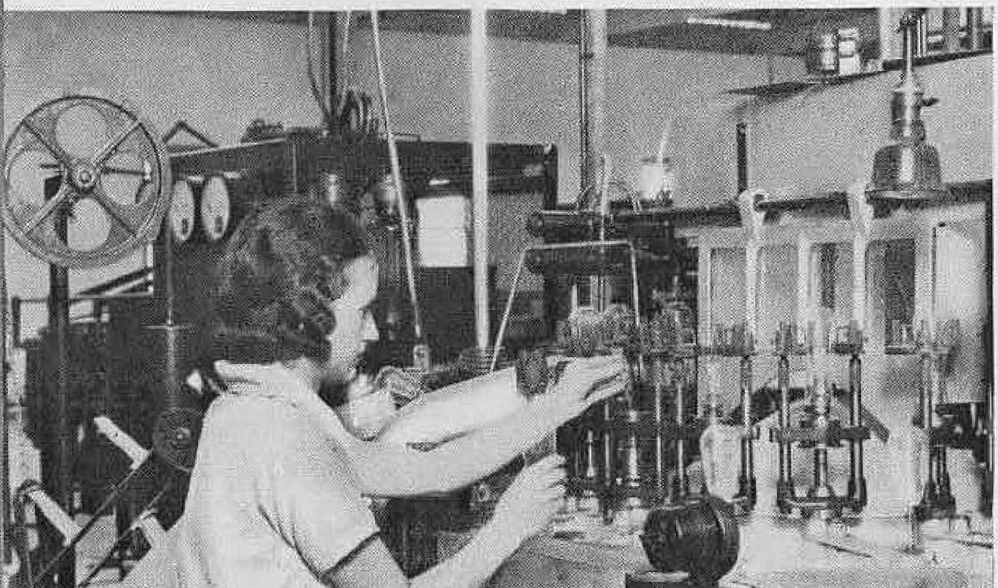
The
RADIOTRON
Designer's Handbook

PRICE 1/-

THIS handbook has been prepared expressly for the set-designer, but will be found invaluable to wireless engineers, experimenters, service mechanics and salesmen.

The
RADIOTRON
Designer's Handbook

Radiotron Works at Ashfield, Sydney.



Modern exhausting and sealing machine.

CONTENTS.

Radiotron Designer's Handbook.

FOREWORD.

This handbook has been compiled with the object of supplying full and comprehensive information in as concise a form as possible. The aim throughout has been to omit unnecessary matter and include information on all points likely to arise in the design of radio receivers, amplifiers, public address equipment and any equipment incorporating Radiotron valves.

The greater part of the formulae, etc., is new to Australia, and as most of the tables have been specially calculated to meet practical needs, it should prove of inestimable value, particularly to design engineers.

Special attention is drawn to the wide range of subjects, especially the many useful pages of Wire Tables which are most complete and include parallel SWG and B and S gauges, not only giving those dimensions usually published, but also others which are needed in the design of transformers, chokes and coils.

Tables of resistance wires include Nichrome, Advance and Eureka. A most valuable feature is the table of the safe current carrying capacities of these wires when wound on a spool. In addition there is a complete series of formulae which will assist in solving many problems encountered with valves, tuned circuits, A.C. and D.C. circuits.

A separate section deals with the design of transformers (power audio, loud-speaker input, push-pull and Class B), whilst tables of Driver and Class B valves supply a definite need.

Wire Tables.

BARE COPPER WIRE (20°C=68°F)

B. & S. No.	Diameter Mils.	Area Circular Mils.	Area Square Inches	Ohms per 1000 Feet	Ohms per Pound	Feet per Pound	Pounds per 1000 Feet
0000	460	211,600	.166,2	.04901	.00007652	1.561	640.5
000	410	167,800	.131,8	06180	.0001217	1.968	507.9
00	364.8	133,100	.104,5	.07793	.0001935	2.482	402.8
0	324.9	105,500	.082,89	.09827	.0003076	3.130	319.5
1	289.3	83,700	.065,73	.1239	.0004891	3.947	253.3
2	257.6	66,400	.052,13	.1563	.0007778	4.977	200.9
3	229.4	52,600	.041,34	.1970	.001237	6.276	159.3
4	204.3	41,700	.032,78	.2485	.001966	7.914	126.4
5	181.9	33,100	.026,00	.3133	.003127	9.980	100.2
6	162.0	26,250	.020,62	.3951	.004972	12.58	79.46
7	144.3	20,820	.016,35	.4982	.007905	15.87	63.02
8	128.5	16,510	.01297	.6282	.01257	20.01	49.98
9	114.4	13,090	.010,28	.7921	.01999	25.23	39.63
10	101.9	10,380	.008,155	.9989	.03178	31.82	31.43
11	90.7	8,230	.006,467	1.260	.05053	40.12	24.92
12	80.8	6,530	.005,129	1.588	.08035	50.59	19.77
13	72.0	5,180	.004,067	2.003	.1278	63.80	15.68
14	64.1	4,110	.003,225	2.525	.2032	80.44	12.43
15	57.1	3,257	.002,558	3.184	.3230	101.4	9.858
16	50.8	2,583	.002,028	4.016	.5136	127.9	7.818
17	45.3	2,048	.001,609	5.064	.8167	161.3	6.200
18	40.3	1,624	.001,276	6.385	1.299	203.4	4.917
19	35.89	1,288	.001,012	8.051	2.065	256.5	3.899
20	31.96	1,022	.000,802,3	10.15	3.283	323.4	3.092
21	28.46	810	.000,636,3	12.80	5.221	407.8	2.452
22	25.35	642	.000,504,6	16.14	8.301	514.2	1.945
23	22.57	509	.000,400,2	20.36	13.20	648.4	1.542
24	20.10	404	.000,317,3	25.67	20.99	817.7	1.223
25	17.90	320.4	.000,251,7	32.37	33.37	1,031.0	0.9699
26	15.94	254.1	.000,199,6	40.81	53.06	1,300	0.7692
27	14.20	201.5	.000,158,3	51.47	84.37	1,639	0.6100
28	12.64	159.8	.000,125,5	64.90	134.2	2,067	0.4837
29	11.26	126.7	.000,099,53	81.83	213.3	2,607	0.3836
30	10.03	100.5	.000,078,94	103.2	339.2	3,287	0.3042
31	8.928	79.70	.000,062,60	130.1	539.3	4,145	0.2413
32	7.950	63.21	.000,049,64	164.1	857.6	5,227	0.1913
33	7.080	50.13	.000,039,37	206.9	1,364.0	6,591	0.1517
34	6.305	39.75	.000,031,22	260.9	2,168	8,310	0.1203
35	5.615	31.52	.000,024,76	329.0	3,448	10,480	0.09542
36	5.000	25.00	.000,019,64	414.8	5,482	13,210	.07568
37	4.453	19.83	.000,015,57	532.1	8,717	16,660	.06001
38	3.965	15.72	.000,012,35	659.6	13,860	21,010	.04759
39	3.531	12.47	.000,009,793	831.8	22,040	26,500	.03774
40	3.145	9.888	.000,007,766	1,049.0	35,040	33,410	.02993
(41)	2.75	7.5625	.000,005,940	1,370	59,990	43,700	.02289
(42)	2.50	6.2500	.000,004,909	1,660	87,700	52,800	.01892
(43)	2.25	5.0625	.000,003,976	2,050	133,700	65,300	.01532
(44)	2.00	4.0000	.000,003,142	2,600	214,000	82,600	.01211
(45)	1.75	3.0625	.000,002,405	3,390	350,200	107,900	.00927
(46)	1.50	2.2500	.000,001,767	4,610	676,800	146,800	.00681

WIRE TABLES—(continued)

BARE COPPER WIRE (60°F)

S.W.G. No.	Diameter Mils.	Area Circular Mils.	Area Square Inches	Ohms per 1000 Feet	Ohms per Pound	Feet per Pound	Pounds per 1000 Feet
4/0	400	160,000	.125,66	.06368	.00013146	2.064	484.4
3/0	372	138,400	.108,69	.0736	.00017574	2.390	418.9
2/0	348	121,100	.095,11	.0841	.0002295	2.730	366.7
1/0	324	105,000	.082,45	.0971	.0003054	3.147	317.8
1	300	90,000	.070,69	.1132	.0004155	3.670	272.5
2	276	76,180	.059,83	.1338	.0005800	4.338	230.6
3	252	63,500	.049,88	.1605	.0008345	5.200	192.3
4	232	53,820	.042,27	.1893	.0011617	6.139	162.9
5	212	44,940	.035,30	.2267	.0016661	7.348	136.1
6	192	36,860	.028,95	.2764	.002476	8.961	111.6
7	176	30,980	.024,33	.3289	.003507	10.66	93.8
8	160	25,600	.020,11	.3980	.005135	12.90	77.5
9	144	20,740	.016,286	.4914	.007827	15.93	62.78
10	128	16,380	.012,868	.6219	.012537	20.16	49.61
11	116	13,460	.010,568	.7570	.018587	24.55	40.74
12	104	10,820	.008,495	.942	.02877	30.54	32.75
13	92	8,464	.006,648	1.204	.04698	39.01	25.63
14	80	6,400	.005,027	1.592	.08216	51.60	19.38
15	72	5,184	.004,072	1.966	.12523	63.73	15.69
16	64	4,096	.003,217	2.488	.2006	80.65	12.40
17	56	3,136	.002,463	3.249	.3422	105.4	9.49
18	48	2,304	.001,809,6	4.422	.6340	143.3	6.98
19	40	1,600	.001,256,6	6.368	1.3146	206.4	4.844
20	36	1,296	.001,017,9	7.860	2.004	254.8	3.924
21	32	1,024	.000,804,2	9.950	3.209	322.6	3.100
22	28	784	.000,615,8	12.997	5.475	421.2	2.374
23	24	576	.000,452,4	17.69	10.144	573.4	1.744
24	22	484	.000,380,1	21.05	14.366	682.6	1.465
25	20	400	.000,314,2	25.47	21.03	825.8	1.211
26	18	324	.000,254,5	31.45	32.06	1,019	0.981
27	16.4	269	.000,211,2	37.88	46.52	1,229	0.814
28	14.8	219	.000,172,03	46.52	70.14	1,508	0.6632
29	13.6	185	.000,145,27	55.09	98.37	1,786	0.5600
30	12.4	153.8	.000,120,76	66.27	142.35	2,148	0.4655
31	11.6	134.6	.000,105,68	75.7	185.87	2,455	0.4074
32	10.8	116.6	.000,091,61	87.4	247.4	2,832	0.3531
33	10.0	100.0	.000,078,54	101.9	336.5	3,302	0.3028
34	9.2	84.64	.000,066,48	120.4	469.8	3,901	0.2563
35	8.4	70.56	.000,055,42	144.4	676.0	4,682	0.2136
36	7.6	57.76	.000,045,36	176.4	1,008.7	5,718	0.1749
37	6.8	46.24	.000,036,32	220.4	1,574	7,143	0.1400
38	6.0	36.00	.000,028,27	283.0	2,596	9,174	0.1090
39	5.2	27.04	.000,021,24	376.8	4,603	12,210	0.0819
40	4.8	23.04	.000,018,096	442.2	6,340	14,330	0.0698
41	4.4	19.36	.000,015,205	526.3	8,979	17,060	0.05862
42	4.0	16.00	.000,012,566	636.8	13,146	20,640	.04844
43	3.6	12.96	.000,010,179	786.3	20,040	25,480	.03924
44	3.2	9.734	.000,008,042	995.0	32,090	32,260	.03100
45	2.8	7.840	.000,006,158	1,299.7	54,750	42,120	.02374
46	2.4	5.760	.000,001,524	1,779	101,440	57,340	.01744
47	2.0	4.000	.000,003,142	2,547	210,300	82,580	.01211
48	1.6	2.560	.000,002,011	3,980	513,500	129,000	.00775
49	1.2	1.440	.000,001,131	7,077	1,623,000	229,400	.00436
50	1.0	1.000	.000,000,785,4	10,190	3,365,000	303,000	.00303

TURNS PER INCH AND INSULATED WIRE DIAMETER

B. & S. No.	Diameter (mils)		Turns per inch (exact winding)					
	*Enam.	D.C.C.	Bare	Enam.	S.C.C.	D.C.C.	S.C.C.	S.S.C.
8	130.6	142.5	7.78	7.65	7.32	7.01	—	—
9	116.5	126.4	8.74	8.58	8.23	7.91	—	—
10	104.0	112.9	9.81	9.61	9.26	8.85	—	—
11	92.7	100.2	11.02	10.7	10.4	9.98	—	—
12	82.8	90.3	12.37	12.0	11.6	11.07	—	—
13	74.0	81.5	13.89	13.5	12.9	12.27	—	—
14	66.1	73.6	15.60	15.1	14.4	13.59	—	—
15	59.1	66.6	17.52	16.9	16.1	15.0	—	—
16	52.8	60.3	19.68	18.9	17.9	16.5	18.9	18.2
17	47.1	54.8	22.1	21.2	19.8	18.2	21.1	20.2
18	42.1	49.8	24.8	23.7	22.0	20.0	23.6	22.5
19	37.7	45.4	27.8	26.5	24.4	22.0	26.3	25.0
20	33.8	41.5	31.3	29.5	27.0	24.1	29.4	27.7
21	30.2	38.0	35.1	33.1	29.8	26.3	32.7	30.7
22	27.0	33.8	39.4	37.0	33.5	29.5	36.6	34.1
23	24.1	31.1	44.3	41.4	36.9	32.1	40.6	37.5
24	21.5	28.6	49.7	46.5	40.6	34.9	45.2	41.4
25	19.2	26.4	55.8	52.0	44.6	37.8	50.0	45.6
26	17.1	24.4	62.7	58.4	49.0	40.9	55.8	50.0
27	15.3	22.7	70.4	65.3	53.4	44.0	61.7	54.9
28	13.6	21.1	82.8	73.5	58.4	47.3	68.4	60.2
29	12.2	19.8	88.8	81.9	63.2	50.5	75.1	65.3
30	10.8	18.5	99.7	92.5	68.9	54.0	83.3	71.4
31	9.7	17.4	112.0	103	74.6	57.4	91.7	77.5
32	8.7	16.5	125.8	114	80.0	60.6	100	83.3
33	7.7	15.6	141.2	129	86.2	64.1	109	90.0
34	6.9	14.8	158.6	144	92.5	67.5	120	97.0
35	6.2	14.1	178	161	99.9	70.9	131	104
36	5.5	13.0	200	181	111	76.9	142	111
37	4.9	12.5	224	204	117	80.0	153	117
38	4.4	12.0	252	227	125	83.3	166	125
39	3.9	11.5	283	256	133	86.9	181	133
40	3.5	11.1	318	285	140	90.0	196	140
(41)	3.05	—	363	327	—	—	—	—
(42)	2.64	—	400	378	—	—	—	—
(43)	2.37	—	444	421	—	—	—	—
(44)	2.12	—	500	471	—	—	—	—
(45)	1.91	—	571	523	—	—	—	—
(46)	1.72	—	666	581	—	—	—	—

* Nominal Value. Actual dimensions vary slightly.

WIRE TABLES—(continued)

TURNS PER INCH AND INSULATED WIRE DIAMETER

S.W.G. No.	Diameter (mils)		Turns per inch (exact winding)					
	*Enam.	D.C.C.	Bare	Enam.	S.C.C.	D.C.C.	S.S.C.	D.S.C.
10	132	142	7.81	7.63	7.35	7.04	—	—
11	120	130	8.62	8.33	8.07	7.69	—	—
12	108	118	9.62	9.26	8.93	8.48	—	—
13	96	106	10.87	10.42	10.00	9.43	—	—
14	84	94	12.50	11.90	11.36	10.64	—	—
15	75.5	84	13.89	13.25	12.66	11.90	—	—
16	67.5	76	15.63	14.81	14.08	13.16	14.93	14.71
17	59	68	17.86	16.95	15.87	14.71	16.95	16.67
18	50.7	59	20.83	19.72	18.18	16.95	20.00	19.61
19	42.6	51	25.00	23.47	21.28	19.61	23.81	23.26
20	38.5	47	27.78	25.97	23.81	21.28	26.32	25.64
21	34.3	43	31.25	29.15	26.32	23.26	29.41	28.57
22	30.0	39	35.71	33.33	29.41	25.64	33.33	32.26
23	25.7	34	41.67	38.91	34.48	29.41	38.46	37.04
24	23.6	32	45.45	42.37	37.04	31.25	42.55	40.00
25	21.5	30	50.00	46.51	40.00	33.33	46.51	43.48
26	19.4	28	55.56	51.55	43.48	35.71	51.81	48.78
27	17.7	26.4	60.98	56.50	46.73	37.88	56.50	52.91
28	16.0	24.8	67.57	62.50	50.51	40.32	62.11	57.80
29	14.8	23.6	73.53	67.57	53.76	42.37	67.11	62.11
30	13.4	22.4	80.65	74.63	57.47	44.64	72.99	67.11
31	12.6	21.6	86.21	79.37	60.24	46.30	77.52	70.92
32	11.7	20.8	92.59	85.47	63.29	48.08	82.64	75.19
33	10.9	20.0	100.00	91.74	66.67	50.00	88.50	80.00
34	10.0	19.2	108.7	100.0	70.42	52.08	95.24	85.47
35	9.1	17.4	119.0	109.9	80.65	57.47	103.1	91.74
36	8.3	16.6	131.6	120.5	86.21	60.24	112.4	99.01
37	7.4	15.8	147.1	135.1	99.21	63.29	123.5	107.5
38	6.6	15.0	166.7	151.5	100.0	66.67	137.0	117.6
39	5.7	14.2	192.3	175.4	108.7	70.42	153.8	129.9
40	5.3	13.8	208.3	188.7	113.6	72.46	163.9	137.0
41	4.8	—	227.3	208.3	—	—	178.6	151.5
42	4.4	—	250.0	227.3	—	—	192.3	161.3
43	3.9	—	277.8	256.4	—	—	208.3	172.4
44	3.5	—	312.5	285.7	—	—	227.3	185.2
45	3.1	—	357.1	322.6	—	—	250.0	200.0
46	2.65	—	416.7	377.4	—	—	277.8	217.4
47	2.25	—	500.0	444.4	—	—	312.5	238.1
48	—	—	—	—	—	—	—	—

* Nominal Value. Actual dimensions vary slightly.

MULTI-LAYER COIL WINDING & WEIGHT OF INSULATED WIRE

B. & S. No.	Enamelled: Turns per Square Inch	Enamelled: Ohms per Cubic Inch	Enamelled: Turns per Square Inch Layer Insulated	D.C.C.: Turns per Square Inch	D.C.C.: Ohms per Cubic Inch	Weight—lbs. per 1000 ft.: Enam.	Weight—lbs. per 1000 ft.: D.C.C.	Weight—lbs. per 1000 ft.: D.S.C.
8	57	.00315	Paper insulated each layer. 20% allowance for waste space at ends of layers	48	.00265	50.55	51.15	
9	72	.00475		59	.00388	40.15	40.60	
10	90	.00748		76	.00631	31.80	32.18	
11	113	.01183		93	.00974	25.25	25.60	
12	141	.01878		114	.01519	20.05	20.40	
13	177	.0295		140	.0233	15.90	16.20	
14	221	.0464		171	.0359	12.60	12.91	
15	277	.0734		208	.0551	10.00	10.33	
16	348	.1162		260	.0869	7.930	8.210	7.955
17	437	.1840		316	.1331	6.275	6.540	6.315
18	548	.2910		378	.2008	4.980	5.235	5.015
19	681	.4560		455	.3048	3.955	4.220	3.990
20	852	.7200		545	.4605	3.135	3.373	3.173
21	1,065	1.134		650	.6920	2.490	2.685	2.520
22	1,340	1.800		865	1.162	1.970	2.168	2.006
23	1,665	2.820		1,030	1.774	1.565	1.727	1.593
24	2,100	4.488	4 mil. paper: 1,420	1,215	2.596	1.215	1.398	1.272
25	2,630	7.080	1,750	1,420	3.822	.988	1.129	1.018
26	3,320	11.27	2,030	1,690	5.740	.7845	.9140	.8100
27	4,145	17.75	2,620	1,945	8.330	.6220	.7560	.6450
28	5,250	28.34	3,250	2,250	12.15	.4940	.6075	.5140
29	6,510	44.32	3,920	2,560	17.30	.3915	.4890	.4130
30	8,175	70.15	4,780	2,930	25.15	.3105	.3955	.3330
31	10,200	110.4	2 mil. paper: 6,780	3,330	36.05	.2465	.3257	.2678
32	12,650	172.6	8,250	3,720	50.76	.1960	.2700	.2170
33	16,200	279.0	10,600	4,140	71.30	.1550	.2270	.1750
34	19,950	433.2	12,400	4,595	99.77	.1230	.1928	.1412
35	25,000	684.5	15,200	5,070	138.7	.0980	.1600	.1130
36	31,700	1,094	1 mil. paper: 21,500	5,550	191.6	.0776	.1361	.0920
37	39,600	1,723	26,300	6,045	263	.0616	.1204	.0740
38	49,100	2,693	32,000	6,510	357	.0488	.1049	.0623
39	62,600	4,332	40,000	6,935	480	.0387	.0937	.0504
40	77,600	6,770	48,400	7,450	650	.0307	.0838	.0429

WIRE TABLES—(continued)

MULTI-LAYER COIL WINDING & WEIGHT OF INSULATED WIRE

SWG No.	Enamelled.			D.C.C.		Weight–lbs. per 1000ft.		
	Turns per Square Inch	Ohms per Cubic Inch	Turns per Square Inch Layer Insulated	Turns per Square Inch	Ohms per Cubic Inch	Enam.	D.C.C.	D.S.C.
10	58.22	.00295	Paper insulated each layer. 20% allowance for waste space at ends of layers.	49.56	.00256	47.77	50.77	
11	69.39	.00437		59.14	.00373	44.40	41.83	
12	85.75	.00673		71.91	.00565	33.04	33.71	
13	108.6	.0109		88.92	.00893	25.89	26.50	
14	141.6	.0189		113.2	.0150	19.60	20.12	
15	175.6	.0287		141.6	.0234	15.87	16.36	
16	219.3	.0456		173.2	.0358	12.56	12.67	12.56
17	287.3	.0776		216.4	.0585	9.607	10.03	9.640
18	388.9	.1431		287.3	.1055	7.060	7.43	7.093
19	550.8	.290		384.6	.204	4.910	5.262	4.945
20	674.4	.440		452.8	.296	3.987	4.267	4.011
21	849.7	.705		541.0	.448	3.152	3.409	3.181
22	1,109	1.200		657.4	.710	2.419	2.649	2.446
23	1,513	2.23		864.9	1.26	1.779	1.918	1.807
24	1,789	3.14	4 mil. paper 1,220	976.6	1.71	1.498	1.667	1.305
25	2,162	4.58	1,460	1,109	2.35	1.241	1.392	1.247
26	2,663	6.95	1,760	1,274	3.33	1.008	1.152	1.013
27	3,192	10.05	2,080	1,436	4.51	.836	.977	.844
28	3,906	15.18	2,500	1,624	6.28	.683	.811	.689
29	4,570	20.9	2,870	1,798	8.23	.578	.699	.582
30	5,565	30.7	3,430	1,989	10.98	.478	.604	.486
31	6,304	39.8	3,840	2,144	13.45	.419	.524	.428
32	7,310	53.1	4,360	2,314	16.83	.364	.467	.371
33	8,409	71.2	2 mil. paper 5,680	2,500	21.15	.313	.412	.329
34	10,000	100.5	6,670	2,714	27.3	.264	.328	.271
35	12,080	145	7,920	3,306	39.3	.221	.317	.228
36	14,520	212	9,360	3,624	53.1	.181	.238	.188
37	18,220	336	11,400	4,007	73.5	.146	.207	.151
38	22,950	544	14,100	4,436	104.5	.114	.169	.119
39	30,770	965	1 mil. paper 20,900	4,956	155.0	.0854	.138	.0868
40	35,610	1,310	24,000	5,256	193.5	.0726	.123	.0791
41	43,390	1,905	28,800			.0608		.0677
42	51,620	2,740	33,700			.0505		.0571
43	65,740	4,300	41,800			.0408		.0473
44	81,620	6,760	50,800			.0324		.0386
45	104,300	11,250				.0249		.0309
46	142,100	21,000				.0182		.0231
47	197,100	41,700				.0126		.0172
48								

RESISTANCE WIRE TABLE

20°C (68°F)

B. & S. No.	Dia. mils.	Advance Wire				Nicrome Wire		
		Ohms per 1,000 feet	Lbs. per 1,000 feet	Feet per Ohm	Current Milli Amps *	Ohms per 1,000 feet	Lbs. per 1,000 feet	Current Milli Amps ‡
8	128	17.9	50	55.9	—	40.8	45	—
9	114	22.6	39	44.2	—	51.9	36	—
10	102	28.0	32	35.7	—	64.9	29	—
11	91	35.5	25	28.2	—	81.5	23	—
12	81	44.8	20	22.3	—	102	18	—
13	72	56.7	15.7	17.6	—	130	14	—
14	64	71.7	12.4	13.9	—	164	11	—
15	57	90.4	9.8	11.1	—	207	9.2	—
16	51	113	7.8	8.85	—	259	7.2	—
17	45	145	6.2	6.90	—	333	5.6	—
18	40	184	4.9	5.44	800	421	4.42	—
19	36	226	3.9	4.43	650	520	3.58	—
20	32	287	3.1	3.48	522	659	2.83	—
21	28.5	362	2.5	2.76	420	831	2.24	—
22	25.3	460	1.9	2.17	335	1,055	1.77	—
23	22.6	575	1.5	1.74	273	1,321	1.41	—
24	20.1	728	1.2	1.37	220	1,670	1.12	460
25	17.9	919	.97	1.09	178	2,106	.89	390
26	15.9	1,162	.77	.861	144	2,669	.70	330
27	14.2	1,455	.61	.687	117	3,347	.56	278
28	12.6	1,850	.48	.541	95	4,251	.44	228
29	11.3	2,300	.38	.435	78	5,286	.35	196
30	10.0	2,940	.30	.340	63	6,750	.276	165
31	8.9	3,680	.24	.272	52	8,521	.199	158
32	8.0	4,600	.19	.217	43	10,546	.177	117
33	7.1	5,830	.15	.172	36	13,390	.139	97
34	6.3	7,400	.12	.135	29	17,006	.110	82
35	5.6	9,360	.095	.107	24	21,524	.037	69
36	5.0	11,760	.076	.085	20	27,000	.069	58
37	4.5	14,550	.060	.0687	17	33,333	.056	49
38	4.0	18,375	.047	.0544	14.5	42,187	.045	41
39	3.5	24,100	.038	.0415	12	55,102	.034	34
40	3.1	30,593	.028	.0327	10	70,239	.025	23
(41)	2.75	38,888	.0229	.0257	8.5	89,256	.0209	24
(42)	2.5	46,400	.0189	.0215	7.5	108,000	.0173	20.5
(43)	2.25	58,103	.0153	.0172	6.8	133,333	.0140	17.5
(44)	2.0	73,500	.0121	.0136	6.0	163,750	.0110	14.5
(45)	1.75	96,078	.0092	.0104	5.0	220,408	.0084	12.0
(46)	1.5	130,666	.0068	.0076	4.0	300,000	.0062	9.5

* D.S.C. wound on spool. For further detail, see under Resistance spools and slabs.

‡ Bare wire on slab—well ventilated. Spacing between turns equal to wire diameter.

RESISTANCE WIRE TABLE

S.W.G. No.	Dia. mils.	Eureka Wire				Nichrome Wire		
		Ohms per 1,000 feet	Lbs. per 1,000 feet	Feet per Ohm	Current Milli Amps *	Ohms per 1,000 feet	Lbs. per 1,000 feet	Current Milli Amps ‡
10	128	17.4	49.7	57.5	—	40.8	45	—
11	116	21.2	40.9	47.2	—	50.2	37.3	—
12	104	26.4	32.9	37.9	—	62.4	29.5	—
13	92	33.8	25.7	29.6	—	79.7	23.4	—
14	80	44.6	19.5	22.4	—	105.4	17.7	—
15	72	55.1	15.8	18.15	—	130	14.0	—
16	64	69.8	12.5	14.33	—	164	11.3	—
17	56	91.1	9.5	10.98	—	215	8.7	—
18	48	123.9	7.0	8.07	—	292	6.4	—
19	40	178.5	4.9	5.60	—	421	4.42	—
20	36	220.4	3.9	4.53	650	520	3.58	—
21	32	279.1	3.12	3.58	510	659	2.83	—
22	28	364	2.38	2.75	390	861	2.17	—
23	24	496	1.75	2.02	300	1,170	1.60	—
24	22	590	1.47	1.70	250	1,390	1.33	—
25	20	714	1.21	1.40	210	1,680	1.12	—
26	18	882	0.99	1.134	170	2,080	.897	400
27	16.4	1,062	.82	.942	140	2,510	.746	350
28	14.8	1,305	.67	.766	117	3,080	.607	300
29	13.6	1,545	.56	.647	101	3,650	.513	250
30	12.4	1,858	.47	.538	85	4,390	.427	230
31	11.6	2,123	.41	.471	75	5,010	.373	205
32	10.8	2,450	.35	.408	66	5,780	.324	185
33	10.0	2,857	.304	.350	57	6,750	.276	165
34	9.2	3,376	.257	.296	49	7,970	.235	145
35	8.4	4,049	.215	.247	41	9,560	.195	125
36	7.6	4,947	.175	.202	35	11,690	.160	110
37	6.8	6,179	.140	.1618	29	14,600	.128	91
38	6.0	7,936	.109	.1260	23	18,700	.100	76
39	5.2	10,565	.082	.0947	19	24,900	.075	62
40	4.8	12,395	.070	.0807	16	29,200	.064	55
41	4.4	14,756	.059	.0677	13	34,800	.0536	48
42	4.0	17,855	.049	.0560	11	42,180	.0450	41
43	3.6	22,045	.039	.0454	9.5	52,000	.0358	35
44	3.2	27,888	.031	.0359	8.0	65,900	.0283	30
45	2.8	36,216	.024	.0276	6.5	86,100	.0217	25
46	2.4	49,588	.018	.0202	5.0	117,000	.0160	20
47	2.0	71,428	.012	.0140	4.0	168,000	.0112	15
48	1.6	111,333	.008	.0090	3.0	263,600	.0071	—

* D.S.C. wound on spool. For further detail, see under Resistance spools and slabs.
‡ Bare wire on slab—well ventilated. Spacing between turns equal to wire diameter.

RELATIVE RESISTANCE & TEMPERATURE COEFFICIENTS.

Material.	At 20°C. Relative resistance.	20°C. to 100°C. Temp. coeft. per 1°C.
Copper	1	.0040
Iron (pure)	5.8	.0062
German Silver (18% Nickel Silver)	17	.00027
Eureka	29	± .00002
Advance	28	± .00002
Manganin	27.5	± .00002
Nichrome	64	.00017

The values of relative resistance vary somewhat, while the temperature coefficients over other temperature ranges than that specified may differ widely.

FUSE WIRE TABLE.

Fusing Current Amps.	Copper.		Tin.		Allo-Tin.		Lead.	
	Dia. inch	S.W.G. Approx.	Dia. inch.	S.W.G. Approx.	Dia. inch.	S.W.G. Approx.	Dia. inch.	S.W.G. Approx.
1	.0021	47	.0072	37	.0083	35	.0081	35
2	.0034	43	.0113	31	.0132	29	.0128	30
3	.0044	41	.0149	28	.0173	27	.0168	27
4	.0053	39	.0181	26	.0210	25	.0203	25
5	.0062	38	.0210	25	.0243	23	.0236	23
10	.0098	33	.0334	21	.0386	19	.0375	20
15	.0129	30	.0437	19	.0506	18	.0491	18
20	.0156	28	.0529	17	.0613	16	.0595	17
25	.0181	26	.0614	16	.0711	15	.0690	15
30	.0205	25	.0694	15	.0803	14	.0779	14
40	.0248	23	.0840	14	.0973	13	.0944	13
50	.0288	22	.0975	13	.1129	11	.1095	12
70	.0360	20	.1220	10	.1413	9	.1371	9
100	.0457	18	.1548	8	.1792	7	.1739	7

General Formulæ.

Ohms Law: $I = \frac{E}{R}$ where I = amperes.
E = volts.
R = ohms.

Resistances in Series: $R = R_1 + R_2 + R_3 + \ldots$

Resistances in Parallel: $$R = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

Reactance of Coil $= 2\,\pi\,f\,L$
$= 6.28\,f\,L$ ohms.

Reactance of Condenser $$= \frac{1}{2\,\pi\,f\,C} = \frac{0.159}{f \times C}$$

where
f = frequency.
L = henries.
C = farads.

Alternating Current:

$$I = \frac{E}{\sqrt{R^2 + (2\,\pi\,f\,L)^2}}$$ for inductance and resistance.

$$\text{and } I = \frac{E}{\sqrt{R^2 + \left(\frac{1}{2\,\pi\,f\,C}\right)^2}}$$ for capacity and resistance in series

$$\text{and } I = \frac{E}{\sqrt{R^2 + \left(2\,\pi\,f\,L - \frac{1}{2\,\pi\,f\,C}\right)^2}}$$ for inductance, capacity & resistance in series.

Capacity of Condensers in parallel: $C = C_1 + C_2 + \ldots$

Capacity of Condensers in series: $$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \ldots}$$

Average Value of Sine Wave Voltage (or Current):

Average value $$= \frac{2 \times E_{max.}}{\pi} = 0.637\,E_{max.} = 0.9\,E_{RMS.}$$

R.M.S. value (Root-mean-square) $$= \frac{E_{max.}}{\sqrt{2}} = 0.707\,E_{max.}$$

Capacity (dimensions).

To convert centimeters capacity to micro-microfarads, multiply by 1.11.

Valve Formulæ and Information.

Amplification factor: $\mu = g_m \times r_p = \dfrac{de_p}{de_g}$

Mutual conductance: $g_m = \dfrac{\mu}{r_p} = \dfrac{di_p}{de_g}$

Plate resistance: $r_p = \dfrac{\mu}{g_m} = \dfrac{de_p}{di_p}$

TRIODES.

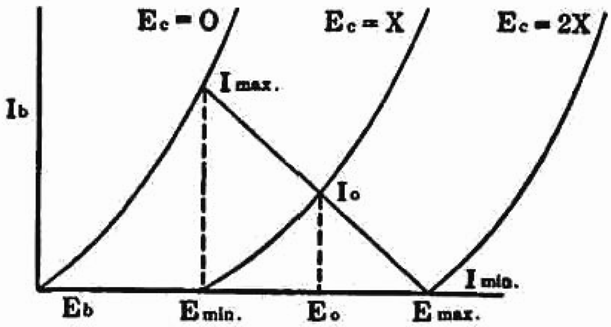


Fig. 1

Power Output $= \frac{1}{8}(I_{max.} - I_{min.})\ (E_{max.} - E_{min.})$

% Second Harmonic Distortion

$$= \frac{\frac{1}{2}(I_{max.} + I_{min.}) - I_0}{I_{max.} - I_{min.}} \times 100 = \frac{\frac{1}{2}(E_{max.} + E_{min.}) - E_0}{E_{max.} - E_{min.}} \times 100$$

Load resistance $= \dfrac{E_{max.} - E_{min.}}{I_{max.} - I_{min.}}$ = slope of load line $(I_{max.}\ I_{min.})$

Rule of thumb for approximate power output (does not hold for very small valves or for types 20 or 89 triode.)

Undistorted power output $= \frac{1}{5} \times$ watts plate dissipation.

POWER PENTODES.

Pentode

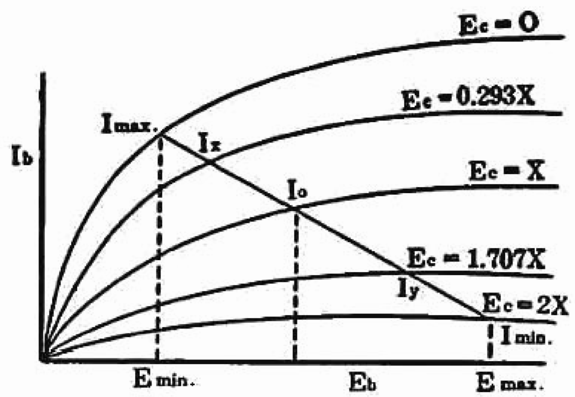


Fig. 2

Power Output $= \frac{1}{32} [(I_{max.} - I_{min.}) + 1.414 (I_x - I_y)]^2 R_p$

$$R_p = \frac{E_{max.} - E_{min.}}{I_{max.} - I_{min.}} = \text{slope of load line} = \text{load resistance.}$$

% Second Harmonic Distortion

$$= \frac{I_{max.} + I_{min.} - 2 I_0}{(I_{max.} - I_{min.}) + 1.414 (I_x - I_y)} \times 100$$

% Third Harmonic Distortion

$$= \frac{I_{max.} - I_{min.} - 1.414 (I_x - I_y)}{I_{max.} - I_{min.} + 1.414 (I_x - I_y)} \times 100$$

% Total Distortion

$$= \sqrt{(\%\ \text{2nd Harm. Distortion})^2 + (\%\ \text{3rd Harm. Distortion})^2}$$

Rule of thumb for approximate power output of pentodes:—
Undistorted Power Output $= \frac{1}{4} \times$ watts plate dissipation.

GENERAL VALVE FORMULAE.

Amplification

$$= \frac{\text{Amplification factor} \times \text{plate load resistance.}}{\text{plate load resistance} + \text{plate resistance.}}$$

$$= \frac{g_m \times \text{plate resistance} \times \text{plate load resistance.}}{1{,}000{,}000 \times (\text{plate resistance} + \text{plate load resistance}).}$$

where g_m = micromhos.
resistances in ohms.

These formulæ apply to all cases.

Conversion conductance is defined as the ratio of the intermediate-frequency component of the output current to the radio frequency component of the signal voltage.

Power Output and Plate Voltage.

Power output is very much dependant on plate voltage whether with triode or pentode.

Power output is approximately proportional to $E_p^{\frac{5}{2}}$

Plate Voltage. Volts.	Plate Voltage. %	Power Output. Watts (typical).	Power Output. %
250	100	3.0	100
200	80	1.7	57
180	72	1.3	44
150	60	.84	28
135	54	.6	20
100	40	.3	10

Tuning Coils and Resonant Circuits.

Wave Motion.

Wavelength in metres.
Inductance in microhenries (L).
Capacity in microfarads (C).

$$\text{Wavelength} = 1884 \sqrt{L \times C}$$

$$\text{Frequency} = \frac{159{,}200}{L \times C} \text{ cycles per second.}$$

$$\text{Wavelength} \times \text{frequency} = 2.998 \times 10^8$$

Resonant Circuits (low resistance).

Resonance occurs when—

$$2\pi f L = \frac{1}{2\pi f C}$$

$$\text{i.e., when } LC = \frac{1}{39.48 \times f^2}$$

L = henries.
C = farads.
f = frequency (cycles per second).

$$\text{or } LC = \frac{2.533 \times 10^{10}}{f^2}$$

where L = microhenries
C = microfarads

Dynamic Resistance of Tuned Circuit (at resonance).

$$R = \frac{L}{r \times C}$$ ohms where r = equivalent R.F. series resistance.

Stage Gain in R.F. or I.F. Circuits (assuming high valve plate resistance and normal coils)—approximately.

$$\text{Stage Gain} = \frac{g_m \times R}{1{,}000{,}000}$$

where g_m = micromhos
R = dynamic resistance of tuned circuit (ohms)

Peak Separation in Band-pass Tuners.

$$= \frac{\sqrt{X^2 - r^2}}{2\pi L} \text{ cycles}$$

where X = coupling reactance.
r = equivalent R.F. series resistance (each coil).
L = henries.

Useful Rule of Thumb (approximate only).

Wavelength is proportional to the number of turns on a coil.

CHART OF FREQUENCY AND WAVELENGTH.

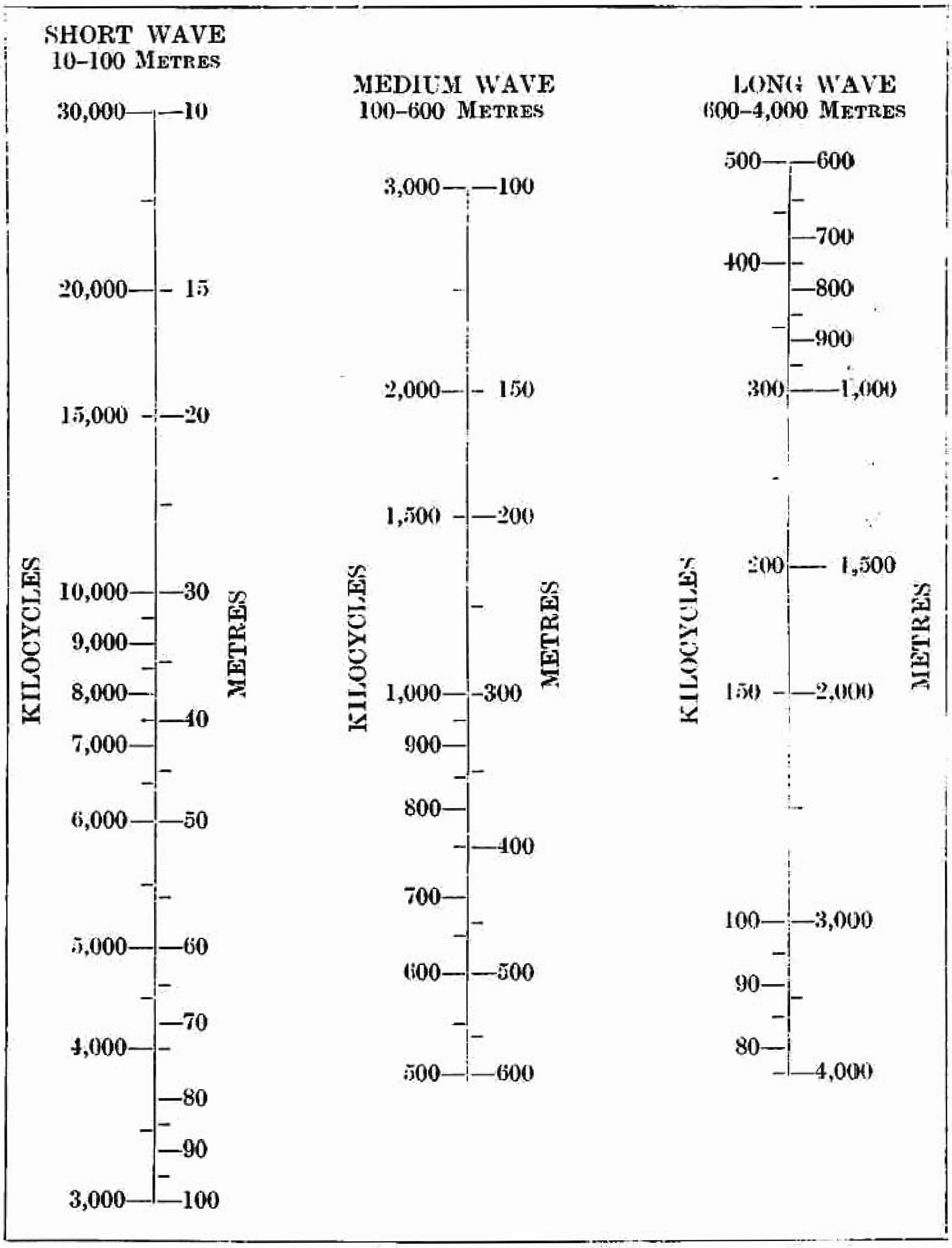


Fig. 3

RESISTOR COLOUR CODE

Body		End		Dot	
Brown	= 1	Black	= 0	Black	= No ciphers
Red	= 2	Brown	= 1	Brown	= 1 ,,
Orange	= 3	Red	= 2	Red	= 2 ,,
Yellow	= 4	Orange	= 3	Orange	= 3 ,,
Green	= 5	Yellow	= 4	Yellow	= 4 ,,
Blue	= 6	Green	= 5	Green	= 5 ,,
Violet	= 7	Blue	= 6	Blue	= 6 ,,
Grey	= 8	Violet	= 7	Violet	= 7 ,,
White	= 9	Grey	= 8	Grey	= 8 ,,
		White	= 9	White	= 9 ,,

CHART OF COIL TURNS, INDUCTANCE AND DIAMETER.

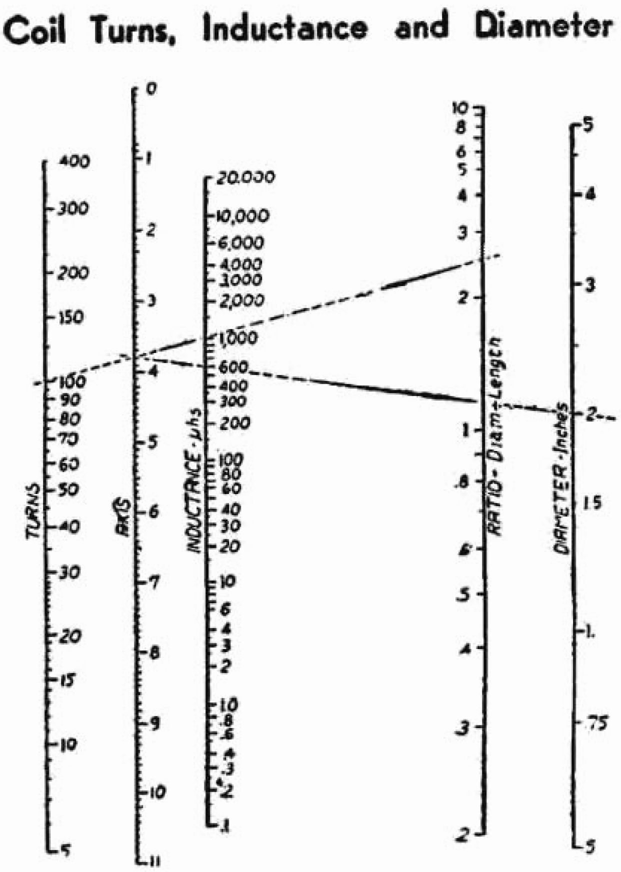


Fig. 4

Knowing the turns of a coil, its length of winding, and the diameter, the inductance may be found by using a straight edge from the turns column to the ratio (length of winding) column, intersecting the axis column; then a second line from the intersection of the axis column to the diameter column. The inductance in microhenries will be the point where the second line intersects the inductance column. In the above chart the first line is laid from 100 turns to 2.5 ratio (which is length of winding), this first line intersecting the axis at 3.8 on the scale. The second line is from 3.8 on the axis scale to the 2 inch diameter, intersecting the inductance column at 600 microhenries.

Knowing the diameter, ratio and the inductance, the number of turns may be found by reversing the process. As shown in the chart, draw a line from 2 inch diameter through the 600 microhenries intersecting axis at 3.8 on the scale; then run line from 3.8 on axis scale to 2.5 on ratio (length of winding) the extension of this line cutting the turns scale at 100 which is the number of turns.

After finding number of turns, consult wire table to determine size of wire which will permit given number of turns in a given length of winding.

CHART OF CAPACITY, FREQUENCY AND INDUCTANCE.

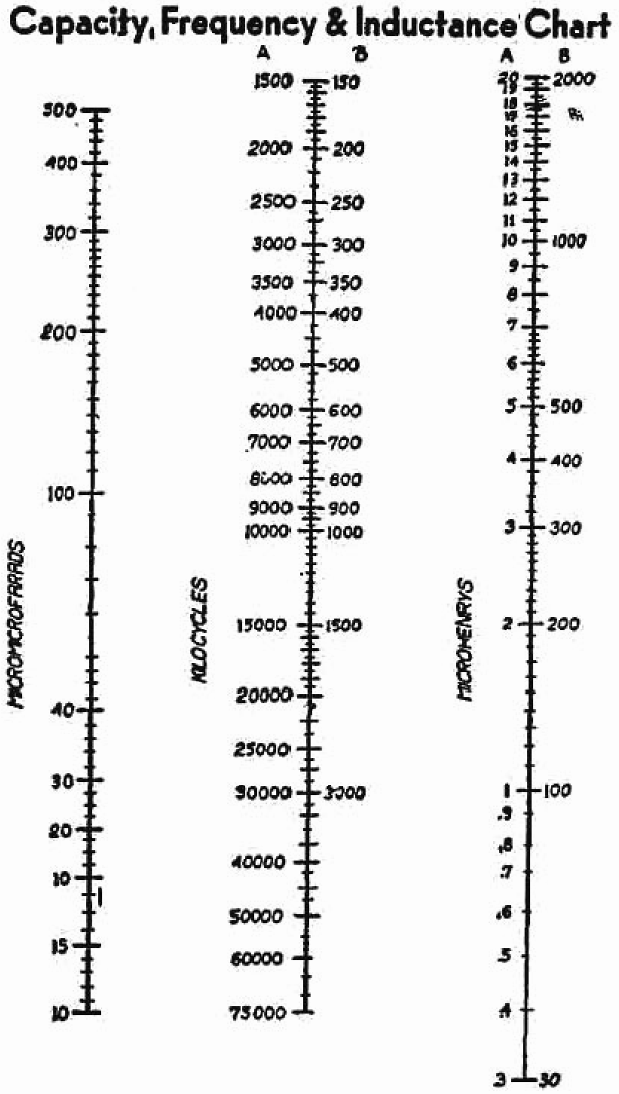


Fig. 5

Knowing capacity in micromicrofarads and the frequency in kilocycles to be covered by a condenser at maximum capacity the inductance required for a coil may be found by running a straight line from the micromicrofarads column through the kilocycle column, the line intersecting the inductance column.

Knowing the condenser capacity and the inductance of the coil, the frequency to which the coil will tune can be found by running a line from the micromicrofarads column to the microhenries column, the point of intersection on the kilocycle column will be the frequency of coil and condenser.

Knowing the kilocycles and the inductance, the size of condenser to be used to cover that frequency can be found in the same manner indicated; extension of a straight line from microhenries through kilocycles will terminate on the micromicrofarads line.

Reactances

Inductance (Henries)	REACTANCE IN OHMS						
	50 cycles	100 cycles	1000 cycles	5000 cycles	175 K.C.	465 K.C.	1000 K.C.
250	78,500	157,000	1,570,000	7,850,000	—	—	—
100	31,400	62,800	628,000	3,140,000	—	—	—
50	15,700	31,400	314,000	1,570,000	—	—	—
25	7,850	15,700	157,000	785,000	—	—	—
10	3,140	6,280	62,800	314,000	—	—	—
5	1,570	3,140	31,400	157,000	—	—	—
1	314	628	6,280	31,400	1,100,000	2,920,000	6,280,000
.1	31.4	62.8	628	3,140	110,000	292,000	628,000
.01	3.14	6.28	62.8	314	11,000	29,200	62,800
Micro-H. 1,000	.314	.628	6.28	31.4	1,100	2,920	6,280
200	.0628	.1257	1.257	6.28	220	484	1,257
100	.0314	.0628	0.628	3.14	110	292	628

Capacity Micro-Fds.	REACTANCE IN OHMS						
	50 cycles	100 cycles	1000 cycles	5000 cycles	175 K.C.	465 K.C.	1000 K.C.
.00003	—	—	—	1,060,000	30,000	11,400	5,300
.0001	—	—	1,590,000	318,000	9,100	3,420	1,590
.00025	—	—	637,000	127,000	3,600	1,368	637
.0005	—	—	318,000	63,700	1,800	684	318
.001	3,180,000	1,590,000	159,000	31,800	910	342	159
.006	530,000	265,000	26,500	5,300	150	57.0	26.5
.01	318,000	159,000	15,900	3,180	91	34.2	15.9
.1	31,800	15,900	1,590	318	9.1	3.42	1.59
.25	12,700	6,370	637	127	3.6	1.368	.637
.5	6,370	3,180	318	63.7	1.8	.684	.318
1	3,180	1,590	159	31.8	.91	.342	.159
2	1,590	796	79.6	15.9	.45	.171	.08
4	796	398	39.8	7.96	.23	.086	.04
8	398	127	12.7	3.98	.11	.043	.02
25	127	63.5	6.35	1.27	.04	.0136	.006

CONVERSION FACTORS.

MULTIPLY	BY	PRODUCT
Amperes	×1,000,000,000,000	micromicroamperes
Amperes	×1,000,000	microamperes
Amperes	×1,000	milliamperes
Cycles	×.000,001	megacycles
Cycles	×.001	kilocycles
Farads	×1,000,000,000,000	micromicrofarads
Farads	×1,000,000	microfarads
Farads	×1,000	millifarads
Henrys	×1,000,000	microhenrys
Henrys	×1,000	millihenrys
Kilocycles	×1,000	cycles
Kilowatts	×1,000	watts
Megacycles	×1,000,000	cycles
Mhos	×1,000,000	micromhos
Mhos	×1,000	millimhos
Microamperes	×.000,001	amperes
Microfarads	×.000,001	farads
Microhenrys	×.000,001	henrys
Micromhos	×.000,001	mhos
Microvolts	×.000,001	volts
Micromicrofarads	×.000,000,000,001	farads
Milliamperes	×.001	amperes
Millihenrys	×.001	henrys
Millimhos	×.001	mhos
Millivolts	×.001	volts
Milliwatts	×.001	watts
Volts	×1,000,000	microvolts
Volts	×1,000	millivolts
Watts	×1,000	milliwatts

DECIMAL EQUIVALENTS OF FRACTIONS.

$\frac{1}{32}$	.03125	$\frac{17}{32}$	.53125
$\frac{1}{16}$	.0625	$\frac{9}{16}$	.5625
$\frac{3}{32}$	.09375	$\frac{19}{32}$	.59375
$\frac{1}{8}$	.125	$\frac{5}{8}$	.625
$\frac{5}{32}$	.15625	$\frac{21}{32}$	.65625
$\frac{3}{16}$	.1875	$\frac{11}{16}$	.6875
$\frac{7}{32}$	.21875	$\frac{23}{32}$	.71875
$\frac{1}{4}$	.25	$\frac{3}{4}$	.75
$\frac{9}{32}$	.28125	$\frac{25}{32}$	.78125
$\frac{5}{16}$	.3125	$\frac{13}{16}$	.8125
$\frac{11}{32}$	.34375	$\frac{27}{32}$	.84375
$\frac{3}{8}$	.375	$\frac{7}{8}$	.875
$\frac{13}{32}$	.40625	$\frac{29}{32}$	.90625
$\frac{7}{16}$	.4375	$\frac{15}{16}$	.9375
$\frac{15}{32}$	.46875	$\frac{31}{32}$	.96875
$\frac{1}{2}$	.5	1	1.0

Screws and Screw Threads.

B.A. SCREW THREADS.

B.A. No.	Outside dia.	Core dia.	Clearing drill.	Tapping drill.
0	.236	.189	1/4" or "B"	Nos. 9-10
1	.209	.166	Nos. 2-3	18-19
2	.185	.147	10-11	25-26
3	.161	.123	18-19	30-31
4	.142	.111	26-27	33-34
5	.126	.098	29-30	39-40
6	.110	.085	32-33	44
7	.098	.075	38-39	48
8	.087	.066	42-43	51
9	.075	.056	46-47	53
10	.067	.050	49-50	55

WHITWORTH SCREW THREADS.

Outside dia.	Core dia.	Threads per inch	Tapping drill
1/8"	.093	40	41
3/16"	.134	24	9/64"
1/4"	.186	20	No. 12
5/16"	.241	18	1/4"
3/8"	.295	16	5/16"
1/2"	.393	12	13/32"
5/8"	.508	11	17/32"
3/4"	.622	10	5/8"
1"	.840	8	27/32"

WOOD SCREWS.

Gauge No.	Shank dia.	Clearance drill No.	Gauge No.	Shank dia.	Clearance drill No.
1	.066	44	9	.178	9
2	.080	41	10	.192	4
3	.094	35	11	.206	2
4	.108	30	12	.220	1
5	.122	28	13	.234	1/4"
6	.136	24	14	.248	17/64"
7	.150	19	15	.262	9/32"
8	.164	15	16	.276	19/64"

TWIST DRILL SIZES.

Drill No.	Dia. Inch	Drill No.	Dia. Inch	Drill No.	Dia. Inch	Drill No.	Dia. Inch
1	.2280	21	.1590	41	.0960	61	.0390
2	.2210	22	.1570	42	.0935	62	.0380
3	.2130	23	.1540	43	.0890	63	.0370
4	.2090	24	.1520	44	.0860	64	.0360
5	.2055	25	.1495	45	.0820	65	.0350
6	.2040	26	.1470	46	.0810	66	.0330
7	.2010	27	.1440	47	.0785	67	.0320
8	.1990	28	.1405	48	.0760	68	.0310
9	.1960	29	.1360	49	.0730	69	.02925
10	.1935	30	.1285	50	.0700	70	.0280
11	.1910	31	.1200	51	.0670	71	.0260
12	.1890	32	.1160	52	.0635	72	.0250
13	.1850	33	.1130	53	.0595	73	.0240
14	.1820	34	.1110	54	.0550	74	.0225
15	.1800	35	.1100	55	.0520	75	.0210
16	.1770	36	.1065	56	.0465	76	.0200
17	.1730	37	.1040	57	.0430	77	.0180
18	.1695	38	.1015	58	.0420	78	.0160
19	.1660	39	.0995	59	.0410	79	.0145
20	.1610	40	.0980	60	.0400	80	.0135

Decibels.

The Decibel is the unit of ratios of power, voltage or current in amplifiers. It is a logarithmic ratio, since audibility is not proportional to energy but to the logarithm of energy ratios.

Provided that the impedance is the same throughout the gain in decibels is equal to

$$20 \log_{10} \frac{E_1}{E_2} = 20 \log_{10} \frac{I_1}{I_2} = 10 \log_{10} \frac{P_1}{P_2}$$

where P is energy expressed in watts.

When the impedances concerned are not equal the gain in Decibels is equal to

$$20 \log_{10} \frac{E_1}{E_2} + 10 \log_{10} \frac{Z_1}{Z_2} + 10 \log_{10} \frac{K_1}{K_2}$$

$$= 20 \log_{10} \frac{I_1}{I_2} + 10 \log_{10} \frac{Z_1}{Z_2} + 10 \log_{10} \frac{K_1}{K_2}$$

where Z_1 and Z_2 are the corresponding impedances and K_1 and K_2

the values of power factor for the impedances. The expression for the energy case is the same for any values of impedances.

In general, it is preferable to make all calculations in terms of energy, until, in the final stage, this may be converted into voltage or current.

As Decibels are only ratios it is necessary to fix a basis from which to work, and the standard of reference is taken as 6 milliwatts into 500 ohms, i.e., 1.73 volts across 500 ohms.

Take for example a Reiss microphone, which is 70 db. down and which works into 250 ohms. Now 70 db. is an energy ratio of 10 million times, so that the energy from the microphone is 1 ten-millionth part of 6 milliwatts. This is fed into 250 ohms, so that the voltage will be 0.00038 volt. If a 10:1 ratio microphone transformer is used this will become 0.0038 volt on the grid of the first valve.

The following approximate values will serve for most amplifier calculations:—

Reiss Microphone.—70 db. down.

Carbon Microphone.—(Approximately) 10 db. down (close up), 30 db. down (at a distance).

Neophone.—0 db. down (close up), 24 db. down (at a distance).

Phono. Pickup.—Very sensitive type, 1 volt peak; ordinary type, 0.5 volt peak; insensitive type, 0.25 volt peak.

The most valuable application of Decibels is in the case of changing volume in a fixed amplifier. The minimum audible change of volume is approximately 2 Decibels, consequently the increase in volume has to be at least 2 db. to be audible.

Table of Minimum Audible Changes in Volume.
(3 watts taken as standard.)

*Increase to	*Decrease to
4.75 w.	1.9 w.
7.5	1.2
12	0.75
19	0.475
30	0.30

* In steps of 2 db. to + 10 db. and — 10 db. respectively.

DECIBELS—(continued)

Voltage Ratio	Energy Ratio	db.	Voltage Ratio	Energy Ratio
.8913	.7943	1	1.122	1.259
.7943	.6310	2	1.259	1.585
.7079	.5012	3	1.413	1.995
.6310	.3981	4	1.585	2.512
.5623	.3162	5	1.778	3.162
.5012	.2512	6	1.995	3.981
.4467	.1995	7	2.239	5.012
.3981	.1585	8	2.512	6.310
.3548	.1259	9	2.818	7.943
.3162	.1000	10	3.162	10.000
.2818	.07943	11	3.548	12.59
.2512	.06310	12	3.981	15.85
.2239	.05012	13	4.467	19.95
.1995	.03981	14	5.012	25.12
.1778	.03162	15	5.623	31.62
.1585	.02512	16	6.310	39.81
.1413	.01995	17	7.079	50.12
.1259	.01585	18	7.943	63.10
.1122	.01259	19	8.913	79.43
.1000	.01000	20	10.000	100.00
.056	.00316	25	17.78	316.2
.03162	.001	30	31.62	1,000
.018	.000316	35	56.23	3,162
.010	.0001	40	100.0	10,000
.0056	.0000316	45	177.8	31,620
.003162	.00001	50	316.2	100,000
.001	.000001	60	1,000	1,000,000
.00032	.0000001	70	3,162	10,000,000
.0001	.00000001	80	10,000	100,000,000
.000032	.000000001	90	31,620	1,000,000,000
.00001	.0000000001	100	100,000	10,000,000,000

Resistance Slabs, Spools and Voltage Dividers.

Flat Slabs wound with Bare Wire—

Calculate surface area as total area covered by winding (both sides).

Conservative rating:—½ watt per square inch.

Normal rating:—¾ watt per square inch.

Maximum rating:—

Not freely ventilated:—¾ watt per square inch.

Freely ventilated:—1 watt per square inch.

Bank of Slabs separated by ½ inch spacing, freely ventilated:—½ watt per square inch.

Single Slab Nichrome wire on heat-resisting former—1½ watts per square inch.

Circular Formers wound with Bare Wire—

Calculate surface area as total area covered by winding.

Normal service (not freely ventilated) :—$\frac{3}{4}$ watt per square inch.

Very freely ventilated (Nichrome wire on heat-resisting former) :—$1\frac{1}{4}$ watts per square inch.

Rheostats wound on Slate, etc.—

Calculate surface area as total area covered by winding.

Good ventilation, maximum rating:—3 watts per square inch.

RESISTANCE SPOOLS.

Spools of insulated resistance wire present special problems, due to the necessity for heat radiation.

The correct design procedure is to determine the external surface area from the watts dissipated, allowing 2 square inches of cylindrical area (disregarding end area) for each watt dissipated, as shown in the following formulae :—

$$\begin{aligned} \text{Area (square inches)} &= 2 \times \text{watts.} \\ &= 2 \times \text{volts} \times \text{amps.} \\ &= 2 \times \text{amps} \times \text{amps} \times \text{ohms.} \\ &= \frac{2 \times \text{volts} \times \text{volts.}}{\text{ohms.}} \end{aligned}$$

For conditions where low temperature rise only can be permitted the surface area should be two or more times that given by the formula, while for well ventilated positions where temperature rise is not objectionable the area may be reduced to half that given by the formula.

The values given refer only to normal spools which are longer than their diameters. For special cases allow $2\frac{1}{2}$ square inches of total effective radiating area for each watt dissipated.

Audio Transformer Design.

(1) D.C. Primary Current.

Where current flow is more than 5 milliamps the transformer should be used with "parallel feed" (see under Resistance Capacity Coupling).

(2) Primary Inductance.

The following table gives minimum values of inductance in Henries for three values of bass response:—

Plate resistance of preceding valve.	Bass response 2 Decibels down at 150 cycles.	100 cycles.	50 cycles.
7,500 ohms	10.5H	15.75H	31.5H
10.000 "	14 H	21.0 H	42.0H
15,000 "	21 H	31.5 H	63 H
20,000 "	28 H	42 H	84 H
30,000 "	42 H	63 H	126 H
50,000 "	70 H	105 H	210 H
100,000 "	140 H	210 H	420 H

N.B.—For explanation of Decibels see separate heading.

Special Note: Where transformer is used with insufficient inductance and a good bass response is desired, this can be done only at the expense of sensitivity by loading the secondary with a resistance of value equal to the recommended ohms load for maximum power output from the preceding valve, multiplied by the square of the transformer step-up ratio. This applies equally to choke or transformer coupling from a screen-grid valve, except that in this case the resistance goes straight across the choke or transformer primary. (Very high values of inductance are required for screen-grid valves, and values of 500 Henries shunted by ¼ megohm are suggested for normal requirements, although not recommended where good quality is essential.)

(3) Turns Ratio.

The maximum number of turns in the transformer secondary is fixed by the winding capacity, which leads to high note loss. For the usual layer winding about 15,000 turns is the maximum which can be used without excessive high note loss, while for good quality the limit is approximately 10,000 turns. The number of turns can be increased very largely by sectional winding, that is by winding two separate coils, each half the length, and mounting them side by side, suitably connected in series, with the primary placed underneath or between the two halves of the secondary. The turns ratio is given by the ratio of secondary turns (limited by capacity) to primary turns (limited by inductance).

For the usual size of laminations typical windings are:—

Primary, 5,000 turns, 40 B. and S. enamelled.
Secondary, 15,000 turns, 40 B. and S. enamelled.
Turns ratio, 3 to 1.

(4) Connections.

The primary is always wound nearest the core.
IP (Inner Primary) goes to Plate.
OP (Outer Primary) goes to B +.
IS (Inner Secondary) goes to C —.
OS (Outer Secondary) goes to Grid.

(5) Push-Pull Audio Transformers.

For push-pull input the transformer secondary is centre-tapped, as is also the loudspeaker input transformer. In this case the two secondary ends go to the grids and the centre-tap to C —.

(6) Push-Pull to Push-Pull Audio Transformers.

For large quality amplifiers two audio valves in push-pull are used to drive two power valves in push-pull. The primary and secondary windings are both centre-tapped, the primary centre-tap connecting to B + and the two ends to the two plates. Special precautions are necessary regarding the primary inductance, which must have a total inductance (plate to plate) of **twice** that necessary for a single valve, i.e., its number of turns must be increased by 41% over the number necessary for a single valve. This causes difficulties in quality amplifier design and may lead to expensive transformer construction, with differential winding and either a large core or an alloy core. Naturally, if this circuit be adopted, the audio valves would be chosen with the lowest possible A.C. plate resistance. One advantage of this arrangement is that there is no saturation of the core due to D.C. and a higher effective inductance is obtained. It is usual to limit the step-up ratio to 1.5 to 1 or 2 to 1 (whole primary to whole secondary) for good quality with normal transformer dimensions.

When using two 56 or 37 Radiotrons in push-pull a very suitable transformer could be constructed as detailed below:—

Primary: 7,000 turns 40 B. and S. tapped at 3,500 turns.

Secondary: Either 14,000 turns 40 B. and S. tapped at 7,000 turns; or 10,000 turns 40 B. and S. tapped at 5,000 turns.

With the larger secondary winding it is preferable to wind the secondary in two sections.

Power Transformer Design.

(1) First decide upon the laminated core and then calculate the windings.

For a radio power transformer the cross sectional area of the core inside the winding should be about 1¼ square inches. Any reduction of core size below this value will mean an increase in winding turns (both primary and secondary) and is poor economy. On the other hand, an increase in core size is beneficial.

(2) The number of turns on the primary is fixed solely by the core size.

Example:—For 240 volts and 50 cycle supply—

$$\text{Primary turns} = \frac{1{,}400}{\text{Core area (square inches)}}$$

So that for a core cross sectional area of 1¼ square inches the primary turns will be 1,120. For mains voltages below 240 the number of turns may be decreased, but for voltages above 240 the number of turns must be increased in proportion.

(3) Secondaries.

The number of turns on each secondary winding is determined by the following formula:—

$$\text{Secondary turns} = \frac{\text{Primary turns} \times \text{Secondary volts.}}{\text{Primary volts.}}$$

This will give the open-circuit (no load) voltage only, and since the voltage will drop considerably with load it is necessary to allow for this by winding more turns on each secondary than is given by the formula. The exact voltage drop due to the resistance of the windings has to be calculated from a knowledge of the current, gauge of wire and its resistance, etc.

(4) Gauge of Wire for Primary.

Assuming mains volts = 240.

$$\text{Current in primary} = \frac{1.25}{240} \times \text{Sec. volts} \times \text{Sec. amps.}$$

If there is more than one secondary winding the primary current is the sum of all these values. To determine the gauge of wire refer to the wire tables, allowing 1,200 circular mils (cross sectional area) per ampere. For a standard radio power transformer 25 B and S is satisfactory, but for heavy duty a larger gauge is required.

(5) Gauge of Wire for Secondary.

The current in the filament windings is known and a suitable gauge can be found from the tables, allowing 1,000 to 1,200 circular mils per ampere. The current in each half of a centre-tapped secondary supplying a rectifier is 0.78 times the rectified (D.C.) current, while for half-wave rectification the current in the secondary is 1.56 times the D.C. current. Allowance should be made for this current when deciding upon the gauge of wire to be used.

(6) Voltage Drop in Windings.

Take each secondary winding in turn.

$$\text{Voltage drop} = \text{current in secondary} \times \text{resistance of secondary} + 1.25\left\{\frac{\text{sec. turns}}{\text{pri. turns}} \times \text{pri. current} \times \text{pri. resistance.}\right\}$$

Sufficient additional turns should be added to each secondary winding to allow for this drop.

If these calculations are found too complicated the number of turns on each secondary winding may be increased about 8% and the error will not be very great.

Special Note: Valve filament or heater voltages should be exactly of the rated value. Fluctuations in the supply voltage may cause the filament voltages to rise or fall, but the average voltage should be the rated voltages for the valves.

Resistance Capacity Coupling.

Although it is frequently stated that R.C. Coupling gives better quality than transformer coupling, this is not necessarily the case, and both can give excellent quality when correctly designed, or very poor quality when incorrectly designed.

With most triode valves the correct plate resistor is one having a resistance from 5 to 20 times the valve A.C. plate resistance. The value of 500,000 ohms should not be exceeded for any valve; where normal audio amplification is required, a lower value is to be preferred in most cases. The minimum value which may be used is equal to the recommended "ohms load for stated power output" shown on the characteristic chart. The optimum is a value intermediate between these two limits, and can only be stated definitely when the plate peak volts swing is known. For good quality with a moderate output about 100,000 ohms is good practice for use with low A.C. plate resistance valves, and about 250,000 ohms for the highest ones.

The grid resistor of the following valve has an important effect on both quality and volume, and it should have at least twice and preferably four times the resistance of the plate resistor. The maximum which can be used is one megohm, but one-half megohm is preferable, while power valves are often limited to much lower values, even to as low as 10,000 ohms. In the latter case, R.C. Coupling is impossible unless a large power valve is used as driver.

The Coupling Condenser should have a value, as shown in the following table:—

	Coupling condenser (microfarads)	
Grid resistor (ohms)	Minimum.	Recommended.
10,000	0.5	2.0
50,000	0.1	0.4
100,000	0.05	0.2
500,000	0.01	0.04
1,000,000	0.005	0.02

Too low a value of coupling condenser causes poor bass response and poor response to transients, but there is no maximum capacity. Values 10 times those recommended show slightly improved response to both bass and transients.

The negative grid bias used has a very marked effect on both distortion and voltage output. It should be as small a value as possible, provided that no grid current flows even on the strongest signals. It may be assumed that grid current commences at zero volts for 2 volt battery valves and at — 1.0 volt on indirectly heated valves.

Example:—

Required plate voltage swing, 30 volts peak amplitude (60 volts total swing).

Valve effective amplification = 30 (see formula below);

Therefore grid peak amplitude = 1 volt.

Allow — 1 volt as limit of swing owing to grid current (for indirectly heated valve);

Then working bias = — 2 volts.

(The corresponding bias for a battery valve would be — 1 volt.)

Amplification with R.C. Coupling.

Let R = Plate resistor.
r = A.C. plate resistance.
F = Amplification factor.

Then effective amplification will be—

$$\frac{F \times R}{R + r} \quad \text{(theoretically)}$$

$$\text{or} \quad \frac{3}{4} \times \frac{F \times R}{R + r} \quad \text{(practically)}$$

Accurate Calculations for R.C. Coupling.

For complete information on R.C. Coupling it is necessary to refer to the Plate Volts-Plate Current characteristics.

(1) From the point of supply plate voltage, zero plate current, draw a line (A) to the point (B) zero plate voltage, plate current equal to:—

$$\frac{\text{Supply plate voltage} \times 1{,}000 \text{ milliamps.}}{\text{Plate resistor (ohms)}}$$

(2) Choose the approximate bias (X), and where the above line cuts this bias line draw a second line (CD) of slope (volts divided by amps) equal to the resistance of the plate resistor and the grid resistor in parallel.

(3) On this second line (the load line of the valve) mark the extremes of grid swing (E, F), and then by referring to the plate-volts axis, the plate-volts swing (GH) will be found.

(4) The cathode bias resistor may now be determined, since both plate current and grid bias are known (see separate section).

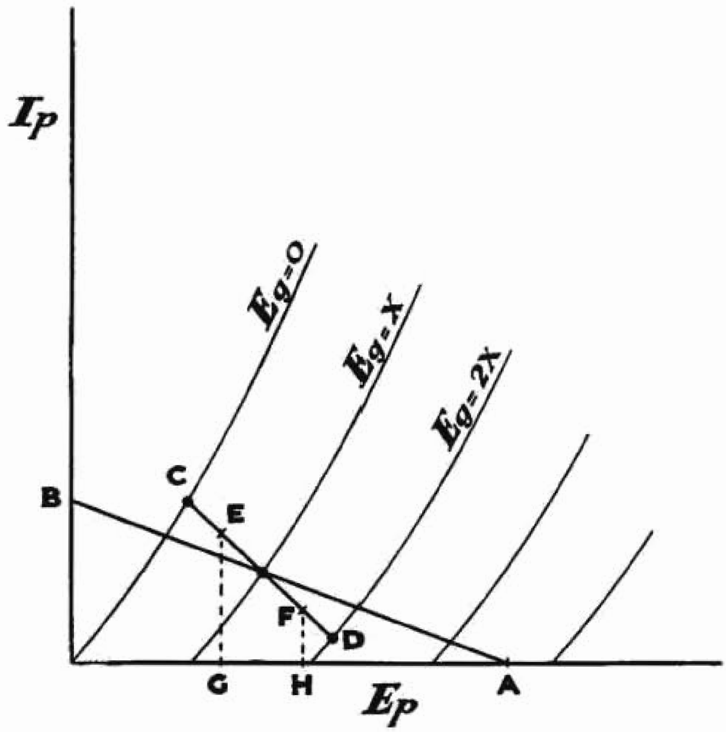


Fig. 6

R.C. Coupling with High Plate Supply Voltage.

To obtain greater output with minimum distortion it is sometimes preferred to use a higher plate supply voltage. This procedure is quite safe provided the supply voltage does not reach twice the recommended maximum and that the plate resistor used is sufficient to reduce the plate current to not more than the recommended value. As with ordinary R.C. Coupling the grid bias used should be just sufficient to avoid grid current with peak signals.

Resistance-Capacity-Transformer Coupling.

In order to prevent the D.C. plate current from flowing in the transformer primary it is good practise to use R.C. Coupling with the transformer between the coupling condenser and the grid of the following valve. This method gives better quality because of the elimination of D.C. current, and also provides effective decoupling. The best plate resistor is one of 3 to 5 times the A.C. plate resistance of the valve, but this must be finally settled by the supply voltage and plate current. The coupling condenser should be from 1 to 4 microfarads, the higher capacity with low inductance transformers.

For grid decoupling see "Cathode resistor calculations."

OPERATING CONDITIONS FOR RESISTANCE—COUPLED A-F AMPLIFIER SERVICE.

Tube																		
2A6 and 75	PLATE SUPPLY∞	(Volts)	100				135				180				250			
	SCREEN SUPPLY	(Volts)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	GRID BIAS	(Volts)	-1.05	-1.05	-1.10	-1.05	-1.05	-1.10	-1.05	-1.10	-1.25	-1.20	-1.30	-1.30	-1.30	-1.30	-1.35	-1.35
	CATHODE RESISTOR	(Ohms)	10500	15400	11550	15000	6200	9150	5850	10000	4900	7100	5450	9000	3170	5200	3380	5600
	PLATE RESISTOR	(Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR*	(Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT	(Milliamp.)	0.10	0.07	0.09	0.07	0.17	0.12	0.18	0.11	0.25	0.17	0.24	0.14	0.41	0.25	0.40	0.24
	VOLT. OUTPUT**	(Peak Volts)	11-18	10-14	15-19	14-19	17-23	17-21	20-30	18-27	28-33	24-30	32-40	30-38	33-38	28-35	36-46	35-44
	VOLTAGE AMPLIFICATION		30	29	36	37	42	38	50	48	48	46	56	55	51	48	59	58
2B7 and 6B7	PLATE SUPPLY∞	(Volts)	100				135				180				250			
	SCREEN SUPPLY	(Volts)	20	20	20	20	20	20	20	20	25	25	25	25	50	50	50	50
	GRID BIAS	(Volts)	-2.00	-2.50	-2.15	-2.60	-1.80	-2.25	-1.95	-2.40	-2.10	-2.60	-2.10	-2.60	-4.5	-5.0	-4.5	-5.0
	CATHODE RESISTOR	(Ohms)	5550	12200	9350	19250	3800	8300	4850	10900	3700	7600	3500	7300	5500	11400	5500	11400
	PLATE RESISTOR	(Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR*	(Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT	(Milliamp.)	0.27	0.15	0.23	0.13	0.35	0.20	0.30	0.16	0.43	0.26	0.45	0.26	0.65	0.35	0.65	0.35
	VOLT. OUTPUT**	(Peak Volts)	28-30	25-27	36-38	32-33	38-40	32-35	48-50	42-44	50-53	45-48	65-68	64-66	55-65	55-60	65-70	66-75
	VOLTAGE AMPLIFICATION		35	36	47	46	36	38	53	56	50	53	63	70	54	55	65	75
55 and 85	PLATE SUPPLY∞	(Volts)	100				135				180				250			
	SCREEN SUPPLY	(Volts)	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	GRID BIAS	(Volts)	-4.75	-3.75	-5.00	-5.50	-6.80	-4.75	-7.00	-7.00	-7.50	-7.00	-7.00	-7.50	-11	-10	-14	-12
	CATHODE RESISTOR	(Ohms)	16800	25800	21200	46000	21200	24300	22000	42500	16300	28000	14900	31200	17600	28500	25200	38600
	PLATE RESISTOR	(Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR*	(Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT	(Milliamp.)	0.28	0.14	0.23	0.12	0.32	0.19	0.31	0.16	0.46	0.25	0.47	0.24	0.625	0.35	0.55	0.32
	VOLT. OUTPUT**	(Peak Volts)	24-26	17-22	27-29	26-27	34-36	27-30	38-42	36-40	38-40	36-38	40-44	40-45	55-60	45-55	65-75	66-70
	VOLTAGE AMPLIFICATION		6.1	6.0	6.6	6.2	6.1	6.1	6.5	6.3	6.4	6.4	6.7	6.5	6.4	6.3	6.7	6.6
77	PLATE SUPPLY∞	(Volts)	100				135				180				250			
	SCREEN SUPPLY	(Volts)	20	20	20	20	25	25	25	25	30	30	30	30	52	54	50	52
	GRID BIAS	(Volts)	-1.10	-1.25	-1.05	-1.25	-1.20	-1.35	-1.25	-1.40	-1.25	-1.50	-1.30	-1.55	-2	-2.2	-2.1	-2.3
	CATHODE RESISTOR	(Ohms)	3760	6450	3400	7250	3100	5600	3750	6300	2180	4550	2600	4850	3100	5700	3500	6200
	PLATE RESISTOR	(Megohm)	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50	0.25	0.50
	GRID RESISTOR*	(Megohm)	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50	0.25	0.25	0.50	0.50
	PLATE CURRENT	(Milliamp.)	0.22	0.14	0.23	0.13	0.29	0.18	0.25	0.17	0.43	0.25	0.38	0.24	0.52	0.31	0.48	0.295
	VOLT. OUTPUT**	(Peak Volts)	15-23	17-22	16-29	18-28	21-32	27-31	29-37	34-38	31-43	36-41	36-52	45-52	50-60	50-55	60-70	60-70
	VOLTAGE AMPLIFICATION		40	39	54	53	54	52	61	62	76	85	92	93	80	75	100	110

∞ Voltage at plate will be PLATE SUPPLY voltage minus voltage drop in plate resistor caused by plate current.

* For the following amplifier tube. The tabulated values illustrate design practice. For any particular set of conditions, however, the grid resistor for the following amplifier tube should conform to the recommendations given on the DATA page of the type involved.

**Developed across plate resistor of inter-stage coupling circuit including grid resistor of following tube. Value to left is maximum undistorted output voltage obtainable; value to right is maximum output voltage obtainable with some distortion.

Note: In the above data, the use of a coupling condenser between the plate resistor and the grid resistor of the following tube is assumed. A 0.1 microfarad condenser is usually adequate to insure good low-frequency response.

Cathode Resistor Calculations.

In circuits where a resistor in the cathode lead is used to give "free" bias, it is essential to determine the correct value of resistance.

Let I be the total current in milliamperes flowing through the cathode resistor. It will be the sum of the currents to all the electrodes, i.e., plate current, screen current, anode grid current (if any).

Let E be the negative grid bias required in volts, as shown by the Radiotron Characteristic Chart. Then the resistance of the cathode resistor will be:—

$$R = \frac{E}{I} \times 1{,}000 \text{ ohms}$$

Valves having directly heated filaments may be used in a similar way, provided that a separate filament winding (for A.C.), or a separate A battery, is used for each valve with a cathode resistor.

Bypassing.

It is necessary to bypass each cathode resistor by a suitable condenser in order to avoid "degeneration" or loss of gain. If too small a capacity is used in an audio amplifier, the bass response will be seriously diminished. Suitable minimum recommended values for quality audio amplifiers are shown in the following table:—

Cathode resistor ..	300	400	500	1000	2000	3000
Capacity microfds.	20	16	12	6	3	2

N.B.—The bypass condensers should be omitted in the case of push-pull amplifiers.

There is a method of avoiding such large capacities by decoupling the grid circuit, as shown in the diagram.

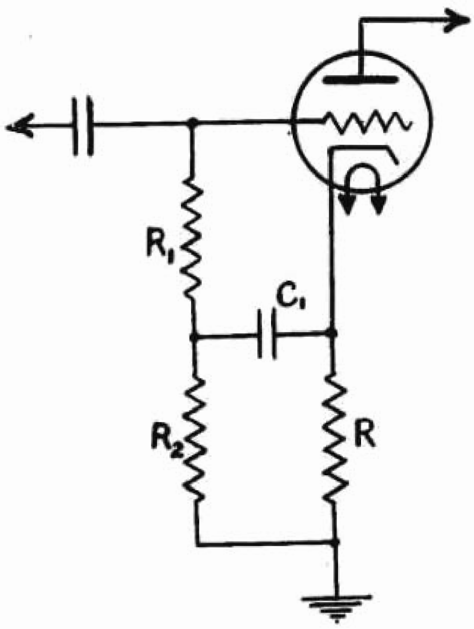


Fig. 7

In this circuit R_1 is the usual grid resistor (say, 0.5 megohm). R_2 is an additional decoupling resistance, approximately 20,000 ohms, and the bypass condenser C_1 1 microfarad, or even less.

Where loss of gain is no detriment the bypass condenser may be completely omitted, in which case an improved frequency response will result. For transformer coupling a similar method may be used, the transformer secondary winding taking the place of R_1 in the diagram.

Amplifier Grid Circuit Resistance.

As a positive charge may accumulate on the grid more rapidly than it can leak away through the grid resistor, it is advisable to keep the total resistance of the grid circuit as low as possible. In minor cases the only effect is to "choke" the signal, so that it is either very much distorted or to make the amplifier sound "dead." It is much more serious in the case of large power amplifier valves than with other types since it will result in valve failure; but it is also serious in the case of directly heated amplifier valves following indirectly heated valves in battery receivers, the trouble occurring during switching on and off.

The maximum resistance allowed in the grid circuit of any valve is 1 megohm, but it is recommended that this value be not used except with extreme caution. For normal use a maximum of 0.25 or 0.5 megohm is recommended, whilst for pentode power valves 0.25 megohm is the maximum which can be safely recommended.

Large triode power valves such as the 2A3 or the 50 are limited to still lower values of grid resistance, about 10,000 ohms being the maximum recommended for each type, except that with self bias the value for the 2A3 may be increased to the maximum allowable resistance of 0.5 megohm.

Power Valve Sensitivity Factors.

The sensitivity of any valve is given by the Sensitivity Factor, which is equal to the milliwatts output per (R.M.S.) volt squared input.

(This does not apply to Class B valves.)

Valve Type	Sensitivity Factor	Valve Type	Sensitivity Factor
Radiotron 47	24	Radiotron 53 (parallel triodes)	22
,, 41	22	,, 6A4	19.5
,, 42	22	,, 59 Pentode	18
,, 2A5	22	,, 89 Pentode	11

Valve Type		Sensitivity Factor
Radiotron 43		10
,,	48	9.8
,,	2A3 Push-pull	8.3
,,	38	8
,,	33	7.6
,,	2A3 (single)	3.75
,,	59 (Triode)	3.2
,,	12A	3.1
,,	10	2.6
,,	46 (Triode)	2.5

Valve Type		Sensitivity Factor
Radiotron 89 (Triode)		1.85
,,	55	1.75
,,	85	1.75
,,	50	1.4
,,	45	1.3
,,	71A	0.95
,,	49 (Triode)	0.85
,,	31	0.83
,,	20	0.43

Power Amplifiers.

Class A.

A Class A amplifier is one in which the plate current flows at all times, that is, through the full 360° of the cycle. The ideal Class A amplifier is one in which the alternating component of the plate current is an exact reproduction of the form of the input signal.

Class B.

A Class B amplifier is one in which the plate current is nearly zero when no signal is applied, so that plate current flows during one half only of the cycle. Class B amplifiers are used in push-pull, so that each valve handles one half of the cycle and most of the harmonics are cancelled out.

Class C.

A Class C amplifier is one in which the grid bias is more than sufficient to reduce the plate current to zero, so that plate current flows during less than one half cycle. This method is only applicable to R.F. transmission.

Prime Class A (or Class AB).

This is a type of amplifier intermediate between Class A and Class B, and which when used in push-pull gives a large power output with low distortion.

Grid Current.

Confusion has arisen owing to some Class B amplifiers operating with no grid current, while others operate with grid current flowing during part or the whole of the cycle. It seems preferable to use the term Class B solely for amplifiers taking grid current, and to use the term "Quiescent Push-pull" for those which do not take grid current during the greater part of the cycle. Class 30 in push-pull are examples of Q.P.P.

Class B Amplifiers.

The design of Class B amplifiers must be approached from a different angle to that for Class A amplifiers. It is necessary to have a plate supply having very good regulation, particularly so in the case of types 46 and 79, whose static plate current is fairly low. The first stage in the design is to decide upon the plate voltage and the type of valve to be used. Then from the chart the values of load resistance and power output can be determined (assuming sufficient grid input to fully load the valves). From the table below the values of peak grid input power and peak grid input resistance should be determined, and finally the driver valve and input transformer.

$$\text{Driver minimum peak power output} = \frac{\text{Grid peak power input (milliwatts)}}{\text{Transformer peak efficiency.}}$$

$$\begin{array}{l}\text{Transformer ratio} \\ \text{(Primary to } \tfrac{1}{2} \text{ Secondary)}\end{array} = \sqrt{\frac{\text{Driver load resistance (ohms).}}{\text{Peak grid input resistance (ohms)}}}$$

With usual design the transformer peak efficiency will be about 70%.

It should be noted that a change in load resistance or plate voltage will largely affect the power output, power input, and distortion, and that with a driver valve which is unable to fully load the Class B stage the optimum load will be greater and the grid peak input resistance will be greater.

CLASS B VALVES.

Operation Characteristics.

Type	Fil. Volts	Plate Volts	Average Power Input Milliwatts	Grid Peak Power Input Milliwatts	Grid Peak Input Resistance Ohms	Load Resistance Plate to Plate Ohms	Power Output Watts
46, 46	2.5	400	650	1,350	1,850	5,800	20
49, 49	2.0	180	140	300	3,000	12,000	3.5
59, 59	2.5	400	850	2,050	1,220	6,000	20
89, 89	6.3	250	230	500	1,250	15,000	5.3
19	2.0	135	170	370	3,500	10,000	2.1
53	2.5	300	350	800	1,200	10,000	10
79	6.3	250	380	1,050	860	14,000	8

CLASS B AMPLIFIERS—(continued)

DRIVER VALVES.

Type	Fil. Volts	Plate Volts	Neg. Grid Bias Volts	Plate Curr.(MA)	Ohms* Load	Power Output Milliwatts	Peak Power Output Milliwatts
27	2.5	250	21.0	5.2	30,000	306	712
30	2.0	180	13.5	3.1	30,000	135	270
31	2.0	180	30.0	12.3	15,000	270	540
37	6.3	250	18.0	7.5	30,000	285	570
46	2.5	250	33.0	22.0	10,000	975	1,950
49	2.0	135	20.0	5.7	15,000	175	350
53	2.5	294	6.0	7.0	30,000	374	748
		250	5.0	6.0	30,000	256	512
55–85	2.5–6.3	250	20.0	8.0	30,000	292	584
56	2.5	250	13.5	5.0	60,000	230	460
59	2.5	250	28.0	26.0	10,000	940	1,880
79							
89	6.3	250	31.0	32.0	10,000	910	1,820

* Taken for low distortion. Lower values give greater power output but greater distortion.

PUSH-PULL DRIVER VALVES.

Type	Fil. Volts	Plate Volts	Neg. Grid Bias Volts	Plate Curr.(MA)	Ohms* Load	Power Output Milliwatts	Peak Power Output Milliwatts
37	6.3	250	18.0	15.0†	30,000‡	732	1,464
56	2.5	250	13.5	10.0†	60,000‡	740	1,480

† Both valves. ‡ Plate to plate.

FORMULÆ FOR CLASS B AMPLIFIERS.

(1) **Load resistance for each valve** = $\frac{1}{4}$ × load resistance plate to plate.

(2) **Transformer peak efficiency.**

N.B.—Only one half of the secondary carries current at the one time.

Let r = resistance of one half of the secondary.
R = resistance of primary.
n = transformer ratio, primary to one half secondary.
Rg = peak grid input resistance.

Then (approximately)

$$\text{Transformer efficiency} = \frac{Rg \times 100}{Rg + \left(\frac{R}{n^2}\right) + r} \%$$

(3) Power Output.

Let W = Power output in watts (both valves).
E = Total plate voltage swing per valve.
I = Peak plate current in milliamps.
R = Load resistance per valve.

Then

$$W = \frac{EI}{2} = \frac{RI^2}{2} = \frac{E^2}{2R}$$

(4) Driver Peak Power.

= 2 × average power output.
= ¼ × (plate volts total swing × plate current total swing).

Universal (AC-DC) Receivers.

Receivers using series heaters with a rectifier valve are very critical on heater current, due to its effect on the rectifier. The maximum tolerance on heater voltage is plus or minus 10%, and on heater current 6%, although on D.C. mains sets (without rectifiers) the tolerance is very much greater. Over-running causes heater-cathode breakdown in the rectifier, while under-running may lead to overheating or arc-over in the rectifier.

Circuits should be arranged so that in the event of the filter condenser or rectifier breaking down no injurious voltage is applied to the remaining valves. A fuse to blow at ¼ amp. is a safeguard when inserted in the plate circuit of the rectifier valve, since even a momentary breakdown of the condenser may cause an arc-over in the rectifier sufficient to burn out several valves.

It is recommended that Universal Receivers be fitted with tappings at 10 volt intervals to allow for different mains supply voltages.

Rectifiers.

Filter Circuits.—A filter circuit is always necessary with any type of rectifier and the type of filter circuit used affects the output voltage, regulation and valve maximum rating.

A condenser-input filter is one with a condenser directly across the rectifier input, the usual capacity being from 2 to 8 microfarads. This type gives the highest D.C. voltage for a fixed A.C. input.

A choke-input filter is one in which the rectified currents flow through a choke of at least 20 Henries before reaching the first filter condenser. This method gives a lower D.C. voltage for the same A.C. input, but it has the advantages of a higher permissible A.C. voltage input (since it eases the peak load current from the rectifier valve) and also has improved regulation (i.e., the D.C. voltage does not drop so rapidly with increasing load).

Condensers in Filter Circuits.—In a condenser-input filter the first condenser must be able to withstand a peak voltage of 1.41 times the R.M.S. transformer voltage (each side), but in all other cases the peak voltage is approximately equal to the D.C. voltage.

D.C. Voltage Output of Rectifiers.—The D.C. voltage output of any rectifier **at no load** may be determined by the following formula:

$$V_{DC} = \text{volts R.M.S.} \times 1.41$$

The D.C. voltage output of a vacuum rectifier on load is given by the published curves.

The D.C. voltage output of a mercury rectifier on load is constant from a small load up to full load, and is given by:—

$$V_{DC} = (\text{volts R.M.S.} \times 0.9) - 15$$

In all cases the D.C. volts drop in the choke must be subtracted to give the effective output volts.

N.B.—The current in each half of a centre-tapped transformer secondary supplying a rectifier is 0.78 times the D.C. current, while for half-wave rectification the current in the secondary is 1.56 times the D.C. current.

Loudspeaker Matching.

In order to match the loudspeaker to the output valve or valves it is necessary to choose a ratio of transformer which will give the correct load impedance. Unfortunately, all loudspeakers, dynamic as well as other types, have widely different impedances at different frequencies. It is usual to match the speaker at about 500 cycles per second where the impedance is a minimum and the impedance is then too high at the extremes of the frequency range. This is not serious for triode power valves, which are not critical on load impedance, but it is very serious with pentodes and leads to accentuation of both high and low notes (due to the speaker rise in impedance) and pronounced distortion. With a pentode valve and a normal dynamic speaker the harmonic distortion at about 100 cycles and at 2,000 cycles may exceed 15%, due solely to the loudspeaker rise in impedance at these frequencies. It is usual to by-pass the accentuated higher frequencies through a fixed condenser between plate and cathode of the pentode, and this method will also reduce the distortion; but a better method is to use a resistance-capacity filter shunted across the L.S. input transformer primary. Suitable values for this are .01 microfarad and 10,000 ohms connected in series.

Matching formulae:—

(1) Single output valve—

$$\text{Transformer ratio} = \sqrt{\frac{\text{Valve load resistance.}}{\text{Voice coil impedance.}}}$$

(2) Push-pull and Class B Output—

Transformer ratio (plate to plate)

$$= \sqrt{\frac{\text{Valve load resistance (plate to plate).}}{\text{Voice coil impedance.}}}$$

Special Note on Triode Valves.

With triode power valves an increase in load impedance causes a reduction in sensitivity (and volume) with less distortion, this being the exact reverse of pentodes.

Loudspeaker Input Transformer Inductance.

With pentodes it is usual to design the transformers with a low inductance, so that the falling impedance tends to correct some of the bass accentuation. Although this method may be adopted with pentodes, a very high inductance is needed for the best results with triodes, as shown in the following table:—

Triode Power Valves.

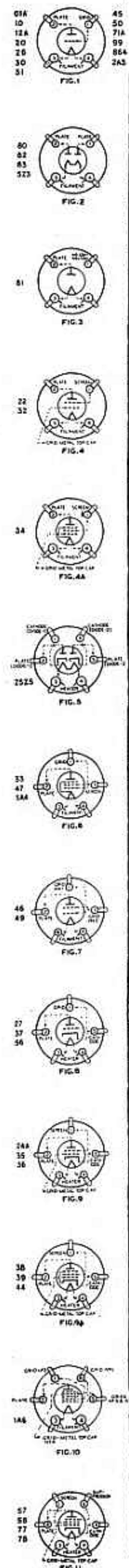
Load Resistance (ohms)	Transformer Primary Inductance.	
(Plate to plate in case of push-pull**)	2 d.b. down* at 100 cycles	2 d.b. down* at 50 cycles
2,500	5.5 Henries	11 Henries
5,000	11 ,,	22 ,,
7,500	16.5 ,,	33 ,,
10,000	22 ,,	44 ,,

* Owing to other factors (transient response and distortion on low frequencies) it is advisable to use at least double these values of inductance.

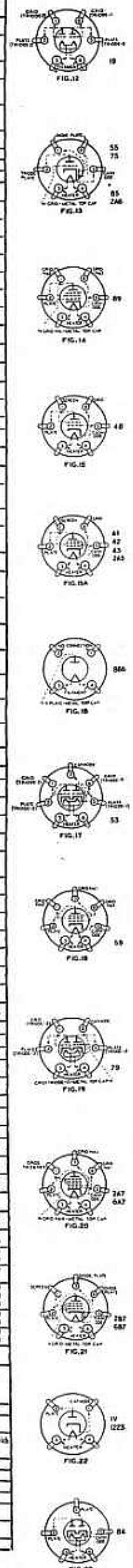
** With push-pull the plate to plate load resistance is twice that for a single valve.

RADIOTRON CHARACTERISTIC CHART

BOTTOM VIEWS OF SOCKET CONNECTIONS



BOTTOM VIEWS OF SOCKET CONNECTIONS



TRIODE AMPLIFIER VALVES

Type	Application	Base	Cap	Socket Connections	Dimensions Max. Overall Length	Diam.	Cathode Type	Filament or Heater Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Negative Grid Bias Volts D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load for Stated Power Output	Power Output Milli-Watts
01A	AMPLIFIER	4-PIN	—	FIG. 1	4 11/16"	1 13/16"	FIL.	5.0	0.25	DC	90 135*	— —	4.5 9.0	— —	2.5 3.0	— —	11000 10000	725 800	8.0 8.0	— —	— —
12A	AMPLIFIER	4-PIN	—	FIG. 1	4 11/16"	1 13/16"	FIL.	5.0	0.25	DC	90 135 180*	— — —	4.5 9.0 13.5	— — —	3.0 6.2 7.7	— — —	5400 5100 4700	1575 1650 1800	8.5 8.5 8.5	5000 9000 10650	35 130 285
26	AMPLIFIER	4-PIN	—	FIG. 1	4 11/16"	1 13/16"	FIL.	1.5	1.05	AC or DC	135 180*	— —	9.0 13.5	10.0 14.5	3.5 6.2	— —	7600 7300	1100 1150	8.3 8.3	— —	— —
27	AMPLIFIER	5-PIN	—	FIG. 8	4 11/16"	1 13/16"	HTR.	2.5	1.75	AC or DC	135 250 275*	— — —	9.0 21.0 —	9.0 21.0 —	4.5 5.2 —	— — —	9000 9250 —	1000 975 —	9.0 9.0 —	— — —	— — —
30	AMPLIFIER	4-PIN	—	FIG. 1	4 1/8"	1 9/16"	FIL.	2.0	0.06	DC	90 135 180*	— — —	4.5 9.0 13.5	— — —	2.5 3.0 3.1	— — —	11000 10300 10300	850 900 900	9.3 9.3 9.3	— — —	— — —
37	AMPLIFIER	5-PIN	—	FIG. 8	4 1/4"	1 9/16"	HTR.	6.3	0.3	AC or DC	180 250*	— —	13.5 18.0	13.5 18.0	4.3 7.5	— —	10200 8400	900 1100	9.2 9.2	— —	— —
56	AMPLIFIER	5-PIN	—	FIG. 8	4 1/4"	1 9/16"	HTR.	2.5	1.0	AC or DC	250*	—	13.5	13.5	5.0	—	9500	1450	13.8	—	—
99	AMPLIFIER	4-PIN	—	FIG. 1	4 1/4"	1 3/16"	FIL.	3.3	0.063	DC	90*	—	4.5	—	2.5	—	15500	425	6.6	—	—
864	AMPLIFIER	4-PIN	—	FIG. 1	4"	1 3/16"	FIL.	1.1	0.25	DC	135*	—	9.0	—	3.5	—	12700	640	8.2	—	—

SCREEN GRID VALVES

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
22	R.F. AMPLIFIER	4-PIN	CAP	FIG. 4	5 9/32"	1 13/16"	FIL.	3.3	0.132	DC	135 135*	45 67.5*	1.5 1.5	— —	1.7 3.7	0.6 1.3	725000 325000	375 500	270 160	— —	— —
24A	R.F. AMPLIFIER	5-PIN	CAP	FIG. 9	5 9/32"	1 13/16"	HTR.	2.5	1.75	AC or DC	180 250*	90* 90*	3.0 3.0	3.0 3.0	4.0 4.0	1.7 max.	400000 600000	1000 1050	400 630	— —	— —
24A	BIASED DETECTOR	5-PIN	CAP	FIG. 9	5 9/32"	1 13/16"	HTR.	2.5	1.75	AC or DC	275*	20 to 45	5.0 approx.	5.0 approx.	Plate current adjusted to 0.1 ma. (no signal) Plate coupling resistor 250000 ohms.						
32	R.F. AMPLIFIER	4-PIN	CAP	FIG. 4	5 9/32"	1 13/16"	FIL.	2.0	0.06	DC	135 180*	67.5* 67.5*	3.0 3.0	— —	1.7 1.7	0.4 max.	950000 1200000	640 650	610 780	— —	— —
32	BIASED DETECTOR	4-PIN	CAP	FIG. 4	5 9/32"	1 13/16"	FIL.	2.0	0.06	DC	135 180*	45 67.5*	4.5 6.0	approx.	Plate current adjusted to 0.2 ma. (no signal) Plate coupling resistor 100000 ohms						
36	R.F. AMPLIFIER	5-PIN	CAP	FIG. 9	4 11/16"	1 9/16"	HTR.	6.3	0.3	AC or DC	180 250*	90* 90*	3.0 3.0	3.0 3.0	3.1 3.2	1.7 max.	500000 550000	1050 1080	525 595	— —	— —
36	BIASED DETECTOR	5-PIN	CAP	FIG. 9	4 11/16"	1 9/16"	HTR.	6.3	0.3	AC or DC	180 250*	67.5 90*	6.0 approx. 8.0 approx.		Plate current adjusted to 0.1 ma (no signal) Plate coupling resistor 250000 ohms.						

SUPER-CONTROL SCREEN GRID VALVES

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
35	R.F. AMPLIFIER	5-PIN	CAP	FIG. 9	5 9/32"	1 13/16"	HTR.	2.5	1.75	AC or DC	180 250*	90* 90*	3.0 min.	3.0 min.	6.3 6.5	2.5 max.	300000 400000	1020 1050	305 420	— —	— —

R.F. PENTODE VALVES

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
57	R.F. AMPLIFIER	6-PIN	CAP	FIG. 11	4 11/16"	1 9/16"	HTR.	2.5	1.0	AC or DC	250*	100*	3.0	3.0	2.3	0.6	1.0 meg.	1225	1500 approx.	—	—
57	BIASED DETECTOR	6-PIN	CAP	FIG. 11	4 11/16"	1 9/16"	HTR.	2.5	1.0	AC or DC	275*	100*	3.9	3.9	Cathode current 0.97 ma. (no signal) Plate coupling resistor 250000 ohms. Cathode resistor 4000 ohms.						
77	R.F. AMPLIFIER	6-PIN	CAP	FIG. 11	4 11/16"	1 9/16"	HTR.	6.3	0.3	AC or DC	250*	100*	3.0	3.0	2.3	0.6	1.5 meg.	1250	1500	—	—
77	BIASED DETECTOR	6-PIN	CAP	FIG. 11	4 11/16"	1 9/16"	HTR.	6.3	0.3	AC or DC	250*	100*	4.3	4.3	Cathode current 0.43 ma. (no signal) Plate coupling resistor 500000 ohms. Cathode resistor 10000 ohms						

SUPER-CONTROL R.F. PENTODE VALVES

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
34	R.F. AMPLIFIER	4-PIN	CAP	FIG. 4A	5 9/32"	1 13/16"	FIL.	2.0	0.06	DC	135 180*	67.5* 67.5*	3.0 min.	— —	2.8 2.8	1.0 1.0	600000 1 meg.	600 620	360 620	— —	— —
39/44	R.F. AMPLIFIER	5-PIN	CAP	FIG. 9A	4 11/16"	1 9/16"	HTR.	6.3	0.3	AC or DC	180 250*	90* 90*	3.0 min.	3.0 min.	5.8 5.8	1.4 1.4	750000 1 meg.	1000 1050	750 1050	— —	— —
58	R.F. AMPLIFIER	6-PIN	CAP	FIG. 11	4 11/16"	1 9/16"	HTR.	2.5	1.0	AC or DC	250*	100*	3.0 min.	3.0 min.	8.2	2.0	800000	1600	1280	—	—
78	R.F. AMPLIFIER	6-PIN	CAP	FIG. 11	4 11/16"	1 9/16"	HTR.	6.3	0.3	AC or DC	180 250* 250*	75 100 125*	3.0 min.	3.0 min.	4.0 7.0 10.5	1.0 2.0 3.0	1 meg. 800000 600000	1100 1450 1650	1100 1160 990	— — —	— — —

CONVERTER VALVES (Combined First Detector Oscillator)

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
1A6	PENTAGRID ‡	6-PIN	CAP	FIG. 10	4 11/16"	1 9/16"	FIL.	2.0	0.06	DC	135 180*	67.5* 67.5*	3.0 min.	—	1.2 1.3	2.5 2.4	400000 500000	Anode grid (2) 135* Volts 2.5 ma. Oscill. grid (1) resistor 50000 ohms. Conversion Conductance 300 micromhos.			
2A7/6A7	PENTAGRID ‡	small 7-PIN	CAP	FIG. 20	4 11/16"	1 9/16"	HTR.	2.5 6.3	0.8 0.3	AC or DC	250*	100*	3.0 min.	3.0 min.	3.5	2.2	300000	Anode grid (2) 200* Volts Oscill. grid (1) resistor 50000 ohms. Conversion Conductance 520 micromhos.			

‡ Grids Nos. 3 and 5 are Screen, Grid No. 4 is signal input control grid.

DUO-DIODE DETECTOR VALVES

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
55/85	DUO-DIODE TRIODE	6-PIN	CAP	FIG. 13	4 11/16"	1 9/16"	HTR.	2.5 6.3	1.0 0.3	AC or DC	250*	—	20.0	20.0	8.0	—	7500	1100	8.3	20000	350
75/2A6	DUO-DIODE HIGH MU TRIODE	6-PIN	CAP	FIG. 13	4 11/16"	1 9/16"	HTR.	6.3 2.5	0.3 0.8	AC or DC	250*	—	2.0	2.0	Plate coupling resistor 100000 ohms. 0.8	—	91000	1100	100	—	—
2B7/6B7	DUO-DIODE PENTODE (A.F.)	small 7-PIN	CAP	FIG. 21	4 11/16"	1 9/16"	HTR.	2.5 6.3	0.8 0.3	AC or DC	250*	50	4.5	4.5	0.65	0.15	Plate coupling resistor 200000 ohms.				
2B7/6B7	DUO-DIODE PENTODE (R.F.)	small 7-PIN	CAP	FIG. 21	4 11/16"	1 9/16"	HTR.	2.5 6.3	0.8 0.3	AC or DC	250*	125*	3.0	3.0	9.0	2.3	650000	1125	730	—	—

TRIODE POWER VALVES (Class A)

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
2A3	SINGLE TRIODE	4-PIN	—	FIG. 1	5 5/8"	2 1/16"	FIL.	2.5	2.5	AC or DC	250*	—	43	45	60	—	765	5500	4.2	2500	3500
2A3	PUSH-PULL TRIODES (2 Valves)	4-PIN	—	FIG. 1	5 5/8"	2 1/16"	FIL.	2.5	each 2.5	AC or DC	300*	—	60	62	each 40	—	Fixed bias Self bias (700 ohms.)			3000 5000	15000 10000
10	SINGLE TRIODE	4-PIN	—	FIG. 1	5 5/8"	2 1/16"	FIL.	7.5	1.25	AC or DC	350 425*	— —	27 35	31 39	16 18	— —	5150 5000	1550 1600	8.0 8.0	11000 10200	900 1600
20	SINGLE TRIODE	4-PIN	—	FIG. 1	4 1/8"	1 3/16"	FIL.	3.3	0.132	DC	90 135*	— —	16.5 22.5	— —	3.0 6.5	— —	8000 6300	415 525	3.3 3.3	9600 6500	45 110
31	SINGLE TRIODE	4-PIN	—	FIG. 1	4 1/8"	1 9/16"	FIL.	2.0	0.130	DC	135 180*	— —	22.5 30.0	— —	8.0 12.3	— —	4100 3600	925 1050	3.8 3.8	7000 5700	185 375
45	SINGLE TRIODE	4-PIN	—	FIG. 1	5 5/8"	2 1/16"	FIL.	2.5	1.5	AC or DC	180 250 275*	— — —	30.0 48.5 54.5	31.5 50 56	31 34 36	— — —	1650 1610 1700	2125 2175 2050	3.5 3.5 3.5	2700 3900 4600	825 1600 2000
46	DUAL PURPOSE USED AS SINGLE TRIODE □	5-PIN	—	FIG. 7	5 5/8"	2 1/16"	FIL.	2.5	1.75	AC or DC	250*	—	31.5	33.0	22	—	2380	2350	5.6	6400	1250
50	SINGLE TRIODE	4-PIN	—	FIG. 1	6 1/4"	2 11/16"	FIL.	7.5	1.25	AC or DC	350 450*	— —	59.0 80.0	63.0 84.0	45 55	— —	1900 1800	2000 2100	3.8 3.8	4100 4350	2400 4600
53	TWIN CLASS B USED AS SINGLE TRIODE △	Medium 7-PIN	—	FIG. 17	4 11/16"	1 13/16"	HTR.	2.5	2.0	AC or DC	250 294*	— —	5.0 6.0	5.0 6.0	6.0 7.0	— —	11100 11000	3100 3200	35 35	approx. 30000	approx. 400
59	TRIPLE PURPOSE USED AS SINGLE TRIODE ¶	Medium 7-PIN	—	FIG. 18	5 5/8"	2 1/16"	HTR.	2.5	2.0	AC or DC	250*	—	26	28	26	—	2400	2600	6.0	5000	1250
71A	SINGLE TRIODE	4-PIN	—	FIG. 1	4 11/16"	1 13/16"	FIL.	5.0	0.25	AC or DC	135 180*	— —	27.0 40.5	29.5 43.0	17.5 20.0	— —	1820 1750	1650 1700	3.0 3.0	3000 4800	400 790
89	TRIPLE PURPOSE USED AS SINGLE TRIODE ¶	6-PIN	—	FIG. 14	4 11/16"	1 9/16"	HTR.	6.3	0.4	AC or DC	180 250*	— —	22.5 31.0	22.5 31.0	20 32	— —	3000 2600	1550 1800	4.7 4.7	6500 5500	400 900
49	DUAL PURPOSE USED AS SINGLE TRIODE □	5-PIN	—	FIG. 7	4 11/16"	1 13/16"	FIL.	2.0	0.12	DC	135*	—	20	—	5.7	—	4000	1125	4.5	8000	170

¶ Grid No. 1 is Control grid. Grids Nos. 2 and 3 tied to plate. □ Grid No. 2 tied to plate. △ Grids tied, plates tied together.

PENTODE POWER VALVES (Class A)

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
2A5	PENTODE	6-PIN	—	FIG. 15A	4 11/16"	1 13/16"	HTR.	2.5	1.75	AC or DC	250*	250*	16.5	16.5	34	6.5	80000	2200	132	7000	3000
6A4	PENTODE	5-PIN	—	FIG. 6	4 11/16"	1 13/16"	FIL.	6.3	0.3	AC or DC	180*	180*	12	15	22	3.9	45500	2200	100	8000	1400
33	PENTODE	5-PIN	—	FIG. 6	4 11/16"	1 13/16"	FIL.	2.0	0.26	DC	135*	135*	13.5	—	14.5	3.0	50000	1450	70	7000	700
38	PENTODE	5-PIN	CAP	FIG. 9A	4 11/16"	1 9/16"	HTR.	6.3	0.3	AC or DC	180 250*	180 250*	18 25	18 25	14 22	2.4 3.8	110000 100000	1050 1200	120 120	11600 10000	1000 2500
41	PENTODE	6-PIN	—	FIG. 15A	4"	1 9/16"	HTR.	6.3	0.4	AC or DC	180 250*	180 250*	13.5 18.0	13.5 18.0	18.5 32.0	3.0 5.5	81000 68000	1850 2200	150 150	9000 7600	1500 3400
42	PENTODE	6-PIN	—	FIG. 15A	4 11/16"	1 13/16"	HTR.	6.3	0.7	AC or DC	250*	250*	16.5	16.5	34	6.5	60000	2200	132	7000	3000
43	PENTODE	6-PIN	—	FIG. 15A	4 11/16"	1 13/16"	HTR.	25	0.3	AC or DC	95 135*	95 135*	15 20	15 20	20 34	4.0 7.0	45000 35000	2000 2300	90 80	4500 4000	900 2000
47	PENTODE	5-PIN	—	FIG. 6	5 5/8"	2 1/16"	FIL.	2.5	1.75	AC or DC	250*	250*	15.0	16.5	31	6.0	60000	2500	150	7000	2700
48	PENTODE	6-PIN	—	FIG. 15	5 5/8"	2 1/16"	HTR.	30	0.4	DC	95 125*	95 100*	20.0 22.5	— —	47 50	9.0 9.0	10000 10000	2800 2800	28 28	2000 2000	1600 2500
59	TRIPLE PURPOSE USED AS PENTODE •	Medium 7-PIN	—	FIG. 18	5 5/8"	2 1/16"	HTR.	2.5	2.0	AC or DC	250*	250*	18	18	35	9.0	40000	2500	100	6000	3000
89	TRIPLE PURPOSE USED AS PENTODE •	6-PIN	CAP	FIG. 14	4 11/16"	1 9/16"	HTR.	6.3	0.4	AC or DC	180 250*	180 250*	18 25	18 25	20 32	3.0 5.5	80000 70000	1550 1800	125 125	8000 6750	1500 3400

• Grid No. 1 is Control grid. Grid No. 2 is Screen. Grid No. 3 is Suppressor (tied to Cathode).

CLASS B. POWER VALVES

Type	Application	Base	Cap	Socket Connections	Length	Diam.	Cathode Type	Volts	Amps.	Supply	Plate Supply Volts *Max.	Screen Volts *Max.	Neg. Grid Bias D C on Fil.	A C on Fil.	Plate Current Milli-Amp.	Screen Current Milli-Amp.	A C Plate Resistance Ohms	Mutual Conductance Micro-Mhos	Voltage Amplification Factor	Ohms Load	Power Output Milli-Watts
46	TWO SEPARATE VALVES ×	5-PIN	—	FIG. 7	5 5/8"	2 1/16"	FIL.	2.5	each 1.75	AC or DC	300 400*	— —	0 0	0 0	4.0 6.0 Each valve no signal				Load plate to plate	5200 5800	16000 20000
49	TWO SEPARATE VALVES ×	5-PIN	—	FIG. 7	4 11/16"	1 13/16"	FIL.	2.0	0.12	DC	180*	—	0	—	2.0 Each valve no signal				Load plate to plate	— 12000	— 3500
59	TWO SEPARATE VALVES +	Medium 7-PIN	—	FIG. 18	5 5/8"	2 1/16"	HTR.	2.5	2.0	AC or DC	300 400*	— —	0 0	0 0	10 13 Each valve no signal				Load plate to plate	4600 6000	15000 20000
89	TWO SEPARATE VALVES +	6-PIN	CAP	FIG. 14	4 11/16"	1 9/16"	HTR.	6.3	0.4	AC or DC	180 250*	— —	0 0	0 0	3 — Each valve no signal				Load plate to plate	9400 —	3500 —
19	TWIN VALVE	6-PIN	—	FIG. 12	4 1/4"	1 9/16"	FIL.	2.0	0.26	DC	135* 135* 135*	— — —	0 3 6	— — —	10 4 1 Total Ip. no signal				Load plate to plate	10000 10000 10000	2100 1900 1600
53	TWIN VALVE	Medium 7-PIN	—	FIG. 17	4 11/16"	1 13/16"	HTR.	2.5	2.0	AC or DC	250 300*	— —	0 0	0 0	28 35 Total Ip. no signal				Load plate to plate	8000 10000	8000 10000
79	TWIN VALVE	6-PIN	CAP	FIG. 19	4 11/16"	1 9/16"	HTR.	6.3	0.6	AC or DC	180 250*	— —	0 0	0 0	7.5 10.5 Total Ip. no signal				Load plate to plate	7000 14000	5500 8000

× Both Grids tied together in each valve.
+ Grids Nos. 1 and 2 tied together, No. 3 to plate.

RECTIFIER VALVES

Type	Description	Base	Cap	Socket Connections	Dimensions Max. Overall Length	Diam.	Cathode Type	Filament or Heater Volts	Amps.	Supply	Max. Volts Heater to Cathode	Max. A C Volts (R.M.S.) per Plate	Max. Peak Inverse Volts	Max. Continuous D C Output Current (m.a.)	Max. Peak Plate Current (m.a.)
5Z3	FULL WAVE VACUUM	4-PIN	—	FIG. 2	5 5/8"	2 1/16"	FIL.	5.0	3.0	AC	—	500	—	250	—
25Z5	VOLTAGE DOUBLER FULL WAVE VACUUM	6-PIN	—	FIG. 5	4 1/4"	1 9/16"	HTR.	25	0.3	AC or DC	125	125	—	100	—
80	FULL WAVE VACUUM	4-PIN	—	FIG. 2	4 11/16"	1 13/16"	FIL.	5.0	2.0	AC	—	350 400 550	—	125 110 135 The 550 volt rating applies only with 20 Henry input choke.	
84	FULL WAVE VACUUM	5-PIN	—	FIG. 23	4 1/4"	1 9/16"	HTR.	6.3	0.5	AC or DC	300	350	—	50 (75 for	Half Wave)
12Z3	HALF WAVE VACUUM	4-PIN	—	FIG. 22	4 1/4"	1 9/16"	HTR.	12.6	0.3	AC or DC	350	250	—	60	—
1V	HALF WAVE VACUUM	4-PIN	—	FIG. 22	4 1/4"	1 9/16"	HTR.	6.3	0.3	AC or DC	500	350	—	50	—
81	HALF WAVE VACUUM	4-PIN	—	FIG. 3	6 1/4"	2 1/16"	FIL.	7.5	1.25	AC	—	700	—	85	—
82	FULL WAVE MERCURY†	4-PIN	—	FIG. 2	4 11/16"	1 13/16"	FIL.	2.5	3.0	AC	—	500	Plate to plate 1400	125	400
83	FULL WAVE MERCURY†	4-PIN	—	FIG. 2	5 5/8"	2 1/16"	FIL.	5.0	3.0	AC	—	500	Plate to plate 1400	250	800
866	HALF WAVE MERCURY†	4-PIN	CAP.	FIG. 16	6 1/4"	2 7/16"	FIL.	2.5	5.0	AC	—	—	7500	—	600

† Valve voltage drop 15 volts approx.
Max. voltage heater to cathode, 45 volts, except for Rectifiers, which are separately tabulated.

Additional Radiotrons not shown on chart: WD11, WX12, UX200A, UX240, UV199, 841, 842, 852, 865, 868 (photo tube), 874, 876, 886.

Issued by AMALGAMATED WIRELESS VALVE COY. LTD. UNIFIED SALES-ENGINEERING SERVICE. 1st February, 1934

WHILST it is not claimed that this book will solve all the designer's problems, the fact that it incorporates technical data in a condensed form that has been found as a result of experience to be of practical application, makes it an invaluable reference to all those engaged in design, experimental or service work.

The Valve Company has organised a special Engineering and Technical Service Department and we particularly invite all users of Radiotron valves to avail themselves of this service. We seek suggestions and even requests for additional data from our many clients, and expressly invite both local and Interstate engineers, experimenters and technicians to communicate with us, giving full details of any problems associated with the use of Radiotron valves.

AMALGAMATED WIRELESS VALVE CO. LTD.,
47 York Street, Sydney.

JOHN SANDS LTD. SYDNEY