

Section 9

CHARTS AND GRAPHS

Table 9-1. Decibels

Power ratio	Voltage or current ratio	-Db+	Voltage or current ratio	Power ratio	Power ratio	Voltage or current ratio	- Db+	Voltage or current ratio	Power ratio
10^{-1}		10		10	0.316	0.562	5.0	1.78	3.16
10^{-2}	10^{-1}	20	10	10^2	0.309	0.556	5.1	1.80	3.24
10^{-3}		30		10^3	0.302	0.550	5.2	1.82	3.31
10^{-4}	10^{-2}	40	10^2	10^4	0.295	0.543	5.3	1.84	3.39
10^{-5}		50		10^5	0.288	0.537	5.4	1.86	3.47
10^{-6}	10^{-3}	60	10^3	10^6	0.282	0.530	5.5	1.88	3.55
10^{-7}		70		10^7	0.275	0.525	5.6	1.91	3.63
10^{-8}	10^{-4}	80	10^4	10^8	0.269	0.519	5.7	1.93	3.72
10^{-9}		90		10^9	0.263	0.513	5.8	1.95	3.80
10^{-10}	10^{-5}	100	10^5	10^{10}	0.257	0.507	5.9	1.97	3.89
1.000	1.000	0	1.00	1.00	0.251	0.501	6.0	2.00	3.98
0.977	0.989	0.1	1.01	1.02	0.246	0.496	6.1	2.02	4.07
0.955	0.977	0.2	1.02	1.05	0.240	0.490	6.2	2.04	4.17
0.933	0.966	0.3	1.04	1.07	0.234	0.484	6.3	2.07	4.27
0.912	0.955	0.4	1.05	1.10	0.229	0.479	6.4	2.09	4.37
0.891	0.944	0.5	1.06	1.12	0.224	0.473	6.5	2.11	4.47
0.871	0.933	0.6	1.07	1.15	0.219	0.468	6.6	2.14	4.57
0.851	0.923	0.7	1.08	1.18	0.214	0.462	6.7	2.16	4.68
0.832	0.912	0.8	1.10	1.20	0.209	0.457	6.8	2.19	4.79
0.813	0.902	0.9	1.11	1.23	0.204	0.452	6.9	2.21	4.90
0.794	0.891	1.0	1.12	1.26	0.200	0.447	7.0	2.24	5.01
0.776	0.881	1.1	1.14	1.29	0.195	0.442	7.1	2.27	5.13
0.759	0.871	1.2	1.15	1.32	0.191	0.437	7.2	2.29	5.25
0.741	0.861	1.3	1.16	1.35	0.186	0.432	7.3	2.32	5.37
0.724	0.851	1.4	1.18	1.38	0.182	0.427	7.4	2.34	5.50
0.708	0.841	1.5	1.19	1.41	0.178	0.422	7.5	2.37	5.62
0.692	0.832	1.6	1.20	1.45	0.174	0.417	7.6	2.40	5.75
0.676	0.822	1.7	1.22	1.48	0.170	0.412	7.7	2.43	5.89
0.661	0.813	1.8	1.23	1.51	0.166	0.407	7.8	2.46	6.03
0.646	0.804	1.9	1.25	1.55	0.162	0.403	7.9	2.48	6.17
0.631	0.794	2.0	1.26	1.59	0.159	0.398	8.0	2.51	6.31
0.617	0.785	2.1	1.27	1.62	0.155	0.394	8.1	2.54	6.46
0.603	0.776	2.2	1.29	1.66	0.151	0.389	8.2	2.57	6.61
0.589	0.767	2.3	1.30	1.70	0.148	0.385	8.3	2.60	6.76
0.575	0.759	2.4	1.32	1.74	0.145	0.380	8.4	2.63	6.92
0.562	0.750	2.5	1.33	1.78	0.141	0.376	8.5	2.66	7.08
0.550	0.741	2.6	1.35	1.82	0.138	0.372	8.6	2.69	7.24
0.537	0.733	2.7	1.37	1.86	0.135	0.367	8.7	2.72	7.41
0.525	0.724	2.8	1.38	1.91	0.132	0.363	8.8	2.75	7.59
0.513	0.716	2.9	1.40	1.95	0.129	0.359	8.9	2.79	7.76
0.501	0.708	3.0	1.41	2.00	0.126	0.355	9.0	2.82	7.94
0.490	0.700	3.1	1.43	2.04	0.123	0.351	9.1	2.85	8.13
0.479	0.692	3.2	1.45	2.09	0.120	0.347	9.2	2.88	8.32
0.468	0.684	3.3	1.46	2.14	0.118	0.343	9.3	2.92	8.51
0.457	0.676	3.4	1.48	2.19	0.115	0.339	9.4	2.95	8.71
0.447	0.668	3.5	1.50	2.24	0.112	0.335	9.5	2.99	8.91
0.437	0.661	3.6	1.51	2.29	0.110	0.331	9.6	3.02	9.12
0.427	0.653	3.7	1.53	2.34	0.107	0.327	9.7	3.06	9.33
0.417	0.646	3.8	1.55	2.40	0.105	0.324	9.8	3.09	9.55
0.407	0.638	3.9	1.57	2.46	0.102	0.320	9.9	3.13	9.77
0.398	0.631	4.0	1.59	2.51	0.1000	0.316	10.0	3.16	10.00
0.389	0.624	4.1	1.60	2.57	0.0977	0.313	10.1	3.20	10.23
0.380	0.617	4.2	1.62	2.63	0.0955	0.309	10.2	3.24	10.47
0.372	0.610	4.3	1.64	2.69	0.0933	0.306	10.3	3.27	10.72
0.363	0.603	4.4	1.66	2.75	0.0912	0.302	10.4	3.31	10.96
0.355	0.596	4.5	1.68	2.81	0.0891	0.299	10.5	3.35	11.22
0.347	0.589	4.6	1.70	2.88	0.0871	0.295	10.6	3.39	11.48
0.339	0.582	4.7	1.72	2.95	0.0851	0.292	10.7	3.43	11.75
0.331	0.575	4.8	1.74	3.02	0.0832	0.288	10.8	3.47	12.02
0.324	0.569	4.9	1.76	3.09	0.0813	0.285	10.9	3.51	12.30

Table 9-1. Decibels (Continued)

Power ratio	Voltage or current ratio	-Db+	Voltage or current ratio	Power ratio	Power ratio	Voltage or current ratio	-Db+	Voltage or current ratio	Power ratio
0.0794	0.282	11.0	3.55	12.59	0.0251	0.159	16.0	6.31	39.81
0.0776	0.279	11.1	3.59	12.88	0.0246	0.157	16.1	6.38	40.74
0.0759	0.275	11.2	3.63	13.18	0.0240	0.155	16.2	6.46	41.69
0.0741	0.272	11.3	3.67	13.49	0.0234	0.153	16.3	6.53	42.66
0.0724	0.269	11.4	3.72	13.80	0.0229	0.151	16.4	6.61	43.65
0.0708	0.266	11.5	3.76	14.13	0.0224	0.150	16.5	6.68	44.67
0.0691	0.263	11.6	3.80	14.45	0.0219	0.148	16.6	6.76	45.71
0.0676	0.260	11.7	3.85	14.79	0.0214	0.146	16.7	6.84	46.77
0.0661	0.257	11.8	3.89	15.14	0.0209	0.145	16.8	6.92	47.86
0.0646	0.254	11.9	3.94	15.49	0.0204	0.143	16.9	7.00	48.98
0.0631	0.251	12.0	3.98	15.85	0.0200	0.141	17.0	7.08	50.12
0.0617	0.248	12.1	4.03	16.22	0.0195	0.140	17.1	7.16	51.29
0.0603	0.246	12.2	4.07	16.60	0.0191	0.138	17.2	7.24	52.48
0.0589	0.243	12.3	4.12	16.98	0.0186	0.137	17.3	7.33	53.70
0.0575	0.240	12.4	4.17	17.38	0.0182	0.135	17.4	7.41	54.95
0.0562	0.237	12.5	4.22	17.78	0.0178	0.133	17.5	7.50	56.23
0.0550	0.234	12.6	4.27	18.20	0.0174	0.132	17.6	7.59	57.54
0.0537	0.232	12.7	4.32	18.62	0.0170	0.130	17.7	7.67	58.88
0.0525	0.229	12.8	4.37	19.05	0.0166	0.129	17.8	7.76	60.26
0.0513	0.227	12.9	4.42	19.50	0.0162	0.127	17.9	7.85	61.66
0.0501	0.224	13.0	4.47	19.95	0.0159	0.126	18.0	7.94	63.10
0.0490	0.221	13.1	4.52	20.42	0.0155	0.125	18.1	8.04	64.57
0.0479	0.219	13.2	4.57	20.89	0.0151	0.123	18.2	8.13	66.07
0.0468	0.216	13.3	4.62	21.38	0.0148	0.122	18.3	8.22	67.61
0.0457	0.214	13.4	4.68	21.88	0.0145	0.120	18.4	8.32	69.18
0.0447	0.211	13.5	4.73	22.39	0.0141	0.119	18.5	8.41	70.79
0.0437	0.209	13.6	4.79	22.91	0.0138	0.118	18.6	8.51	72.44
0.0427	0.207	13.7	4.84	23.44	0.0135	0.116	18.7	8.61	74.13
0.0417	0.204	13.8	4.90	23.99	0.0132	0.115	18.8	8.71	75.86
0.0407	0.202	13.9	4.96	24.55	0.0129	0.114	18.9	8.81	77.62
0.0398	0.200	14.0	5.01	25.12	0.0126	0.112	19.0	8.91	79.43
0.0389	0.197	14.1	5.07	25.70	0.0123	0.111	19.1	9.02	81.28
0.0380	0.195	14.2	5.13	26.30	0.0120	0.110	19.2	9.12	83.18
0.0372	0.193	14.3	5.19	26.92	0.0118	0.108	19.3	9.23	85.11
0.0363	0.191	14.4	5.25	27.54	0.0115	0.107	19.4	9.33	87.10
0.0355	0.188	14.5	5.31	28.18	0.0112	0.106	19.5	9.44	89.13
0.0347	0.186	14.6	5.37	28.84	0.0110	0.105	19.6	9.55	91.20
0.0339	0.184	14.7	5.43	29.51	0.0107	0.104	19.7	9.66	93.33
0.0331	0.182	14.8	5.50	30.20	0.0105	0.102	19.8	9.77	95.50
0.0324	0.180	14.9	5.56	30.90	0.0102	0.101	19.9	9.89	97.72
0.0316	0.178	15.0	5.62	31.62	0.0100	0.100	20.0	10.00	100.00
0.0309	0.176	15.1	5.69	32.36					
0.0302	0.174	15.2	5.75	33.11					
0.0295	0.172	15.3	5.82	33.88					
0.0288	0.170	15.4	5.89	34.67					
0.0282	0.168	15.5	5.96	35.48					
0.0275	0.166	15.6	6.03	36.31					
0.0269	0.164	15.7	6.10	37.15					
0.0263	0.162	15.8	6.17	38.02					
0.0257	0.160	15.9	6.24	38.90					

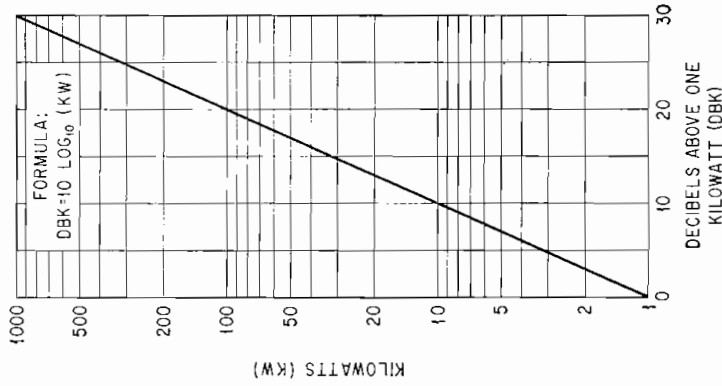


FIG. 9-2. Transformation of kilowatts to decibels above 1 kw.

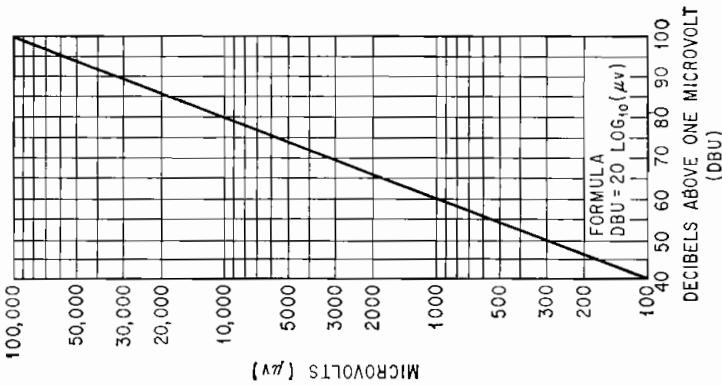


FIG. 9-1. Transformation of microvolts to decibels above 1 μv.

Charts and Graphs

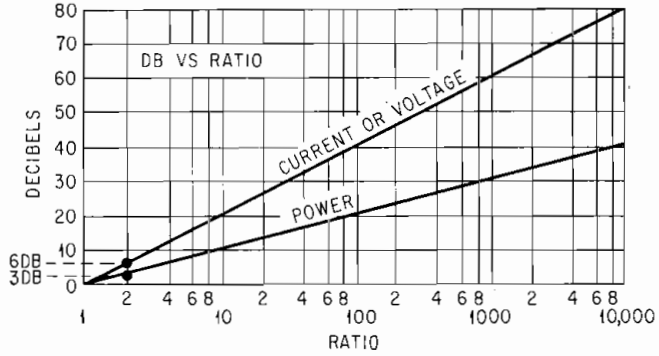


FIG. 9-3. Decibels vs. ratio.

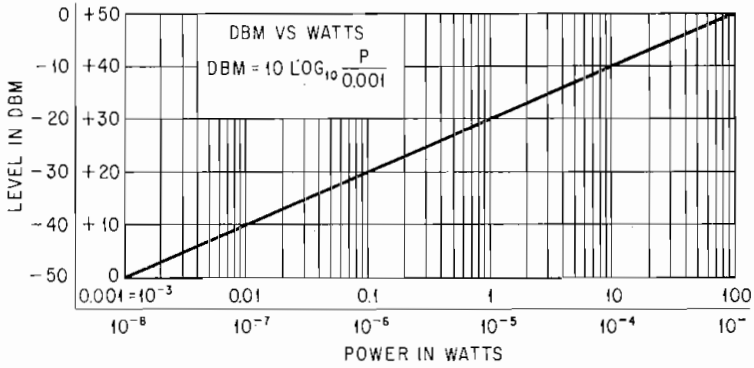


FIG. 9-4. Dbm vs. watts.

Table 9-2. Volume Level to Power and Voltage Conversion

Reference Level

0 dbm = 1 mw, 600 ohms

Milliwatts	Volts	Dbm
0.000001	0.0007746	-60
0.000010	0.002449	-50
0.000100	0.007746	-40
0.001	0.02449	-30
0.010	0.07746	-20
0.100	0.2449	-10
1.000	0.7746	0
Watts	Volts	Dbm
0.001000	0.7746	0
0.002512	1.228	+4
0.006310	1.946	+8
0.01000	2.449	+10
0.1000	7.746	+20
1.000	24.49	+30
10.00	77.46	+40

RESISTANCE VALUES OF SYMMETRICAL ATTENUATION NETWORKS *

For ready reference and to satisfy most of the practical needs of the various artificial line pads, the following charts have been prepared:

Figures 9-5 to 9-7, inclusive, are curves for determining the three components of pads which are symmetrical but have different input and output impedances. The curves are marked to indicate pad ratios for which it was calculated, and the values of *A* are for the higher pad series leg resistances shown in Fig. 9-5, while *C* values for the lower pad series leg resistances are shown in Fig. 9-7. *B* is for the shunt or transverse resistor shown in Fig. 9-6.

There is a minimum loss for each impedance ratio for which a pad can be designed and for convenience each curve on the figures is terminated by a circle at the lower value of resistance which corresponds to this minimum pad loss. For L networks double the values of *A* and *C*.

Figure 9-8 gives the resistance values for the series legs *A* of symmetrical pads having 1-to-1 impedance ratios. Figure 9-9 gives the transverse resistance values for these pads. For values not shown multiply the value shown for 100 ohms by the ratio of the desired value to 100. Double the series leg values for L networks.

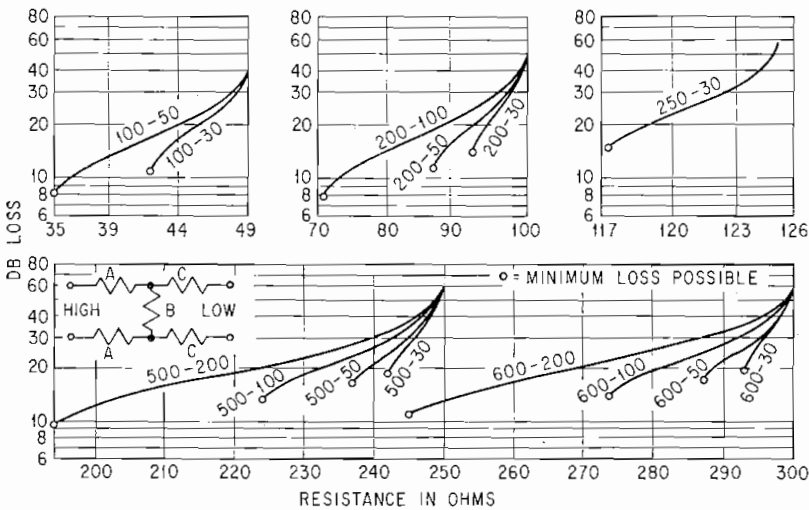


FIG. 9-5. Symmetrical attenuation networks for standard ratios—values of *A*.

* By Frank H. McIntosh, Consulting Radio Engineer, Washington, D.C.

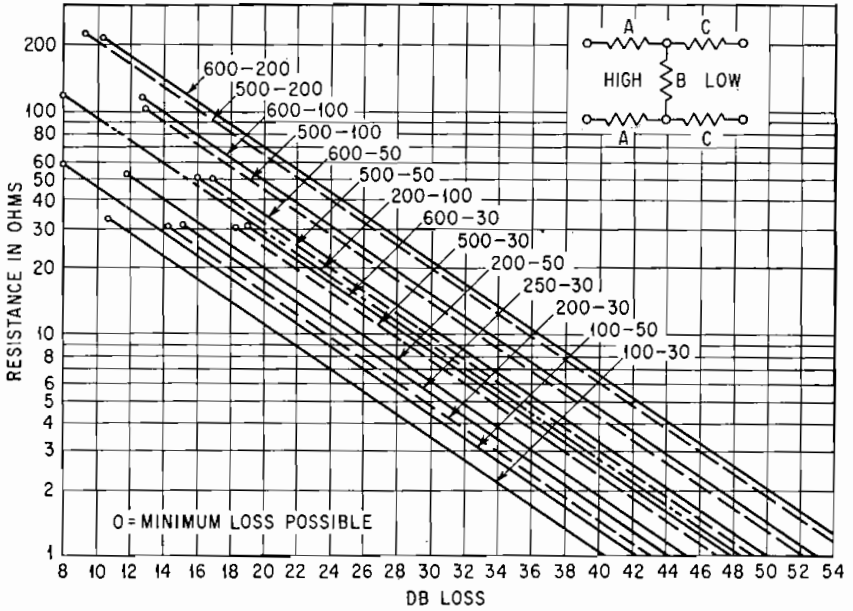


FIG. 9-6. Symmetrical attenuation networks for standard ratios—values of B.

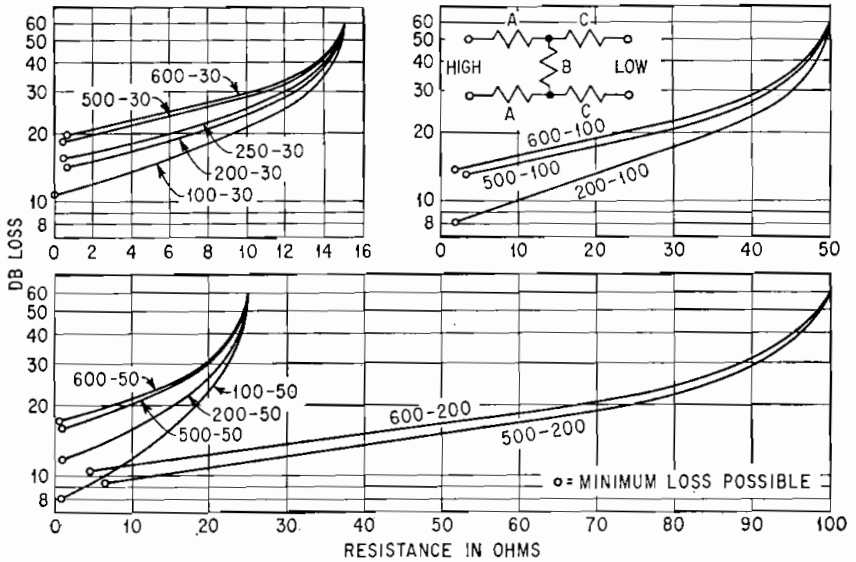


FIG. 9-7. Symmetrical attenuation networks for standard ratios—values of C.

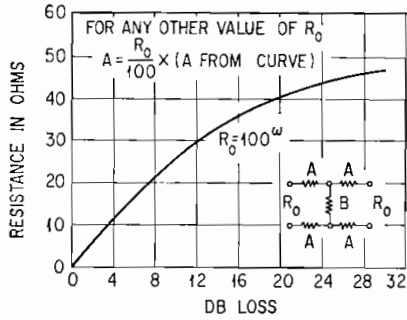


FIG. 9-8. H-type artificial line—value of series resistance A.

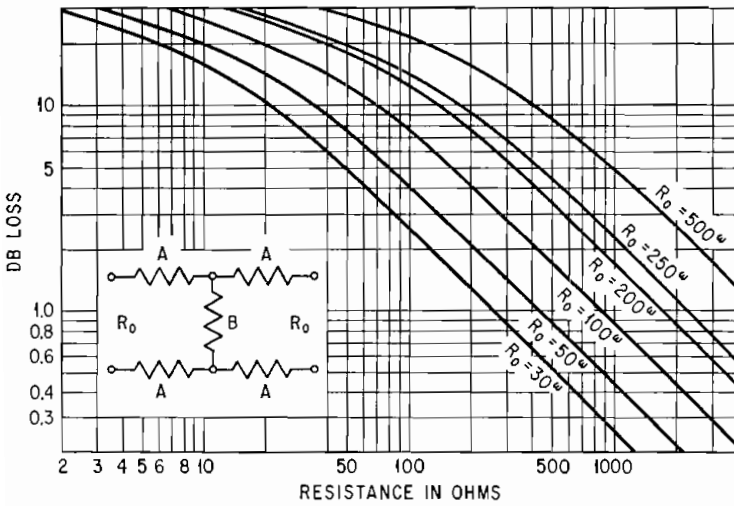
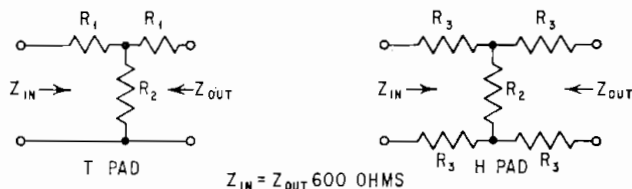


FIG. 9-9. H-type artificial line—value of transverse resistance B.

Table 9-3. Resistive Pads



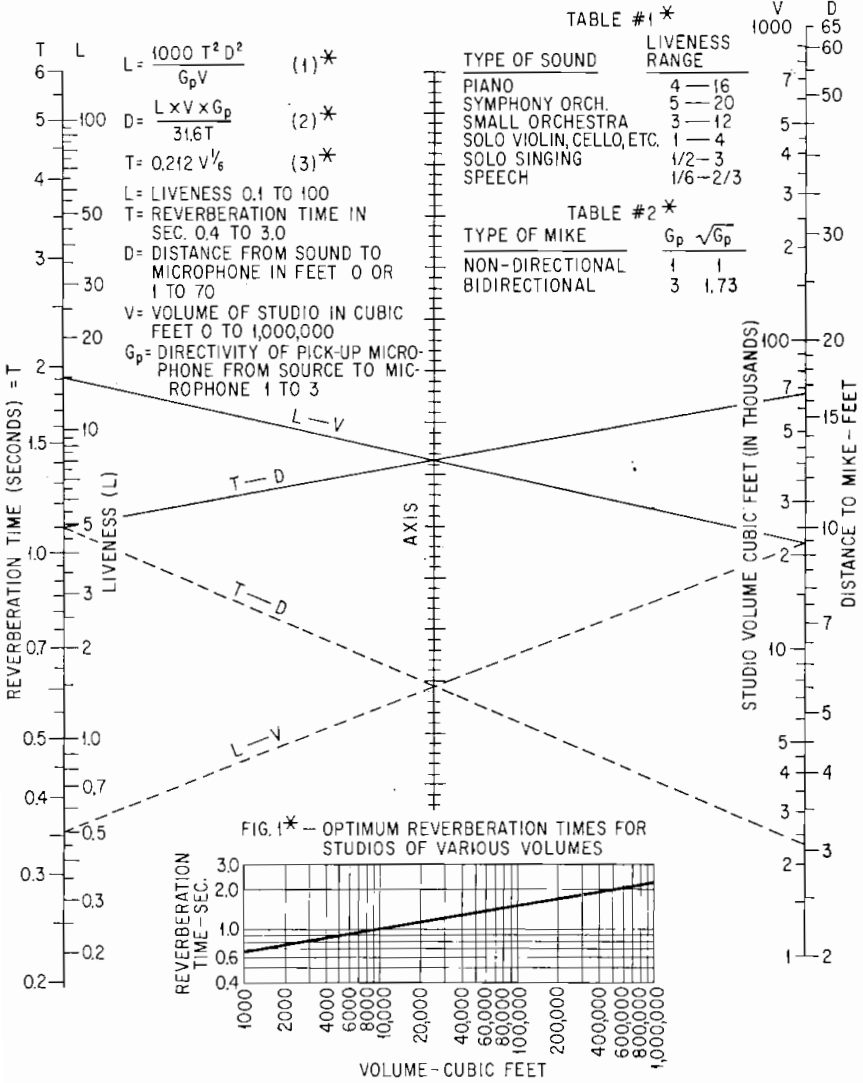
FOR IMPEDANCES OTHER THAN 600 OHMS,
MULTIPLY ALL RESISTORS BY FACTOR $\frac{Z_x}{600}$

For impedances other than 600 ohms, multiply all resistors by factor $Z_x/600$.

$$Z_{in} = Z_{out} = 600 \text{ ohms}$$

Loss	EIA resistor values *			Loss	EIA resistor values *		
	R_1	R_2	R_3		R_1	R_2	R_3
$\frac{1}{2}$	18	10,000	8.2	16	430	200	220
1	36	5,100	18	17	470	180	220
2	68	2,700	36	18	470	150	240
3	100	1,800	51	19	470	130	240
4	130	1,200	68	20	510	120	240
5	160	1,000	82	22	510	100	270
6	200	820	100	24	510	75	270
7	220	680	110	26	560	62	270
8	270	560	130	28	560	47	270
9	300	470	150	30	560	39	270
10	300	430	160	32	560	30	300
11	330	360	160	34	560	24	300
12	360	330	180	36	560	18	300
13	390	270	200	38	560	15	300
14	390	240	200	40	560	12	300
15	430	220	200				

* EIA resistor values nearest to the exact values are given.



*COURTESY OF WESTERN ELECTRIC CO.

FIG. 9-10. Nomograph for microphone distances in liveness broadcasting. (Reprinted from *Tele-Tech.*)

Constants $V = 22,000$ cu ft; $T = 1.1$ sec.

Example 1 (solid lines): Placement of general microphone. From Table 1 use liveness of 15. Connect 22,000 on V and 15 on L . Mark reference on the axis. Then extend a line from 1.1 on T through reference on axis to 16.5 ft on D . **Answer:** 16½ ft from mike to sound source.

Example 2 (dash lines): Placement of solo vocal microphone. From Table 1 use liveness of ½. Connect 22,000 on V and ½ on L . Mark reference on the axis. Then extend line from 1.1 on T through this reference to 3 ft on D . For bidirectional mike multiply 3 ft by $\sqrt{3}$, or 1.73. This yields 5 to 6 ft for actual distance.

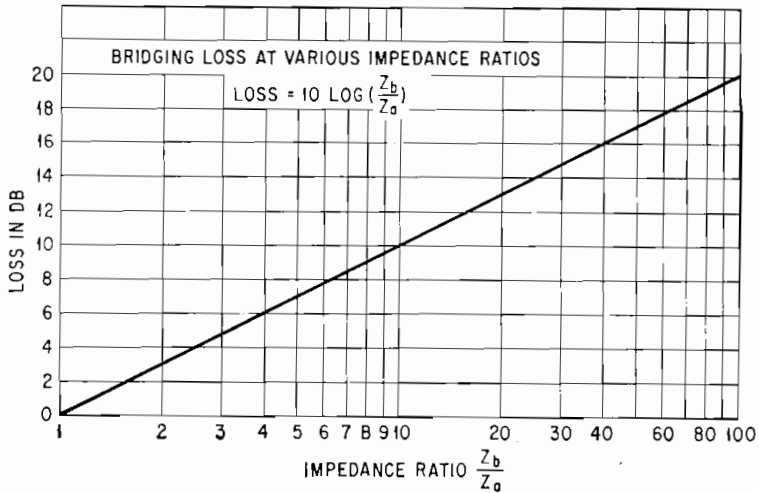


FIG. 9-11. Bridging loss at various impedance ratios. Loss = $10 \log Z_b/Z_a$.

PARALLEL-T NOMOGRAPH °

Summary: Values of five parameters for parallel-T networks are obtained directly with one setting of a straightedge, for frequencies in audio and ultrasonic ranges, to expedite the design of the network used directly in an amplifier chain to eliminate a single frequency. The same network can be used in a negative feedback path to enhance a single frequency.

This nomograph (Fig. 9-12) facilitates calculating parallel-T networks for experimental work in multiplex FM equipment design. The subcarrier frequencies used are in the range from about 20 to 75 kc. With one setting of a straightedge, all parameters of the parallel-T network needed to eliminate the undesired frequency f can be obtained to three significant figures.

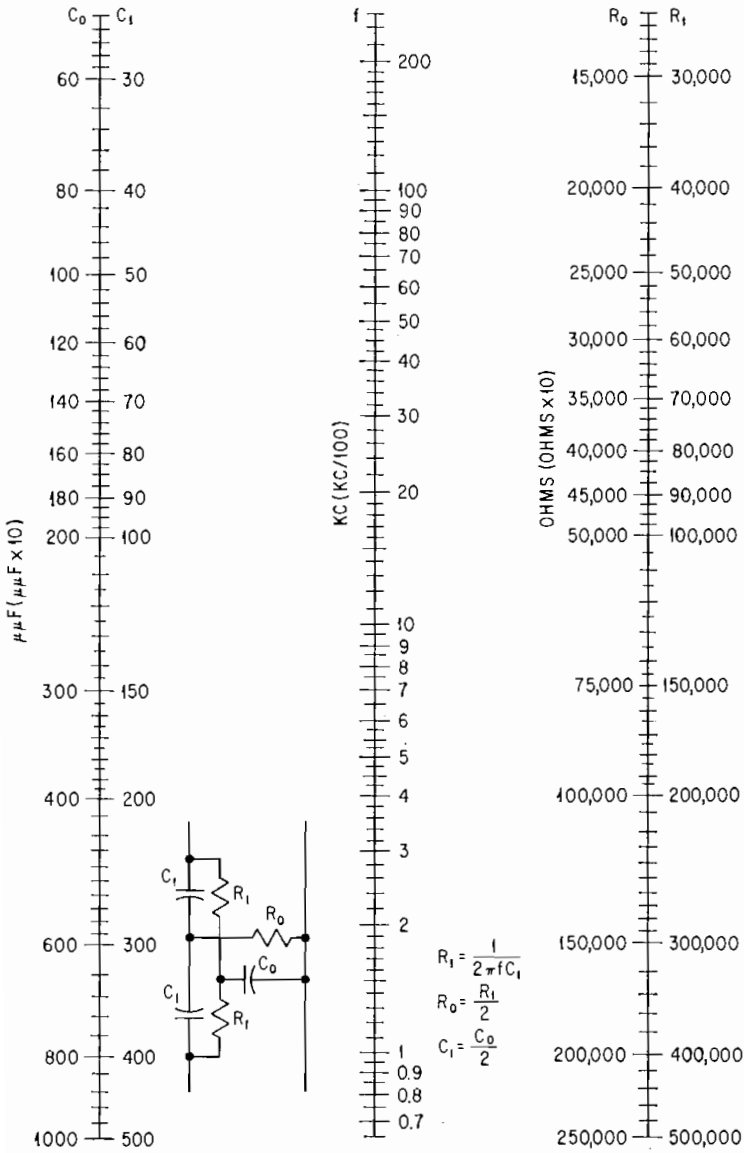
Example. If a specific frequency f of 10 kc is to be eliminated and C_1 is selected by the designer to be $100 \mu\mu\text{f}$, run a straightedge from $100 \mu\mu\text{f}$ on the C_1 scale through 10 kc on the f scale. All other values can now be read directly from the nomograph. Thus, R_1 is 159,000 ohms, R_0 is 79,500 ohms and C_0 is $200 \mu\mu\text{f}$.

Any two of the five parameters can be selected as the initial starting point of design. The other three can then be found with one setting of the straightedge.

If the f scale is divided by 100, the C and R scales must be multiplied by 10. This changes the range of the nomograph to cover from 7 cps at the low end to about 2,000 cps at the high end.

For a 100-cps elimination network and a value of $1,000 \mu\mu\text{f}$ for C_1 , these scale-multiplying factors must be used. The other parameters are then $R_1 = 1.59$ megohms, $R_0 = 795,000$ ohms, and $C_0 = 2,000 \mu\mu\text{f}$.

° By Donald F. Carter, Chief Electrical Engineer, Harkins and Hershfield, Phoenix, Ariz. Reprinted from *Electronics*, Nov. 1, 1957.



CENTER SCALE GIVES FREQUENCY ATTENUATED BY PARALLEL-T NETWORK

FIG. 9-12. Parallel-T nomograph.

MICROPHONE NOMOGRAPH °

Summary: The chart (Fig. 9-13) relates sound pressure level, microphone sensitivity, and output in decibels and volts as an aid in the design of microphone systems and related equipment. Typical sound levels for common sounds are indicated.

Microphone response is usually expressed in decibels referred to 1 volt/dyne/cm². Thus a microphone which produces 1 volt when exposed to a sound pressure of 1 dyne/cm² has a response of 0 db. Most microphones are far less sensitive than this.

Unless otherwise specified, the open-circuit voltage is used in arriving at the response figure.

The nomograph is based on the definition of pressure response in the American Standard Specification for Laboratory Standard Microphones.

Expressed symbolically, this definition becomes

$$\rho = 20 \log \frac{e_o}{p} \quad (9-1)$$

where ρ = pressure response

e_o = open-circuit output voltage

p = pressure, dynes/cm²

Equation (9-1) can be rewritten

$$= 20 \log e_o - 20 \log p \quad (9-2)$$

Sound pressure is commonly expressed in decibels relative to a reference pressure $p_0 = 2 \times 10^{-4}$ dynes/cm². When so expressed it is called sound pressure level (SPL) and is defined by

$$SPL = 20 \log \frac{p}{p_0} \quad \text{db} \quad (9-3)$$

Equations (9-2) and (9-3) yield

$$\rho = 20 \log e_o - SPL + 74 \text{ db} \quad (9-4)$$

Should absolute sound pressures be required, they can be filled in on the left-hand scale by noting that 100 db = 20 dynes/cm², 80 db = 2 dynes/cm², 60 db = 0.2 dyne/cm², and so forth.

A microphone with a response of -50 db is to be used to measure sound levels of 35 db or more. For what minimum input voltage should the amplifier be designed?

A straight line drawn between 35 db on the SPL scale and -50 db on the ρ scale intersects the e_o scale at about 35 μ v. This is the open-circuit microphone voltage.

Sound level in a jet-engine test control room is 112 db; a pneumatic chipper at a distance of 5 ft has a sound level of 122 db. At takeoff and 80 ft from the tail, an F-84 has a sound level of 130 db, all typical values.

° By William B. Conover, Transformer Laboratories Department, General Electric Company, Pittsfield, Mass. Reprinted from *Electronics*, October, 1955.

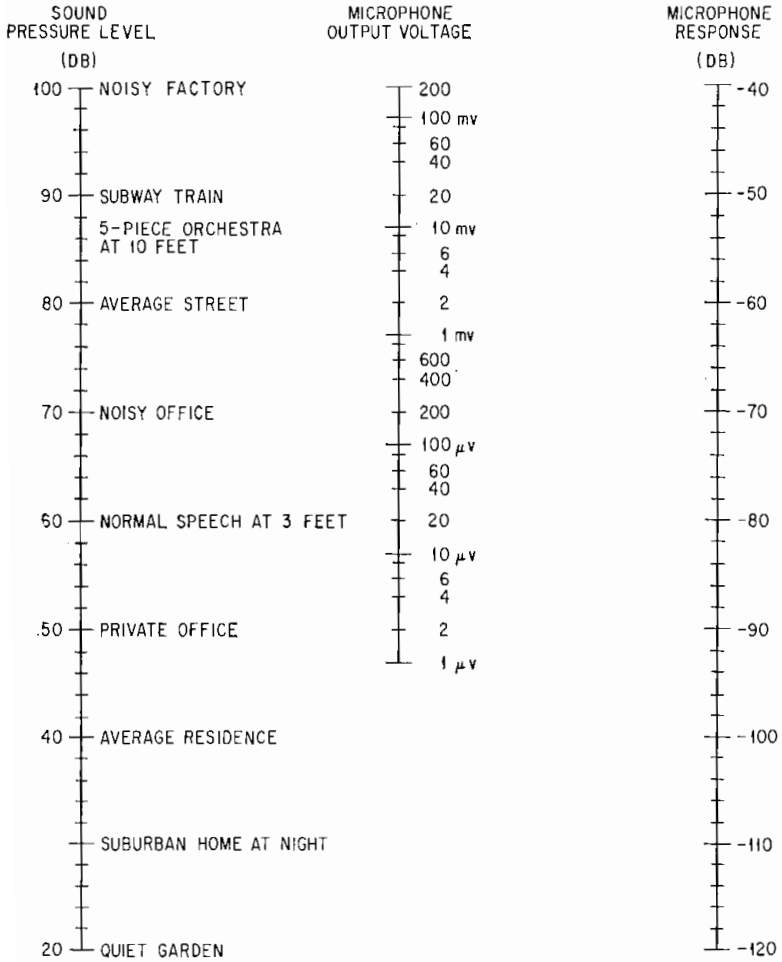


FIG. 9-13

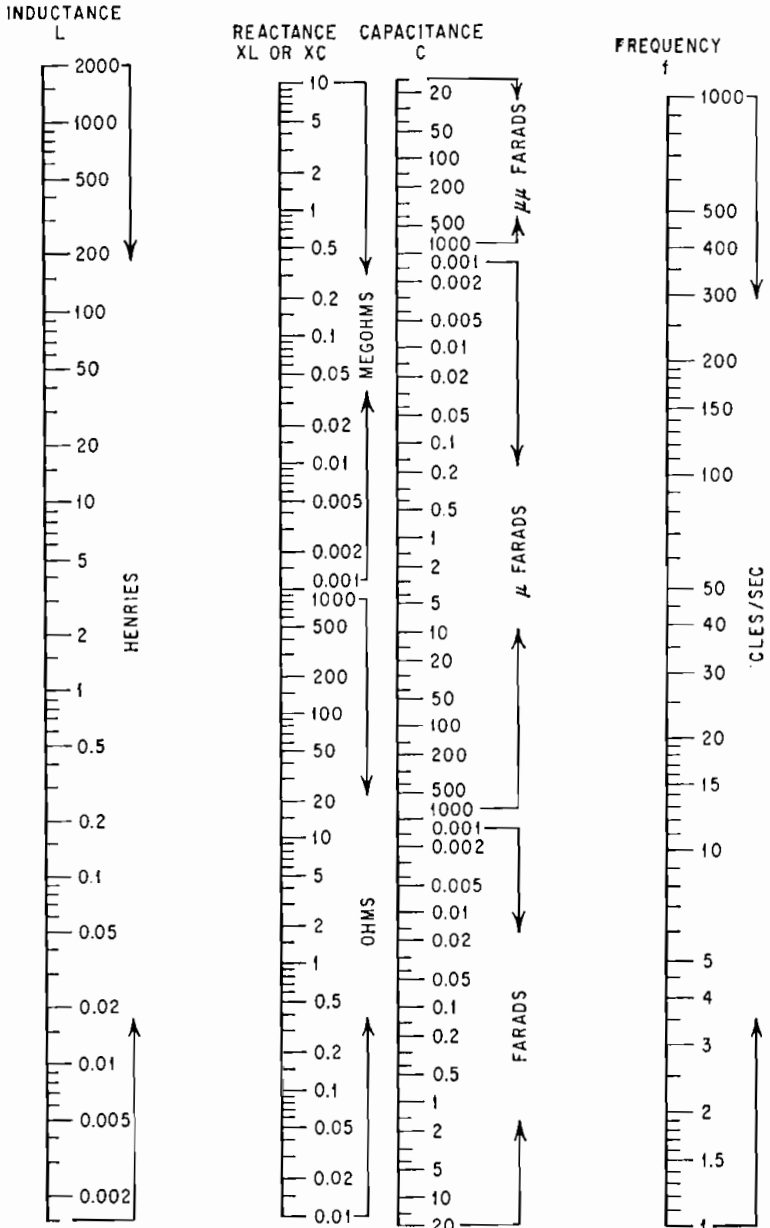


FIG. 9-14a

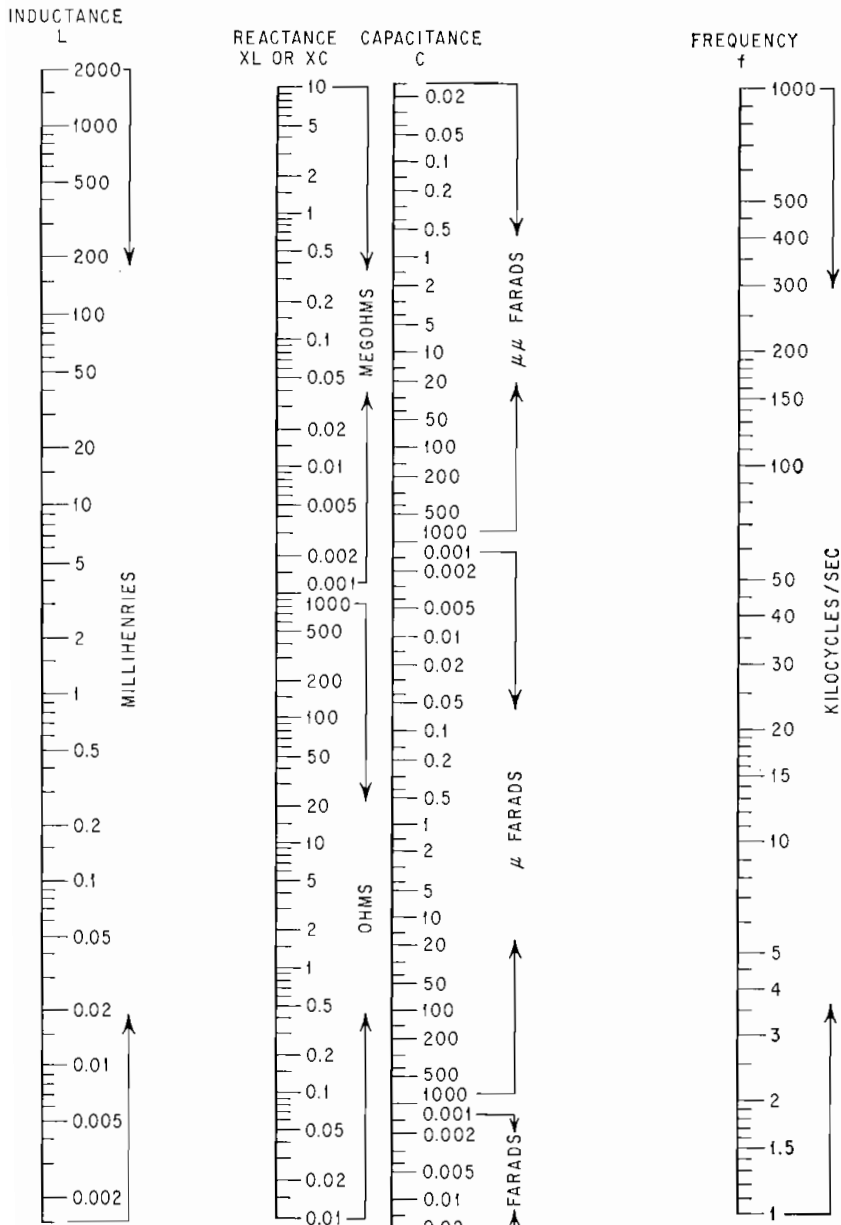


FIG. 9-14b

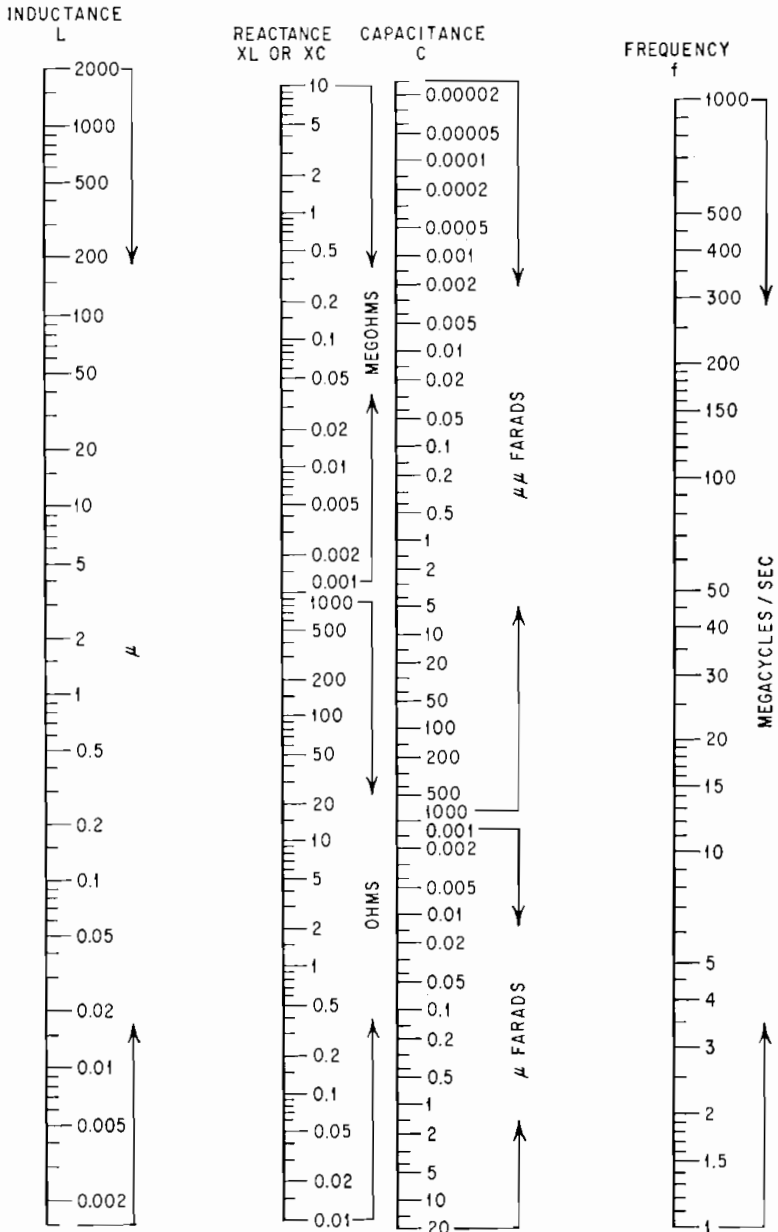


FIG. 9-14c

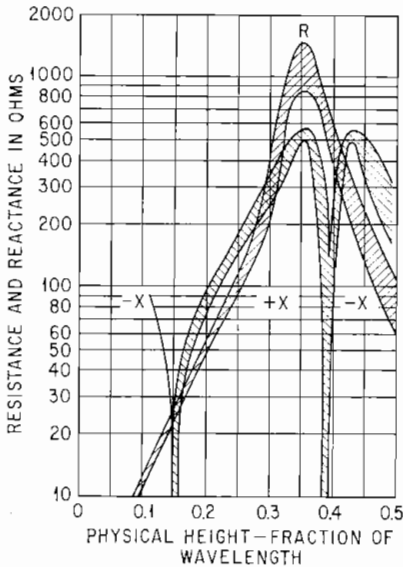


FIG. 9-15. Average characteristics for guyed radiators of uniform cross section. Data compiled from measurements of KNX and KIRO's 4-ft triangular radiators and a large number of 12- to 18-in. triangular radiators. (Prepared by J. B. Hatfield.)

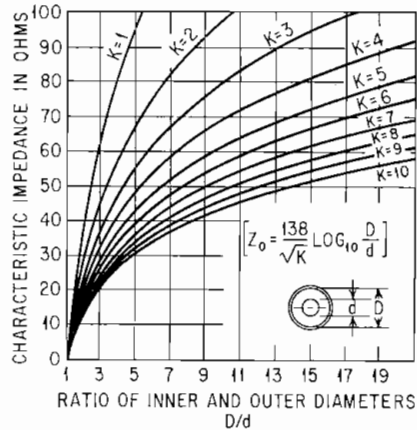


FIG. 9-16. Characteristic impedance of coaxial lines with various dielectrics.

COAXIAL-LINE IMPEDANCE CHART *

Summary: Characteristic impedances of coaxial lines are related graphically to dielectric constants and the ratios of outer to inner conductor diameters. Dielectric constants of common materials are also tabulated.

This chart (Fig. 9-16) simplifies the solution for the characteristic impedance of a single coaxial line.

Example. If a characteristic impedance of 50 ohms is desired and the insulating material is air, then from the chart the D/d ratio is 2.3. If metal tubing with an inside diameter $D = 0.250$ in. is chosen for the outer conductor, the outside diameter of the metal inner conductor is 0.109 in.

* By Herbert L. Levin, Electron Tube Laboratory, Federal Telecommunication Laboratories, Nutley, N.J. Reprinted from *Electronics*, Nov. 1, 1957.

Dielectric Constant K from 1 to 10,000 Mc at 25°C

<i>Ceramics</i>		<i>Plastics</i>	
Alumina 85%	8.3-8.0	Bakelite BM 120	3.7
Alumina 95%	8.9-9.3	Epoxy resin	3.1
Alumina 97%	9.0-9.6	Formica XX	3.6
Aluminum silicate	5.5-5.2	Kel-F	2.3
Fosterite	6.2-6.0	Micarta 254	3.4
Magnesium silicate	5.9-5.3	Nylon 610	2.8
Steatite	6.5-5.3	Plexiglass	2.6
Porcelain, standard electrical	5.5	Polystyrene	2.6
Porcelain, zircon	9.2	Styrofoam 103.7	1.03
		Teflon	2.1
		Tenite II	2.9
		Vinylite VG 5901	2.9
<i>Glasses</i>		<i>Miscellaneous</i>	
Corning:		Air	1
7052	5.1	Butyl rubber	2.4
7070	4.0	Mica	5.4
7720 nonex	4.7	Neoprene 38% GN	4.0
7740 Pyrex	4.6	Silastic 120	5.7
7900 Vycor (96% silica)	3.8	Silastic 152	2.9
8871 (lead potash)	8.4		
9010 (lead free)	6.5		
Quartz, fused	3.78		
Sapphire, synthetic	8.6-10.6		

If a ceramic such as Alumina 95 per cent with $K = 9$ were introduced as the dielectric and the Z_0 of 50 ohms were still desired, then from Fig. 9-16 $D/d = 12.3$. If the D of 0.250 were also still desired, then $d = 0.020$ in.

The chart shows that if in this example d were not changed when the ceramic material replaced air, then Z_0 would drop from 50 to 16.5 ohms.

COUPLING AND TUNING CAPACITOR FOR VARIOUS ANTENNAS

Figure 9-17 has been found to be a useful tool for adjusting the transmitter output circuit using capacity coupling to the antenna or transmission line. The values of capacity shown are approximate, but sufficiently close for practical purposes, since stray capacity of leads and components has not been taken into account. The capacity shown is the total capacity required for both the first and second sections of the low-pass filters.

The introduced resistance is the net resistance component when section is adjusted resulting from the effect of the R_a (antenna or line resistance) and the coupling capacity (CC).

The Z is the load impedance for the tubes determined by the dynamic characteristic for the particular tube and its operating voltages.

The value of introduced resistance used generally now lies between 50 and 100 ohms with the upper limit determined by the stray capacity. Formerly with high C ratios, introduced resistances were from 7 to 20 ohms, which resulted generally in higher circuit losses.

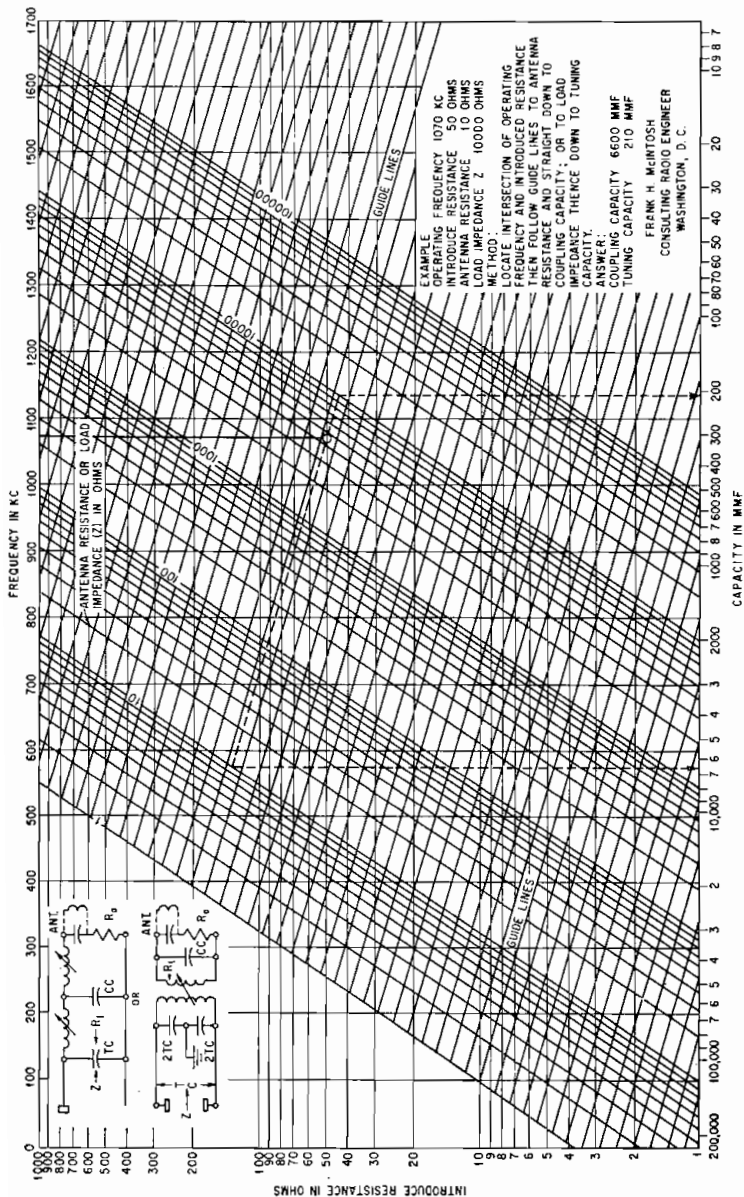


Fig. 9-17. Capacity-coupled circuits. Chart showing coupling and tuning capacities for various antenna resistances, tube load impedances, and introduced resistances for various given frequencies.

APPLICATION OF PROXIMITY-EFFECT CURVE °

1. The curve in Fig. 9-18 shows the amount by which the measured field strength, as measured by a field-strength meter which employs a shielded loop, will depart from an inverse distance function because of induction field or proximity effect due to measuring close to the antenna.

2. It is based upon the calculation of the horizontal component of magnetic field close to an antenna, after the manner of George H. Brown.

3. It can be used first as a guide determining how close one can measure to a given antenna before the correction due to proximity would be expected to exceed a given percentage.

4. It can be used to correct out the error due to proximity before plotting field-strength measurements to determine accurately the inverse distance field. This permits measurements to be made sufficiently close to the tower to eliminate the effects of conductivity.

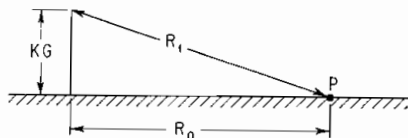
Derivation

1. G. H. Brown, *Directional Antennas*, IRE, January, 1937, on page 81 and in formula (7) gives the general formula for the magnetic flux density at any point in space from a vertical radiator over a perfectly conducting earth. By restricting this point P to the earth's surface, certain simplifications can be made in Brown's formula. Specifically Z goes to zero and $r_1 = r_2$ and $r_0 = x$.

2. The simplified formula becomes:

$$B_{\phi} = \frac{j2 \times 10^{-9} I_0}{r_0 \sin kG} [\epsilon^{-jk r_1} - \epsilon^{-jk r_0} \times \cos kG]$$

where $k = \frac{2\pi}{\lambda}$



3. Now when the distance r_0 becomes so great that $r_0 \approx r_1$

$$B_{\phi}(\text{far field}) = \frac{j2 \times 10^{-9} I_0}{r_0 \sin kG} [1 - \cos kG] \times \epsilon^{-jk r_0}$$

4. Now let $57.3kr_1 = r_1$ (degrees); $57.3kr_0 = r_0$ (degrees); $57.3kg = G$ (degrees).

5. Also convert from exponential to trigonometric form.

6. The resulting ratio is

$$\frac{B_{\phi}}{B_{\phi}(\text{far field})} = K = \frac{\{[\cos r_1 - \cos G \times \cos r_0]^2 + [\sin r_1 - \cos G \times \sin r_0]^2\}^{1/2}}{[1 - \cos G]}$$

7. Therefore:

$$\frac{\text{Field measurement}}{K} = \text{adjusted field}$$

° Silliman, Moffet, and Rohrer.

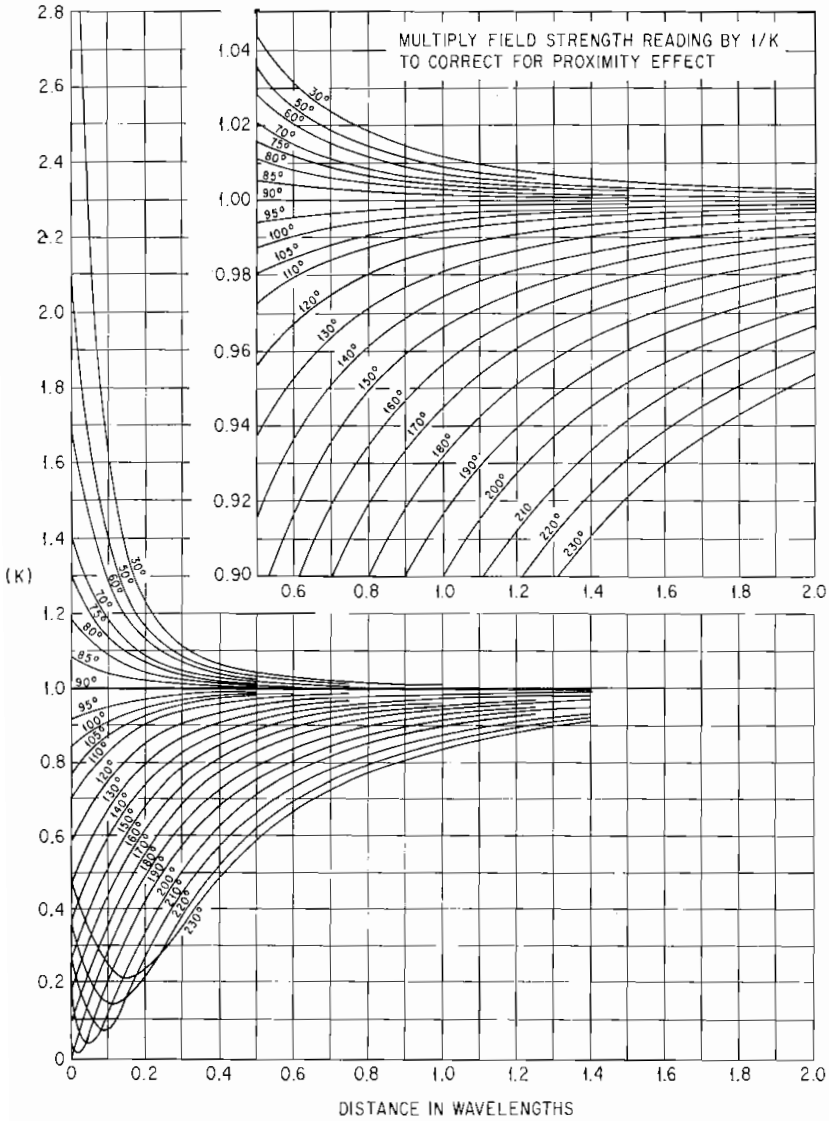


FIG. 9-18. Proximity effect for various tower heights.

WAVEGUIDE LOSS CHARTS *

Summary: Graphical presentation of attenuation values provides data for typical commercial microwave equipment. When effective resistivity is known or estimated, attenuation in decibels per foot can be determined at 1 to 75 kmc. Internal rectangular dimensions are also given.

Attenuation per foot of a particular commercial rectangular waveguide at a given frequency can be computed from published information, but for rapid extrapolation or comparison the accompanying charts (see Fig. 9-19) offer a ready solution.

One must know or be able to estimate the effective resistivity of the conducting surface. This is the product of d-c resistivity and a surface roughness factor K_T , which

Nominal Internal Dimensions for Standard Hollow Rectangular Waveguides

WR No.	Wide	Narrow	WR No.	Wide	Narrow
10	0.100	0.050	112	1.122	0.497
12	0.122	0.061	137	1.372	0.622
15	0.148	0.074	159	1.590	0.795
19	0.188	0.094	187	1.872	0.872
22	0.224	0.112	229	2.290	1.145
28	0.280	0.140	284	2.840	1.340
34	0.340	0.170	340	3.400	1.700
42	0.420	0.170	430	4.300	2.150
51	0.510	0.255	510	5.100	2.550
62	0.622	0.311	650	6.500	3.250
75	0.750	0.375	770	7.700	3.850
90	0.900	0.400	975	9.750	4.875

is unity for an ideal polished surface. Materials having low d-c resistivities require smooth surfaces for low effective resistivity and low loss. In materials having high d-c resistivities the current penetrates deeper into the material and K_T is near unity even for moderately rough surfaces. Thus surface roughness has almost no effect on high-resistivity materials.

Another factor is the size of the hollow waveguide cross section. Lowest losses are obtained by use of the largest possible waveguide. The chart shows the penalty resulting from use of a smaller size.

Measured attenuation of two sizes of rectangular copper waveguides shows that the effective resistivity is about 2.2×10^{-6} ohm-cm from 4 to 6 kmc. This is about 28 per cent above the d-c resistivity of 1.72×10^{-6} ohm-cm. Measurements on WR-229 drawn of 90-10 brass show an effective resistivity of 4.3×10^{-6} ohm-cm at 4 kmc, which is about 7.5 per cent above the d-c resistivity of 4×10^{-6} ohm-cm.

Plotting points on the graph were determined from the equation

$$\alpha = \frac{5.963(RK_T/\lambda)^{3/2}(1/b + \lambda^2/2a^3)}{\sqrt{1 - \lambda^2/4a^2}}$$

where α = attenuation in rectangular waveguide, db/ft

R = d-c resistivity of conducting surface, ohm-cm

a = wide dimension of waveguide, in.

b = narrow dimension of waveguide, in.

λ = free-space wavelength, in.

K_T = surface roughness factor

RK_T = effective resistivity of conducting surface, ohm-cm

* By A. F. Pomeroy, Bell Telephone Laboratories, Murray Hill, N.J. Reprinted from *Electronics*, October 1, 1957.

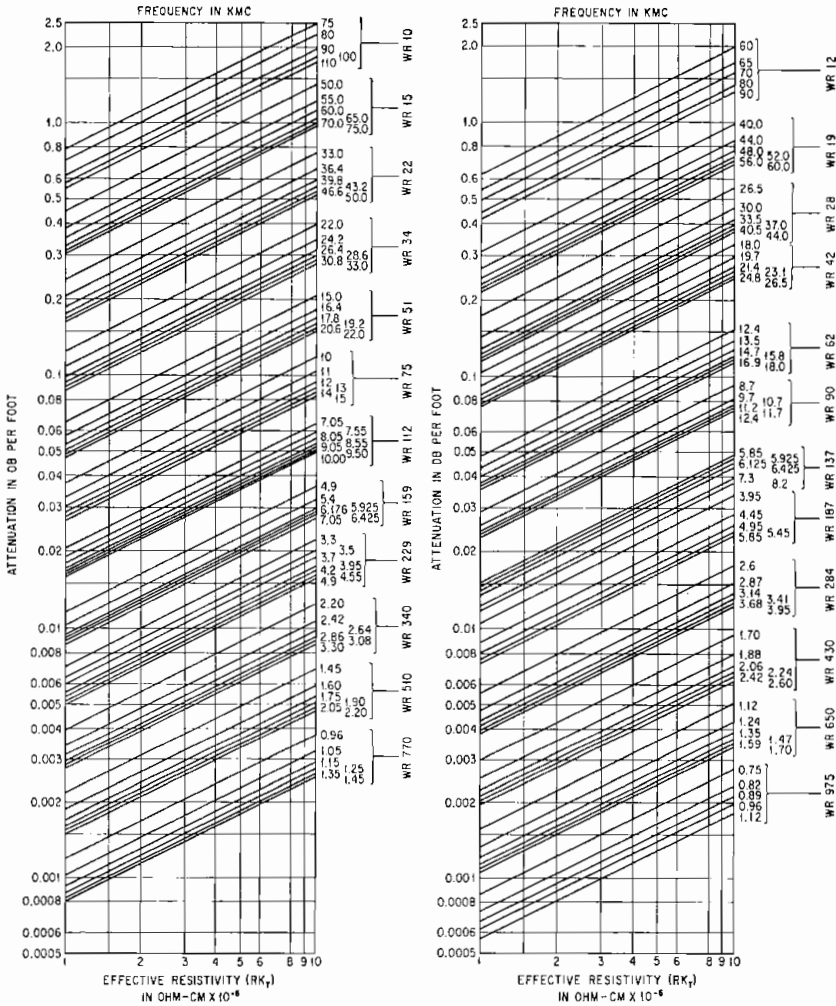


FIG. 9-19. Waveguide loss charts.

Example. Suppose it is necessary to find the attenuation of WR51 made of high-conductivity copper at frequencies from 16.4 to 20.6 kmc. Using 2.5×10^{-6} ohm-cm as an effective resistivity, we read on the chart 0.092 db/ft at 16.4 kmc and 0.078 db/ft at 20.6 kmc. The attenuation of other sizes can be found in a similar manner.

Representative frequencies in the recommended ranges were chosen for each size shown in Fig. 9-19. Interpolation between the characteristics to find the loss for other frequencies is straightforward.

The effective resistivity should be nearly constant over a small frequency interval, which leads to another use of these characteristics. To find an average effective resistivity over a band of frequencies, measured values of decibels per foot can be plotted on the characteristics and an ordinate drawn through the average value of effective resistivity. This result is probably more accurate than any one of the individual determinations.

Thanks are due Miss J. D. Goeltz and Mrs. Dolores G. Hill for their work in computing the attenuations used in plotting the characteristics.

Bibliography

Pomeroy, A. F., and E. M. Suarez: Determining Attenuation of Waveguide from Electrical Measurements on Short Samples. *IRE Trans. RGMTT*, April, 1956, p. 122.

Benson, F. A.: Waveguide Attenuation and Its Correlation with Surface Roughness, *Proc. IRE*, 100, part III, p. 85, March, 1953.

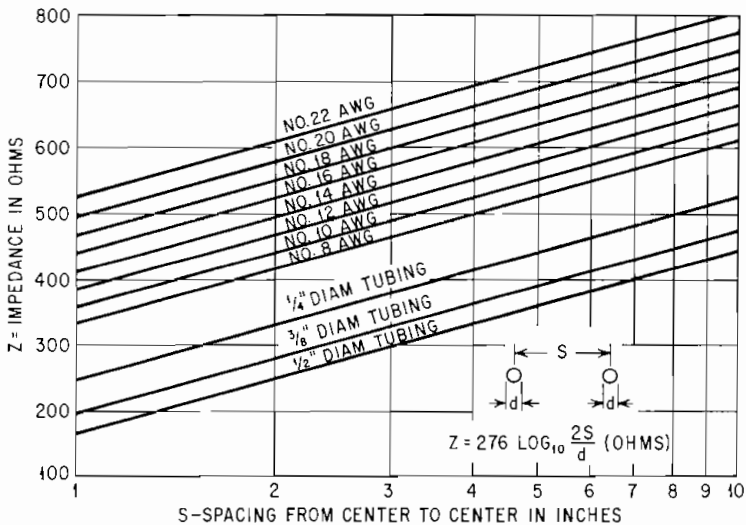


FIG. 9-20. Characteristic impedance of parallel-line wires.

L-NETWORK DESIGN *

Summary: Technique for using Smith chart to speed design of L matching networks for transmission lines and waveguides using lumped parameters. Shaded-area charts show at a glance impedance ranges that can be matched with each type of L network.

The familiar Smith chart for transmission lines is also a useful tool for designing matching networks. As an example, consider the case where it is desired to match an impedance $Z_L = (0.3 - j1.6)R_0$ to R_0 with the L matching network shown in Fig. 9-21. It is assumed that the inductances are lossy so that $R_1 = X_1 \tan \theta = 0.2X_1$ and

* By H. F. Mathis, Goodyear Aircraft Corp., Akron, Ohio. Reprinted from *Electronics*, Feb. 1, 1957.

$G_2 = -B_2 \tan \theta = -0.2B_2$. All impedances and admittances are normalized with respect to R_o and $G_o = 1/R_o$, respectively.

Let $Z_A = Z_L + R_1 + jX_1$ and $Y_A = 1/Z_A$. Since $Y_A + G_2 + jB_2 = 1$, Y_A must lie on curve $Y = 1 - k(\tan \theta - j)$, where k is a real variable. This curve is circle OA' with center C . To locate C , lines OC and OD are drawn as indicated in Fig. 9-20. Point D bisects its line. Point C is located as indicated.

Point C is inverted to obtain C' on line OC so that $C'O = OC$. Since Y_A must lie on circle OA' , Z_A must lie on circle OH whose center is C' . To determine Z_A , plot curve $Z = Z_L + p(\tan \theta + j)$, where p is a real variable. Point A , where this curve intersects circle OH , is the desired value of Z_A . The value of Y_A is found by inverting point A to obtain A' . Finally, $R_1 + jX_1 = (Z_A - Z_L)R_o = (0.498 - j0.610) - (0.3 - j1.6)R_o = (0.198 + j0.990)R_o$ and $G_2 + jB_2 = (1 - Y_A)G_o = 1 - (0.803 + j0.985) \cdot G_o = (0.197 - j0.985)G_o$.

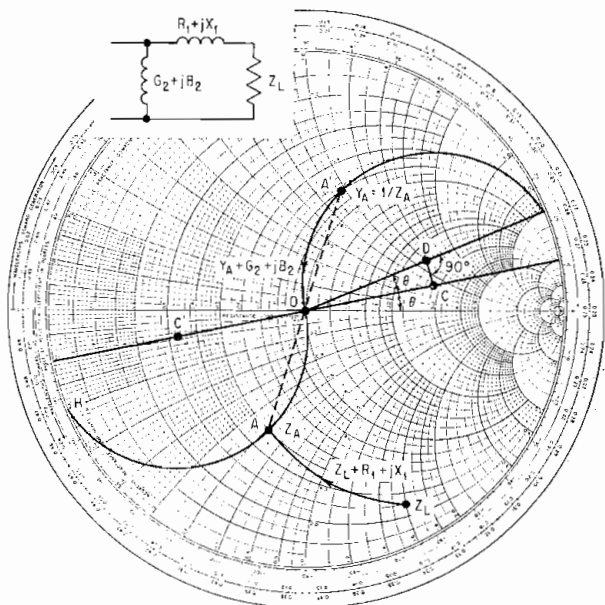


FIG. 9-21. Smith-chart procedure for determining parameters of L matching network.

General Procedure. In general, for L matching networks plot Z_L or Y_L first on the Smith chart. Next, plot the impedance or admittance into which Z_L is to be transformed, and find a suitable path connecting these points.

It is impossible to match all possible values of Z_L with a given type of L network. For example, if $Z_L = 0.5R_o$, the matching network shown in Fig. 9-21 could not be used. Impedances which can be matched with a given type of L network are shown as areas on Smith charts in Fig. 9-22. It is assumed that it is desired to transform Z_L into R_o and that Z_L is normalized with respect to R_o .

Bibliography

- Smith, P. H.: Transmission-line Calculator, *Electronics*, January, 1939, p. 29.
- Smith, P. H.: An Improved Transmission-line Calculator, *Electronics*, January, 1944, p. 130.

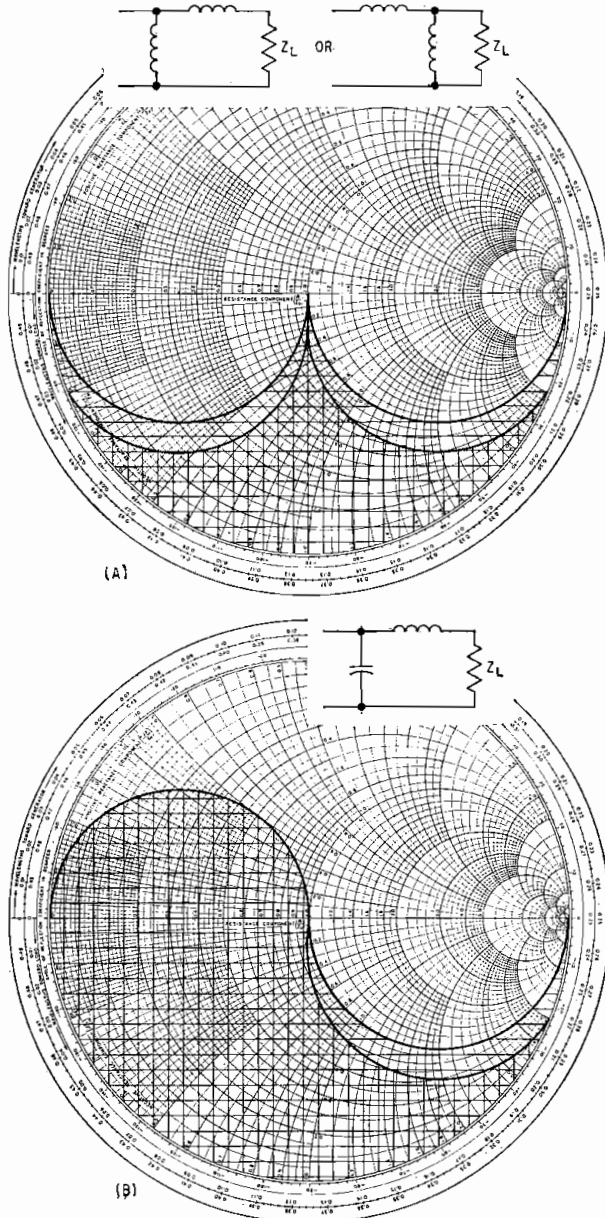


FIG. 9-22. For each network, horizontally shaded areas on the accompanying Smith chart show impedances which can be matched with lossless reactance. Vertically shaded areas can be matched with reactances for which $\tan \theta = 0.2$.

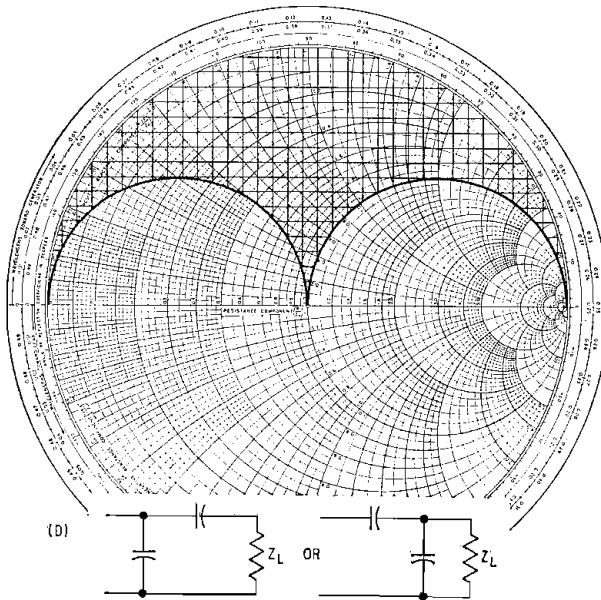
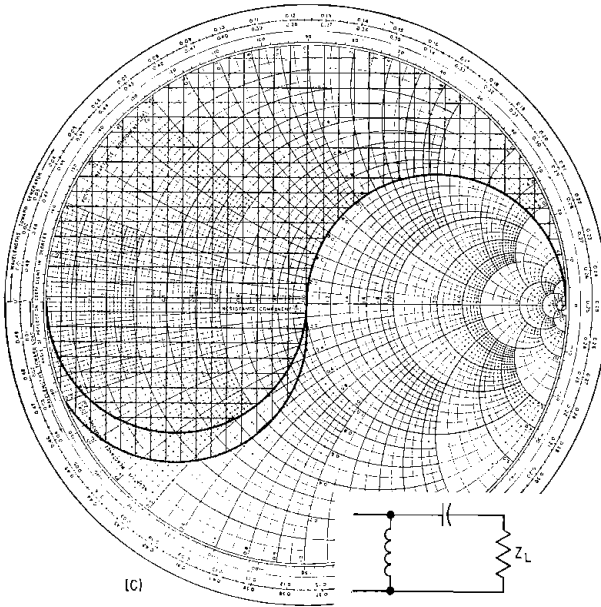


FIG. 9-22. (Continued on next page.)

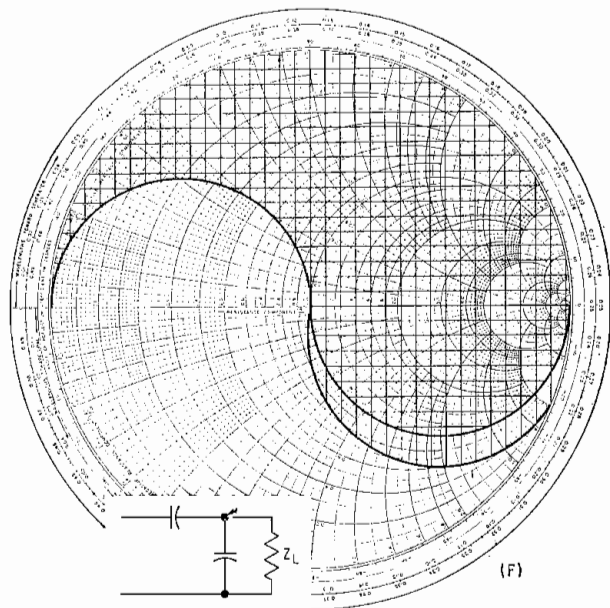
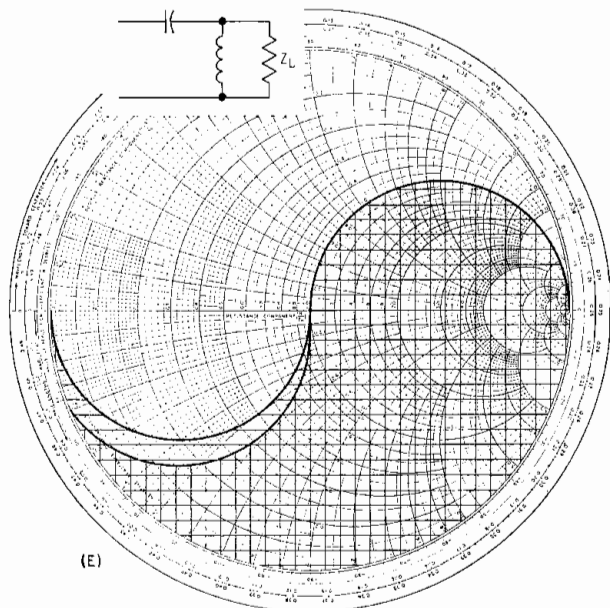


FIG. 9-22. (Continued.)

Table 9-4. Comparison of Open-wire Solid-dielectric Lines and Waveguides

Characteristics	Parallel open wires	Bead supported	Stub supported	Solid dielectric (Polyethylene)	Coaxial rubber	Waveguide	Pulse cables
Insulation resistance	O.K. in dry air, drops in rain	O.K. in dry air or nitrogen	O.K. dry or slightly wet	O.K. dry or wet	O.K. dry, drops when wet. Varies with temperature	O.K.	Same as rubber
Corona voltage and dielectric strength	Depends on dry air and spacing, low	Depends on dry air, depends on size, low	Depends on size, low	Depends on size, high	Depends on dry air, size, medium high	Depends on size, dry air, pressure, low	Depends on size, high
Dielectric constant	Low, air (1)	Low, air plus beads	Low, air (1)	Medium (2.3)	Medium high (3-4)	High (5-6)	Same as rubber
Power factor	Low in dry air, goes up in wet	Low in dry air, goes up in wet	O.K. dry or slightly wet	O.K. dry or wet	High dry, higher if wet. No good for HF	Low, goes down with size	Same as rubber
D-c conductor resistance	Low, goes down with size	Same	Same	Flatter than concentrics, goes down with size	High, goes down with size	Same as head-supported	High, goes down with size
Ease of installation	Easy	More difficult	Difficult	Easier than concentric	Same as solid dielectric	Easy	Same as rubber
Ease of maintenance	Easy	Very difficult	Not very	Easy	Yes, more than solid dielectric	Yes	Same as rubber
Flexible	Somewhat, depends on size	Some, depends on size	No	Yes, flexibility goes down with size	Yes	No	Yes
Mechanically strong	Yes, but separators are weak points	Yes, beads are weak points	Yes, but stubs are fragile	Yes, but can be instructed	Yes	Yes, but can be crushed	Yes
Can be sealed	Yes	Yes, but you have to do the right job	Yes	Yes	Yes	Yes	Yes
Self-shielding (electrical)	No	Yes	Yes	Yes, depends on the braid construction	Same as solid dielectric	Yes	Same as solid dielectric
Fire resistive	Yes	Yes	Yes	Yes, except largest size	Not completely	Yes	Same as rubber
High-temperature resistant	Yes, depends on material of separators	Yes, depends on rubber gaskets or solder	Yes, same as bead supported	180-200°F for short time	220-250°F for short time	Yes, depends on rubber gasket or solder	Same as rubber
Transmission at high frequency	Limited by spacing	Good at low, medium frequency losses high at microwave	Good at high frequency not at low, need spec for each	Good, at low and medium not so good at micro-wave	Poor, loss too high	Rest, but each frequency needs spec guide	Poor, loss too high
Stand shock vibration	Good	Fair, beads are weak points	Good, stubs are weak points	Very good	Very good	Very good	Very good
Low temperatures	Yes	Yes, but allow for expansion	Same as beaded	Yes	Yes	Yes, but allow for expansion	Yes

Charts and Graphs

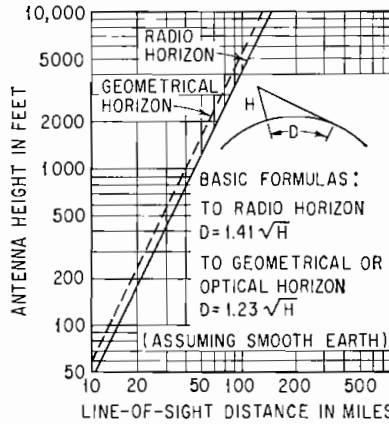


FIG. 9-23. Distance to horizon vs. height of transmitting antenna.

FLUORESCENT LAMP

VISIBLE LIGHT 20.5%	SHORT WAVE I-R 26.5%	LONG WAVE INFRA-RED 53%
------------------------	-------------------------	----------------------------

TUNGSTEN LAMP AT 3000°K

VISI-BLE LIGHT 12%	SHORT WAVE INFRA-RED 70%	LONG WAVE I-R 18%
← TOTAL LAMP WATTS →		

LUMINOSITY CURVE OF THE AVERAGE EYE

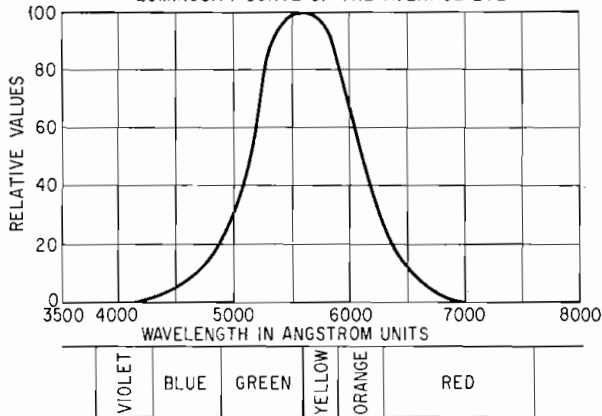


FIG. 9-24. Fluorescent and tungsten lamp spectral distribution and luminosity curve of the average human eye.

HEATER SURGE CHART *

Summary: The effect of heater current surges when voltage is applied to cold tube and efficiency of surge-restricting arrangements can be evaluated with this chart. Hot and cold characteristic curves are typical for most tubes.

To minimize damaging effects of high initial current when heater voltage is applied to a cold tube, starting current surges should be restricted.

The magnitude of heater current surges under various conditions can be calculated by use of the graph (Fig. 9-25), which consists basically of two curves plotted on coordinates of heater current and voltage relative to normal full-voltage conditions. The first curve, a straight line, represents the resistance of a cold heater. It represents a resistance which is 0.15 of the normal operating resistance. This is typical of most receiving tubes. The second curve shows the locus of points at which thermal equilibrium is obtained for steadily applied voltages. Deviations from this curve are relatively small for common receiving-type tubes.

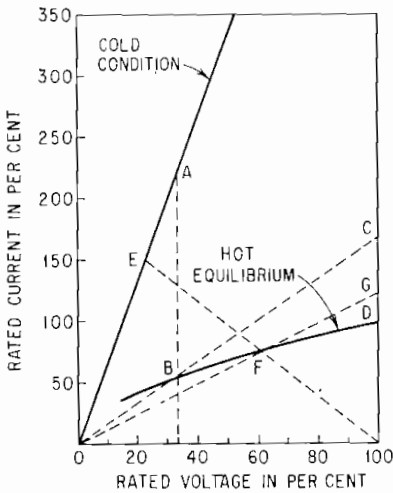


FIG. 9-25. Current-voltage plot for hot and cold tube conditions used to evaluate surge.

The results of applying heater voltage in steps can be shown by simple constructions. If a line is constructed at a chosen value of initial voltage, the magnitude of the initial cold-resistance surge is shown by point *A* and thermal equilibrium occurs at point *B*. A line through the origin and point *B* represents the heater resistance attained in the partially heated equilibrium condition. If 100 per cent voltage is then applied, a current surge of magnitude indicated by point *C* occurs, and final equilibrium is attained at the normal operating point *D*.

The effect of applying 100 per cent rated voltage through a series resistor can be shown by the construction of a line having a slope based on the ratio of the series resistance to the normal hot resistance of the tube. The cold-tube surge is indicated by point *E*, and equilibrium occurs at *F*. Construction of a line from the origin through point *F* then represents this equilibrium heater resistance. If the resistor is then shorted out, 100 per cent voltage will be applied and will result in a momentary current indicated by point *G*. Final equilibrium will occur at the normal operating point *D*.

* By M. P. Feyerherm, Defense Electronic Products, Radio Corporation of America, Camden, N.J. Reprinted from *Electronics*, June 1, 1957.

A CONVENIENT SLIDE-RULE SHORT CUT TO CONVERT ELECTRICAL DEGREES TO FEET, OR VICE VERSA WHEN FREQUENCY AND EITHER FEET OR DEGREES IS KNOWN

From the expression

$$\text{Feet} = \frac{\text{degrees}}{360^\circ} \times \frac{300}{f(\text{Mc})} \times 3.281 = \text{degrees} \times \frac{2.734}{f(\text{Mc})}$$

the following ratio may be set up on the slide rule using *C* and *D* scales:

$$\frac{2.734}{f(\text{Mc})} = \frac{\text{feet}}{\text{degrees}}$$

Set 2.734 on scale *C* over frequency in megacycles on scale *D*; read feet and degrees on scales *C* and *D*, respectively. In some instances it may be convenient to use the folded scales *CF* and *DF*.

GREAT-CIRCLE DISTANCE AND BEARING CALCULATIONS

The need often arises in allocations problems for a simple and reliable method of computing the position of one radio station or area with respect to another expressed in degrees clockwise from true north. It is often equally important that the distance between these two points be known.

Bearings and distance can be computed in many ways. The method set forth here utilizes a table developed by Lieutenant Arthur A. Ageton, USN, which permits the simple solution of navigational problems. If the table is properly read and interpolations carefully made, the bearings and distances derived through use of the calculation sheet will be found to be in very close agreement with lengthy mathematical computations.

To use this method one must first obtain Hydrographic Office Publication No. 211, entitled "Dead Reckoning Altitude and Azimuth Table" from the Hydrographic Office, Washington, D.C., or the Superintendent of Documents, Government Printing Office, Washington, D.C.

The calculation sheet can be shortened in some respects if used only for determining bearings and distances between points within a limited area such as the United States or North America. As shown, bearings and distances can be calculated between any two points on the surface of the earth if the latitude and longitude of the two positions are known.

If a considerable number of calculations are to be made, it is suggested that the calculation sheet be duplicated in quantity. Furthermore, it is suggested that until one becomes thoroughly acquainted with the method the various *steps* be check-marked as they are completed.

Great Circle Distance and Bearing Calculation Sheet

(Based on Agaton, *H.O. Publ. 211, Tables*)

FROM: Location _____ (La) _____ ° ' " (Lo) _____ ° ' " _____
 TO: Location _____ (La') _____ ° ' " (Lo') _____ ° ' " _____

Symbols Used

- | | | | |
|---|--|----|--|
| A | Numbers in the A columns of the H.O. 211 tables | D | Great-circle distance when converted to minutes of arc |
| B | Numbers in the B columns of the H.O. 211 tables | K | An arc used in the calculations |
| t | (Lo ~ Lo') The smaller angle between the two meridians, Lo and Lo' | Dn | The great-circle distance in nautical miles |
| C | Bearing East or West of 0° true | Ds | The great-circle distance in statute miles (K ~ La) The magnitude of the difference between arc K and La |

Rules

- | | |
|--|---|
| <p>If La and La' are in the same hemisphere: (N or S)</p> <p>K: Take K from bottom of columns in H.O. No. 211 tables if t is greater than 90°.</p> <p>D: Take D from bottom of columns in H.O. No. 211 when t and (K ~ La) are each greater than 90°.</p> <p>C: Take C from bottom of columns in H.O. No. 211 when K is less than La.</p> <p>(K ~ La): Subtract K and La to find difference.</p> | <p>If La and La' are in different hemispheres: (N and S)</p> <p>K: Take K from bottom of columns in H.O. No. 211 tables if t is greater than 90°.</p> <p>D: If t and (K ~ La) are each less than 90°, take D from top of table, otherwise, from bottom.</p> <p>C: Take C from bottom of tables in H.O. No. 211 tables unless (K ~ La) is greater than 180°.</p> <p>(K ~ La): Add K and La to find magnitude. If (K ~ La) exceeds 180°, subtract 180° before entering H.O. No. 211 table to find B3.</p> |
|--|---|

Calculations

[Follow rules closely for K, D, C, and B3—also (K ~ La)]

	ADD	SUBTRACT	ADD	SUBTRACT
Lo' _____	A1 _____	A3 _____	B2 _____	A2 _____
Lo _____	B1+ _____	B2- _____	B3+ _____	A5- _____
t = _____	A2 = _____	A4 = _____	B4 = _____	A6 = _____
La' _____				
K = _____				
La _____				
(K ~ La) = _____				

$D = \text{_____}^\circ \text{ ' } \text{_____}''$ $D: \text{_____}^\circ \times 60 = \text{_____}' + \text{_____}' = Dn \text{ _____ miles}$ $Dn \text{ _____ miles} \times 1.152 = Ds = \text{_____ miles}$

$C^* = \text{_____}^\circ \text{ ' } \text{_____}'' \frac{E}{W} \text{ of } 0^\circ \text{ true}$

* NOTE: When Lo' is west of Lo, C will indicate bearings in degrees west of 0° true. When Lo' is east of Lo, C will indicate bearings in degrees east of 0° true.

Steps

1. List coordinates for locations.
2. Subtract Lo and Lo' to find arc t.
3. Enter H.O. No. 211 with t to find A1.
4. Enter table with La' to find B1 and A3.
5. Add A1 and B1 for A2.
6. Enter table with A2 to find B2.
7. Subtract B2 from A3 for A4.
8. Enter table with A4 for arc K.
9. Determine arc for (K ~ La).
10. Enter table with (K ~ La) for B3.
11. Add B2 and B3 for B4.
12. Enter table with B4 to find A5 and arc D.
13. Subtract A5 from A2 for A6.
14. Enter table with A6 for bearing C.
15. Follow steps shown to find Ds and Dn.

Table 9-5. Temperature-conversion Chart °

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-200	-328.0	-100	-148.0	0	32.0	100	212.0	200	392.0	300	572.0	400	752.0	500	932.0	600	1,112.0	700	1,292.0
-201	-329.8	-101	-149.8	1	33.8	101	213.8	201	393.8	301	573.8	401	753.8	501	933.8	601	1,113.8	701	1,293.8
-202	-331.6	-102	-151.6	-2	28.4	102	215.6	202	395.6	302	575.6	402	755.6	502	935.6	602	1,115.6	702	1,295.6
-203	-333.4	-103	-153.4	-3	26.6	103	217.4	203	397.4	303	577.4	403	757.4	503	937.4	603	1,117.4	703	1,297.4
-204	-335.2	-104	-155.2	-4	24.8	104	219.2	204	399.2	304	579.2	404	759.2	504	939.2	604	1,119.2	704	1,299.2
-205	-337.0	-105	-157.0	-5	23.0	105	221.0	205	401.0	305	581.0	405	761.0	505	941.0	605	1,121.0	705	1,301.0
-206	-338.8	-106	-158.8	-6	21.2	106	222.8	206	402.8	306	582.8	406	762.8	506	942.8	606	1,122.8	706	1,302.8
-207	-340.6	-107	-160.6	-7	19.4	107	224.6	207	404.6	307	584.6	407	764.6	507	944.6	607	1,124.6	707	1,304.6
-208	-342.4	-108	-162.4	-8	17.6	108	226.4	208	406.4	308	586.4	408	766.4	508	946.4	608	1,126.4	708	1,306.4
-209	-344.2	-109	-164.2	-9	15.8	109	228.2	209	408.2	309	588.2	409	768.2	509	948.2	609	1,128.2	709	1,308.2
-210	-346.0	-110	-166.0	-10	14.0	110	230.0	210	410.0	310	590.0	410	770.0	510	950.0	610	1,130.0	710	1,310.0
-211	-347.8	-111	-167.8	-11	12.2	111	231.8	211	411.8	311	591.8	411	771.8	511	951.8	611	1,131.8	711	1,311.8
-212	-349.6	-112	-169.6	-12	10.4	112	233.6	212	413.6	312	593.6	412	773.6	512	953.6	612	1,133.6	712	1,313.6
-213	-351.4	-113	-171.4	-13	8.6	113	235.4	213	415.4	313	595.4	413	775.4	513	955.4	613	1,135.4	713	1,315.4
-214	-353.2	-114	-173.2	-14	6.8	114	237.2	214	417.2	314	597.2	414	777.2	514	957.2	614	1,137.2	714	1,317.2
-215	-355.0	-115	-175.0	-15	5.0	115	239.0	215	419.0	315	599.0	415	779.0	515	959.0	615	1,139.0	715	1,319.0
-216	-356.8	-116	-176.8	-16	3.2	116	240.8	216	420.8	316	600.8	416	780.8	516	960.8	616	1,140.8	716	1,320.8
-217	-358.6	-117	-178.6	-17	1.4	117	242.6	217	422.6	317	602.6	417	782.6	517	962.6	617	1,142.6	717	1,322.6
-218	-360.4	-118	-180.4	-18	-0.4	118	244.4	218	424.4	318	604.4	418	784.4	518	964.4	618	1,144.4	718	1,324.4
-219	-362.2	-119	-182.2	-19	-2.2	119	246.2	219	426.2	319	606.2	419	786.2	519	966.2	619	1,146.2	719	1,326.2
-220	-364.0	-120	-184.0	-20	-4.0	120	248.0	220	428.0	320	608.0	420	788.0	520	968.0	620	1,148.0	720	1,328.0
-221	-365.8	-121	-185.8	-21	-5.8	121	249.8	221	429.8	321	609.8	421	789.8	521	969.8	621	1,149.8	721	1,329.8
-222	-367.6	-122	-187.6	-22	-7.6	122	251.6	222	431.6	322	611.6	422	791.6	522	971.6	622	1,151.6	722	1,331.6
-223	-369.4	-123	-189.4	-23	-9.4	123	253.4	223	433.4	323	613.4	423	793.4	523	973.4	623	1,153.4	723	1,333.4
-224	-371.2	-124	-191.2	-24	-11.2	124	255.2	224	435.2	324	615.2	424	795.2	524	975.2	624	1,155.2	724	1,335.2
-225	-373.0	-125	-193.0	-25	-13.0	125	257.0	225	437.0	325	617.0	425	797.0	525	977.0	625	1,157.0	725	1,337.0
-226	-374.8	-126	-194.8	-26	-14.8	126	258.8	226	438.8	326	618.8	426	798.8	526	978.8	626	1,158.8	726	1,338.8
-227	-376.6	-127	-196.6	-27	-16.6	127	260.6	227	440.6	327	620.6	427	800.6	527	980.6	627	1,160.6	727	1,340.6
-228	-378.4	-128	-198.4	-28	-18.4	128	262.4	228	442.4	328	622.4	428	802.4	528	982.4	628	1,162.4	728	1,342.4
-229	-380.2	-129	-200.2	-29	-20.2	129	264.2	229	444.2	329	624.2	429	804.2	529	984.2	629	1,164.2	729	1,344.2
-230	-382.0	-130	-202.0	-30	-22.0	130	266.0	230	446.0	330	626.0	430	806.0	530	986.0	630	1,166.0	730	1,346.0
-231	-383.8	-131	-203.8	-31	-23.8	131	267.8	231	447.8	331	627.8	431	807.8	531	987.8	631	1,167.8	731	1,347.8
-232	-385.6	-132	-205.6	-32	-25.6	132	269.6	232	449.6	332	629.6	432	809.6	532	989.6	632	1,169.6	732	1,349.6
-233	-387.4	-133	-207.4	-33	-27.4	133	271.4	233	451.4	333	631.4	433	811.4	533	991.4	633	1,171.4	733	1,351.4
-234	-389.2	-134	-209.2	-34	-29.2	134	273.2	234	453.2	334	633.2	434	813.2	534	993.2	634	1,173.2	734	1,353.2

-235	-391.0	-135	-211.0	-85	-31.0	35	95.0	135	275.0	285	455.0	335	635.0	435	815.0	535	965.0	635	1,175.0	735	1,355.0
-236	-392.8	-136	-212.8	-36	-32.8	36	96.8	136	276.8	286	456.8	336	636.8	436	816.8	536	966.8	636	1,176.8	736	1,356.8
-237	-394.6	-137	-214.6	-37	-34.6	37	98.6	137	278.6	287	458.6	337	638.6	437	818.6	537	968.6	637	1,178.6	737	1,358.6
-238	-396.4	-138	-216.4	-38	-36.4	38	100.4	138	280.4	288	460.4	338	640.4	438	820.4	538	1,000.4	638	1,180.4	738	1,360.4
-239	-398.2	-139	-218.2	-39	-38.2	39	102.2	139	282.2	289	462.2	339	642.2	439	822.2	539	1,002.2	639	1,182.2	739	1,362.2
-240	-400.0	-140	-220.0	-40	-40.0	40	104.0	140	284.0	290	464.0	340	644.0	440	824.0	540	1,004.0	640	1,184.0	740	1,364.0
-241	-401.8	-141	-221.8	-41	-41.8	41	105.8	141	285.8	291	465.8	341	645.8	441	825.8	541	1,005.8	641	1,185.8	741	1,365.8
-242	-403.6	-142	-223.6	-42	-43.6	42	107.6	142	287.6	292	467.6	342	647.6	442	827.6	542	1,007.6	642	1,187.6	742	1,367.6
-243	-405.4	-143	-225.4	-43	-45.4	43	109.4	143	289.4	293	469.4	343	649.4	443	829.4	543	1,009.4	643	1,189.4	743	1,369.4
-244	-407.2	-144	-227.2	-44	-47.2	44	111.2	144	291.2	294	471.2	344	651.2	444	831.2	544	1,011.2	644	1,191.2	744	1,371.2
-245	-409.0	-145	-229.0	-45	-49.0	45	113.0	145	293.0	295	473.0	345	653.0	445	833.0	545	1,013.0	645	1,193.0	745	1,373.0
-246	-410.8	-146	-230.8	-46	-50.8	46	114.8	146	294.8	296	474.8	346	654.8	446	834.8	546	1,014.8	646	1,194.8	746	1,374.8
-247	-412.6	-147	-232.6	-47	-52.6	47	116.6	147	296.6	297	476.6	347	656.6	447	836.6	547	1,016.6	647	1,196.6	747	1,376.6
-248	-414.4	-148	-234.4	-48	-54.4	48	118.4	148	298.4	298	478.4	348	658.4	448	838.4	548	1,018.4	648	1,198.4	748	1,378.4
-249	-416.2	-149	-236.2	-49	-56.2	49	120.2	149	300.2	299	480.2	349	660.2	449	840.2	549	1,020.2	649	1,200.2	749	1,380.2
-250	-418.0	-150	-238.0	-50	-58.0	50	122.0	150	302.0	250	482.0	350	662.0	450	842.0	550	1,022.0	650	1,202.0	750	1,382.0
-251	-419.8	-151	-239.8	-51	-59.8	51	123.8	151	303.8	251	483.8	351	663.8	451	843.8	551	1,023.8	651	1,203.8	751	1,383.8
-252	-421.6	-152	-241.6	-52	-61.6	52	125.6	152	305.6	252	485.6	352	665.6	452	845.6	552	1,025.6	652	1,205.6	752	1,385.6
-253	-423.4	-153	-243.4	-53	-63.4	53	127.4	153	307.4	253	487.4	353	667.4	453	847.4	553	1,027.4	653	1,207.4	753	1,387.4
-254	-425.2	-154	-245.2	-54	-65.2	54	129.2	154	309.2	254	489.2	354	669.2	454	849.2	554	1,029.2	654	1,209.2	754	1,389.2
-255	-427.0	-155	-247.0	-55	-67.0	55	131.0	155	311.0	255	491.0	355	671.0	455	851.0	555	1,031.0	655	1,211.0	755	1,391.0
-256	-428.8	-156	-248.8	-56	-68.8	56	132.8	156	312.8	256	492.8	356	672.8	456	852.8	556	1,032.8	656	1,212.8	756	1,392.8
-257	-430.6	-157	-250.6	-57	-70.6	57	134.6	157	314.6	257	494.6	357	674.6	457	854.6	557	1,034.6	657	1,214.6	757	1,394.6
-258	-432.4	-158	-252.4	-58	-72.4	58	136.4	158	316.4	258	496.4	358	676.4	458	856.4	558	1,036.4	658	1,216.4	758	1,396.4
-259	-434.2	-159	-254.2	-59	-74.2	59	138.2	159	318.2	259	498.2	359	678.2	459	858.2	559	1,038.2	659	1,218.2	759	1,398.2
-260	-436.0	-160	-256.0	-60	-76.0	60	140.0	160	320.0	260	500.0	360	680.0	460	860.0	560	1,040.0	660	1,220.0	760	1,400.0
-261	-437.8	-161	-257.8	-61	-77.8	61	141.8	161	321.8	261	501.8	361	681.8	461	861.8	561	1,041.8	661	1,221.8	761	1,401.8
-262	-439.6	-162	-259.6	-62	-79.6	62	143.6	162	323.6	262	503.6	362	683.6	462	863.6	562	1,043.6	662	1,223.6	762	1,403.6
-263	-441.4	-163	-261.4	-63	-81.4	63	145.4	163	325.4	263	505.4	363	685.4	463	865.4	563	1,045.4	663	1,225.4	763	1,405.4
-264	-443.2	-164	-263.2	-64	-83.2	64	147.2	164	327.2	264	507.2	364	687.2	464	867.2	564	1,047.2	664	1,227.2	764	1,407.2
-265	-445.0	-165	-265.0	-65	-85.0	65	149.0	165	329.0	265	509.0	365	689.0	465	869.0	565	1,049.0	665	1,229.0	765	1,409.0
-266	-446.8	-166	-266.8	-66	-86.8	66	150.8	166	330.8	266	510.8	366	690.8	466	870.8	566	1,050.8	666	1,230.8	766	1,410.8
-267	-448.6	-167	-268.6	-67	-88.6	67	152.6	167	332.6	267	512.6	367	692.6	467	872.6	567	1,052.6	667	1,232.6	767	1,412.6
-268	-450.4	-168	-270.4	-68	-90.4	68	154.4	168	334.4	268	514.4	368	694.4	468	874.4	568	1,054.4	668	1,234.4	768	1,414.4
-269	-452.2	-169	-272.2	-69	-92.2	69	156.2	169	336.2	269	516.2	369	696.2	469	876.2	569	1,056.2	669	1,236.2	769	1,416.2
-270	-454.0	-170	-274.0	-70	-94.0	70	158.0	170	338.0	270	518.0	370	698.0	470	878.0	570	1,058.0	670	1,238.0	770	1,418.0
-271	-455.8	-171	-275.8	-71	-95.8	71	159.8	171	339.8	271	519.8	371	699.8	471	879.8	571	1,059.8	671	1,239.8	771	1,419.8
-272	-457.6	-172	-277.6	-72	-97.6	72	161.6	172	341.6	272	521.6	372	701.6	472	881.6	572	1,061.6	672	1,241.6	772	1,421.6
-273	-459.4	-173	-279.4	-73	-99.4	73	163.4	173	343.4	273	523.4	373	703.4	473	883.4	573	1,063.4	673	1,243.4	773	1,423.4
-273.2	-459.7	-174	-281.2	-74	-101.2	74	165.2	174	345.2	274	525.2	374	705.2	474	885.2	574	1,065.2	674	1,245.2	774	1,425.2

Absolute zero.

Table 9-5. Temperature-conversion Chart * (Continued)

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
Absolute Zero																			
-175	-283.0	-75	-103.0	75	167.0	175	347.0	275	527.0	375	707.0	475	887.0	575	1,067.0	675	1,247.0	775	1,427.0
-176	-284.8	-76	-104.8	76	168.8	176	348.8	276	528.8	376	708.8	476	888.8	576	1,068.8	676	1,248.8	776	1,428.8
-177	-286.6	-77	-106.6	77	170.6	177	350.6	277	530.6	377	710.6	477	890.6	577	1,070.6	677	1,250.6	777	1,430.6
-178	-288.4	-78	-108.4	78	172.4	178	352.4	278	532.4	378	712.4	478	892.4	578	1,072.4	678	1,252.4	778	1,432.4
-179	-290.2	-79	-110.2	79	174.2	179	354.2	279	534.2	379	714.2	479	894.2	579	1,074.2	679	1,254.2	779	1,434.2
-180	-292.0	-80	-112.0	80	176.0	180	356.0	280	536.0	380	716.0	480	896.0	580	1,076.0	680	1,256.0	780	1,436.0
-181	-293.8	-81	-113.8	81	177.8	181	357.8	281	537.8	381	717.8	481	897.8	581	1,077.8	681	1,257.8	781	1,437.8
-182	-295.6	-82	-115.6	82	179.6	182	359.6	282	539.6	382	719.6	482	899.6	582	1,079.6	682	1,259.6	782	1,439.6
-183	-297.4	-83	-117.4	83	181.4	183	361.4	283	541.4	383	721.4	483	901.4	583	1,081.4	683	1,261.4	783	1,441.4
-184	-299.2	-84	-119.2	84	183.2	184	363.2	284	543.2	384	723.2	484	903.2	584	1,083.2	684	1,263.2	784	1,443.2
-185	-301.0	-85	-121.0	85	185.0	185	365.0	285	545.0	385	725.0	485	905.0	585	1,085.0	685	1,265.0	785	1,445.0
-186	-302.8	-86	-122.8	86	186.8	186	366.8	286	546.8	386	726.8	486	906.8	586	1,086.8	686	1,266.8	786	1,446.8
-187	-304.6	-87	-124.6	87	188.6	187	368.6	287	548.6	387	728.6	487	908.6	587	1,088.6	687	1,268.6	787	1,448.6
-188	-306.4	-88	-126.4	88	190.4	188	370.4	288	550.4	388	730.4	488	910.4	588	1,090.4	688	1,270.4	788	1,450.4
-189	-308.2	-89	-128.2	89	192.2	189	372.2	289	552.2	389	732.2	489	912.2	589	1,092.2	689	1,272.2	789	1,452.2
-190	-310.0	-90	-130.0	90	194.0	190	374.0	290	554.0	390	734.0	490	914.0	590	1,094.0	690	1,274.0	790	1,454.0
-191	-311.8	-91	-131.8	91	195.8	191	375.8	291	555.8	391	735.8	491	915.8	591	1,095.8	691	1,275.8	791	1,455.8
-192	-313.6	-92	-133.6	92	197.6	192	377.6	292	557.6	392	737.6	492	917.6	592	1,097.6	692	1,277.6	792	1,457.6
-193	-315.4	-93	-135.4	93	199.4	193	379.4	293	559.4	393	739.4	493	919.4	593	1,099.4	693	1,279.4	793	1,459.4
-194	-317.2	-94	-137.2	94	201.2	194	381.2	294	561.2	394	741.2	494	921.2	594	1,101.2	694	1,281.2	794	1,461.2
-195	-319.0	-95	-139.0	95	203.0	195	383.0	295	563.0	395	743.0	495	923.0	595	1,103.0	695	1,283.0	795	1,463.0
-196	-320.8	-96	-140.8	96	204.8	196	384.8	296	564.8	396	744.8	496	924.8	596	1,104.8	696	1,284.8	796	1,464.8
-197	-322.6	-97	-142.6	97	206.6	197	386.6	297	566.6	397	746.6	497	926.6	597	1,106.6	697	1,286.6	797	1,466.6
-198	-324.4	-98	-144.4	98	208.4	198	388.4	298	568.4	398	748.4	498	928.4	598	1,108.4	698	1,288.4	798	1,468.4
-199	-326.2	-99	-146.2	99	210.2	199	390.2	299	570.2	399	750.2	499	930.2	599	1,110.2	699	1,290.2	799	1,470.2

* Reprinted from *Electronics*, May 1, 1957.

Table 9-6. Conversion Table for Units of Length

MULTIPLY NUMBER OF → TO OBTAIN NUMBER OF ↓	ANGSTROMS	MICRONS	MILS	INCHES	FEET	MILES	MILLIMETERS	CENTIMETERS	KILOMETERS
ANGSTROMS	1	10^4	2.540×10^5	2.540×10^8	3.048×10^9	1.609×10^{13}	10^7	10^8	10^{13}
MICRONS	10^{-4}	1	2.540×10	2.540×10^4	3.048×10^5	1.609×10^9	10^3	10^4	10^9
MILS	3.937×10^{-6}	3.937×10^{-2}	1	10^3	1.2×10^4	6.336×10^7	3.937×10	3.937×10^2	3.937×10^7
INCHES	3.937×10^{-9}	3.937×10^{-5}	10^{-3}	1	12	6.336×10^4	3.937×10^{-2}	3.937×10^{-1}	3.937×10^4
FEET	3.281×10^{-10}	3.281×10^{-6}	8.333×10^{-5}	8.333×10^{-2}	1	5.280×10^3	3.281×10^{-3}	3.281×10^{-2}	3.281×10^3
MILES	6.214×10^{-14}	6.214×10^{-10}	1.578×10^{-8}	1.578×10^{-5}	1.894×10^{-4}	1	6.214×10^{-7}	6.214×10^{-6}	6.214×10^{-1}
MILLIMETERS	10^{-7}	10^{-3}	2.540×10^{-2}	2.540×10	3.048×10^2	1.609×10^6	1	10	10^6
CENTIMETERS	10^{-8}	10^{-4}	2.540×10^{-3}	2.540	3.048×10	1.609×10^5	0.1	1	10^5
KILOMETERS	10^{-13}	10^{-9}	2.540×10^{-8}	2.540×10^{-5}	3.048×10^{-4}	1.609	10^{-6}	10^{-5}	1

TRANSISTOR CHARACTERISTICS FOR CIRCUIT DESIGNERS °

Summary: Tables indicate physical properties, maximum electrical ratings, small-signal low-frequency parameters, and average characteristics for grounded-base, grounded-emitter, grounded-collector, and switching circuits for 218 transistor types: 106 junction triodes, 46 high-frequency triodes, 6 tetrodes, 23 high-power units, 25 point-contact, and 12 phototransistors.

Abbreviations Used in Tables

α	Current gain	I_e	Emitter current
β	Base-current amplification factor	I_{e0}	Emitter cutoff current
BW	Bandwidth	NF	Noise figure
C_c	Collector capacitance	r_b	Base resistance
$f_{c\alpha}$	Alpha cutoff frequency	r_c	Collector resistance
g-b	Grounded base	r_e	Emitter resistance
g-c	Grounded collector	R_g	Generator resistance
g-e	Grounded emitter	R_i	Input resistance
I_b	Base current	R_L	Load resistance
I_{b2}	Second base current (tetrode)	R_o	Output resistance
I_c	Collector current	V_c	Collector voltage
I_{c0}	Collector cutoff current		

° By Seymour Schwartz, Lincoln Laboratory, Massachusetts Institute of Technology, Lexington, Mass. Reprinted from *Electronics*, January, 1956.

Successful transistor circuit design requires not only familiarity with transistor equivalent circuits and characteristic curves but also an understanding of the behavior of the parameters describing the transistor and the variation of these parameters with bias and temperature. Tables 9-7 to 9-12 have been compiled as a systematic presentation of data necessary for transistor circuit design.

Each of the charts presents physical properties; maximum electrical ratings; typical small-signal low-frequency parameters; average characteristics for grounded-emitter, grounded-base, and grounded-collector circuits; and switching characteristics. Figure 9-27 illustrates the circuits referenced in Tables 9-8 and 9-9.

Small-signal parameters are expressed as resistances. This permits a familiar physical representation of the transistor in circuit design. The box on page 9-50 enables transformation between h and r parameters.

All the characteristics are for fixed-bias conditions. However, these values vary with operating conditions. Examples of these variations are shown in Fig. 9-26a to c.

Figure 9-26a illustrates how collector capacitance C_c varies with collector voltage V_c . In designing an IF tuned circuit, the tuning capacitor must be large enough to swamp out the effects of the variation of collector capacitance. If the IF stage is a grounded-emitter rather than a grounded-base stage, the collector capacitance is magnified by the base-current amplification factor β .

In IF stages where neutralization is used to maximize gain by balancing out C_c , instability may occur when the battery voltage decreases. This variation of C_c with V_c permits use of the transistor as a reactance element in FM applications.

At low current bias (Fig. 9-26b to d) the noise factor of the transistor decreases and emitter resistance r_e , base resistance r_b , and collector resistance r_c increase, providing increased power gain and larger values of input and output impedance. This is advantageous in hearing aids where low bias currents are used.

Temperature Effects

In the germanium transistor, noticeable changes in α , β , and I_{co} take place at approximately 60°C as shown in Fig. 9-26e. These changes can lead to instability at high temperatures by α becoming equal to or greater than unity or by I_{co} increasing and causing a collector runaway effect due to self-heating.

Temperature problems are minimized in silicon transistors as seen in Fig. 9-26f. The value I_{co} becomes almost negligible in design consideration as the upper limit or temperature range is above 100°C. In such special applications as d-c amplifiers, the slightest change in α over the normal temperature operating range can produce a significant change in d-c gain of the grounded-emitter stage.

The low-frequency low-power triode junction transistor, Table 9-7, is most commonly used. The majority are utilized in hearing aids, audio systems, low-power control systems, and low-speed computing circuits. Present units are available in the $p-n-p$ and $n-p-n$ fused germanium, the $n-p-n$ grown silicon types. Of the fused type of transistor, the $p-n-p$ is more available commercially and consequently has found a wider range of applications. The $n-p-n$ fused type is suitable for complementary symmetry circuitry. The grown silicon type is used for high-temperature and low- I_{co} applications.

The germanium and silicon grown transistors are used in almost the same manner as the fused transistor. Frequently, the grown types, owing to their lower value of collector capacitance and higher value of a cutoff, can be employed as high-frequency transistors.

The maximum power ratings on most of the low-power transistors are of the order of 50-mw collector dissipation at room temperature. Some of these units have external heat sinks and are able to dissipate considerably more power.

The rating most commonly employed is the maximum power rating. Maximum current and maximum voltage ratings cannot be achieved simultaneously because the product of these two ratings usually exceeds maximum rating. The maximum voltage rating is set at a value safely below the collector voltage breakdown value while the maximum current is selected where β has not decreased to too low a value.

Table 9-8, high-frequency transistors, includes $p-n-p$ and $n-p-n$ fused junction, $n-p-n$ grown junction, and $p-n-p$ surface-barrier units. Except for the $n-p-n$ grown type, which is of either germanium or silicon, all these units use germanium.

Physically, one of the main distinctions between these units and the low-frequency units is the closer spacing between emitter and collector junctions. Electrical characteristics are higher α cutoff, lower collector voltage breakdown, and in many units lower collector capacitance and lower base resistance. The widest application is in radio receivers and high-speed switching circuits.

In selecting a high-frequency transistor for a grounded-emitter IF amplifier, note that the β -cutoff frequency of the amplifier is equal to a cutoff frequency divided by β .

Table 9-9 lists tetrode junction transistors which are high-frequency triode $n-p-n$ grown junction transistors with an extra base lead and a narrower base region. The electrical characteristics of the grown tetrode transistor are almost identical to the grown triode transistor except for a lower value of base resistance and higher value of α -cutoff frequency. The extra base lead makes the tetrode applicable in specialized control circuits and AVC applications. Bias for the extra base lead is usually obtained from a bleeder across the main supply.

High-power Units

The high-power transistor, Table 9-10, is in most cases the largest of all transistors. One element is attached to the container. In most units the case can be connected to the chassis either directly or through a thin mica spacer. The types used as power transistors are the germanium $p-n-p$ fused and silicon $n-p-n$ grown.

The $p-n-p$ fused transistors are usually the high-power units whose larger physical size provides collector power dissipation up to 20 watts. The larger physical size also contributes a high collector capacitance and lower α -cutoff frequency. Medium-power $p-n-p$ and $n-p-n$ fused units which retain their smaller physical size and most of the electrical characteristics of the low-power transistors are used in applications requiring collector power dissipation below $\frac{1}{2}$ watt.

The characteristics peculiar to the high-power transistor are the lower values of input resistance, output resistance, and α , resulting from the higher values of bias currents employed. Bias stability techniques are used to minimize the effect of runaway due to self-heating of the collector.

The point-contact transistor, Table 9-11, is limited to high-speed switching circuitry. Phototransistor devices, Table 9-12, are divided into two basic types: the two-lead and three-lead devices. In the two-lead unit, one lead is attached to the base and the other to the collector. The three-lead device has leads going to the emitter, base, and collector, respectively.

The two-lead device is used in circuits providing d-c amplification for unmodulated light, while the three-lead device can be used in circuits employing a-c amplification for modulated light.

Acknowledgment is given to Ann M. Field and Elizabeth A. Sewell for their assistance in compiling these data.

Table 9-7. Junction-triode

Manufacturer	Type No.	Type	Max coil power, mW	Max coil voltage, volts	Max coil current, ma	Max ambient temp., °C	Small-signal low-			
							Bias		β	r_e , ohms
							V_{ce} , volts	I_c , ma		
Amperex Electronic Corp. 230 Duffy Ave. Hicksville, N.Y.	OC70	<i>p-n-p</i> fused ^a	25 (45°C)	-10	-10	45	-2	0.5	30	39
	OC71	<i>p-n-p</i> fused ^a	25 (45°C)	-10	-10	45	-2	3	47	6.5
CBS-Hytron Danvers, Mass.	2N36	<i>p-n-p</i> fused	50	-20	-8	50	-6	1	45	30
	2N37	<i>p-n-p</i> fused	50	-20	-8	50	-6	1	30	30
	2N38	<i>p-n-p</i> fused	50	-20	-8	50	-6	1	15	25
	HA-1	<i>p-n-p</i> fused	50	-20	-8	50	-3	0.5	40	24
	HA-2	<i>p-n-p</i> fused	50	-20	-8	50	-3	0.5	30	35
	HA-3	<i>p-n-p</i> fused	50	-20	-8	50	-3	0.5	35	30
	HC-1	<i>p-n-p</i> fused	50	-20	-8	50	-6	1	45	30
Germanium Prod. Corp. 26 Cornelison Ave. Jersey City, N.J.	NPN-3/ 2N103	<i>n-p-n</i> grown	50 (25°C)	35	10	75	4.5	-1	4	25
	RD2517A/ 2N97	<i>n-p-n</i> grown	50 (25°C)	30	10	75	4.5	-1	13.3	25
	RD2518A/ 2N97A	<i>n-p-n</i> grown	50 (25°C)	40	10	85	4.5	-1	13.3	25
	RD2521A/ 2N98	<i>n-p-n</i> grown	50 (25°C)	40	10	75	4.5	-1	40	25
	RD2522A/ 2N98A	<i>n-p-n</i> grown	50 (25°C)	40	10	85	4.5	-1	40	25
	RD2523A/ 2N99	<i>n-p-n</i> grown	50 (25°C)	40	10	75	4.5	-1	40	25
	RD2525A/ 2N100	<i>n-p-n</i> grown	25 (25°C)	25	5	50	4.5	-1	140	25
General Electric Co. Electronics Park Syracuse, N.Y.	2N43	<i>p-n-p</i> fused	150 (25°C)	-45 ^e	-50	100	-5	1	49	32
	2N44	<i>p-n-p</i> fused	150 (25°C)	-45 ^e	-50	100	-5	1	21.2	26.5
	2N45	<i>p-n-p</i> fused	150 (25°C)	-45 ^e	-50	100	-5	1	11.5	20
	2N43A	<i>p-n-p</i> fused	150 (25°C)	-45 ^e	-50	100	-5	1	43.4	15
	2N43A USAF	<i>p-n-p</i> fused	150 (25°C)	-45	-50	100	-5	1	43.4	15
General Transistor Corp. 95-18 Sutphin Blvd. Jamaica, N.Y.	2N76	<i>p-n-p</i> fused	50 (25°C)	-20 ^e	-10	60	-5	1	19	17
	GT-14	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	28	30
	GT-20	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	.....	.....	45	30
	GT-34	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	.....	.....	15	30
	GT-81	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	.....	.....	65	30
	GT-83	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	.....	.....	45	30
	GT-87	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	.....	.....	28	30
	GT-88	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	.....	.....	65	30
	2N34	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	40	30
	2N36	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	45	30
	2N37	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	30	30
	2N38	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	15	30
	2N39	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	45	30
	2N40	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	28	30
2N42	<i>p-n-p</i> fused	70 (50°C)	-25	.....	85	-4.5	1	13	30	
Hughes Aircraft Co. Culver City, Calif.	HA5001	<i>n-p-n</i> alloyed	500 (25°C)	30	100	85	5	1	65.6	16.5
	HA5002	<i>n-p-n</i> alloyed	500 (25°C)	20	100	85	5	1	27.5	16
Hydro-Aire Inc. Burbank, Calif.	HA5003	<i>n-p-n</i> alloyed	500 (25°C)	20	100	85	5	1	99	26
	J-1	<i>p-n-p</i> fused	150 (25°C)	-40	-10	50	-6	1	34	30
	J-2	<i>p-n-p</i> fused	150 (25°C)	-40	-10	50	-6	1	15	30
	J-3	<i>p-n-p</i> fused	150 (25°C)	-40	-10	50	-6	1	9	30
	HA-1	<i>p-n-p</i> fused	100 (25°C)	-20	-10	50	-6	1	40	30
	CQ-1	<i>p-n-p</i> fused	150 (25°C)	-40	-10	50	-6	1	9	30
	2N39	<i>p-n-p</i> fused	47 (25°C)	-27	-12	60	-4.5	1	32.4	.....
Nat'l Union Electric 350 Scotland Rd. Orange, N.J.	2N40	<i>p-n-p</i> fused	47 (25°C)	-27	-12	60	-4.5	1	15.7-32.4	.....
	2N42	<i>p-n-p</i> fused	47 (25°C)	-18	-12	60	-4.5	1	9	.....
	T34D	<i>p-n-p</i> fused ^a	56 (25°C)	-27	-12	70	-4.5	1	32.4	.....
	T34E	<i>p-n-p</i> fused ^a	56 (25°C)	-27	-12	70	-4.5	1	15.7-32.4	.....
	T34F	<i>p-n-p</i> fused ^a	56 (25°C)	-18	-12	70	-4.5	1	9	20
Philco Corp. 4700 Wissahickon Ave. Philadelphia, Pa.	2N47	<i>p-n-p</i> fused ^a	50 (25°C)	-35	-20	.....	-5	1	39	25
	2N49	<i>p-n-p</i> fused ^a	50 (25°C)	-35	-20	.....	-5	1	39	25
RCA Harrison, N.J.	2N104	<i>p-n-p</i> fused ^b	110 (25°C)	-30	50	85	-6	1	44	24.5
	2N77	<i>p-n-p</i> fused ^a	35 (25°C)	-25	15	50	-4	0.7	40	36
Raytheon Mfg. Co. 55 Chapel St. Newton, Mass.	CK721	<i>p-n-p</i> fused ^c	.....	-15 ^f	-10	70	-6	1	45	25
	CK722	<i>p-n-p</i> fused ^c	.....	-22 ^f	-10	70	-6	1	22	25
	CK725	<i>p-n-p</i> fused ^c	.....	-12 ^f	-10	70	-6	1	90	25
	CK727	<i>p-n-p</i> fused ^c	.....	-6 ^f	-10	70	-1.5	0.5	35	50
	2N63	<i>p-n-p</i> fused ^c	.....	-22 ^f	-10	85	-6	1	22	25

Low-power Transistors

frequency parameters						Grounded-emitter connection					Grounded-base				Grounded-collector				
r_b , ohms	r_c , megohms	f_{aco} , Mc	C_c , $\mu\mu\text{f}$	I_{co} , μa	NF, db	I_b , ma	R_L , ohms	R_L , ohms	R_g , ohms	Gain, db	R_i , ohms	R_L , ohms	R_g , ohms	Gain, db	R_i , ohms	R_L , ohms	R_g , ohms	Gain, db	
1,000	1.43	.....	.....	-8	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
500	0.625	.....	.....	-8	10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
450	0.95	0.5	.....	.....	.....	.....	.....	30,000	1,000	40	.....	.....	.....	.....	.....	.....	.....	.....	.....
350	0.55	0.5	.....	.....	.....	.....	.....	30,000	1,000	36	.....	.....	.....	.....	.....	.....	.....	.....	.....
350	0.5	0.5	.....	.....	.....	.....	.....	30,000	1,000	32	.....	.....	.....	.....	.....	.....	.....	.....	.....
700	1.7	.....	.....	-12	12	.....	.....	30,000	1,000	30	.....	.....	.....	.....	.....	.....	.....	.....	.....
350	0.8	.....	.....	-12	27	.....	.....	30,000	1,000	30	.....	.....	.....	.....	.....	.....	.....	.....	.....
450	0.6	.....	.....	.....	.....	.....	.....	1,200	1,000	35	.....	.....	.....	.....	.....	.....	.....	.....	.....
450	0.95	0.7	.....	-12	.....	.....	.....	30,000	1,000	40	.....	.....	.....	.....	.....	.....	.....	.....	.....
100	2.0	0.75	20	5	22	0.25	225	100,000	100,000	33	45	250,000	30	2,500	500	matched	.....	7	
100	3.0	1.0	19	2	20	0.07	400	100,000	100,000	38	35	250,000	32	7,000	500	matched	.....	11	
100	10.0	1.0	19	2	15	0.07	400	100,000	100,000	38	35	250,000	32	7,000	500	matched	.....	11	
150	5.0	2.5	14	2	20	0.025	850	100,000	100,000	47	35	250,000	35	20,000	500	matched	.....	15	
150	10.0	2.5	14	2	15	0.025	850	100,000	100,000	47	35	250,000	35	20,000	500	matched	.....	15	
150	5.0	3.5	10	2	15	0.025	850	100,000	100,000	47	35	250,000	35	20,000	500	matched	.....	15	
400	5.0	5.0	14	2	20	0.007	3,500	100,000	100,000	53	45	250,000	35	70,000	500	matched	.....	20	
400	1.0	1.0	40	-10	22	.....	1,000	30,000	600	39	80	50,000	100	28	30,000	600	30,000	15	
300	1.0	1.0	40	-10	22	.....	700	30,000	600	38	55	50,000	100	28	15,000	600	15,000	12	
250	1.0	1.0	40	-10	22	.....	450	30,000	600	36	50	50,000	100	28	7,500	600	7,500	11	
575	1.43	1.0	40	-5	10	.....	1,000	30,000	600	39	60	50,000	100	28	30,000	600	30,000	15	
575	1.43	1.0	40	-5	30	.....	1,000	30,000	600	39	60	50,000	100	28	30,000	600	30,000	15	
800	1.5	0.65	.....	-10	16	.....	1,000	30,000	600	38	55	50,000	100	28	15,000	600	15,000	12	
800	1.5	0.65	.....	-10	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
800	1.5	0.65	.....	-10	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
800	1.5	0.65	.....	-10	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
800	1.5	0.70	.....	-10	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
800	1.5	0.50	.....	-10	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
800	1.5	1.0	.....	-10	16	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
350	2.0	.....	.....	-15	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
850	2.0	.....	.....	-15	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	2.0	.....	.....	-15	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	2.0	.....	.....	-15	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
850	2.0	.....	.....	-15	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	2.0	.....	.....	-15	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	2.0	.....	.....	-15	24	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
900	2	2.5	15	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	1	0.8	.....	12	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	1	1.5	.....	10	15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	1.0	1.0	.....	-10	11	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
300	0.7	0.5	.....	-15	22	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
300	0.5	0.5	.....	-20	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
350	0.75	.....	.....	-10	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
200	0.5	0.5	.....	-20	33	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	-1-2	.....	.....	-10	20	.....	.....	30,000	500	39	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	-1-2	.....	.....	-10	24	.....	.....	30,000	500	38	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	0.5-2	.....	.....	-20	28	.....	.....	30,000	500	36	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	-1-2	.....	.....	-10	20	.....	.....	30,000	500	39	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	-1-2	.....	.....	-10	24	.....	.....	30,000	500	38	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	0.5-2	.....	.....	-20	28	.....	.....	30,000	500	36	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	1.0	1.0	49	-10	15	.....	1,000	50,000	500	42	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	1.0	1.0	49	-10	12	.....	1,000	50,000	500	42	.....	.....	.....	.....	.....	.....	.....	.....	.....
750	2.25	0.7	.....	-10	12	.....	1,200	50,000	500	43	140	400,000	32.8	500,000	20,000	matched	.....	13.9	
560	2.3	0.7	.....	-10	9	.....	1,350	50,000	500	42.6	130	400,000	33.2	10,000	300	matched	.....	16.2	
700	2.0	.....	.....	-6	22	.....	1,500	20,000	200	41	70	100,000	31	600,000	20,000	matched	.....	15	
250	2.0	.....	.....	-6	25	.....	500	20,000	200	36	45	100,000	32	200,000	20,000	matched	.....	10	
1,500	2.0	.....	.....	-6	20	.....	2,700	20,000	200	42	110	100,000	30	1,000,000	20,000	matched	.....	16	
500	2.0	.....	.....	-6	12	.....	.....	20,000	1,000	36	.....	200,000	100	28	540,000	10,000	100,000	14	
350	2.0	.....	.....	-6	25	.....	800	20,000	200	39	50	100,000	32	350,000	20,000	matched	.....	13	

Table 9-7. Junction-triode Low-

Manufacturer	Type No.	Type	Max coll power, mW	Max coll voltage, volts	Max coll current, ma	Max ambient temp, °C	Small-signal low-				
							Bias		β	r_e , ohms	
							V_{e1} , volts	I_e , ma			
Raytheon (Continued)	2N64	p-n-p fused	.....	-15 ^f	-10	85	-6	1	45	25
	2N65	p-n-p fused	.....	-12 ^f	-10	85	-6	1	90	25
Sylvania Electric 1740 Broadway New York, N.Y.	2N34	p-n-p fused	50 (25°C)	-40	-10	...	-6	1	40	26	
	2N35	n-p-n fused	50 (25°C)	-40	-10	...	6	-1	40	26	
Texas Instruments 6000 Lemmon Ave. Dallas, Tex.	200	n-p-n grown	50 (25°C)	30	5	50	5	-1	9	22	
	201	n-p-n grown	50 (25°C)	30	5	50	5	-1	19	22	
	202	n-p-n grown	50 (25°C)	30	5	50	5	-1	49	35	
	206S	n-p-n grown ^a	50 (25°C)	30	5	50	2.5	-0.5	35	.....
	207S	n-p-n grown ^a	50 (25°C)	30	5	50	2.5	-0.5	19	.....
	208S	n-p-n grown ^a	50 (25°C)	30	10	50	2.5	-10	19	.....
	300	p-n-p fused	50 (25°C)	-30	-10	50	-5	1	9	.....
	301	p-n-p fused	50 (25°C)	-30	-10	50	-5	1	19	.....
	903	n-p-n grown	150 (25°C)	30	10	150	5	-1	9-19	150	
	904	n-p-n grown	150 (25°C)	30	10	150	5	-1	19-39	150	
	905	n-p-n grown	150 (25°C)	30	10	150	5	-1	39	150	
	904A	n-p-n grown	150 (25°C)	30	10	150	5	-1	19	150	
	210	n-p-n grown	50 (25°C)	30 ^g	5	50	22.5	-2	.....	.....
	302	p-n-p fused	50 (25°C)	-30	-10	50	-5	1	44	.....
	350	.....	50 (25°C)	-12	.....	.....	.....	.....	.....	.....
	Transitron 407 Main St. Melrose, Mass.	2N85	p-n-p fused	750	-45	-100	100	-12	10	40	2.5
		2N86	p-n-p fused	750	-60	-100	100	-12	10	20	2.5
2N87		p-n-p fused	750	-30	-100	100	-12	10	20	2.5	
2N88		p-n-p fused ^a	25	-12	-10	85	-1.3	0.5	25	50	
2N89		p-n-p fused ^a	25	-12	-10	85	-1.3	0.5	25	50	
2N90		p-n-p fused ^a	25	-12	-10	85	-1.3	2.5	40	10	
2N91		p-n-p fused	125	-15	-500	85	-3	30	25	1.5	
2N92		p-n-p fused	125	-25	-200	85	-3	5	30	5	
2N34		p-n-p fused	125	-25	-20	100	-6	1	40	18	
2N36		p-n-p fused	125	-25	-20	100	-6	1	45	18	
2N37		p-n-p fused	125	-25	-20	100	-6	1	30	20	
2N38		p-n-p fused	125	-25	-20	100	-6	1	15	20	
2N43		p-n-p fused	375	-45	-50	100	-6	1	33	20	
2N44		p-n-p fused	375	-45	-50	100	-6	1	16	20	
2N45		p-n-p fused	375	-45	-50	100	-6	1	9	20	
2N63		p-n-p fused	125	-25	-20	100	-6	1	20	20	
2N64		p-n-p fused	125	-25	-20	100	-6	1	30	20	
2N65	p-n-p fused	125	-25	-20	100	-6	1	50	18		
Tung-Sol Electric 100 Eighth Ave. Newark, N.J.	DR126	p-n-p fused ^d	50 (25°C)	-10 ^g	.....	85	-1.5	0.5	24	26
	DR128	p-n-p fused ^d	50 (25°C)	-10 ^g	.....	85	-1.5	0.5	49	34
	DR129	p-n-p fused ^d	50 (25°C)	-25 ^g	.....	85	-1.5	0.5	32.4	26
	DR130	p-n-p fused ^d	50 (25°C)	-25 ^g	.....	85	-1.5	0.5	13	20.5
Western Electric 120 Broadway New York, N.Y.	DR154	p-n-p fused ^d	50 (25°C)	-25 ^g	.....	85	-1.5	0.5	124	55
	2N27	n-p-n grown	50 (60°C)	30	5	85	4.5	-1	18-198	50	
2N28	n-p-n grown	50 (60°C)	30	5	85	4.5	-1	5-198	125		
Westinghouse Box 284 Elmira, N.Y.	2N54	p-n-p fused ^a	200 (25°C)	-45	-10	60	-6	1	33	25	
	2N55	p-n-p fused ^a	200 (25°C)	-45	-10	60	-6	1	20	20	
	2N56	p-n-p fused ^a	200 (25°C)	-45	-10	60	-6	1	13	5	

All sockets A to H except where otherwise noted.

^a Socket type A.

^b Socket types B to H.

^c Socket types A, I, and J.

^d Socket type not given.

power Transistors (Continued)

frequency parameters					Grounded-emitter connection					Grounded-base				Grounded-collector				
r_b , ohms	r_e , megohms	f_{max} , Mc	C_c , μ pf	I_{c0} , μ a	NF, db	I_b , ma	R_i , ohms	R_L , ohms	R_g , ohms	Gain, db	R_i , ohms	R_L , ohms	R_g , ohms	Gain, db	R_i , ohms	R_L , ohms	R_g , ohms	Gain, db
700	2.0	.....	.....	-6	22	.....	1,500	20,000	500	41	70	100,000	30	31	500,000	20,000	matched	15
1,500	2.0	.....	.....	-6	20	.....	2,700	20,000	500	42	110	100,000	30	30	1,000,000	20,000	matched	16
800	2.0	0.6	15	-5	18	-0.03	1,200	30,000	500	40	.....	.....	.....	.....	20,000	500	matched	16
800	2.0	0.8	18	5	16	0.03	1,200	30,000	500	40	.....	.....	.....	.....	20,000	500	matched	16
150	0.4	0.9	15	10	26	.....	480	20,000	500	37	35	100,000	60	30	9,500	500	15,000	12
170	0.4	1.1	17	10	23	.....	970	20,000	500	40	40	100,000	60	30	15,500	500	15,000	14.5
200	0.4	1.3	19	10	20	.....	1,250	20,000	1,250	43	45	100,000	60	31	32,000	500	15,000	17
.....	.....	.....	.....	3	11	.....	.....	20,000	1,000	32	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	3.5	21	.....	.....	20,000	1,000	29	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	4	26	.....	.....	300	1,000	26	.....	.....	.....	.....	.....	.....	.....	.....
550	0.4	.....	.....	-10	25	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,000	0.4	.....	.....	-10	20	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
500	0.5	3	.....	1(25°C)	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,250	0.5	3	.....	1(25°C)	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2,500	0.5	3	.....	1(25°C)	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,250	0.5	8	.....	1(25°C)	23	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	50(25°C)	.....	.....	.....	10,000	500	39	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	-10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
300	0.10	0.8	.....	-10	20	.....	.....	1,000	500	30	.....	.....	.....	.....	.....	.....	.....	.....
300	0.125	0.8	.....	-10	20	.....	.....	1,000	500	26	.....	.....	.....	.....	.....	.....	.....	.....
300	0.125	0.8	.....	-20	20	.....	.....	1,000	500	26	.....	.....	.....	.....	.....	.....	.....	.....
1,000	0.5	0.5	.....	-10	10	.....	.....	20,000	1,000	36	.....	.....	.....	.....	.....	.....	.....	.....
1,000	2.0	0.5	.....	-10	20	.....	.....	20,000	1,000	36	.....	.....	.....	.....	.....	.....	.....	.....
600	0.5	0.5	.....	-10	20	.....	.....	600	1,000	26	.....	.....	.....	.....	.....	.....	.....	.....
50	2.0	.....	.....	-15	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
500	1.0	.....	.....	-10	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
600	1.0	.....	.....	-10	20	.....	.....	30,000	1,000	40	.....	.....	.....	.....	.....	.....	.....	.....
700	1.0	.....	.....	-10	20	.....	.....	30,000	1,000	40	.....	.....	.....	.....	.....	.....	.....	.....
500	1.0	.....	.....	-15	22	.....	.....	30,000	1,000	35	.....	.....	.....	.....	.....	.....	.....	.....
250	1.0	.....	.....	-25	24	.....	.....	30,000	1,000	32	.....	.....	.....	.....	.....	.....	.....	.....
500	1.0	.....	.....	-15	20	.....	.....	30,000	1,000	40	.....	.....	.....	.....	.....	.....	.....	.....
300	1.0	.....	.....	-15	22	.....	.....	30,000	1,000	37	.....	.....	.....	.....	.....	.....	.....	.....
250	1.0	.....	.....	-15	22	.....	.....	30,000	1,000	33	.....	.....	.....	.....	.....	.....	.....	.....
350	2.0	.....	.....	-10	25	.....	.....	30,000	1,000	38	.....	.....	.....	.....	.....	.....	.....	.....
700	2.0	.....	.....	-10	22	.....	.....	30,000	1,000	39	.....	.....	.....	.....	.....	.....	.....	.....
1,500	2.0	.....	.....	-10	20	.....	.....	30,000	1,000	41	.....	.....	.....	.....	.....	.....	.....	.....
900	1.5	0.9	.....	-9	14	-0.006	.....	30,000	1,000	33	.....	.....	.....	.....	.....	.....	.....	.....
1,400	2.0	0.9	.....	-8	18	-1.5	.....	300	.....	24	.....	.....	.....	.....	.....	.....	.....	.....
1,200	2.0	0.7	.....	-10	18	-0.006	.....	30,000	1,000	35	.....	.....	.....	.....	.....	.....	.....	.....
650	1.3	0.5	.....	-14	21	-0.006	.....	30,000	1,000	27	.....	.....	.....	.....	.....	.....	.....	.....
600	1.2	0.7	.....	-10	18	-0.006	.....	30,000	1,000	40	.....	.....	.....	.....	.....	.....	.....	.....
700	2.0	2	17	10	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1,000	1.0	0.95	25	10	30	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
400	1.0	0.5	.....	-6	.....	.....	700	50,000	700	39.5	125	300,000	125	31	35,000	1,000	35,000	15
400	1.0	0.5	.....	-6	.....	.....	550	67,000	550	39	125	300,000	125	31	27,000	1,000	27,000	13
400	1.0	0.5	.....	-6	.....	.....	450	85,000	450	37	125	300,000	125	31	20,000	1,000	20,000	11

Characteristics measured at 25°C unless otherwise noted.
 ° Characteristics measured at 30°C.
 † Characteristics measured at 27°C.
 * Temperature not given.

Table 9-8. High-

Manufacturer	Type No.	Type	Max coil power, mw	Max coil voltage, volts	Max coil current, ma	Max ambient temp, °C	Storage temp, °C	Typical small-signal			
								Bias		β	r_e , ohms
								V_c , volts	I_c , ma		
General Electric	2N78	<i>n-p-n</i> rate grown	50 (30°C)	15	20	100	100 max	5	-1	27.5	...
	2N123	<i>p-n-p</i> fused	150 (25°C)	-15	150	...	85	-5	1	30-150	...
	2N135	<i>p-n-p</i> alloyed	100 (25°C)	-20	-50	...	85	-5	1	20	...
	2N136	<i>p-n-p</i> alloyed	100 (25°C)	-20	-50	...	85	-5	1	40	...
	2N137	<i>p-n-p</i> alloyed	100 (25°C)	-10	-50	...	85	-5	1	60	...
Germanium Prod.	RD2523A (2N99)	<i>n-p-n</i> grown	50 (25°C)	40	10	75	.....	5	-1	40	25
	RD2525A (2N100)	<i>n-p-n</i> grown	25 (25°C)	25	5	50	.....	5	-1	100	25
	RD2521A (2N98)	<i>n-p-n</i> grown	50 (25°C)	40	10	75	.....	5	-1	40	25
	RD2517A	<i>n-p-n</i> grown	50 (25°C)	30	10	75	.....	5	-1	13	25
	Hydro-Aire	HF-1	<i>p-n-p</i> fused	35 (25°C)	-15	-5	55	-4.5	1	25	30
IP-1		<i>p-n-p</i> fused	35 (25°C)	-15	-5	55	.....	-4.5	1	20	30
Philco	SB-100	surface barrier ^a	10 (40°C)	-4.5	-5	...	-55 to 85	-3	0.5	19	50
Raytheon	CK-760	<i>p-n-p</i> fused	.....	-6 ^c	-5	...	-55 to 85	-6	1	45	22
	CK-761	<i>p-n-p</i> fused	.....	-6 ^c	-5	...	-55 to 85	-6	1	50	22
	CK-762	<i>p-n-p</i> fused	.....	-6 ^c	-5	...	-55 to 85	-6	1	60	22
Sylvania	2N94	<i>n-p-n</i> alloyed	50 (25°C)	20	10	...	-55 to 85	6	-0.5	30	52
	2N94A	<i>n-p-n</i> alloyed	50 (25°C)	20	10	...	-55 to 85	6	-0.5	30	52
Texas Inst.	220	<i>n-p-n</i> grown ^a	50 (25°C)	30	5	50	.....	22.5	...	...	...
	221	<i>n-p-n</i> grown ^a	50 (25°C)	30	5	50	.....	22.5	...	...	...
	222	<i>n-p-n</i> grown ^a	50 (25°C)	30	5	50	.....	22.5	...	...	...
	223	<i>n-p-n</i> grown ^a	50 (25°C)	30	5	50	.....	22.5	...	...	...
	904A	<i>n-p-n</i> grown	150 (25°C)	30	10	150	.....	5	-1	≥19	150
	224-1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	225-1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	226-1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
	5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
227-1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
4	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Tung-Sol	DR-155	<i>p-n-p</i> fused ^b	50 (25°C)	-10	...	85	-55 to 85	-1.5	0.5	32	...
	2N112	<i>p-n-p</i> fused	50 (25°C)	-10	-8	85	-55 to 85	-6	1	32	31
	2N113	<i>p-n-p</i> fused	50 (25°C)	-10	-8	85	-55 to 85	-6	1	32	31
Western Electric	2N27	<i>n-p-n</i> grown	50 (60°C)	30	5	85	.....	4.5	-1	20-198	50

Socket types A to H unless otherwise noted.
^a Socket type A only.
^b Socket types A and J.

frequency Transistors

low-frequency parameters								HF parameters	High-frequency circuit conditions				High-speed switching characteristics			
r_b , ohms	r_c , microhms	$f_{\alpha cut}$, Mc	C_c , $\mu\mu\text{f}$	I_{co} , μA	I_{eo} , μA	NF, db	$\tau_{1/2}$, μsec	Application	R_i , ohms	R_o , ohms	Power gain, db	Circuit	Rise time, μsec	Fall time, μsec	Reverse emitter voltage, volts	Circuit
...	...	5.5	6	1	...	14	...	RF amp	1,000	6,000	20					
...	...	7.5	14	-2	5	10	1,000	IF amp	1,500	10,000	30					
...	...	4.5	14	5	...	...	...	Switching	...	...	...		0.1	0.2	5	
...	...	6.5	14	5	...	...	...	RF/IF amp	...	...	29					
...	...	10	14	5	...	...	...	RF/IF amp	...	...	31					
...	...	10	14	5	...	...	...	RF/IF amp	...	...	33					
150	5.0	3.5	10	2	...	15	...	IF amp uncut	500	10,000	22		<0.2	<0.3		
400	5.0	5.0	14	2	...	20	...	IF amp uncut	750	10,000	23		<0.2	<0.3		
150	5.0	2.0	14	2	...	20	...	IF amp uncut	500	10,000	22		<0.2	<0.3		
100	3.0	1.0	19	2	...	20	...	IF amp uncut	350	10,000	20		<0.2	<0.3		
500	1.0	5.0	10	-10	...	...	...						
500	1.0	2.1	10	-10	...	...	...						
...	0.4	30 (osc)	2.2	-0.5	0.5	...	800									
70	1.0	5	14	-2	2	25	1,000									
70	1.0	10	14	-2	2	25	1,000									
70	1.0	20	14	-2	2	25	1,000									
500	2.0	3.5	10	3	-3	15	1,000	IF (g-b)	80	100,000	25 ^d	C	0.15	0.15	≥ 0	F
								IF (g-e)	500	25,000	32 ^d	D				
								IF (g-b)	80	100,000	25 ^d	D	0.1	0.1	≥ 0	
								IF (g-e)	800	25,000	35 ^d	D				
								RF (g-b)	80	15,000	20 ^e	E				
...	...	...	...	50	...	...	...	262-ke (g-e) IF	750	70,000	31	A				
...	...	...	...	50	...	...	...	262-ke (g-e) IF	750	70,000	33	A				
...	...	...	...	50	...	...	...	262-ke (g-e) IF	750	70,000	35	A				
...	...	...	...	50	...	...	...	262-ke conv	300	60,000	20	B				
1,250	0.5	≥ 8	...	1	...	...	...	Neut 262-ke g-e IF	600	70,000	26	H				
...	...	...	...	...	...	...	...	...	...	...	28					
...	...	...	...	...	...	...	...	...	...	...	30					
...	...	...	...	...	...	...	...	...	...	...	32					
...	...	...	...	...	...	...	...	...	...	...	34					
...	...	...	...	...	...	...	...	Neut 455-ke g-e IF	500	50,000	24	H				
...	...	...	...	...	...	...	...	...	...	...	26					
...	...	...	...	...	...	...	...	...	...	...	28					
...	...	...	...	...	...	...	...	...	...	...	30					
...	...	...	...	...	...	...	...	...	...	...	32					
...	...	...	...	...	...	...	...	Neut 262-ke g-b IF	65	120,000	18	I				
...	...	...	...	...	...	...	...	...	...	...	20					
...	...	...	...	...	...	...	...	...	...	...	22					
...	...	...	...	...	...	...	...	...	...	...	24					
...	...	...	...	...	...	...	...	Neut 455-ke g-b IF	65	150,000	18	I				
...	...	...	...	...	...	...	...	...	...	...	20					
...	...	...	...	...	...	...	...	...	...	...	22					
...	...	...	...	...	...	...	...	...	...	...	24					
...	...	...	...	...	...	...	...	...	...	...	26					
...	1.0	1.4	...	-15	...	28	...	IF	600	25,000	32	G				
110	1.2	5	...	-10	...	28	...	IF	600	25,000	32	G				
110	1.2	10	...	-10	...	28	...	IF	600	25,000	33	G				
700	2.0	2	17	10	...	...	...						

Characteristics measured at 25°C unless otherwise noted.
^c Characteristics measured at 27°C.
^d Bandwidth 12 kc.
^e Bandwidth 25 kc.

Table 9-9. Crown *n-p-n*

Manufacturer	Type No.	Max coil power, mW	Max coil voltage, volts	Max coil current, ma	Max base-to-base current, ma	Application
Germanium Prod.	RDX-302/3N23	50 (25°C)	30	5	5	Video amp, switching 10-Mc osc Video amp, switching 20-Mc osc Video amp, switching 35-Mc osc 20-Mc IF Video amp, switching 50-Mc osc 20- to 30-Mc IF Low-level, low-freq age Video amp, R-F
	RDX-301/3N23A	50 (25°C)	30	5	5	
	RDX-300/3N23B	50 (25°C)	30	5	5	
	RDX-300A, 3N23C	50 (25°C)	30	5	5	
Texas Inst.	700	50 (25°C)	30	5	5	
Western Electric	3N22	30 (25°C)	12	5	5	

All sockets A, F, G, H, and M.

Table 9-10.

Manufacturer	Type No.	Type	Max power output, watts				Max coil voltage, volts		Max coil current, amp	Small signal			
			Class A	Class B (push-pull)	D-C switch	Max coil power, watts	Circuit			Bias			
							μ -c	μ -b		f_{osc} , kc	V_c , volts	I_c , ma	
Amperex	2N115	<i>p-n-p</i> fused *	1.5	2.5	...	2 (45°C)	-12(B) -6(A)	...	-1	300	...	...
	2-OC72	<i>p-n-p</i> fused *	...	...	...	0.045 (45°C)	13(B)	...	0.045	10	...	...
CBS-Hytron Hydro-Airc Minneapolis- Honeywell Regulator Co. 2753 4th Ave. S Minneapolis, Minn.	HD-107	<i>p-n-p</i> fused *	...	...	...	0.5 (25°C)	-40	...	...	150	-10	50
	JP-1	<i>p-n-p</i> fused *	0.45	0.9	1.5	0.5 (25°C)	...	-45	-0.1	50	-22.5	20	
	H-1	<i>p-n-p</i> fused *	5	10	40	20 (21°C)	-30	-60	-0.8	20	-2	...	
	2N57	<i>p-n-p</i> fused *	6	12	48	20 (21°C)	-30	-60	-1	20	-2	...	
Sylvania	H-2	<i>p-n-p</i> fused *	8.5	18	68	20 (21°C)	-30	-60	-1.4	20	-2	...	
	H-3	<i>p-n-p</i> fused *	2	4	16	5 (21°C)	-30	-60	-0.35	20	-2	...	
	H-4	<i>p-n-p</i> fused †	2	6	16	5 (21°C)	-30	-60	-0.5	20	-2	...	
Texas Inst.	2N68	<i>p-n-p</i> alloyed †	0.75	10	...	4 (25°C)	...	-25	-1.5	...	-6	50	
	2N95	<i>n-p-n</i> alloyed †	0.75	10	...	4 (25°C)	...	25	1.5	...	6	-50	
Transistor Products 241-251 Crescent Ave. Waltham, Mass.	2N101	<i>p-n-p</i> alloyed	...	Electrically identical	...	to 2N68	...	...	...	...	...	...
	2N102	<i>n-p-n</i> alloyed	...	Electrically identical	...	to 2N95	...	...	...	...	...	...
	X-2	<i>n-p-n</i> grown	...	...	...	...	...	35	0.075	225	5	-1
	951	<i>n-p-n</i> grown Silicon	...	0.45 (25°C) 0.3 (100°C) 0.15 (150°C)	...	1 (25°C) 0.5 (100°C) 0.15 (150°C)	...	50	...	0.06
	952	<i>n-p-n</i> grown Silicon	...	0.6 (25°C) 0.4 (100°C) 0.15 (150°C)	...	1 (25°C) 0.5 (100°C) 0.15 (150°C)	...	80	...	0.05
	953	<i>n-p-n</i> grown Silicon	...	1 (25°C) 0.5 (100°C) 0.15 (150°C)	...	1 (25°C) 0.5 (100°C) 0.14 (150°C)	...	120	...	0.04
Transitron	X-107	<i>p-n-p</i> fused *	1	...	...	2 (25°C)	-30	-60	-1	...	-24	80
	X-120	<i>p-n-p</i> fused *	7.5	...	...	15 (25°C)	-30	-60	-4	...	-28	360
Tung-Sol Western Electric	2N83	<i>p-n-p</i> fused †	5	15	40	10 (25°C)	-30	-45	-1	200	-20	100	
	2N84	<i>p-n-p</i> fused †	5	10	30	10 (25°C)	-22	-30	-1	200	-20	100	
Western Electric	DR-150	<i>p-n-p</i> fused	...	1	3.5	5 (25°C)	...	-25	-1	250	-15	10	
	2N66	<i>n-p-n</i> fused *	...	...	...	5 (25°C)	-40	-60	-0.8	500	-1.5	100
											-40	0	

* Type A sockets.

† Socket types A to II.

Junction-tetrode Transistors

Small-signal low-frequency Parameters								Typical operation	
Bias		I_{B2} , ma	α	r_{e1} , ohms	r_{b1} , ohms	r_{e2} , megohms	I_{C2} , μ a	Freq. Mc Circuit J	Power-gain at 5 Mc Circuit K
V_{e1} , volts	I_{e1} , ma								
4.5	1	0	0.95	30	70	2	10	10-20	12
4.5	1	0	0.97	30	100	2	10	20-35	14
4.5	1	0	0.98	30	200	2	10	35-50	15
4.5	1	0	0.99	30	300	2	10	50-80	17
5	-1	0	0.95	30	1,000	1	10	15	
9	-2	-4.5	0.90	25	100	1	10		
9	-2	0	0.975	25	1,000	1	10		

Characteristics measured at 25°C.

Power Transistors

low-frequency parameters										Typical operating conditions							
β	r_e , ohms	r_{b1} , ohms	r_{e1} , ohms	C_c , μ af	Rise time, μ sec	I_{C1} , μ a	Class and circuit	Supply voltage, volts	Coil current, ma	Base current, ma	Zero signal current, ma	Power output, watts	Power gain, db	Driving power, mw	R_{in} , ohms	R_{L1} , ohms	R_{L2} , ohms
10	2	70	5,000	...	...	...	B(g-e)	-6	1,280	...	5	5	27	...	...	...	...
9	2	150	100,000	...	...	...	B(g-e)	-6	...	...	0.2	...	27	...	...	5,000	100
...	...	...	...	...	1.5	-8,000	A(g-b)	-22	5	...	0.7	...	30	...	...	...	...
...	...	...	...	...	...	...	A(g-e)	-28	400	50	5	...	15	158	20	70	...
...	...	...	...	...	1.2	-8,000	A(g-e)	-28	510	4	10	...	16	630	100	140	...
...	...	...	...	...	...	...	A(g-e)	-28	500	45	...	6.25	16	156	35	56	...
...	...	...	...	...	...	...	B(g-e)	-28	640	4	12.5	...	13	625	140	128	...
...	...	...	...	...	0.5	-8,000	A(g-e)	-28	600	30	...	7.5	20	75	40	47	...
...	...	...	...	...	...	...	B(g-e)	-28	800	...	4	17.5	16	440	100	80	...
...	...	...	...	...	1.2	-1,000	A(g-e)	-28	150	15	...	1.9	16	48	100	187	...
...	...	...	...	...	...	...	B(g-e)	-28	220	...	0.5	4.4	12	278	240	320	...
...	...	...	...	...	0.6	-1,000	A(g-e)	-28	150	10	...	1.9	21	15	60	187	...
...	...	...	...	...	...	...	B(g-e)	-28	318	...	0.5	6.25	14	250	200	224	...
40	1	30	100,000	300	...	-100	A(g-b)	-12	150	...	0.6	...	23	...	75	100	50
...	...	...	...	...	...	...	B(g-e)	-12	550	...	5	...	15	...	50	12	50
...	...	...	...	...	...	...	B(g-e)	-12	550	...	5	...	10	...	250	12	100
...	...	...	...	...	...	...	B(g-b)	-24	950	...	10	...	10	...	2	24	2
40	1	30	100,000	300	...	100	A(g-b)	12	150	...	0.6	...	23	...	75	100	...
...	...	...	...	...	...	...	B(g-e)	12	550	...	5	...	15	...	50	12	...
...	...	...	...	...	...	...	B(g-e)	12	550	...	5	...	10	...	250	12	...
...	...	...	...	...	...	...	B(g-b)	24	950	...	10	...	10	...	2	24	...
9	25	0.75	200,000	...	...	25	B(g-b)	22.5	40	...	0.5	...	9.5	...	...	1,000	...
...	...	...	...	...	...	...	B(g-b)	22.5	40	...	0.5	...	22.7	...	...	1,000	...
...	...	...	...	...	...	5	B(g-e)	28	30	...	0.45 (25°C)	...	20	...	...	1,500	1,000
...	...	...	...	...	...	...	...	...	...	...	0.15 (150°C)	...	...	...	...	...	...
...	...	...	...	...	...	6	B(g-e)	45	25	...	0.6 (25°C)	...	21	...	...	4,000	1,000
...	...	...	...	...	...	...	...	...	...	...	0.15 (150°C)	...	...	...	...	...	...
...	...	...	...	...	...	8	B(g-e)	67.5	20	...	1 (25°C)	...	23	...	...	8,000	1,000
...	...	...	...	...	...	...	...	...	...	...	0.15 (150°C)	...	...	...	...	...	...
22	0.85	12	50,000	...	...	-120	A(g-b)	-28	-80	...	1	...	24	1	1.5	375	...
20	0.65	1	10,000	...	...	-200	A(g-b)	-28	-360	...	5	...	20	50	0.8	100	...
8	0.3	15	20,000	400	1.5	-100	B(g-e)	-30	-180	...	2.5	...	24	...	...	600	100
12	0.3	15	20,000	400	1.5	-100	B(g-e)	-20	-160	...	2.0	...	22	...	...	400	100
33	...	...	30,000	...	...	...	...	...	...	...	...	...	...	...	...	...	...
45	...	...	...	400	...	75	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	300	...	...	...	...	...	...	...	...	...	...	...

† Socket types A and K.
‡ Push-pull connection.

Table 9-11. Point-

Manufacturer	Type No.	Application	Max coll power, mw	Max coll voltage, volts	Max coll current, ma	Max reverse emitter voltage, volts	Max emitter current, ma	Max emitter power, mw
Hydro-Airc	A-0	Amp, osc	0 (25°C)	-20	-8	...	...	...
	A-1	Amp, osc	50 (25°C)	-20	-8	...	...	...
	A-2	Amp, osc	50 (25°C)	-20	-8	...	...	...
	A-3	Amp, osc	50 (25°C)	-20	-8	...	...	...
	S-0	Switching	50 (25°C)	-40	-8	-30	...	...
	S-1	Switching	50 (25°C)	-40	-8	-30	...	...
	S-2	Switching	50 (25°C)	-30	-8	-30	...	...
	S-2	Switching	50 (25°C)	-30	-8	-30	...	...
Sprague Electric Transistor Prod.	5A	Switching	80 (25°C)	-50	-10	-50	...	...
	2A	Amp, osc, sw	120 (25°C)	-50	-8	-50	...	...
	2C	Switching ^a	100 (25°C)	-50	-8	-50	...	...
	2D	Amp, osc ^a	100 (25°C)	-50	-8	-50	...	...
	2E	Amplifier ^a	100 (25°C)	-50	-8	-50	...	...
	2G	Switching ^a	120 (25°C)	-50	-8	-50	...	...
	2H	Amplifier ^a	100 (25°C)	-50	-8	-50	...	...
	2L	Switching ^a	50 (25°C)	-50	-8	-50	...	...
	2N32	Switching ^a	50 (25°C)	-40	-8	-40	...	...
	2N33	Switching ^a	50 (25°C)	-8, 5	-7	-1	-15	...
	2N50	Switching ^a	50 (25°C)	-15	-1	-1	-15	...
	2N51	Sw, osc ^a	100 (25°C)	-50	-8	-50	...	...
	2N52	Amp, osc ^a	120 (25°C)	-50	-8	-50	...	...
	2N53	Switching ^a	120 (25°C)	-50	-8	-50	...	...
Western Electric	2N21	Switching	120 (25°C)	-100	-60	-100	60	80 (25°C) ^b
	2N21A	Amp, osc, sw	120 (25°C)	-100	-60	-100	60	80 (25°C) ^b
	2N110	Switching	200 (25°C)	-100	-75	-100	75	100 (25°C) ^b
	2N67	High-speed sw	100 (25°C)	-100	-60	-100	60	60 (25°C) ^b

Socket types A to H unless otherwise noted.

^a Socket types A and L

Maximum ambient temperature 50°C unless otherwise noted.

^b Maximum ambient temperature 85°C.

Characteristics of A-0, A-1, A-2, A-3, 2N21, 2N21A, 2N110 and 2N67 measured at 25°C.

PARAMETER CONVERSION FORMULAS

$$H_{21} = \frac{R_{21}}{R_{22}} = -\alpha$$

$$H_{11} = R_{11} - \frac{R_{21}R_{12}}{R_{22}}$$

$$\approx r_e + (1 - \alpha)r_b$$

$$H_{12} = \frac{R_{12}}{R_{22}} \approx \frac{r_b}{r_c}$$

$$H_{22} = \frac{1}{R_{22}} \approx \frac{1}{r_c}$$

$$r_c = \frac{1}{H_{22}}$$

$$r_b = r_c H_{12}$$

$$|\alpha| = |H_{21}|$$

$$r_e = H_{11} - r_b(1 - \alpha)$$

TRANSISTOR SOCKETS

Code	Manufacturer	Type
A	Solder connections	.....
B	Elco Corp.	3-pin polarized
		3-pin printed-circuit
C	Cinch Mfg. Corp.	3-pin polarized
D	Super-Ear Prod. Co.	3-pin polarized
E	Mylex Tube Socket Corp.	3-pin polarized
F	Elco Corp.	4-pin polarized
		4-pin printed-circuit
G	Super-Ear Prod. Co.	5-pin
H	Elco Corp.	5-pin
		5-pin printed-circuit
I	Super-Ear Prod. Co.	3-pin equal spacing
J	Cinch Mfg. Corp.	5-pin
K	Amphenol Co.	.....
L	Cinch Mfg. Corp.	.....
M	Cinch Mfg. Corp.	4-pin polarized

contact Transistors

Small-signal low-frequency parameters										Large-signal parameters					
Bias		$-\alpha$	r_e , ohms	r_b , ohms	r_c , ohms	f_{aco} , Mc	C_c , $\mu\mu\text{f}$	NF, db	I_{co} , μa	Rise time, μsec	Turnoff time, μsec	Off I_c , ma	On V_c , volts	Emitter rev resist., ohms	α (at max rise time)
V_c , volts	I_c , ma														
-1	0.3	2	425	200	13,000	3	.....	.....	-1,200	0.2 ^c 0.5 ^d 1 ^e 0.12	.....	-1	-1	50,000	.....
-1	0.3	2	425	200	13,000	2	.....	.....	-1,500						
-1	0.3	2	375	175	13,000	1	.....	.....	-2,000						
-1	0.3	2	350	150	13,000	0.3	.....	.....	-2,000						
.....
.....
-10	1	3	.....	.....	.....	5	.....	43	.....	0.12	0.5	-1	-1	50,000	.....
.....
.....
.....
-10	1	2.5 ^f	200	90	10,000	2	.....	45	-1.1	0.2	1.3	-1.1	-1	200,000	5
-10	1	2.5 ^f	200	90	10,000	2	.....	45	-1.1	0.2	1.3	-1.1	-1	200,000	5
-10	1	2.5 ^f	200	90	15,000	1.5	.....	.....	-0.9	0.3	1.3	-0.9	-1	200,000	4
-10	1	3	900	500	20,000	20	.....	.....	-0.9	0.02	0.9	-0.9	-0.8	2,000,000	7

^c Fall time = 1 μsec .
^d Fall time = 2 μsec .
^e Fall time = 6 μsec .
^f Large-signal $\alpha = 2.4$.

Table 9-12. Phototransistors

Manu- facturer	Type No.	Type	Max coll volt- age, volts	Max coll cur- rent, ma	Max coll power, mw	Max dark current, μa	Max am- bient temp., $^{\circ}\text{C}$	Cut- off freq., kc	Noise, ft-c	Sensitivity, $\mu\text{a}/\text{ft-c}$
General Transistor	GT-66	Pused, 3 lead *	12	20	50 (25 $^{\circ}\text{C}$)	15	.....	750	6×10^{-5}	25
Texas Inst.	800	Grown, 2 lead †	20	20	50 (25 $^{\circ}\text{C}$)	250	40	20	.....	35
Transistor Prod.	1N188	Grown, 2 lead	100	.....	40 (25 $^{\circ}\text{C}$)	.....	50	.....	3-10 μv	10 $\mu\text{a}/\text{milliiumen}$
	1N189	Nonrect, 2 lead	.....	.....	30 (25 $^{\circ}\text{C}$)	20	50	.....	.....	0.08%/ft-c
	10A	Grown, 2 lead	15	.....	100 (25 $^{\circ}\text{C}$)	500	50	.....	15-100 μv	4 ma for 300 ft-c
	10B	Grown, 2 lead	15	.....	100 (25 $^{\circ}\text{C}$)	50	50	.....	15-100 μv	50% for 10 ft-c
	5B	Grown, 2 lead	50	.....	100 (25 $^{\circ}\text{C}$)	20	50	.....	3-10 μv	1 ma for 300 ft-c
	5C	Grown, 2 lead	50	.....	100 (25 $^{\circ}\text{C}$)	5	50	.....	3-10 μv	50% for 40 ft-c
	11A	Nonrect, 2 lead	15	.....	50 (25 $^{\circ}\text{C}$)	4,000 ohms	50	.....	.....	2,000 ohms for 300 ft-c
	11B	Nonrect, 2 lead	15	.....	50 (25 $^{\circ}\text{C}$)	4,000 ohms	50	.....	.....	3,000 ohms for 300 ft-c
	17A	Grown, 2 lead	.....	.....	.....	.....	.....	.....	Be ow 1 μv}	.....
Western Electric	1N85	Grown, 2 lead *	90	1	50	20	85	25	$2 \times 10^{-6} \mu\text{a}$	0.35 $\mu\text{a}/\mu\text{w}$

* Socket type A.
 † Socket type A to H.

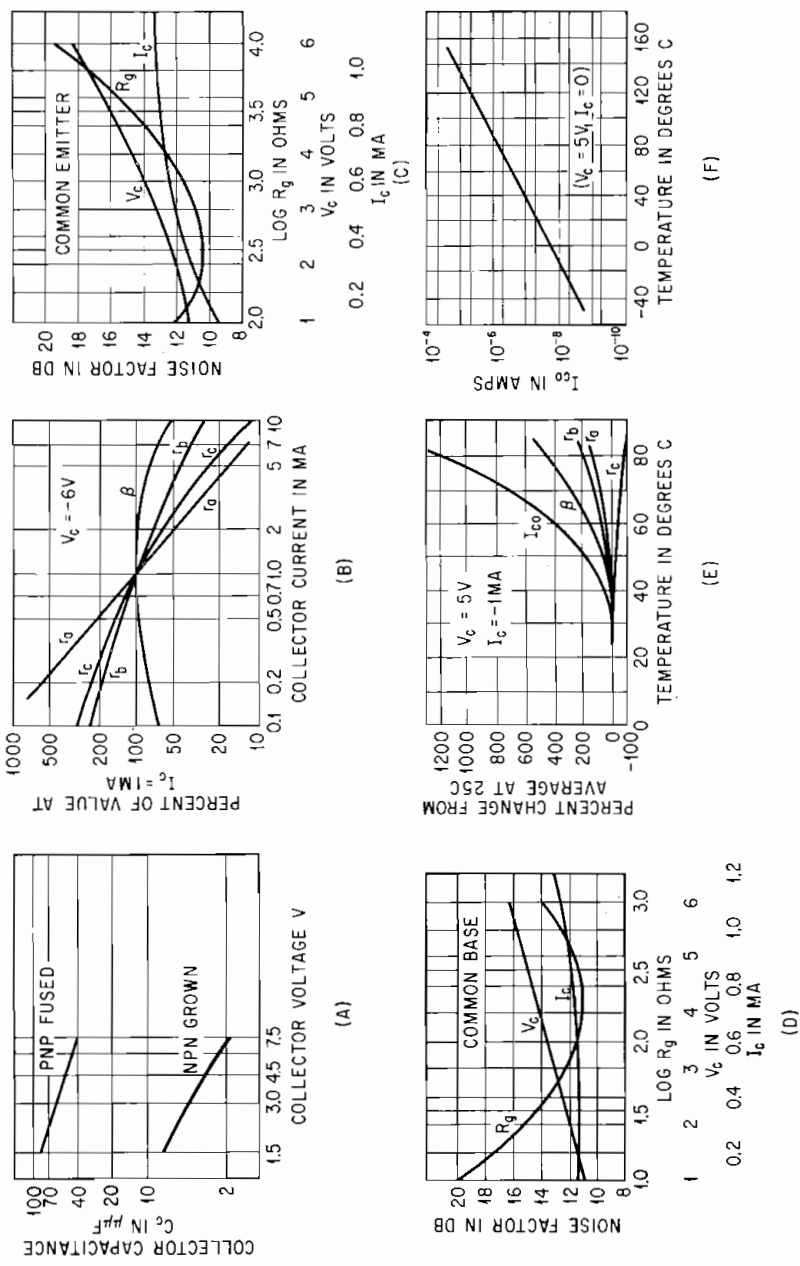


Fig. 9-26. Variation of transistor parameters with operating point (A to D) and ambient temperature (E, F).

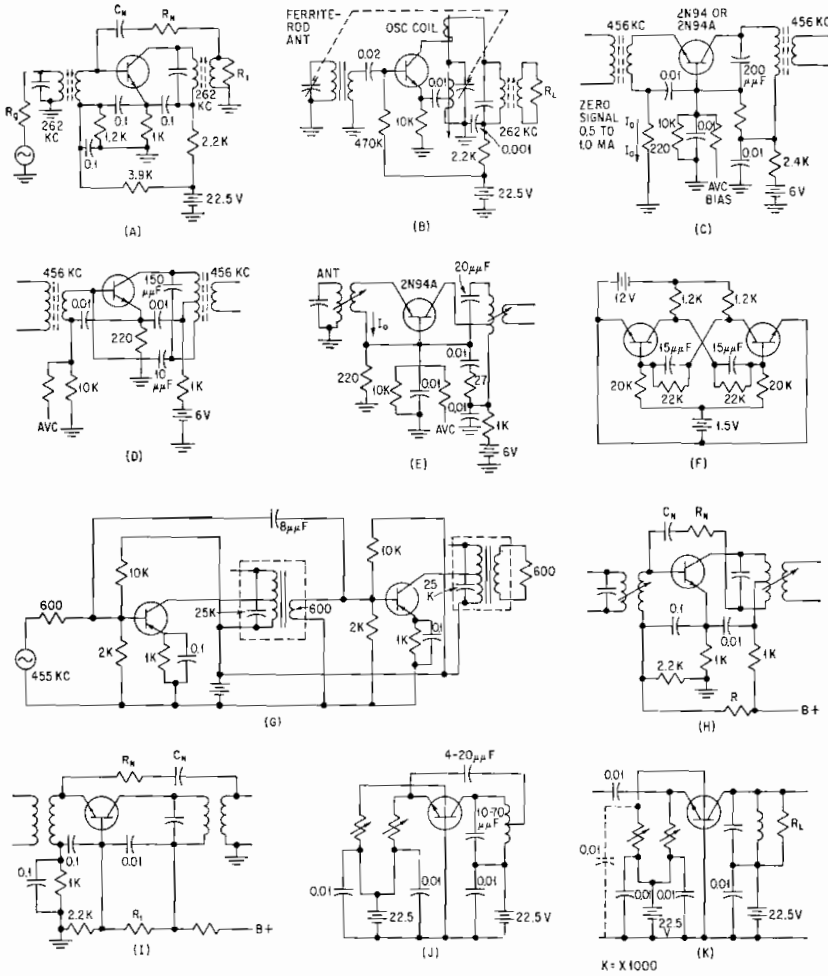


FIG. 9-27. Typical circuits for high-frequency transistors (A to I) and junction tetrode transistors (J, K) referred to in Tables 9-8 and 9-9.

Table 9-13. NAB Data Concerning Tower Failures

Information obtained from 298 television stations during 1958 indicated that 11 towers failed for various reasons. Briefly, 6 towers failed because of high winds, 2 fell during construction, and 3 failed because of structural weakness or faulty design. The following is a detailed breakdown of these 11 failures:

<i>Height, ft</i>	<i>Type</i>	<i>Weather conditions</i>	<i>Cause and comments</i>
826	SS	High wind	Broke in half during high wind
487	SS	97-mph wind	Failed at 125 ft above ground in wind
370	SS	Est. wind 190 knots	Due to gusty turbulence
570	SS	Hurricane "Carol"	Broke off TV tower at 200-ft level, Aug. 31, 1954
1250	G	50- to 60-mph winds	"Tower was completed to the 1,250 point. However, the top set of guys were not completely installed and in the process of tensioning these guys, high winds came up (50 to 60 m.p.h.), the unguyed portion of the tower began to oscillate, finally broke off at the 1150' point and in falling, cut a permanent guy at the 1000' level which in turn caused the entire structure to fail."
100	G	High winds	During process of erecting, 100 ft had been erected and temporary guy lines attached. Under high winds the temporary lines failed
450	SS	40-mile squall	Faulty design of tower
500	G	High level winds	Structural weakness
1262	G	.....	Fell during erection, Feb. 4, 1957
649	G	.....	Due to excessive strain during the process of attempting to lower a 12-bay antenna from it all at once. Actual cause of collapse not known, but it is not believed to have been caused by tower weakness
550	G	.....	Collapsed during construction. Cause not fully determined, but accident was during guy tensioning

Table 9-14. Decimal Equivalents

$\frac{1}{32}$	0.03125	$\frac{17}{32}$	0.53125
$\frac{1}{16}$	0.0625	$\frac{3}{16}$	0.5625
$\frac{3}{32}$	0.09375	$\frac{19}{32}$	0.59375
$\frac{1}{8}$	0.125	$\frac{5}{8}$	0.625
$\frac{5}{32}$	0.15625	$\frac{21}{32}$	0.65625
$\frac{3}{16}$	0.1875	$\frac{11}{16}$	0.6875
$\frac{7}{32}$	0.21875	$\frac{23}{32}$	0.71875
$\frac{1}{4}$	0.25	$\frac{3}{4}$	0.75
$\frac{9}{32}$	0.28125	$\frac{25}{32}$	0.78125
$\frac{5}{16}$	0.3125	$\frac{13}{16}$	0.8125
$\frac{11}{32}$	0.34375	$\frac{27}{32}$	0.84375
$\frac{3}{8}$	0.375	$\frac{7}{8}$	0.875
$\frac{13}{32}$	0.40625	$\frac{29}{32}$	0.90625
$\frac{7}{16}$	0.4375	$\frac{15}{16}$	0.9375
$\frac{15}{32}$	0.46875	$\frac{31}{32}$	0.96875
$\frac{1}{2}$	0.5	1.0	1.0

Table 9-15. Standard Metal Gauges

No.	American or B & S °	U.S. Standard †	Birmingham or Stubs ‡
1	0.2893	0.28125	0.300
2	0.2576	0.265625	0.284
3	0.2294	0.250	0.259
4	0.2043	0.234375	0.238
5	0.1819	0.21875	0.220
6	0.1620	0.203125	0.203
7	0.1443	0.1875	0.180
8	0.1285	0.171875	0.165
9	0.1144	0.15625	0.148
10	0.1019	0.140625	0.134
11	0.09074	0.1250	0.120
12	0.08081	0.109375	0.109
13	0.07196	0.09375	0.095
14	0.06408	0.078125	0.083
15	0.05707	0.0703125	0.072
16	0.05082	0.0625	0.065
17	0.04526	0.05625	0.058
18	0.04030	0.050	0.049
19	0.03589	0.04375	0.042
20	0.03196	0.0375	0.035
21	0.02846	0.034375	0.032
22	0.02535	0.03125	0.028
23	0.02257	0.028125	0.025
24	0.02010	0.025	0.022
25	0.01790	0.021875	0.020
26	0.01594	0.01875	0.018
27	0.01420	0.0171875	0.016
28	0.01264	0.015625	0.014
29	0.01126	0.0140625	0.013
30	0.01003	0.0125	0.012
31	0.008928	0.0109375	0.010
32	0.007950	0.01015625	0.009
33	0.007080	0.009375	0.008
34	0.006350	0.00859375	0.007
35	0.005615	0.0078125	0.005
36	0.005000	0.00703125	0.004
37	0.004453	0.006640625	
38	0.003965	0.00625	
39	0.003531		
40	0.003145		

° Used for copper, brass, aluminum, etc.; nonferrous alloy sheets, rods, and wire.

† Used for iron, steel, nickel, and ferrous alloy materials.

‡ Used for seamless tubes and by some manufacturers for brass and copper materials.

Charts and Graphs

Table 9-16. Drill Sizes

<i>Number</i>	<i>Will clear screw</i>	<i>Brass, iron, steel tapping *</i>
1		
2	12-24	
3	.....	14-24
4	12-20	
5		
6		
7		
8		
9		
10	10-32	
11	10-24	
12		
13		
14		
15		
16	.....	12-24
17		
18	8-32	
19	.....	12-20
20		
21	.....	10-32
22		
23		
24		
25	.....	10-24
26		
27		
28	6-32	
29	.....	8-32
30		
31		
32		
33	4-36, 4-40	
34		
35	.....	6-32
36		
37		
38		
39	3-48	
40		
41		
42	.....	4-36, 4-40
43	2-56	
44		
45	.....	3-48
46		
47		
48		
49	.....	2-56
50		
51		
52		
53		
54		

* For tapping plastic, bakelite, lucite, hard rubber, micalex, etc., use one size larger drill.

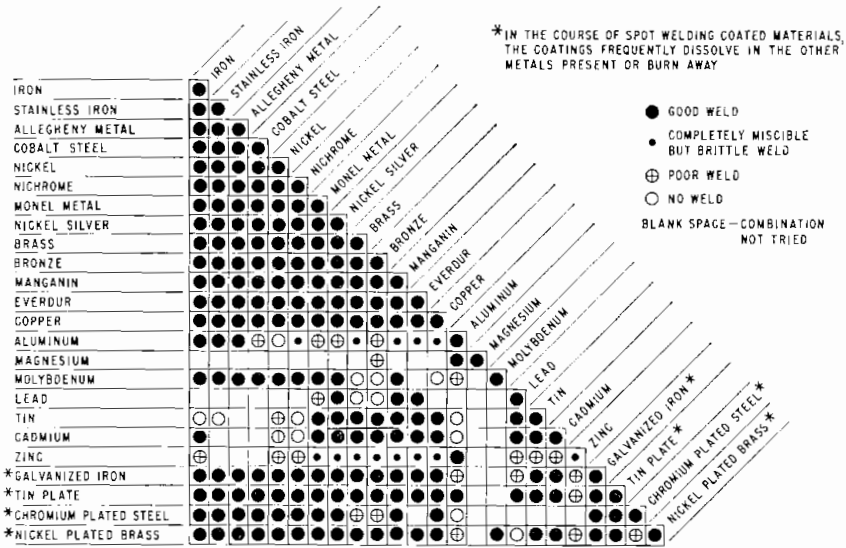


FIG. 9-28. The welding characteristics of some 250 combinations of metals.

STANDARD SYMBOLS FOR ELECTRONICS

The most-used schematic symbols for electronic components are collected here for convenient reference, as abstracted from the 54-page American Standards Association publication Y32.2-1954, "Graphical Symbols for Electrical Diagrams" and (for transistors) from MIL-STD-15A, "Military Standard Electrical and Electronic Symbols." (See Figs. 9-29a, 9-29b, and 9-29c.)

Symbols may have any orientation, size, and line weight. The open-circle terminal symbol can be added to leads if desired. Arrowheads can be either filled or open unless otherwise noted. Electrically actuated devices are normally shown in the power-off position. One-line symbolism has been adopted for waveguide diagrams, as indicated for microwave symbols.

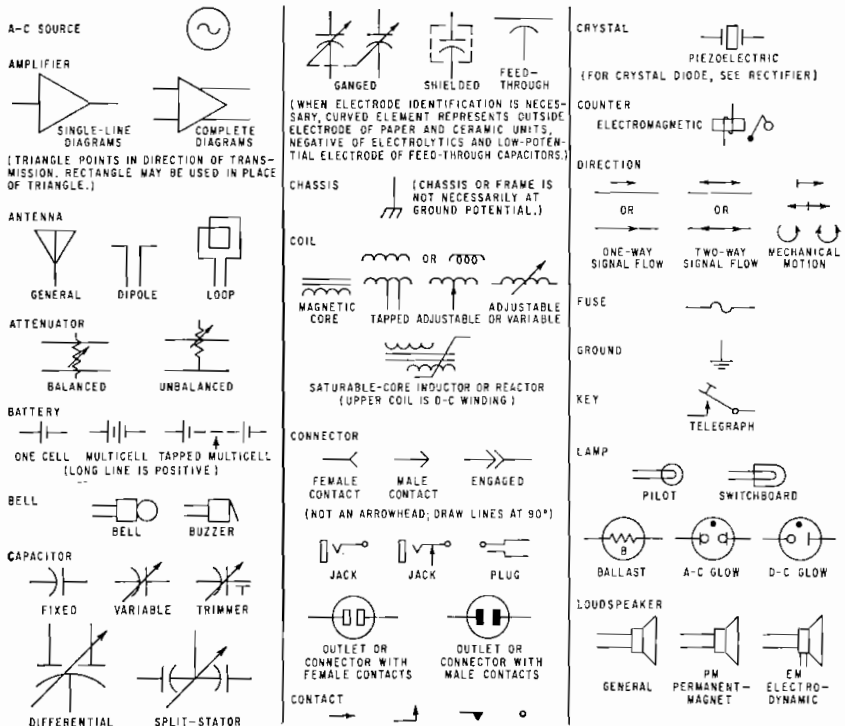


Fig. 9-29a

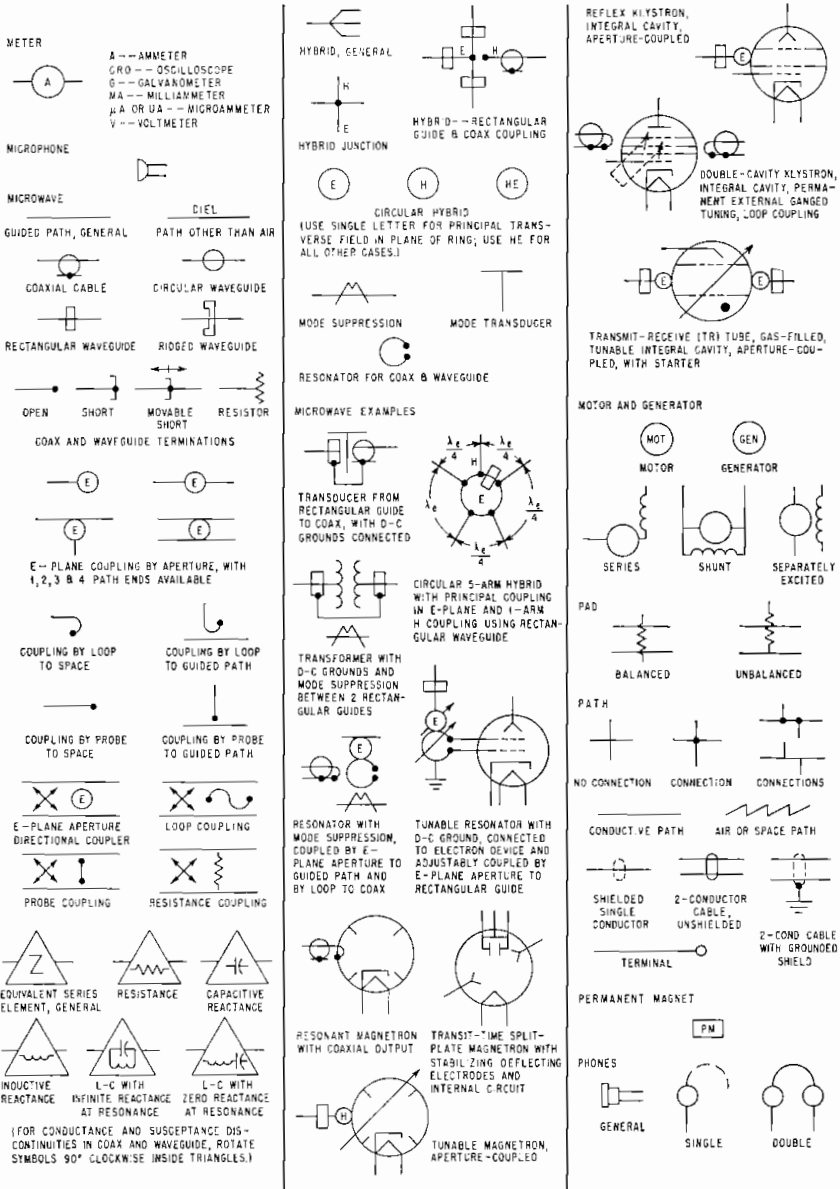


FIG. 9-29b

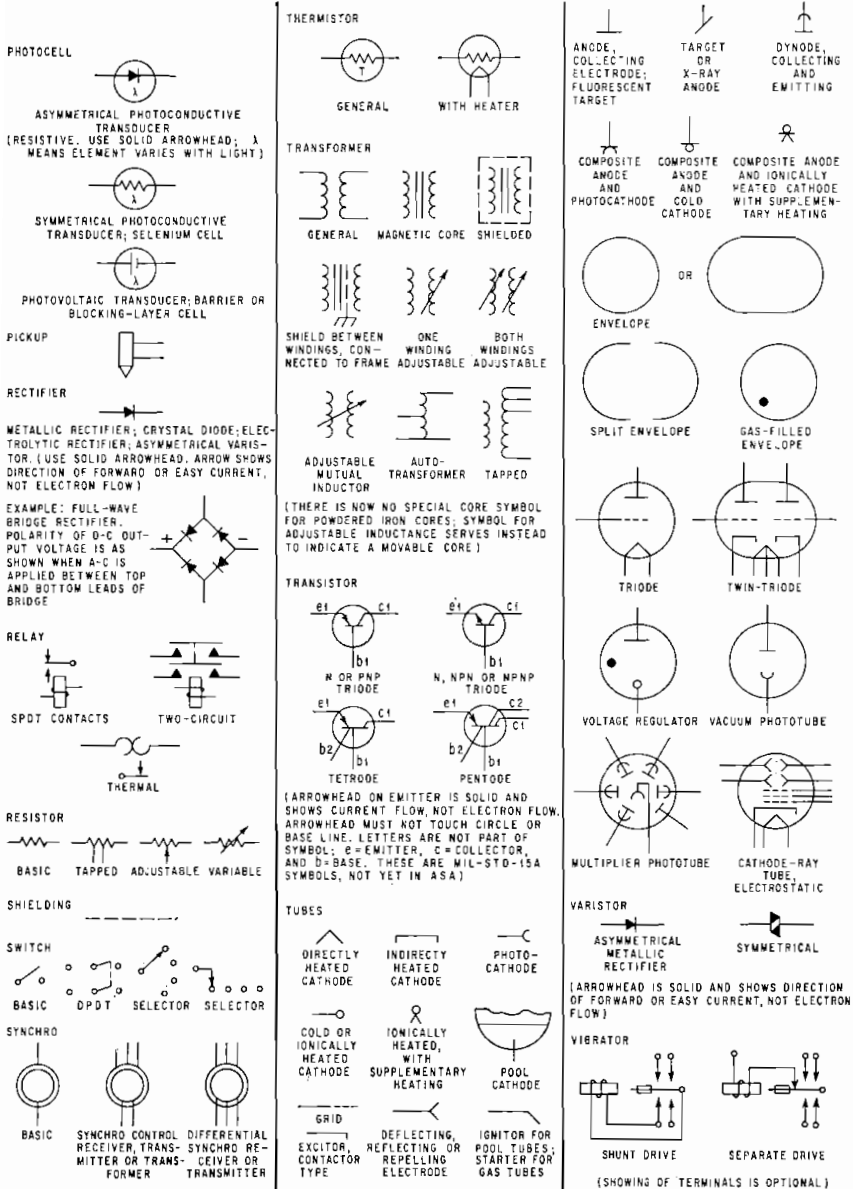


Fig. 9-29c

Table 9-17. Standard Telephone-cable Color Code

Pair No.	Color	Mate	Pair No.	Color	Mate
1	Blue	White	26	Blue White	Red
2	Orange	White	27	Blue Orange	Red
3	Green	White	28	Blue Green	Red
4	Brown	White	29	Blue Brown	Red
5	Slate	White	30	Blue Slate	Red
6	Blue White	White	31	Orange White	Red
7	Blue Orange	White	32	Orange Green	Red
8	Blue Green	White	33	Orange Brown	Red
9	Blue Brown	White	34	Orange Slate	Red
10	Blue Slate	White	35	Green White	Red
11	Orange White	White	36	Green Brown	Red
12	Orange Green	White	37	Green Slate	Red
13	Orange Brown	White	38	Brown White	Red
14	Orange Slate	White	39	Brown Slate	Red
15	Green White	White	40	Slate White	Red
16	Green Brown	White	41	Blue	Black
17	Green Slate	White	42	Orange	Black
18	Brown White	White	43	Green	Black
19	Brown Slate	White	44	Brown	Black
20	Slate White	White	45	Slate	Black
21	Blue	Red	46	Blue White	Black
22	Orange	Red	47	Blue Orange	Black
23	Green	Red	48	Blue Green	Black
24	Brown	Red	49	Blue Brown	Black
25	Slate	Red	50	Blue Slate	Black

NOTE: The last pair in all cables is a red with white mate, viz.,

6-pair cable	6th pair	Red	White
11-pair cable	11th pair	Red	White
16-pair cable	16th pair	Red	White
26-pair cable	26th pair	Red	White
51-pair cable	51st pair	Red	White

RESISTOR COLOR CODE

The chart shown in Fig. 9-30a indicates the appropriate significant figure of resistance and the multiplier. The fourth colored band, if any, indicates the tolerance. If none is shown, the tolerance is 20 per cent, with other tolerances as follows: gold, 5 per cent; silver, 10 per cent.

CAPACITOR COLOR CODE

The value of capacitors is similarly shown by colored bands or dots as indicated in Figs. 9-30a and 9-30b. Note that the bands and dots (for disc ceramics) apply for the ceramic-type capacitors, while the various dot systems are applicable to mica- and paper-type condensers. The various systems that have been used in recent years are included, even though some of them are obsolete. The tolerances are indicated by the appropriate colored dot, and the voltage rating is obtained by multiplying the value of the appropriate dot by 100.

STANDARD COLOR CODE — RESISTORS AND CAPACITORS

INSULATED UNINSULATED COLOR	FIRST RING BODY COLOR FIRST FIGURE	SECOND RING END COLOR SECOND FIGURE	THIRD RING DOT COLOR MULTIPLIER
BLACK	0	0	NONE
BROWN	1	1	0
RED	2	2	00
ORANGE	3	3	,000
YELLOW	4	4	0,000
GREEN	5	5	00,000
BLUE	6	6	,000,000
VIOLET	7	7	0,000,000
GRAY	8	8	00,000,000
WHITE	9	9	000,000,000

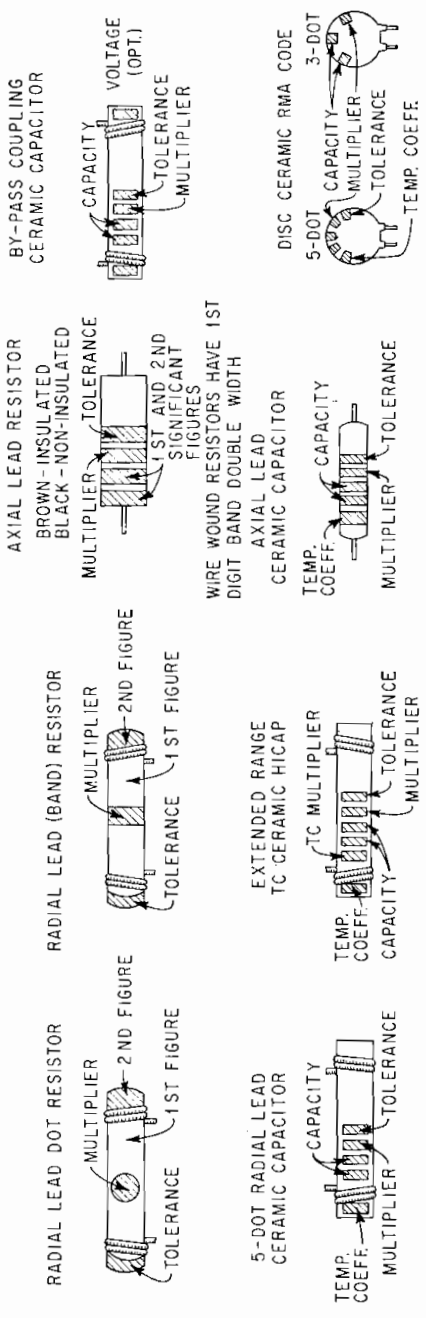
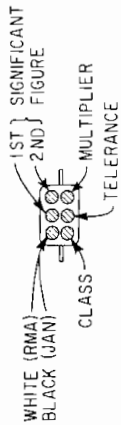


Fig. 9-30a. Standard color code—resistors and capacitors.

MOLDED MICA TYPE CAPACITORS

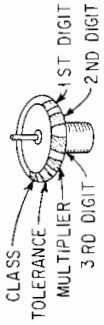
CURRENT STANDARD CODE



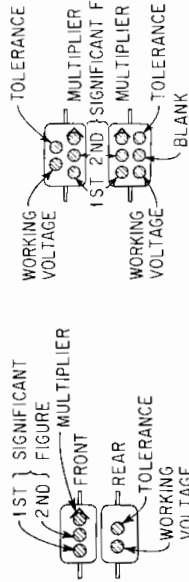
RMA 3-DOT (OBSOLETE)
RATED 500 W.V.D.C. ± 20% TOL.



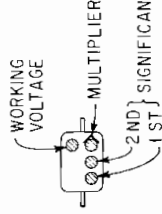
BUTTON SILVER MICA CAPACITOR



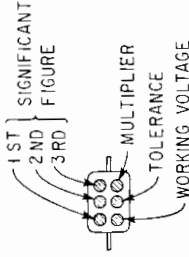
RMA (5-DOT OBSOLETE CODE)



RMA 4-DOT (OBSOLETE)

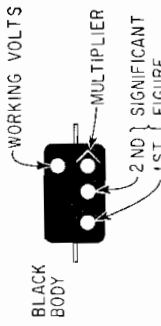


RMA 6-DOT (OBSOLETE)

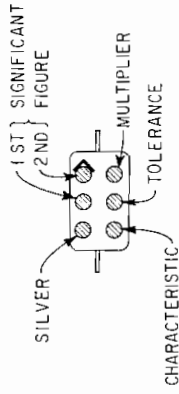


MOLDED PAPER TYPE CAPACITORS

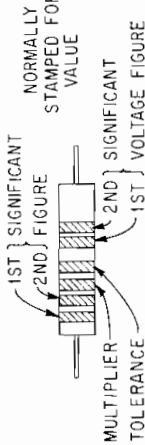
MOLDED FLAT CAPACITOR
COMMERCIAL CODE



JAN. CODE CAPACITOR



TUBULAR CAPACITOR



A 2 DIGIT VOLTAGE RATING INDICATES MORE THAN 900 V.
ADD 2 ZEROS TO END OF 2 DIGIT NUMBER.

Fig. 9-30b. Standard color code.

INDEX

- ACC/AGA recommendations on antenna structures, 1-352 to 1-371
background, 1-353
beacons, applicable documents, 1-360, 1-365
 mechanical construction, 1-362, 1-363, 1-368, 1-369
 optical systems, 1-361, 1-362, 1-366, 1-367
 quality assurance, 1-363, 1-364, 1-369
 requirements, 1-360, 1-361, 1-365, 1-366
lighting system, detail requirements, 1-359
development and installation, 1-354
installation requirements, 1-359, 1-364, 1-365
operation, 1-359, 1-360, 1-365
operational requirements, 1-359, 1-364
purpose, 1-359, 1-364
marking system, development and installation, 1-354
 engineering notes on, 1-357, 1-358
 operational requirements, 1-356
 purpose of, 1-356
 rotating disk hazard marker, 1-358
 rotating disk, sleeve and disk support, 1-358
 rotating disk, substructure for, 1-358
 technical requirements, 1-356, 1-357
problem, 1-352
program of development, assessment and evaluation, 1-353, 1-354
 assessment by engineers, 1-354
 assessment by pilots in controlled tests, 1-355
 assessment by pilots in uncontrolled tests, 1-354, 1-355
 assessment by tower owners, 1-354
 evaluation of questionnaire data, 1-355, 1-356
questionnaires used by Committee, 1-369 to 1-372
recommendations, 1-352, 1-353
tower selection, 1-354
- Acoustical design for rooms, 6-23 to 6-42, 6-57, 6-58
acoustic treatment guide, 6-40
convex cylindrical panels, sectional dimensions for, 6-42
convex wood panels, 6-29 to 6-32
 direct and reflected response in interference measurements, 6-31
 interference between direct and reflected waves, 6-31
- Acoustical design for rooms, convex wood panels, polar distribution from, 6-30
vibrating, growth and decay curve of, 6-32
 definitions, 6-25, 6-41, 6-42
flat panels, direct and reflected response in interference measurements, 6-31
 interference between direct and reflected waves, 6-31
 polar distributions from, 6-30
good acoustics, 6-25
interference phenomena, 6-32
noise, exclusion of, 6-33
objectionable shapes, 6-32
optimum size of studio, 6-26
orchestra shell, 6-33
parallel reflecting surfaces, effect of, 6-27
physical design factors, 6-25
polycylindrical wood panels, 6-32, 6-33
 reverberation time of listening studio, 6-32
preferred studio dimensions, 6-28
projection booth, 6-33 to 6-36
 sound-insulated window for, 6-34
 sound-insulating wall construction, 6-36
 sound-retarding door for, 6-35
references, 6-41
requirements, 6-25
reverberation, 6-25, 6-26
room resonances, 6-27
shape of reflecting surfaces, 6-27 to 6-30
shape of studio, 6-27
small combination studio, 6-37 to 6-40
 arrangement of, 6-37
 ceiling, 6-38
 exclusion of air-borne noise, 6-39
 exclusion of building vibration, 6-39
 exclusion of external noise, 6-39
 exclusion of noises from ventilation ducts, 6-39
 floor, 6-38
 loudspeaker chamber, 6-39
 loudspeaker screen, 6-39
 projection booth, 6-39, 6-40
 proportions of studio, 6-37
 purpose of studio, 6-37
 recording booth, 6-39, 6-40
 shape of studio, 6-38
 size of studio, 6-37
 sound-absorption treatment, 6-39
 vestibule, 6-40
 walls, 6-35
small film-recording studio, 6-38

- Acoustical design for rooms, small review room, 6-38
 sound absorption, 6-30
 optimum, 6-29
 sound diffusion, 6-27 to 6-30
 structural resonance, 6-27
- Adjustments of standard broadcast antenna structures (see Standard broadcast antenna structures, adjustments)
- Aeolight, defined, 1-385, 1-386
- Air Coordinating Committee (see ACC/AGA recommendations on antenna structures)
- Air-dielectric cable (see Transmission lines)
- Air hazard criteria for antenna structures, 1-327, 1-345 to 1-347, 1-351
 Federal airways traffic, adjacent to airways, 1-330, 1-331
 on airways, 1-330
 flyways and military corridors, 1-331, 1-332
 heliports, 1-330
 low altitude intercity routes, 1-331
 military and joint use airports, 1-330
 public use civil airports, approach and landing minimums, 1-329, 1-330
 classification of airports, 1-328
 obstruction limit surfaces, 1-328, 1-329
- AM stations (see Standard broadcast stations)
- American Standards Association, standards of, 1-407
- AM/FM relay systems (see Relay systems)
- AM/FM stations, automatic logging, 8-108 to 8-122
 auxiliary broadcast services (see Relay systems)
 CONELRAD, 8-123 to 8-156
 facsimile used, 8-192 to 8-197
 frequencies, 1-19 to 1-22
 lightning protection, 8-157 to 8-165
 Magniphase protection system, 8-160 to 8-165
 maintenance of equipment, 8-166 to 8-191
 parameters, control of (see Automatic logging)
 proof of performance, 8-198 to 8-214
 relay systems (see Relay systems)
 remote control (see Remote control of broadcast stations)
 remote pickup (see Remote-pickup broadcast systems)
 special effects, 6-171 to 6-195
 stereophonic broadcasting, 8-254 to 8-261
 studio facilities (see AM/FM studio facilities)
 tuner for mobile remote-pickup broadcast systems, 7-58 to 7-60
- AM/FM studio facilities, acoustics (see Acoustical design for rooms)
 combined studio and transmitter facilities, 6-3
 control room, 6-4
 control room-announce booth, 6-20 to 6-23
 acoustical panels, mounting of, 6-24
 construction, 6-21
 design of, 6-20
 equipment arrangement, 6-23
 AM/FM studio facilities, control room-announce booth, isolation, 6-21
 location, 6-20
 microphone requirements, 6-23
 microphone response curve, 6-24
 reverberation control, 6-21, 6-22
 ventilation, 6-23
 ductwork, 6-4
 equipment, planning of, 6-4 to 6-20
 house monitoring, 6-4
 large studio, 6-13 to 6-20
 equipment list for, 6-19 to 6-20
 floor plan of, 6-14
 jack panels for, 6-18
 main control room for, 6-16
 rack layout for, 6-17
 subcontrol block diagram for, 6-15
 technical facilities of, 6-17 to 6-20
 liveness in broadcasting (see Program pickups)
 maintenance of equipment (see Maintenance of equipment)
 medium-sized studio, 6-10 to 6-13
 automatic-turntable system, block diagram of, 6-13
 equipment list, 6-10
 floor plan of, 6-9
 jack panel for, 6-12
 rack layout for, 6-12
 record-audition system, block diagram of, 6-13
 system diagram of, 6-11
 technical facilities of, 6-12, 6-13
 microphones (see Microphones)
 program pickups (see Program pickups)
 small studio, 6-6 to 6-10
 equipment list for, 6-6
 floor plan of, 6-5
 jack panel for, 6-7
 rack layout for, 6-7
 system diagram of, 6-8
 technical facilities of, 6-7 to 6-10
 special effects, 6-171 to 6-195
- Anchor for antenna structures, 2-73 to 2-76
- Announce booth (see AM/FM studio facilities, control room-announce booth)
- Antenna structures, abandoned towers, 1-326
- ACC/AGA recommendations (see ACC/AGA recommendations on antenna structures)
- aeronautical study of, 1-312, 1-316, 1-317
- air hazard criteria (see Air hazard criteria for antenna structures)
- airspace control surfaces, 1-348, 1-350
- anchors for, 2-73 to 2-76
- assembly of, 2-44 to 2-46
 bolts, 2-45
 number of faces, 2-45
 preassembly by welding, 2-45, 2-46
- atomic blasts, effect of, 2-66, 2-67
- automatic logging, 8-110
- beacons (see ACC/AGA recommendations on antenna structures)
- beverage antenna, 8-134 to 8-137
- bonding, jumper type, 2-71
 weld type, 2-71

- Antenna structures, charts and graphs, coupling and tuning capacitor, **9-20, 9-21**
 distance to horizon vs. height, **9-32**
 tower failures, NAB data concerning, **9-54**
 climbing facilities, **2-50**
 CONELRAD, **8-133 to 8-137**
 configuration, **2-46 to 2-48**
 effect of fixed base on guyed tower, **2-46**
 fixed-base tower, **2-47**
 rigid-frame trusses, **2-47, 2-48**
 straight base vs. pivot on guyed tower, **2-46**
 tapered-base tower, **2-47**
 tower weight, **2-46**
 uniform-cross-section radiator, **2-46**
 connections, rigid transmission line, **2-199**
 cost of, **2-41 to 2-43**
 factors increasing, **2-41**
 coupling and tuning capacitor, charts relating to, **9-20, 9-21**
 definitions, **1-312 to 1-315, 2-221**
 design of (*see* Design of antenna structures)
 directional (*see* Directional antennas)
 distance to horizon vs. height, **9-32**
 earthquake loading, effect of, **2-66**
 elevators for, **2-50, 2-51**
 erection of, factors influencing, **2-79**
 insurance during, **2-79, 2-80**
 farm areas, **1-325, 1-326**
 control of receiving towers, **1-326**
 control of transmitting towers, **1-325, 1-326**
 provision of, **1-332 to 1-335**
 Federal Communications Commission rules, **1-312 to 1-324**
 FM (*see* FM antenna structures)
 form to describe proposed structures, **1-312, 1-315**
 foundations, **2-72 to 2-78**
 galvanizing, **2-51, 2-52**
 grounding system, **2-72**
 guys (*see* Guys for antenna structures)
 icing, effect of, **2-65, 2-66**
 inspection of, **2-78, 2-79**
 checkoff list for, **2-78, 2-79**
 insulators for, **2-67 to 2-70**
 lighting of (*see* Lighting, antenna structures)
 lightning, effect of, **2-72**
 marking (*see* Marking of antenna structures)
 materials used, **2-43, 2-44**
 cylindrical shape, **2-44**
 shape of, **2-44**
 steel angle shape, **2-44**
 multiplex, FM, **2-216, 2-217**
 standard broadcast, **2-247**
 standard broadcast, directional, **2-101 to 2-104, 2-158 to 2-165**
 television, **2-247**
 new, specific criteria to be used, **1-324 to 1-351**
 proposed amendments compared to present rulings, **1-335 to 1-338**
 proximity-effect curve, application of, chart relating to, **9-23**
- Antenna structures, ray paths (*see* Wave propagation, ray paths)
 receiving, to measure field strengths, **2-284**
 remote-pickup broadcast systems, **7-30, 7-31, 7-42 to 7-45, 7-47, 7-48, 7-52**
 runway approach zone, standard, **1-349, 1-350**
 self-supporting towers, vs. guyed towers, **2-42, 2-43**
 soils appropriate for, **2-72, 2-73**
 standard broadcast (*see* Standard broadcast antenna structures)
 Stations WWV and WWVH, **1-428, 1-429**
 steel guy material, fatigue, **2-54**
 TD-2 System, **4-24**
 television (*see* Television antenna structures)
 terminal, definition, **2-221**
 tower failures, NAB data concerning, **9-54**
 types of antennas, flange antenna attachment, **2-49**
 ladder mounted on tower face, **2-49**
 ladder steps welded to tower structure, **2-49**
 side antenna attachment, **2-48**
 step bolts on cylindrical mount, **2-49**
 telescopic antenna mast attachment, **2-48**
 UHF (*see* UHF antenna structures)
 television translators (*see* UHF television translators, antenna structures)
 unused towers, **1-326**
 VHF (*see* VHF antenna structures)
 wave propagation (*see* Wave propagation)
 winds, effect of (*see* Winds, effect on antenna structures)
- Applications, assignment, **1-5, 1-6**
 construction permit, **1-4, 1-5**
 licenses (*see* Licenses)
 subsidiary communications authorization, **1-6**
 television stations, **1-36, 1-191 to 1-196**
 transfer to corporation holding, **1-6**
 transmission by remote control, **1-6**
- ASA, standards of, **1-407**
- Atmospheric effects (*see* Wave propagation)
- Atomic blasts, effect on antenna structures, **2-66, 2-67**
- Attenuation networks (*see* Symmetrical attenuation networks)
- A2 System (*see* Network facilities, A2 System)
- Audio special effects, **6-171 to 6-195**
 bat crack, electronic, **6-187, 6-188**
 bells, **6-180**
 boing, **6-187**
 buzzers, **6-180**
 chimes, **6-180, 6-181**
 electronic, **6-188, 6-189**
 door, **6-189, 6-190**
 squeak, wooden, **6-192**
 electronic gun, **6-175 to 6-177**
 method explained, **6-176, 6-177**
 problems associated with, **6-175, 6-176**
 floor boards, **6-193, 6-194**
 footsteps, on gravel, **6-193**
 on stone slab, **6-193**

- Audio special effects, footsteps, on wooden floor board, 6-193
- Foster gun and Foster remote control, 6-176
- block diagram of, 6-175
 - glass crash, 6-195
 - horses' hooves, 6-190, 6-192
 - manual sound effects, 6-189 to 6-195
 - oscillators, 6-188
 - prop table, 6-195
 - reverberation, 6-180 to 6-184
 - acoustical, 6-181
 - bronze sheet, 6-182, 6-183
 - definitions, 6-180
 - echo chamber, 6-181
 - Engineering Department CBS Report E 578-M, 6-181, 6-182
 - mechanical, 6-182, 6-183
 - patching echo chamber, 6-181
 - piano echo, 6-182, 6-183
 - reverberation time, 6-181
 - room dimensions, 6-182
 - room location, 6-181
 - room shape, 6-182
 - room volume, 6-181
 - sound isolation, 6-181
 - tape echo, 6-182, 6-183
 - sink, 6-190, 6-191
 - electric, block diagram of, 6-191
 - sound effects console, 6-171 to 6-175
 - amplifiers, 6-172
 - block diagram of, 6-173
 - circuit plan for connection to control room, 6-174
 - pickups, 6-172
 - turntables, 6-171, 6-172
 - stairs, 6-194, 6-195
 - tape devices, 6-184 to 6-186
 - SFXer Binnie and Hartman, 6-184, 6-185
 - tape repeater, 6-186
 - telephone, bell ringing, 6-177
 - busy signal, 6-179
 - circuit of electronic telephone with transistors, 6-178
 - circuit of regular telephone, 6-177
 - circuits for two-way telephone filter effect, 6-179
 - clicks, 6-177
 - effects using transistors, 6-179
 - filter, 6-179
 - ringing in line or at other end, 6-177
 - window, 6-192, 6-193
- Audio transmission standards for television, 8-250 to 8-253
- audio signal, modification of, 8-251
 - Audio Transmission Level Study, 8-250, 8-251
 - automatic gain control, 8-252
 - bandwidth restriction, 8-251
 - CBS revised standards, 8-252, 8-253
 - implementation of a program, 8-252
 - irritating sounds, 8-251
 - listener reaction, 8-251
 - loudness discrepancies, reasons for, 8-250, 8-251
 - program peaking practices, 8-250, 8-251
- Audio transmission standards for television, recommendations, 8-251, 8-252
- reverberation, 8-251
 - strident delivery, 8-251
 - volume compression, 8-251
- Automatic gain control, 8-252
- Automatic logging, 8-108 to 8-122
- alarm light panel, 8-111
 - antenna structures, 8-110
 - audio equipment, 8-110
 - equipment, 8-110 to 8-122
 - frequency stability, 8-109, 8-110
 - history of, in England, 8-108
 - local operation, 8-122
 - logger-receiver, alarm circuits, 8-120 to 8-122
 - schematic diagram of, 8-121
 - measuring circuits, 8-120
 - rear view of, 8-118
 - schematic diagram of circuits, 8-119
 - view of printing mechanism, 8-118
 - view of selective alarm adjustable cam switches, 8-117
 - view of synchronizing gears, 8-118
- logger-transmitter, block diagram of, 8-112
- control circuit, 8-115, 8-116
 - input circuits, 8-111 to 8-115
 - input circuits, schematic diagram of, 8-113
 - ratio-computer circuit, 8-115
 - rear view of, 8-114
 - side view of, 8-115
 - signal-measuring circuit, 8-115, 8-116
 - telemeter circuit, 8-116
- philosophy of, 8-108 to 8-111
- power output, 8-110
- print-wheel synchronizing, 8-116
- ratio computer used to indicate tower RF current ratios, 8-114
- recording instrument panel, 8-111
- tower-light alternating current, schematic for, 8-120
- transmitter selector switch, 8-116, 8-117, 8-120
- video equipment, 8-110
- Auxiliary broadcast services (*see* Relay systems)
- Aviation, ACC/AGA recommendations (*see* ACC/AGA recommendations on antenna structures)
- air hazard criteria for antenna structures (*see* Air hazard criteria for antenna structures)
- airspace control surfaces, 1-348, 1-350
- airspace panel procedures, 1-327, 1-328
- booster and satellite stations, 1-328
- civil airfields with U.S. Army, Navy, Air Force and Air National Guard on tenant status, 1-339 to 1-344
- new airports, specific criteria to be used, 1-324 to 1-351
- runway approach zone, standard, 1-349, 1-350
- U.S. Air Force bases permitting civil use, 1-338
- U.S. Navy bases permitting civilian use, 1-344, 1-345

- Bandwidth, color television, 5-5
 diagram illustrating relationship with picture detail, 5-5
 FM antenna structures, 2-216, 2-217
 FM transmitters, 3-35, 3-36
 multiplex service for FM stations, definition of, 8-19
 distortion measurements on main carrier, 8-25
 panoramic of main carrier relative to first sidebands, 8-25
 restriction for audio transmission, television standards, 8-251
 television antenna structures, 2-242, 2-243
 television microwave system, 4-71
(See also Frequencies)
- Beacons for antenna structures (see ACC/AGA recommendations for antenna structures)
- Bell Telephone System network facilities, areas served by, 4-5
 arrangements of, 4-8 to 4-13
 differential audio delay, 4-11
 functions of major corporate units, 4-4, 4-5
 grades of service, audio, 4-11, 4-12
 video, 4-12
 Long Lines Department, 4-5, 4-6
 network layouts, 4-10
 network sections, 4-8, 4-9
 operation of, 4-6
 operation orders, 4-10
 reversible operation, 4-9
 round-robin operation, 4-9, 4-10
 routes, 4-7, 4-8
 message service, 4-7
 separation of audio and video networks, 4-10
 service preferences, 4-12
 special services, 4-13
(See also Network facilities)
- Beverage antenna, CONELRAD, 8-134 to 8-137
- Bonding for antenna structures, jumper type, 2-71
 weld type, 2-71
- Bridging loss at various impedance ratios, 9-12
- Broadcast stations, AM (see Standard broadcast stations)
 AM/FM (see AM/FM stations)
 auxiliary (see Relay systems, broadcast)
 citizens, 1-27, 1-28
 developmental, 1-255, 1-267 to 1-270
 experimental, 1-254 to 1-297
 FM (see FM stations)
 international (see International broadcasting stations)
 motion picture, 1-25 to 1-27
 radio, 1-33 to 1-252
 remote pickup (see Remote-pickup broadcast systems)
 standard (see Standard broadcast stations)
- Buildings, effect of on wave propagation, 2-19 to 2-22
- Cable (see Transmission lines)
- Camera, color-television, 5-9, 5-57 to 5-65
- Camera chains, maintenance of, horizontal deflection, 8-176
 operating potentials of picture tube, 8-176
 picture amplifiers, 8-176
 tube checks, 8-176, 8-177
 vertical deflection, 8-176
- Capacitor color code, 9-61 to 9-63
- Carrier systems (see Network facilities)
- C.C.I.R., background of organization, 1-396, 1-397
 international exchange of programs, standards, 1-396 to 1-407
- Charts and graphs, 9-3 to 9-63
 antenna structures, coupling and tuning capacitor, 9-20, 9-21
 distance to horizon vs. height, 9-32
 tower failures, NAB data concerning, 9-54
 bridging loss at various impedance ratios, 9-12
 capacitor color code, 9-61 to 9-63
 coaxial-line impedance chart, 9-19
 dielectric constants, 9-20
 decibels, 9-3 to 9-6
 db vs. current, voltage, power ratio, 9-6
 dbm vs. watts, 9-6
 transformation of kilowatts to dbk, 9-5
 transformation of microvolts to dbu, 9-5
 decimal equivalents, 9-54
 drill sizes, 9-56
 electrical degrees converted to feet, or reverse, slide-rule short cut, 9-34
 electronics, standard symbols for, 9-58 to 9-60
 eye, human, fluorescent lamp spectral distribution, 9-32
 frequency vs. L , C , XL/XC , 9-16 to 9-18
 luminosity curve of, 9-32
 tungsten lamp spectral distribution, 9-32
 great-circle distance and bearing calculations, 9-34, 9-35
 sheet for, 9-35
 heater surge chart, 9-33
 L matching networks, 9-26 to 9-30
 Smith charts for, 9-27 to 9-30
 length, conversion table for units of, 9-39
 metal gauges, standard, 9-55
 metals, welding characteristics of, 9-57
 microphone distances in liveness broadcasting, nomograph for, 9-11
 microphone nomograph, 9-14, 9-15
 parallel-line wires, characteristic impedance of, 9-26
 parallel-T networks, example, 9-12
 nomograph, 9-12, 9-13
 summary, 9-12
 proximity-effect curve, application of, 9-22, 9-23
 derivation, 9-22
 tower heights, 9-23
 radiators, guyed, average characteristics for, 9-19
 resistive pads, 9-10
 resistor color code, 9-61 to 9-63

- Charts and graphs, symmetrical attenuation networks, resistance values of, 9-7 to 9-12
 higher pad series leg resistances, 9-7
 lower pad series leg resistances, 9-8
 series resistance, 9-9
 shunt or transverse resistor, 9-8
 transverse resistance, 9-9
- telephone-cable color code, 9-61
- transistors, 9-39 to 9-53
 grown *n-p-n* junction tetrode, 9-48, 9-49
 grown *n-p-n* junction tetrode, circuitry of, 9-53
 high-frequency, 9-46, 9-47
 high-frequency, circuitry of, 9-53
 high-power units, 9-41, 9-48, 9-49
 low-power, junction triode, 9-42 to 9-45
 parameter conversion formulas, 9-50
 parameter variation, 9-52
 phototransistors, 9-51
 point contact, 9-50, 9-51
 temperature-conversion chart, 9-36 to 9-38
 temperature effects, 9-40, 9-41
 transistor sockets, 9-50
- volume level to power and voltage conversion, 9-6
- waveguide loss charts, 9-24 to 9-26
 nominal internal dimensions for standard hollow rectangular waveguides, 9-24
- waveguides, comparison with open-wire solid-dielectric lines, 9-31
- Circuits, remote control of, 8-102 to 8-105
- Citizens radio service, 1-27, 1-28
 eligibility for use of, 1-28
 frequencies, 1-28
 tolerances, 1-30
 uses of, by broadcasters, 1-27, 1-28
- Clamping, television, 4-153 to 4-155
- Coaxial cable (*see* Transmission lines)
- Coaxial-cable carrier systems (*see* Network facilities, coaxial-cable carrier systems)
- Coaxial-line impedance chart, 9-19
 dielectric constants, 9-20
- Color code, capacitor, 9-61 to 9-63
 resistor, 9-61 to 9-63
 telephone-cable, 9-61
- Color television, band shaping, 5-12
 bandwidth, 5-5
 diagram illustrating relationship with picture detail, 5-5
 color camera, block diagram of, 5-9
 color-camera performance, 5-57 to 5-65
 amount of scan, 5-62
 beam alignment, 5-61
 beam landing, 5-61
 centering, 5-61, 5-62
 color balance, 5-62, 5-63
 final, 5-64
 focus tracking, 5-62
 G-5 control, 5-60
 gain controls, 5-63, 5-64
 image accelerator, 5-61
 image-orthicon operation, 5-59 to 5-64
 image-orthicon pickup tube, diagram of, 5-59
 lighting, 5-64, 5-65
 matching transfer characteristics, 5-63
- Color television, color-camera performance, multiplier focus, 5-60
 objective-lens iris setting, 5-58
 pedestals, 5-64
 Q controls, 5-57, 5-58
 registration, 5-61
 shading, 5-59 to 5-60
 show controls, 5-57, 5-58
 subject material, 5-64, 5-65
 test-chart lighting, 5-58
 color errors, tolerable, 5-48, 5-49
 color fidelity, 5-21 to 5-49
 color frequency standard, 5-16
 color matting, 6-159, 6-161
 block diagram of system, 6-158
 color-receiving system, 5-18 to 5-20
 block diagram of major functions, 5-19
 color registration chart, 1-410
 color registration slide transparency, 1-410
 color-system analysis, 5-21 to 5-23
 color system, diagrams of, 5-24
 color-transmitting system, 5-17, 5-18
 block diagram of major functions, 5-18
 color plexer, 5-50 to 5-56
 compatibility, 5-3
 displaying RGB signals, 5-9, 5-10
 diagram of three-gun kinescope picture tube, 5-9
 electronic aspects of, 5-11 to 5-20
 encoding and decoding distortions, 5-32 to 5-37
 burst amplitude error, 5-35
 burst phase error, 5-35
 carrier unbalance, 5-36
 demodulation, 5-34
 gain stability of M, I, and Q transmission paths, 5-34
 matrixing errors, 5-33
 modulation, 5-34
 subcarrier-frequency error, 5-37
 two-phase modulation errors, 5-35, 5-36
 video unbalance, 5-36, 5-37
 encoding RGB signals, 5-11
- eye, characteristics of, 5-23 to 5-25
 color adaptation, 5-23 to 5-25
 primary colors, 5-25
 reference white, 5-25
- film handling and processing, 6-153
 frequency interlace, 5-15, 5-16
 generating RGB signals, 5-8
 I matrix, 5-12
 lighting (*see* Lighting for television studios)
- linear RGB pickup tubes and kinescopes interconnected by wire, diagram of, 5-22
- linearity correctors to compensate for color error from nonlinear transducers, 5-22
- M luminance signal, 5-12
 matrix coefficients, 5-48
 matrixing, 5-11
- monochrome camera, block diagram of circuits, 5-4
 monochrome kinescope picture tube, diagram of, 5-4
 monochrome-television system, 5-6 to 5-8
 block diagram of, 5-6
 radiated picture signal, 5-7

- Color television, monochrome-television system, receiver, 5-7, 5-8
 waveform and radiated picture signal, 5-7
- Q matrix, 5-12
- phase accuracies, 5-48
- phase and amplitude of subcarrier, each of six colors, 5-14
 pure red signal, 5-14
- phase relationship of I, Q, and burst signals, 5-14
- position of subcarrier burst during horizontal blanking interval, 5-14
- primary colors, 5-8
- proof-of-performance measurements, envelope delay, 8-244, 8-246
 transmitter power output, 8-219
- resolution, 5-5
- scanning, 5-4, 5-5
 diagram of electron beam, 5-5
- signal analysis (see Television signal analysis)
- special effects (see Audio special effects; Video special effects)
- subcarrier-frequency accuracy, 5-48
- synchronizing, 5-6
- system colorimetry, 5-47, 5-48
- system exponent, 5-48
- test equipment, 5-66 to 5-72
 burst-controlled oscillator, 5-72
 color-burst generator, diagram of, 5-71
 dot patterns, signals for, 5-72
 grating, signals for, 5-72
 studio tests, 5-66 to 5-72
 transmitter tests, 5-66, 5-72
 WA-1 color-bar generator, 5-68
 block diagram of, 5-69
 WA-6 color-signal analyzer, 5-68
 WA-7 linearity checker, 5-71, 5-72
 WA-8 color-stripe generator, 5-68 to 5-71
 block diagram of, 5-70
 WA-9 calibration pulse generator, 5-67, 5-68
 block diagram of, 5-67
- three variables of color, 5-8 to 5-10
- transducers, errors in, 5-25 to 5-32
 comparison of narrow-band light source and RGB light produced by kinescopes, 5-26
 nonlinearities in, 5-27
- transfer characteristics, 5-28, 5-29
 effect of differing nonlinearities, 5-31
 effect of identical nonlinearities, 5-31
 effect of stray light, 5-32
 graphical displays of, 5-29, 5-30
 linear plots, 5-29, 5-30
 linearizing a system, 5-32
 log-log plots, 5-30
 neutral-density filter, 5-28
 nonlinear, 5-29
 window glass, 5-28
- transmission and reception of I, Q, and burst signals, block diagram of, 5-13
- transmission characteristics, 5-48
- transmission-system distortions, 5-37 to 5-47
 envelope delay, 5-39 to 5-42
- Color television, transmission-system distortions, envelope delay, differential gain, 5-46
 differential phase, 5-46, 5-47
 general method for, 5-42, 5-43
 incremental gain, 5-43
 incremental phase, 5-46, 5-47
 gain characteristic, 5-37, 5-38
 perfectly linear transmission system, 5-37
 phase characteristic, 5-38, 5-39
 transmitter and receiver matrix functions, diagram of, 5-23
 transmitter power output, synchronizing waveform and proof of performance, 8-219
 two-phase modulation, 5-13 to 5-15
 video-tape recording, 6-136, 6-138
 waveforms of I and Q signals, 5-14
- Colorplexer, 5-50 to 5-56
 adders, 5-53
 aperture compensation, 5-52
 block diagram of, 5-52
 automatic carrier balance, 5-52, 5-53
 block diagram of, 5-53
 bandshaping, 5-51, 5-52
 circuit description, 5-51
 design of, 5-51 to 5-53
 functions of, 5-50, 5-51
 diagram of, 5-50
 matrix, 5-51, 5-52
 modulators, 5-52, 5-53
 operation of, 5-53 to 5-56
 output amplifiers, 5-53
 waveforms, 5-54 to 5-56
- Commercial radio operators, applications, 1-299, 1-302
 code tests, 1-299, 1-304
 examinations, 1-299, 1-302 to 1-304
 Federal Communications Commission rules, 1-299, 1-311
 licensing, 1-299 to 1-301
 scope of authority, 1-299, 1-305 to 1-310
 service, 1-299, 1-311
- Compatible single-sideband system for standard broadcast, 8-34 to 8-52
 adjustment of, 8-39 to 8-41
 advantages of, 8-34, 8-37 to 8-39
 audio-frequency output, 8-39
 envelope distortion, 8-47
 fidelity improved, 8-38, 8-39
 formulas, 8-43, 8-45
 full-carrier single-sideband adapter, output of, 8-43
 full-carrier single-sideband signal, 8-43
 harmonic distortion, 8-44
 history of, 8-35
 installation, 8-39 to 8-41
 interference reduced, 8-37, 8-38
 adjacent-channel interference, 8-37
 co-channel interference, 8-37, 8-38
 radiation interference of television receivers, 8-38
- KDKA's experience with, 8-41 to 8-52
 view of equipment, 8-40, 8-51
 modulation, depths of, 8-45, 8-46
 phase-modulated carrier-frequency output, 8-39

- Compatible single-sideband system for standard broadcast, phase shift, 8-45, 8-46
 received-signal observations, 8-49 to 8-51
 receiver-selectivity curves, 8-50
 references, 8-41
 selective fading distortion reduced, 8-38
 signal-to-noise ratio improved, 8-38, 8-39
 single-sideband waves, amplitude components, 8-35
 envelope waveform, 8-36
 phase-modulation components, 8-35
 revolving vector representation, 8-36
 spectrum diagram of, 8-36
 viewed on panoramic analyzer, 8-36, 8-37
 system, block diagram of, 8-42
 explained, 8-35 to 8-40
 testing, 8-39 to 8-41
 transmitter measurements, 8-48, 8-49
 components needed at 100 per cent amplitude modulation, 8-48
 sideband spectra, 8-49
 sidebands with phase modulation, 8-48, 8-49
- Concrete for antenna structures, 2-73 to 2-78
- CONELRAD, 8-123 to 8-156
 alert receivers, 8-127 to 8-133
 FM alert unit, 8-131 to 8-133
 schematic diagram of, 8-132
 standard broadcast alert units, 8-127 to 8-131
 alert system, 8-126 to 8-137
 Beverage antenna, 8-134 to 8-137
 conductor height, 8-134
 grounds, 8-135, 8-136
 length, 8-134
 lightning protection, 8-137, 8-138
 pole erection, 8-134, 8-135
 schematic diagrams of, 8-135, 8-136
 transmission lines, 8-136
 cluster control stations and alternates, 8-142, 8-147 to 8-154
 definitions, 1-37, 1-249
 distortion zones, 8-123 to 8-125
 experimental broadcast services, 1-254, 1-258, 1-259
 filtering, 8-133
 FM stations, 1-37, 1-249 to 1-252
 noncommercial educational, 1-38, 1-252, 1-253
 history of, 8-123 to 8-126
 intelligibility standard, 8-124, 8-125
 intelligible signal, 8-125, 8-126
 international broadcast stations, 1-38, 1-252, 1-253
 loop antenna, 8-133, 8-134
 schematic diagram of, 8-134
 methods for obtaining equipment, 8-155, 8-156
 Federal contributions method, 8-155
 surplus property method, 8-155, 8-156
 over-all capabilities, 8-143
 radio alerts, 1-37, 1-250, 1-251
 radio all clear, 1-37, 1-251
 references, 8-156
 relay systems, 1-254, 1-258, 1-259
- CONELRAD, relay systems, remote-pickup broadcast systems, 7-53, 8-143, 8-144
 remote-control requirements, 8-88, 8-90
 sequential switching of transmitters, 8-140 to 8-143
 circuit diagram of, 8-141
 shielding, 8-133
 special reception techniques, 8-133 to 8-137
 standard broadcast stations, 1-37, 1-249 to 1-252
 alert receiver, 8-127 to 8-131
 station cluster, 8-142
 supervision, 1-37, 1-250
 system operation, 1-37, 1-251
 television stations, 1-37, 1-249 to 1-252
 tests, 1-37, 1-251, 1-252
 transmitter, Collins type converted, 8-137 to 8-139
 Gates type converted, 8-137, 8-138
 Raytheon type converted, 8-138
 RCA type converted, 8-139, 8-140
 Western Electric type converted, 8-140
 wave antenna (*see* Beverage antenna *above*)
- Construction, permit, 1-5
 application for, 1-4
 assignment of, 1-5
 transfer of corporate holding, 1-6
- Control of Electromagnetic Radiation (*see* CONELRAD)
- Control room, AM/FM studio, 6-4, 6-20 to 6-23
 television remote pickup, 7-62, 7-65, 7-66
- CSSB (*see* Compatible single-sideband system for standard broadcast)
- Decibels, charts and graphs relating to, 9-3 to 9-6
 db vs. current, voltage, power ratio, 9-6
 dbm vs. watts, 9-6
 transformation of kilowatts to dbk, 9-5
 transformation of microvolts to dbm, 9-5
- Decimal equivalents, 9-54
- Densitometer, definition, 1-387
- Design of antenna structures, column load on tower, 2-83
 diagonal struts, 2-82
 foundation loading, 2-85
 guy anchor, 2-85, 2-86
 guy load, 2-84, 2-85
 horizontal struts, 2-83
 load in vertical member, 2-83, 2-84
 wind-load calculation, 2-81, 2-82
- Developmental broadcast stations, administrative procedure, 1-255, 1-267, 1-268
 definitions, 1-255, 1-267
 equipment, 1-255, 1-268
 frequencies, 1-255, 1-267
 licensing policies, 1-255, 1-268
 technical operation, 1-255, 1-269, 1-270
- Dielectric cable (*see* Transmission lines)
- Diplexer, notch, 2-245, 2-246
- Directional antennas, Magniphase antenna systems, 8-161
- Directional antennas, maintenance of, 2-166 to 2-183
 detector-noise limiter, 2-169
 factors affecting, 2-166, 2-167

- Directional antennas, maintenance of, inspection, **2-168**
 maintenance report, components, **2-169, 2-170**
 daily work schedules, **2-172, 2-174, 2-181, 2-182**
 diagrams, **2-171, 2-173**
 measurements, **2-171, 2-173**
 meters, **2-169, 2-171**
 monitoring points, **2-171, 2-172**
 schematic diagram of coupling and phasing networks, **2-173**
 weekly log, **2-174 to 2-176**
 meter readings, **2-168, 2-169**
 phase monitor, effect of, **2-167**
 procedures, **2-168 to 2-176**
 readjustments, **2-176 to 2-181**
 aids, **2-176 to 2-181**
 vector calculator, **2-178 to 2-181**
 transmission lines, effect of, **2-167**
 (See also Standard broadcast antenna structures)
- Driffeld curve defined, **1-389**
- Drill sizes, **9-56**
- Earthquake loading, effect on antenna structures, **2-66**
- Effective radiated power, maximum, **1-14**
 minimum, **1-14**
- EIA (see Electronic Industries Association)
- Electrical degrees converted to feet, or reverse, slide-rule short cut, **9-34**
- Electrical injuries, avoidance of, **8-188 to 8-190**
 treatment of, **8-188 to 8-190**
- Electromagnetic spectrum, **2-4**
- Electronic Industries Association, National Stereophonic Radio Committee (see National Stereophonic Radio Committee)
- specifications on wind pressure, **2-64**
 standards of, **1-409, 1-410**
 television relay systems, proposed standards, **4-88 to 4-97**
 television test charts, **1-409, 1-410**
 color registration chart, **1-410**
 color registration slide transparency, **1-410**
 IRE facsimile test chart, **1-410**
 linear reflectance chart, **1-410**
 linearity chart, **1-409**
 logarithmic reflectance chart, **1-410**
 resolution chart, **1-409**
 test pattern (see Television-signal analysis)
- wind-pressure effect on antenna structures, specifications for, **2-64**
- Electronics, standard symbols for, **9-58 to 9-60**
- Elevators for antenna structures, **2-50, 2-51**
- Erasing head, types of, defined, **1-387**
- ERP, maximum, **1-14**
 minimum, **1-14**
- Experimental broadcast services, **1-254 to 1-297**
 CONELRAD, **1-254, 1-258, 1-259**
 facsimile, administrative procedure, **1-255, 1-264**
 definitions, **1-254, 1-262**
 equipment, **1-255, 1-265**
- Experimental broadcast services, facsimile, frequencies, **1-254, 1-264**
 licensing policies, **1-255, 1-264, 1-265**
 technical operation, **1-255, 1-265, 1-266**
- Federal Communications Commission rules, **1-254 to 1-297**
- Eye, color characteristics of, **5-23 to 5-25**
 color adaptation, **5-23 to 5-25**
 primary colors, **5-25**
 reference white, **5-25**
 fluorescent lamp spectral distribution, **9-32**
 luminosity curve of, **9-32**
 tungsten lamp spectral distribution, **9-32**
- Facsimile, **8-192 to 8-197**
 equipment, **8-193**
 dry electrosensitive paper recorders, **8-193**
 electrolytic process recorders, **8-193**
 pressure recording, **8-193**
 experimental broadcast services (see Experimental broadcast services)
- FM multiplexing (see FM multiplexing)
- speed of transmission, **8-193, 8-194**
 formula for, **8-194**
 synchronization, **8-194**
 transmission material, **8-192, 8-193**
- Federal Communications Commission, administrative practices, **1-3 to 1-6**
 application processing, **1-4**
 applying for construction permit, **1-4**
 assignment of construction permit, **1-5**
 assignment of license, **1-5, 1-6**
 construction permit, **1-5**
 hearings, **1-4, 1-5**
 licenses (see Licenses)
 selecting a frequency, **1-3, 1-4**
 transfer of corporation holding, **1-6**
 antenna structures, **1-312 to 1-324**
 auxiliary broadcast services, **1-254 to 1-297**
 bandpass for circuitry of television transmitters, **3-72**
 commercial radio operators, **1-209, 1-311**
 experimental broadcast services, **1-254 to 1-297**
 field-strength measurements, **2-285, 2-286**
 TASO changes for, **2-286, 2-287**
 frequencies (see Frequencies)
 hearings of, **1-4, 1-5**
 logs, rules and regulations pertaining to, **1-417 to 1-419**
 radio broadcast services, **1-33 to 1-252**
 relay systems, broadcast, **1-254 to 1-297**
 remote-pickup broadcast service, **7-7**
 television proof of performance, **8-216 to 8-218**
- Feed systems, of standard broadcast antenna structures, and plant layout, **2-105**
 two-tower directional, **2-99 to 2-101**
 adjustments, **2-147, 2-148**
 block diagram of, **2-100**
 current, **2-134 to 2-136**
 formulas for loop and base, impedance and current, **2-134 to 2-136**
 impedance, **2-134 to 2-136**
 networks for matching impedances, **2-136 to 2-138**

- Feed systems, of standard broadcast antenna structures, two-tower directional, networks, phase shifting, **2-143, 2-144**
 networks, power-dividing, **2-144**
 reactance, small and large values of variable, **2-145**
 transmission lines, **2-138 to 2-143**
 of television antenna structures, **2-243 to 2-246**
 aural transmission, **2-245, 2-246**
 branching, **2-243, 2-244**
 bridge systems, **2-245**
 filterplexer, **2-246**
 isolation using traveling-wave feeds, **2-246**
 notch diplexer, **2-245, 2-246**
 separate antennas, **2-245**
 standing wave, **2-244**
 traveling wave, **2-244, 2-245**
 types, **2-243 to 2-245**
 visual transmission, **2-245**
- Field pickup (*see* Remote-pickup broadcast systems; Television remote pickup)
- Field strengths, $F(50,10)$, **2-31, 2-32**
 $F(50,50)$, **2-29, 2-30**
 54-890-mc measurement, **2-277 to 2-289**
 antenna-supporting mast, **2-284**
 chart recorder, **2-284, 2-285**
 equipment principles, **2-279, 2-280**
 FCC standard method, **2-285, 2-286**
 map of service contours for a television station, **2-279**
 meters for, **2-280 to 2-284**
 power supplies, **2-285**
 problems of surveys, **2-287, 2-288**
 procedures, **2-285**
 receiving antennas, **2-284**
 references, **2-288, 2-289**
 signal fading near radio horizon, **2-288**
 station wagon equipped for, **2-283**
 strength requirements for grades of service, **2-278**
 TASO changes for FCC method, **2-286, 2-287**
 TASO method, for field trials, **2-287**
 for special studies, **2-287**
 techniques, **2-285**
 VHF meter, **2-282**
- 540-1600-ke measurement, **2-290 to 2-300**
 coverage established, **2-299**
 detailed plotting, **2-292**
 directional, **2-296 to 2-298**
 harmonic radiation, **2-299, 2-300**
 log for radial measurement, **2-293**
 maps preferred for, **2-292, 2-293**
 monitoring points for directional radial measurement, **2-298**
 nondirectional, **2-293 to 2-296**
 plotting for nondirectional radial measurement, **2-294 to 2-296**
 procedure, **2-298, 2-299**
 formulas for, **2-28, 2-30, 2-31**
 over plane earth, **2-9 to 2-11**
 prediction of for television service, **2-28 to 2-33**
- Field strengths, proof of performance, television, upper and lower sidebands, **8-222, 8-223, 8-235 to 8-237**
 radial, **2-291 to 2-300**
 reasons for, **2-291**
 sky-wave signals, **2-300**
 sporadic E layer, **2-28**
 standard broadcast antenna structures, attenuated for single-tower nondirectional, **2-96, 2-97**
 four-tower parallelogram, **2-164, 2-165**
 inverse at one mile for single-tower nondirectional, **2-95, 2-96**
 three towers, **2-156**
 two-tower directional at one mile, **2-99**
- Film, test, standards for, **1-412 to 1-416**
- Film handling and processing (*see* Television film handling and processing)
- Film projectors (*see* Television film projectors)
- Filter networks, filterplexer, **2-246**
 load location, **2-249**
 RF, **2-249**
 RF switching features for emergencies, **2-250**
- Filterplexer, **2-246**
- First aid, **8-186 to 8-191**
 bleeding, control of severe, **8-187, 8-188**
 burns, treatment of, **8-189**
 electrical injuries, avoidance of, **8-188 to 8-190**
 treatment of, **8-188 to 8-190**
 prone pressure method of resuscitation, **8-186, 8-187**
 radiation hazards, **8-190**
 shock, not electrical, **8-191**
- Flexible cables (*see* Transmission lines)
- FM antenna structures, Andrew multi-V, **2-218**
 bandwidth, **2-216, 2-217**
 Collins 37M ring, **2-218, 2-219**
 field pattern, calculation of, **2-212**
 field tuning of, **2-217**
 multiplex, problems of, **2-216, 2-217, 8-24**
 polarization, **2-215**
 radiation patterns, **2-211 to 2-215**
 formula for, **2-211**
 vertical, **2-213 to 2-215**
 vertical, calculation of, **2-214**
 RCA type VFA, **2-219, 2-220**
 side mounting of, **2-215, 2-216**
 simplified form currently used, **2-212, 2-213**
 standing-wave ratio, **2-216, 2-217**
 theory of, **2-211, 2-212**
- FM multiplexing, **8-16 to 8-33, 8-194 to 8-197, 8-257 to 8-260**
 antenna structures, **2-216, 2-217, 8-24**
 bandwidth, definition of, **8-19**
 distortion measurements on main carrier, **8-25**
 panoramic of main carrier relative to first sidebands, **8-25**
 block diagram of system, **8-258**
 cross talk, causes of, **8-17, 8-18**
 definition of the system, **8-16, 8-17**
 direct mixing system, block diagram of, **8-195**
 exciter, **8-19 to 8-26**
 interstage filter, diagram of, **8-23**

- FM multiplexing, exciter, 300-kc attenuation circuits in first multiplier stages, 8-20 to 8-22
- FCC regulations, 8-197
- functions performed by stations, block diagram of, 8-31
- multiplex installation, view of, 8-26
- phase-modulation system, block diagram of, 8-195
- phase shift, 8-20, 8-23
- carrier, with no amplitude variations, circuitry of, 8-24
- receiver, 8-26, 8-27
- block diagram of, 8-196
- receiving, 8-32, 8-33
- automatic operation, 8-33
- process, block diagram of, 8-18
- remote control, 8-29 to 8-32
- control functions performed, 8-30, 8-31
- monitoring, 8-31, 8-32
- receiver switching, 8-30
- second subchannel, 8-32
- telemetering, 8-30, 8-31
- Rural Radio Network, 8-28
- Serrasoid modulator, schematic diagram of, 8-21
- subcarrier generator, 8-25, 8-26
- sum-and-difference technique, 8-259
- system requirements, 8-27
- transmitting, 8-29 to 8-32
- process, block diagram of, 8-18
- system, block diagram of, 8-258
- waveforms, 8-20, 8-22
- (See also Facsimile; Stereophonic broadcasting)
- FM receiver, TD-2 System, 4-23
- FM relay systems (see Relay systems)
- FM remote pickup (see Remote-pickup broadcast systems)
- FM stations, administrative procedure, 1-35, 1-128, 1-129, 1-162 to 1-164
- application for, 1-3 to 1-6
- automatic logging (see Automatic logging)
- auxiliary broadcast services (see Relay systems)
- classes of, 1-12, 1-13
- classification of, 1-34, 1-125 to 1-128
- CONELRAD, 1-37, 1-249 to 1-252
- noncommercial educational, 1-38, 1-252, 1-253
- equipment, 1-35, 1-131 to 1-135, 1-164 to 1-168
- facsimile used (see Facsimile)
- frequencies (see Frequencies)
- licensing policies, 1-35, 1-129 to 1-131
- lightning protection (see Lightning protection for broadcast stations)
- logs, 1-35, 1-36, 1-138, 1-139, 1-171
- FCC rulings, 1-417 to 1-419
- NAB sample, 1-420, 1-421
- Magniphase protection system, 8-160 to 8-165
- maintenance of equipment (see Maintenance of equipment)
- multiplexing (see FM multiplexing)
- noncommercial educational, classification of, 1-35, 1-161, 1-162
- FM stations, noncommercial educational, CONELRAD, 1-38, 1-252, 1-253
- parameters, control of (see Automatic logging)
- power of, 1-12, 1-13
- proof of performance (see Proof-of-performance measurements)
- relay system (see Relay systems)
- remote control of (see Remote control of broadcast stations)
- remote pickup (see Remote-pickup broadcast systems)
- special effects, 6-171 to 6-195
- stereophonic broadcasting, 8-254 to 8-261
- studio facilities (see AM/FM studio facilities)
- subsidiary communications authorizations, 1-13
- technical operation, 1-35, 1-36, 1-135 to 1-138, 1-168 to 1-170
- technical standards, 1-35, 1-144 to 1-161
- time of operation, 1-13
- FM transmitters, 3-32 to 3-60
- bandwidth, 3-35, 3-36
- direct FM system, 3-37
- frequency-controlled FM modulator, schematic diagram of, 3-38
- Gates FM-5B 5,000-watt, 3-46, 3-47
- schematic diagram, 3-48
- Gates FM-250B 250-watt, schematic diagram, 3-47
- General Electric Phasitron FM modulator, schematic diagram, 3-39
- ITA Company, 100-watt FM transmitter, 3-40
- control circuitry, 3-41
- exciter, 3-41, 3-42
- general packaging, 3-40
- meter circuitry, 3-41
- neutralizing, 3-44
- output circuits, 3-45
- RF power amplifiers, 3-43
- input circuit of Class C, 3-43
- 250-watt, 3-45
- 1,000-watt, 3-45
- Serrasoid FM modulator, block diagram of, 3-41
- RF waveforms of, 3-42
- maintenance of equipment (see Maintenance of equipment)
- modulation theory, 3-32 to 3-35
- AM sideband representation, 3-33
- AM vector representation, 3-33
- amplitude-modulation RF envelope, 3-33
- FM vector representation, 3-34
- frequency-modulation RF envelope, 3-34
- noise reduction, 3-36
- phasitron system, 3-37 to 3-39
- preemphasis, 3-36, 3-37
- RCA, 3-53 to 3-60
- automatic frequency control, 3-53, 3-54
- BTE-10B FM exciter, block diagram of, 3-52
- BTF-5B 5,000-watt transmitter, 3-56
- block diagram of, 3-56

- FM transmitters, RCA, control circuits, **3-58, 3-59**
 cooling system, **3-59**
 intermediate-power amplifier, schematic diagram of, **3-57**
 250-watt, **3-57**
 modulator, schematic diagram of, **3-53**
 off-frequency detector, schematic diagram of, **3-55**
 oscillator, schematic diagram of, **3-53**
 performance data, **3-60**
 phase detector, **3-54 to 3-56**
 schematic diagram, **3-54**
 vector diagram, **3-54**
 power amplifier 5,000-watt, **3-58**
 5,000-watt, schematic diagram of, **3-58**
 power supply, **3-59**
 RF section, **3-56 to 3-58**
 Standard Electronics, **3-46 to 3-51**
 Serrasoid FM modulator, block diagram of, **3-48**
 3-kw amplifier, schematic diagram of, **3-51**
 3-kw FM transmitter, **3-51**
 250-watt amplifier, schematic diagram, **3-51**
 250-watt FM transmitter, **3-40, 3-50**
 TD-2 System, **4-22, 4-23**
- Formulas, column load on antenna structures, **2-83**
 compatible single-sideband system for standard broadcast, **8-43, 8-45**
 diagonal struts of antenna structures, **2-83**
 electrical degrees converted to feet, or reverse, slide-rule short cut, **9-34**
 facsimile, speed of transmission, **8-194**
 field strengths for television service, **2-28, 2-30**
 foundation loading of antenna structures, **2-85**
 great-circle distance and bearing calculations, **9-34, 9-35**
 guy anchor for antenna structures, **2-85**
 guy load of antenna structures, **2-84, 2-85**
 horizontal struts of antenna structures, **2-83**
 liveness in broadcasting, **6-44**
 load in vertical member of antenna structures, **2-84**
 microphone placement, **6-48, 6-49**
 microphones, setting relative gain, **6-52**
 radiation pattern of FM antenna structures, **2-211**
 standard broadcast antenna structures, coupled resistance for two-tower directional, **2-131**
 feed systems for two-tower directional, loop and base, impedance and current, **2-134 to 2-136**
 field strength, horizontal-plane rms, two-tower directional, **2-133, 2-134**
 inverse at one mile for single-tower, **2-96**
 impedance of transmission lines, **2-106**
- Formulas, standard broadcast antenna structures, loop impedance for two-tower directional, **2-131**
 phase-shifting networks for feed systems of two-tower directional, **2-143**
 power gain for two-tower directional, **2-133, 2-134**
 radiation patterns, of multiple array, **2-102, 2-158 to 2-165**
 for two-tower directional, **2-118 to 2-120**
 for two-tower pattern, **2-102**
 vertical, theoretical for single-tower nondirectional, **2-111, 2-112**
 self-impedance of single-tower nondirectional, **2-91**
 transmission lines for feed systems of two-tower directional, **2-138**
 vertical-radiation pattern of single-tower nondirectional, **2-91**
 voltage distribution for single-tower nondirectional, **2-89**
- television service with interference from one undesired station, **2-34**
 transistors, parameter conversion, **9-50**
 transmission lines, rigid, average power rating, **2-193**
 peak power rating, **2-192, 2-193**
 UHF television translators, required clearance from obstructions, **8-71**
 wave propagation, in free space, **2-4, 2-5**
 transmission loss between antennas, **2-5, 2-9**
 over plane earth, **2-9, 2-10**
 transmission loss between antennas, **2-11**
 over smooth spherical earth, **2-13**
 wind load on antenna structures, **2-81, 2-82**
- 47A transmission-measuring system, **4-120 to 4-122**
- Foundations for antenna structures, **2-72 to 2-78**
 anchors, **2-73**
 concrete-type rock, **2-76**
 cone type, for rocky soils, **2-76**
 expanding rock, **2-76**
 reinforced-concrete guy, **2-75**
 on piles, **2-75**
 screw-type earth, **2-76**
 screw-type swamp, **2-75**
 two-piece metal for clay or loam, **2-76**
 wedge-type rock, **2-75**
- concrete, **2-73 to 2-78**
 base pier of reinforced concrete, **2-74**
 boring log, **2-74**
 freezing, **2-77**
 mix, **2-75, 2-76**
 pouring, **2-77**
 reinforcing, **2-73, 2-74**
 strength, **2-77, 2-78**
- loading, **2-85**
 piers, **2-73**
 reinforced-concrete base, **2-74**
 reinforced concrete on piles, **2-74**
 soil exploration, **2-72, 2-73**
 soils, allowable bearing value of, **2-73**
- Free space, wave propagation in, **2-4 to 2-9**

- Frequencies, 1-7 to 1-31
- AM/FM stations, radio order circuits, 1-22
 - remote-pickup broadcast stations, 1-19 to 1-21
 - studio transmitter link stations, 1-21, 1-22
 - citizens radio service, 1-28
 - tolerances, 1-30
 - developmental broadcast stations, 1-255, 1-267
 - experimental broadcast services, facsimile, 1-254, 1-264
 - FM stations, 1-13, 1-14
 - allocation of, 1-34, 1-126 to 1-128
 - field-strength measurement (*see* Field strengths, 54-890-mc measurement)
 - intercity relay stations, 1-22, 1-256, 1-278, 1-279
 - tolerances, 1-28
 - non-commercial educational, allocation of, 1-35, 1-161, 1-162
 - noncommercial tolerances, 1-29
 - STL, 1-256, 1-278, 1-279
 - tolerances, 1-29
 - international broadcast stations, 1-37, 1-237
 - microwave systems, 4-68
 - motion picture radio service, 1-26, 1-27
 - base and mobile stations, 1-26
 - operational fixed stations, 1-27
 - tolerances, 1-30
 - network facilities, TD-2 System, 4-21, 4-22
 - remote-pickup broadcast systems, 7-28, 7-29
 - conditions of use, 7-29
 - remote-pickup stations, 1-255, 1-271, 1-272
 - tolerances, 1-29
 - selection of, 1-3, 1-4, 1-16
 - standard, Canadian time signals, 1-429
 - foreign, 1-430
 - (*See also* WWV and WWVH *below*)
 - standard broadcast stations, 1-9 to 1-12
 - allocation by classes of stations, 1-33, 1-42 to 1-47
 - stability of, 8-109
 - STL, 1-256, 1-278, 1-279
 - tolerances, 1-28
 - summary of allocation of services, 1-31, 1-32
 - television stations, 1-15, 1-16
 - antenna structures, 2-221
 - auxiliary broadcast stations, 1-256, 1-283 to 1-285
 - experimental, 1-254, 1-259, 1-260
 - field-strength measurement (*see* Field strengths, 54-890-mc measurement)
 - intercity relay stations, 1-23
 - tolerances, 1-29, 1-30
 - radio order circuits, 1-25
 - relay systems, 1-256, 1-283 to 1-285
 - remote-pickup stations, 1-22, 1-23
 - tolerances, 1-29, 1-30
 - STL stations, 1-23, 1-29, 1-30
 - tolerances, 1-29
 - UIF television translators, 1-15 to 1-17, 1-256, 1-290, 1-291
 - tolerances, 1-30
- Frequencies, WWV and WWVH, 1-423 to 1-430
 - accuracy, 1-429
 - antennas, 1-428, 1-429
 - audio, 1-425
 - broadcast program of, 1-424
 - distance range of reception, 1-429
 - modulation, 1-428, 1-429
 - musical pitch, 1-427
 - radiated power, 1-428, 1-429
 - radio, 1-423 to 1-425
 - radio propagation forecasts, 1-427, 1-428
 - services of, 1-423
 - time intervals, 1-425, 1-426
 - pulse wave form, 1-426
 - time signals, 1-427
 - authorization to rebroadcast, 1-430
 - (*See also* Bandwidth)
- Frequency modulation (*see* FM)
- Fresnel, 6-93 to 6-95
 - optics of, 6-93
 - remote control, 6-95
 - spotlight for remote pickup, 7-84
 - zone clearance, 4-101, 4-102
- Gain, television antenna structures, 2-38 to 2-40
- Gain control, automatic, 8-252
- Glossary of terms, acoustics, 6-25, 6-41, 6-42
 - antenna structures, 1-312 to 1-315, 2-221
 - magnetic recording, 1-390, 1-391
 - recording and reproducing, 1-385 to 1-396
 - television, 4-161 to 4-167
 - television lighting, 6-99 to 6-101
 - television-signal analysis, 4-161 to 4-167
- Graphs (*see* Charts and graphs)
- Great-circle distance and bearing calculations, 9-34, 9-35
 - sheet for, 9-35
- Grooves of records (*see* Records, groove)
- Guys for antenna structures, anchoring, 2-75, 2-85, 2-86
 - arrangement of, 2-55, 2-56
 - connections, 2-55, 2-57
 - clips, 2-55 to 2-57
 - clips, Lauglulin safety, 2-56
 - proper method of application, 2-56
 - Swage fitting, 2-56
 - wire-rope, 2-56
 - servicing, 2-57, 2-58
 - sleeves, 2-57
 - sockets, 2-56, 2-57
- grounding system, 2-72
- insulators, 2-69, 2-70
- loading, 2-84, 2-85
- steel guy material, 2-53 to 2-55
 - AM guys, 2-55
 - bird caging, 2-54
 - prestressing, 2-54
 - rope and strand, 2-53, 2-54
- tension of, 2-57 to 2-62
 - calibrated-rule method, 2-58
 - dynamometer method, 2-61, 2-62
 - shunt-type, 2-59, 2-60
 - hydraulic cylinder method, 2-60
 - spring method, 2-60

- Guys for antenna structures, tension of, transit-intercept method, **2-60**
vibration method, **2-60, 2-61**
vibration of, **2-62**
vs. self-supporting towers, **2-42, 2-43**
zinc coat, **2-55**
- Halo effect of television signal, **4-158**
- Handling film (*see* Television film handling and processing)
- Heater surge chart, **9-33**
- Hills, effect on wave propagation, **2-16 to 2-19**
- Horn-gap installation for lightning protection, **8-158**
- Hurricanes, effect on antenna structures, **2-63, 2-64**
- Hurter curve defined, **1-389**
- Icing, effect on antenna structures, **2-65, 2-66**
falling ice, **2-66**
prevention of, **2-66**
television antenna structures, **2-226**
methods of deicing, **2-226**
- Image-orthicon tube, **8-180 to 8-184**
average life of, **8-181**
criteria for deletion of tube from service, **8-181**
maximum life of, **8-181**
minimum life of, **8-181**
techniques for prolonging life of, **8-181**
6474/1854, 8-182 to 8-184
average life of, **8-182**
in black-and-white cameras, **8-184**
criteria for deletion of tube from service, **8-182**
maximum life of, **8-182**
minimum life of, **8-182**
techniques for prolonging life of, **8-182**
- color, diagram of, **5-59**
operating precautions, **8-183, 8-184**
operation of, **5-59 to 5-64**
procedures not recommended, **8-183**
procedures recommended, **8-183**
references, **8-184**
- Injuries, electrical, avoidance of, **8-188 to 8-190**
treatment of, **8-188 to 8-190**
- Institute of Radio Engineers, current standardization reports, **1-407, 1-408**
- Insulators for antenna structures, base, **2-67 to 2-69**
for guyed towers, **2-67**
raising above ground, **2-68, 2-69**
for self-supporting towers, push-pull type, **2-67**
guys, **2-69, 2-70**
clipping, **2-69**
cone type, **2-70**
strain type, **2-69**
sectional towers, **2-70**
- Intercity network facilities (*see* Network facilities)
- Intercity relay systems (*see* Relay systems)
- Interference, television (*see* Television-signal analysis, interference)
- International broadcast stations, administrative procedure, **1-37, 1-241, 1-242**
CONELRAD, **1-38, 1-252, 1-253**
definitions, **1-37, 1-237**
equipment, **1-37, 1-243, 1-244**
frequencies, **1-37, 1-237**
licensing policies, **1-37, 1-242**
logs, **1-37, 1-245, 1-247**
technical operation, **1-35, 1-244, 1-245**
- International exchange of programs, standards, **1-396 to 1-407**
discs, lateral-cut recordings on, **1-397 to 1-399**
center hole diameter, **1-397**
direction of cut, **1-397**
direction of rotation, **1-397**
frequency characteristics for, **1-398, 1-399**
grooves, innermost diameter of, **1-397**
number left blank, **1-398**
type of, **1-397**
label information, minimum, **1-398**
maximum diameter, **1-397**
speed of rotation, **1-397**
type of disc, **1-397**
- flutter, **1-405**
- magnetic type single-track recording, **1-399 to 1-405**
direction of winding, **1-399**
frequency characteristics, **1-401 to 1-403**
label information, minimum, **1-401**
long gap head method for measuring magnetization, **1-404**
standardization of, **1-405**
short gap head method for measuring magnetization, **1-404**
standardization of, **1-404, 1-405**
speed of tape, **1-399**
strength of tape, **1-399**
tape leader, **1-400**
tape reel, maximum outside diameter **1-400**
tape spools, **1-399 to 1-401**
width of tape, **1-399**
- television films, sound standards, **1-406, 1-407**
- WOW, **1-405**
- International Radio Consultative Committee, background of organization, **1-396, 1-397**
international exchange of programs, standards, **1-396 to 1-407**
- Ionospheric effects (*see* Wave propagation)
- IRE, current standardization reports, **1-407, 1-408**
- Joint Industry/Government Tall Structures Committee Report, **1-324 to 1-351**
air hazard criteria for antenna structures (*see* Air hazard criteria for antenna structures)
history of, **1-324, 1-325**
- L matching networks, **9-26 to 9-30**
references, **9-27**
Smith charts for, **9-27 to 9-30**
- Length, conversion table for units of, **9-39**

- Level irregularities, 4-128 to 4-131
- Licenses, application for, 1-5
 assignment of, 1-5, 1-6
 commercial radio operators, 1-299 to 1-301
 developmental broadcast stations, 1-255, 1-268
 experimental broadcast services, facsimile, 1-255
 FM, 1-35, 1-129 to 1-131
 intercity, 1-256, 1-279 to 1-281
 international broadcast stations, 1-37, 1-242
 License Application Engineering Data for television proof of performance, 8-216 to 8-218
 remote-pickup broadcast systems, 1-255, 1-272 to 1-276, 7-29, 7-30
 standard broadcast stations, 1-34, 1-73 to 1-75
 statutory time limit, 1-5
 STL, 1-256, 1-279 to 1-281
 television, 1-254, 1-260, 1-261
 transfer of corporation holding, 1-6
 UHF television translators, 1-256, 1-291 to 1-293
- Lighting, antenna structures, 1-312, 1-317 to 1-324, 1-326, 2-80, 2-81, 2-93
 ACC/AGA recommendations (*see* ACC/AGA recommendations on antenna structures)
 for television studios, 6-72 to 6-102
 color television, 5-58, 5-64, 5-65
 color-value wall, 6-99
 cost estimating for, 6-70, 6-71, 6-79
 design requirements, 6-73
 electrical distribution, 6-75 to 6-77
 connector-strip installation, 6-80
 electrical systems, 6-80 to 6-82
 equipment lists, 6-81, 6-82
 fluorescent bank, 6-98
 follow spot, 6-97
 fresnel, 6-93 to 6-95
 glossary of terms, 6-99 to 6-101
 igloo, 6-99
 lamp replacement, 6-99
 lighting control, 6-82 to 6-88
 automatic infinite present system, 6-86, 6-87
 autotransformer dimmer board, 6-84, 6-85
 control board, 10-scene, C-1, all-electronic, 6-85, 6-88
 costs, 6-87, 6-88
 dimmer control circuits, 6-82 to 6-88
 glossary of terms, 6-99, 6-100
 magnetic-amplifier dimmer bank, 6-85, 6-86
 patch panel with retractable cords, 6-83
 patch panel, wall-mounted, 6-84
 silicon-controlled rectifier dimmer, 6-85, 6-86
 silicon-controlled rectifier dimmer bank, 6-85 to 6-87
 tube bank of thyatron dimmers, 6-85
 lighting-load requirements, 6-77 to 6-79
 lighting practices, 6-88 to 6-92
- Lighting, for television studios, lighting practices, lighting routine on the show, 6-90 to 6-92
 monochrome operation, 6-89, 6-90
 pattern projectors, 6-96
 gobos for insertion in, 6-96
 optics for, 6-96
 planning of, 6-72
 projected backgrounds for special effects, 6-166, 6-167, 6-169
 punch scoop, 6-98
 rear screen projector, 6-98
 references, 6-101, 6-102
 reflector lamp banks, 6-96, 6-97
 remote-pickup studio, 7-72, 7-84 to 7-86
 scoop, 6-93
 strip light, 6-97, 6-98
 suspension systems, 6-73 to 6-75
 counterweight, 6-73, 6-76
 mobilrail, 6-75, 6-77
 overhead catwalk, 6-75
 pantograph light lifts for, 6-75, 6-79
 pipe battens, 6-73 to 6-75
 pipe grids motor-operated, 6-75
 tent, 6-99
- Lightning, effect on antenna structures, 2-72
- Lightning protection for broadcast stations, 8-157 to 8-165
 arc suppression, 8-160
 schematic diagram of circuits, 8-160
 CONELRAD Beverage antenna, 8-136, 8-137
 grounding, 8-160
 guy wires, 8-158, 8-159
 horn-gap installation, 8-158
 Magniphase protection system, 8-160 to 8-165
 metallic surface in contact with earth, 8-157
 meter protection, 8-159, 8-160
 make-before-break type switches, 8-159
 remote antenna current meter, pickup coil placement, 8-159
 remote meter-protection circuit, 8-159
 standard broadcast antenna structures, 2-93 to 2-95
 static generated in antenna structure, 8-157
 tower-light protection, 8-160
 towers, 8-158
- Linearity of television signal (*see* Television-signal analysis, nonlinearity)
- Liveness in broadcasting (*see* Program pickups)
- Logger-receiver, 8-117 to 8-122
- Logger-transmitter, 8-112 to 8-116
- Logging, automatic (*see* Automatic logging)
- Logs, design of, 1-420, 1-422
 FCC rules and regulations, 1-417 to 1-419
 field-strength measurements, radial, 2-293
 FM stations, 1-35, 1-36, 1-138, 1-139, 1-171
 FCC rulings, 1-417 to 1-419
 NAB sample, 1-420, 1-421
 international broadcast stations, 1-37, 1-245, 1-246
 standard broadcast stations, 1-34, 1-46 to 1-69
 antenna current, 1-419

- Logs, standard broadcast stations, current ratios, 1-419, 1-420
 NAB sample, 1-419, 1-420
 phasing relation, 1-419, 1-420
 television stations, FCC rulings, 1-417 to 1-419
 NAB sample, 1-420, 1-422
- Magnetic recording, amplifiers, 6-108 to 6-110
 playback, block diagram of, 6-110
 recording, block diagram of, 6-109
 standard playback curve, 6-110
 standard recording curve, 6-109
 bias, 6-104
 cartridge type, 6-106
 circuit connections, 6-113, 6-114
 bridging pad added, 6-113
 bridging transformer added, 6-113
 converting high-impedance recorder-reproducers, 6-114
 definition of terms, 1-390, 1-391
 delayed broadcast, 6-111
 erase, 6-104, 6-105
 erase and record-reproduce heads, 6-108
 international exchange of programs, 1-399 to 1-405
 magnetic-disc type, 6-107, 6-108
 magnetic medium explained, 6-117
 maintenance of equipment, 6-114 to 6-116
 azimuth alignment of heads, 6-115
 capstan idler pressure, 6-115
 cleaning, 6-115
 lubrication, 6-114
 playback level adjust, 6-115
 playback response, 6-115
 record response, 6-115, 6-116
 signal-to-noise measurements, 6-115
 tension scales, 6-116
 tensions, 6-115
 multiple-track tape, 6-106, 6-107
 reel-to-reel type, 6-105, 6-106
 single-channel consoles, 6-114
 feeding the console, 6-114
 special effects, 6-184 to 6-186
 standards (*see* Recording standards, magnetic)
 tape, print-through, 6-111
 types of, 6-110, 6-111
 theory of, 6-103 to 6-105
 transport mechanism, 6-105
 uses for broadcasting, 6-111, 6-112
 video tape (*see* Video-tape recording)
- Magnetic reproducing (*see* Magnetic recording)
- Magnaphase protection system, 8-160 to 8-165
 bridge unit, 8-161
 balanced, 8-162
 circuit description, 8-162 to 8-164
 cutoff bias, 8-162
 schematic diagram of circuits, 8-164
 description of, 8-161, 8-162
 directional-antenna systems, 8-161
 external alarm and counter circuit, schematic diagram of, 8-165
 jacks, BNC, 8-162
 line coupler, 8-162
- Magnaphase protection system, line coupler, 10-kw maximum, 8-161
 50-kw maximum, 8-161
 schematic diagram of, 8-163
 power-rollback operation, 8-161
 relay cutoff circuit, schematic diagram of, 8-165
 specifications for, 8-165
- Maintenance of equipment, 8-166 to 8-191
 antenna structures, directional (*see* Directional antennas)
 television, 2-275
 cables, 8-186
 camera chains, 8-176, 8-177
 capacitors, 8-185, 8-186
 casual maintenance, 8-166, 8-167
 film projectors, 8-172 to 8-176
 magnetic recording, 6-114 to 6-116
 monitors, 8-185
 monoscope camera, 8-185
 patch panels, 8-186
 preventive maintenance, 8-166 to 8-170
 remote pickup, 8-177, 8-178
 preventive-maintenance schedule, daily, 8-169
 monthly, 8-169
 after 1,000 hours, 8-169
 weekly, 8-169
 television, 8-177, 8-178
 resistors, 8-186
 safety, 8-170, 8-171
 stabilizing amplifier, 8-185
 studio preventive-maintenance schedule, daily, 8-167, 8-168
 weekly, 8-168
 monthly, 8-168
 after 1,000 hours, 8-169
 switching systems, 8-184, 8-185
 synchronizing generator, 8-177
 television microwave system, 4-111
 television operating centers, 4-39
 test equipment, 8-172 to 8-180
 tests, 8-172 to 8-180
 transmitter preventive-maintenance schedule, daily, 8-169, 8-170
 weekly, 8-170
 monthly, 8-170
 quarterly, 8-170
 semiannually, 8-170
 transmitters, standard broadcast, 3-28 to 3-30
 television, 3-87, 3-88
 equipment, 3-87, 3-88
 signal-quality, 3-88
 tubes, 8-178 to 8-180
 UHF television translators, 8-82
- Marking of antenna structures, 1-326
 ACC/AGA recommendations, 1-354 to 1-358
 application, 2-53
 Federal Communications Commission requirements, 2-52
 painting of, 1-312, 1-317, 1-323, 1-324, 2-93
 surface treatment, 2-52, 2-53
- Mechanical recording and reproducing standards (*see* Recording standards)
- Metal gauges, standard, 9-55

- Metals, welding characteristics of, 9-57
- Metering for remote control (*see* Remote control of broadcast stations)
- Microphones, 8-174
- adjusting for balance, 6-62
 - bidirectional pattern, in dead room, 6-56
 - in live room, 6-56
 - Budleman, 7-83
 - cardioid pattern, 6-57
 - control room announce booth, requirements, 6-23
 - response curve, 6-24
 - erroneous ideas about, 6-53 to 6-56
 - facts concerning, 6-53 to 6-56
 - method of setting relative gain, 6-52, 6-53
 - mixer dial settings, 6-50
 - nomograph, 9-14, 9-15
 - for microphone distances, 9-11
 - number used, 6-46 to 6-60
 - placement of, 6-65
 - accentuation microphones, 6-49, 6-50
 - over-all microphone, 6-48, 6-47
 - formulas for, 6-48, 6-49
 - remote pickup, 7-6, 7-68, 7-82 to 7-84
 - response patterns, 6-56, 6-57
 - stereophonic broadcasting, 8-256, 8-257
 - television-signal analysis, 4-153
 - unidirectional pattern, 6-57
- Microwave systems, television (*see* Television microwave systems)
- Moiré effect of television signal, 4-158
- Motion picture radio service, 1-25 to 1-27
- base and mobile stations, 1-26
 - frequencies, 1-26, 1-27
 - operational fixed stations, 1-27
- Multiburst test signal, 4-122, 4-123
- Multiplex, antenna structures, FM, 2-216, 2-217
- standard broadcast, 2-247
 - directional, 2-101 to 2-104, 2-158 to 2-165
 - television, 2-247
- Multiplexing, FM (*see* FM multiplexing)
- Music programs (*see* Program pickups)
- National Association of Broadcasters (NAB), logs, AM stations, 1-419, 1-420
- antenna current, 1-419
 - current ratios, 1-419, 1-420
 - phasing relation, 1-419, 1-420
 - FM stations, 1-420, 1-421
 - television stations, 1-420, 1-422
- standards of, 1-408
- recording and reproducing (*see* Recording standards)
- National Bureau of Standards, frequencies of WWV and WWVH, 1-423 to 1-430
- National Stereophonic Radio Committee, 8-260, 8-261
- Broadcast Receivers Panel, 8-261
 - Broadcast Transmitters Panel, 8-261
 - Field Testing Panel, 8-261
 - Interconnecting Facilities Panel, 8-261
 - Subjective Aspects Panel, 8-261
 - System Specifications Panel, 8-261
- Network facilities, A2 System, 4-13 to 4-21
- amplifiers, types of, 4-18
 - attenuation of video line facilities, 4-15
 - A2A amplifiers, 4-17, 4-18
 - A2A clamper, 4-18
 - A2A equalization system, 4-15 to 4-17
 - A2A intermediate repeater, 4-19
 - A2A power supply, 4-18
 - A2A receiving terminal, 4-20
 - A2A system design, 4-19, 4-20
 - A2A terminating conditions, 4-20
 - A2A transmission objectives, 4-20, 4-21
 - cable terminations, 4-15
 - defined, 4-13
 - equalizers, fixed, 4-16, 4-17
 - variable, 4-16, 4-17
 - inside cabling, 4-15
 - video-cable facilities, 4-13 to 4-15
- audio, 4-46 to 4-60
- integrity (*see* B-22 Cable System and cable carrier systems *below*)
 - local (*see* local audio channels *below*)
- B-22 Cable System, 4-53 to 4-58
- bridging, 4-54
 - cable facilities, 4-53
 - equalization, 4-54
 - program amplifiers, 4-53
 - regulation, 4-54
 - reversible facilities, 4-54 to 4-58
- Bell Telephone System (*see* Bell Telephone System network facilities)
- cable carrier systems, bridging arrangements, 4-60
- development of, 4-58
 - terminal equipment, 4-58 to 4-60
 - terminal schematic of type C-1 program, 4-59
- coaxial-cable carrier systems, automatic switching, 4-37
- computer, 4-32
 - cosine equalizer, 4-31
 - development of, 4-28, 4-29
 - dynamic equalizers, 4-31, 4-32
 - equalization plan, 4-30
 - equalizer assignment, 4-32, 4-33
 - equalizing auxiliary repeater, transmission schematic of, 4-34
 - excess-carrier-ratio modulation, 4-37
 - fixed equalization, 4-31
 - L-3 amplifiers, 4-35
 - L-3 coaxial-cable carrier system, 4-29, 4-30
 - L-3 coaxial video terminal, 4-35, 4-36
 - L-3 video modulator, 4-36
 - manual equalization, 4-31
 - power supply, 4-33 to 4-35
 - quality control, 4-30, 4-31
 - television branching, 4-38
- common-carrier operation, 4-4
- flexibility, 4-4
 - local audio channels, 4-46 to 4-52
 - equalization, 4-47
 - facilities, 4-46, 4-47
 - isolating measures, 4-51, 4-52
 - transmission objectives, 4-48
 - transmitting pads, 4-50, 4-51

- Network facilities, local audio channels, volume indicator, bridged across a termination, 4-50
 connected across bridge output, 4-50
 connected across loops, 4-48
 connected by bridge circuits, 4-51
 volume-indicator readings, correction of, 4-52
 volume-indicator scale for peak checking, 4-52
 volume measurements, 4-48, 4-49
- local video channels (*see* A2 System *above*)
- multiple-channel, requirements, 4-3
- network defined, 4-3
- radio, 4-3 to 4-60
 reliability, 4-4
 requirements, 4-3, 4-4
 TD-2 System, 4-21 to 4-28
 antennas, 4-24
 automatic protection, 4-26 to 4-28
 automatic protection switching, 4-27
 bridging arrangements, 4-25, 4-26
 channel-separation filter, 4-25
 development of, 4-21, 4-22
 FM receiver, 4-23
 FM transmitter, 4-22, 4-23
 frequency-assignment plan, 4-21, 4-22
 repeaters, 4-24
 television, 4-3 to 4-60
- television operating centers, 4-38 to 4-44
 control-office plan, 4-38
 functions, 4-38
 high-impedance switching, 4-39, 4-40
 layout, 4-39
 low-impedance switching, 4-40
 maintenance, 4-39
 monitor trunks, 4-42, 4-43
 office-equipment arrangements, 4-39
 service orders, 4-39
 splitting pads, mounting arrangement for, 4-42
 switch control, 4-44
 switch unit, 4-41
 switching equipment, 4-42
 switching plan, 4-40, 4-41
 test trunks, 4-42, 4-43
 trouble reports, 4-39
 video switch, cabling plan for, 4-43
- video, 4-13 to 4-46
 A2 System (*see* A2 System *above*)
 frequency response, 4-45, 4-46
 gain, differential, 4-46
 intercity (*see* TD-2 System *and* coaxial-cable carrier systems *above*)
 levels of transmission, 4-44, 4-45
 objectives of transmission, 4-44 to 4-46
 phase, differential, 4-46
- Networks, impedance-matching, standard broadcast antenna structures, 2-136 to 2-138
- L matching, 9-26 to 9-30
 matching of, standard broadcast antenna structures, 2-106, 2-107
 parallel-T, 9-12
 phase-shifting, standard broadcast antenna structures, 2-106, 2-107, 2-143, 2-144
- Networks, power-dividing, standard broadcast antenna structures, 2-107, 2-144
 symmetrical attenuation, 9-7 to 9-12
- Noncommercial educational FM stations, classification of, 1-35, 1-161, 1-162
 CONELRAD, 1-38, 1-252, 1-253
- Nonlinearity of television signal, 4-156, 4-157
- NSRC (*see* National Stereophonic Radio Committee)
- Operating logs (*see* Logs)
- Optical recording, definition of terms, 1-392
 standards (*see* Recording standards)
- Optical reproducing, definition of terms, 1-392
 standards (*see* Recording standards)
 transmission, definition of terms, 1-395, 1-396
- Painting antenna structures (*see* Marking of antenna structures)
- Parallel-line wires, characteristic impedance of, 9-26
- Parallel-T networks, example, 9-12
 nomograph, 9-12
 summary, 9-12
- Parameters, control of (*see* Automatic logging)
- Pattern projectors, 6-96
- Personnel, first aid for (*see* First aid)
- Phototransistors, chart relating to, 9-51
- Plane earth, wave propagation over, 2-9 to 2-13
- Plate voltage metering, 8-98 to 8-101
- Poid, defined, 1-393
- Processing film (*see* Television film handling and processing)
- Program pickups, 6-43 to 6-66
 acoustics, 6-57, 6-58
 greater coverage, 6-43, 6-44
 improvement of, 6-53 to 6-66
 increased sense of reality, 6-44 to 6-46
 liveness in broadcasting, 6-43 to 6-53
 liveness formula, 6-44
 microphones (*see* Microphones)
 music programs, 6-51
 dance orchestra, 6-64
 field setups, 6-66
 in overcrowded studio, 6-53
 piano, 6-60, 6-61
 piano with vocalist, 6-61
 plan and elevation for overcrowded studio, 6-54
 salon orchestra, 6-62
 small orchestra, 6-62, 6-63
 small orchestra with vocalist, 6-63
 string groups, 6-61
 symphony orchestra, 6-46, 6-50, 6-63 to 6-65
 symphony orchestra with vocals, 6-47, 6-63
 with vocals, 6-51
 single announcer, 6-58, 6-59
 speeches, 6-51
 studio size and number of artists, 6-48
 values of monaural liveness range, 6-44

- Program transmission (see Network facilities)
- Projector lens resolution target, 16-mm, standards for, 1-416
- Proof-of-performance measurements, audio-frequency, 8-198 to 8-214
- equipment required, 8-200, 8-201
- attenuator, 8-200, 8-201
- audio oscillator, 8-200
- communications-type receiver, 8-201
- cost of, 8-201
- field-strength meter, 8-201
- level indicator, 8-201
- meter, distortion and noise, 8-201
- modulation monitor, 8-201
- oscilloscope, 8-201
- transformer, isolation and matching, 8-201
- FM stations, audio-frequency harmonic distortion, 8-205
- audio-frequency response, 8-205
- filing, 8-199, 8-200
- output noise, 8-206
- required measurements, 8-200
- times when measurements are made, 8-199
- forms, 8-206 to 8-214
- audio-frequency harmonic content, data and curves, 8-209, 8-213
- audio-frequency response, over-all, 8-207, 8-211
- audio-frequency response curves, 8-208, 8-212
- carrier shift, 8-210
- hum data, 8-210
- noise data, 8-210
- output noise, 8-214
- improved facilities as result of measurements, 8-206
- methods, 8-200 to 8-206
- precautions, 8-202
- personnel qualified for making measurements, 8-198, 8-199
- reason for, 8-198
- standard broadcast stations, audio-frequency harmonic distortion, 8-203
- audio-frequency response, 8-202, 8-203
- audio-signal-generator equipment, 8-202
- carrier hum, 8-204, 8-205
- extraneous noise, 8-204, 8-205
- filed at station, 8-199
- output noise, 8-206
- percentage carrier shift, 8-203, 8-204
- required measurements, 8-200
- spurious radiations, 8-205
- times when measurements are made, 8-199
- television, 8-215 to 8-249
- antenna structures, 8-221, 8-233 to 8-235
- attenuation, over-all, 8-222, 8-234 to 8-236
- RF harmonics, 8-224, 8-237 to 8-240
- audio-frequency response, 8-229, 8-230, 8-246, 8-247
- distortion, 8-230
- FM and AM noise, 8-230, 8-248, 8-249
- Proof-of-performance measurements, television, color, envelope delay, 8-244, 8-246
- transmitter power output, 8-219
- differential phase, 8-228, 8-243, 8-246
- envelope delay, 8-228, 8-229, 8-244, 8-246
- examples from CBS, 8-230 to 8-249
- AM and FM noise, 8-248, 8-249
- antenna, 8-233 to 8-235
- attenuation, over-all, block diagram for measurements, 8-236
- vs. frequency of visual transmitter, 8-234, 8-235
- attenuation, RF harmonics, 8-237 to 8-240
- aural transmission-line content, 8-240
- block diagram of equipment for measuring, 8-238
- detector characteristics, 8-239
- response characteristics of notching filters, 8-239
- visual transmission-line content, 8-240
- audio-frequency-response data sheet, 8-246, 8-247
- aural transmitter, 8-245 to 8-248
- data sheet, 8-245
- differential phase, 8-243, 8-246
- block diagram of equipment, 8-243
- distortion, 8-248
- envelope delay, 8-244, 8-246
- block diagram of equipment, 8-244
- color television, 8-244, 8-246
- field strength of upper and lower sidebands, 8-235 to 8-237
- block diagram, 8-237
- frequency monitors, 8-235
- impedance measured at diplexer input of antenna, 8-232
- out-of-band emissions, 8-237
- output, variation of, 8-235
- output-noise-level data sheet, 8-246
- radiation pattern, calculated vertical, 8-234
- reflectometer calibration, aural transmitter, 8-234
- visual transmitter, 8-233
- test pattern, 8-240, 8-241
- transmitter input, 8-241
- transmitter output, 8-241
- transfer characteristics, 8-240, 8-242, 8-243
- block diagram for measurements, 8-242
- transmission line, 8-233 to 8-235
- transmitter power-output determination, 8-232
- transmitting antenna designed for null fill-in, 8-234
- visual transmitter, 8-235 to 8-238
- voltage standing-wave ratio of antenna and transmission line, 8-232, 8-233
- waveform of transmitted signal, 8-238 to 8-240

- Proof-of-performance measurements, television, examples from CBS, waveforms, analysis of synchronizing, 8-249
- FCC definitions, 8-218
- FCC Form 302, 8-216, 8-217
- field strength of upper and lower sidebands, 8-222, 8-223, 8-235 to 8-237
- method of measurement, 8-223
- frequency monitors, 8-221, 8-235
- H* presentation, CRO photograph of, 8-225
- License Application Engineering Data, 8-216 to 8-218
- out-of-band emissions, 8-223, 8-224, 8-237
- attenuation of RF harmonics, 8-224
- output, variation of, 8-221, 8-222, 8-235
- method of measurement, 8-222
- pulse cross display obtained from *A/V*, photograph of, 8-225
- reasons for, 8-215
- test pattern transmitted, 8-226, 8-240, 8-241
- transfer characteristic, 8-226 to 8-228, 8-242
- differential gain, 8-227, 8-228
- low-frequency linearity, 8-227
- transmission line, 8-221, 8-233 to 8-235
- transmitter power output, 8-218 to 8-221, 8-232
- black and white, synchronizing waveform for, 8-220
- color television, synchronizing waveform for, 8-219
- waveform of transmitted signal, 8-224 to 8-226, 8-238 to 8-240
- times of horizontal synchronizing pulses, 8-226
- times of vertical blanking pulse, 8-227
- times of vertical synchronizing pulses, 8-227
- Propagation, wave (*see* Wave propagation)
- Proximity-effect curve, application of, 9-22, 9-23
- derivation, 9-22
- tower heights, 9-23
- Radiation hazards, 8-190
- Radiation patterns, FM antenna structures, 2-211 to 2-215
- remote-pickup broadcast system, 7-43 to 7-45
- standard broadcast antenna structures, formulas for, 2-102, 2-111, 2-112, 2-118 to 2-120, 2-158 to 2-165
- shape, directional with more than two towers, 2-158 to 2-162
- four-tower parallelogram, 2-160, 2-161
- three towers in line, 2-158 to 2-161
- three towers not in line, 2-161, 2-162
- two-tower directional, 2-97, 2-98
- size, directional with more than two towers, 2-162 to 2-165
- four-tower parallelogram, 2-162 to 2-164
- three towers in line, 2-164
- three towers not in line, 2-164
- Radiation patterns, standard broadcast antenna structures, size, two-tower directional, 2-98, 2-99, 2-120 to 2-134
- systematization, two-tower directional, 2-120 to 2-130
- vertical, 2-262
- single-tower nondirectional, 2-90, 2-91
- television antenna structure, azimuthal, 2-229 to 2-234
- vertical, 2-222, 2-235 to 2-238
- UHF antenna, slotted cylinder, 2-267, 2-268
- VHF antenna, AMCI slotted ring, 2-252, 2-253
- traveling-wave, vertical, 2-261
- Radiators, guyed, average characteristics for, 9-19
- Radio broadcast services, 1-33 to 1-252
- (*See also* AM/FM stations; Network facilities; Standard broadcast stations)
- Radio operators (*see* Commercial radio operators)
- Radio spectrum, 2-4
- Radio towers (*see* Antenna structures)
- Radio-wave propagation (*see* Wave propagation)
- Receivers, automatic logging (*see* Automatic logging)
- color television, 5-18 to 5-20
- matrix functions, diagram of, 5-23
- CSSB, selectivity curves, 8-50
- FM, TD-2 System, 4-23
- remote-pickup broadcast systems, 7-5, 7-6, 7-18 to 7-20, 7-33, 7-35 to 7-37, 7-43
- stereophonic broadcast panel, 8-261
- television system, monochrome, 5-8
- Recorder, types of, definitions, 1-386 to 1-388, 1-390 to 1-392
- video tape, 6-119 to 6-132
- Recording, magnetic (*see* Magnetic recording)
- standards (*see* Recording standards)
- types of, definitions, 1-386, 1-389, 1-390, 1-393 to 1-396
- video tape (*see* Video-tape recording)
- Recording standards, definition of terms, 1-385 to 1-396
- glossary of terms, 1-385 to 1-396
- international exchange of programs (*see* International exchange of programs standards)
- magnetic, 1-379 to 1-385
- characteristics of system, 1-381, 1-382, 1-401 to 1-403
- definition of terms, 1-390, 1-391
- erasing function, 1-380
- flutter, 1-379, 1-380
- frequency-response limits, 1-379, 1-380
- methods of establishing the system, 1-383
- long gap head method of measuring magnetization, 1-384, 1-404
- standardization of, 1-385, 1-405
- short gap head method of measuring magnetization, 1-383, 1-384, 1-404
- standardization of, 1-384, 1-385, 1-404, 1-405

- Recording standards, magnetic, signal-to-noise ratio, 1-383
 sound track position, 1-381
 tape, dimensions, 1-379, 1-399
 length, 1-380
 methods of measuring magnetization of, 1-383 to 1-385, 1-403 to 1-405
 reel, 1-380 to 1-382, 1-399 to 1-401
 speed, 1-379, 1-399
 wind, 1-380, 1-399
 WOW, 1-379, 1-380
 (See also Magnetic recording)
- mechanical, 1-374 to 1-379
 disk reproducing system rumble, 1-374, 1-375
 label information, minimum, 1-379
 recorded level, 1-377, 1-378
 records (see Records)
 reproducer stylus contour, 1-377
 signal-to-noise ratio, 1-378
 turntable (see Turntable)
 WOW factor, 1-374
- Records, center hole concentricity, 1-376
 center hole diameter, 1-376
 for international exchange, 1-397
 groove, definition of terms, 1-388, 1-389
 innermost diameter, 1-378
 for international exchange, 1-397
 number left blank, 1-378
 for international exchange, 1-398
 outermost diameter, 1-378
 shape, 1-377
 stopping, 1-378
 type used for international exchange, 1-397
- international exchange of programs, standards (see International exchange of programs standards, discs)
- label information, minimum, for international exchange, 1-398
- lateral, frequency characteristics for, 1-376, 1-377
 for international exchange, 1-398, 1-399
- outer diameters, 1-375, 1-376
 for international exchange, 1-397
- type used for international exchange, 1-397
- vertical, frequency characteristics for, 1-376
- warping of, 1-376
- References, acoustics, 6-41
 compatible single-sideband system for standard broadcast, 8-50
 CONELRAD, 8-156
 field-strength measurements, 2-288, 2-289
 image-orthicon tube, 8-184
 L matching networks, 9-27
 lighting for television studios, 6-101, 6-102
 standard broadcast antenna structures, 2-110
 television film handling and processing, 6-154
 television microwave systems, 4-86, 4-87
 UHF television translators, 8-82
 wave propagation, 2-39, 2-40
 waveguide loss charts for microwave systems, 9-24
- Relay systems, broadcast, 1-17 to 1-25, 1-254 to 1-297
 categories, 1-17, 1-18
 CONELRAD, 1-254, 1-258, 1-259
 remote-pickup broadcast systems, 7-53, 8-143, 8-144
 conflict of interest with aviation, 1-328
 Federal Communications Commission rules, 1-254 to 1-297
 intercity FM, 1-22
 administrative procedure, 1-256, 1-279
 definitions, 1-256, 1-278
 equipment, 1-256, 1-281
 licensing policies, 1-256, 1-279 to 1-281
 technical operation, 1-256, 1-281, 1-282
 radio order circuits, AM/FM, 1-22
 remote-pickup broadcast systems (see Remote-pickup broadcast systems)
- site selection, 2-37, 2-38
 STL, 1-21, 1-22
 administrative procedure, 1-256, 1-279
 definitions, 1-255, 1-278
 equipment, 1-256, 1-281
 licensing policies, 1-256, 1-279 to 1-281
 technical operation, 1-256, 1-281, 1-282
- television, administrative procedure, 1-256, 1-285 to 1-288
 amplitude vs. frequency characteristics, audio signal, 4-92, 4-93
 composite picture signal, 4-92
 assignment of channels, 1-23, 1-24
 definitions, 1-256, 1-283, 4-88 to 4-90
 differential gain, composite picture signal, 4-94, 4-95
 EIA proposed standards, 4-88 to 4-97
 equipment, 1-256, 1-288
 frequencies, 1-22, 1-23, 1-25, 1-29, 1-30, 1-256, 1-283 to 1-285
 harmonic distortion, audio signal, 4-92, 4-93
 input impedance, audio signal, 4-90
 composite picture signal, 4-90
 input level, audio signal, 4-90, 4-91
 composite picture signal, 4-90
 intercity, 1-23, 4-89
 privately owned, 4-98 to 4-111
 intracity, 4-89
 load impedance, audio signal, 4-91
 composite picture signal, 4-91
 low-frequency response, composite picture signal, 4-93
 microwave system (see Television microwave system)
 output level, audio signal, 4-92
 composite picture signal, 4-91
 performance characteristics, 4-90 to 4-96
 polarity, composite picture signal, 4-92
 portable-mobile, 4-89
 power supplies, composite picture signal, 4-97
 radio order circuits, 1-25
 receiving terminal, 4-89
 relative envelope delay vs. frequency characteristics, composite picture signal, 4-93

- Relay systems, television, relay band,
4-90
 relay channel, 4-90
 remote-pickup stations, 1-22, 1-23, 4-89
 repeater station, 4-89
 signal-to-hum ratio, composite picture
 signal, 4-97
 signal-to-noise degradation, audio signal,
 4-95
 composite picture signal, 4-95, 4-96
 weighting network, 4-96
 source impedance, composite picture
 signal, 4-91
 step-function transient response, com-
 posite picture signal, 4-93
 STL, 1-23, 4-89
 technical operation, 1-256, 1-288 to 1-290
 transmitting terminal, 4-89
- Remote control of broadcast stations, 1-34,
 1-61, 1-62, 8-83 to 8-107
 antenna current, 8-97
 for connections to pickup coil, rectifying
 and filtering RF, 8-97, 8-98
 application for authorization, 8-83 to 8-85
 circuits, 8-102 to 8-105
 latch relay, 8-103
 locally controlled, by circuit breaker,
 8-105
 by knob, 8-105
 by motor, 8-104
 by push buttons, 8-103, 8-104
 by switch, 8-102, 8-103
 momentary relay, 8-104
 motor control unit, 8-105
 secondary overload relay unit, 8-106
 CONELRAD requirements, 8-88, 8-90
 control connections, schematic diagram of,
 8-107
 current metering circuits, 8-102
 directional stations, 8-87
 remote base currents in, 8-98
 schematic diagram of switching unit,
 8-99
 FM multiplexing, 8-29 to 8-32
 history of, 8-83
 layout of pattern for connections, 8-105
 metering, circuits, 8-97
 connections, schematic diagram of, 8-107
 filament voltage, 8-101
 schematic diagram of, 8-101
 frequency, 8-95 to 8-97
 line voltage, 8-101
 schematic diagram of, 8-102
 modulation, 8-95 to 8-97
 plate voltage (*see* plate voltage metering
 below)
 tower-light current, 8-101, 8-102
 schematic diagram of, 8-102
 meters, frequency, 8-95
 modulation, 8-95
 monitors, circuit diagram of connections,
 8-96
 frequency, 8-95
 modulation, 8-96
 schematic diagram of connections, 8-96
 nondirectional AM and FM, 10-kw maxi-
 mum transmitter power, 8-83 to 8-87
- Remote control of broadcast stations, nondi-
 rectional AM and FM, transmitter
 power greater than 10 kw, 8-87
 operation of, 8-91 to 8-106
 operator requirements, 8-88
 phase monitor, 8-89
 plate voltage metering, 8-98 to 8-101
 multiplier, 8-99 to 8-101
 schematic diagram of, 8-100
 PCK-10, 8-100, 8-101
 plate current, 8-100, 8-101
 measured with d-c filaments, 8-101
 schematic diagram of, 8-100
 PV-10 unit, 8-98 to 8-99
 schematic diagram of connections, 8-99
 remote pickup, 7-21, 7-27, 7-50, 7-51
 RF pickup method, 8-88
 studio control unit, schematic diagram of,
 8-93
 system, 8-91 to 8-106
 D-C, 8-89 to 8-91
 block diagram of, 8-90
 communication with transmitter, 8-90
 dual control points, block diagram of
 system using, 8-91
 fire, 8-90
 off-air monitor, 8-90
 studio unit, 8-90
 transmitter unit, 8-90
 two metallic circuits utilized, block dia-
 gram of, 8-92
 transmitter control unit, schematic dia-
 gram of, 8-94
 voltage metering circuits, 8-102
- Remote-pickup broadcast systems, 1-18 to
 1-21
 administrative procedure, 1-255, 1-272
 CONELRAD, 7-53, 8-143, 8-144
 definitions, 1-255, 1-271, 1-392, 1-393
 equipment, 1-255, 1-276
 frequencies, 1-19 to 1-21, 1-29, 1-255,
 1-271, 1-272, 7-28, 7-29
 licensing policies, 1-255, 1-272 to 1-276,
 7-29, 7-30
 maintenance of equipment (*see* Mainte-
 nance of equipment)
 technical operation, 1-255, 1-276, 1-277
 television (*see* Television remote pickup)
 26 Mc, 7-3 to 7-27
 conversion, 7-7 to 7-20
 BC 603 receiver, 7-18, 7-19
 schematic, 7-20
 BC 604 transmitter, 7-9 to 7-14
 audio circuits, 7-10
 filament circuit wiring diagram, 7-11
 schematic of original filament and
 converted heater, 7-13
 materials needed, 7-7 to 7-9
 PE 103 dynamotor, 7-15 to 7-18
 PE 104 dynamotor, schematic, 7-17
 power supply for receiver, 7-19, 7-20
 transmitter mounting, 7-15
 schematic, 7-16
 crystals, 7-4
 FCC authorization, 7-7
 installation, 7-20, 7-21
 dynamotor, 7-20, 7-21

- Remote-pickup broadcast systems, 26 Mc,
 installation, receiver, 7-20
 remote control, 7-21
 transmitter, 7-20
 transmitting antenna, 7-20
 operation, 7-21 to 7-27
 antenna output-tuning indicator, 7-23
 cueing, 7-25 to 7-27
 modulation, method of, 7-24
 problems encountered, 7-23 to 7-25
 of transmitter, 7-22, 7-23
 microphone, 7-6
 receiver, 7-5, 7-6
 bass frequency reemphasis circuit for,
 7-5
 remote-control unit, 7-27
 remote use, 7-6
 transmitter, 7-4, 7-5
- 160 Mc, 7-28 to 7-48
 base-station antenna location, 7-30,
 7-31
 conversion, 7-28 to 7-39
 base-station receiver, 7-35
 schematic diagram of, 7-36, 7-37
 base-station transmitter, 7-35
 control head, schematic diagram of,
 7-40
 dynamotor relay, 7-32
 external carrier switch and power
 connection, 7-34
 frequency-compensation line amplifier,
 7-38
 frequency-compensation network,
 7-32
 frequency-response curve, 7-38
 mobile transmitter, audio and control
 modifications, 7-32 to 7-35
 schematic diagram of, 7-39
 receiver, RF, 7-33
 transmitter, RF, 7-33
 transmitter-receiver, intercabling
 diagram of, 7-41
- frequency allocation, 7-28, 7-29
 conditions of use, 7-29
 licensing, 7-29, 7-30
 tests of, 7-42 to 7-48
 antennas, 7-43 to 7-45
 and polarization compared, 7-47,
 7-48
 receiving, 7-43
 transmitting, 7-43
 equipment, 7-42 to 7-45
 pattern of receiving antenna, 7-43
 to 7-45
 polarization, five-element Yagi-
 antenna radiation pattern,
 horizontal, 7-44
 vertical, 7-44
 purpose of, 7-42
 receiver, 7-43
 sensitivity curve of, 7-43
 receiving antenna changes, 7-47, 7-48
 relay broadcast field test, 7-46
 results of transmission from car to
 roof, 7-45 to 7-47
 transmitter, 7-42
 transmitting-antenna changes, 7-47
- Remote-pickup broadcast systems, 450 Mc,
 7-49 to 7-53
 antenna, mounted on helicopter, 7-52
 one-quarter-wave whip, 7-52
 CONELRAD, 7-53
 remote-control panel, 7-50, 7-51
 speaker panel, 7-50, 7-51
 television emergency mobile unit, 7-49,
 7-50
 transmitter-receiver mounted in baggage
 compartment, 7-51
 unit for, 7-50 to 7-52
 mobile, 7-54 to 7-61
 AM/FM tuner, 7-58 to 7-60
 amplifier, 7-57
 console, 7-55 to 7-57
 block diagram of output, 7-56
 equipment, 7-54 to 7-61
 generator, 110 volt a-c, 7-59, 7-60
 mobile-radio system, 7-60, 7-61
 power-distribution panel, 7-60, 7-61
 schematic diagram of, 7-61
 public-address system, 7-58
 input selector switch, 7-59
 rack-mounted equipment, 7-59
 tape recorder, 7-58
 turntables, 7-55 to 7-58
 cueing modification, 7-56
 leveling device for, 7-58
 vehicle choices, 7-54
- Reproducer, types of, definitions, 1-386 to
 1-388, 1-390 to 1-392
- Reproducing (*see* Recording)
- Resistive pads, charts and graphs relating to,
 9-10
- Resistor color code, 9-61 to 9-63
- Resuscitation policy (*see* First aid)
- RGB signals, 5-8 to 5-11
- Rigid transmission lines (*see* Transmission
 lines, rigid)
- Room acoustical design (*see* Acoustical design
 for rooms)
- Safety, 8-170, 8-171
 first aid (*see* First aid)
- SCA, application for, 1-6
 FM stations, 1-13
- Sensitometry, defined, 1-393
- Serrasoid Modulator, 3-48
- Serrations of television signal, 4-155, 4-156
- Shadow loss (*see* Wave propagation)
- Single-sideband system (*see* Compatible
 single-sideband system for standard
 broadcast)
- Single-tower nondirectional antenna struc-
 tures (*see* Standard broadcast antenna
 structures)
- Site selection, radio relay stations, 2-37, 2-38
 television stations, 2-38, 2-39
 UHF television translators, 8-76 to 8-78
- Smith charts for L matching networks, 9-26
 to 9-30
- Society of Motion Picture and Television
 Engineers standards, 1-410 to 1-416
 projector lens resolution target, 16-mm,
 1-416
 television leaders, 1-412

- Society of Motion Picture and Television Engineers standards, television test film, 1-410, 1-411
 color 16-mm, 1-411
 color 35-mm, 1-411
 16-mm, 1-411
 35-mm, 1-410, 1-411
 television test slides, color, 1-412
 test films, 1-412 to 1-416
 16-mm, buzz track, 1-415
 400-cycle signal level, 1-415
 jiffy, 1-414
 magnetic azimuth alignment, 1-413
 magnetic multifrequency, 1-413
 multifrequency, 1-414
 scanning-beam illumination, 1-414, 1-415
 sound focusing, 1-415
 sound service, 1-413
 steadiness, 1-415
 3,000-cycle signal level, 1-415
 travel ghost, block target, 1-416
 35-mm, magnetic four-track cinema-scope, 1-412
 visual, 1-412, 1-413
- Soils appropriate for antenna structures, 2-72, 2-73
- Sound effects (*see* Audio special effects)
- Sound track, definitions, 1-386, 1-392, 1-394, 1-396
- Special effects (*see* Audio special effects; Video special effects)
- Staircase test signal (*see* Television-signal analysis)
- Standard broadcast antenna structures, 2-87 to 2-165
 adjustments, common-point impedance, 2-108
 field-strength check, 2-108
 final operating, 2-109
 fine, 2-109
 low-power operation, 2-108
 meter calibrations, 2-108
 phase-monitor system, 2-108
 component ratings, 2-108
 currents, base driving-point, 2-106
 directional, maintenance of (*see* Directional antennas)
 with more than two towers, 2-101 to 2-104
 compared with two-tower array, 2-101
 radiation-pattern shape, 2-158 to 2-162
 with more than four towers, 2-104
 two-tower (*see* two-tower directional *below*)
- four-tower parallelogram, 2-104
 field strength, horizontal-plane rms, 2-164, 2-165
 radiation-pattern shape, 2-160, 2-161
 radiation-pattern size, 2-162 to 2-164
 impedance, base driving-point, 2-105
 characteristic of transmission lines, 2-106
 installation of rigid transmission line, 2-201
 lightning protection for, 2-93 to 2-95
 multipurpose, two-pattern arrays, 2-108, 2-110
- Standard broadcast antenna structures, multipurpose, two transmitters using same towers, 2-110
- networks, matching of, 2-106, 2-107
 phase-shifting, 2-107
 power-dividing, 2-107
- plant layout, 2-105
 and feeder systems, 2-105
 and ground-system design, 2-105
 and monitoring system, 2-105
 and transmission line, 2-105
 and transmitter building, 2-105
- purposes of, 2-87
 references, 2-110
- single-tower nondirectional, 2-88 to 2-97, 2-111 to 2-118
 adjustments, 2-95
 current distribution, 2-88 to 2-90
 formula for, 2-88
 practical compared with theoretical, 2-88
 excitation of sectionalized tower, 2-114, 2-115
 field strength, attenuated, 2-96, 2-97
 inverse at one mile, 2-95, 2-96
 ground system, 2-91 to 2-93
 wire plov for, 2-92, 2-93
 lighting choke coil, 2-94
 lighting of tower, 2-93
 lightning protection, 2-93 to 2-95
 meter switching circuits, 2-94
 painting of tower, 2-93
 radiation as function of tower height, 2-113
 radiation pattern, vertical, theoretical, formulas for, 2-111, 2-112
 sectionalized towers, 2-90
 measurements, 2-118
 self-impedance, 2-91
 shunt-fed above base, 2-89
 with slant feed cable, 2-89, 2-90
 theoretical radiation, 2-112 to 2-117
 theoretical self-impedance, 2-112 to 2-117
- transformers, Austin-type, 2-94
- vertical radiation, characteristics, 2-116, 2-117
 pattern, 2-90, 2-91
 voltage distribution, 2-88 to 2-90
 formula for, 2-89
 theoretical, 2-89
- three towers in line, 2-103, 2-104
 field strength, horizontal-plane rms, 2-156
 radiation pattern, shape, 2-158 to 2-161
 size, 2-164
- three towers not in line, 2-104
 field strength, horizontal-plane rms, 2-156
 radiation pattern, shape, 2-161, 2-162
 size, 2-164
- two-tower directional, 2-97 to 2-101, 2-118 to 2-158
 adjustments, 2-145 to 2-148
 estimated base driving-point current, 2-147
 estimated base driving-point impedance, 2-147

- Standard broadcast antenna structures, two-tower directional, adjustments, feeder system, **2-147, 2-148**
 measured base mutual impedance, **2-146, 2-147**
 measured base self-impedance, **2-146**
 theoretical mesh circuit equation, **2-145, 2-146**
- Bessel function, **2-151 to 2-158**
 feeder systems, **2-99 to 2-101**
 field ratio, general value of, **2-120**
 field strength at one mile, **2-99**
 formula for horizontal-plane, **2-120**
 minimum-depth term, **2-149, 2-150**
 formula for, **2-118 to 2-120**
 monitoring system, **2-99**
 radiation pattern, formulas for, **2-102, 2-118 to 2-120**
 radiation-pattern shape, **2-97, 2-98**
 radiation-pattern size, **2-98, 2-99, 2-120, to 2-134**
 coupled-resistance formula, **2-131**
 field strength for horizontal-plane rms, **2-133, 2-134**
 field strength of reference tower, **2-120 to 2-131**
 loop-impedance formula, **2-131**
 mutual-impedance curves, **2-131, 2-132**
 power for system losses, **2-134**
 power gain, **2-133, 2-134**
 sectionalized towers, **2-133**
 top-loaded towers, **2-133**
 systematization of patterns, **2-120 to 2-130**
 tower with negative resistance, **2-148, 2-149**
 vertical polarization, **2-88**
- Standard broadcast relay systems (*see* Relay systems)
- Standard broadcast remote pickup (*see* Remote-pickup broadcast systems)
- Standard broadcast stations, administrative procedure, **1-33, 1-40**
 allocation of facilities, **1-33, 1-40 to 1-42**
 application for, **1-3 to 1-6**
 automatic logging (*see* Automatic logging)
- auxiliary broadcast services (*see* Relay systems)
- classes of, **1-7, 1-8**
 compatible single-sideband system for (*see* Compatible single-sideband system for standard broadcast)
- CONELRAD, **1-37, 1-249 to 1-252**
 alert receiver, **8-127 to 8-131**
 cost of antenna structures, **2-42**
 data and measurements, **1-34, 1-75, 1-76**
 definitions, **1-33, 1-38 to 1-40**
 equipment, **1-33, 1-48 to 1-57**
 facsimile used (*see* Facsimile)
- frequencies (*see* Frequencies)
- licensing policies, **1-34, 1-73 to 1-75**
 logs (*see* Logs)
- maintenance of equipment (*see* Maintenance of equipment)
- operating schedule, minimum, **1-8**
 operation, **1-34, 1-62 to 1-68**
- Standard broadcast stations, power of, **1-7, 1-8**
 relay systems (*see* Relay systems)
- studio facilities (*see* AM/FM studio facilities)
- technical operation, **1-34, 1-57 to 1-61**
 technical standards, **1-34, 1-77 to 1-124**
 10 per cent rule, **1-8**
 time of operation, **1-8**
- Standard broadcast transmitters, **3-3 to 3-31**
 250-watt, **3-22**
 specifications for, **3-23**
 1,000-watt, **3-22**
 specifications for, **3-22**
 5-kw, **3-13**
 specifications for, **3-16**
 Continental Electronics type, **3-15**
 10-kw, **3-13**
 specifications for, **3-14**
 Continental Electronics type, **3-15**
 50-kw, specifications for, **3-13**
 Collins 21E 5-kw, **3-18**
 Collins 21M 10-kw, **3-18**
 Collins 300J-2 250-watt, **3-28**
 schematic diagram of, **3-26, 3-27**
 Continental Electronics type 315B 5-kw, **3-19**
 Continental Electronics type 316B 10-kw, **3-19**
 Continental Electronics type 317B 50-kw, **3-5 to 3-7**
 schematic diagram of, **3-4**
 Fritz Bauer FB-1000J 1,000-watt, **3-25**
 Fritz Bauer FB-5000-C 5-kw, **3-21**
 schematic diagram of, **3-20**
 Gates model BC-1T 1,000-watt, **3-25**
 schematic diagram of, **3-24**
 Gates model BC-5P 5-kw, **3-21**
 Gates model BC-50B 50-kw, **3-7 to 3-9**
 schematic diagram of, **3-6**
 Gates model BC-260-GY 250-watt, **3-28**
 General Electric type BT-50-A 50-kw, **3-9, 3-10**
 schematic diagram of, **3-8**
 maintenance, **3-28 to 3-30**
 air filters, **3-29**
 breakers, **3-29**
 cleaning, **3-28, 3-29**
 contactors, **3-29**
 high-power tubes, **3-30**
 preventive schedule, **8-169, 8-170**
 rectifier tubes, **3-30**
 relays, **3-29**
 rotating equipment, **3-29**
 small tubes, **3-30**
 switches, **3-29**
 tightening, **3-29**
- personnel training for maintenance, **3-31**
 RCA type BTA-1R 1,000-watt, **3-25**
 RCA type BTA 5H 5-kw, **3-18**
 schematic diagram of, **3-17**
 RCA type BTA-10H 10-kw, **3-18**
 schematic diagram of, **3-17**
 RCA type BTA-50G 50-kw, **3-10 to 3-13**
 block diagram of, **3-11**
 schematic diagram of, **3-10**
 tests of performance, **3-30**

- Standard frequencies (*see* Frequencies)
- Standard symbols for electronics, **9-58 to 9-60**
- Standards, **1-373 to 1-415**
- American Standards Association, **1-407**
 - Electronic Industries Association (*see* Electronic Industries Association)
 - Institute of Radio Engineers, current reports, **1-407, 1-408**
 - international exchange of programs (*see* International exchange of programs standards)
 - National Association of Broadcasters, **1-408**
 - organizations participating in development of, **1-373**
 - recording and reproducing (*see* Recording standards)
 - Society of Motion Picture and Television Engineers (*see* Society of Motion Picture and Television Engineers standards)
- Standing-wave ratio, FM antenna structures, **2-216, 2-217**
- Stereophonic broadcasting, **8-254 to 8-261**
- definitions, **8-254**
 - disc, **8-255, 8-256**
 - FM multiplexing (*see* FM multiplexing)
 - history of, **8-254, 8-255**
 - live pickups, **8-256, 8-257**
 - channel separation, **8-257**
 - microphone placement, **8-256, 8-257**
 - National Stereophonic Radio Committee (*see* National Stereophonic Radio Committee)
 - program sources, **8-255, 8-256**
 - tape, **8-255**
- STL relay systems, **1-21 to 1-23, 4-89**
- Studio facilities (*see* AM/FM studio facilities; Television studio facilities)
- Studio to transmitter link (*see* Relay systems)
- Stylus for recording, definitions, **1-386, 1-394, 1-395**
- Subsidiary communications authorization, application for, **1-6**
- FM stations, **1-13**
- Suspension lighting systems, **6-73 to 6-75**
- Symbols for electronics, standard, **9-58 to 9-60**
- Symmetrical attenuation networks, resistance values of, charts and graphs, **9-7 to 9-12**
- higher pad series leg resistances, **9-7**
 - lower pad series leg resistances, **9-8**
 - series resistance, **9-9**
 - shunt or transverse resistor, **9-8**
 - transverse resistance, **9-9**
- TASO method for measuring field strengths, changes of, FCC method, **2-286, 2-287**
- field trials, **2-287**
 - special studies, **2-287**
- TD-2 System (*see* Network facilities)
- Telephone cable color code, **9-61**
- Television, audio transmission standards (*see* Audio transmission standards for television)
- color (*see* Color television)
 - Television, glossary of terms, **4-161 to 4-167**
 - Television antenna structures, antenna terminal, **2-221**
 - aximuthal patterns, **2-229 to 2-234**
 - addition of fields of crossed dipoles, **2-231**
 - definition, **2-222**
 - directionalized horizontal, **2-235**
 - evolution of, **2-234**
 - field patterns of, **2-233, 2-234**
 - omnidirectional, **2-232**
 - bandwidth, **2-242, 2-243**
 - cost, **2-42**
 - definition, **2-221**
 - deicing methods, **2-226**
 - design of, **2-226 to 2-250**
 - emergency antenna, **2-249**
 - emergency provisions, **2-249, 2-250**
 - feed systems (*see* Feed systems)
 - filter networks (*see* Filter networks)
 - frequencies, **2-221**
 - gain, **2-238 to 2-240**
 - definition, **2-222, 2-223**
 - economics, **2-223**
 - requirements, **2-223**
 - terrain, **2-223**
 - transmitter power, **2-223**
 - input impedance, **2-223, 2-240 to 2-242**
 - installation, advance planning, **2-273**
 - antenna mounting trestles, **2-273**
 - assembly, **2-274**
 - assembly precautions, **2-273, 2-274**
 - checking shipment, **2-274**
 - erection, **2-274**
 - preinstallation procedure, **2-273, 2-274**
 - pressurized equipment, **2-274**
 - unpacking precautions, **2-273, 2-274**
 - vertical alignment, **2-274, 2-275**
 - maintenance, daily operation, **2-275**
 - weekly, **2-275**
 - semiannually, **2-275**
 - mounting methods, **2-248**
 - flange mounting, **2-248**
 - pedestal mounting, **2-248**
 - multiplex, **2-247**
 - population distribution, **2-223**
 - proof of performance, **8-221, 8-233 to 8-235**
 - radiation patterns (*see* azimuthal patterns *above*, vertical patterns *below*)
 - radiators, **2-226 to 2-229**
 - half-wave dipole, **2-227, 2-228**
 - helical element, **2-228, 2-230**
 - loop, **2-228**
 - slot, **2-228, 2-229**
 - RF switching features for emergencies, **2-250**
 - safety near RF fields, **2-275, 2-276**
 - standby provisions, **2-249, 2-250**
 - system performance, **2-246, 2-247**
 - TD-2 system, **4-24**
 - tests, after erection, **2-273**
 - after shipment, before erection, **2-272, 2-274**
 - before application of power, **2-275**
 - before shipment, **2-271, 2-272**
 - pattern, **2-271, 2-272**
 - reflectometer test, **2-273**

- Television antenna structures, theory of, 2-226 to 2-250
- UHF (*see* UHF antenna structures)
- vertical patterns, 2-235 to 2-238
- definition, 2-222
- requirements, 2-222
- VHF (*see* VHF antenna structures)
- winds, effect of, 2-222 to 2-226
- vertical patterns, calculated, 2-224
- Television film handling and processing, 6-139 to 6-154
- abrasions, 6-140
- black-and-white practices, 6-150 to 6-153
- dupe negatives, 6-152
- leaders, 6-152, 6-153
- lighting for quality, 6-150, 6-151
- master positives, fine grains, 6-152
- original negatives, 6-151
- photography for quality, 6-150, 6-151
- prints, 6-152
- sound negatives, 6-152
- cleanliness, 6-141 to 6-143
- carbon tetrachloride, 6-142
- fungus growth removal, 6-142, 6-143
- n*-heptane and Freon-113, 6-142
- inhibited methyl chloroform, 6-142
- color practices, A & B printing, 6-153
- black-and-white prints from color negatives, 6-153
- dupe negatives, 6-153
- internegatives, 6-153
- lighting for quality, 6-153
- master positives, 6-153
- negatives, 6-153
- photography for quality, 6-153
- prints, 6-153
- cue marks, 6-140
- daily storage rack, 6-146
- density range for, 6-139
- dirt, 6-140
- editing area, 6-144, 6-145
- editing bench, 6-147
- editing room, 6-146
- filming, 6-151
- record, 6-148
- film cement, 6-145
- film splicer, 6-145
- fire prevention, 6-153, 6-154
- footage counter, 6-146
- horizontal unsteadiness, 6-140
- mailing charges for shipment, 6-150
- previewing, 6-148
- receiving films, 6-148
- references, 6-154
- rewinds, 6-145
- scheduling commercials, 6-148
- scrapping tools, 6-145
- scratches, 6-140
- screening, 6-148
- shipping cases, 6-149
- shipping records, 6-148
- slide-storage cabinet, 6-146
- small viewer, 6-145
- sound track, 6-140, 6-141
- space for, 6-143, 6-144
- special effects, projected backgrounds, 6-170
- Television film handling and processing, splices, 6-140, 6-147
- sprocket perforations, 6-140
- tinting, 6-140
- transshipping, 6-149
- vertical unsteadiness, 6-140
- Television film projectors, 8-172 to 8-176
- cleanliness, 8-173
- distortion, 8-174
- film loops, difficulties with, 8-173
- final results checked, 8-176
- film scratched, 8-173
- hum level high, 8-174
- lamps, handling of, 8-173
- low illumination, 8-173
- microphonics, 8-174
- motor repairs, 8-174
- oiling, 8-173
- photoelectric cell, no voltage for, 8-174
- picture indistinct, 8-173
- picture jump, 8-173
- picture with defective sound, 8-173, 8-174
- preamplifier, oscillation in, 8-174
- projected backgrounds for special effects, 6-167, 6-168
- projector mechanism noisy, 8-173
- sound with defective picture, 8-174
- spares, 8-173
- sprocket holes torn, 8-173
- television test film, 8-174 to 8-176
- alignment of sound record with scanning beam, 8-175
- flutter, 8-175
- picture steadiness test, 8-175, 8-176
- scanning-beam illumination uniform, 8-175
- sound optical assembly adjustment, 8-174, 8-175
- system frequency response, 8-175
- system-gain test, 8-175
- travel-ghost test, 8-175
- (*See also* Television-signal analysis)
- travel ghost, 8-173
- WOW, 8-174
- Television intercity reversible microwave relay system, privately owned, 4-98 to 4-111
- assembly, 4-109 to 4-111
- basic reversible system, 4-105, 4-107
- schematic diagram of, 4-106
- decoder, 4-108, 4-109
- equipment, 4-103 to 4-108
- Indicon coder, 4-107, 4-108
- installation, 4-109 to 4-111
- maintenance, 4-111
- operation, 4-103, 4-108
- path considerations, 4-100 to 4-103
- fade margin, 4-102
- Fresnel-zone clearance, 4-101, 4-102
- inverse bending, 4-100, 4-101
- multipath, 4-101
- personnel problems, 4-111
- reliability calculations, 4-103
- (*See also* Television relay systems)
- Television leader, standards for, 1-412
- Television microwave systems, 4-61 to 4-87
- bandwidth, 4-71

- Television microwave systems, bandwidth, and thermal noise, 4-71
- equipment tests, 4-73 to 4-86
- fading, 4-63 to 4-66
- greater than standard refraction, 4-65
- multipath, 4-65
- reflected-ray, 4-65, 4-66
- substandard refraction, 4-65
- types of, 4-64 to 4-66, 4-74
- frequencies, 4-68
- microwave tests, 4-76
- mixer crystals, 4-85, 4-86
- modulation deviation increased, 4-83
- modulator, improving video characteristics of, 4-83
- multihop evaluation, 4-73
- performance improvement, 4-82 to 4-86
- performance specifications, 4-62
- power gain, 4-71
- privately owned (*see* Television intercity reversible microwave relay system)
- receiver tests, 4-81, 4-82
- references, 4-86, 4-87
- reliability factor vs. fading amplitudes, 4-72
- remote pickup, 7-72 to 7-79
- signal-level measurements, 4-67 to 4-69, 4-86
- frequencies, 4-68
- noise factors in, 4-70 to 4-72
- parabolic antenna gain over dipole 4-67
- propagation-signal, 4-69
- space loss, 4-70
- system evaluation, 4-69 to 4-72
- no-loss maximum distance between parabola and passive reflector, 4-69
- testing equipment, 4-75, 4-76
- threshold value improved, 4-84, 4-85
- transmission-line tuning stubs, 4-86
- transmitter, decreasing noise generated by, 4-83
- transmitter tests, 4-77 to 4-81
- color subcarrier phase shift, 4-80, 4-81
- deviation, 4-78
- frequency measurements, 4-78
- linearity measurements, 4-80
- modulator, 4-78, 4-79
- power output, 4-77, 4-78
- video signal-to-noise ratio, 4-79, 4-80
- video deemphasis, 4-84
- video preemphasis, 4-84
- wave propagation, 4-62, 4-63
- Fresnel-zone radius, 4-63
- tests, 4-76, 4-77
- waveguide loss charts, 9-24 to 9-26
- nominal internal dimensions for standard hollow rectangular waveguides, 9-24
- references, 9-26
- waveguides, comparison with open wire solid dielectric lines, 9-31
- Television-network facilities (*see* Network facilities)
- Television proof of performance (*see* Proof-of-performance measurements)
- Television relay systems (*see* Relay systems)
- Television remote pickup, 7-62 to 7-90
- audio equipment, 7-82 to 7-84
- Television remote pickup, audio equipment, amplifiers, 7-82
- Budelman radio microphone, 7-83
- receivers, 7-83
- microphones, 7-82 to 7-84
- frequencies, 1-29, 1-255, 1-271, 1-272
- lighting equipment, 7-84 to 7-86
- Fresnel spotlight, 7-84
- horizontal polecat with clip-on lights, 7-86
- scoop with barn doors, 7-84
- vertical polecat with clip-on lights, 7-85
- maintenance of equipment, 8-177, 8-178
- microwave equipment, 7-72 to 7-79
- amphibious duck used, 7-76, 7-78
- crane used to elevate equipment, 7-75, 7-76
- gasoline motor-generator used, 7-77
- line-of-sight requirements, 7-73
- narrow beam of, 7-74
- reflectors used, 7-76
- mobile unit, 7-62 to 7-72
- access to roof of, 7-64
- air conditioning for control room, 7-71
- audio-video connections, 7-71
- cable storage, 7-68
- camera-cable storage, 7-67
- control room, interior view of, 7-65
- control-room requirements, 7-62, 7-65, 7-66
- control unit, darkening of, 7-65
- dolly storage, 7-68
- electric-power considerations, 7-67 to 7-71
- generators, gasoline, 7-70, 7-71
- isolation transformer, 7-70
- lighting of control room, 7-72
- microphone storage, 7-68
- microwave reflector storage, 7-64
- patch panel, 7-69
- portable battery charger, 7-72
- roof platform, 7-63
- storage requirements, 7-66, 7-68
- three-camera monochrome operation, 7-63
- transporting cameras, 7-66
- tripod storage, 7-68
- operation of, 7-86 to 7-90
- lighting panel, 7-87
- plywood for Fearless dolly, 7-89
- power-distribution panel, 7-87
- public space permit, 7-87
- special temporary electric service, 7-89
- radio communications equipment, 7-74 to 7-82
- control equipment, 7-80
- radio telephone in station wagon, 7-79
- transmitter-receiver, 7-80
- transmitter-receiver on mobile-unit roof, 7-81
- walkie-talkie transceivers, 7-81
- video equipment, 7-82
- (*See also* Remote-pickup broadcast system, 450 Mc)
- Television-signal analysis, 4-112 to 4-167
- burned-in image, 4-158, 4-159
- clamping, 4-153 to 4-155

- Television-signal analysis, clamping, failure,
4-154
 expanded horizontal, 4-154
 expanded vertical, 4-154
 horizontal, 4-154
 vertical, 4-154
loss of, 4-155
 horizontal, 4-154
 vertical, 4-155
vertical, 4-127
color, NTSC, 4-116 to 4-118
 horizontal, IRE roll-offs presentation,
 4-117
 wideband presentation, 4-117
 vertical, wideband presentation, 4-118
color bars, 4-126, 4-127
 expanded horizontal, 4-127
 horizontal, wideband, 4-126
 monochrome, picture, 4-126
 typical color information, 4-126
color-signal impairments, 4-159 to 4-161
 differential gain distortion, 4-160
 differential phase distortion, 4-160
 high chrominance-signal level, 4-159
 horizontal, 4-159
 lagging chrominance, 4-160, 4-161
 leading chrominance, 4-160, 4-161
 loss of color, 4-160
 low chrominance-signal level, 4-159
 horizontal, 4-159
47A transmission-measuring system, 4-120
 to 4-122
 modulated, horizontal, 4-121
 picture, 4-121
 receiving-unit presentation, 4-121, 4-122
 unmodulated, horizontal, 4-120
glossary of terms, 4-161 to 4-167
halo, 4-158
horizontal scanning interval, 4-113 to 4-115
interference, 4-145 to 4-153
 120 cycles, 4-147
 horizontal, 4-147
 vertical, 4-147
 1,000 cycles, 4-147
 horizontal, 4-147
 vertical, 4-147
 31.5 kc, horizontal, 4-149
 vertical, 4-150
 311 kc, 4-148
 horizontal, 4-149
 vertical, 4-150
 1 Mc, 4-149
 horizontal, 4-149
 vertical, 4-150
 3.6 Mc, 4-149
 horizontal, 4-149
 vertical, 4-150
clamped, 120 cycles, horizontal, 4-148
 vertical, 4-148
cross talk, 4-150, 4-151
 horizontal, 4-150
 vertical, 4-151
glitch, 4-146, 4-148
 vertical, 4-148
high-frequency, 4-146
impulse noise, 4-153
light random noise, horizontal, 4-152
Television-signal analysis, interference, low-
frequency, 4-145, 4-146
 message-channel, 4-152
 microphonics, 4-153
 random noise, 4-151 to 4-153
 horizontal, 4-152
 vertical, 4-152
 single-frequency, 4-145
level irregularities, 4-128 to 4-131
 bleeding whites, horizontal, 4-130
 vertical, 4-130
 blooming, 4-128
 long-duration level changes, 4-129 to
 4-131
 partial clamping failure, expanded
 vertical, 4-130
 horizontal, 4-130
 short-duration level changes, 4-131
 sync compression, horizontal, 4-130
moiré, 4-158
multiburst test signal, 4-122, 4-123
 frequencies normally used, horizontal,
 4-123
 gradual gain, horizontal, 4-123
 gradual loss, horizontal, 4-123
 horizontal, 4-122
 picture, 4-123
 vertical, 4-123
nonlinearity, 4-156, 4-157
 axis shift, 4-157
 through low-pass filter,
 4-157
 harmonic distortion, 500 kc, 4-156
 serrations, 4-155, 4-156
staircase, 4-127
 horizontal, 4-122
 modulated, horizontal, 4-128
 picture, 4-128
 unmodulated, horizontal, 4-128
 variable over-all duty cycle, horizontal,
 4-128
tearing, 4-156
test pattern, ELA, 4-122 to 4-125
 aspect ratio, 4-124
 contrast, 4-124
 horizontal linearity, 4-124
 interlace, 4-124
 picture, 4-124
 resolution, 4-125
 ringing, 4-124, 4-125
 streaking, 4-124
 vertical linearity, 4-124
 proof of performance, 8-226, 8-240,
 8-241
 typical broadcasters, contrast, 4-125
 linearity, 4-125
 picture unimpaired, 4-125
 resolution, 4-125
 ringing, 4-126
 smearing, 4-125
 streaking, 4-125
test signals, 4-118 to 4-127
 monoburst, horizontal, 4-118
 sine waves, 4-118
transmission-frequency irregularities, 4-131
 to 4-145
 change of setup, 4-137, 4-138

- Television signal analysis, transmission-frequency irregularities, echo impairment effect vs. image size and echo displacement, 4-142
- echoes, 4-141 to 4-145
- edge effect, 4-140
- high-frequency gain changes, 4-133
- high-setup test pattern, 4-138
- horizontal, 4-138
- vertical, 4-138
- hourglass, 4-141
- increase in setup, 4-138
- loss of setup, 4-137, 4-138
- low-frequency gain changes, 4-133
- low resolution, receiver scanning spot too large, 4-141
- roll-off from 1 Mc, 4-141
- expanded horizontal, 4-141
- low-setup test pattern, 4-137
- horizontal, 4-137
- vertical, 4-138
- negative-echo test pattern, 4-144
- expanded horizontal, 4-144
- horizontal, 4-144
- vertical, 4-144
- negative-streaking test pattern, 4-135
- expanded vertical, 4-136
- horizontal, 4-136
- vertical, 4-136
- negative-streaking window signal, 4-135
- expanded vertical, 4-135
- horizontal, 4-135
- vertical, 4-135
- overshoots, on back porch, 4-140
- following whites or blacks, 4-140
- on front porch, 4-140
- window signal, horizontal, 4-140
- positive-echo test pattern, 4-143
- expanded horizontal, 4-143
- horizontal, 4-143
- vertical, 4-143
- positive-echo window signal, 4-143
- expanded horizontal, 4-144
- horizontal, 4-143
- vertical, 4-144
- positive-streaking window signal, 4-134
- expanded vertical, 4-135
- horizontal, 4-134
- vertical, 4-134
- resolution, 4-140, 4-141
- ringing, 4-135, 4-139
- ringing 3-Mc test pattern, 4-139
- expanded horizontal, 4-139
- ringing 4-Mc test pattern, 4-139
- expanded horizontal, 4-139
- smearing, 4-133, 4-134, 4-136, 4-137
- smearing test pattern, 4-136
- expanded vertical, 4-137
- horizontal, 4-136
- vertical, 4-136
- streaking, 4-133 to 4-137
- window signal, highs depressed,
- horizontal, 4-132
- highs raised, horizontal, 4-132
- lows depressed, highs raised,
- horizontal, 4-132
- lows depressed, horizontal, 4-132
- Television signal analysis, transmission-frequency irregularities, window signal, lows raised, highs raised, horizontal, 4-132
- lows raised, horizontal, 4-132
- ringing, horizontal, 4-132
- unimpaired, horizontal, 4-132
- unimpaired video signal, A-scope,
- expanded horizontal presentation, 4-115
- expanded vertical presentation, 4-116
- horizontal presentation, 4-114
- vertical presentation, 4-115
- picture-monitor presentation, 4-113
- vertical blanking, picture presentation, 4-117
- vertical scanning interval, 4-115, 4-116
- window test signal, 61C modulated,
- horizontal, 4-120
- picture, 4-120
- vertical, 4-120
- 61C unmodulated, horizontal, 4-120
- picture, 4-120
- broadcaster's horizontal, 4-119
- picture, 4-119
- vertical, 4-119
- Television special effects (*see* Audio special effects: Video special effects)
- Television stations, allocations on spectrum, 2-4
- applications, 1-3 to 1-6, 1-36, 1-191 to 1-196
- audio transmission standards (*see* Audio transmission standards for television)
- authorizations, 1-36, 1-191 to 1-196
- automatic logging (*see* Automatic logging)
- auxiliary broadcast services (*see* Television relay systems)
- channel utilization, 1-36, 1-174 to 1-191
- CONELRAD, 1-37, 1-249 to 1-252
- distribution of noise-limited service, 2-36
- probability, 2-35
- distribution of service limited by interference, 2-36
- distribution of service probability limited by interference, 2-36
- effective radiated power, 1-14
- experimental, administrative procedure, 1-254, 1-260
- definitions, 1-254, 1-259
- equipment, 1-254, 1-261
- licensing policies, 1-254, 1-260, 1-261
- technical operation, 1-254, 1-262, 1-263
- field strengths, prediction of, 2-28 to 2-33
- logs, FCC rulings, 1-417 to 1-419
- NAB sample, 1-420, 1-422
- maintenance of equipment (*see* Maintenance of equipment)
- monitoring equipment, 1-37, 1-220 to 1-236
- network facilities (*see* Network facilities)
- operating requirements, 1-36, 1-196 to 1-203
- prediction of service, with interference
- from several sources, 2-34, 2-35
- with one undesired station, 2-33, 2-34
- formula for, 2-34
- time and location distributions, 2-33

- Television stations, proof of performance
(*see* Proof-of-performance measurements)
site selection, **2-38, 2-39**
studio facilities (*see* Television studio facilities)
technical standards, **1-36, 1-204 to 1-220**
time of operation, **1-15**
translator stations (*see* UHF television translators)
- Television studio facilities, cost estimating for, **6-67 to 6-71**
acoustics, **6-69**
air conditioning, **6-69, 6-70**
building-trades wage scales, **6-71**
construction, **6-67, 6-68**
conversion of studios and offices, **6-68**
flooring, **6-69**
heat, **6-69**
indices of building costs, **6-71**
land improvement, **6-68**
lighting, **6-70, 6-71, 6-79**
new studio, office building, **6-68**
power service, **6-70, 6-71**
rigging, **6-70, 6-71**
transmitter plant, **6-68**
lighting (*see* Lighting for television studios)
maintenance of equipment (*see* Maintenance of equipment)
special effects (*see* Audio special effects; Video special effects)
- Television test charts, standards (*see* Electronic Industries Association, standards of, television test charts)
- Television test film, maintenance, **8-174 to 8-176**
standards, **1-412 to 1-416**
(*See also* Television-signal analysis)
- Television test slides, color, standards for, **1-412**
- Television towers (*see* Antenna structures)
- Television translators (*see* UHF television translators)
- Television transmitters, **3-61 to 3-88**
aural, circuitry, **3-75 to 3-78**
aural exciter, **3-75 to 3-77**
block diagram, **3-75**
clipped trapezoid, **3-77**
frequency multipliers, **3-77**
position modulator, **3-77**
reactance-tube modulator, **3-76**
RF amplifiers, **3-78**
proof-of-performance measurements, **8-234, 8-245 to 8-248**
control circuitry, **3-80 to 3-82**
schematic diagram of, **3-81**
starting sequence, **3-81, 3-82**
stopping sequence, **3-82**
General Electric type TT-36-A, schematic diagram of system, **3-82, 3-83**
installation, **3-83, 3-84**
maintenance of equipment (*see* Maintenance of equipment)
microwave, decreasing noise generated by, **4-83**
tests, **4-77 to 4-81**
personnel training for maintenance, **3-88**
- Television transmitters, power output, proof of performance, **8-218 to 8-221, 8-232**
protective circuitry, **3-80 to 3-82**
rectifiers, **3-78 to 3-80**
quarter-phasing, **3-79**
regulated power supplies, **3-78 to 3-80**
tests, **3-84 to 3-87**
amplitude vs. frequency sweep detection, **3-84**
linearity testing, **3-85, 3-86**
square-wave response—high frequency, **3-87**
square-wave response—low frequency, **3-86**
vestigial-sideband detector IF response, **3-86**
- visual, circuitry, **3-61 to 3-75**
amplifier, uncompensated, **3-62**
block diagram of, **3-62**
constant-current curves, **3-73**
constant-impedance VSB filter, **3-74**
differentiator key derivation, **3-68**
diode clamp, **3-66**
double-tuned circuit, **3-73**
FCC bandpass, **3-72**
keyed clamp, **3-67**
modulated stage, **3-70 to 3-72**
modulator output stage, **3-66**
nonconstant-impedance VSB filter, **3-74**
output circuits, **3-73 to 3-75**
power modulator, **3-72**
RF amplifiers, **3-72, 3-73**
series peaking compensation, **3-64, 3-65**
series shunt compensation, **3-65**
shorted delay line key derivator, **3-68**
shunt compensation, **3-64**
square-law-type modulation, **3-71**
stretcher circuits, **3-69**
subcarrier trap, **3-74**
sync separator, **3-67**
visual exciter, **3-69, 3-70**
crystal oscillator, **3-70**
frequency-multiplication spectrum, **3-70**
white clipper, **3-69**
wideband amplifiers, **3-72, 3-73**
proof of performance, **8-233, 8-235 to 8-238**
- Terminology (*see* Glossary of terms)
- Test films (*see* Television test film)
- Test pattern (*see* Television-signal analysis)
- Tests, color-television equipment (*see* Color television, test equipment)
- CONELRAD, **1-37, 1-251, 1-252**
compatible single-sideband system for standard broadcast, **8-39 to 8-41**
maintenance of equipment, **8-172 to 8-180**
microwave, **4-76**
equipment, **4-73 to 4-86**
wave propagation, **4-76, 4-77**
picture steadiness, **8-175**
remote-pickup broadcast system, **7-42, 7-48**
standard broadcast transmitters, **3-30**

- Tests, system gain, 8-175
 television antenna structures (*see* Television antenna structures)
 television operating centers, test trunks, 4-42, 4-43
 television test charts (*see* Electronics Industries Association)
 television transmitters, 3-84 to 3-87
 microwave, 4-77 to 4-81
 travel ghost, 8-175
 UHF television translators, 8-81, 8-82
- Time signals, Canadian, 1-429
 foreign, 1-430
 WWV and WWVH, 1-427
 authorization to rebroadcast, 1-430
- Tornadoes, effect on antenna structures, 2-64
- Towers (*see* Antenna structures)
- Transducers, color television (*see* Color television)
- Transistor, 8-3 to 8-15, 9-36 to 9-53
 advantages of, 8-4
 base, 8-6
 charts and graphs relating to, 9-36 to 9-53
 collector, 8-6
 diode, relationship between, 8-5, 8-6
 simple conducting circuit, 8-7
 emitter, 8-6
 equivalent symbols for with three-element vacuum tube, 8-7
 grown *n-p-n* junction tetrode, charts relating to, 9-48, 9-49, 9-53
 handling of, 8-14, 8-15
 high-frequency, charts relating to, 9-46, 9-47
 circuitry, 9-53
 high-power units, charts relating to, 9-41, 9-48, 9-49
 junction, 8-7, 9-42 to 9-45, 9-48, 9-49, 9-53
 limitations of, 8-4, 8-5
 low-frequency performance of, 8-12 to 8-14
 current gain, 8-12, 8-13
 low-power, junction triode, charts relating to, 9-42 to 9-45
n-type germanium, defined, 8-5
p-type germanium, defined, 8-5
 parameter conversion formulas, 9-50
 parameter variation, charts relating to, 9-52
 phototransistors, charts relating to, 9-51
 point-contact, charts relating to, 9-50, 9-51
 power, handled in substantial amounts, 8-4
 precautions, 8-14, 8-15
 reverse connected, 8-7
 temperature effects, 9-40, 9-41
 transistor sockets, chart relating to, 9-50
 vacuum tube, alpha, definitions of, 8-8
 beta, definitions of, 8-8
 bias arrangements, 8-10 to 8-12
 circuit configurations, 8-8, 8-9
 common-base, 8-8
 common-collector, 8-8
 common-emitter, 8-8
 electron flow in, 8-7
 emitter followers, 8-10
 input impedance, 8-9, 8-10
 output impedance, 8-9, 8-10
 relationship between, 8-6 to 8-12
- Translator stations (*see* UHF television translators)
- Transmission in optical reproducing, definition of terms, 1-395, 1-396
- Transmission-frequency irregularities (*see* Television-signal analysis)
- Transmission lines, attenuation, 2-189, 2-190
 coaxial-line impedance chart, 9-20
 dielectric constants, 9-20
 CONELRAD, beverage antenna, 8-136
 continuous air-dielectric cable, 2-186
 installation, 2-206 to 2-208
 effect on maintenance of directional antennas, 2-167
 electrical characteristics of, 2-189 to 2-196
 emergency provisions, 2-249
 feed systems of standard broadcast antenna structures, two-tower directional, 2-138 to 2-143
 flexible, 2-186
 installation, 2-206 to 2-208
 horizontal run to station, 2-249
 impedance, 2-196
 installation, 2-196 to 2-210
 main tower run, 2-248, 2-249
 open-wire line, 2-188, 2-189
 and plant layout of standard broadcast antenna structures, 2-105
 power ratings, 2-191 to 2-196
 rigid, 2-186, 2-187
 adapter, 2-198
 antenna connections, 2-199
 bill of materials, 2-197
 break in arrangement, 2-205
 break-away section, 2-205
 flange, soft soldered field, 2-199
 flexible section, 2-206
 formula, for average-power rating, 2-193
 for peak-power rating, 2-192, 2-193
 gas barrier, 2-198
 gas inlet, 2-198
 hanger, horizontal, 2-203
 rigid, 2-199
 spring and sliding, 2-200
 horizontal anchor, 2-204
 horizontal run, protected, 2-203
 installation, 2-197 to 2-206
 inside transmitter building, 2-204
 lateral brace for, 2-203
 mitered elbow, 2-199
 power rating, 2-192 to 2-194
 reducer, 2-198
 straight coupling, 2-204
 switching arrangement, 2-205
 tower installation, 2-200, 2-202
 tuner, multiple stub, 2-206
 single stub, 2-206
 slug, 2-206
- semiflexible air-dielectric cable, 2-185, 2-186
 installation, 2-206 to 2-208
 power rating, 2-194, 2-195
 solid-dielectric cable, 2-185
 installation, 2-206 to 2-208
 power rating, 2-195, 2-196

- Transmission lines, television proof of performance, **8-221, 8-233 to 8-235**
 tuning stubs for television microwave systems, **4-86**
 used with AMCI slotted-ring VHF antenna, **2-252, 2-253**
 vicinity of tower top, **2-248**
 voltage standing-wave ratio, **2-190, 2-191**
 waveguides, **2-188**
 bill of materials, **2-209**
 compared with open-wire solid-dielectric lines, **9-31**
 installation, **2-208 to 2-210**
 loss charts, **9-24 to 9-26**
 nominal internal dimensions for standard hollow rectangular waveguides, **9-24**
 power rating, **2-196**
- Transmitters, automatic logging (*see* Automatic logging)
 color television, **5-17, 5-18**
 matrix functions, diagram of, **5-23**
 power output, **8-219**
 compatible single-sideband system for standard broadcast, measurements, **8-48, 8-49**
- CONELRAD, Collins type converted, **8-137 to 8-139**
 Gates type converted, **8-137, 8-138**
 Raytheon type converted, **8-138**
 RCA type converted, **8-139, 8-140**
 sequential switching of, **8-140 to 8-143**
 Western Electric type converted, **8-140**
- FM (*see* FM transmitters)
 operating logs (*see* Logs)
 remote-pickup broadcast systems, **7-4, 7-5, 7-9 to 7-16, 7-20, 7-32 to 7-35, 7-39, 7-42**
 standard broadcast (*see* Standard broadcast transmitters)
 stereophonic broadcast, **8-261**
 television (*see* Television transmitters)
- Trees, effect on wave propagation, **2-22**
- Tropospheric effects (*see* Wave propagation)
- Tubes, **8-178 to 8-180**
 air-cooled, **8-179**
 heater surge chart, **9-33**
 high-power radio, **8-179, 8-180**
 image-orthicon (*see* Image-orthicon tube)
 transistors (*see* Transistors)
 transmitters, **3-30**
 water-cooled, **8-178, 8-179**
- Turntable, center pin diameter, **1-375**
 direction of rotation for international exchange, **1-397**
 and disk rotation, **1-374**
 height, **1-375**
 mobile remote-pickup broadcast station, **7-55 to 7-58**
 cueing modification, **7-56**
 leveling device for, **7-58**
 platen, **1-375**
 recovery time, **1-375**
 sound-effects console, **6-171, 6-172**
 speed, **1-374**
 speed used for international exchange, **1-397**
- Two-tower directional-antenna structures (*see* Standard broadcast antenna structures)
- UHF antenna structures, beam tilt, **2-261, 2-262**
 helical, one to five bays, **2-268 to 2-270**
 ten-bay, **2-269, 2-270**
 high gain needed, **2-261**
 null filling, **2-261**
 nulls eliminated, **2-261**
 pattern synthesis, **2-263**
 radiation reduced above horizon, **2-262, 2-263**
 slotted-cylinder type, **2-263 to 2-268**
 coupling elements, **2-266, 2-267**
 ERP increased, **2-266 to 2-268**
 mechanical description, **2-264**
 ultragain, **2-264 to 2-266**
- UHF television translators, **8-53 to 8-82**
 administrative procedure, **1-256, 1-291**
 alignment, **8-81, 8-82**
 amplifier, 100-watt, **8-67**
 100-watt, cavity for a tetrode, schematic diagram of, **8-68**
 linear, **8-61 to 8-63**
 photograph of cavity, **8-63**
 schematic diagram of cavity, **8-62**
 VHF, **8-58, 8-59**
 antenna structure, amplification at, **8-56**
 half-wave dipoles fed in phase, **8-73**
 horizontal pattern of two antennas placed side by side, **8-74**
 impedance matching with T transformers, **8-75**
 receiving, **8-56, 8-57**
 transmitting, **8-72 to 8-75**
 vertical pattern of dipoles, **8-74**
 area-coverage problems, **8-71 to 8-77**
 calculations, **8-75 to 8-77**
 code wheel for automatic identification, **8-66, 8-67**
 control circuitry, **8-64 to 8-67**
 block diagram of, **8-64**
 definition, **1-16, 1-256, 1-290**
 equipment, **1-256, 1-293 to 1-295**
 frequencies, **1-15 to 1-17, 1-256, 1-290, 1-291**
 tolerances, **1-30**
 injection sources, **8-63, 8-64**
 oscillator-multiplier chain, block diagram of, **8-63**
 oscillator-multiplier, frequencies for each possible conversion, **8-65**
 installation, **8-77 to 8-81**
 check list for, **8-79 to 8-81**
 elements of, **8-54**
 view of, **8-54**
 internal interferences, **8-70, 8-71**
 heterodyne-repeater, **8-53**
 licensing policies, **1-256, 1-291 to 1-293**
 line-of-sight requirements, **8-71, 8-72**
 formula, required clearance of obstruction, **8-71**
 maintenance, **8-82**
 mixers, **8-59 to 8-61**
 conversion, **8-60**

- UHF television translators, mixers, mixer circuit for heterodyning signals from VHF to UHF, 8-61
- path attenuation calculation, 8-76
- path loss, free-space, 8-76
- power of, 1-16
- references, 8-82
- signal-reception system, 8-54 to 8-57
- noise considerations, 8-54 to 8-56
- requirements, 8-54
- rms noise voltage, 8-55
- sites, 8-76, 8-77
- layout, 8-77, 8-73
- technical operation, 1-256, 1-296, 1-297
- test equipment, 8-78 to 8-81
- testing, 8-81, 8-82
- translators, 8-57 to 8-71
- block diagram of, 8-57, 8-58
- defined, 8-53
- input, 8-68 to 8-70
- input, attenuation of cables, 8-70
- in tandem, 8-70
- Vegetation, effect on wave propagation, 2-22
- VHF antenna structures, AMC1 slotted ring antenna, 2-251 to 2-254
- description, 2-251, 2-252
- construction, 2-254
- theory of operation, 2-252 to 2-254
- helical antenna, 2-254 to 2-257
- high-channel, 2-255 to 2-257
- low-channel, 2-257
- supergain antenna, 2-251
- superturnstiles, 2-250, 2-251
- traveling-wave antenna, 2-257 to 2-261
- universal curve, 2-259
- vertical field pattern, 2-260
- Video special effects, 6-155 to 6-170
- color matting, block diagram of system, 6-158
- electronic camera distortions, 6-161, 6-162
- polarity reversal, 6-162
- ripple, 6-162
- scanning reversal, 6-161
- scanning size change, 6-161
- unorthodox operating techniques, 6-162
- electronic switching, 6-155 to 6-161
- block diagram of system, 6-156
- circuit plan, 6-156, 6-157
- techniques, 6-155, 6-156
- front projection of backgrounds, 6-165
- keyed insertion, 6-159, 6-160
- background camera picture, 6-160
- final key-inserted picture, 6-160
- key-insertion camera picture, 6-160
- subject camera picture, 6-160
- matting, 6-160, 6-161
- optical effects, 6-162 to 6-165
- dove prism, 6-163
- etched lenses, 6-164, 6-165
- filters, 6-164
- Hartley lens, 6-165
- kaleidoscope, 6-163, 6-164
- multifaceted prisms, 6-162, 6-163
- projected backgrounds, 6-165 to 6-170
- arc slide projector, 6-166
- film processing, 6-170
- Video special effects, projected backgrounds, film projectors, 6-167, 6-168
- light sources, 6-166, 6-167
- projection lenses, 6-165, 6-166
- screen materials, 6-168, 6-169
- screen materials, diffusion characteristics of, 6-168
- slide processing, 6-170
- slide sizes, 6-167
- rear projection of backgrounds, 6-165, 6-169, 6-170
- lighting for, 6-169
- shooting, 6-170
- split screen, 6-159
- wipe function generation, 6-157 to 6-159
- box wipe, 6-159
- circuit plan, 6-157
- diagonal wipe, 6-159
- horizontal wipe, 6-159
- wedge insert, 6-159
- Video-tape recording, 6-117 to 6-138
- color recorder, 6-136, 6-138
- cueing, 6-132, 6-133
- high-frequency response, 6-118
- interchangeability, 6-133 to 6-138
- limitations of the process, 6-118, 6-119
- low-frequency response, 6-119
- magnetic medium explained, 6-117
- misalignment, quadrature, angular misalignment of heads, 6-136
- guide too close to head, 6-134
- guide too high, 6-135
- mobile recorder, cruiser equipped with, 6-138
- model of, 6-137
- problems in, 6-119
- process of recording, 6-117
- process of reproducing, 6-117, 6-118
- prospects for, 6-138
- recorder, 6-119 to 6-132
- automatic compensation sensor, 6-132
- blanking switcher, 6-126
- block diagram of, 6-124
- capstan servo generator, 6-129
- commercial recorder-reproducer, 6-119 to 6-121
- control systems, 6-127 to 6-132
- demodulator, 6-127
- drum and guide, profile view, 6-120
- master control unit, block diagram of, 6-128
- modulation, 6-123 to 6-125
- modulation system, 6-121, 6-122
- processing amplifier, 6-127
- record amplifier, 6-125
- record-amplifier driver, 6-125
- switcher, 6-125 to 6-127
- tape-guide amplifier, 6-131
- tape-guide servo control, 6-130 to 6-132
- tape tracking servo system, 6-129, 6-130
- tape transport controls, 6-129
- track dimensions currently used for recorded tape, 6-121
- video-head subassembly, 6-120
- signal-to-noise ratio, 6-119
- time-base banding, 6-133 to 6-138
- Voltage (see Field strengths)

- Wave propagation, atmospheric effects (*see* ionosphere effect and troposphere effect *below*)
- bibliography, **2-39, 2-40**
- buildings, effect of, **2-19 to 2-22**
- defined, **2-3**
- electromagnetic spectrum, **2-4**
- field strengths (*see* Field strengths)
- in free space, **2-4 to 2-9**
- antenna structures, **2-5**
 - areas of, **2-6**
 - free-space field intensity, **2-7**
 - gains, **2-6**
 - patterns, **2-6**
 - received power, **2-7, 2-8**
 - received power between half-wave dipoles, **2-7**
 - transmission loss between, **2-5, 2-7 to 2-9**
 - formulas for, **2-4, 2-5**
- hills, effect of, **2-16 to 2-19**
- ionosphere effect, **2-24 to 2-27**
- F*² layer, **2-25, 2-26**
 - meteoric ionization, **2-26**
 - sporadic *E* layer, **2-25 to 2-27**
- over plane earth, **2-9 to 2-13**
- antenna structures, minimum effective height, **2-11**
 - received power, **2-12**
 - transmission loss between, **2-11, 2-12**
 - field strengths, **2-9 to 2-11**
- radio spectrum, **2-4**
- ray paths, above plane earth, **2-9**
- above spherical earth, **2-13**
 - behind hills, **2-18**
 - over rough terrain, **2-17**
- shadow loss, for random locations, **2-21**
- relative to free space, **2-19**
 - relative to plane earth, **2-20**
- over smooth spherical earth, **2-13 to 2-16**
- beyond line of sight, **2-13 to 2-16**
 - decibel loss, **2-14**
 - distance to horizon, **2-15**
 - within line of sight, **2-13**
- statistical evaluation of, **2-27 to 2-37**
- Wave propagation, study of terrain, **2-248**
- television allocations of spectrum, **2-4**
 - microwave systems, **4-62, 4-63**
 - tests, **4-76, 4-77**
- trees, effect of, **2-22**
- troposphere effect, **2-22 to 2-24**
- ducts, **2-22, 2-23**
 - fading, **2-24**
 - scatter, **2-24**
 - stratification, **2-22, 2-23**
 - vegetation, effect of, **2-22**
- WWV and WWVH forecasts, **1-427, 1-428**
- Waveforms, color television, I and Q signals, **5-14**
- synchronizing, **8-219**
 - colorplexer, **5-54 to 5-56**
 - FM modulator, Serrasoid, **3-42**
 - monochrome-television system, **5-7**
 - single-sideband wave (*see* Compatible single-sideband system for standard broadcast)
 - television, proof of performance, **8-224 to 8-227, 8-238 to 8-240, 8-249**
 - WWV and WWVH, **1-426**
- Waveguide (*see* Transmission lines)
- Waveguide loss charts, **9-24 to 9-26**
- Wax in mechanical recording, definition of terms, **1-396**
- Winds, effect on antenna structures, calculating wind load, **2-81, 2-82**
- hurricanes, **2-63, 2-64**
 - television structures, **2-222 to 2-226**
 - vertical patterns, calculated, **2-224**
- pressure, **2-64, 2-65**
- FIA specifications, **2-64**
 - loading, **2-65**
 - and tower failure, **2-64, 2-65**
- tornadoes, **2-64**
- velocity, **2-62, 2-64**
- indicated vs. true, **2-62, 2-63**
- Window test signal (*see* Television-signal analysis)
- WWV and WWVH (*see* Frequencies, WWV and WWVH)

