2	6 kV	1000	2000 W	water	4CW2000A	Tetrode
1	8 kV	250	1500 W	air	3CX1500A7	Triode
1	6 kV	500	1000 W	air	4CX1000A	Tetrode
1	6 kV	500	800 W	water	4CW800B	Tetrode
1	6 kV	500	800 W	water	4CW800F	Tetrode
0.8	4.5 kV	300	400 W	air	8874	Triode
0.8	4.5 kV	300	300 W	air	8875	Triode
0.8	4.5 kV	300	200 W	conduction	8873	Triode
0.6	30 kV	500	100 W	air	4PR1000A	Tetrode
0.6	8 kV	400	500 W	air	3-500Z	Triode
0.2	20 kV	1800	400 W	air	4PR400A	Tetrode
0.2	50 kV	1000	250 W	air	4PR250C	Tetrode
0.1	18 kV	1200	125 W	air	4PR125A	Tetrode
0.1	15 kV	500	65 W	convection	4PR65A	Tetrode

*Consult EIMAC Application Engineering Department at the appropriate plant for regulator range characteristics.

RF POWER AMPLIFIER

Grid Pulsed Service

Peak RF Pwr. Output Typical ^a (kW—W)	Rated Plate Diss. (kW—W)	Frequency† F1/Upper Useful (MHz)	Maximum Plate Voltage (kVdc)	Maximum Plate Current ^a (A)	Cooling	EIMAC Type Number	Tube Type
3900 kW	1250 kW	30/50	30	195	water	8974/X-2159	Tetrode
2000 kW	650 kW	50/100	30	100	water	8973/X-2170	Tetrode
1000 kW	100 kW	108/150	30	50	water	4CW100,000E	Tetrode
500 kW	50 kW	110/220	30	33	vapor	4CV50,000E	Tetrode
500 kW	50 kW	110/220	30	33	water	4CW50,000E	Tetrode
160 kW	15 kW	110/225	12	20	air	4CX15,000A	Tetrode
80 kW	10 kW	110/220	10	13	air	4CX10,000D	Tetrode
80 kW	10 kW	110/220	10	13	air	4CX5000A	Tetrode
80 kW	10 kW	100/220	10	13	air	4CX5000R	Tetrode
34 kW	1.0 kW	110/—	15	3.5	air	4PR1000A	Tetrode
28 kW*	250 W	500/1500	7	6.0	air	4CPX250K	Tetrode
28 kW*	250 W	500/1500	7	6.0	air	4CX250K	Tetrode
28 kW*	250 W	500/1500	7	6.0	air	4CX250M	Tetrode
26 kW	1500 W	500/—	5	8	air	8938	Triode
11 kW	400 W	110/—	10	1.7	air	4PR400A	Tetrode
10 kW‡	250 W	500/1500	5.5	0.8	air	4CPX250K	Tetrode
4000 W	125 W	120/—	9	0.7	air	4PR125A	Tetrode
2600 W	300 W	110/220	3	1.3	air	4CX300Y	Tetrode
2000 W	65 W	150/—	7.5	0.4	convection	4PR65A	Tetrode
1600 W	200 W	500/—	3	0.8	conduction	8873	Triode
1600 W	400 W	500/—	3	0.8	air	8874	Triode
1600 W	300 W	500/—	3	0.8	air	8875	Triode
1600 W	250 W	500/—	3	0.8	air	4CX250B	Tetrode
1600 W	250 W	500/—	3	0.8	air	4CX250F	Tetrode
1600 W	250 W	500/1500	3	0.8	air	4CX250K	Tetrode
1600 W	250 W	500/1500	3	0.8	air	4CX250M	Tetrode

^aAverage during the pulse. Power output data is plate power (does not include circuit losses), calculated or measured at low frequency.

† F1 is the maximum frequency at which maximum ratings apply. Operation at the upper useful frequency normally involves operation at reduced plate voltage and reduced plate power input.

*Plate and screen-grid pulsed.

‡ Cathode driven, screen pulsed.

AF POWER AMPLIFIER OR MODULATOR SERVICE

AF Pwr. Output Typical (2 tubes) (kW—W)	Plate Diss. at Typical Conditions Per Tube (kW—W)	Class of Service	Driving Power (2 tubes) (W)	Cooling	EIMAC Type Number	Tube Type
1900 kW	420 kW	AB1	0	water	8974/X-2159	Tetrode
950 kW	210 kW	AB1	0	water	8973/X-2170	Tetrode
660 kW	260 kW	AB1	0	vapor	4CV250,000B	Tetrode
660 kW	260 kW	AB1	0	water	4CW250,000B	Tetrode
246 kW	57 kW	AB1	0	vapor	4CV100,000C	Tetrode
246 kW	57 kW	AB1	0	water	4CW100,000D	Tetrode
200 kW	46 kW	AB1	0	water	4CW100,000E	Tetrode
195 kW	42 kW	AB1	0	water	4CW50,000E	Tetrode
195 kW	42 kW	AB1	0	vapor	4CV50,000E	Tetrode
195 kW	42 kW	AB1	0	vapor	4CV50,000J	Tetrode
195 kW	42 kW	AB1	0	water	4CW50,000J	Tetrode
70 kW	20 kW	AB1	0	air	4CX35,000C	Tetrode
66 kW	20.5 kW	AB1	0	vapor	4CV35,000A	Tetrode
57 kW	14 kW	AB1	0	water	4CW25,000A	Tetrode
57 kW	14 kW	AB1	0	air	4CX15,000A	Tetrode
31.9 kW	9 kW	AB1	0	air	4CX10,000D	Tetrode
29.1 kW	10 kW	AB1	0	air	3CX10,000A1	Triode
29.1 kW	10 kW	AB1	0	water	3CW20,000A1	Triode
17.5 kW	4.20 kW	AB1	0	air	4CX5000A	Tetrode
17.5 kW	4.20 kW	AB1	0	air	4CX5000R	Tetrode
14.5 kW	4.75 kW	AB1	0	vapor	4CV8000A	Tetrode
13.0 kW	2.50 kW	AB2	113	water	3CW5000A3/F3	Triode
13.0 kW	2.50 kW	AB2	113	air	3CX2500A3/F3	Triode
11.4 kW	3.30 kW	AB1	0	air	4CX3000A	Tetrode
10.0 kW	2.95 kW	AB1	0	water	3CW5000A1/F1	Triode
10.0 kW	2.95 kW	AB1	0	air	3CX3000A1/F1	Triode
3.90 kW	900 W	AB2	4.7	air	4-1000A	Tetrode
3.22 kW	920 W	AB1	0	air	5CX1500A	Pentode
3.20 kW	920 W	AB1	0	air	4CX1500A	Tetrode
1.72 kW	500 W	AB1	0	air	4-500A	Tetrode
1.66 kW	458 W	AB1	0	air	5-500A	Pentode
1.75 kW	400 W	AB2	3.5	air	4-400C	Tetrode
1.42 kW	445 W	AB2	25	air	3-500Z	Triode
1.31 kW	340 W	AB2	26	air	3-400Z	Triode
1.04 kW	190 W	AB2	1.9	air	4-250A	Tetrode
800 W	225 W	AB1	0	air	4CX300A	Tetrode
780 W	350 W	AB1	0	air	8930	Tetrode
600 W	200 W	AB1	0	air	4CX250BC 4CX250F 4X150A 7609	Tetrode
400 W	125 W	AB2	1.0	air	4-125A	Tetrode
270 W	63 W	AB2	1.3	convection	4-65A	Tetrode

SWITCH TUBE OR PULSED REGULATOR SERVICE

Peak Plate Current* (A)	Maximum Hold-off Voltage (kVdc)	Rated Plate Diss.* (kW—W)	Cooling	EIMAC Type Number	Tube Type
780	60	1250 kW	water	8974/X-2159	Tetrode
400	60	650 kW	water	8973/X-2170	Tetrode
300	40	250 kW	water	4CW250,000B	Tetrode
150	130	1000 kW	water	9009/X-2062K	Tetrode
150	100	400 kW	water	9008/X-2062J	Tetrode
150	75	100 kW	water	Y-676A	Tetrode
150	60	35 kW	air	Y-546	Tetrode ¹
150	60	100 kW	water	Y-647	Tetrode ²
150	40	100 kW	water	4CW100,000D	Tetrode
150	60	100 kW	water	Y-676	Tetrode ³
150	40	100 kW	water	4CW100,000E	Tetrode
150	40	35 kW	air	4CX35,000C	Tetrode
100	35	50 kW	water	4CW50,000E	Tetrode
100	35	50 kW	vapor	4CV50,000E	Tetrode
70	20	25 kW	water	4CW25,000A	Tetrode
60	20	15 kW	air	4CX15,000A	Tetrode
60	30	15 kW	air	Y-456	Tetrode ⁴
50	30	25 kW	water	Y-569	Tetrode ⁵
50	15	1.5 kW	air	3CPX1500A7	Triode
40	15	10 kW	air	4CX10,000D	Tetrode
40	20	20 kW	water	3CW20,000A7	Triode
40	15	5 kW	air	4CX5000A	Tetrode
40	15	5 kW	air	4CX5000R	Tetrode
40	25	10 kW	water	Y-442	Tetrode ⁶
25	20	3 kW	air	4CX3000A	Tetrode
18	20	60 W	air	4PR60C	Tetrode
15	10	3 kW	air	3CX3000A7/F7	Triode
12	4	600 W	air	4CX600B/F	Tetrode
12	4	800 W	water	4CW800B/F	Tetrode
12	15	750 W	air	8941	Planar Triode
12	8	750 W	air	8942	Planar Triode
12	4	750 W	air	8940	Planar Triode
10	50	1.0 kW	air	8960	Tetrode
10	7	1.5 kW	air	4CX1500A	Tetrode
8	30	1.0 kW	air	4PR1000A	Tetrode
8	40	1.0 kW	air	Y-364	Tetrode ⁷
8	7.5 (oil)	600 W	air or oil	8954	Tetrode
6	12	150 W	air	Y-518	Planar Triode
6	7	250 W	air	4CPX250K	Tetrode
6	4	150 W	air	Y-519	Planar Triode
5	12	150 W	air	Y-540	Planar Triode
5	10	150 W	air	8755	Planar Triode
5	4	150 W	air	8847A	Planar Triode
5	3.5	100 W	air	7211	Planar Triode
5	3.5	150 W	air	8757	Planar Triode
5	3.5	100 W	air	8403	Planar Triode
4	50	250 W	air	4PR250C	Tetrode
4	20	400 W	air	4PR400A	Tetrode
3	10	400 W	air	Y-504	Triode ⁸
3	4.5	100 W	air	7815RAL	Planar Triode
3	3.5	100 W	air	7815R	Planar Triode
3	3.5	100 W	air	7855	Planar Triode
2.1	18	125 W	air	4PR125A	Tetrode
1.5	4.5	100 W	air	8745	Planar Triode
1.2	15	65 W	convection	4PR65A	Tetrode

¹ Specially processed 4CX35,000C

⁵ Prototype 4CW25,000A

² Specially processed 4CW100,000D

⁶ Specially processed 4CX5000R

³ Specially processed 4CW100,000E

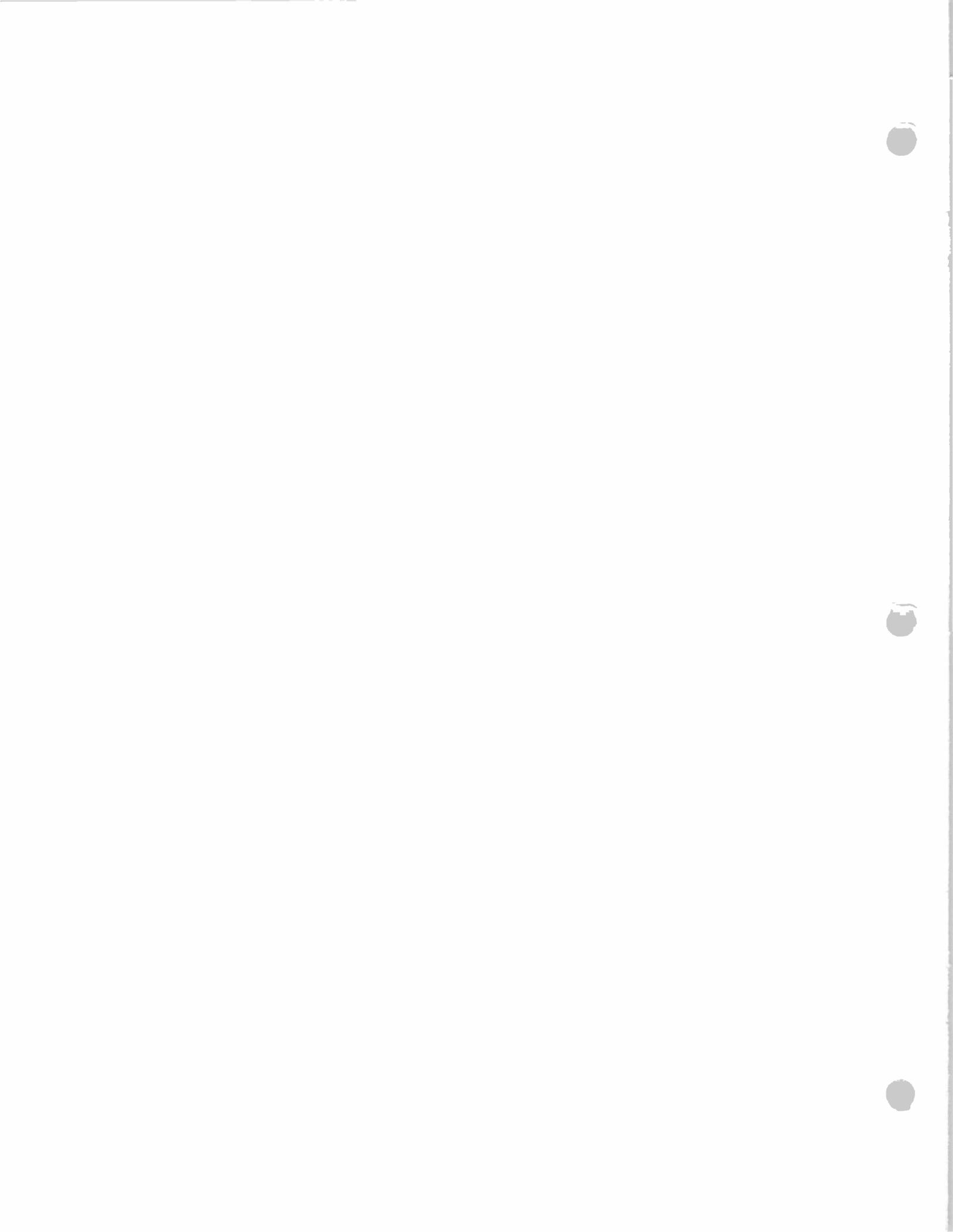
⁷ Specially processed 4PR1000A

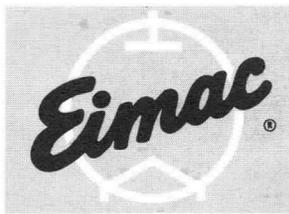
⁴ Specially processed 4CX15,000A

⁸ Specially processed 3-400Z

*Contact EIMAC Application Engineering Department at the appropriate plant for peak pulse ratings.







E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

NUMBER 5
**TUBE
 PERFORMANCE
 COMPUTER**
 DETAILED INSTRUCTIONS

TUBE PERFORMANCE COMPUTER FOR R-F AMPLIFIERS (CLASS B, C, AND FREQUENCY MULTIPLIERS)

It is quite easy to make a close estimate of the performance of a vacuum tube in radio-frequency power-amplifier service, or an approximation in the case of harmonic-amplifier service. Such estimates will give r-f output power, d-c input power, grid driving power, and all d-c current values.

These estimates can be made easily by using the Eimac Tube Performance Computer and the characteristic curves of a tube, plotted on plate-voltage/grid-voltage coordinates (constant-current curves). Only the ability to multiply figures taken from the curves, by means of the computer, is required.

By graphically laying out the trace of the plate and grid voltages as they rise and fall about the applied d-c plate voltage and d-c grid bias, a clear understanding of the action taking place within a tube is possible. With such an understanding the operating conditions can be altered readily to suit one's particular requirements.

**Simple Action in
 Class-C R-F Amplifiers**

In an amplifier a varying voltage is applied to the control grid of the tube. Simultaneously the plate voltage will vary in a similar manner, due to the action of the amplified current flowing in the plate circuit. In radio-frequency applications with resonant circuits, these voltage variations are smooth sine-wave variations, 180° out of phase (as the grid voltage rises and becomes *more* positive, the plate voltage falls and becomes *less* positive) as indicated in Fig. 1. Note how these variations center about the d-c plate voltage and the d-c control-grid bias.

Let us now see how such variations of the plate and grid voltages of a tube appear on the constant-current curves of a tube. In Fig. 2 these variations have been indicated next to the plate-voltage and grid-voltage scales of a typical constant-current curve. At some instant of time, shown as "t" on the time scales, the grid voltage

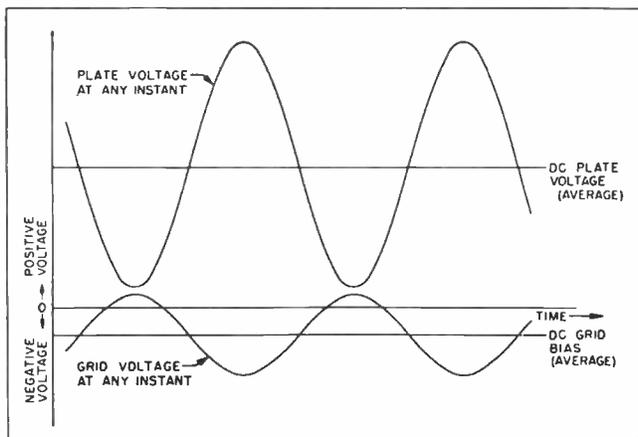


Figure 1

has a value which is the point marked "eg" on the grid-voltage sine wave. If one now finds the point on the tube curves corresponding to these values (where a line drawn from "eg" and a line drawn from "ep" cross) he will be at point A in Fig. 2. As the values of grid voltage "eg" and plate voltage "ep" vary over the r-f cycle, the point A moves up and down a line, which in the case of the normal r-f power amplifier is a straight line. This line is called the "Operating Line."

Any point on the operating line (when drawn on constant-current curves as in Fig. 2 or Fig. 4) tells the instantaneous values of plate current, screen current, and grid current which must flow when those particular values of grid and plate voltage are applied to the tube. Thus by reading off the values of the currents and plotting them against the time "t", one can obtain a curve of

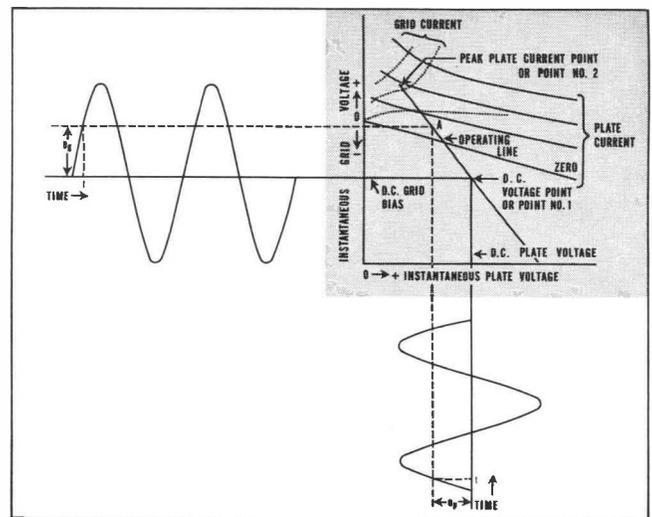


Figure 2

instantaneous values of plate and grid current. See Fig. 3.

If we analyze the plate and grid-current values shown, we can predict that they will cause a d-c ammeter to show a particular reading. This is called the d-c component of the current. Also, we can predict that if the plate current flows through a properly loaded resonant r-f circuit a certain amount of radio-frequency power will be delivered to that circuit. If the circuit is tuned to the fundamental frequency (same frequency as

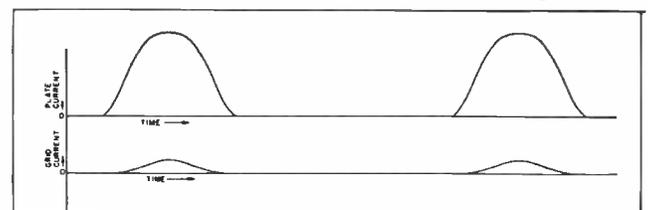


Figure 3

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the r-f grid voltage) the power delivered will be due to the fundamental, or principal, radio-frequency component of plate current. If the circuit is tuned to a harmonic of the grid-voltage frequency, e.g., two or three times the frequency, the power delivered will be due to a harmonic component of the plate current.

Use of the Eimac Tube Performance Computer

The Eimac Tube Performance Computer gives us the means to make these simple calculations. It is a means with which to determine the d-c component, the fundamental r-f component, or the approximate harmonic component of the current flowing in a tube when the tube is operating as a radio-frequency amplifier, and enables one to state what all meter readings will be and to predict the r-f output power and the required driving power. With these factors known we are able to forecast what will happen if any of the operating conditions are changed.

The Eimac Tube Performance Computer is a simple aid to enable one to select suitable values from the characteristic curves of a tube, and by means of simple calculations to forecast the performance of the tube in radio-frequency power amplifiers.

The basic steps are outlined under "Instructions" on the computer. This requires selecting d-c plate and grid-bias voltages, being guided by the typical operating values given on the technical data sheet for the tube type, and by general experience. Next, a suitable "Operating Line" must be chosen on the constant-current curves for the tube type (plotted on grid-voltage/plate-voltage coordinates).

The computer, when properly placed over this operating line, enables one to obtain instantaneous values of the currents flowing at every 15° of the electrical cycle. The formulas given on the computer were derived by Chaffee¹ to give the various average and harmonic components of the resulting currents. Knowing these current component values and the radio-frequency voltage values which are indicated through use of the computer, one can readily calculate the complete performance of the tube.

The fundamental methods of making such computations, and the considerations necessary to stay within ratings of the tube types while accomplishing various forms of modulation have been covered in the literature, 2, 3, 4, 5, 7. The method for the case of harmonic-amplifier service is approximate and should be used only for tetrode and pentode tubes where the plate voltage has little effect on the amount of plate current flowing. A more exact method, showing that for harmonic operation the operating line is a simple Lissajou figure, has been described by Brown.²

The results obtained by using this computer for power-amplifier service can be applied in combination

with the other methods given in the literature to give good accuracy with simpler procedures. The resulting accuracy is well within the normal variation of tube characteristics due to the normal variation in manufacturing dimensions of a tube. Since the published tube curves are only typical of the characteristics to be expected from a particular tube type, the calculated performance is well within the values obtained when different tubes of a given tube type are operated under the assumed conditions.

Example Showing Detailed Use of the Eimac Tube Performance Computer

Radio-Frequency Power Amplifier, Class-C (Telegraphy or FM)

Let us say that we have an Eimac 4-65A tetrode and want to make it work effectively. Also, let us assume that we have a 2000-volt d-c plate power supply available.

Within frequency limits, we know that a tube should be able to run in class-C amplifier service with about 75% efficiency, or in other words to convert 75% of the d-c plate input power into r-f output power. The difference, or 25% of the input power, is dissipated or lost as heat on the plate of the tube. The d-c plate input power is then about four times the power dissipated on the plate.

The 4-65A tetrode has a maximum rated plate dissipation of 65 watts, and, to illustrate performance near the maximum rating, we'll choose an input power four times the dissipation rating, or about 260 watts per tube. At 2000 volts the plate current per tube must then be 130 ma. It is usual practice in the case of tetrodes and the medium or low- μ triodes in class-C amplifier service for the d-c grid-bias voltage to be roughly two or three times the grid voltage necessary to cut off the flow of the plate current. By referring to the curves for the 4-65A, we decide to use a d-c grid-bias voltage of -130 volts.

Let us now locate the "Operating Line" on the constant-current curves for the 4-65A. See Fig. 4. First, mark the point where the d-c grid bias and d-c plate voltage cross. The "Operating Line" must go through this point. Call it point No. 1. Next, we must decide what the peak value of plate current of the tube must be and how low we can let the instantaneous value of plate voltage go when the tube is passing this much current. This is necessary in order to locate the other end of the "Operating Line," point No. 2.

The peak value of plate current in class-C amplifiers usually runs about four times the d-c plate current. The minimum value of instantaneous plate voltage is usually set by the fact that if the voltage is too low, the grid current in triodes and the screen current in tetrodes will be needlessly high, resulting in high grid or screen dissipation. Also, little will be gained as far as output power



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ADDENDUM

USE OF EIMAC TUBE PERFORMANCE COMPUTER FOR CLASS A, AB, AND B SERVICE

While the Eimac Tube Performance Computer is designed for class C service, it may be used for class A, AB or B service wherein the idling (quiescent) plate current is not zero. When it is desired to calculate performance for operating conditions having a large order of idling plate current, the plate current flow during the positive half of the plate voltage swing becomes appreciable and cannot be ignored. When the tube functions over 180° or more of the operating cycle, a full set of ordinate points must be employed for the computations. The Eimac Computer is therefore used in a two-step process.

First, the operating line is determined and the Eimac Computer used in the normal fashion to derive the instantaneous values of plate, screen and grid current during the negative half of the plate voltage swing. These current points are logged as explained under the class C service description.

Second, the instantaneous current points over the positive portion of the plate voltage cycle must be determined and combined with those points determined for the negative half of the cycle. This is done in the following fashion: A line is pencilled on the Eimac Computer over the operating line, and of equivalent length. The Computer is now inverted and rotated 180° and again aligned with the

chosen operating line on the Constant Current Graph so that inverted point G on the Computer falls on the idling current value (point 1) on the graph and inverted point A passes through a minimum peak current point representing maximum positive plate voltage swing. The pencilled line on the Computer now represents an extension of the operating line into the area of positive peak voltage swing. The extended operating line is a straight line, twice as long as the original operating line. Instantaneous values of plate, screen and grid current (if any) are those observed where the reversed ordinate lines on the Computer cross the extended operating line.

The current points measured with the Computer inverted are logged and these, together with the points obtained in the first operation (Computer right side up) provide a full set of instantaneous peak current values necessary for calculation of class A, AB or B parameters. With the first set of computer readings termed A, B, C, D, E, F, and G; the second (inverted) set may be termed A', B', C', D', E', and F', with the sets used in the following formulae¹:

¹Formulae are modifications of Chaffee's which permit using current values directly from the Constant Current curves.

- | | | |
|---|---|---|
| (1) D.C. Current
(Meter Reading) | = | $\frac{1}{12} \left[\frac{A+A'}{2} + (B+B') + (C+C') + (D+D') + (E+E') + (F+F') + G \right]$ |
| (2) Peak Fundamental RF Current | = | $\frac{1}{12} \left[(A-A') + 1.93 (B-B') + 1.73 (C-C') + 1.41 (D-D') + (E-E') + 0.52 (F-F') \right]$ |
| (3) Approx. 2 ^d Harmonic RF current
(tetrodes or pentodes only) | = | $\frac{1}{12} \left[(A+A') + 1.73 (B+B') + (C+C') - (E+E') - 1.73 (F+F') - 2G \right]$ |
| (4) Approx. 3 ^d Harmonic RF current
(tetrodes or pentodes only) | = | $\frac{1}{12} \left[(A-A') + 1.41 (B-B') - 1.41 (D-D') - 2 (E-E') - 1.41 (F-F') \right]$ |
| (5) Power Output | = | $\frac{\text{Peak Fundamental RF current} \times \text{Peak RF voltage}}{2}$ |
| (6) Resonant Load Impedance | = | $\frac{\text{Peak RF Voltage}}{\text{Peak Fund. RF Current}}$ |

AN EXAMPLE: USING THE EIMAC TUBE PERFORMANCE COMPUTER FOR CLASS AB-1 SERVICE

Operating data is to be derived for an Eimac 4CW-50,000C tetrode operating at a plate potential of 10 KV and a screen potential of 1.5 KV. Grid current is zero; that is, the tube is operated in the class AB-1 mode, with the grid never being driven positive.

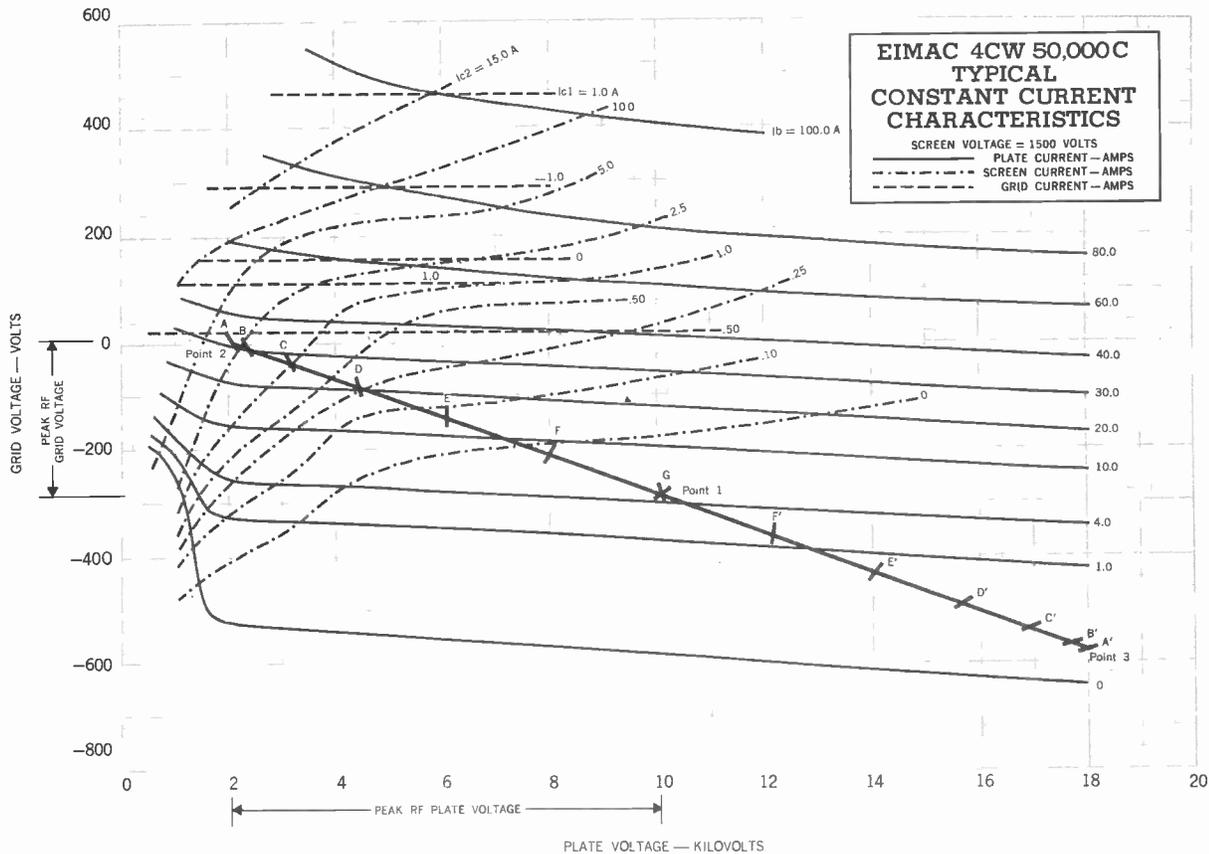
Within frequency limits, a plate circuit efficiency of about 55-65% may be assumed for class AB-1 operation, and maximum d.c. input is therefore about 2.2 to 2.75 times the anode dissipation. A maximum power input of 2.2 x 50,000 = 110 kilowatts is chosen. At 10 KV, the maximum d.c. plate current is then 11.0 amperes. This is within the maximum rated plate current of 15 amperes for class AB service as specified on the data sheet.

In class AB service the tube does not operate in a cut-off condition, rather a certain value of idling plate current exists. This must be taken into account when choosing point (1) on the Constant Current graph. Generally speaking, high values of resting plate current provide reduced level of intermodulation distortion products and somewhat lower plate efficiency. Idling plate current is usually chosen so that anode dissipation under quiescent conditions is about 50-70% of the maximum dissipation rating. In this example, idling plate current is chosen to be 4.5 amperes. From the graph, it is determined that a grid potential of about -295 volts is required to produce the desired plate current at the chosen screen and plate potentials. The intersection of the -295 volt bias line and the 10 KV plate line determines the idling point on the operating line (point 1).

Next, the peak value of plate current must be determined, and the minimum value of instantaneous plate voltage chosen to pass this amount of current. Determination of these values will locate point (2) and will define the operating line.

Class AB-1 service limits grid voltage excursions to negative grid regions on the Constant Current graph. Point (2) therefore may never be located above the zero grid voltage line. In addition, the minimum instantaneous plate voltage is usually not allowed to swing as low as the d.c. screen potential, as screen dissipation tends to become abnormally high. The location of point (2) thus has certain restrictive limits defined by screen dissipation and the maximum positive grid signal voltage. In this case for the 4CW50,000C, minimum instantaneous plate voltage is about 2 KV. Peak r.f. voltage is thus 10,000 - 2,000 = 8,000 volts.

Peak r.f. plate current in a class AB-1 amplifier usually runs about 2.5 to 3.0 times the average d.c. plate current. In this case, a maximum peak plate current of about 2.9 times the maximum signal d.c. plate current of 11.0 amperes, or 32 amperes is chosen. This defines point (2) which is at the intersection of the 2 KV minimum plate voltage line and the 32 ampere Constant Current line. This point falls within the limits defined in the previous paragraph. A straight line is drawn between points (1) and (2) which is the negative plate cycle portion of the operating line.



When the operating line is extended to the right of point (1) it can be observed that the tube conducts over the rest of the cycle where (by virtue of the "flywheel" effect of the resonant tank circuit), the instantaneous plate voltage swings as far above the normal d.c. value as it swings below. It is important to note that operation

with less than cutoff bias requires that the Eimac Computer employ points on the operating line falling to the right of point (1). The operating line, accordingly, is extended and the Computer is employed in a two-part operation, as shown in the following example:

4CW50,000C COMPUTATIONS

D.C. Plate Voltage = 1.5 KV
D.C. Screen Voltage = 10 KV

Power Input = 110 KW
Max. D.C. Plate Current = 11 amp.
Zero-Signal Plate Current = 4.5 amp.
D.C. Grid Voltage = -295 volts
Peak Plate Current = 32 amp.
Peak RF Voltage = 8,000

Constant Current Graph and Operating Line determine:

Step One

Step Two

Eimac Computer Readings Instantaneous Peak Current (amps)			Inverted Computer Readings Instantaneous Peak Current (amps)		
Ordinate Crossing	Plate	Screen	Ordinate Crossing	Plate	Screen
A	32	3	A'	0.20	—
B	31	2	B'	0.25	—
C	28	1.2	C'	0.30	—
D	22	0.25	D'	0.50	—
E	15	0.07	E'	0.80	—
F	9	—	F'	1.50	—
G	4.5	—			

$$\text{D.C. Plate Current} = \frac{1}{12} \left[\frac{32.2}{2} + 31.25 + 28.3 + 22.5 + 15.8 + 10.5 + 4.5 \right] = 10.75 \text{ amp.}$$

$$\text{Plate Power Input} = 10 \text{ KV} \times 10.75 \text{ A} = 107,500 \text{ watts}$$

$$\text{Peak Fundamental RF Current} = \frac{1}{12} \left[31.8 + 59.4 + 47.7 + 30.3 + 14.2 + 3.9 \right] = 15.6 \text{ amp.}$$

$$\text{Power Output} = \frac{15.6 \times 8000}{2} = 62,500 \text{ watts}$$

$$\text{Plate Dissipation} = 45,000 \text{ watts}$$

$$\text{Efficiency} = \frac{62,500}{107,500} \times 100 = 58.2\%$$

$$\text{Resonant Load Impedance} = \frac{8000}{15.6} = 512 \text{ ohms}$$

$$\text{D.C. Screen Current} = \frac{1}{12} \left[\frac{3}{2} + 2 + 1.2 + 0.25 + 0.07 \right] = 417 \text{ ma.}$$



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TUBE PERFORMANCE COMPUTOR
For RF Amplifiers (Class B, C, and Frequency Multipliers)

Use with constant current curves to obtain plate, grid, and screen current values; also output and driving power.

DC Current (meter reading)	$1/12 (0.5A+B+C+D+E+F)$
Peak Fundamental RF	$1/12 (A+1.93B+1.73C+1.41D+E+0.52F)$
Peak 2nd Harmonic RF (Approx.)*	$1/12 (A+1.73B+C-E-1.73F)$
Peak 3rd Harmonic RF (Approx.)*	$1/12 (A+1.41B-1.41D-2E-1.41F)$

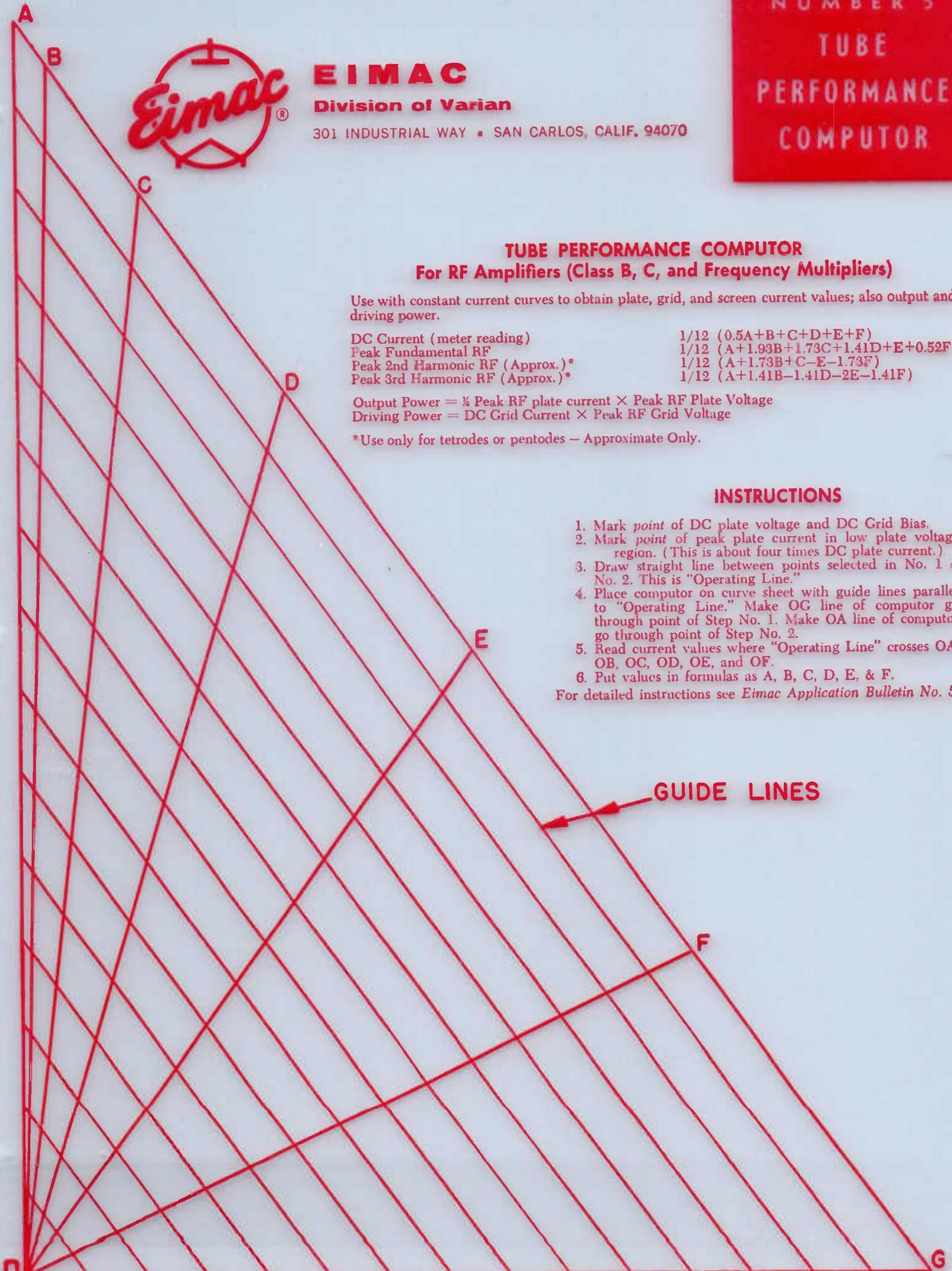
Output Power = $\frac{1}{2}$ Peak RF plate current \times Peak RF Plate Voltage
 Driving Power = DC Grid Current \times Peak RF Grid Voltage

*Use only for tetrodes or pentodes – Approximate Only.

INSTRUCTIONS

1. Mark point of DC plate voltage and DC Grid Bias.
 2. Mark point of peak plate current in low plate voltage region. (This is about four times DC plate current.)
 3. Draw straight line between points selected in No. 1 & No. 2. This is "Operating Line."
 4. Place computer on curve sheet with guide lines parallel to "Operating Line." Make OG line of computer go through point of Step No. 1. Make OA line of computer go through point of Step No. 2.
 5. Read current values where "Operating Line" crosses OA, OB, OC, OD, OE, and OF.
 6. Put values in formulas as A, B, C, D, E, & F.
- For detailed instructions see *Eimac Application Bulletin No. 5.*

GUIDE LINES





**TUBE PERFORMANCE COMPUTOR
For RF Amplifiers (Class B, C, and Frequency Multipliers)**

Use with constant current curves to obtain plate, grid, and screen current values; also output and driving power.

- DC Current (meter reading)
- Peak Fundamental RF
- Peak 2nd Harmonic RF (Approx.)
- Peak 3rd Harmonic RF (Approx.)
- $I_{1/2} (A + 1.41B - 1.41D - 2E - 1.41F)$
- $I_{1/2} (A + 1.73B + C - E - 1.73F)$
- $I_{1/2} (A + 1.93B + 1.73C + 1.41D + E + 0.22F)$
- $I_{1/2} (0.25A + B + C + D + E + F)$

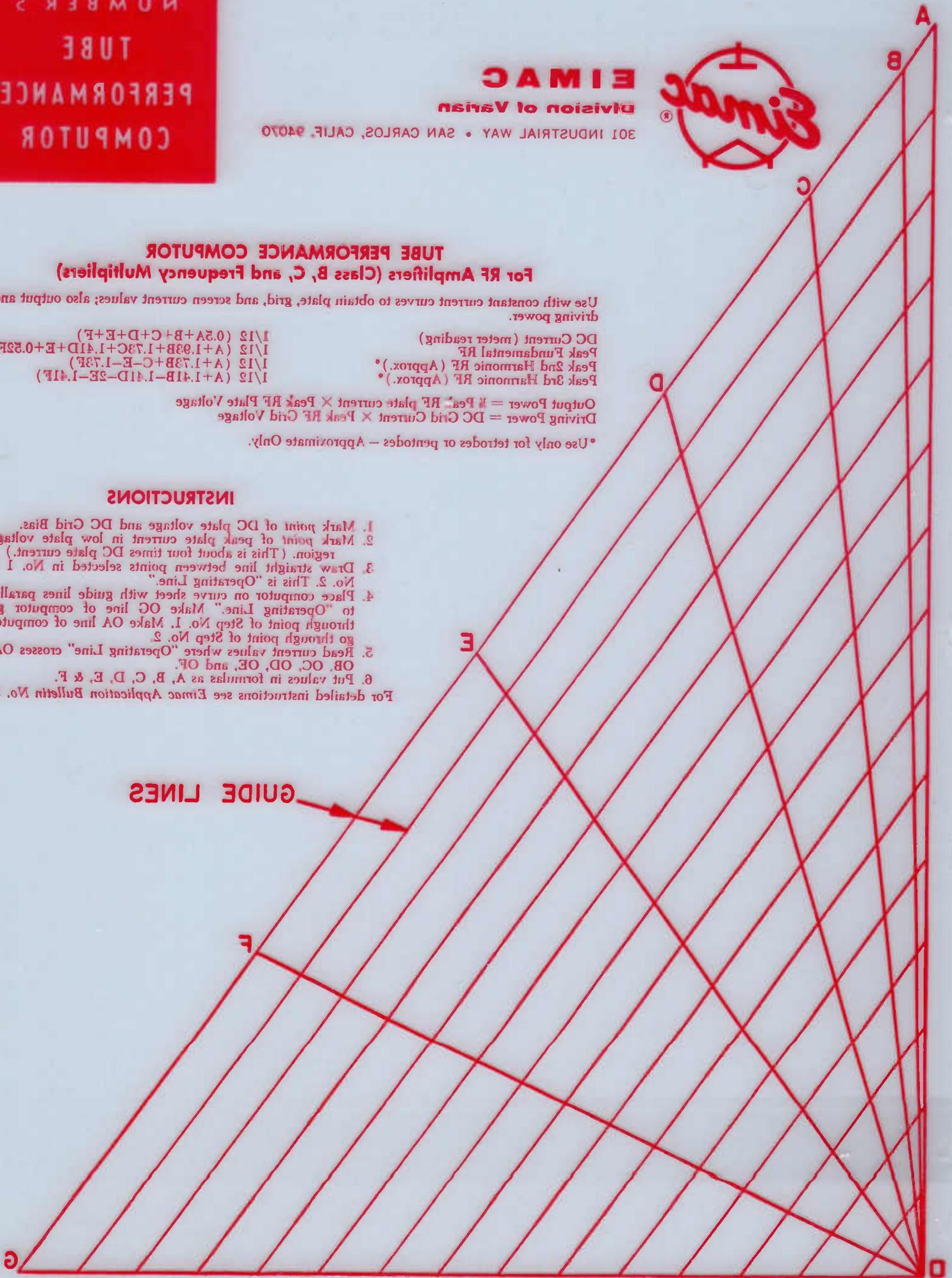
Output Power = $\frac{1}{2}$ Peak RF plate current \times Peak RF Plate Voltage
 Driving Power = DC Grid Current \times Peak RF Grid Voltage

* Use only for tetrodes or pentodes - Approximate Only.

INSTRUCTIONS

1. Mark point of DC plate voltage and DC Grid Bias.
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 6. Put values in formulas as A, B, C, D, E, & F.
- For detailed instructions see Eimac Application Bulletin No. 2.

GUIDE LINES



is concerned. The minimum value of plate voltage is usually in the region where the plate constant-current curves bend upward. See Fig. 4. (In the case of the triode this is near the "diode line," the imaginary line where the instantaneous grid and plate voltages are equal.) The practical procedure in calculating tube performance is to arbitrarily choose point No. 2, complete the calculations, and compare the results.

In the case of the 4-65A let us choose a peak value of plate current about four times the d-c plate current of 130 ma, or 500 ma. Let us choose a minimum instantaneous plate voltage of 250 volts and thus fix the upper end of the "Operating Line." Next, locate this point on the tube curves. This is point No. 2 on Fig. 4. (The plate currents which flow at various combinations of plate and grid voltages are shown by the plate-current lines. The value of current for each line is noted. In-between values can be estimated closely enough for our purposes.) Now draw a straight line between points No. 1 and No. 2. This line is the "Operating Line" and shows the current and voltage values at each instant in the r-f cycle when current is being taken from the tube. (The non-conducting half of the r-f cycle would be shown by extending this line an equal distance on the opposite side of point No. 1. However, there is little use in doing so, because no current flows during this half of the cycle.)

The Eimac Tube Performance Computer can now

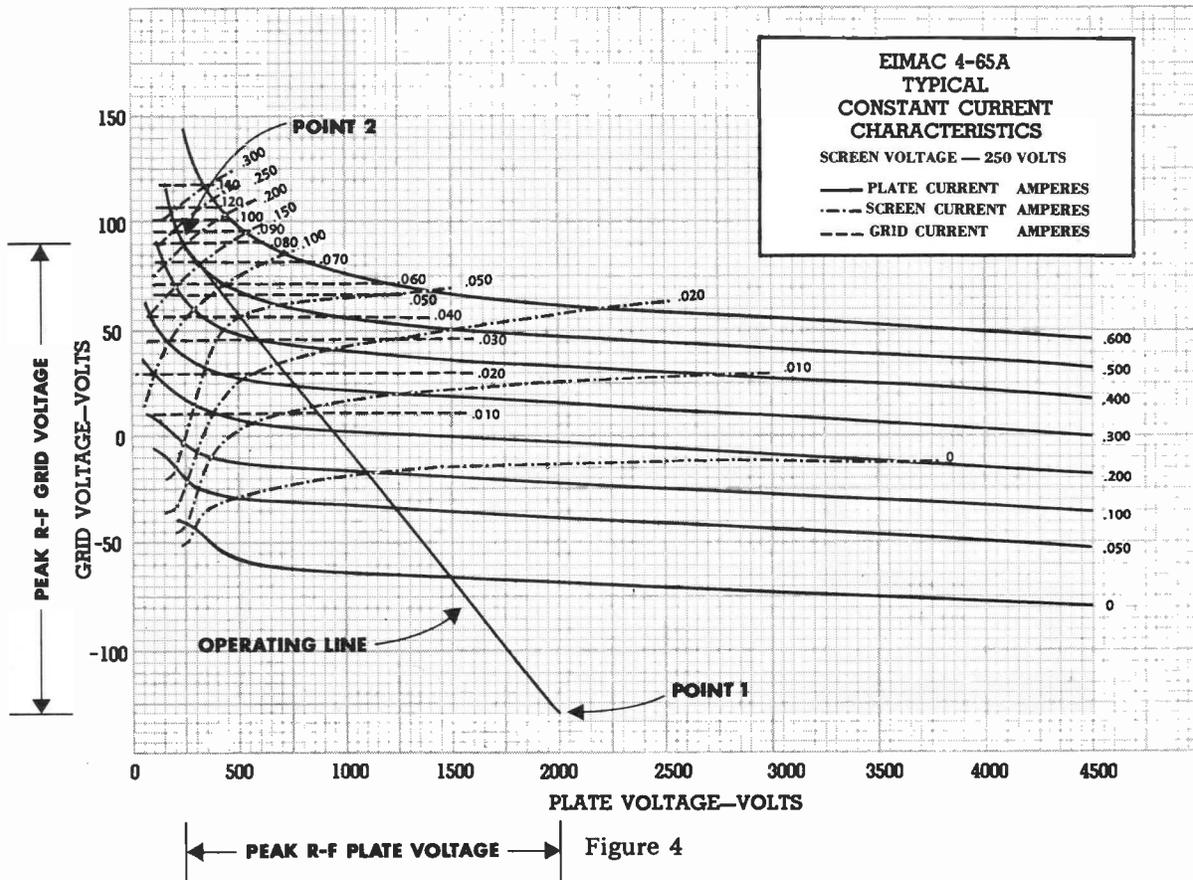
be used to obtain the meter readings and power values from this "Operating Line." Place the computer on the constant-current curve sheet so that the "guide lines" of the computer are parallel with the operating line. Now slide the computer without turning it until the line OG passes through the d-c voltage point No. 1 and line OA passes through the peak-current point No. 2. *Make sure the guide lines are still parallel to the "Operating Line."*

Note that the lines OB, OC, OD, OE, and OF of the computer all cross over the "Operating Line."

At each point where the lines OA, OB, etc., cross the "Operating Line" we need to determine the instantaneous values of plate current and grid current (and screen current if a tetrode or pentode is used) which are flowing at that particular moment in the r-f cycle. Later, from these key values of current, we will calculate the values of d-c plate current and grid current (and screen current) as well as the r-f components of the plate current.

These current values should be listed for each point where the lines OA, OB, etc. cross the operating line so that they can be combined later to calculate the various tube currents. At points where OF and OE cross, the current values are usually zero for class-C operation.

Now in the example chosen, let us read off the instantaneous plate-current values where these lines cross the "Operating Line." At the point where the line OA crosses the "Operating Line" the plate current is 500 ma.



Where OB crosses the operating line the plate current is also 500 ma. At OC the plate current is about 450 ma, OD 300 ma, OE 90 ma, OF and OG 0 ma. Similarly we can see that the instantaneous screen current at the crossing of OA and the "Operating Line" is 200 ma, and the instantaneous grid current is almost 80 ma. Values are read for the other crossings and written down. These values are put in simple columns for calculating:

Crossing of line	Simplified name in Formulas	Instantaneous values of currents		
		Plate	Screen	Control grid
OA	A	500 ma	200 ma	80 ma
OB	B	500	155	70
OC	C	450	60	42
OD	D	300	15	17
OE	E	90	0	0
OF	F	0	0	0

Now in order to obtain the d-c value of plate, screen, and control-grid currents the formula (see computer) says to add up the above values but use only one-half of the A values (giving 250 ma for plate, 100 ma for screen, and 40 ma for grid), and then divide by 12, as follows:

$$\text{D-C meter reading} = 1/12 (0.5 A+B+C+D+E+F)$$

Plate	Screen	Control grid
250 ma	100 ma	40 ma
500	155	70
450	60	42
300	15	17
90	0	0
0	0	0
Total 1590 ma	330 ma	169 ma
D-C current = 1/12 total = (approximately)		
133 ma	28 ma	14 ma

Now, to calculate the r-f output power it is necessary to use the formula for the peak r-f current which is present in the tube plate current. Since we are using the tube as a straight r-f power amplifier, we use the formula for "Peak Fundamental R-F" as shown on the computer. (If we were estimating the performance of a doubler or tripler we would use the formula for "Peak 2nd Harmonic R-F" or "Peak 3rd Harmonic R-F".)

From the computer we see that the formula for the peak fundamental r-f current is:

$$1/12 (A+1.93B+1.73C+1.41D+E+0.52F)$$

$$A = 500 = 500 \text{ ma}$$

$$1.93B = 1.93 \times 500 = 965$$

$$1.73C = 1.73 \times 450 = 778$$

$$1.41D = 1.41 \times 300 = 423$$

$$E = 90 = 90$$

$$\text{Total} = 2756 \text{ ma}$$

$$\text{Peak fundamental current} = 1/12 \text{ total}$$

$$= 2756/12 = 230 \text{ ma}$$

We now have the various current values. In order to calculate the powers involved, it is necessary to know not only the d-c voltage values but the greatest amount

each voltage swings away from the d-c value. This is known as the peak value of the r-f voltage. Because the plate voltage swings from 2000 volts down to 250 volts the peak r-f plate voltage is the difference, or 1750 volts. Similarly the grid voltage must rise and fall between the operating points No. 1 and No. 2, or from -130 volts to +90 volts. This is a peak swing of 220 volts and the peak r-f grid voltage is 220 volts.

Let us now use the formulas for output power and driving power:

Output power = $\frac{1}{2}$ peak r-f plate current x peak r-f plate voltage.

We found the peak r-f plate current to be 230 ma or .230 ampere, and the peak r-f plate voltage to be 1750 volts.

$$\text{So, Output Power} = \frac{1}{2} \times 0.230 \times 1750 = 201 \text{ watts,}$$

$$\text{and Input Power} = \text{D-C Plate Current} \times \text{D-C Plate Voltage}$$

$$= 0.133 \times 2000 = 266 \text{ watts}$$

$$\text{Plate Dissipation} = \text{D-C Input Power} - \text{R-F Output Power}$$

$$= 266 - 201 = 65 \text{ watts}$$

$$\text{Efficiency} = \text{R-F Output Power divided by}$$

$$\text{D-C Input Power}$$

$$= 201/266 = 75.5\%$$

$$\text{Driving Power} = \text{D-C Grid Current} \times \text{Peak R-F Grid Voltage}$$

$$= 0.014 \times 220 = 3.1 \text{ watts}$$

The power consumed by the bias source is simply the product of the d-c grid current and the d-c grid voltage, or $0.014 \times 130 = 1.7$ watts.

The difference between the driving power and the power consumed by the bias source is the power dissipated on the control grid, or $3.1 - 1.7 = 1.4$ watts.

The power dissipated on the screen grid is simply the product of the d-c screen current and the d-c screen voltage because the screen grid has no impedance between it and the d-c screen supply. Thus it is $0.028 \times 250 = 7.0$ watts.

The performance of the tube can now be summarized:

D-C Plate Voltage	2000 volts	Driving Power	3.1 watts
D-C Screen Voltage	250 volts	Grid Dissipation	1.4 watts
D-C Grid Voltage	-130 volts	Screen Dissipation	7.0 watts
D-C Plate Current	133 ma	Plate Input Power	266 watts
D-C Screen Current	28 ma	Plate Output Power	201 watts
Peak R-F Grid Voltage	220 volts	Plate Dissipation	65 watts

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For RF Amplifiers (Class B, C, and Frequency Multipliers)

Use with constant current curves to obtain plate, grid, and screen current values; also output and driving power.

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Peak Fundamental RF	$1/12 (A+1.93B+1.73C+1.41D+E+0.52F)$
Peak 2nd Harmonic RF (Approx.) ^o	$1/12 (A+1.73B+C-E-1.73F)$
Peak 3rd Harmonic RF (Approx.) ^o	$1/12 (A+1.41B-1.41D-2E-1.41F)$

Output Power = $\frac{1}{2}$ Peak RF plate current \times Peak RF Plate Voltage

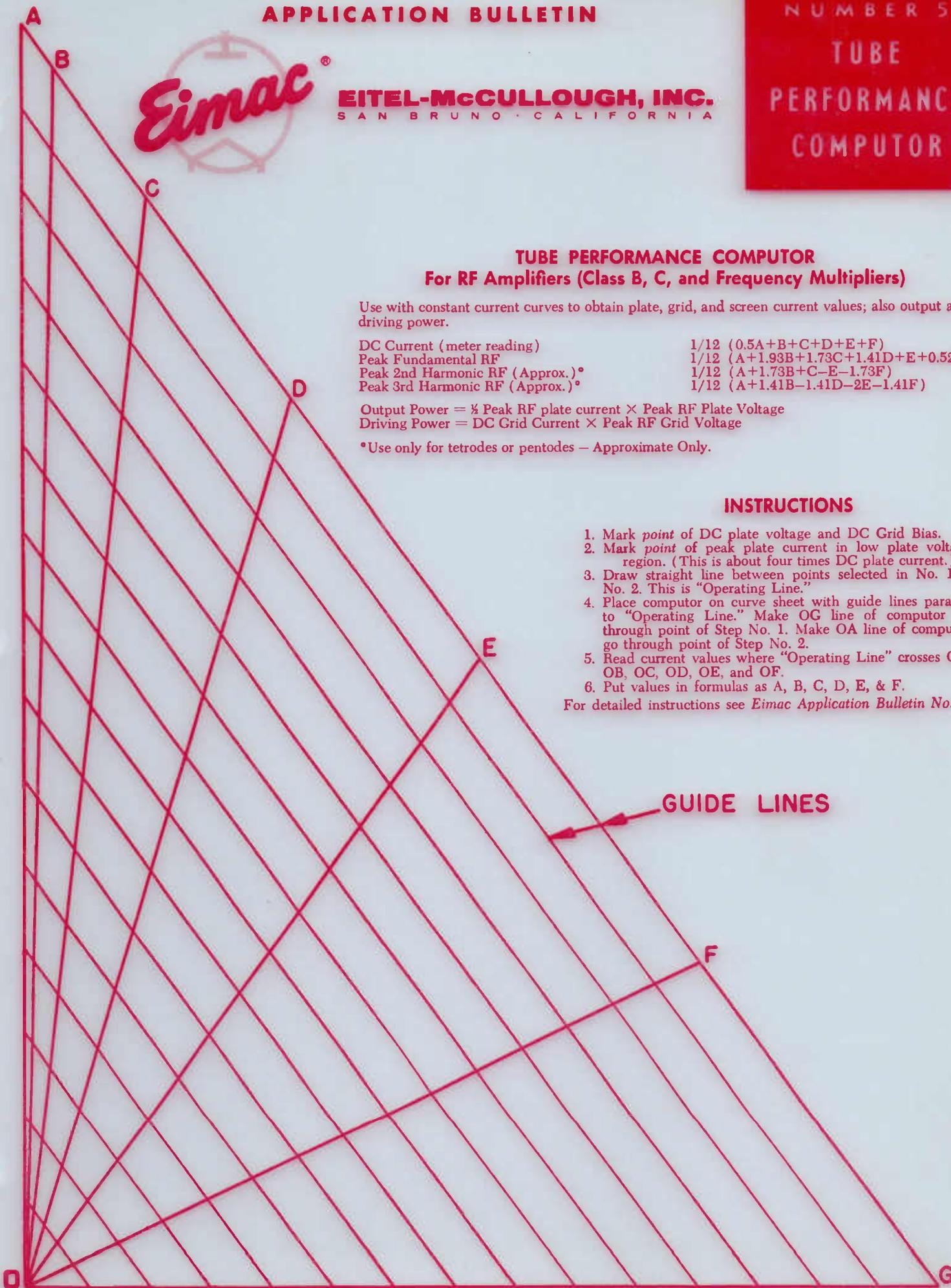
Driving Power = DC Grid Current \times Peak RF Grid Voltage

^oUse only for tetrodes or pentodes – Approximate Only.

INSTRUCTIONS

1. Mark *point* of DC plate voltage and DC Grid Bias.
 2. Mark *point* of peak plate current in low plate voltage region. (This is about four times DC plate current.)
 3. Draw straight line between points selected in No. 1 & No. 2. This is "Operating Line."
 4. Place computer on curve sheet with guide lines parallel to "Operating Line." Make OG line of computer go through point of Step No. 1. Make OA line of computer go through point of Step No. 2.
 5. Read current values where "Operating Line" crosses OA, OB, OC, OD, OE, and OF.
 6. Put values in formulas as A, B, C, D, E, & F.
- For detailed instructions see *Eimac Application Bulletin No. 5.*

GUIDE LINES



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CLASS C AMPLIFIER CALCULATIONS WITH THE AID OF CONSTANT CURRENT CHARACTERISTICS

In calculating and predicting the operation of a vacuum tube as a class-C radio frequency amplifier, the considerations which determine the operating conditions are plate efficiency, power output required, maximum allowable grid and plate dissipation, maximum allowable plate voltage and maximum allowable plate current. The values chosen for these factors will depend both on the demands of a particular application and the tube selected to do the job.

The plate and grid currents of a class-C amplifier are periodic pulses, the durations of which are always less than 180 degrees. For this reason the average plate and grid currents, power output, driving power, etc., cannot be directly calculated but must be determined by a Fourier analysis from points selected along the line of operation as plotted on the constant-current characteristics. This may be done either analytically or graphically. While the Fourier analysis has the advantage of accuracy, it also has the disadvantage of being tedious and involved.

An approximate analysis which has proven to be sufficiently accurate for most purposes is presented in the following material. This system has the advantage of giving the desired information at the first trial. The system, which is an adaption of a method developed by Wagener¹, is direct because the important factors, power output, plate efficiency and plate voltage may be arbitrarily selected at the beginning.

In the material which follows, the following set of symbols will be used. These symbols are illustrated graphically in Figure 1.

Symbols

- P_i = Plate power input
- P_o = Plate power output
- P_d = Plate dissipation
- n = Plate efficiency expressed as a decimal
- E_{bb} = D-c plate supply voltage
- E_{pm} = Peak fundamental plate voltage
- E_{bmin} = Minimum instantaneous plate voltage
- I_b = Average plate current
- I_{pm} = Peak fundamental plate current
- I_{bmax} = Maximum instantaneous plate current
- θ_p = One-half angle of plate current flow
- E_{cc} = D-c grid bias voltage (a negative quantity)
- E_{c2} = D-c screen voltage

¹ W. G. Wagener "Simplified Methods for Computing Performance of Transmitting Tubes," Proc. I.R.E., Vol. 25, p. 47, (Jan. 1937).

(Reprinted from the Eimac News Industrial Edition, March 1945)

Indicates Revision 11-10-49

- E_{gm} = Peak fundamental grid excitation voltage
- e_{cmp} = Maximum positive instantaneous grid voltage
- I_c = Average grid current
- i_{cmax} = Maximum instantaneous grid current
- P_d = Grid driving power (including both grid and bias losses)
- P_g = Grid dissipation
- μ = Amplification factor of triode
- μ_{12} = Grid-screen amplification factor of tetrode

Method

The first step in the use of the system to be described is to determine the power which must be delivered by the class-C amplifier. In making this determination it is well to remember that ordinarily from 5 to 10 per cent of the power delivered by the amplifier tube or tubes will be lost in well-designed tank and coupling circuits at frequencies below 20 Mc. Above 20 Mc. the tank and coupling circuit losses are ordinarily somewhat above 10 per cent.

The plate power input necessary to produce the required output is determined by the plate efficiency:

$$P_i = \frac{P_o}{n}$$

For most applications it is desirable to operate at the highest possible efficiency. High-efficiency operation usually requires less expensive tubes and power supplies, and the amount of artificial cooling needed is frequently less than for low-efficiency operation. On the other hand, high-efficiency operation often requires more driving power and higher operating plate voltages. Eimac triodes and tetrodes will operate satisfactorily at 80 per cent efficiency at the highest recommended plate voltages and at 75 per cent efficiency at medium plate voltages.

The first determining factor in selecting a tube or tubes for any particular application is the maximum allowable plate dissipation. The total plate dissipation rating for the number of tubes used must be equal to or greater than that calculated from

$$P_p = P_i - P_o$$

After selecting a tube or tubes to meet the power output and plate dissipation requirements it becomes necessary to determine from the tube characteristics whether the tube selected is capable of the required operation and, if so, to determine the driving power, grid bias and grid current.

The complete procedure necessary to determine the class-C-amplifier operating conditions is as follows²:

1. Select plate voltage, power output and efficiency.
2. Determine plate input from

$$P_1 = \frac{P_o}{n}$$

3. Determine plate dissipation from

$$P_p = P_1 - P_o$$

P_p must not exceed maximum rated plate dissipation for tube or tubes selected.

4. Determine average plate current from

$$I_b = \frac{P_1}{E_{bb}}$$

I_b must not exceed maximum rated plate current for tube selected.

5. Determine approximate i_{bmax} from

$$\begin{aligned} i_{bmax} &= 4.5 I_b \text{ for } n=0.80 \\ i_{bmax} &= 4.0 I_b \text{ for } n=0.75 \\ i_{bmax} &= 3.5 I_b \text{ for } n=0.70 \end{aligned}$$

6. Locate the point on constant-current characteristics where the constant plate current line corresponding to the approximate i_{bmax} determined in step 5 crosses the line of equal plate and grid voltages ("diode line") in the case of triodes; or in the case of tetrodes where the plate current line turns rapidly upward. Read e_{bmin} at this point.³

7. Calculate E_{pm} from

$$E_{pm} = E_{bb} - e_{bmin}$$

8. Calculate the ratio $\frac{I_{pm}}{I_b}$ from

$$\frac{I_{pm}}{I_b} = \frac{2n E_{bb}}{E_{pm}}$$

9. From the ratio of $\frac{I_{pm}}{I_b}$ calculated in step 8 determine the

ratio $\frac{i_{bmax}}{I_b}$ from Chart 1.

10. Calculate a new value for i_{bmax} from ratio found in step 9.

$$i_{bmax} = (\text{ratio from step 9}) I_b$$

11. Read e_{cmp} and i_{cmax} from constant current characteristics for values of e_{bmin} and i_{bmax} determined in steps 6 and 10.

12. Calculate the cosine of one-half the angle of plate current flow from

$$\text{Cos } \theta_p = 2.3 \left(\frac{I_{pm}}{I_b} - 1.57 \right)^4$$

13. Calculate the grid bias voltage from

$$E_{cc} = \frac{1}{1 - \text{Cos } \theta_p} \left[\text{Cos } \theta_p \left(\frac{E_{pm}}{\mu} - e_{cmp} \right) - \frac{E_{bb}}{\mu} \right], \text{ for triodes;}$$

$$\text{or } E_{cc} = \frac{1}{1 - \text{Cos } \theta_p} \left[-e_{cmp} \text{Cos } \theta_p - \frac{E_{c2}}{\mu_{12}} \right], \text{ for tetrodes.}$$

14. Calculate the peak fundamental grid excitation voltage from

$$E_{gm} = e_{cmp} - E_{cc}$$

15. Calculate the ratio $\frac{E_{gm}}{E_{cc}}$ for values of E_{cc} and E_{gm} found

in steps 13 and 14.

16. Read ratio $\frac{i_{cmax}}{I_c}$ from Chart 2 for ratio $\frac{E_{gm}}{E_{cc}}$ found in step 15.

17. Calculate average grid current from ratio found in step 16 and value of i_{cmax} found in step 11.

$$I_c = \frac{i_{cmax}}{\text{ratio from step 16}}$$

18. Calculate approximate grid driving power from

$$P_d = 0.9 E_{gm} I_c^5$$

19. Determine grid dissipation from

$$P_g = P_d + E_{cc} I_c$$

P_g must not exceed the maximum rated grid dissipation for the tube selected.

Example

A typical application of this procedure is shown in the example below.

1. Desired power output..... 1250 watts
Desired plate voltage..... 4000 volts
Desired plate efficiency..... 75 per cent ($n=0.75$)

$$2. \quad P_1 = \frac{1250}{0.75} = 1670 \text{ watts}$$

$$3. \quad P_p = 1670 - 1250 = 420 \text{ watts}$$

Try type 450TL; Max. $P_p = 450W$; $\mu = 18$

$$4. \quad I_b = \frac{1670}{4000} = 0.417 \text{ ampere}$$

(Max. I_b for 450TL = 0.600 ampere)

5. Approximate $i_{bmax} = 4.0 \times 0.417 = 1.67$ ampere

$$6. \quad e_{bmin} = 315 \text{ volts (see figure 2)}$$

$$7. \quad E_{pm} = 4000 - 315 = 3685 \text{ volts}$$

$$8. \quad \frac{I_{pm}}{I_b} = \frac{2 \times 0.75 \times 4000}{3685} = 1.63$$

$$9. \quad \frac{i_{bmax}}{I_b} = 3.45 \text{ (from Chart 1)}$$

$$10. \quad i_{bmax} = 3.45 \times 0.417 = 1.44 \text{ amperes}$$

$$11. \quad e_{cmp} = 280 \text{ volts}$$

$$i_{cmax} = 0.330 \text{ amperes (see figure 3)}$$

$$12. \quad \text{Cos } \theta_p = 2.32 (1.63 - 1.57) = 0.139$$

$$13. \quad E_{cc} = \frac{1}{1 - 0.139} \left[0.139 \left(\frac{3685}{18} - 280 \right) - \frac{4000}{18} \right] = -270 \text{ volts}$$

$$14. \quad E_{gm} = 280 - (-270) = 550 \text{ volts}$$

$$15. \quad \frac{E_{gm}}{E_{cc}} = \frac{550}{-270} = -2.04$$

$$16. \quad \frac{i_{cmax}}{I_c} = 5.69 \text{ (from Chart 2)}$$

$$17. \quad I_c = \frac{0.330}{5.69} = 0.058 \text{ amperes}$$

$$18. \quad P_d = 0.9 \times 550 \times 0.058 = 28.7 \text{ watts}$$

$$19. \quad P_g = 28.7 + (-270 \times 0.058) = 13.0 \text{ watts (Max } P_g \text{ for 450TL} = 65 \text{ watts)}^6$$

² In the case of push-pull or parallel amplifier tubes the analysis should be carried out on the basis of a single tube, dividing P_1 , P_o and P_p by the number of tubes before starting the analysis and multiplying I_b , I_c and P_d by the same factor after completing the analysis.

³ In a few cases the lines of constant plate current will inflect sharply upward before reaching the diode line. In these cases e_{bmin} should not be read at the diode line but at the point where the plate current line intersects a line drawn from the origin through these points of inflection.

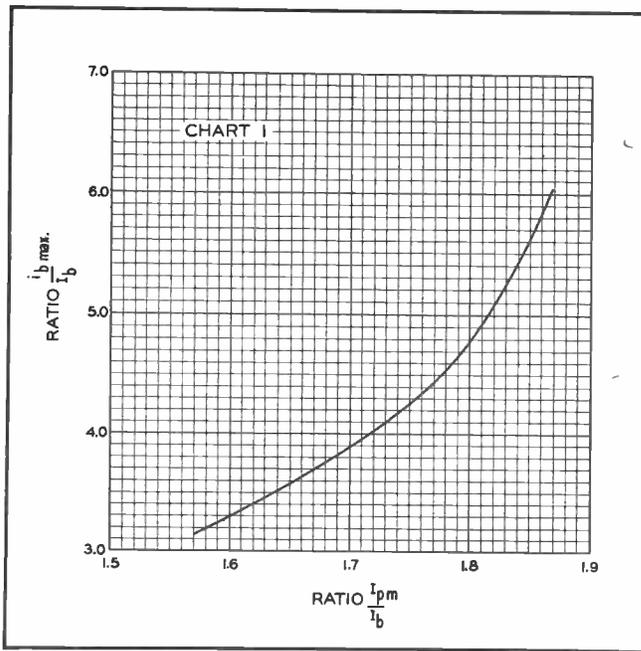


Chart 1

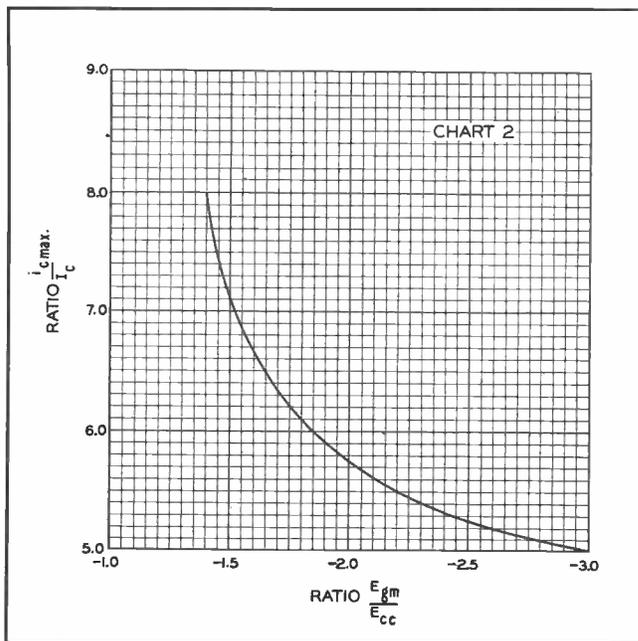


Chart 2

4 If this calculation gives $\cos \theta_p$ as zero or a negative quantity class-B operation is indicated and new operating conditions should be chosen on a basis of higher efficiency (less plate dissipation, more power output or less power input).

5 The calculated driving power is that actually used in supplying the grid and bias losses. Suitable allowance in driver design must be made to allow for losses in the coupling circuits between the driver plate and the amplifier grid.

6 "Vacuum Tube Ratings" Eimac News, Industrial Edition, Jan. 1945.

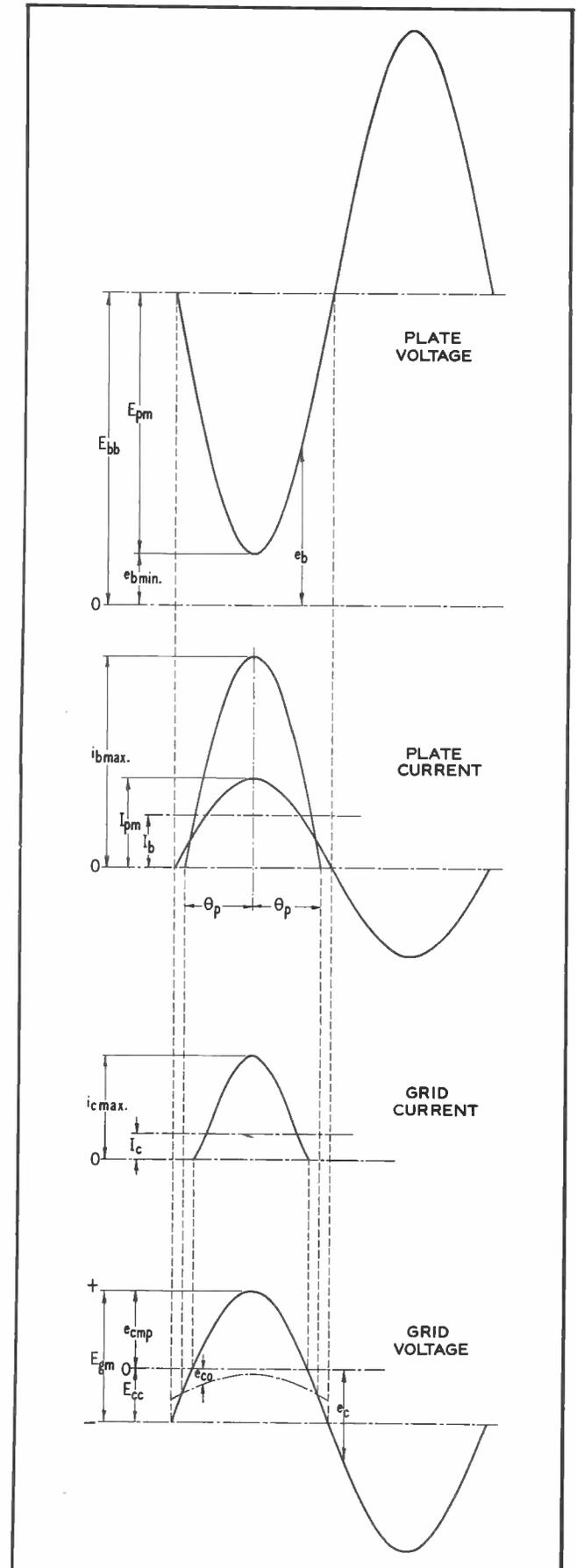


Figure 1. Symbols

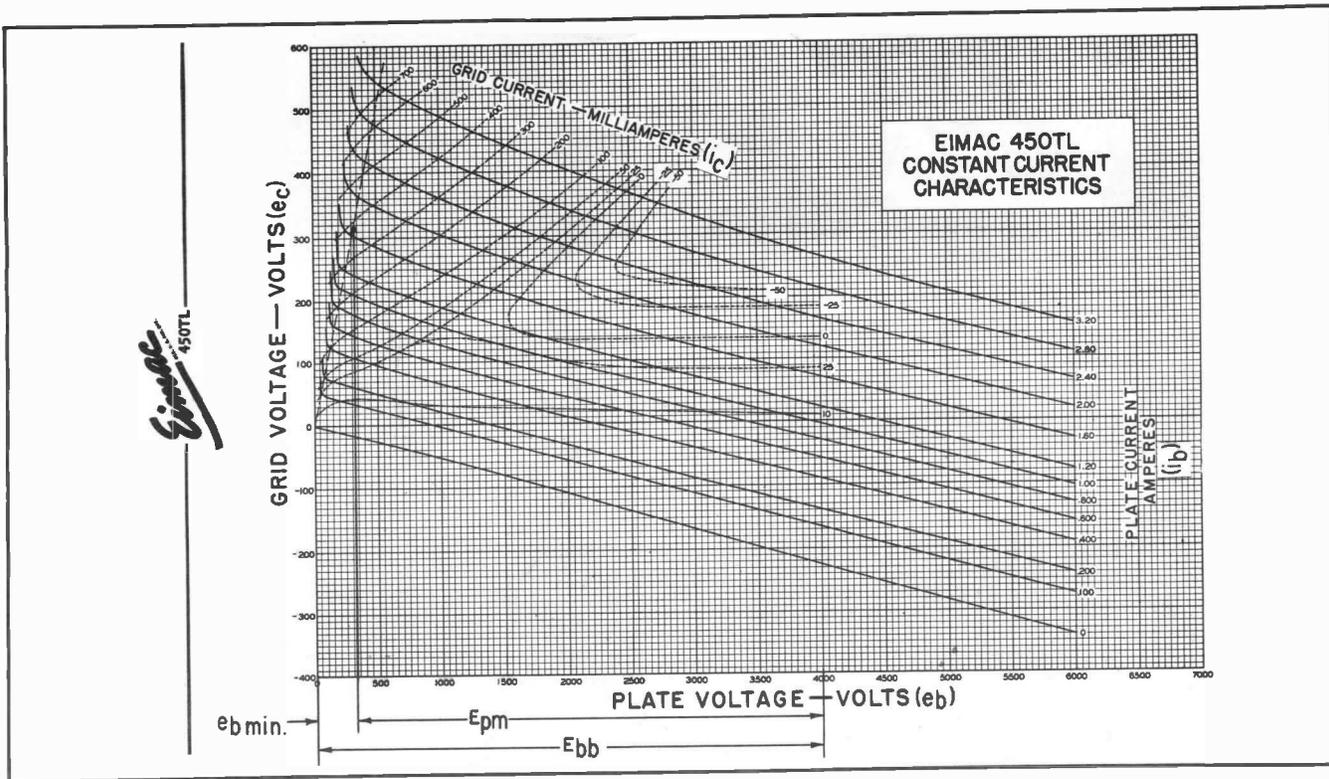


Figure 2. 450TL constant-current characteristics showing method of determining $e_{b \min}$ and E_{pm} in steps 6 and 7 from value of i_b obtained in step 5.

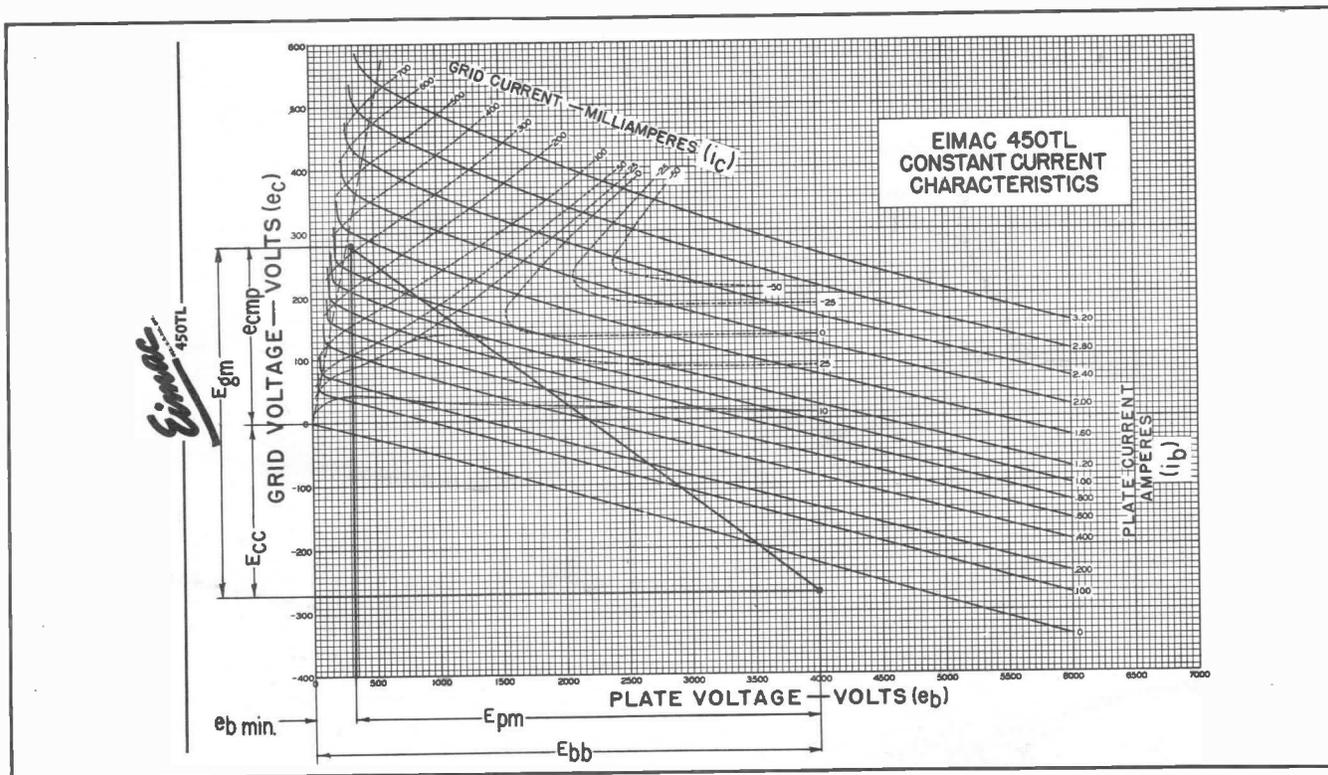


Figure 3. Method of determining e_{cm} and i_c on 450TL constant-current characteristics from values of $e_{b \min}$ and E_{pm} found in steps 6 and 7 and value of i_b found in step 10. The value of E_{cc} and E_{gm} from steps 13 and 14 and the operating line are also shown.

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23

NUMBER 5
TUBE
PERFORMANCE
COMPUTOR
DETAILED INSTRUCTIONS

TUBE PERFORMANCE COMPUTOR FOR RF AMPLIFIERS (CLASS B, C, AND FREQUENCY MULTIPLIERS)

It is quite easy to make a close estimate of the performance of a vacuum tube in radio frequency power amplifier service, or an approximation in the case of harmonic amplifier service. Such estimates will give RF output power, DC input power, grid driving power and all DC current values.

These estimates can be made easily by using the Eimac Tube Performance Computer and the characteristic curves of a tube, plotted on plate voltage/grid voltage curves (constant current curves). Only the ability to multiply out figures taken from the curves by means of the computer is required.

By graphically laying out the trace of the plate and grid voltages as they rise and fall about the applied DC plate voltage and DC grid bias a clearer understanding is possible of the action taking place within a tube. With such an understanding the operating conditions can be altered readily to suit one's particular requirements.

Simple Action in Class C RF Amplifiers

In an amplifier a varying voltage is applied to the control grid of the tube. Simultaneously the plate voltage will vary in a similar manner, due to the action of the amplified current flowing in the plate circuit. In radio frequency applications with resonant circuits these voltage variations are smooth sine wave variations, 180° out of phase (as the grid voltage rises and becomes *more* positive, the plate voltage falls and becomes *less* positive) as indicated in Fig. 1. Note how these variations center about the DC plate voltage and the DC control grid bias.

Let us now see how such variations of the plate and grid voltages of a tube appear on the constant current curve sheet of a tube. In Fig. 2 these

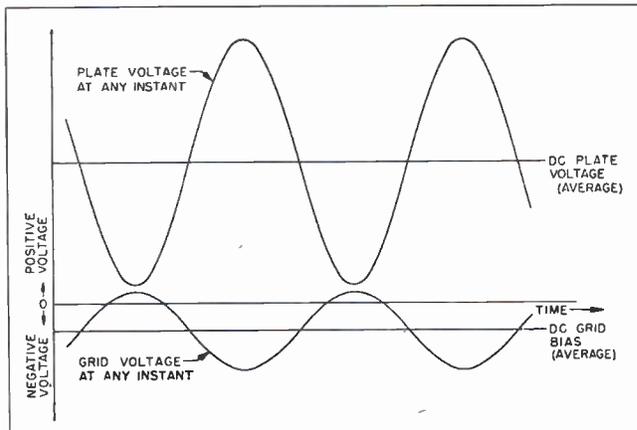


Figure 1

variations have been indicated next to the plate voltage and grid voltage scales of a typical constant current curve. At some instant of time, shown as "t" on the time scales, the grid voltage has a value which is the point marked "eg" on the grid voltage sine wave. At this same instant of time the plate voltage has a value which is the point "ep" marked on the plate voltage sine wave. If now one finds the point on the tube curve sheet corresponding to these values (where a line drawn from "eg" and a line drawn from "ep" cross) he will be at point A in Fig. 2. As the values of grid voltage "eg" and plate voltage "ep" vary over the RF cycle, the point A moves up and down a line, which in the case of the normal RF power amplifier is a straight line. This line is called the "Operating Line."

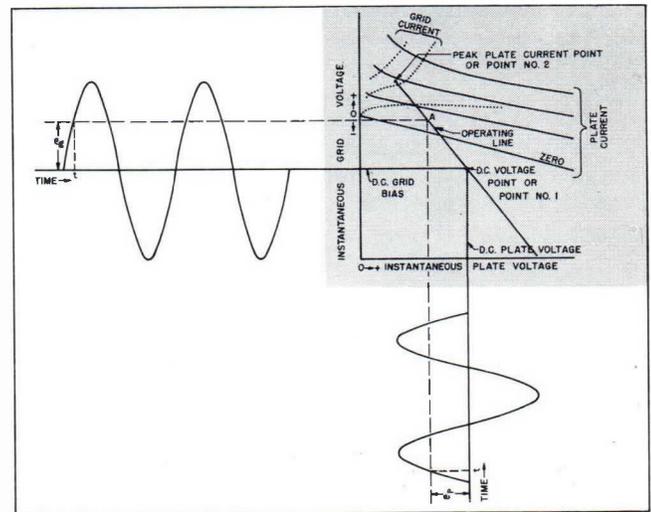


Figure 2

Any point on the operating line (when drawn on a curve sheet as in Fig. 2 or Fig. 4) tells the instantaneous values of plate current, screen current, and grid current which must flow when those particular values of grid and plate voltage are applied to the tube. Thus by reading off the values of the currents and plotting them against the time, t, one can obtain a curve of instantaneous values of plate and grid current. See Fig. 3.

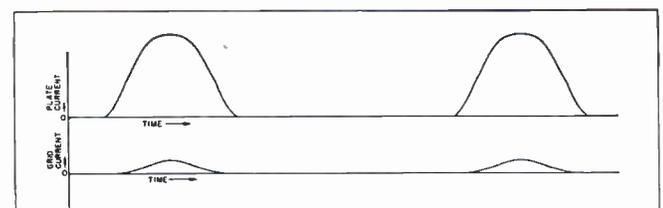


Figure 3

If we analyze the plate and grid current values shown, we can predict that they will cause a DC ammeter to show a particular reading. This is called the DC component of the current. Also, we can predict that if the plate current flows through a properly loaded resonant RF circuit a certain amount of radio frequency power will be delivered to that circuit. If the circuit is tuned to the fundamental frequency (same frequency as the RF grid voltage) the power delivered will be due to the fundamental (or principle radio frequency) component of plate current. If the circuit is tuned to a harmonic of the grid voltage frequency (for instance, two, or three times the frequency) the power delivered will be due to a harmonic component of the plate current.

The Eimac Tube Performance Computer gives us the means to make these simple calculations. It is a means with which to determine the DC component, the fundamental RF component, or the approximate harmonic component of the current flowing in a tube when the tube is operating as a radio frequency amplifier, and enables one to state what all meter readings will be and to predict the RF output power and the required driving power. With these factors known we are then able also to forecast what will happen if any of the operating conditions are changed.

Use of the Eimac Tube Performance Computer

The Eimac Tube Performance Computer is a simple aid to enable one to select suitable values from the characteristic curves of a tube, and by means of simple calculations to forecast the performance of the tube in radio frequency power amplifiers.

The basic steps are outlined under "Instructions" on the computer. This requires selecting DC plate and grid bias voltages, being guided by the typical operating values given on the technical data sheet for the tube type and by general experience. Next, a suitable "Operating Line" must be chosen on the constant current curves for the tube type (plotted on grid voltage/plate voltage scales).

The computer when properly placed over this operating line enables one to obtain instantaneous values of the currents flowing at every 15° of the electrical cycle. The formulas given on the computer were derived by Chaffee¹ to give the various average and harmonic components of the resulting currents. Knowing these current component values and the radio frequency voltage values which are indicated by the use of the computer, one can readily calculate the complete performance of the tube.

The fundamental methods of making such computations, and the considerations necessary to stay within ratings of the tube types, and accomplish various forms of modulation have been covered in the literature.^{2,3,4,5,6,7} The method for the case of harmonic amplifier service is approximate and should be used only for tetrode and pentode tubes, where the plate voltage has little effect on the amount of plate current flowing. A more exact method, showing that for harmonic operation the

operating line is a simple Lissajou figure, has been described by Brown.⁸

The results of using this computer for power amplifier service can be applied in combination with the other methods given in the literature to give good accuracy with simpler procedures. The resulting accuracy is well within the normal variation of tube characteristics due to the normal variation in manufacturing dimensions of a tube. Since the published tube curves are only typical of the characteristics to be expected from a particular tube type, the calculated performance is well within the values expected when different tubes of a given tube type are operated under the assumed conditions.

Example Showing Detailed Use of the Eimac Tube Performance Computer Radio Frequency Power Amplifier, Class C (Telegraphy or FM)

Let us say we have an Eimac 4-65A tetrode and want to make it work effectively. Also let us say we have a 2000 volt DC plate power supply available.

Within frequency limits, we know a tube should be able to run in class-C amplifier service with about 75% efficiency, or, in other words, to convert 75% of the DC plate input power into RF output power. The difference, or 25% of the input power, is dissipated or lost as heat on the plate of the tube. The DC plate input power is then about four times the power dissipated on the plate.

The 4-65A tetrode has a maximum rated plate dissipation of 65 watts, so, to illustrate performance near the maximum rating, we'll choose an input power four times the plate dissipation, or 260 watts per tube. At 2000 volts the plate current per tube must then be 130 ma. It is usual practice, in the case of tetrodes and the medium or low mu triodes in class-C amplifier service for the DC grid bias voltage to be roughly two or three times the grid voltage necessary to cut off the flow of plate current. By referring to the curves of the 4-65A we decide to use a DC grid bias voltage of -120 volts.

Let us now locate the "Operating Line" on the constant current curves of the 4-65A. See Fig. 4. First mark the point where the DC grid bias and DC plate voltage cross. The "Operating Line" must go through this point. Call it point No. 1. Next, we must decide what the peak value of plate current of the tube must be and how low we can let the instantaneous value of plate voltage go when the tube is passing this much current. This is necessary in order to locate the other end of the "Operating Line," point No. 2.

The peak value of plate current usually runs about four times the DC plate current. The minimum value of instantaneous plate voltage is usually set by the fact that if the voltage is too low the grid and screen currents will be needlessly high, and also little will be gained as far as output power is concerned. The minimum value of plate voltage is usually in the region where the plate constant current curves bend upward. See Fig.

4. (In the case of the triode this is near the "diode line" or line where the instantaneous grid and plate voltages are equal.) The practical procedure in calculating tube performance is to arbitrarily choose point No. 2 and complete the calculations. Then try other locations of point No. 2, complete the calculations, and compare the results.

In the case of the 4-65A let us choose a peak value of plate current about four times the DC plate current of 130 ma, or 500 ma. Let us choose a minimum instantaneous plate voltage of 250 volts and thus fix the upper end of the "Operating Line." Next, locate this point on the tube curves. This is point No. 2 on Fig. 4. (The plate currents which flow at various combinations of plate and grid voltages are shown by the plate current lines. The value of current for each line is noted. In-between values can be estimated closely enough for our purposes.) Now draw a straight line between points No. 1 and No. 2. This line is the "Operating Line" and shows the current and voltage values for each part of the RF cycle when current is being taken from the tube. (The non-conducting half of the RF cycle would be shown by extending this line an equal distance on the opposite side of point No. 1. However, there is little use in so doing because no current flows during this half of the cycle.)

The Eimac Tube Performance Computer can now be used to obtain the meter readings and power values from this "Operating Line." Place the com-

puter on the constant current curve sheet so that the "guide lines" of the computer are parallel with the operating line. Now slide the computer about without turning it until the line OG passes through the DC voltage point No. 1 and line OA passes through the peak current point No. 2. Make sure the guide lines are still parallel to the "Operating Line."

Note that the lines OB, OC, OD, OE and OF of the computer all cross over the "Operating Line."

At each point where the lines OA, OB, etc., cross the "Operating Line" we need to determine the instantaneous values of plate current and grid current (and screen current if a tetrode or pentode is used) which is flowing at that particular moment in the RF cycle. Later, from these key values of current, we will calculate the values of DC plate current and grid current (and screen current) as well as the RF components of the plate current.

At each of these points, where the instantaneous current values are to be determined, a mark should be made on the constant current curve sheet of the tube. By noting where this mark lies with respect to the plate current curves, one can estimate the value of plate current flowing at this part of the cycle. Next, the location of this mark with respect to the control grid curves is noted and a value of grid current is estimated. Finally, by referring the mark to the screen grid curves, if the tube is a tetrode or pentode, a value of screen current is noted. These current values should be listed for each

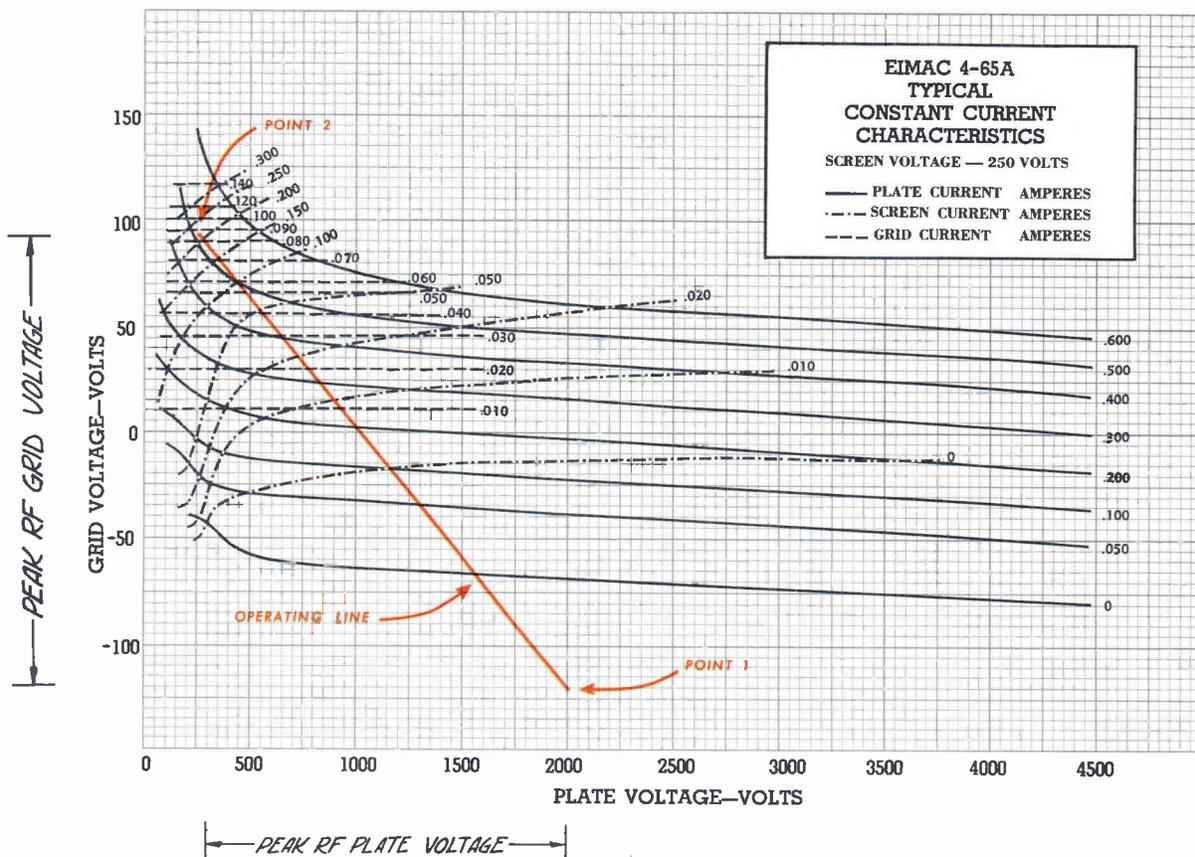


Figure 4

point where the lines OA, OB, etc., cross the operating line so that they can be combined later to calculate the various tube currents. At points where OF and OE cross, the current values are often zero.

Now in the example chosen, let us read off the instantaneous plate current values where these lines cross the "Operating Line." At the point where the line OA crosses the "Operating Line" the plate current is 500 ma. Where OB crosses the operating line the plate current can be estimated as 510 ma since the point is about 1/10 of the way from the 500 ma line to the 600 ma line. At OC the plate current is 460 ma, OD 290 ma, OE 75 ma, OF and OG 0 ma. Similarly we can estimate the instantaneous screen current at the crossing of OA and the "Operating Line" as 165 ma, and the instantaneous grid current at 60 ma. Values are read for the other crossings and written down. These values are put in simple columns for calculating:

Crossing of line	Simplified Name in Formulas	Instantaneous Values of Currents		
		Plate	Screen	Control Grid
OA	A	500 Ma	165 Ma	60 Ma
OB	B	510	100	50
OC	C	460	25	30
OD	D	290	5	14
OE	E	80	0	0
OF	F	0	0	0

Now in order to obtain the DC value of plate, screen, and control grid currents the formula (see computer) says to add up the above values but use only one-half of the A values (giving 250 ma for plate, 82 ma for screen, and 30 ma for grid), and then divide by 12, as follows:

$$\text{DC Meter Reading} = 1/12 (0.5 A + B + C + D + E + F)$$

DC Meter Reading = 1/12 (0.5 A + B + C + D + E + F)	Plate	Screen	Control Grid
	250 Ma	82 Ma	30 Ma
	510	100	50
	460	25	30
	290	5	14
	80		
<hr/>	<hr/>	<hr/>	<hr/>
Total 1590 Ma	212 Ma	124 Ma	
DC Current = 1/12 Total =			
132 Ma	18 Ma	10 Ma	

Now to calculate the RF output power it is necessary to use the formula for the peak RF current which is present in the tube plate current. Since we are using the tube as a straight RF power amplifier we use the formula for "Peak Fundamental RF" as shown on the computer. (If we were estimating the performance of a doubler or tripler we would use the formula for "Peak 2nd Harmonic RF" or "Peak 3rd Harmonic RF".)

From the computer we see that the formula for the peak fundamental RF current is:

$$1/12 (A + 1.93 B + 1.73 C + 1.41 D + E + 0.52 F)$$

$$\begin{aligned} A &= 500 = 500 \text{ Ma} \\ 1.93 B &= 1.93 \times 510 = 985 \\ 1.73 C &= 1.73 \times 460 = 796 \\ 1.41 D &= 1.41 \times 290 = 409 \\ E &= 80 = 80 \end{aligned}$$

$$\text{Total} = 2770 \text{ Ma}$$

$$\begin{aligned} \text{Peak fundamental current} &= 1/12 \text{ Total} \\ &= 2770/12 = 230 \text{ Ma} \end{aligned}$$

We now have the various current values. In

order to calculate the powers involved it is necessary to know, not only the DC voltage values, but the greatest amount each voltage swings away from the DC value. This is known as the peak value of the RF voltage. Because the plate voltage swings from 2000 volts down to 250 volts the peak RF voltage is the difference, or 1750 volts. Similarly the grid voltage must rise and fall between the operating points No. 1 and No. 2, or from -125 volts to +95 volts. This is a peak swing of 220 volts and the peak RF grid voltage is 220 volts.

Let us now use the formulas for output power and driving power:

Output power = $1/2$ peak RF plate current x peak RF plate voltage.

We found the peak RF plate current to be 230 ma or .230 amperes, and the peak RF plate voltage to be 1750 volts.

So; Output Power = $1/2 \times .230 \times 1750 = 201$ watts,
and Input Power = DC Plate Current x DC Plate Voltage
= .132 x 2000 = 264 watts

Plate Dissipation = DC Input Power - RF Output Power
= 264 - 201 = 63 watts

Efficiency = RF Output Power divided by
DC Input Power
= 201/264 = 76%

Driving Power = DC Grid Current x Peak RF Grid Voltage
So the Driving Power = .010 x 220 = 2.2 watts

The power consumed by the bias source is simply the product of the DC grid current and the DC grid voltage, or .010 x 120 = 1.2 watts.

The difference between the driving power and the power consumed by the bias source is the power dissipated on the control grid, or 2.2 - 1.2 = 1.0 watts.

The power dissipated on the screen grid is simply the product of the DC screen current and the DC screen voltage, because the screen grid has no impedance between it and the DC screen supply. Thus it is .018 x 250 = 4.5 watts.

The performance of the tube can now be summarized:

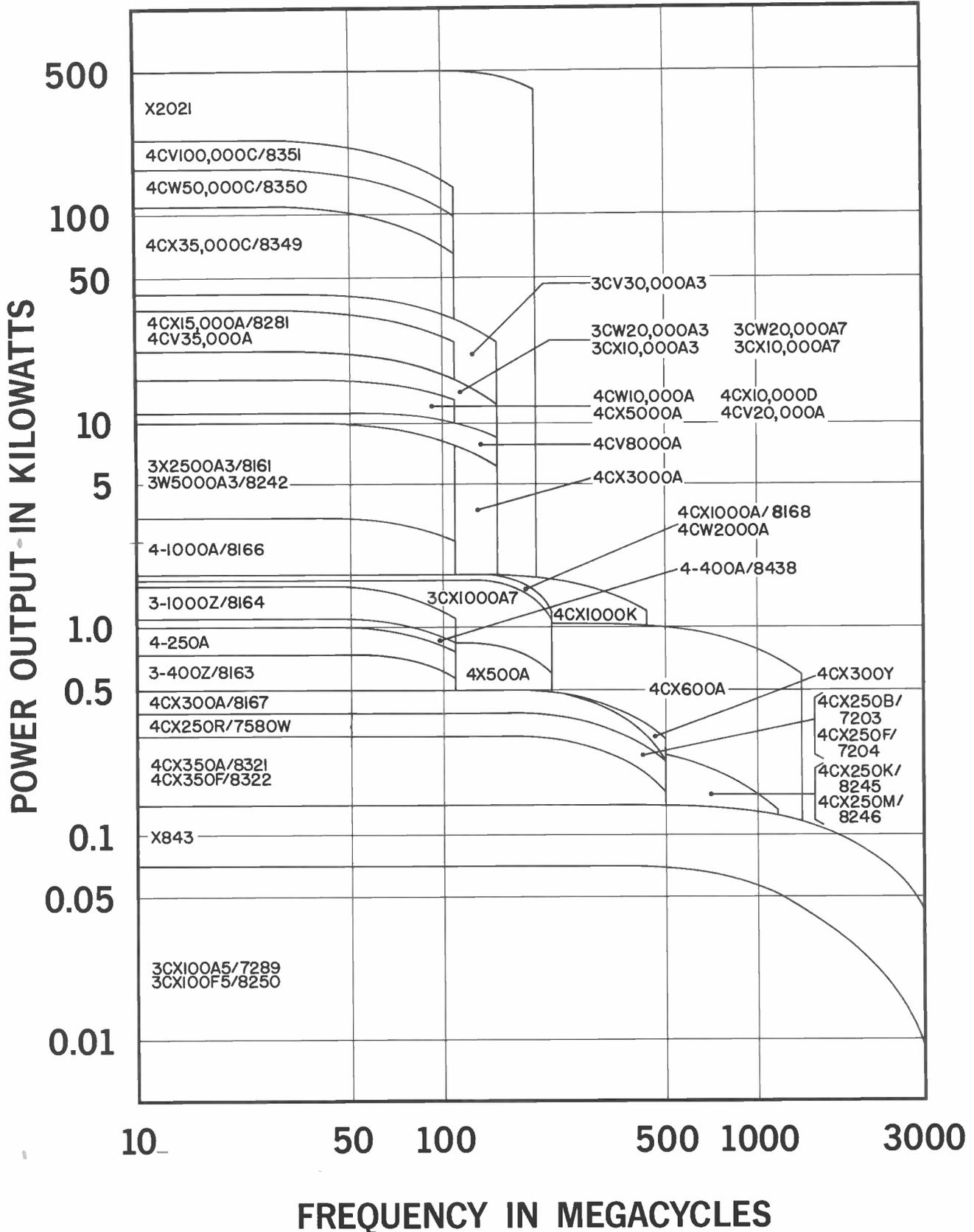
DC Plate Voltage 2000 Volts	Driving Power	2.2 Watts
DC Screen Voltage 250 Volts	Grid Dissipation	1.0 Watts
DC Grid Voltage -120 Volts	Screen Dissipation	4.5 Watts
DC Plate Current 132 Ma	Plate Power Input	264 Watts
DC Screen Current 18 Ma	Plate Power Output	201 Watts
DC Grid Current 10 Ma	Plate Dissipation	63 Watts
Peak RF Grid Voltage	220 Volts	

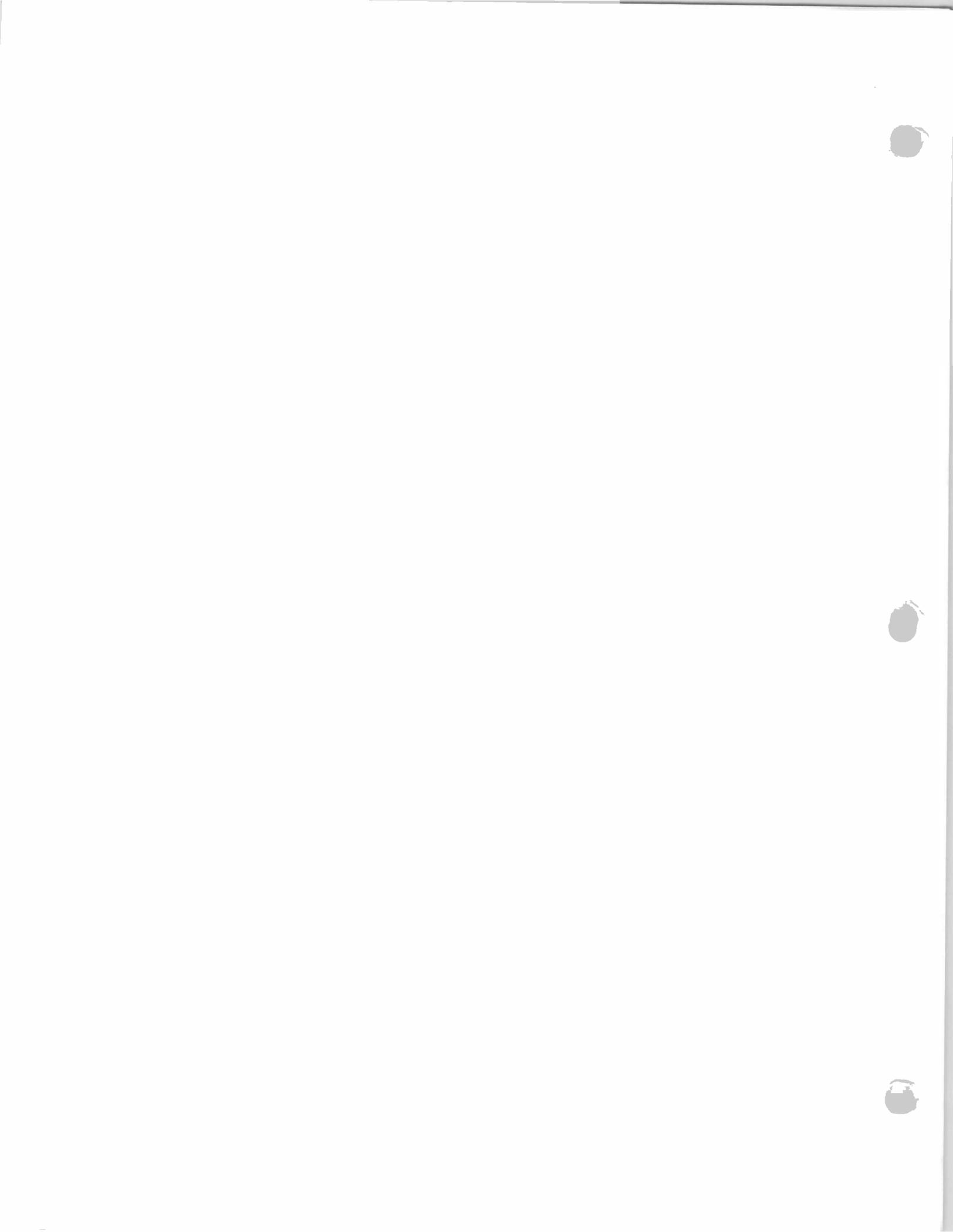
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2. H. P. Thomas, "Determination of Grid Driving Power in Radio Frequency Power Amplifiers," Proc. IRE, Vol. 21, pp. 1134-1141; August 1933
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7. "Vacuum Tube Ratings," Eimac Application Bulletin Number 6
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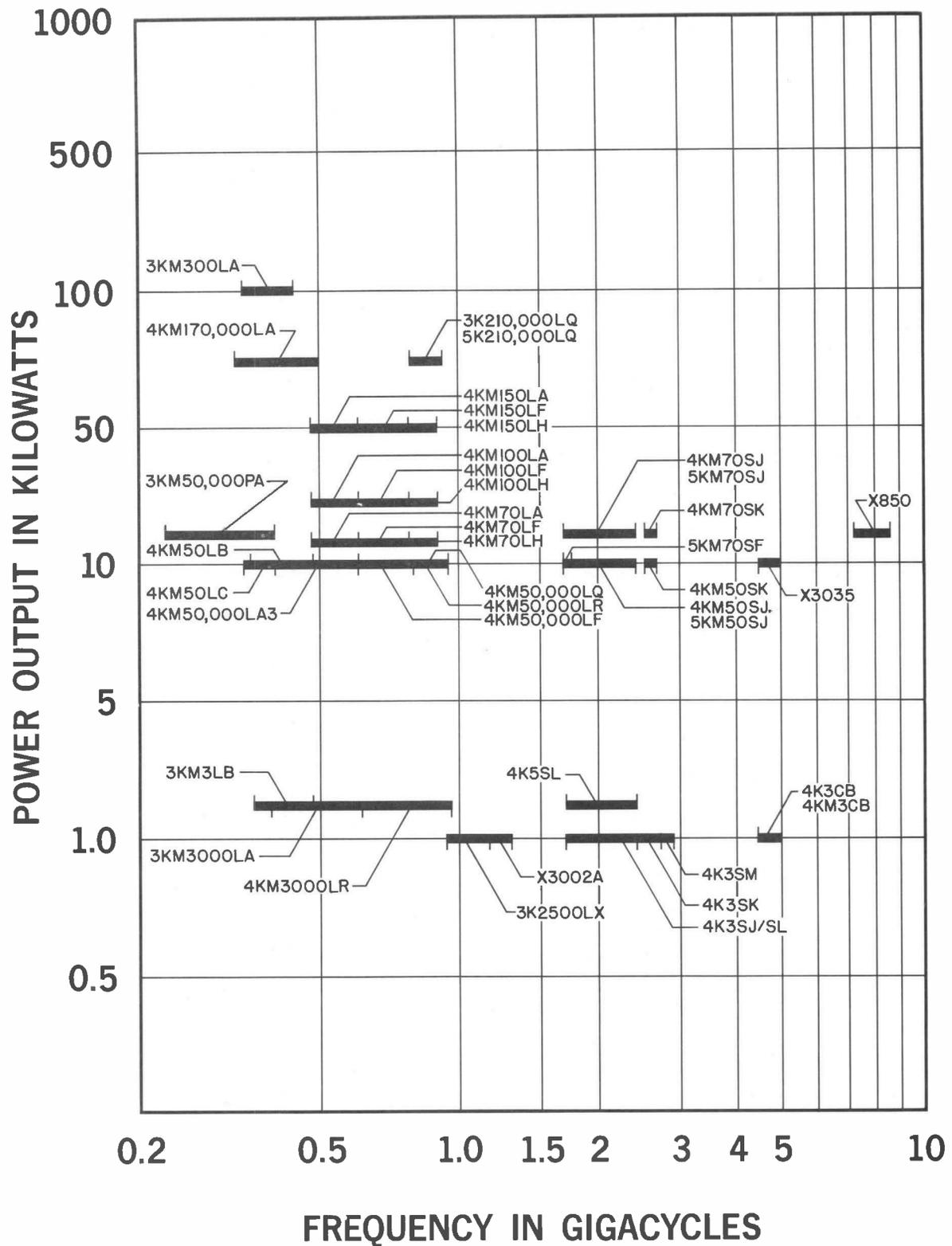


POWER GRID TUBES



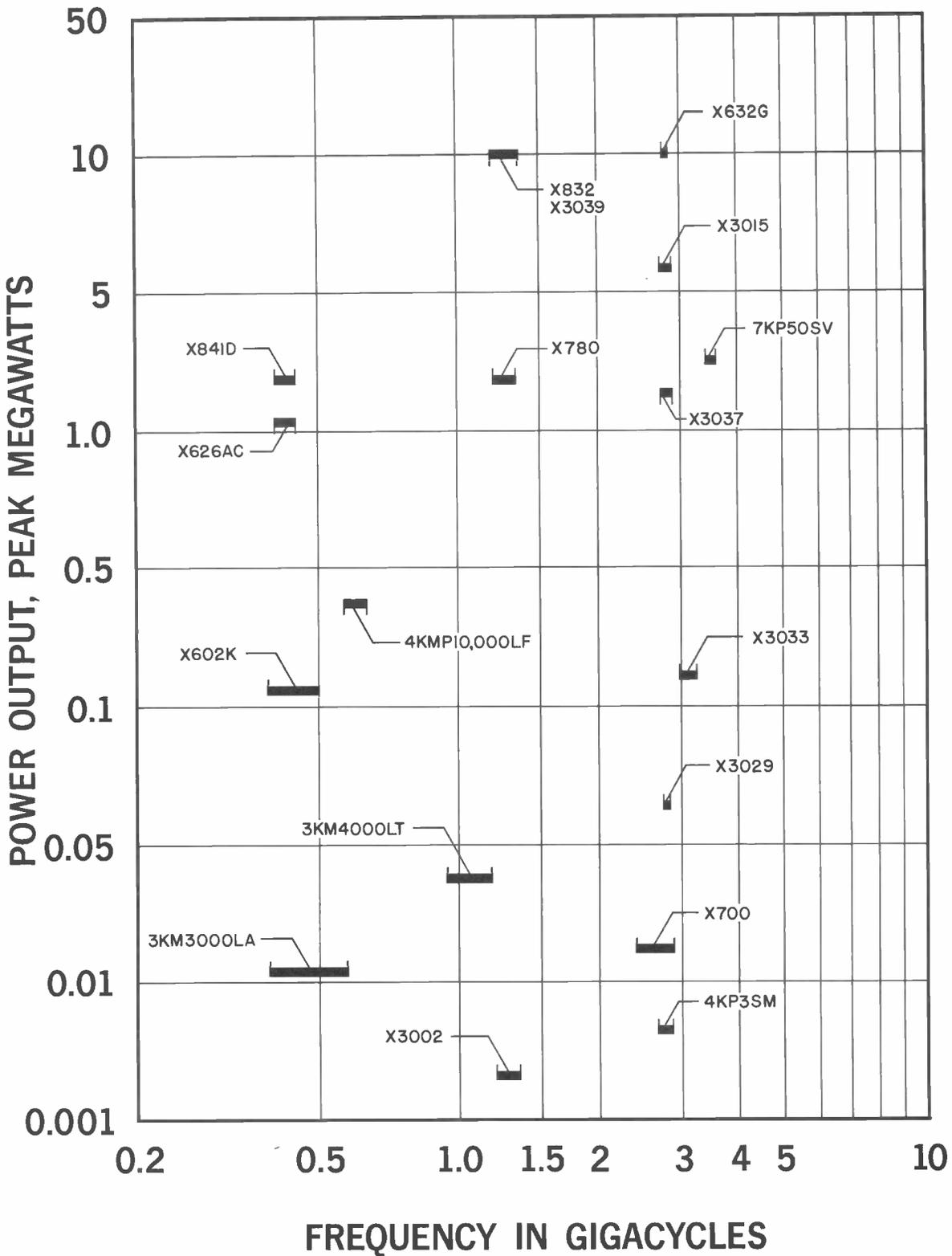


CW POWER KLYSTRONS

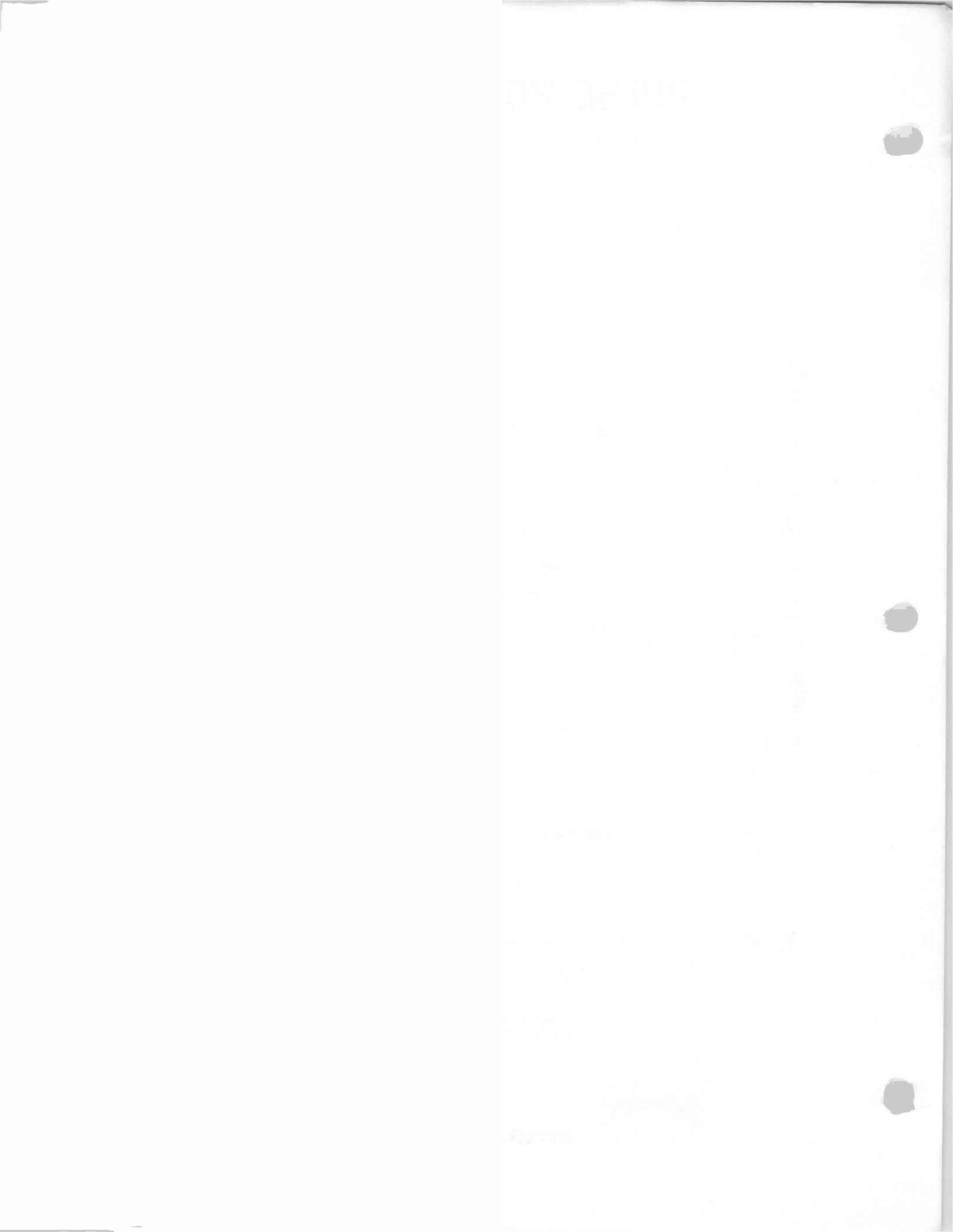


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PULSE POWER KLYSTRONS



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Specialty Distributing Co., Inc.
763 Juniper Street, N. E.
(404) 873-2521

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999564
Industrial Electronics Inc.
646 Queen St.
506-095
Pacific Electronics
1336 Dillingham Blvd.
817-118, 816-865
Precision Radio Ltd.
1160 South King Street
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Radio Television Corp. Ltd.
432 Keawe Street
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20 E. Sycamore
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Wicks Radio Equipment Co.
513 South Staples Street
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(214) 742-8257
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(214) 747-7508
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(214) 824-3001

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(713) 526-4661

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Lubbock

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(806) 765-5741

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Sterling Electronics, Inc.
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Salt Lake City
Ballard Supply Corp.
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Broadcast Services, Inc.
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(801) 355-4641
Electronic Sales Corp. (ELSCO)
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(801) 466-8631

S. R. Ross, Inc.
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(801) 328-0591
Standard Supply Company
225 E. 6th South Street, Box 1047
(801) 355-2971

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Charlottesville
Virginia Radio Supply Co., Inc.
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715 Henry Avenue
(703) 296-4184

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Priest Electronics, Inc.
6431 Tidewater Drive
(703) 885-2021

Richmond
Meridian Electronics Inc.
1001 West Broad Street
(703) 353-6648

Roanoke
H. C. Baker Sales Company, Inc.
17-19 Franklin Road, S.W.
(703) 344-9209

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415 Westlake Ave., North
(206) 622-6600

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(509) 924-2343
Northwest Electronics, Inc.
730 East First Avenue
Term. Box 3047
(509) 534-2644

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Charleston
Mountain Electronics Company
708 Bigley Avenue
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Eau Claire
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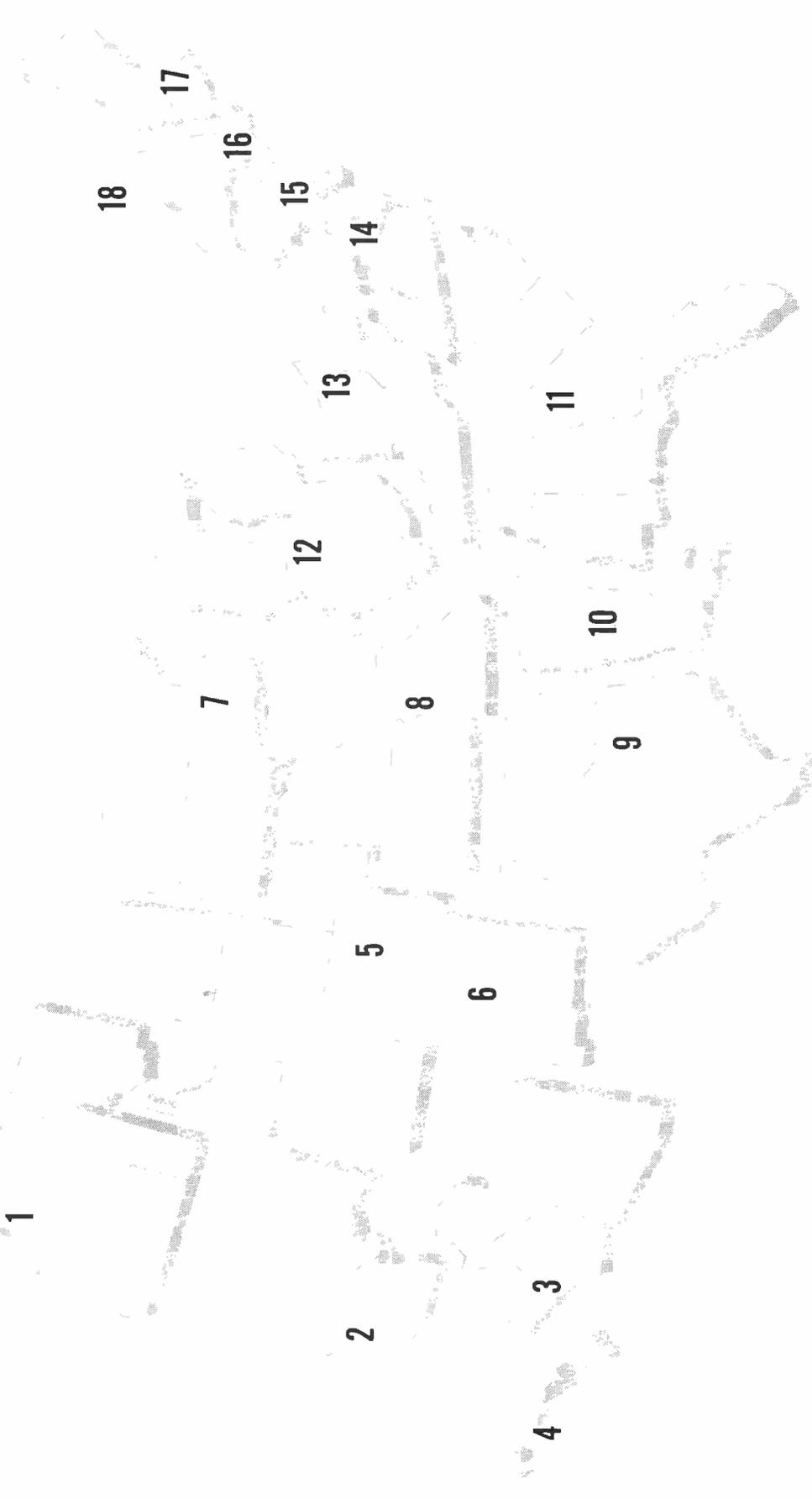
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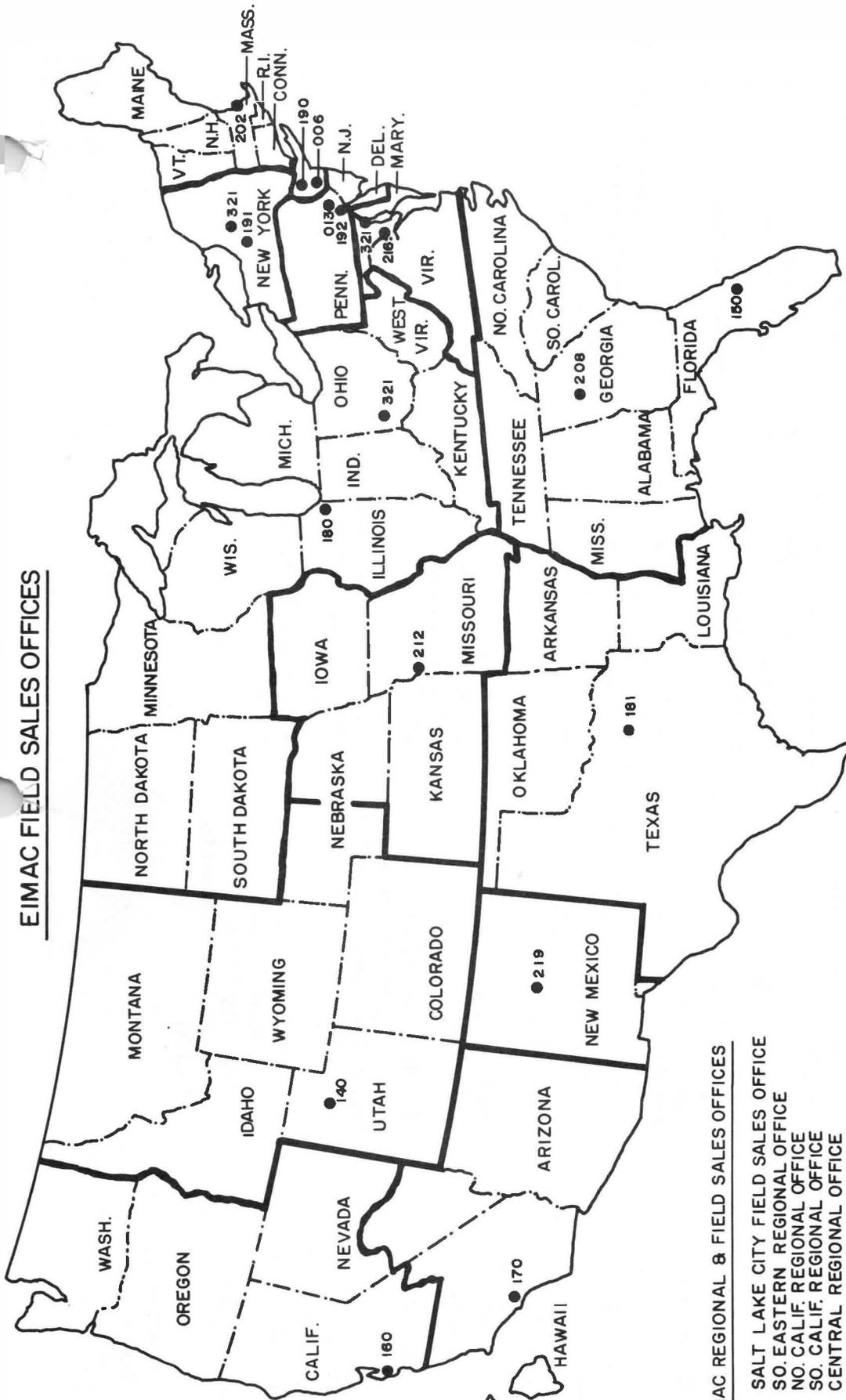
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EITEL-McCULLOUGH, INC.
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**USER
PRICE**

October 15, 1960

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1K015CA	\$ 618.00	4-125A	\$ 36.00
1K015CG	618.00	4-250A	46.50
1K20KA	475.00	4-400A	48.00
1K20XD	475.00	4-1000A	132.00
1K20XK	475.00	4CN15A	55.00
1K20XS	475.00	◆ 4CW2000A	218.00
1K75CH	810.00	◆ 4CW10,000A	576.00
1K75CK	810.00	4CX125C	55.00
1K125CA	298.00	◆ 4CX250B	39.35
1K125CB	298.00	◆ 4CX250F	39.35
1K125CC	730.00	4CX250K	64.25
2-01C	18.50	◆ 4CX250M	92.50
◆ 2-25A	20.00	4CX300A	55.00
◆ 2-50A	23.00	4CX1000A	156.00
2-150D	38.55	4CX5000A	495.00
2-240A	42.85	◆ 4CX10,000D	550.00
◆ 2-450A	113.00	◆ 4E27A/5-125B	50.00
2-2000A	228.00	◆ 4K50,000LQ	3,760.00
2C39A	22.50	4KM3000LQ	3,750.00
◆ 2C39WA	32.00	4KM3000LR	2,420.00
2X1000A	127.50	4KM50,000LA	4,230.00
◆ 2X3000F	168.00	4KM50,000LQ	3,760.00
322 <i>(must from list)</i>	25.80	◆ 4KM170,000LA	20,500.00
3C24	16.05	4KMP10,000LF	10,800.00
◆ 3CPN10A5	32.00	4PR60A	100.00
◆ 3CW20,000A3	560.00	◆ 4PR65A	35.75
◆ 3CX100A5	32.00	◆ 4PR125A	50.00
◆ 3CX10,000A3	468.00	4PR400A	60.00
3K2500LX	2,360.00	4PR1000A	145.00
3K2500SG	2,950.00	◆ 4W300B	57.00
3K3000LQ	2,360.00	◆ 4W20,000A	1,950.00
◆ 3K50,000LA	4,200.00	◆ 4X150A	25.00
3K50,000LF	4,200.00	◆ 4X150D	28.00
3K50,000LQ	4,200.00	4X150G	58.00
3KM3000LA	2,470.00	4X250B	42.50
3KM4000LT	1,880.00	4X500A	128.50
3KM50,000PA	11,000.00	6C21	82.50
◆ 3W5000A1	237.00	6K50,000LQ	8,250.00
◆ 3W5000A3	225.00	◆ 25T	18.50
◆ 3W5000F1	243.00	◆ 35T	21.50
◆ 3W5000F3	231.00	35TG	36.00
3X100A5	25.00	◆ 75TH	30.00
◆ 3X2500A3	200.00	◆ 75TL	30.00
◆ 3X2500F3	206.00	◆ 1001G	107.00
◆ 3X3000A1	212.00	100TH	23.60
◆ 3X3000F1	218.00	100TL	23.60
◆ 4-65A	28.50	152TH	75.00

All Prices subject to change without notice. Minimum factory order \$10.00

◆ Indicates change from sheet dated March 15, 1960

(Continued)



VACUUM TUBES (continued)

152TL	.....	\$	75.00	✓
◆ 250R	.....		38.55	✓
◆ 250TH	.....		38.55	✓
◆ 250TL	.....		38.55	✓
◆ 253	.....		37.25	✓
◆ 304TH	.....		64.50	✓
◆ 304TL	.....		64.50	✓
450TH	.....		77.00	✓
450TL	.....		77.00	✓
◆ 592/3-200A3	.....		46.00	✓
◆ 750TL	.....		150.00	✓
◆ 1000T	.....		150.00	✓
◆ 1500T	.....		279.00	✓
◆ 2000T	.....		387.00	✓
7034	.....	see	4X150A	✓
7035	.....	see	4X150D	✓
7203	.....	see	4CX250B	✓
7204	.....	see	4CX250F	✓
7289	.....	see	3CX100A5	✓
◆ 7580/4CX250BA	.....		45.00	✓
◆ 8020(100R)	.....		21.50	✓
◆ KY21A	.....		26.75	✓
◆ RX21A	.....		25.75	✓

PREFORMED CONTACT FINGER STOCK
(Available in 3-Foot Lengths Only)

			per	
			piece	
◆ CF-100	.....	17/32"	5.77	
◆ CF-200*	.....	13/16"	6.70	
◆ CF-300	.....	31/32"	6.23	
◆ CF-400*	.....	1-17/32"	8.30	
◆ CF-500	.....	1-3/8"	6.70	
◆ CF-600*	.....	2-1/4"	9.23	
◆ CF-700	.....	17/32"	6.23	
◆ CF-800	.....	23/32"	6.23	
◆ CF-900	.....	31/64"	5.77	

*Double-sided

UNTREATED FINGER STOCK (Punched and
formed, not heat-treated or plated)
Available in 3-foot lengths only).

◆ CF-101	.....	17/32"	4.92
CF-301	.....	31/32"	5.77
CF-501	.....	1-3/8"	6.23

AIR SYSTEM SOCKETS

SK-300	.....	107.15
SK-400	.....	17.65
SK-500	.....	20.70
SK-600	.....	11.90
SK-602	.....	11.90
SK-610	.....	12.65
SK-620	.....	16.80
SK-630	.....	18.85
SK-640	.....	5.35
SK-650	.....	8.60

◆ SK-655	.....	\$	5.85
SK-700	.....		21.45
SK-710	.....		21.45
◆ SK-711	.....		26.50
SK-740	.....		9.80
SK-760	.....		9.80
SK-770	.....		9.80
SK-800A	.....		55.70
SK-810	.....		55.70
◆ SK-890	.....		65.00
SK-900	.....		68.55
◆ SK-1300	.....		64.50

CHIMNEYS FOR AIR SYSTEM SOCKETS

SK-306	.....	6.45
SK-406	.....	8.60
SK-506	.....	15.35
SK-606	.....	.65
SK-626	.....	.80
SK-636	.....	7.07
SK-806	.....	8.55
SK-906	.....	11.43
◆ SK-1306	.....	6.45

HEAT DISSIPATING CONNECTORS
(Alodine Finished)

◆ HR-1	1.10
◆ HR-2	1.20
◆ HR-3	1.20
◆ HR-4	1.20
◆ HR-5	1.20
◆ HR-6	1.20
◆ HR-7	1.65
◆ HR-8	1.65
◆ HR-9	2.80
◆ HR-10	1.65

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For 4X150, 4X250 and
2C39 Series

◆ SK-60457
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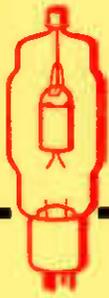
4X150G COLLETS

◆ Collet .008290	3.20
◆ Collet .008291	3.20
◆ Collet .008292	4.00
◆ Collet 882931	4.00
◆ Collet 008294	4.00

VACUUM SWITCH

◆ VS-2	28.50
VS-4	29.00
VS-5	38.55
VS-6	34.25
12V Coil	10.29
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6

PULSE

Eimac
TUBES

When, in 1936, government engineers first tried Eimac tubes as pulsed oscillators, radar became a reality in the United States. The ability of standard Eimac tube types to withstand voltages many times in excess of their maximum CW ratings and to deliver high orders of emission current over relatively long periods of time made possible the attainment of the high peak power required for a practical radar system.

Throughout the years since 1936, the development of improved pulse equipment has been paced by new Eimac tubes and the continual improvement of existing types for better and more reliable operation under pulsed conditions.

Important milestones in the use of Eimac tubes in pulse service are:

- Eimac 100T tubes used as pulsed VHF oscillators in the Navy's first radar tests at sea aboard the USS New York in 1938.
- Eimac VT-127's, a modification of the 100T used as oscillators and Eimac 304T's used as modulators in the SCR-268, one of the Army's first radar sets.
- Eimac 15E and 15R miniature transmitting tubes developed for and used as pulsed oscillators and high voltage rectifiers in ASB airborne search radar.
- Eimac 327A and 227A tubes developed for use as pulsed oscillators in Navy search radar sets of the SC and SK series.
- Eimac 527 tube developed for and used in SK-1M and SR radar for high-power search.
- Eimac 1000T, later modified for mass production and designated 6C21, used as modulator for the Army's famous SCR-584 radar.

During World War II Eimac produced nearly 2 million tubes of its own design for pulse service. In the process of developing and producing these tubes Eimac has gained "know how" about the pulse operation of tubes which is unequaled in the vacuum tube industry. This knowledge has made it possible to develop new tubes having outstanding characteristics for pulse operation. Among these tubes are oscillators and amplifiers capable of delivering pulse powers from a few tens of kilowatts to megawatts and modulators which will key currents from a few amperes to hundreds of amperes.

Years of experience have been gained regarding the pulse capabilities of standard Eimac types. Some of this information is presented on the following pages. However, many pulse applications are so specialized in nature that they do not lend themselves to general rules or tabular presentation. If your problem is of this sort, avail yourself of the services of the Eimac Field Engineering Department.

REVISED 2-1-55

PULSE SERVICE NOTES

In pulse service, where the "on-time" is small compared to the "off-time," Eimac tubes with their ample reserve of filament emission and freedom from internal insulators can be run to a much higher peak-power than is permissible in continuous services. In continuous service, the published voltage and current maxima of Eimac tubes are generally set at values considerably less than the inherent limitations of the design, due to the need to consider the average power dissipated on the anode, grids, and entire tube structure. In pulse service, it is usually reasonable to increase the applied electrode voltages and resulting pulse currents above the maximum values shown for continuous service on the data sheets.

Because of the wide variety of operating conditions in pulse service, it seems advisable to indicate possibilities of tube performance rather than specific operating conditions. It is the user's responsibility to see that no basic limitations of the tubes are exceeded and to introduce factors of safety according to the needs of the particular application.

The principal basic limitations of the tube are given below:

1. *Average Electrode Dissipation.* The dissipation limits of the electrodes are given on the tube data sheet and usually under Radio Frequency Power Amplifier or Oscillator Service. The dissipation must be average over a full repeated pulse cycle. The length of the applied pulse must not be so great that the temperature rises excessively on any one pulse. Pulse times as high as 0.1 second are often not unreasonable. Above about 0.1 seconds the rise in temperature of the electrodes rather than the average power during the pulse becomes the basic limitation and this type of service is discussed under Item 5, "Long Pulse Operation."

Usually, the average electrode dissipation is the product of the dissipation on the element during the on-time, multiplied by the duty cycle (ratio of on-time to a full cycle time). This assumes that the pulse is essentially a square wave. The dissipation may be considerably greater if intermediate values of current between zero and the maximum value flow for appreciable time. Sometimes uneven heating of an element may be a further limitation. In the case of a radiation-cooled anode, this effect is apparent and the temperature of the hottest spot should not be allowed to exceed the normal maximum anode temperature.

2. *Envelope and Seal Temperatures.* The temperature requirements of the bulb and seals will be met if the ordinary cooling instructions are followed. In continuous radio fre-

quency service, a limiting upper frequency is usually specified above which operation at reduced ratings or increased cooling is recommended. In pulse service above this frequency, care should be taken to see that the heating of the leads due to rf charging currents will not be greater than normal.

3. *Available Cathode Emission.* In continuous service, the tube currents are usually limited by dissipation of the electrodes and for convenience are given in terms of dc components read on a meter external to the tube. In pulse service, one needs to know the available total cathode emission in order to engineer the application.

With thoriated tungsten filaments operating at rated voltage in Eimac tubes, the available emission throughout life is above 80 milliamperes per watt of filament power. By raising the filament voltage 10%, this figure can be approximately doubled. Above 10%, the emission will not be further increased, except for short periods of time due to the failure to maintain the optimum emitting surface conditions.

With oxide coated cathodes, the available peak emission is not clearly defined or as easily generalized as in the case of thoriated tungsten filaments. It appears that the available emission for pulse work in typical oxide coated cathodes used in Eimac tubes can conservatively be estimated as 500 ma. per watt of heater power. This figure assumes that the pulse duration is not over about 3 micro-seconds. There is some evidence that above 3 micro-seconds, the maximum usable space current may have to be reduced.

4. *Voltage Insulation.* The breakdown voltage of Eimac tubes is usually well above the values given for continuous service. The basic limit is related to the maximum instantaneous voltage applied to the anode of the tube at any instant. It is also somewhat affected by the regulation of the supply voltage and length of time the voltage is applied. The accompanying table is a rough guide to the values of dc anode voltage that can be applied to the tube.
5. *Long Pulse Operation.* When the length of the applied pulse exceeds about 0.1 seconds (100 milliseconds) the power limitation is no longer the average power dissipated on the electrodes and one must consider the temperature rise of the electrodes (principally the grid wires) during the time the pulse is on. If the pulse duration is in excess of 2.5 seconds the tube must be treated as in continuous service and the normal data sheet ratings apply.

The maximum capabilities of a thoriated tungsten tube in pulse service when the pulse duration is between 0.1 seconds and 2.5 seconds can be computed by using the accompanying curve and table.

As long as the off-time between pulses is 5 seconds or more the pulse may be repeated even though the maximum tube capability for a given pulse length is utilized. Because the grid dissipation is the principal limitation, the curve and table give factors to compute the permissible grid dissipation during the pulse. The product of the two factors is the number of times the rated grid dissipation can be exceeded for a given pulse duration.

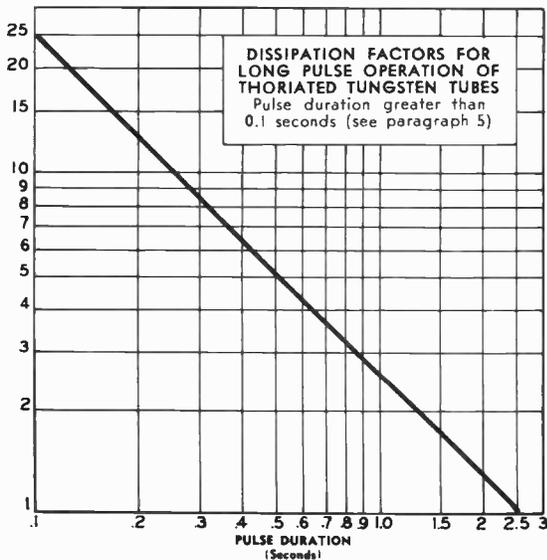
The factor from the curve is to be used directly for the plate and screen dissipation.

When first running up the voltage on a tube in pulse service, or after the tube has been idle for some time, occasional internal flash breakdowns in a tube are to be expected. The circuit should be designed so that the high rush of current and resulting high transient voltage surges will not be destructive to equipment. The transients, due to momentary breakdown of the insulation of the vacuum space, have very high frequency components. As a consequence, high voltages will develop across small lead inductances. Spark gaps, bypass capacitors and inductance filters are often used to dissipate or divert this energy into harmless channels.

Protective devices should be designed to remove the applied voltage quickly when a breakdown occurs. If overload protective action is fast, and the regulation of the source voltage poor enough, no damage to the tube will result and operation can be resumed.

No guarantee is made that the tube will not break down at the voltages given on the chart. It is estimated from considerable experience that these are approximately safe maximum values to be considered in design work.

The maximum capabilities of a thoriated tungsten tube in pulse service when the pulse duration is between 0.1 seconds and 2.5 seconds can be computed by using the accompanying curve and table.



MAXIMUM RATINGS FOR PULSED SERVICE

Tube Type	MAXIMUM PLATE VOLTAGE			Max. Screen Voltage Kilovolts	Grid Factor Long Pulse Operation*
	RF Service Plate Pulsed Kilovolts	RF Service Grid Pulsed Kilovolts	Pulse Modulator Service Kilovolts		
2C39A	3.5	...	...	...	...
3C24	10	7.5	15	...	.68
3X2500A3	15	10	...	...	.68
3X2500F3	15	10	...	...	.68
3X3000A1	15	10	...	...	.68
3X3000F1	15	10	...	...	.68
3W5000A3	15	10	...	...	.68
3W5000F3	15	10	...	...	.68
3W10,000A3	...	15	...	...	**
4E27A/5-125B	12	9	18	2.0	1.68
4-65A	10	7.5	15	2.0	.57
4-125A	12	9	18	2.0	1.87
4-250A	15	10	20	2.5	2.7
4-400A	15	10	20	2.5	2.7
4-1000A	20	15	30	2.5	1.54
4PR60A	...	...	20	1.5	...
4W20,000A	20***	15	30	5.0	**
4X150A	7	2	3	1.0	...
4X150D	7	2	3	1.0	...
4X150G	7	2	3	1.0	...
4X500A	10	7.5	15	2.0	.95
4X500F	10	7.5	15	2.0	.95
6C21	20	15	30	...	...
15E	12.5	10	15	...	...
25T	10	7.5	15	...	.77
35T	10	7.5	15	...	.84
35TG	10	7.5	15	...	.84
UH-50	5	4	7.5	...	...
75TH	12	9	17	...	.67
75TL	12	9	17	...	.62
100TH	15	10	20	...	1.01
100TL	15	10	20	...	1.11
152TH	12	9	18	...	.71
152TL	12	9	18	...	.65
250TH	18	15	25	...	1.03
250TL	18	15	25	...	.89
304TH	12	9	18	...	.71
304TL	12	9	18	...	.65
327A	20	15	30	...	...
450TH	20	15	30	...	1.09
450TL	20	15	30	...	1.0
527	20	18	30	...	...
592/3-200A3	18	15	25	...	.80
750TL	20	15	30	...	1.09
1000T	20	15	30	...	1.1
1500T	20	15	30	...	1.61
2000T	20	15	30	...	1.8

*Combine with factor taken from curve for various pulse duration times.

**The unipotential thoriated tungsten cathodes of the 3W10,000A3 and 4W20,000A necessitate the use of a slightly different method in the determination of pulse duration time and grid dissipation than that used on the filamentary type tubes. The permissible grid dissipation for desired pulse duration times can be determined by using the following equations:

3W10,000A3 Grid
Max. Grid Dissipation, $kw = \frac{27}{\text{pulse duration (millisec)}}$

4W20,000A Grid
Max. Grid Dissipation, $kw = \frac{39}{\text{pulse duration (millisec)}}$

4W20,000A Screen
Max. Screen Dissipation, $kw = \frac{95}{\text{pulse duration (millisec)}}$

***The value given is for use of the tube in air. If the anode to screen portion is surrounded by a suitable liquid dielectric, the voltage may be increased to 30 kilovolts.

APPLICATION (Continued)

ELECTRICAL

Filament Operation—For maximum tube life, the filament voltage, as measured at the base pins, should be the rated value of 6.3 volts. Variations must be kept within the range from 6.0 to 6.6 volts. In applications which require the diode to deliver high peak currents, it is important to maintain the filament voltage at the rated value.

CAUTION SHOULD BE OBSERVED WHEN MEASURING RECTIFIER FILAMENT VOLTAGE. THE FILAMENT CIRCUIT MAY BE AT HIGH POTENTIAL.

The thoriated-tungsten filament of the 2-25A reaches operating temperature in a fraction of a second after application of voltage. Plate voltage may be applied simultaneously with filament voltage.

Plate Operation—With low room illumination, the plate of the 2-25A begins to show color as the maximum plate dissipation rating of 15 watts is approached. The maximum peak inverse voltage rating of 25,000 volts should not be exceeded at any time.

Performance—The accompanying table shows some maximum performance capabilities of the 2-25A when used as a power-supply rectifier.

2-25A MAXIMUM-PERFORMANCE CAPABILITIES

Circuit Type	Capacitor-Input Filter			Choke-Input Filter	
	A-C Input Voltage (volts rms)	D-C Output Voltage (volts)	D-C Output Current (ma)	D-C Output Voltage (volts)	D-C Output Current (ma)
Single-Phase, Half-Wave	8800	10,000	40	.....	.....
Single-Phase, Full-Wave	8800 ¹	10,000	80	7900	100
Single-Phase, Bridge	17,600	20,000	80	15,800	100

¹One-half the transformer secondary voltage.

Maximum D-C Current Ratings—Plate dissipation rather than peak current usually limits the d-c current which the 2-25A is capable of delivering to the load. Because the plate dissipation associated with a given d-c current depends upon the amount of ripple and its wave-shape, circuit conditions will determine the maximum d-c current rating of the tube.

Choke-Input Filter—The maximum d-c current rating of the 2-25A is 50 milliamperes when the load incorporates a choke-input filter with the "critical" value (or larger) of input inductance (L_0 in Fig. 1):

$$L_0 = \frac{R_{eff}}{18.8f} \quad \text{for full-wave single-phase rectifiers,}$$

$$L_0 = \frac{R_{eff}}{75f} \quad \text{for half-wave three-phase rectifiers,}$$

$$L_0 = \frac{R_{eff}}{660f} \quad \text{for full-wave three-phase rectifiers,}$$

where: L_0 = "critical" value of input inductance (henries),

f = supply-line frequency (cycles per second),

$$R_{eff} = \frac{\text{Load voltage (volts)}}{\text{Load current (amps)}}$$

Choke-input filters are not normally used with single-phase half-wave rectifiers.

Capacitor-Input Filter—The 2-25A is particularly suitable for power-supply applications demanding high voltage at low current. Under these conditions capacitor-input filter circuits become desirable. The maximum d-c current rating of the 2-25A when no input choke is incorporated in the filter depends upon

the total series resistance of the capacitor-charging circuit relative to the effective load resistance seen by each tube. The circuit diagrams and tabulation in Fig. 2 are so arranged and labeled that this required series resistance may be found for a wide range of load conditions. This may be done by determining the value of the following quantities:

E_c is the filter-input d-c voltage. While this is usually the entire load voltage, in the case of voltage multipliers it is the load voltage divided by the multiplication factor.

I_p is the d-c current per tube. This is the entire load current only in the case of the simple half-wave rectifier or half- or full-wave multiplier. In the case of full-wave center-tapped or bridge rectifiers, I_p is half the load current.

R_c is the total charging-circuit resistance. A certain minimum value of charging-circuit resistance is necessary to limit the peak value of current to which the tubes will be subjected under given load conditions. This required minimum depends upon the d-c current per tube (I_p), and has been tabulated in Fig. 2 as a percentage of the effective load resistance per tube (E_c/I_p). The total charging-circuit resistance involves the internal resistance of the rectifier tube, R_p , the added series resistor, R_s , and the equivalent internal resistance of the a-c voltage supply, R_i .

R_p is the plate resistance of the 2-25A, which may be taken as 1200 ohms.

R_i is the equivalent internal resistance of the supply. This may be taken as the regulation of the high-voltage supply expressed as a decimal multiplied by the load resistance used in measuring this regulation.

R_s is the series resistor which must be inserted in the charging circuit to bring the total charging-circuit resistance (R_c) up to the required minimum. Its value may be found from the formula associated with each of the circuits of Fig. 2. This resistor must be inserted in such a position in the circuit that it protects all tubes.

Tubes may be operated in parallel to increase the output capability in a given circuit. When two tubes are placed in parallel at each place where one is shown in the circuits of Fig. 2, the plate resistance (R_p) will be half as great and the maximum allowable load current twice as great as indicated.

Peak Inverse Voltage—The peak inverse voltage rating of the 2-25A is 25,000 volts. In single-phase power-supply rectifier circuits the peak inverse voltage to be used in design is the peak a-c supply voltage (1.41 times E_{rms} in Fig. 2) in the case of bridge circuits, and twice this value in the case of half- and full-wave rectifiers and voltage multipliers. Peak inverse voltage in three-phase operation depends upon the circuit employed, and will be found listed in the handbooks.

Special Applications—The ratings given for capacitor-input filter circuits assume values of input capacitance large enough to hold the ripple to a low value. In special applications where a larger percent ripple is tolerable, and filter capacitance is low, the 2-25A is capable of larger d-c output currents.

As a unidirectional conductor in d-c circuits where the current is continuous and the percent ripple is moderate, the maximum current rating of the 2-25A is 90 milliamperes.

The plate characteristic curve for the 2-25A serves as a guide to special applications. The maximum plate dissipation rating of 15 watts, the maximum peak inverse voltage rating of 25,000 volts, and the maximum peak plate current of 1.0 ampere must not be exceeded.

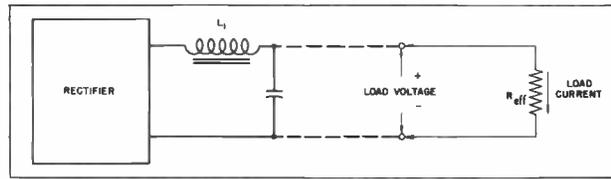
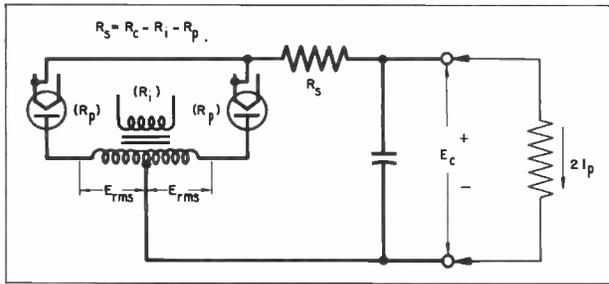
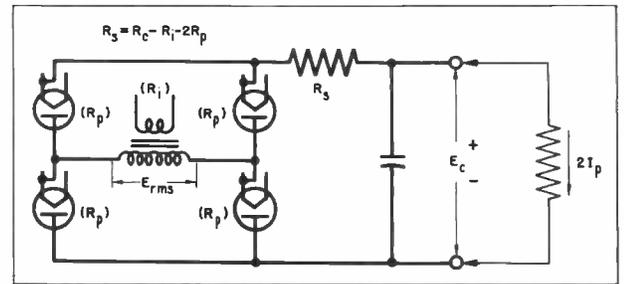


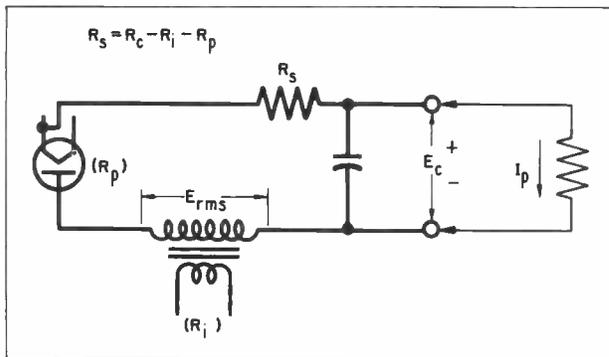
Fig. 1. Rectifier with Choke-Input Filter



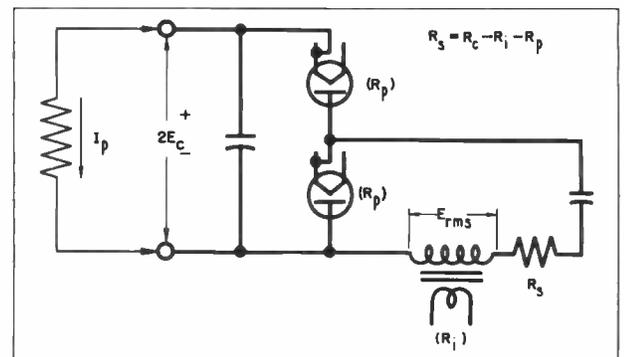
a. Full-Wave Center-Tapped Rectifier



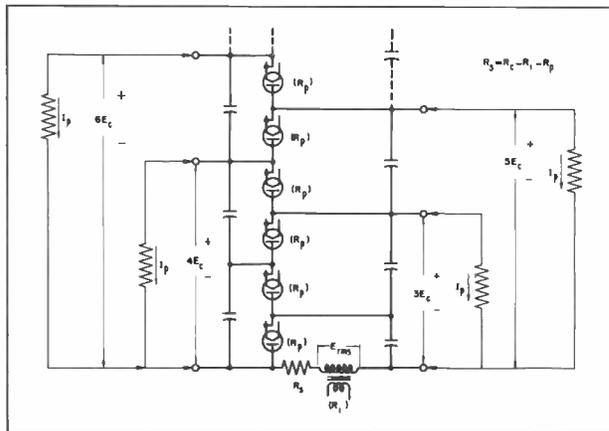
b. Full-Wave Bridge Rectifier



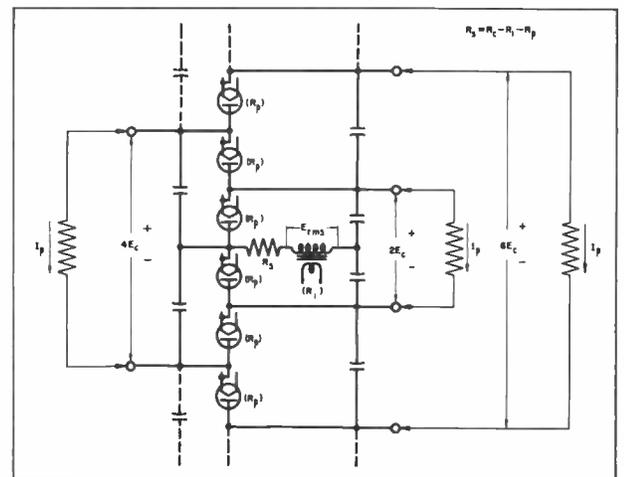
c. Half-Wave Rectifier



d. Half-Wave Voltage Doubler



e. Half-Wave Voltage Multiplier (with common ground when R_s is inserted on the "high" side of E_{rms})



f. Full-Wave Voltage Multiplier

Eimac 2-25A Maximum D-C Current Ratings for R-C Filter Applications								
D-C Plate Current (I_p)	35.0	37.5	40.0	42.5	45.0	47.5	50.0	milliamperes per tube
Total Charging-Circuit Resistance (R_c)	1.3	2.0	3.4	5.5	9.0	16	27	percent of Effective Load Resistance per Tube (E_c/I_p)
A-C Supply Voltage (E_{rms})	0.80	0.83	0.88	0.94	1.05	1.23	1.50	times Filter-Input D-C Voltage (E_c)
Peak Inverse Voltage ($1/2$ these values for circuit b.)	2.3	2.4	2.5	2.7	3.0	3.5	4.3	times Filter-Input D-C Voltage (E_c)

Fig. 2. Eimac 2-25A Basic R-C Circuits (for any one of the indicated loads)

R_1 = Equivalent resistance of voltage source.

R_p = 1200 ohms (600 ohms for two tubes in parallel)

PLATE CURRENT--AMPERES

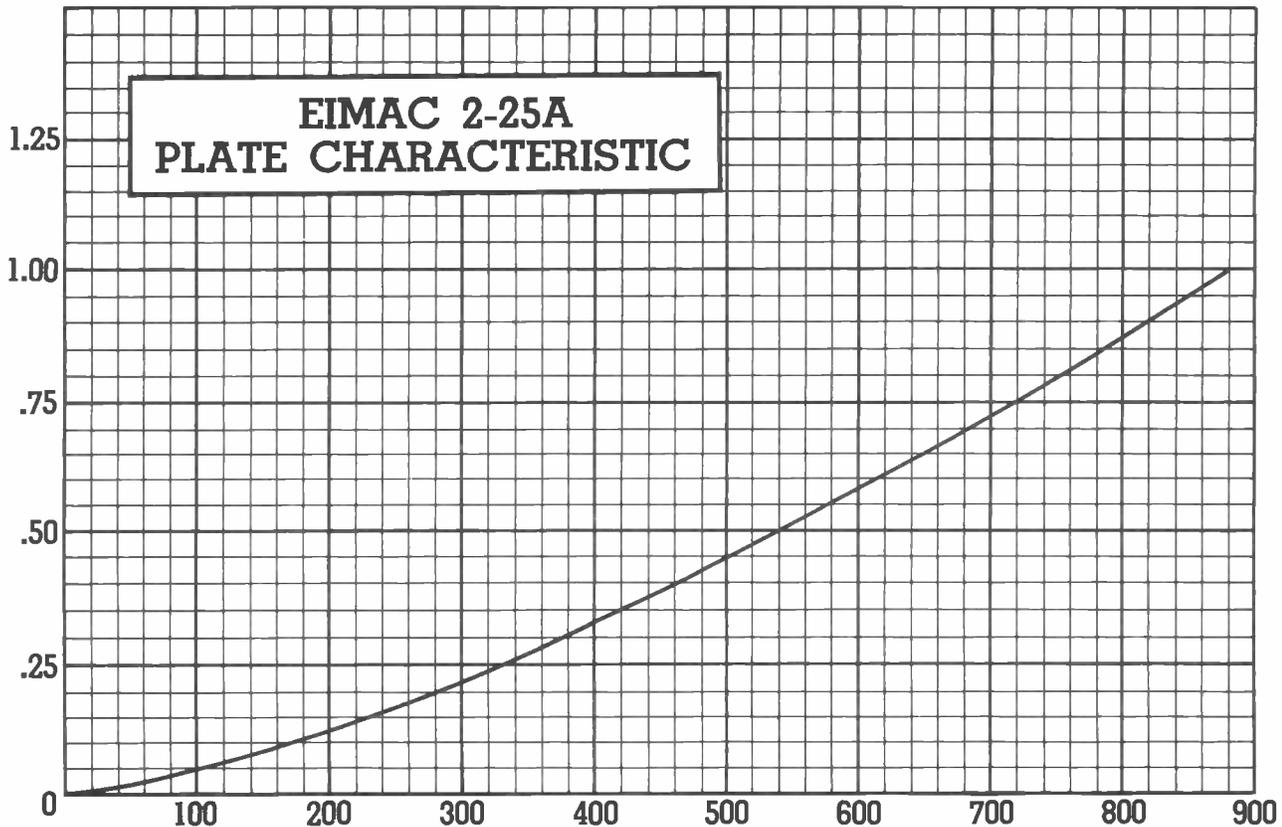
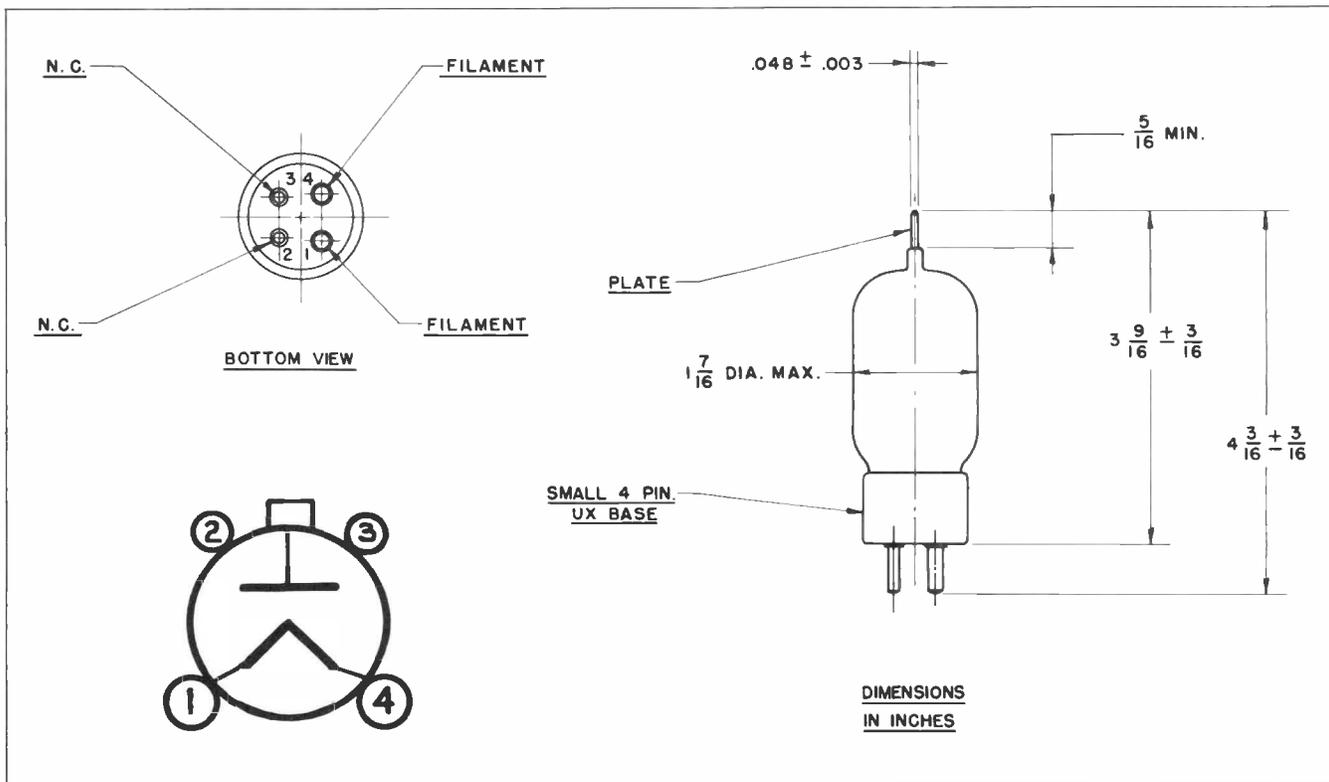


PLATE VOLTAGE--VOLTS



APPLICATION (Continued)

is "Tempilaq" a temperature-sensitive lacquer available from the Tempil Corporation, 132 W. 22nd St., New York 11, N. Y.

ELECTRICAL

Filament Operation—For maximum tube life, the filament voltage, as measured at the base pins, should be the rated value of 5.0 volts. Variations must be kept within the range from 4.75 to 5.25 volts. In applications which require the diode to deliver high peak currents, it is important to maintain the filament voltage at the rated value.

CAUTION SHOULD BE OBSERVED WHEN MEASURING RECTIFIER FILAMENT VOLTAGE. THE FILAMENT CIRCUIT MAY BE AT A HIGH POTENTIAL.

The thoriated-tungsten filament of the 2-50A reaches operating temperature in a fraction of a second after application of voltage. Plate voltage may be applied simultaneously with filament voltage.

Plate Operation—With low room illumination the plate of the 2-50A begins to show color as the maximum plate dissipation rating of 30 watts is approached. The maximum peak inverse voltage rating of 30,000 volts should not be exceeded at any time.

Performance—The accompanying table shows some maximum performance capabilities of the 2-50A when used as a power-supply rectifier.

2-50A MAXIMUM-PERFORMANCE CAPABILITIES

Circuit Type	Capacitor-Input Filter			Choke-Input Filter	
	A-C Input Voltage (volts rms)	D-C Output Voltage (volts)	D-C Output Current (ma)	D-C Output Voltage (volts)	D-C Output Current (ma)
Single-Phase, Half-Wave	10,600	12,500	60	.....	.....
Single-Phase, Full-Wave	10,600 ¹	12,500	120	9500	150
Single-Phase, Bridge	21,200	25,000	120	19,000	150

¹One-half the transformer secondary voltage.

Maximum D-C Current Ratings—Plate dissipation rather than peak current usually limits the d-c current which the 2-50A is capable of delivering to the load. Because the plate dissipation associated with a given d-c current depends upon the amount of ripple and its wave-shape, circuit conditions will determine the maximum d-c current rating of the tube.

Choke-Input Filter—The maximum d-c current rating of the 2-50A is 75 milliamperes when the load incorporates a choke-input filter with the "critical" value (or larger) of input inductance (L_o in Fig. 1):

$$L_o = \frac{R_{eff}}{18.8f} \quad \text{for full-wave single-phase rectifiers,}$$

$$L_o = \frac{R_{eff}}{75f} \quad \text{for half-wave three-phase rectifiers,}$$

$$L_o = \frac{R_{eff}}{660f} \quad \text{for full-wave three-phase rectifiers,}$$

where: L_o = "critical" value of input inductance (henries),
 f = supply-line frequency (cycles per second),

$$R_{eff} = \frac{\text{Load voltage (volts)}}{\text{Load current (amps)}}$$

Choke-input filters are not normally used with single-phase half-wave rectifiers.

Capacitor-Input Filter—The 2-50A is particularly suitable for power-supply applications demanding high voltage at low current. Under these conditions capacitor-input filter circuits become desirable. The maximum d-c current rating of the 2-50A

when no input choke is incorporated in the filter depends upon the total series resistance of the capacitor-charging circuit relative to the effective load resistance seen by each tube. The circuit diagrams and tabulation in Fig. 2 are so arranged and labeled that this required series resistance may be found for a wide range of load conditions. This may be done by determining the value of the following quantities:

E_c is the filter-input d-c voltage. While this is usually the entire load voltage, in the case of voltage multipliers it is the load voltage divided by the multiplication factor.

I_p is the d-c current per tube. This is the entire load current only in the case of the simple half-wave rectifier or half- or full-wave multiplier. In the case of full-wave center-tapped or bridge rectifiers, I_p is half the load current.

R_c is the total charging-circuit resistance. A certain minimum value of charging-circuit resistance is necessary to limit the peak value of current to which the tubes will be subjected under given load conditions. This required minimum depends upon the d-c current per tube (I_p), and has been tabulated in Fig. 2 as a percentage of the effective load resistance per tube (E_c/I_p). The total charging-circuit resistance involves the internal resistance of the rectifier tube, R_p , the added series resistor, R_s , and the equivalent internal resistance of the a-c voltage supply, R_i .

R_p is the plate resistance of the 2-50A, which may be taken as 1000 ohms.

R_i is the equivalent internal resistance of the supply. This may be taken as the regulation of the high-voltage supply expressed as a decimal multiplied by the load resistance used in measuring this regulation.

R_s is the series resistor which must be inserted in the charging circuit to bring the total charging-circuit resistance up to the required minimum. Its value may be found from the formula associated with each of the circuits of Fig. 2. This resistor must be inserted in such a position in the circuit that it protects all tubes.

Tubes may be operated in parallel to increase the output capability in a given circuit. When two tubes are placed in parallel at each place where one is shown in the circuits of Fig. 2, the plate resistance (R_p) will be half as great and the maximum allowable load current twice as great as indicated.

Peak Inverse Voltage—The peak inverse voltage rating of the 2-50A is 30,000 volts. In single-phase power-supply rectifier circuits the peak inverse voltage to be used in design is the peak a-c supply voltage (1.41 times E_{rms} in Fig. 2) in the case of bridge circuits, and twice this value in the case of half- and full-wave rectifiers and voltage multipliers. Peak inverse voltage in three-phase operation depends upon the circuit employed, and will be found listed in the handbooks.

Special Applications—The ratings given for capacitor-input filter circuits assume values of input capacitance large enough to hold the ripple to a low value. In special applications where a larger percent ripple is tolerable, and filter capacitance is low, the 2-50A is capable of larger d-c output currents.

As a unidirectional conductor in d-c circuits where the current is continuous and the percent ripple is moderate, the maximum current rating of the 2-50A is 145 milliamperes.

The plate characteristic curve for the 2-50A serves as a guide to special applications. The maximum plate dissipation rating of 30 watts, the maximum peak inverse voltage rating of 30,000 volts, and the maximum peak plate current of 1.0 ampere must not be exceeded.

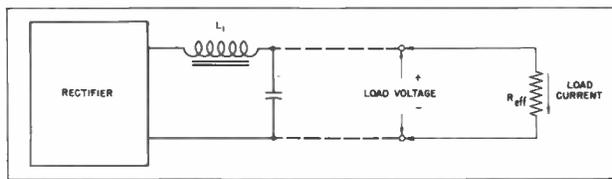
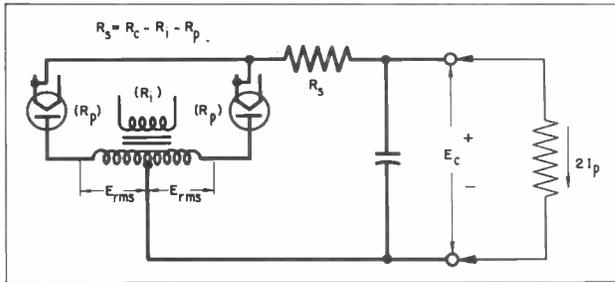
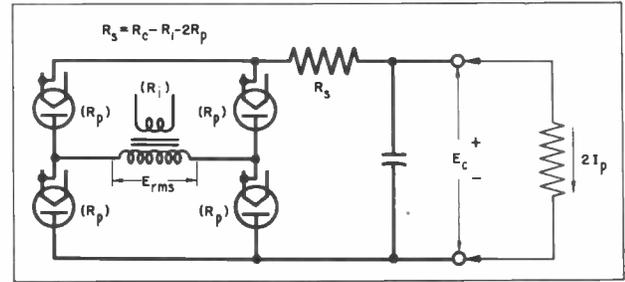


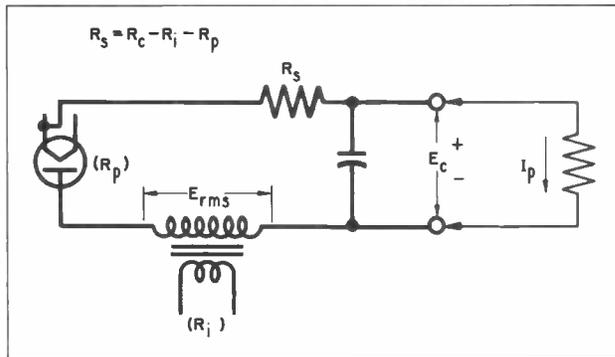
Fig. 1. Rectifier with Choke-Input Filter



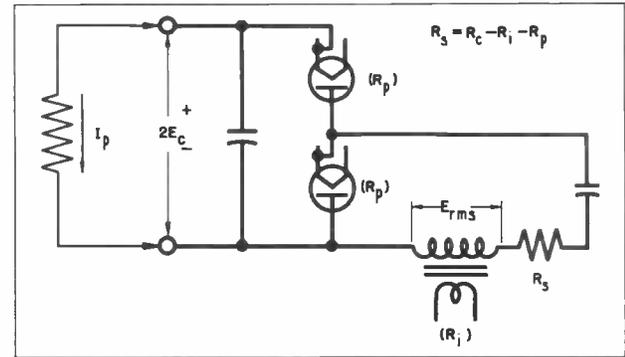
a. Full-Wave Center-Tapped Rectifier



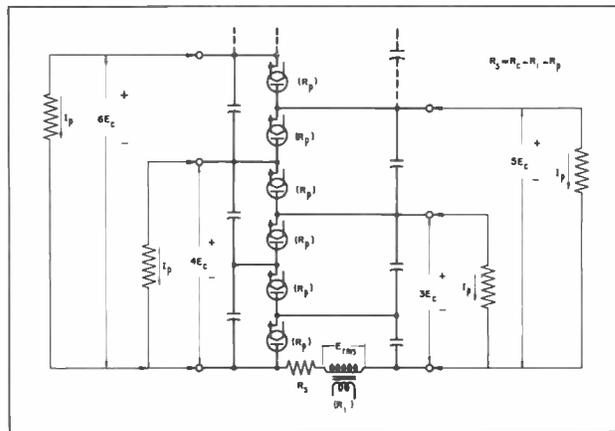
b. Full-Wave Bridge Rectifier



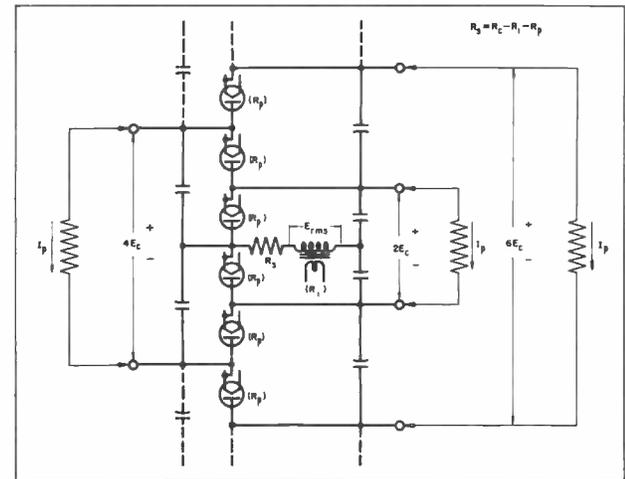
c. Half-Wave Rectifier



d. Half-Wave Voltage Doubler



e. Half-Wave Voltage Multiplier (with common ground when R_s is inserted on the "high" side of E_{rms})



f. Full-Wave Voltage Multiplier

Eimac 2-50A Maximum D-C Current Ratings for R-C Filter Applications						
D-C Plate Current (I_p)	55	60	65	70	75	milliamperes per tube
Total Charging-Circuit Resistance (R_c)	1.3	2.4	4.7	8.5	17	percent of effective Load Resistance per Tube (E_c/I_p)
A-C Supply Voltage (E_{rms})	0.80	0.85	0.92	1.04	1.28	times Filter-Input D-C Voltage (E_c)
Peak Inverse Voltage ($1/2$ these values for circuit b.)	2.3	2.4	2.6	3.0	3.7	times Filter-Input D-C Voltage (E_c)

Fig. 2 Eimac 2-50A Basic R-C Circuits (for any one of the indicated loads)

R_1 = Equivalent resistance of voltage source

R_p = 1000 ohms (500 ohms for two tubes in parallel)

PLATE CURRENT--AMPERES

**EIMAC 2-50A
PLATE CHARACTERISTIC**

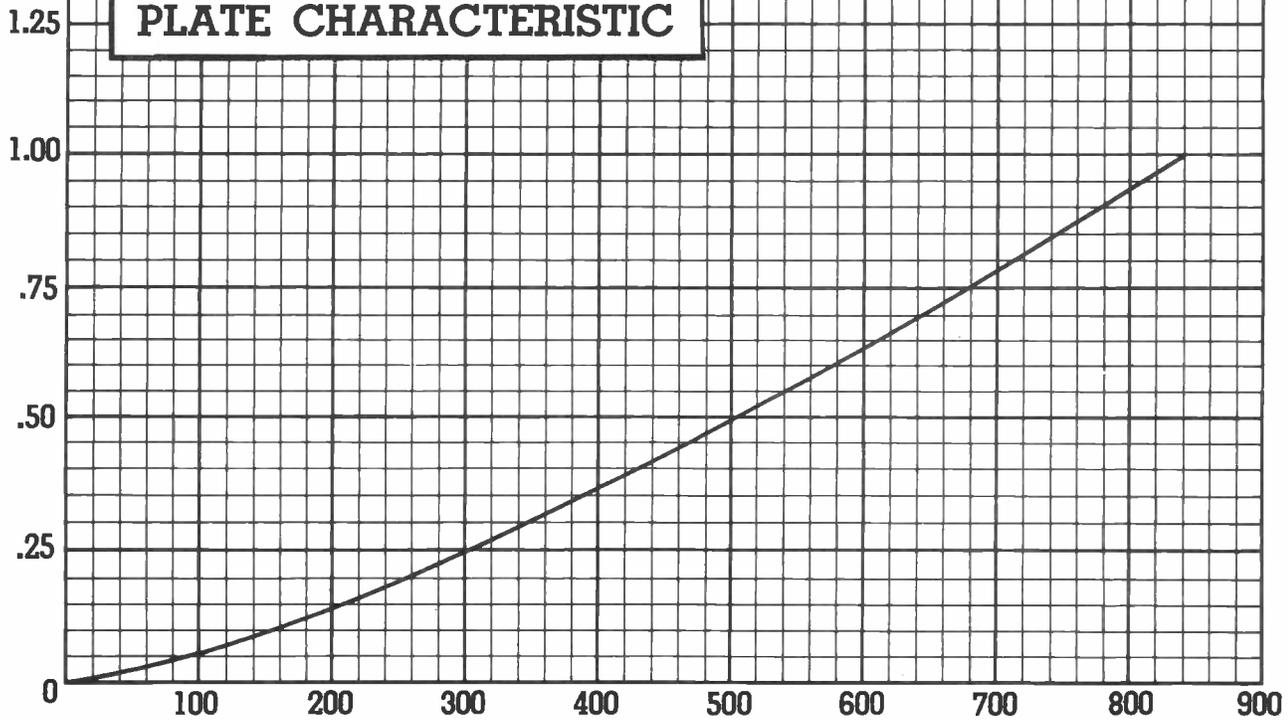
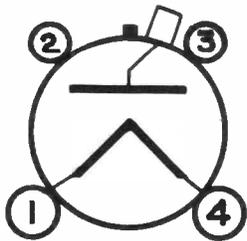
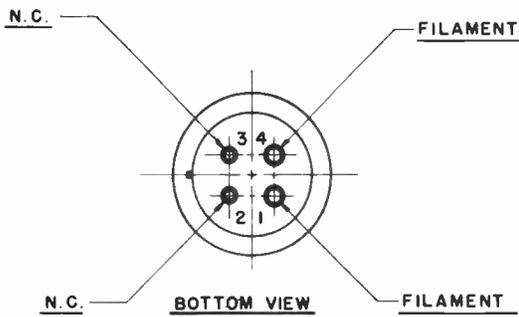
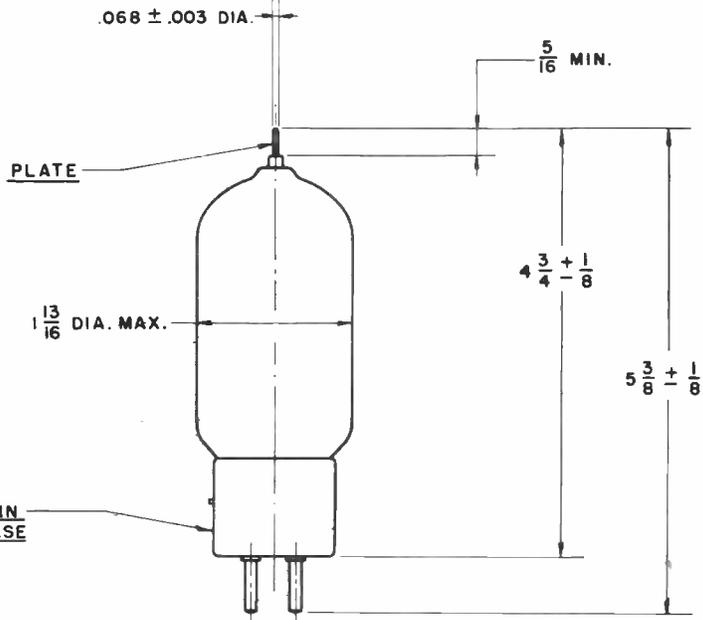


PLATE VOLTAGE--VOLTS



MEDIUM 4 PIN
BAYONET BASE



DIMENSIONS
IN INCHES



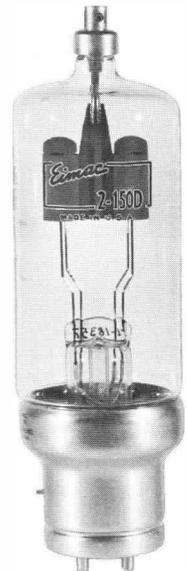
EIMAC
 A Division of Varian Associates
 SAN CARLOS, CALIFORNIA

2-150D
 HIGH-VACUUM
 RECTIFIER

The Eimac 2-150D is a high vacuum diode rectifier intended for use in rectifier units, voltage multipliers, or in special applications, whenever conditions of extreme ambient temperatures, high operating frequency, high peak inverse voltages, or the production of high-frequency transients would prevent the use of gas-filled rectifier tubes.

The 2-150D has a maximum d-c current rating of 250 milliamperes and a maximum peak inverse voltage rating of 30,000 volts. Cooling is by convection and radiation.

A single 2-150D will deliver 200 milliamperes at 11,800 volts to a capacitor-input filter with 10,600 volts single-phase supply. Four 2-150D's in a bridge circuit will deliver 500 milliamperes at 19,000 volts to a choke-input filter with 21,200 volts single-phase supply.



GENERAL CHARACTERISTICS

ELECTRICAL

Filament:	Thoriated Tungsten
Voltage	- - - - - 5.0 volts
Current	- - - - - 13.0 amperes

MECHANICAL

Base	- - - - -	50-watt jumbo 4-pin bayonet
Basing	- - - - -	Refer to outline drawing
Socket	- - - - -	Refer to discussion under "Application"
Mounting Position	- - - - -	Vertical, base down or up
Cooling	- - - - -	Convection and Radiation
Maximum Temperature of Plate Seal	- - - - -	225°C
Recommended Heat Dissipating Plate Connector	- - - - -	Eimac HR-6
Maximum Over-all Dimensions:		
Length	- - - - -	8.88 inches
Diameter	- - - - -	2.50 inches
Net Weight	- - - - -	9 ounces
Shipping Weight (approx.)	- - - - -	1 pound

MAXIMUM RATINGS (Per tube)

PEAK INVERSE PLATE VOLTAGE	- - - - -	30,000 MAX. VOLTS
PLATE DISSIPATION	- - - - -	90 MAX. WATTS
D-C PLATE CURRENT ¹	- - - - -	250 MAX. MA
PEAK PLATE CURRENT	- - - - -	3.0 MAX. AMPERES

¹Averaged over one cycle for each tube. Applies only when the rectifier is coupled to the load by a choke-input filter incorporating the "critical" value (or larger) of input inductance. For maximum d-c current ratings under this and other load conditions see discussion under "Application."

APPLICATION

MECHANICAL

Mounting — The 2-150D must be mounted vertically with the base either down or up. The lead to the plate terminal of the tube should be flexible.

The 50-watt jumbo 4-pin bayonet base fits an E. F. Johnson Co. No. 123-211, a National Co. No. XM-50, or an equivalent socket. In some circuits, particularly those of the voltage multipliers illustrated in Fig. 2, it may be necessary to mount the socket on stand-off insulators, or on a sheet of insulating material, to provide adequate insulation to ground.

Cooling — The 2-150D is cooled by convection and radiation. Clearance should be provided around the glass envelope adequate for the free circulation of air. An Eimac HR-6 Heat Dissipating Connector or equivalent is required on the plate terminal.

The maximum temperature at the plate seal must not exceed 225°C. A convenient accessory for measuring this temperature is "Tempilaq," a temperature-sensitive lacquer available from the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y.

ELECTRICAL

Filament Operation — For maximum tube life, the filament voltage, as measured at the base pins, should be the rated value of 5.0 volts. Variations must be kept within the range from 4.75 to 5.25 volts. In applications which require the diode to deliver high peak currents, it is important to maintain the filament voltage at the rated value.

CAUTION SHOULD BE OBSERVED WHEN MEASURING RECTIFIER FILAMENT VOLTAGE. THE FILAMENT CIRCUIT MAY BE AT HIGH POTENTIAL.

The thoriated-tungsten filament of the 2-150D reaches operating temperature in a fraction of a second after application of voltage. Plate voltage may be applied simultaneously with filament voltage.

Plate Operation — With low room illumination, the plate of the 2-150D begins to show color as the maximum plate dissipation rating of 90 watts is approached. The maximum peak inverse voltage rating of 30,000 volts should not be exceeded at any time.

Performance — The accompanying table shows some maximum performance capabilities of the 2-150D when used as a power-supply rectifier.

Circuit Type	2-150D MAXIMUM-PERFORMANCE CAPABILITIES				
	Capacitor-Input Filter		Choke-Input Filter		
	A-C Input Voltage (volts rms)	D-C Output Voltage (volts)	D-C Output Current (ma)	D-C Output Voltage (volts)	D-C Output Current (ma)
Single-Phase, Half-Wave	10,600	11,800	200	.....	.....
Single-Phase, Full-Wave	10,600 ¹	11,800	400	9500	500
Single-Phase, Bridge	21,200	23,600	400	19,000	500

¹One-half the transformer secondary voltage.

Maximum D-C Current Ratings — Plate dissipation rather than peak current usually limits the d-c current which the 2-150D is capable of delivering to the load. Because the plate dissipation associated with a given d-c current depends upon the amount of ripple and its wave-shape, circuit conditions will determine the maximum d-c current rating of the tube.

Choke-Input Filter — The maximum d-c current rating of the 2-150D is 250 milliamperes when the load incorporates a choke-input filter with the "critical" value (or larger) of input inductance (L_i in Fig. 1):

$$L_o = \frac{R_{eff}}{18.8f} \text{ for full-wave single-phase rectifiers,}$$

$$L_o = \frac{R_{eff}}{75f} \text{ for half-wave three-phase rectifiers,}$$

$$L_o = \frac{R_{eff}}{660f} \text{ for full-wave three-phase rectifiers,}$$

where: L_o = "critical" value of input inductance (henries),
 f = supply-line frequency (cycles per second),

$$R_{eff} = \frac{\text{Load voltage (volts)}}{\text{Load current (amps)}}$$

Choke-input filters are not normally used with single-phase half-wave rectifiers.

Capacitor-Input Filter — The 2-150D is particularly suitable for power-supply applications demanding high voltage at low current. Under these conditions capacitor-input filter circuits become desirable. The maximum d-c current rating of the 2-150D when no input choke is incorporated in the filter depends upon the total series resistance of the capacitor-charging circuit relative to the effective load resistance seen by each tube. The circuit diagrams and tabulation in Fig. 2 are so arranged and labeled that this required series resistance may be found for a wide range of load conditions. This may be done by determining the value of the following quantities.

E_i is the filter-input d-c voltage. While this is usually the entire load voltage, in the case of voltage multipliers it is the load voltage divided by the multiplication factor.

I_p is the d-c current per tube. This is the entire load current only in the case of the simple half-wave rectifier or half- or full-wave multiplier. In the case of full-wave center-tapped or bridge rectifiers, I_p is half the load current.

R_i is the total charging-circuit resistance. A certain minimum value of charging-circuit resistance is necessary to limit the peak value of current to which the tubes will be subjected under given load conditions. This required minimum depends upon the d-c current per tube (I_p), and has been tabulated in Fig. 2 as a percentage of the effective load resistance per tube (E_i/I_p). The total charging-circuit resistance involves the internal resistance of the rectifier tube, R_p , the added series resistor, R_s , and the equivalent internal resistance of the a-c voltage supply, R_1 .

R_p is the plate resistance of the 2-150D, which may be taken as 300 ohms.

R_1 is the equivalent internal resistance of the supply. This may be taken as the regulation of the high-voltage supply expressed as a decimal multiplied by the load resistance used in measuring this regulation.

R_s is the series resistor which must be inserted in the charging circuit to bring the total charging-circuit resistance up to the required minimum. Its value may be found from the formula associated with each of the circuits of Fig. 2. This resistor must be inserted in such a position in the circuit that it protects all tubes.

Tubes may be operated in parallel to increase the output capability in a given circuit. When two tubes are placed in parallel at each place where one is shown in the circuits of Fig. 2, the plate resistance (R_p) will be half as great and the load maximum allowable load current twice as great as indicated.

Peak Inverse Voltage — The peak inverse voltage rating of the 2-150D is 30,000 volts. In single-phase power-supply rectifier circuits the peak inverse voltage to be used in design is the peak a-c supply voltage (1.41 times E_{rms} in Fig. 2) in the case of bridge circuits, and twice this value in the case of half- and full-wave rectifiers and voltage multipliers. Peak inverse voltage in three-phase operation depends upon the circuit employed, and will be found listed in the handbooks.

Special Applications — The ratings given for capacitor-input filter circuits assume values of input capacitance large enough to hold the ripple to a low value. In special applications where a larger percent ripple is tolerable, and filter capacitance is low, the 2-150D is capable of larger d-c output currents.

As a unidirectional conductor in d-c circuits where the current is continuous and the percent ripple is moderate, the maximum current rating of the 2-150D is 500 milliamperes.

The plate characteristic curve for the 2-150D serves as a guide to special applications. The maximum plate dissipation rating of 90 watts, the maximum peak inverse voltage rating of 30,000 volts, and the maximum peak plate current of 3.0 amperes must not be exceeded.

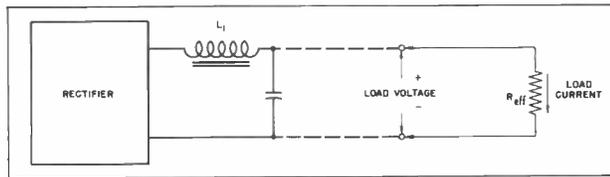
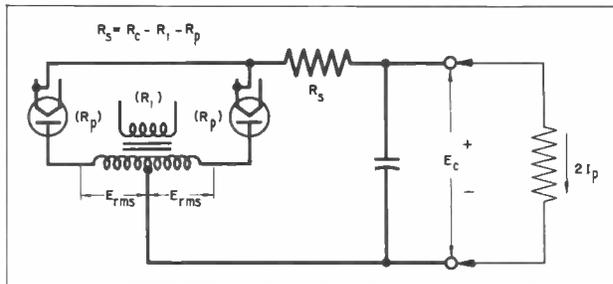
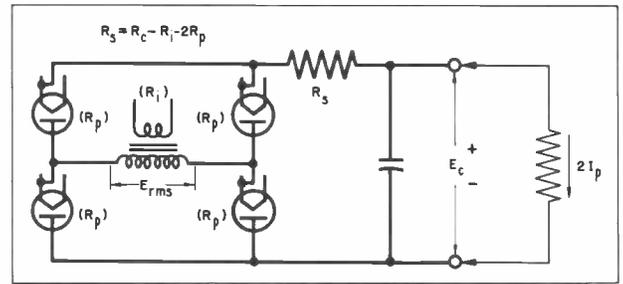


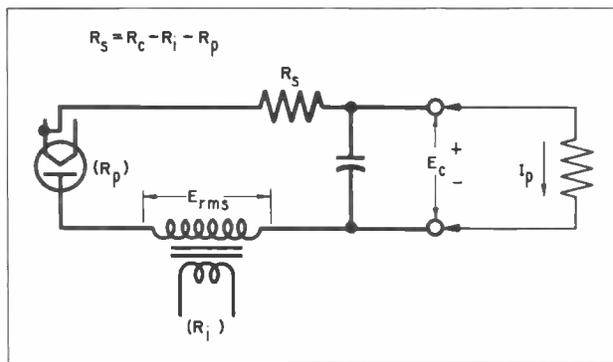
Fig. 1. Rectifier with Choke-Input Filter



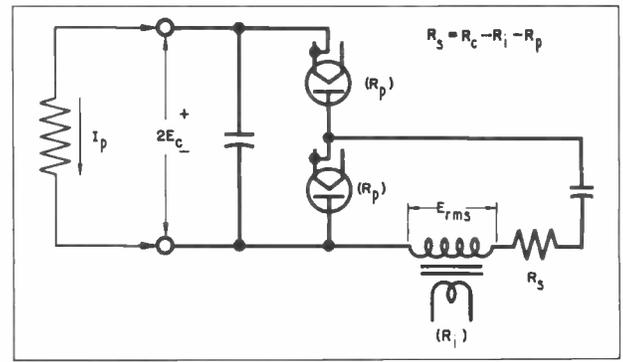
a. Full-Wave Center-Tapped Rectifier



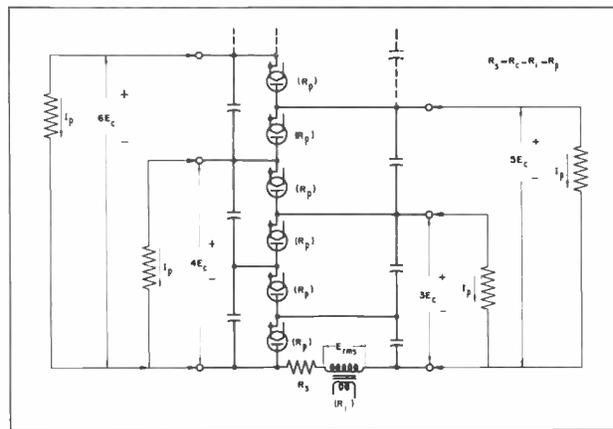
b. Full-Wave Bridge Rectifier



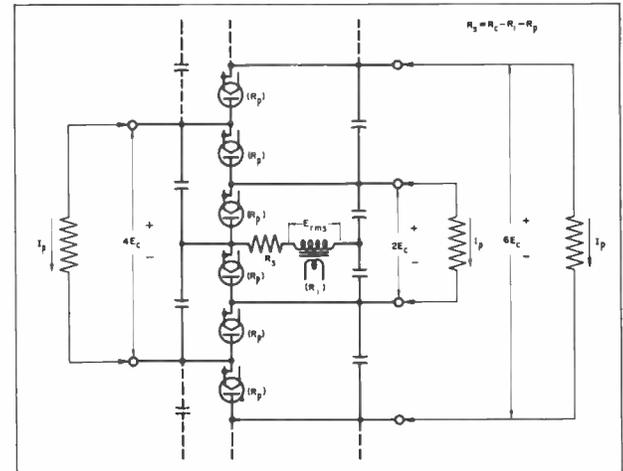
c. Half-Wave Rectifier



d. Half-Wave Voltage Doubler



e. Half-Wave Voltage Multiplier (with common ground when R_s is inserted on the "high" side of E_{rms})



f. Full-Wave Voltage Multiplier

Eimac 2-150D Maximum D-C Current Ratings for R-C Filter Applications						
D-C Plate Current (I_p)	150	175	200	225	250	milliamperes per tube
Total Charging-Circuit Resistance (R_c)	0.7	1.6	3.9	9.6	27	percent of Effective Load Resistance per Tube (E_c/I_p)
A-C Supply Voltage (E_{rms})	0.78	0.82	0.90	1.07	1.50	times Filter-Input D-C Voltage (E_c)
Peak Inverse Voltage ($1/2$ these values for circuit b.)	2.2	2.4	2.6	3.0	4.3	times Filter-Input D-C Voltage (E_c)

Fig. 2 Eimac 2-150D Basic R-C Circuits (for any one of the indicated loads)

R_i = Equivalent resistance of voltage source

R_p = 300 ohms (150 ohms for two tubes in parallel)

PLATE CURRENT--AMPERES

**EIMAC 2-150D
PLATE CHARACTERISTIC**

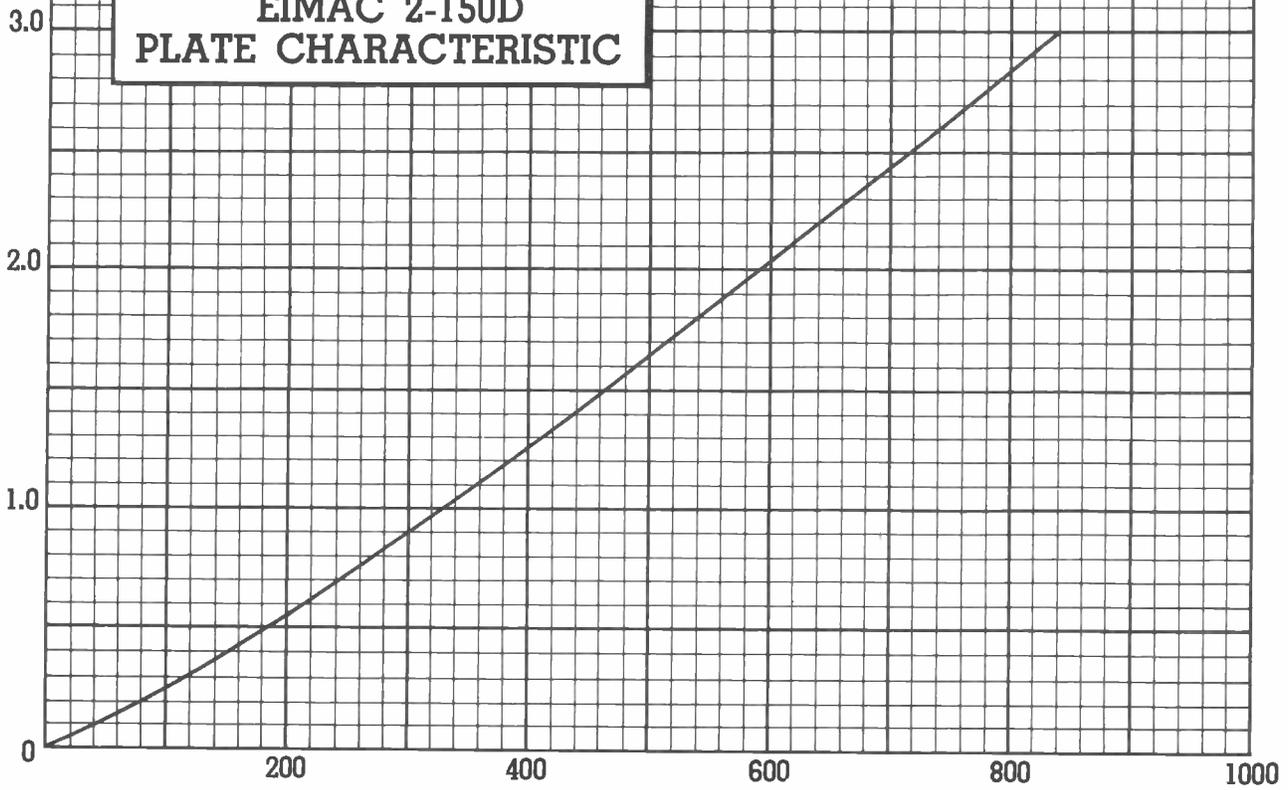
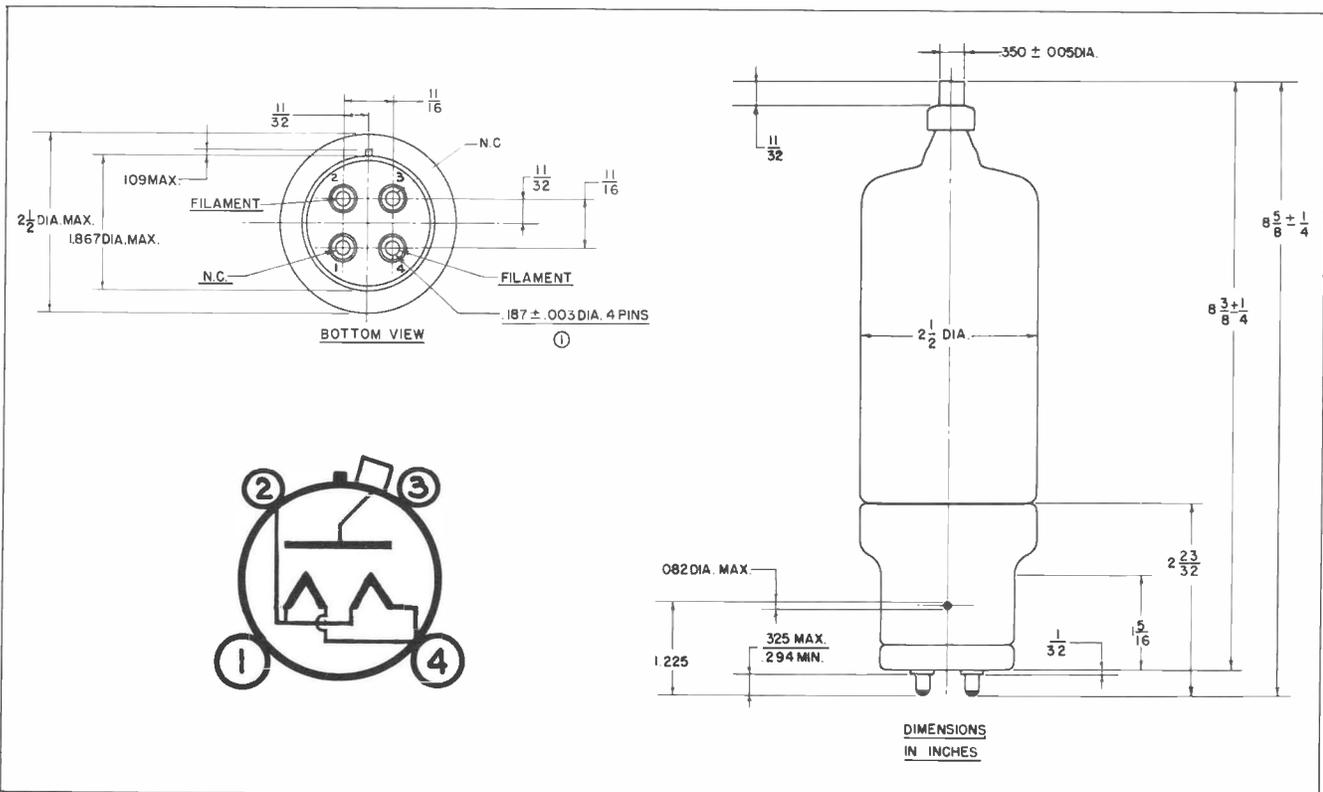


PLATE VOLTAGE--VOLTS



APPLICATION (Continued)

225°C. A convenient accessory for measuring this temperature is "Tempilaq", a temperature-sensitive lacquer available from the Tempil Corporation, 132 W. 22nd St., New York 11, N. Y.

ELECTRICAL

Filament Operation—For maximum tube life, the filament voltage, as measured at the base pins, should be the rated value of 7.5 volts. Variations must be kept within the range from 7.15 to 7.85 volts. In applications which require the diode to deliver high peak currents, it is important to maintain the filament voltage at the rated value. All four socket terminals should be used, placing two in parallel for each filament connection.

CAUTION SHOULD BE OBSERVED WHEN MEASURING RECTIFIER FILAMENT VOLTAGE. THE FILAMENT CIRCUIT MAY BE AT HIGH POTENTIAL.

The thoriated-tungsten filament of the 2-240A reaches operating temperature in a fraction of a second after application of voltage. Plate voltage may be applied simultaneously with filament voltage. All four socket terminals should be used, putting two in parallel for each filament connection.

Plate Operation—With low room illumination, the plate of the 2-240A begins to show color as the maximum plate dissipation rating of 150 watts is approached. The maximum peak inverse voltage rating of 25,000 volts should not be exceeded at any time.

Performance—The accompanying table shows some maximum performance capabilities of the 2-240A when used as a power-supply rectifier.

Circuit Type	2-240A MAXIMUM-PERFORMANCE CAPABILITIES					
	A-C Input Voltage (volts rms)	Capacitor-Input Filter		Choke-Input Filter		
	D-C Output Voltage (volts)	D-C Output Current (amperes)	D-C Output Voltage (volts)	D-C Output Current (amperes)		
Single-Phase, Half-Wave	9,000	10,000	0.320	.....	.....
Single-Phase, Full-Wave	9,000 ¹	10,000	0.640	8,000	1.00	
Single-Phase, Bridge	18,000	20,000	0.640	16,000	1.00	

¹One-half the transformer secondary voltage.

Maximum D-C Current Ratings—Plate dissipation rather than peak current usually limits the d-c current which the 2-240A is capable of delivering to the load. Because the plate dissipation associated with a given d-c current depends upon the amount of ripple and its wave-shape, circuit conditions will determine the maximum d-c current rating of the tube.

Choke-Input Filter—The maximum d-c current rating of the 2-240A is 500 milliamperes when the load incorporates a choke-input filter with the "critical" value (or larger) of input inductance (L_0 in Fig. 1):

$$L_0 = \frac{R_{eff}}{18.8f} \text{ for full-wave single-phase rectifiers,}$$

$$L_0 = \frac{R_{eff}}{75f} \text{ for half-wave three-phase rectifiers,}$$

$$L_0 = \frac{R_{eff}}{660f} \text{ for full-wave three-phase rectifiers,}$$

where: L_0 = "critical" value of input inductance (henries),
 f = supply-line frequency (cycles per second),

$$R_{eff} = \frac{\text{Load voltage (volts)}}{\text{Load current (amps)}}$$

Choke-input filters are not normally used with single-phase half-wave rectifiers.

Capacitor-Input Filter—The 2-240A is particularly suitable for power-supply applications demanding high voltage at low cur-

rent. Under these conditions capacitor-input filter circuits become desirable. The maximum d-c current rating of the 2-240A when no input choke is incorporated in the filter depends upon the total series resistance of the capacitor-charging circuit relative to the effective load resistance seen by each tube. The circuit diagrams and tabulation in Fig. 2 are so arranged and labeled that this required series resistance may be found for a wide range of load conditions. This may be done by determining the value of the following quantities:

E_c is the filter-input d-c voltage. While this is usually the entire load voltage, in the case of voltage multipliers it is the load voltage divided by the multiplication factor.

I_p is the d-c current per tube. This is the entire load current only in the case of the simple half-wave rectifier or half- or full-wave multiplier. In the case of full-wave center-tapped or bridge rectifiers, I_p is half the load current.

R_c is the total charging-circuit resistance. A certain minimum value of charging-circuit resistance is necessary to limit the peak value of current to which the tubes will be subjected under given load conditions. This required minimum depends upon the d-c current per tube (I_p), and has been tabulated in Fig. 2 as a percentage of the effective load resistance per tube (E_c/I_p). The total charging-circuit resistance involves the internal resistance of the rectifier tube, R_p , the added series resistor, R_s , and the equivalent internal resistance of the a-c voltage supply, R_i .

R_p is the plate resistance of the 2-240A, which may be taken as 200 ohms.

R_i is the equivalent internal resistance of the supply. This may be taken as the regulation of the high-voltage supply expressed as a decimal multiplied by the load resistance used in measuring this regulation.

R_s is the series resistor which must be inserted in the charging circuit to bring the total charging-circuit resistance up to the required minimum. Its value may be found from the formula associated with each of the circuits of Fig. 2. This resistor must be inserted in such a position in the circuit that it protects all tubes.

Tubes may be operated in parallel to increase the output capability in a given circuit. When two tubes are placed in parallel at each place where one is shown in the circuits of Fig. 2, the plate resistance (R_p) will be half as great and the maximum allowable load current twice as great as indicated.

Peak Inverse Voltage—The peak inverse voltage rating of the 2-240A is 25,000 volts. In single-phase power-supply rectifier circuits the peak inverse voltage to be used in design is the peak a-c supply voltage (1.41 times E_{rms} in Fig. 2) in the case of bridge circuits, and twice this value in the case of half- and full-wave rectifiers and voltage multipliers. Peak inverse voltage in three-phase operation depends upon the circuit employed and will be found listed in the handbooks.

Special Applications—The ratings given for capacitor-input filter circuits assume values of input capacitance large enough to hold the ripple to a low value. In special applications where a larger percent ripple is tolerable, and filter capacitance is low, the 2-240A is capable of larger d-c output currents.

As a unidirectional conductor in d-c circuits where the current is continuous and the percent ripple is moderate, the maximum current rating of the 2-240A is 800 milliamperes.

The plate characteristic curve for the 2-240A serves as a guide to special applications. The maximum plate dissipation rating of 150 watts, the maximum peak inverse voltage rating of 25,000 volts, and the maximum peak plate current of 4.0 amperes must not be exceeded.

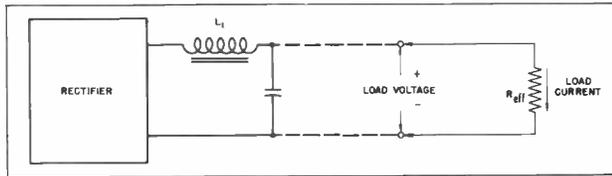
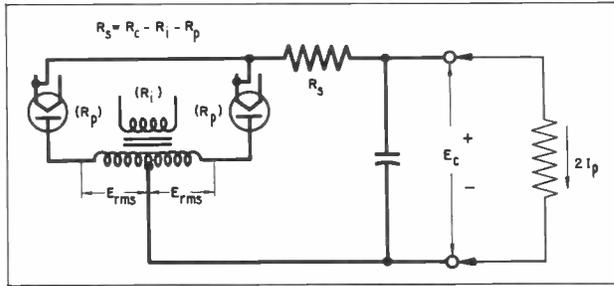
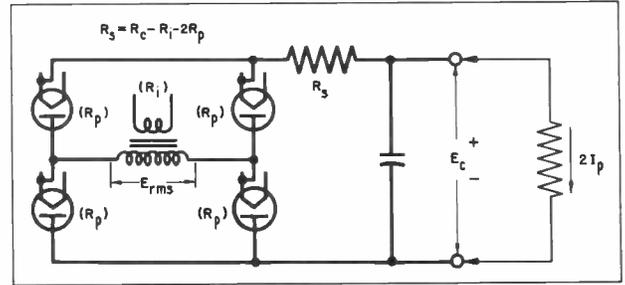


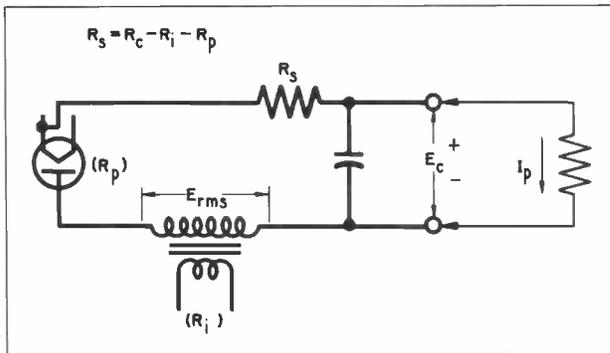
Fig. 1. Rectifier with Choke-Input Filter



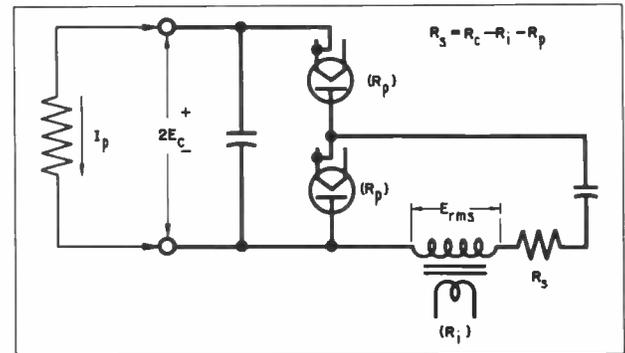
a. Full-Wave Center-Tapped Rectifier



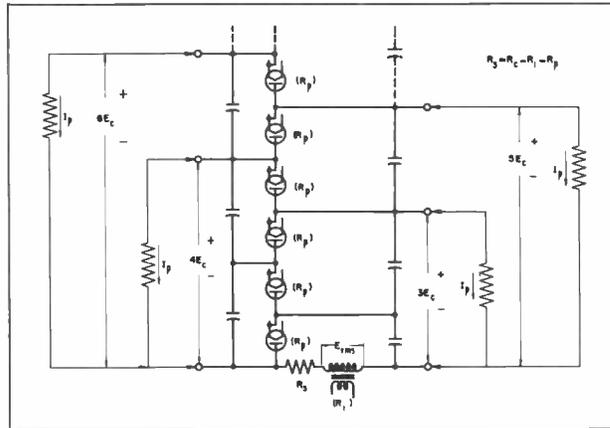
b. Full-Wave Bridge Rectifier



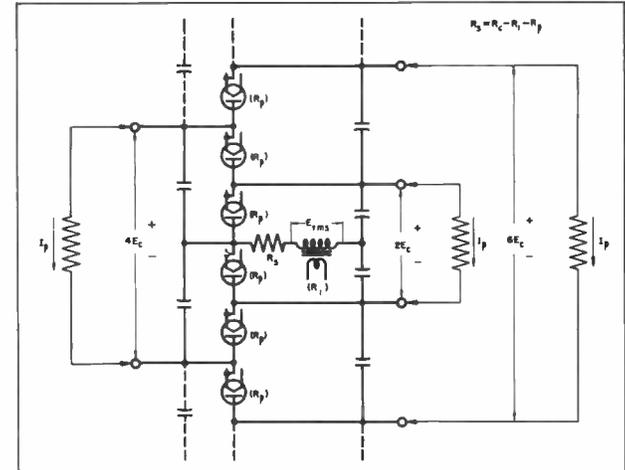
c. Half-Wave Rectifier



d. Half-Wave Voltage Doubler



e. Half-Wave Voltage Multiplier (with common ground when R_s is inserted on the "high" side of E_{rms})



f. Full-Wave Voltage Multiplier

Eimac 2-240A Maximum D-C Current Ratings for R-C Filter Applications								
D-C Plate Current (I_p)	280	300	320	340	360	380	400	milliamperes per tube
Total Charging-Circuit Resistance (R_c)	1.0	1.8	3.0	5.0	7.5	12	20	percent of Effective Load Resistance per Tube (E_c/I_p)
A-C Supply Voltage (E_{rms})	0.80	0.83	0.87	0.94	1.01	1.14	1.33	times Filter-Input D-C Voltage (E_c)
Peak-Inverse Voltage ($1/2$ these values for circuit b.)	2.3	2.4	2.5	2.7	2.9	3.2	3.8	times Filter-Input D-C Voltage (E_c)

Fig. 2 Eimac 2-240A Basic R-C Circuits (for any one of the indicated loads)

R_i = Equivalent resistance of voltage source

R_p = 200 ohms (100 ohms for two tubes in parallel)

PLATE CURRENT—AMPERES

EIMAC 2-240A PLATE CHARACTERISTIC

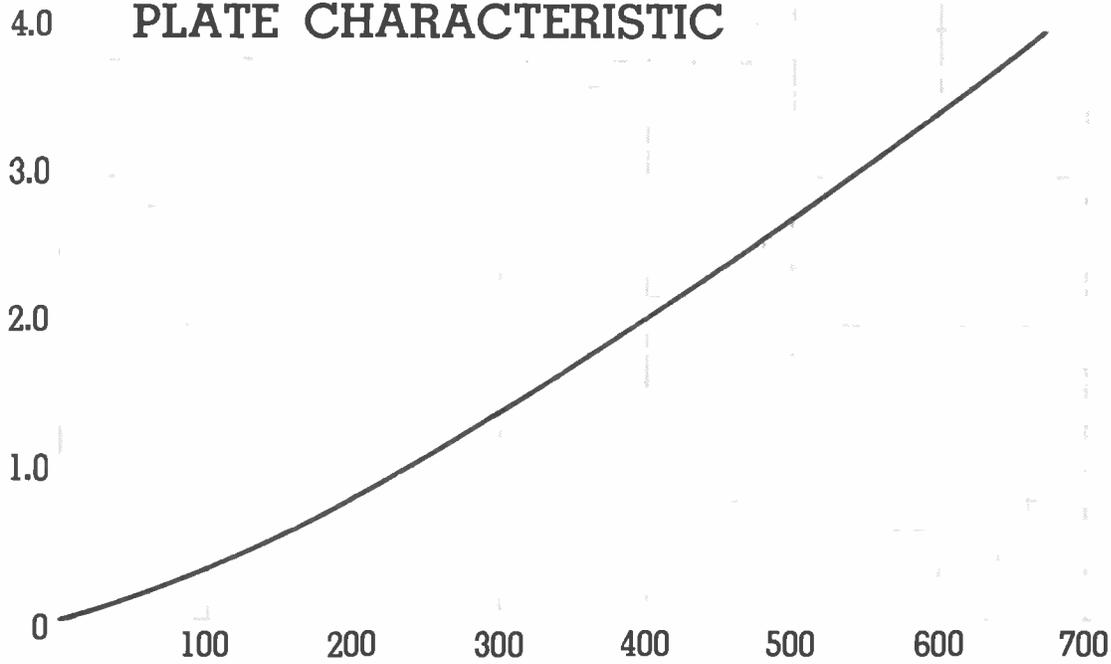
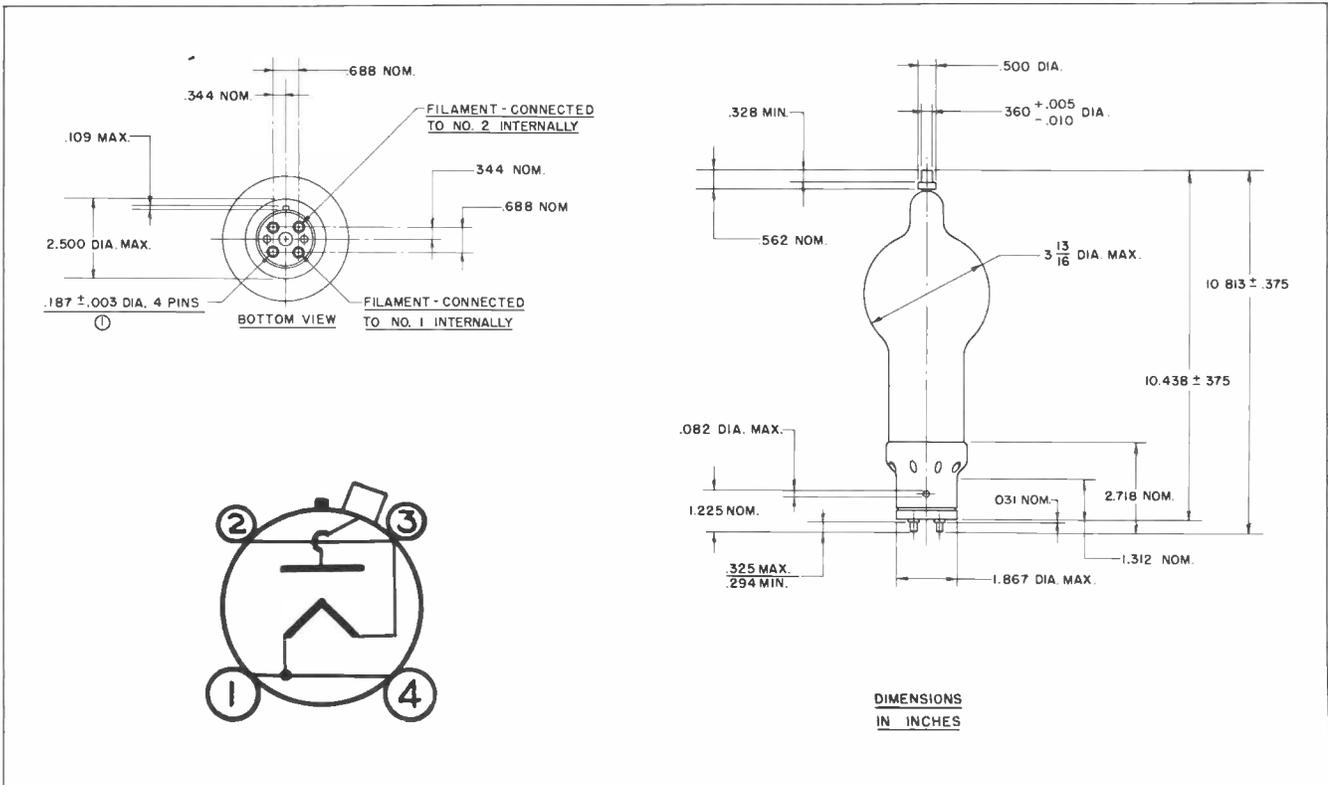


PLATE VOLTAGE—VOLTS





EIMAC

A Division of Varian Associates
SAN CARLOS, CALIFORNIA

2-450A

HIGH-VACUUM
RECTIFIER

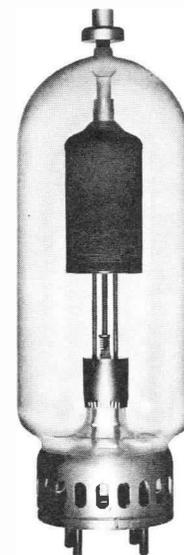
The Eimac 2-450A is a high-vacuum diode rectifier intended for use in rectifier units, voltage multipliers, or in special applications where high peak-inverse voltages, extreme temperatures, high operating frequency, or the production of high-frequency transients would prevent the use of mercury-vapor or gas-filled rectifier tubes.

ELECTRICAL CHARACTERISTICS

Filament:	Thoriated Tungsten	Min.	Nom.	Max.	
Voltage	- - - - -		7.5		volts
Current	- - - - -	25.0		28.0	amperes

MECHANICAL

Base	- - - - -	- - - - -	- - - - -	- - - - -	4-pin, metal shell
Socket	- - - - -	- - - - -	- - - - -	- - - - -	E. F. Johnson Co. 124-214 or equivalent
Operating Position	- - - - -	- - - - -	- - - - -	- - - - -	vertical, base down or up
Recommended Plate Connector	- - - - -	- - - - -	- - - - -	- - - - -	Eimac HR-8
Maximum Operating Temperatures:					
Plate Seal	- - - - -	- - - - -	- - - - -	- - - - -	225°C
Envelope	- - - - -	- - - - -	- - - - -	- - - - -	250°C
Net Weight	- - - - -	- - - - -	- - - - -	- - - - -	2.4 pounds
Shipping Weight (approximate)	- - - - -	- - - - -	- - - - -	- - - - -	9 pounds



COOLING

The temperature of the plate seal and envelope must not be allowed to exceed 225°C and 250°C respectively. When several tubes are being operated in the same compartment and at or near maximum rated plate dissipation, forced-air cooling is required. In any event, it should be remembered that the listed temperatures are maximums and that lower operating temperatures will result in longer life and improved reliability. The use of a temperature-sensitive paint, sparingly applied in the referenced areas, is recommended to determine the effectiveness of the cooling employed in any given installation.

MAXIMUM RATINGS

Peak Inverse Plate Voltage	- - - - -	- - - - -	- - - - -	- - - - -	30,000 MAX. VOLTS
Plate Dissipation	- - - - -	- - - - -	- - - - -	- - - - -	450 MAX. WATTS
D-C Plate Current	- - - - -	- - - - -	- - - - -	- - - - -	1 MAX. AMPERE
Peak Plate Current	- - - - -	- - - - -	- - - - -	- - - - -	8 MAX. AMPERES

MAXIMUM POWER-SUPPLY CAPABILITIES*

Circuit	Maximum A-C Input Voltage (volts rms)	Approx. D-C Output Voltage (volts)	Maximum D-C Output Current (amps)
Single-Phase, Full-Wave (2 tubes)	- - - - - 21,200 total	9,300	2.0
Single-Phase, Bridge (4 tubes)	- - - - - 21,200 total	18,600	2.0
Three-Phase, Full-Wave (6 tubes)	- - - - - 12,250 per leg	28,000	3.0

*Choke-input filter with L equal to or greater than twice "critical"; zero circuit loss assumed; tube drop considered.

CHOKE-INPUT FILTER

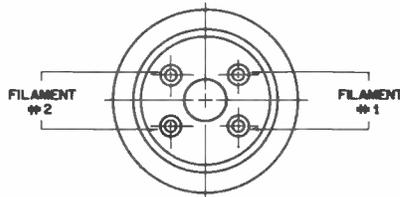
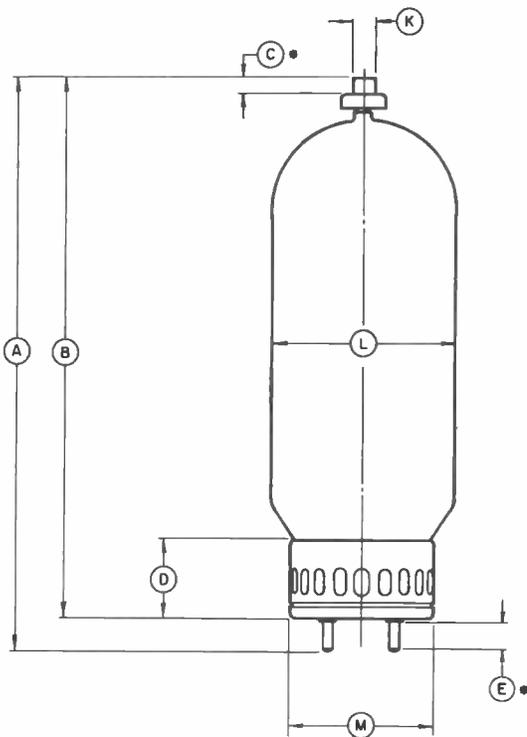
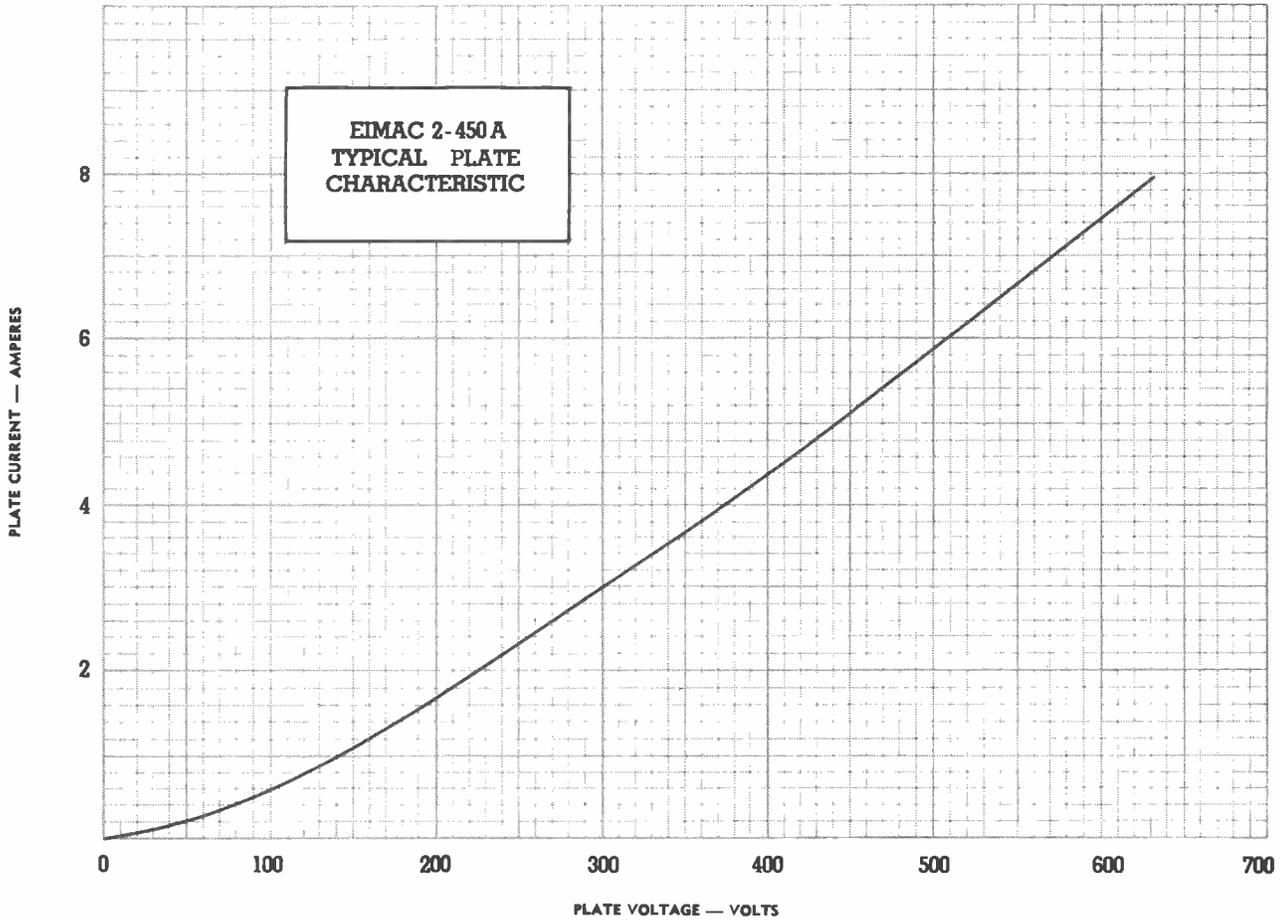
The maximum d-c current rating of the 2-450A is 1.0 amperes when the load incorporates a choke-input filter with the "critical" value (or larger) of input inductance. This value may be calculated from the appropriate formula below:

$$L_o = \frac{R_{eff}}{18.8f} \left\{ \begin{array}{l} \text{for full-wave} \\ \text{single wave} \\ \text{power supplies} \end{array} \right. \quad L_o = \frac{R_{eff}}{75f} \left\{ \begin{array}{l} \text{for half-wave} \\ \text{three-phase} \\ \text{power supplies} \end{array} \right. \quad L_o = \frac{R_{eff}}{660f} \left\{ \begin{array}{l} \text{for full-wave} \\ \text{three-phase} \\ \text{power supplies} \end{array} \right.$$

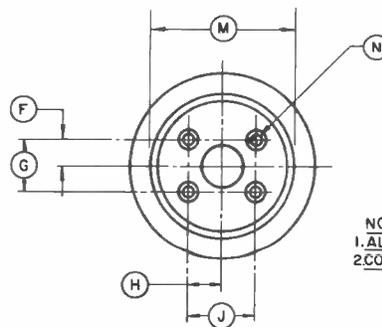
where: L_o = "critical" value of input inductance (henries) f = supply-line frequency (cycles per second)

$$R_{eff} = \frac{\text{Load voltage (volts)}}{\text{Load current (amps)}}$$

THESE SPECIFICATIONS ARE BASED ON DATA APPLICABLE AT PRINTING DATE. SINCE EIMAC HAS A POLICY OF CONTINUING PRODUCT IMPROVEMENT, SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.



DIMENSION DATA			
REF.	NOM.	MIN.	MAX.
A		13 1/8	14 1/8
B		12 1/4	13 1/4
C		.445	.465
D	1 3/4		
E		.662	.712
F		.610	.640
G		1.235	1.265
H		.829	.859
J		1.672	1.702
K		558 DIA.	568 DIA.
L			4 5/8 DIA.
M			3 5/8 DIA.
N		.247 DIA.	.251 DIA.



NOTES:
1. ALL DIMENSIONS IN INCHES.
2. CONTACT SURFACE (N).



APPLICATION (Continued)

for the free circulation of air. An Eimac HR-8 heat Dissipating Connector or equivalent is required on the plate terminal.

The maximum temperature at the plate seal must not exceed 225°C. A convenient accessory for measuring this temperature is "Tempilaq", a temperature-sensitive lacquer available from the Tempil Corporation, 132 W. 22nd St, New York 11, N. Y.

ELECTRICAL

Filament Operation—For maximum tube life, the filament voltage, as measured at the base pins, should be the rated value of 10.0 volts. Variations must be kept within the range from 9.5 to 10.5 volts. In applications which require the diode to deliver high peak currents, it is important to maintain the filament voltage at the rated value. All four socket terminals should be used, putting two in parallel for each filament connection.

CAUTION SHOULD BE OBSERVED WHEN MEASURING RECTIFIER FILAMENT VOLTAGE. THE FILAMENT CIRCUIT MAY BE AT HIGH POTENTIAL.

The thoriated-tungsten filament of the 2-2000A reaches operating temperature in a fraction of a second after application of voltage. Plate voltage may be applied simultaneously with filament voltage.

Plate Operation—The plate of the 2-2000A operates at dull red color at the maximum plate dissipation rating of 1200 watts. The maximum peak-inverse-voltage rating of 75,000 volts should not be exceeded at any time.

Performance—The accompanying table shows some maximum performance capabilities of the 2-2000A when used as a power-supply rectifier.

Circuit Type	2-2000A MAXIMUM-PERFORMANCE CAPABILITIES				
	A-C Input Voltage (volts rms)	D-C Output Voltage (volts)	D-C Output Current* (amperes)	Capacitor-Input Filter D-C Output Voltage (volts)	Choke-Input Filter D-C Output Current (amperes)
Single-Phase, Half-Wave	26,500	31,500	0.600	.....	.....
Single-Phase, Full-Wave	26,500 ¹	31,500	1.20	23,800	1.50
Single-Phase, Bridge	53,000	63,000	1.20	47,600	1.50

¹One-half the transformer secondary voltage.

Maximum D-C Current Ratings—Plate dissipation rather than peak current usually limits the d-c current which the 2-2000A is capable of delivering to the load. Because the plate dissipation associated with a given d-c current depends upon the amount of ripple and its wave-shape, circuit conditions will determine the maximum d-c current rating of the tube.

Choke-Input Filter—The maximum d-c current rating of the 2-2000A is 750 milliamperes when the load incorporates a choke-input filter with the "critical" value (or larger) of input inductance (L_0 in Fig. 1):

$$L_0 = \frac{R_{\text{eff}}}{18.8f} \quad \text{for full-wave single-phase rectifiers,}$$

$$L_0 = \frac{R_{\text{eff}}}{75f} \quad \text{for half-wave three-phase rectifiers,}$$

$$L_0 = \frac{R_{\text{eff}}}{660f} \quad \text{for full-wave three-phase rectifiers,}$$

where: L_0 = "critical" value of input inductance (henries),
 f = supply-line frequency (cycles per second),

$$R_{\text{eff}} = \frac{\text{Load voltage (volts)}}{\text{Load current (amps)}}$$

Choke-input filters are not normally used with single-phase half-wave rectifiers.

Capacitor-Input Filter—The 2-2000A is particularly suitable for power-supply applications demanding high voltage at low cur-

rent. Under these conditions capacitor-input filter circuits become desirable. The maximum d-c current rating of the 2-2000A when no input choke is incorporated in the filter depends upon the total series resistance of the capacitor-charging circuit relative to the effective load resistance seen by each tube. The circuit diagrams and tabulation in Fig. 2 are so arranged and labeled that this required series resistance may be found for a wide range of load conditions. This may be done by determining the value of the following quantities:

E_c is the filter-input d-c voltage. While this is usually the entire load voltage, in the case of voltage multipliers it is the load voltage divided by the multiplication factor.

I_p is the d-c current per tube. This is the entire load current only in the case of the simple half-wave rectifier or half- or full-wave multiplier. In the case of full-wave center-tapped or bridge rectifiers, I_p is half the load current.

R_c is the total charging-circuit resistance. A certain minimum value of charging-circuit resistance is necessary to limit the peak value of current to which the tubes will be subjected under given load conditions. This required minimum depends upon the d-c current per tube (I_p), and has been tabulated in Fig. 2 as a percentage of the effective load resistance per tube (E_c/I_p). The total charging-circuit resistance involves the internal resistance of the rectifier tube, R_p , the added series resistor, R_s , and the equivalent internal resistance of the a-c voltage supply, R_i .

R_p is the plate resistance of the 2-2000A, which may be taken as 400 ohms.

R_i is the equivalent internal resistance of the supply. This may be taken as the regulation of the high-voltage supply expressed as a decimal multiplied by the load resistance used in measuring this regulation.

R_s is the series resistor which must be inserted in the charging circuit to bring the total charging-circuit resistance up to the required minimum. Its value may be found from the formula associated with each of the circuits of Fig. 2. This resistor must be inserted in such a position in the circuit that it protects all tubes.

Tubes may be operated in parallel to increase the output capability in a given circuit. When two tubes are placed in parallel at each place where one is shown in the circuits of Fig. 2, the plate resistance (R_p) will be half as great and the maximum allowable load current twice as great as indicated.

Peak Inverse Voltage—The peak-inverse-voltage rating of the 2-2000A is 75,000 volts. In single-phase power-supply rectifier circuits the peak inverse voltage to be used in design is the peak a-c supply voltage (1.41 times E_{rms} in Fig. 2) in the case of bridge circuits, and twice this value in the case of half- and full-wave rectifiers and voltage multipliers. Peak inverse voltage in three-phase operation depends upon the circuit employed, and will be found listed in the handbooks.

Special Applications—The ratings given for capacitor-input filter circuits assume values of input capacitance large enough to hold the ripple to a low value. In special applications where a larger percent ripple is tolerable, and filter capacitance is low, the 2-2000A is capable of larger d-c output currents.

As a unidirectional conductor in d-c circuits where the current is continuous and the percent ripple is moderate, the maximum current rating of the 2-2000A is 1500 milliamperes.

The plate characteristic curve for the 2-2000A serves as a guide to special applications. The maximum plate dissipation rating of 1200 watts, the maximum peak-inverse-voltage rating of 75,000 volts, and the maximum peak plate current of 12 amperes must not be exceeded.

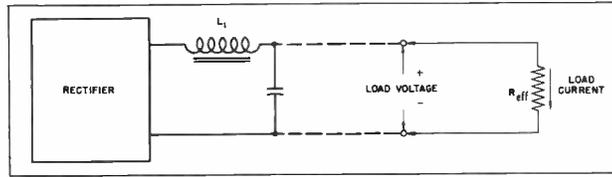
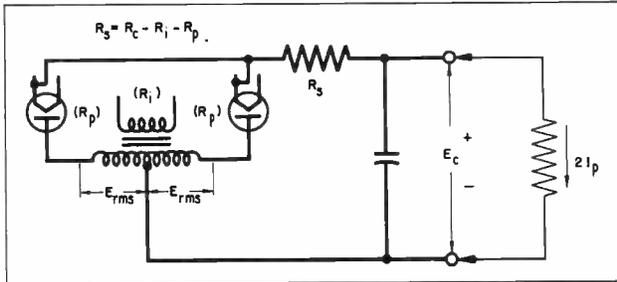
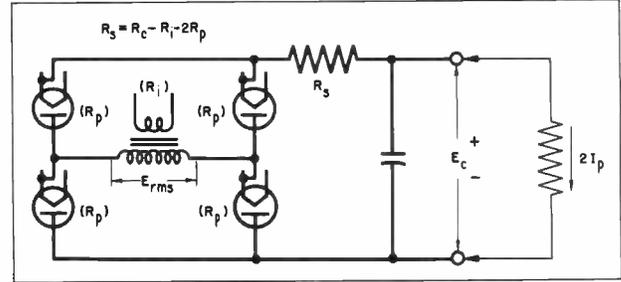


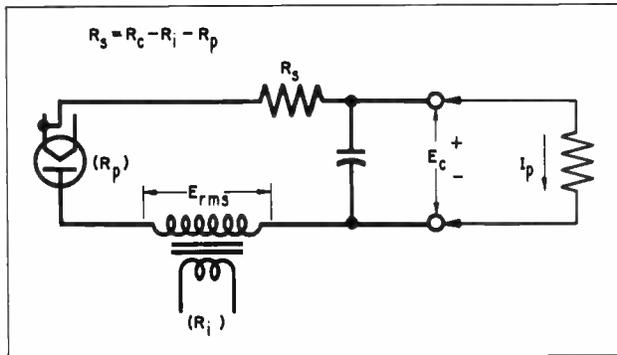
Fig. 1. Rectifier with Choke-Input Filter



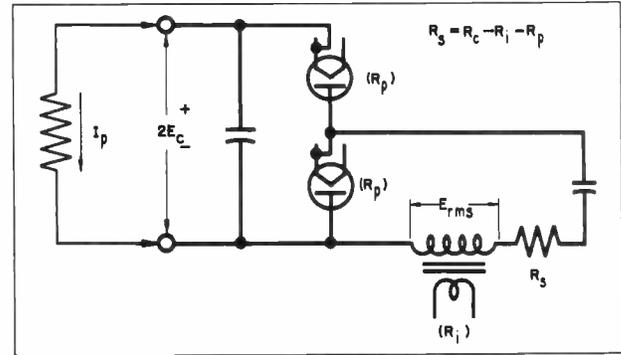
a. Full-Wave Center-Tapped Rectifier



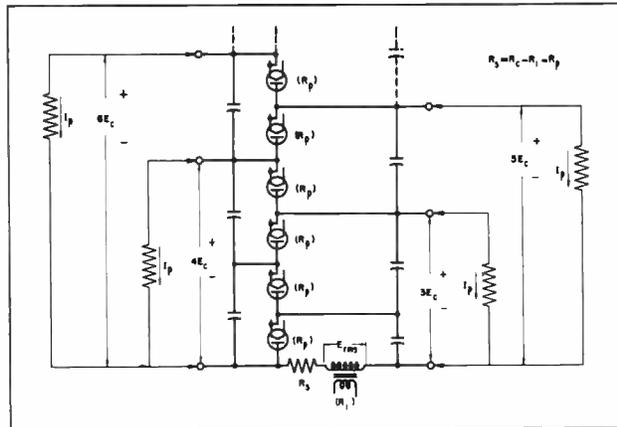
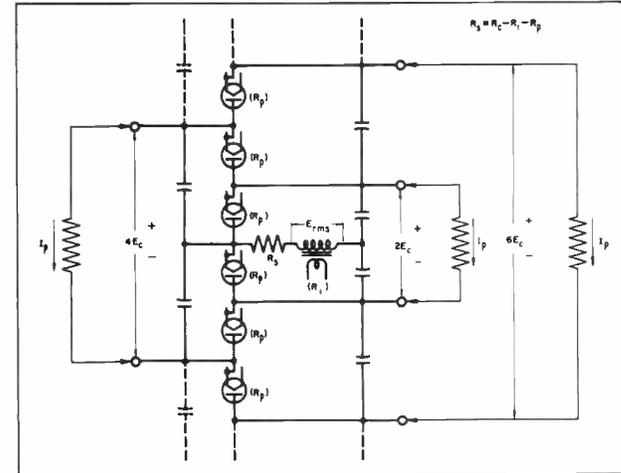
b. Full-Wave Bridge Rectifier



c. Half-Wave Rectifier



d. Half-Wave Voltage Doubler


 e. Half-Wave Voltage Multiplier (with common ground when R_s is inserted on the "high" side of E_{rms})


f. Full-Wave Voltage Multiplier

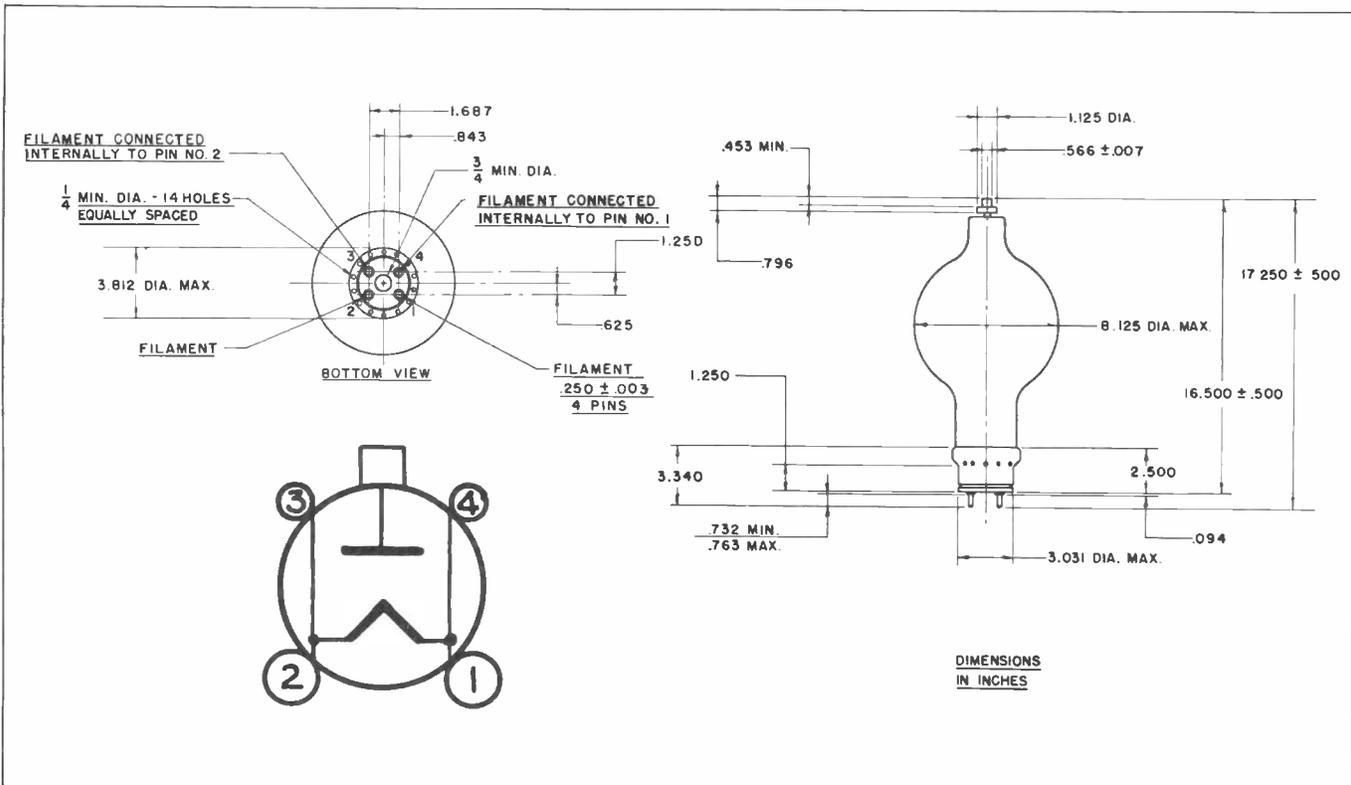
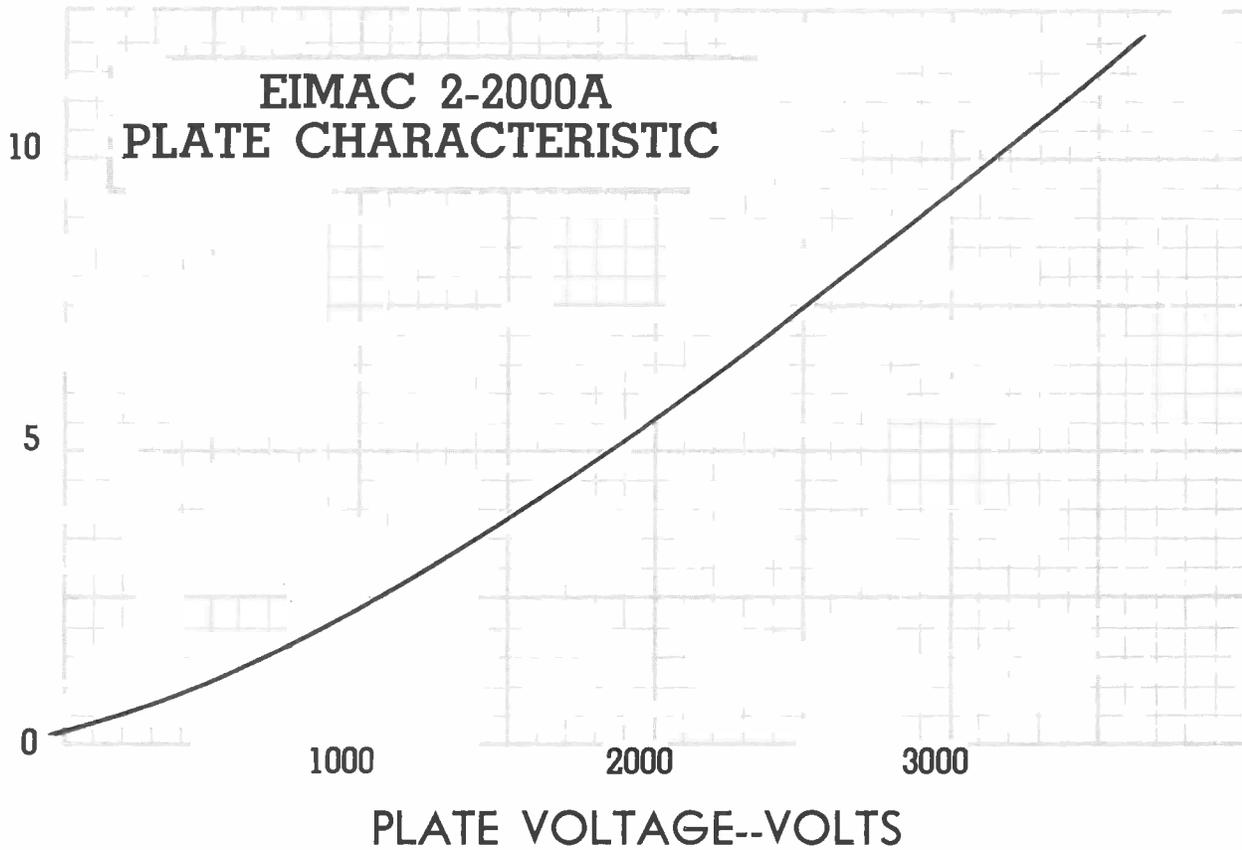
Eimac 2-2000A Maximum D-C Current Ratings for R-C Filter Applications						
D-C Plate Current (I_p)	550	600	650	700	750	milliamperes per tube
Total Charging-Circuit Resistance (R_c)	1.1	2.1	3.8	7.0	13	percent of Effective Load Resistance per Tube (E_c/I_p)
A-C Supply Voltage (E_{rms})	0.80	0.84	0.90	1.00	1.16	times Filter-Input D-C Voltage (E_c)
Peak Inverse Voltage ($1/2$ these values for circuit b.)	2.3	2.4	2.6	2.8	3.3	times Filter-Input D-C Voltage (E_c)

Fig. 2 Eimac 2-2000A basic R-C Circuits (for any one of the indicated loads)

 R_1 = Equivalent resistance of voltage source

 R_p = 400 ohms (200 ohms for two tubes in parallel)

PLATE CURRENT--AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

2X3000F

HIGH-VACUUM
RECTIFIER

The Eimac 2X3000F is a high-vacuum, forced-air cooled, external-anode diode intended for use in high-power rectifier units whenever high peak-inverse voltages, extreme ambient temperatures, high operating frequency, or the production of high-frequency transients would prevent the use of mercury-vapor or gas-filled rectifier tubes.

CHARACTERISTICS

ELECTRICAL

Filament:	Thoriated Tungsten								
Voltage	-	-	-	-	-	-	-	7.5	volts
Current	-	-	-	-	-	-	-	51	amperes

MECHANICAL

Operating Position	-	-	-	-	-	-	-	-	Vertical, base down or up
Maximum Operating Temperatures:									
Glass-to-Metal Seals	-	-	-	-	-	-	-	-	175° C
Anode Core	-	-	-	-	-	-	-	-	175° C
Net Weight	-	-	-	-	-	-	-	-	5.7 pounds
Shipping Weight (Approximate)	-	-	-	-	-	-	-	-	17 pounds

MAXIMUM RATINGS

PEAK INVERSE PLATE VOLTAGE	-	-	-	-	-	-	-	-	25,000 MAX.	VOLTS
PLATE DISSIPATION	-	-	-	-	-	-	-	-	3,000 MAX.	WATTS
DC PLATE CURRENT	-	-	-	-	-	-	-	-	3 MAX.	AMPERES
PEAK PLATE CURRENT	-	-	-	-	-	-	-	-	20 MAX.	AMPERES

TYPICAL POWER-SUPPLY CAPABILITIES*

Circuit	Maximum AC Input Voltage (volts rms)	Approx. DC Output Voltage (volts)	Maximum DC Output Current (amps)
Single-Phase, Full-Wave (2 tubes)	17,700 total	8,000	6.0
Single-Phase, Bridge (4 tubes)	17,700 total	16,000	6.0
Three-Phase, Full-Wave (6 tubes)	10,200 per leg	24,000	9.0

*Choke-input filter with L equal to or greater than twice "critical"; zero circuit loss assumed.

COOLING

Sufficient forced air cooling must be provided to maintain seal and anode core temperature at 175°C or below. Air-flow must be started when filament power is applied and it is advisable to continue air-cooling for two minutes after all voltages are removed.

The table below lists minimum air-flow requirements to maintain tube temperatures below 175°C with air flowing in both the base-to-anode and anode-to-base directions. This tabulation presumes air at 40°C and sea level. A separate supply of approximately six cubic feet per minute, directed into the filament structure is also required to maintain rated filament seal temperatures. This is best accomplished using a small diameter insulating tubing directed into the stem, between the filament seals.

Plate Dissipation (Watts)	MINIMUM COOLING AIR-FLOW REQUIREMENTS			
	BASE-TO-ANODE FLOW		ANODE-TO-BASE FLOW	
	AIR-FLOW (CFM)	PRESSURE DROP (inches of water)	AIR-FLOW (CFM)	PRESSURE DROP (inches of water)
1000	15	0.1	25	0.2
2000	45	0.4	75	1.2
3000	95	1.4	155	4.5

Note: An extra 375 watts have been added to these plate dissipation figures in preparing this tabulation, to compensate for filament dissipation.

For operation at high altitudes or higher ambient temperatures, these quantities should be increased. In all cases it is suggested that actual temperatures be measured to insure adequate cooling.



PM

Eimac
EITEL-McCULLOUGH, Inc.
 SAN BRUNO, CALIFORNIA

4PR60A

RADIAL-BEAM
 PULSE TETRODE

MODULATOR
 AMPLIFIER

The Eimac 4PR60A is a high-vacuum tetrode intended for pulse-modulator service in circuits employing inductive or resistive loads. This tube unilaterally replaces the 715C and the 5D21.

- ▶ The 4PR60A has a maximum plate dissipation rating of 60 watts, is cooled by radiation and convection, and delivers pulse power output in the range of 300 kilowatts with one kilowatt of pulse driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode: Oxide-coated, Unipotential	
Heater Voltage - - - - -	26.0 volts
Heater Current - - - - -	2.25 amperes
Minimum Heating Time - - - - -	3 minutes
Direct Interelectrode Capacitances (Average)	
Grid-Plate (without shielding) - - - - -	0.3 $\mu\mu\text{f}$
Input - - - - -	43.0 $\mu\mu\text{f}$
Output - - - - -	9.0 $\mu\mu\text{f}$

MECHANICAL

Minimum Shock Test - - - - -	200g
Base - - - - -	Fits E. F. Johnson Co. Socket Number 122-234 or equivalent
Mounting Position - - - - -	Any
Cooling - - - - -	Radiation and Convection
Recommended Heat Dissipating Plate Connector - - - - -	Eimac HR-8
Maximum Over-All Dimensions	
Length - - - - -	6 inches
Diameter - - - - -	3 $\frac{1}{8}$ inches
Net Weight - - - - -	12 ounces
Shipping Weight - - - - -	1.75 pounds

RATINGS

MAXIMUM RATINGS—Pulse Modulator Service (Per Tube)

D-C PLATE VOLTAGE - - -	20 MAX. KILOVOLTS
D-C SCREEN VOLTAGE ¹ - - -	1.5 MAX. KILOVOLTS
D-C GRID VOLTAGE ² - - -	—1.0 MAX. KILOVOLT
PEAK POSITIVE GRID VOLTAGE -	300 MAX. VOLTS
PEAK PLATE CURRENT - - -	18 MAX. AMPERES
PEAK POSITIVE PLATE VOLTAGE -	25 MAX. KILOVOLTS
PLATE DISSIPATION (AVERAGE) -	60 MAX. WATTS
SCREEN DISSIPATION (AVERAGE)	8 MAX. WATTS
SEAL TEMPERATURES - - -	200 MAX. DEG. C

DUTY

For peak plate currents in excess of 5 amperes, the duty shall not exceed 0.001, and the product of peak current in amperes and pulse duration in microseconds shall not exceed 40. The tube shall not be operated for longer than 5 microseconds in any 100 microsecond interval.

For peak plate current values of less than 5 amperes, the pulse duration-current factor of 40 applies, and the plate dissipation rating of 60 watts determines the maximum permissible duty.

TYPICAL OPERATION

Pulse Modulator (Per Tube)

D-C Plate Voltage - - - - -	15.8	20.0	kilovolts
Pulse Plate Current - - - - -	14.0	16.0	amperes
D-C Screen Voltage - - - - -	1.25	1.25	kilovolts
Pulse Screen Current* - - - - -	4.0	3.0	amperes
D-C Grid Voltage - - - - -	-600	-600	volts
Pulse Grid Current* - - - - -	1.1	1.1	amperes
Pulse Positive Grid Voltage - - - - -	100	100	volts
Duty - - - - -	.001	.001	
Pulse Length - - - - -	2	2	μsec
Peak Positive Plate Voltage - - - - -	25	25	kilovolts
Peak Plate Current - - - - -	16	18	amperes
Pulse Power Input - - - - -	220	320	kilowatts
Pulse Power Output - - - - -	210	305	kilowatts
Plate Output Voltage - - - - -	15.0	19.0	kilovolts

¹Screen grid series protective resistance shall be 20,000 ohms, minimum.

▶ ²Control grid series resistance shall be 100,000 ohms, maximum.

*Approximate values.



APPLICATION

MECHANICAL

Mounting—The 4PR60A may be mounted and operated in any position. A flexible connecting strap should be provided between the plate terminal and the external plate circuit.

The 4PR60A is designed to withstand 200g shocks of short duration transferred to the tube through clamps on the metal skirt. Such clamps must be shaped to fit the contour of the skirt and must be fastened to the tube before being tightened to the chassis in order that no distorting force will be applied. No lateral pressure or clamping action should be applied to the base pins or to any part of the tube other than the skirt. The skirt is internally connected to the cathode.

Adequate ventilation must be provided so that the seals and envelope under operating conditions do not exceed 200°C.

ELECTRICAL

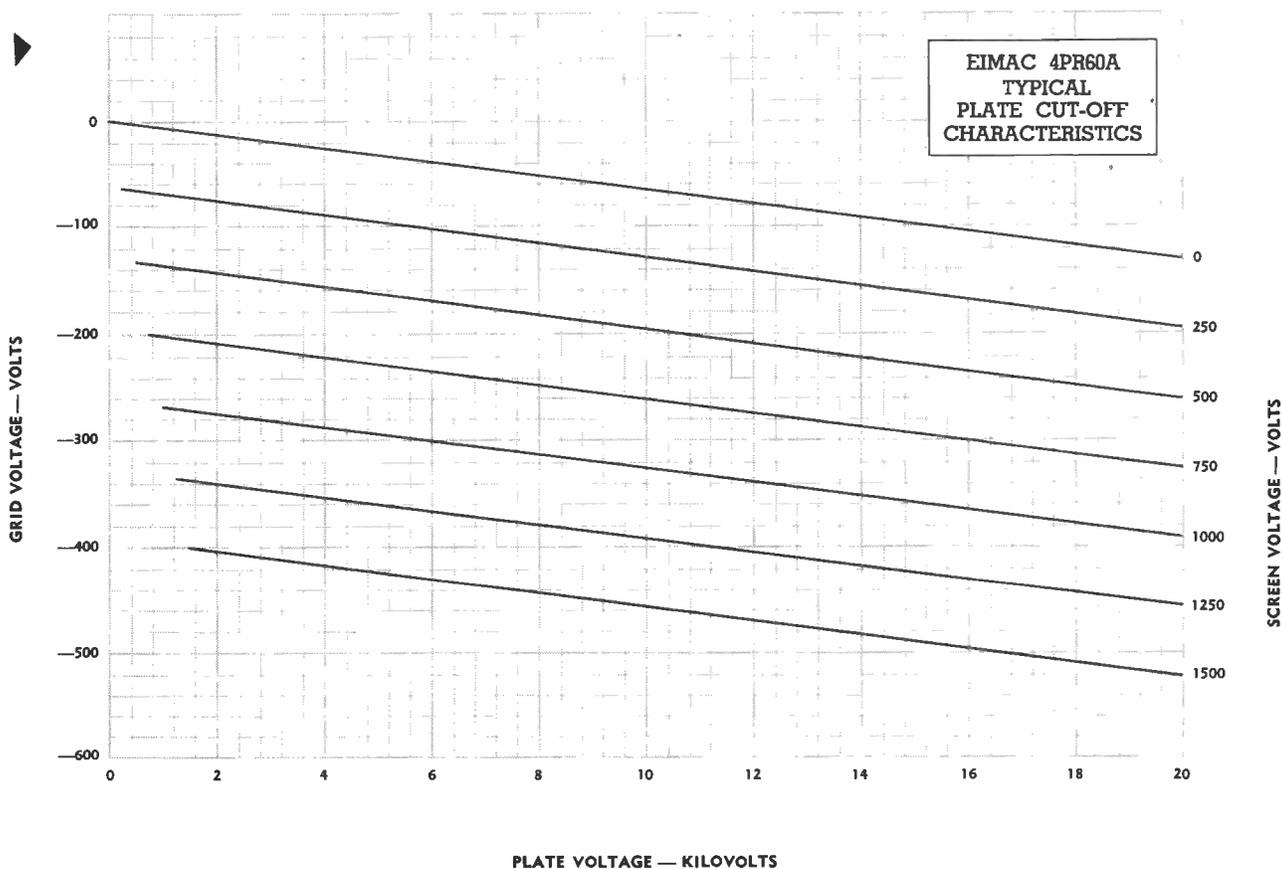
Heater Voltage—The heater voltage, as measured directly at the heater pins, should be the rated

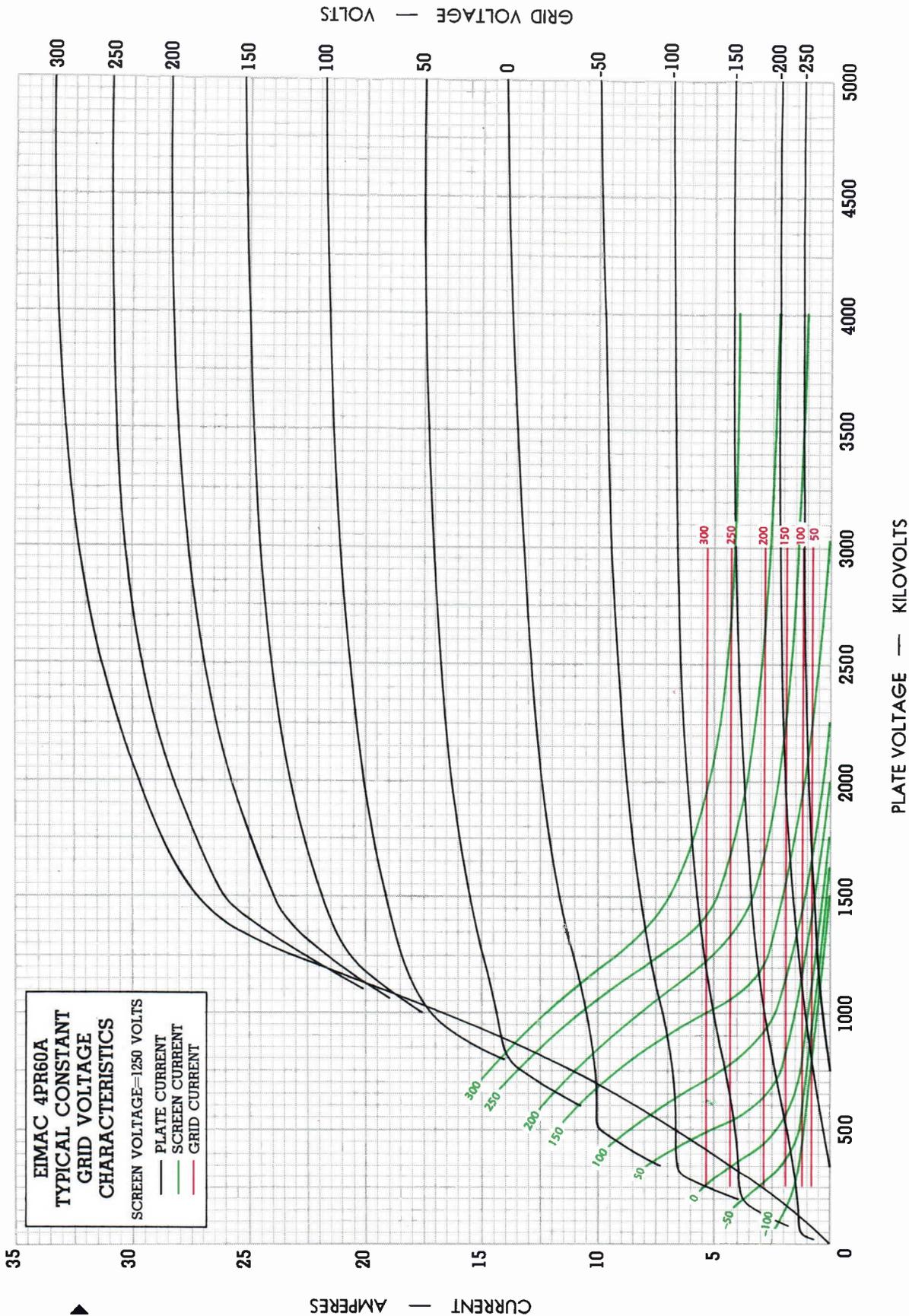
value of 26.0 volts. Variations in heater voltage must be kept within the range from 23.4 to 28.6 volts.

Screen Dissipation—The average power dissipated by the screen of the 4PR60A must not exceed eight watts. A protective series resistance of not less than 20,000 ohms must be inserted in the screen-voltage supply circuit and the screen should be adequately by-passed directly to the cathode by means of a suitable capacitor.

Plate Voltage—The plate-supply voltage for the 4PR60A should not exceed 20 kilovolts. In circuits employing inductive loading, the peak instantaneous plate voltage should not exceed 25 kilovolts.

Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4PR60A should not be allowed to exceed 60 watts. Plate dissipation in excess of maximum rating is permissible for short periods of time, such as during adjustment procedures. The 4PR60A should not be operated without a heat dissipating plate connector such as the recommended Eimac HR-8.





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▲ Indicates change from sheet dated 8-15-52.



EITEL-McCULLOUGH, INC.
SAN CARLOS CALIFORNIA

8252
4PR60B

**RADIAL-BEAM
PULSE TETRODE**

**MODULATOR
AMPLIFIER**

The Eimac 8252/4PR60B is a high-vacuum tetrode intended for pulse-modulator service in circuits employing inductive or resistive loads. This tube unilaterally replaces the 715C and the 5D21 and supersedes the 4PR60A.

The 8252/4PR60B has a maximum plate dissipation rating of 60 watts, is cooled by radiation and convection, and delivers pulse output power in the region of 300 kilowatts with less than one kilowatt of pulse driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Cathode: Oxide-coated, Unipotential				
Heater Voltage - - - - -		26.0		volts
Heater Current - - - - -		2.1		amperes
Cathode Heating Time - - - - -	3	5		minutes
Direct Interelectrode Capacitances				
Grid-Plate - - - - -			2.0	$\mu\mu\text{f}$
Input - - - - -	35		50	$\mu\mu\text{f}$
Output - - - - -	6.0		11	$\mu\mu\text{f}$

MECHANICAL

Minimum Shock Test - - - - -	190g, 0.5ms half sine
Base - - - - -	Fits E. F. Johnson Co. Socket Number 122-234 or equivalent
Mounting Position - - - - -	Any
Cooling - - - - -	Radiation and Convection
Recommended Heat Dissipating Plate Connector - - - - -	Eimac HR-8
Maximum Seal and Envelope Temperatures - - - - -	200°C
Maximum Over-All Dimensions	
Length - - - - -	6.000 inches
Diameter - - - - -	3.063 inches
Net Weight - - - - -	12 ounces
Shipping Weight - - - - -	2.5 pounds

RATINGS

MAXIMUM RATINGS—Pulse Modulator Service (Per Tube)

D-C PLATE VOLTAGE - - - - -	20 MAX. KILOVOLTS
D-C SCREEN VOLTAGE - - - - -	1.5 MAX. KILOVOLTS
D-C GRID VOLTAGE† - - - - -	-1.0 MAX. KILOVOLT
PEAK POSITIVE GRID VOLTAGE - - - - -	300 MAX. VOLTS
PEAK PLATE CURRENT - - - - -	18 MAX. AMPERES
PEAK POSITIVE PLATE VOLTAGE - - - - -	25 MAX. KILOVOLTS
PLATE DISSIPATION (AVERAGE) - - - - -	60 MAX. WATTS
SCREEN DISSIPATION (AVERAGE) - - - - -	8 MAX. WATTS
GRID DISSIPATION (AVERAGE) - - - - -	1 MAX. WATT
DUTY - - - - -	See chart page 4

†Effective grid-circuit resistance must not exceed 100,000 ohms.

TYPICAL OPERATION

Pulse Modulator (Per Tube)

D-C Plate Voltage - - - - -	16.0	20.0	kilovolts
Pulse Plate Current - - - - -	10.0	18.0	amperes
D-C Screen Voltage - - - - -	1.25	1.25	kilovolts
Pulse Screen Current* - - - - -	1.8	2.7	amperes
D-C Grid Voltage - - - - -	-550	-600	volts
Pulse Grid Current* - - - - -	0.20	0.75	ampere
Pulse Positive Grid Voltage - - - - -	30	150	volts
Duty - - - - -	0.0025	.001	
Pulse Duration - - - - -	5	2	μsec
Peak Positive Plate Voltage - - - - -	25	25	kilovolts
Pulse Input Power - - - - -	160	360	kilowatts
Pulse Output Power - - - - -	150	337	kilowatts
Pulse Output Voltage - - - - -	15.0	18.75	kilovolts





APPLICATION

MECHANICAL

MOUNTING—The 4PR60B may be mounted and operated in any position. A flexible connecting strap must be provided between the plate terminal and the external plate circuit.

The 4PR60B is designed to withstand 200g shocks of 0.5 millisecond duration transferred to the tube through clamps on the metal skirt. Such clamps must be shaped to fit the contour of the skirt and must be fastened to the tube before being tightened to the chassis in order that no distorting force will be applied. No lateral pressure or clamping action should be applied to the base pins or to any part of the tube other than the skirt. The skirt is internally connected to the cathode. The 4PR60B must be protected from severe vibration.

Cooling—Adequate ventilation must be provided so that seal and/or envelope temperatures do not exceed 200°C under any operating or standby condition. When the 4PR60B is operated where air circulation is restricted, these temperatures can easily reach 225°C or more which will accelerate seal deterioration and cause early tube failure.

Adequate control of the base temperature, in particular, is necessary. Envelope and plate-seal temperatures do not ordinarily require special attention provided that an HR-8 heat-dissipating plate connector is used. However, each individual application of the 4PR60B should be carefully evaluated to assure safe operating temperatures. A blower is usually required only when normal air circulation is restricted, when the ambient temperature exceeds 25°C, when the altitude is other than sea level, or when a combination of these factors exists.

ELECTRICAL

Heater Operation—The heater voltage, as measured directly at the heater pins, should be maintained at the rated value of 26.0 volts. Maximum variations in heater voltage must be kept within the range of 23.4 to 28.6 volts. Where consistent performance and long tube life are factors, the heater voltage must be kept within the range of 24.7 to 27.3 volts. The peak pulse-emission capability of the cathode may be impaired at low heater voltages, and high heater voltages contribute to short tube life.

A heater noise test is conducted periodically on 4PR60B samples. This test insures that the heater/cathode assembly will not generate excessive r-f noise during vibration over the frequency range of 10 to 50 cps.

A 500-hour heater cycling test is also conducted periodically on 4PR60B samples. This test consists of at least 1000 complete on-off cycles and insures that grid-to-cathode shorts will not occur as a result of cumulative hysteresis effects upon mechanical joints in the cathode assembly.

Cathode Operation—It is essential that the minimum cathode heating time of three minutes be observed prior to the flow of cathode current. Conservative design for reliable tube operation in pulse circuits dictates the use of five minutes minimum heating time.

The "Cathode Current Derating Chart" on page 4 depicts the current capabilities of the 4PR60B cathode at various pulse durations and duty factors. To use this chart, enter with pulse duration and note the intersection with desired pulse *cathode* current (the total of plate, screen, and grid currents during a particular pulse condition). At this intersection read off values of maximum duty and/or pulse repetition rate.

Under a given set of operating conditions, element dissipations may limit the maximum permissible duty to a value less than that which cathode considerations would dictate. When this occurs, it will usually be found that screen dissipation is the limiting factor under low tube-voltage-drop conditions and that plate dissipation limits the maximum duty under high tube-voltage-drop conditions.

Control-Grid Operation—The average power dissipated by the control grid of the 4PR60B must not exceed one watt. Control-grid dissipation is not usually a limiting factor with this tube, but can be computed as the product of pulse grid current, pulse positive grid voltage, and duty factor. Similarly, pulse driving power is pulse grid current times pulse grid voltage swing (bias voltage plus positive grid voltage).

Screen-Grid Operation—The average power dissipated by the screen of the 4PR60B must not exceed eight watts. Screen dissipation is the product of d-c screen voltage, pulse screen current, and duty factor. Excessive screen dissipation is likely to occur under conditions of low tube-voltage drop during conduction. This condition can be relieved by using a lower plate load resistance which will cause higher tube-voltage drop during conduction.

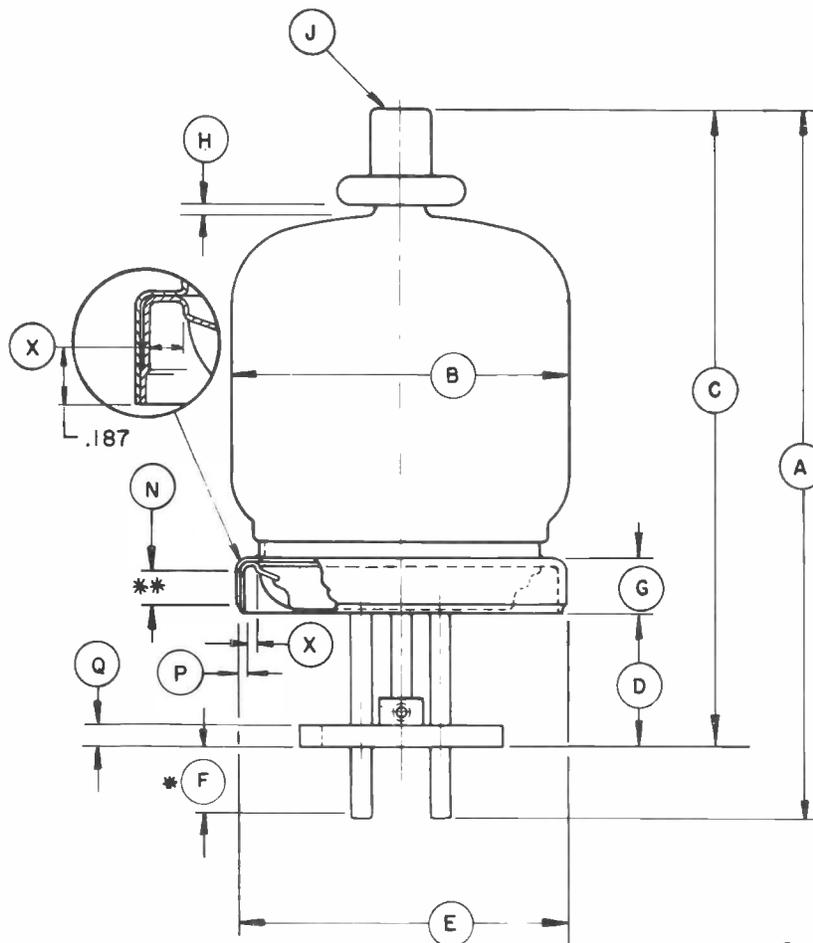
A bleeder resistance designed to draw at least 10 milliamperes of current should be connected directly from screen to cathode of the 4PR60B. This bleeder resistance will insure that only a positive current load is presented to the screen supply.

Plate Operation—The plate of the 4PR60B is radiation cooled and is rated at 60 watts maximum dissipation. Average plate dissipation must not exceed 60 watts. The 4PR60B should not be operated without a heat-dissipating plate connector such as the recommended Eimac HR-8.

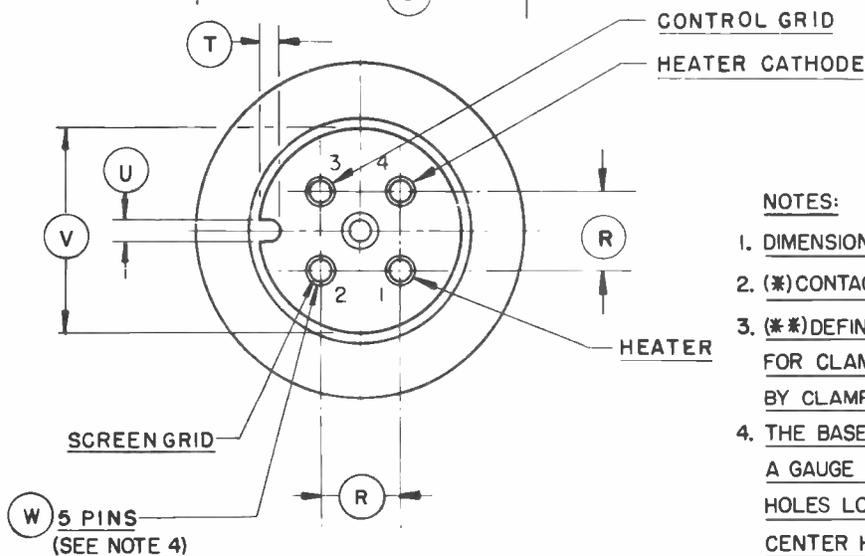
Average plate dissipation may be calculated as the product of pulse plate current, pulse tube-voltage drop, and duty factor. Excessive average plate dissipation is likely to occur at high values of pulse tube-voltage drop. The calculated value of plate dissipation may be well below 60 watts in a given case, but excessive dissipation may result if pulse rise and fall times are appreciable compared to pulse duration. This excessive plate dissipation occurs because long rise and fall times slow down the plate voltage swing and allow plate current to flow for longer periods in the high voltage-drop region.

The plate-supply voltage for the 4PR60B should not exceed 20 kilovolts. In circuits employing inductive loading, the peak instantaneous plate voltage should not exceed 25 kilovolts.

4PR60B OUTLINE DRAWING AND DIMENSIONS



DIMENSION DATA		
REF.	MIN.	MAX.
A	5.750	6.000
B		3.063 DIA.
C	5.344	5.594
D	1.125	1.250
E	2.885 DIA.	2.905 DIA.
F	.328	
G	.438	.500
H	.016	
J	CAP: C1-41 (JEDEC DESIGNATION)	
N	.250	
P	.043	.057
Q	.188	
R	.687	
T	.171	.203
U	.171	.203
V	1.788 DIA.	1.813 DIA.
W	.183 DIA.	.191 DIA.
X	.157	

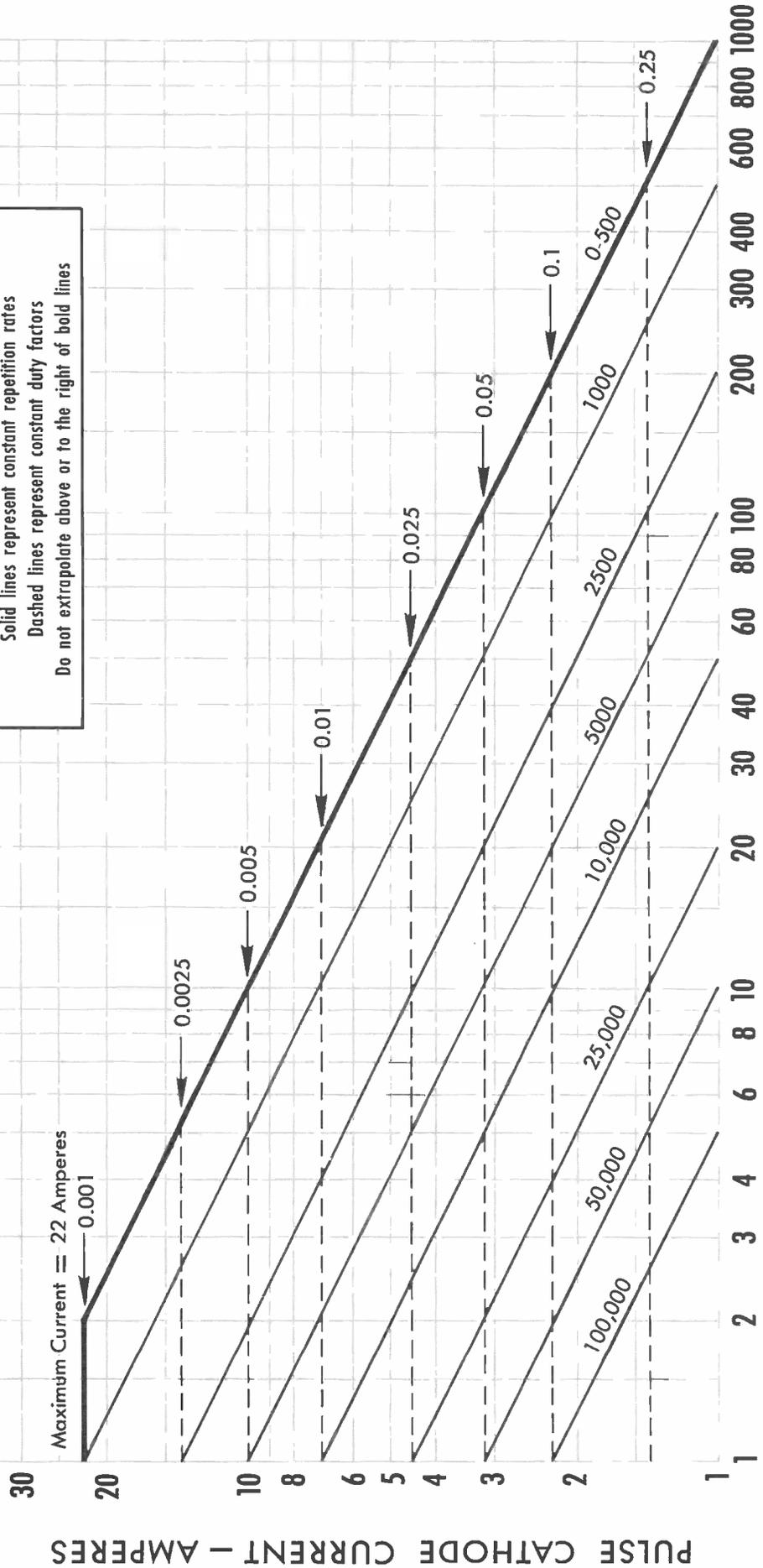


NOTES:

1. DIMENSIONS IN INCHES.
2. (*) CONTACT AREA.
3. (**) DEFINES CYLINDRICAL AREA AVAILABLE FOR CLAMPING WHICH MUST NOT BE DISTORTED BY CLAMPING ACTION.
4. THE BASE PINS SHALL BE CAPABLE OF ENTERING A GAUGE 1/4 INCH THICK HAVING FOUR .214" DIA. HOLES LOCATED ON 11/16 CENTERS AND A CENTER HOLE .250 DIA

EIMAC 4PR60B CATHODE CURRENT DERATING CHART

Solid lines represent constant repetition rates
Dashed lines represent constant duty factors
Do not extrapolate above or to the right of bold lines



PULSE DURATION - MICROSECONDS

PULSE CATHODE CURRENT - AMPERES



EIMAC 4PR60B TYPICAL PLATE CURRENT CUT-OFF CHARACTERISTICS

PLATE CURRENT = 10 MICROAMPERES

SCREEN VOLTAGE = 0 VOLTS

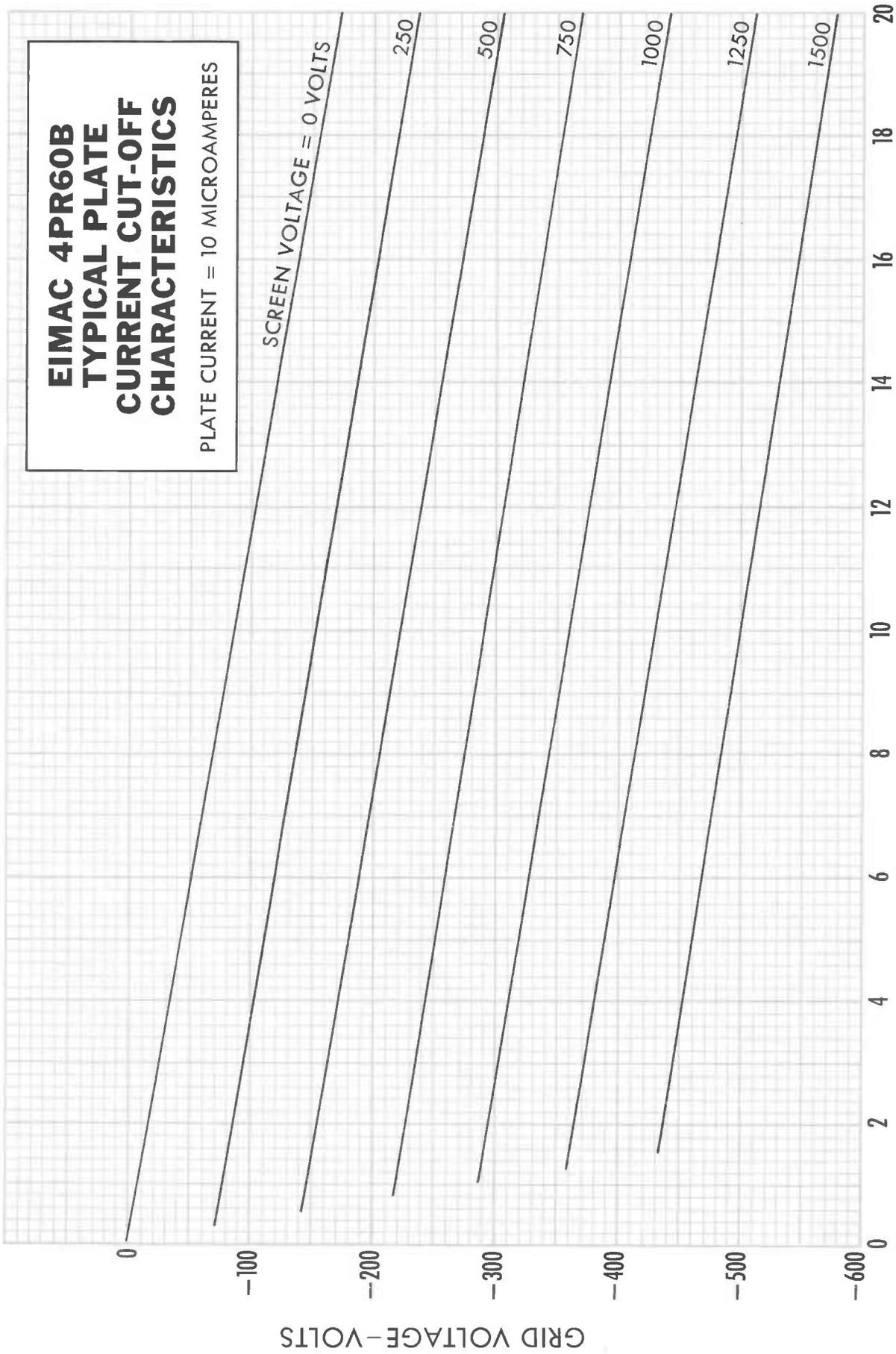
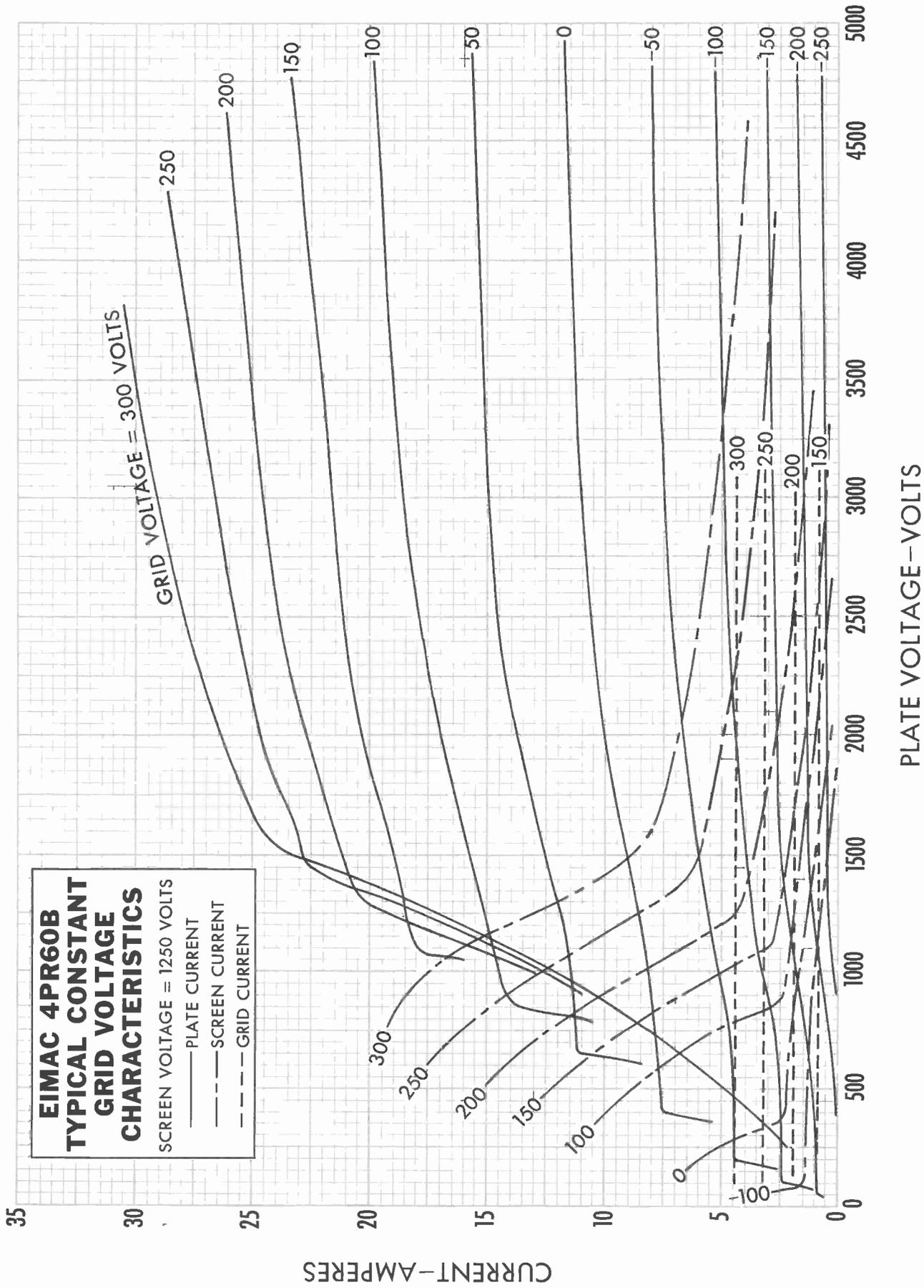


PLATE VOLTAGE - KILOVOLTS

GRID VOLTAGE - VOLTS





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 C A L I F O R N I A

**575A
 673**
**MERCURY-VAPOR
 RECTIFIERS**

The EIMAC 575A and 673 are half-wave mercury vapor-rectifiers incorporating features which enable them to withstand high peak inverse voltages and to conduct at relatively low applied voltages. The tubes differ only in basing.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Oxide-coated		
Voltage	- - - - -	5.0 volts
Current	- - - - -	9.0 to 11.5 amperes
Filament Heating Time	- - - - -	30 seconds
Anode Starting Voltage (approx.)	- - - - -	20 volts

MECHANICAL

Base	- - - - -	575A	50 watt, A4-29
		673	Industrial, A4-18
Recommended Socket	- - - - -	575A	E. F. Johnson #123-211
		673	E. F. Johnson #123-206
Maximum Overall Dimensions:			
Length	- - - - -	575A	11-1/8 inches
		673	11-7/16 inches
Diameter	- - - - -		2-9/16 inches
Net Weight	- - - - -		12 ounces



MAXIMUM RATINGS (per tube)

CONDENSED MERCURY TEMPERATURE LIMITS*	- - - - -	20-50	20-60	°C
PEAK INVERSE ANODE VOLTAGE	- - - - -	15	10	kV
PEAK ANODE CURRENT:				
Quadrature Filament Excitation**	- - - - -	10	10	Amps
In-Phase Filament Excitation	- - - - -	6	7	Amps
AVERAGE ANODE CURRENT: (Maximum averaging time - 20 seconds)				
Quadrature Filament Excitation**	- - - - -	2.5	2.5	Amps
In-Phase Filament Excitation	- - - - -	1.5	1.75	Amps
MAXIMUM AC SHORT CIRCUIT CURRENT***	- - - - -	100	100	Amps

*Condensed Mercury temperature rises approximately 18°C above ambient.
 **Quadrature excitation refers to filament voltage 90°±30° out of phase with anode voltage.
 ***Max. duration 100 milliseconds.

APPLICATION

MECHANICAL

Mounting: The 575A and 673 must be mounted vertically base down.

Cooling: Provisions should be made for adequate air circulation around the tube. The temperature of the condensed mercury should be kept within the ranges given under "MAXIMUM RATINGS." This temperature should be maintained at 40°±5°C for most satisfactory operation of the tube. To measure the condensed-mercury temperature a thermocouple or small thermometer may be attached to the glass near the tube base using a small amount of putty. A condensed-mercury temperature lower than the



recommended value raises the voltage at which the tube becomes conducting and tends to reduce the life of the filament. A temperature higher than recommended lowers the voltage at which the tube becomes conducting and reduces the peak inverse voltage rating of the tube. The approximate condensed-mercury temperature rise above ambient is 18°C.

ELECTRICAL

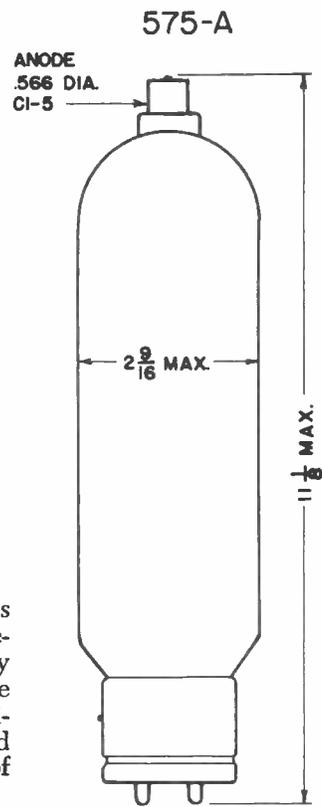
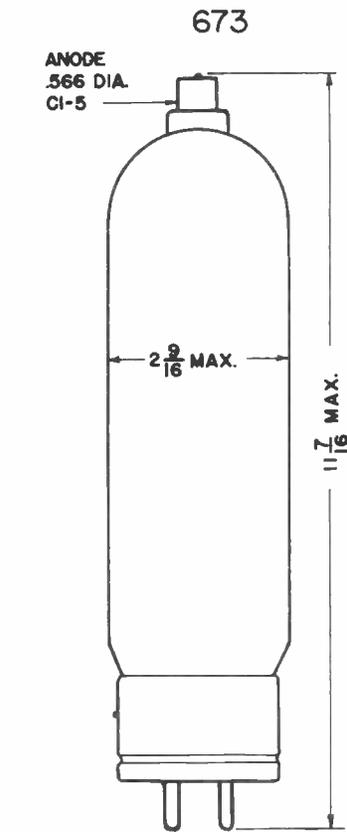
Filament Voltage: For maximum tube life, the filament voltage as measured directly at the filament pins, should be held at the rated value of 5.0 volts. Unavoidable variations in filament voltage must be kept within the range of 4.8 to 5.2 volts. A filament voltage less than the minimum recommended value may cause a high tube voltage drop, with consequent bombardment of the filament and eventual loss of emission. A filament voltage higher than the recommended maximum value will also decrease the life of the filament.

Caution should be observed in measuring the filament voltage as the filament circuit may be at a high dc potential.

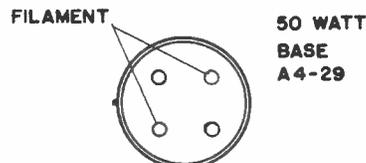
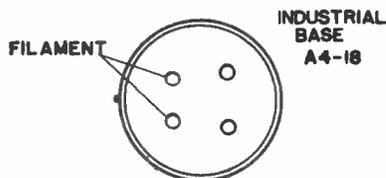
The filament should be allowed to reach operating temperature before the plate voltage is applied. Under normal conditions, a delay of approximately 30 seconds will be required. The delay time should be increased if there is any evidence of arc-back within the tube.

When it is necessary to use a shield around the tube care must be taken to insure adequate ventilation and maintenance of normal condensed-mercury temperature. When a mercury-vapor rectifier is first installed, the filament should be operated at normal voltage for approximately ten minutes with no plate voltage applied, in order that the mercury may be properly distributed.

Shielding: Electromagnetic and electrostatic fields tend to cause the mercury vapor to break down, are detrimental to tube life and make proper operation difficult. Consequently, the tube should be isolated from such fields as exist around a transmitter or other similar equipment.



NOTE: These dimensions reflect standard manufacturing tolerances. They should not be made the basis for purchase specifications unless checked with EIMAC, Division of Varian.





TECHNICAL DATA

869B 869BL MERCURY-VAPOR RECTIFIERS

The EIMAC 869B and 869BL are half-wave mercury-vapor rectifiers incorporating features which enable them to withstand high peak inverse voltages and to conduct at relatively low applied voltages. The 869B and 869BL carry maximum ratings of 20 kV peak inverse voltage, 5 amperes dc and 20 amperes peak cathode current.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Oxide-coated	
Voltage - - - - -	5.0 V
Current - - - - -	17 to 21 A
Filament Heating Time - - - - -	60 Sec
Anode Starting Voltage (approx.) - - - - -	30 V

MECHANICAL

Base - - - - -	See Drawing
Maximum Overall Dimensions:	
Length - - - - -	14-7/16 in.
Diameter - - - - -	3 in.
Net Weight - - - - -	20 oz.



MAXIMUM RATINGS (Single Tube)

CONDENSED MERCURY TEMPERATURE RANGE*	30-60	30-50	30-40° C
PEAK INVERSE ANODE VOLTAGE - - - - -	10	15	20 MAX KV
PEAK ANODE CURRENT:			
Quadrature Excitation** - - - - -	20	20	20 MAX AMPS
In-Phase Excitation - - - - -	10	10	10 MAX AMPS
AVERAGE ANODE CURRENT: (30 second maximum averaging time)			
Quadrature Excitation - - - - -	5.0	5.0	5.0 MAX AMPS
In-Phase Excitation - - - - -	2.5	2.5	2.5 MAX AMPS
MAXIMUM AC SHORT-CIRCUIT CURRENT*** - - - - -	100	100	100 MAX AMPS

*Condensed Mercury rises approximately 20°C above ambient.

**Quadrature excitation refers to anode current and filament current $90^{\circ} \pm 30^{\circ}$ out of phase.

***Maximum duration 100 milliseconds.

Data based on load return to center tap on filament transformer.

APPLICATION

MECHANICAL

Mounting: The 869B and 869BL must be mounted vertically, base down. The 869BL includes 3 inch insulated flexible leads with lugs.

Cooling: Provisions should be made for adequate air circulation around the tube. The temperature of the condensed mercury in the 869B and 869BL should be kept within the ranges given under "MAXIMUM RATINGS."

This temperature should be maintained at $40^{\circ} \pm 5^{\circ} \text{C}$ for most satisfactory operation of the tube. To measure the condensed-mercury temperature a thermocouple or small thermometer may be attached to the glass near the tube base using a small amount of putty. A condensed-mercury temperature lower than the recommended value raises the voltage at which the tube becomes conducting and tends to reduce the life of the filament. A temperature higher



than recommended lowers the voltage at which the tube becomes conducting and reduces the peak inverse voltage rating of the tube.

In some installations a blast of air must be directed at the base of the tube to insure adequate cooling.

ELECTRICAL

Filament Voltage: For maximum tube life, the filament voltage as measured directly at the filament pins, should be held at the rated value of 5.0 volts. Unavoidable variations in filament voltage must be kept within the range of 4.8 to 5.2 volts. A filament voltage less than the minimum recommended value may cause a high tube voltage drop, with consequent bombardment of the filament and eventual loss of emission. A filament voltage higher than the recommended maximum value will also decrease the life of the filament.

Caution should be observed in measuring the filament voltage as the filament circuit may be at a high dc potential.

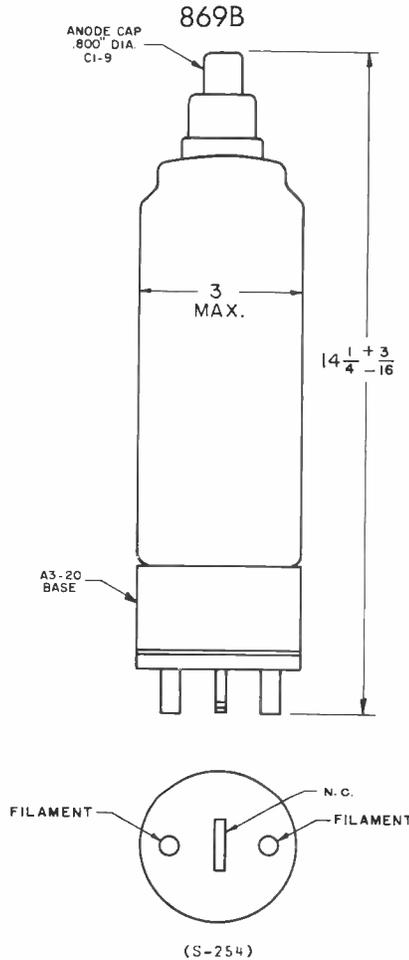
The filament should be allowed to reach operating temperature before the plate voltage is applied. Under normal conditions, a delay of approximately 60 seconds will be required. The delay time should

be increased if there is any evidence of arc-back within the tube.

When it is necessary to use a shield around the tube care must be taken to insure adequate ventilation and maintenance of normal condensed-mercury temperature. When a mercury-vapor rectifier is first installed, the filament should be operated at normal voltage for approximately ten minutes with no plate voltage applied, in order that the mercury may be properly distributed.

X-Ray Radiation: Above approximately 16,000 peak inverse voltage, a rectifier will produce X-Rays. In most equipment, there is adequate shielding so that this does not constitute a health hazard, however, this should be checked in any new equipment. A standard reference on this subject is "X-Ray Protection, Handbook No. 93," National Bureau of Standards.

Shielding: Electromagnetic and electrostatic fields tend to cause the mercury vapor to break down, are detrimental to tube life and make proper operation difficult. Consequently, the 869B and 869BL should be isolated from such fields as exist around a transmitter or other similar equipment.



NOTE: These dimensions reflect standard manufacturing tolerances. They should not be made the basis for purchase specifications unless checked with EIMAC Division of Varian, 301 Industrial Way, San Carlos, California, 94070.

869BL has 3 inch insulated flexible filament leads with spade terminals for #10 screw instead of pins shown on the 869B outline.



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6894
6895

**MERCURY-VAPOR
 RECTIFIERS**

The EIMAC 6894 and 6895 are half-wave mercury-vapor rectifiers especially designed for high voltage power rectifier applications. They are mercury filled for high efficiency, long life and the ability to operate at high peak inverse voltage.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Oxide-coated		
Voltage - - - - -		5.0 V
Current - - - - -		9.0 to 11.0 A
Filament Heating Time - - - - -		30 Sec
Anode Starting Voltage (approx.) - - - - -		20 V

MECHANICAL

Base - - - - -	6894	50 watt, A4-29
	6895	Industrial A4-18
Recommended Socket - - - - -	6894	E.F. Johnson #123-211
	6895	E.F. Johnson #123-206
Maximum Overall Dimensions:		
Length - - - - -	6894	10-17/32 in.
	6895	10-13/32 in.
Diameter - - - - -		2-9/16 in.
Net Weight - - - - -		4 oz.



MAXIMUM RATINGS (per tube)

PEAK INVERSE ANODE VOLTAGE		
20° -50°C Condensed Mercury Temperature Range* - - - - -		20 MAX KV
20° -55°C Condensed Mercury Temperature Range - - - - -		15 MAX KV
20° -60°C Condensed Mercury Temperature Range - - - - -		10 MAX KV
PEAK ANODE CURRENT:		
Quadrature Filament Excitation** - - - - -		11.5 MAX AMPS
In-Phase Filament Excitation - - - - -		8.3 MAX AMPS
AVERAGE ANODE CURRENT		
Quadrature Filament Excitation - - - - -		2.5 MAX AMPS
In-Phase Filament Excitation - - - - -		1.8 MAX AMPS
MAXIMUM AC SHORT CIRCUIT CURRENT*** - - - - -		100 MAX AMPS

*Condensed Mercury Temperature rises approximately 20°C above ambient.

**Quadrature Excitation refers to filament voltage $90^{\circ} \pm 30^{\circ}$ out of phase with anode voltage.

***Max. duration 100 milliseconds.

All data based on load return to center tap of filament transformer.

APPLICATION

MECHANICAL

Mounting: The 6894 and 6895 must be mounted vertically, base down. These two tubes differ only in their basing and socketry.

Cooling: Provisions should be made for adequate air circulation around the tube. The temperature of the condensed mercury should be kept within



the ranges given under "MAXIMUM RATINGS."

This temperature should be maintained at 40° ± 5°C for most satisfactory operation of the tube. To measure the condensed-mercury temperature a thermocouple or small thermometer may be attached to the glass near the tube base using a small amount of putty. A condensed-mercury temperature lower than the recommended value raises the voltage at which the tube becomes conducting and tends to reduce the life of the filament. A temperature higher than recommended lowers the voltage at which the tube becomes conducting and reduces the peak inverse voltage rating of the tube.

ELECTRICAL

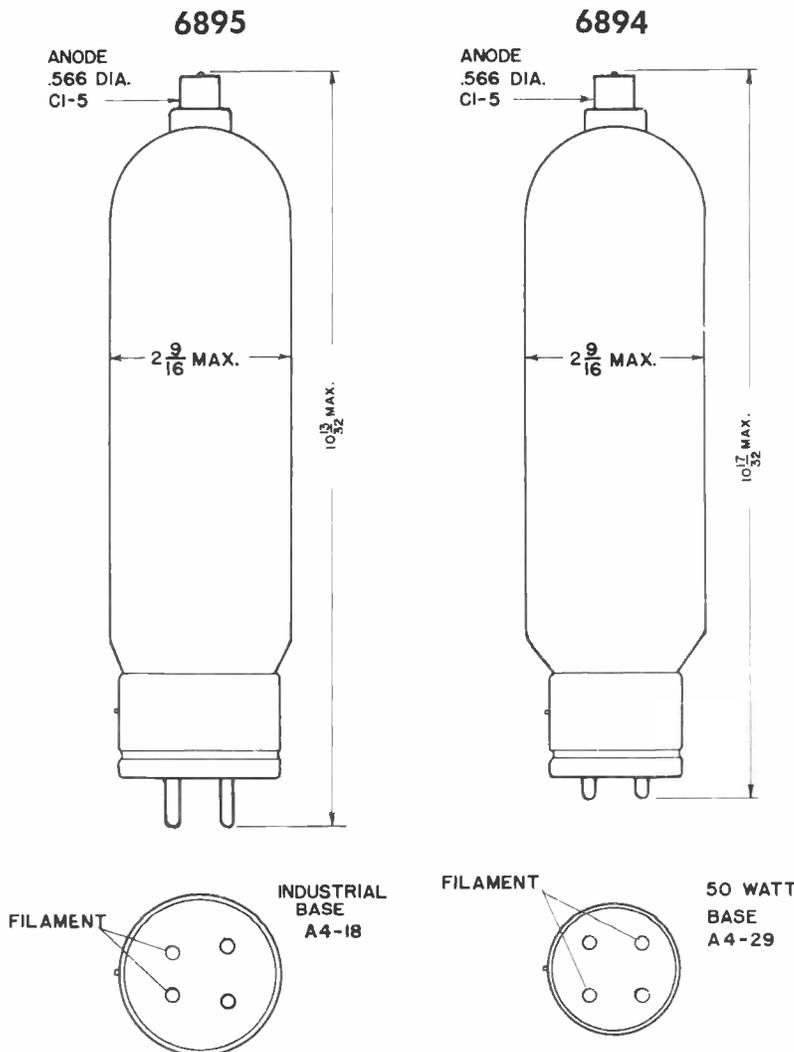
Filament Voltage: For maximum tube life, the filament voltage as measured directly at the filament pins, should be held at the rated value of 5.0 volts. Unavoidable variations in filament voltage must be kept within the range 4.8 to 5.2 volts. A filament voltage less than the minimum recommended value may cause a high tube voltage drop, with consequent bombardment of the filament and eventual loss of emission. A filament voltage higher than the recommended maximum value will also decrease the life of the filament.

Caution should be observed in measuring the filament voltage as the filament circuit may be at a high dc potential.

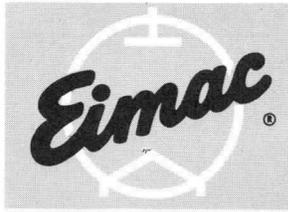
The filament should be allowed to reach operating temperature before the plate voltage is applied. Under normal conditions, a delay of approximately 30 seconds will be required. The delay time should be increased if there is any evidence of arc-back within the tube.

When it is necessary to use a shield around the tube care must be taken to insure adequate ventilation and maintenance of normal condensed-mercury temperature. When a mercury-vapor rectifier is first installed, the filament should be operated at normal voltage for approximately ten minutes with no plate voltage applied, in order that the mercury may be properly distributed.

Shielding: Electromagnetic and electrostatic fields tend to cause the mercury vapor to break down, are detrimental to tube life and make proper operation difficult. Consequently, the tube should be isolated from such fields as exist around transmitter or other similar equipment.



NOTE: These dimensions reflect standard manufacturing tolerances. They should not be made the basis for purchase specifications unless checked with EIMAC Division of Varian, 301 Industrial Way, San Carlos, Calif. 94070.



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 Division of Varian
 S A N C A R L O S
 C A L I F O R N I A

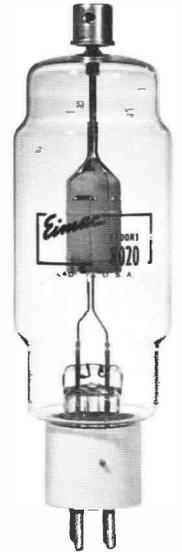
8020

**HIGH-VACUUM
 RECTIFIER**

The EIMAC 8020 diode is a high-vacuum rectifier intended for use in rectifier units, voltage multipliers, or in special applications, whenever conditions of extreme ambient temperatures, high operating frequency, high peak inverse voltages, or the production of high-frequency transients would prevent the use of gas-filled rectifier tubes.

The 8020 has a maximum dc current rating of 100 milliamperes and a maximum peak inverse voltage rating of 40,000 volts. Cooling is by convection and radiation.

A single 8020 will deliver 80 milliamperes at 17,000 volts to a capacitor-input filter with 14,000 volts single-phase supply. Four 8020's in a bridge circuit will deliver 200 milliamperes at 25,000 volts to a choke-input filter with 28,000 volts single-phase supply.



GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten		
Voltage	- - - - -	5.0 volts
Current	- - - - -	6.5 amperes

MECHANICAL

Base	- - - - -	Medium 4-pin bayonet
Basing	- - - - -	Refer to outline drawing
Socket	- - - - -	Refer to discussion under "Application"
Mounting Position	- - - - -	Vertical, base down or up
Cooling	- - - - -	Convection and radiation
Maximum Temperature of Plate Seal	- - - - -	225°C
Recommended Heat Dissipating Plate Connector	- - - - -	EIMAC HR-8
Maximum Overall Dimensions:		
Length	- - - - -	8.00 inches
Diameter	- - - - -	2.32 inches
Net Weight	- - - - -	4 ounces
Shipping Weight (approx.)	- - - - -	1 pound

MAXIMUM RATINGS (Per Tube)

Peak Inverse Plate Voltage	- - - - -	40,000 volts
Plate Dissipation	- - - - -	60 watts
DC Plate Current ¹	- - - - -	100 ma
Peak Plate Current	- - - - -	1.5 ampere

¹ Averaged over one cycle for each tube. Applies only when the rectifier is coupled to the load by a choke-input filter incorporating the "critical" value (or larger) of input inductance. For maximum dc current ratings under this and other load conditions see discussion under "Application."

APPLICATION

MECHANICAL

Mounting—The 8020 must be mounted vertically with the base either down or up. The lead to the plate terminal of the tube should be flexible.

The medium 4-pin bayonet base fits an E. F. Johnson Co. No. 122-124, a National Co. No. XC-4 or CIR-4, or an equivalent socket. In some circuits, particularly those of the voltage multipliers illustrated in Fig. 2, it may be necessary to

mount the socket on stand-off insulators, or on a sheet of insulating material, to provide adequate insulation to ground.

Cooling—The 8020 is cooled by convection and radiation. Clearance should be provided around the glass envelope adequate for free circulation of air. An EIMAC HR-8 Heat Dissipating Connector or equivalent is required on the plate terminal.



APPLICATION (Continued)

The maximum temperature at the plate seal must not exceed 225°C. A convenient accessory for measuring this temperature is "Tempilaq," a temperature-sensitive lacquer available from the Tempil Corporation, 132 W. 22nd St., New York 11, N. Y.

ELECTRICAL

Filament Operation—For maximum tube life, the filament voltage, as measured at the base pins, should be the rated value of 5.0 volts. Variations must be kept within the range from 4.75 to 5.25 volts. In applications which require the diode to deliver high peak currents, it is important to maintain the filament voltage at the rated value.

Caution should be observed when measuring rectifier filament voltage. The filament circuit may be at high potential.

The thoriated-tungsten filament of the 8020 reaches operating temperature in a fraction of a second after application of voltage. Plate voltage may be applied simultaneously with filament voltage.

Plate Operation—With low room illumination, the plate of the 8020 begins to show color as the maximum plate dissipation rating of 60 watts is approached. The maximum peak inverse voltage rating of 40,000 volts should not be exceeded at any time.

Performance—The accompanying table shows some maximum performance capabilities of the 8020 when used as a power-supply rectifier.

8020 MAXIMUM PERFORMANCE CAPABILITIES					
Circuit Type	Capacitor-Input Filter			Choke-Input Filter	
	AC Input Voltage (volts rms)	DC Output Voltage (volts)	DC Output Current (ma)	DC Output Voltage (volts)	DC Output Current (ma)
Single-Phase, Half-Wave	14,000	17,000	80	.....	...
Single-Phase, Full-Wave	14,000 ¹	17,000	160	12,500	200
Single-Phase, Bridge	28,000	34,000	160	25,000	200

¹ One-half the transformer secondary voltage.

Maximum DC Current Ratings—Plate dissipation rather than peak current usually limits the dc current which the 8020 is capable of delivering to the load. Because the plate dissipation associated with a given dc current depends upon the amount of ripple and its wave-shape, circuit conditions will determine the maximum dc current rating of the tube.

Choke-Input Filter—The maximum dc current rating of the 8020 is 100 milliamperes when the load incorporates a choke-input filter with the "critical" value (or larger) of input inductance (L in Fig. 1):

$$L_o = \frac{R_{eff}}{18.8f} \quad \text{for full-wave single-phase rectifiers,}$$

$$L_o = \frac{R_{eff}}{75f} \quad \text{for half-wave three-phase rectifiers,}$$

$$L_o = \frac{R_{eff}}{660f} \quad \text{for full-wave three-phase rectifiers,}$$

where: L_o = "critical" value of input inductance (henries),
 f = supply-line frequency (cycles per second),

$$R_{eff} = \frac{\text{Load voltage (volts)}}{\text{Load current (amps)}}$$

Choke-input filters are not normally used with single-phase half-wave rectifiers.

Capacitor-Input Filter—The 8020 is particularly suitable for power-supply applications demanding high voltage at low current. Under these conditions capacitor-input filter circuits become desirable. The maximum dc current rating of the 8020 when no input choke is incorporated in the filter depends upon the total series resistance of the capacitor-charging circuit relative to the effective load resistance seen by each tube. The circuit diagrams and tabulation in Fig. 2 are so arranged and labeled that this required series resistance may be found for a wide range of load conditions. This may be done by determining the value of the following quantities:

E_c is the filter-input dc voltage. While this is usually the entire load voltage, in the case of voltage multipliers it is the load voltage divided by the multiplication factor.

I_p is the dc current per tube. This is the entire load current only in the case of the simple half-wave rectifier or half- or full-wave multiplier. In the case of full-wave center-tapped or bridge rectifiers, I_p is half the load current.

R_c is the total charging-circuit resistance. A certain minimum value of charging-circuit resistance is necessary to limit the peak value of current to which the tubes will be subjected under given load conditions. This required minimum depends upon the dc current per tube (I_p), and has been tabulated in Fig. 2 as a percentage of the effective load resistance per

tube $\left(\frac{E_c}{I_p} \right)$. The total charging circuit resistance involves

the internal resistance of the rectifier tube, R_p , the added series resistor, R_s , and the equivalent internal resistance of the ac voltage supply, R_1 .

R_p is the plate resistance of the 8020, which may be taken as 1000 ohms.

R_1 is the equivalent internal resistance of the supply. This may be taken as the regulation of the high-voltage supply expressed as a decimal multiplied by the load resistance used in measuring this regulation.

R_s is the series resistor which must be inserted in the charging circuit to bring the total charging-circuit resistance up to the required minimum. Its value may be found from the formula associated with each of the circuits of Fig. 2. This resistor must be inserted in such a position in the circuit that it protects all tubes.

Tubes may be operated in parallel to increase the output capability in a given circuit. When two tubes are placed in parallel at each place where one is shown in the circuits of Fig. 2, the plate resistance (R_p) will be half as great and the maximum allowable load current twice as great as indicated.

Peak Inverse Voltage—The peak inverse voltage rating of the 8020 is 40,000 volts. In single-phase power-supply rectifier circuits the peak inverse voltage to be used in design is the peak ac supply voltage (1.41 times E_{rms} in Fig. 2) in the case of bridge circuits, and twice this value in the case of half- or full-wave rectifiers and voltage multipliers. Peak inverse voltage in three-phase operation depends upon the circuit employed, and will be found listed in the handbooks.

Special Applications—The ratings given for capacitor-input filter circuits assume values of input capacitance large enough to hold the ripple to a low value. In special applications where a large percent ripple is tolerable and filter capacitance is low, the 8020 is capable of larger dc output currents.

As a unidirectional conductor in dc circuits where the current is continuous and the percent ripple is moderate, the maximum current rating of the 8020 is 200 milliamperes.

The plate characteristic curve for the 8020 serves as a guide to special applications. The maximum plate dissipation rating of 60 watts, the maximum peak inverse voltage rating of 40,000 volts, and the maximum peak plate current of 1.5 amperes must not be exceeded.

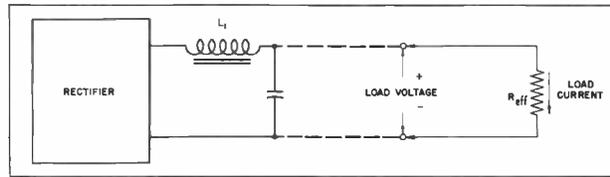
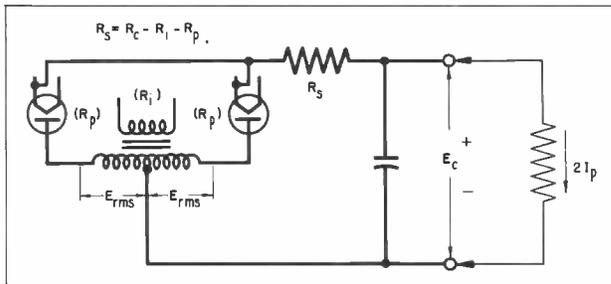
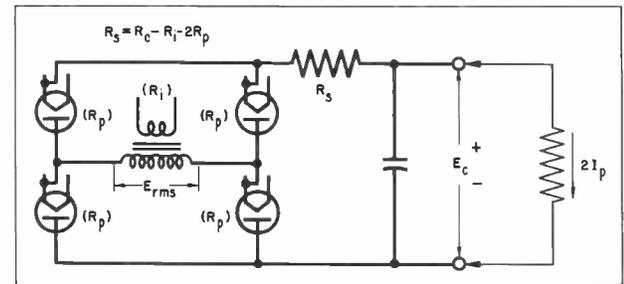


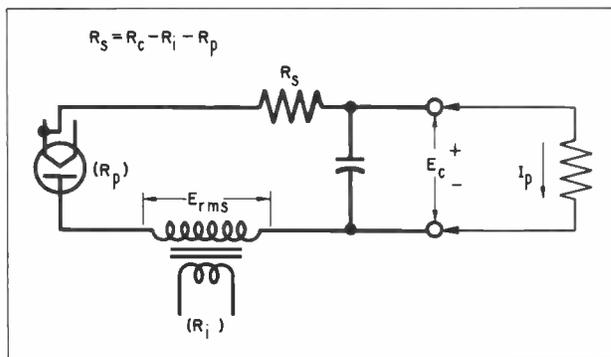
Fig. 1. Rectifier with Choke-Input Filter



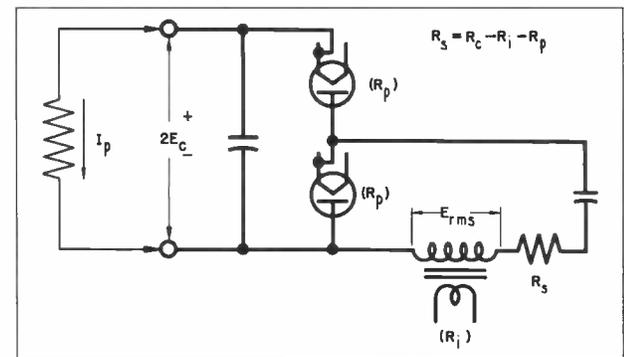
a. Full-Wave Center-Tapped Rectifier



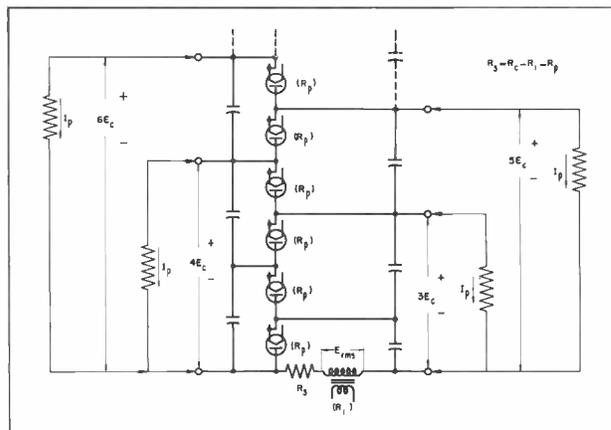
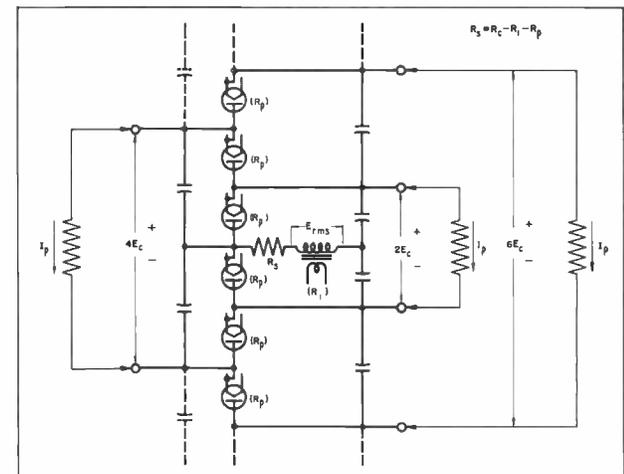
b. Full-Wave Bridge Rectifier



c. Half-Wave Rectifier



d. Half-Wave Voltage Doubler


 e. Half-Wave Voltage Multiplier (with common ground when R_s is inserted on the "high" side of E_{rms})


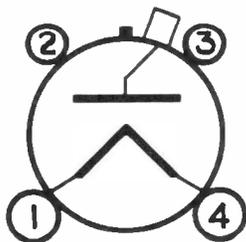
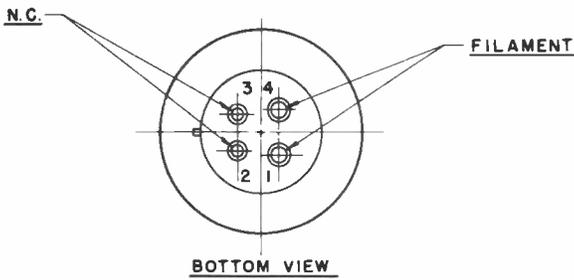
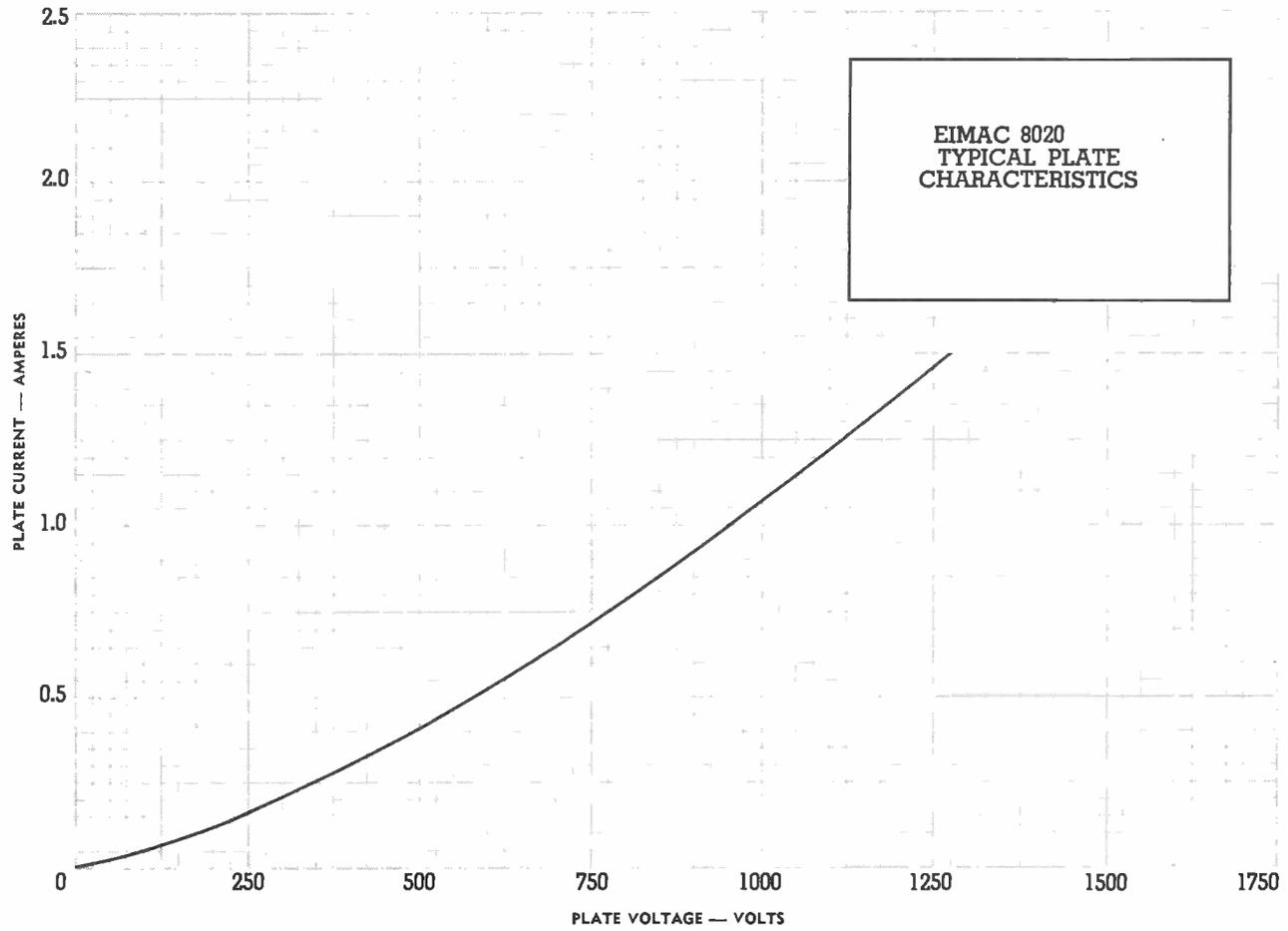
f. Full-Wave Voltage Multiplier

Eimac 8020 Maximum D-C Current Ratings for R-C Filter Applications								
D-C Plate Current (I_p)	70	75	80	85	90	95	100	milliamperes per tube
Total Charging-Circuit Resistance (R_c)	0.8	1.2	1.8	3.0	4.7	7.6	12	percent of Effective Load Resistance per Tube ($\frac{E_c}{I_p}$)
A-C Supply Voltage (E_{rms})	0.78	0.80	0.83	0.87	0.92	1.01	1.14	times Filter-Input D-C Voltage (E_c)
Peak Inverse Voltage ($1/2$ these values in circuit "b".)	2.2	2.3	2.4	2.5	2.6	2.9	3.2	times Filter-Input D-C Voltage (E_c)

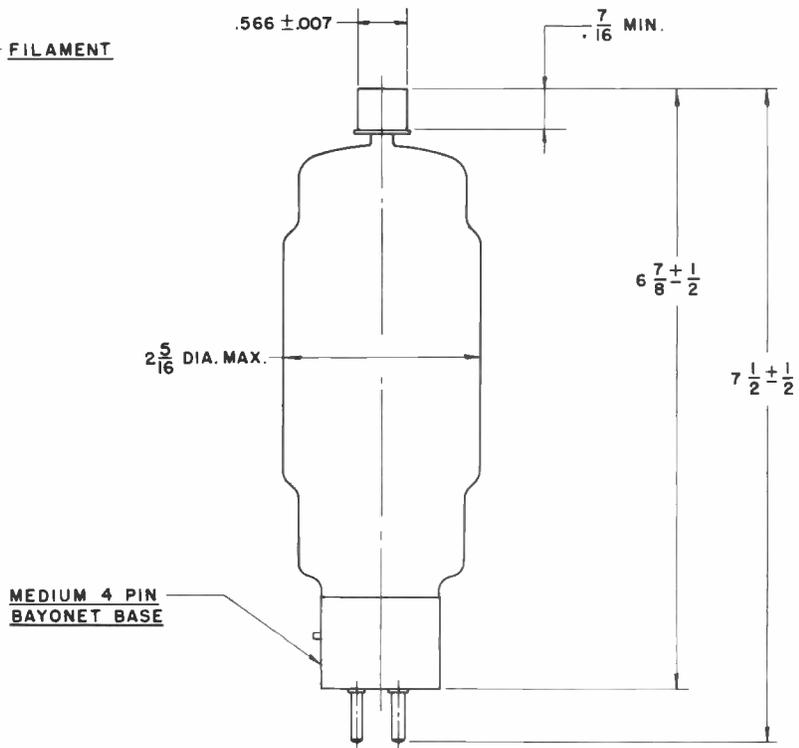
 Fig. 2. EIMAC 8020 Basic R-C Circuits (for any one of the indicated loads)
 R_1 = Equivalent resistance of voltage source
 R_p = 1000 ohms (500 ohms for two tubes in parallel)

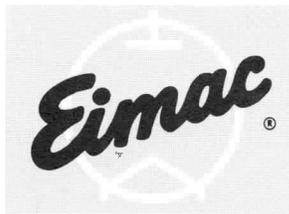


8020



**DIMENSIONS
IN INCHES**





E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

KY21A

**GRID-CONTROLLED
 MERCURY-VAPOR
 RECTIFIER**

The EIMAC KY21A is a grid-controlled mercury vapor-rectifier incorporating features which enable it to withstand high peak inverse voltages and to conduct at relatively low applied voltages. The oxide-coated, edge-wise-wound, shielded ribbon filament, provides a large emission reserve and long life.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Oxide-coated

Voltage	- - - - -	2.5 volts
Current	- - - - -	10 amperes
Tube Voltage Drop (approx.)	- - - - -	10 volts
Ionization Time (approx.)	- - - - -	10 μ sec
Deionization Time (approx.)	- - - - -	1000 μ sec

MECHANICAL

Base	- - - - -	Medium, 5-pin, #A5-11
Recommended Socket	- - - - -	E. F. Johnson #122-225
Maximum Overall Dimensions:		
Length	- - - - -	8.0 inches
Diameter	- - - - -	2 $\frac{1}{8}$ inches
Net Weight	- - - - -	4 ounces
Shipping Weight	- - - - -	3 pounds

MAXIMUM RATINGS (Single Tube)

PEAK INVERSE ANODE VOLTAGE*	- - - - -	11,000 VOLTS
PEAK ANODE CURRENT	- - - - -	3 AMPERES
AVERAGE ANODE CURRENT	- - - - -	.75 AMPERES
SUPPLY FREQUENCY	- - - - -	150 CPS
CONDENSED-MERCURY TEMPERATURE RANGE**	- - - - -	20-60° CENTIGRADE

*Temperatures in excess of 60°C limit the peak-inverse rating to 5500 volts with a corresponding reduction in permissible RMS supply voltages to one-half those listed in the table.
 **Operation at 40° plus or minus 5° is recommended.



APPLICATION

MECHANICAL

Mounting — The KY21A must be mounted vertically, base down. In order to carry the ten amperes of filament current the adjacent pins have been connected in parallel within the base. Similar connections should be made in the socket.

Cooling — Provisions should be made for adequate air circulation around the tube. The temperature of the condensed mercury in the KY21A should be kept within the ranges given under "MAXIMUM RATING."

This temperature should be maintained at 40° \pm 5°C for most satisfactory operation of

the tube. To measure the condensed-mercury temperature a thermocouple or small thermometer may be attached to the glass near the tube base using a small amount of putty. A condensed-mercury temperature lower than the recommended value raises the voltage at which the tube becomes conducting and tends to reduce the life of the filament. A temperature higher than recommended lowers the voltage at which the tube becomes conducting and reduces the peak inverse voltage rating of the tube.

ELECTRICAL

Filament Voltage — For maximum tube life, the filament voltage as measured directly at

the filament pins, should be held at the rated value of 2.5 volts. Unavoidable variations in filament voltage must be kept within the range of 2.4 to 2.6 volts. A filament voltage less than the minimum recommended value may cause a high tube voltage drop, with consequent bombardment of the filament and eventual loss of emission. A filament voltage higher than the recommended maximum value will also decrease the life of the filament.

Caution should be observed in measuring the filament voltage as the filament circuit may be at a high dc potential.

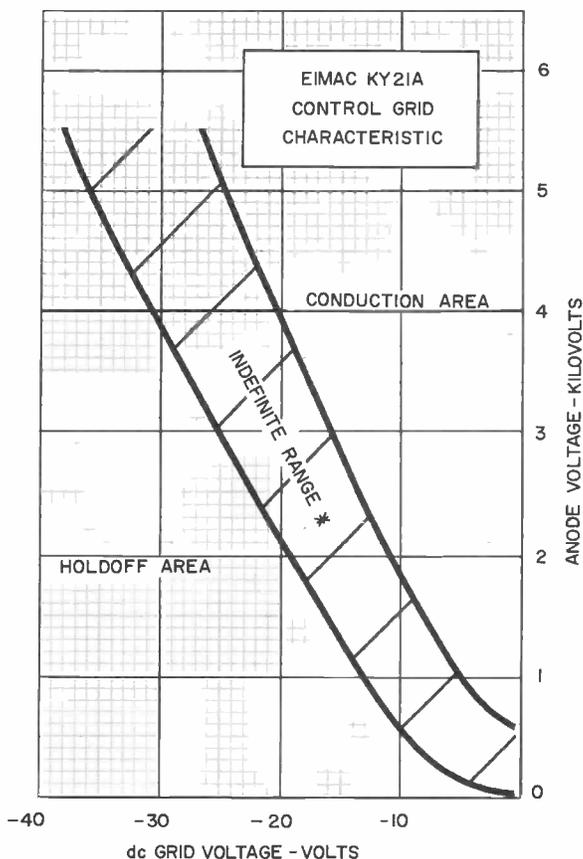
The filament of the KY21A should be allowed to reach operating temperature before the plate voltage is applied. Under normal conditions, a delay of approximately 30 seconds will be required. The delay time should be increased if there is any evidence of arc-back within the tube.

When it is necessary to use a shield around

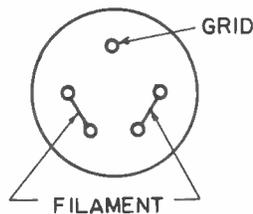
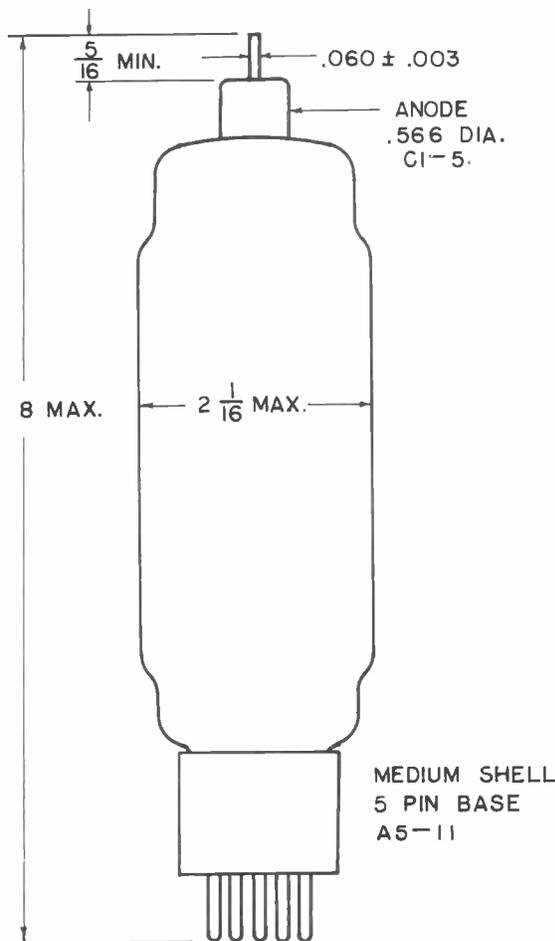
the KY21A care must be taken to insure adequate ventilation and maintenance of normal condensed-mercury temperature. When a KY21A is first installed, the filament should be operated at normal voltage for approximately ten minutes with no plate voltage applied, in order that the mercury may be properly distributed.

Shielding — Electromagnetic and electrostatic fields tend to cause the mercury vapor to break down, are detrimental to tube life and make proper operation difficult. Consequently, the KY21A should be isolated from such fields as exist around a transmitter or other similar equipment.

Grid Circuit — The KY21A is prevented from conducting by placing a negative potential on the grid. The relationship between negative grid control voltage and anode voltage is shown in the characteristic curve below.



* Depends on temperature, age and tube-to-tube variation.



NOTE: These dimensions reflect standard manufacturing tolerances. They should not be made the basis for purchase specifications unless checked with EIMAC Division of Varian.



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

RX21A

MERCURY-VAPOR
RECTIFIER

The Eimac RX21A is a half-wave mercury vapor-rectifier incorporating features which enable it to withstand high peak inverse voltages and to conduct at relatively low applied voltages. The oxide-coated, edgewise-wound, shielded ribbon filament, provides a large emission reserve and long life.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament:	Oxide-coated	
	Voltage - - - - -	2.5 volts
	Current - - - - -	10 amperes
Tube Voltage Drop (approx.)	- - - - -	10 volts

MECHANICAL

Base - - - - -	Medium, 5-pin, #A5-11
Recommended Socket - - - - -	E.F. Johnson #122-225
Maximum Overall Dimensions:	
Length - - - - -	8.0 inches
Diameter - - - - -	2-1/16 inches
Net Weight - - - - -	4 ounces
Shipping Weight - - - - -	3 pounds

MAXIMUM RATINGS (Single tube)

PEAK INVERSE ANODE VOLTAGE* - - - - -	11,000 MAX. VOLTS
PEAK ANODE CURRENT - - - - -	3 MAX. AMPERES
AVERAGE ANODE CURRENT - - - - -	.75 MAX. AMPERES
SUPPLY FREQUENCY - - - - -	150 MAX. CPS
CONDENSED-MERCURY TEMPERATURE RANGE** - - - - -	- 20-60° CENTIGRADE

* Temperatures in excess of 60°C limit the peak-inverse rating to 5500 volts with a corresponding
 ** Operating at 40 plus or minus 5 C is recommended.



APPLICATION

MECHANICAL

Mounting: The RX21A must be mounted vertically, base down. In order to carry the ten amperes of filament current the adjacent pins have been connected in parallel within the base. Similar connections should be made in the socket.

Cooling: Provisions should be made for adequate air circulation around the tube. The temperature of the condensed mercury in the RX21A should be kept within the ranges given under "MAXIMUM RATINGS".

This temperature should be maintained at 40° ±5°C for most satisfactory operation of the tube. To measure the condensed-mercury temperature a thermocouple or small thermometer may be attached to the glass near the tube base using a small amount of putty. A condensed-mercury temperature lower than

the recommended value raises the voltage at which the tube becomes conducting and tends to reduce the life of the filament. A temperature higher than recommended lowers the voltage at which the tube becomes conducting and reduces the peak inverse voltage rating of the tube.

ELECTRICAL

Filament Voltage: For maximum tube life, the filament voltage as measured directly at the filament pins, should be held at the rated value of 2.5 volts. Unavoidable variations in filament voltage must be kept within the range of 2.4 to 2.6 volts. A filament voltage less than the minimum recommended value may cause a high tube voltage drop, with consequent bombard-

ment of the filament and eventual loss of emission. A filament voltage higher than the recommended maximum value will also decrease the life of the filament.

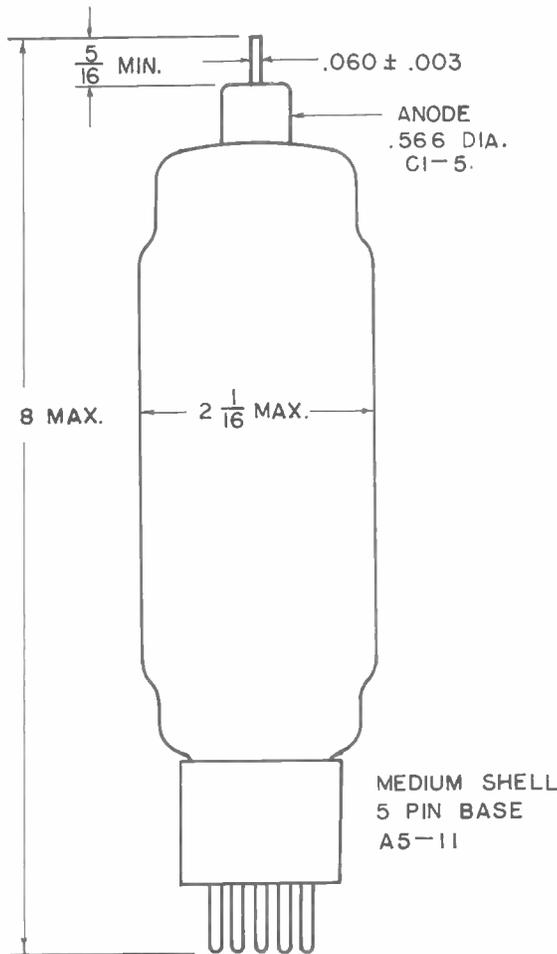
Caution should be observed in measuring the filament voltage as the filament circuit may be at a high dc potential.

The filament of the RX21A should be allowed to reach operating temperature before the plate voltage is applied. Under normal conditions, a delay of approximately 30 seconds will be required. The delay time should be increased if there is any evidence of arc-back within the tube.

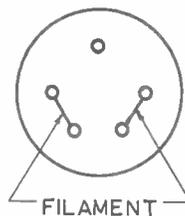
When it is necessary to use a shield around the RX21A

care must be taken to insure adequate ventilation and maintenance of normal condensed-mercury temperature. When an RX21A is first installed, the filament should be operated at normal voltage for approximately ten minutes with no plate voltage applied, in order that the mercury may be properly distributed.

Shielding: Electromagnetic and electrostatic fields tend to cause the mercury vapor to break down, are detrimental to tube life and make proper operation difficult. Consequently, the RX21A should be isolated from such fields as exist around a transmitter or other similar equipment.



NOTE: These dimensions reflect standard manufacturing tolerances. They should not be made the basis for purchase specifications unless checked with Eitel-McCullough, Inc.





triodes ▶

Look in the general section for---

- Your nearest distributor of modern, fully guaranteed Eimac electron tubes and electron tube accessories.
- Your nearest Eimac Field Engineer, who stands ready to give you immediate engineering assistance, information on deliveries and prices, or provide other information not found in the catalog.
- Eimac tube type numbering system.
- Tube Replacement Chart.
- Prices on Eimac products.

IMPORTANT EIMAC "EXTRAS"

Application Engineering. The Eimac Application Engineering Department is available at all times for consultation. New tube operating techniques are continually being explored, tested and proved by Eimac engineers, whose combined knowledge and experience are at your service. Additional contributions by this Eimac department are its Application Bulletins, a service which you receive without obligation.

Field Engineering. Serving as an extension of the Application Engineering Department outside the Eimac plant, Eimac Field Engineers cover the United States, operating out of offices in major cities. They will help you personally with experimental work, problems of technique, etc. Engineers from Eitel-McCullough, Inc. are available, too, for field consultation throughout the country. As Eimac tubes are world renowned, the same services extend to various countries overseas through the Eimac Export Department.

triodes



EITEL-McCULLOUGH, INC.
CALIFORNIA

2C39A

HIGH-MU
UHF
TRIODE

The Eimac 2C39A is a ceramic-metal high-mu planar triode with a plate-dissipation rating of 100 watts, designed for use as a power amplifier, oscillator, or frequency multiplier at frequencies to above 2500 megacycles. The new ceramic-metal construction results in extreme ruggedness, mechanical uniformity, reliable operation at seal temperatures up to 250°C, and longer life expectancy than its glass prototypes.

The 2C39A in a class-C r-f grounded grid circuit at 500 megacycles will typically deliver 27 watts useful power output with 6 watts driving power. As an r-f oscillator at 2500 megacycles the 2C39A will deliver a minimum of 12 watts useful power output.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Cathode: Oxide-Coated, Unipotential				
Heating Time	-	60	-	seconds
Heater: Voltage (See "Applications")	-	6.3	-	volts
Current	0.95	-	1.10	amperes
Amplification Factor	-	100	-	
Direct Interelectrode Capacitances (In Shielded Fixture):				
Grid-Plate	-	1.86	2.16	uuf
Grid-Cathode	-	5.60	7.60	uuf
Plate-Cathode	-	-	0.035	uuf
Transconductance ($I_b=70$ ma.)	20,000	-	30,000	umhos
Frequency for Maximum Ratings	-	-	2,500	mc

MECHANICAL

Base, Socket and Connections	See drawing
Operating Position	Any
Cooling	Forced Air
Maximum Operating Temperatures:	
Ceramic-to-Metal Seals	250° C
Anode Core	250° C

Maximum Over-all Dimensions:	
Length	2.75 inches
Diameter	1.27 inches
Net Weight	2.5 ounces
Shipping Weight (Single Tube, Approx.)	7.0 ounces

RADIO-FREQUENCY POWER AMPLIFIER, OR OSCILLATOR

MAXIMUM RATINGS (Per tube)

D-C PLATE VOLTAGE	1000 MAX. VOLTS
D-C CATHODE CURRENT	125 MAX. MA
D-C GRID VOLTAGE	-150 MAX. VOLTS
D-C GRID CURRENT	50 MAX. MA
HEATER VOLTAGE	SEE APPLICATION NOTES
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE	30 MAX. VOLTS
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE	400 MAX. VOLTS
PLATE DISSIPATION	100 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Key-down conditions, per tube) (Power-Amplifier Grid-Isolation Circuit, CW Operation, 500 Mc.)	
D-C Plate Voltage	800 volts
D-C Grid Voltage	-20 volts
D-C Plate Current	80 ma
D-C Grid Current	32 ma
Driving Power (approx.) ¹	6 watts
Useful Power Output	27 watts

TYPICAL OPERATION (R-F Oscillator, 2500 Mc.) ²	
D-C Plate Voltage	900 volts
D-C Grid Voltage	-22 volts
D-C Plate Current	90 ma
D-C Grid Current	27 ma
Useful Power Output	12 watts

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER OR OSCILLATOR

MAXIMUM RATINGS (Carrier conditions, per tube)

D-C PLATE VOLTAGE ³	600 MAX. VOLTS
D-C GRID VOLTAGE	-150 MAX. VOLTS
D-C GRID CURRENT	50 MAX. MA
D-C CATHODE CURRENT	100 MAX. MA
PEAK INSTANTANEOUS POSITIVE GRID VOLTAGE	30 MAX. VOLTS
PEAK INSTANTANEOUS NEGATIVE GRID VOLTAGE	400 MAX. VOLTS
PLATE DISSIPATION	70 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Plate-Modulated Radio-Frequency Power Amplifier Grid-Isolation Circuit, 500 Mc., Per Tube)	
D-C Plate Voltage	600 volts
D-C Grid Voltage	-16 volts
D-C Plate Current	65 ma
D-C Grid Current	35 ma
Driving Power (approx.) ¹	5 watts
Useful Carrier Power Output	16 watts

¹Driving power listed is the total power which must be supplied to a practical grid circuit at the frequency shown.

²These 2500-megacycle conditions conform to the minimum requirements of the MIL-E-1 specifications for the 2C39A.

³For less than 100% modulation, higher d-c plate voltage may be used if the sum of the peak positive modulating voltage and the d-c plate voltage does not exceed 1200 volts.



APPLICATION

MECHANICAL

Mounting—The 2C39A may be operated in any position. It should be firmly held in place by spring-finger collets bearing on the terminal surfaces. The tube should seat against the under side of the "anode flange" (see outline drawing). In applications involving severe shock and vibration, the tube may be clamped in place by applying a suitable clamping device to the anode flange. It is recommended that no other portion of the tube be subjected to clamping forces.

Connections—The tube terminals are in the form of concentric cylinders of graduated diameters so that the 2C39A may be conveniently used with coaxial tuning devices. Spring-finger collets should be used to make contact with the anode, grid, cathode, and heater terminals. Adequate contact area and spring pressure should be provided to minimize heating and to prevent erratic circuit performance at the higher frequencies. Non-contacting or intermittently-contacting collet fingers will cause troublesome circuit behavior, especially at very-high and ultra-high frequencies. Electrode contact surfaces should be kept clean and free of oxide coatings.

Cooling—Sufficient cooling must be provided for the anode and body seals to maintain operating temperatures below the rated maximum values:

Ceramic to Metal Seals 250°C
Anode Core 250°C

At sea level, with an inlet air temperature of 25°C, 13.0 cubic feet per minute of air flow is required to cool the anode at 100 watts plate dissipation when the air cowling as illustrated is used. Pressure across the anode under these conditions is 0.6 inches of water. Operation at higher altitudes or with higher inlet temperatures requires increased volumes of flow to obtain equivalent cooling. When using the anode cowling as illustrated here, it is necessary to provide additional facilities for seal cooling.

It should be borne in mind that operating temperature is the sole criterion of cooling effectiveness, regardless of the coolant type, flow rate or coolant temperature.

ELECTRICAL

Heater Operation—The rated heater voltage for the 2C39A is 6.3 volts and the working voltage should be determined from the table below. The heater voltage should be maintained within plus or minus 10% of its intended value to minimize variations in circuit performance and to obtain maximum tube life.

At ultra-high frequencies transit-time effects can influence the cathode temperature. The amount of r-f driving power diverted to heating the cathode by back-bombardment will depend upon the frequency, the plate current, and the r-f driving power being supplied to the tube. The following table is intended as a general guide.

Frequency (Mc.)	E_c (Volts)
Up to 400	6.3
400 to 1000	6.0
1000 to 1500	5.5
1500 to 2000	5.0
2000 and above	4.5

If the conditions of operation result in extreme cathode back-heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to the proper value.

Cathode Operation—The oxide-coated unipotential cathode in the 2C39A and one side of the heater are connected internally. The absolute maximum rated d-c current is 125 milliamperes.

It is recommended that rated heater voltage be applied for a minimum of 30 seconds before other operating voltages are applied. Tube performance will become stabilized approximately 60 seconds after the heater voltage is applied.

Control-Grid Operation—The maximum rated grid dissipation is 2.0 watts.

At operating frequencies near 500 megacycles, the driving power necessary for maximum output of a typical grounded-grid amplifier is in the order of 6 watts and as the operating frequency is increased, the driving power requirements increase. Most of this additional driving power is absorbed in circuit losses other than grid dissipation, however, and the actual grid dissipation will increase very little.

The grid bias required by various 2C39A tubes may vary between limits approximately 50% above and below the nominal value and means should be provided in the equipment to accommodate such variations.

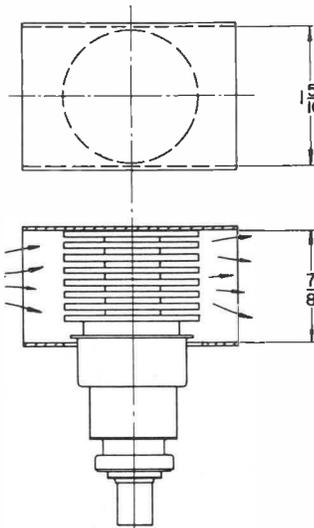
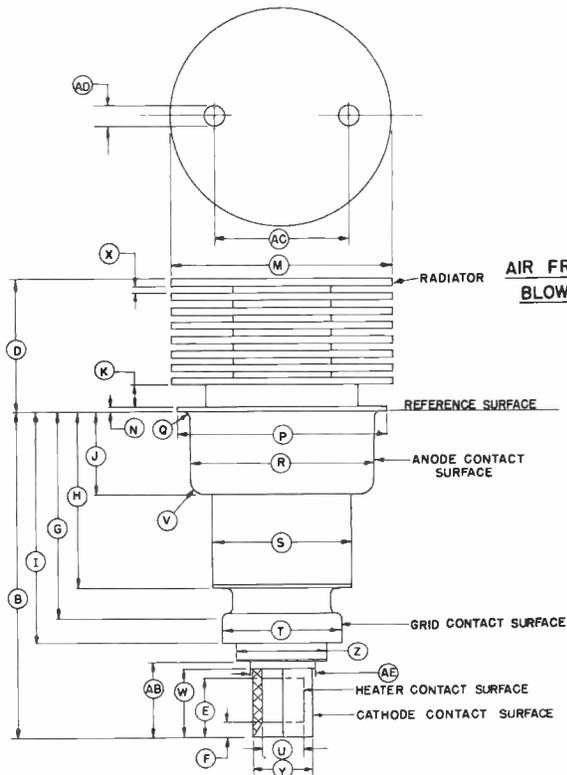
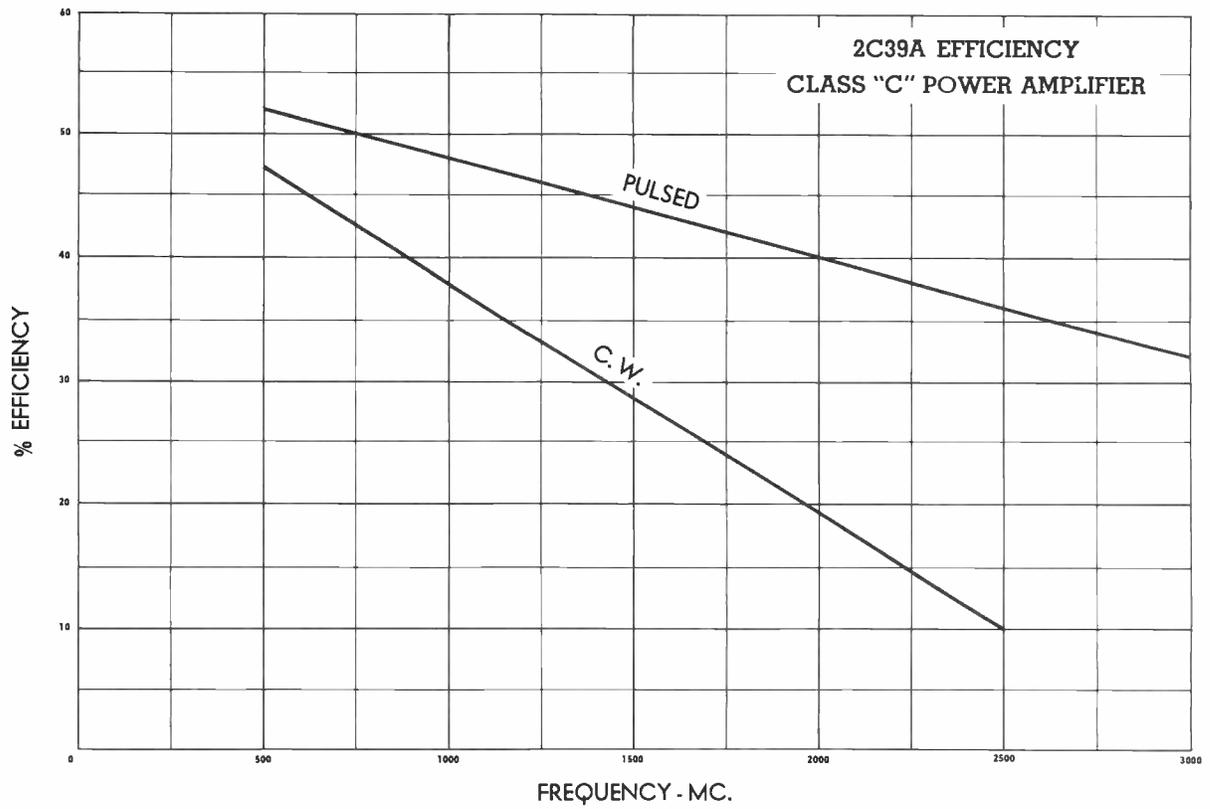
When grid-leak bias is used, suitable means must be provided to protect the tube against loss of excitation at plate voltages above 600 volts and the grid-leak resistor should be made variable to facilitate maintaining the bias voltage and plate current at the desired values when tubes are changed in the equipment.

Plate Operation—The maximum rated plate dissipation is 100 watts. In plate-modulated applications, the plate dissipation under carrier conditions must be limited to 70 watts to avoid exceeding the plate-dissipation rating with 100% sine-wave modulation.

In general, low-voltage high-current operation is preferable to high-voltage low-current operation from the standpoint of optimum life.

An excellent indication of operating conditions is the ratio of grid current to plate current; when the 2C39A is operated with grid-current values greater than half those of the plate current, either the drive is excessive or the plate loading is too light for the excitation present. The tube should never be operated unloaded, even for short periods of time. Drive should be held to the lowest value consistent with reasonable efficiency.

Special Applications—If it is desired to operate this tube under conditions widely different from those given here, write to Eitel-McCullough, Inc., San Carlos, California, for information and recommendations.



**RECOMMENDED COWLING
FOR
FORCED-AIR COOLING
OF ANODE**

REF.	NOM.	MIN.	MAX.
B		1.815	1.875
D		.766	.826
E		.341	.401
F		.026	.086
G		1.095	1.135
H		.880	.920
I		1.281	1.329
J		.462	.477
K		.125	.185
M		1.234	1.264
N	.031		
P		1.180	1.195
Q	.031		
R		1.024	1.039
S		.752	.792
T		.653	.668
U		.213	.223
V	.094		
W		.400	.460
X		.016	.046
Y		.313	.328
Z		.455	.470
AB		.420	.480
AC	.750		
AO	.125		
AE		.333	.348

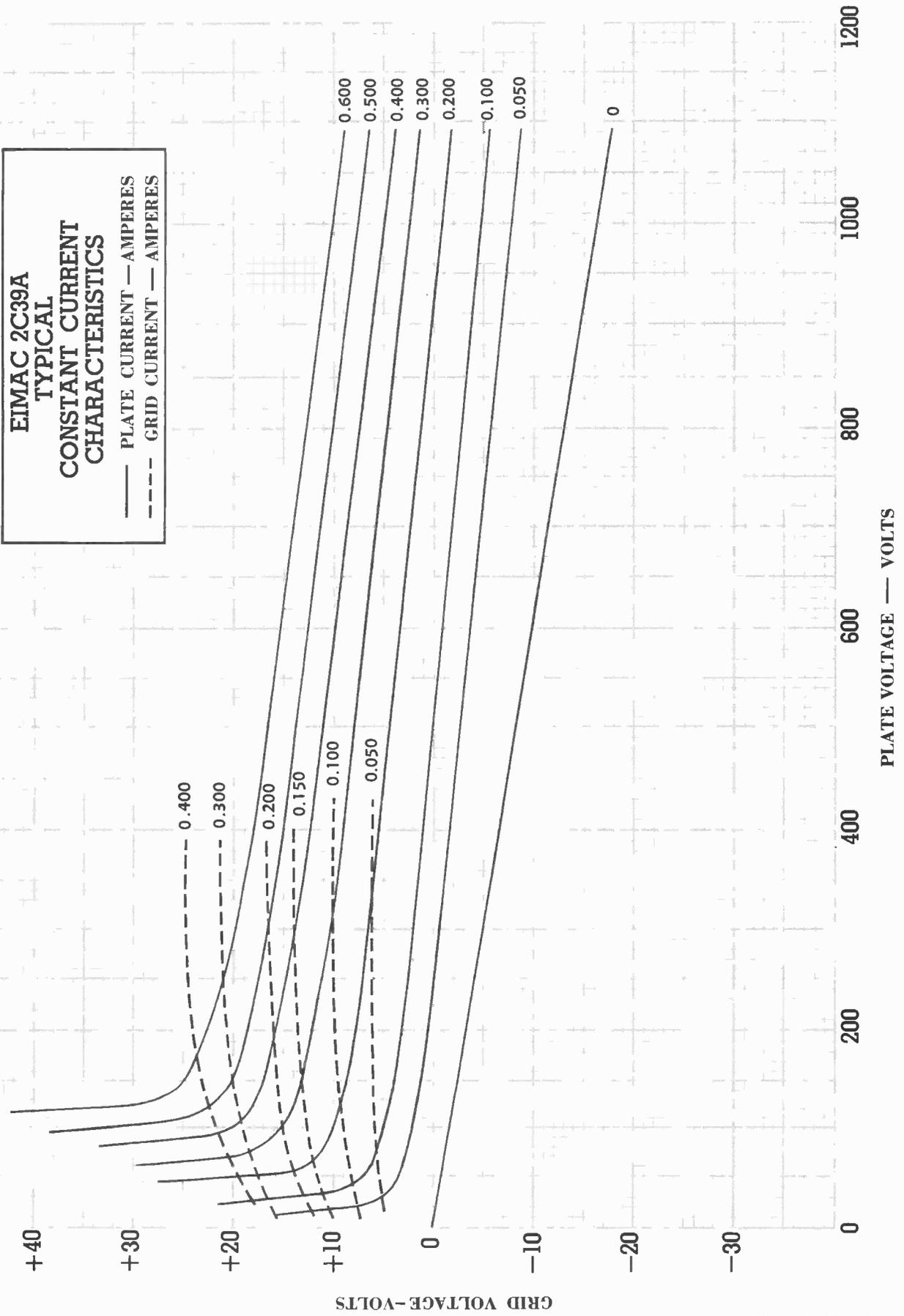
NOTES:

1. The total indicated runout of the anode contact surface and the grid contact surface with respect to the cathode contact surface shall not exceed .020.
2. The total indicated runout of the cathode contact surface with respect to the heater contact surface shall not exceed .012.



**EIMAC 2C39A
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS**

— PLATE CURRENT — AMPERES
- - - GRID CURRENT — AMPERES



TENTATIVE DATA

Eimac
EITEL-McCULLOUGH, INC.
 SAN BRUNO, CALIFORNIA

2C39B

HIGH-MU UHF
 TRIODE

Supersedes
 Types 2C38, 2C39,
 2C39A

The Eimac 2C39B is a ceramic-and-metal UHF transmitting triode with a plate dissipation rating of 100 watts. It is useful as a CW amplifier or oscillator at frequencies up to 2500 mc., and in pulse applications at frequencies up to 3000 mc.

The terminals of the 2C39B are a graduated series of cylindrical surfaces, which fit conveniently into sockets made integral with coaxial circuit elements. The maximum envelope-temperature rating for the 2C39B is 200°C, and the tube is cooled by forced air. The 2C39B is the unilateral replacement for the 2C39A.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode: Oxide-Coated, Unipotential	
Heater Voltage	6.3 volts
Heater Current	1.025 amperes
Heating Time	60 seconds
Amplification Factor	100
Transconductance (Plate Current 70ma.)	25,000 μ mhos
Direct Interelectrode Capacitances, (average)	
Grid-Plate	2.01 μ mfd
Grid-Cathode	6.60 μ mfd
Plate-Cathode	0.035 μ mfd
Highest Frequency for Maximum Ratings	2500 mc.

MECHANICAL

Terminal Location	See Outline Drawing
Mounting Position	Any
Cooling	Forced Air
Maximum Envelope Temperature	CORRECTION: MAXIMUM ENVELOPE TEMPERATURE = 250°C. 200°C.
Maximum Over-all Dimensions:	
Length	2 3/4 inches
Diameter	1 17/64 inches
Net Weight	2.5 ounces
Shipping Weight (Approximately)	7 ounces



RADIO-FREQUENCY POWER AMPLIFIER, OSCILLATOR OR MODULATOR

MAXIMUM RATINGS (Per tube)	
D-C PLATE VOLTAGE	1000 MAX. VOLTS
D-C CATHODE CURRENT	125 MAX. MA
D-C GRID VOLTAGE	150 MAX. VOLTS
D-C GRID CURRENT	50 MAX. MA
HEATER VOLTAGE	SEE APPLICATION NOTES
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE	30 MAX. VOLTS
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE	400 MAX. VOLTS
PLATE DISSIPATION	100 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Key-down conditions, per tube) (Power-Amplifier Grid-Isolation Circuit, CW Operation, 500 Mc.)	
D-C Plate Voltage	800 volts
D-C Grid Voltage	-20 volts
D-C Plate Current	80 ma
D-C Grid Current	32 ma
Driving Power (approx.) ¹	6 watts
Useful Power Output	27 watts

TYPICAL OPERATION (R-F Oscillator, 2500 Mc.) ²	
D-C Plate Voltage	900 volts
D-C Grid Voltage	-22 volts
D-C Plate Current	90 ma
D-C Grid Current	27 ma
Useful Power Output	15 watts

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER OR OSCILLATOR

MAXIMUM RATINGS (Carrier conditions, per tube)	
D-C PLATE VOLTAGE ³	600 MAX. VOLTS
D-C GRID VOLTAGE	150 MAX. VOLTS
D-C GRID CURRENT	50 MAX. MA
D-C CATHODE CURRENT	100 MAX. MA
PEAK INSTANTANEOUS POSITIVE GRID VOLTAGE	30 MAX. VOLTS
PEAK INSTANTANEOUS NEGATIVE GRID VOLTAGE	400 MAX. VOLTS
PLATE DISSIPATION	70 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Plate-Modulated Radio-Frequency Power Amplifier Grid-Isolation Circuit, 500 Mc., Per Tube)	
D-C Plate Voltage	600 volts
D-C Grid Voltage	-16 volts
D-C Plate Current	75 ma
D-C Grid Current	40 ma
Driving Power (approx.) ¹	6 watts
Useful Carrier Power Output	18 watts

¹Driving power listed is the total power which must be supplied to a practical grid circuit at the frequency shown.

²These 2500 Mc. conditions conform to the proposed requirements of the USAF specification for the 2C39B.

³For less than 100% modulation, higher d-c plate voltage may be used if the sum of the peak positive modulating voltage and the d-c plate voltage does not exceed 1200 volts.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

MECHANICAL

Mounting—The 2C39B may be operated in any position. It should be held firmly in the socket by the contact fingers bearing on the terminal surfaces, and in cases of extremely heavy vibration or shock the tube can be clamped in place. Clamping forces may be applied only to the flange above the anode terminal surface. The under side of this flange should make contact with the stop which controls the vertical position of the tube in the socket. No other surfaces of the tube should be used for vertical reference points, nor should clamping forces be applied to any part of the tube other than the flange referred to above.

Connections—The tube terminal surfaces are in the form of concentric cylinders having graduated diameters, as illustrated on the outline drawing. Spring collets or fingers should be fitted to these cylindrical surfaces to make contact with the anode, grid, cathode and heater terminals. It is important to provide adequate contact area and spring pressure, and to maintain good contact by keeping the contact surfaces free of oxidation and accumulated dirt.

Cooling—The maximum rated temperature of the ceramic-to-metal seals used in the 2C39B is 200°C., and sufficient cooling air must be forced to flow over the envelope surfaces to maintain their temperatures below the maximum rated value.

The anode is cooled by forced air flow through the fins on the anode cooler. When the air cowling illustrated here is used, the air flow required to dissipate 100 watts at sea level, with the air at 25°C, is 12.5 cubic feet per minute.

The only criterion for cooling effectiveness is temperature. Under operating conditions involving less than the rated maximum power dissipation from the anode, reduced air-flow rates are permissible providing the temperatures are maintained below the maximum rating. This also applies when air cowlings, different from that type shown here, are used.

A convenient method of measuring temperature is the use of a temperature-sensitive paint, which melts and changes its appearance permanently above certain specified temperatures. One such product is "Tempilac" sold by the Tempil Corporation, 11 West 25th Street, New York, 10, N. Y.

The air flow-rate should be increased at high altitudes to obtain equivalent cooling. The flow rates in cubic feet per minute at 35,000 feet altitude will usually be double the sea level requirements.

ELECTRICAL

Heater Voltage—The maximum rated heater voltage for the 2C39B is 6.3 volts, which provides adequate cathode emission for applications requiring peak cathode currents in excess of 3.0 amperes.

When the 2C39B is used in applications requiring less than 3.0 amperes peak cathode emission, the heater voltage can be reduced to 5.6 volts, to prolong the life of the tube.

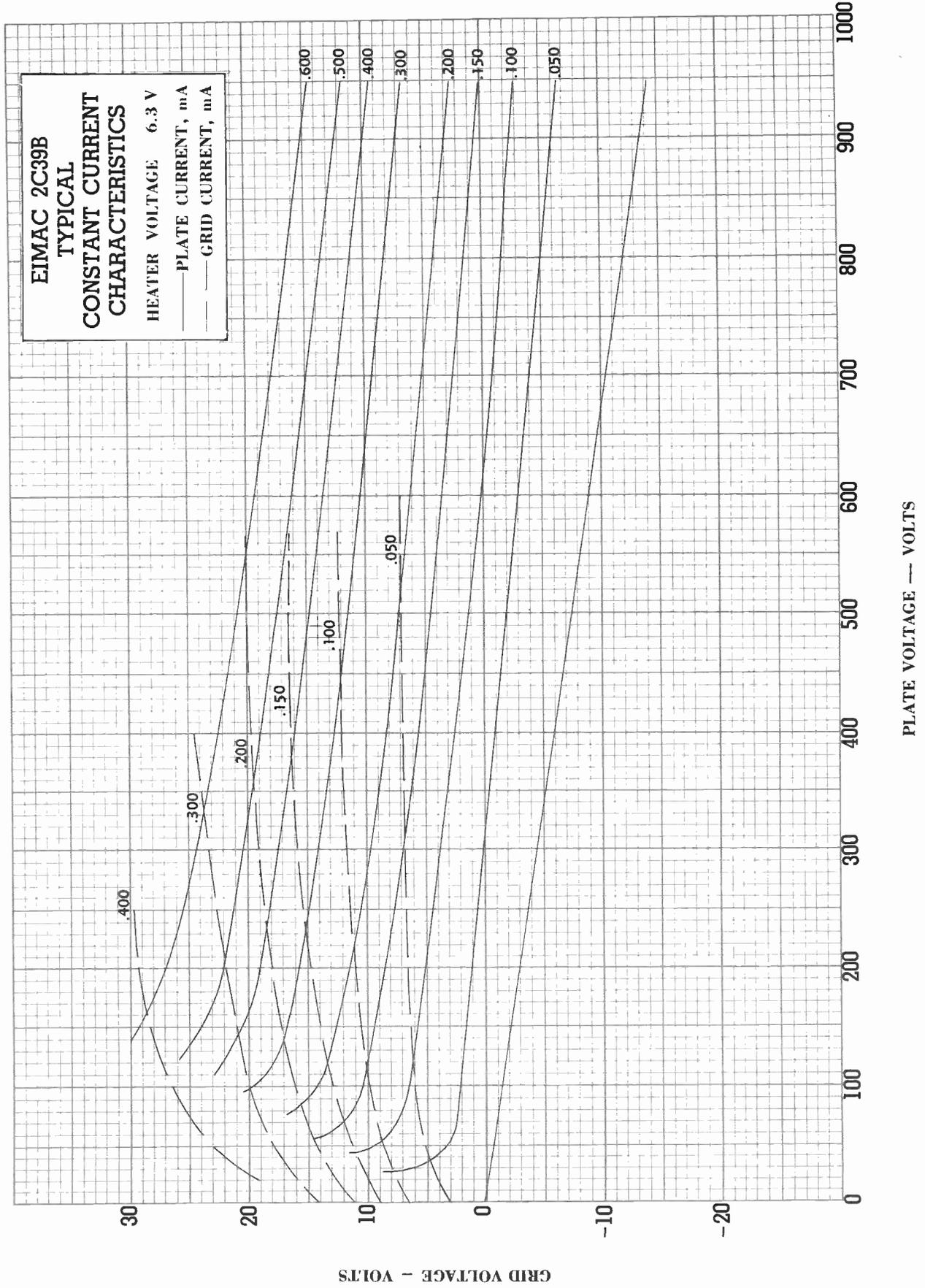
The heater voltage should be maintained within $\pm 5\%$ of the selected operating voltage to maintain uniform circuit performance. For best tube life the heater voltages must be kept within the range from 5.1 volts to 6.9 volts, except in circuits where transit-time effects occur.

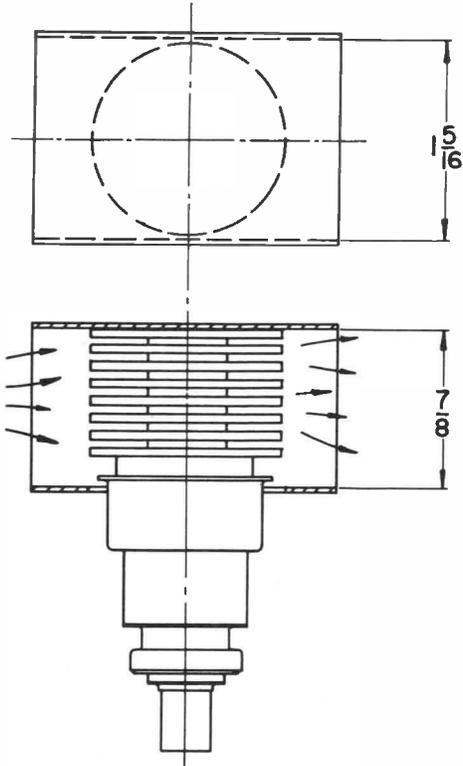
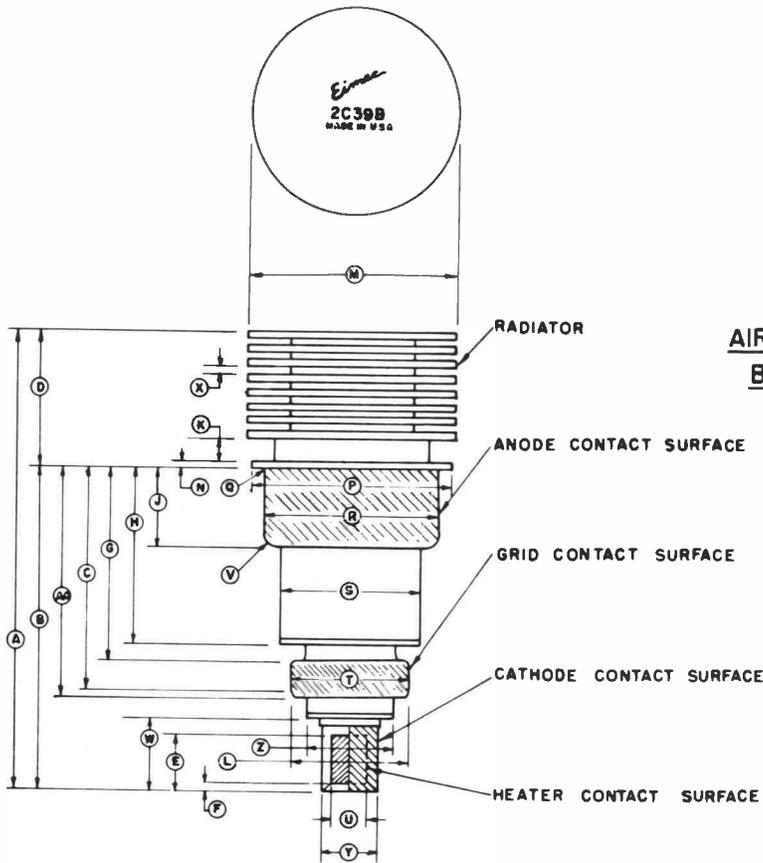
Transit-time effects can result in r-f heating of the cathode when the tube is operated near its upper useful frequency limit, with large driving power. The amount of r-f heating depends on the frequency, driving power, grid current and several other circuit variables whose effects can not be predicted reliably, so no fixed rule can be given by which these effects may be compensated. In each individual case it is necessary to systematically reduce the heater voltage until a point is identified where the circuit performance starts to deteriorate with further heater voltage reduction. The operating voltage should be ten percent greater than that voltage, but not less than 4.5 volts. In cases where the heater voltage is too low to permit immediate circuit operation, the heater voltage may be raised to 6.3 volts until dynamic operation of the circuit starts, after which the heater voltage can be reduced to the selected operating voltage.

Operation—Longer tube life will be obtained when the tube is operated at low voltage and high current, instead of high voltage and low current. The plate circuit must always be kept adequately loaded and the grid driving power should be kept as low as possible, consistent with satisfactory efficiency.

The ratio of grid current to plate current is a good indicator of circuit conditions. Grid current in excess of half the plate current indicates that the driving power is excessive for the circuit conditions and should be reduced.

Equipment which relies on grid-leak bias to protect the tube should have effective plate-current overload protection when operating at more than 800 volts. Grid-leak resistors should be made variable, to permit adjustment of the bias and the plate current to the correct values under changing circuit conditions.





**RECOMMENDED COWLING
 FOR
 FORCED-AIR COOLING
 OF ANODE**

NOTES:

1. THE TRUE INDICATED RUNOUT OF THE ANODE CONTACT SURFACE AND THE GRID CONTACT SURFACE WITH RESPECT TO THE CATHODE CONTACT SURFACE SHALL NOT EXCEED .020.
2. THE TRUE INDICATED RUNOUT OF THE CATHODE CONTACT SURFACE WITH RESPECT TO THE HEATER CONTACT SURFACE SHALL NOT EXCEED .012.

	NOM.	MIN.	MAX.
A			2 3/4
B		1.805	1.875
C		1.258	
D		.736	.826
E		.341	
F			.086
G			1.135
H		1.000	
J		.459	.479
K		1/8	
L			.668
M		1 15/64	1 17/64
N	1/32		
P		1.175	1.199
Q			1/32
R		1.021	1.039
S			13/16
T		.652	.668
U		.213	.223
V			3/32
W		.400	
X		1/64	
Y		.312	.328
Z			.515
AA		1.289	1.329



EITEL-McCULLOUGH, INC.
SAN BRUNO · CALIFORNIA

TENTATIVE DATA

2C39WA

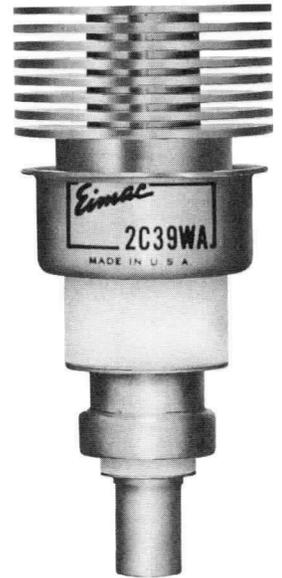
**HIGH-MU UHF
TRIODE**

The Eimac 2C39WA is a planar triode of ceramic and metal construction designed for use as an oscillator, frequency multiplier, or power amplifier in the VHF and UHF ranges and particularly suitable for use in grid-isolation circuits. The Eimac 2C39WA is manufactured and tested to exacting tolerances to insure consistent and uniform tube performance.

CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Cathode: Oxide-Coated, Unipotential				
Heating Time	-	60		seconds
Heater: Voltage	-	5.8		volts
Current ($E_f=5.8v$)	0.87		1.03	ampere
Amplification Factor	-	100		
Transconductance				
($E_f=5.5v$, $E_b=600v$, $R_k=30ohms$)	18,000		30,000	umhos
Frequency for Maximum Ratings	-		2500	mc
Interelectrode Capacitances (In Shielded Fixture):				
Grid-Cathode	-	-	-	Min. 5.6 Max. 7.6 uuf
Grid-Plate	-	-	-	1.86 2.16 uuf
Plate-Cathode	-	-	-	0.035 uuf



MECHANICAL

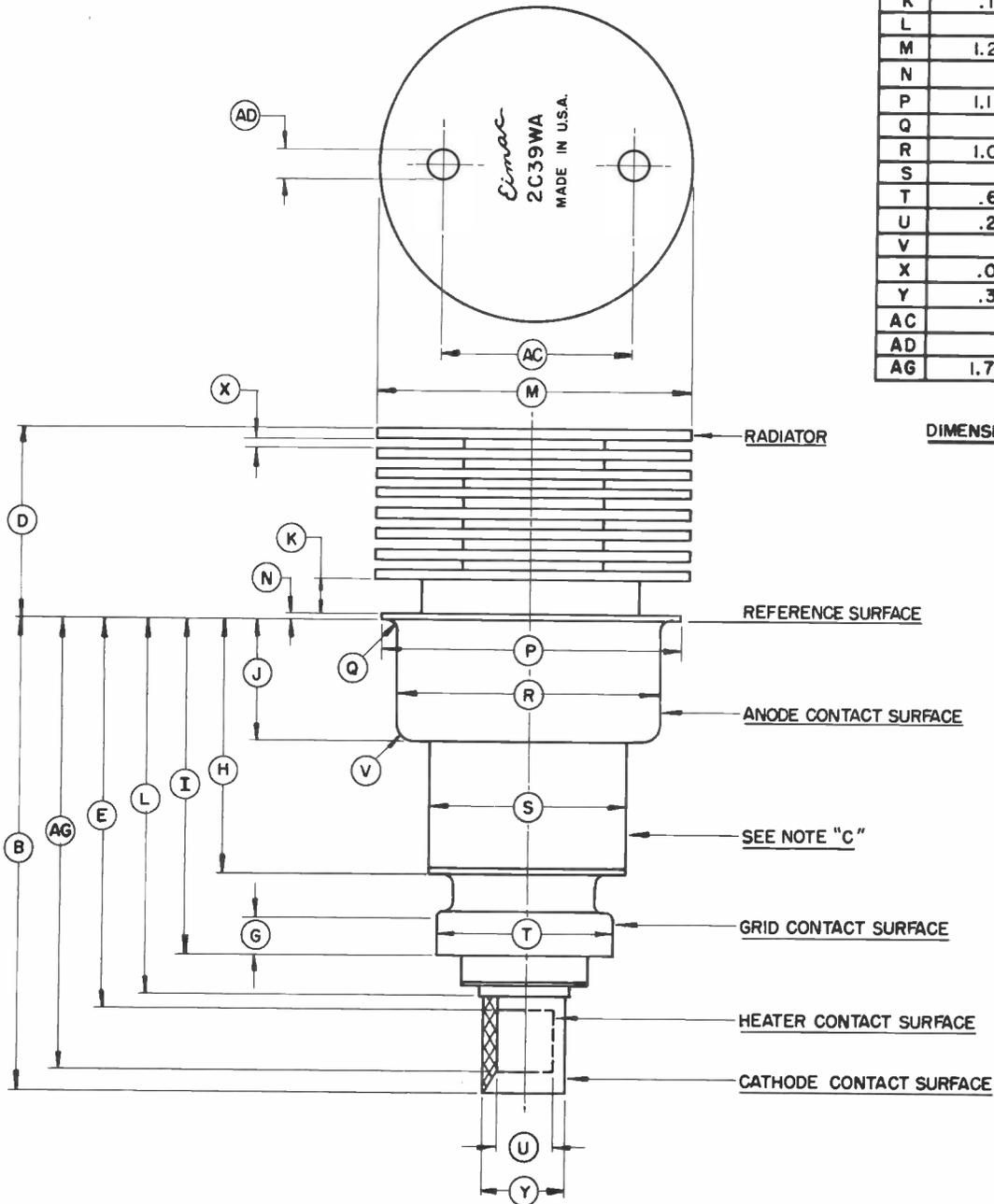
Terminals	-	-	-	-	Graduated cylindrical surfaces
Maximum Seal and Anode Core Temperature	-	-	-	-	200° C
Cooling	-	-	-	-	Forced air
Operating Position	-	-	-	-	Any
Maximum Over-All Dimensions:					
Length	-	-	-	-	2.75 inches
Diameter	-	-	-	-	1.27 inches
Net Weight	-	-	-	-	2.5 ounces
Shipping Weight (Approximate)	-	-	-	-	7 ounces

MAXIMUM RATINGS Class-C oscillator, multiplier, or amplifier.

(Carrier or key-down conditions)	(Plate Mod)	(Teleg. or FM)
D-C PLATE VOLTAGE	600	1000 MAX. VOLTS
D-C CATHODE CURRENT	100	125 MAX. MA
D-C GRID VOLTAGE	-150	-150 MAX. VOLTS
D-C GRID CURRENT	50	50 MAX. MA
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE	30	30 MAX. VOLTS
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE	400	400 MAX. VOLTS
PLATE DISSIPATION (WITH 12.5 CFM AIR FLOW)	70	100 MAX. WATTS
GRID DISSIPATION	2	2 MAX. WATTS



2C39WA



DIMENSION DATA		
REF	MIN.	MAX.
B	1.805	1.875
D	.736	.826
E		1.534
G	.140	
H		1.000
I	1.289	1.329
J	.459	.479
K	.125	
L		1.475
M	1.234	1.266
N		.031
P	1.175	1.199
Q		.031
R	1.021	1.039
S		.813
T	.652	.668
U	.213	.223
V		.094
X	.016	
Y	.312	.328
AC		.750
AD		.125
AG	1.719	

DIMENSIONS IN INCHES



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

7815
3CPN10A5
UHF
PULSE
TRIODE

The Eimac 7815/3CPN10A5 is a low duty pulse rated version of the 3CX100A5 with the anode cooler removed. A longer grid-anode ceramic insulator is incorporated, making the tube useful at high altitude. The nominal plate dissipation rating is 10 watts but may be increased if sufficient cooling is provided. Cooling is accomplished by conduction through a suitable heat sink or convection. Where greater plate dissipation is required, the 7815R/3CPX100A5 should be used.

The tube is usable in pulse applications to 3000 Megacycles. Electrical characteristics except for plate dissipation are similar to the 3CX100A5.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.
Cathode: Oxide-coated, Unipotential			
Heating time - - - - -	60		seconds
Heater:			
Voltage - - - - -		6.0	volts
Current - - - - -	0.90		1.05 amperes
Amplification Factor - - - - -		100	
Transconductance (I _b = 70 milliamperes) - - - - -		25,000	Micromhos
Direct Interelectrode Capacitances			Min. Max.
Grid-Cathode - - - - -			5.6 7.0 uuf
Grid-Plate - - - - -			1.86 2.10 uuf
Plate-Cathode - - - - -			0.035 uuf
Frequency for Maximum Ratings - - - - -			3000 Megacycles

MECHANICAL

Terminals - - - - -	Graduated Cylindrical Surfaces
Maximum Operating Temperatures:	
Ceramic-to-Metal Seals - - - - -	250°C
Anode Core - - - - -	250°C
Operating Position - - - - -	Any
Cooling - - - - -	Conduction and Convection
Maximum Overall Dimensions:	
Length - - - - -	2.701 inches
Diameter - - - - -	1.195 inches
Net Weight - - - - -	2.0 ounces
Shipping Weight (approx.) - - - - -	7.0 ounces

PLATE PULSED OSCILLATOR OR AMPLIFIER

CLASS-C

MAXIMUM RATINGS

PEAK PULSE PLATE VOLTAGE - - - - -	3500 MAX. VOLTS
DC GRID VOLTAGE - - - - -	-150 MAX. VOLTS
PULSE PLATE CURRENT - - - - -	3.0 MAX. VOLTS
DC CATHODE CURRENT - - - - -	125 MAX. MA
PULSE GRID CURRENT - - - - -	1.8 MAX. AMPS
PLATE DISSIPATION (AVG) - - - - -	10 MAX. WATTS
GRID DISSIPATION (AVG) - - - - -	2 MAX. WATTS

TYPICAL OPERATION

Pulse Plate Voltage - - - - -	3500	3500 volts
Pulse Plate Current - - - - -	3.0	3.0 amps
DC Plate Current (avg) - - - - -	7.5	9 mA
DC Grid Current (avg) - - - - -	4.5	3 mA
Pulse Power Output - - - - -	1600	2000 watts
Frequency - - - - -	3000	2500 Mc
Pulse Length - - - - -	3	5 usec
Duty Factor - - - - -	0.0025	0.003

(Effective 1-1-63) © Copyright, 1963 by Eitel-McCullough, Inc.

**GRID PULSED OSCILLATOR OR AMPLIFIER****CLASS-C**

MAXIMUM RATINGS

DC PLATE VOLTAGE	-	-	-	-	2000 MAX. VOLTS
DC GRID VOLTAGE	-	-	-	-	-150 MAX. VOLTS
PULSE PLATE CURRENT	-	-	-	-	3.0 MAX. AMPS
DC CATHODE CURRENT	-	-	-	-	125 MAX. MA.
PLATE DISSIPATION (AVG)	-	-	-	-	10 MAX. WATTS
GRID DISSIPATION (AVG)	-	-	-	-	2 MAX. WATTS

TYPICAL OPERATION

DC Plate Voltage	-	-	-	-	1600	1700 volts
DC Grid Voltage	-	-	-	-	-45	-45 volts
Pulse Plate Current	-	-	-	-	3.0	1.9 amps
Pulse Grid Current	-	-	-	-	1.8	1.1 amps
Pulse Power Output	-	-	-	-	1000	1500 watts
Frequency	-	-	-	-	3000	1100 Mc
Pulse Length	-	-	-	-	3	3.5 usec
Duty Factor	-	-	-	-	0.0025	0.001

APPLICATION**MECHANICAL**

Mounting—The 3CPN10A5 may be operated in any position. It should be firmly held in place by spring-finger collets bearing on the terminal surfaces. In use the tube should seat against the underside of the anode-terminal flange which is on the plane of reference for longitudinal dimensions. In applications involving severe shock and vibration, the tube may be clamped in place by applying a suitable clamping device to the anode-terminal flange. It is recommended that no other portion of the tube be subjected to clamping forces.

Connections—The terminals are in the form of concentric cylinders of graduated diameters conveniently used with coaxial tuning devices. Spring-fingered collets should be used to make contact with the anode, grid, cathode and heater terminals. Adequate contact area and spring pressure should be provided to minimize heating and to prevent erratic circuit performance at the higher frequencies. Non-contacting or intermittently-contacting collet fingers will cause troublesome circuit behavior, especially at very-high and ultra-high frequencies. Electrode contact surfaces should be kept clean and free of oxide coatings.

Cooling—Sufficient cooling air must be provided for the anode and body seals to maintain operating temperatures below the rated maximum value of 250°C.

The nominal plate dissipation rating is 10 watts and is dependent on convection cooling to a heat sink. Where adequate cooling is provided this value may be extended. Where greater plate dissipation is required use of the 3CPX100A5 is recommended.

It should be borne in mind that operating temperature is the sole criterion of cooling effectiveness, regardless of the coolant type, flow rate or coolant temperature. One method of measuring the surface temperatures is the use of temperature sensitive lacquer, such as "Tempilaq."

ELECTRICAL

Heater Operation—The rated heater voltage for the 3CPN10A5 is 6.0 volts. The heater voltage for the 3CPN10A5 should be maintained within plus or minus 5% of its intended value to minimize variations in circuit performance and to obtain maximum tube life.

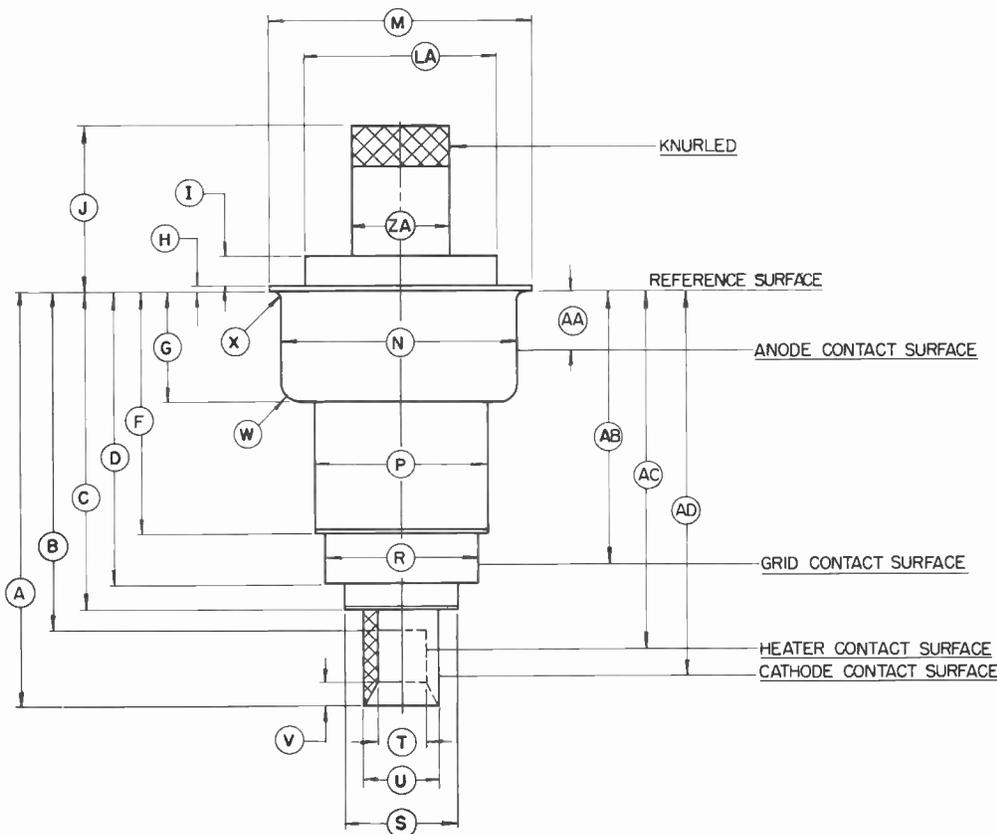
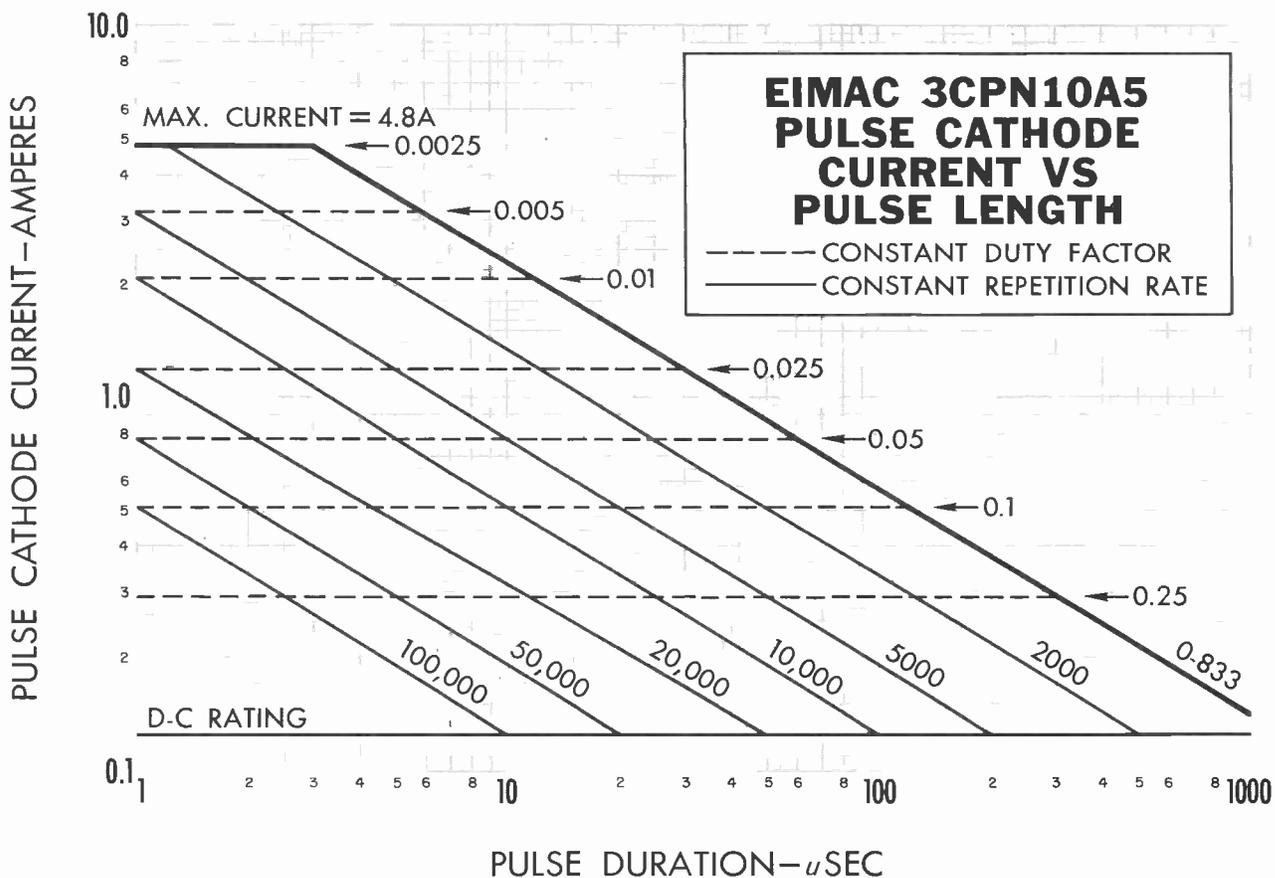
At frequencies above approximately 1000 megacycles, transit time effects begin to influence cathode temperature. The amount of driving power diverted to heating the cathode by back-bombardment will depend upon the frequency, the plate current, driving power, and duty factor. If the conditions of operation result in appreciable cathode back-heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to a lower value. The heater of the 3CPX10A5 must not be operated at less than 4.5 volts in any case.

Cathode Operation—The oxide-coated unipotential cathode in this tube must be protected against excessively high emission currents. For all types of operation the maximum rated dc current is 125 milliamperes. In pulse service, current must be limited according to the curve on page 3.

It is recommended that the rated heater voltage be applied for a minimum of 60 seconds before other operating voltages are applied.

Control Grid Operation—Grid dissipation must not exceed the rated maximum 2.0 watts grid dissipation power. In pulse applications the instantaneous peak grid-to-cathode voltage must be limited to +250 to -750 volts.

Special Applications—If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Tube Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California for information and recommendations.



DIMENSIONS IN INCHES			
DIMENSIONAL DATA			
REF.	MIN.	MAX.	NOM.
A	1.815	1.875	
B		1.534	
C		1.475	
D	1.289	1.329	
F	.970	1.010	
G	.462	.477	
H		.040	
I		.185	
J	.766	.826	
M	1.180	1.195	
N	1.025	1.035	
P	.772	.792	
R	.655	.665	
S		.545	
T	.213	.223	
U	.315	.325	
V		.086	
W		.100	
X		.035	
LA			.850
ZA	.427	.447	

ELECTRODE CONTACT AREA		
REF.		
AA	.198 ± .163	ANODE
AB	1.225 ± .040	GRID
AC	1.631 ± .097	HEATER
AD	1.645 ± .170	CATHODE



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

7815R
3CPX100A5

**UHF
PULSE
TRIODE**

The Eimac 7815R/3CPX100A5 is a pulse rated version of the 3CX100A5. A longer grid-anode ceramic insulator is incorporated, making the tube useful at high altitude. The nominal plate dissipation rating is 100 watts.

The tube is usable in pulse applications to 3000 Megacycles. Electrical characteristics are similar to the 3CX100A5.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.
Cathode: Oxide-coated, Unipotential			
Heating time - - - - -	60		seconds
Heater:			
Voltage - - - - -		6.0	volts
Current - - - - -	0.90		1.05 amperes
Amplification Factor - - - - -		100	
Transconductance (I _b = 70 milliamperes) - - - - -		25,000	Micromhos

Direct Interelectrode Capacitances	Min.	Max.
Grid-Cathode - - - - -	5.7	7.0 uuf
Grid-Plate - - - - -	1.85	2.10 uuf
Plate-Cathode - - - - -		0.035 uuf
Frequency for Maximum Ratings - - - - -		3000 Megacycles

MECHANICAL

Terminals - - - - -	Graduated Cylindrical Surfaces
Maximum Operating Temperatures:	
Ceramic-to-Metal Seals - - - - -	250°C
Anode Core - - - - -	250°C
Operating Position - - - - -	Any
Cooling - - - - -	Forced Air
Maximum Overall Dimensions:	
Length - - - - -	2.701 inches
Diameter - - - - -	1.264 inches
Net Weight - - - - -	2.5 ounces
Shipping Weight (approx.) - - - - -	7.0 ounces

PLATE PULSED OSCILLATOR OR AMPLIFIER

CLASS-C

MAXIMUM RATINGS	
PEAK PULSE PLATE VOLTAGE - - - - -	3500 MAX. VOLTS
DC GRID VOLTAGE - - - - -	-150 MAX. VOLTS
PULSE PLATE CURRENT - - - - -	3.0 MAX. VOLTS
DC CATHODE CURRENT - - - - -	125 MAX. MA
PULSE GRID CURRENT - - - - -	1.8 MAX. AMPS
PLATE DISSIPATION (AVG) - - - - -	100 MAX. WATTS
GRID DISSIPATION (AVG) - - - - -	2 MAX. WATTS

TYPICAL OPERATION

Pulse Plate Voltage - - - - -	3500	3500 volts
Pulse Plate Current - - - - -	3.0	3.0 amps
DC Plate Current (avg) - - - - -	7.5	9 mA
DC Grid Current (avg) - - - - -	4.5	3 mA
Pulse Power Output - - - - -	1600	2000 watts
Frequency - - - - -	3000	2500 Mc
Pulse Length - - - - -	3	5 usec
Duty Factor - - - - -	0.0025	0.003

**GRID PULSED OSCILLATOR OR AMPLIFIER****CLASS-C****MAXIMUM RATINGS**

DC PLATE VOLTAGE	-	-	-	-	2000 MAX. VOLTS
DC GRID VOLTAGE	-	-	-	-	-150 MAX. VOLTS
PULSE PLATE CURRENT	-	-	-	-	3.0 MAX. AMPS
DC CATHODE CURRENT	-	-	-	-	125 MAX. MA.
PLATE DISSIPATION (AVG)	-	-	-	-	100 MAX. WATTS
GRID DISSIPATION (AVG)	-	-	-	-	2 MAX. WATTS

TYPICAL OPERATION

DC Plate Voltage	-	-	-	-	1600	1700 volts
DC Grid Voltage	-	-	-	-	-45	-45 volts
Pulse Plate Current	-	-	-	-	3.0	1.9 amps
Pulse Grid Current	-	-	-	-	1.8	1.1 amps
Pulse Power Output	-	-	-	-	1000	1500 watts
Frequency	-	-	-	-	3000	1100 Mc
Pulse Length	-	-	-	-	3	3.5 usec
Duty Factor	-	-	-	-	0.0025	0.001

APPLICATION**MECHANICAL**

Mounting—The 3CPX100A5 may be operated in any position. It should be firmly held in place by spring-finger collets bearing on the terminal surfaces. In use the tube should seat against the underside of the anode-terminal flange which is on the plane of reference for longitudinal dimensions. In applications involving severe shock and vibration, the tube may be clamped in place by applying a suitable clamping device to the anode-terminal flange. It is recommended that no other portion of the tube be subjected to clamping forces.

Connections—The terminals are in the form of concentric cylinders of graduated diameters conveniently used with coaxial tuning devices. Spring-fingered collets should be used to make contact with the anode, grid, cathode and heater terminals. Adequate contact area and spring pressure should be provided to minimize heating and to prevent erratic circuit performance at the higher frequencies. Non-contacting or intermittently-contacting collet fingers will cause troublesome circuit behavior, especially at very-high and ultra-high frequencies. Electrode contact surfaces should be kept clean and free of oxide coatings.

Cooling—Sufficient cooling air must be provided for the anode and body seals to maintain operating temperatures below the rated maximum value of 250°C. At sea level, with 20°C air, approximately 12.5 CFM of cooling air directed across the anode through a suitable cowling will maintain safe anode temperature. In pulse applications requiring low plate dissipation and/or small size, the coolerless 3CPN10A5 should be considered.

The nominal plate dissipation rating is 10 watts and is dependent on convection cooling to a heat sink. Where adequate cooling is provided this value may be extended. Where greater plate dissipation is required use of the 3CPX100A5 is recommended.

It should be borne in mind that operating temperature is the sole criterion of cooling effectiveness, regardless of the coolant type, flow rate or coolant temperature.

One method of measuring the surface temperatures is the use of temperature sensitive lacquer, such as "Tempilaq."

ELECTRICAL

Heater Operation—The rated heater voltage for the 3CPX100A5 is 6.0 volts. The heater voltage for the 3CPX100A5 should be maintained within plus or minus 5% of its intended value to minimize variations in circuit performance and to obtain maximum tube life.

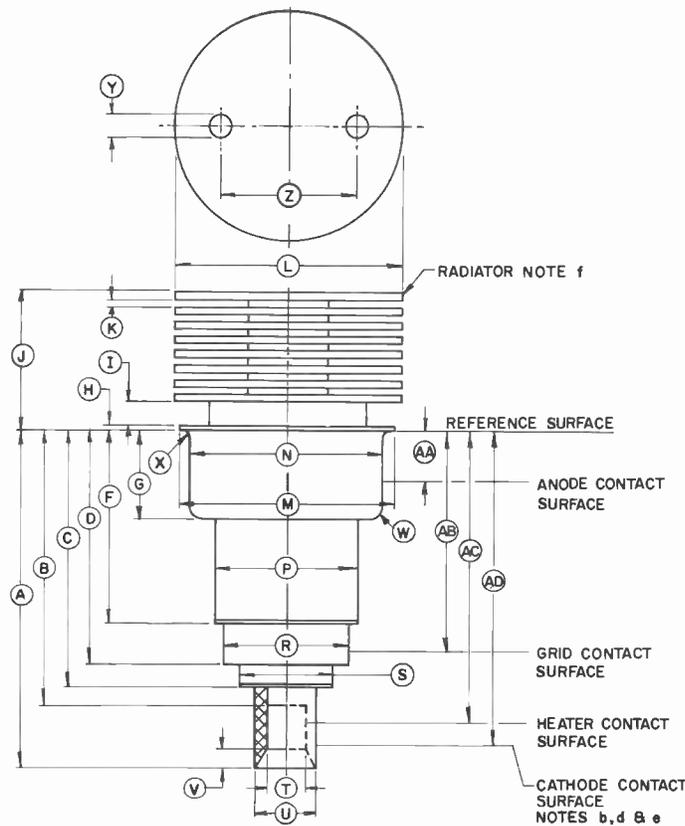
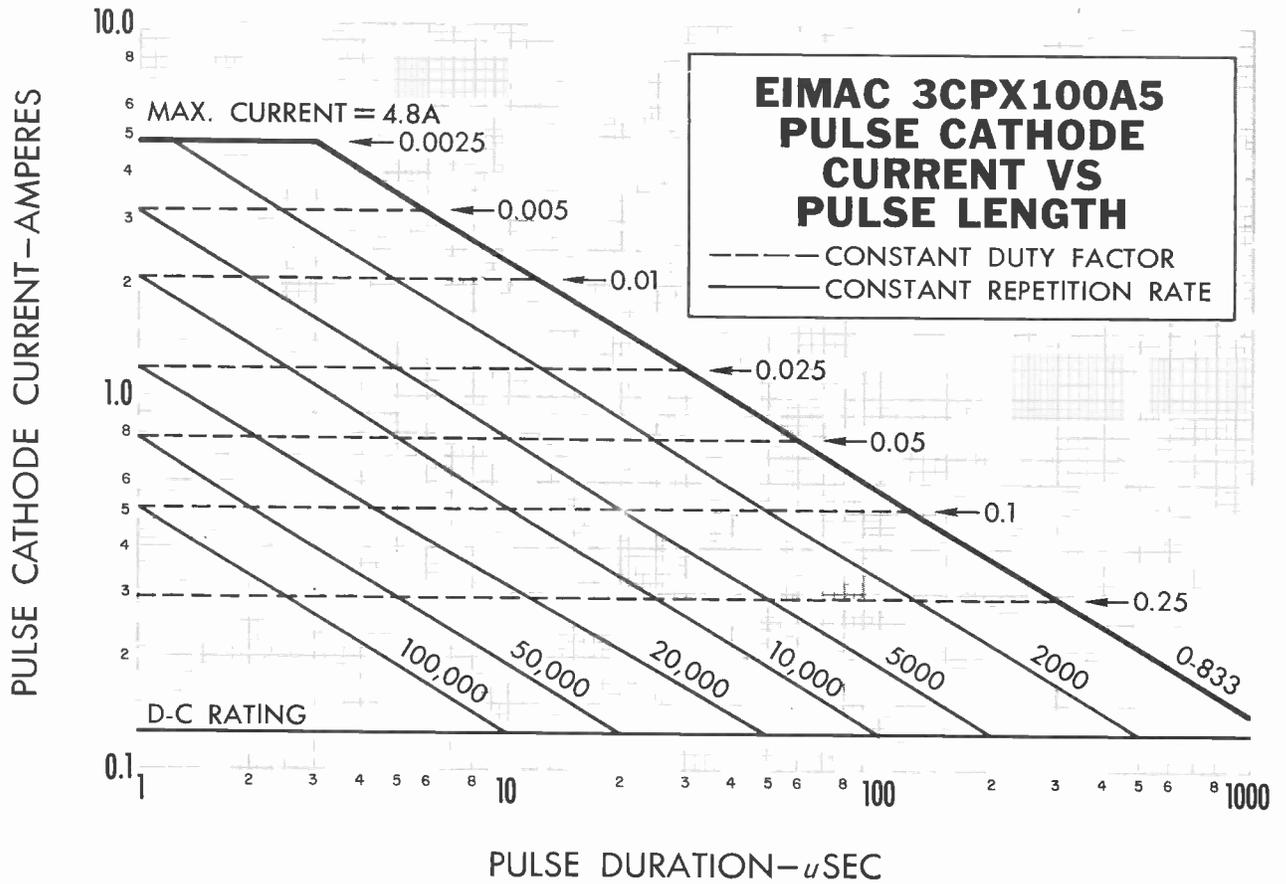
At frequencies above approximately 1000 megacycles, transit time effects begin to influence cathode temperature. The amount of driving power diverted to heating the cathode by back-bombardment will depend upon the frequency, the plate current, driving power, and duty factor. If the conditions of operation result in appreciable cathode back-heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to a lower value. The heater of the 3CPX100A5 must not be operated at less than 4.5 volts in any case.

Cathode Operation—The oxide-coated unipotential cathode in this tube must be protected against excessively high emission currents. For all types of operation the maximum rated dc current is 125 milliamperes. In pulse service, current must be limited according to the curve on page 3.

It is recommended that the rated heater voltage be applied for a minimum of 60 seconds before other operating voltages are applied.

Control Grid Operation—Grid dissipation must not exceed the rated maximum 2.0 watts grid dissipation power. In pulse applications the instantaneous peak grid-to-cathode voltage must be limited to +250 to -750 volts.

Special Applications—If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Tube Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California for information and recommendations.



DIMENSIONS IN INCHES

DIMENSIONAL DATA			
REF.	MIN.	MAX.	NOM.
A	1.815	1.875	
B		1.534	
C		1.475	
D	1.289	1.329	
F	.970	1.010	
G	.462	.477	
H		.040	
I	.125	.185	
J	.766	.826	
K	.025	.046	
L	1.234	1.264	
M	1.180	1.195	
N	1.025	1.035	
P	.772	.792	
R	.685	.665	
S		.545	
T	.213	.225	
U	.315	.325	
V		.086	
W		.100	
X		.035	
Y	.105	.145	
Z	.650	.650	
AA	.035	.361	
AB	1.165	1.265	
AC	1.534	1.726	
AD	1.475	1.815	



EIMAC 3CPX100A5 TYPICAL CONSTANT CURRENT CHARACTERISTICS

--- GRID CURRENT — AMPERES
— PLATE CURRENT — AMPERES

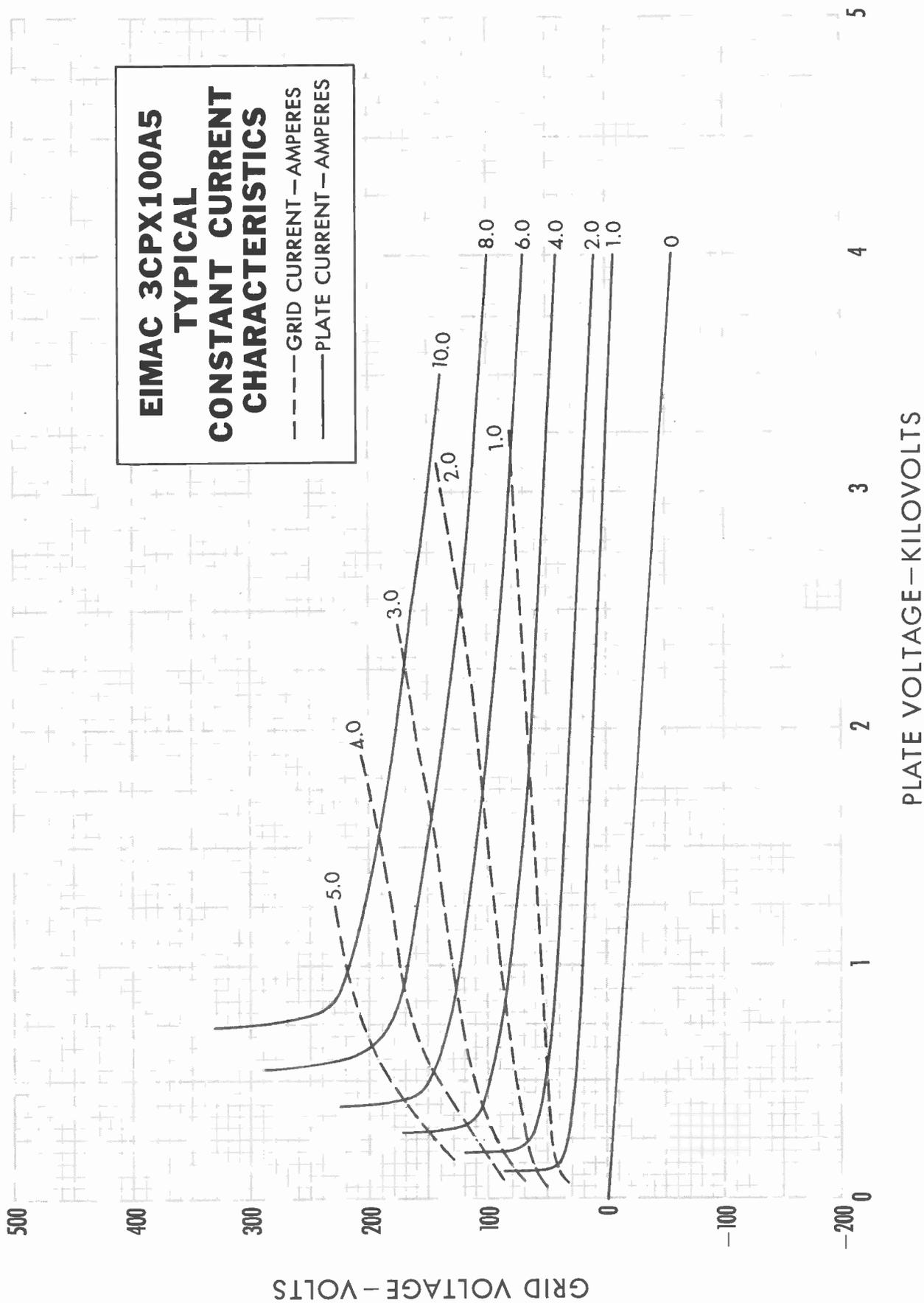


PLATE VOLTAGE — KILOVOLTS



TECHNICAL DATA

3CV1500A7

HIGH-MU
POWER TRIODE

The 3CV1500A7 is an integral-boiler, ceramic/metal, vapor cooled zero-bias triode, intended for Class AB2 linear amplifier service in either grid driven or cathode driven configuration. Except for the anode dissipation rating, the 3CV1500A7 is electrically identical to the EIMAC 8283/3CX-1000A7.

The 3CV1500A7 is especially recommended when the ambient noise level must be reduced to a minimum, since high-pressure/high-volume forced-air cooling is not required.



GENERAL CHARACTERISTICS¹

ELECTRICAL

Filament: Thoriated-tungsten Mesh

Voltage	5.0 ± 0.25 V
Current, at 5.0 volts	30 A
Amplification Factor (average)	200
Direct Interelectrode Capacitances (grounded filament) ²	
Cin	32.0 pF
Cout	0.15 pF
Cgp	14.0 pF
Direct Interelectrode Capacitances (grounded grid) ²	
Cin	32.0 pF
Cout	14.0 pF
Cpk	0.15 pF
Frequency of Maximum Rating:	
CW	220 MHz

1. Characteristics and operating values are based upon performance tests. These figures may change without notice as a result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.
2. Capacitance values are for a cold tube, as measured in a shielded fixture in accordance with Electronic Industries Association Standard RS-191.

MECHANICAL

Maximum Overall Dimensions:

Length	5.110 in; 129.8 mm
Diameter	3.355 in; 85.2 mm
Net Weight	2.38 lb; 1.08 kg
Operating Position	Vertical, base down
Maximum Operating Temperature:	
Ceramic/metal seals	250°C
Cooling	Vapor and Forced Air
Base	Special Breechlock
Recommended Socket	EIMAC SK-861

(Effective 6-15-71) © by Varian

Printed in U.S.A.

**RADIO FREQUENCY LINEAR AMPLIFIER
CATHODE DRIVEN Class AB₂**

MAXIMUM RATINGS:

DC PLATE VOLTAGE	3500 VOLTS
DC PLATE CURRENT	1.0 AMPERE
PLATE DISSIPATION	1500 WATTS
GRID DISSIPATION	45 WATTS

1. Adjust to specified zero-signal dc plate current.
2. The intermodulation distortion products are referenced against one tone of a two equal tone signal.
3. Approximate values.

TYPICAL OPERATION (Frequencies to 30 MHz)
Class AB₂ Peak Envelope or Modulation Crest Conditions

Plate Voltage	2000	2500	3500	Vdc
Grid Voltage ¹	0	0	-12	Vdc
Zero-Signal Plate Current	238	305	129	mAdc
Single Tone Plate Current	875	800	857	mAdc
Two-Tone Plate Current	600	585	590	mAdc
Single-Tone Grid Current ³	230	205	225	mAdc
Two-Tone Grid Current ³	130	120	120	mAdc
Peak rf Drive Voltage ³	80	74	110	v
Peak Driving Power	80	60	100	w
Plate Dissipation	800	830	940	W
Useful Output Power	940	1170	2060	W
Resonant Load Impedance	1100	1670	2300	Ω
Intermodulation Distortion Products ²				
3rd Order	-29	-31	-31	db
5th Order	-37	-40	-39	db

**AUDIO FREQUENCY POWER AMPLIFIER OR
MODULATOR Class AB₂, Grid Driven(Sinusoidal Wave)**

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE ¹	3500 VOLTS
DC PLATE CURRENT	1.0 AMPERE
PLATE DISSIPATION	1500 WATTS
GRID DISSIPATION	45 WATTS

1. See zero-bias operation in Application Section.
2. Approximate value.
3. Per Tube.
4. Nominal drive power is one-half peak power.

TYPICAL OPERATION (Two Tubes)

Plate Voltage	2000	2500	Vdc
Grid Voltage	0	0	Vdc
Zero-Signal Plate Current	400	500	mAdc
Max. Signal Plate Current	2.0	2.0	Adc
Max. Signal Grid Current ²	590	480	mAdc
Peak af Grid Voltage ³	95	90	v
Peak Driving Power ⁴	25	44	w
Plate Input Power	4000	5000	W
Max. Signal Plate Dissipation	1650	1900	W
Plate Output Power	2350	3100	W
Load Resistance (plate to plate)	1900	2580	Ω

NOTE: TYPICAL OPERATION data are obtained by measurement or calculation from published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid current. The grid current which results when the desired plate current is obtained is incidental and varies from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf grid voltage is applied.

RANGE VALUES FOR EQUIPMENT DESIGN

	<u>Min.</u>	<u>Max.</u>	
Heater: Current at 5.0 volts	28.0	33.0	A
Cathode Warmup Time	5	---	sec.
Interelectrode Capacitance ¹ (grounded grid connection)			
C _{in}	29.0	35.0	pF
C _{out}	12.0	16.0	pF
C _{pk}	---	0.2	pF

1. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

APPLICATION

MECHANICAL

MOUNTING - The 3CV1500A7 must be mounted with its axis vertical, base down, with sufficient clearance for an insulated makeup water line to connect to the side of the integral anode boiler and an outlet steam line to attach to the top of the boiler. The use of the EIMAC socket SK-861 is recommended.

COOLING - Cooling is accomplished by the presence of distilled water at a controlled level in the integral anode boiler. The energy dissipated by the anode causes the water to boil at the anode surface, to be converted into steam and carried away to a condenser. This boiling action keeps the anode surface at approximately 100°C.

The water in the boiler must be maintained at the correct level, as shown on the outline drawing for the tube. This is normally accomplished with a special control unit, mounted with the correct relationship to the tube so as to maintain the water level in the tube boiler at the specified level. A condenser unit is used to convert the steam back to water, which is then returned to reservoir/control-box/boiler system.

Forced-air cooling of the tube base is required, with 15 cfm minimum directed across and through the socket and base of the tube. Air flow should be applied simultaneously with the application of electrode voltages, including the filament, and may be removed simultaneously with the removal of filament voltage.

ELECTRICAL

FILAMENT - Rated filament voltage for the 3CV1500A7 is 5.0 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain optimum performance and maximum tube life. In no case should it be allowed to deviate from 5.0 volts by more than plus or minus five per cent.

INPUT CIRCUIT - When the 3CV1500A7 is operated as grounded-grid rf amplifier, the use of a resonant tank in the cathode circuit is recommended to obtain greatest linearity and power output. For best results with a single-ended amplifier, it is suggested that the cathode tank circuit operate at a "Q" of five or more.

CLASS-C OPERATION - Although designed for Class-AB2 service, the 3CV1500A7 may be operated as a Class-C power amplifier or oscillator, or as a plate-modulated rf amplifier. The zero-bias characteristic can be used to advantage in Class-C amplifiers by employing only grid leak bias. If driving power fails, plate dissipation is kept to a low level since the tube will operate at normal, static zero-bias conditions.

ZERO-BIAS OPERATION - Operating at zero-bias is not recommended with plate voltages over 2500 volts since plate dissipation may be exceeded. Similarly, the safety of zero-bias operation as mentioned above under "Class-C Operation" is not available at plate voltages above 2500 volts. Straight Class-C or Class-AB2 operation is, of course, permissible up to 3500 volts where other ratings are not exceeded. Higher plate voltage may be used with the proper bias.

PLATE DISSIPATION - The plate dissipation of 1500 watts attainable through vapor cooling provides a large margin of safety in most applications. The rating may be exceeded during tuning for brief periods.

Since the tube anode is usually at high potential to ground, water and steam connections to the anode are made through insulating tubing. These insulating sections should be long enough so that column resistance is above 100,000 ohms per 1000 supply volts. It is essential that high purity water be used to minimize power loss and corrosion of metal fittings. Good distilled or de-ionized water will have a resistance of 1 to 2 megohms per cm³. Water should be discarded if resistivity falls to 50,000 ohms cm³.

HIGH VOLTAGE - Normal operating voltages used with the 3CV1500A7 are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open primary circuits of the power supply and to discharge high-voltage condensers whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that HIGH VOLTAGE CAN KILL.

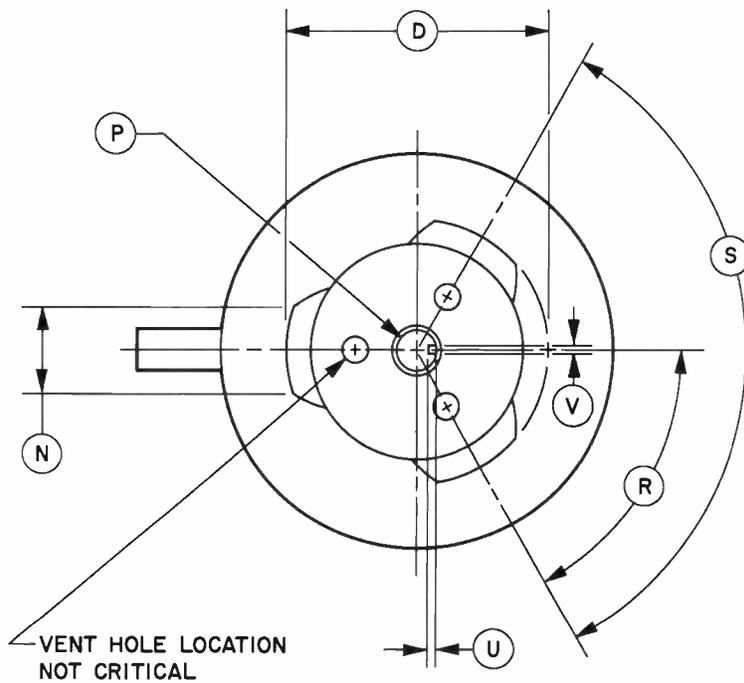
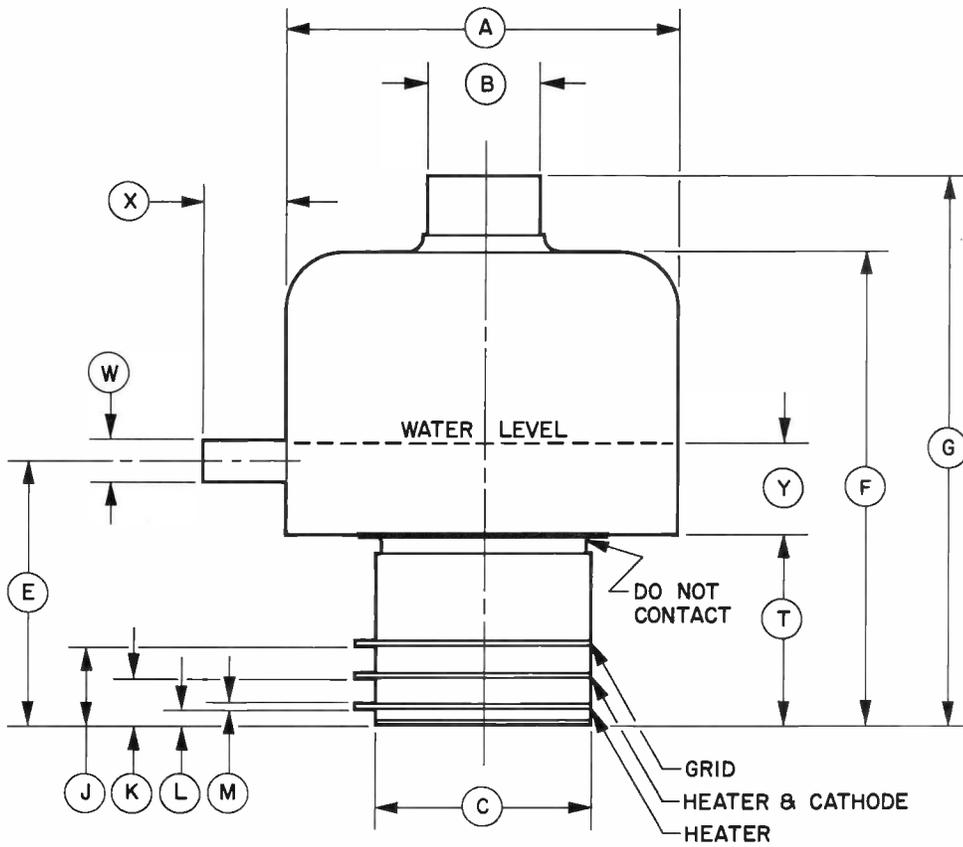
RADIO FREQUENCY RADIATION - Avoid exposure to strong rf fields even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. Under 30 MHz, most of the energy will pass completely through the human body with little attenuation or heating effect. Public health agencies are concerned with the hazard, however, even at these frequencies, and it is worth noting that some commercial dielectric heating units actually operate at frequencies as low as the 13 and 27 MHz bands.

INTERELECTRODE CAPACITANCE - The actual internal interelectrode capacitance of a tube is influenced by many variables in most applications, such as stray capacitance to the chassis, capacitance added by the socket used, stray capacitance between tube terminals, and wiring effects. To control the actual capacitance values within the tube, as the key component involved, the industry and the Military Services use a standard test procedure as described in Electronic Industries Association Standard RS-191. This requires the use of specially constructed test fixtures which effectively shield

all external tube leads from each other and eliminates any capacitance reading to "ground". The test is performed on a cold tube. Other factors being equal, controlling internal tube capacitance in this way normally assures good interchangeability of tubes over a period of time, even when the tube may be made by different manufacturers. The capacitance values shown in the manufacturer's technical data, or test specifications, normally are taken in accordance with Standard RS-191.

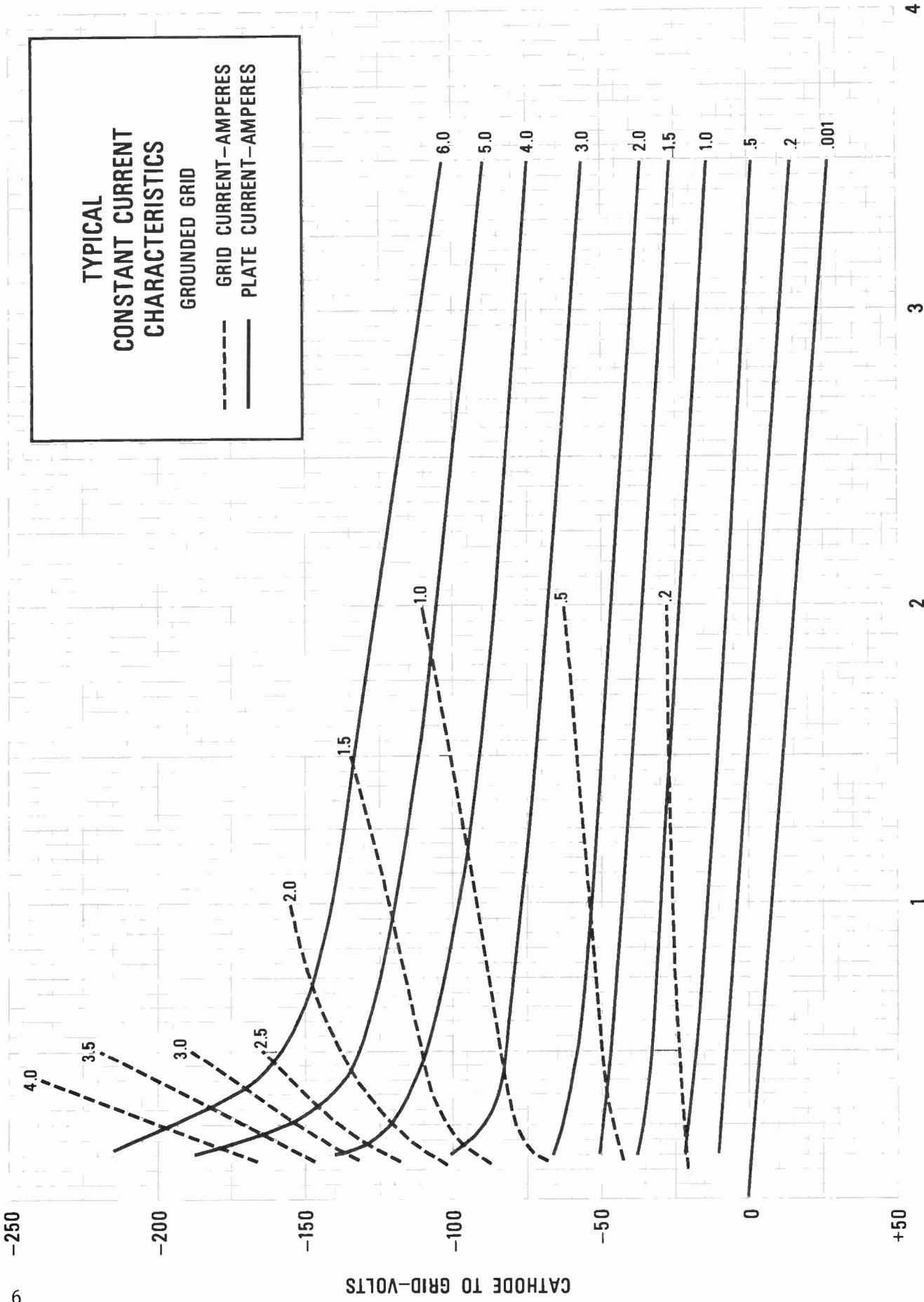
The equipment designer is therefore cautioned to make allowance for the actual capacitance values which will exist in any normal application. Measurements should be taken with the socket and mounting which represent approximate final layout if capacitance values are highly significant in the design.

SPECIAL APPLICATION - If it is desired to operate this tube under conditions widely different from those listed here, write to Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070, for information and recommendations.



DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	--	--	3.355	--	--	85.22
B	--	--	1.000	--	--	25.40
C	1.870	1.900	--	47.50	48.26	--
D	2.250	2.300	--	57.15	58.42	--
E	--	--	2.400	--	--	60.96
F	4.190	4.315	--	106.43	109.60	--
G	4.850	5.110	--	123.19	129.79	--
J	0.690	0.710	--	17.53	18.03	--
K	0.415	0.435	--	10.54	11.05	--
L	0.140	0.165	--	3.57	4.19	--
M	0.020	0.030	--	0.50	0.76	--
N	0.700	0.800	--	17.78	20.32	--
P	0.314	0.316	--	7.98	8.03	--
R	55°	65°	--	55°	65°	--
S	115°	125°	--	115°	125°	--
T	--	--	1.720	--	--	43.69
U	0.025	0.048	--	0.64	1.22	--
V	0.045	0.070	--	1.14	1.78	--
W	--	--	0.375	--	--	9.53
X	--	--	0.750	--	--	19.05
Y	0.500	1.000	--	--	--	--

NOTES:
 1. REF. DIMENSIONS ARE FOR INFO.
 ONLY & ARE NOT REQUIRED FOR
 INSPECTION PURPOSES.





EIMAC
 A Division of Varian Associates
 CALIFORNIA

3CW5000H3
 INDUSTRIAL
 MEDIUM-MU
 WATER-COOLED
 POWER TRIODE

The EIMAC 3CW5000H3 is a water-cooled, ceramic-metal power triode designed primarily for use in industrial radio-frequency heating services. Its water-cooled anode is conservatively rated at 5 kilowatts of plate dissipation with low water flow and pressure drop.

Input of 12.5 kilowatts is permissible up to 75 megahertz. Plentiful reserve emission is available from its 375 watt filament. The grid structure is rated at 150 watts making this tube an excellent choice for severe applications.

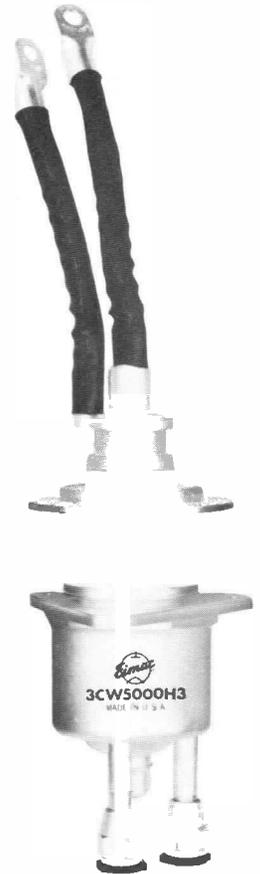
GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated-Tungsten	<u>Min.</u>	<u>Nom.</u>	<u>Max.</u>	
Voltage - - - - -		7.5		Volts
Current - - - - -	48		53	amps
Amplification Factor - - - - -		20		
Interelectrode Capacitances, Grounded Cathode Connection:				
Grid-Filament - - - - -	29.2		40.2	$\mu\mu\text{f}$
Plate-Filament - - - - -	0.60		1.20	$\mu\mu\text{f}$
Grid-Plate - - - - -	17.8		24.2	$\mu\mu\text{f}$
Frequency for Maximum Ratings -			75	MHz

MECHANICAL

Base - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	See Outline
Operating Position - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	Vertical, base up or down
Cooling - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	Water and Forced Air
Maximum Operating Temperatures -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	250°C
Maximum Dimensions:										
Height - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	See Outline
Diameter - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	See Outline
Net Weight - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	7.5 Pounds



THESE SPECIFICATIONS ARE BASED ON DATA APPLICABLE AT PRINTING DATE. SINCE EIMAC HAS A POLICY OF CONTINUING PRODUCT IMPROVEMENT, SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

RF INDUSTRIAL OSCILLATOR

Class-C (Filtered DC Power Supply)

MAXIMUM RATINGS:

DC PLATE VOLTAGE - - - -	6000 volts
DC PLATE CURRENT - - - -	2.5 amps
DC GRID VOLTAGE - - - -	—1000 volts
DC GRID CURRENT - - - -	0.4 amp
PLATE INPUT POWER - - - -	12.5 kW
PLATE DISSIPATION (NOMINAL) - -	5 kW

TYPICAL OPERATION*

DC Plate Voltage - - - -	4000	6000 volts
DC Plate Current - - - -	2.5	2.08 amps
DC Grid Voltage - - - -	—300	—500 volts
DC Grid Current - - - -	.245	.180 amps
Peak Positive Grid Voltage - -	280	265 volts
Driving Power - - - -	142	136 watts
Plate Input Power - - - -	10,000	12,500 kW
Plate Dissipation - - - -	2,500	2,500 kW
Plate Output Power - - - -	7,500	10,000 kW
Approximate Load Impedance -	910	1,625 ohms

*Loaded Conditions

Note: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves. No allowance for circuit losses has been made.

APPLICATION

ELECTRICAL

Filament

The rated filament voltage for the 3CW5000H3 is 7.5 volts. Filament voltage, as measured at the tube, must be maintained at 7.5 volts plus or minus five percent for maximum tube life and consistent performance.

Control Grid Operation

The grid current rating is 0.4 ampere dc. This value should not be exceeded for more than very short periods such as during tuning. Over-current protection in the grid circuit should be provided. Ordinarily it will not be necessary to operate with more than 0.275 amperes grid current to obtain reasonable efficiency. In industrial heating service with varying loads, grid current should be monitored continuously with a dc current meter. The maximum grid dissipation rating is 150 watts.

Plate Operation

Maximum plate voltage rating of 6000 volts and maximum plate current of 2.5 amperes dc should not be applied simultaneously as rated plate dissipation may be exceeded. The 12.5 kilowatts input rating applies for Class C amplifier or oscillator service with no modulation.

Plate over-current protection should be provided to remove plate voltage quickly in the event of an overload or an arc-over at the load. In addition current limiting power supply resistors should be used. These precautions are especially important in industrial service with its wide variations in loading.

Spark gaps from plate to ground should be used to prevent transient voltages from flashing across the tube envelope during any fault conditions.

High Frequency Operation

The 3CW5000H3 is usable to 110 MHz. At this frequency, plate voltage must be reduced to 4000 volts in Class C service.

MECHANICAL

Mounting

The 3CW5000H3 must be mounted vertically, either base up or down. A grid contact flange is provided for bolting to a strap or a grid deck. Heavy flexible leads are provided for applying the filament voltage.

Cooling

Anode cooling is accomplished by circulating water through the integral anode-water jacket.

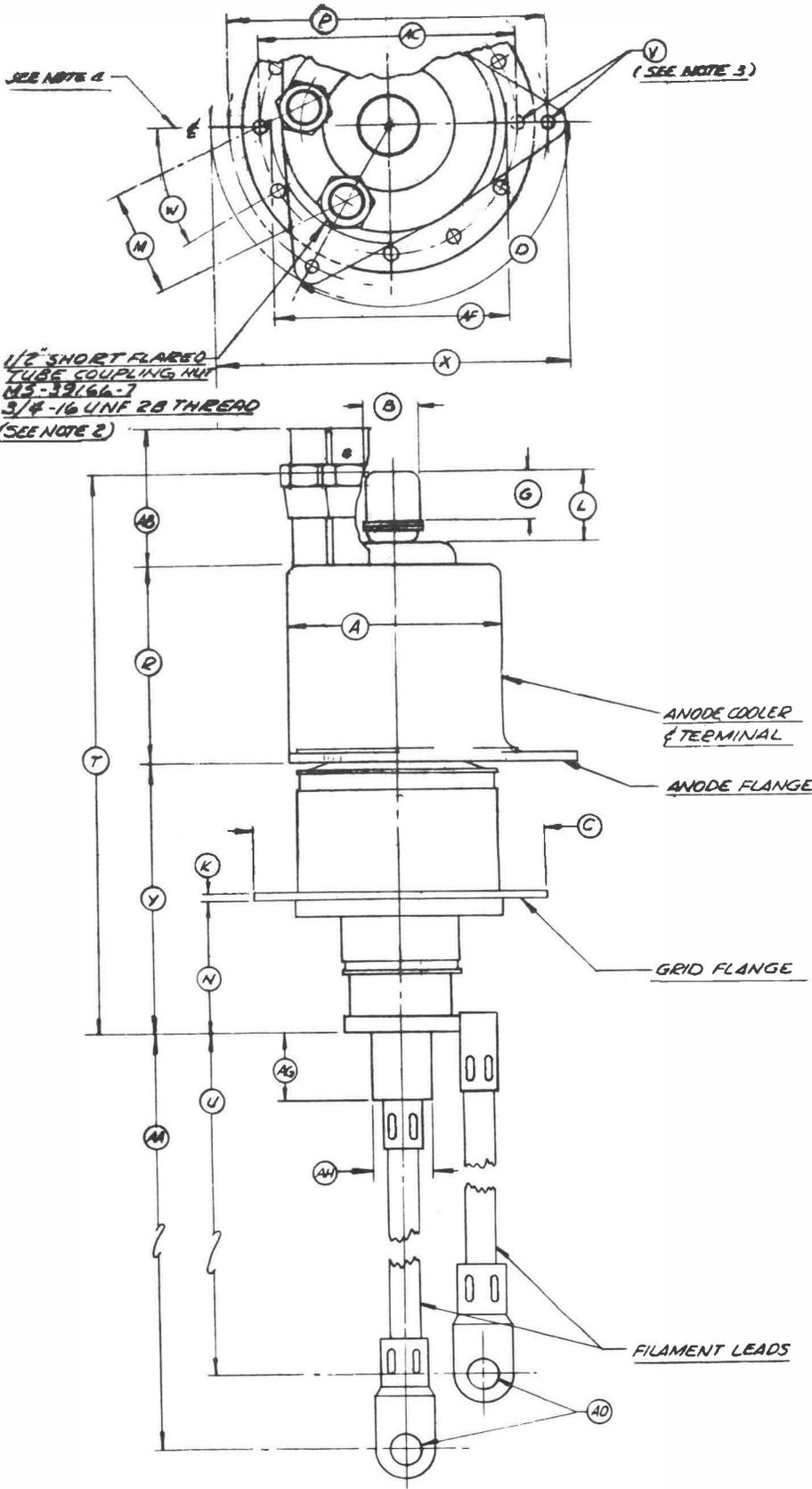
The table below lists the minimum water flow requirement for adequate anode cooling at various plate dissipation levels. In all cases, the outlet water temperature must not exceed 70°C nor should inlet water pressure exceed 60 psi. This table is based upon 15°C temperature rise inlet to outlet water.

MINIMUM WATER-COOLING REQUIREMENT		
Plate Dissipation (kW)	Water Flow (gpm)	Pressure Drop (psi)
3.0	0.65	0.27
5.0	1.10	0.70
7.0	1.75	1.75

Additional stem cooling air must be provided. 13 CFM of air directed against the center filament contact ring $\frac{1}{2}$ " below the outer filament contact ring by a $1\frac{1}{2}$ " I.D. air duct arranged at a 45° angle with the center line of the tube will provide adequate cooling.

Special Application

If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Division, EIMAC, Division of Varian, 301 Industrial Way, San Carlos, California for information and recommendations.



DIMENSIONS IN INCHES			
DIMENSIONAL DATA			
DIML.	MIN.	MAX.	REF.
A	3.300	3.400	
B	.780	.883	
C	4.230	4.250	
D	118°	122°	
G	.687	.812	
K			.125
L	1.000	1.125	
M			1.500
N	1.703	1.953	
P	4.615	4.635	
R	2.625	2.875	
T	8.000	9.000	
U	7.937	8.837	
V			.250
W	29°	31°	
X	5.330	5.420	
Y	3.875	4.250	
AA	8.937	9.437	
AB			2.000
AC	3.855	3.885	
AD			.390
AF			3.625
AG	.812	.937	
AH	.859	.890	

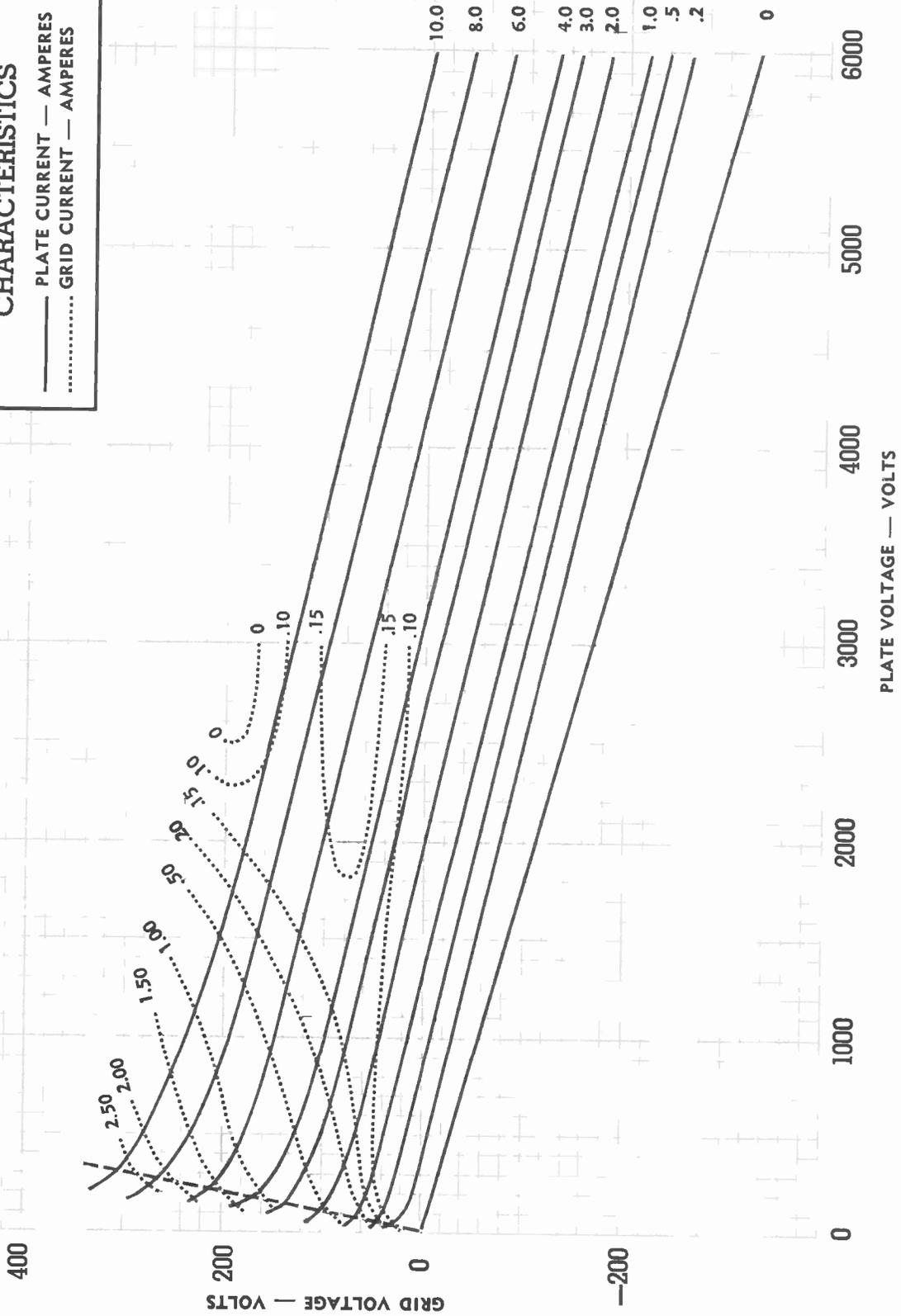
NOTE:
 1. REF. DIM. ARE FOR INFO ONLY & ARE NOT REQ'D FOR INSP. PURPOSES.
 2. EITHER FITTING CAN BE USED AS INLET OR OUTLET.
 3. 3 HOLES IN ANODE FLANGE, 12 HOLES IN GRID FLANGE.
 4. MTG. FLANGE, FIL. LEADS & WATER FITTINGS ARE TO BE ORIENTED AS SHOWN.

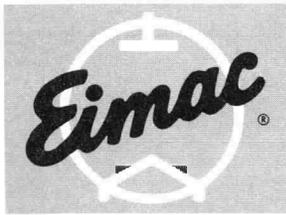


3CW5000H3

EIMAC 3CW5000H3 CONSTANT CURRENT CHARACTERISTICS

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

3CW25,000A3

MEDIUM-MU

**WATER-COOLED
POWER TRIODE**

The Eimac 3CW25,000A3 is a water-cooled, ceramic-metal power triode designed primarily for use in industrial radio-frequency heating services. Its water-cooled anode is rated at 25 kilowatts of plate dissipation with low water flow and pressure drop.

Full input of 60 kilowatts is permissible up to 100 megacycles. Plentiful reserve emission is available from its one kilowatt filament. The grid structure is rated at 500 watts making this tube an excellent choice for severe applications.

It is also recommended as a grounded grid FM amplifier, a conventional plate-modulated amplifier or as a linear amplifier in new equipment designs.



GENERAL CHARACTERISTICS

ELECTRICAL	Min.	Nom.	Max	
Filament: Thoriated-Tungsten				
Voltage		6.3		volts
Current	152		172	amperes
Amplification Factor		20		
Interelectrode Capacitances, Grounded Cathode:				
Grid-Filament	48		58	$\mu\mu\text{f}$
Plate-Filament	1.2		1.5	$\mu\mu\text{f}$
Grid-Plate	30		38	$\mu\mu\text{f}$
Frequency for Maximum Ratings				100 Mc

MECHANICAL	
Base	Coaxial
Recommended Socket	Eimac SK-1300
Operating Position	Vertical, base up or down
Cooling	Water & Forced air
Maximum Operating Temperatures:	
Ceramic-to-Metal Seals	250°C
Maximum Dimensions:	
Height	9.4 inches
Diameter	5.0 inches
Net Weight	12 pounds

RF INDUSTRIAL OSCILLATOR

Class-C (Filtered DC Power Supply)

MAXIMUM RATINGS

DC PLATE VOLTAGE	10,000 VOLTS
DC PLATE CURRENT	6.0 AMPS
DC GRID CURRENT	1.0 AMP
PLATE INPUT POWER	60 KW
PLATE DISSIPATION	25 KW

TYPICAL OPERATION

DC Plate Voltage	7000	10,000	volts
DC Plate Current	6.0	6.0	amps
DC Grid Voltage	-600	-800	volts
DC Grid Current . . . . .	.66	.315	amps
Peak Positive Grid Voltage	440	360	volts
Driving Power	660	365	watts
Plate Input Power	42	60	kW
Plate Dissipation	12	18	kW
Plate Output Power	30	42	kW
Approximate Load Impedance	600	750	ohms



**RADIO-FREQUENCY POWER AMPLIFIER
PLATE-MODULATED**

Class-C

MAXIMUM RATINGS

DC PLATE VOLTAGE	7000 MAX. VOLTS
DC PLATE CURRENT	5.0 MAX. AMPS
PLATE DISSIPATION	16.5 MAX. KW
GRID DISSIPATION	500 MAX. WATTS

TYPICAL OPERATION

DC Plate Voltage	5000	7000 volts
DC Grid Voltage	-600	-820 volts
DC Plate Current	5.0	5.0 amps
DC Grid Current	600	600 mA
Driving Power	600	750 watts
Plate Output Power	17.8	27.5 kW

**RADIO-FREQUENCY
LINEAR AMPLIFIER Class-AB₂**

MAXIMUM RATINGS

DC PLATE VOLTAGE	10000 MAX. VOLTS
DC PLATE CURRENT	6.0 MAX. AMPS
PLATE DISSIPATION	25 MAX. KW
GRID DISSIPATION	500 MAX. WATTS

TYPICAL OPERATION

DC Plate Voltage	7000	10000 volts
DC Grid Voltage*	-250	-400 volts
Zero-Sig Plate Current	2.0	2.0 amps
Max-Sig DC Plate Current	6.0	6.0 amps
Max-Sig DC Grid Current	375	333 mA
Peak RF Grid Voltage	530	700 volts
Driving Power	200	240 watts
Plate Output Power	26.4	41 kW

*Adjust to give specified zero-signal dc plate current

Note: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves. No allowance for circuit losses has been made.

APPLICATION

ELECTRICAL

Filament—The rated filament voltage for the 3CW-25,000A3 is 6.3 volts. Filament voltage, as measured at the socket, must be maintained at 6.3 volts plus or minus five percent for maximum tube life and consistent performance.

Control Grid Operation—The grid current rating is one ampere dc. This value should not be exceeded for more than very short periods such as during tuning and over-current protection in the grid circuit should be provided. Ordinarily it will not be necessary to operate with more than 0.4 to 0.6 amperes grid current to obtain reasonable efficiency. In industrial heating service with varying loads, grid current should be monitored continuously with a dc current meter. The maximum grid dissipation rating is 500 watts.

Plate Operation—The maximum plate input power rating is 60 kilowatts at 10,000 volts and 6.0 amperes dc. This rating applies for Class C amplifier or oscillator

service and for Class AB applications. When used as a plate modulated rf amplifier, input is reduced to 7000 volts at 5.0 amperes dc. Maximum input may be exceeded for short periods during tuning without exceeding plate dissipation ratings.

Plate over-current protection should be provided to remove plate voltage quickly in the event of an overload or an arc-over at the load. In addition current limiting power supply resistors should be used. These precautions are especially important in industrial service with its wide variations in loading.

Spark gaps from plate to ground should be used to prevent transient voltages from flashing across the tube envelope during any fault conditions.

High Frequency Operation—The 3CW25,000A3 is usable to 140 Mc. At this frequency, plate voltage must be reduced to 7000 volts in class A, B or C service. For plate-modulated applications at 140 Mc, plate voltage is reduced to 5500 volts.



Mounting—The 3CW25,000A3 must be mounted vertically, either base up or down. Where the tube is installed in a base up position, it is suggested that any clamping pressure or rf contact be made only in the area shown as “V” on the outline drawing.

Socket—The Eimac SK-1300 socket is used with the 3CW25,000A3 for making connections to the filament and grid. Where the socket is to be removable—as in base-up operation—the SK-1310 should be used.

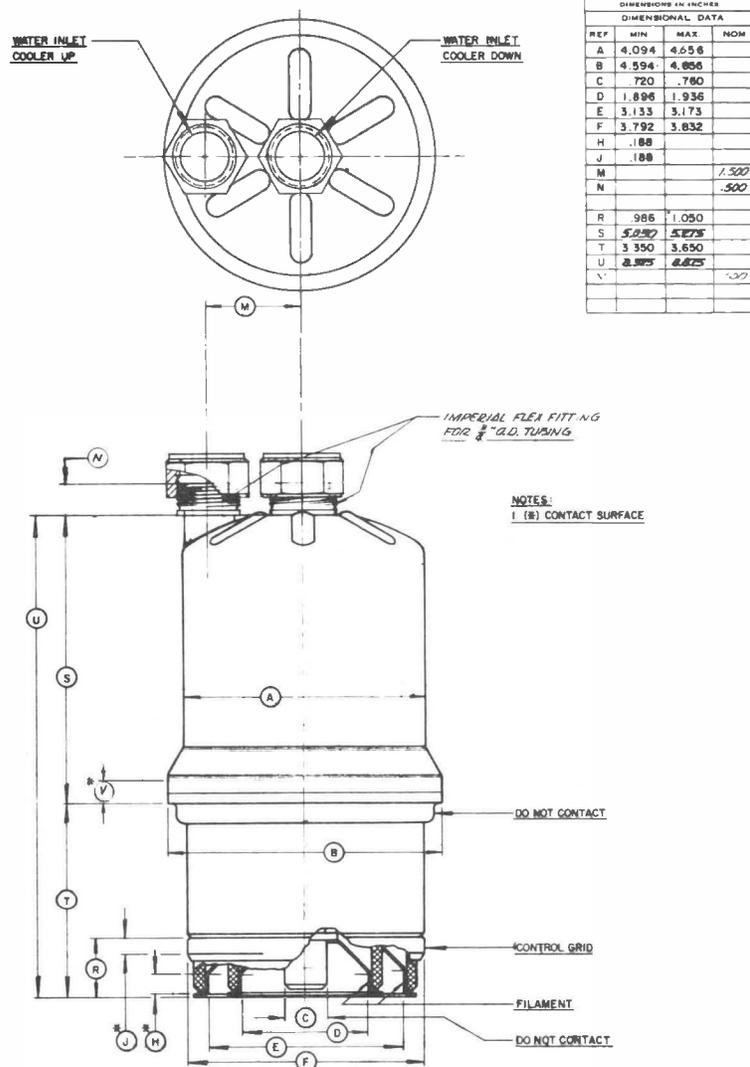
Cooling—Anode cooling is accomplished by circulating water through the integral anode-water jacket. With the tube in the anode-up position the water inlet is the outer water fitting and the outlet will be the center water fitting. When the tube is mounted base up, these are reversed.

The table below lists the minimum water flow requirement for adequate anode cooling at various plate dissipation levels. In all cases, inlet water temperature must be limited to 60°C or below, outlet water temperature must not exceed 70°C nor should inlet water pressure exceed 60 psi.

Minimum Water-Cooling Requirement		
Plate Dissipation (kW)	Water Flow (GPM)	Pressure Drop (PSI)
10	6	0.2
15	9	0.4
20	12	0.7
25	15	1.1

Additional forced-air cooling of the tube’s base is also required to maintain ceramic-to-metal seal temperatures below the 250°C maximum. Approximately 50 cfm of cooling air directed into the base structure, through the socket will generally satisfy this requirement.

Special Application—If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California for information and recommendations.



DIMENSIONS IN INCHES			
DIMENSIONAL DATA			
REF	MIN	MAX	NOM
A	4.094	4.656	
B	4.594	4.856	
C	.720	.760	
D	1.896	1.936	
E	3.133	3.173	
F	3.792	3.832	
H	.188		
J	.188		
M		1.500	
N		.500	
R	.986	1.050	
S	5.080	5.275	
T	3.350	3.650	
U	8.875	8.875	
V		.100	

NOTES:
1 (B) CONTACT SURFACE



3CW25,000A3

EIMAC 3CW25,000A3

TYPICAL

CONSTANT CURRENT CHARACTERISTICS

- PLATE CURRENT — AMPERES
- - - GRID CURRENT — AMPERES

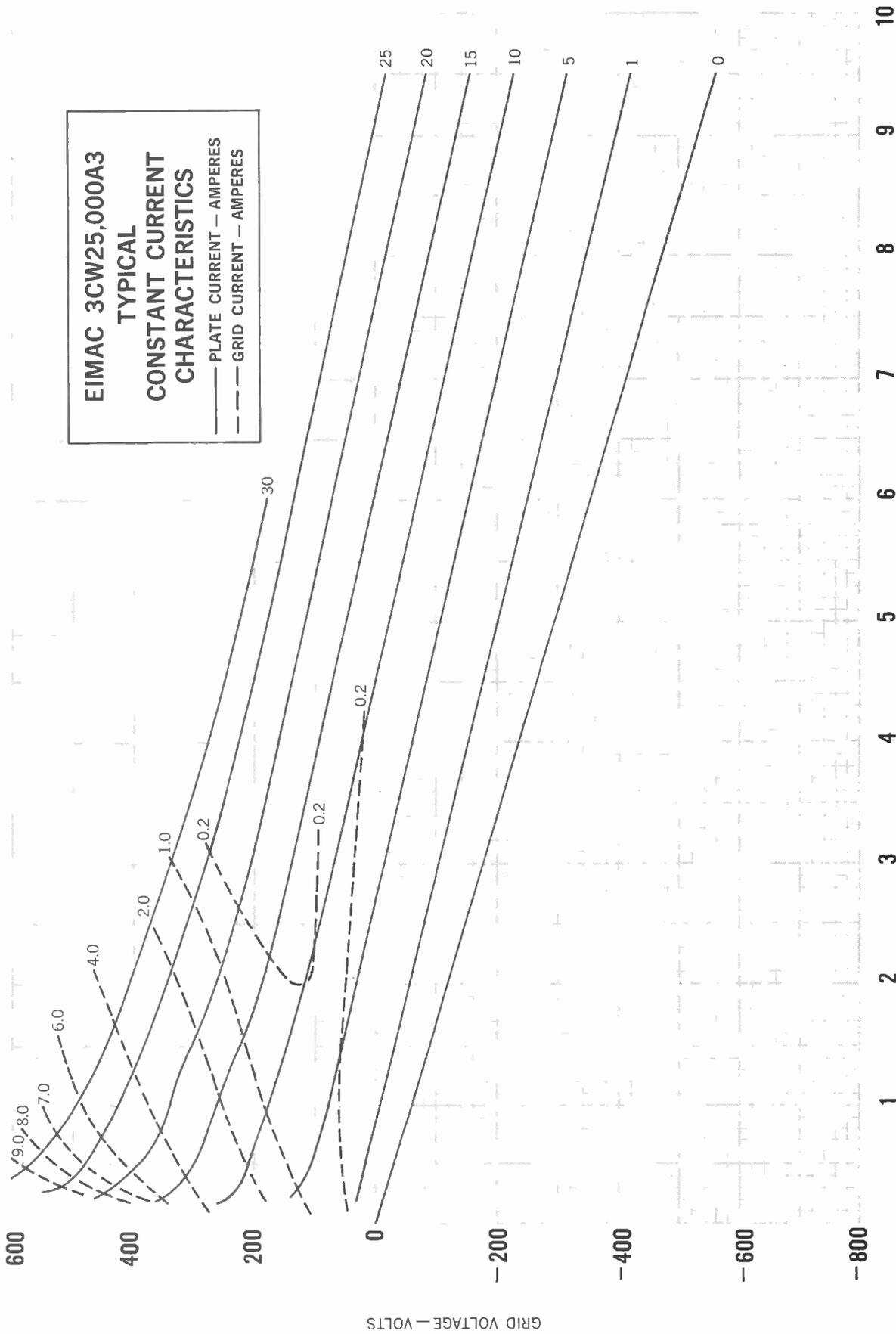
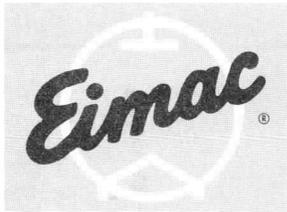


PLATE VOLTAGE — KILOVOLTS



EITEL-McCULLOUGH, INC.
SAN CARLOS CALIFORNIA

7289
3CX100A5
8250
3CX100F5

HIGH-MU UHF
TRIODES

The Eimac 7289/3CX100A5 and 8250/3CX100F5 are ceramic-and-metal planar UHF triodes intended to supersede 2C39 types. The 7289/3CX100A5 has a 6.0-volt heater, while the 8250/3CX100F5 has a 26.5-volt heater. They are manufactured to exacting dimensional tolerances to provide the greatest mechanical uniformity. Extended and critical electrical testing results in increased reliability and a minimum variation in electrical characteristics. Full ratings apply at altitudes up to 60,000 feet and they are capable of sustained, reliable operation at elevated temperatures.

The mechanical and electrical characteristics of these tubes make them desirable for grid isolation circuits in cavity devices. They will deliver 27 watts of useful power at 500 megacycles and at 2900 megacycles, 9.5 watts of useful power can be realized.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode:	Oxide-coated, Unipotential						
	Heating time				60		Seconds
Heater		MIN.	NOM.	MAX.			
	3CX100A5 Voltage (see applications)		6.0				Volts
	Current ($E_f = 6.0$ volts)	0.90		1.05			Amperes
	3CX100F5 Voltage (see applications)		26.5				Volts
	Current ($E_f = 26.5$ volts)	0.20		0.24			Amperes
Amplification Factor			100				
Transconductance ($I_b = 70$ milliamperes)			25,000				Micromhos
Direct Interelectrode Capacitance							
	C _{gk}		5.6		7.0		$\mu\mu f$
	C _{gp}		1.95		2.15		$\mu\mu f$
	C _{pk}				0.035		$\mu\mu f$
Frequency for Maximum Ratings					2500		Megacycles

MECHANICAL

Terminals:	Graduated Cylindrical Surfaces	
Maximum Operating Temperatures		
	Ceramic to Metal Seals	250°C (300°C short term overload value)
	Anode Core	250°C (300°C short term overload value)
Operating Position		Any
Cooling		Forced Air
Maximum Overall Dimensions		
	Length	2.701 Inches Max.
	Diameter	1.264 Inches Max.
Net Weight		2.5 Ounces
Shipping Weight (approx.)		7.0 Ounces



RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR

MAXIMUM RATING (Per Tube)	
DC PLATE VOLTAGE	1000 VOLTS MAX.
DC CATHODE CURRENT	0.125 AMP. MAX.
DC GRID VOLTAGE	-150 VOLTS MAX.
DC GRID CURRENT	0.050 AMP. MAX.
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE	30 VOLTS MAX.
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE	-400 VOLTS MAX.
PLATE DISSIPATION	100 WATTS MAX.
GRID DISSIPATION	2 WATTS MAX.

TYPICAL OPERATION (Per Tube)

	Power Amplifier Grounded-Grid (Key-down conditions)		
	500 Mc	2500 Mc	2900 Mc
DC PLATE VOLTAGE	800	900	1000 Volts
DC GRID VOLTAGE (approx.)	-20	-22	-9.5 Volts
DC PLATE CURRENT	80	90	100 Milliamp.
DC GRID CURRENT (approx.)	30	25	15 Milliamp.
DRIVING POWER (approx.)	6		Watts
USEFUL OUTPUT POWER	27	15	9.5 Watts

PLATE MODULATED RADIO FREQUENCY AMPLIFIER OR OSCILLATOR

MAXIMUM RATINGS (Per Tube)	
DC PLATE VOLTAGE	600 VOLTS MAX.
DC CATHODE CURRENT	0.100 AMP. MAX.
DC GRID VOLTAGE	-150 VOLTS MAX.
DC GRID CURRENT	0.050 AMP. MAX.
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE	30 VOLTS MAX.
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE	-400 VOLTS MAX.
PLATE DISSIPATION	70 WATTS MAX.
GRID DISSIPATION	2 WATTS MAX.

TYPICAL OPERATION (Per Tube)

500 Mc, Grounded-Grid, Carrier Conditions.	
DC PLATE VOLTAGE	600 Volts
DC GRID VOLTAGE (approx.)	-15 Volts
DC PLATE CURRENT	65 Milliamp.
DC GRID CURRENT (approx.)	35 Milliamp.
DRIVING POWER (approx.)	5 Watts
USEFUL CARRIER POWER OUTPUT	16 Watts



APPLICATION

MECHANICAL

Mounting — The 3CX100A5 and 3CX100F5 may be operated in any position. They should be firmly held in place by spring-finger collets bearing on the terminal surfaces. In use the tubes should seat against the under side of the anode-terminal flange which is on the plane of reference for longitudinal dimensions. In applications involving severe shock and vibration, the tubes may be clamped in place by applying a suitable clamping device to the anode-terminal flange. It is recommended that no other portion of the tube be subjected to clamping forces.

Connections — The terminals of each tube are in the form of concentric cylinders of graduated diameters so that they may be conveniently used with coaxial tuning devices. Spring-fingered collets should be used to make contact with the anode, grid, cathode and heater terminals. Adequate contact area and spring pressure should be provided to minimize heating and to prevent erratic circuit performance at the higher frequencies. Non-contacting or intermittently-contacting collet fingers will cause troublesome circuit behavior, especially at very-high and ultra-high frequencies. Electrode contact surfaces should be kept clean and free of oxide coatings.

Cooling — Sufficient cooling must be provided for the anode and body seals to maintain operating temperatures below the rated maximum values:

Ceramic to Metal Seals	250°C	(300°C short term overload value)
Anode Core	250°C	(300°C short term overload value)

At sea level, with an inlet air temperature of 20°C (68°F), 12.5 cubic feet per minute of air flow is required to cool the anode at 100 watts plate dissipation when the air cowling as illustrated is used. Operation at higher altitudes or with higher inlet temperatures requires increased volumes of flow to obtain equivalent cooling. When using the anode cowling as illustrated here, it is necessary to provide additional facilities for seal cooling.

It should be borne in mind that operating temperature is the sole criterion of cooling effectiveness, regardless of the coolant type, flow rate or coolant temperature. One method of measuring the surface temperatures is the use of temperature sensitive lacquer, such as "Tempilaq." This product can be obtained from the Tempil Corp., 132-34 West 22nd Street, New York 11, New York. When temperature sensitive materials are used, extremely thin applications must be used to avoid interference with the transfer of heat from the tube to the air stream, which would cause inaccurate indications.

ELECTRICAL

Heater Operation — The rated heater voltage for the 3CX100A5 is 6.0 volts, and for the 3CX100F5 26.5 volts. The working voltage should be selected from the table below. The heater voltage for each type should be maintained within plus or minus of 5% of its intended value to minimize variations in circuit performance and to obtain maximum tube life.

At frequencies above approximately 1000 megacycles, transit time effects begin to influence the cathode temperature. The amount of driving power diverted to heating the cathode by back-bombardment will depend upon the frequency, the plate current and driving power being supplied to the tube. If the conditions of operation result in appreciable cathode back-heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to the proper value. The following table is intended as a general guide in this respect.

Mc	3CX100A5 Ef	3CX100F5 Ef
Up to 1000 - - - - -	6.0	26.5
1000 to 2000 - - - - -	5.5	24.3
2000 and above - - - - -	5.0	22.1

The heater of the 3CX100A5 must not be operated at less than 4.5 volts in any case, nor should the heater of the 3CX100F5 be operated at less than 20.0 volts in any case.

Cathode Operation — The oxide-coated unipotential cathode in these tubes must be protected against excessively high emission currents. For all types of operation the maximum rated dc current is 125 milliamperes. The cathode and one side of the heater are connected together internally.

It is recommended that the rated heater voltage be applied for a minimum of 30 seconds before other operating voltages are applied. Tube performance will become stabilized 60 seconds after the heater voltage is applied.

Control Grid Operation — Grid dissipation must not exceed the rated maximum 2.0 watts grid dissipation power.

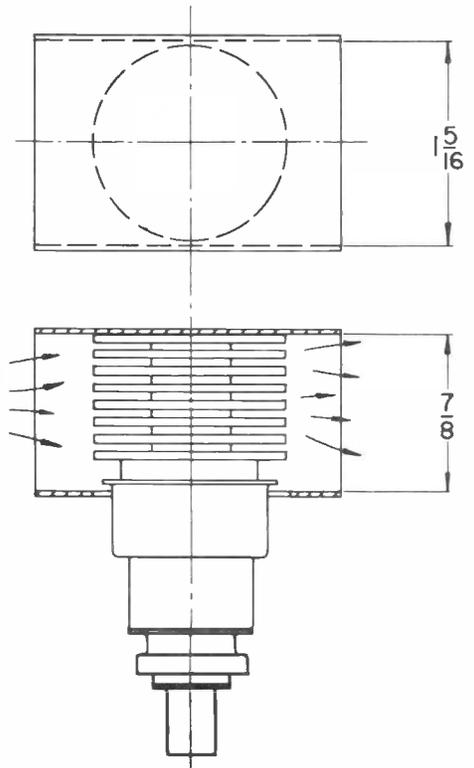
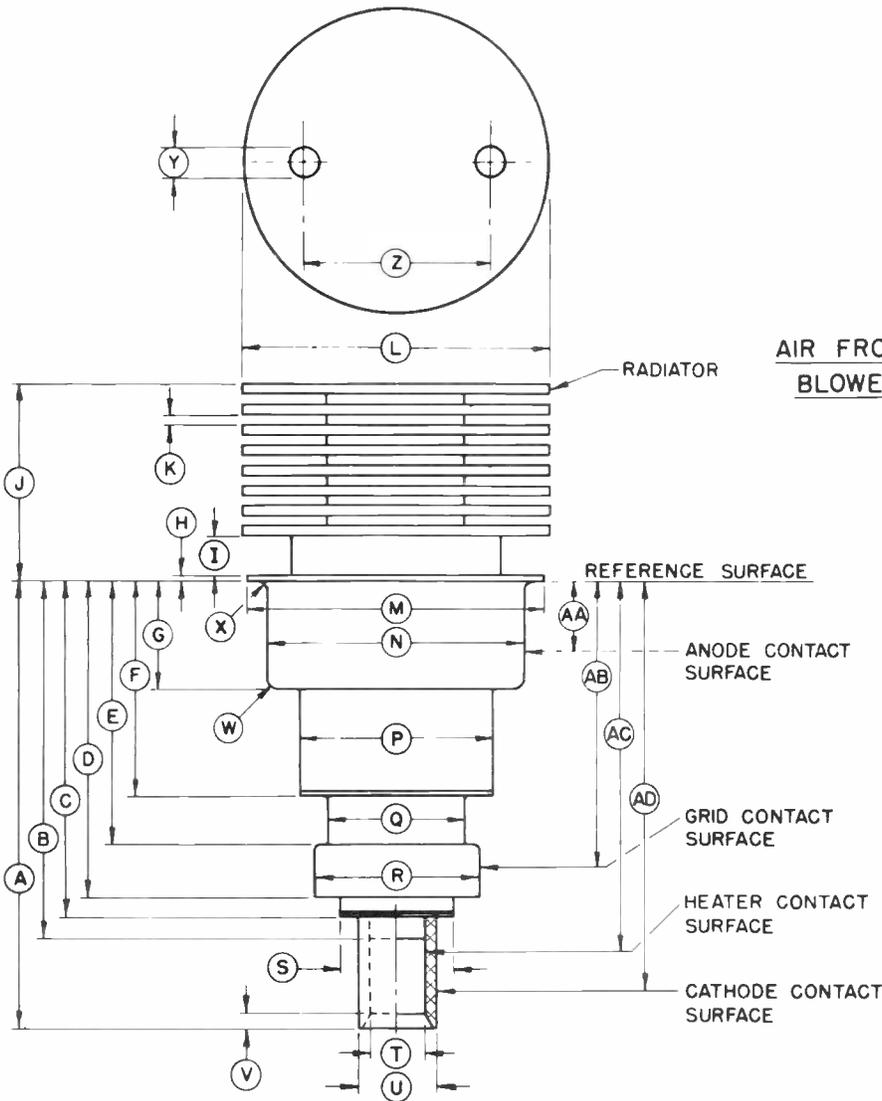
At operating frequencies near 500 megacycles, the driving power necessary for maximum output is in the order of 6 watts and as the operating frequency is increased the driving power requirements increase. Most of this increased driving power is absorbed in circuit losses other than grid dissipation, however, so that the grid dissipation will increase very little.

The maximum rated dc grid voltage is —150 volts and the grid may be driven to a maximum of 30 peak volts positive or to —400 peak volts negative.

The grid bias required by various individual tubes may vary between limits approximately 50% above and below the center value, and means should be provided in the equipment to accommodate such variation.

Plate Operation — The maximum rated plate dissipation power is 100 watts. In plate modulated applications, the carrier plate dissipation power must be limited to 70 watts to avoid exceeding the plate dissipation rating with 100% sine wave modulation.

Special Applications — If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California for information and recommendations.

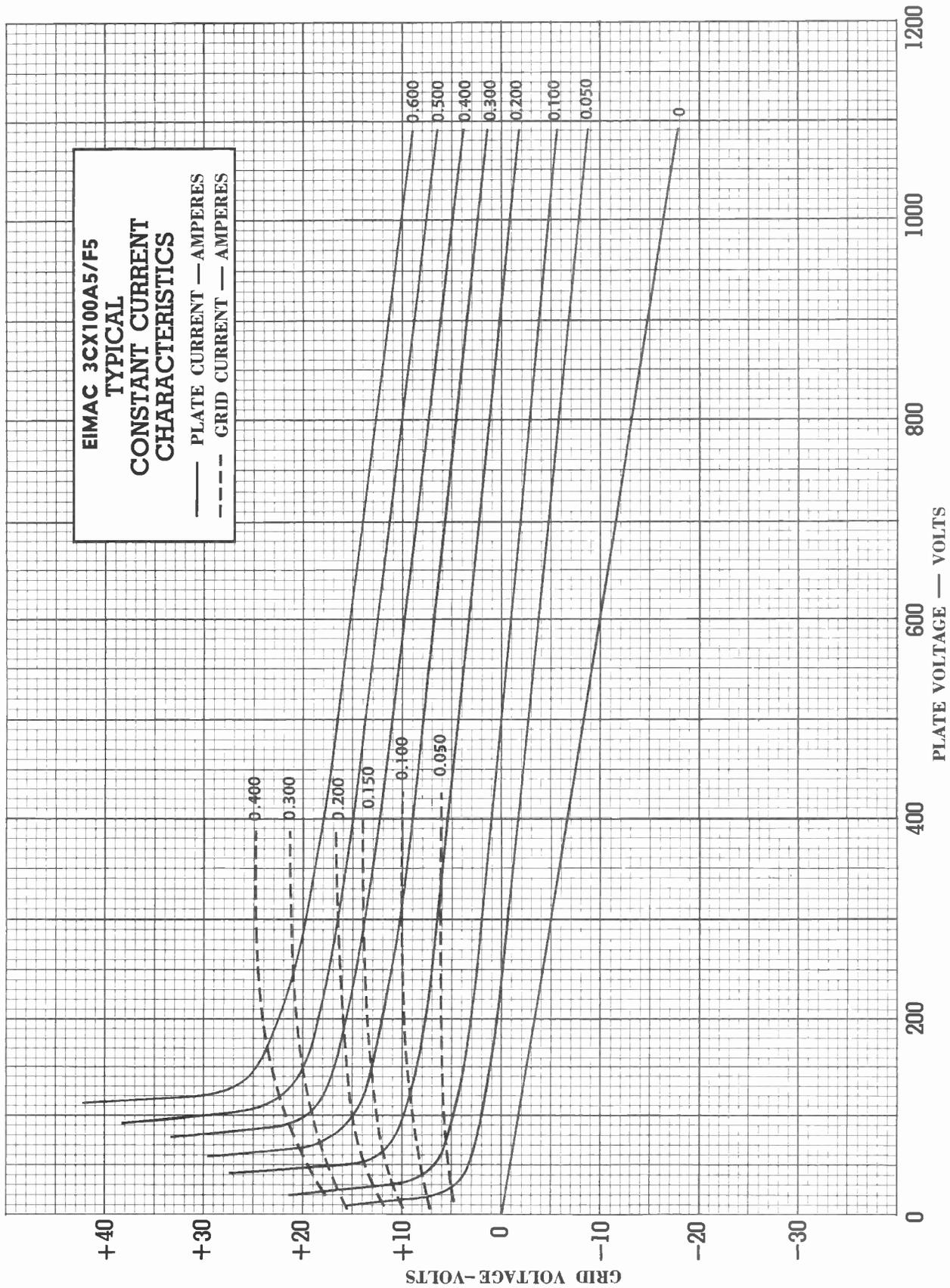


**RECOMMENDED COWLING
FOR
FORCED-AIR COOLING
OF ANODE**

REF.	NOM.	MIN.	MAX.
A		1.815	1.875
B			1.534
C			1.475
D		1.289	1.329
E		1.085	1.135
F		.880	.920
G		.462	.477
H			.040
I		.125	.185
J		.766	.826
K		.025	.046
L		1.234	1.264
M		1.180	1.195
N		1.025	1.035
P		.772	.792
Q		.541	.561
R		.655	.665
S			.545
T		.213	.223
U		.315	.325
V			.086
W			.100
X			.035
Y		.105	.145
Z		.650	.850
AA		.035	.361
AB		1.185	1.265
AC		1.534	1.728
AD		1.475	1.815

NOTES:

1. The total indicated runout of the anode contact surface and the grid contact surface with respect to the cathode contact surface shall not exceed .020.
2. The total indicated runout of the heater contact surface with respect to the cathode contact surface shall not exceed .012.





TECHNICAL DATA

8161
3CX2500A3

MEDIUM MU
TRIODE

The EIMAC 3CX2500A3 is an all ceramic and metal, medium-mu, forced-air cooled, external anode transmitting triode with a maximum plate dissipation rating of 2500 watts. Relatively high power output as an amplifier, oscillator, or modulator may be obtained from this tube at low plate voltages. The 3CX2500A3 is an exact replacement for the EIMAC 3X2500A3 and is suggested for use where higher ambient temperatures are to be expected or greater reliability is required. The all ceramic and metal construction allows a greater margin of safety with respect to tube operating temperatures while permitting higher processing temperatures to insure longer life.

The tube has a rugged, low-inductance cylindrical filament-stem structure, which readily becomes part of a linear filament tank circuit for VHF operation. The grid provides thorough shielding between the input and output circuits for grounded-grid applications and is conveniently terminated in a ring between the plate and filament terminals. The 3CX2500A3 may be installed or removed without the aid of tools.



GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten	Min.	Nom.	Max.	
Voltage	-	7.5	-	volts
Current	-	49	53	amperes
Amplification Factor	-	19	26	
Direct Interelectrode Capacitances				
Grid-Plate	-	16.8	23.2	pF
Grid-Filament	-	29.2	40.2	pF
Plate-Filament	-	0.6	1.2	pF
Tranconductance (I _b =830 ma., E _b =3000 v.)	-	20,000	-	umhos
Highest Frequency for Maximum Ratings	-	-	75	MHz

MECHANICAL

Base	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	See drawing
Mounting	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Vertical, base down or up
Cooling	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Forced Air
Maximum Anode Core and Seal Temperatures	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	250°C
Maximum Over-all Dimensions:																			
Length	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8.6 inches
Diameter	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.16 inches
Net Weight	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6.25 pounds
Shipping Weight (Average)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17 pounds

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Conventional Neutralized Amplifier, (Frequencies below 75 MHz.)
Class-C FM or Telegraphy (Key-down conditions, per tube)

MAXIMUM RATINGS

DC PLATE VOLTAGE	-	6000	VOLTS
DC PLATE CURRENT	-	2.5	AMPS
PLATE DISSIPATION	-	2500	WATTS
GRID DISSIPATION	-	150	WATTS

TYPICAL OPERATION (Frequencies below 75 MHz per tube)

DC Plate Voltage	-	-	-	-	4000	5000	6000	volts
DC Plate Current	-	-	-	-	2.5	2.5	2.08	amps
DC Grid Voltage	-	-	-	-	-300	-450	-500	volts
DC Grid Current*	-	-	-	-	245	265	180	ma
Peak RF Grid Input Voltage*	-	-	-	-	580	750	765	volts
Driving Power*	-	-	-	-	142	197	136	watts
Grid Dissipation*	-	-	-	-	68	78	46	watts
Plate Power Input	-	-	-	-	10,000	12,500	12,500	watts
Plate Dissipation	-	-	-	-	2500	2500	2500	watts
Plate Power Output	-	-	-	-	7500	10,000	10,000	watts

*Approximate values.

**PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER**

Conventional Neutralized Amplifier,
(Frequencies below 75 MHz.)
Class-C Telephony (Carrier conditions,
per tube)

MAXIMUM RATINGS

DC PLATE VOLTAGE - 5000 VOLTS
DC PLATE CURRENT - 2.0 AMPS
PLATE DISSIPATION - 1670 WATTS
GRID DISSIPATION - 150 WATTS

TYPICAL OPERATION (Frequencies below 75 MHz per tube)

DC Plate Voltage	-	-	-	-	-	4000	4500	5000	volts
DC Plate Current	-	-	-	-	-	1.67	1.47	1.25	amps
DC Grid Voltage	-	-	-	-	-	-450	-500	-550	volts
DC Grid Current*	-	-	-	-	-	180	140	150	ma
Peak RF Grid Input Voltage*	-	-	-	-	-	685	715	760	volts
Driving Power*	-	-	-	-	-	125	100	115	watts
Grid Dissipation*	-	-	-	-	-	43	30	32	watts
Plate Power Input	-	-	-	-	-	6670	6615	6250	watts
Plate Dissipation	-	-	-	-	-	1670	1315	950	watts
Plate Power Output	-	-	-	-	-	5000	5300	5300	watts

*Approximate values.

AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

Class-AB or B

MAXIMUM RATINGS

DC PLATE VOLTAGE - 6000 VOLTS
DC PLATE CURRENT - 2.5 AMPS
PLATE DISSIPATION - 2500 WATTS
GRID DISSIPATION - 150 WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

DC Plate Voltage	-	-	-	-	-	4000	5000	6000	volts
DC Grid Voltage ¹	-	-	-	-	-	-150	-190	-240	volts
Zero-Signal DC Plate Current	-	-	-	-	-	0.6	0.5	0.4	amps
Max-Signal DC Plate Current	-	-	-	-	-	4.0	3.2	3.0	amps
Effective Load, Plate to Plate	-	-	-	-	-	2200	3600	4650	ohms
Peak AF Grid Input Voltage (per tube)*	-	-	-	-	-	340	360	390	volts
Max-Signal Peak Driving Power*	-	-	-	-	-	340	230	225	watts
Max-Signal Nominal Driving Power*	-	-	-	-	-	170	115	113	watts
Max-Signal Plate Output Power	-	-	-	-	-	11,000	11,000	13,000	watts

*Approximate values.

¹Adjust to give listed zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EIMAC DIVISION OF VARIAN, FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

Cooling—Forced-air cooling must be provided to hold the ceramic-to-metal seals and anode core temperature below the maximum rating of 250°C. At ambient temperatures above 50°C, at higher altitudes and at operating temperatures above 30 MHz, additional air flow must be provided. Sea level and 10,000 foot altitude air-flow requirements to maintain seal temperatures below 200°C in 50°C ambient air are tabulated below (for operation below 30 MHz).

Anode-to-Base Air Flow ¹				
Sea Level			10,000 Feet	
Anode Dissipation Watts	Air Flow CFM	Pressure Drop Inches Water	Air Flow CFM	Pressure Drop Inches Water
1500	33	.6	48	.9
2500	66	1.25	96	1.82

Base-to-Anode Air Flow				
Sea Level			10,000 Feet	
Anode Dissipation Watts	Air Flow CFM	Pressure Drop Inches Water	Air Flow CFM	Pressure Drop Inches Water
1500	32	.6	47	.9
2500	57	1.0	83	1.5

*Since the power dissipated by the filament represents about 400 watts and since grid dissipation can, under some conditions represent another 150 watts, allowance has been made in preparing this tabulation for an additional 550 watts.

¹ When air is supplied in the anode-to-base direction, a minimum of 3 cfm must be directed into the filament-stem structure between the inner and outer filament terminals to maintain the base seals below 250°C. No separate air is required with base-to-anode airflow.

Simultaneous removal of all power and air (as in the case of a power failure) will not

ordinarily injure the tube, but it is recommended that cooling airflow continue for at least three minutes after filament power has been removed.

Filament Voltage — The filament voltage, as measured directly at the tube, should be 7.5 volts with maximum allowable variations due to line fluctuation of from 7.12 to 7.87 volts.

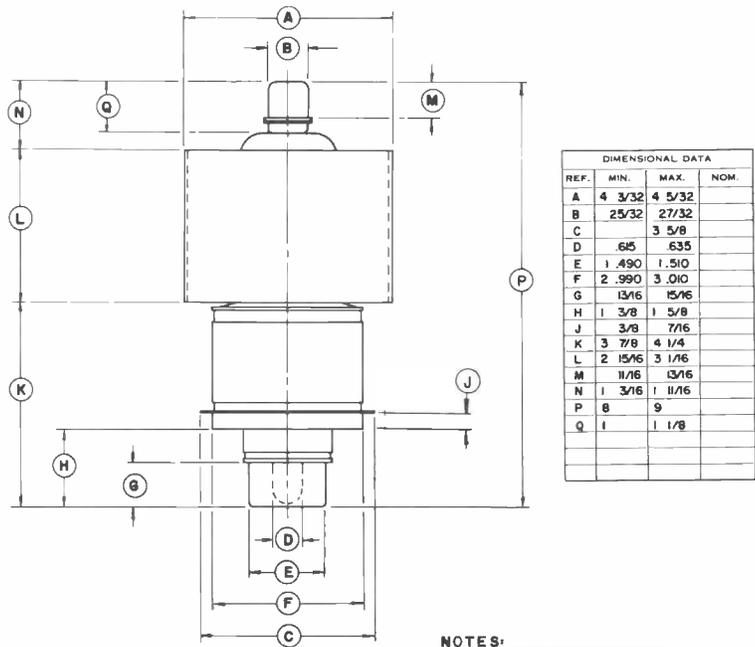
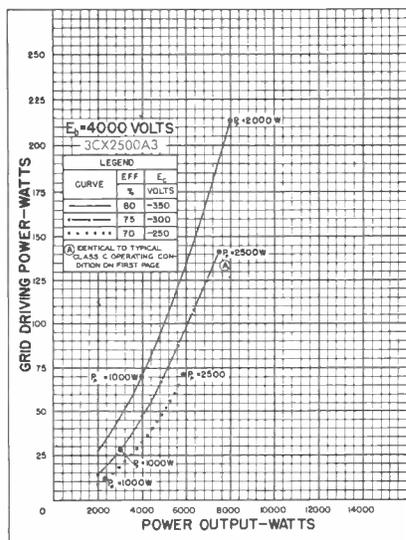
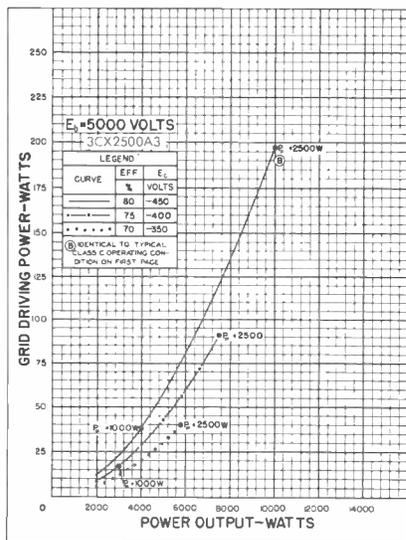
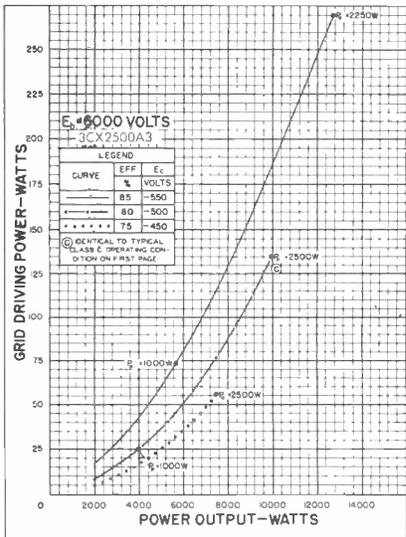
Bias Voltage — There is little advantage in using bias voltages in excess of those given under "TYPICAL OPERATION" except in certain very specialized applications. Where bias is obtained from a grid resistor, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage — The plate-supply voltage for the 3CX2500A3 should not exceed 6000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "TYPICAL OPERATION" for the power output desired.

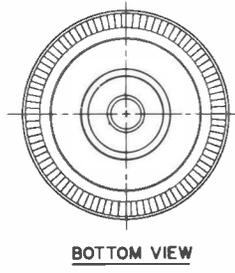
Grid Dissipation — The power dissipated by the grid of the 3CX2500A3 must never exceed 150 watts. Grid dissipation is the product of dc current and peak positive grid voltage.

In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.

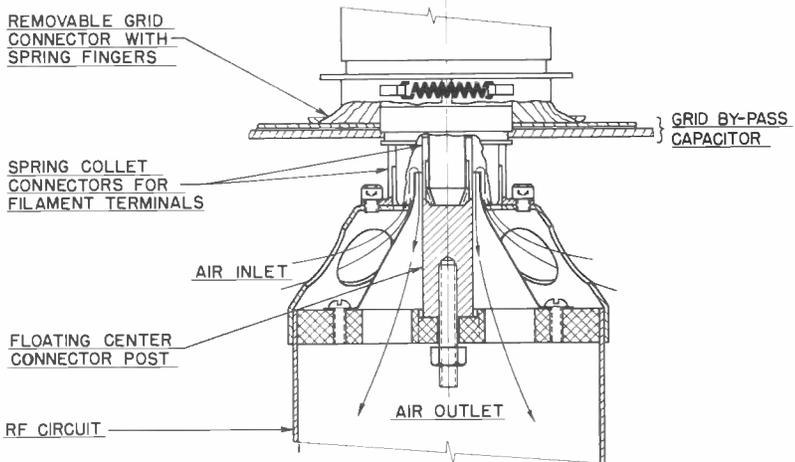
In VHF operation, particularly above 75 MHz the dc grid current must not exceed 200 ma under any conditions of plate loading. With lightly loaded conditions the grid driving power should be reduced so that the grid current does not exceed one-tenth of the plate current.



DIMENSIONAL DATA			
REF.	MIN.	MAX.	NOM.
A	4 3/32	4 5/32	
B	25/32	27/32	
C		3 5/8	
D	.645	.635	
E	1.490	1.510	
F	2.990	3.010	
G	13/16	15/16	
H	1 3/8	1 5/8	
J	3/8	7/16	
K	3 7/8	4 1/4	
L	2 15/16	3 1/16	
M	1 1/16	13/16	
N	1 3/16	1 11/16	
P	8	9	
Q	1	1 1/8	



- NOTES:**
- .040 MAXIMUM RUNOUT OF GRID CONTACT SURFACE WITH RESPECT TO AXIS DETERMINED BY ANODE AND OUTER FILAMENT CONTACT SURFACE.
 - .025 MAXIMUM RUNOUT OF INNER FILAMENT CONTACT SURFACE WITH RESPECT TO OUTER FILAMENT CONTACT SURFACE.
 - DIMENSIONS IN INCHES.



TYPICAL TUBE CONNECTORS AND STEM COOLING

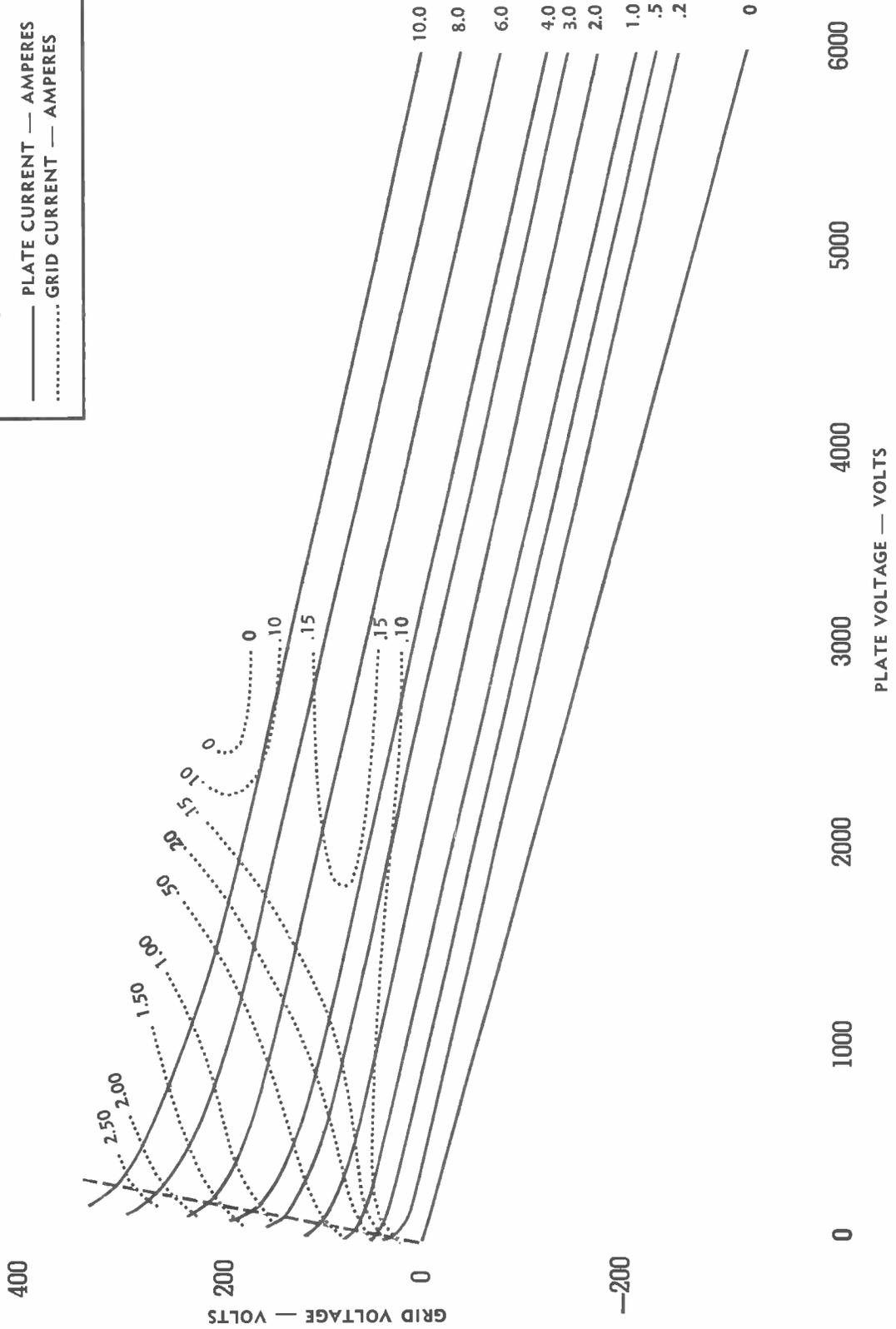
DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and approximate grid driving power at plate voltages of 4000, 5000 and 6000 volts. These charts show combined grid and bias losses only. The driving-power and power-output figures do not include circuit losses. The plate dissipation in watts is indicated by Pp. Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 4000, 5000 and 6000 volts respectively.



**EIMAC 3CX2500A3
CONSTANT CURRENT
CHARACTERISTICS**

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





E I M A C
 Division of Varian
 S A N C A R L O S
 C A L I F O R N I A

8251
3CX2500F3
 MEDIUM MU
 TRIODE

The EIMAC 3CX2500F3 is an all ceramic and metal, medium-mu, forced-air cooled, external anode transmitting triode with a maximum plate dissipation rating of 2500 watts. Relatively high power output as an amplifier, oscillator, or modulator may be obtained from this tube at low plate voltages. The 3CX2500F3 is an exact replacement for the EIMAC 3X2500F3 and is suggested for use where higher ambient temperatures are to be expected or greater reliability is required. The all ceramic and metal construction allows a greater margin of safety with respect to tube operating temperatures while permitting higher processing temperatures to insure longer life.

The tube is equipped with flexible filament and grid leads which simplify socketing and equipment design for industrial and communication frequencies below 30 megahertz.



GENERAL CHARACTERISTICS

ELECTRICAL

	<i>Min.</i>	<i>Nom.</i>	<i>Max.</i>	
Filament: Thoriated Tungsten		7.5		volts
Voltage				
Current	48		53	amperes
Amplification Factor	19		26	
Direct Interelectrode Capacitances				
Grid-Plate	16.8		23.2	pF
Grid-Filament	29.2		40.2	pF
Plate-Filament	0.6		1.2	pF
Tranconductance (I _b =830 ma., E _b =3000 v.)		20,000		umhos
Highest Frequency for Maximum Ratings			30	MHz

MECHANICAL

Base					See outline drawing
Mounting					Vertical, base down or up
Maximum Anode Core and Seal Temperatures					250°C
Cooling					Forced Air
Maximum Over-all Dimensions:					
Length (Does not include filament connectors)					8.6 inches
Diameter					4.16 inches
Length of filament Connectors (Approximate)					9.5 inches
Net Weight					7.5 pounds
Shipping Weight (Approximate)					17 pounds

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Conventional Neutralized Amplifier,
 Class-C FM or Telegraphy
 (Key-down Conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	6000 VOLTS
DC PLATE CURRENT	2.5 AMPS
PLATE DISSIPATION	2500 WATTS
GRID DISSIPATION	150 WATTS

TYPICAL OPERATION (Frequencies below 30 MHz)

DC Plate Voltage	4000	5000	6000	volts
DC Plate Current	2.5	2.5	2.08	amps
DC Grid Voltage	300	450	500	volts
DC Grid Current	245	265	180	ma
Peak RF Grid Input Voltage*	580	750	765	volts
Driving Power*	142	197	136	watts
Grid Dissipation*	68	78	46	watts
Plate Input Power	10,000	12,500	12,500	watts
Plate Dissipation	2500	2500	2500	watts
Plate Output Power	7500	10,000	10,000	watts

*Approximate values.



PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Conventional Neutralized Amplifier, Class-C Telephony (Carrier Conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE -	5500 VOLTS
DC PLATE CURRENT -	2.0 AMPS
PLATE DISSIPATION -	1670 WATTS
GRID DISSIPATION -	150 WATTS

TYPICAL OPERATION (Frequencies below 30 MHz)

DC Plate Voltage	- - - - -	4000	4500	5000	volts
DC Plate Current	- - - - -	1.67	1.47	1.25	amps
DC Grid Voltage	- - - - -	-450	-500	-550	volts
DC Grid Current*	- - - - -	180	140	150	ma
Peak RF Grid Input Voltage*	- - - - -	685	715	760	volts
Driving Power*	- - - - -	125	100	115	watts
Grid Dissipation*	- - - - -	43	30	32	watts
Plate Input Power	- - - - -	6670	6615	6250	watts
Plate Dissipation	- - - - -	1670	1315	950	watts
Plate Output Power	- - - - -	5000	5300	5300	watts

*Approximate values.

AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

Class-AB or B

MAXIMUM RATINGS

DC PLATE VOLTAGE -	6000 VOLTS
DC PLATE CURRENT -	2.5 AMPS
PLATE DISSIPATION -	2500 WATTS
GRID DISSIPATION -	150 WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

DC Plate Voltage	- - - - -	4000	5000	6000	volts
DC Grid Voltage ¹	- - - - -	-150	-190	-240	volts
Zero-Signal DC Plate Current	- - - - -	0.6	0.5	0.4	amps
Max-Signal DC Plate Current	- - - - -	4.0	3.2	3.0	amps
Effective Load, Plate to Plate	- - - - -	2200	3600	4650	ohms
Peak AF Grid Input Voltage (per tube)*	- - - - -	340	360	390	volts
Max-Signal Peak Driving Power*	- - - - -	340	230	225	watts
Max-Signal Nominal Driving Power*	- - - - -	170	115	113	watts
Max-Signal Plate Output Power	- - - - -	11,000	11,000	13,000	watts

*Approximate values.

¹Adjust to give listed zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EIMAC DIVISION OF VARIAN, FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

Cooling—Forced-air cooling must be provided to hold the ceramic-to-metal seals and anode core temperature below the maximum rating of 250°C. At ambient temperatures above 50°C, at higher altitudes and at operating temperatures above 30 MHz, additional air flow must be provided. Sea level and 10,000 foot altitude air-flow requirements to maintain seal temperatures below 200°C in 50°C ambient air are tabulated below (for operation below 30 MHz).

Filament Voltage — The filament voltage, as measured directly at the tube, should be 7.5 volts with maximum allowable variations due to line fluctuation of from 7.12 to 7.87 volts. Tube life may be extended by operation at the lower end of this range.

Bias Voltage — There is little advantage in using bias voltages in excess of those given under "TYPICAL OPERATION" except in certain very specialized applications. Where bias is obtained from a grid resistor, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage — The plate-supply voltage for the 3CX2500F3 should not exceed 6000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "TYPICAL OPERATION" for the power output desired.

Grid Dissipation — The power dissipated by the grid of the 3CX2500F3 must never exceed 150 watts. Grid dissipation is the product of dc current and peak positive grid voltage.

In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading. With lightly loaded conditions the grid driving power should be reduced so that the grid current does not exceed one-tenth of the plate current.

Anode-to-Base Air Flow¹

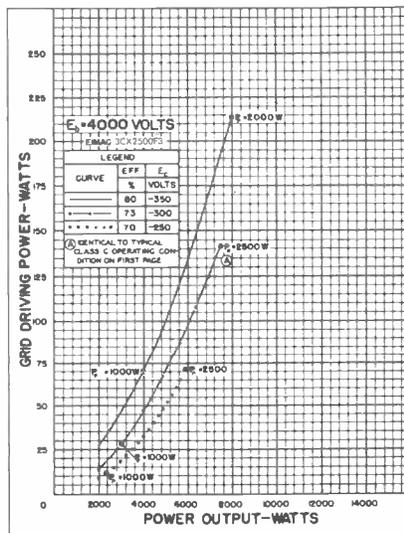
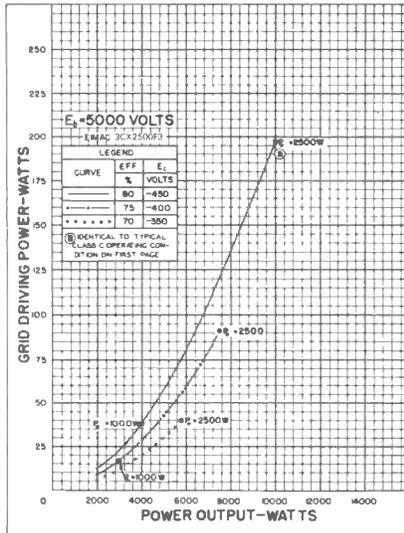
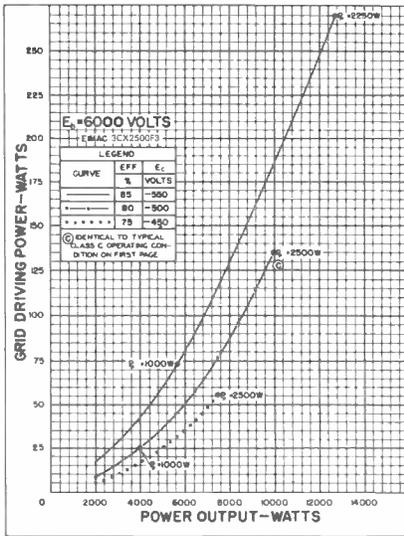
Anode Dissipation Watts	Sea Level		10,000 Feet	
	Air Flow CFM	Pressure Drop Inches Water	Air Flow CFM	Pressure Drop Inches Water
1500	33	.6	48	.9
2500	66	1.25	96	1.82

Base-to-Anode Air Flow

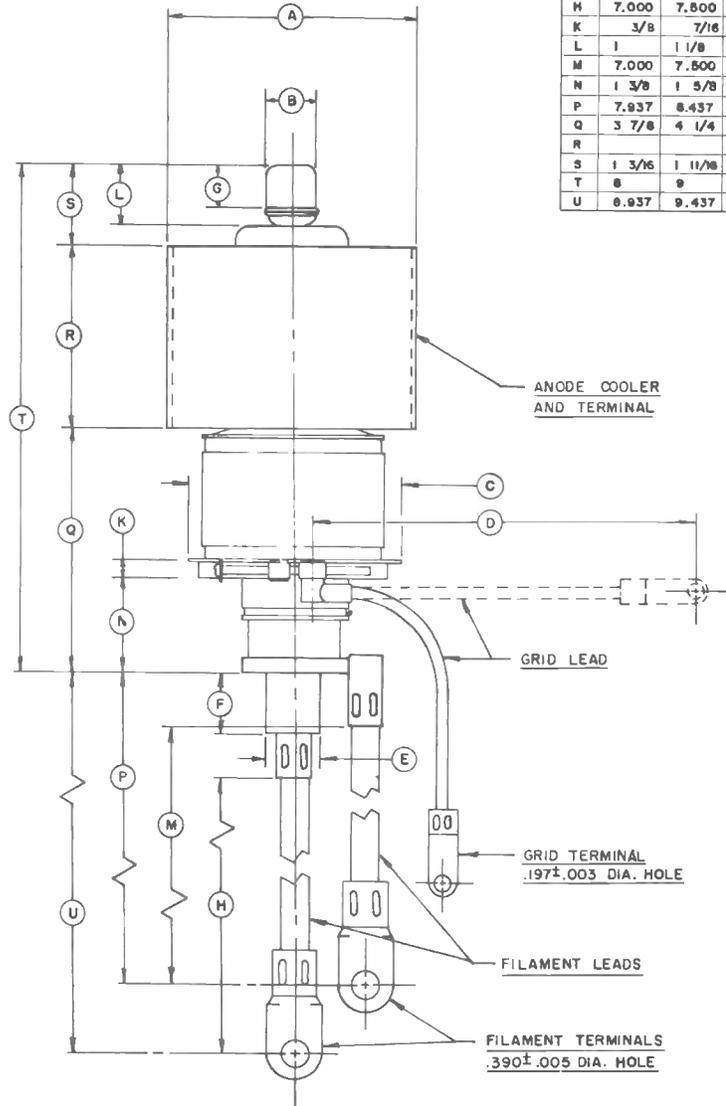
Anode Dissipation Watts	Sea Level		10,000 Feet	
	Air Flow CFM	Pressure Drop Inches Water	Air Flow CFM	Pressure Drop Inches Water
1500	32	.6	47	.9
2500	57	1.0	83	1.5

*Since the power dissipated by the filament represents about 400 watts and since grid dissipation can, under some conditions represent another 150 watts, allowance has been made in preparing this tabulation for an additional 550 watts.

¹When air is supplied in the anode-to-base direction, a minimum of 3 cfm must be directed into the filament-stem structure between the inner and outer filament terminals to maintain the base seals below 250°C. No separate air is required with base-to-anode airflow.



DIMENSIONAL DATA			
REF.	MIN.	MAX.	NOM.
A	4 3/32	4 5/32	
B	2 5/32	2 7/32	
C		3 5/8	
D	8.375	6.625	
E	.859	.890	
F	.012	.037	
G	1 1/16	1 3/16	
H	7.000	7.800	
K	3/8	7/16	
L	1	1 1/8	
M	7.000	7.800	
N	1 3/8	1 5/8	
P	7.937	8.437	
Q	3 7/8	4 1/4	
R			
S	1 3/16	1 11/16	
T	8	9	
U	8.937	9.437	



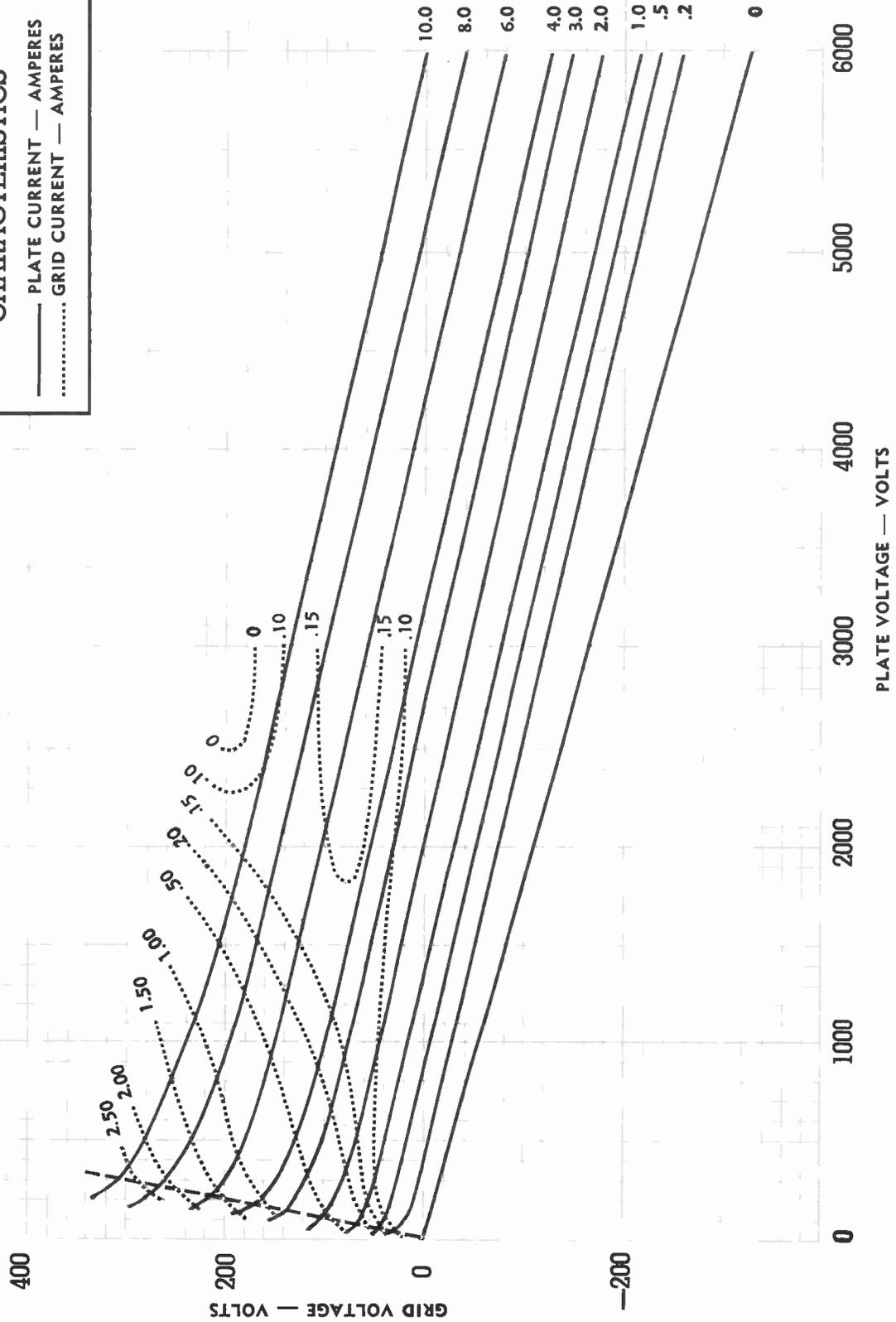
DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and approximate grid driving power at plate voltages of 4000, 5000 and 6000 volts. These charts show combined grid and bias losses only. The driving-power and power-output figures do not include circuit losses. The plate dissipation in watts is indicated by Pp. Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 4,000, 5000 and 6000 volts respectively.



**EIMAC 3CX2500F3
CONSTANT CURRENT
CHARACTERISTICS**

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





TECHNICAL DATA

3CX2500H3

MEDIUM-MU
AIR-COOLED
POWER TRIODE

The EIMAC 3CX2500H3 is a ceramic/metal, forced air cooled, external anode power triode designed primarily for use in industrial radio-frequency heating services. Its anode is conservatively rated at 2.5 kilowatts of plate dissipation with low air flow and pressure drop.

Input of 12.5 kilowatts is permissible up to 75 megahertz. Plentiful reserve emission is available from its 390 watt filament. The grid structure is rated at 150 watts making this tube an excellent choice for severe applications.

GENERAL CHARACTERISTICS¹

ELECTRICAL

Filament: Thoriated Tungsten

Voltage	7.5 ± 0.37 V
Current, at 7.5 volts	50 A
Amplification Factor (Average)	20

Direct Interelectrode Capacitance (grounded cathode)²

Input	35.0 pF
Output	0.9 pF
Feedback	20.0 pF

Frequency of Maximum Rating:

CW	75 MHz
----	--------

1. Characteristics and operating values are based upon performance tests. These figures may change without notice as the result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.
2. Capacitance values are for a cold tube as measured in a special shielded fixture.

MECHANICAL

Maximum Overall Dimensions:

Length (excluding leads)	9.000 in; 228.60 mm
Diameter	4.250 in; 107.95 mm
Net Weight	6.5 lb; 14.3 kg
Operating Position	Vertical, base up or down
Maximum Operating Temperature:	
Ceramic/Metal Seals	250°C
Cooling	Forced Air
Base	See Outline



RADIO FREQUENCY INDUSTRIAL OSCILLATOR

Class C (Filtered DC Power Supply)

ABSOLUTE MAXIMUM RATINGS

DC PLATE VOLTAGE	6000	VOLTS
DC GRID VOLTAGE	-1000	VOLTS
DC PLATE CURRENT	2.5	AMPERES
PLATE DISSIPATION	2500	WATTS
PLATE INPUT POWER	12.5	kW
DC GRID CURRENT	0.4	AMPERE

TYPICAL OPERATION (Frequencies to 75 MHz)²

Plate Voltage	4000	6000	Vdc
Grid Voltage	-300	-500	Vdc
Plate Current	2.50	2.08	Adc
Grid Current ¹	0.245	0.180	mAdc
Peak rf Grid Voltage ¹	280	265	v
Calculated Driving Power ¹	142	136	W
Plate Input Power	10.0	12.5	kW
Plate Dissipation	2.5	2.5	W
Plate Output Power	7.5	10.0	W
Resonant Load Impedance	910	1625	Ω

- 1. Approximate value.
- 2. Loaded Conditions

NOTE: TYPICAL OPERATION data are obtained from direct measurement or by calculation from published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, screen and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid and screen current. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. In the case of Class C Service, if grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf grid voltage is applied.

RANGE VALUES FOR EQUIPMENT DESIGN

	<u>Min.</u>	<u>Max.</u>	
Filament: Current at 7.5 volts	48	53	A
Interelectrode Capacitance ¹ (grounded filament connection)			
Input	29.2	40.2	pF
Output	0.6	1.2	pF
Feedback	16.8	23.2	pF

1. Capacitance values are for a cold tube as measured in a shielded fixture.

APPLICATION

MECHANICAL

MOUNTING - The 3CX2500H3 must be mounted vertically either base up or down. A mounting flange is provided on the grid terminal to allow bolting the tube to a grid deck or a strap. Filament voltage is applied through two heavy flexible leads.

COOLING - Forced-air cooling must be provided to hold the ceramic/metal seals and anode core temperature below the maximum rating of 250°C. At ambient temperatures above 50°C, at higher altitudes and at operating temperatures above 30 MHz, additional air flow must be pro-

vided. Sea level and 5000 foot altitude air flow requirements to maintain seal temperatures below 200°C in 50°C ambient air are tabulated below (for operation below 30 MHz).

Anode-to-Base Air Flow				
	Sea Level		5000 Feet	
	Air Flow CFM	Pressure Drop Inches Water	Air Flow CFM	Pressure Drop Inches Water
Anode Dissipation watts				
1500	33	0.6	40	0.74
2500	66	1.25	79	1.49

Base-to-Anode Air Flow				
Anode Dissipation watts	Sea Level		5000 Feet	
	Air Flow CFM	Pressure Drop Inches Water	Air Flow CFM	Pressure Drop Inches Water
1500	32	0.6	39	0.74
2500	57	1.0	68	1.23

*Since the power dissipated by the filament represents about 400 watts and since grid dissipation can, under some conditions represent another 150 watts, allowance has been made in preparing this tabulation for an additional 500 watts.

Additional stem cooling air must be provided. 14 CFM of air directed against the center rod 1/2" below the outer filament contact ring by a 1 1/2" I.D. air duct arranged at a 45° angle with the center line of the tube will provide adequate cooling.

ELECTRICAL

FILAMENT - The rated filament voltage for the 3CX2500H3 is 7.5 volts. Filament voltage, as measured at the tube, must be maintained at 7.5 volts plus or minus five percent for maximum tube life and consistent performance.

GRID OPERATION - The grid current rating is 0.4 ampere dc. This value should not be exceeded for more than very short periods such as during tuning. Over-current protection in the grid circuit should be provided. Ordinarily it will not be necessary to operate with more than 0.275 ampere grid current to obtain reasonable efficiency. In industrial heating service with varying loads, grid current should be monitored continuously with a dc current meter. The maximum grid dissipation rating is 150 watts.

PLATE OPERATION - Maximum plate voltage rating of 6000 volts and maximum plate current of 2.5 amperes dc should not be applied simul-

taneously as rated plate dissipation may be exceeded. The 12.5 kilowatts input rating applies for Class C amplifier or oscillator service with no modulation.

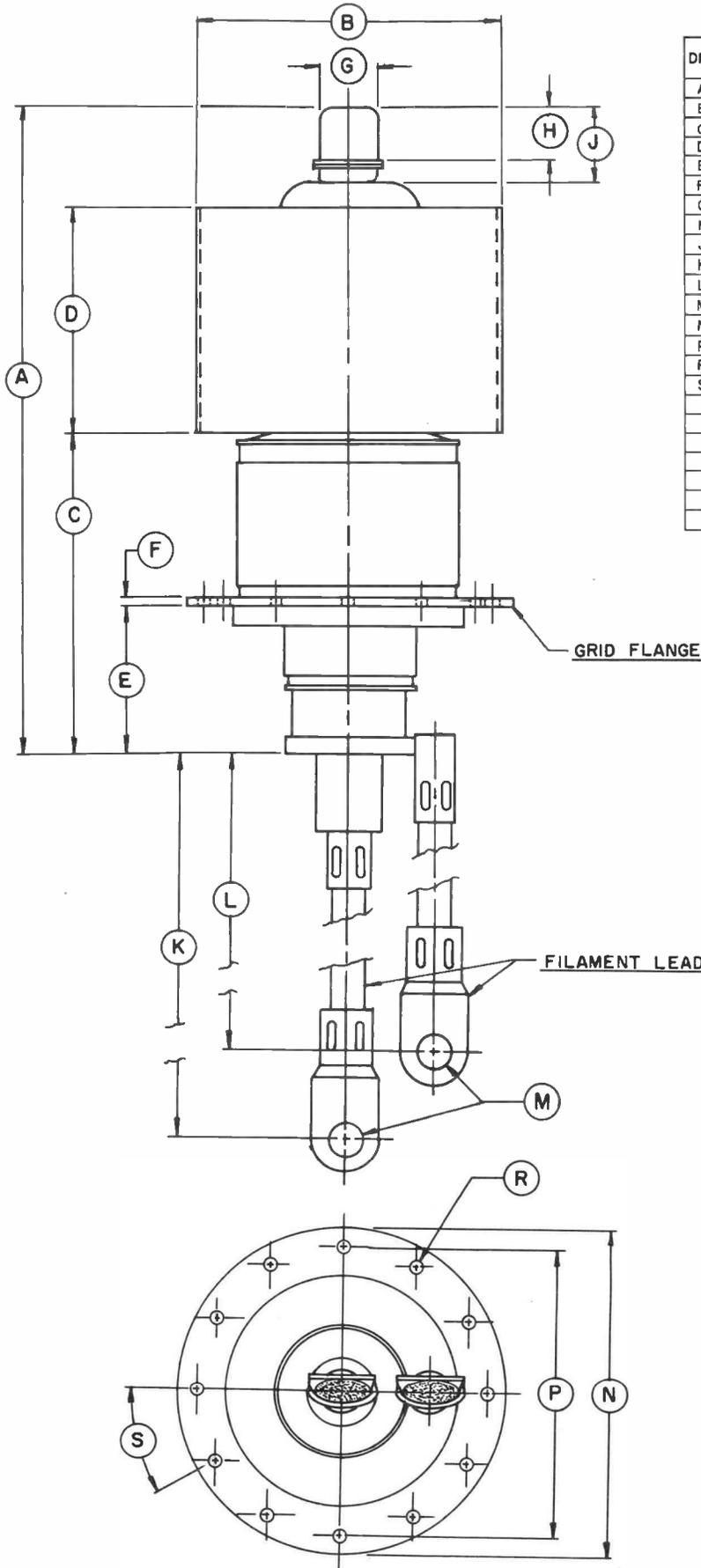
Plate over-current protection should be provided to remove plate voltage quickly in the event of an overload or an arc-over at the load. In addition current limiting power supply resistors should be used. These precautions are especially important in industrial service with its wide variations in loading.

Spark gaps from plate to ground should be used to prevent voltages from flashing across the tube envelope during any fault conditions.

HIGH FREQUENCY OPERATION - The 3CX-2500H3 is usable to 110 MHz. At this frequency, plate voltage must be reduced to 4000 volts in Class C service.

HIGH VOLTAGE - The 3CX2500H3 operates at voltages which can be deadly, and the equipment must be designed properly and operating precautions must be followed. Equipment must be designed so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open the primary circuits of the power supplies and to discharge high voltage condensers whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that HIGH VOLTAGE CAN KILL.

SPECIAL APPLICATIONS - If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070 for information and recommendations.



DIMENSIONAL DATA

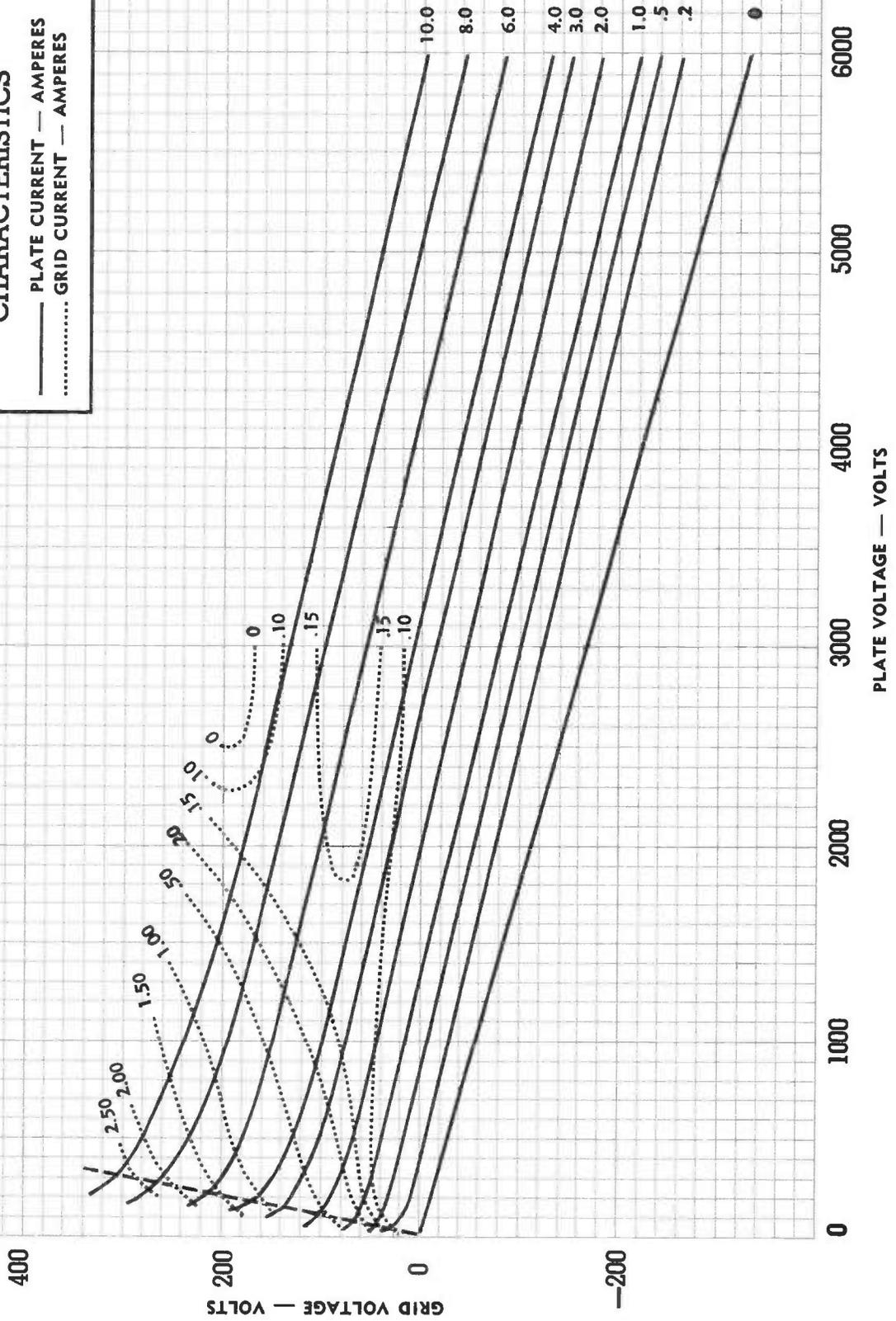
DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	8.000	9.000	--	203.20	228.60	--
B	4.093	4.156	--	103.96	105.56	--
C	3.875	4.250	--	98.43	107.95	--
D	2.937	3.062	--	74.60	77.77	--
E	1.703	1.953	--	43.26	49.61	--
F	--	--	0.125	--	--	3.18
G	0.781	0.843	--	19.84	21.41	--
H	0.687	0.812	--	17.45	20.62	--
J	1.000	1.125	--	25.40	28.58	--
K	8.937	9.437	--	227.00	239.70	--
L	7.937	8.437	--	201.60	214.30	--
M	--	--	0.390	--	--	9.91
N	4.230	4.250	--	107.44	107.95	--
P	3.855	3.885	--	97.92	98.68	--
R	--	--	0.250	--	--	6.35
S	29°	31°	--	29°	31°	--

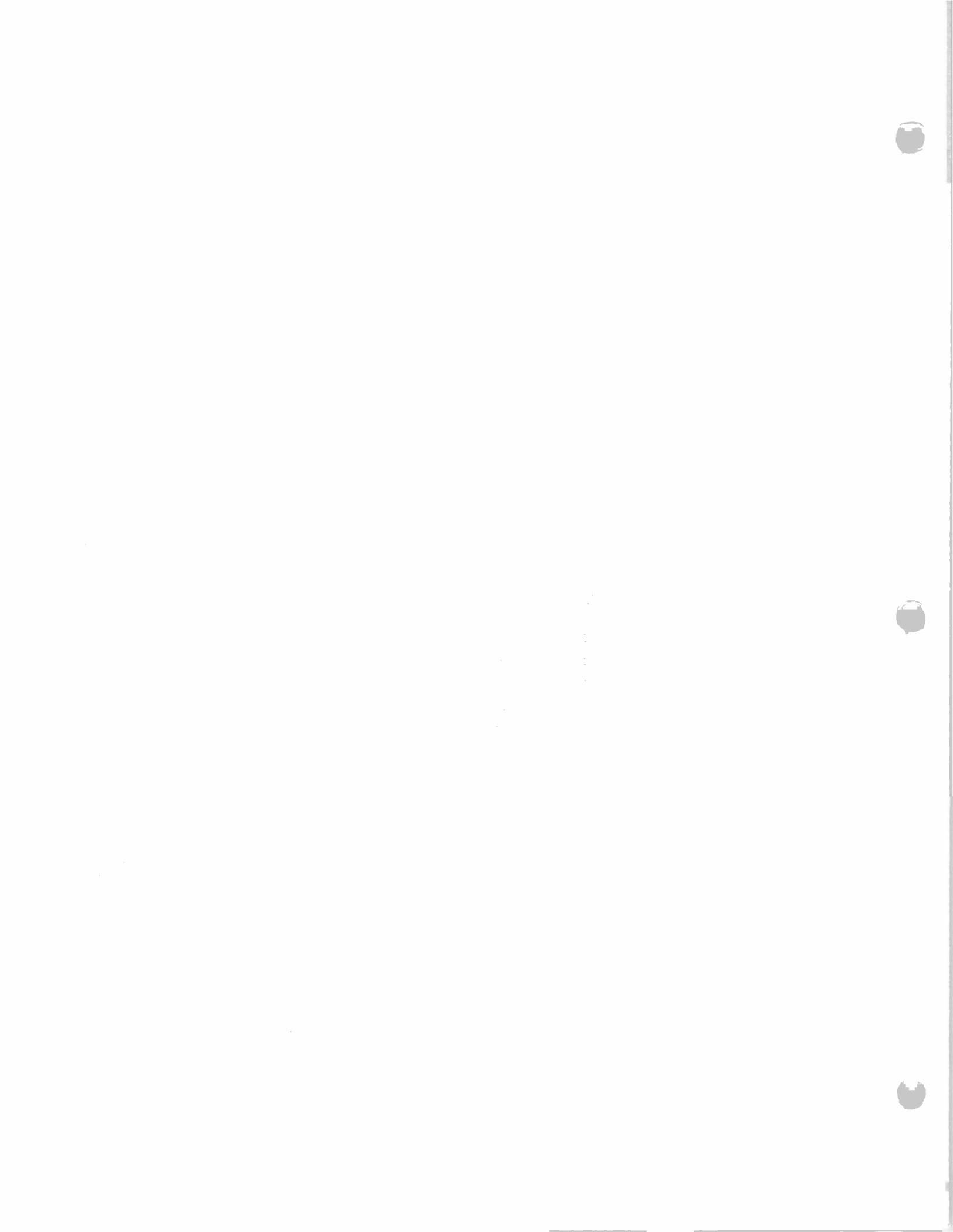
NOTES:

1. REFERENCE DIMENSIONS ARE FOR INFORMATION ONLY AND ARE NOT REQUIRED FOR INSPECTION PURPOSES.
2. THERE ARE 12 HOLES IN GRID FLANGE.
3. GRID FLANGE AND FILAMENT LEADS ARE TO BE ORIENTED AS SHOWN

**EIMAC 3CX2500H3
CONSTANT CURRENT
CHARACTERISTICS**

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





APPLICATION

MECHANICAL

Mounting: The 3W5000A1 must be mounted vertically with its base up or down at the convenience of the designer. The filament connections should be made through spring collets and care must be taken not to impart strain to the terminals or base.

The tube must be protected from severe shock and vibration during shipment and operation.

Cooling: Sufficient cooling must be provided to maintain seal and anode core temperature at 175°C or below. Cooling water and air-flow must be started when filament power is applied and it is advisable to continue for two minutes after all voltages are removed.

The table below lists minimum water-flow requirements to maintain tube temperatures below 175°C for various water-inlet temperatures. The water outlet temperature must not exceed 70°C and inlet water pressure must be less than 60 pounds per square inch. A separate air-flow supply of approximately six cubic feet per minute, directed into the filament structure is also required to maintain rated filament seal temperatures. This is best accomplished using a small diameter insulating tubing directed into the stem, between the filament seals.

MINIMUM WATER COOLING REQUIREMENTS								
Water Inlet Temp. (°C)	Plate Dissipation							
	2 KW		3 KW		4 KW		5 KW	
	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI
20	1.7	0.68	2.6	1.3	3.9	2.3	5.6	3.9
30	2.3	1.1	3.2	1.7	4.5	2.8	6.2	4.5
40	3.0	1.6	3.8	2.2	5.3	3.5	6.9	5.3
50	3.9	2.3	4.7	3.0	6.0	4.3	7.7	6.1

Note:

An extra 425 watts have been added to these plate dissipation figures in preparing this tabulation, to compensate for grid and filament dissipation.

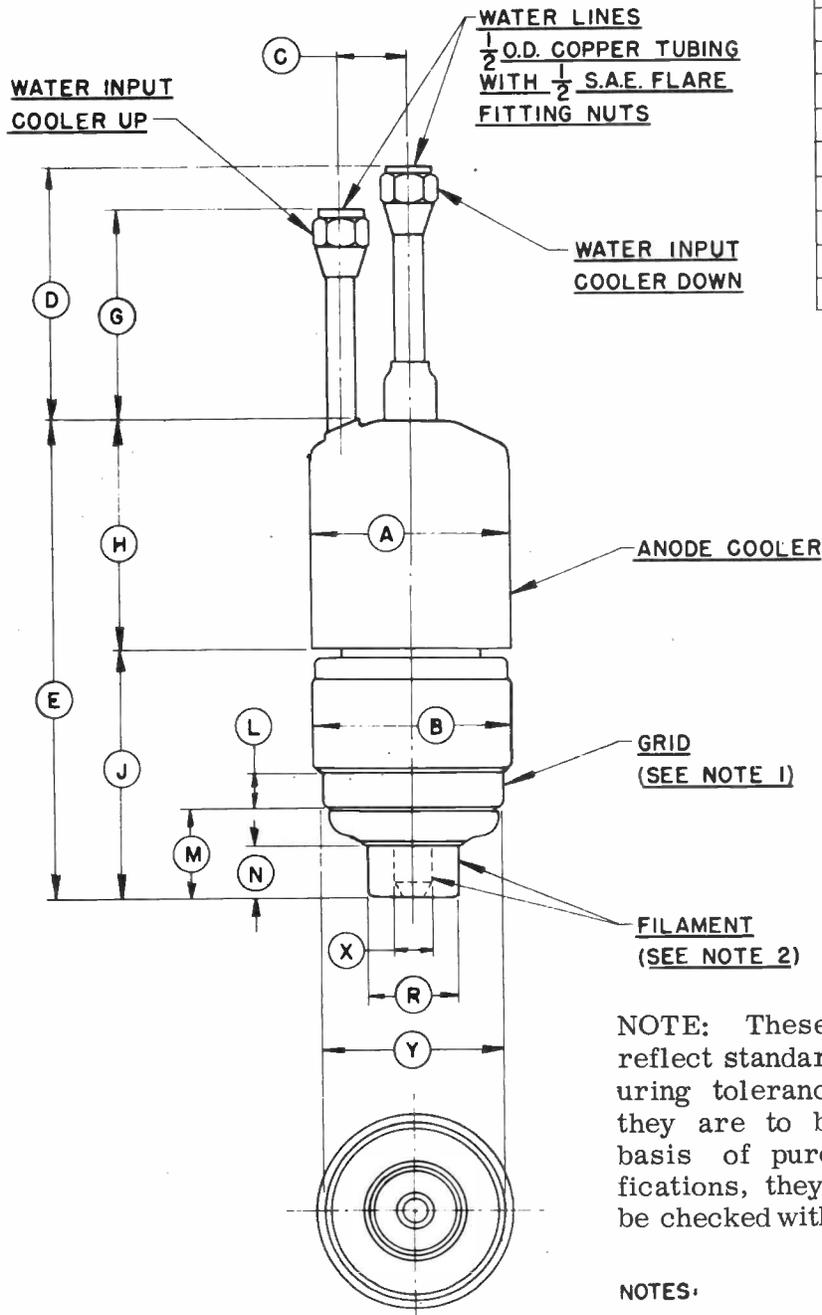
For operation at high altitudes or higher ambient temperatures, these quantities should be increased. In all cases it is suggested that actual temperatures be measured to insure adequate cooling.

ELECTRICAL

Filament: The rated filament voltage for the 3W5000A1 is 7.5 volts and should not exceed this value by more than five percent if maximum tube life is to be realized. Reduction of filament voltage to about 7.2 volts will actually enhance tube life and provision should be made for this adjustment where the lower emission can be tolerated.

Grid Operation: The grid dissipation rating of the 3W5000A1 is 50 watts. This is the product of the peak positive grid voltage and average dc grid current. When tubes are used in parallel in amplifier or modulator service, provision should be made for individual adjustment of bias voltage, in order to match the tubes. In practice, individual adjustment of drive voltage will not be necessary.

Special Applications: If it is desired to operate the tube under conditions widely different from those given here, write to Power Grid Tube Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California, for information and recommendations.



DIMENSION DATA			
REF.	NOM.	MIN.	MAX.
A		3.234	3.266
B			3.625
C		1.062	1.187
D		4.000	4.500
E		7.562	8.062
G		3.250	3.750
H		3.625	3.875
J		3.937	4.187
L		.375	.437
M		1.437	1.562
N		.812	.937
R		1.490	1.510
X		.615	.635
Y		2.990	3.010

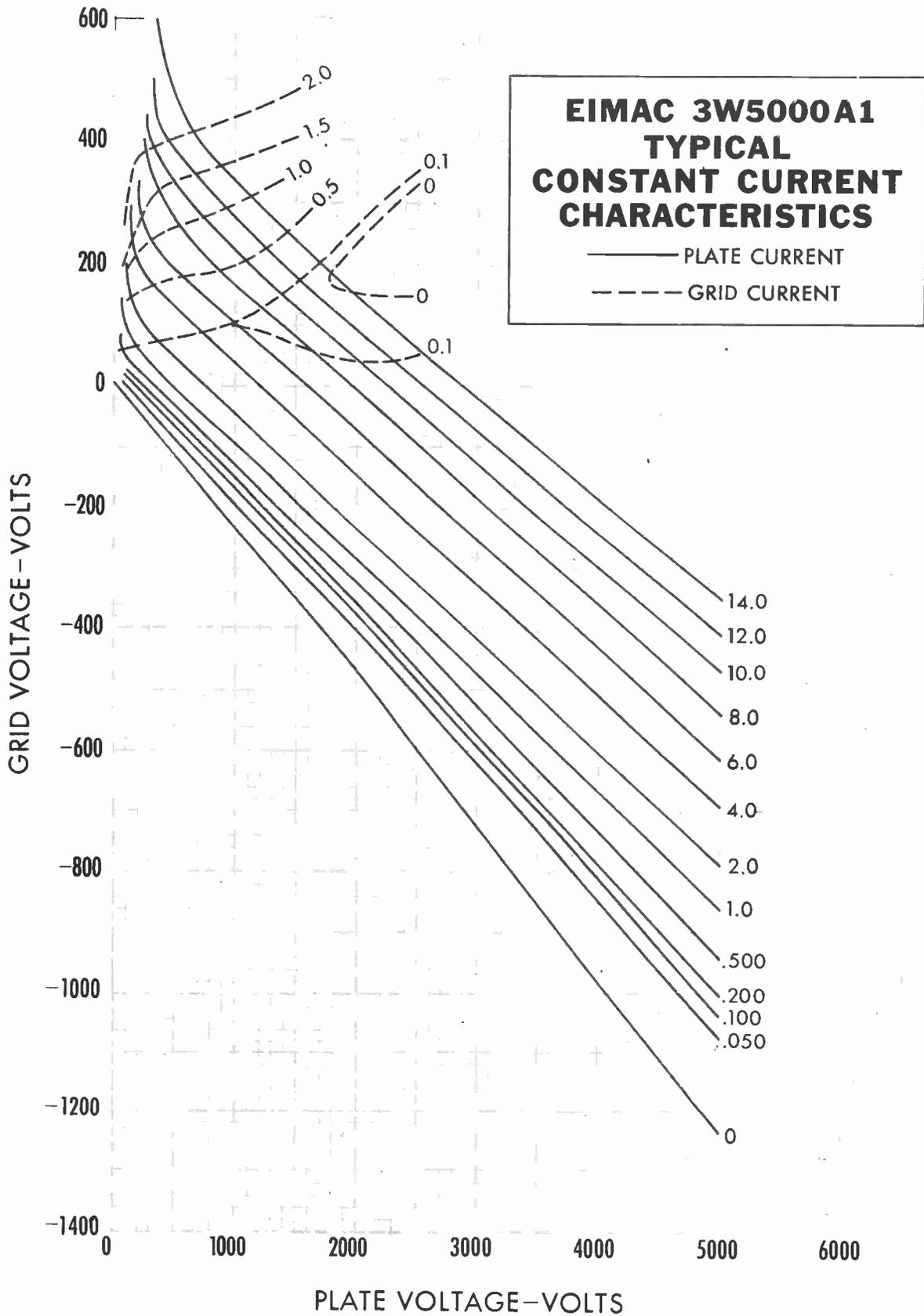
NOTE: These dimensions reflect standard manufacturing tolerances. Where they are to be made the basis of purchase specifications, they should first be checked with the factory.

NOTES:

1. .025" MAXIMUM RUNOUT OF INNER FILAMENT CONTACT SURFACE WITH RESPECT TO OUTER FILAMENT CONTACT SURFACE.
2. DIMENSIONS IN INCHES.



3W5000A1





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

8242
3W5000A3

MEDIUM-MU
POWER TRIODE

The Eimac 8242/3W5000A3 is a water-cooled, medium-mu power triode intended for amplifier, oscillator or modulator service. It has a maximum plate dissipation rating of 5000 watts and is capable of high output at relatively low plate voltages. A single 3W5000A3 will deliver a radio frequency plate power-output of 7500 watts at a plate voltage of 4000 volts.

NOTE: The 8242/3W5000A3 is a water-cooled version of the air-cooled 8161/3X25000A3.

The 8242/3W5000A3 should be used where water cooling is preferred and for industrial applications or installations where reserve anode dissipation is desired.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated tungsten				
Voltage	-	7.5	-	volts
Current	49	-	54	amperes
Amplification Factor (Average)	-	20	-	
Direct Interelectrode Capacitances (Average)				
Grid-Plate	17.8	-	24.2	$\mu\mu\text{f}$
Grid-Filament	29.2	-	40.2	$\mu\mu\text{f}$
Plate-Filament	0.60	-	1.20	$\mu\mu\text{f}$
Transconductance ($I_b = 830 \text{ ma}$, $E_b = 3000\text{v}$)	-	20,000	-	μmhos
Frequency for Maximum Ratings	-	-	75	mc

MECHANICAL

Base	-	-	-	see drawing
Mounting	-	-	-	vertical, base down or up
Maximum Over-All Dimensions:				
Length	-	-	12.56	inches
Diameter	-	-	3.63	inches
Net Weight	-	-	4.8	pounds
Cooling	-	-	-	Water and forced air



RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR

(Frequencies below 75 Mc.)

Class-C FM or Telegraphy

(Key-down conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	6000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	2.5 MAX. AMPS
PLATE DISSIPATION	-	-	-	5000 MAX. WATTS
GRID DISSIPATION	-	-	-	150 MAX. WATTS

TYPICAL OPERATION

(Frequencies below 75 Mc., per tube)

D-C Plate Voltage	-	-	-	4000	5000	6000	volts
D-C Plate Current	-	-	-	2.5	2.5	2.08	amps
D-C Grid Voltage	-	-	-	-300	-450	-500	volts
D-C Grid Current	-	-	-	245	265	180	ma
Peak R-F Grid Input Voltage	-	-	-	580	750	765	volts
Driving Power (approx.)	-	-	-	142	197	136	watts
Grid Dissipation	-	-	-	68	78	46	watts
Plate Power Input	-	-	-	10,000	12,500	12,500	watts
Plate Dissipation	-	-	-	2500	2500	2500	watts
Plate Power Output	-	-	-	7500	10,000	10,000	watts

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

(Frequencies below 75 Mc.)

Class-C Telephony

(Carrier conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	5000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	2.0 MAX. AMPS
PLATE DISSIPATION	-	-	-	3350 MAX. WATTS
GRID DISSIPATION	-	-	-	150 MAX. WATTS

TYPICAL OPERATION

(Frequencies below 75 Mc., per tube)

D-C Plate Voltage	-	-	-	4000	4500	5000	volts
D-C Plate Current	-	-	-	1.67	1.55	1.45	amps
Total Bias Voltage	-	-	-	-450	-500	-550	volts
Fixed Bias Voltage	-	-	-	-230	-325	-410	volts
Grid Resistor	-	-	-	1500	1500	1400	ohms
D-C Grid Current	-	-	-	150	120	100	ma
Peak R-F Grid Input Voltage	-	-	-	680	720	760	volts
Driving Power (approx.)	-	-	-	102	86	76	watts
Grid Dissipation	-	-	-	35	26	21	watts
Plate Power Input	-	-	-	6670	6970	7250	watts
Plate Dissipation	-	-	-	1670	1670	1670	watts
Plate Power Output	-	-	-	5000	5300	5580	watts



AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class B (Sinusoidal wave, two tubes unless otherwise specified)

MAXIMUM RATINGS

D C PLATE VOLTAGE	-	-	-	-	6000 MAX. VOLTS
MAX-SIGNAL D C PLATE CURRENT, PER TUBE	-	-	-	-	2.5 MAX. AMPS
PLATE DISSIPATION, PER TUBE	-	-	-	-	5000 MAX. WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

D C Plate Voltage	-	-	-	4000	5000	6000	volts
D C Grid Voltage ¹	-	-	-	-150	-190	-240	volts
Zero-Signal D C Plate Current	-	-	-	0.6	0.5	0.4	amps
Max-Signal D C Plate Current	-	-	-	4.0	3.2	3.0	amps
Effective Load, Plate to Plate	-	-	-	2200	3600	4650	ohms
Peak A-F Grid Input Voltage (per tube)*	-	-	-	340	360	390	volts
Max-Signal Peak Driving Power*	-	-	-	340	230	225	watts
Max-Signal Nominal Driving Power*	-	-	-	170	115	113	watts
Max-Signal Plate Output Power	11,000	11,000	13,000				watts

*Approximate values.

¹Adjust to give listed zero-signal plate current.

TYPICAL OPERATION CLASS AB₂ (Two Tubes)

Modulator service for 4000 and 5000 volt operation, to modulate one or two tubes, as shown under "Plate Modulated Radio Frequency Amplifier" (Page 1)

D C Plate Voltage	-	4000	5000	4000	5000	volts
D C Grid Voltage (approx.)*	-	-155	-200	-145	-190	volts
Zero-Signal D C Plate Current	-	0.4	0.4	0.6	0.5	amps
Max-Signal D C Plate Current	-	1.35	1.13	2.70	2.26	amps
Effective Load, Plate to Plate	-	6600	10,000	3300	5000	ohms
Peak A-F Grid Input Voltage (per tube)	-	240	275	285	310	volts
Max-Signal Peak Driving Power	-	42	40	134	118	watts
Max-Signal Nominal Driving Power (approx.)	-	21	20	67	59	watts
Max-Signal Plate Power Output	-	3700	4000	7400	8000	watts
Will Modulate one Tube	-	-	-	-	-	-
R F Final Input of	-	6670	7250	-	-	watts
Will Modulate two tubes	-	-	-	-	-	-
R F Final Input of	-	-	-	13,340	14,500	watts

*Adjust to give stated zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-MCCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS

APPLICATION

Cooling—Minimum recommended water-flow rate and pressure drop values for different water-inlet temperatures and plate dissipations are tabulated on the opposite page. The outlet water temperature must not exceed a maximum of 70° C under any conditions. The inlet water pressure must not exceed a maximum of 60 pounds per square inch.

The grid-terminal contact surface and adjacent glass must be cooled by forced air. The quantity, velocity and direction must be adjusted to limit the maximum seal temperature to 175° C.

The filament stem structure also requires forced-air cooling. A minimum of 6 cubic feet per minute must be directed into the space between the inner and outer filament contacting surfaces.

Air and water flow must be started before filament power is applied and maintained for at least five minutes after the filament power has been removed.

Filament Voltage—The filament voltage, as measured directly at the tube, should be 7.5 volts with maximum allowable variations due to line fluctuation of from 7.12 to 7.87 volts.

Bias Voltage—There is little advantage in using bias voltages in excess of those given under "Typical Operation," except in certain very specialized applications. Where bias is obtained from a grid resistor, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage—The plate supply voltage for the 3W5000A3 should not exceed 6000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "Typical Operation" for the power output desired.

In Class-C FM or Telegraphy service, a 0.1 henry choke, shunted by a spark gap, should be series connected between the plates of the amplifier tubes and the high voltage plate supply capacitor to offer protection from transients and surges. In plate modulated service, where a plate modulation transformer is used, the protective choke is not normally required.

Grid Dissipation—The power dissipated by the grid of the 3W5000A3 must never exceed 150 watts. Grid dissipation may be calculated from the following expression

$$P_g = e_{cmp} I_c$$

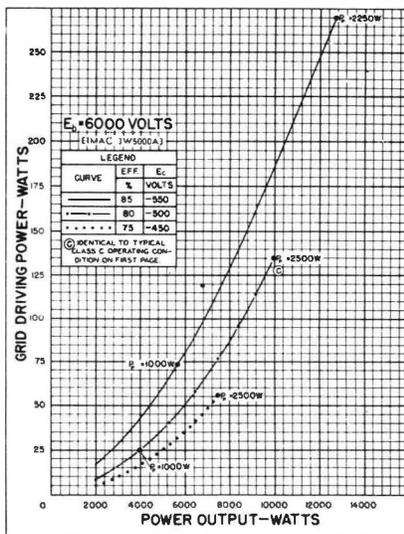
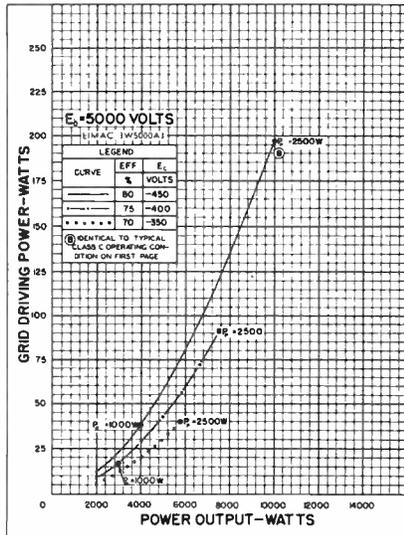
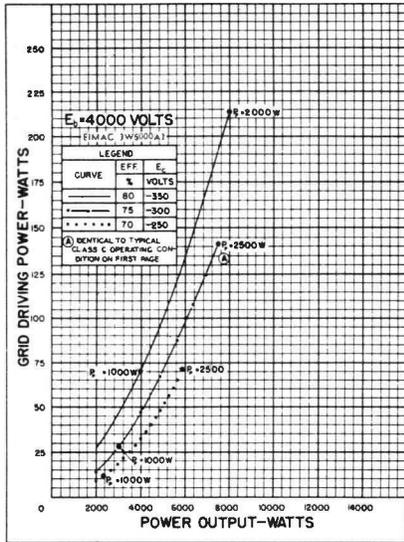
where P_g = Grid dissipation,

e_{cmp} = Peak positive grid voltage, and

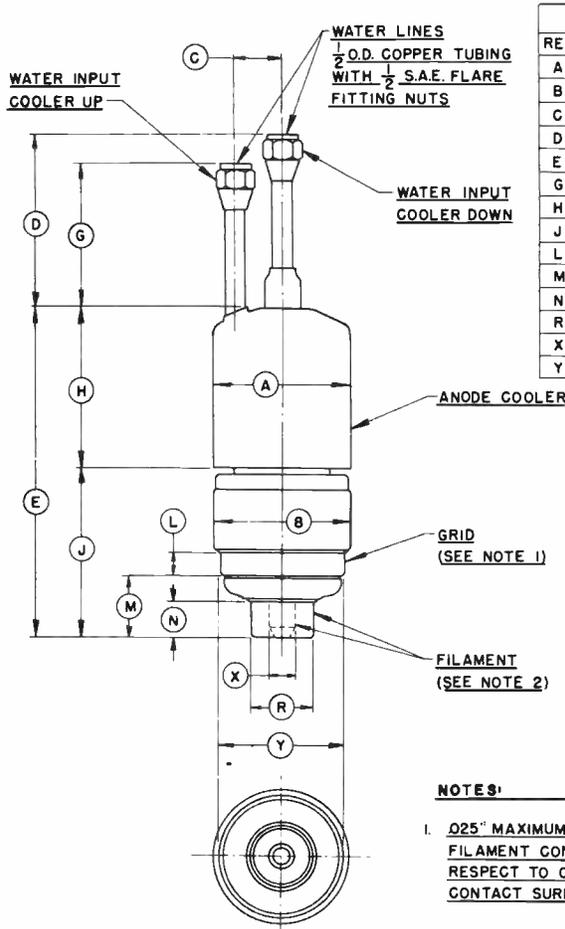
I_c = D-C grid current

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid. Any suitable peak v.t.v.m. circuit may be used.

In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.



MINIMUM WATER COOLING REQUIREMENTS								
Water Inlet Temp. 1°C	Plate Dissipation							
	2 KW		3 KW		4 KW		5 KW	
	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI
20	1.7	0.68	2.6	1.3	3.9	2.3	5.6	3.9
30	2.3	1.1	3.2	1.7	4.5	2.8	6.2	4.5
40	3.0	1.6	3.8	2.2	5.3	3.5	6.9	5.3
50	3.9	2.3	4.7	3.0	6.0	4.3	7.7	6.1



DIMENSION DATA			
REF.	NOM.	MIN.	MAX.
A		3.234	3.266
B			3.625
C		1.062	1.187
D		4.000	4.500
E		7.562	8.062
G		3.250	3.750
H		3.625	3.875
J		3.937	4.187
L		.375	.437
M		1.437	1.562
N		.812	.937
R		1.490	1.510
X		.615	.635
Y		2.990	3.010

NOTES:

1. .025" MAXIMUM RUNOUT OF INNER FILAMENT CONTACT SURFACE WITH RESPECT TO OUTER FILAMENT CONTACT SURFACE.

DRIVING POWER vs. POWER OUTPUT

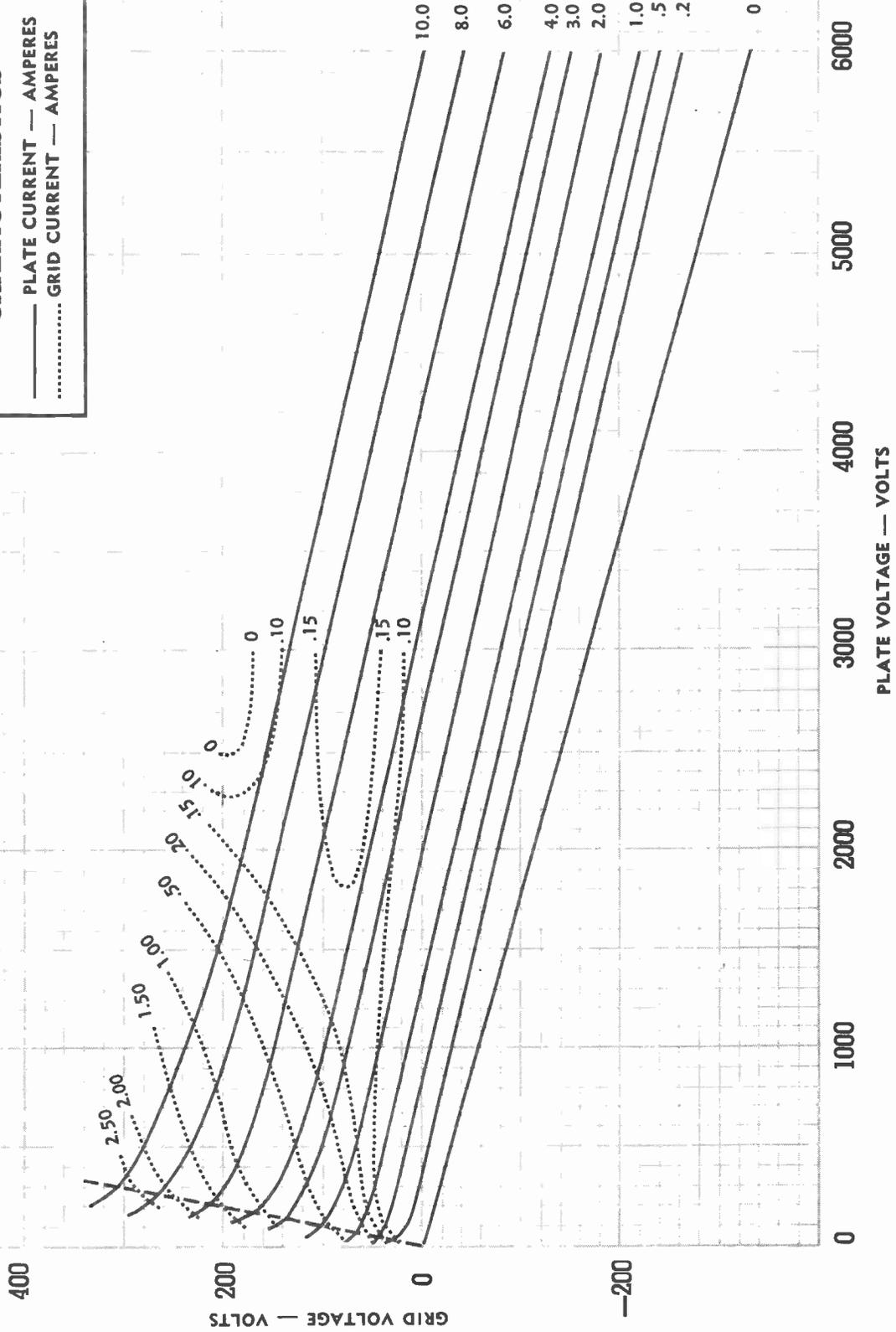
The three charts on this page show the relationship of plate efficiency, power output and approximate grid driving power at plate voltages of 4000, 5000 and 6000 volts. These charts show combined grid and bias losses only. The driving-power and power-output figures do not include circuit losses. The plate dissipation in watts is indicated by Pp. Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 4000, 5000 and 6000 volts respectively.



EIMAC 3W5000A3

CONSTANT CURRENT CHARACTERISTICS

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

8241
3W5000F1

LOW-MU
WATER-COOLED
TRIODE

The Eimac 8241/3W5000F1 is a low- μ water-cooled power triode intended for use as an audio amplifier or modulator. The maximum rated plate dissipation is 5000 watts.

Two 3W5000F1's in class-AB₁ audio service will deliver more than 10 kilowatts maximum-signal plate output power at 6000 plate volts without drawing grid current.

The 3W5000F1 is provided with "flying leads" for simplifying filament and grid connections.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten	Min.	Nom.	Max.	
Voltage - - - - -	-	7.5		volts
Current - - - - -	49		54	amperes
Amplification Factor - - - - -	4.4		5.6	
Direct Interelectrode Capacitances (Average)				
Grid-Plate - - - - -		17		uufd
Grid-Filament - - - - -		29		uufd
Plate-Filament - - - - -		2.5		uufd
Transconductance ($I_b = 1.0$ amp., $E_b = 3000$ V) - - - - -		11,000		umhos
Maximum Frequency - - - - -			30	Mc

MECHANICAL

Base - - - - -	See outline drawing
Mounting Position - - - - -	Vertical, base down or up
Cooling - - - - -	Forced air
Maximum Temperatures:	
Grid and Filament Seals - - - - -	175° C
Anode Cooler Core - - - - -	250° C
Maximum Diameter - - - - -	3.63 inches
Net Weight - - - - -	4.8 pounds
Shipping Weight - - - - -	15 pounds



AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR

TYPICAL OPERATION (Sinusoidal wave, two tubes) (Class AB₁)

Class-AB₁

MAXIMUM RATINGS (Per tube)

DC PLATE VOLTAGE	6000 MAX.	VOLTS
DC PLATE CURRENT	2.5 MAX.	AMPERES
PLATE DISSIPATION	3000 MAX.	WATTS
GRID DISSIPATION	50 MAX.	WATTS

DC Plate Voltage - - - -	4000	5000	6000	volts
DC Grid Voltage (Approx)*	-860	-1080	-1300	volts
Zero-Signal DC Plate Current	500	400	335	mA
Max-Signal DC Plate Current	3.00	2.80	2.65	amps
Effective Load. Plate-to-Plate	2160	3320	4560	ohms
Peak AF Grid Input Voltage (per tube) - - - -	760	995	1250	volts
Max-Signal Driving Power -	0	0	0	watts
Max-Signal Plate Input Power - - - -	12,000	14,000	16,000	watts
Max-Signal Plate Dissipation (per tube) - - - -	3000	3000	3000	watts
Max-Signal Plate Output Power - - - -	6000	8000	10,000	watts
Total Harmonic Distortion**	1.8	2.6	2.1	percent

*Adjust to stated Zero-Signal DC Plate Current. Can be expected to vary $\pm 15\%$. Effective grid-circuit resistance must not exceed 200,000 ohms.

**At maximum signal without negative feedback.



APPLICATION

MECHANICAL

Mounting: The 3W5000F1 must be mounted vertically with its base up or down at the convenience of the designer. The base is fitted with heavy filament leads to facilitate connections. These leads should be arranged to prevent mechanical stress on the filament structure. The grid is also fitted with a flying lead.

The tube must be protected from severe shock and vibration during shipment and operation.

Cooling: Sufficient cooling must be provided to maintain seal and anode core temperature at 175° C or below. Cooling must be started when filament power is applied and it is advisable to continue for two minutes after all voltages are removed.

The table below lists minimum water-flow requirements to maintain tube temperatures below 175°C for various water-inlet temperatures. The water outlet temperature must not exceed 70° C and inlet water pressure must be less than 60 pounds per square inch. A separate air-flow supply of approximately six cubic feet per minute, directed into the filament structure is also required to maintain rated filament seal temperatures. This is best accomplished using a small diameter insulating tubing directed into the stem, between the filament seals.

MINIMUM WATER COOLING REQUIREMENTS								
Water Inlet Temp. (°C)	Plate Dissipation							
	2 KW		3 KW		4 KW		5 KW	
	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI
20	1.7	0.68	2.6	1.3	3.9	2.3	5.6	3.9
30	2.3	1.1	3.2	1.7	4.5	2.8	6.2	4.5
40	3.0	1.6	3.8	2.2	5.3	3.5	6.9	5.3
50	3.9	2.3	4.7	3.0	6.0	4.3	7.7	6.1

Note:

An extra 425 watts have been added to these plate dissipation figures in preparing this tabulation, to compensate for grid and filament dissipation.

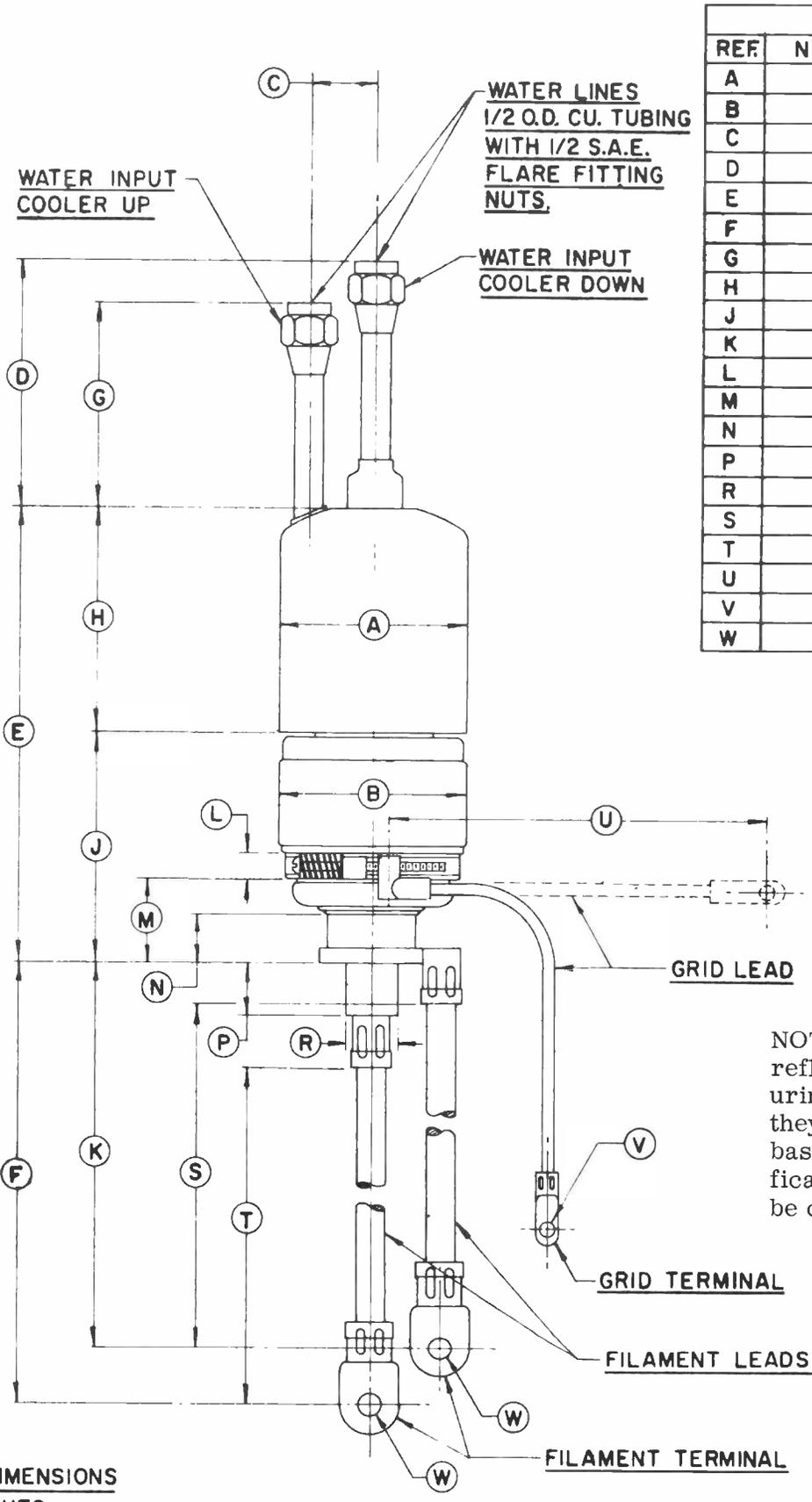
For operation at high altitudes or higher ambient temperatures, these quantities should be increased. In all cases it is suggested that actual temperatures be measured to insure adequate cooling.

ELECTRICAL

Filament: The rated filament voltage for the 3W5000F1 is 7.5 volts and should not exceed this value by more than five percent if maximum tube life is to be realized. Reduction of filament voltage to about 7.2 volts will actually enhance tube life and provision should be made for this adjustment where the lower emission can be tolerated.

Grid Operation: The grid dissipation rating of the 3W5000F1 is 50 watts. This is the product of the peak positive grid voltage and average dc grid current. When tubes are used in parallel in amplifier or modulator service, provision should be made for individual adjustment of bias voltage, in order to match the tubes. In practice, individual adjustment of drive voltage will not be necessary.

Special Applications: If it is desired to operate the tube under conditions widely different from those given here, write to Power Grid Tube Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California, for information and recommendations.



DIMENSION DATA			
REF	NOM.	MIN.	MAX.
A		3.234	3.266
B			3.625
C		1.062	1.187
D		4.000	4.500
E		7.562	8.062
F		8.937	9.437
G		3.250	3.750
H		3.625	3.875
J		3.937	4.187
K		7.937	8.437
L		.375	.437
M		1.437	1.562
N		.812	.937
P		.812	.937
R		.859	.890
S		7.000	7.500
T		7.000	7.500
U		6.375	6.625
V		.194	.200
W		.385	.395

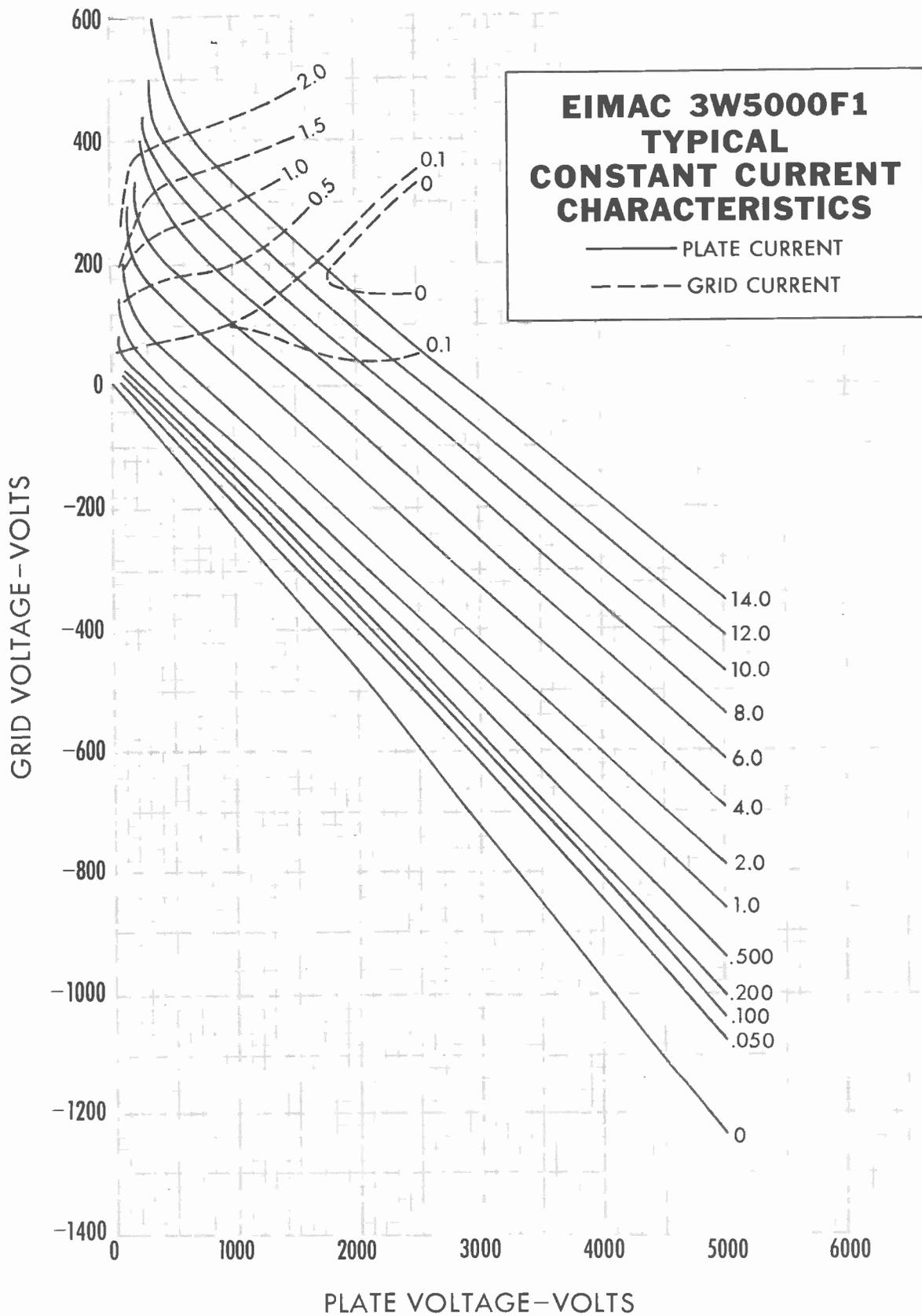
NOTE: These dimensions reflect standard manufacturing tolerances. Where they are to be made the basis of purchase specifications, they should first be checked with the factory.

ALL DIMENSIONS IN INCHES

(TENTATIVE)



3W5000F1





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

8243
3W5000F3

MEDIUM-MU
POWER TRIODE

The Eimac 8243/3W5000F3 is a water-cooled, medium-mu power triode intended for amplifier, oscillator or modulator service. It has a maximum plate dissipation rating of 5000 watts and is capable of high output at relatively low plate voltages. A single 3W5000F3 will deliver a radio frequency plate power-output of 7500 watts at a plate voltage of 4000 volts.

The tube is equipped with flexible filament and grid leads which simplifies socketing and equipment design for industrial and communication frequencies below 30 Mc.

NOTE: The 8243/3W5000F3 is a water-cooled version of the air-cooled 8251/3X2500F3.

The 8243/3W5000F3 should be used where water cooling is preferred and for industrial applications or installations where reserve anode dissipation is desired.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated tungsten				
Voltage	-	7.5	-	volts
Current	49	-	54	amperes
Maximum allowable starting current	-	-	100	amperes
Amplification Factor (Average)	-	20	-	
Direct Interelectrode Capacitances (Average)				
Grid-Plate	17.8	-	24.2	$\mu\mu\text{f}$
Grid-Filament	29.2	-	40.2	$\mu\mu\text{f}$
Plate-Filament	0.60	-	1.20	$\mu\mu\text{f}$
Transconductance ($I_b = 830 \text{ ma}$, $E_b = 3000\text{v}$)	-	20,000	-	μmhos
Frequency for Maximum Ratings	-	-	30	mc

MECHANICAL

Base	-	-	-	-	-	-	-	-	-	see drawing
Mounting	-	-	-	-	-	-	-	-	-	vertical, base down or up
Maximum Over-All Dimensions:										
Length (Does not include filament connectors)	-	-	-	-	-	-	-	-	12.56	inches
Diameter	-	-	-	-	-	-	-	-	3.63	inches
Net Weight	-	-	-	-	-	-	-	-	4.8	pounds
Shipping Weight (Average)	-	-	-	-	-	-	-	-	15	pounds
Cooling	-	-	-	-	-	-	-	-	-	Water and forced air



RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR

(Frequencies below 30 Mc.)

Class-C FM or Telegraphy

(Key-down conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	-	6000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	-	2.5 MAX. AMPS
PLATE DISSIPATION	-	-	-	-	5000 MAX. WATTS
GRID DISSIPATION	-	-	-	-	150 MAX. WATTS

TYPICAL OPERATION

(Frequencies below 30 Mc., per tube)

D C Plate Voltage	-	-	-	4000	5000	6000	volts
D-C Plate Current	-	-	-	2.5	2.5	2.08	amps
D-C Grid Voltage	-	-	-	-300	-450	-500	volts
D-C Grid Current	-	-	-	245	265	180	ma
Peak R-F Grid Input Voltage	-	-	-	580	750	765	volts
Driving Power (approx.)	-	-	-	142	197	136	watts
Grid Dissipation	-	-	-	68	78	46	watts
Plate Power Input	-	-	-	10,000	12,500	12,500	watts
Plate Dissipation	-	-	-	2500	2500	2500	watts
Plate Power Output	-	-	-	7500	10,000	10,000	watts

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

(Frequencies below 30 Mc.)

Class-C Telephony

(Carrier conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	-	5000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	-	2.0 MAX. AMPS
PLATE DISSIPATION	-	-	-	-	3350 MAX. WATTS
GRID DISSIPATION	-	-	-	-	150 MAX. WATTS

TYPICAL OPERATION

(Frequencies below 30 Mc., per tube)

D C Plate Voltage	-	-	-	4000	4500	5000	volts
D-C Plate Current	-	-	-	1.67	1.55	1.45	amps
Total Bias Voltage	-	-	-	-450	-500	-550	volts
Fixed Bias Voltage	-	-	-	-230	-325	-410	volts
Grid Resistor	-	-	-	1500	1500	1400	ohms
D-C Grid Current	-	-	-	150	120	100	ma
Peak R-F Grid Input Voltage	-	-	-	680	720	760	volts
Driving Power (approx.)	-	-	-	102	86	76	watts
Grid Dissipation	-	-	-	35	26	21	watts
Plate Power Input	-	-	-	6670	6970	7250	watts
Plate Dissipation	-	-	-	1670	1670	1670	watts
Plate Power Output	-	-	-	5000	5300	5580	watts

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class B (Sinusoidal wave, two tubes unless otherwise specified)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	-	6000 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT, PER TUBE	-	-	-	-	2.5 MAX. AMPS
PLATE DISSIPATION, PER TUBE	-	-	-	-	5000 MAX. WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

D-C Plate Voltage	-	-	-	4000	5000	6000	volts
D-C Grid Voltage ¹	-	-	-	-150	-190	-240	volts
Zero-Signal D-C Plate Current	-	0.6	0.5	0.4	amps		
Max-Signal D-C Plate Current		4.0	3.2	3.0	amps		
Effective Load, Plate to Plate	-	2200	3600	4650	ohms		
Peak A-F Grid Input Voltage (per tube)*	-	-	-	340	360	390	volts
Max-Signal Peak Driving Power*		340	230	225	watts		
Max-Signal Nominal Driving Power*	-	-	-	170	115	113	watts
Max-Signal Plate Output Power	11,000	11,000	13,000	watts			

*Approximate values.

¹Adjust to give listed zero-signal plate current.

TYPICAL OPERATION CLASS AB₂ (Two Tubes)

Modulator service for 4000 and 5000 volt operation, to modulate one or two tubes, as shown under "Plate Modulated Radio Frequency Amplifier" (Page 1)

D-C Plate Voltage	-	4000	5000	4000	5000	volts
D-C Grid Voltage (approx.)*	-	-155	-200	-145	-190	volts
Zero-Signal D-C Plate Current	-	0.4	0.4	0.6	0.5	amps
Max-Signal D-C Plate Current	-	1.35	1.13	2.70	2.26	amps
Effective Load, Plate to Plate	-	6600	10,000	3300	5000	ohms
Peak A-F Grid Input Voltage (per tube)		240	275	285	310	volts
Max-Signal Peak Driving Power	-	42	40	134	118	watts
Max-Signal Nominal Driving Power (approx.)	-	21	20	67	59	watts
Max-Signal Plate Power Output	-	3700	4000	7400	8000	watts
Will Modulate one Tube R-F Final Input of	-	6670	7250			watts
Will Modulate two tubes R-F Final Input of	-			13,340	14,500	watts

*Adjust to give stated zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS

APPLICATION

► **Cooling**—Minimum recommended water-flow rate and pressure drop values for different water-inlet temperatures and plate dissipations are tabulated on the opposite page. The outlet water temperature must not exceed a maximum of 70° C under any conditions. The inlet water pressure must not exceed a maximum of 60 pounds per square inch.

The grid-terminal contact surface and adjacent glass must be cooled by forced air. The quantity, velocity and direction must be adjusted to limit the maximum seal temperature to 150° C.

The filament stem structure also requires forced-air cooling. A minimum of 6 cubic feet per minute must be directed into the space between the inner and outer filament contacting surfaces.

Air and water flow must be started before filament power is applied and maintained for at least five minutes after the filament power has been removed.

Filament Voltage—The filament voltage, as measured directly at the tube, should be 7.5 volts with maximum allowable variations due to line fluctuation of from 7.12 to 7.87 volts.

Bias Voltage—There is little advantage in using bias voltages in excess of those given under "Typical Operation," except in certain very specialized applications. Where bias is obtained from a grid resistor, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage—The plate supply voltage for the 3W5000F3 should not exceed 6000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "Typical Operation" for the power output desired.

In Class-C FM or Telegraphy service, a 0.1 henry choke, shunted by a spark gap, should be series connected between the plates of the amplifier tubes and the high voltage plate supply capacitor to offer protection from transients and surges. In plate modulated service, where a plate modulation transformer is used, the protective choke is not normally required.

Grid Dissipation—The power dissipated by the grid of the 3W5000F3 must never exceed 150 watts. Grid dissipation may be calculated from the following expression

$$P_g = e_{cmp} I_c$$

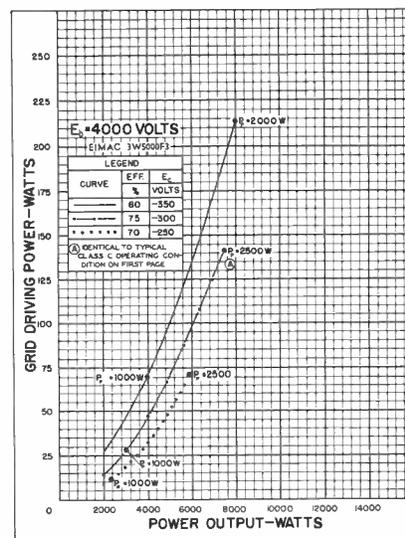
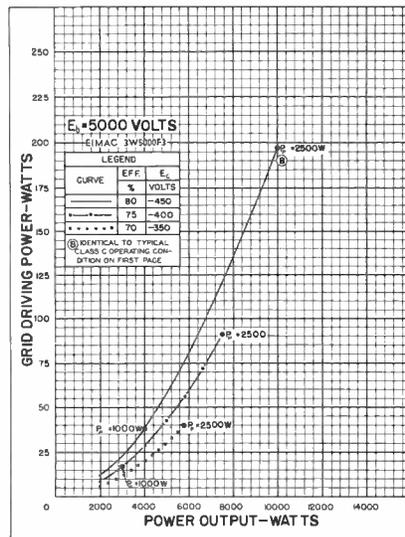
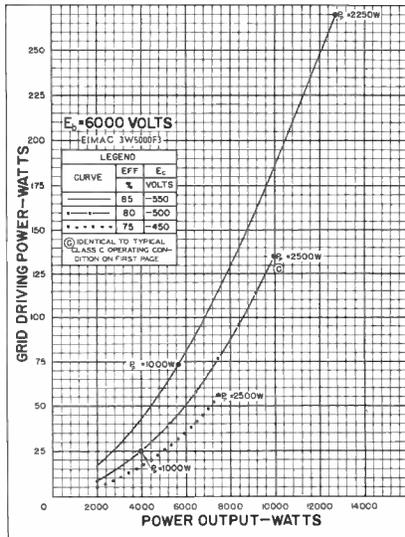
where P_g = Grid dissipation,

e_{cmp} = Peak positive grid voltage, and

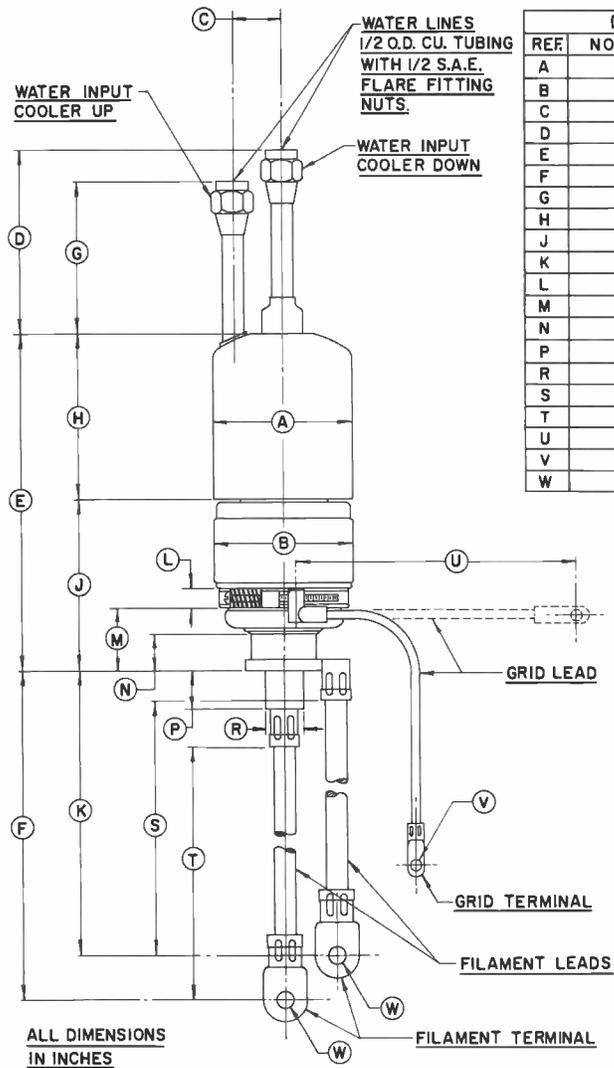
I_c = D-C grid current

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid. Any suitable peak v.t.v.m. circuit may be used.

In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.



MINIMUM WATER COOLING REQUIREMENTS								
Water Inlet Temp. (°C)	Plate Dissipation							
	2 KW		3 KW		4 KW		5 KW	
	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI	Flow Rate GPM	Pressure Drop PSI
20	1.7	0.68	2.6	1.3	3.9	2.3	5.6	3.9
30	2.3	1.1	3.2	1.7	4.5	2.8	6.2	4.5
40	3.0	1.6	3.8	2.2	5.3	3.5	6.9	5.3
50	3.9	2.3	4.7	3.0	6.0	4.3	7.7	6.1



DIMENSION DATA			
REF.	NOM.	MIN.	MAX.
A		3.234	3.266
B			3.625
C		1.062	1.187
D		4.000	4.500
E		7.562	8.062
F		8.937	9.437
G		3.250	3.750
H		3.625	3.875
J		3.937	4.187
K		7.937	8.437
L		.375	.437
M		1.437	1.562
N		.812	.937
P		.812	.937
R		.859	.890
S		7.000	7.500
T		7.000	7.500
U		6.375	6.625
V		.194	.200
W		.385	.395

DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and approximate grid driving power at plate voltages of 4000, 5000 and 6000 volts. These charts show combined grid and bias losses only. The driving-power and power-output figures do not include circuit losses. The plate dissipation in watts is indicated by Pp. Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 4000, 5000 and 6000 volts respectively.

► Indicates change from sheet dated 8-26-58

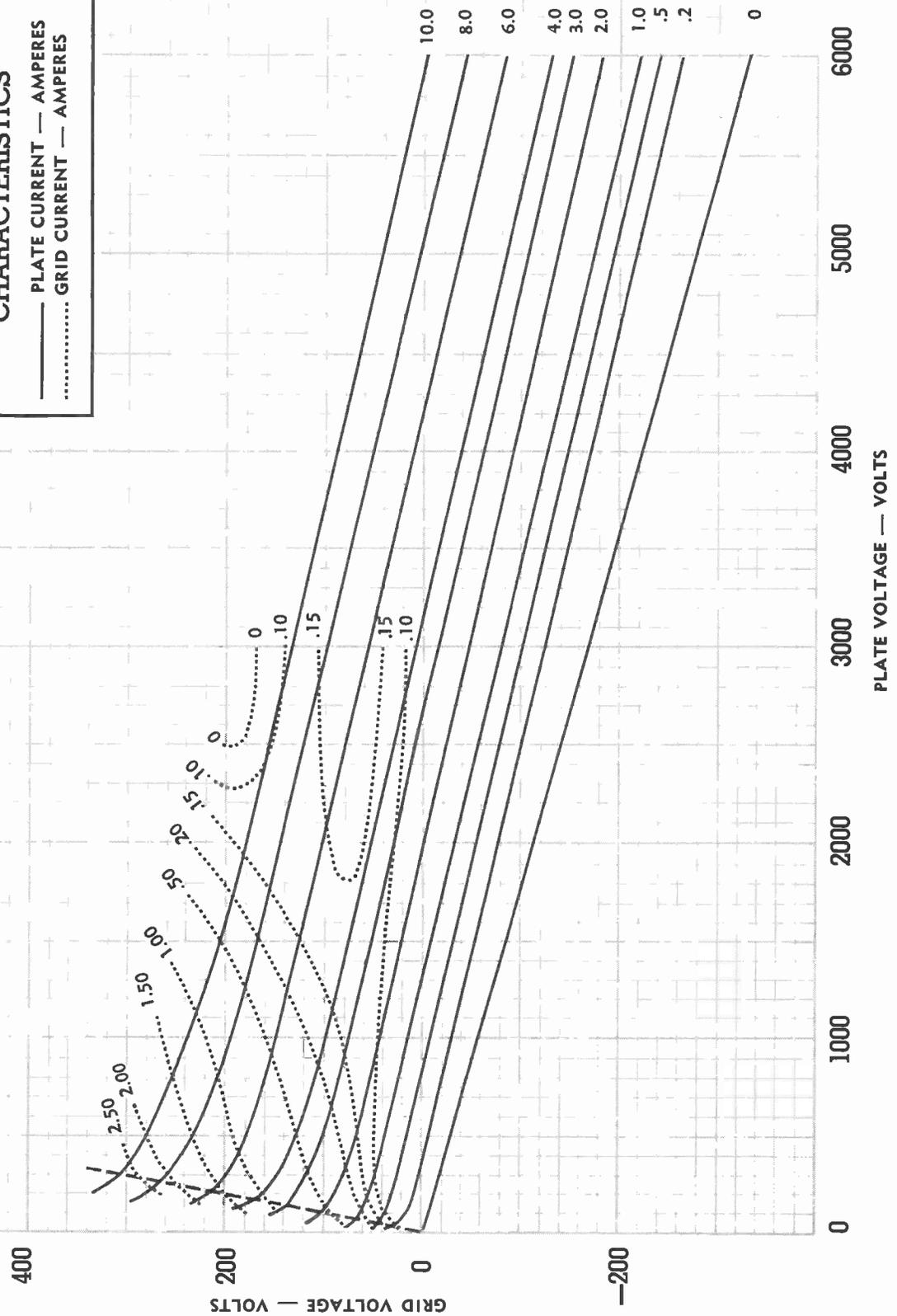


3W5000F3

EIMAC 3W5000F3

CONSTANT CURRENT CHARACTERISTICS

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN BRUNO · CALIFORNIA

3X100A5

HIGH-MU

TRIODE

The Eimac 3X100A5 is a high-mu transmitting triode of planar construction designed for use as a power amplifier, oscillator, or frequency multiplier in the VHF and UHF ranges. The 3X100A5 is physically and electrically identical to the Eimac 2C39A but additional production tests, including long-pulse cathode evaluation, assure higher quality.

The 3X100A5 will deliver a minimum of 12 watts useful power output as an r-f oscillator at 2500 megacycles and up to 27 watts power output as an amplifier at 500 megacycles.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Cathode: Oxide-Coated, Unipotential				
Heating Time	-	60	-	seconds
Heater: Voltage (See "Applications")	-	6.3	-	volts
Current	0.95	-	1.10	amperes
Amplification Factor	-	100	-	
Direct Interelectrode Capacitances:				
Grid-Plate	1.86	2.16	-	uuf
Grid-Cathode	5.60	7.60	-	uuf
Plate-Cathode	-	0.035	-	uuf
Transconductance ($I_b = 70$ ma.)	20,000	30,000	-	umhos
Frequency for Maximum Ratings	-	2,500	-	mc

MECHANICAL

Base, Socket and Connections	See drawing			
Operating Position	Any			
Cooling	Forced Air			
Maximum Operating Temperatures:				
Metal-to-Glass Seals	175° C			
Anode Core	175° C			
Maximum Over-all Dimensions:				
Length	2.75	inches		
Diameter	1.27	inches		
Net Weight	2.8	ounces		
Shipping Weight (Approximate)	7	ounces		



RADIO-FREQUENCY POWER AMPLIFIER, OR OSCILLATOR

MAXIMUM RATINGS (Per tube)

D-C PLATE VOLTAGE	1000 MAX. VOLTS
D-C CATHODE CURRENT	125 MAX. MA
D-C GRID VOLTAGE	150 MAX. VOLTS
D-C GRID CURRENT	50 MAX. MA
HEATER VOLTAGE	SEE APPLICATION NOTES
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE	30 MAX. VOLTS
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE	400 MAX. VOLTS
PLATE DISSIPATION	100 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Key-down conditions, per tube)
(Power-Amplifier Grid-Isolation Circuit, CW Operation, 500 Mc.)

D-C Plate Voltage	800 volts
D-C Grid Voltage	-20 volts
D-C Plate Current	80 ma
D-C Grid Current	32 ma
Driving Power (approx.) ¹	6 watts
Useful Power Output	27 watts

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER OR OSCILLATOR

MAXIMUM RATINGS (Carrier conditions, per tube)

D-C PLATE VOLTAGE ³	600 MAX. VOLTS
D-C GRID VOLTAGE	150 MAX. VOLTS
D-C GRID CURRENT	50 MAX. MA
D-C CATHODE CURRENT	100 MAX. MA
PEAK INSTANTANEOUS POSITIVE GRID VOLTAGE	30 MAX. VOLTS
PEAK INSTANTANEOUS NEGATIVE GRID VOLTAGE	400 MAX. VOLTS
PLATE DISSIPATION	70 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION
(Plate-Modulated Radio-Frequency Power Amplifier Grid-Isolation Circuit, 500 Mc., Per Tube)

D-C Plate Voltage	600 volts
D-C Grid Voltage	-16 volts
D-C Plate Current	65 ma
D-C Grid Current	35 ma
Driving Power (approx.) ¹	5 watts
Useful Carrier Power Output	16 watts

¹Driving power listed is the total power which must be supplied to a practical grid circuit at the frequency shown.

²These 2500-megacycle conditions conform to the minimum requirements of the MIL-E-1 specifications for the 2C39A.

³For less than 100% modulation, higher d-c plate voltage may be used if the sum of the peak positive modulating voltage and the d-c plate voltage does not exceed 1200 volts.



APPLICATION

MECHANICAL

Mounting—The 3X100A5 may be operated in any position. It should be firmly held in place by spring-finger collets bearing on the terminal surfaces. The tube should seat against the under side of the "anode flange" (see outline drawing). In applications involving severe shock and vibration, the tube may be clamped in place by applying a suitable clamping device to the anode flange. It is recommended that no other portion of the tube be subjected to clamping forces.

Connections—The tube terminals are in the form of concentric cylinders of graduated diameters so that the 3X100A5 may be conveniently used with coaxial tuning devices. Spring-finger collets should be used to make contact with the anode, grid, cathode, and heater terminals. Adequate contact area and spring pressure should be provided to minimize heating and to prevent erratic circuit performance at the higher frequencies. Non-contacting or intermittently-contacting collet fingers will cause troublesome circuit behavior, especially at very-high and ultra-high frequencies. Electrode contact surfaces should be kept clean and free of oxide coatings.

Cooling—Forced air must be supplied to the anode cooler and to the metal-to-glass seals in sufficient quantity to maintain their temperatures below 175° C.

At sea level, with an inlet air temperature of 20° C, 12.5 cubic feet per minute of air flow is required to cool the anode at 100 watts plate dissipation when the illustrated air cowling is used. Operation at higher altitudes or with higher inlet air temperatures will require increased volumes of flow to obtain equivalent cooling. When using the anode cowling as illustrated here, it is necessary to provide air for seal cooling separately.

It should be borne in mind that operating temperature is the sole criterion of cooling effectiveness, regardless of the coolant type, flow rate, or coolant temperature. One method of measuring surface temperatures is by the use of a temperature-sensitive lacquer, such as "Tempilaq." This product can be obtained from the Tempil Corporation, 132-34 West 22nd Street, New York 11, N.Y. or from various chemical or scientific-equipment suppliers. When temperature-sensitive materials are used, extremely thin applications must be used to avoid inaccurate indications and interference with the heat transfer from the tube to the air stream.

ELECTRICAL

Heater Operation—The rated heater voltage for the 3X100A5 is 6.3 volts and the working voltage should be determined from the table below. The heater voltage should be maintained within plus or minus 10% of its intended value to minimize variations in circuit performance and to obtain maximum tube life.

At ultra-high frequencies transit-time effects can influence the cathode temperature. The amount of r-f driving power diverted to heating the cathode by back-bombardment will depend upon the frequency, the plate current, and the r-f driving power being supplied to the tube. The following table is intended as a general guide.

Frequency (Mc.)	E_f (Volts)
Up to 400	6.3
400 to 1000	6.0
1000 to 1500	5.5
1500 to 2000	5.0
2000 and above	4.5

If the conditions of operation result in extreme cathode back-heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to the proper value.

Cathode Operation—The oxide-coated unipotential cathode in the 3X100A5 and one side of the heater are connected internally. The absolute maximum rated d-c current is 125 milliamperes.

It is recommended that rated heater voltage be applied for a minimum of 30 seconds before other operating voltages are applied. Tube performance will become stabilized approximately 60 seconds after the heater voltage is applied.

Control-Grid Operation—The maximum rated grid dissipation is 2.0 watts.

At operating frequencies near 500 megacycles, the driving power necessary for maximum output of a typical grounded-grid amplifier is in the order of 6 watts and as the operating frequency is increased, the driving power requirements increase. Most of this additional driving power is absorbed in circuit losses other than grid dissipation, however, and the actual grid dissipation will increase very little.

The grid bias required by various 3X100A5 tubes may vary between limits approximately 50% above and below the nominal value and means should be provided in the equipment to accommodate such variations.

When grid-leak bias is used, suitable means must be provided to protect the tube against loss of excitation at plate voltages above 600 volts and the grid-leak resistor should be made variable to facilitate maintaining the bias voltage and plate current at the desired values when tubes are changed in the equipment.

Plate Operation—The maximum rated plate dissipation is 100 watts. In plate-modulated applications, the plate dissipation under carrier conditions must be limited to 70 watts to avoid exceeding the plate-dissipation rating with 100% sine-wave modulation.

In general, low-voltage high-current operation is preferable to high-voltage low-current operation from the standpoint of optimum life.

An excellent indication of operating conditions is the ratio of grid current to plate current; when the 3X100A5 is operated with grid-current values greater than half those of the plate current, either the drive is excessive or the plate loading is too light for the excitation present. The tube should never be operated unloaded, even for short periods of time. Drive should be held to the lowest value consistent with reasonable efficiency.

Special Applications—If it is desired to operate this tube under conditions widely different from those given here, write to Eitel-McCullough, Inc., San Bruno, California, for information and recommendations.



3X100A5

**EIMAC 3X100A5
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS**

— PLATE CURRENT — AMPERES
- - - GRID CURRENT — AMPERES

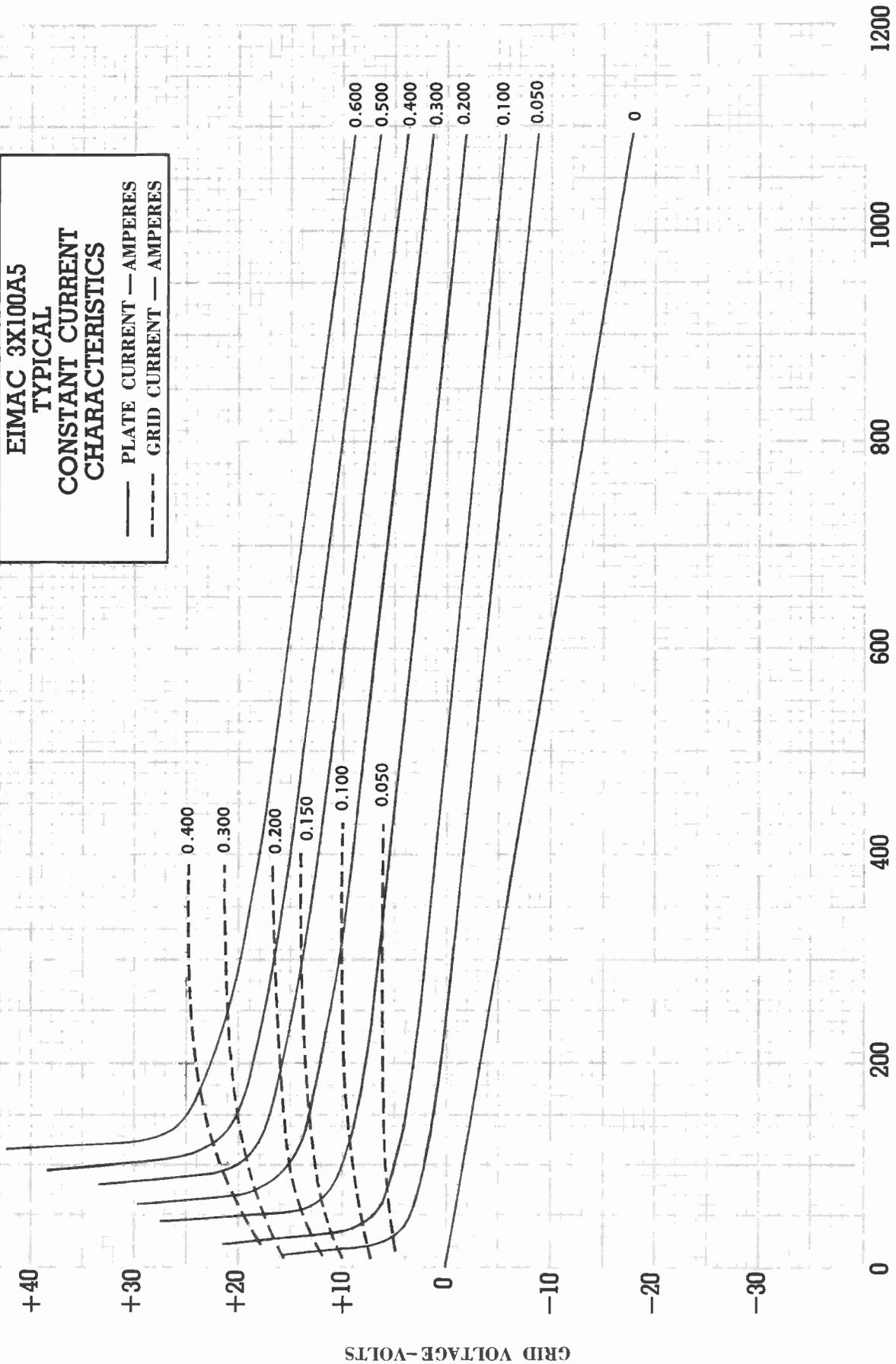
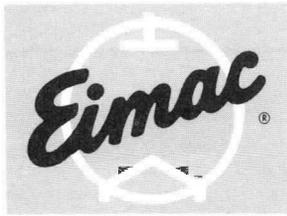


PLATE VOLTAGE — VOLTS

GRID VOLTAGE—VOLTS



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

8161
3X2500A3

MEDIUM MU TRIODE

The Eimac 8161/3X2500A3 is a medium-mu, forced-air-cooled, external-anode transmitting triode with a maximum plate-dissipation rating of 2500 watts. Relatively high power output as an amplifier, oscillator or modulator may be obtained from this tube at low plate voltages. A single tube will deliver a radio-frequency output of 7500 watts at 4000 plate volts at frequencies up to 110 Mc., as well as at lower frequencies.

The tube has a rugged, low-inductance cylindrical filament-stem structure, which readily becomes part of a linear filament tank circuit for V.H.F. operation. The grid provides thorough shielding between the input and output circuits for grounded-grid applications and is conveniently terminated in a ring between the plate and filament terminals. The 8161/3X2500A3 may be installed or removed without the aid of tools.

The approved Federal Communications Commission rating for the 8161/3X2500A3 is 5000 watts of carrier power when used as a plate-modulated amplifier and 1250 watts of carrier power when used as a grid-modulated or linear amplifier.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated Tungsten				
Voltage		7.5		volts
Current	49		54	amperes
Amplification Factor	19		26	
Direct Interelectrode Capacitances				
Grid-Plate	16.8		23.2	uuf
Grid-Filament	29.2		40.2	uuf
Plate-Filament	0.6		1.2	uuf
Transconductance ($I_b=830$ ma., $E_b=3000$ v.)		20,000		umhos
Highest Frequency for Maximum Ratings			75	mc

MECHANICAL

Base				See drawing
Mounting				Vertical, base down or up
Cooling				Forced air
Maximum Anode Cooler Core and Seal Temperatures				175° C
Maximum Over-All Dimensions:				
Length				8.6 inches
Diameter				4.16 inches
Net Weight				6.25 pounds
Shipping Weight (Average)				17 pounds

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

(Conventional Neutralized Amplifier—Frequencies below 75Mc.)
Class-C FM or Telegraphy (Key-down conditions, per tube)

MAXIMUM RATINGS	
D-C PLATE VOLTAGE	6000 MAX. VOLTS
D-C PLATE CURRENT	2.5 MAX. AMPS
PLATE DISSIPATION	2500 MAX. WATTS
PLATE COOLER CORE TEMPERATURE	175 MAX. ° C
GRID DISSIPATION	150 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc. per tube)

D-C Plate Voltage	4000	5000	6000	volts
D-C Plate Current	2.5	2.5	2.08	amps
D-C Grid Voltage	-300	-450	-500	volts
D-C Grid Current*	245	265	180	ma
Peak R-F Grid Input Voltage*	580	750	765	volts
Driving Power*	142	197	136	watts
Grid Dissipation*	68	78	46	watts
Plate Power Input	10,000	12,500	12,500	watts
Plate Dissipation	2500	2500	2500	watts
Plate Power Output	7500	10,000	10,000	watts

RADIO-FREQUENCY POWER AMPLIFIER

Grounded-Grid Circuit
Class-C FM Telephony

MAXIMUM RATINGS (Frequencies between 75 and 110 Mc.)	
D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C PLATE CURRENT	2.0 MAX. AMPS
D-C GRID CURRENT	200 MAX. MA
PLATE DISSIPATION	2500 MAX. WATTS
PLATE COOLER CORE TEMPERATURE	175 MAX. ° C
GRID DISSIPATION	150 MAX. WATTS

TYPICAL OPERATION (110 Mc., per tube)

D-C Plate Voltage	3700	4000	volts
D-C Grid Voltage	-450	-500	volts
D-C Plate Current	1.8	1.85	amps
D-C Grid Current*	190	190	ma
Driving Power*	1600	1900	watts
Useful Power Output	6850	7500	watts

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

(Conventional Neutralized Amplifier—Frequencies below 75 Mc.)
Class-C Telephony (Carrier conditions, per tube)

MAXIMUM RATINGS	
D-C PLATE VOLTAGE	5000 MAX. VOLTS
D-C PLATE CURRENT	2.0 MAX. AMPS
PLATE DISSIPATION	1670 MAX. WATTS
PLATE COOLER CORE TEMPERATURE	175 MAX. ° C
GRID DISSIPATION	150 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc., per tube)

D-C Plate Voltage	4000	4500	5000	volts
D-C Plate Current	1.67	1.47	1.25	amps
D-C Grid Voltage	-450	-500	-550	volts
D-C Grid Current*	180	140	150	ma
Peak R-F Grid Input Voltage*	685	715	760	volts
Driving Power*	125	100	115	watts
Grid Dissipation*	43	30	32	watts
Plate Power Input	6670	6615	6250	watts
Plate Dissipation	1670	1315	950	watts
Plate Power Output	5000	5300	5300	watts

*Approximate values.



AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

Class-AB or B

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	-	6000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	-	2.5 MAX. AMPS
PLATE DISSIPATION	-	-	-	-	2500 MAX. WATTS
GRID DISSIPATION	-	-	-	-	150 MAX. WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

D-C Plate Voltage	-	-	-	-	4000	5000	6000	volts
D-C Grid Voltage ¹	-	-	-	-	-150	-190	-240	volts
Zero-Signal D-C Plate Current	-	-	-	-	0.6	0.5	0.4	amps
Max-Signal D-C Plate Current	-	-	-	-	4.0	3.2	3.0	amps
Effective Load, Plate to Plate	-	-	-	-	2200	3600	4650	ohms
Peak A-F Grid Input Voltage (per tube)*	-	-	-	-	340	360	390	volts
Max-Signal Peak Driving Power*	-	-	-	-	340	230	225	watts
Max-Signal Nominal Driving Power*	-	-	-	-	170	115	113	watts
Max-Signal Plate Output Power	-	-	-	-	11,000	11,000	13,000	watts

*Approximate values.

¹Adjust to give listed zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS

APPLICATION

► **Cooling**—Forced-air cooling must be provided to hold the glass-to-metal seals and the anode cooler core below the maximum rated temperature of 175° C. Although the air requirements stated below are sufficient to maintain rated tube temperatures under many conditions, air in excess of the amounts shown will usually result in longer tube life. At ambient temperatures higher than 20° C., at high altitudes, and at operating frequencies above 30 megacycles, additional air flow must be provided. In all cases, tube temperatures are the criteria which govern air requirements. Surface temperatures may be measured conveniently with the aid of temperature-sensitive paints.

Anode-to-Base Air-Flow				
Plate Dissipation (Watts)	Sea Level		10,000 Feet	
	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)
2000	58.5	0.8	85.5	1.15
2500	85.5	1.6	125	2.3

Base-to-Anode Air-Flow				
Plate Dissipation (Watts)	Sea Level		10,000 Feet	
	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)
2000	35.5	0.25	52	0.35
2500	42	0.5	61.5	0.75

Under the same conditions, a minimum air-flow rate of 6 CFM directed into the filament-stem structure between the inner and outer filament terminals is required to maintain the base seals below 175° C.

Simultaneous removal of all power and air (as in the case of a power failure) will not ordinarily injure the tube, but it is not recommended as a standard operating practice.

Filament Voltage—The filament voltage, as measured directly at the tube, should be 7.5 volts with maximum allowable variations due to line fluctuation of from 7.12 to 7.87 volts.

Bias Voltage—There is little advantage in using bias voltages in excess of those given under "Typical Operation" except in certain very specialized applications. Where bias is obtained from a grid resistor, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

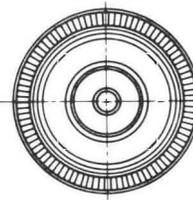
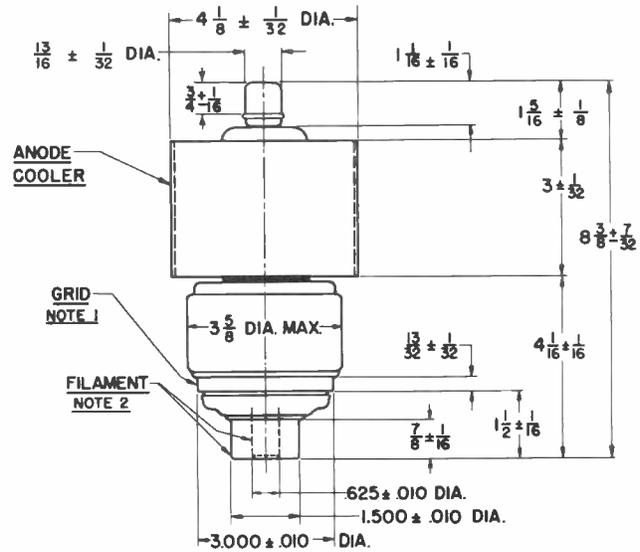
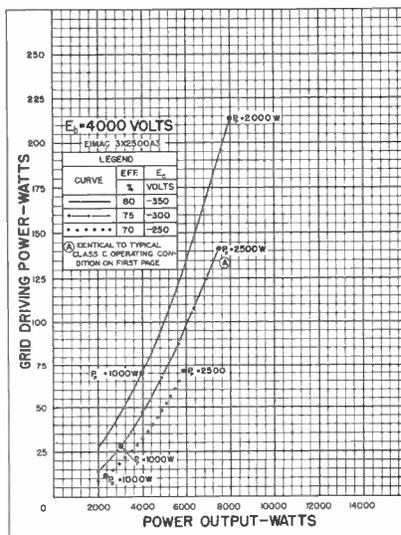
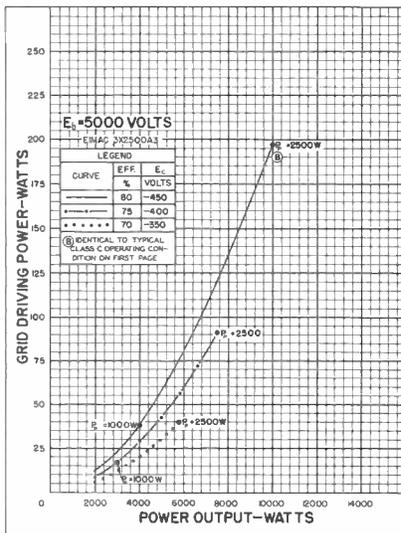
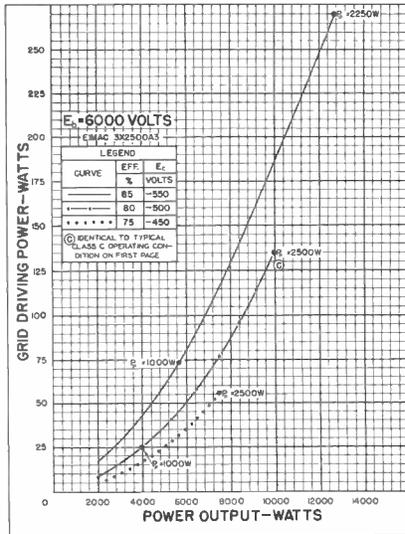
Plate Voltage — The plate-supply voltage for the 3X2500A3 should not exceed 6000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "Typical Operation" for the power output desired.

In Class-C FM or Telegraphy service a 0.1 -henry choke, shunted by a spark gap, should be series connected between the plates of the amplifier tubes and the high-voltage plate-supply capacitor to offer protection from transients and surges. In plate-modulated services where a plate-modulation transformer is used the protective choke is not normally required.

Grid Dissipation—The power dissipated by the grid of the 3X2500A3 must never exceed 150 watts. Grid dissipation is the product of d-c grid current and peak positive grid voltage.

In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.

In VHF operation, particularly above 75 Mc., the d-c grid current must not exceed 200 ma. under any conditions of plate loading. With lightly loaded conditions the grid driving power should be reduced so that the grid current does not exceed one-tenth of the plate current.



DIMENSIONS
IN INCHES

NOTE 1
 .040" MAXIMUM RUNOUT OF GRID CONTACT SURFACE WITH RESPECT TO AXIS DETERMINED BY ANODE AND OUTER FILAMENT CONTACT SURFACE.

NOTE 2
 .025" MAXIMUM RUNOUT OF INNER FILAMENT CONTACT SURFACE WITH RESPECT TO OUTER FILAMENT CONTACT SURFACE.

REMOVABLE GRID CONNECTOR WITH SPRING FINGERS

SPRING COLLET CONNECTORS FOR FILAMENT TERMINALS

AIR INLET

FLOATING CENTER CONNECTOR POST

RF CIRCUIT

GRID BY-PASS CAPACITOR

AIR OUTLET

TYPICAL TUBE CONNECTORS AND STEM COOLING

DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and approximate grid driving power at plate voltages of 4000, 5000 and 6000 volts. These charts show combined grid and bias losses only. The driving-power and power-output figures do not include circuit losses. The plate dissipation in watts is indicated by Pp. Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 4000, 5000 and 6000 volts respectively.

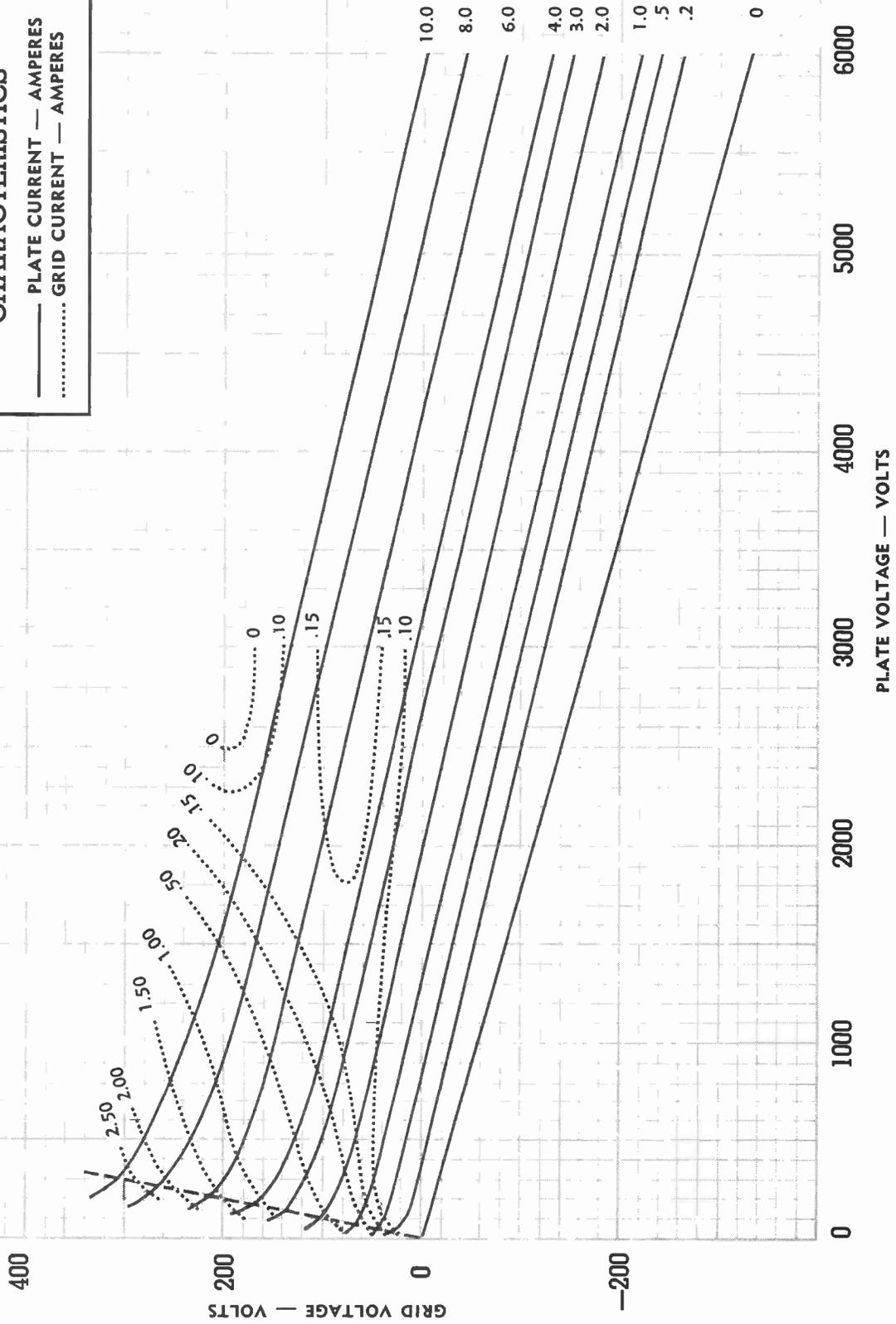


3X2500A3

EIMAC 3X2500A3

CONSTANT CURRENT CHARACTERISTICS

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

8251
3X2500F3

MEDIUM-MU
TRIODE

The Eimac 8251/3X2500F3 is a medium-mu, forced-air cooled, external-anode power triode intended for amplifier, oscillator, or modulator service. It has a maximum plate-dissipation rating of 2500 watts and is capable of high output at relatively low plate voltages. A single 8251/3X2500F3 will deliver a radio-frequency plate power output of 7500 watts at a plate voltage of 4000 volts.

The tube is equipped with flexible filament and grid leads which simplify socketing and equipment design for industrial and communication frequencies below 30 megacycles.

The approved Federal Communications Commission rating for the 8251/3X2500F3 is 5000 watts of carrier power when used as a plate-modulated amplifier and 1250 watts of carrier power when used as a grid-modulated or linear amplifier.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated Tungsten				
Voltage	-	7.5	-	volts
Current	-	48	53	amperes
Amplification Factor	-	19	26	
Direct Interelectrode Capacitances:				
Grid-Plate	-	16.8	23.2	uuf
Grid-Filament	-	29.2	40.2	uuf
Plate-Filament	-	0.6	1.2	uuf
Transconductance ($I_b=830$ ma., $E_b=3000$ v.)	-	20,000	-	umhos
Highest Frequency for Maximum Ratings	-	-	30	mc

MECHANICAL

Base	-	-	-	See outline drawing
Mounting	-	-	-	Vertical, base down or up
Maximum Anode Cooler Core and Seal Temperatures	-	-	-	175° C
Cooling	-	-	-	Forced air
Maximum Over-All Dimensions:				
Length (Does not include filament connectors)	-	-	-	8.6 inches
Diameter	-	-	-	4.16 inches
Length of Filament Connectors (Approximate)	-	-	-	9.5 inches
Net Weight	-	-	-	7.5 pounds
Shipping Weight (Approximate)	-	-	-	17 pounds



RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Conventional Neutralized Amplifier,
Class-C FM or Telegraphy (Key-Down Conditions)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	6000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	2.5 MAX. AMPS
PLATE DISSIPATION	-	-	-	2500 MAX. WATTS
GRID DISSIPATION	-	-	-	150 MAX. WATTS

TYPICAL OPERATION (Frequencies below 30 Mc)

D-C Plate Voltage	-	-	-	4000	5000	6000	volts
D-C Plate Current	-	-	-	2.5	2.5	2.08	amps
D-C Grid Voltage	-	-	-	-300	-450	-500	volts
D-C Grid Current	-	-	-	245	265	180	ma
Peak R-F Grid Input Voltage*	-	-	-	580	750	765	volts
Driving Power*	-	-	-	142	197	136	watts
Grid Dissipation*	-	-	-	68	78	46	watts
Plate Input Power	-	-	-	10,000	12,500	12,500	watts
Plate Dissipation	-	-	-	2500	2500	2500	watts
Plate Output Power	-	-	-	7500	10,000	10,000	watts

*Approximate values.

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Conventional Neutralized Amplifier,
Class-C Telephony (Carrier Conditions)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	5500 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	2.0 MAX. AMPS
PLATE DISSIPATION	-	-	-	1670 MAX. WATTS
GRID DISSIPATION	-	-	-	150 MAX. WATTS

TYPICAL OPERATION (Frequencies below 30 Mc)

D-C Plate Voltage	-	-	-	4000	4500	5000	volts
D-C Plate Current	-	-	-	1.67	1.47	1.25	amps
D-C Grid Voltage	-	-	-	-450	-500	-550	volts
D-C Grid Current*	-	-	-	180	140	150	ma
Peak R-F Grid Input Voltage*	-	-	-	685	715	760	volts
Driving Power*	-	-	-	125	100	115	watts
Grid Dissipation*	-	-	-	43	30	32	watts
Plate Input Power	-	-	-	6670	6615	6250	watts
Plate Dissipation	-	-	-	1670	1315	950	watts
Plate Output Power	-	-	-	5000	5300	5300	watts

*Approximate values.



AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

Class-AB or B

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	-	6000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	-	2.5 MAX. AMPS
PLATE DISSIPATION	-	-	-	-	2500 MAX. WATTS
GRID DISSIPATION	-	-	-	-	150 MAX. WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

D-C Plate Voltage	-	-	-	-	4000	5000	6000	volts
D-C Grid Voltage ¹	-	-	-	-	-150	-190	-240	volts
Zero-Signal D-C Plate Current	-	-	-	-	0.6	0.5	0.4	amps
Max-Signal D-C Plate Current	-	-	-	-	4.0	3.2	3.0	amps
Effective Load, Plate to Plate	-	-	-	-	2200	3600	4650	ohms
Peak A-F Grid Input Voltage (per tube)*	-	-	-	-	340	360	390	volts
Max-Signal Peak Driving Power*	-	-	-	-	340	230	225	watts
Max-Signal Nominal Driving Power*	-	-	-	-	170	115	113	watts
Max-Signal Plate Output Power	-	-	-	-	11,000	11,000	13,000	watts

*Approximate values.

¹Adjust to give listed zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS

APPLICATION

Cooling—Forced-air cooling must be provided to hold the glass-to-metal seals and the anode cooler core below the maximum rated temperature of 175° C. Although the air requirements stated below are sufficient to maintain rated tube temperatures under many conditions, air in excess of the amounts shown will usually result in longer tube life. At ambient temperatures higher than 20° C and at high altitudes additional air flow must be provided. In all cases, tube temperatures are the criteria which govern air requirements. Surface temperatures may be measured conveniently with the aid of temperature-sensitive paints.

Anode-to-Base Air-Flow				
Plate Dissipation (Watts)	Sea Level		10,000 Feet	
	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)
2000	58.5	0.8	85.5	1.15
2500	85.5	1.6	125	2.3

Base-to-Anode Air-Flow				
Plate Dissipation (Watts)	Sea Level		10,000 Feet	
	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)	Air-Flow (CFM)	Pressure Drop (Inches H ₂ O)
2000	35.5	0.25	52	0.35
2500	42	0.5	61.5	0.75

Under the same conditions, a minimum air-flow rate of 6 CFM directed into the filament-stem structure between the inner and outer filament terminals is required to maintain the base seals below 175° C.

Simultaneous removal of all power and air (as in the case of a power failure) will not ordinarily injure the tube, but it is not recommended as a standard operating practice.

Filament Voltage—The filament voltage as measured directly at the tube, should be 7.5 volts with maximum allowable variations due to line fluctuation of from 7.12 to 7.87 volts. Tube life may be extended by operation at the lower end of this range.

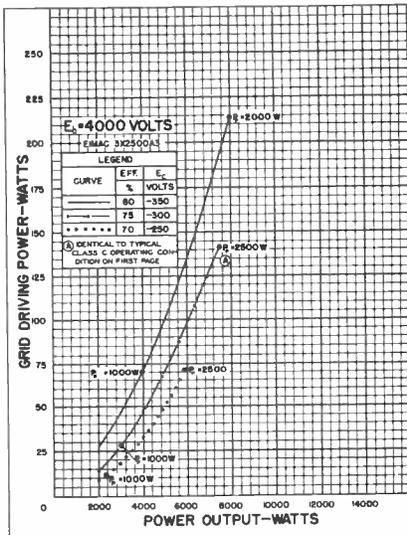
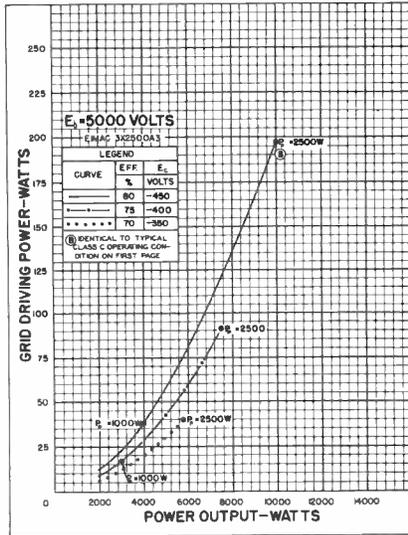
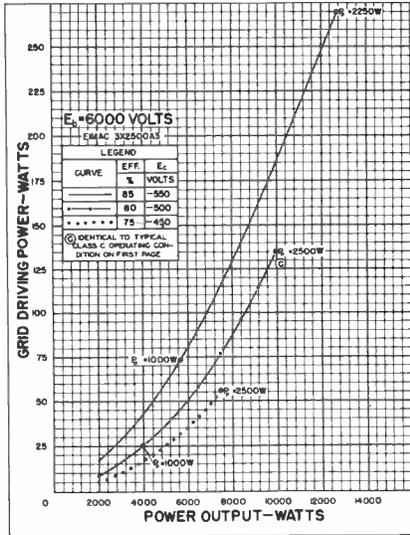
Bias Voltage—There is little advantage in using bias voltages in excess of those given under "Typical Operation," except in certain very specialized applications. Where bias is obtained from a grid resistor, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage — The plate-supply voltage for the 3X2500F3 should not exceed 6000 volts.

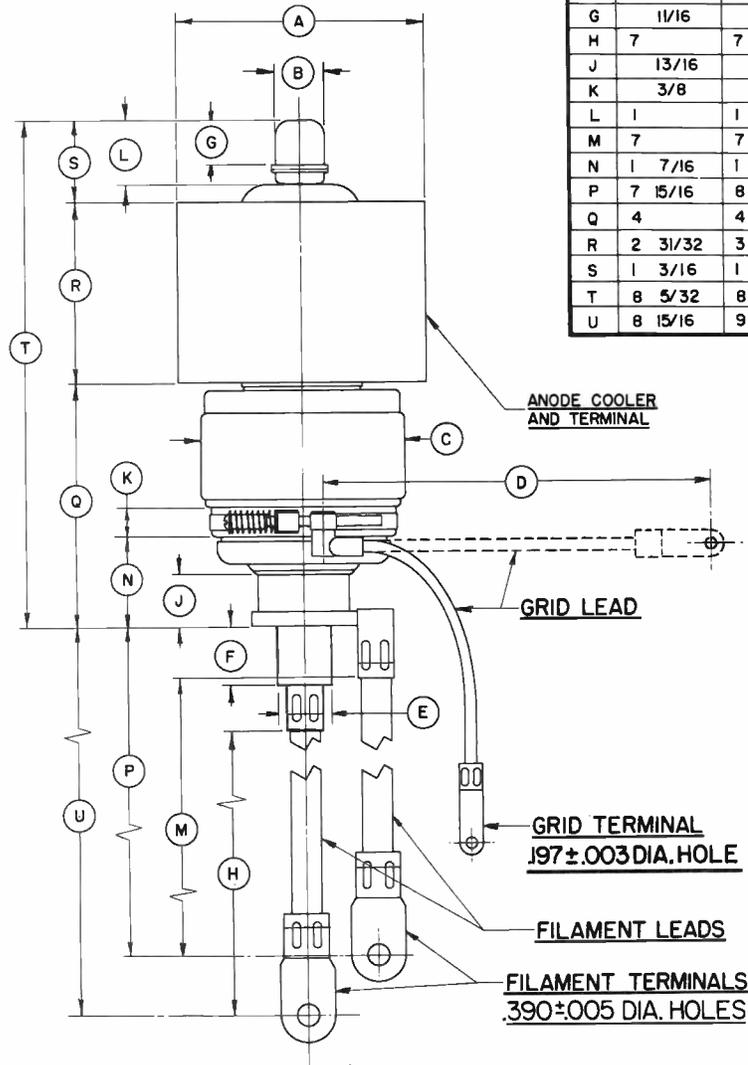
In Class-C FM or Telegraphy service, a 0.1-henry choke, shunted by a spark gap, should be series connected between the plates of the amplifier tubes and the high-voltage plate-supply capacitor to offer protection from transients and surges. In plate-modulated service, where a plate-modulation transformer is used, the protective choke is not normally required.

Grid Dissipation—The power dissipated by the grid of the 3X2500F3 must never exceed 150 watts. Grid dissipation is the product of dc grid current and peak positive grid voltage.

In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading. With lightly loaded conditions the grid driving power should be reduced so that the grid current does not exceed one-tenth of the plate current.



DIMENSION DATA		
REF.	MIN	MAX
A	4 3/32	4 5/32
B	25/32	27/32
C		3 5/8
D	6 3/8	6 5/8
E	55/64	57/64
F	13/16	15/16
G	11/16	13/16
H	7	7 1/2
J	13/16	15/16
K	3/8	7/16
L	1	1 1/8
M	7	7 1/2
N	1 7/16	1 9/16
P	7 15/16	8 7/16
Q	4	4 1/8
R	2 31/32	3 1/32
S	1 3/16	1 7/16
T	8 5/32	8 19/32
U	8 15/16	9 7/16



ALL DIMENSIONS
IN INCHES

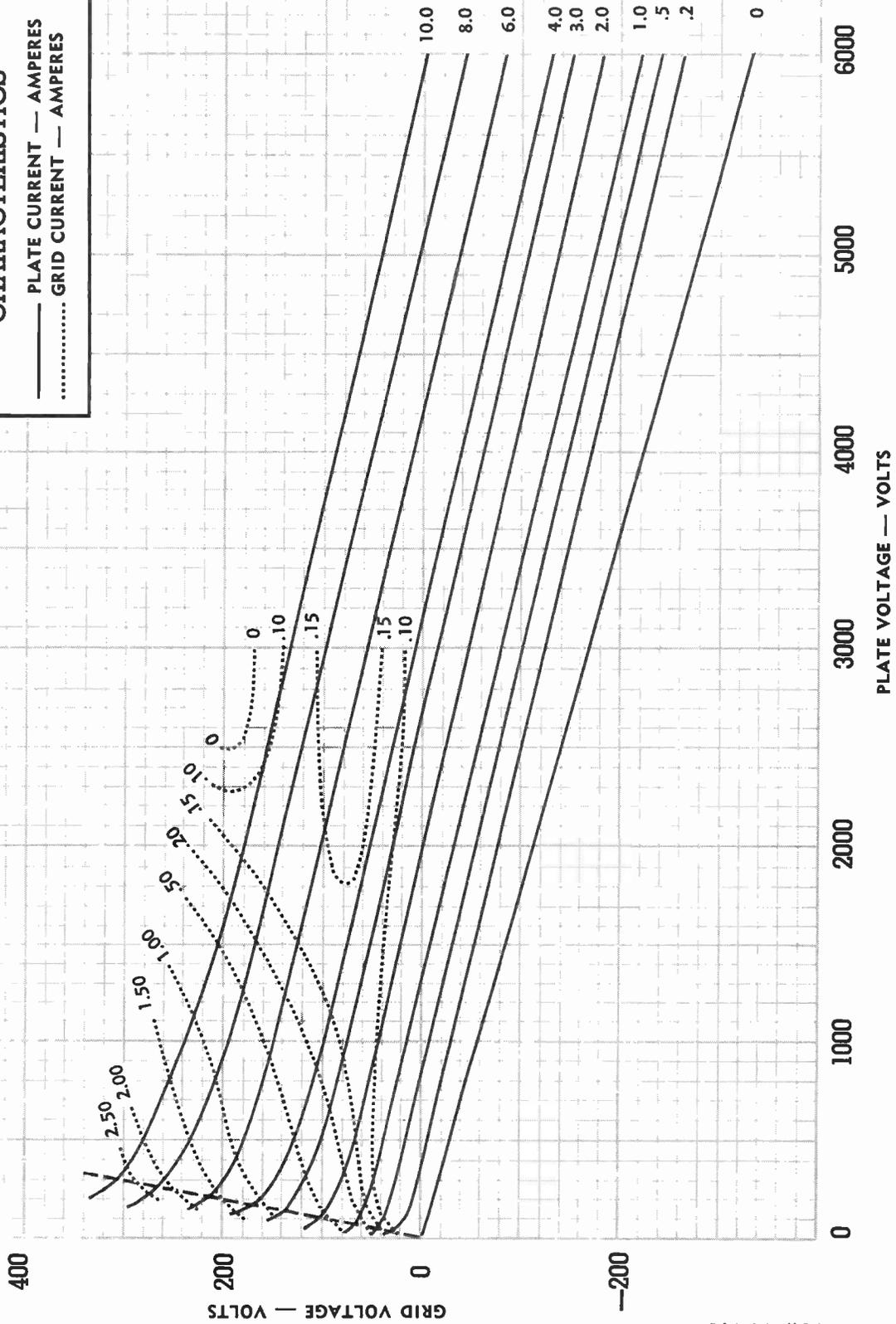


3X2500F3

EIMAC 3X2500F3

CONSTANT CURRENT CHARACTERISTICS

— PLATE CURRENT — AMPERES
..... GRID CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

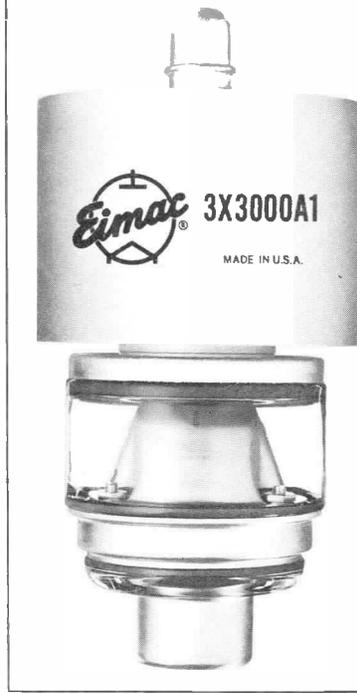
8238
3X3000A1

LOW-MU
TRIODE

The Eimac 8238/3X3000A1 is a low-mu forced-air cooled power triode intended for use as an audio amplifier or modulator. The maximum rated plate dissipation is 3000 watts.

Two 3X3000A1's in class-AB₁ audio service will deliver up to 10 kilowatts maximum-signal plate output power at 6000 plate volts without drawing grid current.

The 3X3000A1 is provided with a low inductance, coaxial filament structure. A water-cooled version, the 3W5000A1, rated at 5 kW plate dissipation, is also available.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated Tungsten				
Voltage - - - - -	-	7.5	-	volts
Current - - - - -	49		54	amperes
Amplification Factor - - - - -	4.4		5.6	
Direct Interelectrode Capacitances (Average)				
Grid-Plate - - - - -		17		uufd
Grid-Filament - - - - -		29		uufd
Plate-Filament - - - - -		2.5		uufd
Transconductance (I _b = 1.0 amp., E _b = 3000. V) - - - - -		11,000		umhos
Maximum Frequency - - - - -			75	Mc

MECHANICAL

Base - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	See outline drawing
Mounting Position - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	Vertical. base down or up
Cooling - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	Forced air
▶ Maximum Temperatures:										
Grid and Filament Seals - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	175°C
Anode Cooler Core - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	250°C
Maximum Diameter - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	4.16 inches
Maximum Height - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	8.59 inches
Net Weight - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	6.25 pounds
Shipping Weight - - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	- - - - -	16 pounds

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR

TYPICAL OPERATION (Sinusoidal wave, two tubes) Class AB₁

Class-AB₁

MAXIMUM RATINGS (Per tube)

DC PLATE VOLTAGE	6000 MAX.	VOLTS
DC PLATE CURRENT	2.5 MAX.	AMPERES
PLATE DISSIPATION	3000 MAX.	WATTS
GRID DISSIPATION	50 MAX.	WATTS

*Adjust to stated Zero-Signal DC Plate Current. Can be expected to vary ±15%. Effective grid-circuit resistance must not exceed 200,000 ohms.

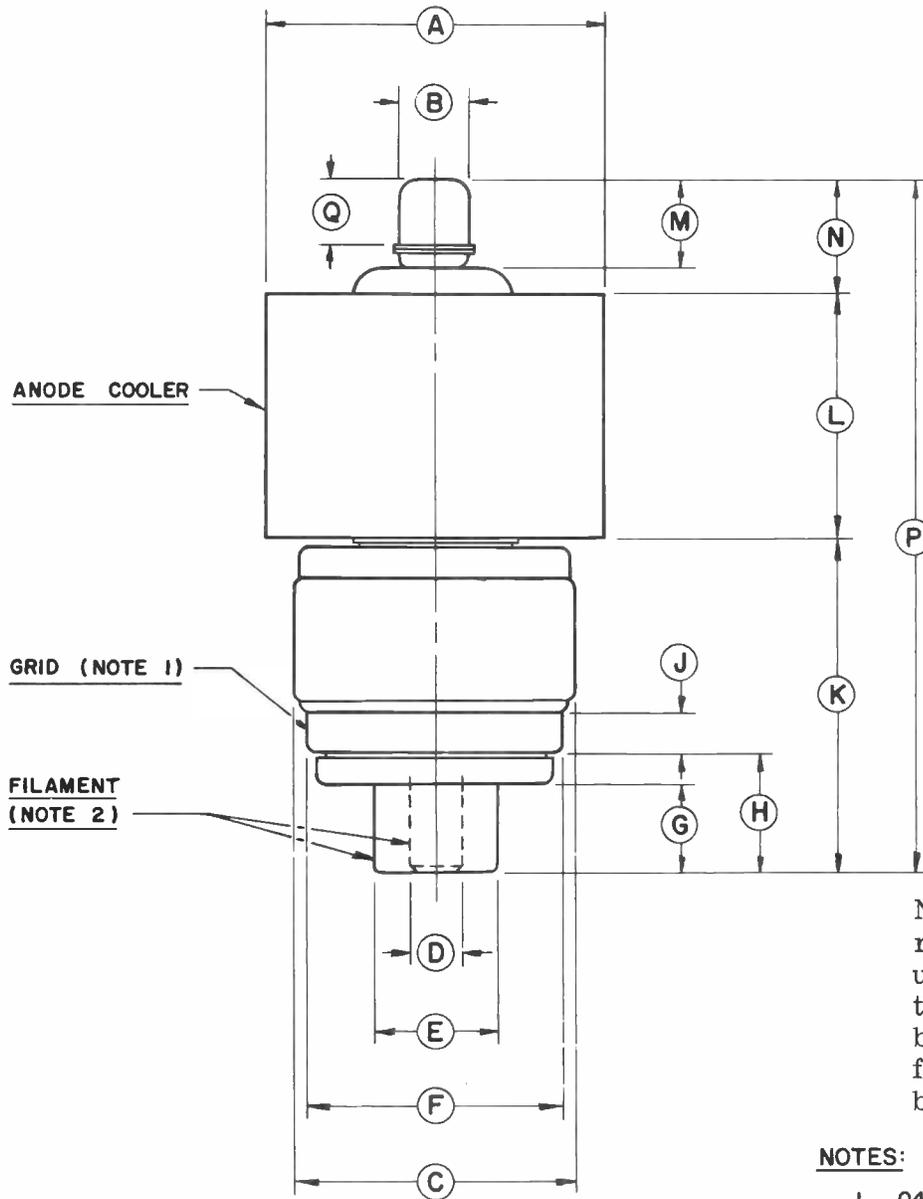
**At maximum signal without negative feedback.

DC Plate Voltage - - - - -	4000	5000	6000	volts
DC Grid Voltage (Approx)* - - - - -	-860	-1080	-1300	volts
Zero-Signal DC Plate Current - - - - -	500	400	335	mA
Max-Signal DC Plate Current - - - - -	3.00	2.80	2.65	amps
Effective Load. Plate-to-Plate - - - - -	2160	3320	4560	ohms
Peak AF Grid Input Voltage (per tube) - - - - -	760	995	1250	volts
Max-Signal Driving Power - - - - -	0	0	0	watts
Max-Signal Plate Input Power - - - - -	12.000	14.000	16.000	watts
Max-Signal Plate Dissipation (per tube) - - - - -	3000	3000	3000	watts
Max-Signal Plate Output Power - - - - -	6000	8000	10.000	watts
Total Harmonic Distortion** - - - - -	1.8	2.6	2.1	percent



DIMENSIONS IN INCHES
DIMENSIONAL DATA

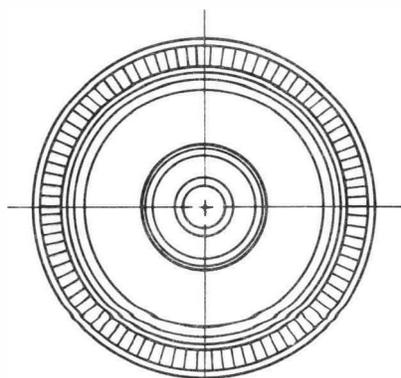
REF.	MIN.	MAX.	NOM.
A	4.093	4.156	
B	.781	.843	
C		3.625	
D	.615	.635	
E	1.490	1.510	
F	2.990	3.010	
G	.812	.937	
H	1.437	1.562	
J	.375	.437	
K	4.	4.125	
L	2.968	3.031	
M	1.	1.125	
N	1.187	1.437	
P	8.156	8.593	
Q	.687	.812	

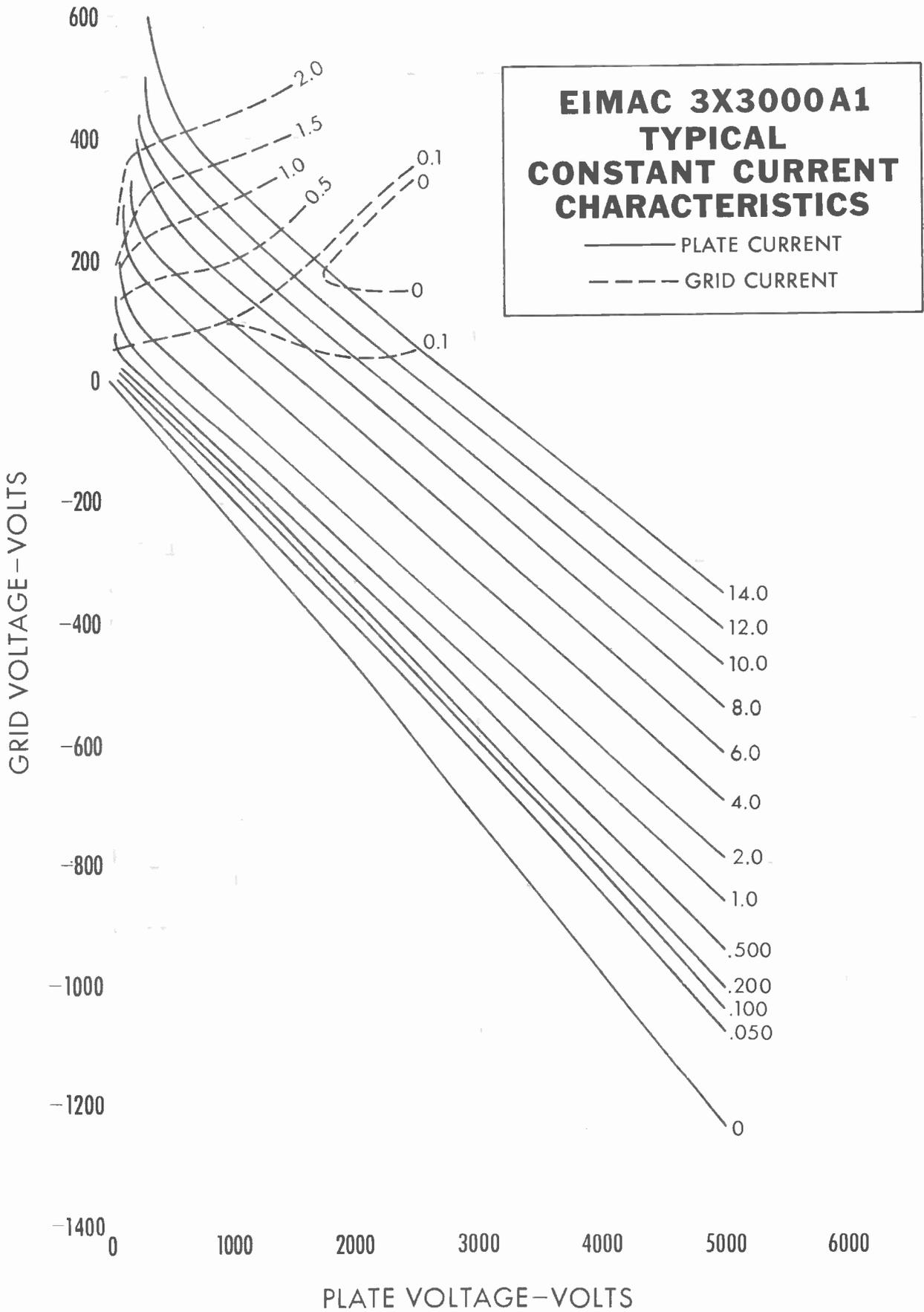


NOTE: These dimensions reflect standard manufacturing tolerances. Where they are to be made the basis of purchase specifications, they should first be checked with the factory.

NOTES:

1. .040 MAX. RUNOUT OF GRID CONTACT SURFACE WITH RESPECT TO AXIS DETERMINED BY ANODE AND OUTER FILAMENT CONTACT SURFACE.
2. .025 MAX. RUNOUT OF INNER FILAMENT CONTACT SURFACE WITH RESPECT TO OUTER FILAMENT CONTACT SURFACE.







E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

TENTATIVE DATA

3X3000A7

**HIGH-MU
 POWER TRIODE**

The Eimac 3X3000A7 is an external-anode power triode intended to be used as a zero-bias Class-B amplifier in audio or radio-frequency applications. Operation with zero grid bias offers circuit simplicity by eliminating the bias supply. In addition, grounded-grid operation is attractive since a power gain of over twenty times can be obtained with the 3X3000A7.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament:	Thoriated-Tungsten	
Voltage	- - - - -	7.5 volts
Current	- - - - -	51 amperes
Amplification Factor	- - - - -	200
Interelectrode Capacitances:		
Grid-Filament	- - - - -	38 uuf
Grid-Plate	- - - - -	24 uuf
Plate-Filament	- - - - -	0.6 uuf
Frequency for Maximum Ratings	- - - - -	75 Mc



MECHANICAL

Base	- - - - -	See outline drawing
Operating Position	- - - - -	Vertical, base up or down
Cooling	- - - - -	Forced air
Maximum Operating Temperatures:		
Anode Core and Seals	- - - - -	175°C
Maximum Dimensions:		
Height	- - - - -	8.6 inches
Diameter	- - - - -	4.16 inches
Net Weight	- - - - -	6.25 pounds

**AF AMPLIFIER OR MODULATOR
 CLASS-B, GRID-DRIVEN**

MAXIMUM RATINGS (Per Tube)	
DC PLATE VOLTAGE	5000 VOLTS
DC PLATE CURRENT	2.5 AMPS
PLATE DISSIPATION	3 KW
GRID DISSIPATION	225 WATTS

*Approximate Values

**TYPICAL OPERATION, Two Tubes,
 Sinusoidal Wave**

DC Plate Voltage	- - - - -	4000 volts
DC Grid Voltage	- - - - -	0 volts
Zero-Sig DC Plate Current*	- - - - -	0.640 amps
Max-Sig DC Plate Current	- - - - -	4.00 amps
Max-Sig DC Grid Current	- - - - -	0.860 amps
Driving Power	- - - - -	120 watts
Peak AF Driving Voltage (per tube)	- - - - -	185 volts
Load Resistance, Plate-to-Plate	- - - - -	2200 ohms
Max-Sig Plate Output Power	- - - - -	11,000 watts



RF LINEAR AMPLIFIER CLASS-B, GROUNDED-GRID

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	- 5000 VOLTS
DC PLATE CURRENT	- - - -	- 2.5 AMPS
PLATE DISSIPATION	- - - -	- 3 KW
GRID DISSIPATION	- - - -	- 225 WATTS

*Approximate Value

TYPICAL OPERATION, Single-Tone Conditions

DC Plate Voltage	- - - -	4000	5000 volts
Zero-Sig DC Plate Current*	- - - -	0.32	0.44 amps
Max-Sig DC Plate Current	- - - -	2.00	1.56 amps
Max-Sig DC Grid Current	- - - -	0.42	0.33 amps
Driving Impedance	- - - -	50	50 ohms
Resonant Load Impedance	- - - -	1120	1850 ohms
Max-Sig Driving Power	- - - -	360	215 watts
Peak Envelope Plate Output Power	- - - -	5500	5500 watts
Power Gain	- - - -	15.3	25.6 times

RF LINEAR AMPLIFIER CARRIER CONDITIONS, GRID-DRIVEN

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	- 5000 VOLTS
DC PLATE CURRENT	- - - -	- 2.5 AMPS
PLATE DISSIPATION	- - - -	- 3 KW
GRID DISSIPATION	- - - -	- 225 WATTS

*Approximate Value

†Modulation Crest Conditions

TYPICAL OPERATION

DC Plate Voltage	- - - -	4000	volts
DC Grid Voltage	- - - -	0	volts
Zero-Sig DC Plate Current*	- - - -	0.32	amps
DC Plate Current	- - - -	0.815	amps
DC Grid Current	- - - -	0.205	amps
Driving Impedance†	- - - -	220	ohms
Peak Driving Voltage†	- - - -	160	volts
Driving Power	- - - -	15	watts
Plate Output Power	- - - -	1100	watts

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves and confirmed by direct tests. No allowance for circuit losses, either input or output, has been made.

APPLICATION

Input Circuit—When the 3X3000A7 is operated as a grounded-grid rf amplifier, the use of a resonant tank in the cathode circuit is recommended in order to obtain greatest linearity and power output. For best results with a single-ended amplifier it is suggested that the cathode tank circuit operate at a "Q" of five or more.

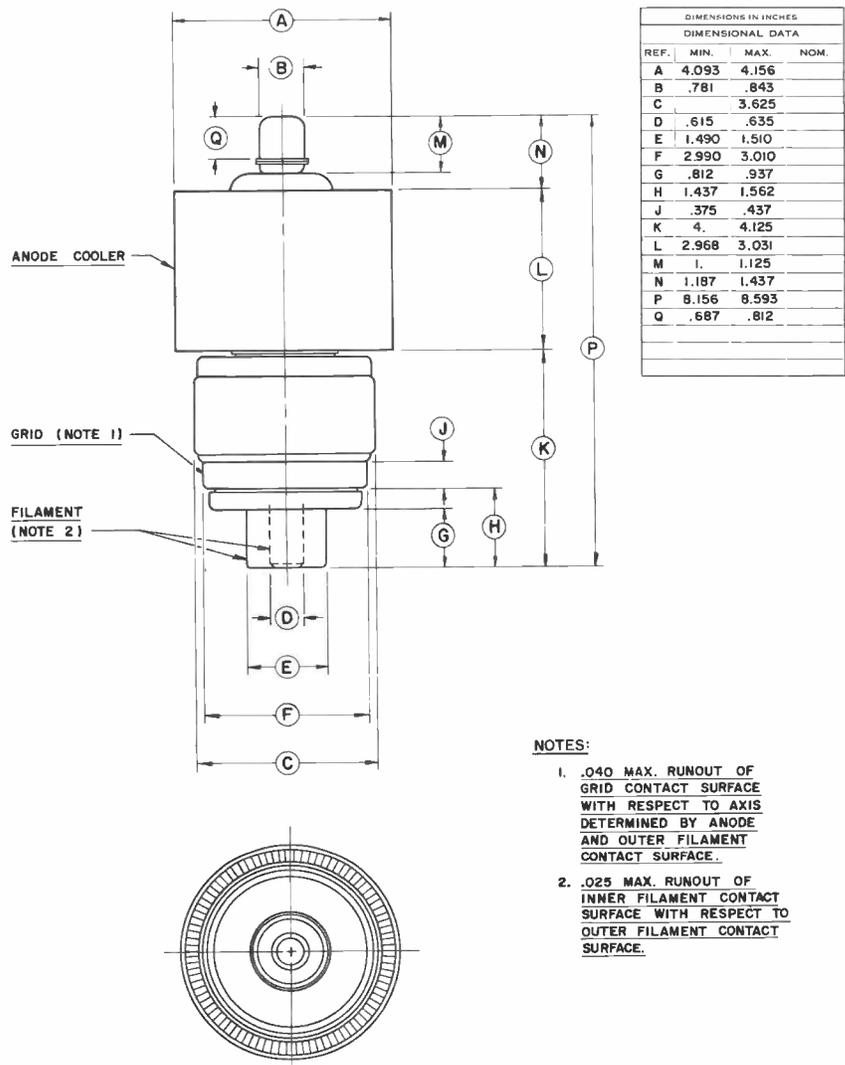
Cooling—The maximum temperature rating for the anode core and seals of the 3X3000A7 is 175°C. Sufficient forced-air cooling must be provided to keep the temperature of the anode core and the temperatures of the glass-to-metal seals below 175°C. Tube life is usually prolonged if these areas are maintained at

temperatures below the maximum rating. Minimum air flow requirements to maintain anode-core and seal temperatures below 175°C at sea level with an inlet-air temperature of 50°C are tabulated for air-flow in the anode-to-base and base-to-anode directions. At higher ambient temperatures, frequencies above 30 Mc or at higher altitude, a greater quantity of air will be required. It is suggested that temperatures be monitored in any new installation to insure proper cooling.

In addition, a minimum air flow of 7 cfm must be directed into the filament stem structure, between the inner and outer filament conductors. This rate of air flow provides sufficient stem cooling at ambient temperatures up to 55°C.

Minimum Cooling Air-Flow Requirements				
Plate** Dissipation (Watts)	Anode-To-Base Air-Flow		Base-To-Anode Air Flow	
	Air Flow (CFM)	Pressure Drop (Inches of Water)	Air Flow (CFM)	Pressure Drop (Inches of Water)
1000	42	0.4	25	0.15
2000	109	2.25	63	0.75
3000	215	7.8	130	2.6

**Since the power dissipated by the filament is about 375 watts and since grid dissipation can, under some circumstances, represent another 225 watts, allowance has been made in preparing this tabulation for an additional 600 watts dissipation.





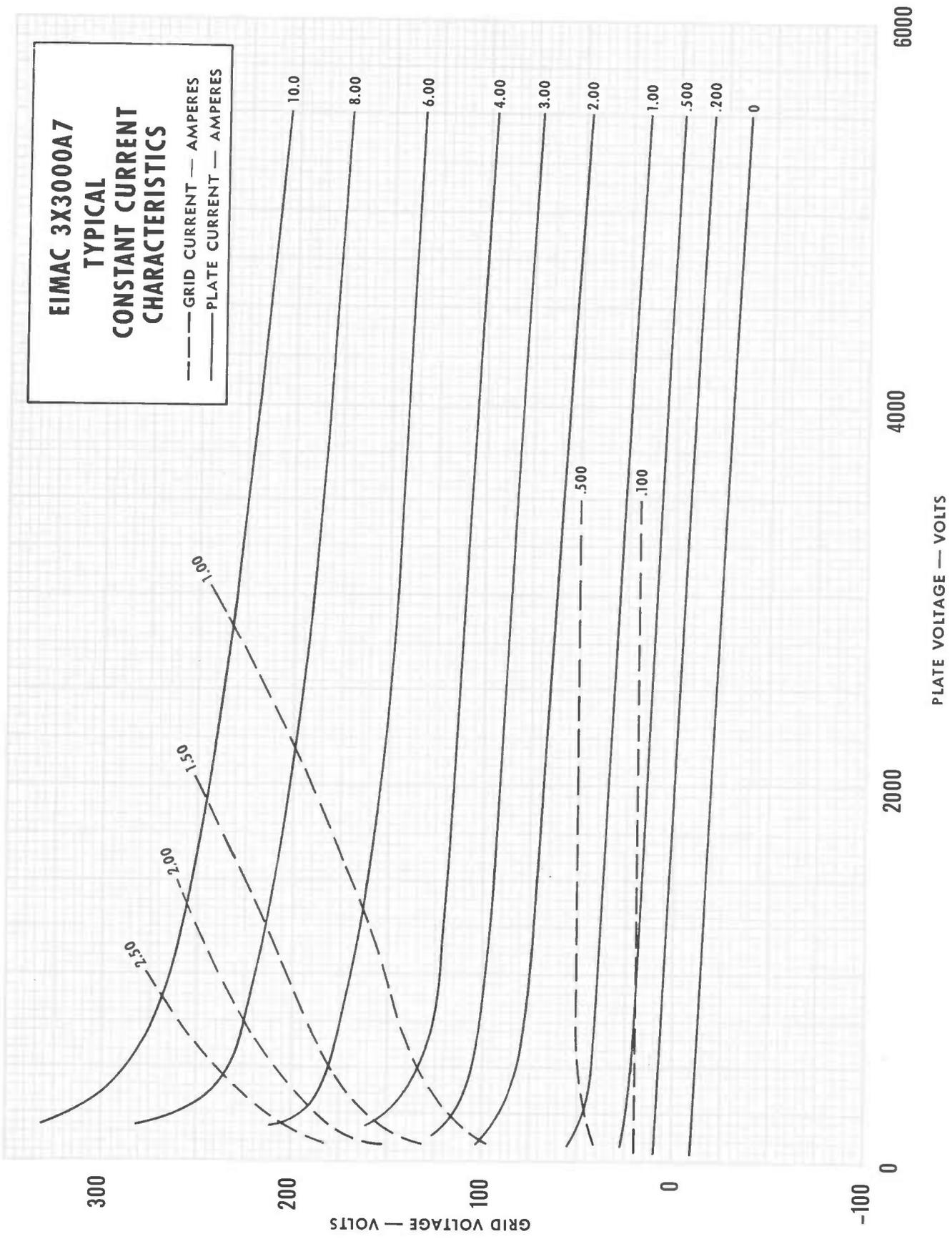
3X3000A7

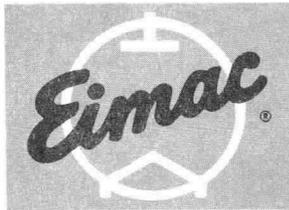
EIMAC 3X3000A7

TYPICAL

CONSTANT CURRENT CHARACTERISTICS

--- GRID CURRENT — AMPERES
— PLATE CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

8239
3X3000F1

LOW-MU
TRIODE

The Eimac 8239/3X3000F1 is a low-mu forced-air cooled power triode intended for use as an audio amplifier or modulator. The maximum rated plate dissipation is 3000 watts.

Two 3X3000F1's in class-AB₁ audio service will deliver up to 10 kilowatts maximum-signal plate output power at 6000 plate volts without drawing grid current. The 3X3000F1 is provided with "flying leads" for filament and grid connections.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated Tungsten				
Voltage - - - - -	-	7.5		volts
Current - - - - -	49		54	amperes
Amplification Factor - - - - -	4.4		5.6	
Direct Interelectrode Capacitances (Average)				
Grid-Plate - - - - -	-	17		uufd
Grid-Filament - - - - -	-	29		uufd
Plate-Filament - - - - -	-	2.5		uufd
Transconductance (I _b = 1.0 amp., E _b = 3000 V) - - - - -	-	11,000		umhos
Maximum Frequency - - - - -	-	-	30	Mc

MECHANICAL

Base - - - - -	See outline drawing
Mounting Position - - - - -	Vertical, base down or up
Cooling - - - - -	Forced air
▶ Maximum Temperatures:	
Grid and Filament Seals - - - - -	175°C
Anode Cooler Core - - - - -	250°C
Maximum Diameter - - - - -	4.16 inches
Net Weight - - - - -	7.5 pounds
Shipping Weight - - - - -	17 pounds



AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR

TYPICAL OPERATION (Sinusoidal wave, two tubes) Class AB₁

Class-AB₁

MAXIMUM RATINGS (Per tube)

DC PLATE VOLTAGE	6000 MAX.	VOLTS
DC PLATE CURRENT	2.5 MAX.	AMPERES
PLATE DISSIPATION	3000 MAX.	WATTS
GRID DISSIPATION	50 MAX.	WATTS

*Adjust to stated Zero-Signal DC Plate Current. Can be expected to vary ±15%. Effective grid-circuit resistance must not exceed 200,000 ohms.

**At maximum signal without negative feedback.

DC Plate Voltage - - - -	4000	5000	6000	volts
DC Grid Voltage (Approx)*	-860	-1080	-1300	volts
Zero-Signal DC Plate Current	500	400	335	mA
Max-Signal DC Plate Current	3.00	2.80	2.65	amps
Effective Load, Plate-to-Plate	2160	3320	4560	ohms
Peak AF Grid Input Voltage (per tube) - - - -	760	995	1250	volts
Max-Signal Driving Power -	0	0	0	watts
Max-Signal Plate Input Power - - - -	12,000	14,000	16,000	watts
Max-Signal Plate Dissipation (per tube) - - - -	3000	3000	3000	watts
Max-Signal Plate Output Power - - - -	6000	8000	10,000	watts
Total Harmonic Distortion**	1.8	2.6	2.1	percent

APPLICATION

MECHANICAL

Mounting: The 3X3000F1 must be mounted vertically with its base up or down at the convenience of the designer. The base is fitted with heavy filament leads to facilitate connections. These leads should be arranged to prevent mechanical stress on the filament structure. The grid is also fitted with a flying lead.

The tube must be protected from severe shock and vibration during shipment and operation.

Cooling: Sufficient forced air cooling must be provided to maintain seal temperature at 175° C or below. Air-flow must be started when filament power is applied and it is advisable to continue air-cooling for two minutes after all voltages are removed.

The table below lists minimum air-flow requirements to maintain tube temperatures below 175° C with air flowing in both the base-to-anode and anode-to-base directions. This tabulation presumes air at 25° C and sea level. A separate supply of approximately six cubic feet per minute, directed into the filament structure is also required to maintain rated filament seal temperatures. This is best accomplished using a small diameter insulating tubing directed into the stem, between the filament seals.

MINIMUM COOLING AIR-FLOW REQUIREMENTS				
BASE-TO-ANODE FLOW			ANODE-TO-BASE FLOW	
Plate Dissipation (Watts)	AIR-FLOW (CFM)	PRESSURE DROP (inches of water)	AIR-FLOW (CFM)	PRESSURE DROP (inches of water)
1000	14	0.1	20	0.1
2000	37	0.3	61	0.8
3000	74	1.0	122	3.0

Note:

An extra 425 watts have been added to these plate dissipation figures in preparing this tabulation, to compensate for grid and filament dissipation.

For operation at high altitudes or higher ambient temperatures, these quantities should be increased. In all cases it is suggested that actual temperatures be measured to insure adequate cooling.

ELECTRICAL

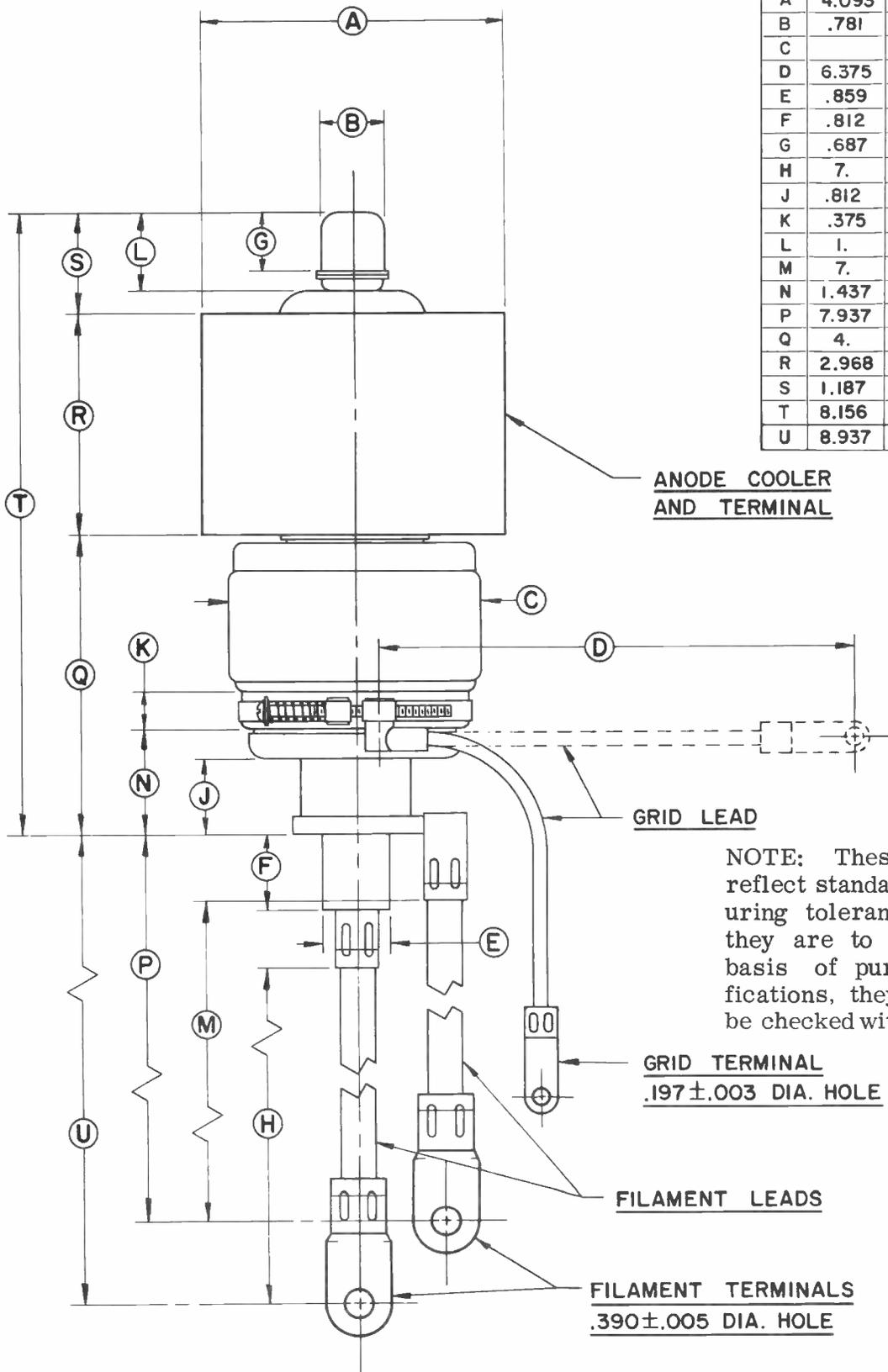
Filament: The rated filament voltage for the 3X3000F1 is 7.5 volts and should not exceed this value by more than five percent if maximum tube life is to be realized. Reduction of filament voltage to about 7.2 volts will actually enhance tube life and provision should be made for this adjustment where the lower emission can be tolerated.

Grid Operation: The grid dissipation rating of the 3X3000F1 is 50 watts. This is the product of the peak positive grid voltage and average dc grid current. When tubes are used in parallel in amplifier or modulator service, provision should be made for individual adjustment of bias voltage, in order to match the tubes. In practice, individual adjustment of drive voltage will not be necessary.

Special Applications: If it is desired to operate the tube under conditions widely different from those given here, write to Power Grid Tube Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California, for information and recommendations.

DIMENSIONS IN INCHES

DIMENSIONAL DATA			
REF.	MIN.	MAX.	NOM.
A	4.093	4.156	
B	.781	.843	
C		3.625	
D	6.375	6.625	
E	.859	.890	
F	.812	.937	
G	.687	.812	
H	7.	7.500	
J	.812	.937	
K	.375	.437	
L	1.	1.125	
M	7.	7.500	
N	1.437	1.562	
P	7.937	8.437	
Q	4.	4.125	
R	2.968	3.031	
S	1.187	1.437	
T	8.156	8.593	
U	8.937	9.437	



ANODE COOLER AND TERMINAL

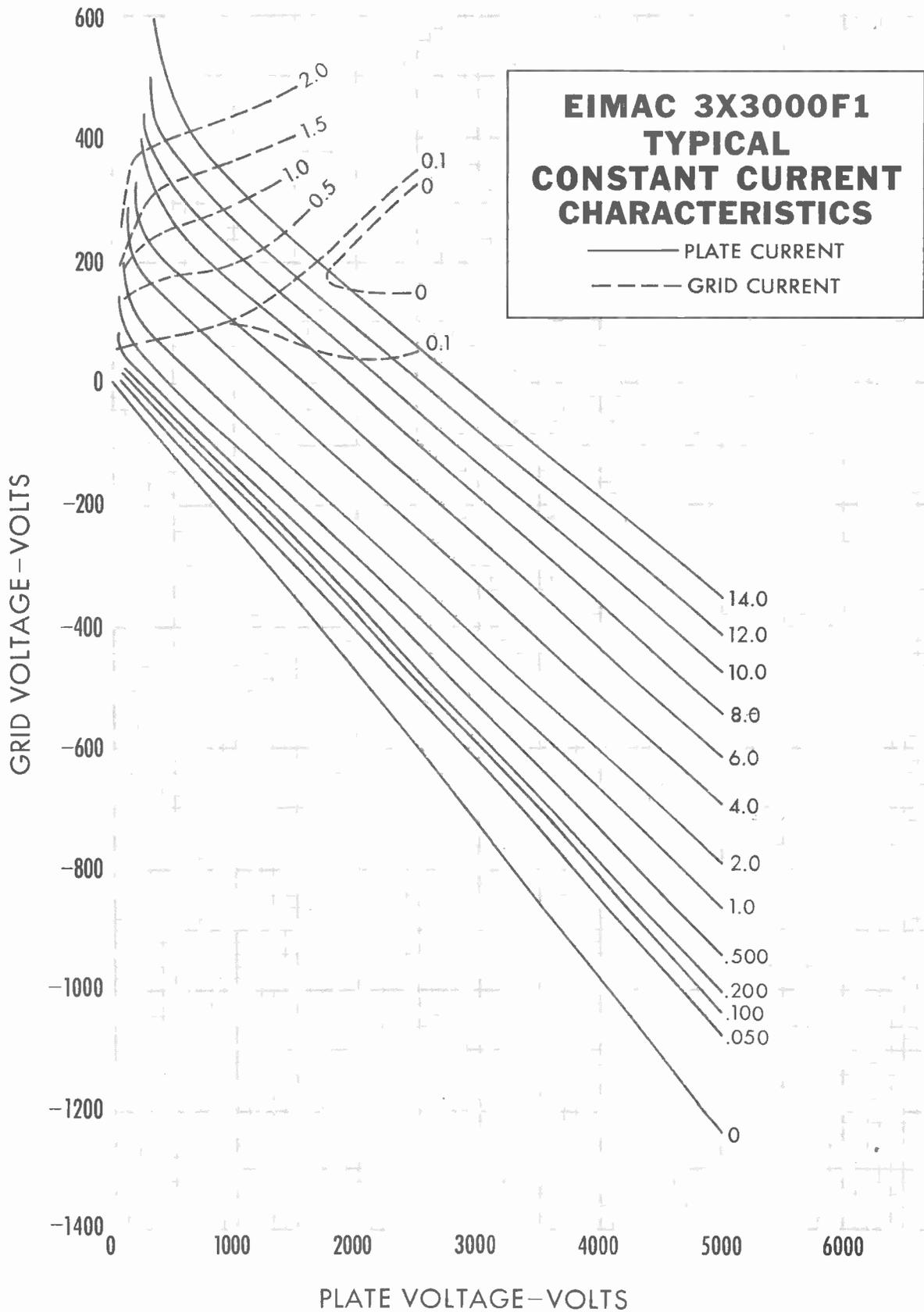
GRID LEAD

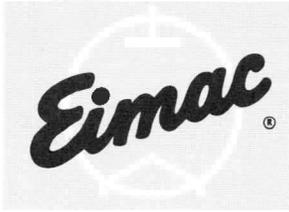
NOTE: These dimensions reflect standard manufacturing tolerances. Where they are to be made the basis of purchase specifications, they should first be checked with the factory.

GRID TERMINAL
.197±.003 DIA. HOLE

FILAMENT LEADS

FILAMENT TERMINALS
.390±.005 DIA. HOLE





E I M A C
 Division of Varian
 S A N C A R L O S
 C A L I F O R N I A

TENTATIVE DATA

8162
3X3000F7
 HIGH-MU
 POWER TRIODE

The Eimac 8162/3X3000F7 is an external-anode power triode intended to be used as a zero-bias Class-B amplifier in audio or radio-frequency applications. Operation with zero grid bias offers circuit simplicity by eliminating the bias supply. In addition, grounded-grid operation is attractive since a power gain of over twenty times can be obtained with the 8162/3X3000F7.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated-Tungsten					
Voltage	-	-	-	-	7.5 volts
Current	-	-	-	-	51 amperes
Amplification Factor	-	-	-	-	200
Interelectrode Capacitances:					
Grid-Filament	-	-	-	-	38 uuf
Grid-Plate	-	-	-	-	24 uuf
Plate-Filament	-	-	-	-	0.6 uuf
Frequency for Maximum Ratings	-	-	-	-	30 Mc

MECHANICAL

Base	-	-	-	-	-	-	See outline drawing
Operating Position	-	-	-	-	-	-	Vertical, base up or down
Cooling	-	-	-	-	-	-	Forced air
Maximum Operating Temperatures:							
Anode Core and Seals	-	-	-	-	-	-	150°C
Maximum Dimensions:							
Height (Does not include filament connectors)	-	-	-	-	-	-	8.6 inches
Diameter	-	-	-	-	-	-	4.16 inches
Net Weight	-	-	-	-	-	-	7.5 pounds



A-F AMPLIFIER OR MODULATOR
 CLASS-B, GRID-DRIVEN

TYPICAL OPERATION, Two Tubes,
 Sinusoidal Wave

MAXIMUM RATINGS (Per Tube)

D-C PLATE VOLTAGE	5000 VOLTS
D-C PLATE CURRENT	2.5 AMPS
PLATE DISSIPATION	3 KW
GRID DISSIPATION	225 WATTS

D-C Plate Voltage	4000	volts
D-C Grid Voltage	0	volts
Zero-Sig D-C Plate Current*	0.640	amps
Max-Sig D-C Plate Current	4.00	amps
Max-Sig D-C Grid Current	0.860	amps
Driving Power	120	watts
Peak A-F Driving Voltage (per tube)	185	volts
Load Resistance, Plate-to-Plate	2200	ohms
Max-Sig Plate Output Power	11,000	watts



R-F LINEAR AMPLIFIER
CLASS-B, GROUNDED-GRID

TYPICAL OPERATION, Single-Tone Conditions

MAXIMUM RATINGS		D-C Plate Voltage	4000	5000	volts
D-C PLATE VOLTAGE	5000 VOLTS	Zero-Sig D-C Plate Current*	0.32	0.44	amps
D-C PLATE CURRENT	2.5 AMPS	Max-Sig D-C Plate Current	2.00	1.56	amps
PLATE DISSIPATION	3 KW	Max-Sig D-C Grid Current	0.42	0.33	amps
GRID DISSIPATION	225 WATTS	Driving Impedance	50	50	ohms
		Resonant Load Impedance	1120	1850	ohms
		Max-Sig Driving Power	360	215	watts
		Peak Envelope Plate Output			
		Power	5500	5500	watts
		Power Gain	15.3	25.6	times

R-F LINEAR AMPLIFIER
CARRIER CONDITIONS, GRID-DRIVEN

TYPICAL OPERATION

MAXIMUM RATINGS		D-C Plate Voltage	4000	volts
D-C PLATE VOLTAGE	5000 VOLTS	D-C Grid Voltage	0	volts
D-C PLATE CURRENT	2.5 AMPS	Zero-Sig D-C Plate Current*	0.32	amps
PLATE DISSIPATION	3 KW	D-C Plate Current	0.815	amps
GRID DISSIPATION	225 WATTS	D-C Grid Current	0.205	amps
		Driving Impedance †	220	ohms
		Peak Driving Voltage †	160	volts
		Driving Power	15	watts
		Plate Output Power	1100	watts

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves and confirmed by direct tests. No allowance for circuit losses, either input or output, has been made.

APPLICATION

INPUT CIRCUIT - When the 3X3000F7 is operated as a grounded-grid r-f amplifier, the use of a resonant tank in the cathode circuit is recommended in order to obtain greatest linearity and power output. For best results with a single-ended amplifier it is suggested that the cathode tank circuit operate at a "Q" of five or more.

COOLING - The maximum temperature rating for the anode core and seals of the 3X3000F7 is 150°C. Sufficient forced-air cooling must be provided to keep the temperature of the anode core and the temperatures of the glass-to-metal seals below 150°C. Tube life is usually prolonged if these areas are maintained at temperatures below the maximum rating. Minimum air flow requirements to maintain anode-core and seal temperatures below 150°C with inlet-air temperatures of 40°C and 55°C are tabulated. A maximum ambient temperature of 40°C will apply to most commercial installations, while the 55°C data is useful when designing equipment in conformance with MIL-E-5400 Curve A (Class I).

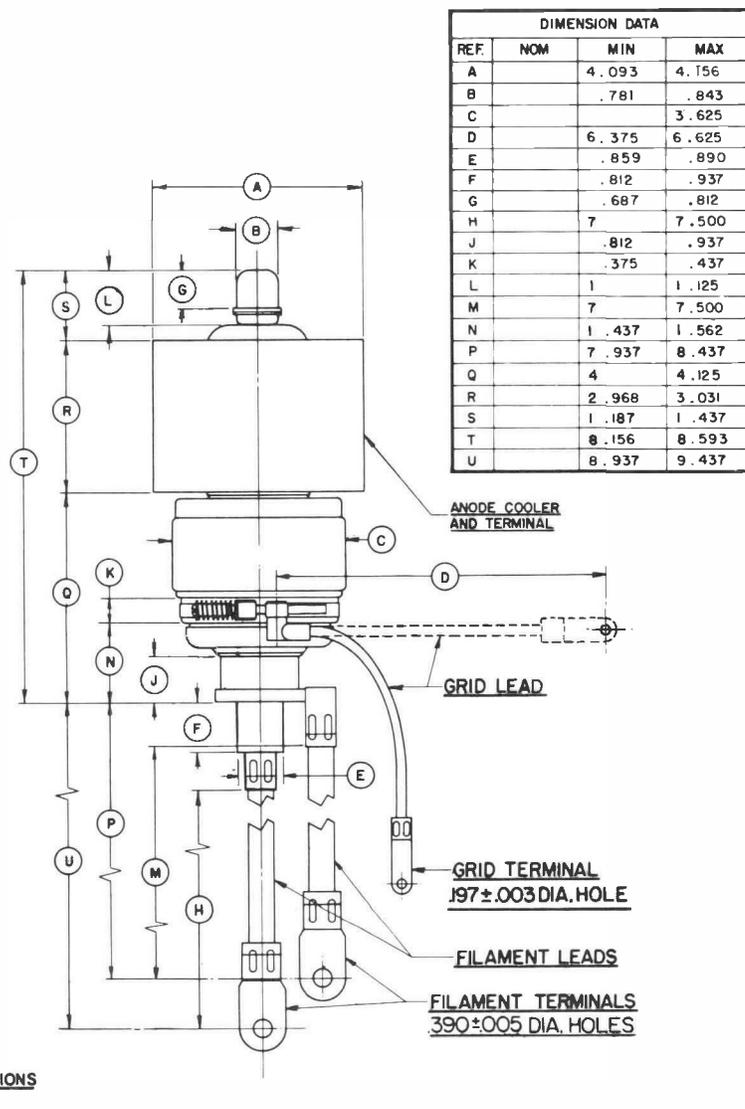
In addition, a minimum air flow of 7 CFM must be directed into the filament stem structure, between the inner and outer filament conductors. This rate of air flow provides sufficient stem cooling at ambient temperatures up to 55°C.

*Approximate Values

†Modulation Crest Conditions

SEA LEVEL PRESSURE, ANODE-TO-BASE AIR FLOW				
Plate** Dissipation (Watts)	40°C Max Ambient Air Temp.		55°C Max Ambient Air Temp.	
	Air Flow (CFM)	Pressure Drop (Inches of Water)	Air Flow (CFM)	Pressure Drop (Inches of Water)
1000	45	0.43	65	0.65
2000	120	1.6	170	2.5
3000	235	4.0	330	6.0

**Since the power dissipated by the filament is about 375 watts and since grid dissipation can, under some circumstances, represent another 225 watts, allowance has been made in preparing this tabulation for an additional 600 watts dissipation.



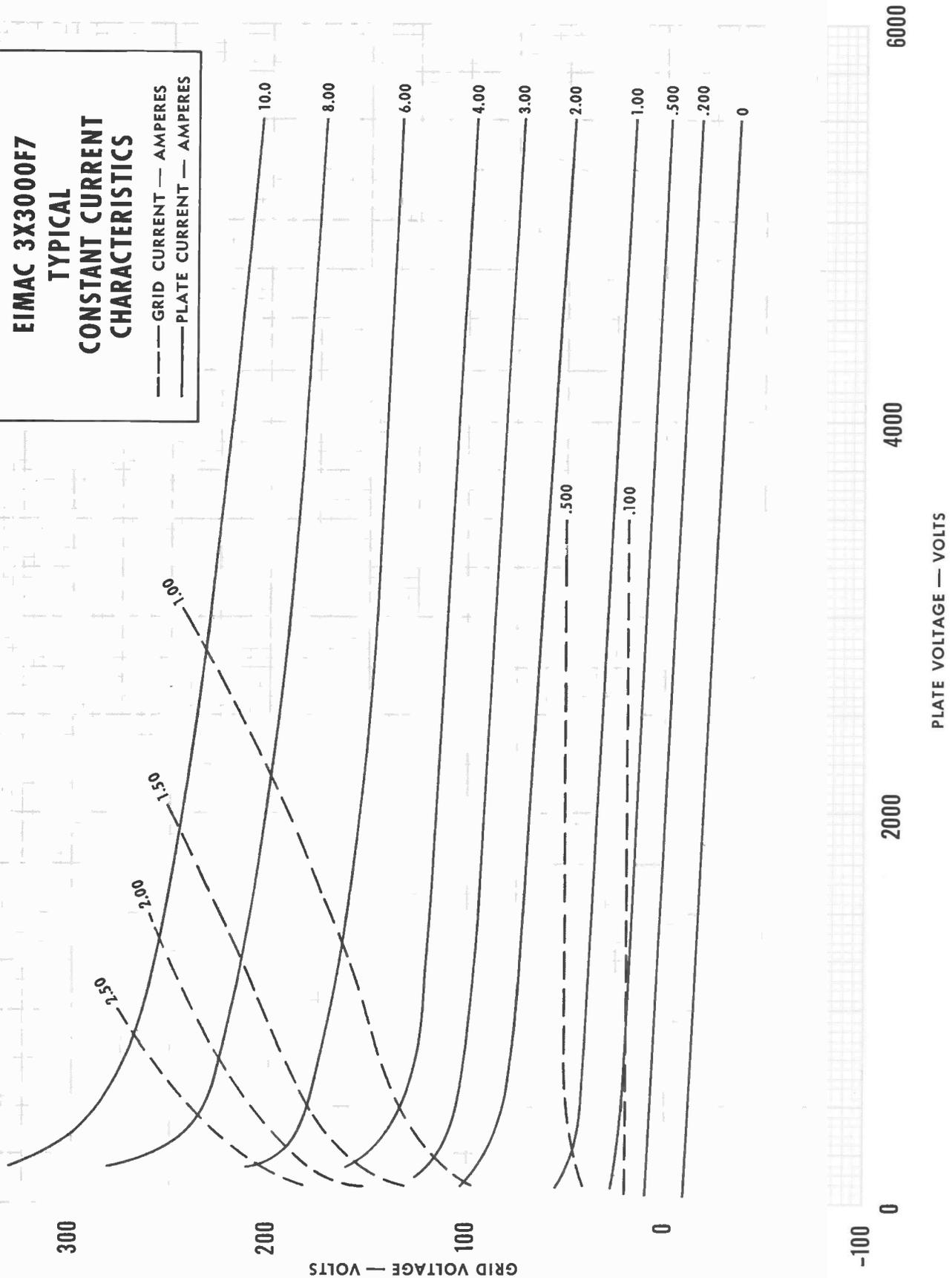


3X3000F7

EIMAC 3X3000F7

TYPICAL CONSTANT CURRENT CHARACTERISTICS

--- GRID CURRENT — AMPERES
— PLATE CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS · CALIFORNIA

TENTATIVE DATA

3CX10,000A3

**MEDIUM-MU
POWER TRIODE**

The Eimac 3CX10,000A3 is a ceramic and metal power triode intended primarily for use as a power oscillator in industrial-heating applications. It is also useful as a grounded-grid FM amplifier, as a conventional plate-modulated amplifier at broadcast frequencies, or as a linear amplifier.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated-Tungsten								
Voltage	-	-	-	-	7.5	volts		
Current	-	-	-	-	100	amperes		
Amplification Factor	-	-	-	-	20			
Interelectrode Capacitances:								
Grid-Filament	-	-	-	-	-	-	-	60 uuf
Grid-Plate	-	-	-	-	-	-	-	40 uuf
Plate-Filament	-	-	-	-	-	-	-	2.0 uuf
Frequency for Maximum Ratings	-	-	-	-	-	-	-	110 Mc



MECHANICAL

Base	-	-	-	-	-	-	-	Coaxial
Recommended Socket	-	-	-	-	-	-	-	Eimac SK-1300
Operating Position	-	-	-	-	-	-	Vertical,	base up or down
Cooling	-	-	-	-	-	-	-	Forced air
Maximum Operating Temperatures:								
Anode Core	-	-	-	-	-	-	-	250°C
Ceramic-to-Metal Seals	-	-	-	-	-	-	-	250°C
Maximum Dimensions:								
Height	-	-	-	-	-	-	-	8.5 inches
Diameter	-	-	-	-	-	-	-	7.0 inches
Net Weight	-	-	-	-	-	-	-	12 pounds

**R-F INDUSTRIAL OSCILLATOR
CLASS-C**

TYPICAL OPERATION

MAXIMUM RATINGS

D-C PLATE VOLTAGE	7000 MAX. VOLTS
D-C PLATE CURRENT	4.0 MAX. AMPS
PLATE DISSIPATION	10 MAX. KW
GRID DISSIPATION	250 MAX. WATTS

D-C Plate Voltage	6000	7000 volts
D-C Grid Voltage	-575	-670 volts
D-C Plate Current	4.0	4.0 amps
D-C Grid Current	610	670 ma
Plate Input Power	24	28 kw
Plate Output Power	18.9	22.4 kw

**R-F POWER AMPLIFIER
GROUNDED-GRID, CLASS-C**

TYPICAL OPERATION

MAXIMUM RATINGS

D-C PLATE VOLTAGE	7000 MAX. VOLTS
D-C PLATE CURRENT	4.0 MAX. AMPS
PLATE DISSIPATION	10 MAX. KW
GRID DISSIPATION	250 MAX. WATTS

D-C Plate Voltage	6000	7000 volts
D-C Grid Voltage	-535	-625 volts
D-C Plate Current	4.0	4.0 amps
D-C Grid Current	545	530 ma
Driving Power	3700	4100 watts
Plate Output Power	20.5	24.5 kw



R-F POWER AMPLIFIER
PLATE-MODULATED, CLASS-C

TYPICAL OPERATION

MAXIMUM RATINGS

D-C PLATE VOLTAGE	5500 MAX. VOLTS
D-C PLATE CURRENT	3.0 MAX. AMPS
PLATE DISSIPATION	6.5 MAX. KW
GRID DISSIPATION	250 MAX. WATTS

D-C Plate Voltage	4000	5000 volts
D-C Grid Voltage	-480	-600 volts
D-C Plate Current	3.0	3.0 amps
D-C Grid Current	660	550 ma
Driving Power	530	515 watts
Plate Output Power	9.7	12.4 kw

R-F LINEAR AMPLIFIER
GROUNDED-GRID, CLASS-AB2

TYPICAL OPERATION

MAXIMUM RATINGS

D-C PLATE VOLTAGE	7000 MAX. VOLTS
D-C PLATE CURRENT	4.0 MAX. AMPS
PLATE DISSIPATION	10 MAX. KW
GRID DISSIPATION	250 MAX. WATTS

D-C Plate Voltage	6000	7000 volts
Zero-Sig Grid Voltage*	-270	-325 volts
Max-Sig D-C Plate Current	4.0	4.0 amps
Max-Sig D-C Grid Current	300	250 ma
Driving Power	1900	2050 watts
Plate Output Power	18	20 kw

*Adjust to give 500 milliamperes zero-signal d-c plate current.

APPLICATION

► Cooling - The maximum temperature rating for the external surfaces of the 3CX10,000A3 is 250°C. Sufficient forced-air cooling must be provided to keep the temperature of the anode core and the temperature of the ceramic-metal seals below 250°C. Tube life is usually prolonged if these areas are maintained at temperatures below this maximum rating. Minimum air-flow requirements to maintain anode-core and seal temperatures below 225°C with an inlet-air temperature of 50°C are tabulated below.

Plate** Dissipation (Watts)	Sea Level		10,000 Feet	
	Air Flow (CFM)	Pressure Drop (Inches of Water)	Air Flow (CFM)	Pressure Drop (Inches of Water)
4000	70	0.15	102	0.22
6000	152	0.36	220	0.52
8000	270	0.92	392	1.34
10,000	423	1.93	615	2.80

**Since the power dissipated by the filament is about 750 watts and since grid dissipation can, under some circumstances, represent another 250 watts, allowance has been made in preparing this tabulation for an additional 1000 watts dissipation.

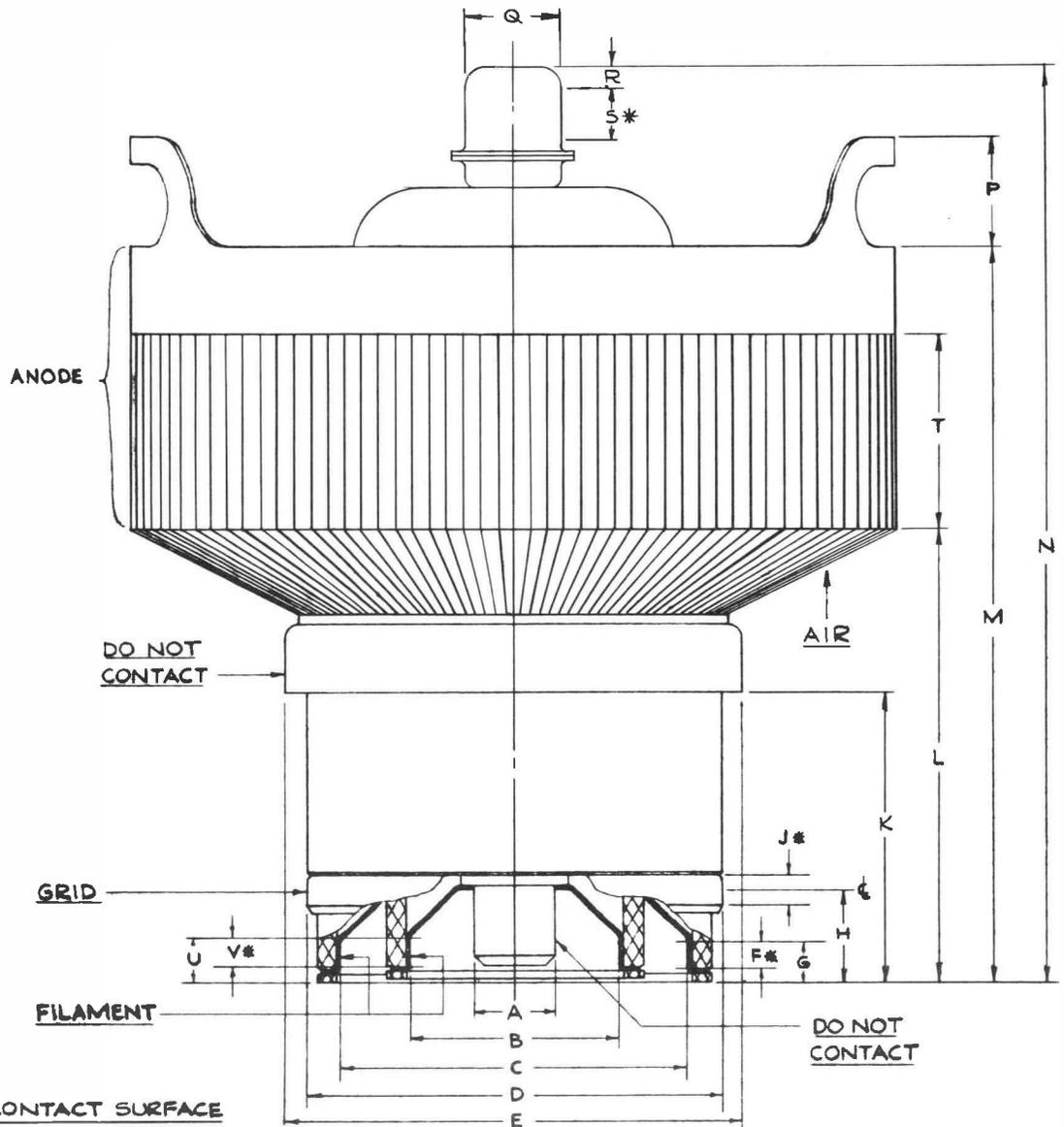
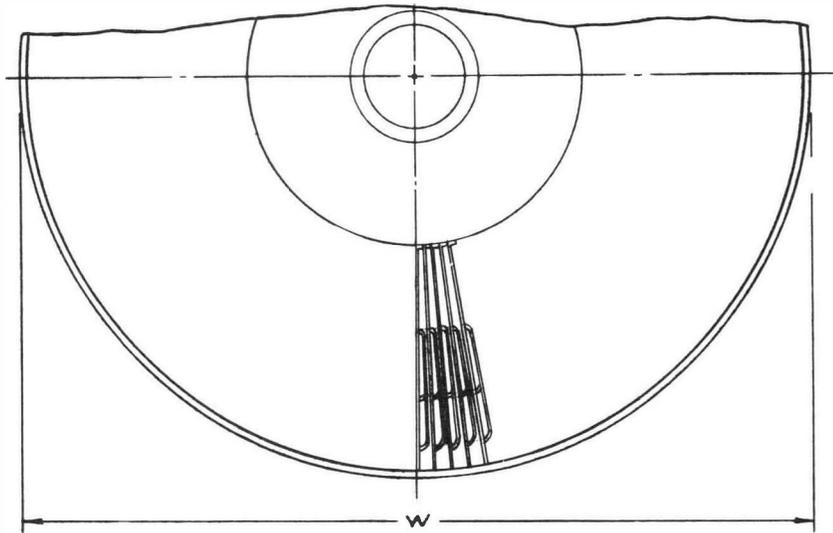
Filament Operation - The rated filament voltage for the 3CX10,000A3 is 7.5 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain maximum tube life. In no case should it be allowed to deviate from the rated value by more than five percent.

Special Applications - If it is desired to operate this tube under conditions widely different from those given here, write to the Application Engineering Department, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California, for information and recommendations.

► Indicates change from sheet dated 8-15-60)



DIM	NOM.	MIN.	MAX.
A	.740		
B	1.916		
C	3.153		
D	3.803		
E	4.185		
F	1/4		
G	.384		
H	.864		
J	1/4		
K	2.706		
L	4 3/16		
M	6 3/16		
N	8 1/2		
P	1		
Q	.875		
R	3/16		
S	1/2		
T	1 13/16		
U	.394		
V	1/4		
W	6.995		

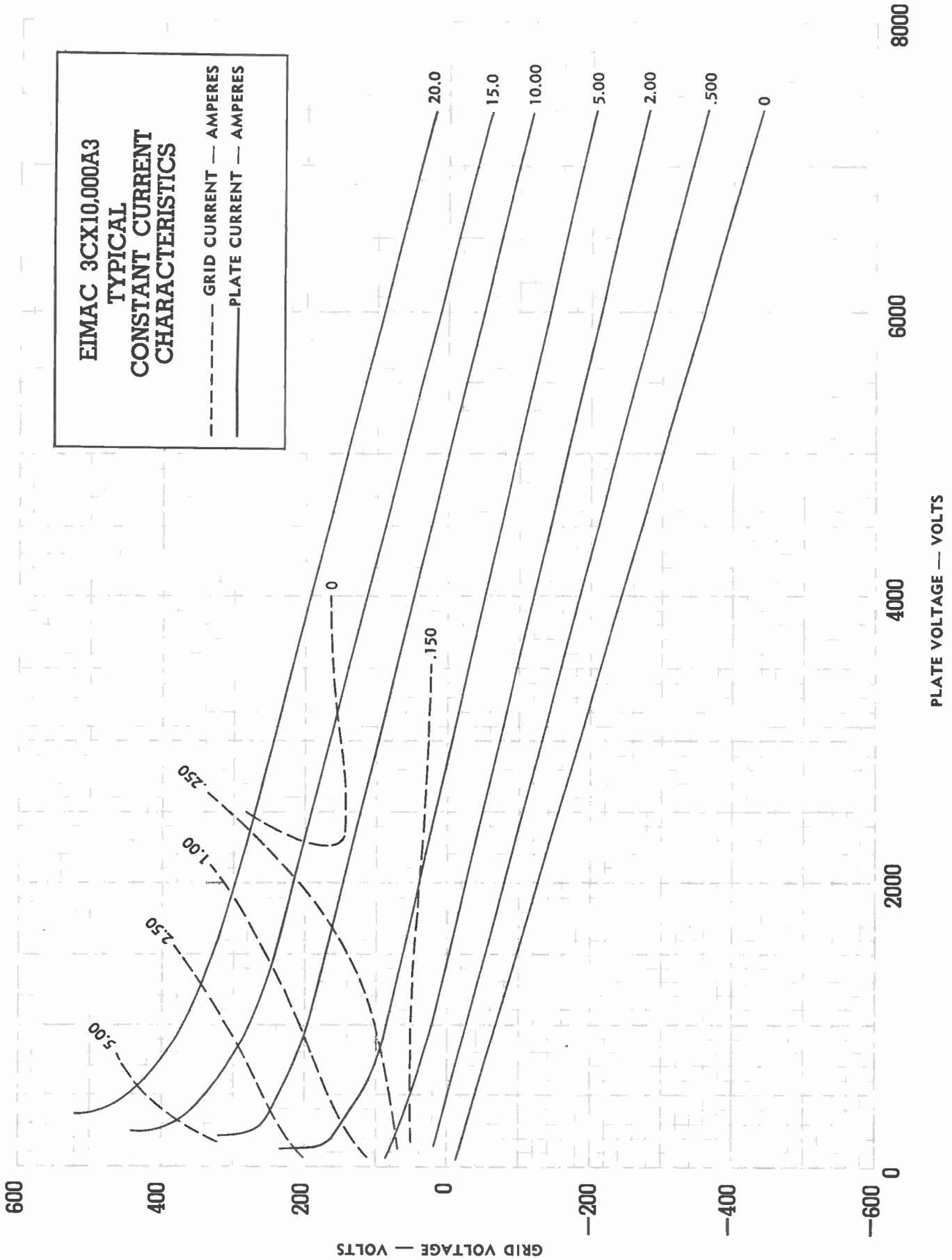


NOTE:

1. * DENOTES CONTACT SURFACE



3CX10,000A3





EIMAC

A Division of Varian Associates
SAN CARLOS, CALIFORNIA

25T
MEDIUM-MU TRIODE

•
**MODULATOR
OSCILLATOR
AMPLIFIER**

The Eimac 25T is a medium-mu, power triode having a maximum plate dissipation of 25 watts and is intended for use as an amplifier, oscillator or modulator. It can be used at its maximum ratings at frequencies as high as 60 Mc.

Cooling of the 25T is accomplished by radiation from the plate, which operates at a visible red color at maximum dissipation and by means of air convection around the envelope.

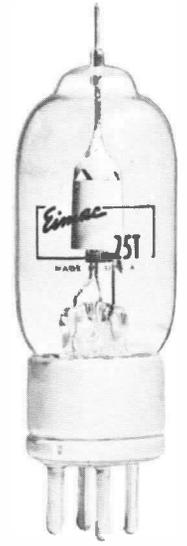
GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage - - - - -	6.3 volts
Current - - - - -	3.0 amperes
Amplification Factor (Average)	- 24
Direct Interelectrode Capacitances (Average)	
Grid-Plate - - - - -	1.5 $\mu\mu\text{f}$
Grid-Filament - - - - -	2.2 $\mu\mu\text{f}$
Plate-Filament - - - - -	0.2 $\mu\mu\text{f}$
Transconductance ($i_b = 25 \text{ ma.}, E_b = 1000 \text{ v.}$)	2500 μmhos
Frequency for Maximum Ratings	- 60 Mc.

MECHANICAL

Base - - - - -	Small 4-pin, RMA type A4-5
Basing (See outline drawing) - - - - -	RMA type 3G
Mounting - - - - -	Vertical, base down or up
Cooling - - - - -	Convection and Radiation
Recommended Heat Dissipating Connector:	
Plate - - - - -	HR-1
Maximum Overall Dimensions:	
Length - - - - -	4.38 inches
Diameter - - - - -	1.44 inches
Net Weight - - - - -	1.5 ounces
Shipping Weight (Average) - - - - -	1.0 pound



AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-B

MAXIMUM RATINGS, PER TUBE

D-C PLATE VOLTAGE - - - - -	2000 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT - - - - -	75 MAX. MA.
PLATE DISSIPATION - - - - -	25 MAX. WATTS
GRID DISSIPATION - - - - -	7 MAX. WATTS

TYPICAL OPERATION, CLASS AB₂

Sinusoidal wave, two tubes unless otherwise specified

D-C Plate Voltage - - - - -	750	1000	1250	Volts
D-C Grid Voltage (approx.)* - - - - -	-20	-30	-42	Volts
Zero-Signal D-C Plate Current - - - - -	43	32	24	Ma.
Max-Signal D-C Plate Current - - - - -	127	127	130	Ma.
Effective Load, Plate-to-Plate - - - - -	12,000	17,000	21,400	Ohms
Peak A-F Grid Input Voltage (per tube) - - - - -	110	120	135	Volts
Max-Signal Peak Driving Power - - - - -	5.5	6.0	6.8	Watts
Max-Signal Nominal Driving Power (approx.) - - - - -	2.8	3.0	3.4	Watts
Max-Signal Plate Power Output - - - - -	60	85	112	Watts

*Adjust to give stated zero-signal plate current.

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE - - - - -	1600 MAX. VOLTS
D-C PLATE CURRENT - - - - -	60 MAX. MA.
PLATE DISSIPATION - - - - -	17 MAX. WATTS
GRID DISSIPATION - - - - -	7 MAX. WATTS

TYPICAL OPERATION

D-C Plate Voltage - - - - -	1000	1250	1600	Volts
D-C Plate Current - - - - -	60	60	53	Ma.
D-C Grid Voltage - - - - -	-120	-140	-170	Volts
D-C Grid Current - - - - -	14	13	11	Ma.
Peak R-F Grid Input Voltage - - - - -	235	255	280	Volts
Driving Power - - - - -	3.3	3.3	3.1	Watts
Grid Dissipation - - - - -	1.6	1.5	1.2	Watts
Plate Power Input - - - - -	60	75	85	Watts
Plate Dissipation - - - - -	13	15	17	Watts
Plate Power Output - - - - -	47	60	68	Watts

The above figures show actual measured tube performance and do not allow for variations in circuit losses.

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy or FM Telephony (Key-down conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE - - - - -	2000 MAX. VOLTS
D-C PLATE CURRENT - - - - -	75 MAX. MA.
PLATE DISSIPATION - - - - -	25 MAX. WATTS
GRID DISSIPATION - - - - -	7 MAX. WATTS

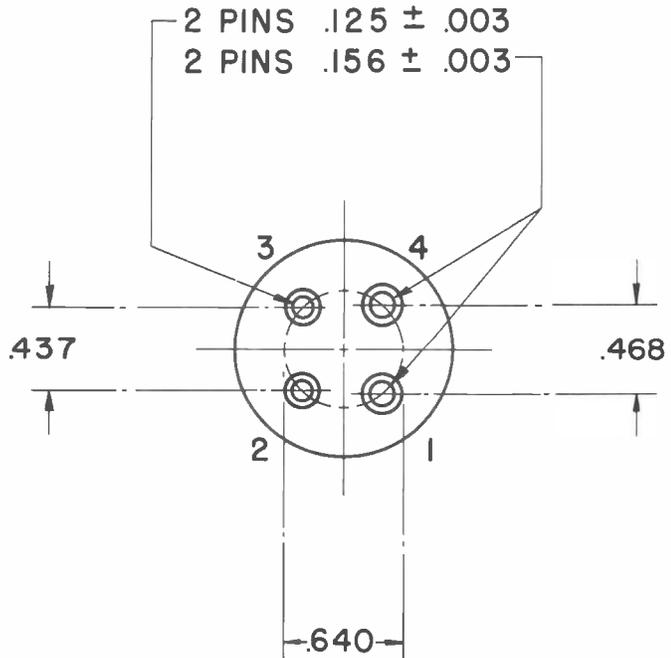
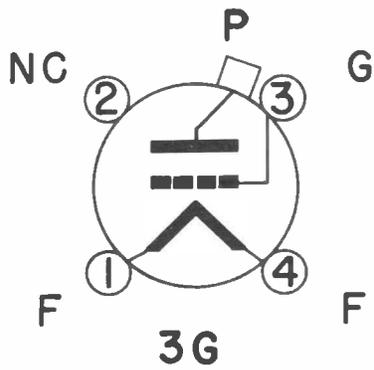
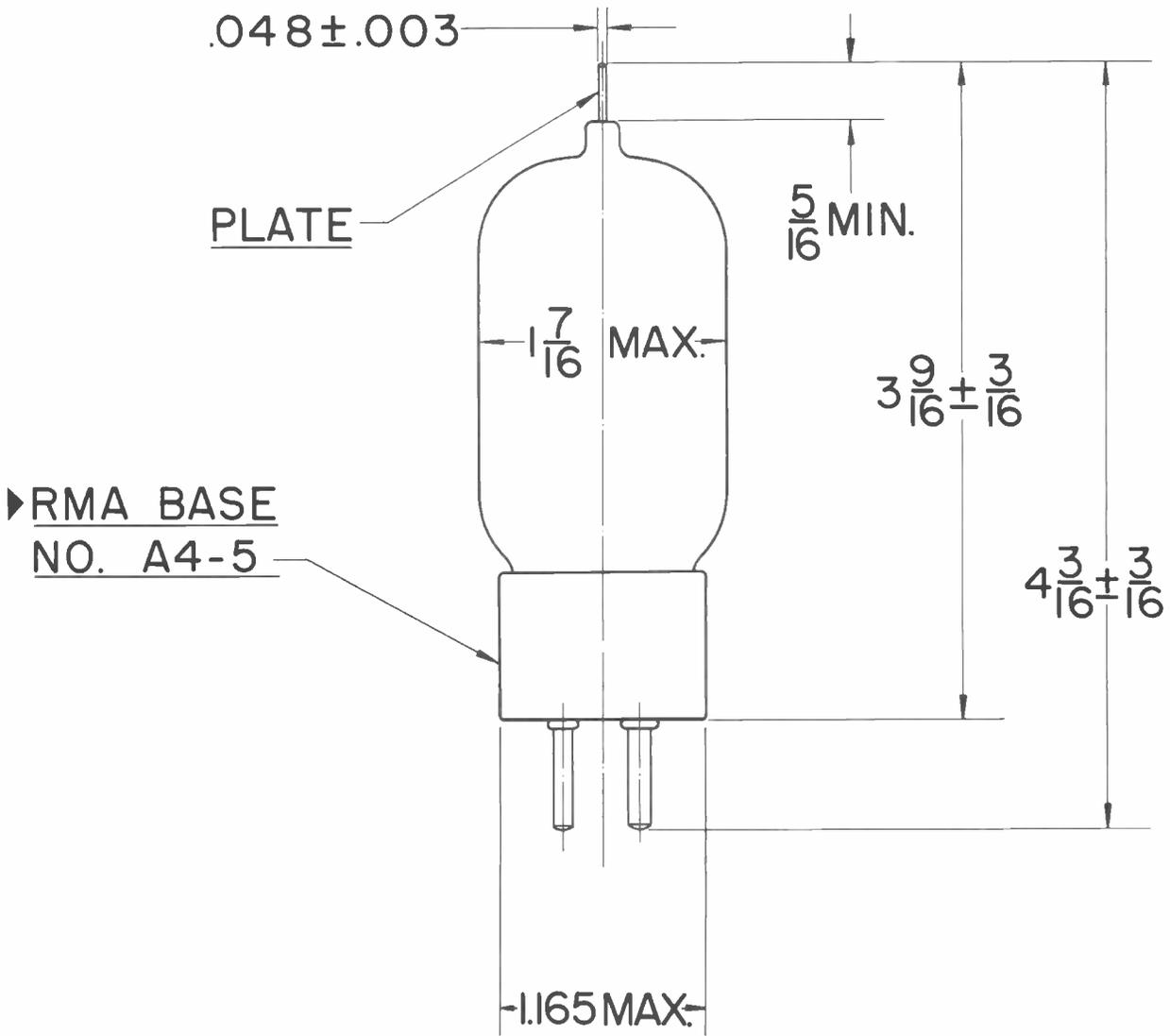
TYPICAL OPERATION

D-C Plate Voltage - - - - -	1000	1500	2000	Volts
D-C Plate Current - - - - -	72	67	63	Ma.
D-C Grid Voltage - - - - -	-70	-95	-130	Volts
D-C Grid Current - - - - -	9	13	18	Ma.
Peak R-F Grid Input Voltage - - - - -	170	195	245	Volts
Driving Power - - - - -	1.3	2.2	4.0	Watts
Grid Dissipation - - - - -	.9	1.3	2.1	Watts
Plate Power Input - - - - -	72	100	125	Watts
Plate Dissipation - - - - -	25	25	25	Watts
Plate Power Output - - - - -	47	75	100	Watts

The above figures show actual measured tube performance and do not allow for variations in circuit losses.



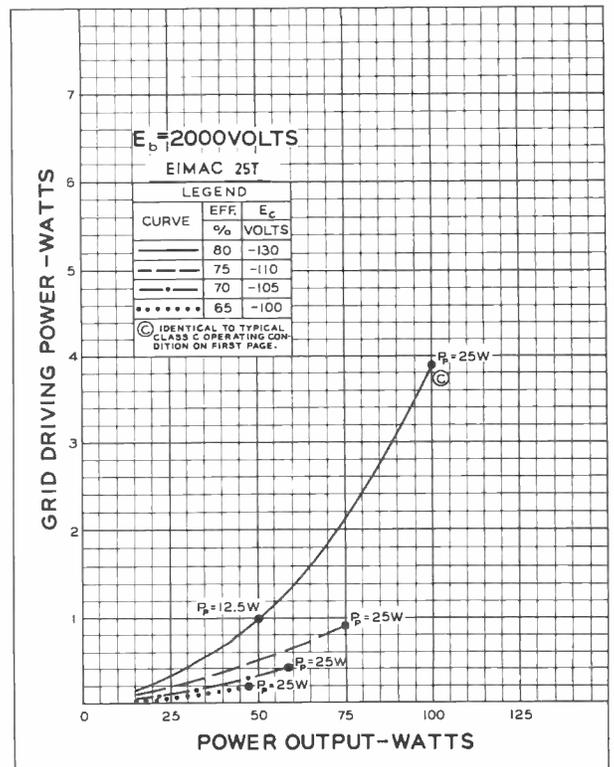
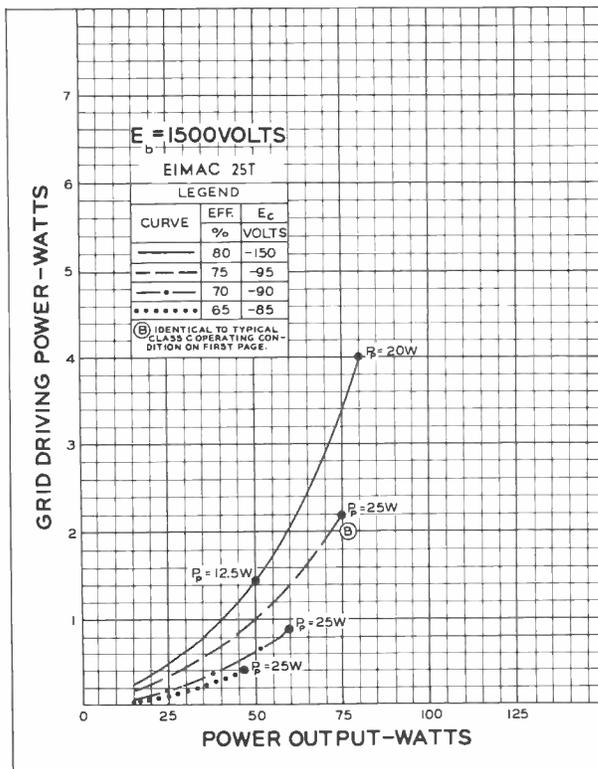
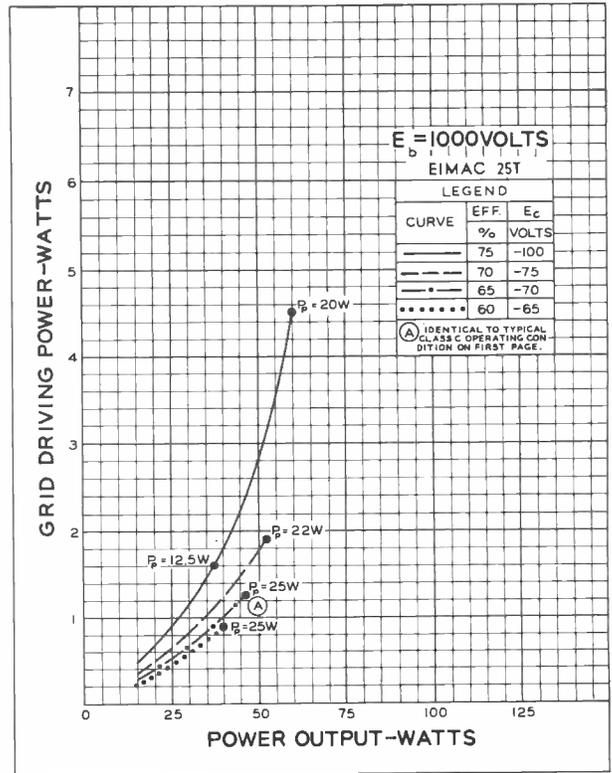
25T

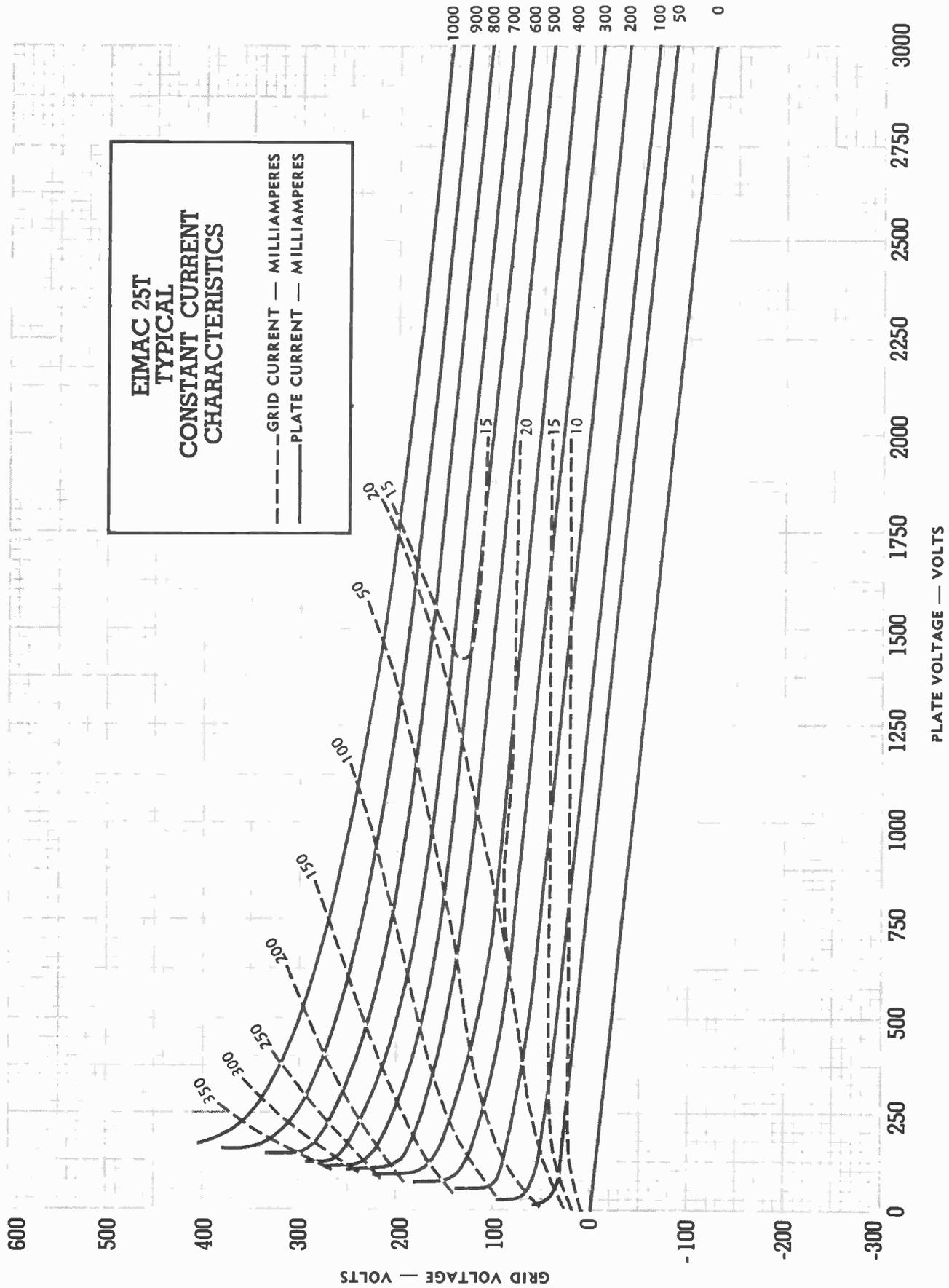


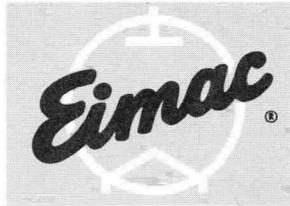
DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and grid driving power at plate voltages of 1000, 1500 and 2000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 1000, 1500, and 2000 volts respectively.







E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

35TG
 HIGH-MU TRIODE
 •
 MODULATOR
 OSCILLATOR
 AMPLIFIER

The EIMAC 35TG is a high-mu triode having a maximum plate dissipation of 50 watts. It is intended for use as an amplifier, oscillator or modulator, and can be used at its maximum ratings at frequencies up to 100 MHz. It is basically the same as the EIMAC 35T except that the grid terminal is located at the side of the bulb.

The 35TG is cooled by radiation and by free circulation of air around the envelope.

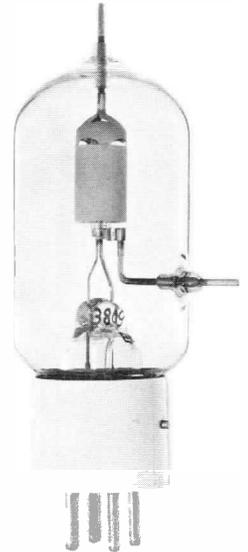
GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated Tungsten		5.0		volts
Voltage				
Current			4.2	amps
Amplification Factor	3.6		43	
Direct Interelectrode Capacitances:				
Grid-Plate	1.25		2.05	pF
Grid-Filament	2.00		3.20	pF
Plate-Filament	0.10		0.35	pF
Transconductance ($I_b = 100$ mA)		2850		umhos
Frequency for Maximum Ratings			100	MHz

MECHANICAL

Base: UX Medium 4-pin. Fits E. F. Johnson Co. 122-124, or National XC-4 or CIR-4 sockets.	
Basing	See outline drawing
Mounting	Vertical, base down or up
Cooling	Convection and radiation
Recommended Heat Dissipating Plate Connector	EIMAC HR-3
Maximum Overall Dimensions:	
Length	5.5 inches
Diameter	1.8 inches
Net weight	2.5 ounces
Shipping weight (Average)	1.25 pounds



AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR

Class AB (Sinusoidal wave, two tubes unless otherwise specified)

MAXIMUM RATINGS

DC Plate Voltage	2000	volts
DC Plate Current	150	mA
Plate Dissipation	50	watts
Grid Dissipation	15	watts

TYPICAL OPERATION

DC Plate Voltage	600	1000	1500	2000	volts
DC Grid Voltage (approx.)*	0	-8	-25	-40	volts
Zero-signal DC Plate Current	90	67	45	34	mA
Max-signal DC Plate Current	300	240	200	167	mA
Effective Load Plate-to-Plate	4250	7900	16,200	27,500	ohms
Peak AF Input Voltage (per tube)	130	240	250	255	volts
Peak Driving Power (approx.)	18	14	10	8	watts
Nominal Driving Power (app.)	9	7	5	4	watts
Max-signal Plate Power Output	95	140	200	235	watts

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy or FM Telephony (Key-down conditions, per tube)¹

MAXIMUM RATINGS

DC Plate Voltage	2000	volts
DC Plate Current	150	mA
Plate Dissipation	50	watts
Grid Dissipation	15	watts

TYPICAL OPERATION

DC Plate Voltage	1000	1500	2000	volts
DC Grid Voltage	-60	-120	-135	volts
DC Plate Current	125	125	125	mA
DC Grid Current	40	40	45	mA
Peak RF Grid Input Voltage	165	250	285	volts
Driving Power (approx.)	7	9	13	watts
Grid Dissipation	4.2	5.0	6.8	watts
Plate Power Input	125	188	250	watts
Plate Dissipation	38	47	50	watts
Plate Power Output	87	141	200	watts

PLATE MODULATED RADIO FREQUENCY POWER AMPLIFIER

Class-C Telephony (Carrier conditions, per tube)¹

MAXIMUM RATINGS

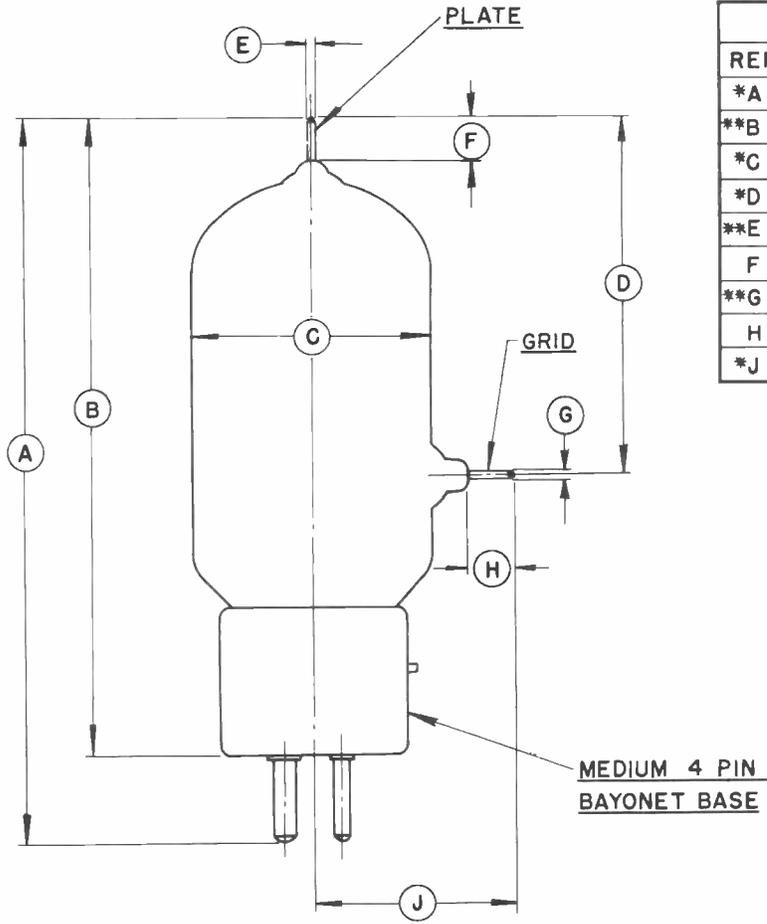
DC Plate Voltage	1600	volts
DC Plate Current	120	mA
Plate Dissipation	33	watts
Grid Dissipation	15	watts

TYPICAL OPERATION

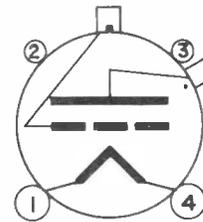
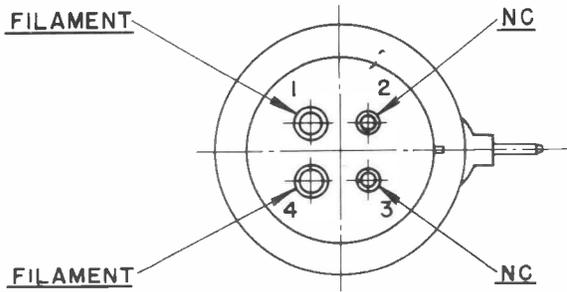
DC Plate Voltage	750	1000	1500	volts
DC Grid Voltage	-100	-125	-150	volts
DC Plate Current	95	100	90	mA
DC Grid Current	40	40	40	mA
Peak RF Driving Voltage (approx.)	210	240	270	volts
Driving Power (approx.)	9	10	11	watts
Plate Dissipation	20	25	30	watts
Plate Input	70	100	135	watts
Plate Power Output	50	75	105	watts

*Adjust for stated zero-signal plate current.

¹ The performance figures listed under Typical Operation are for radio frequencies up to the VHF region and are obtained by calculation from the characteristic tube curves and confirmed by direct tests. The driving power given includes power taken by the tube grid and the bias circuit. The driving power and output power do not allow for losses in the associated resonant circuits. These losses are not included because they depend principally upon the design and choice of the circuit components.



DIMENSION DATA			
REF.	NOM.	MIN.	MAX.
*A		5 3/8	5 3/4
**B		4 3/4	5 1/8
*C			1.813
*D		2.060	2.680
**E		.065	.071
F		.312	
**G		.065	.071
H		.312	
*J		1.370	1.630



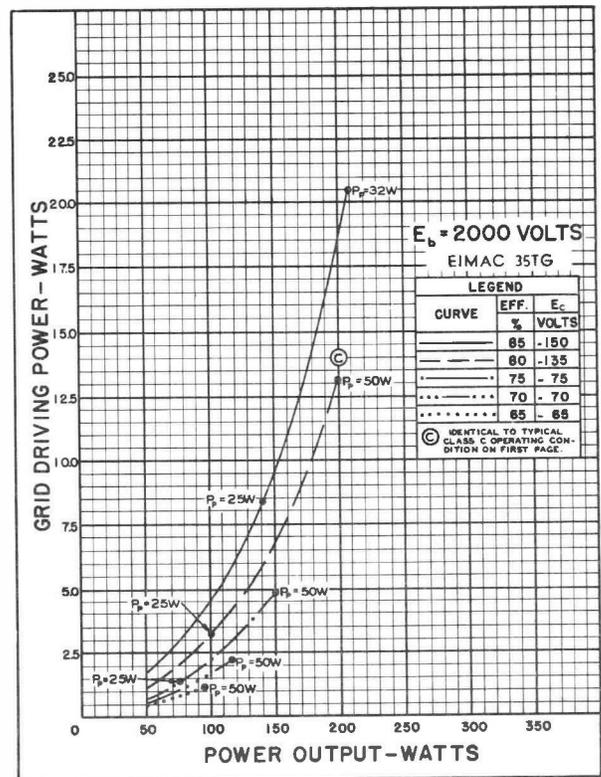
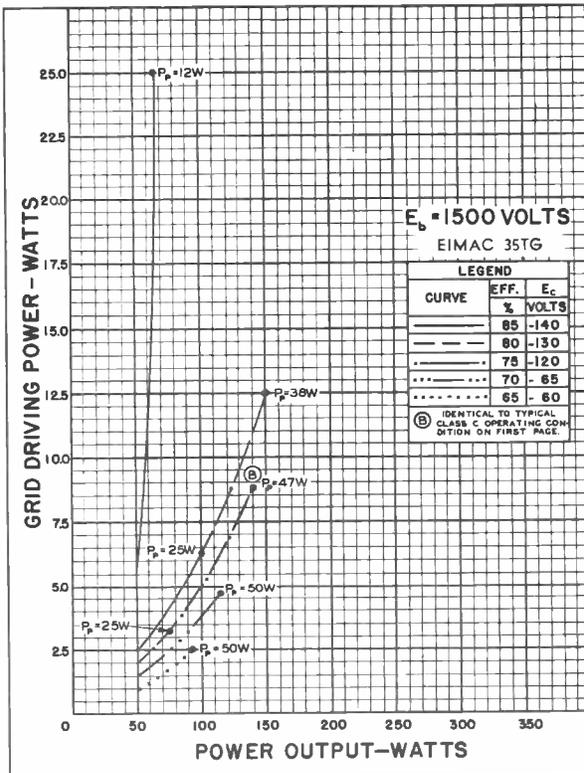
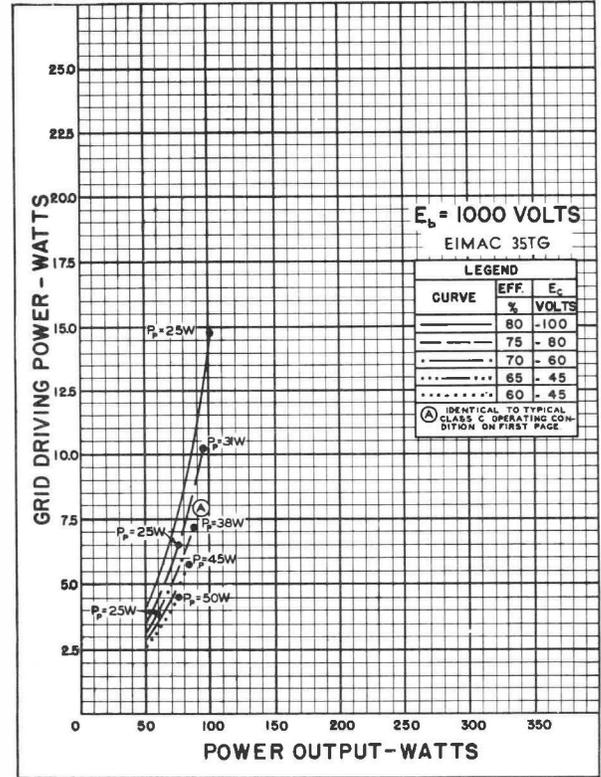
NOTES:

1. DIMENSIONS IN INCHES.
2. *STANDARD DESIGN TESTS & QUALIFICATION TESTS.
3. **QUALIFICATION TESTS.

DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and grid driving power at plate voltages of 1000, 1500 and 2000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 1000, 1500, and 2000 volts respectively.

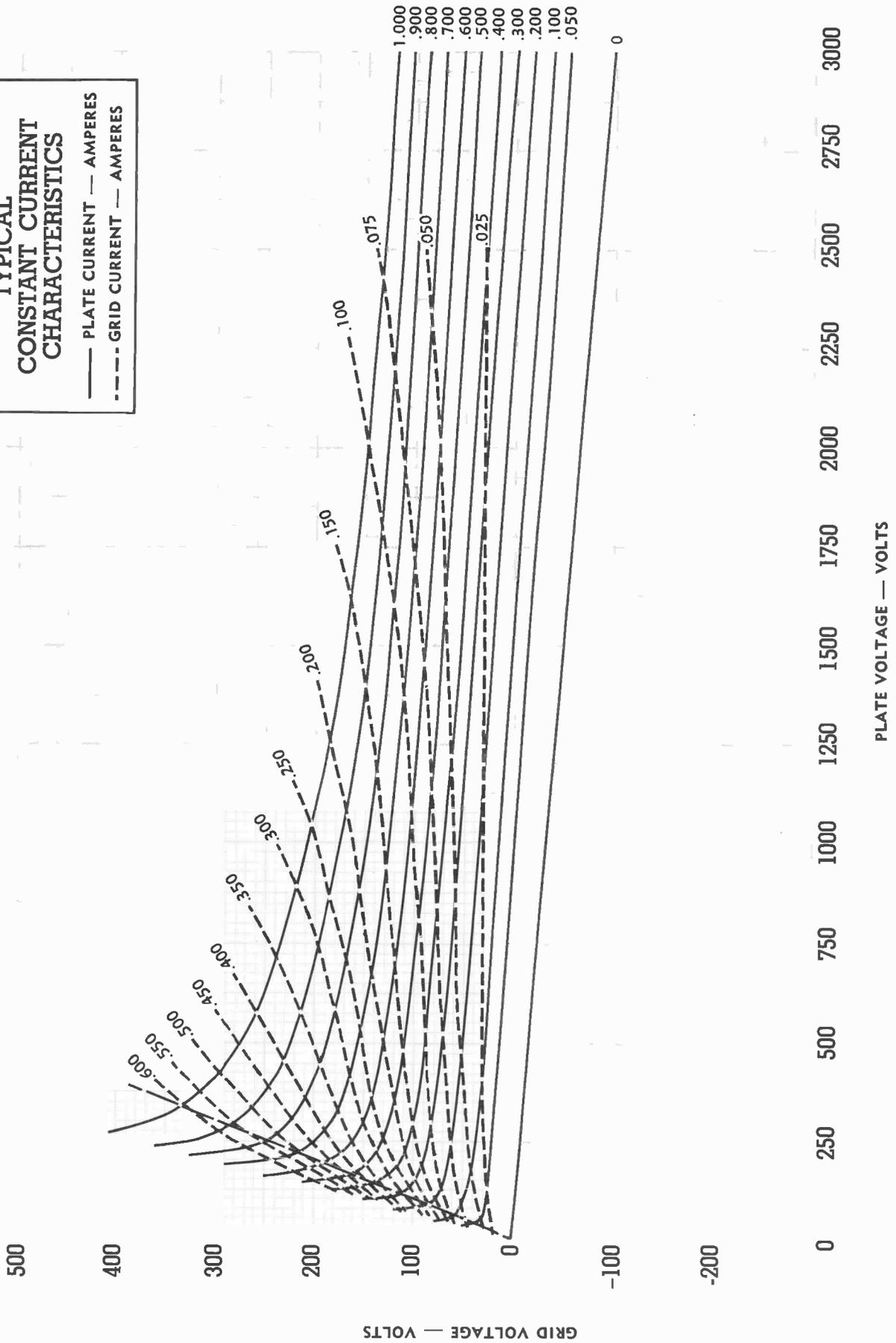




35TG

**EIMAC 35TG
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS**

— PLATE CURRENT — AMPERES
- - - GRID CURRENT — AMPERES





EIMAC

A Division of Varian Associates
ANN ARBOR, MICHIGAN, U.S.A.

75TH
MEDIUM-MU TRIODE
MODULATOR
OSCILLATOR
AMPLIFIER

The Eimac 75TH is a medium-mu power triode intended for use as an amplifier, oscillator, or modulator. It has a maximum plate dissipation rating of 75 watts and a maximum plate voltage rating of 3000 volts at frequencies up to 40 Mc. Forced-air cooling is not required in properly designed equipment operating at frequencies below 40 Mc.

The 75TH in Class-C R-F service will deliver up to 225 watts plate power output with 10 watts driving power. Two 75TH's in Class-B modulator service will deliver up to 300 watts maximum-signal plate power output with 3 watts driving power.

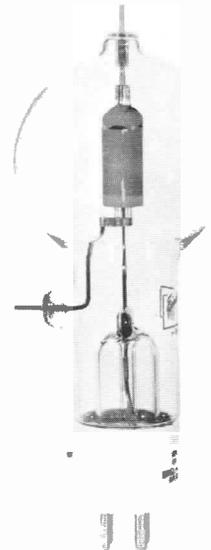
GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten	
Voltage - - - - -	5.0 volts
Current - - - - -	6.25 amperes
Amplification Factor (Average) - - - - -	20
Direct Interelectrode Capacitances (Average)	
Grid-Plate - - - - -	2.3 $\mu\mu\text{f}$
Grid-Filament - - - - -	2.7 $\mu\mu\text{f}$
Plate-Filament - - - - -	0.3 $\mu\mu\text{f}$
Transconductance ($I_b=225 \text{ ma.}, E_b=3000 \text{ v.}$) - - - - -	4150 μmhos
Highest Frequency for Maximum Ratings - - - - -	40 Mc

MECHANICAL

Base - - - - -	Medium 4-pin bayonet
Basing - - - - -	See outline drawing
Socket - - - - -	Johnson type No. 122-224, National type No. XC-4 or CIR-4, or equivalent
Mounting Position - - - - -	Vertical, base down or up
Cooling - - - - -	Convection and radiation
Maximum Temperature of Plate and Grid Seals - - - - -	225°C
Recommended Heat Dissipating Connectors:	
Plate - - - - -	Eimac HR-3
Grid - - - - -	Eimac HR-2
Maximum Overall Dimensions:	
Length - - - - -	7.25 inches
Diameter - - - - -	2.81 inches
Net Weight - - - - -	3 ounces
Shipping Weight (Average) - - - - -	1.5 pounds



RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy (Key-down conditions, 1 tube)

MAXIMUM RATINGS (Frequencies up to 40 Mc.)	
D-C PLATE VOLTAGE - - - - -	3000 MAX. VOLTS
D-C PLATE CURRENT - - - - -	225 MAX. MA.
PLATE DISSIPATION - - - - -	75 MAX. WATTS
GRID DISSIPATION - - - - -	16 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 40 Mc.)

D-C Plate Voltage - - - - -	1000	1500	2000	volts
D-C Grid Voltage - - - - -	-80	-125	-200	volts
D-C Plate Current - - - - -	215	167	150	ma.
D-C Grid Current (approx.) - - - - -	35	23	32	ma.
Peak R-F Grid Input Voltage (approx.) - - - - -	270	280	350	volts
Driving Power (approx.) - - - - -	9	6	10	watts
Plate Power Input - - - - -	215	250	300	watts
Plate Dissipation - - - - -	75	75	75	watts
Plate Power Output - - - - -	140	175	225	watts

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions, per tube)

MAXIMUM RATINGS (Frequencies up to 40 Mc.)	
D-C PLATE VOLTAGE - - - - -	2400 MAX. VOLTS
D-C PLATE CURRENT - - - - -	180 MAX. MA.
PLATE DISSIPATION - - - - -	50 MAX. WATTS
GRID DISSIPATION - - - - -	16 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 40 Mc.)

D-C Plate Voltage - - - - -	1000	1500	2000	volts
D-C Grid Voltage - - - - -	-150	-200	-300	volts
D-C Plate Current - - - - -	135	115	110	ma.
D-C Grid Current (approx.) - - - - -	20	14	15	ma.
Peak R-F Grid Input Voltage (approx.) - - - - -	300	330	440	volts
Driving Power (approx.) - - - - -	6	5	6	watts
Grid Dissipation - - - - -	3	2	2	watts
Plate Power Input - - - - -	135	175	220	watts
Plate Dissipation - - - - -	50	50	50	watts
Plate Power Output - - - - -	85	125	170	watts

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-B

MAXIMUM RATINGS (Per tube)	
D-C PLATE VOLTAGE - - - - -	3000 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT - - - - -	225 MAX. MA.
PLATE DISSIPATION - - - - -	75 MAX. WATTS
GRID DISSIPATION - - - - -	16 MAX. WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage - - - - -	1000	1500	2000	volts
D-C Grid Voltage (approx.) ¹ - - - - -	-30	-60	-90	volts
Zero-Signal D-C Plate Current - - - - -	90	67	50	ma.
Max-Signal D-C Plate Current - - - - -	350	267	225	ma.
Effective Load, Plate-to-Plate - - - - -	5300	11,400	19,300	ohms
Peak A-F Grid Input Voltage (per tube) - - - - -	175	165	175	volts
Max-Signal Driving Power (approx.) - - - - -	7	4	3	watts
Max-Signal Plate Dissipation (per tube) - - - - -	75	75	75	watts
Max-Signal Plate Power Output - - - - -	200	250	300	watts
Total Harmonic Distortion - - - - -	1.5	2.0	2.0	per cent

¹Adjust to give stated zero-signal plate current.

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING MAXIMUM RATINGS, WRITE EIMAC, A DIVISION OF VARIAN ASSOCIATES, FOR INFORMATION AND RECOMMENDATIONS.



APPLICATION

MECHANICAL

Mounting—The 75TH must be mounted vertically, base down or up. The plate and grid leads should be flexible. The tube must be protected from vibration and shock.

Cooling—Heat Dissipating Connectors (Eimac HR-3 and HR-2) should be used at the plate and grid terminals of the 75TH. If the free circulation of air around the tube is restricted, a small fan or centrifugal blower should be used to provide additional cooling for the plate and grid seals.

Cooling requirements will be met if the temperature of the plate and grid seals is not allowed to exceed 225°C. One method of measuring these temperatures is provided by the use of "Tempilaq", a temperature-sensitive lacquer available from the Tempil Corporation, New York 11, N.Y.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the base pins, should be the rated value of 5.0 volts. Variations must be kept within the range of 4.75 to 5.25 volts.

Bias Voltage—Although there is no maximum limit on the bias voltage which may be used on the 75TH, there is little advantage in using bias voltages in excess of those given under "Typical Operation," except in certain very specialized applications. Where bias is obtained by a grid leak, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage—The plate-supply voltage for the 75TH should not exceed 3000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "Typical Operation" for the power output desired.

Grid Dissipation—The power dissipated by the grid of the 75TH must not exceed 16 watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} I_c$$

where P_g = Grid dissipation,

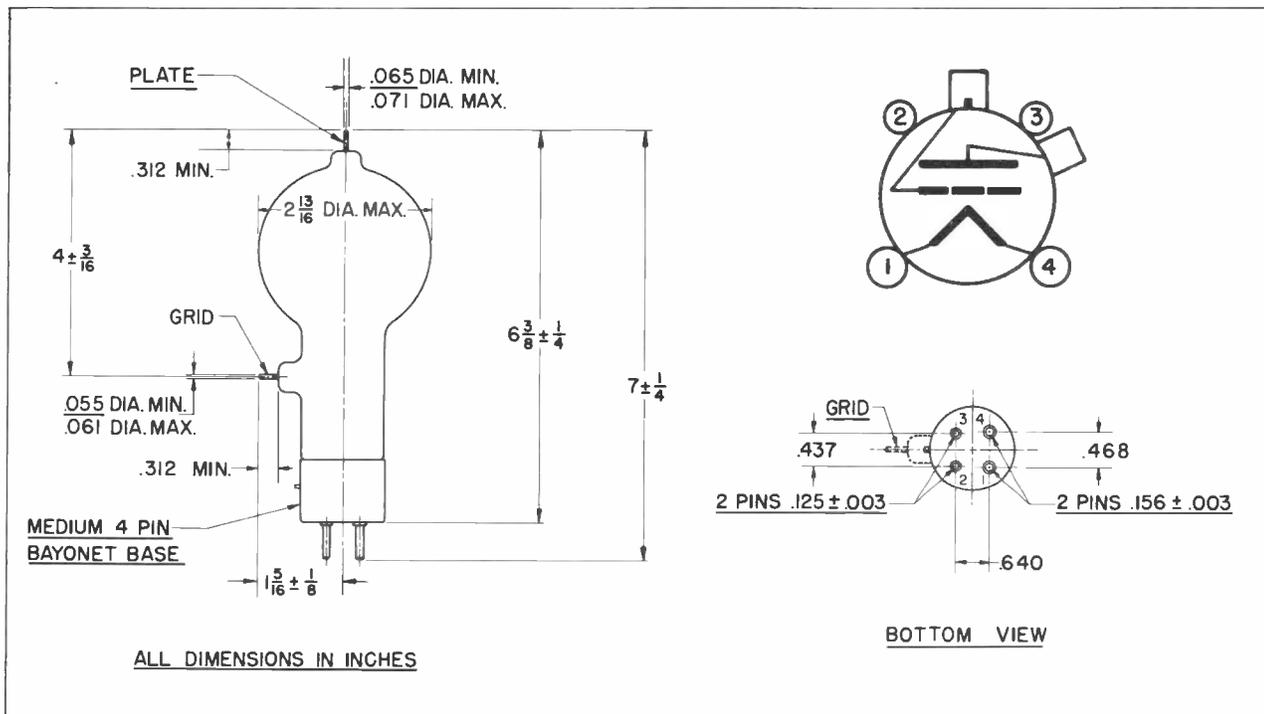
e_{cmp} = Peak positive grid voltage, and

I_c = D-c grid current.

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid¹. In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.

Plate Dissipation—The plate of the 75TH operates at a visibly red temperature at its maximum rated dissipation of 75 watts. Plate dissipation in excess of the maximum rating is permissible only for short periods of time, such as during tuning procedures.

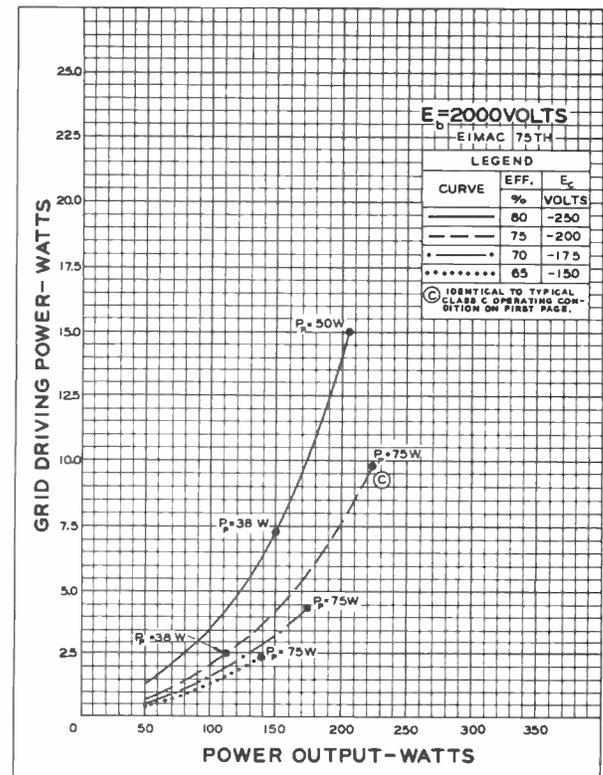
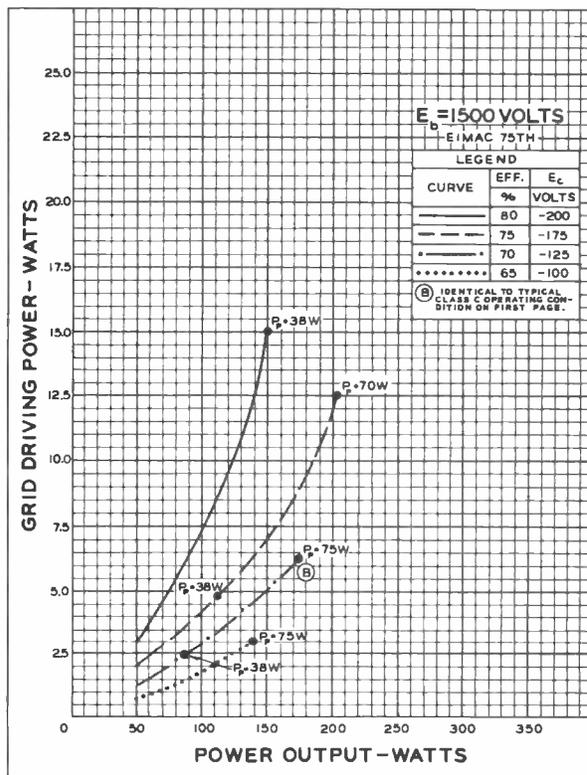
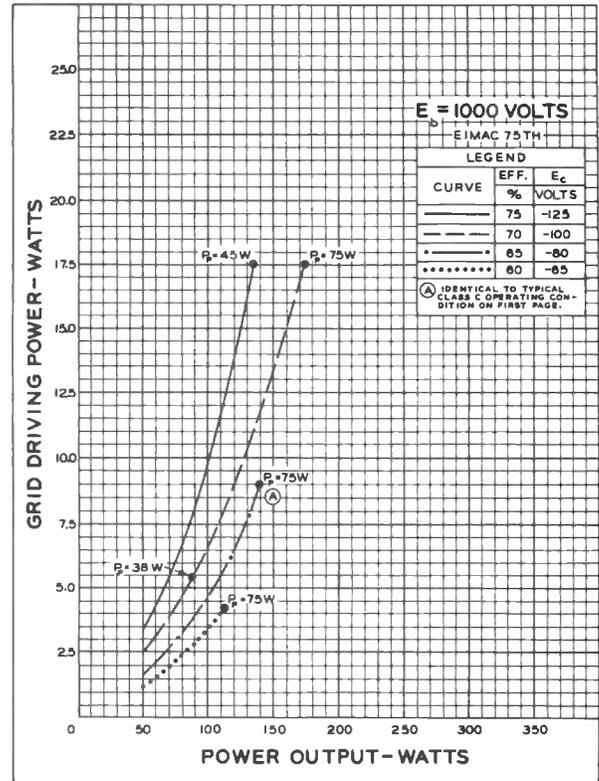
¹ For suitable peak v.t.v.m. circuits see, for instance, "Vacuum Tube Ratings", Eimac News, January, 1945. This article is available in reprint form on request.



DRIVING POWER vs. POWER OUTPUT

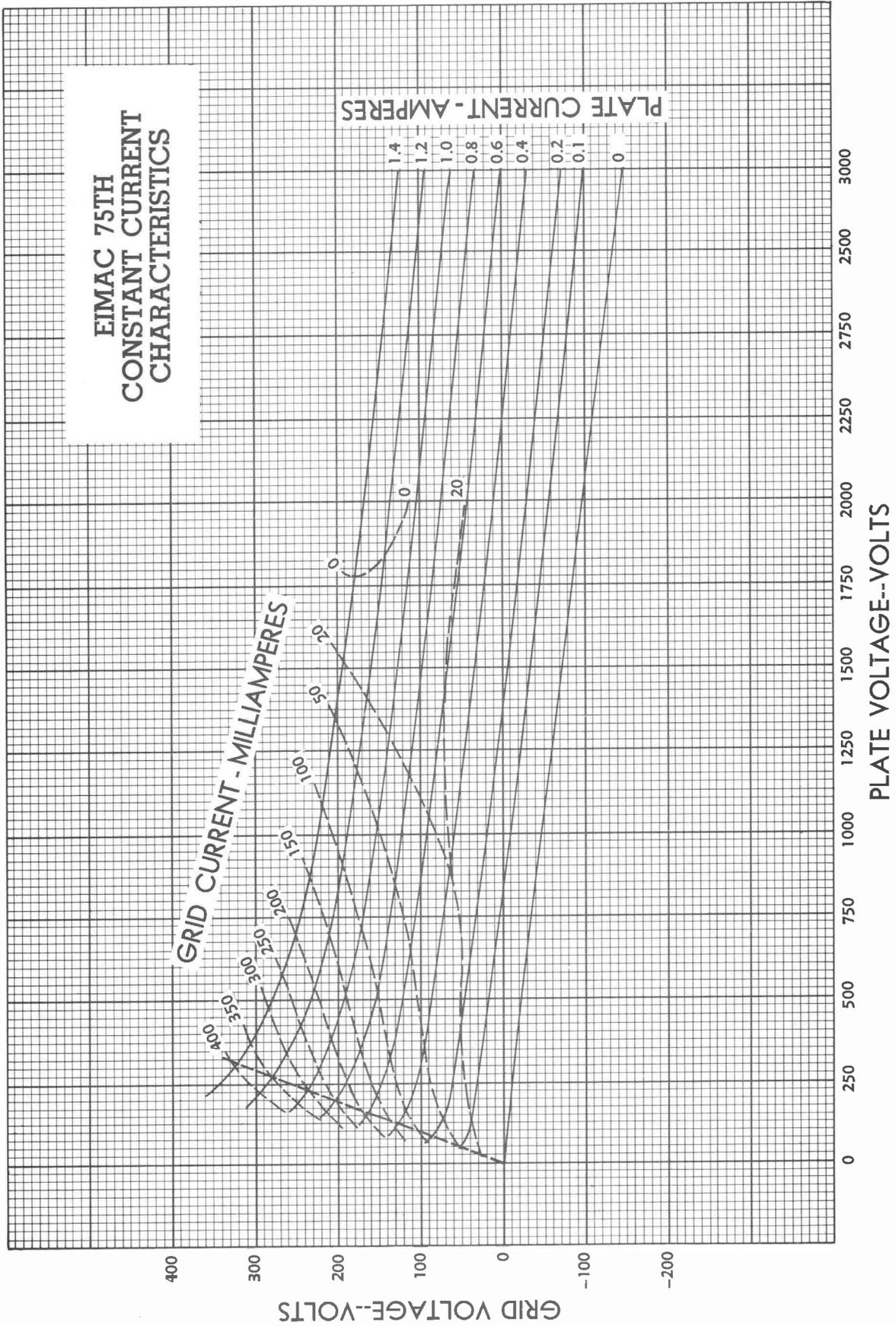
The three charts on this page show the relationship of plate efficiency, power output and grid driving power at plate voltages of 1000, 1500 and 2000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 1000, 1500, and 2000 volts respectively.





75TH





E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

75TL
 LOW-MU TRIODE
 •
 MODULATOR
 OSCILLATOR
 AMPLIFIER

The EIMAC 75TL is a low-mu power triode intended for use as an amplifier, oscillator, or modulator. It has a maximum plate dissipation rating of 75 watts and a maximum plate voltage rating of 3000 volts at frequencies up to 40 MHz. Forced-air cooling is not required in properly designed equipment operating at frequencies below 40 MHz.

The 75TL in Class-C RF service will deliver up to 225 watts plate power output with 8 watts driving power. Two 75TL's in Class-B modulator service will deliver up to 350 watts maximum-signal plate power output with 5 watts driving power.

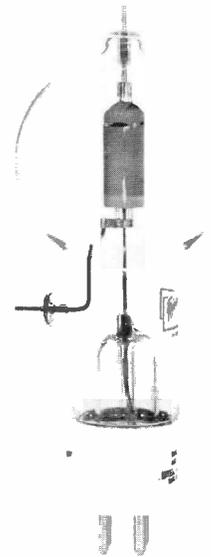
GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten			
Voltage	- - - - -	5.0	volts
Current	- - - - -	6.25	amperes
Amplification Factor (Average)	- - - - -	12	
Direct Interelectrode Capacitances (Average)			
Grid-Plate	- - - - -	2.4	pF
Grid-Filament	- - - - -	2.6	pF
Plate-Filament	- - - - -	0.4	pF
Transconductance ($I_b = 225$ ma., $E_b = 2500$ v.)	- - - - -	3350	μ mhos
Highest Frequency for Maximum Ratings	- - - - -	40	MHz

MECHANICAL

Base	- - - - -	Medium 4-pin bayonet
Basing	- - - - -	See outline drawing
Socket	- - -	Johnson type No. 122-224, National type No. XC-4 or CIR-4, or equivalent
Mounting Position	- - - - -	Vertical, base down or up
Cooling	- - - - -	Convection and radiation
Maximum Temperature of Plate and Grid Seals	- - - - -	225°C
Recommended Heat Dissipating Connectors:		
Plate	- - - - -	EIMAC HR-3
Grid	- - - - -	EIMAC HR-2
Maximum Overall Dimensions:		
Length	- - - - -	7.25 inches
Diameter	- - - - -	2.81 inches
Net Weight	- - - - -	3 ounces
Shipping Weight (Average)	- - - - -	1.5 pounds



RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy (Key-down conditions, 1 tube)
 Maximum Ratings (Frequencies up to 40 MHz)

DC Plate Voltage	- - - - -	3000	volts
DC Plate Current	- - - - -	225	ma.
Plate Dissipation	- - - - -	75	watts
Grid Dissipation	- - - - -	13	watts

Typical Operation (Frequencies up to 40 MHz)

DC Plate Voltage	- - - - -	1000	1500	2000	volts
DC Grid Voltage	- - - - -	-150	-250	-300	volts
DC Plate Current	- - - - -	215	167	150	ma.
DC Grid Current	- - - - -	28	22	21	ma.
Peak RF Grid Input Voltage (approx.)	- - - - -	320	355	425	volts
Driving Power (approx.)	- - - - -	8	6	8	watts
Plate Power Input	- - - - -	215	250	300	watts
Plate Dissipation	- - - - -	75	75	75	watts
Plate Power Output	- - - - -	140	175	225	watts

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions, per tube)
 Maximum Ratings (Frequencies up to 40 MHz)

DC Plate Voltage	- - - - -	2400	volts
DC Plate Current	- - - - -	180	ma.
Plate Dissipation	- - - - -	50	watts
Grid Dissipation	- - - - -	13	watts

Typical Operation (Frequencies up to 40 MHz)

DC Plate Voltage	- - - - -	1000	1500	2000	volts
Total Bias Voltage	- - - - -	-250	-370	-500	volts
Fixed Bias Voltage	- - - - -	-130	-260	-350	volts
Grid Resistor	- - - - -	7500	6000	6000	ohms
DC Plate Current	- - - - -	135	130	130	ma.
DC Grid Current (approx.)	- - - - -	16	18	20	ma.
Peak RF Grid Input Voltage (approx.)	- - - - -	410	545	695	volts
Driving Power (approx.)	- - - - -	6	10	14	watts
Grid Dissipation	- - - - -	2	3	4	watts
Plate Power Input	- - - - -	135	195	260	watts
Plate Dissipation	- - - - -	50	50	50	watts
Plate Power Output	- - - - -	85	145	210	watts

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION," POSSIBLY EXCEEDING MAXIMUM RATINGS, WRITE EIMAC DIVISION OF VARIAN FOR INFORMATION AND RECOMMENDATIONS.

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB₁

Maximum Ratings (Per tube)

DC Plate Voltage	3000	volts
Max-Signal DC Plate Current	225	ma.
Plate Dissipation	75	watts

Typical Operation (Sinusoidal wave, two tubes unless otherwise specified)

DC Plate Voltage	1500	2000	volts
DC Grid Voltage	-130	-190	volts
Peak AF Grid Input Voltage (per tube)	-130	190	volts
Zero-Signal DC Plate Current	67	50	ma.
Max-Signal DC Plate Current	143	130	ma.
Driving Power	0	0	watt
Effective Load, Plate-to-Plate	10,200	21,200	ohms
Max-Signal Plate Power Output	64	110	watts
Max-Signal Plate Dissipation (per tube)	75	75	watts
Total Harmonic Distortion	3.0	3.5	per cent

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB₂

Maximum Ratings (Per tube)

DC Plate Voltage	3000	volts
Max-Signal DC Plate Current	225	ma.
Plate Dissipation	75	watts
Grid Dissipation	13	watts

Typical Operation (Sinusoidal wave, two tubes unless otherwise specified)

DC Plate Voltage	1000	1500	2000	volts
DC Grid Voltage ¹	-70	-130	-190	volts
Peak AF Grid Input Voltage (per tube)	215	250	300	volts
Zero-Signal DC Plate Current	100	67	50	ma.
Max-Signal DC Plate Current	350	285	250	ma.
Max-Signal Avg. Driving Power (approx.)	7	6	5	watts
Max-Signal Peak Driving Power	26	23	19	watts
Effective Load, Plate-to-Plate	5300	11,000	18,000	ohms
Max-Signal Plate Power Output	200	280	350	watts
Max-Signal Plate Dissipation (per tube)	75	75	75	watts
Total Harmonic Distortion	2.0	4.5	6.0	per cent

¹ Adjust to give stated zero-signal plate current. The effective grid-circuit resistance for each tube must not exceed 250,000 ohms in class-AB₁ operation

APPLICATION

MECHANICAL

Mounting—The 75TL must be mounted vertically, base down or up. The plate and grid leads should be flexible. The tube must be protected from vibration and shock.

Cooling—Heat Dissipating Connectors (EIMAC HR-3 and HR-2) should be used at the plate and grid terminals of the 75TL. If the free circulation of air around the tube is restricted, a small fan or centrifugal blower should be used to provide additional cooling for the plate and grid seals.

Cooling requirements will be met if the temperature of the plate and grid seals is not allowed to exceed 225°C. One method of measuring these temperatures is provided by the use of "Tempilaq," a temperature-sensitive lacquer available from the Tempil Corporation, New York 11, N.Y.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the base pins, should be the rated value of 5.0 volts. Variations must be kept within the range of 4.75 to 5.25 volts.

Bias Voltage—Although there is no maximum limit on the bias voltage which may be used on the 75TL, there is little advantage in using bias voltages in excess of those given under "Typical Operation," except in certain very specialized applications. Where bias is obtained by a grid leak, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage—The plate-supply voltage for the 75TL should not exceed 3000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "Typical Operation" for the power output desired.

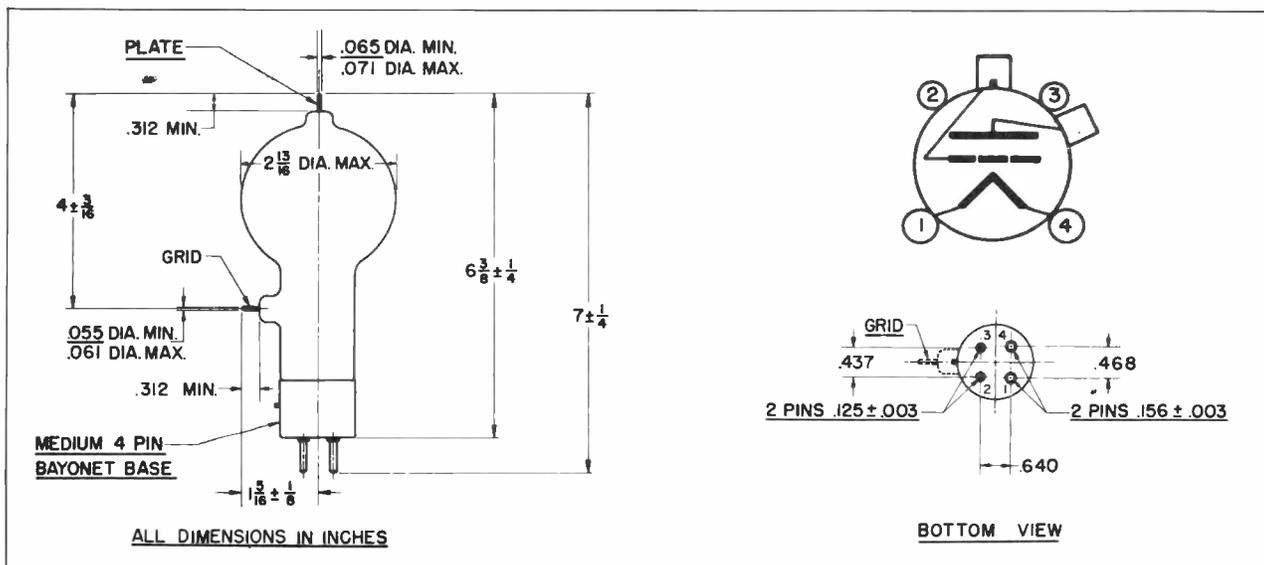
Grid Dissipation—The power dissipated by the grid of the 75TL must not exceed 13 watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} I_c$$

where P_g = Grid dissipation,
 e_{cmp} = Peak positive grid voltage, and
 I_c = DC grid current.

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid. In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.

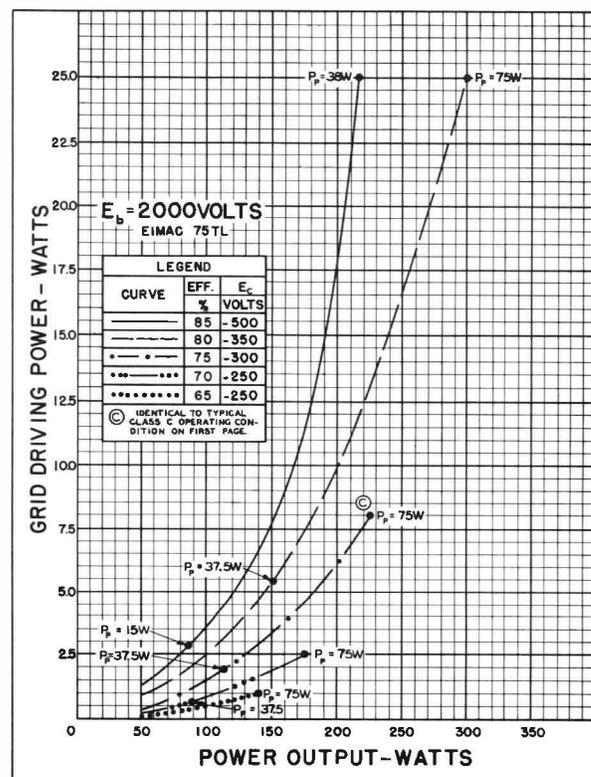
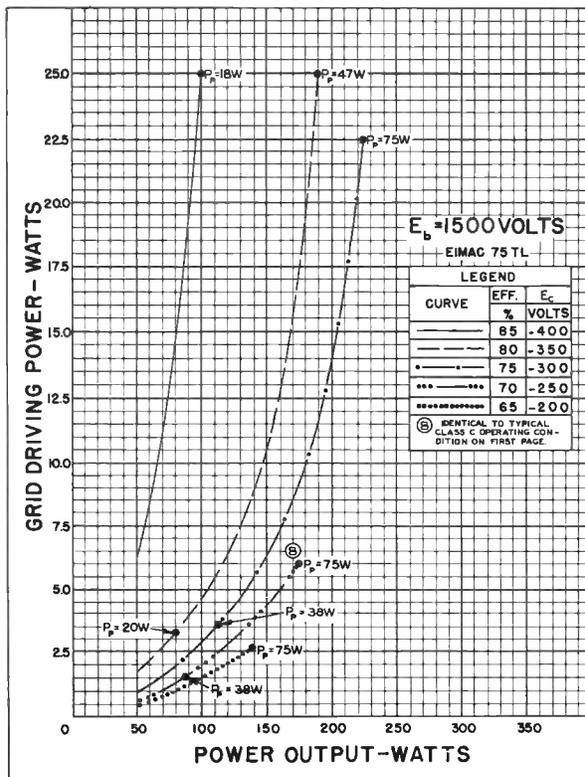
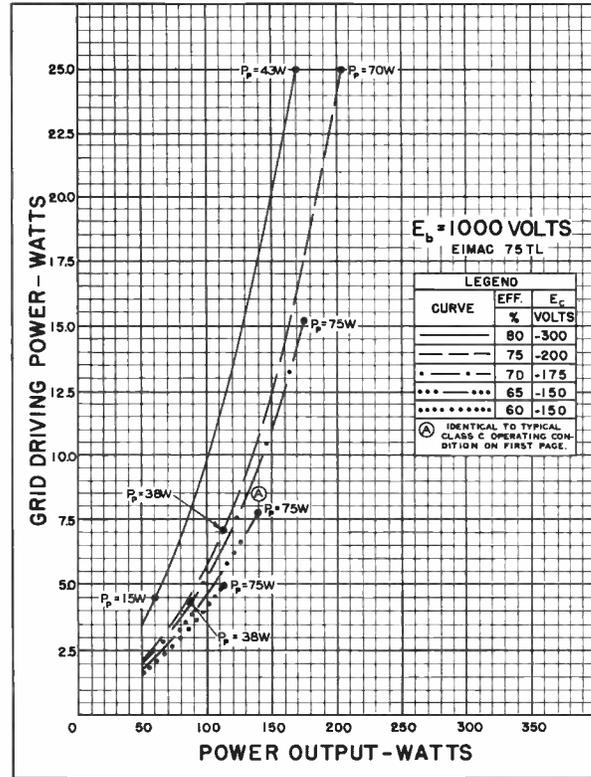
Plate Dissipation—The plate of the 75TL operates at a visibly red temperature at its maximum rated dissipation of 75 watts. Plate dissipation in excess of the maximum rating is permissible only for short periods of time, such as during tuning procedures.



DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and grid driving power at plate voltages of 1000, 1500 and 2000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 1000, 1500, and 2000 volts respectively.

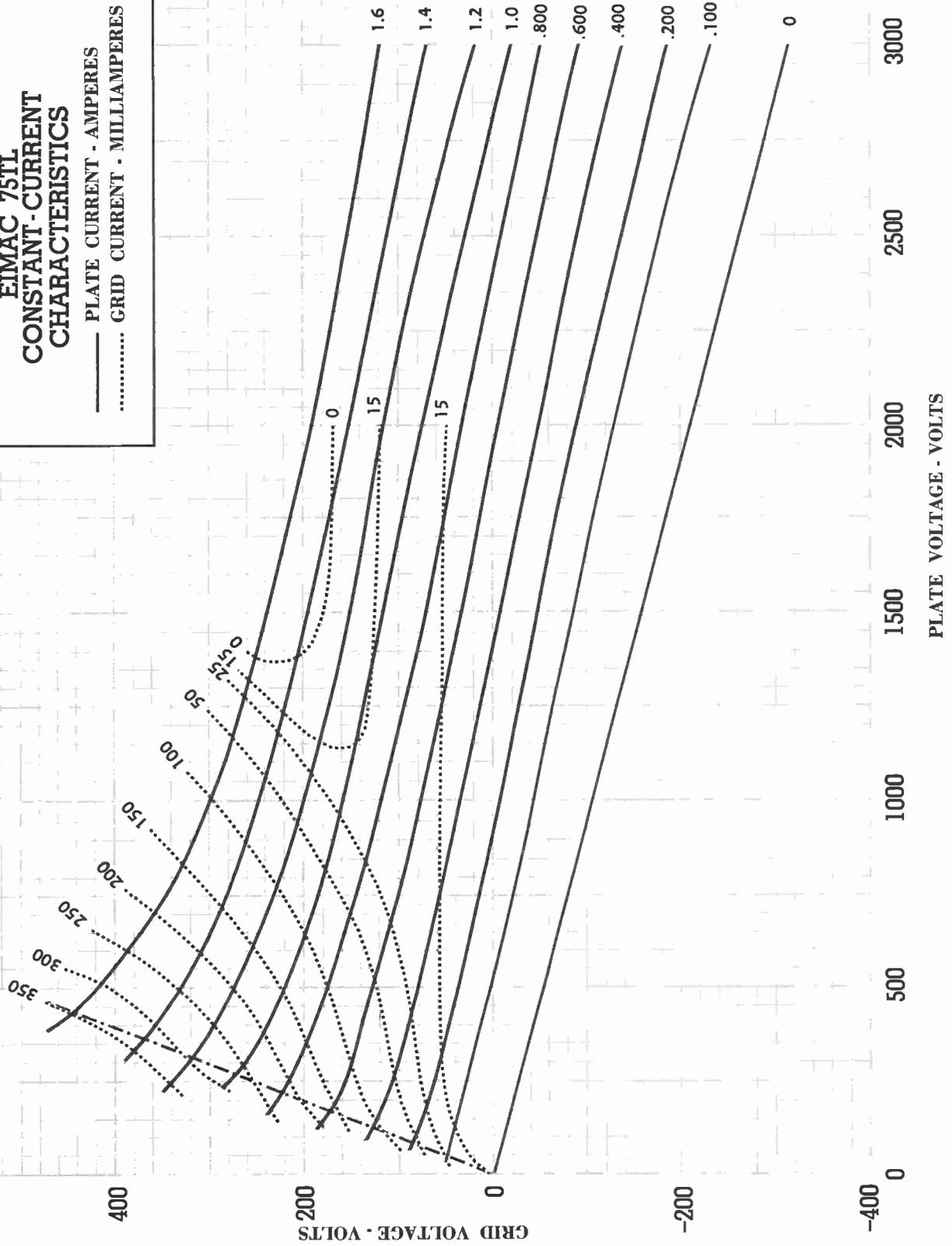




75TL

EIMAC 75TL CONSTANT-CURRENT CHARACTERISTICS

— PLATE CURRENT - AMPERES
..... GRID CURRENT - MILLIAMPERES





APPLICATION

MECHANICAL

Mounting—The 152TH must be mounted vertically, base down or up. The plate and grid leads should be flexible, and the tube must be protected from vibration and shock.

Cooling—Heat Dissipating Connectors (Eimac HR-5 and HR-6 or equivalent) must be used at the plate and grid terminals of the 152TH. Forced-air cooling is not required in properly designed equipment operating at frequencies below 40 Mc. If the free circulation of air around the tube is restricted, a small fan or centrifugal blower should be used to provide additional cooling.

The temperature of the plate and grid seals must not be allowed to exceed 225° C. One method of measuring these temperatures is by the use of "Tempilaq," a temperature-sensitive lacquer manufactured by the Tempil Corporation, 132-34 West 22nd St., New York 11, N. Y.

ELECTRICAL

Filament Voltage—The filaments of the 152TH may be operated either at 10.0 volts when connected in series or at 5.0 volts when connected in parallel (see basing diagram). For maximum tube life the filament voltage should be maintained at the rated value. Variations must not be allowed to exceed $\pm 5\%$.

Bias Voltage—When grid-leak bias is used, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation, and the grid-leak resistor should be made adjustable to facilitate maintaining the bias voltage and plate current at the desired value from tube to tube.

Grid Dissipation—The power dissipated by the grid of the 152TH must not exceed 30 watts. Grid dissipation may be calculated from the following expression.

$$P_g = e_{\text{cmp}} I_c$$

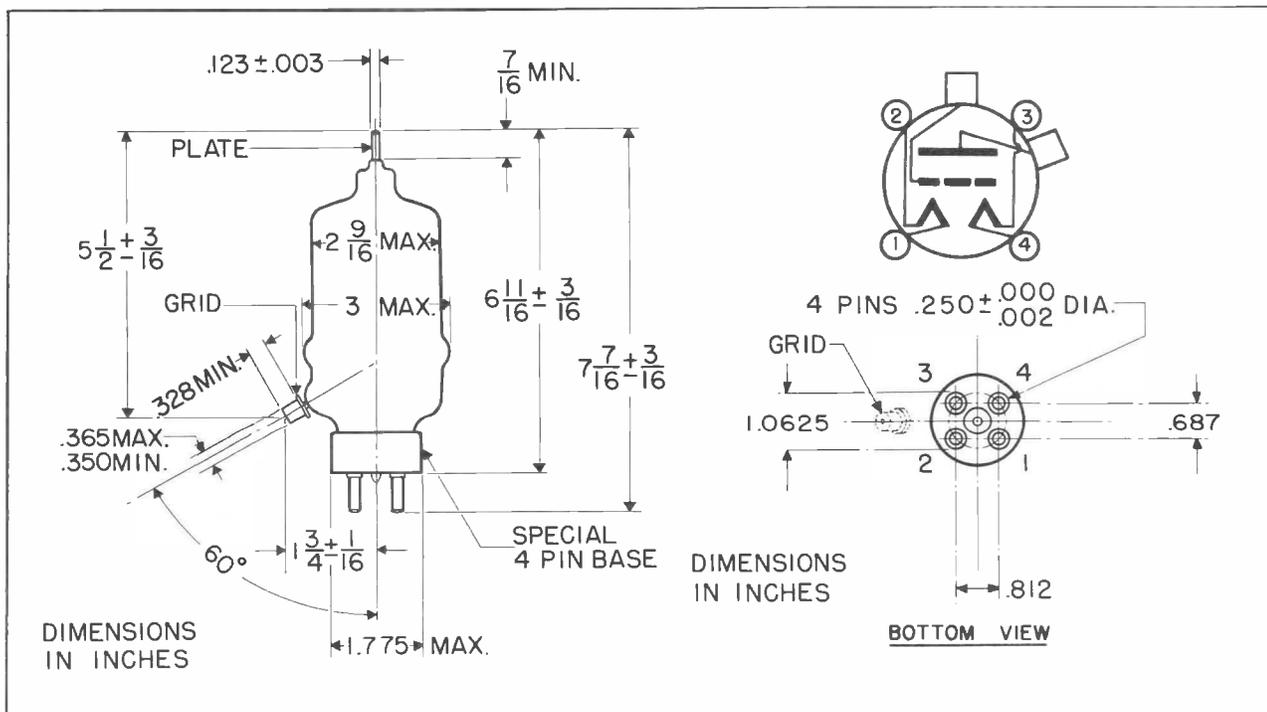
where P_g = grid dissipation,

e_{cmp} = peak positive grid voltage, and

I_c = d-c grid current

e_{cmp} may be measured by means of a suitable peak-reading voltmeter connected between filament and grid. In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.

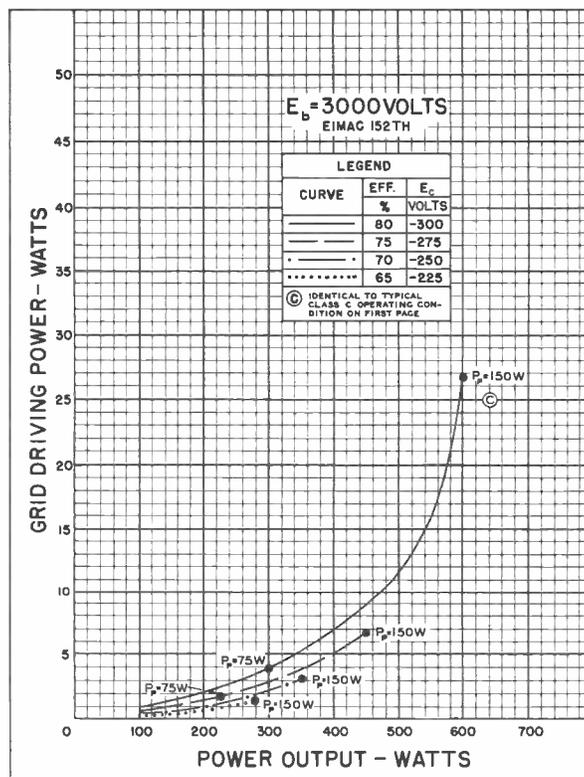
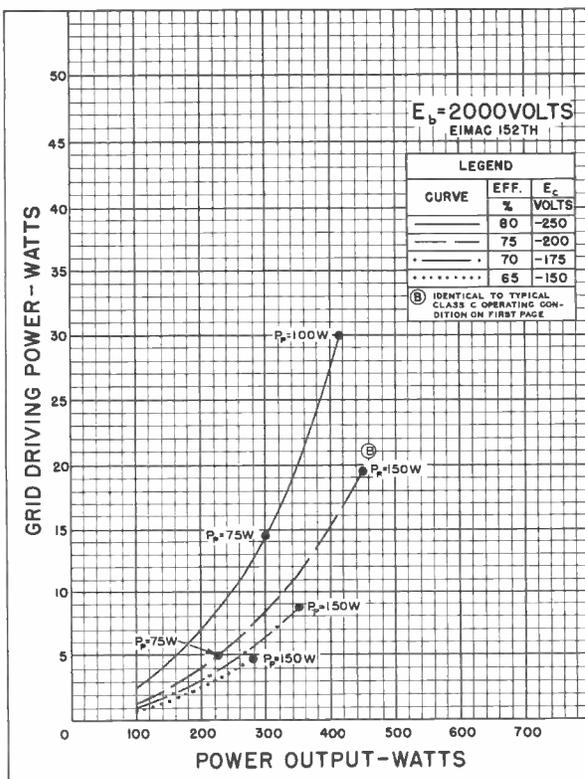
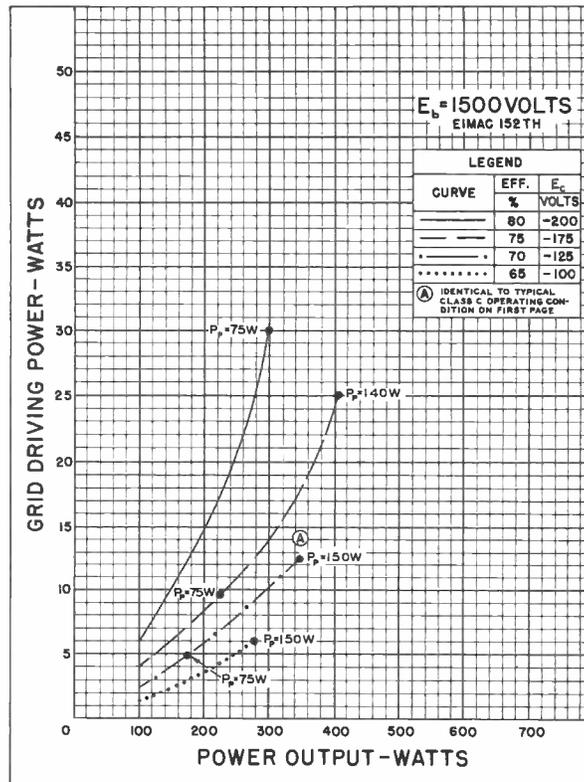
Plate Dissipation—The plates of the 152TH operate at a visible red color at the maximum rated dissipation of 150 watts. Plate dissipation in excess of the maximum rating is permissible only for short periods of time, such as during tuning procedures.



DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and grid driving power at plate voltages of 1500, 2000 and 3000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 1500, 2000, and 3000 volts respectively.

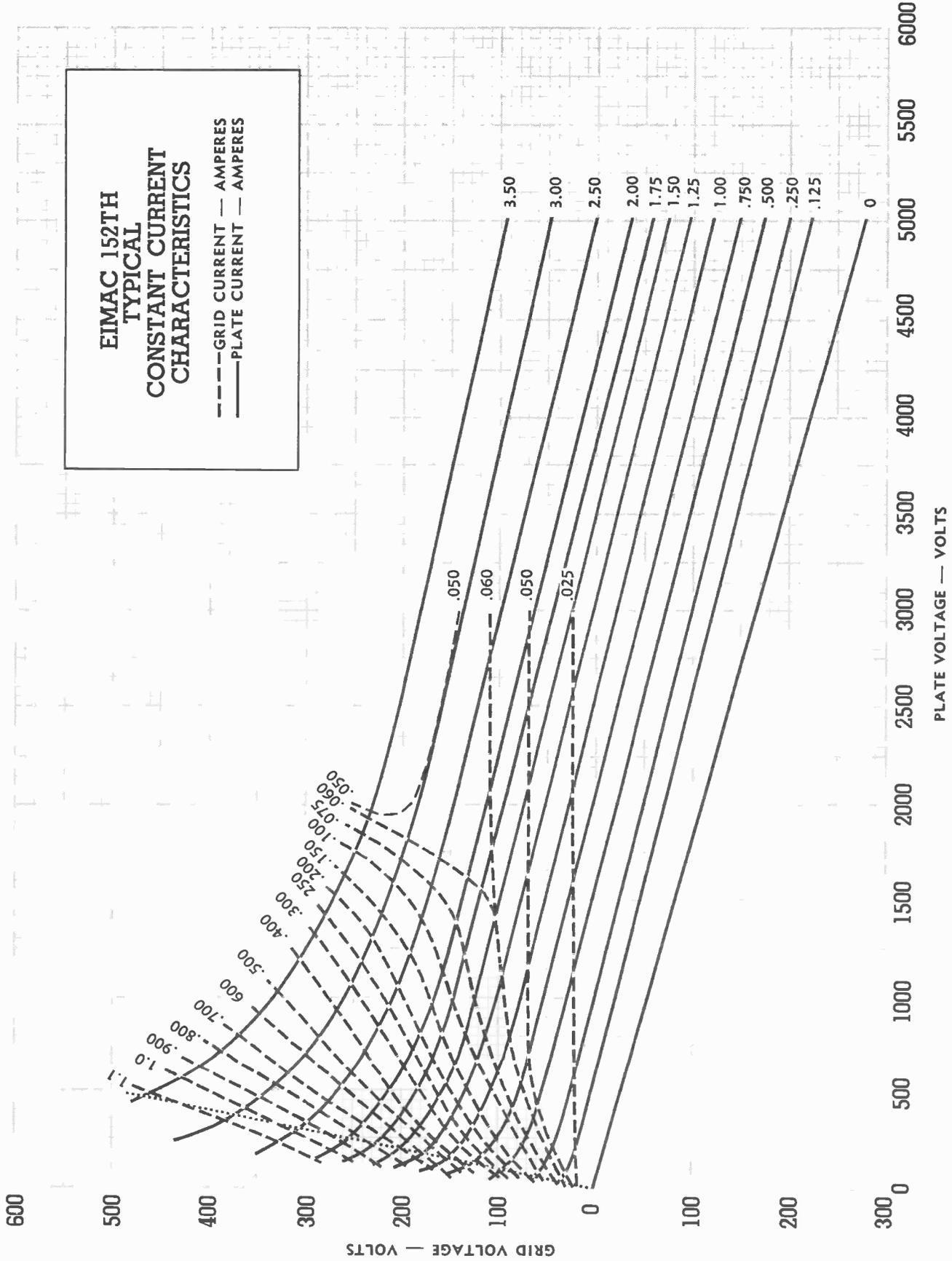




152TH

EIMAC 152TH TYPICAL CONSTANT CURRENT CHARACTERISTICS

--- GRID CURRENT — AMPERES
— PLATE CURRENT — AMPERES





E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

152TL
 LOW-MU TRIODE
 •
 MODULATOR
 OSCILLATOR
 AMPLIFIER

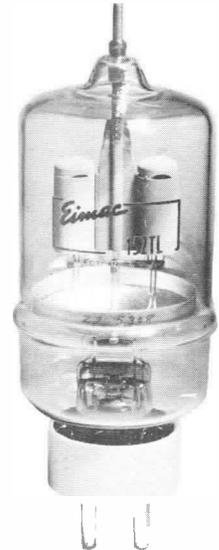
GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 or 10.0 volts
Current	12.5 or 6.25 amperes
Amplification Factor (Average)	12
Direct Interelectrode Capacitances (Average)	
Grid-Plate	4.4 pF
Grid-Filament	4.5 pF
Plate-Filament	0.7 pF
Transconductance ($i_p = 500$ ma., $E_b = 3000V$, $E_c = -85V$)	7150 umhos

MECHANICAL

Base	Special 4 pin, No. 5000B
Basing	RMA type 4BC
Maximum Overall Dimensions	
Length	7.625 inches
Diameter	2.563 inches
Net Weight	7 ounces
Shipping weight (Average)	2.0 pounds



AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class B

	ZERO GRID CURRENT OPERATION - 2 TUBES			TYPICAL OPERATION 2 TUBES			MAX. RATING
	1500	2000	3000	1500	2000	3000	
DC Plate Voltage	1500	2000	3000	1500	2000	3000	3000 volts
Max.-Signal DC Plate Current, per tube*	—	—	—	—	—	—	450 ma.
Plate Dissipation, per tube*	—	—	—	—	—	—	150 watts
DC Grid Voltage (approx.)	-105	-160	-260	-105	-160	-260	volts
Peak AF Grid Input Voltage	210	320	520	500	620	675	volts
Zero-Signal DC Plate Current	135	100	65	135	100	65	ma.
Max.-Signal DC Plate Current	286	260	220	570	500	335	ma.
Max.-Signal Driving Power (approx.)	—	—	—	15	13	3	watts
Effective Load, Plate-to-Plate	5100	10500	24000	5500	9000	20400	ohms
Max.-Signal Plate Power Output	130	220	370	560	700	700	watts

*Averaged over any sinusoidal audio frequency cycle.

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class C *Telegraphy

(Key down conditions without modulation)

	TYPICAL OPERATION - 1 TUBE			MAX. RATING
	1500	2000	3000	
DC Plate Voltage	1500	2000	3000	3000 volts
DC Plate Current	333	300	250	450 ma.
DC Grid Current	45	42	40	75 ma.
DC Grid Voltage	-250	-300	-400	volts
Plate Power Output	350	450	600	watts
Plate Input	500	600	750	watts
Plate Dissipation	150	150	150	150 watts
Peak RF Grid Input Voltage (approx.)	400	455	550	volts
Driving Power (approx.)	16	18	20	watts

*The above figures show actual measured tube performance, and do not allow for variations in circuit losses.



152TL

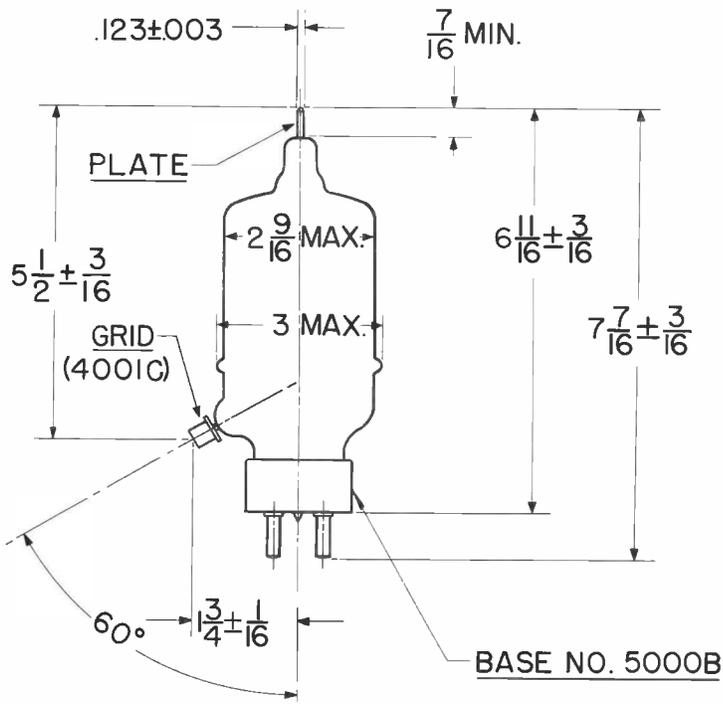
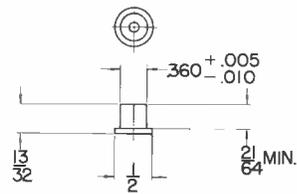
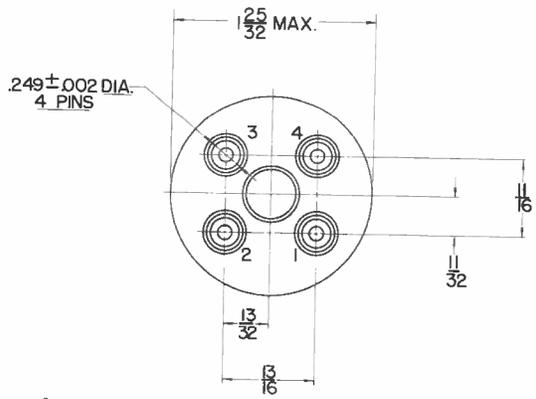
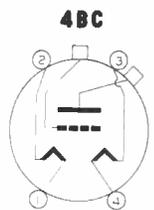
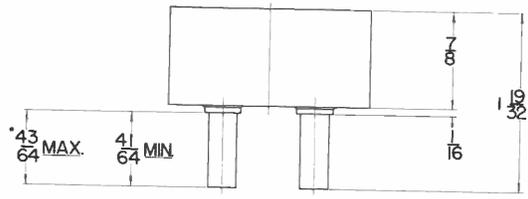
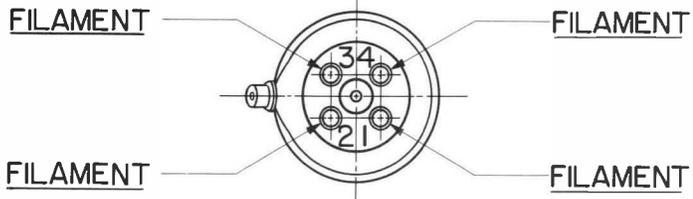


PLATE CAP
(SEE TUBE OUTLINE DRAWING)

GRID CAP
NO. 4001C



BASE NO. 5000B

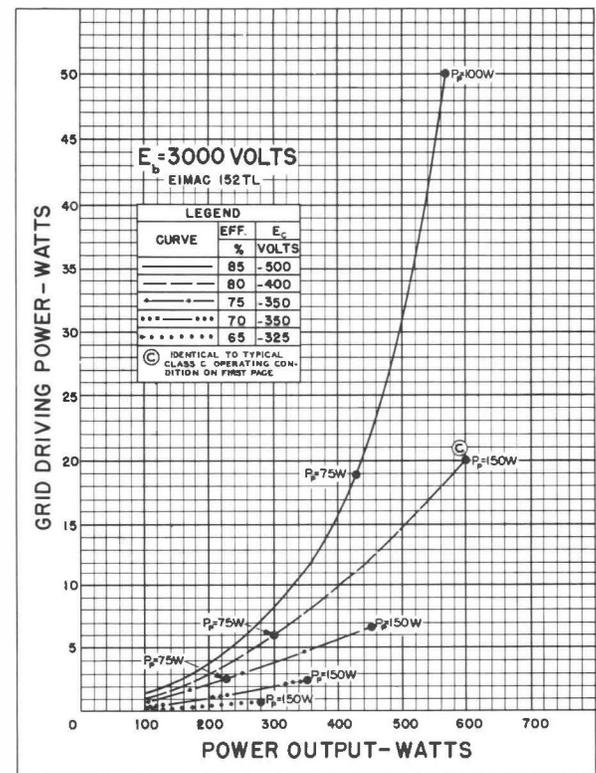
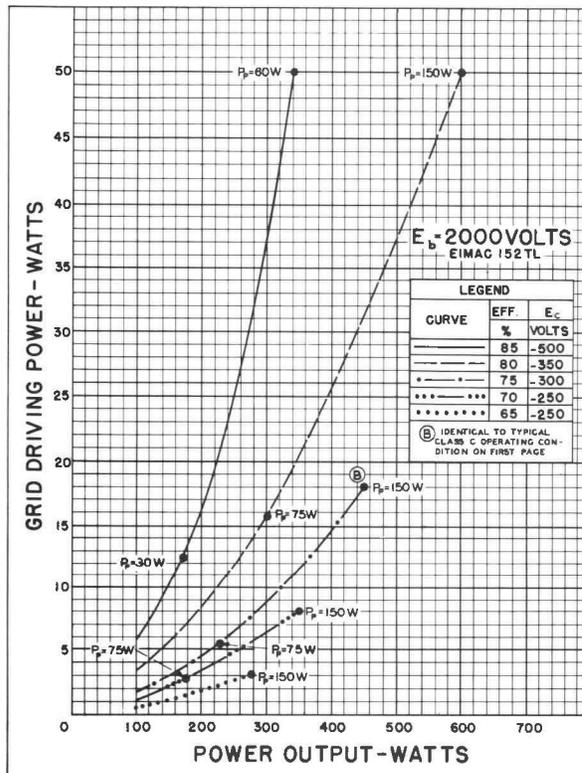
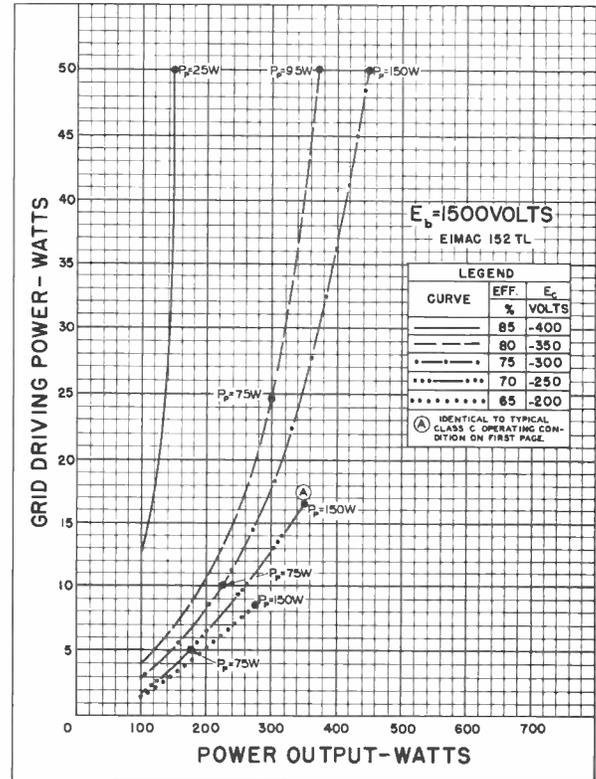


*ON FINISHED TUBE ADD .060 FOR SOLDER

DRIVING POWER vs. POWER OUTPUT

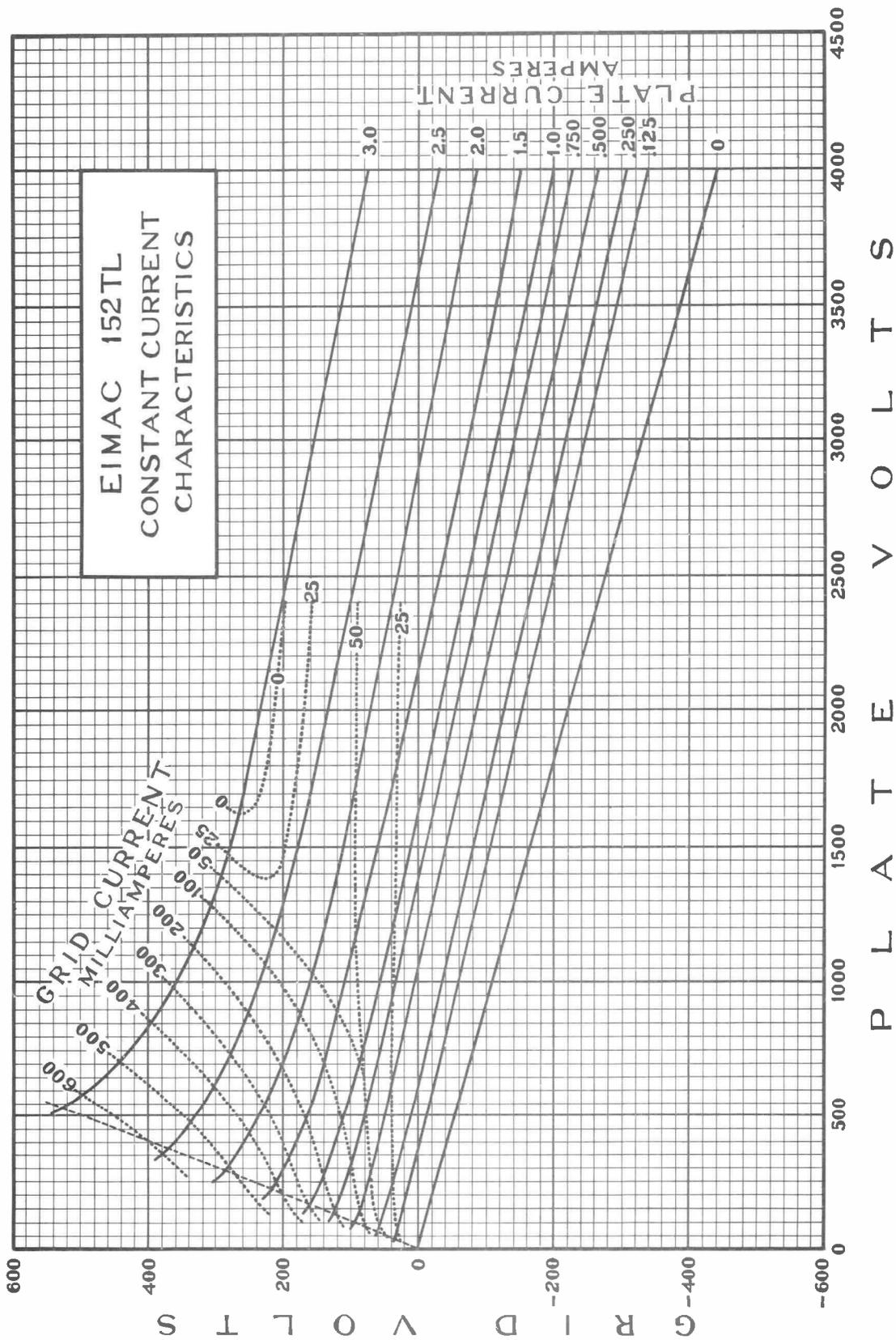
The three charts on this page show the relationship of plate efficiency, power output and grid driving power at plate voltages of 1500, 2000 and 3000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 1500, 2000, and 3000 volts respectively.





152TL





EIMAC

A Division of Varian Associates
SAN CARLOS, CALIFORNIA

750TL
MEDIUM-MU TRIODE

•
**MODULATOR
OSCILLATOR
AMPLIFIER**

The Eimac 750TL is a medium-mu power triode intended for use as an amplifier, oscillator, or modulator. It has a maximum plate dissipation rating of 750 watts and a maximum plate voltage rating of 10,000 volts at frequencies up to 40 Mc. The 750TL is cooled by air-circulation and radiation.

The 750TL in class-C r-f service will deliver up to 3000 watts plate power output with 125 watts driving power. Two 750TL's in class-AB₂ modulator service will deliver up to 3500 watts maximum-signal plate power output with 46 watts driving power.

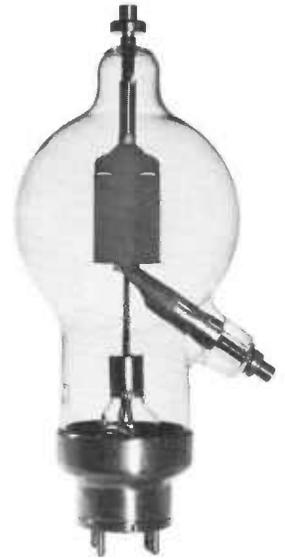
GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten	Min.	Nom.	Max.	
Voltage	-	7.5	-	volts
Current	-	20.0	22.7	amperes
Amplification Factor	-	14.5	16.5	
Direct Interelectrode Capacitances:				
Grid-Plate	-	5.0	7.0	μf
Grid-Filament	-	7.0	10.0	μf
Plate-Filament	-	0.9	1.5	μf
Transconductance (I _b =250 ma., E _b =5000 v.)	-	3500	-	μmhos
Frequency for Maximum Ratings	-	-	40	mc

MECHANICAL

Base	-	-	-	-	Special 4-pin
Connections	-	-	-	-	See outline drawing
Socket	-	-	-	-	Johnson type No. 124-214 or equivalent
Mounting Position	-	-	-	-	Vertical, base down or up
Cooling	-	-	-	-	Air-circulation and radiation
Recommended Plate and Grid Heat-Dissipating Connectors	-	-	-	-	Eimac HR-8
Maximum Overall Dimensions:					
Length	-	-	-	-	17.0 inches
Diameter	-	-	-	-	7.13 inches
Net Weight (Average)	-	-	-	-	2.9 pounds
Shipping Weight (Average)	-	-	-	-	13 pounds



AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

Class-AB₂ (Sinusoidal wave)

MAXIMUM RATINGS (Per tube)

D-C PLATE VOLTAGE	-	-	-	10,000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	1000 MAX. MA
PLATE DISSIPATION	-	-	-	750 MAX. WATTS
GRID DISSIPATION	-	-	-	100 MAX. WATTS

TYPICAL OPERATION (Two tubes unless otherwise specified)

D-C Plate Voltage	-	-	-	4000	5000	6000	volts
D-C Grid Voltage ¹	-	-	-	-230	-320	-390	volts
Zero-Signal D-C Plate Current	-	-	-	250	200	166	ma
Max-Signal D-C Plate Current	-	-	-	950	860	834	ma
Effective Load, Plate-to-Plate	-	-	-	8270	12,300	16,300	ohms
Peak A-F Grid Voltage (per tube)	-	-	-	490	560	650	volts
Max-Signal Driving Power*	-	-	-	38	28	46	watts
Max-Signal Plate Power Input	-	-	-	3800	4300	5000	watts
Max-Signal Plate Power Output	-	-	-	2300	2800	3500	watts

¹Adjust to stated zero-signal plate current.

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony (Key-down conditions, per tube)

MAXIMUM RATINGS (Frequencies up to 40 Mc.)

D-C PLATE VOLTAGE	-	-	-	10,000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	1000 MAX. MA
PLATE DISSIPATION	-	-	-	750 MAX. WATTS
GRID DISSIPATION	-	-	-	100 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 40 Mc.)

D-C Plate Voltage	-	-	-	3000	4000	5000	6000	volts
D-C Grid Voltage	-	-	-	-350	-450	-550	-700	volts
D-C Plate Current	-	-	-	713	625	600	625	ma
D-C Grid Current*	-	-	-	120	90	90	105	ma
Peak R-F Grid Voltage	-	-	-	805	885	985	1040	volts
Driving Power*	-	-	-	97	83	86	125	watts
Grid Dissipation*	-	-	-	55	40	38	50	watts
Plate Power Input	-	-	-	2140	2500	3000	3750	watts
Plate Power Output	-	-	-	1390	1750	2250	3000	watts

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

CLASS-C TELEPHONY (Carrier conditions, per tube)

MAXIMUM RATINGS (Frequencies up to 40 Mc.)

D-C PLATE VOLTAGE	-	-	-	8000 MAX. VOLTS
D-C PLATE CURRENT	-	-	-	800 MAX. MA
PLATE DISSIPATION	-	-	-	500 MAX. WATTS
GRID DISSIPATION	-	-	-	100 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 40 Mc.)

D-C Plate Voltage	-	-	-	3000	4000	5000	6000	volts
D-C Grid Voltage	-	-	-	-500	-650	-800	-950	volts
D-C Plate Current	-	-	-	415	400	400	415	ma
D-C Grid Current*	-	-	-	55	60	55	60	ma
Peak R-F Grid Voltage	-	-	-	830	985	1150	1330	volts
Driving Power*	-	-	-	45	50	60	75	watts
Grid Dissipation*	-	-	-	15	15	16	20	watts
Plate Power Input	-	-	-	1250	1600	2000	2500	watts
Plate Power Output	-	-	-	750	1100	1500	2000	watts

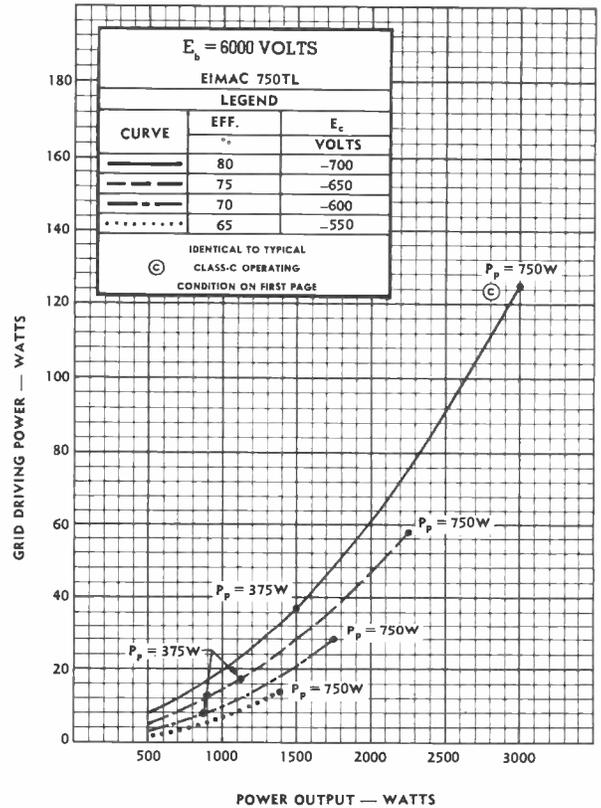
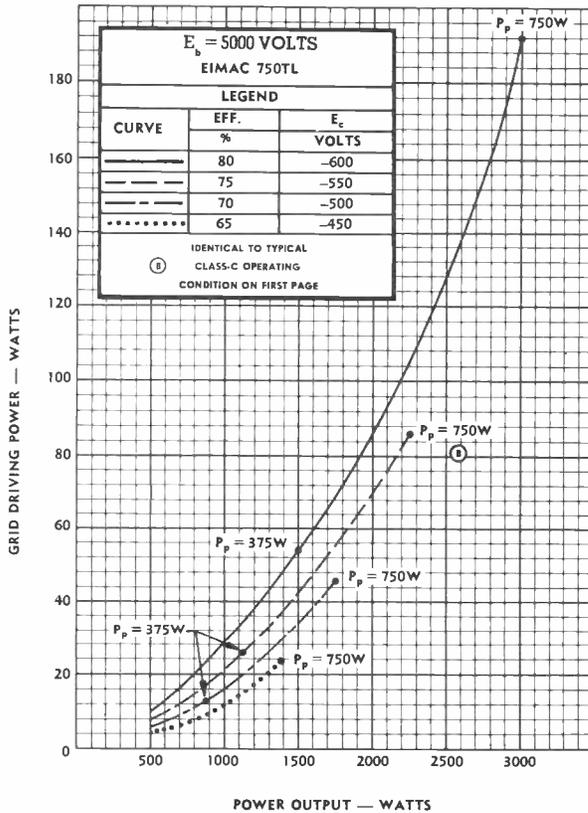
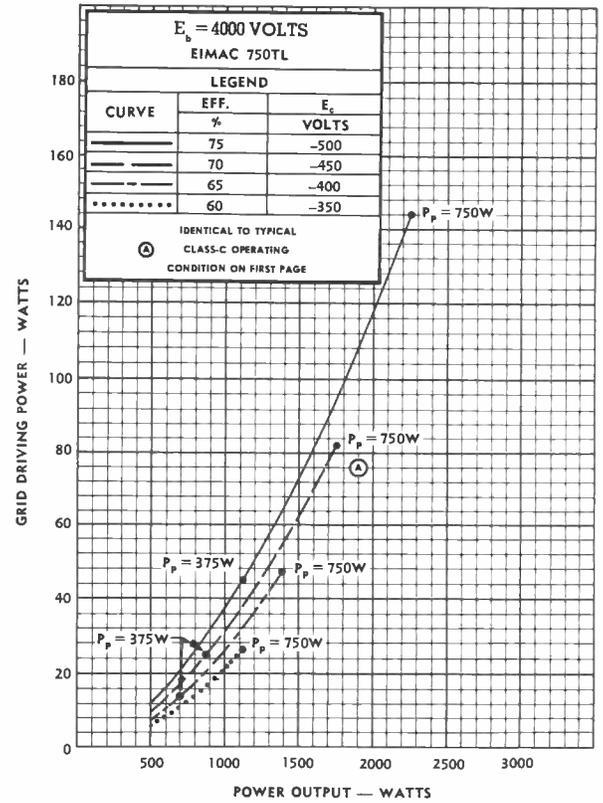
*Approximate values

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION" POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EIMAC DIVISION OF VARIAN ASSOCIATES, FOR INFORMATION AND RECOMMENDATIONS



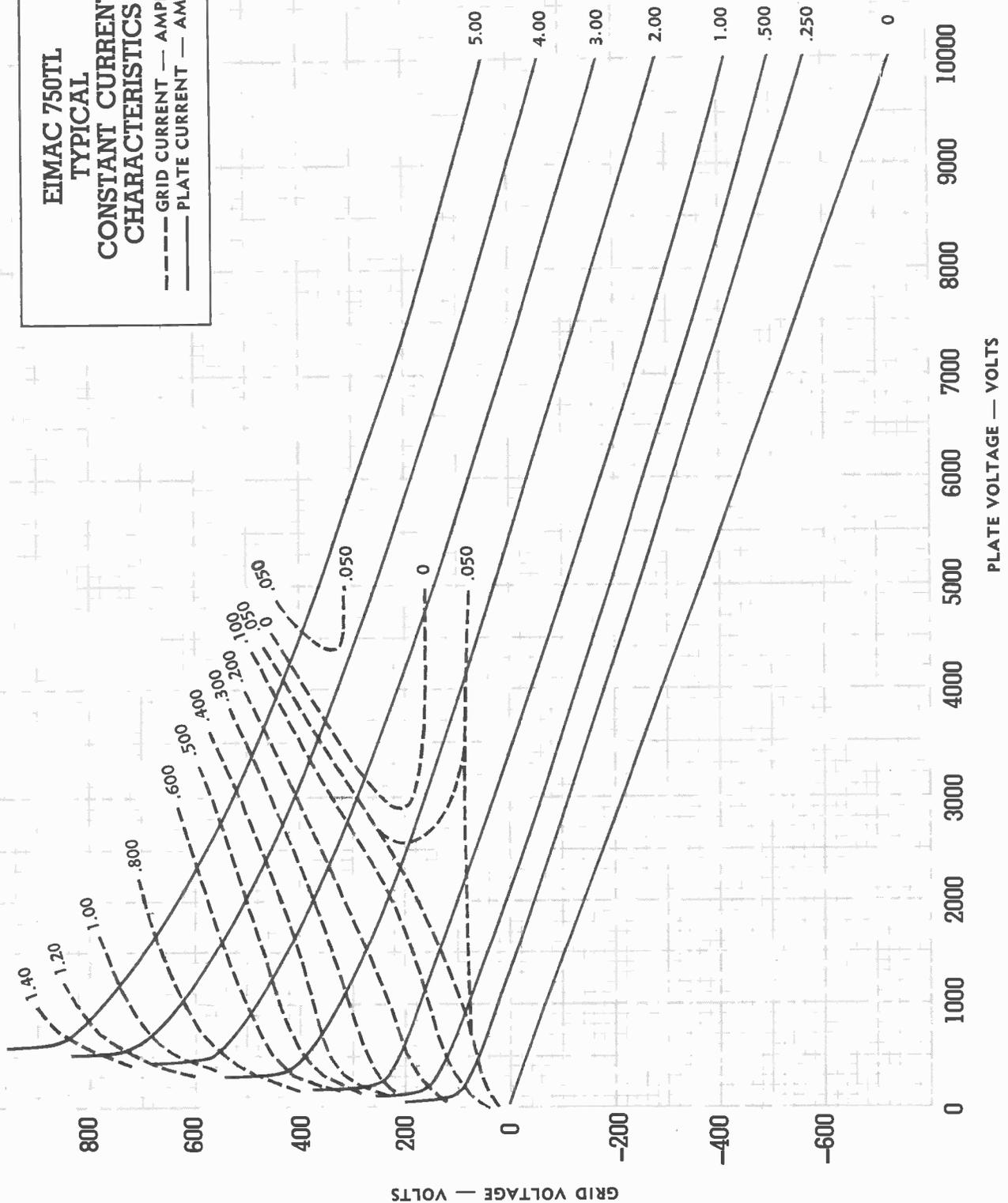
DRIVING POWER vs. POWER OUTPUT

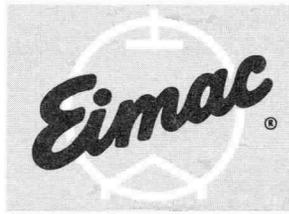
The three charts on this page show the relationship of plate efficiency, power output and approximate grid driving power at plate voltages of 4000, 5000 and 6000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p . Points A, B and C are identical to the typical Class-C operating conditions shown on the first page under 4000, 5000 and 6000 volts, respectively.



**EIMAC 750TL
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS**

--- GRID CURRENT — AMPERES
— PLATE CURRENT — AMPERES





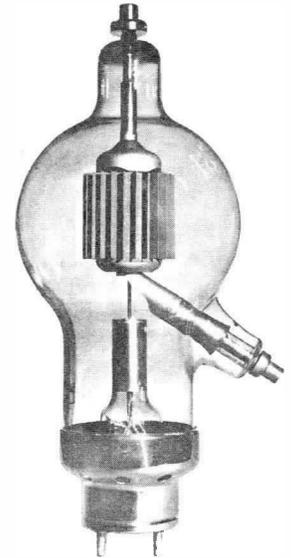
E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

1500T

**MEDIUM-MU
 TRIODE**

The EIMAC 1500T is a medium-mu power triode intended for use as an amplifier, oscillator or modulator. It has a maximum plate-dissipation rating of 1500 watts and a maximum plate voltage rating of 8000 volts at frequencies up to 40 MHz.

The 1500T in Class-C rf service will deliver up to 4500 watts plate power output with 85 watts driving power. Two 1500T's in Class-B modulator service will deliver up to 7000 watts maximum-signal plate output with 115 watts nominal driving power.



GENERAL CHARACTERISTICS¹

ELECTRICAL

Filament: Thoriated Tungsten

Voltage 7.5 ± 0.375 V

Current, at 7.5 volts 24.0 A

Transconductance (Average):

$I_b = 1.25A, E_b = 6000$ volts 10,000 μ mhos

Amplification Factor (Average): 24

Direct Interelectrode Capacitances (grounded filament)²

Grid-Plate 7.2 pF

Grid-Filament 9.9 pF

Plate-Filament 1.5 pF

Frequency of Maximum Rating:

CW 40 MHz

1. Characteristics and operating values are based upon performance tests. These figures may change without notice as the result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.
2. In Shielded Fixture.

MECHANICAL

Maximum Overall Dimensions:

Length 17.000 in; 431.80 mm

Diameter 7.125 in; 180.98 mm

Net Weight 36 oz; 1020 gm

Operating Position Vertical, base up or down

Maximum Operating Temperature:

Plate and Base Seals 225°C

Cooling Radiation and forced air

Base Special 4-pin

Recommended Socket Johnson 124-214 or equivalent

Recommended Heat-Dissipating Connectors:

Plate HR-8

Grid HR-8



RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR Class C Telephony or FM Telephony (Key-Down Conditions)

ABSOLUTE MAXIMUM RATINGS

DC PLATE VOLTAGE	8000	VOLTS
DC PLATE CURRENT	1.25	AMPERE
PLATE DISSIPATION	1500	WATTS
GRID DISSIPATION	125	WATTS

TYPICAL OPERATION (Frequencies to 40 MHz)

Plate Voltage	5000	6000	7000	Vdc
Grid Voltage	-375	-600	-500	Vdc
Plate Current	1.00	1.00	0.86	Adc
Grid Current	150	165	110	mAdc
Grid Dissipation ¹	59	61	30	W
Peak rf Grid Voltage ¹	850	1100	885	v
Calculated Driving Power ¹	115	160	85	W
Plate Input Power	5000	6000	6000	W
Plate Dissipation	1500	1500	1500	W
Plate Output Power	3500	4500	4500	W

1. Approximate value.

PLATE MODULATED RADIO FREQUENCY POWER AMPLIFIER GRID DRIVEN Class C Telephony (Carrier Conditions)

ABSOLUTE MAXIMUM RATINGS

DC PLATE VOLTAGE	6500	VOLTS
DC PLATE CURRENT	1.0	AMPERE
PLATE DISSIPATION ¹	1000	WATTS
GRID DISSIPATION ²	125	WATTS

1. Corresponds to 1500 watts at 100% sine-wave modulation.
2. Average, with or without modulation.

TYPICAL OPERATION (Frequencies to 40 MHz)

Plate Voltage	4000	5000	6000	Vdc
Grid Voltage	-450	-550	-650	Vdc
Plate Current	0.75	0.70	0.66	Adc
Grid Current	85	75	70	mAdc
Grid Dissipation ¹	30	26	25	W
Peak rf Grid Voltage ¹	860	950	1050	v
Calculated Driving Power ¹	68	67	70	W
Plate Input Power	3000	3500	4000	W
Plate Dissipation	1000	1000	1000	W
Plate Output Power	2000	2500	3000	W

1. Approximate value.

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR Class B, Grid Driven (Sinusoidal Wave)

ABSOLUTE MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE	8000	VOLTS
DC PLATE CURRENT	1.25	AMPERE
PLATE DISSIPATION	1500	WATTS
GRID DISSIPATION	125	WATTS

Zero-Signal Plate Current	0.50	0.40	0.33	Adc
Max. Signal Plate Current	1.88	1.72	1.65	Adc
Peak af Grid Voltage ²	485	535	570	v
Peak Driving Power ³	190	210	230	w
Max. Signal Plate Dissipation	1500	1500	1450	W
Plate Output Power	4500	5600	7000	W
Load Resistance (plate to plate)	4150	6150	8200	Ω

TYPICAL OPERATION (Two Tubes)

Plate Voltage	4000	5000	6000	Vdc
Grid Voltage ^{1/4}	-95	-145	-190	Vdc

1. Approximate value.
2. Per tube.
3. Nominal drive power is one-half peak power.
4. Adjust to give stated zero-signal plate current.

NOTE: TYPICAL OPERATION data are obtained by measurement or calculation from published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid current. The grid current which results when the desired plate current is obtained is incidental and varies from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf grid voltage is applied.



RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.
Filament: Current at 7.5 volts	22.0	25.0 A
Interelectrode Capacitances ¹ (grounded filament connection)		
Grid-Plate	5.5	9.0 pF
Grid-Filament	7.5	12.5 pF
Plate-Filament	---	2.0 pF

APPLICATION

MECHANICAL

MOUNTING - The 1500T must be mounted vertically, base up or base down. Flexible leads should be provided between the grid and plate terminals and the external grid and plate circuits. The tube must be protected from vibration and shock.

COOLING - Forced-air cooling is required on the envelope and also in the base of the tube. Envelope cooling may be accomplished by locating an 8- or 10-inch fan about one foot from the tube and directing the air at the middle of the envelope.

Base cooling requires an air flow of 2½ cu. ft. per min. directed up through the bottom of the base toward the filament press. The base of the tube is provided with a 1-inch diameter hole for this purpose. If a socket is used with a 1-inch diameter matching hole and the manifold is of the same diameter, a static pressure of less than 0.1 inch of water is required at the manifold to provide the 2½ cu. ft. per min.

One type of socket provides a ¼ inch diameter pipe for the air inlet to the base. With this type of socket a static pressure of 5½ inches of water is required at the pipe to obtain the necessary 2½ cu. ft. per min. volume.

Suitable electrical interlocks should be provided to remove the plate and filament voltages in the event that the supply of cooling air is interrupted.

ELECTRICAL

FILAMENT VOLTAGE - The filament voltage, as measured directly at the filament pins, should be between 7.125 and 7.875 volts. All four socket terminals should be used by employing two for

each connection to filament supply. See base diagram and outline drawing.

BIAS VOLTAGE - There is little advantage in using bias voltages in excess of those given under Typical Operation, except in certain very specialized applications. Where bias is obtained by a grid bias resistor, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation. The grid bias resistor should be adjustable to facilitate maintaining the bias voltage and plate current at the desired values from tube to tube.

GRID DISSIPATION - The power dissipated by the grid of the 1500T must not exceed 125 watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} \times I_c$$

where: P_g = Grid dissipation

e_{cmp} = Peak positive grid voltage, and

I_c = dc grid current

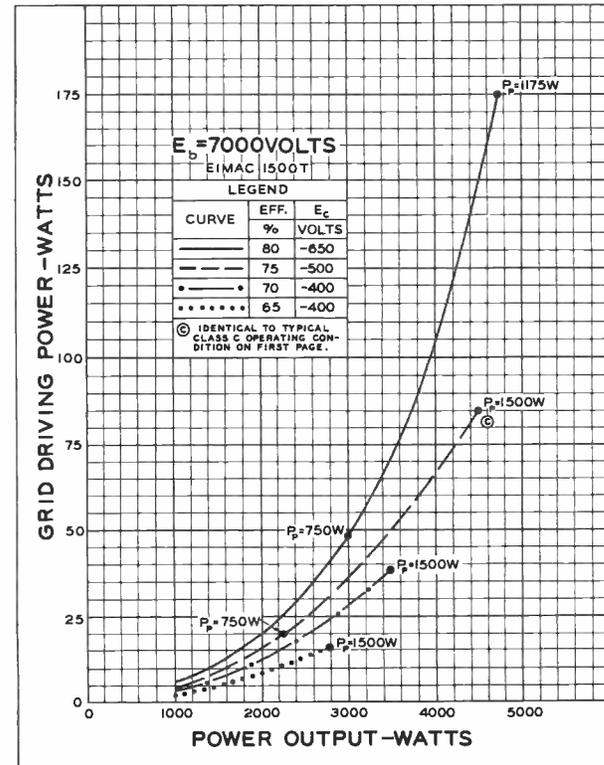
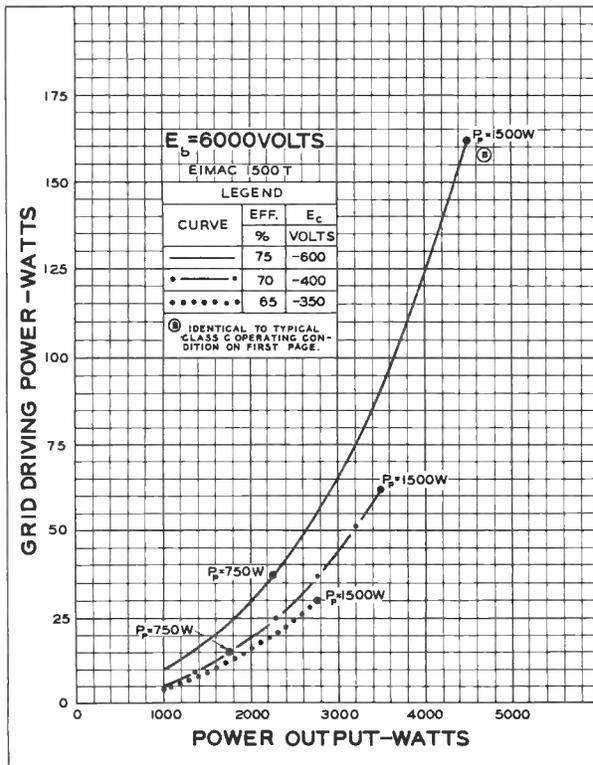
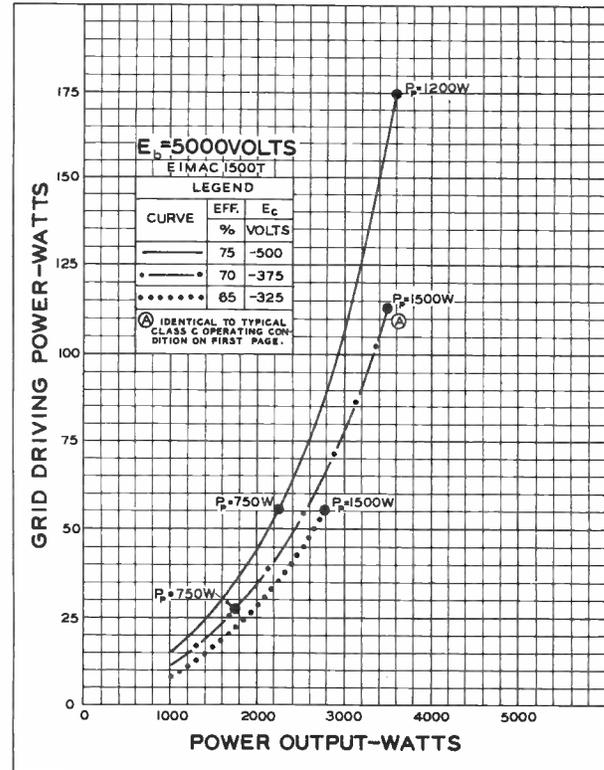
e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid. In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.

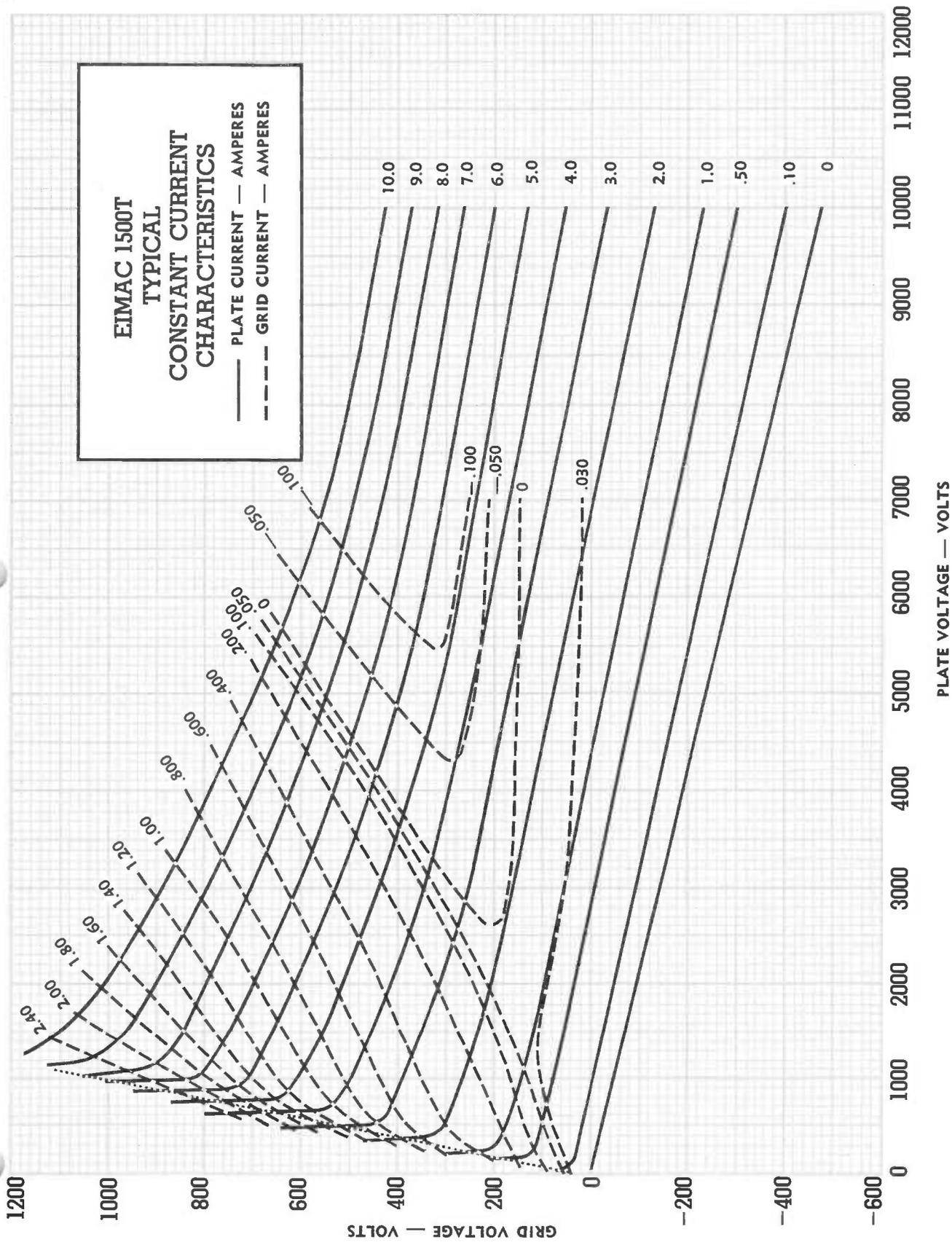
PLATE DISSIPATION - The plate is a red-orange color when dissipating 1500 watts. Under normal operating conditions the power dissipated by the plate of the 1500T should not be allowed to exceed the maximum rating. Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

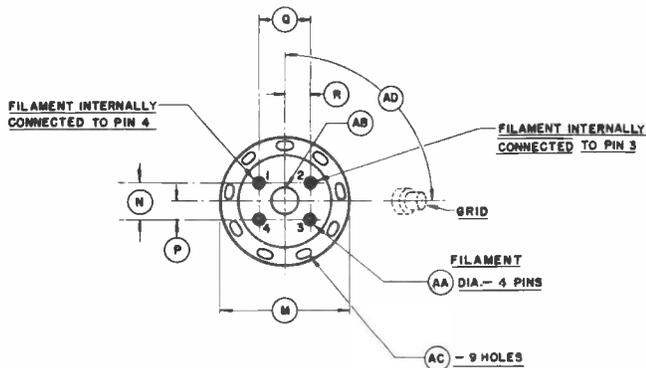
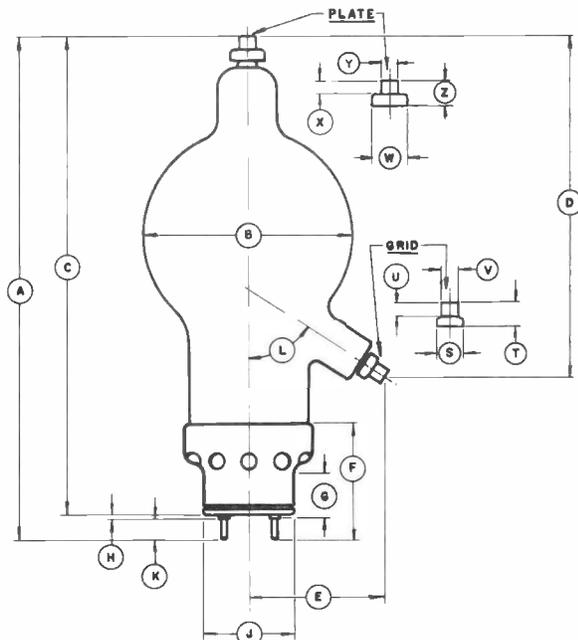
DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and approximate grid driving power at plate voltages of 5000, 6000, and 7000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 5000, 6000, and 7000 volts respectively.







DIMENSIONAL DATA

DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	16.000	17.000	--	406.40	431.80	--
B	--	7.125	--	--	180.98	--
C	15.250	16.250	--	387.35	412.75	--
D	10.875	11.625	--	276.23	295.28	--
E	4.313	4.813	--	109.55	122.25	--
F	--	--	3.750	--	--	95.25
G	--	--	1.313	--	--	33.35
H	--	--	0.094	--	--	2.39
J	--	3.013	--	--	76.53	--
K	0.731	0.763	--	18.57	19.38	--
L	37°	87°	--	37°	87°	--
M	--	4.250	--	--	107.95	--
N	--	--	1.250	--	--	31.75
P	--	--	0.625	--	--	15.88
Q	--	--	1.688	--	--	42.88
R	--	--	0.844	--	--	21.44
S	--	--	0.875	--	--	22.23
T	--	--	0.812	--	--	20.62
U	0.484	--	--	12.30	--	--
V	0.558	0.568	--	14.18	14.43	--
W	--	--	1.125	--	--	28.58
X	0.453	--	--	11.51	--	--
Y	0.558	0.568	--	14.18	14.43	--
Z	--	--	0.797	--	--	20.24
AA	0.249	0.251	--	6.32	6.38	--
AB	0.750 DIA.	--	--	19.05 DIA.	--	--
AC	0.250 DIA.	--	--	6.35 DIA.	--	--
AD	80°	100°	--	80°	100°	--

NOTES:
 1. REF DIMS. ARE FOR INFO ONLY & ARE NOT REQD. FOR INSPECTION PURPOSES.



E I M A C
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2000T
 MEDIUM-MU TRIODE
 MODULATOR
 OSCILLATOR
 AMPLIFIER

The 2000T is a medium-mu, high-vacuum transmitting triode intended for amplifier, oscillator and modulator service. It has a maximum plate dissipation rating of 2000 watts. Cooling of the 2000T is accomplished by radiation from the plate, which operates at a visibly red temperature at maximum dissipation, and by means of forced air circulation around the envelope and at the seals.

GENERAL CHARACTERISTICS

ELECTRICAL

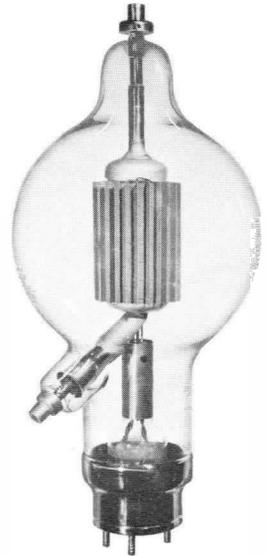
Filament: Thoriated Tungsten	
Voltage	10.0 volts
Current	23.5 amperes

Note: Dual connections for each filament lead are provided within the base of the tube (see basing diagram). Corresponding socket terminals must be connected in parallel to provide proper distribution of filament and R-F charging currents.

Amplification Factor (Average)	23
Direct Interelectrode Capacitances (Average)	
Grid-Plate	8.5 $\mu\mu$ fd.
Grid-Filament	12.7 $\mu\mu$ fd.
Plate-Filament	1.7 $\mu\mu$ fd.
Transconductance ($i_b = 1.75$ amp., $E_b = 6000$ v.)	11,000 μ mhos
Frequency for Maximum Ratings	40 Mc.

MECHANICAL

Base	Special 4-pin, No. 5006B
Basing	RMA type 4BD
Mounting	Vertical, base down or up
Cooling	(See "Cooling" under "Application") Radiation and forced air
Recommended Heat Dissipating Connectors:	Eimac HR-8
Plate	Eimac HR-8
Grid	
Maximum Overall Dimensions:	
Length	17.75 inches
Diameter	8.125 inches
Net weight	3.5 pounds
Shipping weight (Average)	13 pounds



AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class AB₂ (Sinusoidal wave, two tubes unless otherwise specified)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	8000 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT, PER TUBE	1.75 MAX. AMPS.
PLATE DISSIPATION, PER TUBE	2000 MAX. WATTS

TYPICAL OPERATION—2 TUBES

D-C Plate Voltage	4000	5000	6000	7000	Volts
D-C Grid Voltage (approx.)*	-140	-180	-230	-280	Volts
Zero-Signal D-C Plate Current	400	400	400	300	Ma.
Max-Signal D-C Plate Current	2.30	2.20	2.60	1.80	Amps
Effective Load, Plate-to-Plate	3400	5000	7000	9200	Ohms
Peak A-F Grid Input Voltage (per tube)	500	520	580	600	Volts
Max-Signal Peak Driving Power	300	280	380	350	Watts
Max-Signal Nominal Driving Power (approx.)	150	140	190	175	Watts
Max-Signal Plate Power Output	5200	7000	8000	8600	Watts

*Adjust to give stated zero-signal plate current

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy or FM Telephony (Key-down conditions, per tube)

MAXIMUM RATINGS (Frequencies below 40 Mc.)

D-C PLATE VOLTAGE	8000 MAX. VOLTS
D-C PLATE CURRENT	1.75 MAX. AMPS.
PLATE DISSIPATION	2000 MAX. WATTS
GRID DISSIPATION	150 MAX. WATTS

TYPICAL OPERATION, PER TUBE* (Frequencies below 40 Mc.)

D-C Plate Voltage	5000	6000	7000	Volts
D-C Grid Voltage	-350	-500	-600	Volts
D-C Plate Current	1.35	1.35	1.15	Amps.
D-C Grid Current	175	165	120	Ma.
Peak R-F Grid Input Voltage	840	1000	1060	Volts
Driving Power (approx.)	140	160	115	Watts
Grid Dissipation	85	82	55	Watts
Plate Power Input	6750	8000	8000	Watts
Plate Dissipation	2000	2000	2000	Watts
Plate Power Output	4750	6000	6000	Watts

*The performance figures listed under Typical Operation are for radio frequencies up to the VHF region and are obtained by calculation from the characteristic tube curves and confirmed by direct tests. The driving power given includes power taken by the tube grid and the bias circuit. The driving power and output power do not allow for losses in the associated resonant circuits. These losses are not included because they depend principally upon the design and choice of the circuit components.

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions, per tube)

MAXIMUM RATINGS (Frequencies below 40 Mc.)

D-C PLATE VOLTAGE	6000 MAX. VOLTS
D-C PLATE CURRENT	1.4 MAX. AMPS.
PLATE DISSIPATION	1350 MAX. WATTS
GRID DISSIPATION	150 MAX. WATTS

TYPICAL OPERATION, PER TUBE* (Frequencies below 40 Mc.)

D-C Plate Voltage	4000	5000	6000	Volts
D-C Plate Current	1.25	1.20	1.13	Amps.
Total Bias Voltage	-600	-700	-800	Volts
Fixed Bias Voltage	-300	-330	-375	Volts
Grid Resistor	1500	2000	2500	Ohms
D-C Grid Current	200	185	170	Ma.
Peak R-F Grid Input Voltage (approx.)	1140	1240	1320	Volts
Driving Power (approx.)	228	230	225	Watts
Grid Dissipation	108	100	88	Watts
Plate Power Input	5000	6000	6750	Watts
Plate Dissipation	1350	1350	1350	Watts
Plate Power Output	3650	4650	5400	Watts

*The performance figures listed under Typical Operation are for radio frequencies up to the VHF region and are obtained by calculation from the characteristic tube curves and confirmed by direct tests. The driving power given includes power taken by the tube grid and the bias circuit. The driving power and output power do not allow for losses in the associated resonant circuits. These losses are not included because they depend principally upon the design and choice of the circuit components.

APPLICATION

MECHANICAL

Mounting—The 2000T must be mounted vertically, base up or base down. Flexible connecting straps should be provided between the grid and plate terminals and the external grid and plate circuits. The tube must be protected from severe vibration and shock.

Cooling—Forced-air cooling is required on the envelope and also in the base of the tube. Envelope cooling may be accomplished by locating an ordinary 8- or 10-inch fan about one foot from the tube and directing the air at the middle of the envelope.

Base cooling requires an air flow of $2\frac{1}{2}$ cu. ft. per min. directed up through the bottom of the base toward the filament press. The base of the tube is provided with a 1-inch diameter hole for this purpose. If a socket is used with a 1-inch diameter matching hole and the manifold is of the same diameter, a static pressure of less than 0.1 inch of water is required at the manifold to provide the $2\frac{1}{2}$ cu. ft. per min.

One type of socket provides a $\frac{1}{4}$ inch diameter pipe for the air inlet to the base. With this type of socket a static pressure of $5\frac{1}{2}$ inches of water is required at the pipe to obtain the necessary $2\frac{1}{2}$ cu. ft. per min. volume.

Suitable electrical interlocks should be provided to remove the plate and filament voltages in the event that the supply of cooling air is interrupted.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated value of 10 volts. Unavoidable variations in filament voltage must be kept within the range from 9.5 to 10.5 volts. All four socket terminals should be used, putting two in parallel for each filament connection.

Bias Voltage—Although there is no maximum limit on the bias voltage which may be used on the 2000T there is

little advantage in using bias voltages in excess of those given under "Typical Operation," except in certain very specialized applications. Where bias is obtained by a grid leak, suitable protective means must be provided to prevent excessive plate dissipation in the event of loss of excitation.

Plate Voltage—The plate supply voltage for the 2000T should not exceed 8000 volts. In most cases there is little advantage in using plate-supply voltages higher than those given under "Typical Operation" for the power output desired.

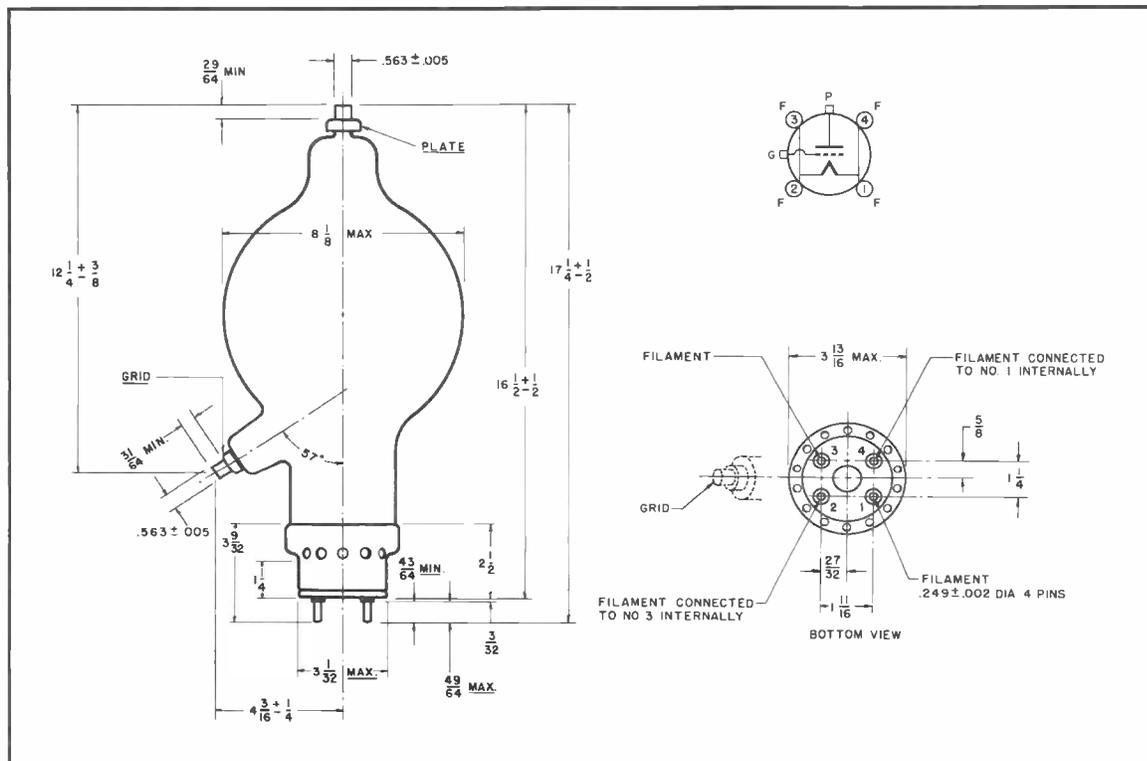
Grid Dissipation—The power dissipated by the grid of the 2000T must not exceed 150 watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} I_c$$

where P_g = Grid dissipation,
 e_{cmp} = Peak positive grid voltage, and
 I_c = D-c grid current.

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid. In equipment in which the plate loading varies widely, such as oscillators used for radio-frequency heating, care should be taken to make certain that the grid dissipation does not exceed the maximum rating under any condition of loading.

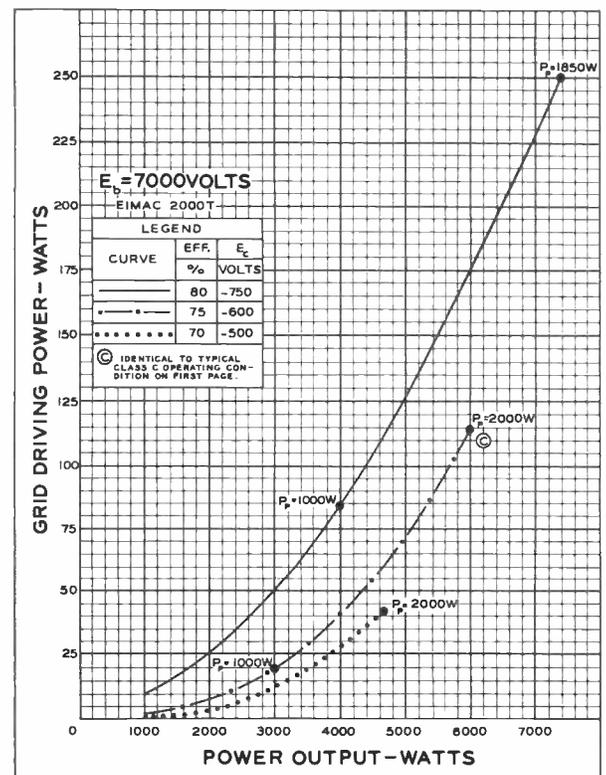
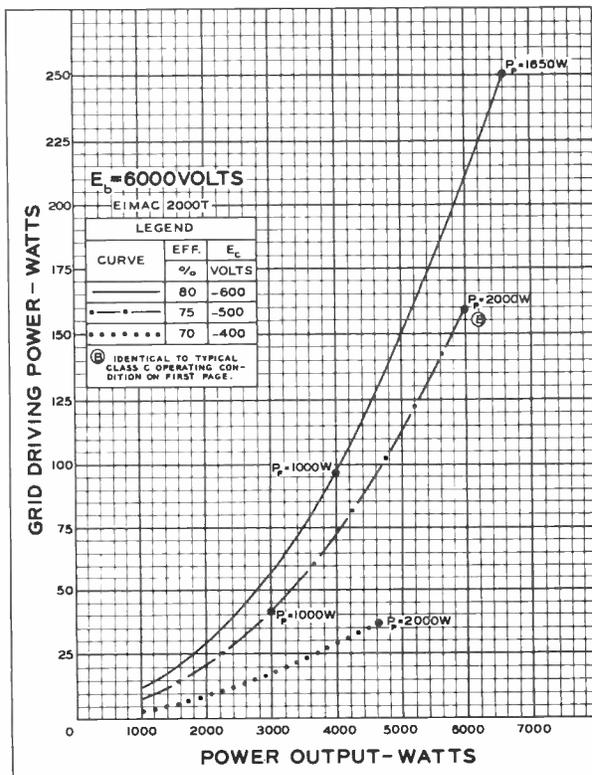
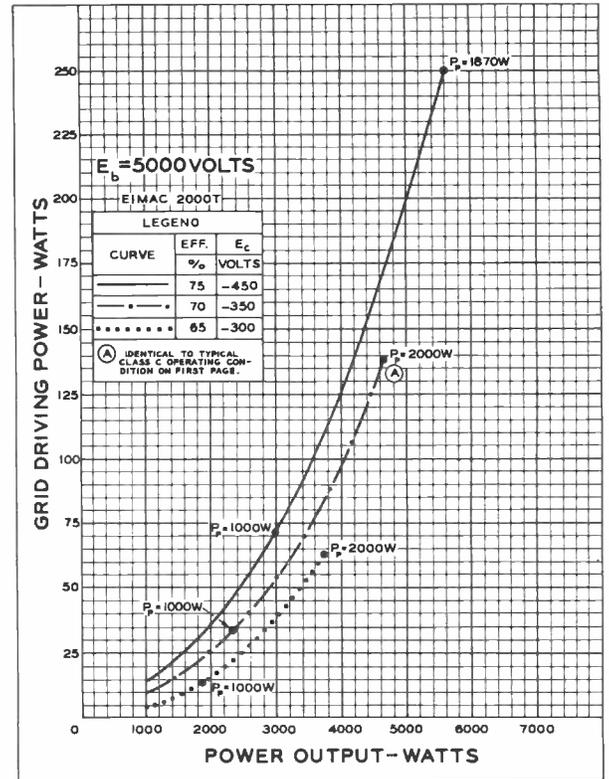
Plate Dissipation—Under normal operating conditions, the power dissipated by the plate of the 2000T should not be allowed to exceed 2000 watts. Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.



DRIVING POWER vs. POWER OUTPUT

The three charts on this page show the relationship of plate efficiency, power output and grid driving power at plate voltages of 5000, 6000, and 7000 volts. These charts show combined grid and bias losses only. The driving power and power output figures do not include circuit losses. The plate dissipation in watts is indicated by P_p .

Points A, B, and C are identical to the typical Class C operating conditions shown on the first page under 5000, 6000, and 7000 volts respectively.



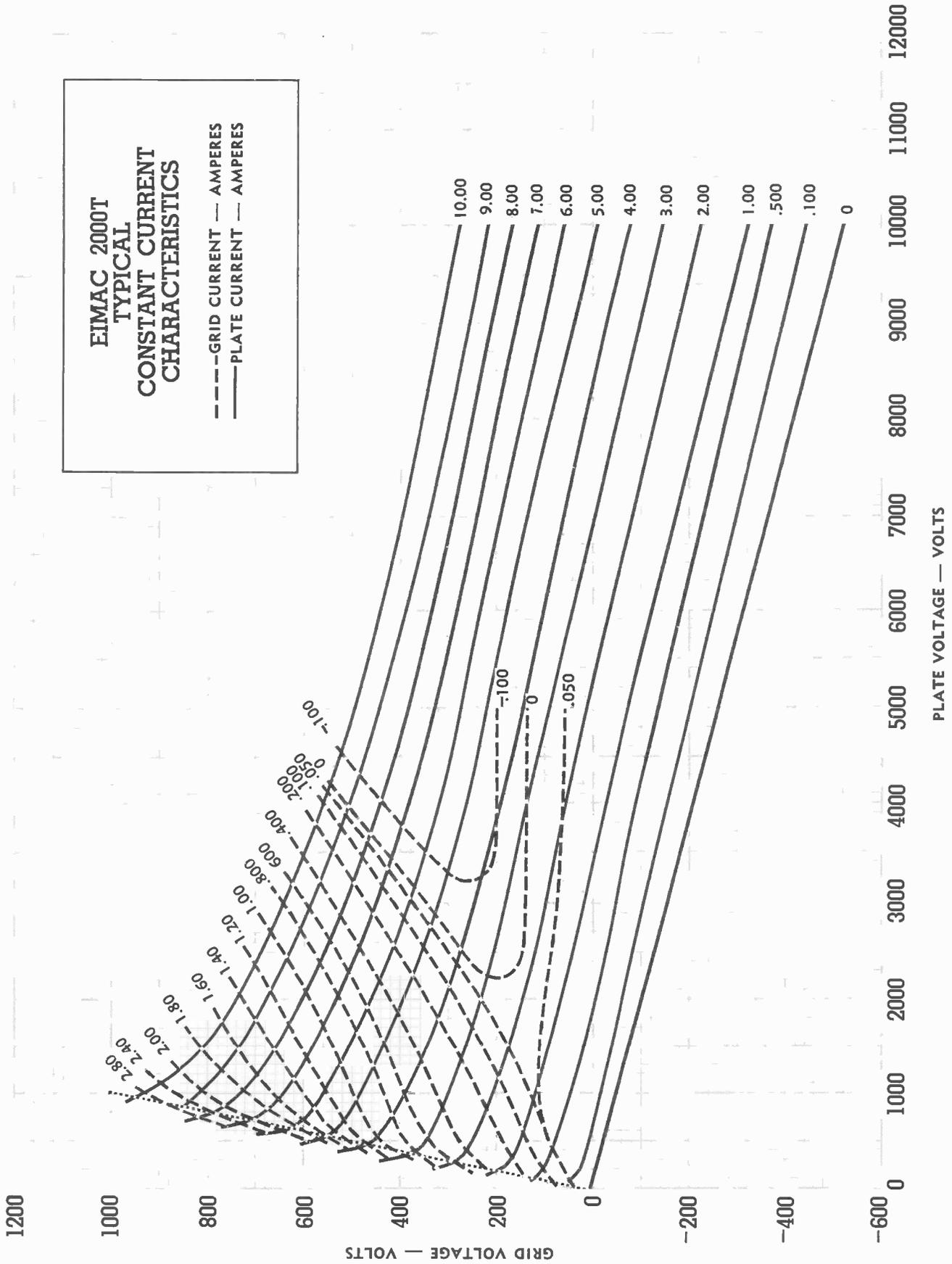


2000T

EIMAC 2000T

TYPICAL CONSTANT CURRENT CHARACTERISTICS

--- GRID CURRENT — AMPERES
— PLATE CURRENT — AMPERES





E I M A C
 Division of Varian
 S A N C A R L O S
 C A L I F O R N I A

6696A

**WATER COOLED
 MEDIUM-MU
 POWER TRIODE**

The Eimac 6696A is a water cooled ceramic-metal triode designed for industrial heating service. It is recommended also for use in broadcast and communications amplifiers.

Low-loss ceramic and metal construction permits operation at full ratings at frequencies up to 40 Mc. Useful power output can be obtained at frequencies up to 80 Mc at reduced plate voltage.

The 6696A anode is capable of dissipating 60 kilowatts at a moderate rate of water flow. A forced-air cooled version of this tube, type 6697A, and a vapor cooled version, type 7480, are also available.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.
Filament: Thoriated-Tungsten			
Voltage - - - - -		13	volts
Current - - - - -	190		220 amperes
Starting Current - - - - -			800 amperes
Amplification Factor - - - - -		20	
Direct Interelectrode Capacitances			
Grid-Plate - - - - -	47		57 pf
Grid-Filament - - - - -	65		85 pf
Plate-Filament - - - - -	2.0		3.2 pf
Frequency for Maximum Ratings - - - - -			40 Mc

MECHANICAL

Base - - - - -	Coaxial
Operating Position - - - - -	Vertical, base up
Cooling - - - - -	Water and forced air
Maximum Seal Temperature - - - - -	200°C
Maximum Outlet Water Temperature - - - - -	70°C
Maximum Height - - - - -	19.4 inches
Maximum Diameter - - - - -	4.72 inches
Net Weight - - - - -	17 pounds

**RADIO-FREQUENCY POWER AMPLIFIER
 OR OSCILLATOR**

Class-C Telegraphy or FM Telephony
 (Key-down conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE - - - - -	16.0 KV
DC GRID VOLTAGE - - - - -	-3200 VOLTS
DC PLATE CURRENT - - - - -	11 AMPS
DC GRID CURRENT - - - - -	2.0 AMPS
GRID DISSIPATION - - - - -	1000 WATTS
PLATE DISSIPATION - - - - -	60 KW

TYPICAL OPERATION

DC Plate Voltage - - - - -	10	15 kV
DC Grid Voltage - - - - -	-1200	-1600 volts
Peak RF Grid Voltage - - - - -	1900	2100 volts
DC Plate Current - - - - -	10.0	7.0 amps
DC Grid Current - - - - -	810	300 mA
Resonant Load Impedance - - - - -	440	970 ohms
Driving Power, approx. - - - - -	1500	600 watts
Plate Output Power, approx. - - - - -	72	80 kW

**PLATE-MODULATED RADIO-FREQUENCY
POWER AMPLIFIER**

Class-C Telephony (Carrier conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	10.0 KV
DC GRID VOLTAGE	- - - -	-3200 VOLTS
DC PLATE CURRENT	- - - -	8.5 AMPS
DC GRID CURRENT	- - - -	2.0 AMPS
GRID DISSIPATION	- - - -	1000 WATTS
PLATE DISSIPATION	- - - -	40 KW

TYPICAL OPERATION

DC Plate Voltage	- - - -	9.5 kV
DC Grid Voltage	- - - -	-1600 volts
Peak RF Grid Voltage	- - - -	2300 volts
DC Plate Current	- - - -	8.4 amps
DC Grid Current	- - - -	900 mA
Resonant Load Impedance	- - - -	510 ohms
Driving Power, approx.	- - - -	2.0 kW
Plate Output Power, approx.	- - - -	60 kW

**AUDIO-FREQUENCY AMPLIFIER
OR MODULATOR**

Class-AB

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	11.0 AMPS
PLATE DISSIPATION	- - - -	60 KW

TYPICAL OPERATION (Two Tubes).

DC Plate Voltage	- - - -	10	12 kV
DC Grid Voltage	- - - -	-450	-600 volts
Peak AF Driving Voltage (per tube)	- - - -	875	1060 volts
Zero-Sig DC Plate Current	- - - -	3.0	2.0 amps
Max-Sig DC Plate Current	- - - -	17.4	20.0 amps
Load Resistance, Plate-to-Plate	- - - -	1170	1230 ohms
Max-Sig Driving Power, approx.	- - - -	550	600 watts
Max-Sig Plate Output Power, approx.	- - - -	110	152 kW

RADIO-FREQUENCY AM LINEAR AMPLIFIER

Class-AB (Carrier conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	9.0 AMPS
PLATE DISSIPATION	- - - -	60 KW

**TYPICAL OPERATION (AM Carrier conditions except
where noted).**

DC Plate Voltage	- - - -	12	12 kV
DC Grid Voltage	- - - -	-550	-550 volts
Peak RF Grid Voltage	- - - -	510	640 volts
DC Plate Current	- - - -	4.3	6.8 amps
DC Grid Current	- - - -	0	0 amps
Resonant Load Impedance	- - - -	780	500 ohms
Driving Power, approx.*	- - - -	450	1500 watts
Plate Output Power, approx.	- - - -	18	28 kW

*At modulation crest.

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB, Single-Sideband Suppressed-Carrier Service

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	11.0 AMPS
PLATE DISSIPATION	- - - -	60 KW

**TYPICAL OPERATION (Peak-envelope or modulation-crest
conditions in cathode-drive circuit).**

DC Plate Voltage	- - - -	12	12 kV
DC Cathode Voltage	- - - -	600	600 volts
Peak RF Driving Voltage	- - - -	830	1020 volts
DC Plate Current	- - - -	5.2	9.8 amps
DC Grid Current, approx.	- - - -	60	200 mA
Resonant Load Impedance	- - - -	880	700 ohms
Driving Power, approx.	- - - -	3.5	8.2 kW
Plate Power Output, approx.	- - - -	43	83 kW

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves. No allowance for circuit losses has been made.

APPLICATION

MECHANICAL

Mounting—

The 6696A should be mounted vertically anode down in the waterjacket (Machlett type F-17393 or equivalent). Filament and grid connections are made through clamp rings or spring-finger contacts to the O.D. of the sturdy copper terminals of the tube. Satisfactory anode contact can be made to the water jacket.

Anode Cooling—

Minimum cooling requirements are given in the accompanying table, where the pressure drop is measured at the jacket fittings. The water supply line must be connected to the inlet fitting of the water jacket.

MINIMUM ANODE COOLING REQUIREMENTS		
Plate Dissipation kW	Water Flow Rate gpm	Pressure Drop psi
20	5.7	1.3
30	8.0	2.1
40	11.2	3.3
50	14.5	5.0
60	18.0	7.2

Base Cooling—

Forced-air cooling of the ceramic base and seals may be required, depending on ambient conditions and operating frequency. Air flow rate and direction should be determined to limit envelope temperatures to 200°C maximum and to maintain uniform temperature distribution around the seals. Spot temperatures are conveniently measured with Tempilaq (spray type) or equivalent. Often a flow of about 100 cfm, directed axially downward towards the tube, is sufficient.

ELECTRICAL

Filament Operation—

The rated filament voltage, as measured at the tube terminals, should be maintained within $\pm 5\%$ to assure long life and good performance within the rated power capability of the tube. To accommodate special requirements, the filament voltage may be centered near either of these extremes, e.g. at plus 5 percent for exceptionally high emission at a sacrifice of life, or at minus 5 percent for exceptionally long life where perhaps only half the full emission capability is required.

Grid Dissipation—

Grid dissipation should be limited to 1,000 watts maximum. Grid dissipation may be calculated approximately as the product of peak positive grid voltage and dc grid current.

In many r-f amplifier applications where it is impractical to measure the positive grid voltage, the dc grid current rating serves as a satisfactory guide. The maximum dc grid current rating under normal full

load conditions is 2 amperes. In most cases, however, high power output and good efficiency can be realized with grid current less than one ampere. By limiting the grid current in this manner there is obviously more latitude for grid current excursions resulting from changes in loading.

High Frequency Operation—

The maximum ratings listed apply at frequencies up to 40 Mc. Useful output can be obtained at higher frequencies if the plate voltage and plate input power are reduced accordingly. For operation up to 60 Mc these parameters should be reduced to 75% of the listed dc plate voltage rating; for operation up to 80 Mc they should be reduced to 50%.

Aging—

The manner of operating most high power tubes differs in at least some respects from conditions under which the tubes are tested, therefore, some aging is almost always required to condition a new tube to its new environment. In basic terms, the different operating conditions are manifest as different distributions of heat and voltage gradients. Satisfactory aging is most easily achieved by gradual application of voltages, e.g. first filament voltage, then partial plate voltage, and drive, working up to the final values. If continuous or stepped plate voltage control is not used, sufficient load should be connected before snapping on full voltage to limit transients to about 120% of the dc voltage.

Tube Protection—

Since the possibility of fault overloads due to occasional tube or circuit instabilities is ever present, good engineering practice holds that suitable protective circuitry and devices be included in the equipment. In addition to the standard overcurrent relays, some series resistance should be placed in the output of the power supply to limit surge currents. In cases where no filter is used, the resistors may be placed in each rectifier lead to reduce the power loss during normal operation. In certain applications, furthermore, it is helpful to attach sphere gaps or rings to the tube terminals to divert any excessive transient voltages from the envelope and seals.

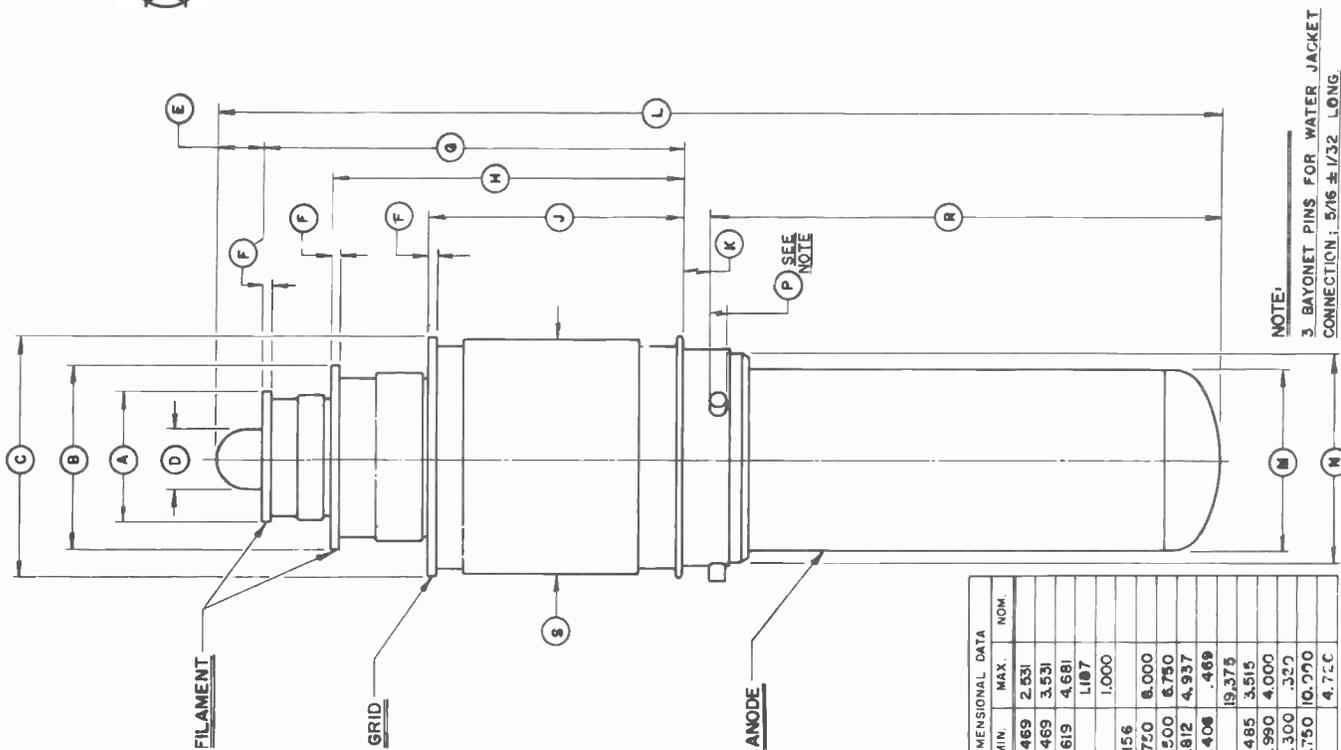
The use of an electronic fault diverter, or "crowbar" is probably the best way to insure high performance reliability and freedom from gassing or catastrophic failures. The crowbar system consists of circuitry to sense incipient fault currents and trigger the crowbar device, which is connected to short the power supply energy to ground, preferably within about 10 microseconds. The crowbar device, which is usually an ignitron, hydrogen thyratron, or spark gap, diverts most of the fault energy from the protected tube until the relay and circuit breakers open.

Special Applications—

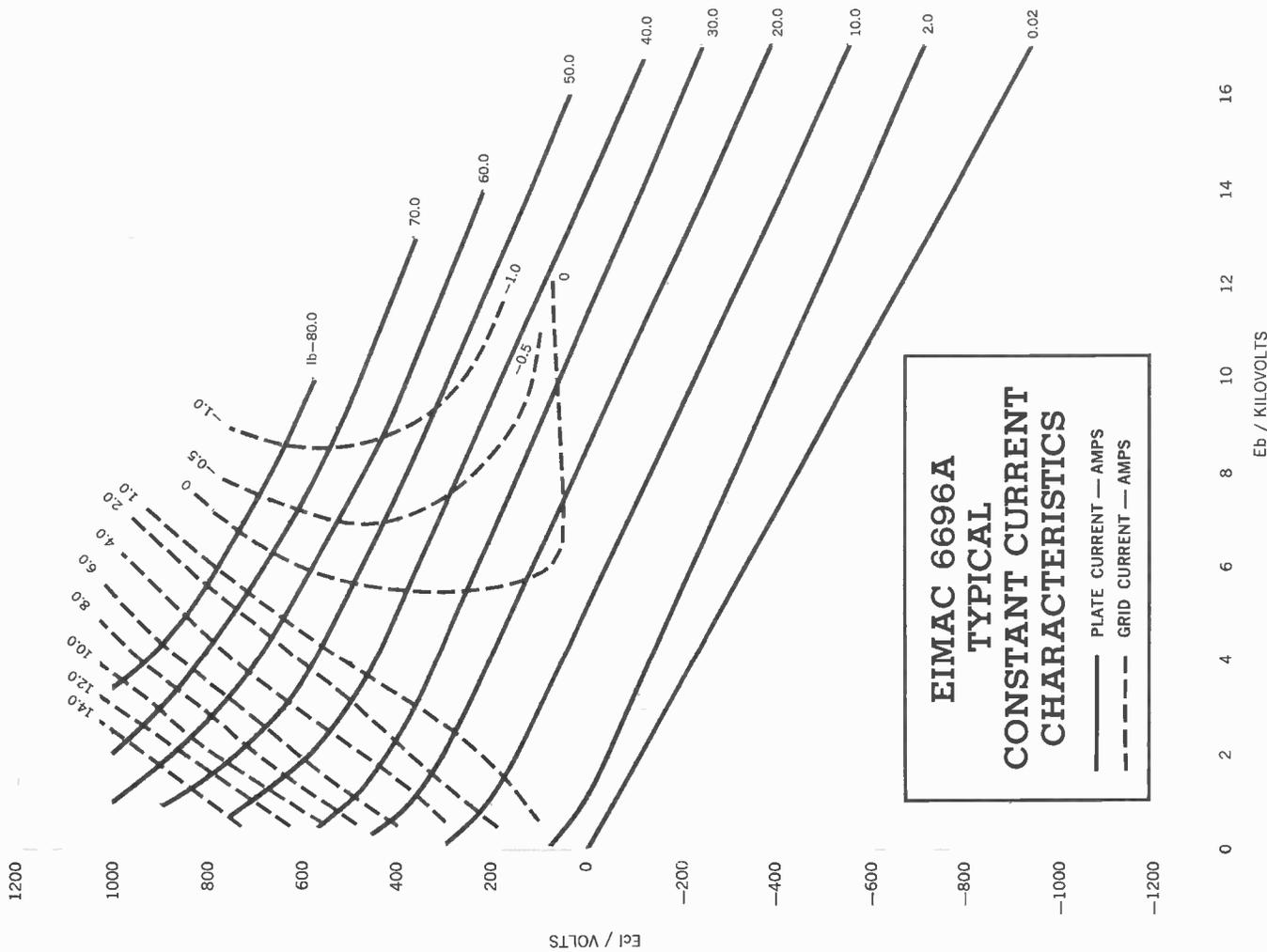
If it is desired to operate this tube under conditions widely different from those given herein, write to Power Grid Tube Marketing, Eimac, Division of Varian, 301 Industrial Way, San Carlos, California.

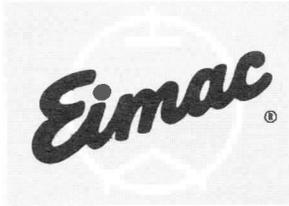


6696A



REF	DIMENSIONAL DATA		
	MIN	MAX	NOM
A	2.469	2.531	
B	3.469	3.531	
C	4.619	4.681	
D		1.087	
E		1.000	
F	.156		
G	7.750	8.000	
H	6.500	6.750	
J	4.812	4.937	
K	.408	.469	
L		19.375	
M	3.485	3.515	
N	3.990	4.000	
P	.300	.320	
R	9.750	10.000	
S		4.750	





E I M A C
 Division of Varian
 S A N C A R L O S
 C A L I F O R N I A

6697A
 FORCED-AIR COOLED
 MEDIUM-MU
 POWER TRIODE

The Eimac 6697A is a forced-air cooled ceramic-metal triode designed for AM broadcast and communications amplifiers and for industrial heating service.

Low-loss ceramic and metal construction permits operation at full ratings at frequencies up to 40 Mc. Useful power output can be obtained at frequencies up to 80 Mc at reduced plate voltage.

The 6697A anode is capable of dissipating 35 kilowatts. A water cooled version of this tube, type 6696A, and a vapor cooled version, type 7480, are also available.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.
Filament: Thoriated-Tungsten			
Voltage - - - - -		13	volts
Current - - - - -	190		220 amperes
Starting Current - - - - -			800 amperes
Amplification Factor - - - - -		20	

Direct Interelectrode Capacitances

Grid-Plate - - - - -	47	57 pf
Grid-Filament - - - - -	65	85 pf
Plate-Filament - - - - -	2.0	3.2 pf

Frequency for Maximum Ratings - - - - - 40 Mc

MECHANICAL

Base - - - - -	Coaxial
Operating Position - - - - -	Vertical, base up
Cooling - - - - -	Forced Air
Maximum Seal Temperature - - - - -	200°C
Maximum Incoming Air Temperature - - - - -	50°C
Maximum Height - - - - -	19.9 inches
Maximum Diameter - - - - -	5.28 inches
Net Weight - - - - -	43 pounds

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony
 (Key-down conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE - - - - -	16.0 KV
DC GRID VOLTAGE - - - - -	-3200 VOLTS
DC PLATE CURRENT - - - - -	11 AMPS
DC GRID CURRENT - - - - -	2.0 AMPS
GRID DISSIPATION - - - - -	1000 WATTS
PLATE DISSIPATION - - - - -	35 KW

TYPICAL OPERATION

DC Plate Voltage - - - - -	10	15 kV
DC Grid Voltage - - - - -	-1200	-1600 volts
Peak RF Grid Voltage - - - - -	1900	2100 volts
DC Plate Current - - - - -	10.0	7.0 amps
DC Grid Current - - - - -	810	300 mA
Resonant Load Impedance - - - - -	440	970 ohms
Driving Power, approx. - - - - -	1500	600 watts
Plate Output Power, approx. - - - - -	72	80 kW

**PLATE-MODULATED RADIO-FREQUENCY
POWER AMPLIFIER**

Class-C Telephony (Carrier conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	10.0 KV
DC GRID VOLTAGE	- - - -	-3200 VOLTS
DC PLATE CURRENT	- - - -	8.5 AMPS
DC GRID CURRENT	- - - -	2.0 AMPS
GRID DISSIPATION	- - - -	1000 WATTS
PLATE DISSIPATION	- - - -	23 KW

TYPICAL OPERATION

DC Plate Voltage	- - - - -	9.5 kV
DC Grid Voltage	- - - - -	-1600 volts
Peak RF Grid Voltage	- - - - -	2300 volts
DC Plate Current	- - - - -	8.4 amps
DC Grid Current	- - - - -	900 mA
Resonant Load Impedance	- - - - -	510 ohms
Driving Power, approx.	- - - - -	2.0 kW
Plate Output Power, approx.	- - - - -	60 kW

**AUDIO-FREQUENCY AMPLIFIER
OR MODULATOR**

Class-AB

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	11.0 AMPS
PLATE DISSIPATION	- - - -	35 KW

TYPICAL OPERATION (Two Tubes).

DC Plate Voltage	- - - - -	10 kV
DC Grid Voltage	- - - - -	-450 volts
Peak AF Driving Voltage (per tube)	- - - - -	875 volts
Zero-Sig DC Plate Current	- - - - -	3.0 amps
Max-Sig DC Plate Current	- - - - -	17.4 amps
Load Resistance, Plate-to-Plate	- - - - -	1170 ohms
Max-Sig Driving Power, app	- - - - -	550 watts
Max-Sig Plate Output Power approx.	- - - - -	110 kW

RADIO-FREQUENCY AM LINEAR AMPLIFIER

Class-AB (Carrier conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	9.0 AMPS
PLATE DISSIPATION	- - - -	35 KW

TYPICAL OPERATION (AM Carrier conditions except
where noted).

DC Plate Voltage	- - - - -	12 kV
DC Grid Voltage	- - - - -	-550 volts
Peak RF Grid Voltage	- - - - -	510 volts
DC Plate Current	- - - - -	4.3 amps
DC Grid Current	- - - - -	0 amps
Resonant Load Impedance	- - - - -	780 ohms
Driving Power, approx.*	- - - - -	450 watts
Plate Output Power, approx.	- - - - -	18 kW

*At modulation crest.

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB, Single-Sideband Suppressed-Carrier Service

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	11.0 AMPS
PLATE DISSIPATION	- - - -	35 KW

TYPICAL OPERATION (Peak-envelope or modulation-crest
conditions in cathode-drive circuit).

DC Plate Voltage	- - - - -	12 kV
DC Cathode Voltage	- - - - -	600 volts
Peak RF Driving Voltage	- - - - -	830 volts
DC Plate Current	- - - - -	5.2 amps
DC Grid Current, approx.	- - - - -	60 mA
Resonant Load Impedance	- - - - -	880 ohms
Driving Power, approx.	- - - - -	3.5 kW
Plate Power Output, approx.	- - - - -	43 kW

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves. No allowance for circuit losses has been made.



APPLICATION

MECHANICAL

Mounting—

The 6697A should be mounted vertically anode down in the air distributor (Machlett type F-17759 or equivalent). Filament and grid connections are made through clamp rings or spring-finger contacts to the O.D. of the sturdy copper terminals of the tube. Anode contact can be made to the top ring of the air distributor.

Anode Cooling—

Minimum cooling requirements are given in the accompanying table, based on a maximum incoming air temperature of 50°C at sea level.

MINIMUM ANODE COOLING REQUIREMENTS		
Plate Dissipation kW	Air Flow Rate cfm	Pressure Drop inches water
10	240	0.2
20	700	1.5
30	1350	5.0
35	1700	8.0

Base Cooling—

Forced-air cooling of the ceramic base and seals may be required, depending on ambient conditions and operating frequency. Air flow rate and direction should be determined to limit envelope temperatures to 200°C maximum and to maintain uniform temperature distribution around the seals. Spot temperatures are conveniently measured with Tempilaq (spray type) or equivalent. Often the anode air supply can be deflected to cool the envelope and seals.

ELECTRICAL

Filament Operation—

The rated filament voltage, as measured at the tube terminals, should be maintained within $\pm 5\%$ to assure long life and good performance within the rated power capability of the tube. To accommodate special requirements, the filament voltage may be centered near either of these extremes, e.g. at plus 5 percent for exceptionally high emission at a sacrifice of life, or at minus 5 percent for exceptionally long life where perhaps only half the full emission capability is required.

Grid Dissipation—

Grid dissipation should be limited to 1,000 watts maximum. Grid dissipation may be calculated approximately as the product of peak positive grid voltage and dc grid current.

In many r-f amplifier applications where it is impractical to measure the positive grid voltage, the dc grid current rating serves as a satisfactory guide. The maximum dc grid current rating under normal full

load conditions is 2 amperes. In most cases, however, high power output and good efficiency can be realized with grid current less than one ampere. By limiting the grid current in this manner there is obviously more latitude for grid current excursions resulting from changes in loading.

High Frequency Operation—

The maximum ratings listed apply at frequencies up to 40 Mc. Useful output can be obtained at higher frequencies if the plate voltage and plate input power are reduced accordingly. For operation up to 60 Mc these parameters should be reduced to 75% of the listed dc plate voltage rating; for operation up to 80 Mc they should be reduced to 50%.

Aging—

The manner of operating most high power tubes differs in at least some respects from conditions under which the tubes are tested, therefore, some aging is almost always required to condition a new tube to its new environment. In basic terms, the different operating conditions are manifest as different distributions of heat and voltage gradients. Satisfactory aging is most easily achieved by gradual application of voltages, e.g. first filament voltage, then partial plate voltage, and drive, working up to the final values. If continuous or stepped plate voltage control is not used, sufficient load should be connected before snapping on full voltage to limit transients to about 120% of the dc voltage.

Tube Protection—

Since the possibility of fault overloads due to occasional tube or circuit instabilities is ever present, good engineering practice holds that suitable protective circuitry and devices be included in the equipment. In addition to the standard overcurrent relays, some series resistance should be placed in the output of the power supply to limit surge currents. In cases where no filter is used, the resistors may be placed in each rectifier lead to reduce the power loss during normal operation. In certain applications, furthermore, it is helpful to attach sphere gaps or rings to the tube terminals to divert any excessive transient voltages from the envelope and seals.

The use of an electronic fault diverter, or "crowbar" is probably the best way to insure high performance reliability and freedom from gassing or catastrophic failures. The crowbar system consists of circuitry to sense incipient fault currents and trigger the crowbar device, which is connected to short the power supply energy to ground, preferably within about 10 microseconds. The crowbar device, which is usually an ignitron, hydrogen thyratron, or spark gap, diverts most of the fault energy from the protected tube until the relay and circuit breakers open.

Special Applications—

If it is desired to operate this tube under conditions widely different from those given herein, write to Power Grid Tube Marketing, Eimac, Division of Varian, 301 Industrial Way, San Carlos, California.



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

7211

HIGH-MU UHF
TRIODE

The Eimac 7211 is a ceramic-and-metal planar triode designed for use as a power amplifier, oscillator, or frequency multiplier in applications requiring greater power output than can be realized from the 7289/3CX100A5. Although similar in appearance, the Eimac 7211 incorporates a significantly improved and enlarged cathode which increases the power input capability to a maximum of 190 watts at frequencies to 2500 mc.

Exact dimensional tolerances inherent in the manufacturing processes provide the Eimac 7211 with the maximum mechanical uniformity. Critical electrical testing results in increased reliability and a minimum variation in electrical characteristics.



GENERAL CHARACTERISTICS

Electrical

	Min.	Nom.	Max.
Cathode: Oxide-coated, Unipotential			
Heating time - - - - -	60		seconds
Heater:			
Voltage - - - - -		6.3	volts
Current - - - - -	1.2		1.4 amperes
Amplification Factor - - - - -		80	
Direct Interelectrode Capacitances			Min. Max.
Grid-Cathode - - - - -			7.0 9.0 uuf
Grid-Plate - - - - -			2.1 2.4 uuf
Plate-Cathode - - - - -			0.06 uuf
Frequency for Maximum Ratings - - - - -			2500 mc

Mechanical

Terminals - - - - -	Graduated Cylindrical Surfaces
Maximum Operating Temperatures:	
Ceramic-to-metal Seals - - - - -	250°C
Anode Core - - - - -	250°C
Operating Position - - - - -	Any
Cooling - - - - -	Conduction and Forced Air
Maximum Overall Dimensions:	
Length - - - - -	2.701 inches
Diameter - - - - -	1.264 inches
Net Weight - - - - -	2.5 ounces
Shipping Weight - - - - -	7.0 ounces

Radio Frequency Power Amplifier or Oscillator

MAXIMUM RATING (Per Tube)	
DC PLATE VOLTAGE - - - - -	1000 VOLTS MAX.
DC CATHODE CURRENT - - - - -	0.190 AMP. MAX.
DC GRID VOLTAGE - - - - -	-150 VOLTS MAX.
DC GRID CURRENT - - - - -	0.045 AMP. MAX.
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE - - - - -	30 VOLTS MAX.
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE - - - - -	-400 VOLTS MAX.
PLATE DISSIPATION - - - - -	100 WATTS MAX.
GRID DISSIPATION - - - - -	2 WATTS MAX.

TYPICAL OPERATION (Per Tube)	Power Amplifier Grounded-Grid (key-down conditions)	
	500 Mc	2500 Mc
DC PLATE VOLTAGE - - - - -	900	900 Volts
DC GRID VOLTAGE (approx.) - - - - -	-30	-20 Volts
DC PLATE CURRENT - - - - -	140	140 Ma.
DC GRID CURRENT (approx.) - - - - -	40	15 Ma.
DRIVING POWER (approx.) - - - - -	9	-- Watts
USEFUL OUTPUT POWER - - - - -	65	25 Watts



PLATE MODULATED RADIO FREQUENCY AMPLIFIER OR OSCILLATOR

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE	- - - -	600 VOLTS MAX.
DC CATHODE CURRENT	- - - -	0.140 AMP. MAX.
DC GRID VOLTAGE	- - - -	-150 VOLTS MAX.
DC GRID CURRENT	- - - -	0.050 AMP. MAX.
INSTANTANEOUS PEAK POSITIVE GRID VOLTAGE	- - - -	30 VOLTS MAX.
INSTANTANEOUS PEAK NEGATIVE GRID VOLTAGE	- - - -	-400 VOLTS MAX.
PLATE DISSIPATION	- - - -	70 WATTS MAX.
GRID DISSIPATION	- - - -	2 WATTS MAX.

TYPICAL OPERATION (Per Tube) 500 Mc, Grounded-Grid, Carrier Conditions.

DC PLATE VOLTAGE	- - - -	600 Volts
DC GRID VOLTAGE (approx.)	- - - -	-20 Volts
DC PLATE CURRENT	- - - -	100 Milliamp.
DC GRID CURRENT (approx.)	- - - -	35 Milliamp.
DRIVING POWER (approx.)	- - - -	8 Watts
USEFUL CARRIER POWER OUTPUT	- - - -	25 Watts

APPLICATION

MECHANICAL

Mounting —

The 7211 may be operated in any position. It should be firmly held in place by spring-finger collets bearing on the terminal surfaces. In use the tube should seat against the underside of the anode-terminal flange which is on the plane of reference for longitudinal dimensions. In applications involving severe shock and vibration, the tube may be clamped in place by applying a suitable clamping device to the anode-terminal flange. It is recommended that no other portion of the tube be subjected to clamping forces.

Connections —

The terminals are in the form of concentric cylinders of graduated diameters conveniently used with coaxial tuning devices. Spring-fingered collets should be used to make contact with the anode, grid, cathode and heater terminals. Adequate contact area and spring pressure should be provided to minimize heating and to prevent erratic circuit performance at the higher frequencies. Non-contacting or intermittently-contacting collet fingers will cause troublesome circuit behavior, especially at very-high and ultra-high frequencies. Electrode contact surfaces should be kept clean and free of oxide coatings.

Cooling —

Sufficient cooling air must be provided for the anode and body seals to maintain operating temperatures below the rated maximum value of 250° C.

At sea level, with an inlet air temperature of 20°C (68°F), 12.5 cubic feet per minute of air flow is required to cool the anode at 100 watts plate dissipation when the air cowling as illustrated is used. Operation at higher altitudes or with higher inlet temperatures requires increased volumes of flow to obtain equivalent cooling. When using the anode cowling as illustrated here, it is necessary to provide additional facilities for seal cooling.

It should be borne in mind that operating

temperature is the sole criterion of cooling effectiveness, regardless of the coolant type, flow rate or coolant temperature. One method of measuring the surface temperatures is the use of temperature sensitive lacquer, such as "Tempilaq."

ELECTRICAL

Heater Operation —

The rated heater voltage for the 7211 is 6.3 volts. The heater voltage for the 7211 should be maintained within plus or minus 5% of its intended value to minimize variations in circuit performance and to obtain maximum tube life.

At frequencies above approximately 1000 megacycles, transit time effects begin to influence cathode temperature. The amount of driving power diverted to heating the cathode by back-bombardment will depend upon the frequency, the plate current, driving power, and duty factor. If the conditions of operation result in appreciable cathode back-heating, it may be necessary to start dynamic tube operation at normal heater voltage followed by a reduction of heater voltage to a lower value.

Cathode Operation —

The oxide-coated unipotential cathode in this tube must be protected against excessively high emission currents. For all types of operation the maximum rated dc current is 190 milliamperes.

It is recommended that the rated heater voltage be applied for a minimum of 60 seconds before other operating voltages are applied.

Control Grid Operation —

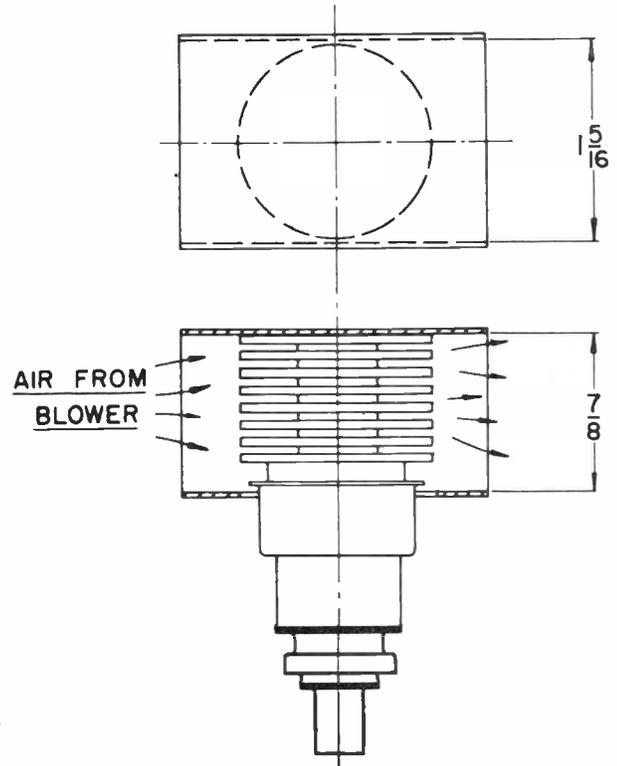
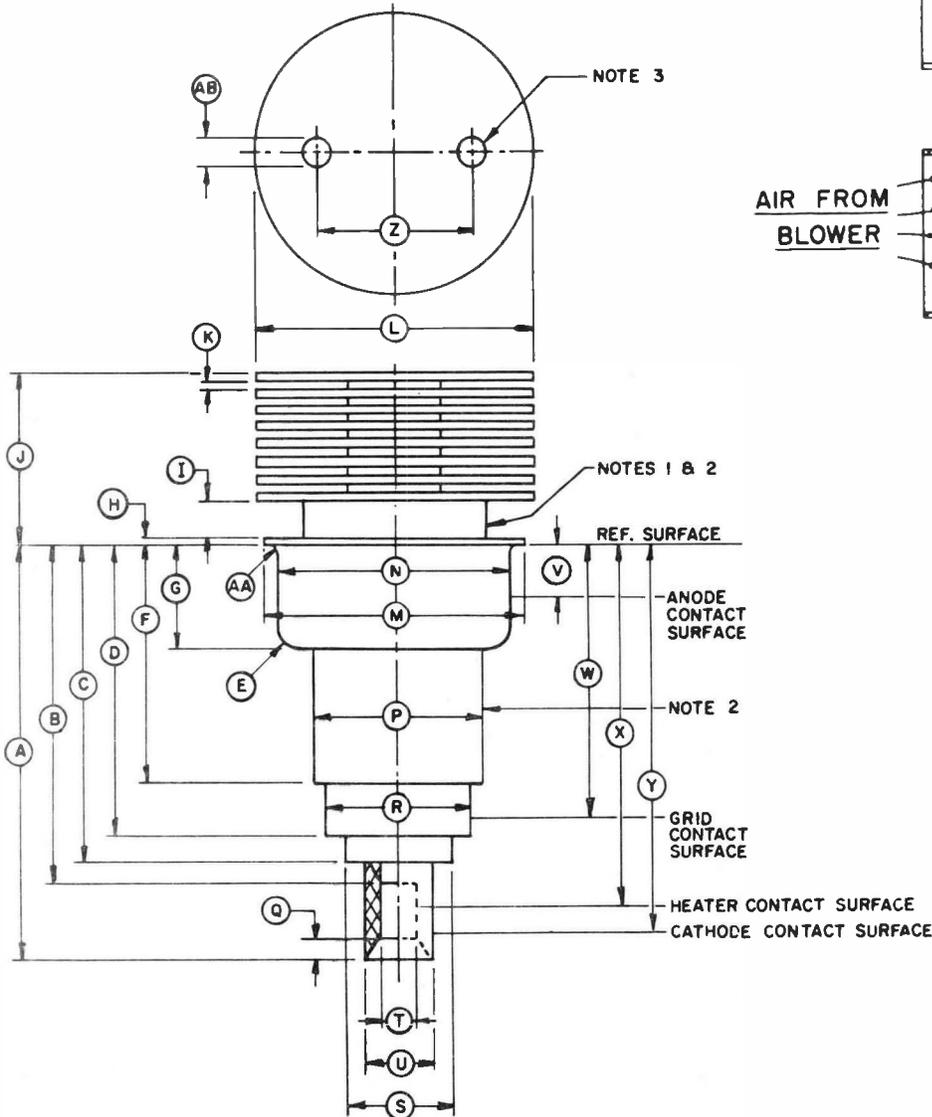
Grid dissipation must not exceed the rated maximum 2.0 watts grid dissipation power. In pulse applications the instantaneous peak grid-to-cathode voltage must be limited to —250 to —750 volts.

Special Applications —

If it is desired to operate this tube under conditions widely different from those given here, write to PowerGrid Tube Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California, for information and recommendations.

NOTES:

1. MEASURE ANODE SHANK TEMPERATURE ON THIS SURFACE.
2. DO NOT CLAMP OR LOCATE ON THIS SURFACE.
3. HOLE PROVIDED FOR TUBE EXTRACTOR THROUGH TOP FIN ONLY.



**RECOMMENDED COWLING
FOR
FORCED-AIR COOLING
OF ANODE**

DIMENSIONAL DATA			
REF.	MIN.	MAX.	NOM.
A	1.815	1.875	
B		1.534	
C		1.475	
D	1.289	1.329	
E		.100	
F	.970	1.010	
G	.462	.477	
H		.040	
I	.125	.185	
J	.766	.826	
K	.025	.046	
L	1.234	1.264	
M	1.180	1.195	
N	1.025	1.035	
P	.772	.792	
Q		.086	
R	.655	.665	
S		.545	
T	.213	.223	
U	.315	.325	
Z	.650	.850	
AA		.035	
AB	.105	.145	

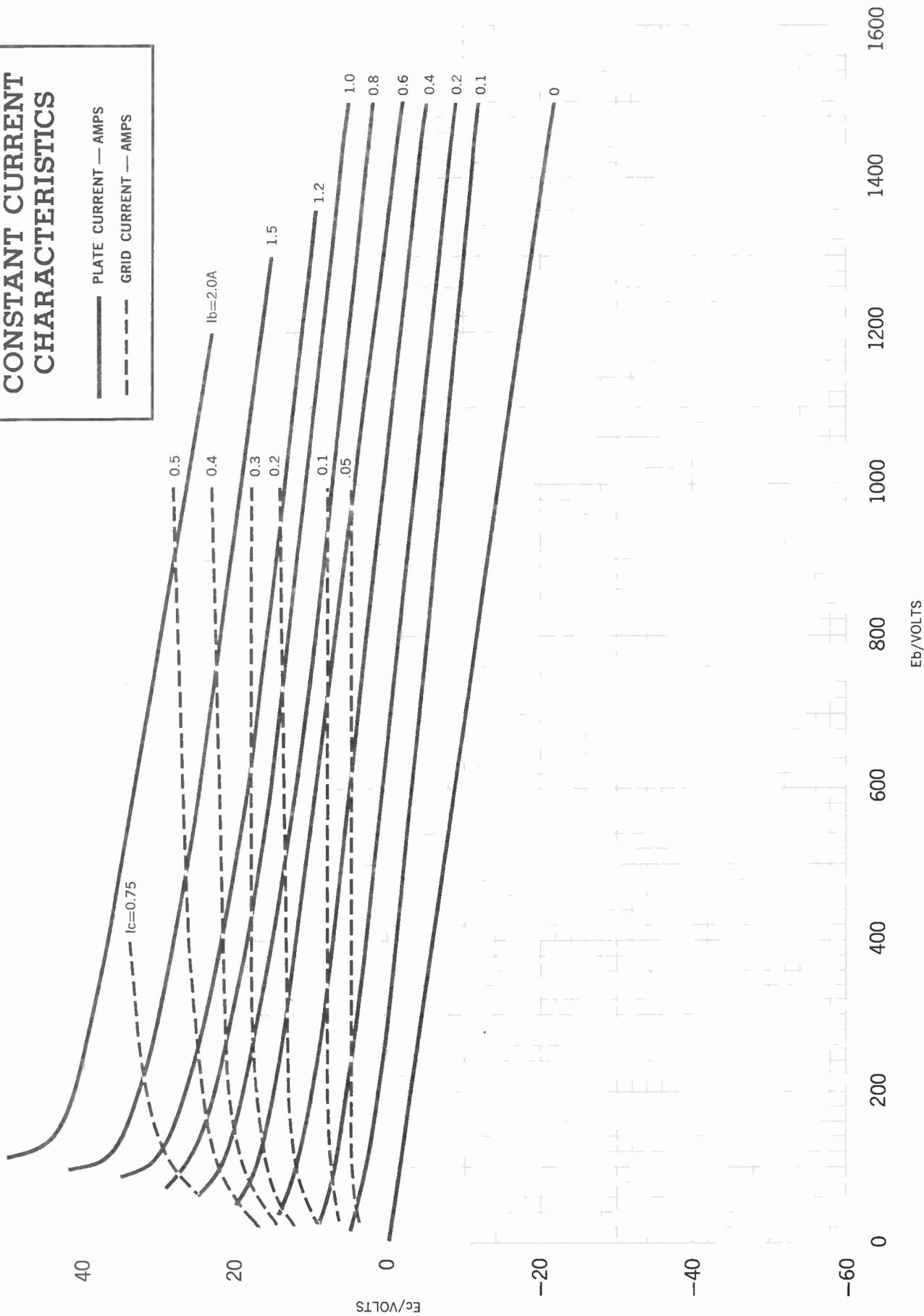
NOTES:

1. The total indicated runout of the anode contact surface and the grid contact surface with respect to the cathode contact surface shall not exceed .020.
2. The total indicated runout of the heater contact surface with respect to the cathode contact surface shall not exceed .012.



EIMAC 7211 CONSTANT CURRENT CHARACTERISTICS

— PLATE CURRENT — AMPS
- - - GRID CURRENT — AMPS





E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

7480

**VAPOR COOLED
 MEDIUM-MU
 POWER TRIODE**

The Eimac 7480 is a vapor cooled ceramic-metal triode designed for AM broadcast and communications amplifiers and for industrial heating service.

Low-loss ceramic and metal construction permits operation at full ratings at frequencies up to 40 MHz. Useful power output can be obtained at frequencies up to 80 MHz at reduced plate voltage.

The 7480 anode is capable of dissipating 80 kilowatts continuously, and higher power during intermittent operation or momentary overloads. A water cooled version of this tube, type 6696A, and a forced-air cooled version, type 6697A, are also available.



CHARACTERISTICS

ELECTRICAL

Filament: Thoriated-Tungsten	Min.	Nom.	Max.	
Voltage		13		V
Current	190		220	A
Amplification Factor		20		
Direct Interelectrode Capacitances				
Grid-Plate	50		60	pF
Grid-Filament	65		85	pF
Plate-Filament	2.0		3.2	pF
Frequency for Maximum Ratings			40	MHz

MECHANICAL

Recommended Terminal Connectors	Small Filament	Eimac SK-1610
	Large Filament	Eimac SK-1611
	Grid	Eimac SK-1612
Operating Position		Vertical, base up
Cooling		Vaporization of water
Maximum Seal Temperature		200° C
Recommended Boiler		Eimac BR-400 Series or equivalent
Maximum Height		20.1 in
Maximum Diameter		7.12 in
Net Weight		50 lbs

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony
 (Key-down conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	16.0 KV
DC GRID VOLTAGE	- - - -	-3200 VOLTS
DC PLATE CURRENT	- - - -	11 AMPS
DC GRID CURRENT	- - - -	2.0 AMPS
GRID DISSIPATION	- - - -	1000 WATTS
PLATE DISSIPATION	- - - -	80 KW

TYPICAL OPERATION

DC Plate Voltage	- - - -	10	15 kV
DC Grid Voltage	- - - -	-1200	-1600 volts
Peak RF Grid Voltage	- - - -	1900	2100 volts
DC Plate Current	- - - -	10.0	7.0 amps
DC Grid Current	- - - -	810	300 mA
Resonant Load Impedance	- - - -	440	970 ohms
Driving Power, approx.	- - - -	1500	600 watts
Plate Output Power, approx.	- - - -	72	80 kW

**PLATE-MODULATED RADIO-FREQUENCY
POWER AMPLIFIER**

Class-C Telephony (Carrier conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	10.0 KV
DC GRID VOLTAGE	- - - -	-3200 VOLTS
DC PLATE CURRENT	- - - -	8.5 AMPS
DC GRID CURRENT	- - - -	2.0 AMPS
GRID DISSIPATION	- - - -	1000 WATTS
PLATE DISSIPATION	- - - -	53 KW

TYPICAL OPERATION

DC Plate Voltage	- - - - -	9.5 kV
DC Grid Voltage	- - - - -	-1600 volts
Peak RF Grid Voltage	- - - - -	2300 volts
DC Plate Current	- - - - -	8.4 amps
DC Grid Current	- - - - -	900 mA
Resonant Load Impedance	- - - - -	510 ohms
Driving Power, approx.	- - - - -	2.0 kW
Plate Output Power, approx.	- - - - -	60 kW

**AUDIO-FREQUENCY AMPLIFIER
OR MODULATOR**

Class-AB

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	11.0 AMPS
PLATE DISSIPATION	- - - -	80 KW

TYPICAL OPERATION (Two Tubes).

DC Plate Voltage	- - - - -	10	12 kV
DC Grid Voltage	- - - - -	-450	-600 volts
Peak AF Driving Voltage (per tube)	- - - - -	875	1060 volts
Zero-Sig DC Plate Current	- - - - -	3.0	2.0 amps
Max-Sig DC Plate Current	- - - - -	17.4	20.0 amps
Load Resistance, Plate-to-Plate	- - - - -	1170	1230 ohms
Max-Sig Driving Power, approx.	- - - - -	550	600 watts
Max-Sig Plate Output Power, approx.	- - - - -	110	152 kW

RADIO-FREQUENCY AM LINEAR AMPLIFIER

Class-AB (Carrier conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	9.0 AMPS
PLATE DISSIPATION	- - - -	80 KW

TYPICAL OPERATION (AM Carrier conditions except
where noted).

DC Plate Voltage	- - - - -	12	12 kV
DC Grid Voltage	- - - - -	-550	-550 volts
Peak RF Grid Voltage	- - - - -	510	640 volts
DC Plate Current	- - - - -	4.3	6.8 amps
DC Grid Current	- - - - -	0	0 amps
Resonant Load Impedance	- - - - -	780	500 ohms
Driving Power, approx.*	- - - - -	450	1500 watts
Plate Output Power, approx.	- - - - -	18	28 kW

*At modulation crest.

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB, Single-Sideband Suppressed-Carrier Service

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - - -	16.0 KV
DC PLATE CURRENT	- - - -	11.0 AMPS
PLATE DISSIPATION	- - - -	80 KW

TYPICAL OPERATION (Peak-envelope or modulation-crest
conditions in cathode-drive circuit).

DC Plate Voltage	- - - - -	12	12 kV
DC Cathode Voltage	- - - - -	600	600 volts
Peak RF Driving Voltage	- - - - -	830	1020 volts
DC Plate Current	- - - - -	5.2	9.8 amps
DC Grid Current, approx.	- - - - -	60	200 mA
Resonant Load Impedance	- - - - -	880	700 ohms
Driving Power, approx.	- - - - -	3.5	8.2 kW
Plate Power Output, approx.	- - - - -	43	83 kW

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves. No allowance for circuit losses has been made.

APPLICATION

MECHANICAL

Mounting

The 7480 should be mounted vertically anode down in the boiler (Eimac type BR-400 or equivalent). Filament and grid connections are made through clamp rings or spring-finger contacts to the O.D. of the sturdy copper terminals of the tube. Satisfactory anode contact can be made to the boiler.

Anode Cooling

Efficient cooling is accomplished by vaporization of water in the boiler and transport of the vapor to a condenser at a temperature of about 100°C. The boiler, which is at anode potential, is isolated electrically from the rest of the system by sections of insulating pipe in the vapor and condensate return lines. The control box connected across the boiler on the ground side of the insulating tubes, displays the water level in the boiler, actuates warning or interlock circuits if the level is too low, and permits overflow if the level is too high. A reservoir is usually associated with the control box, either integral or remote, to replenish the system with distilled water as required.

Application information and typical system layout drawings are available from EIMAC. All accessory components and special hardware is available from Eimac except condensers, for which commercial sources exist.

Base Cooling

Forced-air cooling of the ceramic base and seals may be required, depending on ambient conditions and operating frequency. Air flow rate and direction should be determined to limit envelope temperatures to 200°C maximum and to maintain uniform temperature distribution around the seals. Spot temperatures are conveniently measured with Tempilaq (spray type) or equivalent. Often a flow of about 100 cfm, directed axially downward towards the tube, is sufficient.

ELECTRICAL

Filament Operation

The rated filament voltage, as measured at the tube terminals, should be maintained within $\pm 5\%$ to assure long life and good performance within the rated power capability of the tube. To accommodate special requirements, the filament voltage may be centered near either of these extremes, e.g. at plus 5 percent for exceptionally high emission at a sacrifice of life, or at minus 5 percent for exceptionally long life where perhaps only half the full emission capability is required.

Grid Dissipation

Grid dissipation should be limited to 1,000 watts maximum. Grid dissipation may be calculated approximately as the product of peak positive grid voltage and dc grid current.

In many r-f amplifier applications where it is impractical to measure the positive grid voltage, the dc grid current rating serves as a satisfactory guide. The maximum dc grid current rating under normal full load conditions is 2 amperes. In most cases, however, high power output and good efficiency can be realized with grid current less than one ampere. By limiting the grid current in this manner there is obviously more latitude for grid current excursions resulting from changes in loading.

High Frequency Operation

The maximum ratings listed apply at frequencies up to 40 MHz. Useful output can be obtained at higher frequencies of the plate voltage and plate input power are reduced accordingly. For operation up to 60 MHz these parameters should be reduced to 75% of the listed dc plate voltage rating; for operation up to 80 MHz they should be reduced to 50%.

Aging

The manner of operating most high power tubes differs in at least some respects from conditions under which the tubes are tested, therefore, some aging is almost always required to condition a new tube to its new environment. In basic terms, the different operating conditions are manifest as different distributions of heat and voltage gradients. Satisfactory aging is most easily achieved by gradual application of voltages, e.g. first filament voltage, then partial plate voltage, and drive, working up to the final values. If continuous or stepped plate voltage control is not used, sufficient load should be connected before snapping on full voltage to limit transients to about 120% of the dc voltage.

Tube Protection

Since the possibility of fault overloads due to occasional tube or circuit instabilities is ever present, good engineering practice holds that suitable protective circuitry and devices be included in the equipment. In addition to the standard overcurrent relays, some series resistance should be placed in the output of the power supply to limit surge currents. In cases where no filter is used, the resistors may be placed in each rectifier lead to reduce the power loss during normal operation. In certain applications, furthermore, it is helpful to attach sphere gaps or rings to the tube terminals to divert any excessive transient voltages from the envelope and seals.

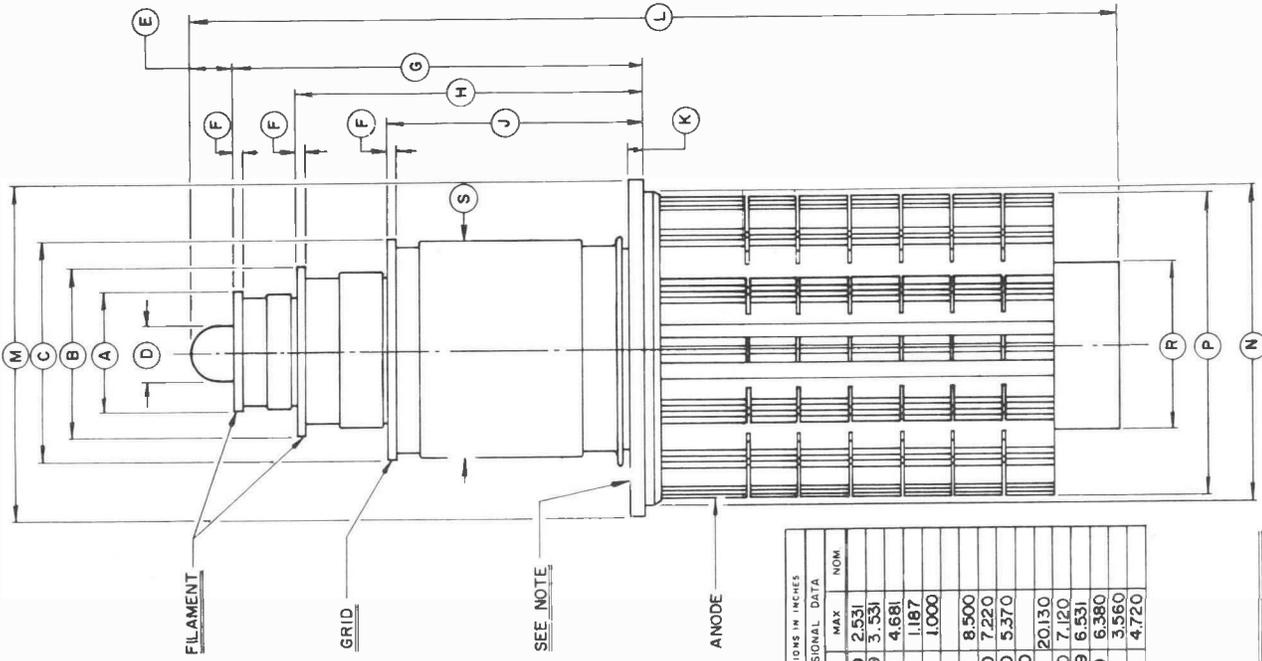
The use of an electronic fault diverter, or "crowbar" is probably the best way to insure high performance reliability and freedom from gassing or catastrophic failures. The crowbar system consists of circuitry to sense incipient fault currents and trigger the crowbar device, which is connected to short the power supply energy to ground, preferably within about 10 microseconds. The crowbar device, which is usually an ignitron, hydrogen thyratron, or spark gap, diverts most of the fault energy from the protected tube until the relay and circuit breakers open.

Special Applications

If it is desired to operate this tube under conditions widely different from those given herein, write to EIMAC, Division of Varian, 301 Industrial Way, San Carlos, California 94070.

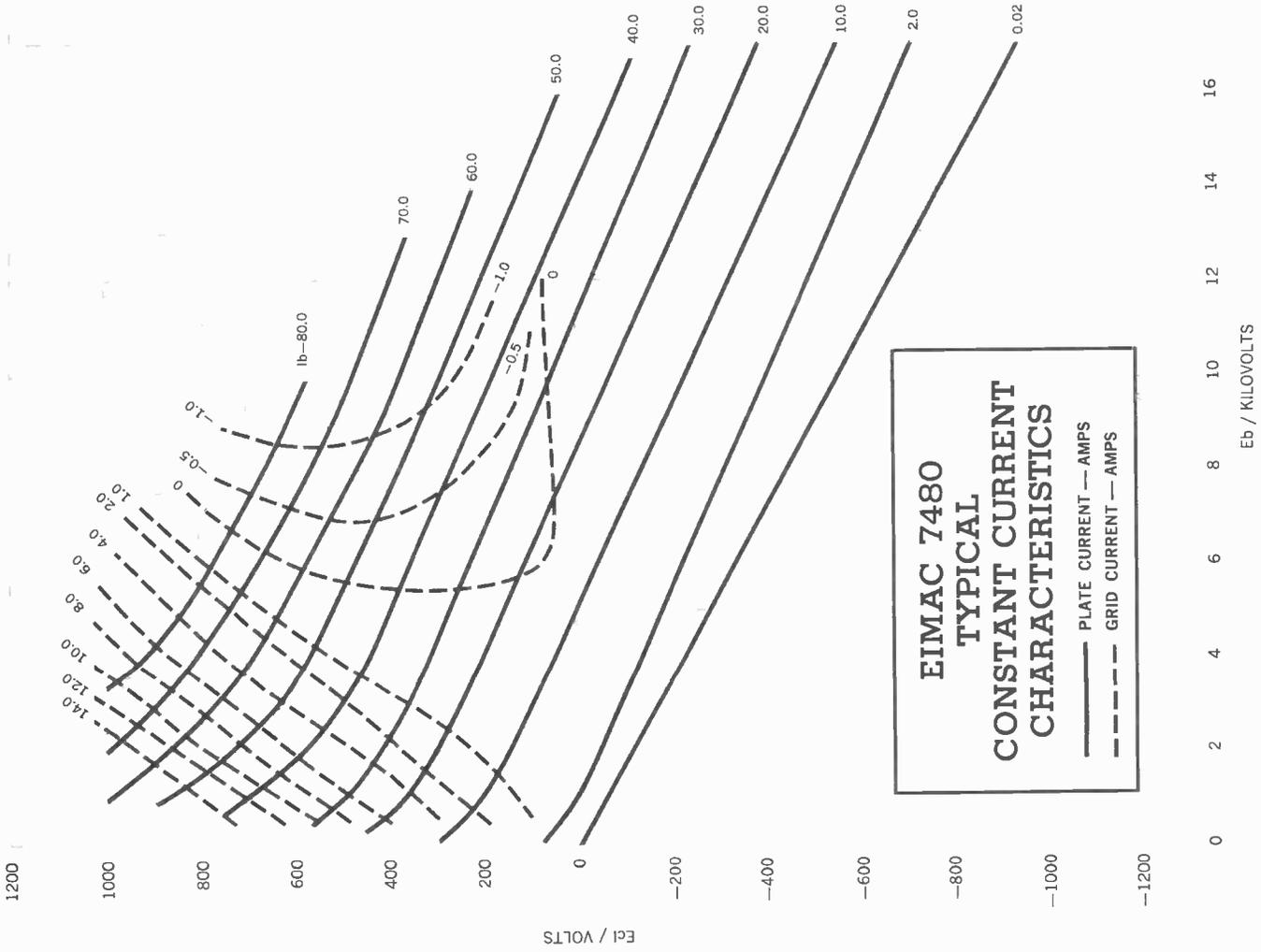


7480



REF	DIMENSIONS IN INCHES		
	MIN	MAX	NOM
A	2.469	2.531	
B	3.469	3.531	
C	4.619	4.681	
D		1.187	
E	.156	1.000	
F	6.120	8.500	
G	6.900	7.220	
H	5.250	5.370	
J		2.250	
K		20.130	
L		7.000	
M		6.469	
N		6.120	
P		6.380	
R		3.560	
S		4.720	

NOTE:
 3 HOLES, 1/4-20 TAP, .38 DEEP
 EQUALLY SPACED ON 5.740-.5760
 POINT CIRCLE, FOR LIFTING.





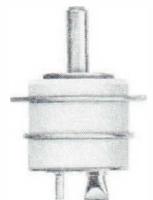
TECHNICAL DATA

PRELIMINARY DATA

8892

PLANAR TRIODE

The 8892 is a compact, rugged ceramic/metal planar triode intended for CW use or as a plate- or grid-pulsed oscillator or amplifier. It features high power output, high plate efficiency and excellent frequency stability under severe environmental conditions. The construction of the 8892 readily lends itself to cavity circuit operation resulting in an extremely compact rf source. The 8892 is capable of providing in excess of 1 kW peak power at 6 GHz.



GENERAL CHARACTERISTICS¹

ELECTRICAL

Cathode: Oxide Coated, Unipotential

Heater: Voltage	6.3 (±5%) V
Current, at 6.3 volts	0.65 A
Cathode Heating Time	60 sec.
Transconductance (Average)	30 mmhos
Amplification Factor (Average)	60
Direct Interelectrode Capacitance, without heater voltage	
Grid-Cathode	5.00 pF
Grid-Plate	1.60 pF
Plate-Cathode (maximum)	0.06 pF
Plate Dissipation (maximum) ²	50 W
Grid Dissipation (maximum)	1.5 W

1. The data presents the nominal design objectives for this product and the characteristics and specifications of this type are subject to change. The device is now under development and is made available for experimental purposes only. For the most recent information concerning the status of this development, please contact your nearest Varian Electron Tube and Device Field Office or the Product Manager, Eimac Division of Varian, Salt Lake City, Utah.

2. With forced air cooling or appropriate conduction and/or convection cooling.

MECHANICAL

Maximum Overall Dimensions:

Length	1.059 in; 26.90 mm
Diameter	0.758 in; 19.3 mm
Net Weight	0.25 oz; 7.0 gm
Operating Position	Any
Maximum Operating Temperature:	
Ceramic/Metal Seals	250°C
Cooling	Conduction and Forced Air

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RF OSCILLATOR

Class C, Pulsed

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	2.0 kVdc
PEAK PLATE VOLTAGE	2.5 kv
DC PLATE CURRENT	100 mAdc
DC GRID CURRENT	30 mAdc
PEAK PLATE CURRENT	3.0 a
PEAK GRID CURRENT	1.2 a

DC GRID VOLTAGE	-100 Vdc
PULSE DURATION ¹	3.0 μ s
DUTY FACTOR ¹ . . . . .	.0025
PEAK HEATER-CATHODE VOLTAGE ²	\pm 50 V
FREQUENCY	6.0 GHz

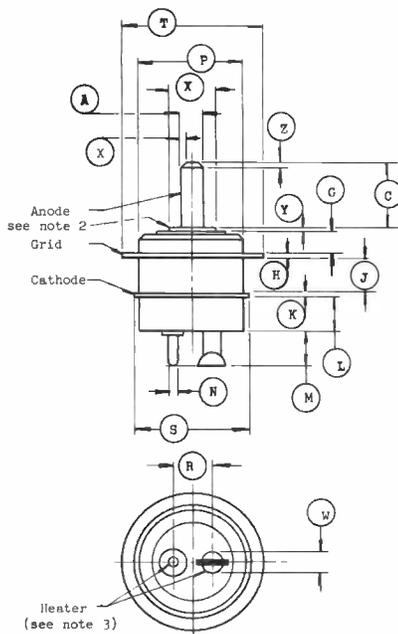
1. For applications requiring longer pulse duration and/or higher duty factor, please consult the Product Manager, EIMAC-Division of Varian, Salt Lake City, Utah.
2. The heater is electrically isolated from the cathode.

APPLICATION

The cathode and grid flanges should not be altered in any way such as by machining or filing, since final seal could be damaged. Maximum torque applied to flanges during installation should not exceed 15 inch pounds.

For optimum rf performance, the anode line should make good rf contact on the anode area indicated in the outline drawing.

Soldered connections may be made to the anode stud, grid or cathode flanges, and heater contacts where adequate heat sinking and good soldering practices are followed to minimize the heat applied to the tube and the thermal gradient across the metal to ceramic brazed areas.



DIM.	DIMENSIONAL DATA					
	INCHES			MILLIMETERS		
	MIN	MAX	REF	MIN	MAX	REF
A	0.122	0.128	--	3.10	3.25	--
C	0.325	0.335	--	8.26	8.51	--
G	0.120	0.130	--	3.05	3.30	--
H	0.025	0.031	--	0.64	0.79	--
J	0.167	0.177	--	4.24	4.50	--
K	0.025	0.031	--	0.64	0.79	--
L	0.170	0.185	--	4.32	4.70	--
M	0.170	0.190	--	4.32	4.83	--
N	0.047	0.053	--	1.19	1.35	--
P	0.535	0.565	--	13.59	14.35	--
R	0.185	0.215	--	4.70	5.46	--
S	0.598	0.608	--	15.19	15.44	--
T	0.748	0.758	--	19.00	19.25	--
W	--	--	0.100	--	--	2.54
X	0.250	0.260	--	6.35	6.60	--
Y	--	0.020	--	--	0.51	--

- Note:
1. Ref. Dims. are for info. only & are not req'd. for inspection purposes.
 2. For optimum rf performance the Anode line should make rf contact at this point on the Anode Cup.
 3. Heater is electrically isolated from cathode.



TECHNICAL DATA

PRELIMINARY DATA

8893

PLANAR TRIODE

The 8893 is a compact, rugged ceramic/metal planar triode intended for CW use or as a plate- or grid-pulsed oscillator or amplifier. It features high power output, high plate efficiency and excellent frequency stability under severe environmental conditions. The construction of the 8893 readily lends itself to cavity circuit operation resulting in an extremely compact rf source.



GENERAL CHARACTERISTICS¹

ELECTRICAL

Cathode: Oxide Coated, Unipotential

Heater: Voltage	6.3 (±5%) V
Current, at 6.3 volts	1.3 A
Cathode Heating Time	60 sec.
Transconductance (Average)	30 mmhos
Amplification Factor (Average)	60
Direct Interelectrode Capacitance, without heater voltage	
Grid-Cathode	8.00 pF
Grid-Plate	2.35 pF
Plate-Cathode (maximum)	0.10 pF
Plate Dissipation (maximum) ²	100 W
Grid Dissipation (maximum)	1.5 W

1. The data presents the design objectives for this product and the characteristics and specifications of this type are subject to change. The device is now under development and is made available for experimental purposes only. For the most recent information concerning the status of this development, please contact your nearest Varian Electron Tube and Device Field Office or the Product Manager, Eimac Division of Varian, Salt Lake City, Utah.
2. With forced air cooling or appropriate conduction and/or convection cooling.

MECHANICAL

Maximum Overall Dimensions:

Length	1.074 in; 27.30 mm
Diameter	0.758 in; 19.30 mm
Net Weight	0.35 oz; 10.0 gm
Operating Position	Any
Maximum Operating Temperature:	
Ceramic/Metal Seals	250°C
Cooling	Forced Air



RF OSCILLATOR
Class C, Pulsed

ABSOLUTE MAXIMUM RATINGS

DC PLATE VOLTAGE	2.0 kVdc
PEAK PLATE VOLTAGE	3.5 kv
DC PLATE CURRENT	150 mA _{dc}
DC GRID CURRENT	45 mA _{dc}
PEAK PLATE CURRENT	5.0 a
PEAK GRID CURRENT	1.5 a
DC GRID VOLTAGE	-100 Vdc
PULSE DURATION ¹	6.0 μs
DUTY FACTOR ¹	.004
PEAK HEATER-CATHODE VOLTAGE ²	±50 V
FREQUENCY	4.0 GHz

1. For applications requiring longer pulse duration and/or higher duty factor, please consult the Product Manager, EIMAC-Division of Varian, Salt Lake City, Utah.
2. The heater is electrically isolated from the cathode.

REPRESENTATIVE OPERATION (Grid-Pulsed Oscillator)

Frequency	2.5 GHz
Heater Voltage	6.3 V
Heater Current	1.3 A
Duty Factor	0.01 maximum
Pulse Width	30 microseconds maximum
Peak Plate Voltage	1.5 kv
Peak Plate Current	3a maximum
Power Output (useful)	1 kw, minimum

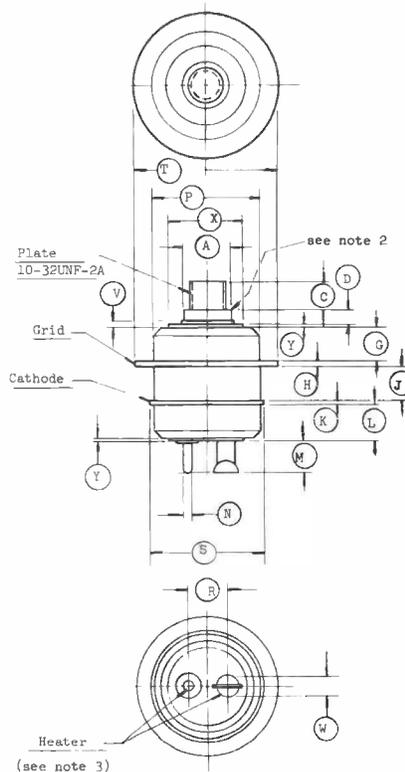
APPLICATION

The cathode and grid flanges should not be altered in any way such as by machining or filing, since final seal could be damaged. Maximum torque applied to flanges during installation should not exceed 15 inch pounds.

For optimum rf performance, the anode line should make good rf contact on the anode area indicated in the outline drawing.

For further details on cooling or other aspects of tube operation, refer to the "Application Notes for Planar Triodes" bulletin which can be obtained on request.

DIM.	INCHES			MILLIMETERS		
	MIN	MAX	REF	MIN	MAX	REF
A	0.247	0.253	--	6.27	6.43	--
C	0.120	0.160	--	3.05	4.06	--
D	0.070	0.090	--	1.78	2.29	--
G	0.182	0.192	--	4.62	4.88	--
H	0.025	0.031	--	0.64	0.79	--
J	0.170	0.180	--	4.32	4.57	--
K	0.025	0.031	--	0.64	0.79	--
L	0.170	0.180	--	4.32	4.57	--
M	0.170	0.190	--	4.32	4.83	--
N	0.047	0.053	--	1.19	1.35	--
P	0.635	0.665	--	16.13	16.89	--
R	0.186	0.214	--	4.72	5.44	--
S	0.698	0.708	--	17.73	17.98	--
T	0.748	0.758	--	19.00	19.25	--
V	--	0.040	--	--	1.02	--
W	--	--	0.100	--	--	2.54
X	0.545	0.570	--	13.84	14.48	--
Y	--	0.020	--	--	0.51	--



- Notes: 1. Ref Dims. are for info. only and are not reqd for insp. purposes.
 2. For optimum rf performance the Anode line should make rf contact at this point on the Anode Cup.
 3. Heater is electrically isolated from cathode.



TECHNICAL DATA

PRELIMINARY DATA

8911

PLANAR TRIODE

The 8911 (formerly X2153) is a compact, rugged ceramic/metal planar triode intended for CW plate- or grid-pulsed oscillator, amplifier, or frequency multiplier use. It features high power output, high plate dissipation and excellent frequency stability under severe environmental conditions. The construction of the 8911 readily lends itself to cavity circuit operation resulting in an extremely compact rf source. The 8911 is capable of providing in excess of 1 kw peak power at 6 GHz.



Actual Size

GENERAL CHARACTERISTICS¹

ELECTRICAL

Cathode: Oxide Coated, Unipotential

Heater: Voltage 6.3 ± 5% V

Current, at 6.3 volts 0.65 A

Cathode Heating Time 60 sec.

Transconductance (Average) 30 mmhos

Amplification Factor (Average) 60

Direct Interelectrode Capacitance, without heater voltage

Grid-Cathode 5.00 pF

Grid-Plate 1.50 pF

Plate-Cathode (maximum) 0.06 pF

Plate Dissipation (maximum)². 50 W

Grid Dissipation (maximum) 1.5 W

1. The data presents the nominal design objectives for this product and the characteristics and specifications of this type are subject to change. The device is now under development and is made available for experimental purposes only. For the most recent information concerning the status of this development, please contact your nearest Varian Electron Tube and Device Field Office or the Product Manager, Eimac Division of Varian, Salt Lake City, Utah.

2. With forced air cooling or appropriate conduction and/or convection cooling.

MECHANICAL

Maximum Overall Dimensions:

Length 0.943 in; 23.95 mm

Diameter 0.758 in; 19.25 mm

Net Weight 0.25 oz; 7.0 gm

Operating Position Any

Maximum Operating Temperature:

Ceramic/Metal Seals 250°C

Cooling Conduction and Forced Air

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RF OSCILLATOR

Class C, Pulsed

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	2.0 kVdc
PEAK PLATE VOLTAGE	3.0 kv
DC PLATE CURRENT	100 mAdc
DC GRID CURRENT	30 mAdc
PEAK PLATE CURRENT	3.0 a
PEAK GRID CURRENT	1.2 a

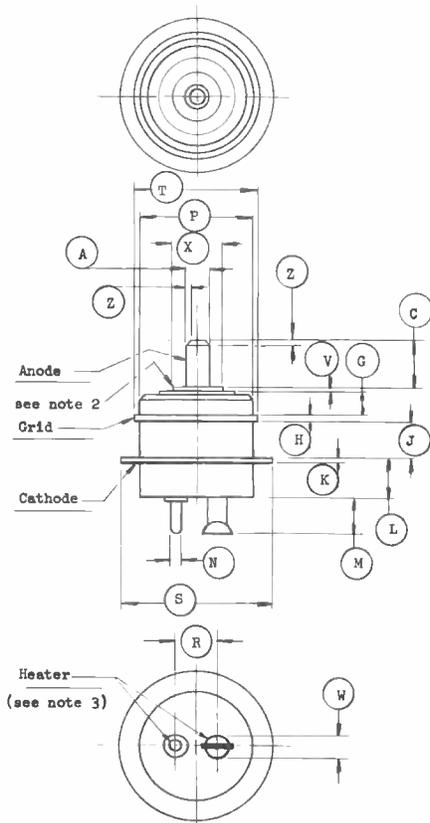
DC GRID VOLTAGE	-100 Vdc
PULSE DURATION ¹	3.0 μ s
DUTY FACTOR ¹ . . . . .	.0025
PEAK HEATER-CATHODE VOLTAGE ²	\pm 50 v
FREQUENCY	6.0 GHz

1. For applications requiring longer pulse duration and/or higher duty factor, please consult the Product Manager, EIMAC-Division of Varian, Salt Lake City, Utah.
2. The heater is electrically isolated from the cathode.

APPLICATION

The cathode and grid flanges should not be altered in any way such as by machining or filing, since final seal could be damaged. Maximum torque applied to flanges during installation should not exceed 15 inch pounds. For optimum rf performance, the anode line should make good rf contact on the anode area indicated in the outline drawing.

Soldered connections may be made to the anode stud, grid or cathode flanges, and heater contacts where adequate heat sinking and good soldering practices are followed to minimize the heat applied to the tube and the thermal gradient across the metal to ceramic brazed areas. For operating information refer to EIMAC bulletin #15, "Operating Instructions for Planar Triodes".



DIM.	DIMENSIONAL DATA					
	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	0.122	0.128	--	3.10	3.25	--
B	0.200	0.210	--	5.08	5.33	--
C	0.120	0.130	--	3.05	3.30	--
H	0.025	0.031	--	0.64	0.79	--
J	0.167	0.177	--	4.24	4.50	--
K	0.025	0.031	--	0.64	0.79	--
L	0.170	0.185	--	4.32	4.70	--
M	0.170	0.190	--	4.32	4.83	--
N	0.047	0.053	--	1.19	1.35	--
P	0.535	0.565	--	13.59	14.35	--
R	0.185	0.215	--	4.70	5.46	--
S	0.748	0.758	--	19.00	19.30	--
T	0.598	0.608	--	15.19	15.44	--
V	--	0.020	--	--	0.51	--
W	--	--	0.100	--	--	2.54
X	0.250	0.260	--	6.35	6.60	--
Z	--	--	0.030	--	--	0.76

- Notes:
1. Ref. dims. are for info. only & are not required for insp. purposes.
 2. For optimum rf performance the Anode Line should contact the Anode Cup at this point.
 3. Heater is electrically isolated from Cathode.



TECHNICAL DATA

PRELIMINARY DATA

8912

PLANAR TRIODE

The 8912 (formerly X2154) is a compact, rugged ceramic/metal planar triode intended for CW plate- or grid-pulsed oscillator, amplifier, or frequency multiplier use. It features high power output, high plate dissipation and excellent frequency stability under severe environmental conditions. The construction of the 8912 readily lends itself to cavity circuit operation resulting in an extremely compact rf source. The 8912 is capable of providing in excess of 1 kw peak power at 6 GHz.



Actual Size

GENERAL CHARACTERISTICS¹

ELECTRICAL

Cathode: Oxide Coated, Unipotential

Heater: Voltage	6.3 ± 5% V	
Current, at 6.3 volts	0.65 A	
Cathode Heating Time	60 sec.	
Transconductance (Average)	30 mmhos	
Amplification Factor (Average)	85	
Direct Interelectrode Capacitance, without heater voltage		
Grid-Cathode		5.00 pF
Grid-Plate		1.50 pF
Plate-Cathode (maximum)		0.06 pF
Plate Dissipation (maximum) ²		50 W
Grid Dissipation (maximum)		1.5 W

1. The data presents the nominal design objectives for this product and the characteristics and specifications of this type are subject to change. The device is now under development and is made available for experimental purposes only. For the most recent information concerning the status of this development, please contact your nearest Varian Electron Tube and Device Field Office or the Product Manager, Eimac Division of Varian, Salt Lake City, Utah.
2. With forced air cooling or appropriate conduction and/or convection cooling.

MECHANICAL

Maximum Overall Dimensions:

Length	1.013 in; 25.73 mm
Diameter	0.608 in; 15.44 mm
Net Weight	0.25 oz; 7.0 gm
Operating Position	Any
Maximum Operating Temperature:	
Ceramic/Metal Seals	250°C
Cooling	Conduction and Forced Air

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RF OSCILLATOR

Class C, Pulsed

ABSOLUTE MAXIMUM RATINGS:

DC PLATE VOLTAGE	2.0 kVdc
PEAK PLATE VOLTAGE	2.5 kv
DC PLATE CURRENT	100 mA _{dc}
DC GRID CURRENT	30 mA _{dc}
PEAK PLATE CURRENT	3.0 a at .0025 DUTY
	1.5 a at .01 DUTY
PEAK GRID CURRENT	1.2 a at .0025 DUTY
	0.7 a at .01 DUTY

DC GRID VOLTAGE	-100 Vdc
PULSE DURATION ¹	3.0 μs
DUTY FACTOR ¹ . . . . .	.01
PEAK HEATER-CATHODE VOLTAGE ²	±50 v
FREQUENCY	6.0 GHz

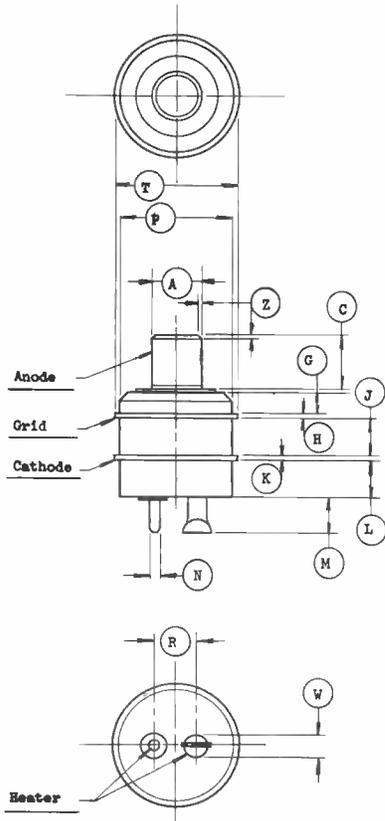
1. For applications requiring longer pulse duration and/or higher duty factor, please consult the Product Manager, EIMAC-Division of Varian, Salt Lake City, Utah.
2. The heater is electrically isolated from the cathode.

APPLICATION

The cathode and grid flanges should not be altered in any way such as by machining or filing, since final seal could be damaged. Maximum torque applied to flanges during installation should not exceed 15 inch pounds.

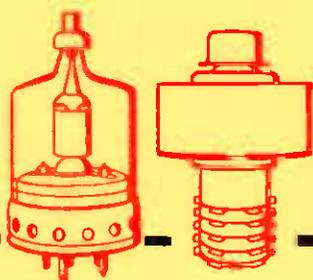
For optimum rf performance, the anode line should make good rf contact on the anode area indicated in the outline drawing.

Soldered connections may be made to the anode stud, grid or cathode flanges, and heater contacts where adequate heat sinking and good soldering practices are followed to minimize the heat applied to the tube and the thermal gradient across the metal to ceramic brazed areas. For operating information refer to EIMAC bulletin #15, "Operating Instructions for Planar Triodes".



DIM.	DIMENSIONAL DATA					
	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	0.245	0.260	--	6.22	6.60	--
C	0.240	0.255	--	6.10	6.48	--
G	0.120	0.155	--	3.05	3.93	--
H	0.025	0.031	--	0.64	0.79	--
J	0.167	0.177	--	4.24	4.50	--
K	0.025	0.031	--	0.64	0.79	--
L	0.170	0.185	--	4.32	4.70	--
M	0.170	0.190	--	4.32	4.83	--
N	0.047	0.053	--	1.19	1.35	--
P	0.535	0.565	--	13.59	14.35	--
R	0.185	0.215	--	4.70	5.46	--
T	0.598	0.608	--	15.19	15.44	--
W	--	--	0.100	--	--	2.54

Note;
1. Ref. Dims. are for info. only and are not req'd. for inspection purposes.



tetrodes • pentodes ▶

Look in the general section for---

- Your nearest distributor of modern, fully guaranteed Eimac electron tubes and electron tube accessories.
- Your nearest Eimac Field Engineer, who stands ready to give you immediate engineering assistance, information on deliveries and prices, or provide other information not found in the catalog.
- Eimac tube type numbering system.
- Tube Replacement Chart.
- Prices on Eimac products.

IMPORTANT EIMAC "EXTRAS"

Application Engineering. The Eimac Application Engineering Department is available at all times for consultation. New tube operating techniques are continually being explored, tested and proved by Eimac engineers, whose combined knowledge and experience are at your service. Additional contributions by this Eimac department are its Application Bulletins, a service which you receive without obligation.

Field Engineering. Serving as an extension of the Application Engineering Department outside the Eimac plant, Eimac Field Engineers cover the United States, operating out of offices in major cities. They will help you personally with experimental work, problems of technique, etc. Engineers from Eitel-McCullough, Inc. are available, too, for field consultation throughout the country. As Eimac tubes are world renowned, the same services extend to various countries overseas through the Eimac Export Department.



EITEL-McCULLOUGH, INC.
SAN BRUNO - CALIFORNIA

4-65A

**RADIAL-BEAM
POWER TETRODE**

**MODULATOR
OSCILLATOR
AMPLIFIER**

The Eimac 4-65A is a small radiation-cooled transmitting tetrode having a maximum plate-dissipation rating of 65 watts. The plate operates at a red color at maximum dissipation. Short, heavy leads and low interelectrode capacitances contribute to stable efficient operation at high frequencies.

Although it is capable of withstanding high plate voltages, the internal geometry of the 4-65A is such that it will deliver relatively high power output at a low plate voltage.

The quick-heating filament allows conservation of power during standby periods in mobile applications.



GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	6.0 volts
Current	3.5 amperes
Grid-Screen Amplification Factor (Average)	5
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.08 $\mu\mu\text{f}$
Input	8.0 $\mu\mu\text{f}$
Output	2.1 $\mu\mu\text{f}$
Transconductance (Ib = 125 ma., Eb = 500 v., Ec ₂ = 250 v.)	4000 μmhos
Frequency for Maximum Ratings	150 Mc.

MECHANICAL

Base	5-pin—Fits	{ National HX-29 Socket Johnson 122-101 Socket Vertical, base down or up Convection and Radiation Eimac HR-6
Mounting		
Cooling		
Recommended Heat Dissipating Connector		
Maximum Over-all Dimensions		
Length		4.38 inches
Diameter		2.38 inches
Net Weight		3 ounces
Shipping Weight		1.5 pounds

► **RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR**

Class-C Telephony or FM Telephony

MAXIMUM RATINGS (Key-down conditions, per tube)

D-C PLATE VOLTAGE	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	150 MAX. MA
PLATE DISSIPATION	65 MAX. WATTS
SCREEN DISSIPATION	10 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION

D-C Plate Voltage	600	1000	1500	2000	3000	volts
D-C Screen Voltage	250	250	250	250	250	volts
D-C Grid Voltage	—75	—80	—85	—90	—100	volts
D-C Plate Current	150	150	150	140	115	ma
D-C Screen Current*	40	40	40	40	22	ma
D-C Grid Current*	18	17	18	11	10	ma
Peak R-F Grid Voltage	170	175	180	190	170	volts
Driving Power*	3.1	3.0	3.2	2.1	1.7	watts
Screen Dissipation*	10	10	10	10	5.5	watts
Plate Power Input	90	150	225	280	345	watts
Plate Dissipation	45	55	60	65	65	watts
Plate Power Output	45	95	165	215	280	watts

*Approximate values.

► **PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER**

Class-C Telephony (Carrier conditions unless otherwise specified, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	2500 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	120 MAX. MA
PLATE DISSIPATION	45 MAX. WATTS
SCREEN DISSIPATION	10 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION

D-C Plate Voltage	600	1000	1500	2000	2500	volts
D-C Screen Voltage	250	250	250	250	250	volts
D-C Grid Voltage	—120	—125	—125	—130	—135	volts
D-C Plate Current	120	120	120	120	110	ma
D-C Screen Current*	40	40	40	40	25	ma
D-C Grid Current*	15	16	16	16	12	ma
Screen Dissipation*	10	10	10	10	6.3	watts
Peak A-F Screen Voltage, 100% Modulation	250	250	250	250	250	volts
Peak R-F Grid Voltage	215	220	220	225	215	volts
Driving Power*	3.2	3.5	3.5	3.6	2.6	watts
Plate Power Input	72	120	180	240	275	watts
Plate Dissipation	27	30	40	45	45	watts
Plate Power Output	45	90	140	195	230	watts

*Approximate values.

Note: Typical operation data are based on conditions of adjusting the r-f grid drive to a specified plate current, maintaining fixed conditions of grid bias and screen voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid and screen currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

▶ AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	- - - - -	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	- - - - -	600 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT, PER TUBE	- - - - -	150 MAX. MA
PLATE DISSIPATION, PER TUBE	- - - - -	65 MAX. WATTS
SCREEN DISSIPATION, PER TUBE	- - - - -	10 MAX. WATTS

TYPICAL OPERATION

Class-AB₁ (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	- - - - -	1000	1500	1750	volts
D-C Screen Voltage	- - - - -	500	500	500	volts
D-C Grid Voltage ¹	- - - - -	-100	-110	-115	volts
Zero-Signal D-C Plate Current	- - - - -	60	60	40	ma
Max-Signal D-C Plate Current	- - - - -	170	180	170	ma
Max-Signal D-C Screen Current*	- - - - -	30	20	23	ma
Max-Signal D-C Grid Current	- - - - -	0	0	0	
Effective Plate-to-Plate Load	- - - - -	9000	15,000	20,000	ohms
Peak A-F Grid Voltage (per tube)	- - - - -	85	85	90	volts
Max-Signal Plate Power Input	- - - - -	170	270	300	watts
Max-Signal Plate Power Output	- - - - -	80	145	175	watts

*Approximate value.

¹Adjust to stated zero-signal D-C Plate Current.

The effective grid circuit resistance for each tube must not exceed 250,000 ohms.

TYPICAL OPERATION

Class-AB₂ (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	- - - - -	600	1000	1500	1800	volts
D-C Screen Voltage	- - - - -	250	250	250	250	volts
D-C Grid Voltage**	- - - - -	-40	-40	-45	-50	volts
Zero-Signal D-C Plate Current	- - - - -	60	60	60	50	ma
Max-Signal D-C Plate Current	- - - - -	300	300	250	220	ma
Max-Signal D-C Screen Current*	- - - - -	80	60	40	30	ma
Effective Plate-to-Plate Load	- - - - -	3600	6800	14,000	20,000	ohms
Peak A-F Grid Voltage (per tube)	- - - - -	120	105	100	90	volts
Max-Signal Peak Driving Power*	- - - - -	7.4	6.0	3.8	2.6	watts
Max-Signal Nominal Driving Power*	- - - - -	3.7	3.0	1.9	1.3	watts
Max-Signal Plate Power Input	- - - - -	160	300	375	395	watts
Max-Signal Plate Power Output	- - - - -	90	170	250	270	watts

*Approximate values.

**Adjust to stated Zero-Signal D-C Plate Current.

▶ RADIO-FREQUENCY LINEAR POWER AMPLIFIER SINGLE SIDE BAND SUPPRESSED CARRIER

Class-B (One tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	- - - - -	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	- - - - -	600 MAX. VOLTS
PLATE DISSIPATION	- - - - -	65 MAX. WATTS
SCREEN DISSIPATION	- - - - -	10 MAX. WATTS
GRID DISSIPATION	- - - - -	5 MAX. WATTS

*Adjust to stated Zero-Signal Plate Current.

**Approximate values.

***Due to the intermittent nature of voice, average dissipation is considerably less than Max-Signal Dissipation. If the amplifier is to be tested using a sine-wave signal source, arrangements must be made to lower the duty.

TYPICAL OPERATION

Class-AB₂ (Voice wave only, per tube)

D-C Plate Voltage	- - - - -	1500	2000	2500	volts
D-C Screen Voltage	- - - - -	300	400	500	volts
D-C Grid Voltage*	- - - - -	-55	-80	-105	volts
Zero-Signal D-C Plate Current	- - - - -	35	25	20	ma
Max-Signal D-C Plate Current	- - - - -	200	270	230	ma
Max-Signal D-C Screen Current**	- - - - -	45	65	45	ma
Max-Signal Peak R-F Grid Voltage	- - - - -	150	190	165	volts
Max-Signal D-C Grid Current**	- - - - -	15	20	8	ma
Max-Signal Driving Power**	- - - - -	2.3	3.8	1.3	watts
Max-Signal Plate Power Input	- - - - -	300	540	575	watts
Max-Signal Plate Dissipation***	- - - - -	105	190	225	watts
Average Plate Dissipation	- - - - -	60	65	50	watts
Max-Signal Useful Power Output	- - - - -	150	300	325	watts

IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATIONS," POSSIBLY EXCEEDING MAXIMUM RATINGS, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.



APPLICATION

MECHANICAL

Mounting—The 4-65A must be mounted vertically, base up or base down. The socket must provide clearance for the glass tip-off which extends from the center of the base. A flexible connecting strap should be provided between the plate terminal and the external plate circuit, and the Eimac HR-6 cooler (or equivalent) used on the tube plate lead. The socket must not apply lateral pressure against the base pins. The tube must be protected from severe vibration and shock.

Adequate ventilation must be provided so that the seals and envelope under operating conditions do not exceed 225°C. For operation above 50 Mc., the plate voltage should be reduced, or special attention should be given to seal cooling.

In intermittent-service applications where the "on" time does not exceed a total of five minutes in any ten minute period, plate seal temperatures as high as 250°C are permissible. When the ambient temperature does not exceed 30°C it will not ordinarily be necessary to provide forced cooling of the bulb and plate seal to hold the temperature below this maximum at frequencies below 50 Mc, provided that a heat-radiating plate connector is used, and the tube is so located that normal circulation of air past the envelope is not impeded.

ELECTRICAL

Filament Voltage—The filament voltage, as measured directly at the filament pins, should be between 5.7 volts and 6.3 volts.

Bias Voltage—D-C bias voltage for the 4-65A should not exceed -500 volts. If grid-leak bias is used, suitable protective means must be provided to prevent excessive plate or screen dissipation in the event of loss of excitation.

Grid Dissipation—Grid dissipation for the 4-65A should not be allowed to exceed five watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} I_c$$

where P_g = Grid dissipation,
 e_{cmp} = Peak positive grid voltage, and
 I_c = D-c grid current.

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid.*

Screen Voltage—The D-C screen voltage for the 4-65A should not exceed 400 volts except in the case of class-AB audio operation and Single Side Band R-F amplifier operation where it should not exceed 600 volts.

Screen Dissipation—The power dissipated by the screen of the 4-65A must not exceed 10 watts. Screen dissipation is likely to rise to excessive values when the plate volt-

age, bias voltage or plate load is removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 10 watts in the event of circuit failure.

Plate Voltage—The plate-supply voltage for the 4-65A should not exceed 3,000 volts. Above 50 Mc. it is advisable to use a lower plate voltage than the maximum, since the seal heating due to R-F charging currents in the screen leads increases with plate voltage and frequency. See instructions on seal cooling under "Mechanical" and "Shielding."

Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-65A should not be allowed to exceed 65 watts in unmodulated applications.

In high-level-modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 45 watts.

Plate dissipation in excess of maximum rating is permissible for short periods of time, such as during tuning procedures.

OPERATION

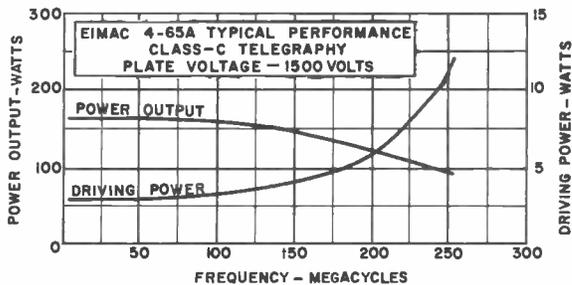
Class-C FM or Telegraphy—The 4-65A may be operated as a class-C FM or telegraph amplifier without neutralization up to 110 Mc. if reasonable precautions are taken to prevent coupling between input and output circuits external to the tube. In single ended circuits, plate, grid, filament and screen by-pass capacitors should be returned through the shortest possible leads to a common chassis point. In push-pull applications the filament and screen terminals of each tube should be by-passed to a common chassis point by the shortest possible leads, and short, heavy leads should be used to interconnect the screens and filaments of the two tubes. Care should be taken to prevent leakage of radio-frequency energy to leads entering the amplifier, in order to minimize grid-plate coupling between these leads external to the amplifier.

Where shielding is adequate, the feedback at frequencies above 110 Mc. is due principally to screen-lead-inductance effects, and it becomes necessary to introduce in-phase voltage from the plate circuit into the grid circuit. This can be done by adding capacitance between plate and grid external to the tube. Ordinarily, a small metal tab approximately 3/4" square and located adjacent to the envelope opposite the plate will suffice for neutralization. Means should be provided for adjusting the

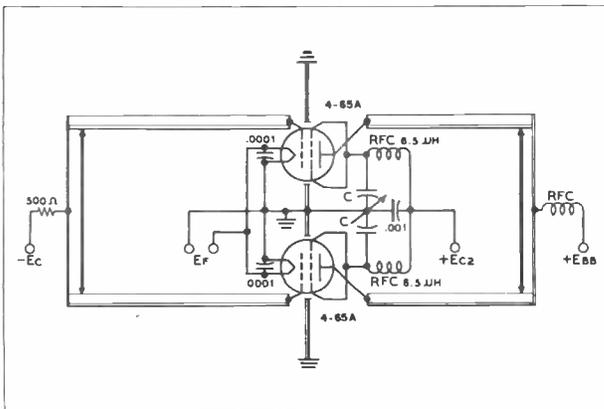
*For suitable peak V.T.V.M. circuits see, for instance, "Vacuum Tube Ratings," Eimac News, January 1945. This article is available in reprint form on request.

spacing between the neutralizing capacitor plate and the envelope. An alternate neutralization scheme for use above 110 Mc is illustrated in the diagram on page 4. In this circuit, feedback is eliminated by series-tuning the screen to ground with a small capacitor. The socket screen terminals should be strapped together as shown on the diagram, by the shortest possible lead, and the lead from the mid point of this screen strap to the capacitor, C, and from the capacitor to ground should be made as short as possible.

Driving power and power output under maximum output and plate voltage conditions are shown below. The power output shown is the actual plate power delivered by the tube; the power delivered to the load will depend upon the efficiency of the plate tank and output coupling system. The driving power is likewise the driving power required by the tube (includes bias loss). The driver output power should exceed the driving power requirements by a sufficient margin to allow for coupling-circuit losses. The use of silver-plated linear tank-circuit elements is recommended for all frequencies above 75 Mc.



Class-C AM Telephony—The R-F circuit considerations discussed above under Class-C FM or Telegraphy also apply to amplitude-modulated operation of the 4-65A. When the 4-65A is used as a class-C high-level modulated



Screen-tuning neutralization circuit for use above 100 Mc. C is a small split-stator capacitor.

$$C_{(\mu\mu fd)} = \frac{640,000}{f^2 (\text{Mc.})}, \text{ approx.}$$

amplifier, both the plate and screen should be modulated. Modulation voltage for the screen is easily obtained by supplying the screen voltage via a series dropping resistor from the unmodulated plate supply, or by the use of an audio-frequency reactor in the positive screen-supply lead, or from a separate winding on the modulation transformer. When screen modulation is obtained by either the series-resistor or the audio-reactor methods, the audio-frequency variations in screen current which result from the variations in plate voltage as the plate is modulated automatically give the required screen modulation. Where a reactor is used, it should have a rated inductance of not less than 10 henries divided by the number of tubes in the modulated amplifier and a maximum current rating of two to three times the operating D-C screen current. To prevent phase-shift between the screen and plate modulation voltages at high audio frequencies, the screen by-pass capacitor should be no larger than necessary for adequate R-F by-passing.

For high-level modulated service, the use of partial grid-leak bias is recommended. Any by-pass capacitors placed across the grid-leak resistance should have a reactance at the highest modulation frequency equal to at least twice the grid-leak resistance.

Class-AB₁ and Class-AB₂ Audio—Two 4-65As may be used in a push-pull circuit to give relatively high audio output power at low distortion. Maximum ratings and typical operating conditions for class-AB₁ and class-AB₂ audio operation are given in the tabulated data.

Screen voltage should be obtained from a source having reasonably good regulation, to prevent variations in screen voltage from zero-signal to maximum-signal conditions. The use of voltage regulator tubes in a standard circuit should provide adequate regulation.

Grid bias voltage for class-AB₂ service may be obtained from batteries or from a small fixed-bias supply. When a bias supply is used, the D-C resistance of the bias source should not exceed 250 ohms. Under class-AB₁ conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

The peak driving power figures given in the class-AB₂ tabulated data are included to make possible an accurate determination of the required driver output power. The driver amplifier must be capable of supplying the peak driving power without distortion. The driver stage should, therefore, be capable of providing an undistorted average output equal to half the peak driving power requirement. A small amount of additional driver output should be provided to allow for losses in the coupling transformer.

In some cases the maximum-signal plate dissipation shown under "Typical Operation" is less than the maximum rated plate dissipation of 4-65A. In these cases, with sine wave modulation, the plate dissipation reaches a maximum value, equal to the maximum rating, at a

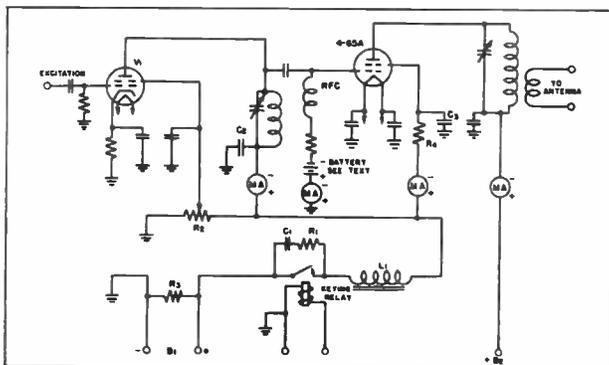
point somewhat below maximum-signal conditions.

The power output figures given in the tabulated data refer to the total power output from the amplifier tubes. The useful power output will be from 5 to 15 per cent less than the figures shown, due to losses in the output transformer.

Because of the intermittent nature of the voice, and the low average power, it is possible in cases where size and weight are important to operate a class-AB stage at higher peak power values than those indicated for sine wave.

In order to obtain peak power above that shown for sine wave (peak is twice average for sine wave), the plate-to-plate load impedance must be made proportionately lower than the value shown for a particular plate voltage. Also, more peak driving power will be required. At no time should the average plate or grid dissipation exceed the maximum values shown.

KEYING THE TETRODE AMPLIFIER



Tetrode Keying Circuit

The flow of plate current in an R-F tetrode amplifier depends not only on the control grid bias and excitation, but also on the voltage applied to the screen grid.

One easy method of keying is to remove the excitation and screen grid voltage simultaneously, while leaving the plate voltage still applied to the amplifier stage. This method also has an advantage in that the final tube can be made to draw a safe amount of current key-up position, maintaining a steadier drain on the power supply while keying. This tends to minimize "blinking lights" on weak AC supply lines when using moderate power. By properly choosing the values of L, C, and R, in the circuit, perfectly clean-cut highest speed hand keying can easily be obtained that is entirely devoid of clicks.

The keying circuit is shown in the diagram and V_1 is the driver tube, which may be any one of the small tetrodes such as an 807, 2E26, 6146, 6L6 or 6AG7, used either as a frequency multiplier or a straight-through amplifier. This tube should furnish about five watts of

output power which allows ample driving power for one 4-65A, including circuit losses. Capacitance coupling is shown in the diagram, but this, of course, could just as well be link coupling.

Steady driving power is fed to the grid of V_1 from the exciter. The keying circuit controls the plate and screen voltages on V_1 , as well as the screen voltage on the 4-65A, all obtained from a common power supply B_1 . This supply should furnish sufficient voltage to the plate of V_1 to obtain the necessary driving power. Normally this voltage will be about the correct voltage for the screen of the 4-65A and resistor R_4 may be omitted.

When the key is up there is no excitation to the 4-65A, and consequently no grid leak bias. At the same time, the screen voltage has also been removed so that very little current is drawn by the plate. With plate voltages up to 2000 volts, the amount of current drawn is not sufficient to heat the plate beyond its rated plate dissipation and a fixed bias is not required. However, with plate voltages over 2000 volts, a small fixed bias supply is needed to keep the plate dissipation within the rated limit. An ordinary 22½ volt C battery in the control grid circuit will furnish sufficient bias to completely cut the plate current off at 3000 volts, while some lower value of bias can be used to permit a safe amount of current to flow in key-up position, presenting a more constant load to the power supply.

A tapped resistor R_2 serves to supply screen voltage to V_1 and by adjusting this tap, the excitation to the 4-65A may be easily controlled. This method of controlling the output of a tetrode is not recommended in the larger tetrodes, however, as it is wasteful of power and the lowered power output obtained is due to a loss in efficiency. R_2 also serves as a means of keeping the screen of the 4-65A at ground potential under key-up conditions, stabilizing the circuit. R_3 is the normal power supply bleeder.

The keying relay must be insulated to withstand the driver plate voltage. Key clicks may be completely eliminated by the proper selection of L_1 , R_1 and C_1 in series with and across the relay. In many applications values of 500 ohms for R_1 and 0.25 μ fd for C_1 have been found entirely satisfactory. Choke L_1 is best selected by trial and usually is on the order of 5 henries. A satisfactory choke for this purpose can be made by using any small power-supply choke, capable of handling the combined current of the final screen grid and the driver stage, and adjusting the air gap to give the proper inductance. This may be checked by listening for clean keying on the "make" side of the signal or by observation in a scope.

R-F by-pass condensers C_2 and C_3 will have some effect on the required value of L_1 as well as C_1 . These by-pass condensers should be kept at as small a value of capacity as is needed. In most cases .002 μ fd is sufficient.



SHIELDING

The internal feedback of the tetrode has been substantially eliminated, and in order to fully utilize this advantage, it is essential that the design of the equipment completely eliminates any feedback external to the tube. This means complete shielding of the output circuit from the input circuit and earlier stages, proper reduction to low values of the inductance of the screen lead to the R-F ground, and elimination of R-F feedback in any common power supply leads.

Complete shielding is easily achieved by mounting the socket of the tube flush with the deck of the chassis as shown in the sketch on page 7.

The holes in the socket permit the flow of convection air currents from below the chassis up past the seals in the base of the tube. This flow of air is essential to cool the tube and in cases where the complete under part of the chassis is enclosed for electrical shielding, screened holes or louvers should be provided to permit air circulation. Note that shielding is completed by aligning the internal screen shield with the chassis deck and by proper R-F by-passing of the screen leads to R-F ground. The plate and output circuits should be kept above deck and the input circuit and circuits of earlier stages should be kept below deck or completely shielded.

DIFFERENT SCREEN VOLTAGES

The published characteristic curves of tetrodes are shown for the commonly used screen voltages. Occasionally it is desirable to operate the tetrode at some screen voltage other than that shown on the characteristic curves. It is a relatively simple matter to convert the published curves to corresponding curves at a different screen voltage by the method to be described.

This conversion method is based on the fact that if all inter-electrode voltages are either raised or lowered by the same relative amount, the shape of the voltage field pattern is not altered, nor will the current distribution be altered; the current lines will simply take on new proportionate values in accordance with the three-halves power law. This method fails only where insufficient cathode emission or high secondary emission affect the current values.

For instance, if the characteristic curves are shown at a screen voltage of 250 volts and it is desired to determine conditions at 500 screen volts, all voltage scales should be multiplied by the same factor that is applied to the screen voltage (in this case—2). The 1000 volt plate voltage point now becomes 2000 volts, the 50 volt grid voltage point, 100 volts, etc.

The current lines then all assume new values in accordance with the 3/2 power law. Since the voltage was increased by a factor of 2, the current lines will all be increased in value by a factor of 2^{3/2} or 2.8. Then all the current values should be multiplied by the factor 2.8. The 100 ma. line becomes a 280 ma. line, etc.

Likewise, if the screen voltage given on the characteristic curve is higher than the conditions desired, the voltages should all be reduced by the same factor that is used to obtain the desired screen voltage. Correspond-

ingly, the current values will all be reduced by an amount equal to the 3/2 power of this factor.

For convenience the 3/2 power of commonly used factors is given below:

Voltage Factor	.25	.5	.75	1.0	1.25	1.50	1.75
Corresponding Current Factor	.125	.35	.65	1.0	1.4	1.84	2.3
Voltage Factor	2.0	2.25	2.5	2.75	3.0		
Corresponding Current Factor	2.8	3.4	4.0	4.6	5.2		

SINGLE SIDE BAND SUPPRESSED CARRIER OPERATION

The 4-65A may be operated as a class B linear amplifier in SSSC operation and peak power outputs of over 300 watts per tube may be readily obtained. This is made possible by the intermittent nature of the voice. If steady audio sine wave modulation is used, the single side band will be continuous and the stage will operate as a C-W class-B amplifier. With voice modulation the average power will run on the order of 1/5th of this continuous power.

The same precautions regarding shielding, coupling between input and output circuits, and proper R-F by-passing must be observed, as described under Class-C Telegraphy Operation.

Due to the widely varying nature of the load imposed on the power supplies by SSSC operation, it is essential that particular attention be given to obtaining good regulation in these supplies. The bias supply especially, should have excellent regulation, and the addition of a heavy bleeder to keep the supply well loaded will be found helpful.

Under conditions of zero speech signal, the operating bias is adjusted so as to give a plate dissipation of 50 watts at the desired plate and screen voltages. Due to the intermittent nature of voice, the average plate dissipation will rise only slightly under full speech modulation to approximately 65 watts. At the same time, however, the peak speech power output of over 300 watts is obtained.

SSSC TUNING PROCEDURE

Tuning the SSSC transmitter is best accomplished with the aid of an audio frequency oscillator and a cathode-ray oscilloscope. The audio oscillator should be capable of delivering a sine wave output of a frequency of around 800 to 1000 cycles so that the frequency will be somewhere near the middle of the pass-band of the audio system. Since successful operation of the class-B stage depends on good linearity and the capability of delivering full power at highest audio levels, the final tuning should be made under conditions simulating peak modulation conditions. If a continuous sine wave from the audio oscillator is used for tuning purposes, the average power at full modulation would be about five times that of speech under similar conditions of single side band operation and the final amplifier would be subjected to a heavy overload. One method of lowering the duty cycle of the audio oscillator to closer approxi-

mate speech conditions would be to modulate the oscillator with a low frequency.

An alternate method would be to use the continuous audio sine wave, making all adjustments at half voltages and half currents on the screen and plate, thus reducing the power to one quarter. The stand-by plate dissipation under these conditions should be set at about 10 watts. Following these adjustments, minor adjustments at full voltages and 50 watts of stand-by plate dissipation could then be made, but only allowing the full power to remain on for ten or fifteen second intervals.

The first step is to loosely couple the oscilloscope to the output of the exciter unit. The final amplifier with its filament and bias voltages turned on should also be coupled to the exciter at this time. With the audio oscillator running, adjust the exciter unit so that it delivers double side band signals. Using a linear sweep on the oscilloscope, the double side band pattern will appear on the screen the same as that obtained from a 100% sine wave modulated AM signal. Next vary the audio gain control so that the exciter can be checked for linearity. When the peaks of the envelope start to flatten out the upper limit of the exciter output has been reached and the maximum gain setting should be noted. The coupling to the final stage should be varied during this process and a point of optimum coupling determined by watching the oscilloscope pattern and the grid meter in the final stage.

Next, adjust the exciter for single side band operation and if it is working properly, the pattern on the oscilloscope will resemble an unmodulated AM carrier. The phasing controls should be adjusted so as to make the envelope as smooth on the top and bottom as possible. If the above conditions are satisfied, the exciter unit can be assumed to be operating satisfactorily.

Next, loosely couple the oscilloscope link to the output of the final amplifier and again adjust the exciter unit to give double side band output.

If the reduced duty cycle method is used, the following tuning procedure may be followed:

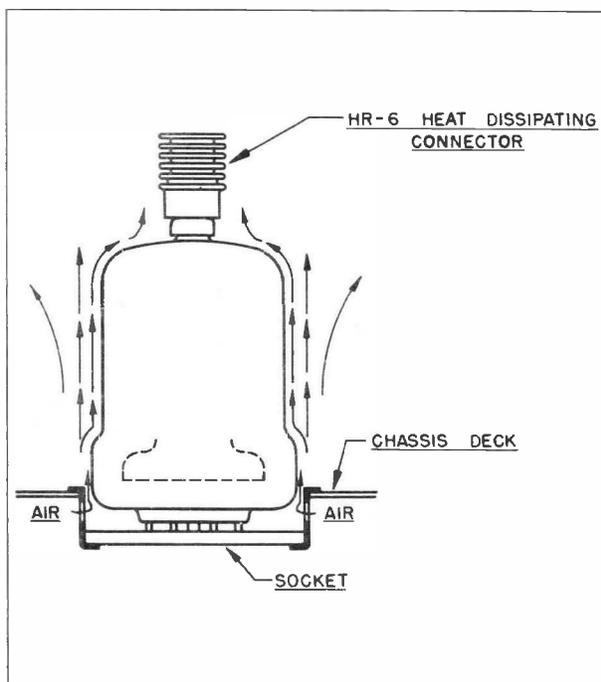
1. Cut the audio output to zero.
2. Apply 120 volts of bias to the 4-65A control grid.
3. Apply the operating plate voltage followed by the operating screen voltage.
4. Reduce bias voltage to obtain 50 watts of stand-by plate dissipation.
5. Increase audio gain, checking the oscilloscope pattern for linearity as in the case of the exciter, and adjust for optimum antenna coupling.
6. Re-adjust exciter unit for single side band operation.
7. Disconnect test signal and connect microphone.
8. Adjust the audio gain so that the voice peaks give the same deflection on the oscilloscope screen as was obtained from the test signal peaks.

If the alternate method is used with a 100% duty cycle from the audio oscillator, then step 3 should be to apply half voltages and the stand-by plate dissipation should be set at 10 watts.

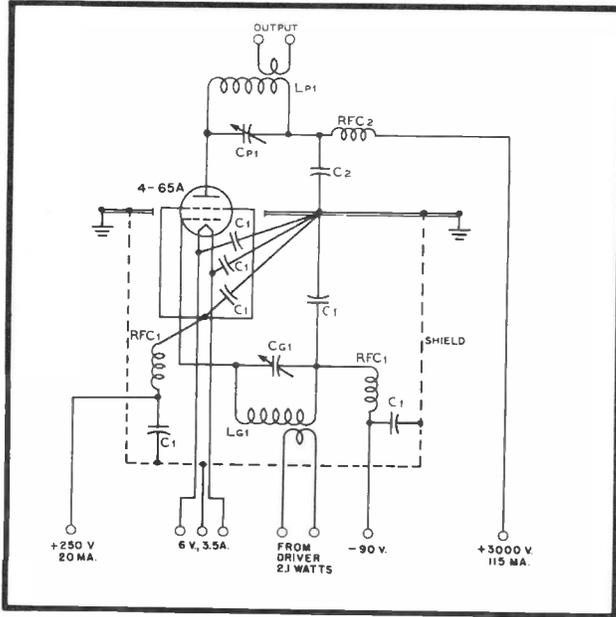
After the audio oscillator is disconnected and step 8 completed at half voltages, the full voltages can then be applied and the stand-by plate dissipation adjusted for 50 watts.

It is essential that the microphone cable be well shielded and grounded to avoid R-F feedback that might not occur when the lower impedance audio oscillator is used as an audio source.

Typical operational data are given for SSSC in the first part of this data sheet.

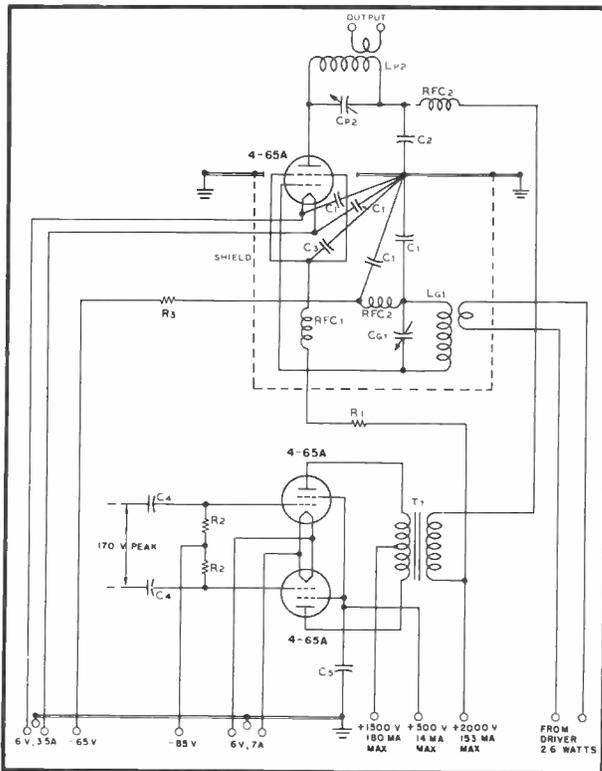


COMPONENTS FOR TYPICAL CIRCUITS

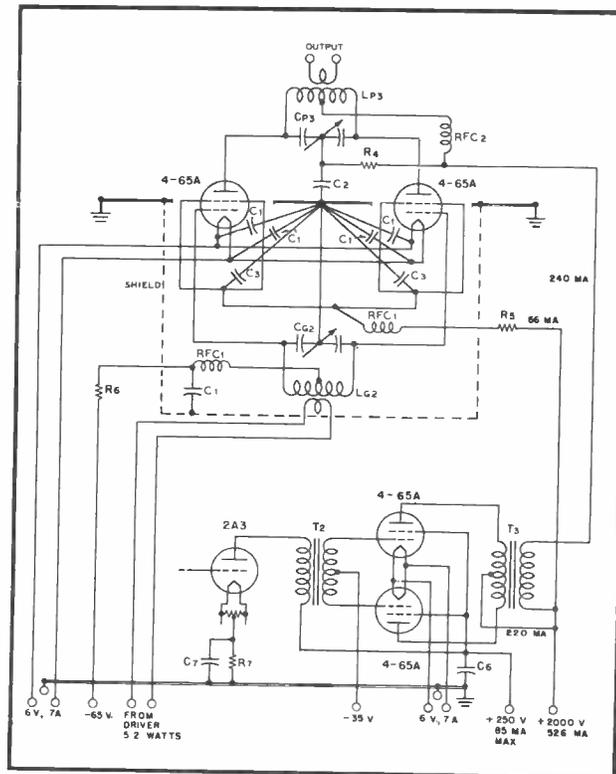


Typical radio-frequency power amplifier circuit, Class-C telegraphy, 345 watts input.

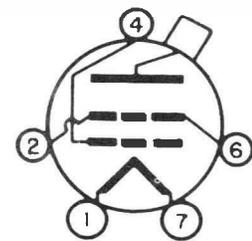
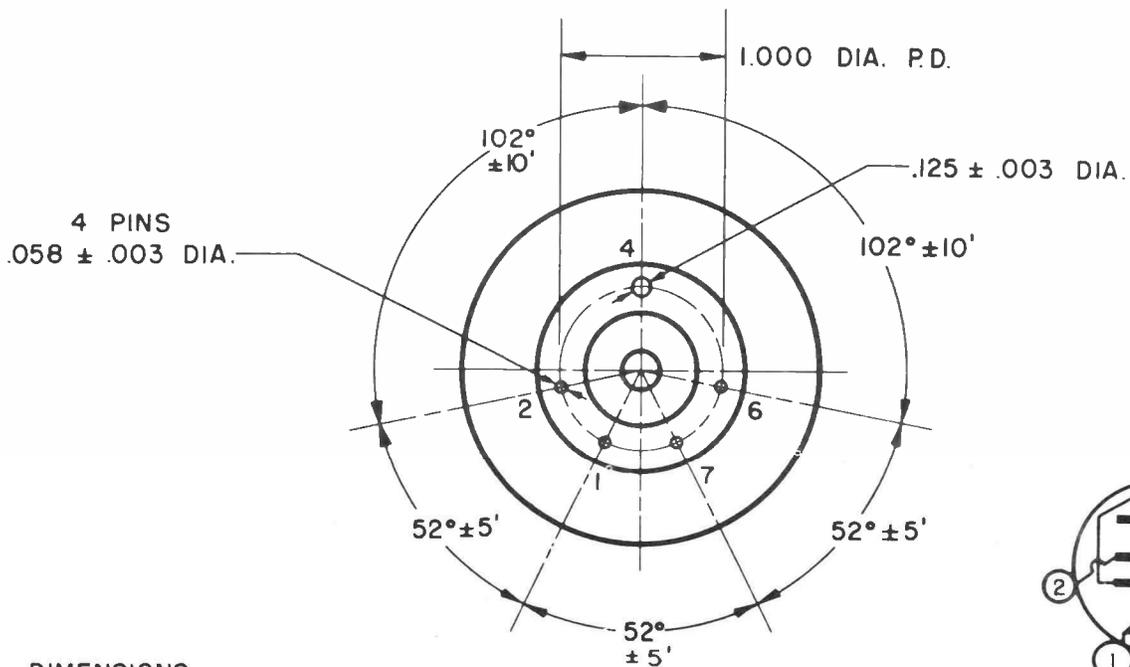
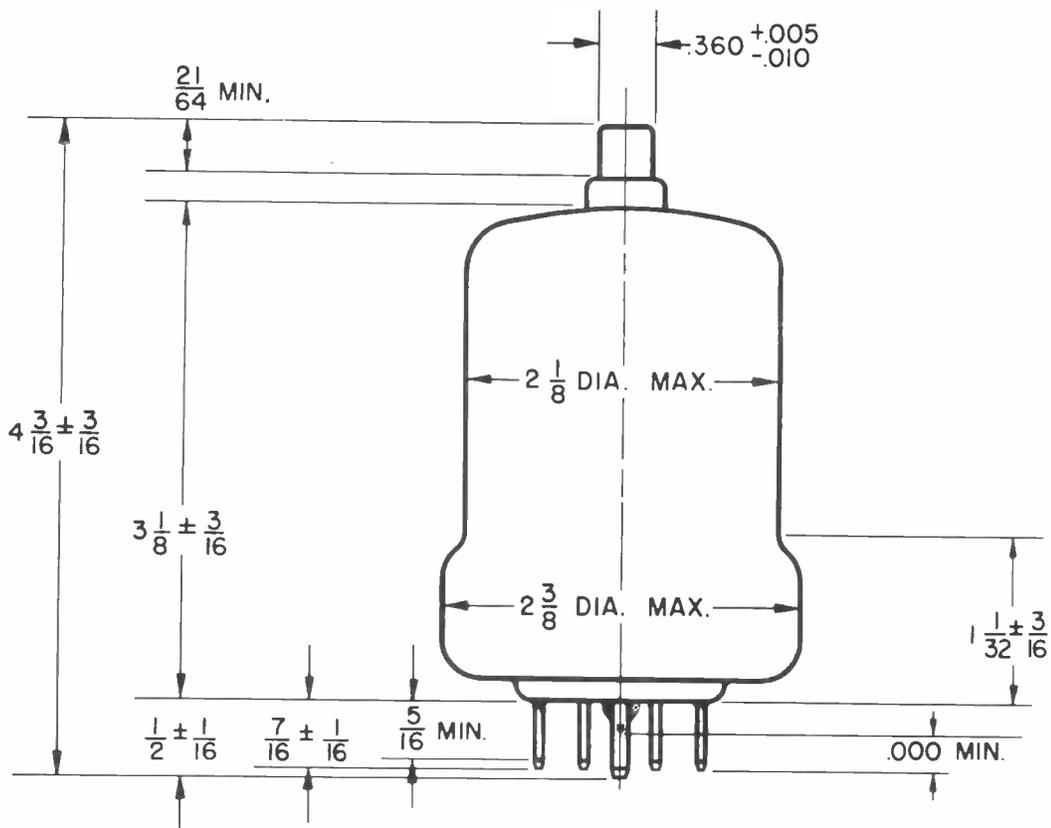
- L_{p1}-C_{p1}— Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
- L_{p2}-C_{p2}— Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
- L_{p3}-C_{p3}— Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .375".
- L_{g1}-C_{g1}— Tuned circuit appropriate for operating frequency.
- L_{g2}-C_{g2}— Tuned circuit appropriate for operating frequency.
- C₁— .002- μ fd. 500V Mica
- C₂— .002- μ fd. 5000V Mica
- C₃— .001- μ fd. 2500V Mica
- C₄— .1- μ fd. 1000V paper
- C₅— .1- μ fd. 600 V paper
- C₆— 16- μ fd. 450V Electrolytic
- C₇— 10- μ fd. 100V Electrolytic
- R₁— 53,000 ohms 200 watt—60,000 ohm adjustable
- R₂— 250,000 ohms 1 watt
- R₃— 5,000 ohms 5 watt
- R₄— 25,000 ohms 2 watts
- R₅— 26,500 ohms 200 watts—30,000 ohm adjustable
- R₆— 2,500 ohms 5 watts
- R₇— 750 ohms 5 watts
- RFC₁— 2.5 mhy. 125 ma. R-F choke
- RFC₂— 1 mhy. 500 ma. R-F choke
- T₁— 150 watt modulation transformer; ratio primary to secondary impedance approx. 1:1.1 Pri. impedance 15,000 ohms, sec. impedance 16,700 ohms.
- T₂— 5 watt driver transformer impedance ratio primary to 1/2 secondary 1.5:1.
- T₃— 300 watt modulation transformer; impedance ratio pri. to sec. approx. 2.4:1; Pri. impedance = 20,000 ohms, sec. impedance = 8,333 ohms.



Typical high-level-modulated R-F amplifier, 240 watts plate input. Modulator requires zero driving power.

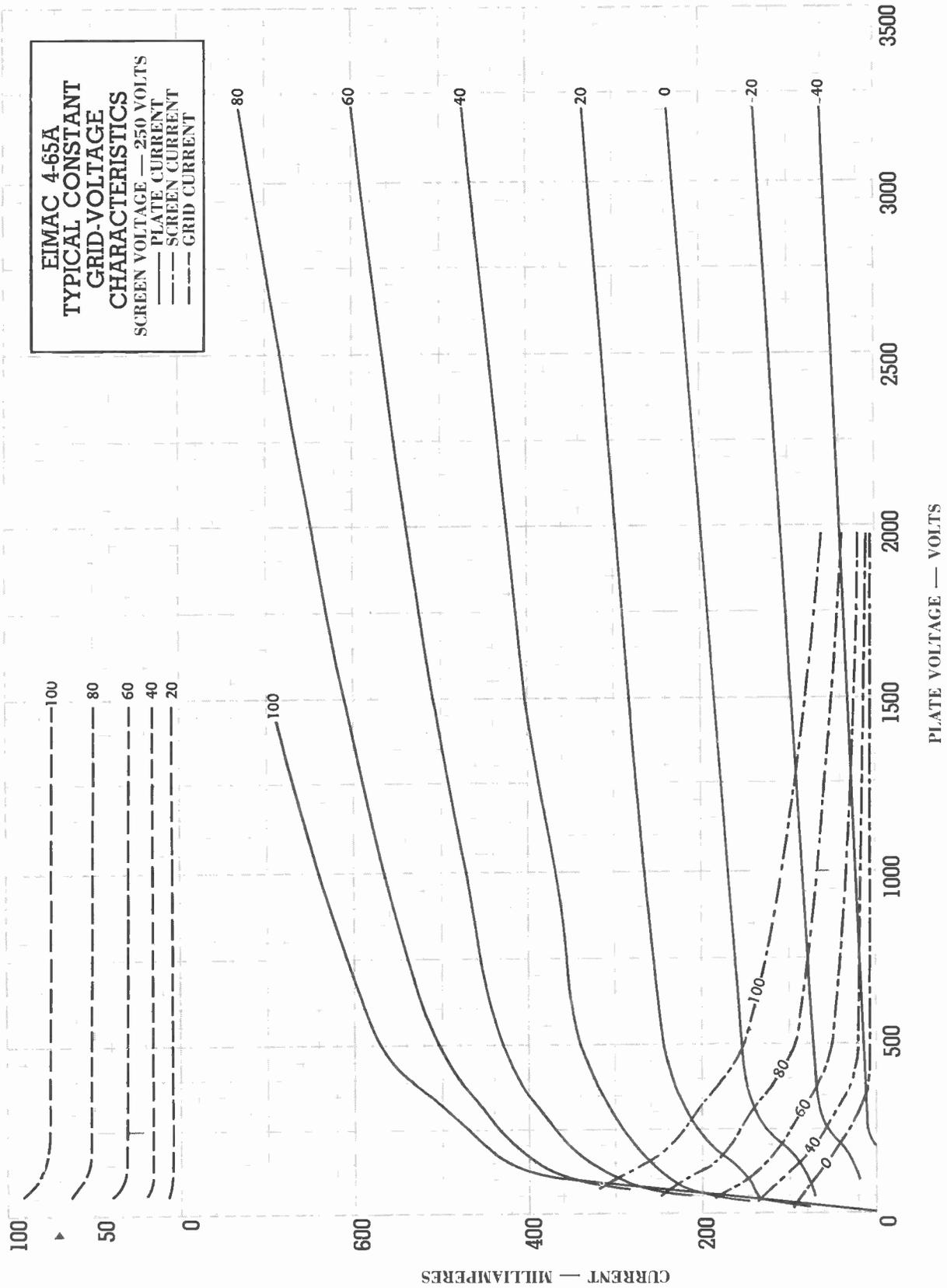


Typical high-level-modulated R-F amplifier circuit, with modulator and driver stages, 480 watts plate input.



ALL DIMENSIONS
IN INCHES

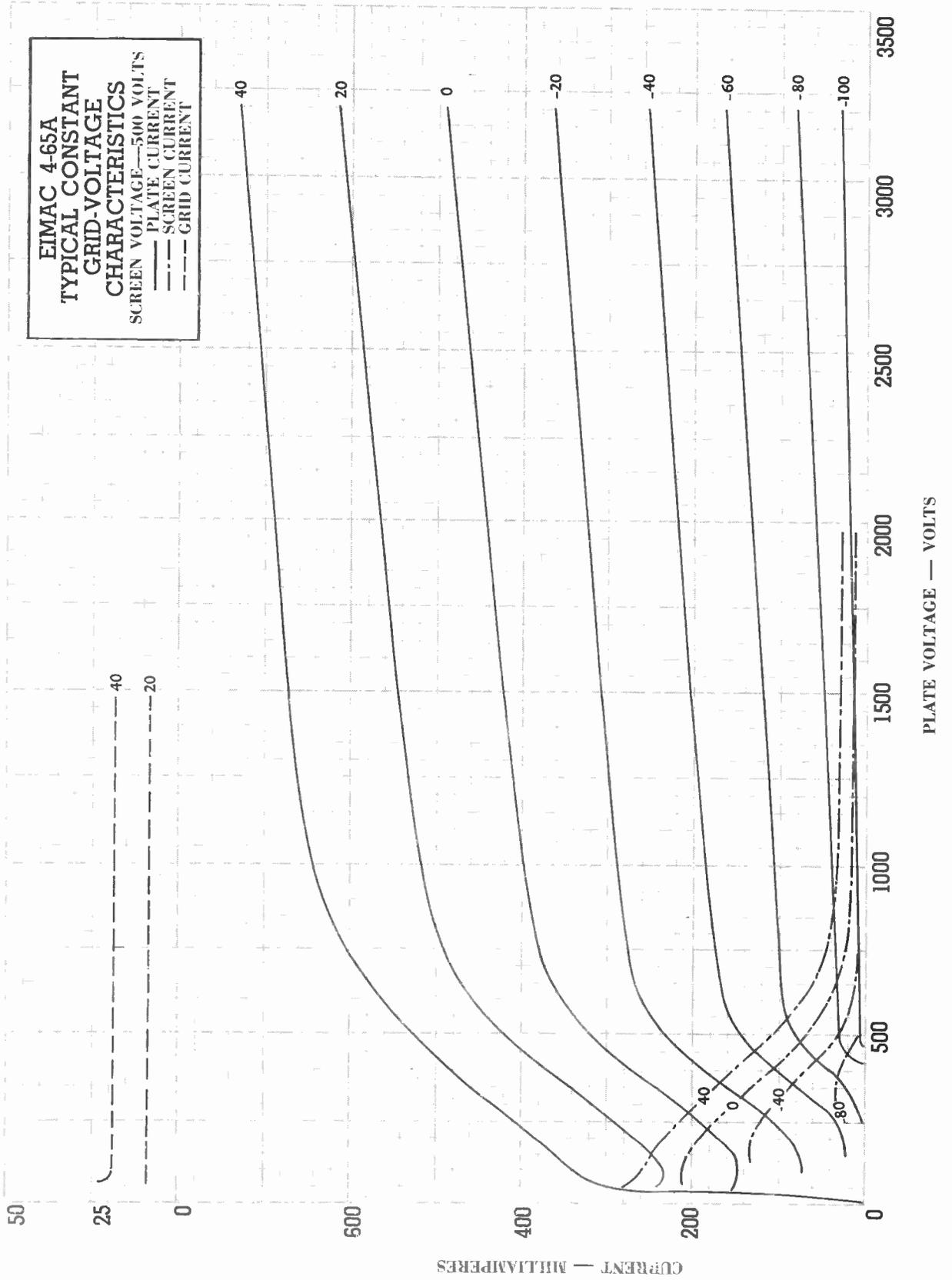
BOTTOM VIEW



► Indicates change from sheet dated 1-30-53



4-65A

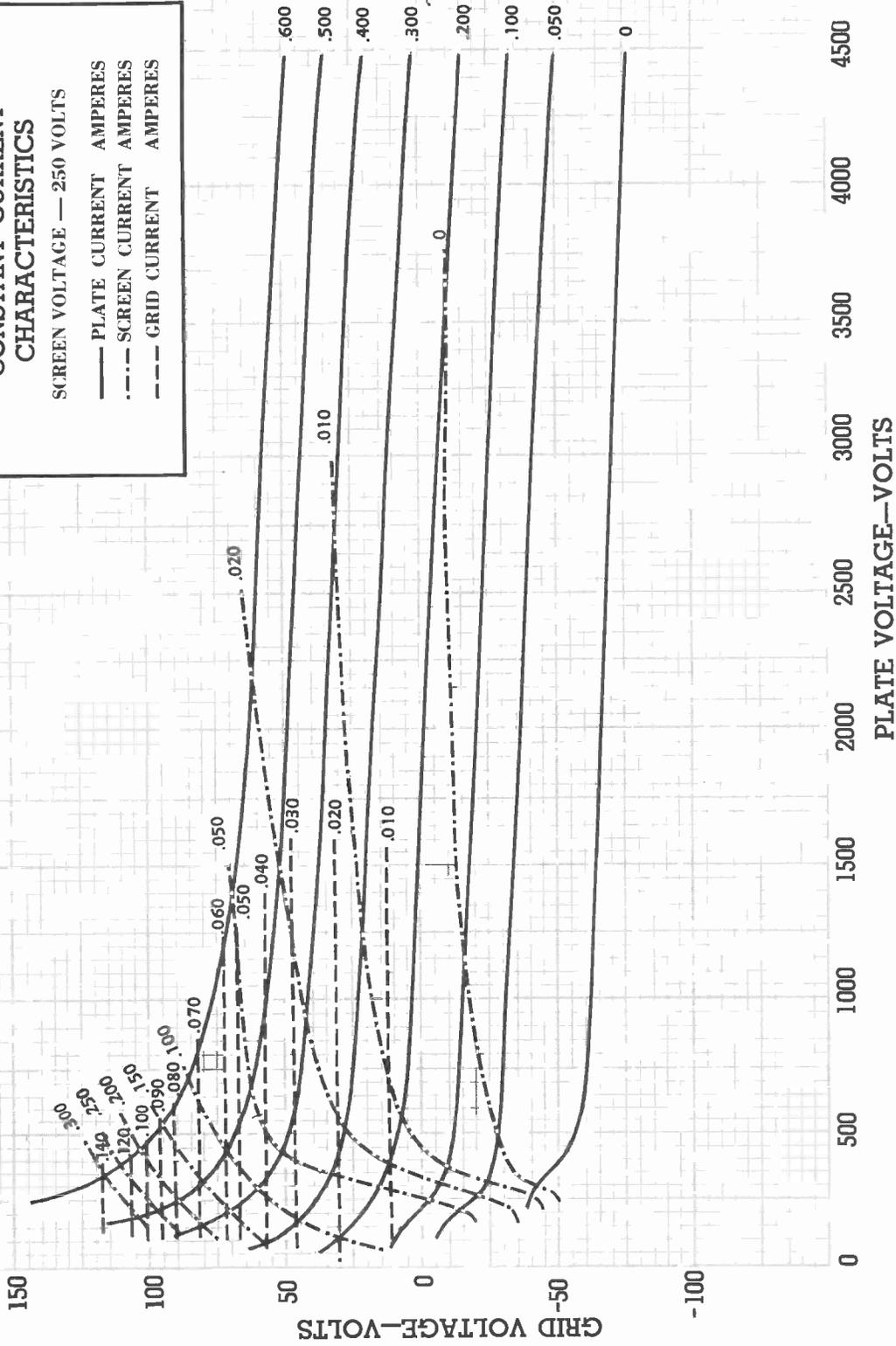


EIMAC 4-65A

**TYPICAL
CONSTANT CURRENT
CHARACTERISTICS**

SCREEN VOLTAGE — 250 VOLTS

- PLATE CURRENT AMPERES
- - - SCREEN CURRENT AMPERES
- - - GRID CURRENT AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS · CALIFORNIA

4-250A

(5D22)
**RADIAL-BEAM
POWER TRODE**
**MODULATOR
OSCILLATOR
AMPLIFIER**

The Eimac 4-250A is a compact, ruggedly constructed power tetrode having a maximum plate dissipation rating of 250 watts. It is intended for use as an amplifier, oscillator or modulator. The low grid-plate capacitance of this tetrode coupled with its low driving-power requirement allows considerable simplification of the associated circuit and driver stage.

The 4-250A is cooled by radiation from the plate and by circulation of forced-air through the base and around the envelope.

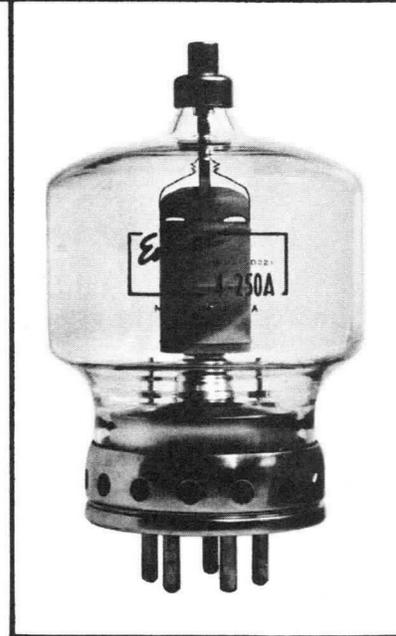
GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	14.5 amperes
Grid-Screen Amplification Factor (Average)	5.1
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.12 $\mu\mu\text{f}$
Input	12.7 $\mu\mu\text{f}$
Output	4.5 $\mu\mu\text{f}$
Transconductance ($I_b = 100 \text{ ma.}, E_b = 2500\text{V.}, E_{c2} = 500\text{V.}$)	4000 μmhos
Frequency for Maximum Ratings	110 Mc.

MECHANICAL

Base	5-pin metal shell	
Recommended Socket	E. F. Johnson Co. socket No. 122-275, National Co. No. HX-100, or equivalent.	
Basing	See drawing	
Mounting Position	Vertical, base down or up	
Cooling	Radiation and forced air	
Recommended Heat Dissipating Plate Connector	Eimac HR-6	
Maximum Temperature of Base and Plate Seals	Base Seals	200° C.
	Plate Seal	170° C.
Maximum Over-all Dimensions	Length	6.38 inches
	Diameter	3.56 inches
Net Weight	8.0 ounces	
Shipping Weight	2.0 pounds	



Note: Typical operation data are based on conditions of adjusting the r-f grid drive to a specified plate current, maintaining fixed conditions of grid bias and screen voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid and screen currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

**RADIO-FREQUENCY POWER AMPLIFIER
AND OSCILLATOR**

Class-C FM or Telegraphy (Key-down conditions, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE ¹	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C GRID VOLTAGE	-500 MAX. VOLTS
D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 110 Mc.)

D-C Plate Voltage	2500	3000	4000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	-150	-180	-225	volts
D-C Plate Current	300	345	312	ma
D-C Screen Current	60	60	45	ma
D-C Grid Current	9	10	9	ma
Screen Dissipation	30	30	22.5	watts
Grid Dissipation	0.35	0.8	0.46	watts
Peak R-F Grid Input Voltage (approx.)	220	265	303	volts
Driving Power (approx.) ²	1.70	2.6	2.46	watts
Plate Power Input	750	1035	1250	watts
Plate Dissipation	175	235	250	watts
Plate Power Output	575	800	1000	watts

**PLATE-MODULATED RADIO-FREQUENCY
AMPLIFIER**

Class-C Telephony

(Carrier conditions unless otherwise specified, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE ¹	3200 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C GRID VOLTAGE	-500 MAX. VOLTS
D-C PLATE CURRENT	275 MAX. MA
PLATE DISSIPATION	165 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 110 Mc.)

D-C Plate Voltage	2500	3000	volts
D-C Screen Voltage	400	400	volts
D-C Grid Voltage	-200	-310	volts
D-C Plate Current	200	225	ma
D-C Screen Current	30	30	ma
D-C Grid Current	9	9	ma
Peak A-F Screen Voltage (100% modulation)	350	350	volts
Screen Dissipation	12	12	watts
Grid Dissipation	1.8	2.7	watts
Peak R-F Grid Input Voltage (approx.)	255	365	volts
Driving Power (approx.)	2.2	3.2	watts
Plate Power Input	500	675	watts
Plate Dissipation	125	165	watts
Plate Power Output	375	510	watts

¹Above 110 Mc. the maximum plate voltage rating depends upon frequency. See page four.

²Driving power increases above 40 Mc. See page four.



4-250A

(5D22)

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS AB

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	- - - - -	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	- - - - -	600 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	- - - - -	350 MAX. MA
PLATE DISSIPATION	- - - - -	250 MAX. WATTS
SCREEN DISSIPATION	- - - - -	35 MAX. WATTS
GRID DISSIPATION	- - - - -	10 MAX. WATTS

TYPICAL OPERATION CLASS AB₁

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	- - -	1500	2000	2500	3000	volts
D-C Screen Voltage	- - -	600	600	600	600	volts
D-C Grid Voltage ^{1,2}	- - -	-95	-104	-110	-116	volts
Zero-Signal D-C Plate Current	- - -	120	110	120	120	ma
Max-Signal D-C Plate Current	- - -	400	405	430	417	ma
Zero-Signal D-C Screen Current	- - -	-0.4	-0.3	-0.3	-0.2	ma
Max-Signal D-C Screen Current	- - -	23	22	13	10.5	ma
Effective Load, Plate-to-Plate	- - -	6250	9170	11,400	15,000	ohms
Peak A-F Grid Input Voltage (per tube)	- - -	64	88	90	93	volts
Driving Power	- - -	0	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	- - -	145	175	225	250	watts
Max-Signal Plate Power Output	- - -	310	460	625	750	watts
Total Harmonic Distortion	- - -	4	2.5	2	2.5	per cent

TYPICAL OPERATION CLASS AB₂

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	- - -	1500	2000	2500	3000	volts
D-C Screen Voltage	- - -	300	300	300	300	volts
D-C Grid Voltage ¹	- - -	-48	-48	-51	-53	volts
Zero-Signal D-C Plate Current	- - -	100	120	120	125	ma
Max-Signal D-C Plate Current	- - -	485	510	500	473	ma
Zero-Signal D-C Screen Current	- - -	0	0	0	0	ma
Max-Signal D-C Screen Current	- - -	34	26	23	33	ma
Effective Load, Plate-to-Plate	- - -	5400	8000	10,900	16,000	ohms
Peak A-F Grid Input Voltage (per tube)	- - -	96	99	100	99	volts
Max-Signal Avg. Driving Power (approx.)	- - -	2.1	2.3	2.2	1.9	watts
Max-Signal Peak Driving Power	- - -	4.7	5.5	4.8	4.6	watts
Max-Signal Plate Dissipation (per tube)	- - -	150	185	205	190	watts
Max-Signal Plate Power Output	- - -	428	650	840	1040	watts
Total Harmonic Distortion	- - -	3	4	4	4.5	per cent

¹Adjust for stated zero-signal plate current.
²The effective grid-circuit resistance must not exceed 250,000 ohms.

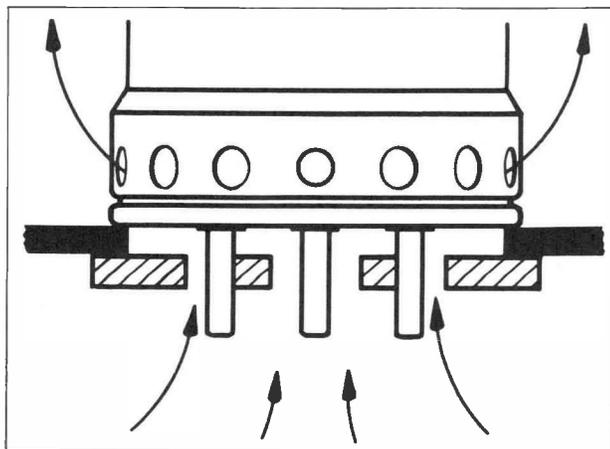
IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

Mechanical

Mounting—The 4-250A must be mounted vertically, base down or base up. The socket must be constructed so as to allow an unimpeded flow of air through the holes in the base of the tube and must also provide clearance for the glass tip-off which extends from the center of the base. The tube should be mounted above the chassis deck to allow free circulation of air in the manner shown in the mounting diagram below. The above requirements are met by the E. F. Johnson Co. socket No. 122-275, the National Co. socket No. HX-100, or a similar socket.

A flexible connecting strap should be provided between the HR-6 Heat Dissipating Plate Connector on the plate terminal and the external circuit. The tube must be protected from severe vibration and shock.



4-250A mounting providing base cooling, shielding and isolation of output and input compartments.

► **Cooling**—Adequate cooling must be provided for the seals and envelope of the 4-250A. At frequencies above 30Mc, cooling air in the amount of five cubic feet per minute through the base of the tube is required. This quantity is obtained when the pressure drop across the base of the tube is equal to 0.20 inch of water column. At frequencies below 30Mc the volume may be reduced to two cubic feet per minute. At this reduced air flow, the pressure drop is equal to 0.10 inch of water column. Base-cooling air should be applied simultaneously with filament power. The temperature of the plate seal, as measured on the top of the plate cap, should not exceed 170°C in continuous-service applications.

A relatively slow movement of air past the tube is sufficient to prevent a plate seal temperature in excess of the maximum rating at frequencies below 30 Mc. At frequencies above 30 Mc., radio-frequency losses in the leads and envelope contribute to seal and envelope heating and special attention should be given to bulb and plate seal cooling. A small fan or centrifugal blower directed toward the upper portion of the envelope will usually provide sufficient circulation for cooling at frequencies above 30 Mc. (The Eimac SK-400 Air-System Socket provides a convenient method of mounting and cooling the 4-250A at VHF, should the user desire to use it. Full information is available on the SK-400 Air-System Socket data sheet, or it will be sent from the factory on request.)

In intermittent-service applications where the "on" time does not exceed a total of five minutes in any ten-minute period, plate-seal temperatures as high as 220° C. are permissible. When the ambient temperature does not exceed 30° C. it will not ordinarily be necessary to provide forced cooling of the bulb and plate seal to hold the temperature below this maximum at frequencies below 30 Mc., provided that a heat-radiating plate connector is used, and the tube is so located that normal circulation of air past the envelope is not impeded. The five cubic feet per minute base-cooling requirement must be observed in intermittent service.

Electrical

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the base pins, should be the rated value of 5.0 volts. Variations should be held within the range of 4.75 to 5.25 volts.

► Indicates change from sheet dated 8-24-53.

Bias Voltage—D-c bias voltage for the 4-250A should not exceed 500 volts. If grid-leak bias is used, suitable protective means must be provided to prevent excessive plate or screen dissipation in the event of loss of excitation.

Grid Dissipation—Grid dissipation for the 4-250A should not be allowed to exceed ten watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{cmp} I_c$$

where P_g = Grid dissipation
 e_{cmp} = Peak positive grid voltage, and
 I_c = D-C grid current.

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid².

Screen Voltage—The d-c screen voltage for the 4-250A should not exceed 600 volts.

Screen Dissipation—The power dissipated by the screen of the 4-250A must not exceed 35 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load is removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 35 watts in the event of circuit failure.

Plate Voltage—The plate-supply voltage for the 4-250A should not exceed 4000 volts for frequencies below 110 Mc. Above 110 Mc., the maximum permissible plate voltage is less than 4000 volt, as shown by the graph on page four.

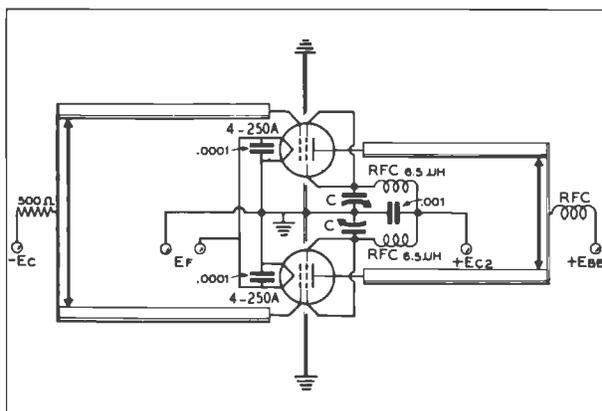
Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-250A should not be allowed to exceed 250 watts in unmodulated applications.

In plate-modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 165 watts.

Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

Operation

Class-C FM or Telegraphy—The 4-250A may be operated as a class-C amplifier, FM or telegraphy, without neutralization up to 30 Mc. if reasonable precautions are taken to prevent coupling between input and output circuits external to the tube. A grounded metallic plate on which the socket may be mounted and to which suitable connectors may be attached to ground the tube base shell, provides an effective isolating shield between grid and plate circuits. In single-ended circuits, plate, grid, filament and screen by-pass capacitors should be returned through the shortest possible leads to a common chassis point. In push-pull applications the filament and screen terminals of each tube should be by-passed to a common chassis point by the shortest possible leads, and short, heavy leads should be used to interconnect the screens and filaments of the two tubes. Care should be taken to prevent leakage of radio-frequency energy to leads



Screen-tuning neutralization circuit for use above 45 Mc.
 C — Approximately 100 μ mf. per section, maximum.

entering the amplifier in order to minimize grid-plate coupling between these leads external to the amplifier.

At frequencies from 30 Mc. to 45 Mc. ordinary neutralization systems may be used.

Where shielding is adequate, the feed-back at frequencies above 45 Mc. is due principally to screen-lead-inductance effects, and it becomes necessary to introduce in-phase voltage from the plate circuit into the grid circuit. This can be done by adding capacitance between plate and grid external to the tube. Ordinarily, a small metal tab approximately 3/4-inch square connected to the grid terminal and located adjacent to the envelope opposite the plate will suffice for neutralization. Means should be provided for adjusting the spacing between the neutralizing capacitor plate and the envelope. An alternative neutralization scheme is illustrated in the diagram below. In this circuit, feed-back is eliminated by series-tuning the screen to ground with a small capacitor. The socket screen terminals should be strapped together, as shown on the diagram, by the shortest possible lead, and the leads from the screen terminal to the capacitor, C, and from the capacitor to ground should be made as short as possible.

Driving power and power output under maximum output and plate voltage conditions are shown on page 4. The power output shown is the actual plate power delivered by the tube; the power delivered to the load will depend upon the efficiency of the plate tank and output coupling system. The driving power is likewise the driving power required by the tube (includes bias loss). The driver output power should exceed the driving power requirement by a sufficient margin to allow for coupling-circuit losses. The use of silver-plated linear tank-circuit elements is recommended for all frequencies above 110 Mc.

Class-C AM Telephony—The r-f circuit considerations discussed above under Class-C FM or Telegraphy also apply to amplitude-modulated operation of the 4-250A. When the 4-250A is used as a class-C plate-modulated amplifier, modulation should be applied to both plate and screen. Modulation voltage for the screen may be obtained from a separate winding on the modulation transformer, by supplying the screen voltage via a series dropping resistor from the unmodulated plate supply, or by the use of an audio-frequency reactor in the positive screen-supply lead. When screen modulation is obtained by either the series-resistor or the audio-reactor method, the audio-frequency variations in screen current which result from the variations in plate voltage as the plate is modulated automatically give the required screen modulation. Where a reactor is used, it should have a rated inductance of not less than 10 henries divided by the number of tubes in the modulated amplifier and a maximum current rating of two or three times the operating d-c screen current. To prevent phase shift between the screen and plate modulation voltages at high audio frequencies, the screen by-pass capacitor should be no larger than necessary for adequate r-f by-passing.

For plate-modulated service, the use of partial grid-leak bias is recommended. Any by-pass capacitors placed across the grid-leak resistance should have a reactance at the highest modulation frequency equal to at least twice the grid-leak resistance.

Class-AB₁ and Class-AB₂ Audio—Two 4-250A's may be used in a push-pull circuit to give relatively high audio output power at low distortion. Maximum ratings and typical operating conditions for class-AB₁ and class-AB₂ audio operation are given in the tabulated data.

Screen voltage should be obtained from a source having reasonably good regulation to prevent variations in screen voltage from zero-signal to maximum-signal conditions. The use of voltage regulator tubes in a standard circuit should provide adequate regulation.

Grid bias voltage for class-AB₂ service may be obtained from batteries or from a small fixed-bias supply. When a bias supply is used the d-c resistance of the bias source should not exceed 250 ohms. Under class-AB₁ conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

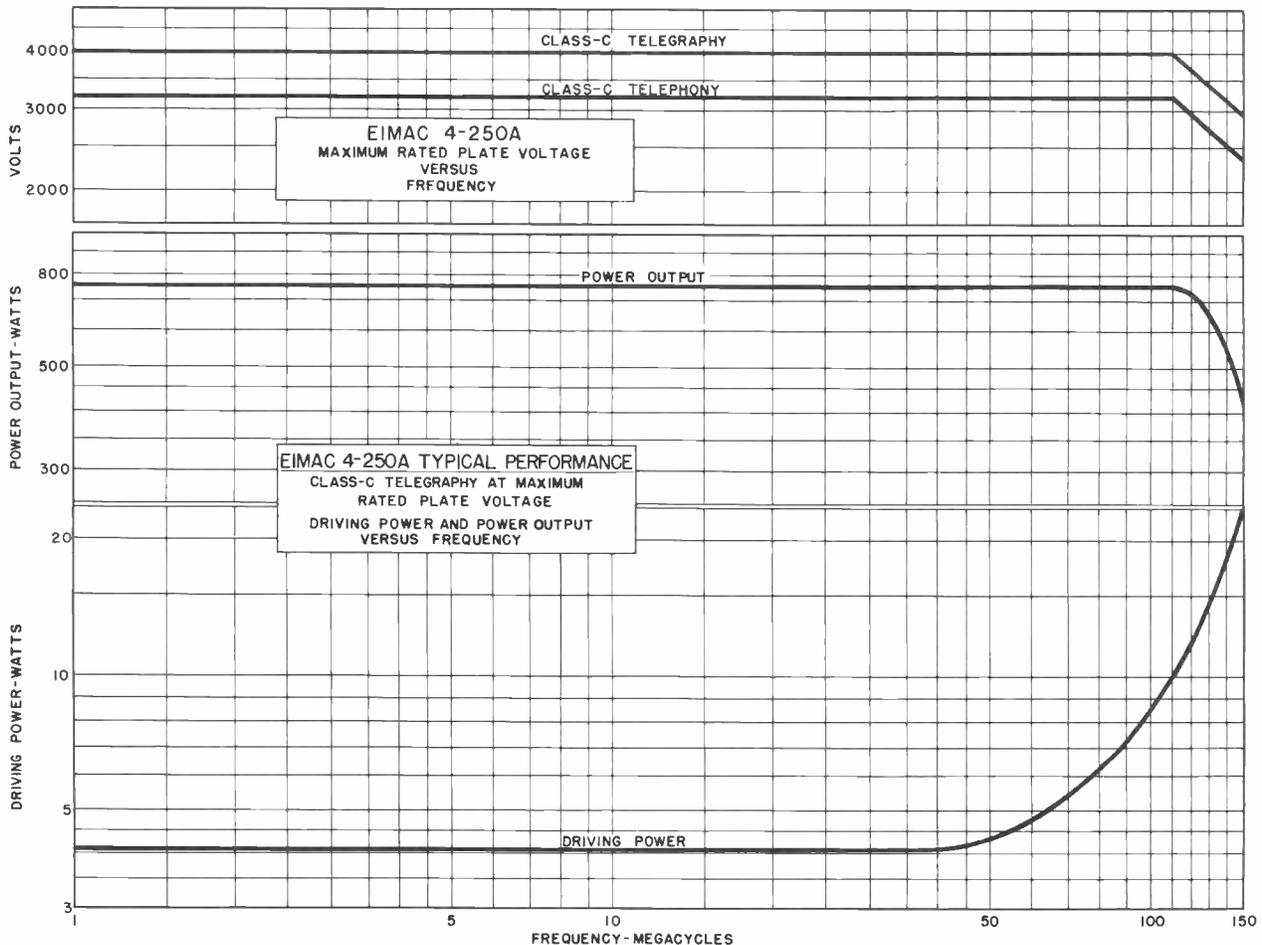
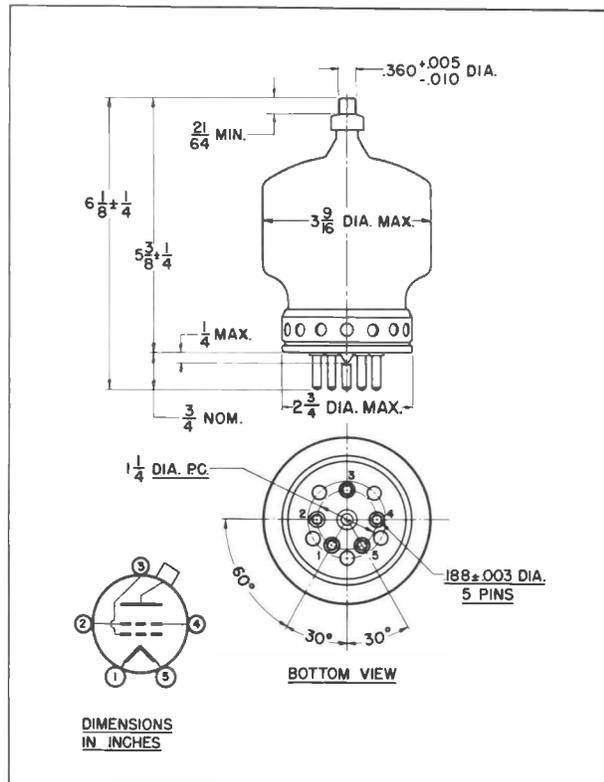
² For suitable peak v.t.v.m. circuits see, for instance, "Vacuum Tube Ratings," Eimac News, January, 1945. This article is available in reprint form on request.



The peak driving power figures given in the class-AB₂ tabulated data are included to make possible an accurate determination of the required driver output power. The driver amplifier must be capable of supplying the peak driving power without distortion. The driver stage should, therefore, be capable of providing an undistorted average output equal to half the peak driving power requirement. A small amount of additional driver output should be provided to allow for losses in the coupling transformer.

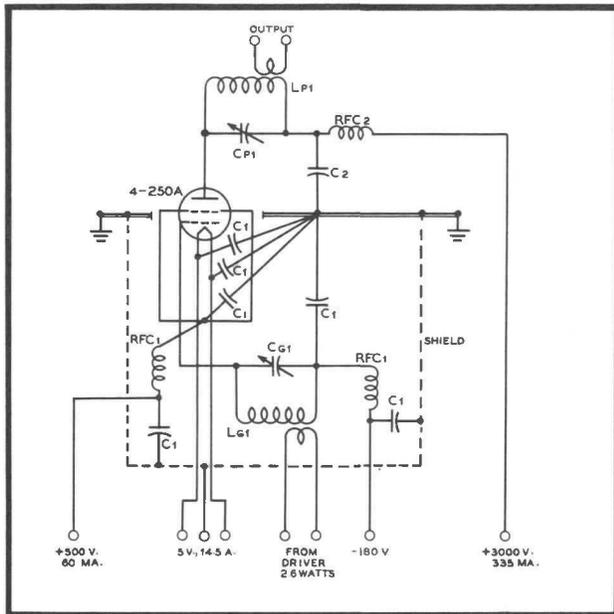
In some cases the maximum-signal plate dissipation shown under "Typical Operation" is less than the maximum rated plate dissipation of the 4-250A. In these cases, the plate dissipation reaches a maximum value, equal to the maximum rating, at a point somewhat below maximum-signal conditions.

The power output figures given in the tabulated data refer to the total power output from the amplifier tubes. The useful power output will be from 5 to 15 per cent less than the figures shown, due to losses in the output transformer.

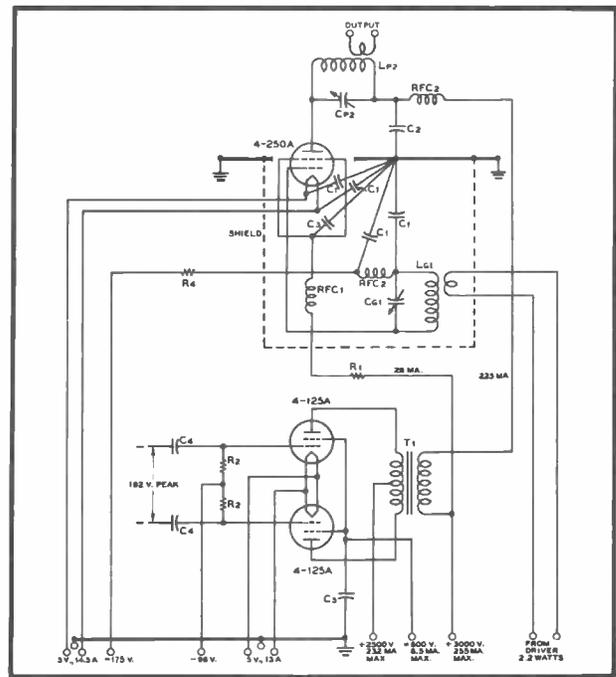




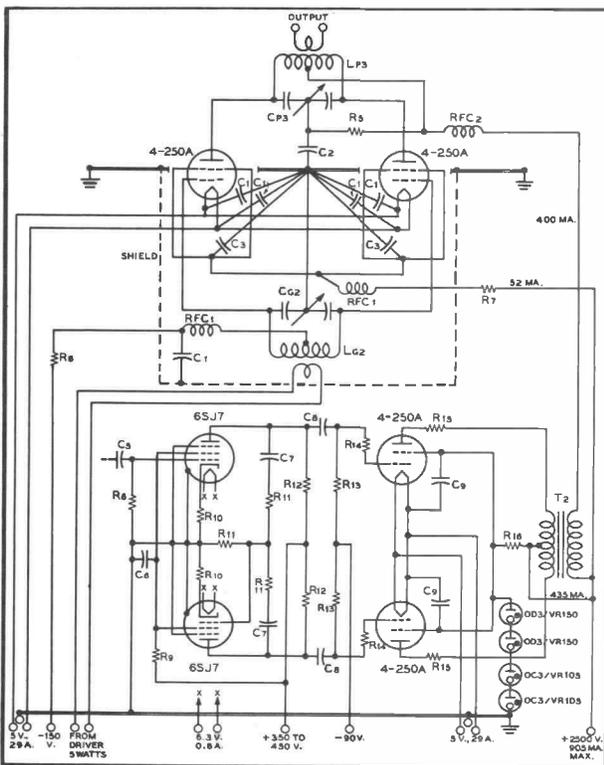
4-250A
(5D22)



Typical radio frequency power amplifier circuit, Class-C telegraphy, 1000 watts input.



Typical high-level-modulated r-f amplifier circuit, with modulator stage, 675 watts input.



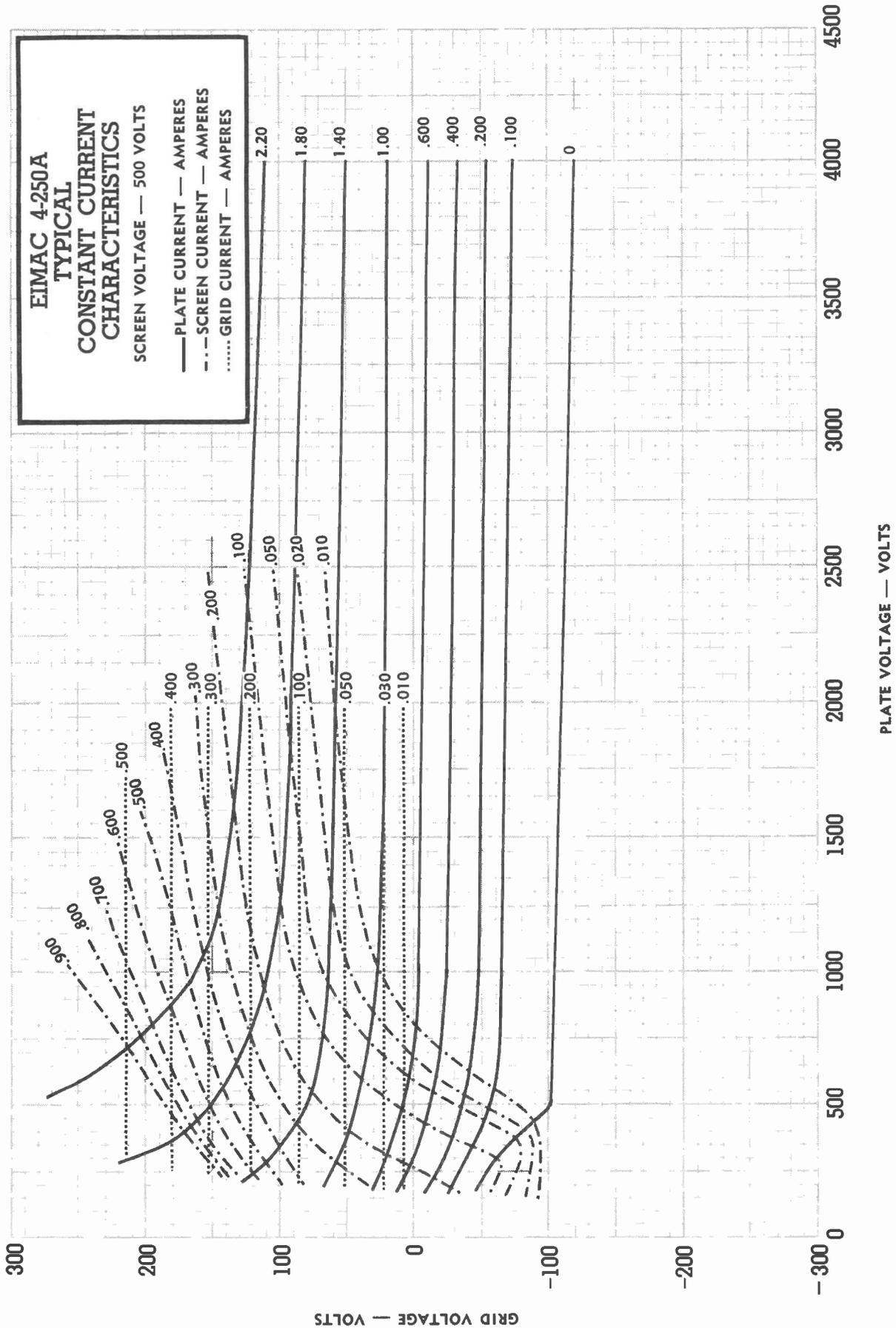
Typical high-level-modulated r-f amplifier circuit, with modulator and driver stages, 1000 watts input.

COMPONENTS FOR TYPICAL CIRCUITS

- L_{p1} - C_{p1} — Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
- L_{p2} - C_{p2} — Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
- L_{p3} - C_{p3} — Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .375".
- L_{g1} - C_{g1} — Tuned circuit appropriate for operating frequency.
- L_{g2} - C_{g2} — Tuned circuit appropriate for operating frequency.
- C₁ — .002-ufd. 500-v. mica
- C₂ — .002-ufd. 5000-v. mica
- C₃ — .001-ufd., 2500-v. mica
- C₄ — .1-ufd., 1000-v. paper
- C₅ — .1-ufd. 600-v. paper
- C₆ — .5-ufd. 600-v. paper
- C₇ — .03-ufd., 600-v. paper
- C₈ — .1-ufd., 1000-v. paper
- C₉ — .25-ufd., 1000-v. paper
- R₁ — 86,700 ohms, adjustable 100,000 ohms, 100 watts
- R₂ — 250,000 ohms, 1/2 watt
- R₄ — 15,000 ohms, 5 watts
- R₅ — 25,000 ohms, 2 watts
- R₆ — 2,500 ohms, 5 watts
- R₇ — 35,000 ohms, 160 watts
- R₈ — 250,000 ohms, 1/2 watt
- R₉ — 200,000 ohms, 2 watts
- R₁₀ — 500 ohms, 1/2 watt
- R₁₁ — 1 megohm, 1/2 watt
- R₁₂ — 100,000 ohms, 1 watt
- R₁₃ — 200,000 ohms, 1/2 watt
- R₁₄ — 10,000 ohms, 1/2 watt
- R₁₅ — 50 ohms, 10 watts
- R₁₆ — 100,000 ohms, 100 watts
- RFC₁ — 2.5-mhy., 125-ma. r-f choke
- RFC₂ — 1-mhy., 500-ma. r-f choke
- T₁ — 350-watt modulation transformer; ratio pri. to sec. approx. 1.5 : 1; pri. impedance 20,300 ohms, sec. impedance 13,300 ohms.
- T₂ — 600-watt modulation transformer; ratio pri. to sec. approx. 1.8 : 1; pri. impedance 11,400 ohms, sec. impedance 6,250 ohms.



4-250A
(5D22)





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

4CS100L

QUICK-HEAT
POWER TETRODE

The Eimac 4CS100L is a metal-ceramic power tetrode with a quick-heating cylindrical cathode intended for use in portable and mobile transmitters. Power output 3 db down from normal is available within one second after the application of rated heater voltage. Tube operation in approximately 150 milliseconds can be obtained by using a built-in control diode and a minimum amount of additional circuitry.

The conduction cooled 4CS100L has a maximum plate dissipation rating of 100 watts and may be operated at frequencies up to 250 megacycles.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode:	Oxide-coated, directly heated	Min.	Nom.	Max.
	Heating time (rated filament voltage)	1	2	seconds
	Heating time (at 6.2 volts)	- - - -	0.15	second
Heater:	Voltage (See "Application")	- - - -	2.1	volts
	Current (Ef=2.1 volts)	- - -	7.15	8.10 amperes
	Absolute Maximum Filament Voltage for fast warm-up (See "Application")	- - -	6.2	volts
	Amplification Factor (grid to screen)	- - -	10	13
	Transconductance (Ib=150 ma)	- - - -	20,000	umhos



Direct Interelectrode Capacitances, Grounded Cathode:

Input	- - - - -	26.0 pf
Output*	- - - - -	5.2 pf
Feedback	- - - - -	0.05 pf

*When mounted on a metal chassis, approximately 6.0 pf anode-to-ground capacitance is added to this value.

Frequency for Maximum Ratings	- - - - -	250 Mc
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Control Diode Ratings:

Plate Resistance (Id=0.01A, Ec=0v)	- - - - -	1200 ohms
(Id=0.01A, Ec= -40v)	- - - - -	1600 ohms
Plate Dissipation (Maximum)	- - - - -	0.5 watts
DC Plate Voltage (Maximum)	- - - - -	150 volts
DC Plate Current (Maximum)	- - - - -	20 mA

MECHANICAL

Base	- - - - -	Special 9-pin
Recommended Socket	- - - - -	Eimac, SK-660
Operating Position	- - - - -	Any
Maximum Operating Temperatures:		
Ceramic to Metal Seals	- - - - -	250° C
Anode Core	- - - - -	250° C
Cooling	- - - - -	Conduction
Maximum Over-all dimensions:		
Height	- - - - -	2.464 inches
Width	- - - - -	1.728 inches
Net Weight	- - - - -	4 ounces

**RADIO-FREQUENCY
LINEAR AMPLIFIER**

Class AB₁ (Single Sideband Suppressed-Carrier Operation)

MAXIMUM RATINGS

DC PLATE VOLTAGE	-	2000 MAX. VOLTS
DC SCREEN VOLTAGE	-	400 MAX. VOLTS
DC PLATE CURRENT	-	200 MAX. MA
PLATE DISSIPATION	-	**100 MAX. WATTS
SCREEN DISSIPATION	-	8 MAX. WATTS

*Approximate values

1 Adjust grid bias to obtain listed zero-signal plate current

**With adequate heat sink contact

TYPICAL OPERATION

DC Plate Voltage	- -	1000	1500	2000	volts
DC Screen Voltage	- -	400	400	400	volts
DC Grid Voltage ¹	- -	-33	-33	-33	volts
Zero-Signal DC					
Plate Current	- -	30	30	30	mA
DC Plate Current	- -	150	150	140	mA
DC Screen Current*	- -	5	4	8	mA
Peak RF Grid Voltage*	- -	24	24	24	volts
Plate Input Power	- -	145	220	280	watts
Plate Output Power	- -	65	125	185	watts
Two-Tone Average DC					
Plate Current	- -	96	96	96	mA
Two-Tone Average DC					
Screen Current	- -	3	3	3	mA

**RADIO-FREQUENCY
LINEAR AMPLIFIER**

Class AB₁ (Carrier Conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	-	2000 MAX. VOLTS
DC SCREEN VOLTAGE	-	400 MAX. VOLTS
DC PLATE CURRENT	-	200 MAX. MA
PLATE DISSIPATION	-	**100 MAX. WATTS
SCREEN DISSIPATION	-	8 MAX. WATTS

*Approximate values

1 Adjust grid bias to obtain listed zero-signal plate current

**With adequate heat sink contact

TYPICAL OPERATION

DC Plate Voltage	- -	1000	1500	2000	volts
DC Screen Voltage	- -	400	400	400	volts
DC Grid Voltage ¹	- -	-33	-33	-33	volts
Zero-Signal DC					
Plate Current	- -	30	30	30	mA
DC Plate Current	- -	55	55	55	mA
DC Screen Current*	- -	0	0	0	mA
Peak RF Grid Voltage*	- -	12	12	12	volts
Plate Output Power	- -	10	17	30	watts

**AUDIO-FREQUENCY AMPLIFIER
OR MODULATOR**

Class AB₁

MAXIMUM RATINGS (per tube)

DC PLATE VOLTAGE	-	2000 MAX. VOLTS
DC SCREEN VOLTAGE	-	400 MAX. VOLTS
DC PLATE CURRENT	-	200 MAX. MA
PLATE DISSIPATION	-	**100 MAX. WATTS
SCREEN DISSIPATION	-	8 MAX. WATTS

*Approximate values

1 Adjust grid bias to obtain listed zero-signal plate current

**With adequate heat sink contact

TYPICAL OPERATION (Sinusoidal wave, two tubes)

DC Plate Voltage	- -	1000	1500	2000	volts
DC Screen Voltage	- -	400	400	400	volts
DC Grid Voltage ¹	- -	-33	-33	-33	volts
Zero-Signal					
DC Plate Current	- -	60	60	60	mA
Max. Signal					
DC Plate Current	- -	300	300	280	mA
Max. Signal					
DC Screen Current	- -	10	8	16	mA
Effective Load,					
Plate to Plate	- -	4700	8600	13800	ohms
Peak AF Grid input					
voltage* (per tube)	- -	24	24	24	volts
Driving Power	- -	0	0	0	watts
Max. Signal					
Plate Output Power	- -	130	250	370	watts

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves. No allowance is made for circuit losses of any kind. Adjustment of the rf grid drive to obtain the specified plate current at the specified grid bias, screen voltage, and plate voltage is assumed. If this procedure is followed there will be little variation in output power when tubes are changed, even though there may be some variations in grid and screen currents. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf driving voltage is applied.

APPLICATION

MECHANICAL

MOUNTING

The 4CS100L may be mounted in any position provided that the anode beryllium oxide insulator is properly mated to an adequate heat sink. A heat-conducting socket, such as the Eimac SK-660, or a socket having equivalent characteristics, is required. The screen must be by-passed by the Eimac SK-665 capacitor. This capacitor also includes a provision for a dc connection to the tube's screen ring. There is no pin connection on the tube base for a screen connection.

COOLING

Maximum ratings for the 4CS100L depend on adequate conduction cooling to maintain all tube and seal temperatures at 250° C or below. Maximum anode dissipation depends on intimate mating of the BeO anode insulator to an adequate heat-sink. A conductive lubricant is suggested

to insure proper seating of the BeO insulator to the heat-sink. Tube temperatures can be expected to run up to 120° C above the beryllia-to-heat-sink surface temperature.

Base cooling is also by conduction through the Eimac SK-660 socket (or equivalent). To insure proper cooling, tube temperatures should be monitored with temperature sensitive lacquer or by some other means in any new installation.

VIBRATION

This tube is capable of satisfactorily withstanding ordinary shock and vibration, such as encountered in normal operation and handling. The tubes will function well in portable, automobile and truck mobile installations or similar environments.

ELECTRICAL

HEATER OPERATION

With the rated heater voltage of 2.1 volts applied, the warm-up time is approximately 1 second for power output 3 db down from normal. Approximately 2 seconds are required for full output power. The heater voltage must be maintained within $\pm 5\%$ of its rated value to minimize variations in performance and to obtain maximum tube life.

However, the warm-up time may be reduced to approximately 0.15 second by applying overvoltage to the heater for a short period of time, as controlled by the control diode, and then switching to rated heater voltage when the cathode has reached normal operating temperature. Overvoltage must be limited to 3 times nominal ($E_f=6.2$ volts maximum), for the proper length of time. This feature permits "push-to-talk" operation, of portable and mobile equipment with significant extension of battery life.

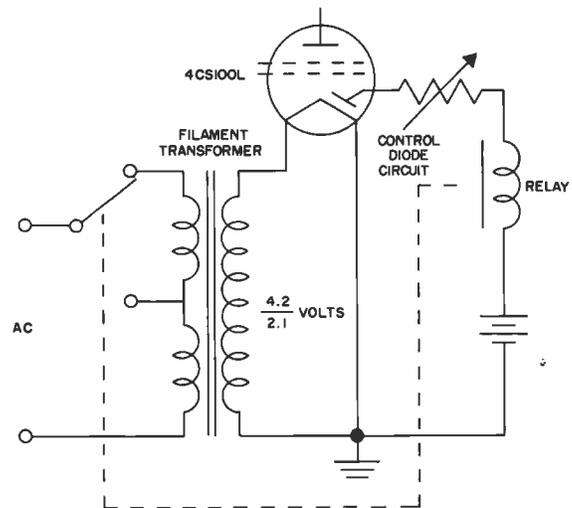
CONTROL DIODE OPERATION

Extreme caution must be taken to insure that heater overvoltage is not applied beyond the time at which the cathode reaches operating temperature, since the voltage used is sufficient to destroy the cathode. Proper operation will be insured if overvoltage is removed when control diode anode current reaches 65% of its steady state operating value.

The control diode built into the tube is designed specifically for sensing cathode temperature, and in combination with a properly designed relay circuit will allow overvoltage for a short period followed by a switch to normal voltage. Since the control diode section of the tube is intended for dc switching use only, the control diode anode polarity should not be made negative with respect

to the cathode. A typical simplified control circuit is shown; more sophisticated, fail-safe circuits can be used.

In any application, the actual circuit details will depend on such factors as the operating time of the relay used and the degree of overvoltage used initially. It is recommended that the Power Grid Tube Marketing, Eitel-McCullough, Inc., San Carlos, California be contacted for assistance in the use of the Eimac 4CS100L, in applications requiring the use of heater overvoltage.



CONTROL-GRID OPERATION

The grid dissipation rating of the 4CS100L is 0.5 watts and precautions should be observed to avoid exceeding this rating. The 4CS100L is a high transconductance tube requiring low drive voltage for full power output. The design features which make this tube capable of maximum power

operation with low grid drive also make it necessary to avoid drawing significant grid current. Although the tube was designed primarily for Class AB₁ operation, it may be used for Class C applications if the above control grid precautions are carefully observed.

SCREEN-GRID OPERATION

The maximum rated power dissipation for the screen grid is 8 watts, and the screen input power should be kept below that level. The product of the peak screen voltage and the indicated dc screen current approximates the screen input power except when the screen current indication is near zero or negative.

In the usual tetrode amplifier, where no signal voltage appears between cathode and screen, the peak screen voltage is equal to the dc screen voltage.

Protection for the screen can be provided by an overcurrent relay and by interlocking the screen supply so that the plate voltage must be applied before screen voltage can be applied.

The screen current may reverse under certain conditions, and produce negative current indications on the screen milliammeter. This is a normal characteristic of most tetrodes. The screen power supply should be designed with this characteristic in mind, so that the correct operating voltage will be maintained on the screen under

all conditions. A current path from screen to cathode must be provided by a bleeder resistor or shunt regulator connected between screen and cathode and arranged to pass approximately 15 milliamperes per connected screen. An electron tube series regulator can be used only when an adequate bleeder resistor is provided.

A screen by-pass capacitor such as the Eimac SK-665 may be used. Connection to the screen is made to the contact on the SK-655 or to the screen ring on the tube.

PLATE OPERATION

Connection to the anode may be made at the top cap or to the tapped holes on the anode "saddle." The maximum plate-dissipation rating for the 4CS100L is 100 watts. Plate dissipation may be permitted to exceed the maximum rated value if rated core and seal temperature is maintained.

The maximum rated plate voltage for Class AB₁ operation at frequencies up to 250 megacycles is 2000 volts.

SPECIAL APPLICATIONS

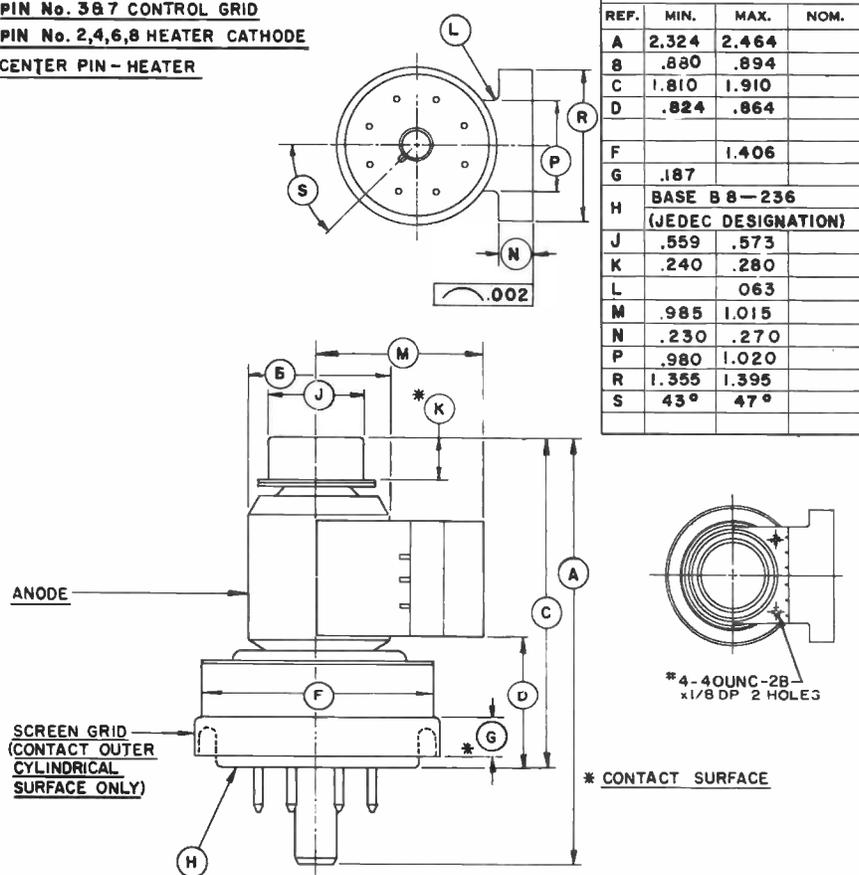
If it is desired to operate this tube under conditions widely different from those given here, write to Eitel-McCullough, Inc. for information and recommendations.

PIN No. 1 & 5 CONTROL DIODE ANODE

PIN No. 3 & 7 CONTROL GRID

PIN No. 2,4,6,8 HEATER CATHODE

CENTER PIN - HEATER

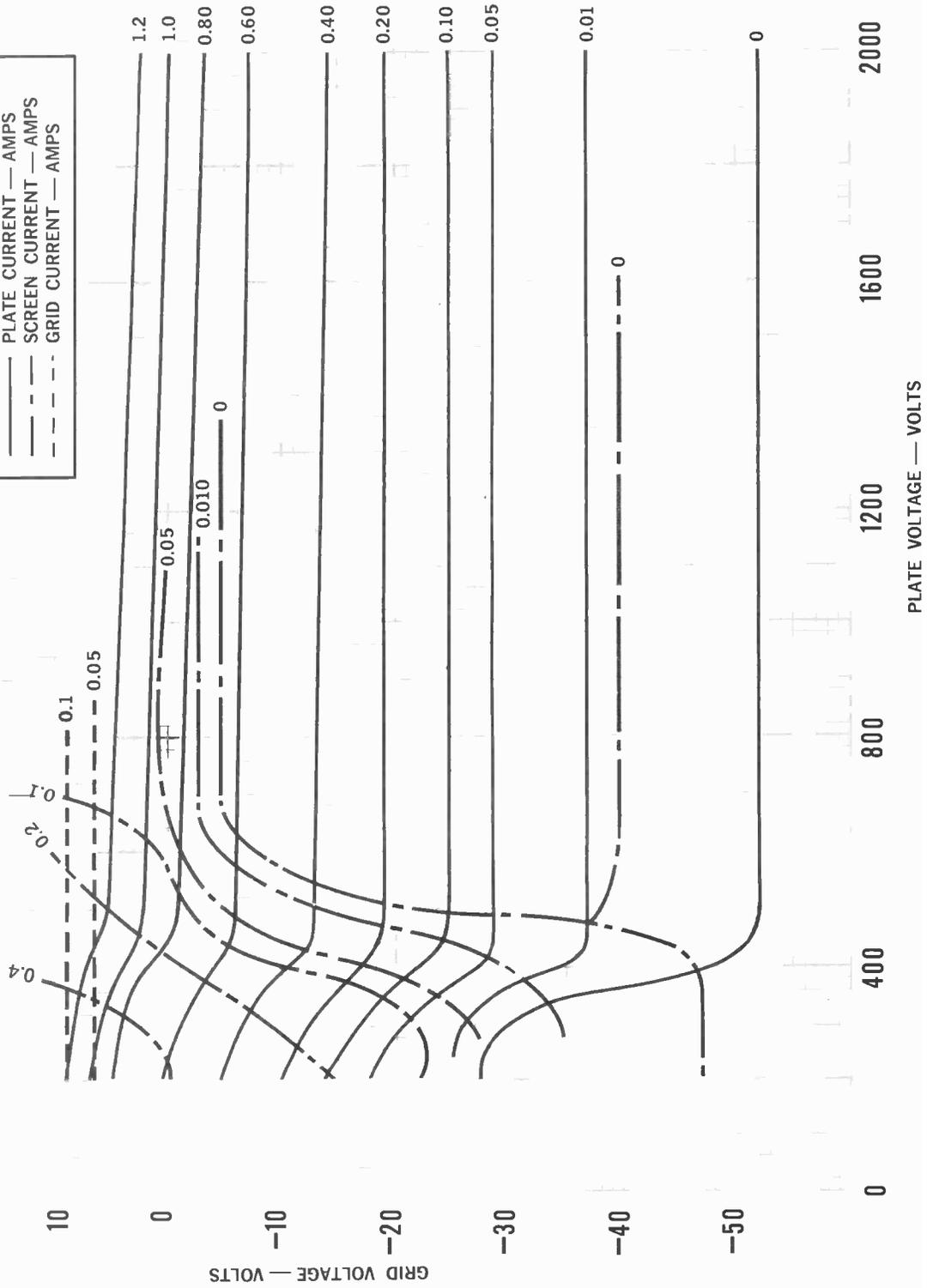




EIMAC 4CS100L TYPICAL CONSTANT CURRENT CHARACTERISTICS

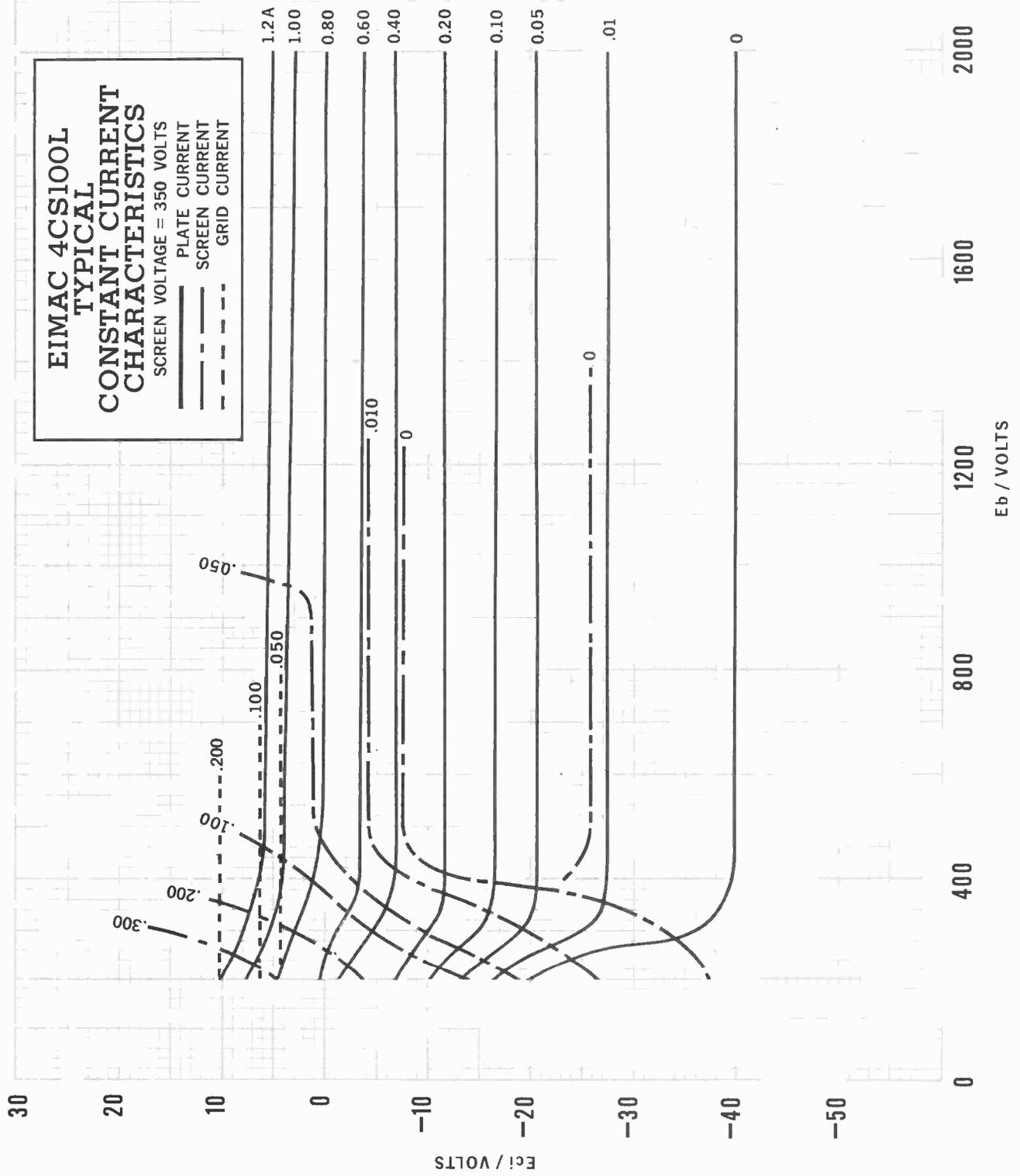
SCREEN VOLTAGE = 400 VOLTS

- PLATE CURRENT — AMPS
- SCREEN CURRENT — AMPS
- - - GRID CURRENT — AMPS



**EIMAC 4CS100L
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS**
SCREEN VOLTAGE = 350 VOLTS

— PLATE CURRENT
- - - SCREEN CURRENT
- - - GRID CURRENT





E I M A C
 Division of Varian
 SAN CARLOS
 CALIFORNIA

8438

4-400A

**RADIAL-BEAM
 POWER TETRODE**

**MODULATOR
 OSCILLATOR
 AMPLIFIER**

The EIMAC 8438/4-400A is a compact, ruggedly constructed power tetrode having a maximum plate dissipation rating of 400 watts. It is intended for use as an amplifier, oscillator or modulator. The low grid-plate capacitance of this tetrode coupled with its low driving-power requirement allows considerable simplification of the association circuit and driver stage.

The 8438/4-400A is cooled by radiation from the plate and by circulation of forced-air through the base, around the envelope, and over the plate seal. Cooling can be greatly simplified by using an EIMAC SK-400 Air-System Socket and its accompanying glass chimney. This socket is designed to maintain the correct balance of cooling air between the component parts of the tube.†



GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten	
Voltage - - - - -	5.0 volts
Current - - - - -	14.5 amperes
Grid-Screen Amplification Factor (Average) - - - - -	5.1
Direct Interelectrode Capacitances (Average)	
Grid-Plate - - - - -	0.12 μmfd
Input - - - - -	12.5 μmfd
Output - - - - -	4.7 μmfd
Transconductance ($I_b=100\text{ma.}$, $E_b=2500\text{V.}$, $E_{c2}=500\text{V.}$)	4,000 μmhos
Frequency for Maximum Ratings - - - - -	110 MHz

MECHANICAL

Base - - - - -	See drawing
Basing - - - - -	See drawing
Mounting Position - - - - -	Vertical, base down or up
Cooling - - - - -	Radiation and forced air
Recommended Heat Dissipating Plate Connector - - - - -	EIMAC HR-6
Recommended Socket - - - - -	EIMAC SK-400 Air System Socket
Maximum Over-all Dimensions	

Length - - - - -	6.38 inches
Diameter - - - - -	3.56 inches
Net Weight - - - - -	9 ounces
Shipping Weight - - - - -	2.5 pounds

If an Air-System Socket is used, mounted on a 1/4 inch deck, the over-all dimensions of the system including chimney and HR-6 Heat Dissipating Plate Connector are:

Length - - - - -	8.0 inches
Diameter - - - - -	5.5 inches

Note: Typical operation data are based on conditions of adjusting the rf grid drive to a specified plate current, maintaining fixed conditions of grid bias and screen voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid and screen currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

†Guarantee applies only when the 4-400A is used as specified with adequate air in the SK-400 Air-System Socket or equivalent.

MECHANICAL

Mounting — The 4-400A must be mounted vertically, base up or down. The socket must be constructed so as to allow an unimpeded flow of air through the holes in the base of the tube and must also provide clearance for the glass tip-off which extends from the center of the base. The metal tube-base shell should be grounded by means of suitable spring fingers. The above requirements are met by the EIMAC SK-400 Air-System Socket. A flexible connecting strap should be provided between the EIMAC HR-6 cooler on the plate terminal and the external plate circuit. The tube must be protected from severe vibration and shock.

Cooling — Adequate forced-air cooling must be provided to maintain the base seals at a temperature below 200°C., and the plate seal at a temperature below 225°C.

When the EIMAC SK-400 Air-System Socket is used, a minimum air flow of 14 cubic feet per minute at a static pressure of 0.25 inches of water, as measured in the socket at sea level, is required to provide adequate cooling under all conditions of operation. Seal temperature limitations may require that cooling air be supplied to the tube even when the filament alone is on during standby periods.

In the event an Air-System Socket is not used, provision must be made to supply equivalent cooling of the base, the envelope, and the plate lead.

Tube temperatures may be measured with the aid of "Tempilaq," a temperature-sensitive lacquer manufactured by the Tempil Corporation, 132 West 22nd Street, New York 11, N.Y.

ELECTRICAL

Filament Voltage — For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated voltage of 5.0 volts. Variations in filament voltage must be kept within the range from 4.75 to 5.25 volts.

Bias Voltage — The dc bias voltage for the 4-400A should not exceed 500 volts. If grid leak bias is used, suitable means must be provided to prevent excessive plate or screen dissipation in the event of loss of excitation, and the grid-leak resistor should be made adjustable to facilitate maintaining the bias voltage and plate current at the desired values from tube to tube. In operation above 50 MHz, it is advisable to keep the bias voltage as low as is practicable.

Screen Voltage — The dc screen voltage for the 4-400A should not exceed 600 volts in rf applications. In audio applications a maximum dc screen voltage of 800 volts may be used. The screen voltages shown under "Typical Operation" are representative voltages for the type of operation involved.

Plate Voltage — The plate-supply voltage for the 4-400A should not exceed 4000 volts in CW and audio applications. In plate-modulated telephony service the dc plate-supply voltage should not exceed 3200 volts, except below 30 MHz, intermittent service, where 4000 volts may be used.

Grid Dissipation — Grid dissipation for the 4-400A should not be allowed to exceed 10 watts. Grid dissipation may be calculated from the following expression:

$$P_g = e_{emp} I_e$$

where P_g = Grid dissipation

e_{emp} = Peak positive grid to cathode voltage, and

I_e = dc grid current

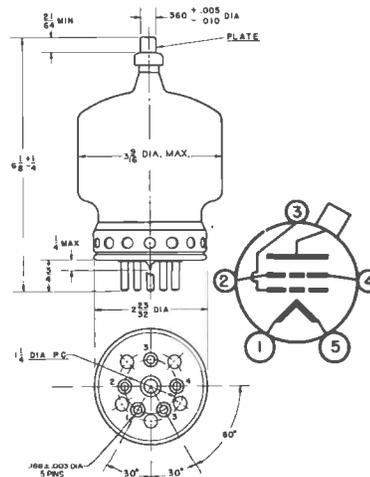
e_{emp} may be measured by means of a suitable peak voltmeter connected between filament and grid. (For suitable peak v.t.v.m. circuits see EIMAC Application Bulletin Number 6, "Vacuum Tube Ratings." This bulletin is available on request.)

Screen Dissipation — The power dissipated by the screen of the 4-400A must not exceed 35 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 35 watts in event of circuit failure.

Plate Dissipation — Under normal operating conditions, the plate dissipation of the 4-400A should not be allowed to exceed 400 watts.

In plate modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 270 watts. The plate dissipation will rise to 400 watts under 100% sinusoidal modulation.

Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.





4-400A

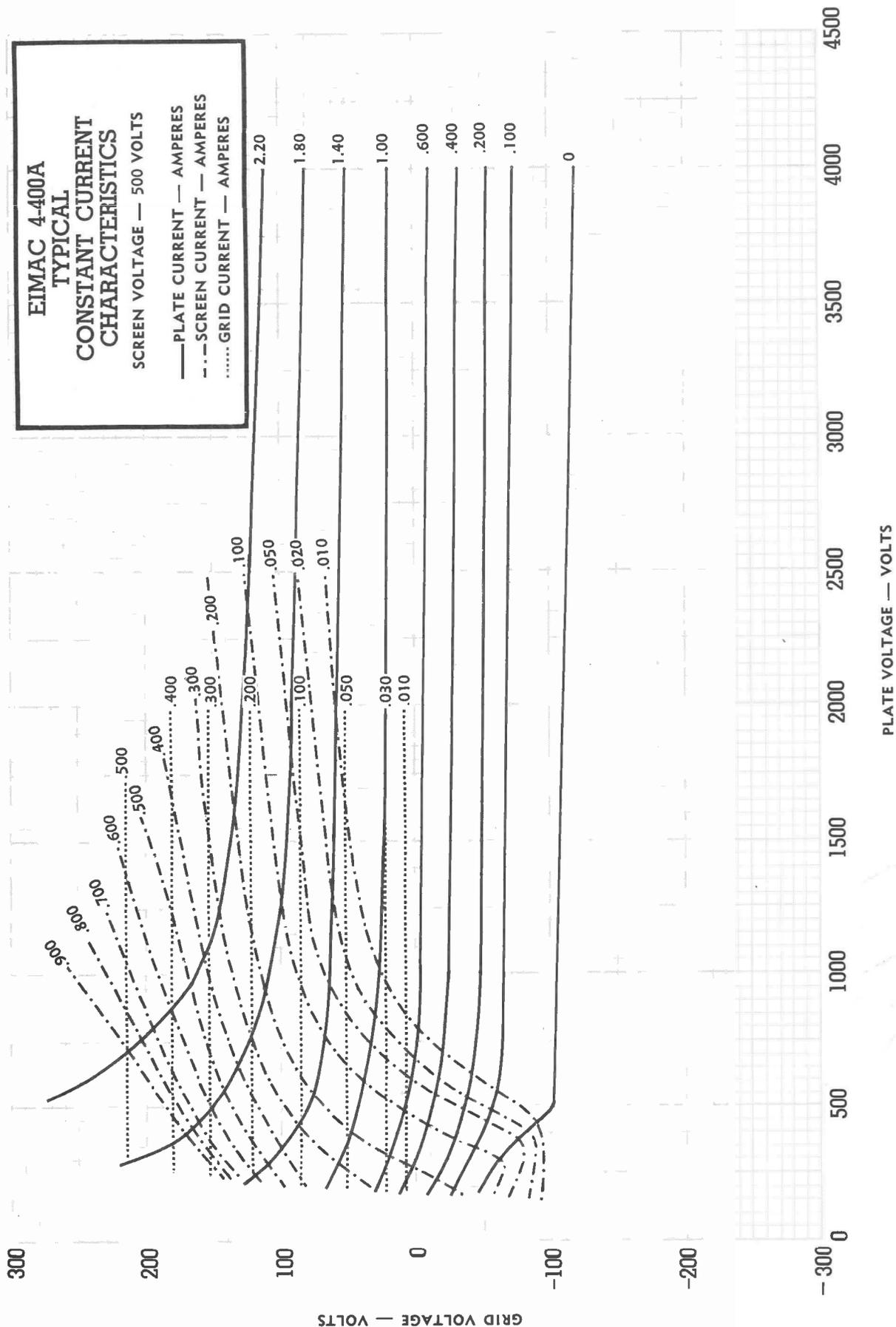
EIMAC 4-400A

TYPICAL

CONSTANT CURRENT CHARACTERISTICS

SCREEN VOLTAGE — 500 VOLTS

- PLATE CURRENT — AMPERES
- - - SCREEN CURRENT — AMPERES
- GRID CURRENT — AMPERES





TECHNICAL DATA

8876

RADIAL-BEAM
POWER TETRODE

The 8876 is a ceramic/metal forced-air cooled, external-anode radial-beam tetrode with a maximum plate dissipation rating of 250 watts and a maximum input-power rating of 500 watts. The 8876 is designed for very long life and reliable performance in oscillator, amplifier, or modulator service. In most applications, it may be used as a direct replacement for the 7203/4CX250B, with only minor circuit retuning required.



GENERAL CHARACTERISTICS¹

ELECTRICAL

Cathode: Oxide Coated, Unipotential

Heater: Voltage	6.0 ± 0.3 V
Current, at 6.0 volts	2.4 A
Cathode-Heater Potential, maximum	±150 V

Amplification Factor (Average):

Grid to Screen	5
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Direct Interelectrode Capacitances (grounded cathode)²

C _{in}	17.0 pF
C _{out}	4.5 pF
C _{gp}	0.04 pF

Direct Interelectrode Capacitances (grounded grid and screen)²

C _{in}	13.6 pF
C _{out}	4.5 pF
C _{pk}	0.01 pF

Frequency of Maximum Rating:

CW	500 MHz
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1. Characteristics and operating values are based upon performance tests. These figures may change without notice as the result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.

2. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

MECHANICAL

Maximum Overall Dimensions:

Length	2.46 in; 62.5 mm
Diameter	1.64 in; 41.7 mm

Net Weight	4 oz; 113 gm
Operating Position	Any

Maximum Operating Temperature:

Ceramic/Metal Seals	250°C
Anode Core	250°C

Cooling Forced Air
 Base Special 9-pin JEDEC-B8-236
 Recommended Socket EIMAC SK-600 Series
 Recommended Chimney EIMAC SK-600 Series

RADIO FREQUENCY LINEAR AMPLIFIER

GRID DRIVEN (SSB)

Class AB₁

MAXIMUM RATINGS:

DC PLATE VOLTAGE	2000	VOLTS
DC SCREEN VOLTAGE	400	VOLTS
DC GRID VOLTAGE	-250	VOLTS
DC PLATE CURRENT	0.25	AMPERE
PLATE DISSIPATION	250	WATTS
SCREEN DISSIPATION	12	WATTS
GRID DISSIPATION	2	WATTS

TYPICAL OPERATION (Frequencies to 175 MHz)

Class AB₁, Grid Driven, Peak Envelope or Modulation Crest Conditions

Plate Voltage	1000	1500	2000	Vdc
Screen Voltage	350	350	350	Vdc
Grid Voltage ¹	-55	-55	-55	Vdc
Zero-Signal Plate Current	100	100	100	mAdc
Single Tone Plate Current	250	250	250	mAdc
Two-Tone Plate Current	190	190	190	mAdc
Single-Tone Screen Current ²	10	8	5	mAdc
Two-Tone Screen Current ²	2	-1	-2	mAdc
Single-Tone Grid Current ²	0	0	0	mAdc
Peak rf Grid Voltage ²	50	50	50	v
Plate Output Power	120	215	300	W
Resonant Load Impedance	2000	3000	4000	Ω

1. Adjust to specified zero-signal dc plate current.
2. Approximate value.

RADIO FREQUENCY LINEAR AMPLIFIER

GRID DRIVEN, CARRIER CONDITIONS

Class AB₁

MAXIMUM RATINGS:

DC PLATE VOLTAGE	2000	VOLTS
DC SCREEN VOLTAGE	400	VOLTS
DC GRID VOLTAGE	-250	VOLTS
DC PLATE CURRENT	0.25	AMPERE
PLATE DISSIPATION	250	WATTS
SCREEN DISSIPATION	12	WATTS
GRID DISSIPATION	2	WATTS

TYPICAL OPERATION (Frequencies to 175 MHz)

Class AB₁, Grid Driven

Plate Voltage	1000	1500	2000	Vdc
Screen Voltage	350	350	350	Vdc
Grid Voltage ¹	-55	-55	-55	Vdc
Zero-Signal Plate Current	100	100	100	mAdc
Carrier Plate Current	150	150	150	mAdc
Carrier Screen Current	-3	-4	-4	mAdc
Peak rf Grid Voltage ²	25	25	25	v
Plate Output Power	30	50	65	W

1. Adjust to specified zero-signal dc plate current.
2. Approximate value

RADIO FREQUENCY POWER AMPLIFIER

OR OSCILLATOR

Class C Telephony or FM Telephony

(Key-Down Conditions)

MAXIMUM RATINGS:

DC PLATE VOLTAGE	2000	VOLTS
DC SCREEN VOLTAGE	300	VOLTS
DC GRID VOLTAGE	-250	VOLTS
DC PLATE CURRENT	0.25	AMPERE
PLATE DISSIPATION	250	WATTS
SCREEN DISSIPATION	12	WATTS
GRID DISSIPATION	2	WATTS

TYPICAL OPERATION (Frequencies to 175 MHz) | 500 MHz

Plate Voltage	500	1000	1500	2000	2000	Vdc
Screen Voltage	250	250	250	250	300	Vdc
Grid Voltage	-90	-90	-90	-90	-90	Vdc
Plate Current	250	250	250	250	250	mAdc
Screen Current ¹	45	38	21	19	10	mAdc ²
Grid Current ¹	35	31	28	26	25	mAdc ²
Peak rf Grid Voltage ¹ ..	114	114	112	112	---	v
Measured Driving Power ¹	4.0	3.5	3.2	2.9	---	W
Plate Input Power	125	250	375	500	500	W
Plate Output Power	70	190	280	390	300	W ²
Heater Voltage	6.0	6.0	6.0	6.0	5.7	V

1. Approximate value.
2. Measured values for a typical cavity amplifier circuit.

PLATE MODULATED RADIO FREQUENCY POWER AMPLIFIER-GRID DRIVEN

Class C Telephony (Carrier Conditions)

MAXIMUM RATINGS:

DC PLATE VOLTAGE	1500	VOLTS
DC SCREEN VOLTAGE	300	VOLTS
DC GRID VOLTAGE	-250	VOLTS
DC PLATE CURRENT	0.20	AMPERE
PLATE DISSIPATION ¹	165	WATTS
SCREEN DISSIPATION ²	12	WATTS
GRID DISSIPATION ²	2	WATTS

TYPICAL OPERATION (Frequencies to 175 MHz)

Plate Voltage	500	1000	1500	Vdc
Screen Voltage	250	250	250	Vdc
Grid Voltage	-100	-100	-100	Vdc
Plate Current	200	200	200	mAdc
Screen Current ³	31	22	20	mAdc
Grid Current ³	15	14	14	mAdc
Peak rf Grid Voltage ³	118	117	117	v
Calculated Driving Power	1.8	1.7	1.7	W
Plate Input Power	100	200	235	W

1. Corresponds to 250 watts at 100% sine-wave modulation.
2. Average, with or without modulation.
3. Approximate value.

AUDIO FREQUENCY POWER AMPLIFIER OR MODULATOR

Class AB, Grid Driven (Sinusoidal Wave)

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE	2000	VOLTS
DC SCREEN VOLTAGE	400	VOLTS
DC GRID VOLTAGE	-250	VOLTS
DC PLATE CURRENT	0.25	AMPERE
PLATE DISSIPATION	250	WATTS
SCREEN DISSIPATION	12	WATTS
GRID DISSIPATION	2	WATTS

†. Approximate value

TYPICAL OPERATION (Two Tubes)

Plate Voltage	1000	1500	2000	Vdc
Screen Voltage	350	350	350	Vdc
Grid Voltage ^{1/3}	-55	-55	-55	Vdc
Zero-Signal Plate Current	200	200	200	mAdc
Max Signal Plate Current	500	500	500	mAdc
Max Signal Screen Current ¹	20	16	10	mAdc
Max Signal Grid Current ¹	0	0	0	mAdc
Peak rf Grid Voltage ²	50	50	50	v
Peak Driving Power	0	0	0	W
Plate Input Power	500	750	1000	W
Plate Output Power	240	430	600	W
Load Resistance (plate to plate)	3500	6200	9500	Ω

2. Per tube.
3. Adjust to give stated zero-signal plate current.

NOTE: TYPICAL OPERATION data are obtained from direct measurement or by calculation from published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, screen and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid and screen current. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. In the case of Class C Service, if grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf grid voltage is applied.

RANGE VALUES FOR EQUIPMENT DESIGN

	Min.	Max.
Heater: Current at 6.0 volts	2.2	2.7 A
Cathode Warmup Time	60	--- sec.
Interelectrode Capacitances ¹ (grounded cathode connection)		
C _{in}	15.0	18.0 pF
C _{out}	4.0	5.0 pF
C _{gp}	---	0.06 pF

1. Capacitance values are for a cold tube as measured in a special shielded fixture in accordance with Electronic Industries Association Standard RS-191.

APPLICATION

MECHANICAL

MOUNTING - The 8876 may be operated in any position. An EIMAC Air-System Socket, SK-600 series, or a socket having equivalent characteristics, is required. Sockets are available with or without built-in screen capacitors and may be obtained with either grounded or ungrounded cathode terminals.

COOLING - Sufficient forced-air cooling must be provided for the anode, base seals, and body seals to maintain operating temperatures below the rated maximum values. Air requirements to maintain anode core temperatures at 200°C with an inlet air temperature of 50°C are tabulated below. These requirements apply when a socket of the EIMAC SK-600 series and an EIMAC SK-606 chimney are used with air flow in the base to anode direction.

SEA LEVEL			10,000 FEET	
Plate Dissipation(watts)	Air Flow (CFM)	Pressure Drop(In.of water)	Air Flow (CFM)	Pressure Drop(In.of water)
200	5.0	0.52	7.3	0.76
250	6.4	0.82	9.3	1.20

The blower selected in a given application must be capable of supplying the desired airflow at a back pressure equal to the pressure drop shown above plus any drop encountered in ducts and filters. The blower must be designed to deliver the air at the desired altitude.

At 500 MHz or below, base cooling air requirements are satisfied automatically when the tube is operated in an EIMAC Air-System Socket and the recommended air flow rates are used. Experience has shown that if reliable long life operation is to be obtained, the cooling air flow must be maintained during standby periods when only the heater voltage is applied to the tube. The anode cooler should be inspected periodically and cleaned when necessary to remove any dirt which might interfere with effective cooling.

VIBRATION - This tube is designed to provide reliable service under ordinary shock and vibration conditions, such as encountered in mobile installations. However, when severe shock, or high-level and high-frequency vibration are expected, it is suggested that the EIMAC 4CX300A or 4CX250R be employed.

ELECTRICAL

HEATER - The rated heater voltage for the 8876 is 6.0 volts and the voltage must be maintained within $\pm 5\%$ to obtain good tube life and stable performance. Regulation to a tolerance better than $\pm 5\%$ normally will be beneficial as regards life expectancy.

At frequencies above approximately 300 MHz transit-time effects begin to influence the cathode temperature. The amount of driving power diverted to heating the cathode by back-bombardment will depend upon frequency, plate current, and driving power. When the tube is driven to maximum input as a class-C amplifier, the heater voltage should be reduced according to the table below;

300 MHz or lower	6.00 volts
301 to 400 MHz	5.85 volts
401 to 500 MHz	5.70 volts

CATHODE OPERATION - The oxide coated unipotential cathode must be protected against excessively high emission currents. The maximum rated dc input current is 200 mA for plate-modulated operation and 250 mA for all other types of operation except pulse.

The cathode is internally connected to the four even-numbered base pins and all four of the corresponding socket terminals should be used to make connection to the external circuits. At radio frequencies it is important to keep the cathode leads short and direct and to use conductors with large areas to minimize the inductive reactances in series with the cathode leads.

It is recommended that rated heater voltage be applied for a minimum of 60 seconds before other operating voltages are applied. If faster warmup is required, an over-voltage of 8.0 volts may be applied to the heater and held for 30 seconds, at which time the voltage must be reduced to the rated value. Full operating cathode temperature is reached in 30 seconds with this technique. From a cold start, it is imperative that the over-voltage be held not over 30 seconds, and if the tube has not completely cooled since previous use, a shorter period of over-voltage must be used.

Where the circuit design requires the cathode and heater to be operated at different potentials, the rated maximum heater-to-cathode voltage is 150 volts regardless of polarity.

GRID OPERATION - The maximum rated dc grid bias voltage is -250 volts and the maximum grid dissipation rating is 2.0 watts. In ordinary audio and radio-frequency amplifiers the grid dissipation usually will not approach the maximum rating. At operating frequencies above the 100 MHz region, driving power requirements for amplifiers increase noticeably. At 500 MHz as much as 20 watts of driving power may have to be supplied. However, most of the driving power is absorbed in circuit losses other than grid dissipation, so that grid dissipation is increased only slightly. Satisfactory 500 MHz operation of the tube in a stable amplifier is indicated by grid-current values below approximately 15 mA.

The grid voltage required by different tubes may vary between limits approximately 20% above and below the center value, and means should be provided in the equipment to accommodate such variation. It is especially important that variations between individual tubes be compensated when tubes are operated in parallel or push-pull circuits, to assure equal load sharing.

The maximum permissible grid-circuit resistance per tube is 100,000 ohms.

SCREEN OPERATION - The maximum rated power dissipation for the screen is 12 watts, and the screen input power should be kept below that level. The product of the peak screen voltage and the indicated dc screen current approximates the screen input power except when the screen current indication is near zero or negative.

In the usual tetrode amplifier, where no signal voltage appears between cathode and screen, the peak screen voltage is equal to the dc screen voltage.

When signal voltages appear between screen and cathode, as in the case of screen-modulated amplifiers or cathode-driven tetrode amplifiers, the peak screen-to-cathode voltage is the sum of the dc screen voltage and the peak ac or rf signal voltage applied to screen or cathode.

Protection for the screen should be provided by an over-current relay and by interlocking the screen supply so that plate voltage must be applied before screen voltage can be applied.

The screen current may reverse under certain conditions and produce negative current indications on the screen milliammeter. This is a normal characteristic of most tetrodes. The screen power supply should be designed with this characteristic in mind so that the correct operating voltage will be maintained on the screen under all conditions. A current path from screen to cathode must be provided by a bleeder resistor, gaseous voltage regulator tubes, or an electron

tube *shunt* regulator connected between screen and cathode and arranged to pass approximately 15 milliamperes per connected screen. An electron tube *series* regulator can be used only when an adequate bleeder resistor is provided.

Self-modulation of the screen in plate-modulated tetrode amplifiers using these tubes may not be satisfactory because of the screen-voltage screen-current characteristics. Screen modulation from a tertiary winding on the modulation transformer or by means of a small separate modulator tube will usually be more satisfactory. Screen-voltage modulation factors between 0.75 and 1.0 will result 100% modulation for plate-modulated rf amplifiers using the 8876.

PLATE OPERATION - The maximum rated plate dissipation power is 250 watts. In plate-modulated applications the carrier plate dissipation power must be limited to 165 watts to avoid exceeding the plate dissipation rating with 100% sine wave modulation. The maximum dissipation rating may be exceeded for brief periods during circuit adjustment without damage to the tube.

MULTIPLE OPERATION - Tubes operating in parallel or push-pull must share the load equally. It is good engineering practice to provide individual metering and individual adjustment of bias or screen voltage to equalize the inputs.

Where overload protection is provided, it should be capable of protecting the surviving tube (s) in the event that one tube fails.

VHF OPERATION - The 8876 is suitable for use in the VHF region. Such operation should be conducted with heavy plate loading, minimum bias, and the lowest driving power consistent with satisfactory performance. It is often preferable to operate at a sacrifice in efficiency to obtain increased tube life.

HIGH VOLTAGE - Normal operating voltages used with the 8876 are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open primary circuits of the power supply and to discharge high-voltage condensers whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that HIGH VOLTAGE CAN KILL.

INTERELECTRODE CAPACITANCE - The actual internal interelectrode capacitance of a tube is influenced by many variables in most applications, such as stray capacitance to the chassis, capacitance added by the socket used, stray capacitance between tube terminals, and wiring effects. To control the actual capacitance values within the tube, as the key component involved, the industry and the Military Services use a standard test procedure as described in Electronic Industries Association Standard RS-191. This requires the use of specially constructed test fixtures which effectively shield all external tube leads from each other and eliminates any capacitance reading to "ground". The test is performed on a cold tube. Other factors being equal, controlling internal tube capacitance in this way normally assures good interchangeability of tubes over a period of

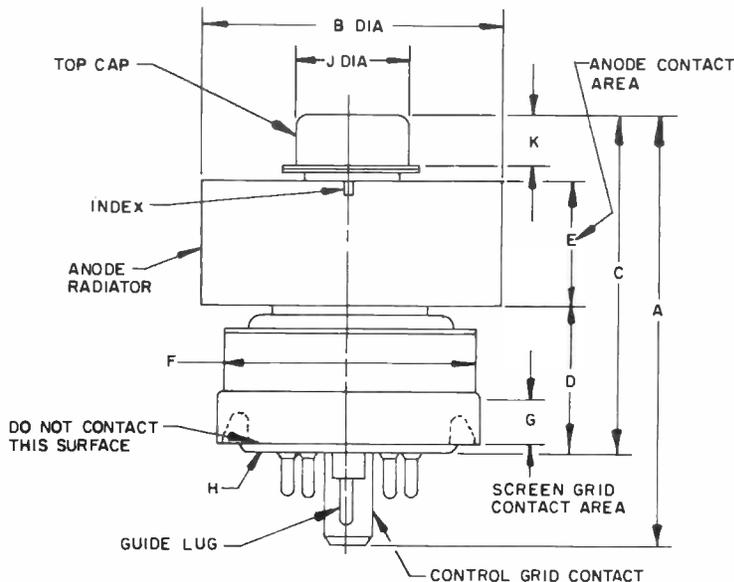
time, even when the tube may be made by different manufacturers. The capacitance values shown in the manufacturer's technical data, or test specifications, normally are taken in accordance with Standard RS-191.

The equipment designer is therefore cautioned to make allowance for the actual capacitance values which will exist in any normal application. Measurements should be taken with the socket and mounting which represent approximate final layout if capacitance values are highly significant in the design.

SPECIAL APPLICATIONS - If it is desired to operate these tubes under conditions widely different from those given here, write to Power Grid Tube Division, EIMAC Division of Varian, San Carlos, Calif. 94070 for information and recommendations.

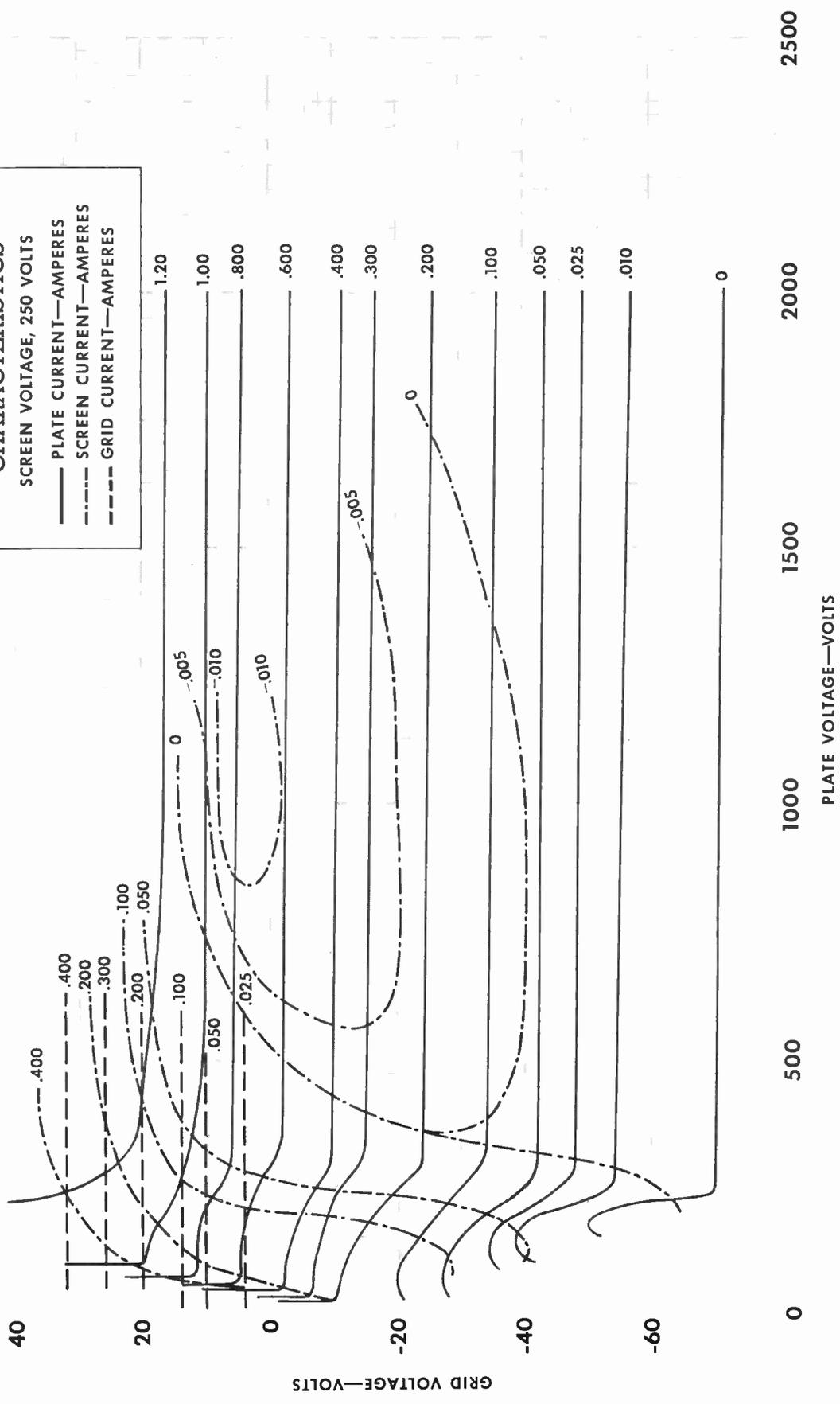
PIN DESIGNATION	
PIN NO. 1	SCREEN GRID
PIN NO. 2	CATHODE
PIN NO. 3	HEATER
PIN NO. 4	CATHODE
PIN NO. 5	I.C. DO NOT USE FOR EXTERNAL CONNECTION.
PIN NO. 6	CATHODE
PIN NO. 7	HEATER
PIN NO. 8	CATHODE
CENTER PIN - CONTROL GRID	

DIMENSIONAL DATA				
DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	2.342	2.464	59.03	62.59
B	1.610	1.640	40.89	41.66
C	1.810	1.910	45.97	48.51
D	0.750	0.810	19.05	20.57
E	0.710	0.790	18.03	20.07
F	--	1.406	--	35.71
G	0.187	--	4.75	--
H	BASE BB-236 (JEDEC DESIGNATION)			
J	0.559	0.573	14.20	14.55
K	0.240	--	6.10	--



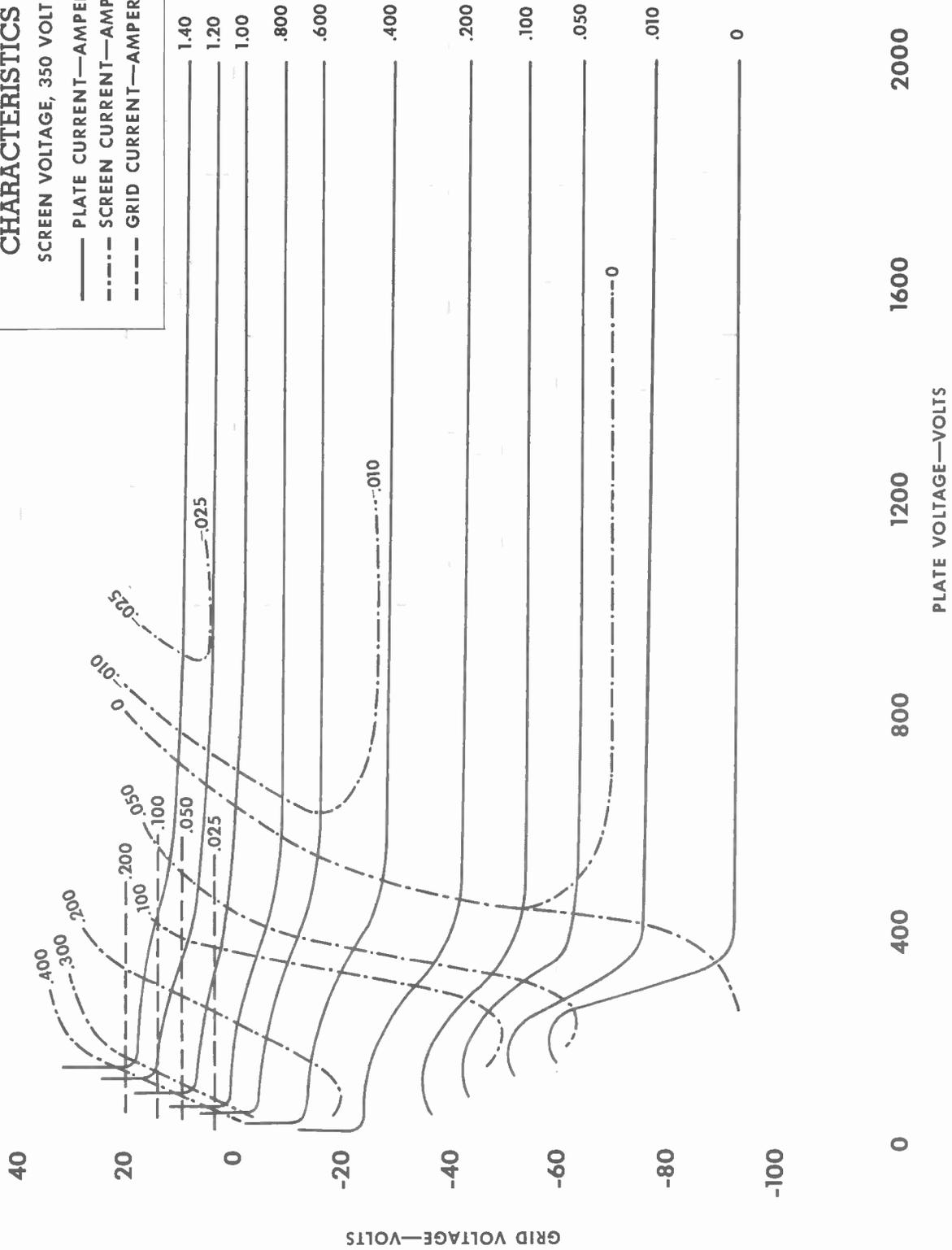
**TYPICAL
CONSTANT-CURRENT
CHARACTERISTICS**
SCREEN VOLTAGE, 250 VOLTS

- PLATE CURRENT—AMPERES
- - - SCREEN CURRENT—AMPERES
- · - · - GRID CURRENT—AMPERES



**TYPICAL
CONSTANT-CURRENT
CHARACTERISTICS**
SCREEN VOLTAGE, 350 VOLTS

- PLATE CURRENT—AMPERES
- - - - SCREEN CURRENT—AMPERES
- - - - GRID CURRENT—AMPERES





E I M A C
 Division of Varian
 S A N C A R L O S
 C A L I F O R N I A

4CV20,000A

VAPOR-COOLED
 RADIAL-BEAM
 POWER-TETRODE

The Eimac 4CV20,000A is a vapor-cooled, ceramic-metal, power tetrode designed for use as an oscillator, modulator, or amplifier in audio and radio-frequency applications. The vapor-cooled anode is conservatively rated at 20 kilowatts of plate dissipation when mounted in an Eimac BR-200 boiler.

A pair of these tubes in class AB₁ audio frequency or radio frequency linear amplifier service will deliver 35 kilowatts output. The frequency for maximum ratings is 30 megacycles; operation to 110 megacycles is possible at reduced input.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated Tungsten				
Voltage	- - - - -	7.5		V
Current	- - - - -	73	78	A
Amplification Factor (Grid-Screen)	- - - - -	4.5		
Direct Interelectrode Capacitances, Grounded Cathode:				
Input	- - - - -	108	122	pF
Output	- - - - -	18	23	pF
Feedback	- - - - -		1.0	pF
Direct Interelectrode Capacitances, Grounded Grid:				
Input	- - - - -	48	58	pF
Output	- - - - -	18	23	pF
Feedback	- - - - -		1.0	pF
Frequency for Maximum Ratings	- - - - -		30	MHz

MECHANICAL

Base	- - - - -	Special, Concentric
Recommended Socket	- - - - -	Eimac, SK-300A
Recommended Boiler	- - - - -	Eimac, BR-200
Operating Position	- - - - -	Axis vertical, base up
Cooling	- - - - -	Vapor & Forced air
Maximum Seal Temperature	- - - - -	250° C
Maximum Anode Core Temperature	- - - - -	250° C
Maximum Over-all Dimensions:		
Height	- - - - -	9.13 in
Diameter	- - - - -	7.75 in
Net Weight	- - - - -	21 lbs

**RADIO FREQUENCY POWER AMPLIFIER
 OR OSCILLATOR**

Class-C Telephony or FM Telephony

MAXIMUM RATINGS

DC PLATE VOLTAGE (to 30 Mc)	- - 7500 VOLTS
(30-60 Mc)	- - 7000 VOLTS
(60-110 Mc)	- - 6500 VOLTS
DC SCREEN VOLTAGE	- - - 1500 VOLTS
DC PLATE CURRENT (to 30 Mc)	- - 3.0 AMPS
(30-60 Mc)	- - 2.8 AMPS
(60-110 Mc)	- - 2.6 AMPS
PLATE DISSIPATION	20,000 WATTS
SCREEN DISSIPATION	- - - 250 WATTS
GRID DISSIPATION	- - - 75 WATTS

TYPICAL OPERATION (Below 30 Mc)

DC Plate Voltage	- - - 6000	7500 volts
DC Screen Voltage	- - - 500	500 volts
DC Grid Voltage	- - - -290	-300 volts
DC Plate Current	- - - 3.0	3.0 amps
DC Screen Current*	- - - 500	500 mA
DC Grid Current	- - - 290	290 mA
Peak RF Grid Voltage*	- - - 520	530 volts
Driving Power	- - - 150	155 watts
Plate Output Power	- - - 12,900	17,000 watts

*Approximate Values



PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER

Class-C Telephony (Carrier conditions except where noted)

MAXIMUM RATINGS

Table with 2 columns: Parameter and Value. Includes DC Plate Voltage (5000 VOLTS), DC Screen Voltage (1000 VOLTS), DC Plate Current (2.5 AMPS), Plate Dissipation (13,500 WATTS), Screen Dissipation (250 WATTS), and Grid Dissipation (75 WATTS).

* Corresponds to 20,000 watts at 100-percent sine-wave modulation.

** Approximate values.

TYPICAL OPERATION

(Frequencies below 30 megacycles)

Table with 3 columns: Parameter, Value 1, Value 2. Includes DC Plate Voltage (4000, 5000 volts), DC Screen Voltage (500, 500 volts), Peak AF Screen Voltage (470, 490 volts), DC Grid Voltage (-320, -340 volts), DC Plate Current (2.2, 2.2 amps), DC Screen Current (335, 330 mA), DC Grid Current (160, 150 mA), Peak RF Grid Voltage (490, 510 volts), Grid Driving Power (78.5, 76.5 watts), Plate Dissipation (3050, 3250 watts), and Plate Output Power (5750, 7750 watts).

RADIO-FREQUENCY LINEAR AMPLIFIER

Class AB₁

MAXIMUM RATINGS (per tube)

Table with 2 columns: Parameter and Value. Includes DC Plate Voltage (7500 VOLTS), DC Screen Voltage (1500 VOLTS), DC Plate Current (4.0 AMPS), Plate Dissipation (20,000 WATTS), Screen Dissipation (250 WATTS), and Grid Dissipation (75 WATTS).

* Per Tube

** Approximate values.

TYPICAL OPERATION (Peak-Envelope or Modulation-Crest Conditions)

Table with 3 columns: Parameter, Value 1, Value 2. Includes DC Plate Voltage (5000, 7500 volts), DC Screen Voltage (1500, 1500 volts), DC Grid Voltage (-250, -260 volts), Max-Signal Plate Current, Max-Signal Plate Current (4.0, 4.0 amps), Zero-Signal Plate Current (2.0, 2.0 amps), Max-Signal Screen Current (165, 150 mA), Peak RF Grid Voltage (240, 250 volts), Driving Power (0, 0 watts), Plate Dissipation (9700, 12,500 watts), Plate Output Power (10,300, 17,500 watts), and Resonant Load Impedance (590, 1030 ohms).

AUDIO-FREQUENCY AMPLIFIER OR MODULATOR

Class-AB₁

MAXIMUM RATINGS

Table with 2 columns: Parameter and Value. Includes DC Plate Voltage (7500 VOLTS), DC Screen Voltage (1500 VOLTS), DC Plate Current (4.0 AMPS), Plate Dissipation (20,000 WATTS), Screen Dissipation (250 WATTS), and Grid Dissipation (75 WATTS).

* Approximate values

TYPICAL OPERATION (Two Tubes)

Table with 3 columns: Parameter, Value 1, Value 2. Includes DC Plate Voltage (5000, 7500 volts), DC Screen Voltage (1500, 1500 volts), DC Grid Voltage (-250, -260 volts), Max-Signal Plate Current (8.0, 8.0 amps), Zero-Signal Plate Current (4.0, 4.0 amps), Max-Signal Screen Current (330, 300 mA), Peak RF Driving Voltage (240, 250 volts), Driving Power (0, 0 watts), Load Resistance, Plate-to-Plate (1180, 2060 ohms), Max-Signal Plate Dissipation (9700, 12,500 watts), and Max-Signal Plate Output Power (20,600, 35,000 watts).

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves. No allowance is made for circuit losses of any kind. Adjustment of the rf grid drive to obtain the specified plate current at the specified grid bias, screen voltage, and plate voltage is assumed. If this procedure is followed, there will be little variation in output power when tubes are changed, even though there may be some variations in grid and screen currents. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf driving voltage is applied.

APPLICATION

MECHANICAL

MOUNTING — The 4CV20,000A must be operated with its axis vertical, base up in an Eimac BR-200 boiler. Care must be exercised when installing to insure that the boiler is level, the water is at the proper level and that the flange of the tube makes a vapor tight seal against the rubber "O" ring and boiler. A typical vapor cooling system is shown below.

SOCKET — The Eimac SK-300A socket is available for use with the 4CV20,000A. Filament, control grid and screen grid connections are made to this socket.

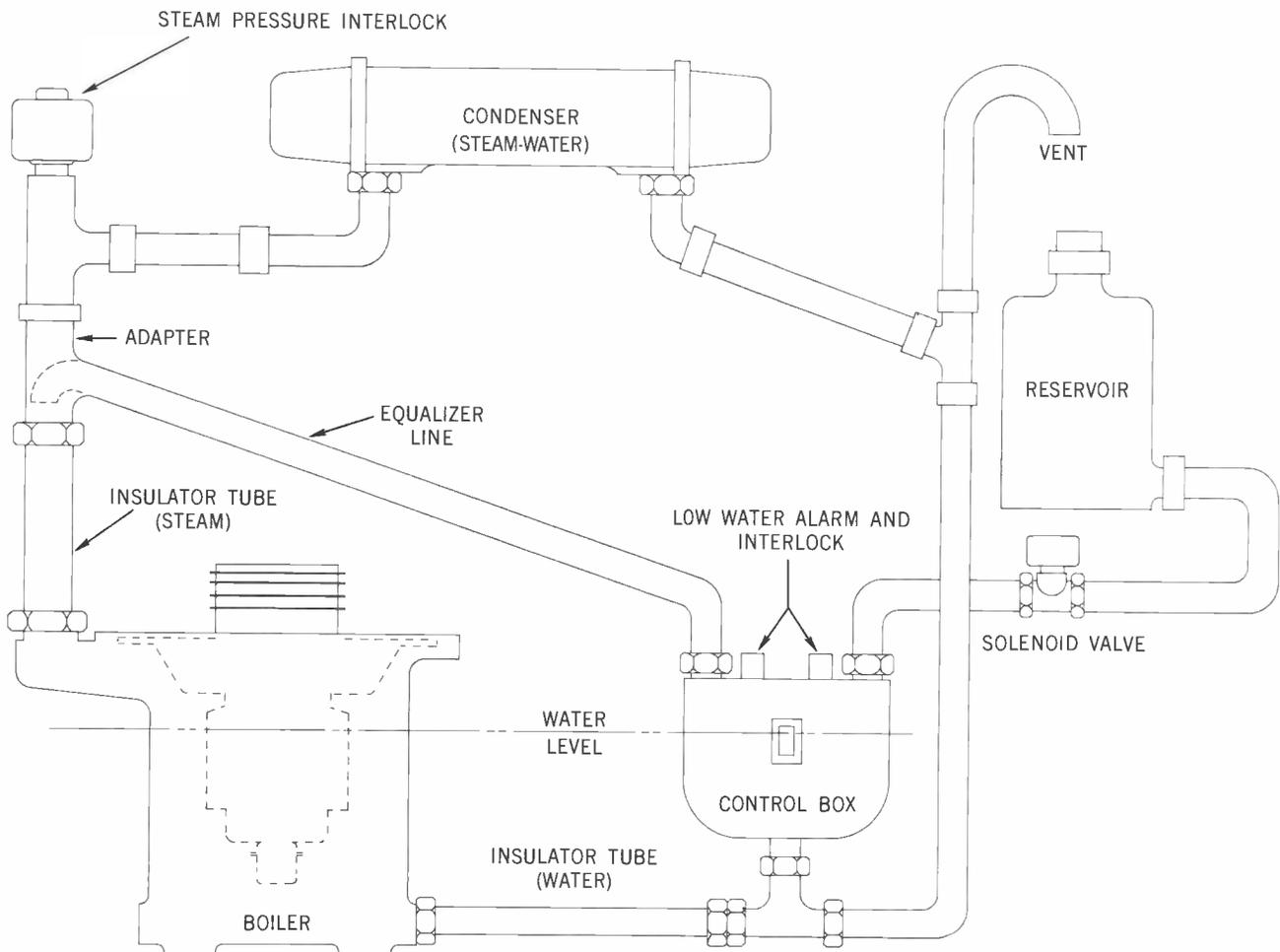
COOLING — Cooling is accomplished by immersing the anode in the distilled water filled BR-200 boiler. The energy dissipated at the anode causes the water to boil at the surfaces of the anode, be converted into steam and be carried away to the condenser. The boiling action keeps the anode surfaces at approximately 100°C. In a properly designed boiler-tube system (such as the 4CV20,000A and BR-200), it is extremely unlikely that the anode surfaces will ever exceed 110°C - well below the 250°C maximum rating - at full dissipation ratings.

The water in the boiler must be maintained at a constant level as indicated by the mark on the boiler, just below the top of the fins on the anode cooler. This is accomplished automatically in the vapor cooling system shown. Condensate from the condenser is returned to the boiler to maintain this constant fluid level. Any losses or drops in liquid level are sensed by the control box, CB-202. A low water level in the control box activates the solenoid water valve, allowing make-up water from the reservoir to enter the boiler. When the proper level is reached, the control box de-energizes the solenoid, stopping the flow from the reservoir. A second switch in the control box is energized if the water level drops to a lower level because of an empty reservoir or a constriction in the line. This switch may be used to shut down the equipment or activate an alarm.

For reliable operation, it is important that the control box and boiler be mounted so that the level sensed by the control box is exactly the same as the level in the boiler.

Cooling of the tube base is accomplished by blowing 25-50 CFM of air into the socket in the area of the filament seals.

VAPOR COOLING SYSTEM



ELECTRICAL

FILAMENT OPERATION — The rated filament voltage for the 4CV20,000A is 7.5 volts. Filament voltage, as measured at the socket, must be maintained at 7.5 volts plus or minus five percent to obtain maximum tube life. The use of a constant voltage filament transformer is recommended.

CONTROL-GRID OPERATION — The 4CV20,000A control grid has a maximum dissipation rating of 75 watts. Precautions should be observed to avoid exceeding this rating. Grid dissipation is the product of the dc grid current and the peak positive grid voltage swing.

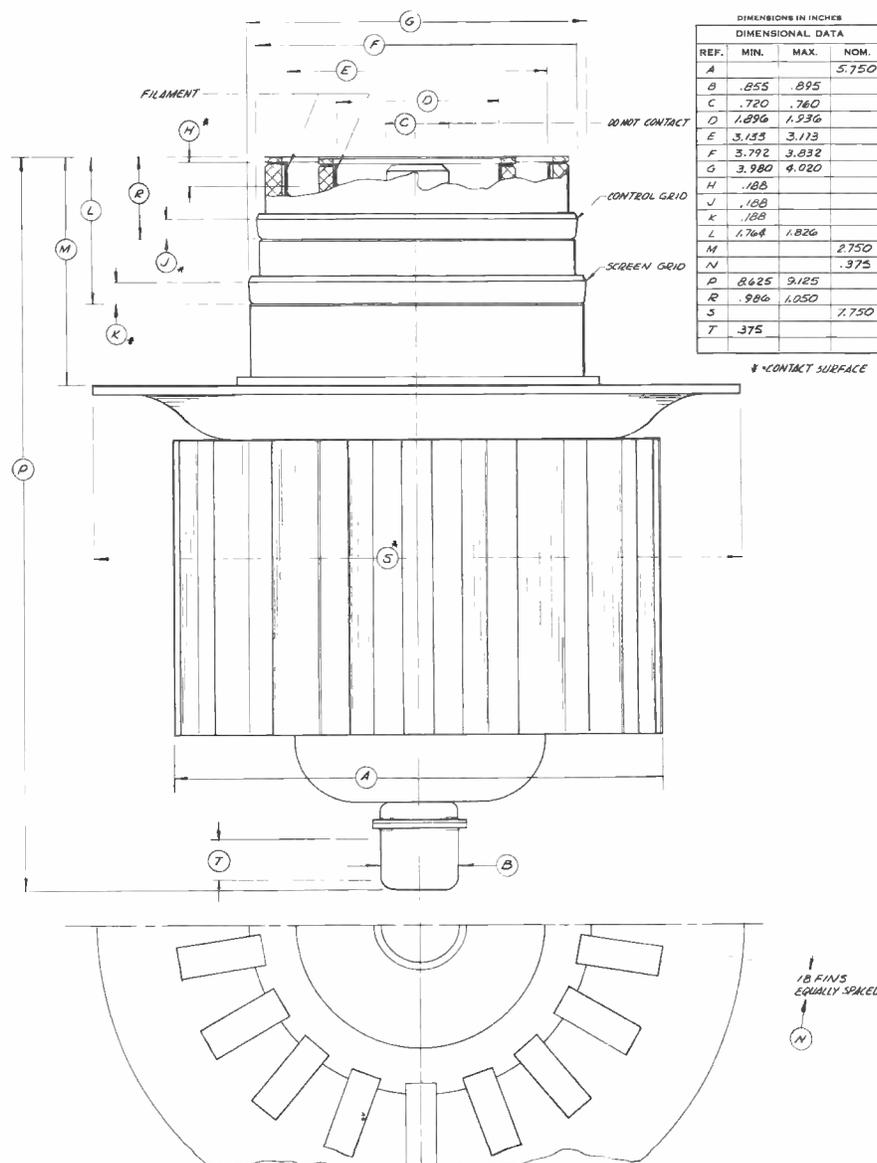
SCREEN-GRID OPERATION — The power dissipated by the screen must not exceed 250 watts. Screen dissipation, in cases where no ac is applied to the screen is the product of screen voltage and screen current. If the screen voltage is modulated, the screen dissipation will depend upon loading, driving power and screen voltage.

Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit the screen dissipation in the event of these failures.

PLATE DISSIPATION — The plate dissipation rating of 20,000 watts attainable through vapor cooling provides a large margin of safety. It is unlikely that this rating will be exceeded, even during tuning periods.

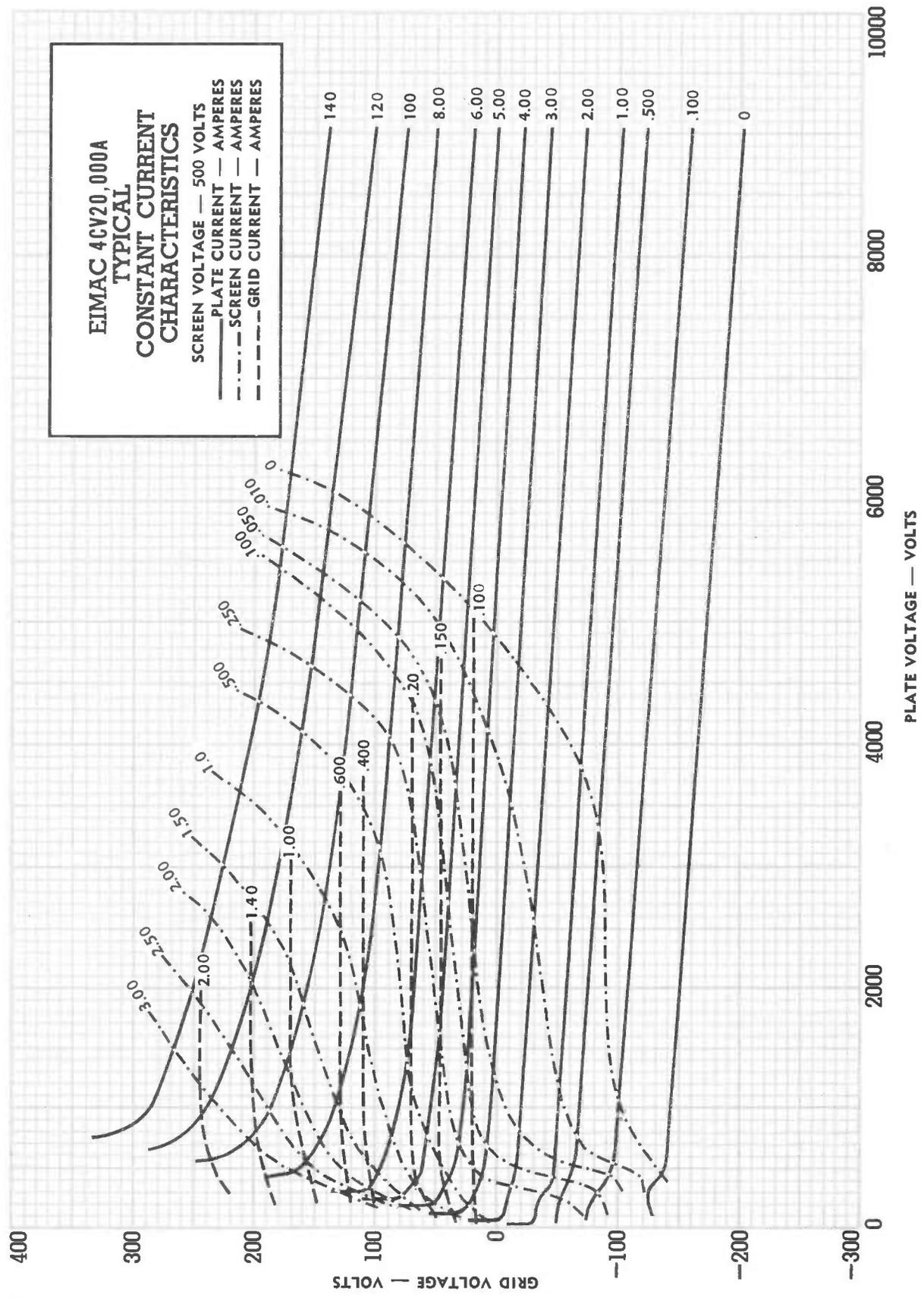
When the 4CV20,000A is used as a plate-modulated rf amplifier, this rating is reduced to 13,500 watts with a reduced plate input rating of 5000 volts and 2.5 amps.

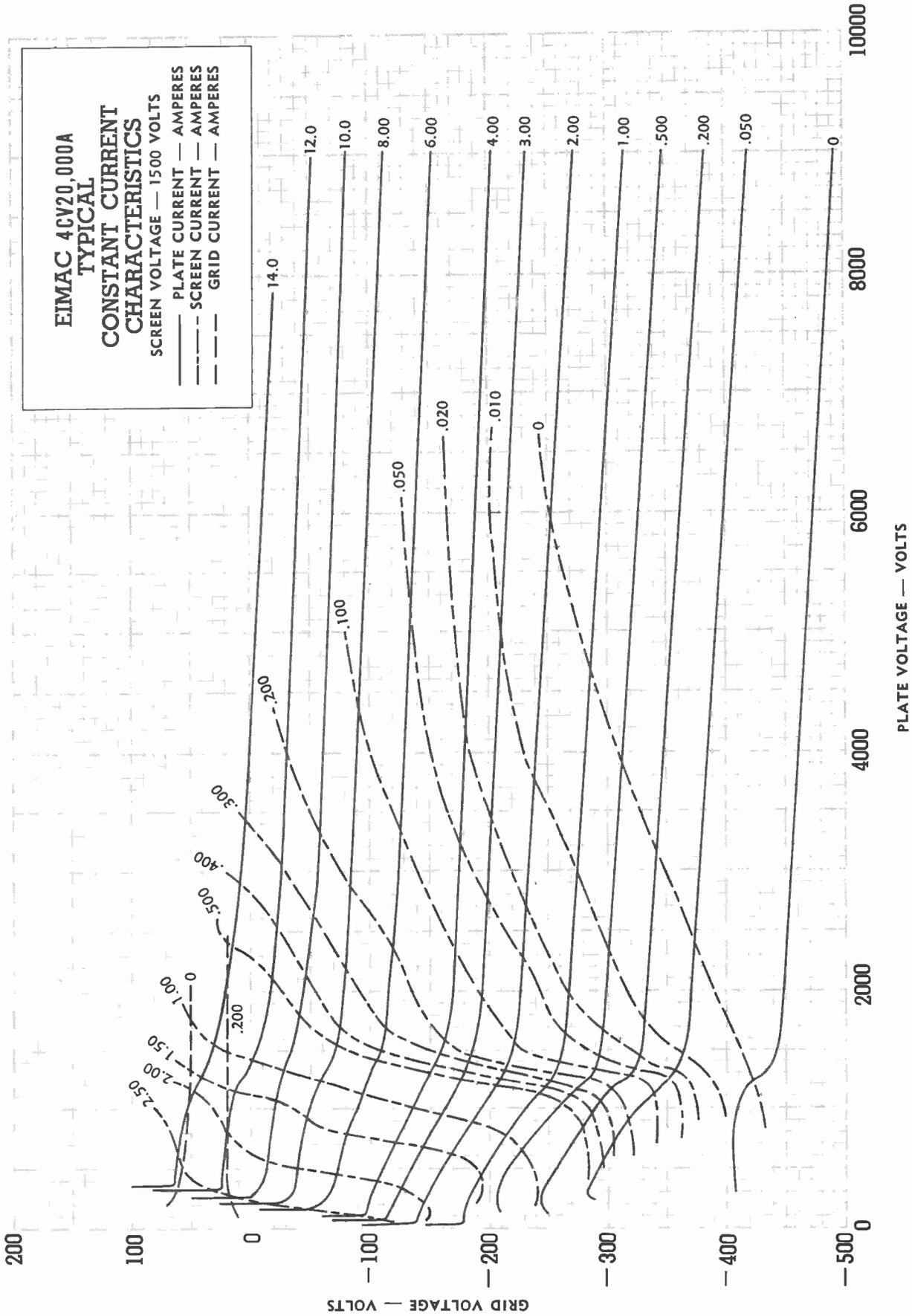
SPECIAL APPLICATIONS — If it is desired to operate this tube under conditions widely different from those given here, write to Power Grid Tube Marketing Department, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California for information and recommendations.



**EIMAC 4CV20,000A
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS**

SCREEN VOLTAGE — 500 VOLTS
— PLATE CURRENT — AMPERES
- - - - SCREEN CURRENT — AMPERES
- - - - GRID CURRENT — AMPERES







TECHNICAL DATA

4CV75,000A

VAPOR COOLED
POWER TETRODE

The EIMAC 4CV75,000A is a ceramic/metal, vapor-cooled power tetrode intended for use at the 50 to 80 kilowatt output power level. It is recommended for use as a Class C rf amplifier or oscillator, a Class AB rf linear amplifier, or a Class AB push-pull af amplifier or modulator. The 4CV-75,000A is also useful as a plate and screen modulated Class C rf amplifier.

The vapor-cooled anode is rated at 75 kilowatts of dissipation when mounted in the EIMAC BR-320 boiler assembly.



BR-320 Boiler
installed

GENERAL CHARACTERISTICS¹

ELECTRICAL

Filament: Thoriated Tungsten

Voltage	10 ± 0.5 V
Current, at 10.0 volts	300 A
Amplification Factor (Grid-Screen, average)	4.5
Direct Interelectrode Capacitances (grounded filament)	
Cin	440 pF
Cout	55 pF
Cgp	2.3 pF
Direct Interelectrode Capacitances (grounded grid)	
Cin	175 pF
Cout	57 pF
Cpk	0.4 pF
Frequency for Maximum Ratings:	
CW	30 MHz

1. Characteristics and operating values are based on performance tests. These figures may change without notice as a result of additional data or product refinement. EIMAC Division of Varian should be consulted before using this information for final equipment design.

MECHANICAL

Maximum Overall Dimensions:(without boiler)

Length	17.450 in; 443.2 mm
Diameter	9.300 in; 236.2 mm
Net Weight	60 lb; 27.3 kg
Operating Position	Vertical, base down
Maximum Operating Temperature:	
Base and Anode Seals	250°C
Recommended Socket	EIMAC SK-1500 Series
Recommended Boiler	EIMAC BR-320
Cooling	Vapor and Forced Air

(Effective 6-15-71) © by Varian

Printed in U.S.A.

**RADIO FREQUENCY LINEAR AMPLIFIER
GRID DRIVEN**
Class AB₁

MAXIMUM RATINGS:

DC PLATE VOLTAGE	15,000	VOLTS
DC SCREEN VOLTAGE	2500	VOLTS
DC PLATE CURRENT	15	AMPERES
PLATE DISSIPATION	75,000	WATTS
SCREEN DISSIPATION	1750	WATTS
GRID DISSIPATION	500	WATTS

TYPICAL OPERATION (Frequencies to 30 MHz)
Class AB₁, Grid Driven, Peak Envelope or Modulation
Crest Conditions

Plate Voltage	10.0	15.0	kVdc
Screen Voltage	1.5	1.5	kVdc
Grid Voltage ¹	-290	-340	Vdc
Zero-Signal Plate Current	2.0	1.0	Adc
Single Tone Plate Current	8.7	7.55	Adc
Single-Tone Screen Current ²	0.385	0.310	Adc
Peak rf Grid Voltage ²	270	310	v
Plate Dissipation	32	30.5	W
Plate Output Power	55	82.5	kW

1. Adjust to specified zero-signal dc plate current.
2. Approximate value .

**RADIO FREQUENCY POWER AMPLIFIER OR
OSCILLATOR** Class C Telegraphy or FM Telephony
(Key-Down Conditions)

MAXIMUM RATINGS:

DC PLATE VOLTAGE	15,000	VOLTS
DC SCREEN VOLTAGE	2500	VOLTS
DC GRID VOLTAGE	-2000	VOLTS
DC PLATE CURRENT	15	AMPERES
PLATE DISSIPATION	75	WATTS
SCREEN DISSIPATION	1750	WATTS
GRID DISSIPATION	500	WATTS

TYPICAL OPERATION (Frequencies to 30 MHz)

Plate Voltage	10.0	15.0	15.0	kVdc
Screen Voltage	750	750	1500	Vdc
Grid Voltage	-425	-480	-1020	Vdc
Plate Current	6.7	6.45	11.8	Adc
Screen Current ¹	0.925	0.810	1.0	Adc
Grid Current ¹	0.320	0.355	0.100	Adc
Peak rf Grid Voltage ¹	575	640	1220	v
Calculated Driving Power	185	225	120	W
Plate Input Power	67	96.5	177	kW
Plate Dissipation	12	14	38	kW
Plate Output Power	55	82.5	139	kW

1. Approximate value.

**PLATE MODULATED RADIO FREQUENCY POWER
AMPLIFIER-GRID DRIVEN**
Class C Telegraphy (Carrier Conditions)

MAXIMUM RATINGS:

DC PLATE VOLTAGE	12,500	VOLTS
DC SCREEN VOLTAGE	2000	VOLTS
DC GRID VOLTAGE	-2000	VOLTS
DC PLATE CURRENT	15	AMPERES
PLATE DISSIPATION ¹	50,000	WATTS
SCREEN DISSIPATION ²	1750	WATTS
GRID DISSIPATION ²	500	WATTS

1. Corresponds to 75,000 watts at 10% sine-wave modulation.
2. Average, with or without modulation.

TYPICAL OPERATION (Frequencies to 30 MHz)

Plate Voltage	7.5	10.0	kVdc
Screen Voltage	750	750	Vdc
Grid Voltage	-460	-520	Vdc
Plate Current	7.0	6.6	Adc
Screen Current ¹	1.2	0.985	Adc
Grid Current ¹	0.375	0.370	mAdc
Peak af Screen Voltage ¹ (100% modulation)	640	675	v
Peak rf Grid Voltage ¹	630	680	v
Calculated Driving Power	235	250	W
Plate Input Power	52.5	66	kW
Plate Dissipation	10.5	11	kW
Plate Output Power	42	55	kW

1. Approximate value.

**AUDIO FREQUENCY POWER AMPLIFIER OR
MODULATOR** Class AB₁, Grid Driven
(Sinusoidal Wave)

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE	15,000	VOLTS
DC SCREEN VOLTAGE	2500	VOLTS
DC PLATE CURRENT	15	AMPERES
PLATE DISSIPATION	75,000	WATTS
SCREEN DISSIPATION	1750	WATTS
GRID DISSIPATION	500	WATTS

1. Approximate value.
2. Per Tube.

TYPICAL OPERATION (Two Tubes)

Plate Voltage	10.0	15.0	kVdc
Screen Voltage	1.5	1.5	Vdc
Grid Voltage ^{1/3}	-290	-340	Vdc
Zero-Signal Plate Current	4.0	2.0	Adc
Max. Signal Plate Current	17.4	15.1	Adc
Zero-Signal Screen Current ¹	0	0	Adc
Max. Signal Screen Current ¹	0.77	0.62	Adc
Max. Signal Grid Current ¹	0	0	Adc
Peak af Grid Voltage ²	270	310	v
Peak Driving Power	0	0	w
Plate Input Power	143	195.0	kW
Max. Signal Plate Dissipation	33	30.5	kW
Plate Output Power	110	165	kW
Load Resistance(plate to plate)	1150	2560	Ω

3. Adjust to give stated zero-signal plate current.

NOTE: TYPICAL OPERATION data are obtained from direct measurement or by calculation from published characteristic curves. Adjustment of the rf grid voltage to obtain the specified plate current at the specified bias, screen and plate voltages is assumed. If this procedure is followed, there will be little variation in output power when the tube is changed, even though there may be some variation in grid and screen current. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. In the case of Class C Service, if grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct rf grid voltage is applied.

RANGE VALUES FOR EQUIPMENT DESIGN

	<u>Min.</u>	<u>Max.</u>
Heater: Current at 10.0 volts	280	310 A
Cathode Warmup Time	10	--- sec.
Interelectrode Capacitances (grounded filament connection)		
C _{in}	410	470 pF
C _{out}	50	60 pF
C _{gp}	1.5	3.2 pF
Interelectrode Capacitances (grounded grid connection)		
C _{in}	155	195 pF
C _{out}	52	62 pF
C _{pk}	---	0.6 pF

APPLICATION

MECHANICAL

MOUNTING - The 4CV75,000A must be mounted vertically, anode up, in an EIMAC BR-320 boiler. Care must be exercised to insure that the axis of the tube/boiler combination is vertical and that the water in the boiler is at the level indicated on the outline drawing of the tube and boiler. The anode flange on the tube must seat securely against the rubber "O" ring, forming a liquid-tight seal between the tube and boiler.

SOCKETING - The EIMAC SK-1500 series is available for use with the 4CV75,000A. Filament, control grid, and screen grid connections are made to this socket. Springfinger contacts on the socket are used to make connections to the concentric rings on the tube base.

COOLING - Anode cooling is accomplished by immersion in a "boiler" filled with distilled water. Energy dissipated by the anode causes the water to boil at the anode surface, be converted into steam, and carried away to an external condenser. The condensate is then returned to the boiler, completing the cycle.

This boiling action maintains the anode surface at a fairly constant temperature near 100°C. The vapor-cooled tube has good overload capabilities; excess dissipation for moderate periods only causes more water to boil.

A control box (EIMAC CB-202) is used to sense water level in the boiler and signal for make-up water from a reservoir, and also to shut down the system in case of low water level. In order to perform its function, the control box must be mounted so that its water level mark is at the same elevation as the water level mark on the boiler.

Since the tube anode and boiler are usually at high potential to ground, water and steam connections to the boiler are made through insulated tubing.

A pressure equalizing line is required between the steam side of the system and the top of the control box. Its function is to provide the same pressure in the control box as in the boiler.

Separate cooling of the tube base is required and is accomplished by directing a minimum of 60 cfm of air at 25°C maximum at sea level (rising to 100 cfm of air at 50°C maximum at sea level) into

the socket from the side, in the area of the filament seals. In addition, a minimum of 2 cfm of air should be directed into the base well of the tube, to maintain a safe temperature in this area. Base air cooling should be applied before or simultaneously with the application of electrode voltages, including the filament, and should be maintained for a short period after all voltages are removed to allow for tube cool-down.

ELECTRICAL

FILAMENT - The rated filament voltage for the 4CV75,000A is 10.0 volts and, as measured at the socket or the base of the tube, should be maintained within plus or minus five percent to obtain maximum tube life and consistent performance.

Filament starting (inrush) current should be limited to a maximum of 900 amperes.

Voltage between filament and the base plates of either tube or the SK-1500 socket should not exceed 100 volts.

CONTROL GRID OPERATION - The 4CV75,000A control grid is rated at 500 watts of dissipation. Grid dissipation is the approximate product of a grid current and peak positive grid voltage.

SCREEN DISSIPATION - The power dissipated by the screen grid must not exceed 1750 watts. Where no ac voltage is applied to the screen, dissipation is the product of dc screen voltage and dc screen current. With screen modulation the the dissipation is dependent on rms screen voltage and rms screen current. Plate voltage, plate load, or bias voltage must never be removed while filament and screen voltages are present on the tube since the screen dissipation rating will be exceeded. Suitable protective means must be provided to prevent any of these conditions.

The 4CV75,000A may exhibit reverse screen current, depending on operating conditions. The screen supply voltage must be maintained constant for any values of negative and positive screen current which may be encountered. Dangerously high plate current may flow if the screen power supply exhibits a rising voltage characteristic with negative screen current. Stabilization may be accomplished with a bleeder resistor connected from screen to cathode, or an electron-tube regulator circuit may be used in the screen supply. A bleeder resistor must be used if a series regulator is employed.

PLATE DISSIPATION - The plate dissipation of 75 kilowatts attainable with vapor cooling provides a large margin of safety in most applica-

tions. The rating may be exceeded for brief periods during tuning. When the 4CV75,000A is used as a plate-modulated rf amplifier, plate dissipation under carrier conditions is limited to 50 kilowatts.

FAULT PROTECTION - In addition to the normal plate-overcurrent interlock, screen-current interlock, and vapor-cooling control box interlock, it is good practice to protect the tube from internal damage caused by an internal plate arc which may occur at high plate voltages.

A protective resistance of 5 to 25 ohms should always be connected in series with the tube anode, to absorb power-supply stored energy if a plate arc should occur. An electronic crowbar, which will discharge power-supply capacitors in a few microseconds after the start of a plate arc, is recommended.

X-RADIATION - High-vacuum tubes operating at voltages higher than 10 kilovolts produce progressively more dangerous X-ray radiation as the voltage is increased. The 4CV75,000A, operating at its rated voltages and currents, is a potential X-ray hazard. Only limited shielding is afforded by the tube envelope. Moreover, the X-ray radiation level can increase significantly with aging and gradual deterioration, due to leakage paths or emission characteristics as they are affected by the high voltage. X-ray shielding must be provided on all sides of tubes operating at these voltages to provide adequate protection throughout the tube's life. Periodic checks on the X-ray level should be made, and the tube should never be operated without adequate shielding in place when voltages above 10 kilovolts are in use. Lead glass, which attenuates X-rays, is available for viewing windows. If there is any doubt as to the requirement for or the adequacy of shielding, an expert in this field should be contacted to perform an X-ray survey of the equipment.

Operation of high-voltage equipment with interlock switches "cheated" and cabinet doors open in order to be better able to locate an equipment malfunction can result in serious X-ray exposure.

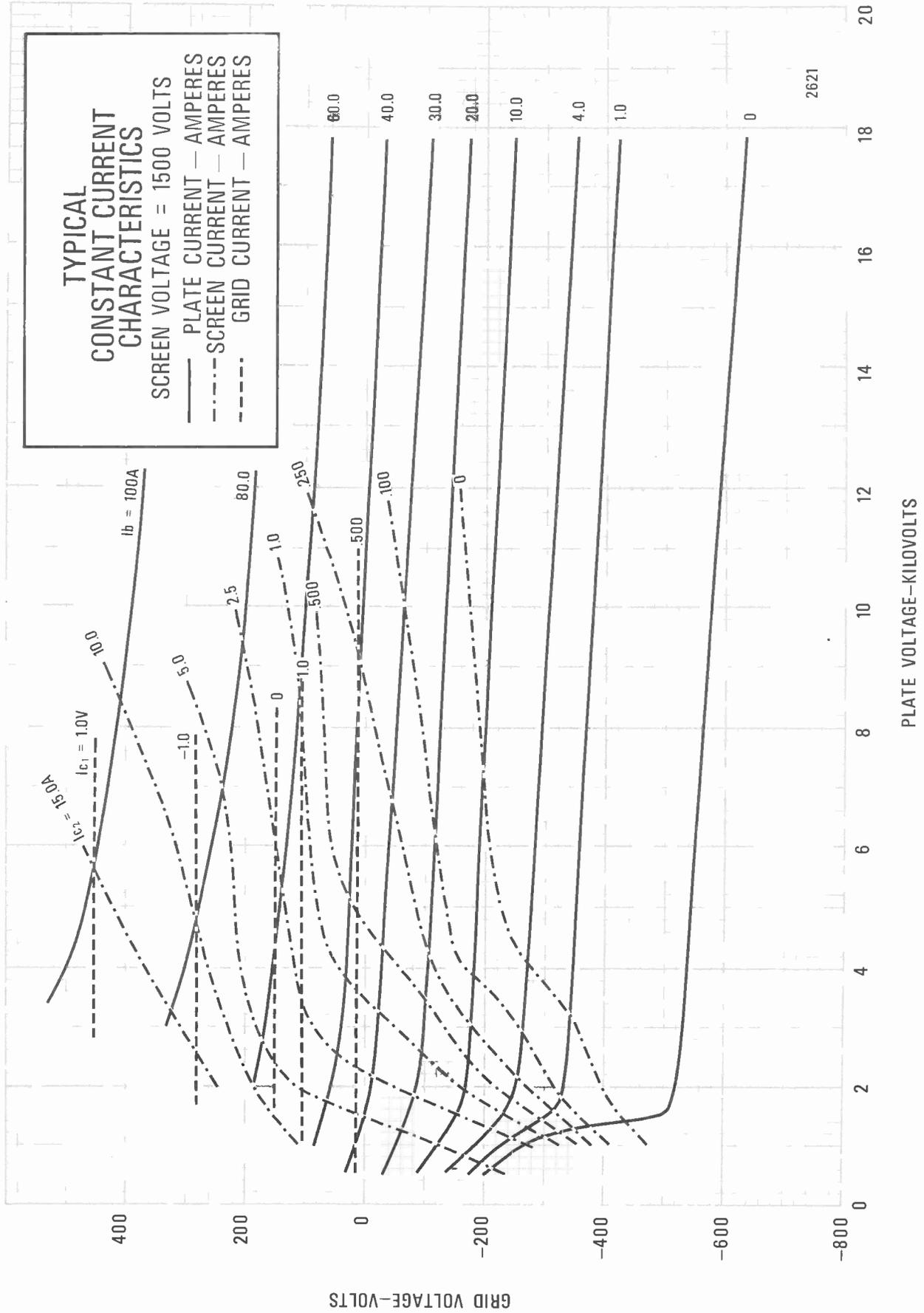
HIGH VOLTAGE - Normal operating voltages used with the 4CV75,000A are deadly, and the equipment must be designed properly and operating precautions must be followed. Design all equipment so that no one can come in contact with high voltages. All equipment must include safety enclosures for high-voltage circuits and terminals, with interlock switches to open primary circuits of the power supply and to dis-

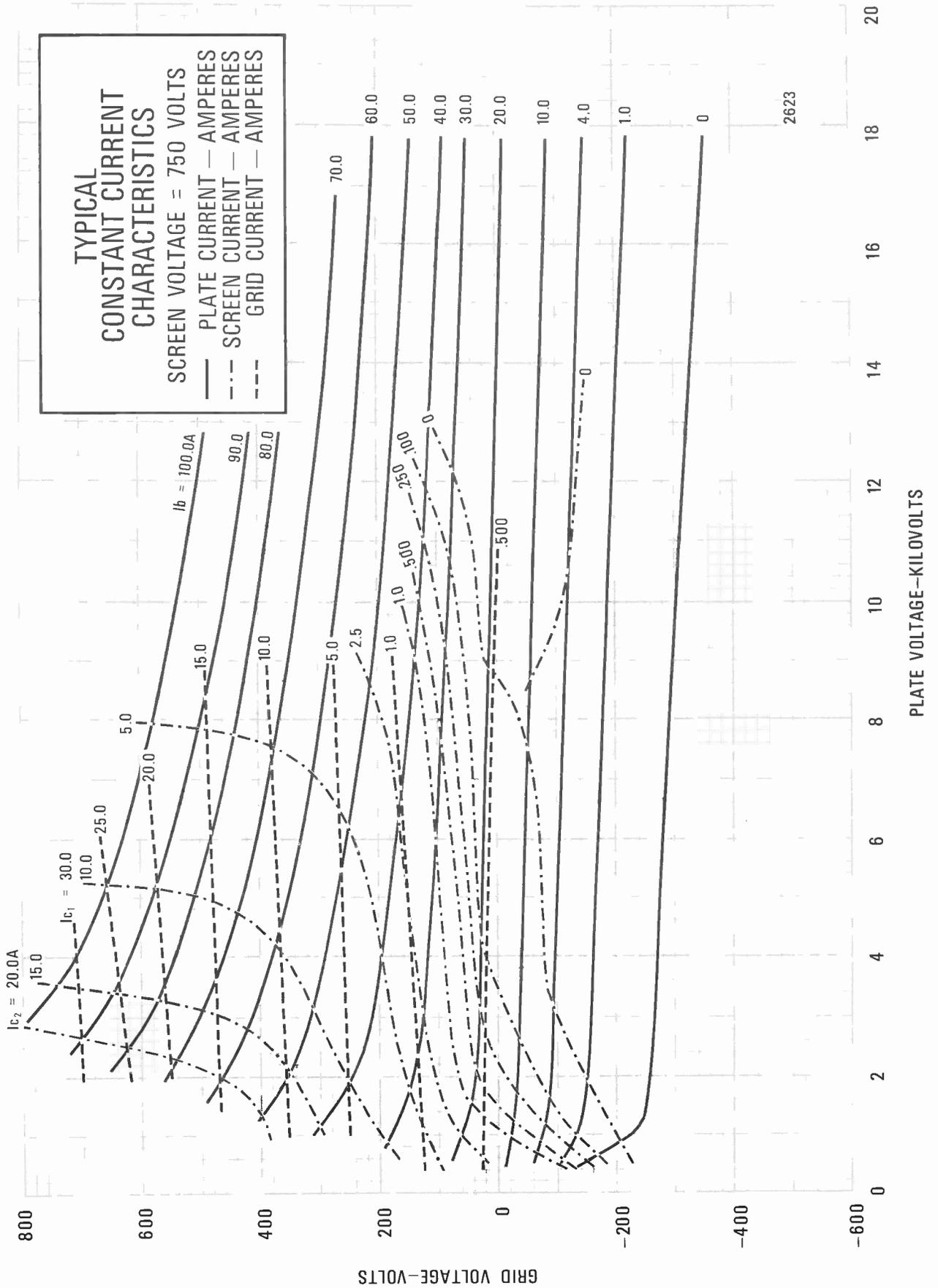
charge high-voltage condensers whenever access doors are opened. Interlock switches must not be bypassed or "cheated" to allow operation with access doors open. Always remember that HIGH VOLTAGE CAN KILL

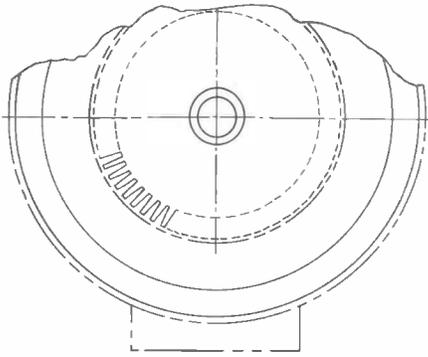
RADIO FREQUENCY RADIATION - Avoid exposure to strong rf fields even at relatively low frequency. Absorption of rf energy by human tissue is dependent on frequency. Under 30 MHz, most of the energy will pass completely through the human body with little attenuation of heating

effect. Public health agencies are concerned with the hazard, however, even at these frequencies, and it is worth noting that some commercial dielectric heating units actually operate at frequencies as low as the 13 and 27 MHz bands.

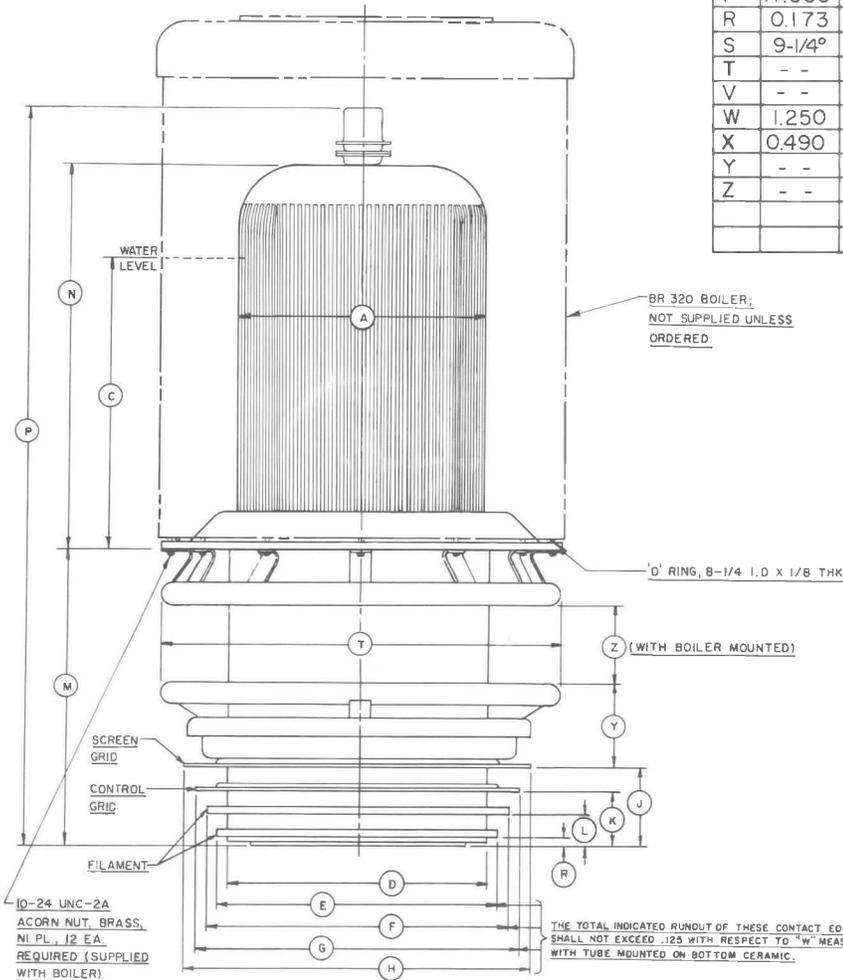
SPECIAL APPLICATION - If it is desired to operate this tube under conditions widely different from those listed here, write to Power Grid Tube Division, EIMAC Division of Varian, 301 Industrial Way, San Carlos, California 94070, for information and recommendations.



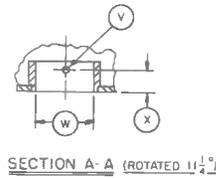
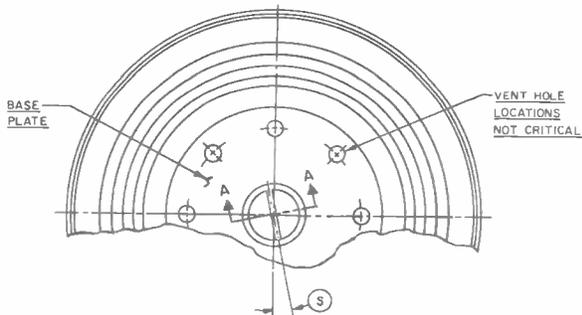




DIM.	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
	A	5.562	5.812	- -	141.28	147.63
C	4.500	7.000	- -	114.30	177.80	- -
D	5.980	6.020	- -	151.89	152.91	- -
E	6.510	6.560	- -	165.35	166.62	- -
F	6.980	7.020	- -	177.29	178.30	- -
G	7.480	7.520	- -	189.99	191.00	- -
H	7.975	8.015	- -	202.56	203.58	- -
J	1.750	1.800	- -	44.45	45.72	- -
K	1.220	1.270	- -	30.99	32.26	- -
L	0.690	0.740	- -	17.53	18.80	- -
M	6.942	7.192	- -	176.33	182.68	- -
N	8.725	8.950	- -	221.62	227.33	- -
P	17.000	17.450	- -	431.80	443.23	- -
R	0.173	0.213	- -	4.39	5.41	- -
S	9-1/4°	13-1/4°	- -	- -	- -	- -
T	- -	- -	9.250	- -	- -	234.95
V	- -	0.135	- -	- -	3.43	- -
W	1.250	1.270	- -	31.75	32.26	- -
X	0.490	0.530	- -	12.45	13.46	- -
Y	- -	- -	2.000	- -	- -	50.80
Z	- -	- -	2.000	- -	- -	50.80



NOTES:
1. REF. DIMENSIONS ARE FOR INFO.
ONLY & ARE NOT REQUIRED FOR
INSPECTION PURPOSES.





EIMAC

Division of Varian

301 INDUSTRIAL WAY • SAN CARLOS, CALIF. 94070

PHONE: (415) 592-1221 • CABLE: "EIMAC" SAN CARLOS

4CV250 000

Vapor Cooled
Power Tetrode
TENTATIVE

The EIMAC 4CV250,000 is a ceramic-metal, vapor-cooled power tetrode intended for use at the 250 to 500 kilowatt output power level. It is recommended for use as a Class-C r-f amplifier or oscillator, a Class-AB r-f linear amplifier or a Class AB push-pull a-f amplifier or modulator. The 4CV250,000 is also useful as a plate and screen modulated Class-C r-f amplifier.

The vapor-cooled anode is rated at 250 kilowatts of plate dissipation when mounted in the EIMAC BR-600 series boiler.

GENERAL CHARACTERISTICS

ELECTRIC

Filament:	Thoriated Tungsten	
Voltage	- - - - -	12 volts
Current	- - - - -	640 amps
Amplification Factor (Grid-Screen) (average)	- - - - -	4.5
Direct Interelectrode Capacitances, Grounded Cathode:		
Input	- - - - -	875 pf
Output	- - - - -	115 pf
Feedback	- - - - -	1.2 pf
Frequency for Maximum Ratings	- - - - -	30 MHz

MECHANICAL

Base	- - - - -	Special
Maximum Seal Temperature	- - - - -	250 °C
Maximum Anode Flange Temperature	- - - - -	130 °C
Recommended Boiler	- - - - -	EIMAC BR-600 Series
Operating Position	- - - - -	Vertical, base up
Maximum Dimensions:		
Height	- - - - -	27-1/2 inches
Diameter	- - - - -	13 inches
Cooling	- - - - -	Vapor & water
Net Weight	- - - - -	180 pounds
Shipping Weight (approximate)	- - - - -	300 pounds

4CV250,000

Vapor-Cooled, Power Tetrode

Tentative Data

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony (Key-down Conditions)

MAXIMUM RATINGS

DC Plate Voltage	- - - - -	25,000	Max. Volts
DC Screen Voltage	- - - - -	2,500	Max. Volts
DC Plate Current	- - - - -	50	Max. Amps
Plate Dissipation	- - - - -	250,000	Max. Watts
Screen Dissipation	- - - - -	3,500	Max. Watts
Grid Dissipation	- - - - -	1,500	Max. Watts

TYPICAL OPERATION

(Frequencies below 30 megacycles)

DC Plate Voltage	- - - - -	14	24	kv
DC Screen Voltage	- - - - -	1,200	800	volts
DC Grid Voltage	- - - - -	-800	-900	volts
DC Plate Current	- - - - -	26	30.4	amps
DC Screen Current	- - - - -	2.4	3.1	amps
DC Grid Current	- - - - -	1	1.6	amps
Driving Power	- - - - -	1.3	2.2	kW
Plate Output Power	- - - - -	255	600	kW

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER

Class-C Telephony (Carrier Conditions Except Where Noted)

MAXIMUM RATINGS

DC Plate Voltage	- - - - -	18,000	Max. Volts
DC Screen Voltage	- - - - -	2,000	Max. Volts
DC Plate Current	- - - - -	40	Max. Amps
Plate Dissipation*	- - - - -	67,000	Max. Watts
Screen Dissipation	- - - - -	3,500	Max. Watts
Grid Dissipation	- - - - -	1,500	Max. Watts

*Corresponds to 250,000 watts at 100 per cent sine wave modulation

4CV250,000

Vapor-Cooled, Power Tetrode

Tentative Data

TYPICAL OPERATION

(Frequencies below 30 Megacycles)

DC Plate Voltage	- - - - -	14 kv
DC Screen Voltage	- - - - -	800 volts
Peak AF Screen Voltage (For 100% Modulation)**	- - - - -	800 volts
DC Grid Voltage	- - - - -	-800 volts
DC Plate Current	- - - - -	29 Amps
DC Screen Current	- - - - -	3.6 Amps
DC Grid Current	- - - - -	1.8 Amps
Peak RF Grid Voltage	- - - - -	1,200 volts
Grid Driving Power	- - - - -	2.5 kW
Plate Output Power	- - - - -	292 kW

**Approximate Value

AUDIO-FREQUENCY AMPLIFIER OR MODULATOR

Class AB₁

MAXIMUM RATINGS (Per Tube)

DC Plate Voltage	- - - - -	25,000 Max. Volts
DC Screen Voltage	- - - - -	2,500 Max. Volts
DC Plate Current	- - - - -	40 Max. Amps
Plate Dissipation	- - - - -	250,000 Max. Watts
Screen Dissipation	- - - - -	3,500 Max. Watts
Grid Dissipation	- - - - -	1,500 Max. Watts

TYPICAL OPERATION (Two Tubes)

DC Plate Voltage	- - - - -	15	22 kv
DC Screen Voltage	- - - - -	1.8	1.8 kv
DC Grid Voltage	- - - - -	-700	-780 volts
Max-Signal Plate Current	- - - - -	37	35 amps
Max-Signal Screen Current**	- - - - -	1.5	1.3 amps
Peak AF Driving Voltage*	- - - - -	700	780 volts
Driving Power	- - - - -	0	0 watts
Max-Signal Plate Output Power	- - - - -	420	615 kW

* Per Tube

**Approximate Value

4CV250,000
Vapor-Cooled, Power Tetrode
Tentative Data

APPLICATION

Mechanical

Mounting

The 4CV250,000 must be mounted vertically, anode down, in an EIMAC BR-600 series boiler. Care must be exercised to insure that the axis of the tube/boiler combination is perfectly vertical and that water in the boiler is at the level indicated. The anode flange on the tube must seat securely against the rubber "O" ring, forming a vapor-tight seal between tube and boiler.

Cooling

Cooling is accomplished by immersing the anode of the 4CV250,000 in a "Boiler" filled with distilled water. Energy dissipated by the anode causes the water to boil at the anode surfaces, be converted into steam and be carried away to an external condenser. The condensate is then returned to the boiler, completing the cycle.

This boiling action maintains the anode surfaces at a fairly constant temperature near 100°C. In a properly designed tube/boiler system (such as the EIMAC BR-600) it is extremely unlikely that anode surface temperature will exceed 110°C - well below the 130°C maximum - at full dissipation ratings. The vapor-cooled tube has good overload capabilities; excess dissipation for moderate periods only causes more water to boil.

Since the tube anode and boiler are usually at high potential to ground, water and steam connections to the boiler are made through insulating tubing. These insulating sections may be rather short - two to three feet is sufficient for most applications.

An equalizer line is needed between the steam side of the system and the top of the control box. Its function is to provide the same pressure characteristics in the control box as those in the boiler. In this way, errors in water level sensing due to pressure differentials are eliminated.

Separate water cooling of the tube base is required. Approximately .8 GPM at 40 psi (series connected) is sufficient to cool the filament and grid terminals.

4CV250,000
Vapor-Cooled, Power Tetrode
Tentative Data

APPLICATION

Electrical

Filament

The rated filament voltage for the 4CV250,000 is 12 volts. Filament voltage, as measured at the socket, should be maintained at this value, ± 2 volts, to obtain maximum life and consistent performance.

Control-Grid Operation

The 4CV250,000 control grid is rated at 1,500 watts of dissipation and protective measures should be included in circuitry to insure that this rating is not exceeded. Grid dissipation is the approximate product of grid current and peak positive grid voltage.

Screen Dissipation

The power applied to the screen grid must not exceed 3,500 watts. Where no a-c is applied to the screen, dissipation is the product of d-c screen voltage and d-c screen current. With screen modulation the dissipation is dependent on loading, driving power, and screen voltages. Plate voltage, plate load or bias voltage must never be removed while filament and screen voltages are present since the screen dissipation rating will be exceeded. Suitable protective means must be provided to prevent any of these conditions.

Plate Dissipation

The plate dissipation of 250 kilowatts attainable through vapor cooling provides a large margin of safety in most applications. The rating may be exceeded for brief periods during tuning. When the 4CV250,000 is used as a plate-modulated r-f amplifier, plate dissipation under carrier conditions is limited to 167,000 watts.

Special Application

Where it is desired to operate this tube under conditions widely different from those listed here, write to Power Grid Tube Product Manager, EIMAC-Division of Varian, 301 Industrial Way, San Carlos, California, for information and recommendations.

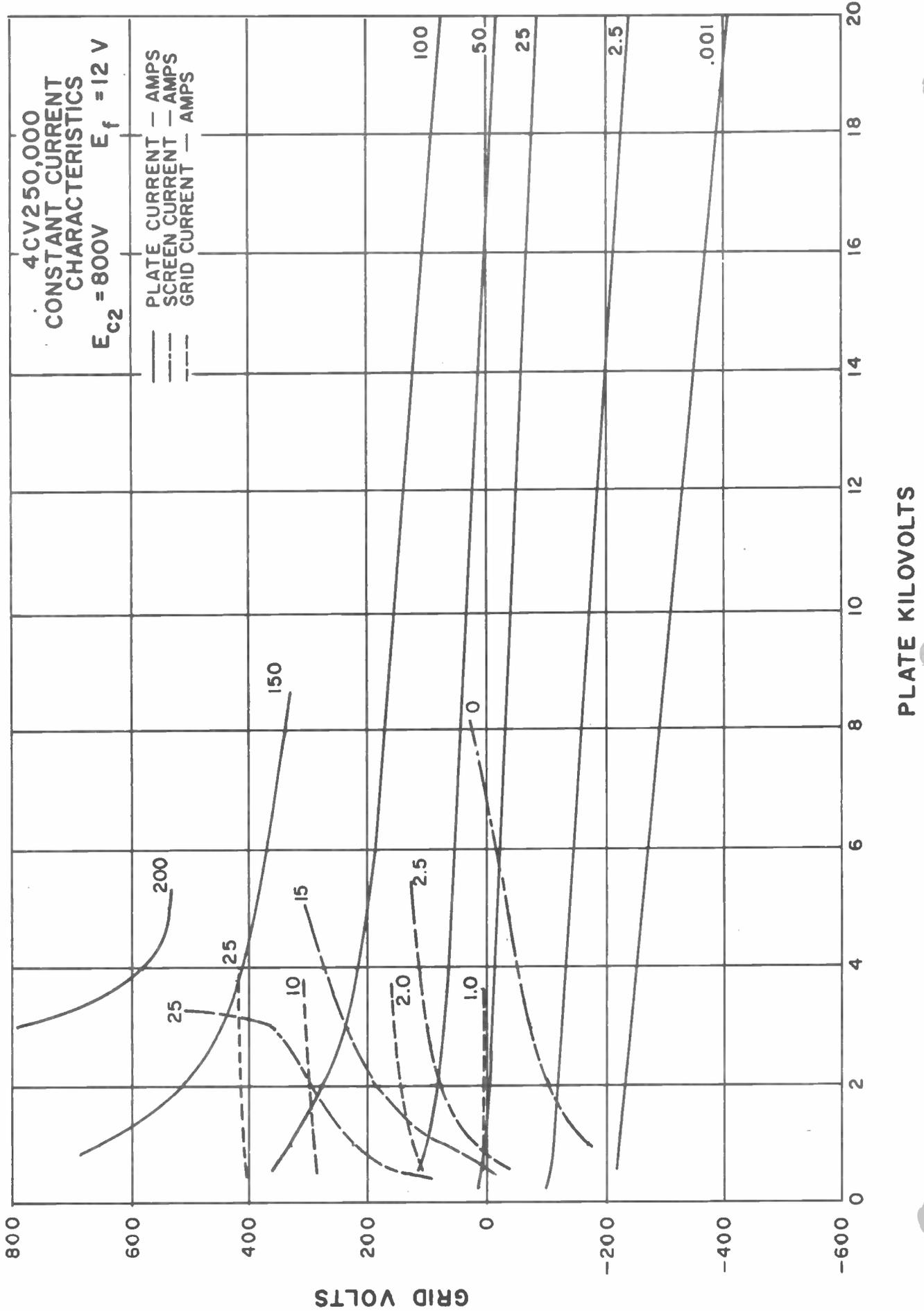
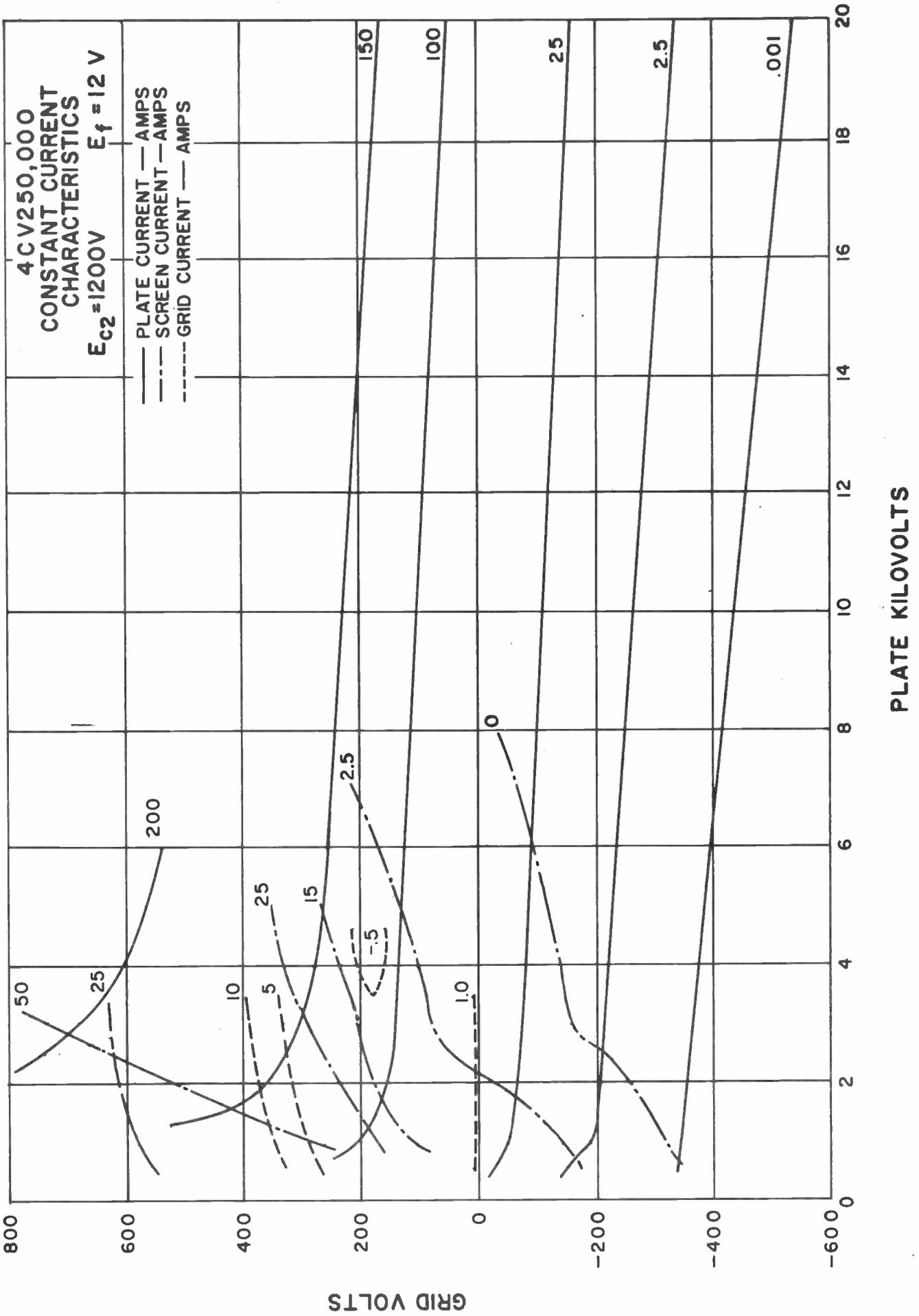
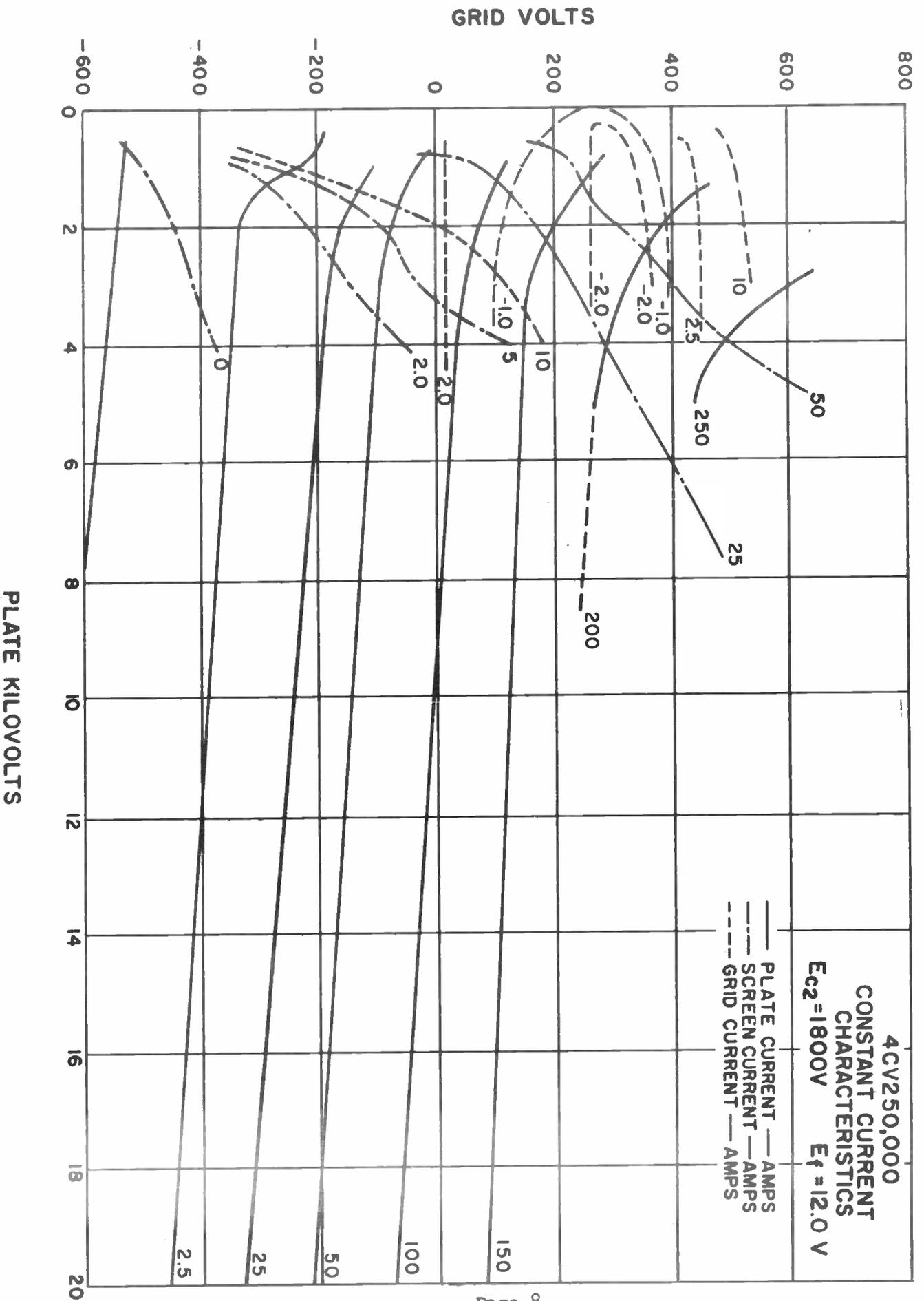


PLATE KILOVOLTS

GRID VOLTS

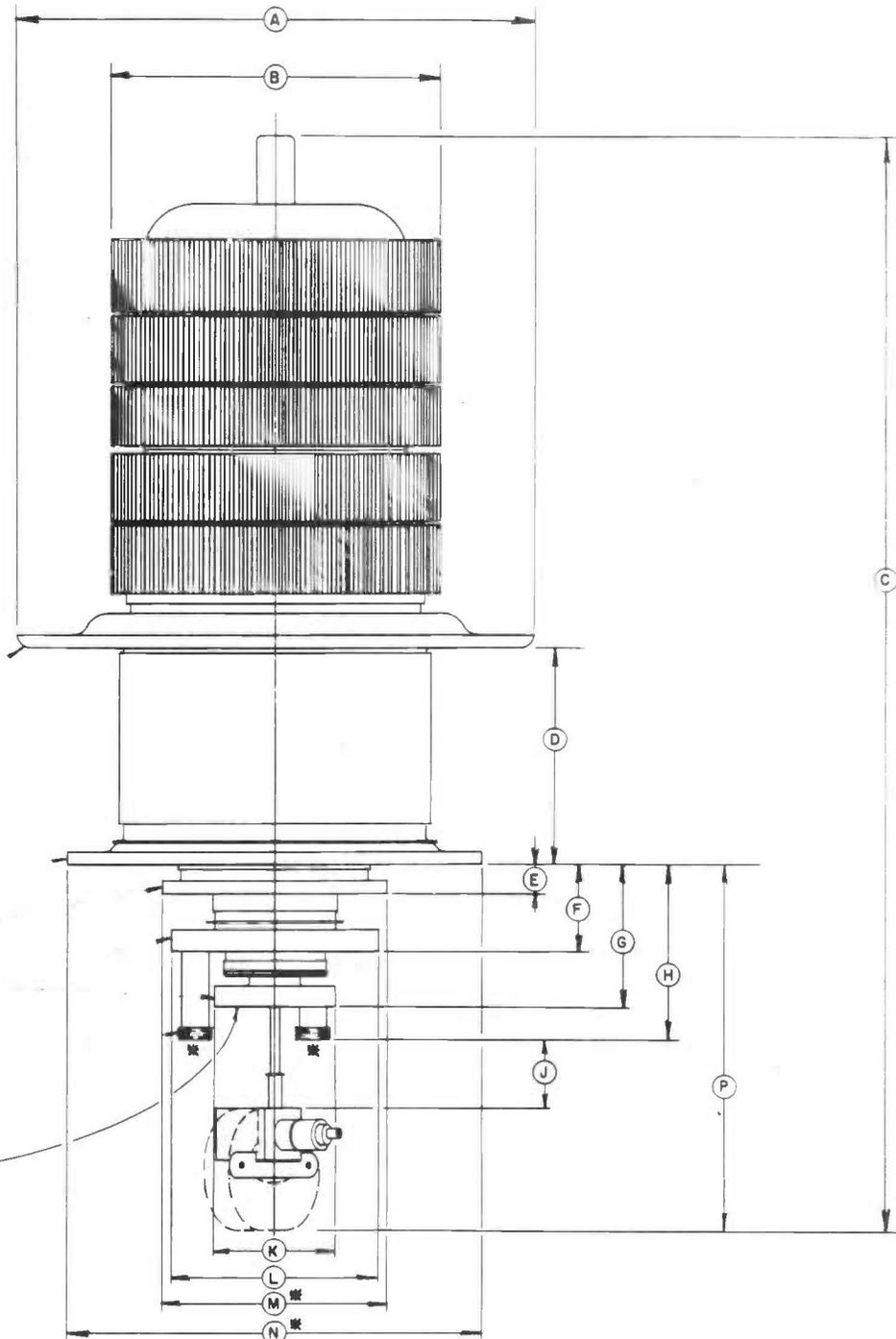




DIMENSIONS IN INCHES

DIMENSIONAL DATA			
DIM.	MIN.	MAX.	REF.
A	14.937	15.062	15.000
B	9.437	9.562	9.500
C		32 1/4	31 3/4
D	6.250	6.375	6.250
E	.750	.875	.812
F	2.437	2.562	2.500
G	4.062	4.187	4.125
H	5.000	5.125	5.062
J	1 3/4	2 1/4	2"
K	3.437	3.562	3.500
L	5.937	6.062	6.000
M	6.437	6.562	6.500
N	11.937	12.062	12.000
P	10 3/8	10 3/4	10 9/16

NOTE:
 1. REF. DIMS. ARE FOR INFO. ONLY & ARE NOT REQ'D. FOR INSP. PURPOSES.
 2. (*) CONTACT SURFACES



4CV250,000A
 MADE IN U.S.A.

BRAND

26I DIA.
 2 Holes



TYP FITTING

(8) * 8-32UNC x 3/8 DP.
 HOLES EQUALLY SPACED
 ON 4.500 DIA. P.C.

(6) 3/8 DIA HOLES
 EQUALLY SPACED
 ON 11.000 DIA. P.C.

(4) * 8-32UNC x 3/8 DP.
 HOLES EQUALLY SPACED
 ON 2.125 DIA. P.C.

NO.	DESCRIPTION OF CHANGE	ECO.	DATE	BY
NO.	DESCRIPTION OF CHANGE	ECO.	DATE	BY
NO.	DESCRIPTION OF CHANGE	ECO.	DATE	BY
NO.	DESCRIPTION OF CHANGE	ECO.	DATE	BY
NO.	DESCRIPTION OF CHANGE	ECO.	DATE	BY
NO.	DESCRIPTION OF CHANGE	ECO.	DATE	BY

TOLERANCES UNLESS OTHERWISE SPECIFIED:
 FRACTIONS ± 1/64 DECIMALS ± 0.010 ANGLES ± 1°
 DO NOT SCALE DRAWING
 CHECKER: DJH 11-16-66 SCALE: NONE

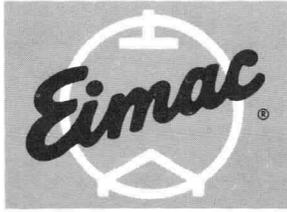
CODE IDENT 06980
 PART No 4CV250,000A

DESCRIPTION
 ELECTRON TUBE
 ETTEL-MCCULLOUGH, INC.
 SAN DIEGO, CALIFORNIA

NO. C 4CV250,000A-60
 CHANGE

NO. 4CV250,000A-60





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

TENTATIVE DATA
8350
4CW50,000C
RADIAL-BEAM
POWER TETRODE

The Eimac 8350/4CW50,000C is a ceramic-metal, water cooled power tetrode intended for use at the 50 to 150 kilowatt output power level. It is recommended for use as a Class-C rf amplifier or oscillator, a Class-AB, rf linear amplifier or a Class-AB, push-pull af amplifier or modulator. The 8350/4CW50,000C is also useful as a plate and screen modulated Class-C rf amplifier.

The water cooled anode is rated at 50 kilowatts of plate dissipation with low water flow requirements.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament:	Thoriated Tungsten		
Voltage	- - - - -	10	volts
Current	- - - - -	300	amps
Amplification Factor (Grid-Screen) (average)	- - -	4.5	

Direct Interelectrode Capacitances, Grounded Cathode:

Input	- - - - -	430	uuf
Output	- - - - -	45	uuf
Feedback	- - - - -	2.3	uuf

Frequency for Maximum Ratings:	- - - - -	30	Mc
--------------------------------	-----------	----	----

MECHANICAL

Base	- - - - -	Special. graduated rings
Maximum Seal Temperature	- - - - -	250°C
Maximum Anode Core Temperature	- - - - -	250°C
Recommended Socket	- - - - -	Eimac, SK-1500
Operating Position	- - - - -	Vertical, base up or down
Maximum Dimensions:		
Height	- - - - -	16.5 inches
Diameter	- - - - -	8.02 inches
Cooling	- - - - -	Water and Forced air
Net Weight	- - - - -	60 pounds
Shipping Weight-	- - - - -	85 pounds
(approximately)		



**RADIO-FREQUENCY POWER AMPLIFIER
OR OSCILLATOR**

Class-C Telegraphy or FM Telephony (Key-down conditions)

MAXIMUM RATINGS

DC PLATE VOLTAGE	- - -	20,000 MAX. VOLTS
DC SCREEN VOLTAGE	- - -	2500 MAX. VOLTS
DC PLATE CURRENT	- - -	15.0 MAX. AMPS
PLATE DISSIPATION	- - -	50,000 MAX. WATTS
SCREEN DISSIPATION	- - -	1750 MAX. WATTS
GRID DISSIPATION	- - -	500 MAX. WATTS

TYPICAL OPERATION

DC Plate Voltage	- - -	10	15	20	kV
DC Screen Voltage	- - -	750	750	750	volts
DC Grid Voltage	- - -	-420	-480	-540	volts
DC Plate Current	- - -	10.7	10.5	9.7	amps
DC Screen Current	- - -	2.25	2.1	1.65	amps
DC Grid Current	- - -	1.2	1.15	.89	amps
Peak RF Grid Voltage	- - -	680	740	790	volts
Driving Power	- - -	815	850	705	volts
Plate Dissipation	- - -	23	32	30	kW
Plate Output Power	- - -	84	124	165	kW

Note: Maximum plate voltage and plate current cannot be applied simultaneously without exceeding dissipation ratings.



PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER

Class-C Telephony (Carrier conditions except where noted)

MAXIMUM RATINGS

DC PLATE VOLTAGE - - -	15,000 MAX. VOLTS
DC SCREEN VOLTAGE - - -	2000 MAX. VOLTS
DC PLATE CURRENT - - -	15.0 MAX. AMPS
PLATE DISSIPATION* - - -	33,000 MAX. WATTS
SCREEN DISSIPATION - - -	1750 MAX. WATTS
GRID DISSIPATION - - -	500 MAX. WATTS

*Corresponds to 50,000 watts at 100 percent sinewave modulation

TYPICAL OPERATION

DC Plate Voltage - - -	10	12.5	15	kV
DC Screen Voltage - - -	750	750	750	volts
Peak AF Screen Voltage (For 100% modulation) - - -	705	675	745	volts
DC Grid Voltage - - -	-490	-500	-510	volts
DC Plate Current - - -	7.4	8.15	8.95	amps
DC Screen Current - - -	1.2	1.4	1.55	amp
DC Grid Current - - -	.470	.650	.790	amp
Peak RF Grid Voltage - - -	670	710	730	volts
Grid Driving Power - - -	315	460	570	watts
Plate Dissipation - - -	14	18.5	24	kW
Plate Output Power - - -	60	83.5	110	kW

AUDIO-FREQUENCY AMPLIFIER OR MODULATOR

Class-AB₁

MAXIMUM RATINGS (Per Tube)

DC PLATE VOLTAGE - - -	20,000 MAX. VOLTS
DC SCREEN VOLTAGE - - -	2500 MAX. VOLTS
DC PLATE CURRENT - - -	15.0 MAX. AMPS
PLATE DISSIPATION - - -	50,000 MAX. WATTS
SCREEN DISSIPATION - - -	1750 MAX. WATTS
GRID DISSIPATION - - -	500 MAX. WATTS

* Per Tube

**Approximate value

TYPICAL OPERATION (Two Tubes)

DC Plate Voltage - - -	10	15	20	kV
DC Screen Voltage - - -	1.5	1.5	1.5	kV
DC Grid Voltage - - -	-280	-320	-360	volts
Max-Signal Plate Current	18.4	16.4	17.3	amps
Zero-Signal Plate Current	6.0	4.0	3.0	amps
Max-Signal Screen Current** - - -	.780	.550	.500	amp
Zero-Signal Screen Current	0	0	0	amps
Peak AF Driving Voltage*	260	300	340	volts
Driving Power - - - -	0	0	0	watts
Load Resistance, Plate-to- Plate - - - -	1140	1980	2590	ohms
Max-Signal Plate Dissipation*- - -	35	38	48	kW
Max-Signal Plate Output Power - - -	114	170	250	kW

TYPICAL OPERATION, Peak-Envelope or Modulation-Crest Conditions.

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB₁

MAXIMUM RATINGS

DC PLATE VOLTAGE - - -	20,000 MAX. VOLTS
DC SCREEN VOLTAGE - - -	2500 MAX. VOLTS
DC PLATE CURRENT - - -	15.0 MAX. AMPS
PLATE DISSIPATION - - -	50,000 MAX. WATTS
SCREEN DISSIPATION - - -	1750 MAX. WATTS
GRID DISSIPATION - - -	500 MAX. WATTS

*Approximate value

DC Plate Voltage - - -	10	15	20	kV
DC Screen Voltage - - -	1.5	1.5	1.5	kV
DC Grid Voltage - - -	-280	-320	-360	volts
Max-Signal Plate Current	9.2	8.2	8.65	amps
Zero-Signal Plate Current	3.0	2.0	1.5	amp
Max-Signal Screen Current* - - -	.390	.275	.250	amp
Peak RF Grid Voltage - - -	260	300	340	volts
Driving Power - - - -	0	0	0	watts
Plate Dissipation - - -	35	38	48	kW
Plate Output Power - - -	57	85	125	kW
Resonant Load Impedance -	570	990	1295	ohms

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves and confirmed by direct tests. No allowance is made for circuit losses of any kind. Adjustment of the RF grid drive to obtain the specified plate current at the specified grid bias, screen voltage, and plate voltage is assumed. If this procedure is followed, there will be little variation in output power when tubes are changed, even though there may be some variations in grid and screen currents. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct RF driving voltage is applied.

APPLICATION

MECHANICAL

MOUNTING — The 4CW50,000C must be operated with its axis vertical. The base of the tube may be down or up at the convenience of the circuit designer.

SOCKET — The Eimac SK-1500 socket is recommended for use with the 4CW50,000C. Base cooling is accomplished by directing 50-100 CFM of air horizontally into the socket from the side. Temperature of the ceramic-metal seals must be limited to 250°C.

COOLING — Anode cooling is accomplished by circulating water through the integral anode-water jacket. A new more efficient design assures adequate cooling with low water flow rates. The table below lists minimum cooling water requirements at various dissipation levels.

Plate Dissipation* (kilowatts)	Water Flow GPM
20	7.2
30	10.2
40	12.9
50	15.2

*Since the power dissipated by the filament represents about 3000 watts and since grid-plus screen dissipation can, under some conditions, represent another 2250 watts, allowance has been made in preparing this tabulation for an additional 5250 watts dissipation.

The cooling table above assumes a water temperature rise of 20°C. Under no circumstances should the outlet water temperature exceed 70°C. Inlet water pressure should not exceed 75 psi. The pressure drop across the anode at full flow is less than 5 psi.

When the tube is mounted in the anode-up position, cooling water must enter the anode-water jacket through the outer connector; the outlet being the center connector; when the tube is mounted in an inverted position (base up) these connections are reversed, that is, the inlet connection is on the center water fitting and the water outlet is connected to the outer anode fitting.

Water flow must be started before applying any voltages to the tube. Water-flow and water temperature interlock switches are suggested for incorporation in any system to prevent tube damage due to inadequacy of flow. It is not necessary to continue water flow after the removal of all power.

ELECTRICAL

FILAMENT OPERATION — The rated filament voltage for the 4CW50,000C is 10.0 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain maximum tube life. In no case should it be allowed to deviate by more than plus or minus 5 percent from the rated value.

ELECTRODE DISSIPATION RATINGS — The maximum dissipation ratings for the 4CW50,000C must be respected to avoid damage to the tube. An exception is the plate dissipation, which may be permitted to rise above the rated maximum during brief periods, such as may occur during tuning.

PLATE DISSIPATION — The plate-dissipation rating for the 4CW50,000C is 50,000 watts for most applications, but for Class C plate modulated applications, the maximum allowable dissipation is 33,000 watts for carrier conditions.

CONTROL-GRID OPERATION — The 4CW50,000C control grid has a maximum dissipation rating of 500 watts. Grid dissipation is the product of dc grid current and peak positive grid voltage. Precautions should be observed to avoid exceeding this rating. The grid bias and driving power should be kept near the values shown in the "Typical Operation" sections of the data sheet whenever possible. The maximum grid circuit resistance should not exceed 100,000 ohms per tube.

SCREEN-GRID OPERATION — The power dissipated by the screen of the 4CW50,000C must not exceed 1750 watts. Screen dissipation, in cases where there is no ac applied to the screen, is the simple product of the screen voltage and the screen current. If the screen voltage is modulated, the screen dissipation will depend upon loading, driving power, and carrier screen voltage.

Screen Dissipation is likely to rise to excessive values when the plate voltage, bias voltage, or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit the screen dissipation to 1750 watts in the event of circuit failure.

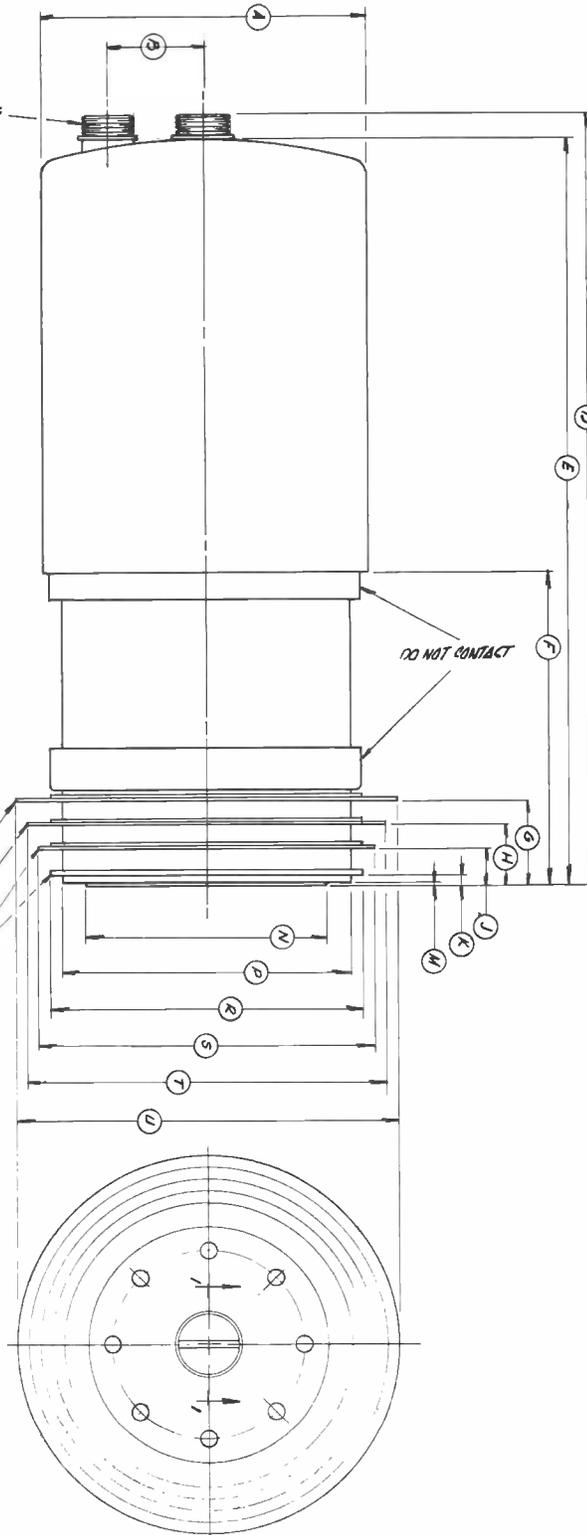
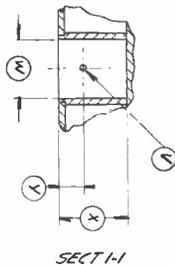
SPECIAL APPLICATIONS — If it is desired to operate this tube under conditions widely different from those given here, write to the Power Grid Tube Marketing Department, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California for information and recommendations.

DIMENSION DATA		
REF	MIN.	MAX.
A	6.750	6.875
B	1.968	2.062
D	16.000	16.500
E	15.500	15.875
F	6.500	6.750
G	1.750	1.800
H	1.220	1.270
J	.690	.740
K	.188	.228
M	.045	.075
N	4.980	5.020
P	5.980	6.020
R	6.510	6.560
S	6.980	7.080
T	7.480	7.580
U	7.975	8.015
V		.135 DIA.
W	1.250	1.270
X		1.250
Y	.490	.530

IMPERIAL FLEX FITTING
FOR 3/8" O.D. TUBING

DO NOT CONTACT

SCREEN
CONTROL
FILAMENT





EIMAC 4CW50,000C TYPICAL CONSTANT CURRENT CHARACTERISTICS

SCREEN VOLTAGE = 750 VOLTS

- PLATE CURRENT — AMPERES
- - - SCREEN CURRENT — AMPERES
- - - - GRID CURRENT — AMPERES

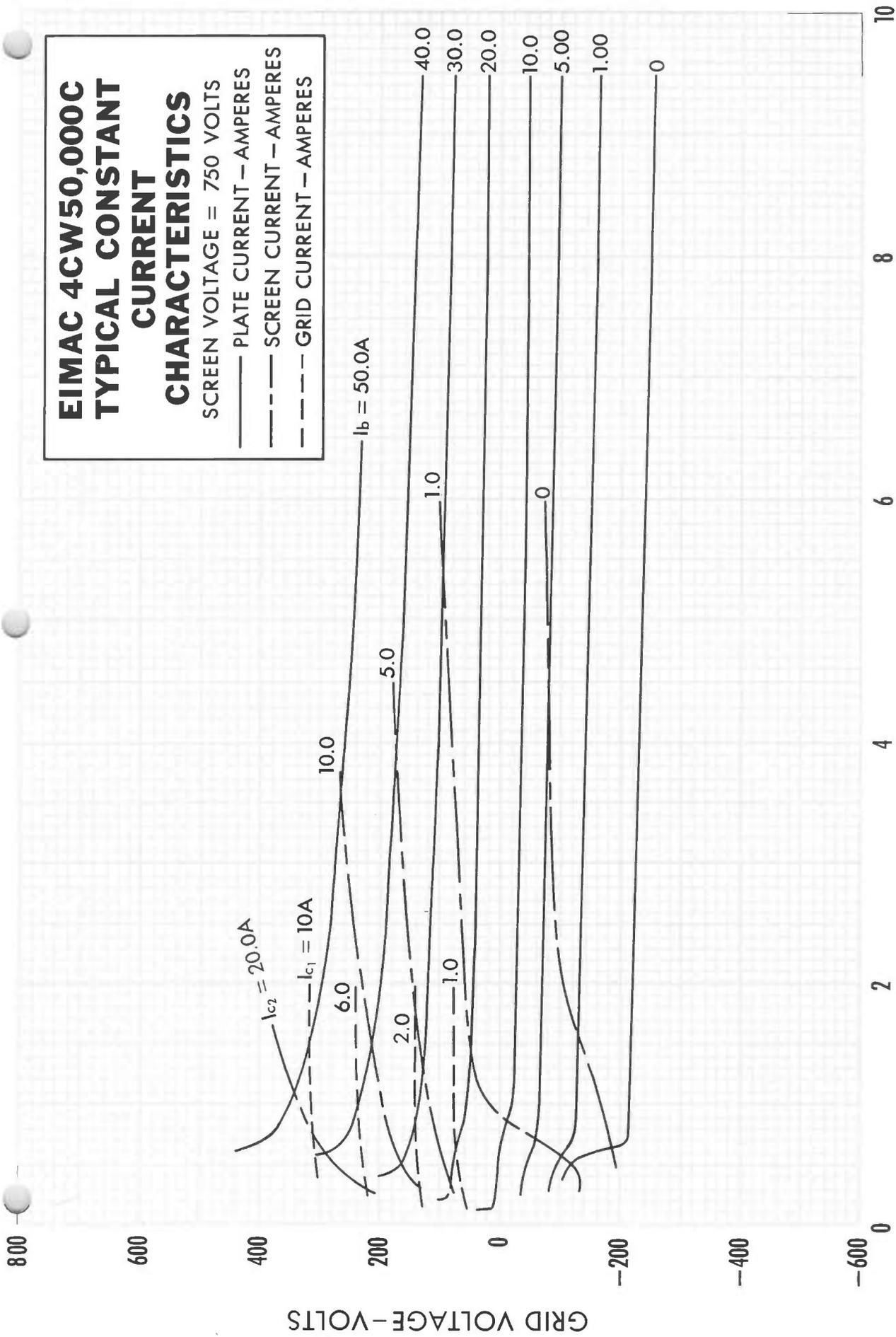


PLATE VOLTAGE - KILOVOLTS



4CW50,000C

EIMAC 4CW50,000C TYPICAL CONSTANT CURRENT CHARACTERISTICS

SCREEN VOLTAGE = 1500 VOLTS

- PLATE CURRENT — AMPERES
- - - SCREEN CURRENT — AMPERES
- - - - GRID CURRENT — AMPERES

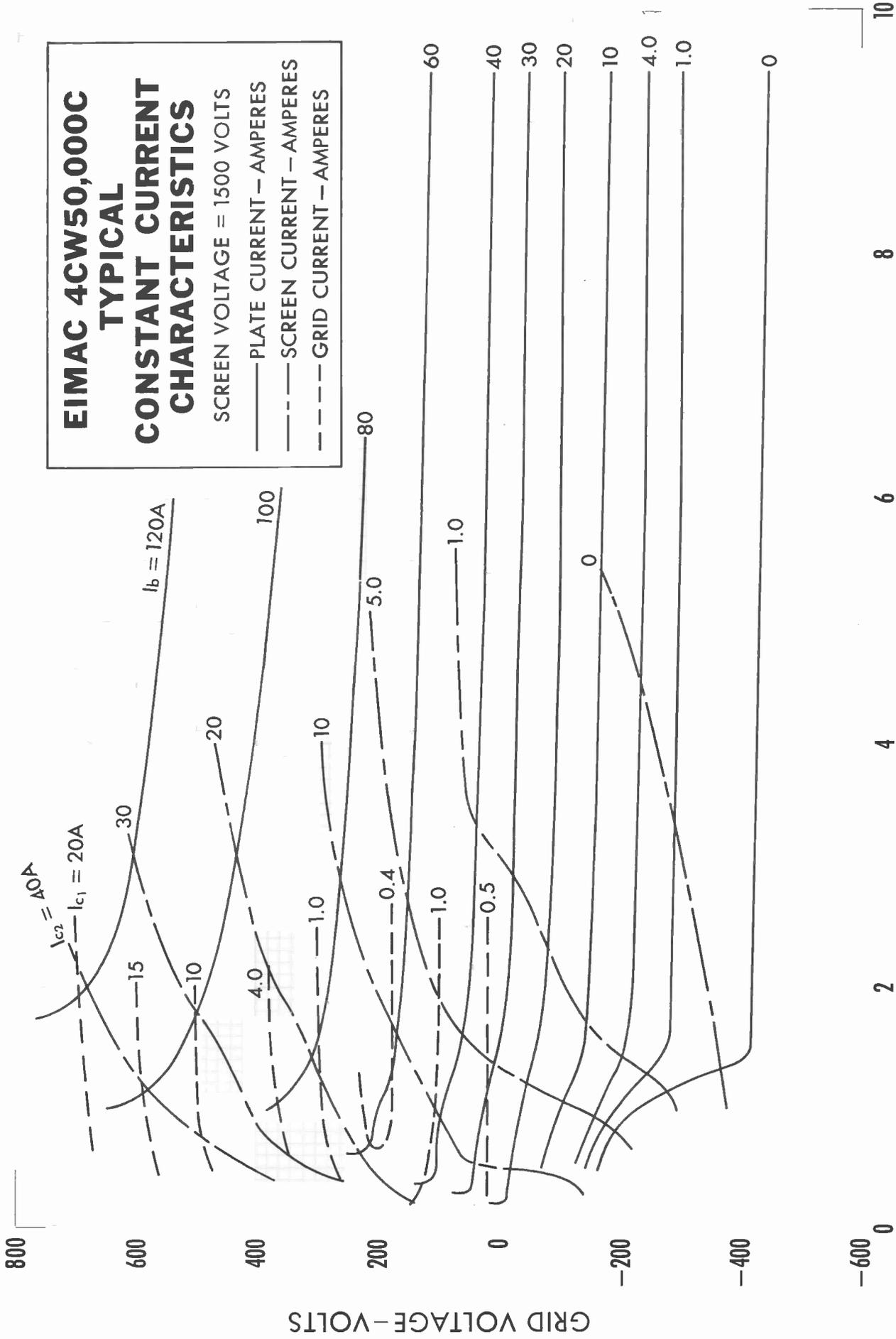


PLATE VOLTAGE — KILOVOLTS



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

TENTATIVE DATA

4CX600A

(formerly X2009)

The 4CX600A is a compact radial-beam tetrode with low lead inductances and low inter-electrode capacitances, designed for use in distributed amplifiers and in UHF service up to 1300 Mc. Maximum plate dissipation is 600 watts.

A feature of this tube is the integral screen-cathode by-pass capacitor. One side of the heater is terminated in a "deck" attached to this capacitor while the other heater contact is brought out on a pin on the tube base. The control grid is brought out to four threaded pins on the base.

GENERAL CHARACTERISTICS

ELECTRICAL

Heater Voltage	-	-	-	-	-	-	-	-	6.0	Volts
Current (average)	-	-	-	-	-	-	-	-	4.8	Amperes
Cathode: Oxide-coated, Unipotential										
Amplification Factor	-	-	-	-	-	-	-	-	-	8
Transconductance ($I_b = 300$ mA)	-	-	-	-	-	-	-	-	25,000	umhos
Frequency for maximum ratings	-	-	-	-	-	-	-	-	1300	Mc
Interelectrode capacitances:										
Input	-	-	-	-	-	-	-	-	42	uuf
Output	-	-	-	-	-	-	-	-	10	uuf
Screen-cathode	-	-	-	-	-	-	-	-	110	uuf

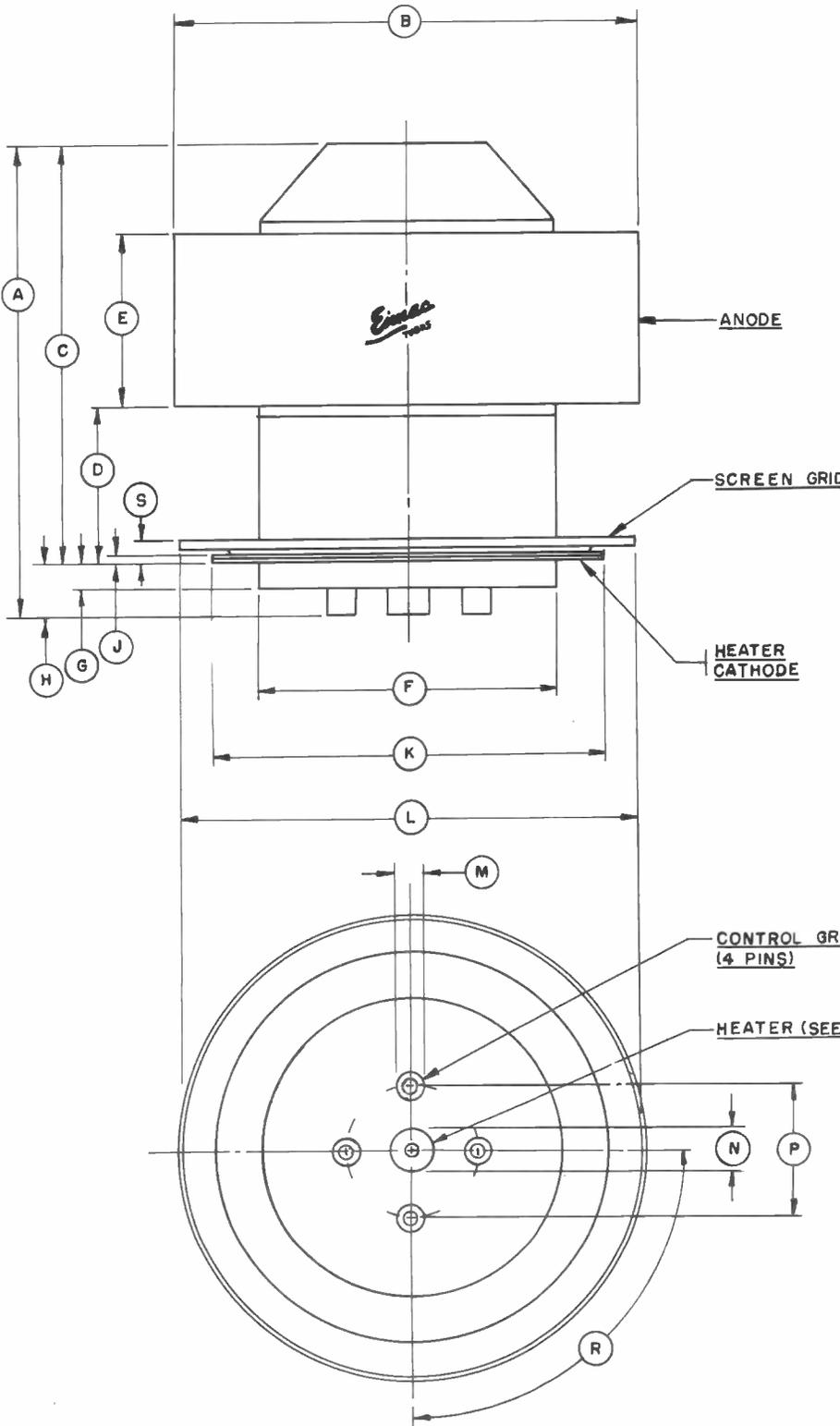
MECHANICAL

Base	-	-	-	-	-	-	-	-	-	5 Pin, Special
Maximum operating temperatures:										
Anode core	-	-	-	-	-	-	-	-	-	250° C
Ceramic-metal seals	-	-	-	-	-	-	-	-	-	250° C
Cooling	-	-	-	-	-	-	-	-	-	Forced air

MAXIMUM RATINGS Class-C Amplifier

DC Plate Voltage	-	-	-	-	-	-	-	-	3000	Max. Volts
DC Screen Voltage	-	-	-	-	-	-	-	-	400	Max. Volts
DC Grid Voltage	-	-	-	-	-	-	-	-	-150	Max. Volts
DC Plate Current	-	-	-	-	-	-	-	-	500	Max. mA
Plate Dissipation	-	-	-	-	-	-	-	-	600	Max. Watts
Screen Dissipation	-	-	-	-	-	-	-	-	15	Max. Watts
Grid Dissipation	-	-	-	-	-	-	-	-	3	Max. Watts

This information applies to a tentative tube design and is subject to change. Further application information is available from Power Grid Tube Marketing, Eitel-McCullough, Inc., San Carlos, California.



DIMENSIONS IN INCHES

DIMENSIONAL DATA			
REF.	MIN.	MAX.	NOM.
A	2.050	2.200	
B	2.030	2.080	
C	1.750	1.900	
D	.645	.780	
E	.710	.790	
F	1.305	1.325	
G	.110	.135	
H	.295	.350	
J	.035	.050	
K	1.710	1.750	
L	1.900	2.025	
M	.120	.135	
N	NOTE 1	NOTE 1	
P	NOTE 1	NOTE 1	
R	88°	92°	
S	.120	.160	

NOTES:

1. MEASURED .100 INCHES FROM END OF PIN
2. *2-56 UNC-28 X 3/16 DEEP TAP



EITEL-McCULLOUGH, INC.
SAN CARLOS · CALIFORNIA

4CX5000A

**RADIAL-BEAM
POWER TETRODE**

The Eimac 4CX5000A is a compact high-power ceramic and metal tetrode cooled by forced air. It is useful as an oscillator, amplifier, or modulator at frequencies up to 110 megacycles and is particularly suited for use as a linear single-sideband amplifier, class-AB₁ audio amplifier, or as a screen-modulated radio-frequency amplifier.

A pair of these tubes will deliver 17.5 kilowatts of audio-frequency or radio-frequency power with zero driving power. The rated plate dissipation is five kilowatts for most classes of service and six kilowatts for class-AB operation.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.
Filament: Thoriated Tungsten			
Voltage	-	7.5	volts
Current	-	73	78 amperes
Amplification Factor (Grid-Screen)	-	4.25	5.0

Direct Interelectrode Capacitances, Grounded Cathode:

Input	-	106	uuf
Output	-	18	uuf
Feedback	-	0.75	uuf

Direct Interelectrode Capacitances, Grounded Grid and Screen:

	Nom.	
Input	47	uuf
Output	18	uuf
Feedback	0.14	uuf

MECHANICAL

Base	-	Special concentric
Maximum Seal Temperature	-	250° C
Maximum Anode-Core Temperature	-	250° C
Recommended Socket	-	Eimac SK-300
Operating Position	-	Axis vertical, base up or down
Maximum Dimensions:		
Height	-	9.13 inches
Diameter	-	4.94 inches
Cooling	-	Forced air
Net Weight	-	9.5 pounds
Shipping Weight (Approximate)	-	22 pounds

**RADIO-FREQUENCY POWER AMPLIFIER
OR OSCILLATOR (Up to 30 megacycles)**

Class-C Telegraphy (Key-down conditions)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	7500 MAX. VOLTS
D-C SCREEN VOLTAGE	-	1500 MAX. VOLTS
D-C PLATE CURRENT	-	3 MAX. AMPERES
PLATE DISSIPATION	-	5000 MAX. WATTS
SCREEN DISSIPATION	-	250 MAX. WATTS
GRID DISSIPATION	-	75 MAX. WATTS

TYPICAL OPERATION
(Frequencies below 30 megacycles)

D-C Plate Voltage	-	7500 volts
D-C Screen Voltage	-	500 volts
D-C Grid Voltage	-	-350 volts
D-C Plate Current	-	2.8 amperes
D-C Screen Current	-	0.5 ampere
D-C Grid Current	-	0.25 ampere
Peak R-F Grid Voltage	-	590 volts
Driving Power	-	150 watts
Plate Dissipation	-	5000 watts
Plate Output Power	-	16,000 watts



RADIO FREQUENCY POWER AMPLIFIER OR OSCILLATOR (From 30 to 110 megacycles)

Class-C Telegraphy or FM Telegraphy (Key-down conditions)

MAXIMUM RATINGS

Table with 2 columns: Parameter and Rating. Includes D-C Plate Voltage (30 to 60 megacycles: 7000 MAX. VOLTS), D-C Screen Voltage (1500 MAX. VOLTS), D-C Plate Current (30 to 60 megacycles: 2.8 MAX. AMPERES), Plate Dissipation (5000 MAX. WATTS), Screen Dissipation (250 MAX. WATTS), Grid Dissipation (75 MAX. WATTS).

TYPICAL OPERATION (Frequencies between 88 and 108 megacycles)

Table with 2 columns: Parameter and Value. Includes D-C Plate Voltage (6500 volts), D-C Screen Voltage (750 volts), D-C Grid Voltage (-350 volts), D-C Plate Current (2.3 amperes), D-C Screen Current (0.2 ampere), D-C Grid Current (0.05 ampere), Driving Power (25 watts), Useful Output Power (10,000 watts).

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER

Class-C Telephony (Carrier conditions except where noted)

MAXIMUM RATINGS

Table with 2 columns: Parameter and Rating. Includes D-C Plate Voltage (5000 MAX. VOLTS), D-C Screen Voltage (1000 MAX. VOLTS), D-C Plate Current (2.5 MAX. AMPERES), Plate Dissipation* (3500 MAX. WATTS), Screen Dissipation (250 MAX. VOLTS), Grid Dissipation (75 MAX. WATTS).

*Corresponds to 5000 watts at 100-percent sine-wave modulation.

TYPICAL OPERATION (Frequencies below 30 megacycles)

Table with 2 columns: Parameter and Value. Includes D-C Plate Voltage (5000 volts), D-C Screen Voltage (500 volts), Peak A-F Screen Voltage (450 Volts), D-C Grid Voltage (-400 volts), D-C Plate Current (1.4 amperes), D-C Screen Current (0.26 ampere), D-C Grid Current (0.05 ampere), Peak R-F Grid Voltage (520 volts), Grid Driving Power (25 watts), Plate Dissipation (1100 watts), Plate Output Power (5.8 kilowatts).

SCREEN-MODULATED RADIO-FREQUENCY POWER AMPLIFIER

(Carrier conditions except where noted)

MAXIMUM RATINGS, Class-C Telephony (Per Tube)

Table with 2 columns: Parameter and Rating. Includes D-C Plate Voltage (7500 MAX. VOLTS), D-C Screen Voltage (750 MAX. VOLTS), D-C Plate Current (3.0 MAX. AMPERES), Plate Dissipation (5000 MAX. WATTS), Grid Dissipation (75 MAX. WATTS).

TYPICAL OPERATION (Frequencies below 30 megacycles, per tube)

Table with 2 columns: Parameter and Value. Includes D-C Plate Voltage (7500 volts), D-C Screen Voltage (350 volts), Peak A-F Screen Voltage (550 volts), D-C Grid Voltage (-300 volts), D-C Plate Current (0.9 amperes), D-C Screen Current* (-0.01 amperes), D-C Grid Current (0.015 amperes), Peak R-F Grid Voltage (350 volts), Grid Driving Power (7 watts), R-F Load Impedance (2000 ohms), Plate Dissipation (4000 watts), Useful Output Power (2750 watts).

*D-C Screen Current is a function of loading; values of plus or minus 20 milliamperes may be considered typical at carrier level.

NOTE: Two tubes can be employed under conditions listed in the first column to obtain more than five kilowatts plate output power. Likewise, three tubes can be utilized at conditions listed in the second column to obtain better than ten kilowatts output power.

AUDIO-FREQUENCY AMPLIFIER OR MODULATOR

Class-AB₁

MAXIMUM RATINGS (Per Tube)

Table with 2 columns: Parameter and Rating. Includes D-C Plate Voltage (7500 MAX. VOLTS), D-C Screen Voltage (1500 MAX. VOLTS), D-C Plate Current (4.0 MAX. AMPERES), Plate Dissipation (6000 MAX. WATTS), Screen Dissipation (250 MAX. WATTS), Grid Dissipation (75 MAX. WATTS).

TYPICAL OPERATION, two tubes

Table with 2 columns: Parameter and Value. Includes D-C Plate Voltage (4000, 5000, 6000, 7000 volts), D-C Screen Voltage (1250, 1250, 1250, 1250 volts), D-C Grid Voltage (-270, -280, -310, -325 volts), Max.-Signal Plate Current (5.10, 4.40, 4.25, 3.65 amperes), Zero-Signal Plate Current (1.25, 1.00, 0.83, 0.70 amperes), Max.-Signal Screen Current (0.35, 0.33, 0.30, 0.24 amperes), Zero-Signal Screen Current (0, 0, 0, 0 amperes), Peak A-F Driving Voltage (250, 240, 270, 235 volts), Driving Power (0, 0, 0, 0 watts), Load Resistance, Plate-to-Plate (1500, 2370, 2940, 4100 ohms), Max.-Signal Plate Dissipation (4200, 4200, 4200, 4200 watts), Max.-Signal Plate Output Power (11,500, 13,500, 17,000, 17,500 watts).

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB₁

MAXIMUM RATINGS

Table with 2 columns: Parameter and Rating. Includes D-C Plate Voltage (7500 MAX. VOLTS), D-C Screen Voltage (1500 MAX. VOLTS), D-C Plate Current (4.0 MAX. AMPERES), Plate Dissipation (6000 MAX. WATTS), Screen Dissipation (250 MAX. WATTS), Grid Dissipation (75 MAX. WATTS).

TYPICAL OPERATION, Peak-Envelope or Modulation-Crest Conditions, (Frequencies below 30 megacycles)

Table with 2 columns: Parameter and Value. Includes D-C Plate Voltage (7500 volts), D-C Screen Voltage (1250 volts), D-C Grid Voltage* (-300 volts), Max.-Signal Plate Current (1.9 amperes), Zero-Signal Plate Current (0.50 ampere), Max.-Signal Screen Current (0.20 ampere), Peak R-F Grid Voltage (300 volts), Driving Power (0 watts), Plate Dissipation (4200 watts), Plate Output Power** (10,000 watts).

*Adjust grid voltage to obtain specified Zero-Signal plate current. **PEP output or r-f output power at crest of modulation envelope.

NOTE: In most cases, "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves and confirmed by direct tests. No allowance for circuit losses, either input or output, has been made. Exceptions are distinguished by a listing of "Useful" output power as opposed to "Plate" output power. Values appearing in these groups have been obtained from existing equipment(s) and the output power is that measured at the load.



APPLICATION

MECHANICAL

Mounting—The 4CX5000A must be operated with its axis vertical. The base of the tube may be down or up at the convenience of the circuit designer.

Socket—The Eimac Air-System Socket Type SK-300 is designed especially for the concentric base terminals of the 4CX5000A. The use of recommended air-flow rates through this socket provides effective forced-air cooling of the tube. Air forced into the bottom of the socket passes over the tube terminals and through an Air Chimney, the SK-306, into the anode cooling fins.

Cooling—The maximum temperature rating for the external surfaces of the 4CX5000A is 250°C. Sufficient forced-air circulation must be provided to keep the temperature of the anode at the base of the cooling fins and the temperature of the ceramic-metal seals below 250°C. Air-flow requirements to maintain seal temperatures at 200°C in 50°C ambient air are tabulated below.

Plate Dissipation* (Watts)	SEA LEVEL		10,000 FEET	
	Air Flow (CFM)	Pressure Drop (Inches of water)	Air Flow (CFM)	Pressure Drop (Inches of water)
2000	100	0.6	146	0.9
3000	160	1.4	230	2.0
4000	230	2.8	330	4.0
5000	310	4.0	450	5.8
6000	400	5.1	580	7.4

*Since the power dissipated by the filament represents about 560 watts and since grid-plus-screen dissipation can, under some conditions, represent another 200 to 300 watts, allowance has been made in preparing this tabulation for an additional 1000 watts dissipation.

The blower selected in a given application must be capable of supplying the desired air flow at a back pressure equal to the pressure drop shown above plus any drop encountered in ducts and filters.

At other altitudes and ambient temperatures the flow rate must be increased to obtain equivalent cooling. The flow rate and corresponding pressure differential must be determined individually in such cases, using maximum rated temperatures as the criteria for satisfactory cooling.

ELECTRICAL

Filament Operation—The rated filament voltage for the 4CX5000A is 7.5 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain maximum tube life. In no case should it be allowed to deviate by more than 5 percent from the rated value.

Electrode Dissipation Ratings—The maximum dissipation ratings for the 4CX5000A must be respected to avoid damage to the tube. An exception is the plate dissipation, which may be permitted to rise above the maximum rating during brief periods, such as may occur during tuning.

Control Grid Operation—The 4CX5000A control grid has a maximum dissipation rating of 75 watts. Precautions should be observed to avoid exceeding this rating. The grid bias and driving power should be kept near the values shown in the "Typical Operation" sections of the data sheet whenever possible.

Screen-Grid Operation—The power dissipated by the screen of the 4CX5000A must not exceed 250 watts.

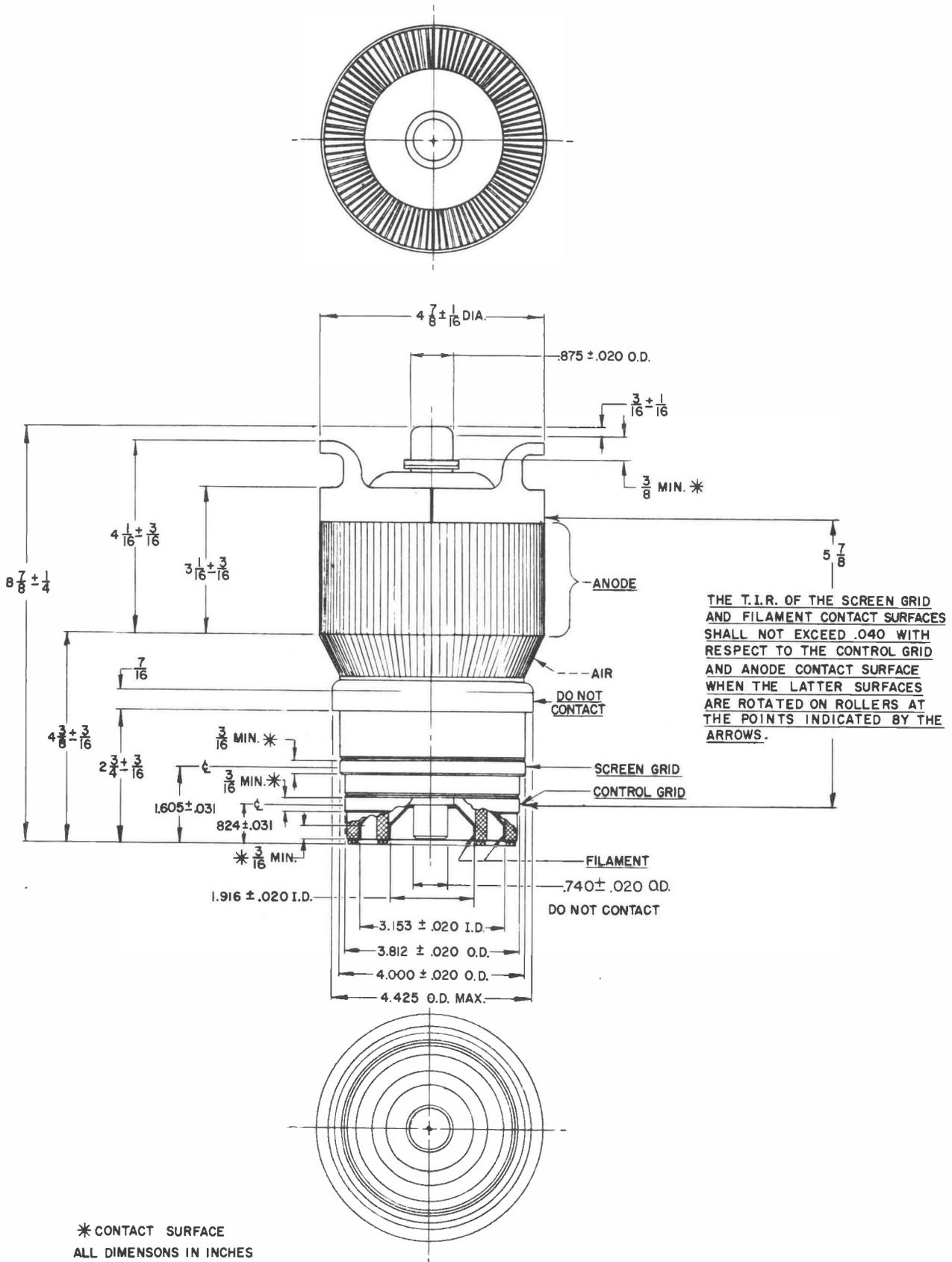
Screen dissipation, in cases where there is no ac applied to the screen, is the simple product of the screen voltage and the screen current. If the screen voltage is modulated, the screen dissipation will depend upon loading, driving power, and carrier screen voltage.

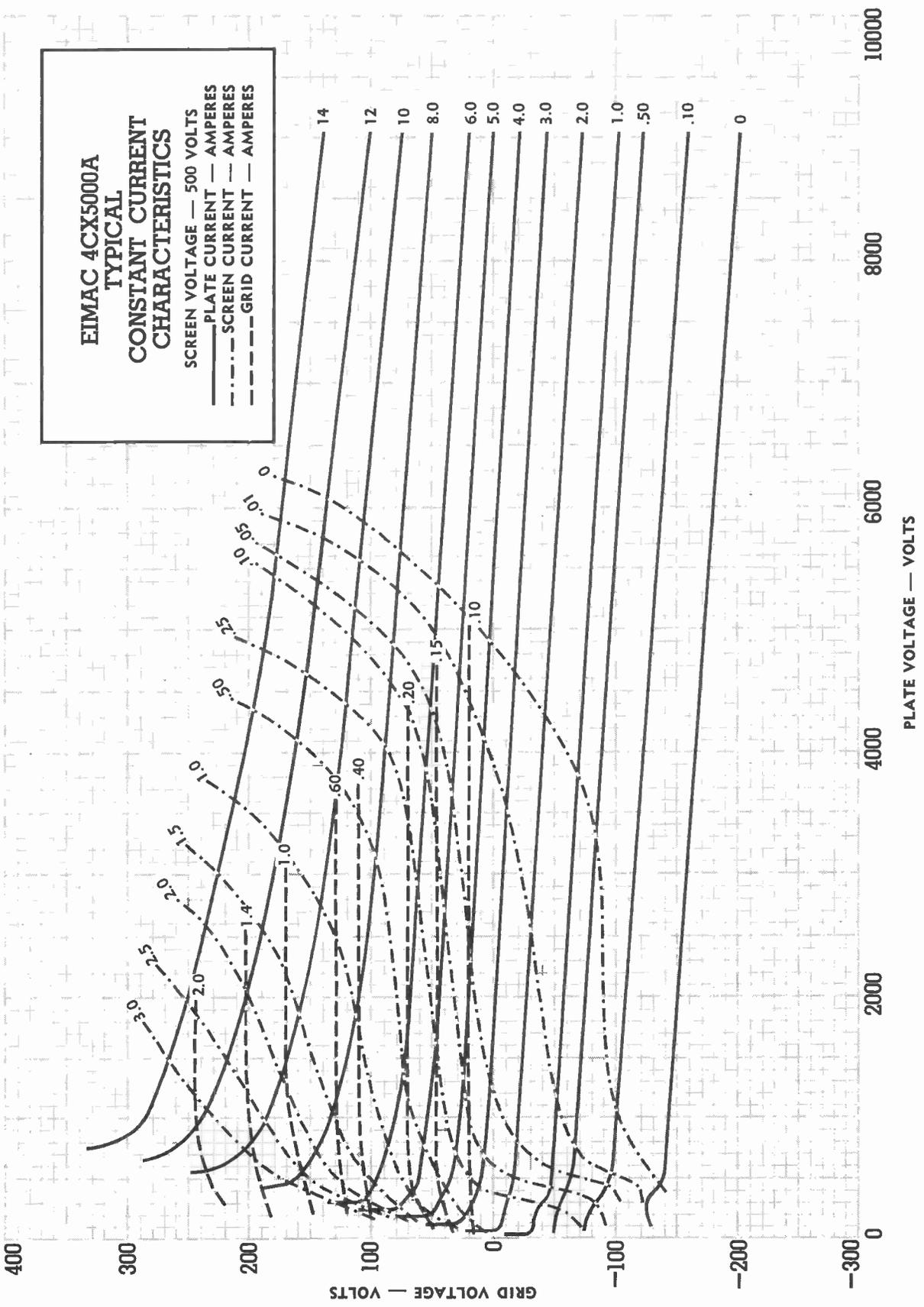
Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage, or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit the screen dissipation to 250 watts in the event of circuit failure.

Plate Dissipation—The plate-dissipation rating for the 4CX5000A is 5000 watts for most applications but for audio and SSB amplifier applications, the maximum allowable dissipation is 6000 watts.

When the 4CX5000A is operated as a plate-modulated r-f power amplifier, the input power is limited by conditions not connected with the plate efficiency, which is quite high. Therefore, except during tuning there is little possibility that the 3500-watt maximum plate dissipation rating will be exceeded.

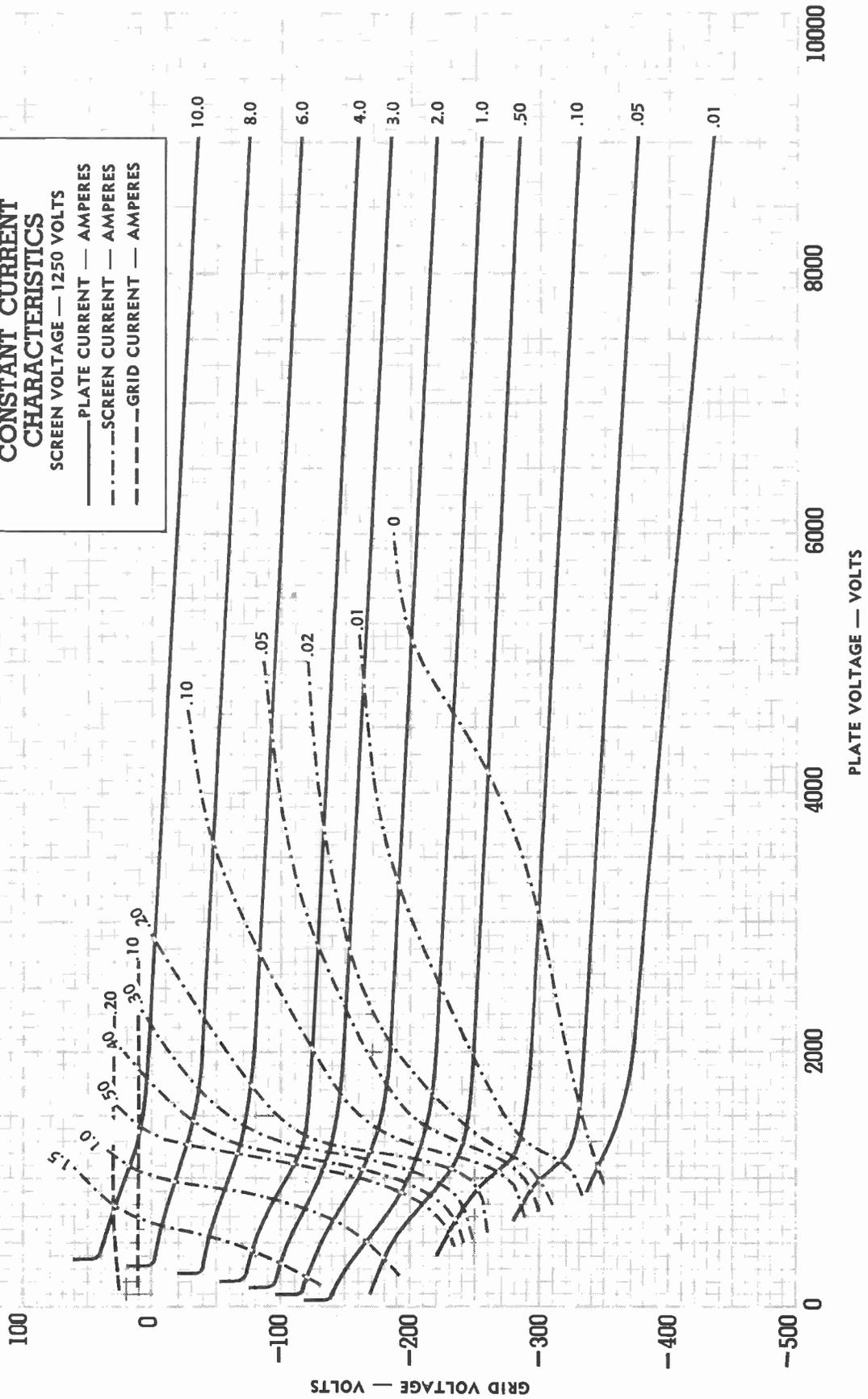
Special Applications—If it is desired to operate this tube under conditions widely different from those given here, write to the Application Engineering Department, Eitel-McCullough, Inc., 301 Industrial Road, San Carlos, California, for information and recommendations.







EIMAC 4CX5000A
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE — 1250 VOLTS
— PLATE CURRENT — AMPERES
- · - · - SCREEN CURRENT — AMPERES
- - - - - GRID CURRENT — AMPERES





EITEL - McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

Item (34)
TENTATIVE DATA

4CX35,000A/
4CX35,000C

Radial-Beam

Power Tetrodes

The Eimac 4CX35,000A and 4CX35,000C ceramic-metal power tetrodes are intended for use at the fifty kilowatt output power level. The 4CX35,000A is recommended for use as a Class-C r-f amplifier or oscillator, Class-AB₁ r-f amplifier, or Class-AB₁ push-pull a-f amplifier or modulator. The 4CX35,000C is a special version with a longer screen-anode insulator intended specifically for use as a plate-and screen-modulated Class-C r-f amplifier. Both types carry full ratings to 110 megacycles.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament:	Thoriated Tungsten						
Voltage	-	-	-	-	-	10.0	Volts
Current	-	-	-	-	-	300	Amperes
Amplification Factor (Grid-Screen) (Average)						5.5	
Direct Interelectrode Capacitances, Grounded Cathode (Average):							
Tube Type:				4CX35,000A		4CX35,000C	
Input	-	-	-	415		445	μμf
Output	-	-	-	45		45	μμf
Feedback	-	-	-	2.3		2.3	μμf
Frequency for Maximum Ratings				-		110	Megacycles

MECHANICAL

Base	-	-	-	-	-	Special, graduated rings	
Recommended Socket	-	-	-	-	-	Eimac SK-1500	
Operating Position	-	-	-	-	-	Axis-vertical, base up or down	
Cooling	-	-	-	-	-	Forced air	
Maximum Seal Temperature	-	-	-	-	-	250°C	
Maximum Anode Core Temperature	-	-	-	-	-	250°C	
Maximum Over-all Dimensions:							
Tube Type:				4CX35,000A		4CX35,000C	
Height	-	-	-	13.5		15.5	Inches
Diameter	-	-	-	9.75		9.75	Inches
Net Weight	-	-	-	48		50	Pounds

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	-	-	10,000	VOLTS
D-C SCREEN VOLTAGE	-	-	-	-	-	2500	VOLTS
D-C PLATE CURRENT	-	-	-	-	-	10.0	AMPERES
PLATE DISSIPATION	-	-	-	-	-	35,000	WATTS
SCREEN DISSIPATION	-	-	-	-	-	1500	WATTS
GRID DISSIPATION	-	-	-	-	-	450	WATTS

TYPICAL OPERATION

D-C Plate Voltage	-	-	-	-	-	10,000	Volts
D-C Screen Voltage	-	-	-	-	-	750	Volts
D-C Grid Voltage	-	-	-	-	-	-425	Volts
D-C Plate Current	-	-	-	-	-	6.80	Amperes
D-C Screen Current	-	-	-	-	-	925	Ma
D-C Grid Current	-	-	-	-	-	320	Ma
Peak R-F Grid Voltage	-	-	-	-	-	575	Volts
Driving Power	-	-	-	-	-	185	Watts
Plate Dissipation	-	-	-	-	-	11,700	Watts
Plate Output Power	-	-	-	-	-	56,500	Watts

PLATE-MODULATED RADIO-FREQUENCY

POWER AMPLIFIER

(Applies Only to 4CX35,000C)

Class-C Telephony (Carrier conditions except where noted)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	-	-	10,000	VOLTS
D-C SCREEN VOLTAGE	-	-	-	-	-	1250	VOLTS
D-C PLATE CURRENT	-	-	-	-	-	10.0	AMPERES
PLATE DISSIPATION	-	-	-	-	-	23,500	WATTS
SCREEN DISSIPATION	-	-	-	-	-	1500	WATTS
GRID DISSIPATION	-	-	-	-	-	450	WATTS

TYPICAL OPERATION

D-C Plate Voltage	-	-	-	-	-	10,000	Volts
D-C Screen Voltage	-	-	-	-	-	750	Volts
Peak A-F Screen Voltage (for 100-percent modulation)*	-	-	-	-	-	705	Volts
D-C Grid Voltage	-	-	-	-	-	-525	Volts
D-C Plate Current	-	-	-	-	-	6.70	Amperes
D-C Screen Current	-	-	-	-	-	1.05	Amperes
D-C Grid Current	-	-	-	-	-	315	Ma
Peak R-F Grid Voltage	-	-	-	-	-	680	Volts
Driving Power	-	-	-	-	-	215	Watts
Plate Dissipation (at 100% Modulation)*	-	-	-	-	-	17,100	Watts
Plate Output Power	-	-	-	-	-	55,600	Watts

* Approximate Value

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB₁, Grid-Driven

MAXIMUM RATINGS (Single-Tone Conditions)

D-C PLATE VOLTAGE	-	-	-	-	-	10,000	VOLTS
D-C SCREEN VOLTAGE	-	-	-	-	-	2500	VOLTS
D-C PLATE CURRENT	-	-	-	-	-	10.0	AMPERES
PLATE DISSIPATION	-	-	-	-	-	35,000	WATTS
SCREEN DISSIPATION	-	-	-	-	-	1500	WATTS
GRID DISSIPATION	-	-	-	-	-	450	WATTS

TYPICAL OPERATION

D-C Plate Voltage	-	-	-	-	-	10,000	Volts
D-C Screen Voltage	-	-	-	-	-	1500	Volts
D-C Grid Voltage *	-	-	-	-	-	-290	Volts
Zero-Sig D-C Plate Current	-	-	-	-	-	2.00	Amperes
Max-Sig D-C Plate Current	-	-	-	-	-	8.75	Amperes
Max-Sig D-C Screen Current	-	-	-	-	-	270	Ma
Peak R-F Grid Voltage	-	-	-	-	-	265	Volts
Driving Power	-	-	-	-	-	0	Watts
Plate Dissipation	-	-	-	-	-	32,500	Watts
Max-Sig Plate Output Power	-	-	-	-	-	55,000	Watts
Resonant Load Impedance	-	-	-	-	-	590	Ohms

AUDIO-FREQUENCY AMPLIFIER OR MODULATOR

Class-AB₁

MAXIMUM RATINGS (Per Tube)

D-C PLATE VOLTAGE	-	-	-	-	-	10,000	VOLTS
D-C SCREEN VOLTAGE	-	-	-	-	-	2500	VOLTS
D-C PLATE CURRENT	-	-	-	-	-	10.0	AMPERES
PLATE DISSIPATION	-	-	-	-	-	35,000	WATTS
SCREEN DISSIPATION	-	-	-	-	-	1500	WATTS
GRID DISSIPATION	-	-	-	-	-	450	WATTS

TYPICAL OPERATION (Two Tubes, Sinusoidal Wave)

D-C Plate Voltage	-	-	-	-	-	10,000	Volts
D-C Screen Voltage	-	-	-	-	-	1500	Volts
D-C Grid Voltage *	-	-	-	-	-	-290	Volts
Zero-Sig D-C Plate Current	-	-	-	-	-	4.00	Amperes
Max-Sig D-C Plate Current	-	-	-	-	-	17.5	Amperes
Max-Sig D-C Screen Current	-	-	-	-	-	540	Ma
Peak A-F Driving Voltage (Per Tube)	-	-	-	-	-	265	Volts
Driving Power	-	-	-	-	-	0	Watts
Load Resistance, Plate-to-Plate	-	-	-	-	-	1180	Ohms
Plate Dissipation (Per Tube)	-	-	-	-	-	32,500	Watts
Max-Sig Plate Output Power	-	-	-	-	-	110,000	Watts

* Adjust grid voltage to obtain specified zero-signal plate current.

NOTE: In most cases, "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves and confirmed by direct tests. No allowance for circuit losses, either input or output, has been made. Exceptions are distinguished by a listing of "Useful" output power as opposed to "Plate" output power. Values appearing in these groups have been obtained from existing equipment and the output power is that measured at the load.

APPLICATION

MECHANICAL

MOUNTING - The 4CX35,000A or 4CX35,000C must be operated with its axis vertical. The base of the tube be down or up.

SOCKET - The Eimac SK-1500 Socket is recommended for use with the 4CX35,000A and 4CX35,000C. The SK-1500 is not an air-system socket.*

COOLING - The maximum temperature rating for the external surfaces of the 4CX35,000A and the 4CX35,000C is 250°C. Sufficient forced-air cooling must be provided to keep the temperature of the anode core and the temperature of the ceramic-metal seals below 250°C. Tube life is usually prolonged if these areas are maintained at temperatures below this maximum rating. Estimated air-flow requirements to maintain anode-core and seal temperatures below 225°C with an inlet-air temperature of 50°C are tabulated below for operation below 30 Mc. These data are for air flowing in the anode-to-base direction. At higher altitudes, higher frequencies, or higher ambient temperatures the flow rate must be increased to obtain equivalent cooling.

Plate Dissipation** (Watts)	SEA LEVEL		10,000 FEET	
	Air Flow (CFM)	Pressure Drop (Inches of Water)	Air Flow (CFM)	Pressure Drop (Inches of Water)
15,000	545	1.5	795	2.2
20,000	800	2.5	1170	3.6
35,000	1760	7.0	2560	10.2

** Since the power dissipated by the filament represents about 3000 watts and since grid-plus-screen dissipation can, under some conditions, represent another 1950 watts, allowance has been made in preparing this tabulation for an additional 5000 watts dissipation.

ELECTRICAL

FILAMENT OPERATION - The rated filament voltage for the 4CX35,000A and the 4CX35,000C is 10.0 volts. Filament voltage, as measured at the socket, should be maintained at this value to obtain maximum tube life. In no case should it be allowed to deviate from the rated value by more than $\pm 5\%$.

SPECIAL APPLICATIONS - For additional data, write to Power Grid Tube Marketing, Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California.

* Separate base cooling is required.



Note: Typical operation data are based on conditions of adjusting to a specified plate current, maintaining fixed conditions of grid bias, screen voltage, suppressor voltage and r-f grid voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid, screen and suppressor currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

APPLICATION

Mounting—The 4W20,000A must be mounted vertically. Base-down or base-up mounting is optional.

The co-axial contact surfaces provided for connection to the filament, cathode, grid, screen, and anode are of successively larger diameters to facilitate removal and replacement of tubes.

Cavity circuits may be designed around the dimensions shown in the outline drawing. At very high frequencies the points of contact between the tube and the external circuit will be required to carry high values of charging current. It is, therefore, essential that the contactors make firm and uniform contact between the terminal surfaces of the tube and the external circuit. Particular care should be taken that the contactors are not inadvertently forced out of shape, and that all contact surfaces are maintained free from dust or other foreign matter which would prevent uniform electrical connection. At VHF, poor contact by one finger of a multi-finger collet can result in local overheating which may damage the tube seals.

Although contact fingers or slotted collets are often made an integral part of cavity circuits, there is some advantage to reversing the plan by providing contact-finger assemblies which are designed to be clamped firmly to the terminal surfaces of the tube itself and to make sliding contact with the cavity as the tube is inserted. This arrangement facilitates replacement of worn or damaged contactors and tends to remove incidental local heating from the vicinity of the tube seals. Tubes held in reserve for emergency replacement may be fitted with contact finger assemblies and water-line extensions to minimize lost time in making changes.

Cathode Heating Power — The cathode of the 4W20,000A is a unipotential, thoriated tungsten cylinder, heated by electron bombardment of its inner surface. Bombardment is obtained by using the cylindrical cathode as the anode of a diode. A helical filament is mounted on the axis of the cathode cylinder to supply the bombarding electrons. A d-c potential of approximately 1400 volts is applied between the filament and the cathode cylinder, and the recommended cathode heating power of 2500 watts is obtained with approximately 1.8 amperes.

The inner filament is designed to operate under space-charge limited conditions so that the cathode temperature may be varied by changing the voltage applied between the inner filament and the cathode cylinder.

For maximum tube life the filament voltage, as measured directly at the filament terminals, must be reduced after the cathode has reached operating tem-

perature. The proper filament voltage for a given cathode bombardment power may be found in the table below. The filament voltage should remain at the 10.0-volt value until the cathode has reached operating temperature, an interval of approximately thirty seconds. The filament voltage should be maintained to within 5% of the proper operating value and the cathode bombardment power should be held within plus or minus 100 watts of the recommended value.

Cathode Bombardment Power	2000	2250	2500	2750	3000
Filament Voltage	6.0	5.2	4.3	3.2	2.0

A cathode bombardment power of 2250 watts is normal for average CW conditions. In applications requiring peak values of cathode current in excess of 75 amperes the cathode bombardment power may be increased to a value between 2250 and 3000 watts as required.

Further increases in cathode efficiency will result in a decrease in the cathode bombardment power requirements. The cathode bombardment power supply should, therefore, be capable of providing a minimum of approximately 2000 watts.

Caution: It must be kept in mind that the filament is at a potential of 1400 volts d-c with respect to ground. The filament transformer and voltmeter must be adequately insulated for this voltage.

Grid Voltage Regulation—The practice of designing grid voltage supplies to maintain adequate regulation under conditions of varying grid current is particularly desirable with the 4W20,000A. Because the cathode of the 4W20,000A is a complete cylinder, grid temperatures run higher than usual. For this reason, even with no excitation, control grid current reversal might conceivably be several milliamperes and safe design should allow for possible peaks on the order of 100 milliamperes.

Anode Cooling—The water-cooled anode requires 8 gallons per minute of cooling water for the rated 20 kilowatts of plate dissipation. This corresponds to a pressure drop of 7 pounds per square inch across the water jacket. The inlet water pressure must not exceed a maximum of 50 pounds per square inch.

The outlet water temperature must not exceed a maximum of 70°C under any conditions.

Seal Cooling—The grid and screen tube contact surfaces and adjacent glass and ceramic must be cooled by high-velocity air which may be accomplished by means of ring manifolds. The quantity, velocity and direction of air must be adjusted to limit the maximum seal temperatures to 150°C.

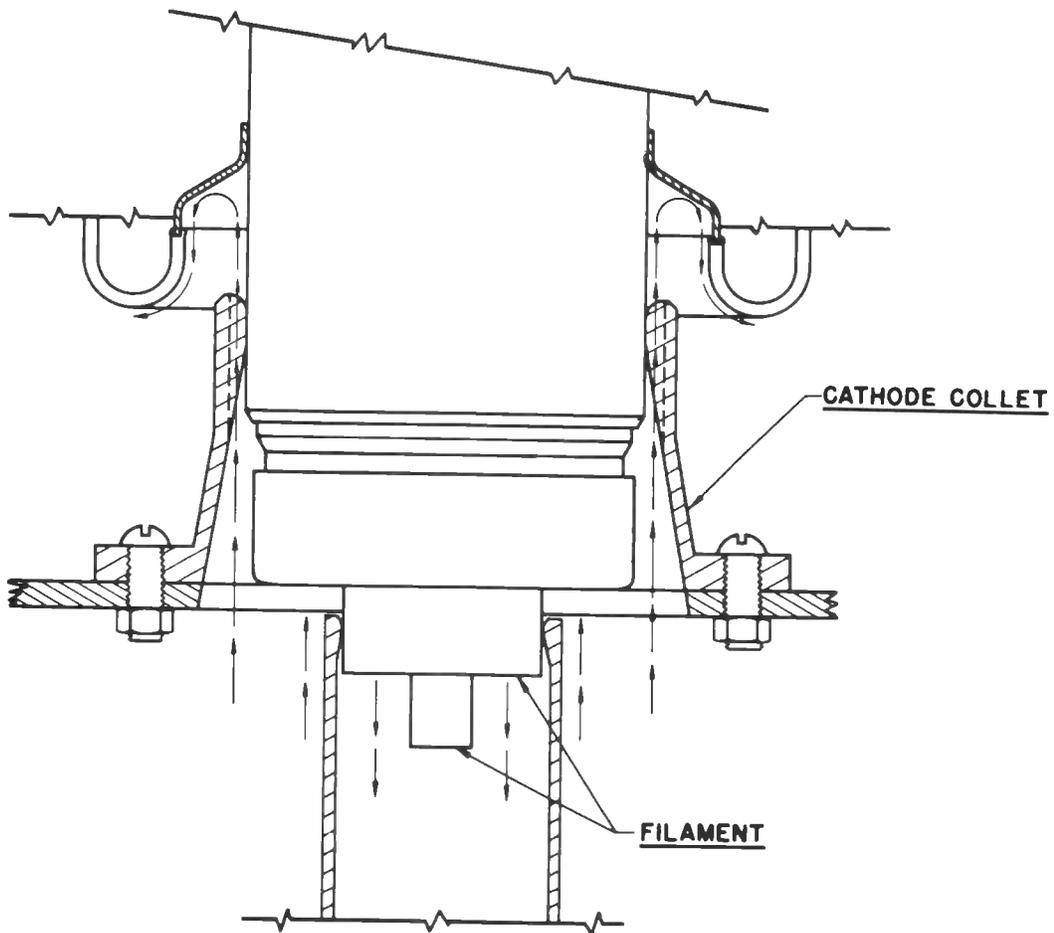
IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

The cathode and filament stem also require forced-air cooling in sufficient quantity so that the region on the cathode terminal opposite the glass of the grid terminal seal does not exceed a maximum of 150°C. The major portion of this air must be guided along the surface of the terminal sleeve. The remaining air flows through the nine holes inside the terminal sleeve, cools the filament stem and vents through the three holes in the tube base enclosed by the outer filament spring collet connection.

By employing a cathode collet such as is shown in the accompanying drawings, the recommended cooling requirements will be fulfilled with an air flow of 60 cubic feet per minute at a static manifold pressure of 2 inches of water column.

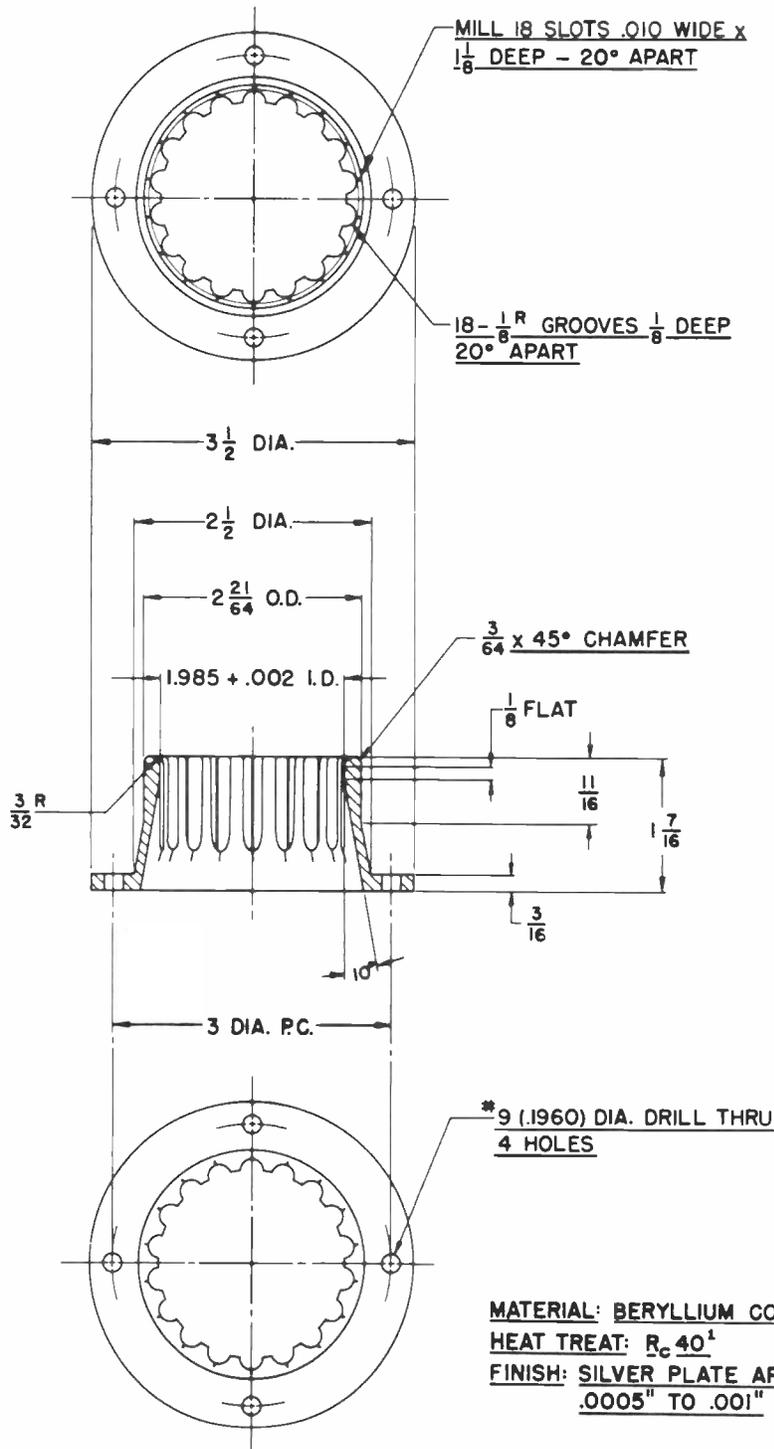
Air and water flow must be started before filament and cathode power are applied and maintained for at least two minutes after the filament and cathode power have been removed.

4W20,000A
SUGGESTED STEM AIR COOLING

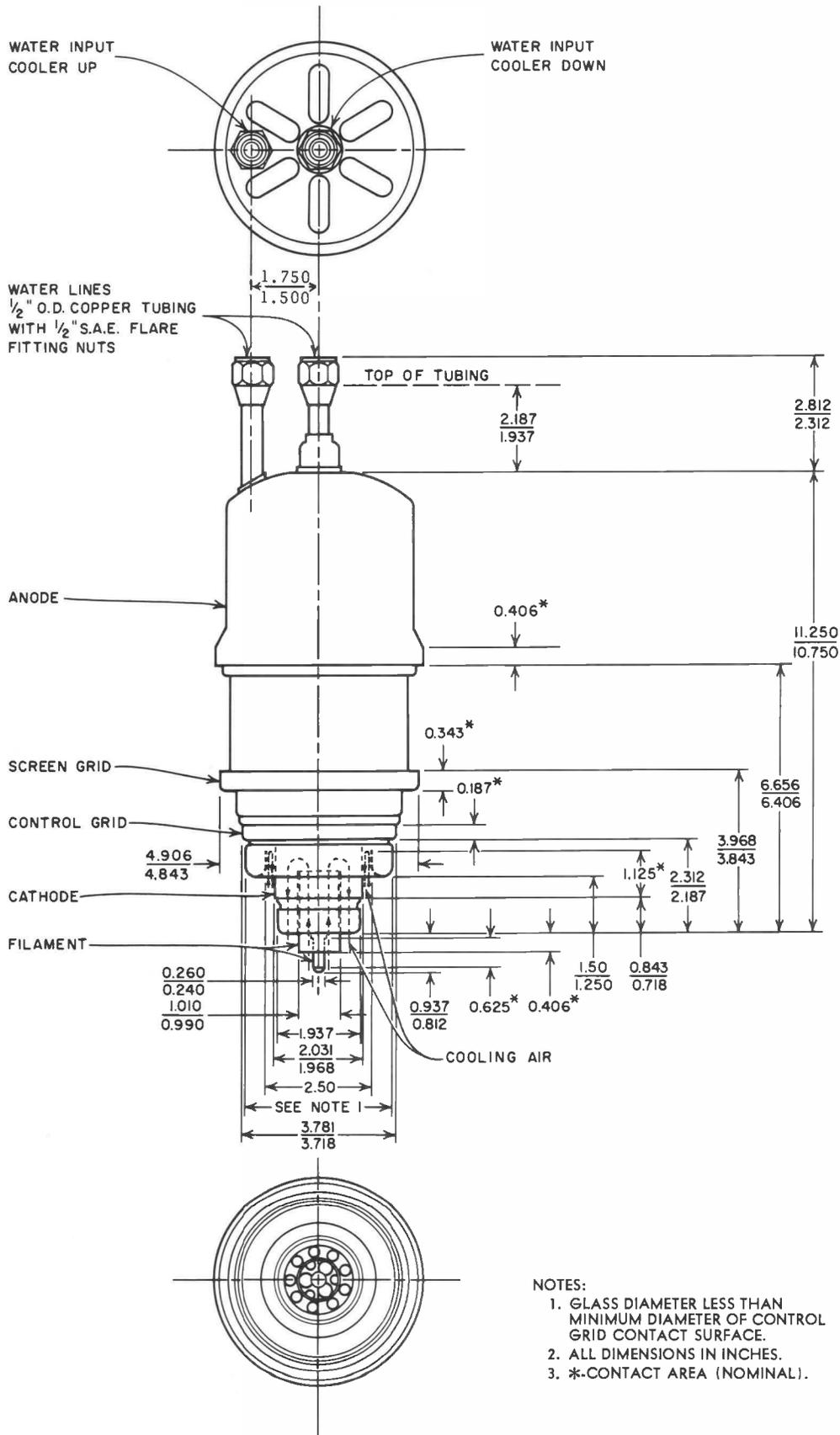




4W20,000A
CATHODE COLLET



¹ 385°C FOR APPROX. 5-6 HRS.
IN NON-REDUCING ATMOSPHERE



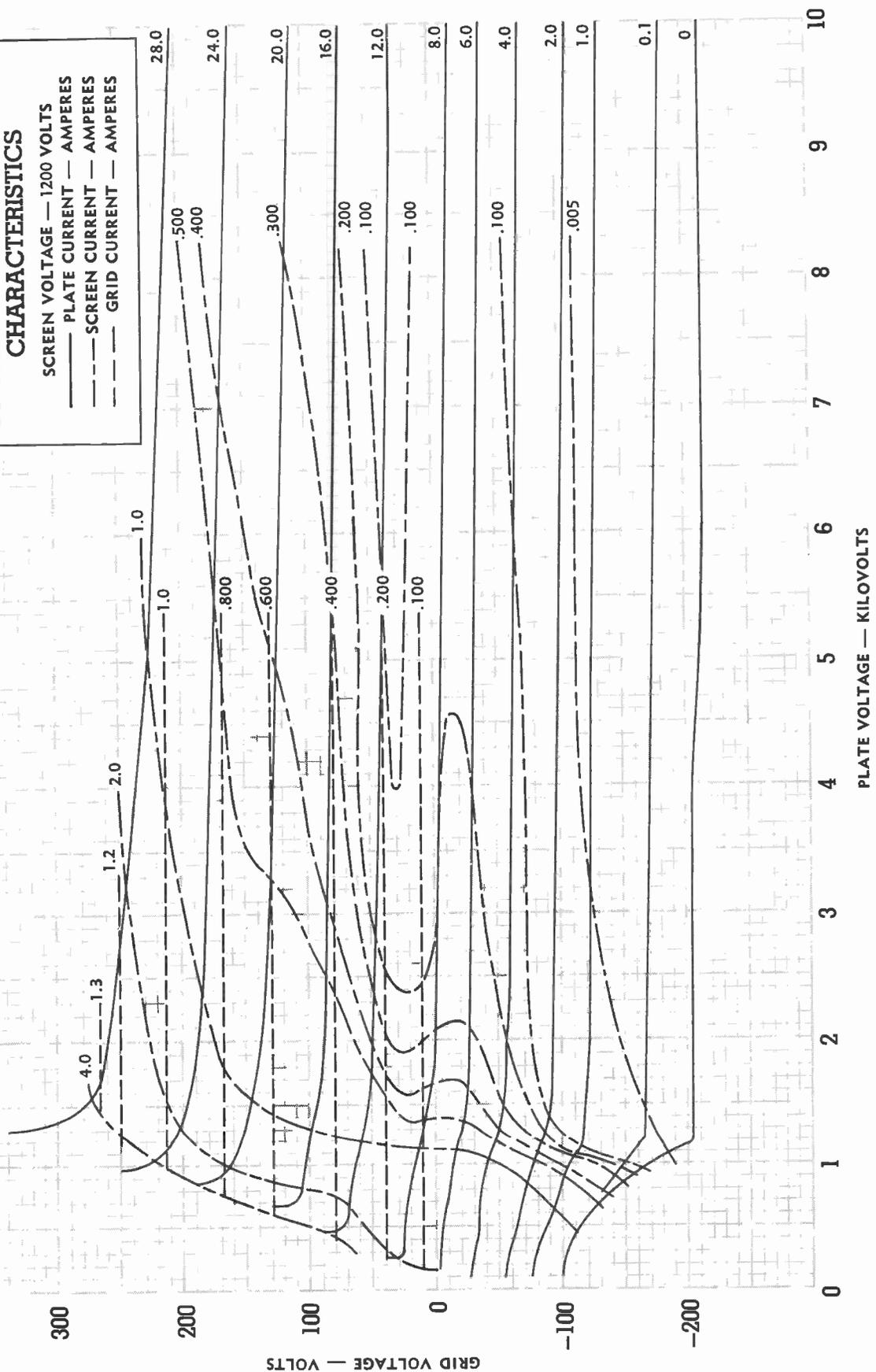
- NOTES:
1. GLASS DIAMETER LESS THAN MINIMUM DIAMETER OF CONTROL GRID CONTACT SURFACE.
 2. ALL DIMENSIONS IN INCHES.
 3. *-CONTACT AREA (NOMINAL).



4W20,000A

EIMAC 4W20,000A TYPICAL CONSTANT CURRENT CHARACTERISTICS

SCREEN VOLTAGE — 1200 VOLTS
— PLATE CURRENT — AMPERES
- - - SCREEN CURRENT — AMPERES
- - - GRID CURRENT — AMPERES



**PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER**

Class-C Telephony (Carrier Conditions)

MAXIMUM RATINGS

D-C PLATE VOLTAGE:	
Up to 150 megacycles	1600 MAX. VOLTS
150 to 500 megacycles	1000 MAX. VOLTS
D-C SCREEN VOLTAGE	300 MAX. VOLTS
D-C GRID VOLTAGE	-250 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	165 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 150 megacycles)

D-C Plate Voltage	500	1000	1600 volts
D-C Screen Voltage	250	250	250 volts
D-C Grid Voltage	-150	-150	-150 volts
D-C Plate Current	200	200	200 ma
D-C Screen Current*	25	20	18 ma
D-C Grid Current*	23	21	21 ma
Peak R-F Grid Input Voltage*	173	172	172 volts
Driving Power	4.0	3.6	3.6 watts
Plate Input Power	100	200	320 watts
Plate Output Power	47	140	250 watts

*Approximate values.

AUDIO-FREQUENCY AMPLIFIER OR MODULATORClass-AB₁**MAXIMUM RATINGS (per tube)**

D-C PLATE VOLTAGE	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C PLATE CURRENT	250 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

D-C Plate Voltage	1000	1500	2000 volts
D-C Screen Voltage	350	350	350 volts
D-C Grid Voltage ¹	-55	-55	-55 volts
Zero-Signal D-C Plate Current	200	200	200 ma
Max-Signal D-C Plate Current	500	500	500 ma
Max-Signal D-C Screen Current	20	16	10 ma
Effective Load, Plate to Plate	3500	6200	9500 ohms
Peak A-F Grid Input Voltage (per tube)*	50	50	50 volts
Driving Power	0	0	0 watts
Max-Signal Plate Output Power	240	430	600 watts

*Approximate values.

¹Adjust grid bias to obtain listed zero-signal plate current.**RADIO-FREQUENCY LINEAR AMPLIFIER**Class-AB₁ (Carrier Conditions)**MAXIMUM RATINGS**

D-C PLATE VOLTAGE:	
Up to 150 megacycles	2000 MAX. VOLTS
150 to 500 megacycles	1250 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C PLATE CURRENT	250 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 150 Mc)

D-C Plate Voltage	1000	1500	2000 volts
D-C Screen Voltage	350	350	350 volts
D-C Grid Voltage ¹	-55	-55	-55 volts
Zero-Signal D-C Plate Current	100	100	100 ma
D-C Plate Current	150	150	150 ma
D-C Screen Current*	-3	-4	-4 ma
Peak R-F Grid Voltage*	25	25	25 volts
Plate Output Power	30	50	65 watts

*Approximate values.

¹Adjust grid bias to obtain listed zero-signal plate current.**RADIO-FREQUENCY LINEAR AMPLIFIER, SSB**Class-AB₁ (Single-Tone Conditions)**MAXIMUM RATINGS**

D-C PLATE VOLTAGE:	
Up to 150 megacycles	2000 MAX. VOLTS
150 to 500 megacycles	1250 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C PLATE CURRENT	250 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 150 megacycles)

D-C Plate Voltage	1000	1500	2000 volts
D-C Screen Voltage	350	350	350 volts
D-C Grid Voltage ¹	-55	-55	-55 volts
Peak R-F Grid Voltage*	50	50	50 volts
Zero-Signal D-C Plate Current	100	100	100 ma
Single-Tone D-C Plate Current	250	250	250 ma
Two-Tone D-C Plate Current	190	190	190 ma
Single-Tone D-C Screen Current*	10	8	5 ma
Two-Tone D-C Screen Current*	2	—1	—2 ma
R-F Load Impedance	1750	3100	4750 ohms
Single-Tone Plate Input Power	250	375	500 watts
Single-Tone Plate Output Power	120	215	300 watts

*Approximate values.

¹Adjust to obtain listed zero-signal plate current.

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves and confirmed by direct tests. No allowance for circuit losses, either input or output, has been made.

In class-C operation, adjustment of the r-f grid drive to obtain listed plate current at the listed grid bias, screen voltage, and plate voltage is assumed. Resultant screen and grid currents will vary from tube to tube, but little change in output power will be noted.

In class-AB₁ linear operation, screen current will also vary from tube to tube but is a useful indicator of relative linearity. In general, less screen current means better linearity, providing other conditions are held constant. The same degree of linearity will be obtained from different tubes if loading and drive are adjusted to give the same plate and screen currents, although output power may vary from tube to tube.



APPLICATION MECHANICAL

Mounting—The 4X150R and 4X150S may be operated in any position. An Eimac Air-System Socket, SK-600 series, or a socket having equivalent characteristics, is required. Sockets are available with or without built-in screen capacitors and may be obtained with either grounded or ungrounded cathode terminals.

Cooling—Sufficient forced-air cooling must be provided for the anode, base seals, and body seals to maintain operating temperatures below the rated maximum values. Air requirements to maintain anode core temperatures at 200°C with an inlet air temperature of 50°C are tabulated below. These requirements apply when a socket of the Eimac SK-600 series and an Eimac SK-606 chimney are used with air flow in the base to anode direction.

Plate Dissipation (Watts)	SEA LEVEL		10,000 FEET	
	Air Flow (CFM)	Pressure Drop (Inches of Water)	Air Flow (CFM)	Pressure Drop (Inches of Water)
200	5.0	0.52	7.3	0.76
250	6.4	0.82	9.3	1.20

The blower selected in a given application must be capable of supplying the desired airflow at a back pressure equal to the pressure drop shown above plus any drop encountered in ducts and filters. The blower must be designed to deliver the air at the desired altitude.

At 500 Mc or below, base-cooling air requirements are satisfied automatically when the tube is operated in an Eimac Air-System Socket and the recommended air-flow rates are used. Experience has shown that if reliable long-life operation is to be obtained, the cool-

ing air-flow must be maintained during standby periods when only the heater voltage is applied to the tube. The anode cooler should be inspected periodically and cleaned when necessary to remove any dirt which might interfere with effective cooling.

Shock and Vibration—The 4X150R and 4X150S are two Eimac tube types unique in that shock and vibration testing are performed with *maximum rated plate and screen voltages* applied. Two samples of production tubes are randomly selected periodically and tested under the conditions outlined below.

With *maximum rated plate and screen voltages* applied, each of the tubes in this sample is subjected to six shocks of 90 G (minimum) half-sine-wave motion, with a duration of 11±2 milliseconds, in each of the three major axes (X1, X2, and Y1).

With *maximum rated plate and screen voltages* applied and with control-grid voltage adjusted to allow the flow of 100 ma through a plate load resistor of 4900 ohms, each of the tubes in this sample is vibrated in the three major axes throughout the range of 5-750-5 cps in a minimum time of six minutes per axis. The vibration level is maintained at 10 G from 28 cps to 750 cps and at 0.25 inch D.A. from 5 cps to 28 cps. During this test noise voltage developed across the plate load resistor cannot exceed 30 volts rms. Sufficient plate power-supply voltage (2500 volts) is employed to assure that a minimum of 2000 volts appears at the plate of the tube under test even though 490 volts drop across the plate load resistor results from d-c plate-current flow.

The equipment designer is cautioned to provide adequate tube support to prevent relative motion between tube and socket in equipments where shock and/or vibration are anticipated.

ELECTRICAL

Heater—The rated heater voltage for the 4X150R and 4X150S is 6.0 volts and 26.5 volts respectively, and the voltage should be maintained as closely as practicable. Short-time changes of +10% will not damage the tube, but variations in performance must be expected. The heater voltage must be maintained with ±5% to minimize these variations and to obtain maximum tube life.

At frequencies above approximately 300 megacycles, transit-time effects begin to influence the cathode temperature. The amount of driving power diverted to heating the cathode by back-bombardment will depend upon frequency, plate current, and driving power. When the tube is driven to maximum input as a "straight-through" class-C amplifier, the heater voltage should be reduced according to the table below:

Frequency, Mc	4X150R	4X150S
300 and lower	6.00 volts	26.5 volts
301 to 400	5.75 volts	25.5 volts
401 to 500	5.50 volts	24.3 volts

Cathode—The cathode of each type is connected to the four even-numbered base pins to provide a low-inductance path, or permit separation of input and

output circuits if required.

Rated heater voltage should be applied before other operating voltages are applied.

Heater-to-cathode maximum voltage is ±150 volts.

Control-Grid—Maximum rated d-c bias voltage is -250 volts. D-C resistance, grid-to-cathode, should be no more than 100,000 ohms.

Screen-Grid—Maximum screen dissipation for each type is 12 watts, normally computed by multiplying d-c screen voltage by the average screen current. This computation is essentially correct except in the case of heavy plate loading when secondary-emission current may mask the normal screen current.

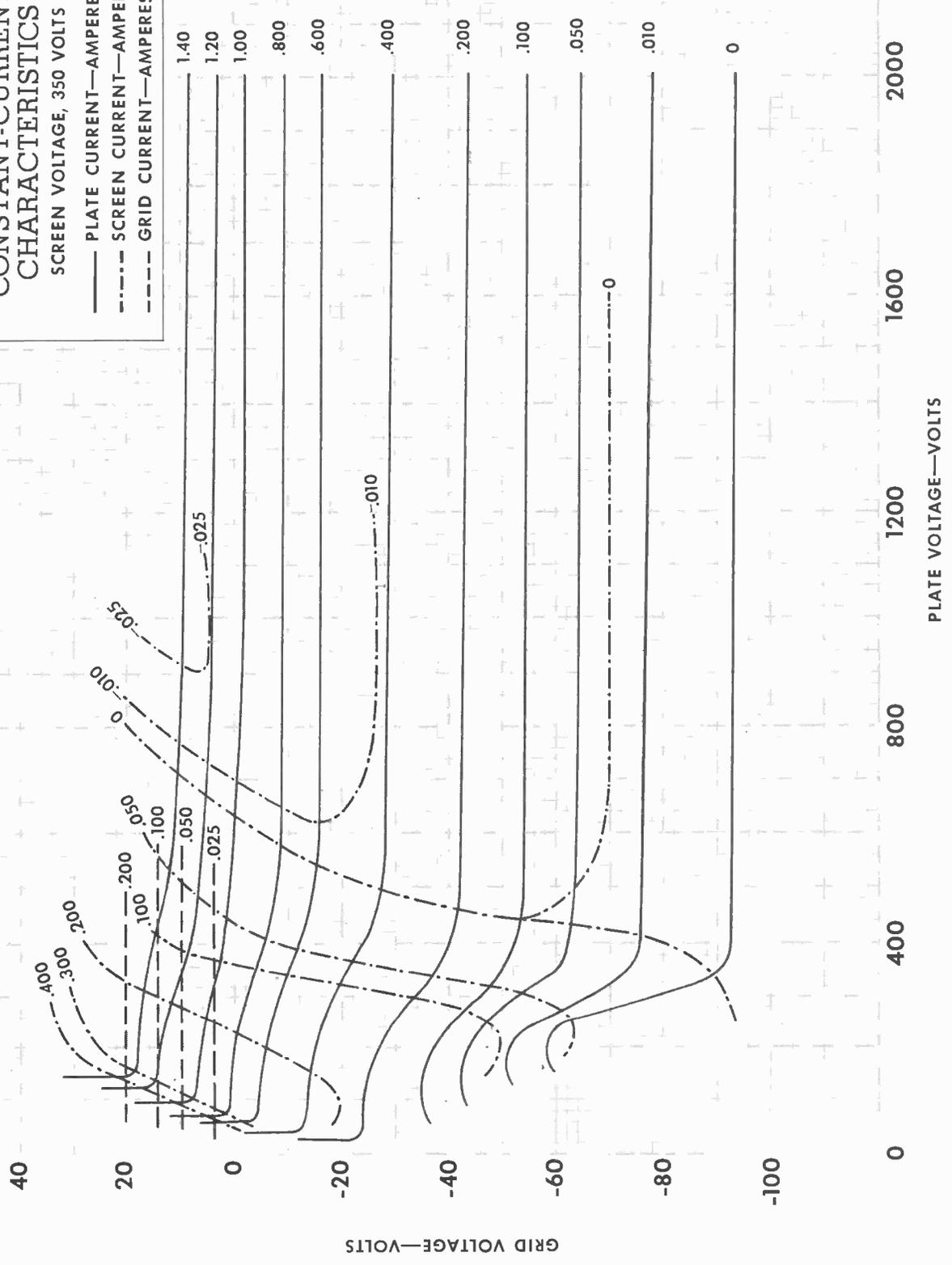
All tetrodes, under some conditions of loading and drive, will exhibit secondary emission from the screen which changes the net current to the screen and may even cause the screen current meter to reverse. Normally, secondary emission is harmless provided the screen voltage is stable. To insure stable screen voltage, it is recommended that a bleeder resistor calculated to pass 15 ma from screen to ground be used.

Plate Dissipation—The maximum plate dissipation for either type is 250 watts. The usual single-sideband voice signal is complex and full peak envelope power



EIMAC 4X150R & 4X150S
TYPICAL
CONSTANT-CURRENT
CHARACTERISTICS
SCREEN VOLTAGE, 350 VOLTS

- PLATE CURRENT—AMPERES
- - - - SCREEN CURRENT—AMPERES
- - - - GRID CURRENT—AMPERES

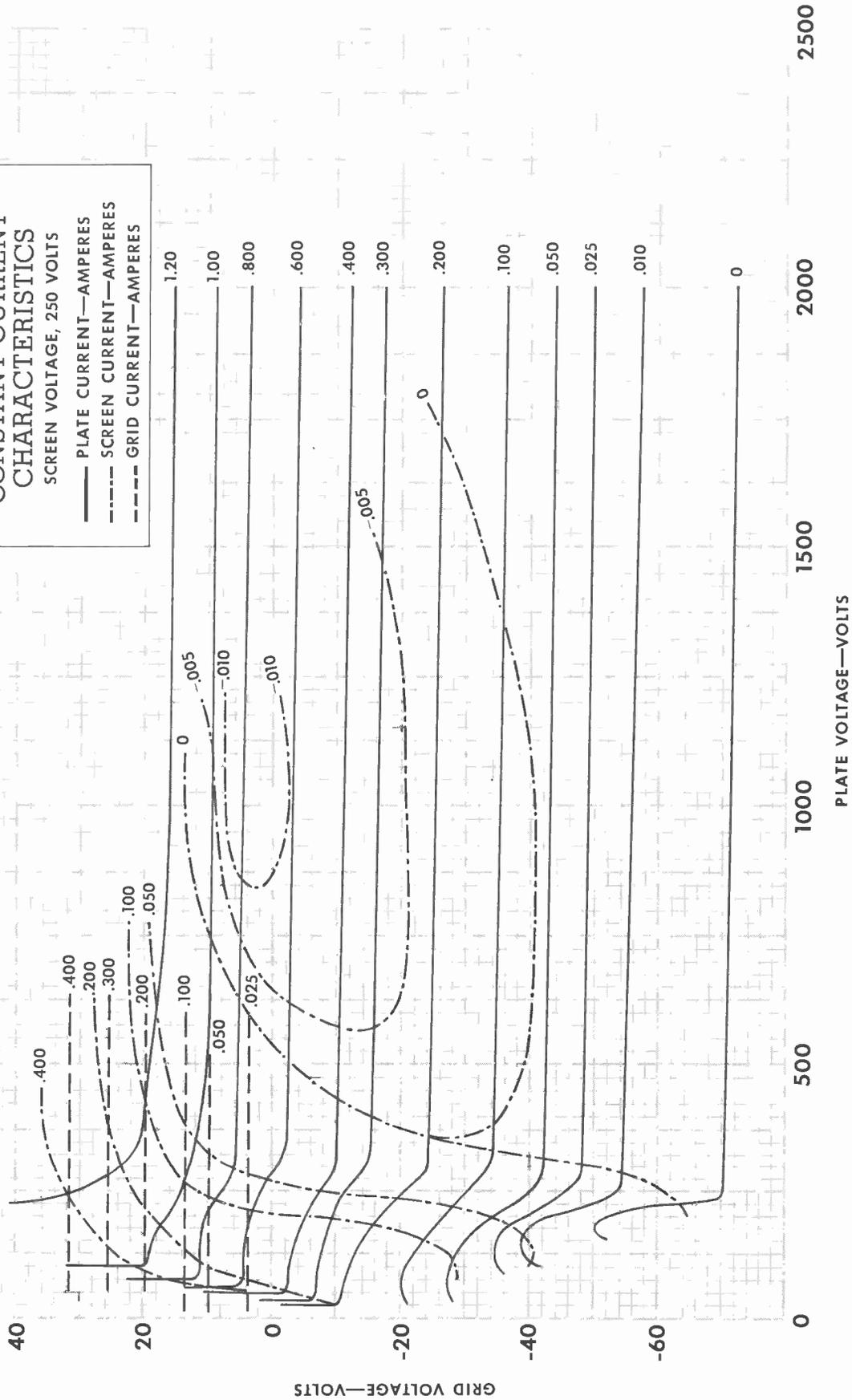




EIMAC 4X150R & 4X150S
TYPICAL
CONSTANT-CURRENT
CHARACTERISTICS

SCREEN VOLTAGE, 250 VOLTS

- PLATE CURRENT—AMPERES
- - - - SCREEN CURRENT—AMPERES
- - - - GRID CURRENT—AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS · CALIFORNIA

4X250B

**RADIAL-BEAM
POWER TETRODE**

The 4X250B is a compact, forced-air cooled, external-anode radial-beam tetrode with a maximum plate dissipation rating of 250 watts. The 4X250B is capable of producing 390 watts of output power at frequencies up to 175 megacycles, and at the maximum rated frequency of 500 megacycles a minimum of 225 watts may be obtained.

The 4X250B has low driving-power requirements and is capable of producing up to 70 watts of output power with a plate supply of 500 volts, making it an excellent choice for mobile applications.



GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Cathode: Oxide-Coated, Unipotential				
Heating Time	30	60		seconds
Cathode-to-heater Potential			±150	volts
Heater: Voltage 4X250B		6.0		volts
Current 4X250B	2.3		2.9	amperes
Amplification Factor (Grid-to-Screen)	4.4		6.0	
Transconductance ($I_b = 200$ ma)		12,000		umhos
Direct Interelectrode Capacitances, Grounded Cathode:				
Input	14.2		17.2	uuf
Output	4.0		5.0	uuf
Feedback			0.06	uuf
Direct Interelectrode Capacitances, Grounded Grid and Screen:				
Input			13.0	uuf
Output		4.0		5.0
Feedback			0.01	uuf
Frequency for Maximum Ratings				500 mc

MECHANICAL

Base					Special 9-pin
Maximum Operating Temperatures:					
Glass-to-Metal Seals					175° C
Ceramic-to-Metal Seals					250° C
Anode Core					250° C
Recommended Socket					Eimac SK-600 Series
Operating Position					Any
Maximum Dimensions:					
Height					2.464 inches
Seated Height					1.910 inches
Diameter					1.640 inches
Cooling					Forced Air
Net Weight					4 ounces
Shipping Weight (Approximate)					1.6 pounds

**RADIO-FREQUENCY POWER AMPLIFIER
OR OSCILLATOR**

Class-C Telephony or FM Telephony
(Key-down conditions)

MAXIMUM RATINGS	
D-C PLATE VOLTAGE	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	300 MAX. VOLTS
D-C GRID VOLTAGE	-250 MAX. VOLTS
D-C PLATE CURRENT	250 MAX. MA
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION

	Frequencies up to 175Mc				500Mc
	500	1000	1500	2000	2000
D-C Plate Voltage	-	-	-	-	2000 volts
D-C Screen Voltage	-	-	-	-	300 volts
D-C Grid Voltage	-90	-90	-90	-90	-90 volts
D-C Plate Current	-	-	-	-	250 ma
D-C Screen Current*	-	-	-	-	10** ma
D-C Grid Current*	-	-	-	-	25** ma
Peak R-F Grid Voltage*	-	-	-	-	— volts
Driving Power*	-	-	-	-	— watts
Plate Input Power	-	-	-	-	500 watts
Plate Output Power	-	-	-	-	225** watts
Heater Voltage	-	-	-	-	5.5 volts

*Approximate values.

**Measured values for a typical cavity amplifier circuit.



PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	- - - -	1500 MAX. VOLTS
D-C SCREEN VOLTAGE	- - - -	300 MAX. VOLTS
D-C GRID VOLTAGE	- - - -	-250 MAX. VOLTS
D-C PLATE CURRENT	- - - -	200 MAX. MA
PLATE DISSIPATION	- - - -	165 MAX. WATTS
SCREEN DISSIPATION	- - - -	12 MAX. WATTS
GRID DISSIPATION	- - - -	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 175 Mc)

D-C Plate Voltage	- - - -	500	1000	1500 volts
D-C Screen Voltage	- - - -	250	250	250 volts
D-C Grid Voltage	- - - -	-100	-100	-100 volts
D-C Plate Current	- - - -	200	200	200 ma
D-C Screen Current*	- - - -	31	22	20 ma
D-C Grid Current*	- - - -	15	14	14 ma
Peak R-F Grid Input Voltage*	- - - -	118	117	117 volts
Driving Power*	- - - -	1.8	1.7	1.7 watts
Plate Input Power	- - - -	100	200	300 watts
Plate Output Power	- - - -	60	145	235 watts

*Approximate values.

AUDIO-FREQUENCY AMPLIFIER OR MODULATOR

Class-AB₁

MAXIMUM RATINGS (Per tube)

D-C PLATE VOLTAGE	- - - -	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	- - - -	400 MAX. VOLTS
D-C PLATE CURRENT	- - - -	250 MAX. MA
PLATE DISSIPATION	- - - -	250 MAX. WATTS
SCREEN DISSIPATION	- - - -	12 MAX. WATTS
GRID DISSIPATION	- - - -	2 MAX. WATTS

TYPICAL OPERATION (Sinusoidal wave, two tubes unless noted)

D-C Plate Voltage	- - - -	1000	1500	2000 volts
D-C Screen Voltage	- - - -	350	350	350 volts
D-C Grid Voltage ¹	- - - -	-55	-55	-55 volts
Zero-Signal D-C Plate Current	- - - -	200	200	200 ma
Max-Signal D-C Plate Current	- - - -	500	500	500 ma
Max-Signal D-C Screen Current	- - - -	20	16	10 ma
Effective Load, Plate to Plate	- - - -	3500	6200	9500 ohms
Peak A-F Grid Input Voltage (per tube)*	- - - -	50	50	50 volts
Driving Power	- - - -	0	0	0 watts
Max-Signal Plate Output Power	- - - -	240	430	600 watts

*Approximate values.

¹Adjust grid bias to obtain listed zero-signal plate current.

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB₁ (Carrier conditions)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	- - - -	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	- - - -	400 MAX. VOLTS
D-C PLATE CURRENT	- - - -	250 MAX. MA
PLATE DISSIPATION	- - - -	250 MAX. WATTS
SCREEN DISSIPATION	- - - -	12 MAX. WATTS
GRID DISSIPATION	- - - -	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 175 Mc)

D-C Plate Voltage	- - - -	1000	1500	2000 volts
D-C Screen Voltage	- - - -	350	350	350 volts
D-C Grid Voltage ¹	- - - -	-55	-55	-55 volts
Zero-Signal D-C Plate Current	- - - -	100	100	100 ma
D-C Plate Current	- - - -	150	150	150 ma
D-C Screen Current*	- - - -	-3	-4	-4 ma
Peak R-F Grid Voltage*	- - - -	25	25	25 volts
Plate Output Power	- - - -	30	50	65 watts

*Approximate values.

¹Adjust grid bias to obtain listed zero-signal plate current.

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB₁ (Single-Sideband Suppressed-Carrier Operation)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	- - - -	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	- - - -	400 MAX. VOLTS
D-C PLATE CURRENT	- - - -	250 MAX. MA
PLATE DISSIPATION	- - - -	250 MAX. WATTS
SCREEN DISSIPATION	- - - -	12 MAX. WATTS
GRID DISSIPATION	- - - -	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 175 Mc, peak-envelope conditions except where noted)

D-C Plate Voltage	- - - -	1000	1500	2000 volts
D-C Screen Voltage	- - - -	350	350	350 volts
D-C Grid Voltage ¹	- - - -	-55	-55	-55 volts
Zero-Signal D-C Plate Current	- - - -	100	100	100 ma
Peak R-F Grid Voltage*	- - - -	50	50	50 volts
D-C Plate Current	- - - -	250	250	250 ma
D-C Screen Current*	- - - -	10	8	5 ma
Plate Input Power	- - - -	250	375	500 watts
Plate Output Power	- - - -	120	215	300 watts
Two-Tone Average D-C Plate Current	- - - -	190	190	190 ma
Two-Tone Average D-C Screen Current*	- - - -	2	-1	-2 ma

*Approximate values.

¹Adjust grid bias to obtain listed zero-signal plate current.

NOTE: "TYPICAL OPERATION" data are obtained by calculation from published characteristic curves and confirmed by direct tests. Adjustment of the r-f grid drive to obtain the specified plate current at the specified grid bias, screen voltage, and plate voltage is assumed. If this procedure is followed, there will be little variation in output power when tubes are changed, even though there may be some variations in grid and screen currents. The grid and screen currents which result when the desired plate current is obtained are incidental and vary from tube to tube. These current variations cause no difficulty so long as the circuit maintains the correct voltage in the presence of the variations in current. If grid bias is obtained principally by means of a grid resistor, the resistor must be adjustable to obtain the required bias voltage when the correct r-f driving voltage is applied.

APPLICATION

MECHANICAL

Mounting—The 4X250B may be operated in any position. An Eimac Air-System Socket, SK-600 series, or a socket having equivalent characteristics, is required. Sockets are available with or without built-in screen by-pass capacitors and may be obtained with either grounded or ungrounded cathode terminals.

The tube will fit in a standard Loktal socket, but use of the Loktal socket is *not* recommended. The use of a Loktal socket in the usual way does not provide for cooling the base of the tube.

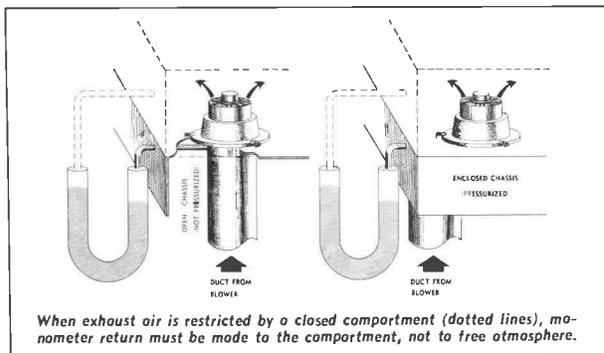
► **Cooling**—Sufficient cooling must be provided for the anode, base seals and body seals to maintain operating temperatures below the rated maximum values:

Ceramic-to-Metal Seals	250°C
Glass-to-Metal Seals	175°C
Anode Core	250°C

Air requirements to maintain seal temperatures at 175°C in 50°C ambient air are tabulated below. These requirements apply when the Eimac SK-600 or SK-610 socket is used with air flow in the *base to anode* direction.

Plate Dissipation (Watts)	SEA LEVEL		10,000 FEET	
	Air Flow (CFM)	Pressure Drop (Inches of Water)	Air Flow (CFM)	Pressure Drop (Inches of Water)
200	3.8	0.28	5.5	0.40
250	5.6	0.53	8.1	0.77

The blower selected in a given application must be capable of supplying the desired airflow at a back pressure equal to the pressure drop shown above plus any drop encountered in ducts and filters. The blower must be designed to deliver the air at the desired altitude.



METHODS OF MEASURING PRESSURE DIFFERENTIAL

At 500 Mc. or below, base-cooling air requirements are satisfied automatically when the tube is operated in an Eimac Air-System Socket and the recommended air-flow rates are used. Experience has shown that if reliable long-life operation is to be obtained, the cooling air flow must be maintained during standby periods when only the heater voltage is applied to the tube. The anode cooler should be inspected periodically and cleaned when necessary to remove any dirt, which might interfere with effective cooling.

If cooling methods other than forced air are used, if the recommended air-flow rates are not supplied or if

there is any doubt that the cooling is adequate, it should be borne in mind that operating temperature is the sole criterion of cooling effectiveness. One method of measuring the surface temperatures is by the use of a temperature-sensitive lacquer. When temperature-sensitive materials are used, extremely thin applications must be used to avoid interference with the transfer of heat from the tube to the air stream, which would cause inaccurate indications.

Vibration—These tubes are capable of satisfactorily withstanding ordinary shock and vibration, such as encountered in shipment and normal handling. The tubes will function well in automobile and truck mobile installations and similar environments. However, when shock and vibration are expected to exceed approximately 5g units, it is suggested that the Eimac 4CX300A be employed.

ELECTRICAL

Heater—The rated heater voltage for the 4X250B is 6.0 volts and this voltage should be maintained as closely as practicable. Short-time variations of the voltage of $\pm 10\%$ of the rated value will not damage the tube, but variations in performance must be expected. The heater voltage should be maintained within $\pm 5\%$ of its rated value to minimize variations in performance and to obtain maximum tube life.

At frequencies above approximately 300 megacycles transit-time effects begin to influence the cathode temperature. The amount of driving power diverted to heating the cathode by back-bombardment will depend upon the frequency, the plate current, and driving power being supplied to the tube. When the tube is driven to maximum input as a "straight-through" class-C amplifier, the heater voltage should be reduced according to the table below:

Frequency, Mc.	4X250B
300 and lower	6.0 volts
301 to 400	5.75 volts
401 to 500	5.50 volts

In no case should the heater of the 4X250B be operated at less than 5.4 volts.

Cathode Operation—The oxide-coated unipotential cathode must be protected against excessively high emission currents. The maximum rated d-c input current is 200 milliamperes for plate-modulated operation, and 250 milliamperes for all other types of operation except pulsed.

Higher cathode currents are permitted in pulsed operation and the maximum permissible pulse currents will depend entirely on the pulse lengths and the pulse repetition rates. The maximum rated pulse plate current of 6.0 amperes may be used only when the pulses do not exceed five microseconds in duration, and when the repetition rate does not exceed 1000 pulses per second. The curve of Fig. 2 shows the maximum permissible pulse currents and pulse durations for repetition rates of 1000 pps or less. For higher repetition rates the indicated pulse durations must be shortened by the factor $1000/n$, where n is the number of pulses per second.



The cathode is internally connected to the four even-numbered base pins, and all four of the corresponding socket terminals should be used to make connection to the external circuits. At radio frequencies it is important to keep the cathode leads short and direct and to use conductors with large areas to minimize the inductive reactances in series with the cathode leads.

It is recommended that rated heater voltage be applied for a minimum of 30 seconds before other operating voltages are applied. Where the circuit design requires the cathode and heater to be operated at different potentials, the rated maximum heater-to-cathode voltage is 150 volts regardless of polarity.

Control-Grid Operation—The maximum rated d-c grid bias voltage is -250 volts and the maximum grid dissipation rating is 2.0 watts. In ordinary audio and radio-frequency amplifiers the grid dissipation usually will not approach the maximum rated power. At operating frequencies above the 100-megacycle region, driving-power requirements for amplifiers increase noticeably until at 500 megacycles as much as 30 watts of driving power may have to be supplied. However, most of the driving power is absorbed in circuit losses other than the grid dissipation, so that the grid dissipation is only slightly increased. Satisfactory 500-megacycle operation of the tubes in a stable, "straight-through" amplifier is indicated by grid-current values below approximately 25 milliamperes.

The grid voltage required by different tubes may vary between limits approximately 20% above and below the center value, and means should be provided in the equipment to accommodate such variation. It is especially important that variations between individual tubes be compensated when tubes are operated in parallel or push-pull circuits, to assure equal load sharing.

Screen-Grid Operation—The maximum rated power dissipation for the screen grid is 12 watts, and the screen input power should be kept below that level. The product of the peak screen voltage and the indicated d-c screen current approximates the screen input power except when the screen current indication is near zero or negative.

In the usual tetrode amplifier, where no signal voltage appears between cathode and screen, the peak screen voltage is equal to the d-c screen voltage.

When signal voltages appear between screen and cathode, as in the case of screen-modulated amplifiers or cathode-driven tetrode amplifiers, the peak screen-to-cathode voltage is the sum of the d-c screen voltage and the peak a-c or r-f signal voltage applied to screen or cathode.

Protection for the screen can be provided by an over-current relay and by interlocking the screen supply so that the plate voltage must be applied before screen voltage can be applied.

The screen current may reverse under certain conditions, and produce negative current indications on the screen milliammeter. This is a normal characteristic of most tetrodes. The screen power supply should be designed with this characteristic in mind, so that the

correct operating voltage will be maintained on the screen under all conditions. A current path from screen to cathode must be provided by a bleeder resistor, gaseous voltage regulator tubes, or an electron tube *shunt* regulator connected between screen and cathode and arranged to pass approximately 15 milliamperes per connected screen. An electron tube *series* regulator can be used only when an adequate bleeder resistor is provided.

Self-modulation of the screen in plate-modulated tetrode amplifiers using this tube may not be satisfactory because of the screen-voltage-screen-current characteristics. Screen modulation from a tertiary winding on the modulation transformer or by means of a separate small modulator tube will usually be more satisfactory. Screen-voltage modulation factors between 0.75 and 1.0 will result in 100% modulation of plate-modulated r-f amplifiers using the 4X250B

Plate Operation—The maximum rated plate-dissipation power is 250 watts. In plate-modulated applications the carrier plate-dissipation power must be limited to 165 watts to avoid exceeding the plate-dissipation rating with 100% sine-wave modulation. The maximum dissipation rating may be exceeded for brief periods during circuit adjustment without damage to the tube.

At frequencies up to approximately 30 megacycles the top cap on the anode cooler may be used for a plate terminal. At higher frequencies, a circular clamp or spring-finger collet encircling the cylindrical outer surface of the anode cooler should be used.

Multiple Operation—Tubes operating in parallel or push-pull must share the load equally. It is good engineering practice to provide for individual metering and individual adjustment of the bias or screen voltage to equalize the inputs.

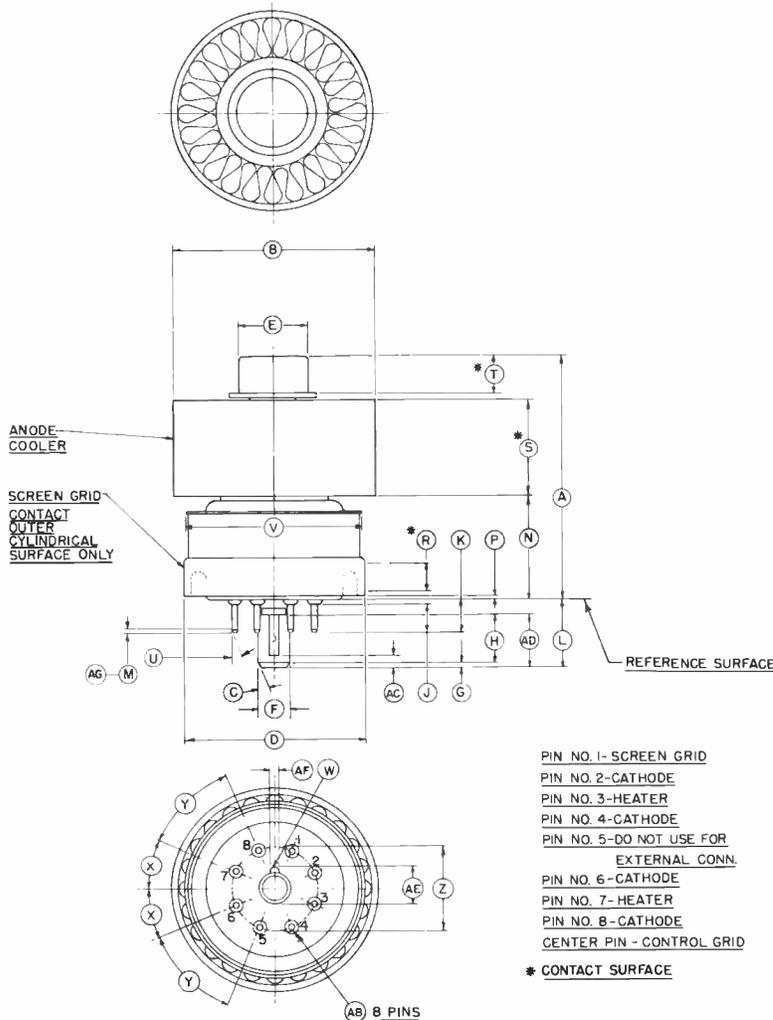
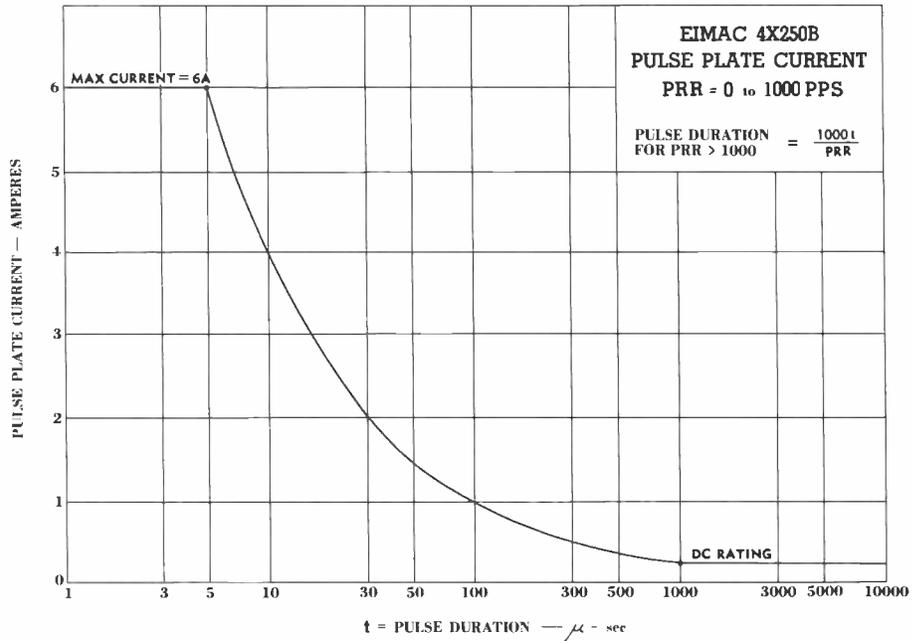
Where overload protection is provided, it should be capable of protecting the surviving tube/s in the event that one tube should fail.

UHF Operation—The 4X250B is useful in the UHF region. UHF operation should be conducted with heavy plate loading, minimum bias and the lowest driving power consistent with satisfactory performance. It is often preferable to operate at a sacrifice in efficiency to obtain increased tube life.

Some of the added circuit loss observed in UHF operation is in the base insulator of the tube. It is sometimes necessary to use more than the recommended minimum air-flow rates to maintain safe operating base temperatures at UHF.

These tubes may be used in frequency multiplier applications. Such operation results in low plate efficiency and requires high driving voltages. If the frequency multiplier is used as an output power stage, it is preferable to operate the final tube as a frequency doubler rather than a frequency tripler.

Special Applications—If it is desired to operate these tubes under conditions widely different from those given here, write to Application Engineering Department, Eitel-McCullough, Inc., San Carlos, California, for information and recommendations.



DIMENSIONS IN INCHES		
REF.	MIN.	MAX.
A	1.810	1.910
B	1.610 DIA.	1.640 DIA.
C	30°	
D	1.417 DIA.	1.433 DIA.
E	.559 DIA.	.573 DIA.
F	.255 DIA.	.265 DIA.
G	.031	
H	.360	
J	.187	
K		.250
L	.514	.554
M	.035	
N	.750	.810
P	.020	
R	.187	
S	.710	.790
T	.240	.280
U	22 1/2°	
V		1.406 DIA.
W		.043 R.
X	22 1/2°	
Y	45°	
Z	.680 DIA.P.C.	.694 DIA.P.C.
AB	.045 DIA.	.053 DIA.
AC	.068	.108
AD		.456
AE	.298	.308
AF	.078	.086
AG	.005R. MIN.(ALTERNATE TO M&U)	



4X250B

**EIMAC 4X250B
TYPICAL**

**G R O U N D E D G R I D
CONSTANT CURRENT
CHARACTERISTICS**

SCREEN TO GRID VOLTAGE — 300 VOLTS
— PLATE CURRENT — AMPERES
- - - - SCREEN CURRENT — AMPERES
- - - - GRID CURRENT — AMPERES

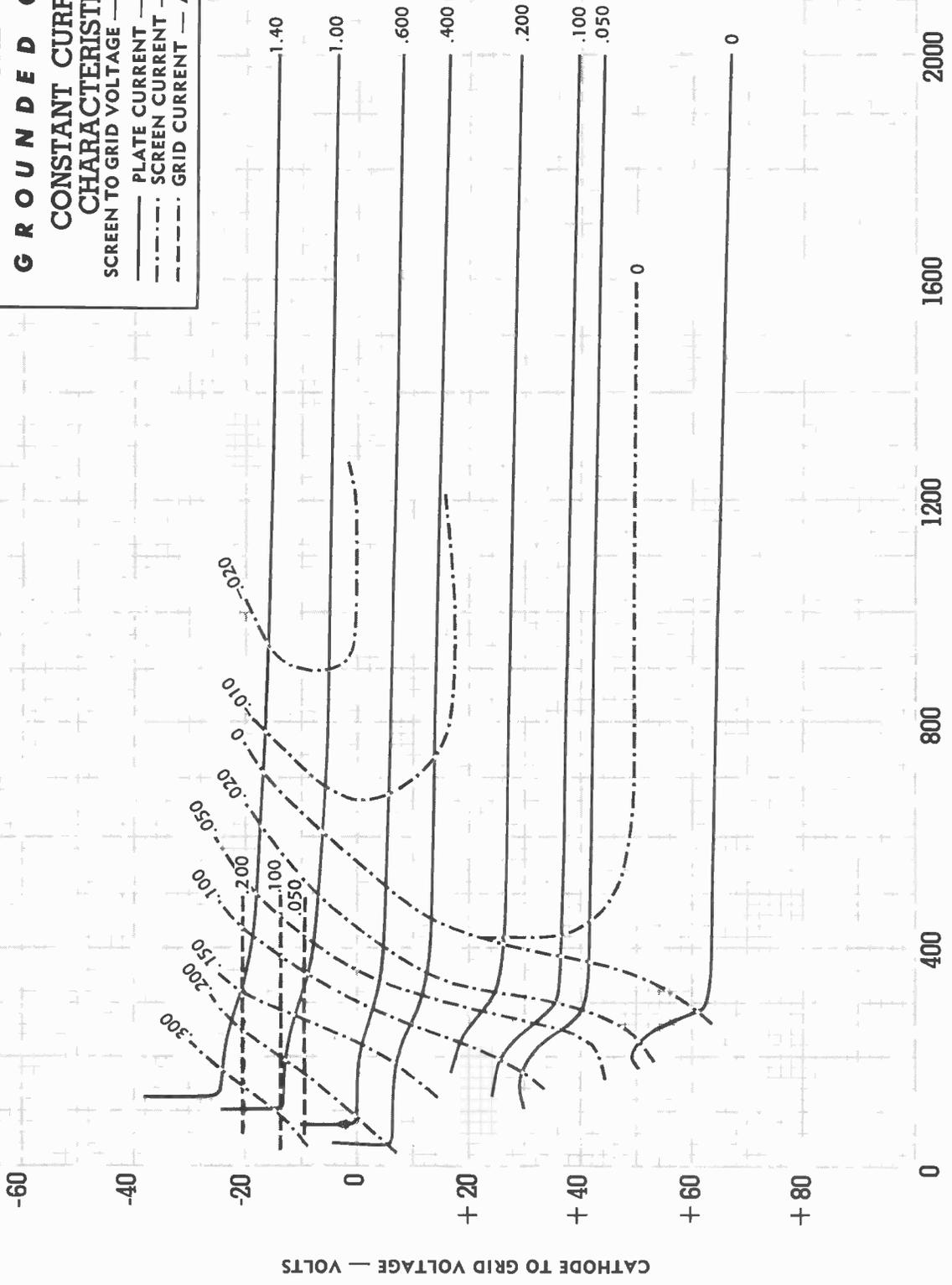


PLATE TO GRID VOLTAGE — VOLTS



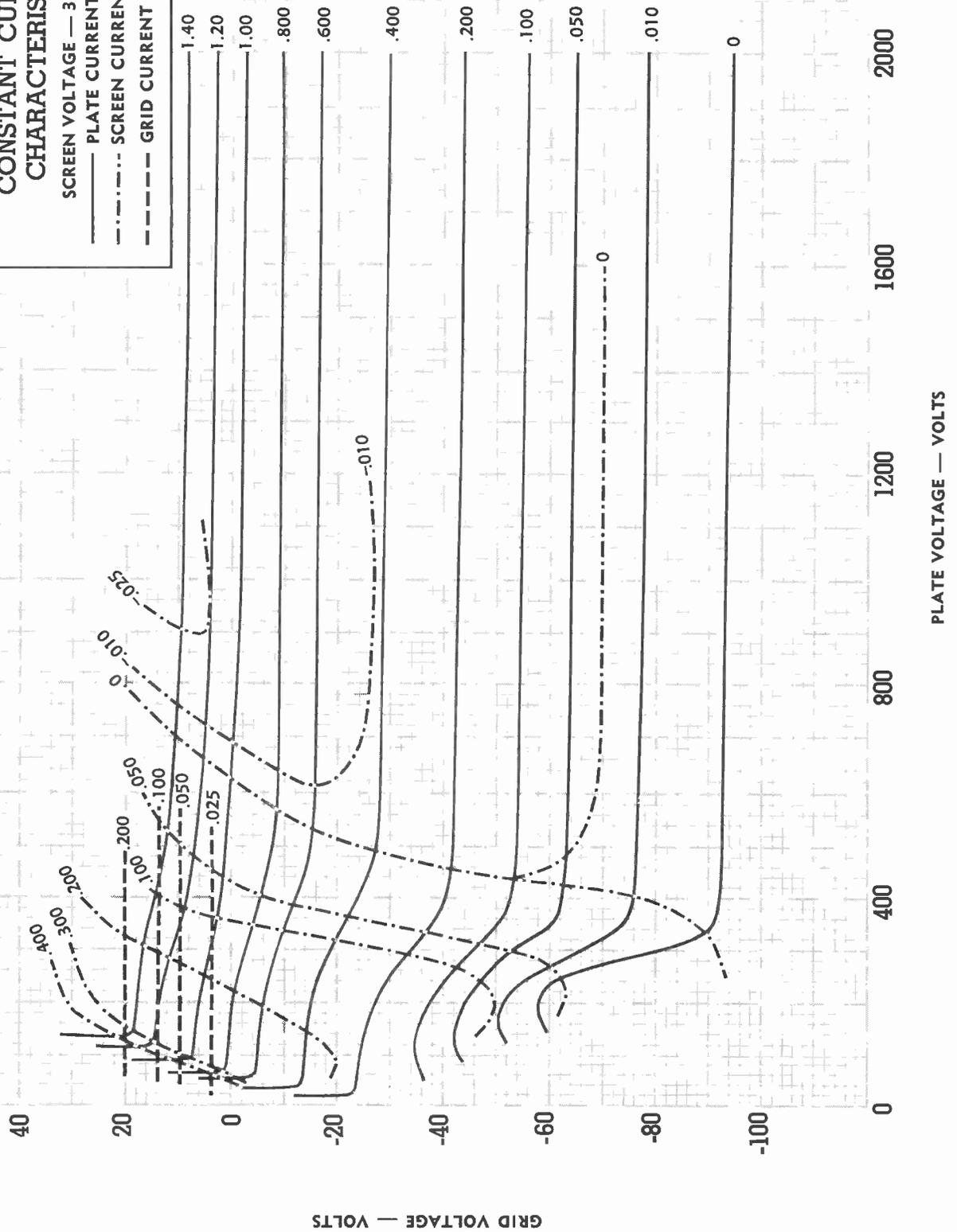
EIMAC 4X250B

TYPICAL

**CONSTANT CURRENT
CHARACTERISTICS**

SCREEN VOLTAGE — 350 VOLTS

- PLATE CURRENT — AMPERES
- · - · - · SCREEN CURRENT — AMPERES
- - - - - GRID CURRENT — AMPERES





4X250B

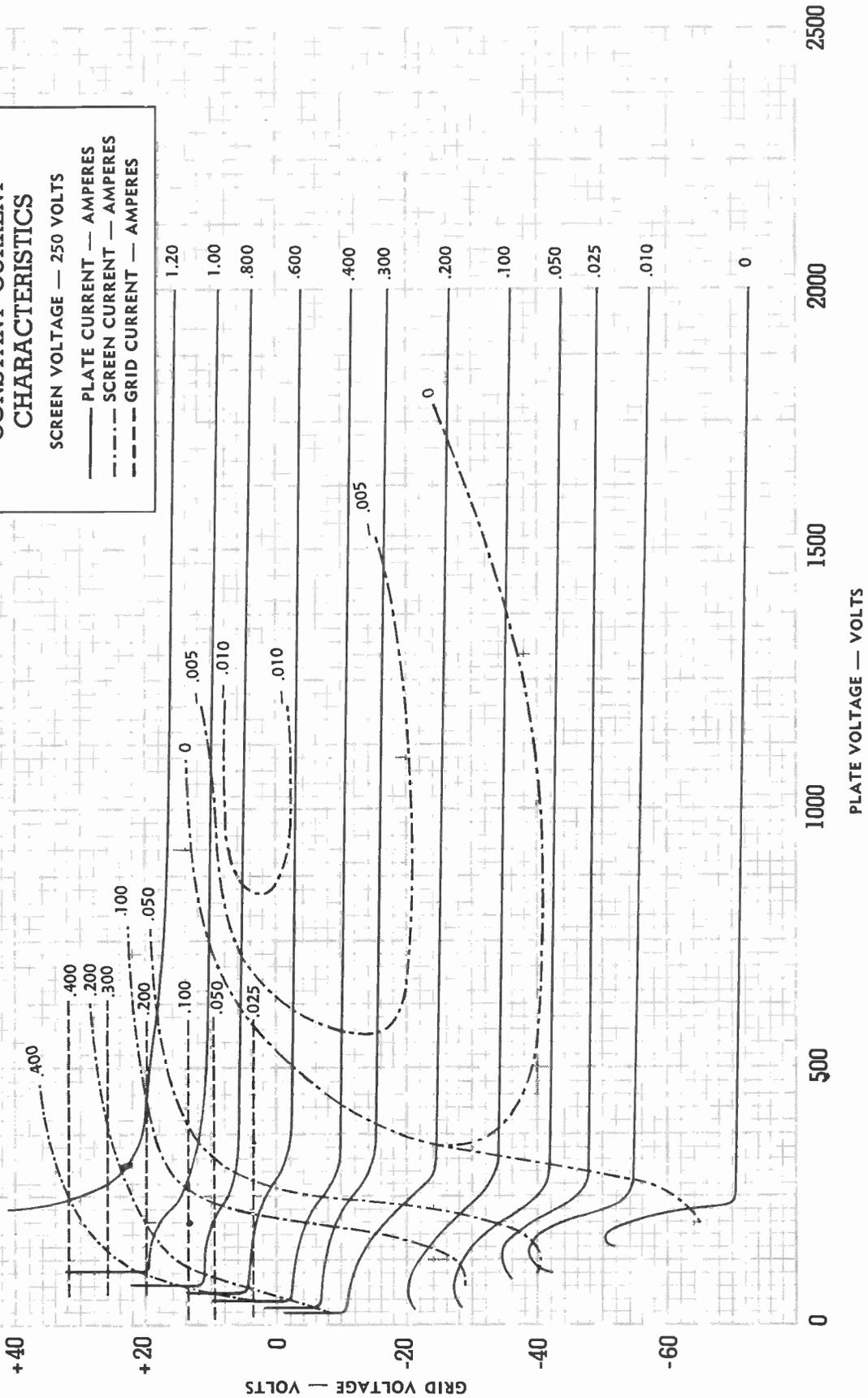
EIMAC 4X250B

TYPICAL

CONSTANT CURRENT CHARACTERISTICS

SCREEN VOLTAGE — 250 VOLTS

- PLATE CURRENT — AMPERES
- - - SCREEN CURRENT — AMPERES
- - - GRID CURRENT — AMPERES



TENTATIVE DATA

EITEL-McCULLOUGH, Inc.
SAN BRUNO, CALIFORNIA

4X5000A

**RADIAL-BEAM
POWER TETRODE**

The Eimac 4X5000A is a compact high power forced-air-cooled tetrode of metal and ceramic construction. The 4X5000A is useful as an oscillator, amplifier or modulator at frequencies up to 30 megacycles at full ratings. Its characteristics make it particularly useful as a linear single-sideband amplifier, class AB₁ audio amplifier or as a screen-modulated radio-frequency amplifier.

A pair of these tubes will deliver 17.5 kilowatts of audio-frequency or radio-frequency power with zero driving power. The plate dissipation is rated at five kilowatts for most applications, and six kilowatts for Class-AB operation.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten		
Voltage	- - - - -	7.5 volts
Current	- - - - -	75 amperes
Grid-Screen Amplification Factor (Average)	- - - - -	5
Direct Interelectrode Capacitances (Average)		
	Grounded Cathode	Grounded Grid
Feedback	0.75 uuf	0.14 uuf
Input	106 uuf	47 uuf
Output	18 uuf	18 uuf
Highest Frequency for Maximum Ratings	- - - - -	30 mc

MECHANICAL

Base	- - - - -	Special, Concentric
Recommended Socket	- - - - -	Eimac SK-300
Mounting	- - - - -	Axis vertical, base down or up
Cooling	- - - - -	Forced Air
Maximum Over-all Dimensions:		
Length	- - - - -	9-1/8 inches
Diameter	- - - - -	4-15/16 inches
Net Weight	- - - - -	9 1/2 pounds
Shipping Weight (Approx.)	- - - - -	22 pounds



Note: Typical operation data are based on conditions of adjusting the r-f drive to a specified plate current, maintaining fixed conditions of grid bias and screen voltage. It will be found that if this procedure is followed, there will be little variation in power output between tubes even though there may be some variation in grid and screen currents. Where grid bias is obtained principally by means of a grid resistor, to control plate current it is necessary to make the resistor adjustable.

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C, Key-down conditions, per tube:

MAXIMUM RATINGS

D-C PLATE VOLTAGE	7500 MAX. VOLTS
D-C SCREEN VOLTAGE	1500 MAX. VOLTS
D-C PLATE CURRENT	3.0 MAX. AMPERES
PLATE DISSIPATION	5000 MAX. WATTS
SCREEN DISSIPATION	250 MAX. WATTS
GRID DISSIPATION	75 MAX. WATTS

TYPICAL OPERATION (Frequencies below 30 mc.)

D-C Plate Voltage	- - - - -	7500 volts
D-C Screen Voltage	- - - - -	500 volts
D-C Grid Voltage	- - - - -	-350 volts
D-C Plate Current	- - - - -	2.8 amperes
D-C Screen Current	- - - - -	0.5 amperes
D-C Grid Current	- - - - -	0.25 amperes
Peak R-F Grid Voltage	- - - - -	590 volts
Driving Power	- - - - -	150 watts
Grid Dissipation	- - - - -	60 watts
Screen Dissipation	- - - - -	250 watts
Plate Dissipation	- - - - -	5000 watts
Plate Power Output	- - - - -	16,000 watts

PLATE-MODULATED RADIO-FREQUENCY POWER AMPLIFIER

Class-C Telephony, Carrier Conditions
unless otherwise specified, one tube:

MAXIMUM RATINGS

D-C PLATE VOLTAGE	5000 MAX. VOLTS
D-C SCREEN VOLTAGE	1000 MAX. VOLTS
D-C PLATE CURRENT	2.5 MAX. AMPERES
PLATE DISSIPATION*	3500 MAX. WATTS
SCREEN DISSIPATION	250 MAX. VOLTS
GRID DISSIPATION	75 MAX. WATTS

TYPICAL OPERATION, Frequencies below 30 mc.:

D-C Plate Voltage	- - - - -	5000 volts
D-C Screen Voltage	- - - - -	500 volts
D-C Grid Voltage	- - - - -	-400 volts
D-C Plate Current	- - - - -	1.4 amperes
D-C Screen Current	- - - - -	0.26 amperes
D-C Grid Current	- - - - -	0.050 amperes
Peak R-F Grid Voltage	- - - - -	520 volts
Grid Driving Power	- - - - -	25 watts
Grid Dissipation	- - - - -	6 watts
Screen Dissipation	- - - - -	130 watts
Plate Dissipation	- - - - -	1100 watts
Peak A-F Screen Voltage for 100% modulation	- - - - -	450 volts
Plate Power Output	- - - - -	5.8 kilowatts

*Corresponds to 5 kw at 100%, sine-wave modulation.

CLASS-AB RADIO-FREQUENCY OR AUDIO POWER AMPLIFIER

MAXIMUM RATINGS per tube:

D-C PLATE VOLTAGE	7500 MAX. VOLTS
D-C SCREEN VOLTAGE	1500 MAX. VOLTS
D-C PLATE CURRENT	4.0 MAX. AMPERES
PLATE DISSIPATION	6000 MAX. WATTS
SCREEN DISSIPATION	250 MAX. WATTS
GRID DISSIPATION	75 MAX. WATTS

TYPICAL OPERATION, Class-AB₁ R-F Linear Amplifier, one tube,

Peak Envelope or Modulation Crest Conditions,
Frequencies below 30 mc.:

D-C Plate Voltage	- - - - -	7500 volts
D-C Screen Voltage	- - - - -	1250 volts
D-C Grid Voltage*	- - - - -	-300 volts
D-C Plate Current	- - - - -	1.9 amperes
Zero-Signal Plate Current	- - - - -	0.50 amperes
D-C Screen Current	- - - - -	0.20 amperes
D-C Grid Current	- - - - -	0 amperes
Driving Power	- - - - -	0 watts
Peak R-F Grid Voltage	- - - - -	300 volts
Screen Dissipation	- - - - -	250 watts
Plate Dissipation	- - - - -	4200 watts
Plate Power Output**	- - - - -	10,000 watts

*Adjust grid voltage to obtain specified Zero-signal plate current.

**Peak envelope Power Output or R-F Power Output at crest of modulation envelope.

TYPICAL OPERATION, Class-AB₁ Audio Amplifier, two tubes unless otherwise specified:

D-C Plate Voltage	- - - - -	4000	5000	6000	7000	volts
D-C Screen Voltage	- - - - -	1250	1250	1250	1250	volts
D-C Grid Voltage	- - - - -	-270	-280	-310	-325	volts
D-C Zero-Signal Plate Current	- - - - -	1.25	1.00	0.83	0.70	amperes
D-C Max-Signal Plate Current	- - - - -	5.10	4.40	4.25	3.65	amperes
D-C Zero-Signal Screen Current	- - - - -	0	0	0	0	amperes
D-C Max-Signal Screen Current	- - - - -	0.35	0.33	0.30	0.24	amperes
Load Resistance, P-to-P	- - - - -	1500	2370	2940	4100	ohms
Peak A-F Driving Voltage	- - - - -	250	240	270	235	volts
Driving Power	- - - - -	0	0	0	0	watts
Max-Signal Plate Dissipation	- - - - -	4200	4200	4200	4200	watts
Max-Signal Power Output	- - - - -	11,500	13,500	17,000	17,500	watts

APPLICATION

MECHANICAL

Mounting—The 4X5000A must be mounted with its axis vertical. The base of the tube may be down or up at the convenience of the circuit designer.

Socket—The Eimac Air-System Socket Type SK-300 is designed especially for the concentric base terminals of the 4X5000A. The use of recommended air-flow rates through this socket provides effective forced-air cooling of the tube. Air forced into the bottom of the socket passes over the tube terminals, after which a duct guides it into the anode cooling fins.

Cooling—The maximum temperature rating for the external surfaces of the 4X5000A is 200°C. Sufficient forced air circulation must be provided to keep the temperature of the anode at the base of the cooling fins and the temperature of the ceramic stem surfaces below 200°C.

When the tube is mounted in the Eimac SK-300 Socket, plate dissipation power of 5,000 watts requires 175 CFM air flow, corresponding to a pressure differential across tube and socket of 1.5 inches water column. Cooling at the 6,000-watt dissipation power level requires 210 CFM air flow, corresponding to a pressure

differential of 2.25 inches water column across the tube and socket.

The flow rates and pressure differentials specified above apply to air at sea level pressure and at 20°C ambient temperature.

If the 4X5000A is operated in a socket of a design different from that of the SK-300, the air-flow rates must be determined independently for each design, using the maximum rated temperature as the criterion for satisfactory cooling.

A convenient method of measuring temperatures is the use of a temperature-sensitive paint, applied sparingly to the tube surfaces. When heavy coats are applied, the air-cooled surface of the paint may not reach the tube temperature because the paint conducts heat poorly and errors can occur. One type of temperature-sensitive paint can be obtained from the Tempil Corporation, 11 West 25th Street, New York, 10, N.Y.

The air inlet to the cooling system should be equipped with an effective air filter, which should be inspected periodically to assure adequate air flow into the system.

ELECTRICAL

Filament Operation—The rated filament voltage for the 4X5000A is 7.5 volts. The actual operating voltage should be maintained within the range from 7.15 to 7.85 volts, as measured at the base of the tube.

Electrode Dissipation Ratings—The maximum dissipation ratings for the 4X5000A must be respected to avoid damage to the tube. An exception is the plate dissipation, which may be permitted to rise above the maximum rating during brief periods, such as may occur during tuning.

Grid Dissipation—The grid dissipation can be determined approximately by use of the expression:

$$P_{g1} = e_{cmp} I_c$$

where: P_{g1} = Grid dissipation, watts;
 e_{cmp} = Peak grid-filament positive voltage, volts;
 I_c = D-C grid current, amperes.

The value of the peak positive grid voltage can be measured by means of a suitable peak-reading vacuum tube voltmeter.

Screen Dissipation—The screen dissipation, in cases where there is no a-c applied to the screen, is the simple product of the screen voltage and the screen current.

In case the screen voltage is modulated, the screen dissipation will depend strongly on the loading, driving power, and carrier screen voltage.

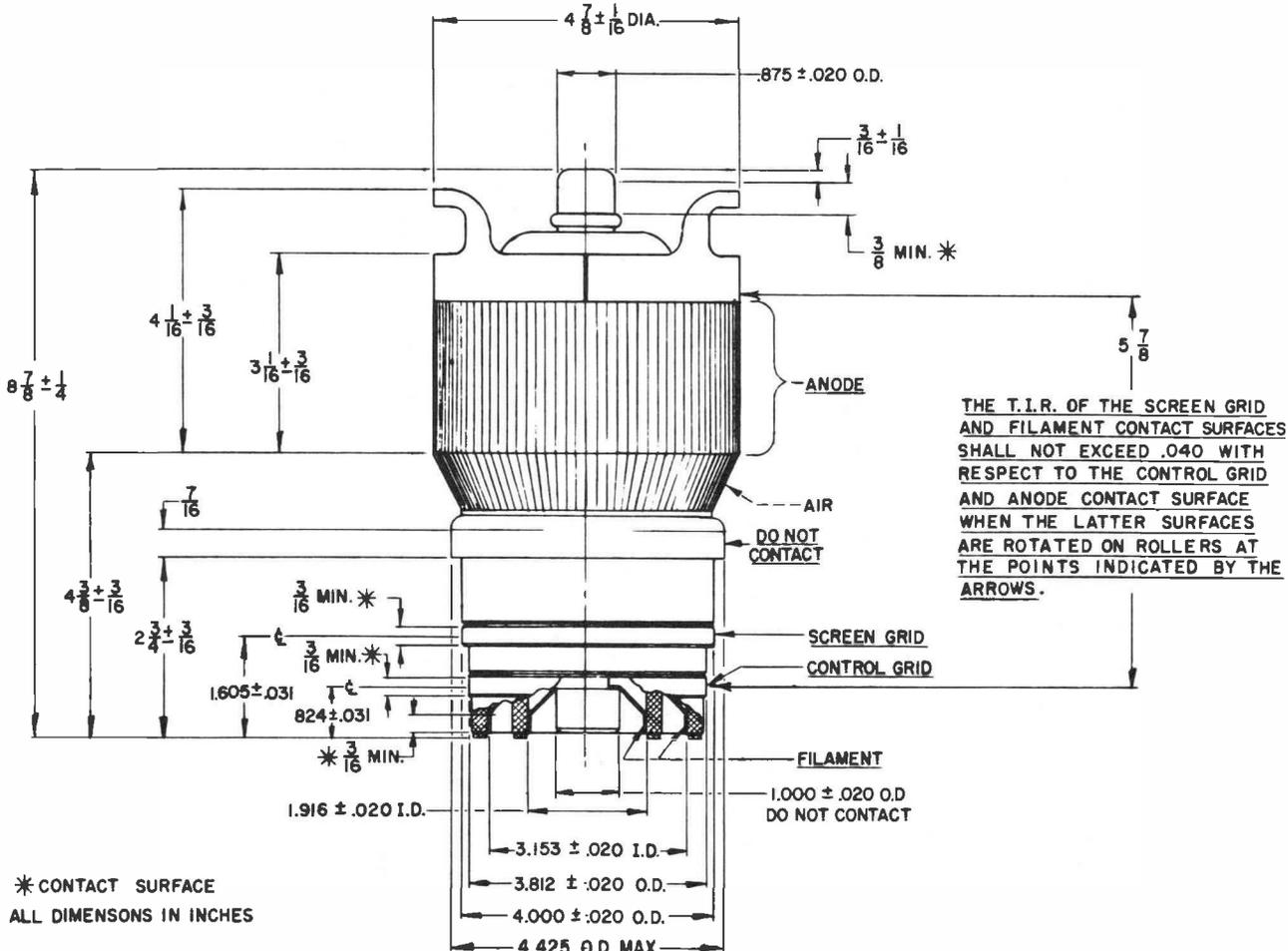
Plate Dissipation—The plate dissipation rating for the 4X5000A is 5000 watts for most applications, but for audio and SSB amplifier applications, the maximum dissipation rating is 6000 watts.

In class-AB and class-B amplifiers, the maximum plate dissipation does not coincide with maximum power output, but occurs at some lower power level determined jointly by the bias voltage and the driving voltage applied to the tube. Accordingly, it is advisable to limit the plate dissipation under full power conditions to approximately 70% of the maximum rated plate dissipation of the tubes used.

Screen modulated operation produces maximum plate dissipation under carrier conditions. The dissipation diminishes as the modulation increases.

When the 4X5000A is operated as a plate-modulated r-f power amplifier, the power input is limited by conditions not connected with the plate efficiency, which is quite high. Therefore, except during tuning there is little possibility that the 3500-watt maximum plate dissipation rating will be exceeded.

Special Applications—If it is desired to operate this tube under conditions widely different from those given here, write to Eitel-McCullough, Inc., San Bruno, California, for information and recommendations.



EIMAC 4X5000A

TYPICAL

CONSTANT CURRENT CHARACTERISTICS

SCREEN VOLTAGE - 500 VOLTS

- PLATE CURRENT - AMPERES
- SCREEN CURRENT - AMPERES
- GRID CURRENT - AMPERES

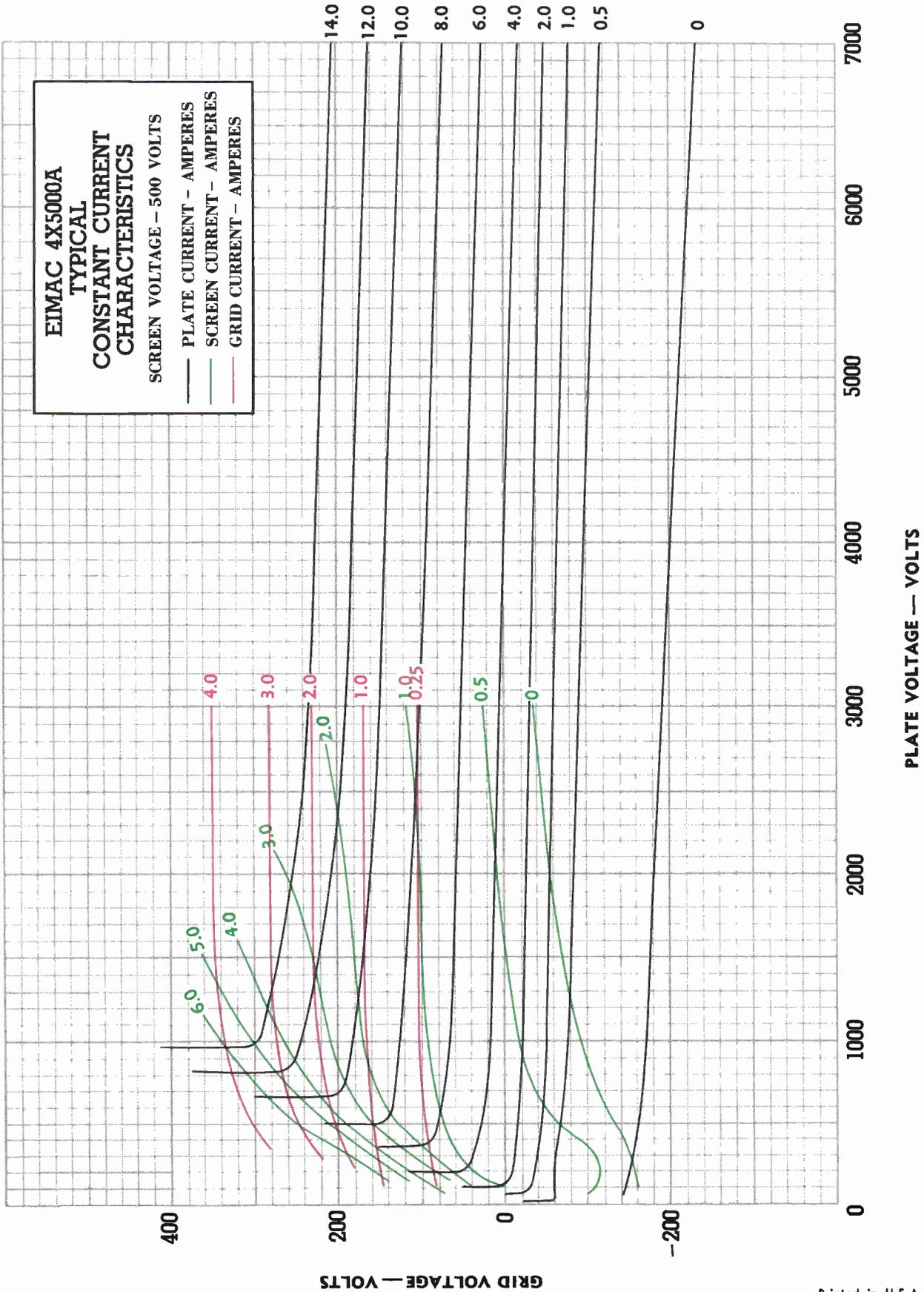


PLATE VOLTAGE — VOLTS



EITEL-McCULLOUGH, INC.
SAN CARLOS · CALIFORNIA

7580

**RADIAL-BEAM
POWER TETRODE**

The 7580 is a compact, high-perveance, radial-beam tetrode designed specially for maximum power output as a class-AB₁ linear amplifier. It is capable of 470 watts peak envelope power output under two-tone conditions. A pair of 7580 tubes will provide audio or ultrasonic power of 595 watts operating in amplifier or modulator service, class-AB₁, with a transformer efficiency of 95%.

The upper frequency for use of the 7580 at maximum ratings is 500 megacycles.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Cathode: Oxide-Coated, Unipotential				
Heating Time	30	60		seconds
Cathode-to-Heater Potential	—		±150	volts
Heater: Voltage		6.0		volts
Current	2.3		2.9	amperes
Direct Interelectrode Capacitances, Grounded Cathode:				
Input	16.0		18.5	uuf
Output	4.0		5.0	uuf
Grid-to-Plate			0.06	uuf



MECHANICAL

Base	Special 9-pin
Maximum Operating Temperatures:	
Ceramic-to-Metal Seals	250°C
Anode Core	250°C
Recommended Socket	Eimac SK-600 Series
Operating Position	Any
Maximum Dimensions:	
Height	2.464 inches
Seated Height	1.910 inches
Diameter	1.640 inches
Cooling	Forced Air
Net Weight	4 ounces
Shipping Weight (Approximate)	1.6 pounds

RADIO-FREQUENCY LINEAR AMPLIFIER

Class-AB₁ - Single Sideband

MAXIMUM RATINGS

D-C PLATE VOLTAGE	2000 MAX. VOLTS
D-C SCREEN VOLTAGE	500 MAX. VOLTS
D-C GRID VOLTAGE	—250 MAX. VOLTS
D-C PLATE CURRENT	.250 MAX. AMP
PLATE DISSIPATION	250 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS

TYPICAL OPERATION

Two-Tone where peak envelope power is at least twice the average power output—Actual measurements—Tank circuit efficiency estimated at 95%.

D-C Plate Voltage	1500	2000	volts
Zero-Signal D-C Plate Current	.133	.070	amp
Two-Tone D-C Plate Current	.250	.245	amp
D-C Screen Voltage	350	400	volts
Two-Tone D-C Screen Current	—10	+1	ma
D-C Grid-Bias Voltage	—62	—80	volts
Peak Signal Voltage	56	80	volts
3rd Order Intermodulation products referred to signal level	—30	—23	db
5th Order Intermodulation products referred to signal level	—35	—27	db
Worst 3rd Order Intermodulation as drive signal is reduced	—29	—21	db
Load Resistance	2160	2840	ohms
Peak Envelope Power	262	470	watts

**RADIO-FREQUENCY LINEAR AMPLIFIER**Class-AB₁ (Carrier with Double Sidebands)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	-	-	-	2000	MAX. VOLTS
D-C SCREEN VOLTAGE	-	-	-	500	MAX. VOLTS
D-C GRID VOLTAGE	-	-	-	-250	MAX. VOLTS
D-C PLATE CURRENT	-	-	-	.250	MAX. AMP
PLATE DISSIPATION	-	-	-	250	MAX. WATTS
SCREEN DISSIPATION	-	-	-	12	MAX. WATTS

AUDIO-FREQUENCY LINEAR AMPLIFIERClass-AB₁

MAXIMUM RATINGS (Per Tube)

D-C PLATE VOLTAGE	-	-	-	2000	MAX. VOLTS
D-C SCREEN VOLTAGE	-	-	-	500	MAX. VOLTS
D-C GRID VOLTAGE	-	-	-	-250	MAX. VOLTS
D-C PLATE CURRENT	-	-	-	.250	MAX. AMP
PLATE DISSIPATION	-	-	-	250	MAX. WATTS
SCREEN DISSIPATION	-	-	-	12	MAX. WATTS

TYPICAL OPERATION—Single Tube

(Quantities shown for carrier conditions, no modulation)

D-C Plate Voltage	-	-	-	-	1500	2000	volts
D-C Plate Current	-	-	-	-	.172	.172	amp
D-C Screen Voltage	-	-	-	-	350	400	volts
D-C Screen Current (Approx)	-	-	-	-	-3	-5	ma
D-C Grid-Bias Voltage	-	-	-	-	-58	-76	volts
Peak Grid-Signal Voltage	-	-	-	-	30	39	volts
Plate-Load Resistance	-	-	-	-	2320	3150	ohms
Power Output for Tank Circuit	-	-	-	-	-	-	-
Efficiency of 95%	-	-	-	-	55	100	watts

TYPICAL OPERATION (Two Tubes Push-Pull)

D-C Plate Voltage	-	-	-	-	1500	2000	volts
D-C Plate Current No Signal	-	-	-	-	.200	.140	amp
D-C Plate Current at Full Signal	-	-	-	-	.490	.500	amp
D-C Screen Voltage	-	-	-	-	300	350	volts
D-C Screen Current No Signal	-	-	-	-	-2	-4	ma
D-C Screen Current at Full Signal	-	-	-	-	0	+4	ma
D-C Grid-Bias Voltage (Approx)	-	-	-	-	-48	-66	volts
Plate-to-Plate Load Resistance	-	-	-	-	5920	8016	ohms
Power Output for Transformer	-	-	-	-	-	-	-
Efficiency of 95%	-	-	-	-	390	595	watts

MAXIMUM RATINGS FOR OTHER TYPES OF OPERATION

Class-C Telegraphy or FM

D-C PLATE VOLTAGE	-	-	-	2000	MAX. VOLTS
D-C SCREEN VOLTAGE	-	-	-	300	MAX. VOLTS
D-C GRID VOLTAGE	-	-	-	-250	MAX. VOLTS
D-C PLATE CURRENT	-	-	-	.250	MAX. AMP
PLATE DISSIPATION	-	-	-	250	MAX. WATTS
SCREEN DISSIPATION	-	-	-	12	MAX. WATTS
GRID DISSIPATION	-	-	-	2	MAX. WATTS

Class-C Plate Modulated

D-C PLATE VOLTAGE	-	-	-	1500	MAX. VOLTS
D-C SCREEN VOLTAGE	-	-	-	300	MAX. VOLTS
D-C GRID VOLTAGE	-	-	-	-250	MAX. VOLTS
D-C PLATE CURRENT	-	-	-	.200	MAX. AMP
PLATE DISSIPATION	-	-	-	165	MAX. WATTS
SCREEN DISSIPATION	-	-	-	12	MAX. WATTS
GRID DISSIPATION	-	-	-	2	MAX. WATTS

APPLICATION**MECHANICAL**

Mounting—The 7580 may be mounted in any position. An Eimac Air-System Socket of the SK-600 series or equivalent is recommended. These sockets may be obtained with or without the r-f screen by-pass capacitor, and with or without the four cathode terminals grounded to the socket shell. A simple Lock-in socket restricts the flow of cooling air and is not recommended.

Cooling—The 7580 has an efficient louvered anode cooler. The maximum allowable temperature for any external surface is 250°C.

For long service life at sea level, at an ambient temperature of 25°C and maximum rated anode dissipation of 250 watts, a *minimum* of 4.6 cfm air should flow from tube base through the anode cooler. The corresponding pressure drop with the recommended socket and chimney will be approximately .32 inch water column. See table for other dissipation levels and conditions.

4.6 cfm of air at 25°C is the same as a mass air flow of 18 pounds per hour. Higher ambient temperature requires greater air mass and volume. Higher

altitude requires equivalent mass air flow for a given ambient temperature and therefore requires greater volume at increased back pressure.

The use of temperature-sensitive laquer is recommended to determine the effectiveness of a cooling system under operating conditions.

Plate Dissipation (Watts)	55°C AMBIENT			
	SEA LEVEL		10,000 FEET ALTITUDE	
	Air Flow (CFM)	Pressure Drop (Inches of Water)	Air Flow (CFM)	Pressure Drop (Inches of Water)
75	1.15	.025	1.8	.036
125	2.3	.09	3.35	.13
250	6.4	.59	9.3	.86

Vibration and Shock—The 7580 is designed to withstand low-frequency vibration of 25 cps, 0.80 inch total excursion as outlined in MIL-E-1D, no voltage. It will withstand a bump test as described in MIL-E-1D for a hammer angle of 20°.

ELECTRICAL

Heater—For maximum life and uniform performance, the heater voltage should be maintained within plus or minus 5% of the rated 6.0 volts at operating frequencies up to 300 Mc. For CW use between 300 and 400 Mc, 5.75 volts is recommended. For CW use, 400 to 500 Mc, 5.5 volts is recommended.

Cathode—The cathode is connected to the four even-numbered base pins to provide a low-inductance path, or permit separation of input and output circuits if required.

Rated heater voltage should be applied for 30 seconds before other operating voltages are applied.

Heater-to-cathode maximum voltage is ± 150 volts.

Control Grid—Maximum rated d-c bias voltage is -250 volts. D-C resistance, grid to cathode, should be no more than 100,000 ohms.

Screen Grid—Screen dissipation maximum is 12 watts, normally computed by multiplying d-c screen voltage by the average screen current. This computation is essentially correct except in the case of heavy plate loading when secondary-emission current may mask the normal screen current.

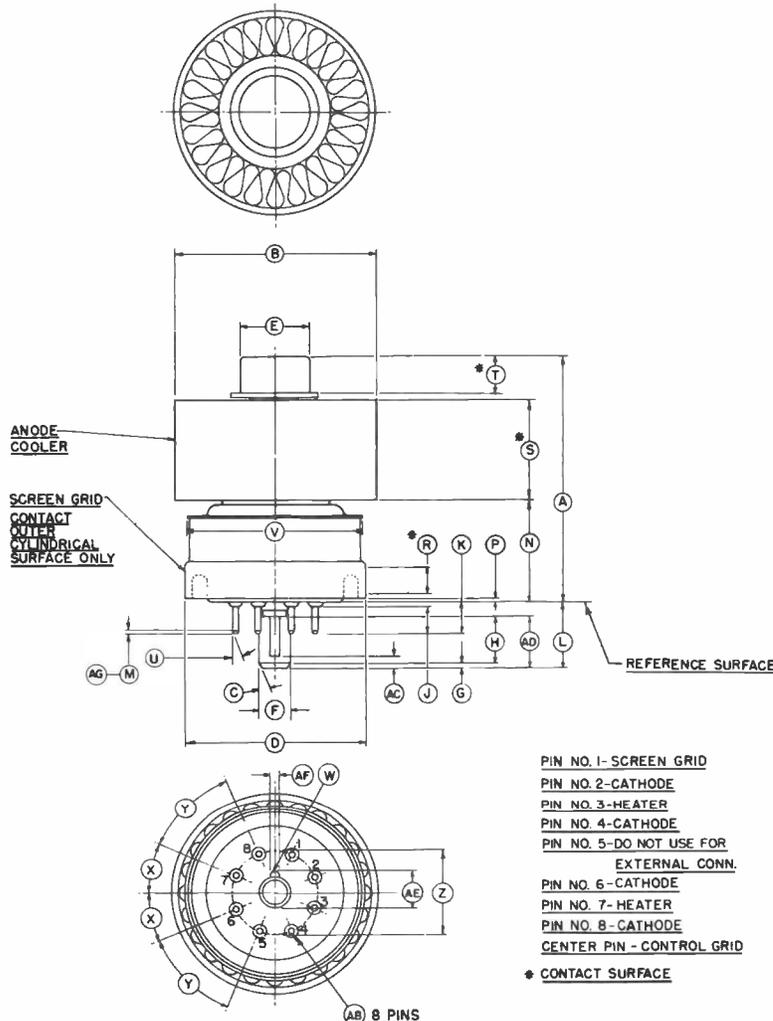
All tetrodes, under some conditions of loading and drive, will have secondary emission from the screen

which changes the net current to the screen and may even cause the screen meter to reverse. Normally, secondary emission is harmless provided the screen voltage is stable. To insure stable screen voltage, it is recommended that a bleeder resistor to pass 15 ma from screen to ground be used.

Plate Dissipation—The maximum plate dissipation is 250 watts. The usual single-sideband voice signal is complex and full peak envelope power shown in Typical Operating Conditions, may be developed without exceeding this plate dissipation. Single-tone testing for short periods with greater than 250 watts plate dissipation is permissible.

Multiple Operation — To obtain maximum power with minimum distortion from tubes operated in multiple it is desirable to adjust individual screen or grid-bias voltages so the peak plate current for each tube is equal at the crest of the exciting voltage. Under these conditions, individual d-c plate currents will be approximately equal for full input signal for class-AB₁ operation.

Special Application—If it is desired to use the 7580 under conditions widely different from those given here, consult the Power Grid Tube Marketing Department, Eitel-McCullough, Inc., San Carlos, California, or any of our regional offices or representatives.

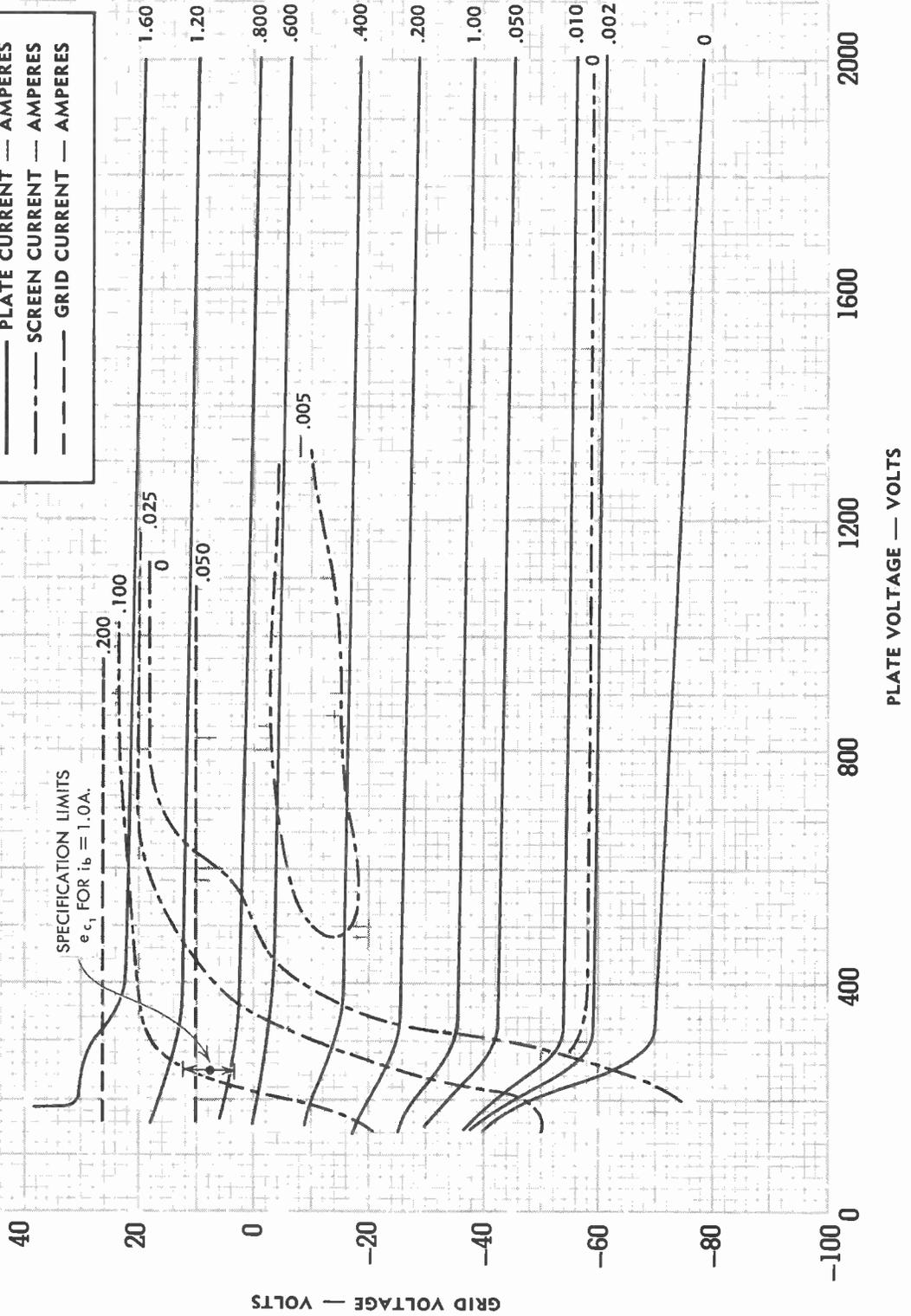


DIMENSIONS IN INCHES		
REF.	MIN.	MAX.
A	1.810	1.910
B	1.610 DIA.	1.640 DIA.
C	30°	
D	1.417 DIA.	1.433 DIA.
E	.559 DIA.	.573 DIA.
F	.255 DIA.	.265 DIA.
G	.031	
H	.360	
J	.187	
K	.250	
L	.514	.554
M	.035	
N	.750	.810
P	.020	
R	.187	
S	.710	.790
T	.240	.280
U	22 1/2°	
V	1.406 DIA.	
W	.043 R.	
X	22 1/2°	
Y	45°	
Z	.680 DIA. P.C.	.694 DIA. P.C.
AB	.045 DIA.	.053 DIA.
AC	.068	.108
AD	.456	
AE	.298	.308
AF	.078	.086
AG	.005 R. MIN. (ALTERNATE TO M&U)	

EIMAC 7580 TYPICAL CONSTANT CURRENT CHARACTERISTICS

SCREEN VOLTAGE — 250 VOLTS

- PLATE CURRENT — AMPERES
- - - SCREEN CURRENT — AMPERES
- - - GRID CURRENT — AMPERES

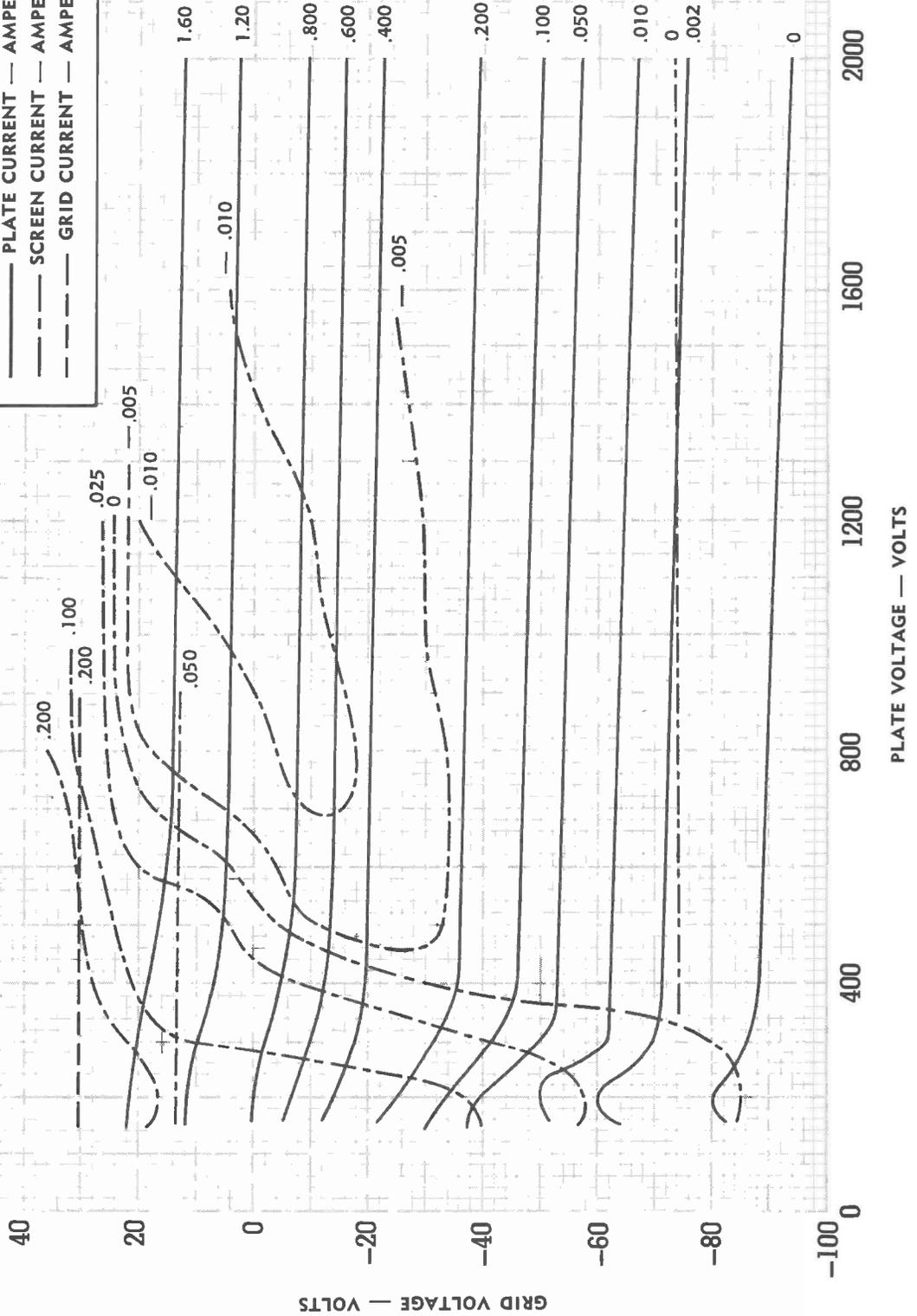




EIMAC 7580 TYPICAL CONSTANT-CURRENT CHARACTERISTICS

SCREEN VOLTAGE — 300 VOLTS

- PLATE CURRENT — AMPERES
- - - SCREEN CURRENT — AMPERES
- - - GRID CURRENT — AMPERES





EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

PRELIMINARY DATA*

X2013-B

The Eimac X2013-B is a quick filament heating, metal-ceramic tetrode intended for use in portable and mobile transmitters. Power output 3 db down from normal is available within one second after the application of rated filament voltage. Tube operation in 100 milliseconds can be obtained utilizing a built-in control diode and a minimum amount of additional circuitry.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode:	Directly heated, oxide coated		
Voltage		2.5	volts
Current		8.0	amperes
Absolute maximum filament voltage			
for fast warm-up (Note 1)		15	volts
Heating time at rated filament voltage		1.0	second
Heating time at 15 volts		0.1	second
Amplification Factor (grid-screen)		13	
Transconductance ($I_b = 150$ mA; $E_{c2} = 400$ V;			
$E_b = 800$ V)		15,000	μ mhos
Frequency for maximum ratings		250	mcs
Interelectrode capacitance (grounded cathode):			
Input (maximum)		28.0	$\mu\mu$ f
Output (maximum)		6.0	$\mu\mu$ f
Feed-through (maximum)		0.07	$\mu\mu$ f
Control Diode:			
Maximum plate resistance			
($I_d = .010$ A)		1,200	ohms

*This information applies to a laboratory tube design and is subject to change. No obligations are assumed as to future manufacture unless otherwise arranged.



MECHANICAL

Base.	9	Pin, special
Maximum operating temperatures:		
Anode core	250° C	
Ceramic-to-metal seals	250° C	
Socket		Eimac, X-4011
Operating position		Any

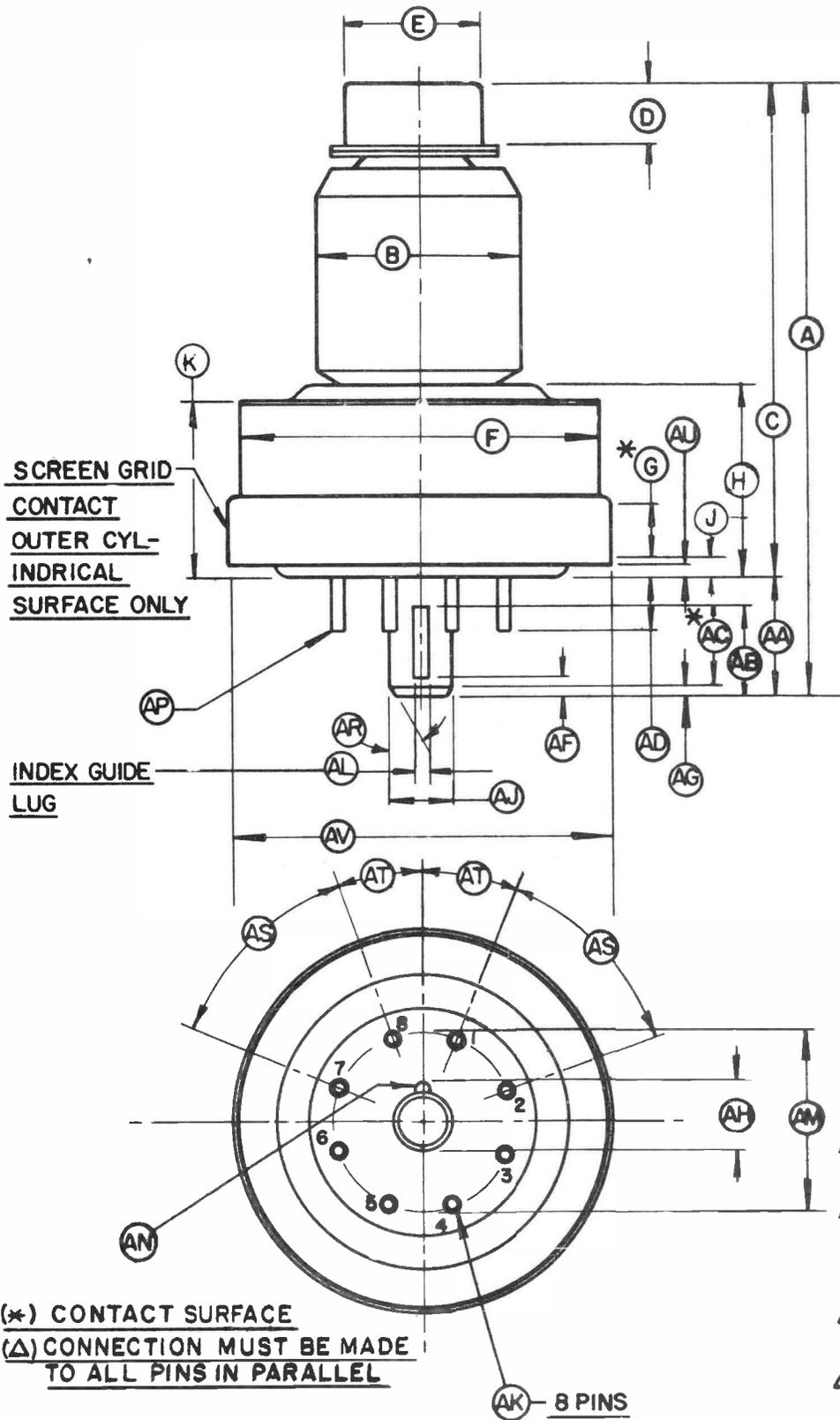
MAXIMUM RATINGS

DC Anode Voltage	2000	Max. volts
DC Screen Voltage	400	Max. volts
DC Grid Voltage	-250	Max. volts
DC Control Diode Voltage	±250	Max. volts
DC Anode Current	250	Max. mA
DC Control Diode Current	20	Max. mA
Anode Dissipation (radiation cooled)*	15	Max. watts
Screen Dissipation	8	Max. watts
Control Diode Anode Dissipation	0.5	Max. watts
Grid Current	2	Max. mA

*Also available with forced air cooled anode rated at 350 watts maximum dissipation.

Note 1: Extreme caution must be taken to insure that filament overvoltage is not applied beyond the time at which the cathode reaches operating temperature since the voltage used is sufficient to destroy the tube. Proper operation will be insured if overvoltage is removed when control diode anode current reaches 65% of its steady state operating value.

It is recommended that Application Engineering Department, Eitel-McCullough, Inc., San Carlos, California, be contacted for additional details and circuit approval prior to using the X2013-B in applications requiring the use of filament overvoltages.



DIMENSIONS IN INCHES			
DIMENSIONAL DATA			
REF	MIN	MAX	NOM
A	2.324	2.464	
B	.880	.894	
C	1.810	1.910	
D	.240	.280	
E	.559 DIA	.573 DIA	
F		1.406 DIA	
G	.187		
AA	.514	.554	
AB		.456	
AC	.360		
AD		.250	
AF	.068	.108	
AG			.031
AH	.298	.308	
AJ	.255 DIA	.265 DIA	
AK	.045 DIA	.053 DIA	
AL	.078	.086	
AM	.680 DIA	.694 DIA	
AN		.043 R	
AP	.005 R. MIN. OR .035 X 22.5°		
AR			30°
AS	44.0	46.0	45°
AT	21.5	23.5	22.5°
AU	.020	.050	
AV	1.417 DIA	1.433 DIA	
H	.700	.760	
J	.050	.090	
K	.600	.660	

CONNECTIONS

- PIN NO. 1: SCREEN GRID**
- Δ **PIN NO. 2: CATHODE-HEATER 1**
- PIN NO. 3: CONTROL GRID**
- Δ **PIN NO. 4: CATHODE-HEATER 1**
- PIN NO. 5: ANODE OF CONTROL DIODE**
- Δ **PIN NO. 6: CATHODE-HEATER 1**
- PIN NO. 7: CONTROL GRID**
- Δ **PIN NO. 8: CATHODE-HEATER 1**
- CENTER PIN: HEATER 2**

OUTLINE

X2013



OBJECTIVE DATA

The EIMAC X-2099 is a compact, quick heat tetrode designed for push-to-talk mobile and airborne applications. The tube warms up to 70% peak current or 50% RF power output in 250 milliseconds. The X-2099 can be driven by low-level solid state up to its rated plate dissipation of 500 watts. The tube is air cooled, ceramic-metal construction.

The data supplied in this sheet is for guidance only. Before establishing final design specifications contact Product Manager, Power Grid Division, EIMAC Division of Varian.



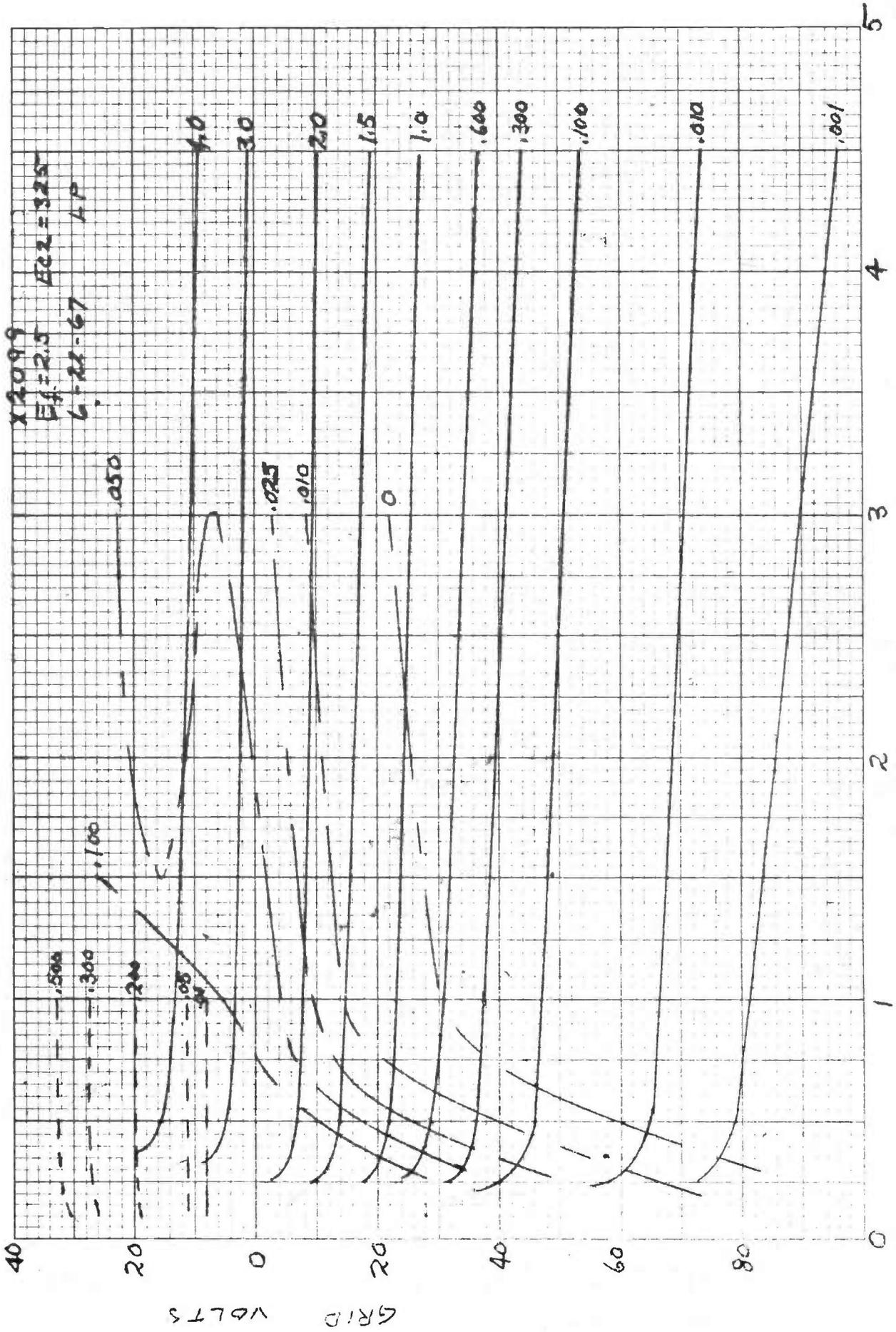
GENERAL CHARACTERISTICS

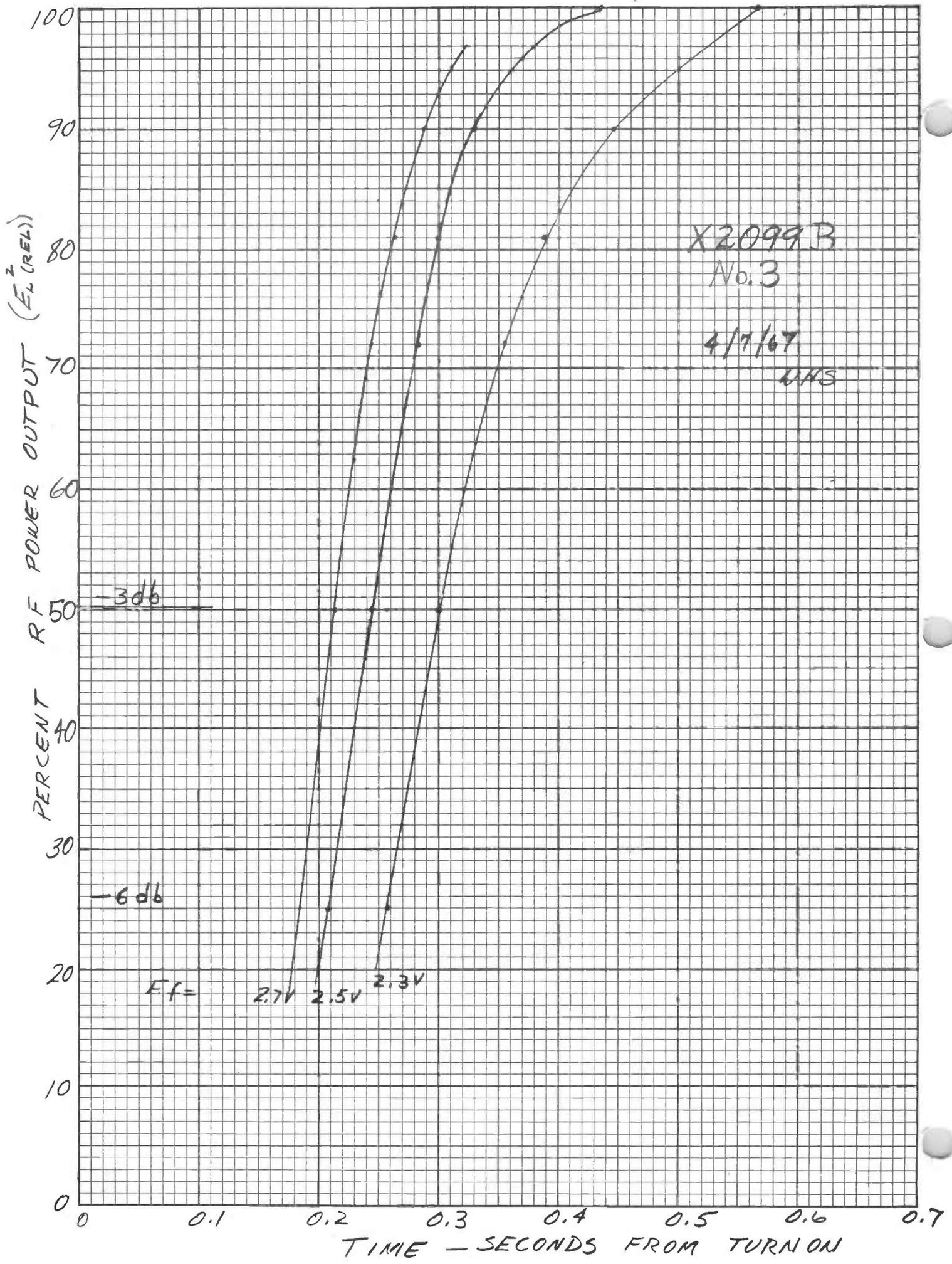
ELECTRICAL

Cathode: Oxide Coated, Uni-Potential	
Heating Time, nominal (see curves)	250 ms
Heater:	
Voltage, nominal (see curves)	2.5 V
Current, nominal (Inrush current approximately twice operating current)	10.5 A
Direct Interelectrode Capacitances, grounded cathode	
Input	56.0 pF
Output	6.1 pF
Feedback	0.14 pF
Direct Interelectrode Capacitances, grounded grid	
Input	33.0 pF
Output	6.2 pF
Feedback	0.02 pF

MECHANICAL

Base	Special 9-pin
Maximum Operating Temperatures:	
Ceramic-to-Metal Seals	250°C
Anode Core	250°C
Nominal Dimensions:	
Height	3.50 in.
Seated Height	3.00 in.
Diameter	2.65 in.
Cooling	Forced Air
Net Weight	8 ozs.







other products ▶

Look in the general section for---

- Your nearest distributor of modern, fully guaranteed Eimac electron tubes and electron tube accessories.
- Your nearest Eimac Field Engineer, who stands ready to give you immediate engineering assistance, information on deliveries and prices, or provide other information not found in the catalog.
- Eimac tube type numbering system.
- Tube Replacement Chart.
- Prices on Eimac products.

IMPORTANT EIMAC "EXTRAS"

Application Engineering. The Eimac Application Engineering Department is available at all times for consultation. New tube operating techniques are continually being explored, tested and proved by Eimac engineers, whose combined knowledge and experience are at your service. Additional contributions by this Eimac department are its Application Bulletins, a service which you receive without obligation.

Field Engineering. Serving as an extension of the Application Engineering Department outside the Eimac plant, Eimac Field Engineers cover the United States, operating out of offices in major cities. They will help you personally with experimental work, problems of technique, etc. Engineers from Eitel-McCullough, Inc. are available, too, for field consultation throughout the country. As Eimac tubes are world renowned, the same services extend to various countries overseas through the Eimac Export Department.



VacCap

EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

**CERAMIC
VacCap*
VACUUM
CAPACITORS**



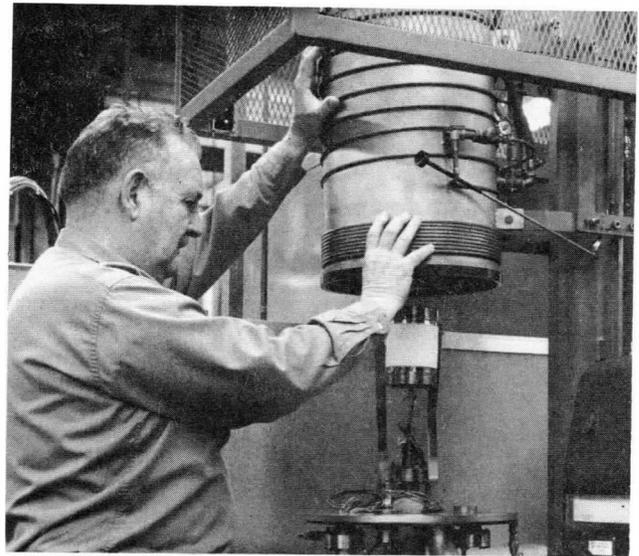
When Eitel-McCullough introduced the vacuum capacitor into the United States in June of 1938, the device incorporated a series of concentric rings of varying diameter. This configuration, now "universal" for vacuum capacitors, worked well with transmitter designs of that era. However, today's advanced transmitter designs demand considerably increased power and current ratings, sometimes beyond the capability of ring-into-ring capacitors.

Eimac VacCap* vacuum capacitors take into account these modern requirements through a unique patented design which results in higher rf rms current ratings. The old concentric-ring design has been replaced by a group of thick-walled sections of copper tubing, brazed to a

heavy end-bell. Smaller diameter copper tubes, brazed to an end-bell at the opposite end of the capacitor, work into the larger tubes. This configuration provides for very effective heat dissipation. With the new design, each section of tubing has its own individual rf path to the end-bell, whereas ring-into-ring designs require that the rf current flow up one ring wall, down the other side, up the next ring wall, down again, and so on. The tube-into-tube design is used on both fixed and variable VacCap* vacuum capacitors, along with newly-designed copper bellows. All-copper-and-ceramic construction permits higher bakeout temperatures to be used during manufacture of the capacitors, and assures an improved vacuum for higher reliability and longer life.



Final Assembly of VacCap* Variable Vacuum Capacitor



Fixed VacCap* Vacuum Capacitor in High Temperature Differential Pump System

ESTABLISHMENT OF RATINGS

All maximum peak-voltage ratings on the following data sheets are for 60-cycle alternating current. All maximum rms current ratings were established at a radio frequency of 16 Mc, with a uniform end-bell and connecting-strap temperature of 100°C. Measurements were made using radiation and convection cooling only. No other cooling was employed in establishing these ratings.

Higher voltage and current ratings than those

listed on the following data sheets are available on special order. Heat sink, forced-air, or water cooling may be used.

Our application engineers will be pleased to make tests in our laboratory under your specific conditions. Requests for application engineering assistance or further information should be addressed to Eitel-McCullough, Inc., 301 Industrial Way, San Carlos, California, Attn: Application Engineering, Power Grid Tube Divison.

EIMAC VacCap* VACUUM CAPACITOR NUMBERING SYSTEM

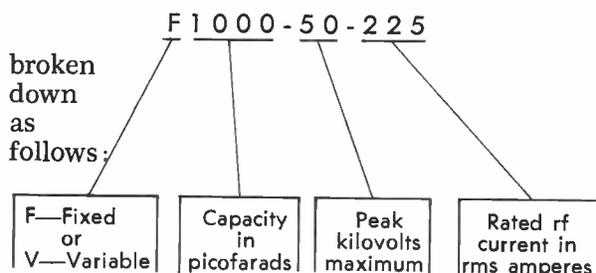
Since 1945, all electron devices developed by Eitel-McCullough, Inc., have been given an identifying type number chosen in accordance with a coded system designed to convey essential information about the product in as brief a manner as possible.

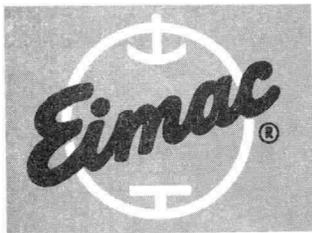
Eimac VacCap* ceramic vacuum capacitor type numbers consist of (1) a letter denoting whether the capacitor is a fixed (F) or variable (V) unit; and (2) three sets of hyphenated numbers.

The first set of digits indicates the capacity value of the product, in picofarads. The second set of digits designates the maximum peak kilovolt rating. The third set specifies the maximum

rf current in rms amperes.

This coding method and the information conveyed by the system is illustrated below. Assume that the unit is a fixed ceramic capacitor with ratings of 1000 picofarads, 50 kilovolts, and 225 amperes. The descriptive number is:





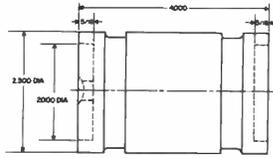
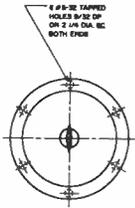
VacCap

EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

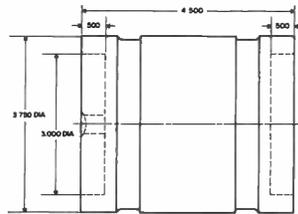
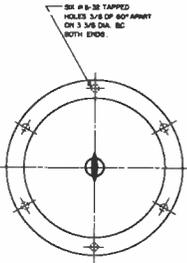
**FIXED
CERAMIC
VacCap*
CAPACITORS**

Sheet 1 of 2

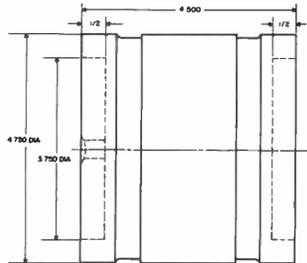
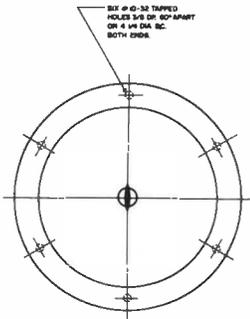
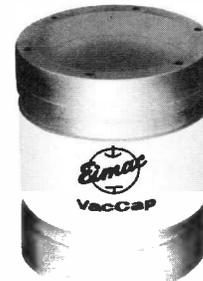
TYPE	CAPACITY (pf)	VOLTAGE RATING (Peak kV)	CURRENT RATING (rms amps)	OUTLINE DRAWING
F200-7.5-100	200	7.5	100	A
F350-7.5-125	350	7.5	125	C
F500-7.5-125	500	7.5	125	C
F750-7.5-175	750	7.5	175	E
F1000-7.5-175	1000	7.5	175	E
F1500-7.5-200	1500	7.5	200	F
F200-10-100	200	10	100	A
F350-10-125	350	10	125	C
F500-10-125	500	10	125	C
F750-10-175	750	10	175	E
F1000-10-175	1000	10	175	E
F1500-10-200	1500	10	200	F
F50-20-100	50	20	100	A
F75-20-100	75	20	100	A
F100-20-100	100	20	100	A
F250-20-125	250	20	125	C
F350-20-125	350	20	125	C
F500-20-175	500	20	175	E
F750-20-200	750	20	200	F
F1000-20-200	1000	20	200	F
F50-25-100	50	25	100	A
F75-25-100	75	25	100	A
F100-25-100	100	25	100	A
F250-25-125	250	25	125	C
F350-25-125	350	25	125	C
F500-25-175	500	25	175	E
F750-25-200	750	25	200	F
F1000-25-200	1000	25	200	F
F50-30-100	50	30	100	A
F75-30-100	75	30	100	A
F100-30-100	100	30	100	A
F250-30-125	250	30	125	C
F350-30-125	350	30	125	C
F500-30-175	500	30	175	E
F750-30-200	750	30	200	F
F1000-30-200	1000	30	200	F



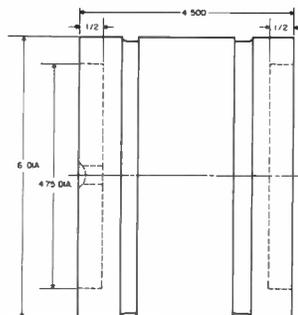
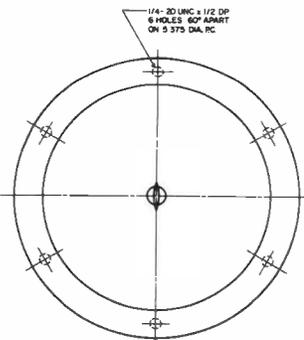
OUTLINE DWG. A



OUTLINE DWG. C



OUTLINE DWG. E



OUTLINE DWG. F





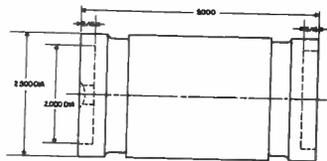
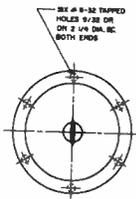
VacCap

EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

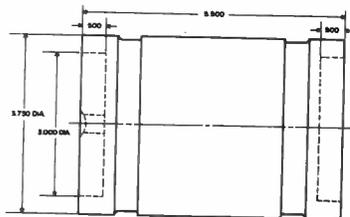
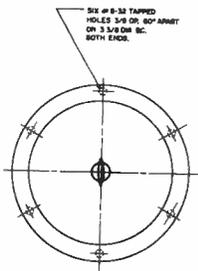
**FIXED
CERAMIC
VacCap*
CAPACITORS**

Sheet 2 of 2

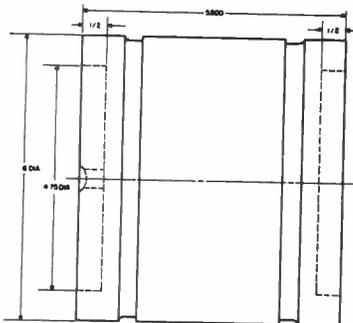
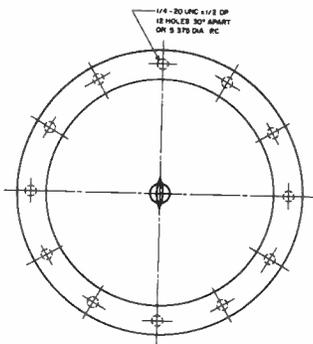
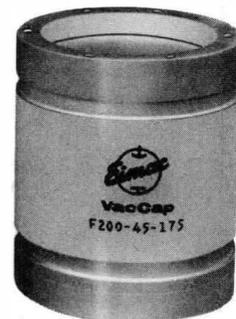
TYPE	CAPACITY (pf)	VOLTAGE RATING (Peak kV)	CURRENT RATING (rms amps)	OUTLINE DRAWING
F50-40-100	50	40	100	B
F80-40-100	80	40	100	B
F100-40-125	100	40	125	D
F200-40-125	200	40	125	D
F500-40-200	500	40	200	G
F1000-40-225	1000	40	225	H
F50-45-100	50	45	100	B
F80-45-100	80	45	100	B
F100-45-125	100	45	125	D
F200-45-125	200	45	125	D
F500-45-200	500	45	200	G
F1000-45-225	1000	45	225	H
F50-50-100	50	50	100	B
F80-50-100	80	50	100	B
F100-50-125	100	50	125	D
F200-50-125	200	50	125	D
F500-50-200	500	50	200	G
F1000-50-225	1000	50	225	H



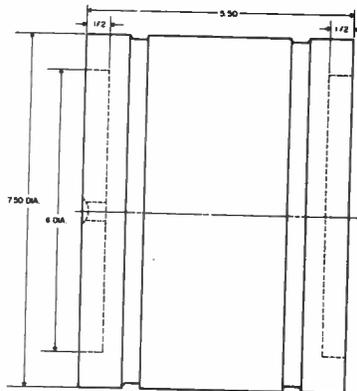
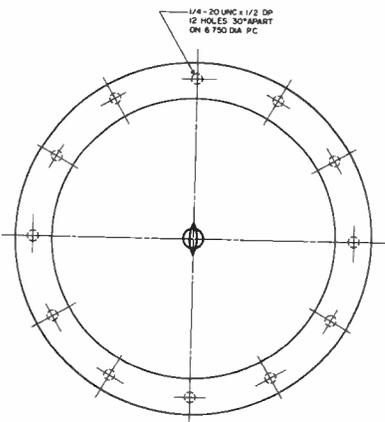
OUTLINE DWG. B



OUTLINE DWG. D



OUTLINE DWG. G



OUTLINE DWG. H



EITEL-McCULLOUGH, INC.

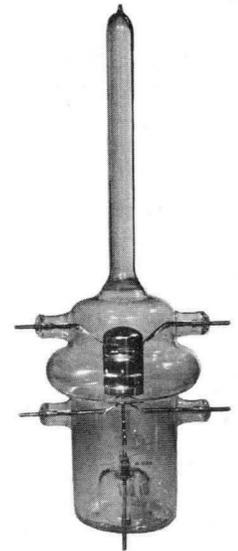
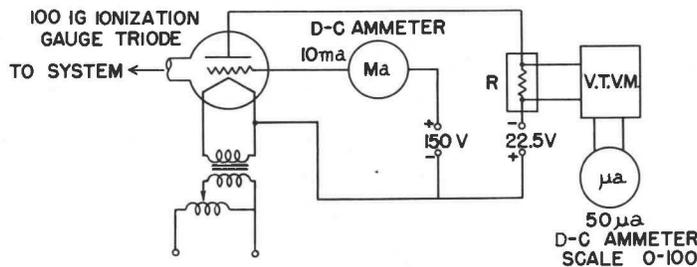
SAN BRUNO, CALIFORNIA

100 IG
IONIZATION
GAUGE
TRIODE

The Eimac 100 IG ionization gauge is designed for use in high vacuum exhaust systems, and will measure pressures from approximately 10^{-3} millimeters of mercury to less than 10^{-8} millimeters of mercury. The Nonex glass envelope can be sealed directly to exhaust systems employing Nonex or Kovar-sealing glass and can be sealed to Pyrex by means of a graded seal.

The 100 IG is a triode vacuum tube consisting of a pure tungsten filament and molybdenum grid and plate. No insulators are used within the tube, and the envelope is designed to provide long leakage paths between the plate and other tube elements.

Positive ion current indications are obtained with either a sensitive galvanometer or a vacuum tube amplifier. A typical circuit employing an Eimac 100 IG ionization gauge triode and a vacuum tube voltmeter is shown below.



The filament temperature of the 100 IG must be low enough so that the emission is temperature-limited. With a good vacuum, the filament voltage will be between 2.0 and 4.0 volts, and the filament current will be approximately 8.0 amperes. With a poor vacuum, it will be necessary to increase the filament voltage to approximately 7.5 volts, and the current will be about 12 amperes. (The tube should not be operated long at high filament voltage.)

CAUTION: Filament voltage should not be applied until vacuum has been obtained as indicated by a spark coil glow test.

If grid voltage is obtained from a rectified a-c power supply and if the line voltage is not stable, it will be desirable to employ a gaseous regulator tube. A positive voltage of 150 volts with respect to the filament and current of 5 milliamperes is standard for the 100 IG.

The recommended plate voltage is -22.5 volts with respect to the filament. A plate voltage from -20 to -45 volts will give satisfactory operation, but plate voltages of 0 to -20 volts will result in low and incorrect plate currents.

In order to fully realize the capabilities of the 100 IG, it will be necessary to make "R" in the above figure variable. One circuit that has been employed with success is a group of 6 resistors and a rotary switch arranged so that only one resistor is across the input to the vacuum tube voltmeter at a time. By selecting resistors that increase by a factor of 10, the 0-100 scale microammeter will change calibration by the same factor, and will be convenient to read. With resistance values of 500, 5K, 50K, 500K, 5 megohms and 50 megohms, the maximum (full scale meter deflection) input voltage to the vacuum tube voltmeter will be $\frac{1}{2}$ volt.

The calibration of the gauge depends upon the composition of the gas in the system. For dry air the pressure is given by the following formula:

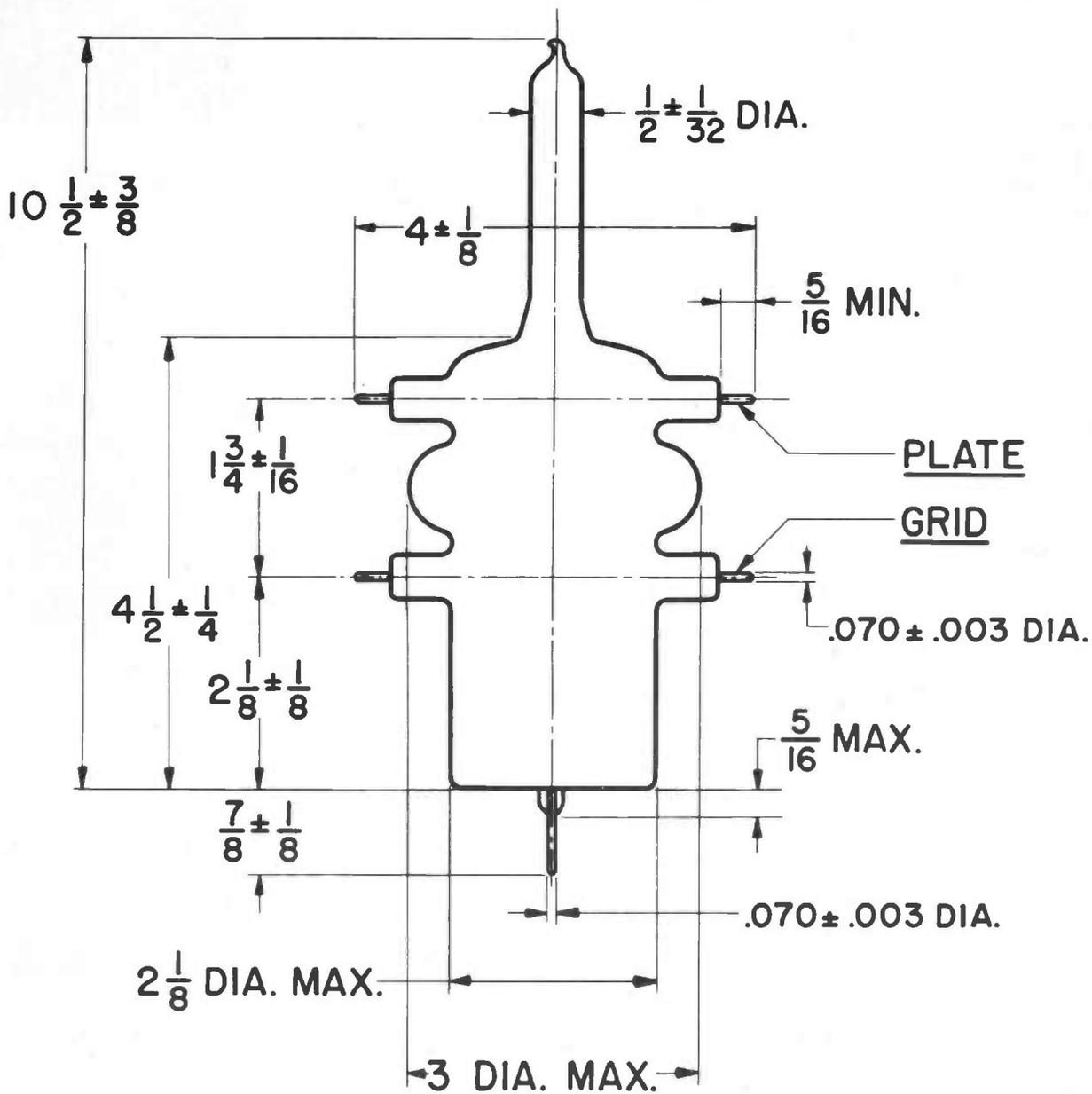
$$\text{Pressure (mm. of Hg)} = I_p (3.3 \times 10^{-5})$$

where I_p = Plate current in microamperes
 when Grid Voltage . . . = +150 volts
 Grid Current = .005 amperes
 Plate Voltage = -22.5 volts

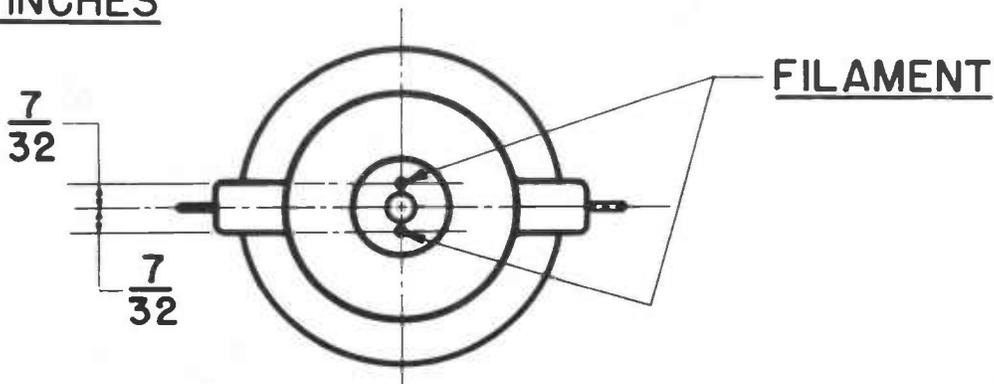
A bake-out of the tube at 450° Centigrade and outgassing of the tube elements is necessary whenever the exhaust system has been opened to air or the elements need cleaning. Outgassing is accomplished by heating the grid and plate to a dull cherry red by either r-f induction or by direct electron bombardment. Recommended outgassing voltages for the 100 IG are as follows:

Filament Outgassing Voltage (approximately)	8 volts
Plate Outgassing Voltage	800 volts
Plate Outgassing Current	120 ma

The grid and a 1000 ohm resistor is placed in series with the plate during outgassing. The recommended outgassing time is approximately five minutes, or until the pressure in the exhaust system has become stabilized.



DIMENSIONS
IN INCHES





EITEL-McCULLOUGH, INC.
S A N C A R L O S · C A L I F O R N I A

SK-600

**AIR-SYSTEM
SOCKET**

The Eimac SK-600 is one of the air-system sockets recommended for use with those tubes listed at the bottom of this data sheet or other tube types having the same special nine-pin base. A ceramic SK-606 Air-Chimney is available and is recommended for use with the socket when air-cooled tubes are to be employed.

When this socket is used, connection is made to each of the tube electrodes except the anode, and to one side of the integral screen-grid by-pass capacitor.

BASE CONNECTIONS

The SK-600 Air-System Socket consists of eight screen-grid contact fingers, seven pin contacting terminals (no contact is made to pin No. 5), a center control-grid terminal, and an integral screen by-pass capacitor. The cathode of the tube is connected to its external circuits by the four even-numbered base pins which are connected in parallel to minimize the effects of lead inductance; these contact terminals are insulated from the socket body.

SCREEN-GRID BY-PASS CAPACITOR

Incorporated in the socket structure is a low inductance screen by-pass capacitor, 2700 ± 500 uuf, which provides a short radio-frequency path to ground. The capacitor contains a silvered-mica dielectric and is rated at 400 volts d-c.

When this socket is mounted on a grounded chassis, one side of the screen-grid by-pass capacitor will automatically be grounded.

MATERIALS AND FINISHES

The metal shell, or body, of the socket is silver-plated brass. The screen-grid contact fingers and base pin terminals are fabricated of beryllium-copper, heat-treated after forming, then silver-plated. The center control-grid terminal is silver-plated brass as are the toe clamps which are supplied for mounting purposes.

The socket insulating material, polytrifluorochloroethylene, is chemically inert, non-flammable, will not absorb water or water vapors, and is not affected by acids or alkalies. It will not react to normal solvents, except in the case of halogenated compounds which will induce minor dimensional changes. Its physical characteristics are stable over a temperature range of -196°C to $+199^{\circ}\text{C}$ and it is resistant to embrittlement and thermal shock.

NET WEIGHT 3.5 Ounces

INSTALLATION

The SK-600 Air-System Socket can be mounted on chassis decks or partitions or in coaxial tuning devices with no modification to the socket. Chassis mounting is accomplished by cutting a $2\frac{1}{4}$ " diameter hole in the chassis deck or partition. The socket is then placed in the hole and held securely by the three toe clamps provided.

If the socket is to be used in a coaxial line, it may be mounted directly on the end of the input line outer conductor. The socket skirt fits snugly on a $1\frac{1}{8}$ " diameter cylinder and four screw holes are provided for fastening as shown in the outline drawing.

TUBE EXTRACTOR

The SK-604A is a spring-steel device useful for inserting and extracting tubes of the type used in the SK-600 Air-System Socket. It is recommended for use where the construction of the equipment makes it difficult or impossible to grasp the tube by hand or when it is necessary to handle the tubes while they are still hot from recent use.

THE SK-600 AIR-SYSTEM SOCKET IS RECOMMENDED FOR USE WITH THE FOLLOWING TUBES:

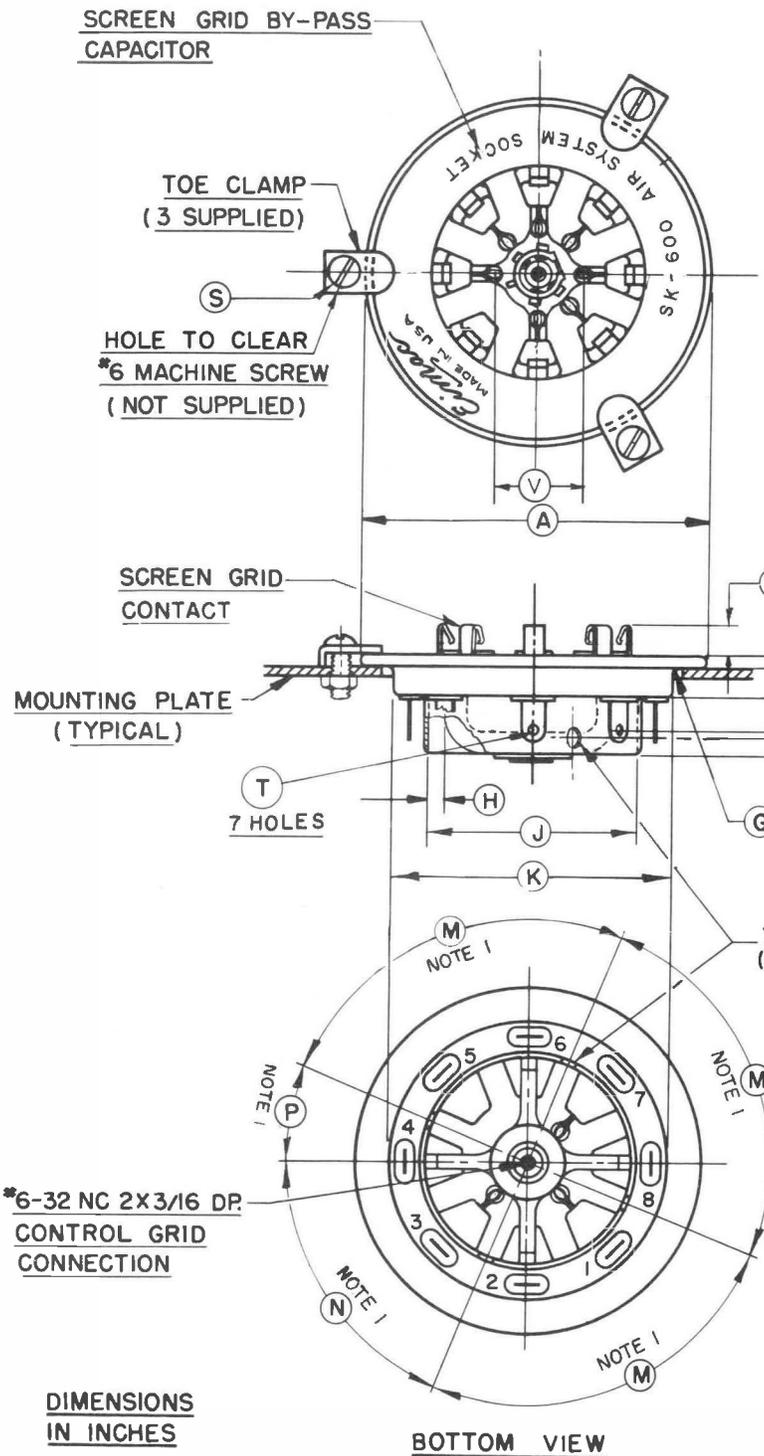
- | | | |
|-------------|--------------|---------|
| 4X150A/7034 | 4X250F/7204 | 4CX250R |
| 4X150D/7035 | 4CX250B/7203 | 4W300B |
| 4X150F/7609 | 4CX250F | 7580 |
| 4X250B | | |



**SK-600
Air-System Socket**



SK-600 Air-System Socket



DIMENSION DATA			
REF.	MIN.	MAX.	NOM.
A	2.688 O.D.	2.750 O.D.	
B	.234	.266	
C	.203	.235	
D	.125	.157	
E	.844	.906	
F			.250
G		.031R	
H			.078
J	1.633 I.D.	1.643 I.D.	
K	2.188 O.D.	2.208 O.D.	
L	.172	.204	
M	89° NOTE *1	91° NOTE *1	
N	66.5° "	68.5° "	
P	21.5° "	23.5° "	
R			.144 DIA.
S	.142 DIA.		
T			.090 DIA.
V			.687 DIA.

CONNECTIONS

- NO. 1 SCREEN GRID
- " 2 CATHODE
- " 3 HEATER
- " 4 CATHODE
- " 5 NO CONNECTION
- " 6 CATHODE
- " 7 HEATER
- " 8 CATHODE

**DIMENSIONS
IN INCHES**

NOTES:
1 - TOLERANCES ARE NOT CUMULATIVE



EITEL-McCULLOUGH, INC.
SAN CARLOS · CALIFORNIA

SK-610

**AIR-SYSTEM
SOCKET**

The Eimac SK-610 is one of the air-system sockets recommended for use with those tubes listed at the bottom of this data sheet or other tube types having the same special nine-pin base. A ceramic SK-606 Air-Chimney is available and is recommended for use with the socket when air-cooled tubes are to be employed.

When this socket is used, connection is made to each of the tube electrodes except the anode, and to one side of the integral screen-grid by-pass capacitor.

BASE CONNECTIONS

The SK-610 Air-System Socket consists of eight screen-grid contact fingers, seven pin contacting terminals (no contact is made to pin No. 5), a center control-grid terminal, and an integral screen by-pass capacitor. The cathode of the tube is connected to its external circuits by the four even-numbered base pins which are connected in parallel to minimize the effects of lead inductance. These terminal lugs are connected directly to the metal shell of the socket and will automatically be grounded when the socket is mounted to a metal chassis.

SCREEN-GRID BY-PASS CAPACITOR

Incorporated in the socket structure is a low inductance screen by-pass capacitor, 2700 ± 500 uuf, which provides a short radio-frequency path to ground. The capacitor contains a silvered-mica dielectric and is rated at 400 volts d-c.

When this socket is mounted on a grounded chassis, one side of the screen-grid by-pass capacitor will automatically be grounded.

MATERIALS AND FINISHES

The metal shell, or body, of the socket is silver-plated brass. The screen-grid contact fingers and base pin terminals are fabricated of beryllium-copper, heat-treated after forming, then silver-plated. The center control-grid terminal is silver-plated brass as are the toe clamps which are supplied for mounting purposes.

The socket insulating material, polytrifluorochloroethylene, is chemically inert, non-flammable, will not absorb water or water vapors, and is not affected by acids or alkalies. It will not react to normal solvents, except in the case of halogenated compounds which will induce minor dimensional changes. Its physical characteristics are stable over a temperature range of -196°C to $+199^{\circ}\text{C}$ and it is resistant to embrittlement and thermal shock.

NET WEIGHT 3.5 Ounces

INSTALLATION

The SK-610 Air-System Socket can be mounted on chassis decks or partitions or in coaxial tuning devices with no modification to the socket. Chassis mounting is accomplished by cutting a $2\frac{1}{4}$ " diameter hole in the chassis deck or partition. The socket is then placed in the hole and held securely by the three toe clamps provided.

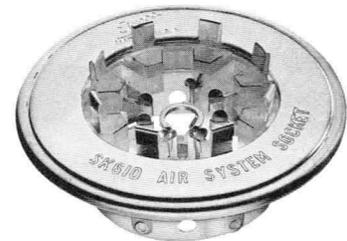
If the socket is to be used in a coaxial line, it may be mounted directly on the end of the input line outer conductor. The socket skirt fits snugly on a $1\frac{1}{2}$ " diameter cylinder and four screw holes are provided for fastening as shown in the outline drawing.

TUBE EXTRACTOR

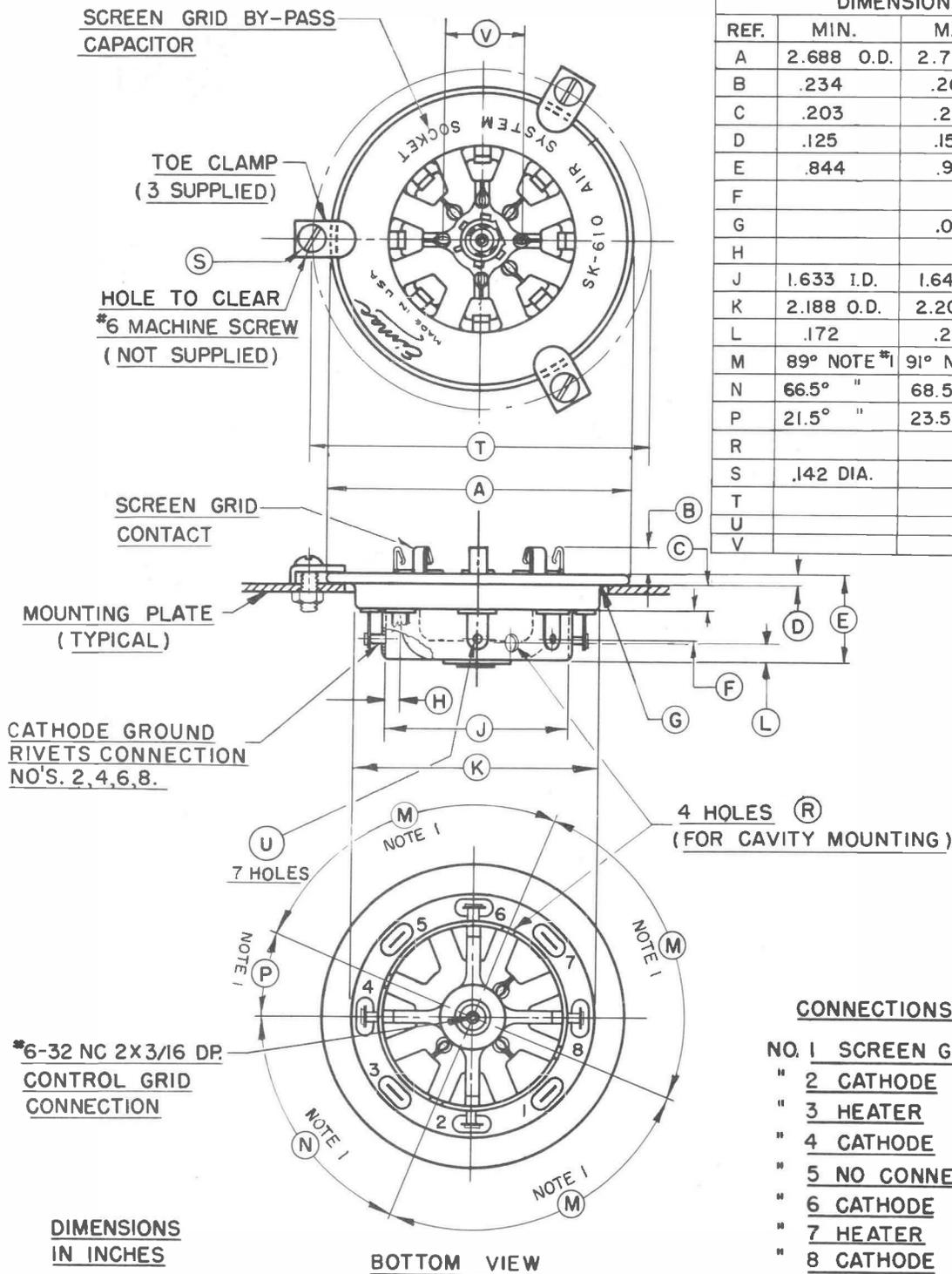
The SK-604A is a spring-steel device useful for inserting and extracting tubes of the type used in the SK-610 Air-System Socket. It is recommended for use where the construction of the equipment makes it difficult or impossible to grasp the tube by hand or when it is necessary to handle the tubes while they are still hot from recent use.

THE SK-610 AIR-SYSTEM SOCKET IS RECOMMENDED FOR USE WITH THE FOLLOWING TUBES:

- | | | |
|-------------|--------------|---------|
| 4X150A/7034 | 4X250F/7204 | 4CX250R |
| 4X150D/7035 | 4CX250B/7203 | 4W300B |
| 4X150F/7609 | 4CX250F | 7580 |
| 4X250B | | |



**SK-610
Air-System Socket**



DIMENSION DATA			
REF.	MIN.	MAX.	NOM.
A	2.688 O.D.	2.750 O.D.	
B	.234	.266	
C	.203	.235	
D	.125	.157	
E	.844	.906	
F			.250
G		.031R	
H			.078
J	1.633 I.D.	1.643 I.D.	
K	2.188 O.D.	2.208 O.D.	
L	.172	.204	
M	89° NOTE #1	91° NOTE #1	
N	66.5° "	68.5° "	
P	21.5° "	23.5° "	
R			.144 DIA.
S	.142 DIA.		
T			3.000 DIA.
U			.090 DIA.
V			.687 DIA.

CONNECTIONS

- NO. 1 SCREEN GRID
- " 2 CATHODE
- " 3 HEATER
- " 4 CATHODE
- " 5 NO CONNECTION
- " 6 CATHODE
- " 7 HEATER
- " 8 CATHODE

NOTES:
1 - TOLERANCES ARE NOT CUMULATIVE



VS-2 VS-4 VS-6

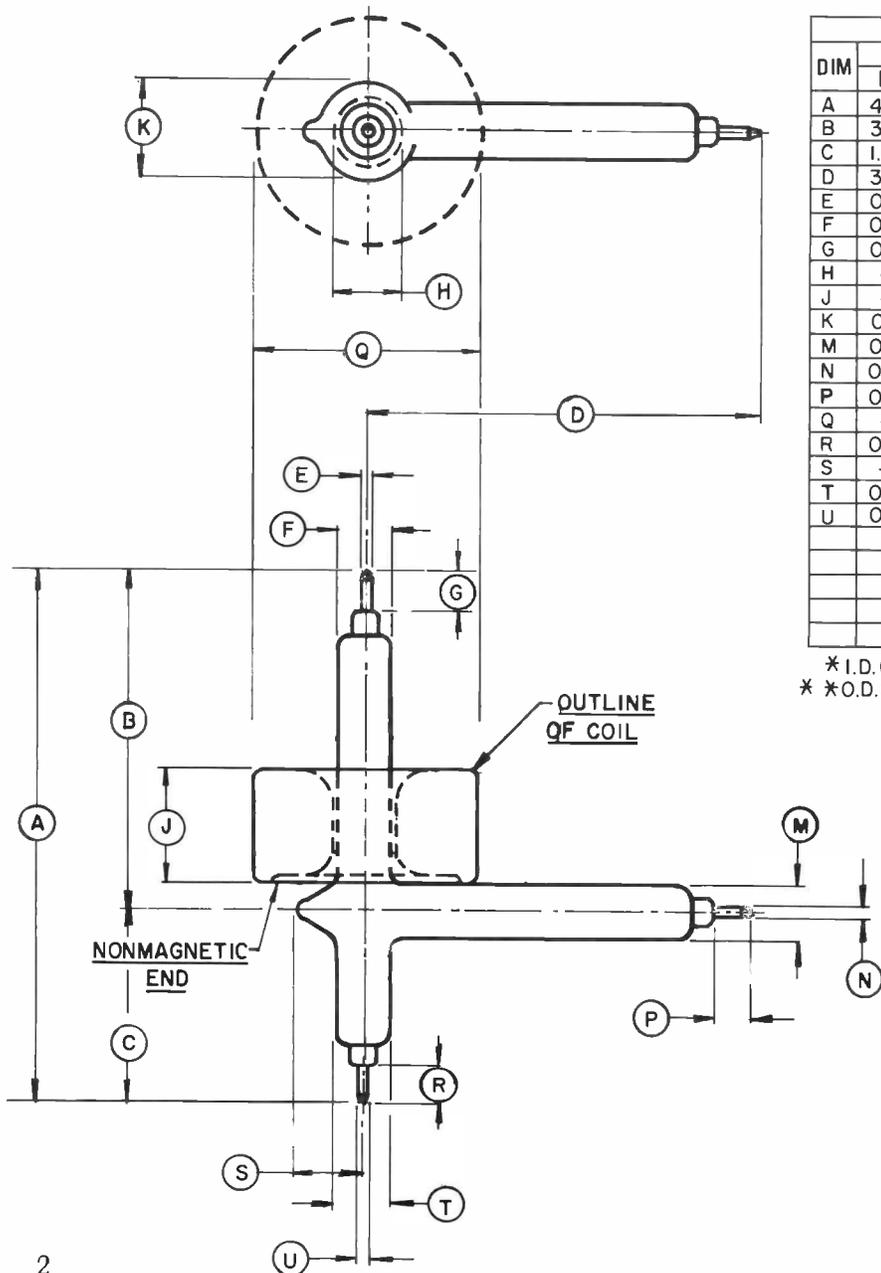
MOUNTING - The operating coil is mounted in rubber grommets over the glass barrel on the arm containing the iron core. The non-magnetic end of the coil is placed toward the contacts.

In order to prevent damage from shock and vibration, the switch should be fastened to the equipment with rubber covered metal strips over the glass tubing.

CONTACTS - The normally open contact is housed in the glass barrel containing the iron core: the normally closed contact being directly opposite this core.

DC RATINGS - While not designed for dc applications, the VS series may be used at reduced ratings in dc service. The following ratings have been established:

	VS-2	VS-4	VS-6
Voltage -	14,000	14,000	14,000 Vdc
Current -	4	4	6 Adc

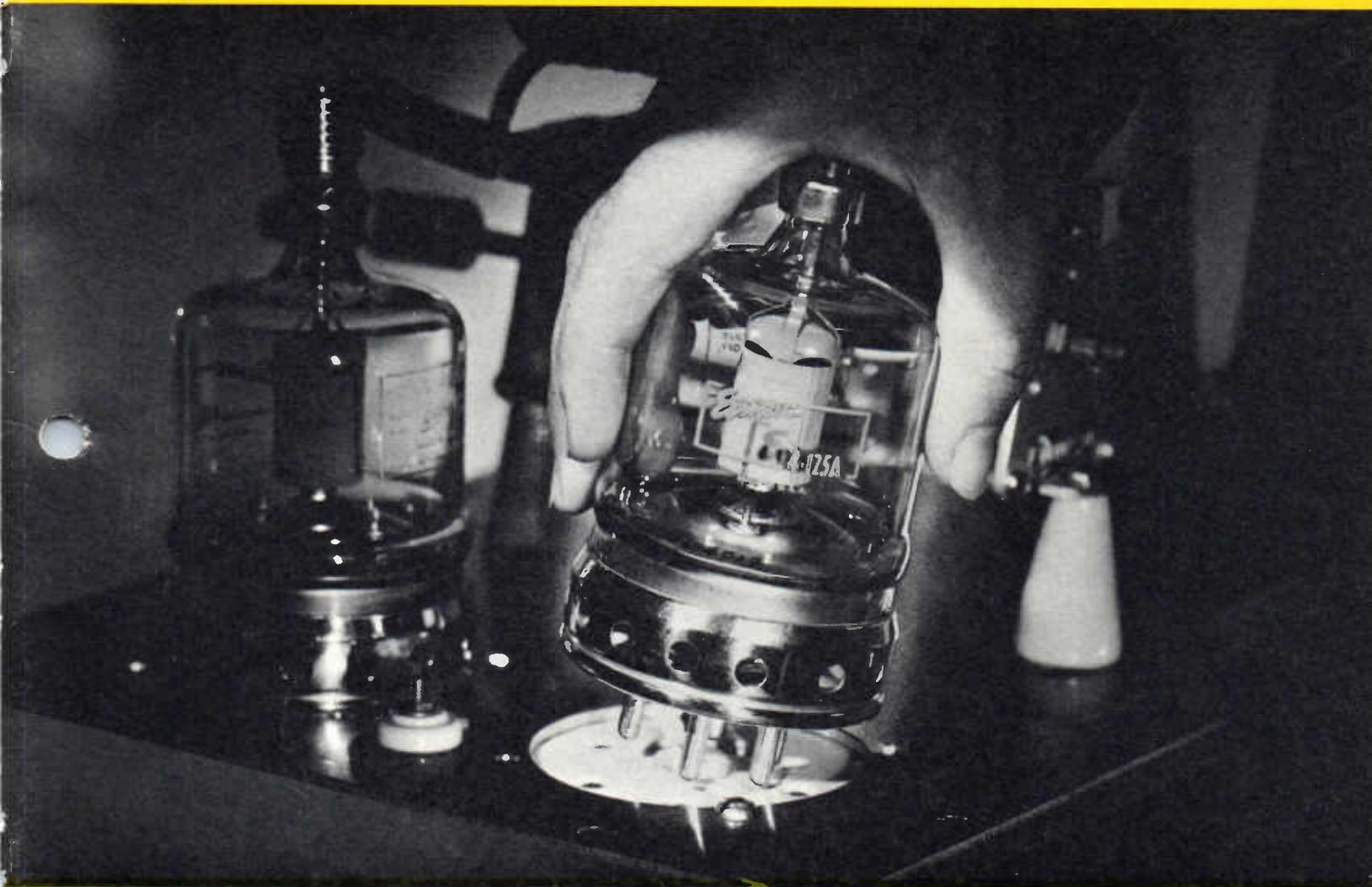


DIM	DIMENSIONAL DATA					
	INCHES			MILLIMETERS		
	MIN.	MAX.	REF.	MIN.	MAX.	REF.
A	4.750	4.875	- -	120.65	123.82	- -
B	3.000	3.125	- -	76.20	79.37	- -
C	1.687	1.812	- -	42.85	46.02	- -
D	3.437	3.562	- -	87.30	90.47	- -
E	0.090	0.103	- -	2.29	2.62	- -
F	0.468	0.531	- -	11.89	13.49	- -
G	0.343	0.406	- -	8.71	10.31	- -
H	- -	- -	9/16 *	- -	- -	4.76 *
J	- -	- -	1.031	- -	- -	26.19
K	0.750	1.000	- -	19.05	25.40	- -
M	0.437	0.562	- -	11.10	14.27	- -
N	0.090	0.103	- -	2.29	2.62	- -
P	0.343	0.406	- -	8.71	10.31	- -
Q	- -	- -	2-1/32**	- -	- -	51.59**
R	0.343	0.406	- -	8.71	10.31	- -
S	- -	0.750	- -	- -	19.05	- -
T	0.437	0.562	- -	11.10	14.27	- -
U	0.090	0.103	- -	2.29	2.62	- -

* I.D. COIL
* * O.D. COIL

VS-2

THE CARE AND FEEDING OF POWER TETRODES



APPLICATION BULLETIN NUMBER EIGHT

EITEL • M • CULLOUGH • INC.

SAN BRUNO CALIFORNIA

The information presented herein is based on data believed accurate, but no responsibility is accepted for the successful application of the systems or principles discussed. Likewise, no responsibility is assumed for patent infringement, if any, resulting from the application of this information.

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THE CARE AND FEEDING OF POWER TETRODES

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INTRODUCTION

The user of transmitting tubes is no doubt familiar with the usual r-f circuits built around neutralized triodes, and the many considerations in layout, circuit design, adjustment, keying, modulation, and care required to get the best performance and life for his particular needs. He probably is not so familiar with an accumulation of factual experience using the latest designs of the four-electrode transmitting tube, the tetrode.

It is the purpose of this application bulletin to cite some of the experience which has been had with current and new tetrodes to help users obtain the full capabilities of the tubes.

Briefly stated these new tubes:

1. Have internal feedback coupling reduced to a very small value.
2. Permit design of amplifier stages which operate with driving power less than 1% of output power in most cases, and with negligible driving power in many audio cases.
3. Operate efficiently and with good life at audio and radio frequencies, including the VHF region (30 to 300 Mc.) and in some cases into the UHF region (300 to 3000 Mc.).

4. Take abuse (providing it's done intelligently and not with a hammer).
5. Allow designers to build compact, simple, flexible equipment with the least chance of spurious interfering radiations.

The practical desired results, however, can not be had unless the design, adjustment and operation of the complete equipment are right. This recital of some experience with Eimac tetrodes can not presume to supply the normal skill and good techniques necessary to build successful electronic equipment. It may make it easier by showing layouts, circuit considerations, adjustment techniques, and operating values, which have worked. In many ways the problem is little different from building successful equipment with triodes.

The bulletin tries to give a general understanding, and clues to understanding, some of the behavior of circuits using tetrodes. For specific ratings, operating values and information on a particular tube type, the technical data sheet for the tube type should be studied. It comes with the tube, or may be had for the asking.

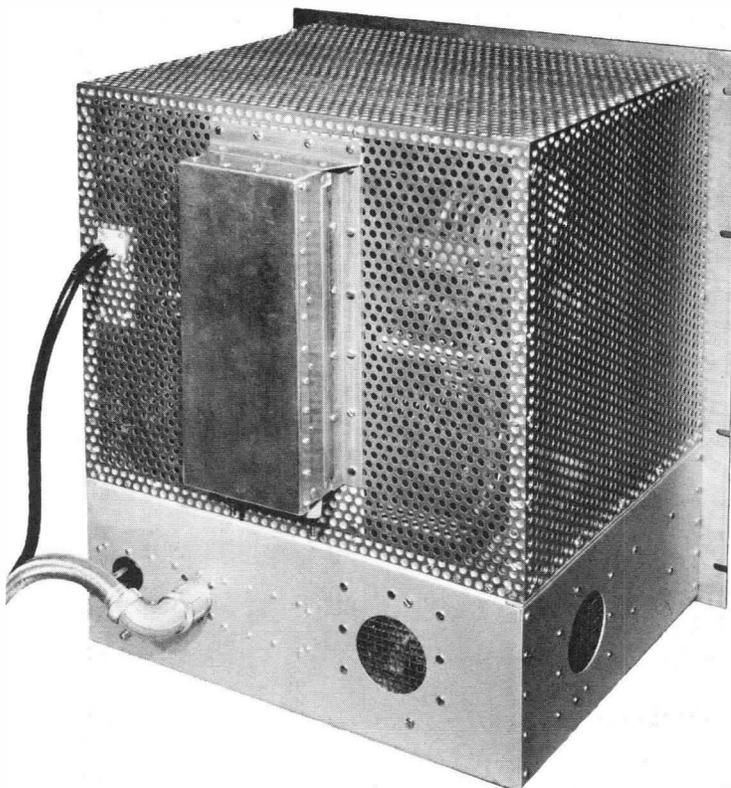


Fig. 1

Well arranged, filtered, and shielded r-f amplifier. Designed and built by R. L. Norton (W6CEM), and in use at WIFH.

LAYOUT

B-1. General

The metallic enclosure in which the tetrode or tetrodes operate serves the following three purposes:

1. Completes the shielding between the output (plate circuit) and the input (grid circuit).
2. It channels the forced cooling air, or convection air currents, so as to cool the tube adequately and, incidentally, the associated component parts as well.
3. It confines the radio frequency energy and helps permit selection of the desired frequency as the only one to be coupled out to the useful load circuit.

A good example of a suitable enclosure is shown in Fig 1.

B-1-a. Shielding

By referring to Figs. 2, 3, 4, 5, and 6, one

can readily see several r-f layouts which have been satisfactory in practice. Note that in all cases the tube is mounted vertically with the base down, and the socket is mounted flush with the deck separating the compartment below the tube and the compartment above the tube. In all cases the grid and filament (or cathode terminals) are on the base end of the tube and extend into the lower compartment. The plate circuit and plate terminal are in the upper compartment.

In the case of tubes having metal base shells, grounding clips should be carried by the bolts mounting the socket so as to bring the base shell to chassis potential. This completes the shielding between the output and input circuits since the base shell of the tube comes up opposite the screen shield within the tube itself.

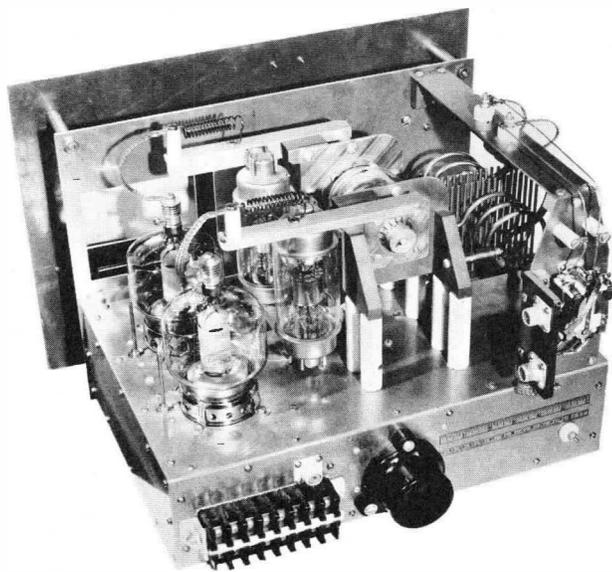


Fig. 2

Push-pull r-f amplifier employing 4-250A tetrodes.
Designed and built by C. F. Bane (W6WB)².

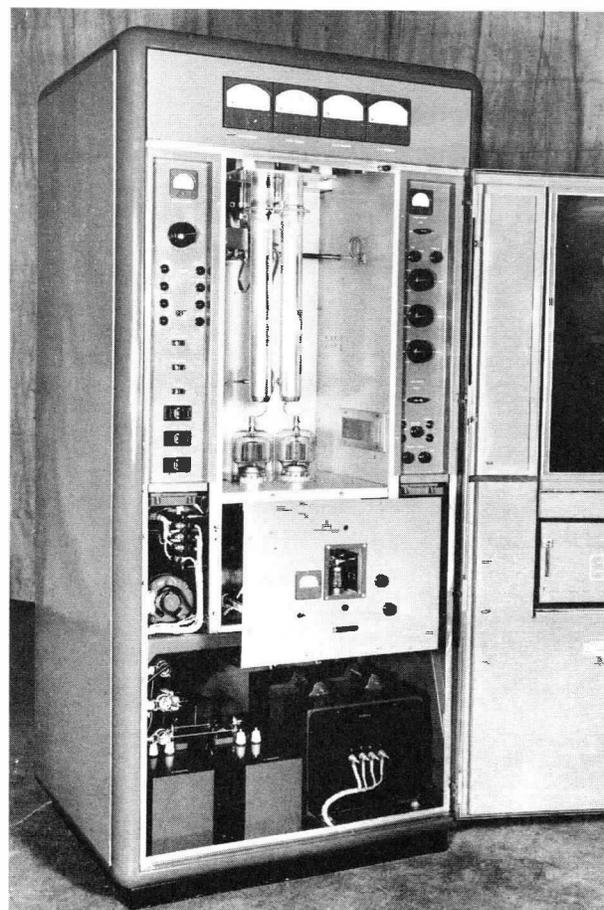


Fig. 3

Push-pull 88-108 Mc. 1 Kw. amplifier employing 4-400A tetrodes. Radio Engineering Laboratories, Model 701 transmitter.

SECTION **B**

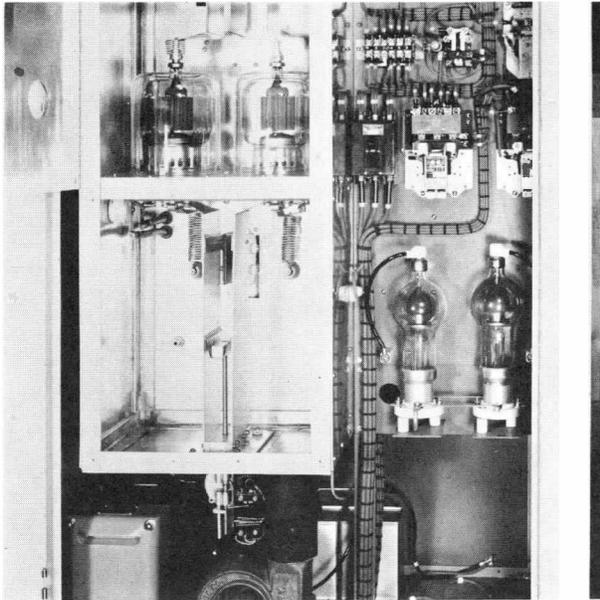


Fig. 4

Push-pull 110 Mc. amplifier employing 4-1000A tetrodes. Gates Radio Co. Model BF 3 kw transmitter.

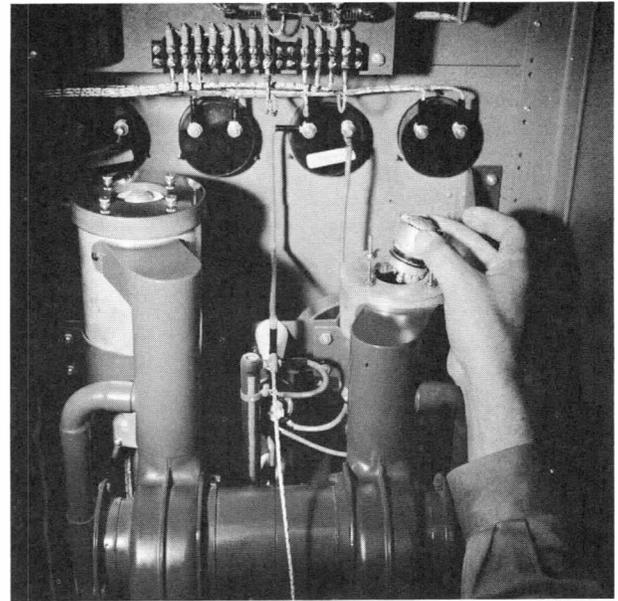


Fig. 6

Experimental 950 Mc. doubler final and tripler driver employing 4X150A tetrodes. Designed and built by Eitel-McCullough Laboratories.

By having the tube and circuits in completely enclosed compartments and by properly filtering incoming supply wires, it is possible to prevent the coupling out of radio frequency energy by means other than the desired output coupling.

Such filtering prevents the coupling out of energy which may be radiated promiscuously or

be fed back to the input or earlier stages to cause trouble. Energy fed back to the input circuit causes undesirable interaction in tuning, or self oscillation. If energy is fed back to the earlier stages, the trouble may be greater due to the larger power gain over several stages.

The layout for an audio stage follows similar general arrangements. See Fig. 7.

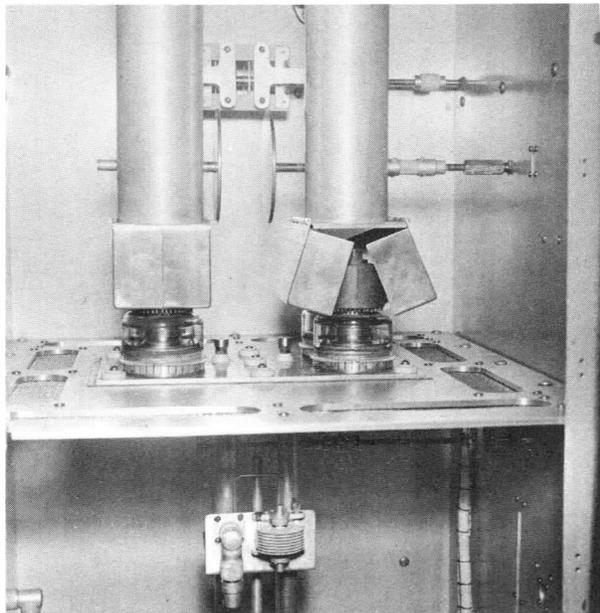


Fig. 5

Experimental push-pull parallel 110 Mc. 3 kw amplifier employing 4X500A tetrodes. Designed and built by Eitel-McCullough Laboratories.

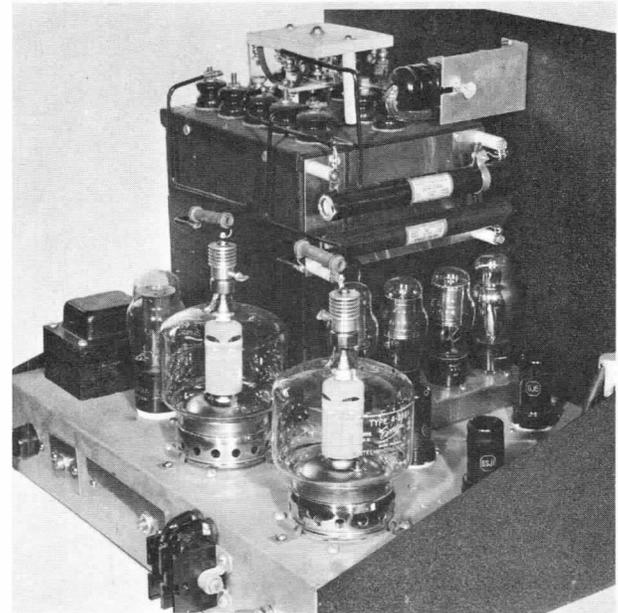


Fig. 7

Experimental 500 watt Class-AB₁ audio amplifier. Designed and built by Eitel-McCullough Laboratories.

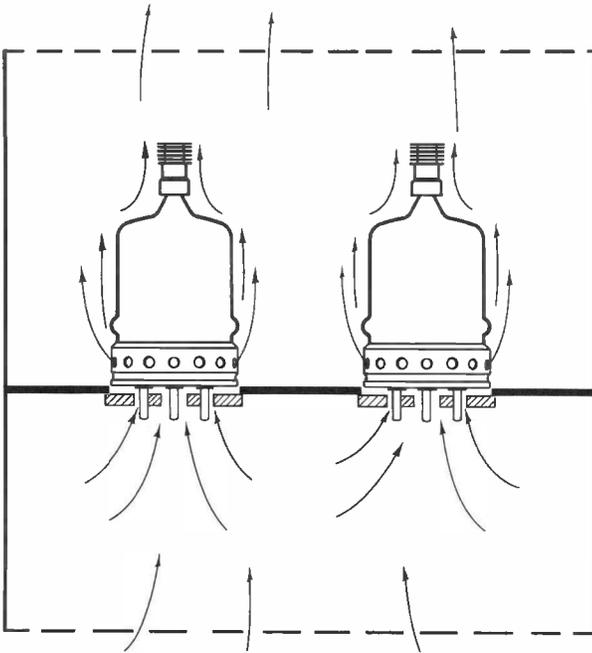


Fig. 8

4-125A mounting providing cooling, shielding and isolation of output and input compartments.

B-1-b. Air Cooling

If the flow of cooling air is upward it will be consistent with the normal flow of convection currents. See Figs. 8 and 9. In all cases the socket is an open structure or has adequate vent holes to allow cooling of the base end of the tube. Cooling air enters through the grid circuit compartment below the socket through a screened opening, passes through the socket cooling the base end of the tube, sweeps upward cooling the

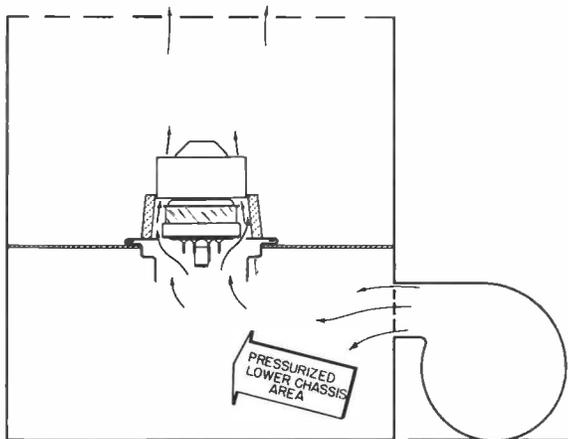


Fig. 9

4X150A chassis mounting providing cooling, shielding and isolation of output and input compartments.

glass envelope and into the output circuit compartment. The output compartment also has a mesh-covered opening which permits the air to vent out readily. These arrangements apply whether the tube is cooled by forced air or convection circulated air. If the tube is to be forced-

air cooled, a suitable fan or blower is used to pressurize the compartment below the tubes. No holes should be provided for the air to pass from the lower to the upper compartment other than the passages through the socket and tube base. Some pressure must be built up to force the proper amount of air through the socket. In the case of convection cooling, open louvers or screened areas permit ready entrance of cool air, and all access holes or vents should have large areas to provide a minimum resistance to the flow of air.

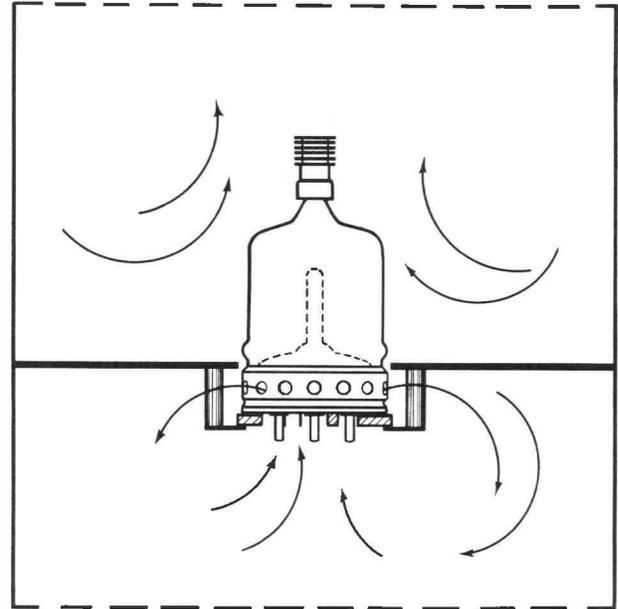


Fig. 10

DO NOT SUB-MOUNT A METAL BASE SHELL TUBE. Base cooling is prevented and no improvement in shielding results.

DO NOT SUB-MOUNT A TUBE WITH METAL BASE SHELL SO THAT THE CHASSIS DECK OR MOUNTING DECK COMES UP ABOVE THE VENT HOLES OF THE BASE SHELL OF THE TUBE. See Fig. 10. No improvement in isolating output and input circuits results, and such an arrangement *prevents* the flow of cooling air, whether forced or by convection currents. If a tube must be recessed into the mounting deck because of space limitations, a recessing cylinder with wide clearances should be used to permit the air from the base holes to vent into the compartment above deck.

The method shown in Figs. 8 and 9 of supplying the cooling air to the tube has worked successfully, provided the desired flow is obtained, and it is to be preferred over methods which try to force cooling air transversely across the tube base.

SECTION B

In the case of the 4X150A, 4-400A, and 4-1000A tetrodes, there are available complete air system sockets. See Fig. 11. These permit cooling air to be blown axially onto the base of the tube, through or past the base, confined by a suitable chimney to cool the glass portion of the tube, and then forced onto the plate terminal or through the anode cooler. This combined system permits a single stream of air to cool a tube completely in a manner determined to be well balanced by the manufacturer. Since the air channel is well defined and its resistance to the flow of air standardized, a simple measurement of the air pressure at the input indicates the proper flow of air. This assumes that there are no other air flow restrictions.

B-2. Component Parts

If one is to maintain the isolation of the output and input circuits indicated on the general layout, there must be some thought given to the location of the component parts. All component parts of the grid or input circuit and any earlier stages must be kept out of the plate circuit compartment. Similarly, plate circuit parts must be kept out of the input compartment. It must be noted, however, that the screen lead of the tube and connections to it via the socket are common to both the output and input resonant circuits. Due to the plate-screen capacitance of the tube, the r-f plate voltage (developed in the output circuit) causes an r-f current to flow out the screen lead to the chassis. In the case of a push-pull stage, this current may flow from the screen terminal of one tube to the screen terminal of the other tube. Similarly, due to the grid to screen capacitance of the tube, the r-f voltage in the input circuit will cause an r-f current to flow in this same lead to chassis, or to the opposite tube of the push-pull circuit.

Curiously enough, the inductance of this lead, common to both the output and input circuits, has the desirable feature of providing voltage of opposite polarity to neutralize the feedback voltage of the residual plate to control-grid capacitance of the tube. (This is discussed under section D-2 "Neutralization".) It should be noted, however, that the mutual coupling from the screen lead to the input resonant circuit might possibly be a source of trouble if accentuated.

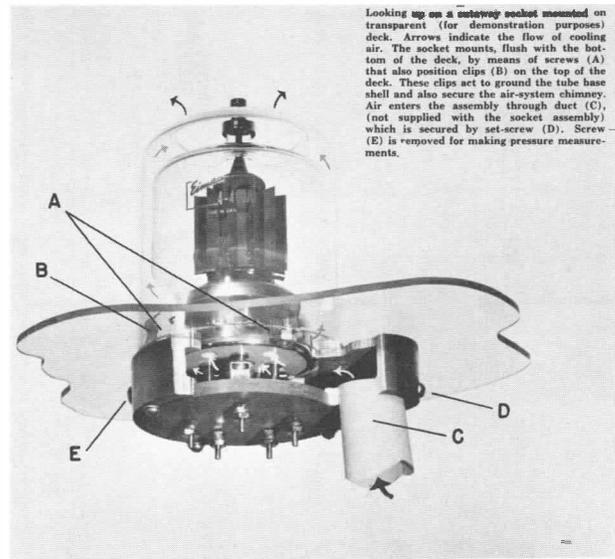


Fig 11

Eimac 4-400A/4000 Air System Socket providing balanced tube cooling by a single stream of air.

Parasitic oscillations are usually unavoidably present in new designs. Such parasitic oscillations result from the minor characteristics of some of the lead wires and circuit components and such incidental circuits must be altered to prevent their occurrence. This is a straight-forward "de-bugging" and will not affect the performance of the fundamental frequency.

Thus, after the general arrangement of the layout of the new amplifier is known, the location of the component parts is the next step. No attempt is made to discuss details other than those which are peculiar to power tetrodes.

No given layout can be guaranteed to be a cure-all for trouble. It is believed that certain basic ideas and arrangements can be considered as good practice, which will make "de-bugging" easier. Certain of the component parts might just as well be laid out following one of these arrangements.

The photographs of equipment are examples of good layout. The bypassing arrangements near the tetrode socket illustrated in Figs. 12, 13 and 14 are examples of successful arrangements. They are not presumed to be perfect nor the only possible good arrangements.

B-3. Lead Lengths

Some of the inter-connecting lead wires close to the tube should be made extremely low inductance to minimize the chances of forming possible VHF parasitic circuits. If two or more tubes are used they should be placed reasonably

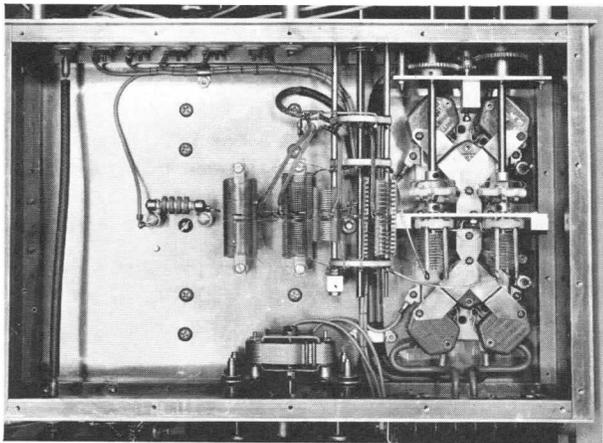


Fig. 12

Underside of push-pull multi-band r-f amplifier employing 4-250A tetrodes. Designed and built by C. F. Bane (W6WB)⁵.

close together to help provide short inter-connecting leads. The lead lengths of radio frequency circuits involving the fundamental frequency can usually be much longer and will depend a good deal on the frequency of the fundamental. All of the d-c, keying, modulating, and control circuit wires can be quite long, if properly arranged, and so be kept away from the active r-f circuits.

The following inter-connecting leads in a tetrode power amplifier should preferably have quite low inductance: the filament and screen bypassing leads, the leads from grid and plate to the tuning capacitor of the r-f circuit and return, and the inter-connections from tube to tube in push-pull or parallel arrangements. For a lead to have low inductance, it must have a large surface and be short in length, as in a strap or a ribbon. This consideration also applies to that portion of a lead inside of a bypass capacitor.

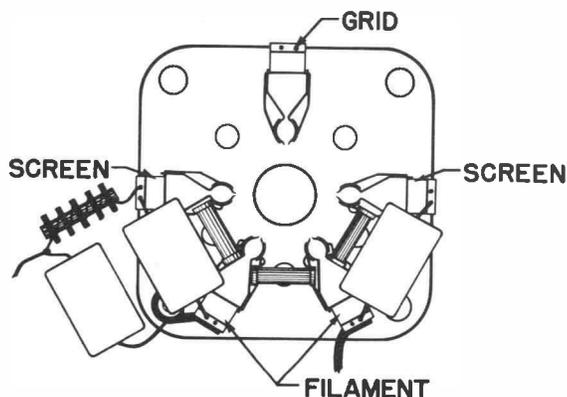


Fig. 13

Typical socket bypassing of screen and filament terminals as used by C. F. Murdock (W6OMC). Note use of parallel low inductance ceramic and larger mica capacitors.

B-4. Filament Bypassing

Low inductance bypass capacitors should be used in bypassing the filament. It is good practice to place one directly between the filament socket terminals. If the circuit allows it, strap one filament directly to the chassis, and if not, use a second bypass capacitor from one terminal to chassis.

If two or more tubes are in a push-pull or parallel circuit, one can use a short strap inter-connecting one of the filament terminals of each socket, Fig. 14c, g; or the tubes can be bypassed as in the single tube case, Fig. 14b, f. The mid-point of the inter-connecting strap can be bypassed or grounded directly.

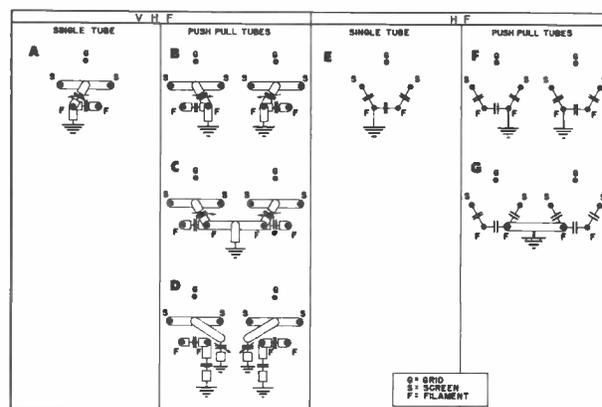


Fig. 14

Various screen and filament bypassing arrangements.

In case separate filament supplies are used, as in individual metering circuits, filament bypasses as shown in Fig. 14d have been found satisfactory.

With tubes having a completely isolating screen cone terminal such as the 4X500A and 4X150A, the general circuit arrangement is usually different. The filament or cathode should go directly or through bypasses to the cavity wall or chassis to which the screen terminal is bypassed. Typical cavities or arrangements are shown in Figs. 5, 6, 9 and 17. In the case of the 4X150A air system socket, the cathode terminals are secured to the mounting cup which also forms one plate of the screen bypass capacitor.

B-5. Screen Bypassing and Screen Series Tuning

Low inductance leads are generally advisable for screen terminal connections. For all frequencies it has been found good practice for the

SECTION B-C

screen bypass capacitor to go directly from screen to one filament terminal. This applies to tubes in push-pull as well as single tubes. In the VHF region the connection to the screen terminals should be made to the mid-point of a strap placed between the two screen terminals of the socket. This provides for equal division of the r-f current in the two screen leads and minimizes the heating effects.

Above the self neutralizing frequency of the tetrode (about 25 Mc. for the 4-1000A and around 80 Mc. for the 4-125A) the screen bypass capacitors are usually variable capacitors. (See section D-2 "Neutralization"). The variable capacitors are placed in the circuit at the same location as the bypass capacitors. Care should be taken to keep the inductance of the leads low.

The information in Fig. 14 and paragraphs

above apply directly to tubes having the screen grid mounted on internal supporting lead rods, as in the types 4-65A, 4-125A, 4-250A, 4-400A, 4X500F and 4-1000A.

The types 4X150A, 4X150G, and 4X500A have isolating screen cone terminals. These tubes seem to work best when the screen bypass capacitor is a flat sandwich type of capacitor (using silver coated mica for a dielectric) built directly onto the peripheral screen contacting collet of the socket. This arrangement is illustrated in Figs. 5, 6, and 17. Provided the screen contacting collets do not introduce appreciable inductance, it has been found that capacitors having values of about 800 micro-microfarads or greater are suitable for VHF and UHF frequencies. At lower frequencies the usual bypass capacitor values of about .001 to .003 mfd are suitable.

CIRCUIT CONSIDERATIONS

C-1. Basic Circuits

The basic circuits of tetrode amplifiers for both audio and r-f power amplifiers are in general similar to those for triode amplifiers. The tubes perform the same functions and differ principally in having much lower driving power requirements and much greater inherent isolation between output and input circuits. Such differences as exist in the details and associated circuits are discussed in the following paragraphs and sub-sections.

In designing the basic r-f circuits, reference should be made to the technical data sheet of the particular tube type for the electrode voltages and currents, and the output and driving power to be expected.

Because of the ability of the screen to assist in the flow of plate current, the grid can control a large plate current without going positive. For this reason low distortion audio amplifiers in class AB₁ are possible. Thus, the tube requires audio driving voltage only (with no grid current flowing) while delivering large audio power, such as 750 watts from a pair of 4-250A's or 3 kw from a pair of 4-1000A tetrodes. For such a circuit refer to Fig. 15 where a pair of receiving tubes in a resistance coupled, phase inverting circuit is all that is required to drive the tetrode. For a typical equipment design see Atkins & Mandoli', and Fig. 7.

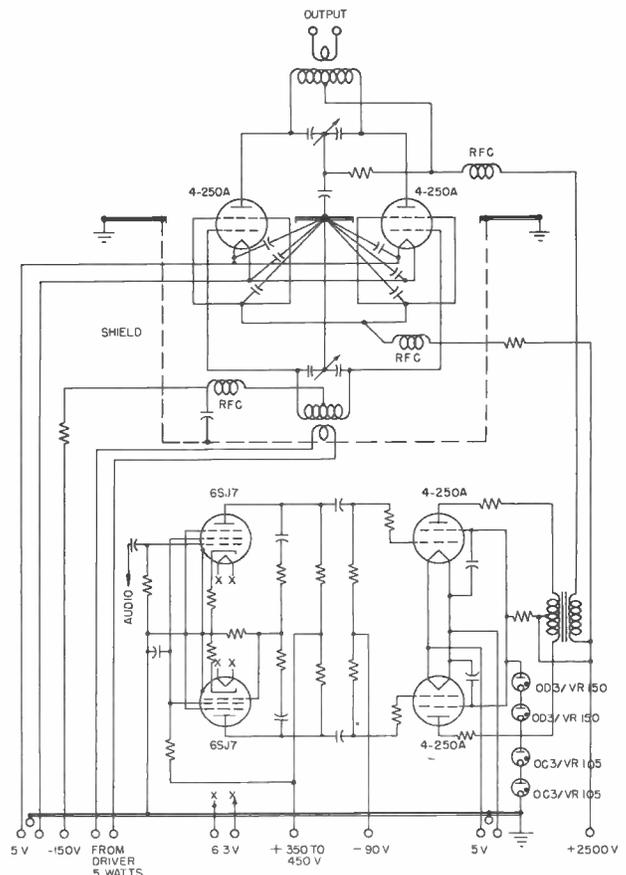


Fig. 15

Typical high-level-modulated r-f amplifier circuit with modulator and driver stages, 1000 watts input.

VHF circuits appear very simple and clean as shown in Figs. 3, 4, and 5. Care in bypassing and neutralizing (if required) is very important. For details see Sections B-4, B-5 and D-2. A typical schematic circuit is shown in Fig. 16. An understanding of transmission line circuits is helpful though no more necessary in tetrode circuits than triode circuits.

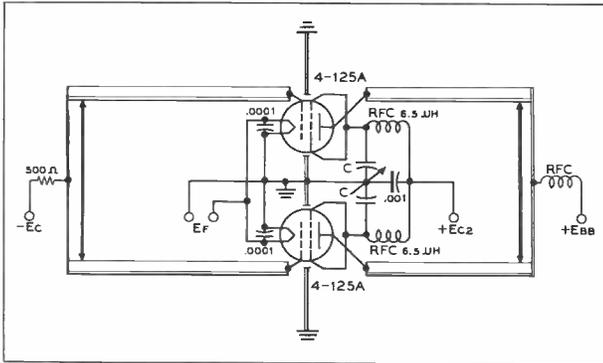


Fig. 16

Screen-tuning neutralization circuit for use above 100 Mc. with 4-125A tetrode.

Some tetrodes are able to operate well into the UHF region, and coaxial type cavity circuits are normally employed. In general, microwave and cavity techniques apply to the cavity construction. As indicated in Fig. 17, screen bypassing is introduced as part of the cavity construction.

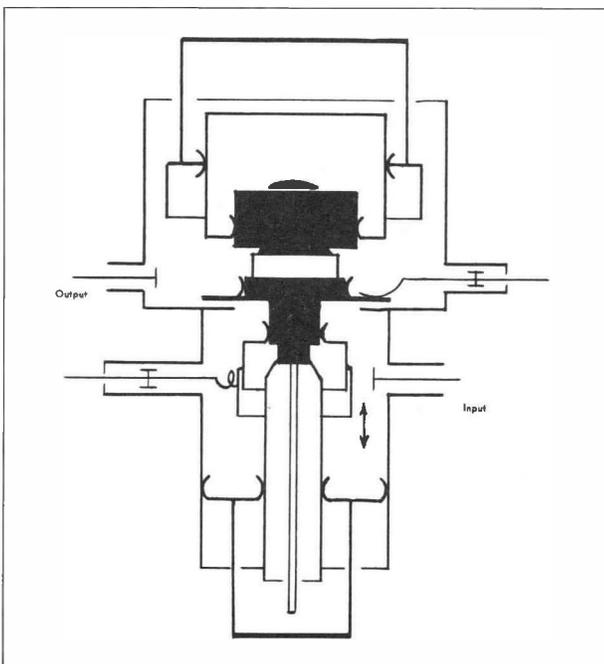


Fig. 17

Schematic cavity section of 1250 Mc. amplifier employing 4X150G tetrode.

C-2. Bypassing, Filtering, Screening

Essentially the requirements for confining the r-f energy to the desired circuits by bypassing, filtering, and screening are the same with tetrode power amplifiers as with triode amplifiers. See section B-1, 4, 5 and D-2 for discussion of best arrangements.

C-3. Power Supply Consideration

In general, power supply problems for the plate and grid are the same as for the triode amplifier. The need for screen voltage introduces some new considerations and provides some new possibilities.

Voltage for the screen grid of a power tetrode can readily be taken from the power supply used for the plate of the tube. In this case a series resistor, or potential dividing resistor, is chosen so that with the intended screen current the voltage drop through the resistor is adequate to give the desired screen voltage. It is, of course, possible to take the screen voltage from a low voltage supply, frequently using one already available in the equipment. There is considerable latitude so that an available voltage can be used. Sometimes a combination might be employed where a dropping resistor is used in conjunction with a low voltage or intermediate voltage supply. Frequently a combination of series resistor and voltage source can be chosen so that the rated screen dissipation will not be exceeded regardless of the variations in screen current. With a fixed screen supply, there are advantages in using an appreciable amount of fixed grid bias so as to provide protection against loss of excitation, or for cases where the driver stage is being keyed.

If the screen voltage is taken through a dropping resistor from the plate supply, there is usually little point in using a fixed grid bias because an unreasonable amount would be required to protect the tube if the excitation failed. When a screen dropping resistor is used, most of the bias is normally supplied through a grid resistor and other means are used for tube protection.

Under operating conditions with normal screen voltage the cut-off bias is low (about $1/5$ the screen voltage). When a stage loses excitation and runs statically, the screen current falls close to zero. (See static curves of tube in question.) If the screen voltage is obtained through a simple dropping resistor from the plate supply, the screen voltage will then rise close to full plate voltage. Because the cut-off bias required is proportional to the screen voltage, the grid bias required will be much greater than the amount of bias desired under normal operating conditions. For further discussion see C-4 "Protection" and C-5 "Keying".

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If the output power of a transmitter or amplifier stage is to be adjustable by varying the plate voltage, it is advisable to take the screen voltage through a dropping resistor from the plate supply. Then, as the plate supply voltage is raised or lowered, the screen voltage rises or falls also and the plate current will follow. Alternatively, the screen supply could be separate but with large series resistance to give poor regulation, and the changes in screen current would cause the screen voltage to rise or fall. It is necessary to have the plate current proportional to the plate voltage if the same loading adjustment (load resistance) is to serve for all power levels. If the plate current does not follow the plate voltage, the loading would have to be changed for each power level. This added control over the screen voltage is necessary because the plate current in a tetrode is principally controlled by screen voltage when excitation is present, and very little by plate voltage alone.

FIXED SCREEN SUPPLY		SCREEN VOLTAGE THROUGH DROPPING RESISTOR
FIXED GRID BIAS	RESISTOR GRID BIAS	RESISTOR GRID BIAS
All variable grid drive applications, i.e. Audio Amplifiers. Video Amplifiers. Linear R-F Amplifiers. Grid Mod. R-F Amp. Provides protection against loss of excitation, or keyed driver.	Screen Mod. R-F Amp. Reduces effects of excitation variations.	Plate Mod. R-F Amp. Variable loading applications. Power level adjustable by changing plate voltage. Protection can be had for loss of excitation or keyed excitor stage by using the screen voltage control of Fig. 20.

Fig. 18

Applications and circuits to which fixed and resistor type screen and grid supplies are best suited.

In Fig. 18 a chart summarizes some of the reasons for choosing either a fixed screen supply or dropping resistor type of screen supply. Similarly the type of the grid bias is important and should be chosen with both the application and the protection of the tube in mind. The d-c screen and grid currents are sensitive to changes in excitation and loading, and these changes affect the d-c grid and screen voltages if the supplies have appreciable internal resistance. These effects may be very beneficial if properly employed but in some cases are undesirable. For all variable grid drive applications a fixed screen supply and a fixed control grid bias are necessary. It should be noted, however, that for a plate modulated r-f amplifier, an r-f amplifier where a variable loading condition is expected, or where output power is to be controlled by changing plate voltage, a screen source with poor regulation is desirable, i.e., screen voltage obtained through a screen dropping resistor.

CIRCUIT FAILURE	FIXED SCREEN SUPPLY		SCREEN VOLTAGE THROUGH DROPPING RESISTOR	
	FIXED GRID BIAS	RESISTOR GRID BIAS	FIXED GRID BIAS	RESISTOR GRID BIAS
Loss of Excitation	No Protection Required	Plate Current Relay	Plate Current Relay	Plate Current Relay or Screen Control Circuit—Fig. 20
Loss of Antenna Loading	Screen Current Relay	Screen Current Relay	Grid Current Relay	Nothing Required
Excess Antenna Loading	Screen Under-Current Relay	Screen Under-Current Relay	Plate Current Relay	Plate Current Relay
Failure of Plate Supply	Screen Current Relay	Screen Current Relay	Grid Current Relay	Nothing Required
Failure of Screen Supply	Grid Current Relay	Nothing Required	—	—
Failure of Grid Bias Supply	Plate Current Relay or Screen Current Relay	—	Plate Current Relay Grid Current Relay	—

Fig. 19 Protection Chart

This chart indicates the location of a suitable relay which should act to remove the principal supply voltage from the stage or transmitter to prevent damage to the tubes.

C-4. Protection

Eimac tetrodes are designed to stand considerable abuse. For instance, the excess anode dissipation resulting from detuning the plate circuit of the tube will have no ill effects if not applied for periods of time sufficient to overheat the bulb and the seal structure.

Similarly the grid and screen will stand some excess dissipation. In the latter cases, however, the maximum dissipation indicated on the data sheet should not be exceeded except for time intervals of less than a second. The maximum dissipation rating of the grid and screen is usually considerably above the typical values used for maximum output so that ample operating leeway is provided. The time of duration of overloads on the control and screen grids is necessarily short because of the small heat storage capacity of the wires. Furthermore, grid temperatures cannot be seen, as in the case of the plate temperature, and no visual warning of accidental overload is had.

The type and degree of protection required in an r-f amplifier against circuit failures will vary with the type of screen and grid voltage supply. Fig. 18 indicates some of the inherent protection provided by certain types of supplies, and Fig. 19 presents a chart of protection as related to certain kinds of circuit failures. For screen voltage taken through a dropping resistor from the plate supply, a plate relay provides almost universal protection. For a fixed screen supply a screen relay provides protection in most cases, and, for protection against excess antenna loading and consequent high plate dissipation, a screen undercurrent relay should also be used. (Starting up in the latter case will, of course, require a temporary hold-in circuit.)

Plate, screen, and grid bias voltages may be applied simultaneously to a tetrode. Grid bias and excitation can usually be applied alone to the tube, especially if a grid leak resistor is used. Plate voltage can be applied to the tetrode before the screen voltage, with or without excitation to the control grid. NEVER APPLY SCREEN VOLTAGE BEFORE PLATE VOLTAGE. The only exceptions would be when the tube is cut off so that no space current (screen or plate current) will flow, or the excitation and screen voltage are low. If screen voltage is applied before the plate voltage and space current can flow, the maximum allowable screen dissipation will almost always be exceeded and damage to the tube will result.

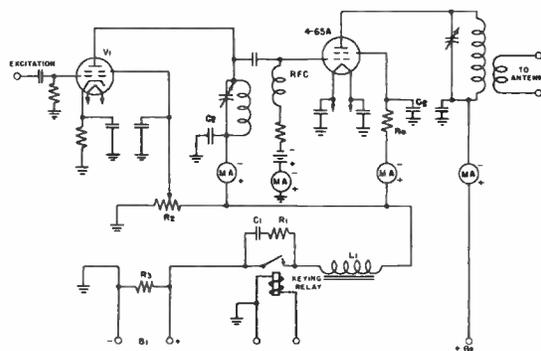


Fig. 21

Tetrode amplifier keying circuit used by B. O. Ballou (W6BET)⁴.

C-5. Keying

The tetrode power amplifier can be keyed using the same basic principles employed with any power amplifier. In addition, the screen electrode provides another low power circuit where keying can be introduced. Suitable filters, of course, must be used so that the make and break is slow enough to avoid high frequency sidebands known as "key clicks". The usual "key click" filter techniques apply.

There are several good methods of controlling the tetrode r-f power amplifier when exciter keying is used. With the screen voltage fixed and with fixed bias greater than cut-off, the tube will pass no current when the excitation is removed.

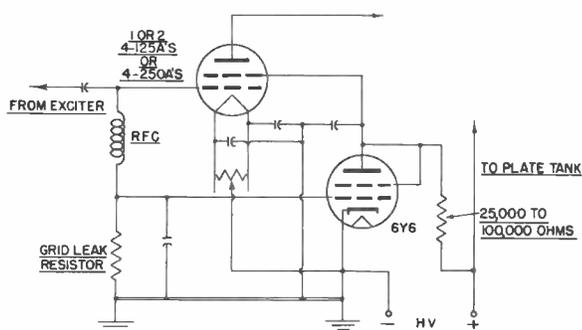


Fig. 20

Screen voltage control circuit for exciter keying or protection against loss of excitation when supplying screen from high voltage source

It is also possible to key the exciter stage when the screen voltage is taken through a dropping resistor and grid leak bias is used. See Fig. 20. In this system a high transconductance, low mu triode is connected between screen and cathode, and the controlling bias for the small triode is taken from the tetrode bias developed in the grid leak resistor. When normal excitation is present on the tetrode r-f amplifier and grid bias is developed, the triode control tube is cut off and the screen voltage circuit operates normally. If excitation voltage is removed from the tetrode power amplifier, the bias voltage developed in the resistor drops to zero and the control triode becomes conducting. The current drawn by the triode control tube will increase the IR drop in the screen dropping resistor and lower the screen voltage to a very low value.

There is still some screen voltage on the tetrode and a small static plate current flows which, however, is usually not enough for the plate dissipation rating to be exceeded. This value can be reduced further by putting a second control triode in parallel with the first (also a smart precaution against failure of the single triode), by putting a gas regulator tube in series with the lead to the screen before the screen r-f bypass capacitor, or by introducing a small amount of fixed bias on the tetrode between the grid resistor and the tetrode grid. These procedures are usually not required. In fact, the static plate current gives a desirable bleeder action for the plate supply.

Fig. 21 shows a method of keying a tetrode r-f power amplifier where the low voltage power supply for the screen of the tetrode and for the plate and screen of the driver stage is

keyed directly. The circuit is described by Ballou^{2, 11}. This permits keying in a relatively low voltage, low current circuit. The key click filter capacitor, resistor, and choke are simple and assure positive control of the keying wave shape.

C-6. Modulating

A tetrode r-f amplifier can be amplitude modulated in all the usual ways: plate modulation, screen modulation, grid modulation, or cathode modulation. Of these, plate modulation is the type most extensively used, and a discussion of several simple methods of obtaining simultaneous modulation of the screen will be helpful in this respect.

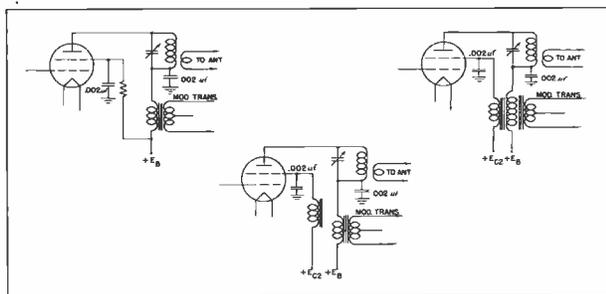


Fig. 22

Basic high-level-modulating circuits for tetrodes.

Fig. 22 shows three of the basic plate modulation (or high level modulating) circuits, and Fig. 15 shows a complete schematic involving a plate modulated r-f amplifier and the audio modulator stage, using a pair of 4-250A tetrodes to modulate a pair of 4-250A tetrodes.

In plate modulation it is necessary to introduce not only amplitude modulation of the plate voltage, but also to develop about 70% amplitude modulation of the screen voltage of the tube as well, for 100% carrier modulation. Modulation of the screen voltage can be developed in one of the following three ways:

1. By supplying the screen voltage through a dropping resistor connected to the unmodulated d-c plate supply.
2. When a low voltage fixed screen supply is used, a modulation choke is placed in series with the supply. In the case of voice modulation this is about a 10 henry choke.
3. A third winding on the modulation transformer designed to develop the required screen modulation voltage.

It is interesting to note that in all three cases the screen of the tetrode tube supplies the necessary audio power. During the portion of the modulation cycle when the plate voltage is increased, the screen current decreases. If the screen is supplied through an impedance such as the screen dropping resistor, or modulation choke, the voltage drop in this series impedance becomes less and the screen voltage rises in the desired manner. On the other part of the modulation cycle when the plate voltage is decreased, the screen current increases causing a greater voltage drop in the screen series impedance, thus lowering the voltage on the screen of the tube.

It will be noted that in the plate circuit as the plate voltage increases, the plate current increases, which requires power to be supplied from the audio modulator. In the screen circuit however, as the screen voltage increases, the screen current decreases. This corresponds to audio power being supplied from the tetrode and d-c screen voltage source, and delivered to the dropping resistor or series impedance. In the case of the modulation transformer the power is supplied back to the audio source. In all cases, this power is a few per cent of the plate power input to the tube and is therefore negligible.

Where modulation voltage appears on an electrode of a tube, the r-f bypass capacitor of this electrode should be kept to about .002 mmfd or less in order to avoid bypassing high modulation frequencies.

In grid modulation or screen modulation, where 100% modulation capabilities are desired, the tube efficiency under carrier conditions is about half that expected in the r-f amplifier when plate (high level) modulation is used. This efficiency is usually on the order of 35% and thus grid or screen modulation is not used unless there is a desire to save on the physical size of the modulation source.

When grid modulation is used, the screen voltage and grid bias must be taken from sources with good regulation. This usually means a separate low voltage power supply source. In the case of screen modulation, the grid bias should be taken from a grid leak bias resistor. The procedure in screen modulation is otherwise similar

to the standard procedure of modulating with an electrode other than the plate. The r-f amplifier is adjusted to good class-C operating conditions, and then the grid bias is increased, or the screen voltage is reduced, until the output antenna current falls to half its former value. This gives a

carrier condition which will permit 100% amplitude modulation. Under these conditions the unmodulated carrier power is about $\frac{1}{3}$ that of the corresponding unmodulated class-C amplifier. The grid bias or screen voltage can then be modulated up and down about this carrier point.

CIRCUIT ADJUSTMENT AND CHOICE OF OPERATING CONDITIONS

D-1 Stabilizing the Amplifier

At this point it is assumed that the amplifier has been built, supply and control circuits tested out, the filament voltage checked at the tube sockets, air cooling is correct, and the grid and plate circuits resonate at the desired frequency. The next step is to apply voltage to the amplifier and test for stability.

D-1-a. Testing for Parasitic Oscillations

In the case of the tetrode r-f power amplifier, it will be necessary to investigate not only for the possibility of self oscillation, but lack of feedback on the fundamental frequency. The basic steps of checking for self oscillation are three fold:

1. The amplifier should be operated without r-f excitation and without fixed grid bias, with light loading and with low voltages applied to the screen and plate. The voltage should be high enough to develop full plate dissipation, however. For this test grid leak bias should be used. If the screen and plate voltage supplies cannot be adjusted directly to low voltages, suitable series resistance should be used, either in series with the rectifier output or transformer primary so that the voltages developed at the tube will be low. (Simple light bulbs of the right size will serve as resistors in series with the primary of the rectifier transformers.) The r-f circuits should be tuned off resonance to see if self oscillation of the amplifier can be started. The presence of any current on the grid milliammeter means that self oscillation is present.
2. By means of a wave meter the frequency of self oscillation of the r-f power amplifier is found.

3. The circuit supporting the self oscillation must be determined and altered so that such oscillations cannot exist, and without disturbing the performance on the normal frequency of the amplifier.

The subject of parasitic oscillations in amplifiers has been well covered in the literature, and the following references will be helpful: Mix³, Fyler⁴, Bane⁵.

D-1-b. Correction of Parasitic Oscillation

The usual self oscillations in r-f power amplifiers have been found to fall in the following three classes:

1. Oscillation at a VHF frequency from about 40 to 150 Mc., regardless of the normal frequency of the amplifier.
2. Self oscillation on the fundamental frequency of the amplifier.
3. Oscillation at a low radio frequency below the normal frequency of the amplifier.

The low frequency oscillation in an amplifier usually involves the r-f chokes, especially when chokes are used in both the output and input circuits. Because the possible feedback coupling in a tetrode is negligible at such low frequencies, this type of oscillation due to feedback through the tube is generally not found in the tetrodes under discussion.

Oscillation near the fundamental frequency, if it occurs, involves the normal resonant circuits, and brings up the question of neutralizing the r-f power amplifier. This general subject is discussed thoroughly under "Neutralization" section D-2.

In case a parasitic self oscillation is found on a very high frequency, the inter-connecting leads of the tube, the tuning capacitor and by pass capacitors are involved. This type of oscillation does not usually occur when the power amplifier is designed for operation in the VHF region

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and where the r-f circuits external to the tube have negligibly small tuning capacitors. Without tuning capacitors the highest-frequency oscillating circuit possible is then the fundamental and there would be no higher frequency circuit available for the parasitic. (The only exception would be where higher order modes of line circuits might provide a parasitic circuit. However, little trouble has been found in this respect.)

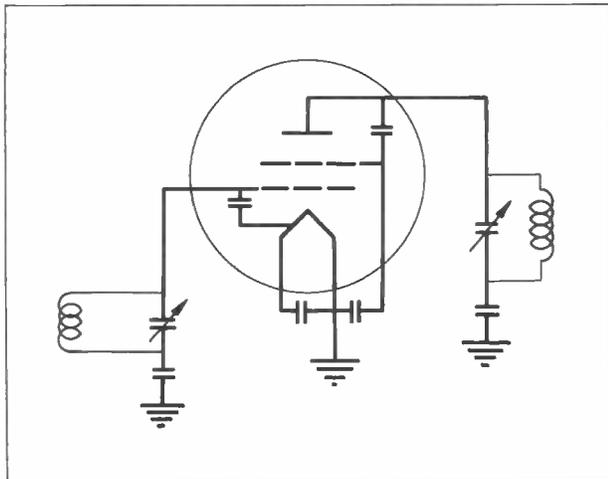


Fig. 23

Usual circuit supporting VHF parasitic oscillation in HF r-f amplifiers.

The VHF oscillation occurs commonly in amplifier constructions where the radio frequency circuits are composed of coils and capacitors, as in the HF and LF region. As will be seen in Fig. 23, the parasitic oscillation uses the capacitors of the fundamental resonant circuit as bypass capacitors, and the associated grid and plate leads for the inductances of the parasitic circuit. The tube capacitances help form the tuned-plate tuned-grid oscillation circuits. The circuit is indicated by the heavy lines in Fig. 23.

There are several straight-forward ways to suppress the VHF parasitic oscillation. In general, it will probably be more easily suppressed if the general layout and bypassing methods indicated earlier are followed.

It turns out that the frequency usually met in a VHF parasitic oscillation is well above the self neutralizing frequency of the tube. (See D-2-b "Analysis of Neutralizing Circuits".) However, if the self neutralizing frequency of the tube can be increased and the frequency of the parasitic lowered, complete suppression of the parasitic may result, or its suppression by resistor-coil parasitic suppressors made easier.

The following table lists the usual frequency around which the VHF parasitic may occur with usual circuit lead lengths:

4-1000A	90-110-Mc.
4X500F	130-145 Mc.
4X500A	Approx. 225 Mc.
4-400A	130-150 Mc.
4-250A	130-150 Mc.
4-125A	130-145 Mc.
4-65A	130-170 Mc.

It is also possible to predict fairly closely with a grid dip wavemeter the frequency to be expected in a given equipment. The circuit should be complete and no voltages on the tube. The grid terminal may be strapped to the filament or screen because the grid circuit does not usually seem to be involved. Couple the meter to the plate or screen lead.

The following two methods of eliminating the VHF parasitic oscillation have been used successfully:

1. By placing a small coil and resistor combination in the plate lead between the plate of the tube and the tank circuit. See Fig. 24. The resistor-coil combination is usually made up of a non-inductive resistor of about 50 to 100 ohms, shunted by 3 or 4 turns about $\frac{1}{2}$ " in diameter and frequently wound right around the resistor. In some cases it may be necessary to use such a suppressor in both the plate and grid leads. The resistor coil combination operates on the principle that the resistor loads the VHF circuit but is shunted by the coil for the lower fundamental frequency.

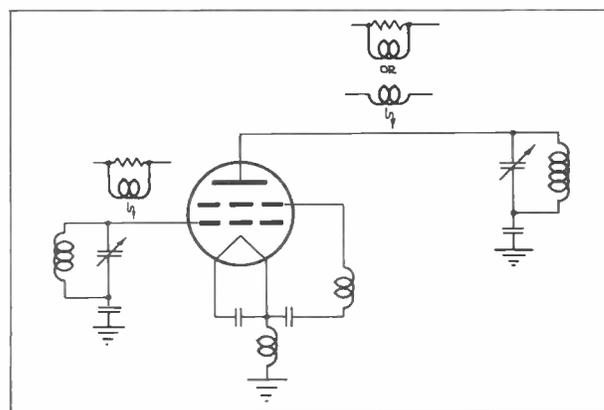


Fig. 24

Placement of parasitic suppressors to eliminate VHF parasitic oscillations in HF r-f amplifiers.

2. By the use of small parasitic chokes in the plate lead. See Fig. 24. The size of this coil will vary considerably depending upon the tube and the circuit layout, and may run from about 4 to 10 turns of about a $\frac{1}{2}$ " diameter. Apparently, the presence of this choke in the frequency determining part of the circuit lowers the frequency of a possible VHF parasitic so that it falls near the self neutralizing frequency of the tube and bypass leads. (See D-2-b "Analysis of Neutralizing Circuits.") In addition to varying the size of the suppressor choke, the amount of inductance common to the screen and filament in the filament grounding strap may be a factor. This can be varied simultaneously with the suppressor choke.

Of the two methods indicated above for suppressing VHF parasitic oscillations, the first one is probably the simpler to use and has been widely employed. No detailed study has been made of the circuits involved in the second method, but the method has been used successfully as indicated by Mix³ and Bane⁵. A further discussion of the theory believed active in the second case is given under section D-2 "Neutralization".

The procedure of checking for self oscillation in an r-f power amplifier described above in section D-1 will normally show up most trouble and allow for its correction. If, however, the correction is marginal it may sometimes happen that under operating conditions the self oscillation will be triggered off. The oscillation may occur only on the peaks of amplitude modulation or on keying surges. By observing the r-f envelope on a cathode ray oscilloscope, the oscillation can usually be seen. The trouble can be fully eliminated by pursuing further the corrective procedures outlined under D-1-b above.

A more difficult self oscillation to locate is one occurring on a harmonic of the fundamental frequency and occurring only when the stage is operating. It will show up when testing for the presence of abnormal power in the harmonics under operating conditions.

In the case of an audio amplifier employing tetrodes, small non-inductive resistors of about 100 ohms resistance should be placed in series with the plate, and possibly the grid as well, in case self oscillation of the amplifier occurs in the very high frequency portion of the r-f spectrum. Should the audio or d-c voltage drop in the resistor be objectionable, it can be shunted with a small coil.

D-2. Neutralization

Whether or not a tetrode should be neutralized seems to be an open question. As stated previously, the feedback within tetrodes is a very small fraction of the feedback present in triodes. In a great many cases the isolation provided by a tetrode is enough so that there is no need to use any neutralization to counteract the negligible feedback. This applies to all low frequency r-f amplifiers. Whether or not neutralization should be used in the HF, the VHF and UHF regions depends entirely upon the particular tube type, the operating conditions and the desired isolation of output and input circuits. In the case of tubes having isolating screen cone terminals, as for instance the 4X150A and 4X150G, no neutralization has been found necessary up through their highest useful amplifier frequency, approximately 500 Mc. and 1000 Mc. respectively. In the case of the 4X500A, also employing the isolating screen cone terminal, it is occasionally found desirable to use neutralization at 100 Mc., though this is frequently not necessary. In the case of tetrodes having internal screen support lead rods, such as the 4-125A and 4-250A types, the need to employ neutralization in the HF region may be found in amplifiers operating with high power gain and high plate voltages, if complete isolation of output and input circuits is desired. Frequently it is not necessary.

At frequencies below the VHF region, neutralization usually employs a capacitance bridge circuit to balance out the feedback due to the residual plate to grid capacitance. This assumes that the screen is well bypassed to ground and so provides the expected screening action. In the VHF and UHF regions the screen is not necessarily at r-f ground potential and the neutralizing circuit becomes more involved. For suitable VHF circuits and simple explanation, see Section D-2-b "Analysis of Neutralizing Circuits".

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If neutralization on the fundamental frequency below the VHF region is found desirable, normal cross-neutralization of push-pull amplifiers is simplest. The neutralizing capacitors are small and each capacitor need only be a wire connected to each side of the grid circuit, brought through the chassis deck, and allowed to "look" at the plate of the tube on the opposite half of the circuit. This is illustrated in Fig. 2. The wire or rod can be $\frac{1}{2}$ " to 1" away from the glass, and by adjusting its length or spacing the last trace of coupling can be eliminated from the amplifier. A simple insulating collet mounted on the chassis deck will support the wire or rod and allow it to be adjusted.

In the case of a single-ended stage, either a push-pull output or a push-pull input circuit can be used to provide the out-of-phase voltage necessary for neutralization. Because of the low voltage and the small size of the r-f input circuit, it is usually simpler to make the input circuit push-pull, and the circuit becomes a "grid neutralization" circuit. See Fig. 25. The neutralizing capacitor, C_n , is again very small and similar to those described above under cross-neutralization. To maintain the balance of the input circuit while tuning, it is desirable to have a padding capacitor, C_i , equal in size to the input capacitance of the tetrode.

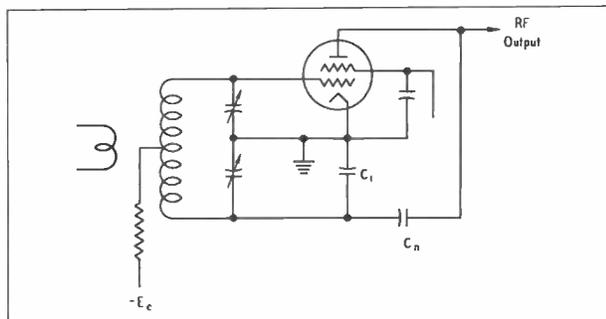


Fig. 25

Push-pull grid neutralization, basic circuit.

Single-ended r-f stages can also be easily grid-neutralized without using a conventional push-pull input circuit. See Fig. 26. In this method described by Bruene⁶, the input resonant circuit is taken off ground a small amount by making the input circuit bypass capacitor, C , somewhat smaller than usual. The voltage to ground across capacitor, C , is out of phase with the grid voltage and can be fed back to plate to provide neutralization. In this case the neutralizing capacitor, C_n , is considerably larger than the capacitance plate to grid and is about the size of those used for neutralizing triodes.

The basic circuit of the Bruene method is shown in Fig. 26a. It can be redrawn as a capaci-

bridge showing clearly the grid neutralization circuit. See Fig. 26b. Balance is had when
$$\frac{C_n}{C} = \frac{C_{gp}}{C_{gf}}$$
 where C_{gp} is the feedback capacitance grid to plate of the tetrode, and C_{gf} is the total input capacitance, including tube and stray capacitance.

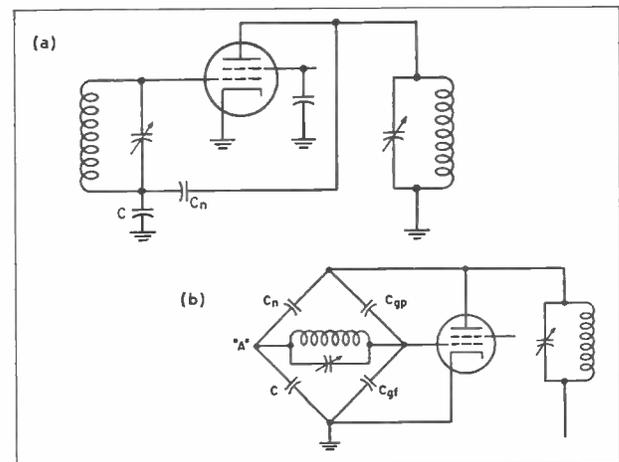


Fig. 26

Single-ended grid neutralization described by Bruene⁶.

a) Basic Circuit. b) Arranged as capacitance bridge.

Single-ended amplifiers can also be neutralized by taking the plate circuit a small amount off ground as was done in the single-ended grid neutralizing scheme, and by using the tube capacitances as part of the bridge circuit. This method has been described by Hultberg⁷.

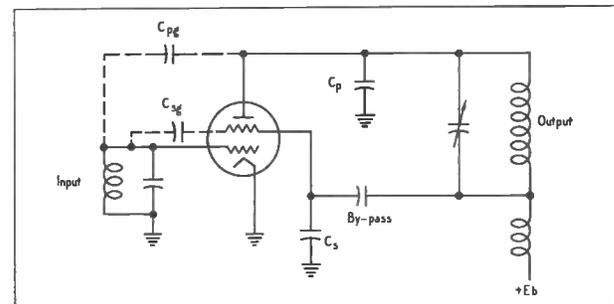


Fig. 27

Single-ended plate neutralization, basic circuit. See Hultberg⁷.

Such a circuit is shown in Fig. 27. It differs from the usual r-f amplifier circuit in that the plate bypass capacitor is returned to the screen side of the screen bypass capacitor, C_s , and in adding stray capacitance from plate to ground, C_p . The size of screen bypass capacitor, C_s , and the amount of stray capacitance in C_p are chosen to balance out the voltages induced in the input

circuit by the internal tube capacitances plate to grid, C_{pg} , and screen to grid, C_{sg} .

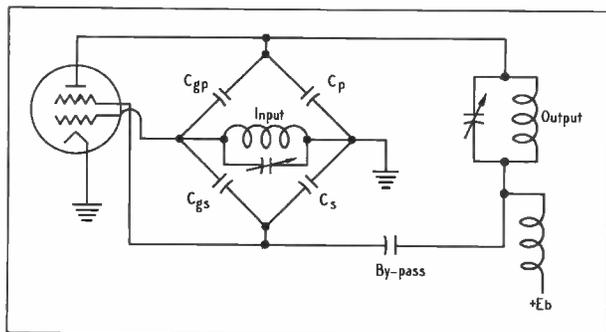


Fig. 28

Single-ended plate neutralization showing capacitance bridge circuit present.

The circuit is redrawn in Fig. 28 in the usual bridge circuit form. Balance is had when

$$\frac{C_p}{C_s} = \frac{C_{pg}}{C_{gs}}$$

In usual tetrode structures the capacitance from screen to grid is roughly half the published tube input capacitance. (The tube input capacitance is mainly the sum of the capacitance of the grid to screen and the capacitance grid to cathode. Since as a first guess these two capacitances are roughly equal, one is not far off in using half the listed tube input capacitance.)

It should be noted that in all neutralizing capacitance bridge circuits it is assumed that the frequency is low enough so that inductances in the connecting leads and tube structures can be neglected. This is usually not the case in the VHF region, especially in single-ended tetrode stages where bridge circuits balance with a very small voltage in part of the bridge circuit. At VHF the small amount of voltage developed in the residual inductance of the screen circuit can be enough to accomplish neutralization in itself. See section D-2-b "Analysis of Neutralizing Circuits."

D-2-a. Procedure

The neutralizing process for tetrodes follows the standard procedure. The first step in rough adjustment is to break the d-c connections of the plate voltage and screen voltage leaving the r-f circuits intact. (If the d-c current path is not broken, some current is found to flow in either one of these circuits even though their voltages are zero, and the presence of this current causes the amplifier to work in the normal

manner, generating r-f power in the plate circuit. It will then be incorrect to adjust for zero power in the plate circuit.)

As an indicator of neutralization adjustment, one can use either a sensitive r-f meter coupled to the plate circuit or observe the reaction on the grid current as the plate circuit is tuned. When the plate circuit is tuned through resonance, the grid current will dip when the circuit is out of neutralization in the same manner as it does with triode neutralization adjustments. The neutralizing circuit is adjusted until the indication has been reduced to a minimum.

For the final trimming of the neutralization adjustment, the stage should be returned to operating condition at reduced power similar to that used when testing for parasitic oscillations, or under the final loaded operating conditions. At the higher frequencies and in the VHF region, it will be found that a small additional trimming adjustment of the neutralizing circuit is usually required. When the plate circuit is tuned through resonance, the minimum plate current and maximum control grid current should occur simultaneously. The d-c screen current should be maximum at the same time.

The neutralizing procedures indicated above apply not only to the HF radio frequencies, but also apply in the VHF or UHF regions. In the latter cases the neutralizing circuit is different and the conventional cross-neutralization schemes will not be applicable. See below.

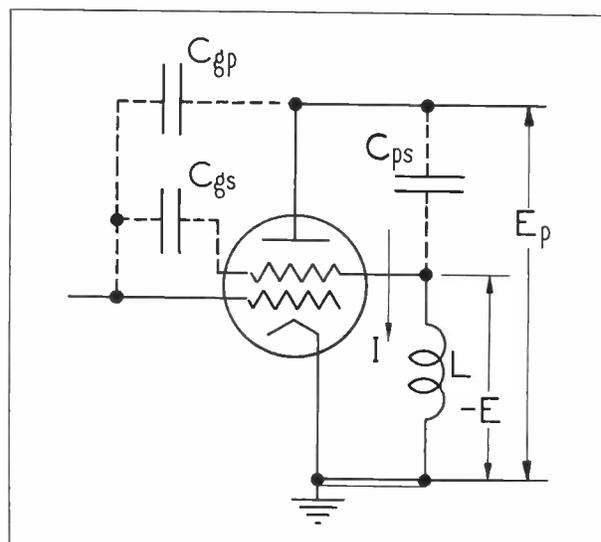


Fig 29

Tetrode characteristics involved in feedback circuit.

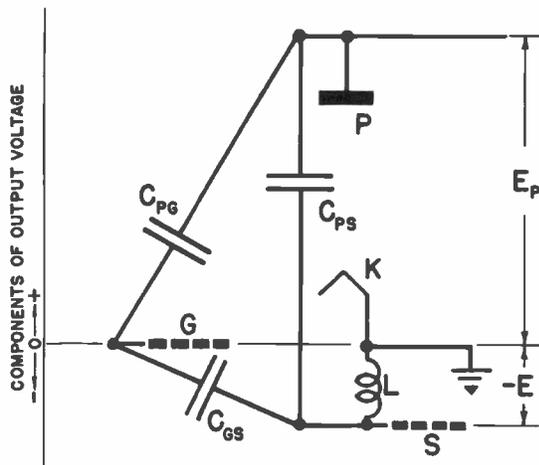


Fig. 30

Graphical presentation of components of output circuit voltages in tetrode when self neutralized.

D-2-b. Analysis of Neutralizing Circuits

Careful analysis of the feedback circuits of tetrodes in the VHF region has been made⁸ and the basic concepts follow. In Fig. 29 the tetrode circuit elements involved in the feedback circuits are indicated. These circuit elements are inherent and inside the vacuum enclosure of the tube, and involve the residual capacitance plate-to-grid, the capacitance from plate to screen, the capacitance from screen to grid, and the inductance of the screen lead to the tube. It will be noted that the r-f voltage developed in the plate circuit E_p causes a current I to flow through the plate to screen C_{ps} , and the inductance L in the screen leads. The passage of this current through the inductance L develops a voltage $-E$ which has a polarity opposite to that of the plate voltage E_p .

In Fig. 30 these same circuit elements and voltages have been arranged with a graphical representation where the height above or below the zero line represents magnitude and polarity of the r-f voltage of that part of the circuit with respect to zero or filament voltage. Because all of the circuit components involved are pure reactances, the voltages are either in phase or out of phase and so can be represented as positive and negative with respect to each other. The voltages plotted are the components only of the r-f output circuit voltage E_p and no attempt is made to show the normal driving voltage on the grid. The plate "P" is shown at a high positive potential above zero and the magnitude is represented by

the distance above the zero line as shown by the dimension E_p . The voltage developed in the screen lead inductance places the screen at a negative voltage with respect to the plate voltage. The screen of the tube "S" is shown to be below the filament line, or negative, by the amount $-E$. If the circuit were perfectly neutralized, the control grid "G" would lie on the zero potential line or at filament potential insofar as any action of the r-f plate voltage " E_p " on the input circuit is concerned. If there is no component of output voltage developed between grid and filament, the circuit is neutralized.

The total r-f voltage between plate and screen comprises plate voltage E_p and screen lead inductance voltage $-E$. This total voltage is applied across a potential divider consisting of the capacitance plate to grid, C_{pg} , in series with the capacitance grid to screen, C_{gs} . When this potential divider is suitably matched to the magnitudes of the voltage E_p and screen lead voltage $-E$, the control grid will have no voltage difference to filament as a result of the output circuit voltage E_p .

It should be noted in Fig. 30 that the potential dividing action between capacitances plate-to-grid, C_{pg} , and grid-to-screen, C_{gs} , will not be affected by the operating frequency. It should be noted also that the division of voltage between plate and screen and screen and ground due to the charging current, I , will vary greatly with frequency. There will, therefore, be some particular frequency at which this potential dividing circuit places the grid at filament potential as far as the plate circuit action is concerned, and this is called the *self neutralizing frequency* of the tetrode. At this particular frequency the tetrode is inherently neutralized due to the circuit elements within the tube structure and any external added screen lead inductance to ground. Typical self neutralizing frequencies with normal screen by-passing circuits are as follows:

Approximate Self Neutralizing Frequencies of Tetrodes

4-1000A	25 to 30 Mc.
4-400A	45 Mc.
4-250A	45 Mc.
4X500F	75 to 90 Mc.
4-125A	75 to 90 Mc.
4-65A	80 to 120 Mc.
4X150A	} apparently above the useful range of the tube.
4X150G	
4X500A	

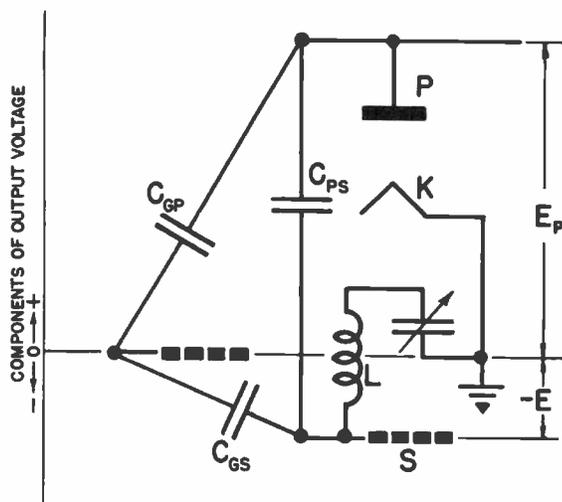


Fig. 31

Components of output voltage of a tetrode when neutralized by added series screen-lead capacitance.

When the tube is operated below the self neutralizing frequency, the normal cross neutralizing circuits apply. In this case a neutralizing capacitor approximately equal to the plate grid capacitance of the tube brings voltage of opposite polarity from the output circuit to the grid or from the input circuit to the plate.

If the operating frequency is higher than the self neutralizing frequency of the tetrode, the voltage $-E$ developed in the screen grid lead inductance is too large to give the proper voltage division between the internal capacitances of the tube. One obvious method of reducing the voltage in the screen lead reactance is to series tune the screen lead to ground so as to lower the total reactance. This takes the form of a series variable capacitor as shown in the graphical representation in Fig. 31.

Another method would be to change the potential divider network made up of the tube capacitances. This could be done by adding capacitance external to the tube between grid and plate. The method is shown in Fig. 32. This added capacitance plate-to-grid is on the same order of size as the residual grid plate capacitance of the tetrode and hence is similar in construction to the neutralizing capacitance used at lower frequency. However, in this case the small wire or rod standing up beside the tube "looking" at the plate (and so forming a neutral-

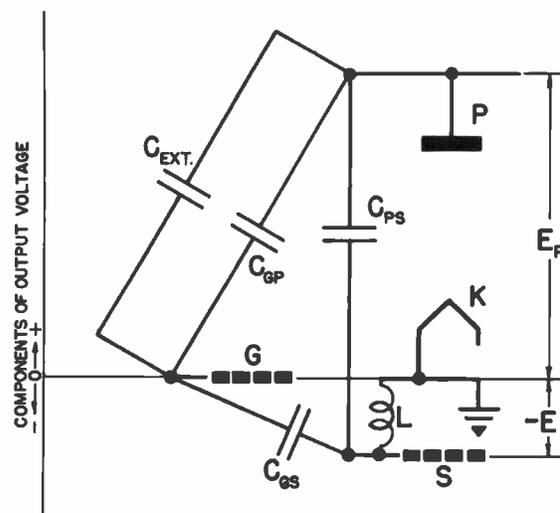


Fig. 32

Components of output voltage of a tetrode when neutralized by added external grid-to-plate capacitance.

izing capacitor) is connected to the grid of the tube rather than to an opposite polarity in the input circuit.

If the r-f power amplifier, operating above the self neutralizing frequency of the tube, must tune over a range of frequencies, it is probably easier to use the screen series tuning capacitor method and make this control available to the operator. If operation is desired over a range of frequencies including the self neutralizing frequency of the tube, this circuit is also desirable because the incidental lead inductance in the variable tuning capacitor lowers the self neutralizing frequency of the circuit so that the neutralizing series capacitor can be made to operate over the total desired frequency range. Obviously, if the range is too great, switching of neutralizing circuits will be required. Usually, a small 50 or 100 mmfd variable capacitor in the screen lead has been found satisfactory.

D-2-c. Self-Neutralization of the VHF Parasitic

Another method of changing the self neutralizing frequency of a tetrode is had when using the general bypassing arrangement of screen and filament shown in Fig. 23. The screen lead is bypassed with minimum inductance to the filament terminal of the tube. Some inductance is introduced in the common filament and screen grounding lead.

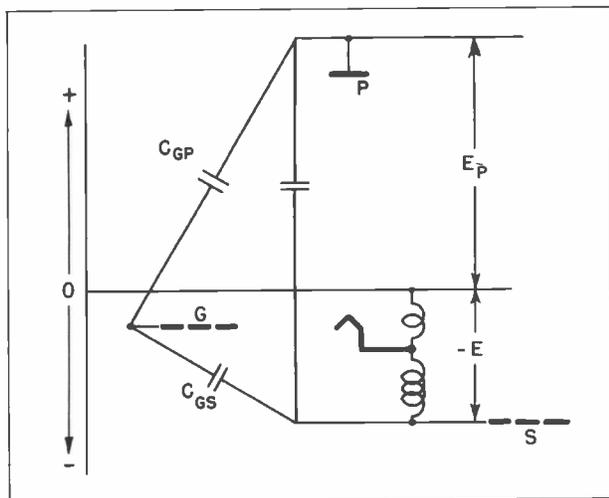


Fig. 33

Components of output voltage of a tetrode neutralized by adding inductance common to screen and cathode return.

The circuit arrangement is plotted with components of plate voltage in Fig. 33. The grid is shown below the zero voltage or chassis potential, indicating that the voltage developed in the total screen lead inductance to chassis is excessive. If now the filament is tapped up on this inductance, a point can be found where the voltage difference between grid and filament is zero as far as the components of plate voltage are concerned. The arrangement will be found to self neutralize at a higher frequency than if the filament and screen were separately bypassed to chassis.

It has been found in tubes, such as the 4-65A, 4-125A, 4-250A, 4-400A and 4-1000A, that the usual VHF parasitic is higher in frequency than the normal self neutralizing frequency of the tube. Thus, by increasing the self neutralizing frequency of the tube and screen bypass arrangement, the tendency of the VHF parasitic to occur is reduced.

If now the frequency of the VHF parasitic is reduced by increasing the inductance of the plate lead (presuming this is the principle frequency defining circuit), it can be made to approach the self neutralizing frequency of the tube and so suppress the parasitic.

It is interesting to note that the later addition of cross-neutralization for the fundamental HF or LF frequency should not disturb this VHF neutralization provided the fundamental neutralizing circuit involves only voltages of the lower or fundamental frequency.

In its purest form this might mean having

zero impedance for the VHF parasitic frequency between the point in the grid circuit where the neutralizing capacitor is connected and the chassis.

D-3. Properly Adjusting Excitation and Loading

In adjusting an r-f amplifier for proper excitation and proper loading, it will be noticed that the procedure is different, depending upon whether the screen voltage is taken from a fixed supply or a dropping resistor supply with poor regulation.

In the case where both the screen supply and grid bias are from fixed sources with good regulation, the plate current is almost entirely controlled by the r-f excitation. One should first vary the excitation until the desired plate current flows. The loading is then varied until the maximum power output is obtained. Following these adjustments the excitation is then trimmed along with the loading until the desired control grid, and screen grid currents are had.

In the case of an r-f amplifier where both the screen and grid bias are taken from sources with poor regulation, the stage will handle very much like the triode r-f power amplifier. The plate current will be adjusted principally by varying the loading, and the excitation will be trimmed to give the desired control grid current. In this case the screen current will be almost entirely set by the choice of the dropping resistor. It will be found that excitation and loading will vary the screen voltage considerably and these should be trimmed to give about the normal screen voltage.

D-4. Operating Voltages and Currents for Various Applications

Probably the simplest way to get an idea of the capabilities of the tube, and the voltages and currents to be used on the various electrodes, is to refer to the technical data sheet for that tube type. A number of typical operating conditions are given for various classes of service. A great many other operating conditions are possible, but these particular ones are usually selected to show the maximum capabilities of the tube for different plate voltages. At no time should the maximum ratings for that class of service be exceeded.

As long as none of the maximum ratings of the tube are exceeded, a wide choice of voltages on the plate, screen, or grid, and a wide range of plate current values is available. In general it will be found that for efficient operation the

ratios of d-c grid current, d-c screen current, d-c plate current should be kept somewhere near the ratios indicated on the data sheet. Thus, if $\frac{1}{2}$ or $\frac{2}{3}$ of the indicated plate current is to be used, the d-c grid current and d-c screen current should be approximately $\frac{1}{2}$ or $\frac{2}{3}$ of the values indicated on the data sheet.

For those interested in estimating tube performance from the characteristic curves of the tube, two application bulletins are available^{9 10}. These application bulletins describe simple means of calculating or estimating from characteristic curves the performance of tubes as class-C r-f amplifiers.

In referring to the characteristic curves of a tube, it should be recognized that these curves are typical of a normal tube. As in all manufactured products, some tolerance is allowed. In general, the currents indicated will be within plus or minus 10% of the values shown.

D-5. Effect of Different Screen Voltages

Typical operating values for a tetrode for a particular value of screen voltage are given on the published data sheet. The screen voltage is not critical and the value used has been chosen as a convenient value consistent with low driving power and reasonable screen dissipation. If lower values of screen voltage are used, more driving power will be required on the grid to obtain the same plate current. If higher values of screen voltage are used less driving power will be required. Thus, high power gain can be had provided the circuit has adequate stability. Care should be observed that the screen dissipation limit is not exceeded. The value of screen voltage can be chosen to suit available power supplies or amplifier conditions.

For a method of altering the coordinate and curve scales of the tube curves to obtain a set of curves for another screen voltage, see page 5 of the Eimac 4-65A Technical Data Sheet¹¹.

D-6. Balance of Push-Pull Amplifiers

In a push-pull r-f amplifier lack of balance of plate circuit or plate dissipation is usually due to lack of symmetry in the r-f circuit. Normally, the tetrodes are similar enough that such unbalance is not associated with the tube and its characteristics. This point can readily be checked by interchanging the tubes in the sockets (provided both tubes have the d-c voltages to plate, screen, and grid in common) and seeing whether the unbalanced condition remains with the socket location or moves with the tubes. If it remains

with the socket location, the circuit requires adjustment. If appreciable unbalance is associated with the tubes, it is possible that one tube is not normal and should be investigated further.

The basic indicators of balance are the plate current per tube and the plate dissipation of each tube. It is assumed that the circuit applies the same d-c plate voltage, d-c screen voltage, and d-c grid bias to each tube from common supplies. Also, it is assumed that the plate circuit is mechanically and electrically symmetrical or approximately so to begin with.

Unbalance in a push-pull r-f amplifier is usually caused by unequal r-f voltages applied to the grids of the tubes, or by the r-f plate circuit applying unequal r-f voltages to the plates of the tubes. The r-f grid excitation should first be balanced until equal d-c plate currents flow in each tube. Then the r-f plate circuit should be balanced until equal plate dissipation appears on each tube.

The balance of plate current is a more important criterion than equality of screen current or grid current. This results from the fact that tubes are more uniform in the plate current characteristics, and also that the screen current is very sensitive to lack of voltage balance in the r-f plate circuit.

Once the d-c plate currents per tube have been made equal by adjusting the r-f grid circuit, the r-f plate circuit can be adjusted to give equal plate dissipations, as noted. Or, if the tubes have equal screen current characteristics, the r-f plate circuit could be balanced until equal screen currents result. If the tubes differ somewhat in screen current characteristics, and the circuit has common d-c supply voltages, the final trimming of the plate circuit balance could be made by interchanging tubes and adjusting the circuit to give the same screen current for each tube regardless of its location.

It should be noted that the d-c grid current has not been used as an indicator of balance of the r-f power amplifier. It is probable that after following the above procedure the grid currents will be fairly well balanced, but in itself it is not a safe indicator of balance of grid excitation.

In audio power amplifiers operating in Class-AB₁ or Class-AB₂, the idle d-c plate current per tube should be balanced by separate bias adjustments for each tube. In many cases some lack of balance of the plate currents will have negligible effect on the overall performance of the amplifier.

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When tubes are operating in the idle position close to cut-off, operation is in a region where the plate current cannot be held to a close percentage tolerance. At this point the action of the positive screen and plate voltages is in delicate balance with the opposing negative grid voltage. The state of balance is indicated by the plate current. Very minor variations of individual grid wires or diameter of grid wires upset the balance, and it is practically impossible to control such minor variations in manufacture. In many audio amplifier applications, especially where the larger power tetrodes are used, the circuit should be designed to permit the bias to be adjusted individually on the tubes.

D-7. Harmonic Amplifiers and Control of Harmonics

The use of power tetrodes to give good efficiency in harmonic amplifiers and to control the presence of unwanted harmonics in the output circuit is inherently sound. Because of the shielding built into the tetrode, the coupling between the output and input circuits (and the input and output circuits) has been reduced to a negligibly small value. (To estimate harmonic amplifier performance see Brown¹² and the Eimac application bulletin "Tube Performance Computer"¹⁰.)

A pulse of plate current delivered by the tube to the output circuit contains energy on the fundamental and most harmonic frequencies. The output plate circuit resonance, coupling, and shielding must be designed to select the desired frequency and avoid radiation of the undesired frequencies.

It is not generally appreciated that the pulse of grid current also contains energy on the harmonic frequencies and control of these harmonic energies may be quite important. The ability of the tetrode to isolate the output circuit from the input circuit over a very wide range of frequencies is important in avoiding feed-through of harmonic voltages from the grid circuit. An important part of this shielding is the fact that properly designed tetrodes permit the construction of complete shielding in the amplifier layout so that coupling external to the tube is also prevented.

It has been found that the plate circuit efficiency of tetrode harmonic amplifiers is quite high. In triode amplifiers, if feed-back of the output harmonic frequency occurs, the phase of the voltage fed back is usually such as to reduce the harmonic content of the plate pulse, and thereby lower the plate circuit efficiency. Since

tetrodes have negligible feedback, the efficiency of a harmonic amplifier is usually up to expected efficiencies.

Also, the high amplification factor of a tetrode causes the plate voltage to have little effect on the flow of plate current, and it is easier to obtain plate pulses with high harmonic energies without using excessive grid bias. A well designed tetrode also permits large r-f voltages to be developed in the plate circuit while still passing high peaks of plate current in the r-f pulse. These two factors help further to increase the plate efficiency.

In r-f amplifiers operating either on the fundamental or a desired harmonic frequency, the control of unwanted harmonics is very important. The subject is well covered in the literature discussing the reduction of interference with television receivers. The following steps permit reduction of the unwanted harmonic energies present in the output circuit:

1. The circuit impedance between plate and cathode should be very low for the high harmonic frequencies. Usually this is obtained by having some or all of the tuning capacitance of the resonant circuit close to the tube.
2. Complete shielding of the output compartment.
3. The use of inductive output coupling from the resonant plate circuit and possibly a capacitive or Faraday shield between the coupling coil and the tank coil, or a high frequency attenuating circuit such as a pi, or pi-L net.
4. The use of low pass filters for all supply leads and wires coming into the output and input compartments.
5. The use of resonant traps for particular frequencies.

D-8. Driving Power Requirements

The technical data sheet for a particular tube gives the approximate driving power required. For radio frequencies below the VHF region, the driving powers are obtained by calculation and confirmed by direct tests. The listed driving power gives the total power taken by the tube grid and the bias circuit. This driving power figure does not allow for losses in the r-f resonant circuit since such losses depend principally on the design of that circuit. The circuit losses can be kept to a low value by proper design. Some allowance for them must be made, however, in determining the total driving power to be supplied by the driver stage.

In the case of tetrodes operating in the VHF and UHF region, the approximate driving power given under typical operation on the data sheets is obtained by direct measurement in operating equipment. Because it is impossible to separate the circuit action and the tube action, the driving power listed is the total power taken by the tube and a practical amplifier circuit.

The total driving power required from the exciter stage in the VHF and UHF region is presumably composed of the following:

1. The power taken by the grid itself and the bias circuit (which is equal to that for the same grid voltages and current acting in a low frequency circuit).
2. The resistance losses caused by the r-f charging currents passing through the leads of the tube into the tube capacitances.
3. Power fed through to the output circuit and power dissipated on plate and screen due to the presence of cathode lead inductance.
4. Excess energies taken on by the space current electrons within the tube due to the rapidly varying grid voltage. Some of this excess energy shows up in bombardment of the cathode and general tube structure.
5. Some dielectric loss in the insulating material of the tube envelope.
6. Losses in the r-f grid circuit and a portion of the input line coupled to the driving circuit.

The total driving power in the VHF and UHF region is often greater than the grid dissipation capability of the tube. As indicated above, the portion of the driving power which appears as grid dissipation can be calculated in the normal manner¹³ (d-c grid current times the peak positive grid voltage).

D-9. VHF and UHF Operating Conditions for Satisfactory Plate Efficiency and Minimum Drive.

When operating a tube in the VHF and UHF region the driving power can usually be minimized without appreciably affecting the plate conversion efficiency, by the following steps:

1. A minimum d-c control grid bias should be used. Frequently, it is advisable to bring this down to approximately cut-off.
2. A high value of d-c screen voltage is advisable even though it appears to increase the fraction of the cycle during which plate current flows.
3. Using the minimum r-f excitation voltage necessary to obtain plate circuit performance, even though the d-c grid current is considerably lower than one would expect at lower frequencies.
4. The cathode lead inductance common to the output and input circuits should be kept to a low value.

It is found that the choice of driving conditions as indicated above does not necessarily decrease the plate efficiency as much as at lower radio frequencies. The steps indicated above should be tried experimentally to determine whether or not the plate circuit efficiency is appreciably effected. As will be indicated below under section E-3, it is preferable to sacrifice plate efficiency somewhat and improve the life expectancy of the tube in the VHF and UHF region.

It has also been observed that optimum output power at these frequencies is obtained when the loading is greater than would be used at lower frequencies. Apparently the use of lower r-f voltage in the plate circuit is desirable. Fortunately, this same condition reduces driving power and screen current and, as will be noted later, improves life expectancy.

LIFE

E-1. Maximum Tube Ratings.

The technical data sheet for each tube type gives the basic maximum ratings for each class of service. Also on the technical data sheet will be found references to cooling air and maximum temperature, and mechanical considerations as they may affect life. Careful observance of the information on the data sheet will avoid damage to the tube and shortening of its useful life. A

reprint on Vacuum Tube Ratings is available¹³.

In general, the tube ratings are so chosen that operation within the ratings will give a minimum of 1000 hours of guaranteed life. The typical life expectancy is therefore considerably greater and will depend upon a great many factors, some of which are discussed below. In general, operation below the maximum ratings will increase the life expectancy of the tube. This

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is especially true with reduction in the plate dissipation of the tube. Very roughly speaking, the life expectancy will go up directly as the plate dissipation and total watts being handled by the tube go down.

If tubes are to be used in pulse service with short pulses and appreciable off-time between pulses, the tube ratings are quite different. For information and assistance on pulse application write to the Field Engineering Department of Eitel-McCullough, Inc., San Bruno, California, or refer to Application Bulletin No. 3 "Pulse Service Notes"¹⁴.

E-2. Cooling

Adequate cooling of the tube envelope and metal-to-glass seals is one of the principle factors affecting tube life. Deteriorating effects increase directly with the temperature of the tube envelope and seals. The technical data sheet for the particular tube type should be studied thoroughly with reference to the air cooling requirements. Even if no air cooling is specified, ample free space for circulation of air around the tube is required or else some air must be forced past the tube.

Excess cooling air will have only beneficial results and inadequate cooling air is almost certain to invite premature failure of the tube.

Tubes operated in the VHF and UHF region are inherently subjected to greater heating action than tubes operated at lower frequencies. This results directly from the flow of larger r-f charging currents into the tube capacitances, dielectric losses, and a tendency for electrons to bombard parts of the tube structure other than the normal grid and plate. See section E-3 for a discussion of "VHF and UHF Life Considerations." Greater cooling air is therefore required at these higher frequencies. For tubes designed to operate in the VHF and UHF region, such as the Eimac tetrodes, the cooling air is specified for the normal top frequencies of the tube.

E-3. VHF and UHF Life Considerations

A tube designed for VHF and UHF work must have very small size if practical resonant circuits are to be built around them. Furthermore, these tubes operate less efficiently and have much greater incidental losses than at lower frequency. For these reasons, the power which must be dissipated from the electrodes and tube envelope seals is very much greater per unit of area than for tubes designed solely for low frequency.

If the tubes are to become a part of a VHF line circuit or cavity UHF circuit, the inductance associated with the electrode supports and leads must be reduced to a very small value. In the case of the 4X150A, 4X150G, and 4X500A, some of the electrode leads and supports take the form of large surfaces, conical or cylindrical in shape, and extremely short. This means that the amount of heat conducted out through the metal-to-glass seals is greatly increased. It also means that the terminal connections of the tube are large surfaces with relatively thin walls.

The mechanical layout of sockets, connections, and circuits close to the tube must allow ample cooling air to be blown against the tube seals and surfaces. Also ample contacting surface to carry the heavy radio frequency charging currents must be provided. Since these two requirements may tend to conflict, considerable thought must be given to an adequate layout.

E-3-a. Connectors

Where the tube terminals are large cylindrical surfaces, the contacting portions of the socket are either spring collets or a multiplicity of spring fingers. Usually these multiple contacting surfaces are made of beryllium copper to preserve the spring tension at the relative high temperatures present on tube terminals and are silver plated to reduce r-f resistance.

Rigid clamping connectors should be avoided even though the radius of the curvature seems to be close to that of the cylindrical contacting surface of the tube. It has been found that such rigid clamping connectors will distort the tube terminal and fracture the adjacent metal-to-glass seal. Similarly set screw connecting devices are questionable on large cylindrical tube terminals unless they act to distribute the pressure uniformly and without any distorting effects.

If the connectors fail to provide multiple contacts to the cylindrical tube seals, concentration of r-f charging current will result and the overheating may be destructive. Once the connector loses its spring action the heating is aggravated and damage to the tube is very apt to occur. All tube connectors should be inspected and serviced regularly to be sure that uniform, good contact to the tube results.

E-3-b. Tube Temperatures

Forced air cooling of the seals and tube envelope, as well as of an external anode, is imperative. Both air flow and maximum temperatures are given on the data sheets and both

should be measured to be certain that ample air and cooling results. The problem of making temperature measurements under these conditions is severe. The most practical technique has been to use a very light spray of very thin temperature indicating paint, such as Tempilaq—made by the Tempil Corporation, 132 West 22nd Street, New York 11, N. Y. By using an extremely thin spray and not covering solidly, a temperature gradient across the indicating paint due to the action of the cooling air will be avoided.

E-3-c. Backheating by Electrons

Another action involving the motion of electrons within the tube is present at VHF and UHF and has been commonly referred to as backheating of the cathode. Due to the fact that the time of flight of the electrons from the cathode through the grid structure to the plate becomes an appreciable part of the cycle, the electrons can be stopped in flight and turned back by the rapidly changing grid voltage. Under these conditions the electrons are turned back or deflected from their normal paths and given excess energy with which the electrons bombard the cathode and other portions of the tube structure. This effect can be greatly aggravated by the choice of operating conditions to the extent that very destructive effects occur. The tube can even be destroyed within a few minutes under severe conditions.

Fortunately, the conditions which tend to minimize this back-bombardment by electrons are the same as those giving minimum driving conditions as discussed under "VHF Operating Conditions" section D-9. The tendency for electrons to be turned back in flight is reduced by the use of the lowest possible r-f grid voltage on the tube. This is obtained by using the lowest possible d-c grid bias. In tetrodes this effect is inherently much lower because of the action of the d-c accelerating voltage on the screen of the tube. The d-c screen voltage acts to continue accelerating the electrons toward the anode, and also inherently permits the use of very much smaller grid voltages. Consequently, under favorable conditions the number of electrons turned back to heat the cathode and tube structure can be kept to a practical low level. In addition to the use of low d-c grid bias, a high screen voltage is desirable.

At the same time the plate circuit should

always operate with heavy loading (low external plate impedance) so that the minimum instantaneous value of plate voltage shall stay sufficiently positive to continue accelerating electrons to the anode. For this reason best life is had when the tetrode amplifier is heavily loaded as indicated by having small values of d-c screen and d-c control grid current.

NEVER OPERATE WITH LIGHT PLATE LOADING. If the plate load is removed so that the minimum instantaneous plate voltage tends to fall to values around cathode potential (as it must do when the loading is removed completely and excitation is present), the number of electrons turned back can be completely destructive to the tube. It has been found that under conditions of "no loading" the electron bombardment of the insulating glass portion of the tube is often sufficient to cause a suck-in of the glass. Automatic protection should be installed to remove all voltages from the tube when the plate circuit loading becomes too light for the amount of excitation applied.

It should be noted that parasitic oscillations are seldom loaded heavily, as indicated by the high grid currents often had during such self oscillation. Thus excessive r-f plate voltages are developed which at VHF can be damaging in the same manner as unloaded operation on a VHF fundamental frequency. Should such unloaded VHF parasitic oscillation be present simultaneously with apparently satisfactory operation on the fundamental, unexplained reduction of life may result.

Occasionally, also, an output line circuit can resonate simultaneously to a harmonic frequency as well as to the fundamental frequency. The higher resonant modes of practical line circuits are not normally harmonically related, but sometimes the tuning curve of a mode will cross the fundamental tuning curve and at that point the circuit will build up resonant voltages at both the harmonic frequency and fundamental frequency. The harmonic resonance is usually lightly loaded and the damaging action is similar to that of lightly loaded parasitic or fundamental operation. Again the operation of the tube and circuit on the fundamental may appear normal, but with lower than expected efficiency, and damaging action to some degree can occur.

In addition to operating the tube with minimum bias, high screen voltage, and heavy loading on the plate circuit, some degree of com-

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pensation for the remaining back heating of the cathode may be required. This can be accomplished by lowering the filament voltage or heater voltage until the cathode operates at normal temperature. It has been found with tetrodes that by taking precautions necessary to minimize

back bombardment by electrons the compensation for back heating of the cathode is not large and may often be neglected. In cases where it is suspected, it is advisable to discuss the subject in detail with the Field Engineering Department of Eitel-McCullough, Inc., in San Bruno, California.

TECHNICAL ASSISTANCE

The Field Engineering Department of Eitel-McCullough, Inc., will gladly assist tube users in the choice of tubes and operating conditions. This is especially important where a prototype design of

equipment and later manufacture is planned. Such assistance makes use of the accumulated detailed experience with the tube types involved and is handled confidentially and without charge.

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