RADIO MANUAL

CALLING MEN AT WAR

RADIO OPERATORS AND CIVILIAN RADIO ENGINEERS

A BROADCAST OF USEFUL DATA

TUNE IN FOR FORMULAS, CODES, DATA. LAWS, FACTS, TABLES, CHARTS, ETC.

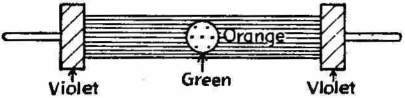
BERNARDS. 77, THE GRAMPIANS, WESTERN GATE, LONDON, W.6.

BRITISH COLOUR CODES

Resistances.

The colour of the body represents the first figure of the resistance value, and the colour of the tip or end band the second figure. The colour of the spot on tne centre band denotes the number of cyphers that follow the first two figures.

Colour	Figure	Colour	Figure
Black	0	Green	5
Brown	1	Blue	6
Red	2	Violet	7
Orange	3	Grey	8
Yellow	4	White	9



Example-; Orange body, Violet Tip and Green spot = 3,700,000 ohms resistance

WANDER PLUGS

Value	Colour
Highest + H.T.	Red
2nd highest + H.T.	Yellow
3rd highest + H.T.	Green
4th highest + H.T.	Blue
L.T. Positive	Pink
Negative (L.T.-, H.T.-, G.B.+,)	Black
Highest G.B.-	Brown
2nd highest G.B.-	Grey
3rd highest G.B.-	White

Any additional battery lead is Violet, and any centre tap is white.

FUSES

Value	Colour	Value	Colour
60 mA	Black	1 Amp	Dark Blue
100 mA	Grey	1·5 Amp	Light Blue
150 mA	Red	2 Amp	Purple
250 mA	Brown	3 Amp	White
500 mA	Yellow	5 Amp	Black&White
750 mA	Green		

FIXED CONDENSER LEADS

Value	Colour
Highest Capacity +'	Red
2nd highest Capacity +	Yellow
3rd " " +	Green
4th " " +	Blue
5th " " +	Violet
Principal Negative Lead	Black
2nd Negative "	Brown
3rd " "	Grey
Centre lead of Voltage doubler Condensers	White

When 2 capacities are of the same value, the one of the higher voltage rating has the higher colour in the table.

Common Positive junctions are marked	+
" Negative " " "	−
Series connections are marked	±
Unconnected sections are marked	&

Examples:—

8+8 – Two 8µF condensers with common positive lead
8−8 – " " " " negative "
8±8 – A series voltage doubler connection
8&8 – Two isolated 8µ F condensers.

MAINS TRANSFORMER LEADS

Primary Value	Colour
10 volt tapping	Black and Green
210 " "	Black and Yellow
230 " "	Black and Red
250 " "	Black and Brown
Zero "	Black

Secondaries Value	Colour
High tension ends	Red
" " centre tap	Red and Yellow
Rectifier heater ends	Green
" centre tap	Green and Yellow
Valve heater ends	Brown
" " centre tap	Brown and Yellow
Additional L.T winding ends	Blue
" " centre tap	Blue and Yellow
Earthing Lead	Bare Wire

FIXED CONDENSERS

COLOUR CODE FOR CAPACITY IN mmf

First Dot	Second Dot	Third Dot
Black = 0	Black = 0	
Brown = 1	Brown = 1	Brown = 0
Red = 2	Red = 2	Red = 00
Orange = 3	Orange = 3	Orange = 000
Yellow = 4	Yellow = 4	Yellow = 0000
Green = 5	Green = 5	Green = 00000
Blue = 6	Blue = 6	Blue = 000000
Purple = 7	Purple = 7	Purple = 0000000
Grey = 8	Grey = 8	Grey = 00000000
White = 9	White = 9	White = 000000000

Example :– 1st dot Green, 2nd dot Red, and 3rd dot Brown = 520 mmf capacity.

WAVELENGTH OF A TUNED CIRCUIT.

$W = 1884{\cdot}96\sqrt{L.C.}$ where L = inductance in microhenries, and C = capacity in microfarads.

FREQUENCY OF A TUNED CIRCUIT.

$f = \frac{10^6}{2\pi\sqrt{L.C.}}$ where f = frequency in cycles per second and, h and C have values as shown in the previous formula.

INDUCTANCE OF A COIL

$L = \pi^2 d^2 n^2 T K$ where L = inductance in microhenries, d = diameter of coil in cms, n = number of turn per cm, T = length of coil in cms, and K = a constant depending on ratio of diameter to length of coil.
Value for K given below.

d/T	K	d/T	K	d/T	K
·00	1·00	·8	·735	4·0	·365
·1	·959	·9	·711	5·0	·320
·2	·920	1·0	·688	6·0	·285
·3	·884	1·5	·595	7·0	·258
·4	·850	2·0	·526	8·0	·237
·5	·818	2·5	·472	9·0	·218
·6	·788	3·0	·429	10·0	·203
·7	·761				

VARIABLE CONDENSER CAPACITY

$C = \frac{.0885\ NS}{10^6\ d}$ Where N = number of moving vanes S = area of one moving vane in sq. cms, and d = thickness of air gap between fixed and moving vanes in cms.

REACTANCE OF A COIL

$R = 2\pi f h$ where f = frequency in c.p.s. and h = inductance in henrys.

REACTANCE OF A CONDENSER

$R = \frac{1}{2\pi f c}$ where f = frequency in c.p.s. and C = capacity in farads.

WAVELENGTH

$W = 1884\sqrt{LC}$ where W = metres, L = inductance in microhenries, C = capacity in microfarads. Also $W \times f = 3 \times 10^8$

LOW FREQUENCY AMPLIFICATION

The voltage stage gain of a L.F. transformer coupled-amplifier is approximately as follows

$$A = \mu \frac{N_2}{N_1} \times \frac{P}{\sqrt{P^2 \times R^2}}$$

Where μ = voltage gain of valve, N_2 = number of secondary turns of transformer, N_1 = number of primary turns of transformer, R = A.C. resistance of valve, and P = reactance of primary coil in ohms.

RESISTANCE COUPLED. L.F. AMPLIFICATION

Voltage stage gain of a resistance coupled L.F. amplifier is as follows.

$A = \mu \times \frac{R}{R+T}$ where μ = amplification factor of valve, R = external coupling resistance in Ohms. and T = A.C. resistance (impedance) of valve.

JELLY ELECTROLYTE FOR ACCUMULATORS

A fast setting mixture which jellifies in 10 minutes is prepared as follows:-
1 part pure sodium silicate of specific gravity 1·200 mixed with 3 parts of cold sulphuric acid of 1·400 specific gravity.

EUREKA RESISTANCE WIRE

S.W.G.	DIA in INCHES	TURNS per INCH D.S.C.	LENGTH per Ohm in inches	Ohms per yard.	Wt per 1000yds in lbs
16	·064	14·7	173·8	·21	37·2
18	·048	19·6	96·8	·37	20·93
20	·036	25·6	54·4	·66	11·77
22	·028	32·2	32·9	1·10	7·12
24	·022	40·0	20·3	1·77	4·392
26	·018	48·8	13·7	2·64	2·942
28	·014	57·8	9·2	3·91	1·989
30	·012	67	6·5	5·57	1·399
32	·010	75	4·9	7·35	1·059
34	·009	85	3·6	10·12	·768
36	·007	90	2·4	14·84	·525
38	·006	11·8	1·5	23·80	·327

BIAS RESISTANCE

Grid Leak Bias

$$V_g = I_g \times R_g \qquad R_g = \frac{V_g}{I_g} \qquad R_g = \frac{V_g - E}{I_g}$$

Where Rg = grid Leak resistance, Vg = bias voltage, Ig = d.c. grid current, and E = voltage of series battery

Cathode Bias

$$R_g = \frac{V_g}{A_g + A_s + A_a}$$

where Vg & Rg are as above, and Ag, As, and Aa are grid, screen, and anode currents respectively.

METER CONVERSIONS

To Extend Range of a Milliammeter

Shunt resistance $R_S = \frac{R_M}{n-1}$

To Extend Range of a Voltmeter

Series resistance $R_T = R_M \times (n-1)$

To use a Milliammeter as a Voltmeter

Series resistance $R_T = \frac{E}{I_M} - R_M$

Where n = factor by which it is desired to multiply the range of meter, R_M = resistance of meter, E = required voltage reading, and I_M = reading of current meter at full scale deflection.

SPECIFIC RESISTANCE

$R = \frac{TP}{A}$ Where T = specific resistance of a centimetre cube, P = length of wire in cm, A = cross sectional area of wire in sq cms, and R = the resistance of the wire at 0° C. If T is in Microhms R is in microhms; if T is in ohms, R is in ohms.

SPECIFIC RESISTANCES OF MATERIALS.

Material	Resistance in Microhms per c m cube.	Material	Resistance in Microhms per cm cube
Silver	1·47	Mercury	94·07
Copper	1·588	Manganin	46·7
Aluminium	2·665	Eureka	51·0
Iron	9·07	Nichrome	95·0
Platinium	10·92	Water	7×10^{16}
Tin	13·05	Mica	5×10^{22}
Lead	20·4	Glass	5×10^{24}

1 micrahm = ·000001 of an ohm

DECIBELS AND POWER RATIO

The Decibel is the comparative unit of sound strength. 1 decibel = the sound that can just be discerned by the human ear.

DECIBELS CONVERSION TABLE

DECIBELS	POWER RATIO	DECIBELS	POWER RATIO
1	1·25	−1	·8
2	1·6	−2	·625
3	2·0	−3	·5
4	2·5	−4	·4
5	3·2	−5	·3125
6	4·0	−6	·25
7	5·0	−7	·2
8	6·0	−8	·166
9	8·0	−9	·125
10	10·0	−10	·1
20	100·0	−20	·01
30	1000	−30	·001
40	10000	−40	·0001
50	100000	−50	·00001
60	1000000	−60	·000001

WAVELENGTH AND FREQUENCY TABLES.

To use these tables which give inductance capacity values for Radio Frequencies the following examples are shown :-

1. Given a tuned circuit total capacity ·0005 mfd and inductance 245 microhenries, what is the natural wavelength and frequency. Answer – the L.C.constant is·0005 X 245 = ·1225, therefore wavelength is 660 metres and frequency 454·5 Kilocycles.

2. What inductance is needed to tune a ·0005 mfd. condenser to 1900 metres. Answer – L.C. for 1900 metres = 1·016, therefore inductance is 1·016 divided by ·0005 which equels 2·032 microhenries.

3. A circuit with a natural frequency of 1250 Kc is required, the tuning coil inductance being 81 microhenries. What capacity should be connected across the coil.

Answer L.C. for 1250 Kc = ·01622 hence capacity is ·01622 ÷ by 81 which equals·0002 microfarads.

Wave Length	Frequency Kilocycles	L.C.	Wave Length	Frequency Kilocycles	L.C.
10	30000	·000028	540	555·6	·0821
15	20000	·000063	580	517·2	·0947
20	15000	·000112	620	483·9	·1082
30	10000	·000253	660	454·5	·1225
40	7500	·000450	700	428·6	·1378
50	6000	·00070	740	405·4	·1540
75	4000	·00158	780	384·6	·1712
100	3000	·00281	820	365·9	·1893
120	2500	·00405	860	348·8	·2052
140	2144	·00551	920	326·1	·2381
160	1875	·00720	960	312·5	·2595
180	1667	·00912	1000	300·0	·2816
200	1500	·01126	1100	272·7	·3404
220	1364	·01362	1200	250·0	·4052
240	1250	·01622	1300	230·8	·4757
260	1154	·01903	1400	214·3	·5518
280	1071	·02207	1500	200·0	·6335
300	1000	·02533	1600	187·5	·7204
340	882·4	·03255	1700	176·5	·8134
380	789·5	·04065	1800	166·7	·9120
420	714·3	·04966	1900	157·9	1·0160
460	652·2	·05960	2000	150·0	1·1260
500	600·0	·07040	2500	119·0	1·7600

OHMS LAW

Amperes = Volts ÷ Resistance

" = $\frac{\text{Watts}}{\text{Volts}}$ (Watts ÷ Volts)

" = $\sqrt{\text{Watts} \div \text{Resistance}}$

Volts = Resistance X Amperes

" = $\frac{\text{Watts}}{\text{Amperes}}$ (Watts ÷ Amperes)

" = $\sqrt{\text{Watts} \times \text{Resistance}}$

Watts = $(\text{Amperes})^2 \times \text{Resistance}$

" = $(\text{Volts})^2 \div \text{Resistance}$

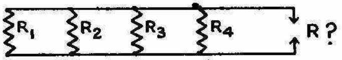
" = Amperes X Volts

Resistance = Volts ÷ Amperes

" = $(\text{Volts})^2 \div \text{Watts}$

" = $\text{Watts} \div (\text{Amperes})^2$

RESISTANCES IN PARALLEL



$$R = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} + \text{ETC.}$$

2 Parallel Resistances $R = (R_1 \times R_2) \div (R_1 + R_2)$

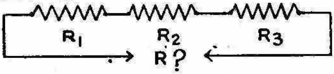
3 Parallel Resistances

$$R = \frac{R_1 \times R_2 \times R_3}{(R_1 \times R_2) + (R_2 \times R_3) + (R_3 \times R_1)}$$

4 Parallel Resistances

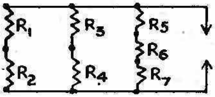
$$R = \frac{R_1 \times R_2 \times R_3 \times R_4}{(R_1 \times R_2 \times R_3) + (R_2 \times R_3 \times R_4) + (R_3 \times R_4 \times R_1) + (R_4 \times R_1 \times R_2)}$$

RESISTANCES IN SERIES.



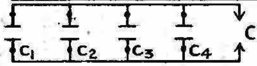
$$R = R_1 + R_2 + R_3 + \text{ETC.}$$

RESISTANCE IN SERIES-PARALLEL



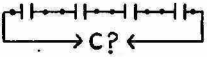
$$R = \frac{1}{\frac{1}{R_1+R_2} + \frac{1}{R_3+R_4} + \frac{1}{R_5+R_6+R_7}}$$

CONDENSERS IN PARALLEL



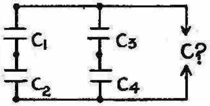
$C = C_1 + C_2 + C_3 + C_4 +$ ETC.

CONDENSERS IN SERIES



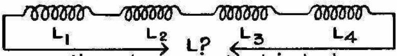
$C = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4} +$ ETC.

CONDENSERS IN SERIES-PARALLEL



$$C = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}} + \frac{1}{\frac{1}{C_3} + \frac{1}{C_4}}$$

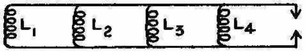
INDUCTANCES IN SERIES



Where there is no mutual inductance

$L = L_1 + L_2 +, L_3 + L_4 +$ ETC.

INDUCTANCES IN PARALLEL



$\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \frac{1}{L_4} +$ ETC.

COPPER WIRE TABLES

S.W.G.	DIA IN INCHES	RESISTANCE IN OHMS PER YD.	RESISTANCE IN OHMS PER LB.	LBS PER OHM	WEIGHT IN LBS PER 1000 YDS.	YARDS PER LB.	TURNS PER INCH				
							ENAMEL COVERED	S.S.C.	D.S.C.	S.C.C.	D.C.C.
28	·0148	·1398	70·12	·0141	1·980	503·0	61·4	60·4	56·2	48·1	40·2
29	·0136	·1655	98·65	·0101	1·680	596·6	66·2	65·2	60·2	51·0	42·4
30	·0124	·1991	142·75	·0069	1·396	716·6	73·3	70·0	67·1	54·4	44·7
31	·0116	·2275	185·80	·0054	1·222	820·0	77·8	76·3	70·9	56·8	46·3
32	·0108	·2625	248·20	·0040	1·059	943·3	83·0	81·3	75·2	63·3	50·5
33	·0100	·3061	337·50	·0029	·9081	1100	88·9	87·0	80·0	66·7	52·6
34	·0092	·3617	471·00	·0023	·7686	1300	98·0	93·4	85·5	70·4	54·9
35	·0084	·4338	676·50	·0014	·6408	1556	106	101	91·8	80·6	61·0
36	·0076	·5300	1009	·00098	·5254	1903	116	110	102	86·2	64·1
37	·0068	·6620	1574	·00064	·4199	2380	128	120	110	92·6	67·6
38	·0060	·8503	2598	·00038	·3269	3056	143	133	121	100	71·4
39	·0052	1·132	4645	·00022	·2456	4066	168	149	134	109	75·8
40	·0048	1·328	6360	·00016	·2092	4766	180	159	142		
41	·0044	1·581	9020	·00011	·1758	5700	194	169	150		
42	·0040	1·913	13150	·00008	·1453	6866	211	191	167		
43	·0036	2·362	20120	·00005	·1177	7560	230	206	179		
44	·0032	2·989	32210	·00003	·0929	10766	253	225	192		
45	·0028	3·904	54980	·00002	·0712	14066	282	247	208		

COPPER WIRE TABLES

S.W.G.	DIA IN INCHES	RESISTANCE IN OHMS PER YD	RESISTANCE IN OHMS PER LB.	LBS PER OHM	WEIGHT IN LBS PER 1000 YDS.	YARDS PER LB.	TURNS PER INCH				
							ENAMEL COVERED.	S.S.C.	D.S.C.	S.C.C.	D.C.C.
10	·128	·001868	·0120	83·30	148·8	6·67		7·64	7·55	7·35	7·04
11	·116	·002275	·0200	50·00	122·2	8·16		8·41	8·30	8·06	7·69
12	·104	·002831	·0280	35·70	98·22	10·23		9·35	9·22	8·93	8·48
13	·092	·003617	·0550	18·10	76·86	13·00		10·5	10·4	10·00	9·43
14	·080	·004784	·0820	12·20	58·12	17·16		12·1	11·8	11·4	10·6
15	·072	·005904	·1400	7·14	47·08	21·23		13·3	13·1	12·5	11·6
16	·064	·007478	·2021	4·95	37·2	26·86	15·0	14·9	14·6	14·1	13·2
17	·056	·009762	·3423	2·38	28·48	35·00	17·1	16·9	16·5	15·9	14·7
18	·048	·01328	·6351	1·56	20·92	47·66	19·8	20·0	19·4	18·5	17·2
19	·040	·01913	1·315	·757	14·53	68·66	23·7	23·8	23·0	21·7	20·0
20	·036	·02362	2·012	·497	11·77	85·0	26·1	29·4	25·3	23·8	21·7
21	·032	·02990	3·221	·309	9·299	107·6	29·4	28·4	28·2	26·3	23·8
22	·028	·03905	5·498	·181	7·120	140·6	33·3	33·3	31·8	29·4	26·3
23	·024	·05313	10·14	·098	5·231	191·6	38·8	38·5	36·4	33·3	29·4
24	·022	·06324	14·38	·069	4·395	228·3	42·1	42·1	40·0	35·7	31·3
25	·020	·07653	21·08	·0471	3·632	275·3	46·0	46·0	43·5	38·5	33·3
26	·018	·09448	32·21	·0309	2·942	340·0	50·6	50·6	47·6	41·7	35·7
27	·0164	·11138	46·55	·0215	2·442	410·0	55·1	55·1	51·6	44·6	37·9

MORSE AND INTERNATIONAL TELEGRAPH CODE SYMBOLS

LETTER	CODE SYMBOL	LETTER	CODE SYMBOL
A	•—	N	—•
B	—•••	O	———
C	—•—•	P	•——•
D	—••	Q	——•—
E	•	R	•—•
F	••—•	S	•••
G	——•	T	—
H	••••	U	••—
I	••	V	•••—
J	•———	W	•——
K	—•—	X	—••—
L	•—••	Y	—•——
M	——	Z	——••

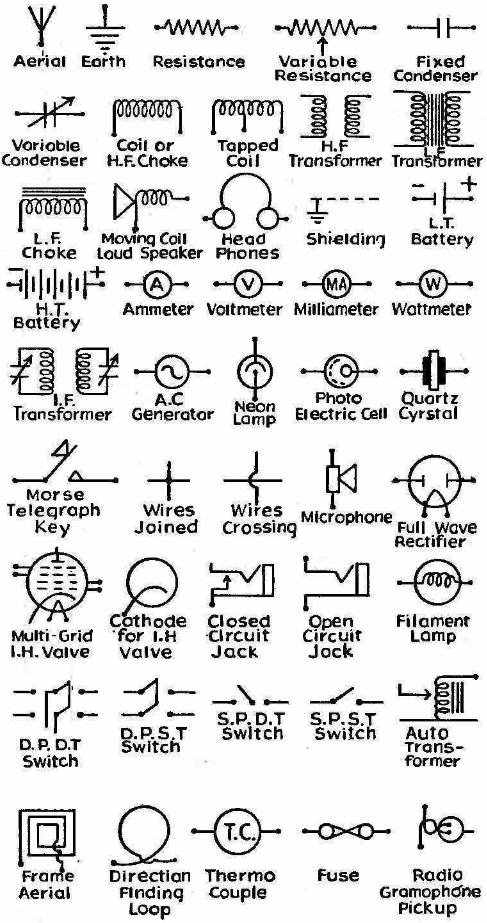
NUMBERS

NUMBER	CODE	NUMBER	CODE
1	•————	6	—••••
2	••———	7	——•••
3	•••——	8	———••
4	••••—	9	————•
5	•••••	0	—————

PUNCTUATION MARKS ETC.

PERIOD	•• •• ••
COMMA	•—•—•—
INTERROGATION	••——••
QUOTATION MARKS	•—••—•
EXCLAMATION	——••——
COLON	———•••
SEMICOLON	—•—•—•
PARENTHESIS	—•——•—
FRACTION BAR	—••—•
WAIT SIGN	•—•••
DOUBLE DASH (BREAK)	—•••—
ERROR (ERASE) SIGN	••••••••
END OF MESSAGE	•—•—•
END OF TRANSMISSION	•••—•—
INTERNATIONAL DISTRESS SIGNAL (S.O.S.)	•••———•••

THEORETICAL RADIO SYMBOLS



SAFE CURRENT CARRYING CAPACITY OF BARE COPPER WIRE

SWG	AMPS	SWG	AMPS	SWG	MILLIAMPS
10	35	26	1·0	42	50
12	28	28	·7	44	50
14	19	30	·5	45	25
16	13	32	·4	46	20
18	7	34	·25	47	12
20	4	56	·15	48	8
22	2·5	38	·1	49	5
24	1·5	40	·07	50	3

CAPACITY OF FIXED CONDENSERS.

$$C = \frac{\cdot 0885\ AP(n-1)}{d}$$

Reactance of a condenser $= \frac{1}{2\pi fC}$

Where :-

C = capacity in farads

A = area of overlap of plates in sq cms.

P = dielectric constant of separating material

n = number of metal plates

d = distance separating plates in cms

f = frequency in cycles per seconds

Dielectric constants of insulating materials commonly used.

Air = 1. Glass = 6·8 to 10. Mica = 5 to 7. Ebonite = 2·56 to 3·48. Shellac = 2·95 to 3·73. Fibre = 5·1 to 5·9. India rubber (Para) = 2·34. Paraffin Wax = 1·92 to 2·47. Vulcanised Rubber = 2·94.