Transmitting Tubes

RCA TUBE
HANDBOOK
HB-3

TRANSMITTING TUBE SECTION

This Section contains data on vacuum power tubes, rectifier tubes, magnetrons, and other tube types used in broadcast, television, and communications transmitters, as well as in other types of electronic equipment handling appreciable power.

For further Technical Information, write to Commercial Engineering, Tube Division, Radio Corporation of America, Harrison, N. J.

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The *Maximum Ratings* shown are for Continuous Commercial Service, unless otherwise shown.

a Intermittent Commercial and Amateur Service ratings are also shown in data.

b Typical power output is for two tubes, except for twin-unit types.

c Cermolox type is a beam power tube with precision-aligned grids, unitized electrode-and-terminal in coaxial configuration, and ceramic-metal construction.

Cooling	Name
C - Conduction	BPT - Beam Power Tube
	CT - Beam Power Tube—Cermolox Type[c]
FA - Forced-Air	P - Pentode
	PP - Twin Pentode
	T - Triode
N - Natural	TBPT - Twin Beam Power Tube
	TP - Triode Pentode
	TR - Tetrode
L - Liquid (See Data)	TT - Twin Triode
	TTR - Twin Tetrode

Typical Operation Power Output Approx. Watts	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings Volts	Max. Plate Ratings Dissipation Watts
Class A Amplifiers, AF						
-	**6F4**[t]	6.3	N	T	150	2
-	**958A**[t]	1.25	N	T	135	0.6
-	**5718**[t]	6.3	N	T	165	3.3
-	**7060**[t]	12-15	N	TP	300	3
0.135	**955**[t]	6.3	N	T	250	1.6
0.333	**3A5**[t]	1.4/2.8	N	TT	135	0.5
0.6	**5556**	4.5	N	T	350	7.5
1.4	**5618**	3/6	N	P	300	5
2.7	**5686**[t]	6.3	N	BPT	275	8.25
3	**1619**	2.5	N	BPT	400	15
Class A Amplifiers, AF (cont'd)						
3.8	**801A**	7.5	N	T	600	20
3.9	**2E24**	6.3[d]	N	BPT	300	10
6.5[a]	**802**	6.3	N	P	500	-
30	**845**	10	N	T	1250	100
Class AB_1 Amplifiers, AF[b]						
15[a]	**807**	6.3	N	BPT	400	25[e]
15[a]	**1625**	12.6	N	BPT	400	25[e]
17.5	**1619**	2.5	N	BPT	400	15
20.5[a]	**7551**[t]	12-15	N	BPT	300	10
20.5[a]	**7558**[t]	6.3	N	BPT	300	10
22[a]	**6146**	6.3	N	BPT	400	20[e]
22[a]	**6146W/7212**	6.3	N	BPT	400	20[e]
22[a]	**6159**	26.5	N	BPT	400	20[e]
22[a]	**6159W/7357**	26.5	N	BPT	400	20[e]
22[a]	**6883**	12.6	N	BPT	400	20[e]
22[a]	**7212**	6.3	N	BPT	400	20[e]
22[a]	**7357**	26.5	N	BPT	400	20[e]
22[a]	**8032**	13.5	N	BPT	400	20[e]
26.5[a]	**1614**[t]	6.3	N	BPT	375	21
40[a]	**2E26**	6.3	N	BPT	600	10
40[a]	**6893**	12.6	N	BPT	600	10
44	**829B**	6.3/12.6	N	TBPT	750	30
56[a]	**807**	6.3	N	BPT	600	25
56[a]	**1625**	12.6	N	BPT	600	25
80	**6816**	6.3	FA	CT	1000	115
80	**6884**	26.5	FA	CT	1000	115
80	**7457**	6.3	FA	CT	1000	115

d Quick filament-heating type.

e Triode connection, grid No. 2 connected to plate.

t Data for this type located in *Receiving-Type Industrial Tubes* Section.

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Typical Operation: Power Output Approx. Watts	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class AB_1 Amplifiers, AF[b] (cont'd)						
80	**7842**	6.3	C	CT	1000	-
80	**7843**	26.5	C	CT	1000	-
80	**7844**	6.3	C	CT	600	-
82[a]	**6146**	6.3	N	BPT	600	20
82[a]	**6146W/ 7212**	6.3	N	BPT	600	20
82[a]	**6159**	26.5	N	BPT	600	20
82[a]	**6159W/ 7357**	26.5	N	BPT	600	20
82[a]	**6883**	12.6	N	BPT	600	20
82[a]	**7212**	6.3	N	BPT	600	20
82[a]	**7357**	26.5	N	BPT	600	20
82[a]	**8032**	13.5	N	BPT	600	20
115	**845**	10	N	T	1250	100
190[a]	**7271**	13.5	FA	BPT	1100	60
300[a]	**828**	10	N	BPT	1750	70
345	**6155/ 4-125A**	5	FA	BPT	3000	125
380[a]	**813**	10	N	BPT	2250	100
410[a]	**7094**	6.3	FA	BPT	1500	100
580	**7034/ 4X150A**	6	FA	BPT	2000	250
580	**7035/ 4X150D**	26.5	FA	BPT	2000	250
590	**7203/ 4CX250B**	6	FA	BPT	2000	250
590	**7204/ 4CX250F**	26.5	FA	BPT	2000	250
635	**6156/ 4-250A**	5	FA	BPT	4000	250
1600	**7650**	6.3	FA	CT	3000	600

[d] Quick filament-heating type.

Typical Operation: Power Output Approx. Watts	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class AB_2 Amplifiers, AF[b]						
36	**1619**	2.5	N	BPT	400	15
40[a]	**6524**	6.3	N	TBPT	500	20
40[a]	**6850**	12.6	N	TBPT	500	20
42[a]	**2E24**	6.3[d]	N	BPT	400	10
42[a]	**2E26**	6.3	N	BPT	600	10
42[a]	**815**	6.3/ 12.6	N	TBPT	400	20
42[a]	**6893**	12.6	N	BPT	600	10
72	**1624**	2.5	N	BPT	600	25
80[a]	**807**	6.3	N	BPT	600	25
80[a]	**1625**	12.6	N	BPT	600	25
90[a]	**6146**	6.3	N	BPT	600	20
90[a]	**6146W/ 7212**	6.3	N	BPT	600	20
90[a]	**6159**	26.5	N	BPT	600	20
90[a]	**6159W/ 7357**	26.5	N	BPT	600	20
90[a]	**6883**	12.6	N	BPT	600	20
90[a]	**7212**	6.3	N	BPT	600	20
90[a]	**7357**	26.5	N	BPT	600	20
90[a]	**8032**	13.5	N	BPT	600	20
140	**6816**	6.3	FA	CT	1000	115
140	**6884**	26.5	FA	CT	1000	115
140	**7457**	6.3	FA	CT	1000	115
140	**7842**	6.3	C	CT	1000	-
140	**7843**	26.5	C	CT	1000	-
140	**7844**	6.3	C	CT	1000	-
550	**6155/ 4-125A**	5	FA	BPT	3000	125
630	**7034/ 4X150A**	6	FA	BPT	2000	250

Typical Operation Power Output Approx. Watts	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings Volts	Max. Plate Ratings Dissipation Watts
Class AB_2 Amplifiers, AF[b] (cont'd)						
630	**7035/ 4X150D**	26.5	FA	BPT	2000	250
1240	**6156/ 4-250A**	5	FA	BPT	4000	250
Class B Amplifiers, AF[b]						
45	**801A**	7.5	N	T	600	20
105[a]	**809**	6.3	N	T	750	25
175	**830B**	10	N	T	1000	60
235[a]	**811A**	6.3	N	T	1250	45
235[a]	**812A**	6.3	FA	T	1250	45
250[a]	**8005**	10	N	T	1250	75
260	**838**	10	N	T	1250	100
370	**805**	10	N	T	1500	125
590[a]	**810**	10	N	T	2500	125
600[a]	**8000**	10	N	T	2500	125
1640	**5786**	11	FA	T	4000	600
1650[a]	**833A**	10	N	T	3000	300
2400[a]	**833A**	10	FA	T	4000	400
8800	**5762/ 7C24**	12.6	FA	T	6200	3000
8800	**5762A**	12.6	FA	T	6200	4000
10000	**891R**	22	FA	T	10000	3500
10500	**892R**	22	FA	T	12500	4000
15000	**889A**	11	L	T	8500	5000
15000	**889RA**	11	FA	T	8500	5000
22000	**891**	22	L	T	15000	5000
22000	**892**	22	L	T	15000	7500
22500	**207**	22	L	T	15000	7500
46000	**880**	12.6	L	T	10500	15000
50000	**9C25**	6	FA	T	11500	17500

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Typical Operation Power Output Approx. Watts	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings Volts	Max. Plate Ratings Dissipation Watts
Class B Amplifiers, AF[b] (cont'd)						
55000	**5771**	7.5	L	T	12500	22500
61000	**9C21**	19.5	L	T	15000	40000
61000	**9C22**	19.5	FA	T	15000	20000
100000	**5671**	11	FA	T	15000	25000
117000	**5770**	11	L	T	15000	50000
Class B Amplifiers, RF Telephony						
2	**5556**	4.5	N	T	350	10
3.5[a]	**802**	6.3	N	P	500	10
7.5	**801A**	7.5	N	T	600	20
10.5[a, f]	**815**	6.3/ 12.6	N	TBPT	400	20
12.5[a]	**807**	6.3	N	BPT	600	25
12.5[a]	**809**	6.3	N	T	750	25
12.5[a]	**1625**	12.6	N	BPT	600	25
16[a]	**804**	7.5	N	P	1250	40
20	**834**	7.5	N	T	1250	50
25[a]	**814**	10	N	BPT	1250	50
26	**830B**	10	N	T	1000	60
36[a]	**828**	10	N	BPT	1250	70
40	**860**	10	N	TR	3000	100
40[a]	**8005**	10	N	T	1250	75
42.5	**838**	10	N	T	1250	100
50[a]	**813**	10	N	BPT	2000	100
53	**803**	10	N	P	2000	125
57.5	**805**	10	N	T	1500	125
58	**6155/ 4-125A**	5	FA	BPT	3000	125
60[a]	**810**	10	N	T	2000	125
65[a]	**8000**	10	N	T	2000	125
126	**6156/ 4-250A**	5	FA	BPT	4000	250

[f] Both sections.

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Typical Operation: Power Output Approx. Watts	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class B Amplifiers, RF Telephony (cont'd)						
150[a]	**833A**	10	N	T	3000	300
225[a]	**833A**	10	FA	T	4000	400
400	**827R**	7.5	FA	BPT	3500	800
1800	**892R**	22	FA	T	12500	4000
2000	**889A**	11	L	T	8500	5000
2000	**889RA**	11	FA	T	8500	5000
4000	**207**	22	L	T	15000	10000
4000	**892**	22	L	T	15000	10000
9000	**880**	12.6	L	T	10500	20000
10000	**9C25**	6	FA	T	11500	17500
12000	**5771**	7.5	L	T	12500	22500

Typical Operation: Power Output Approx. Watts	Typical Operation: Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class B Amplifiers, Television Service							
230	900	**6161**	6.3	FA	T	1600	250
250	216	**7034/ 4X150A**	6	FA	BPT	1250	250
250	216	**7035/ 4X150D**	26.5	FA	BPT	1250	250
440	216	**7203/ 4CX250B**	6	FA	BPT	2000	250
440	216	**7204/ 4CX250F**	26.5	FA	BPT	2000	250
1200	900	**6181**	120	FA	BPT	2000	2000

[f] Both sections.
[t] Data for this type located in *Receiving-Type Industrial Tubes* Section.

Typical Operation: Power Output Approx. Watts	Typical Operation: Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class B Amplifiers, Television Service (cont'd)							
4000	216	**5762/ 7C24**	12.6	FA	T	3700	3000
6350	216	**5762A**	12.6	FA	T	4500	4000
12000	216	**6166**	5	FA	BPT	6000	10000
12000	800	**6448**	1.35	L	BPT	7000	26000
14000	216	**6166A/ 7007**	5	FA	BPT	7500	12000
19000	800	**6806**	1.35	L	BPT	9000	36000
Class C Amplifiers, Plate-Modulated RF Telephony							
-	-	**4037**	6.3	N	T	275	4.25
-	-	**5876**	6.3	N	T	275	4.25
-	-	**5876A**	6.3	N	T	275	4.25
1.7	3000	**7801**	12.6	C	CT	750	-
1.7	3000	**7870**	6.3	C	CT	750	-
3.5[a]	500	**6939**[t]	6.3/ 12.6	N	PP	200	4
4	-	**5556**	4.5	N	T	350	7
5.5[a]	500	**5893**	6	N	T	260	5
6	-	**1613**	6.3	N	P	275	7
6.4[a]	30	**5763**	6	N	BPT	250	8
6.4[a]	30	**6417**	12.6	N	BPT	250	8
6.5[a]	175	**7551**[t]	13.5	N	BPT	250	7
6.5[a]	175	**7558**[t]	6.3	N	BPT	250	7
6.5	175	**7905**[t]	6.3	N	BPT	250	7
6.7[a]	500	**6263**	6	N	T	275	5.5
6.7[a]	500	**6263A**	6	N	T	275	5.5
8[a]	-	**802**	6.3	N	P	400	6.7
9[a,f]	462	**6524**	6.3	N	TBPT	400	13.5
9[a,f]	462	**6580**	12.6	N	TBPT	400	13.5
11	-	**837**	12.6	N	P	400	8

Typical Operation Power Output Approx. Watts	Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings Volts	Dissipation Watts
Class C Amplifiers, Plate-Modulated RF Telephony (cont'd)							
11.5[a]	-	**1614**	6.3	N	BPT	325	14[e]
13	-	**1619**	2.5	N	BPT	325	10
13.5[a]	-	**2E24**	6.3[d]	N	BPT	400	6.7
13.5[a]	-	**2E26**	6.3	N	BPT	400	6.7
13.5[a]	-	**6893**	12.6	N	BPT	400	6.7
15	-	**1614**	6.3	N	BPT	325	14
17[a,f]	-	**832A**	6.3/ 12.6	N	TBPT	600	10
17	400	**7801**	12.6	C	CT	750	-
17	400	**7870**	12.6	C	CT	750	-
18	-	**801A**	7.5	N	T	500	13.5
24	-	**1624**	2.5	N	BPT	500	16.5
28[a]	-	**807**	6.3	N	BPT	475	16.5
28[a]	-	**1625**	12.6	N	BPT	475	16.5
30[a,f]	-	**815**	6.3/ 12.6	N	TBPT	325	13.5
34[a]	-	**6146**	6.3	N	BPT	480	13.3
34[a]	-	**6146W/ 7212**	6.3	N	BPT	480	13.3
34[a]	-	**6159**	26.5	N	BPT	480	13.3
34[a]	-	**6159W/ 7357**	26.5	N	BPT	480	13.3
34[a]	-	**6883**	12.6	N	BPT	480	13.3
34[a]	60	**7212**	6.3	N	BPT	480	13.3
34[a]	60	**7357**	26.5	N	BPT	480	13.3
34[a]	60	**8032**	13.5	N	BPT	480	13.3
38[a]	-	**809**	6.3	N	T	600	17.5
45	400	**6816**	6.3	FA	CT	800	75
45	400	**6884**	26.5	FA	CT	800	75
45	400	**7457**	6.3	FA	CT	800	75
45	400	**7842**	6.3	C	CT	800	-

[d] Quick filament-heating type.

Typical Operation Power Output Approx. Watts	Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings Volts	Dissipation Watts
Class C Amplifiers, Plate-Modulated RF Telephony (cont'd)							
45	400	**7843**	26.5	C	CT	800	-
45	400	**7844**	6.3	C	CT	800	-
50[a]	-	**804**	7.5	N	P	1000	27
50[a,f]	-	**829B**	6.3/ 12.6	N	TBPT	600	21
50	-	**830B**	10	N	T	800	40
58	-	**834**	7.5	N	T	1000	35
65	1000	**5588**	6.3	FA	T	800	130
70[a,f]	-	**829B**	6.3/ 12.6	FA	TBPT	600	28
85[a]	-	**812A**	6.3	N	T	1000	30
87[a]	-	**814**	10	N	BPT	1000	34
88[a]	-	**811A**	6.3	N	T	1000	30
90[a]	60	**7271**	13.5	FA	BPT	900	40
100[a]	-	**828**	10	N	BPT	1000	47
100	-	**838**	10	N	T	1000	67
105	-	**860**	10	N	TTR	2000	67
115[a]	-	**8005**	10	N	T	1000	50
120	900	**6161**	6.3	FA	T	1300	167
140	-	**805**	10	N	T	1250	85
155	-	**803**	10	N	P	1600	85
180[a]	60	**7094**	6.3	FA	BPT	1000	67
180[a]	-	**813**	10	FA	BPT	1600	67
230	150	**7034/ 4X150A**	6	FA	BPT	1600	165
230	150	**7035/ 4X150D**	26.5	FA	BPT	1600	165
235	175	**7203/ 4CX250B**	6	FA	BPT	1500	165
235	175	**7204/ 4CX250F**	26.5	FA	BPT	1500	165

[e] Triode connection, grid No. 2 connected to plate.
[f] Both sections.

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Typical Operation: Power Output Approx. Watts	Typical Operation: Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class C Amplifiers, Plate-Modulated RF Telephony (cont'd)							
250[a]	-	**810**	10	N	T	1600	85
250[a]	-	**8000**	10	N	T	1600	85
300	-	**6155/ 4-125A**	5	FA	BPT	2500	83
510	-	**6156/ 4-250A**	5	FA	BPT	3200	165
600	400	**7650**	6.3	FA	CT	2000	400
635	-	**833A**	10	N	T	2500	200
800	600	**7213**	5.5	FA	CT	2000	1000
810	-	**5786**	11	FA	T	2500	400
825	-	**827R**	7.5	FA	BPT	3000	550
950	400	**6181**	120	FA	BPT	1600	1300
1000	-	**833A**	10	FA	T	3000	270
4000	-	**889A**	11	L	T	6000	3000
4000	-	**889RA**	11	FA	T	6000	3000
4200	30	**5762/ 7C24**	12.6	FA	T	5000	2000
4200	30	**5762A**	12.6	FA	T	5000	2700
4500	900	**6448**	1.35	L	BPT	4500	16500
5000	-	**892R**	22	FA	T	10000	2500
5500	60	**6166**	5	FA	BPT	5000	6600
6000	-	**207**	22	L	T	10000	6600
6000	-	**892**	22	L	T	10000	6600
6000	60	**6166A/ 7007**	5	FA	BPT	5500	8000
10000	400	**6806**	1.35	L	BPT	5500	17000
18000	-	**9C25**	6	FA	T	9000	11500
27000	-	**880**	12.6	L	T	10500	12000
29000	-	**5771**	7.5	L	T	10000	15000
38000	-	**9C21**	19.5	L	T	12500	28000
38000	-	**9C22**	19.5	FA	T	12500	14000
40000	1.6	**5671**	11	FA	T	12500	17000
45000	-	**5770**	11	L	T	12500	33000

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Typical Operation: Power Output Approx. Watts	Typical Operation: Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class C Amplifiers, Grid-Modulated RF Telephony							
3.8	-	**1619**	2.5	N	BPT	400	15
4[a]	-	**802**	6.3	N	P	500	10
5.5	-	**837**	12.6	N	P	500	12
8	-	**1624**	2.5	N	BPT	600	25
10.5[a,f]	-	**815**	6.3/ 12.6	N	TBPT	400	20
21[a]	-	**804**	7.5	N	P	1250	40
29[a]	-	**814**	10	N	BPT	1250	50
36[a]	-	**828**	10	N	BPT	1250	70
50[a]	-	**813**	10	N	BPT	2000	100
53	-	**803**	10	N	P	2000	125
65[a]	-	**8000**	10	N	T	2000	125
400	-	**827R**	7.5	FA	BPT	3500	800
600	400	**7650**	6.3	FA	CT	2000	400
Class C Amplifiers, Suppressor-Modulated RF Telephony							
3.5[a]	-	**802**	6.3	N	P	500	10
5	-	**837**	12.6	N	P	500	12
21[a]	-	**804**	7.5	N	P	1250	40
53	-	**803**	10	N	P	2000	125
Class C Amplifiers, Television Service							
230	900	**6161**	6.3	FA	T	1600	250
1200	900	**6181**	120	FA	BPT	2000	2000
4000	216	**5762/ 7C24**	12.6	FA	T	3700	3000
4000	216	**5762A**	12.6	FA	T	3700	4000
5300[f]	216	**8D21**	3.2	L	TTR	6000	6000
12000	216	**6166**	5	FA	BPT	6000	10000
12000	216	**6166A/ 7007**	5	FA	BPT	7500	12000

[f] Both sections.

RADIO CORPORATION OF AMERICA
Electron Tube Division Harrison, N. J.

Typical Operation		RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings	
Power Output Approx. Watts	Freq. Mc					Volts	Dissipation Watts
Class C Amplifiers, RF Telegraphy							
-	1000	**5718**[t]	6.3	N	T	165	3.3
0.475	1700	**5675**	6.3	N	T	300	5
0.5	-	**955**[t]	6.3	N	T	180	-
0.6	-	**958A**[t]	1.25	N	T	135	0.6
1.8	-	**6F4**[t]	6.3	N	T	150	2
2	40	**3A5**[t]	1.4-2.8	N	TT	135	1
2.2	500	**7554**	6.3	N	T	250	2.5
3.2	3000	**7801**	12.6	C	CT	750	-
3.2	3000	**7870**	6.3	C	CT	750	-
3.5	40	**7060**[t]	12-15	N	T-P	300	2.75
4	-	**1626**	12.6	N	T	250	5
4	40	**7054**[t]	13.5	N	P	300	5
4	40	**8077/ 7054**[t]	13.5	N	P	300	5
5	500	**4037**	6.3	N	T	360	6.25
5	500	**5876**	6.3	N	T	360	6.25
5	500	**5876A**	6.3	N	T	360	6.25
5[a]	500	**6939**[t]	6.3/ 12.6	N	PP	250	6
5.4[g]	40	**5618**	3/6	N	P	300	5
5.5	1000	**5893**	6	N	T	320	7
6	-	**5556**	4.5	N	T	350	10
6.5	160	**5686**	6.3	N	BPT	275	8.25
7[a]	500	**6263**	6	N	T	330	8
7[a]	500	**6263A**	6	N	T	330	8
7[g]	175	**7905**[t]	6.3[d]	N	BPT	300	10
7.5[a]	500	**6264A**	6	N	T	330	8
8.5[a]	175	**7551**[t]	13.5	N	BPT	300	10
8.5[a]	175	**7558**[t]	6.3	N	BPT	300	10
9	-	**1613**[t]	6.3	N	P	350	10
10.3[a]	30	**5763**	6	N	BPT	300	12
10.3[a]	30	**6417**	12.6	N	BPT	300	12

[d] Quick filament-heating type. [f] Both sections.

RCA TRANSMITTING TUBE GUIDE

Typical Operation		RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings	
Power Output Approx. Watts	Freq. Mc					Volts	Dissipation Watts
Class C Amplifiers, RF Telegraphy (cont'd)							
16[a]	-	**802**	6.3	N	P	500	10
17	2500	**6897**	6.3	FA	T	1000	100
19.5	-	**1619**	2.5	N	BPT	400	15
20[a]	125	**2E24**	6.3[d]	N	BPT	500	10
20[a]	125	**2E26**	6.3	N	BPT	500	10
20[a]	125	**6893**	12.6	N	BPT	500	10
21	-	**1614**	6.3	N	BPT	375	21
22	-	**837**	12.6	N	P	500	12
25	-	**801A**	7.5	N	T	600	20
26 (a,f)	-	**832A**	6.3/ 12.6	N	TBPT	750	15
27	400	**7801**	12.6	C	CT	750	-
27	400	**7870**	6.3	C	CT	750	-
30[g]	175	**4604**	6.3[d]	N	BPT	750	25
35	-	**1624**	2.5	N	BPT	600	25
40[a]	-	**807**	6.3	N	BPT	600	25
40[a]	-	**1625**	12.6	N	BPT	600	25
40	1215	**6816**	6.3	FA	CT	1000	115
40	1215	**6884**	26.5	FA	CT	1000	115
40	1215	**7457**	6.3	FA	CT	1000	115
40	1215	**7842**	6.3	C	CT	1000	-
40	1215	**7843**	26.5	C	CT	1000	-
40	1215	**7844**	6.3	C	CT	1000	-
44 (a,f)	-	**815**	6.3/ 12.6	N	TBPT	400	20
46 (a,f)	100	**6524**	6.3	N	TBPT	500	20
46 (a,f)	100	**6850**	12.6	N	TBPT	500	20
52[a]	60	**6146**	6.3	N	BPT	600	20
52[a]	60	**6146W/ 7212**	6.3	N	BPT	600	20

[g] Intermittent Commercial and Amateur Service only.
[t] Data for this type located in *Receiving-Type Industrial Tubes* Section.

RCA TRANSMITTING TUBE GUIDE

Typical Operation: Power Output Approx. Watts	Typical Operation: Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class C Amplifiers, RF Telegraphy (cont'd)							
52[a]	60	**6159**	26.5	N	BPT	600	20
52[a]	60	**6159W/ 7357**	26.5	N	BPT	600	20
52[a]	60	**6883**	12.6	N	BPT	600	20
52[a]	60	**7212**	6.3	N	BPT	600	20
52[a]	60	**7357**	26.5	N	BPT	600	20
52[a]	60	**8032**	13.5	N	BPT	600	20
55[a]	-	**809**	6.3	N	T	750	25
70[a, f]	-	**829B**	6.3/ 12.6	N	TBPT	750	30
75	-	**834**	7.5	N	T	1250	50
80[a]	-	**804**	7.5	N	P	1250	40
85	470	**8072**	12-15	C	BPT	2200	-
86[a]	-	**826**	7.5	FA	T	1000	60
90[a, h]	-	**826**	7.5	N	T	1000	45
90[a, f]	-	**829B**	6.3/ 12.6	FA	TBPT	750	40
90	-	**830B**	10	N	T	1000	60
100	1000	**5588**	6.3	FA	T	1000	200
130[a]	-	**812A**	6.3	N	T	1250	45
130[a]	-	**814**	10	N	BPT	1250	50
130	-	**838**	10	N	T	1250	100
135[a]	-	**811A**	6.3	N	T	1250	45
150[a]	-	**828**	10	N	BPT	1250	70
160[a]	60	**7271**	13.5	FA	BPT	1100	60
165	-	**860**	10	N	TTR	3000	100
170[a]	-	**8005**	10	N	T	1250	75
180	900	**6161**	6.3	FA	T	1600	250
210	-	**803**	10	N	P	2000	125
215	-	**805**	10	N	T	1500	125
235	470	**8121**	13.5	FA	BPT	2200	150
250	500	**7203/ 4CX250B**	6	FA	BPT	2000	250

TRANSMITTING TUBE GUIDE

TRANSMITTING TUBE GUIDE

Typical Operation: Power Output Approx. Watts	Typical Operation: Freq. Mc	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation Watts
Class C Amplifiers, RF Telegraphy (cont'd)							
250	500	**7204/ 4CX250F**	26.5	FA	BPT	2000	250
255[a]	60	**7094**	6.3	FA	BPT	1250	100
275[a]	-	**813**	10	N	BPT	2000	100
300	470	**8122**	13.5	FA	BPT	2200	400
325	220	**5713**	3.3	FA	T	1500	250
370	150	**7034/ 4X150A**	6	FA	BPT	2000	250
370	150	**7035/ 4X150D**	26.5	FA	BPT	2000	250
375[a]	-	**810**	10	N	T	2000	250
375[a]	-	**8000**	10	N	T	2000	125
375	-	**6155/ 4-125A**	5	FA	BPT	3000	125
375	1215	**7650**	6.3	FA	CT	2500	700
600	900	**6181**	120	FA	BPT	2000	2000
1000[a]	-	**833A**	10	N	T	3000	300
1000	-	**5786**	11	FA	T	3000	600
1000	-	**6156/ 4-250A**	5	FA	BPT	4000	250
1050	-	**827R**	7.5	FA	BPT	3500	800
1350	600	**7213**	5.5	FA	CT	2500	1500
1440[a]	-	**833A**	10	FA	T	4000	400
6500[a,f]	300	**8D21**	3.2	L	TTR	6000	6000
7000	30	**5762/ 7C24**	12.6	FA	T	6200	3000
7000	30	**5762A**	12.6	FA	T	6200	4000
9000	216	**6166**	5	FA	BPT	6900	10000
10000	-	**899A**	11	L	T	8500	5000
10000	-	**899RA**	11	FA	T	8500	5000

f Both sections.

h Intermittent Commercial and Amateur Service.

Typical Operation: Power Output Approx. (Watts)	Typical Operation: Freq. (Mc)	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation (Watts)
Class C Amplifiers, RF Telegraphy (cont'd)							
10000	-	**891**	22	L	T	12000	6000
10000	-	**891R**	22	FA	T	10000	4000
10000	-	**892R**	22	FA	T	18000	4000
10000	216	**6166A/7007**	5	FA	BPT	7500	12000
11000	900	**6448**	1.35	L	BPT	7000	26000
13500	900	**6806**	1.35	L	BPT	9000	35000
14000	-	**892**	22	L	T	15000	10000
15000	-	**207**	22	L	T	15000	10000
32500	-	**9C25**	6	FA	T	11500	17500
40000	25	**880**	12.6	L	T	10500	20000
44000	25	**5771**	7.5	L	T	12500	22500
65000	-	**9C22**	19.5	FA	T	17000	20000
70000	1.6	**5671**	11	FA	T	15000	25000
100000	-	**9C21**	19.5	L	T	17000	40000
114000	-	**5770**	11	L	T	17000	50000
500000	0.425	**6949**	7.3-7.8	L	T	20000	400000
Class C Amplifiers or Oscillators Self-Rectifying							
175[j]	27	**811A**	6.3	N	T	1750	45[k]
200[j]	27	**812A**	6.3	N	T	1750	145
225	-	**813**	10	N	BPT	2800	100
330[j]	50	**8005**	10	N	T	1750	75
650[j]	30	**8000**	10	N	T	2500	125
835[a]	-	**833A**	10	N	T	4250	300
1050	-	**5786**	11	FA	T	4250	600
1150	-	**833A**	10	FA	T	5650	400
3350	-	**5762/7C24**	12.6	FA	T	7000	3000
3350	-	**5762A**	12.6	FA	T	7000	4000

j Two tubes.
k Not recommended as oscillator in this class of service.

RCA TRANSMITTING TUBE GUIDE

Typical Operation: Power Output Approx. (Watts)	Typical Operation: Freq. (Mc)	RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings: Volts	Max. Plate Ratings: Dissipation (Watts)
Class C Amplifiers or Oscillators With Separate Plate Supply							
135	-	**811A**	6.3	N	T	1125	45[k]
135	-	**812A**	6.3	N	T	1125	45[k]
280	-	**813**	6.3	N	BPT	1800	100
330[j]	27	**8005**	10	N	T	1125	75
700[j]	30	**8000**	10	N	T	1800	125
1100[a]	-	**833A**	10	N	T	2700	300
1150	-	**5786**	11	FA	T	2700	600
1460	-	**833A**	10	FA	T	3600	400
5650	-	**5762/7C24**	12.6	FA	T	5600	3000
5650	-	**5762A**	12.6	FA	T	5600	4000
Linear RF Amplifiers Single-Sideband Suppressed Carrier—Two-Tone Modulation							
80	30	**8072**	12-15	C	BPT	2200	-
95[a]	60	**7271**	13.5	FA	BPT	1100	60
120	30	**811A**	6.3	N	T	1250	45
170	30	**8121**	13.5	FA	BPT	1100	60
295	30	**7203/4CX250B**	6	FA	BPT	2000	250
295	30	**7204/4CX250F**	26.5	FA	BPT	2000	250
360	500	**7580**	6	FA	BPT	2000	250
380	30	**8122**	13.5	FA	BPT	2200	400
680	30	**7650**	6.3	FA	BPT	2500	600
600000	10	**6949**	7.3-7.8	L	T	20000	400000

m See data for exact classification in each case.
n Peak value.
p See data for further information on each type.
r In phase operation, unless otherwise specified.
s Quadrature operation.
t Data for this type located in *Receiving-Type Industrial Tubes* Section.

RCA TRANSMITTING TUBE GUIDE

Typical Operation		RCA Type	Filament or Heater Volts	Cooling	Name	Max. Plate Ratings	
Power Output Approx. kw	Freq. Mc					Volts	Dissipation Watts
Plate-Pulsed Amplifiers or Oscillators[m]							
1.2	3300	**5893**	6	N	T	1750[n]	6
4.5	1215	**7649**	6.3	FA	CT	3000[n]	115
14	1250	**5946**	6.3	FA	T	7500[n]	250
39	1215	**7651**	6.3	FA	CT	8000[n]	600
65	1215	**7214**	5.5	FA		10000[n]	1500
-	500	**8184**	22-23	FA	CT	25000[n]	10000
2000	425	**6952**	0.95	L	BPT	55000[n]	8000
2000	425	**4605V2**	0.95	L	BPT	55000[n]	8000
Grid-Pulsed Amplifiers or Oscillators[m]							
2.3	1215	**7649**	6.3	FA	CT	2250	115
20	1215	**7214**	5.5	FA	CT	5000	1500
20	1215	**7651**	6.3	FA	CT	5000	600

Power Tubes for Special Applications[p]

Control Amplifier
3C33

CW Oscillator (Klystron)
2K26

Frequency Multipliers

5618	**6161**	**6850**	**7554**
5763	**6264A**	**6939**[t]	**7558**[t]
5876	**6417**	**7054**[t]	**7905**[t]
5876A	**6524**	**7551**[t]	**8077/7054**[t]
5893			

Linear RF Power Amplifier—AM Telephony
7580

Modulator—Rectangular-Wave Modulation
3E29 **6293** **7358**

Pulsed-Oscillators (Magnetrons)
6521 **6865A** **7008** **7111**

Class C Oscillator
6026 **6562/5794A** **7533**

Traveling-Wave Tube
6861

RCA Type	Filament or Heater Volts	Maximum Plate Ratings[r] Peak Reverse Volts	Peak Amperes	Average Amperes
Rectifiers				
Half-Wave, Mercury-Vapor Types				
816	2.5	7500	0.5	0.125
866A	2.5	10000	1	0.25
866A	2.5	2500	2	0.5
872A	5	10000	5	1.25
8008	5	10000	5	1.25
575A	5	15000	6	1.5
673	5	15000	6	1.5
6894	5	20000	8.3	1.8
6895	5	20000	8.3	1.8
575A	5	15000[s]	10[s]	2.5[s]
673	5	15000[s]	10[s]	2.5[s]
615/7018	2.5	2000	10	2.5
869B	5	20000	10	2.5
5558	5	5000	15	2.5
6894	5	20000[s]	11.5[s]	2.5[s]
6895	5	20000[s]	11.5[s]	2.5[s]
5561	5	10000	16	4
869B	5	15000[s]	20[s]	5[s]
635/7019	2.5	1000	77	6.4
635L/7020	2.5	1000	77	6.4
5561	5	3000	40	6.4
857B	5	22000	40	10
Full-Wave, Mercury-Vapor Type				
604/7014	2.5	900	10	2.5
Half-Wave, Gas Types				
3B28	2.5	10000	1	0.25
3B25	2.5	4500	2	0.5
3B28	2.5		2	0.5
Half-Wave, Vacuum Types				
5825	1.6	60000	0.04	0.002
2X2A	2.5	12500	0.06	0.0075
8013A	2.5	40000	0.15	0.02
579B	2.5	20000	0.27	0.25
8020	5	40000	0.75	0.1
1616	2.5	6000	0.8	0.13
836	2.5	5000	1	0.25

For footnotes, see reverse side.

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Electron Tube Division Harrison, N. J.

* FOR DETAILED DATA ON TYPES NOT LISTED IN THESE CHARTS, REFER TO INDIVIDUAL DATA SHEETS IN THE TRANSMITTING TUBE SECTION

These charts are arranged in three parts and contain in the order listed:

VACUUM POWER TUBES FOR CW APPLICATIONS (Unless Otherwise Specified[a])

RCA TYPE	DESCRIPTION & COOLING METHOD (C–Conduction, FA–Forced Air, L–Liquid, N–Natural, W–Water)		FILAMENT (F) OR HEATER		CLASS C TELEGRAPHY (CCS) UNLESS OTHERWISE SPECIFIED UNDER MAXIMUM PLATE VOLTS											
						MAXIMUM RATINGS								TYPICAL OPERATION		
			VOLTS	AMP	FREQ FOR FULL INPUT MC	PLATE VOLTS	GRID-NO.2 VOLTS	Grid-NO.1 VOLTS	PLATE MA	GRID-NO.2 INPUT WATTS	GRID-NO.1 CURRENT IN MA OR INPUT (W) IN WATTS	PLATE DISSIPATION WATTS	AMPLIFICATION OR MU FACTOR	FREQ MC	DRIVER OR DRIVING (T) POWER WATTS	POWER OUTPUT WATTS
2C39A	Triode	FA	6.3	1	2500	1000		-150	125		50	100	100			
2C39WA	Triode	FA	6	1	2500	For data, refer to MIL-E-1/778E (Navy) Specification										
2C40	Lighthouse Triode	N	6.3	0.75	3370	500		-50	25		8	6.5				
2C40A[a]	Lighthouse Triode	N	6.3	0.75	3370	500		-50	25		8	6.5				
2C43	Lighthouse Triode	N	6.3	0.9	1500	500			40			12				

[a] Type **3C33** for **Modulators**, types **3E29, 3E29A, 4610** for **Regulators**, type **2C40A** for **CW** and **RF-Pulse Applications.**

RCA TYPE	DESCRIPTION & COOLING METHOD (C–Conduction, FA–Forced Air, L–Liquid, N–Natural, W–Water)		FILAMENT (F) OR HEATER		CLASS C TELEGRAPHY (CCS) UNLESS OTHERWISE SPECIFIED UNDER MAXIMUM PLATE VOLTS											
						MAXIMUM RATINGS								TYPICAL OPERATION		
			VOLTS	AMP	FREQ FOR FULL INPUT MC	PLATE VOLTS	GRID-NO.2 VOLTS	GRID-NO.1 VOLTS	PLATE MA	GRID-NO.2 INPUT WATTS	GRID-NO.1 CURRENT IN MA OR INPUT (W) IN WATTS	PLATE DISSIPATION WATTS	AMPLIFICATION OR MU FACTOR	FREQ MC	DRIVER OR DRIVING (T) POWER WATTS	POWER OUTPUT WATTS
2E24	Beam Pwr. Tube[b]	N	6.3F	0.65	125	500	200	-175	75	2.5	3.5	10	7.5	125	0.2T	20
2E26	Beam Pwr. Tube	N	6.3	0.8	125	500	200	-175	75	2.5	3.5	10	6.5	125	0.15T	20
3C33[a]	Twin Triode	N	12.6	1.125		±2000[c]			120			15	11			
3E29[a]	Twin Beam Power Tube	N	6.3	2.25		5000	850	-225	10[c]	3	1W	15	9			40[c]
3E29A[a]	Twin Beam Power Tube	N	12.6	1.125												
4-125A/4D21	Beam Pwr. Tube	FA	5F	6.5	120	3000	400	-500	225	20	5W	125				
4-250A/5D22	Beam Pwr. Tube	FA	5F	14.5	75	4000	600	-500	350	35	10W	250				
4E27A/5-125B	Beam Pwr. Tube	N	5F	7.5	75	4000	750	-500	200	20	5W	125				
4X500A	Beam Pwr. Tube	FA	5F	12.2 to 13.7	120	4000	500	-500	350	30	10W	500				
8D21	Twin Tetrode	W	3.2F	125	300	6000	1000	-1000	2000	400	50W	6000	5	300	500T	6500
9C21	Triode	W	19.5F	415	15	17,000		-2000	9000		1500	40,000	40	15	1800T	100,000

3E29, 3E29A: Max "ON" Time: 12 μsec. Time Interval: 1200 μsec. Peak Plate Volts: 5750 (3E29), 7500 (3E29A). Typical Operation: Pulse duration: 1.2 μsec. Duty factor: 0.001

[a] Type **3C33** for **Modulators**, types **3E29**, **3E29A**, **4610** for **Regulators**, type **2C40A** for **CW** and **RF-Pulse Applications**.

[b] Quick-heating type less than 2-second filament heating time.

[c] Peak value.

RCA TYPE	DESCRIPTION & COOLING METHOD (C-Conduction, FA-Forced Air, L-Liquid, N-Natural, W-Water)		FILAMENT (F) OR HEATER		CLASS C TELEGRAPHY (CCS) UNLESS OTHERWISE SPECIFIED UNDER MAXIMUM PLATE VOLTS											
						MAXIMUM RATINGS								TYPICAL OPERATION		
			VOLTS	AMP	FREQ FOR FULL INPUT MC	PLATE VOLTS	GRID-NO.2 VOLTS	GRID-NO.1 VOLTS	PLATE MA	GRID-NO.2 INPUT WATTS	GRID-NO.1 CURRENT IN MA OR INPUT (W) IN WATTS	PLATE DISSIPATION WATTS	AMPLIFICATION OR MU FACTOR	FREQ MC	DRIVER OR DRIVING (T) POWER WATTS	POWER OUTPUT WATTS
9C22	Triode	FA	19.5F	415	5	17,000		-2000	8000		1500	20,000	41	5	1450T	65,000
207	Triode	W	22F	52	1.6	15,000		-3000	2000		200	10,000	20	1.6	235T	15,000
801A	Triode	N	7.5F	1.25	60	600		-200	70		15	20	8	60	4T	25
802	Pentode	N	6.3	0.9	30	500	250	-200	60	6	7.5	10		30	0.25T	16
803	Pentode	N	10	5	20	2000	600	-500	175	30	50	125		20	2T	210
805	Triode	N	10F	3.25	30	1500		-500	210		70	125		30	8.5T	215
807	Beam Pwr. Tube	N	6.3	0.9	60	600	300	-200	100	3.5	5	25	8	60	0.3	40
809	Triode	N	6.3F	2.5	60	750		-200	100		35	25	50	60	2.5T	55
810	Triode	N	10F	4.5	30	2000		-500	250		70	125	36	30	12T	375
813	Beam Pwr. Tube	N	10F	5	30	2000	400	-300	180	22	25	100	8.5	30	1.9T	275
814	Beam Pwr. Tube	N	10F	3.25	30	1250	400	-300	150	10	15	50		30	1.5T	130
815	Twin Beam Power Tube	N	6.3 12.6	1.6 0.8	125	400	225	-175	150	4.5	7	20	6.5	125	0.23T	44
827R	Beam Pwr. Tube	FA	7.5F	25	110	3500	1000	-500	500	150	150	800	16	110	50T	1050
828	Beam Pwr. Tube	N	10F	3.25	30	1250	400	-300	160	16	15	70		30	2.1T	150

RCA TYPE	DESCRIPTION & COOLING METHOD (C-Conduction, FA-Forced Air, L-Liquid, N-Natural, W-Water)		FILAMENT (F) OR HEATER VOLTS	FILAMENT (F) OR HEATER AMP	CLASS C TELEGRAPHY (CCS) UNLESS OTHERWISE SPECIFIED UNDER MAXIMUM PLATE VOLTS: FREQ FOR FULL INPUT MC	MAXIMUM RATINGS: PLATE VOLTS	GRID-NO.2 VOLTS	GRID-NO.1 VOLTS	PLATE MA	GRID-NO.2 INPUT WATTS	GRID-NO.1 CURRENT IN MA OR INPUT (W) IN WATTS	PLATE DISSIPATION WATTS	AMPLIFICATION OR MU FACTOR	TYPICAL OPERATION: FREQ MC	DRIVER OR DRIVING (T) POWER WATTS	POWER OUTPUT WATTS
829B	Twin Beam Power Tube	FA	6.3/12.6	2.25/1.125	200	750	225	-175	240	7	15	40	9	200	0.4T	90
		N	6.3/12.6	2.25/1.125		750	225	-175	240	6	15	30	9	200	0.3T	70
830B	Triode	N	10F	2	15	1000		-300	150		30	60	25	15	7T	90
832A	Twin Beam Power Tube	N	6.3/12.6	1.6/0.8	200	750	250	-175	90	5	6	15	6.5	200	0.19T	26
834	Triode	N	7.5F	3.1	100	1250		-400	100		20	50	10.5	100	4.5T	75
837	Pentode	N	12.6	0.7	20	500	200	-200	80	8	8	12		20	0.4T	22
845	Triode	N	10F	3.25		1250[d]		-400	120			150	5.3			115
860	Tetrode	N	10F	3.25	30	3000	500	-800	150	10	40	100		30	7T	165
880	Triode	W	12.6F	320	1.5	15,000		-1600	4500		1000	20,000	20	1.5	880T	50,000
889A	Triode	W	11F	125	50	8500		-1000	2000		250	5000	21	50	400T	10,000
889RA	Triode	FA	11F	125	40	8500		-1000	2000		250	5000	21	40	400T	10,000
891	Triode	W	22F	60	1.6	12,000		-3000	2000		150	6000	8.5	1.6	375T	10,000
891R	Triode	FA	22F	60	1.6	10,000		-3000	2000		150	4000	8.5	1.6	375T	10,000
892	Triode	W	22F	60	1.6	15,000		-3000	2000		400	10,000	50	1.6	565T	14,000
892R	Triode	FA	22F	60	1.6	12,500		-3000	2000		400	4000	50	1.6	495T	10,000
1613	Pentode	N	6.3	0.7	45	350	275	-100	50	2.5	5	10		45	0.22T	9

[d] Class AB. AF Power Amplifier

CLASS C TELEGRAPHY (CCS) UNLESS OTHERWISE SPECIFIED UNDER MAXIMUM PLATE VOLTS

RCA TYPE	DESCRIPTION & COOLING METHOD (C-Conduction, FA-Forced Air, L-Liquid, N-Natural, W-Water)		FILAMENT (F) OR HEATER VOLTS	FILAMENT (F) OR HEATER AMP	FREQ FOR FULL INPUT MC	MAXIMUM RATINGS: PLATE VOLTS	MAXIMUM RATINGS: GRID-NO.2 VOLTS	MAXIMUM RATINGS: GRID-NO.1 VOLTS	MAXIMUM RATINGS: PLATE MA	MAXIMUM RATINGS: GRID-NO.2 INPUT WATTS	MAXIMUM RATINGS: GRID-NO.1 CURRENT IN MA OR INPUT (W) IN WATTS	MAXIMUM RATINGS: PLATE DISSIPATION WATTS	AMPLIFICATION OR MU FACTOR	TYPICAL OPERATION: FREQ MC	TYPICAL OPERATION: DRIVER OR DRIVING (T) POWER WATTS	TYPICAL OPERATION: POWER OUTPUT WATTS
1614	Beam Pwr. Tube	N	6.3	0.9	80	375	300	-125	110	3.5	5	21		80	0.1T	21
1619	Beam Pwr. Tube	N	2.5F	2	45	400	300	-125	75	3.5	5	15		45	0.36T	19.5
1624	Beam Pwr. Tube	N	2.5F	2	60	600	300	-200	90	3.5	5	25		60	0.43T	35
1625	Beam Pwr. Tube	N	12.6	0.45	60	600	300	-200	100	3.5	5	25	8	60	0.3T	40
1626	Triode	N	12.6	0.25	30	250		-150	25		8	5	5	30	0.5T	4
4610[a]	Twin Triode	N	6.3 / 12.6	2.25 / 1.125		3000			100			30				
5556	Triode	N	4.5F	1.1	6	350		-150	40		10	10				
5713	Triode	FA	3.3	11.5	220	1500		-250	300		50	250	25	220	8T	290
5786	Triode	FA	11F	12.5	160	3000		-500	500		150	600	32	160	36T	1000
6146[e]	Beam Pwr. Tube	N	6.3	1.25	60	600	250	-150	140	3	3.5	20	4.5	60	0.2T	52
6146A[e]	Beam Pwr. Tube	N	6.3	1.25	60	600	250	-150	140	3	3.5	25	4.5		0.2T	52
6155	Beam Pwr. Tube	FA	5F	6.5	120	3000	400	-500	225	20	15	125				

[a] Type **3C33** for **Modulators**, types **3E29**, **3E29A**, **4610** for **Regulators**, type **2C40A** for **CW** and **RF-Pulse Applications**.

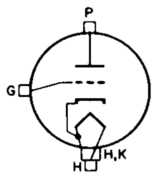
[e] For detailed data on later version of this type refer to 6146B/8298A data sheets, located in the *TRANSMITTING TUBE SECTION*.

RCA TYPE	DESCRIPTION & COOLING METHOD (C-Conduction, FA-Forced Air, L-Liquid, N-Natural, W-Water)		FILAMENT (F) OR HEATER VOLTS	FILAMENT (F) OR HEATER AMP	CLASS C TELEGRAPHY (CCS) UNLESS OTHERWISE SPECIFIED UNDER MAXIMUM PLATE VOLTS: FREQ FOR FULL INPUT MC	MAXIMUM RATINGS: PLATE VOLTS	GRID-NO.2 VOLTS	GRID-NO.1 VOLTS	PLATE MA	GRID-NO.2 INPUT WATTS	GRID-NO.1 CURRENT IN MA OR INPUT (W) IN WATTS	PLATE DISSIPATION WATTS	AMPLIFICATION OR MU FACTOR	TYPICAL OPERATION: FREQ MC	DRIVER OR DRIVING (T) POWER WATTS	POWER OUTPUT WATTS
6156	Beam Pwr. Tube	FA	5F	14.1	75	4000	600	-500	350	35	20	250				
6159	Beam Pwr. Tube	N	26.5	0.3	60	600	250	-150	140	3	3.5	20	4.5	60	0.2T	52
6181	Beam Pwr. Tube	FA	120 Max.	1.6	900	2000	500	-300	1250	40	200	2000	7	900	150	600
6883[f]	Beam Pwr. Tube	N	12.6	0.625	60	600	250	-150	140	3	3.5	20	4.5	60	0.2	52
6893	Beam Pwr. Tube	N	12.6	0.4	125	500	200	-175	75	2.5	3.5	10	6.5	125	0.15	20
6897	Lighthouse Triode	FA	6.3	1.03	2500	1000		-150			50W	100				
7271	Beam Pwr. Tube	FA	13.5	1.25	60	1100	425	-300	340	20	25	60	8	60	4	160
8000	Triode	N	10F	4.5	30	2000		-500	250		40	125	16.5	30	8T	375
8005	Triode	N	10F	3.25	60	1250		-200	200		45	75	20	60	6.5T	170
8032	Beam Pwr. Tube	N	13.5	0.585	60	600	250	-150	140	3	3.5	20	4.5	60	0.2	52
8165/ 4-65A	Beam Pwr. Tube	FA	6	3.2 to 3.8	150	3000	400	-500	150	10	5W	65				
8166/ 4-1000A	Beam Pwr. Tube	FA	7.5F	20 to 22.7	110	6000	1000	-500	700	75	25W	1000				
8168/ 4CX1000A	Beam Pwr. Tube	FA	6.0	8.1to 9.9	110	3000[g]	400		1000	12	0W	1000				

RCA TYPE	DESCRIPTION & COOLING METHOD (C–Conduction, FA–Forced Air, L–Liquid, N–Natural, W–Water)		FILAMENT (F) OR HEATER VOLTS	FILAMENT (F) OR HEATER AMP.	FREQ FOR FULL INPUT MC	CLASS C TELEGRAPHY (CCS) UNLESS OTHERWISE SPECIFIED — MAXIMUM RATINGS: PLATE VOLTS	GRID-NO.2 VOLTS	GRID-NO.1 VOLTS	PLATE MA	GRID-NO.2 INPUT WATTS	GRID-NO.1 CURRENT IN MA OR INPUT (W) IN WATTS	PLATE DISSIPATION WATTS	UNDER MAXIMUM PLATE VOLTS: AMPLIFICATION OR MU FACTOR	TYPICAL OPERATION: FREQ MC	DRIVER OR DRIVING (T) POWER WATTS	POWER OUTPUT WATTS
8170/ 4CX5000A	Beam Pwr. Tube	FA	7.5	73 to 78	30	7500	1500		3000	250	75W	5000				
8239/ 3X3000F1	Triode	FA	7.5	49 to 54		6000[d]			2500		50W	3000				
8438/ 4-400A	Beam Pwr. Tube	FA	5	14.5	110	4000	600	-500	350	35	10W	400				

[f] For detailed data on later version of this type refer to 6883B/8032A/8552 and 6146B data sheets, located in the *TRANSMITTING TUBE SECTION*. [g] Linear RF Power Amplifier service, plate current at peak envelope conditions.

TERMINAL DIAGRAMS



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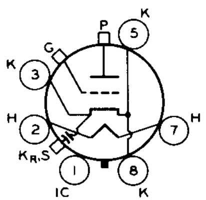

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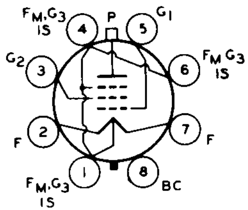

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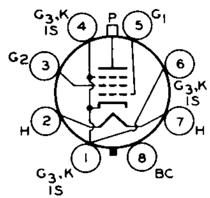

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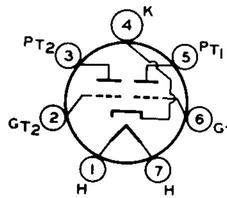

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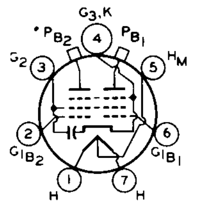

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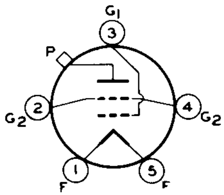

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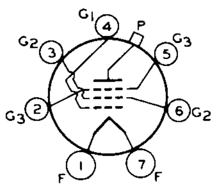

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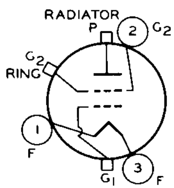

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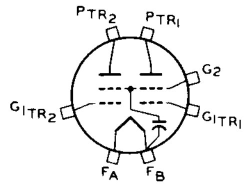

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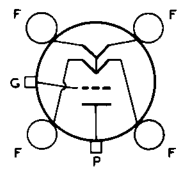

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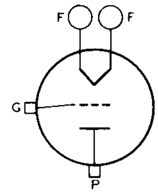

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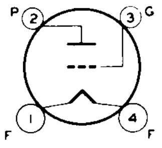

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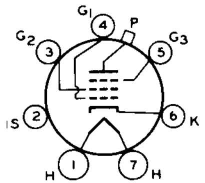

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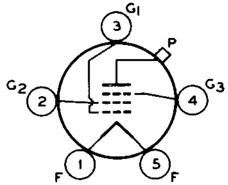

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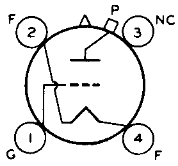

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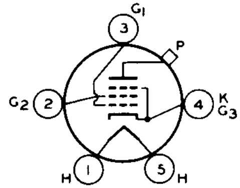

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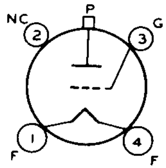

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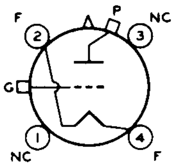

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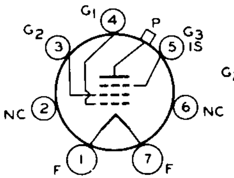

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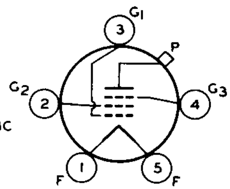

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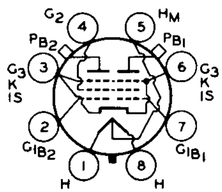

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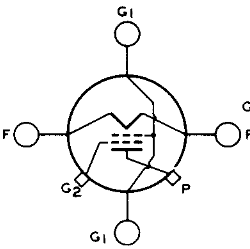

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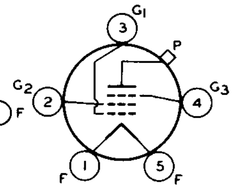

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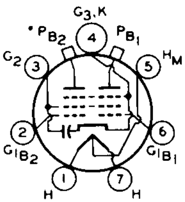

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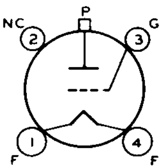

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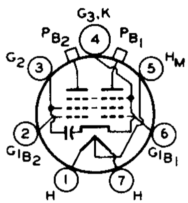

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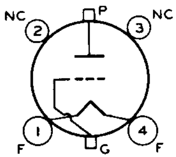

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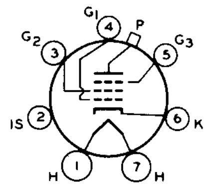

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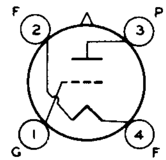

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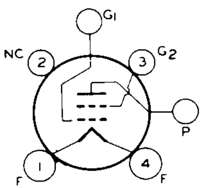

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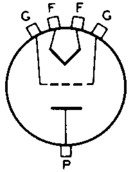

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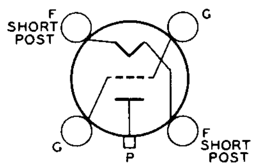

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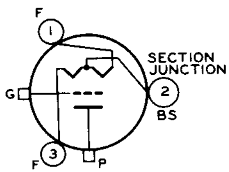

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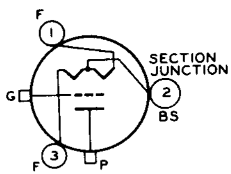

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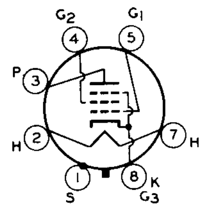

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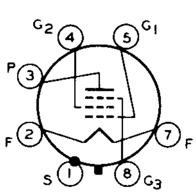

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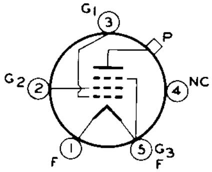

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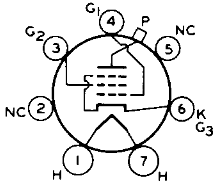

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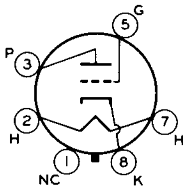

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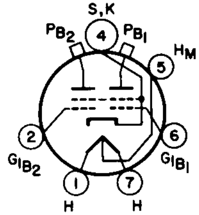

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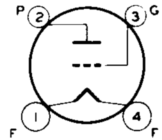

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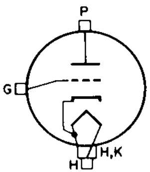

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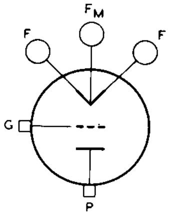

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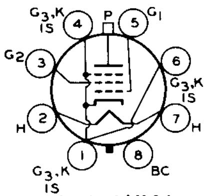

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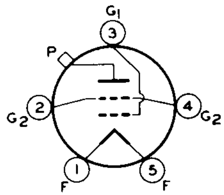

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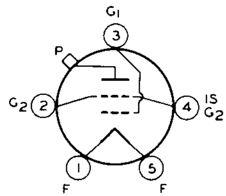

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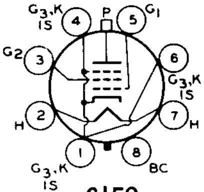

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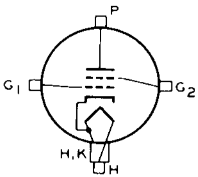

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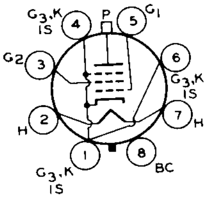

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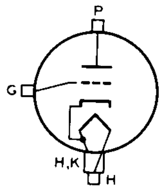

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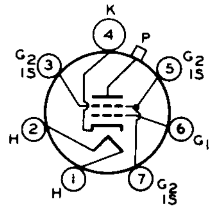

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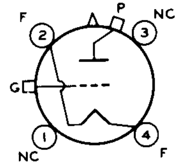

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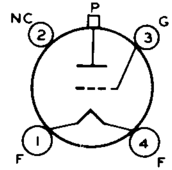

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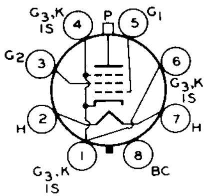

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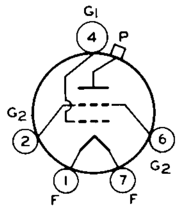

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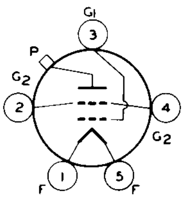

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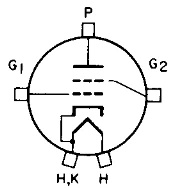

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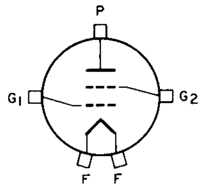

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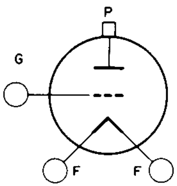

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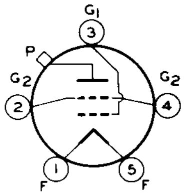


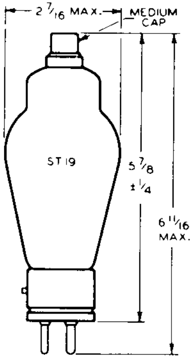
8438/4-400A

MAXIMUM ENVELOPE TEMPERATURES and KEY TO DIMENSIONAL OUTLINES

Tube Type	Max. Envelope Temperature °C		Key No.	Tube Type	Max. Envelope Temperature °C		Key No.	Tube Type	Max. Envelope Temperature °C		Key No.
	Term. or Rad.	Bulb or Plate Core			Term. or Rad.	Bulb or Plate Core			Term. or Rad.	Bulb or Plate Core	
2C39A	175	175	51	813	-	-	3	4610	-	-	16
2C39WA	200	200	51	814	-	-	24	5556	-	-	43
2C40	175	175	29	815	-	-	19	5713	140	180	53
2C40A	175	175	29	827R	175	150	45	5786	165		
2C43	200	200	30	828	-	-	24		200[b]	180	28
2E24	-	210	33	829B	-	235[c] 265[d]	16	6146	-	220	14
2E26	-	210	33	830B	-	-	15	6146A	-	220	13
3C33	-	250	32	832A	-	200	31	6155	180	220	21
3E29	-	-	16	834	-	-	52	6156	180	220	5
3E29A	-	-	16	837	-	-	11	6159	-	220	14
4-125A/4D21	170	170	17	845	-	-	8	6181	180	-	26
4-250A/5D22	170	170	4	860	-	-	35	6883	-	220	13
4E27A/5-125B	225	225	20	880	150	150	39	6893	-	210	33
4X500A	150	150	50	889A	-	-	22	6897	250	250	49
8D21	150	150	46	889RA	180	150	37	7271	-	250	44
9C21	165	180	40	891	-	150	23	8000	-	-	9
9C22	165	180	34	891R	180	150	36	8005	-	-	1
207	-	Note[a]	38	892	-	150	23	8032	-	220	13
801A	-	-	12	892R	180	150	36	8165/4-65A	200	225	18
802	-	-	11	1613	-	-	42	8166/4-1000A	150	200	41
803	-	-	7	1614	-	-	25	8168/4CX1000A	250	250	48
805	-	-	6	1619	-	-	25	8170/4CX5000A	250	250	27
807	-	-	11	1624	-	-	11	8239/3X3000F1	-	-	47
809	-	-	2	1625	-	-	11	8438/4-400A	200	225	4
810	-	-	9	1626	-	-	10				

[a] Outlet water temperature, 70°C max.
[b] Filament temperature.
[c] Forced-air cooling.
[d] Natural cooling.

DIMENSIONS IN INCHES



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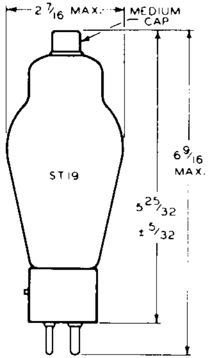

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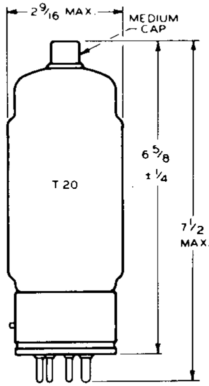

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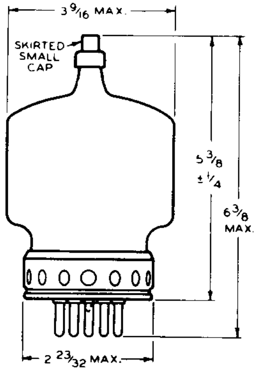

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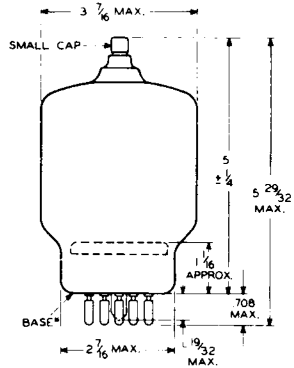

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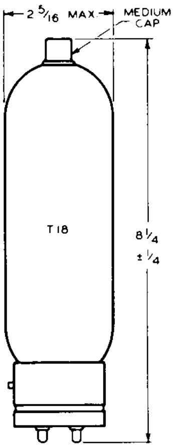

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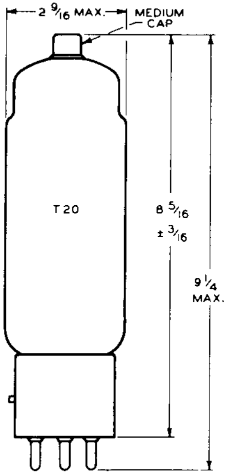

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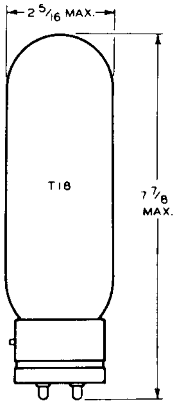

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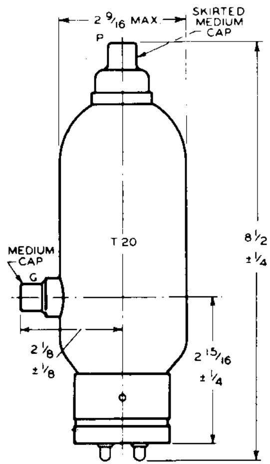

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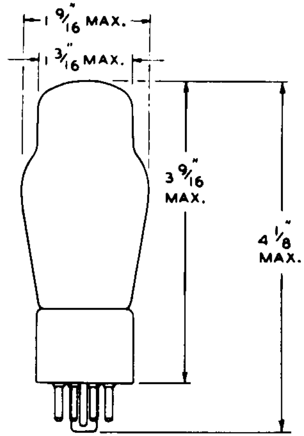

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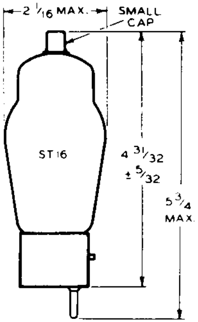

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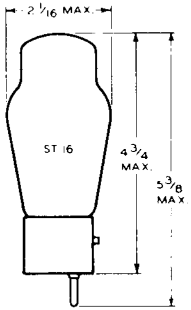

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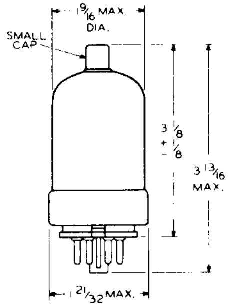

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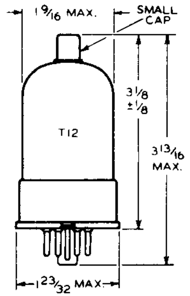

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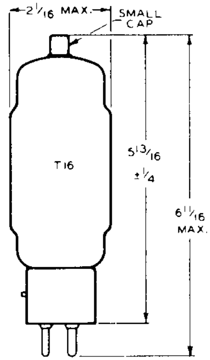

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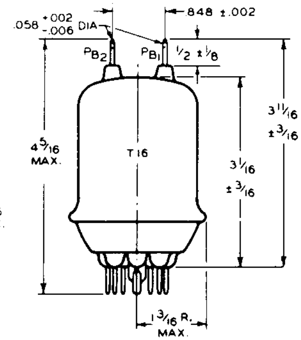

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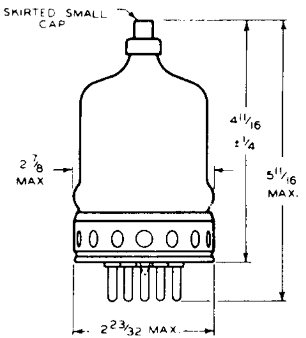

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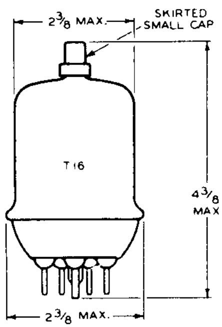

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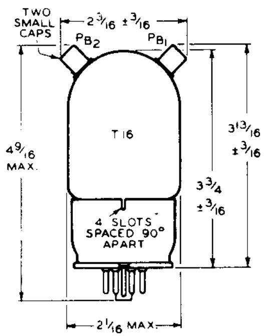

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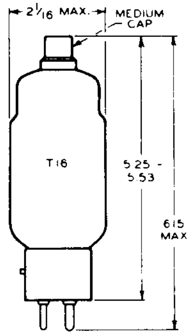

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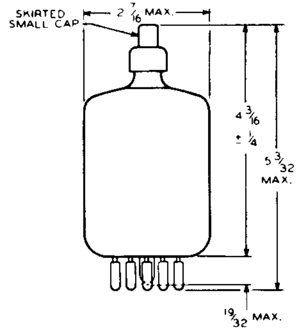

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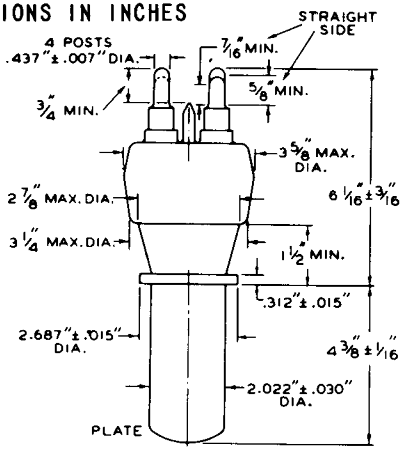

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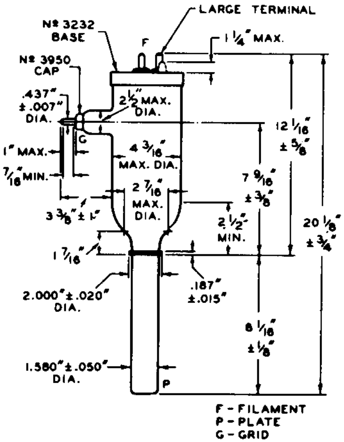

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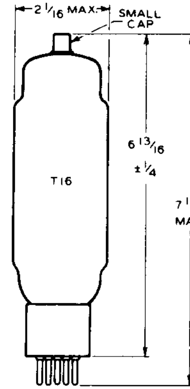

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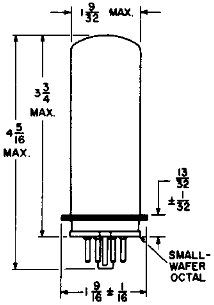

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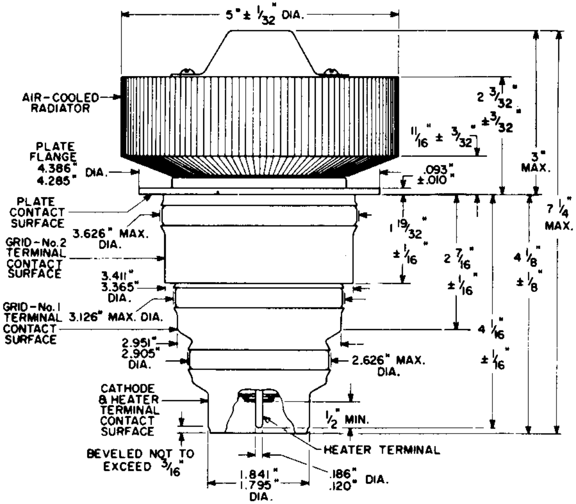

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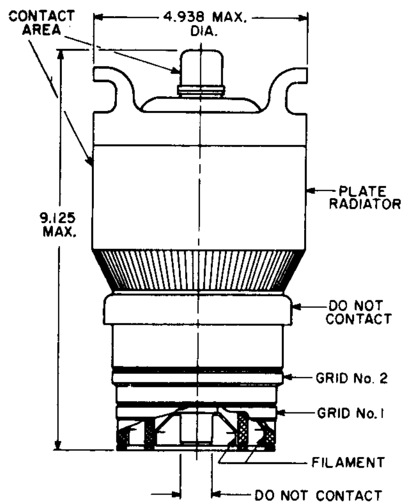

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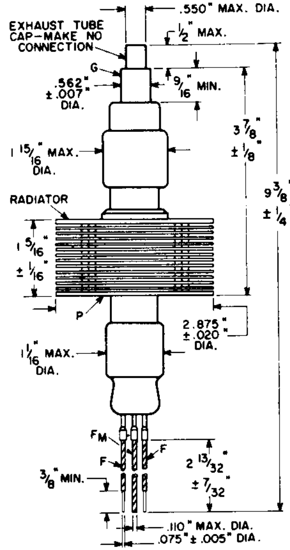

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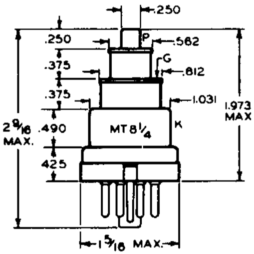

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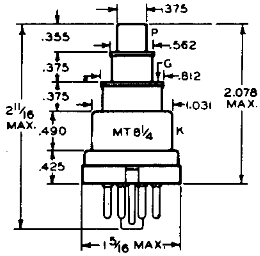

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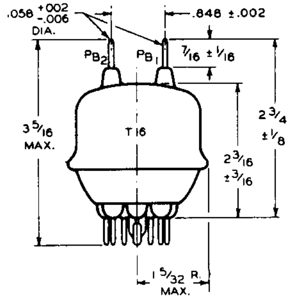

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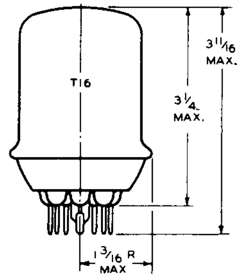

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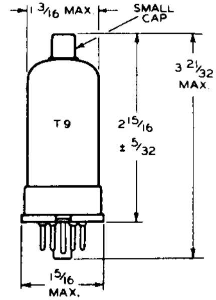

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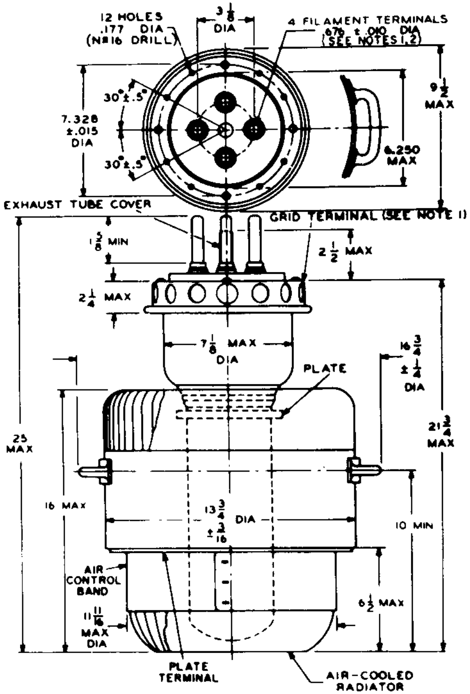

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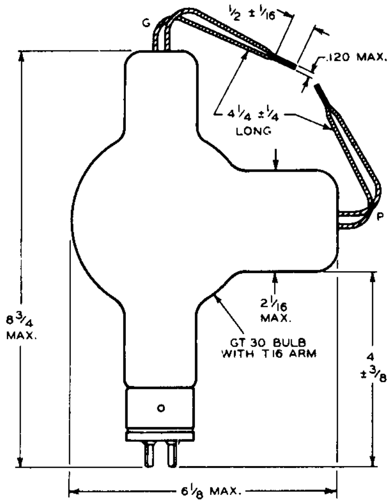

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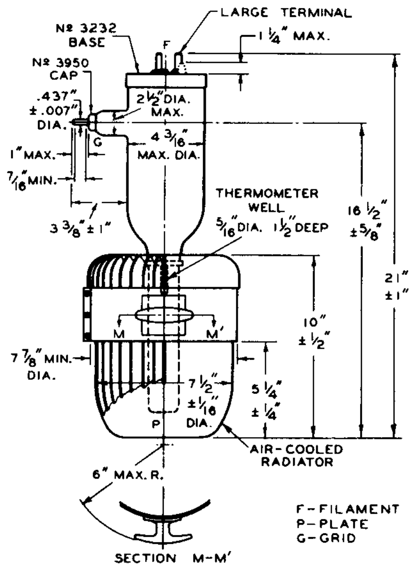

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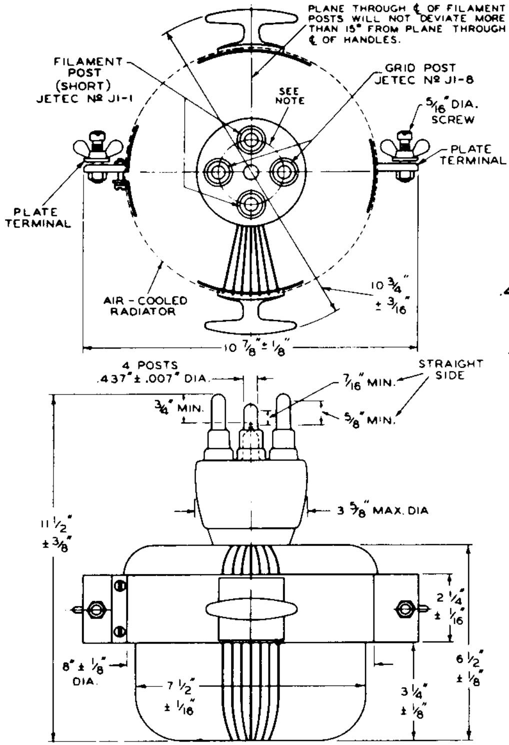

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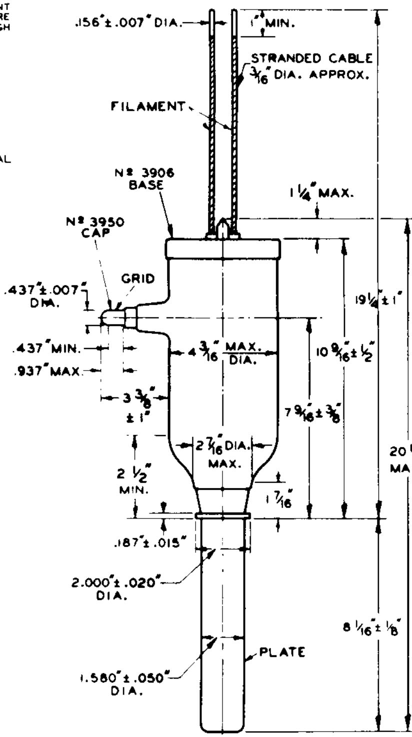

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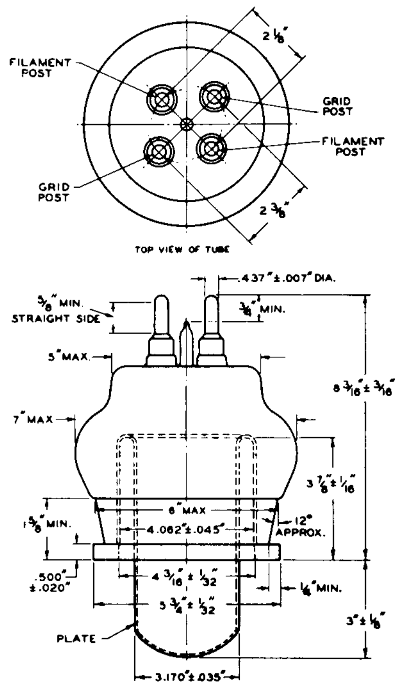

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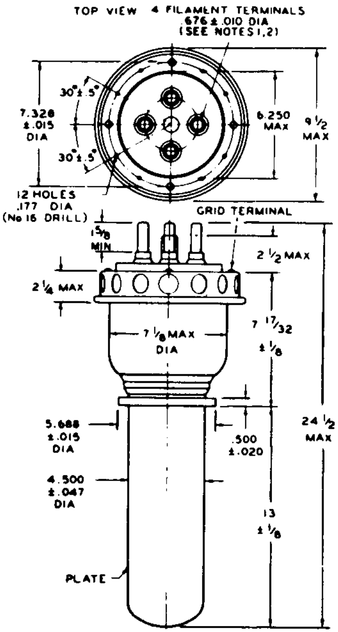

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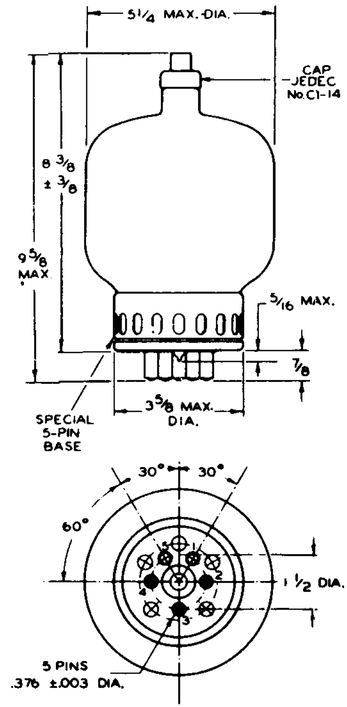

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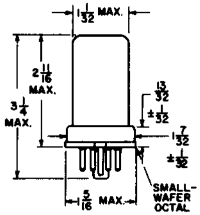

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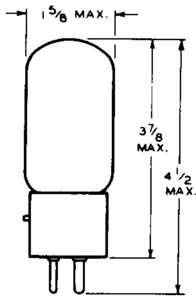

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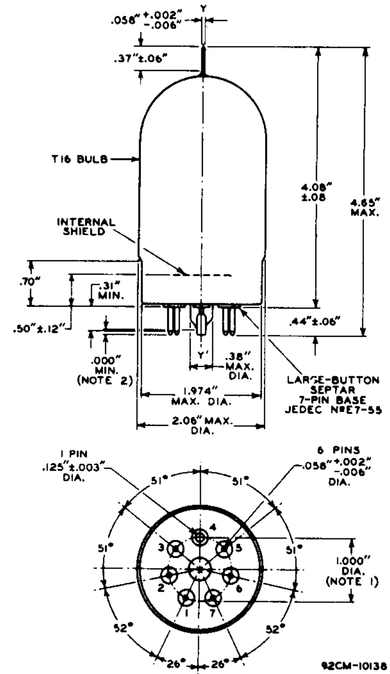

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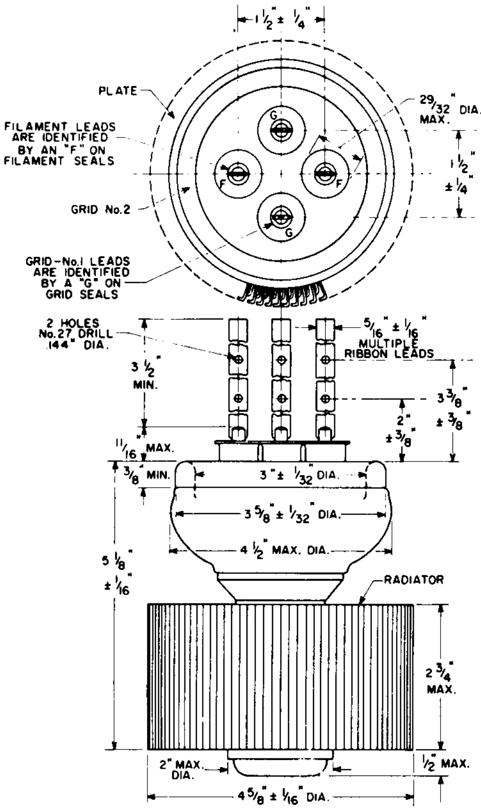

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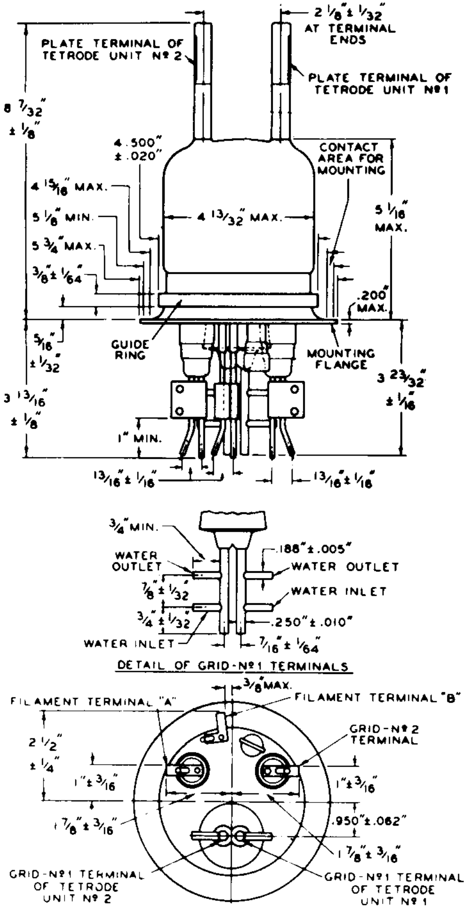

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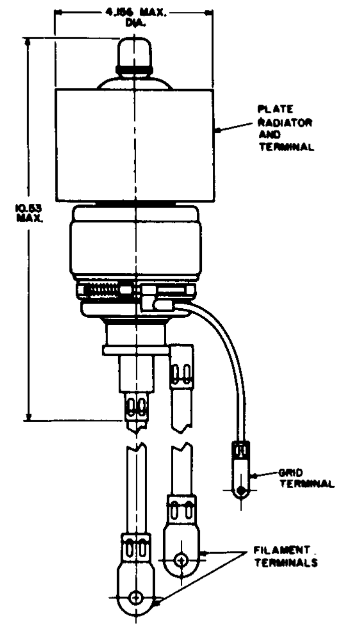

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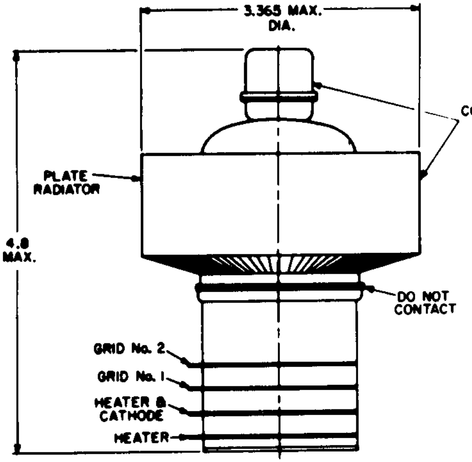

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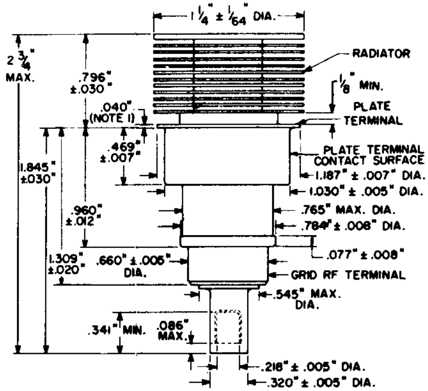

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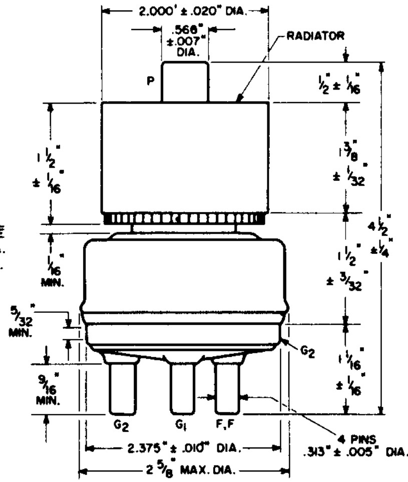

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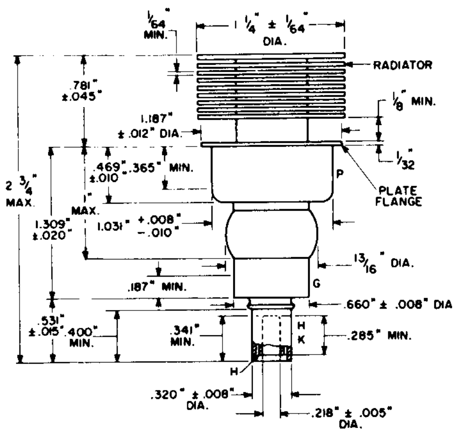

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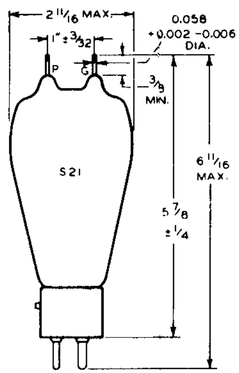

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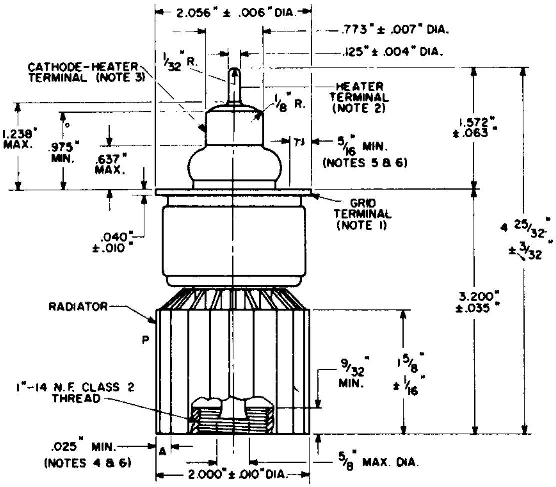

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RCA Transmitting Tube Operating Considerations

The following operating considerations for RCA transmitting tubes are intended for use with the data sheets on individual tube types given in the Handbook. Operating considerations unique to a particular tube type are not included in this presentation but are covered by the Handbook data sheets for the given type.

RATINGS

Refer to the *General Section* of the Handbook for a detailed discussion on Rating Systems and Tube Ratings.

CLEANING

As with other high-voltage equipment, it is essential that external parts of power tubes be kept free from accumulated dirt and moisture to minimize surface leakage and the possibility of arc-over.

Some tube configurations contain re-entrant areas at the edge of the insulator seals. Particular care should be taken to prevent foreign matter from coming in contact with these areas. Unless adequately protected by filtered air, these areas collect dirt rapidly as a result of electrostatic forces and the nature of the air circulation around the tube.

The external parts of the tube should periodically be wiped free of dirt. A recommended procedure for cleaning ceramic-metal tubes is as follows:

1. Remove silicone grease or similar material by use of acetone, or equivalent.

   Caution: Do not allow silicone grease or similar materials to remain on any rf contact surfaces. Severe burning of the contact surfaces of cylindrical-terminal types will occur if the contact fingers do not mate firmly with clean metal contact surfaces.

2. Clean rf contact surfaces with a very fine grade of silicon carbide abrasive pad, or equivalent.

   Caution: Do not permit the cleaning pad to come in contact with the ceramic surfaces. Rub gently to prevent removal of plating.

COOLING CONSIDERATIONS

Tube life can always be extended by maintaining envelope temperatures substantially below the maximum temperature ratings.

The user is cautioned that typical cooling characteristics in the published data are offered only as a guide, and that maximum envelope temperatures in the intended operation are the final rating criteria.

Temperature measurements of the tube envelope must be made to insure operation within maximum ratings. For glass-bulb types, the bulb "hot-spot" must be located with the tube operating in its intended application. A simple technique for locating the "hot-spot" in low-power, receiving-type tubes is to apply a low-temperature-melting paint, such as Tempilaq[a], to the entire bulb surface; the point at which this material first begins to melt is the hottest point on the bulb. For most power tubes, however, this technique is not satisfactory because of radiation effects. Therefore, it is recommended that a thermocouple be moved over the envelope to locate the hottest point on the bulb. (Although the individual thermocouple readings are not precise, the relative readings are sufficient.) Spots of various higher temperature Tempilaq paints may then be applied only to the hottest area; the lowest Tempilaq paint which will not melt must be at or below the maximum temperature rating. See Ref. 1. In general, the hottest point of a ring terminal is at the seal or junction of the terminal and its adjacent glass or ceramic insulator. For some tube types the temperature measurement points are specified on the *Dimensional Outline* in the published data.

All types of heat transfer—radiation, convection, conduction, and combinations thereof—are employed in the various cooling techniques: natural, forced-air, liquid, and conduction cooling.

Natural Cooling—This method is generally used for glass-bulb types having plate dissipation ratings up to about 300 watts.

Temperature should be measured at the hottest point on the bulb using techniques previously discussed.

Adequate free space around the tube is required for all natural cooled types. Avoid reflective heat surfaces such as tube shields. These and other design considerations affecting natural methods of cooling are described in Ref.2.

Forced-Air Cooling—

Glass-Bulb-Types—Forced-air cooling may be applied to glass-bulb types to enhance the convection cooling and reduce bulb temperature. In some glass-bulb types, ratings are given for both natural and forced-air cooling. (The ratings with forced-air cooling reflect the higher permitted value of dissipation.) In general, any natural-cooled type may require some forced-air cooling if operation is near the maximum ratings or if limited space is available around the tube. The final decision can be made only after temperature measurements are made to insure operation below the maximum temperature rating.

Radiator Types—The external plate construction lends itself to compactness, higher frequency operation, increased power capability and intense-cooling techniques. Because the plate is part of the envelope, transfer of heat by radiation from the plate to the envelope is eliminated. The simplest intense-cooling technique is forced-air. All RCA forced-air-cooled, external-plate types contain integral radiators, which are brazed, pressed, or otherwise secured to the plate to insure intimate thermal contact.

Most of the heat within an electron tube is generated at the plate; additional heat generated from the other electrodes migrates to the plate. Precaution, however, must be taken to insure that none of the other terminals exceed their maximum rated temperature value. It may be necessary to direct some forced air across these terminals.

In general, there are two basic types of radiators: the stacked-disc type of finned radiator for TRANSVERSE FORCED-AIR COOLING, and the radial-fin type of radiator for AXIAL FORCED-AIR COOLING.

Transverse Cooling—Air flow is directed across the radiator from an orifice in a plane normal to the major axis of the tube and at the center of the radiator. More efficient cooling may be accomplished by providing a cowling to direct and confine the air. Pressure drop across the radiator itself is normally insignificant. Typical cooling characteristics for transverse cooling, such as shown in Fig.1, are given in the published data. The following steps illustrate the use of the chart:

1. Estimate probable *Plate Dissipation* from electrical conditions, locate as point "A" on the abscissa axis (80 watts in example), and erect a perpendicular line "ac".
2. Determine temperature rise by subtracting estimated incoming-air temperature (assume 36°C in example) from estimated

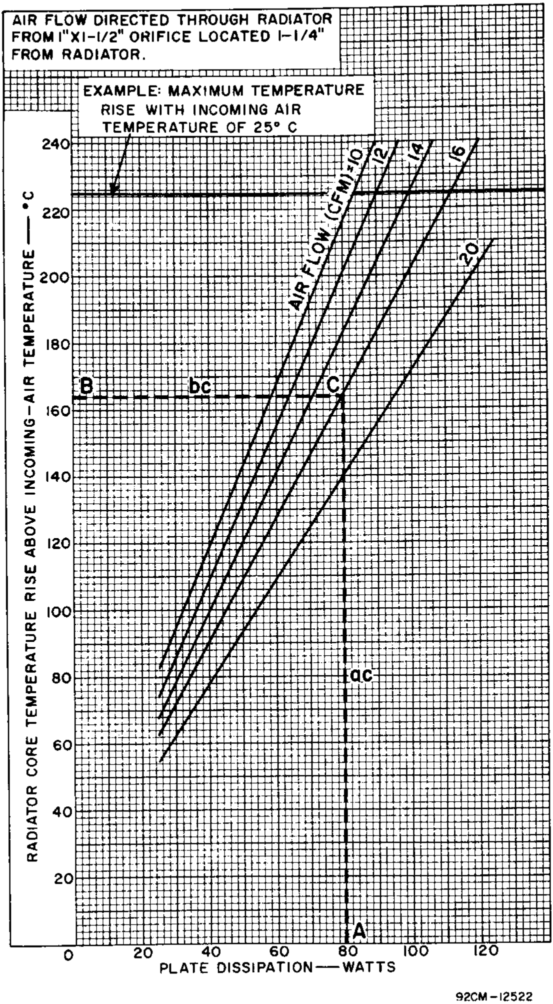

FIG.1 - EXAMPLE OF TYPICAL COOLING CHARACTERISTICS

tube operating temperature (assume 200°C in example), locate the determined value (200°C-36°C = 164°C in example) as point "B" on the ordinate axis, and construct horizontal line "bc".

3. Determine air flow by interpolating the air flow curves at the intersection of lines "ac" and "bc", point "C" (16 cfm in example).

Axial Cooling—Air flow is directed through the radiator by suitable ducts. Air flow may be in either direction unless otherwise specified. Typical cooling characteristics for axial cooling, such as shown in Fig.2, are given in the published data. The following steps illustrate the use of the chart:

1. Select a tube operating temperature as discussed in this section, locate as point "A" on the abscissa (assume 200°C in example), erect perpendicular line "ab", extend this line until it crosses the estimated plate dissipation curve (240 watts in example) for temperature (solid line), and designate as point "B".
2. Determine air flow by constructing a horizontal line "bc" from point "B" to the ordinate axis and designate point "C" (3.5 cfm in example).
3. Determine the pressure drop across the radiator for the air flow in (2), locate point "D" on line "bc" at the estimated plate dissipation curve (240 watts in example) for pressure drop (dashed line), construct a perpendicular line "de" to the abscissa axis, designate as point "E", and read pressure drop (0.24 inch of water in the example).

See Ref. 3 for detailed information on the blower requirements for forced-air-cooled tubes.

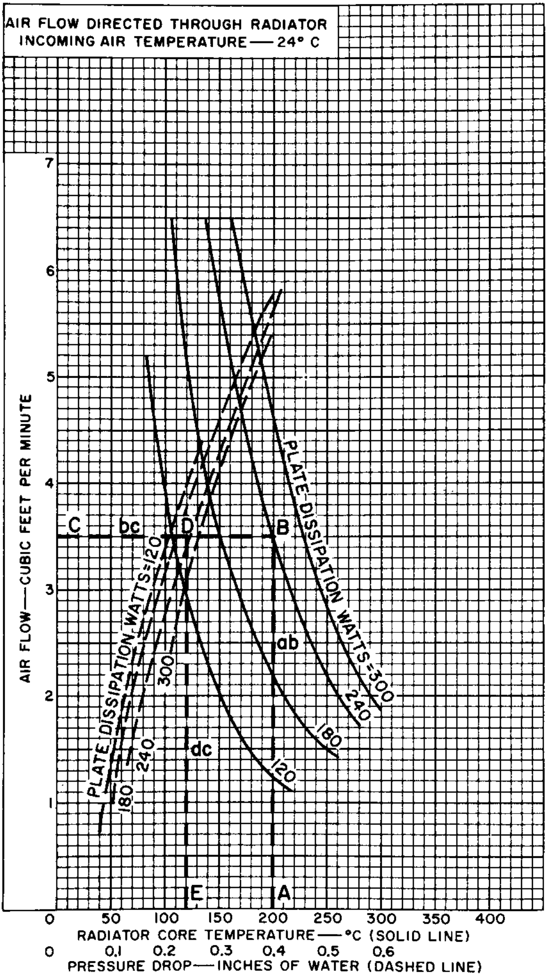

FIG.2 - EXAMPLE OF TYPICAL COOLING CHARACTERISTICS

Liquid Cooling—The liquid-cooling system consists, in general, of a source of cooling liquid, a feed-pipe system which carries the liquid to the water jacket surrounding, and provision for interlocking with the power supplies the liquid flow through the cooling courses. A more sophisticated system would also contain a liquid regeneration loop, flow regulators, and gages. For more detailed information on liquid-cooling systems, see Refs. 4 and 5.

Proper functioning of the coolant system is of the utmost importance. Even a momentary failure of the liquid flow may damage the tube. Without coolant the heat of the filament or heater alone may be sufficient to cause serious harm to some tube types. It is necessary, therefore, to provide a method of preventing tube operation in case the coolant supply should fail. A suitable method is the use of coolant-flow interlocks which open the power supplies when the flow is insufficient or ceases. If there is an interruption of the power supplies, it is then necessary to return the filament or heater voltage to zero and to restart in the normal manner described in the published data. The coolant flow must start before application of any voltage and continue for several seconds after removal of all voltages.

The absolute minimum coolant flow required through the system is given in the published data. Under no circumstances should the temperature of the coolant at any outlet ever exceed the maximum value given in the published data.

When the coolant fluid is water and the tube is used in equipment under conditions such that the ambient temperature is below 0°C, precautions should be taken to prevent the water from freezing in the system.

Use of Water as Coolant—For availability and ease in handling, water is recommended as the coolant wherever possible. It is of utmost importance to maintain a high quality of water in the cooling system. Contamination in the water will hasten scale formation, corrosion, and excessive electrolysis; any one of these conditions can greatly reduce tube life.

Use of Liquids other than Water as Coolant–When ambient temperatures fall below 0°C, it is possible to use coolants such as ethylene-glycol-water solution and FC75[b]. Neither of these two coolants is as effective a coolant as water, therefore, the plate dissipation and flow data must be modified from that given for water. A more extensive discussion of ethylene-glycol-water solution and FC75 as coolants is given in Ref.4. For information on the use of any coolant for which ratings are not given in the data, contact your RCA field representative or the nearest District Sales Office. A coolant such as oil will require a special plating on the metal of the tube envelope, such as nickel and rhodium to protect the metal surfaces from chemical attack.

Conduction Cooling—The conduction-cooling system consists, in general, of a constant temperature device (heat sink) and suitable heat-flow path (coupling) between the heat sink and tube. Primary consideration of the system should be given to the design of a heat-flow path (coupling device) with high thermal conductivity.

Heat Sink—The heat sink should be designed to act as a constant-temperature device to prevent any increase in temperature by dissipating the heat beyond the equipment compartment. Heat sinks can take the form of solids or liquids. In most applications such a heat sink is available in the form of equipment chassis, plate line, or output cavity.

Coupling—There are numerous insulating materials available to serve as the heat-coupling device, such as beryllium oxide (beryllia)[C], high-aluminum oxide (high-alumina), mica, and other insulating bodies. Since the thermal conductivity of these insulators varies considerably, the choice of insulator will depend primarily on the plate dissipation in the given application. For a detailed discussion on conduction cooling, see Ref. 6.

In hf operation the inductive element of the plate circuit is usually a relatively long coil, which does not provide a good thermal path from plate to chassis. Larger shunt capacity can be tolerated, however, and heat can be conducted through a portion of it to the chassis. In uhf operation the permissible shunt capacity of the plate circuit is limited, but the inductive element is short and can usually be made with sufficient cross-sectional area to form an excellent thermal path. In vhf operation a careful compromise of the above is required to obtain adequate rf performance and reasonable cooling.

PRECAUTIONS

The voltages at which power tubes are operated are extremely dangerous. Protection circuits must be provided which will protect operation and maintenance personnel, protect the tube in the event of abnormal circuit operation, and protect the tube circuits in the event of abnormal tube operation. Power tubes require mechanical protective devices such as interlocks, relays, and circuit breakers. Circuit breakers alone may not provide adequate protection in certain high-power-tube circuits when the power-supply filter, modulator, or pulse-forming network stores considerable energy. Additional protection may be provided by the use of high-speed electronic circuits or electronic "crow-bars" to bypass the fault current until mechanical circuit breakers are opened.

Great care should be taken during the adjustment of circuits. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical system. The interlock devices should function to break the primary circuit of the high-voltage supplies and discharge high-voltage capacitors when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

ELECTRICAL CONSIDERATIONS

Cathode—RCA transmitting tubes use a wide variety of cathodes. All utilize thermionic emission and should be operated at a constant temperature.

Refer to the *General Section* of the Handbook for a detailed discussion on TYPES OF CATHODES AND THEIR USE.

Filament or Heater—The rated filament or heater voltage should be applied for the heating time specified in the published data to allow the cathode to reach normal operating temperature before voltages are applied to other electrodes.

The life of the cathode can be conserved by adjusting to the lowest filament or heater supply voltage that will give the desired performance. In general, the filament or heater voltage values given in the published data include the maximum value and the typical value. Exceeding the maximum value will damage or severely shorten the life of the cathode.

The filament or heater voltage should be adjusted to the typical value initially, then reduced to provide satisfactory tube performance; any further reduction will show some degradation.

Good regulation of the filament or heater voltage about the value found above is, in general, economically advantageous from the view-point of tube life. When the rated value is shown with a percentage value in the published data, the percentage value indicates the tolerable momentary fluctuations from the rated value. For longer life, especially at higher operating frequencies, these fluctuations should be reduced by improved power supply regulation.

The cathode may be subjected to back bombardment as the frequency is increased with resultant increase in temperature. In pulse types back bombardment normally need not be considered when the duty factor is small. However, higher duty factors increase the possibility of this effect. In any event, the filament or heater supply voltage should be reduced as described above.

Standby Operation—During standby periods, the tube may be operated at decreased filament or heater voltage to conserve life. It is recommended that the filament or heater voltage be reduced to no less than 80 per cent of normal during standby periods of up to 2 hours. For longer periods, the filament or heater voltage should be turned off.

Filament Overvoltage Pulse Circuits—In certain battery-operated equipment, such as emergency-type, remote-area, or mobile applications, it is of utmost importance to conserve battery power. Quick-heating RCA power tubes provide useful power outputs within about one second from a cold start. This fast "warm-up" feature eliminates the need for standby filament power, resulting in significant conservation of battery power.

In general, "warm-ups" of about one second are adequate in equipment where the microphone switch actuating the transmitter power relay is located in the cradle of the handset, such as a conventional telephone, or similar wall-type installation. However, when the switch is the push-button type located on the hand-set, faster "warm-ups" are demanded. Extremely fast "warm-ups" of less than 200 milliseconds are possible for such "push-to-talk" microphone switches by the use of a suitably designed filament overvoltage pulse circuit or "hot-shot" circuit.

The diagram shown in Fig. 3 depicts the filament-voltage waveform during a transmission using a "hot-shot" circuit. An overvoltage

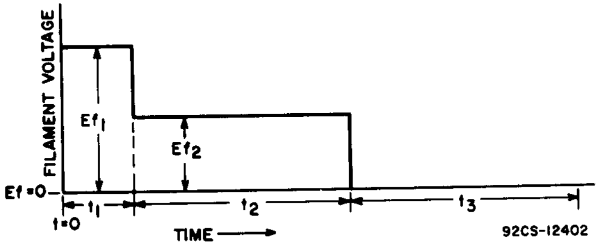

FIG.3 - FILAMENT VOLTAGE WAVE FORM

Ef_1 is applied for time t_1. A transfer switch then reduces the filament voltage to the rated value, Ef_2, for the remainder of transmission time t_2. During standby time t_3, the filament voltage is zero.

The block diagram shown in Fig. 4 depicts the basic requirements of a "hot-shot" circuit in conjunction with the communication equipment. The auxiliary circuit must provide a low-impedance filament overvoltage source, a rated filament voltage source, an accurately timed means of switching these sources, and a protective circuit to prevent possible damage to the tube filament from repeated applications of overvoltage with insufficient time for the filament to cool between transmissions. Both filament voltages are obtained from the transmitter power supply. Power is supplied simultaneously to the transmitter and timer

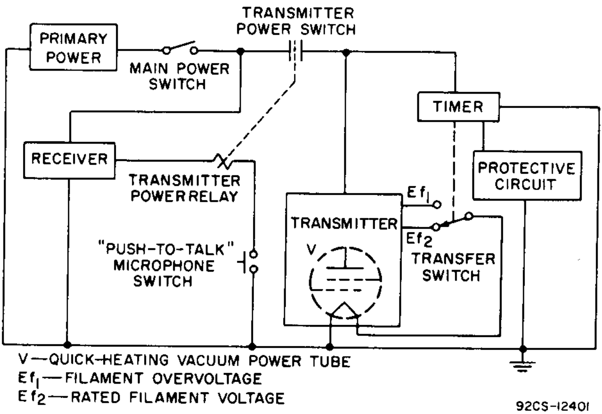

FIG.4 - BASIC RECEIVER-TRANSMITTER WITH AUXILIARY "HOT-SHOT" CIRCUIT

by the **"push-to-talk"** microphone switch. The **transfer switch**, which is initially connected to the **filament overvoltage** source, is switched by the **timer** to the **rated filament voltage** source in the required time (pulse duration) after application of power to the transmitter.

Before a "hot-shot" circuit can be designed for a quick-heating tube, it is necessary to establish maximum ratings for the peak voltage (on the order of 2 to 3 times the rated filament voltage) and duration of the filament overvoltage pulse for the desired heating time. Filament overvoltage pulse ratings are given in the published data on quick-heating tube types.

Any "hot-shot" circuit design must provide protection against the application of the filament overvoltage pulse to a hot filament.

It is recommended that a dummy filament, simulating the resistance of the specific tube type, be used in the initial testing or checking of a "hot-shot" circuit design. Otherwise, any fault—especially an excessive pulse duration can cause catastrophic failure of the tube.

Plate Voltage Supply—Power-amplifier tubes usually obtain plate voltage from rectifiers provided with suitable filter circuits, although batteries or local dc generators are sometimes used, especially in portable and mobile equipment.

A time-delay relay should be provided in the plate-supply circuit to delay application of plate voltage until the filament or heater has reached normal operating temperature.

An interlocking relay system should be provided to prevent application of plate voltage prior to the application of sufficient bias voltage and/or rf drive to grid No. 1; otherwise, with insufficient bias, the resultant high plate current may cause excessive plate dissipation with consequent damage to the tube. RF-load shorts or other causes of high output VSWR may also cause high dissipations, excessive voltage gradients, or insulator flash-overs. The VSWR should be monitored and the detected signal used to actuate the interlock system to remove the plate voltage in less than 10 milliseconds after the fault occurs.

In beam power tubes with closely spaced electrodes, extremely high-voltage gradients occur even with moderate tube operating voltages. Consequently, momentary fault currents may cause catastrophic failure unless protection is provided. A series impedance in the plate lead is recommended. A resultant plate impedance, which will provide a plate-voltage-supply regulation of no better than 10 per cent, is usually sufficient.

Grid-No.2 Voltage Supply—The grid No.2 must be protected by a time-delay and interlocking relay similar to the plate-voltage-supply protection described for Plate Voltage Supply. The plate voltage should be applied simultaneously with or before the grid-No.2 voltage; otherwise, with voltage on grid No.2 only, grid-No.2 current may be large enough to cause excessive grid-No.2 dissipation. If the grid-No.2 voltage is obtained from the plate voltage supply, these precautions will have been accomplished.

Grid-No.2 current is composed of a positive-current component resulting from cathode emission to grid No.2 and a negative-current component resulting from secondary-emission phenomena. Because the net result of these component currents is read on a meter in the grid-No.2 circuit, grid-No.2 dissipation can not be accurately determined. Operation similar to conditions given under *Typical Operation* in the published data will minimize the possibility of exceeding maximum dissipation.

In tubes with precision-aligned grids, such as Cermolox tubes, the grid-No.2 circuit must be capable of maintaining the proper grid-No.2 voltage in the presence of moderate negative dc current as well as normal values of positive current. Complete protection can be achieved by the use of a well-regulated power supply, a grid-No.2-to-ground impedance that is low enough to prevent gradual build-up of grid-No.2 voltage and/or catastrophic build-up (runaway) under negative-current conditions, and a current-overload relay to protect the grid No.2 against positive or negative currents on the order of one-tenth the required plate current.

Grid-No. 1 Voltage Supply—The grid-No. 1 bias circuit should preferably be adjustable to permit small variations of grid-No. 1 voltage. This bias adjustment will permit setting the desired plate current, and it will minimize variations in tube performance. Sufficient fixed bias or cathode resistor bias should be provided to protect the tube in the event that the drive signal is lost.

The design of the bias-voltage supply should include an instantaneous over-current relay. The action of the over-current relay and the inherent regulation of the supply should be such that no damage to the tube or supply will result from an accidental short at the tube connection or from an internal tube fault.

The rf-power-input transmission line should be provided with VSWR protection to remove drive power as well as plate (and grid No. 2) voltage within 10 milliseconds in the event of abnormal changes in input VSWR during operation.

CLASSES OF SERVICE

AF Power Amplifiers—The current and power values in the Maximum Ratings are averaged over any audio-frequency cycle of sine-wave form. The driver stage should be capable of supplying at low distortion the No. 1 grid(s) with the value of peak af voltage given in the *Typical Operation* of the published data. In no case should the Grid-No. 1-Circuit Resistance exceed the value specified under *Maximum Circuit Values*. Transformer or impedance coupling devices are recommended.

Individual bias adjustment for each tube (unit) should be used to balance the loading and minimize distortion. In push-pull operation the bias of each tube (unit) should be adjusted to divide the value of zero-signal plate current in the published data equally between the two tubes (units).

Except for class A amplifiers, the average plate and grid No.2 currents vary with the amplitude of the driving signal. Hence, serious distortion and inadequate power output will result with large input signals unless the plate and grid-No.2 power supplies are well regulated.

Class A—This class normally does not draw grid-No.1 current or requires tube driving power and can employ simple cathode bias. Where class A_2 (indicating grid-No.1 current flows during part of the cycle) is specified, the grid-No.1 circuit precautions discussed under class AB_2 operation will apply.

Class AB_1—The subscript 1 in class AB_1 indicates that grid-No.1 current does not flow during any part of the cycle.

Class B and Class AB_2—These classes normally draw grid-No.1 current (indicated by the subscript 2 in AB_2) with large signals and, therefore, require tube driving power. To minimize distortion, the grid-No.1 bias supply preferably should be regulated or held to a low value of effective resistance. Transformer coupling should be used.

RF Power Amplifiers or Oscillators—On modern ceramic-metal envelope types, the frequency selected is usually the maximum value at which reasonable gain and efficiency are obtained. In glass-envelope types, the maximum frequency is selected as the frequency above which excessive rf envelope losses require voltage deratings and reduced efficiency requires input deratings.

Driving power values given in the published data include only the power that must be delivered to the tube and bias supply. The term, "driving power", is normally used only at low frequencies where circuit losses are small.

Where *Driver-Power Output* is shown in the ublished data, the rf losses associated with a typical input circuit are also included.

In cathode-drive circuits, a portion of the driver-power output and the developed rf power output act in series to supply the load circuit. If the driving power is increased, the output ill always increase. In a grid-drive circuit, a saturation effect takes place; i.e., above a certain value of driving voltage and current, the output increases very slowly and may even decrease. It is important to recognize this difference and not try to saturate a cathode-.rive stage; otherwise, the maximum grid-No.1 and grid-No.2 input may easily be exceeded.

Parasitic oscillations may be experienced under certain operating conditions. Such oscillations result in erratic performance and may cause damage to the tube and/or associated circuitry. Operating conditions and external circuits should be adjusted for operation without oscillations. References 10 and 11 are suggested for further information on the detection and suppression of parasitic oscillations.

Class C Plate-Modulated-Power Amplifiers— In plate-modulated class C amplifier service, the tube can be modulated 100 per cent. The grid-No.2 voltage must be modulated simultaneously with the plate voltage so that the ratio of grid-No.2 voltage to plate voltage remains constant.

Grid-No.2 voltage should be obtained preferably from a separate source modulated from a separate winding on the modulation transformer.

Bias voltage may be obtained from a grid-No.1 resistor, but preferably is obtained from a combination of grid-No.1 resistor with either fixed supply or cathode resistor to protect the tube in the event the drive signal is lost.

In cathode-drive, plate-modulated, class C rf power amplifier service, the tube can be modulated 100 per cent if the rf driver stage is simultaneously modulated 100 per cent. Care should be taken to insure that the driver-modulation and amplifier-modulation voltages are exactly in phase.

Class C CW Power Amplifiers—In class C rf telegraphy service, the tube may generally be supplied with bias by any convenient method: from fixed supply, by grid-No.1 resistor, by cathode resistor, or by combination methods. However, when the tube is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, an amount of fixed bias must be used to limit the plate current and, therefore, the plate dissipation to a safe value. Some fixed bias is preferred in any event to protect the tube in case the drive signal is lost.

Grid-No.2 voltage should be obtained preferably from a separate source. It can also be obtained from the plate-supply voltage with a voltage divider, or through a series resistor. A series grid-No.2 resistor should be used only when the tube is used in a circuit which is not keyed.

Linear RF Power Amplifiers—The classes of operation suitable for linear rf power amplifiers include: class A, class AB_1, class AB_2, class B with bias, and class B with zero bias. Class A operation is the more nearly linear, but it is also the least efficient. Application is generally limited to low-power-level amplification. Class AB_1 produces the best compromise for linearity, efficiency, and gain. Class AB_2 or class B operation provides higher output for applications where sufficient driving power is available to permit some "swamping", and where linearity requirements are less stringent. Class B zero-bias operation with suitable high mu triodes may be used when adequate driving power is available.

In general, grid-No.2 voltage should be obtained from a separate, well-regulated source. In circuits where the grid-No.1 current is drawn, a separate, well-regulated source is also required.

(1) - **Single-Sideband, Suppressed Carrier Service**—Single sideband suppressed carrier operation is a form of linear amplifier service in which only one sideband is transmitted, and the carrier is suppressed.

The values of *Distortion Products Level* given under *Typical Operation* in the published data are referenced to either of the two tones for "two-tone" modulation and are without the use of feedback to enhance linearity.

(2) - **Class B and Class C Television Service**—Television is a form of linear amplifier service in which the rf carrier is modulated by a video signal. Typical operation is given at conditions of a specified bandwidth measured between the half-power points.

The values for the pertinent parameters given under *Typical Operation* in the published data are given at the synchronizing (sync) level and pedestal level (black level or blanking level).

(3) - **Class B Telephony Service**—Class B telephony service is a form of linear amplifier service in which the grid is excited with an rf carrier that is modulated at audio frequencies in one of the preceding stages. Under these conditions, plate dissipation is greatest when the carrier is unmodulated. Grid bias should be obtained from a dc voltage source of good regulation.

Pulsed RF Amplifiers and Oscillators—This service consists of the generation and amplification of an rf signal, the envelope of which is a waveform limited to intermittent pulses of defined shape, duration, and repetition frequency. Pulse duration and duty factor are sometimes limited directly by the maximum ratings. More frequently, the maximum ratings define a relationship between these factors as a maximum "ON" time in a given time interval in order to cover pulse-train inputs. Typical operation, in general, is given for conditions with a rectangular waveshape pulse of a given duration and duty factor. For operation at pulse durations or duty factors other than those given in the published data, see Ref.12.

In the amplifier service, the power supply pulses should preferably start shortly after and end shortly before the rf drive pulse to reduce the possibility of parasitic oscillations. If the rf drive pulses are "gated" within the power-supply pulses (the rf drive pulse starts shortly after and ends shortly before the power-supply pulses), the desired "gate" conditions should be observed carefully when no rf drive pulse is present to be assured that no oscillations are present.

The peak input energy required during the pulse is normally obtained from capacitor banks that must store many times this peak value to prevent excessive voltage droop. Consequently, it is particularly important to observe all the precautions for limiting tube input during faults which are described under Grid-No.2 Voltage Supply.

Pulse-Modulated RF Amplifiers—This service consists of the simultaneous amplification and pulse modulation of a cw rf signal. If differs from the other more conventional modulated rf amplifier services in that the modulating waveform is limited to intermittent pulses of defined shape, duration, and repetition frequency. This type of amplification/modulation is normally done at low power levels; hence, few power tubes are rated specifically for this service.

Pulse Modulator Service—The tube supplies a modulation signal consisting of intermittent pulses of defined shape, duration, and repetition frequency. Ratings, waveforms, and precautions are similar to those given for pulsed rf amplifier service (except there is no rf drive signal).

Observation of the exact waveforms must be made with an oscilloscope. In this manner, transient voltage or current spikes caused by unavoidable circuit reactances may be observed. Transient values must be held within the maximum ratings given in the published data.

High-power pulse modulators, when used to "clip" or "flat-top" the output waveform by the overdriving technique, must provide grid-No.1 and grid-No.2 input protection.

Plate current flow during the "OFF" time will contribute to plate dissipation; the bias voltage should be sufficient to hold the plate current below the required levels for any tube. The control limits, such as found in the Characteristics Range Values will provide information in determining the required bias. Current flow during the rise time and the fall time of a "rectangular" pulse can contribute significantly to plate dissipation; this current flow should be considered if the theoretical plate dissipation is close to the rated value.

Voltage Regulator Service—The tube acts as a "pass tube" having a controllable voltage drop in a series-regulated voltage-supply circuit. The plate voltage rating can be interpreted as applying to the actual plate-to-cathode voltage of the tube rather than the supply voltage. In this case, adequate protective devices must be used to protect the tube in the event of a shorted load. Special precaution should be made to observe the maximum circuit values for grid-No.1 and grid-No.2 impedance. For information on voltage regulator circuits, see Refs. 13,14, and 15.

It is recommended that only tube types rated for this service be used since the use of a high power vacuum tube in a high-voltage, low-current application will frequently result in the selection of a tube inadequately controlled in the low-current region.

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[a] Made by the Tempil Corp., 132 W. 22nd Street, New York 1, New York.

[b] Manufactured by the Fluorchemical Division, Minnesota Mining and Manufacturing Co., 900 Bush Avenue, St. Paul 6, Minnesota.

[c] Warning: Beryllia dust and fumes are highly toxic to mucous membranes and may cause serious ulcers when imbedded under the skin. See References 7, 8, and 9.

REFERENCES

Copies for references 1, 3, 4, and 6 may be obtained by writing to Commercial Engineering, Radio Corporation of America, Harrison, New Jersey.

1. *Techniques for Measuring Electron-Tube Bulb Temperatures, RCA Application Note, AN-200.*

2. *Design Manual of Natural Methods of Cooling Electronic Equipment*, Department of the Navy, Bureau of Ships, Navships 900, 192.

3. *Blower Requirements for RCA Forced-Air-Cooled Tubes*, RCA Application Note, AN-161.

4. *Application Guide for RCA Super-Power Tubes*, 1CE-279A.

5. *Design Manual of Methods of Liquid Cooling Electronic Equipment*, Department of the Navy, Bureau of Ships, Navships 900, 195.

6. J. W. Gaylord, *"The Conduction Cooling of Power Tubes in Vehicular Communication Equipment,"* IEEE Transactions on Vehicular Communications, September, 1963.

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8. Donald P. O'Neil, *"Toxic Materials Machined Safely,"* American Machinist, June 4. 1955.

9. Sidney Laskin, Robert A. N. Turner, and Herbert E. Stokinger, *"Analysis of Dust and Fume Hazards in a Beryllium Plant,"* U.S. Atomic Energy Commission, MDDC-1355.

10. F. E. Terman, *"Radio Engineers' Handbook,"* pages 498 to 503 of 1943 edition. Published by McGraw-Hill Pub. Co., Inc.

11. EE Staff of MIT, *"Applied Electronics,"* page 619.

12. *Predicted Cathode Capability*, RCA Power Tube Engineering Note, IEN-1.

13. F. V. Hunt, & R. W. Hickman, Review of Scientific Instruments, *"On Electronic Voltage Stabilizers,"* January, 1939.

14. F. E. Terman, *"Radio Engineers' Handbook,"* pages 614 and 615 of 1943 edition. Published by McGraw-Hill Pub. Co., Inc.

15. Cruft Electronics Staff, *"Electronic Circuits and Tubes,"* page 575. Published by McGraw-Hill Pub. Co., Inc.

Transmitting Tube Ratings vs Operating Frequency

The MAXIMUM RATINGS given for each type on its data pages apply only when the type is operated at frequencies lower than some specified value which depends on the design of the type. As the frequency is raised above the specified value, the radio-frequency currents, dielectric losses, and heating effects increase rapidly. Most types can be operated above their specified maximum frequency provided the plate voltage and plate input are reduced in accordance with the information given in the following tabulation.

TUBE TYPE	OPERATING FREQUENCY Mc	MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE & PLATE INPUT		
		TELEPHONY		TELEGRAPHY
		Class B, Class C Grid or Suppressor Modulated	Class C Plate-Modulated	Class C Unmodulated
8D21	300	100	–	100
207	Same as for Type 892			
211	15 30 80	100 88 70	100 80 50	100 80 50
801-A	60 75 120	100 93 78	100 80 50	100 80 50
803	20 40 60	100 86 80	100 77 60	100 77 60
805	30 45 80	100 90 77	100 82 55	100 82 55
807	60 80 125	100 90 75	100 80 55	100 80 55
809	60 70 120	100 93 75	100 88 50	100 88 50
810	30 60 100	100 88 80	100 70 50	100 70 50
813[a]	30 60 120	100 88 76	100 75 50	100 75 50

[a] In Self-Rectifying Oscillator or Amplifier Service, and in Amplifier or Oscillator Service with Separate, Rectified, Unfiltered, Single-Phase, Full-Wave Plate Supply, the 813 has the same maximum permissible percentages as those shown for Class C Telegraphy.

Transmitting Tube Ratings vs Operating Frequency

TUBE TYPE	OPERATING FREQUENCY Mc	MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE & PLATE INPUT		
		TELEPHONY		TELEGRAPHY
		Class B, Class C Grid or Suppressor Modulated	Class C Plate-Modulated	Class C Unmodulated
814	30	100	100	100
	50	90	80	80
	75	85	64	64
815	125	100	100	100
	175	85	80	80
	200	75	70	70
828	30	100	100	100
	50	90	80	80
	75	80	65	65
830-B	15	100	100	100
	30	87	77	77
	60	74	54	54
832-A	200	-	100	100
	250	-	89	89
834	100	100	100	100
	170	89	80	80
	350	73	53	53
835	20	100	100	100
	40	85	80	80
	100	70	50	50
837	20	-	100	100
	40	-	76	76
	60	-	62	62
838	30	100	100	100
	60	85	75	75
	120	70	50	50
860	Same as for Type 838			
880		*Voltage* / *Input*		
	25	100 / 100	100	100
	50	80 / 94	72	75
	75	68 / 85	56	62
	100	60 / 75	45	50
889-A	50	100	100	100
	100	85	75	75
	150	72	50	50
889R-A				*Volt.* / *Input*
	40	100	100	100 / 100
	65	85	78	87 / 73
	100	72	60	65 / 50

RADIO CORPORATION OF AMERICA
Electronic Components and Devices Harrison, N. J.

Transmitting Tube Ratings vs Operating Frequency

TUBE TYPE	OPERATING FREQUENCY Mc	MAXIMUM PERMISSIBLE PERCENTAGE OF MAXIMUM RATED PLATE VOLTAGE & PLATE INPUT		
		TELEPHONY		TELEGRAPHY
		Class B, Class C Grid or Suppressor Modulated	Class C Plate-Modulated	Class C Unmodulated
891	1.6	–	–	100
	7.5	–	–	75
	20	–	–	50
891-R	1.6	–	–	100
	7.5	–	–	75
	20	–	–	50
892	1.6	100	100	100
	7.5	85	85	75
	20	76	75	50
892-R	1.6	100	100	100
	7.5	85	75	75
	20	76	50	50
1613	45	–	100	100
	60	–	90	90
	90	–	85	85
1614	80	–	100	100
	120	–	75	75
1619	45	100	100	100
	60	93	90	90
	90	85	77	77
1624	60	100	100	100
	80	90	80	80
	125	75	55	55
1625	Same as for Type 807			
1626	30	–	–	100
	60	–	–	96
	90	–	–	93
5713	220	–	–	100
5763			*Volt.* / *Input*	*Volt.* / *Input*
	50	–	100 / 100	100 / 100
	175	–	100 / 80	100 / 80
5771				*Volt.* / *Input*
	1.6	100	100	120 / 112.5
	25	100	100	100
	50	75	75	75
5786	160	–	100	100
6417	Same as for Type 5763			
8005	60	100	100	100
	80	90	75	75
	100	83	60	60

CIRCUITS FOR HOT-CATHODE MERCURY-VAPOR & GAS RECTIFIER TUBES

Numerical Relationships Among Electrical Quantities

E = Trans. Sec. Voltage (RMS)
E_{av} = Average DC Output Voltage
E_{bmi} = Peak Inverse Anode Voltage
E_m = Peak DC Output Voltage
E_r = Major Ripple Voltage (RMS)
f = Supply Frequency
f_r = Major Ripple Frequency
I_{av} = Average DC Output Current
I_b = Average Anode Current
I_p = Anode Current (RMS)
I_{pm} = Peak Anode Current
P_{al} = Line Volt-Amperes
P_{ap} = Trans. Pri. Volt-Amperes
P_{as} = Trans. Sec. Volt-Amperes
P_{dc} = DC Power ($E_{av} \times I_{av}$)

Note: Conditions assumed involve sine-wave supply; zero voltage drop in tubes; no losses in transformer and circuit; no back emf in the load circuit; and no phase-back.

RATIO	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5*	Fig. 6	Fig. 7	Fig. 8
Voltage Ratios								
E/E_{av}	2.22	1.11	1.11	0.854	0.854	0.427	0.785	0.74
E_{bmi}/E	1.41	2.83	1.41	2.45	2.45	2.45	2.83	2.83
E_{bmi}/E_{av}	3.14	3.14	1.57	2.09	2.09	1.05	2.22	2.09
E_m/E_{av}	3.14	1.57	1.57	1.21	1.05	1.05	1.11	1.05
E_r/E_{av}	1.11	0.472	0.472	0.177	0.04	0.04	0.106	0.04
Frequency Ratio								
f_r/f	1	2	2	3	6	6	4	6
Current Ratios								
I_p/I_{av}	1.57	0.785	0.785	0.578	0.289	0.578	0.5	0.408
I_b/I_{av}	1	0.5	0.5	0.33	0.167	0.33	0.25	0.167
Resistive Load								
I_{pm}/I_{av}	3.14	1.57	1.57	1.21	0.52	1.05	1.11	1.05
I_{pm}/I_b	3.14	3.14	3.14	3.63	3.14	3.14	4.5	6.3
Inductive Load■								
I_{pm}/I_{av}	—	1	1	1	0.5	1	1	1
Power Ratios								
Resistive Load								
P_{as}/P_{dc}	3.49	1.74	1.24	—	—	—	—	—
P_{ap}/P_{dc}	2.69	1.23	1.24	—	—	—	—	—
P_{al}/P_{dc}	2.69	1.23	1.24	—	—	—	—	—
Inductive Load■								
P_{as}/P_{dc}	—	1.57	1.11	1.71	1.48	1.05	1.57	1.81
P_{ap}/P_{dc}	—	1.11	1.11	1.21	1.05	1.05	1.11	1.29
P_{al}/P_{dc}	—	1.11	1.11	1.21	1.05	1.05	1.11	1.05

* Bleeder current of 2% full-load current will provide exciting current for balance coil and thus avoid poor regulation at light loading.

■ The use of a large filter-input choke is assumed.

CIRCUITS FOR HOT-CATHODE MERCURY-VAPOR & GAS RECTIFIER TUBES

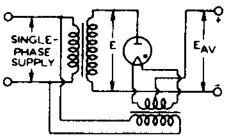

FIG. 1 HALF-WAVE SINGLE-PHASE

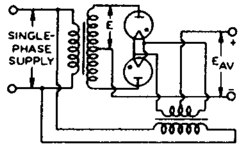

FIG. 2 FULL-WAVE SINGLE-PHASE

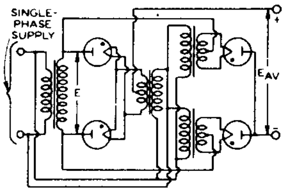

FIG. 3 SERIES SINGLE-PHASE

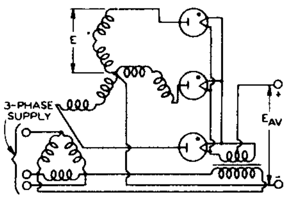

FIG. 4 HALF-WAVE THREE-PHASE

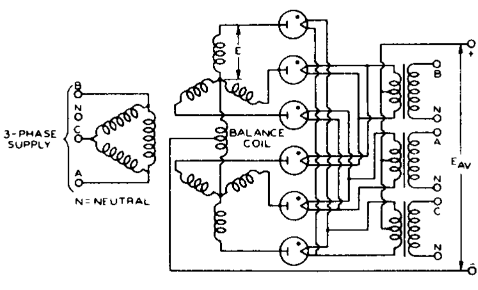

FIG 5 PARALLEL THREE-PHASE (QUADRATURE OPERATION)

92CL-7673A

CIRCUITS FOR HOT-CATHODE MERCURY-VAPOR & GAS RECTIFIER TUBES

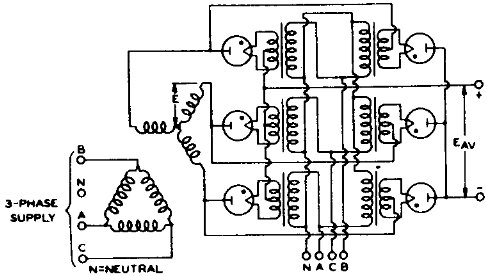

FIG. 6 SERIES THREE-PHASE (QUADRATURE OPERATION)

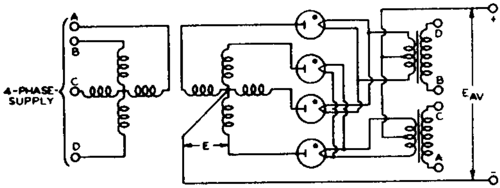

FIG. 7 HALF-WAVE FOUR-PHASE (QUADRATURE OPERATION)

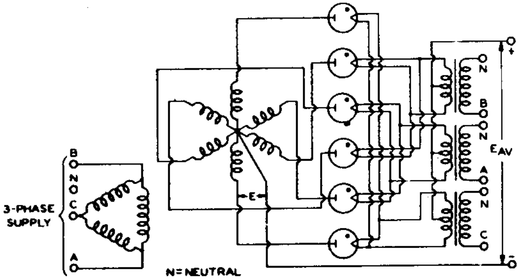

FIG. 8 HALF-WAVE SIX-PHASE (QUADRATURE OPERATION)

92CL-7673B