CHAPTER 38

TABLES, CHARTS AND SUNDRY DATA

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SECTION 1 : UNITS

(i) General physical units (ii) Electrical and magnetic units (iii) Photometric units (iv) Temperature.

(i) General physical units

TABLE 1 : UNITS

Quantity	English	Metric
Length	1 mil = 0.001 inch = 0.00254 cm 1 inch = 1000 mils = 2.54 cm 1 foot = 12 inches = 30.48 cm 1 yard = 3 feet = 0.9144 m 1 mile = 1760 yards = 1.6093 Km 1.152 miles = 1 nautical mile = 1.853 Km 60 naut. miles = 1 degree = 111.100 Km	1 mm = 39.37 mils 1 cm = 0.3937 inches = 0.0328 foot 1 m = 1.094 yards = 3.272 feet 1 Km = 0.6214 mile
		1 micron = 10^{-6} metre = 0.0001 cm = 10 000 Angstroms 1 Angstrom (A^0) = 10^{-10} metre = 10^{-8} cm = 0.0001 micron
Area	1 mil^2 = 6.452×10^{-10} m^2 1 circ. mil* = 0.7854×10^{-6} in^2 = 5.067×10^{-10} m^2 1 in^2 = 6.452 cm^2† 1 ft^2 = 144 in^2 = 0.0929 m^2 1 yd^2 = 9 ft^2 = 0.8361 m^2	1 cm^2 = 0.1550 in^2 = 0.001 076 ft^2 1 m^2 = 10.76 ft^2
Volume	1 in^3 = 16.39 cm^3† = 0.016 39 litres ** 1 ft^3 = 1728 in^3 = 28.32 litres	1 cm^3 = 0.061 02 in^3 1 litre = 61.02 in^3
Mass	(Avoirdupois) 1 grain = 0.0648 grams 1 dram = 1.772 grams 1 ounce = 16 drams = 28.35 grams 1 pound = 16 ounces = 7000 grains = 453.6 grams 112 pounds = 1 hundredweight = 50.800 Kg 1 ton = 20 cwt = 1016.1 Kg	1 gram = 15.432 grains = 0.035 27 ounce = 0.002 205 lb 1 Kg = 2.205 lb 1000 Kg = 0.9842 ton = 1 metric ton

(Continued on page 1330)

*1 circular mil is the area of a circle 0.001 inch diameter.

† cm^2 = sq. cm = square centimetres (similarly for other symbols). cm^3 = cub. cm = cubic centimetres.

**1 litre = 2.202 lb of fresh water at 62 °F

Quantity	English	Metric
Force	1 pound weight = 4.448×10^5 dynes 1 poundal = 1.382×10^4 dynes	1 dyne = 0.2248×10^{-5} pound weight = 0.001 0197 gm weight 1 gram weight = 980.62 dynes‡
Intensity of Pressure	1 atmosphere = 760 mm mercury at 0 °C = 1.0132×10^6 dynes/cm² 1 lb/ft² = 478.8 dynes/cm² 1 lb/in² = 0.6894×10^5 dynes/cm² 1 ton/ft² = 1.072×10^6 dynes/cm² 1 inch of mercury at 0 °C = 3.386×10^4 dynes/cm² = 34.53 gms/cm²	1 dyne/cm² = 0.9869×10^{-6} atmosphere 1 mm mercury at 0 °C = 1.333×10^3 dynes/cm² = 1.359 gms/cm² = 1.316×10^{-3} atmosphere
Angles	1 degree (1 °) = 0.017 4533 radian 1 radian = 57° 17′ 44.806″ = 57° 17.7468′ = 57.295 780 ° 1 quadrant = 90 ° = $\pi/2$ = 1.571 radians 1 revolution = 360 ° = 2π = 6.283 radians	

‡The internationally accepted value of gravitational acceleration at latitude 45° and sea level.

(ii) Electrical and magnetic units

There are several systems of units in common use, but they may be divided into three clearly distinguished groups :

1. **Unrationalized systems,** including
   (a) Absolute† c.g.s.* electrostatic system.
   (b) Absolute† c.g.s.* electromagnetic system.
   (c) Absolute† m.k.s. (metre-kilogram-second) system. Otherwise known as the Giorgi system.

2. **Rationalized systems** including
   (a) Rationalized m.k.s. system (Giorgi).

3. **Practical systems**

The common practical system includes the volt, ampere, coulomb, ohm, farad, henry and watt.

All fundamental physical relationships are normally worked out in one of the unrationalized systems, and the final result may be converted into practical units for general use.

Rationalized systems have been developed to simplify certain calculations. They may be used as alternatives to unrationalized systems.

The m.k.s. system is increasing in popularity because neither the c.g.s. electrostatic system nor the c.g.s. electromagnetic system is convenient for use with all problems, and the combined use of the two systems has been generally adopted in the past. Another reason for its popularity is that it includes many of the practical units, the second, joule, watt, coulomb, ampere, volt, ohm, mho, farad and henry. The rationalized m.k.s. system has been standardized by the American I.R.E. (January 1948).

The Giorgi m.k.s. system absolute system was adopted by the International Electrotechnical Commission (I.E.C.) in Bruxelles, June 1935 (see Proceedings of National Academy of Sciences Vol. 21 No. 10 pp. 579-583, October 1935 ; reprinted by Harvard University, Publications from the Graduate School of Engineering 1935-36 No. 167). See also A. E. Kennelly " I.E.C. adopts MKS System of Units," Electrical Engineering 54.12 (Dec. 1935) 1373. See also References below.

In any one sequence of calculations it is essential to retain the same system throughout. The final result may then, if desired, be converted to any other system. Table 2 should enable any engineer to convert from one quantity in any system to any other of the major systems.

REFERENCES TO MKS SYSTEM

Carr, H. L. A. " The M.K.S. or Giorgi system of units—the case for its adoption " Proc. I.E.E. Part I 97.107 (Sept. 1950) 235.

Rawcliffe, G. H. " The rationalization of electrical units and its effect on the M.K.S. System " Proc. I.E.E. Part I 97.107 (Sept. 1950) 241.

Marriott, H., and A. L. Cullen " The rationalization of electrical theory and units " Proc. I.E.E. Part I 97.107 (Sept. 1950) 245.

Bradshaw, E. " Rationalized M.K.S. units in electrical engineering education " Proc. I.E.E. Part I 97.107 (Sept. 1950) 252.

A brief description of all systems including the m.k.s. is given in " Applied Electronics " (Massachusetts Institute of Technology ; John Wiley & Sons Inc. New York ; Chapman & Hall Ltd., London, 1943) Appendix B.

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*c.g.s. = centimetre-gramme-second.

†An absolute system is one which includes length, mass and time in its fundamental dimensions.

TABLE 2: THE PRINCIPAL ELECTRICAL AND MAGNETIC UNITS

Quantity	Practical (English)	Giorgi MKS	C.G.S. Electrostatic	C.G.S. Electromagnetic
Length	1 foot, 1 inch	1 metre	1 centimetre	1 centimetre
Mass	1 pound	1 kilogram	1 gram	1 gram
Force	1 pound weight	1 dyne-five = 1 newton	1 dyne	1 dyne
Time	1 second		1 second	1 second
Work, Energy	1 joule		1 erg	1 erg
Power	1 watt		1 erg/second	1 erg/second
Charge	1 coulomb		1 statcoulomb	1 abcoulomb
Current	1 ampere		1 statampere	1 abampere
Electromotive force	1 volt		1 statvolt	1 abvolt
Resistance Resistivity	1 ohm 1 ohm/cm cube or 1 ohm-centimetre		1 statohm	1 abohm
Conductance Conductivity	1 siemens = 1 mho 1 mho/cm cube		1 statmho	1 abmho
Capacitance	1 farad		1 statfarad	1 abfarad
Inductance	1 henry		1 stathenry	1 abhenry
		MKS unrationalized	MKS rationalized	
Flux (ϕ)	1 line = 1 maxwell	1 weber	1 weber	1 line = 1 maxwell
Flux density (B)	1 line/sq in	1 weber/sq metre	1 weber/sq metre	1 gauss
Magnetizing force (H)	1 ampere-turn /in	1 praoersted	1 ampere-turn /metre	1 oersted
Magnetomotive force (F)	1 ampere-turn	1 pragilbert	1 ampere-turn	1 gilbert
Reluctance		1 pragilbert/ weber	1 ampere-turn/ weber	1 gilbert/ maxwell
Permeability of free space (μ_o)		10^{-7} henry/ metre (or 10^{-7} weber/sq metre/praoersted)	4×10^{-7} henry/metre	1 abhenry/cm (or 1 gauss/ oersted)

RELATIONSHIPS BETWEEN UNITS

1 metre = 100 centimetres	1 centimetre = 1/100 metre
1 kilogram = 1000 grams	1 gram = 1/1000 kilogram
1 newton = 10^5 dynes	1 dyne = 10^{-5} newton

1 joule = 10^7 ergs	1 erg = 10^{-7} joule
1 watt = 10^7 ergs/second	1 erg/second = 10^{-7} watt

1 coulomb = 3×10^9 statcoulombs = 0.1 abcoulomb
1 statcoulomb = 3.33×10^{-11} abcoulomb   1 abcoulomb = 3×10^{10} statcoulombs

1 ampere = 3×10^9 statamperes = 0.1 abampere
1 statampere = 3.33×10^{-11} abampere   1 abampere = 3×10^{10} statamperes

1 volt = 3.33×10^{-3} statvolt = 10^8 abvolts
1 statvolt = 3×10^{10} abvolts = 300 volts   1 abvolt = 3.33×10^{-11} statvolt

1 ohm = 1.11×10^{-12} statohm = 10^9 abohms
1 statohm = 9×10^{20} abohms   1 abohm = 1.11×10^{-21} statohm

1 mho = 9×10^9 statmhos = 10^{-9} abmho
1 statmho = 1.11×10^{-21} abmho   1 abmho = 9×10^{20} statmhos

1 farad = 9×10^{11} statfarads = 10^{-9} abfarad
1 statfarad = 1.11×10^{-21} abfarad   1 abfarad = 9×10^{20} statfarads
= 1.11×10^{-12} farad   1 $\mu\mu$F = 0.9 statfarad

1 henry = 1.11×10^{-12} stathenry = 10^9 abhenrys
1 stathenry = 9×10^{20} abhenrys   1 abhenry = 1.11×10^{-21} stathenrys

1 weber = 10^8 maxwells = 10^8 lines   1 maxwell = 10^{-8} weber

1 weber/sq metre = 10^4 gauss   1 gauss = 10^{-4} weber/sq metre

1 praoersted = 10^{-3} oersted   1 oersted = 10^3 praoersted
1 ampere-turn/inch = 0.495 oersted = 495 praoersteds
1 ampere-turn/metre = 0.01257 oersted = 12.57 praoersteds

1 ampere-turn = 1.257 gilberts	1 gilbert = 0.796 ampere-turn
1 pragilbert = 0.1 gilbert	1 gilbert = 10 pragilberts
1 ampere-turn = 12.57 pragilberts	1 pragilbert = 0.0796 ampere-turn

1 pragilbert/weber = 10^{-9} gilbert/maxwell = 0.0796 ampere-turn/weber
1 ampere-turn/weber = 1.257×10^{-8} gilbert/maxwell

(iii) Photometric units

TABLE 3 : PHOTOMETRIC UNITS

Quantity	Symbol	Unit	Relationship
Luminous Flux	F	Lumen	1 lumen $= \frac{1}{4\pi} \times$ flux emitted by one candle
Light Intensity	I	Candle	Flux emitted by 1 candle $= 4\pi$ lumens
Illumination	E	Footcandle = lumens/ft^2 Phot = cm candle = lumens/cm^2 Lux = metre candle = lumens/m^2	

Relationship between units of illumination

Unit	Foot-candle	Phot	Lux
1 Foot-candle	1	0.001076	10.76
1 Phot	929	1	10^4
1 Lux	0.0929	10^{-4}	1

(iv) Temperature

TABLE 4 : TEMPERATURE

Freezing point of water (normal pressure)	= 32° Fahrenheit = 0° Centigrade* = 273.16° Kelvin (Absolute)
Boiling point of water (normal pressure)	= 212° Fahrenheit = 100° Centigrade* = 373.16° Kelvin (Absolute)
1 Fahrenheit degree	$= \frac{5}{9}$ Centigrade* degree = 0.5556 Centigrade* degree = 0.5556 Kelvin degree
1 Centigrade* degree	= 1.800 Fahrenheit degree = 1.0 Kelvin degree
Temperature in °C	$= \frac{5}{9}$ (°F − 32)
Temperature in °F	= 1.8 (°C) + 32
Temperature in °K Absolute temperature	= (°C) + 273.16
Temperature in °C	= (°K) − 273.16
Absolute Zero	= 0°K = −273.16°C = −459.68°F

*The Ninth General Conference on Weights and Measures held in Paris in October. 1948, decided to abandon the designation Centigrade and use Celsius (International Temperature Scale) instead. For most practical purposes the two scales may be regarded as identical.

SECTION 2 : COLOUR CODES

(i) Colour code for fixed composition resistors (ii) Colour code for fixed wire-wound resistors (iii) Table of R.M.A. colour code markings for resistors (iv) Colour code for moulded mica capacitors (v) Colour code for ceramic dielectric capacitors (vi) Colour code for i-f transformers (vii) Colour code for a-f transformers and output transformers (viii) Colour code for power transformers (ix) Colour code for loud-speakers (x) Colour code for chassis wiring (xi) Colour code for battery cables (xii) Colour code for metallized paper capacitors.

(i) Colour code for fixed composition resistors

(A) R.M.A. Standards GEN-101, REC-116, July 1948.

In fixed composition resistors with axial leads the nominal resistance value is indicated by bands of colour of equal width around the body of the resistor (Fig. 38.1).

Band A indicates the first significant figure.
Band B indicates the second significant figure.
Band C indicates the decimal multiplier.
Band D, if any, indicates the tolerance limits about the nominal resistance value.

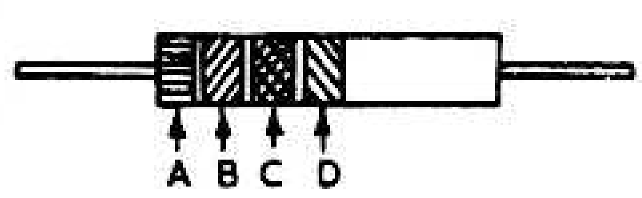

FIG. 38.1

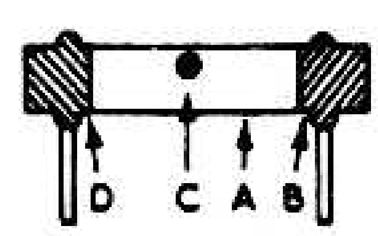

FIG. 38.2

Fig. 38.1. *R.M.A. colour code for fixed composition resistors (axial leads).*
Fig. 38.2. *R.M.A. colour code for fixed composition resistors (radial leads).*

TABLE 5 : COLOUR CODE

Colour	Significant Figure	Decimal Multiplier	Tolerance %
Black	0	1	
Brown	1	10	
Red	2	10^2	
Orange	3	10^3	
Yellow	4	10^4	
Green	5	10^5	
Blue	6	10^6	
Violet	7	10^7	
Grey	8	10^8	
White	9	10^9	
Gold	—	10^{-1}	± 5
Silver	—	10^{-2}	± 10
No Colour	—	—	± 20

Body colour : Black indicates uninsulated. Any other colour indicates insulated.

Colour code with radial leads

Resistors with radial leads may use the same colour code as those with axial leads, but alternatively* they may be colour coded as in Fig. 38.2 where

Body A corresponds to Band A above,
End B corresponds to Band B above,
Dot C (or band C) corresponds to Band C above,
Band D corresponds to Band D above.

See also Sect. 3(i)—Standard fixed composition resistors.

*As JAN-R-11 and old R.M.A. specification.

(B) British Standard BS. 1852 : 1952

for fixed resistors for telecommunication purposes.

Interpretation of marking :

Fig. 38.3A	Fig. 38.3B or Fig. 38.3C	Interpretation
1st band (A)	Body (A)	Indicates first significant figure of resistance value.
2nd band (B)	First tip (B)	Indicates second significant figure.
3rd band (C)	Spot (C)	Indicates multiplier.
4th band (D)	Second tip (D)	If present, indicates percentage tolerance on nominal resistance value. If no colour appears in this position the tolerance is $\pm$ 20 per cent.
5th band (E)	—	If present, indicates grade of resistor.

Colour values :

As Table 5 with the addition of

Colour	Tolerance %
Brown	$\pm$ 1
Red	$\pm$ 2
Colour	**Grade**
Salmon pink	Grade 1 (" high stability ")

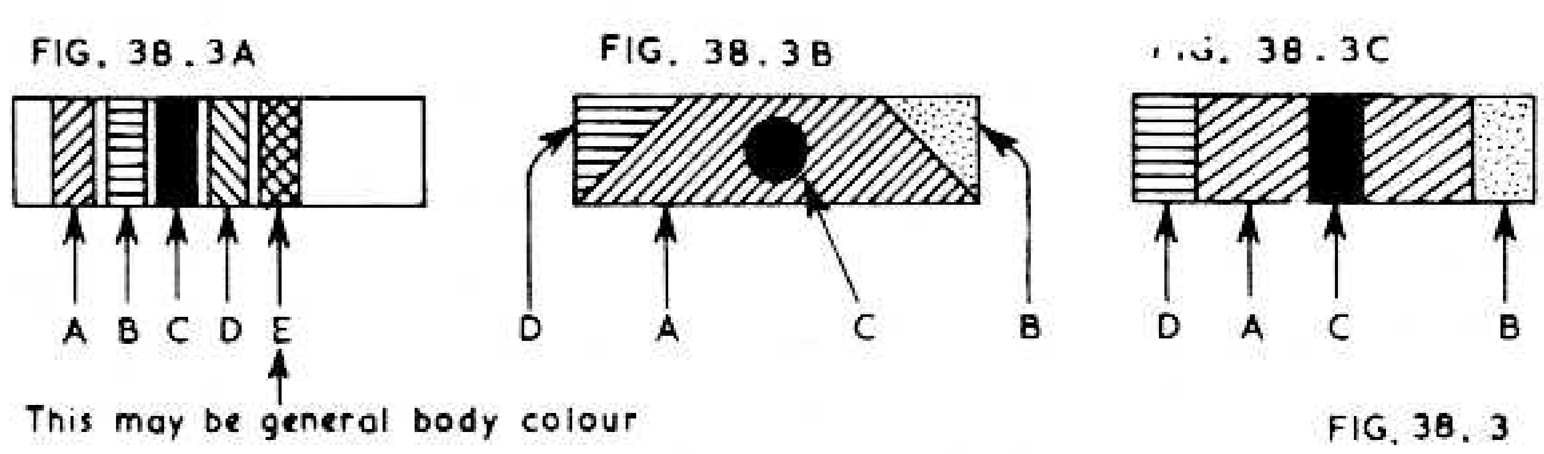

Fig. 38.3A. *British Standard coloured band marking (preferred).*
Fig. 38.3B. *British Standard body, tip and spot marking.*
Fig. 38.3C. *British Standard body, tip and central band marking.*

(ii) Colour code for fixed wire-wound resistors

(A) R.M.A. Standard REC-117, July 1948

In fixed wire-wound resistors with axial leads the nominal resistance value is indicated by bands of colour around the body of the resistor (Fig. 38.3).

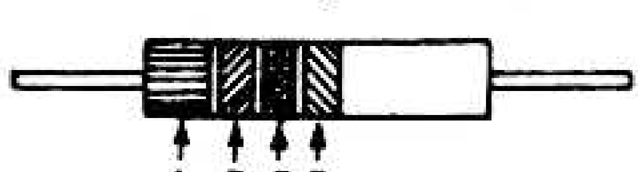

FIG. 38.3

Fig. 38.3. *R.M.A. colour code for fixed wire wound resistors (axial leads).*

Band A is of double width, thereby indicating a wire-wound resistor. The colour of Band A, and those of bands B, C and D, have the same indications regarding resistance and tolerance as for composition resistors. The body colour also has the same indications as for composition resistors.

See also Sect. 3(ii) for standard fixed wire wound resistors.

(B) British Standard colour code for fixed resistors. See (i) (B) above.

(iii) Table of R.M.A. colour code markings for resistors

TABLE 6: STANDARD COLOUR CODING FOR RESISTORS

Preferred values of resistance (ohms) ±20% D = no col	±10% D = silver	±5% D = gold	**Old standard resistance values (ohms)**	Resistance designation A	B	C
			50	Green	Black	Black
		51		Green	Brown	Black
	56	56		Green	Blue	Black
		62		Blue	Red	Black
68	68	68		Blue	Gray	Black
		75	**75**	Violet	Green	Black
	82	82		Gray	Red	Black
		91		White	Brown	Black
100	100	100	**100**	Brown	Black	Brown
		110		Brown	Brown	Brown
	120	120		Brown	Red	Brown
		130		Brown	Orange	Brown
150	150	150	**150**	Brown	Green	Brown
		160		Brown	Blue	Brown
	180	180		Brown	Gray	Brown
		200	**200**	Red	Black	Brown
220	220	220		Red	Red	Brown
		240		Red	Yellow	Brown
			250	Red	Green	Brown
	270	270		Red	Violet	Brown
		300	**300**	Orange	Black	Brown
330	330	330		Orange	Orange	Brown
			350	Orange	Green	Brown
		360		Orange	Blue	Brown
	390	390		Orange	White	Brown
			400	Yellow	Black	Brown
		430		Yellow	Orange	Brown
			450	Yellow	Green	Brown
470	470	470		Yellow	Violet	Brown
			500	Green	Black	Brown
		510		Green	Brown	Brown
	560	560		Green	Blue	Brown
			600	Blue	Black	Brown
		620		Blue	Red	Brown
680	680	680		Blue	Gray	Brown
		750	**750**	Violet	Green	Brown
	820	820		Gray	Red	Brown
		910		White	Brown	Brown
1,000	1,000	1,000	**1,000**	Brown	Black	Red
		1,100		Brown	Brown	Red
	1,200	1,200	**1,200**	Brown	Red	Red
		1,300		Brown	Orange	Red
1,500	1,500	1,500	**1,500**	Brown	Green	Red
		1,600		Brown	Blue	Red
	1,800	1,800		Brown	Gray	Red
		2,000	**2,000**	Red	Black	Red
2,200	2,200	2,200		Red	Red	Red
		2,400		Red	Yellow	Red
			2,500	Red	Green	Red
	2,700	2,700		Red	Violet	Red
		3,000	**3,000**	Orange	Black	Red

Preferred values of resistance (ohms)			Old standard resistance values (ohms)	Resistance designation		
±20% D = no col	±10% D = silver	± 5% D = gold		A	B	C
3,300	3,300	3,300		Orange	Orange	Red
			3,500	Orange	Green	Red
		3,600		Orange	Blue	Red
	3,900	3,900		Orange	White	Red
			4,000	Yellow	Black	Red
		4,300		Yellow	Orange	Red
4,700	4,700	4,700		Yellow	Violet	Red
			5,000	Green	Black	Red
		5,100		Green	Brown	Red
	5,600	5,600		Green	Blue	Red
		6,200		Blue	Red	Red
6,800	6,800	6,800		Blue	Gray	Red
		7,500	**7,500**	Violet	Green	Red
	8,200	8,200		Gray	Red	Red
		9,100		White	Brown	Red
10,000	10,000	10,000	**10,000**	Brown	Black	Orange
		11,000		Brown	Brown	Orange
	12,000	12,000	**12,000**	Brown	Red	Orange
		13,000		Brown	Orange	Orange
15,000	15,000	15,000	**15,000**	Brown	Green	Orange
		16,000		Brown	Blue	Orange
	18,000	18,000		Brown	Gray	Orange
		20,000	**20,000**	Red	Black	Orange
22,000	22,000	22,000		Red	Red	Orange
		24,000		Red	Yellow	Orange
			25,000	Red	Green	Orange
	27,000	27,000		Red	Violet	Orange
		30,000	**30,000**	Orange	Black	Orange
33,000	33,000	33,000		Orange	Orange	Orange
		36,000		Orange	Blue	Orange
	39,000	39,000		Orange	White	Orange
			40,000	Yellow	Black	Orange
		43,000		Yellow	Orange	Orange
47,000	47,000	47,000		Yellow	Violet	Orange
			50,000	Green	Black	Orange
		51,000		Green	Brown	Orange
	56,000	56,000		Green	Blue	Orange
			60,000	Blue	Black	Orange
		62,000		Blue	Red	Orange
68,000	68,000	68,000		Blue	Gray	Orange
		75,000	**75,000**	Violet	Green	Orange
	82,000	82,000		Gray	Red	Orange
		91,000		White	Brown	Orange
100,000	100,000	100,000	**100,000**	Brown	Black	Yellow
		110,000		Brown	Brown	Yellow
	120,000	120,000	**120,000**	Brown	Red	Yellow
		130,000		Brown	Orange	Yellow
150,000	150,000	150,000	**150,000**	Brown	Green	Yellow
		160,000		Brown	Blue	Yellow
	180,000	180,000		Brown	Gray	Yellow
		200,000	**200,000**	Red	Black	Yellow

Preferred values of resistance (ohms)			Old standard resistance values (ohms)	Resistance designation		
±20% D = no col	±10% D = silver	± 5% D = gold		A	B	C
220,000	220,000	220,000		Red	Red	Yellow
		240,000		Red	Yellow	Yellow
			250,000	Red	Green	Yellow
	270,000	270,000		Red	Violet	Yellow
		300,000	**300,000**	Orange	Black	Yellow
330,000	330,000	330,000		Orange	Orange	Yellow
		360,000		Orange	Blue	Yellow
	390,000	390,000		Orange	White	Yellow
			400,000	Yellow	Black	Yellow
		430,000		Yellow	Orange	Yellow
470,000	470,000	470,000		Yellow	Violet	Yellow
			500,000	Green	Black	Yellow
		510,000		Green	Brown	Yellow
	560,000	560,000		Green	Blue	Yellow
			600,000	Blue	Black	Yellow
		620,000		Blue	Red	Yellow
680,000	680,000	680,000		Blue	Gray	Yellow
		750,000	**750,000**	Violet	Green	Yellow
	820,000	820,000		Gray	Red	Yellow
		910,000		White	Brown	Yellow
1.0 MΩ	1.0 MΩ	1.0 MΩ	**1.0 MΩ**	Brown	Black	Green
		1.1 MΩ		Brown	Brown	Green
	1.2 MΩ	1.2 MΩ		Brown	Red	Green
		1.3 MΩ		Brown	Orange	Green
1.5 MΩ	1.5 MΩ	1.5 MΩ	**1.5 MΩ**	Brown	Green	Green
		1.6 MΩ		Brown	Blue	Green
	1.8 MΩ	1.8 MΩ		Brown	Gray	Green
		2.0 MΩ	**2.0 MΩ**	Red	Black	Green
2.2 MΩ	2.2 MΩ	2.2 MΩ		Red	Red	Green
		2.4 MΩ		Red	Yellow	Green
	2.7 MΩ	2.7 MΩ		Red	Violet	Green
		3.0 MΩ	**3.0 MΩ**	Orange	Black	Green
3.3 MΩ	3.3 MΩ	3.3 MΩ		Orange	Orange	Green
		3.6 MΩ		Orange	Blue	Green
	3.9 MΩ	3.9 MΩ		Orange	White	Green
			4.0 MΩ	Yellow	Black	Green
		4.3 MΩ		Yellow	Orange	Green
4.7 MΩ	4.7 MΩ	4.7 MΩ		Yellow	Violet	Green
			5.0 MΩ	Green	Black	Green
		5.1 MΩ		Green	Brown	Green
	5.6 MΩ	5.6 MΩ		Green	Blue	Green
			6.0 MΩ	Blue	Black	Green
		6.2 MΩ		Blue	Red	Green
6.8 MΩ	6.8 MΩ	6.8 MΩ		Blue	Gray	Green
			7.0 MΩ	Violet	Black	Green
		7.5 MΩ		Violet	Green	Green
			8.0 MΩ	Gray	Black	Green
	8.2 MΩ	8.2 MΩ		Gray	Red	Green
			9.0 MΩ	White	Black	Green
		9.1 MΩ		White	Brown	Green
10 MΩ	10 MΩ	10 MΩ	**10 MΩ**	Brown	Black	Blue

(iv) Colour code for moulded mica capacitors

The Standard American R.T.M.A. Colour Marking (R.C.M.) uses six dots for moulded mica capacitors.

(R.T.M.A. Standard REC-115-A, May 1951) (Fig. 38.4).

Dot (1) : White indicates R.T.M.A. moulded mica capacitor colour coding. Black indicates JAN colour coding (see below). Any other colour indicates old R.M.A. 6 dot system.
Dot (2) : First digit of capacitance (see Table 7 below).
Dot (3) : Second digit of capacitance (see Table 7 below).
Dot (4) : Class of capacitor (see REC-115-A).
Dot (5) : Tolerance (see Table 7 below).
Dot (6) : Multiplier for capacitance (see Table 7 below).

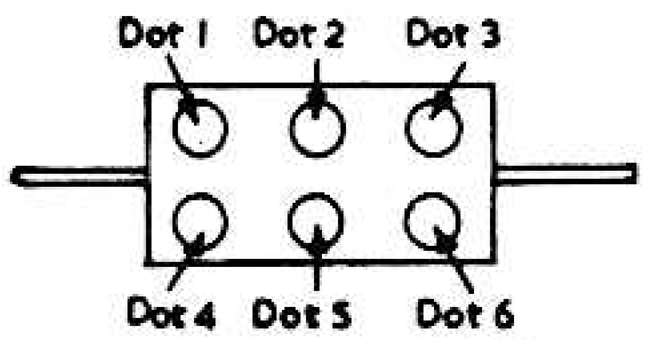

FIG. 38.4

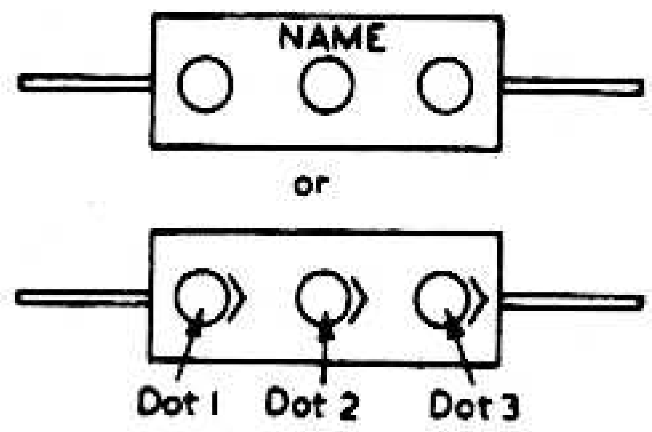

FIG. 38.5

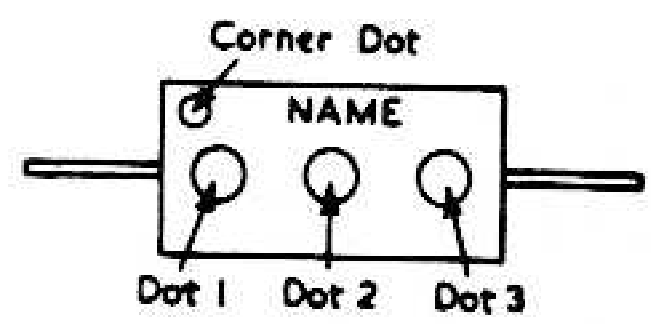

FIG. 38.6

Fig. 38.4. *Colour code for moulded mica capacitors* (6 *dot*).
Fig. 38.5. *Colour code for moulded mica capacitors* (3 *dot*).
Fig. 38.6. *Colour code for moulded mica capacitors* (4 *dot*).

TABLE 7 : R.T.M.A. MOULDED MICA CAPACITORS

Colour	Numeral	Multiplier	Tolerance	Class
Black	0	1	20%	A
Brown	1	10		B
Red	2	100	2%	C
Orange	3	1000	3%	D
Yellow	4	10 000		E
Green	5		5%	
Blue	6			
Violet	7			
Grey	8			I
White	9			J
Gold		0.1		
Silver		0.01	10%	

JAN-C-5 six dot colour marking (Fig. 38.4)

In the JAN-C-5 code the black Dot 1 signifies a mica dielectric capacitor. Dot 4 gives the capacitor characteristic (for details see JAN specification). The remaining dots have the same significance as in the R.C.M. system.

Old R.M.A. six dot colour marking (Fig. 38.4)

Dots 1, 2 and 3 signify the first three significant figures of the capacitance. Dot 4 signifies the rated direct working voltage. Dot 5 gives the percentage tolerance. Dot 6 gives the decimal multiplier.

Three dot system

This applies only to capacitors with 500 volt ratings and $\pm$ 20% tolerances in capacitance (Fig. 38.5).

Dot 1 gives the first significant figure.
Dot 2 gives the second significant figure.
Dot 3 gives the decimal multiplier.

Four dot system

To extend the usefulness of the three dot system, a fourth dot is sometimes added in the top left-hand corner (Fig. 38.6) to indicate the percentage tolerance.

See also Sect. 3(v) for standard moulded mica capacitors.

(v) Colour code for ceramic dielectric capacitors

(A) R.M.A. Standard REC-107, Oct. 1947

The colour markings consist of five colours, one of which unambiguously marks the end of the capacitor bearing the inner-electrode terminal while the remaining four colour markings are successively closely adjacent along the length of the capacitor; an indicator is provided to avoid ambiguity in the interpretation of the significance of the position of the colour markings.

The end colour indicates the temperature coefficient in accordance with Table 8 below.

The first and second colour markings indicate the first and second digits of the value of the capacitance in micro-microfarads.

The third colour marking indicates the decimal multiplier of the value of the capacitance.

The fourth colour marking indicates the capacitance tolerance in accordance with Table 8 below.

TABLE 8

Position	End	Nos. 1, 2	No. 3	No. 4	
				Capacitance tolerance	
Colour	Temperature coeff. parts/million/°C	Significant figure	Decimal multiplier	$C > 10\ \mu\mu F$	$C \leqslant 10\ \mu\mu F$
black	0	0	1	±20%	
brown	−30	1	10	± 1%	±0.1 μμF
red	−80	2	10^2	± 2%	
orange	−150	3	10^3	±2.5%	
yellow	−220	4	10^4		
green	−330	5		± 5%	±0.5 μμF
blue	−470	6			
violet	−750	7			
grey	+30	8	0.01		±0.25 μμF
white	General purpose condenser*	9	0.1	±10%	±1.0 μμF

Capacitance change

silver +25% (Class 4 capacitors)
silver +25%, − 50% (Class 5 capacitors)

*May have any nominal temperature coefficient between +120 and −750 parts per million per degree Centigrade, at option of the manufacturer.

(B) British R.I.C. colour code for ceramic dielectric capacitors, RIC/133 (Ref. F7)

Colour	End Colour (Temperature Coefficient)*	1st dot, 1st significant figure	2nd dot, 2nd significant figure	3rd dot Multiplier	4th dot Tolerance	
					10 $\mu\mu$F or less	More than 10 $\mu\mu$F
Black	NP0.	0	0	1	±2.0 $\mu\mu$F	±20%
Brown	N030	1	1	10	±0.1 $\mu\mu$F	± 1%
Red	N080	2	2	100		± 2%
Orange	N150	3	3	1000		±2.5%
Yellow	N220	4	4	10 000		
Green	N330	5	5		±0.5 $\mu\mu$F	± 5%
Blue	N470	6	6			
Violet	N750	7	7			
Grey	P030	8	8	0.01	±0.25 $\mu\mu$F	
White	P100	9	9	0.1	±1.0 $\mu\mu$F	±10%

*N signifies negative, P signifies positive temperature coefficient. Figures give parts per million per °C.

See also Sect. 3(vi) for standard ceramic dielectric capacitors.

(vi) Colour code for i-f transformers

(R.M.A. Standard REC-114, March 1948, for 455 Kc/s)

Blue—plate lead.
Red—B + lead.
Green—grid (or diode) lead.
White—grid (or diode) return.

(For "full-wave" transformer, the second diode lead will be violet).

(vii) Colour code for a-f transformers and output transformers

(R.M.A. Standard U.S.A. S410, M4-507, May 1935)

Blue—plate (finish) lead of primary.
Red—B+ (this applies whether primary is plain or centre-tapped).
Brown—plate (start) lead on C.T. primaries. Blue may be used for this lead if polarity is not important.
Green—grid (finish) lead to secondary (hot end of voice coil).
Black—grid return (this applies whether the secondary is plain or centre tapped).
Yellow—grid (start) lead on centre-tapped secondaries. (Green may be used for this lead if polarity is not important).

Note : These markings apply also to line-to-grid and valve-to-line transformers.

(viii) Colour code for power transformers

(R.M.A. Standard S410, M4-505, May 1935)

1. Primary leads—no tap — Black
   If tapped—Common — Black
   Tap : Black and yellow 50/50 striped design
   Finish : Black and red 50/50 striped design
2. Rectifier—Plate winding — Red
   Centre tap : Red and yellow 50/50 striped design
3. Rectifier—Filament winding — Yellow
   Centre tap : Yellow and blue 50/50 striped design
4. Amplifier—Filament winding No. 1 — Green
   Centre tap : Green and yellow 50/50 striped design

5. Amplifier—Filament winding No. 2 Brown
   Centre tap : Brown and yellow 50/50 striped design
6. Amplifier—Filament winding No. 3 Slate
   Centre tap : Slate and yellow 50/50 striped design

(ix) Colour code for loudspeakers

(R.M.A. Standard U.S.A. M5-181 Nov. 1936)

Loudspeaker field coils

Black and red*—start.
Yellow and red*—finish.
Slate and red—tap (if any).

Note : If two field coils are fitted to the same loudspeaker, the basic colour coding is used for the lower resistance field, and green is substituted for the red in the higher resistance field.

Loudspeaker transformer primaries

Centre-tapped
Blue or brown—start
Blue—finish
Red—centre tap
Untapped
Red†—start
Blue—finish

Loudspeaker transformer secondaries

Black—start
Green—finish

Standard pin arrangement 4A

Pin 1 (large) Yellow and red (field finish).
Pin 2 Blue or brown (transformer start) for push-pull.
No connection or red (transformer start).
Pin 3 Blue (transformer finish).
Pin 4 (large) Black and red (field start).

Standard pin arrangement 5A

Pin 1 Yellow and red (field finish).
Pin 2 Blue or brown (transformer start).
Pin 3 Red (transformer centre-tap).
Pin 4 Blue (transformer finish).
Pin 5 Black and red (field start).

The start, tap and finish of all windings occur in clockwise order around the plug pins when the plug is viewed from the socket end.

(x) Colour code for chassis wiring

(A) R.M.A. Standard U.S.A. REC-108-A (December 1949)

Colour	Circuit
Black	Grounds, grounded elements, and returns
Brown	Heaters or filaments, off ground
Red	Power supply B+
Orange	Screen grids
Yellow	Cathodes
Green	Control grids
Blue	Plates
Violet	Not used
Grey	A.C. power lines
White	Above or below ground returns, a.v.c., etc.

*Some manufacturers use a single colour, omitting the red.
†Some manufacturers use brown whether tapped or untapped.

When leads for antenna and ground connections are provided on the receiver, it shall be standard to colour code the antenna lead blue and the ground lead black. Special antenna connection leads shall be coded with combinations of blue and black.

(B) RTMA Standard Colour marking of thermoplastic insulated hook-up wire, GEN-104 (July 1951)

Colour coding for thermoplastic hook-up wire without fabric braids shall be accomplished either by the use of solid coloured insulation or by natural colour or white insulation with coloured helical stripes. It is intended that these wires be interchangeable by colour with fabric braid wires. Where, in fabric, braids consist of solid colours with tracer threads of contrasting colours, this standard implies that base colour stripe (wide stripe) is used in lieu of solid coloured fabric braid. Helical tracer stripes are used in lieu of contrasting colour threads in fabric braid-covered wire.

(xi) Colour code for battery cables

(American R.M.A. Standard S-410, M4-508, April 1939)

A +	Red	B intermediate	White
A −	Black	C +	Brown
B +	Blue	C intermediate	Orange
B −	Yellow	C −	Green

(xii) Colour code for metallized paper capacitors

A 3 dot colour code may be used to indicate capacitance in $\mu\mu$F. Dot 1 gives the first significant figure. Dot 2 gives the second significant figure (Table 7 col. 2). Dot 3 gives the multiplier (Table 7 col. 3).

SECTION 3: STANDARD RESISTORS AND CAPACITORS

(i) Standard fixed composition resistors (ii) Standard fixed wire wound resistors (iii) Fixed paper dielectric capacitors in tubular non-metallic cases (iv) Metal encased fixed paper dielectric capacitors for d.c. application (v) Standard fixed mica dielectric capacitors (vi) Standard ceramic dielectric capacitors (vii) Standard variable capacitors (viii) Standard variable composition resistors (ix) Standard metallized paper dielectric capacitors (x) Standard electrolytic capacitors (xi) References to standard resistors and capacitors.

The information in this Section is in the form of summaries or extracts from certain recognized standards, and is necessarily incomplete. The purpose of this Section is, in part, to draw the attention of design engineers to the importance of the information obtainable from such standards. However, all design engineers are urged to secure up-to-date copies of the official standard specifications under which they work.

See also Chapter 4 Sect. 9 for general information.

(i) Standard fixed composition resistors

(A) American R.M.A. Standard REC-116, July 1948

Values of resistance from 1 ohm to 100 megohms. The preferred values of resistance, over the range from 50 ohms to 10 megohms, are shown in Table 6 in Sect. 2(iii). The complete list is given in the R.M.A. Standard REC-116. These preferred values have been adopted in U.S.A. and to some extent in England, but not universally. The old standard resistance values, shown in bold typeface, are generally used where the preferred values have not been adopted.

The tolerance in resistance is ±5%, ±10% or ±20% as desired.

The resistance-temperature characteristic is expressed as the change of resistance between ambient temperatures of +25°C and +85°C in the form of the percentage of the resistance at 25°C.

The **voltage coefficient** is given by

$$\text{Voltage coefficient} = \frac{100\,(R_1 - R_2)}{R_2\,(E_1 - E_2)} = \frac{111\,(R_1 - R_2)}{E_1 R_2}$$

where E_1 = rated continuous working voltage (to give rated power dissipation, or maximum continuous voltage rating, whichever is the higher)

$E_2 = E_1/10$

R_1 = resistance measured with applied voltage E_1

and R_2 = resistance measured with applied voltage E_2.

The test is carried out firstly with reduced voltage (E_2), and immediately afterwards with voltage E_1.

The **noise** is measured by connecting the resistor in a d.c. circuit and comparing the noise voltage with an audio frequency of 1000 c/s. The measuring equipment includes an amplifier, filter and valve voltmeter (for details see REC-116). The noise is expressed in microvolts per volt (applied direct voltage).

Ambient temperature—effect on maximum working voltage

Temperature	40°	60°	80°	85°	100°	110°C
Max. voltage	100%	77.5%	55%	50%	20%	0

For colour code see Sect. 2(i).

(B) American JAN-R-11 (Ref. E1)

Some commercial resistors are manufactured in accordance with JAN-R-11 specifications while these are compulsory for use in American Army/Navy equipment.

There are two resistance-temperature characteristics ; characteristic F has one half the change in resistance of characteristic E. The de-rating curve is tabulated on page 187. The maximum surface temperature is 135°C. The maximum continuous working voltage is :

Type RC15	(¼ watt)	200	volts (d.c. or r.m.s.)
RC10, 16	(¼ watt)	250	,, ,,
RC20, 21, 25	(½ watt)	350	,, ,,
RC30, 31, 35	(1 watt)	500	,, ,,
RC38	(1 watt)	1000	,, ,,
RC40, 41, 45	(2 watts)	500	,, ,,
RC65	(4 watts)	500	,, ,,
RC75, 76	(5 watts)	500	,, ,,

The voltage coefficient shall not exceed 0.035% per volt for ¼ and ½ watt ratings, or 0.02% per volt for larger ratings. Tests are specified for temperature cycling, humidity, vibration, effect of soldering, overloading etc., also salt water immersion and insulation strength where applicable. The root mean-square value of the noise generated shall not exceed 3.0 r.m.s. μV/V at the rated continuous working voltage for ¼ and ½ watt ratings, or 1.2 r.m.s. μV/V for larger ratings, frequency characteristic —3 db at 70 and 5000 c/s). Marking, resistance values and tolerances are as R.M.A. REC-116.

Amendment No. 3 provides for a characteristic G which has an ambient temperature of 70°C with a linear de-rating characteristic which reaches zero at 130°F.

(C) British R.I.C. Specification No. RIC/112

Grade 1 (high stability). Issue No. 1, May 1950. Resistance values follow the series, 1, 1.1, 1.2, 1.3, 1.5, 1.6, 1.8, 2.0, 2.2, 2.4, 2.7, 3.0, 3.3, 3.6, 3.9, 4.3, 4.7, 5.1, 5.6, 6.2, 6.8, 7.5, 8.2, 9.1, 10 for all tolerances. Range 10 ohms to 10 megohms with some limitations.

Tolerances ± 1%, ±2%, ±5%.

Ratings ⅛, ¼, ½, ¾, 1, 2 watts.

Colour code (five colours)—see Sect. 2(i)B.

The surface temperature shall not exceed 150°C. The voltage coefficient shall not exceed 0.002% per volt. The noise shall not exceed 0.5 μV per volt (d.c.). Resistance change with soldering shall not exceed ±0.3%.

Temperature coefficient :

Watts	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1 and 2	Temp. coeff.
Res up to	100K	250K	0.5M	1M	2M	0 to −0.0004
Res. up to	0.5M	1M	2.5M	5M	10M	0 to −0.0008
Res. up to	2.5M	5M	10M	10M	—	0 to −0.001

Permissible variation in resistance after climatic and durability tests, endurance, tropical exposure, humid atmosphere, salt atmosphere :

Permissible variation	$\frac{1}{8}$W	$\frac{1}{4}$W	$\frac{1}{2}$W	$\frac{3}{4}$W	1 and 2 W
1% up to resistance of	10K	25K	50K	100K	200K
1½% ,, ,, ,, ,,	100K	250K	0.5M	1M	2M
2% ,, ,, ,, ,,	0.5M	1M	2.5M	5M	10M
3% ,, ,, ,, ,,	2.5M	5M	10M	10M	—

Rating curve (dissipation) 100% to 70°C ambient temperature, then decreasing linearly to 0% at 150°C.

(D) British R.I.C. Specification No. RIC/113

Grade 2. Issue No. 1, June 1950.

Resistance values as Table 5 for corresponding tolerances.

Range 10 ohms to 10 megohms with some limitations.

Tolerances ±20%, ±10%, ±5%.

Ratings—axial, non-insulated : ½, 1 watt

radial, non-insulated 1/10, ¾, 1, 2½ watts.

axial, insulated : ¼, ½, ¾, 1 watt.

Colour code—see Sect. 2(i)C.

The surface temperature shall not exceed 120°C. The voltage coefficient shall not exceed 0.025% per volt (below 1 megohm), or 0.05% (1 megohm and above). Temperature coefficient shall not exceed 0.12%. Resistance change with soldering shall not exceed ±2%. Rating curve (dissipation) : 100% at 70°C, decreasing linearly to 0% at 110°C, and increasing to 175% at 40°C ambient temperature.

(ii) Standard fixed wire wound resistors

(A) American R.M.A. Standard REC-117, July 1948

There are three styles :

Style No.	RRU3	RRU4	RRU6
Max. watts dissipation at 40°C ambient	½	1	2
Minimum resistance, ohms	0.24	0.47	1.0
Maximum resistance, ohms	820	5100	8200
Standard tolerances :			
More than 10 ohms	5% 10% 20%	5% 10% 20%	5% 10% 20%
10 ohms or less	10% 20%	10% 20%	10% 20%

The preferred values of resistance are as for composition resistors, except for the extension to lower values.

Ambient temperature—effect on max. working voltage

Temperature	40°	70°	100°	110°C
Max. voltage	100%	60%	20%	0

Power rating—in still air at 40°C ambient temperature the temperature rise should not exceed 70°C for styles 3 and 4, and 95°C for style 6, for the rated power input. At temperatures higher than 40°C, with reduced working voltage and power dissipation as tabulated above, the hot spot temperature should not exceed 110°C for styles 3 and 4, and 135°C for style 6.

Resistance change with temperature

The change in resistance referred to an ambient temperature of 25°C shall not be more than ±0.025% per 1°C for all resistors over 10 ohms, and not over ±0.15% per 1°C for 10 ohms and lower.

Marking

Typical marking RRU3 511 J.

RRU3 indicates fixed wire wound resistor, style 3.

511 indicates resistance. The first two digits are the significant figures of the value of resistance in ohms, while the last digit indicates the number of zeros which follow the significant figure. The letter R indicates a decimal point e.g. 511 indicates 51 × 10 = 510 ohms. R56 indicates 0.56 ohms.

J indicates the tolerance :

symbol	J	K	L
tolerance	±5%	±10%	±20%

(B) American JAN-R-26A, JAN-R-19, JAN-R-184 should also be examined. See (xi) below for list.

(C) British R.I.C. Specification No. RIC/111

Resistors, fixed, wirewound, non-insulated. Issue No. 1, July 1950.
Resistance values (all tolerances) as column 3 in Table 6.
Tolerances ±1%, ±2%, ±5%, ±10%.
Colour code as Fig. 38.2B, with Table 5.

(iii) Fixed paper dielectric capacitors in tubular non-metallic cases

(A) American R.M.A. Standard REC-118, Sept. 1948

TABLE 9

Nominal capacitance	Standard tolerance	Voltage Ratings					
1.0 μF	+20%, −10%	100	200	400	—	—	—
0.5	+20%, −10%	100	200	400	600	—	—
0.25	+20%, −10%	100	200	400	600	—	—
0.15	+20%, −10%	100	200	400	600	1000	—
0.10	+20%, −20%	100	200	400	600	1000	—
0.05	+20%, −20%	100	200	400	600	1000	1600
0.03	+20%, −20%	100	200	400	600	1000	1600
0.02	+20%, −20%	100	200	400	600	1000	1600
0.01	+20%, −20%	100	200	400	600	1000	1600
0.005	+40%, −20%	—	—	—	600	1000	1600
0.003	+40%, −20%	—	—	—	600	1000	1600
0.002	+40%, −20%	—	—	—	600	1000	1600
0.001	+60%, −25%	—	—	—	600	1000	1600

Insulation Resistance at 25°C

TABLE 10

Nominal capacitance	Insulation resistance not less than:
1.0 μF	1000 megohms
0.5	2000 megohms
0.25	4000 megohms
0.001 to 0.15	5000 megohms

To determine the minimum insulation resistance at temperatures from 20°C to 40°C, multiply the values above by the factor :

°C	20	25	30	35	40
Factor	1.42	1.00	0.71	0.51	0.35

At still higher temperatures see Table 11.

TABLE 11

Capacitance μF	Insulation resistance at elevated temperatures	
	65°C Class W*	85°C Class M*
1.0	not less than 25 megohms	not less than 10 megohms
0.5	not less than 50 megohms	not less than 20 megohms
0.25	not less than 100 megohms	not less than 40 megohms
0.15	not less than 166 megohms	not less than 66 megohms
0.10	not less than 250 megohms	not less than 100 megohms
0.05	not less than 250 megohms	not less than 200 megohms
0.03 to 0.001	not less than 250 megohms	not less than 250 megohms

***Classification**

Class W Operating temperature range −30°C to +65°C. Power factor not greater than 2%. Resistance to humidity as below. Insulation resistance at 65°C as below.

Class M Operating temperature range −30°C to +85°C. Power factor not greater than 1%. Insulation resistance at 85°C as above.

Humidity resistance (Class W only)

After humidity treatment (see REC-118 for details), the insulation resistance shall not be less than :

Nominal capacitance	0.001 to 0.15	0.25	0.5	1.0 μF
Insulation resistance	1750	1400	700	350 MΩ

Power Factor Class M—not more than 1%.
Class W—not more than 2%.

Marking. Typical marking RCP10 W 6 504 K

RCP10 = RMA Standard Capacitor employing Paper Dielectric, with non-metallic cylindrical enclosure equipped with axially positioned wire leads.

W = Class (see above).

6 = Voltage in units of 100 volts.

504 = Indicating capacitance 50×10^4 giving capacitance in micro-micro-farads.

K = tolerance.

K indicates +10%, −10%
L indicates +20%, −10%
M indicates +20%, −20%
X indicates +40%, −20%
Y indicates +60%, −25%

(B) **American JAN-C-91** should also be examined. See (xi) below for list.

(C) **British R.I.C. Specification No. RIC/131**

Issue No. 1, July 1950.

Capacitance values conform to the series 1, 2, 5, 10, etc.

Capacitance range 0.001 to 2 μF.

Tolerances ±25% up to and including 0.01 μF.
±20% above 0.01 μF.
±10% (Red Group only).

Maximum voltage ratings (d.c.) 150, 350, 500, 750, 1000 volts at rated temperature

Rated temperature 70°C (Red and Yellow) ; 60°C (Green).

Power factor shall not exceed 0.01.

Insulation resistance (one month after delivery) shall not be less than 2000 ohm-farads or 10 000 MΩ whichever is the less, for Red and Yellow, or 500 ohm-farads or 2500 MΩ, whichever is the less, for Green.

Tests are specified for climatic and durability, humid atmosphere, tropical exposure, endurance etc.

This specification also includes capacitors in metallic and ceramic cases.

(iv) Metal encased fixed paper dielectric capacitors for d.c. application

(A) American R.M.A. Standard TR-113 (April 1949)

TABLE 12

Nominal Capacitance	Standard Tolerance	Voltage ratings* (up to 40°C)					
50 μF	±10%				600		
25	±10%				600		
20	±10%				600		
15	±10%				600	1000	1500
12	±10%				600	1000	1500
10	±10%				600	1000	1500
8	±10%				600	1000	1500
6	±10%				600	1000	1500
4	±10%				600	1000	1500
2	±10%		200		600	1000	1500
1	+20%, −10%		200	400	600	1000	1500
0.5	+20%, −10%		200	400	600	1000	1500
0.25	+20%, −10%		200	400	600	1000	1500
0.1	+20%, −20%	100	200	400	600	1000	1500
0.05	+20%, −20%			400	600	1000	1500
0.02	+20%, −20%	100			600	1000	1500
0.01	+40%, −20%	100	200		600	1000	1500
0.006	+40%, −20%	100			600	1000	1500
0.003	+40%, −20%				600	1000	1500
0.001	+60%, −25%	100					

* Voltage ratings above 1500V are not shown here.

Life : The voltage ratings given above, and the reduced voltage ratings for temperatures above 40°C, are based on an expected life of 1 year continuous operation at these temperatures. Longer life can be expected by operation at still lower voltages, e.g. 5 years at 70% of the values indicated.

Working voltage : The average working voltage over 24 hours should not exceed the adjusted rated voltage by more than 5%. A voltage of 110% of the rated voltage may be applied for not more than 10% of the operating time in any 24 hour period.

Alternating current component : In cases where alternating voltages are present in addition to direct voltages, the capacitor working voltage should be taken as the sum of the direct voltage and the peak value of the alternating voltage, provided that the peak alternating voltage does not exceed 20% of the direct voltage and that the frequency is 60 c/s or less. At higher frequencies the voltage should be adjusted as tabulated below :

Frequency	60	100	200	400	1000	4000	10 000 c/s
Ripple	20	16	12	9	6.2	2.8	1 %

Insulation resistance

Minimum insulation resistance in megohms :

TABLE 13

Temperature	25°C	40°C	55°C	70°C	85°C	
Characteristic A	3000	1000	300	100	30	MΩ
Characteristic B	1000	300	100	30	10	MΩ
Characteristic C	500	150	50	15	5	MΩ

Effect of temperature on capacitance (basis = 25°C)

TABLE 14

Temperature	85°C	50°C	25°C	0°C	−40°C
Maximum tolerances :					
Characteristic A	±5%	±2%	±0	± 2%	± 5%
Characteristic B or C	±5%	±2%	±0	+ 2%, −30%	+ 5%, −30%

Effect of ambient temperature on voltage rating

Where condensers are used at ambient temperatures in excess of 40°C, the working voltage shall be reduced as indicated below :

TABLE 15

Temperature	40°C	50°C	60°C	70°C	80°C	85°C
Voltage rating (1)	100%	98%	94%	86%	74%	65%
Voltage rating (2)	100%	97.5%	92%	82.5%	66%	55%

Voltage rating (1) applies to condensers with a watt-second rating from 0 to 5. Voltage rating (2) applies to watt-second ratings over 5 (Voltage ratings over 2000 V are not included here).

Watt-second rating

Watt-second rating $= \frac{1}{2}CE^2$

where C = capacitance in microfarads

and E = nominal rating in kilovolts.

For other details and standard tests see TR-113-A.

Marking—Typical marking 71 B 1 A H 205 K.

71 indicates style (case form)*

B indicates terminal designation

(A indicates wire lead, B indicates solder lug, C indicates screw and nuts).

1 indicates schematic circuit and number of terminals*.

A indicates characteristic (A, B or C)—see above.

H indicates nominal voltage rating, as under :

Code letter	B	C	E	F	G	H	etc.
Voltage	100	200	400	600	1000	1500	etc.

205 indicates capacitance (here 20 × 10^5 $\mu\mu$F).

K indicates tolerance :

Code letter	K	L	V	M	W
Tolerance	±10%	±15%	−10%, +20%	±20%	−0, +25%
Code letter	X		Y		
Tolerance	−20%, +40%		−25%, +60%		

*For details see TR-113-A.

The tolerance code may be omitted if the tolerance is standard (see table above).

(B) American JAN-C-25 should also be examined. See (xi) below for list.

(C) British R.I.C. Specification No. RIC/131

This specification includes both metallic and non-metallic cases—see Sect. 3(iii)C.

(v) Standard fixed mica dielectric capacitors

(**A**) Standard molded mica capacitors (American R.M.A. Standard REC-115-A, May 1951).

Nominal capacitance ($\mu\mu$F)

TABLE 19

10	36	100	300	820	2400	6800	.020 μF
12	39	110	330	910	2700	7500	.022 μF
15	43	120	360	1000	3000	8200	.024 μF
18	47	130	390	1100	3300	9100	.027 μF
20	51	150	430	1200	3600	.010 μF	.030 μF
22	56	160	470	1300	3900	.011 μF	.033 μF
24	62	180	510	1500	4300	012 μF	.036 μF
27	68	200	560	1600	4700	.013 μF	.039 μF
30	75	220	620	1800	5100	.015 μF	.043 μF
33	82	240	680	2000	5600	.016 μF	.047 μF
	91	270	750	2200	6200	.018 μF	

These are available in 11 styles, but any one value of capacitance is only available in a limited number of styles.

Standard d.c. voltage ratings

At temperature $-20°$C to $+85°$C ; barometric pressure 28 in. to 32 in. of mercury ; relative humidity 10% to 80%.

TABLE 20

Voltage rating	Available in styles
300	20, 25, 30, 35, 40
500	20, 25, 30, 35, 40
600	45, 50, 55 56, 60, 61
1000	40
1200	45, 50, 55, 56, 60, 61
2500	45, 50, 55, 56, 60, 61

Standard Classification

TABLE 21

Class	Q* not less than	Insul. Resist. not less than	Temp. coeff.† not more than	Capacit. drift not more than
A	30%	3000 MΩ	$\pm$ 1000 ppm	$\pm$ (5% + 1) $\mu\mu$F
B	100	6000	$\pm$ 500	$\pm$ (3% + 1)
C	100	6000	$\pm$ 200	$\pm$ (0.5% + 0.5)
I	100	6000	+ 150, -50	$\pm$ (0.3% + 0.2)
D	100	6000	$\pm$ 100	$\pm$ (0.3% +0.1)
J	100	6000	+ 100, -50	$\pm$ (0.2% + 0.2)
E	100	6000	+ 100, -20	$\pm$ (0.1% + 0.1)

*Not less than this percentage of values tabulated below :

Nomin. capacit.	7	10	20	40	60	100	200	1000 $\mu\mu$F
Minimum Q	120	160	280	450	580	760	1000	1000

(Q is measured at approximately 1 Mc/s).

†Temperature coefficient of capacitance, being capacitance change in parts per million per °C.

Insulation resistance after humidity cycle:
Class A capacitors—not less than 1000 megohms.
Other classes—not less than 2000 megohms.

Marking (alternative to colour code for which see Sect. 2(iv)).
Typical marking RCM 20 A 050 M
RCM = RMA Standard Capacitor employing Mica dielectric.
20 = style designation (see SP158B).
A = class designation (see above).
050 = 05 × 10° = 5 μμF (capacitance).
M indicates tolerance as under:

Code letter	G	H	J	K	M
Tolerance	±2%	±3%	±5%	±10%	±20%

(B) American JAN-C-5 should also be examined. See (xi) below for list.

(C) British R.I.C. Specification RIC/132
Mica dielectric, stacked foil (Ref. F6).
Tolerance ±20%. Power factor shall not exceed 0.001. Insulation resistance shall not be less than 10 000 megohms. Capacitance values conform to the series 10, 15, 22, 33, 47, 68 and 100. Range from 100 to 10 000 μμF. Voltage ratings 350, 750 volts.

(D) British R.I.C. Specification RIC/137
Mica dielectric, metallized (Ref. F10).
Tolerances ±20%, ±10%, ±5%, ±2%, subject to a minimum of ±1 μμF. Power factor shall not exceed 0.001 except on values below 47 μμF where the limit is 0.002. Insulation resistance shall not be less than 10 000 megohms. Capacitance values conform to the series, according to tolerance, given by the first three columns of Table 6. Range from 10 to 10 000 μμF. Voltage ratings 350, 750 volts (d.c.) at 70°C.

(vi) Standard ceramic dielectric capacitors

(A) American R.M.A. Standard REC-107, Oct. 1947
Nominal capacitances (μμF)

TABLE 22

0.5	0.75	1.0	1.5	2.0	3.0	4.0	5.0	6.0	7.0
8.0	9.0	10	12	13	15	18	20	22	24
27	30	33	36	39	43	47	51	56	62
68	75	82	91	100	110	120	130	150	160
180	200	220	240	270	300	330	360	390	420
470	510	560	620	680	750	820	910	1000	1100
1 200	1 300	1 500	1 600	1 800	2 000	2 200	2 400	2 700	3 000
3 300	3 600	3 900	4 200	4 700	5 100	5 600	6 200	6 800	7 500
8 200	9 100	10 000	11 000	12 000	13 000	15 000			

Tolerances in capacitance

TABLE 23

Classes 1, 2, 3	Classes 4, 5	All classes
±20%	±20%	(Capacit. 10 μμF or less)
±10%		±2.0 μμF
± 5%		±1.0 μμF
± 2½%		±0.5 μμF
± 2%		±0.25 μμF
± 1%		±0.1 μμF

Working voltage (peak)
Classes 1, 2, 3: 500 volts (down to 3.4 in. mercury)
Classes 4, 5: 350 volts (down to 3.4 in. mercury)

Q and insulation resistance

Class	Q not less than	Insulation resistance not less than
1	1000*	7500 megohms
2	650*	7500
3	335*	7500
4	100	1000
5	40	1000

*For capacitances 30 μμF and over. Lower values for lower capacitances.

Capacitance drift with temperature cycling

Classes 1, 2, 3 : not more than 0.3% or 0.25 μμF whichever is the greater.

Capacitance-temperature characteristic

Classes 1, 2 and 3 :

Standard characteristics—Change of capacitance over the range −55°C to +85°C per unit of capacitance at 25°C per degree change in temperature : +100, +30, zero, −30, −80, −150, −220, −330, −470, −750 parts per million per °C.

Classes 4 and 5 :

Maximum change in capacitance from its value at 25°C over temperature range from −55°C to +85°C :

Class 4 ±25% ; Class 5 −50%, +25%.

Tolerances on temperature coefficient

(when based on 2 point measurement, one at 25°C and one at 85°C) ±15, ±30, ±60, ±120, ±250, ±500 parts per million per °C.

An alternative method of measurement, with unsymmetrical tolerances, is also given in REC-107.

Humidity tests—see REC-107.

Marking

Inner electrode terminal indicated by dot or depression.

Typical marking : R2 CC 20 CH 100 G

- R2 indicates RMA Class 2
- CC indicates ceramic capacitor
- 20 indicates style (see REC-107)
- CH indicates temperature characteristic and capacitance tolerance (see Table 1 below)
- 100 indicates capacitance (here $10 \times 10^0 = 10$ μμF). For values incorporating decimal fractions, R indicates decimal point, e.g., 1R5 indicates 1.5 μμF, R75 indicates 0.75 μμF
- G indicates tolerance (see Table 24 below)

TABLE 24

Letter symbol	Tolerance for capacitance of	
	10 μμF or less	more than 10 μμF
B	±0.1 μμF	
C	±0.25	
D	±0.50	
F	±1.0	± 1%
G	±2.0	± 2%
H		± 2.5%
J		± 5%
K		±10%
M		±20%

For alternative colour code see Sect. 2(v).

TABLE 25

First letter symbol	Capacitance-temperature coefficient or per cent decrease* in	Second letter symbol	Capacitance tolerance on temp. coeff. or per cent increase* in
A	+ 100 parts/mln/°C		
B	+ 30 parts/mln/°C	F	15 parts/mln/°C
C	Zero parts/mln/°C	G	30 parts/mln/°C
H	− 30 parts/mln/°C	H	60 parts/mln/°C
L	− 80 parts/mln/°C	J	120 parts/mln/°C
P	− 150 parts/mln/°C	K	250 parts/mln/°C
R	− 220 parts/mln/°C	L**	500 parts/mln/°C
S	− 330 parts/mln/°C	Y	25%
T	− 470 parts/mln/°C	Z	50%
U	− 750 parts/mln/°C		
Y	−25%		
Z	−50%		

*From that at 25°C over temperature range −55°C to 85°C.
**Use only with first letter symbol S (characteristic) to indicate general purpose condenser which may have any nominal temperature coefficient between +120 and −750 parts per million per °C.

TABLE 26

Standard capacitance-temperature characteristics

Capacit. $\mu\mu F$	First letter of temperature characteristic symbol									
	A	B	C	H	L	P	R	S	T	U
0.5 to 2.0	K	K	—	K	K	K	K	KL	K	—
3	JK	JK	JK	JK	JK	JK	JK	JKL	JK	JK
4 to 9	HJK	HJK	HJK	HJK	HJK	HJK	HJK	HJKL	JK	HJK
10 to 91	GHJK	GHJK	GHJK	GHJK	GHJK	GHJK	GHJK	HJKL	HJK	HJK
100 to 1600	GHJK	FGHJK	FGHJK	FGHJK	GHJK	GHJK	GHJK	HJKL	HJK	HJK

(B) American JAN-C-20A and JAN-C-81 should also be examined. See (xi) below for list.

(C) British R.I.C. Specification RIC/133

Ceramic dielectric, Grade 1. (Ref. F7).

Capacitance values conform to the series, according to tolerance, given by the first 3 columns of Table 6. Range from 1 to 1000 $\mu\mu$F. Tolerances ±20%, ±10%, ±5%, ±2%, subject to minimum of ±1 $\mu\mu$F. Voltage ratings 500 and 750 volts (d.c.).

Temperature coefficient (standard) +100, −30, −80, −470, −750 parts per million per °C, with tolerance ±40 ppm or ±15%, whichever is the greater. A special tolerance (available only on values of 47 $\mu\mu$F and above) shall be ±40 ppm or 7½%, whichever is the greater.

The power factor shall not exceed 0.0015. The insulation resistance shall not be less than 10 000 megohms.

Colour code (optional): see Sect. 2(v)B.

(vii) Standard variable capacitors

(A) R.M.A. air dielectric, tuning

The standard capacitance range (American R.M.A. REC-106-A Class A) without trimmers (compensators) is given by table 27.

TABLE 27

No. of plates	Difference in capacitance ($\mu\mu F$)	Min. capacitance ($\mu\mu F$) R-F	Min. capacitance ($\mu\mu F$) Osc.
25	530.0	not greater than 15.0	—
23	485*	not greater than 15.0	—
21	441*	not greater than 13.5	13.0
19	397*	not greater than 13.0	12.0
17	353*	not greater than 12.5	11.5
15	309*	—	11.0
13	265*	—	10.5
11	221*	—	10.0

The standard capacitance range (American R.M.A. REC-101 Class B) without trimmers is given by table 28.

TABLE 28

No. of plates	Difference in capacitance ($\mu\mu F$)	Min. Capacitance ($\mu\mu F$) R-F	Min. Capacitance ($\mu\mu F$) Osc.
27	420	not greater than 13	9
25	388*	not greater than 12	*
23	355*	not greater than 11	*
21	323*	not greater than 10	*

*Calculated in proportion to the number of dielectrics.

Tolerance in capacitance (Class A and Class B):
Reference section $\pm(1\ \mu\mu F + 1\%$ of tabulated value).
Other sections compared with reference section $\pm(1\ \mu\mu F + \frac{1}{2}\%)$.

Capacitance characteristics with maximum number of plates**

TABLE 29

	REC-106-A Class A		REC-101 Class B	
Dielectrics	24	20	26	18
Rotation	Difference in capacitance ($\mu\mu F$) from that of zero position: R-F Section(s)	Oscillator	R-F Section(s)	Oscillator
0*	0.0	0.0	0.0	0.0
10%	9.4	7.3	7.3	5.1
20%	33.7	29.1	22.3	15.2
25%	47.9	41.8	31.8	21.1
30%	63.6	55.1	42.9	27.7
40%	101.9	84.5	71.4	43.3
50%	154.6	119.0	109.9	61.9
60%	222.6	157.5	159.7	82.9
70%	299.9	196.8	219.6	104.9
75%	340.1	215.4	252.0	115.7
80%	380.4	232.4	285.3	126.0
90%	461.3	262.5	354.6	145.5
100%	530.0	285.2	420.0	162.0

**With smaller number of plates, the capacitance values given above should be determined in proportion to the number of dielectrics.
*180° from 100% rotation position (i.e. mechanically maximum position).

Trimmers (compensators) : Each adds a maximum of 2.0 $\mu\mu$F to the minimum capacitance of the section. The minimum capacitance change of each compensator is 15 $\mu\mu$F.

Rotor torque : Class A : From 2 to 6 inch-ounces. Class B : From 2 to 5 inch-ounces.

Slotted plates : The outside rotor plates shall be slotted radially.

(B) R.I.C. air dielectric, tuning

RIC/141 (Ref. F11). This specification was incomplete at the time of going to press.

(C) R.I.C. Capacitors, variable, preset, air dielectric

RIC/142 (Ref. F12). This specification was incomplete at the time of going to press.

(D) R.I.C. Capacitors, variable, preset, mica dielectric

RIC/143 (Ref. F13). Single plate : variable between 2 to 15, 3 to 30, or 4 to 40 $\mu\mu$F. Multiple plate types with max. capacitance up to 3000 $\mu\mu$F are included. The specification was incomplete at the time of going to press.

(viii) Standard variable composition resistors ("potentiometers")

(A) American RTMA Standard variable control resistors REC-121-A, July 1952.

Resistance values 5 000, 10 000, 25 000, 100 000, 250 000, 500 000 ohms, 1.0, 2.0 megohms (total)

Tapers

Linear :

Midpoint resistance = half total resistance. Minimum resistance between either terminal and shaft = 0.05% of total resistance for total resistances 100 000 ohms and greater (higher percentages for lower total resistances).

"S" taper :

25% resistance with 25% ± 3% rotation
50% resistance with 50% ± 3% rotation
75% resistance with 75% ± 3% rotation
Minimum resistance as for linear type.

10% clockwise modified logarithmic taper

10% resistance with 50% ± 3% rotation. Min. resistances 0.02% and 1% of total resistance for 100 000 ohms and greater.

20% clockwise modified logarithmic taper

20% resistance with 50% ± 3% rotation.
Minimum resistances as for 10% logarithmic taper.

10% counterclockwise modified logarithmic taper

20% counterclockwise modified logarithmic taper

(both as for clockwise type with ends reversed).

(B) American JAN-R-94 should also be examined. See (xi) below for list.

(C) British Radio Industry Council Specification No. RIC/122 for rotary variable resistors (Ref. F1).

Resistance in multiples of 1, 2, 5. Tolerances ± 20%.

Dissipation range : 0.1 to 1.5 watts.

Resistance range : 1000 ohms to 2 megohms.

Logarithmic taper : (1) resistance between 5% and 15% of actual overall resistance at 45% to 55% effective rotation (2) resistance between 2% and 5% of actual overall resistance at 20% to 30% effective rotation

Linear law : resistance between 35% and 65% of actual overall resistance at 45% to 55% effective rotation.

Hop-on resistance : less than 50 ohms or 0.05% of overall resistance, whichever is the greater.

Hop-off resistance : less than 1% of overall resistance.

Noise : not greater than 50 mV when tested under specified conditions with 20 volts d.c. applied.

(ix) Standard metallized paper dielectric capacitors

RIC/136 (Ref. F9).

Capacitance values conform to series 1, 2, 5, 10 etc. Range of values from 0.0001 to 2 μF. Tolerance ±25%. Voltage ratings 150, 250, 350, 500 volts (d.c), 300 volts r.m.s. (20 to 120 c/s). The power factor shall not exceed 0.015 at 1000 c/s. The insulation resistance shall not be less than (a) for 2-foil types : 200 ohm-farads or 1200 megohms, whichever is the less, (b) for single-foil—castellated—types (below 0.05 μF) : 10 000 megohms, (c) to case : 10 000 megohms, Colour code—see Sect. 2(xii).

(x) Standard electrolytic capacitors

(A) JAN-C-62 specification : Capacitors, dry-electrolytic, polarized

Working temperature

Designation	A	B	C	D	E	F
Temp. (°C)	0 to 85	−20 to +85	−40 to +85	0 to 65	−20 to 65	−40 to 65

Voltage limits

TABLE 30

Designation	Working voltage (d.c.)	Surge voltage (d.c.)
E	15	20
F	25	40
G	50	75
H	100	150
J	150	200
K	200	250
M	250	300
N	300	350
P	350	400
Q	400	450
R*	450	500

*Available only with working temperature designations D, E and F.

Direct current leakage (under specified test conditions at rated working voltage) shall not exceed either 10 mA or the value calculated below, whichever is the smaller.

$$I = KC + 0.3$$

where I = d.c. leakage current in milliamperes

C = rated capacitance in microfarads

and K = 0.01 for rated working voltage 15 to 100,
0.02 for rated working voltage 101 to 250,
0.025 for rated working voltage 251 to 350,
0.04 for rated working voltage 351 to 450.

Tolerance in capacitance −10% ; +250%.

Equivalent series resistance (under specified test conditions at maximum rated voltage) shall not exceed the value of P tabulated below, divided by the rated capacitance in microfarads.

Rated working voltage	P	Rated working voltage	P
15	600	250	230
25	500	300	210
50	400	350	200
100	330	400	200
150	300		
200	250	450	200

Test conditions : 20°C to 40°C. Frequency 120 c/s.

Maximum r.m.s. ripple current (extracts from table)

Rated cap.	Working voltage					
	100	150	200	250	350	450 V
10 μF	—	—	130	130	140	150 mA
20 μF	130	170	170	170	180	180 mA
30 μF	160	180	180	200	200	200 mA
40 μF	170	190	190	190	200	200 mA
50 μF	190	200	200	200	200	200 mA

(B) **British R.I.C. Specification RIC/134** (Ref. F8)

Range of capacitance 1 to 1000 μF.

Voltage ratings : At 60°C—12, 25, 50, 150, 275, 350, 450, 500.
At 70°C—12, 25, 50, 120, 220, 280, 360, 400.

Tolerances : +50%, −20% for working voltages above 100 V (except etched foil types up to and including 16 μF) ; +100 −20% for working voltages of 100 V and less, and all etched foil types up to and including 16 μF. Ripple rating at 70°C is 0.75 of the ripple rating at 60°C. Power factor at 50 c/s shall not exceed 0.2 for working voltages up to and including 100 V ; 0.15 for working voltages above 100 V. The leakage current of single winding capacitors shall not exceed $0.5\ V\sqrt{C}\mu$A or 100 μA, whichever is the greater, where V is the rated voltage and C the actual capacitance in μF.

(xi) References to standard resistors and capacitors

(A) British Standard for Service Equipment

These standards are not complete, and have been largely superseded by the R.C.S.C. Components Book (see below)

A1. BS/RC.G/1. General guide on radio components (Issue 1) Aug. 1944.

A2. BS/RC.G/110 Guide on fixed resistors (Issue 1) Aug. 1944. Superseded by RCG110.

A3. BS/RC.S/110 Group test-specification for fixed resistors (Issue 2) July 1946 ; Amended Aug. 1947, May 1948. Superseded by RCS112.

A4. BS/RC.S/110.1. Test schedule for fixed resistors (Issue 2) July 1946 ; amended Oct. 1946, Feb. 1947, Aug. 1947. Superseded by RCS112.

A5. BS/RC.G/130. Guide on fixed capacitors (Issue 1) Aug. 1945. Superseded by RCG130.

A7. BS/RC.S/130.3. Test schedule for ceramic dielectric fixed capacitors (Issue 1) March 1944 ; amended Jan. 1946, Mar. 1946, Aug. 1947, Dec. 1947.

A8. BS/RC.S/130.4. Test schedule for electrolytic capacitors (Issue 1) March 1944. Superseded by RCS134.

A9. BS/RC.S/130.6m. Test schedule for miniature paper-dielectric capacitors (metallised paper type) (Issue 2) June 1945, amended Jan. 1946, March 1946, Aug. 1947.

A10. BS/RC.S/130.7m. Test schedule for miniature (High K) type ceramic dielectric fixed capacitors (Issue 1) July 1944. Amended Aug. 1947.

A11. BS/RC.S/141. Group test specification for air dielectric rotary variable capacitors (Issue 1) Nov. 1945 ; amended Aug. 1948. Superseded by RCS141.

A12. BS/RC.S/141.1. Test schedule for air dielectric rotary variable capacitors (Issue 1) Nov. 1945 ; amended Aug. 1948. Superseded by RCS141.

A13. BS/RC.S/141.1m. Test and performance specification for miniature variable capacitors (air-spaced ganged type) (Issue 1) July 1944. Superseded by RCS 141.

(B) British R.C.S.C. Components Book

This book is available to manufacturers of British Service Equipment, and is available for reference at Standards Libraries.

New Issues and amendments are made from time to time.
RCS1 General specification for Electronic Components.
RCG4 Guide to approved components.
RCS11 Specification for the climatic and durability testing of service electronic components.
RCG100.9 Guide to the tropic proofing of electrical equipment.

Resistors

RCG110 Guide on fixed resistors.
RCL110.11 Working schedule, fixed resistors.
RCS111 Specifications for wire-wound resistors.
RCS112 Specifications, fixed composition resistors.
RCS121 Specifications for rotary wire-wound resistors.
RCL121 List of standard rotary wire-wound resistors.
RCS122 Specifications for rotary composition resistors.
RCL122 List of standard rotary composition resistors.

Capacitors—general

RCG130 Guide on capacitors, fixed.

Capacitors, fixed, paper dielectric

RCL130.11 Working schedule—Rectangular metal case.
RCL130.12 Working schedule—Tubular type stud mounting and insulated.
RCL130.13 Working schedule—Tubular metal case, non-insulated.
RCS131 Specification.

Capacitors, fixed, mica dielectric

RCL130.21 Working schedule—metallized case.
RCL130.22 Working schedule—metallized, wax protected.
RCL130.23 Working schedule—foil, moulded case.
RCL130.24M Working schedule—miniature foil and metallized types.
RCS132 Specification (excluding wax-protected types).
RCS132.1 Specification for wax-protected types.

Capacitors, fixed, ceramic dielectric

RCL130.31 Working schedule—Cup and disc types, and temperature compensating types.
RCL130.71M Working schedule—high K.
RCS133 Specification.

[illegible]acitors, fixed electrolytic

RCS134 Specificati[illegible].
R[illegible]34 Standar[illegible]—tubular, metal case.

Capacitors, fixed, paper dielectric (metallized)

RCS136 Specification.
RCS136.1 Specification, humidity class 3, insulated only.
RCL136 Standard list—tubular, insulated and non-insulated.

Capacitors, variable

BS/RCS141 Group test specification, air dielectric, rotary
BS/RCS141.1 Test schedule, air dielectric, rotary.
BS/RCS141.1m Test specification, air-spaced, ganged, miniature.
RCL141.11m Working schedule, air-spaced, ganged, miniature.
RCL141.12m Working schedule, air dielectric trimmer, miniature.
RCL141.14 Working schedule, air dielectric trimmer, with locking device.
RCL141.15 Working schedule, air dielectric trimmer, concentric.
RCS141.2m Test specification, air-spaced trimmer, vane type, miniature.

(D) American R.M.A. Standards for resistors and capacitors

D1. REC-116 Standard fixed composition resistors (July 1948).
D2. REC-117 Standard fixed wire wound resistors (July 1948).
D3. REC-118 Standard fixed paper dielectric capacitors in tubular non-metallic cases (Sept. 1948).
D4. TR-113-A Metal encased fixed paper dielectric capacitors for d.c. application (May 1951).
D5. REC-115-A Standard molded mica capacitors (May 1951).

D6. REC-107-A Standard ceramic dielectric capacitors (Aug. 1952).
D7. REC-106-A Standard variable capacitors Class A (Jan. 1949).
D8. REC-101 Standard variable capacitors, Class B (Oct. 1946).
D9. REC-121-A Standard variable composition resistors (July 1952).
D10. S-417 ; M4-571 through 574-Wet electrolytics.
D11. S-418 ; M4-591 through 598-Dry electrolytics.

(E) American Joint Army/Navy Standards for resistors and capacitors.

E1. JAN-R-11 (31 May 1944) : Resistors, fixed composition. Amendment No. 3 (22 March 1949).
E2. JAN-R-19 (31 July 1944) : Resistors, variable wire-wound (low operating temperature). Amendment No. 2 (12 Jan. 1949).
E3. JAN-R-22 (31 July 1944) : Rheostats, wire wound, power-type. Amendment No. 4 (26 June 1950).
E4. JAN-R-26A (17 Sept. 1948) : Resistors, fixed, wire wound, power type. Amendment No. 1 (28 July 1949).
E4A. JAN-R-93 (16 June 1945) : Resistors, accurate, fixed, wire-wound. Amendment No. 3 (Jan. 1949).
E5. JAN-R-94 (4 Oct. 1948) : Resistors, variable, composition. Amendment No. 2 (17 Jan. 1949).
E6. JAN-R-184 (31 July 1945) : Resistors, fixed, wire wound, low power. Amendment No. 2 (17 Jan. 1949).
E7. JAN-C-5 (20 April 1944) : Capacitors, mica-dielectric, fixed. Amendment No. 2 (6 Jan. 1949).
E8. JAN-C-20A (4 Dec. 1947) : Capacitors, ceramic-dielectric, fixed (temperature compensating). Amendment No. 2 (15th June 1950).
E9. JAN-C-25 (24 July 1947) : Capacitors, direct-current, paper-dielectric, fixed (hermetically sealed in metallic cases). Amendment No. 4 (June 1950).
E10. JAN-C-62 (30 November 1944) : Capacitors, dry-electrolytic, polarized. Amendment No. 3 (Jan. 1949).
E11. JAN-C-81 (27 August 1945) : Capacitors, ceramic-dielectric, variable. Amendment No. 1 (Oct. 1948).
E12. JAN-C-91 (21 Aug. 1947) : Capacitors, paper dielectric, fixed (non-metallic cases). Amendment No. 2 (25 Aug. 1950).
E13. JAN-C-92 (30 Dec. 1944) : Capacitors, air-dielectric, variable (trimmer capacitors). Amendment No. 4 (25 Aug. 1950).

(F) British Radio Industry Council*

F1. RIC/111.
F2. RIC/112. } Superseded by British Standard BS.1852 : 1952.
F3. RIC/113.
F4. RIC/122. Resistors, rotary, variable, composition track (with or without switches).
F5. RIC/131. Capacitors, fixed, paper dielectric, tubular foil. Issue No. 1, July 1950.
F6. RIC/132. Capacitors, fixed, mica dielectric, stacked foil. Issue No. 1, July 1950.
F7. RIC/133. Capacitors, fixed, ceramic dielectric, Grade 1. Issue No. 1, April 1951.
F8. RIC/134. Capacitors, fixed, electrolytic. Issue No. 1, April 1951.
F9. RIC/136. Capacitors, fixed, paper dielectric, tubular, metallized. Issue No. 1, February 1951.
F10. RIC/137. Capacitors, fixed, mica dielectric, metallized. Issue No. 1, April 1951.
F11. RIC/141. Capacitors, variable, air dielectric, tuning. Issue No. 1, Feb. 1951.
F12. RIC/142. Capacitors, variable, preset, air dielectric. Issue No. 1, Sept. 1951.
F13. RIC/143. Capacitors, variable, preset, mica dielectric. Issue No. 1, Sept. 1951.

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*It is hoped that these Radio Industry Council Specifications will, in due course, be incorporated into British Standard Specifications.

SECTION 4: STANDARD FREQUENCIES

(i) Standard frequency ranges (ii) Frequency bands for broadcasting (iii) Standard intermediate frequencies.

(i) Standard frequency ranges

The Final Acts of the International Telecommunication and Radio Conferences at Atlantic City, 1947, proposed the following nomenclature of frequencies.

Frequencies shall be expressed in kilocycles per second (Kc/s) at and below 30 000 Kc/s and in megacycles per second (Mc/s) above this frequency.

TABLE 32

Frequency sub-division	Frequency range	Metric sub-division
v-l-f (very low frequency)	below 30 Kc/s	myriametric waves
l-f (low frequency)	30 to 300 Kc/s	kilometric waves
m-f (medium frequency)	300 to 3 000 Kc/s	hectometric waves
h-f (high frequency)	3 000 to 30 000 Kc/s	decametric waves
v-h-f (very high frequency)	30 000 Kc/s to 300 Mc/s	metric waves
u-h-f (ultra high frequency)	300 to 3 000 Mc/s	decimetric waves
s-h-f (super high frequency)	3 000 to 30 000 Mc/s	centimetric waves
e-h-f (extremely high frequency)	30 000 to 300 000 Mc/s	millimetric waves

(ii) Frequency bands for broadcasting

The International Telecommunication and Radio Conference at Atlantic City, 1947, allocated the following frequency bands for broadcasting purposes.

TABLE 33

Band shared with maritime mobile	150—160 Kc/s
Low frequency (not world-wide)	160—285 Kc/s
Medium frequency (Region 1 only)	525—535 Kc/s
Medium frequency (world wide)	535—1605 Kc/s
Short wave frequencies (world wide)	5.95—6.2 Mc/s
	9.5—9.775 Mc/s
	11.7—11.975 Mc/s
	15.1—15.45 Mc/s
	17.7—17.9 Mc/s
	21.45—21.75 Mc/s
	25.6—26.1 Mc/s
Very high frequency (world wide)	88—100 Mc/s
(U.S.A.)	88—108 Mc/s

In Australia, the band 100-108 Mc/s has been allocated for the aeronautical mobile service until required for broadcasting service.

(iii) Standard Intermediate Frequencies

It is recommended that superheterodyne receivers operating in the medium frequency broadcast band use an intermediate frequency of 455 Kc/s. This frequency is reserved as a clear channel for the purpose in most countries of the world.

The European " Copenhagen Frequency Allocations " provide the following two intermediate frequency bands : 415—490 Kc/s and 510—525 Kc/s.

An intermediate frequency of 175 Kc/s is also used.

The American RTMA has standardized the following intermediate frequencies (REC-109-B, March 1950) : Standard broadcast receivers—either 260 or 455 Kc/s. V-H-F broadcast receivers—10.7 Mc/s.

SECTION 5 : WAVELENGTHS AND FREQUENCIES

(*i*) *Wavelength-frequency conversion tables* (*ii*) *Wavelengths of electromagnetic radiations.*

(i) Wavelength-frequency conversion table

Convenient points selected for rapid reference.

TABLE 34 : MEDIUM-FREQUENCY BROADCAST BAND

Frequency Kc/s	Wavelength m	Frequency Kc/s	Wavelength m	Frequency Kc/s	Wavelength m	Frequency Kc/s	Wavelength m
540	555.5	810	370.4	1080	277.8	1350	222.2
550	545.5	820	365.9	1090	275.2	1360	220.6
560	535.7	830	361.4	1100	272.7	1370	219.0
570	526.3	840	357.1	1110	270.3	1380	217.4
580	517.2	850	352.9	1120	268.2	1390	215.8
590	508.5	860	348.8	1130	265.5	1400	214.3
600	500.0	870	344.8	1140	263.2	1410	212.8
610	491.8	880	340.9	1150	260.9	1420	211.3
620	483.9	890	337.1	1160	258.6	1430	209.8
630	476.2	900	333.3	1170	256.4	1440	208.3
640	468.8	910	329.7	1180	254.2	1450	206.9
650	461.5	920	326.1	1190	252.1	1460	205.5
660	454.5	930	322.6	1200	250.0	1470	204.1
670	447.8	940	319.1	1210	247.9	1480	202.7
680	441.2	950	315.8	1220	245.9	1490	201.3
690	434.8	960	312.5	1230	243.9	1500	200.0
700	428.6	970	309.3	1240	241.9	1510	198.7
710	422.5	980	306.1	1250	240.0	1520	197.4
720	416.7	990	303.0	1260	238.1	1530	196.1
730	411.0	1000	300.0	1270	236.2	1540	194.8
740	405.4	1010	297.0	1280	234.4	1550	193.5
750	400.0	1020	294.1	1290	232.6	1560	192.3
760	394.7	1030	291.2	1300	230.8	1570	191.1
770	389.6	1040	288.5	1310	229.0	1580	189.9
780	384.6	1050	285.7	1320	227.3	1590	188.7
790	379.7	1060	283.0	1330	225.6	1600	187.5
800	375.0	1070	280.4	1340	223.9		

TABLE 35 : SHORT WAVE BAND

Frequency Mc/s	Wavelength m	Frequency Mc/s	Wavelength m	Frequency Mc/s	Wavelength m	Frequency Mc/s	Wavelength m
1.5	200	11	27.3	21	14.3	65	4.62
2.0	150	12	25.0	22	13.6	70	4.29
3.0	100	13	23.1	23	13.0	75	4.00
4.0	75.0	14	21.4	25	12.0	80	3.75
5.0	60.0	15	20.0	30	10.0	85	3.53
6.0	50.0	16	18.8	35	8.57	88	3.41
7.0	42.9	17	17.6	40	7.50	90	3.33
8.0	37.5	18	16.7	45	6.67	95	3.16
9.0	33.3	19	15.8	50	6.00	100	3.00
10.0	30.0	20	15.0	55	5.45	105	2.86
				60	5.00	108	2.78

(ii) Wavelengths of electromagnetic radiations

TABLE 36

Rays	Wavelengths		
	Angstrom units	Microns	Metres
Cosmic rays	10^{-6}—10^{-2}	10^{-10}—10^{-6}	
Gamma rays	10^{-2}—1	10^{-6}—10^{-4}	
X-Rays	10^{-1}— 10^{2}	10^{-5}—10^{-2}	
Ultraviolet rays	100—3900	10^{-2}—0.39	
Visible light rays	3900—7600	0.39—0.76	
Infrared rays	7600—10^{6}	0.76—10^{2}	
Electric or radio rays		10^{2}—10^{10}	10^{-4}—10^{4}
Radio broadcasting rays		10^{7}—10^{9}	10—10^{3}

SECTION 6: STANDARD SYMBOLS AND ABBREVIATIONS

(i) Introduction (ii) Multipliers (iii) Some units and multipliers (iv) Magnitude letter symbols (v) Subscripts for magnitude letter symbols (vi) Magnitude letter symbols with subscripts (vii) Mathematical signs (viii) Abbreviations (ix) Abbreviations of titles of periodicals (x) References to periodicals (xi) References to standard symbols and abbreviations.

(i) Introduction

Owing to the lack of international standardization, the editor has been forced to select suitable symbols for use in this Handbook. The choice which has been made is believed to be a reasonable compromise, and capable of being understood readily throughout the English-speaking world.

(ii) Multipliers

In general, small letters are used for quantities below unity, and capital letters for quantities above unity.

d = deci	= 1/10	= 10^{-1}
c = centi	= 1/100	= 10^{-2}
m = milli	= 1/1000	= 10^{-3}
μ = micro	= 1/1000 000	= 10^{-6}
$\mu\mu$ = micromicro	= 1/1000 000 000 000	= 10^{-12}
K or k = kilo	= 1000	= 10^{3}
M = meg	= 1000 000	= 10^{6}

(iii) Some units and multipliers

A = ampere	mA = milliampere	μA = microampere
F = farad	μF = microfarad	$\mu\mu$F* = micromicrofarad
H = henry	mH = millihenry	μH = microhenry
Ω = ohm	MΩ = megohm	
V = volt	mV = millivolt	KV or kV = kilovolt
W = watt	mW = milliwatt	
m = metre	cm = centimetre	mm = millimetre

*Alternatively, pF = picofarad = $\mu\mu$F = micromicrofarad.

(iv) Magnitude letter symbols†

B = susceptance
C = capacitance
C_r, g = conductance
D = total harmonic distortion
E, e = electromotive force
F_p = power factor
f = frequency
g, C_r = conductance
H_1 = fundamental frequency component of distortion
H_2, H_3, etc. = second (third etc.) harmonic components of distortion
I, i = current
K = dielectric constant
L = inductance
M = mutual inductance
P = power
Q = charge, quantity of electricity
also Q = figure of merit of a reactor
R = resistance
X = reactance
X_L = inductive reactance
X_c = capacitive reactance
Y = admittance
Z = impedance (scalor)
$\mathbf{Z}$ = impedance (vector)

Δ = increment of
ϵ = 2.7182818
η = efficiency
λ = wavelength
π = 3.14159
$\omega = 2\pi f$ = angular velocity.

Magnetic units

B = magnetic flux density
H = magnetic field strength, magnetizing force
ϕ = magnetic flux
μ = magnetic permeability

Operators

d = differential ; δ = partial differential
j = 90° rotational = $\sqrt{-1}$.

(v) Subscripts for magnitude letter symbols

in = input
out = output
max = maximum (reduced to m when combined with another subscript)
min = minimum
av = average
b = plate—steady or total value
bb = plate supply
c = grid—steady or total value
c_1 = grid no. 1 ; similarly c_2, c_3 etc.
cc = grid supply
co = at point of plate current cutoff
f = filament
g = grid—varying component

†A magnitude letter symbol is used to designate the magnitude of a physical quantity in mathematical equations and expressions. Two or more magnitude symbols printed together represent a product.

g_1 = grid no. 1 ; similarly g_2, g_3 etc.
h = heater
k = cathode
o = quiescent (no signal)
p = plate (anode)—varying component
s = screen or metal shell or other self-shielding envelope
t = triode

N.B. Grids are numbered in order, beginning at the cathode and working outwards towards the plate.

(vi) Magnitude letter symbols with subscripts

Symbols for filament or heater circuits

E_f = filament or heater (terminal) voltage
E_{hk} = voltage of heater with regard to cathode
I_f = filament or heater current.

Symbols for plate circuits

All voltages are taken as being with respect to the cathode unless otherwise indicated.

E_{bb} = plate supply voltage
E_b = average or quiescent value of plate voltage
E_{bo} = quiescent (no signal) value of plate voltage
E_{bm} = maximum value of plate voltage
E_p = r.m.s. value of varying component of plate voltage
E_{pm} = maximum value of varying component of plate voltage
e_b = instantaneous total plate voltage
e_p = instantaneous value of varying component of plate voltage
I_b = average or quiescent value of plate current
I_{bm} = peak total plate current
I_{bo} = quiescent (no signal) value of plate current
I_p = r.m.s. value of varying component of plate current
I_{pm} = maximum value of varying component of plate current
I_s = total electron emission
i_b = instantaneous total plate current
i_p = instantaneous value of varying component of plate current.

Symbols for grid circuits

E_c = average or quiescent value of grid voltage
E_{cm} = maximum value of grid voltage
E_g = r.m.s. value of varying component of grid voltage
E_{gm} = maximum value of varying component of grid voltage
e_c = instantaneous total grid voltage
e_g = instantaneous value of varying component of grid voltage
I_c = average or quiescent value of grid current
I_g = r.m.s. value of varying component of grid current
i_c = instantaneous total grid current
i_g = instantaneous value of varying component of grid current.

Symbols for valve characteristics

(A) Inside the valve

E_{pg} = voltage of plate with regard to grid
μ = amplification factor
μ_t = amplification factor (triode connected)
μ_{g1g2} = mu factor from grid no. 1 to grid no. 2, and similarly for other electrodes
g_m = mutual conductance (= g_{gp}) or " slope "
g_c = conversion conductance
g_d = dynamic conductance (slope of dynamic characteristic)
g_p = plate conductance
g_g = grid conductance
g_n = plate-grid transconductance (inverse mutual conductance) = g_{pg}
g_{jk} = transconductance from electrode j to electrode k

r_p = plate resistance
r_g = grid resistance
r_{g2} = screen (grid no. 2) resistance
C_{gp} = grid-plate capacitance
C_{gk} = grid-plate cathode capacitance
C_{pk} = plate-cathode capacitance
C_{gh} = grid-heater capacitance
C_{ph} = plate-heater capacitance
C_{in} = input capacitance
C_{out} = output capacitance.

(B) Valve and circuit

R_L = plate load resistor
Z_L = plate load impedance
R_k = cathode resistor
C_k = cathode by-pass capacitor
C_c = coupling condenser
R_{g1} = grid resistor
R_{g2} = following grid resistor
r_i = input resistance
r_o = output resistance
R_s = screen series resistor
C_s = screen by-pass capacitor
P_i = power input
P_o = power output
P_p = plate (anode) dissipation
P_{g2} = screen (grid no. 2) dissipation
A = amplification (voltage gain of stage)
A_o = amplification (voltage gain of stage) at mid-frequency
I_{hm1} = peak fundamental current
I_{hm2} = peak second harmonic current.

(vii) Mathematical signs

$+$	plus
$-$	minus
$\pm$	plus or minus
$\times$ or .	multiplied by
$\div$ or /	divided by
$=$	equal to
$\neq$	not equal to
$\approx$	approximately equal to
$\geqslant$	equal to or greater than
$\leqslant$	equal to or less than
$\equiv$	identical with
$>$	greater than
$<$	less than
$\therefore$	therefore
$\propto$	varies as
$\sqrt{\ }$	square root
$\sqrt[n]{\ }$	nth root
!	factorial
F	function
$\int$	integration
∞	infinity
$^\circ$	degree
$'$	minutes of degree
$''$	seconds of degree
δ or Δ	increment
Σ	summation

log x — logarithm of x to base 10
$\log_\epsilon$ x — logarithm of x to base ϵ
j — square root of minus one (90° angular rotation)
ϵ — base of natural logarithms (2.71828)
π — ratio of circumference to diameter of circle (3.141593 approx.)

For trigonometrical symbols and differentiation refer to Chapter 6.

(viii) Abbreviations

a.c. = alternating current
d.c. = direct current
a-f = audio frequency

i-f	=	intermediate frequency
r-f	=	radio frequency
v-h-f	=	very-high-frequency
u-h-f	=	ultra-high-frequency
		(For other frequency designations see Sect. 4.)
AWG	=	American Wire Gauge
B & S	=	same as AWG
SWG	=	Standard Wire Gauge
E	=	enamelled
r.m.s	=	root mean square
db	=	decibel
dbm	=	decibels of power referred to 1 milliwatt
c/s	=	cycles per second
Kc/s	=	kilocycles per second (kc/s may also be used)
Mc/s	=	megacycles per second
Hz	=	Hertz = cycles per second
a.v.c.	=	automatic volume control
a.a.v.c.	=	audio automatic volume control
A-M	=	amplitude modulation
F-M	=	frequency modulation
SSC	=	single silk covered
DSC	=	double silk covered
SCC	=	single cotton covered
DCC	=	double cotton covered.

Note : Abbreviations are used to indicate either singular or plural, either as a noun or as an adjective.

(ix) Abbreviations of titles of periodicals

Standard Abbreviations	Title and Publisher
A.R.T.S. & P.	Australian Radio Technical Services and Patents Bulletin (47 York St., Sydney, Australia).
Audio Eng. (formerly Radio)	Audio Engineering (Radio Magazines Inc. 10 McGovern Ave., Lancaster, Pa.).
Australian Radio & Electronics (formerly Australasian Radio World)	Radio & Electronics (Aust.) Pty. Ltd., 17 Bond St., Sydney.
A.W.A. Tec. Rev.	A.W.A. Technical Review (Amalgamated Wireless Australasia Ltd., 47 York St., Sydney, Australia).
B.B.C. Quarterly	British Broadcasting Corporation, 35 Marylebone High St., London, W.1.
B.S.T.J.	Bell System Technical Journal (American Telephone & Telegraph Coy., 195 Broadway, New York 7, N.Y. U.S.A.).
Bell. Lab. Rec.	Bell Laboratories Record (Bell Telephone Laboratories Inc. 463 West Street, New York 14, N.Y.).
British P.O.E.E.J	Post Office Electrical Engineers' Journal, Institution of P.O.E.E. Engr-in-chief's office Alder House, Aldersgate St., London E.C.1.
Brown-Boveri Review	Brown Boveri & Co. Ltd., Baden, Switzerland.
Comm.	Communications (Bryan Davis Publishing Coy., Inc., 52 Vanderbilt Ave., New York 17, N.Y. U.S.A.).
E.E.	Electrical Engineering (American Institute of Electrical Engineers, 33 West 39th St., New York 18 N.Y.).

E.W. & W.E.	Same as Wireless Engineer.
Elect.	Electronics (McGraw-Hill Publishing Co., Inc., West 42nd St., New York 18, N.Y., U.S.A.).
Elect. Comm.	Electrical Communication (International Telephone & Telegraph Corp. 67 Broad St., New York 4, N.Y. U.S.A.).
Electronic Eng.	Electronic Engineering, 28 Essex St., London W.C.2.
Electronic Industries	Caldwell-Clements Inc., 480 Lexington Ave., New York 17, N.Y.
Engineering	J. A. Dixon, 33-36 Bedford St., London W.C.2.
F.M. & T. FM-TV	FM-TV Radio Communication, formerly FM Magazine, FM and Television, FM Radio Electronics (FM Company, 264 Main St., Great Barrington, Mass. U.S.A.).
G.E. Review	General Electric Review (G.E. Co., Schenectady, New York, U.S.A.).
G.R. Exp.	General Radio Experimenter (General Radio Company, 275 Massachusetts Av., Cambridge, 39, Mass., U.S.A.).
J. Acous. Soc. Am.	Journal Acoustical Society of America. Published for A.S.A. by the American Institute of Physics, Prince and Lemon Streets, Lancaster, Pa. U.S.A.
Journal of Applied Physics	American Institute of Physics, 57 East 55th St., New York 22 N.Y.
Jour. I.E.E.	Journal of the Institution of Electrical Engineers (Savoy Place, Victoria Embankment, London, W.C.2., England).
J. Brit. I.R.E.	Journal of British Institution of Radio Engineers (9 Bedford Square, London, W.C.1 England).
Jour. Sci. Instr.	Journal of Scientific Instruments (Institute of Physics, 47 Belgrave Sq., London S.W.1).
Jour. S.M.P.E. Jour. S.M.P.T.E.	Journal of the Society of Motion Picture and Television Engineers 342 Madison Ave., New York 17, U.S.A.
Marconi Review	Marconi's Wireless Telegraph Co. Ltd., Marconi House, Chelmsford.
Phil. Mag.	Philosophical Magazine (Taylor and Francis Ltd., Red Lion Court, Fleet St., London, E.C.4).
Philips Tec. Com.	Philips Technical Communications (Philips Electrical Industries of Australia Pty. Ltd., 69-73 Clarence St., Sydney).
Philips Tec. Rev.	Philips Technical Review (N.V. Philips' Gloeilampenfabrieken, Eindhoven, Holland).
Phys. Rev.	Physical Review (American Institute of Physics, 57 East 55th Street, New York 22, N.Y.).
Proc. I.R.E.	Proceedings of the Institute of Radio Engineers (I.R.E. Inc. 1 East 79 Street, New York 21, N.Y., U.S.A.).
Proc. I.R.E. Aust.	Proceedings of the Institute of Radio Engineers Australia (Science House, Gloucester St., Sydney, Australia).
Proc. Roy. Soc.	Proceedings of the Royal Society Burlington House London W.1.
Q.S.T.	American Radio Relay League Inc. (38 La Salle Rd., West Hartford 7, Conn. U.S.A.).
R.C.A. Rev.	R.C.A. Review (Radio Corporation of America, R.C.A. Laboratories Division, Princeton, N.J. U.S.A.).
R. & E. Retailer	Radio and Electrical Retailer (Australian Radio Publications Pty. Ltd., 30-32 Carrington St., Sydney).
Radio	Radio Magazines Inc. 10 McGovern Ave., Lancaster, Pa).

Radiotronics	Amalgamated Wireless Valve Co. Pty. Ltd. (47 York St., Sydney, Australia).
Radio Craft Radio Electronics	Radiocraft Publications Inc. (25 West Broadway, New York, 7, N.Y. U.S.A.).
Radio Electrical Weekly	Mingay Publishing Co. 146 Foveaux St., Sydney.
Radio Eng.	Radio Engineering. Same as Communications.
Radio & Hobbies, Australia	Associated Newspapers Ltd., 60-70 Elizabeth-St., Sydney.
Radio Review of Australia	Australian Radio Publications Pty. Ltd., 30-32 Carrington St., Sydney.
Rev. of Sci. Instr.	Review of Scientific Instruments (American Inst. of Physics 57 East 55th St., New York 22 N.Y.).
Radio News Radio & TV News	Ziff Davis Publishing Coy. (185 North Wabash Ave., Chicago 1, Ill. U.S.A.).
Service	Bryan Davis Publishing Coy. Inc., 52 Vanderbilt Ave., New York 17, N.Y. U.S.A.).
TV Eng. (formerly Communications; formerly Radio Engineering; formerly Communication and Broadcast Engineering)	Tele Vision Engineering (Bryan Davis Publishing Coy., Inc., 52 Vanderbilt Av., New York 17, N.Y. U.S.A.).
Telecommunications Journal of Australia	Postal Electrical Society of Victoria, G.P.O. Melbourne Australia.
Tele-Tech	Caldwell-Clements Inc. 480 Lexington Ave., New York 17 N.Y.
Trans. A.I.E.E.	Transactions of the American Institute of Electrical Engineers (A.I.E.E., 33 West 39th Street, New York 18 N.Y.).
W.E. W.E. & E.W.	Wireless Engineer (Iliffe & Sons Ltd., Dorset House, Stamford St., London, S.E.1., England).
W.W.	Wireless World (Iliffe & Sons Ltd., Dorset House, Stamford St., London, S.E.1, England).
Western Electric Oscillator	Western Electric Company (Graybar Electric Co, 420 Lexington Ave. New York 17, N.Y.).

(x) References to periodicals

The references to periodicals in this Handbook follow substantially the form recommended in British Standard 1219 : 1945.

Example : Lamson, H.W. " Permeability of dust cores " W.E. 24.288 (Sept. 1947) 267.

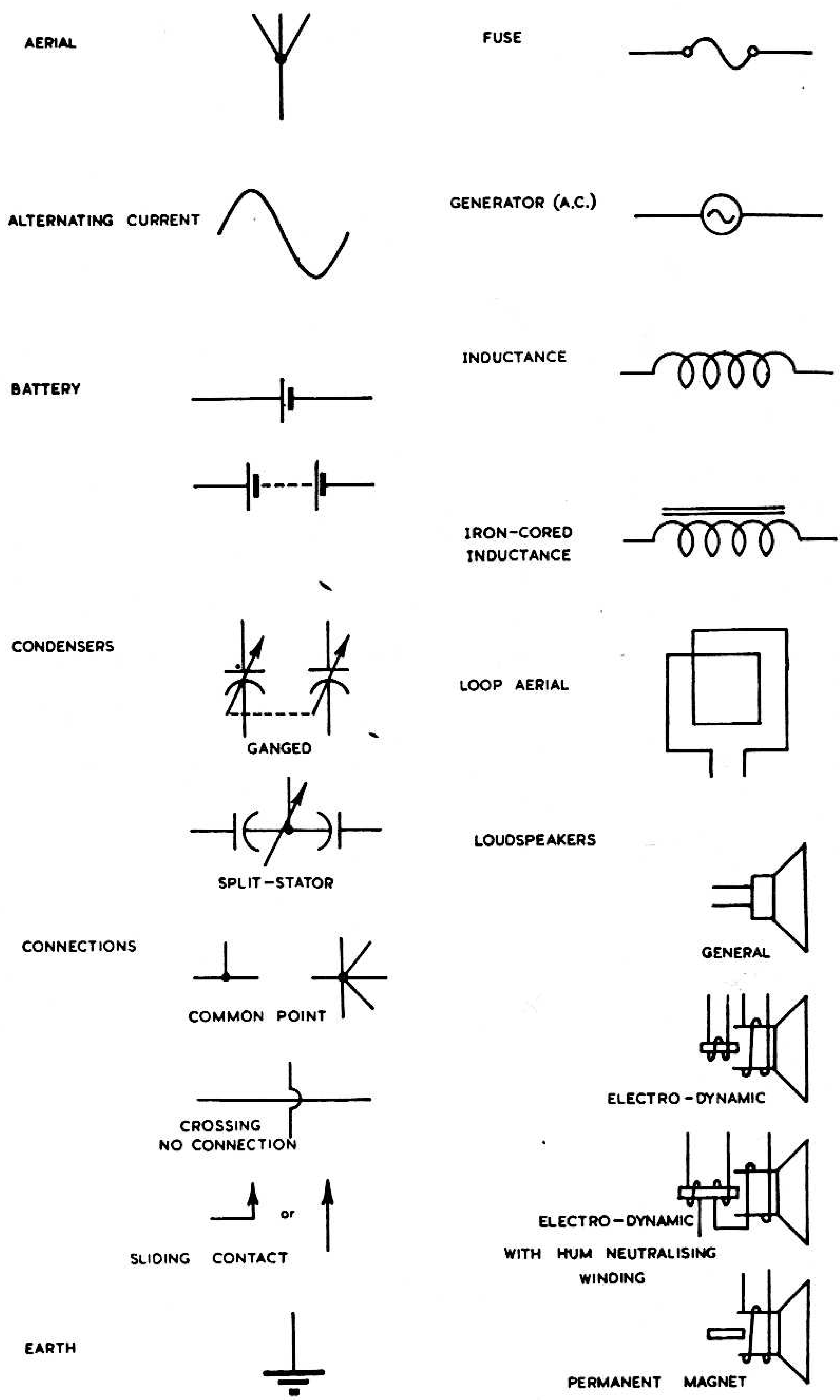
Lamson, H. W. indicates the author.
" Permeability of dust cores " indicates the title.
W.E. indicates the periodical (see abbreviations above).
24 indicates the volume number.
288 indicates the number.
Sept. 1947 indicates the date.
267 indicates the first page of the article.

(xi) References to standard symbols and abbreviations

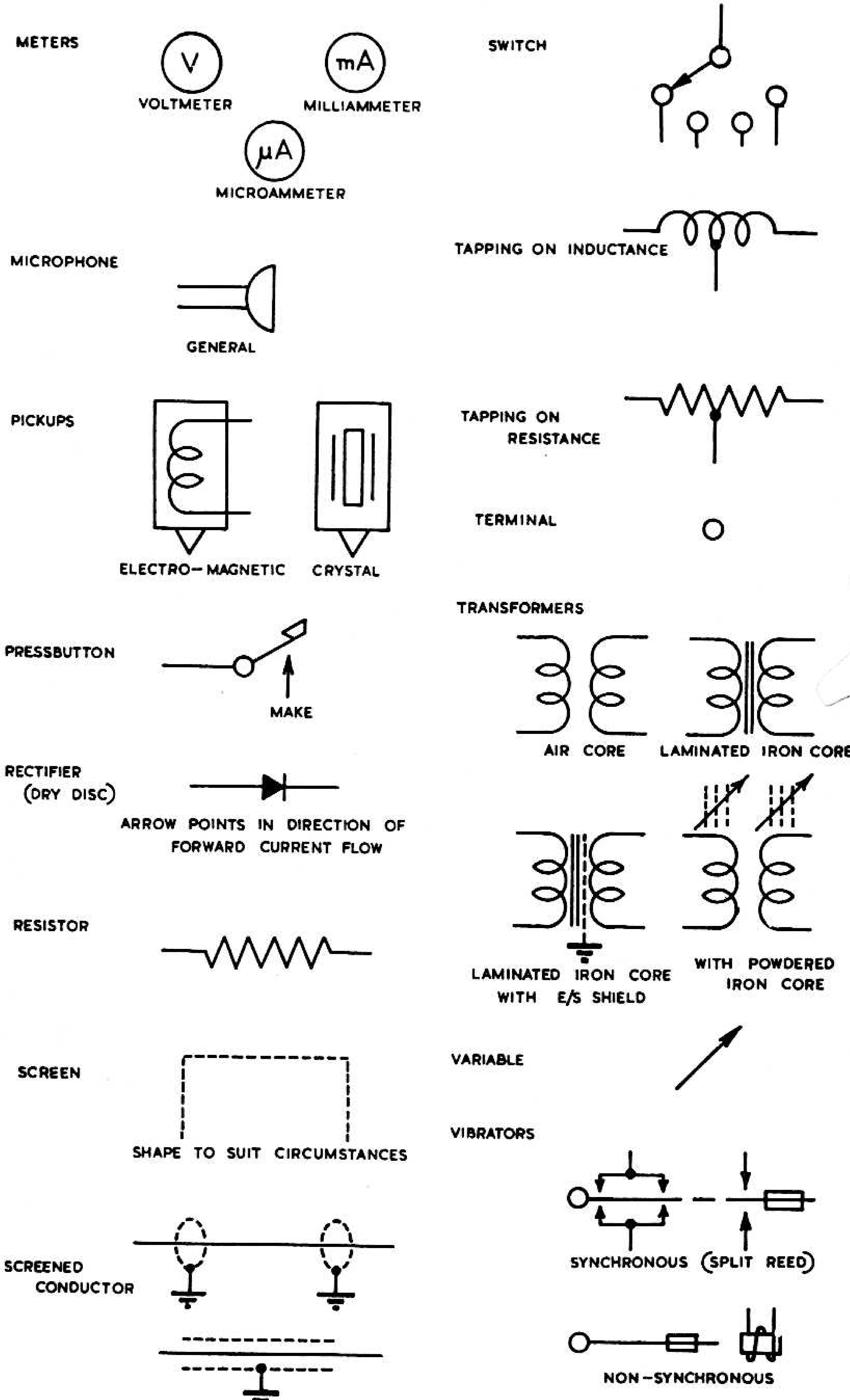
1. " Standards on abbreviations, graphical symbols, letter symbols and mathematical signs." The Institute of Radio Engineers (U.S.A.) 1948.
2. " American standard letter symbols for electrical quantities " A.S.A. Z10.5, 1949.
3. British Standard 1409 : 1950 " Letter symbols for electronic valves " British Standards Institution 28 Victoria St., London, S.W.1.
4. " Standards on designations for electrical, electronic and mechanical parts and their symbols, 1949 " Standard 49 IRE, 21 S1, published Proc. I.R.E. 38.2 (Feb. 1950) 118.
5. " Standards on abbreviations of radio-electronic terms, 1951 " Standard 51 IRE 21 S1, published Proc. I.R.E. 39.4 (April 1951) 397.

SECTION 7 : STANDARD GRAPHICAL SYMBOLS

GRAPHICAL SYMBOLS



GRAPHICAL SYMBOLS



SECTION 8 : PROPERTIES OF MATERIALS AND CHEMICAL AND PHYSICAL CONSTANTS

(i) Properties of insulating materials (ii) Properties of conducting materials (iii) Composition of some common plastics (iv) Weights of common materials (v) Resistance of a conductor at any temperature (vi) References to properties of materials (vii) Chemical and physical constants.

(i) Properties of insulating materials

TABLE 37

Insulating Material	Dielectric Constant 60 c/s	Power Factor (per cent)			Dielectric Strength V/mil	Resistivity ohm-cm	Softens at °C	Coeff. of expansion parts in 10^6 per °C
		60 c/s	1 Mc/s	100 Mc/s				
Air-Normal Pressure	1				19.8-22.8			
Amber	2.7-2.9		0.2-0.6		2300	very high	250	44
Asphalts	2.7-3.1	2.3			25-30			
Casein-Moulded	6.4		5.2		400-700	Poor	177	80
Cellulose-Acetate	6-8	6	10		250-1000	4.5×10^{10}	70	160
Cellulose-Nitrate	4-7	5-15	7-10		300-780	$2\text{-}30 \times 10^{10}$	85	90-160
Ceresin Wax	2.5-2.6		0.05	0.05			57	
Fibre	2.5-5	6-9	5	5	150-180	5×10^{9}	130	25
Glass-Crown	6.2		1		500		1100	8.9
Glass-Electrical	4-5		0.5		2000	8×10^{14}		
Glass-Flint	7		0.4					7.9
Glass-Photographic	7.5		0.8-1					
Glass-Plate	6.8-7.6		0.6-0.8					
Glass-Pyrex	4.5		0.2-0.7	0.54	335	10^{14}	600	3.2
Halowax	3.4-3.8	0.2	0.14	10.5		$10^{13}\text{-}10^{14}$	88	
Magnesium silicate	5.9-6.4	0.13-1.7	0.037-0.38	0.03-0.37	200-240	$>10^{14}$	1350	6-10.5
Methacrylic Resin	2.8	3	2				135	70
Mica	2.5-8	0.2	0.2-6			2×10^{17}		
Mica-Clear India	7-7.3	0.03-0.05	0.02-0.03	0.03	600-1500	5×10^{13}	1200	3-7
Micalex 364	6-8	0.64	0.21	0.22	350		348	8-9
Nylon	3.6	1.8	2	1.8	305	10^{13}	71	57
Paper	2-2.6				1250			
Paraffin Oil	2.2	0.01	0.01	0.04	381			710
Paraffin Wax	2.25	0.02	0.02	0.02	203-305	10^{16}	M.P. 56	
Phenol-formaldehyde	5	2-8	1-2.8	3.8	400-475	1.5×10^{12}		28
Phenol-Yellow	5.3	2.5	0.7		500			

TABLE 37 (Continued)

Insulating Material	Dielectric Constant 60 c/s	Power Factor (per cent)			Dielectric Strength V/mil	Resistivity ohm-cm	Softens at °C	Coeff. of expansion parts in 10^6 per °C
		60 c/s	1 Mc/s	100 Mc/s				
Phenol-Black Moulded	5.5	8	3.5		400-500			40
Phenol-Paper Base	5.5	6	3.5		650-750	10^{10}-10^{13}		30
Phenol-Cloth Base	5.6	5	5		150-500			20
Polyethylene	2.25	0.03	0.03	0.03	1000	10^{17}	104	Varies
Polystyrene	2.5	0.02	0.02	0.03	508-760	10^{17}	80	70
Polyvinyl Chloride	2.9-3.2	1.2	1.6	0.8	400	10^{14}	54	82
Porcelain-Wet Process	6.5-7	2	0.6		150		1610	4-5
Porcelain-Dry Process	6.2-7.5	2	0.7		40-100	5×10^8		3-4
Pyrophillite	5.2		0.2-0.7	0.36	500	1.3×10^{15}		
Quartz-Fused	3 5-4.2	0.09	0.02	0.02	200	10^{14}-10^{18}	1430	0.45
Rubber-Hard	2-3.5	1	0.5-1		450	10^{12}-10^{15}	70	70-80
Shellac	2.5-4	0.6-2.5	0.9-3.1	3	900	10^{16}	85	
Steatite-Commercial	4.9-6.5	0.02	0.2-0.3	0.5			1500	6-8
Steatite-Low-loss	4.4	0.02	0.2	0.13	150-315	10^{14}-10^{15}		
Titanium Dioxide	90-170		.02-0.5		100-210	10^{13}-10^{14}	1600	7-8
Urea Formaldehyde	5-7	3-5	2.8	5	300-550	10^{12}-10^{13}	200	26
Varnished cloth	2-2.5		2-3		450-550			
Vinyl Resins	4		1.7		400-500	10^{14}		70
Wood-Dry Oak	2.5-6.8		4.2					
Wood-Paraffined Maple	4.1				116			

See also Refs. 1, 2, 3, 4, 5, 6.

(ii) Properties of conducting materials

TABLE 38

Material	Relative Resistance	Temperature Coefficient of Resistivity at 20°C	Specific Gravity	Thermal Conductivity at 20°C	Coefficient of Linear Expansion	Melting Point (°C)
		$\times 10^{-4}$			$\times 10^{-6}$	
Aluminium	1.64	40	2.7	0.48	25.5	660
Brass	3.9	20	8.47	0.26	18.9	920
Cadmium	4.4	38	8.64	0.222	28.8	321
Cobalt	5.6	33	8.71	—	12.3	1480
Constantan*	28.45	±2	8.9	0.054	17.0	1210
Copper	1.00	39.3	8.89	0.918	16.7	1083
Gas Carbon	2900	−5	1.88	0.0004	5.4	3500
Gold	1.416	34	19.32	0.705	13.9	1063
Iron-Cast	5.6	60	7.87	0.18	10.2	1535
Karma	77.1	±0.2	—	—	—	—
Lead	12.78	42	11.37	0.083	29.1	327
Magnesium	2.67	40	1.74	0.376	25.4	651
Manganin	26	±0.2	8.5	0.053	18.0	910
Mercury	55.6	8.9	13.55	0.0148	—	−38.87
Molybdenum	3.3	45	10.2	0.346	5.0	2622
Monel Metal	27.8	20	8.8	0.06	14	1350
Nichrome	.65	1.7	8.25	0.035	12.5	1350
Nickel	5.05	47	8.85	0.142	12.8	1452
Nickel Silver	16	2.6	8.72	0.07	18.36	1110
Phosphor Bronze	5.45	—	8.9	0.15	19.0	1050
Platinum	6.16	38	21.4	0.166	8.9	1773
Silver	0.95	40	10.5	1.006	19.5	960.5
Steel	7.6-12.7	16-42	7.8	0.115	10.5-11.6	1480
Steel—Stainless	52.8	—	7.9	0.069	10-11	1410
Tantalum	9.0	33	16.6	0.130	6.5	2850
Tin	6.7	42	7.3	0.155	21.4	231.9
Tungsten	3.25	45	19.2	0.476	4.44	3370
Zinc	3.4	37	7.14	0.265	26.3	419.5
Zirconium	2.38	44	6.4	—	—	1860

*Also known as Advance, Copel, Eureka, Ideal, etc. See also Refs. 1, 5, 6.

(iii) Composition of some common plastics

TABLE 39

Trade Name	Composition
Bakelite	Phenol formaldehyde
Bakelite	Urea formaldehyde
Bakelite	Cellulose acetate
Bakelite	Polystyrene
Beetle	Urea formaldehyde
Cellophane	Regenerated cellulose film
Celluloid	Cellulose nitrate
Distrene	Polystyrene
Duperite	Phenol formaldehyde
Erinoid	Casein
Formica	Phenol formaldehyde (lamination)
Glyptal	Glycerol-phthalic anhydride
Lucite	Methyl methacrylate polymer
Micarta	Phenol formaldehyde (lamination)
Mycalex	Mica bonded glass
Neoprene	Chloroprene synthetic rubber
Nylex	Polyvinyl chloride
Nylon	Synthetic polyamides and super polyamides
Paxolin	Phenol formaldehyde
Perspex	Methyl methacrylate polymer
Plexiglass	Methyl methacrylate polymer
Polythene	Polyethylene
PVC	Polyvinyl chloride
Scarab	Urea formaldehyde
Synthane	Phenol formaldehyde
Trolitul	Polystyrene
Vinylite A	Polyvinyl acetate
Vinylite Q	Polyvinyl chloride
Vinylite V	Vinyl chloride-acetate copolymer
Vinylite X	Polyvinyl butyral
Xylonite	Nitrocellulose

(iv) Weights of common materials

The weights of the following materials are given in pounds per cubic inch.

TABLE 40

Aluminium	0.098	Polystyrene	0.038
Armco iron	0.284	Radio metal	0.299
Brass	0.304	Rho metal	0.292
Constantan	0.321	Steel	
Copper	0.310	Cast	0.278
German silver	0.323	2% silicon	0.278
Iron (cast)	0.281	4% silicon	0.271
Mumetal	0.318	Synthetic wax	
Perm-Alloy B	0.299	Seekay	0.056
Perm-Alloy C	0.310	Halowax	0.056
Perspex	0.043	2129 Alloy	0.292
Polyamide (Nylon)	0.041		

See Sect. 10(viii) for weight of metal sheets.

(v) Resistance of a conductor at any temperature

To find the resistance of a conductor at any temperature :

$$R_t = R_{20}[1 + (t - 20)\alpha]$$

where R_t = resistance at temperature t°C
R_{20} = resistance at 20°C
t = temperature of conductor °C
and α = temperature coefficient of resistivity at 20°C.

Most conductors increase in resistance when their temperature is increased.

(vi) Reference to properties of materials

1. English readers are referred to the Radio Industry Council Specification No. RIC/1000/A " Choice of materials for radio and other electronic equipment and for components therein " Issue No. 1—July 1949.

2. British Standard 1598 : 1949 " Ceramic materials for telecommunication and allied purposes." Gives summary of electrical, mechanical, thermal and general properties of insulators.

3. British Standard 1540 : 1949 " Moulded electrical insulating materials for use at radio frequencies ".

4. D. W. Thomasson " Silicones and other silicon compounds " Electronic Eng. 22.272 (Oct. 1950) 422.

5. Federal Telephone and Radio Corporation " Reference Data for Radio Engineers " 3rd ed. 31-39, 47-53.

6. " Standard Handbook for Electrical Engineers," McGraw-Hill Book Co. Inc. 8th ed. 1949, Sect. 4.

Extensive treatment ; also gives bibliography of insulating materials Sect. 4-619.

(vii) Chemical and physical constants

Some Chemical and Physical Constants as at 1 Dec. 1950, extracted from Table VII, " A re-evaluation of the fundamental atomic constants " Physical Review 81.1 (Jan. 1, 1951) 73.

Electron mass $m = (9.10710 \pm 0.00022) \times 10^{-28} g$

Electronic charge $e = (4.80217 \pm 0.00006) \times 10^{-10}$ esu
$= (1.601844 \pm 0.000021) \times 10^{-20}$ emu

Boltzmann's constant $k = (1.38020 \pm 0.00007) \times 10^{-16}$ erg deg^{-1}

Ratio proton mass to electron mass
$M/m = (1836.093 \pm 0.044)$

Velocity of light $c = (299790.0 \pm 0.7)$ km/sec

The velocity of light in a vacuum, following the recommendation of the International Scientific Radio Union (U.R.S.I.), is to be taken as 299792 ± 2 km/sec (see W.W. March 1953 page 121).

SECTION 9: REACTANCE, IMPEDANCE AND RESONANCE

(i) Inductive reactances (ii) Capacitive reactances (iii) Impedance of reactance and resistance in parallel (iv) Impedance of reactance and resistance in series (v) Resonance (vi) Approximations in the calculation of impedance for reactance and resistance in series and parallel (vii) Reactance chart.

(i) Inductive reactances

(Correct to three significant figures)

TABLE 41

AUDIO FREQUENCIES $X_L = \omega L$

Inductance (Henries)	Reactance in Ohms at :— 30 c/s	50 c/s	100 c/s	400 c/s	1000 c/s	5000 c/s
250	47 100	78 500	157 000	628 000	1 570 000	7 850 000
100	18 800	31 400	62 800	251 000	628 000	3 140 000
50	9 420	15 700	31 400	126 000	314 000	1 570 000
25	4 710	7 850	15 700	62 800	157 000	785 000
10	1 880	3 140	6 280	25 100	62 800	314 000
5	942	1 570	3 140	12 600	31 400	157 000
1	188	314	628	2 510	6 280	31 400
.1	18.8	31.4	62.8	251	628	3 140
.01	1.88	3.14	6.28	25.1	62.8	314
1000 μH	.188	.314	.628	2.51	6.28	31.4
200 μH	.0376	.0628	.126	.502	1 26	6.28
100 μH	.0188	.0314	.0628	.251	.628	3.14

RADIO FREQUENCIES $X_L = \omega L$

Inductance (Henries)	Reactance in Ohms at :— 175 Kc/s	252 Kc/s	465 Kc/s	550 Kc/s	1000 Kc/s	1500 Kc/s
1	1 100 000	1 580 000	2 920 000	3 460 000	6 280 000	9 430 000
.1	110 000	158 000	292 000	346 000	628 000	943 000
.01	11 000	15 800	29 200	34 600	62 800	94 300
1000 μH	1 100	1 580	2 920	3 460	6 280	9 430
200 μH	220	317	584	691	1 260	1 890
100 μH	110	158	292	346	628	943

(ii) Capacitive reactances

(Correct to three significant figures)

TABLE 42

AUDIO FREQUENCIES $X_C = 1/\omega C$

Capacitance Microfarads	Reactance in Ohms at :— 30 c/s	50 c/s	100 c/s	400 c/s	1000 c/s	5000 c/s
.00005	—	—	—	—	—	637 000
.0001	—	—	—	—	1 590 000	318 000
.00025	—	—	—	1 590 000	637 000	127 000
.0005	—	—	3 180 000	796 000	318 000	63 700
.001	—	3 180 000	1 590 000	398 000	159 000	31 800
.005	1 060 000	637 000	318 000	79 600	31 800	6 370
.01	531 000	318 000	159 000	39 800	15 900	3 180
.02	263 000	159 000	79 600	19 900	7 960	1 590
.05	106 000	63 700	31 800	7 960	3 180	637
.1	53 100	31 800	15 900	3 980	1 590	318
.25	21 200	12 700	6 370	1 590	637	127
.5	10 600	6 370	3 180	796	318	63.7
1	5 310	3 180	1 590	398	159	31.8
2	2 650	1 590	796	199	79.6	15.9
4	1 310	796	398	99.5	39.8	7.96
8	663	398	199	49.7	19.9	3.98
10	531	318	159	39.8	15.9	3.18
20	265	159	79.6	19.9	7.96	1.59
50	106	63.7	31.8	7.96	3.18	0.637

RADIO FREQUENCIES $X_C = 1/\omega C$

Capacitance Microfarads	Reactance in Ohms at :— 175 Kc/s	252 Kc/s	465 Kc/s	550 Kc/s	1000 Kc/s	1500 Kc/s
.00005	18 200	12 600	6 850	5 800	3 180	2 120
.0001	9 100	6 320	3 420	2 900	1 590	1 060
.00025	3 640	2 530	1 370	1 160	637	424
.0005	1 820	1 260	685	579	318	212
.001	910	632	342	290	159	106
.005	182	126	68.5	57.9	31.8	21.2
.01	91.0	63.2	34.2	28.9	15.9	10.6
.02	45.5	31.6	17.1	14.5	7.96	5.31
.05	18.2	12.6	6.85	4.79	3.18	2.12
.1	9.10	6.32	3.42	2.89	1.59	1.06
.25	3.64	2.53	1.37	1.16	.637	.424
.5	1.82	1.26	.685	.579	.318	.212
1	.910	.632	.342	.289	.159	.106
2	.455	.316	.171	.145	.0796	.0531
4	.227	.158	.0856	.0723	.0398	.0265

(Table 42—continued)

RADIO FREQUENCIES $X_C = 1/\omega C$

Capacitance $\mu\mu F$	Reactance in Ohms at :— 6 Mc/s	12 Mc/s	18 Mc/s	25 Mc/s	50 Mc/s	100 Mc/s
10	2650	1330	888	637	318	159
22	1206	603	402	290	145	72.4
47	565	282	188	135	67.7	33.9
100	265	133	88.8	63.7	31.8	15.9
220	120.6	60.3	40.2	29.0	14.5	7.24
470	56.5	28.2	18.8	13.5	6.77	3.39
1000	26.5	13.3	8.88	6.37	3.18	1.59
2200	12.06	6.03	4.02	2.90	1.45	0.724
4700	5.65	2.82	1.88	1.35	0.677	0.339
10 000	2.65	1.33	0.888	0.637	0.318	0.159

(iii) Impedance of reactance and resistance in parallel

Table 43 has been prepared to permit the finding of any one of the three quantities X, R or Z when the other two are given. When X and R are given, divide the larger of the two quantities into the smaller one and thus get a ratio less than 1. Find this ratio in the left column and multiply the number obtained in the second column by R or X whichever is the larger and find Z.

Suppose R equals 1000 ohms and X is 200 ohms, which makes $X/R = .20$. Table 43 shows us that Z/R is then 0.1961. Multiplying by R, we have $Z = 0.1961 \times 1000 = 196.1$ ohms.

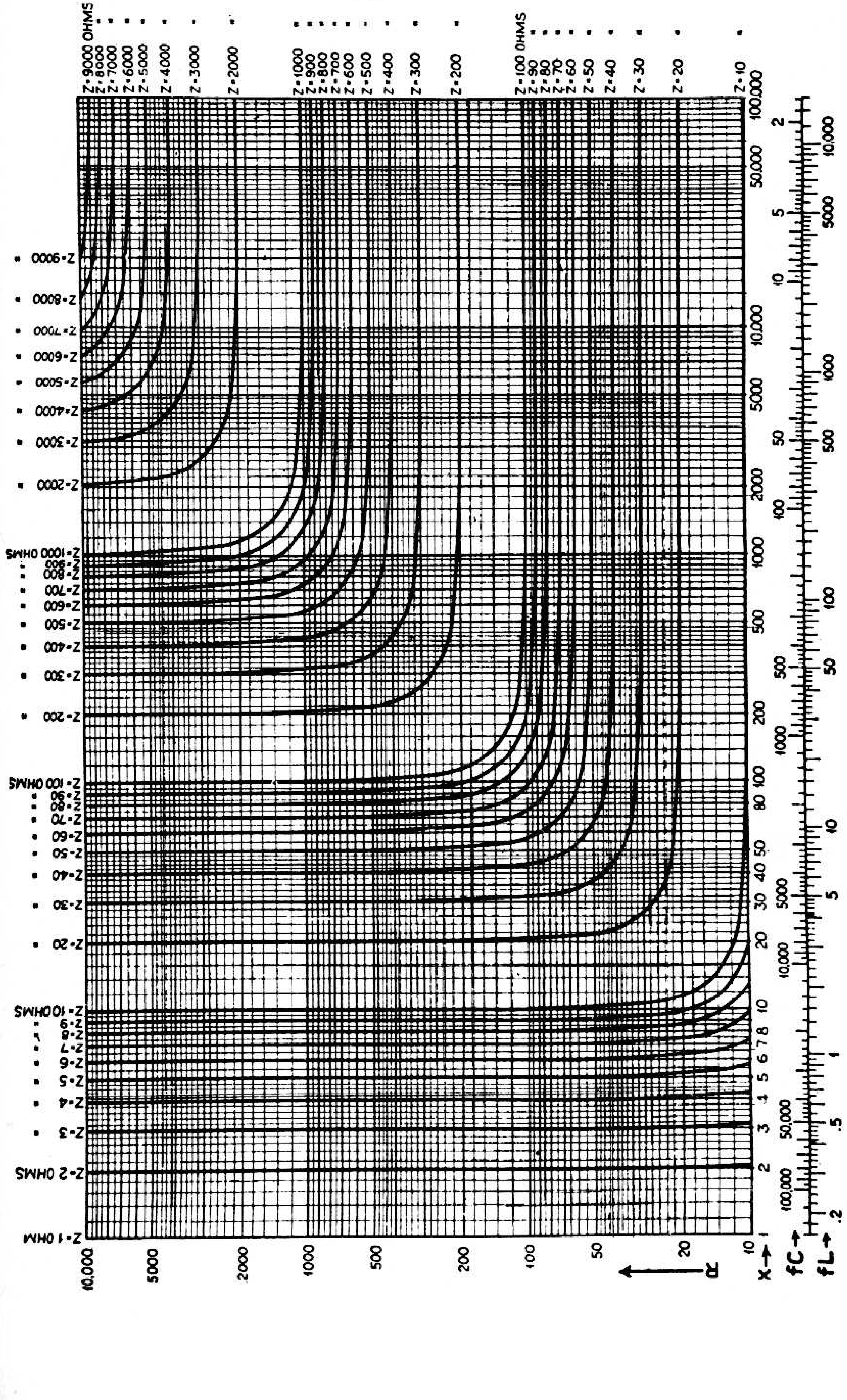
TABLE 43: REACTANCE AND RESISTANCE VALUES IN PARALLEL

X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X
0.10	0.0995	0.49	0.4400	0.88	0.6606
0.11	0.1093	0.50	0.4472	0.89	0.6648
0.12	0.1191	0.51	0.4543	0.90	0.6690
0.13	0.1289	0.52	0.4613	0.91	0.6730
0.14	0.1386	0.53	0.4683	0.92	0.6771
0.15	0.1483	0.54	0.4751	0.93	0.6810
0.16	0.1580	0.55	0.4819	0.94	0.6849
0.17	0.1676	0.56	0.4886	0.95	0.6888
0.18	0.1771	0.57	0.4952	0.96	0.6925
0.19	0.1867	0.58	0.5017	0.97	0.6963
0.20	0.1961	0.59	0.5082	0.98	0.6999
0.21	0.2055	0.60	0.5145	0.99	0.7036
0.22	0.2149	0.61	0.5208	1.00	0.7071
0.23	0.2242	0.62	0.5269	1.10	0.7400
0.24	0.2334	0.63	0.5330	1.20	0.7682
0.25	0.2425	0.64	0.5390	1.30	0.7926
0.26	0.2516	0.65	0.5450	1.40	0.8137
0.27	0.2607	0.66	0.5508	1.50	0.8320
0.28	0.2696	0.67	0.5566	1.60	0.8480
0.29	0.2785	0.68	0.5623	1.70	0.8619
0.30	0.2874	0.69	0.5679	1.80	0.8742
0.31	0.2961	0.70	0.5735	1.90	0.8850
0.32	0.3048	0.71	0.5789	2.00	0.8944
0.33	0.3134	0.72	0.5843	2.20	0.9104
0.34	0.3219	0.73	0.5895	2.40	0.9231
0.35	0.3304	0.74	0.5948	2.60	0.9333
0.36	0.3387	0.75	0.6000	2.80	0.9418
0.37	0.3470	0.76	0.6051	3.00	0.9487
0.38	0.3552	0.77	0.6101	3.20	0.9545
0.39	0.3634	0.78	0.6150	3.40	0.9594
0.40	0.3714	0.79	0.6199	3.60	0.9635
0.41	0.3793	0.80	0.6246	3.80	0.9671
0.42	0.3872	0.81	0.6289	4.00	0.9702
0.43	0.3950	0.82	0.6341	5.00	0.9807
0.44	0.4027	0.83	0.6387	6.00	0.9864
0.45	0.4103	0.84	0.6432	7.00	0.9902
0.46	0.4179	0.85	0.6477	8.00	0.9921
0.47	0.4254	0.86	0.6520	9.00	0.9939
0.48	0.4327	0.87	0.6564	10.00	0.9950

By means of Chart 38.1 it is possible to determine either the parallel impedance (Z), reactance (X) or resistance (R) knowing the other two values. Expressing the capacitance (C) in microfarads, the inductance (L) in henrys and the frequency (F) in cycles use the bottom scale and read directly on to the chart.

REACTANCE AND RESISTANCE IN PARALLEL

CHART 38.1



(iv) Impedance of reactance and resistance in series

To use Table 44, find the ratio R/X or X/R, refer to the table and find the corresponding ratio Z/X or Z/R. The table can also be used when Z is given together with one of the other quantities. It was for this reason that the table had to be extended for values of R/X or X/R from 0.1 to 1.0 since otherwise it would have been sufficient to include values from 1 upwards or downwards but not both. Example : suppose $X = 1600$ ohms and $R = 1000$ ohms. Then $X/R = 1.6$; the table shows $Z/R = 1.8868$. Then Z equals 1 8868 R or 1886.8 ohms.

TABLE 44 : REACTANCE AND RESISTANCE VALUES IN SERIES

X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X
0.10	1.0050	0.53	1.1318	0.96	1.3862
0.11	1.0060	0.54	1.1365	0.97	1.3932
0.12	1.0072	0.55	1.1413	0.98	1.4001
0.13	1.0084	0.56	1.1461	0.99	1.4071
0.14	1.0097	0.57	1.1510	1.00	1.4141
0.15	1 0112	0.58	1.1560	1.1	1.4866
0.16	1.0127	0.59	1.1611	1.2	1.5621
0.17	1.0144	0.60	1.1662	1.3	1.6401
0.18	1.0161	0.61	1.1714	1.4	1.7205
0.19	1.0179	0.62	1.1765	1.5	1.8028
0.20	1.0198	0.63	1.1819	1.6	1.8868
0.21	1.0218	0.64	1.1873	1.7	1.9723
0.22	1.0239	0.65	1.1927	1.8	2.0591
0.23	1.0261	0.66	1.1981	1.9	2.1471
0.24	1.0284	0.67	1.2037	2.0	2.2361
0.25	1.0308	0.68	1.2093	2.1	2.3259
0.26	1.0333	0.69	1.2149	2.2	2.4166
0.27	1.0358	0.70	1.2207	2.3	2.5080
0.28	1.0384	0.71	1.2264	2.4	2.6000
0.29	1.0412	0.72	1.2322	2.5	2.6926
0.30	1.0440	0.73	1.2381	2.6	2.7857
0.31	1.0469	0.74	1.2440	2.7	2.8792
0.32	1.0499	0.75	1.2500	2.8	2.9732
0.33	1.0530	0.76	1.2560	2.9	3.0676
0.34	1.0562	0.77	1.2621	3.0	3.1623
0.35	1.0595	0.78	1.2682	3.1	3.2573
0.36	1.0628	0.79	1.2744	3.2	3.3526
0.37	1.0662	0.80	1.2806	3.3	3.4482
0.38	1.0698	0.81	1.2869	3.4	3.5440
0.39	1.0733	0.82	1.2932	3.5	3.6400
0.40	1.0770	0.83	1.2996	3.6	3.7362
0.41	1.0808	0.84	1.3060	3.7	3.8327
0.42	1.0846	0.85	1.3125	3.8	3.9293
0.43	1.0885	0.86	1.3190	3.9	4.0262
0.44	1.0925	0.87	1.3255	4.0	4.1231
0.45	1.0966	0.88	1.3321	4.1	4.2202
0.46	1.1007	0.89	1.3387	4.2	4.3174
0.47	1.1049	0.90	1.3454	4.3	4.4147
0.48	1.1092	0.91	1.3521	4.4	4.5122
0.49	1.1136	0.92	1.3588	4.5	4.6098
0.50	1.1180	0.93	1.3656	4.6	4.7074
0.51	1.1225	0.94	1.3724	4.7	4.8052
0.52	1.1271	0.95	1.3793	4.8	4.9030

TABLE 44 (Continued)

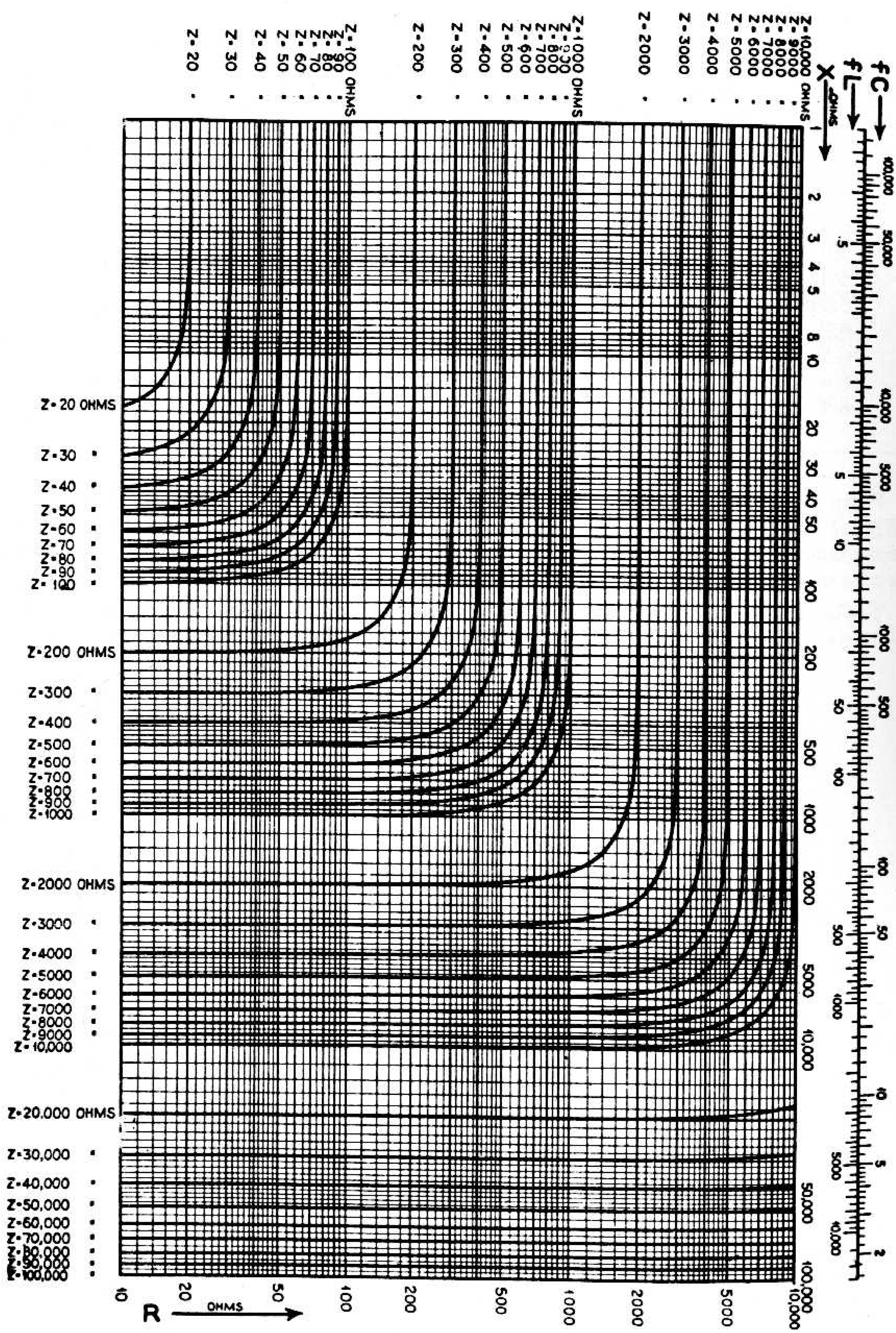
X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X	X/R or R/X	Z/R or Z/X
4.9	5.0009	6.6	6.6752	8.3	8.3600
5.0	5.0990	6.7	6.7741	8.4	8.4594
5.1	5.1971	6.8	6.8731	8.5	8.5580
5.2	5.2952	6.9	6.9720	8.6	8.6576
5.3	5.3935	7.0	7.0711	8.7	8.7572
5.4	5.4918	7.1	7.1701	8.8	8.8566
5.5	5.5901	7.2	7.2691	8.9	8.9560
5.6	5.6885	7.3	7.3681	9.0	9.0554
5.7	5.7871	7.4	7.4671	9.1	9.1548
5.8	5.8856	7.5	7.5662	9.2	9.2542
5.9	5.9841	7.6	7.6654	9.3	9.3536
6.0	6.0828	7.7	7.7646	9.4	9.4530
6.1	6.1814	7.8	7.8638	9.5	9.5524
6.2	6.2801	7.9	7.9630	9.6	9.6518
6.3	6.3789	8.0	8.0623	9.7	9.7512
6.4	6.4777	8.1	8.1615	9.8	9.8507
6.5	6.5764	8.2	8.2608	9.9	9.9503
				10.0	10.0499

From Chart 38.2 (page 1384) it is possible to determine either the series impedance (Z), reactance (X) or resistance (R) knowing the other two values. Expressing the capacitance (C) in microfarads, the inductance (L) in henrys and the frequency (f) in c/s, use the top scale and read directly on to the chart.

Tables 43, 44 and charts 38.1, 38.2 are reprinted from the Aerovox Research Worker 11, Nos. 1 and 2 (Jan. and Feb. 1939) by courtesy of the Aerovox Corporation.

CHART 38.2

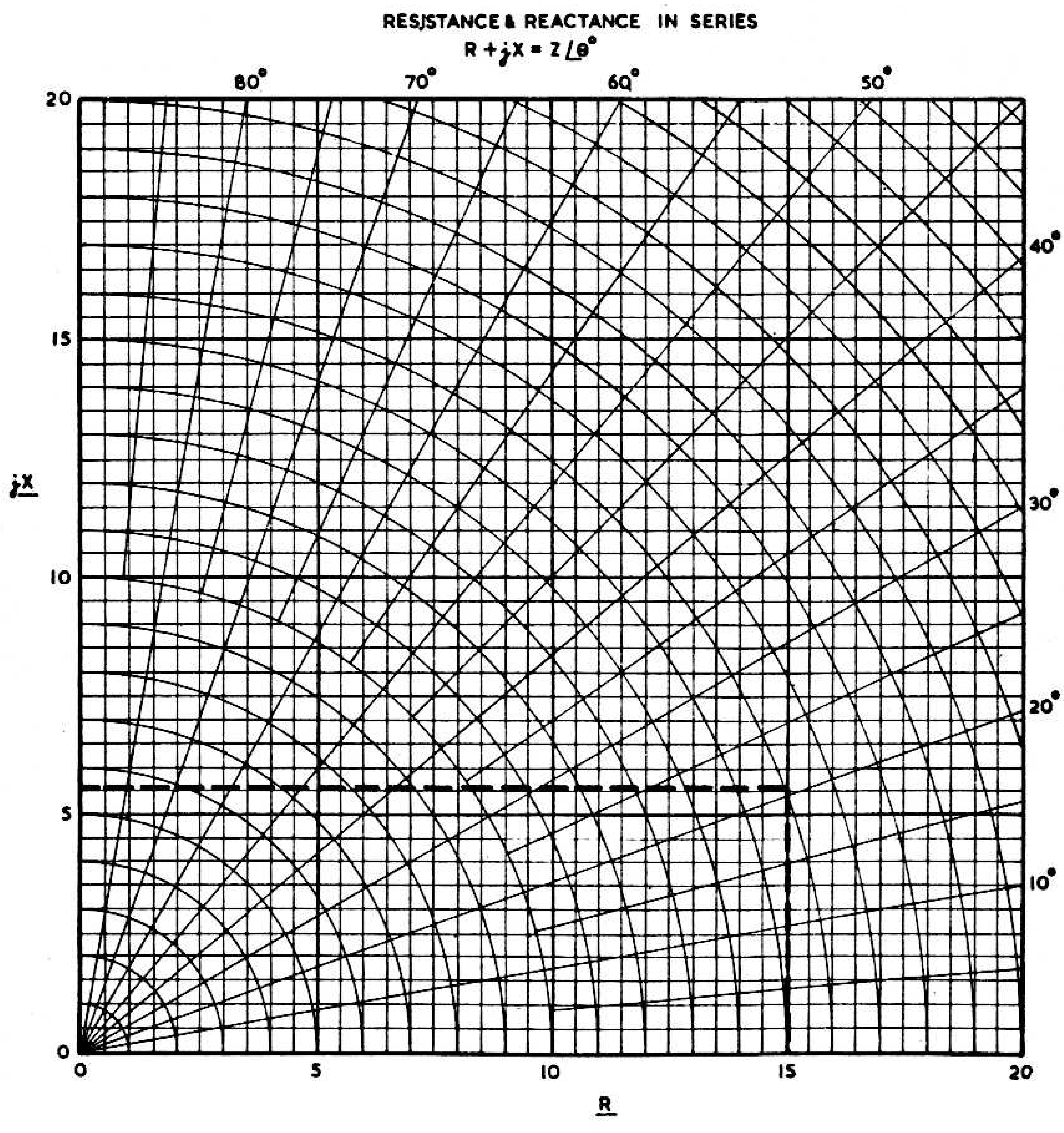
REACTANCE AND RESISTANCE IN SERIES



Resistance and reactance in series—Alternative method

Chart 38.3 assists in the evaluation of the impedance Z and its phase angle θ when the values of resistance R and reactance X are known. Firstly read R along the horizontal scale, then read upwards to the value of jX; the magnitude of Z is given by the radius which may be read by running the eye down the arc to the horizontal axis. The angle of Z is given directly by the angle at the point of intersection. For example, $R = 15$ ohms in series with $jX = 5.6$ ohms gives $R + jX = 16$ ohms, $\angle 20°$ (approx.). When any value of R or X is greater than the limits on the chart, both scales should be multiplied by the same factor. For example, $R = 150$ ohms in series with $jX = 56$ ohms gives $R + jX = 160$ ohms, $\angle 20°$. Negative reactances may be treated as positive when using the chart, but the angle of Z will then be negative.

CHART 38.3



(v) Resonance

(A) Resonance frequency table (audio frequencies)

TABLE 45 : RESONANCE FREQUENCY C/S

$C(\mu F)$	50	100	200	400	1000	2000	5000	10 000
1	10.1	2.53	633	158	25.3	6.33	1.01	0.253
0.5	20.3	5.07	1.27	317	50.7	12.7	2.03	0.507
0.25	40.5	10.1	2.53	633	101	25.3	4.05	1.01
0.1	101	25.3	6.33	1.58	253	63.3	10.1	2.53
0.05	203	50.7	12.7	3.17	507	127	20.3	5.07
0.02	507	127	31.7	7.91	1.27	317	50.7	12.7
0.01	1010	253	63.3	15.8	2.53	633	101	25.3
0.005	2030	507	127	31.7	5.07	1.27	203	50.7
0.002	5070	1270	317	79.1	12.7	3.17	507	127
0.001	10 100	2530	633	158	25.3	6.33	1.01	253

Inductance values above the stepped line are in millihenrys and those below in henrys.

(B) R-F solenoid design chart

Chart 38.4 enables the radio engineer to determine the approximate number of turns on a solenoid of specified diameter and length, to resonate at a specified frequency with a specified capacitance. (Chart by P. G. Sulzer in Tele-Tech, May 1951, p. 45 and reproduced by kind permission).

The following example will indicate the method :

It is desired to design a coil for a harmonic generator which is to operate at a frequency of 10 Mc/s with a total capacitance of 50 $\mu\mu$F. Drawing a straight line between 10 Mc/s on the f scale and 50 $\mu\mu$F on the C scale, the inductance L is found to be approximately 5 μH. This value need not be recorded unless it is required for some other purpose. Assuming that the winding is to be one inch in diameter by two inches long, the intersection of the appropriate lines is found in the graph at the right-hand side of the chart. This intersection is projected horizontally to the left as shown, and then a straight line is drawn to the 5 μH point on the L scale. The result is found to be 22 turns, as indicated on the n scale.

(vi) Approximations in the calculation of impedance for reactance and resistance in series and parallel

When a resistance and a reactance are in series, and the reactance is numerically smaller than the resistance, the value of the resistance may be taken as being an approximation to the impedance, with the errors indicated below :

R/X =	1	2	3	4	5	7	10
error =	29%	11%	5%	3%	2%	1%	0.5%

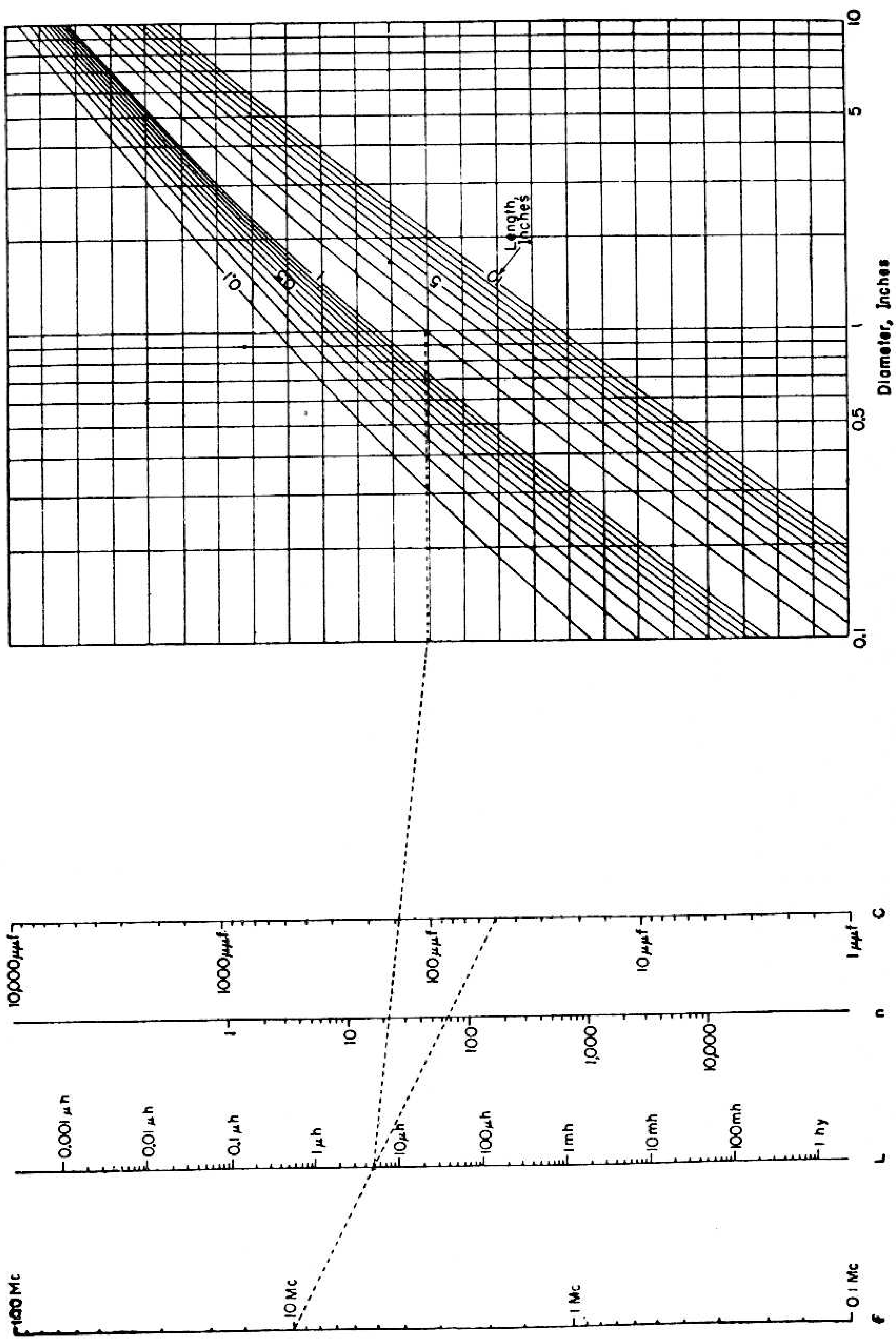
When a resistance and a reactance are in parallel, and the reactance is numerically larger than the resistance, the value of the resistance may be taken as being an approximation to the impedance, with the errors indicated below :

X/R =	1	2	3	4	5	7	10
error =	41%	12%	5.5%	3%	2%	1%	0.5%

(vii) Reactance chart

A very complete form of reactance chart, including reactance, frequency, inductance, capacitance, susceptance, wavelength and time constant, is given by H. A. Wheeler " Reactance Chart " Proc. I.R.E. 38.12 (Dec. 1950) 1392.

CHART 38.4: R-F SOLENOID DESIGN CHART—*see page* 1386.



SECTION 10 : SCREW THREADS, TWIST DRILLS AND SHEET GAUGES

(*i*) *Standard American screws used in radio manufacture* (*ii*) *B.A. screw threads* (*iii*) *Whitworth screw threads* (*iv*) *Unified screw threads* (*v*) *Drill sizes for self-tapping screws* (*vi*) *Wood screws* (*vii*) *Twist drill sizes* (*viii*) *Sheet steel gauges.*

(i) Standard American screws used in radio manufacture

(American Standard B1.1—1935 ; coarse thread).

TABLE 46

Size of screw and T.P.I.	Outside dia. in inches	Pitch dia. in inches	Root dia. in inches	Tap drill steel	Tap drill cast iron	Clearance drill
2-56	.0860	.0744	.0628	No. 49 (.0730)	No. 49 (.0730)	No. 43 (.0890)
3-48	.0990	.0855	.0719	No. 44 (.0860)	No. 44 (.0860)	No. 39 (.0995)
4-40	.1120	.0958	.0795	No. 42 (.0935)	No. 43 (.0890)	No. 33 (.1130)
5-40	.1250	.1088	.0925	No. 34 (.1110)	No. 35 (.1110)	No. 30 (.1285)
6-32	.1380	.1177	.0974	No. 32 (.1160)	No. 33 (.1130)	No. 28 (.1405)
8-32	.1640	.1437	.1234	No. 27 (.1440)	No. 28 (.1405)	No. 19 (.1660)
10-24	.1900	.1629	.1359	No. 21 (.1590)	No. 22 (1.570)	No. 11 (.1910)
10-32*	.1900	.1697	.1494	No. 19 (.1660)	No. 20 (.1610)	No. 11 (.1910)
12-24	.2160	.1889	.1619	No. 16 (.1770)	No. 17 (.1730)	No. 2 (.2210)
¼-20	.2500	.2175	.1850	No. 7 (.2010)	No. 8 (.1990)	¼ in.

*Fine thread.

(ii) B.A. screw threads

TABLE 47

Dimensions given are only approximate

B.A. No.	Outside dia.	Core dia.	Turns per in.	Clearing drill	Tapping drill
0	.236	.189	25.4	¼ in. or " B "	10-12
1	.209	.166	28.3	2-3	18-19
2	.185	.147	31.4	10-11	25-26
3	.161	.127	34.8	18-19	30-31
4	.142	.111	38.5	26-27	33-34
5	.126	.098	43.1	29-30	39-40
6	.110	.085	47.9	32-33	44
7	.098	.076	52.9	38-39	48
8	.087	.066	59.2	42-43	51
9	.075	.056	65.1	46-47	53
10	.067	.050	72.5	49-50	55

(iii) Whitworth screw threads

TABLE 48

Outside dia.	Core dia.	Threads per inch	Tapping drill
1/8 in.	.093 in.	40	41
3/16 in.	.134	24	9/64 in.
1/4 in.	.186	20	12
5/16 in.	.241	18	1/4 in.
3/8 in.	.295	16	5/16 in.
1/2 in.	.393	12	13/32 in.
5/8 in.	.509	11	17/32 in.
3/4 in.	.622	10	5/8 in.
1 in.	.840	8	27/32 in.

(iv) Unified screw threads

Provisional British Standard B.S. 1580 : 1949.

American Standard A.S.A. B1.1—1949.

TABLE 49

Designation	Pitch	Turns	Major diameter	Effective diameter*	Minor diameter	
			Nut and bolt	Nut and bolt	Nut (design size)†	Bolt
Coarse Thread	in.	per in.	in.	in.	in.	in.
1/4-20.UNC	0.05000	20	0.2500	0.2175	0.1959	0.1887
5/16-18.UNC	0.05556	18	0.3125	0.2764	0.2524	0.2443
3/8-16.UNC	0.06250	16	0.3750	0.3344	0.3073	0.2983
7/16-14.UNC	0.07143	14	0.4375	0.3911	0.3602	0.3499
1/2-12.UNC	0.08333	12	0.5000	0.4459	0.4098	0.3978
9/16-12.UNC	0.08333	12	0.5625	0.5084	0.4723	0.4603
5/8-11.UNC	0.09091	11	0.6250	0.5660	0.5266	0.5135
3/4-10.UNC	0.10000	10	0.7500	0.6850	0.6417	0.6273
7/8-9.UNC	0.11111	9	0.8750	0.8028	0.7547	0.7387
1-8.UNC	0.12500	8	1.0000	0.9188	0.8647	0.8466
Fine Thread						
1/4-28.UNF	0.03571	28	0.2500	0.2268	0.2113	0.2062
5/16-24.UNF	0.04167	24	0.3125	0.2854	0.2674	0.2614
3/8-24.UNF	0.04167	24	0.3750	0.3479	0.3299	0.3239
7/16-20.UNF	0.05000	20	0.4375	0.4050	0.3834	0.3762
1/2-20.UNF	0 05000	20	0.5000	0.4675	0.4459	0.4387
9/16-18.UNF	0.05556	18	0.5625	0.5264	0.5024	0.4943
5/8-18.UNF	0.05556	18	0.6250	0.5889	0.5649	0.5568
3/4-16.UNF	0.06250	16	0.7500	0.7094	0.6823	0.6733
7/8-14.UNF	0.07143	14	0.8750	0.8286	0.7977	0.7874
1-12.UNF	0.08333	12	1.0000	0.9459	0.9098	0.8978

*American : Pitch diameter.

†Corresponds to a flat of $p/4$ where p = pitch.

Note : The final decimal point is subject to slight modification when the British Standard has been approved.

(v) Drill sizes for self-tapping screws

TABLE 50

Screw No.	Metal thickness* mils	Drill size	Screw No.	Metal thickness* mils	Drill size
2	16	52	4	50	41
2	20	52	4	62	39
2	25	51	4	78	38
2	31	50	6	16	37
2	39	49	6	20	37
2	50	49	6	25	36
2	62	48	6	31	36
4	16	44	6	39	35
4	20	44	6	50	34
4	25	43	6	62	32
4	31	42	6	78	31
4	39	42	6	99	30

*For steel or brass. Use a somewhat smaller hole for softer metals.

(vi) Wood screws

TABLE 51

No.	American National Standard		British Practice	
	shank dia. in.	clearance drill No.	shank dia. in.	clearance drill No.
0	0.060	50	0.063	52
1	.073	49	.066	51
2	.086	44	.080	46
3	.099	39	.094	41
4	.112	33	.108	35
5	.125	30	.122	30
6	.138	28	.136	28
7	.151	24	.150	23
8	.164	19	.164	18
9	.177	16	.178	14
10	.190	11	.192	9
11	.203	6	.206	4
12	.216	2	.220	1
14	.242	E	.248	E
16	.268	I	.276	K

(vii) Twist drill sizes

TABLE 52

Number drills

Drill No.	Dia. Inch	Drill No.	Dia. Inch	Drill No.	Dia. Inch
1	.2280	28	.1405	55	.0520
2	.2210	29	.1360	56	.0465
3	.2130	30	.1285	57	.0430
4	.2090	31	.1200	58	.0420
5	.2055	32	.1160	59	.0410
6	.2040	33	.1130	60	.0400
7	.2010	34	.1110	61	.0390
8	.1990	35	.1100	62	.0380
9	.1960	36	.1065	63	.0370
10	.1935	37	.1040	64	.0360
11	.1910	38	.1015	65	.0350
12	.1890	39	.0995	66	.0330
13	.1850	40	.0980	67	.0320
14	.1820	41	.0960	68	.0310
15	.1800	42	.0935	69	.0292
16	.1770	43	.0890	70	.0280
17	.1730	44	.0860	71	.0260
18	.1695	45	.0820	72	.0250
19	.1660	46	.0810	73	.0240
20	.1610	47	.0785	74	.0225
21	.1590	48	.0760	75	.0210
22	.1570	49	.0730	76	.0200
23	.1540	50	.0700	77	.0180
24	.1520	51	.0670	78	.0160
25	.1495	52	.0635	79	.0145
26	.1470	53	.0595	80	.0135
27	.1440	54	.0550		

Letter drills

Letter	Dia. Inch	Letter	Dia. Inch	Letter	Dia. Inch
A	0.2340	J	0.2770	S	0.3480
B	0.2380	K	0.2810	T	0.3580
C	0.2420	L	0.2900	U	0.3680
D	0.2460	M	0.2950	V	0.3770
E	0.2500	N	0.3020	W	0.3860
F	0.2570	O	0.3160	X	0.3970
G	0.2610	P	0.3230	Y	0.4040
H	0.2660	Q	0.3320	Z	0.4130
I	0.2720	R	0.3390		

(viii) Sheet metal gauges

TABLE 53 : Thickness and weight per square foot

Gauge	Birmingham Gauge (B.G.)		American Manufacturers Standard Gauge* for sheet steel		B & S (American) for non-ferrous sheet			
	inch	steel lb/ft²	inch	lb/ft²	inch	lb per square foot copper	brass	aluminium
10	.1250	5.100	.1345	5.625	.1019	4.71	4.51	1.44
11	.1113	4.541	.1196	5.000	.0907	4.19	4.02	1.28
12	.0991	4.043	.1046	4.375	.0808	3.74	3.58	1.14
13	.0882	3.599	.0897	3.750	.0720	3.33	3.19	1.01
14	.0785	3.203	.0747	3.125	.0641	2.96	2.84	.903
15	.0699	2.852	.0673	2.8125	.0571	2.64	2.53	.804
16	.0625	2.550	.0598	2.500	.0508	2.35	2.25	.716
17	.0556	2.268	.0538	2.250	.0453	2.10	2.01	.638
18	.0495	2.020	.0478	2.000	.0403	1.86	1.78	.568
19	.0440	1.795	.0418	1.750	.0359	1.66	1.59	.506
20	.0392	1.599	.0359	1.500	.0320	1.48	1.42	.450
21	.0349	1.424	.0329	1.375	.0285	1.32	1.26	.401
22	.03125	1.275	.0299	1.250	.0253	1.17	1.12	.357
23	.02782	1.134	.0269	1.125	.0226	1.05	1.00	.318
24	.02476	1.010	.0239	1.000	.0201	.931	.890	.283
25	.02204	0.898	.0209	.8750	.0179	.829	.793	.252
26	.01961	0.800	.0179	.7500	.0159	.738	.706	.225
27	.01745	0.712	.0164	.6875	.0142	.657	.628	.200
28	.015625	0.636	.0149	.6250	.0126	.589	.560	.178
29	.0139	0.567	.0135	.5625	.0113	.521	.499	.159
30	.0123	0.502	.0120	.5000	.0100	.464	.444	.141
31	.0110	0.449	.0105	.4375	.00893	.413	.395	.126
32	.0098	0.400	.0097	.40625	.00795	.368	.353	.112
33	—	—	.0090	.3750	.00708	.328	.314	.100
34	—	—	.0082	.34375	.00635	.292	.279	.089
35	—	—	.0075	.3125	.00562	.260	.249	.079

*Based on 41.820 lb. per sq. foot per inch thick ; variations in thickness are to be expected. Other gauges are based directly on thickness ; variations in weight per square inch are to be expected.

American Standard Preferred Thicknesses for uncoated thin flat metals (ASA. B32.1—1941).

This series of thickness is given in inches.

TABLE 54

	0.180	0.090	0.045	0.022	0.011	
	0.160	0.080	0.040	0.020	0.010	0.005
	0.140	0.071	0.036	0.018	0.009	
	0.125	0.063	0.032	0.016	0.008	0.004
0.224	0.112	0.056	0.028	0.014	0.007	
0.200	0.100	0.050	0.025	0.012	0.006	

SECTION 11: TEMPERATURE RISE AND RATINGS

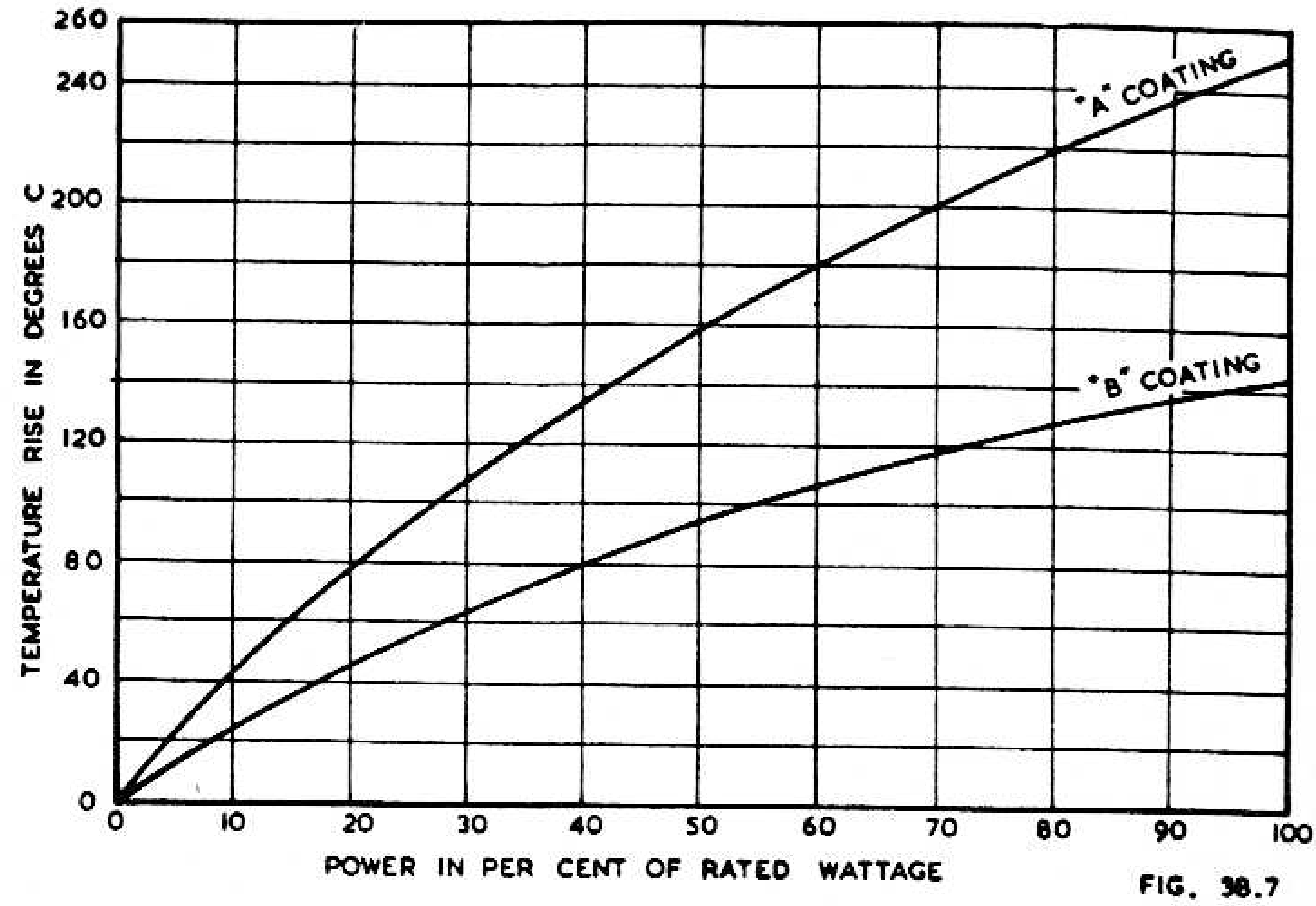


FIG. 38.7

Fig. 38.7. Curves of temperature rise of power wire-wound resistors in free air. The temperature is considerably affected by the radiating properties of the coating. Type A coating refers to a vitreous enamel which is used for "tropic proofed" application and type B coating refers to an organic cement coating.

TABLE 55: SIZES OF WIRES FUSED BY ELECTRIC CURRENTS

Fusing Current (Amperes)	Copper $a = 10\,244$ Dia. Inch	Copper S.W.G. Approx.	Aluminium $a = 7585$ Dia. inch	Aluminium S.W.G. Approx.	German Silver $a = 5230$ Dia. inch	German Silver S.W.G. Approx.	Tin $a = 1642$ Dia. inch	Tin S.W.G. Approx.	Tin-Lead Alloy $a = 1318$ Dia. inch	Tin-Lead Alloy S.W.G. Approx.	Lead $a = 1379$ Dia. inch	Lead S.W.G. Approx.
1	.0021	47	.0026	46	.0033	44	.0072	37	.0083	35	.0081	35
2	.0034	43	.0041	42	.0053	39	.0113	31	.0132	29	.0128	30
3	.0044	41	.0054	39	.0069	37	.0149	28	.0173	27	.0168	27
4	.0053	39	.0065	37	.0084	35	.0181	26	.0210	25	.0203	25
5	.0062	38	.0076	36	.0097	33	.0210	25	.0243	23	.0236	23
10	.0098	33	.0120	30	.0154	28	.0334	21	.0386	19	.0375	20
20	.0156	28	.0191	25	.0245	23	.0529	17	.0613	16	.0595	17
30	.0205	25	.0250	20	.0320	21	.0694	15	.0803	14	.0779	14

SECTION 12: FUSES

The fusing current of wire depends largely upon external conditions such as atmospheric temperature, method of mounting, proximity of other objects, and time of operation. For sizes up to about 25 amps, a simple construction may be used with metals such as aluminium or special alloys which produce a minimum vapour on fusing.

Copper wire, operated near the fusing current, is particularly subject to corrosion and should therefore be coated with a metal—such as tin—which does not oxidise so readily.

Table 55 applies only to conditions with the wire freely suspended in air. The maximum safe working current may be taken as approximately 67% of the fusing current under the same conditions.

Fuses designed for intermediate values of current may be calculated from the formula

$$\text{diameter} = \left(\frac{\text{current}}{a}\right)^{2/3}$$

where a is the factor given in Table 55.

See Chapter 35 Sect. 9(iv) for fuses in radio receivers.

SECTION 13 : CHARACTERISTICS OF LIGHT ; PANEL LAMPS

(i) Visibility curves of human eye, and relative spectral energy curves of sunlight and tungsten lamp (ii) Velocity of light (iii) American panel lamp characteristics.

(i) Visibility curves of human eye, and relative spectral energy curves of sunlight and tungsten lamp (Fig. 38.8)

The wavelength of light is measured in Angstrom†Units (A°). One Angstrom Unit is equal to 1/10 000 of a micron, that is 1/10 of a milli-micron. A micron is 1/1 000 000 (10^{-6}) of a metre.

The wavelengths visible to the human eye extend from about 4000 to 7000 A°. Beyond these extends the region of " invisible light " which, although invisible to the human eye, may be detected by the photo-tube or other means.

The eye, when accustomed to high light intensity, is most sensitive to a wavelength of 5550 A°, in the green-yellow region. The relative visibility curve for these conditions is Curve A, which is taken after H. E. Ives*. As the light intensity is reduced, the wavelength at which the eye is most sensitive decreases until at very low intensity it is approximately as shown in Curve B.

Different light sources have different spectral energy curves. The curve for sunlight (Curve C is for sunlight at the earth's surface at a zenith distance of 25°) is more nearly constant over the range of visible light than that for a tungsten lamp (Curve D is for a 1000 watt gasfilled tungsten lamp, 20 lumens per watt). The relative positions of curves C and D are quite arbitrary.

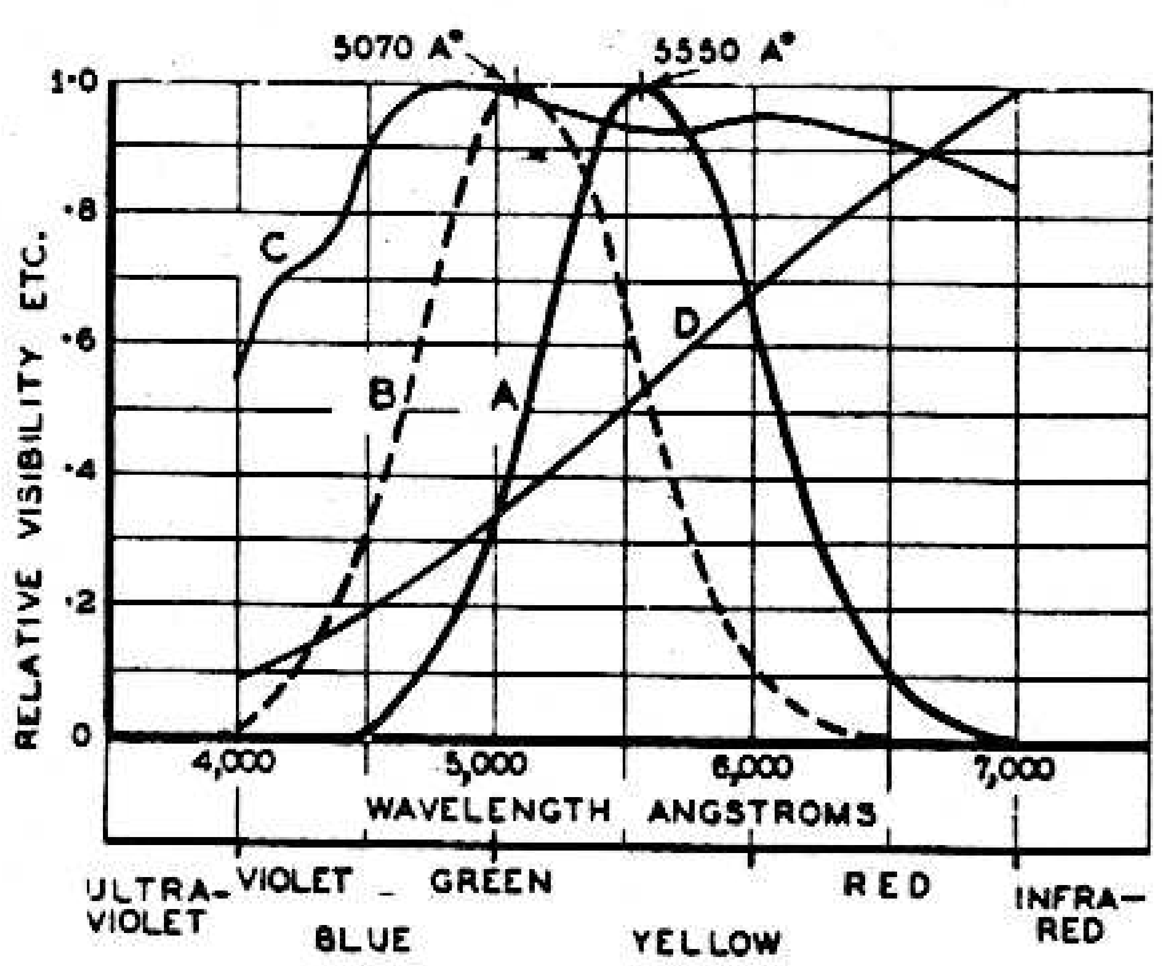


FIG. 38. 8

Fig. 38.8. *Relative visibility curves, etc. (for description see text).*

(ii) Velocity of light

Velocity of light in a vacuum $= 2.9979 \times 10^8$ metres/sec.

$\approx 3 \times 10^8$ metres/sec.

See Editorial, W.E. 28.331 (April 1951) 99.

Also Electronic Eng. (Dec. 1950) 524.

Photometric units—see page 1334.

See also page 1376 (vii) Chemical and Physical Constants.

*See R. A. Houston, " Vision and Colour Vision," Longmans Green and Co. (1932) Chapter 5.

†The name Angstrom is Swedish, pronounced "ongstrem."

(iii) American panel lamp characteristics

(RTMA Standard REC-137, October 1951).

TABLE 56 : AMERICAN STANDARD PANEL LAMPS

Trade Number	Circuit Volts	Design Volts	Amperes or Watts	Approx. C.P.	Life*	Bulb	Base
40	6.3	6.3	0.15A	$\frac{1}{2}$	3000	T-3$\frac{1}{4}$	(A)
41	2.5	2.5	0.50A	$\frac{1}{2}$	3000	T-3$\frac{1}{4}$	(A)
44	6.3	6.3	0.25A	$\frac{3}{4}$	3000	T-3$\frac{1}{4}$	(B)
46	6.3	6.3	0.25A	$\frac{3}{4}$	3000	T-3$\frac{1}{4}$	(A)
49	2	2	0.06A	—	1000	T-3$\frac{1}{4}$	(B)
48	2	2	0.06A	—	1000	T-3$\frac{1}{4}$	(A)
47	6.3	6.3	0.15A	$\frac{1}{2}$	3000	T-3$\frac{1}{4}$	(B)
—	115-125	120	10W	3	3000+	C7	(C)

A. Miniature screw base. B. Miniature bayonet base, single contact. C. Candelabra bayonet base, double contact.

SECTION 14 : GREEK ALPHABET

TABLE 57 : GREEK ALPHABET

Name	Large	Small	English Equivalent
alpha	A	α	a
beta	B	β	b
gamma	Γ	γ	g
delta	Δ	δ	d
epsilon	E	ϵ	e (short e as in " met ")
zeta	Z	ζ	z
eta	H	η	e (long e as in " meet ")
theta	Θ	θ	th
iota	I	ι	i
kappa	K	$\varkappa$	k
lambda	Λ	λ	l
mu	M	μ	m
nu	N	ν	n
xi	Ξ	ξ	x
omicron	O	o	o (as in " olive ")
pi	Π	π	p
rho	P	ρ	r
sigma	Σ	σ	s
tau	T	τ	t
upsilon	Y	υ	u
phi	Φ	φ	ph
chi	X	χ	ch (as in " school ")
psi	Ψ	ψ	ps
omega	Ω	ω	o (as in " hole ")

* Rated average laboratory life expectancy in hours at design volts.

SECTION 15 : DEFINITIONS

Most words which need explanation are explained or defined in the text and a reference is given in the index. The definitions below are supplementary and not inclusive.

See also other references at end of definitions (pp. 1403-1404).

A

A-battery Battery for supplying power to the valve filaments. (English name L.T. battery).
Absolute value Refers to magnitude without regard to direction or sign. Designated $|A|$.
A.C./D.C. receiver One which operates from either power source.
Acoustical feedback The operation of a microphone by the return to it of sound waves from the loudspeaker in the same sound system, reinforcing the input. It can cause sustained oscillation, or howling. A similar effect can occur from a microphonic valve.
Air-core Having no iron in its magnetic circuit.
Algebraic sum The sum of two or more quantities paying due regard to the positive or negative sign before each quantity.
Alternating current (or voltage) One that alternates regularly in direction, which is periodic and has an average value (over a period) of zero.
Ambient temperature The temperature of the air at a particular point, usually as indicated by a thermometer.
Amplification Increase in signal voltage (or power).
Angular velocity of a rotating body is the angle through which any radius turns in one second, generally expressed in radians per second.
Anode Positive electrode or plate.
Antinode A point on a stationary wave system which has a maximum amplitude.
Asymmetrical Having different characteristics for conduction in the two directions.
Attenuation Decrease in signal voltage or power.
Audio frequency A frequency within the range of frequencies audible to the normal human ear (say 25-16 000 c/s).
Axial leads Leads from the ends of resistors, capacitors, etc.

B

B-battery The battery which supplies power to the plate and screen circuits. (English name is H.T. battery).
B-supply A plate and screen voltage source for a receiver and amplifier.
Band Frequencies between a specific upper and lower limit.
Band-pass Passing a specific band of frequencies only.
Bandspread A means for spreading the coverage, on the dial, of a band of frequencies.
Bass Low audio frequencies.
Bass boost To boost the amplification at bass frequencies relatively to that at higher frequencies.
Beating A periodic variation in the amplitude of an oscillation (or sound) which is the resultant of two or more oscillations (or sounds) of different frequencies.
Bias Voltage applied to the grid to obtain the desired operating point.
Bleeder resistor Resistor connected across a voltage source to provide an additional load. The term is sometimes applied to a voltage divider carrying a relatively heavy current to provide good regulation.
Blocking Cutting off the plate current by a high negative bias on the grid. For Grid Blocking see page 21.

Bogie Each individual characteristic in the manufacturing specification is normally prescribed as a bogie value with plus and minus tolerances. The bogie value of a characteristic is the exact value specified for that characteristic by the valve manufacturing specifications.

Bucking Two forces opposing one another.

By-pass condenser One which allows alternating current to by-pass part of a circuit.

C

C-battery Battery which supplies voltage to the grid. Also known as bias battery.

Capacitor Condenser.

Carrier frequency The frequency of a component of a modulated wave which is the same as that of the wave before modulation is applied.

Carrier wave The unmodulated wave radiated by a broadcast station.

Cascade In an amplifier, when the output of one valve is used to control the grid circuit of another valve, the valves are said to be in cascade.

Cathode Negative electrode.

Cathode current The total electronic current passing through the cathode.

Channel The assigned band of frequencies within which a broadcast station is expected to keep its modulated carrier.

Choke coil Inductance.

Co-axial Having a common axis.

Compliance The ratio of the displacement of a body to the force applied. The inverse of stiffness.

Condenser Capacitor. See Chapter 4.

Consonance The agreeable effect produced by certain intervals (in music).

Constant A quantity which retains its fixed value under all conditions.

Converter The stage in a receiver which converts the frequency from radio frequency to intermediate frequency.

Co-planar In the same plane.

Core The centre of a coil.

Cross modulation The modulation of the carrier of the desired signal by an undesired signal.

Cut-off frequency The frequency beyond which the attenuation increases rapidly.

Cycle A cycle is one complete series of values of a periodic quantity. These values repeat themselves at regular intervals.

D

Delay Time delay is when an interval of time occurs between cause and effect. Voltage delay, as in an a.v.c. system, is when a specified voltage has to be developed before there is any effect.

Demodulation A process by which the carrier frequency is removed, and the modulating frequencies retained.

Denominator The part of a fraction below the fraction bar.

Detection Demodulation by means of an asymmetrical conducting device.

Dissipation Loss of electrical energy.

Dissonance The disagreeable effect produced by certain intervals (in music).

Dividend Number to be divided by divisor.

Divisor Number by which the dividend is to be divided.

Drain To take current from a voltage source.

Driver A power amplifier stage which drives a Class B or other following stage requiring input power.

Dynamic (1) Having a moving coil in a magnetic field.
(2) When applied to a valve with signal voltage on the grid, usually with plate load in circuit.
(3) "Dynamic characteristic" is the mutual characteristic when a (usually resistive) load is in the plate circuit.

E

Effective current The value of alternating or varying current which produces the same heating effect as the same value of direct current. It is the same as r.m.s. current.

Efficiency The ratio or percentage of output to input.

Electromotive force That force which tends to cause an electric current to flow in a circuit. The practical unit is the volt.

Empirical Obtained from experimental data.

Envelope The envelope of a periodic wave is obtained by passing one smooth curve through the maximum, another through the minimum, points or peaks of the wave.

Equation A mathematical equation is a statement that the terms to the left of the equal sign are equal to those on the right.

Equivalent circuit A relatively simple circuit which may be used in calculations as having the same effect as the actual circuit.

Excitation A signal voltage applied to the control electrode of a valve.

Exponential curve The same as a logarithmic curve. See Chapter 6 Sect. 2(xvii) for exponential functions.

Expression A mathematical expression is a combination of terms giving the value of some quantity.

F

Factor Any of the numbers whose product equals the given number.

Factorial n Is the multiple product $n(n - 1)(n - 2) \ldots . 3 \times 2 \times 1$.

First detector The same as Converter.

Frequency The number of cycles per second ; the reciprocal of the period.

Frequency changer The same as Converter.

Function A function is a quantity whose value depends on the value of a variable quantity.

Fundamental frequency The lowest frequency of a number of harmonically related frequencies.

G

Generator A device which develops electrical voltage either direct or alternating at any frequency.

Gramophone Also known as a Phonograph.

Ground Earth, or conductor serving as the earth.

H

Hard valve A valve which has reverse grid current less than the specified maximum for its type.

Harmonic frequency A frequency which is a multiple of the fundamental frequency. Twice fundamental frequency is called the second harmonic, etc.

Hertz Cycles per second.

High level A relative term indicating the level of the final stages of an amplifier.

High-pass filter A filter which passes all frequencies above a critical value.

Honeycomb winding A coil winding in which spaces are left between turns so as to give the appearance of a honeycomb.

Hunting (of a rotary machine) An oscillation of angular velocity about a state of uniform rotation.

I

Integer A whole number, having no fraction or decimal portion

Intensity The strength of a quantity such as current, voltage or pressure.

Intermediate frequency A frequency to which the incoming signal is changed in superheterodyne reception.

Intermodulation The modulation of the components of a complex wave by each other, in a non-linear system.

L

Layer winding A coil winding in which one layer is wound over another.

Lead A connecting wire.

Linear Having an input versus output characteristic which, when plotted on ordinary graph paper, is a straight line. A distortionless amplifier is linear, because its amplification is constant for all values of input voltage.

Linear reflex detector (also called infinite input impedance detector) An anode-bend detector having its negative bias supplied from a high resistance cathode bias resistor which is by-passed for radio frequencies only.

Line voltage The voltage of the power lines. Mains voltage.

Load Any device which absorbs electrical power.

Locus The path followed by a moving point.

Loudness A subjective evaluation which is primarily a function of intensity but is strongly influenced by frequency.

Low level A relative term indicating the level of the early stages of an amplifier (e.g. pre-amplifier).

Low-pass filter A filter which passes all frequencies below a critical value.

M

Manual Adjusted by hand.

Maximum signal Usually applied to the conditions under which the amplifier just reaches the point of " maximum undistorted power output."

Maximum undistorted power output The maximum power output for a specified distortion.

Microphonic A valve or other component which amplifies sound waves or vibration sufficiently to produce a loud sound or continuous howl in the loudspeaker.

Mirror image One curve is a mirror image of another when the first one, seen through a mirror, is identical with the second.

Mixer The stage in a superheterodyne receiver in which the incoming signal is mixed with the voltage from a local oscillator to produce the intermediate frequency signal. Also a control which combines the output from a number of microphones in any desired proportion to the input of the main amplifier.

Modulation The process by which the amplitude, frequency or phase of a carrier wave is modified in accordance with the characteristics of a signal.

Monaural Hearing with one ear only.

Motorboating Regeneration at low audio frequencies causing sounds like those of a motor boat.

N

Network An electrical circuit. See Chapter 4.

Neutralization The process of balancing out an undesirable effect, such as regeneration.

Node A point on a stationary wave system which has zero amplitude.

Non-linear The opposite of linear. Distorted.

Numerator The part of a fraction above the fraction bar.

O

Open circuit A circuit which is not complete and can therefore carry no current.

Order " Of the order of " indicates " that the value is in the general vicinity of." The expression is looser than " approximately equal to."

Output stage The final stage in an amplifier which supplies audio frequency power to a loudspeaker. Also known as power amplifier.

P

Parallel Conductors or components are in parallel when the current flowing in the circuit is divided between them.

Parameter Where there are three variables, any one of them (called the parameter) may be given a series of fixed values, and two dimensional curves may then be drawn to show the relationships between the remaining two variables.

Penultimate Last but one.

Period The time for one complete cycle of values ; the reciprocal of the frequency.

Phonograph Also known as a gramophone.

Pitch A subjective observation of a musical sound, principally dependent on frequency but also affected by intensity.

Polarity (1) electrical—a term applied to electrical apparatus when it is desired to indicate which terminal is positive and which is negative ;
(2) magnetic—that quality of a body by virtue of which certain characteristic properties are manifested over certain regions of its surface, which are known as poles, and whose polarity is indicated by the term north or south pole.

Potential The potential at a point is the potential difference between that point and earth.

Potential difference The potential difference between two points is equal to the work done in transferring unit quantity of positive electricity from one point to the other. The practical unit is the volt.

Power pack The power supply of a radio receiver or amplifier. It converts the available voltage to the values required by the plate, screen, and grid circuits.

Q

Q factor The ratio of reactance to resistance of a coil, condenser or resonant circuit.

Quiescent Stationary. The quiescent operating point is that with instantaneous zero signal voltage.

R

Radial lead A lead at 90° to the axis.

Radio frequency Any frequency at which electromagnetic radiation is used for telecommunication.

Reciprocal of a number is 1 divided by the number.

Rectification The process of converting an alternating current to unidirectional current by means of an asymmetrical conducting device.

Ripple frequency The frequency of the a.c. component of a current when this component is small relative to the d.c. component.

Roll-off A frequency response characteristic is said to have a roll-off when the attenuation at high or low frequencies has the same form as that of a single section low- or high-pass *RC* filter. The term is also used in a loose sense to cover any characteristic with gradually increasing attenuation at high or low frequencies, in distinction to a sharp cut-off.

S

Scalar Has magnitude and sign but no direction.

Series Conductors or components are in series when traversed by the same current.

Short circuit A low resistance connection, usually accidental, across part of a circuit, resulting in excessive current flow.

Shunt Same as parallel.

Sideband A band of frequencies within which lie the frequencies of the waves produced by modulation.

Side frequency A frequency produced by modulation.

Signal voltage The audio frequency voltage in an a-f amplifier ; the modulating voltage in an r-f or i-f amplifier, also applied to the whole modulated carrier voltage.

Sinusoidal Having the form of a sine (or cosine) wave.

" Small compared with " A vague term indicating that it may be neglected in a rough approximation, or that its square may be neglected with only a small error—say " less than one tenth of."

Soft valve One which has reverse grid current in excess of the specified maximum for its type.

Space current The same as cathode current.

Steradian The solid angle subtended at the centre of a sphere by an area on its surface numerically equal to the square of the radius. The maximum possible value is 2π steradians.

Strain Is the deformation produced by an applied stress, for example change in length per unit length produced by a tensile stress.

Stress is the deforming force per unit area. Examples are tensile stress, compressive stress and bending stress.

Subharmonic A component of a complex wave having a frequency which is an integral sub-multiple of the basic frequency. Example : basic frequency 300 c/s ; subharmonics 150, 100, 75, 60, 50 c/s.

Subscript Printed below the line. For example the letter *m* in g_m is a subscript.

Superscript Printed above the line. For example the figure 2 in x^2 is a superscript.

N.B. Q' is called " Q dash."

Supersonic Air waves having frequencies above those which may be heard by the human ear. The preferred term is ultrasonic.

Symmetrical Having the same characteristics for conduction in both directions.

T

Tap A connection at some point other than the ends.

Term A portion of an expression which is separated from the other portions by + or — signs. In a sequence, series or progression the terms may be separated by commas.

Terminal A point to which electrical connections may be made.

Tertiary Third.

Tolerance The maximum permissible variation from an assigned value.

Transducer A transducer is a device by means of which energy may flow from one or more transmission systems to one or more other transmission systems. The energy transmitted by these systems may be of any form (for example it may be electrical, mechanical or acoustical), and it may be of the same form or different forms in the various input and output systems (e.g. electro-acoustical).

An **electrical transducer** is an electrical network by means of which energy may flow from one or more transmission systems to one or more other transmission systems ; in most cases it has two input and two output terminals. An **electron-tube transducer** is an electrical transducer containing one or more electron tubes (valves). Examples are an amplifier, and a frequency converter.

Treble High audio frequencies.

U

Ultrasonic Air waves having frequencies above those which may be heard by the human ear.

Unidirectional current Current which may change in value but never reverses its direction.

Unity The figure 1.

V

Variable A quantity whose value changes.

Variational The variational slope of a curve at a point is the differential slope at that point.

Vector A quantity having both magnitude and direction.

" Very small compared with " A vague term indicating that it may be neglected with only a small error—say " less than one twenty-fifth of."

Voice coil Moving coil of a dynamic loudspeaker.

W

Work function The thermionic work function of a conductor is the definite amount of work which must be applied to release one electron. An electron must possess kinetic energy at least as great as the work function of the conductor to pass out through the surface.

Z

Zero signal Having no signal input voltage.

See also

" American Standard Definitions of Electrical Terms " A.S.A. C42-1941 (American

Institute of Electrical Engineers, New York).

British Standard 204 : 1943 " Glossary of Terms used in Telecommunication " (British Standards Institution).

Also Supplement No. 3 (1949) to BS204 : 1943 " Fundamental Radio Terms."

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" Standards on electron tubes : Definitions of Terms, 1950," Proc. I.R.E. 38.4 (April 1950) 426.

38 IRE 6 S1 Standards on Electroacoustics 1938.

38 IRE 17 S1 Standards on Radio Receivers 1938.

50 IRE 24 S1 Standards on Wave Propagation, 1950.
(Proc. I.R.E. 38.11 November 1950 p. 1264).

52 IRE 17 S1 Standards on Receivers : Definitions of Terms, 1952.
[Proc. I.R.E. 40.12 (Dec. 1952) 1681].

SECTION 16 : DECIMAL EQUIVALENTS OF FRACTIONS

TABLE 58 : DECIMAL EQUIVALENTS OF FRACTIONS

Fractions of an inch	Decimal	Fractions of an inch	Decimal
1/64	0.0156	1/2	0.5000
1/32	0.0313	33/64	0.5156
3/64	0.0469	17/32	0.5313
1/16	0.0625	35/64	0.5469
5/64	0.0781	9/16	0.5265
3/32	0.0938	37/64	0.5781
7/64	0.1094	19/32	0.5938
1/8	0.1250	39/64	0.6094
9/64	0.1406	5/8	0.6250
5/32	0.1563	41/64	0.6406
11/64	0.1719	21/32	0.6563
3/16	0.1875	43/64	0.6719
13/64	0.2031	11/16	0.6875
7/32	0.2188	45/64	0.7031
15/64	0.2344	23/32	0.7188
1/4	0.2500	47/64	0.7344
17/64	0.2656	3/4	0.7500
9/32	0.2813	49/64	0.7656
19/64	0.2969	25/32	0.7813
5/16	0.3125	51/64	0.7969
21/64	0.3281	13/16	0.8125
11/32	0.3438	53/64	0.8281
23/64	0.3594	27/32	0.8438
3/8	0.3750	55/64	0.8594
25/64	0.3906	7/8	0.8750
13/32	0.4063	57/64	0.8906
27/64	0.4219	29/32	0.9063
7/16	0.4375	59/64	0.9219
29/64	0.4531	15/16	0.9375
15/32	0.4688	61/64	0.9531
31/64	0.4844	31/32	0.9688
		63/64	0.9844

SECTION 17 : MULTIPLES AND SUB-MULTIPLES

TABLE 59 : MULTIPLES AND SUB-MULTIPLES

Multiply reading in	by	to obtain reading in
Amperes	1 000 000 000 000	micromicroamperes
Amperes	1 000 000	microamperes
Amperes	1000	milliamperes
Farads	1 000 000 000 000	micromicrofarads
Farads	1 000 000	microfarads
Farads	1000	millifarads
Henrys	1 000 000	microhenrys
Henrys	1000	millihenrys
Volts	1 000 000	microvolts
Volts	1000	millivolts
Mhos	1 000 000	micromhos
Mhos	1000	millimhos
Watts	1000	milliwatts
Cycles per second	0.000 001	megacycles per second
Cycles per second	0.001	kilocycles per second
Microamperes	0.000 001	amperes
Milliamperes	0.001	amperes
Micromicrofarads } Picofarads	0.000 000 000 001	farads
Microfarads	0.000 001	farads
Millifarads	0.001	farads
Microhenrys	0.000 001	henrys
Microvolts	0.000 001	volts
Millivolts	0.001	volts
Micromhos	0.000 001	mhos
Millimhos	0.001	mhos
Milliwatts	0.001	watts
Kilowatts	1000	watts
Megacycles per second	1 000 000	cycles per second
Kilocycles per second	1000	cycles per second
Megohms	1 000 000	ohms

SECTION 18 : NUMERICAL VALUES AND FACTORIALS

(*i*) *Numerical values* (*ii*) *Factorials.*

(i) Numerical values

TABLE 60

	Numeric		Reciprocal	
	Approx.	More accurately	Approx.	More accurately
π	3.1416	3.141 593	0.318 3	0.318 309 9
2π	6.2832	6.283 185	0.159 21	0.159 156
3π	9.4248	9.424 778	0.106 1	0.106 103
4π	12.566	12.566 371	0.0796	0.079 577 4
5π	15.708	15.707 963	0 0637	0.063 662
$\pi/2$	1.5708	1.570 796	0.6366	0.636 620
$\pi/3$	1.0472	1.047 198	0.9549	0.954 930
$\pi/4$	0.7854	0.785 398	1.273	1.273 23
$\pi/6$	0.5236	0.523 598	1.910	1.909 86
π^2	9.8696	9.869 604	0.1013	0.101 321
$(2\pi)^2$	39.4784	39.478 414	0.0253	0.025 330 3
π^3	31.0062	31.006 277	0.0322	0.032 252
$\sqrt{\pi}$	1.7725	1.772 454	0.5642	0.564 190
$\sqrt{\pi/2}$	1.2533	1.253 31	0.7979	0.797 887
$\sqrt[3]{\pi}$	1.4646	1.464 592	0.6818	0.681 784
$\log_{10}\pi$	0.4971	0.497 150	2.011	2.011 46
$\log_{10}\pi/2$	0.1961	0.196 120	5.099	5.098 92
$\log_{10}\pi^2$	0.9943	0.994 300	1.006	1.005 73
$\log_{10}\sqrt{\pi}$	0.2486	0.248 575	4.023	4.022 93
ϵ	2.718	2.718 282	0.3679	0.367 879
ϵ^2	7.389	7.389 057	0.1353	0.135 335
$\sqrt{\epsilon}$	1.649	1.648 721	0.6065	0.606 531
$\log_{10}\epsilon$	0.4343	0.434 294	2.3026	2.302 585
$\sqrt{2}$	1.414	1.4142	0.7071	0.707 113 5
$\sqrt{3}$	1.732	1.7321	0.5773	0.577 334 2
$\sqrt{5}$	2.236	2.2361	0.4472	0.447 206
$\sqrt[3]{2}$	1.260	1.2599	0.7939	0.793 873
$\sqrt[3]{3}$	1.442	1.4422	0.6933	0.693 385
$\sqrt[3]{4}$	1.587	1.5874	0.6300	0.629 960
$\sqrt[3]{5}$	1.710	1.7100	0.5848	0.584 79

(ii) Factorials

TABLE 61

n	$n! = 1.2.3 \ldots . n$	$1/n!$
1	1	1
2	2	0.5
3	6	0.166 667
4	24	$0.416\,667 \times 10^{-1}$
5	120	$0.833\,333 \times 10^{-2}$
6	720	$0.138\,889 \times 10^{-2}$
7	5040	$0.198\,413 \times 10^{-3}$
8	40 320	$0.248\,016 \times 10^{-4}$
9	362 880	$0.275\,573 \times 10^{-5}$
10	3 628 800	$0.275\,573 \times 10^{-6}$

SECTION 19 : WIRE TABLES*

TABLE 62

Bare Copper Wire, A.W.G. (20° C. = 68° F.)

AWG No.	Diameter Mils	Area Circular Mils	Area Square Inches	Ohms per 1000 Feet	Ohms per Pound	Feet per Pound	Pounds per 1000 Feet
0000	460	211 600	.166 2	.04901	.000 076 52	1.561	640.5
000	410	167 800	.131 8	.06180	.000 121 7	1.968	507.9
00	364.8	133 100	.104 5	.07793	.000 193 5	2.482	402.8
0	324.9	105 500	.082 89	.09827	.000 307 6	3.130	319.5
1	289.3	83 700	.065 73	.1239	.000 489 1	3.947	253.3
2	257.6	66 400	.052 13	.1563	.000 777 8	4.977	200.9
3	229.4	52 600	.041 34	.1970	.001 237	6.276	159.3
4	204.3	41 700	.032 78	.2485	.001 966	7.914	126.4
5	181.9	33 100	.026 00	.3133	.003 127	9.980	100.2
6	162.0	26 250	.020 62	.3951	.004 972	12.58	79.46
7	144.3	20 820	.016 35	.4982	.007 905	15.87	63.02
8	128.5	16 510	.012 97	.6282	.012 57	20.01	49.98
9	114.4	13 090	.010 28	.7921	.019 99	25.23	39.63
10	101.9	10 380	.008 155	.9989	.031 78	31.82	31.43
11	90.7	8 230	.006 467	1.260	.050 53	40.12	24.92
12	80.8	6 530	.005 129	1.588	.080 35	50.59	19.77
13	72.0	5 180	.004 067	2.003	.1278	63.80	15.68
14	64.1	4 110	.003 225	2.525	.2032	80.44	12.43
15	57.1	3 257	.002 558	3.184	.3230	101.4	9.858
16	50.8	2 583	.002 028	4.016	.5136	127.9	7.818
17	45.3	2 048	.001 609	5.064	.8167	161.3	6.200
18	40.3	1 624	.001 276	6.385	1.299	203.4	4.917
19	35.89	1 288	.001 012	8.051	2.065	256.5	3.899
20	31.96	1 022	.000 802 3	10.15	3.283	323.4	3.092
21	28.46	810	.000 636 3	12.80	5.221	407.8	2.452
22	25.35	642	.000 504 6	16.14	8.301	514.2	1.945
23	22.57	509	.000 400 2	20.36	13.20	648.4	1.542
24	20.10	404	.000 317 3	25.67	20.99	817.7	1.223
25	17.90	320.4	.000 251 7	32.37	33.37	1 031.0	0.9699
26	15.94	254.1	.000 199 6	40.81	53.06	1 300	0.7692
27	14.20	201.5	.000 158 3	51.47	84.37	1 639	0.6100
28	12.64	159.8	.000 125 5	64.90	134.2	2 067	0.4837
29	11.26	126.7	.000 099 53	81.83	213.3	2 607	0.3836
30	10.03	100.5	.000 078 94	103.2	339.2	3 287	0.3042
31	8.928	79.70	.000 062 60	130.1	539.3	4 145	0.2413
32	7.950	63.21	.000 049 64	164.1	857.6	5 227	0.1913
33	7.080	50.13	.000 039 37	206.9	1 364.0	6 591	0.1517
34	6.305	39.75	.000 031 22	260.9	2 168	8 310	0.1203
35	5.615	31.52	.000 024 76	329.0	3 448	10 480	0.095 42
36	5.000	25.00	.000 019 64	414.8	5 482	13 210	.075 68
37	4.453	19.83	.000 015 57	532.1	8 717	16 660	.060 01
38	3.965	15.72	.000 012 35	659.6	13 860	21 010	.047 59
39	3.531	12.47	.000 009 793	831.8	22 040	26 500	.037 74
40	3.145	9.888	.000 007 766	1 049.0	35 040	33 410	.029 93
(41)	2.75	7.5625	.000 005 940	1 370	59 990	43 700	.022 89
(42)	2.50	6.2500	.000 004 909	1 660	87 700	52 800	.018 92
(43)	2.25	5.0625	.000 003 976	2 050	133 700	65 300	.015 32
(44)	2.00	4.0000	.000 003 142	2 600	214 000	82 600	.012 11
(45)	1.75	3.0625	.000 002 405	3 390	356 200	107 900	.009 27
(46)	1.50	2.2500	.000 001 767	4 610	676 800	146 800	.006 81

*See also A. F. Maine " Rapid coil calculations for magnetic devices " Jour. Brit. I.R.E. 12.7 (July 1952) 403 for nomographs.

Table 63
Bare Copper Wire S.W.G. (60° F)

SWG No.	Diameter Mils.	Area Circular Mils.	Area Square Inches	Ohms per 1000 Feet	Ohms per Pound	Feet per Pound	Pounds per 1000 Feet
4/0	400	160 000	.125 66	.06368	.000 131 46	2.064	484.4
3/0	372	138 400	.108 69	.0736	.000 175 74	2.390	418.9
2/0	348	121 100	.095 11	.0841	.000 229 5	2.730	366.7
1/0	324	105 000	.082 45	.0971	.000 305 4	3.147	317.8
1	300	90 000	.070 69	.1132	.000 415 5	3.670	272.5
2	276	76 180	.059 83	.1338	.000 580 0	4.338	230.6
3	252	63 500	.049 88	.1605	.000 834 5	5.200	192.3
4	232	53 820	.042 27	.1893	.001 161 7	6.139	162.9
5	212	44 940	.035 30	.2267	.001 666 1	7.348	136.1
6	192	36 860	.028 95	.2764	.002 476	8.961	111.6
7	176	30 980	.024 33	.3289	.003 507	10.66	93.8
8	160	25 600	.020 11	.3980	.005 135	12.90	77.5
9	144	20 740	.016 286	.4914	.007 827	15.93	62.78
10	128	16 380	.012 868	.6219	.012 537	20.16	49.61
11	116	13 460	.010 568	.7570	.018 587	24.55	40.74
12	104	10 820	.008 495	.942	.028 77	30.54	32 75
13	92	8 464	.006 648	1.204	.046 98	39.01	25.63
14	80	6 400	.005 027	1.592	.082 16	51.60	19.38
15	72	5 184	.004 072	1.966	.125 23	63.73	15.69
16	64	4 096	.003 217	2.488	.2006	80.65	12.40
17	56	3 136	.002 463	3.249	.3422	105.4	9.49
18	48	2 304	.001 809 6	4.422	.6340	143.3	6.98
19	40	1 600	.001 256 6	6.368	1.3146	206.4	4.844
20	36	1 296	.001 017 9	7.860	2.004	254.8	3.924
21	32	1 024	.000 804 2	9.950	3.209	322.6	3.100
22	28	784	.000 615 8	12.997	5.475	421.2	2.374
23	24	576	.000 452 4	17.69	10.144	573.4	1.744
24	22	484	.000 380 1	21.05	14.366	682.6	1.465
25	20	400	.000 314 2	25.47	21.03	825.8	1 211
26	18	324	.000 254 5	31.45	32.06	1 019	0.981
27	16.4	269	.000 211 2	37.88	46.52	1 229	0.814
28	14.8	219	.000 172 03	46.52	70.14	1 508	0.6632
29	13.6	185	.000 145 27	55.09	98.37	1 786	0.5600
30	12.4	153.8	.000 120 76	66.27	142.35	2 148	0.4655
31	11.6	134.6	.000 105 68	75.7	185.87	2 455	0.4074
32	10.8	116.6	.000 091 61	87.4	247.4	2 832	0.3531
33	10.0	100.0	.000 078 54	101.9	336.5	3 302	0.3028
34	9.2	84.64	.000 066 48	120.4	469.8	3 901	0.2563
35	8.4	70.56	.000 055 42	144.4	676.0	4 682	0.2136
36	7.6	57.76	.000 045 36	176.4	1 008.7	5 718	0.1749
37	6.8	46.24	.000 036 32	220.4	1 574	7 143	0.1400
38	6.0	36.00	.000 028 27	283.0	2 596	9 174	0.1090
39	5.2	27.04	.000 021 24	376.8	4 603	12 210	0.0819
40	4.8	23.04	.000 018 096	442.2	6 340	14 330	0.0698
41	4.4	19.36	.000 015 205	526.3	8 979	17 060	0.058 62
42	4.0	16.00	.000 012 566	636.8	13 146	20 640	.048 44
43	3.6	12.96	.000 010 179	786.3	20 040	25 480	.039 24
44	3.2	9.734	.000 008 042	995.0	32 090	32 260	.031 00
45	2.8	7.840	.000 006 158	1 299.7	54 750	42 120	.023 74
46	2.4	5.760	.000 004 524	1 769	101 440	57 340	.017 44
47	2.0	4.000	.000 003 142	2 547	210 300	82 580	.012 11
48	1.6	2.560	.000 002 011	3 980	513 500	129 000	.007 75
49	1.2	1.440	.000 001 131	7 077	1 623 000	229 400	.004 36
50	1.0	1.000	.000 000 785 4	10 190	3 365 000	303 000	.003 03

TABLE 64

TURNS PER INCH AND INSULATED WIRE DIAMETER A.W.G. COPPER WIRE

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

*Nominal Value. Actual dimensions vary slightly.

TABLE 65

TURNS PER INCH AND INSULATED WIRE DIAMETER, S.W.G. COPPER WIRE

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

*Nominal Value. Actual dimensions vary slightly.

TABLE 66

MULTI-LAYER COIL WINDING AND WEIGHT OF INSULATED WIRE, A.W.G.

COPPER WIRE

AWG No.	Enamelled			D.C.C.		Weight—lbs. per 1000ft.		
	Turns per square inch*	Ohms per cubic inch*	Turns per square inch layer insulated	Turns per square inch*	Ohms per cubic inch*	Enam.	D.C.C.	D.S.C.
8	57	.003 15	Paper insulated each layer. 20% allowance for waste space at ends of layers.	48	.002 65	50.55	51.15	
9	72	.004 75		59	.003 88	40.15	40.60	
10	90	.007 48		76	.006 31	31.80	32.18	
11	113	.011 83		93	.009 74	25.25	25.60	
12	141	.018 78		114	.015 19	20.05	20.40	
13	177	.029 5		140	.023 3	15.90	16.20	
14	221	.046 4		171	.035 9	12.60	12.91	
15	277	.073 4		208	.055 1	10.00	10.33	
16	348	.116 2		260	.086 9	7.930	8.210	7.955
17	437	.184 0		316	.133 1	6.275	6.540	6.315
18	548	.291 0		378	.200 8	4.980	5.235	5.015
19	681	.456 0		455	.304 8	3.955	4.220	3.990
20	852	.720 0		545	.460 5	3.135	3.373	3.173
21	1 065	1.134		650	.6920	2.490	2.685	2.520
22	1 340	1.800		865	1.162	1.970	2.168	2.006
23	1 665	2.820		1 030	1.774	1.565	1.727	1.593
24	2 100	4.488	4 mil. paper: 1 420	1 215	2.596	1.245	1.398	1.272
25	2 630	7.080	1 750	1 420	3.822	.988	1.129	1.018
26	3 320	11.27	2 030	1 690	5.740	.7845	.9140	.8100
27	4 145	17.75	2 620	1 945	8.330	.6220	.7560	.6450
28	5 250	28.34	3 250	2 250	12.15	.4940	.6075	.5140
29	6 510	44.32	3 920	2 560	17.30	.3915	.4890	.4130
30	8 175	70.15	4 780	2 930	25.15	.3105	.3955	.3330
31	10 200	110.4	2 mil. paper: 6 780	3 330	36.05	.2465	.3257	.2678
32	12 650	127.6	8 250	3 720	50.76	.1960	.2700	.2170
33	16 200	279.0	10 600	4 140	71.30	.1550	.2270	.1750
34	19 950	433.2	12 400	4 595	99.77	.1230	.1928	.1412
35	25 000	684.5	15 200	5 070	138.7	.0980	.1600	.1130
36	31 700	1 094	1 mil. paper: 21 500	5 550	191.6	.0776	.1361	.0920
37	39 600	1 723	26 300	6 045	263	.0616	.1204	.0740
38	49 100	2 693	32 000	6 510	357	.0488	.1049	.0623
39	62 600	4 332	40 000	6 935	480	.0387	.0937	.0504
40	77 600	6 770	48 400	7 450	650	.0307	.0838	.0429

*For exact winding with no allowance for space factor.

TABLE 67

MULTI-LAYER COIL WINDING AND WEIGHT OF INSULATED WIRE, S.W.G. COPPER WIRE

SWG No.	Enamelled			D.C.C.		Weight—lbs. per 1000ft.		
	Turns per square inch*	Ohms per cubic inch*	Turns per square inch layer insulated	Turns per square inch*	Ohms per cubic inch*	Enam.	D.C.C.	D.S.C.
10	58.22	.002 95	Paper insulated each layer. 20% allowance for waste space at ends of layers.	49.56	.00256	47.77	50.77	
11	69.39	.004 37		59.14	.003 73	44.40	41.83	
12	85.75	.006 73		71.91	.005 65	33.04	33.71	
13	108.6	.0109		88.92	.008 93	25.89	26.50	
14	141.6	.0189		113.2	.0150	19.60	20.12	
15	175.6	.0287		141.6	.0234	15.87	16.36	
16	219.3	.0456		173.2	.0358	12.56	12.67	12.56
17	287.3	.0776		216.4	.0585	9.607	10.03	9.640
18	388.9	.1431		287.3	.1055	7.060	7.43	7.093
19	550.8	.290		384.6	.204	4.910	5.262	4.945
20	674.4	.440		452.8	.296	3.987	4.267	4.011
21	849.7	.705		541.0	.448	3.152	3.409	3.181
22	1 109	1.200		657.4	.710	2.419	2.649	2.446
23	1 513	2.23		864.9	1.26	1.779	1.918	1.807
24	1 789	3.14	4 mil. paper: 1 220	976.6	1.71	1.498	1.667	1.305
25	2 162	4.58	1 460	1 109	2.35	1.241	1.392	1.247
26	2 663	6.95	1 760	1 274	3.33	1.008	1.152	1.013
27	3 192	10.05	2 080	1 436	4.51	.836	.977	.844
28	3 906	15.18	2 500	1 624	6.28	.683	.811	.689
29	4 570	20.9	2 870	1 798	8.23	.578	.699	.582
30	5 565	30.7	3 430	1 989	10.98	.478	.604	.486
31	6 304	39.8	3 840	2 144	13.45	.419	.524	.428
32	7 310	53.1	4 360	2 314	16.83	.364	.467	.371
33	8 409	71.2	2 mil. paper: 5 680	2 500	21.15	.313	.412	.329
34	10 000	100.5	6 670	2 714	27.3	.264	.328	.271
35	12 080	145	7 920	3 306	39.3	.221	.317	.288
36	14 520	212	9 360	3 624	53.1	.181	.238	.188
37	18 220	336	11 400	4 007	73.5	.146	.207	.151
38	22 950	544	14 100	4 436	104.5	.114	.169	.119
39	30 770	965	1 mil. paper: 20 900	4 956	155.0	.0854	.138	.0868
40	35 610	1 310	24 000	5 256	193.5	.0726	.123	.0791
41	43 390	1 905	28 800			.0608		.0677
42	51 620	2 740	33 700			.0505		.0571
43	65 740	4 300	41 800			.0408		.0473
44	81 620	6 760	50 800			.0324		.0386
45	104 300	11 250				.0249		.0309
46	142 100	21 000				.0182		.0231
47	197 100	41 700				.0126		.0172
48								

*For exact winding with no allowance for space factor.

TABLE 68

RESISTANCE WIRE TABLE, A.W.G.

20° C. (68° F.)

AWG No.	Dia. mils.	Advance Wire				Nichrome Wire**		
		Ohms per 1,000 feet	Lbs. per 1,000 feet	Feet per Ohm	Current Milli Amps*	Ohms per 1,000 feet	Lbs. per 1,000 feet	Current Milli Amps†
8	128	17.9	50	55.9	—	40.8	45	—
9	114	22.6	39	44.2	—	51.9	36	—
10	102	28.0	32	35.7	—	64.9	29	—
11	91	35.5	25	28.2	—	81.5	23	—
12	81	44.8	20	22.3	—	102	18	—
13	72	56.7	15.7	17.6	—	130	14	—
14	64	71.7	12.4	13.9	—	164	11	—
15	57	90.4	9.8	11.1	—	207	9.2	—
16	51	113	7.8	8.85	—	259	7.2	—
17	45	145	6.2	6.90	—	333	5.6	—
18	40	184	4.9	5.44	800	421	4.42	—
19	36	226	3.9	4.43	650	520	3.58	—
20	32	287	3.1	3.48	522	659	2.83	—
21	28.5	362	2.5	2.76	420	831	2.24	—
22	25.3	460	1.9	2.17	335	1 055	1.77	—
23	22.6	575	1.5	1.74	273	1 321	1.41	—
24	20.1	728	1.2	1.37	220	1 670	1.12	460
25	17.9	919	.97	1.09	178	2 106	.89	390
26	15.9	1 162	.77	.861	144	2 669	.70	330
27	14.2	1 455	.61	.687	117	3 347	.56	278
28	12.6	1 850	.48	.541	95	4 251	.44	228
29	11.3	2 300	.38	.435	78	5 286	.35	196
30	10.0	2 940	.30	.340	63	6 750	.276	165
31	8.9	3 680	.24	.272	52	8 521	.199	158
32	8.0	4 600	.19	.217	43	10 546	.177	117
33	7.1	5 830	.15	.172	36	13 390	.139	97
34	6.3	7 400	.12	.135	29	17 006	.110	82
35	5.6	9 360	.095	.107	24	21 524	.087	69
36	5.0	11 760	.076	.085	20	27 000	.069	58
37	4.5	14 550	.060	.0687	17	33 333	.056	49
38	4.0	18 375	.047	.0544	14.5	42 187	.045	41
39	3.5	24 100	.038	.0415	12	55 102	.034	34
40	3.1	30 593	.028	.0327	10	70 239	.025	28
(41)	2.75	38 888	.0229	0257	8.5	89 256	.0209	24
(42)	2.5	46 400	.0189	.0215	7.5	108 000	.0173	20.5
(43)	2.25	58 103	.0153	.0172	6.8	133 333	.0140	17.5
(44)	2.0	73 500	.0121	.0136	6.0	168 750	.0110	14.5
(45)	1.75	96 078	.0092	.0104	5.0	220 408	.0084	12.0
(46)	1.5	130 666	.0068	0076	4.0	300 000	.0062	9.5

**Wire produced by some manufacturers differs considerably from the resistance values given.

*D.S.C. wound on spool.

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

N.B.—To find current for Advance wire wound on slab, multiply Nichrome Current column by approx. 1.5.

TABLE 69

RESISTANCE WIRE TABLE, S.W.G.

SWG No.	Dia. mils.	Eureka Wire				Nichrome Wire**		
		Ohms per 1,000 feet	Lbs. per 1,000 feet	Feet per Ohm	Current Milli Amps*	Ohms per 1,000 feet	Lbs. per 1,000 feet	Current Milli Amps†
10	128	17.4	49.7	57.5	—	40.8	45	—
11	116	21.2	40.9	47.2	—	50.2	37.3	—
12	104	26.4	32.9	37.9	—	62.4	29.5	—
13	92	33.8	25.7	29.6	—	79.7	23.4	—
14	80	44.6	19.5	22.4	—	105.4	17.7	—
15	72	55.1	15.8	18.15	—	130	14.0	—
16	64	69.8	12.5	14.33	—	164	11.3	—
17	56	91.1	9.5	10.98	—	215	8.7	—
18	48	123.9	7.0	8.07	—	292	6.4	—
19	40	178.5	4.9	5.60	—	421	4.42	—
20	36	220.4	3.9	4.53	650	520	3.58	—
21	32	279.1	3.12	3.58	510	659	2.83	—
22	28	364	2.38	2.75	390	861	2.17	—
23	24	496	1.75	2.02	300	1 170	1.60	—
24	22	590	1.47	1.70	250	1 390	1.33	—
25	20	714	1.21	1.40	210	1 680	1.12	—
26	18	882	0.99	1.134	170	2 080	.897	400
27	16.4	1 062	.82	.942	140	2 510	.746	350
28	14.8	1 305	.67	.766	117	3 080	.607	300
29	13.6	1 545	.56	.647	101	3 650	.513	250
30	12.4	1 858	.47	.538	85	4 390	.427	230
31	11.6	2 123	.41	.471	75	5 010	.373	205
32	10.8	2 450	.35	.408	66	5 780	.324	185
33	10.0	2 857	.304	.350	57	6 750	.276	165
34	9.2	3 376	.257	.296	49	7 970	.235	145
35	8.4	4 049	.215	.247	41	9 560	.195	125
36	7.6	4 947	.175	.202	35	11 690	.160	110
37	6.8	6 179	.140	.1618	29	14 600	.128	91
38	6.0	7 936	.109	.1260	23	18 700	.100	76
39	5.2	10 565	.082	.0947	19	24 900	.075	62
40	4.8	12 395	.070	.0807	16	29 200	.064	55
41	4.4	14 756	.059	.0677	13	34 800	.0536	48
42	4.0	17 855	.049	.0560	11	42 180	.0450	41
43	3.6	22 045	.039	.0454	9.5	52 000	.0358	35
44	3.2	27 888	.031	.0359	8.0	63 900	.0283	30
45	2.8	36 216	.024	.0276	6.5	86 100	.0217	25
46	2.4	49 588	.018	.0202	5.0	117 000	.0160	20
47	2.0	71 428	.012	.0140	4.0	168 000	.0112	15
48	1.6	111 333	.008	.0090	3.0	263 600	.0071	—

**Wire produced by some manufacturers differs considerably from the resistance values given.
*D.S.C. wound on spool.

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

N.B.—To find current for Eureka wire wound on slab, multiply Nichrome Current column by approx. 1.5.

TABLE 70 : WINDING DATA CHART

FOR ROUND PLAIN ENAMELLED COPPER WIRE, A.W.G.

(By courtesy of Standard Transformer Corporation, Chicago)

Insulation	Wire	Current	Dia.	Area	Turns per layer									Wire
Layer Insulation Thickness (Inches)	A.W.G. No.	Based on 700 Cir. Mils per Amp. (Maximum) (Amperes)	Overall Enamelled Wire (Nominal) (Inches)	Bare Copper Wire (Nominal) (Cir. Mils)	Lamination Size (Dimension of Centre Leg)									A.W.G. No.
					0.50″	0.62″	0.75″	0.87″	1.00″	1.12″	1.25″	1.37″	1.50″	
.010 Fibre	10	14.90	.1039	10380	—	—	—	9	10	11	12	14	16	10
,,	11	11.80	.0927	8230	—	—	—	10	11	12	14	16	18	11
,,	12	9.35	.0827	6530	—	—	8	11	13	14	16	18	20	12
,,	13	7.42	.0738	5180	—	8	9	13	14	16	18	20	22	13
.007 Fibre	14	5.87	.0659	4110	7	9	11	14	16	18	20	22	25	14
,,	15	4.66	.0588	3260	8	10	12	16	18	20	22	25	28	15
,,	16	3.69	.0524	2580	9	11	13	18	20	22	25	28	31	16
.005 Fibre	17	2.93	.0469	2050	10	12	15	20	22	25	28	31	35	17
,,	18	2.31	.0418	1620	11	14	17	23	25	28	31	35	39	18
.004 Kraft	19	1.84	.0374	1290	12	15	19	25	28	31	35	39	44	19
,,	20	1.46	.0334	1020	14	17	21	28	32	35	39	44	49	20
,,	21	1.16	.0299	810	15	19	23	31	35	39	43	49	55	21
,,	22	0.917	.0267	642	17	22	26	35	39	44	48	55	62	22
,,	23	0.723	.0238	510	20	25	29	39	44	49	54	62	69	23
,,	24	0.578	.0213	404	22	27	33	44	50	55	61	69	77	24
.003 Kraft	25	0.457	.0190	320	25	31	37	49	55	61	68	77	86	25

TABLE 70 : WINDING DATA CHART FOR ROUND PLAIN ENAMELLED COPPER WIRE, A.W.G.

(By courtesy of Standard Transformer Corporation, Chicago)

Insulation	Wire	Current	Dia.	Area	Turns per layer									Wire
Layer Insulation Thickness (Inches)	A.W.G. No.	Based on 700 Cir. Mils per Amp. (Maximum) (Amperes)	Overall Enamelled Wire (Nominal) (Inches)	Bare Copper Wire (Nominal) (Cir. Mils)	Lamination Size (Dimension of Centre Leg)									A.W.G. No.
					0.50″	0.62″	0.75″	0.87″	1.00″	1.12″	1.25″	1.37″	1.50″	
.003 Kraft	26	0.363	.0170	254	27	35	41	55	62	68	76	87	98	26
,,	27	0.289	.0152	202	31	39	46	62	69	77	85	97	108	27
.002 Kraft	28	0.229	.0136	160	34	43	51	69	77	86	95	108	121	28
,,	29	0.181	.0122	127	38	48	57	77	86	95	115	119	133	29
,,	30	0.144	.0108	101	43	53	64	86	96	107	118	134	151	30
.0015 Kraft	31	0.114	.0097	79.7	47	60	72	96	107	119	132	150	168	31
,,	32	0.0903	.0088	63.2	52	66	78	105	118	130	143	164	183	32
,,	33	0.0715	.0078	50.1	59	73	88	118	133	147	162	184	207	33
.001 Kraft	34	0.0568	.0069	39.8	67	83	96	133	150	167	183	209	233	34
,,	35	0.0450	.0061	31.5	75	92	111	150	169	186	205	233	265	35
,,	36	0.0357	.0055	25.0	83	103	125	166	186	206	227	258	293	36
,,	37	0.0283	.0049	19.8	93	115	139	185	209	231	255	290	325	37
.0008 Kraft	38	0.0224	.0044	15.7	102	127	151	205	230	255	284	322	—	38
,,	39	0.0179	.0038	12.5	118	148	177	237	266	296	330	—	—	39
,,	40	0.0141	.0034	9.89	131	163	197	263	295	329	—	—	—	40
,,	41	0.0120	.0032	8.41	139	174	209	279	312	—	—	—	—	41
,,	42	0.0089	.0028	6.25	158	198	238	—	—	—	—	—	—	42

SECTION 20 : LOGARITHM TABLES

	0	1	2	3	4	5	6	7	8	9	Differences 1	2	3	4	5	6	7	8	9
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	4	8	12	17	21	25	29	33	37
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	4	8	11	15	19	23	26	30	34
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	3	7	10	14	17	21	24	28	31
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	3	6	10	13	16	19	23	26	29
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	3	6	9	12	15	18	21	24	27
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	3	6	8	11	14	17	20	22	25
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	3	5	8	11	13	16	18	21	24
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	2	5	7	10	12	15	17	20	22
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	2	5	7	9	12	14	16	19	21
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	2	4	7	9	11	13	16	18	20
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	2	4	6	8	11	13	15	17	19
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	2	4	6	8	10	12	14	16	18
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	2	4	6	8	10	12	14	15	17
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	2	4	6	7	9	11	13	15	17
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	2	4	5	7	9	11	12	14	16
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	2	3	5	7	9	10	12	14	15
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	2	3	5	7	8	10	11	13	15
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	2	3	5	6	8	9	11	13	14
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	2	3	5	6	8	9	11	12	14
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	1	3	4	6	7	9	10	12	13
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	1	3	4	6	7	9	10	11	13
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	1	3	4	6	7	8	10	11	12
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	1	3	4	5	7	8	9	11	12
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	1	3	4	5	6	8	9	10	12
34	5315	5238	5340	5353	5366	5378	5391	5403	5416	5428	1	3	4	5	6	8	9	10	11
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	1	2	4	5	6	7	9	10	11
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	1	2	4	5	6	7	8	10	11
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	1	2	3	5	6	7	8	9	10
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	1	2	3	5	6	7	8	9	10
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	1	2	3	4	5	7	8	9	10
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	1	2	3	4	5	6	8	9	10
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	1	2	3	4	5	6	7	8	9
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	1	2	3	4	5	6	7	8	9
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	1	2	3	4	5	6	7	8	9
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	1	2	3	4	5	6	7	8	9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	1	2	3	4	5	6	7	8	9
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	1	2	3	4	5	6	7	7	8
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	1	2	3	4	5	5	6	7	8
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	1	2	3	4	4	5	6	7	8
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	1	2	3	4	4	5	6	7	8
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	1	2	3	3	4	5	6	7	8
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	1	2	3	3	4	5	6	7	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	1	2	2	3	4	5	6	7	7
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	1	2	2	3	4	5	6	6	7
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	1	2	2	3	4	5	6	6	7
	0	1	2	3	4	5	6	7	8	9	1	2	3	4	5	6	7	8	9

	0	1	2	3	4	5	6	7	8	9	Differences 1	2	3	4	5	6	7	8	9
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	1	2	2	3	4	5	5	6	7
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	1	2	2	3	4	5	5	6	7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	1	2	2	3	4	5	5	6	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	1	1	2	3	4	4	5	6	7
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	1	1	2	3	4	4	5	6	7
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	1	1	2	3	4	4	5	6	6
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	1	1	2	3	4	4	5	6	6
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	1	1	2	3	3	4	5	6	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	1	1	2	3	3	4	5	5	6
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	1	1	2	3	3	4	5	5	6
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	1	1	2	3	3	4	5	5	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	1	1	2	3	3	4	5	5	6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	1	1	2	3	3	4	5	5	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	1	1	2	3	3	4	4	5	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	1	1	2	2	3	4	4	5	6
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	1	1	2	2	3	4	4	5	6
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	1	1	2	2	3	4	4	5	5
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	1	1	2	2	3	4	4	5	5
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	1	1	2	2	3	4	4	5	5
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	1	1	2	2	3	4	4	5	5
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	1	1	2	2	3	3	4	5	5
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	1	1	2	2	3	3	4	5	5
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	1	1	2	2	3	3	4	4	5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	1	1	2	2	3	3	4	4	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	1	1	2	2	3	3	4	4	5
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	1	1	2	2	3	3	4	4	5
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	1	1	2	2	3	3	4	4	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	1	1	2	2	3	3	4	4	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	1	1	2	2	3	3	4	4	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	1	1	2	2	3	3	4	4	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	1	1	2	2	3	3	4	4	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	1	1	2	2	3	3	4	4	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	0	1	1	2	2	3	3	4	4
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	0	1	1	2	2	3	3	4	4
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	0	1	1	2	2	3	3	4	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	0	1	1	2	2	3	3	4	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	0	1	1	2	2	3	3	4	4
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	0	1	1	2	2	3	3	4	4
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	0	1	1	2	2	3	3	4	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	0	1	1	2	2	3	3	4	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	0	1	1	2	2	3	3	4	4
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	0	1	1	2	2	3	3	4	4
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	0	1	1	2	2	3	3	4	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	0	1	1	2	2	3	3	4	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	0	1	1	2	2	3	3	3	4
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**

SECTION 21 : TRIGONOMETRICAL AND HYPERBOLIC TABLES

TABLE 72 : TRIGONOMETRICAL RELATIONSHIPS

Angle	Radians	Sine	Cosine	Tangent	Angle	Radians	Sine	Cosine	Tangent
0°	.0000	.0000	1.000	.0000	45°	.7854	.7071	.7071	1.0000
1	.0175	.0175	.9998	.0175	46	.8029	.7193	.6947	1.0355
2	.0349	.0349	.9994	.0349	47	.8203	.7314	.6820	1.0724
3	.0524	.0523	.9986	.0524	48	.8378	.7431	.6691	1.1106
4	.0698	.0698	.9976	.0699	49	.8552	.7547	.6561	1.1504
5	.0873	.0872	.9962	.0875	50	.8727	.7660	.6428	1.1918
6	.1047	.1045	.9945	.1051	51	.8901	.7771	.6293	1.2349
7	.1222	.1219	.9925	.1228	52	.9076	.7880	.6157	1.2799
8	.1396	.1392	.9903	.1405	53	.9250	.7986	.6018	1.3270
9	.1571	.1564	.9877	.1584	54	.9425	.8090	.5878	1.3764
10	.1745	.1736	.9848	.1763	55	.9599	.8192	.5736	1.4281
11	.1920	.1908	.9816	.1944	56	.9774	.8290	.5592	1.4826
12	.2094	.2079	.9781	.2126	57	.9948	.8387	.5446	1.5399
13	.2269	.2250	.9744	.2309	58	1.0123	.8480	.5299	1.6003
14	.2443	.2419	.9703	.2493	59	1.0297	.8572	.5150	1.6643
15	.2618	.2588	.9659	.2679	60	1.0472	.8660	.5000	1.7321
16	.2793	.2756	.9613	.2867	61	1.0647	.8746	.4848	1.8040
17	.2967	.2924	.9563	.3057	62	1.0821	.8829	.4695	1.8807
18	.3142	.3090	.9511	.3249	63	1.0996	.8910	.4540	1.9626
19	.3316	.3256	.9455	.3443	64	1.1170	.8988	.4384	2.0503
20	.3491	.3420	.9397	.3640	65	1.1345	.9063	.4226	2.1445
21	.3665	.3584	.9336	.3839	66	1.1519	.9135	.4067	2.2460
22	.3840	.3746	.9272	.4040	67	1.1694	.9205	.3907	2.3559
23	.4014	.3907	.9205	.4245	68	1.1868	.9272	.3746	2.4751
24	.4189	.4067	.9135	.4452	69	1.2043	.9336	.3584	2.6051
25	.4363	.4226	.9063	.4663	70	1.2217	.9397	.3420	2.7475
26	.4538	.4384	.8988	.4877	71	1.2392	.9455	.3256	2.9042
27	.4712	.4540	.8910	.5095	72	1.2566	.9511	.3090	3.0777
28	.4887	.4695	.8829	.5317	73	1.2741	.9563	.2924	3.2709
29	.5061	.4848	.8746	.5543	74	1.2915	.9613	.2756	3.4874
30	.5236	.5000	.8660	.5774	75	1.3090	.9659	.2588	3.7321
31	.5411	.5150	.8572	.6009	76	1.3265	.9703	.2419	4.0108
32	.5585	.5299	.8480	.6249	77	1.3439	.9744	.2250	4.3315
33	.5760	.5446	.8387	.6494	78	1.3614	.9781	.2079	4.7046
34	.5934	.5592	.8290	.6745	79	1.3788	.9816	.1908	5.1446
35	.6109	.5736	.8192	.7002	80	1.3963	.9848	.1736	5.6713
36	.6283	.5878	.8090	.7265	81	1.4137	.9877	.1564	6.3138
37	.6458	.6018	.7986	.7536	82	1.4312	.9903	.1392	7.1154
38	.6632	.6157	.7880	.7813	83	1.4486	.9925	.1219	8.1443
39	.6807	.6293	.7771	.8098	84	1.4661	.9945	.1045	9.5144
40	.6981	.6428	.7660	.8391	85	1.4835	.9962	.0872	11.43
41	.7156	.6561	.7547	.8693	86	1.5010	.9976	.0698	14.30
42	.7330	.6691	.7431	.9004	87	1.5184	.9986	.0523	19.08
43	.7505	.6820	.7314	.9325	88	1.5359	.9994	.0349	28.64
44	.7679	.6947	.7193	.9657	89	1.5533	.9998	.0175	57.29

TABLE 73 : HYPERBOLIC SINES, COSINES AND TANGENTS

$\sinh x = \frac{1}{2}(\epsilon^x - \epsilon^{-x})$; $\cosh x = \frac{1}{2}(\epsilon^x + \epsilon^{-x})$; $\tanh x = (\epsilon^x - \epsilon^{-x})/(\epsilon^x + \epsilon^{-x})$

$\epsilon = 2.718 = 1/0.3679$

x	sinh x	cosh x	tanh x	x	sinh x	cosh x	tanh x
0.00	0.000	1.000	0.000 0	2.50	6.050	6.132	0.986 6
0.10	0.100	1.005	0.099 7	2.60	6.695	6.769	0.989 0
0.20	0.201	1.020	0.197 4	2.70	7.406	7.473	0.991 0
0.30	0.304	1.045	0.291 3	2.80	8.192	8.253	0.992 6
0.40	0.411	1.081	0.380 0	2.90	9.060	9.115	0.994 0
0.50	0.521	1.128	0.462 1	3.00	10.018	10.068	0.995 1
0.60	0.637	1.185	0.537 0	3.10	11.077	11.122	0.996 0
0.70	0.759	1.255	0.604 4	3.20	12.246	12.287	0.996 7
0.80	0.888	1.337	0.664 0	3.30	13.538	13.575	0.997 3
0.90	1.027	1.433	0.716 3	3.40	14.965	14.999	0.997 8
1.00	1.175	1.543	0.761 6	3.50	16.543	16.573	0.998 2
1.10	1.336	1.669	0.800 5	3.60	18.285	18.313	0.998 5
1.20	1.509	1.811	0.833 7	3.70	20.211	20.236	0.998 8
1.30	1.698	1.971	0.861 7	3.80	22.339	22.362	0.999 0
1.40	1.904	2.151	0.885 4	3.90	24.691	24.711	0.999 2
1.50	2.129	2.352	0.905 2	4.00	27.290	27.308	0.999 3
1.60	2.376	2.577	0.921 7	4.10	30.162	30.178	0.999 45
1.70	2.646	2.828	0.935 4	4.20	33.336	33.351	0.999 55
1.80	2.942	3.107	0.946 8	4.30	36.843	36.857	0.999 63
1.90	3.268	3.418	0.956 2	4.40	40.719	40.732	0.999 70
2.00	3.627	3.762	0.964 0	4.50	45.003	45.014	0.999 75
2.10	4.022	4.144	0.970 5	4.60	49.737	49.747	0.999 80
2.20	4.457	4.568	0.975 7	4.70	54.969	54.978	0.999 83
2.30	4.937	5.037	0.980 1	4.80	60.751	60.759	0.999 86
2.40	5.466	5.557	0.983 7	4.90	67.141	67.149	0.999 89
				5.00	74.203	74.210	0.999 91

SECTION 22 : LOG. SCALES AND LOG. SCALE INTERPOLATOR

(*i*) *Log scales* (*ii*) *Log scale interpolator.*

(i) Log scales

The exact (to 3 significant figures) relationship between the log. and linear scales are set out in Fig. 38.9. It will be seen that the approximation of Fig. 38.10 is very close and the error is negligible in comparison with ordinary graphical errors. To plot the approximate log. scale, use a decimal rule (inches or centimetres etc.) and mark 0.3, 0.6, 0.9 and 1.0 for each major division, and continue similarly. If linear graph paper is available, select values for 1 and 10 on the log. scale such that the linear scale is 10 or a convenient multiple of 10, then mark log. values as in Fig. 38.10.

See also Chapter 19 Sect. 1(xii) for decibels, slide rules and mental arithmetic.

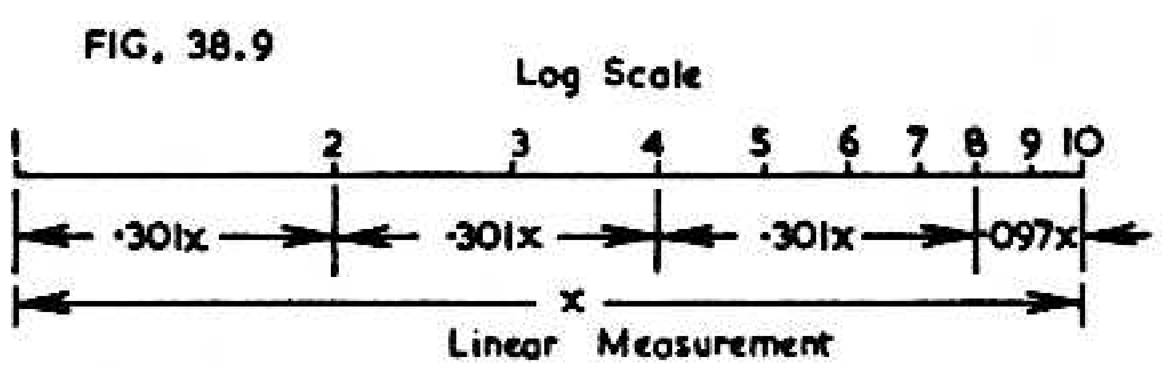

Fig. 38.9. *Log. and linear scales (exact).*

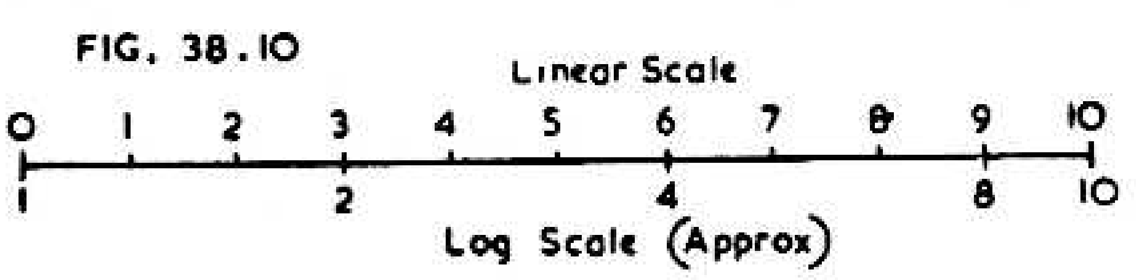

Fig. 38.10. *Log. and linear scales (approx.).*

(ii) Log. scale Interpolator

Often it is desired to know the exact value of a point on a logarithmic scale, when it does not come on one of the scale markings. In such a case, mark on a straight edge of paper the distance from the point to the next lower scale marking which is a multiple of 10, also marking the distance to the next higher marking which is a multiple of 10. The piece of paper with the three pencil marks should then be placed on the Log Scale Interpolator (see opposite page) so that the edge of the paper is roughly horizontal, and the two extreme points come exactly on the outer radial lines, the lower value to the left and the higher value to the right. The value of the point may then be read on the top scale, multiplied by the appropriate multiple of 10.

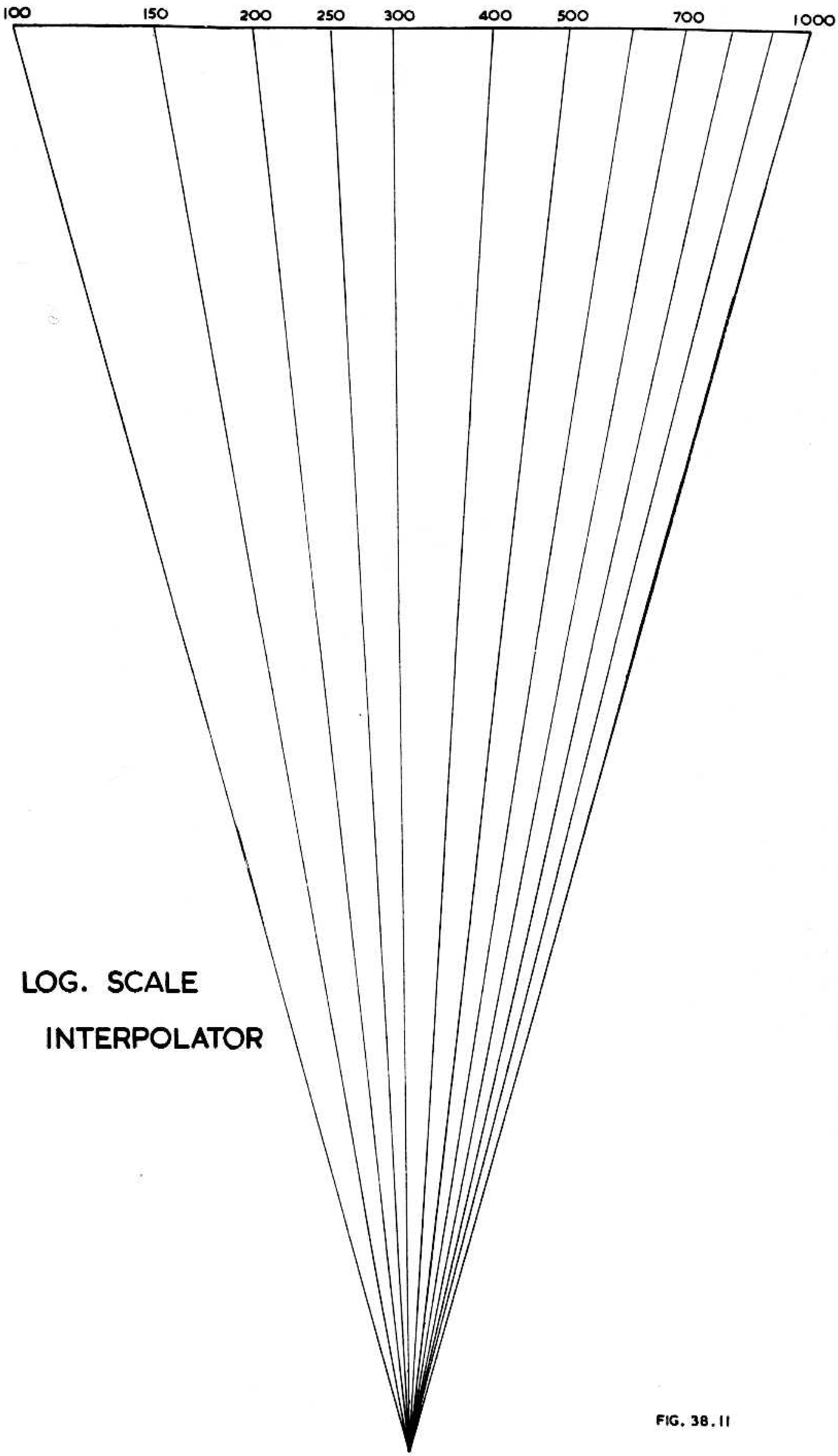

FIG. 38.11