THE
RADIO CONSTRUCTOR

Vol. 25 No. 11 JUNE 1972 20p

DIGITAL FREQUENCY MONITOR

The first part of a 2-part article describing a digital frequency monitor which may be coupled to a standard communications receiver. Operation up to 25 MHz and above.

Special IN THIS ISSUE

Inexpensive Interphone

Crystal Microphone Lead Extender

The largest selection

NEW LOW PRICE TESTED S.C.R.'s

PIV	1A TO-5	3A TO-66	7A TO-66	10A	16A TO-48	30A TO-48
	£p	£p	£p	£p	£p	£p
50	0·23	0·25	0·47	0·50	0·53	1·15
100	0·25	0·33	0·53	0·58	0·63	1·40
200	0·35	0·37	0·57	0·61	0·75	1·60
400	0·43	0·47	0·67	0·75	0·93	1·75
600	0·53	0·57	0·77	0·97	1·25	—
800	0·63	0·70	0·90	1·20	1·50	4·00

SIL. RECTS. TESTED

PIV	300mA	750mA	1A	1·5A	3A	10A	30A
	£p	£p	£p	£p	£p	£p	£p
50	0·40	0·05	0·05	0·07	0·14	0·21	0·47
100	0·04	0·06	0·05	0·13	0·16	0·23	0·75
200	0·05	0·09	0·06	0·14	0·20	0·24	1·00
400	0·06	0·12	0·07	0·20	0·27	0·37	1·25
600	0·07	0·16	0·10	0·23	0·34	0·45	1·85
800	0·10	0·17	0·13	0·25	0·37	0·55	2·00
1000	0·11	0·25	0·15	0·30	0·46	0·63	2·50
1200	—	0·33	—	0·33	0·57	0·76	—

TRIACS

VBOM	2A TO-1	6A TO-66	10A TO-88
	£p	£p	£p
100	30	50	75
200	50	60	90
400	70	75	1-10

FULL RANGE OF ZENER DIODES VOLTAGE RANGE 2-33V. 400mV (DO-7 Case) 13p ea. 1½W (Top-Hat) 18p ea. 10W (SO-10 Stud) 25p ea. All fully tested 5% tol. and marked. State voltage required.

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10 amp POTTED BRIDGE RECTIFIER on heat sink. 100 PIV. 90p each.

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MIXED ELECTRONIC COMPONENTS

Exceptionally good value

Resistors, capacitors, pots, electrolytics and coils plus many other useful items. Approximately 3lbs in weight. Price incl. P. & P. £1.50 only

Plus our satisfaction or money back guarantee.

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BC107/108 10p each; 50-99 9p; 100 up, 8p each; 1,000 off, 7p each. Fully-tested and coded TO-18 case.

FREE

One 50p Pak of your own choice free with orders valued £4 or over.

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2N2926 (Y) (O) 10 for 50p. 25 for £1 20,000 TO CLEAR

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Coded and Guaranteed

Pak No.		EQVT
T1	8 2G3713	OC71
T2	8 D1374	OC75
T3	8 D1216	OC81D
T4	8 2G381T	OC81
T5	8 2G382T	OC82
T6	8 2G344B	OC44
T7	8 2G345B	OC45
T8	8 2G378	OC78
T9	8 2G399A	2N1302
T10	8 2G417	AF117

All 50p each pak

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ORP12 43p
ORP60, ORP61 40p each

GENERAL PURPOSE NPN SILICON SWITCHING TRANS. TO-18 SIM. TO 2N706/8. BSY27/28/95A. All usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

£p			
20 For 0.50	100 For 1.75		
50 For 1.00	500 For 7.50		
	1000 For 18.00		

2N2060 NPN SIL. DUAL TRANS. CODE D1699 TEXAS. Our price 25p each.

PHOTO TRANS.

OCP71 Type. 43p

120 VCB NIXIE DRIVER TRANSISTOR. Sim. BSX21 & C407, 2N1893 FULLY TESTED AND CODED ND 120. 1-24 17p each. TO-5 N.P.N. 25 up 15p each.

SIL. G.P. DIODES £p

300mW 30 .. 0·50
40PIV(Min.) 100 .. 1·50
Sub-Min. 500 .. 5·00
Full Tested 1,000 .. 9·00
Ideal for Organ Builders.

Sil. trans. suitable for P.E. Organ. Metal TO-18 Eqvt. ZTX300 5p each. Any Qty.

D13D1 Silicon Unilateral switch 50p each.

A Silicon Planar, monolithic integrated circuit having thyristor electrical characteristics, but with an anode gate and a built-in "Zener" diode between gate and cathode. Full data and application circuits available on request.

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Plastic encapsulated 2 amp Bridge Rects.

50 v RMS 32p each
100 v RMS 37p each
400 v RMS 46p each

Size 15 mm x 6 mm

KING OF THE PAKS Unequalled Value and Quality

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U4	40 Germanium transistors like OC81, AC128	0.50
U5	60 200mA sub-min. Sil. diodes	0.50
U6	30 Silicon planar transistors NPN sim. BSY95A, 2N706	0.50
U7	16 Silicon rectifiers Top-Hat 750mA up to 1,000V	0.50
U8	50 Sil. planar diodes 250mA. 0A/200/202	0.50
U9	20 Mixed volts 1 watt Zener diodes	0.50
U11	25 PNP silicon planar transistors TO-5 sim. 2N1132	0.50
U13	30 PNP-NPN sil. transistors OC200 & 2S104	0.50
U14	150 Mixed silicon and germanium diodes	0.50
U15	25 NPN Silicon planar transistors TO-5 sim. 2N697	0.50
U16	10 3-Amp silicon rectifiers stud type up to 1000 PIV	0.50
U17	30 Germanium PNP AF transistors TO-5 like ACY 17-22	0.50
U18	8 6-Amp silicon rectifiers BYZ13 type up to 600 PIV	0.50
U19	25 Silicon NPN transistors like BC108	0.50
U20	12 1.5-Amp silicon rectifiers Top-Hat up to 1,000 PIV	0.50
U21	30 A.F. germanium alloy transistors 2G300 series & OC71	0.50
U23	30 Madt's like MAT series PNP transistors	0.50
U24	20 Germanium 1-Amp rectifiers GJM up to 300 PIV	0.50
U25	25 300Mc/s NPN silicon transistors 2N708, BSY27	0.50
U26	30 Fast switching silicon diodes like IN914 micro-min	0.50
U29	10 1-Amp SCR's TO-5 can up to 600 PIV CRS1/25-600	1.00
U31	20 Sil. Planar NPN trans. low noise amp 2N3707	0.50
U32	25 Zener diodes 400 mW D07 case mixed volts, 3-18	0.50
U33	15 Plastic case 1 amp silicon rectifiers 1N4000 series	0.50
U34	30 Sil. PNP alloy trans. TO-5 BCY26, 2S302/4	0.50
U35	25 Sil. planar trans. PNP TO-18 2N2906	0.50
U36	25 Sil. planar NPN trans. TO-5 BFY50/51/52	0.50
U37	30 Sil. alloy trans. SO-2 PNP, OC200 2S322	0.50
U38	20 Fast switching sil. trans. NPN, 400Mc/s 2N3011	0.50
U39	30 RF germ. PNP trans. 2N1303/5 TO-5	0.50
U40	10 Dual trans. 6 lead TO-5 2N2060	0.50
U41	25 RF germ. trans. TO-1 OC45 NKT72	0.50
U42	10 VHF germ. PNP trans. TO-1 NKT667 AF 117	0.50
U43	25 Sil. trans. plastic TO18 A.F. BC113/114	0.50
U44	20 Sil. trans. plastic TO-5 BC115/116	0.50
U45	7 3-Amp SCR's TO-66 case up to 600V	1.00

Code Nos. mentioned above are given as a guide to the type of device in the Pak. The devices themselves are normally unmarked.

POWER TRANSISTOR BONANZA!

GENERAL PURPOSE GERM. PNP

Coded GP100. BRAND NEW TO-3 CASE. POSS. REPLACE.:—OC25-28-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. T13027-3028. 2N250A. 2N456A-457A-458A. 2N511 A & B. 2G220-222. ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

PRICE	1-24	25-99	100 up
	43p each	40p each	38p each

AD161 *NPN*
AD162 *PNP*
M/P COMP GERM TRANS.
OUR LOWEST PRICE OF 55p *PER PAIR.*

SILICON High Voltage 250V NPN TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.

OUR PRICE EACH :

1-24	25-99	100 up
50p	45p	40p

2N3055
115 WATT SIL POWER NPN
50p EACH

SILICON 50 WATTS MATCHED NPN/PNP
BIP 19 NPN TO-3 Plastic.
BIP 20 PNP. Brand new.
VCBO 100/VCEO 50/IC 10A. HFE type 100/ft 3mHZ.
OUR PRICE PER PAIR :

1-24 prs.	25-99 prs.	100 prs.
60p	55p	50p

EX-STOCK TYPE EACH AS PRICED

OC20	50p	OC28	40p	AD149	43p	BD131	70p	BD139	75p
OC22	30p	OC29	40p	AL102	85p	BD132	80p	BD140	85p
OC23	33p	OC35	33p	AL103	85p	BD135	70p	BD155	75p
OC24	45p	OC36	40p	BD121	60p	BD136	80p	BU105	£3
OC25	25p	AD140	40p	BD123	75p	BD137	70p	2N3054	45p
OC26	25p	AD142	40p	BD124	70p	BD138	80p		

RTL MICROLOGIC CIRCUITS

Price each	1-24	25-99	100 up
Epoxy TO-5 case			
uL900 Buffer	35p	33p	27p
uL914 Dual 2I/p gate	35p	33p	27p
uL923 J-K flip-flop	50p	47p	45p

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Prof. Type No.	1-24	25-99	100 up
TSO14 pin type	30p	27p	25p
TSO16 pin type	35p	32p	30p
Low Cost No.			
BPS 14	15p	13p	11p
BPS 16	16p	14p	12p

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Pack	Description	Price £p
Q1	20 Red spot trans. PNP	0.50
Q2	16 White spot R.F. trans. PNP	0.50
Q3	4 OC77 type trans.	0.50
Q4	6 Matched trans. OC44/45/81/81D	0.50
Q5	4 OC75 transistors	0.50
Q6	4 OC72 transistors	0.50
Q7	4 AC128 trans. PNP high gain	0.50
Q8	4 AC126 trans. PNP	0.50
Q9	7 OC81 type trans.	0.50
Q10	7 OC71 type trans.	0.50
Q11	2 AC127/128 comp. pairs PNP/NPN	0.50
Q12	3 AF116 type trans.	0.50
Q13	3 AF117 type trans.	0.50
Q14	3 OC171 H.F. type trans.	0.50
Q15	5 2N2926 sil. epoxy trans.	0.50
Q16	2 GET880 low noise germ. trans.	0.50
Q17	3 NPN 1 ST141 & 2 ST140	0.50
Q18	4 Madt's 2 MAT 100 & 2 MAT 120	0.50
Q19	3 Madt's 2 MAT 101 & 1 MAT 121	0.50
Q20	4 OC44 germ. trans. A.F.	0.50
Q21	3 AC127 NPN germ. trans.	0.50
Q22	20 NKT trans. A.F. R.F. coded	0.50
Q23	10 OA202 sil. diodes sub-min.	0.50
Q24	8 OA81 diodes	0.50
Q25	6 IN914 sil. diodes 75PIV 75mA	0.50
Q26	8 OA95 germ. diodes sub-min. 1N69	0.50
Q27	2 10A 600PIV sil. rects. 1S45R	0.50
Q28	2 Sil. power rects. BYZ13	0.50
Q29	4 Sil. trans. 2 2N696, 1 2N697, 1 2N698	0.50
Q30	7 Sil. switch trans. 2N706 NPN	0.50
Q31	6 Sil. switch trans. 2N708 NPN	0.50
Q32	3 PNP sil. trans. 2 2N1131, 1 2N1132	0.50
Q33	3 Sil. NPN trans. 2N1711	0.50
Q34	7 Sil. NPN trans. 2N2369, 500MHZ	0.50
Q35	3 Sil. PNP TO-5 2 2N2904 & 1 2N2905	0.50
Q36	7 2N3646 TO-18 plastic 300MHZ NPN	0.50
Q37	3 2N3053 NPN sil. trans.	0.50
Q38	7 PNP trans. 4 2N3703, 3 2N3702	0.50
Q39	7 NPN trans. 4 2N3704, 3 2N3705	0.50
Q40	7 NPN amp. 4 2N3707, 2 3N3708	0.50
Q41	3 Plastic NPN TO-18 2N3904	0.50
Q42	6 NPN trans. 2N5172	0.50
Q43	7 BC107 NPN trans.	0.50
Q44	7 NPN trans. 4 BC108, 3 BC109	0.50
Q45	3 BC113 NPN TO-18 trans.	0.50
Q46	3 BC115 NPN TO-5 trans.	0.50
Q47	6 NPN high gain 3 BC167, 3 BC168	0.50
Q48	4 BCY70 NPN trans. TO-18	0.50
Q49	4 NPN trans. 2 BFY51, 2 BFY52	0.50
Q50	7 BSY28 NPN switch TO-18	0.50
Q51	7 BSY95A NPN trans. 300MHZ	0.50
Q52	8 BY100 type sil. rect.	1.00
Q53	25 Sil. & germ. trans. mixed all marked new	1.50

PRINTED CIRCUITS—EX-COMPUTER

Packed with semiconductors and components. 10 boards give a guaranteed 30 trans and 30 diodes. Our price 10 boards, 50p. Plus 10p P. & P. 100 Boards £3. P. & P. 30p.

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Qty.	1-24	25-99	100 up
Price each	45p	40p	35p

F.E.T.'S

2N3819	35p
2N3820	50p
2N3821	35p
2N3823	30p
2N5458	50p
2N5459	40p
BFW 10	40p
MPF105	40p

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TRANSISTOR EQUIVALENTS BOOK. A complete cross reference and equivalents book for European, American and Japanese Transistors. Exclusive to BI-PAK 90p each. Red cover edition.

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Check our 74 Series List before you buy any I.C's. Our prices are the lowest possible. All devices ex-stock. Full spec. guaranteed

BI-PAK Order No.	Price and qty. prices 1-24 £p	25-99 £p	100 up £p
BP00 = SN7400	0·15	0·14	0·12
BP01 = SN7401	0·15	0·14	0·12
BP02 = SN7402	0·15	0·14	0·12
BP03 = SN7403	0·15	0·14	0·12
BP04 = SN7404	0·15	0·14	0·12
BP05 = SN7405	0·15	0·14	0·12
BP07 = SN7407	0·18	0·17	0·16
BP08 = SN7408	0·18	0·17	0·16
BP09 = SN7409	0·18	0·17	0·16
BP10 = SN7410	0·15	0·14	0·12
BP13 = SN7413	0·29	0·26	0·24
BP16 = SN7416	0·43	0·40	0·38
BP17 = SN7417	0·43	0·40	0·38
BP20 = SN7420	0·15	0·14	0·12
BP30 = SN7430	0·15	0·14	0·12
BP40 = SN7440	0·15	0·14	0·12
BP41 = SN7441	0·67	0·64	0·58
BP42 = SN7442	0·67	0·64	0·58
BP43 = SN7443	1·95	1·85	1·75
BP44 = SN7444	1·95	1·85	1·75
BP45 = SN7445	1·95	1·85	1·75
BP46 = SN7446	0·97	0·94	0·88
BP47 = SN7447	0·97	0·94	0·88
BP48 = SN7448	0·97	0·94	0·88
BP50 = SN7450	0·15	0·14	0·12
BP51 = SN7451	0·15	0·14	0·12
BP53 = SN7453	0·15	0·14	0·12
BP54 = SN7454	0·15	0·14	0·12
BP60 = SN7460	0·15	0·14	0·12
BP70 = SN7470	0·29	0·26	0·24
BP72 = SN7472	0·29	0·26	0·24
BP73 = SN7473	0·37	0·35	0·32
BP74 = SN7474	0·37	0·35	0·32
BP75 = SN7475	0·47	0·45	0·42
BP76 = SN7476	0·43	0·40	0·38
BP80 = SN7480	0·67	0·64	0·58
BP81 = SN7481	0·97	0·94	0·88
BP82 = SN7482	0·97	0·94	0·88
BP83 = SN7483	1·10	1·05	0·95

BI-PAK Order No.	Price and qty. prices 1-24 £p	25-99 £p	100 up £p
BP86 = SN7486	0·32	0·30	0·28
BP90 = SN7490	0·67	0·64	0·58
BP91 = SN7491AN	0·87	0·84	0·78
BP92 = SN7492	0·67	0·64	0·58
BP93 = SN7493	0·67	0·64	0·58
BP94 = SN7494	0·77	0·74	0·68
BP95 = SN7495	0·77	0·74	0·68
BP96 = SN7496	0·77	0·74	0·68
BP100 = SN74100	1·75	1·65	1·55
BP104 = SN74104	0·97	0·94	0·88
BP105 = SN74105	0·97	0·94	0·88
BP107 = SN74107	0·40	0·38	0·36
BP110 = SN74110	0·55	0·53	0·50
BP111 = SN74111	1·25	1·15	1·00
BP118 = SN74118	1·00	0·95	0·90
BP119 = SN74119	1·35	1·25	1·10
BP121 = SN74121	0·67	0·64	0·58
BP141 = SN74141	0·67	0·64	0·58
BP145 = SN74145	1·50	1·40	1·30
BP150 = SN74150	1·80	1·70	1·60
BP151 = SN74151	1·00	0·95	0·90
BP153 = SN74153	1·20	1·10	0·95
BP154 = SN74154	1·80	1·70	1·60
BP155 = SN74155	1·40	1·30	1·20
BP156 = SN74156	1·40	1·30	1·20
BP160 = SN74160	1·80	1·70	1·60
BP161 = SN74161	1·80	1·70	1·60
BP164 = SN74164	2·00	1·90	1·80
BP165 = SN74165	2·00	1·90	1·80
BP181 = SN74181	2·75	2·60	2·40
BP182 = SN74182	0·97	0·94	0·88
BP190 = SN74190	3·50	3·25	3·00
BP191 = SN74191	3·50	3·25	3·00
BP192 = SN74192	2·10	1·95	1·75
BP193 = SN74193	2·10	1·95	1·75
BP195 = SN74195	1·10	1·05	0·95
BP196 = SN74196	1·80	1·70	1·60
BP197 = SN74197	1·80	1·70	1·60
BP198 = SN74198	5·50	5·00	4·00
BP199 = SN74199	5·50	5·00	4·00

PRICE-MIX. Devices may be mixed to qualify for quantity prices.
PRICES for quantities in excess of 500 pieces mixed, on application.
Owing to the ever increasing range of TTL 74 Series, please check with us for supplies of any devices not listed above, as it is probably now in stock. WARE 3442.

LINEAR I.C's— FULL SPEC.

Type No.	Price 1-24	25-99	100 up
BP 201C—SL201C	63p	53p	45p
BP 701C—SL701C	63p	50p	45p
BP 702C—SL702C	63p	50p	45p
BP 702—72702	53p	45p	40p
BP 709—72709	53p	45p	40p
BP 709P—μA709C	53p	45p	40p
BP 710—72710	53p	45p	40p
BP 711—μA711	58p	50p	45p
BP 741—72741	75p	60p	50p
μA 703C—μA703C	43p	35p	27p
TAA 263—	70p	60p	55p
TAA 293—	90p	75p	70p
TAA 350	170p	158p	150p

LOGIC DTL 930 SERIES I.C's

ROCK BOTTOM PRICES

Type No.	Price 1-24	25-99	100 up
BP930	12p	11p	10p
BP932	13p	12p	11p
BP933	13p	12p	11p
BP935	13p	12p	11p
BP936	13p	12p	11p
BP944	13p	12p	11p
BP945	25p	24p	22p
BP946	12p	11p	10p
BP948	25p	24p	22p
BP951	65p	60p	55p
BP962	12p	11p	10p
BP9093	40p	38p	35p
BP9094	40p	38p	35p
BP9097	40p	38p	35p
BP9099	40p	38p	35p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only).

NUMERICAL INDICATOR TUBES

MODEL	CD66	GR 116	3015F
Anode voltage (Vdc)	170 min	175 min	5
Cathode cur'nt(mA)	2.3	14	
Numeral h'ght (mm)	16	13	9
Tube height (mm)	47	32	22
Tube diameter (mm)	19	13	12
I.C. driver rec.	BP41 or 141	BP41 or 141	BP47
PRICE EACH	£1.70	£1.55	£1.90

All indicators 0.9 + Decimal point: All side viewing: Full data for all types available on request.

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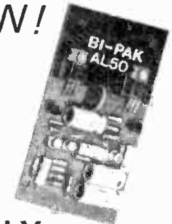

0.1% DISTORTION
HI-FI AUDIO AMPLIFIER
THE AL50

- ★ Frequency response 15Hz to 100,000 - 1dB.
- ★ Load - 3, 4, 8 or 16 ohms.
- ★ Distortion - better than .1% at 1KHz.
- ★ Signal to noise ratio 80dB.

ONLY **£3.25p** each

- ★ Supply voltage 10 - 35 Volts.
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Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry and ALSO was conceived to fill the need for all your A.F. amplification needs. FULLY BUILT - TESTED - GUARANTEED.

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AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (rms) per channel, simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1.5 amps at 35 volts. Size 63mm x 105mm x 30mm.
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TRANSFORMER BMT80 £1.95 p & p 25p.
SPECIAL COMPLETE KIT COMPRISING 2, AL50's, 1, SPM80 & 1, BMT80 ONLY £11, FREE p & p

DTL & TTL INTEGRATED CIRCUITS

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UIC13 = 8 × 7413N	50p	UIC60 = 12 × 7460N	50p	UIC93 = 5 × 7493N	50p
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THE Radio Constructor

Incorporating THE RADIO AMATEUR

JUNE 1972

Vol. 25 No. 11

Published Monthly (1st of Month)
First Published 1947

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9 1SN

Telephone 01-286 6141

Telegrams Databux, London

Annual Subscription: £2.70 (U.S.A. and Canada $7.00) including postage. Remittances should be made payable to "Data Publications Ltd". Overseas readers please pay by cheque or International Money Order.

Technical Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. We regret that such queries cannot be answered over the telephone; they must be submitted in writing and accompanied by a stamped addressed envelope for reply.

Correspondence should be addressed to the Editor, Advertising Manager, Subscription Manager or the Publishers as appropriate.

Opinions expressed by contributors are not necessarily those of the Editor or proprietors.

Production.—Web Offset.

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Published in Great Britain by the Proprietors and Publishers, Data Publications Ltd, 57 Maida Vale, London, W9 1SN

The *Radio Constructor* is printed by Carlisle Web Offset.

JULY ISSUE WILL BE PUBLISHED ON JULY 1st

DIRECT VOLTAGE CALIBRATOR

by
J. K. Owen

A comprehensive instrument which provides check voltages from 1 to 250.

SO FAR AS RADIO RECEIVERS, AMPLIFIERS (A.F. AND r.f.) and their so-called ancillaries – pre-amplifiers, tone controls, power supply units, etc. – are concerned, the advantages of 'rolling your own' are manifest and mainly self-evident. (The title of this magazine is one such piece of evidence.) To a slightly lesser degree, this also applies to the construction of test gear, though here the deterrent factor is the final calibration. Almost certainly, the most useful, and therefore most overworked, item of test gear is the multi-meter.

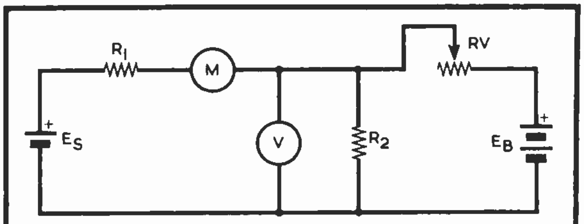
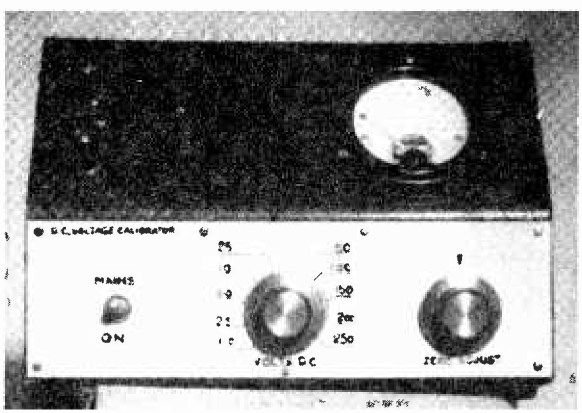


Fig. 1. The basic voltmeter calibration circuit

LOSS OF CALIBRATION

Good commercial multi-meters are plentiful – at a price – and have a stated (and guaranteed) tolerance of accuracy, while over the past few years several less expensive but still very useful models have become available. However, even the best of multi-meters, after being subjected to prolonged use (including some mis-use!) will tend to lose their original calibration. The writer well recalls an occasion when, having noted with complete disbelief a particular voltmeter reading and deciding to check against another meter, was then so struck with the difference between the readings that he decided to pursue the matter further. The end result was an impressive array of six multi-meters, some commercial and some 'hand rolled', all telling a significantly different story and with very little clue as to which was the one which could be believed.



The finished calibration unit. The meter and the two voltmeter terminals are mounted on a sloping front panel

On that day, an idea which had been lurking around the back of the author's mind for a long time began to take shape, and the direct voltage calibrator which forms the subject of this article was the result.

A voltmeter can be calibrated in a number of ways, depending upon the resources available. In a large factory, for instance, the run-of-the-mill test-meters would be checked periodically against a 'standard' kept for this purpose. This itself would be checked against a sub-standard, a highly refined and very accurate piece of equipment, second only to the National Physical Laboratory Standard, to which this might also be sent for periodical calibration and certification. Another method entails the use of a standard cell, this being a special type of primary cell with a very stable e.m.f. This (again at a price) is supplied with an accurate calibration which, provided no current is drawn, can be relied on for some years. Techniques exist, although the complete set-up is far from simple, to utilize this type of cell, which might have an e.m.f. of around 1.3 volt, to calibrate a meter throughout the whole range.

Yet another method is by direct comparison with a known(?) meter, or even by the use of new and (it is hoped!) fresh batteries. Finally – and this is the method used here – if a number of stable and accurately known voltages are available, the meter can be applied direct to these (exercising certain precautions) and any

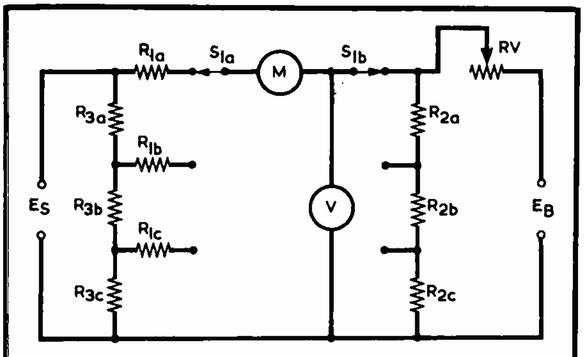


Fig. 2. A development from Fig. 1 which provides three calibration voltages

differences noted. The precautions are to ensure that the voltmeter draws no current from the calibrating voltage, because any current, no matter how small, would affect the accuracy. Fig 1 shows how this is achieved. The standard voltage Es is applied, in series with R1 and microammeter M across the resistor R2. The voltmeter V to be calibrated is also connected across R2, and the variable resistor RV is adjusted until the microammeter reads zero.

The voltage across R2 is then equal to the voltage Es. The resistor R1 is included to limit the out-of-balance current to a safe maximum. Fig 2 gives a practical circuit with three ranges. Es is now no longer a standard cell, but a stabilized voltage which can be derived from the mains. R3a, b and c are accurate resistors which form a potentiometer across Es. The tapping points A, B and C are thus known and, when RV is adjusted as before for zero current through M, the voltage across V is then equal to that at either A, B or C, depending on the position of the switch S1.

COMPLETE CIRCUIT

Fig. 3 gives the complete circuit. Here a standard 275–0–275 volt transformer provides both the stabilised reference e.m.f. and also the 'backing-off' supply.

The stabilisation is provided by two voltage regulators type VR150/30 connected in series, and is therefore nominally 300 volts.

This stabilised voltage is applied via R2 and RV1 across the potentiometer chain R5a–R14a. RV1 is the calibration control, and is used in the initial setting-up procedure and then locked.

The potentiometer delivers 10 'standard' ranges, from 1 volt to 250 volts, and is matched on the other side of the power supply circuit by an identical chain so that at each switch position the zero indicator M1 (a 50 μA meter) is nominally in balance. Since the voltmeter being calibrated is connected across the 'backing-off' supply chain, the voltage across the latter will be affected by the resistance of the meter, hence the

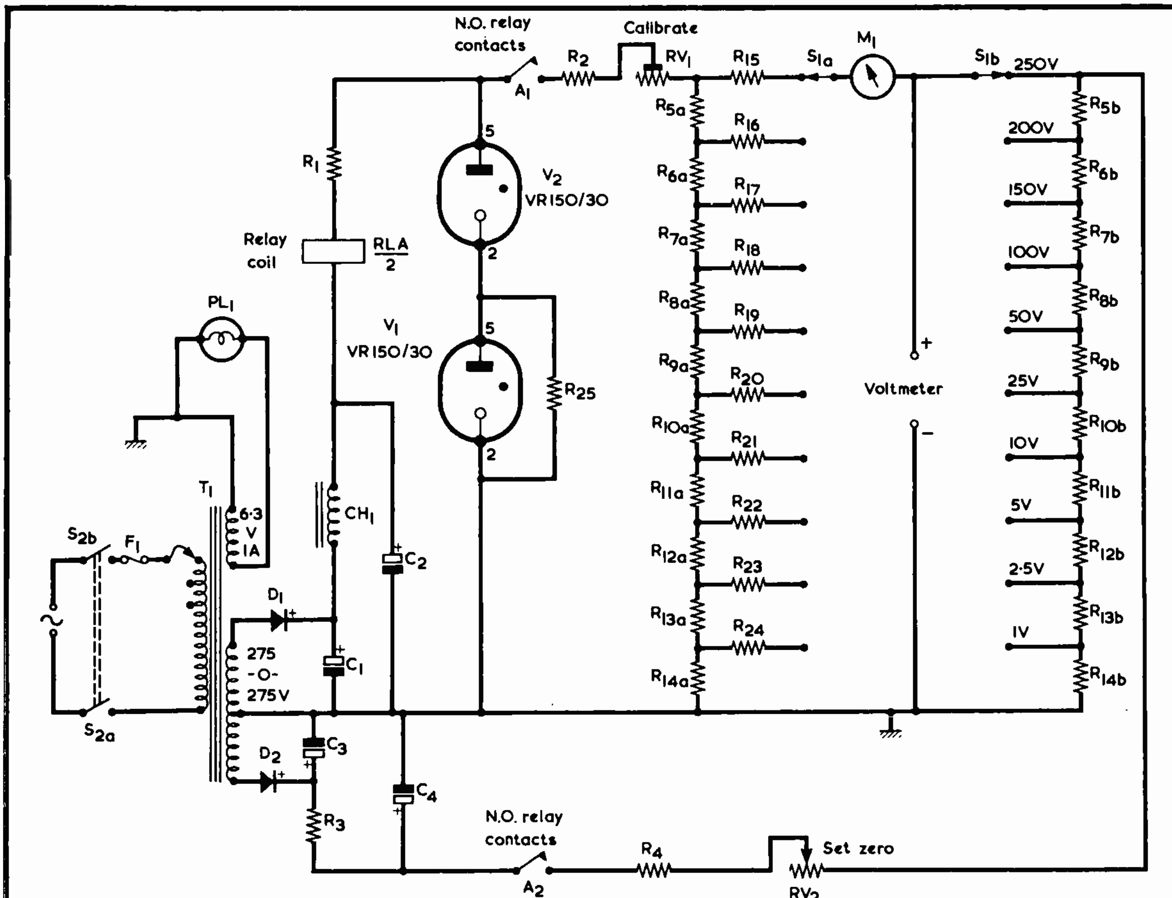


Fig. 3. Complete circuit diagram for the voltage calibration unit

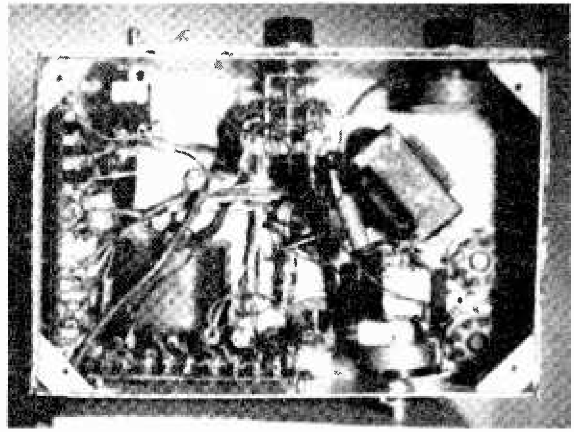
necessity for RV2, the 'zero adjust' control. Returning to the stabilisation circuit, the voltage regulators used, namely VR150/30's, have a nominal regulated voltage of 150, with a striking voltage of 180. The regulation holds over a range of from 5 to 40 mA. For the two in series, this means that a minimum voltage of 360 is required before the tubes 'strike'. This would normally necessitate the use of a 350–0–350 volt transformer, which of course is quite feasible, but is very bulky and considerably more expensive than the 275–0–275 volt component specified. The use of the present transformer is possible because of the inclusion of the relay coil, $\frac{RLA}{2}$, in the regulator circuit. Relay RLA is a relay with two normally-open contacts (in the author's unit the contacts are changeover connected as normally-open) which serve to disconnect the load from the regulator tubes until they have 'fired'. Under no-load condition, the rectified voltage would rise to 1.414 times 275 volts, or close on 390 volts. However, at around 360 volts the tubes 'fire' and the resulting current energises the relay, closing contacts A1 and A2, which in turn connect the loads to the respective supplies. (When two stabiliser tubes are in series it is desirable to connect a high-value resistor across one of them, and the presence of R25 across VR1 may cause VR2 to initially 'fire', followed by VR1, at a lower applied voltage than the figure just mentioned).

Relay contacts A2 are incorporated in the 'backing-off' supply to prevent the gross meter imbalance which would be present, both on switch-on and switch-off, if the 'backing-off' supply was connected while the other side of the 'zero' meter was at chassis potential, due to contacts A1 being open. In practice both the closing and opening of the relay take place with a very definite 'snap' so that the supplies are applied to or removed from both potentiometer chains at exactly the same time. Further protection of the meter is provided by the series current limiting resistors R15 to R24.

The potentiometer chain R5a to R14a is the heart of the instrument, and the accuracy obtainable depends entirely on the accuracy of the resistors used. The values have been chosen so that they can all be obtained in the standard 1% tolerance range, either direct or in series or parallel combinations. If a bridge is available, together with a plentiful supply of resistors, selection can be made from a wider tolerance (and therefore cheaper) range. It is not then necessary to adhere to the exact values quoted, so long as the ratios are precise. For instance, if the 1 volt resistor, instead of being 50Ω, was say 51Ω, the 2.5 volt one would then need to be 76.5Ω instead of 75Ω and so on.

It is not advisable to depart too far from the nominal values, however, as the amount of current drawn from the regulator tubes depends of course upon the value of the load. With the values specified, the total current (in the stabilized half of the supply) is approximately 34 mA, which divides as 14 mA through the tubes and 20 mA in the potentiometer chain.

The table lists the complete chain of resistors, showing in the third column how these may be made up, where necessary, from either series or parallel combinations. The fourth column gives the *total* wattage necessary for each resistor so that if, for instance, a particular value is made up from two others of equal value, either in series or in parallel, then the individual resistors making up that value need only be half that



The under-chassis components in the author's unit. The resistor chains are wired on the tag-boards at the rear and at the side. The sockets for the regulator tubes may be seen adjacent to RV1

wattage. All the resistors listed in the third column are available from Home Radio in the Cat. No. R12 series of ½ watt 1% high stability resistors.

The corresponding chain of resistors, R5(b) to R14(b), in the 'backing-off' supply is nominally identical to the standard chain. Any discrepancy here, however, has no effect on the accuracy – it merely necessitates a re-adjustment of the 'zero adjust' control – so that, provided the discrepancy falls within the range of the control, the requirements are not so stringent. It is still advisable to be as accurate as possible, however, if only to avoid the distraction of a violently swinging zero meter when switching from one range to another. Either 1% or 2% resistors could be used for this chain. All the remaining fixed resistors except R15 to R25 should be 5%. R15 to R25 may be 10%.

COMPONENTS

The other components are all standard types. The mains transformer specified has two 6.3 volt windings in addition to the 275–0–275 volt h.t. winding. One of these 6.3 volt windings supplies a pilot lamp and the other is not connected into circuit.

Variable resistor RV2 is a wirewound potentiometer which is mounted on the front panel of the calibrator and is fitted with a knob. RV1 is a pre-set panel-

TABLE

Showing method of obtaining values in R5 to R14 by either parallel (×) or series (+) combinations of available types.

R5	2.5kΩ	2 × 5kΩ	1 watt
R6	2.5kΩ	2 × 5kΩ	1 watt
R7	2.5kΩ	2 × 5kΩ	1 watt
R8	2.5kΩ	2 × 5kΩ	1 watt
R9	1.25kΩ	750Ω + 500Ω	½ watt
R10	750Ω	Direct	½ watt
R11	250Ω	2 × 500Ω	½ watt
R12	125Ω	82Ω + 43Ω	½ watt
R13	75Ω	2 × 150Ω	½ watt
R14	50Ω	Direct	½ watt

COMPONENTS

Resistors
(All fixed values ½ watt unless otherwise stated. See text for tolerances.)

R1	See text
R2	2.2kΩ 2 watts
R3	2.4kΩ 2 watts
R4	1.5kΩ 2 watts
R5(a), R5(b)	2.5kΩ 1 watt
R6(a), R6(b)	2.5kΩ 1 watt
R7(a), R7(b)	2.5kΩ 1 watt
R8(a), R8(b)	2.5kΩ 1 watt
R9(a), R9(b)	1.25kΩ
R10(a), R10(b)	750Ω
R11(a), R11(b)	250Ω
R12(a), R12(b)	125Ω
R13(a), R13(b)	75Ω
R14(a), R14(b)	50Ω
R15	560kΩ
R16	430kΩ
R17	330kΩ
R18	220kΩ
R19	100kΩ
R20	56kΩ
R21	22kΩ
R22	10kΩ
R23	5.6kΩ
R24	2.2kΩ
R25	470kΩ
RV1	2kΩ wirewound potentiometer, pre-set
RV2	2kΩ wirewound potentiometer
Capacitors	
C1, C2	32 + 32μF, dual electrolytic, 450 V. Wkg.
C3, C4	32 + 32μF, dual electrolytic, 450 V. Wkg.

Transformers	
T1	Mains transformer, secondaries 275–0–275V 90mA, 6.3V 1.55A 6.3V 1A. Cat. No. TM27E (Home Radio)
CH1	10H l.f. choke (see text)
Rectifiers	
D1	BY127
D2	BY127
Regulator Tubes	
V1	VR150/30
V2	VR150/30
Meter	
M1	0–50μA or 50–0–50μA moving-coil (see text)
Switches	
S1	2-pole 10-way, Yaxley
S2	d.p.s.t., toggle
Fuse	
F1	1A cartridge fuse
Relay	
RLA	See text
Pilot Lamp	
PL1	6.3V 0.3A, m.e.s.

Sockets, etc.
2 Octal valveholders
1 fuseholder
1 m.e.s. bulbholder, panel-mounting, with lens
2 terminals

Miscellaneous
2 pointer knobs
Tagboards, as required
Material for chassis and case

mounting potentiometer of the type which has a screwdriver slot on its spindle for adjustment. In the author's unit this potentiometer was mounted at the rear of the chassis and was fitted with a spindle clamp to lock it after it had been adjusted. It may alternatively be mounted inside the chassis, the main requirement being that its setting cannot be accidentally disturbed after initial adjustments.

The choke, CH1, should have an inductance of 10H or more and be capable of passing a current of at least 35mA. The relay should have robust contacts, a coil resistance around 700Ω and be capable of energising reliably at 35mA. Suitable relays are readily available, a typical example being the 700Ω Cat. No. WS162 relay from Home Radio which has two changeover contacts. It is necessary for the total resistance inserted by the choke, the relay coil and R1 in series to be equal to approximately 1,340Ω and this was achieved in the prototype by using a choke with a resistance of 400Ω, a relay with a coil resistance of 670Ω and a value of R1 of 270Ω. The value of R1 may be adjusted to suit the resistances of the choke and relay coil employed. Suitable chokes meeting the inductance and current requirements just mentioned are available through the usual retail channels, but catalogues do not always specify resistance, whereupon this will have to be measured with the actual component obtained. R1 should have a rating of 1 watt.

The meter employed in the prototype was a 0–50μA type. Since its function is to provide a zero indication, some constructors may prefer to employ a 50–0–50μA centre-zero meter.

As far as the layout and construction are concerned, there is nothing critical. The photographs show the layout adopted in the original but this can, of course, be varied to suit the individual.

CALIBRATION

The calibration requires an accurate voltmeter which, switched to an appropriate d.c. range – preferably 250 volts – is connected to the calibrator terminals. The calibrator is set to the same range and switched on. The 'zero adjust' control is then varied to zero the 50μA meter, and the reading on the voltmeter noted. Should this differ from 250 volts (or whichever range is selected) the calibrating resistor RV1 is adjusted until the voltmeter reading agrees with the range selected, and the microammeter zeroed once more. It may be necessary to repeat these adjustments a few times until, with the microammeter correctly zeroed, the voltmeter reading is also correct. No further adjustments are necessary and the calibrator is then ready for use.

In use, of course, the voltmeter to be checked is connected to the terminals, the calibrator is switched to the desired range, and the microammeter zeroed. If the voltmeter is accurate, it should now read the same as the figure indicated by the range switch. ■

NEWS . . . AND .

UNION CASTLE SPECIFY ELECTRONIC AVOMETER

On today's luxury liners, the radio equipment comprises sophisticated electronic instrumentation and demands equally sophisticated test equipment. Here, a radio officer on board the Union Castle ship 'Edinburgh Castle' carries out checks on the ship's radar using the Electronic Avometer type EA 113. The Union Castle Line say that its equipment demands the use of a multimeter with outstanding features of the EA 113 and these have recently been purchased in quantity for use on their entire fleet.

LOAD CELL

An interesting news story to hand concerns a special load cell which has been developed by Transducers (C.E.L.) Limited of Trafford Road, Reading, RG1 8JH, for use in nuclear power stations.

Of the many operations that need to be undertaken to ensure the efficient functioning of a nuclear power station, one of the most important is that of replenishing the nuclear reactor core with fresh fuel elements. When they are spent, these elements (in the form of 30ft. long stacks suspended below a shield plug and gag unit) are extracted from the core by means of a specially designed grab and hoist which is housed inside the shielded pressure vessel of the Refuelling Machine. The grab is positioned very accurately over a particular point, whereupon it is lowered and attached to the head of the fuel assembly. The assembly is then extracted and a new assembly is lowered into its place.

It is essential that any possibility of a fuel assembly jamming during such a raising and lowering operation must be avoided at all costs. To ensure such safety, a special hoist system has been developed by Strachen and Henshaw Ltd., the Bristol-based designers and manufacturers of fuel handling equipment for the nuclear power industry, and an essential feature of this hoist is a highly accurate and reliable electronic weighing system.

This system, which employs load cells specially developed by Transducers (C.E.L.) Ltd. in collaboration with Strachen and Henshaw, determines the rate of change of load as well as monitoring and recording its actual change. By this means a fast and sensitive indication of malfunctioning is provided, ensuring that if anything does go wrong there is sufficient time for the hoist to respond in the correct manner. A trip mechanism is incorporated into the system so that, should the absolute load vary by more than a preset amount, the refuelling hoist is automatically stopped and alarms are raised.

An important feature of the particular load cell being used is its ability to withstand comparatively arduous conditions in particularly high temperatures. Because it is mounted just above the fuel assembly (and not at the top of the chain that supports the assembly, which arrangement would introduce misleading load variations) it has to withstand the hostile environment of the nuclear reactor containment.

At present, several nuclear power stations in the U.K. are being supplied with this hoist equipment. The latest of these are the Hinkley Point 'B' and Hunterston 'B' installations, which are being built by the Nuclear Power Group Ltd. for the Central Electricity Generating Board's Midland Project Group and for the South of Scotland Electricity Board respectively.

RADAR MONITORS BABY'S BREATHING

While testing his firm's radar burglar alarm, John Bloice noticed that even if he kept perfectly still, the detector picked up a small signal – in time with his breathing. He realised that the device he was using, explained a BBC science programme, could have a possible medical application.

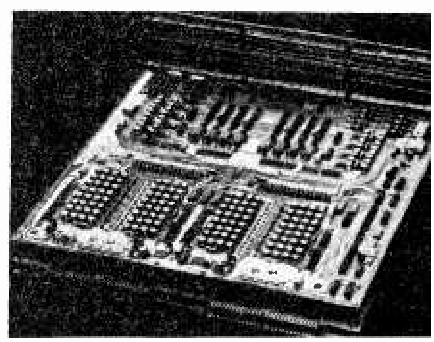
It was modified to give an alarm when certain patients, for example premature babies, stopped breathing. Now it has been built by Memco and tested in hospital wards, mostly with newborn babies. People moving about nearby did not interfere with the operation of the alarm, provided it was carefully positioned and the sensitivity turned down fairly low. Two premature babies in the tests did stop breathing repeatedly – and every time the alarm worked reliably.

And the advantages – it does not have to touch the patient, and lying for hours in a radar beam does not hurt as the beam is extremely weak.

MINICOMPUTERS

The age of the minicomputer as an off-the-shelf component has in fact arrived, and Computer Automation of Rickmansworth, Herts., have already produced two such OEM machines – the 16-bit Naked Mini 16 and its 8-bit cousin the Naked Mini 8. Both of these fully-parallel stored-program digital computers were on show at the IEA exhibition. They are suitable for general-purpose applications and offer as standard especially powerful instruction sets, 1.6 μsec full cycle times, up to 32 K words of random access core memory, a hardware multiply/divide facility, and software selection of byte or word-mode processing.

The dressed versions of the Naked Minis are the stand-alone Alpha 16 and Alpha 8 minicomputers, which include power supply, control panel and chassis.



. . . COMMENT

MARCONI MARINE RECEIVE 1972 QUEEN'S AWARD

The Marconi International Marine Co., Ltd., a GEC-Marconi Electronics company, has received a 1972 Queen's Award to Industry for export achievement.

The Award comes at the end of a year in which overseas sales of marine electronic equipment were 24 per cent up on the previous year, contributing nearly two-thirds of the company's total sales. The company's achievement in North and South America, especially Brazil, were highlights. In Europe, great assistance to the selling force has been provided by the use of a well equipped demonstration vehicle and by a demonstration yacht to exhibit equipment under sea-going conditions.

The recent appointment of representatives to concentrate solely on business in eastern Europe has already had encouraging results with substantial orders from Russia, Finland, Bulgaria, Rumania and other countries.

IN BRIEF

● Within a few weeks of placing an initial £2,000 order for Birch-Stolec interference suppressors following their displays at the Internepcon Exhibition in Tokyo, Okaya of Japan have placed a repeat order of the same value.

● The Swansea Radio Society (GW3 2GK), formerly known as the Swansea Telephone Area Radio Society, has been re-formed and meetings are now held at the 'Palace Bar' High Street, Swansea on the 1st. and 3rd. Tuesday of each month.

● EMI Limited announces the appointment of Mr. P. A. D. Duffell as Director of International Product Marketing.

● Electrovalue, the Egham, Surrey company electronic component distributors, is now stocking the logic checker manufactured by J. H. Associates Ltd.

This new device simply clips on to a selected IC under operating conditions, and displays all "Pin States" at once.

● The Independent Television Authority's new UHF local relay station at Brighton, which has come into programme service, brings the total number of I.T.A. transmitting installations to 100.

● Levell Electronics Ltd., are moving into a new factory which has been designed for increased efficiency, at Moxon Street, Barnet, Hertfordshire.

● At the North Midlands Mobile Rally organised by The Midland Amateur Radio Society and The Stoke-on-Trent Amateur Radio Society it is estimated that between 4-5000 people attended. Over 500 Mobiles were in the Car Parks.

● Adcola Products Ltd., has completed arrangements with Univerzal of Belgrade to assemble and distribute the company's range of soldering instruments throughout Yugoslavia, Bulgaria, Czechoslovakia and Rumania.

● The date of the Anglian Mobile Rally will be Sunday, 18th June, and the venue is The Suffolk Show Ground, Ipswich.

Talk-in Stations will be Top Band, 80, and a separate station for H.F. Bands; there will also be a two and four metre station.

All enquiries to D. W. N. Thomas, 9 Burlington Road, Ipswich, Suffolk, IP1 2EU.

BI-PAK OPEN THEIR FIRST DIRECT RETAIL OUTLET

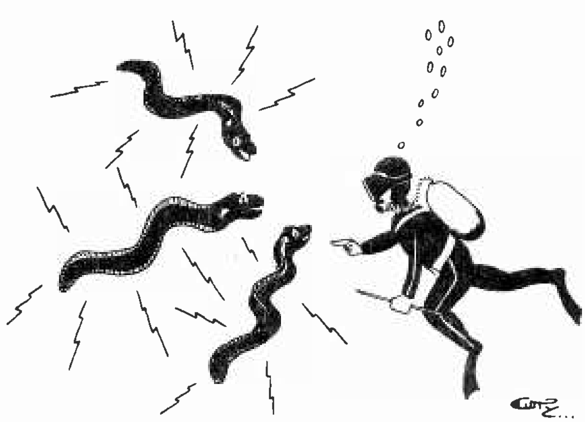
Bi-Pak have now entered the retail market with the opening of their first Electrical Component and Hi-Fi Supermarket at 18, Baldock Street, Ware, Herts. (Continuation of Ware High Street).

In addition to their well known Mail Order lines there is a vast selection of Hi-Fi equipment, transistor radios, cassette and tape recorders, car radios, record playing decks, loudspeakers and enclosures, cartridges and styli etc., electronic equipment and accessories.

Customers are also able to hear the popular System 12 Stereo kit which is on display.

The shop, trading under the name of BI-PAK COMPONENTS is fast proving a Mecca for Electronic, T.V., and Radio Engineers, Hi-Fi Enthusiasts and Radio Amateurs.

Bi-Pak Components is open 9.15 a.m. – 6 p.m. Tuesdays to Saturdays with late night shopping till 8 p.m. on Fridays. Telephone: Ware 61593.



"North Sea Gas is already a fact. Gentlemen I have a proposal regarding North Sea Electricity!"

INEXPENSIVE INTERPHONE

by
P. Bass

How to make a 2-way telephone system for installation in the home or at the office.

THERE MUST BE MANY CONSTRUCTORS who would like to realise the advantages of having their own internal communications system. A number of commercially made systems are available, and these have their advantages and disadvantages.

Dealing first with loudspeaker intercoms, these have the advantages that the system can have a distinctive calling tone, that battery consumption is low, and that relatively thin and inexpensive wiring may be used between stations. The disadvantages are that it is necessary to use a talk/listen switch, which can often be inconvenient, and that conversations are not entirely private.

An alternative system using telephones can be employed, and this overcomes the disadvantages of loudspeaker intercoms since no talk/listen switch needs to be operated and conversation is more private. A bell may be used for calling but this, if battery operated, requires a relatively large current. Also, its sound is not easily distinguished from other devices using bells. When operating over long distances the situation can arise where

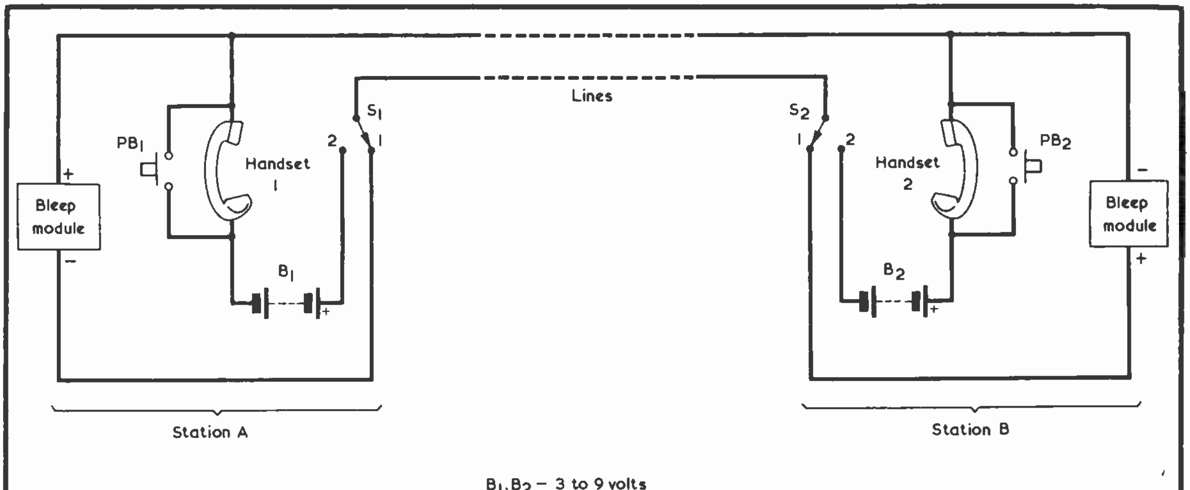


Fig. 1. The circuit of the interphone. It is important to observe correct polarity at the batteries and bleep modules, and in the connecting lines

the bell ceases to function long before the handsets become inoperable.

ALTERNATIVE SYSTEM

The interphone now to be described overcomes all these difficulties and enables a system to be made up incorporating surplus telephone handsets.

The circuit of the interphone appears in Fig. 1. In this diagram only two connections are shown to handsets 1 and 2. The microphone and earphone in each handset are connected in series to give two connections for the circuit. It will be seen that operation is given without the use of microphone transformers; the microphones, earphones and batteries function by simply being connected in series.

When S1 and S2 are in the positions shown in Fig. 1 the system is on 'standby'. No current flows in the circuit and the 'bleep modules' are connected across the lines. If Station A wishes to call Station B, S1 is moved to position 2, and this connects battery B1, station A's handset and the bleep module at Station B in series. PB1 is pressed momentarily; this short-circuits the handset at Station A and allows sufficient current to flow over the lines to operate the bleep module at Station B. When Station B answers, S2 is moved to position 2, thus connecting the handset at Station B and battery B2 in series across the lines. Conversation may now proceed, and when this is concluded both stations 'hang up' by returning S1 and S2 to 'standby'. The operation is similar if Station B wishes to call Station A.

If the operators at both stations should happen to set their switches to position 2 and press their push-buttons simultaneously the batteries are liable to be short-circuited via the lines. However, the risk of this occurring is extremely low and becomes eradicated completely if the operator at either station puts the handset to his ear before pressing the push-button. Any sound in his earphone will at once indicate whether the switch at the other station is also in position 2.

The battery voltage may lie between 3 and 9 volts, being selected for best results with the particular handsets employed and the length of line in use. The battery voltage should not be excessively greater than is needed for correct operation, and it should be the same at both stations.

PRACTICAL DETAILS

It is possible to use microswitches to provide the S1 and S2 functions, these being operated by suitable holders for the handsets. Alternatively, complete ex-G.P.O. telephone units can be purchased, in which suitable contacts are available on the cradle switch. The reader may, alternatively be able to obtain Pye radiotelephone handsets, which contain a single pole changeover switch in the handset itself. If desired, this switch may be employed as S1 or S2, the connections required being shown in Fig. 2.

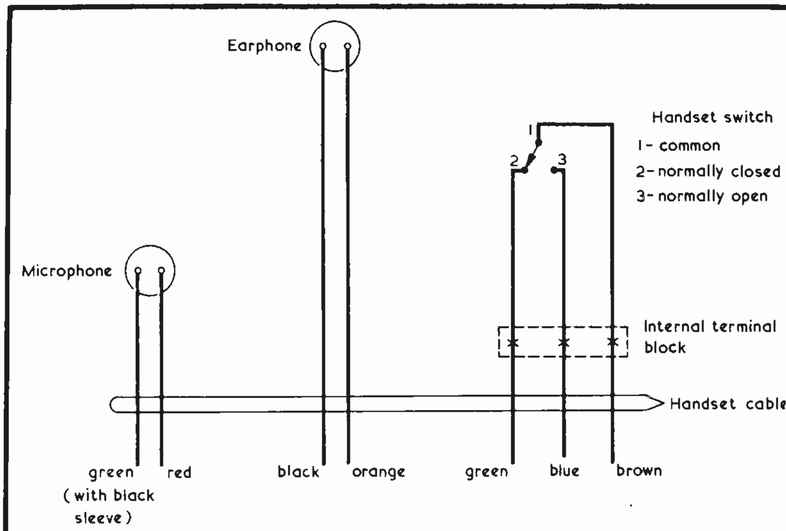


Fig. 2. Connection data for the Pye radiotelephone handset. For interphone use, connect red to black and apply green (with black sleeve) and orange to the interphone circuit. The handset switch may carry out the function of S1 or S2

For the calling push-buttons, PB1 and PB2, domestic bell-pushes may be used. However, if a unit with a dial is obtained the contacts on the dial may be employed instead, the remote bleep module being actuated by turning the dial. Fig. 3 shows the connections. It is necessary to connect one of the dial 'masking' contacts (which close when the dial is moved from its rest position) in series with the dial interruptor contacts, since the interruptor contacts are normally closed and are opened rapidly by the dialling action. A short visual examination of the dial to be employed will soon enable the different contacts to be identified.

BLEEP MODULE

The bleep module can consist of any a.f. relaxation oscillator offering a strong output signal, and a suitable circuit is given in Fig. 4. This may be assembled on a small tagboard and the few components needed do not take up a great deal of space. Only half the primary of the Eagle LT700 output transformer is in circuit.

If it is expected that the bleep module will be switched on for considerable periods, TR2 should be fitted with a small heat sink, such as the Type H2 which is available from Henry's Radio Ltd. For normal calling operations, where the bleep module is only turned on for short periods, the heat sink is not necessary.

The bleep module is capable of working at quite low values of supply voltage and current, and it may be found that it gives a weak output immediately the remote handset, on calling, is switched into circuit. The current which operates the module is then that which flows through the handset. The module will, however, give its full output when the remote push-button is pressed.

Incidentally, the bleep module forms a useful audible warning device in direct substitution for an electric bell or buzzer in other applications. If the tagboard on which the components are mounted is secured to the speaker frame with Araldite, the result is a complete self-contained unit.

Constructors will probably have their own ideas concerning the practical construction of the interphone system. Owing to its simplicity and non-critical requirements, there is considerable scope for ingenuity. The author uses modern Post Office type telephone units, the innards being removed to accommodate the bleep module, miniature loudspeaker and battery. Also, the dials are used to give the push-button operation whilst the cradle switches provide the switching requirement for S1 and S2. However.

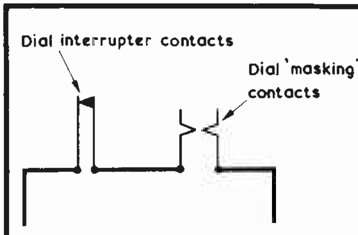


Fig. 3. Dial contacts connected in series may be employed to provide the PB1/PB2 function

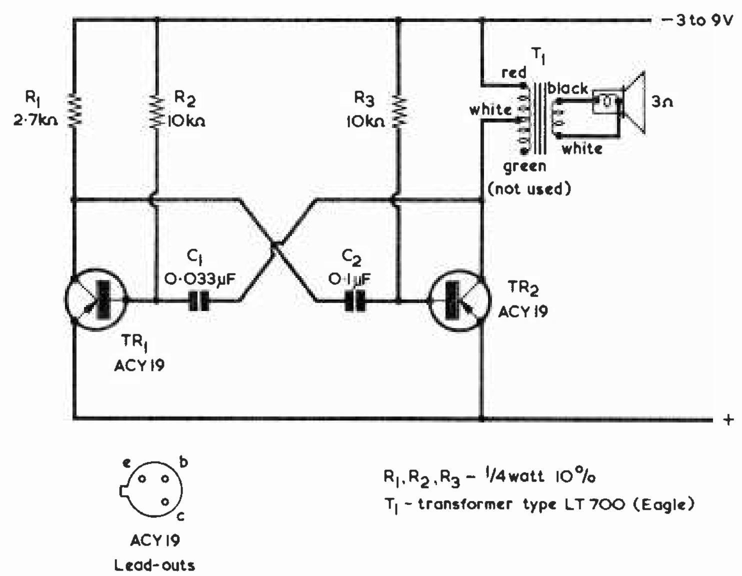


Fig. 4. The bleep module may consist of any relaxation oscillator offering a clearly audible tone. A suitable circuit is given here

the possibilities tend to be limited due to the availability of components, and the constructor may find it necessary to make up a system employing handsets only if complete telephone units cannot be obtained. Always ensure that the handsets contain carbon microphones. Some handsets have moving-coil microphones, which are of no use for the present application. Complete units, or handsets, are available from a number of suppliers including Bi-Pre-Pak Ltd., of 222-224 West Road, Westcliff-on-Sea, Essex, SS0 9DF (see advertisement, page 645) and M. and B. Components Ltd., 38 Bridge End, Leeds, LS1 4EW.

APPLICATIONS

The interphone system may be used wherever communication between two points is required, for example between two offices, between house and garage and, of course, between the traditional 'shack' and house. In this latter connection, long-suffering wives will be overjoyed to see the fruits of a project that actually saves walking!

The author's system has been in daily use in his home for the past 18 months, during which time it has proved itself to be entirely reliable. Neither battery (an Ever Ready 4.5 volt Type 126 is used at each station) has yet been exhausted.

It is hoped that this article will enable constructors, and especially those who have to work within a tight budget, to fulfil a need for a system that 'fills the gap' between a commercial intercom and a conventional telephone. The use of a combination of robust telephone handsets and transistorised circuitry will enable the contructor to extract a high level of economy from his own personal interphone. ■

BOOK REVIEW

* * *

RADIO, TELEVISION AND AUDIO TEST INSTRUMENTS, Second Edition. By Gordon J. King, R. Tech. Eng., M.I.P.R.E., F.S.R.E., M.R.T.S., M.I.T.A.I.
207 pages, 6 x 9¾ in. Published by Newnes-Butterworths. Price £3.80.

The first edition of this book was published in 1962 as 'Radio and Television Test Instruments', and it has been extensively modified for its appearance in second edition form. Two entirely new chapters have been added, one dealing with colour television test instruments and the other with audio test instruments. Further, the swing from valves to transistors has made it necessary for some chapters to be virtually rewritten, and there have also been a number of deletions and additions in the remainder of the text in order to ensure that the details given reflect current usage. The book is intended mainly for the service technician, the student and the experimenter.

As the author states in his preface, 'there must be a great many test instruments collecting dust simply because their users are not fully conversant with every possible use to which they may be put ... Test instruments are costly, and it is economic folly not to exploit them fully.'

The book sets out to describe both the functions of test equipment and the manner in which the equipment is made up. The circuit diagrams for quite a few commercially made items of test gear are included, as also are a number of photographs of equipment and of oscilloscope traces. The equipment covered includes meters for d.c. and a.c., electronic meters, signal generators, oscilloscopes, valve, c.r.t. and transistor testers, instruments for colour television and instruments for audio. There is also a chapter dealing with miscellaneous instruments such as the signal strength meter, grid dip oscillator, oscilloscope trace doubler and Q-meter.

The book is written in the practical and lucid style for which its author has become deservedly well-known, and it should prove to be a helpful handbook for anyone within its intended readership who has occasion to employ test instruments for servicing or for experimental work.

NOTES ON SEMICONDUCTORS

Further Notes—7

COUNTER-PLOT

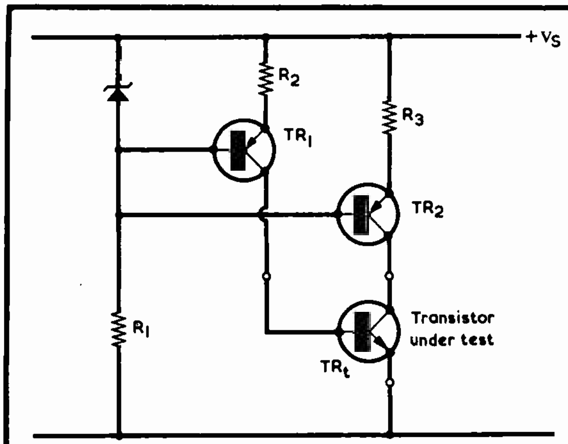
By
PETER WILLIAMS

It is necessary to estimate saturation voltage in transistors employed for switching purposes. This note describes how saturation measurements may be carried out.

THE LAST NOTE CONSIDERED THE CIRCUIT OF A SIMPLE current-gain meter. If the collector supply voltage of the transistor under test is reduced to a low enough level, then the current gain may be reduced to about 10 which is the value usually specified as the saturated value, i.e. it is the lowest value of current gain that would be really useful in switching circuits. Any further reduction of gain would not bring with it any drastic improvement in collector saturation voltage. Typically Vce(sat) at a current gain of 10 might be as low as 100mV, while at a current gain of 5 it might be reduced to 80mV, hardly a worthwhile improvement when the system supply voltage is probably a hundred times larger, i.e. the improvement in collector efficiency is more than offset by the extra losses in the base circuit.

CURRENT CONTROL

It is difficult to control voltages simply at this low level, particularly where large changes in current gain correspond to small changes in voltage. A better solution is to consider the problem afresh, and realize that the operating conditions require currents in base and collector of the test transistor to be in a precisely defined ratio. Thus we may use two current generators instead of one and the problem is solved.



Circuit diagram illustrating a simple means of evaluating transistor saturation voltage

The circuit is shown in the accompanying diagram. Two transistors TR1 and TR2 share a common bias circuit, while their emitter resistors have a ratio equal to the current gain at which saturation of TRt is to be defined.

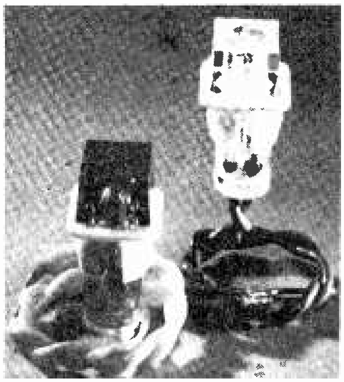
Generally this means R2=10R3 although any other value may be chosen. For example R2 may be increased until the potential of TRt collector rises rapidly – this would pinpoint the onset of saturation. A further useful modification is to replace R1 and the zener diode by a potential divider (as in the last note having a low resistance to allow the standing current to swamp the combined base currents of TR1 and TR2). As the potential at the bases of TR1 and TR2 is then varied, the base and collector currents of TRt must then vary together, maintaining a constant ratio. The variation of saturation voltage with current can then be quickly checked and transistors selected for best switching performance, when minimizing voltage lost from the load is of importance – particularly true for low voltage circuits.

It must be noted that because the voltage to be measured is low, a sensitive voltmeter is necessary. Useful comparative measurements can be made with meters of full-scale deflection up to 2.5V if the scale is reasonably large. A forward biased diode in parallel with the meter protects against damage if the test transistor should go open-circuit. The voltmeter connects across the emitter and collector of TRt.

For both this and the previous circuit, an identical approach may be used for testing p.n.p. transistors, reversing the supply voltage and interchanging n.p.n. and p.n.p. transistors throughout. It is possible but often difficult to make a single circuit cover both polarities. ■

Trade News . . .

MINIATURE NEON INDICATOR LIGHTS



A range of miniature indicator lights for use in electrical and electronic equipment, instruments and control systems is now available from ITT Components Group Europe.

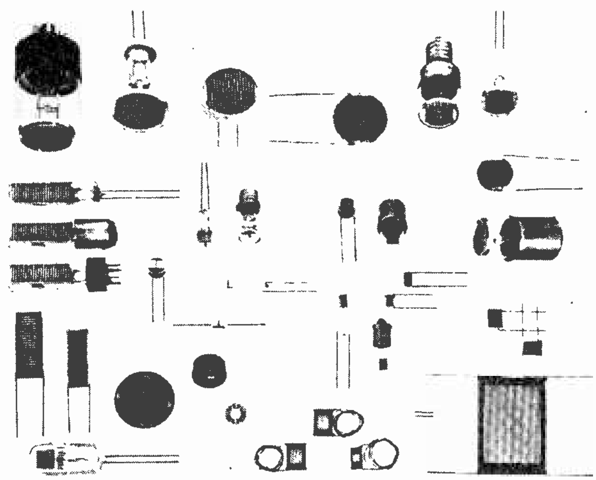
These lamps have thermoplastic housings with square lamp heads which are available with clear, red or yellow faces. Lamps are supplied with a length of cable and panel mounting is effected with a self-locking nylon grommet.

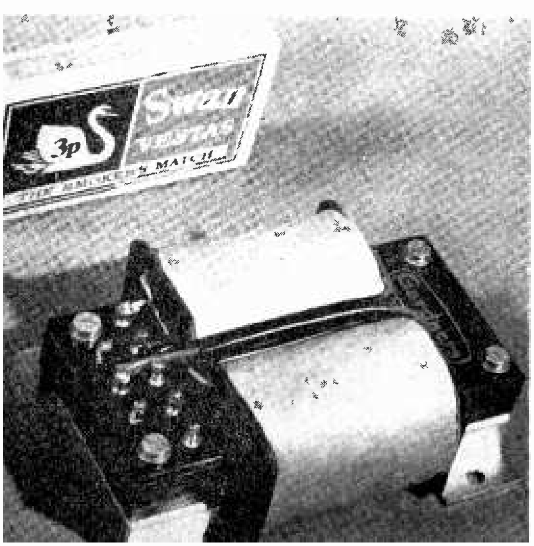
Available for operation at 110V and 240V the lamps require a current of 0,3 mA. Resistors are not included in the pilot lamps and a 100 kilohm (110V) or 270 kilohm (240V) limiting resistance must be built into the equipment in which the lamps are installed.

Prices of the lamps range from 30p for one off to 19p for orders of a thousand. For further information contact ITT Components Group Europe, Electromechanical Product Division, West Road, Harlow, Essex.

CADMIUM SULPHIDE CELLS

Guest International announce the availability of a broad range of cadmium sulphide cells. These cells are photo-conductive types enclosed in either glass or plastic envelopes. They have a very high dark resistance which reduces approximately inversely, proportional to the illumination. The photo-conductive material is specially doped cadmium sulphide on substrate of glass or ceramic, the active layer being formed by means of a patented process. They are suitable for both a.c. and d.c. circuits. Of particular interest are the high current rated types which in many cases enable relays to be operated directly from the cell; the use of single piece substrate gives the units a high reliability when used in this high dissipation form. A standard range of six types is available covering nearly all normal applications. Further information from: Industrial Components Division, Guest International Limited, Nicholas House, Brigstock Road, Thornton Heath, Surrey.





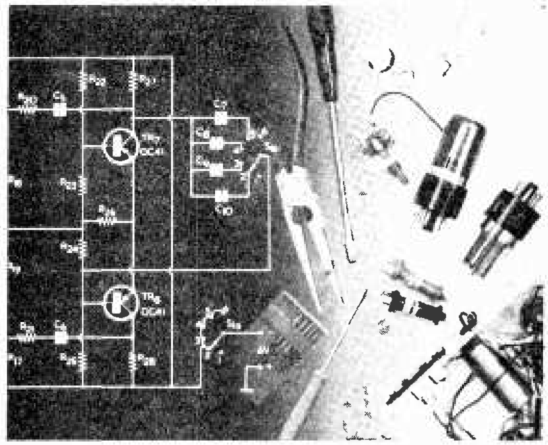
LOW-FIELD ASTATICALLY-WOUND TRANSFORMER

Gardners Transformers Limited announce a new range of low-profile transformers which are designed to overcome the transformer problems associated with the modern tendency towards slimmer electronic equipments.

Gardners state that their newly-developed range of SOLO Series assemblies not only enables design engineers to reduce the height of equipment but, due to the astatic construction, also has the significant additional advantage of a low external field. The use of high-grade core material and the absence of gaps in the magnetic path assist in permitting a high rating to be obtained without the usual level of magnetic field which emanates from more conventional transformers. The risk of hum pick-up in amplifiers or beam distortion in equipments embodying C.R.T's is thereby greatly reduced.

Further details of the new SOLO Series (Drawing A.3869) are readily available to industrial users, from Gardners Transformers Limited, Christchurch, Hampshire, BH23 3PN.

Direct-reading Capacitance Meter



by G. A. FRENCH

LAST MONTH'S 'SUGGESTED CIRCUIT' article described a capacitance bridge capable of measuring very low values of capacitance. This month's article is devoted to a measuring instrument which deals with capacitance values at the other end of the scale, and it introduces a circuit which is capable of measuring values of capacitance from 1μF to 12,000μF. Virtually all the capacitors likely to be encountered in this range are electrolytic, and the instrument provides a polarising voltage which enables such components to exhibit their capacitance value. The maximum polarising voltage applied to the capacitor under test is 6 volts when the correct range is selected in the instrument. If an incorrect range is inadvertently selected, the polarising voltage can rise to a maximum of 9 volts.

A novel feature of the circuit is that the capacitance value is indicated by a 0–1mA moving-coil meter.

ELECTROLYTIC CAPACITORS

Before embarking on a description of circuit operation for the instrument, it is first of all necessary to consider the components whose values it will be called upon to measure. As has just been mentioned, these will almost inevitably be electrolytic capacitors, which are notoriously wide-tolerance components. Even the better class of aluminium electrolytic capacitors are, for instance, manufactured to tolerances of the order of −10% to +50% on nominal value. Again, it would be reasonable to assume some shift in capacitance value for change in polarising voltage, with the result that, for really comprehensive measurements of the values of electrolytic capacitors, it would be desirable to apply polarising voltages equal to those at which the capacitors are intended to work. Whilst a measuring instrument offering this facility is, of course, perfectly feasible, its construction and design may well prove more complex and expensive than is justified by the requirements of the average experimental or servicing workshop. The measuring instrument to be described here does not provide a variable polarising voltage; on the other hand, however, it employs simple and inexpensive circuitry whose principle of operation is easy to understand, and it is capable of offering results that should be more than adequate for everyday use. Measurement indications are as precise as is warranted by the class of component being checked, with the result that it becomes possible to employ low-cost components in those parts of the circuit which directly affect the readings given. Also, the instrument offers precise comparisons between two or more capacitors of the same nominal value.

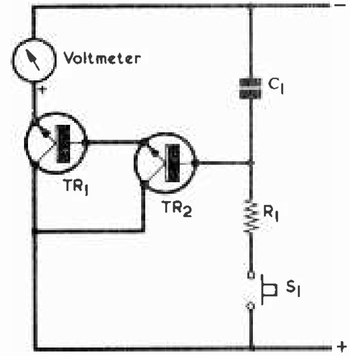


Fig. 1. This basic circuit may be employed for the measurement of capacitance

CIRCUIT OPERATION

The operation of the circuit depends upon the observed fact that the voltage across the plates of any capacitor in good condition, and having a value of around 0.2μF or more, may be directly monitored by a voltmeter which is connected to the capacitor by way of two transistors in the compound emitter follower mode. A circuit illustrating this effect is given in Fig. 1, in which the capacitor C1 is capable of being charged via R1 when push-button S1 is pressed. The two transistors in the compound emitter follower mode are TR1 and TR2, these being modern silicon types having fairly high gain. If C1 is initially discharged there is a zero reading in the voltmeter. Should push-button S1 now be pressed for a time which allows C1 to charge up to say 5 volts, and is then released, the voltmeter will give an indication of 5 volts minus the voltage drop in the base-emitter junctions of TR1 and TR2. Discharge current in the base circuit of TR2 can be expected to be almost negligibly low, and the voltmeter will continue to give its indication for quite a considerable time after the button has been released; although it will eventually fall gradually to zero as C1 discharges by way of TR2, TR1 and the meter, and by way of its own leakage resistance. For non-electrolytic capacitors and electrolytic capacitors in good condition, the retention of the voltmeter readings following the release of S1 is maintained for a surprisingly long time. If the capacitor has a level of leakage current that is higher than average, it will commence to discharge slowly as soon as the push-button is released but, even so, it is still a very easy matter to observe the voltmeter reading at the instant of releasing the push-button.

The circuit of Fig. 1 can be used to

measure the capacitance of C1. If the value of R1 is known and the push-button is held closed for a fixed period of time, the voltage across the plates of C1 when the push-button is released will provide an indication of its capacitance. This voltage can then be read from the voltmeter. Obviously, the circuit must be operated such that, when the push-button is released, the voltage across C1 is not so low that it is less than the forward voltage drop across the base-emitter junctions of the two transistors, and is not, at the same time, so high that the capacitor is nearly fully charged to the supply potential. Matters have to be so arranged that the final voltage across C1 lies between these two extremes, which means that the value of R1 and the length of the period of closure in S1 must be chosen to suit the particular capacitor in the C1 position which is being measured. Also, the supply voltage has to be high enough to allow meaningful readings in the voltmeter, but not so high as to preclude the measurement of low voltage capacitors.

In Fig. 2, which gives the complete circuit of the capacitance meter, the voltmeter of Fig. 1 appears as the 0–1mA moving-coil meter, M1, in series with R1 and R2, whilst capacitor C1 of Fig. 1 is any capacitor which is connected to the Test Terminals. Transistors TR1 and TR2 in Fig. 2 carry out the same function as they did in Fig. 1, whilst the series resistor R1 is replaced by whichever of R3 to R7 is selected by S1(a), which forms one half of the Range switch. Push-button S1 is replaced by transistor TR3, which is held hard on for a fixed period of time by the circuitry around TR4, TR5 and TR6. The supply voltage is nominally 9 volts, which offers a good compromise between the conflicting requirements of a low voltage for the test capacitor and a satisfactorily high voltage for operation of the voltmeter.

To the right, in Fig. 2, we have a 12-volt battery coupled to a simple voltage regulating circuit provided by TR7, R19 and ZD1. The voltage at the emitter of TR7 is nominally 9 volts, and this is applied to the remainder of the circuit. Resistor R18, across the 9 volt supply rails, draws a continual current of around 2mA and provides a marginal improvement in voltage stabilization.

The time during which transistor TR3 is made conductive when the value of a capacitor is being measured is controlled by the 1μF capacitor, C1, and whichever of R13 to R16 is switched in by S1(b), which forms the second half of the Range switch. The capacitor to be measured is connected to the Test Terminals with S2 in Position 1. S2(a) then removes any charge which may be present on the test capacitor by way of limiter resistor R8, whilst S2(b) carries out the same function for C1 via R17.

When S2 is set to Position 2, the effective short-circuits are taken off the test capacitor and C1, and the 9 volt supply is applied to the circuit via S2(b). Both the test capacitor and C1 now commence to charge, their lower plates going positive. Connected to the lower plate of C1 is the compound emitter follower pair given by TR6 and TR5. These are silicon p.n.p. transistors and they carry out a function similar to TR1 and TR2, insofar that, whilst not affecting the voltage across C1, they provide a voltage at a relatively high current which is shifted from that across C1 by the forward voltage drop across their two base-emitter junctions. This voltage appears at the emitter of TR5, which is coupled, by way of limiting resistor R12 and silicon diodes D1 and D2, to the base of TR4. TR4 functions as an emitter follower driving TR3, and the base current in TR4 immediately after S2(b) has been set to Position 2 is high enough to drive TR3 hard on and thereby complete the charging circuit for the test capacitor.

After a period, the voltage on the lower plate of C1 becomes sufficiently positive to prevent further flow of current to the base of TR4 by way of TR6, TR5, D1 and D2. When this occurs, TR4 and TR3 turn off, the turn-off in TR3 being particularly abrupt because of the current amplification given by TR4. Resistors R10 and R11 also assist in producing a rapid turn-off, and they draw the bases of the two transistors below conduction level at the end of the timing period.

Since TR3 is now cut off, charging current no longer flows in the test capacitor, and the voltage across its plates, and hence its capacitance, may be read from the 0–1mA meter.

RANGE SWITCHING

To appreciate the manner in which different ranges are selected and specific capacitances are measured it will be helpful if, next, we examine circuit operation when S1 is set to Range 1 and a 1μF capacitor is connected across the Test Terminals. Both the test capacitor and C1 now have charging resistors of 100kΩ (R3 and R13) and, since they also have the same values, we may expect them to charge at the same rate when S2 is set to Position 2. For the purpose of this discussion, the voltage drop across the collector and emitter of TR3 when it is hard on may be ignored. It is, in any event, of a low order, being about 0.15 volt only.

There are six silicon p.n. junctions between the positive supply rail and the lower plate of C1, these being given respectively by the base-emitter junctions of TR3 and TR4, diodes D2 and D1, and the base-emitter junctions of TR5 and TR6. Assuming that, at the instant of turn-off in TR3, there is a forward voltage drop of 0.5 volt in each junction, TR3 turns off when the lower plate of C1 is 3 volts negative of the positive supply rail, i.e. when it has charged so that 6 volts appears across its plates. At the instant of turn-off the test capacitor will have similarly charged up to 6 volts. The voltmeter given by M1, R1 and R2 will then have, assuming about 1.2 volts drop in the base-emitter junctions of TR1 and TR2, a voltage of 4.8 volts across it. (This 1.2 volt drop is slightly higher than the 0.5 volt per junction figure mentioned just now, which applied to the condition of turn-off). Preset variable resistor R2 will have been previously adjusted to cause the meter to read full-scale deflection under this condition, whereupon the fact that the meter indicates 1mA shows that the test capacitor has a value of 1μF.

Thus, when S1 is set to Range 1, circuit conditions are such that, after operating S2, the meter gives a reading of 1mA when a 1μF capacitor is connected to the Test Terminals. The time taken for this reading to be given is slightly in excess of one-tenth of a second, since the time constant of 1μF and 100kΩ (R3 or R13) is equal to this length of time. Time constant, it will be recalled, is the time taken for the voltage across a capacitor charging via a series resistor to reach 63% of the supply voltage, and is equal, in seconds to the capacitance in microfarads multiplied by the resistance in megohms.

If, on Range 1, a test capacitance of 1μF corresponds to full-scale deflection in the meter, it follows that larger test capacitances will give *lower* meter readings. This is because the larger capacitances charge up to lower voltages during the period when TR3 is conducting. In practice, it is found that useful readings are not given, on Range 1, for capacitances greater than some 5μF, whereupon Range 1 is arbitrarily restricted to 4μF to 1μF. The same 4:1 ratio between maximum and minimum test capacitances is retained in all the other ranges of the instrument. These follow a 1–3–10–30 sequence, thereby providing a small overlap between ranges.

On Range 2, S1(a) selects the 33kΩ resistor R4 whilst S1(b) still selects the 100kΩ resistor, R13. Since R4 is one-third the value of R13 a test capacitance 3 times greater than C1 is required to cause an f.s.d. reading in the meter. Thus, Range 2 covers a range of capacitances 3 times greater than in Range 1, i.e. from 12 to 3μF. On Range 3 R5, at 10kΩ, is one-tenth the value of R13, giving a range of 40 to 10μF. The process continues through Ranges 4 and 5, where the selected test capacitor charging resistors, R6 and R7, are 3.3kΩ and 1kΩ respectively, giving ranges of 120 to 30μF and 400 to 100μF.

It would be unwise to use a series charging resistor for the test capacitor which is lower than 1kΩ since the resulting initial charge current (which is 9mA for 1kΩ) could put rather heavy demands on the simple power supply stabilising arrangements employed. In consequence, the test capacitance charging resistor is re-

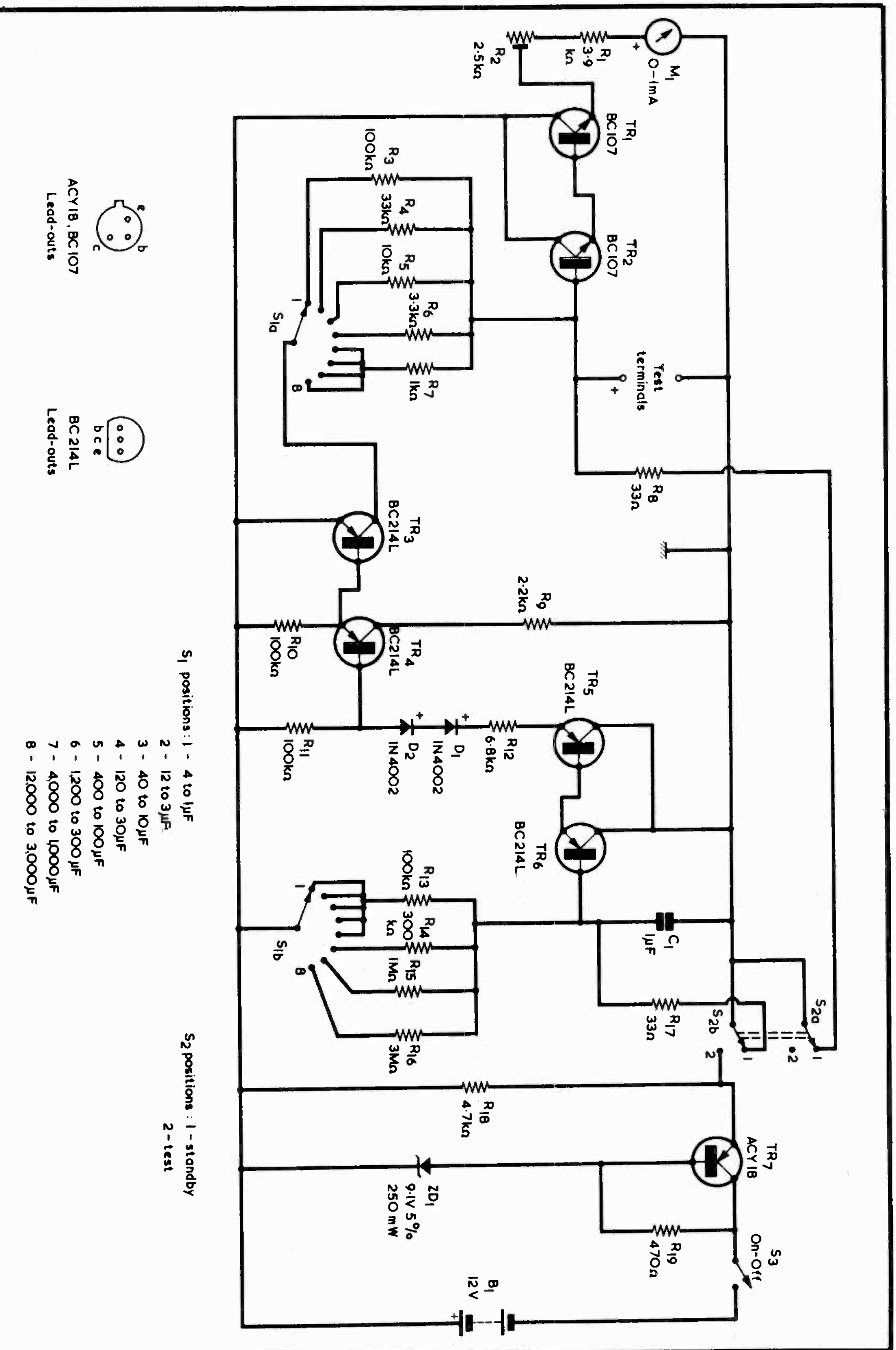


Fig. 2. The circuit of the direct-reading capacitance meter. This measures electrolytic or non-electrolytic capacitors having values from 1 to 12,000µF

tained at 1kΩ on Ranges 6, 7 and 8, and the value of the charging resistor for C1 is increased instead. On Range 6 this value is 300kΩ, whereupon C1 takes 3 times longer to charge than with the 100kΩ value, and allows a range of 1,200 to 300µF (3 times that of Range 5) to be achieved. The next two charging resistors for C1, R15 and R16, are 1MΩ and 3MΩ respectively, giving ranges of 4,000 to 1,000µF and 12,000 to 3,000µF. It should be noted that, on Range 8, it is necessary to wait slightly longer than 3 seconds after operating S2 for the meter to reach its final reading.

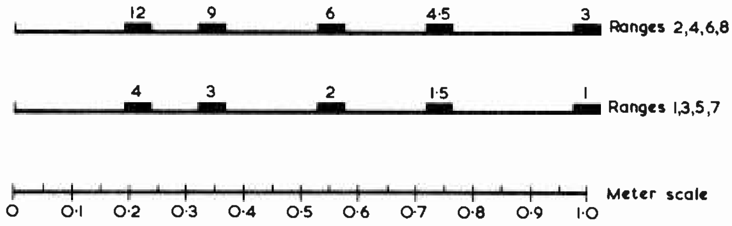


Fig. 3. Meter readings may be converted to the corresponding capacitance values with the aid of this chart

COMPONENTS

None of the components should be difficult to obtain. The transistors type BC214L are obtainable from a number of suppliers, including Henry's Radio, Ltd. The BC107 is a very commonly used type and is generally available, as also is the ACY18. The two diodes, D1 and D2, can be any small silicon rectifier diodes. The author used diodes type 1N4002 simply because they happened to be on hand. The zener diode ZD1 can be any 250mW diode rated at 9.1 volts 5%. For optimum accuracy of readings, the zener diode employed should cause the voltage across R18 to be just slightly less than 9 volts (actually 8.9 volts) and constructors who have a number of diodes on hand may select one which causes this voltage to be given. However, inaccuracies (which only affect capacitance readings lower than f.s.d. in the meter) will not be of a serious nature if the supply voltage is slightly removed from the optimum figure, as would occur with a diode at either extreme of its 5% tolerance figure.

Switch S1(a) (b) may be any 2-pole 8-way rotary switch. Switches S2(a) (b) and S3 are both toggle types. The author originally considered combining these last two switches in a 3-pole rotary component but soon discarded this idea. It is necessary for S2(b) to complete the supply circuit on Position 2 with a positive snap action, and this is provided much more reliably by a toggle switch than by a rotary type.

All the fixed resistors can be ¼ watt and, with the exception of R3 to R7 and R13 to R16, require a tolerance of 10% only. In a measuring instrument of this nature, R3 to R7 and R13 to R16 would normally be close-tolerance components. However, and for the reasons detailed earlier, it hardly seems worth the expense to employ close-tolerance components in the present application, and the writer would suggest that 5% resistors should be more than adequate. The preset variable resistor R2 can be a normal skeleton component.

Capacitor C1 must be a plastic foil component, and *not* an electrolytic type. Here again, the question of tolerance versus cost comes to the fore. Mullard miniature foil capacitors Type C280 are available in 1µF at tolerances of 10% and 20%, and many readers may feel that the 10% version is adequate for present requirements. (The tolerance of Type C280 capacitors is indicated by the fourth colour band from the top, white corresponding to 10% and black to 20%). Alternatively, a 1µF 1% capacitor is available from Home Radio under Cat. No. 2FG37. A second 1µF capacitor, similarly non-electrolytic, is required for setting-up R2.

The current drawn from the 12-volt battery when S2 is in position 1 is about 6mA for the zener diode plus a further 2mA in R18. This current increases when S2 is set to position 2 by a further 5 to 15mA (according to the range selected) during the time when TR3 is conductive, and by the meter current only when TR3 is cut off again. These currents are sufficiently low to allow quite a small battery to be employed. The battery should be discarded when its voltage on load is 11 volts or less.

CONSTRUCTION AND CALIBRATION

The questions of layout and the provision of a suitable case are left to the constructor. Most of the components are small in physical size and could be accommodated in a small case which may be either insulated or metal. Note that the chassis connection is to the negative stabilized supply rail. This enables one of the Test Terminals to be at chassis potential.

The two Test Terminals should be insulated types. It is advisable not to touch the positive Test Terminal if S2 is in Position 2 and no test capacitor is connected, as r.f. pick-up by the body can cause wide meter deflections. The meter cannot be caused to pass more than about 1.6 times its f.s.d. current because of the presence of R1 and R2, and is thereby adequately protected, but it is nevertheless still preferable to avoid touching the terminal. It should be mentioned in this respect that the meter will also pass a current greater than its f.s.d. value if the test capacitance is lower in value than the figures in the range selected, but once again it cannot be caused to pass more than about 1.6 times the f.s.d. value.

In use the capacitance meter is switched on by means of S3, with S2 remaining in Position 1. The capacitor to be measured is then connected to the Test Terminals, with correct polarity if it is an electrolytic type, and S1 is set to a range which is lower than the anticipated capacitance. S2 is then set to Position 2. If the value of the test capacitor falls into the range selected, the meter needle will rise to indicate that capacitance. If the meter needle rises to a low value or is not deflected at all, S2 is returned to Position 1, the next range higher up is selected, and the process repeated. With test capacitors which are in good condition the meter needle will remain stable for quite an appreciable time after it has reached its final indication. With leaky capacitors, it will fall slowly, but the first indication can still be quite easily read. When measuring electrolytic capacitors which have been in store for a considerable period, S2 should be operated a number of times. It may be found that initial readings with such capacitors vary from those finally obtained as the electrolyte in the capacitor becomes 'formed' by the polarising voltage.

After construction has been completed, the instrument is calibrated by connecting the spare 1µF plastic foil capacitor just mentioned to the Test Terminals and selecting Range 1. S2 is operated and R2 adjusted for an f.s.d. reading of 1mA in the meter. The reading may be checked by operating S2 several more times. The instrument is then set up and all the other ranges will be correct.

Fig. 3 shows the capacitance values corresponding to meter readings on all the odd and even scales. For Range 4 the figures on the upper line in Fig. 3 are multiplied by 10, and so on. The variation of meter reading with test capacitance follows an exponential law with subsequent modification to take account of the voltage dropped across the base-emitter junctions of TR1 and TR2. The figures shown in Fig. 3 were calculated on the assumptions of a stabilized supply line voltage of 8.9 volts and 1.2 volts drop in TR1 and TR2, and were subsequently verified in practice. ■

The D.R.C.3 Bandspread Short Wave Receiver

by

Sir Douglas Hall, K.C.M.G., M.A.(Oxon)

This reflex receiver takes advantage of permeability tuning to provide an exceptionally high L/C ratio at all frequencies covered. Overall range from 1.5 to 22MHz.

THE FIRST OF THE 'SPONTAFLEX' D.R.C. (DOUBLE REFLEX Colpitts) designs was published some time ago in the January 1968 issue. Later, a silicon version of the design appeared in February 1970, with various other modifications including an extra stage which allowed 'personal' listening on a miniature speaker from the more powerful signals. The 'Export Spontaflex', published in February 1971, was a further variant of the design.*

The latest model, to be described in this article, incorporates a number of further modifications which result in a markedly improved performance. Three transistors are used, but the final stage is not intended to drive a speaker, but rather to give louder headphone results, and to make possible the use of high impedance headphones. The low resistance DLR5 type specified for earlier D.R.C. receivers are no longer easily available. Any 4kΩ or 8kΩ phones may be used with the present design but, of course, the better the type of phones the better the results. Some low-cost imported headphones are very insensitive. Incidentally, many readers will already have on hand a pair of DLR5 phones bought for use with the earlier D.R.C.2 receiver, and these excellent low impedance phones will give splendid results with the present receiver if used with a 4:1 or 5:1 transformer. The Repanco transformer type TT49 is suitable as, also, is the Eagle LT44. The large winding (primary) of the transformer connects to the output of the receiver and the small winding to the phones. Alternatively, quite good results will be given by two crystal earpieces in parallel, one for each ear. No transformer is necessary with the crystal earpieces.

The receiver may, of course, be used with an amplifier, any type with low or medium impedance input being satisfactory. The amplifier used need not be of high sensitivity owing to the very high gain given by the receiver.

*Sir Douglas Hall, 'The "Spontaflex" Transistor Short Wave Receiver', *The Radio Constructor*, January 1968; 'Developing the "Spontaflex" Short Wave Receiver', *The Radio Constructor*, February 1970; 'The Export Spontaflex – A 13.8 to 645 Metre Portable', *The Radio Constructor*, February 1971.

PERMEABILITY TUNING

An important development is the use of permeability tuning, capacitance tuning being used only for the fine tuning control or bandspread capacitor. The author has often reminded constructors that the signal magnification which can be given by a tuned circuit is closely related to the ratio of inductance to capacitance. If inductance is doubled capacitance must be halved for the same frequency to be tuned, but the dynamic resistance of the tuned circuit, all other things being equal, becomes four times greater. On the short wave bands this effect is particularly marked, and the inductance – capacitance ratio in some short wave tuned circuits is very low indeed. For example, it is quite common for a 1μH coil to be tuned by a capacitor having a maximum capacitance of 300pF. The strays are

The completed receiver in its cabinet

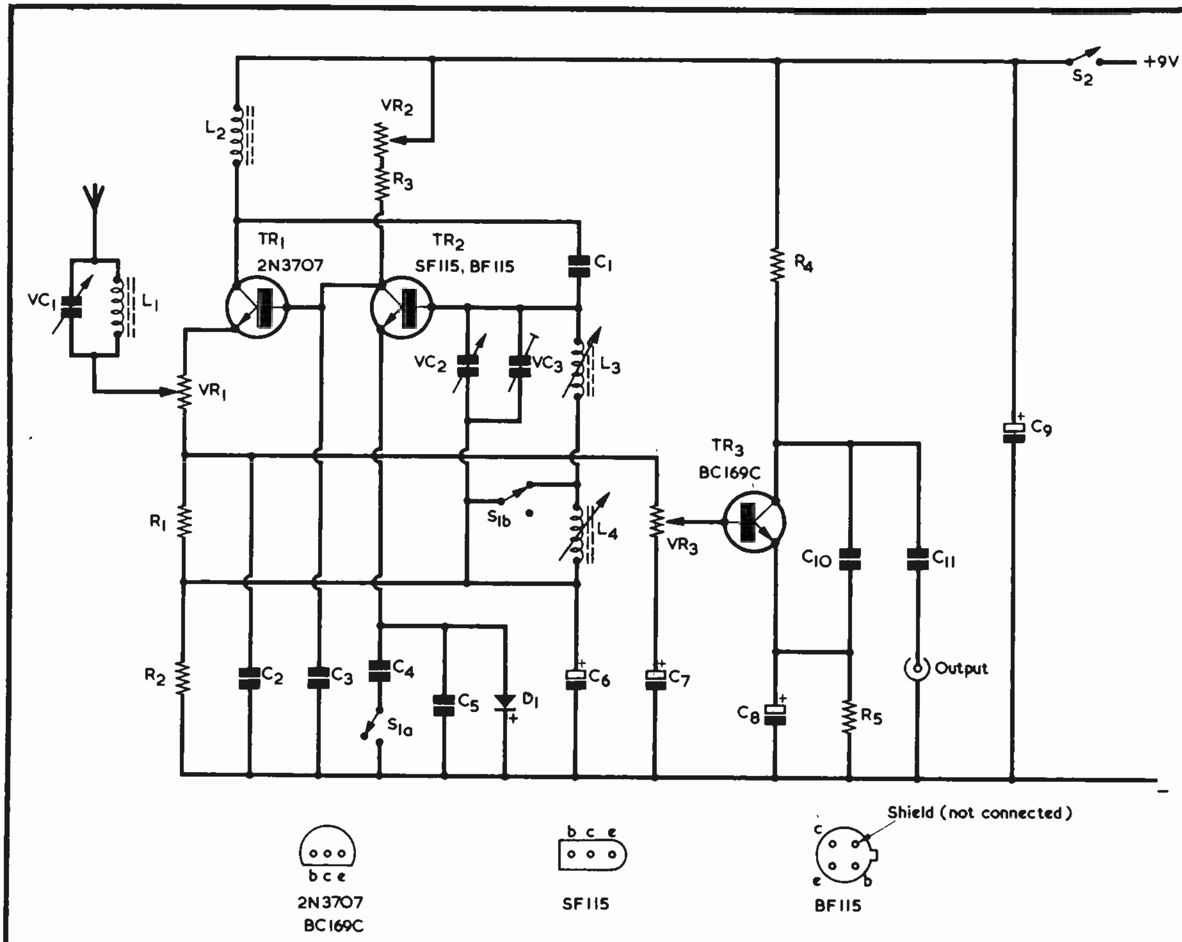


Fig. 1. The circuit of the D.R.C.3 short wave receiver

~robably about 20pF *in toto* and, with the capacitor .t maximum, the circuit would be tuned to about 9MHz. Now let us suppose that the inductance is increased to 10μH and the capacitance reduced to 32pF, i.e. the variable capacitor is set to near minimum allowing for the 20pF strays. The inductance-capacitance ratio will have been improved 100 times with a consequent dramatic effect on signal amplitude, whilst still working at the same frequency as before.

However, there are certain snags which can arise with a very high inductance-capacitance ratio. With simple layouts, hand-capacitance is apt to become troublesome, especially if a bandspread capacitor connected across the coil is at a low setting, and any form of reaction control involving a variable capacitor is liable to cause severe interaction with the tuning control. In the present design, whose circuit is shown in Fig. 1, the first difficulty is overcome by using fairly long spindles on the controls, and by having a small amount of extra capacitance permanently shunted across the tuned circuit in the form of VC3. The second snag is dealt with by using a variable resistor in the collector circuit of TR2 to control reaction, the capacitance across diode D1 being fixed. (In the earlier versions of the D.R.C. circuit, reaction was controlled by a variable capacitor connected across this diode.)

Two ranges are covered with two separate variable inductance tuning assemblies. One covers a range from approximately 1.5 to a little over 6MHz, and the other covers a range from a little under 6MHz to about 22MHz. Thus, all bands from the low frequency end of the medium wave band to the 13 metre broadcast band are covered. The variable inductance tuner is used as a band setter, and a 10pF variable capacitor is used for bandspreading. A further advantage of this arrangement is that the coverage offered by the bandspread capacitor remains constant whatever the setting of the band setter. When variable capacitance tuning is used for the band setter, as is normal, the bandspread capacitor will be found to give a comparatively large coverage when the band setting capacitor is at minimum, and hardly any coverage when it is at maximum.

About 15 different settings of the band setter will be required for complete coverage of either range, when a 10pF bandspread capacitor is used, as here. Sensitivity will be found to be remarkably high for a simple receiver, even using the short telescopic aerial alone, though (particularly on frequencies below about 6MHz) the use of a longer aerial and an earth connection will increase sensitivity still further, but at the cost of selectivity. The author has received reports covering the first D.R.C.2 receiver of a signal being read which

COMPONENTS

Resistors
(All fixed values ½ watt 10%)

R1	1kΩ
R2	1kΩ
R3	47kΩ
R4	10kΩ
R5	2.2kΩ
VR1	500Ω potentiometer, wire-wound
VR2	1MΩ potentiometer, moulded log track
VR3	5kΩ potentiometer, log track, with switch S2

Capacitors

C1	22pF silvered mica
C2	0.01μF paper or plastic foil
C3	330pF silvered mica
C4	47pF silvered mica
C5	47pF silvered mica
C6	100μF electrolytic, 2.5 V.Wkg
C7	100μF electrolytic, 2.5 V.Wkg
C8	100μF electrolytic, 2.5 V.Wkg
C9	1,000μF electrolytic, 10 V.Wkg
C10	0.01μF paper or plastic foil
C11	1μF paper or plastic foil
VC1	500pF variable, 'Dilecon' (Jackson Bros.)
VC2	10pF variable, type C804 (Jackson Bros.)
VC3	40pF trimmer, mica

Inductors

L1	See text
L2	2.5mH r.f. choke type CH1 (Repanco)
L3	See text
L4	See text

Semiconductors

TR1	2N3707
TR2	SF115 or BF115
TR3	BC169C
TR4	OA91

Switches

S1(a)(b)	2-pole 2-way, miniature rotary
S2	s.p.s.t. (part of VR3)

Battery
9-volt battery type PP3 (Ever Ready)

Phones
High resistance phones (see text)

Aerial
Telescopic aerial type TA10 (Henry's Radio)

Miscellaneous
2 ferrite rods, 4 in. by ⅜ in. diameter
1 ferrite rod, 1½ in. by ⅜ in. diameter (see text)
6-way tagboard, Cat. No. BTS11 (Home Radio)
Phono socket
Battery connectors
Tuning drive pulley (or drum) 1¼ in. diameter, Cat. No. DL41 (Home Radio)
¼ in. spindle bush
¼ in. spindle, metal or insulated, as required (see text)
Spindle extenders, or couplers, as required (see text)
¼ in. collar (see text)
¼ in. spring washer
2 ¼ in. plain washers
Tuning drive cord
Knobs
Plywood, Fablon or Contact

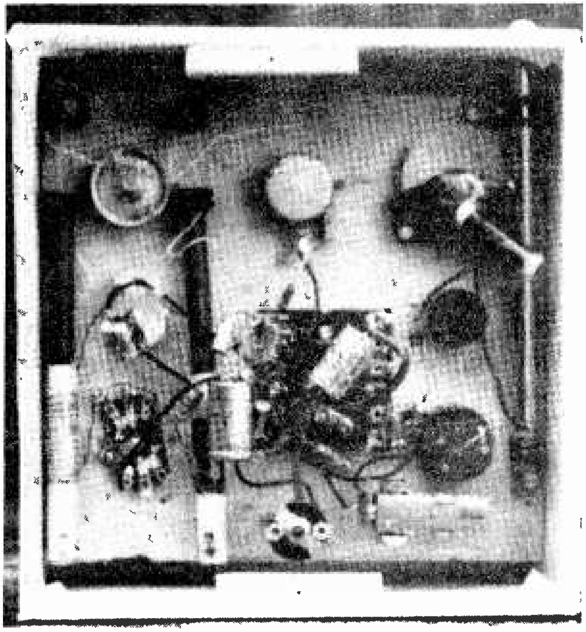
gave only 1μV at the aerial, and of a number of signals being received and read which were indecipherable on an elaborate communications receiver. This latter achievement is due, of course, to the superior signal-to-noise ratio offered by this simple receiver with its minimum of noise-producing components.

CIRCUIT OPERATION

Let us next consider in detail the circuit shown in Fig. 1. The signal is applied from the aerial – which should normally be about 45 to 50 in. in length – to L1 and VC1. These form a medium wave-band wave-trap, and are useful when listening on the 160 metre band if a powerful medium wave station should break through (this being quite a likely hazard when a longish aerial is used). In many cases the wave-trap will be found unnecessary, in which case VC1 should be set to maximum and left alone. L1 consists of 65 turns of 26 to 32 s.w.g. enamelled wire wound in a single layer on a 1½ in. length of ⅜ in. ferrite rod. This length may be broken from a longer rod. Alternatively, if the constructor would prefer not to attempt obtaining the length required in this way, a 1¼ in. rod of ⅜ in. diameter can be used instead. The 1¼ in. rod may be obtained from Amatronix Ltd., 396 Selsdon Road, South Croydon, Surrey.

The aerial signal next appears at VR1, which is an input volume control and also provides the high frequency emitter resistor for TR1, with the latter acting as a common base r.f. amplifier. The amplified signal next appears across L2, a radio frequency choke offering a high impedance, and is then applied to the high impedance input of TR2, the 'Spontaflex' amplifier. Current amplification is given by TR2 in the common collector mode and its output is passed to D1 which rectifies and thereby detects the signal.

TR2 next acts as a common base audio frequency amplifier, and produces an amplified a.f. signal across R3 and VR2. This is fed back to TR1 which now gives current amplification at audio frequencies, the output appearing across R1 with the a.f. volume control VR3 in parallel. The upper end of R1 is positive with respect to the negative supply line so that a positive bias is applied to the base of TR3, C7 enabling VR3 to function as a volume control without upsetting bias conditions. TR3 acts as a common emitter audio amplifier, the final signal appearing across R4 and being fed to the output sockets by C11. C10 is an r.f. bypass capacitor and C9 is the usual large-value capacitor across the battery. Battery current is about 1.5mA only.



A view inside the back of the cabinet

When the receiver is switched by S1(a)(b) to the lower frequency range, both L3 and L4 are operative, with VC2 and VC3 across them. Also, both C4 and C5 appear across the diode and provide the requisite capacitance tap into the tuned circuit. When the high frequency range is selected, L4 is short-circuited and the capacitance tap is given by C5 only.

It will be seen that R3 plus VR2 provide base bias for TR1, while the voltage cross R2 provides base bias for TR2. This direct coupling ensures very constant bias conditions – a matter of great importance on the short wave bands where the smallest deviation can cause frequency drift.

Reaction is provided by the Colpitts method which, as used by the author with his 'Spontaflex' circuit, has been described many times in the past. Reaction in this receiver is controlled by VR2. As this resistor is increased in value, current through TR2 is reduced, causing a drop in amplification at signal frequency and a consequent reduction in its tendency to oscillate. At audio frequencies, however, amplification is maintained even at a very low current, and the amplification offered is increased by the larger load in the collector circuit given by the increased resistance inserted by VR2. Thus, although reaction effect is reduced, audio amplification becomes greater as the resistance inserted by VR2 increases. It is very important that this component should have a moulded track as it passes current, and most normal potentiometers would soon become noisy in use. (A suitable moulded track component is available from Home Radio under Cat. No. VR18B.) It is a log track control, connected so that resistance is reduced and reaction is increased as its knob is turned *anti-clockwise*. This is contrary to usual practice but results in very smooth reaction control with the present circuit. If a suitable moulded track anti-log component should be available, it may be connected in the orthodox manner.

CONSTRUCTION

The first constructional step is to cut a piece of $\frac{1}{4}$ in. plywood as in Fig. 2, and then drill the holes shown.

Next take the 6-way tagboard and mount components on it as shown in Fig. 3(a). For clarity, some of the components are shown as being positioned well outside the outline of the tagboard at the sides. In practice these components should be inside or closer to the board edges as, otherwise, they will later foul other parts. If a BF115 is used for TR2, no connection is made to its shield lead-out. When wired, screw the board to the plywood panel as shown in Fig. 4. It is the same way up in both diagrams.

To make L4, take a piece of Fablon or Contact, 3 in. square. Leave the paper backing on except for a $\frac{1}{2}$ in. strip along one edge. Wind the Fablon or Contact into a tube on one of the 4 in. lengths of ferrite rod, and seal the tube with the uncovered strip. The tube should form a sufficiently loose fit for the rod to drop into it easily under its own weight, but not so loose as to allow the rod to wobble about. Wind on 60 turns side-by-side of 26 s.w.g. enamelled wire as shown in Fig. 3(b), starting at the top. The winding will be found to occupy about $1\frac{1}{2}$ in. along the tube. Cut a $\frac{1}{2}$ in. length of $\frac{3}{8}$ in. wood dowelling, wrap a turn or two of Sellotape round it to make it a tight fit in the coil tube, and plug it in as shown in Fig. 3(b). Drill two holes to take 6BA bolts as illustrated. Put the now completed coil on one side and make the other coil, L3. This is identical in every respect except that 17 turns of 26 s.w.g. enamelled wire are used, spaced out so as to occupy a length of $1\frac{1}{2}$ in. The second coil is now also put on one side.

Next fit the $\frac{1}{4}$ in. bush to the plywood panel indicated, in Fig. 4, as carrying a pulley. Secure the pulley to the end of a 3 in. length of brass or insulated rod of $\frac{1}{4}$ in.

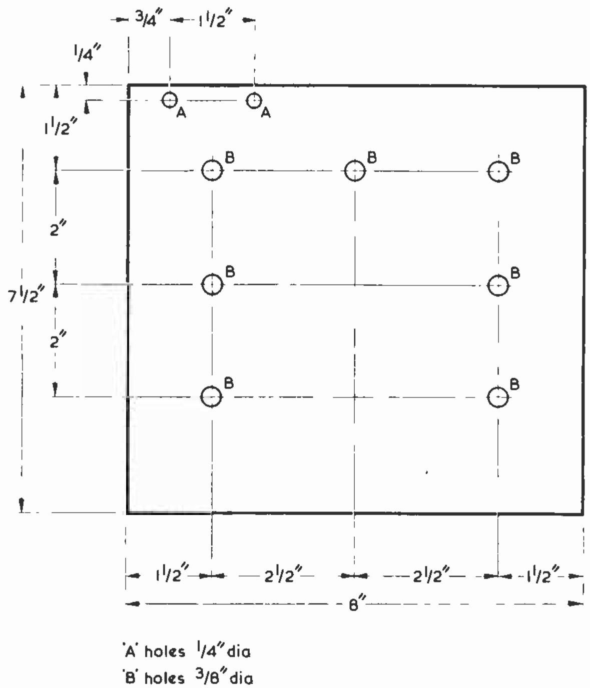


Fig. 2. Dimensions and holes required in the receiver panel. The material is $\frac{1}{4}$in. plywood

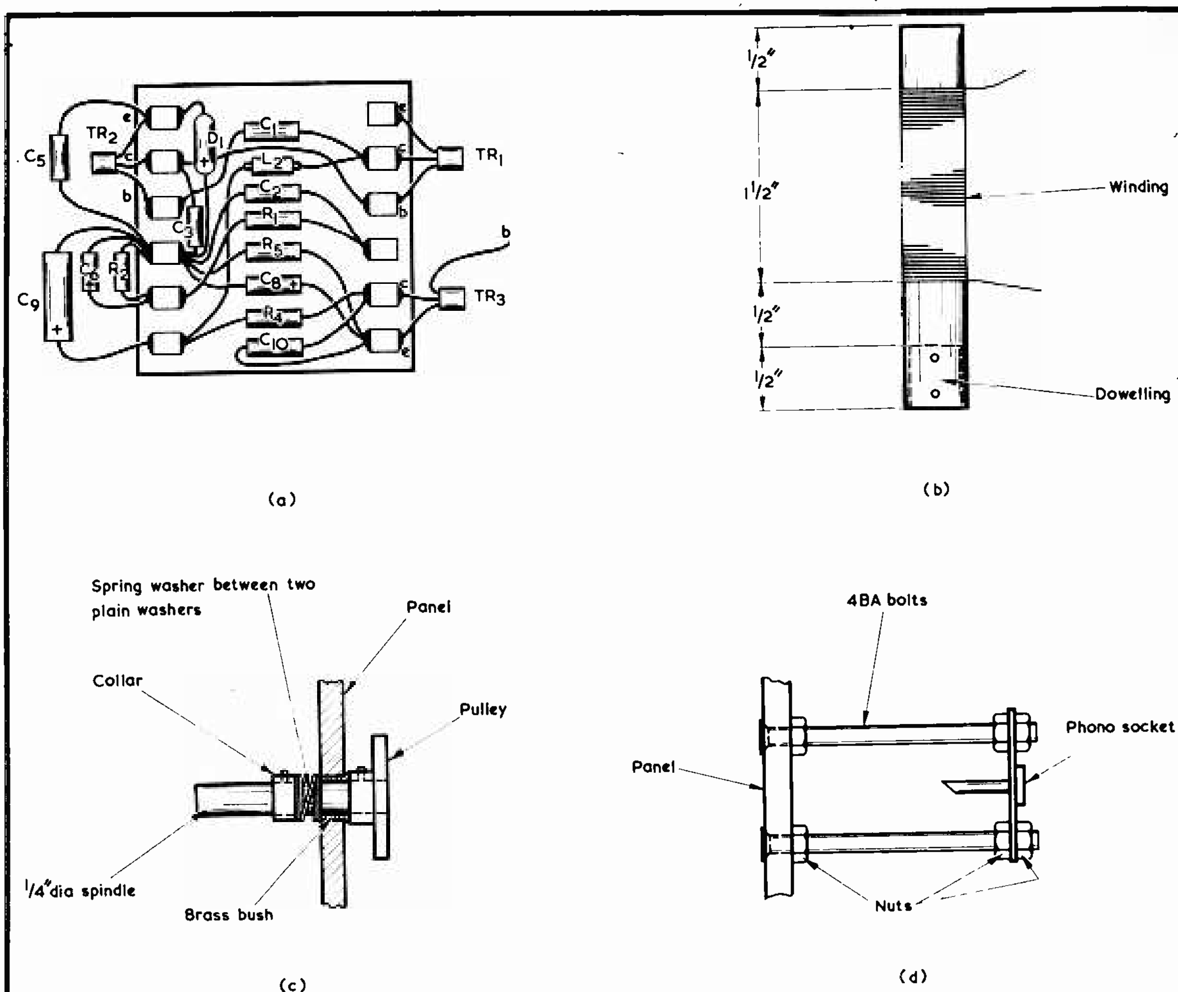


Fig. 3 (a) Wiring up the 6-way tagboard
(b) How coil L4 is made up
(c) Assembly of washers and collar on the pulley drive spindle
(d) The output phono socket is spaced off from the receiver panel by long 4BA bolts

diameter, and pass this rod through the bush. On the other side of the panel fit two plain washers, one spring washer and a collar to the rod, the collar being placed so as to compress the spring washer a little and make the rod slightly stiff to turn. See Fig. 3(c) and Fig. 4. Make a suitable bracket and clip for the aerial and fit these as indicated. Similarly make and fit a clip for the PP3 battery. Mount the output socket as shown in Fig. 3(d). It is fitted at the ends of two 2 in. 4BA bolts so that it will stand level with the back of the case when the receiver is completed.

Complete the wiring and fitting of the components as shown in Fig. 4, leaving the mounting of L3 and L4 to the last. It should be mentioned at this stage that it may be necessary to extend or cut the spindles of some of the controls, this point being dealt with later in this article. Readers are advised to read these later instructions before finally mounting the controls since they may then be able to cut the spindles as required before the appropriate controls are fitted. This point is mainly applicable to controls having metal spindles. Controls with insulated spindles can have their spindles cut after they have been installed and wired.

Coils L4 and L5 are fitted by means of two 6BA bolts each, nuts being used as spacers to keep the coils clear of the panel. The two ferrite rods have tight fitting grommets at one end, the other ends being dropped into the respective coils. Two short lengths of ¼ in. rod are plugged into the top two holes in the panel. Two pieces of tuning drive cord are attached to the hook inside the pulley, taken once round the pulley then over the ¼ in. rods at the top and through the grommets at the upper ends of the ferrite rods. If Fig. 4 is followed it will be seen that, by fitting a knob to the pulley spindle on the other side of the panel, the positions of the ferrite rods inside the coils can be adjusted. Turning the knob clockwise (as seen from the knob side of the panel) allows the ferrite rods to drop into the coils, thus increasing inductance. Turning the knob anti-clockwise will draw the rods out of the coils. The rods remain in the coils by reason of their own weight and it will be obvious that the receiver can only be operated with the panel of Fig. 4 vertical. The two cords from the pulley are now adjusted, at the points where they pass through the grommets at the tops of the ferrite rods, so that each rod reaches the dowelling at the bottom of the

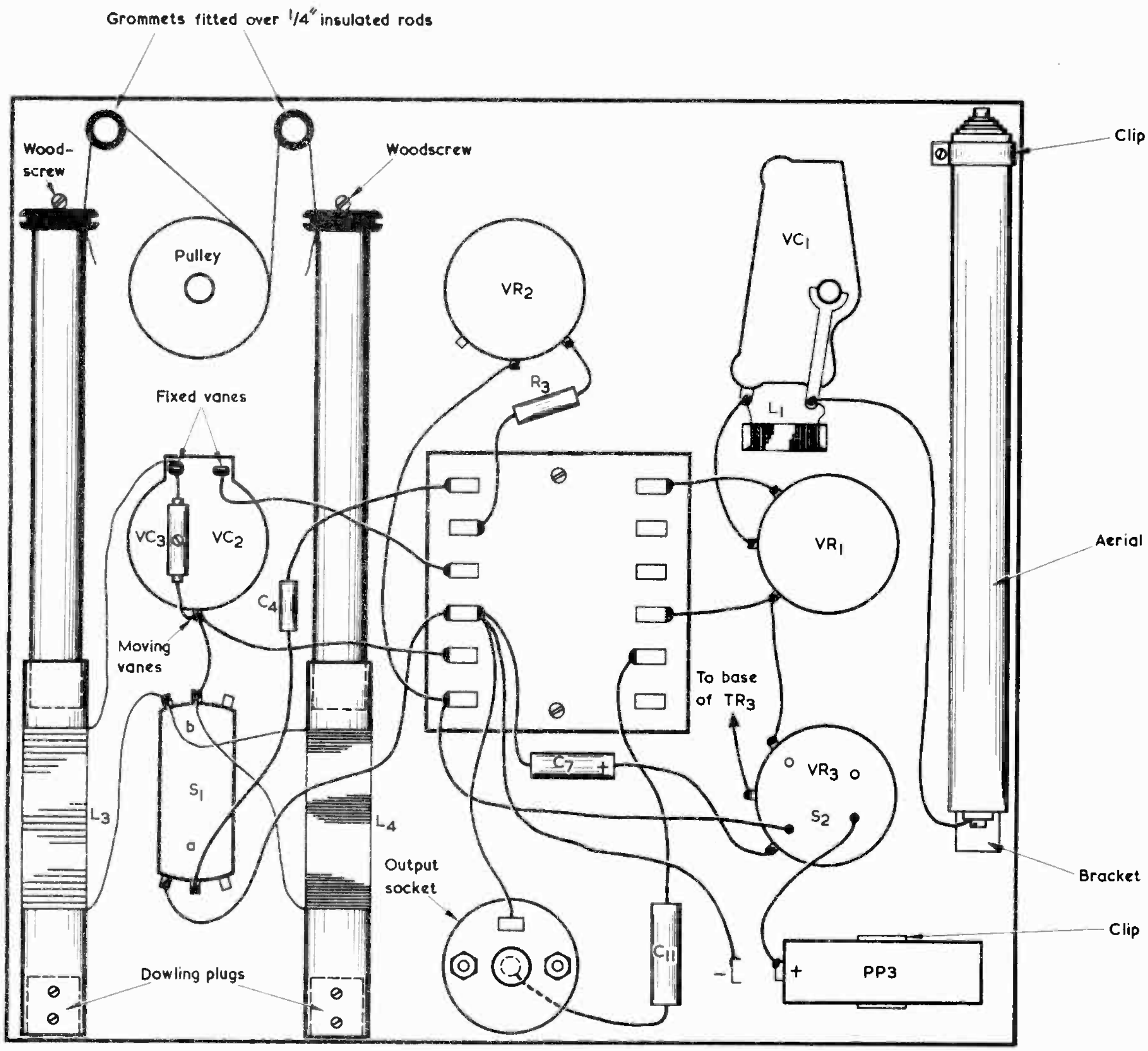


Fig. 4. Layout and wiring on the main receiver panel

coils at the same time. It is convenient to fit small wood screws to the panel to prevent the rods from being completely withdrawn from the coils, and rubber grommets fitted to the two ¼ in. rods at the top of the panel will help to prevent the cords from slipping off.

It is necessary for the spindles of the controls to project forwards by about 2 to 2½ in. in order that the hands of the operator do not approach the r.f. circuits too closely when making adjustments to the receiver. In some instances, the spindles on the controls will already be long enough to meet this requirement whilst with others it will be necessary to cut them or to add spindle extenders or additional lengths of ¼ in. rod and spindle couplers. The final length of each spindle is best judged after the case has been made. The receiver can be placed temporarily in this and the spindle lengths adjusted so that sufficient projects through the front of the case to suit the particular knobs to be employed.

MAKING THE CASE

A simple case can be made as shown in Fig. 5, using ¼ in. plywood for the front, top, bottom and sides. A 12 in. length of ⅜ in. square dowelling is cut into four equal parts which are screwed and glued into position as illustrated. Seven holes (not shown) are required in the front panel to take the spindles of the controls, whilst a further hole is required in the top section for the telescopic aerial. When the case is screwed together, as indicated by the dashed lines in Fig. 5, it will be found that the two side pieces of dowelling will support the panel of Fig. 4 which can, later, be screwed to them. The inside height of the cabinet is greater than the height of the receiver panel. This allows clearance for the telescopic aerial and eases the process of fitting the receiver panel. The latter may be mounted centrally so far as the vertical direction is concerned. The two pieces

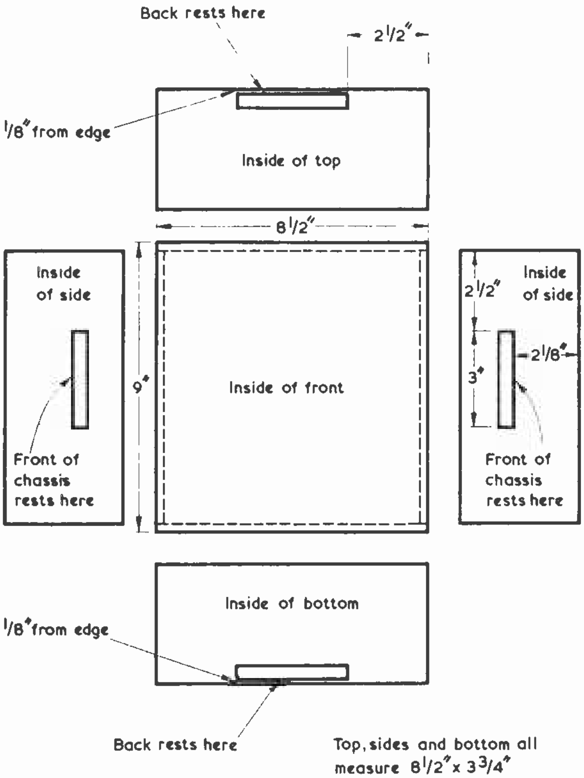
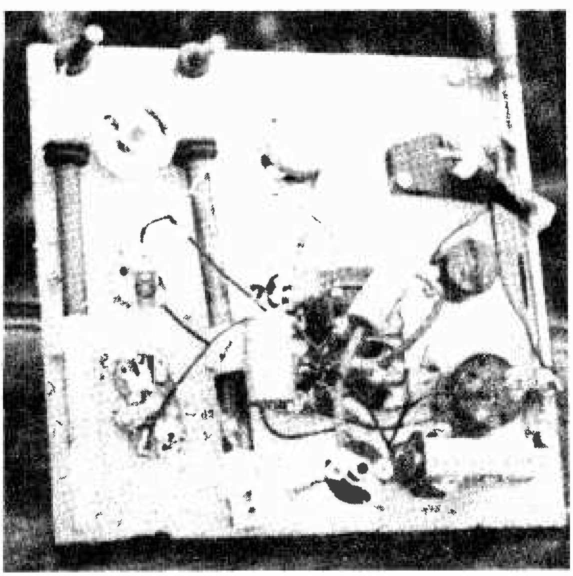
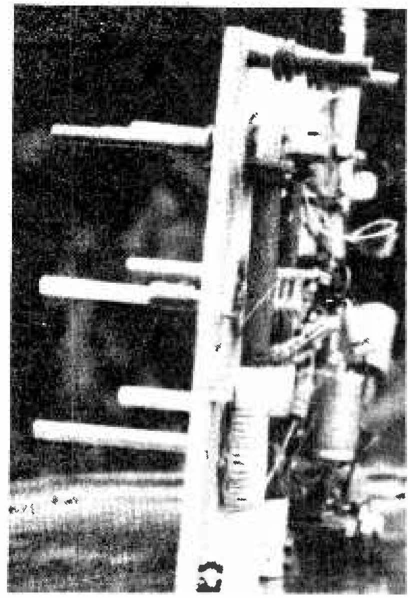


Fig. 5. Component parts for a cabinet for the receiver

of dowelling at top and bottom support a back for the cabinet, which may consist of a piece of hardboard measuring 8½ by 8 in., and having a hole for the output socket. Fablon or Contact may be used to tidy off the finished cabinet and seven suitable knobs fitted.



The main receiver panel, as seen from the rear



Side view of the receiver panel. Note the long control spindles

TESTING

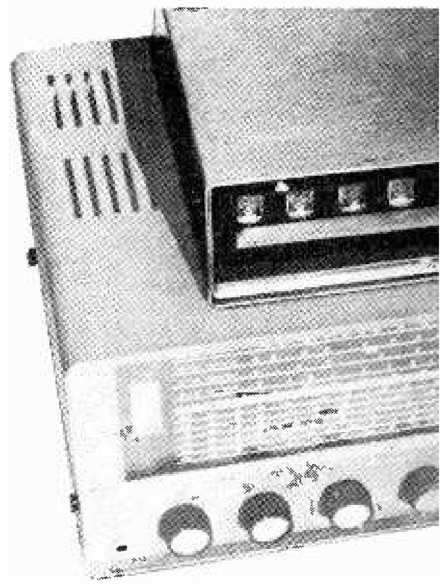
The receiver may next be tried out, and this process is best carried out with the receiver removed from its case and held so that its panel is vertical. The bench vice may be pressed into service for this.

First set VC1, VR1 and VR3 to maximum, VR2 to minimum (remember this means fully *clockwise*), VC2 half way, VC3 fully open and S1 to the low frequency range. Turn the knob controlling the pulley until a signal is heard, advancing VR2 as this is done to increase sensitivity. Fine tuning is carried out with VC2. It is convenient to operate this control with the right hand whilst the left hand is held on the knob of VR2. In practice, always operate with VR2 near the position which causes oscillation, the signal being backed down, as required, by VR1. This method will produce maximum selectivity. VR3 is used to regulate volume once the other controls have been set at optimum for the signal being received. Repeat the process with S1 set to the high frequency range.

When the knack of operating the receiver has been acquired – and this should only take a few minutes – leave S1 set to the high frequency range and adjust the band setter so that the rods are moved out of the coils as far as possible. Set VC2 to the half-way position and adjust VC3 until 13 metre band stations are received. This will probably require less than 10pF to be offered by VC3. The procedure is best carried out during daylight when signals in the 13 metre band are at their best strength.

When the receiver has been checked it may be fitted finally into its case. If desired, the front of the case may carry transfers or other means of identification of the controls. As regards calibration, it is useful to set the bandspread control to the mid point and then calibrate the band setter. For many purposes it will suffice to provide calibration marks for the centres of the various amateur and broadcast bands rather than provide complete calibration. ■

DIGITAL FREQU



Pa

S. A. Money, M

This article is the first of a 2-pa quency monitor which may b munications receiver to indica Operation up to 25M

FOR THE SERIOUS SHORT WAVE LISTENER ONE OF THE most important features in a good receiver, apart from adequate sensitivity and selectivity, is the ability to determine quickly and accurately the frequency to which it is tuned.

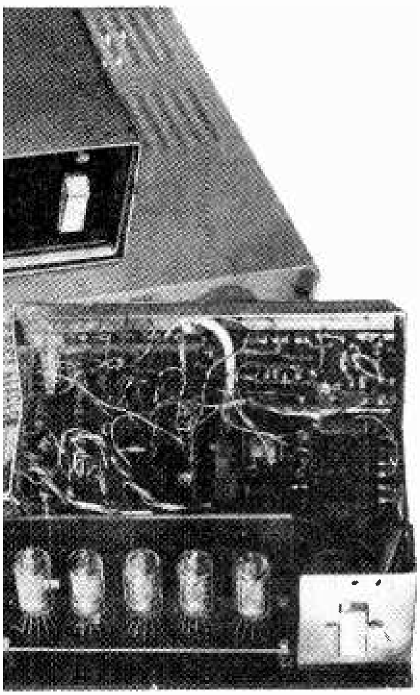
In the modern professional communications type of receiver it is not unusual to find that a digital type frequency synthesiser has been incorporated to provide the tunable local oscillator signal. Such a receiver can be readily tuned to any frequency within its range with an accuracy of hundreds, or even tens of Hz, by simply selecting the desired frequency setting on a series of decimal switches. Naturally a sophisticated receiver of this type is extremely expensive to buy and this generally places it beyond the reach of the average amateur listener who has to be content to use more moderately priced equipment.

FREQUENCY READOUT

The majority of the receivers used by amateurs are in the medium price range and, whilst having perfectly adequate sensitivity and selectivity, are often found to be sadly lacking when their tuning arrangements are considered. In many cases a range of frequencies of 1 MHz or more may be covered by only half an inch of the tuning scale. This is especially true on the higher frequency bands. Such a scale is virtually useless for direct readout of frequency because the user will be lucky if he can judge the indicated frequency to an accuracy of better than 50 or 100 kHz. A few of these receivers are also fitted with some form of precision logging scale which, by the skilful use of a calibration graph, can provide a tolerably accurate readout of the frequency of the station being received. In some cases electrical bandspread tuning may be fitted to give a finer tuning control and reasonable scales for the higher frequency bands. Unfortunately, the calibration of these bandspread scales is usually dependent upon the precise setting of the main tuning dial of the receiver. As a result of these receiver deficiencies the listener usually has to resort to the use of some sort of crystal controlled calibrator or marker generator to

ENCY MONITOR

Cover Feature



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3.C.S., G3FZX

**series describing a digital fre-
coupled to a standard com-
the frequency of reception.
z and above is possible.**

check the frequency of received stations. The use of such devices, although reasonably straightforward, tends to be rather a tedious business.

From the above comments it becomes obvious that the ideal solution would be to have some device which, when connected to the receiver, would provide a direct and accurate digital readout of the received frequency in kHz. With such a system it would be possible to check the frequencies of received stations at a glance without the need for reference to calibration charts or crystal marker generators.

The digital frequency monitor to be described here performs precisely this function and has been found to be an invaluable aid to short wave listening on both the broadcast and amateur bands. It measures the received frequency every tenth of a second and therefore provides a continuously updated display of the frequency to which the receiver is tuned.

In the design extensive use has been made of modern digital integrated circuits which have now become readily available to the amateur constructor. The received frequency is displayed directly in kHz on a series of gas-filled decimal indicator tubes. In order to extract a suitable signal for use in the frequency monitor it will be necessary to make some small additions to the receiver. Since the unit has its own built-in power supply the only connection needed to the receiver will be a signal cable.

It was found that the monitor unit worked reliably up to frequencies of about 25 MHz, which covers most of the interesting short wave bands. By careful selection of components it has been found possible to extend the range of operation up to 30 MHz.

PRINCIPLES OF OPERATION

How can we measure frequency by a digital approach? The obvious method would be simply to count the number of cycles of the input signal that occur in a period of exactly one second. The resultant count total can then be displayed on a series of decimal indicators which will present a direct readout of the measured frequency in Hz. Apart from a few refinements this is basically the technique used in the frequency monitor

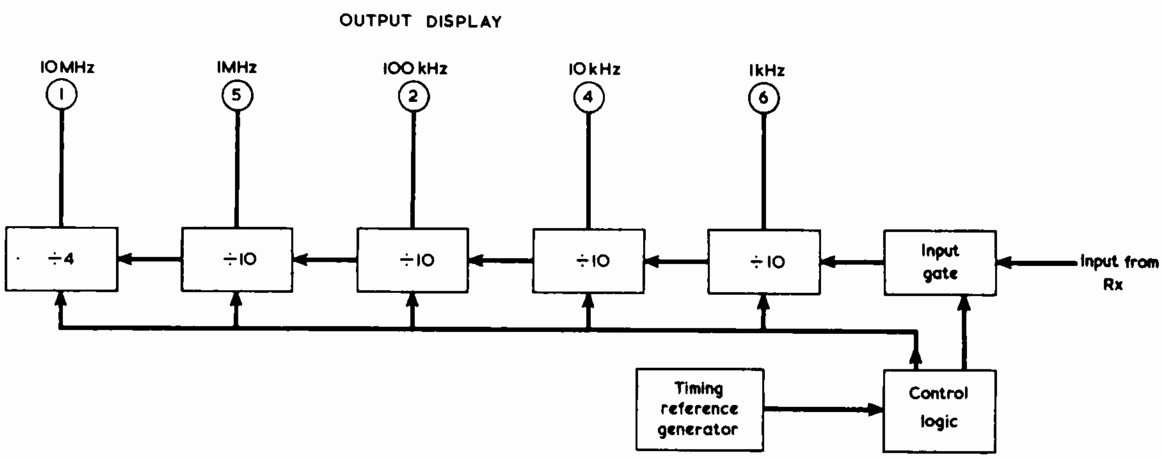


Fig. 1. Block diagram illustrating the basic operation of the monitor

system which will be described. Fig. 1 shows a block schematic diagram of the basic system.

The input signal to be measured is first of all cleaned up by a pulse shaper circuit to produce a constant amplitude square wave. After passing through a gate circuit this square wave is used to drive a chain of decade counter stages connected in cascade. Each of the decade stages in the chain drives a decimal number indicator tube. This set of indicators will now provide a direct readout of the state of the counter chain. The sequence of operations of the input gate and the counter chain is determined by control logic circuits which derive their timing from a crystal controlled reference oscillator. Each complete measurement sequence is initiated by a trigger pulse every tenth of a second which is derived from the mains supply frequency.

Let us now examine the action of the system during the measurement of some unknown input frequency. At the start of the cycle of events the input gate is in the closed condition and the counter is static and set at the value produced by the previous cycle of operations. When the sequence control logic is triggered to start a new measurement the counter is reset to zero but the input gate remains closed. During the next time period of the control sequence the input gate is opened and the counter is allowed to count the cycles of the input signal. At the end of this period the gate is closed and the counter will be set at the total number of cycles of input frequency that occurred during the time that the gate was held open. Since the timing of the sequence control logic is determined by an accurate crystal controlled oscillator it can be arranged that the input gate is held open for a period of exactly one millisecond. The counter output will now represent the number of cycles that occur in a millisecond, which is equivalent to the input frequency measured in kHz. At the end of the measurement sequence the control logic becomes dormant until a new trigger pulse is received. The indicators connected to the counter output will continue to display the frequency reading in kHz until a new cycle is started.

In this description of the operation of the monitor the frequency was displayed in kHz and for most purposes this will be found to be sufficiently precise. Assuming that the receiver in use has a stable local oscillator it would be practicable to display the frequency in hundreds of Hz of desired. To achieve this it is only necessary to alter the timing of the sequence control logic so that the input gate is held open for a period of 10 milliseconds instead of for 1 millisecond. A readout to better than 100 Hz is not really practical due to drift in the receiver local oscillator which will tend to cause the reading to vary continuously and, with the simple tube blanking system used in the monitor design to be described, there may also be an objectionable flicker in the display.

FREQUENCY OFFSET CORRECTION

In order to measure the frequency of a received station it is first of all necessary to extract from the receiver a signal which will drive the frequency monitor. Ideally we should use the carrier of the received signal. Most communications receivers, however, use the superheterodyne principle and convert the frequency of the input signal, whilst it is still at a low level, to produce a fixed intermediate frequency. In this case it is convenient to make use of the local oscillator signal since its frequency will be directly related to that of the input signal.

In a simple superheterodyne receiver the frequency of the local oscillator is normally offset above the signal frequency by an amount equal to the intermediate frequency used in the receiver. Since this oscillator frequency is being measured by the monitor unit the displayed frequency readout will also be offset unless some form of correction is employed.

There are two basic methods by which the effect of the oscillator frequency offset can be corrected. With the first a subtractor stage may be inserted between the output of the counter and the indicator tubes. The fixed intermediate frequency is then subtracted from the total in the counter so that the correct result will be displayed. The logic for a digital subtractor is quite complex so an alternative and simpler approach was sought.

If the counter is started off from a negative value at the start of the counting period it can be arranged to carry out the subtraction process itself. In order to set the counter at a negative number it is in fact set at full scale minus the desired negative number. At the end of the count operation the total displayed by the counter will now be the true count minus the offset from which the count was started.

In some receivers it may be found that the local oscillator frequency is offset below that of the input signal. In this case the counter must be set at the value of the intermediate frequency at the start of the count cycle.

THE DECADE COUNTER

The basic stage of the counter chain consists of four flip-flops arranged to form a decade counter. The output of this counter stage, which is in binary coded decimal form, is then passed through a decoder which provides the drive signals for the ten cathodes of a number indicator tube which in turn provides one digit of the frequency display.

There are complete decimal counter modules, type 7490, available in the 74 series TTL logic range but these are unfortunately not suitable for our purpose since they can only be preset to the 'zero' or 'nine' state. Because of this limitation of the 7490 it is necessary to make up the decade counter stage from a set of four separate flip-flops with a reset gate to provide a decade count. The 7474 dual 'D' type flip-flop was found to be the most convenient since it has a higher switching speed capability than most of the other readily available types and there are two flip-flops in each package. The circuit used for the decade counter stage is shown in Fig. 2(a).

In the 'D' type flip-flop the output Q will take up the same state as the D input when a clock pulse is applied. To make it into a counter stage we must join the inverted output NQ to the D input. Now when a clock pulse is applied to the flip-flop the output will always change state thus providing a binary counter stage. To achieve a decimal count it is first of all necessary to connect four binary counter stages in cascade to give a basic count of 16. When the count reaches ten, which in binary is 1010, the four stages must be reset to the 'zero' state and a 'carry' pulse generated to provide the clock drive for the next decade in the counter chain. The reset gate is set to operate when the second and fourth stages are both in the 'one' state.

The Q output of a 7474 flip-flop may be directly set to the 'one' or 'zero' state by putting its preset or clear input respectively to zero volts. It is not permissible to set both of these inputs to 'zero' at the same time since this produces an ambiguous condition in the flip-flop.

At the start of the count cycle it must be possible to set the counter to any one of its ten states. Because of this requirement the four clear input lines of the decade cannot be connected in parallel since this would only allow the counter to be set at zero. To overcome this restriction four separate gates are used in the reset circuit with each gate feeding one flip-flop.

At the start of the count cycle a setting up pulse from the control logic is applied to either the clear (C) or preset (P) inputs of the flip-flops according to the number to be set up for the offset correction. This means that the outputs of the reset gate and the control logic may need to be applied to the same point on the counter stage. Because they use 'totem pole' output stages it is not permissible to join the outputs of normal TTL gates directly in parallel. This difficulty may be overcome by using Type 946 DTL 2-input gates for the reset gate and for feeding in the setting up pulse from the control logic. The outputs of these DTL gates have been designed so that they may be connected directly in parallel with one another. As an alternative the type 7401 TTL gate may be used. This device, although a TTL type, has open collector outputs which may be wired in parallel with other similar outputs. The pin connections of the 7401 are exactly the same as those of the 946 so that the two types are directly interchangeable.

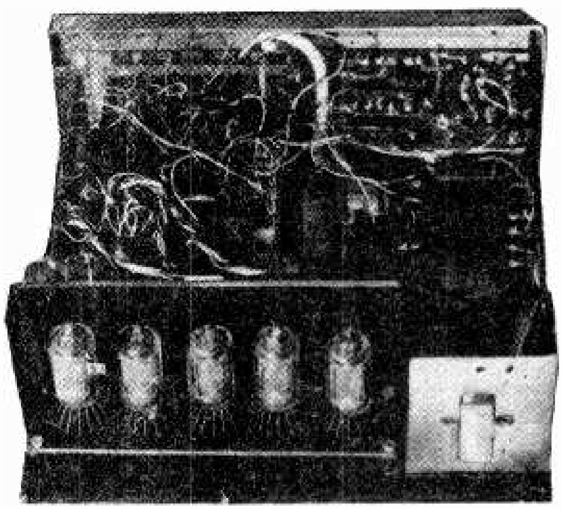
The presetting pulse from the control logic is fed to the counter stages via the four gates of a 946, one feeding each flip-flop. The four gate outputs are routed via a set of wire links (S1–S4) to either the clear or preset inputs of the four flip-flops in the decade.

These four wire links are joined up so that when the presetting pulse is applied each decade will set to the appropriate state to give the complete counter the required offset at the start of the count cycle. Links were used so that if the receiver were changed it would be a simple matter to change the offset if necessary. If desired the presetting pulse inputs could be wired permanently to give a fixed offset pattern.

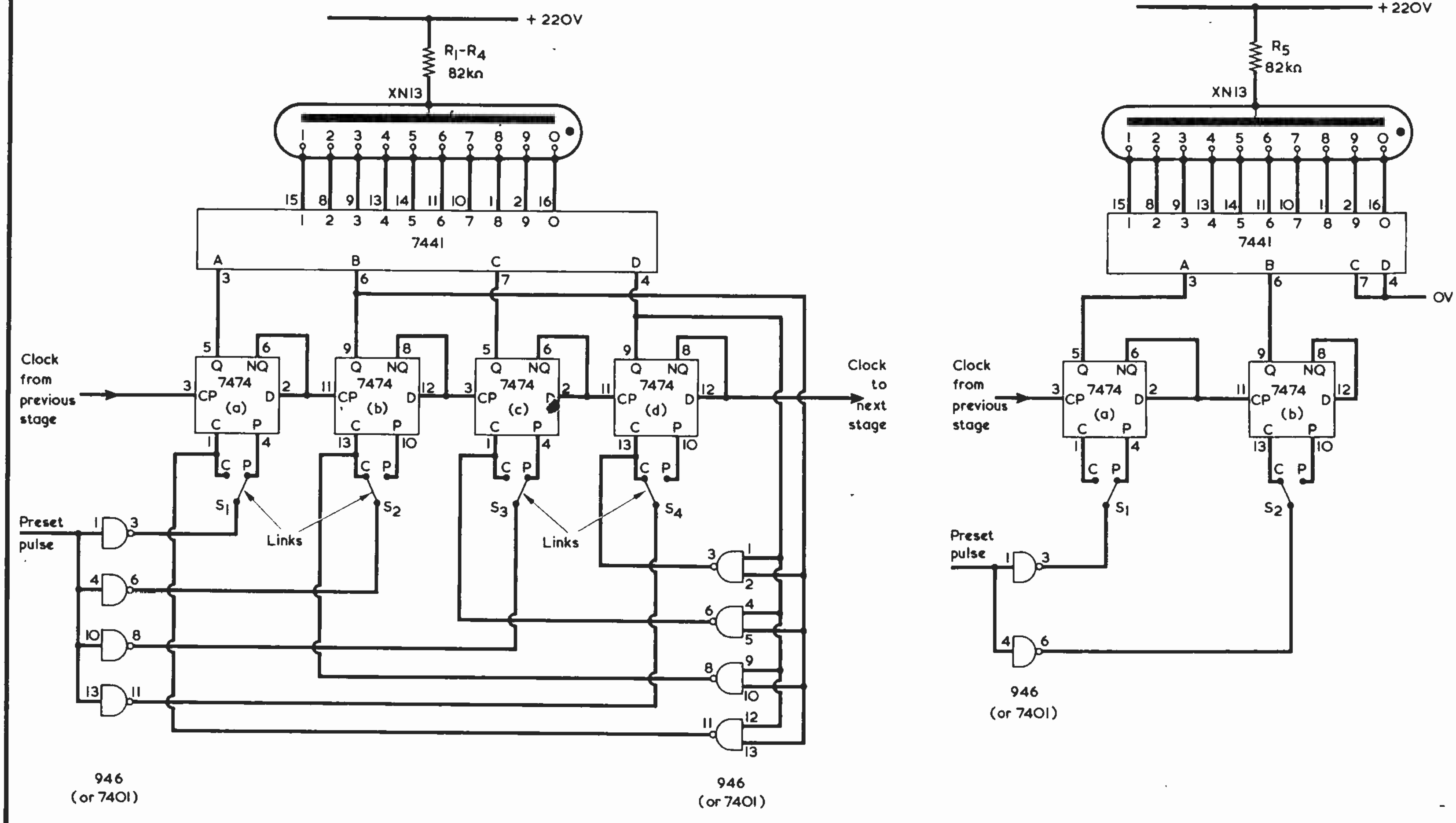
The four Q outputs from each decade are connected to a 7441 decoder and Nixie tube driver. This device converts the four line binary coded decimal output of the counter into ten separate lines which are used to feed the ten cathodes of a decimal indicator tube.

A clock signal for the next decade of the counter chain is obtained from the inverted output NQ of the fourth stage of the decade. This output will fall to 'zero' at position 8 in the count and rises to the 'one' level again when the counter resets to 'zero' at the tenth count. The next decade will be clocked by the 'zero' to 'one' transition of the NQ output, i.e. at the tenth count.

For a frequency display reading up to 39.999MHz the final stage of the main counter will only have to



Front view of the monitor. The five indicator tubes are maintained in position by their lead-out wires



(a)

(b)

Fig. 2(a). One of the decade counter stages. Here, and in succeeding circuit diagrams, OV and +5V supplies are omitted. The requisite connections are made as indicated in the module connection layouts given in Fig. 5. The quad NAND gate type 946 (or 7401) is not 'boxed', its sections being simply grouped together near the type number. The same method of presentation is also used in some of the later diagrams

Fig. 2(b). The final counter stage

count through the states 0, 1, 2 and 3. In the final decade only the first two flip-flops are required and the reset gate circuit may be omitted. To avoid any ambiguous readings on the final indicator tube the C and D inputs of the 7441 decoder driving this stage should be connected to the zero volt line. The final stage circuit appears in Fig. 2(b).

INPUT GATE AND DIVIDER CIRCUITS

A decade counter using 7474's and a reset gate circuit was found to operate erratically at the higher count frequencies due to the delays introduced by the reset gate. To make operation more reliable at these higher frequencies a pair of simple divide-by-two stages are used ahead of the main counter chain. The first of these dividers also acts as the input gate. The gate signal from the control logic is applied to the clear input of the first divider flip-flop. When the gate signal is at the 'one' level the clear input has no effect and the stage operates as a divider, but if the gate signal is at 'zero' the flip-flop is set at 'zero' by its clear input. Since the clear input on a 7474 overrides the clock input the flip-flop will be held in the 'zero' state until the gate control line returns to the 'one' state.

The second stage of the input divider acts as a simple divide-by-two counter. It is set to the 'one' state at the beginning of the count sequence by the pulse that is used to reset the main counter chain. The output of this stage provides the clock drive for the first decade of the main counter. Fig. 3 shows the circuit of the input gate and divider stages.

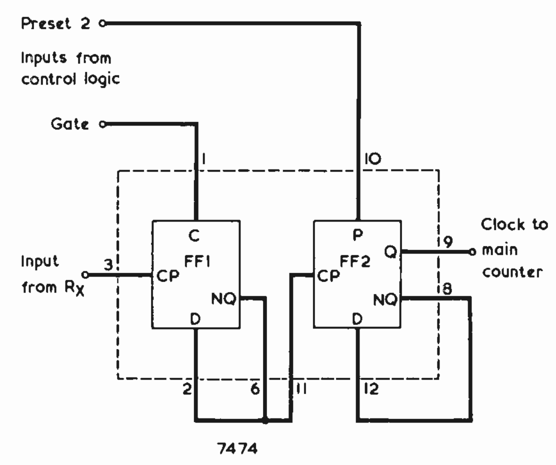


Fig. 3. Circuit of the input gate and divider

THE REFERENCE GENERATOR

The key to the whole operation of the frequency monitor is the reference oscillator, since this determines the precision of the timing of the control sequence and hence the accuracy of the frequency measurement. In order to obtain the necessary stability and frequency accuracy a crystal controlled oscillator circuit is employed. The circuit diagram of this oscillator and its associated frequency divider is given in Fig. 4.

The oscillator itself is made up by using three of the gate elements of a 7400 gate module. Since each gate acts as an amplifier and inverter it is possible to connect two gates in cascade to form a high gain amplifier whose output is in phase with its input. If a quartz crystal is connected between the output of the second gate and the input of the first it will provide a positive feedback path with maximum feedback at the resonant frequency of the crystal. This simple circuit should oscillate at the resonant frequency of the crystal but in practice a few refinements need to be added to get reliable results. The circuit works better if the gates are biased so that they are operating at a point in the linear parts of their characteristics about halfway between the 'zero' and 'one' states. Transistor TR1 and the dc feedback through R8 and C2 provide a form of automatic bias control which holds the input voltage of the first gate at about the desired level. Resistor R6 and capacitor C1 serve to control the bias on the second gate. R7 provides an added load to the output of the second gate and helps to stabilize the operation of the circuit. One of the advantages of this circuit is that no tuned circuit is required and the frequency is controlled almost entirely by the crystal itself.

The remaining two gates of the 7400 are connected in cascade after the basic oscillator to provide pulse

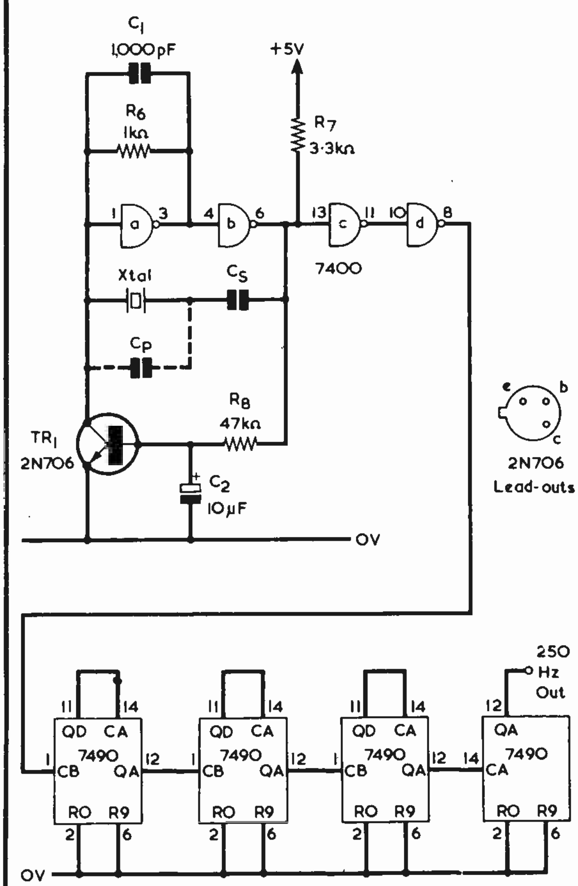


Fig. 4. Circuit of the reference generator, as employed with a 500kHz crystal

COMPONENTS

Resistors
(All fixed values ¼ watt 10%)

R1-R5	82kΩ
R6	1kΩ
R7	3.3kΩ
R8	47kΩ
R9	2.2kΩ
R10	3.3kΩ
R11	1MΩ
R12	390Ω
R13	15kΩ
R14	680Ω
R15	2.2kΩ
R16	1kΩ potentiometer, preset skeleton
R17	100Ω
R18	47kΩ
R19	2.2kΩ

Capacitors

C1	1,000pF silvered mica
C2	10μF electrolytic, 6 V. Wkg.
C3	0.047μF polyester
C4	16,000μF electrolytic, 10 V. Wkg.
C5	2,000μF electrolytic, 15 V. Wkg.
C6	50μF electrolytic, 6 V. Wkg.
C7	1,000pF ceramic
C8	22pF silvered mica

Transformer

T1	Mains transformer: secondaries 220V 50mA, 6.3V 1A.

Diodes

D1	1N4005
D2-D5	1N4001
D6	3.3V 250mW zener diode
D7	1N4001
D8	4.7V 250mW zener diode

Transistors

TR1	2N706
TR2	2N706
TR3	2N706
TR4	2N2907
TR5	2N2907
TR6	OC72
TR7	OC28
TR8	2N706

Integrated Circuits

12-off	7474
9-off	946 (or 7401)
4-off	7400
5-off	7490
5-off	7441

Indicator Tubes

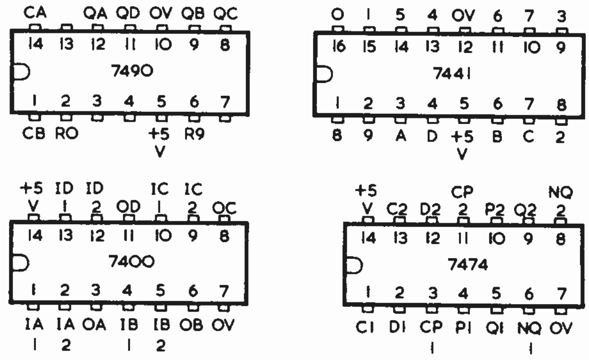
5-off	XN13 (Hivac)

Crystal
500kHz crystal (see text)

Switch

S1	s.p.s.t. toggle or rocker (Fig. 7)

Miscellaneous
Materials for case and printed circuit boards



(946 and 7401 same as 7400)

Fig. 5. Tag numbering of the integrated circuits employed. The tags point away from the reader

shaping and the resultant output waveform from the last gate should be a good square wave.

This oscillator circuit will usually operate first time with crystals of any frequency between about 100 kHz and about 10 MHz. In some cases it may be found that the circuit will tend to 'squeg' but this can usually be overcome by altering the value of the feedback resistor R8.

Quartz crystals are normally specified to operate correctly with a given value of stray capacitance in the circuit across the crystal. In this oscillator it will probably be necessary to adjust the effective capacitance of the circuit to ensure that the circuit oscillates at precisely the marked frequency of the crystal used. A capacitor Cs in series with the crystal and a capacitor Cp in parallel with the crystal are used to give fine control of the oscillator frequency. The process of adjusting the frequency will be described later.

If the frequency is to be in kHz the input signal must be counted for a period of exactly one millisecond. Because we have divided the input frequency by a factor of four in the input gate and divider it will be necessary to extend the time period of the counting operation to four milliseconds in order to obtain the correct readout on the display.

In the unit built by the author the reference oscillator operates at a frequency of 500 kHz and is followed by a divider chain which reduces this frequency to 250 Hz which gives a basic time period of 4 milliseconds in the control logic.

Three 7490 decade counter modules are used to give a division of 1,000 in frequency. Using a 500 kHz crystal this gives an output frequency of 500 Hz. A further divide-by-two stage using part of another 7490 gives the required 250 Hz clock to drive the control logic. For other crystal frequencies it will be necessary to have an alternative division ratio so that the output is still produced at 250 Hz.

COMPONENTS LIST

A Component List accompanies this article. Some of the parts listed will be introduced and referred to in next month's article.

Fig. 5 shows the tag layout of the integrated circuits employed.

(*To be concluded*)

Crystal Microphone Lead Extender

by

S. V. Jenkins

An inexpensive self-contained unit which enables a crystal microphone to be employed at a relatively long distance from its amplifier.

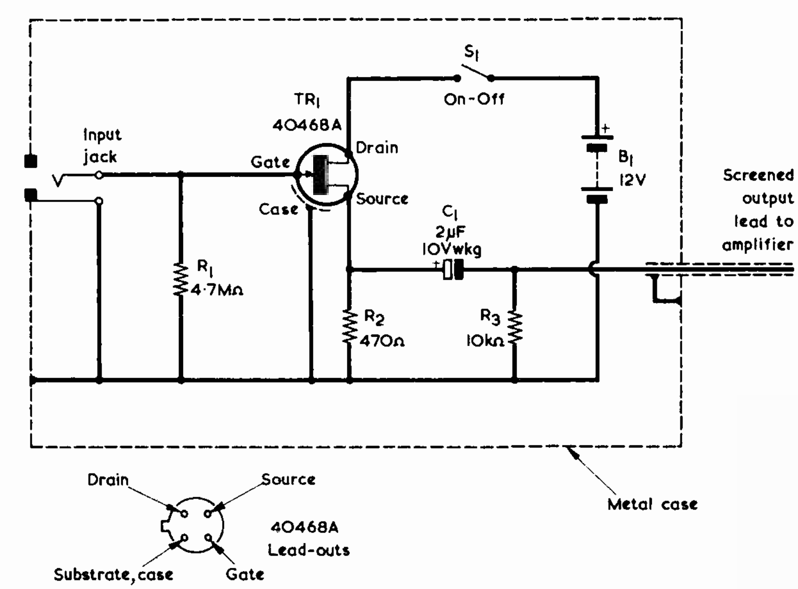
CRYSTAL MICROPHONES ARE DESERVEDLY POPULAR with home constructors and audio hobbyists, and they are used very frequently with the lower-cost type of tape recorder. They suffer, however, from the major disadvantage that the coupling lead to the subsequent amplifier should not be longer than some 8 feet or so. This means that the microphone must always be used close to its amplifier or tape recorder unless some electronic means of extending the lead length can be provided.

LEAD EXTENDER

The unit described in this article overcomes the problem, and it comprises an f.e.t. source follower mounted in a completely self-contained screened box. The microphone lead is plugged into a jack fitted to the box, from which protrudes a long screened cable which then connects to the amplifier. The long cable is at low impedance and can have any length within reason. The fact that it is at low impedance also reduces the possibility of hum pick-up.

The circuit of the unit appears in the accompanying diagram. The crystal microphone plugs into the input jack and thereby connects to the gate of an f.e.t. type 40468A. The terminating resistance for the microphone, R1, has a satisfactorily high value of 4.7MΩ. It could, if felt necessary, be increased to 10MΩ without any significant change in operation of the unit. A low impedance signal, taken from the source of the f.e.t., then appears across the 470Ω resistor R2. This is applied, via the electrolytic capacitor C1, to the output lead. The latter, which may be of any required length within reason, is terminated in a suitable plug for connection

The circuit of the crystal microphone lead extender. The components are completely enclosed in a metal case, on whose front surface are mounted the input jack and the on-off switch. The screened output lead may be taken out at any convenient point



to the following amplifier. R3 is included merely to ensure that C1 charges to the direct voltage across R2 after the unit has been switched on, and it prevents any troublesome direct voltage due to leakage current in C1 from appearing on the output lead. The capacitor should be a good-quality new component. The three resistors can be 10% $\frac{1}{4}$ or $\frac{1}{8}$ watt types, preferably high-stability.

All the parts are fitted in a metal case which completely encloses the components and the battery. With the author's unit, the latter consisted of a PP3 9 volt battery in series with two 1.5 volt 'Pen-light' cells to make up the 12 volts required by the f.e.t. Current consumption is only about 2.5mA, and so the batteries have a long life. Any small metal case capable of accommodating the battery and the other parts may be utilised, and it picks up its earth connection from the amplifier by way of the braiding on the screened output lead.

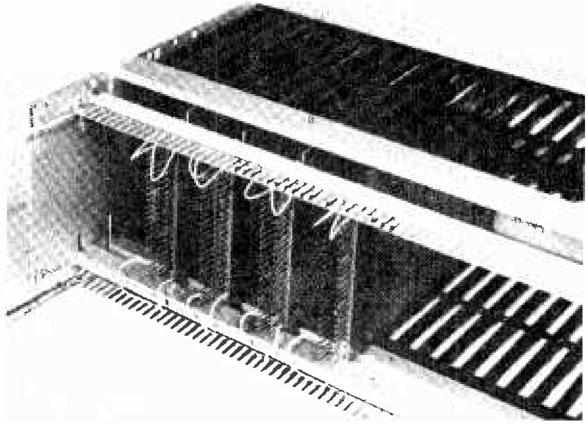
There are so few components that all the parts can be assembled on two 5-way tagstrips mounted inside the box. Very great care has to be taken to ensure that high voltages are not applied to the gate of the f.e.t. as these will cause the gate insulation to break down immediately. Even the leakage voltage on an unearthed mains soldering iron bit can cause damage here, as also can high static voltages. The best method of wiring up consists of initially making the f.e.t. connections to a 4-way transistor holder. After all wiring has been completed and checked, the f.e.t. may then be inserted into this holder. As further protection for the f.e.t. gate, the input connection is taken from a jack, as shown. This ensures that accidental external connections to the gate cannot occur, as would be possible if a coaxial socket with exposed centre contact were employed. Note that there is a connection to the metal case of the f.e.t.; this is joined internally to its substrate.

In use, the unit causes a negligibly low decrease in the signal output from the crystal microphone. When it is desired to operate the microphone at a distance from the associated amplifier, the lead extender is positioned close to the microphone, its low impedance output lead then being used to cover the distance to the amplifier. ■

New Products

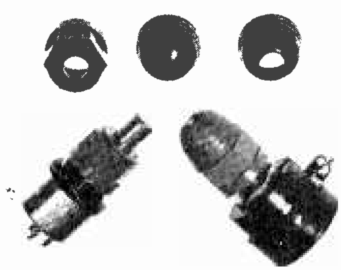
VERO SINGLE LEVEL BUSBAR

Vero Electronics Limited announce the introduction of a single level major wrap busbar as an accessory to Vero card frame system 3 for use where other than maximum length connectors are being fitted. The busbar is manufactured from brass with a rigid PVC insulation. It has been designed to simplify the commoning up of edge connectors and to provide excellent current carrying capacity, thus reducing impedance. The 5mm spacing between pins will be found acceptable for use with any standard card frame pitch. Overall in and out connections are conveniently made via spade terminals. Further information from: Vero Electronics Ltd., Industrial Estate, Chandlers Ford, Hampshire. SO5 3ZR.



PONTENTIOMETER NON-DRIFT NUTS

Girdlestone Electronics Limited announce the introduction of their new range of Potentiometer Non-Drift Nuts type MC.



Designed to prevent accidental alterations to potentiometer settings, the "non-drift" nut can be fitted to the potentiometer spindle and screwed on to the fixing bush, on which it cuts its own thread. The nut has a small clearance hole at the end opposite to the bush, which grips the spindle sufficiently firmly to prevent accidental rotation of the spindle due to vibration or knocking. The nut nevertheless allows intentional adjustment of the potentiometer by a screwdriver or knob.

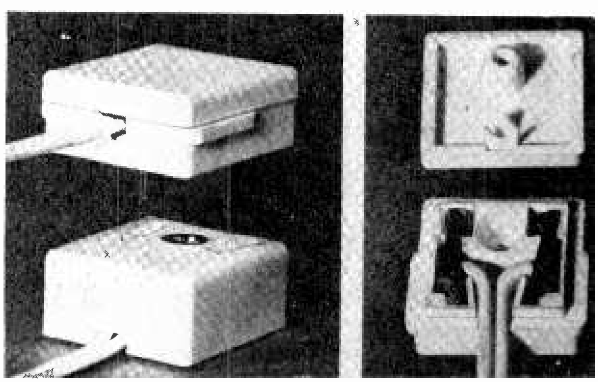
A dome-headed cover can be snapped on to conceal the spindle end, and is also available with a central hole to guide and steady a screwdriver when making adjustments under difficult conditions.

Various types of nuts are available to suit standard spindle diameters and panel thicknesses.

The nuts, which are approved for Service use, have also been allocated N.A.T.O. approved numbers 5355-99-580-0123/6, and are available from: Girdlestone Electronics Ltd., Melton Hill, Woodbridge, Suffolk, IP12 1AX.

MINIATURE TWO-PIN PLUG AND SOCKET

Senate's Miniature Two-Pin Plug and Socket is neat, compact and of modern design. Despite its small size of 15cc, it is rated at 25A when the temperature rise is less than 35°C. This high rating and correspondingly low contact-resistance of 1.4 milliohms is achieved by reinforcing the pressure between receptacle and flat-pin by a tin-plated carbon-steel spring, which also connects the wire without use of screws or solder to ensure a quick and reliable, vibration-proof connection. Mouldings are in white Nylon and incorporate cable-grip of high retaining force which requires no clamping screws. The surface-mounting socket is secured by a single fixing screw and anti-rotation lug. The recommended retail price is 25p for the plug and socket complete in display pack with socket fixing screw. Further details from: Senate Engineering Ltd., 77 Coates Road, Barrow-on-Soar, Loughborough, Leicestershire.



THYRISTOR TURN-OFF METHODS

By

D. E. VAUGHAN

It is an easy matter to turn on a thyristor in a d.c. circuit but it is not always as easy to turn it off again! Our contributor discusses some interesting methods of achieving thyristor turn-off by purely electronic means.

THE THYRISTOR (OR SILICON CONTROLLED RECTIFIER) is a very useful device having many of the properties of a sensitive relay with a high current handling capability. Unfortunately the sensitivity does not extend to its turn-off requirements for which quite energetic methods are necessary. The basic turn-off requirement is that either the current through the thyristor, or the voltage across it, must be reduced to zero for a time greater than a specified turn-off time which is a characteristic parameter of a particular thyristor. It is apparent from this that operation of a thyristor with an a.c. voltage, either unrectified or rectified but unsmoothed, will result in the turn-off requirement being satisfied automatically at least once per cycle, hence the ready applicability of thyristors in this field. The problem of providing reliable turn-off conditions in d.c. circuits is rather more difficult and this article describes some suitable methods.

SWITCH CONTACTS

The simplest method is the use of switch contacts, either mechanically or relay operated, in one of the positions shown in Fig. 1. The method is very reliable but, since the switch contacts must handle the full load current, offers little advantage over direct relay operation other than sensitivity. However, in spite of this and the limited rate of repetition possible, the method has applications.

Of considerable greater interest are methods which perform one or other of the switching functions shown in Fig. 1 by purely electronic means. These are known collectively as forced commutation methods. There are a number of these, most of which require large inductors and capacitors, but this article will consider two methods which require capacitors only. The basic circuit is the same for both methods and is shown in Fig. 2, the difference lying in the detail of the electronic switch.

The action may be described in the following manner. Consider the situation when TH1 is conducting and the electronic switch is open; the potential of point A is close to earth and capacitor C is charged to slightly less than the supply voltage. If the switch is now closed, point B immediately falls to earth potential and, since the charge on C cannot change instantaneously, the potential of point A falls to a value approximately equal to the supply voltage below earth.

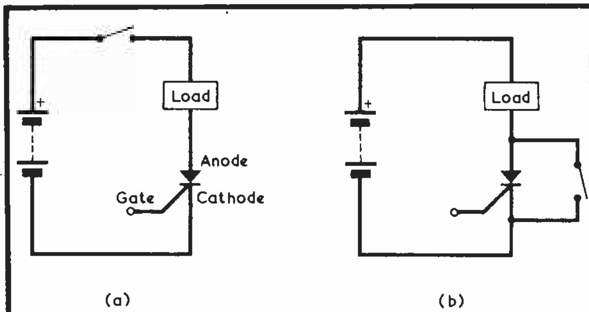


Fig. 1 (a). One method of turning off a thyristor under d.c. conditions consists of opening a switch inserted in the load circuit. The thyristor is turned on initially by allowing conventional current to flow from gate to cathode

(b). In this instance, momentary closure of the switch causes the thyristor to turn off

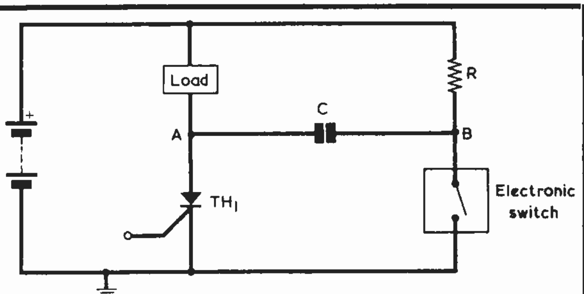


Fig. 2. Basic method of turning off a thyristor by electronic means. The earth symbol is included here, and in Figs. 3 and 4, to facilitate explanation in the text

Consequently TH1 is now reverse-biased (i.e. in a turned-off state). If the charge on C is large enough to hold A below earth potential whilst discharging through the load for a time greater than the turn-off time of TH1, and if the switch remains closed also, TH1 will remain turned-off even after the switch is subsequently opened. Assuming that the electronic switch is fast, repetition rates are limited only by the turn-off time of TH1.

PRACTICAL METHOD

One of the practical methods of achieving this operation is to use another thyristor as the electronic switch, as shown in Fig. 3. This switching thyristor

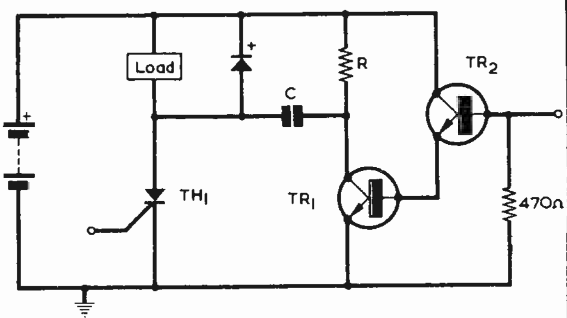


Fig. 3. In this circuit, TH1 is turned off by applying a positive pulse to the gate of TH2. The diode is only required if the load is inductive

(TH2) can have a much lower current rating than the load-supplying thyristor by making R large, limited only by the minimum holding current of TH2 and the recharging time of C. A valuable feature of this circuit is the automatic resetting property by which the switching on of TH1 switches off TH2 by the same action as has just been described. The choice of TH1 is obviously governed by the load current, that of TH2 and R has already been discussed, leaving only the value of C to be decided. The minimum value of C is given by the formula:

$$C\,\text{min} = \frac{k.I.t}{E}$$

where C min is in microfarads,
t is the turn-off time of TH1 in microseconds,
I is the load current in amperes,
E is the supply measured in volts,
k is a factor equal to 1.4 for resistive loads and 1.0 for inductive loads.

Since turn-off time is not usually quoted for thyristors, it is necessary to determine the value of C by experiment employing the formula to suggest a starting point, using also an assumed value of turn-off time and then discovering whether this calculated value is sufficient. If it is, then a lower value can be tried until the minimum is found; alternatively, if the calculated value is not sufficient then it must be increased until the minimum is found. Once the minimum value has been established it is recommended that a value about 50% greater be used to ensure reliable operation at all times.

As an example of values of capacitance to be expected consider an inductive load current of 3 amperes, a supply of 12 volts and a turn-off time of 20 microseconds; for this a 5μF capacitor is required. If a resistive load drawing the same current were considered, a 7μF capacitor would be required. These values of capacitance are for paper or plastic foil components, which are to be preferred on account of the rapid reversals of applied voltage. The author has tried both non-polarised electrolytic capacitors and two polarised electrolytic capacitors back-to-back and has obtained satisfactory performance, provided that the effective capacitance was at least twice that required by non-electrolytic components. However, the reliability of such operation is questionable and, in view of the fact that the commutating capacitor is an essential element, the use of non-electrolytic capacitors is strongly recommended.

COMPOUND TRANSISTOR

A second practical method uses a compound transistor (i.e. one transistor driving a second transistor) for the switch, as shown in Fig. 4. The compound transistor

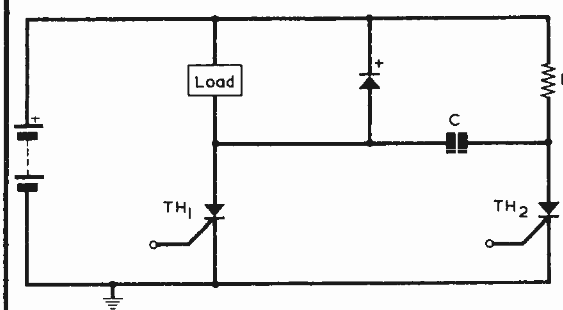


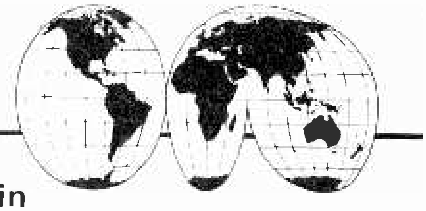
Fig. 4. Here, the turn-off pulse is applied to the base of TR2. Again, the diode is only required if the load is inductive

is required to match the effective current gain (about 10^4) of the thyristor, thus avoiding heavy loading of the trigger pulse. Lack of information again hampers component selection, in this case it concerns peak collector currents in TR1 and TR2. However, a rule of thumb, which almost certainly errs on the side of caution but which has not yet failed the author, is to choose a transistor for the TR1 position whose maximum absolute rating of collector current equals the load current. Similarly for TR2 the choice is made on the basis of a maximum rating equal to the load current divided by the gain of TR1. With this method the turn-off pulse must have a minimum effective width at the collector of TR1 equal to the turn-off time of TH1. This is usually rather less than the driving pulse width at the base of TR1 so that this latter is best determined by trial, typical values for a rectangular pulse being 25 to 40 microseconds. As with the thyristor turn-off method the value of C must also be determined by trial.

The purpose of this article is to describe methods of general use, consequently no detailed circuits are given since these must depend very much on the particular application and the characteristics of the thyristors and transistors available. Nevertheless, guided by the basic design information given, users should find little difficulty in obtaining satisfactory results. ■

SHORT WAVE NEWS

FOR DX LISTENERS



By Frank A. Baldwin

Times = GMT *Frequencies* = kHz

One of the most interesting stations received recently has been Radio Gambia on **4820** (62.24 metres) at 1925 with a talk in dialect. Although suffering with QRM (interference) from CR6RG Angola on the same channel, the programme was clearly heard.

BADX (British Association of Dx'ers) report reception of Radio Gambia with identification in English at 2232 and at 2300 with anthem and sign-off. Although the power is only 3.5kW, BADX report this station recently being the only African at good signal strength around 2000!

NOW HEAR THESE

● **SENEGAL & CONGO**

Ziguinchor operates on **3336** (89.95m) 4kW and has been logged several times of late around 2000. The programme language at the time was French but one needs plenty of selectivity in operation to winkle this one out from the surrounding utility transmissions.

Whilst operating around this part of the dial, listen for RTV Congolaise on **3264** (91.91m) 25kW, the main programme language is French and the station has often been heard best around 1900.

● **NIGER**

On the same band, but only if conditions are good, listen for Radio Niger at Niamey on **3260** (92.02m) 4kW around 1900, usually in French at this time.

● **UNITED ARAB AMIRATES**

Abu Dhabi has been logged on **9695** (30.94m) at 1755 with a programme of Arabic music and songs. BADX report this station with clock chimes for the half hour at 1731 (!) followed by six short 'pips' and identification in Arabic. The programme in English is from 1000 to 1130, sign-off is at 2000.

● **CUBA**

Havana is currently (at the time of writing) being heard on **15425** (19.45m) from 1857 sign-on and programme in French. The English programme commences at 2007. This channel is a move from the previously used **15155**, all according to BADX.

● **IRAN**

Teheran can easily and regularly be heard on **15084** (19.89m) 250kW with programmes of Arabic-type music and songs. The language used is Farsi (Persian) and for those who wish to tape Arabic music this is the channel required for interference-free reception.

Radio Iran has also recently been using **9020**, an old channel for this station, but this has again been discontinued. Radio Iran can now be heard on **12185** (24.62m) where it signs-off at 2130.

● **NORTH VIETNAM**

Radio Hanoi operates on a number of channels but probably the easiest to receive here in the U.K. is that of **15005** from 2000 in English. However, a word of warning, R. Hanoi is apt to operate on different frequencies around this area of the dial virtually from day to day and has been reported from **14996** up to **15018** at times.

Radio Hanoi can also be heard on the nearby **15105** channel around 1930 or so.

● **SOUTH AFRICA**

RSA Johannesburg is currently radiating world news in English to West Africa at 1900 on **15175** (19.77m) 250kW. This should prove of interest to those requiring information on African affairs for, following the world news, African events not reported in the British press are detailed.

● **CANADA**

Those interested in Canadian affairs may care to tune to **17820** (16.84m) 50kW and listen to Sackville with station identification and Canadian news in English at 1845.

● **AUSTRALIA**

Transmissions from this country may be heard on several channels, not all of them are easy to receive by any means, especially the lower-powered stations. Those reported recently in 'Bandspread', the journal of BADX, are as follows – **9570** (31.35m) 50kW R. Australia at 0800 with the fat stock prices; **9680** (30.99m) 10kW VLH9 Melbourne at 0711 with cricket commentary (choice Dx this – just try it and see!); **15240** (19.69m) 10/50kW R. Australia at 0645 with horse racing commentary and with sign-off details at 0758 (Pacific Islands Service); **15425** (19.45m) 50kW VLW15 Perth with identification, time 'pips' and news at 0800; **17795** (16.86m) 50/100kW R. Australia with 'pops' to Pacific Islands at 2202.

Recently logged here was the **9590** (31.28m) 100kW channel at 2130 when the station identification in English and the Pacific Islands service was announced but by 2150 the signal had faded out completely. Undoubtedly the best time for us Pommies to hear Australia is around the 0700 to 0800 mark.

● **PAKISTAN**

Radio Pakistan now radiates the programme in English to the UK from 2000 to 2130 on **7094** (42.28m), **9770** (30.71m) and **11860** (25.30m).

● **BRAZIL**

ZYN32 Radio Nacional de Brasilia has moved from **15455** to **15450.** ZYN32 was heard with a clear identification on the latter channel at 2150 after also being reported on **15448**; moves apparently to avoid QRM from VOA Monrovia.

Other Brazilians currently reported on this band are – **15105** (19.86m) 7.5kW ZYR32 Radio Rural Brasileira at 2250 with identification; **15155** (19.80m) 10kW ZYB9 Radio Dif de Sao Paulo at 2155 with commentary in Portuguese and **15225** (19.71m) 10kW ZYN30 Radio

Cultural de Bahia at 2204 with Latin American music, all according to BADX.

● ANGOLA

Recently logged here was CR6RG on **4795** (62.57m) 10kW with a programme of 'pop' records and identification in Portuguese at 1830.

Other Angolans recently reported by BADX in 'Bandscan' are – **3276** (91.57m) 10kW CR6RZ Emisora Official de Angola at 1825 with African songs; **3345** (89.68m) 10kW CR6RD Radio Clube do Huambo with light music and Portuguese announcements at 1829; **4985** (60.18m) 1kW CR6RB Radio Ecclesia at 1847 with religious choral songs and Portuguese announcements. This last one is a Dx 'gem', not likely to be heard by those operating 'domestic-type' receivers.

● SEYCHELLES

My regular reporter B. Walsh of Romford, Essex, has noted that FEBA Seychelles has now moved to **11955** (25.09m) from **11950**. Also that Radio Pyongyang has moved from **6540** to **6590** (45.52m).

● READER'S LOG

J. V. Moss of Rayleigh with his Meridian 10-transistor superhet, 60 ft long-wire aerial and aerial tuning unit heard the following –

5930 1630 Radio Prague with "Topic of the Day".
7125 1620 Radio Warsaw "Life in Poland".
7130 1626 Radio Deutche Welle, interval signal.
7270 1625 Radio Warsaw, news programme.
9620 1550 Radio Belgrade, newscast.
11620 1555 All India Radio Delhi, Indian music.
11910 1850 Radio Budapest, sign-off in German.
11990 1607 Radio Prague, English 'pop' music.

● LATIN AMERICA

The LA 'season' is slowly beginning to build up at the time of writing and a sample of just what may be heard during two short sessions with rather indifferent conditions follows.

4790 0240 HCVP2 Sistema de Emisora Atalaya, Ecuador with a commentary in Spanish. QRM from YVON in the background. HCVP2 is located in Guayaquil, has a scheduled 0100 to 0455 transmission and has a power of 10kW.

4832 0530 TIHB Radio Capital, Costa Rica, with Latin American music and several identifications. TIHB is located in San Jose, has a 24 hour schedule and is listed at 1kW.

4880 0520 YVMS Radio Universo, Venezuela, with LA music and songs. Located at Barquisimeto, YVMS closes at 0400 and is rated at 10kW.

4980 0228 YVOC Ecos del Torbes, Venezuela, with typical LA music. Located at San Cristobal, YVOC is a well-known 'landmark' for LA Dx'ers.

5010 0545 HIMI Radio Cristal, Dominican Republic, with LA music and songs. HIMI is located at Santo Domingo, has a 24 hour schedule and is rated at 1kW, although often one of the best signals on the band around the time stated here.

5040 0225 YVQH Radio Maturin, Venezuela, with identification and LA songs and music. YVQH closes at 0400 and is rated at 1kW.

AROUND THE DIAL

● HAITI

4VEH the experimental 0.1kW station at Cap Haitien has been logged in the U.K. by Alex Moore of BADX. Alex is a well-known top-line Dx'er and he heard the station identification in Spanish at 2300.

● ECUADOR

HCJB Quito is reported by BADX to have moved from **11775** to **11830** (25.36m) where it was heard with identification in English at 2300.

● CHAD

Fort Lamy has been logged here on the usual **4904** (61.18m) 30kW channel at 1854 with French programming. The station now identifies as "Radiodiffusion Nationale Tchadienne".

● KENYA

The Voice of Kenya is now back on **4804** (62.45m) after having been on **4800** for a period. Logged here at 1840, this is presumably the Kisumu transmitter.

● GHANA

Accra is often heard with the news in English at 2100 on **4915** (61.03m) 10kW whilst, on a higher frequency, it can be heard from Tema on **9545** (31.43m) 100kW, where it has been logged at 1925 with a programme of African music and songs.

Radio Ghana can also be heard on **4980** (60.25m) 20kW, where it has been logged with light music records around 1845.

● VENEZUELA

According to BADX, YVMU Radio Carora is now operating on **4908** (61.12m) which is a move from **5010** (previously on **5020**).

● NEW ZEALAND

Radio New Zealand may be heard around 0815 on **11780** (25.47m) 75kW. ZL3 Wellington was actually logged at 0813 with stock market prices and identification.

● ETHIOPIA

ETLF Addis Ababa has been logged at 2020 with a programme about religion **11890** (25.23m) 100kW.

● CHILE

CE1515 Radio Corporacion at Santiago on **15150** (19.80m) 1kW has been heard in the U.K. at 2300 with identification and music by BADX operators.

● JAPAN

Radio Japan may be heard with the news in English at 1100 on **15195** (19.74m) 100kW.

● CLANDESTINE

The Voice of Malayan Revolution, a Chinese clandestine station, is reported currently operating on **15790** at various times from 1245 through to around 1300 in both Tamil and Malay, also in parallel on **11829**.

The clandestine "Bizim Radio" radiating pro-communist programmes in Turkish is now operating on **5915** (50.72m), **6200** (48.39m), **9500** (31.58m) and on **9585** (31.30m).

In your workshop

Once again, Smithy the Serviceman is drawn away from his work by the activities of his assistant, Dick. On this occasion he discusses the mysteries of standing waves and transmission lines, devoting some time also to television aerials and simple short wave aerials.

"AH!" DICK GAVE A GRUNT OF satisfaction as the dual-standard television receiver on his bench warmed up and a raster appeared on its screen. He looked at the line output valve he had just removed from the set which, judging from the performance given by the new one he had just fitted, was now proven without doubt to be defunct.

He selected 625 lines and tuned over the local u.h.f. channels. The receiver behaved perfectly, giving a good picture with acceptable sound. Dick next selected 405 lines, and found that the local channels on Bands I and III were also being received satisfactorily.

AERIAL MISMATCH

With the receiver tuned to a Band III channel, Dick leaned over sideways to pick up the back of the set preparatory to putting it back on again.

The sound level from the receiver dropped and its picture began to roll.

Puzzled, Dick sat up straight again on his stool. The sound from the receiver returned to its previous state and the picture locked in firmly.

Frowning at this unexpected behaviour on the part of the television set, Dick again leaned over to pick up its back.

Once more the sound dropped and once more the picture rolled.

Dick moved back to his original position, whereupon the set resumed its earlier impeccable performance.

"Hey, Smithy," called out Dick. "This set I've got on my bench is blinking well bewitched!"

"Dear, oh dear," grumbled Smithy, from his side of the Workshop. "Can't you do *any* job without dragging me in? What's the trouble this time?"

"When I sit up straight," replied Dick, "this set works perfectly. But when I move over sideways it goes on the blink!"

By now, Smithy had left his bench and was standing some way behind his assistant.

"Show me," he ordered.

Obligingly, Dick demonstrated the peculiar behaviour of the receiver.

"Humph," grunted Smithy, as Dick resumed his upright position, and the picture and sound returned to normal. "Let's have a butcher's behind that set of yours."

Smithy drew nearer to the receiver. As he came closer it exhibited further variations in its performance, going in and out of the picture roll condition several times. A knowing expression appeared on Smithy's face. He reached behind the set and extended a hand towards the v.h.f. aerial lead at the receiver socket. The set went through several frenzied changes in performance as his hand approached the coaxial cable, ending up with the reproduction of a stable picture when Smithy's hand was firmly grasping the lead.

"This coaxial cable," Smithy remarked laconically, "is just about red-hot so far as standing waves are concerned. Let's have a look at the plug."

The serviceman removed the plug from the receiver socket and unscrewed its cap. The braiding had broken completely away from the collet to which it should have been connected. (Fig. 1).

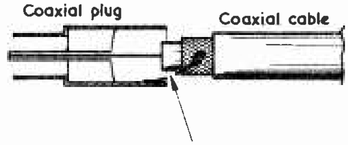


Fig. 1. Mysterious symptoms in a television receiver serviced by Dick were merely due to a break in the connection between the braiding of the coaxial aerial cable and the outer conductor of the plug

"There's nothing wrong with the set," stated Smithy accusingly, as he pointed to the frayed end of the coaxial braiding. "The trouble was due to badly maintained equipment on your bench."

"That plug," said Dick defensively, "hasn't given me any trouble in the past."

"Probably not," retorted Smithy. "I should imagine that, up to now, there were still a few strands of the coaxial braiding connecting to the plug, and that they finally broke away when you put the plug in that set today. Anyway, connect the cable to the plug properly and you'll find that the set will stay stable even if you do cart-wheels round it."

Dick took the cable and plug from Smithy's hand, cut off the section with the frayed braiding, and quickly prepared the new end of the cable for connection to the plug.

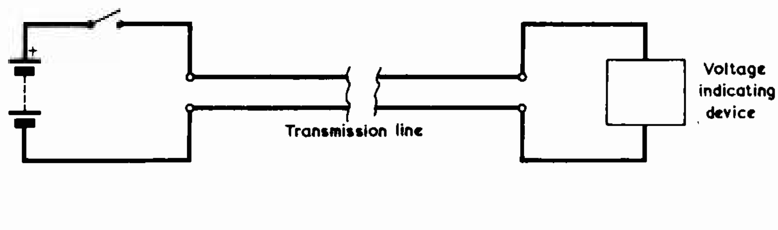
"What," he asked, as he worked on the cable, "is this standing wave business you were nattering on about just now? What *are* standing waves?"

"They're what you get on a feeder or transmission line when it isn't properly terminated," replied Smithy. "In this case the coaxial cable was the transmission line, and the end connecting to the set was open-circuit. Enough signal was still reaching the set via the centre conductor of the cable to produce a picture and sound, but the cable near the open-circuit end was both radiating and receiving at the same time. In consequence, it was susceptible to reflections given by its surroundings, these even including reflections from human beings."

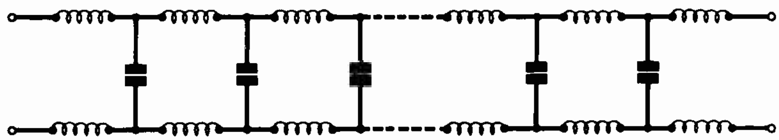
"Oh, I see," remarked Dick brightly. "It was giving an effect something like that you get with badly set-up indoor TV aerials. Where the picture changes as people move around the room."

"That's right," confirmed Smith. "The resultant effects are similar, although they're not entirely due to the same cause. The sensitivity of an incorrectly terminated length of coaxial cable to reflections from its surroundings varies considerably in practice according to the length of the cable and other factors. However, you can nearly always discover a badly terminated TV coaxial cable by grasping it in your hand. If this causes any changes in the strength of the signal that is carried by the cable then you can be certain that there's an incorrect termination nearby. A correctly terminated cable is completely dead in this respect, and grasping it has no effect on signal strength whatsoever."

By now, Dick had reconnected the cable to its plug properly, and he reinserted the latter into the receiver v.h.f. socket. The receiver at once reproduced an excellent picture, together with good sound, which was in no way affected by any movement on Dick's part, or by his firm grasping of the cable.



(a)



(b)

Fig. 2 (a) A battery coupled to a transmission line, which consists of two parallel wires. When the switch is closed the battery voltage appears at the remote end after a very slight delay

(b) The transmission line may be looked upon as a series of small inductors and capacitors. These represent the inductance of the wires which form the line and the capacitance between them

TRANSMISSION LINE

"Blimey," said Dick. "Connecting up that plug properly certainly got rid of those standing waves of yours. You haven't, though, told me what exactly standing waves are."

"Well," replied Smithy. "To understand how standing waves are formed, it is first of all necessary to know a bit about transmission lines."

"Then," replied Dick promptly, "you'd better give me some gen on transmission lines as well. I haven't a clue about them either!"

Smithy sighed.

"I suppose," he remarked resignedly, "that it won't hurt if I do give you a few brief details on the subject. Hang on a jiffy while I bring my stool over."

Smithy walked over to his own bench and returned with his stool.

"Well now," he said as he settled himself comfortably, "a transmission line is used to couple a transmitter to an aerial or, conversely, to couple an aerial to a receiver. In the present instance, we have a coaxial cable transmission line which couples a TV aerial to a TV set. Okay?"

"Yes," replied Dick, "and, of course, we refer to the coaxial cable as being 75Ω impedance."

"We do," agreed Smithy. "Ordinary domestic TV coaxial cable is designed to have an impedance of 75Ω. Now, forget about coaxial cable for a bit and visualise a transmission line which consists of two insulated wires running parallel to each other over a long distance. Let's say that we connect a battery in series with a switch to one end of the lines, and a voltage indicating device such as a voltmeter at the other end. What happens when we close the switch?" (Fig. 2 (a).)

"The voltage indicating device will register a voltage."

"Instantaneously?"

Dick frowned.

"Well, not *entirely* instantaneously, I suppose," he replied thoughtfully. "There must be a very tiny delay before the current flows through the whole length of the wires and the voltage appears at the end."

"Exactly," agreed Smithy. "In fact the current in the wires cannot travel faster than the speed of light, which is 300 million metres per second. If the lines were quite long, say 300 metres, you'd have to wait at least one-millionth of a second after closing the switch before the voltage appeared at the other end."

"One-millionth of a second?" repeated Dick scornfully. "Blimey, Smithy, that's nothing to get steamed up about."

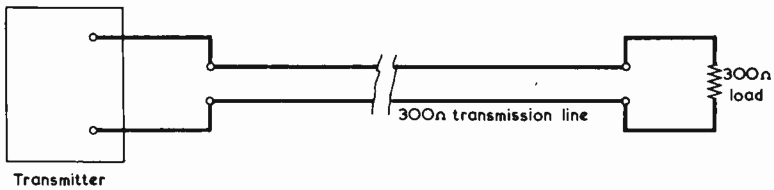
"Isn't it?" replied Smithy. "As it happens, one-millionth of a second is the time occupied by 1 cycle of a 1MHz r.f. signal, by 10 cycles of a 10MHz r.f. signal and by 100 cycles of a 100MHz signal. So if, instead of a battery and switch, we decided to couple a 100MHz transmitter to the wires, the signal appearing at the other end would be at least 100 cycles behind the signal going in at the transmitter end!"

"Gosh," said Dick, impressed. "That delay doesn't sound much when you think in terms of the closing of a switch, but it seems enormous in terms of radio frequency signals."

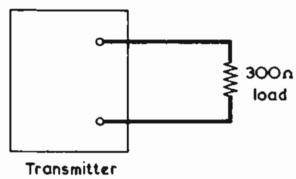
"True enough," agreed Smithy. "Now, let's get back to the battery and switch. When the switch closed, the battery supplied a voltage which charged the capacitance between the wires which form the transmission line, together with a current which flowed through the inductance which the wires themselves exhibit. Both the capacitance and inductance are small but they exist all the same, and they have to be taken into account. You can look upon the lines as consisting of a series of small inductors and capacitors. As the switch closes, the resultant voltage and current pass down the line, charging all the capacitors and flowing through the opposition to current change of all the inductors." (Fig. 2 (b).)

"If," remarked Dick, "the capacitance and inductance have to be taken into account, then the spacing between the two wires and their thickness becomes important. What I mean is that the capacitance will increase if the wires are positioned closer together, and the inductance will change if the wires are made thicker."

"True," agreed Smithy. "Actually, the inductance of a wire decreases as its thickness increases, but that's an incidental point. The presence of the capacitance and inductance causes the transmission line to present what is known as a 'characteristic impedance' at its ends. This characteristic impedance varies according to the spacing between the wires and their thickness. If the wire spacing and thickness are such as to give the line a characteristic impedance of 300Ω, which happens to be a commonly encountered feeder impedance figure, then you can put the line to use by coupling it to a transmitter which is designed to feed into a load of 300Ω. At the other end of the line, you connect a load which has the 300Ω impedance. In practice, this load would be a transmitting aerial but let's say, to keep things easy, that it's a 300Ω resistor. What happens now is that the transmitter feeds in r.f. energy at one end of the transmission line and this flows smoothly all along the line until it reaches the 300Ω load, whereupon the energy becomes dissipated in that load. Ignoring losses in the cable, you get the same effect as if you'd coupled the transmitter output directly to the 300Ω resistor. Indeed, that's the important feature of a transmission



(a)



(b)

Fig. 3 (a) Coupling a transmitter via a transmission line with a characteristic impedance of 300Ω to a 300Ω load. The transmitter output is also at 300Ω impedance

(b) Ignoring losses in the transmission line, the same effect as in (a) is given by connecting the transmitter directly to the load

line; it enables the output of a transmitter to be carried to an aerial which can be situated quite a considerable distance away. Similarly, it also allows a distant aerial to be coupled to a receiver." (Figs. 3 (a) and (b).)

"What are these losses in the line?"

"They're losses due to resistance in the wires, and to dielectric losses in the dielectric between them. They have no effect upon the characteristic impedance of the transmission line."

STANDING WAVES

Frowning, Dick absorbed this information. Suddenly a thought occurred to him.

"I've just realised something," he exclaimed. "If a transmitter feeds an aerial by way of a transmission line, all the radiation takes place at the aerial itself. You get no radiation in the transmission line at all."

Smithy gazed fondly at his assistant.

"That's my boy," he remarked. "You've hit upon an extremely important point there. Suppose you have a transmitter at a low position on the ground and you want to couple it to an aerial which is at a high level. You *could* couple a single wire to the aerial, but there would then be the snag that the wire itself would also radiate, whereupon some of the transmitter power would be radiated from a low level. If, on the other hand, you couple the transmitter to the aerial by way of a transmission line or feeder, all the radiation takes place from the aerial itself, and none is wasted on the way up."

"I'm glad," said Dick proudly, "that I thought of that non-radiating bit all by myself. Now, how about those standing waves?"

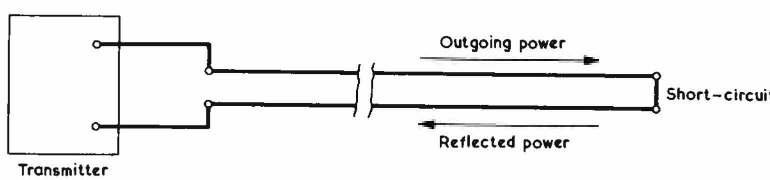
"You get those," replied Smithy, "if the transmission line isn't terminated by the correct impedance. To take an extreme example, let's assume that we have a transmission line that is short-circuited at the end remote from a transmitter that coupled to it. What happens then is that the outgoing power from the transmitter is reflected back along the line by the short-circuit and travels back towards the transmitter. You also get a reflection if the remote end is open-circuit, and once again the outgoing power is reflected back again." (Figs. 4 (a) and (b).)

"Do these reflected signals cause the standing waves?"

"They do," confirmed Smithy. "When the remote end is short-circuited there is maximum current and zero voltage at the short-circuit. This causes the voltage of the returning signal formed at the short-circuit to have opposite polarity to the outgoing signal. When the remote end is open-circuit there is zero current and maximum voltage at the remote end and the voltage of the returning signal formed at the open-circuit has the same polarity as the outgoing signal at that point. Now, we have the situation in either case where we have two waveforms travelling along the line in opposite directions. Both waveforms travel at the same speed and, if you think hard enough and in terms of waveform current, you can visualise the resultant fact that at a number of points along the line the currents tend to cancel each other out, whilst at other points along the line they mutually assist each other and provide maximum amplitude. The maximum amplitude points are spaced out in distances equal to a half-wavelength of the signal." (Fig. 5).

"I can visualise what you mean," remarked Dick, adopting a ferocious frown of concentration. "If, that is, I think about it hard enough!"

"I've only mentioned the current of the outgoing and reflected signals," continued Smithy. "You get the same combination effect with voltage, too. However, the points of cancellation and maximum amplitude for voltage are dead opposite to those for current. In other words, where there's a cancellation point for voltage, there's a maximum amplitude point for current, and vice versa. I should add that a cancellation point is referred to as a 'node', and a point of maximum amplitude as an 'antinode'."



(a)

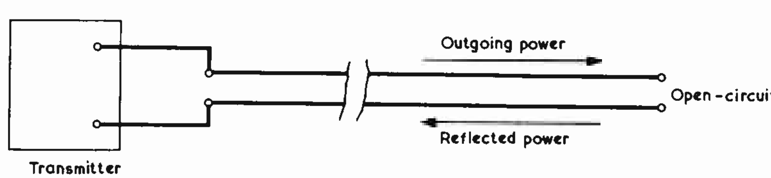


Fig. 4 (a) If the remote end of the transmission line is short-circuited, the outgoing signal from the transmitter is reflected back along the line

(b) The outgoing signal is also reflected back along the line if the remote end of the transmission line is open-circuit

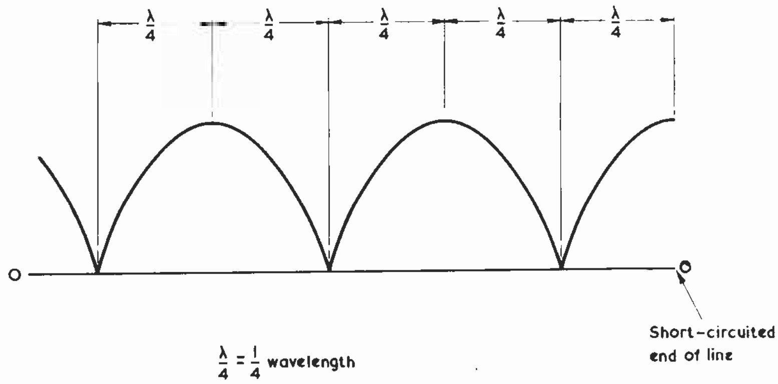


Fig. 5. Distribution of current along a transmission line terminated in a short-circuit

AERIALS

"That node business reminds me of a triode valve," remarked Dick brightly.

Smithy regarded his assistant with suspicion.

"Why?"

"Because," replied Dick quickly, "in a triode valve you have cathode, grid and a node."

"I should have known better than to ask you," groaned Smithy. "Anyhow, the presence of the standing waves means that the feeder is particularly sensitive to its surroundings at a voltage antinode, which explains the effect we had with the incorrectly terminated coaxial cable on that TV set on your bench. The amplitude of the standing waves in a transmission line is at its greatest when the remote end of the line is open-circuited or short-circuited. If you connect a resistive load to the end of the line and vary its value, either downwards from a very high resistance or upwards from a very low resistance, the standing wave amplitude will gradually reduce, and the standing waves will finally disappear altogether when the resistance is equal to the characteristic impedance of the line. When the line is connected in this manner it is said to be 'matched' whilst, if it is improperly loaded, it is said to be 'mismatched'. The degree of mismatch can be defined in terms of the 'standing wave ratio'."

"Standing wave ratio, eh," repeated Dick. "Will this standing wave ratio increase if the load impedance is varied on either side of the correct value?"

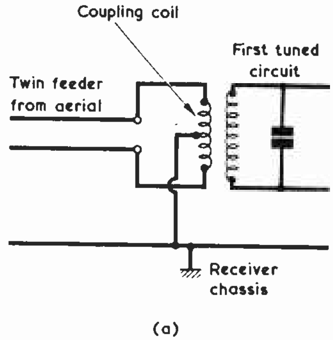
"It will," said Smithy. "If the load impedance is less than the characteristic impedance of the line, the standing wave ratio is equal to the characteristic impedance divided by the load impedance. But if the load impedance is greater than the characteristic impedance, the standing wave ratio is equal to the load impedance divided by the characteristic impedance. In all cases, mismatch results in a standing wave ratio greater than 1, whilst a perfect match gives a standing wave ratio of 1."

"We've been referring to a transmitter feeding a line," said Dick. "What about a transmission line between an aerial and a receiver?"

"The same remarks apply," replied Smithy. "Just look upon the aerial as a transmitter in its own right, since it is sending the signals it picks up to the receiver. I talked about the line terminating load being a resistor. In practice, it will be a transmitting aerial, or the input tuned circuits of a receiver, these being designed to present the same impedance to the line as the resistor would. Another point is that I talked about a 300Ω transmission line which has two parallel wires. This type of line is also known as 'twin feeder' and is used extensively in America and other countries for TV aerial coupling. Twin feeder with 300Ω impedance is also used quite a lot by ham transmitting enthusiasts. More popular in this country, however, is the 75Ω coaxial cable which we use for coupling TV aerials to receivers. In coaxial cable one of the wires of the two-wire transmission line is replaced by the braiding, and the internal insulation maintains constant spacing between this braiding and the inner wire. Twin feeder is referred to as a 'balanced' feeder, and the points it connects to have to be balanced about earth. 75Ω coaxial cable is an 'unbalanced' feeder, and its braiding goes to earth." (Figs. 6 (a) and (b).)

"I wonder," asked Dick, "why these feeder lines have impedance of 75Ω and 300Ω. Why were 75Ω and 300Ω chosen in the first place?"

"Well," said Smithy, "the 75Ω impedance results from the fact that the impedance at the centre of a half-



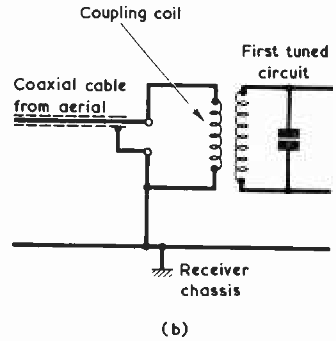


Fig. 6 (a) A balanced feeder connects to points that are balanced about earth, as in this example which shows the input circuit of a receiver. It is assumed that the receiver chassis is at earth potential

(b) Unbalanced feeder has its outer conductor at earth potential

wave dipole is equal to that figure. As you know, a half-wave dipole is an aerial having a length approximately equal to half a wavelength of the signal it is intended to transmit or receive. If it is broken in the middle and connection is made to the two inside ends, these offer an impedance of 75Ω. The aerial is *resonant* at the frequency at which it is intended to work, and it exhibits a voltage and current distribution in which the current maximum corresponds to the voltage minimum and appears at the centre. Actually, a dipole is, in practice, slightly less than a half wavelength long, a typical figure being 95 per cent of the half wavelength. This takes up what is known as 'end-effect', which is an additional capacitive loading appearing at the dipole ends." (Fig. 7 (a).)

"The dipoles we encounter," remarked Dick, "are mainly those used as television aerials."

"That's right," agreed Smithy. "On Band I, which consists of Channels 1 to 5, the usual type of TV aerial consist of a dipole behind which is positioned a reflector. The reflector is normally a little longer than the dipole. The addition of a reflector necessitates some care in the design of the aerial, since it causes a reduction in the impedance of the dipole." (Fig. 7 (b).)

"Funnily enough," remarked Dick. "you only see the simple dipole style of aerial used on Band I frequencies. Nearly all the Band III and u.h.f. aerials employ folded dipoles."

"That's true," agreed Smithy. "A folded dipole has the same length as a simple dipole but it has two conductors with connection made at the centre of one of these only. It offers an impedance of 300Ω, which is 4 times that of the simple dipole. This impedance value also explains why 300Ω is another of the common feeder line impedance figures." (Fig. 7 (c).)

"How can you match a folded dipole to 75Ω feeder?"

"By adding directors," replied Smithy. "Directors are elements which are fitted in front of the dipole and they are a little shorter than the dipole itself. I've already mentioned that the addition of a reflector to a dipole reduces its impedance. Directors reduce the impedance even more. In consequence, a good approach to a TV aerial design using a reflector and directors is to start off with a folded dipole whose impedance, on its own, is 300Ω, and then add the reflector and directors. The reflector and directors not only increase the sensitivity and directivity of the aerial but also bring the dipole impedance down to the desired 75Ω."

"I see," said Dick thoughtfully. "Are there any other ways of varying the impedance of the dipole?"

"Oh yes," replied Smithy. "This can be done, with a folded dipole, by using conductors of different thickness for the two sections. If the thickness of the unbroken section is made greater than the thickness of the section to which the feeder connects, the impedance increases. Conversely, if the thickness of the unbroken section is less than that of the section to which the feeder connects, the impedance decreases. Increasing the distance between the sections reduces the variation in impedance given by using different thicknesses, whereupon the aerial designer has a third variable to play with."

"What about u.h.f. aerials?"

"These," replied Smithy, "normally consist of a folded dipole with a reflector and directors. They are essentially wide-band aerials since, when all u.h.f. channels are on the air, it is intended that a single receiver should be able to pick up four channels, the highest of which is ten channels above the lowest. The scheduled London area channels are, for instance, 23, 26, 30 and 33. Since a u.h.f. channel is 8MHz wide, a u.h.f. aerial is required to have a bandwidth of 88MHz. In practice, u.h.f. aerials have a bandwidth slightly higher than 11 channels, since it has been found convenient to manufacture them for different 'groups'. Thus, you have Group A, which covers Channels 21 to 34; Group B, which covers Channels 39 to 51; and Group C, which covers Channels 50 to 66. U.H.F. aerials have a relatively large quantity of directors, and the reflector can consist, typically, of a number of parallel rods, rather than a single rod element."

SHORT WAVE AERIALS

Smithy rose, preparatory to leaving.

"And that," he remarked, "should give you all the gen you need concerning transmission lines and standing waves. I seem to have thrown in a bit about TV aerials as well!"

"Hang on a bit," said Dick, hastily searching around for a new topic. "What about short wave aerials? There seems to be a lot of interest in short wave listening these days, and I was wondering if this requires any special type of aerial."

Smithy threw an exasperated glance at Dick.

"Dash it all," he grumbled. "You'll still be asking questions when they sound the Last Trump."

He sat down again.

"Briefly," he remarked, "the type of short wave aerial you require depends upon the sort of listening you intend to go in for. If it's just general short wave listening on all frequencies, a long wire erected as high as possible, together with a good earth connection, is probably as good as anything. If you intend listening to, say, the amateur bands only, you could use aerials that are resonant at the bands concerned. A whole host of these have been developed by the ham fraternity and it would be impossible for me to deal with them all at the time being. The simplest is the dipole. This is just the same as the

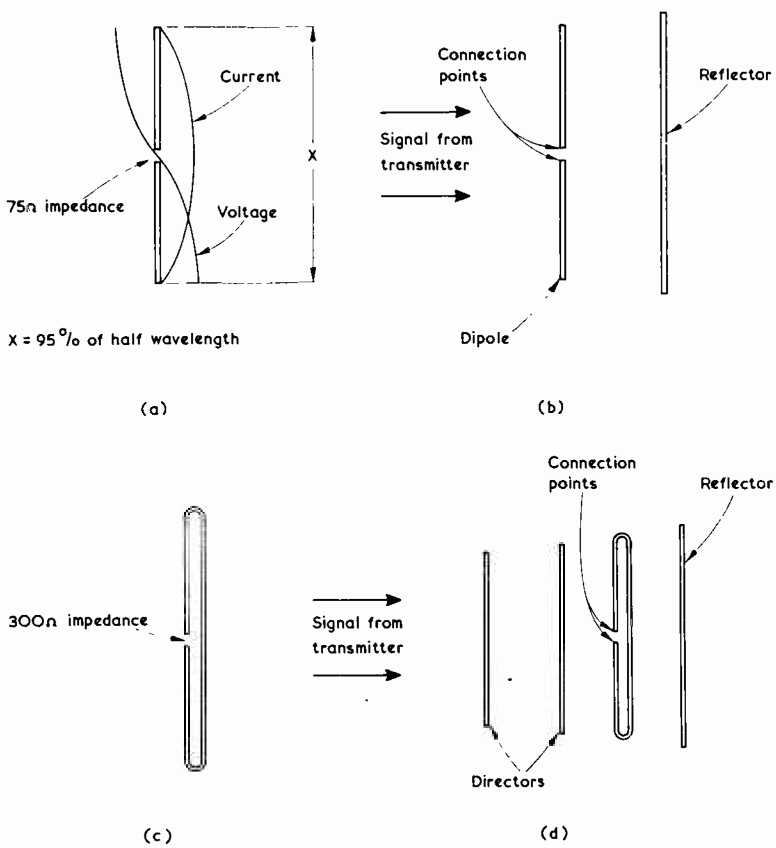


Fig. 7 (a) Essential details of a half-wave dipole aerial

(b) A reflector is normally added behind the dipole in aerials intended for Band I television reception

(c) The folded dipole. This has the same length as the single dipole of (a), but presents an impedance of 300Ω

(d) The elements of a television aerial for Band III (Channels 6 to 13)

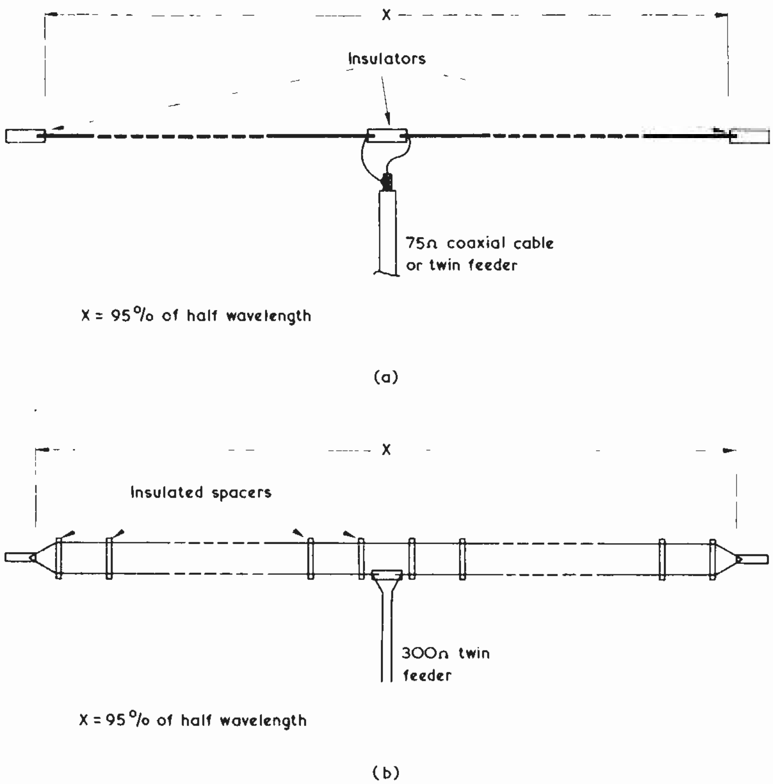


Fig. 8 (a) A simple dipole suitable for short wave reception. A slightly improved performance is possible if twin feeder is employed instead of coaxial cable. In practice, the connections to the coaxial cable or feeder must be made weatherproof

(b) A folded dipole for short wave reception. The two horizontal wires may be spaced by about 6 in. along their length

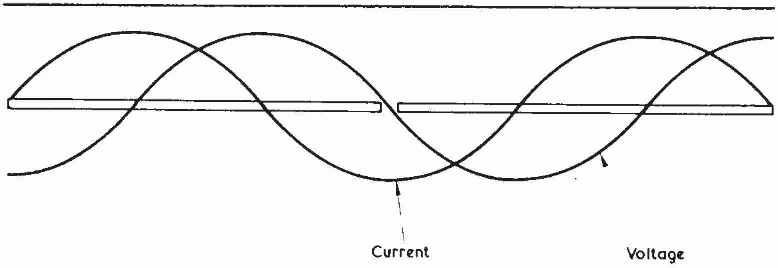


Fig. 9. A simple dipole may be employed for reception at 3 times its basic frequency, since a current antinode then appears at its centre

dipole in a TV aerial except that it's much longer, of course, and is made up of wire strung up between two points. Once again, its length is approximately 95% of a half wavelength of the frequency to be received, and it is most sensitive to signals which reach it broadside on. If you wanted to listen to the 40 metre band you'd require an aerial which is about 20 metres long. To be precise you should work from the actual band frequencies, since the wavelength figures for the amateur bands are nominal only."

Smithy reached over and pulled Dick's note-pad towards him. He then took out his pen and proceeded to scribble out some figures.

"Let's see now," he resumed. "The actual frequency coverage of the amateur 40 metre band is 7 to 7.1MHz, so we should make a 40 metre aerial correspond to the mid-frequency of 7.05MHz. Wavelength in metres is equal to 300 divided by frequency in MHz, whereupon 7.05MHz corresponds to 42.6 metres. Half of that is 21.3 metres and 95% of *that* is 20.2 metres, and so your 40 metre dipole would need to be 20.2 metres long. You could also have a folded half-wave dipole, for which the feeder would then be 300Ω impedance." (Figs. 8 (a) and (b).)

"Can a single aerial work on more than one amateur band?"

"Oh yes," replied Smithy. "Since the amateur bands are multiples of each other in terms of frequency it is possible for a single dipole to cover more than one band. For example, a simple 40 metre dipole will also resonate at the 15 metre band, which covers 21 to 21.45MHz. You get a voltage and current distribution which allows three half waves of the 15 metre signal to appear in the aerial, with a current antinode at the centre. This will give a reasonable match to 75Ω feeder. The aerial won't tune exactly to the 15 metre band because this approach doesn't take account of end-effect at the higher frequency, but results will be quite good in practice." (Fig. 9).

"I seem," said Dick, "to remember hearing about a Windom aerial."

"That," replied Smithy, "is a very popular aerial amongst hams and it consists basically of an aerial that is fed at a point removed from its centre. A typical example has a length of about 41.5 metres with a 300Ω feeder

BACK NUMBERS

For the benefit of new readers we would draw attention to our back number service.
We retain past issues for a period of two years and we can, occasionally, supply copies more than two years old. The cost is the cover price stated on the issue, plus 6p postage.
Before undertaking any constructional project described in a back issue, it must be borne in mind that components readily available at the time of publication may no longer be so.
We regret that we are unable to supply photo copies of articles where an issue is not available.
Libraries and members of local radio clubs can often be very helpful where an issue is not available for sale.

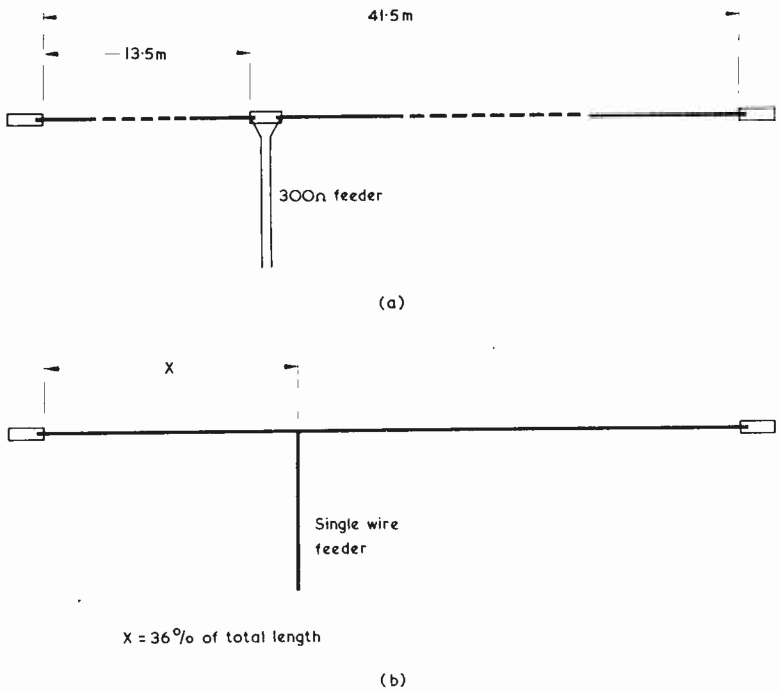


Fig. 10 (a) A modern version of the Windom aerial
(b) The original Windom aerial. This responds at even harmonics of the basic frequency for which the aerial is cut

brought in 13.5 metres from one end. This should give good results on the 80 metre, 40 metre, 20 metre and 10 metre bands. The original Windom aerial was a half wavelength long with a *single* wire tapping into it at a point 14 per cent off the centre. A rather similar type of aerial is the VS1AA version, where a single wire is tapped in 7 metres from one end. If the VS1AA aerial is resonant at 40 metres, it will also give good results on the 20 metre, 15 metre and 10 metre bands." (Figs. 10 (a) and (b).)

TERMINATION

Smithy glanced at his watch and once more rose from his stool.

"Those last two aerials," he remarked, "don't use two-wire transmission lines and, if they are employed with a transmitter, require to be properly matched at the transmitter output stage."

With a resolute gesture, Smithy picked up his stool.

"And now," he said firmly, "I'm going to embark on another form of termination."

"What form of termination is that?"

"The termination of this gensession," pronounced Smithy. "And if you try to impede me by asking any more questions, mate, I shall merely look upon it as characteristic impedance on your part!" ■

AN APPRECIATION

ERNST KRENKEL, RAEM

It was with deep regret that the writer of this note, learnt through "Region I News", edited by Roy F. Stevens, G2BVN, for the International Amateur Radio Union, of the death at the age of 67, of Ernst Krenkel, RAEM, whom he had the great pleasure of meeting at the Region I I.A.R.U. Congress in Malmo, Sweden in 1963.

It was, I think, the first occasion that a representative from the Soviet Union, had been present at a Region I meeting, and a more charming and impressive delegate, would have been difficult to find.

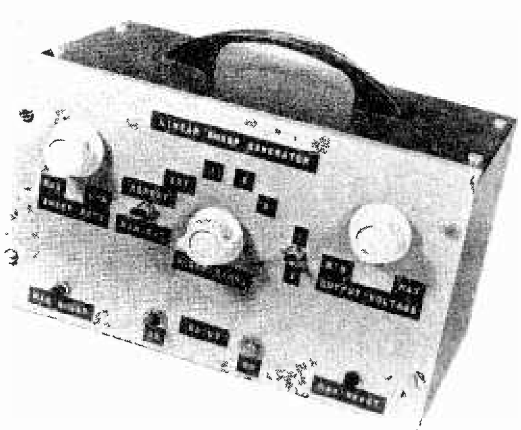
Ernst Krenkel was a Polar explorer from the days when the inhospitable Arctic attracted men of courage in the early decades of the century. In those days the exploits of polar explorers were greeted with the sort of public acclaim granted to astronauts today. Ernst Krenkel helped to establish Soviet scientific expeditions in Franz Josef Land and in many other parts of the Arctic. He acted as radio operator on these expeditions and in 1939 radio signals from his equipment, whilst in Franz Josef Land, were picked up by the American Antarctic Expedition radio station. He took part in the expedition aboard the ice breaker *Sibiryakov*, which first negotiated the Northern Sea Passage, in a single navigational season.

Just before his death, he finished writing a book on his experiences entitled "My Call Signal – RAEM". This book relates his experiences in the Arctic, including an account of the sensational rescue of the crew of the *Chelyuskin* after the vessel had been crushed in the ice in 1934 and his experiences with Ivan Papanin, Vize Schmidt and other famous Arctic explorers.

We are indebted to "Region I News" for some of the details in this appreciation, and we join them in saluting a great man.

Arthur C. Gee, G2UK.

Wide Range Linear Sawtooth Generator



Part 3

by
David Aldous, M.S.E.R.T.

This concluding article describes the setting-up of the linear sawtooth generator.

SETTING-UP PROCEDURE

For setting-up, an oscilloscope is needed with a means of calibrating the vertical deflection to 1 volt per centimetre. The oscilloscope should also have a timebase covering the range of at least 1 sweep per second to about 25kHz. A testmeter of about 20,000 ohms per volt sensitivity covering the ranges 0–200μA and 0–20mA will also be required, both for setting up the charge current controls and also for general measurements in the circuit.

The sweep generator is adjusted first. Turn the range switch to the 'External' position and set S2 to the 'Repeat' position (Position 1). Turn VR1 fully clockwise to give minimum current and set P1 and P2 to half-rotation. Connect the meter, set to read on the 200μA range, to the external charging capacitor terminals (Terminals B and C) with the positive lead to Terminal B. Plug in to the mains and switch on. Adjust P1 to give a reading of between 85 and 90μA. Change the meter range to 20mA, turn VR1 fully anti-clockwise and adjust P2 to give a reading of 15mA. Turn VR1 fully clockwise, then set the meter to read 200μA, and check the current again. This time turn VR1 *slowly* anti-clockwise until the meter begins to respond suddenly, this will indicate that the slider of VR1 is now on the logarithmic part of the track. When this has been located, re-adjust P1 to give a reading of 100μA. Now change the range to 20mA and turn VR1 back to fully anti-clockwise and re-set P2 to give 15mA. This completes the setting-up of the sweep generator.

The Schmitt trigger circuit is adjusted next, and this process is carried out with the aid of the oscilloscope. Connect the oscilloscope to the output terminals, set switch S3 to the fastest range (Range 3), and observe the waveform on the oscilloscope with the timebase set to run at about 10kHz. With VR1 set to mid-travel, carefully adjust P3 until the waveform appears as in Fig. 16(a) and not as in Fig. 16(b). This adjustment should be checked throughout the travel of VR1 and, if necessary, small adjustments made. Some actual recordings taken on a chart recorder are shown in one of the accompanying photographs.

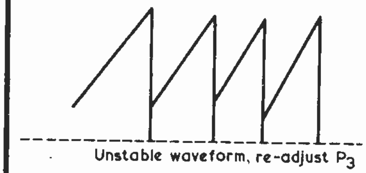


Fig. 16 (a). The required output waveform, given when the generator is operating correctly

(b). An unstable waveform. This is due to an incorrect setting of potentiometer P3 in the Schmitt trigger circuit

The final adjustments are to the output circuit and these are dependent on the requirements of the individual constructor as to what output levels are required. The author's version gave 5.5 volts on the preset range (S4 in Position 1). The uncalibrated output will depend on the setting found for P3 when adjusting the Schmitt trigger.

The preset output may be set to give any desired voltage on position 1 of S4. This is best done whilst observing the output on the oscilloscope and with the unit switched to Range 2 by S3.

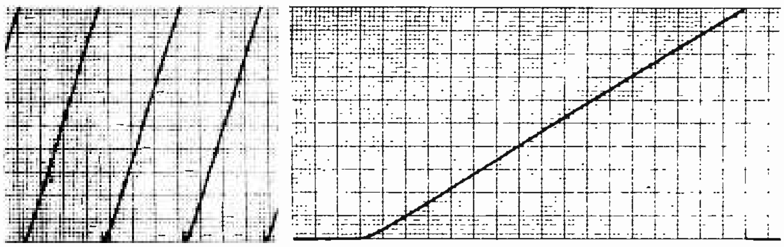
The setting-up procedure is now finished, and all that remains to be done is to fit the top and bottom covers, whereupon the generator is complete.

APPLICATIONS

As mentioned in Part 1, the unit is capable of being used in a number of ways quite apart from its most obvious function of generating a sawtooth waveform. A few of these are now detailed.

As a substitute timebase

The connections for this application are shown in Fig. 17(a). The following notes should be observed. Connect the generator as in the diagram and adjust output in conjunction with the oscil-



Some actual chart recordings, obtained by means of the linear sawtooth generator

loscope horizontal gain to produce a suitable trace length. If required, sync pulses (not larger than 4 volts peak-to-peak) may be applied to Terminal E.

To use as a substitute timebase in a TV set, connect as for the previous function but insert a capacitor of 1 to 10μF in series with the output lead from Terminal F. This capacitor should have a working voltage of 350 and, since it will almost certainly be electrolytic, correct polarity must be observed. It is important to note that the output control, VR2, should be turned fully anti-clockwise before connecting to the injection point in the TV circuit, as this will give the capacitor time to charge and thus prevent

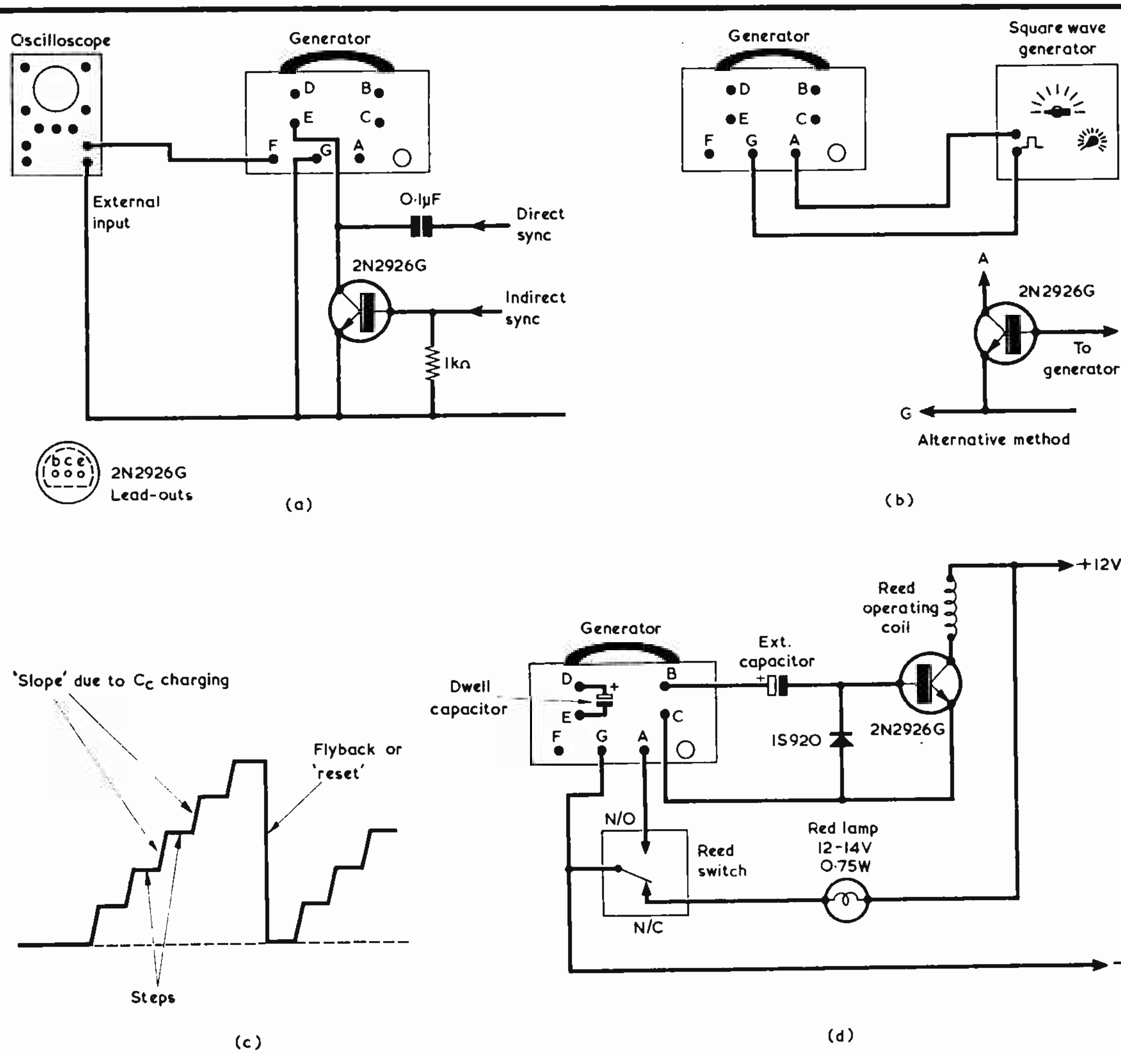


Fig. 17 (a). A set-up in which the sawtooth generator functions as the timebase of an oscilloscope

(b). Coupling a sawtooth generator in order to produce a step waveform

(c). A typical example of the step waveform produced

(d). Another application. Here the sawtooth generator functions as a period timer. Periods of up to 800 seconds can be obtained

dangerously high voltages from appearing at the emitter of TR6. When using the unit, the limited output voltage should be borne in mind when selecting a suitable injection point.

Waveform demonstration

Apart from the linear sawtooth that the apparatus produces, it is possible to obtain a step or 'staircase' function by employing the following method. Connect a square-wave generator having a low output impedance to Terminal A, as in Fig. 17(b), and set the unit to Range 2. Connect the oscilloscope to the output terminals and observe the waveform, switch S2 to 'Manual Sweep' (Position 2) and set the square wave generator to about 10 times the repetition rate of the unit. 'Juggle' with the controls on both generators until a step waveform is obtained, as in Fig.17(c).

The step waveform can be demonstrated in 'slow motion', as it were, if a chart recorder is used in place of the oscilloscope, a synchronous mechanical switch in place of the square-wave generator, and the slowest sweep rate is selected, or external components to give a very slow sweep rate are used.

As a period timer

The connections for this function are shown in Fig.17(d). This application will be useful to those constructors who also take an interest in photography. The lamp shown will come on at the end of the timed period.

S2 should be set to 'Manual Sweep' and S3 switched to 'Ext'. VR1 is calibrated initially by a stop watch and thence by adding suitable scale markings to it. The period is initiated by pressing push-button PB1, this energises the read relay and causes the circuit to 'lock-in' and the lamp to go out. With a capacitor of 10,000μF as the charging element, and a capacitor of 32μF for the dwell timing function, delay times of up to 800 seconds may be achieved. (This also applies, of course, to the normal waveform generation function). The reed operating coil shown in Fig.17(d), is an R.S. Components type 1 (Home Radio Cat. No. WS141) whilst the reed switch is an R.S. Components type 13-RSR (Home Radio Cat. No. WS122A). The reed switch is rated at 200mA max., a.c. or d.c.

The foregoing are just three possible ways in which the unit may be used. No doubt other schemes can be devised by constructors. All the methods shown have been tested by the author and have been found to work satisfactorily.

Editor's Note

Constructors finding difficulty in obtaining capacitor C4, as mentioned in Part 1, are referred to Messrs. V. Attwood, P.O. Box 8, Alresford, Hants who are able to supply, see advertisement Page 702. ■

Radio Topics

By Recorder

RESISTANCE, REACTANCE AND IMPEDance. Well, we all know what resistance is. What some of us get a bit muddled over on occasion are reactance and impedance, so let's just take a quick look at these.

REACTANCE

Both a capacitor and an inductor, when placed in a circuit in which alternating current flows, exhibit a quantity which is analogous to the resistance offered by a resistor. This quantity is reactance. Unlike a resistor, in which current and voltage are in phase when an a.c. generator is applied to it, the current and voltage in a capacitor or an inductor are out of phase. In a capacitor the current leads on the voltage by 90° (or one quarter of a cycle) whilst in an inductor the current lags on the voltage by 90°. It is easy to remember that the current leads in a capacitor and lags in an inductor because if you connect a battery (via a series resistance) to a capacitor, current flows first before the full battery voltage appears across the capacitor. The opposite occurs with an inductor.

An even easier way of remembering that current leads in a capacitor and lags in an inductor is to consider the fact that, in the alphabet, the letter 'C' (for capacitor) leads on the letter 'I' (for inductor).

The reactance offered by a capacitor or an inductor is measured in ohms.

Reactance is given only by a *pure* capacitor or a *pure* inductor. If there is any resistance in the circuit (due to such things as a physical resistor, or the resistance of the wire in the inductor) the phase difference between current and voltage changes from the 90° value. The quantity analogous to resistance is then referred to as impedance, which is also measured in ohms. However, 'impedance' is a blanket term and may also be applied to the case where there is pure reactance or pure resistance, as well as a combination of the two.

To sum up, a resistor has resistance, and a *pure* capacitor or *pure* inductor has reactance. Either resistance, reactance, or a combination of resistance and reactance may be referred to as impedance. It is usual to qualify the word 'impedance' when it applies to resistance, and to employ the term 'resistive impedance'.

NEW CIRCUIT MODULES

Mullard, Ltd., announce two additions to their range of radio and audio circuit modules. These are types LP1186 and LP1185, the first of which is a high-performance, varicap, f.m. tuner, and the second an i.f. amplifier.

The LP1186 has been developed to provide the greater gain and better signal handling now needed because of the increasing number of local f.m. radio stations. The tuner also has the advantage that its compactness and facility for remote control by means of direct current give considerable freedom to the set designer and equipment stylist.

The tuner operates with a supply of 8 volts and draws a current of only 6.1mA. A tuning voltage swing of 2 to 12 volts is required to cover the United Kingdom f.m. band of 87.5 to 104.5MHz, and approximately 2 to 17 volts for the International Band II of 87.5 to 108MHz.

An image suppression of 40dB and an i.f. rejection of 65dB are achieved when the module is used with a tuned aerial and r.f. stage. A separate oscillator is employed, and typical power gain is 30dB.

The LP1185 is designed for use with the LP1186. The two modules form a system that can be used with stereo decoders and provides facilities for a tuning indicator and automatic frequency control.

TABLE

Reactance, in ohms, of various capacitances.

Capacitance	10MHz	1MHz	100kHz	10kHz	1kHz
1μF	—	0.159	1.59	15.9	159
0.1μF	0.159	1.59	15.9	159	1,590
0.01μF	1.59	15.9	159	1,590	15,900
0.001μF	15.9	159	1,590	15.900	159,000

TABLE OF VALUES

For the more elementary home-constructor calculations it is normally adequate to think in terms of reactance only. this applying particularly to capacitors. Since the average capacitor has very little resistance, an idea of its performance as an r.f. or a.f. coupling capacitor, or as a bypass or smoothing capacitor, may be readily obtained by working out its reactance.

The formula for reactance in a capacitor is given by:

$$XC = \frac{1}{2\pi fC},$$

where XC is the reactance in ohms, f is the frequency in Hz, and C is the capacitance in farads. The farad is a lot larger than the units of capacitance we encounter in radio work, so we can make things a lot easier by saying that C is in microfarads and f is in MHz. The answer is bound to be the same because we are dividing the capacitance units by one million and multiplying the frequency units by one million.

Let's now work out a reactance value using nice easy figures. Let's find the reactance offered by1μF at 1MHz. This gives us:

$$XC = \frac{1}{2\pi},$$

which means XC is 1 divided by 2 times 3.142. This works out, to 3 significant figures, as 0.159Ω. Hardly a useful result, you might say, because who on earth is going to use a 1μF capacitor at 1MHz? But that little calculation is the only one we need to find a whole range of other reactances. If, for instance, we divide the capacitance by 10, we multiply the reactance by 10. So, at 1MHz, 0.1μF offers a reactance of 1.59Ω, 0.01μF one of 15.9Ω, 0.001μF one of 159Ω, and so on. Getting more interesting, isn't it? Similarly, dividing the *frequency* by 10 also multiplies the reactance by 10. So, 1μF at 100kHz offers a reactance of 1.59Ω, and 1μF at 10kHz one of 15.9Ω.

As you can see, it is very easy to make up a table showing capacitive reactances for the decades in capacitance and frequency, and I've done this in the accompanying table, which runs from 1MHz to 1kHz and from 1μF to 0.001μF. All the figures in the columns are in ohms. I've left out the reactance figure for 1μF at 10MHz because the calculated value of 0.0159Ω which should be entered here doesn't really represent a practicable case.

The table can easily be extended both up and down in frequency and up and down in capacitance by carrying out the requisite multiplications or divisions by 10. The table shows some interesting points, too. Thus, a 0.1μF capacitor has a reactance of 1,590Ω at 1kHz, which explains why it is quite a useful value for anode to grid coupling in a valve a.f. amplifier, but is not so good for collector to base coupling in a transistor a.f. amplifier.

The reactance of intermediate capacitances can usually be found without much trouble by a simple mutiplication or division sum which doesn't involve the tedious business of dividing by pi times the values, as is necessary if you work direct from the reactance equation. As an example, 0.5μF at 10kHz offers a reactance which is twice that of 1μF at 10kHz. In other words, it's twice 15.9Ω, or 31.8Ω. The same method of calculation can be carried out for different frequencies. Thus, 0.1μF at 2kHz gives a reactance value equal to one half that of 0.1μF at 1kHz, and the resultant figure is 1,590Ω divided by 2, i.e. 795Ω. The same answer is given if, alternatively, you multiply the reactance of 0.1μF at 10kHz by 5.

A table for inductive reactances can be made up just as easily, working from the equation:

$$XL = 2\pi fL,$$

where XL is the reactance in ohms, f is the frequency in Hz and L is the inductance in henrys. The starting-off point is given by finding XL when f is 1Hz and L is 1 henry. This value is 6.28Ω. Remember that, with inductance, reactance goes up as either frequency or inductance go up. The reactance given by 1 henry and 10Hz is 62.8Ω, and the reactance of 10 henrys and 10Hz is 628Ω.

LAWS

Electronics has its laws, of which the most famous is Ohm's Law. There are, of course, other laws, of which one of the most important is Finagle's Law. Finagle's Law states that if, in any system, something can go wrong, it will.

A few other laws exist and, since these do not appear to be quite as well-known, I feel I would be doing readers a service by presenting them here.

First, there are Peterson's Universal Laws of Electronic Exhibitions. These state:

1. At any exhibition the interest of a product is inversely proportional to the number of leaflets describing it.
2. If an exhibition stand has n engineers, at any instant n–1 are idle whilst the engineer required is surrounded by questioners who have got to him first.

Another active worker has been Neasden, and I next present his eight Laws of Probability in Servicing. These state:

1. The last resistor in a box marked '100kΩ' will probably be 10kΩ.
2. The breakdown of a silicon rectifier h.t. supply will probably be due to a short-circuit in the protective capacitor across the rectifier.
3. If a range of standard screwdrivers is taken to an outside repair job, all the screws in it will probably be Philips head.
4. If two TV chassis stand side by side on a bench, one will probably be at neutral potential and the other at live potential.
5. The faulty heater in any open-circuit chain will probably be the last one to be checked.
6. If a new TV set is fitted with a 13 amp fused plug, the only available socket for it will probably be 10 amp round.
7. If a range of Philips screwdrivers is taken to an outside repair job, all the screws in it will probably have slotted heads.
8. If a testmeter without a cut-out and switched to read 100μA f.s.d. is accidentally connected to the 240 volt mains supply it will probably become faulty.

And that, I think is quite enough from me this month. Cheerio for now! ■

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(Continued on page 701)

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(Continued on page 703)

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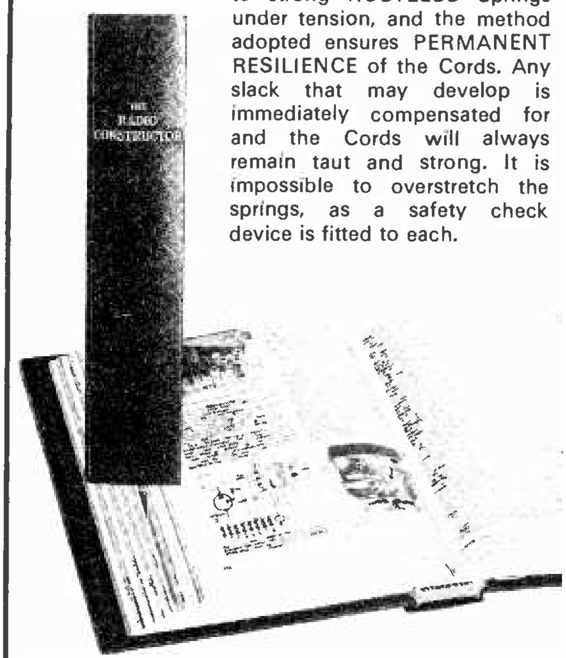

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(This augments Data Sheet 18, published December 1968.)

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11	0.116	2.946	0.1198	8.25	8	2.312	10.57
12	0.104	2.642	0.1076	9	8.75	2.877	8.495
13	0.092	2.337	0.0956	10.25	9.75	3.676	6.648
14	0.080	2.032	0.0834	11.75	11.25	4.862	5.027
15	0.072	1.829	0.0753	13	12.5	6.002	4.072
16	0.064	1.626	0.0672	14.75	14.25	7.596	3.217
17	0.056	1.422	0.0591	16.5	16	9.921	2.463
18	0.048	1.219	0.0510	19.25	18.75	13.504	1.810
19	0.040	1.016	0.0428	23	22.25	19.446	1.257
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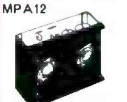

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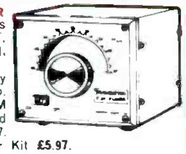

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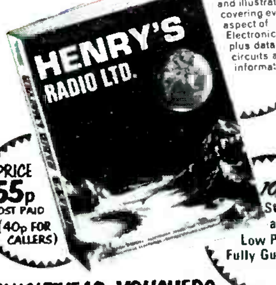

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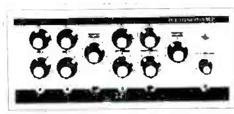

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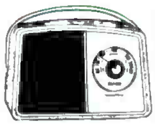

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