QUICK-REFERENCE CATALOGUE

EFFECTIVE

OCTOBER 1, 1954

Eimac

TUBES

EITEL-McCULLOUGH, INC.
San Bruno, California

4PR60A High-vacuum, radial-beam, pulse modulator tetrode. Oxide cathode internal anode. Unilateral replacement for 715B, 715C, and 5D21.	6.0	3.06	26.0	2.2	90,000	Pulse Mod	. . .	20,000	18	60	20,000	1,250	−800	15	. . .	. . .	. . .
4W20000A 20 Kw., water-cooled, high transconductance radial beam, power tetrode. Unipotential thoriated tungsten cathode, non-emitting grid, external anode. Concentric VHF terminals.	12.0**	5.03	10.0†	30.0	75,000	B TV	220	8,000	(avg.) 15	20,000	7,000	1,200	−150	6.0	. . .	. . .	26,000★
						C CW	220	8,000	15	20,000	7,000	1,200	−400	3.4	. . .	830	13,000✦
4X150A **4X150D** 150-watt plate dissipation, forced-air cooled, general purpose, high transconductance radial-beam power tetrode. Oxide coated cathode, external anode. Operates in normal amplifier service through 500 Mc.	2.47	1.64	A 6.0 D 26.5	2.6 0.57	12,000	B Aud.	. . .	1,250	.250	150	1,250	300	−44	.180/.475	5,600	0.075	425
						B TV	500	1,250	(avg.) .250	150	1,250	300	−70	.305	. . .	. . .	250★
						C CW	500	1,250	.250	150	1,250	250	−90	.200	. . .	1.2	195
						C CW	500	1,250	.250	150	1,250	280	−115	.200	. . .	30	140✦
						AM Pl	500	1,000	.200	100	1,000	250	−105	.200	. . .	1.1	145
4X150G 150-watt plate dissipation, forced-air cooled, general purpose radial-beam power tetrode. Oxide coated cathode, external anode. Concentric UHF terminals. Operates up through 1000 Mc.	2.75	1.64	2.5	6.25	12,000	C CW	750	1,250	.250	150	1,250	250	−60	.200	. . .	9	100✦
						Plate Pulse	1,200	7,000	*	150	7,000	1,000	−250	6.0	. . .	. . .	20,000✦
4X500A **4X500F** 500-watt plate dissipation, forced-air cooled, general purpose radial-beam power tetrode. Thoriated tungsten filament, non-emitting grids, external anode.	A 4.75	2.63	5.0	13.5	5,200	C CW	110	4,000	.350	500	4,000	500	−250	.315	. . .	13	980✦
						B TV	220	3,000	.350	500	2,400	500	−100	.400	3,000	25	600✦
	F 5.13	2.81	5.0	13.5	5,200	C CW	110	4,000	.350	500	4,000	500	−250	.315	. . .	13	980✦

PENTODE

4E27A/5-125B 125-watt plate dissipation, radiation cooled, general purpose radial-beam power pentode. See Note 1.	6.19	2.75	5.0	7.5	2,150	B Aud	. . .	4,000	.200	125	2,500	500	−85	.065/.250	20,000	.2	400
						C CW	75	4,000	.200	125	3,000	500	−200	.167	. . .	2	375
						AM Pl	75	3,200	.160	85	2,500	500	−200	.152	. . .	2	295

See page 5 for explanation of class of service symbols.

Note 1 · Thoriated tungsten filament, non-emitting grids, pyrovac plate.

* Max. pulsed cathode current 7 amps., Max. pulse duration 5 microseconds.

** Does not include water couplings.

✦ Typical operation at maximum frequency for full rating.

† Bombardment heated cathode, requires 1400v DC at 1.8 amps.

★ Peak synchronizing level.

BASING

TETRODES

TYPE — DESCRIPTION	MAXIMUM DIMENSIONS Length Inches	MAXIMUM DIMENSIONS Diameter Inches	FILAMENT Volts	FILAMENT Amps.	TRANSCONDUCTANCE µmhos	CLASS OF SERVICE	Max. Frequency Full Rating Mc.	MAX. PLATE RATINGS DC Volts	MAX. PLATE RATINGS DC Amps.	MAX. PLATE RATINGS Dissipation Watts	TYPICAL OPERATING CONDITIONS DC Plate Volts	DC Screen Volts	DC Grid Volts	DC Plate Amps	Plate Load Ohms	Driving Power Watts	Power Output Watts
4-65A 65-watt plate dissipation, radiation cooled, general purpose radial-beam power tetrode. See Note 1.	4.38	2.38	6.0	3.5	4,000	B Aud	. . .	3,000	.150	65	1,800	250	−35	.050/.220	20,000	1.1	270
						C CW	150	3,000	.150	65	3,000	250	−90	.115	. . .	1.7	280
						AM Pl	150	2,500	.120	45	2,500	250	−150	.108	. . .	1.9	225
4-125A 125-watt plate dissipation, radiation cooled, general purpose radial-beam power tetrode. See Note 1.	5.69	2.81	5.0	6.5	2,450	B Aud	. . .	3,000	.225	125	2,500	350	−43	.093/.260	22,200	2.4	400
						C CW	120	3,000	.225	125	3,000	350	−150	.167	. . .	2.5	375
						AM Pl	120	2,500	.200	85	2,500	350	−210	.152	. . .	3.3	300
4-250A 250-watt plate dissipation, radiation and forced-air cooled, general purpose radial-beam power tetrode. See Note 1.	6.38	3.56	5.0	14.5	4,000	B Aud	. . .	4,000	.350	250	3,000	300	−53	.125/.473	16,000	1.9	1,040
						C CW	110	4,000	.350	250	4,000	500	−225	.312	. . .	2.5	1,000
						AM Pl	110	3,200	.275	165	3,000	400	−310	.250	. . .	3.5	585
4-400A 400-watt plate dissipation, radiation and forced-air cooled, general purpose radial-beam power tetrode. See Note 1.	6.38	3.56	5.0	14.5	4,000	B Aud	. . .	4,000	.350	400	4,000	500	−90	.120/.638	14,000	3.5	1,750
						C CW	110	4,000	.350	400	4,000	500	−220	.350	. . .	6	1,100
						C CW	110	4,000	.350	400	4,000	400	−170	.270	. . .	10	720 ✦
						AM Pl	110	3,200	.275	270	3,000	400	−310	.275	. . .	4	640
4-1000A 1000-watt plate dissipation, radiation and forced-air cooled, general purpose radial-beam power tetrode. See Note 1.	9.63	5.25	7.5	21.0	10,000	B Aud	. . .	6,000	.700	1,000	6,000	500	−75	.150/.950	15,000	4.7	3,900
						C CW	110	6,000	.700	1,000	6,000	500	−200	.700	. . .	15	3,400
						C CW	110	6,000	.700	1,000	6,000	500	−180	.625	. . .	200	2,600 ✦
						AM Pl	30	5,500	.600	670	5,500	500	−200	.600	. . .	9	2,630

6C21 High-vacuum, radiation cooled, pulse modulator triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate	12.63	5.13	8.2	17.0	5,800	Pulse Mod	....	30,000	15	300	27,000	−1500	3100	15	1,600	...	...
25T 3C24 25-watt plate dissipation, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate.	4.38	1.44	6.3	3.0	2,500	B Aud	....	2,000	.075	25	1,250	−42	135	.024/.130	21,400	3.4	112
						C CW	60	2,000	.075	25	2,000	−130	...	.063	...	4	100
						AM Pl	60	1,600	.060	17	1,600	−170	...	.053	...	3.1	68
35T 35TG 50-watt plate dissipation, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate.	5.5	1.81	5.0	4.0	2,850	B Aud	....	2,000	.150	50	2,000	−40	130	.034/.167	27,500	4	235
						C CW	100	2,000	.150	50	2,000	−135	...	.125	...	13	200
						AM Pl	100	1,600	.120	33	1,500	−150	...	.090	...	11	105
75TH 75TL 75-watt plate dissipation, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate. H version high-mu, L version low-mu.	7.25	2.81	5.0	6.25	H 4,150 L 3,350	B Aud	....	3,000	.225	75	2,000	H −90 L −190	175 300	.050/.225 .050/.250	19,300 18,000	3 5	300 350
						C CW	40	3,000	.225	75	2,000	H −200 L −300	... ...	.150	... ...	10 8	225
						AM Pl	40	2,400	.180	50	2,000	H −300 L −500	... ...	.110 .130	... ...	6 14	170 210
100TH 100TL 100-watt plate dissipation, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate. H version high-mu, L version low-mu.	7.75	3.19	5.0	6.3	H 4,500 L 3,000	B Aud	....	3,000	.225	100	2,500	H −50 L −145	155 290	.060/.280 .048/.250	22,000	7.5 10	425
						C CW	40	3,000	.225	100	3,000	H −200 L −400	... ...	.165	...	18 20	400
						AM Pl	40	2,500	.180	65	2,500	H −250 L −500	... ...	.140	...	17 23	285
152TH 152TL 150-watt plate dissipation, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate. H version high-mu, L version low-mu.	7.63	2.56	5 or 10	12.5 or 6.25	H 8,300 L 7,150	B Aud	....	3,000	.450	150	3,000	H −150 L −260	430 675	.067/.335 .100/.500	20,300 20,400	3	700
						C CW	40	3,000	.450	150	3,000	H −300 L −400	... ...	.250	...	27 20	600
						AM Pl	40	2,500	.350	100	2,000	H −300 L −550	... ...	.250	...	30 25	400

BASING

6C21

25T

35T

35TG
75TH
75TL
100TH
100TL

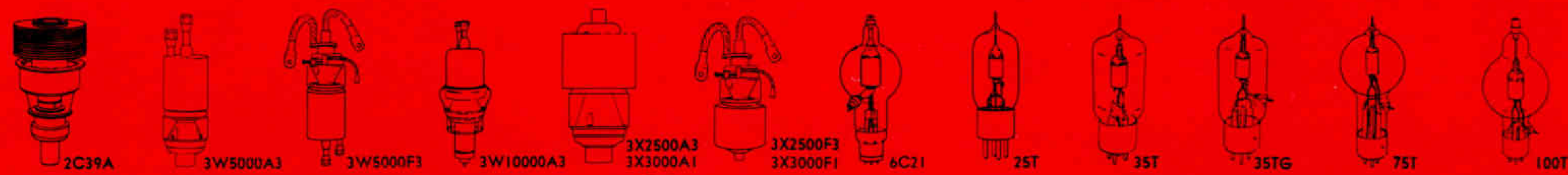
SPECIAL

2C39A
3W5000A3
3W5000F3
3W10000A3
3X2500A3
3X2500F3
3X3000A1
3X3000F1

See page 5 for explanation of class of service symbols.

Note E: Thoriated tungsten filament, non-emitting grid, external anode.
A Coaxial VHF terminals.
F Flexible lead terminals.

* Typical operation, grounded grid at full rating.
† Bombardment heated cathode, requires [illegible] DC at [illegible] amps.
**Does not include water coupling.
‡Cathode Current



TYPE DESCRIPTION	MAXIMUM DIMENSIONS Length Inches	Diameter Inches	FILAMENT Volts	Amps.	TRANSCONDUCTANCE µmhos	CLASS OF SERVICE	Max. Frequency Full Rating Mc.	MAX. PLATE RATINGS DC Volts	DC Amps	Dissipation Watts	TYPICAL OPERATING CONDITIONS DC Plate Volts	DC Grid Volts	Peak A.F. Grid Input Volts Per Tube	DC Plate Amps.	Plate Load Ohms	Driving Power Watts	Power Output Watts
2C39A Forced-air cooled, planar UHF triode. Oxide coated cathode, external anode. Operates as power amplifier, multiplier, and oscillator to 2500 Mc.	2.75	1.26	6.3	1.0	22,000	C CW	2,500	1,000	.125‡	100	800	−20	. . .	.080	. . .	6	27
						AM Pl	2,500	600	.100‡	70	600	−16	. . .	.075	. . .	6	18
3W5000A3 **3W5000F3** 5-Kw. water cooled, general purpose, high transconductance triode. See Note 2.	8.0**	3.0	7.5	51.0	20,000	B Aud		6,000	2.5	5,000	6,000	−240	390	.4/3.0	4,650	115	13,000
						C CW	A 75 F 30	6,000	2.5	5,000	6,000	−500	. . .	2.08	. . .	136	10,000
						AM Pl	A 75 F 30	5,000	2.0	3,350	5,000	−550	. . .	1.45	. . .	76	5,580
3W10000A3 10-Kw., water-cooled, high transconductance triode. Unipotential thoriated tungsten cathode, non-emitting grid, external anode. Concentric VHF terminals.	13.0**	5.0	10.0†	30.0	55,000	B TV	220	5,000	10	10,000	3,250	−190	. . .	4.25	560	400	5,500*
3X2500A3 **3X2500F3** 2.5-Kw, forced-air cooled, general purpose, high transconductance triode. See Note 2.	9.0	4.16	7.5	51.0	20,000	B Aud	. . .	6,000	2.5	2,500	6,000	−240	390	.4/3.0	4,650	113	13,000
						C CW	A 40 F 30	6,000	2.5	2,500	6,000	−500	. . .	2.08	. . .	136	10,000
						C CW	A 110	4,000	2.0	2,500	4,000	−500	. . .	1.85	. . .	1,900	7,500*
						AM Pl	A 40 F 30	5,000	2.0	1,670	5,000	−550	. . .	1.45	. . .	76	5,580
3X3000A1 **3X3000F1** 3-Kw., forced-air cooled, low-mu power triode, intended for use as an audio amplifier, modulator or oscillator for industrial service. See Note 2.	9.0	4.16	7.5	51.0	11,000	B Aud	. . .	6,000	2.5	3,000	6,000	−1300	1250	.335/2.65	4,560	. . .	16,000
						C CW	75	6,000	2.5	3,000	6,000	−1200	. . .	1.50	. . .	. . .	6,500

1500T 1500-watt plate dissipation, radiation and forced-air cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate.	17.0	7.13	7.5	24.0	10,000	B Aud	....	8,000	1.25	1,500	6,000	−190	570	.330/1.65	8,200	115	7,000
						C CW	40	8,000	1.25	1,500	7,000	−500	...	.860	...	85	4,500
						AM Pl	40	6,000	1.00	1,000	6,000	−750	...	.835	...	120	4,000
2000T 2000-watt plate dissipation, radiation and forced-air cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate.	17.75	8.13	10.0	23.5	11,000	B Aud	....	8,000	1.75	2,000	7,000	−280	600	.300/1.80	9,200	175	8,600
						C CW	40	8,000	1.75	2,000	7,000	−600	...	1.15	...	115	6,000
						AM Pl	40	6,000	1.40	1,350	6,000	−800	...	1.13	...	225	5,400

KLYSTRONS

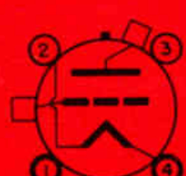
TYPE	DESCRIPTION	MAXIMUM DIMENSIONS		FILAMENT		FREQUENCY RANGE	MAXIMUM RATINGS			CLASS OF SERVICE	TYPICAL OPERATING CONDITIONS				
OSCILLATORS		Length Inches	Diameter Inches	Volts	Amps	Mc.	DC Volts	Resonator DC Amps	Dissipation Watts		Mode	Resonator DC Volts	Resonator DC Amps	Repeller Volts	Power Output Watts
1K015XA (Coaxial Output) **1K015XG** (Waveguide Output)	Ruggedized, integral-cavity reflex Klystrons intended for X-band local oscillator service.	A 2.38	1.18	6.3	0.80	8600-9400	350	.045	15	C CW	6¾	350	40	−170	0.04
		G 3.56	1.47												
AMPLIFIERS							Beam DC Volts	DC Amps	Collector Dissipation Watts			Beam DC Volts	DC Amps	Driving Power Watts	Power Output Watts
3K20000LA **3K20000LF** **3K20000LK**	3 gap 20-Kw. Collector dissipation, water and forced-air cooled Klystron for use in UHF TV band. Use of external cavities provides coverage of entire band with three versions of the tube.	A 50.5	5.69	9.0†	42.0	A 470-580	13,500	1.7	20,000	B TV		13,000	1.5	100 approx.	5,000★
		F 44.0	5.69			F 580-720				C CW		10,000	1.0	10 approx.	2,500
		K 36.75	5.69			K 720-890									
3K50,000LA **3K50,000LF** **3K50,000LK**	3 gap 50-Kw. Collector dissipation, water and forced-air cooled Klystrons for use in UHF TV band. Use of external cavities provides coverage of entire band with three tube types.	A 54	5.13	9.0‡	42.0	A 470-580	19,500	2.56	50,000	B TV		17,200	2.15	55 approx.	12,000★
		F 49	5.13			F 580-720				C CW		12,300	1.33	20 approx.	6,000
		K 45	5.13			K 720-890									

†Cathode bombardment power, 1600 max. watts (2300 Vdc., .69A)
‡Cathode bombardment power, 1700 max. watts (2400 Vdc., .71A)
★ Peak synchronizing level.

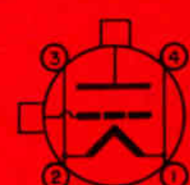
See page 5 for explanation of class of service symbols.

BASING

450TH
450TL
1000T



250TH
250TL



750TL
1500T
2000T

152TH
152TL
304TH
304TL

592/3-200A3

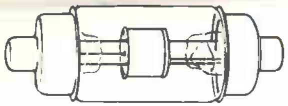
SPECIAL
1K015XA
1K015XG
3K20,000LA
3K20,000LF
3K20,000LK
3K50,000LA
3K50,000LF
3K50,000LK

TRIODES

TYPE DESCRIPTION	MAXIMUM DIMENSIONS Length Inches	MAXIMUM DIMENSIONS Diameter Inches	FILAMENT Volts	FILAMENT Amps.	TRANSCONDUCTANCE µmhos	CLASS OF SERVICE	Max. Frequency Full Rating Mc.	MAX. PLATE RATINGS DC Volts	MAX. PLATE RATINGS DC Amps	MAX. PLATE RATINGS Dissipation Watts	TYPICAL OPERATING CONDITIONS DC Plate Volts	DC Grid Volts	Peak A.F. Grid Input Volts Per Tube	DC Plate Amps.	Plate Load Ohms	Driving Power Watts	Power Output Watts
250TH 250-watt plate dissipa- **250TL** tion, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate. H version high-mu, L version low-mu.	10.13	3.81	5.0	10.5	H 5,600 L 2,650	B Aud	....	4,000	.350	250	3,000	H −65 L −170	260 400	.100/.560 .100/.500	12,250 13,000	42 16	1,180 1,000
						C CW	40	4,000	.350	250	4,000	H −220 L −500	... ...	.313	...	39 33	1,000
						AM Pl	40	3,000	.280	165	3,000	H −200 L −520	... ...	.200	...	14 11	435
304TH 300-watt plate dissipa- **304TL** tion, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate. H version high-mu, L version low-mu.	7.63	3.56	5 or 10	25 or 12.5	16,700	B Aud	....	3,000	.900	300	3,000	H −150 L −290	210 390	.134/.667 .130/.800	10,200 9,100	6 55	1,400 1,800
						C CW	40	3,000	.900	300	3,000	H −300 L −400	... ...	.500	...	53 40	1,200
						AM Pl	40	2,500	.700	200	2,500	H −400 L −550	... ...	.450	...	50 40	925
450TH 450-watt plate dissipa- **450TL** tion, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate. H version high-mu, L version low-mu.	12.63	5.13	7.5	12.0	H 6,650 L 5,000	B Aud	....	6,000	.600	450	5,000	H −115 L −240	267 430	.120/.620	18,600 18,500	10 28	2,200
						C CW	40	6,000	.600	450	5,000	H −300 L −500	... ...	.450	... ...	46 42	1,800
						AM Pl	40	4,500	.500	300	4,500	H −400 L −550	... ...	.345	... ...	35 31	1,250
592/3-200A3 200-watt plate dissipation, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate.	6.0	3.41	10.0	5.0	3,600	B Aud	....	3,500	.250	200	3,000	−90	270	.080/.400	18,000	20	820
						C CW	150	3,500	.250	200	3,500	−270	...	.228	...	15	600
						AM Pl	150	2,600	.200	130	2,500	−300	...	.200	...	19	375
750TL 750-watt plate dissipation, radiation cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate.	17.0	7.13	7.5	21.0	3,500	B Aud	....	10,000	1.0	750	6,000	−390	650	.166/.834	16,300	46	3,500
						C CW	40	10,000	1.0	750	6,000	−700	...	.625	...	125	3,000
						AM Pl	40	8,000	.8	500	6,000	−950	...	.415	...	75	2,000
1000T 1000-watt plate dissipation, radiation and forced-air cooled, general purpose triode. Thoriated tungsten filament, non-emitting grid, pyrovac plate.	12.3	5.13	7.5	15.5	9,050	B Aud	....	7,500	.750	1,000	6,000	−160	335	.220/1.05	13,300	60	4,600
						C CW	50	7,500	.750	1,000	6,000	−350	...	.667	...	60	3,000
						AM Pl	50	6,000	.600	665	6,000	−500	...	.600	...	75	2,935

VACUUM CAPACITORS

FIXED TYPE



Eimac vacuum capacitors are small, vacuum-dielectric units intended principally for use as all or part of the plate tank capacitance. They are also frequently used as high-voltage coupling and by-pass capacitors at high frequencies and as high-voltage neutralizing capacitors. Overall length 6¾", diameter 2¼".

TYPE ➡	VC6-20	VC6-32	VC12-20	VC12-32	VC25-20	VC25-32	VC50-20	VC50-32
Capacitance $\mu\mu fd$	6	6	12	12	25	25	50	50
Max. Peak volts	20,000	32,000	20,000	32,000	20,000	32,000	20,000	32,000
Max. RMS amps.	28	28	28	28	28	28	28	28

VARIABLE TYPE

Eimac variable vacuum capacitors are intended principally for use as plate tank capacitors in radio frequency amplifiers and oscillators. The capacitance variation is linear with respect to shaft rotation and return to previously indexed settings is positive. The low-torque tuning mechanism is designed with adequate bearing surfaces to provide long life.

⬇ TYPE	MAX. DIMENSIONS Length	Height	Width	CAPACITANCE $\mu\mu fd$		Max. Peak RF Voltage Volts		Max. RMS Current Amps	
VVC60-20	5.69	. . .	3.06	10-60		20,000		40	
VVC2-60-20	6.28	3.13	8.13	Parallel 20-120	Split Stator 5-30	Parallel 20,000	Split Stator 40,000	Parallel 80	Split Stator 40
VVC4-60-20	6.28	7.81	7.81	40-240	10-60	20,000	40,000	160	80

BASING

2-25A

2-50A
8020/100R
866A

2-150D

2-240A

2-2000A

250R

253

872A

KY21A

RX21A

SPECIAL
2-01C

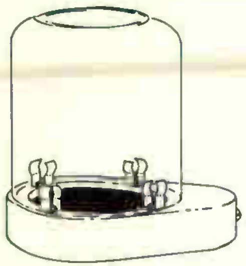
HIGH VACUUM RECTIFIERS

TYPE	DESCRIPTION	MAXIMUM DIMENSIONS Length Inches	Diameter Inches	AVERAGE PLATE CUR. Ma.	PLATE DISSIPATION Watts	PEAK INVERSE VOLTAGE Volts	FILAMENT Volts	Amps.
2-01C	General purpose UHF instrument diode. Accurate to 700 Mc. 5-volt oxide coated cathode. Resonant frequency 2800 Mc. Suited to probe mounting.	1.81	.563	1	0.1	1,000	5.3	0.4
2-25A	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	4.38	1.44	50	15	25,000	6.3	3.0
2-50A	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	5.50	1.82	75	30	30,000	5.0	4.0
2-150D	High vacuum rectifier. High voltage medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	8.88	2.50	250	90	30,000	5.0	13.0
2-240A	High vacuum rectifier. High voltage, high current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	11.2	3.82	500	150	40,000	7.5	12.0
2-2000A	High vacuum rectifier. High voltage, high current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	17.8	8.13	750	1,200	75,000	10.0	25.0
250R	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	10.13	3.82	250	150	60,000	5.0	10.5
253	High vacuum rectifier. High current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	8.75	2.50	350	100	15,000	5.0	10.0
8020/100R	High vacuum rectifier. High voltage, medium current. Instant heating, thoriated tungsten filament. Radiation cooled pyrovac plate.	8	2.32	100	60	40,000	5.0	6.5

MERCURY VAPOR TYPES

TYPE	DESCRIPTION	Length Inches	Diameter Inches	Ma.	Peak Plate Amps.	Volts	Filament Volts	Amps.
KY21A	Grid-controlled, mercury vapor rectifier. 2.5-volt, oxide coated filament. 750-Ma. average plate current.	7.69	2.25	750	3	11,000	2.5	10.0
RX21A	Mercury vapor rectifier. 2.5-volt, oxide coated filament. 750-Ma. average plate current.	7.63	2.25	750	3	11,000	2.5	10.0
866A	Mercury vapor rectifier. 2.5 volt, oxide coated filament. 250-Ma. average plate current.	6.5	2.5	250 500	1 2	10,000 2,000	2.5	5.0
872A	Mercury vapor rectifier. 5.0-volt, oxide coated filament. 1.25 amperes average plate current.	8.5	2.31	1,250	5	10,000	5.0	7.5

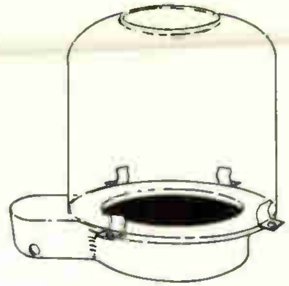
AIR-SYSTEM SOCKETS



4-400A / 4000

4-400A Air System Socket

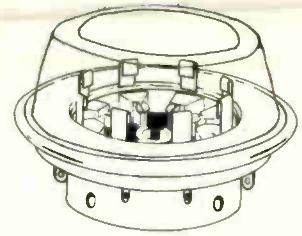
This socket is designed to simplify cooling of the 4-400A Eimac tetrode. Its use insures distribution of the correct amount of cooling air to the various seals of the tube with the most economical blower size.



4-1000A / 4000

4-1000A Air System Socket

This socket is specifically designed for use with the Eimac 4-1000A tetrode. Its function with this tube is the same as the 4-400A socket. These sockets are supplied with all the necessary mounting screws, ground clips, and a pyrex glass chimney for cooling the plate seal area.



4X150A / 4000

4X150A Air System Socket

This socket is designed for use with the Eimac 4X150A power tetrode. In addition to insuring adequate cooling, it makes possible improved circuit arrangements in high frequency applications. It employs a built-in screen to cathode bypass capacitor. Its compact construction reduces lead inductance to a minimum.

TUBE EXTRACTOR

The 4X150 tube extractor may be used for inserting or extracting the 4X150A, 4X150D or 4X150G from normal or deep cavities.

COMPLETE DATA

ON PRODUCTS LISTED IN THIS CATALOGUE ARE AVAILABLE . . . .

A complete technical data sheet for a specific tube type will be sent upon request. Such data sheets are also included in the package with each tube. The sheet contains application information in addition to electrical and mechanical data.

If you wish help in selecting the proper tube type or proper operating conditions for an application, please write for advice to:

Application Engineering Dept.

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

HR HEAT DISSIPATING CONNECTORS

HR Heat Dissipating Connectors are machined from solid dural rod, and are supplied with the necessary machine screws. The table below lists the proper connectors for use with each Eimac tube type.

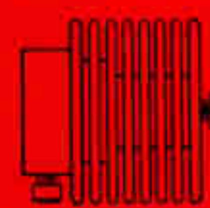
TUBE	Plate Connector	Grid Connector
2-25A	HR-1	....
2-50A	HR-3	....
2-150D	HR-6	....
2-240A	HR-6	....
2-2000A	HR-8	....
3C24	HR-1	HR-1
4-65A	HR-6	....
4-125A	HR-6	....
4-250A	HR-6	....
4-400A	HR-6	....
4-1000A	HR-8	....
4E27A / 5-1258	HR-5	....
4PR60A	HR-8	....
6C21	HR-8	HR-8
KY21A	HR-3	....
RX21A	HR-3	....
25T	HR-1	....
35T	HR-3	....
35TG	HR-3	HR-3
UH50	HR-2	HR-2

TUBE	Plate Connector	Grid Connector
75TH-TL	HR-3	HR-2
100TH-TL	HR-6	HR-2
VT127A	HR-3	HR-3
152TH-TL	HR-5	HR-6
250TH-TL	HR-6	HR-3
250R	HR-6	....
253	HR-8	....
304TH-TL	HR-7	HR-6
327A	HR-4	HR-3
450TH-TL	HR-8	HR-8
592 / 3-200A3	HR-10	HR-5
750TL	HR-8	HR-8
866A	HR-8	....
872A	HR-8	....
1000T	HR-9	HR-9
1500T	HR-8	HR-8
2000T	HR-8	HR-8
8020(100R)	HR-8	....

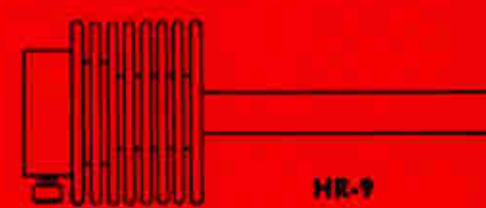
TYPE	Length	Dia.	Hole Dia.
HR-1	11/16"	1/2"	.052"
HR-2	11/16"	1/2"	.062"
HR-3	11/16"	1/2"	.070"
HR-4	7/8"	3/4"	.102"
HR-5	7/8"	3/4"	.125"
HR-6	7/8"	3/4"	.359"
HR-7	1-11/32"	1-3/8"	.125"
HR-8	1-11/32"	1-3/8"	.570"
HR-9	4-11/32"	1-3/8"	.570"
HR-10	1-11/32"	1-3/8"	.510"

HR-1-2-3

HR-4-5-6



HR-7-8-10

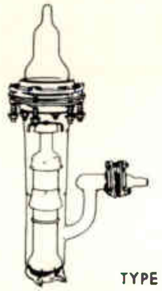


HR-9

EXPLANATION OF CLASS OF SERVICE SYMBOLS

B Aud	Class-AB or -B Audio Frequency Power Amplifier or Modulator. (Typical operations shown are for two tubes.)
B TV	Class-B Linear Radio Frequency Power Amplifier. Visual Television Service.
C CW	Class-C Radio Frequency Power Amplifier and Oscillator. Continuous Wave, Such as for Telegraphy and Frequency Modulated Service.
AM Pl	Amplitude Modulated Radio Frequency Power Amplifier. Plate Modulated or High Level Modulated (Plate and Screen Voltages Modulated).
Pulse Plate	Pulsed Radio Frequency Power Amplifier. Plate and r-f Excitation Voltages Pulsed.
Pulse Mod	Pulse Power Amplifier, Modulator, or Keyer Service.

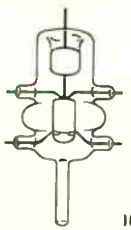
VACUUM PUMP



TYPE HV-1

A glass barrel, triple-jet, air-cooled vacuum pump of the oil-diffusion type. Ultimate vacuum of 4×10^{-7} mm of mercury. Speed without baffle approximately 67 liters per second. Simple to operate, requires no liquid cooling, cold trap, or charcoal trap. Can be disassembled with wrenches. Heater voltage 110 volts. Current 1.7 amperes. Overall length below high-vac manifold 16½". Shipping weight 18 pounds. Complete assembly includes flanges and nipples for connecting to high-vacuum manifold and forepump system, together with necessary gaskets and complete operating instructions.

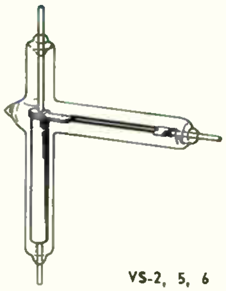
IONIZATION GAUGE



100 IG

Essentially a triode vacuum tube with a pure tungsten filament and molybdenum electrodes for measuring pressures from 10^{-3} to less than 10^{-7} mm of mercury, constructed of "hard" glass for sealing directly to nonex glass vacuum systems.

VACUUM SWITCH



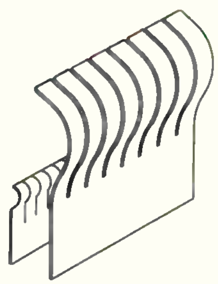
VS-2, 5, 6

A single pole, double throw switch with contacts in high vacuum for high voltage switching. Contact spacing .015". Switch will handle r-f potentials as high as 20 Kv. In DC switching will handle approximately 1.5 amps. at 5 Kv.

CONTACT FINGER STOCK

Eimac pre-formed contact finger stock is especially suitable for making connections to coaxially constructed tubes and those of external-anode design. The heat-treated copper alloy material is silver plated for low r-f losses. It may be bent on a one-half inch radius without breaking.

Contact finger stock may be obtained without heat treatment or silver plating upon request.



TYPE	WIDTH Inches	MATERIAL THICKNESS Inches	FINGER DEFLECTION Inches
17/32"	17/32	.008	1/32
31/32"	31/32	.010	3/32
1-7/16"	1-7/16	.010	1/8

EIMAC TUBES FOR PULSE SERVICES

Eimac tubes, with their "clean" internal construction, ample filament emission reserve, and hard-vacuum, make exceptionally fine pulse modulators, amplifiers, or oscillators. Peak voltages and currents considerably in excess of the published data for continuous operation can be used in pulse work.

Data for specific pulse applications, or our Application Bulletin No. 3 titled "Pulse Service Notes", will be supplied upon request. Our engineering services are also available. Please don't hesitate to call on us; we are anxious to work with you.

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

Note Articals By
JOHN L. REINHARTZ

THE CARE AND FEEDING OF POWER TETRODES

APPLICATION BULLETIN NUMBER EIGHT

EITEL - McCULLOUGH - 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.

Published by the Field Engineering Department of Eitel-McCullough, Inc.

THE CARE AND FEEDING OF POWER TETRODES

CONTENTS

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.

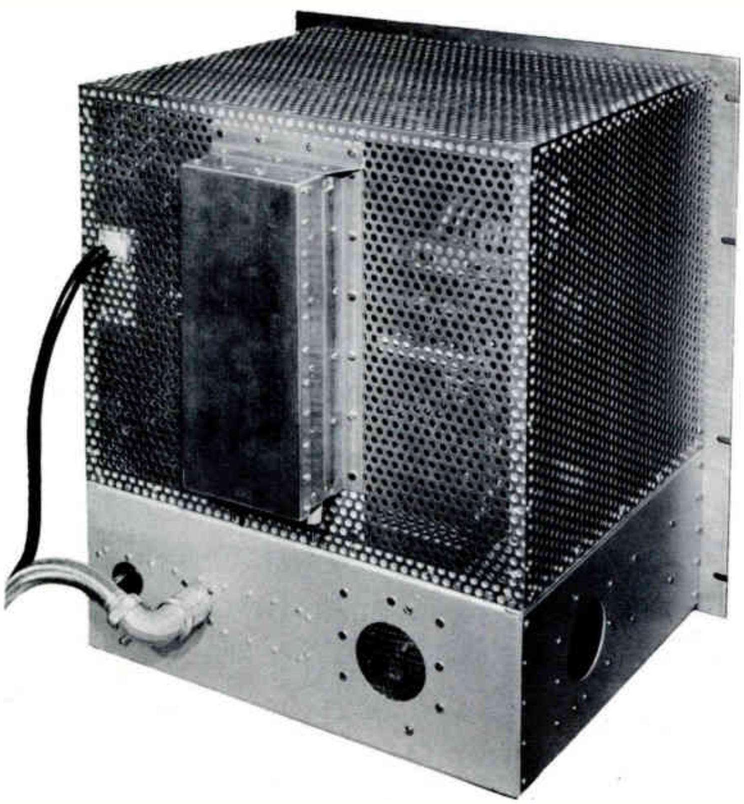


Fig. 1

Well arranged, filtered, and shielded r-f amplifier. Designed and built by R. L. Norton (W6CEM), and in use at W1FH.

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.

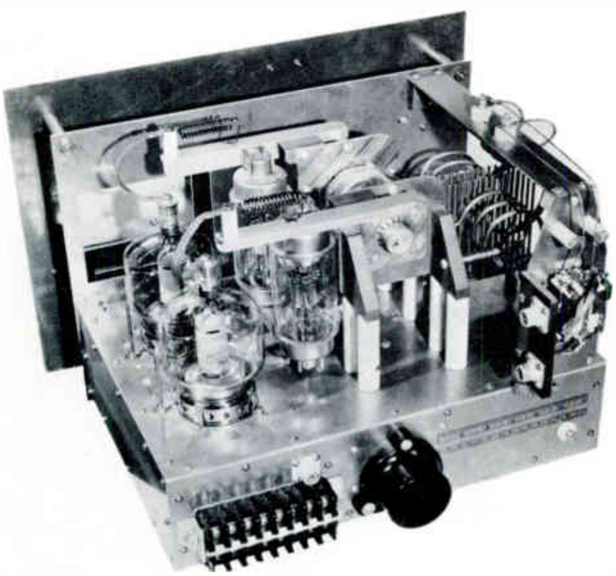


Fig. 2

Push-pull r-f amplifier employing 4-250A tetrodes. Designed and built by C. F. Bane (W6WB)[5].

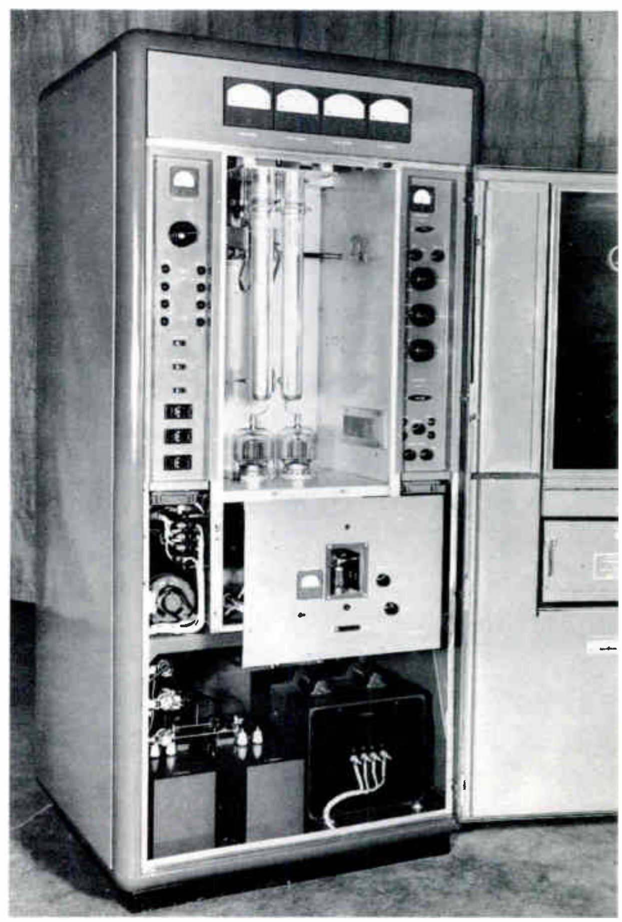


Fig. 3

Push-pull 88-108 Mc. 1 Kw. amplifier employing 4-400A tetrodes. Radio Engineering Laboratories, Model 701 transmitter.

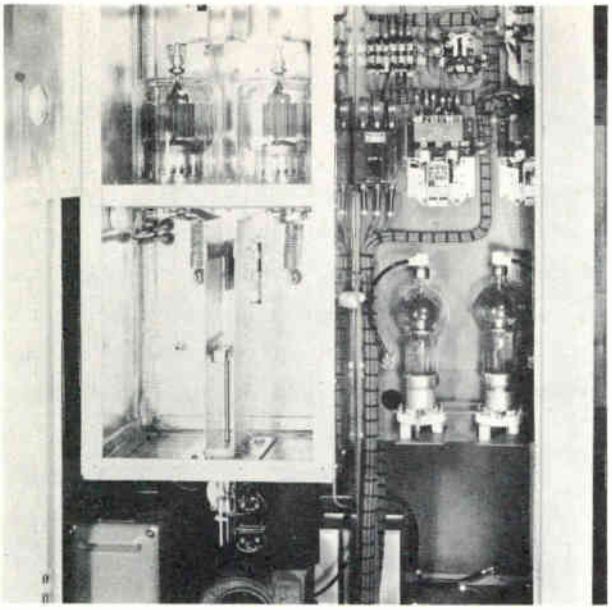


Fig. 4

Push-pull 110 Mc. amplifier employing 4-1000A tetrodes. Gates Radio Co. Model BF 3 kw trasmitter.

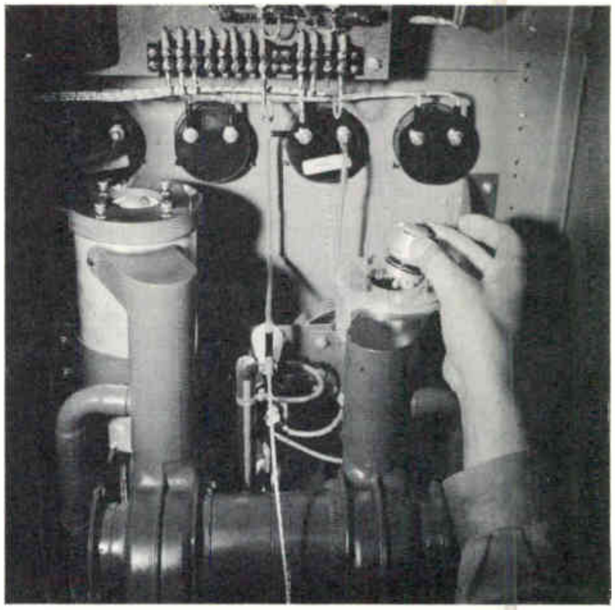


Fig. 6

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.

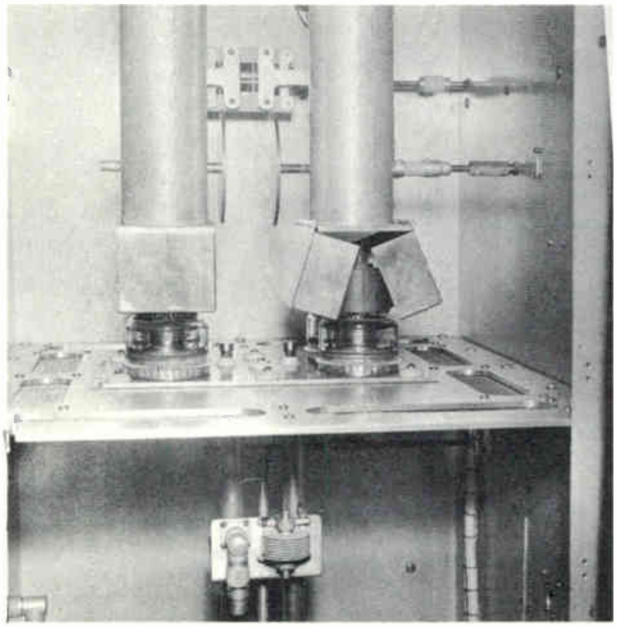


Fig. 5

Experimental push-pull parallel 110 Mc. 3 kw amplifier employing 4X500A tetrodes. Designed and built by Eitel-McCullough Laboratories.

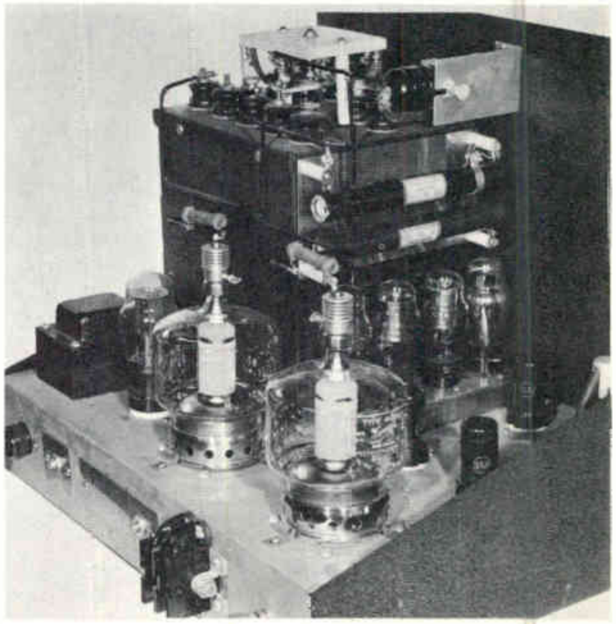


Fig. 7

Experimental 500 watt Class-AB, audio amplifier. Designed and built by Eitel-McCullough Laboratories'.

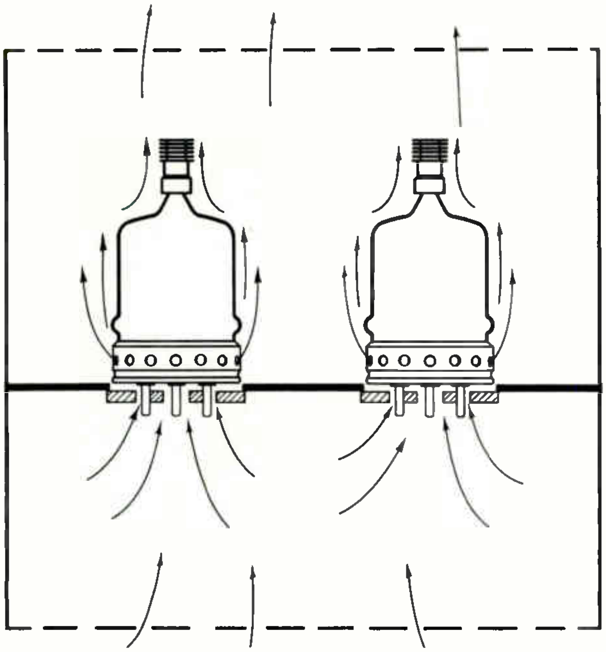


Fig. 8

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 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.

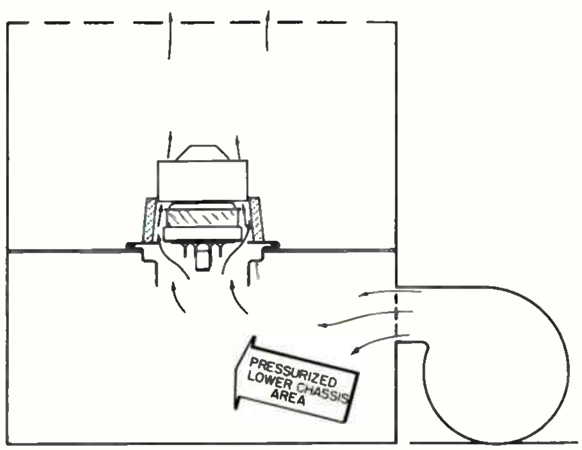


Fig. 9

4X150A chassis mounting providing cooling, shielding and isolation of output and input compartments.

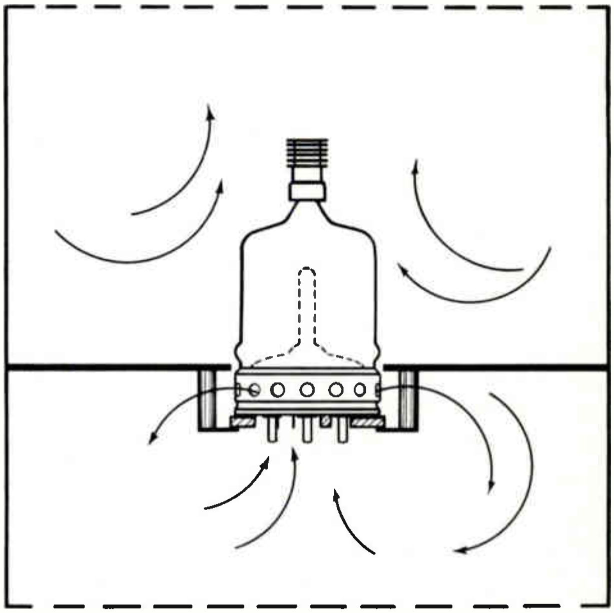


Fig. 10

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 arrangment *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.

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.

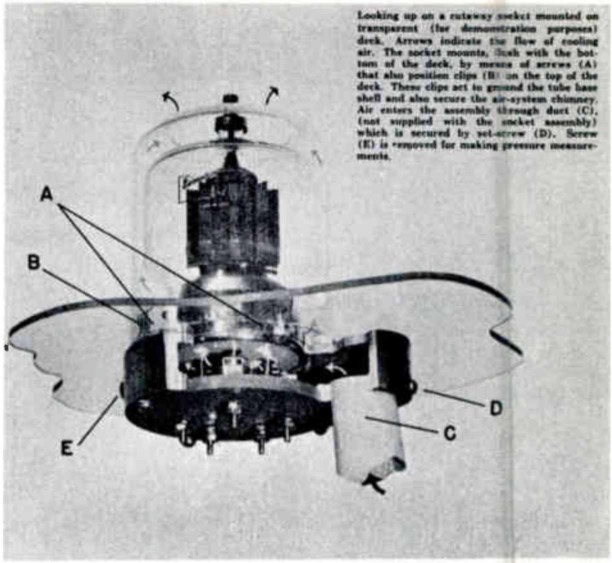


Fig 11

Eimac 4-400A/4000 Air System Socket providing balanced tube cooling by a single stream of air.

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.

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

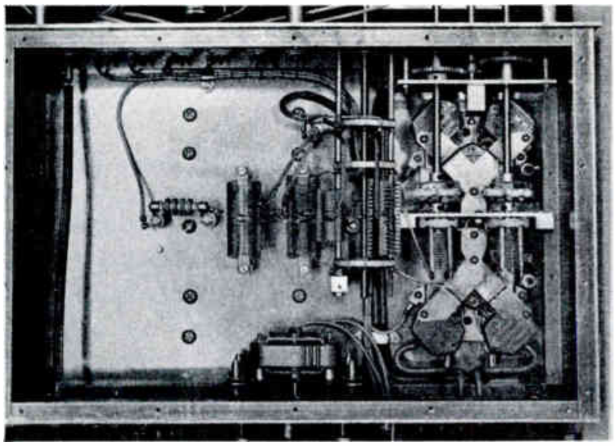


Fig 12

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 by-passing 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.

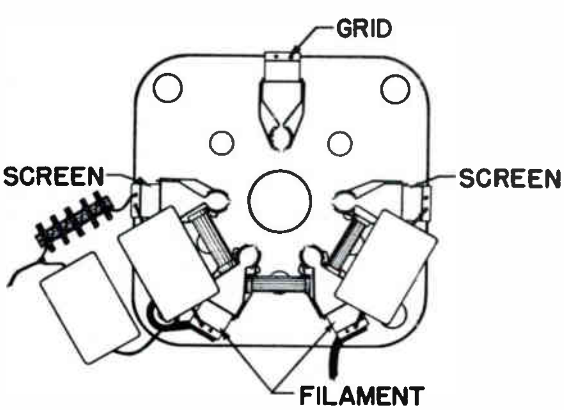


Fig. 13

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 by-passed or grounded directly.

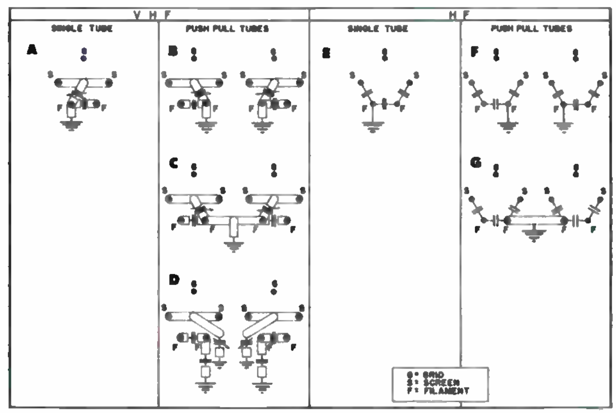


Fig. 14

Various screen and filament bypassing arrangements.

In case separate filament supplies are used, as in individual metering circuits, filament by-passes 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 by-passed. 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 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 AB_1 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[1], and Fig. 7.

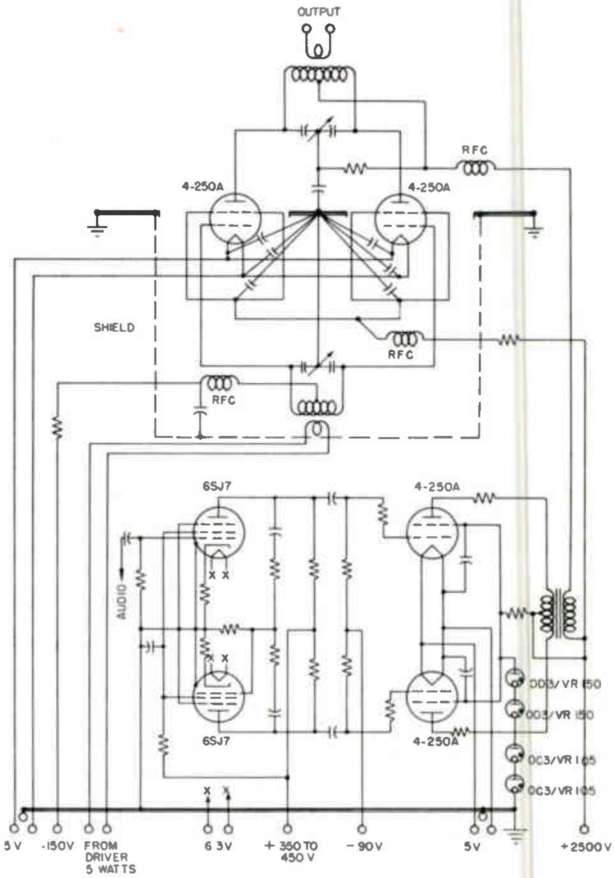


Fig. 15

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.

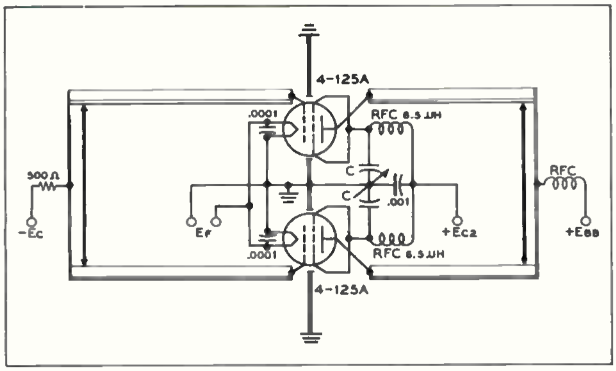


Fig. 16

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.

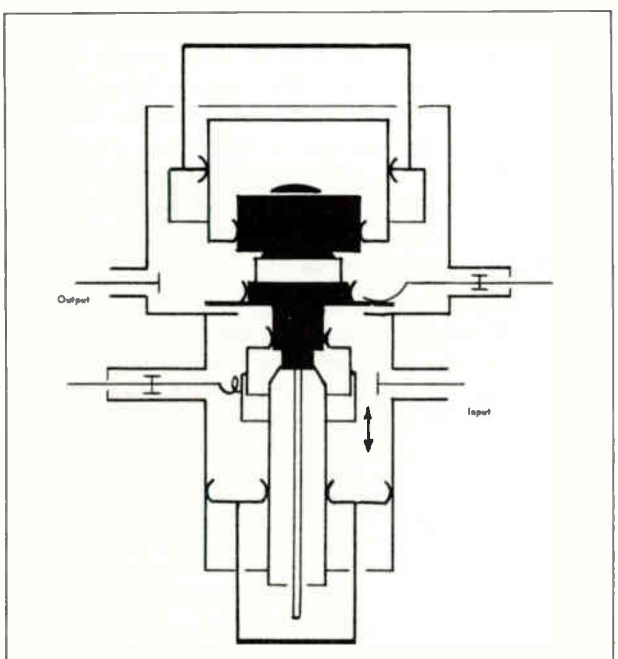


Fig. 17

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".

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 sceen 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. Futhermore, 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.

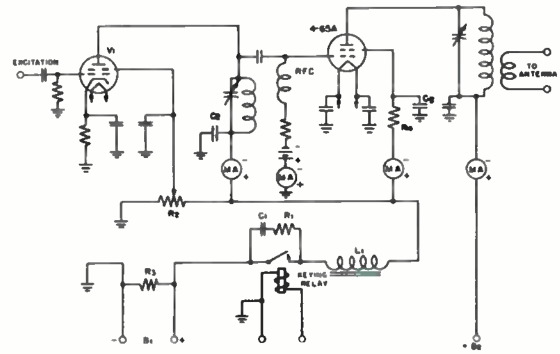


Fig. 21

Tetrode amplifier keying circuit used by B. O. Ballou (W6BET)[1].

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.

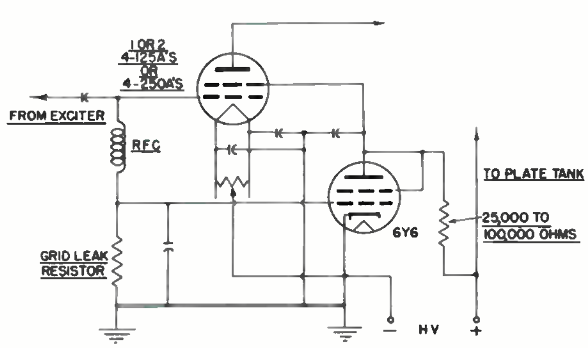


Fig. 20

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.

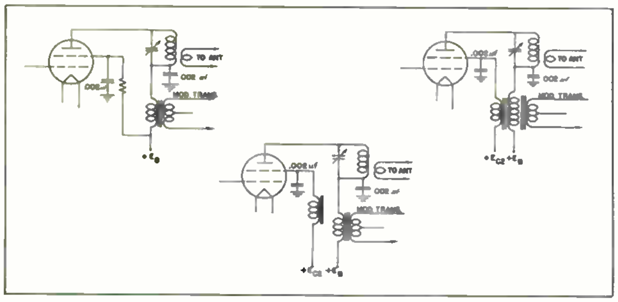


Fig. 22

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 ⅓ 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 milliameter 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: Mix[3], Fyler[4], Bane[5].

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 bypass capacitors are involved. This type of oscillation does not usually occur when the power amplifier is designed for operation in the VHF region 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.)

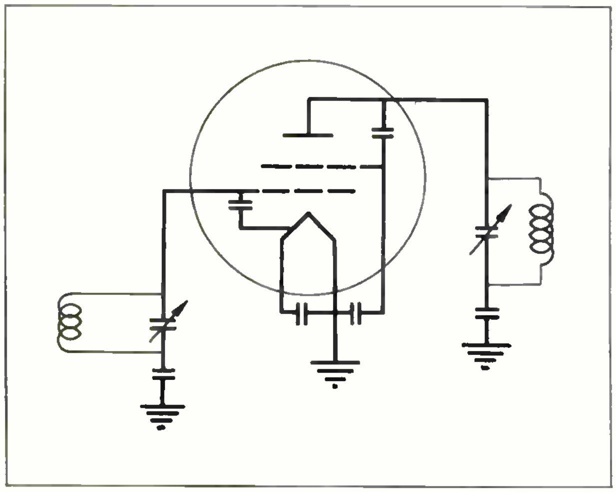


Fig. 23

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 ½" 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.

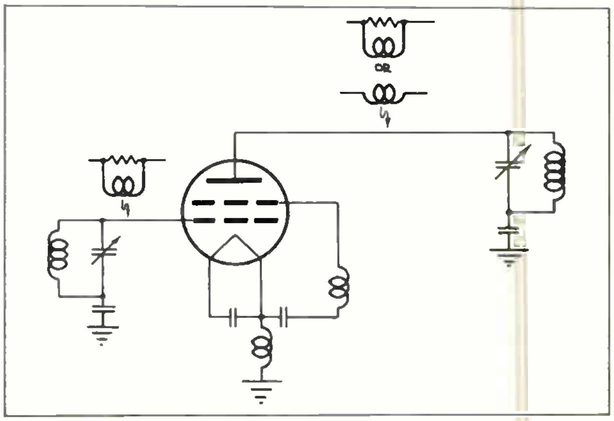


Fig. 24

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 ½" 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 Mix[3] and Bane[5]. 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".

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 ½" 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, Cn, 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, Ci, equal in size to the input capacitance of the tetrode.

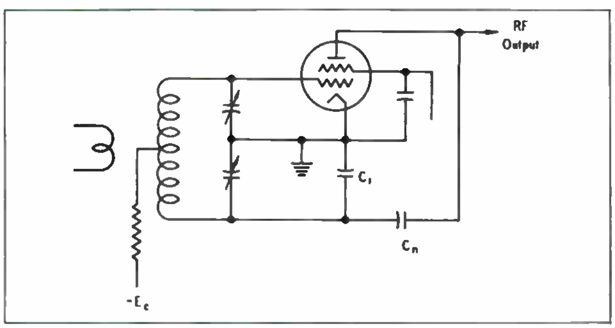


Fig. 25

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 Bruene[6], 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, Cn, 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 capacitance bridge showing clearly the grid neutralization circuit. See Fig. 26b. Balance is had when

$$\frac{Cn}{C} = \frac{Cgp}{Cgf}$$

where Cgp is the feedback capacitance grid to plate of the tetrode, and Cgf is the total input capacitance, including tube and stray capacitance.

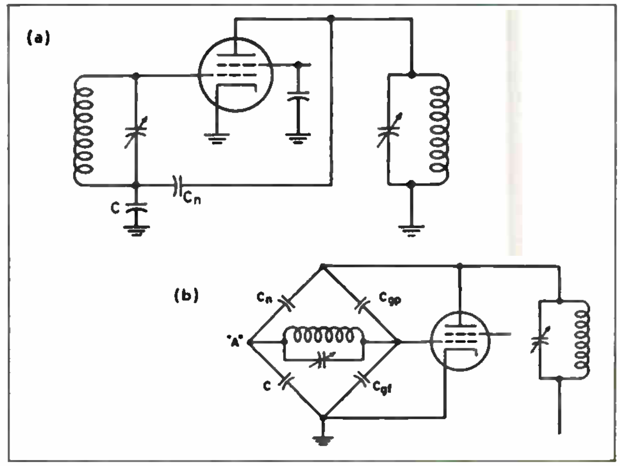


Fig. 26

Single-ended grid neutralization described by Bruene[6].
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 Hultberg[7].

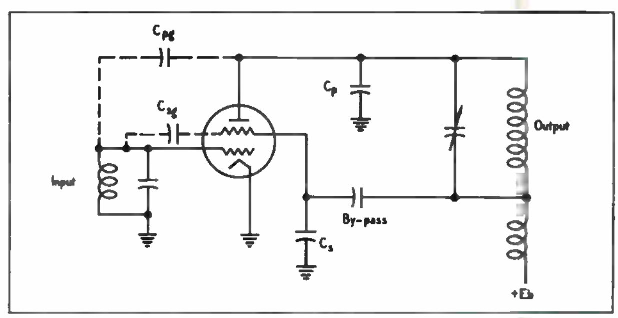


Fig. 27

Single-ended plate neutralization, basic circuit.
See Hultberg[7].

Such a circuit is shown in Fig. 27. It differs from the usual r-f amplifier circuit in that the plate by/pass capacitor is returned to the screen side of the screen bypass capacitor, Cs, and in adding stray capacitance from plate to ground, Cp. The size of screen bypass capacitor, Cs, and the amount of stray capacitance in Cp are chosen to balance out the voltages induced in the input circuit by the internal tube capacitances plate to grid, Cpg, and screen to grid, Csg.

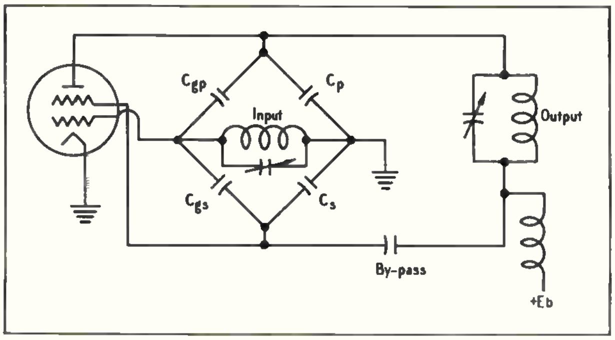


Fig. 28

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

$$\frac{Cp}{Cs} = \frac{Cpg}{Cgs}.$$

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.

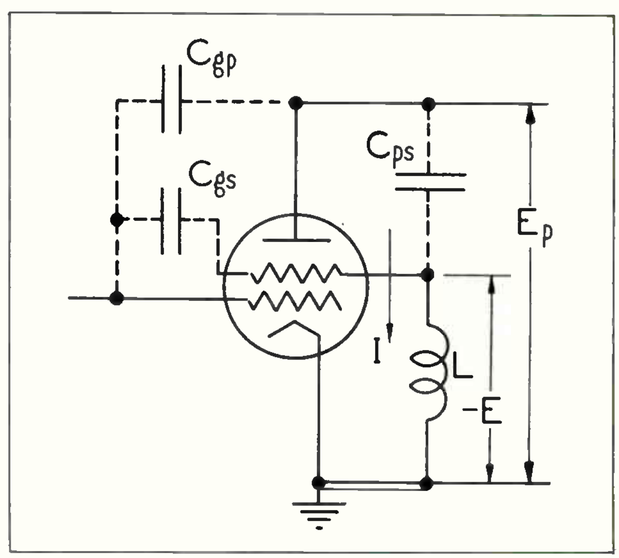


Fig 29

Tetrode characteristics involved in feedback circuit.

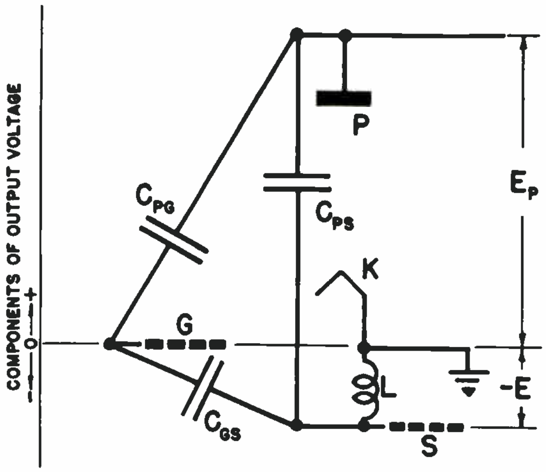


Fig. 30

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 made[8] 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 Ep causes a current I to flow through the plate to screen Cps, 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 Ep.

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 Ep 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 Ep. 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 "Ep" 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 Ep and screen lead inductance voltage -E. This total voltage is applied across a potential divider consisting of the capacitance plate to grid, Cpg, in series with the capacitance grid to screen, Cgs. When this potential divider is suitably matched to the magnitudes of the voltage Ep and screen lead voltage -E, the control grid will have no voltage difference to filament as a result of the output circuit voltage Ep.

It should be noted in Fig. 30 that the potential dividing action between capacitances plate-to-grid, Cpg, and grid-to-screen, Cgs, 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	apparently above the useful range of the tube.
4X500A	apparently above the useful range of the tube.

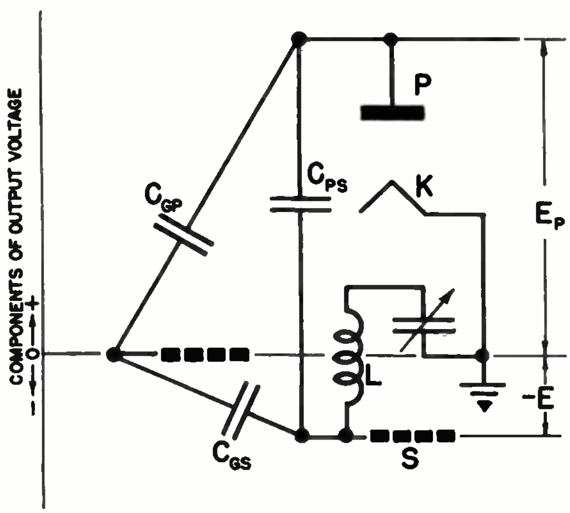


Fig. 31

Components of output voltage of a tetrode when neutralized by added series screen-lead capacitance.

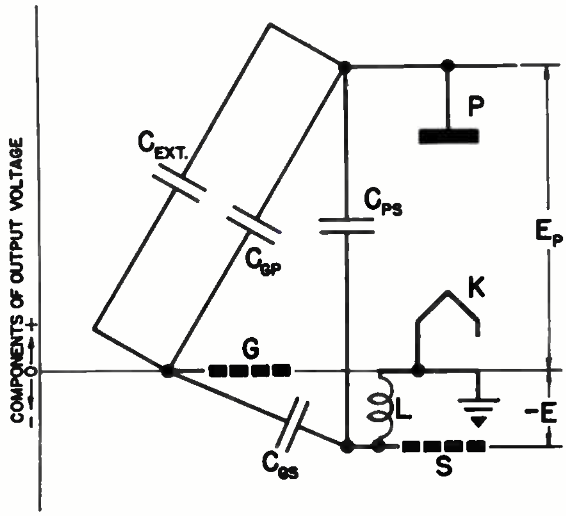


Fig. 32

Components of output voltage of a tetrode when neutralized by added external grid-to-plate 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 neutralizing 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.

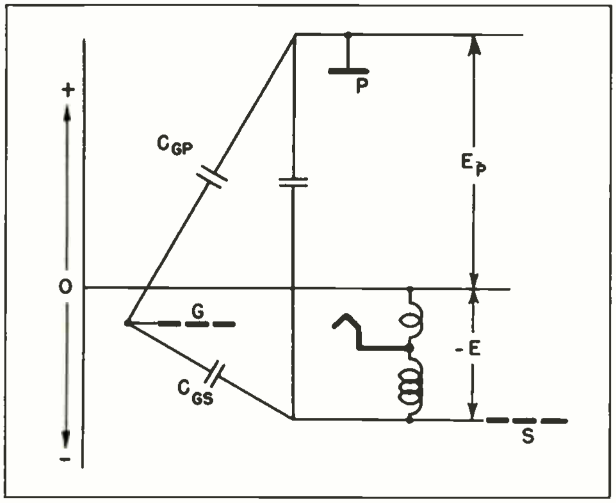


Fig. 33

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 fundamenal 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 ½ or ⅔ of the indicated plate current is to be used, the d-c grid current and d-c screen current should be approximately ½ or ⅔ 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 avaliable[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 Sheet[11].

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-AB_1 or Class-AB_2, 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.

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 Brown[12] and the Eimac application bulletin "Tube Performance Computor"[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 basis. 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 manner[13] (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 available[13].

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 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. For further discussion see Eimac application bulletin[15] on the subject.

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 compensation 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.

REFERENCES

1. Atkins & Mandoli, "500 Watts of Audio from AB_1," QST, p. 13, March, 1948 QST, p. 10, June, 1948
2. Byron Ballou, "Keying the Tetrode Amplifier," QST, p. 46, Dec., 1947
3. Don Mix, "Parasitics," QST, p. 19, June, 1948
4. G. W. Fyler, "Parasitics & Instability in Radio Transmitters," Proc. I.R.E., Sept., 1935
5. C. F. Bane, "Final Final," CQ, p. 15, Dec., 1948, and "A Page from a Designer's Notebook," CQ, p. 19, March 1949
6. Warren B. Bruene, "Single-Ended Tetrode Final," CQ, p. 11, Aug., 1950
7. C. A. Hultberg, "Neutralization of Screen-Grid Tubes to Improve the Stability of Intermediate-Frequency Amplifiers" Proceedings of IRE, p. 663, Dec. 1943
8. W. G. Wagener, "500-Mc. Transmitting Tetrode Design Considerations," Proc. I.R.E., vol. 36, No. 5, May, 1948
9. Application Bulletin No. 4, "Calculating Tube Performance," Eitel-McCullough, Inc., San Bruno, California
10. Application Bulletin No. 5, "Tube Performance Computor," Eitel-McCullough, Inc., San Bruno, California
11. Eimac 4-65A Technical Data Sheet, Eitel-McCullough, Inc., San Bruno, California
12. Robert H. Brown, "Harmonic Amplifier Design," Proc. I.R.E., vol. 35, pp. 771-777, August, 1947
13. Application Bulletin No. 6, "Vacuum Tube Ratings," (Reprinted from January, 1945 industrial edition of the Eimac News) Eitel-McCullough, Inc San Bruno California
14. Application Bulletin No. 3, "Pulse Service Notes," Eitel-McCullough, Inc., San Bruno, California
15. Application bulletin No. 7, "Vacuum Tube Temperature Measurements," Eitel-McCullough, Inc., San Bruno, California

5-83479
October, 1954

NOTES

NOTES

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

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 ouput 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 $\mu\mu$f
Input	8.0 $\mu\mu$f
Output	2.1 $\mu\mu$f
Transconductance (I_b = 125 ma., E_b = 500 v., E_{c2} = 250 v.)	4000 μmhos
Frequency for Maximum Ratings	150 Mc.

MECHANICAL

Base	5-pin—Fits { National HX-29 Socket / Johnson 122-101 Socket
Mounting	Vertical, base down or up
Cooling	Convection and Radiation
Recommended Heat Dissipating Connector	Eimac HR-6
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 Telegraphy 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.

▸ Indicates change from sheet dated 1-30-53

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-AB_1 (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.
[1]Adjust 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-AB_2 (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	180	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-AB_2 (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	65	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.

▶ Indicates change from sheet dated 1-30-53

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 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 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

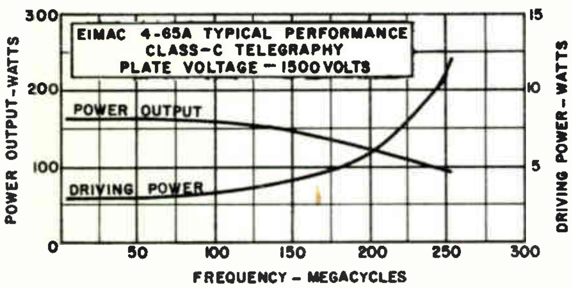
Class-C FM or Telegraphy—The 4-65A may be operated as a class-C FM or telegraph amplifier without neutralization up to 110 Mc. if reasonable precautions are taken to prevent coupling between input and output circuits external to the tube. In single ended circuits, plate, grid, filament and screen by-pass 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 ¾" square and located adjacent to the envelope opposite the plate will suffice for neutralization. Means should be provided for adjusting the

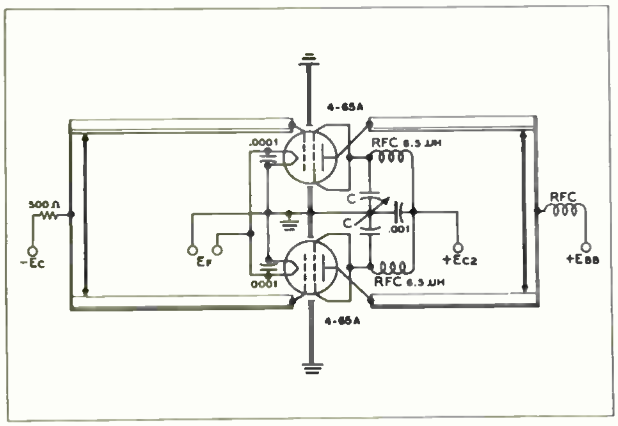
*For suitable peak V.T.V.M. circuits see, for instance, "Vacuum Tube Ratings," **Eimac News**, January 1945. This article is available in reprint form on request.

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 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.



Screen-tuning neutralization circuit for use above 100 Mc.
C is a small split-stator capacitor.

$$C_{(\mu\mu fd)} = \frac{640{,}000}{f^2\ (\text{Mc.})}\text{, approx.}$$

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-AB$_1$ and Class-AB$_2$ 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-AB$_1$ and class-AB$_2$ 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-AB$_2$ 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-AB$_1$ conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

The peak driving power figures given in the class-AB$_2$ 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.

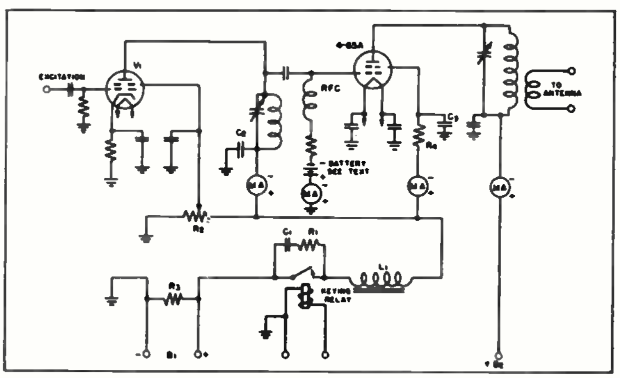
In some cases the maximum-signal plate dissipation shown under "Typical Operation" is less than the maximum rated plate dissipation of 4-65A. In these cases, with sine wave modulation, the plate dissipation reaches a maximum value, equal to the maximum rating, at a point somewhat below maximum-signal 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 μfd 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 μfd 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-electode 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. Correspondingly, 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 approximate 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:

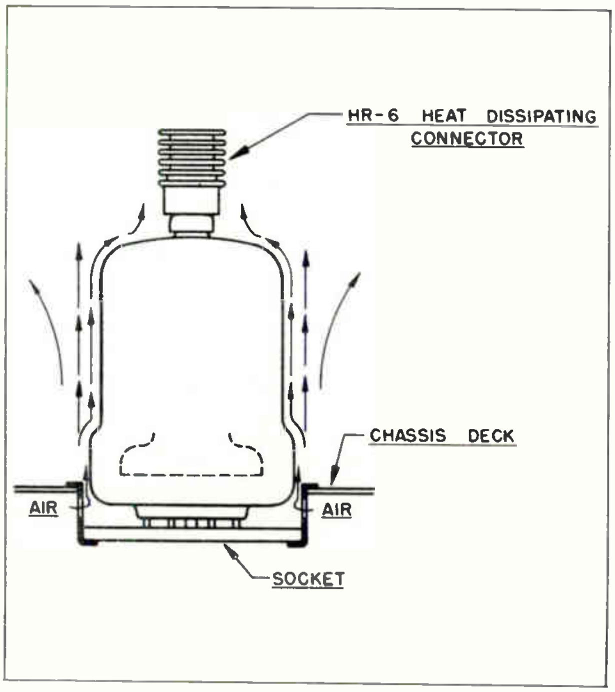
1. Cut the audio output to zero.
2. Apply 120 volts of bias to the 4-65A control grid.
3. Apply the operating plate voltage followed by the operating screen voltage.
4. Reduce bias voltage to obtain 50 watts of stand-by plate dissipation.
5. Increase audio gain, checking the oscilloscope pattern for 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.

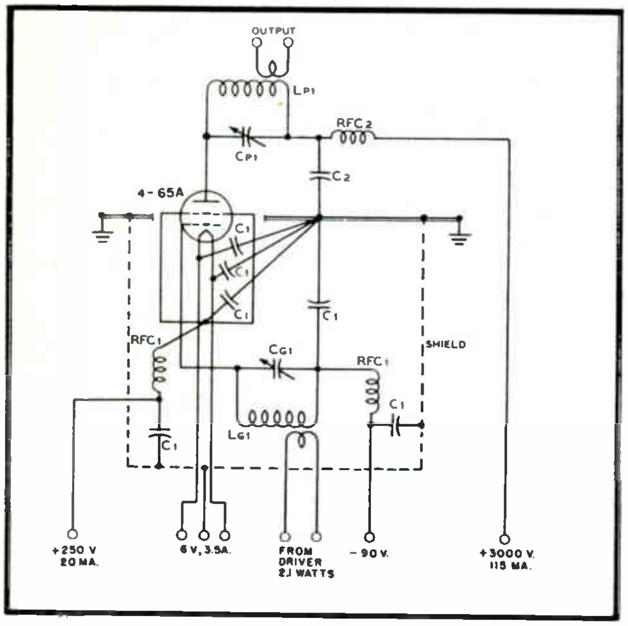
If the alternate method is used with a 100% duty cycle from the audio oscillator, then step 3 should be to apply half voltages and the stand-by plate dissipation should be set at 10 watts.

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.

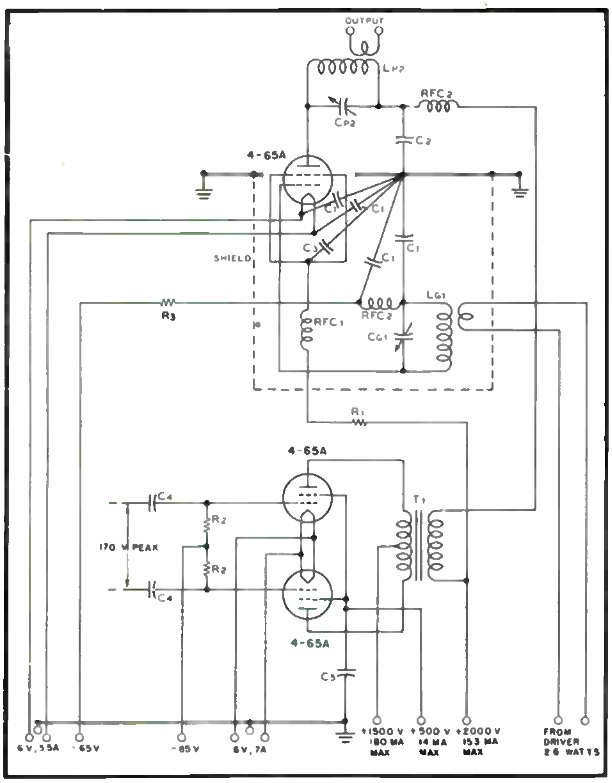




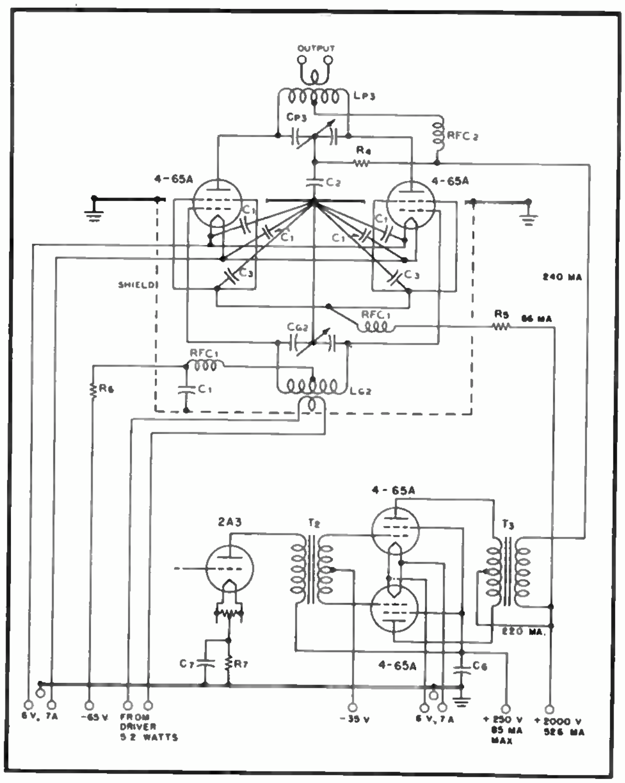
Typical radio-frequency power amplifier circuit, Class-C telegraphy, 345 watts input.

COMPONENTS FOR TYPICAL CIRCUITS

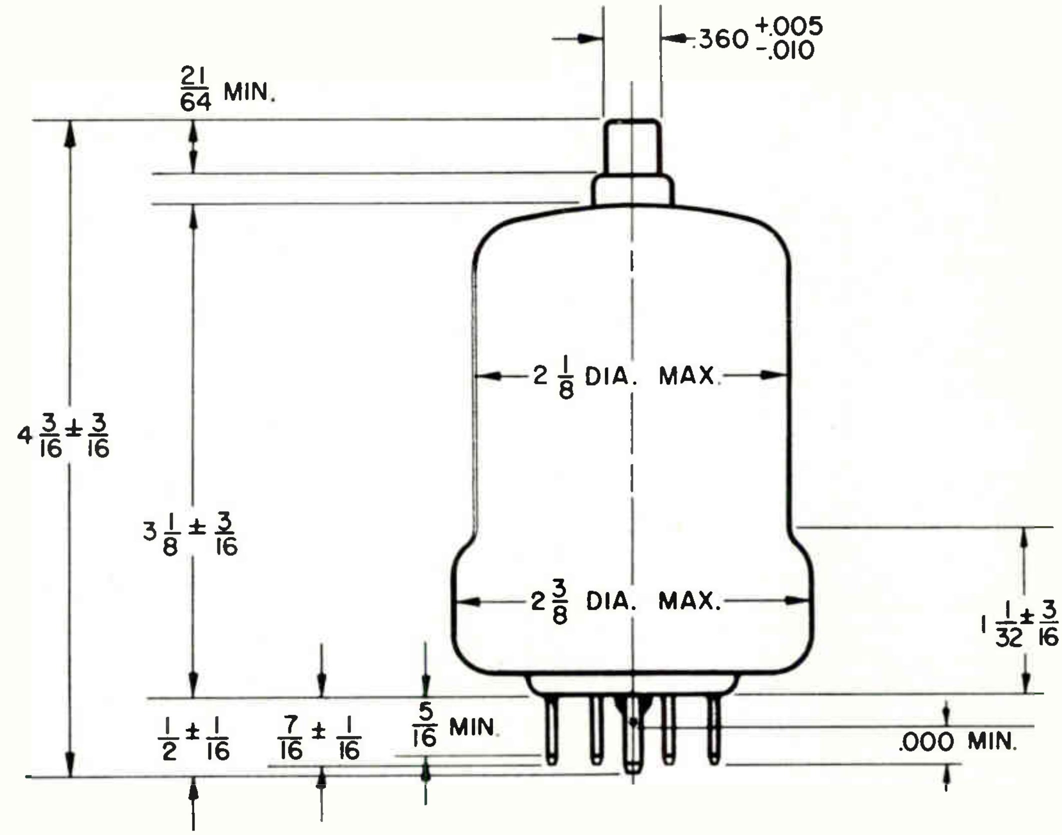
L_{p1}-C_{p1}— Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
L_{p2}-C_{p2}— Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .200".
L_{p3}-C_{p3}— Tank circuit appropriate for operating frequency; Q = 12. Capacitor plate spacing = .375".
L_{g1}-C_{g1}— Tuned circuit appropriate for operating frequency.
L_{g2}-C_{g2}— Tuned circuit appropriate for operating frequency.
C_1— .002 -μfd. 500V Mica
C_2— .002 -μfd. 5000V Mica
C_3— .001 -μfd. 2500V Mica
C_4— .1 -μfd. 1000V paper
C_5— .1 -μfd. 600 V paper
C_6— 16 -μfd. 450V Electrolytic
C_7— 10 -μfd. 100V Electrolytic
R_1—53,000 ohms 200 watt—60,000 ohm adjustable
R_2—250,000 ohms 1 watt
R_3— 5,000 ohms 5 watt
R_4— 25,000 ohms 2 watts
R_5— 26,500 ohms 200 watts—30,000 ohm adjustable
R_6— 2,500 ohms 5 watts
R_7— 750 ohms 5 watts
RFC_1— 2.5 mhy. 125 ma. R-F choke
RFC_2— 1 mhy. 500 ma. R-F choke
T_1—150 watt modulation transformer; ratio primary to secondary impedance approx. 1:1.1 Pri. impedance 15,000 ohms, sec. impedance 16,700 ohms.
T_2—5 watt driver transformer impedance ratio primary to 1/2 secondary 1.5:1.
T_3—300 watt modulation transformer; impedance ratio pri. to sec. approx. 2.4:1; Pri. impedance = 20,000 ohms, sec. impedance = 8,333 ohms.

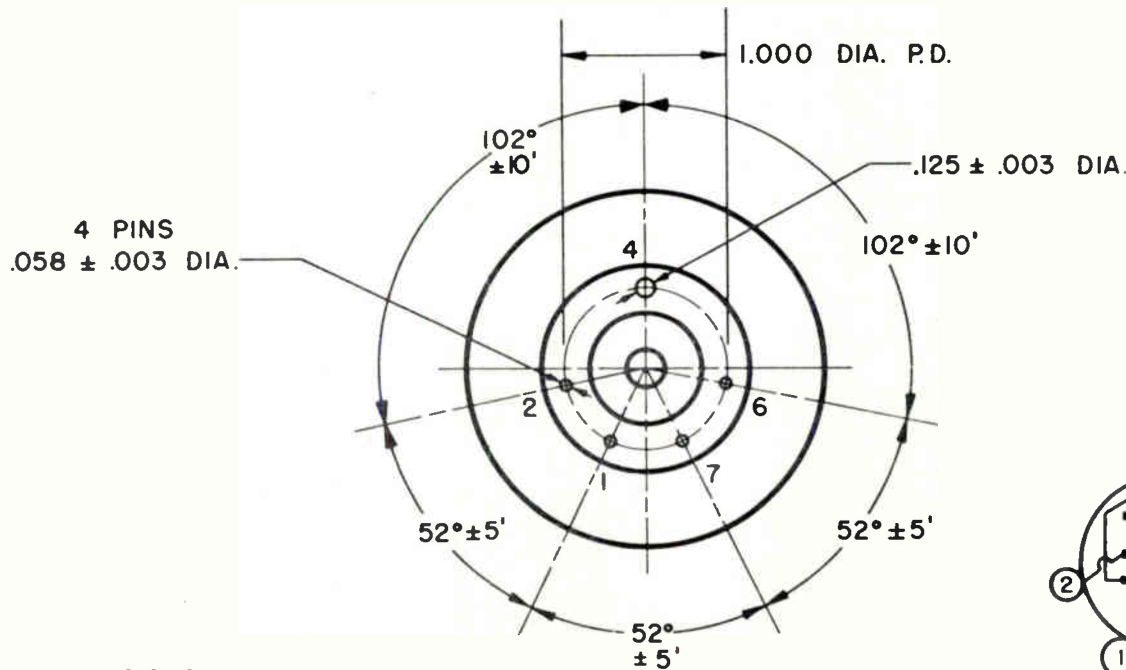


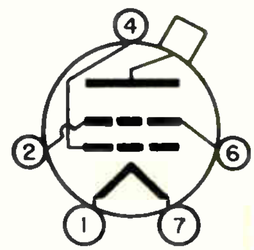
Typical high-level-modulated R-F amplifier, 240 watts plate input. Modulator requires zero driving power.



Typical high-level-modulated R-F amplifier circuit, with modulator and driver stages, 480 watts plate input.

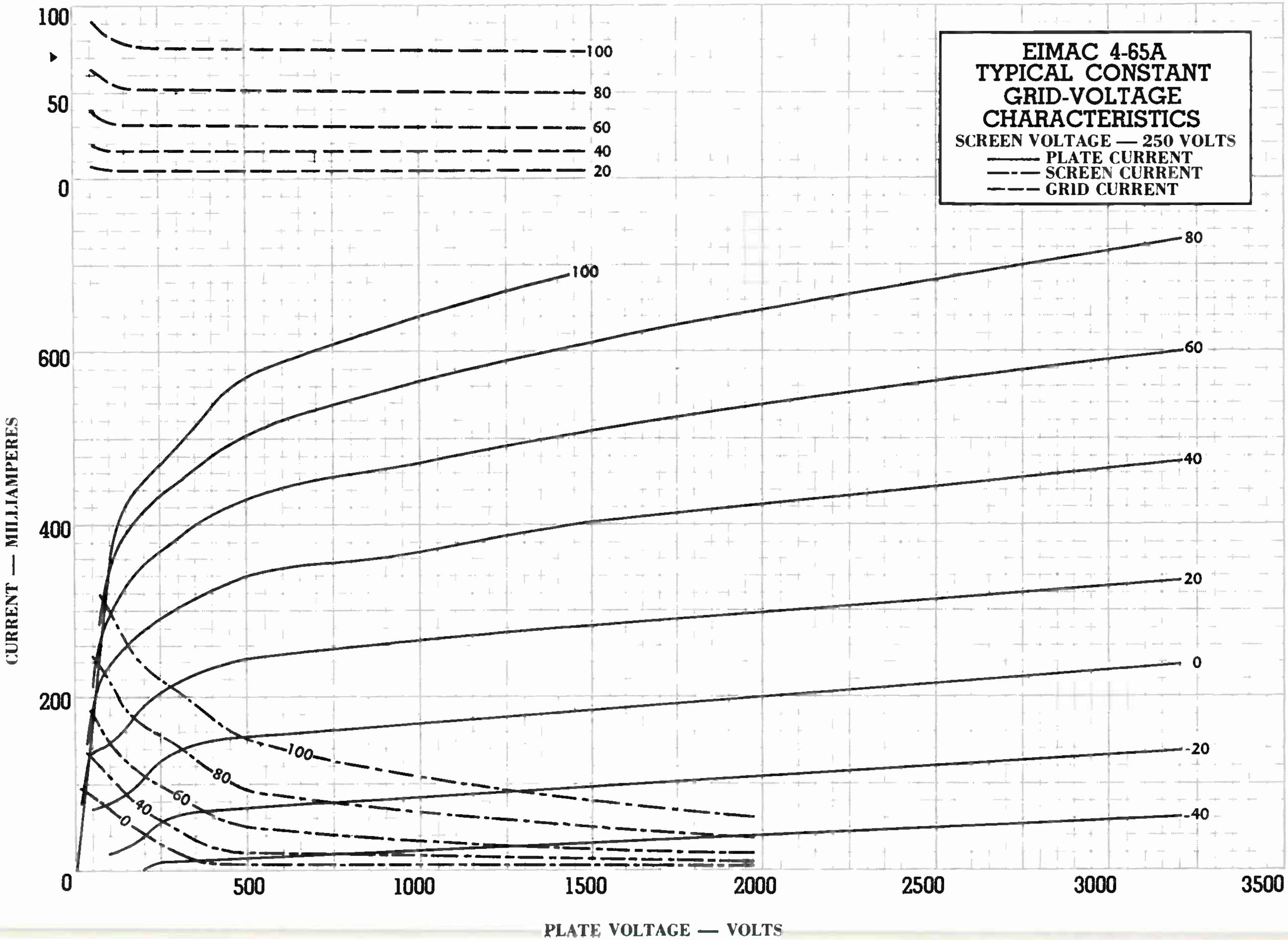






ALL DIMENSIONS IN INCHES

BOTTOM VIEW



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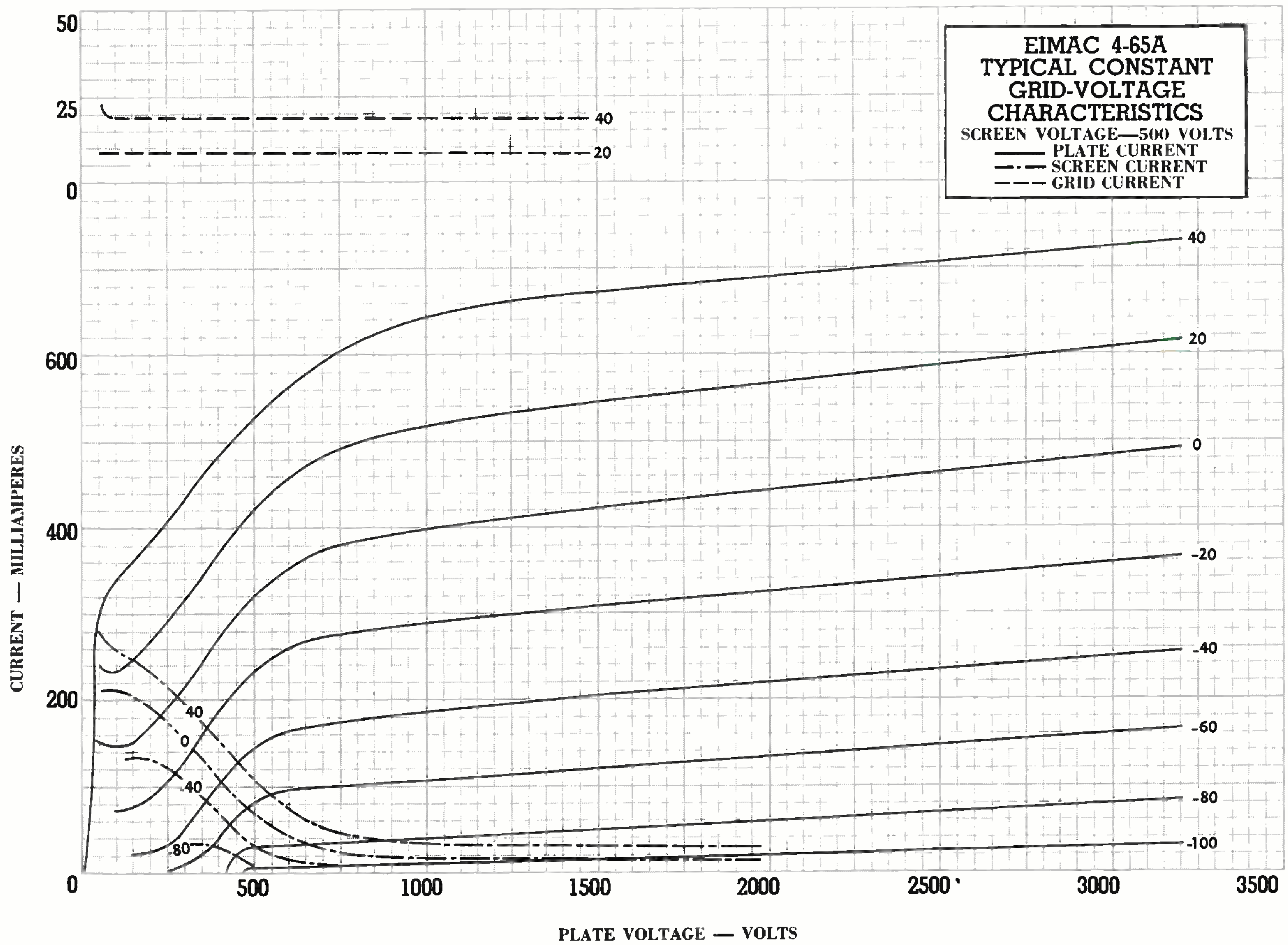
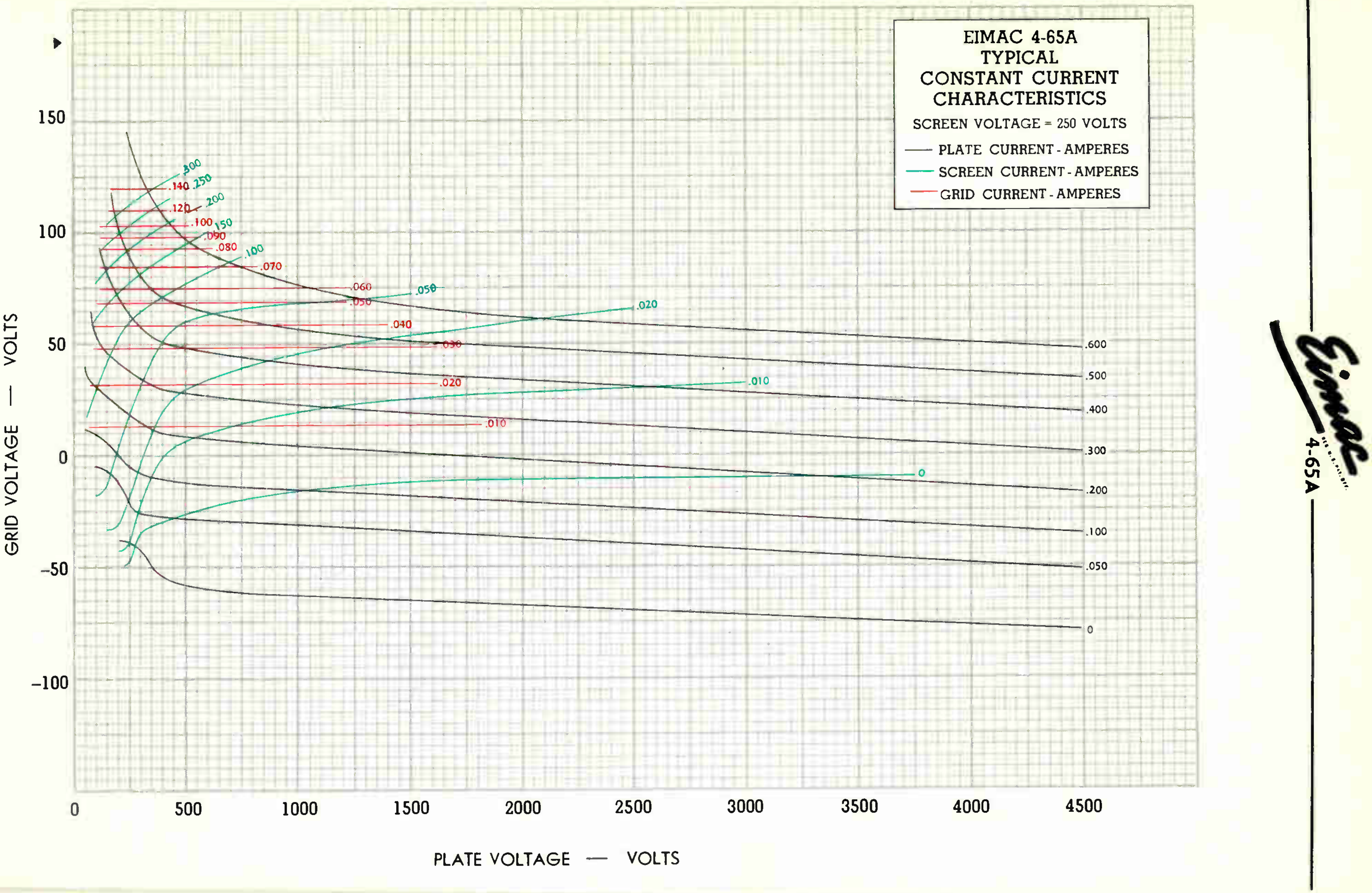
Eimac 4-65A



EIMAC 4-65A
TYPICAL CONSTANT
GRID-VOLTAGE
CHARACTERISTICS
SCREEN VOLTAGE—500 VOLTS
PLATE CURRENT
SCREEN CURRENT
GRID CURRENT
50
25
0
600
400
200
0
40
20
40
20
0
-20
-40
-60
-80
-100
40
0
-40
-80
500
1000
1500
2000
2500
3000
3500
CURRENT — MILLIAMPERES
PLATE VOLTAGE — VOLTS

Eimac
4-65A



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PRINTED IN U.S.A. 6-17—83478

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

4X150A

RADIAL-BEAM POWER TETRODE

These Data apply to type 4X150D which is identical to 4X150A except for the heater rating of 26.5 volts 0.57 ampere.

The Eimac 4X150A is a compact power tetrode intended for use as an amplifier, oscillator or frequency multiplier over a wide range of frequencies extending into the UHF region. It is cooled by forced air.

A single 4X150A operating in a coaxial-cavity amplifier circuit will deliver up to 140 watts of useful power output at 500 megacycles.

The maximum rated plate voltage for the 4X150A is 1250 volts, and the tube is capable of good performance with plate voltages as low as 400 volts. Its high ratio of transconductance to capacitance and its 150-watt plate dissipation rating make the 4X150A useful for wide-band amplifier applications.

The use of the Eimac 4X150A Air-System Socket, or a socket providing equivalent air-cooling facilities, is required.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode: Oxide Coated, Unipotential		
Minimum Heating Time	30	seconds
Cathode-to-Heater Voltage	150	max. volts
Heater: Voltage	6.0	volts
Current	2.6	amperes
Grid-Screen Amplification Factor (Average)	5	
Direct Interelectrode Capacitances (Average)		
Grid-Plate	0.03	μμf
Input	15.5	μμf
Output	4.5	μμf
Transconductance (E_b=500v., E_{c2}=250v., I_b=200 ma)	12,000	μmhos
Frequency for Maximum Ratings	500	Mc

MECHANICAL

Base	9-pin, special
Recommended Socket	Eimac 4X150A Air-System Socket
Base Connections	See outline drawing
Mounting	Any position
Cooling	Forced air
Maximum Over-all Dimensions	
Length	2.47 inches
Diameter	1.65 inches
Seated Height	1.91 inches
Net Weight	5.2 ounces
Shipping Weight	1.6 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 OR OSCILLATOR

Class-C Telegraphy or FM Telephony
(Key-down conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	1250 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	150 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 165 Mc., per tube)

D-C Plate Voltage	600	750	1000	1250	volts
D-C Screen Voltage	250	250	250	250	volts
D-C Grid Voltage	—75	—80	—80	—90	volts
D-C Plate Current	200	200	200	200	ma
D-C Screen Current	37	37	30	20	ma
D-C Grid Current	10	10	10	10	ma
▶ Peak R-F Grid Voltage (approx.)	90	95	95	105	volts
▶ Driving Power	0.7	0.7	0.7	0.8	watts
Plate Power Input	120	150	200	250	watts
Plate Power Output	85	110	150	195	watts

The performance figures for frequencies up to 165 Mc. are obtained by calculation from the tube characteristic curves and confirmed by direct tests. The driving power includes only 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.

▶ TYPICAL OPERATION (Single tube, 500-Mc., coaxial cavity)

D-C Plate Voltage	600	800	1000	1250	volts
D-C Screen Voltage	250	250	250	250	volts
D-C Grid Voltage	—80	—80	—80	—80	volts
D-C Plate Current	200	200	200	200	ma
D-C Screen Current	7	7	7	7	ma
D-C Grid Current	10	10	10	10	ma
Driver Output Power (approx.)	10	10	10	10	watts
Power Input	120	160	200	250	watts
Useful Power Output	65	90	110	140	watts

These typical performance figures were obtained by direct measurement in operating equipment. The output power is useful power measured in a load circuit. The driving power is the total power taken by the tube and a practical resonant circuit. In many cases with further refinement and improved techniques better performance might be obtained.

▶ Indicates change from sheet dated 8-15-52

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	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	100 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 165 Mc.)

D-C Plate Voltage	400	600	800	1000	volts
D-C Screen Voltage	250	250	250	250	volts
D-C Grid Voltage	–90	–95	–100	–105	volts
D-C Plate Current	200	200	200	200	ma
D-C Screen Current	40	35	25	20	ma
D-C Grid Current	7	8	10	15	ma
Peak A-F Screen Voltage at crest of 100% Modulation	140	150	160	170	volts
Peak R-F Grid Input Voltage (approx.)	110	120	120	125	volts
Driving Power (approx.)	1	1	1.5	2	watts
Plate Dissipation	25	40	60	60	watts
Plate Power Input	80	120	160	200	watts
Plate Power Output	55	80	100	140	watts

RADIO-FREQUENCY POWER AMPLIFIER

Class-B Linear, Television Visual Service (per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	1250 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C GRID VOLTAGE	–250 MAX. VOLTS
D-C PLATE CURRENT (AVERAGE)	250 MAX. MA
PLATE DISSIPATION	150 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION (Frequencies up to 216 Mc., 5 Mc. bandwidth)

D-C Plate Voltage	750	1000	1250	volts
D-C Screen Voltage	300	300	300	volts
D-C Grid Voltage	–60	–65	–70	volts
During Sync-Pulse Peak:				
D-C Plate Current	335	330	305	ma
D-C Screen Current	50	45	45	ma
D-C Grid Current	15	20	25	ma
Peak R-F Grid Voltage	85	95	100	volts
R-F Driver Power (approx.)	7	8	9	watts
Useful Power Output	135	200	250	watts
Black Level:				
D-C Plate Current	245	240	230	ma
D-C Screen Current	20	15	10	ma
D-C Grid Current	4	4	4	ma
Peak R-F Grid Voltage (approx.)	65	70	75	volts
R-F Driver Power (approx.)	4.25	4.7	5.5	watts
Plate Power Input	185	240	290	watts
Useful Power Output	75	110	140	watts

CLASS-AB OR -B POWER AMPLIFIER OR MODULATOR

MAXIMUM RATINGS (Per tube)

D-C PLATE VOLTAGE	1250 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C PLATE CURRENT	250 MAX. MA
PLATE DISSIPATION	150 MAX. WATTS
SCREEN DISSIPATION	12 MAX. WATTS
GRID DISSIPATION	2 MAX. WATTS

TYPICAL OPERATION

Class AB (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	600	800	1000	1250	volts
D-C Screen Voltage	300	300	300	300	volts
D-C Grid Voltage (approx.)*	–44	–47	–47	–48	volts
Zero-Signal D-C Plate Current	160	120	120	115	ma
Max-Signal D-C Plate Current	380	380	380	390	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	65	65	60	40	ma
Effective Load, Plate-to-Plate	3550	4625	5850	7200	ohms
Peak A-F Grid Input Voltage (per tube)	44	47	47	48	volts
Driving Power	0	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	45	55	70	90	watts
Max-Signal Plate Power Output	140	195	240	310	watts

*Adjust grid voltage to obtain specified zero-signal plate current. Maximum permissible grid circuit series resistance 100,000 ohms per tube.

TYPICAL OPERATION

Class AB_2 (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	600	800	1000	1250	volts
D-C Screen Voltage	300	300	300	300	volts
D-C Grid Voltage**	–41	–43	–43	–44	volts
Zero-Signal D-C Plate Current	185	160	165	180	ma
Max-Signal D-C Plate Current	485	490	495	475	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	85	75	70	65	ma
Effective Load, Plate-to-Plate	2600	3500	4600	5600	ohms
Peak A-F Grid Input Voltage (per tube)	47	48	49	50	volts
Max-Signal Peak Driving Power	0.15	0.15	0.15	0.15	watts
Max-Signal Nominal Driving Power (approx.)	75	75	75	75	mw
Max-Signal Plate Dissipation (per tube)	60	75	90	85	watts
Max-Signal Plate Power Output	170	240	315	425	watts

**Adjust grid voltage to obtain specified zero-signal plate current.

APPLICATION

MECHANICAL

Mounting—The 4X150A may be mounted in any position. Use of the Eimac 4X150A Air-System Socket, or its equivalent, is required.

The tube will fit a standard "loktal" socket, but the use of such a socket prevents adequate air-cooling of the base of the tube. Use of the "loktal" socket is not recommended.

Connections to the terminals of all the electrodes except the plate are provided by the Air-System Socket. The anode-cooler assembly provides a terminal surface for the plate connection. For high-frequency applications a metal band or a spring-finger collet should be used to make good electrical contact with the cylindrical outer surface of the anode cooler. Points of electrical contact should be kept clean and free of oxidation to minimize r-f losses.

Cooling—The 4X150A requires sufficient forced-air cooling to keep the cooler core and the metal parts of the metal-to-glass seals from exceeding a maximum temperature of 150°C. The air flow must be started when power is applied to the heater, and must continue without interruption until all electrode voltages have been removed from the tube.

The Eimac Air-System Socket directs the air over the surfaces of the tube base, and through the anode cooler to provide effective cooling with a minimum air flow. Seven and one-half cubic feet of cooling air per minute must flow through the Air-System Socket and the anode cooler for adequate cooling. This corresponds to a total pressure drop of 0.6 inches of water through the socket and the anode cooler.

The air requirements stated above are based on operation at sea level and an ambient temperature of 20°C. Operation at high altitude or at high ambient temperatures requires a greater volume of air flow. The necessary design information for such conditions is contained in an article entitled "Blower Selection for Forced-Air-Cooled Tubes", by A. G. Nekut, in the August, 1950, issue of "Electronics."

One method of measuring temperature is provided by the use of the "Tempilaq", a temperature-sensitive lacquer, which melts when a given temperature is reached. Where forced-air cooling is employed, very thin applications of the lacquer must be used. This product is obtainable from the Tempil Corporation, 132 West 22nd St., New York 11, N. Y.

ELECTRICAL

Heater—The heater should be operated as close to 6.0 volts as possible, but it will withstand heater-voltage variations as great as 10% without injury. Some variation in power output must be expected to occur with variations of the heater voltage.

Cathode—The cathode is internally connected to the four even-numbered base pins. All four corresponding socket terminals should be used for connection to the external circuit. The leads should be of large cross-section and as short and direct as possible to minimize cathode-lead inductance.

Grid Dissipation—Grid-circuit driving-power requirements increase with increasing frequency because of circuit losses other than grid dissipation. This becomes noticeable at frequencies near 30 Mc., and increases until at 500 Mc. as much as 30 watts driving power may be required in ordinary circuits.

Despite the increased driving power required by the circuit as a whole at higher frequencies, the power actually consumed by the tube grid does not increase greatly. Satisfactory operation in stable amplifier circuits is indicated by d-c grid-current values below approximately 15 milliamperes.

Screen Dissipation—Bias- or plate-supply failure or unloaded-plate-circuit operation can cause the screen current and dissipation to rise to excessive values. Protection for the screen can be provided by an overload relay in the screen circuit, in addition to the usual plate-overload relay. Use of a screen-current milliammeter is advisable.

Plate Dissipation—The maximum-rated plate dissipation is 150 watts. The maximum-rated plate dissipation for plate-modulated applications is 100 watts under carrier conditions, which permits the plate dissipation to rise to 150 watts under 100% sinusoidal modulation.

Plate dissipation may be permitted to exceed the maximum rating momentarily, as, for instance, during tuning.

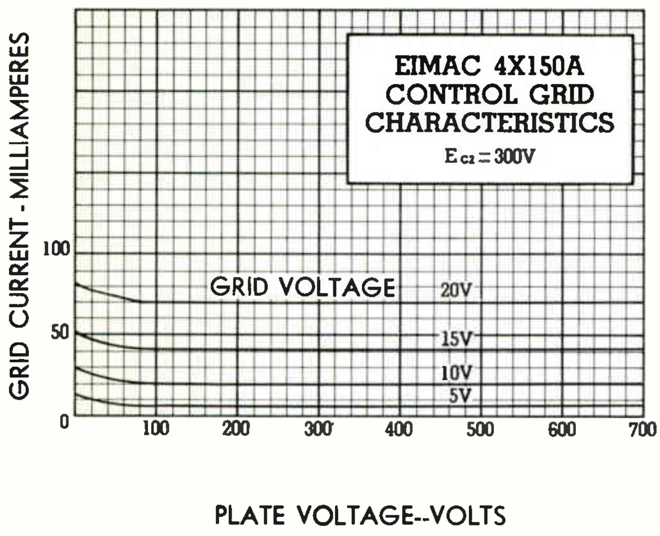
UHF Operation—Transit time effects, which occur at ultra-high frequencies in the 4X150A, can be minimized by adherence to the operating conditions suggested below:

1. Use a minimum d-c bias voltage, not over twice cut-off.
2. Apply only enough drive to obtain satisfactory plate efficiency.
3. Operate the screen at reasonably high voltage, but do not exceed the screen-dissipation rating. The circuit should be loaded to obtain screen-current values close to those given under "Typical Operation" at 500 Mc.
4. Fairly heavy plate loading is required. In general, low-voltage, high-current operation is preferable to operation at high voltage and low current. If conditions require a change to lighter plate loading, the drive should also be reduced to the minimum value for satisfactory operation at the new output level.
5. Parasitic oscillations are usually associated with excessive grid and screen current and are injurious to vacuum tubes. Similarly, tuned-plate circuits which accidentally become simultaneously resonant to harmonics and the fundamental frequency may also cause low efficiency and damage tubes.

Plate Modulation—Plate modulation can be applied to the 4X150A when it is operated as a class-C radio-frequency amplifier. To obtain 100% modulation, the d-c screen voltage must be modulated approximately 55%, in phase with the plate modulation. Self-modulation of the screen by means of a series resistor or reactor may not be satisfactory in this particular tetrode due to the screen-voltage, screen-current characteristics.

Grid Resistance—In class-A and -AB_1 amplifiers, where no grid current flows, the grid-bias voltage may be applied through a resistor. The maximum permissible series resistance per tube is 100,000 ohms.

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


EIMAC 4X150A
CONTROL GRID
CHARACTERISTICS
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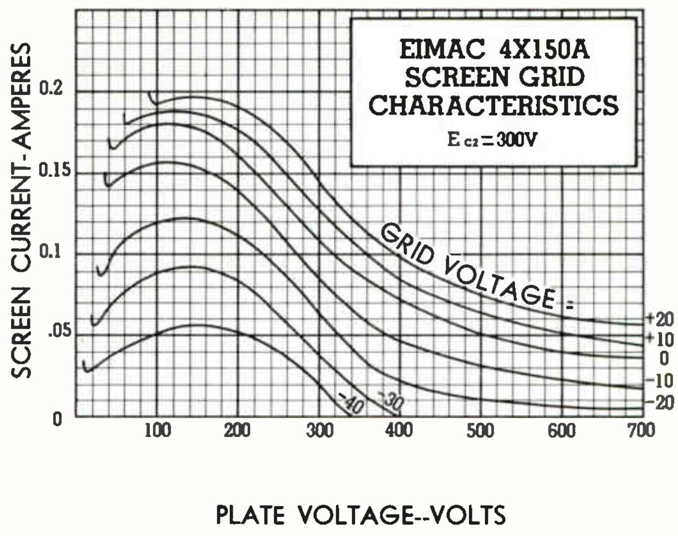
GRID CURRENT - MILLIAMPERES
GRID VOLTAGE
20V
15V
10V
5V
PLATE VOLTAGE--VOLTS


EIMAC 4X150A
SCREEN GRID
CHARACTERISTICS
$E_{c2}=300V$
SCREEN CURRENT - AMPERES
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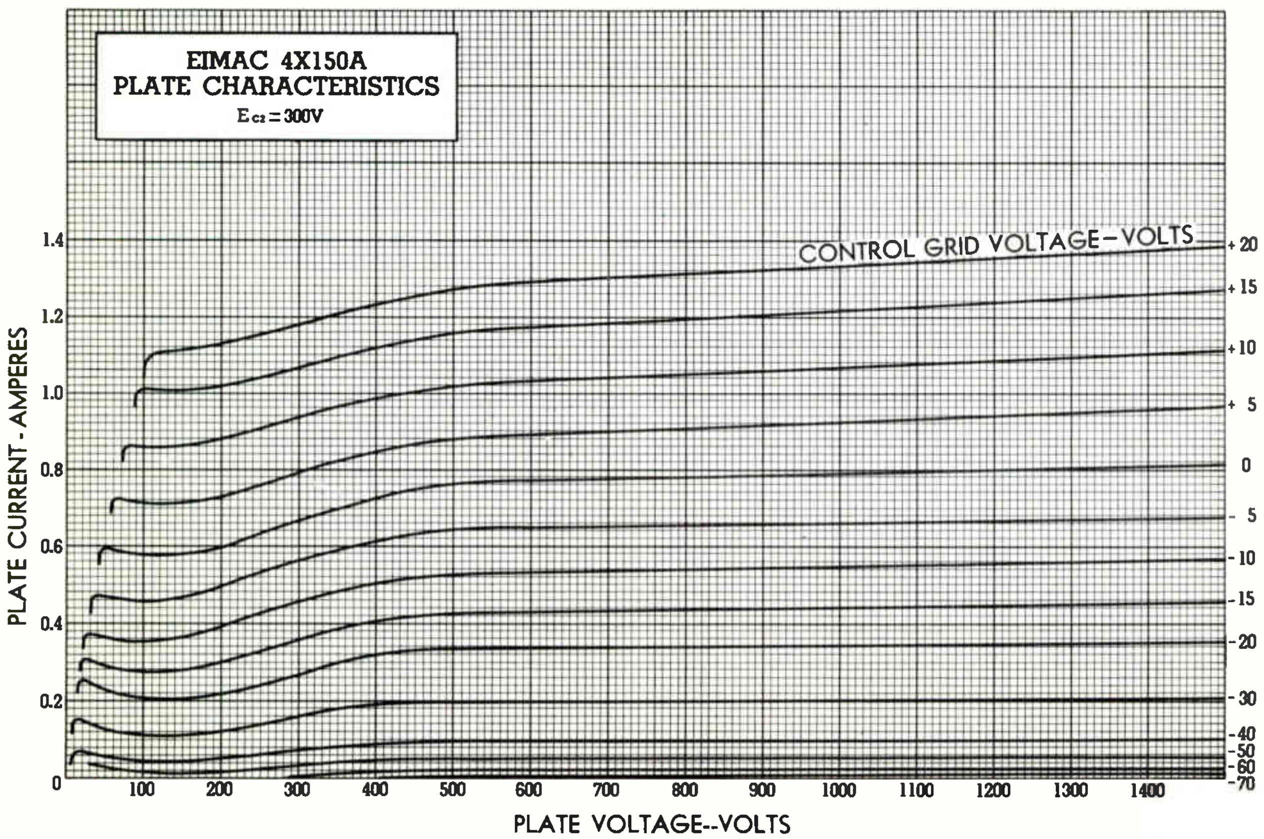
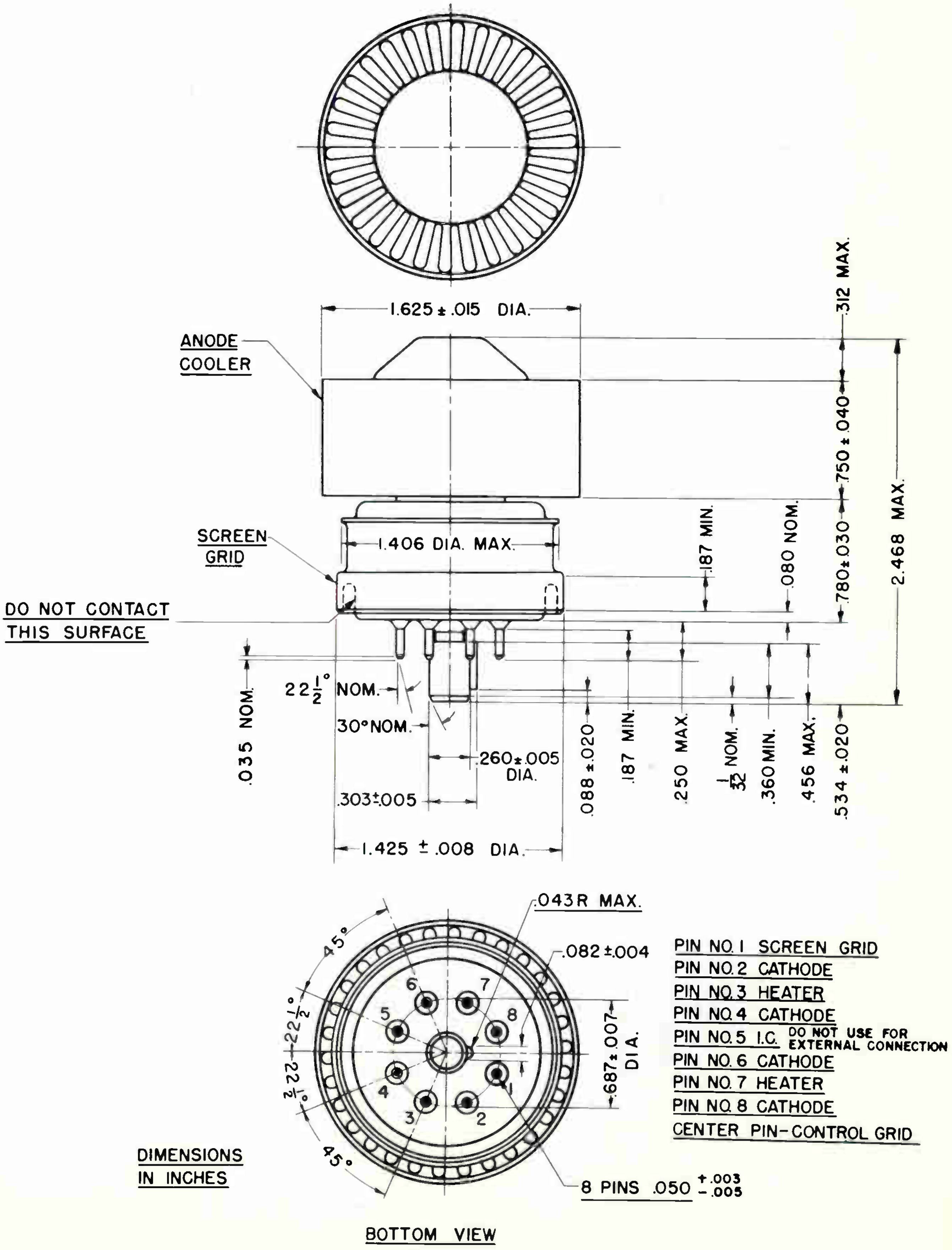
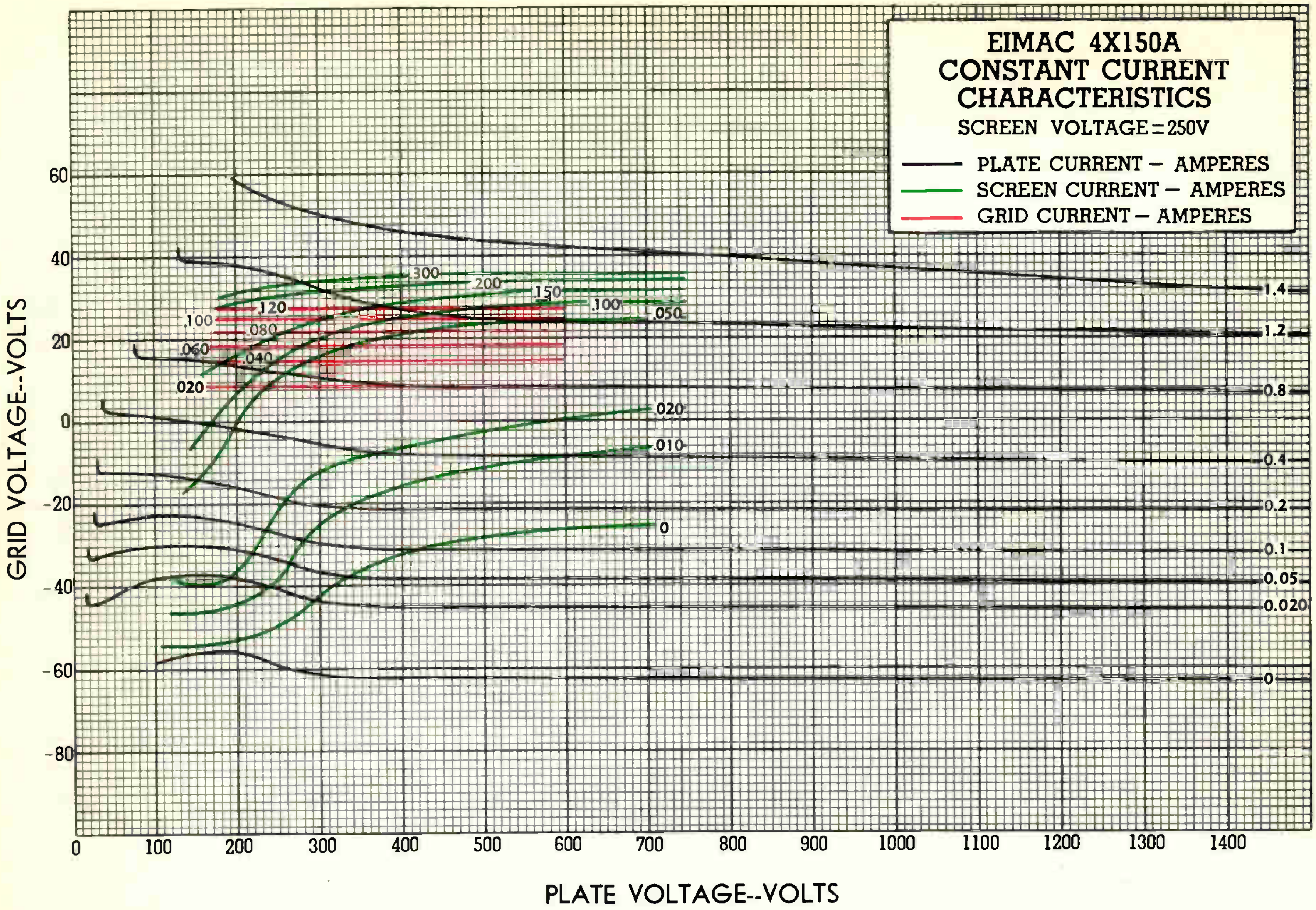
+10
0
-10
-20
-30
-40
PLATE VOLTAGE--VOLTS


EIMAC 4X150A
PLATE CHARACTERISTICS
$E_{c2}=300V$
PLATE CURRENT - AMPERES
CONTROL GRID VOLTAGE—VOLTS
+20
+15
+10
+5
0
-5
-10
-15
-20
-30
-40
-50
-60
-70
PLATE VOLTAGE--VOLTS


1.625 ± .015 DIA.
ANODE COOLER
SCREEN GRID
1.406 DIA. MAX.
DO NOT CONTACT THIS SURFACE
.312 MAX.
.750 ± .040
.780 ± .030
2.468 MAX.
.187 MIN.
.080 NOM.
.035 NOM.
22½° NOM.
30° NOM.
.260 ± .005 DIA.
.303 ± .005
1.425 ± .008 DIA.
.088 ± .020
.187 MIN.
.250 MAX.
1/32 NOM.
.360 MIN.
.456 MAX.
.534 ± .020
.043R MAX.
.082 ± .004
45°
22½°
22½°
45°
.687 ± .007 DIA.
8 PINS .050 +.003 -.005
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
DIMENSIONS IN INCHES
BOTTOM VIEW



Eimac 4X150A

Printed in U.S.A. 4-A1-80483

4-400A

RADIAL-BEAM POWER TETRODE

MODULATOR OSCILLATOR AMPLIFIER

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

The Eimac 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 associated circuit and driver stage.

The 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 4-400A/4000 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 μμfd
Input	12.5 μμfd
Output	4.7 μμfd
Transconductance (I_b=100ma., E_b=2500V., E_{c2}=500V.)	4,000 μmhos
Frequency for Maximum Ratings	110 Mc.

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 4-400A/4000 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 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 Telegraphy or FM Telephony

MAXIMUM RATINGS (Key-down conditions, per tube to 110 Mc.)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	400 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc., one tube)

D-C Plate Voltage	2500	3000	4000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	—200	—220	—220	volts
D-C Plate Current	350	350	350	ma
D-C Screen Current	46	46	40	ma
D-C Grid Current	18	19	18	ma
Screen Dissipation	23	23	20	watts
Grid Dissipation	1.8	1.9	1.8	watts
Peak R-F Grid Input Voltage	300	320	320	volts
Driving Power*	5.4	6.1	5.8	watts
Plate Power Input	875	1050	1400	watts
Plate Dissipation	235	250	300	watts
Plate Power Output	640	800	1100	watts

*Driving Power increases as frequency is increased. At 75 Mc. the driving power required is approximately 12 watts.

TYPICAL OPERATION (110 Mc., two tubes)

D-C Plate Voltage	3500	4000	volts
D-C Screen Voltage	500	500	volts
D-C Grid Voltage	—170	—170	volts
D-C Plate Current	500	540	ma
D-C Screen Current	34	31	ma
D-C Grid Current	20	20	ma
Driving Power (approx.)	20	20	watts
Plate Power Output (approx.)	1300	1600	watts
Useful Power Output	1160	1440	watts

†Guarantee applies only when the 4-400A is used as specified with adequate air in the 4-400A/4000 Air-System Socket or equivalent.

▶ Indicates change from sheet dated 1-30-53.

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions unless otherwise specified. One tube)

MAXIMUM RATINGS (Frequencies below 75 Mc. Continuous Service)

D-C PLATE VOLTAGE	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	270 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc. Continuous Service)

D-C Plate Voltage	2000	2500	3000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	—220	—220	—220	volts
D-C Plate Current	275	275	275	ma
D-C Screen Current	30	28	26	ma
D-C Grid Current	12	12	12	ma
Screen Dissipation	15	14	13	watts
Grid Dissipation	1.1	1.1	1.1	watts
Peak A-F Screen Voltage (100% modulation)	350	350	350	volts
Peak R-F Grid Input Voltage	290	290	290	volts
Driving Power	3.5	3.5	3.5	watts
Plate Power Input	550	688	825	watts
Plate Dissipation	170	178	195	watts
Plate Power Output	380	510	630	watts

▶ **MAXIMUM RATINGS (Frequencies below 30 Mc., Intermittent Service)**

D-C Plate Voltage	4000 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	270 MAX. WATTS
Screen Dissipation	35 MAX. WATTS
Grid Dissipation	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 30 Mc., Intermittent Service)

D-C Plate Voltage	2000	2500	3000	3650	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	—220	—220	—220	—225	volts
D-C Plate Current	275	275	275	275	ma
D-C Screen Current	30	28	26	23	ma
D-C Grid Current	12	12	12	13	ma
Screen Dissipation	15	14	13	12	watts
Grid Dissipation	1.1	1.1	1.1	1.2	watts
Peak A-F Screen Voltage (100% modulation)	350	350	350	350	volts
Peak R-F Grid Input Voltage	290	290	290	315	volts
Driving Power	3.5	3.5	3.5	4.0	watts
Plate Power Input	550	688	825	1000	watts
Plate Dissipation	170	178	195	235	watts
Plate Power Output	380	510	630	765	watts

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS AB

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	800 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	350 MAX. MA.
PLATE DISSIPATION	400 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION CLASS AB_1

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	2500	3000	3500	4000	volts
D-C Screen Voltage	750	750	750	750	volts
D-C Grid Voltage (approx.)*	—130	—137	—145	—150	volts
Zero-Signal D-C Plate Current	190	160	140	120	ma
Max-Signal D-C Plate Current	635	635	610	585	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	28	26	32	40	ma
Effective Load, Plate-to-Plate	6800	8900	11,500	14,500	ohms
Peak A-F Grid Input Voltage (per tube)	130	137	145	150	volts
Driving Power	0	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	370	400	400	400	watts
Max-Signal Plate Power Output	850	1110	1330	1540	watts

*Adjust to give stated zero-signal plate current. The D-C resistance in series with the control grid of each tube should not exceed 250,000 ohms.

TYPICAL OPERATION CLASS AB_2

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	2500	3000	3500	4000	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage (approx.)*	—75	—80	—85	—90	volts
Zero-Signal D-C Plate Current	190	160	140	120	ma
Max-Signal D-C Plate Current	700	700	700	638	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	50	40	38	32	ma
Effective Load, Plate-to-Plate	7200	9100	10,800	14,000	ohms
Peak A-F Grid Input Voltage (per tube)	133	140	145	140	volts
Max-Signal Peak Driving Power	8.6	9.0	10.2	7.0	watts
Max-Signal Nominal Driving Power	4.3	4.5	5.1	3.5	watts
Max-Signal Plate Dissipation (per tube)	320	363	400	400	watts
Max-Signal Plate Power Output	1110	1375	1650	1750	watts

*Adjust for stated zero-signal plate current.

Pulse Service—For information on Pulse Service Ratings, "Application Bulletin No. 3, Pulse Service Notes", will be furnished free on request.

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 4-400A must be mounted vertically, base up or base 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 4-400A/4000 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 4-400A/4000 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, pro-

▶ Indicates change from sheet dated 1-30-53.

vision 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, 11 West 25th Street, New York 10, 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 d-c 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 Mc., it is advisable to keep the bias voltage as low as is practicable.

Screen Voltage—The d-c screen voltage for the 4-400A should not exceed 600 volts in r-f applications. In audio applications a maximum d-c 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 d-c plate-supply voltage should not exceed 3200 volts, except below 30 Mc., 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,

$$P_g = e_{cmp} I_c$$

where P_g = Grid Dissipation
e_{cmp} = Peak positive grid to cathode 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. (For suitable peak v.t.v.m. circuits see Eimac Application Bulletin Number 6, "Vacuum Tube Ratings." This bulletin is available on request.)

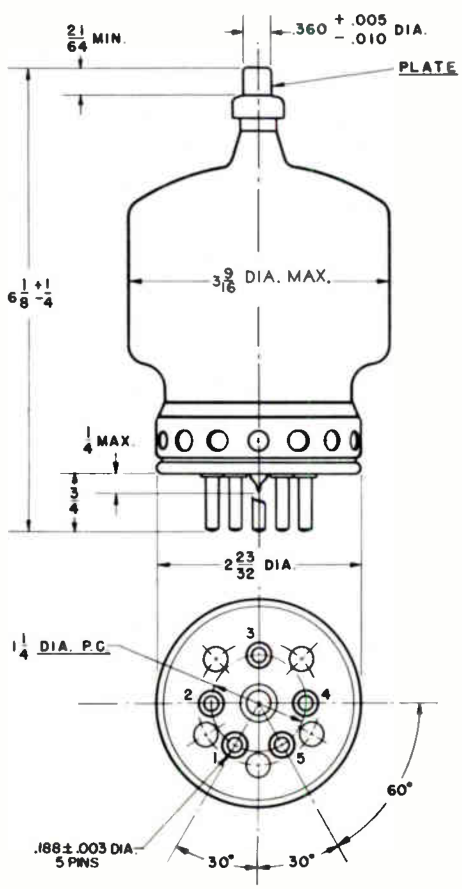
Screen Dissipation—The power dissipated by the screen of the 4-400A must not exceed 35 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 35 watts in event of circuit failure.

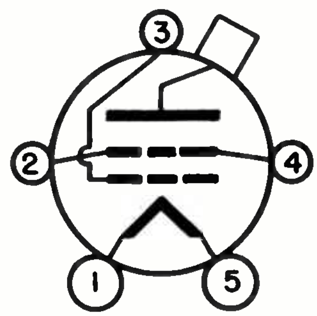
Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-400A should not be allowed to exceed 400 watts.

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.

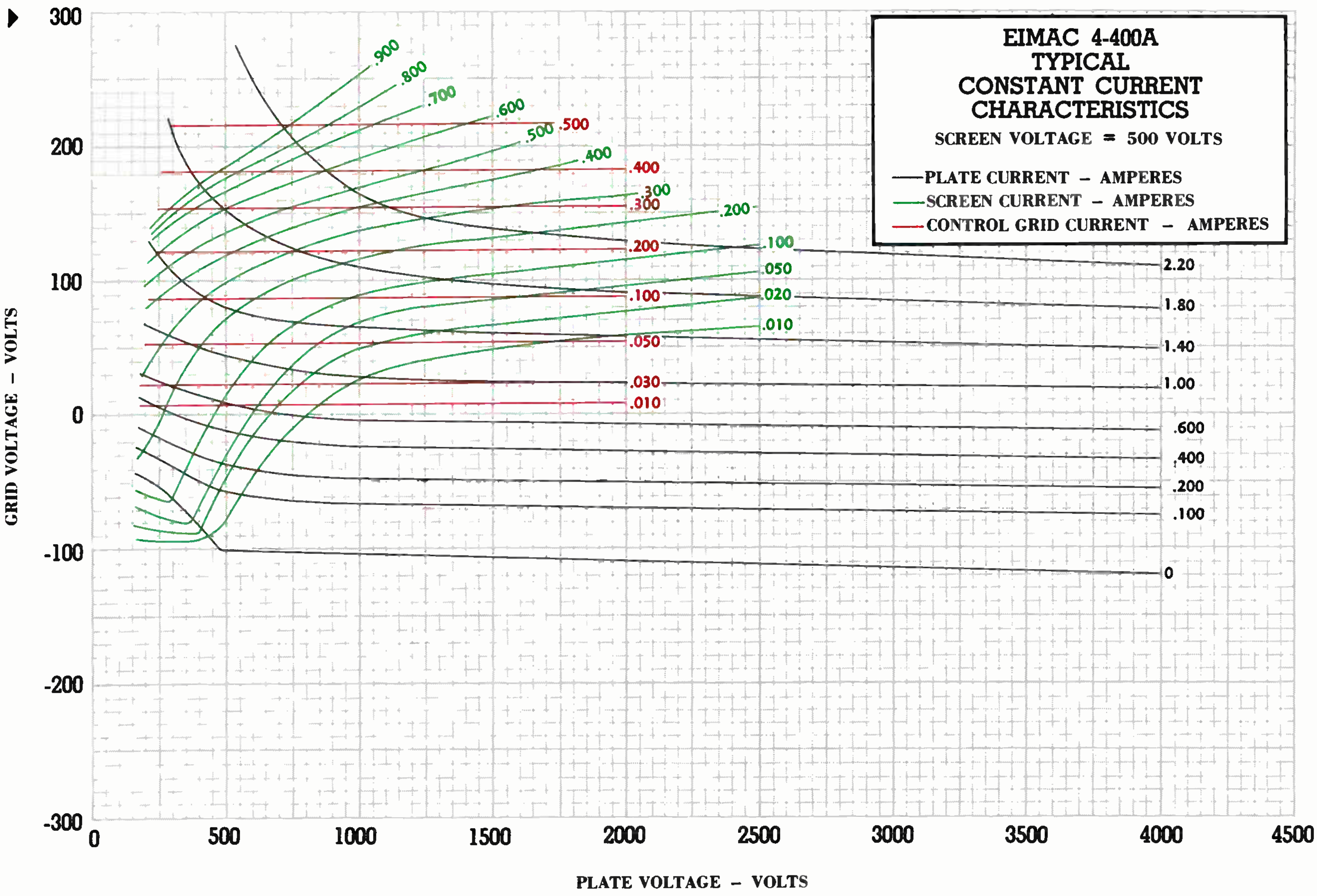
Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

GENERAL INFORMATION PERTAINING TO THE OPERATION OF THE 4-400A MAY BE FOUND IN APPLICATION BULLETIN NO. 8, "THE CARE AND FEEDING OF POWER TETRODES." THIS BULLETIN IS AVAILABLE UPON REQUEST.





▶ Indicates change from sheet dated 1-30-53.



4-400A

▶ Indicates change from sheet dated 1-30-53.

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

4-250A

(5D22)

RADIAL-BEAM POWER TETRODE

•

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 μμf
Input	12.7 μμf
Output	4.5 μμf
Transconductance (I_b=100 ma., E_b=2500V., E_{c2}=500V.)	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 Output	375	510	watts

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

[1]Above 110 Mc. the maximum plate voltage rating depends upon frequency. See page four.

[2]Driving power increases above 40 Mc. See page four.

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 AB_1

(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

[1]Adjust for stated zero-signal plate current.
[2]The effective grid-circuit resistance must not exceed 250,000 ohms.

TYPICAL OPERATION CLASS AB_2

(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

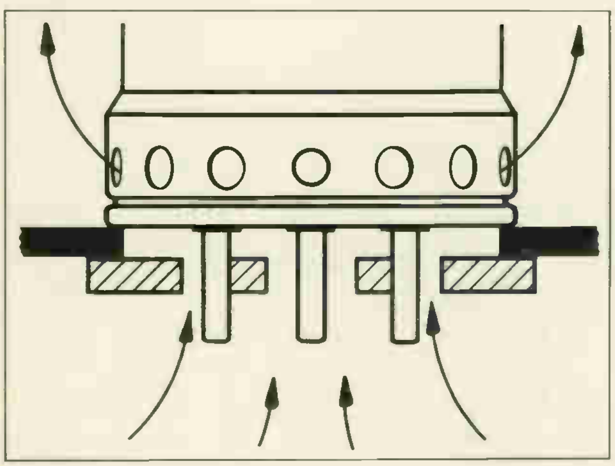
IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

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 metal tube-base shell should be grounded by means of suitable spring fingers. 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. Forced-air circulation in the amount of five cubic feet per minute through the base of the tube is required. This 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 4-400A 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 4-400A 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.

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 grid[3].

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.

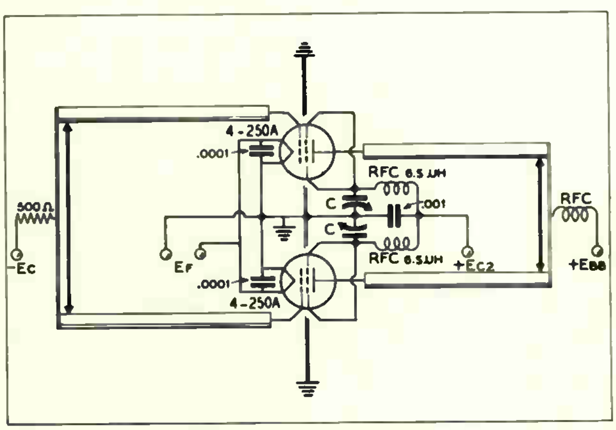
Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

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 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 ¾-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.



Screen-tuning neutralization circuit for use above 45 Mc.
C — Approximately 100$\mu\mu$fd. per section, maximum.

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-AB$_1$ and Class-AB$_2$ 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-AB$_1$ and class-AB$_2$ 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.

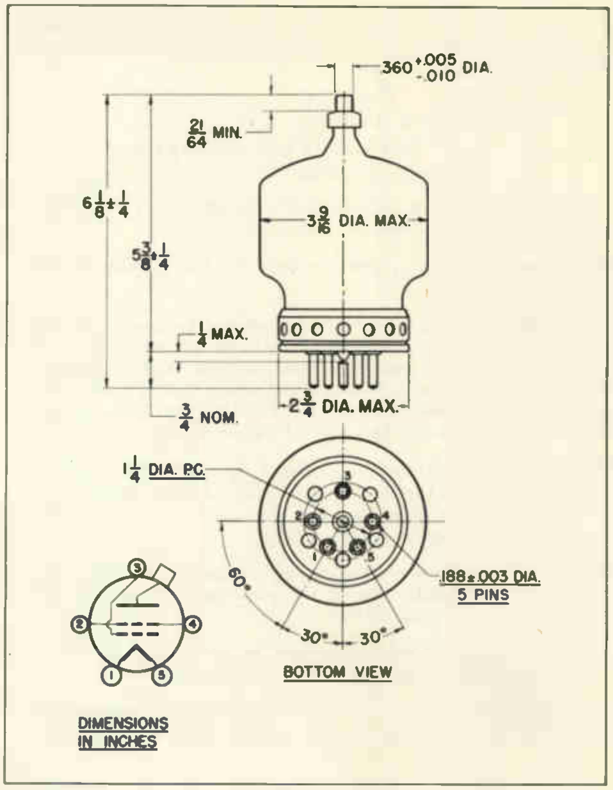
Grid bias voltage for class-AB$_2$ service may be obtained from batteries or from a small fixed-bias supply. When a bias supply is used the d-c resistance of the bias source should not exceed 250 ohms. Under class-AB$_1$ conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

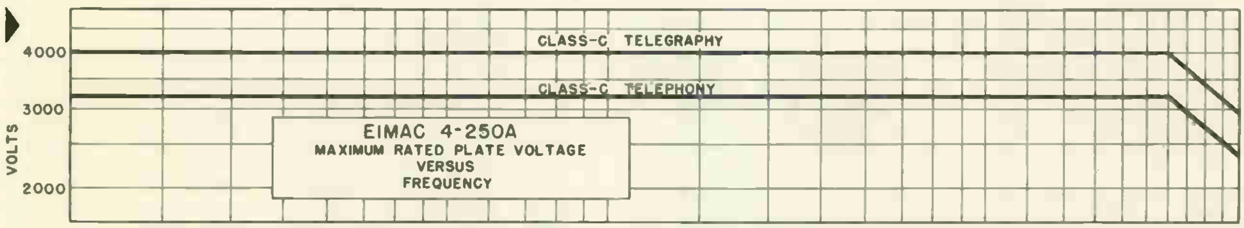
[3] For suitable peak v.t.v.m. circuits see, for instance, "Vacuum Tube Ratings," Eimac News, January, 1945. This article is available in reprint form on request.

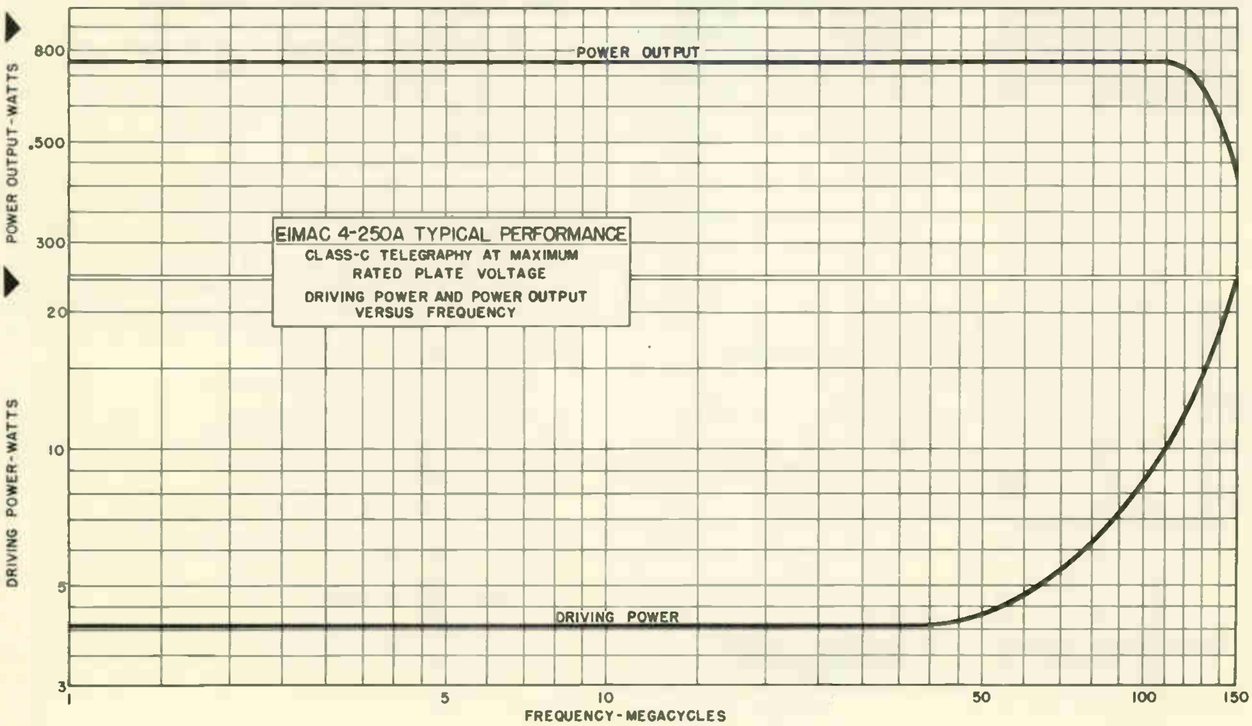
The peak driving power figures given in the class-AB_2 tabulated data are included to make possible an accurate determination of the required driver output power. The driver amplifier must be capable of supplying the peak driving power without distortion. The driver stage should, therefore, be capable 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.

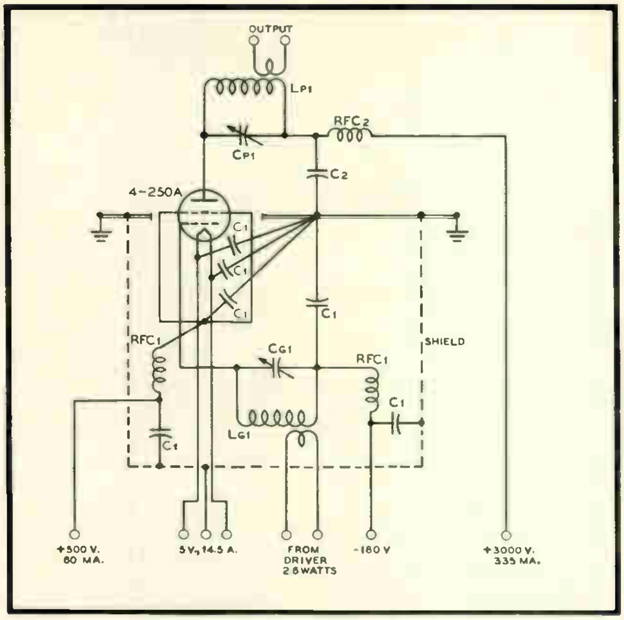
The power output figures given in the tabulated data refer to the total power output from the amplifier tubes. The useful power output will be from 5 to 15 per cent less than the figures shown, due to losses in the output transformer.



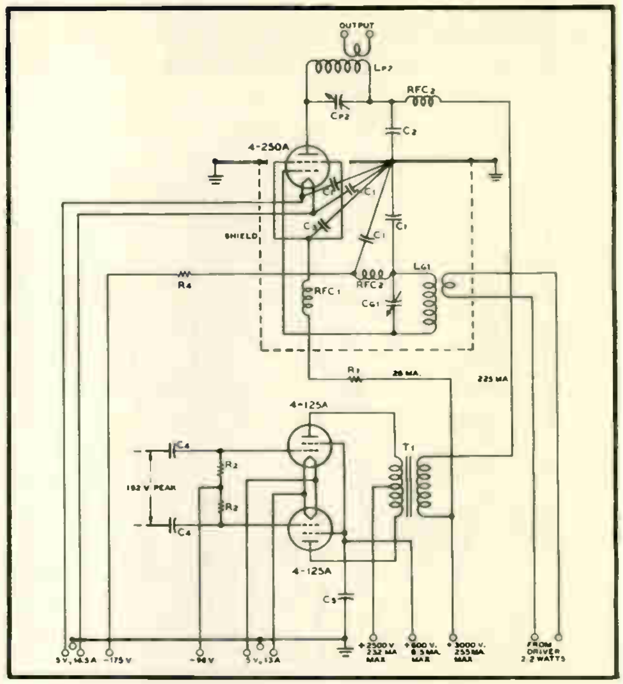




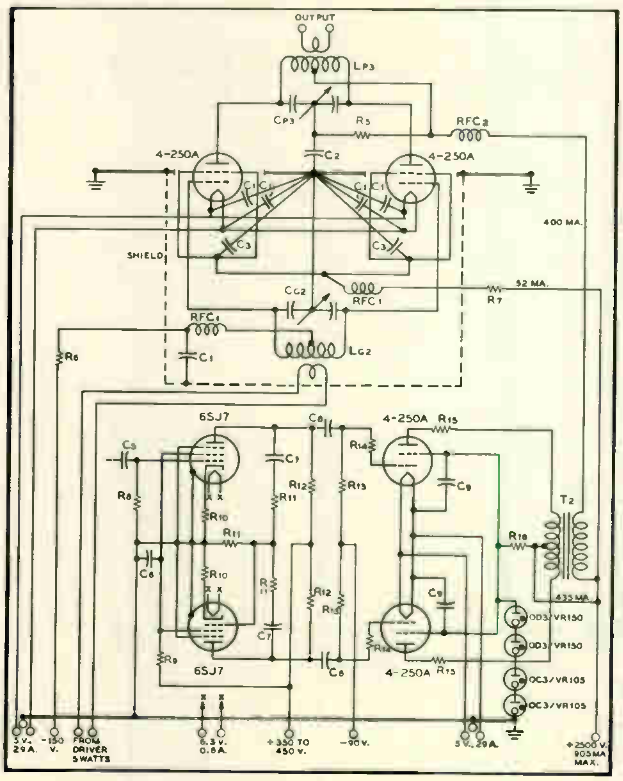
▶ Indicates change from sheet dated 8-15-52.



Typical radio frequency power amplifier circuit, Class-C telegraphy, 1000 watts input.



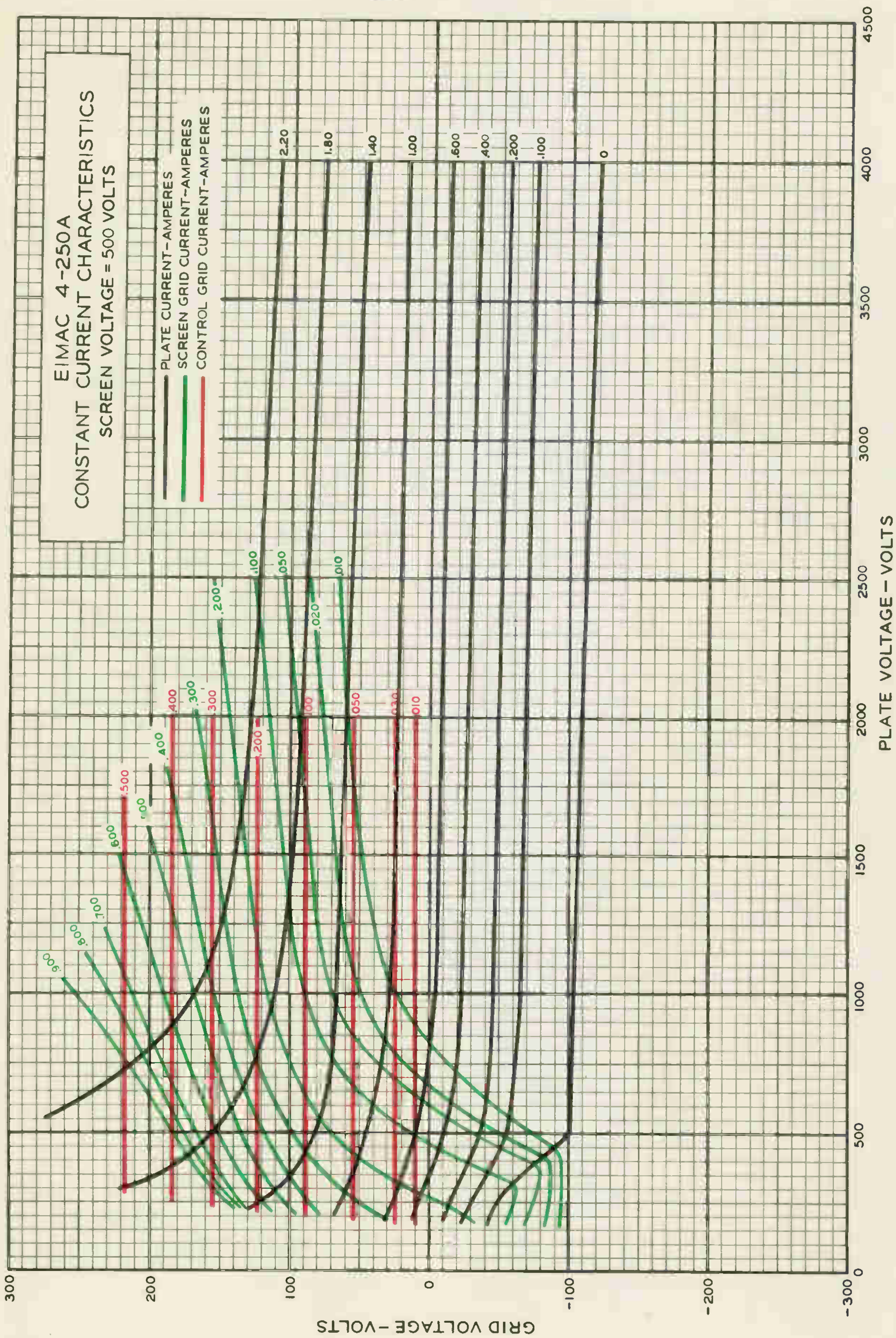
Typical high-level-modulated r-f amplifier circuit, with modulator stage, 675 watts input.



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.
C_1 — .002-ufd. 500-v. mica
C_2 — .002-ufd. 5000-v mica
C_3 — .001-ufd., 2500-v. mica
C_4 — .1-ufd., 1000-v. paper
C_5 — .1-ufd. 600-v. paper
C_6 — .5-ufd. 600-v paper
C_7 — .03-ufd., 600-v. paper
C_8 — .1-ufd., 1000-v. paper
C_9 — .25-ufd., 1000-v. paper
R_1 — 86,700 ohms, adjustable 100,000 ohms, 100 watts
R_2 — 250,000 ohms, 1/2 watt
R_4 — 15,000 ohms, 5 watts
R_5 — 25,000 ohms, 2 watts
R_6 — 2,500 ohms, 5 watts
R_7 — 35,000 ohms, 160 watts
R_8 — 250,000 ohms, 1/2 watt
R_9 — 200,000 ohms, 2 watts
R_{10} — 500 ohms, 1/2 watt
R_{11} — 1 megohm, 1/2 watt
R_{12} — 100,000 ohms, 1 watt
R_{13} — 200,000 ohms, 1/2 watt
R_{14} — 10,000 ohms, 1/2 watt
R_{15} — 50 ohms, 10 watts
R_{16} — 100,000 ohms, 100 watts
RFC_1 — 2.5-mhy., 125-ma. r-f choke
RFC_2 — 1-mhy., 500-ma. r-f choke
T_1 — 350-watt modulation transformer; ratio pri. to sec. approx. 1.5 : 1; pri. impedance 20,300 ohms, sec. impedance 13,300 ohms.
T_2 — 600-watt modulation transformer; ratio pri. to sec. approx. 1.8 : 1; pri. impedance 11,400 ohms, sec. impedance 6,250 ohms.



Printed in U. S. A. 10-C6-80269

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

4-125A

(4D21)

RADIAL-BEAM POWER TETRODE

•

MODULATOR
OSCILLATOR
AMPLIFIER

The Eimac 4-125A is a radial-beam power tetrode intended for use as an amplifier, oscillator, or modulator. It has a maximum plate-dissipation rating of 125 watts and a maximum plate-voltage rating of 3000 volts at frequencies up to 120 Mc.

The low grid-plate capacitance of this tetrode together with its low driving-power requirement allows considerable simplification of the associated circuit and driver stage.

Cooling is by radiation from the plate and by air circulation through the base and around the envelope.

The 4-125A in class-C r-f service will deliver up to 375 watts plate power output with 2.5 watts driving power. Two 4-125A's in class-B modulator service will deliver up to 400 watts maximum-signal power output with 1.2 watts nominal driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten	
Voltage	5.0 volts
Current	6.5 amperes
Grid-Screen Amplification Factor (Average)	5.9
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.05 $\mu\mu$fd
Input	10.8 $\mu\mu$fd
Output	3.1 $\mu\mu$fd
Transconductance (I_b=50 ma., E_b=2500V., E_{c2}=400V.)	2450 μmhos
Highest Frequency for Maximum Ratings	120 Mc

MECHANICAL

Base	5-pin metal shell
Basing	See outline drawing
Socket	E. F. Johnson Co. socket No. 122-275, National Co. No. HX-100, or equivalent
Mounting Position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat-Dissipating Plate Connector	Eimac HR-6
▶ Maximum Over-all Dimensions:	
Length	5.69 inches
Diameter	2.81 inches
Net Weight	6.5 ounces
Shipping Weight	1.5 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.

▶ Indicates change from sheet dated 1-5-53

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy or FM Telephony
(Key-down conditions, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE[1]	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	225 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION
(Frequencies below 120 Mc.)

D-C Plate Voltage	2000	2500	3000	volts
D-C Screen Voltage	350	350	350	volts
D-C Grid Voltage	—100	—150	—150	volts
D-C Plate Current	200	200	167	ma
D-C Screen Current	50	40	30	ma
D-C Grid Current	12	12	9	ma
Screen Dissipation	18	14	10.5	watts
Grid Dissipation	1.6	2	1.2	watts
Peak R-F Grid Input Voltage (approx.)	230	320	280	volts
Driving Power (approx.)[3]	2.8	3.8	2.5	watts
Plate Power Input	400	500	500	watts
Plate Dissipation	125	125	125	watts
Plate Power Output	275	375	375	watts

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB_1

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT, PER TUBE	225 MAX. MA
PLATE DISSIPATION, PER TUBE	125 MAX. WATTS
SCREEN DISSIPATION, PER TUBE	20 MAX. WATTS

TYPICAL OPERATION
(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	1500	2000	2500	volts
D-C Screen Voltage	600	600	600	volts
D-C Grid Voltage[2]	—90	—94	—96	volts
Zero-Signal D-C Plate Current	60	50	50	ma
Max-Signal D-C Plate Current	222	240	232	ma
Zero-Signal D-C Screen Current	—1.0	—0.5	—0.3	ma
Max-Signal D-C Screen Current	17	6.4	8.5	ma
Effective Load, Plate-to-Plate	10,200	13,400	20,300	ohms
Peak, A-F Grid Input Voltage (per tube)	90	94	96	volts
Driving Power	0	0	0	watt
Max-Signal Plate Dissipation (per tube)	87.5	125	125	watts
Max-Signal Plate Power Output	158	230	330	watts
Total Harmonic Distortion	5	2	2.6	per ct.

HIGH-LEVEL MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony
(Carrier conditions unless otherwise specified, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE[1]	2500 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	85 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION
(Frequencies below 120 Mc.)

D-C Plate Voltage	2000	2500	volts
D-C Screen Voltage	350	350	volts
D-C Grid Voltage	—220	—210	volts
D-C Plate Current	150	152	ma
D-C Screen Current	33	30	ma
D-C Grid Current	10	9	ma
Screen Dissipation	11.5	10.5	watts
Grid Dissipation	1.6	1.4	watts
Peak A-F Screen Voltage, 100% Modulation	210	210	volts
Peak R-F Grid Input Voltage (approx.)	375	360	volts
Driving Power (approx.)[3]	3.8	3.3	watts
Plate Power Input	300	380	watts
Plate Dissipation	75	80	watts
Plate Power Output	225	300	watts

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB_2

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT, PER TUBE	225 MAX. MA
PLATE DISSIPATION, PER TUBE	125 MAX. WATTS
SCREEN DISSIPATION, PER TUBE	20 MAX. WATTS

TYPICAL OPERATION
(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	1500	2000	2500	volts
D-C Screen Voltage	350	350	350	volts
D-C Grid Voltage	—41	—45	—43	volts
Zero-Signal D-C Plate Current	87	72	93	ma
Max-Signal D-C Plate Current	400	300	260	ma
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	34	5	6	ma
Effective Load, Plate-to-Plate	7200	13,600	22,200	ohms
Peak A-F Grid Input Voltage (per tube)	141	105	89	volts
Max-Signal Avg. Driving Power (approx.)	2.5	1.4	1	watts
Max-Signal Peak Driving Power	5.2	3.1	2.4	watts
Max-Signal Plate Dissipation (per tube)	125	125	122	watts
Max-Signal Plate Power Output	350	350	400	watts
Total Harmonic Distortion	2.5	1	2.2	per ct.

[1] Above 120 Mc. the maximum plate voltage rating depends upon frequency. See page 4.

[2] The effective grid circuit resistance for each tube must not exceed 250,000 ohms.

[3] Driving power increases above 70 Mc. See page 4.

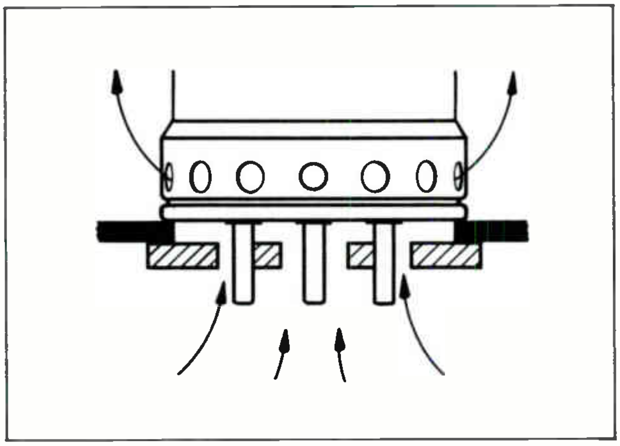
IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

MECHANICAL

Mounting—The 4-125A 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.



4-125A 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 4-125A. In continuous-service applications, the temperature of the plate seal, as measured on the top of the plate cap, should not exceed 170° C. A relatively slow movement of air past the tube is sufficient to prevent seal temperatures in excess of maximum 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 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., however.

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 to hold the temperature below this maximum at frequencies below 30 Mc., provided that a heat-dissipating plate connector is used, and the tube is so located that normal circulation of air past the envelope is not impeded.

Provision must be made for circulation of air through the base of the tube. Where shielding or socket design makes it impossible to allow free circulation of air through the base, it will be necessary to apply forced-air cooling to the stem structure. An air flow of two cubic feet per minute through the base will be sufficient for stem cooling.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated value of 5.0 volts. Unavoidable variations in filament voltage must be kept within the range from 4.75 to 5.25 volts.

Bias Voltage—D-c bias voltage for the 4-125A 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.

Screen Voltage—The d-c screen voltage for the 4-125A should not exceed 400 volts, except for class-AB_1 audio operation.

Plate Voltage—The plate-supply voltage for the 4-125A should not exceed 3000 volts for frequencies below 120 Mc. The maximum permissible plate voltage is less than 3000 volts above 120 Mc., as shown by the graph on page 5.

Grid Dissipation—Grid dissipation for the 4-125A 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[4].

Screen Dissipation—The power dissipated by the screen of the 4-125A must not exceed 20 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 20 watts in the event of circuit failure.

Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-125A should not be allowed to exceed 125 watts in unmodulated applications.

In high-level-modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 85 watts. The plate dissipation will rise to 125 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] 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.

OPERATION

Class-C Telegraphy or FM Telephony—The 4-125A may be operated as a class-C telegraph or FM telephone amplifier without neutralization up to about 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 as shown in the mounting diagram on page three 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 entering the amplifier, to prevent grid-plate coupling between these leads external to the amplifier.

Where shielding is adequate, the feed-back at frequencies above 100 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 ¾-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, but care must be taken to prevent the neutralizing plate from touching 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 posible 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. All connections to the screen terminals should be made to the center of the strap between the terminals, in order to equalize the current in the two screen leads and prevent overheating one of them. The value for C given under the diagram presupposes the use of the shortest possible leads.

At frequencies below 100 Mc. ordinary neutralization systems may be used. With reasonably effective shielding, however, neutralization should not be required below about 30 Mc.

The driving power and power output under typical operating conditions, with maximum output and plate voltage, are shown on page 5. 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. These losses will not ordinarily amount to more than 30 or 40 per cent of the driving power, except at frequencies above 150 Mc. The use of silver-plated linear tank-circuit elements is recommended at frequencies above 100 Mc.

Conventional capacitance-shortened quarter-wave linear grid tank circuits having a calculated Z_0 of 160 ohms or less may be used with the 4-125A up to 175 Mc. Above 175 Mc. linear grid tank circuits employing a "capacitor"-type shortening bar, as illustrated in the diagram below, may be used. The capacitor, C_1, may consist of two silver-plated brass plates one inch square with a piece of .010 inch mica or polystyrene as insulation.

Class-C AM Telephony—The r-f circuit considerations discussed above under Class-C Telegraphy or FM Telephony also apply to amplitude-modulated operation of the 4-125A. When the 4-125A is used as a class-C high-level-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 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. Where screen voltage is obtained from a separate winding on the modulation transformer, the screen winding should be designed to deliver the peak screen modulation voltage given in the typical operating data on page 2.

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.

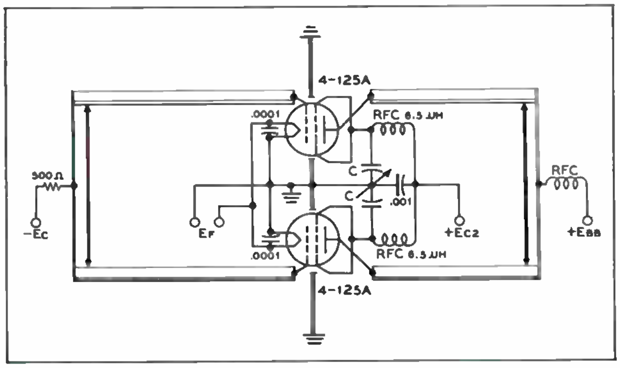
Class-AB_1 and Class-AB_2 Audio—Two 4-125A's may be used in a push-pull circuit to give relatively high audio output power at low distortion. Maximum ratings and typical operating conditions for class-AB_1 and class-AB_2 audio operation are given in the tabulated data.

When type 4-125A tubes are used as class-AB_1 or class-AB_2 audio amplifiers at 1500 plate volts, under the conditions given under "Typical Operation", the screen voltage must 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 will provide adequate regulation. The variation in screen current at plate voltages of 2000 and above is low enough so that any screen power supply having a normal order of regulation will serve. The driver plate supply makes a convenient source of screen voltage under these conditions.

Grid bias voltage for class-AB_2 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-AB_1 conditions the effective grid-circuit resistance for each tube should not exceed 250,000 ohms.

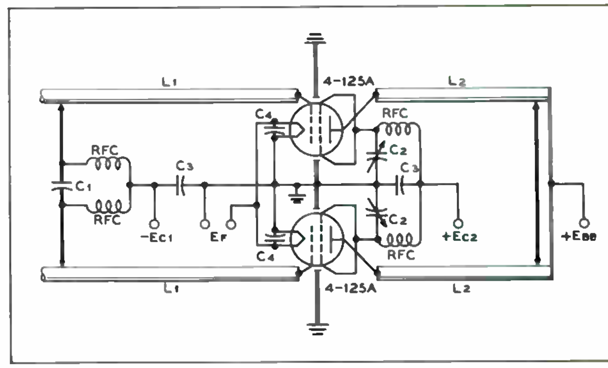
The peak driving power figures given in the class-AB_2 tabulated data are included to make possible an accurate determination of the required driver output power. The driving amplifier must be capable of supplying the peak driving power without distortion. The driver stage should, therefore, be capable 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.

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.



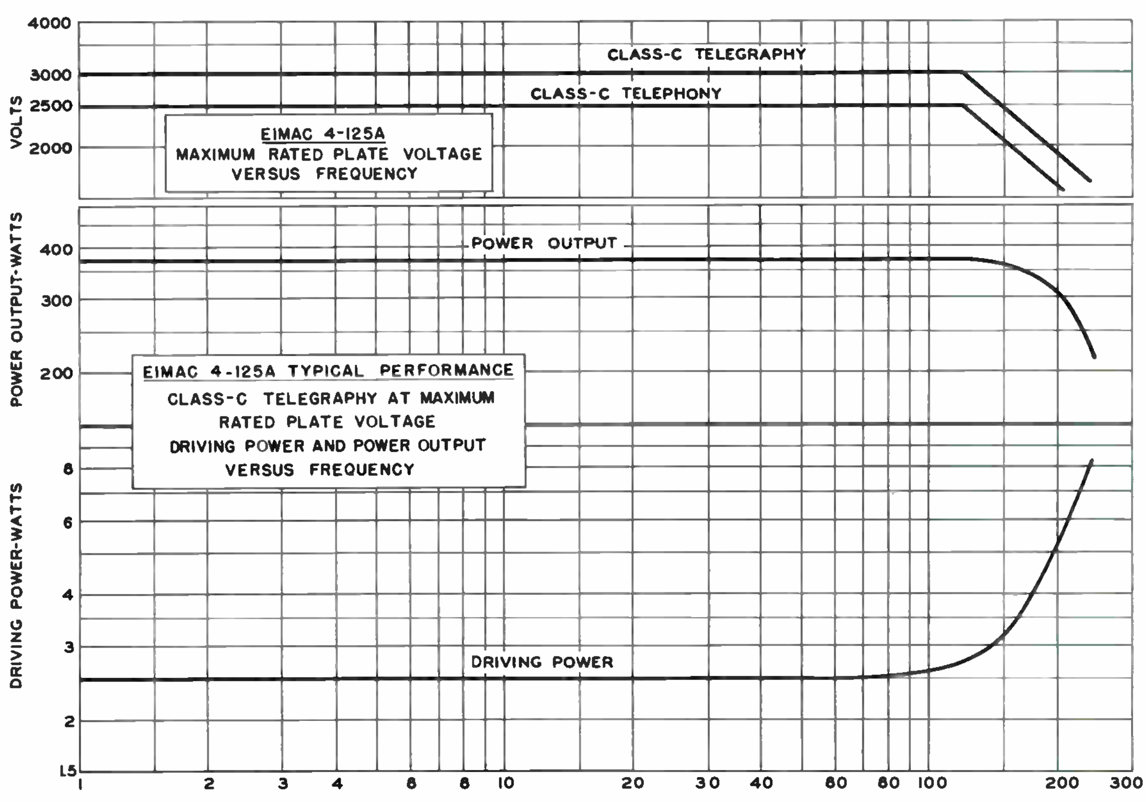
Screen-tuning neutralization circuit for use above 100 Mc.
C is a small split-stator capacitor.

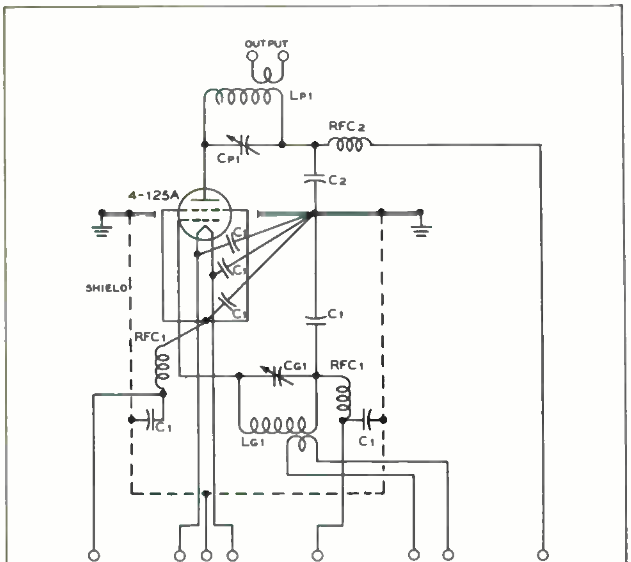
$$C(\mu\mu fd) = \frac{640{,}000}{f^2\ (Mc.)},\ \text{approx.}$$



Typical circuit arrangement useful for frequencies above 175 Mc.

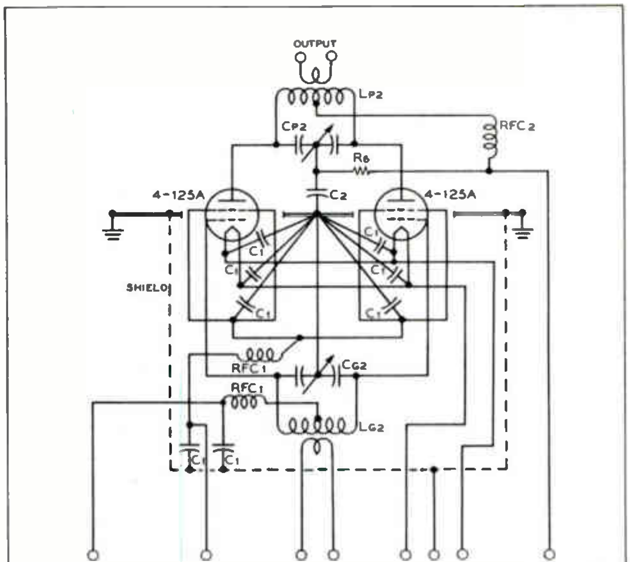
C_1—See above.
C_2—Neutralizing capacitor.
C_3—.001 μfd.
C_4—100 μμfd.
L_1—3/8" dia. copper spaced 1" center-to-center, 6" long.
L_2—7/8" dia. brass, silver plated, spaced 1 1/2" center-to-center, 14" long.





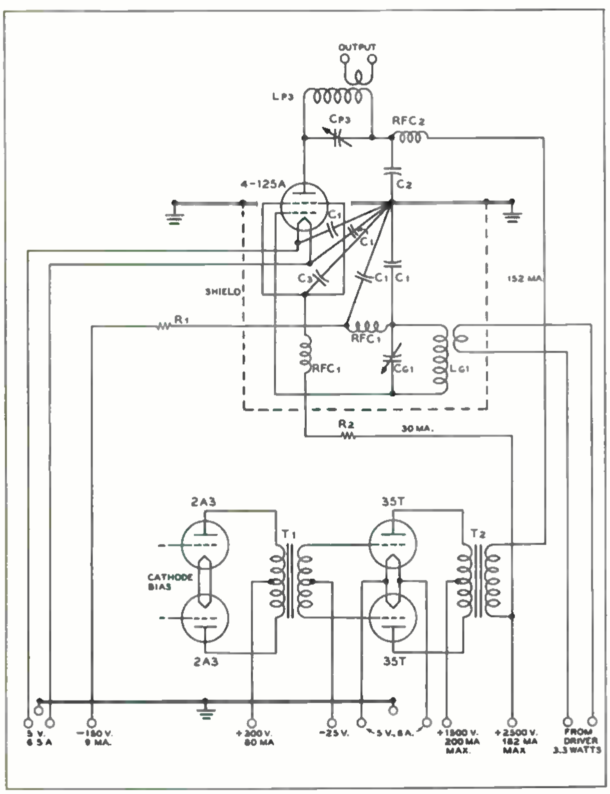
E_{CC2}	E_F	E_{CC1}	P_D	E_{BB}
D.C. SCREEN VOLTS	FILAMENT VOLTS	D.C. GRID VOLTS	DRIVING POWER	D.C. PLATE VOLTS
350 V., 40 MA.	5.0 V.	-150 V., 12 MA.	3.8 WATTS	2500 V., 200 MA.
350 V., 30 MA.	5.0 V.	-150 V., 9 MA.	2.5 WATTS	3000 V., 167 MA.

Typical radio-frequency power amplifier circuit, Class-C telegraphy, 500 watts input.

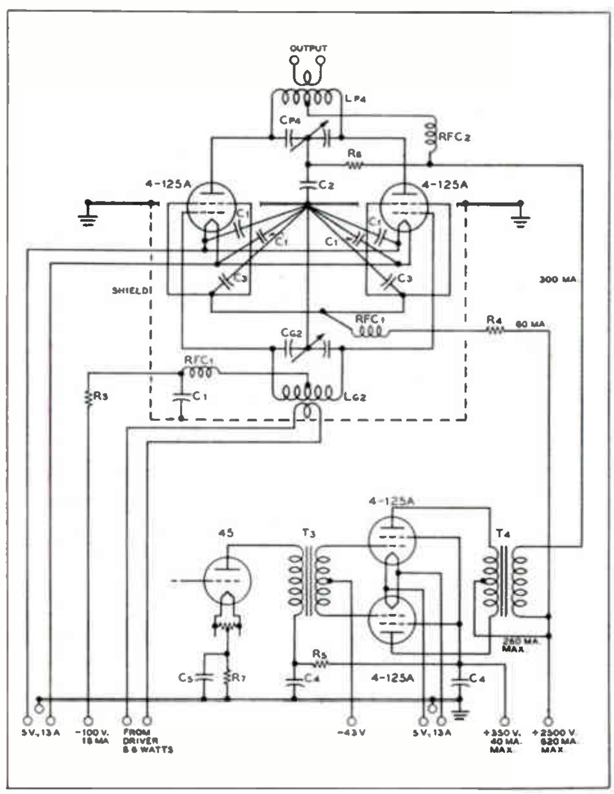


E_{CC1}	E_{CC2}	P_D	E_F	E_{BB}
D.C. GRID VOLTS	D.C. SCREEN VOLTS	DRIVING POWER	FILAMENT VOLTS	D.C. PLATE VOLTS
-150 V., 24 MA.	350 V., 80 MA	7.6 WATTS	5.0 V.	2500 V., 400 MA.
-150 V., 18 MA	350 V., 60 MA.	5.0 WATTS	5.0 V.	3000 V., 335 MA.

Typical radio-frequency power amplifier circuit, Class-C telegraphy, 1000 watts input.



Typical high-level-modulated r-f amplifier circuit, with modulator and driver stages, 380 watts plate input.



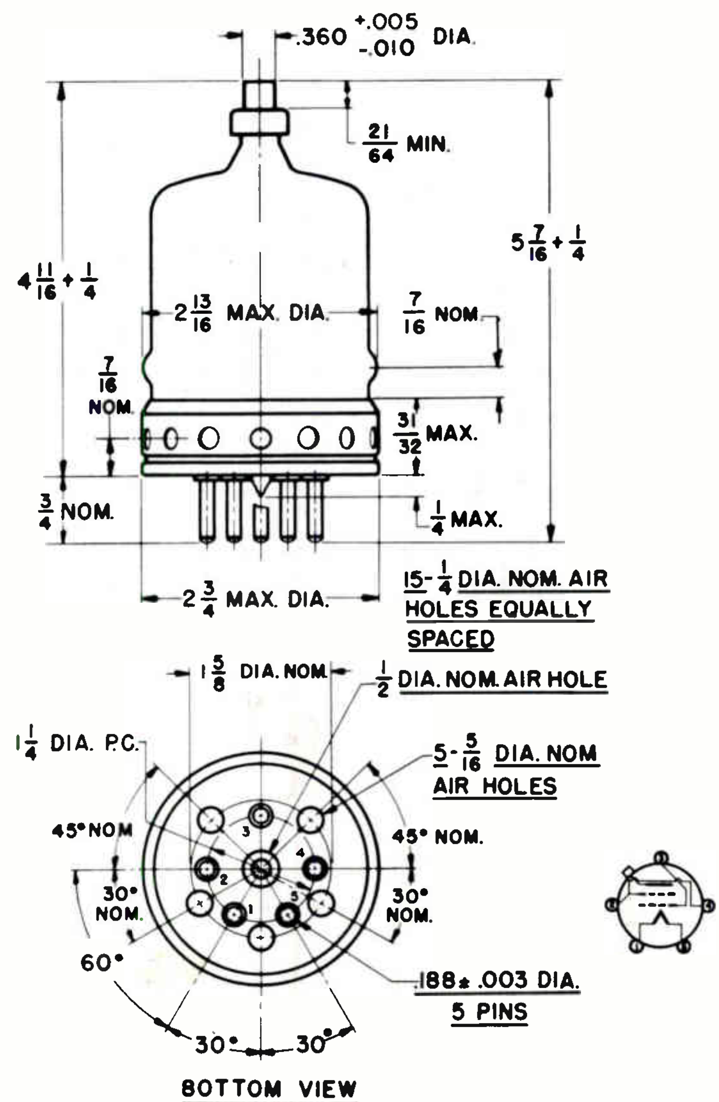
Typical high-level-modulated r-f amplifier circuit, with modulator and driver stages, 750 watts plate input.

See opposite page for list of components.

COMPONENTS FOR TYPICAL CIRCUITS

(Diagrams, Page 6)

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_{p4} - C_{p4} —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 freqency.
C_1 — .002-ufd., 500-v. mica
C_2 — .002-ufd., 5000-v. mica
C_3 — .001-ufd., 2500-v. mica
C_4 — 16-ufd., 450-v. electrolytic
C_5 — 10-ufd., 25-v. electrolytic
R_1 — 7000 ohms, 5 watts
R_2 — 70,000 ohms, 100 watts
R_3 — 3500 ohms, 5 watts
R_4 — 35,000 ohms, 200 watts
R_5 — 560 ohms, 1 watt
R_6 — 25,000 ohms, 2 watts
R_7 — 1500 ohms, 5 watts
RFC_1 — 2.5-mhy., 125-ma. r-f choke
RFC_2 — 1-mhy., 500-ma. r-f choke
T_1 — 10-watt driver transformer; ratio pri. to ½ sec. approx. 2:1.
T_2 — 200-watt modulation transformer; ratio pri. to sec. approx. 1:1; pri. impedance = 16,200 ohms, sec. impedance = 16,500 ohms.
T_3 — 5-watt driver transformer; ratio pri. to ½ sec. approx. 1.1:1.
T_4 — 400-watt modulation transformer; ratio pri. to sec. approx. 2.7:1; pri. impedance = 22,200 ohms, sec. impedance = 8300 ohms.



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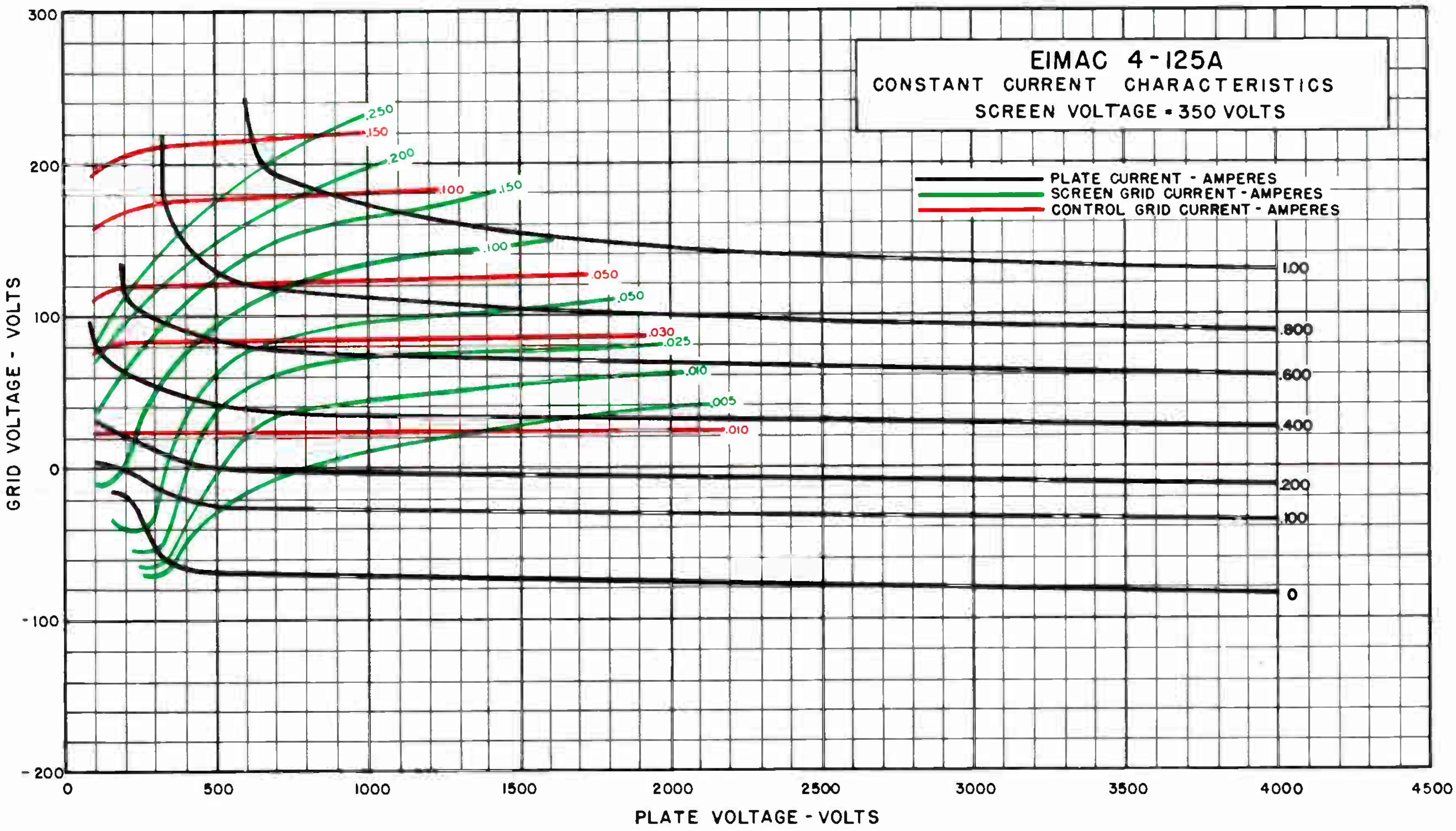


Eimac 4-125A (4D21)

Printed in U. S. A. 11-B6-90576

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

4E27A/5-125B

RADIAL-BEAM POWER PENTODE

•

MODULATOR OSCILLATOR AMPLIFIER

The Eimac 4E27A/5-125B is a power pentode intended for use as a modulator, oscillator or amplifier. The driving-power requirement is very low, and neutralization problems are simplified or eliminated entirely. The tube has a maximum plate-dissipation rating of 125 watts and a maximum plate voltage rating of 4000 volts at frequencies up to 75 Mc. Cooling is by convection and radiation. Type 4E27A/5-125B unilaterally replaces type 4E27.

The 4E27A/5-125B in class-C r-f service will deliver up to 375 watts plate power output with less than 2 watts driving power. It will deliver up to 75 watts of carrier for suppressor modulation.

Two 4E27A/5-125B's will deliver up to 300 watts maximum-signal plate power output in class AB_1 modulator service, 400 watts in class AB_2 with less than 1 watt driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten
- Voltage - 5.0 volts
- Current - 7.5 amperes

Grid-Screen Amplification Factor (Average) - 5.0

Direct Interelectrode Capacitances (Average)
- Grid-Plate - 0.08 μμfd
- Input - 10.5 μμfd
- Output - 4.7 μμfd

Transconductance (I_b=50ma., E_b=2500v., E_{c2}=500v., E_{c3}= 0v.) - 2150 μmhos

Highest Frequencies for Maximum Ratings - 75 Mc.

MECHANICAL

Base - 7-pin, metal shell

Connections - See drawing

Socket* - E. F. Johnson Co. No. 122-237, or equivalent

Mounting Position - Vertical, base down or up

Cooling - Convection and radiation

Recommended Heat Dissipating Plate Connector - Eimac HR-5

Maximum Over-All Dimensions:
- Length - 6.19 inches
- Diameter - 2.75 inches

Net Weight (Average) - 6.0 ounces

Shipping Weight - 2.0 pounds

*See "Cooling" under Application Notes.

Note: Typical operation data are based on conditions of adjusting the r-f grid drive to specified plate current, maintaining fixed conditions of grid bias, screen voltage and suppressor 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.

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony, Frequencies up to 75 Mc.
(Key-down conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	4000	MAX. VOLTS
D-C SCREEN VOLTAGE	750	MAX. VOLTS
D-C GRID VOLTAGE	−500	MAX. VOLTS
D-C PLATE CURRENT	200	MAX. MA
PLATE DISSIPATION	125	MAX. WATTS
SUPPRESSOR DISSIPATION	20	MAX. WATTS
SCREEN DISSIPATION	20	MAX. WATTS
GRID DISSIPATION	5	MAX. WATTS

TYPICAL OPERATION
60 Suppressor Volts, 500 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	3000	volts
D-C Grid Voltage	−120	−130	−150	−170	−200	volts
D-C Plate Current	167	200	200	186	167	ma
D-C Suppressor Current*	6	5	4	3	3	ma
D-C Screen Current*	11	11	11	7	5	ma
D-C Grid Current*	6	8	8	7	6	ma
Peak R-F Grid Input Voltage	170	200	222	240	260	volts
Driving Power*	1.0	1.6	1.8	1.7	1.6	watts
Grid Dissipation*	.3	.6	.6	.5	.6	watts
Screen Dissipation*	5.5	5.5	5.5	3.5	2.5	watts
Plate Dissipation	47	85	100	115	125	watts
Plate Power Input	167	300	400	465	500	watts
Plate Power Output	120	215	300	350	375	watts

TYPICAL OPERATION
Zero Suppressor Volts, 500 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	3000	volts
D-C Grid Voltage	−120	−130	−150	−170	−200	volts
D-C Plate Current	145	180	200	184	167	ma
D-C Screen Current*	17	20	23	18	12	ma
D-C Grid Current*	6	8	11	9	7	ma
Peak R-F Grid Input Voltage	170	200	240	250	270	volts
Driving Power*	1.0	1.6	2.6	2.3	1.9	watts
Grid Dissipation*	.3	.6	1.0	.8	.5	watts
Screen Dissipation*	8.5	10	12	9	6	watts
Plate Dissipation	55	95	125	125	125	watts
Plate Power Input	145	270	400	460	500	watts
Plate Power Output	90	175	275	335	375	watts

TYPICAL OPERATION
Zero Suppressor Volts, 750 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	3000	volts
D-C Grid Voltage	−170	−180	−200	−225	−250	volts
D-C Plate Current	160	200	200	186	167	ma
D-C Screen Current*	21	24	22	12	9	ma
D-C Grid Current*	3	6	6	4	3	ma
Peak R-F Grid Input Voltage	205	235	257	270	290	volts
Driving Power*	.6	1.4	1.5	1.1	.9	watts
Grid Dissipation*	.1	.4	.3	.2	.2	watts
Screen Dissipation*	16	18	17	9	7	watts
Plate Dissipation	45	85	100	115	125	watts
Plate Power Input	160	300	400	465	500	watts
Plate Power Output	115	215	300	350	375	watts

*Approximate Values

Supersedes Sheet Dated 12-1-49

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony, Frequencies up to 75 Mc.
(Carrier conditions, per tube, unless otherwise specified)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3200 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C GRID VOLTAGE	−500 MAX. VOLTS
D-C PLATE CURRENT	160 MAX. MA
PLATE DISSIPATION	85 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION
Zero Suppressor Volts, 500 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	volts
D-C Grid Voltage	−190	−195	−200	−205	volts
D-C Plate Current	149	150	151	152	ma
D-C Screen Current*	20	18	17	16	ma
D-C Grid Current*	7	7	8	8	ma
Peak A-F Screen Voltage (100% Modulation)	350	350	350	350	volts
Peak R-F Grid Input Voltage	260	265	270	275	volts
Driving Power*	2	2	2	2	watts
Grid Dissipation*	0.5	0.5	0.5	0.5	watts
Screen Dissipation*	10	9	8.5	8	watts
Plate Dissipation	64	72	80	85	watts
Plate Power Input	149	225	300	380	watts
Plate Power Output	85	153	220	295	watts

SUPPRESSOR-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony, Frequencies up to 75 Mc.
(Carrier conditions, per tube, unless otherwise specified)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C GRID VOLTAGE	−500 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION

D-C Plate Voltage	1500	2000	2500	3000	volts
D-C Suppressor Voltage	−220	−260	−305	−350	volts
Peak A-F Suppressor Voltage (100% Modulation)	220	260	305	350	volts
D-C Screen Voltage	400	400	400	400	volts
Fixed D-C Screen Voltage	610	645	650	610	volts
Screen Dropping Resistor[1]	5500	9100	10,000	8300	ohms
D-C Grid Voltage	−170	−180	−190	−200	volts
D-C Plate Current	59	59	59	60	ma
D-C Screen Current*	38	27	25	25	ma
D-C Grid Current*	6	5	5	4	ma
Peak R-F Grid Input Voltage	230	235	245	250	volts
Driving Power*	1.4	1.3	1.2	1.2	watts
Grid Dissipation*	.35	.25	.25	.20	watts
Screen Dissipation*	15	11	10	10	watts
Plate Dissipation	54	68	87	105	watts
Plate Power Input	89	118	148	180	watts
Plate Power Output	35	50	61	75	watts

[1]Adjust to stated d-c screen voltage.

AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

Class-AB, Sinusoidal Wave

MAXIMUM RATINGS (Per Tube)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C GRID VOLTAGE	−500 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION (Two tubes unless otherwise specified)
Class-AB_1

D-C Plate Voltage	1500	2000	2500	volts
D-C Suppressor Voltage	0	0	0	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage[1]	−70	−80	−85	volts
Zero-Signal D-C Plate Current	110	85	65	ma
Max-Signal D-C Plate Current	205	210	220	ma
Zero-Signal D-C Screen Current*	0	0	0	ma
Max-Signal D-C Screen Current*	15	13	8	ma
Effective Plate-to-Plate Load	13,700	18,000	20,000	ohms
Peak A-F Grid Voltage (per tube)	70	80	85	volts
Max-Signal Driving Power*	0	0	0	watts
Max-Signal Plate Power Input	310	420	550	watts
Max-Signal Plate Power Output	200	250	300	watts

[1]Adjust to stated zero-signal d-c plate current. The effective grid circuit resistance for each tube must not exceed 250,000 ohms.

TYPICAL OPERATION (Two tubes unless otherwise specified)
Class-AB_2

D-C Plate Voltage	1500	2000	2500	volts
D-C Suppressor Voltage	60	0	0	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage[1]	−70	−80	−85	volts
Zero-Signal D-C Plate Current	110	85	65	ma
Max-Signal D-C Plate Current	365	295	250	ma
Zero-Signal D-C Screen Current*	0	0	0	ma
Max-Signal D-C Screen Current*	11	16	13	ma
Effective Plate-to-Plate Load	7300	13,000	20,000	ohms
Peak A-F Grid Input Voltage (per tube)	100	100	95	volts
Max-Signal Driving Power*	0.5	0.3	0.2	watts
Max-Signal Plate Power Input	550	590	625	watts
Max-Signal Plate Power Output	300	350	400	watts

[1]Adjust to stated zero-signal d-c plate current.
*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 EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

MECHANICAL

Mounting—The 4E27A/5-125B must be mounted vertically, base down or up. The plate lead should be flexible, and the tube must be protected from vibration and shock.

Cooling—A heat dissipating connector (Eimac HR-5 or equivalent) is required at the plate terminal, and provision must be made for the free circulation of air through the socket and through the holes in the base. If the E. F Johnson Co. 122-237 socket recommended under "General Characteristics" is to be used, the model incorporating a ventilating hole should be specified.

At high ambient temperatures, at frequencies above 75 Mc., or when the flow of air is restricted, it may become necessary to provide forced air circulation in sufficient quantity to prevent the temperature of the plate and base seals from exceeding 225°C. Forced movement of air across the tube seals and envelope is always beneficial, though not necessarily required.

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 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.

Grid Voltage—Although a maximum of —500 volts bias may be applied to the grid, there is little advantage in using bias voltages in excess of those listed under "Typical Operation," except in certain specialized applications.

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.

In class-C operation, particularly at high frequency, both grid bias and grid drive should be only great enough to provide satisfactory operation at good plate efficiency.

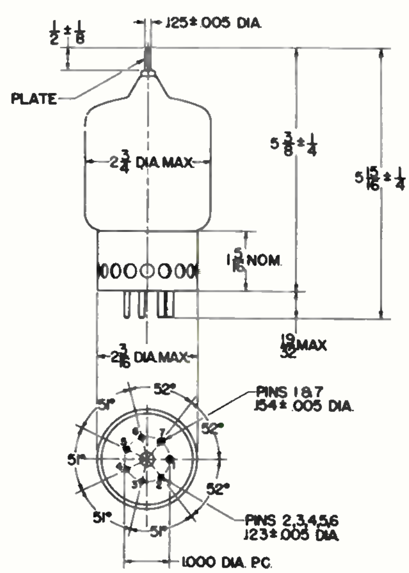
Screen Dissipation—Decrease or removal of plate load, plate voltage or bias voltage may result in screen dissipation in excess of the 20 watt maximum rating. The tube may be protected by an overload relay in the screen circuit set to remove the screen voltage when the dissipation exceeds 20 watts.

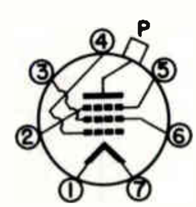
Resistors placed in the screen circuit for the purpose of developing an audio modulating voltage on the screen in modulated radio-frequency amplifiers should be made variable to permit adjustment when replacing tubes.

Plate Dissipation—Plate dissipation in excess of the 125-watt maximum rating is permissible for short periods of time, such as during tuning procedures.

Operation—If reasonable precautions are taken to prevent coupling between the input and output circuits, the 4E27A/5-125B may usually be operated at frequencies up to 75 Mc. without neutralization. A conventional method of obtaining the necessary shielding between the grid and plate circuits is to use a suitable metal chassis with the grid circuit mounted below the deck and the plate circuit above. The tube socket should be mounted flush with the under side of the chassis deck, and spring fingers mounted around the socket opening should make contact between the chassis and the metal base shell of the tube. Power-supply leads entering the amplifier should be by-passed to ground and properly shielded. The output circuit and antenna feeders should be arranged so as to preclude any possibility of feedback to other circuits.

Feedback at high frequencies may be due to the inductance of leads, particularly those of the screen and suppressor-grids. By-passing methods and means of placing these grids at r-f ground potential are discussed in Application Bulletin Number Eight, "The Care and Feeding of Power Tetrodes," available from Eitel-McCullough, Inc., for twenty-five cents. Much of the material contained in this bulletin may be applied to pentodes.





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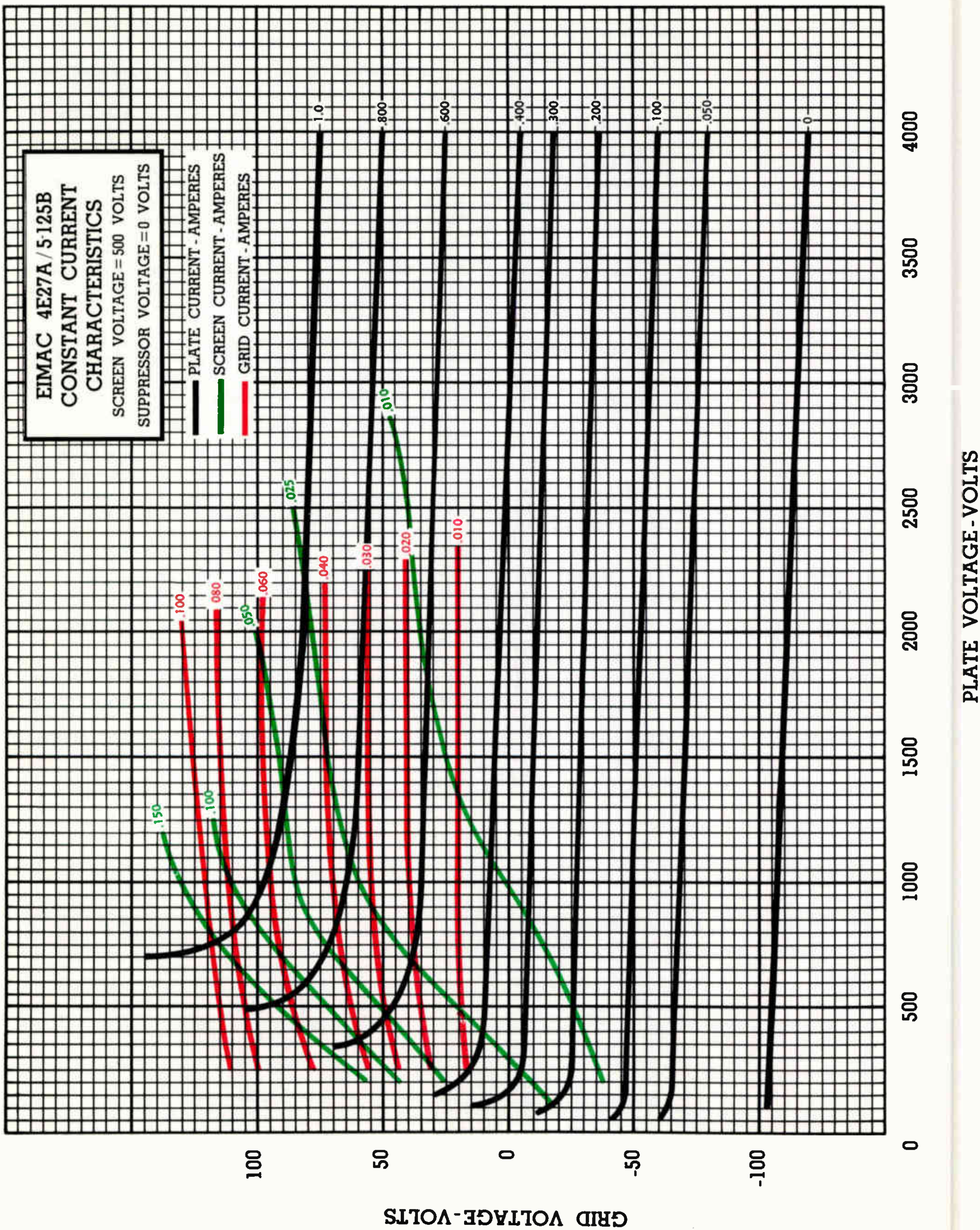
EIMAC 4E27A / 5-125B
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 500 VOLTS
SUPPRESSOR VOLTAGE = 0 VOLTS
PLATE CURRENT - AMPERES
SCREEN CURRENT - AMPERES
GRID CURRENT - AMPERES
PLATE VOLTAGE - VOLTS
GRID VOLTAGE - VOLTS
0
500
1000
1500
2000
2500
3000
3500
4000
100
50
0
-50
-100
1.0
.800
.600
.400
.300
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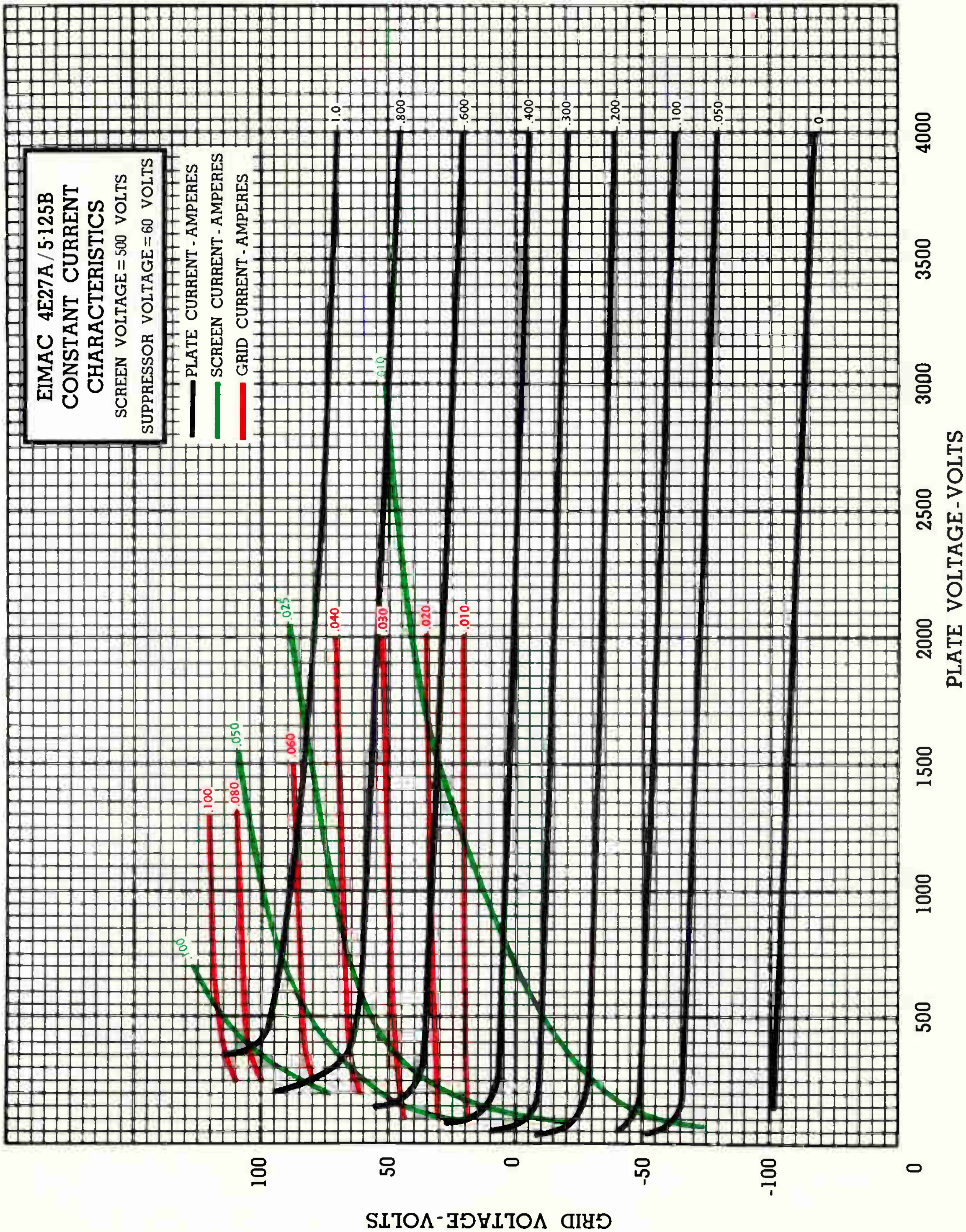
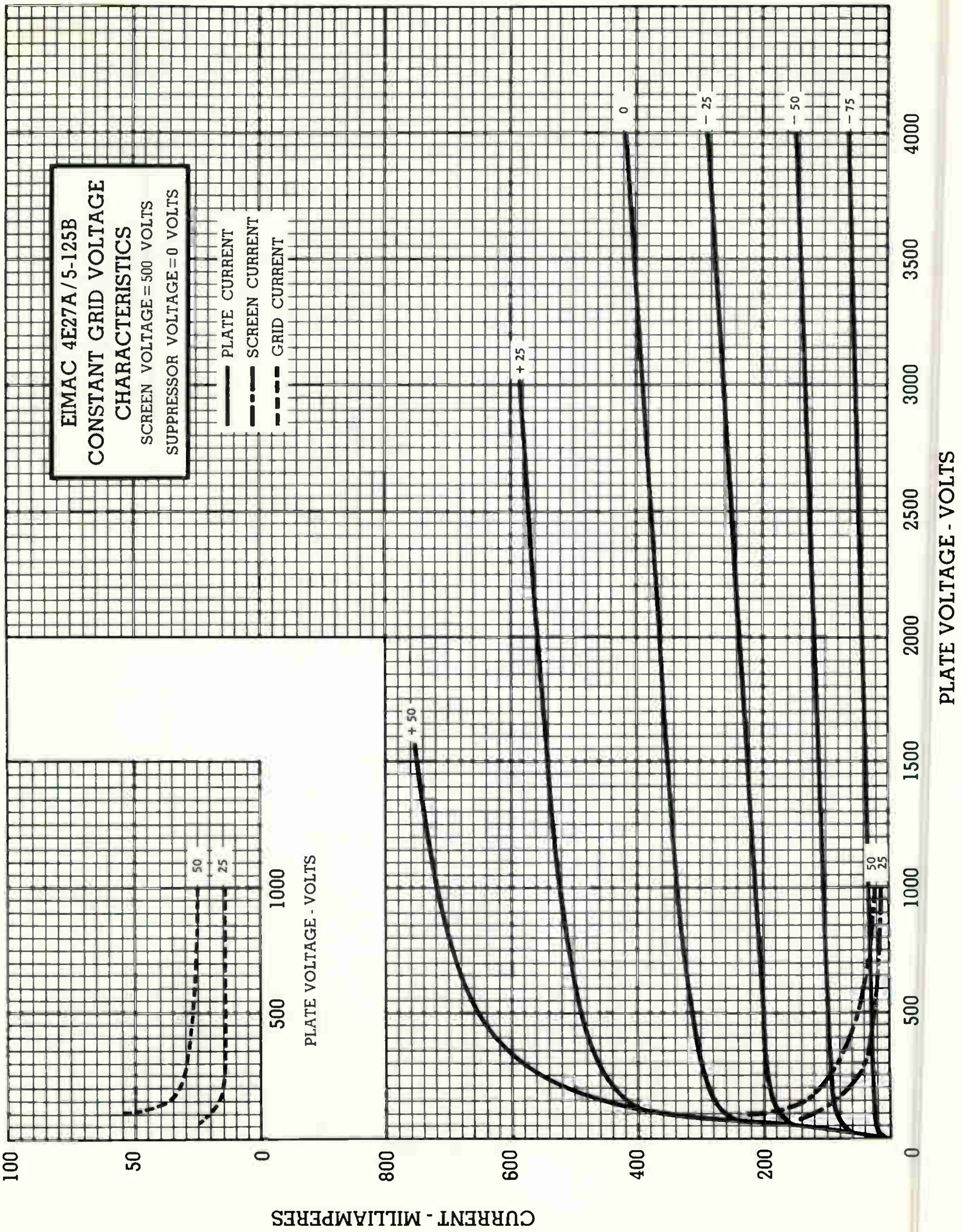
Eimac 4E27A/5-125B





Printed in U. S. A. 4-19-85243

APPLICATION BULLETIN

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

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 Computor 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 computor 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 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."

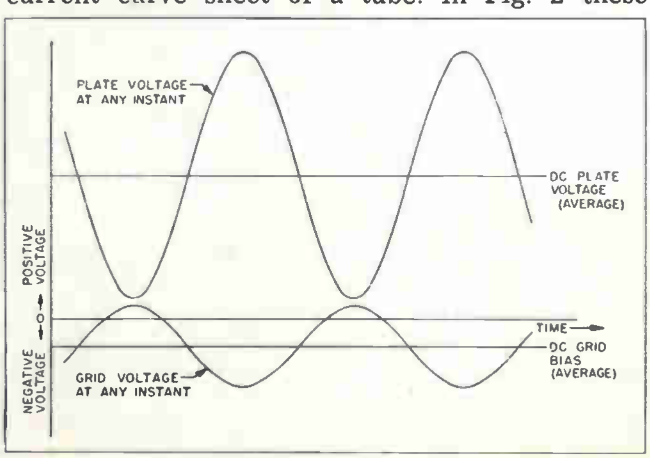


Figure 1

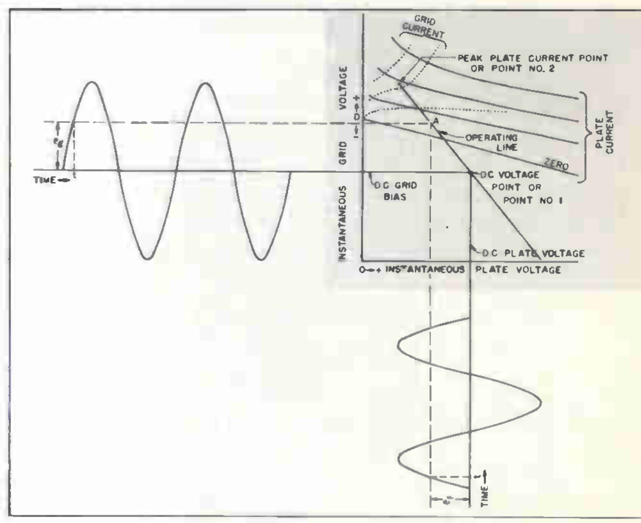


Figure 2

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.

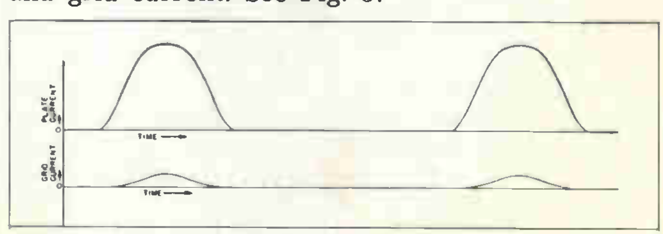


Figure 3

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 Computor 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 Computor

The Eimac Tube Performance Computor 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 computor. 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 computor 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 computor were derived by Chaffee[1] 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 computor, 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 computor for power amplifier service can be applied in combination with the other methods given in the literature to give good accuracy with simpler procedues. 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 Computor

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 Computor can now be used to obtain the meter readings and power values from this "Operating Line." Place the computor on the constant current curve sheet so that the "guide lines" of the computor are parallel with the operating line. Now slide the computor 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 computor 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

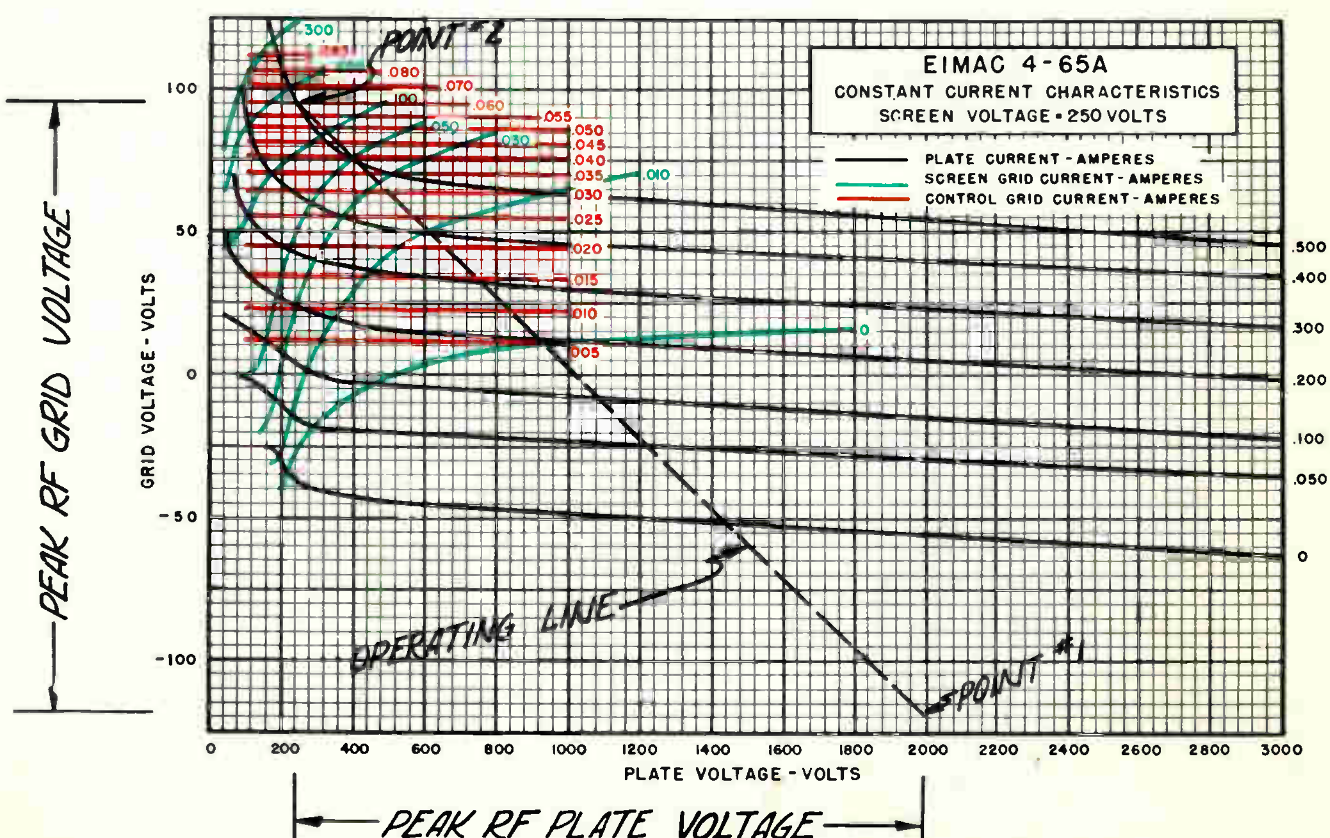


Figure 4

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 computor) 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:

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		
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 computor. (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 computor 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)

A = 500 = 500 Ma
1.93 B = 1.93x 510 = 985
1.73 C = 1.73x 460 = 796
1.41 D = 1.41x 290 = 409
E = 80 = 80

Total = 2770 Ma

Peak fundamental current = 1/12 Total
= 2770/12 = 230 Ma

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 = ½ 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 = ½ x .230 x 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		

REFERENCES

1. E. L. Chaffee, "A Simplified Harmonic Analysis," Review Sci. Inst. 7, page 384, October 1936
2. H. P. Thomas, "Determination of Grid Driving Power in Radio Frequency Power Amplifiers," Proc. IRE, Vol. 21, pp. 1134-1141; August 1933
3. W. G. Wagener, "Simplified Methods for Computing Performance of Transmitting Tubes," Proc. IRE; January 1937
4. R. I. Sarbacher, "Graphical Determination of PA Performance," Electronics; December 1942
5. R. I. Sarbacher, "Performance of Self Biased Modulated Amplifier," Electronics; April 1943
6. "Class C Amplifier Calculations With The Aid of Constant-Current Characteristics," Eimac Application Bulletin Number 4
7. "Vacuum Tube Ratings," Eimac Application Bulletin Number 6
8. Robert H. Brown, "Harmonic Amplifier Design," Proc. IRE, Vol. 35 pp. 771-777; August 1947

PRINTED IN U.S.A. 6-83478

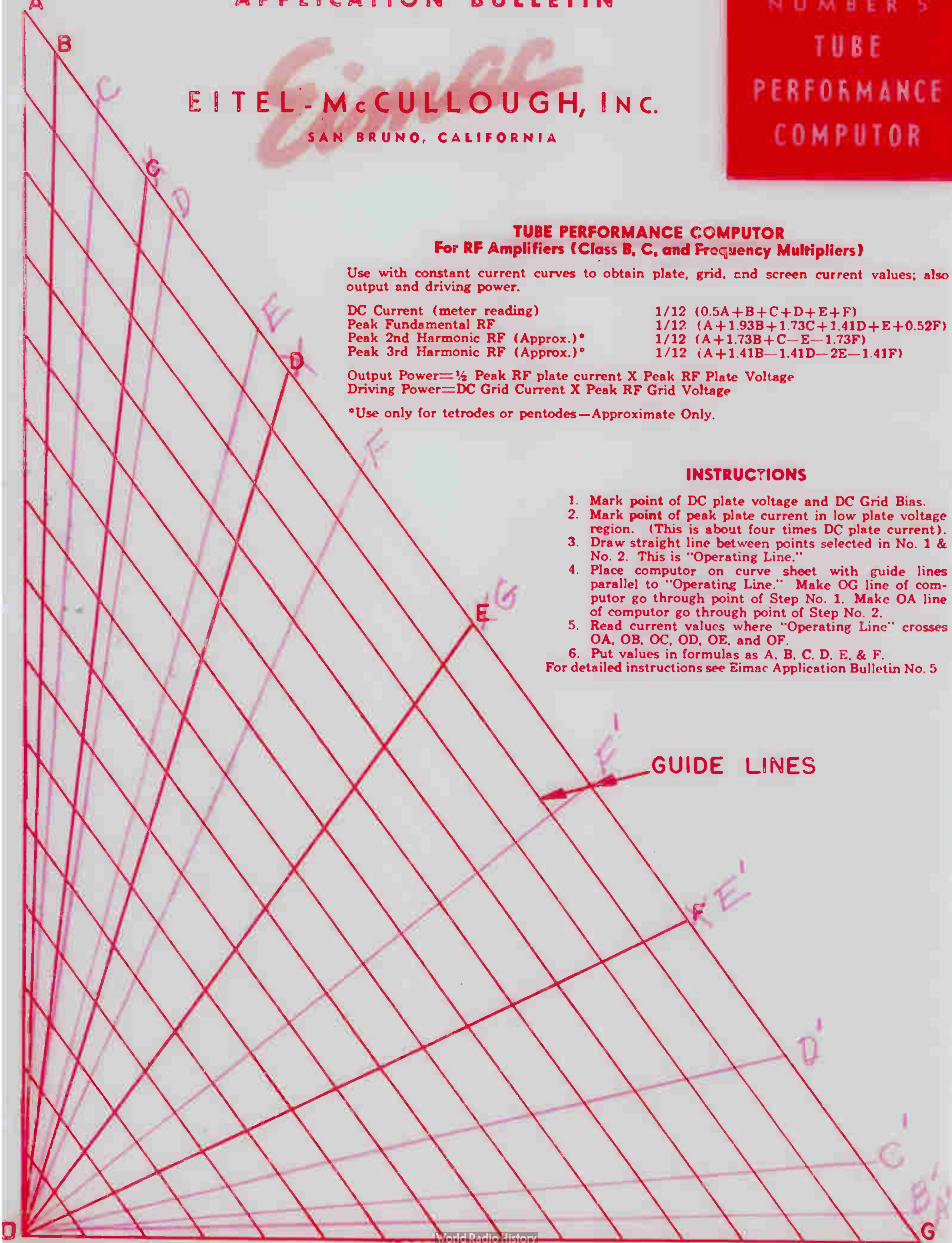
APPLICATION BULLETIN

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

NUMBER 5

TUBE PERFORMANCE COMPUTOR



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=½ Peak RF plate current X Peak RF Plate Voltage
Driving Power=DC Grid Current X 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 computor on curve sheet with guide lines parallel to "Operating Line." Make OG line of computor go through point of Step No. 1. Make OA line of computor 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.

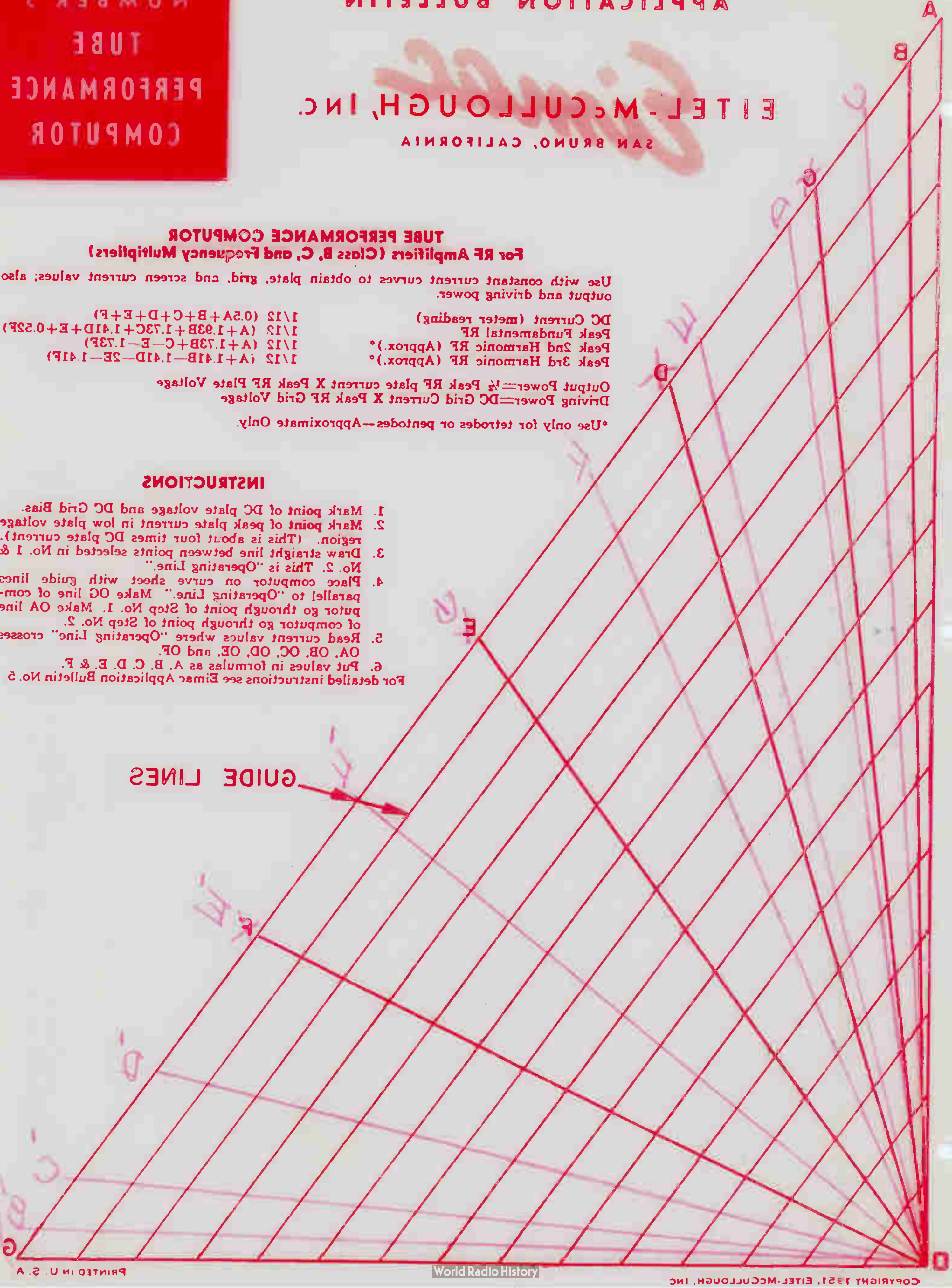
For detailed instructions see Eimac Application Bulletin No. 5

NUMBER 5
TUBE
PERFORMANCE
COMPUTOR

APPLICATION BULLETIN

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA



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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 = ½ Peak RF plate current X Peak RF Plate Voltage
Driving Power = DC Grid Current X Peak RF Grid Voltage

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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

PRINTED IN U. S. A

4E27A/5-125B

RADIAL-BEAM POWER PENTODE

•

MODULATOR OSCILLATOR AMPLIFIER

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

The Eimac 4E27A/5-125B is a power pentode intended for use as a modulator, oscillator or amplifier. The driving-power requirement is very low, and neutralization problems are simplified or eliminated entirely. The tube has a maximum plate-dissipation rating of 125 watts and a maximum plate voltage rating of 4000 volts at frequencies up to 75 Mc. Cooling is by convection and radiation. Type 4E27A/5-125B unilaterally replaces type 4E27.

The 4E27A/5-125B in class-C r-f service will deliver up to 375 watts plate power output with less than 2 watts driving power. It will deliver up to 75 watts of carrier for suppressor modulation.

Two 4E27A/5-125B's will deliver up to 300 watts maximum-signal plate power output in class AB_1 modulator service, 400 watts in class AB_2 with less than 1 watt driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated tungsten	
Voltage	5.0 volts
Current	7.5 amperes
Grid-Screen Amplification Factor (Average)	5.0
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.08 $\mu\mu$fd
Input	10.5 $\mu\mu$fd
Output	4.7 $\mu\mu$fd
Transconductance (I_b=50ma., E_b=2500v., E_{c2}=500v., E_{c3}= 0v.)	2150 μmhos
Highest Frequencies for Maximum Ratings	75 Mc.

MECHANICAL

Base	7-pin, metal shell
Connections	See drawing
Socket*	E. F. Johnson Co. No. 122-237, or equivalent
Mounting Position	Vertical, base down or up
Cooling	Convection and radiation
Recommended Heat Dissipating Plate Connector	Eimac HR-5
Maximum Over-All Dimensions:	
Length	6.19 inches
Diameter	2.75 inches
Net Weight (Average)	6.0 ounces
Shipping Weight	2.0 pounds

*See "Cooling" under Application Notes.

Note: Typical operation data are based on conditions of adjusting the r-f grid drive to specified plate current, maintaining fixed conditions of grid bias, screen voltage and suppressor 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.

RADIO-FREQUENCY POWER AMPLIFIER OR OSCILLATOR

Class-C Telegraphy or FM Telephony, Frequencies up to 75 Mc.
(Key-down conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C GRID VOLTAGE	−500 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION
60 Suppressor Volts, 500 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	3000	volts
D-C Grid Voltage	−120	−130	−150	−170	−200	volts
D-C Plate Current	167	200	200	186	167	ma
D-C Suppressor Current*	6	5	4	3	3	ma
D-C Screen Current*	11	11	11	7	5	ma
D-C Grid Current*	6	8	8	7	6	ma
Peak R-F Grid Input Voltage	170	200	222	240	260	volts
Driving Power*	1.0	1.6	1.8	1.7	1.6	watts
Grid Dissipation*	.3	.6	.6	.5	.6	watts
Screen Dissipation*	5.5	5.5	5.5	3.5	2.5	watts
Plate Dissipation	47	85	100	115	125	watts
Plate Power Input	167	300	400	465	500	watts
Plate Power Output	120	215	300	350	375	watts

TYPICAL OPERATION
Zero Suppressor Volts, 500 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	3000	volts
D-C Grid Voltage	−120	−130	−150	−170	−200	volts
D-C Plate Current	145	180	200	184	167	ma
D-C Screen Current*	17	20	23	18	12	ma
D-C Grid Current*	6	8	11	9	7	ma
Peak R-F Grid Input Voltage	170	200	240	258	270	volts
Driving Power*	1.0	1.6	2.6	2.3	1.9	watts
Grid Dissipation*	.3	.6	1.0	.8	.5	watts
Screen Dissipation*	8.5	10	12	9	6	watts
Plate Dissipation	55	95	125	125	125	watts
Plate Power Input	145	270	400	460	500	watts
Plate Power Output	90	175	275	335	375	watts

TYPICAL OPERATION
Zero Suppressor Volts, 750 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	3000	volts
D-C Grid Voltage	−170	−180	−200	−225	−250	volts
D-C Plate Current	160	200	200	186	167	ma
D-C Screen Current*	21	24	22	12	9	ma
D-C Grid Current*	3	6	6	4	3	ma
Peak R-F Grid Input Voltage	205	235	257	270	290	volts
Driving Power*	.6	1.4	1.5	1.1	.9	watts
Grid Dissipation*	.1	.4	.3	.2	.2	watts
Screen Dissipation*	16	18	17	9	7	watts
Plate Dissipation	45	85	100	115	125	watts
Plate Power Input	160	300	400	465	500	watts
Plate Power Output	115	215	300	350	375	watts

*Approximate Values

Supersedes Sheet Dated 12-1-49

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony, Frequencies up to 75 Mc.
(Carrier conditions, per tube, unless otherwise specified)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3200 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C GRID VOLTAGE	-500 MAX. VOLTS
D-C PLATE CURRENT	160 MAX. MA
PLATE DISSIPATION	85 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION
Zero Suppressor Volts, 500 Screen Volts

D-C Plate Voltage	1000	1500	2000	2500	volts
D-C Grid Voltage	−190	−195	−200	−205	volts
D-C Plate Current	149	150	151	152	ma
D-C Screen Current*	20	18	17	16	ma
D-C Grid Current*	7	7	8	8	ma
Peak A-F Screen Voltage (100% Modulation)	350	350	350	350	volts
Peak R-F Grid Input Voltage	260	265	270	275	volts
Driving Power*	2	2	2	2	watts
Grid Dissipation*	0.5	0.5	0.5	0.5	watts
Screen Dissipation*	10	9	8.5	8	watts
Plate Dissipation	64	72	80	85	watts
Plate Power Input	149	225	300	380	watts
Plate Power Output	85	153	220	295	watts

SUPPRESSOR-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony, Frequencies up to 75 Mc.
(Carrier conditions, per tube, unless otherwise specified)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C GRID VOLTAGE	−500 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION

D-C Plate Voltage	1500	2000	2500	3000	volts
D-C Suppressor Voltage	−220	−260	−305	−350	volts
Peak A-F Suppressor Voltage (100% Modulation)	220	260	305	350	volts
D-C Screen Voltage	400	400	400	400	volts
Fixed D-C Screen Voltage	610	645	650	610	volts
Screen Dropping Resistor[1]	5500	9100	10,000	8300	ohms
D-C Grid Voltage	−170	−180	−190	−200	volts
D-C Plate Current	59	59	59	60	ma
D-C Screen Current*	38	27	25	25	ma
D-C Grid Current*	6	5	5	4	ma
Peak R-F Grid Input Voltage	230	235	245	250	volts
Driving Power*	1.4	1.3	1.2	1.2	watts
Grid Dissipation*	.35	.25	.25	.20	watts
Screen Dissipation*	15	11	10	10	watts
Plate Dissipation	54	68	87	105	watts
Plate Power Input	89	118	148	180	watts
Plate Power Output	35	50	61	75	watts

[1]Adjust to stated d-c screen voltage.

AUDIO-FREQUENCY POWER AMPLIFIER OR MODULATOR

Class-AB, Sinusoidal Wave

MAXIMUM RATINGS (Per Tube)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	750 MAX. VOLTS
D-C GRID VOLTAGE	−500 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SUPPRESSOR DISSIPATION	20 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION (Two tubes unless otherwise specified)
Class-AB_1

D-C Plate Voltage	1500	2000	2500	volts
D-C Suppressor Voltage	0	0	0	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage[1]	−70	−80	−85	volts
Zero-Signal D-C Plate Current	110	85	65	ma
Max-Signal D-C Plate Current	205	210	220	ma
Zero-Signal D-C Screen Current*	0	0	0	ma
Max-Signal D-C Screen Current*	15	13	8	ma
Effective Plate-to-Plate Load	13,700	18,000	20,000	ohms
Peak A-F Grid Voltage (per tube)	70	80	85	volts
Max-Signal Driving Power*	0	0	0	watts
Max-Signal Plate Power Input	310	420	550	watts
Max-Signal Plate Power Output	200	250	300	watts

[1]Adjust to stated zero-signal d-c plate current. The effective grid circuit resistance for each tube must not exceed 250,000 ohms.

TYPICAL OPERATION (Two tubes unless otherwise specified)
Class-AB_2

D-C Plate Voltage	1500	2000	2500	volts
D-C Suppressor Voltage	60	0	0	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage[1]	−70	−80	−85	volts
Zero-Signal D-C Plate Current	110	85	65	ma
Max-Signal D-C Plate Current	365	295	250	ma
Zero-Signal D-C Screen Current*	0	0	0	ma
Max-Signal D-C Screen Current*	11	16	13	ma
Effective Plate-to-Plate Load	7300	13,000	20,000	ohms
Peak A-F Grid Input Voltage (per tube)	100	100	95	volts
Max-Signal Driving Power*	0.5	0.3	0.2	watts
Max-Signal Plate Power Input	550	590	625	watts
Max-Signal Plate Power Output	300	350	400	watts

[1]Adjust to stated zero-signal d-c plate current.
*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 EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

MECHANICAL

Mounting—The 4E27A/5-125B must be mounted vertically, base down or up. The plate lead should be flexible, and the tube must be protected from vibration and shock.

Cooling—A heat dissipating connector (Eimac HR-5 or equivalent) is required at the plate terminal, and provision must be made for the free circulation of air through the socket and through the holes in the base. If the E. F Johnson Co. 122-237 socket recommended under "General Characteristics" is to be used, the model incorporating a ventilating hole should be specified.

At high ambient temperatures, at frequencies above 75 Mc., or when the flow of air is restricted, it may become necessary to provide forced air circulation in sufficient quantity to prevent the temperature of the plate and base seals from exceeding 225°C. Forced movement of air across the tube seals and envelope is always beneficial, though not necessarily required.

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 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.

Grid Voltage—Although a maximum of —500 volts bias may be applied to the grid, there is little advantage in using bias voltages in excess of those listed under "Typical Operation," except in certain specialized applications.

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.

In class-C operation, particularly at high frequency, both grid bias and grid drive should be only great enough to provide satisfactory operation at good plate efficiency.

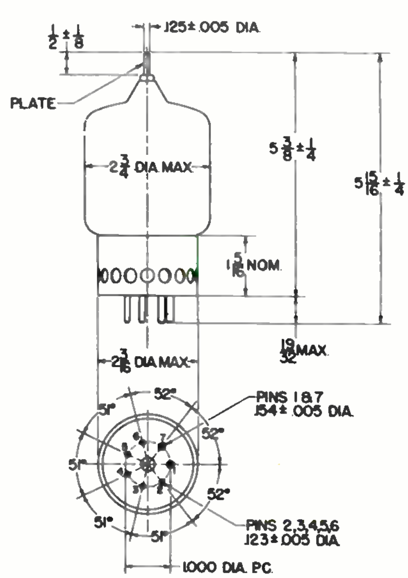
Screen Dissipation—Decrease or removal of plate load, plate voltage or bias voltage may result in screen dissipation in excess of the 20 watt maximum rating. The tube may be protected by an overload relay in the screen circuit set to remove the screen voltage when the dissipation exceeds 20 watts.

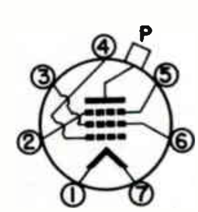
Resistors placed in the screen circuit for the purpose of developing an audio modulating voltage on the screen in modulated radio-frequency amplifiers should be made variable to permit adjustment when replacing tubes.

Plate Dissipation—Plate dissipation in excess of the 125-watt maximum rating is permissible for short periods of time, such as during tuning procedures.

Operation—If reasonable precautions are taken to prevent coupling between the input and output circuits, the 4E27A/5-125B may usually be operated at frequencies up to 75 Mc. without neutralization. A conventional method of obtaining the necessary shielding between the grid and plate circuits is to use a suitable metal chassis with the grid circuit mounted below the deck and the plate circuit above. The tube socket should be mounted flush with the under side of the chassis deck, and spring fingers mounted around the socket opening should make contact between the chassis and the metal base shell of the tube. Power-supply leads entering the amplifier should be by-passed to ground and properly shielded. The output circuit and antenna feeders should be arranged so as to preclude any possibility of feedback to other circuits.

Feedback at high frequencies may be due to the inductance of leads, particularly those of the screen and suppressor-grids. By-passing methods and means of placing these grids at r-f ground potential are discussed in Application Bulletin Number Eight, "The Care and Feeding of Power Tetrodes," available from Eitel-McCullough, Inc., for twenty-five cents. Much of the material contained in this bulletin may be applied to pentodes.





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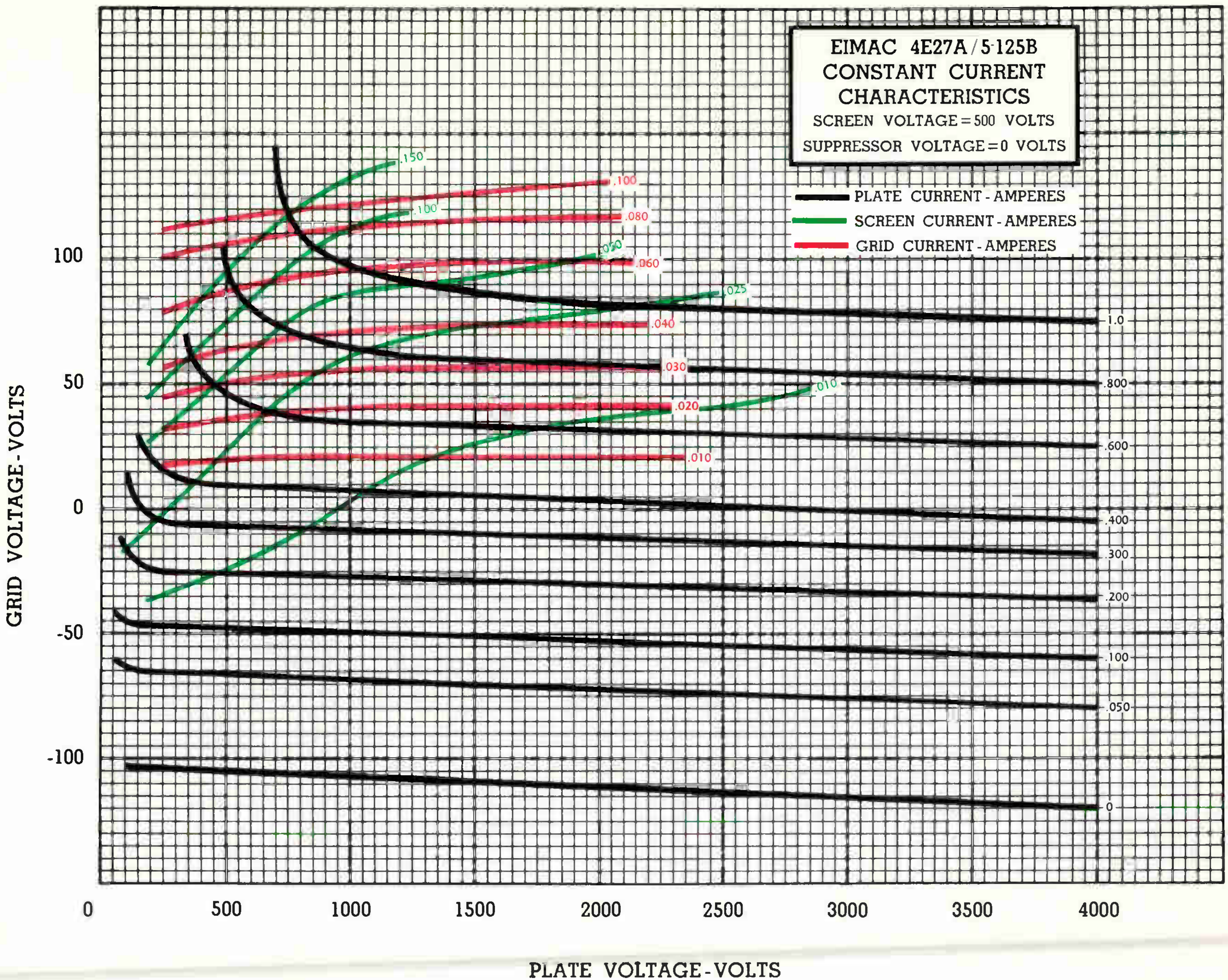
EIMAC 4E27A/5-125B
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 500 VOLTS
SUPPRESSOR VOLTAGE = 0 VOLTS
PLATE CURRENT - AMPERES
SCREEN CURRENT - AMPERES
GRID CURRENT - AMPERES
GRID VOLTAGE - VOLTS
100
50
0
-50
-100
PLATE VOLTAGE - VOLTS
0
500
1000
1500
2000
2500
3000
3500
4000
1.0
.800
.600
.400
.300
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.100
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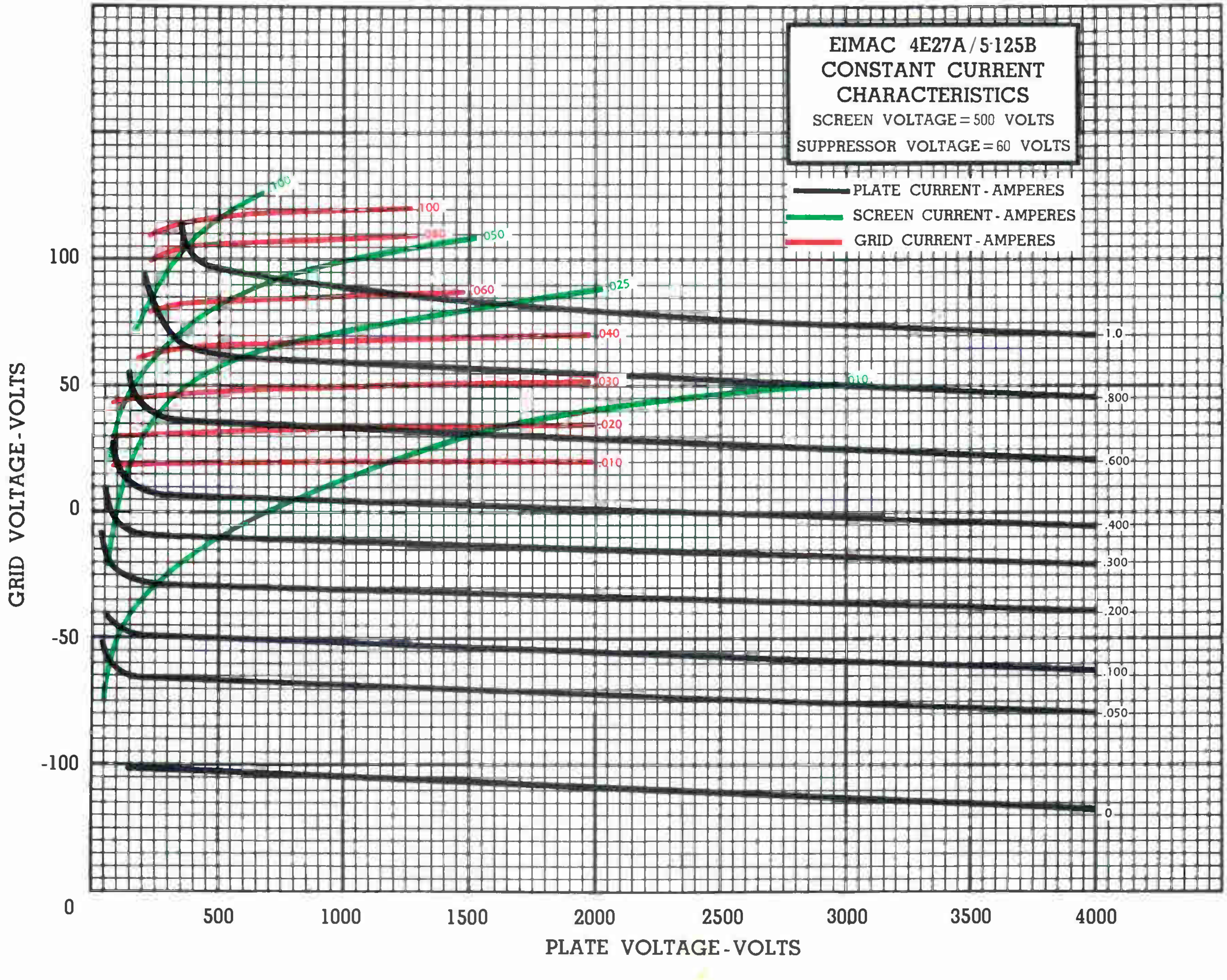

EIMAC 4E27A/5-125B
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE = 500 VOLTS
SUPPRESSOR VOLTAGE = 60 VOLTS
PLATE CURRENT - AMPERES
SCREEN CURRENT - AMPERES
GRID CURRENT - AMPERES
GRID VOLTAGE - VOLTS
100
50
0
-50
-100
0
500
1000
1500
2000
2500
3000
3500
4000
PLATE VOLTAGE - VOLTS
1.0
.800
.600
.400
.300
.200
.100
.050
0
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.025
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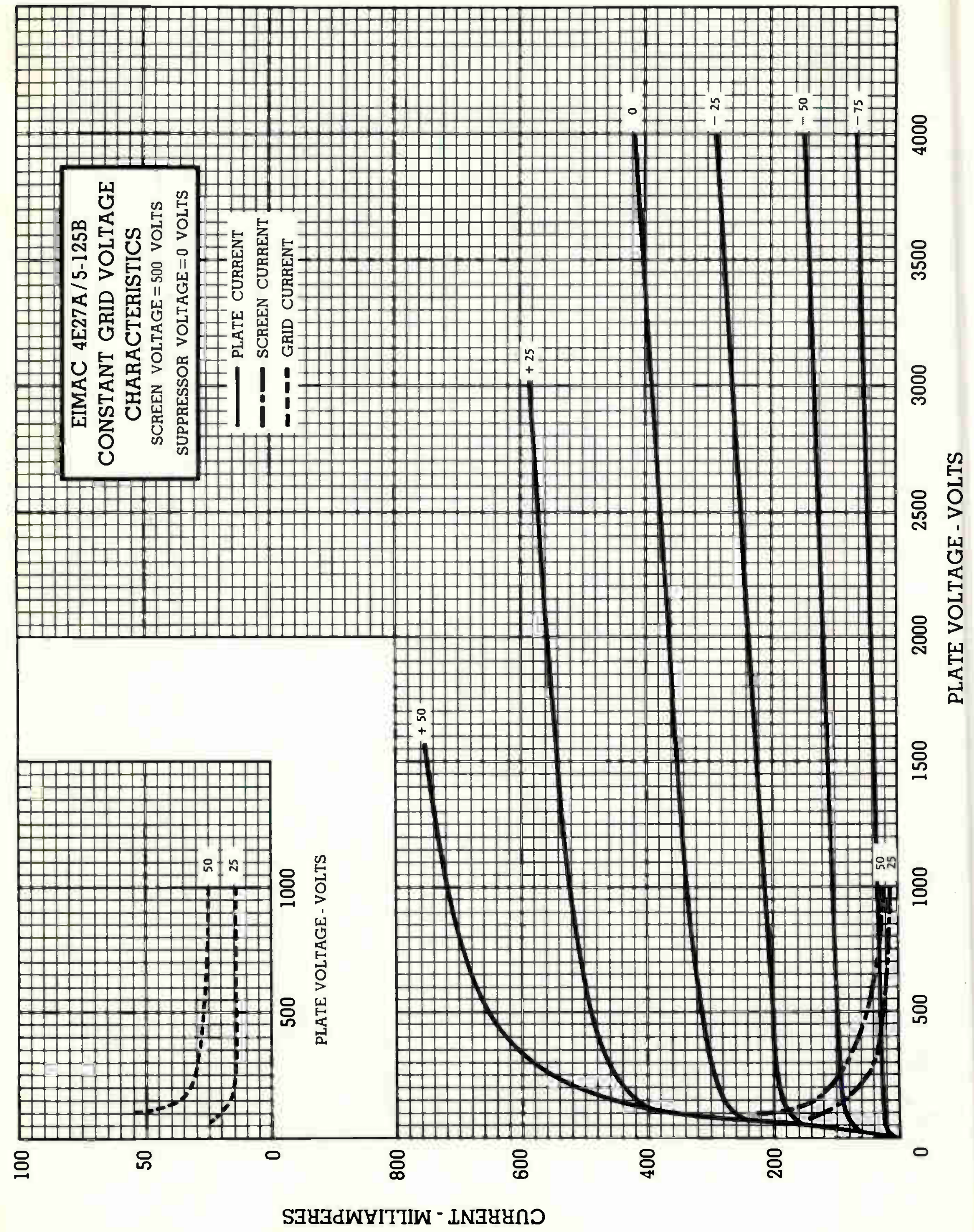


Printed in U. S. A. 4-19-85243

EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

8166
4-1000A

RADIAL-BEAM POWER TETRODE

•

MODULATOR OSCILATOR AMPLIFIER

The Eimac 8166/4-1000A is a radial-beam tetrode with a maximum plate dissipation rating of 1000 watts. Intended for use as an amplifier, oscillator, or modulator, the 8166/4-1000A is capable of efficient operation well into the VHF range.

In FM broadcast service on 110 Megacycles, two 8166/4-1000A tetrodes will deliver a useful output power of over 5000 watts.

Operating under class AB_2 modulator conditions with less than 10 watts of peak driving power, two of these tubes will deliver 3900 watts of output power.

In class AB_1, a pair of 8166/4-1000A tetrodes will deliver 3800 watts of output power.

Cooling of the tube is accomplished by radiation from the plate and by circulation of forced-air through the base and around the envelope. Cooling can be simplified through the use of the Eimac SK-500 Air-System Socket.

GENERAL CHARACTERISTICS

ELECTRICAL

	Min.	Nom.	Max.	
Filament: Thoriated tungsten				
Voltage	-	7.5		volts
Current	20.0		22.7	amperes
Amplification Factor (Grid to Screen)	6.1		7.7	
Direct Interelectrode Capacitances: †				
Grid-Plate	-	-	0.35	uuf
Input	23.8		32.4	uuf
Output	6.8		9.4	uuf
Transconductance (I_b = 300 ma)		10,000		umhos
Highest Frequency for Maximum Ratings		-	110	mc

MECHANICAL

Base	5-pin metal shell
Basing	See drawing
Recommended Socket	Eimac SK-500 Air-System Socket
Operating Position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat-Dissipating Connector:	
Plate	Eimac HR-8
Maximum Over-all Dimensions:	
Length	9.63 inches
Diameter	5.25 inches
Net Weight (tube only)	1.5 pounds
Shipping Weight	12 pounds

†In Shielded Fixture

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 output power 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, it is necessary to make the resistor adjustable to control plate current.

RADIO FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy or FM Telephony

MAXIMUM RATINGS (Key-down conditions, per tube to 110 Mc.)

D-C PLATE VOLTAGE	6000 MAX. VOLTS
D-C SCREEN VOLTAGE	1000 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	700 MAX. MA
PLATE DISSIPATION	1000 MAX. WATTS
SCREEN DISSIPATION	75 MAX. WATTS
GRID DISSIPATION	25 MAX. WATTS

TYPICAL OPERATION (Frequencies below 110 Mc., one tube)

D-C Plate Voltage	3000	4000	5000	6000	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	—150	—150	—200	—200	volts
D-C Plate Current	700	700	700	700	ma
D-C Screen Current	146	137	147	140	ma
D-C Grid Current	38	39	45	42	ma
Screen Dissipation	73	69	73	70	watts
Grid Dissipation	5	6	7	6	watts
Peak R-F Grid Input Voltage (approx.)	290	290	355	350	volts
Driving Power (approx.)*	11	12	16	15	watts
Plate Input Power	2100	2800	3500	4200	watts
Plate Dissipation	670	700	690	800	watts
Plate Output Power	1430	2100	2810	3400	watts

*Apparent driving power requirements increase above 30 Mc. At 110 Mc. the driver should be capable of supplying 200 watts per tube to take care of feed-through, circuit losses, and radiation.

TYPICAL OPERATION (110 Mc., two tubes, push-pull)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	450	500	500	volts
D-C Grid Voltage	—150	—160	—180	volts
D-C Plate Current	1.15	1.25	1.25	amps
D-C Screen Current	280	240	250	ma
D-C Grid Current	80	80	100	ma
Screen Dissipation (per tube)	63	60	63	watts
Driving Power (approx.)	350	400	400	watts
Plate Input Power	4600	6250	7500	watts
Plate Dissipation (per tube)	650	850	900	watts
Useful Output Power	3000	4200	5200	watts

These 110 Mc. typical performance figures were obtained by direct measurement in operating equipment. The output power is useful power measured in a load circuit. The driving power is that taken by the tube and a practical resonant circuit. In many cases with further refinement and improved techniques, better performance might be obtained.

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony (Carrier Conditions)

MAXIMUM RATINGS (Per tube to 110 Mc.)

D-C PLATE VOLTAGE	5000 MAX. VOLTS†
D-C SCREEN VOLTAGE	1000 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	600 MAX. MA
PLATE DISSIPATION	670 MAX. WATTS
SCREEN DISSIPATION	75 MAX. WATTS
GRID DISSIPATION	25 MAX. WATTS

†5500 Max. volts below 30 Mc.

TYPICAL OPERATION (Frequencies below 110 Mc., one tube)

D-C Plate Voltage	3000	4000	5000	5500*	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	—200	—200	—200	—200	volts
D-C Plate Current	600	600	600	600	ma
D-C Screen Current	145	132	130	105	ma
D-C Grid Current	36	33	33	28	ma
Screen Dissipation	72	66	65	52	watts
Grid Dissipation	5	4	4	3	watts
Peak A.F. Screen Voltage (100% modulation)	250	250	250	250	volts
Peak R-F Grid Input Voltage	340	335	335	325	volts
Driving Power**	12	11	11	9	watts
Plate Input Power	1800	2400	3000	3300	watts
Plate Dissipation	410	490	560	670	watts
Plate Output Power	1390	1910	2440	2630	watts

*5500 volt operation may be used below 30 Mc only.

**Apparent driving power requirements increase above 30 Mc. At 110 Mc. the driver should be capable of supplying 200 watts per tube to take care of feed-through, circuit losses, and radiation.

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR

Class AB

MAXIMUM RATINGS (Per Tube)

D-C PLATE VOLTAGE	6000 MAX. VOLTS
D-C SCREEN VOLTAGE	1000 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	700 MAX. MA
PLATE DISSIPATION	1000 MAX. WATTS
SCREEN DISSIPATION	75 MAX. WATTS

TYPICAL OPERATION

Class AB_1 (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	1000	1000	1000	volts
D-C Grid Voltage (approx.)*	—115	—125	—135	volts
Zero-Signal D-C Plate Current	300	240	200	ma
Max-Signal D-C Plate Current	1.05	1.00	0.95	amps
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	60	60	64	ma
Effective Load, Plate-to-Plate	7000	10,000	14,000	ohms
Peak A-F Grid Input Voltage (per tube)	115	125	135	volts
Driving Power	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	930	950	930	watts
Max-Signal Plate Output Power	2340	3100	3840	watts

*Adjust to give stated zero-signal plate current. The D-C resistance in series with the control grid of each tube should not exceed 250,000 ohms.

TYPICAL OPERATION

Class AB_2 (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	4000	5000	6000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage (approx.)*	—60	—70	—75	volts
Zero-Signal D-C Plate Current	300	200	150	ma
Max-Signal D-C Plate Current	1.20	1.10	.95	amps
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	95	90	65	ma
Effective Load, Plate-to-Plate	7000	11,000	15,000	ohms
Peak A-F Grid Input Voltage (per tube)	140	145	130	volts
Max-Signal Peak Driving Power	11.0	11.0	9.4	watts
Max-Signal Nominal Driving Power (approx.)	5.5	5.5	4.7	watts
Max-Signal Plate Dissipation (per tube)	900	850	900	watts
Max-Signal Plate Output Power	3000	3800	3900	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 INFORMATON AND RECOMMENDATIONS

APPLICATION

MECHANICAL

Mounting—The 4-1000A must be operated vertically. The base may be down or up. The recommended socket for this tube is the SK-500 Air-System Socket.

Cooling—Adequate forced-air cooling must be provided to maintain the base seal temperatures below 150°C and the plate seal temperature below 200°C. Cooling is simplified by the use of the Eimac SK-500 Air System Socket, and its SK-506 Air Chimney, which control the flow of air around the tube.

When the Eimac SK-500 Air-System Socket is used, the following flow rates apply to sea level operation, with an ambient temperature of 25°C for the operating conditions described:

At 110 megacycles, with maximum rated plate dissipation, an air-flow rate of 35 cfm is required. The corresponding pressure drop as measured in the socket is 1.9 inches of water column.

At frequencies below 30 megacycles, an air-flow rate of 20 cfm provides adequate cooling. The corresponding pressure drop as measured in the socket is 0.6 inch of water column.

In the event that an Air-System Socket and Air Chimney are not used, air must be circulated through the base of the tube and over the envelope surface and the plate seal in sufficient quantities to maintain the temperatures below the maximum ratings. Seal-temperature ratings may require that cooling air be supplied to the tube if the filament is maintained at operating temperature during standby periods.

In any questionable situation, the only criterion for correct cooling practice is temperature. A convenient medium for measuring tube temperatures is a temperature-sensitive paint.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated voltage of 7.5 volts. Variations in filament voltage must be kept within the range of 7.13 to 7.87 volts.

Bias Voltage—The d-c bias voltage for the 4-1000A should not exceed 500 volts. With grid-leak bias, suitable means must be provided to prevent excessive plate or screen dissipation in the event of loss of excitation. The grid-resistor should be made adjustable to facilitate maintaining the bias voltage and plate current at the desired values from tube to tube. In the case of operation above 50 megacycles, it is advisable to keep the bias voltage as low as possible.

Screen Voltage—The d-c screen voltage for the 4-1000A should not exceed 1000 volts. The screen voltages shown under "Typical Operation" are representative voltages for the type of operation involved.

Plate Voltage—The plate-supply voltage for the 4-1000A should not exceed 6000 volts in CW and audio applications. In plate-modulated telephony service above 30 megacycles, the d-c plate-supply voltage should not exceed 5000 volts; however, below 30 megacycles, 5500-volts may be used.

Grid Dissipation—Grid dissipation for the 4-1000A should not be allowed to exceed 25 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 to cathode voltage
I_c = D-C grid current.

e_{cmp} may be measured by means of a suitable peak voltmeter connected between filament and grid.

Screen Dissipation—The power dissipated by the screen of the 4-1000A must not exceed 75 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 75 watts in event of circuit failure.

Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-1000A should not be allowed to exceed 1000 watts.

In plate-modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 670 watts. The plate dissipation will rise to 1000 watts under 100 per-cent sinusoidal modulation.

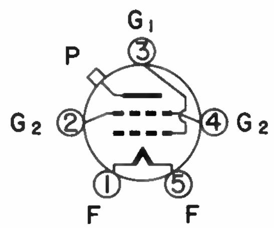
Plate dissipation in excess of the maximum rating is permissible for short periods of time, such as during tuning procedures.

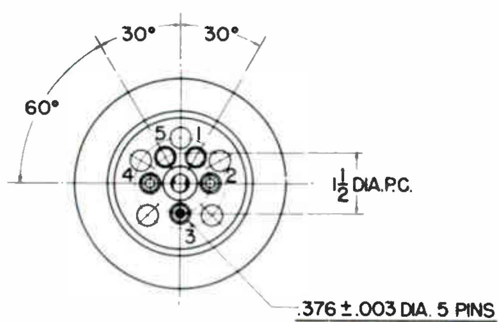
Neutralization—If reasonable precautions are taken to prevent coupling between input and output circuits, the 4-1000A may be operated up to the 10-megacycle region without neutralization. In the region between 10 megacycles and 30 megacycles, the conventional type of cross-neutralizing may be used with push-pull circuits. In single-ended circuits ordinary neutralization systems may be used which provide 180° out of phase voltage to the grid.

At frequencies above 30 megacycles the feedback is principally due to screen-lead-inductance effects. Feedback is eliminated by using series capacitance in the screen leads between the screen and ground. A variable capacitor of from 25 to 50 uufds will provide sufficient capacitance to neutralize each tube in the region of 100 megacycles. When using this method, the two screen terminals on the socket should be strapped together by the shortest possible lead. The lead from the mid-point of this screen strap to the variable capacitor and from the variable capacitor to ground should have as little inductance as possible.

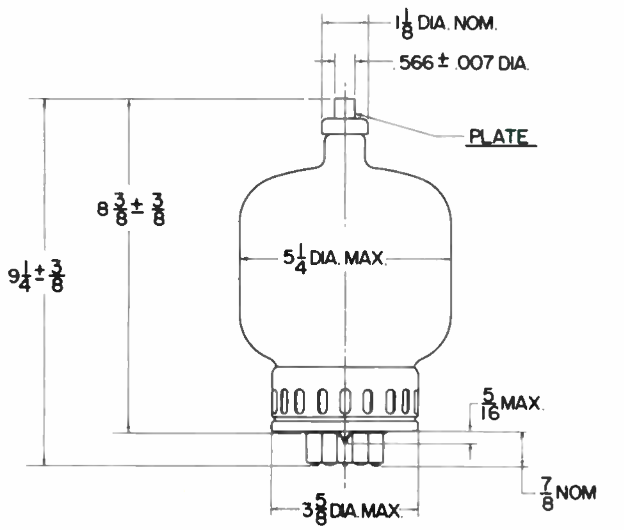
In general, plate, grid, filament, and screen-bypass or screen-neutralizing capacitors should be returned to r-f ground through the shortest possible leads.

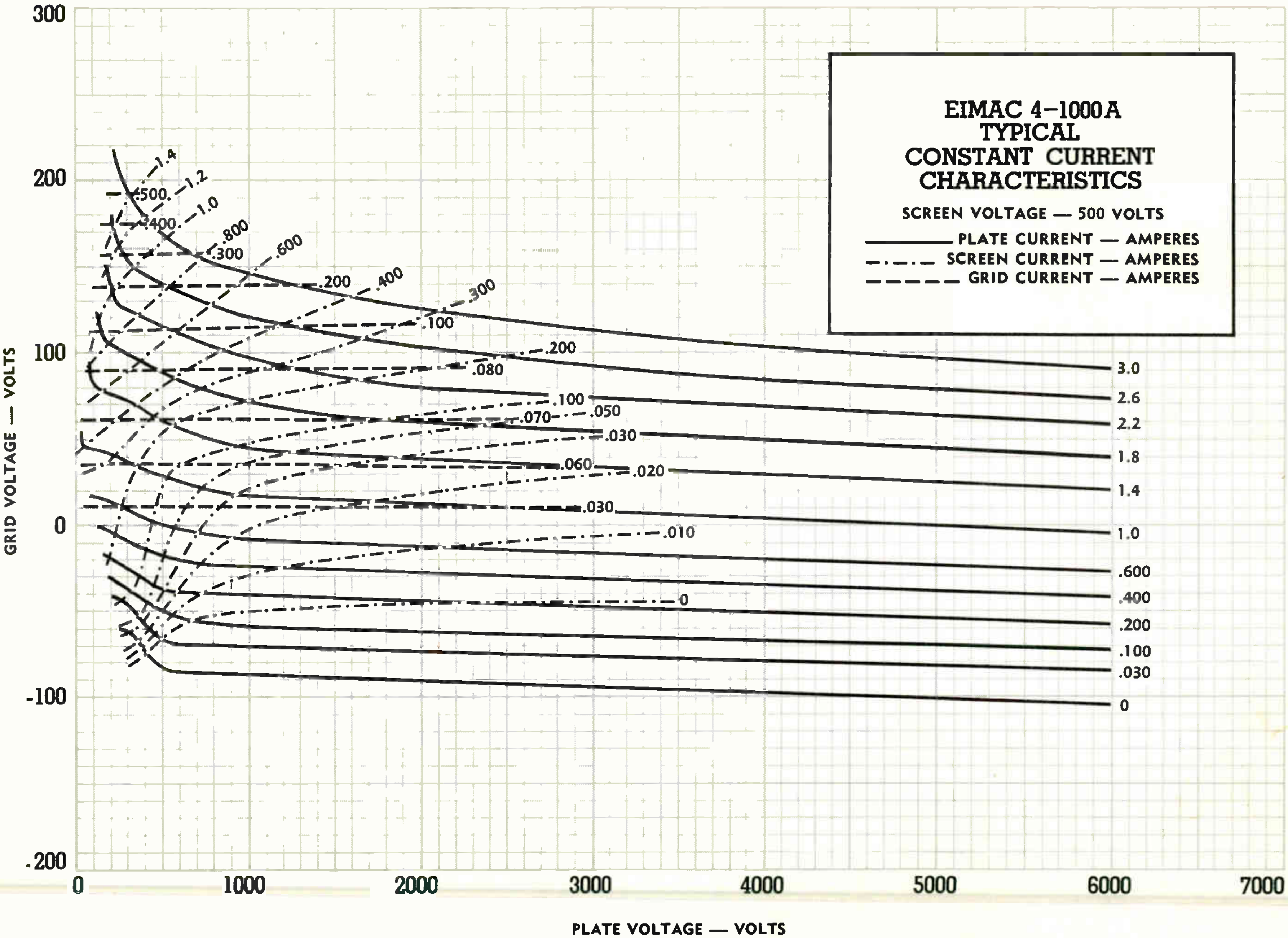
In order to take full advantage of the high power gain obtainable with the 4-1000A, care should be taken to prevent feedback from the output to input circuits. A conventional method of obtaining the necessary shielding between the grid and plate circuits is to use a suitable metal chassis with the grid circuit mounted below the deck and the plate circuit mounted above the deck. Power-supply leads entering the amplifier should be bypassed to ground and properly shielded to avoid feedback coupling in these leads. The output circuit and antenna feeders should be arranged so as to preclude any possibility of feedback into other circuits.





BOTTOM VIEW



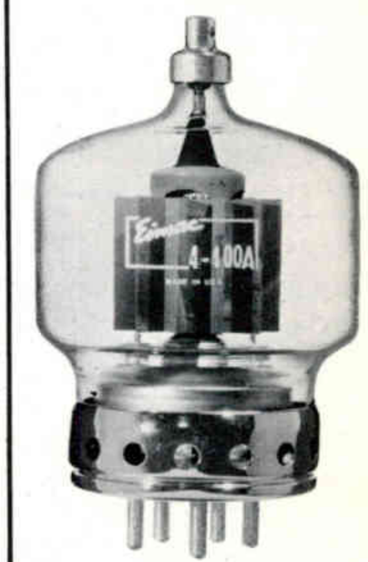

EIMAC 4-1000A
TYPICAL
CONSTANT CURRENT
CHARACTERISTICS
SCREEN VOLTAGE — 500 VOLTS
PLATE CURRENT — AMPERES
SCREEN CURRENT — AMPERES
GRID CURRENT — AMPERES
GRID VOLTAGE — VOLTS
PLATE VOLTAGE — VOLTS
300
200
100
0
-100
-200
0
1000
2000
3000
4000
5000
6000
7000
3.0
2.6
2.2
1.8
1.4
1.0
.600
.400
.200
.100
.030
0
1.4
1.2
1.0
.800
.600
.400
.300
.200
.100
.070
.050
.030
.020
.010
0
.500
.400
.300
.200
.100
.080
.060
.030

4-400A

RADIAL-BEAM POWER TETRODE

MODULATOR OSCILLATOR AMPLIFIER

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA



The Eimac 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 associated circuit and driver stage.

The 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 4-400A/4000 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 μμfd
Input	12.5 μμfd
Output	4.7 μμfd
Transconductance (I_b=100ma., E_b=2500V., E_{c2}=500V.)	4,000 μmhos
Frequency for Maximum Ratings	110 Mc.

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 4-400A/4000 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 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 Telegraphy or FM Telephony

MAXIMUM RATINGS (Key-down conditions, per tube to 110 Mc.)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
D-C PLATE CURRENT	350 MAX. MA
PLATE DISSIPATION	400 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc., one tube)

D-C Plate Voltage	2500	3000	4000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	—200	—220	—220	volts
D-C Plate Current	350	350	350	ma
D-C Screen Current	46	46	40	ma
D-C Grid Current	18	19	18	ma
Screen Dissipation	23	23	20	watts
Grid Dissipation	1.8	1.9	1.8	watts
Peak R-F Grid Input Voltage	300	320	320	volts
Driving Power*	5.4	6.1	5.8	watts
Plate Power Input	875	1050	1400	watts
Plate Dissipation	235	250	300	watts
Plate Power Output	640	800	1100	watts

*Driving Power increases as frequency is increased. At 75 Mc. the driving power required is approximately 12 watts.

TYPICAL OPERATION (110 Mc., two tubes)

D-C Plate Voltage	3500	4000	volts
D-C Screen Voltage	500	500	volts
D-C Grid Voltage	—170	—170	volts
D-C Plate Current	500	540	ma
D-C Screen Current	34	31	ma
D-C Grid Current	20	20	ma
Driving Power (approx.)	20	20	watts
Plate Power Output (approx.)	1300	1600	watts
Useful Power Output	1160	1440	watts

†Guarantee applies only when the 4-400A is used as specified with adequate air in the 4-400A/4000 Air-System Socket or equivalent.

▶ Indicates change from sheet dated 1-30-53.

PLATE MODULATED RADIO FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions unless otherwise specified. One tube)

MAXIMUM RATINGS (Frequencies below 75 Mc. Continuous Service)

D-C PLATE VOLTAGE	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	270 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 75 Mc. Continuous Service)

D-C Plate Voltage	2000	2500	3000	volts
D-C Screen Voltage	500	500	500	volts
D-C Grid Voltage	—220	—220	—220	volts
D-C Plate Current	275	275	275	ma
D-C Screen Current	30	28	26	ma
D-C Grid Current	12	12	12	ma
Screen Dissipation	15	14	13	watts
Grid Dissipation	1.1	1.1	1.1	watts
Peak A-F Screen Voltage (100% modulation)	350	350	350	volts
Peak R-F Grid Input Voltage	290	290	290	volts
Driving Power	3.5	3.5	3.5	watts
Plate Power Input	550	688	825	watts
Plate Dissipation	170	178	195	watts
Plate Power Output	380	510	630	watts

▶ **MAXIMUM RATINGS (Frequencies below 30 Mc., Intermittent Service)**

D-C Plate Voltage	4000 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	270 MAX. WATTS
Screen Dissipation	35 MAX. WATTS
Grid Dissipation	10 MAX. WATTS

TYPICAL OPERATION (Frequencies below 30 Mc., Intermittent Service)

D-C Plate Voltage	2000	2500	3000	3650	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage	—220	—220	—220	—225	volts
D-C Plate Current	275	275	275	275	ma
D-C Screen Current	30	28	26	23	ma
D-C Grid Current	12	12	12	13	ma
Screen Dissipation	15	14	13	12	watts
Grid Dissipation	1.1	1.1	1.1	1.2	watts
Peak A-F Screen Voltage (100% modulation)	350	350	350	350	volts
Peak R-F Grid Input Voltage	290	290	290	315	volts
Driving Power	3.5	3.5	3.5	4.0	watts
Plate Power Input	550	688	825	1000	watts
Plate Dissipation	170	178	195	235	watts
Plate Power Output	380	510	630	765	watts

AUDIO FREQUENCY POWER AMPLIFIER AND MODULATOR—CLASS AB

MAXIMUM RATINGS (PER TUBE)

D-C PLATE VOLTAGE	4000 MAX. VOLTS
D-C SCREEN VOLTAGE	800 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT	350 MAX. MA.
PLATE DISSIPATION	400 MAX. WATTS
SCREEN DISSIPATION	35 MAX. WATTS
GRID DISSIPATION	10 MAX. WATTS

TYPICAL OPERATION CLASS AB_1

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	2500	3000	3500	4000	volts
D-C Screen Voltage	750	750	750	750	volts
D-C Grid Voltage (approx.)*	—130	—137	—145	—150	volts
Zero-Signal D-C Plate Current	190	160	140	120	ma
Max-Signal D-C Plate Current	635	635	610	585	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	28	26	32	40	ma
Effective Load, Plate-to-Plate	6800	8900	11,500	14,500	ohms
Peak A-F Grid Input Voltage (per tube)	130	137	145	150	volts
Driving Power	0	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	370	400	400	400	watts
Max-Signal Plate Power Output	850	1110	1330	1540	watts

*Adjust to give stated zero-signal plate current. The D-C resistance in series with the control grid of each tube should not exceed 250,000 ohms.

TYPICAL OPERATION CLASS AB_2

(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	2500	3000	3500	4000	volts
D-C Screen Voltage	500	500	500	500	volts
D-C Grid Voltage (approx.)*	—75	—80	—85	—90	volts
Zero-Signal D-C Plate Current	190	160	140	120	ma
Max-Signal D-C Plate Current	700	700	700	638	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	50	40	38	32	ma
Effective Load, Plate-to-Plate	7200	9100	10,800	14,000	ohms
Peak A-F Grid Input Voltage (per tube)	133	140	145	140	volts
Max-Signal Peak Driving Power	8.6	9.0	10.2	7.0	watts
Max-Signal Nominal Driving Power	4.3	4.5	5.1	3.5	watts
Max-Signal Plate Dissipation (per tube)	320	363	400	400	watts
Max-Signal Plate Power Output	1110	1375	1650	1750	watts

*Adjust for stated zero-signal plate current.

Pulse Service—For information on Pulse Service Ratings, "Application Bulletin No. 3, Pulse Service Notes", will be furnished free on request.

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 4-400A must be mounted vertically, base up or base 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 4-400A/4000 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 4-400A/4000 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, pro-

▶ Indicates change from sheet dated 1-30-53.

vision 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, 11 West 25th Street, New York 10, 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 d-c 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 Mc., it is advisable to keep the bias voltage as low as is practicable.

Screen Voltage—The d-c screen voltage for the 4-400A should not exceed 600 volts in r-f applications. In audio applications a maximum d-c 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 d-c plate-supply voltage should not exceed 3200 volts, except below 30 Mc., 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,

$$P_g = e_{cmp} I_c$$

where P_g = Grid Dissipation
e_{cmp} = Peak positive grid to cathode 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. (For suitable peak v.t.v.m. circuits see Eimac Application Bulletin Number 6, "Vacuum Tube Ratings." This bulletin is available on request.)

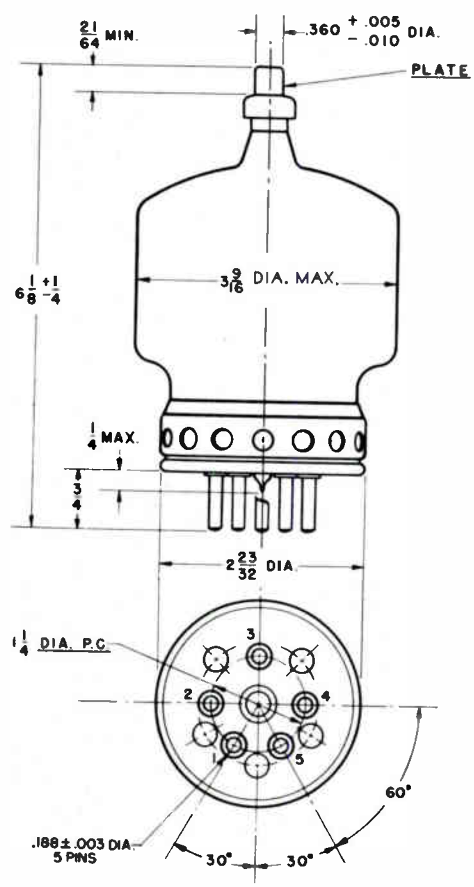
Screen Dissipation—The power dissipated by the screen of the 4-400A must not exceed 35 watts. Screen dissipation is likely to rise to excessive values when the plate voltage, bias voltage or plate load are removed with filament and screen voltages applied. Suitable protective means must be provided to limit screen dissipation to 35 watts in event of circuit failure.

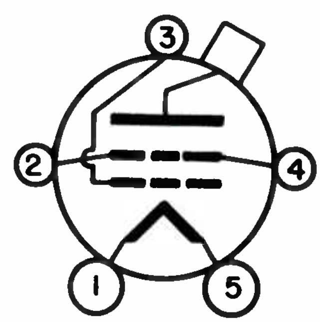
Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-400A should not be allowed to exceed 400 watts.

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.

GENERAL INFORMATION PERTAINING TO THE OPERATION OF THE 4-400A MAY BE FOUND IN APPLICATION BULLETIN NO. 8, "THE CARE AND FEEDING OF POWER TETRODES." THIS BULLETIN IS AVAILABLE UPON REQUEST.





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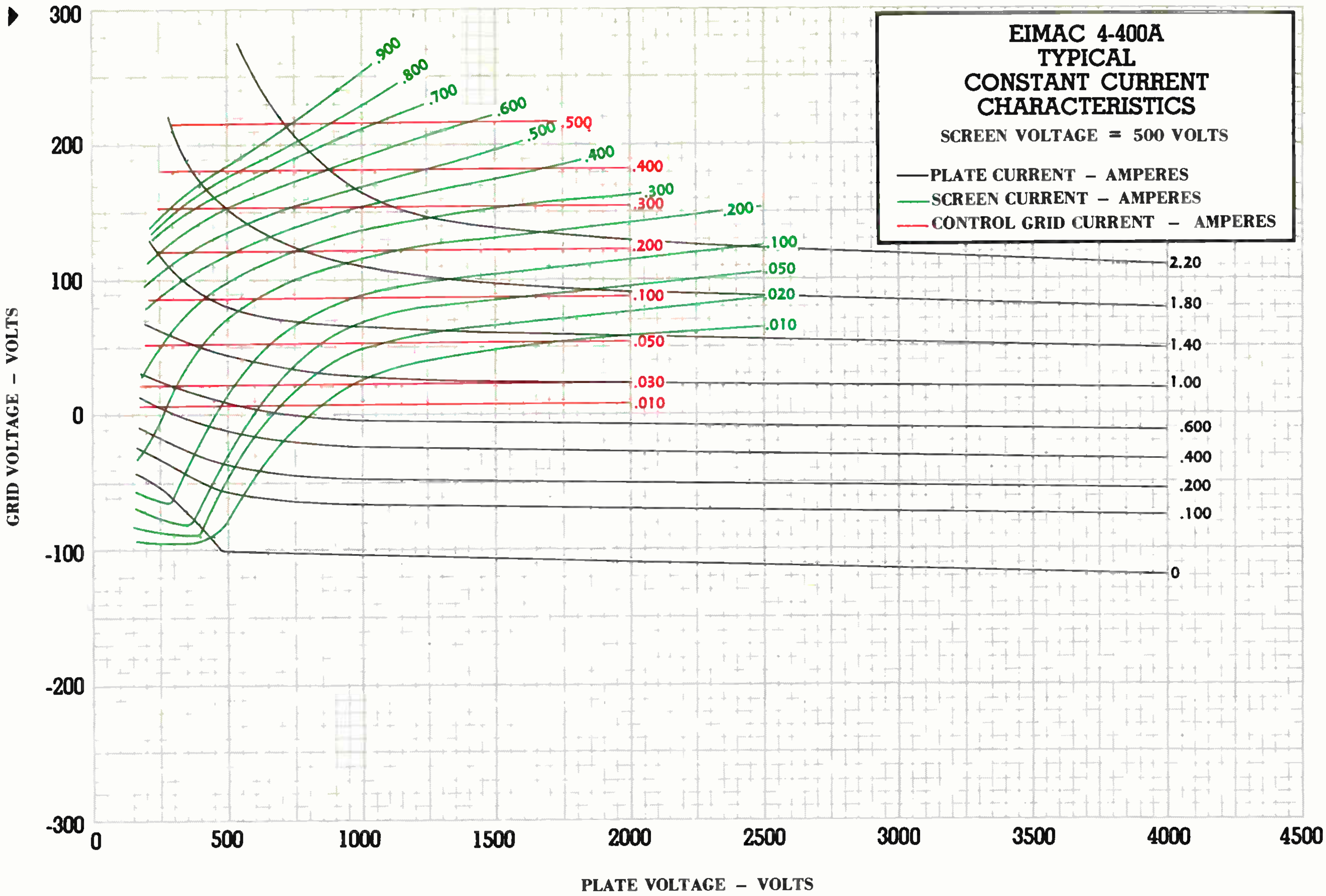


Eimac 4-400A

Printed in U. S. A. 5-C6-85008

Indicates change from sheet dated 1-30-53.

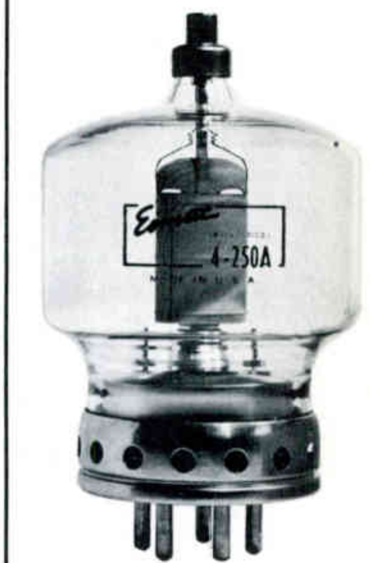
4-250A

(5D22)
RADIAL-BEAM POWER TETRODE
•
MODULATOR
OSCILLATOR
AMPLIFIER

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

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 μμf
Input	12.7 μμf
Output	4.5 μμf
Transconductance (I_b=100 ma., E_b=2500V., E_{c2}=500V.)	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.
Maximum Temperature of Base and Plate Seals — Plate Seal	170° C.
Maximum Over-all Dimensions — Length	6.38 inches
Maximum Over-all Dimensions — 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

[1]Above 110 Mc. the maximum plate voltage rating depends upon frequency. See page four.

[2]Driving power increases above 40 Mc. See page four.

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 AB_1

(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

[1]Adjust for stated zero-signal plate current.
[2]The effective grid-circuit resistance must not exceed 250,000 ohms.

TYPICAL OPERATION CLASS AB_2

(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

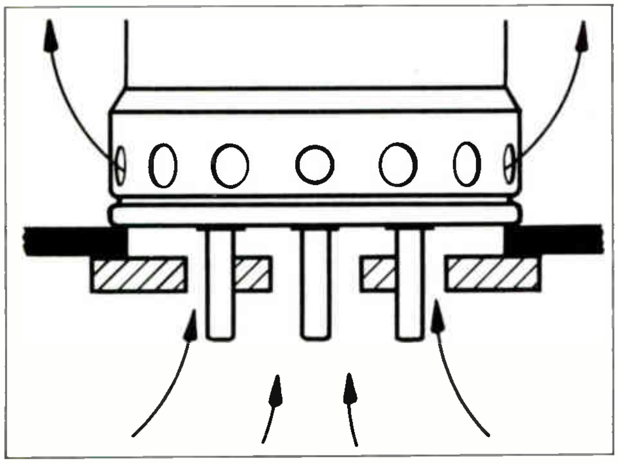
IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

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 4-400A 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 4-400A 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 [illegible]-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 grid[3].

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.

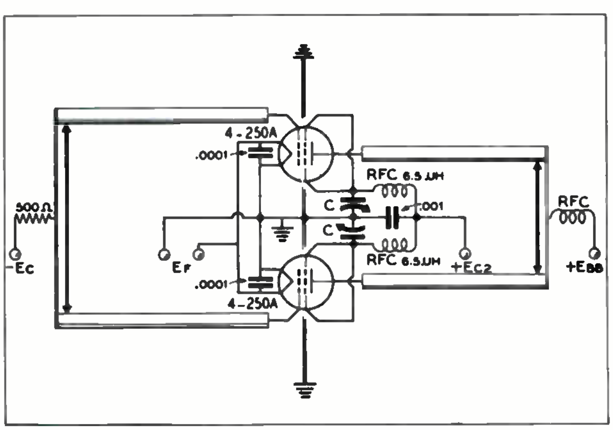
Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-250A should not be allowed to exceed 250 watts in unmodulated applications.

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 entering the amplifier in order to minimize grid-plate coupling between these leads external to the amplifier.



Screen-tuning neutralization circuit for use above 45 Mc.
C — Approximately 100µµfd. per section, maximum.

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 ¾-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-AB_1 and Class-AB_2 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-AB_1 and class-AB_2 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.

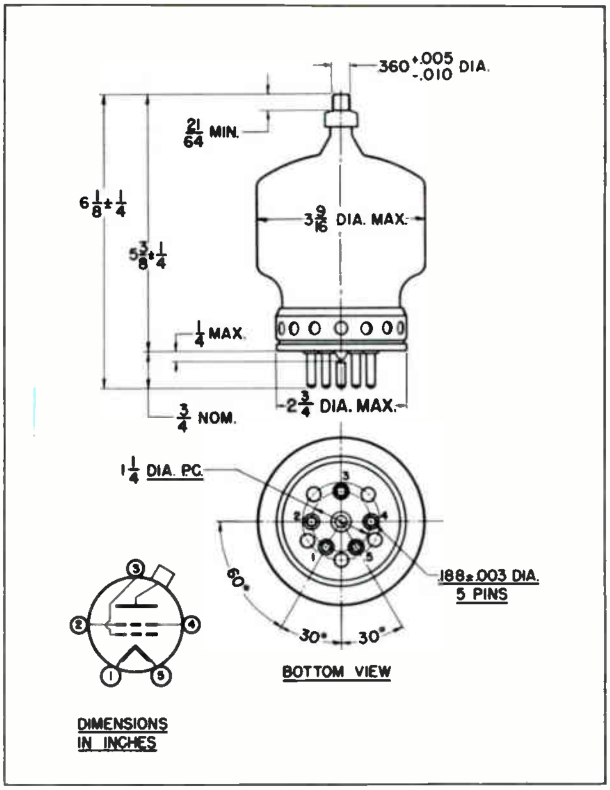
Grid bias voltage for class-AB_2 service may be obtained from batteries or from a small fixed-bias supply. When a bias supply is used the d-c resistance of the bias source should not exceed 250 ohms. Under class-AB_1 conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

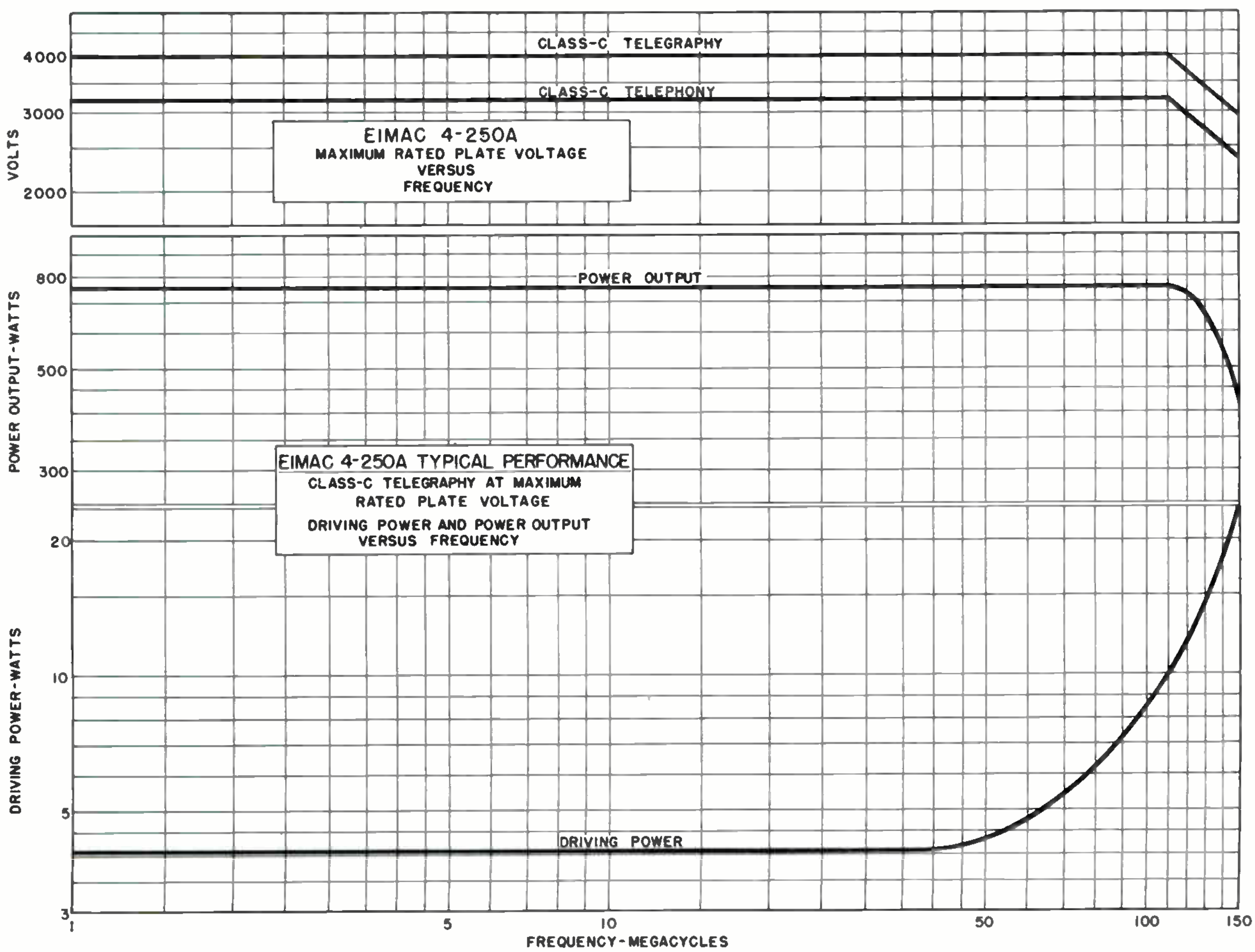
[3] For suitable peak v.t.v.m. circuits see, for instance, "Vacuum Tube Ratings," Eimac News, January, 1945. This article is available in reprint form on request.

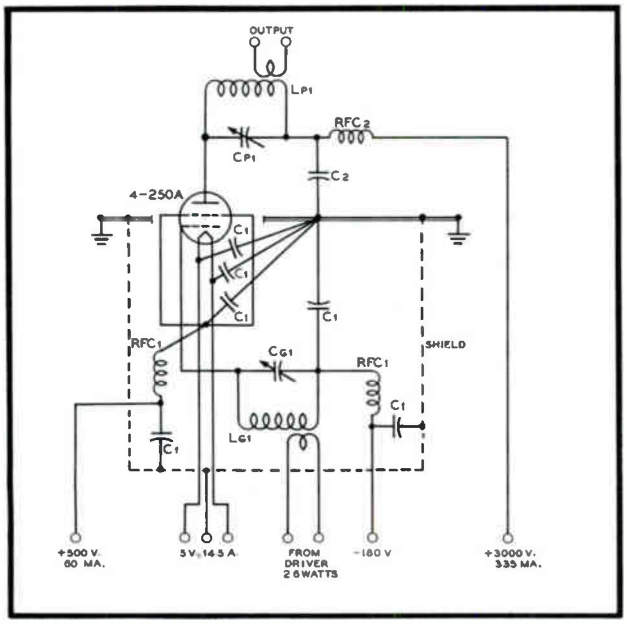
The peak driving power figures given in the class-AB_2 tabulated data are included to make possible an accurate determination of the required driver output power. The driver amplifier must be capable of supplying the peak driving power without distortion. The driver stage should, therefore, be capable 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.

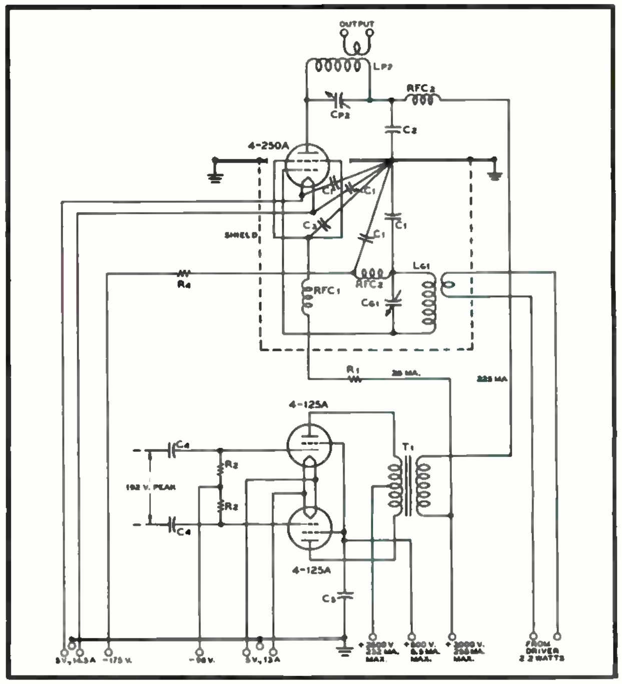
The power output figures given in the tabulated data refer to the total power output from the amplifier tubes. The useful power output will be from 5 to 15 per cent less than the figures shown, due to losses in the output transformer.



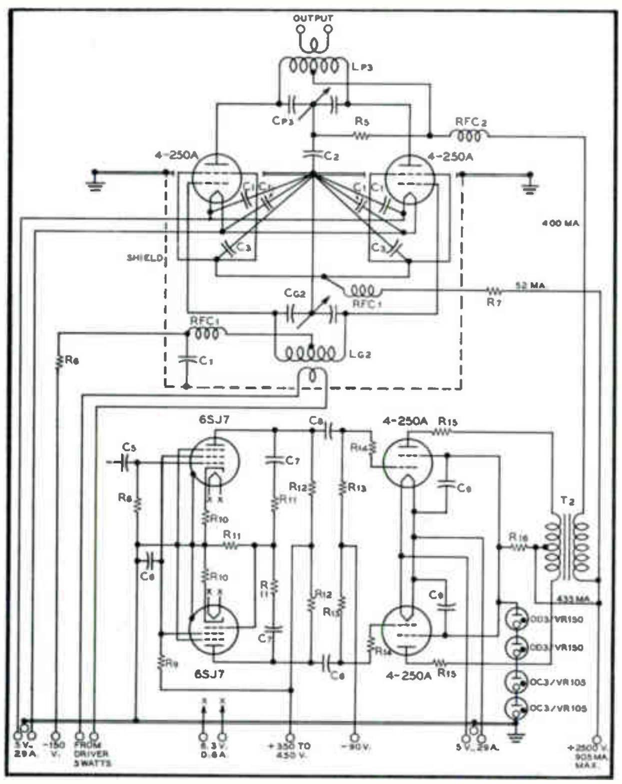




Typical radio frequency power amplifier circuit, Class-C telegraphy, 1000 watts input.



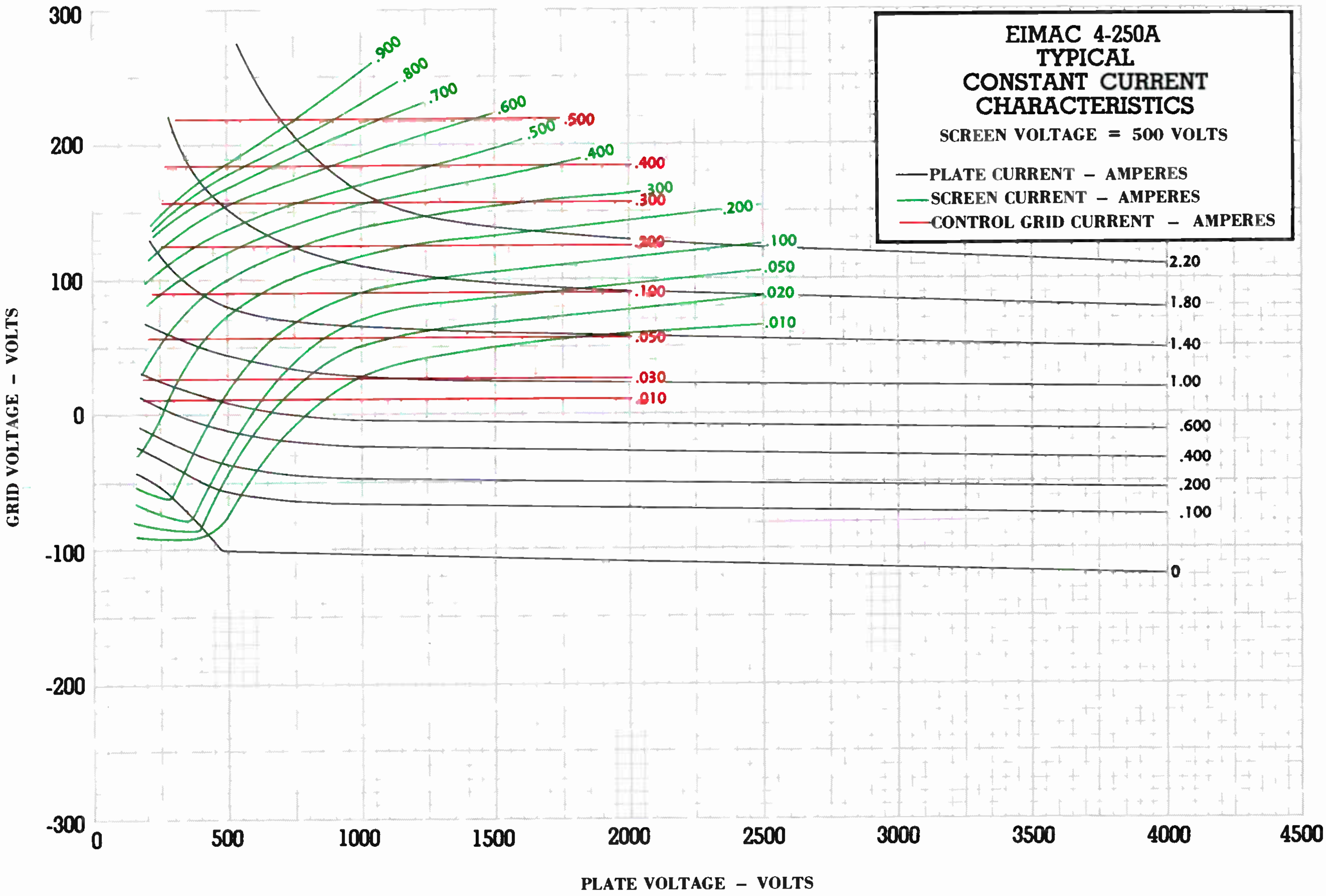
Typical high-level-modulated r-f amplifier circuit, with modulator stage, 675 watts input.



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.
C_1 — .002-ufd. 500-v. mica
C_2 — .002-ufd. 5000-v mica
C_3 — .001-ufd., 2500-v. mica
C_4 — .1-ufd., 1000-v. paper
C_5 — .1-ufd. 600-v. paper
C_6 — .5-ufd. 600-v paper
C_7 — .03-ufd., 600-v. paper
C_8 — .1-ufd., 1000-v. paper
C_9 — .25-ufd., 1000-v. paper
R_1 — 86,700 ohms, adjustable 100,000 ohms, 100 watts
R_2 — 250,000 ohms, ½ watt
R_4 — 15,000 ohms, 5 watts
R_5 — 25,000 ohms, 2 watts
R_6 — 2,500 ohms, 5 watts
R_7 — 35,000 ohms, 160 watts
R_8 — 250,000 ohms, ½ watt
R_9 — 200,000 ohms, 2 watts
R_{10} — 500 ohms, ½ watt
R_{11} — 1 megohm, ½ watt
R_{12} — 100,000 ohms, 1 watt
R_{13} — 200,000 ohms, ½ watt
R_{14} — 10,000 ohms, ½ watt
R_{15} — 50 ohms, 10 watts
R_{16} — 100,000 ohms, 100 watts
RFC_1 — 2.5-mhy., 125-ma. r-f choke
RFC_2 — 1-mhy., 500-ma. r-f choke
T_1 — 350-watt modulation transformer; ratio pri. to sec. approx. 1.5 : 1; pri. impedance 20,300 ohms, sec. impedance 13,300 ohms.
T_2 — 600-watt modulation transformer; ratio pri. to sec. approx. 1.8 : 1; pri. impedance 11,400 ohms, sec. impedance 6,250 ohms.



EIMAC 4-250A (5D22)

Printed in U.S.A. 11-88561

4X150A

RADIAL-BEAM POWER TETRODE

EITEL-McCULLOUGH, INC.

SAN BRUNO, CALIFORNIA

These Data apply to type 4X150D which is identical to 4X150A except for the heater rating of 26.5 volts 0.57 ampere.

The Eimac 4X150A is a compact power tetrode intended for use as an amplifier, oscillator or frequency multiplier over a wide range of frequencies extending into the UHF region. It is cooled by forced air.

A single 4X150A operating in a coaxial-cavity amplifier circuit will deliver up to 140 watts of useful power output at 500 megacycles.

The maximum rated plate voltage for the 4X150A is 1250 volts, and the tube is capable of good performance with plate voltages as low as 400 volts. Its high ratio of transconductance to capacitance and its 150-watt plate dissipation rating make the 4X150A useful for wide-band amplifier applications.

The use of the Eimac 4X150A Air-System Socket, or a socket providing equivalent air-cooling facilities, is required.

GENERAL CHARACTERISTICS

ELECTRICAL

Cathode: Oxide Coated, Unipotential

Minimum Heating Time	30	seconds
Cathode-to-Heater Voltage	150	max. volts
Heater: Voltage	6.0	volts
Current	2.6	amperes
Grid-Screen Amplification Factor (Average)	5	
Direct Interelectrode Capacitances (Average)		
Grid-Plate	0.03	μμf
Input	15.5	μμf
Output	4.5	μμf
Transconductance (E_b=500v., E_{c2}=250v., I_b=200 ma)	12,000	μmhos
Frequency for Maximum Ratings	500	Mc

MECHANICAL

Base	9-pin, special
Recommended Socket	Eimac 4X150A Air-System Socket
Base Connections	See outline drawing
Mounting	Any position
Cooling	Forced air
Maximum Over-all Dimensions	
Length	2.47 inches
Diameter	1.65 inches
Seated Height	1.91 inches
Net Weight	5.2 ounces
Shipping Weight	1.6 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 OR OSCILLATOR

Class-C Telegraphy or FM Telephony (Key-down conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	1250	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	150	MAX. WATTS
SCREEN DISSIPATION	12	MAX. WATTS
GRID DISSIPATION	2	MAX. WATTS

TYPICAL OPERATION (Frequencies up to 165 Mc., per tube)

D-C Plate Voltage	600	750	1000	1250	volts
D-C Screen Voltage	250	250	250	250	volts
D-C Grid Voltage	—75	—80	—80	—90	volts
D-C Plate Current	200	200	200	200	ma
D-C Screen Current	37	37	30	20	ma
D-C Grid Current	10	10	10	10	ma
▶ Peak R-F Grid Voltage (approx.)	90	95	95	105	volts
Driving Power	0.7	0.7	0.7	0.8	watts
Plate Power Input	120	150	200	250	watts
Plate Power Output	85	110	150	195	watts

The performance figures for frequencies up to 165 Mc. are obtained by calculation from the tube characteristic curves and confirmed by direct tests. The driving power includes only 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.

▶ TYPICAL OPERATION (Single tube, 500-Mc., coaxial cavity)

D-C Plate Voltage	600	800	1000	1250	volts
D-C Screen Voltage	250	250	250	250	volts
D-C Grid Voltage	—80	—80	—80	—80	volts
D-C Plate Current	200	200	200	200	ma
D-C Screen Current	7	7	7	7	ma
D-C Grid Current	10	10	10	10	ma
Driver Output Power (approx.)	10	10	10	10	watts
Power Input	120	160	200	250	watts
Useful Power Output	65	90	110	140	watts

These typical performance figures were obtained by direct measurement in operating equipment. The output power is useful power measured in a load circuit. The driving power is the total power taken by the tube and a practical resonant circuit. In many cases with further refinement and improved techniques better performance might be obtained.

▶ Indicates change from sheet dated 8-15-52

PLATE-MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony (Carrier conditions, per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	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	100	MAX. WATTS
SCREEN DISSIPATION	12	MAX. WATTS
GRID DISSIPATION	2	MAX. WATTS

TYPICAL OPERATION (Frequencies up to 165 Mc.)

D-C Plate Voltage	400	600	800	1000	volts
D-C Screen Voltage	250	250	250	250	volts
D-C Grid Voltage	–90	–95	–100	–105	volts
D-C Plate Current	200	200	200	200	ma
D-C Screen Current	40	35	25	20	ma
D-C Grid Current	7	8	10	15	ma
Peak A-F Screen Voltage at crest of 100% Modulation	140	150	160	170	volts
Peak R-F Grid Input Voltage (approx.)	110	120	120	125	volts
Driving Power (approx.)	1	1	1.5	2	watts
Plate Dissipation	25	40	60	60	watts
Plate Power Input	80	120	160	200	watts
Plate Power Output	55	80	100	140	watts

RADIO-FREQUENCY POWER AMPLIFIER

Class-B Linear, Television Visual Service (per tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE	1250	MAX. VOLTS
D-C SCREEN VOLTAGE	400	MAX. VOLTS
D-C GRID VOLTAGE	–250	MAX. VOLTS
D-C PLATE CURRENT (AVERAGE)	250	MAX. MA
PLATE DISSIPATION	150	MAX. WATTS
SCREEN DISSIPATION	12	MAX. WATTS
GRID DISSIPATION	2	MAX. WATTS

TYPICAL OPERATION (Frequencies up to 216 Mc., 5 Mc. bandwidth)

D-C Plate Voltage	750	1000	1250	volts
D-C Screen Voltage	300	300	300	volts
D-C Grid Voltage	–60	–65	–70	volts
During Sync-Pulse Peak:				
D-C Plate Current	335	330	305	ma
D-C Screen Current	50	45	45	ma
D-C Grid Current	15	20	25	ma
Peak R-F Grid Voltage	85	95	100	volts
R-F Driver Power (approx.)	7	8	9	watts
Useful Power Output	135	200	250	watts
Black Level:				
D-C Plate Current	245	240	230	ma
D-C Screen Current	20	15	10	ma
D-C Grid Current	4	4	4	ma
Peak R-F Grid Voltage (approx.)	65	70	75	volts
R-F Driver Power (approx.)	4.25	4.7	5.5	watts
Plate Power Input	185	240	290	watts
Useful Power Output	75	110	140	watts

CLASS-AB OR -B POWER AMPLIFIER OR MODULATOR

MAXIMUM RATINGS (Per tube)

D-C PLATE VOLTAGE	1250	MAX. VOLTS
D-C SCREEN VOLTAGE	400	MAX. VOLTS
D-C PLATE CURRENT	250	MAX. MA
PLATE DISSIPATION	150	MAX. WATTS
SCREEN DISSIPATION	12	MAX. WATTS
GRID DISSIPATION	2	MAX. WATTS

TYPICAL OPERATION

Class AB (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	600	800	1000	1250	volts
D-C Screen Voltage	300	300	300	300	volts
D-C Grid Voltage (approx.)*	–44	–47	–47	–48	volts
Zero-Signal D-C Plate Current	160	120	120	115	ma
Max-Signal D-C Plate Current	380	380	380	390	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	65	65	60	40	ma
Effective Load, Plate-to-Plate	3550	4625	5850	7200	ohms
Peak A-F Grid Input Voltage (per tube)	44	47	47	48	volts
Driving Power	0	0	0	0	watts
Max-Signal Plate Dissipation (per tube)	45	55	70	90	watts
Max-Signal Plate Power Output	140	195	240	310	watts

*Adjust grid voltage to obtain specified zero-signal plate current. Maximum permissible grid circuit series resistance 100,000 ohms per tube.

TYPICAL OPERATION

Class AB_2 (Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	600	800	1000	1250	volts
D-C Screen Voltage	300	300	300	300	volts
D-C Grid Voltage**	–41	–43	–43	–44	volts
Zero-Signal D-C Plate Current	185	160	165	180	ma
Max-Signal D-C Plate Current	485	490	495	475	ma
Zero-Signal D-C Screen Current	0	0	0	0	ma
Max-Signal D-C Screen Current	85	75	70	65	ma
Effective Load, Plate-to-Plate	2600	3500	4600	5600	ohms
Peak A-F Grid Input Voltage (per tube)	47	48	49	50	volts
Max-Signal Peak Driving Power	0.15	0.15	0.15	0.15	watts
Max-Signal Nominal Driving Power (approx.)	75	75	75	75	mw
Max-Signal Plate Dissipation (per tube)	60	75	90	85	watts
Max-Signal Plate Power Output	170	240	315	425	watts

**Adjust grid voltage to obtain specified zero-signal plate current.

APPLICATION

MECHANICAL

Mounting—The 4X150A may be mounted in any position. Use of the Eimac 4X150A Air-System Socket, or its equivalent, is required.

The tube will fit a standard "loktal" socket, but the use of such a socket prevents adequate air-cooling of the base of the tube. Use of the "loktal" socket is not recommended.

Connections to the terminals of all the electrodes except the plate are provided by the Air-System Socket. The anode-cooler assembly provides a terminal surface for the plate connection. For high-frequency applications a metal band or a spring-finger collet should be used to make good electrical contact with the cylindrical outer surface of the anode cooler. Points of electrical contact should be kept clean and free of oxidation to minimize r-f losses.

Cooling—The 4X150A requires sufficient forced-air cooling to keep the cooler core and the metal parts of the metal-to-glass seals from exceeding a maximum temperature of 150°C. The air flow must be started when power is applied to the heater, and must continue without interruption until all electrode voltages have been removed from the tube.

The Eimac Air-System Socket directs the air over the surfaces of the tube base, and through the anode cooler to provide effective cooling with a minimum air flow. Seven and one-half cubic feet of cooling air per minute must flow through the Air-System Socket and the anode cooler for adequate cooling. This corresponds to a total pressure drop of 0.6 inches of water through the socket and the anode cooler.

The air requirements stated above are based on operation at sea level and an ambient temperature of 20°C. Operation at high altitude or at high ambient temperatures requires a greater volume of air flow. The necessary design information for such conditions is contained in an article entitled "Blower Selection for Forced-Air-Cooled Tubes", by A. G. Nekut, in the August, 1950, issue of "Electronics."

One method of measuring temperature is provided by the use of the "Tempilaq", a temperature-sensitive lacquer, which melts when a given temperature is reached. Where forced-air cooling is employed, very thin applications of the lacquer must be used. This product is obtainable from the Tempil Corporation, 132 West 22nd St., New York 11, N. Y.

ELECTRICAL

Heater—The heater should be operated as close to 6.0 volts as possible, but it will withstand heater-voltage variations as great as 10% without injury. Some variation in power output must be expected to occur with variations of the heater voltage.

Cathode—The cathode is internally connected to the four even-numbered base pins. All four corresponding socket terminals should be used for connection to the external circuit. The leads should be of large cross-section and as short and direct as possible to minimize cathode-lead inductance.

Grid Dissipation—Grid-circuit driving-power requirements increase with increasing frequency because of circuit losses other than grid dissipation. This becomes noticeable at frequencies near 30 Mc., and increases until at 500 Mc. as much as 30 watts driving power may be required in ordinary circuits.

Despite the increased driving power required by the circuit as a whole at higher frequencies, the power actually consumed by the tube grid does not increase greatly. Satisfactory operation in stable amplifier circuits is indicated by d-c grid-current values below approximately 15 milliamperes.

Screen Dissipation—Bias- or plate-supply failure or unloaded-plate-circuit operation can cause the screen current and dissipation to rise to excessive values. Protection for the screen can be provided by an overload relay in the screen circuit, in addition to the usual plate-overload relay. Use of a screen-current milliammeter is advisable.

Plate Dissipation—The maximum-rated plate dissipation is 150 watts. The maximum-rated plate dissipation for plate-modulated applications is 100 watts under carrier conditions, which permits the plate dissipation to rise to 150 watts under 100% sinusoidal modulation.

Plate dissipation may be permitted to exceed the maximum rating momentarily, as, for instance, during tuning.

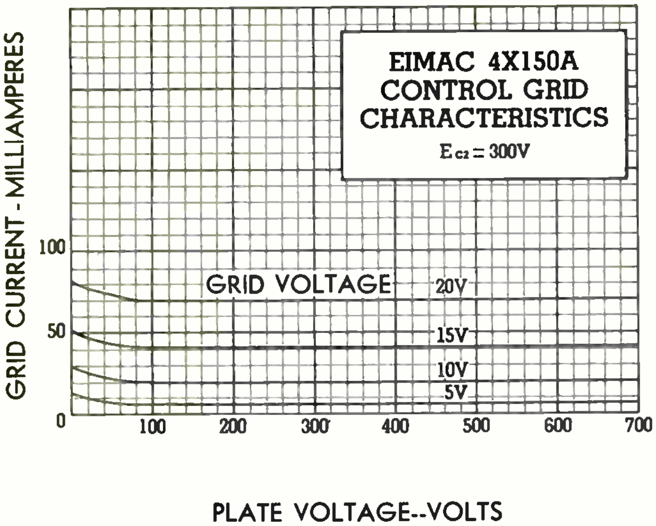
UHF Operation—Transit time effects, which occur at ultra-high frequencies in the 4X150A, can be minimized by adherence to the operating conditions suggested below:

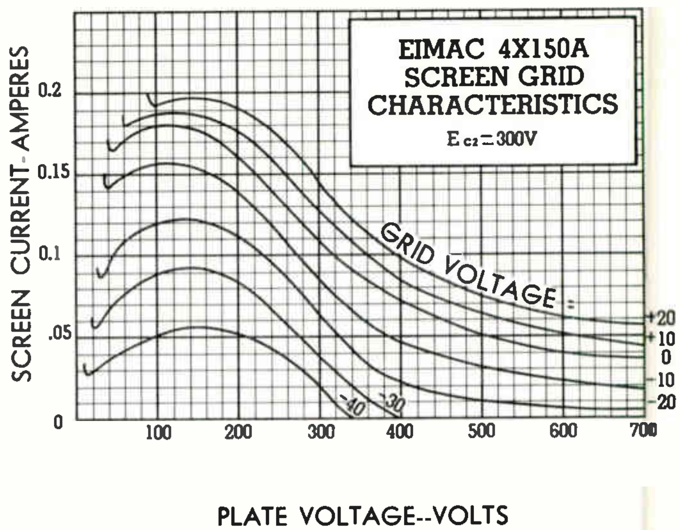
1. Use a minimum d-c bias voltage, not over twice cut-off.
2. Apply only enough drive to obtain satisfactory plate efficiency.
3. Operate the screen at reasonably high voltage, but do not exceed the screen-dissipation rating. The circuit should be loaded to obtain screen-current values close to those given under "Typical Operation" at 500 Mc.
4. Fairly heavy plate loading is required. In general, low-voltage, high-current operation is preferable to operation at high voltage and low current. If conditions require a change to lighter plate loading, the drive should also be reduced to the minimum value for satisfactory operation at the new output level.
5. Parasitic oscillations are usually associated with excessive grid and screen current and are injurious to vacuum tubes. Similarly, tuned-plate circuits which accidentally become simultaneously resonant to harmonics and the fundamental frequency may also cause low efficiency and damage tubes.

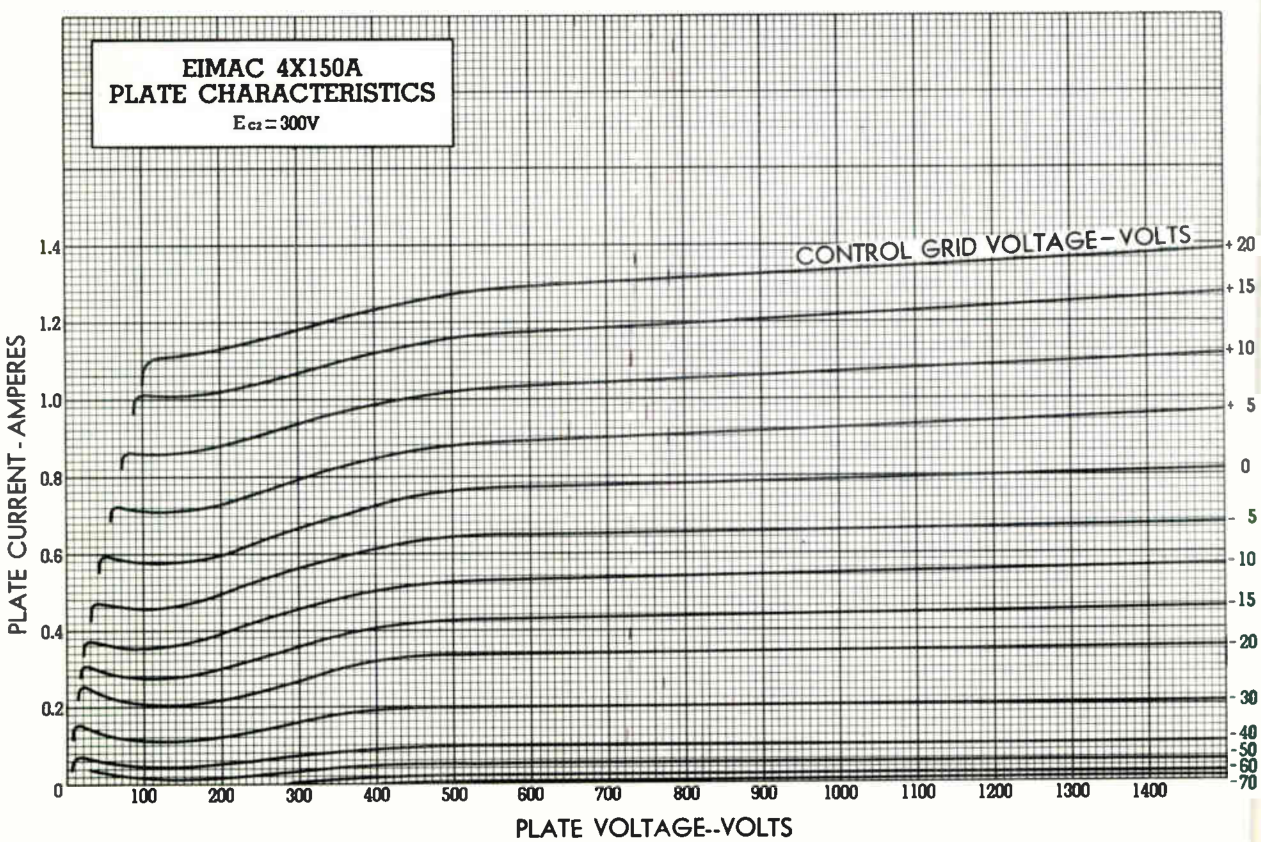
Plate Modulation—Plate modulation can be applied to the 4X150A when it is operated as a class-C radio-frequency amplifier. To obtain 100% modulation, the d-c screen voltage must be modulated approximately 55%, in phase with the plate modulation. Self-modulation of the screen by means of a series resistor or reactor may not be satisfactory in this particular tetrode due to the screen-voltage, screen-current characteristics.

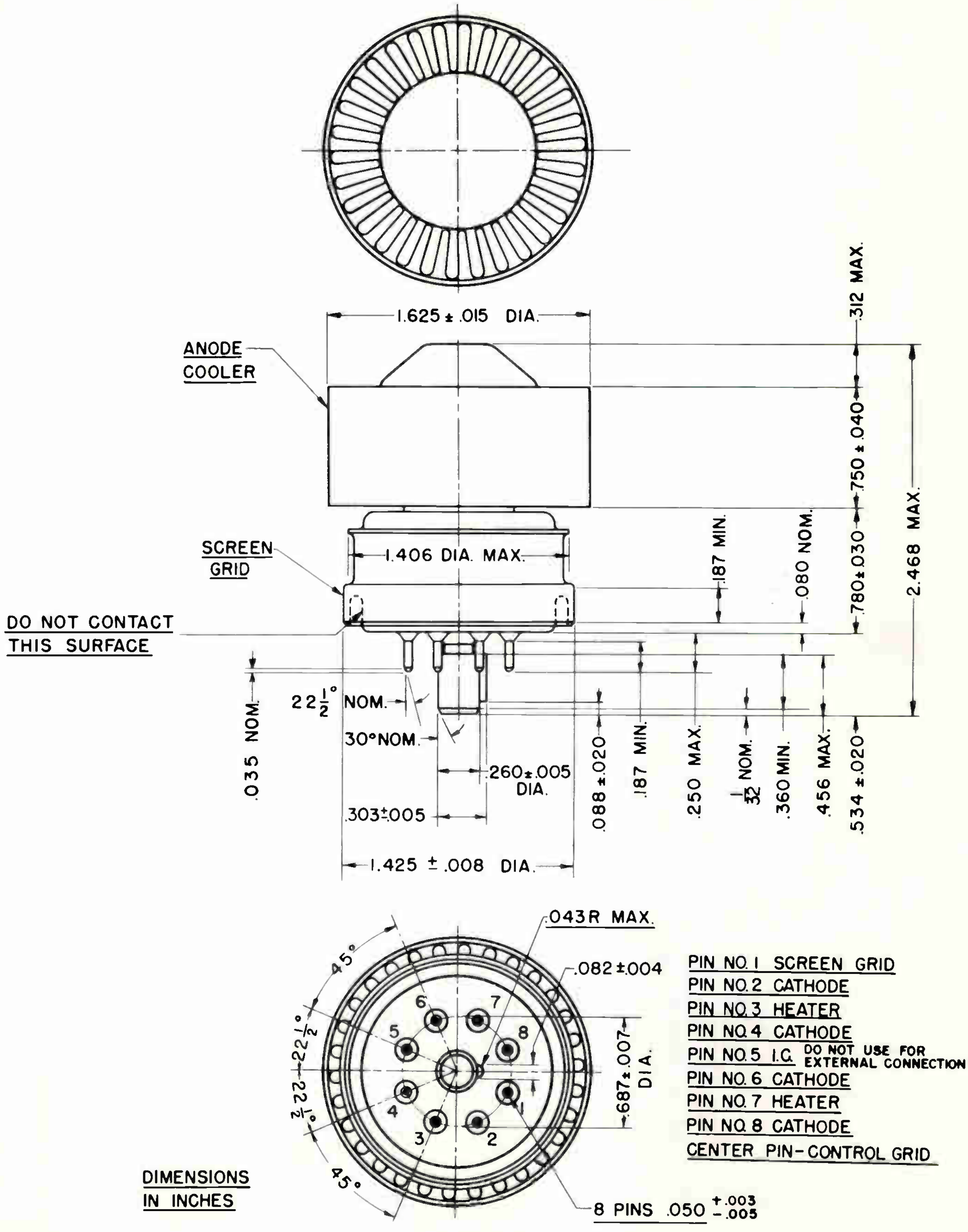
Grid Resistance—In class-A and -AB_1 amplifiers, where no grid current flows, the grid-bias voltage may be applied through a resistor. The maximum permissible series resistance per tube is 100,000 ohms.

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

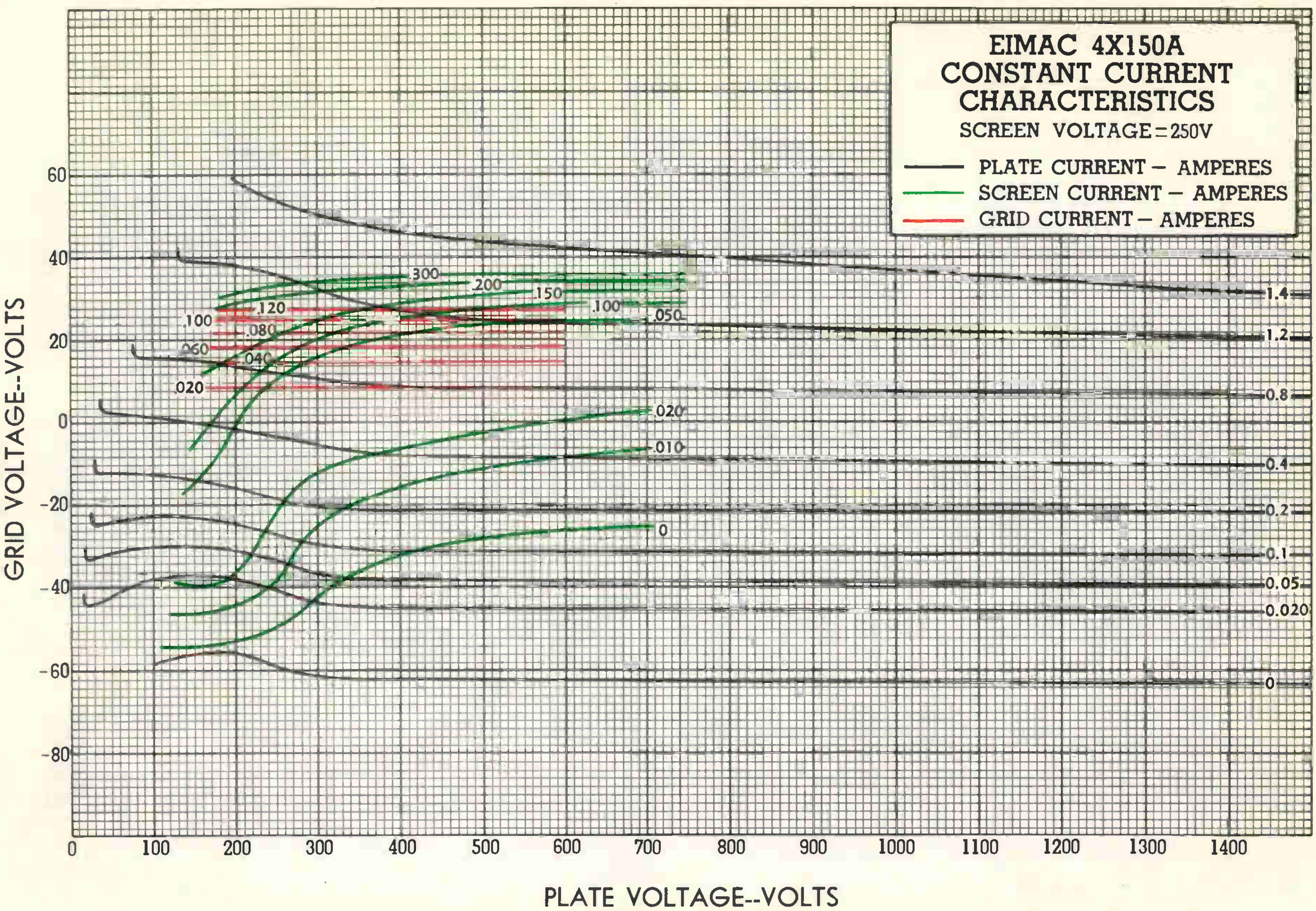

EIMAC 4X150A
CONTROL GRID
CHARACTERISTICS
Ec2 = 300V
GRID CURRENT - MILLIAMPERES
GRID VOLTAGE
20V
15V
10V
5V
0
50
100
100
200
300
400
500
600
700
PLATE VOLTAGE--VOLTS


EIMAC 4X150A
SCREEN GRID
CHARACTERISTICS
Ec2 = 300V
SCREEN CURRENT - AMPERES
0.2
0.15
0.1
.05
0
GRID VOLTAGE =
+20
+10
0
-10
-20
-30
-40
100
200
300
400
500
600
700
PLATE VOLTAGE--VOLTS


EIMAC 4X150A
PLATE CHARACTERISTICS
Ec2 = 300V
PLATE CURRENT - AMPERES
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
CONTROL GRID VOLTAGE - VOLTS
+20
+15
+10
+ 5
0
- 5
-10
-15
-20
-30
-40
-50
-60
-70
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
PLATE VOLTAGE--VOLTS


1.625 ± .015 DIA.
ANODE COOLER
.312 MAX.
.750 ± .040
2.468 MAX.
.780±.030
SCREEN GRID
1.406 DIA. MAX.
.187 MIN.
.080 NOM.
DO NOT CONTACT THIS SURFACE
.035 NOM.
22½° NOM.
30°NOM.
.260±.005 DIA.
.303±.005
.088 ±.020
.187 MIN.
.250 MAX.
1/32 NOM.
.360 MIN.
.456 MAX.
.534 ±.020
1.425 ± .008 DIA.
.043R MAX.
.082 ±.004
45°
22½°
22½°
45°
.687±.007 DIA.
8 PINS .050 +.003 -.005
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
DIMENSIONS IN INCHES

BOTTOM VIEW



4X150A

Printed in U.S.A. 4-A1-88483

EITEL-McCULLOUGH, INC.
SAN BRUNO, CALIFORNIA

4-125A

(4D21)
RADIAL-BEAM POWER TETRODE

•

MODULATOR
OSCILLATOR
AMPLIFIER

The Eimac 4-125A is a radial-beam power tetrode intended for use as an amplifier, oscillator, or modulator. It has a maximum plate-dissipation rating of 125 watts and a maximum plate-voltage rating of 3000 volts at frequencies up to 120 Mc.

The low grid-plate capacitance of this tetrode together with its low driving-power requirement allows considerable simplification of the associated circuit and driver stage.

Cooling is by radiation from the plate and by air circulation through the base and around the envelope.

The 4-125A in class-C r-f service will deliver up to 375 watts plate power output with 2.5 watts driving power. Two 4-125A's in class-B modulator service will deliver up to 400 watts maximum-signal power output with 1.2 watts nominal driving power.

GENERAL CHARACTERISTICS

ELECTRICAL

Filament: Thoriated Tungsten	
Voltage	5.0 volts
Current	6.5 amperes
Grid-Screen Amplification Factor (Average)	5.9
Direct Interelectrode Capacitances (Average)	
Grid-Plate	0.05 $\mu\mu$fd
Input	10.8 $\mu\mu$fd
Output	3.1 $\mu\mu$fd
Transconductance (I_b=50 ma., E_b=2500V., E_{c2}=400V.)	2450 μmhos
Highest Frequency for Maximum Ratings	120 Mc

MECHANICAL

Base	5-pin metal shell
Basing	See outline drawing
Socket	E. F. Johnson Co. socket No. 122-275, National Co. No. HX-100, or equivalent
Mounting Position	Vertical, base down or up
Cooling	Radiation and forced air
Recommended Heat-Dissipating Plate Connector	Eimac HR-6
▶ Maximum Over-all Dimensions:	
Length	5.69 inches
Diameter	2.81 inches
Net Weight	6.5 ounces
Shipping Weight	1.5 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.

▶ Indicates change from sheet dated 1-5-53

RADIO-FREQUENCY POWER AMPLIFIER AND OSCILLATOR

Class-C Telegraphy or FM Telephony
(Key-down conditions, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE[1]	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	225 MAX. MA
PLATE DISSIPATION	125 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION
(Frequencies below 120 Mc.)

D-C Plate Voltage	2000	2500	3000	volts
D-C Screen Voltage	350	350	350	volts
D-C Grid Voltage	—100	—150	—150	volts
D-C Plate Current	200	200	167	ma
D-C Screen Current	50	40	30	ma
D-C Grid Current	12	12	9	ma
Screen Dissipation	18	14	10.5	watts
Grid Dissipation	1.6	2	1.2	watts
Peak R-F Grid Input Voltage (approx.)	230	320	280	volts
Driving Power (approx.)[3]	2.8	3.8	2.5	watts
Plate Power Input	400	500	500	watts
Plate Dissipation	125	125	125	watts
Plate Power Output	275	375	375	watts

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB$_1$

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	600 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT, PER TUBE	225 MAX. MA
PLATE DISSIPATION, PER TUBE	125 MAX. WATTS
SCREEN DISSIPATION, PER TUBE	20 MAX. WATTS

TYPICAL OPERATION
(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	1500	2000	2500	volts
D-C Screen Voltage	600	600	600	volts
D-C Grid Voltage[2]	—90	—94	—96	volts
Zero-Signal D-C Plate Current	60	50	50	ma
Max-Signal D-C Plate Current	222	240	232	ma
Zero-Signal D-C Screen Current	—1.0	—0.5	—0.3	ma
Max-Signal D-C Screen Current	17	6.4	8.5	ma
Effective Load, Plate-to-Plate	10,200	13,400	20,300	ohms
Peak, A-F Grid Input Voltage (per tube)	90	94	96	volts
Driving Power	0	0	0	watt
Max-Signal Plate Dissipation (per tube)	87.5	125	125	watts
Max-Signal Plate Power Output	158	230	330	watts
Total Harmonic Distortion	5	2	2.6	per ct.

HIGH-LEVEL MODULATED RADIO-FREQUENCY AMPLIFIER

Class-C Telephony
(Carrier conditions unless otherwise specified, 1 tube)

MAXIMUM RATINGS

D-C PLATE VOLTAGE[1]	2500 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
D-C GRID VOLTAGE	—500 MAX. VOLTS
D-C PLATE CURRENT	200 MAX. MA
PLATE DISSIPATION	85 MAX. WATTS
SCREEN DISSIPATION	20 MAX. WATTS
GRID DISSIPATION	5 MAX. WATTS

TYPICAL OPERATION
(Frequencies below 120 Mc.)

D-C Plate Voltage	2000	2500	volts
D-C Screen Voltage	350	350	volts
D-C Grid Voltage	—220	—210	volts
D-C Plate Current	150	152	ma
D-C Screen Current	33	30	ma
D-C Grid Current	10	9	ma
Screen Dissipation	11.5	10.5	watts
Grid Dissipation	1.6	1.4	watts
Peak A-F Screen Voltage, 100% Modulation	210	210	volts
Peak R-F Grid Input Voltage (approx.)	375	360	volts
Driving Power (approx.)[3]	3.8	3.3	watts
Plate Power Input	300	380	watts
Plate Dissipation	75	80	watts
Plate Power Output	225	300	watts

AUDIO-FREQUENCY POWER AMPLIFIER AND MODULATOR

Class-AB$_2$

MAXIMUM RATINGS

D-C PLATE VOLTAGE	3000 MAX. VOLTS
D-C SCREEN VOLTAGE	400 MAX. VOLTS
MAX-SIGNAL D-C PLATE CURRENT, PER TUBE	225 MAX. MA
PLATE DISSIPATION, PER TUBE	125 MAX. WATTS
SCREEN DISSIPATION, PER TUBE	20 MAX. WATTS

TYPICAL OPERATION
(Sinusoidal wave, two tubes unless otherwise specified)

D-C Plate Voltage	1500	2000	2500	volts
D-C Screen Voltage	350	350	350	volts
D-C Grid Voltage	—41	—45	—43	volts
Zero-Signal D-C Plate Current	87	72	93	ma
Max-Signal D-C Plate Current	400	300	260	ma
Zero-Signal D-C Screen Current	0	0	0	ma
Max-Signal D-C Screen Current	34	5	6	ma
Effective Load, Plate-to-Plate	7200	13,600	22,200	ohms
Peak A-F Grid Input Voltage (per tube)	141	105	89	volts
Max-Signal Avg. Driving Power (approx.)	2.5	1.4	1	watts
Max-Signal Peak Driving Power	5.2	3.1	2.4	watts
Max-Signal Plate Dissipation (per tube)	125	125	122	watts
Max-Signal Plate Power Output	350	350	400	watts
Total Harmonic Distortion	2.5	1	2.2	per ct.

[1] Above 120 Mc. the maximum plate voltage rating depends upon frequency. See page 4.

[2] The effective grid circuit resistance for each tube must not exceed 250,000 ohms.

[3] Driving power increases above 70 Mc. See page 4.

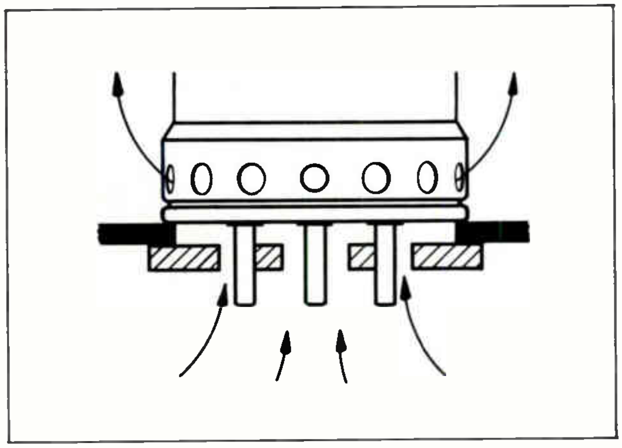
IF IT IS DESIRED TO OPERATE THIS TUBE UNDER CONDITIONS WIDELY DIFFERENT FROM THOSE GIVEN UNDER "TYPICAL OPERATION", POSSIBLY EXCEEDING THE MAXIMUM RATINGS GIVEN FOR CW SERVICE, WRITE EITEL-McCULLOUGH, INC., FOR INFORMATION AND RECOMMENDATIONS.

APPLICATION

MECHANICAL

Mounting—The 4-125A 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.



4-125A 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 4-125A. In continuous-service applications, the temperature of the plate seal, as measured on the top of the plate cap, should not exceed 170° C. A relatively slow movement of air past the tube is sufficient to prevent seal temperatures in excess of maximum 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 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., however.

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 to hold the temperature below this maximum at frequencies below 30 Mc., provided that a heat-dissipating plate connector is used, and the tube is so located that normal circulation of air past the envelope is not impeded.

Provision must be made for circulation of air through the base of the tube. Where shielding or socket design makes it impossible to allow free circulation of air through the base, it will be necessary to apply forced-air cooling to the stem structure. An air flow of two cubic feet per minute through the base will be sufficient for stem cooling.

ELECTRICAL

Filament Voltage—For maximum tube life the filament voltage, as measured directly at the filament pins, should be the rated value of 5.0 volts. Unavoidable variations in filament voltage must be kept within the range from 4.75 to 5.25 volts.

Bias Voltage—D-c bias voltage for the 4-125A 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.

Screen Voltage—The d-c screen voltage for the 4-125A should not exceed 400 volts, except for class-AB_1 audio operation.

Plate Voltage—The plate-supply voltage for the 4-125A should not exceed 3000 volts for frequencies below 120 Mc. The maximum permissible plate voltage is less than 3000 volts above 120 Mc., as shown by the graph on page 5.

Grid Dissipation—Grid dissipation for the 4-125A 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 Dissipation—The power dissipated by the screen of the 4-125A must not exceed 20 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 20 watts in the event of circuit failure.

Plate Dissipation—Under normal operating conditions, the plate dissipation of the 4-125A should not be allowed to exceed 125 watts in unmodulated applications.

In high-level-modulated amplifier applications, the maximum allowable carrier-condition plate dissipation is 85 watts. The plate dissipation will rise to 125 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.

* 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.

OPERATION

Class-C Telegraphy or FM Telephony—The 4-125A may be operated as a class-C telegraph or FM telephone amplifier without neutralization up to about 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 as shown in the mounting diagram on page three 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 entering the amplifier, to prevent grid-plate coupling between these leads external to the amplifier.

Where shielding is adequate, the feed-back at frequencies above 100 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 ¾-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, but care must be taken to prevent the neutralizing plate from touching 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 posible 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. All connections to the screen terminals should be made to the center of the strap between the terminals, in order to equalize the current in the two screen leads and prevent overheating one of them. The value for C given under the diagram presupposes the use of the shortest possible leads.

At frequencies below 100 Mc. ordinary neutralization systems may be used. With reasonably effective shielding, however, neutralization should not be required below about 30 Mc.

The driving power and power output under typical operating conditions, with maximum output and plate voltage, are shown on page 5. 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. These losses will not ordinarily amount to more than 30 or 40 per cent of the driving power, except at frequencies above 150 Mc. The use of silver-plated linear tank-circuit elements is recommended at frequencies above 100 Mc.

Conventional capacitance-shortened quarter-wave linear grid tank circuits having a calculated Z_0 of 160 ohms or less may be used with the 4-125A up to 175 Mc. Above 175 Mc. linear grid tank circuits employing a "capacitor"-type shortening bar, as illustrated in the diagram below, may be used. The capacitor, C_1, may consist of two silver-plated brass plates one inch square with a piece of .010 inch mica or polystyrene as insulation.

Class-C AM Telephony—The r-f circuit considerations discussed above under Class-C Telegraphy or FM Telephony also apply to amplitude-modulated operation of the 4-125A. When the 4-125A is used as a class-C high-level-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 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. Where screen voltage is obtained from a separate winding on the modulation transformer, the screen winding should be designed to deliver the peak screen modulation voltage given in the typical operating data on page 2.

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.

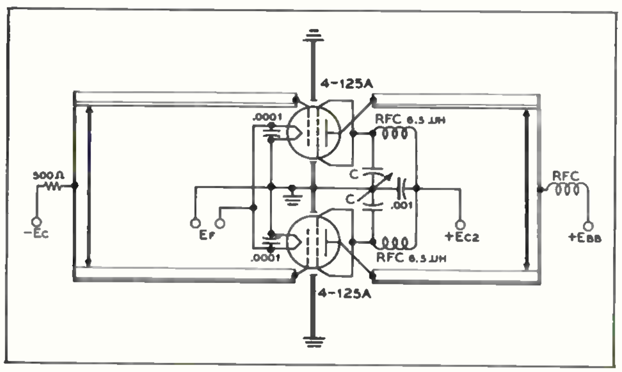
Class-AB_1 and Class-AB_2 Audio—Two 4-125A's may be used in a push-pull circuit to give relatively high audio output power at low distortion. Maximum ratings and typical operating conditions for class-AB_1 and class-AB_2 audio operation are given in the tabulated data.

When type 4-125A tubes are used as class-AB_1 or class-AB_2 audio amplifiers at 1500 plate volts, under the conditions given under "Typical Operation", the screen voltage must 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 will provide adequate regulation. The variation in screen current at plate voltages of 2000 and above is low enough so that any screen power supply having a normal order of regulation will serve. The driver plate supply makes a convenient source of screen voltage under these conditions.

Grid bias voltage for class-AB_2 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-AB_1 conditions the effective grid-circuit resistance for each tube should not exceed 250,000 ohms.

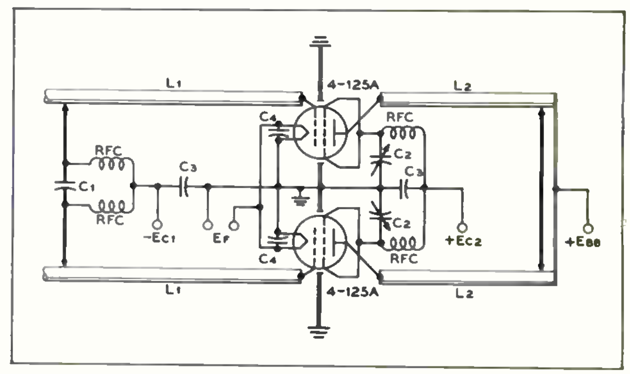
The peak driving power figures given in the class-AB_2 tabulated data are included to make possible an accurate determination of the required driver output power. The driving amplifier must be capable of supplying the peak driving power without distortion. The driver stage should, therefore, be capable 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.

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.



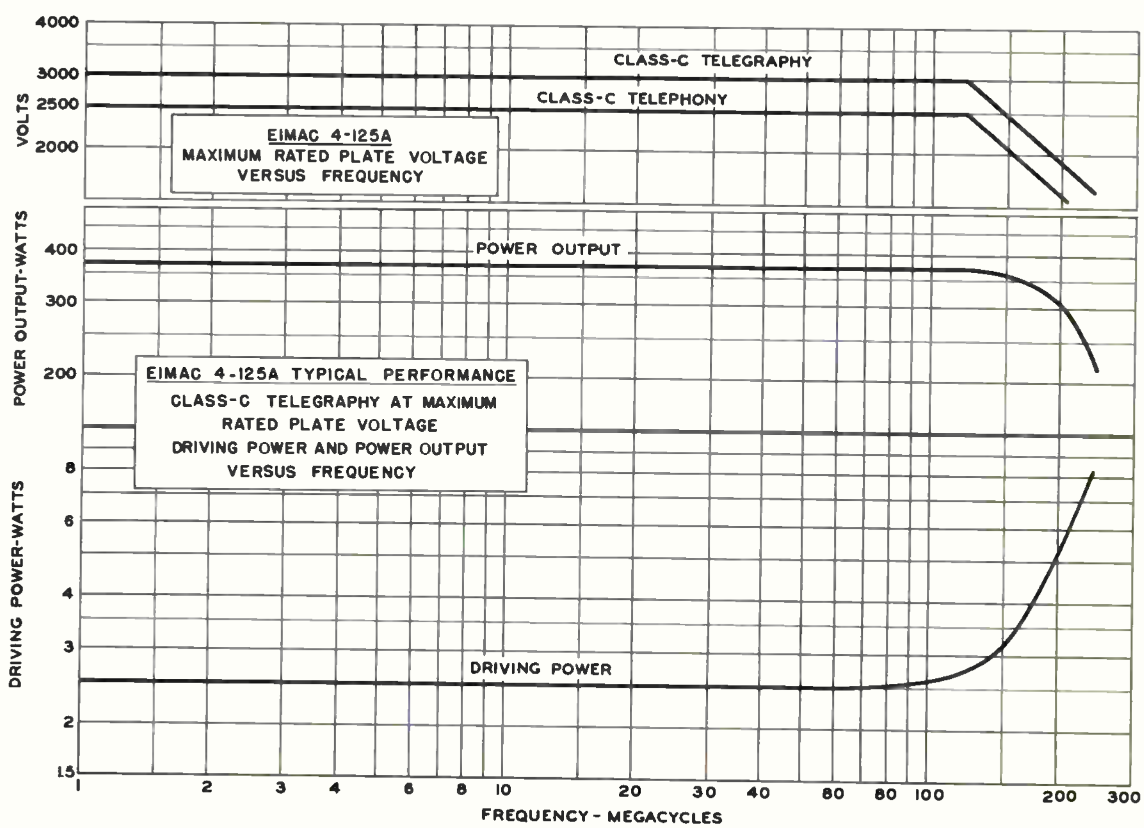
Screen-tuning neutralization circuit for use above 100 Mc.
C is a small split-stator capacitor.

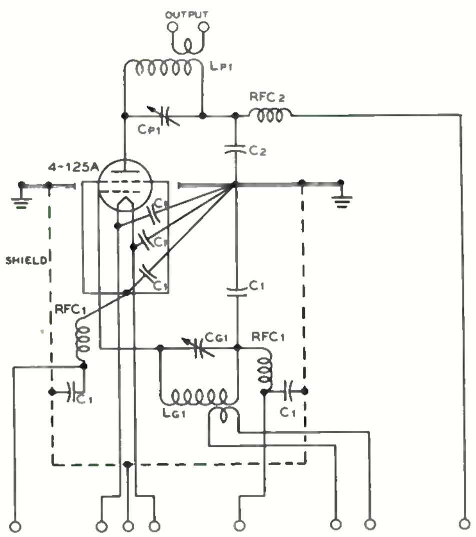
$$C(\mu\mu fd) = \frac{640{,}000}{f^2\ (Mc.)},\ \text{approx.}$$



Typical circuit arrangement useful for frequencies above 175 Mc.

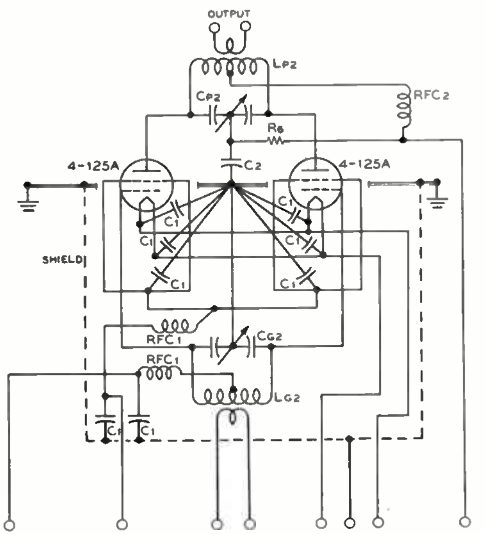
C_1—See above.
C_2—Neutralizing capacitor.
C_3—.001 μfd.
C_4—100 μμfd.
L_1—3/8" dia. copper spaced 1" center-to-center, 6" long.
L_2—7/8" dia. brass, silver plated, spaced 1 1/2" center-to-center, 14" long.





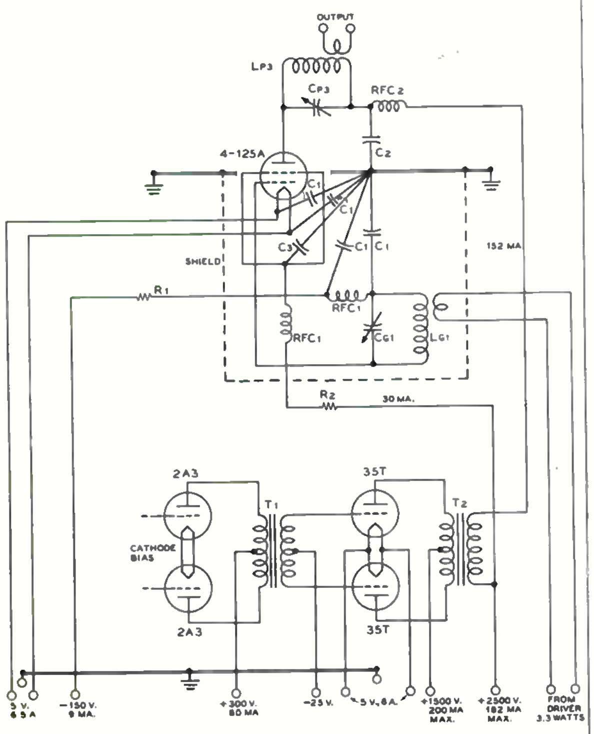
Ecc2	Ef	Ecc1	Pd	Ebb
D.C. SCREEN VOLTS	FILAMENT VOLTS	D.C. GRID VOLTS	DRIVING POWER	D.C PLATE VOLTS
350 V., 40 MA.	5.0 V.	−150 V., 12 MA.	3.8 WATTS	2500 V., 200 MA.
350 V., 30 MA.	5.0 V.	−150 V., 9 MA.	2.5 WATTS	3000 V., 167 MA.

Typical radio-frequency power amplifier circuit, Class-C telegraphy, 500 watts input.

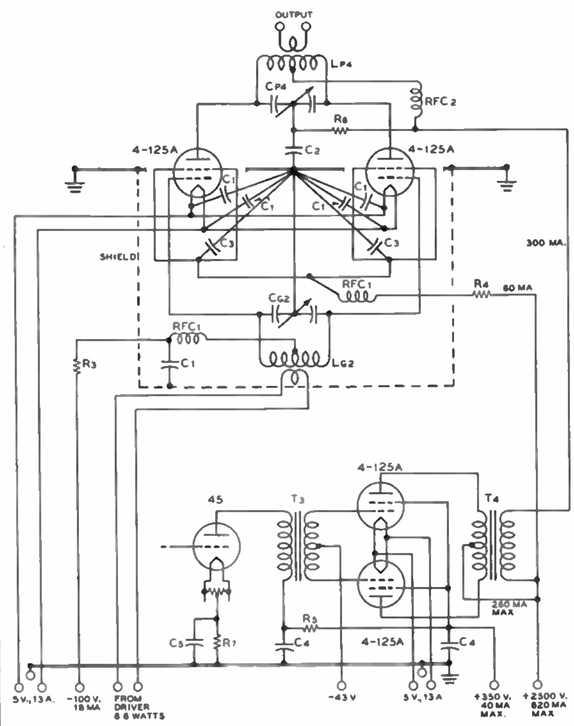


Ecc1	Ecc2	Pd	Ef	Ebb
D.C. GRID VOLTS	D.C. SCREEN VOLTS	DRIVING POWER	FILAMENT VOLTS	D.C PLATE VOLTS
−150 V., 24 MA.	350 V., 80 MA.	7.6 WATTS	5.0 V.	2500 V., 400 MA.
−150 V., 18 MA.	350 V., 60 MA.	5.0 WATTS	5.0 V.	3000 V., 335 MA.

Typical radio-frequency power amplifier circuit, Class-C telegraphy, 1000 watts input.



Typical high-level-modulated r-f amplifier circuit, with modulator and driver stages, 380 watts plate input.



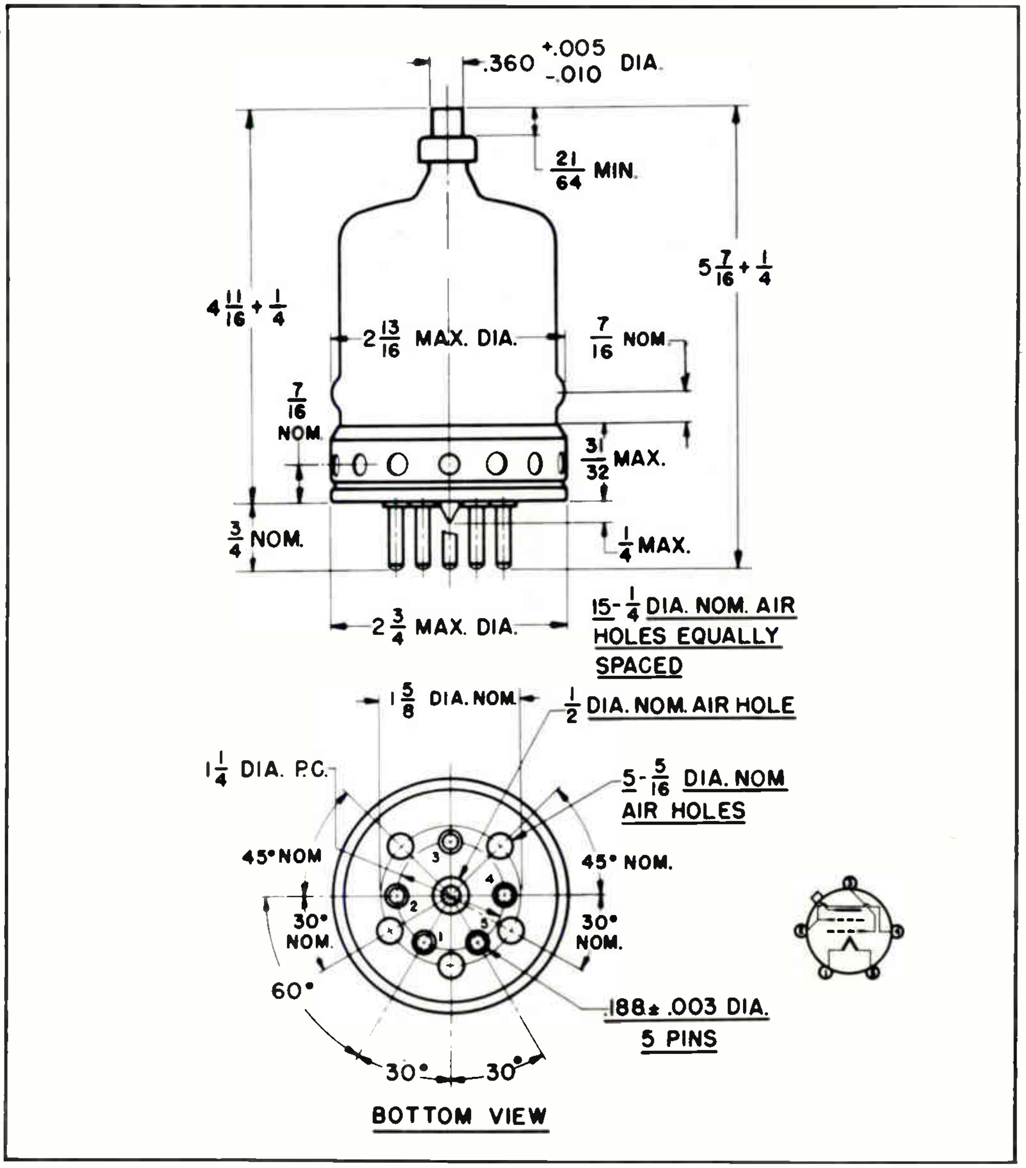
Typical high-level-modulated r-f amplifier circuit, with modulator and driver stages, 750 watts plate input.

See opposite page for list of components.

COMPONENTS FOR TYPICAL CIRCUITS

(Diagrams, Page 6)

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_{p4} - C_{p4} —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 freqency.
C_1 — .002-ufd., 500-v. mica
C_2 — .002-ufd., 5000-v. mica
C_3 — .001-ufd., 2500-v. mica
C_4 — 16-ufd., 450-v. electrolytic
C_5 — 10-ufd., 25-v. electrolytic
R_1 — 7000 ohms, 5 watts
R_2 — 70,000 ohms, 100 watts
R_3 — 3500 ohms, 5 watts
R_4 — 35,000 ohms, 200 watts
R_5 — 560 ohms, 1 watt
R_6 — 25,000 ohms, 2 watts
R_7 — 1500 ohms, 5 watts
RFC_1 — 2.5-mhy., 125-ma. r-f choke
RFC_2 — 1-mhy., 500-ma. r-f choke
T_1 — 10-watt driver transformer; ratio pri. to 1/2 sec. approx. 2:1.
T_2 — 200-watt modulation transformer; ratio pri. to sec. approx. 1:1; pri. impedance = 16,200 ohms, sec. impedance = 16,500 ohms.
T_3 — 5-watt driver transformer; ratio pri. to 1/2 sec. approx. 1.1:1.
T_4 — 400-watt modulation transformer; ratio pri. to sec. approx. 2.7:1; pri. impedance = 22,200 ohms, sec. impedance = 8300 ohms.



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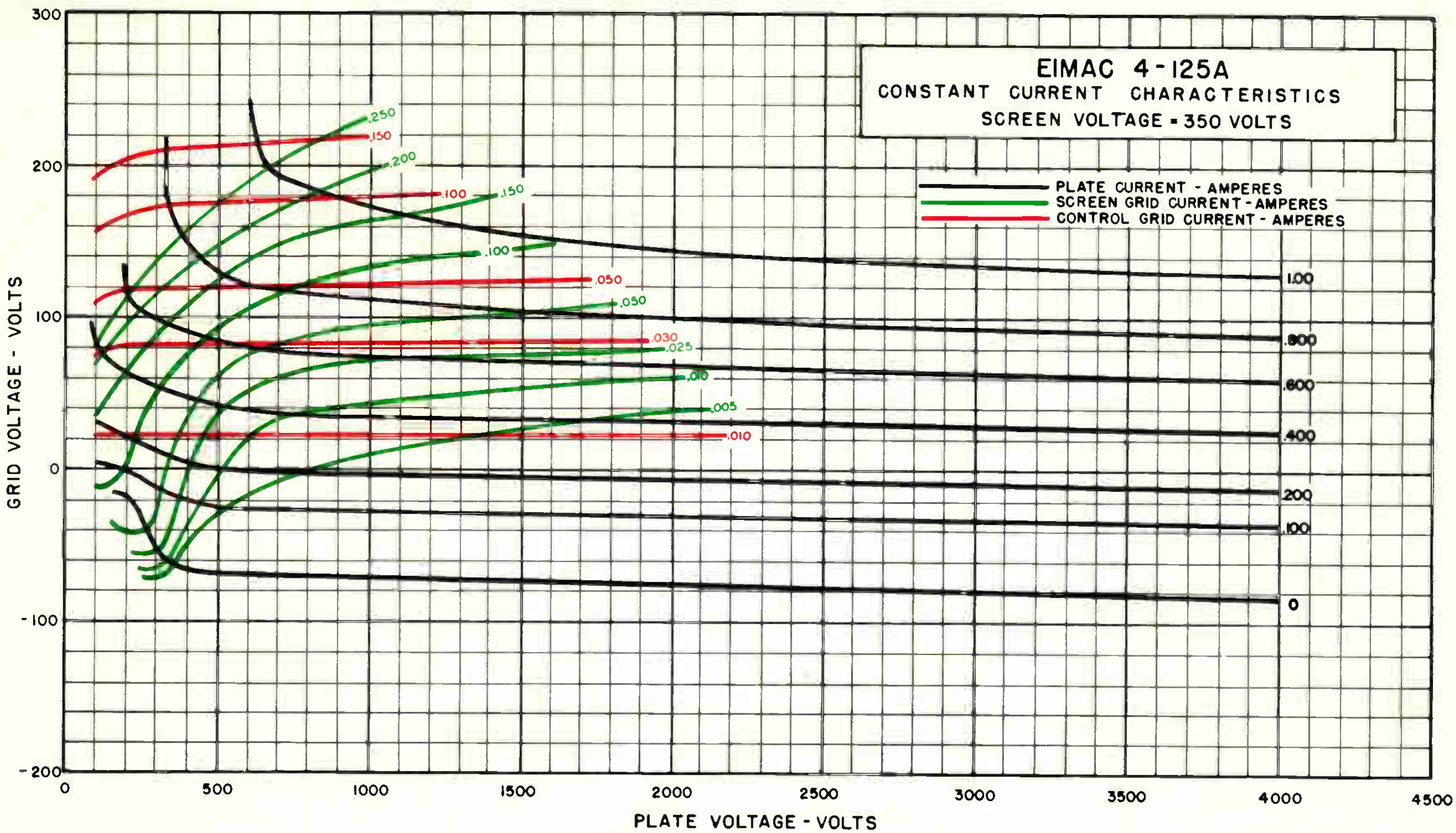


Eimac 4-125A (4D21)

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 ouput 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 μμf
Input	8.0 μμf
Output	2.1 μμf
Transconductance (I_b = 125 ma., E_b = 500 v., E_{c2} = 250 v.)	4000 μmhos
Frequency for Maximum Ratings	150 Mc.

MECHANICAL

Base	5-pin—Fits { National HX-29 Socket / Johnson 122-101 Socket }
Mounting	Vertical, base down or up
Cooling	Convection and Radiation
Recommended Heat Dissipating Connector	Eimac HR-6
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 Telegraphy 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.

▸ Indicates change from sheet dated 1-30-53

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-AB_1 (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.

[1]Adjust 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-AB_2 (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	180	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-AB_2 (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	65	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.

▶ Indicates change from sheet dated 1-30-53

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 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 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

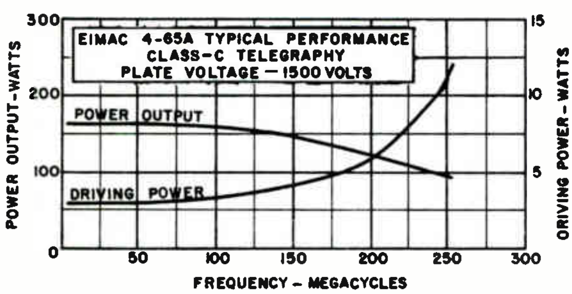
Class-C FM or Telegraphy—The 4-65A may be operated as a class-C FM or telegraph amplifier without neutralization up to 110 Mc. if reasonable precautions are taken to prevent coupling between input and output circuits external to the tube. In single ended circuits, plate, grid, filament and screen by-pass 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 ¾" square and located adjacent to the envelope opposite the plate will suffice for neutralization. Means should be provided for adjusting the

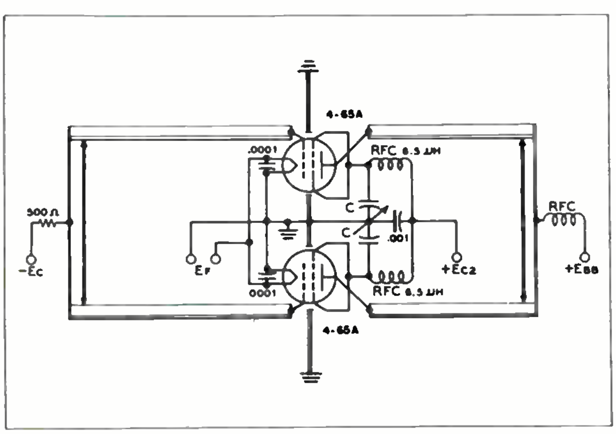
*For suitable peak V.T.V.M. circuits see, for instance, "Vacuum Tube Ratings," Eimac News, January 1945. This article is available in reprint form on request.

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-AB_1 and Class-AB_2 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-AB_1 and class-AB_2 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-AB_2 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-AB_1 conditions the effective grid-circuit resistance should not exceed 250,000 ohms.

The peak driving power figures given in the class-AB_2 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.

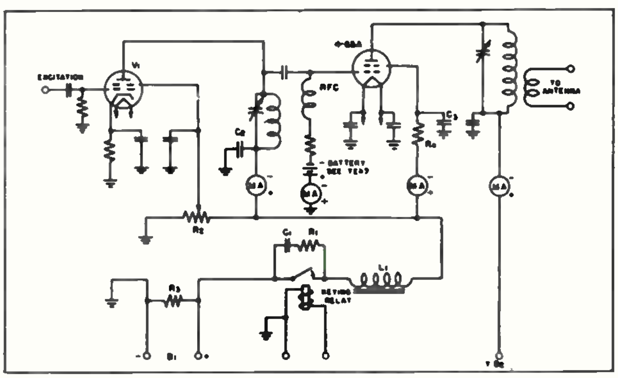
In some cases the maximum-signal plate dissipation shown under "Typical Operation" is less than the maximum rated plate dissipation of 4-65A. In these cases, with sine wave modulation, the plate dissipation reaches a maximum value, equal to the maximum rating, at a point somewhat below maximum-signal 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 μfd 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 μfd 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-electode 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. Correspondingly, 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 approximate 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:

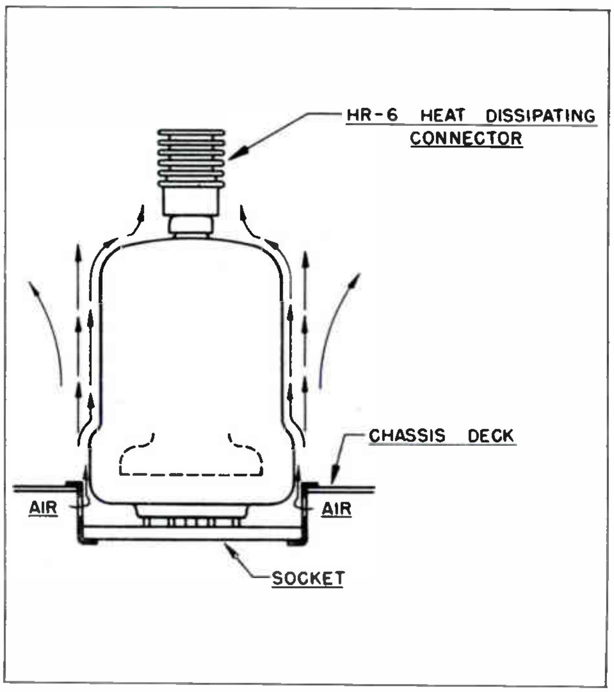
1. Cut the audio output to zero.
2. Apply 120 volts of bias to the 4-65A control grid.
3. Apply the operating plate voltage followed by the operating screen voltage.
4. Reduce bias voltage to obtain 50 watts of stand-by plate dissipation.
5. Increase audio gain, checking the oscilloscope pattern for 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.

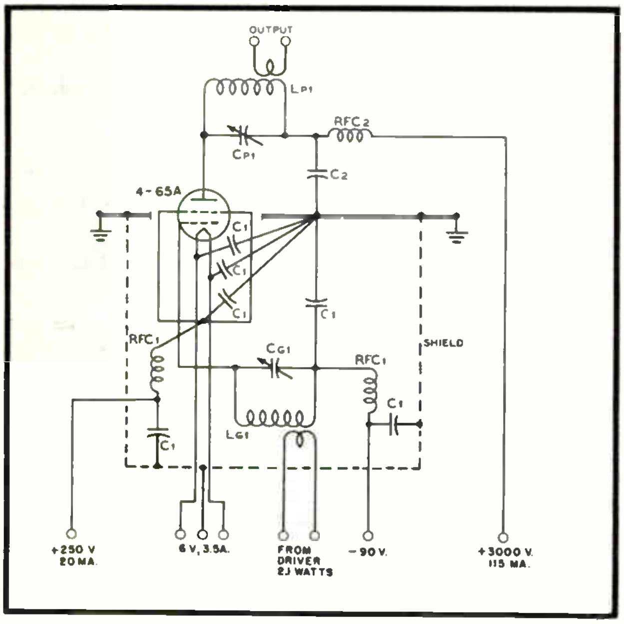
If the alternate method is used with a 100% duty cycle from the audio oscillator, then step 3 should be to apply half voltages and the stand-by plate dissipation should be set at 10 watts.

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.

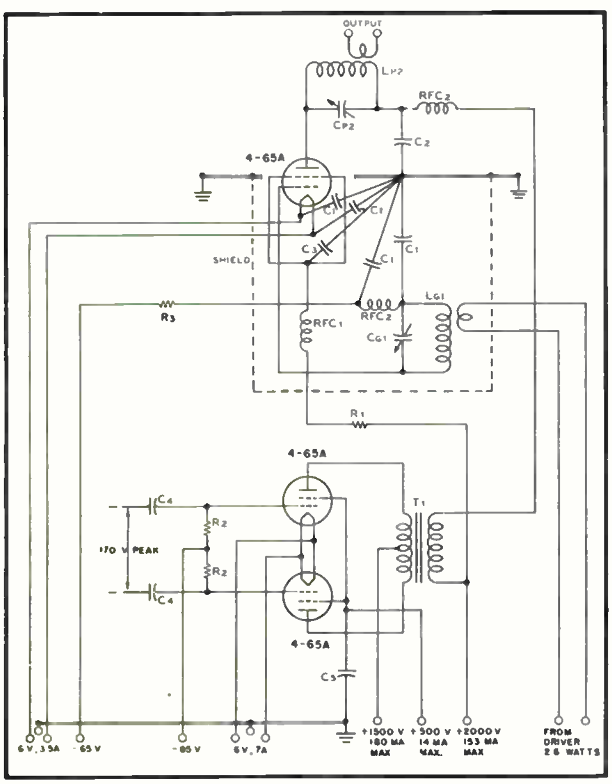




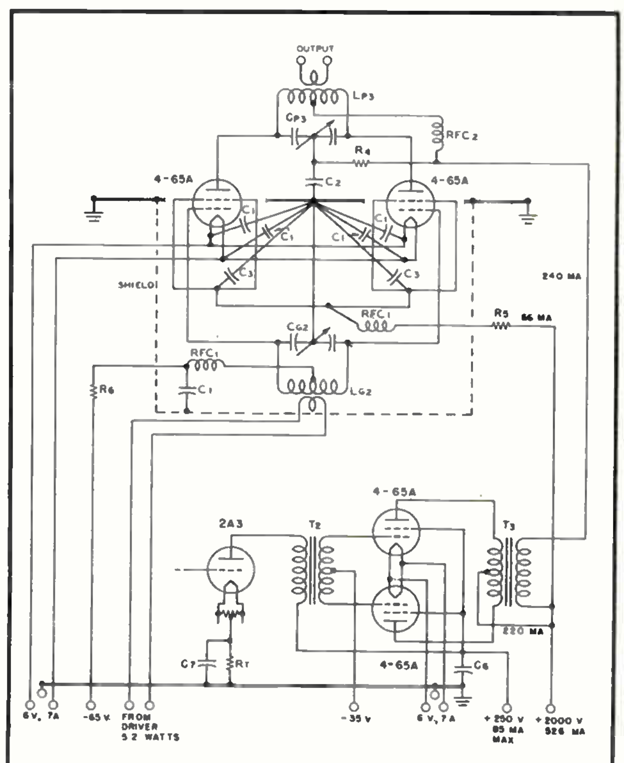
Typical radio-frequency power amplifier circuit, Class-C telegraphy, 345 watts input.

COMPONENTS FOR TYPICAL CIRCUITS

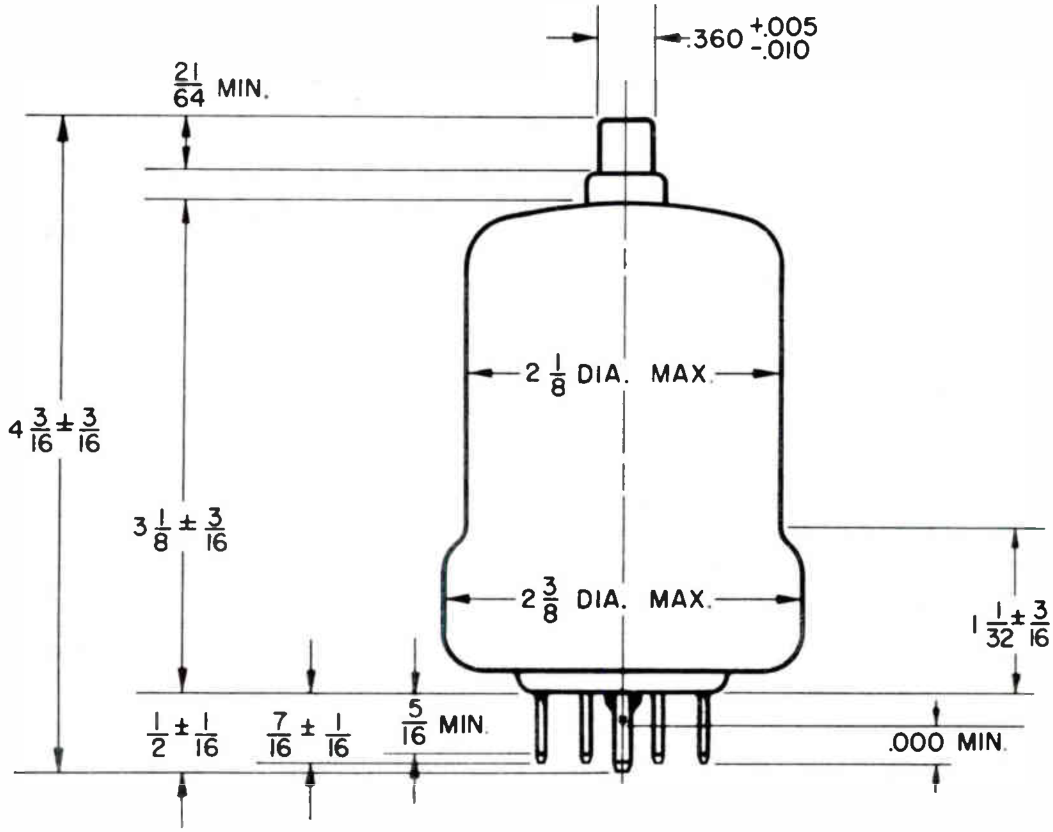
L_{p1}-C_{p1}— Tank circuit appropriate for operating frequency; Q=12. Capacitor plate spacing=.200".
L_{p2}-C_{p2}— Tank circuit appropriate for operating frequency; Q=12. Capacitor plate spacing=.200".
L_{p3}-C_{p3}— Tank circuit appropriate for operating frequency; Q=12. Capacitor plate spacing=.375".
L_{g1}-C_{g1}— Tuned circuit appropriate for operating frequency.
L_{g2}-C_{g2}— Tuned circuit appropriate for operating frequency.
C_1— .002-μfd. 500V Mica
C_2— .002-μfd. 5000V Mica
C_3— .001-μfd. 2500V Mica
C_4— .1 -μfd. 1000V paper
C_5— .1 -μfd. 600 V paper
C_6— 16 -μfd. 450V Electrolytic
C_7— 10 -μfd. 100V Electrolytic
R_1—53,000 ohms 200 watt—60,000 ohm adjustable
R_2—250,000 ohms 1 watt
R_3— 5,000 ohms 5 watt
R_4— 25,000 ohms 2 watts
R_5— 26,500 ohms 200 watts—30,000 ohm adjustable
R_6— 2,500 ohms 5 watts
R_7— 750 ohms 5 watts
RFC_1— 2.5 mhy. 125 ma. R-F choke
RFC_2— 1 mhy. 500 ma. R-F choke
T_1— 150 watt modulation transformer; ratio primary to secondary impedance approx. 1:1.1 Pri. impedance 15,000 ohms, sec. impedance 16,700 ohms.
T_2— 5 watt driver transformer impedance ratio primary to 1/2 secondary 1.5:1.
T_3— 300 watt modulation transformer; impedance ratio pri. to sec. approx. 2.4:1; Pri. impedance=20,000 ohms, sec. impedance=8,333 ohms.

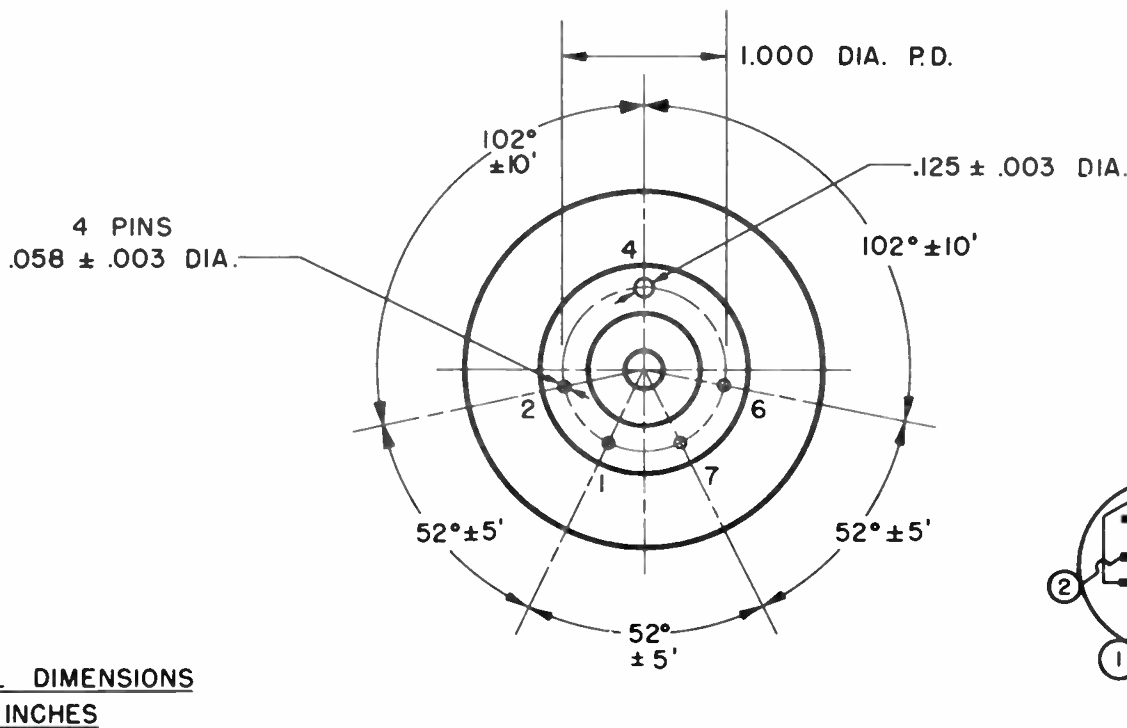


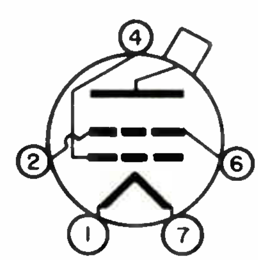
Typical high-level-modulated R-F amplifier, 240 watts plate input. Modulator requires zero driving power.



Typical high-level-modulated R-F amplifier circuit, with modulator and driver stages, 480 watts plate input.

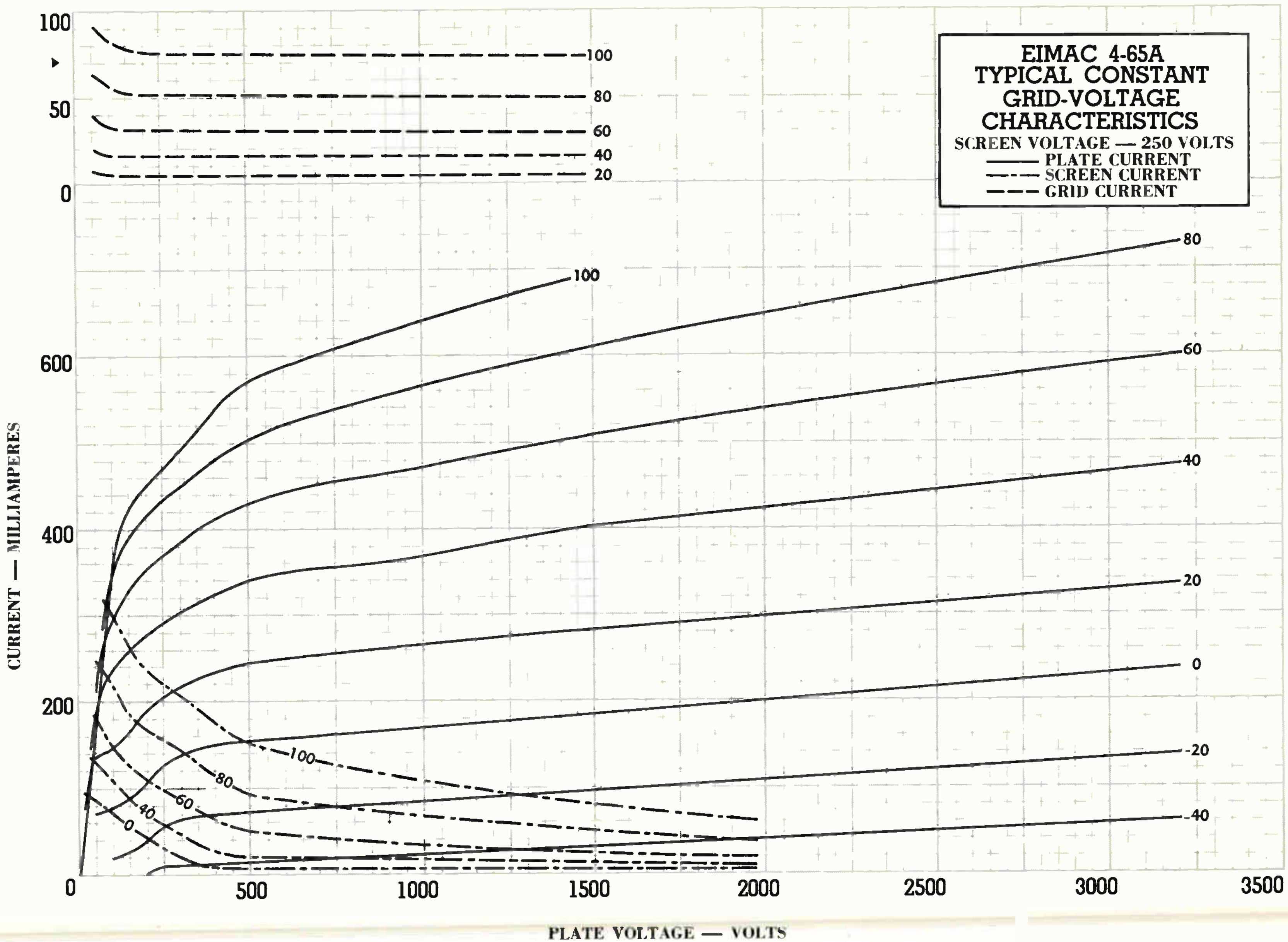






ALL DIMENSIONS IN INCHES

BOTTOM VIEW



4-65A

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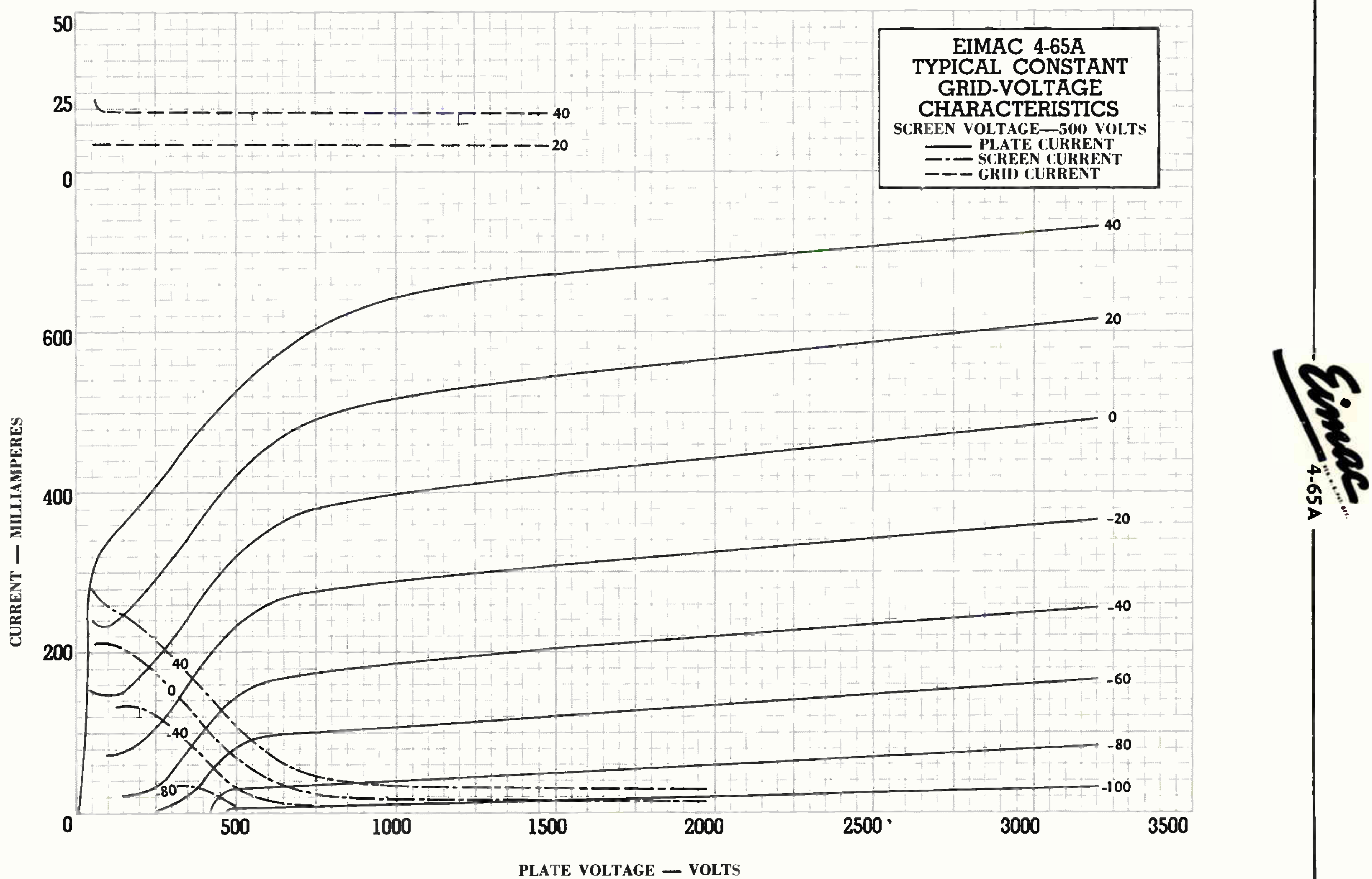
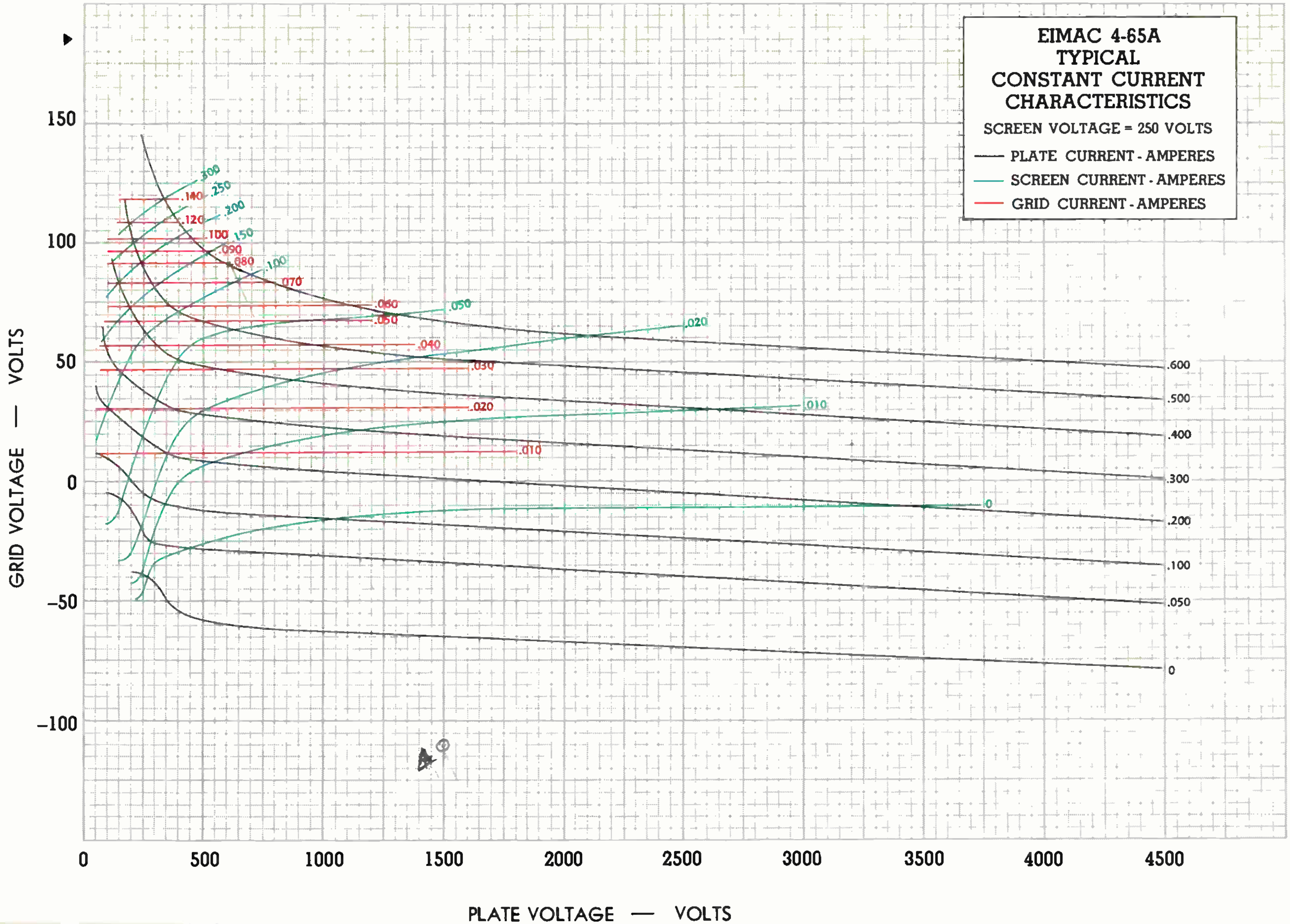


EIMAC 4-65A
TYPICAL CONSTANT
GRID-VOLTAGE
CHARACTERISTICS
SCREEN VOLTAGE—500 VOLTS
PLATE CURRENT
SCREEN CURRENT
GRID CURRENT
CURRENT — MILLIAMPERES
PLATE VOLTAGE — VOLTS
50
25
0
600
400
200
0
500
1000
1500
2000
2500
3000
3500
40
20
40
20
0
-20
-40
-60
-80
-100
40
0
-40
-80

Eimac
4-65A



4-65A

▸ Indicates change from sheet dated 1-30-53

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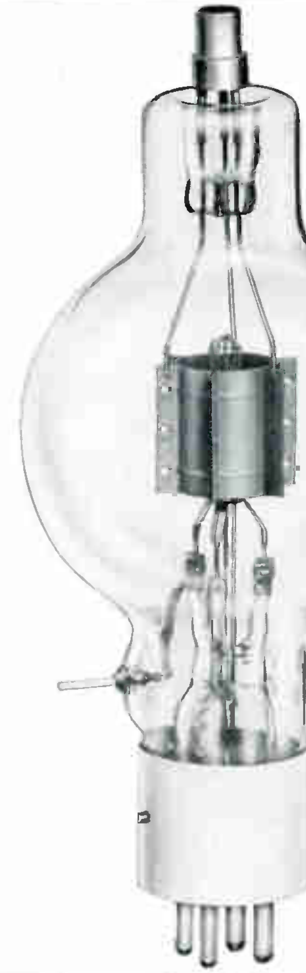
Eimac

100TH



THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC 100TH TUBE ONLY.

Look for the identifying mark (HI) on the filament stem of the tube.

Tantalum elements, fabricated and exhausted by the exclusive Eimac process, makes it impossible for this tube to fail as a result of gas released internally. The new, low-loss, low-capacity anode connector consists of a solid copper button into which are terminated, three solid copper bars. The grid terminal is a solid tungsten rod. These new connectors greatly reduce r.f. losses, particularly on the higher frequencies. Much higher usable value of space current and phenomenally long life are gained because of the high order of thermionic efficiencies. High "mu" and improved grid design permit a marked saving in grid driving power. Sparkling, clear, glass envelopes radiate the maximum of heat.

Characteristics

Filament Voltage	5 to 5.1 Volts
Filament Current	6.5 Amperes
Amplification Factor	30
Grid-Plate Capacity	2 mmfds.
Grid-Filament Capacity	2.2 mmfds.
Plate-Filament Capacity	.3 mmfds.
Bulb	GT 25 Nonex
Base	Isolantite UX 4-prong
Overall Height	7.5 Inches
Maximum Diameter	3.125 Inches

Tube must be operated vertically with ample ventilation provided.

Maximum Ratings for All Frequencies Less Than 40 mc.

Maximum Plate Voltage	3000 Volts
Maximum Plate Current	225 Milliamperes
Maximum Grid Current	50 Milliamperes
Plate Dissipation (normal)	100 Watts

Typical Operating Data (Single tube)
Class "C" Telegraphy or Telephony

Plate Voltage	1000	2000	3000
Plate Current (milliamperes)	135	150	125
Grid Current	50	50	50
Grid Bias Voltage	—70	—140	—210
Power Output (75% eff.)	100	225	300

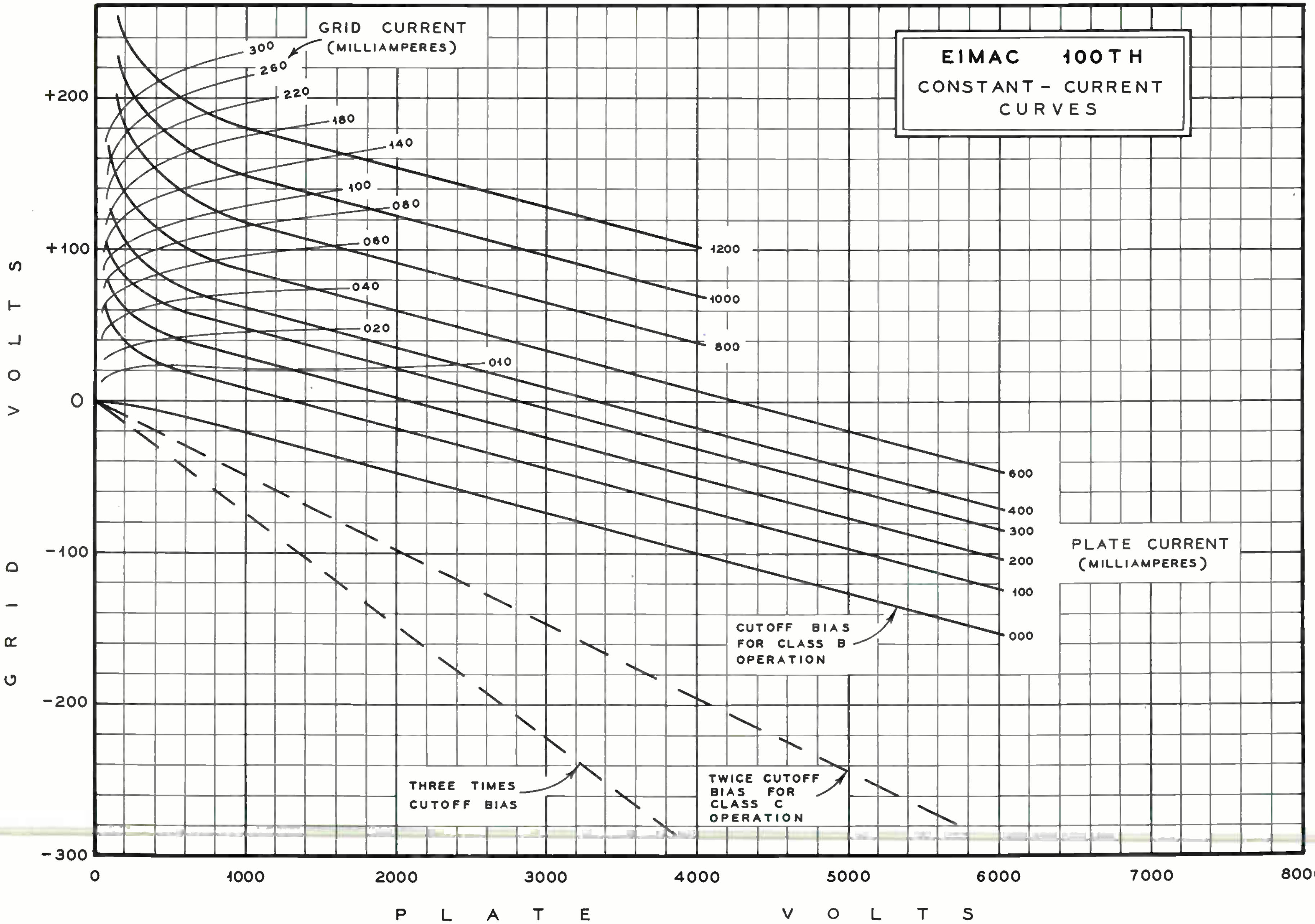
Class "B" Audio

Plate Voltage	Load Impedance (Plate to Plate)	Power Output
3000	30,000 Ohms	500 Watts
2500	22,000 Ohms	460 Watts
2000	16,000 Ohms	380 Watts
1500	9,600 Ohms	300 Watts
1250	7,200 Ohms	260 Watts
1000	5,200 Ohms	210 Watts

Typical Operating Conditions Approved by the Federal Communications Commission for Broadcast Services

	High Level Modulated	Linear Amplifier
Plate Volts	1250	2000
Plate Current (milliamperes)	160	75
Efficiency	50%	33%
Power Output (watts)	100	50

EITEL-McCULLOUGH, INC. San Bruno, California

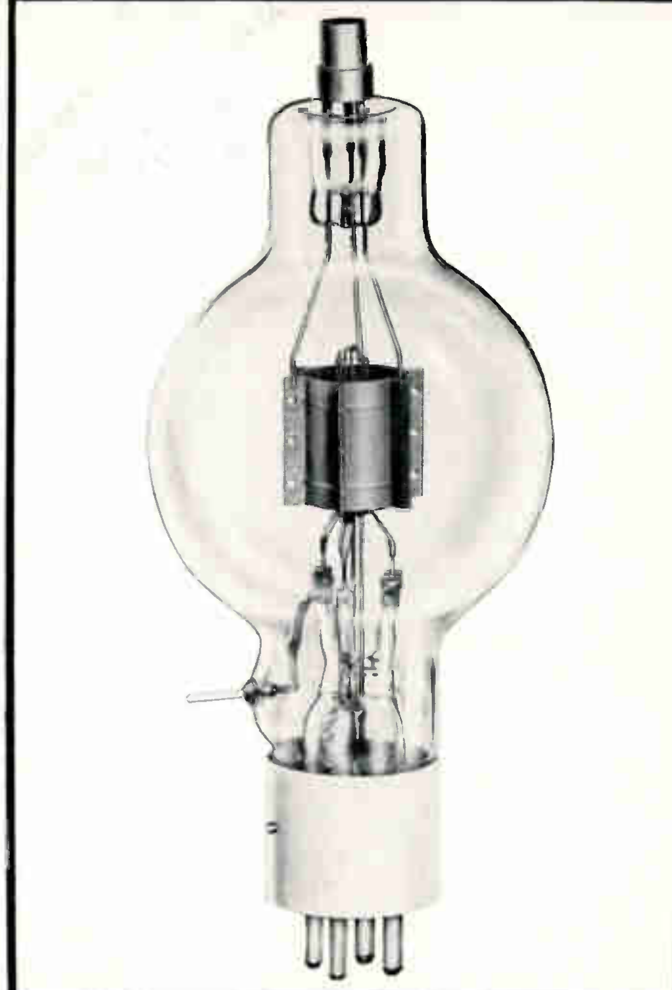

EIMAC 100TH
CONSTANT - CURRENT CURVES
GRID CURRENT (MILLIAMPERES)
300
260
220
180
140
100
080
060
040
020
010
1200
1000
800
600
400
300
200
100
000
PLATE CURRENT (MILLIAMPERES)
CUTOFF BIAS FOR CLASS B OPERATION
THREE TIMES CUTOFF BIAS
TWICE CUTOFF BIAS FOR CLASS C OPERATION
+200
+100
0
-100
-200
-300
GRID VOLTS
0
1000
2000
3000
4000
5000
6000
7000
8000
PLATE VOLTS

Eimac 100TL

THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC 100TL TUBE ONLY.

Look for the identifying mark (LO) on the filament stem of the tube.

Tantalum elements, fabricated and exhausted by the exclusive Eimac process, makes it impossible for this tube to fail as a result of gas released internally. The new, low-loss, low-capacity anode connector consists of a solid copper button into which are terminated, three solid copper bars. The grid terminal is a solid tungsten rod. These new connectors greatly reduce r.f. losses, particularly on the higher frequencies. Much higher usable value of space current and phenomenally long life are gained because of the high order of thermionic efficiencies. High "mu" and improved grid design permit a marked saving in grid driving power. Sparkling clear glass envelopes radiate the maximum of heat.



Characteristics

Filament Voltage	5 to 5.1 Volts
Filament Current	6.5 Amperes
Amplification Factor	12
Grid-Plate Capacity	2.3 mmfds.
Grid-Filament Capacity	2 mmfds.
Plate-Filament Capacity	4 mmfds.
Bulb	GT 25 Nonex
Base	Isolantite UX 4-prong
Overall Height	7.5 Inches
Maximum Diameter	3.125 Inches

Tube must be operated vertically with ample ventilation provided.

Maximum Ratings for All Frequencies Less Than 40 mc.

Maximum Plate Voltage	3000 Volts
Maximum Plate Current	225 Milliamperes
Maximum Grid Current	35 Milliamperes
Plate Dissipation (normal)	100 Watts

Typical Operating Data (Single tube) Class "C" Telegraphy or Telephony

Plate Voltage	1000	2000	3000
Plate Current (milliamperes)	135	150	135
Grid Current	30	30	30
Grid Bias Voltage	—200	—400	—600
Power Output (75% eff.)	100	225	300

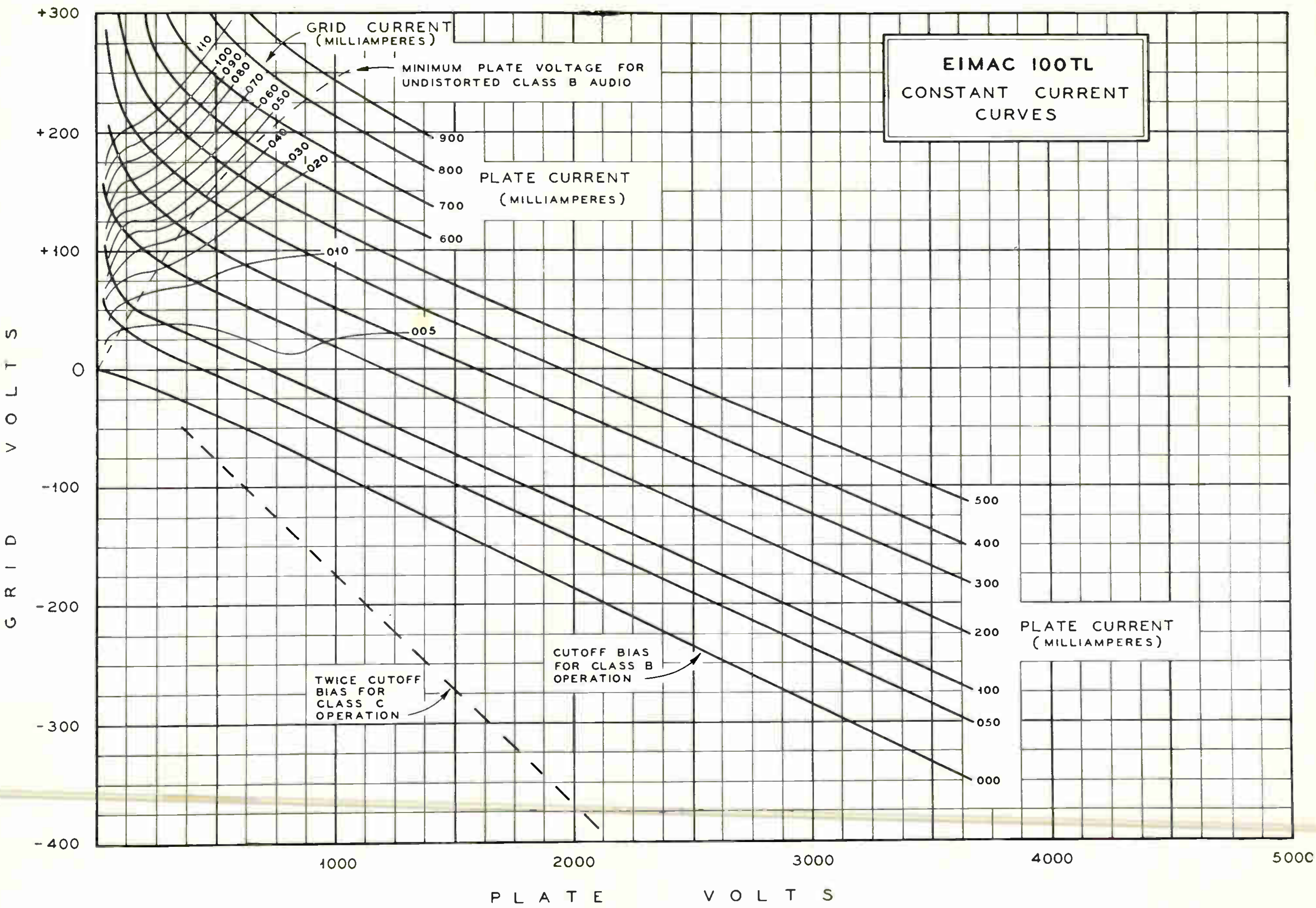
Class "B" Audio

Plate Voltage	Load Impedance (Plate to Plate)	Power Output
3000	30,000 Ohms	465 Watts
2500	22,000 Ohms	430 Watts
2000	16,000 Ohms	350 Watts
1500	9,600 Ohms	270 Watts
1250	7,200 Ohms	230 Watts
1000	5,200 Ohms	170 Watts

Typical Operating Conditions Approved by the Federal Communications Commission for Broadcast Services

	High Level Modulated	Linear Amplifier
Plate Volts	1250	2000
Plate Current (milliamperes)	160	75
Efficiency	50%	33%
Power Output (watts)	100	50

EITEL-McCULLOUGH, Inc. San Bruno, California



EIMAC 100TL
CONSTANT CURRENT CURVES
GRID CURRENT (MILLIAMPERES)
MINIMUM PLATE VOLTAGE FOR UNDISTORTED CLASS B AUDIO
PLATE CURRENT (MILLIAMPERES)
CUTOFF BIAS FOR CLASS B OPERATION
TWICE CUTOFF BIAS FOR CLASS C OPERATION
110
100
090
080
070
060
050
040
030
020
010
005
900
800
700
600
500
400
300
200
100
050
000
+300
+200
+100
0
-100
-200
-300
-400
1000
2000
3000
4000
5000
GRID VOLTS
PLATE VOLTS

Eimac

250TH

THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC 250TH TUBE ONLY.

Look for the identifying mark (HI) on the filament stem of the tube.

250TH contains a greatly improved thoriated cathode which is mounted in such a way that "filament distortion" is practically impossible. This new cathode operates at a very high thermionic efficiency, permitting a higher value of usable space current. Notable features are: remarkable uniformity of electrical characteristics, perfect alignment of the elements, sparkling clear glass bulbs and the "brightness" of all metal parts. Eimac's unique design, long severe exhause technique, use of completely degassed tantalum elements and elimination of the "getter" make it possible to guarantee these tubes against failures caused by gas released internally.

High "mu" and the advanced grid design permits a marked saving in grid driving power and makes the 250TH highly desirable for all applications, particularly for class "B" audio work.

Characteristics

Filament Voltage	5 to 5.1 Volts
Filament Current (approx.)	10.5 Amperes
Amplification Factor (average)	32
Grid-Plate Capacity	3.3 mmfds.
Grid-Filament Capacity	3.5 mmfds.
Plate-Filament Capacity	.3 mmfds.
Bulb	GT 30 Nonex
Base	Standard (50 watt)
Overall Height	9.75 Inches
Maximum Diameter	3.75 Inches

Tube must be operated vertically with ample ventilation provided.

Maximum Ratings for Frequencies Less Than 60 mc.

Maximum Plate Voltage	3000 Volts
Maximum Plate Current	350 Milliamperes
Maximum Grid Current	100 Milliamperes
Plate Dissipation (normal)	250 Watts

Typical Operating Data (Single tube) Class "C" Telegraphy or Telephony

Plate Voltage	1000	2000	3000
Plate Current (milliamperes)	150	350	330
Grid Current (milliamperes)	75	75	75
Grid Bias Voltage	—70	—140	—210
Power Output (75% eff.)	100	500	750

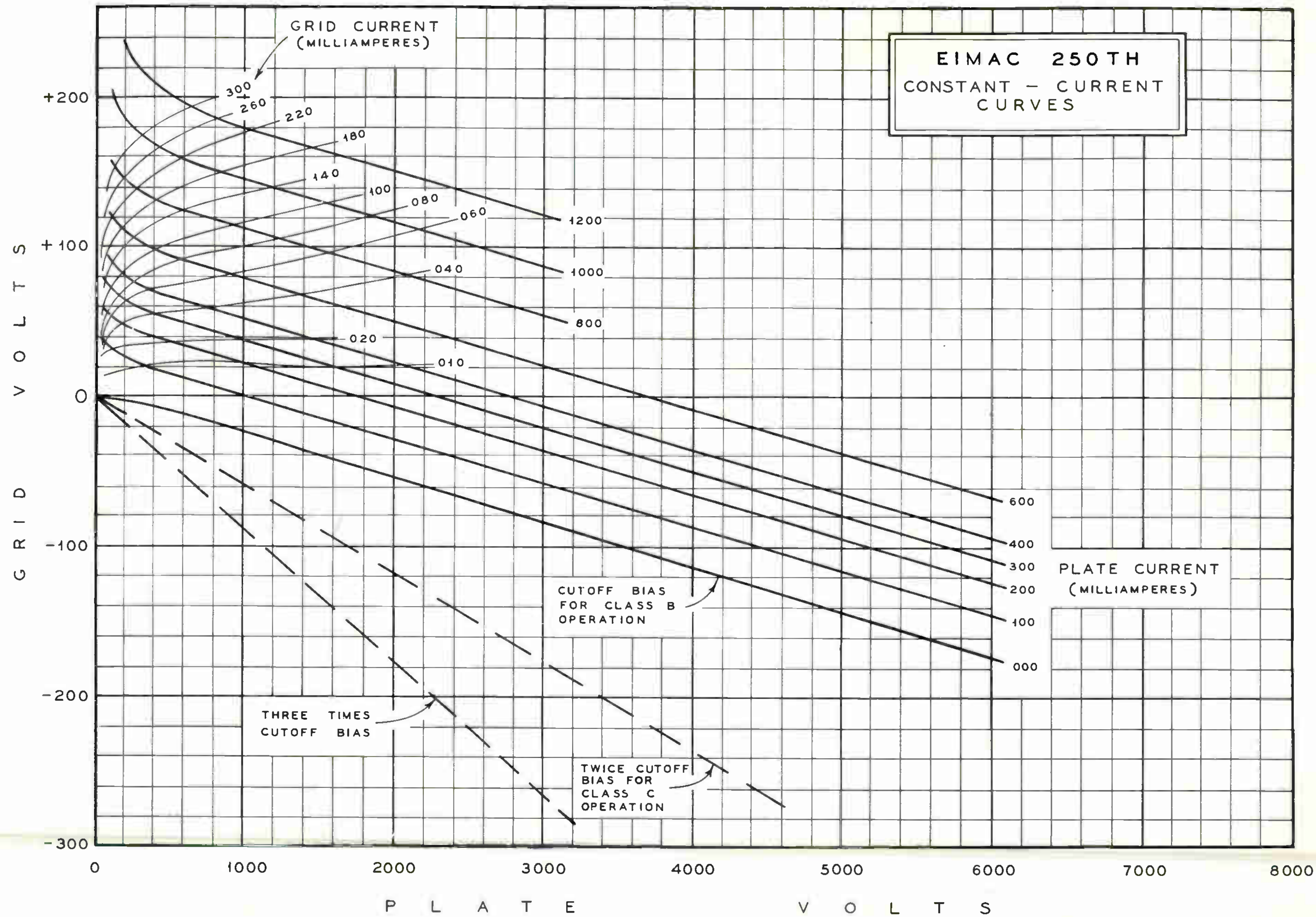
Class "B" Audio

These impedances are recommended for maximum output with the minimum of distortion. They are chosen so that the tube is operated within its recommended ratings.

Plate Voltage	Load Impedance (Plate to Plate)	Power Output
3000	12,400 Ohms	1180 Watts
2500	8,800 Ohms	1000 Watts
2000	6,000 Ohms	900 Watts
1500	4,200 Ohms	630 Watts
1250	3,280 Ohms	540 Watts
1000	2,360 Ohms	350 Watts

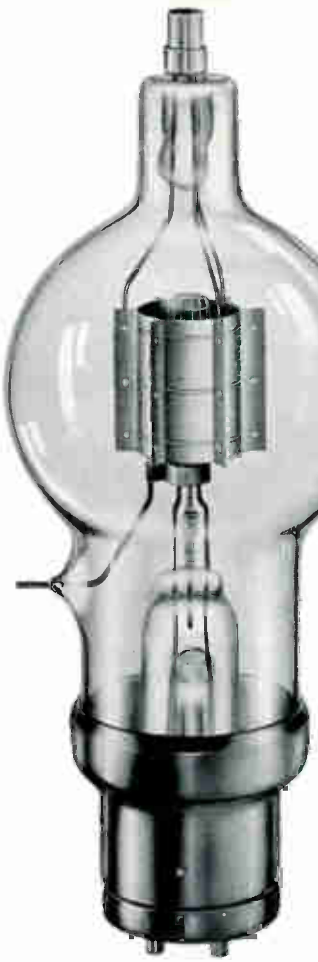
Typical Operating Conditions Approved by the Federal Communications Commission for Broadcast Services

	High Level Modulated	Linear Amplifier	Grid Bias
Plate Volts	2750	3000	2000
Plate Current (milliamperes)	250	125	115
Efficiency	60%	33%	22%
Power Output (watts)	350	125	50


EIMAC 250TH
CONSTANT - CURRENT CURVES
GRID CURRENT (MILLIAMPERES)
300
260
220
180
140
100
080
060
040
020
010
1200
1000
800
600
400
300
200
100
000
PLATE CURRENT (MILLIAMPERES)
CUTOFF BIAS FOR CLASS B OPERATION
THREE TIMES CUTOFF BIAS
TWICE CUTOFF BIAS FOR CLASS C OPERATION
+200
+100
0
-100
-200
-300
GRID VOLTS
0
1000
2000
3000
4000
5000
6000
7000
8000
PLATE VOLTS

Eimac

250TL



THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC 250TL TUBE ONLY.

Look for the identifying mark (LO) on the filament stem of the tube.

250TL contains a greatly improved thoriated cathode which is mounted in such a way that "filament distortion" is practically impossible. This new cathode operates at a very high thermionic efficiency, permitting a higher value of usable space current. Notable features are: remarkable uniformity of electrical characteristics, perfect alignment of the elements, sparkling clear glass bulbs and the "brightness" of all metal parts. Eimac's unique design, long severe exhaust technique, use of completely degassed tantalum elements and elimination of the "getter" make it possible to guarantee these tubes against failures caused by gas released internally.

Characteristics

Filament Voltage	5 to 5.1 Volts
Filament Current (approx.)	10.5 Amperes
Amplification Factor (average)	13
Grid-Plate Capacity	3.5 mmfds.
Grid-Filament Capacity	3 mmfds.
Plate-Filament Capacity	.5 mmfds.
Bulb	GT 30 Nonex
Base	Standard (50 watt)
Overall Height	9.75 Inches
Maximum Diameter	3.75 Inches

Tube must be operated vertically with ample ventilation provided.

Maximum Ratings for Frequencies Less Than 60 mc.

Maximum Plate Voltage	3000 Volts
Maximum Plate Current	350 Milliamperes
Maximum Grid Current	50 Milliamperes
Plate Dissipation (normal)	250 Watts

Typical Operating Data (Single tube)
Class "C" Telegraphy or Telephony

Plate Voltage	1000	2000	3000
Plate Current (milliamperes)	150	350	330
Grid Current (milliamperes)	45	45	45
Grid Bias Voltage	—200	—400	—600
Power Output (75% eff.)	100	500	750

Class "B" Audio

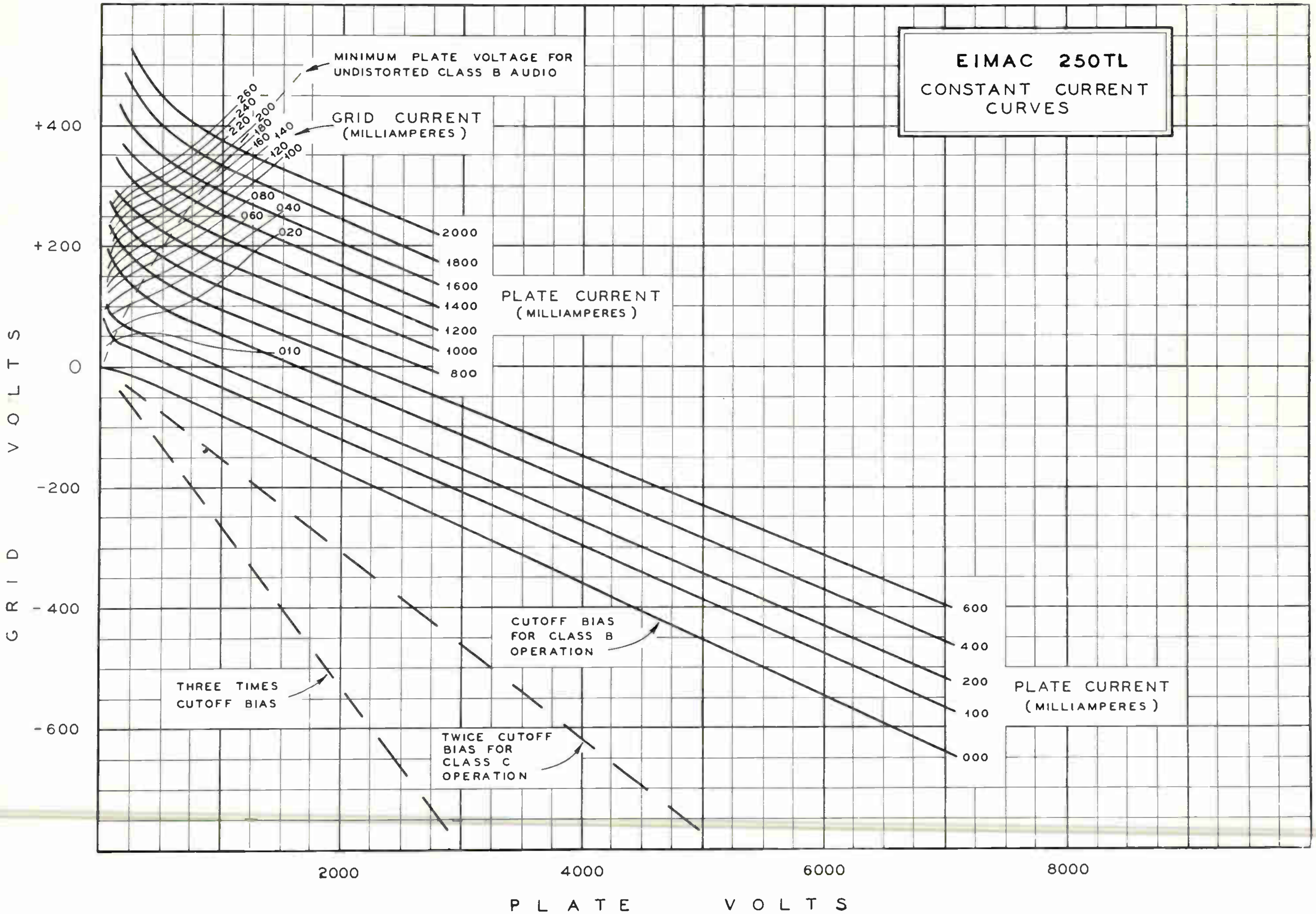
These impedances are recommended for maximum output with the minimum of distortion. They are chosen so that the tube is operated within its recommended ratings.

Plate Voltage	Load Impedance (Plate to Plate)	Power Output
3000	12,400 Ohms	1180 Watts
2500	8,800 Ohms	1000 Watts
2000	6,000 Ohms	900 Watts
1500	4,200 Ohms	630 Watts
1250	3,280 Ohms	540 Watts
1000	2,360 Ohms	350 Watts

Typical Operating Conditions Approved by the Federal Communications Commission for Broadcast Services

	High Level Modulated	Linear Amplifier	Grid Bias
Plate Volts	2750	3000	2000
Plate Current (milliamperes)	250	125	115
Efficiency	60%	33%	22%
Power Output (watts)	350	125	50

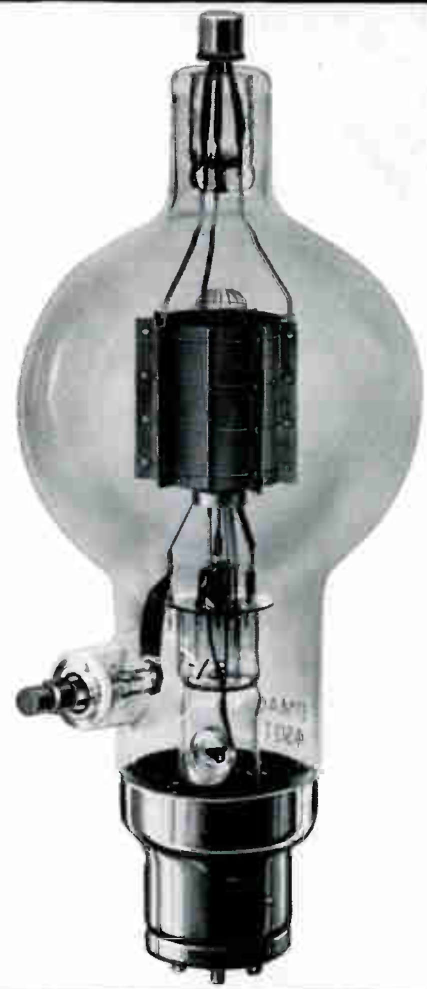
EITEL-McCULLOUGH, INC. San Bruno, California



EIMAC 250TL
CONSTANT CURRENT CURVES
MINIMUM PLATE VOLTAGE FOR UNDISTORTED CLASS B AUDIO
GRID CURRENT (MILLIAMPERES)
260
240
220
200
180
160
140
120
100
080
060
040
020
010
2000
1800
1600
1400
1200
1000
800
PLATE CURRENT (MILLIAMPERES)
600
400
200
100
000
PLATE CURRENT (MILLIAMPERES)
CUTOFF BIAS FOR CLASS B OPERATION
THREE TIMES CUTOFF BIAS
TWICE CUTOFF BIAS FOR CLASS C OPERATION
+400
+200
0
-200
-400
-600
GRID VOLTS
2000
4000
6000
8000
PLATE VOLTS

Eimac

450TH



THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC 450TH TUBE ONLY.

Look for the identifying mark (HI) on the filament stem of the tube.

A radiation cooled triode possessing unusual characteristics and extremely low interelectrode capacities. It is capable of a high order of audio frequency output when used in class "B" circuits. Useful outputs may be obtained on radio frequencies as high as 150 mc and it will operate at its full ratings on frequencies up to 40 mc.

Electrodes are fabricated of completely degassed tantalum; cathode of thoriated tungsten, is so designed that it possesses extremely long life and high thermionic efficiencies. New type grid and plate connectors minimize lead losses on the higher frequencies. Tantalum elements and the exclusive Eimac method of exhaust, makes unnecessary the use of a "getter." Because of this, 450TL is unconditionally guaranteed never to fail because of gas released internally.

Characteristics

Filament Voltage	7.5 to 7.7 Volts
Filament Current (approx.)	12 Amperes
Amplification Factor	30
Grid-Plate Capacity	4 mmfds.
Grid-Filament Capacity	4 mmfds.
Plate-Filament Capacity	.6 mmfds.
Bulb	GT 40 Nonex
Base	Standard (50 watt)
Overall Height	12½ Inches
Maximum Diameter	5 Inches

Tube must be operated vertically with ample ventilation provided.

Maximum Ratings for All Frequencies Less Than 40 Megacycles

Maximum Plate Voltage	6000 Volts
Maximum Plate Current	500 Milliamperes
Maximum Grid Current	125 Milliamperes
Continuous Plate Dissipation	450 Watts

Typical Operating Conditions for Class "C" Telephony

Plate Voltage	1500	2500	3500
Plate Current	300	400	400
Grid Current	100	100	100
Grid Bias Voltage	—125	—250	—375
Power Output (75%)	300	750	1100

Typical Operating Conditions for Class "C" Telegraphy

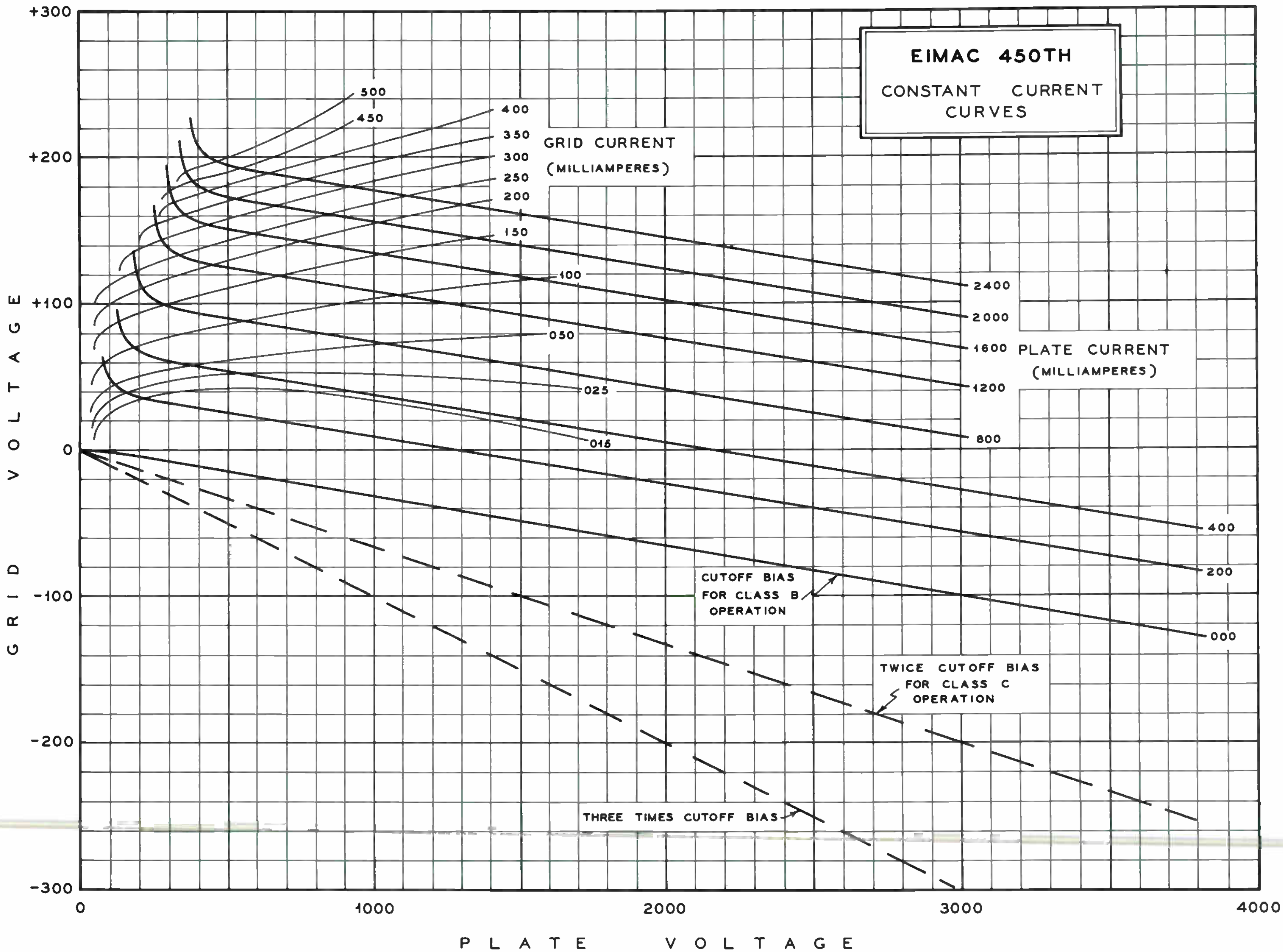
Plate Voltage	1500	2500	3500	4000
Plate Current (max.)	350	500	500	450
Grid Current (max.)	100	100	100	100
Grid Bias Voltage	—125	—250	—375	—400
Power Output (watts)	375	900	1300	1400

Class "B" Audio

Plate Voltage	Recommended Plate to Plate Impedance	Power Output
3500	10,000 Ohms	2000 Watts
3000	8,000 Ohms	1600 Watts
2500	7,200 Ohms	1250 Watts
2000	5,600 Ohms	1000 Watts

Typical Operating Conditions Approved by the Federal Communications Commission for Broadcast Services

	High Level Modulation	Linear Amplification	Grid Bias Modulation
Plate Volts	3000	3000	3500
Plate Current (milliamperes)	280	125	165
Efficiency	60%	33%	22%
Power Output (watts)	500	125	125



EIMAC 450TH
CONSTANT CURRENT CURVES
GRID CURRENT (MILLIAMPERES)
500
450
400
350
300
250
200
150
100
050
025
015
PLATE CURRENT (MILLIAMPERES)
2400
2000
1600
1200
800
400
200
000
CUTOFF BIAS FOR CLASS B OPERATION
TWICE CUTOFF BIAS FOR CLASS C OPERATION
THREE TIMES CUTOFF BIAS
GRID VOLTAGE
+300
+200
+100
0
-100
-200
-300
PLATE VOLTAGE
0
1000
2000
3000
4000

Eimac

450TL

THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC 450TL TUBE ONLY.

Look for the identifying mark (LO) on the filament stem of the tube.

A radiation cooled triode possessing unusual characeristics and extremely low interelectrode capacities. It is capable of a high order of audio frequency output when used in class "B" circuits. Useful outputs may be obtained on radio frequencies as high as 150 mc and it will operate at its full ratings on frequencies up to 40 mc.

Electrodes are fabricated of completely degassed tantalum; cathode of thoriated tungsten, is so designed that it possesses extremely long life and high thermionic efficiencies. New type grid and plate connectors minimize lead losses on the higher frequencies. Tantalum elements and the exclusive Eimac method of exhaust, makes unnecessary the use of a "getter." Because of this, 450TL is unconditionally guaranteed never to fail because of gas released internally.

Characteristics

Filament Voltage	7.5 to 7.7 Volts
Filament Current (approx.)	12 Amperes
Amplification Factor	16
Grid-Plate Capacity	4 mmfds.
Grid-Filament Capacity	4 mmfds.
Plate-Filament Capacity	.6 mmfds.
Bulb	GT 40 Nonex
Base	Standard (50 watt)
Overall Height	12½ Inches
Maximum Diameter	5 Inches

Tube must be operated vertically with ample ventilation provided.

Maximum Ratings for All Frequencies Less Than 40 Megacycles

Maximum Plate Voltage	6000 Volts
Maximum Plate Current	500 Milliamperes
Maximum Grid Current	75 Milliamperes
Continuous Plate Dissipation	450 Watts

Typical Operating Conditions for Class "C" Telephony

Plate Voltage	1500	2500	3500
Plate Current	300	400	400
Grid Current	65	65	65
Grid Bias Voltage	—250	—400	—600
Power Output (75%)	300	750	1100

Typical Operating Conditions for Class "C" Telegraphy

Plate Voltage	1500	2500	3500	4000
Plate Current (max.)	350	500	500	450
Grid Current (max.)	70	70	70	70
Grid Bias Voltage	—250	—400	—600	—700
Power Output (watts)	375	900	1300	1400

Class "B" Audio

Plate Voltage	Recommended Plate to Plate Impedance	Power Output
3500	10,000 Ohms	2000 Watts
3000	8,000 Ohms	1600 Watts
2500	7,200 Ohms	1250 Watts
2000	5,600 Ohms	1000 Watts

Typical Operating Conditions Approved by the Federal Communications Commission for Broadcast Services

	High Level Modulation	Linear Amplification	Grid Bias Modulation
Plate Volts	3000	3000	3500
Plate Current (milliamperes)	280	125	165
Efficiency	60%	33%	22%
Power Output (watts)	500	125	125

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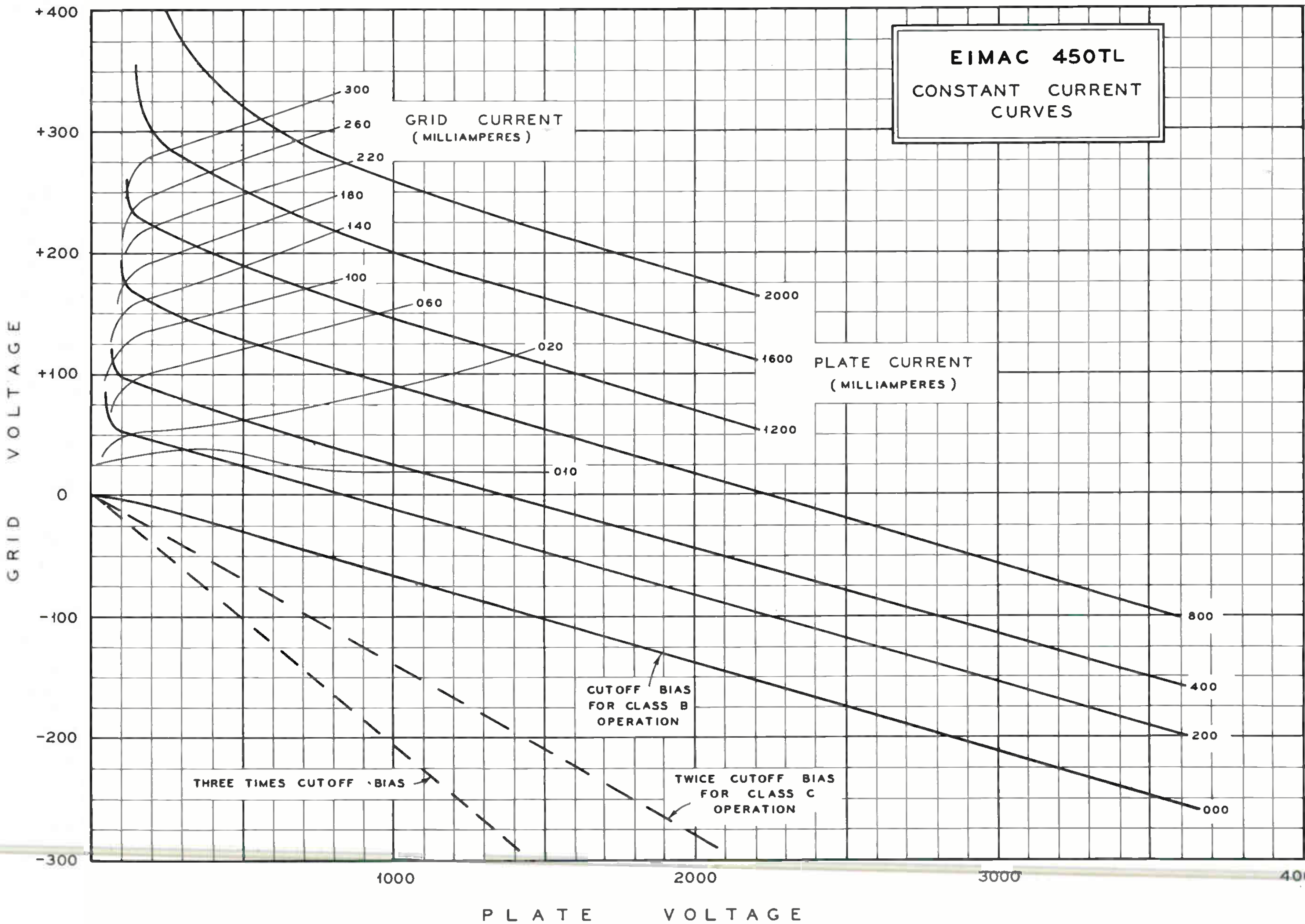
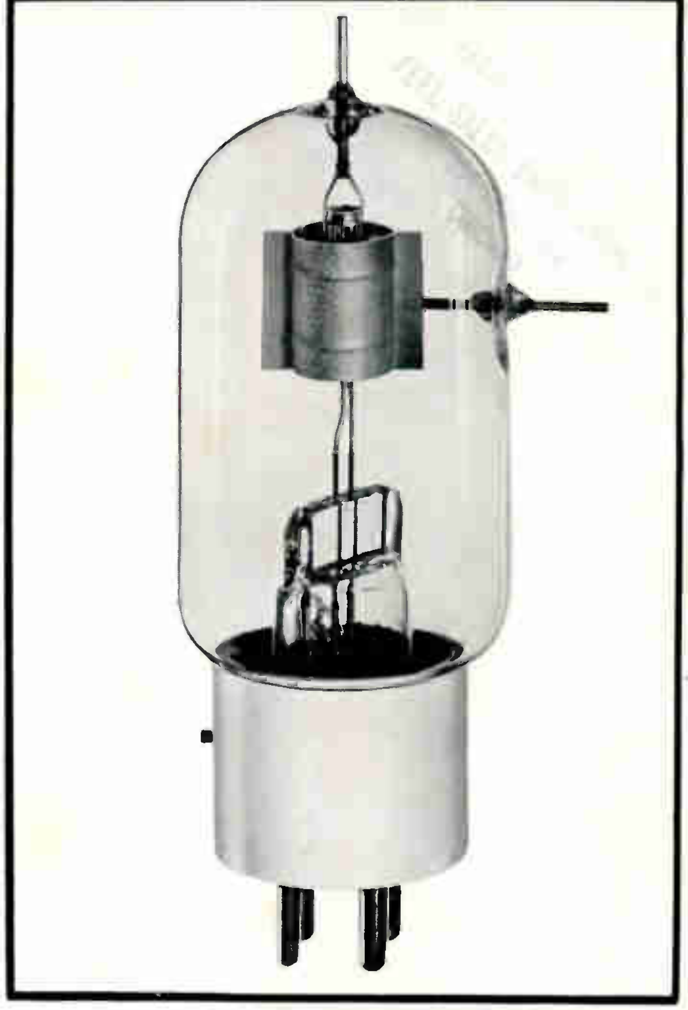

EIMAC 450TL
CONSTANT CURRENT CURVES
GRID CURRENT
(MILLIAMPERES)
300
260
220
180
140
100
060
020
010
PLATE CURRENT
(MILLIAMPERES)
2000
1600
1200
800
400
200
000
CUTOFF BIAS FOR CLASS B OPERATION
TWICE CUTOFF BIAS FOR CLASS C OPERATION
THREE TIMES CUTOFF BIAS
+400
+300
+200
+100
0
-100
-200
-300
GRID VOLTAGE
1000
2000
3000
4000
PLATE VOLTAGE

Eimac

UH35



THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC UH35 TUBE ONLY

This radiation cooled ultra high frequency tube has the lowest interelectrode capacities of any tube available today. Straight line construction provides short, heavy, high voltage leads thereby minimizing interelectrode capacities and increasing electrical efficiency. These short leads are taken from the elements directly through the glass envelop—grid at the top and plate at the side. Only the filament goes through the base.

Although small physically this tube has tremendous power capabilities. May be used in class "C" radio frequency or class "B" audio frequency amplifiers or as a crystal oscillator. Tantalum elements, fabricated and exhausted by an exclusive Eimac process, insure long life and trouble-free performance. Like all Eimac tubes, UH35 is unconditionally guaranteed against tube failures which result from gas released internally.

Characteristics

Filament Voltage	5 to 5.1 Volts
Filament Current (approx.)	4 Amperes
Amplification Factor	30
Base	Standard UX4 Prong
Overall Height	5½ Inches
Grid-Plate Capacity	1.6 mmfds.
Filament-Grid Capacity	1.4 mmfds.
Maximum Diameter	1¾ Inches

Tube must be operated vertically with ample ventilation provided. Seals must be cooled by Radiator Connectors.

Maximum Ratings

	Intermittent Service Telegraphy	Continuous Service Class "C" Telephony
Grid Current (milliamperes)	35	35
Plate Current (milliamperes)	150	125
Plate Dissipation (watts)	70	35
Plate Voltage	1500	1500

As frequency is increased circuit inefficiencies may necessitate a reduction of plate voltage or plate current so that maximum dissipation ratings are not exceeded.

Typical Operating Conditions for Class "C" Telephony

Plate Volts	750	1000	1500
Plate Current (milliamperes)	115	125	100
Grid Current (milliamperes)	35	30	30
Grid Bias (volts)	—60	—75	—120
Power Output (watts)	60	95	120

Excitation power roughly 1/10 the input power.

Typical Operating Conditions for Class "C" Telephony

Plate Volts	1000	1500
Plate Current (milliamperes)	150	150
Grid Current (milliamperes)	30	30
Grid Bias (volts)	—75	—120
Power Output (watts)	112	170

Plate is designed to operate at a cherry-red color on its normal dissipation rating of 35 watts. A perceptible red color is noted at 17 watts. These temperatures are perfectly permissible and no damage will result from such operation. The advantages of using the anode color as a tuning indicator will be readily appreciated as you become familiar with the UH35.

McCULLOUGH, INC. San Bruno, California

Eimac

UH51

THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC UH51 TUBE ONLY

Radiation cooled, ultra high frequency triode designed to replace conventional tubes similar to the Eimac UH50. Straight line construction provides a great improvement over the conventional tube types in that interelectrode capacities are extremely low and electrical efficiencies are greatly increased. Short, straight leads go from grid and plate directly through the glass bulb—grid at the top and plate through the side—thus providing the maximum of interelectrode insulation. The use of a rugged five-volt thoriated tungsten filament permits extra high power operation. Tantalum elements, specially treated by the exclusive Eimac process, insure long life and trouble-free performance. Like all Eimac tubes, UH51 is unconditionally guaranteed against tube failures caused by gas released internally.

Characteristics

Filament Voltage	5 Volts
Filament Current	6.5 Amperes
Amplification Factor	10.6
Grid-Plate Capacity	2.3 mmfds.
Grid-Filament Capacity	2.2 mmfds.
Maximum Plate Voltage	2000 Volts
Maximum Plate Current	175 Milliamperes
Plate Dissipation	50 Watts

Tube must be operated vertically with ample ventilation provided. Seals must be cooled by Radiator Connectors.

Maximum Ratings

	Intermittent Service Telegraphy Class "B" Audio	Continuous Service Class "C" Telephony
Grid Current (milliamperes)	25	25
Plate Current (milliamperes)	175	175
Plate Dissipation (watts)	50	50
Plate Voltage	2000	2000

As frequency is increased circuit inefficiencies may necessitate a reduction of plate voltage or plate current so that maximum dissipation ratings are not exceeded.

Typical Operating Conditions for Class "C" Telephony

Plate Volts	750	1000	1500
Plate Current (milliamperes)	115	150	165
Grid Current (milliamperes)	20	20	20
Grid Bias (volts	—200	—275	—400
Power Output (watts)	60	112	200

Excitation power roughly 1/10 the input power.

Typical Operating Conditions for Class "C" Telegraphy

Plate Volts	1000	1500	2000
Plate Current (milliamperes)	150	150	150
Grid Current (milliamperes)	20	20	20
Grid Bias (volts)	—275	—400	—500
Power Output (watts)	112	170	225

Plate is designed to operate at a cherry-red color on its normal dissipation rating of 50 watts. A perceptible red color is noted at 25 watts. These temperatures are perfectly permissible and no damage will result from such operation. The advantages of using the anode color as a tuning indicator will be readily appreciated as you become familiar with the UH51.

Eimac

RX21

MERCURY VAPOR RECTIFIER

THE Eimac RX21 is a mercury vapor rectifier tube having ratings and capabilities that place it in a field that was heretofore only covered by far more expensive tubes. The use of a tantalum plate, the high vacuum, and unique construction gives this tube unusually high inverse voltage capabilities.

CHARACTERISTICS

Filament Voltage	2.5 Volts
Filament Current	10. Amperes
Peak Inverse Voltage	11,000 Volts
Peak Plate Current	3. Amperes

OPERATING DATA

Using a reasonable input choke to the filter, a pair of RX21 tubes will supply a D.C. output power of 3500 volts at 1.5 amperes in a conventional full wave circuit. With condenser input to the filter the current output should be reduced to .9 amperes.

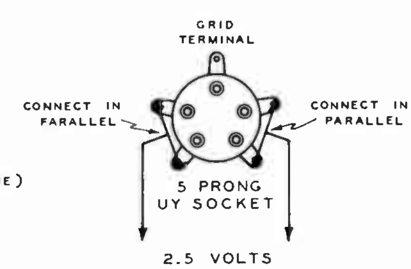
Operating temperature must be maintained between 20°C and 60°C (65°-140°F). If the mercury temperature is too low the operation of the RX21 is seriously impaired. Under ordinary conditions the cathode will bring about the proper operating temperature after a warm up period of approximately 60 seconds. During warm weather this warm up period may be shorter. The reverse is true during cold weather. Under conditions where the tubes are to be operated in extremely cold or extremely warm temperatures some artificial method of maintaining proper temperature must be provided. Tubes should not be placed in confined spaces where the free circulation of air is impeded.

BASE

The base of the RX21 fits a standard five-prong socket. In order to carry the ten amperes current required by the tube the adjacent pins have been connected in parallel within the base. Similar connections should be made on the sockets.

SOCKET CONNECTIONS

(PLATE TERMINAL IS CAP ON TUBE)



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Eimac

KY21

GRID CONTROL
MERCURY VAPOR
RECTIFIER

THE Eimac KY21 tube is a mercury vapor tube to which has been added a control electrode or grid. The control electrode prevents passage of current through the tube until the negative potential on the grid reaches a certain minimum critical value. The grid will not regain control until after the voltage existing between filament and anode has reached approximately zero. If the grid remains slightly negative in respect to the cathode but not sufficient to prevent the passage of anode current it will be found that the anode current does not start over the initial portion of the cycle. These characteristics make possible the use of the KY21 tube as both a rectifier and power control tube. The KY21 tube permits of the control of 5 kilowatts of power (3500 volts at 1.5 amperes) at the highest possible speeds found in manually keyed transmitters. The control power is negligible and can be either supplied by means of D.C. or tone. Properly used, the KY21 tubes effectively eliminate "key clicks," permitting high power operation in congested areas.

CHARACTERISTICS

Filament Voltage	2.5	
Filament Current	10	Amperes
Peak Inverse Voltage	11,000	Volts
Peak Plate Current	3	Amperes

OPERATING DATA—Using a reasonable input choke to the filter, a pair of KY21 tubes will supply a D.C. output power of 3500 volts at 1.5 amperes in a conventional full wave circuit. With condenser input to the filter the current output should be reduced to .9 amperes. Operating temperatures must be maintained between 20°C and 60°C (65°F-140°F). If the mercury temperature is too low the operation of the KY21 is seriously impaired. Under ordinary conditions the cathode will bring about the proper operating temperature after a warm up period of approximately 60 seconds. During warm weather this warm up period may be shorter or the reverse true during cold weather. Under conditions where the transmitter is to be operated in extremely cold or extremely warm temperatures some artificial method of maintaining proper temperature must be provided. Tubes should not be placed in confined spaces where the free circulation of air is impeded.

FILTER—Keying is effected before the power supply filter. If the filter is excessively large, "tails" may appear on the keyed signal due to the time constant of the filter. The less filter that is used the "faster" it is possible to key the transmitter. Good "T9X" signals will usually result from a filter consisting of an 8 to 10 henry choke followed by a ½ to 2 mfd condenser. Keying will be "excellent" for all manual speeds with this filter. Resonant filters are becoming increasingly popular and make an ideal arrangement to use with the KY21 tubes. Rough signals are usually caused by "parasitic oscillations" or other form of maladjustment of the amplifier or preceding equipment.

GRID CIRCUIT—The KY21 tubes are prevented from conducting by placing a negative potential on the grid. The ratio of control voltage to D.C. plate voltage varies from about 55:1 at 1000 volts to 67:1 at 3500 volts. The use of slightly higher than the minimum voltage for cut off is recommended. For keying circuits it is usually more convenient to supply 100 to 150 volts of bias from a small pack. This voltage is satisfactory for all plate voltages.

Extreme care must be exercised in preventing radio frequency and magnetic fields from entering the rectifying circuit, as the ability of the tubes to "cut off" is very materially affected under such conditions.

CIRCUITS—One method of using the KY21 tube is shown on the back of this sheet. There are many other methods whereby the same results can be obtained. KY21 tubes can be used in a bridge circuit in conjunction with other ordinary mercury vapor rectifier tubes such as the RX21. Two tubes in the circuit must have control grids. As the D.C. output voltage is doubled, it is essential that twice the control bias voltage be used.

The KY21 tubes work exceptionally well in polyphase circuits. In a three phase full wave circuit only three tubes must be KY21 tubes. KY21 tubes will key up to 100 words a minute with this arrangement.

BASE—The base of the KY21 tube fits a standard five-prong socket. In order to carry the ten ampere current required by the tube, the adjacent pins have been connected in parallel within the tube base. Similar connections should be made on the socket. The odd pin connects to the grid.

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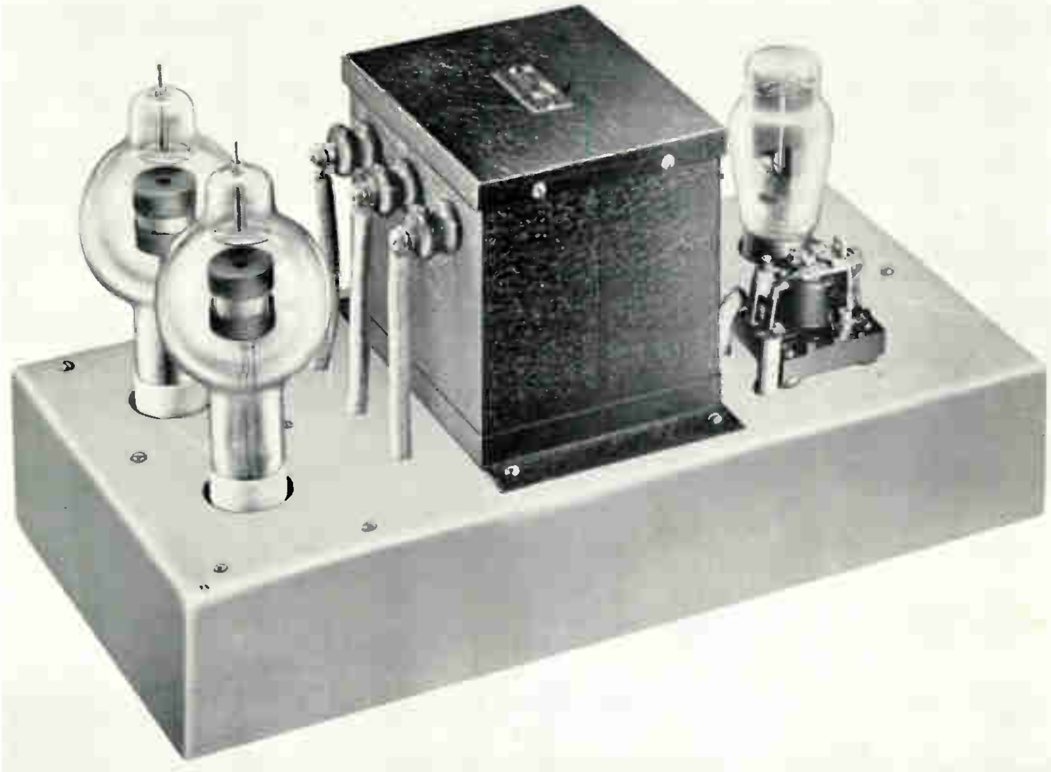
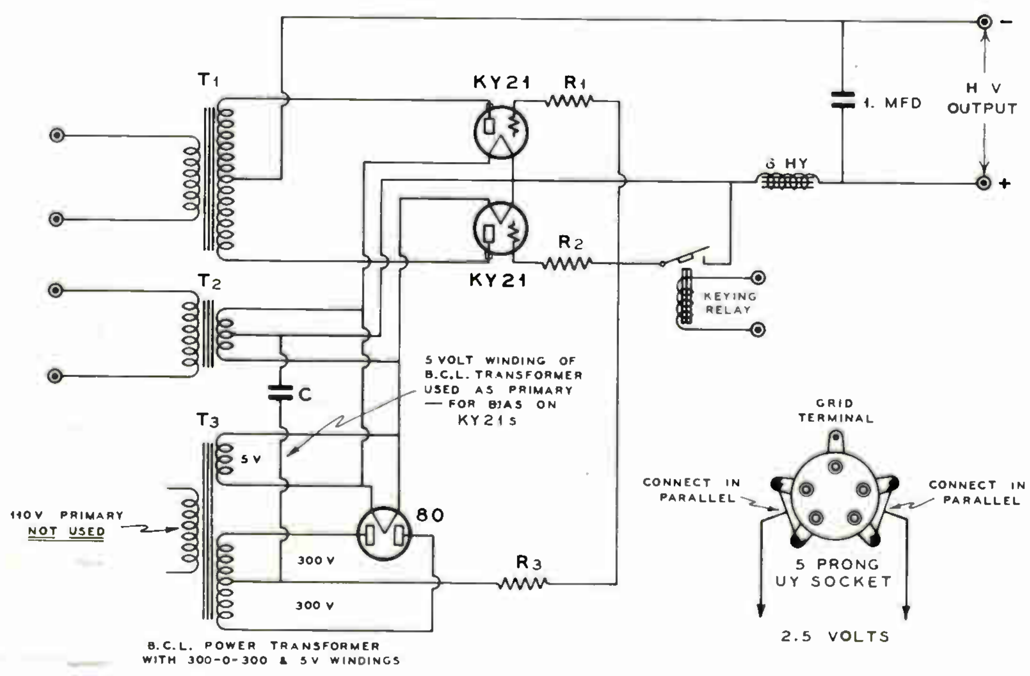


A TYPICAL KEYING-RECTIFIER SET-UP AS USED AT ONE AMATEUR STATION

The circuit is self explanatory. KY21 tubes are prevented from conducting by means of bias voltage obtained from a small "pack" supply which consists of a small BCL power transformer, an '80 rectifier tube, and a ½ mfd filter condenser. In order to utilize commercially available transformer without the expense of special insulation between windings the whole transformer is isolated from ground by insulating the transformer for plate voltage from the metal chassis. The 110 volt primary is not used as the energising voltage is obtained from the already well insulated secondary of the filament transformer. The '80 rectifier tube is lighted by voltage taken directly from the same windings. If a 2½ volt filament transformer is used an '82 could be used. The relay which short circuits the bias voltage must have its armature insulated for plate voltage to ground. The relay used is a converted Ward Leonard 507-507 but this firm is now making a relay specifically for the job and will be known as 507-516. The resistors shown are 1 watt and can vary from 50,000 ohms to ¼ megohm. The power necessary from the bias supply is zero when the key is up and is about ½ mill when the key is down if ¼ megohm resistors are used. The bias voltage necessary is 100 volts or so, though there is no objection to the use of higher values up to 300 volts.

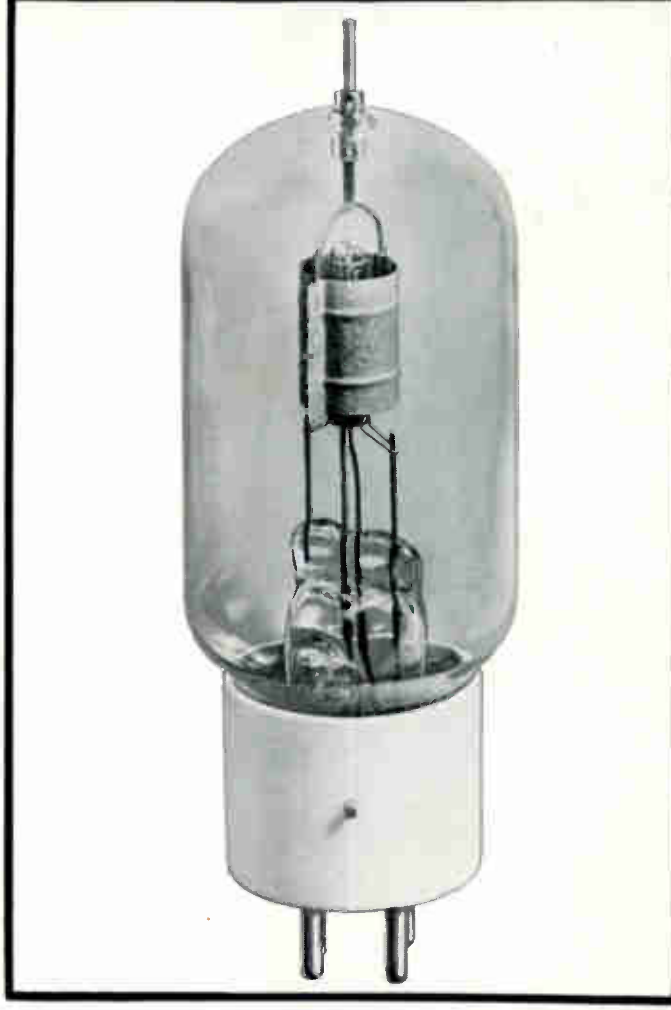
T1 Plate Supply Transformer. T2 Filament transformer for Rectifier. T3 Small BCL transformer. R1, R2, R3 50,000 ohms to ¼ megohm. Relay Insulated for plate Voltage. C ½ mfd 400 volt.



KY21 SOCKET CONNECTIONS
(PLATE TERMINAL IS CAP ON TUBE)

Eimac

35T



THE DATA CONTAINED IN THIS BULLETIN IS APPLICABLE TO THE EIMAC 35T TUBE ONLY

Despite its small physical size this tube has tremendous power capabilities. Excellent electrical characteristics and extremely low interelectrode capacities make it one of the most versatile triodes available today. As a crystal oscillator, frequency multiplier, ultra high frequency oscillator or amplifier, class "C" radio frequency or class "B" audio amplifier no tube of like power ratings can equal it. Tantalum elements, fabricated and exhausted by the exclusive Eimac process, elimination of the "getter" and proper insulation between the electrodes make it possible for Eimac to guarantee this tube, unconditionally, against failure as a result of gas released internally.

Characteristics

Filament Voltage	5 to 5.1 Volts
Filament Current (approx.)	4 Amperes
Amplification Factor	30
Base	Standard UX4 Prong
Overall Height	5½ Inches
Grid-Plate Capacity	1.9 mmfds.
Maximum Diameter	1¾ Inches

Tube must be operated vertically with ample ventilation provided.

Maximum Ratings on Frequencies Up to 100MC

	Intermittent Service Telegraphy Class "B" Audio	Continuous Service Class "C" Telephony
Grid Current (milliamperes)	35	35
Plate Current (milliamperes)	150	125
Plate Dissipation (watts)	70	35
Plate Voltage	2000	2000

Typical Operating Conditions for Class "C" Telephony

Plate Volts	750	1000	1500
Plate Current (milliamperes)	115	125	100
Grid Current (milliamperes)	35	30	30
Grid Bias (volts)	—60	—75	—120
Power Output (watts)	60	95	120

Excitation power roughly 1/10 the input power.

Typical Operating Conditions for Class "C" Telegraphy

Plate Volts	1000	1500	2000
Plate Current (milliamperes)	150	150	150
Grid Current (milliamperes)	30	30	30
Grid Bias (volts)	—75	—120	—150
Power Output (watts)	112	170	225

Class "B" Audio Performance [Two tubes]

Plate Voltage	Bias Voltage	Plate to Plate Load Impedance (ohms)	Power Output (watts)
500	0	2800	60
750	0	6000	100
1000	—22	7200	150
1250	—30	9600	200
1500	—40	12800	230

Plate is designed to operate at a cherry-red color on its normal dissipation rating of 35 watts. A perceptible red color is noted at 17 watts and a real bright red at 70 watts. These temperatures are perfectly permissible and no damage will result from such operation. The advantages of using the anode color as a tuning indicator will be readily appreciated as you become more familiar with the Eimac 35T.

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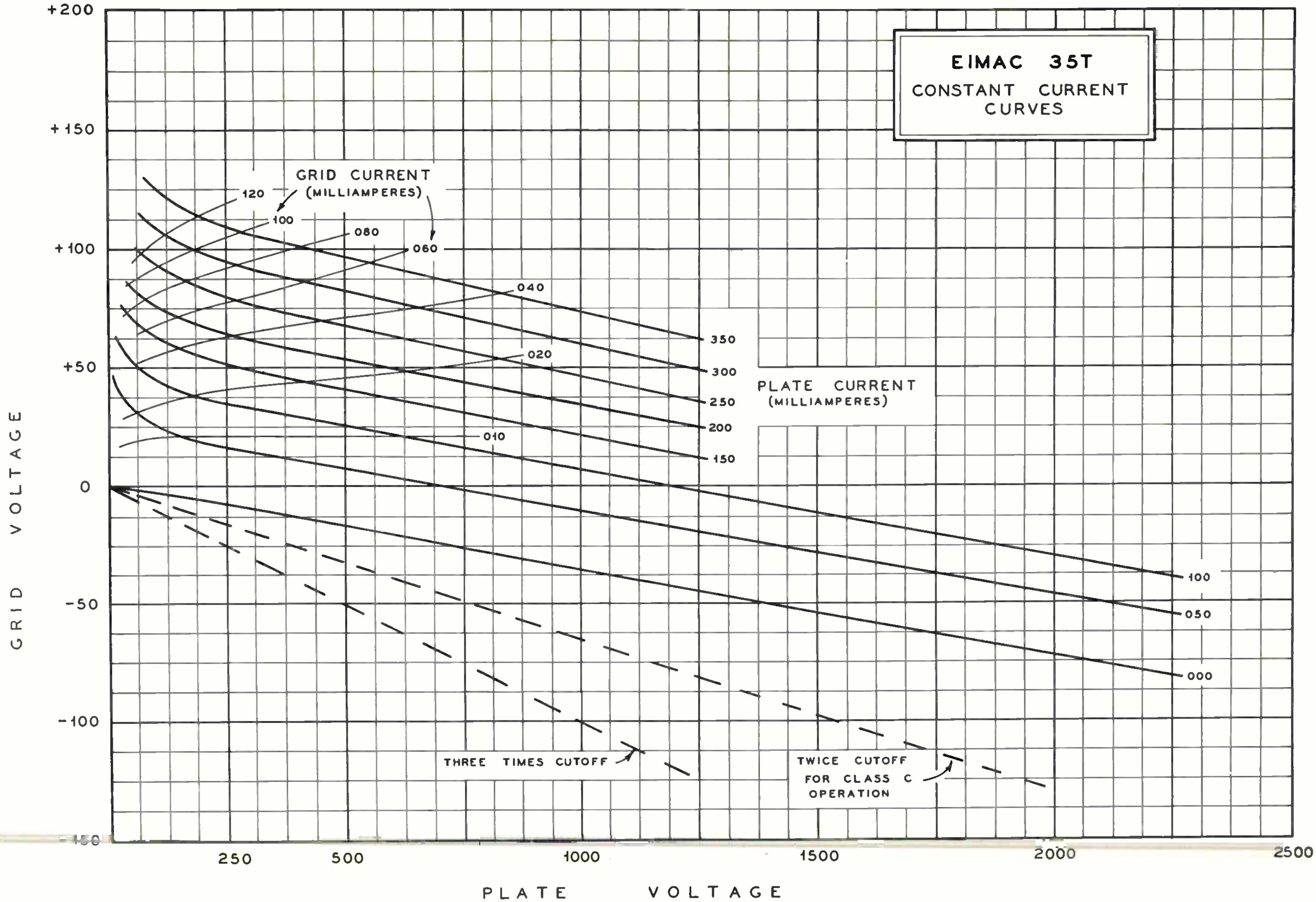
EIMAC 35T
CONSTANT CURRENT CURVES
GRID CURRENT (MILLIAMPERES)
120
100
080
060
040
020
010
PLATE CURRENT (MILLIAMPERES)
350
300
250
200
150
100
050
000
THREE TIMES CUTOFF
TWICE CUTOFF FOR CLASS C OPERATION
+200
+150
+100
+50
0
-50
-100
-150
250
500
1000
1500
2000
2500
GRID VOLTAGE
PLATE VOLTAGE