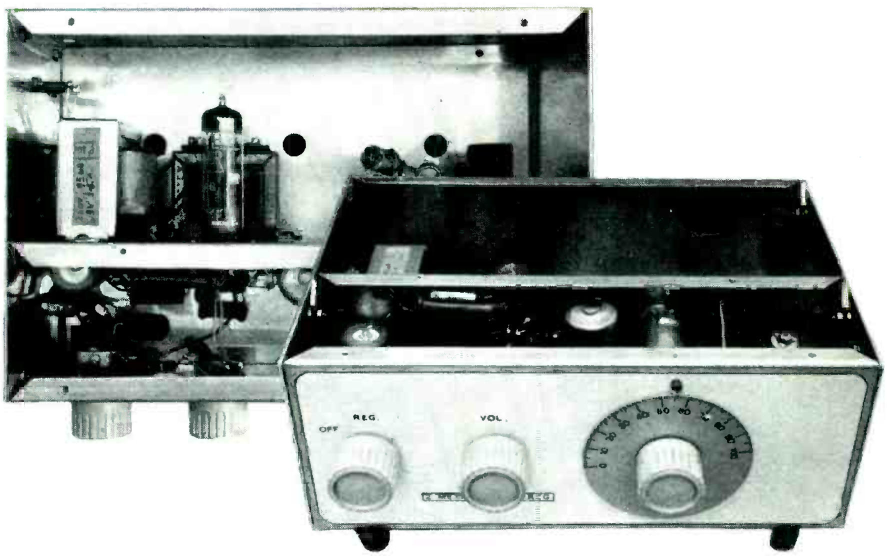
THE

RADIO CONSTRUCTOR

Vol. 25 No. 8 MARCH 1972 20p



'EASY' 2 METRE RECEIVER

Employs a super-regenerative detector, 3 valves
and offers no alignment problems

FEATURED IN THIS ISSUE

Transistor Crystal Marker Unit
D.C. Voltmeter

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PIV	1A TO-5 £p	3A TO-66 £p	7A TO-66 £p	10A £p	16A TO-48 £p	30A TO-48 £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

SILICON RECTIFIERS—TESTED

PIV	300mA £p	750mA £p	1A £p	1.5A £p	3A £p	10A £p	30A £p
50	0.04	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	0.13	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	0.75	

TRIACS

VBOM	2A TO-1 £p	6A TO-66 £p	10A TO-88 £p
100	0.30	0.50	0.75
200	0.50	0.60	0.90
400	0.70	0.75	1.10

LUCAS SILICON RECTIFIERS

35-Amp. 400 P.I.V.. Stud Type £1.10 each.

DIACS

FOR USE WITH TRIACS
BR100 (D32) 37p each

2A POTTED BRIDGE RECTIFIERS 200V 50p

UNIJUNCTION

UT46. Eqvt. 2N2646. Eqvt. TIS43. BEN3000 27p each. 25-99 25p 100 UP 20p.

NPN SILICON PLANAR

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

BRAND NEW TEXAS GERM. TRANSISTORS

Coded and Guaranteed

Pak No.		EQVT
T1	8 2G371B	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 pack

2N2060 NPN SIL. DUAL TRANS. CODE D1599 TEXAS. Our price 25p each.

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

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		£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.

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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ORP12 43p
ORP60. ORP61 40p each

PHOTO TRANS.

OCP71 Type 43p

SILICON PHOTO TRANSISTOR

TO-18 Lens end NPN Sim. to BPX25 & P21. BRAND NEW. Full data available. Fully Guaranteed.

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

FET'S

2N3819	35p
2N3820	50p
2N3821	35p
2N3823	30p
2N5458	50p
2N5459	40p
BFW10	40p
MFP105	40p

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NEW BI-PAK UNTESTED SEMICONDUCTORS

Satisfaction GUARANTEED in Every Pak, or money back.

Pak No.		£p
U1	120 Glass sub-min. general purpose germanium diodes	0.50
U2	60 Mixed germanium transistors AF/RF	0.50
U3	75 Germanium gold bonded diodes sim. OA5, OA47	0.50
U4	30 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, OA 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 AF117	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.

NEW QUALITY TESTED PACKS

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. IN69	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 2905	0.50
Q36	7 2N3646 TO-18 plastic 300MH2 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. 300MH2	0.50
Q52	8 BY100 type sil. rect.	1.00
Q53	25 Sil. & germ. trans. mixed all marked new	1.50

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VCBO 80V VCEO 50V IC 10A PT 30 WATTS HFE 30-170

1-24	25-99	100 up
43p each	40p each	36p each

SILICON High Voltage 250V NPN TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R2400 VCBO 250 VCEO 100 IC 6A 30 Watts. HFE type 20 fT 5MHZ.

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

EX-STOCK TYPE EACH AS PRICED

Type	Price each £p	Type	Price each £p	Type	Price each £p	Type	Price each £p
OC20	0.50	OC29	0.40	AL103	0.85	BD136	0.80
OC22	0.30	OC35	0.33	BD121	0.60	BD137	0.70
OC23	0.33	OC36	0.40	BD123	0.75	BD138	0.80
OC24	0.45	AD140	0.40	BD124	0.70	BD139	0.75
OC25	0.25	AD142	0.40	BD131	0.70	BD140	0.85
OC26	0.25	AD149	0.43	BD132	0.80	BD155	0.75
OC28	0.40	AL102	0.85	BD135	0.70	Bu105	3.00
						2N3054	0.45

SILICON 50 WATTS MATCHED NPN/PNP

BIP19 NPN BIP20 PNP TO-3 Plastic Brand new. VCBO 100/VCEO 50/IC 10A. HFE type 100 ft 3 mHZ.

	1-24 prs.	25–99 prs.	100 prs.
OUR PRICE PER PAIR	60p	55p	50p

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All usable devices no open or short circuits. ALSO AVAILABLE in PNP Sim. to 2N2906, BCY70. When ordering please state preference NPN or PNP.

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50 For	1.00	500 For	7.50		

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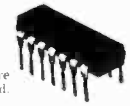

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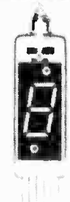
BP00	SN7400	0.15	0.14	0.12	BP86	SN7486	0.32	0.30	0.28
BP01	SN7401	0.15	0.14	0.12	BP90	SN7490	0.67	0.64	0.58
BP02	SN7402	0.15	0.14	0.12	BP91	SN7491AN	0.87	0.84	0.78
BP03	SN7403	0.15	0.14	0.12	BP92	SN7492	0.67	0.64	0.58
BP04	SN7404	0.15	0.14	0.12	BP93	SN7493	0.67	0.64	0.58
BP05	SN7405	0.15	0.14	0.12	BP94	SN7494	0.77	0.74	0.68
BP07	SN7407	0.18	0.17	0.16	BP95	SN7495	0.77	0.74	0.68
BP08	SN7408	0.18	0.17	0.16	BP96	SN7496	0.77	0.74	0.68
BP09	SN7409	0.18	0.17	0.16	BP100	SN74100	1.75	1.65	1.55
BP10	SN7410	0.15	0.14	0.12	BP104	SN74104	0.97	0.94	0.88
BP13	SN7413	0.29	0.26	0.24	BP105	SN74105	0.97	0.94	0.88
BP16	SN7416	0.43	0.40	0.38	BP107	SN74107	0.40	0.38	0.36
BP17	SN7417	0.43	0.40	0.38	BP110	SN74110	0.55	0.53	0.50
BP20	SN7420	0.15	0.14	0.12	BP111	SN74111	1.25	1.15	1.00
BP30	SN7430	0.15	0.14	0.12	BP118	SN74118	1.00	0.95	0.90
BP40	SN7440	0.15	0.14	0.12	BP119	SN74119	1.35	1.25	1.10
BP41	SN7441	0.67	0.64	0.58	BP121	SN74121	0.67	0.64	0.58
BP42	SN7442	0.67	0.64	0.58	BP141	SN74141	0.67	0.64	0.58
BP43	SN7443	1.95	1.85	1.75	BP145	SN74145	1.50	1.40	1.30
BP44	SN7444	1.95	1.85	1.75	BP150	SN74150	1.80	1.70	1.60
BP45	SN7445	1.95	1.85	1.75	BP151	SN74151	1.00	0.95	0.90
BP46	SN7446	0.97	0.94	0.88	BP153	SN74153	1.20	1.10	0.95
BP47	SN7447	0.97	0.94	0.88	BP154	SN74154	1.80	1.70	1.60
[illegible]48	SN7448	0.97	0.94	0.88	BP155	SN74155	1.40	1.30	1.20
BP[illegible]	SN7450	0.15	0.14	0.12	BP156	SN74156	1.40	1.30	1.20
BP51	[illegible]7451	0.15	0.14	0.12	BP160	SN74160	1.80	1.70	1.60
BP53	S[illegible]	0.15	0.14	0.12	BP161	SN74161	1.80	1.70	1.60
BP54	SN74[illegible]	0.15	0.14	0.12	BP164	SN74164	2.00	1.90	1.80
					BP165	SN74165	2.00	1.90	1.80
BP60	SN7460	[illegible]	0.14	0.12	BP181	SN74181	2.75	2.60	2.40
BP70	SN7470	0.29	[illegible]26	0.24	BP182	SN74182	0.97	0.94	0.88
BP72	SN7472	0.29	[illegible]26	0.24	BP190	SN74190	3.50	3.25	3.00
BP73	SN7473	0.37	0.35	0.32	BP191	SN74191	3.50	3.25	3.00
BP74	SN7474	0.37	0.35	0.32	BP192	SN74192	2.10	1.95	1.75
BP75	SN7475	0.47	0.45	0.42	BP193	SN74193	2.10	1.95	1.75
BP76	SN7476	0.43	0.40	0.38	BP195	SN74195	1.10	1.05	0.95
BP80	SN7480	0.67	0.64	0.58	BP196	SN74196	1.80	1.70	1.60
BP81	SN7481	0.97	0.94	0.88	BP197	SN74197	1.80	1.70	1.60
BP82	SN7482	0.97	0.94	0.88	BP198	SN74198	5.50	5.00	4.00
BP83	SN7483	1.10	1.05	0.95	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.

NUMERICAL INDICATOR TUBE *Type* MG-17G



Cold Cathode gas-filled, side-viewing numerals (0-9) and Decimal Point.
COLOUR: Neon Red.
DATA: Anode supply voltage 180 min Vdc.
Cathode current: 0.35 Nom mA dc.
Ideal for use in constructing Digital Clocks, Desk Calculators etc., and many products described in this magazine. We recommend use of BP47 to drive this tube.

Full data available on request
PRICE: 1–5 £1.55. 6–25 £1.40.

BRAND NEW LINEAR I.C's—FULL SPEC.

Type No.	Case	Leads	Description	Price 1-24	25-99	100 up
BP 201C—SL201C	TO-5	8	G.P. Amp	63p	53p	45p
BP 701C—SL701C	TO-5	8	OP Amp	63p	50p	45p
BP 702C—SL702C	TO-5	8	OP Amp Direct OP	63p	50p	45p
BP 702—72702	D.I.L.	14	G.P. OP Amp (Wide Band)	53p	45p	40p
BP 709—72709	D.I.L.	14	High OP Amp	53p	45p	40p
BP 709P—μA709C	TO-5	8	High Gain OP Amp	53p	45p	40p
BP 710—72710	D.I.L.	14	Differential Comparator	53p	45p	40p
BP 711—μA711	TO-5	10	Dual comparator	58p	50p	45p
BP 741—72741	D.I.L.	14	High Gain OP Amp (Protected)	75p	60p	50p
μA 703C—μA703C	TO-5	6	R.F.-I.F. Amp	43p	35p	27p
TAA 263—	TO-72	4	A.F. Amp	70p	60p	55p
TAA 293—	TO-74	10	G.P. Amp	90p	75p	70p
TAA 350	TO-5	8	Wideband Limiting Amplifier	170p	158p	150p

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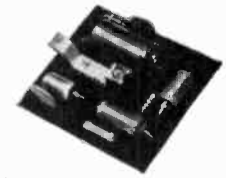
ANOTHER BI-PAK *FIRST!*

THE NEW SGS EA 1000 AUDIO AMPLIFIER MODULE



*** GUARANTEED NOT LESS THAN 3 WATTS RMS**

Especially designed by S.G.S. incorporating their proven Linear I.C. Audio Amp. TAA621 providing unlimited applications for the enthusiast in the construction of radios, record players, Audio and Stereo units. Also ideal for inter-com systems, monitoring applications and phone answering machines. Other uses: **portable applications where supply rails as low as 9V are of prime importance.**

- Sensitivity 40 mV for 1 watt Voltage gain 40 dB but can be varied up to 73 dB for some applications.
- Signal to Noise Ratio 86 dB.
- Frequency response better than 50 Hz to 25 KHz for -3 dB.
- Normal supply Voltage 9–24V
- Suitable for 8–16 ohm loads.
- Overall size 2" 3" ½".
- Typical Total Harmonic distortion at 1 Watt less than 1%.
- Supply Voltage (Vs)=24V 15 ohm load.

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THE Radio Constructor

Incorporating THE RADIO AMATEUR

MARCH 1972

Vol. 25 No. 8

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.

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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.

APRIL ISSUE WILL BE PUBLISHED ON APRIL 1st

TRANSISTOR CRYSTAL MARKER UNIT

By

P. Cairns, M.I.P.R.E., R.Tech.Eng., G3ISP

Capable of accepting crystals between 50 and 500kHz, this marker oscillator provides high level calibration 'pips' up to higher than 30 MHz.

THIS ARTICLE DESCRIBES A FREQUENCY MARKER crystal oscillator for use with virtually all types of communications receiver. The purpose of such marker units is to enable a very accurate h.f. oscillator of known frequency and high harmonic content to be switched into the receiver aerial input. With the receiver b.f.o. switched on, an audible beat note is then heard at regular frequency intervals across all bands of the receiver. Popular choice of frequencies for such markers are 100, 250 and 500kHz, though 1MHz is occasionally used. Crystals are in standard use for these devices as they allow high frequency stability to be achieved over an almost indefinite period. The specification of the marker unit to be described here is given in Table I.

MARKER FREQUENCY

The choice of frequency made by the writer was 250kHz, this representing a fair compromise between too wide and too narrow a marker interval. As most communications receivers are calibrated in at least 0.5MHz intervals this allows not only these points to be checked but also the 1MHz points. Any 250kHz markings between these two points can also be checked. Calibration between 250kHz steps is by means of the vernier or logging scale of the receiver, the number of degrees between any two 250kHz points being divided into the appropriate number of kHz. Thus, if the range between two marker points is logged as 10 degrees, each degree represents 25kHz.

TABLE I
General Specification

Output.	50kHz to 500kHz; frequency and accuracy determined by crystal. Maximum output 6 volts peak-to-peak square wave. Rise time approximately 50nS.
Supply.	With low voltage circuit, 9 – 12 volts d.c. Current drain at 9 volts: 9.5mA. With high voltage supply circuit, 150 – 330 volts d.c.
Dimensions.	1½ by 1½ by 2in. high. Components mounted on standard octal plug.

As some constructors may however already have crystals of other frequencies to hand (100kHz are quite common), or may prefer another choice of frequency to line up with a particular receiver's dial markings, the circuit was designed to function with crystals of any frequency between 50kHz and 500kHz. Several crystals of both these frequencies, together with others which lay between these extremes, were tried out in practice with complete success.

While the actual crystal used and specified by the writer is mounted in a B7G based glass envelope, other types of crystal having the standard ½in. or ¾in. two-pin spacing can be employed. The accuracy of the marker frequency will of course depend upon the accuracy and type of crystal used. Most crystals of the type used for frequency markers in the 100-500kHz range have accuracies of better than 0.1%. This is quite adequate for most general communications purposes. Frequency checks were carried out on a batch of assorted crystals, many of them ex-suplus, the frequencies being measured on a digital counter. The worst error measured was –0.13% while the least error was –0.015%. The crystal used by the writer had a measured frequency of 250,049Hz. (+0.02%).

The cost of the crystal depends of course very much upon the type and accuracy required. Surplus types are generally available in the 75p to £1.50 range. New types of higher accuracy are available, and cost a number of pounds.

The inclusion of a crystal marker in a commications receiver can be a decided advantage allowing, as it does, a constant and accurate check on dial and frequency markings on all bands. To ensure adequate output at the higher frequencies, a waveform having a high harmonic content is desirable. This means a fast rise time. The waveform rise time of the unit described is in the region of 50nS, thus allowing calibration checks well in excess of 30MHz. An oscillogram showing the output waveform appears in one of the accompanying photographs. While some receivers have a self-contained marker unit, many manufacturers advertise them as optional extras for their range of receivers, and prices noted on the commercial market vary between £6 and £9.75. The

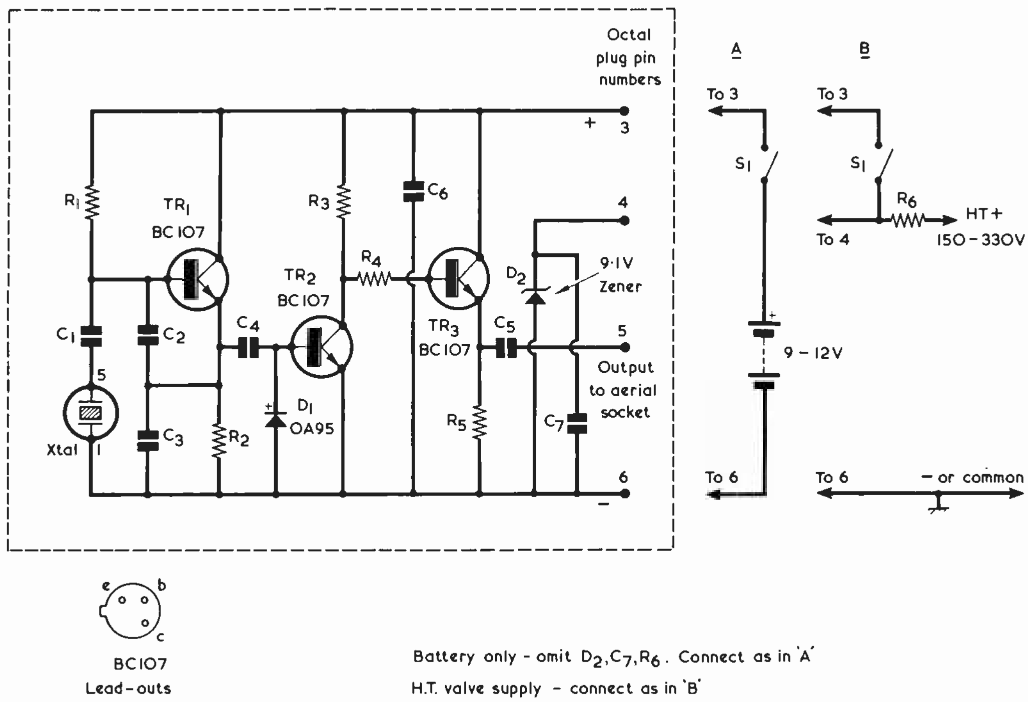


Fig. 1. The circuit of the marker unit. The components within the dashed outline are mounted on the octal plug. S1 and R6 (if used) are positioned, externally, in the receiver with which the marker unit is employed

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 5% unless otherwise stated)
R1 220kΩ
R2 4.7kΩ
R3 1kΩ
R4 10kΩ
R5 1kΩ
*R6 10kΩ – 18kΩ (see Table II), 12 watt wirewound, Cat. No. R17A (Home Radio)

Capacitors
C1 470pF silvered mica
C2 0.01μF polyester
C3 100pF silvered mica
C4 0.002μF polyester
C5 1–5pF ceramic (see text)
C6 0.33μF polyester
*C7 1μF polyester

Semiconductors
TR1 BC107
TR2 BC107
TR3 BC107
D1 OA95
*D2 9.1V 5% 400mW zener diode type BZY88–C9V1
*Not required with 9–12V supply

Switch
S1 s.p.s.t. toggle

Crystal
250kHz crystal, or frequency as desired (see text)

Miscellaneous
Crystal holder, to suit crystal used
Veroboard, 0.15in. matrix (see Fig. 2)
Octal plug and socket

cost of the unit described, less crystal, is at the time of writing just short of £2.

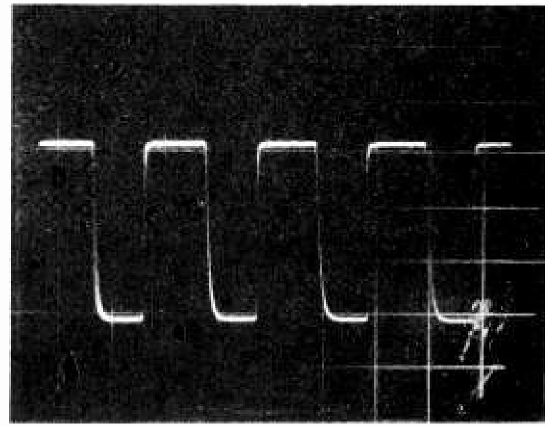
CIRCUIT DIAGRAM

The complete circuit diagram is shown in Fig. 1. The two types of power connection available are also illustrated. With transistor receivers using batteries or a 9–12 volt power unit, components D2, C7 and R6 are omitted. For use with mains valve receivers having a conventional h.t. supply, these components are included, R6 functioning as an external dropper resistor. To allow for a wide range of possible h.t. voltages the value of R6 should be selected from the values shown in

TABLE II

Values of R6 for varying h.t. supply voltages

H.T. Voltage	*Value of R6*
150 – 190	10kΩ
190 – 230	12kΩ
230 – 280	15kΩ
280 – 330	18kΩ



Trace given at 250kHz by the prototype. Signal amplitude is 6 volts peak-to-peak

Table II. The extra current drawn from the h.t. supply is of the order of 17mA.

The circuit in Fig. 1 shows TR1 connected as a Colpitts oscillator in the emitter follower mode. The oscillatory circuit is provided by the crystal which is working in the parallel mode of resonance, C1 providing series blocking and R1 base bias. The output is developed across the emitter load R2 while the necessary positive feedback is achieved across the capacitor divider C2, C3, the centre point being tapped into the signal output from the emitter.

The oscillator output is fed via the coupling capacitor C4 to the base of the squaring amplifier TR2. D1 and the base-emitter junction of TR2 provide symmetrical clipping of the input waveform, D1 also providing a d.c. return for TR2 base. This clipped waveform is amplified by TR2, the drive being sufficient to run this stage between cut-off and saturated conditions and thereby allowing a very fast rise time to be achieved. The squared output signal which is developed across the collector load resistor, R3, is d.c. coupled via the limiting resistor R4 into the base of TR3.

TR3 is an emitter follower output transistor, this providing a very low output impedance and so ensuring negligible loading effect by the receiver aerial input circuit. This stage also gives isolation between the aerial circuit and the oscillator and squaring amplifier. The output developed across the emitter load, R5, is coupled to the receiver aerial circuit via capacitor C5. The value of this component determines the degree of marker signal fed into the receiver and its value will depend to a large extent upon the sensitivity of the receiver in use. Details for setting this capacitor value are given later.

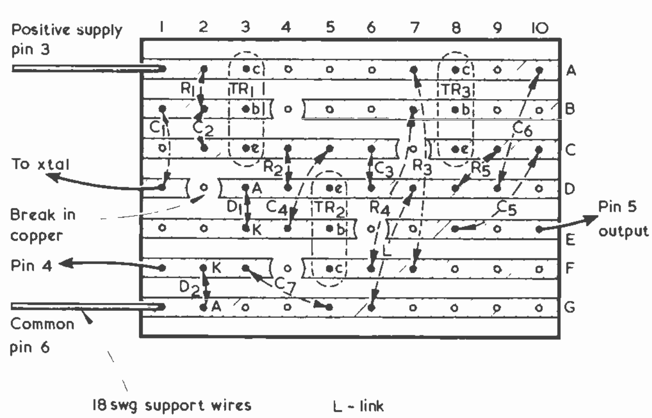
When used with battery or 9–12 volt power units the supply is simply connected to the supply via S1, as shown by 'A' in Fig. 1. C6 provides decoupling of the supply line. In the case of mains-derived valve h.t. supplies, the marker supply is taken from the zener stabilizer, D2, which is fed via the appropriate dropper resistor, R6, as illustrated by 'B'. S1 is again used to turn the unit on and off. The zener diode and dropper resistor are decoupled by C7.

CONSTRUCTION

The type of construction employed by the writer achieves a high degree of compactness, the use of Veroboard allowing reasonably constant results to be given in different units built up to the circuit. The parts are mounted on an octal base, which allows the unit to be easily removed for servicing or for use with another receiver. Most commercial marker units are of the plug-in type. Other types of construction and mounting can be used, however, the circuit not being excessively critical as regards to layout.

The complete circuit, except for R6 and the crystal, is wired on a piece of Veroboard measuring some 2 by 1½in., this being cut to provide the strips and holes shown in Fig. 2. The component layout on this board is also given in Fig. 2. Note the letters 'A' and 'K' alongside the connection points for D1 and D2. These indicate the anode and cathode ends of each diode

Fig. 2. The Veroboard, with the copper side towards the reader



respectively. A 5pF capacitor may be temporarily fitted in the C5 position.

After fitting the components, the Veroboard is mounted vertically on the edge of the octal plug by means of two lengths of 18 s.w.g. tinned copper wire. This octal plug is mounted in the centre of a 1½in. square piece of ⅛in. Paxolin, which forms a base plate. The 18 s.w.g. wire is soldered between the outer copper strips on the bottom of the Veroboard, these being positive and common supply lines, and the appropriate pins in the octal plug, which are pins 3 and 6 respectively. The support wires are bent to shape so as to allow the Veroboard to sit comfortably on the upper edge of the plug base while allowing the ends of the wire to be located directly into the appropriate plug pins.

The crystal holder is mounted in a similar manner on short lengths of 18 s.w.g. support wire, the wires being terminated in pins 2 and 7 of the octal plug. These two pins are unused, and no connections are made to the corresponding tags of the valveholder into which the assembly is plugged. The author used a crystal on a B7G base, and the 18 s.w.g. support wires were taken to pins not employed for the crystal connections. The latter are pins 1 and 5. If a 2-way crystal socket is used, the 18 s.w.g. wires could be soldered to the same pins as are used for circuit connection. Wiring between the crystal socket and the Veroboard and between the Veroboard and pins 4 and 5 of the octal plug is carried out with short direct lengths of p.v.c. covered wire. The earthy side of the crystal may connect to the 18 s.w.g. support wire soldered to pin 6. Figs. 3 and 4 give top and side views of the assembly.

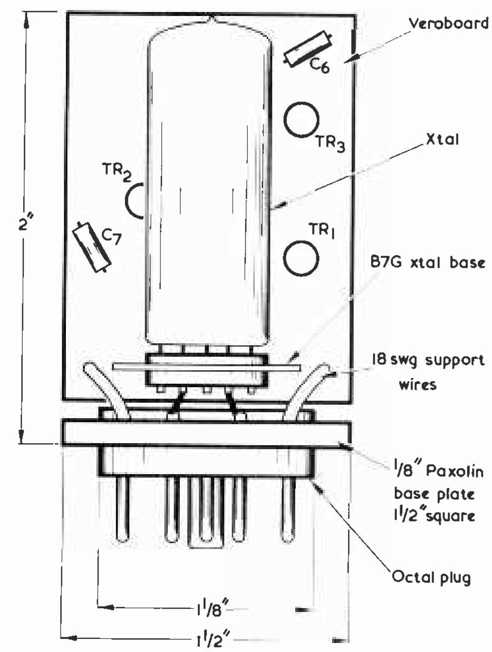


Fig. 4. The octal plug assembly as seen from the crystal side

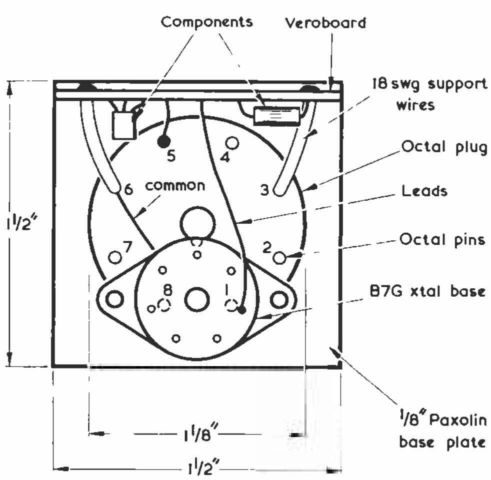
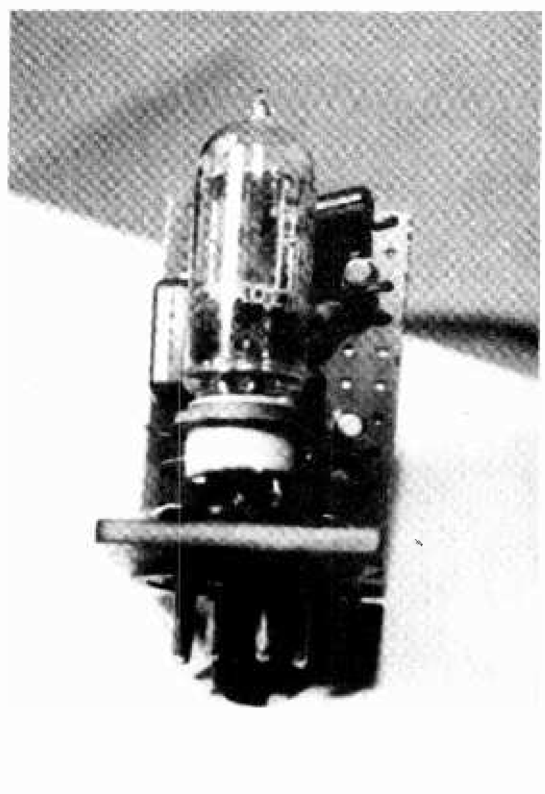


Fig. 3. Top view of the assembly on the octal plug



A view of the unit from the side on which the crystal appears

The corresponding octal valveholder is fitted at a convenient point in the receiver with which the marker unit is to be employed. Connections are then made to tags 3 and 6, or to tags 3, 4 and 6, of the valveholder, as indicated by 'A' or 'B' in Fig. 1. If R6 is used, it should be positioned away from the oscillator section of the receiver.

Side view of the completed marker unit, with the parts mounted on the octal plug

TESTING

When the unit is completed and connected into the receiver, the supply is switched on and the functioning of the unit checked. If an oscilloscope can be brought into use the waveform can be checked by connecting the Y1 input between TR3 emitter and the common supply line. If no oscilloscope is available the output from socket tag 5 is taken to the receiver aerial input socket. The receiver b.f.o. is switched on and the receiver tuned to a suitable point on the dial. For a 250kHz crystal, 500, 750kHz and 1, 1.25, 1.5, 1.75MHz, etc., are suitable points at the lower end of the tuning range. When the receiver is tuned over these points a strong beat note should be heard. It will be necessary to reduce the r.f. gain to a relatively low level to prevent overloading the receiver.

Having proved that the marker unit is functioning correctly it only remains to set the value of C5 for the best level of coupling into the aerial circuit. With the marker unit switched on as just described, select the high frequency end of the receiver h.f. band. In most types of standard receiver this will be in the region of 30MHz. The r.f. gain can be increased to near-maximum. Tune about this point until the beat note is heard. With a 250kHz crystal, beats will be noted on 29.5, 29.75, 30, 30.25 and 30.5MHz, etc. The aerial should be disconnected during these tests. The strength of the beat note around 30MHz will depend to a large extent on the sensitivity of the receiver in use. Thus, the value of C5 can only be selected under test.

With conditions set up as just described, reduce the value of C5 until the beat note falls to an average level of audio output with the receiver set to maximum r.f. gain. With highly sensitive receivers, values in C5 of even 0.5 or 1pF may still be too large, and the output lead from tag 5 of the valveholder may have to be even more loosely coupled to the aerial input. In this instance the lead from tag 5 is brought into close proximity with the aerial input socket or lead, but no direct connection is made. In some cases the coupling lead from tag 5 may have to be screened to prevent stray coupling to other circuits.

With the value of C5 set, the unit is complete and ready to be switched into service at any time. Not only does the use of a frequency marker allow instantaneous calibration checks at the press of a switch, but it will also indicate any long term deterioration in receiver alignment.

While the crystal marker described so far has only been considered as a permanent sub-unit for internal use with a receiver, it could of course be built in a separate case with internal battery or power supply. Such a unit could then be employed not only with a number of different receivers but also as a general purpose frequency standard. The modified circuit in Fig. 5 can be used with the unit, allowing not only a variable output for general use but also for receiver/marker aerial coupling arrangements which obviate the necessity of having to make any internal connections to the receiver. Such a unit will find many uses in the short wave listener's shack and on the test bench.

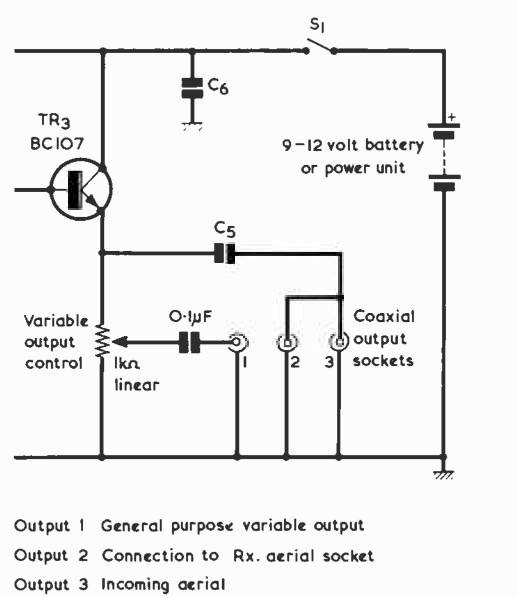


Fig. 5. An alternative output circuit which enables the marker unit to be employed as a self-contained item of equipment

CRYSTAL AVAILABILITY

As stated earlier in this article, the unit may employ crystals having frequencies other than 250kHz. 100kHz crystals are available from Home Radio. 250kHz S.T.C. Crystals Type 4013/CT on a B7G base are available in 1-off quantities from ITT Components Group Europe, Standard Telephones and Cables Ltd., Quartz Crystal Division, Edinburgh Way, Harlow, Middlesex. Also, 250kHz Crystals Type QO1655C, similarly on a B7G base, are available in 1-off quantities from Specialized Components Division, Marconi Communication Systems Ltd., Radford Crescent, Billericay, Essex. A large range of surplus types, some with 'round figure' frequencies, are generally available from Henry's Radio. ■

NOTES ON SEMICONDUCTORS

Further Notes – 4

PROTECTION MONEY

by

PETER WILLIAMS

The addition of a single resistor prevents damage in a series regulator circuit in the event of load short-circuit. The circuit described in last month's note forms the basis of the present discussion.

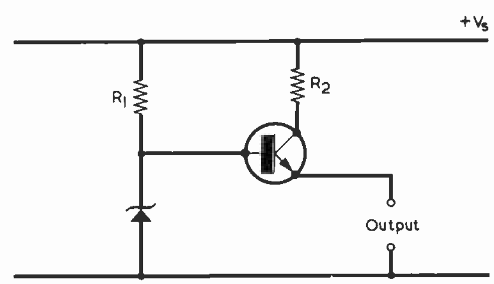
FINAGLE'S FIRST LAW: IN ANY LABORATORY experiment, if anything can go wrong it will. This, the most scientific form of folk wisdom, equivalent to Murphy's Law or the Law of Constant Cussedness, is one that the experimenter should learn at his mother's apron strings (or coaxial cables if he has chosen parents wisely.) In the context of voltage regulators it leads to the following axiom: short-circuit of the load will always occur at the instant at which the maxima of supply voltage and temperature coincide.

LOAD SHORT-CIRCUIT

For the example treated last month, a short-circuit of the load at the instant of maximum supply voltage could have disastrous results. The base current of the transistor would then be a little over 4mA (11.5V/2.7 kΩ) while the maximum transistor current gain might be well over 200 if the minimum were 60. Hence the collector current might try to increase towards 1A which would result in a transistor dissipation of 12W – for a very *short* time. Thus it would be unwise to operate such a regulator with loads that could be readily short-circuited.

There is one simple means of minimizing the dissipation, as shown in the diagram. A resistor R2 may be inserted in series with the collector of the transistor (a) to minimize the short-circuit current and (b) to absorb part even of this reduced power. It can do this with no noticeable deterioration in regulation since the transistor parameters depend only slightly on Vce provided this is more than enough to keep the transistor out of saturation.

A minimum Vce of 1V is usually adequate (or down to less than half of this value if a small drop in output voltage is acceptable). Thus, in the example, to avoid saturation at the lowest supply voltage and maximum current we have a voltage across R2 of 9V – (6 – 0.5)V = 2.5V. With a maximum current of 30mA this gives R2 = 82Ω (nearest preferred value to 2.5V/30mA). Now even with a short-circuit the load current cannot exceed about 150mA (12V/82Ω base current). Further under these conditions the transistor is saturated with small p.d. across it and correspondingly low dissipation.



Adding a resistor in the collector circuit of the series regulator which was discussed last month offers protection against damage resulting from load short-circuit

The worst case dissipation for this circuit is in fact when the p.d. across the transistor is half the difference between supply and output voltages. This voltage is 3V, (half of 12 – 6V), and the corresponding current is about 37mA (3V/82Ω) Hence the worst case dissipation is still only 110mW, which is a considerable improvement on that without the limiting resistor. It is still true however that the short-circuit ratings of higher power supplies can cause damage to the circuits they supply in the event of a fault. In the next note a simple means of current limiting will be considered, by the addition of a single transistor. ■

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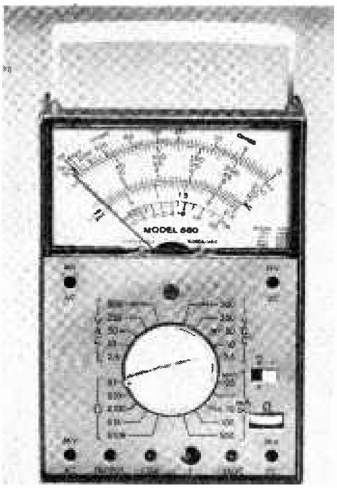


A portable multimeter is as essential to the electronic technician as a stethoscope is to a doctor. Trouble-shooting and testing start with the multimeter which is an indispensable part of the 'travelling' tools most technicians take on the job.

Even an ordinary multimeter is constructed like a watch with a jewelled movement, and it can't take day-to-day handling in a rough environment without losing accuracy.

To cope with this problem DAYSTROM has introduced a group product – the 660 series drop-proofed multimeter. These precision meters are warranted to operate within specification after being dropped from a height of five feet. The meter mechanism floats inside a sealed, high-impact plastic case. In addition the new multimeters have temperature compensation, with shielded and electrically protected meter movement. The meter maintains accuracy in extreme environments and will not be damaged if, as sometimes happens, the user accidentally connects it to a high voltage source.

Daystrom salesmen sometimes demonstrate the 600 series by throwing the meter on the customer's floor. So far, customers have had a worse shock than the meter!

IN BRIEF

● The membership lists of the Radio Amateur Invalid and Bedfast Club show a membership of nearly 400 in 13 countries. Approximately two-fifths of the members hold amateur licences.

● Mr. Christopher Chataway, Minister of Posts and Telecommunications, announced in the House of Commons his agreement to licence, on an experimental footing, a scheme to transmit locally initiated TV programmes in the Woolwich area until July 1976. The transmissions will be by cable and there will be no advertising.

● Lord Willis, the playwright and TV scriptwriter, creator of Dixon of Dock Green and many other TV series, has become chairman of Network Broadcasting Ltd., the commercial radio company.

● A club calling itself the 'Union of European Testcard Hunters' was formed in Holland just over a year ago, its aim: to encourage TV-DX.

The club wishes to extend its membership in the U.K. Those interested should write to P.D. van der Kramer, Europese Testbeeldjagers, Diepenbrockstraat 2, Slikkerver-3210, Holland.

● 'A total of about 90 million joints are soldered each day in Britain.' This was stated during a session on solders and soldering which constituted part of a conference on 'Tin in Modern Technology' organised by the Tin Research Institute in conjunction with the British Institute of Metals.

● Clayridge Electronics Ltd., of 2 Stoke Newington High Street, London, N16 7PL have just issued a new edition of their radio and TV component catalogue. Readers requiring the catalogue should write to above address.

ABERDEEN UNIVERSITY CARRIES OUT ACCEPTANCE TESTS ON COLOUR TV EQUIPMENT ORDERED FROM EMI

An EMI type '2001' colour television camera is checked out by television engineers from Aberdeen University during acceptance tests at the Hayes (Middlesex) plant of EMI Electronics Ltd. Altogether, EMI's Television Equipment Division is supplying the Scottish university with five '2001' broadcast cameras and a fully-equipped colour video recording vehicle (seen here in the background).

Aberdeen University is believed to be the first European teaching establishment which will use full broadcast colour equipment for making educational television material for a closed circuit television network. The 20 ft. long video recording van, equipped with three of the EMI cameras, will also be the first of its type to be fitted with colour broadcast equipment.

The photograph shows (L to R): Mr. J. Kilpatrick, senior engineer, Aberdeen University Television Service; Mr. E. A. Morley, UK sales manager, Television Equipment Division; and Mr. J. Woodward-Nutt, chief engineer, Aberdeen University Television Service

. . . COMMENT

AMSAT PROGRESS

The Radio Amateur Satellite Corporation – AMSAT was started in 1969 to provide satellites and space experiments for the amateur radio service. In a recent issue of the AMSAT NEWSLETTER their President, Perry I. Klein, K3JTE, in his Annual Report for 1971, outlines the progress made to date and the various projects currently underway.

Membership of AMSAT is now over 460, with some 40 societies in group membership, and radio amateurs in 30 countries are represented.

Amongst the accomplishments to date, mention is made of the AMSAT – Aircraft Flight Tests, made in connection with the AMSAT – OSCAR – B Satellite project, in which two series of aircraft flights with a prototype translator being developed for the A–O–B project were made. It is estimated that between 200–300 amateur radio stations took part and one station alone made 17 two-way contacts through the translator. The main purpose of these translator flight tests, was to help interested amateurs prepare for operation with the A–O–B satellite and to gain useful technical and operational experience in using the Satellite once it is in orbit.

AMSAT provided much of the background supporting material on Amateur Satellites to several of the delegations represented at the ITU World Administrative Radio Conference on Space Telecommunications and Radio Astronomy in July 1971, at which a new 'Amateur Satellite Service' was authorised with provision in the 40, 20, 15, 10, 2 and ⅔ metre bands for amateur satellite operation.

Considerable progress has been made with AMSAT-OSCAR–B which it is hoped will be launched sometime in 1972. NASA has undertaken to launch this satellite, which will ride piggy-back with the ITOS-D meteorological Satellite which is being planned and will be put into a 1500 Km polar orbit.

Another proposed project, is to provide amateur radio equipment for use in the ATS-G NASA Satellite to be launched in 1975. This is to be known as *SYNCART* - *Syn*chronous *A*mateur *R*adio *T*ranslator. The ATS–G Satellite, will be in a geostationary orbit and will have a 30 ft. parabolic reflector, which will be available for amateurs to use and will provide the rare opportunity for amateurs to use a synchronous satellite on a regular basis with modest amateur equipment.

NASA is also planning an orbital, manned laboratory, scheduled for launch in 1973. This project, named SKYLAB may also have an AMSAT sponsored project, named SKYLARC aboard, which is to provide 10 metre communication through amateur radio channels on SSB with the astronauts. One of the astronauts is training for SKYLAB, Dr. Owen Garriott, is a radio Amateur, W5LFL.

Pye Telecommunications Limited has announced a new compact, remotely-controlled base station for its radiotelephone systems, known as the type F9U.

This unit fully satisfies the market requirements for a remotely-controlled 5 watt base station for UHF mobile radiotelephone schemes. The controller is no larger than a desk top intercom.

Remote control permits closer installation of the base station to its antennas for minimal feeder loss and greater efficiency – an important factor when using UHF.

The design features great flexibility in mounting the equipment. Although primarily intended for wall mounting, the unit can be easily and conveniently fitted to any suitable horizontal or vertical surface. A mounting cradle, supplied as standard, enables the equipment to be easily dismounted.

If required, the equipment can be simply fixed to the cradle to prevent unauthorised removal. The equipment cover is fitted with a tamper-proof catch. The extensive use made of high quality silicon integrated circuits results in fewer components, higher reliability and easier maintenance. Fully coded printed circuit boards provide easy access to all components.

"Congratulations – Your I.C. INTRUDER ALARM is a complete success!" (With apologies to the author of the article which appeared in our January issue)

QSX

By
FRANK A. BALDWIN
(All Times GMT)

The most interesting news in the world of Broadcast band short wave listening this time is undoubtedly the appearance of Radio Nepal on approximately 5000kHz. The old channel of 9590kHz has been vacated for the afternoon transmission, the new frequency of 5000kHz being in parallel with the usual 4600kHz. The new channel presents a better chance of reception for listeners in the U.K. than that of 4600kHz, this latter frequency being subject to communications interference. Radio Nepal, Katmandu, from the signal strength measured here, would appear to be using the 100kW transmitter on 5000kHz. Logged in mid-December, R. Nepal was heard with Arabic-type music and songs, through the time signals of MSF, with sudden closedown at 1550, presumably due to a fault at the transmitter. In general, the station may be heard from around 1500 to 1650 sign-off and also from around 0115 to past 0145. The frequency is subject to some variation and has been measured on channels varying from 4999.5kHz to 5002kHz.

Another flurry of excitement has been caused by the appearance of VOA (Voice of America) Tangier on the 'out of band' channel of 5436kHz, where it has been logged several times of late with a programme of Arabic-type music and also recorded English musical comedy music. Entitled "The Happy Time", the programme was heard from 2030 until 2057, at which time the news in Arabic was radiated followed by station identification in English and sign-off at 2100.

In the new state of Bangla Desh, Dacca is now on the air with English and Bengali announcements on 15520kHz and other channels – see Short Wave News. Identification is "Radio Bangladesh, Dacca" or "Bangladesh Betar Kendra, Dacca", according to the British Association of Dx'ers (BADX).

● PROGRAMMES IN ENGLISH

Continuing from the last instalment under this heading (January issue) a few more transmissions in English that may be heard by readers are listed herewith, the times being stated first so that some individual planning can be made.

1200 11785 (25.46m) 100kW Vienna, Austria, the news in English.

1500 9860 (30.43m) 240kW Peking, China, news of life and events in China with commentaries.

1900 5930 (50.59m) 100kW Prague, Czechoslovakia, world news from the Czechoslovak point of view.

2045 6190 (48.47m) 100kW Vatican, Vatican State, world news and that of the Catholic church.

2145 6025 (49.79m) 15kW Budapest, Hungary, short wave listeners Dx programme.

2145 6070 (49.42m) 50/100kW Sofia, Bulgaria, programme about scientific research and achievements in Bulgaria.

2200 9805 (30.59m) 100kW Cairo, U.A.R., news and views from the Arabic world, directed to Europe.

● FAR EASTERN DX

Although not so good as last year, conditions for the reception of stations in the Far East have perked up on odd occasions, those transmissions which we have logged being shown here. By the time this appears in print, the 'season' for reception of this area will be waning therefore budding Dx'ers should listen on the channels shown in the hope that they will log something worthwhile in the remaining time available.

3935kHz 2145 (76.24m) 35kW Ryukyu Islands (Okinawa), VOA (Voice of America) transmitter with the news in Korean followed by the identification in English "This is the Voice of America completing this transmission from Okinawa on this frequency" and sign-off at 2200.

4890kHz 2000 (61.35m) 10kW VLT4 Port Moresby, Papua, with news and comment in Pidgin English through to 2015 when signals faded into the noise level.

4907kHz 1725 (61.14m) 15kW Phnom-Penh, Khmer Republic (formerly Cambodia) with songs and music in typical Asian style. Those readers who have not yet heard this station would do well to listen on this channel, the music is most distinctive, more often than not including the clashing of gongs and cymbals. It is easy to visualize the dragons and pagodas!

5052kHz 1618 (59.38m) 10kW Singapore radiating a programme of musical comedy songs from the English stage, King's Rhapsody, White Horse Inn – and all that!

● CHINA

This country can, of course, be easily heard on many differing channels, most of them listed as Peking with powers up to 240kW. However, the actual location of some of these transmitters is open to speculation but one that may interest readers is that of the People's Liberation Army (PLA) at Fukien operating on 7280kHz (41.21m), where it has been heard from midnight onwards with the Home Service. The PLA operate on many short wave frequencies, that most reported probably being the transmitter on 3900kHz (76.92m).

Peking has been logged here recently on 3940kHz (76.15m), 4865kHz (61.66m), 4905kHz (61.16m) and on 5145kHz (58.32m). The identification of Fukien is "Chungkuo jen min fan chun Fuchien chien hsien kwang po tien tai".

● HERE AND THERE

Some short wave stations are easy to log whilst others are relatively more difficult. In the main, the latter category tend to be on the LF bands, such stations having lower powers mainly for the reason that they are intended for local service and not for international audiences. Unfortunately for the Dx'er, the LF bands also carry a multiplicity of commercial services which cause considerable interference to the wanted transmission, thereby making reception difficult to say the least. However, despite the continuing problems, Dx'ers continue to rove these bands and battle on undaunted by the continuing cacophony! A few of the stations that can be heard with a modicum of luck on these frequencies are listed below.

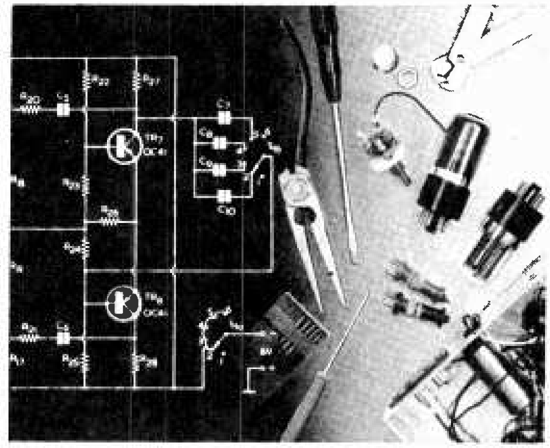
4777kHz 2245 (62.80m) 100kW Libreville, Gabon, logged when featuring African songs and drums interspersed with announcements in French.

4807kHz 1737 (62.41m) 4kW St. Denis, Reunion Is., light music selections and announcements in French. This one is not so easy to log.

4880kHz 1956 (61.48m) 10kW Kinshasha, Congo, drama in African dialect followed by typical rhythmic drum beats. ■

'MAGIC' NUMBER INDICATOR

by G. A. FRENCH



RECENT ARTICLES IN THE 'SUGGESTED Circuit' series have been more than usually long and have described rather ambitious projects. Because of this, the writer felt that it would make a pleasant change to produce a relatively short article for this month's issue and to devote it to the discussion of an extremely simple device. The circuit to be dealt with is very elementary in form and can be assembled by the veriest beginner. It offers an amusing effect which can be completely baffling to people who do not realise the secret behind the manner in which it is used.

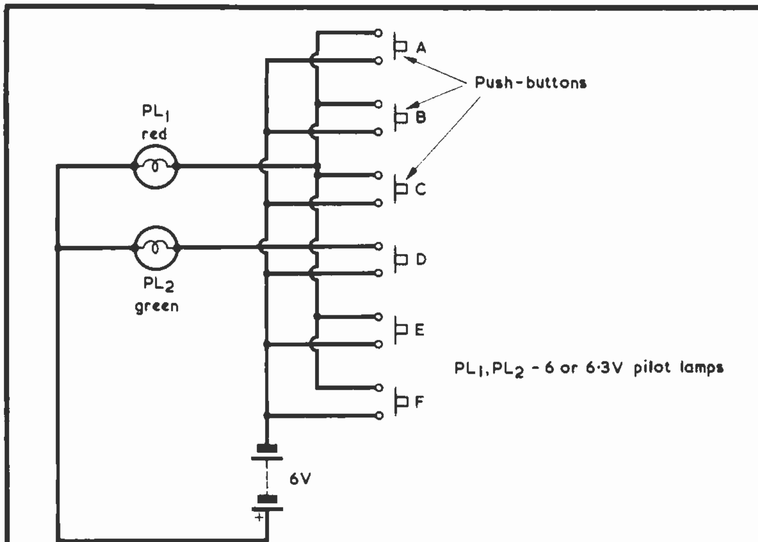
CIRCUIT OPERATION

The device consists of a small box containing a battery and having a front panel on which are mounted six push-buttons and two bulbs, one of the latter being red and the other green. The table which accompanies this article is also fitted on the front panel. The push-buttons are lettered A, B, C, D, E and F respectively. Pressing button D causes the green lamp to be lit, whilst pressing any of the other buttons causes the red lamp to be lit. The circuit appears in the accompanying diagram, in which the battery can be any 6 volt type with sufficient capacity to give a long life. An Ever Ready 'Lantern' battery type 996 would represent a good choice, as also would two 3-volt cycle lamp batteries (Ever Ready type 800) connected in series. The lamps can be 6 or 6.3 volt m.e.s. types fitted in panel-mounting holders having red and green lenses respectively. Suitable bulbs and holders with lenses are available from most radio retail sources, including Henry's Radio Ltd.

To demonstrate the 'magic' properties of the number indicator, an acquaintance is asked to write down on a piece of paper any number between 10 and 1,000,000. He is then asked to change the order in which the digits of the number appear, thereby forming a new number. Next, he is asked to subtract the smaller of the two numbers from the larger and to add together the digits in the result. After carrying out these operations he is finally asked to find, in the table, the number he has obtained and to press the corresponding button. In all cases, assuming he has carried out his calculations correctly, the button indicated will be button D which, when pressed, will illuminate the green light.

This result will occur regardless of the original number and regardless of the order in which its digits are re-arranged before carrying out the subtraction. The buttons other than D, which cause the red light to be illuminated, will only be recommended for use by the table if the person carrying out the calculations has made an error.

It will be seen that the table lists numbers from zero to 59, each number having an accompanying button-



The circuit of the number indicator. Only the green light is illuminated if the calculations described in the article are carried out correctly identifying letter alongside it. Thus, number 16 corresponds to button B and number 17 corresponds to button A. Closer inspection of the table will reveal that button D corresponds only to zero, 9, and multiples of 9, such as 18 and 27.

This is a small part of the secret of the indicator, and it arises from the fact that after the manipulations with the initial random number have been carried out as just described, the result is always zero, 9 or a multiple of 9. To give a demonstration let us choose, at random, the number 67981 and then rearrange its digits to give 18967. 67981 minus 18967 equals 49014. The digits of 49014, when added, equal 18, which is a multiple of 9. Interested readers will find it of interest to try the calculations with *any* initial number, and with *any* random rearrangement of its digits.

TABLE

Number	*Button*	*Number*	*Button*	*Number*	*Button*	*Number*	*Button*
0	D	15	B	30	F	45	D
1	E	16	B	31	E	46	C
2	A	17	A	32	B	47	B
3	C	18	D	33	A	48	E
4	F	19	E	34	F	49	E
5	B	20	C	35	B	50	F
6	B	21	A	36	D	51	C
7	C	22	E	37	A	52	B
8	F	23	F	38	E	53	B
9	D	24	B	39	E	54	D
10	C	25	B	40	C	55	A
11	A	26	B	41	C	56	E
12	A	27	D	42	A	57	C
13	F	28	C	43	B	58	F
14	E	29	A	44	F	59	B

EXPLANATION

The explanation for this intriguing phenomenon involves a little examination of elementary mathematics.

Most readers who have carried out simple division problems will have learned that a quick way of checking whether a number is divisible by 3 is to add up the digits in the number. If the solution results in 3 or a multiple of 3, then the number itself can be divided by 3. Take, for instance, the number 49713. The digits of this number add up to 24 which is a multiple of 3 and which thereby indicates that 49713 is divisible by 3, as it is. Note that we could, if desired, take the process a stage further by adding together the digits of 24. This gives us 6, again a multiple of 3.

If the initial number is even, and its digits add up to 3 or a multiple of 3, the number can be divided both by 3 or by 6.

So far as our present discussion is concerned we are more interested in numbers which can be divided by 9. Here we find that the same rule as for 3 applies. If the digits of any number add up to 9 or to a multiple of 9 that number is divisible by 9. For instance, the digits in the number 78615 add up to 27, whereupon we know that 78615 can be divided by 9. It may be noted, in passing, that the digits of 27 themselves add up to 9.

These pecularities in numbers which can be divided by 9 are fairly well-known, particularly amongst those who carry out a large amount of mathematical calculations. There is, though, a further relationship between 9 and other numbers which is not by any means as well-known, and it is this relationship which forms the main part of the secret of the indicator and its table.

As we have already seen, if a number is not divisible by 9 the sum of its digits is equal to a figure which is similarly not divisible by 9. However, the amount by which that figure exceeds zero, 9 or the nearest multiple of 9 below it, *is equal to the remainder that is left after 9 has been divided into it*. Take, for example, the number 281, whose digits add up to 11. This sum exceeds 9 by 2. If we divide 281 by 9 we find that we get a remainder of 2. We also get a remainder of 2 if we divide 812, 821 and 128 (all variations of the original number) by 9. The digits of another number chosen at random, 94981, add up to 31 which is 4 more than 27 (the nearest lower multiple of 9). If 94981 (or any other arrangement of these digits) is divided by 9, the remainder is 4. Another number, 133, has digits which add up to 7. This is 7 in excess of zero, and 133 gives a remainder of 7 when divided by 9, as also do 313 and 331.

This state of affairs is quite easy to appreciate if we look upon any number which cannot be divided by 9 as being equal to the nearest lower multiple of 9 plus a remainder. The number we examined just now, 281 (which gives a remainder of 2) can be looked upon as 279 (the nearest lower multiple of 9) plus 2. This explanation takes account of the fact that zero is a multiple of 9, which of course it is since zero is 9 multiplied by zero.

We are now in a position to understand why, in the manipulation of a random number as initially described, the difference between the two numbers is always a multiple of 9. The original number consists of a multiple of 9 plus a remainder. When the digits of the number are changed around it consists of another multiple of 9 *plus the same remainder*. When the smaller number is subtracted from the larger we have the case where a multiple of 9 plus a remainder is subtracted from another multiple of 9 plus the same remainder. The remainders cancel out, and the result of the subtraction consists of a multiple of 9 minus another multiple of 9. This result must, itself, be a multiple of 9.

With the indicator, the lower and upper limits on the random numbers to be initially selected are chosen as 10 and 1,000,000. The number 10 is an obvious lower limit since the number chosen must have at least two digits if these are to be rearranged. The upper limit of 1,000,000 takes care of the extreme case where 1 (actually 0,000,001) is subtracted from 1,000,000 to give 999,999. The sum of the digits in 999,999 is 54 which is not so high as to make the table excessively large. Admittedly, a smaller table could be used if the person carrying out the calculations were asked to (in the present example) add the digits 5 and 4 together to give the smaller number 9. However, this approach would draw attention too early to part of the secret of the indicator table and its reliance on the relationship with the figure 9.

The table, as shown here, should not at first sight demonstrate too obviously that the buttons D correspond to zero, 9 and multiples of 9. After some experience of the calculations, nevertheless, most people will see that the answers they obtain are of this nature. It is extremely unlikely, though, that they will know *why* such answers are obtained and so the final mystery behind the functioning of the indicator and its table will still remain unexplained. ■

NOVEL A.F. AMPLIFIER

Since the article under the above title was published in the January 1972 issue it has been found that best results are given with the value of R7 reduced to 100Ω. A transistor with low leakage current should be employed for TR1(a) in Fig. 1.

D. C. VOLTMETER

by
A. RUSSELL

Incorporating a readily obtainable integrated circuit, this voltmeter has a sensitivity of 100kΩ per volt. Any ranges from 0–100mV to 0–100V can be provided to meet the particular requirements of the constructor.

THE D.C. VOLTMETER TO BE DESCRIBED HERE IS BASICally very simple, and ranges can be chosen between 100mV f.s.d. and 100V f.s.d. to suit individual requirements. Sensitivity is 100kΩ per volt on all ranges, which compares favourably with most multimeters, which are rarely rated better than 40kΩ per volt.

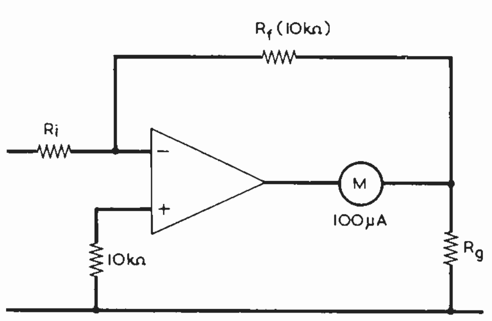


Fig. 1. The basic circuit employed in the d.c. voltmeter

CIRCUIT DESCRIPTION

First of all, let us look at the basic circuit, which is given in Fig. 1. The voltage to be measured is applied to Ri, which is chosen so that 10μA flows when the required f.s.d. voltage is applied to it (remembering that we consider the inverting input to be at a virtual earth). Virtually all of this 10μA flows through the 10kΩ feedback resistor, Rf, this being chosen to give a current gain of 10 times on all ranges. Since 100μA flows through the meter for f.s.d., 90μA must flow through Rg. Hence the value of Rg should be 10/9kΩ, i.e. 1.1kΩ nominally. In practice, this is formed by a 560Ω fixed resistor in series with a 1kΩ variable resistor (the calibration control). This combination gives a leeway of about 500Ω either side of the nominal value, which will be ample.

Let us now look at the practical circuit in Fig. 2. Here, the range is altered by switching in various values for Ri. The resistor values required can be chosen from the Table. We are limited to a maximum of 100V in this design, since it is difficult to obtain close tolerance resistances above 10MΩ. However, in transistor circuitry we will rarely find voltages above 100V.

R6 and D1 are included to protect the meter from forward overloads. D1 will conduct when the voltage across the meter and R6 is about 700mV. This voltage will be about 420mV when the meter is reading f.s.d., and so D1 should conduct when the excess voltage is about 70% of f.s.d., thereby protecting the meter movement. No reverse overload protection was included in the prototype, but if this is thought to be necessary, a germanium diode (such as the OA81) should be connected across the meter and R6 with its polarity opposite to that of D1. This diode will conduct when its forward voltage is about 400mV, i.e. when the

The complete voltmeter in its case. This measures 4 by 6 by 4in

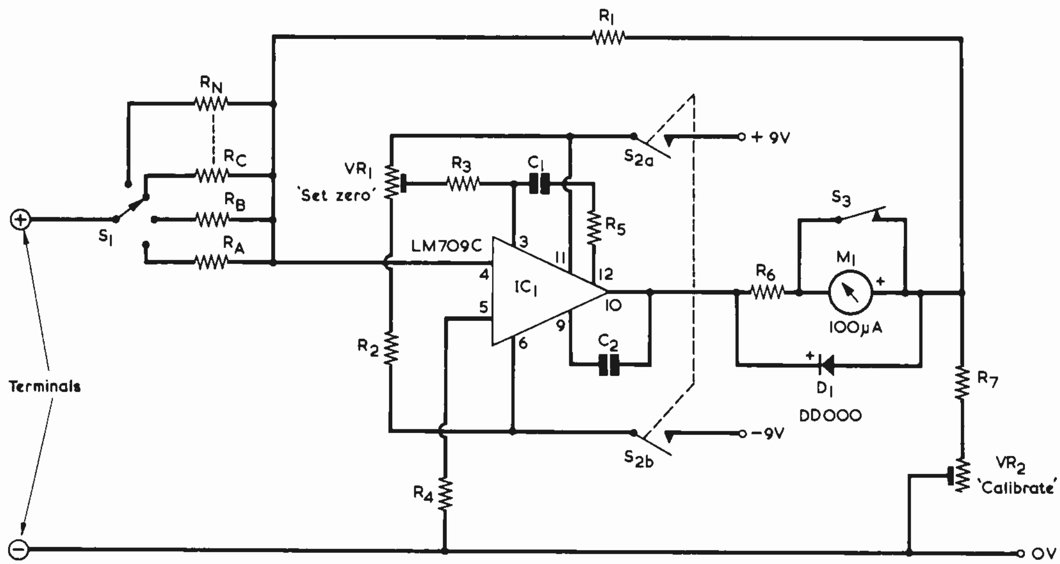


Fig. 2. The working circuit of the voltmeter

COMPONENTS

Resistors
(All fixed values ½ watt 10% unless otherwise stated)
R1 10kΩ
R2 150kΩ
R3 430kΩ
R4 10kΩ
R5 1.5kΩ
R6 3.3kΩ
R7 560Ω
RA-RN Input resistors, see text
VR1 100kΩ potentiometer, preset, panel-mounting
VR2 1kΩ potentiometer, preset, skeleton

Capacitors
C1 2,700pF silvered mica
C2 100pF silvered mica

Semiconductors
IC1 Integrated circuit type LM709C, dual-in-line
D1 DD000 (Lucas)

Meter
M1 0 – 100μA moving-coil, 38 Series (Henelec)

Switches
S1 1 pole miniature rotary (see text)
S2 d.p.s.t. toggle
S3 s.p.s.t. slide switch

Batteries
2 9-volt batteries type PP3 (Ever Ready)

Miscellaneous
1 Red insulated terminal
1 Black insulated terminal
2 Battery connectors
2 Pieces Veroboard, 0.1in. matrix (see Fig. 4)
1 Case (see text)
1 Pointer knob

applied voltage is about equal to f.s.d. the wrong way round.

C1, R5 and C2 are compensation networks as specified by the manufacturer of the integrated circuit.

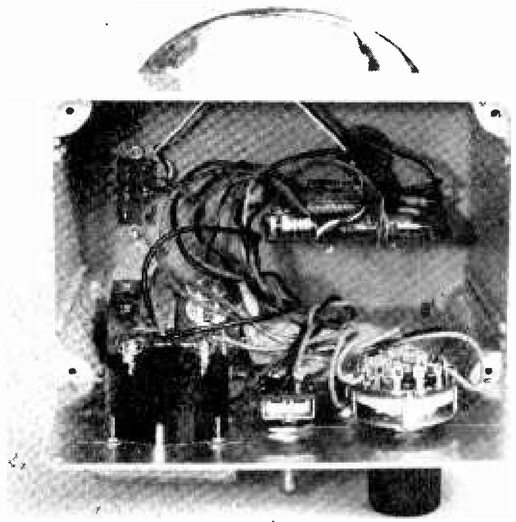
VR1, R2 and R3 are also specified by the manufacturer to balance the offset current that will be present at the input. The offset current would cause the meter to read when no voltage is applied to the input terminals if it were not compensated.

S3 was added to short-circuit the meter terminals whilst transporting the unit. This protects the delicate meter movement, since any oscillations of its coil are damped out by the e.m.f. produced. Ideally, S2 and S3 should be combined, so that the meter is short-circuited automatically when the unit is switched off, but the author could not find a suitable switch at a suitable price! The switch required would need two sets of normally open and one set of normally closed contacts.

COMPONENTS

The design employs an LM709C integrated circuit, and the writer obtained this from L.S.T. Electronic Components, Ltd. The meter was a Henelec model from the '38 Series' with a 1.654 in. square face, and is available from Henry's Radio Ltd. The housing for the unit is a 'Stella 99' instrument case, available from E. R. Nicholls, 46 Lowfield Road, Stockport, Cheshire. This is supplied complete with front panel, handle and four rubber feet. Its dimensions are 4in. by 6in. by 4in.

The input resistors in the Ri position are not specified in the Components List, as these depend upon what



The interior of the author's model. As is explained in the text, this differs slightly from the layout given in the constructional details

ranges are desired. It should be remembered that a moving-coil meter reads most accurately on the latter part of the scale, and the values of f.s.d. that give the greatest accuracy are 10 and $\sqrt{10}$, i.e. 3.16. Thus, for general use, the best ranges to choose would be 1, 3 and 10 and multiples of these. However, the individual constructor may prefer to use an interval at 5, rather than 3, depending on his own requirements. The writer's unit employed 3 ranges only, whereupon the resistors were mounted on the same piece of Veroboard as the integrated circuit and associated components. However, it is probable that most constructors will employ more than 3 ranges, in which case it will be necessary to mount the input resistors on a separate board. This method is shown in the layout diagrams which follow, and these differ in this respect from the photograph showing the interior of the author's model. In the prototype the position of VR1 on the rear of the case also differs from that shown in the layout diagrams.

The input resistors may be selected as indicated in the Table, and should ideally be $\frac{1}{2}$watt 1% tolerance types. Unfortunately, many of the values shown may be difficult to obtain as single resistors in 1%, although they could be made up of series or parallel combinations of resistors. With the loss of a little accuracy, 2% resistors can be employed, whereupon it becomes possible to use resistors from the Home Radio Cat. No. R10M $\frac{1}{2}$watt 2% range. Single resistors from this range may be used for the 10kΩ, 30kΩ, 100kΩ, 300kΩ and 1MΩ values. The 50kΩ value can be given by 20kΩ and 30kΩ in series, and the 500kΩ value by 200kΩ and 300kΩ in series. Values above 1MΩ can be provided by 1% $\frac{1}{2}$watt resistors in the Home Radio Cat. No. R12 range, 3MΩ being given by 1.8MΩ and 1.2MΩ in series, 5MΩ by 3.9MΩ and 1.1MΩ in series, and 10MΩ by 3.9MΩ, 5.6MΩ and 500kΩ in series.

Constructors having access to an accurate resistance-measuring bridge may be able to select suitable input resistors from wider tolerance components.

The range switch is a miniature rotary type having the same number of ways as there are ranges. Normal components of this type have several poles, and only one pole need be wired up here. Also, they are not readily available in 5-way with the result that, if 5 ranges are to be used, a 6-way switch with one way blank will be needed.

S3 is specified as a single-pole single-throw slide switch. These switches are normally available as double-pole double-throw, in which case the unwanted contacts are ignored.

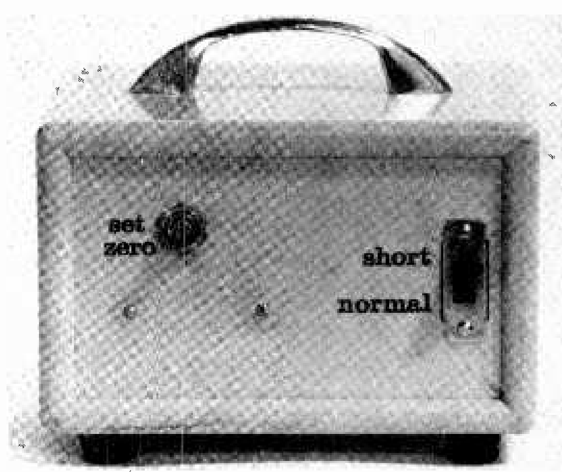
TABLE

Values of input resistance (Ri, and RA to RN in Fig 2) for different voltmeter ranges.

Ranges	Ri
0 – 100mV	10kΩ
0 – 300mV	30kΩ
0 – 500mV	50kΩ
0 – 1V	100kΩ
0 – 3V	300kΩ
0 – 5V	500kΩ
0 – 10V	1MΩ
0 – 30V	3MΩ
0 – 50V	5MΩ
0 – 100V	10MΩ

CONSTRUCTION

Veroboard with a matrix of 0.1in. must be used to accommodate the pins of the integrated circuit, and here a wise word of warning must be added. Soldering on 0.1in. matrix Veroboard is much more difficult than one the commoner 0.15in. matrix board, although if a few simple rules are followed the problems should not be unsurmountable. Use the smallest possible bit on your soldering iron, and don't allow mounds of solder to accumulate on it as these will inevitably fall onto the board sooner or later. If possible, use a fine gauge solder and, after the board is completed, check carefully for blobs of solder short-circuiting adjacent strips.



The rear of the instrument. The slide switch short-circuits the meter movement to damp pointer movement when the instrument is being transported

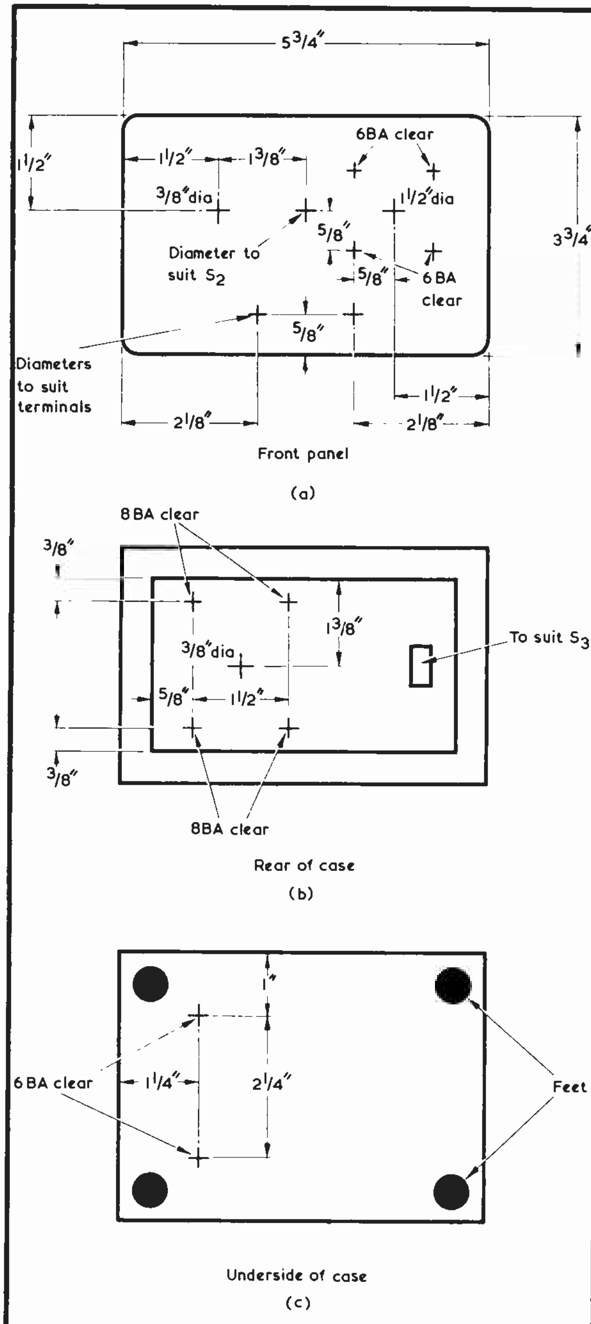


Fig. 3 (a) Drilling centres for the front panel, as viewed from the rear
(b) Hole centres at the back of the case
(c) The holes required in the case underside

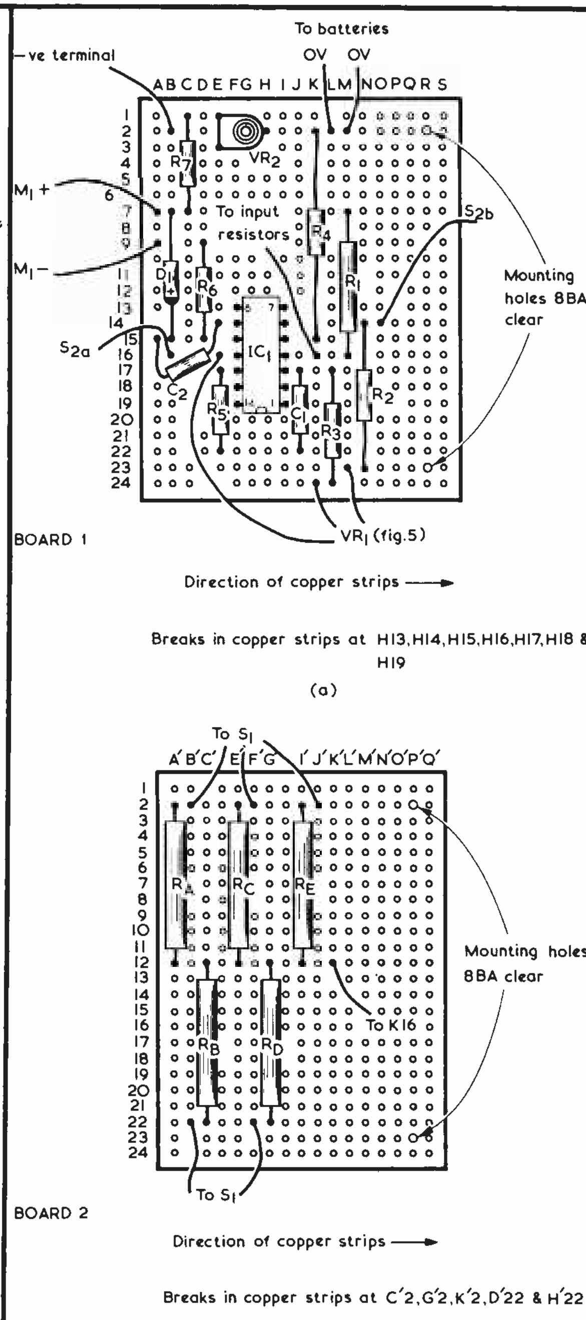


Fig. 4 (a) Board 1, viewed from the component side
(b) The component side of Board 2, with five input resistors fitted. Both boards can be cut from the standard $3\frac{3}{4}$ x $2\frac{1}{2}$in. Veroboard size

Start off by drilling the case and front panel according to Fig. 3. The components should then be soldered onto the Veroboard as shown in Fig. 4, after drilling the mounting holes and making the specified breaks in the copper strips. A $\frac{3}{16}$in. twist drill is ideal for this. The integrated circuit should be the last component to be connected, in order to avoid possible damage by overheating.

VR1 and S3 should be wired up before fixing them to the rear of the case. On the other hand, the meter, the terminals, S1 and S2 should be secured to the front panel before they are wired up. The final wiring is

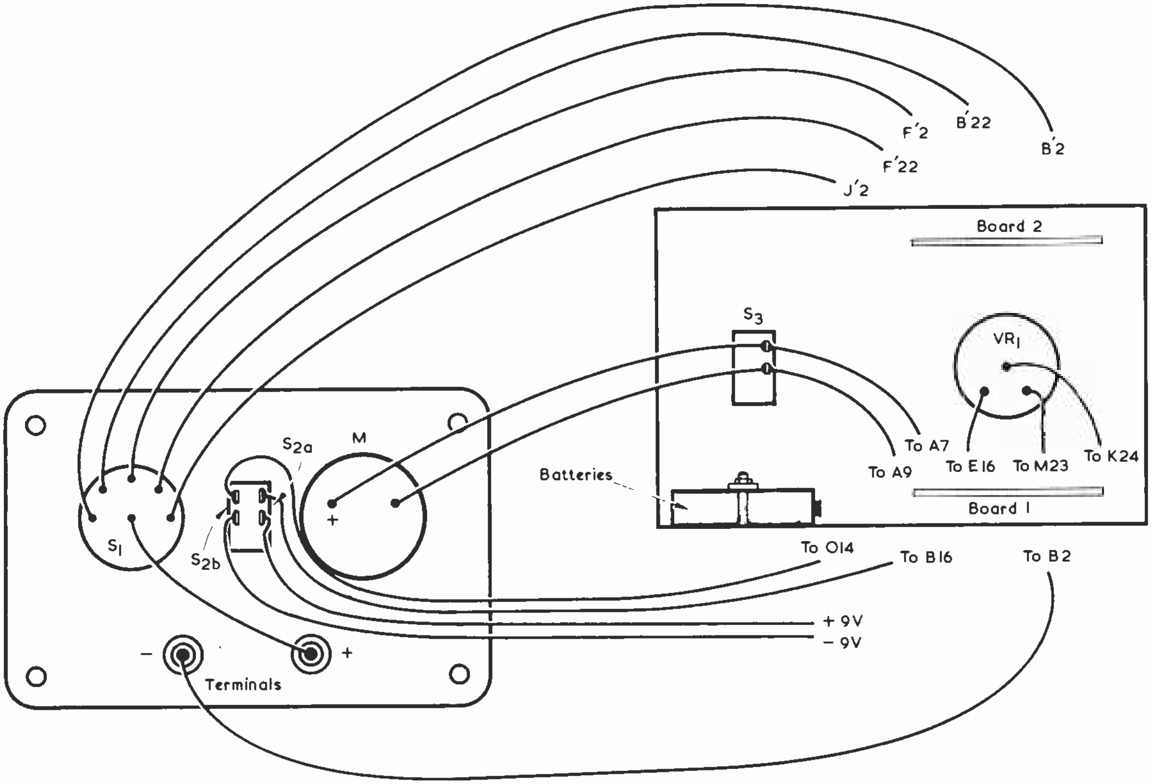


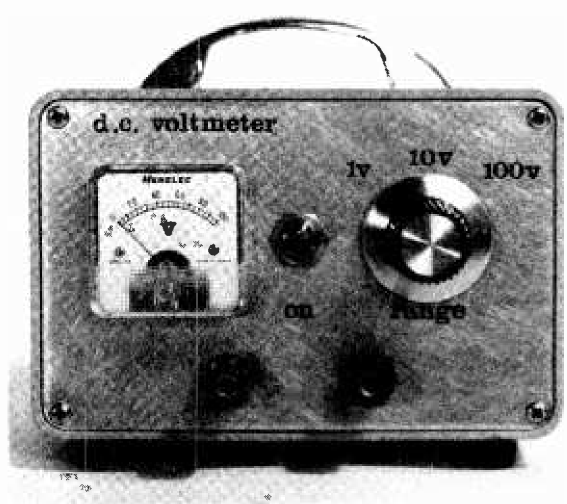
Fig. 5. The final steps in wiring and assembly. Again, five ranges are assumed

carried out as shown in Fig. 5.

Some constructors may prefer to modify the meter so that the letter 'V' covers the 'μA' indication. If this is to be done, gently prise off the clear plastic front and then apply a small white sticky label about ⅜in. square with the letter 'V' printed on it to the meter scale to cover the 'μA' indication. The front can then be replaced and the meter bolted into position. This modification should only be attempted by constructors who are competent to carry it out without damaging the meter movement. Care should be taken to ensure that no dust or dirt enters the meter case when its front is removed.

The diagrams show the wiring up of a unit with 5 ranges. As already mentioned, fewer or more ranges may be provided according to preference.

When the wiring is complete, the two Veroboard panels should be fixed in position using 8BA nuts and bolts. Each board is bolted to a 2½in. length of ½ by ½in.



Another view of the front of the instrument. The prototype had three ranges, but further ranges can readily be added, as desired

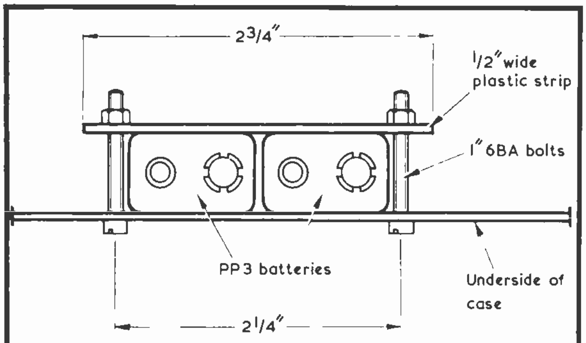


Fig. 6. How the batteries are secured in position

plastic angle, which is then bolted to the back of the case so that the boards project forwards. In the absence of plastic angle a similar form of insulated mounting should be devised. VR1 should be mounted between the two boards, as in Fig. 5.

Details of the battery holder can be seen in Fig. 6. The batteries are clamped in position under a piece of plastic or metal strip about ½in. wide and 2¾in. long, this being bolted to the bottom of the case using 1in. long 6BA bolts and nuts.

CALIBRATION

The only way to calibrate the unit is to measure a known voltage, this being given by either a standard cell or by a low impedance voltage source which can also be read using an accurate multimeter.

First, with the meter short-circuited by S3, adjust the screw on the front of the meter to zero the movement. Now, open S3 so that the unit is set up for normal use and switch on. Short-circuit the input terminals, and set the zero by means of VR1. Then calibrate the meter as described above, turning VR2 until the correct reading is indicated. If this causes the zero setting to be disturbed, reset VR1 and repeat the process until both the zero reading and calibration are correct.

When calibration is complete, the front panel can be screwed on to finish off the unit.

In use, there should only be a very small drift of the zero setting. Excessive zero drift indicates that the batteries need replacing. Both must be replaced together since positive and negative supply voltages should be the same. ■

DEALING WITH HIGH TENSION SHORTS

By
VIVIAN CAPEL

Many TV sets in use these days are of the fully valved or hybrid (valves and transistors) types. Valved radio receivers are also in common use. This article describes how short-circuits between the h.t. positive line and chassis in such receivers may be traced, and also gives some useful tips on the best approach towards general servicing

THE MAJORITY OF TELEVISION SETS and quite a few valve radio receivers are fitted with a fuse of suitable rating in the h.t. line circuit. The first intimation of trouble arises when the user finds that his set is completely dead, and an investigation reveals that the h.t. fuse has blown. Usually he then fits another one, often of a higher rating, and hopes for the best. Sometimes, this gambit has the desired effect and no further trouble is experienced, so the user concludes that the fuse itself was faulty.

FUSE EXAMINATION

This of course is rarely the case, although it sometimes does happen. A dry joint at the fuse cap can cause arcing, and over a period the heat from this arcing burns through the thin fuse wire and causes it to go open-circuit. A careful examination of the fuse will sometimes reveal whether this has happened.

If the fuse wire is still bright over most of its length and has just gone open-circuit where it is soldered into the cap, then this would indicate that the wire had not carried excess current and that possibly the fuse itself was defective. When the wire is broken in one place, usually near the centre where the heat conduction to the end caps is at a minimum, and this is accompanied by slight darkening of the wire, it indicates that a current somewhat in excess of the rating has been passed, causing overheating and fusing of the wire. When the wire has completely disintegrated leaving just a few blobs of metal on the inside of the glass cartridge, then something more than just a slight excess has been passed. There has, instead been a very heavy current many times the fuse rating.

When a receiver is switched on initially, a momentary current surge flows which is greater than the normal running current. Valve heaters are of low resistance when cold and so pass extra current. The use of metal or silicon rectifiers applies the full h.t. voltage to the reservoir and smoothing capacitors immediately, not gradually as is the case with valve rectifiers which take a minute or so to warm up. Thus these high-value capacitors take their maximum charging current at the moment of switching on.

The switching-on surge can well exceed the rating of the main fuse, or of the h.t. fuse in the case of the charging capacitors. This can produce the 'mild' blowing of the fuse just noted, and the remedy is either to fit anti-surge fuses which resist overload for a short duration, or to increase the rating slightly. If this latter course produces a twinge of conscience, comfort may be obtained from the fact that many set-manufacturers have often had to do exactly the same thing, and have increased the specified value of a fuse during the production run of a particular model. Actually, the anti-surge fuses are not as successful in practice as may be hoped, and if the surge should be a little longer than expected they will blow anyway. They are also more expensive than normal fuses.

CHARGING SURGES

Ideally, surges produced by charging capacitors in the h.t. line should be limited by series resistors in the h.t. line from the rectifier, and when modifying a TV receiver from a valve to a silicon rectifier, it is common practice to fit an extra surge limiter. The power rating must be high, at least 10 watts, because the resistor has to carry not only the normal h.t. current but also the ripple current through the reservoir capacitor. There will of course be a drop of h.t. voltage across the resistor.

In the case of television receivers with their large-value capacitors and high h.t. current, a heavy surge can be produced by switching the set off and then on again. This is because the capacitors discharge very quickly through the various h.t. circuits and so will take the full charging current again when switching on. Moreover, the valve heaters will still be warm and the valves will also pass h.t. current immediately on switching on. Thus the initial current will be greater than the normal switching-on surge. The moral here is that if the set is accidentally switched off, let it cool down for a few minutes before switching back on; you may miss part of the programme, but you will miss even more if the fuse blows!

If the fuse blows after the set has warmed up, or if it fails when switching on and is found on examination to have well and truly blown, then normal switching-on surge can be discounted and we must look elsewhere for an actual fault.

Often physical indications pointing to the cause of the trouble can be seen without the need to use any test gear. Burnt or discoloured resistors are the most frequent examples. Usually, the resistor is a decoupling component to the screen-grid or anode of a valve in the receiver section and the associated decoupling capacitor will be found to have gone short-circuit. Other resistors may also be found to have become discoloured. These may be decoupling resistors connected in series along the h.t. positive line, and which were therefore also in the path of the excess current. They will be of lower value than the final one, and hence will not have dissipated so much power or suffered as much damage.

Usually, the discoloration is all that is wrong with such resistors and they can be left in circuit without changing. Measure them first, though, to make sure that they have the correct value. The final anode or screen-grid resistor will have burnt badly, and if not actually burnt-out will have changed value, usually going low, and so will have to be replaced along with the associated decoupling capacitor. The lesson from this is: do not attack the first discoloured resistor and its associated capacitor you may see, the real culprit may be further along the line. The one that is burnt out most is the one to go for.

Sometimes, we find bleeder networks of fairly low value across the h.t. supply. For example the screen-grid or cathode voltage to certain stages may be stabilised by one resistor going to the h.t. positive rail and another to chassis. If either of these decreases in value due to the heat dissipated in it, more current will pass, there will be more heat, and a further drop in value. The companion resistor will be called upon to pass more current, and this too will get hotter and will be equally likely to drop in value, thus passing even more current. Eventually both resistors are badly burnt and form a low resistance path across the h.t. supply. It is therefore always a good plan to look for such networks on the circuit diagram and check them before wasting a lot of time searching elsewhere.

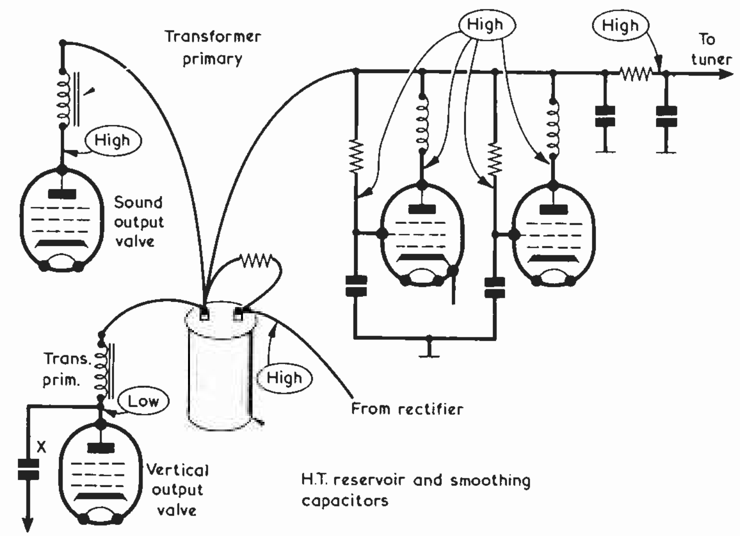


Fig. 1. Locating h.t. short-circuits without unsoldering by comparing resistance readings to chassis at various h.t. points. Higher readings eliminate the circuits being checked, a lower reading identifies the defective one. In this example the capacitor connected to the anode of the vertical output valve is leaky

TESTMETER

The source of an h.t. short-circuit is not always visually obvious, in which case the testmeter must be brought into use. With this switched to an ohms range, a low resistance reading will be obtained between the h.t. positive line and chassis. The next thing is to localise the source of the reading. This can be rather a tedious job; many circuits are taken off the h.t. line and isolating the offending one can mean unsoldering many connections and re-measuring.

The work involved can, however, be minimised by intelligently comparing the resistance readings at various points and tracing through to the lowest. It may happen that a number of wires are found connected to the smoothing capacitor, whose positive tag is often used as an anchoring point for the main h.t. supply leads, as shown in the example given in Fig. 1. One of these leads goes to the smoothing resistor or choke. If we measure at the other side of this resistor and find a higher resistance reading, we know the short-circuit is not there. Another lead passes to the sound output transformer, and if a reading taken on the anode of the sound output valve is also higher, then we must once again look elsewhere. A further lead is taken to the vertical output transformer and, here, a reading on the anode side of the primary winding shows a lower resistance to chassis than is given at the h.t. line. Thus, the fault is localised. The vertical output valve is removed from its holder to ensure that it is not responsible, but the reading persists. A capacitor is noticed going from the anode to the feedback linearity network, and it is found that the resistance to chassis on the other side of this component is the same. Disconnecting the capacitor and measuring across it confirms that it offers a dead short-circuit. After replacing it, it is as well to check for damage that might have been caused by the passage of the excess current, such as a burnt linearity control track.

This example illustrates the general principle that if readings are taken at the other side of resistors or inductors that come directly from the h.t. positive line the appropriate circuit points can either be absolved or condemned without any unsoldering, this being done by simply noting whether the readings are higher or lower than the one obtained from the h.t. line itself.

DIRECT CONNECTIONS

If the tests just outlined are not helpful, attention can be concentrated on those components that are connected directly to the h.t. rail without the intervention of series resistance. It should be remembered, when checking through a transformer primary, that it can develop a leak to the transformer core. If this leak occurs at the h.t. end of the winding, a high resistance reading will be obtained at the anode end and the circuit may be considered to be above blame. If in doubt, rather than disconnect the transformer it is often easier to loosen the fixing screws and move the transformer about. This will cause the resistance reading to fluctuate as contact with the chassis is broken.

When taking the readings, do not waste time measuring at the other side of high value resistors as, even if a dead short-circuit to chassis were present, the current would be insufficient to make any appreciable difference to the total h.t. current and would certainly not be enough to blow a fuse. Carbon resistors will most likely show the overheating signs previously mentioned, so circuits fed by them are not likely to be the faulty ones if the resistor looks fresh and clean. Wirewound resistors sometimes show the effects of overheating but not always since they usually run warm normally, hence circuits associated with them should be checked.

Capacitors will often be found connected to the h.t. line, but not all are decouplers; not all in fact are even returned to a point at or near chassis potential. A resistance reading on the other side will confirm whether or not there is a low resistance path to chassis. It should, of course, be equal to or less than the resistance reading from the h.t. line for the capacitor to be a suspect.

Sometimes, what we can call the 'intervening resistance' between the h.t. line and the suspected circuit is very low, too low to show any difference on whatever ohmmeter the reader may have at his disposal. Such circuits could be in the i.f. amplifier where the i.f. transformer primary (in the case of a television receiver) may only be a few ohms or less. In such a case it is difficult to ascertain which side gives the lower reading. If the short-circuit itself is of low resistance, a better indication may be obtained with a flashlamp bulb and a battery. These should be connected in series with a couple of flying leads and applied across the circuit. The point with lowest resistance to chassis can now be readily determined, as even an ohm in the circuit will cause a noticeable drop in the brilliance of the light.

OTHER CAUSES

Now we come to the case where the h.t. fuse blows and yet the resistance from the h.t. line to chassis seems normal when measured with the set cold. By examining the fuse as previously described we can discover if the short-circuit is 'heavy' or 'mild'. If it is the latter and if the fuse blows rarely only, the trouble is possibly due to the switching-on surge, but if the fuse blows frequently then we must look further for the trouble.

There are many possibilities. Valves sometimes develop interelectrode leaks. These leaks more often than not are only present when the valve is hot and are absent when it is cold. Another cause is in the interstage coupling capacitors. One of these may leak or go short-circuit but, because of its position in the circuit, will not affect the h.t.-to-chassis resistance reading. However, when the set is running the defective component will apply h.t. from the previous anode to the following grid, and this, especially if the next valve is in an output stage, will cause an excessive anode current to pass and blow the h.t. fuse.

A similar effect can be caused if the cathode bypass capacitor in one of the output stages goes short-circuit, or the cathode resistor drastically drops in value. Bias will be removed from the output stage grid and the anode current will increase.

Yet a further cause in television receivers is failure of the line oscillator. The line output stage usually has little if any standing cathode bias, the necessary bias resulting from the drive to its grid from the oscillator. It follows, then, that a cessation of oscillation and grid drive will cause a high increase in anode current, sufficient in most cases to cause the anode to glow red.

Fortunately, all these fault conditions, which are illustrated in Fig. 2, will have an observable effect on the performance of the circuit concerned in addition to drawing excess current from the power supply and blowing the fuse. Since the current will be limited by the saturation current of the valve concerned, little damage can be caused if the receiver is run for a few minutes in this condition. Thus, a clue can be obtained about the cause of the trouble by observing other symptoms.

As constant replacement of fuses can be expensive, the fuseholder contacts can be bridged by an ammeter switched to one of the higher ranges. This will afford further clues by indicating *when* the excess current flows and its magnitude. If the excess current flows immediately on switching on, the faults just described could not be responsible as they all depend on valve conduction which obviously requires that the valves are warmed up. Obviously, the meter must be on a sufficiently high current range to ensure that it will not be damaged by the current.

When the meter indicates that the fault is present a quick visual and aural check can be made of the various parts of the television receiver. Is the raster still present, and of normal width? Is the line and frame scan free from fold-over and reasonably linear? Is the sound of sufficient volume and without distortion? A negative answer to any of these questions will indicate the stage in which the fault is present. Voltage measurements. valve substitutions and other normal fault-finding techniques should then reveal the precise cause.

If there is no low resistance reading to chassis from the h.t. positive line when the set is cold, and if the fault is not due to excessive valve current, the trouble can be caused by components which break down only in the presence of high voltage. The ohmmeter battery voltage will be insufficient to cause the breakdown, and it hence gives no indication.

This high voltage breakdown can range from a dead short-circuit to a high resistance leak, and as a result the effects on the fuse will vary. Capacitors are the most likely offenders, but there are others. Tracking across the insulation from the carbon elements of controls that carry h.t. such as the brilliance control, to the earthed metal case is not uncommon. Tracking can also take place over the Paxolin terminal boards of transformers, and across interconnecting plugs and sockets.

About the only way to tackle this when there is no visual indication or effect on receiver performance is to isolate, so far as the receiver design allows, the individual h.t. circuits. There are two methods of doing this.

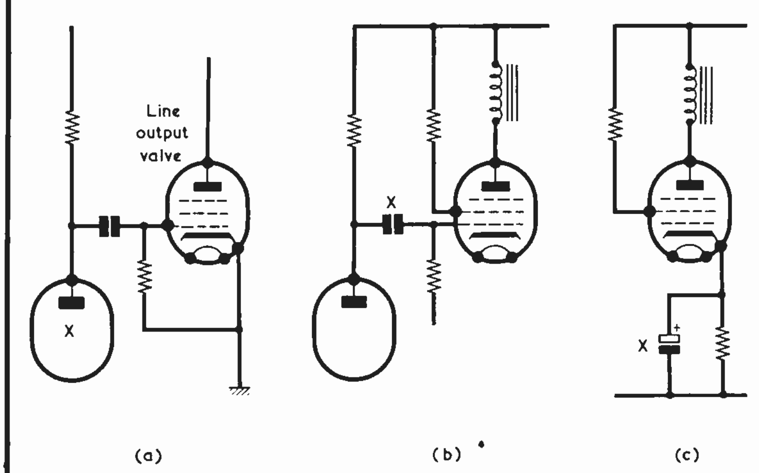


Fig. 2. Some causes of excessive h.t. current which do not affect resistance readings from h.t. positive to chassis. Failure of the line oscillator is indicated in (a), a leaky coupling capacitor in (b), and a short-circuit cathode bypass capacitor in (c)

First of all, each h.t. feed can be disconnected in turn and the receiver then switched on. This is repeated until the stage is reached where the fuse does not blow. The last circuit disconnected is then indicated as the culprit. The alternative method is to disconnect as many h.t. circuits as practicable at the start, and then re-connect them one at a time until the fuse blows. The advantage of the first method is that unsoldering is reduced to a minimum since it is possible that the defective circuit may be among the first few tried. On the other hand, however, we must blow a fuse at each try unless an ammeter is used. The second method is more economical as only one fuse will be blown, but of course more unsoldering will be necessary.

If the short-circuit is a bad one, as revealed by inspection of the fuse, and an ammeter is used to indicate when the current rises, it would be prudent to include a series limiting resistor in the meter circuit while tests are being made. This will not only protect the meter but also the rectifier, which may not take kindly to repeated heavy overloads.

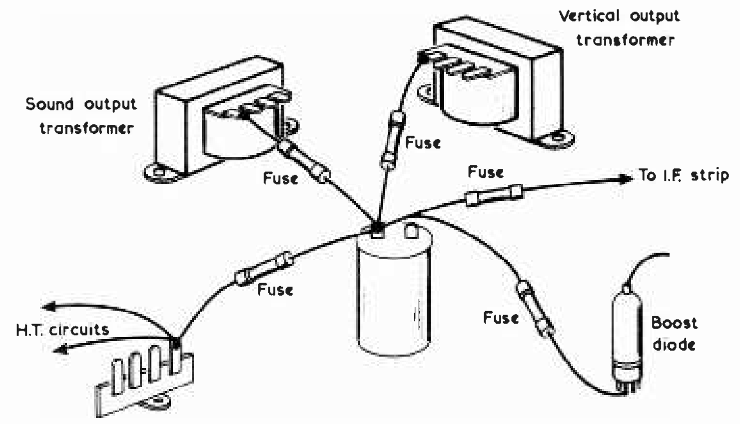


Fig. 3. An intermittent fault can be traced by wiring fuses in individual h.t. circuits

INTERMITTENT FAULTS

Finally, we come to the most difficult and irritating type of short-circuit – the intermittent. The set may work well for hours, days or even weeks, and then the fuse will blow. Immediate examination and testing will reveal no fault and, after replacing the fuse, the set will probably carry on for another extended period.

When the fault does occur and the fuse blows, it may be immediately on switching on, or after the set has been on for some while. If the latter is the case some symptom may occur which could give a clue as to its origin. If it occurs on switching on and the fuse is not badly blown, the switching on surge may be responsible, as previously discussed.

There remain the obstinate cases where no symptoms or other clues at all are to be found. The indiscriminate replacement of possible components can be frustrating and expensive unless one is fortunate enough to hit on the right one at the first attempt.

The final location of faults of this nature calls for some improvisation and patience, but if tackled systematically they can nevertheless be found and cured. One way of dealing with the problem is to split up as many of the h.t. supply leads as possible. Then, in series with each one, solder a fuse of say 100mA. The fuses can be prepared in advance by soldering an inch or two of insulated lead on one end. This lead can be connected to the point from which the original h.t. lead was removed, and then that lead can be soldered to the other end of the fuse. Do not apply the iron to the fuse caps for too long or the fuse wire may become unsoldered inside. Make sure that the fuse caps are free from surrounding components and metalwork, so that there is no possibility of a short-circuit. If things are a bit close, apply some tape around the fuse caps. The general approach is shown in Fig. 3.

Having thus been doctored, the set is re-assembled and used in the ordinary way. The next time the fault occurs it should only be necessary to examine the added fuses to see which one has blown in order to identify the offending circuit. It is important that these added fuses should be rated much lower than the normal h.t. fuse as otherwise this may still blow, leaving the added ones intact so that they do not indicate where the fault lies.

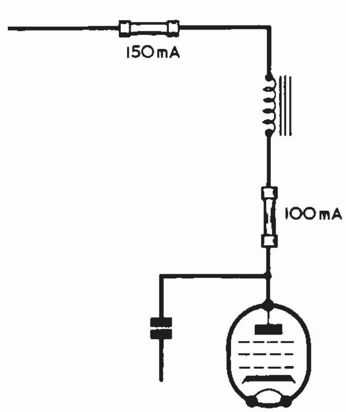


Fig. 4. When an internal transformer leak is suspected, a fuse is fitted on both the h.t. and anode sides of its primary, the anode fuse having the lower rating. If only the fuse on the h.t. side blows, the transformer is faulty

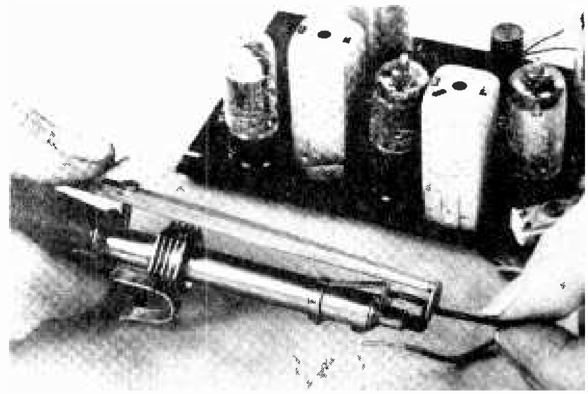
If the defective circuit is itself feeding several sub-circuits it may be necessary to repeat the process with each of these in order to narrow the field down still further. Fuses in the other circuits can be removed and the original connections restored once they have been eliminated. In this manner, it will eventually be possible to pin-point the defective component and replace it.

One baffling source of intermittent h.t. short-circuits is a leakage between the primary and secondary, or core, of a transformer. If the lead to this component is fitted with a temporary fuse in the manner described and if it is found later that it has blown, it could be mistakenly assumed that the trouble lay in the associated valve or any capacitor connected to the valve anode. If a fault in the transformer itself seems a possibility, fuses should be inserted on both the h.t. and anode sides of the primary winding, as in Fig. 4. The fuse on the anode side should be of a lower rating than that on the h.t. side; 100mA and 150mA respectively would be suitable values. If either the anode fuse or both blew, the fault would be in the anode circuit and the transformer could be absolved from blame, but if only the fuse on the h.t. side blew, then indeed the transformer would be indicated as responsible.

So it is with all servicing; by intelligent observation of all the symptoms and a systematic approach even the most obscure fault in the h.t. line can be located and rectified. ■

Trade News . . .

IMPROVED THERMAL CABLE STRIPPER



Adcola Products has incorporated a length stop device on the R400 thermal cable stripper to allow for accurate linear stripping of pvc and polythene cables.

The latest hand model also features an improved screw and locknut adjustment for cable or wire width.

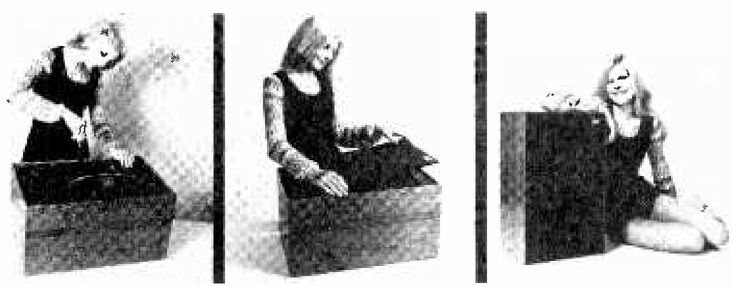
Thermal cable stripping is claimed to be the safest method of stripping the insulation from cable to leave the wire exposed. A low heat on the fixed 'cutting' blade is used in place of a sharp cutting edge for cable stripping.

The R400 has a thermally controlled blade temperature specifically designed for stripping pvc and polythene and it will handle cables up to $\frac{1}{8}$in (3.2mm) thick.

The R400 is priced at £3.23 and the R310 at £2.90.

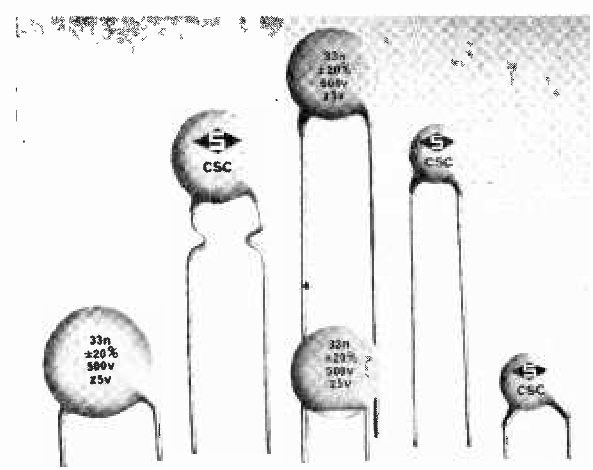
Further details of these thermal cable strippers are available free on request from Adcola Products Ltd., Adcola House, Gauden Road, London S.W.4.

LOUDSPEAKER ENCLOSURES IN KIT FORM FROM EMI



Assembling one of EMI's new loudspeaker enclosures which are available in a variety of finished wood veneers. Prices range from £5.80 for a small bookshelf model to £29.50 for a floor standing enclosure

NEW CERAMIC DISC CAPACITORS

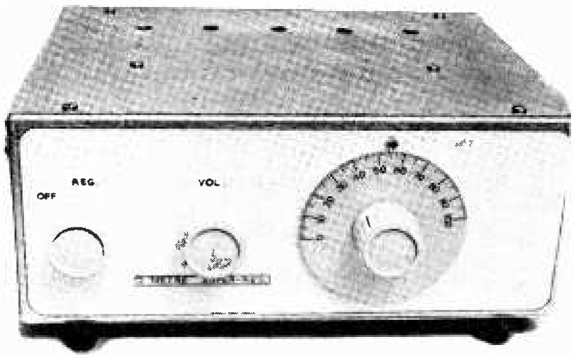


A new range of ceramic disc capacitors (Type CSC) has been introduced by Seatronics (UK) Ltd. These general purpose disc capacitors are manufactured from high dielectric constant ceramics and are designed to provide high capacitance in a more compact size than is usual for capacitors in the voltage range of 50V to 500V.

The capacitance range is 1,000pF to 50,000pF (E6 series) and ± 20 per cent tolerance. The dielectric strength is 250 per cent of the rated working voltage and Type CSC may be used in ambient temperatures from -55°C to +85°C; tan delta is 0.02 maximum.

For further information contact Seatronics (UK) Ltd., 22-25 Finsbury Square, London, EC2A 1DT.

EASY 2
RECE



The completed receiver. Despite the fact that the case is made up of standard chassis sections, the final appearance is neat and professional

B
F. G. Rayer, Asso

**Employing a super-regenerative
alignment problems and employ
excellent project for the new**

Cover Feature

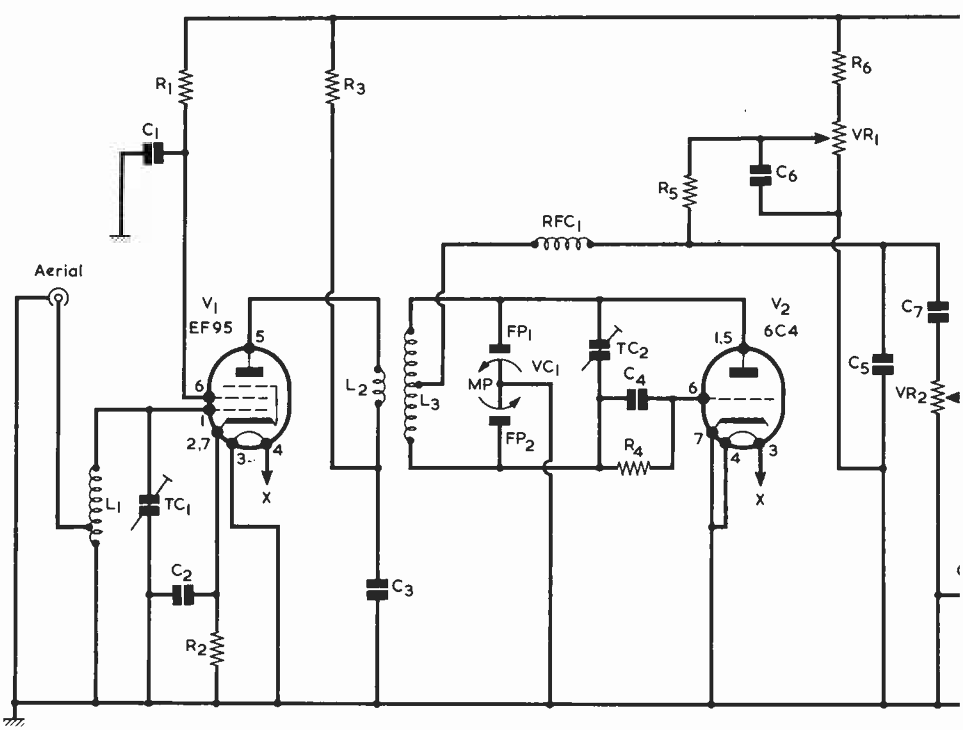


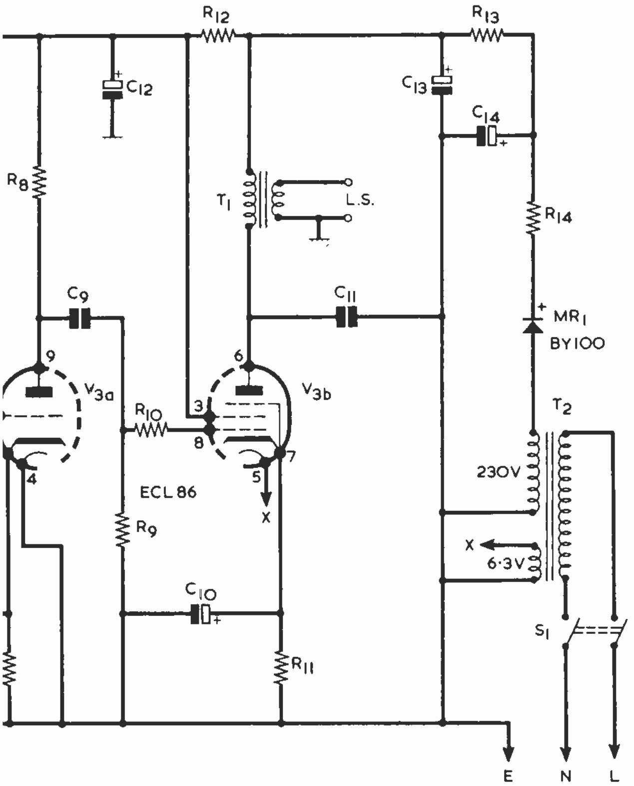
Fig. 1. The circuit of the 'Easy' 2

METRE

IVER

.E.R.E., G3OGR.

tector, this receiver offers no ! valves only. It represents an ımer to 2 metre reception.



re Receiver

This receiver is operated from 240 volt a.c. mains, and can be adjusted for reception over the range 120 to 150MHz, the actual tuning range for the 2 metre band being about 143.6 to 148MHz.

It is worth noting the three different methods commonly employed for obtaining 2 metre reception. First, a v.h.f. superhet designed for the purpose may be used, but building this is a lengthy and expensive procedure. Second, a converter, using a standard communications or equivalent receiver as a tunable i.f. amplifier and detector, represents a popular and good system; but it is necessary to have available the communications receiver. Third, a super-regenerative receiver can be employed, and this allows the home-constructor to receive 2 metre signals with the aid of a circuit design which is quite straightforward and which can be quite easily built.

ADVANTAGES

The receiver described here comes into the third category, and it is interesting to compare its advantages and limitations with those of the first and second categories.

The great advantage of the super-regenerative receiver is its simplicity, and it is by no means a complex and difficult project to build. There are no alignment problems and it is easy to adjust frequency coverage. Also, the receiver can be made up as a complete unit, needing only connection to an aerial, mains supply and speaker.

One of the limitations of the super-regenerative receiver is its lack of selectivity. Where two or more transmissions are close in frequency and could be easily separated by a v.h.f. superhet or 2 metre converter and communications receiver, the super-regenerative receiver may be quite unable to separate them. It is also less sensitive than the superhet or the converter and receiver. Further, the super-regenerative receiver has a loud background hiss when tuning, but this completely disappears when a carrier of sufficient strength is received. The receiver is suitable for the reception of a.m. only, not c.w., s.s.b., or f.m.

In practice, a receiver like that described here represents a straightforward means of obtaining reception on v.h.f. frequencies, provided its limitations are understood. It is not suitable for 2-metre Dx, nor for sorting out as many transmissions as possible during a 2-metre contest. But it is capable of bringing in all sorts of interesting transmissions as well as the local 2 metre amateurs.

CIRCUIT DETAILS

Fig. 1 gives the circuit. V1 is a v.h.f. pentode, providing useful gain and helping to isolate the aerial from the detector stage. L1 is tapped to match a dipole or similar aerial, and inductive coupling is provided to the next stage by L2. Grounded-grid and other circuits have various advantages in more complex equipment, but were not felt justified here for the V1 stage.

COMPONENTS

Resistors
(All fixed values ½ watt 10% unless otherwise stated)
R1 47kΩ
R2 180Ω
R3 2.2kΩ
R4 8.2MΩ
R5 39kΩ
R6 20kΩ
R7 4.7kΩ
R8 220kΩ
R9 470kΩ
R10 47kΩ
R11 220Ω
R12 5.6kΩ 1 watt
R13 1kΩ 2 watt
R14 270Ω 1 watt
VR1 50kΩ potentiometer, linear, with switch S1
VR2 1MΩ potentiometer, log

Capacitors
C1 2,000pF disc ceramic, 350V wkg.
C2 2,000pF disc ceramic, 250V wkg.
C3 2,000pF disc ceramic, 350V wkg.
C4 47pF silvered mica, 250V wkg.
C5 1,000pF tubular ceramic, 250V wkg.
C6 0.25μF paper or plastic foil, 250V wkg.
C7 0.01μF paper or plastic foil, 250V wkg.
C8 4μF electrolytic, 6V wkg.
C9 0.01μF paper or plastic foil, 350V wkg.
C10 25μF electrolytic, 12V wkg.
C11 0.01μF paper or plastic foil, 400V wkg.
C12 32μF electrolytic, 350V wkg.
C13 32μF electrolytic, 350V wkg.
C14 16μF electrolytic, 350V wkg.
VC1 Split-stator, approx. 5 + 5pF (see text)
TC1 30pF trimmer, Mullard concentric
TC2 30pF trimmer, Mullard concentric

Transformers
T1 Speaker transformer, Cat. No. TO46 (Home Radio)
T2 Mains transformer, primary 240V, secondaries 230V at 45mA and 6.3V at 1.5A, Cat. No. TM26A (Home Radio)

Coils
L1, L2, L3, RFC1, See text

Valves
V1 EF95
V2 6C4
V3 ECL86

Rectifier
MR1 BY100

Switch
S1 d.p.s.t., part of VR1

Speaker
3Ω moving-coil speaker

Sockets
1 coaxial aerial socket
1 2-way speaker socket strip
1 B9A valveholder
2 B7G valveholders with skirts and screening cans (for V1 and V2)

Metal-Work
3 flanged members, 10 × 4 in., Cat. No. CU58A (Home Radio)
2 flat plates, 7 × 4 in., Cat. No. CU158 (Home Radio)
2 flat plates, 10 × 7 in., Cat. No. CU188 (Home Radio)

Drives, Knobs
1 Ball drive, Jackson type 4511/F, Cat. No. DL50A (Home Radio)
1 3 in. aluminium scale, Cat. No. DL72 (Home Radio)
1 ¼ in. spindle coupler, Cat. No. DL52 (Home Radio)
3 knobs, Cat. No. KN84F (Home Radio)

Miscellaneous
1 2-way tagstrip (see Fig. 2)
1 10-way tagstrip (see Fig. 3 and text)
4 plastic feet, Cat. No. Z146 (Home Radio)
3-way mains cord
Grommets, solder tags, etc.

V2 is the super-regenerative detector, regeneration being controlled by VR1. The grid resistor and capacitor values allow the stage to go in and out of oscillation at a supersonic frequency, and regeneration is advanced far beyond the point used with an ordinary regenerative detector. VC1 is the tuning capacitor, operated by a ball-drive reduction gear, and trimmer TC2 allows the band covered by VC1 to be accurately set.

V3 is a 2-stage audio amplifier, with VR2 providing gain or volume control. The triode section of V3 is the first a.f. stage, and the pentode section operates the loudspeaker through the output transformer T1.

The internal power supply provides h.t. from the secondary of the mains transformer T2. H.T. to earlier stages is progressively smoothed by the resistors R13 and R12 in the high tension positive line and by the electrolytic capacitors C12 and C13, and the receiver is completely free from hum. The 6.3 volt winding on T2 supplies the heaters.

Except for the effects of stray capacitance and wiring, the frequency is determined by L3, TC2 and VC1, so it is relatively easy to adjust band coverage. The details to be given are for the frequencies mentioned. TC1 is merely peaked for best reception.

METALWORK

The form of assembly employed is easily achieved by using ready-made 'Universal Chassis' flanged members and flat plates, these being available from Home Radio. One 10 by 4in. flanged member provides the 'chassis' and most of the components are mounted

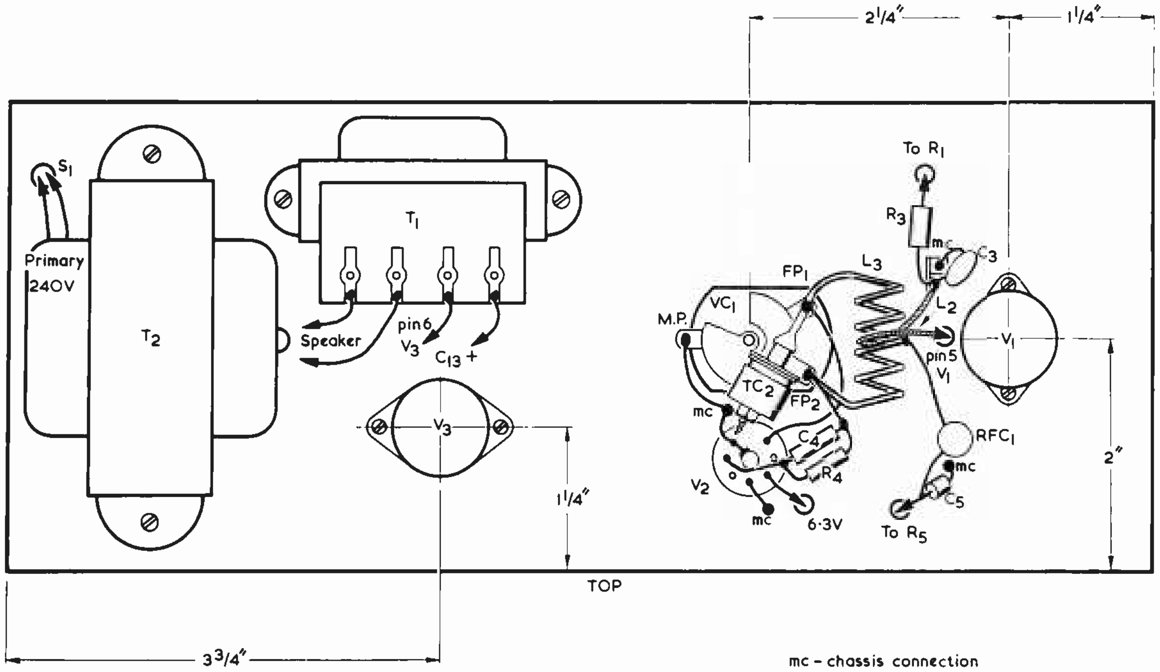


Fig. 2. Wiring and components on the rear of the flanged chassis member

on this. This 'chassis' is completely wired before fitting the other metal parts.

A second 10 by 4in. flanged part is used for the front panel, and is mounted by bolting on a 4 by 7in. flat plate on each side. The flanges of the 'chassis' and panel members face each other, and the edges of the flanges are separated by 2in. The panel surface is thus approximately $2\frac{3}{8}$in. from the 'chassis' surface. When later, at the completion of wiring, the panel is fitted, the few interconnecting leads from the panel components to the chassis can be soldered on, whereupon the receiver is ready for testing.

The case back is another 10 by 4in. flanged plate. A flat top plate is attached with self-tapping screws passing through the flanges of the front panel, central 'chassis' and back member. The bottom plate, which has four plastic feet fitted to it, is secured in the same way. Both the top and bottom plates are 10 by 7in. The bottom plate has half-a-dozen ventilation holes, made with the $\frac{5}{8}$in. B7G chassis cutter used for the valveholder holes for V1 and V2. A row of $\frac{1}{4}$in. or $\frac{3}{8}$in. holes is made near the back of the top plate. These holes are, of course, cut before the plates are fitted.

The accompanying photographs give a good illustration of the method of assembly. In that showing the interior, the 10 by 4in. 'chassis' member is clearly seen between the front panel and the rear plate. The valves project on either side of this 'chassis'. V2 projects towards the front panel whilst V1 and V3 project away from the front panel. Both V1 and V2 have screening cans. The mains transformer and speaker transformer are on the same side of the 'chassis' as are V1 and V3. VR1 and VR2 are mounted directly on the front panel. VC1 is mounted on the 'chassis', being coupled to the ball-drive at the front panel by way of an extension spindle.

Three of the ventilation holes in the bottom plate can be seen in the photograph. The remaining three holes are also to the rear of the 'chassis', allowing adequate access of air to V3 and the mains transformer.

INDUCTORS

Coil L1 is air-cored and self-supporting, and is wound with 16 s.w.g. or a similar stout tinned copper wire. Its outside diameter is $\frac{1}{2}$in. It has 5 turns, spaced to occupy about $\frac{3}{4}$in. length. The aerial tapping is soldered on at 1 turn from the earthy end of L1.

L3 is also air-cored and self-supporting, and it is wound with 16 s.w.g. or similar tinned copper wire. Its outside diameter is $\frac{7}{16}$in. It has 5 turns, spaced to occupy about $\frac{3}{4}$in. length. Its straight ends are $\frac{5}{16}$in. long and are soldered directly to VC1. One lead of the r.f. choke is soldered to the centre of L3.

Coupling coil L2 is a single turn of insulated wire, or of 20 s.w.g. bare tinned copper wire covered with 1mm. sleeving. It has the same diameter as L3, and its ends are shaped to reach tag 5 of V1, (via a hole in the 'chassis') and C3. It is placed centrally in the spaced turns of L3. See the wiring diagram of Fig. 2.

The r.f. choke is wound upon a piece of insulated tube or rod $1\frac{1}{2}$in long and $\frac{5}{16}$in. in diameter, using 34 s.w.g. enamelled wire. Pass the wire through a small hole, or cement it, about $\frac{1}{16}$in. from one end of the tube or rod. This is now the top end of the choke, and is that which connects to the tap in L3. Wind 70 turns side by side and fix the other end of the wire. Do not varnish, paint or apply cement to the whole of the winding. The insulated rod can be mounted vertically on the 'chassis' by a small self-tapping screw driven into a hole drilled up into the centre of the rod. If a tube is used, screw or bolt a small piece of cork, wood or other material in place, so that the tube is a push fit on it.

TUNING CAPACITOR

Tuning Capacitor VC1 has two separate fixed plates, indicated in the diagrams as 'FP1' and 'FP2', and is approximately 5pF each section. It was made by stripping plates from a 100pF Jackson type C804 capacitor, so as to leave plates as shown in the 'Detail of VC1' inset in Fig. 3. All the fixed plates were pulled off with flat-nosed pliers. Moving plates were pulled off to leave two with double spacing at the back, and two with double spacing at the front. Two of the removed fixed plates are then taken, and one soldering lug is cut from each. One fixed plate is then soldered on the left-hand stud, and one on the right-hand stud, as in Fig. 3. Obviously, this is an operation which has to be carried out with care. In the diagrams 'MP' refers to the moving plates.

If available, a butterfly capacitor could alternatively be used, though this would reduce the tuning rotation to 90 degrees. A small split-stator capacitor represents another alternative.

CHASSIS WIRING

Mount the components shown in Figs. 2 and 3, following these diagrams for correct orientation of the valveholders and of VC1. Two solder tags are fitted at each valveholder for chassis connections. Also, a solder tag is fitted under the upper securing nut for T1, the tag being on the opposite side of the 'chassis' to the transformer. Drill the holes in the 'chassis' that are required for the passage of wires. All these holes should be fitted with grommets. Two holes are required near T2, one of these being for the connections to its primary. A second, larger, hole takes its secondary connections, together with connections to T1. The speaker transformer supplied may have tags positioned differently to those shown in Fig. 2, and this point should be checked before

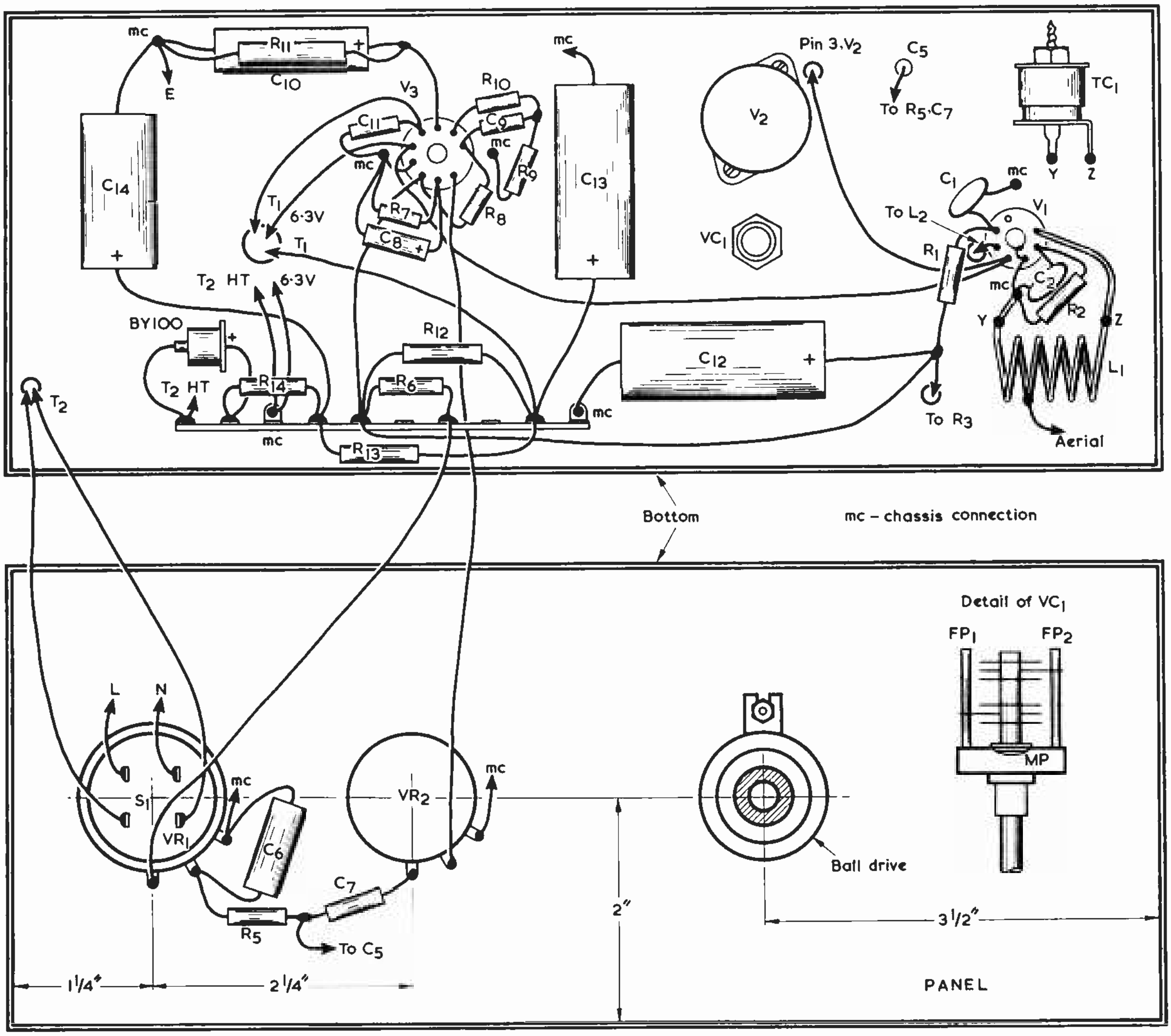


Fig. 3. The front of the chassis member and the back of the front panel. Also shown is a detail of VC1, illustrating the manner in which this component is made up

making connections to this component.

Carry out the wiring around V2 shown in Fig. 2. TC2 is soldered directly to VC1, between FP1 and FP2. Use 20 s.w.g. or stouter wire in the V2 stage, with all leads, except heater wiring but including those of C4 and R4, as short as possible. Shape the ends of L2 so that one end reaches the insulated tag supporting C3 and R3. The other end passes through a hole immediately adjacent to tag 5 of V1 valveholder.

The front, or flanged side, of the 'chassis' is then wired up as in Fig. 3. Solder L1 to tag 1 of V1 and to one of the chassis tags mounted at V1 valveholder. TC1 is soldered across the coil at points Y and Z. Bypass capacitors C1 and C2 should be connected with the minimum length of lead. The lead from R1 to tag 6 of V1 valveholder should also be short.

As illustrated in Fig. 3, a 10-way tagstrip supports the rectifier and other components shown. The tagstrip employed in the prototype is not a standard type as sold by the larger component retailers, and constructors may have to employ a strip in which different tags to those shown connect to chassis. A suitable strip would be the 12-way type, 3in. long, available from Henry's Radio. A slight rearrangement of the connections, to suit the different positions of the earthed tags, would then be required.

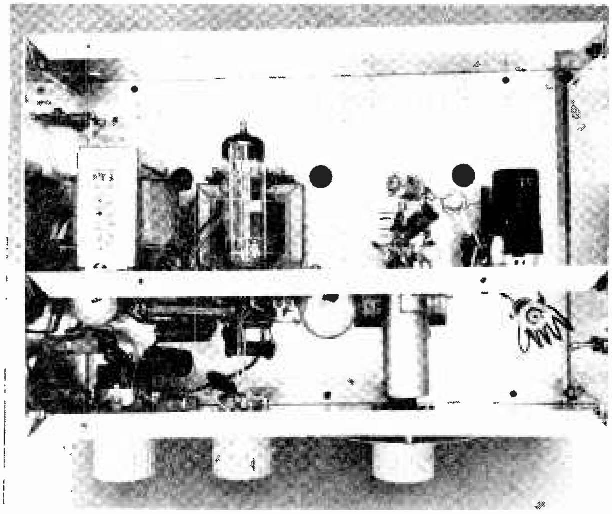
The 6.3 volt secondary leads from T2 pass through the hole in the 'chassis', as shown, and connect to tag 5 of V3 valveholder and to a chassis tag of the tagstrip. The h.t. secondary leads connect to the same chassis tag and to the negative side of the rectifier. The primary leads of T1 pass through the same hole and connect to tag 6 of V3 and, at the tagstrip, to the positive lead-out of C13. The secondary of T2 connects to a speaker socket strip which is mounted on the adjacent 7 by 4in. side plate. This connection will be made later, when the side plate is secured in position. Note that one side of T1 secondary (it does not matter which) connects to chassis. This connection is made, at the speaker socket strip, to a solder tag under one of the strip securing nuts, and is not shown in Figs. 2 and 3.

When the chassis wiring in Fig. 3 is completed it is as well to insert V2 and put on its screening can, as this is tricky (though not impossible) later.

The ball drive specified has a flange, tapped for two short 8BA screws. It is necessary to drill matching holes in the DL72 tuning scale. Place the scale on the drive and mark through the flange holes, so that the appropriate holes may be drilled in the scale. The fixing screws must be very short, or they will impede the rotation of the drive.

VR1 and VR2 are next fitted to the front panel and the components R5, C6 and C7 are wired up. The live and neutral wires of the 3-way mains cord may also be connected to the switch tags. The mains cord passes through an adjacent hole in the flat side plate and it is advisable to pass it through the hole at this stage even though the side plate is not yet mounted. The particular component employed for VR1/S1 may not have the same switch tag positioning as that shown in Fig. 3, and the switch tags should be identified with the aid of a continuity tester before any connections are made to them. The two tags to which the primary of T2 will later connect should be the upper ones, to provide ease of soldering.

The front panel is now mounted in place by fitting the two flat side plates. The speaker socket strip may then be wired up, as already described. A coaxial aerial socket is mounted on the side plate at the V1 end of the



Looking down into the receiver, this photograph clearly illustrates the method of assembling the metalwork and the positions of the main components

'chassis', this being positioned so that its centre connector lug is close to the aerial tapping point in L1. A short length of stout wire connects this lug to the tap in the coil. The earth connection for the coaxial socket is made via the receiver metalwork.

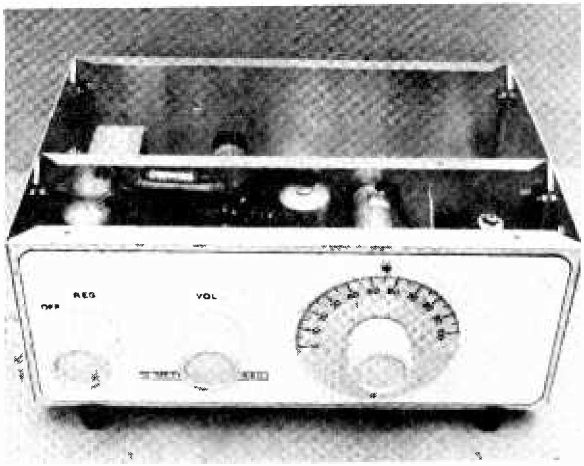
Cut a length of ¼in. rod to couple the spindle of VC1 to the ball-drive. Put a shaft coupler on the rod, fit the rod in the drive bush, and line up the spindle with VC1. The coupler may then be slid along and fixed. The ball-drive is fitted and its lug is locked to the panel with a nut and bolt. The DL72 scale may next be fitted. A suitable panel marker for the scale can be provided by fitting a screw to the panel with its slot vertical, and filling this with paint. In the prototype, the front panel was covered with thin card and marked as shown, but it could be left bright or painted.

A few leads have to be added to complete wiring, and these run across from the 'chassis' to the panel as in Fig. 3. Take the wire from C5 across to the panel, then along against the panel to the junction of R5 and C7. A short wire from tag 1 of V3 runs across to the centre tag of VR2. The panel and chassis are only 4in. wide and there is no difficulty in reaching these wiring points. Also connected are the primary leads of T2 at S1, and the earth lead of the mains cord. The latter connects to the chassis tag under T2 securing nut, as shown. This tag may also take the two 'MC' connections from the front panel.

The mains lead should be a flexible cord preferably running to a 13 amp plug fitted with a 3 amp fuse. The colour coding is brown for Live, blue for Neutral and green-yellow for Earth.

The flanged back plate may finally be fitted. The top and bottom plates can be added after the receiver has been tested and set up.

The speaker is external to the receiver and should be a 3Ω type fitted in a cabinet or on a baffle board. It is important to note that the set should not be operated without a speaker connected. If T1 secondary is not loaded by a speaker there is a risk that high a.f. voltages may appear in the primary circuit and these could damage the transformer or the associated components.



A view from the front with the top cover removed

AERIAL

Various signals were received with a short vertical wire extending upwards from the aerial input socket, but results were very much improved with a dipole. The dipole feeder can be 75Ω coaxial cable, and may be of any convenient length. The inner conductor runs to the centre pin of the coaxial plug, and the outer conductor to the outside of the plug.

A suitable dipole for 2 metres is $38\frac{1}{2}$in. in overall length, and can be made from two pieces of alloy tubing, each 19in. long, and fixed to a block of insulating material with their inner ends about $\frac{1}{2}$in. apart. Take the inner conductor of the coaxial cable to one element, and the outer conductor to the other element. The dipole can be raised on a pole, and can be set vertically or horizontally to suit the polarisation required. If it is placed horizontally, there is only a small directional effect, reception being slightly better broadside to the aerial.

Various multi-element aerials are often used for 2 metre reception. These are directive, and require to be faced towards the point from which signals originate. So some means of rotating these aerials will generally be required.

SETTING UP

For the 2 metre band, both TC1 and TC2 are almost fully unscrewed. The exact length of the winding of L3 has considerable influence on frequency coverage, and the coil may be slightly compressed or stretched, if necessary. The same applies to L1.

Place VR2 about a quarter to one-third from the minimum volume position. Rotate VR1 until a *loud* hissing is heard in the speaker, showing that super-regeneration has started. Tune with VC1, at the same time adjusting VR1 to maintain this condition as needed.

When a reasonably strong transmission is tuned in, the hiss should cease. TC1 can then be peaked for best signal strength, but this capacitor tunes flatly and need only be re-adjusted if TC2 is altered. Use an insulated tool, as TC2 is connected to the h.t. positive circuit.

With weak signals, reception improves if VR1 is backed off a little. The way in which this control operates will soon become clear. VR2 adjusts the volume in the usual way.

In certain areas, and at some particular times, there is a lot of 2 metre Amateur activity. This is most likely during week-ends. In these circumstances, the 2 metre band will soon be found.

In other districts, and during the week, there may be very little 2 metre Amateur activity, shown by an absence of Amateur signals. The extent to which the transmissions of other services in the frequency coverage of the receiver are heard depends on local conditions and usage.

If difficulty is experienced in identifying received stations, it is of assistance to employ a wavemeter to indicate the frequency of reception. A very simple v.h.f. wavemeter, suitable for this function, will be described in next month's issue. ■

GRUNDIG SPONSOR AMATEUR TAPE RECORDING CONTEST ON LOCAL RADIO

Grundig (Great Britain) Limited has organised an Amateur Tape Recording Contest running on eight BBC Local Radio stations. They include Birmingham, Derby, Leeds, Leicester, Manchester, Medway, Oxford and Stoke-on-Trent.

The contest is being run in co-operation with the organisers of the British Amateur Tape Recording Contest. The entry forms, which are available from local Radio stations, are identical to those of the National Contest so that all tapes can go forward for a national prize.

Grundig will award in each area a first prize of a £50 voucher towards any Grundig product and also tapes for the runners-up.

The contest which started on the 1st February will run till the 31st March 1972. This will allow time for the tapes to go forward to the National Contest before their closing date on the 30th June 1972.

SILICON TRANSISTOR SIREN

By

J. Johnstone

This complementary pair multivibrator functions as a tone generator for a number of applications including that described here.

IN MANY CARS, THE OIL WARNING LIGHT IS NOT CLEARLY visible in daytime. If the oil pressure falls during a fast run, the driver may not notice until serious damage has been done to the engine. This simple siren will draw attention as soon as the pressure falls to a dangerous level. No doubt many other applications will come to mind.

COMPLEMENTARY PAIR MULTIVIBRATOR

The circuit (Fig. 1) may seem an unusual arrangement and is in fact a complementary pair multivibrator. This circuit will work on either 6 volt or 12 volt systems. When power is supplied, C1 charges through R2 and the speaker coil until TR1 is turned on. This turns TR2 on, allowing C1 to recharge and repeat the cycle. The tone may be altered by changing the value of C1. All components are very generously rated, and many years of trouble-free use may be expected. The original unit has been operating for the past two years.

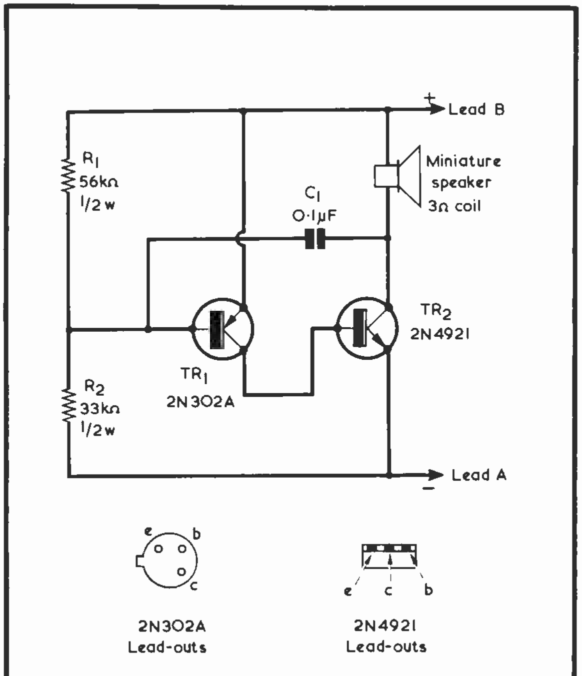


Fig. 1. The circuit of the silicon transistor siren

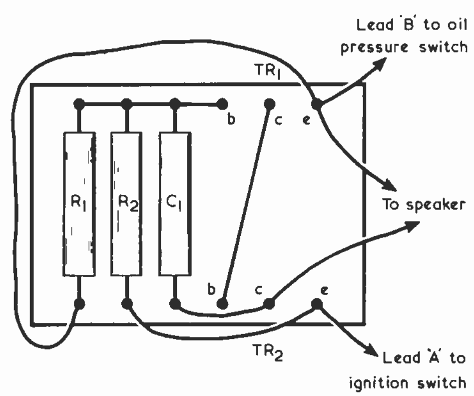


Fig. 2. The prototype siren was built up on a small tagboard, as shown here

The components were assembled on a short length of miniature tag panel, as shown in Fig. 2. This was glued to the back of the speaker with Araldite epoxy resin adhesive. The speaker, in its turn, was bolted to the underside of the dashboard. If the car has positive earth return, connect up as shown. If it has a negative earth, lead 'A' should connect to the oil pressure switch and lead 'B' to the ignition side of the oil warning lamp.

EDITOR'S NOTE

If difficulty is experienced in obtaining the transistors specified, the 2N302A may be replaced by any small p.n.p. germanium transistor of reasonable voltage rating and current handling capability, such as the ACY18. The 2N4921 is a Motorola silicon power transistor having a maximum VCEO of 40 volts, an hFE of 20–100, a maximum Ic of 500mA and a maximum power dissipation of 30 watts. A suitable alternative would be any silicon n.p.n. power transistor of roughly equivalent characteristics, such as the BD121. It need not be mounted on a heat sink. A 1 amp fuse in series with either the positive or negative supply lines would be desirable when initially testing the circuit. ■

D. C. Motor Controller

By

R. WAKEMAN

Intended originally for the control of model trains, this variable voltage d.c. power supply unit incorporates features which could be profitably employed in other fields.

THE CIRCUIT SHOWN IN FIG. 1 WAS ORIGINALLY designed for use as a power control for electric train sets. The unit is capable of operating two locomotives at top speed.

By allowing power to pass to the motor in short bursts a greater take-up is achieved, giving steady even acceleration. The unit is protected from short-circuit on the output by a current limiting system.

The unit can be built separately or it can have its own built-in transformer and rectifier circuit capable of 1.5 amp maximum d.c. current.

SPECIFICATION

The input requirements of the unit are 16 volts d.c. at 1.5 to 2 amp, and the average output voltage can be varied from 1.2 to 12.5 volts at 1 amp. The current limiting circuit starts to take effect at 1.2 amp and the short-circuit current limit is 1.5 amp continuous. Under short-circuit conditions the power dissipation of the series output transistor is 18 watts.

It should be pointed out that the short-circuit condition should not be maintained for exceptionally

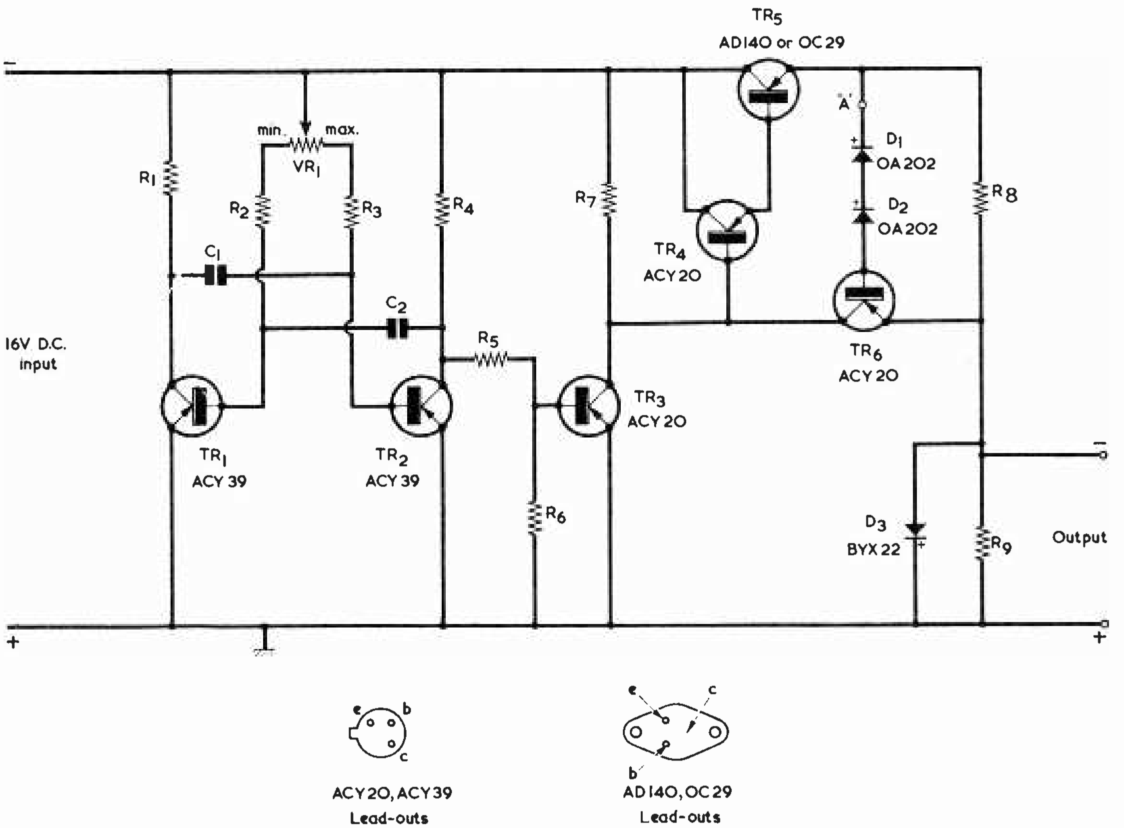


Fig. 1. The circuit of the d.c. motor controller. TR5 acts as a chopper transistor in series with the negative supply to the output

long periods as the series transistor is then run at its maximum dissipation rating for ambient temperatures up to 24°C. TR5 should be mounted directly, without mica washer, on a large heat sink such as the type H11, available from Henry's Radio, Ltd. The heat sink is insulated from the chassis of the unit.

CIRCUIT DESCRIPTION

Fig. 1 gives the circuit of the controller. The transistors TR1 and TR2 are in a multivibrator configuration which produces a waveform at the collector of TR2 as shown in Fig. 2. The frequency of operation of the multivibrator is of the order of 200Hz.

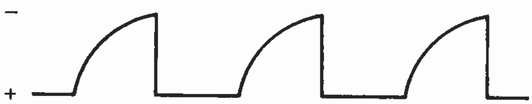


Fig. 2. The waveform at the collector of TR2 when VR1 slider is central on its track

By varying the setting of VR1 the mark-to-space ratio of the multivibrator can be adjusted, the ends of the range being set by R2 and R3. Transistor TR3 functions as an amplifier and gives a fast rise leading edge to the pulses from the multivibrator, as shown in Fig. 3.

With the slider of VR1 at one end of its track, the waveform given in Fig 4(a) is obtained. With the slider of VR1 at the other end of its track, the resultant waveform is that shown in Fig. 4(b). These waveforms are applied to the output transistor, TR5, TR4 and TR5 being in the emitter follower configuration. As is to be expected, the average output voltage becomes larger as the period within the multivibrator cycle when TR5 base is negative increases.

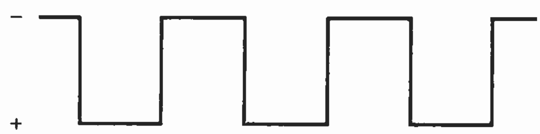


Fig. 3. Transistor TR3 causes the waveform from TR2 to be squared up for driving TR4 and TR5

R8 monitors the output current which is being taken by the load, the current limit being supplied by TR6 which drains off the base current of TR4 if an excess of current is drawn. It might appear that the value specified for R8 (0.5Ω) is low if current limiting is to commence at 1.2 amp. However, the current through R8 consists of high peaks due to the chopping action of TR5 and it is these peaks which provide the voltage needed to turn on TR6.

The function of D1 and D2 is to increase the current value to which the output is to be limited. If a lower value is required one diode should be removed or linked out. The diode D3 must be rated for 1 amp, a suitable type being the BYX22. Its function is to circulate the back e.m.f. of the motor, filling in the gaps between pulses and also allowing the motor to gradually stop after the output has been reduced to minimum.

If VR1 cannot be obtained as a carbon potentiometer with the value specified, a Bulgin wirewound component may be employed instead. This is available from Home Radio under Cat. No. VR22A.

COMPONENTS

Resistors
(All fixed values $\frac{1}{4}$ watt 10% unless otherwise stated)

R1	2.2kΩ
R2	1.2kΩ
R3	1.8kΩ
R4	2.2kΩ
R5	33kΩ
R6	68kΩ
R7	2.2kΩ
R8	0.5Ω 1 watt wirewound
R9	150Ω 2 watt
VR1	15kΩ potentiometer, linear

Capacitors

C1	0.25μF paper or plastic foil
C2	0.25μF paper or plastic foil

Semiconductors

TR1	ACY39
TR2	ACY39
TR3	ACY20
TR4	ACY20
TR5	AD140 or OC29
TR6	ACY20
D1	OA202
D2	OA202
D3	BYX22

OPERATION

When used on an electric train set the controller is much superior to a smooth d.c. power pack type of arrangement. The pulses which are received by the train tend to make the motor creep; the leading edge of the wave, being sharp, gives rise to a high peak current which offers greater control of the motor at low

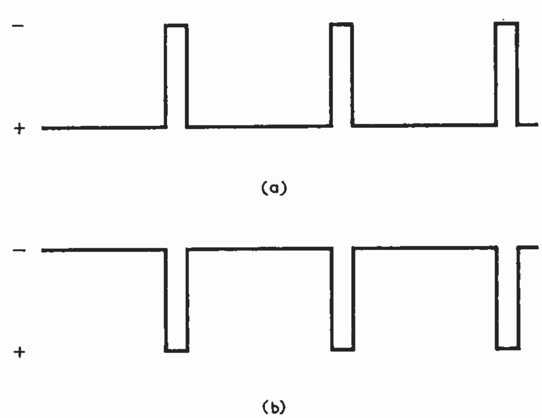


Fig. 4. Waveforms at the collector of TR3 when VR1 is set for (a) minimum output and (b) maximum output

speeds. When the train is stopped fast by VR1 being turned to give minimum output voltage, the regenerative action which ensues takes the train on for a couple of inches.

If derailment is caused and the lines are short-circuited then the current limit becomes effective and closes down the pack until the short-circuit is removed.

To facilitate reversing, a double pole change-over toggle switch can be added to the output to change the polarity. Such a switch is shown in Fig. 5.

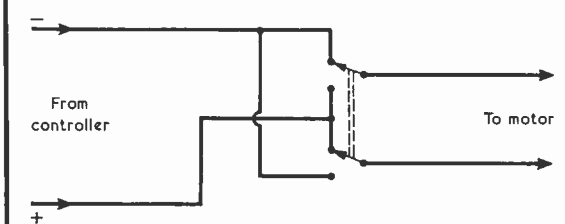


Fig. 5. To provide a reversing facility, a double pole change-over switch may be added. The switch employed must be a toggle type

The circuit of a suitable power supply to feed the control unit is given in Fig. 6. The transformer secondary should offer 12–0–12 volts at 1.5 amp or more. If difficulty is experienced in obtaining the transformer, a suitable alternative is the Douglas Type MT3 (Home Radio Cat. No. TMM1) which offers secondary voltages of 0, 12, 15, 20, 24 and 30 at 2 amps. The 12 volt tap may be used as the centre-tap for the circuit of Fig. 6, and the two rectifiers may be connected to the 0 and 24 volt taps. Suitable rectifiers are the BYZ12 or BYX38. (Both the BYX22 and BYX38 are given suffix numbers which indicate p.i.v. rating. The p.i.v. figures are, in all cases, well above the p.i.v. values encountered in the circuits discussed here.)

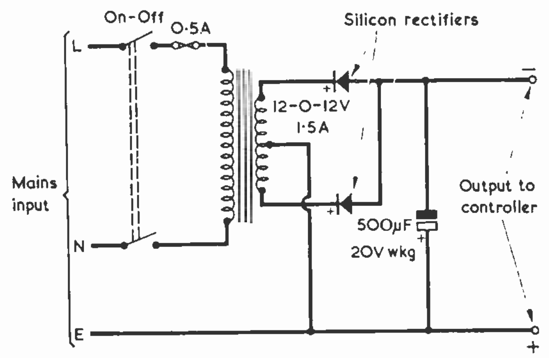


Fig. 6. Circuit of a suitable power supply. The mains transformer and rectifiers are discussed in the text

TESTING

If an oscilloscope is available, check the output of the multivibrator to see that it conforms with Fig. 2, also check the output from TR3 to ensure that pulse width variation takes place. If no pulse is present at the extreme ends of VR1 travel the multivibrator has locked onto one side. The value of R2 or R3 as applicable should then be increased until the fault clears. In the absence of an oscilloscope, the multivibrator output should be audible in a loudspeaker coupled to the circuit via a step-down speaker output transformer, a series 0.1μF capacitor being inserted in one of the leads to the transformer primary.

The current limit can be checked by injecting a voltage between the D1 side of point 'A' and the emitter of TR6, point 'A' being open-circuited. A voltage of between 1 and 1.5, negative to D1, should turn off the output. No other setting-up is required. ■

1919 RADIO TRANSMITTER

Recently donated to the Royal Air Force museum is a 1919 aircraft radio transmitter complete with original test certificates. This valuable acquisition was discovered at a junk sale by Sid Law of Alexandra Road, Croydon. An R.A.F. spokesman engaged in researching the history of the set stated that the transmitter helped to fill in the early days of aircraft communication and that there are very few of the models still in existence.

Sid Law is active on the Radio Amateur Emergency Network with the call G3PAZ, which he operates from his living room. When asked why he didn't keep the 1919 transmitter for use in the Emergency Service he joked that 'under today's broadcasting conditions he would have found himself as a disc jockey on Radio 3'.

Sid Law, donator to the Royal Air Force of a rare 1919 aircraft transmitter, makes a contact on the air. He operates under the call G3PAZ. (Photo: Frazer Ashford)

A BETTER PRINTED CIRCUIT RESIST

by

A. G. BLEWETT

Printed circuit boards can be quickly and reliably prepared by the method described here, which avoids the use of dopes or paints.

IN ORDER TO MAKE SUB-MINIATURE PRINTED CIRCUIT boards for radio control work recently, the author considered the two most popular methods of forming the resist in order to find the best where very small 'lands' are required.

The first, where the lands are formed by painting with dope or ordinary paints, was rejected outright as being too fiddly.

ADHESIVE P.V.C.

The second, where adhesive p.v.c. (such as Fablon) is attached to the copper, and the areas to be etched are cut away, was thought to be better; but it still suffered from disadvantages. First, the p.v.c. stretches whilst being cut, and causes distortion of the shapes. Second, it is unnecessarily thick. Third, the adhesive bond is not complete enough to prevent etchant finding its way underneath at the edges, hence causing ragged edges; and, fourth, the adhesive is not strong enough to prevent very small areas (about ⅛in. round or even smaller) from wandering, or even lifting from the copper.

All these disadvantages become more acute as the printed circuit board and its lands are reduced in area, as occurs with radio control boards and boards containing flat pack integrated circuits.

An alternative plastic resist which suffers from none of these disadvantages is a material used for covering model aircraft surfaces. This is sold in most model shops and is known as 'Solarfilm'.

'Solarfilm' is a polyester film a few thousandths of an inch thick, and has a heat activated adhesive on one side. This is protected by a removable clear film which is peeled off before use, as with Fablon.

The adhesive is activated at a temperature of between 250 to 280°F, and a domestic iron is used to 'iron' it on. The iron must have a temperature control.

PROCEDURE

The best procedure for applying the material is described in the following steps.

1. First bring the iron to the right temperature. Too cool an iron will not activate the adhesive properly and will result in an incomplete bond. On the other hand, too high a temperature will melt the film itself, causing the iron to be covered in a sticky mess of hot plastic! Setting the thermostat on the iron to 'Low' or to 'Man-made fibres such as Acrilan and Courtelle' should be found about right. Check the iron temperature with a small sample piece of 'Solarfilm' before starting any job.
2. Clean the copper area of the printed circuit board thoroughly, bringing it up to a bright finish.
3. Cut the 'Solarfilm' with about ¼in. excess all round, and remove the protective backing.
4. Iron the film on to the copper side of the board, working from the middle towards the edges so as to avoid creases. Any bubbles that are formed can be pricked with a pin and ironed out flat.
5. Film at the edge of the board may be taken round to the non-copper side, being ironed at the edge and on the non-copper side. This achieves an edge seal and there is, of course, no need for neatness here.
6. Remove the high gloss on the 'Solarfilm' by rubbing lightly with fine sandpaper. This ensures that it will take the imprint of carbon paper successfully.
7. Interpose carbon paper between the film and the master drawing, being careful to align the two accurately, and then trace through.
8. Cut away the areas to be etched with a pointed modelling knife or similar, and remove with tweezers.
9. Etch the printed circuit board in the normal way.
10. Remove the remaining 'Solarfilm' to expose the finished printed circuit board.

This method is quite economical, a 36 by 26in. sheet of 'Solarfilm' costing only a little more, at the time of writing, than 50p. In cases of difficulty, sheets can be obtained direct from the manufacturers at 'Solarfilm', Euxton Mill, Dawbers Lane, Euxton, Nr. Chorley, Lancs, PR7 6EB.

The film comes in a range of colours, but white or yellow are considered best for this application, since they give the best contrast when used with blue or black carbon paper. ■

A MODERN HOMODYNE RECEIVER

Part 1

By

G. W. Short

Recent interest in 'direct conversion' receivers has prompted our contributor to offer his own design. In this month's article he discusses the background to homodyne reception, leading up to the basic mode of operation employed in his receiver. In the concluding article, to be published next month, the receiver will be described in full.

DIRECT CONVERSION RECEIVER' is a fairly recent term though, strictly speaking, it might be applied to any type of receiver which converts the incoming signal directly to audio. On this basis even a crystal set would qualify, but in fact the term is usually restricted to receivers in which the audio is recovered with the help of an oscillator.

REACTION CIRCUIT

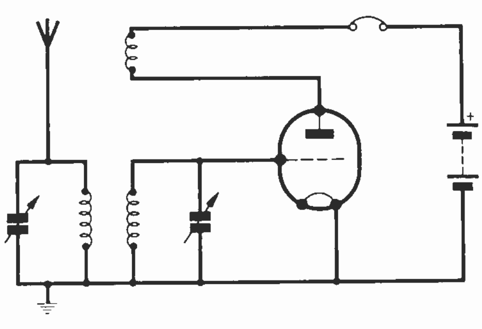
The simplest and earliest of this type of direct conversion receiver was the 'homodyne'. In its original form, described in 1924 by F. M. Colebrook, who became Director of the National Physical Laboratory, it was just a triode dedector with 'reaction' (Fig. 1). The reaction was set to make the circuit oscillate strongly. As many readers will have discovered for themselves, when a signal is tuned in with such an oscillating detector there is first of all an ear-splitting howl caused by the incoming carrier beating with the local oscillation. Then, as the circuit is adjusted closer and closer towards 'zero beat', a point is reached where the beat note suddenly disappears, and the incoming programme is heard, rather faintly and with background hiss but otherwise with good quality.

What has happened is that the local oscillation has become locked to the incoming carrier. The combined signal is then an ordinary a.m. signal with an abnormally strong carrier – the result of the local oscillation which, being now synchronised, adds to the signal carrier. The net result is an a.m. signal with a low depth of modulation, which makes for low distortion of the detected audio. The background hiss arises from the same cause as the background hiss of a c.w. receiver when the b.f.o. is switched on or any sensitive receiver tuned to an unmodulated carrier. That is, the carrier or local oscillation beats with any r.f. noise close to it in frequency, giving a.f. noise at the output of the detector.

Colebrook's homodyne was a very simple affair, but it did embody the important principle of a local oscillation lockeu in frequency to an incoming carrier. All modern direct conversion a.m. receivers use this principle, though the means by which synchronism is obtained may be very different from Colebrook's direct-injection method.

The knowledge that an LC oscillator can be synchronised in this way predates Colebrook's homodyne by a small period. A little over a year earlier, Appleton (the ionosphere researcher) had written a learned paper

Fig. 1. An early approach to direct conversion' reception consisted of using a triode detector with reaction, as illustrated in basic form here



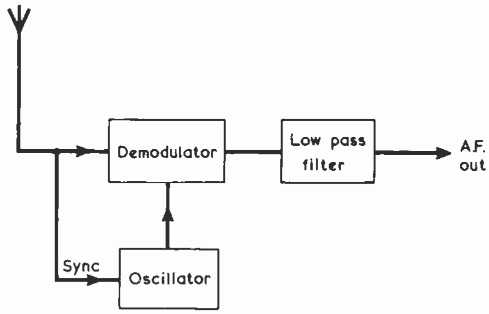


Fig. 2. Demonstrating typical synchrodyne operation

on the subject. Some of his co-workers had actually used Colebrook's method of reception.

Despite this promising beginning, the homodyne never became popular. This may seem strange in the light of present-day interest, but it should be remembered that the superheterodyne method of reception had already been invented and seemed to be the answer to all the problems of the day, since it gave high gain, good selectivity, and a simple method of automatic gain control.

In any case the domestic t.r.f. receivers of the twenties and thirties were often operated as homodynes . . . and very unpopular they were when this was done. In those days of long outdoor wire aerials, an oscillating detector first stage acted as a local c.w. transmitter producing, when off tune, annoying whistles in neighbouring sets. The outdoor aerial also brought with it a particular disadvantage. When it swayed in the wind, the resulting variations in capacitance to earth tended to throw the receiver out of synchronism.

THE SYNCHRODYNE

As Colebrook had realised, the homodyne method of reception can give greatly enhanced selectivity. The way in which it does so is not very obvious from the original circuit, but it becomes clear when one examines the much improved form of the technique known as the 'synchrodyne' (Fig. 2).

In the synchrodyne the path of the incoming signal is split into two separate branches. One branch goes straight to the demodulator, that is, the circuit which carries out the direct conversion to audio. The demodulator is driven by an oscillator, and the other branch of the signal path goes to this oscillator: this is the synchronising path and its job is to injection-lock the oscillator to the incoming carrier of the wanted station.

Now, the demodulator, although usually regarded as a detector (and in certain forms called a 'product detector'), is in reality a kind of frequency changer. The unorthodox thing about *this* frequency-changer, however, is that, unlike the one in a superhet where the oscillator is on a completely different frequency from the signal, here the oscillator is on exactly the same frequency. The 'i.f.' output is at the difference frequency between signal and local oscillation, but the difference frequency is zero! This does not mean that there is no output but that the output is at zero frequency, or d.c.

Not very useful, you may think. But this is where the nature of an a.m. signal comes into the picture. An a.m. signal has a carrier *and sidebands*. The oscillator in a synchrodyne is locked to the carrier frequency, so it is the carrier frequency only which gives a d.c. output. The sidebands, being on slightly different frequencies, give beat-frequency outputs. It just happens that the beat frequencies are the original modulation frequencies, so that the output of the demodulator consists of the original audio modulation frequencies which constitute the programme.

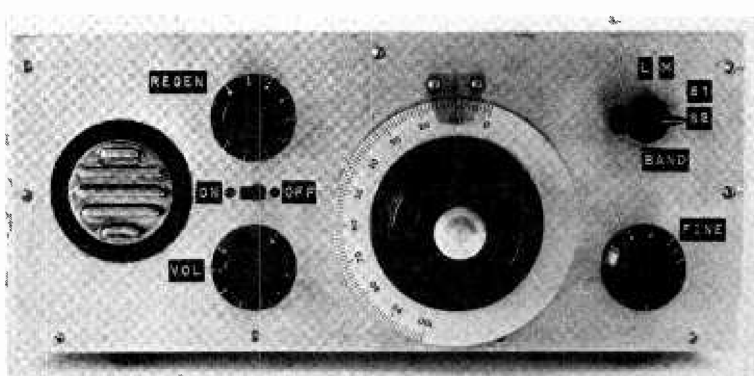
To take an actual example, suppose the carrier frequency is 200kHz, modulated by a.f. at 1kHz. There are in consequence the usual two sideband frequencies, one at 199kHz and the other at 201kHz. Both these beat with the local oscillation on 200kHz to give 1kHz, i.e. the original modulation. The same thing happens with any other modulating frequency, and for any mixture of frequencies which form a voice or music signal.

What happens to unwanted frequencies on other channels? The carrier of an adjacent channel, say 209kHz, gives an output from the demodulator of 9kHz. This is a whistle at a relatively high audio frequency, and is rejected by the low-pass filter which follows the demodulator, whose cut-off frequency can be set at, say, 5kHz. It will be clear that signals on channels above 209kHz, such as 218kHz, come out at still higher frequencies and are also rejected. What about unwanted channels on lower frequencies? If the next lower channel is at 191kHz it gives a beat at 9kHz, which is also dealt with by the low-pass filter. Any still lower channel comes out, once again, at a *higher* difference frequency and is likewise eliminated by the filter.

We therefore have the delightfully simple situation that, so long as the local oscillator stays locked to the wanted carrier, unwanted signals on any other frequency are eliminated. There is no possibility of 'second channel' (image frequency) breakthrough as in a superhet. Note, too, that the selectivity comes from the demodulation process; even r.f. tuning can, in theory, be dispensed with!

OSCILLATOR STABILITY

The problem, of course, is to keep the oscillator synchronised, and we must now look at this requirement



The panel layout of the author's homodyne receiver. Details of this will be given in the article to be published next month more closely. Common sense suggests that the stronger the synchronising signal the easier it should be to lock the local oscillator. This is true, and it provides a starting point for an estimate of the stability needed from the oscillator.

Careful tests will show that even when the tuning is shifted a little to one side or other of the correct point the oscillator remains locked. The stronger the signal, the more detuning can be tolerated. This would be great if all one needed to do were to tune in to strong stations, but in the real world it is necessary to pluck a weak signal from a surrounding array of strong ones, each eager to jump in and take over. In theory, it is indeed possible to stay locked to the wanted weak carrier when there are strong unwanted ones nearby. To do it, you must increase the amplitude of the local oscillation. This makes it *harder* to lock, but it turns out that a weak signal tuned in 'right on the nose' can then dominate a strong one slightly off tune. The price demanded for this performance is great stability of frequency.

If the local oscillator were absolutely stable it would not be necessary to lock it at all. One would just set it to the right frequency and sit back. Unless the transmitter frequency drifted the receiver would stay tuned indefinitely. Unfortunately, absolutely stable oscillators just do not exist, so locking is necessary. If drift is very low, the locking signal need only be small, which is what we want.

How stable must the oscillator be? Suppose, to begin with, that we are in the rather favourable situation of having to lock to one signal when another, of exactly equal strength, is 10kHz away. Now let the oscillator drift, but without loss of sync. If it drifts towards the unwanted carrier, a point will be reached at the half-way mark between the two stations where there is an even chance that the unwanted carrier will take command. In other words, the natural, unlocked frequency must not drift by more than half the channel spacing, in this case by 5kHz.

So far we haven't specified what the carrier frequency is. When we do, we find we have come to the crunch. If the wanted carrier is 500kHz, then the allowable drift in this case of 5kHz amounts to one per cent – 1 part per 100. Not a very difficult stability to achieve. But what if the carrier were 5MHz? A drift of 5kHz is now 1 part in 1,000. And at 50MHz, a stability of 1 in 10,000 is required, or 0.01%. Clearly, life gets harder as one goes up the frequency scale.

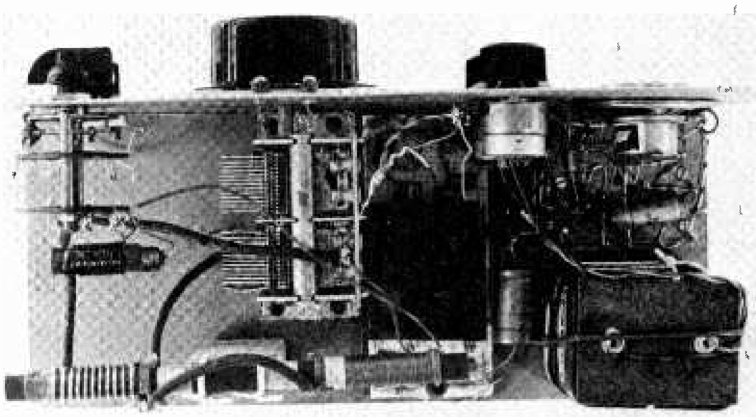
Next, look at the unfavourable situation where the unwanted carrier is not equal in strength to the wanted one but 100 times stronger. The oscillator must be 100 times more stable than before, and this calls for a drift of less than 1 part in 10,000 at 500kHz, 1 in 100,000 at 5MHz, and 1 in a million at 50MHz. Clearly, the synchrodyne is a receiver for lowish frequencies, or quick hands on the tuning control, or oscillators of exceptional stability.

The original synchrodyne designs, published in 1947, were for medium wave receivers. Their originator, D. G. Tucker (now Professor of Electrical Engineering at Birmingham University) had a background in line communications engineering and a special interest in the rectifier types of modulators and demodulators, such as the ring modulator, used in carrier telephony. These have the degree of linearity between input signal and output which is required in the synchrodyne, and were used in the most successful version, though Tucker did also produce a simple version using a triode-hexode frequency changer instead. The synchrodyne created a stir when it first appeared, but subsequent research by Tucker showed that between 1924 and 1947 there had been a number of patented circuits which embodied the essential principle of separating the synchronising path from the main signal path.

INTEREST REVIVES

The most obvious attraction of the synchrodyne (and homodyne, which can be regarded as a synchrodyne whose funcions are all mixed up in one circuit) is its ability to provide high selectivity without the use of a lot of tuned circuits. There is, however, another less obvious attraction. It can be called in as an ally against what many communications engineers have come to regard as the last great enemy – intermodulation. In a shortwave receiver, the aerial tuned circuit cannot be made selective enough to get rid of strong interfering stations somewhere in the band to which it is tuned. The result is that the first stage of the receiver, usually an r.f. amplifier, is presented with a mixture of weak and strong signals. Since no amplifier is perfectly linear the consequence is that the weak ones have the modulation of the strong ones impressed upon them, and no amount of subsequent filtering (in i.f. stages, for example) can then get rid of the interference.

In a direct-conversion receiver, all the selectivity is obtained in one stage, the demodulator. And in the demodulator the strongest signal, the signal which overrides all others, is of course the local oscillation. By dispensing with r.f. amplification and feeding the input signals straight to a demodulator supplied with a good strong local oscillation there is a sporting chance that cross-modulation will be greatly reduced. This is of particular interest on the amateur bands, where there may be very strong interfering signals from broadcast transmitters or the amateur in the next street. Another encouraging fact is that for single-sideband suppressed carrier reception, now popular with amateur transmitters, a small frequency error at the local oscillator is permissible. Given a stability which confines drift to a few tens of cycles during a 'contact' there is no need to attempt precise synchronisation, which is just as well, since in a suppressed-carrier system there is no carrier to provide a locking signal. (It is possible, at the expense of great complexity, to derive one from the audio output, but that's another story).



A view inside the homodyne receiver. Signal pick-up on medium and long waves, and on two short wave bands, is provided by a ferrite rod aerial

IMPROVING THE HOMODYNE

In general, however, we are interested in receiving ordinary double sideband a.m. signals with carrier and and all. In this case it is absolutely necessary to synchronise the oscillator. For most purposes we need some r.f. amplification as well.

The original homodyne did give some protection against cross-modula-

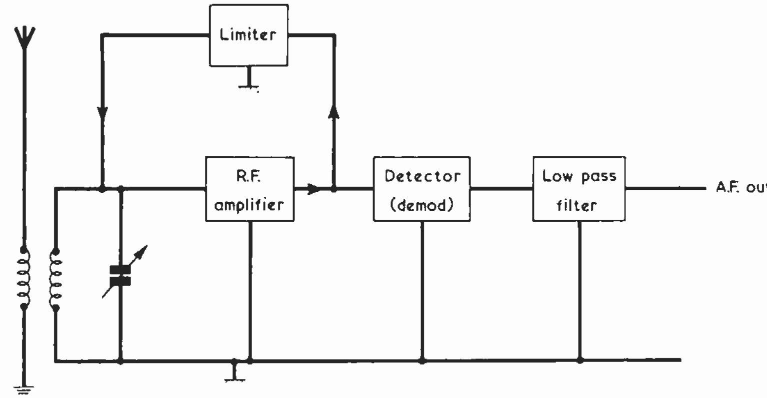


Fig. 3. The homodyne method of reception employed in the author's design

tion, by making the local oscillation the strongest 'signal' around. But it provided no r.f. amplification. What is needed, then, is a circuit which preserves the simplicity of the homodyne but gives r.f. amplification as well. A way of achieving this is shown in Fig. 3.

In Fig. 3, signals are tuned by an aerial circuit, amplified by an otherwise untuned r.f. amplifier, and passed to a detector. So far all we have is a simple t.r.f. receiver. This is turned into a homodyne by introducing regenerative feedback (reaction) from amplifier output to the aerial circuit. This feedback takes place via a limiter. The job of the limiter is twofold: to suppress the modulation of the fed-back carrier and to prevent the amplitude of oscillation from getting too large. What is fed back, when the circuit is oscillating strongly, is a more or less unmodulated carrier of fixed amplitude.

Provided that the fed-back carrier is not so strong that it overloads the amplifier any other signals present will still be amplified in the normal way, except that cross-modulation may be discouraged by making the oscillation stronger than any other signal.

No means of controlling regeneration (other than the limiter) are shown in Fig. 3, but it is very easy to add an attenuator between the limiter and the tuned circuit. Once this is done it becomes possible to set the circuit so that it acts either as a simple non-regenerative receiver with no 'reaction', or as a normal reacting t.r.f., or as a fully oscillating homodyne. For most purposes the ordinary regenerative t.r.f. condition is adequate, since it provides enhanced gain and selectivity without the need for the critical tuning of a homodyne. But when conditions are bad, with a strong interfering station or stations in the band, the superior selectivity of the homodyne is worth the trouble of the careful adjustment which this mode of reception calls for. Single-sideband transmissions can also be received, if the tuning is fine enough, once the knack of hitting the right tuning point is acquired. Readers who have not tried s.s.b. reception before are warned that it takes some practice!

(To be concluded)

FARAD ELECTROLYTIC CAPACITORS

by

J. B. Dance, M.Sc.

Very low voltage electrolytic capacitors are now available with capacitance values of no less than 50 farads.

CAPACITORS OF EXTREMELY LARGE VALUES – IN THE farad range – have been developed by the Gould Ionics Company. They are very useful in such applications as timing circuits which provide delays of the order of months. They can also be used as stand-by power sources, since a capacitor is essentially an energy storage device.

DRY POWDERS

Unlike conventional electrolytic capacitors, the new devices contain only dry powders, including the special material rubidium silver iodide ($RbAg_4I_5$). One of the disadvantages is the low decomposition voltage (0.65V) of this material which limits the voltage per capacitor to about 0.6V.

Nevertheless, ten separate 50 farad capacitors of this type can be fitted into a cylindrical package of 2.5 inches in length by 1 inch in diameter. When connected in series, they form a 5 farad capacitor rated at 5V.

The devices will hold their charge for days or even for weeks. They are therefore being used as memory cells, each cell being of about 10mF capacity at 0.5V. One cell charged in June 1969 was found to have retained 97% of its initial charge when tested over 1¼ years later!

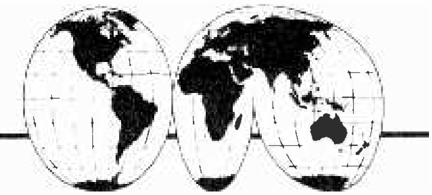
Astable vibrators can be constructed using these capacitors to provide switching periods from 1 second to over a month.

The technique of depositing capacitors of this type directly onto integrated circuit substrates has, for example, produced a 500μF capacitor in a case 0.02 inch long by 0.032 inch diameter. Such developments should greatly extend the field of application of monolithic operational amplifiers, since previously it has been possible to employ only relatively small capacitor values in integrated circuits.

Miniature electrolytic capacitors often have a relatively high leakage current, but the types under discussion have capacitances of 160F per cubic inch and pass only a few picoamps (1pA = 1μμA). Their leakage resistance is about 10,000MΩ and they are free from catastrophic failure.

Further details may be obtained from the U.K. representatives, Messrs. Lyons Instruments Ltd., Hoddesdon, Herts.

SHORT WAVE NEWS
FOR DX LISTENERS



By Frank A. Baldwin

Times = GMT *Frequencies = kHz*

● **BANGLA DESH**
Radio Bangla Desh commenced an Overseas Service on the 1st of January in the English language and this may be heard from 0230 to 0300 on **7095** (42.28m), formerly a channel of Radio Pakistan, and from 1230 to 1300 on **15520** (19.33m) also formerly used by R. Pakistan. The Home Service operates from 0300 to 0300 on **4915** (61.03m) in parallel with **7095** (the latter channel closes at 0220). News in English at 0145. From 0630 to 0800 on **7260** (41.32m) and on **9560** (31.38m) with the news in English at 0730. From 1100 to 1630 in parallel on **4915** (from 1315), **5855** (to 1300), **9853** (30.46m) and on **15520** (to 1220). The news in English is at 1205 and at 1515, all according to 'Bandspread', the journal of the British Association of Dx'ers (BADX).

● **TURKEY**
Voice of Meteorology, Box 401, Ankara, has been heard broadcasting music with announcements and weather news in Turkish on **6890** (43.52m) and also on **6900** (43.55m) from 0500 to 0700, 0800 to 0940, 1200 to 1615 and from 1800 to 1930.

● **NORTH VIETNAM**
The English schedule of the Voice of Vietnam is now as follows – daily from 0500 to 0530, weekdays from 0830 to 0900, daily from 1000 to 1030, 1300 to 1330, 1530 to 1600, 2000 to 2030 and from 2300 to 2330 on **7360** (40.73m), **7416** (40.46m), **9840** (30.49m), **10224** (29.34m) and on **15018** (19.97m).

● **IRAN**
Teheran now radiates the Home Service, until 1720, on the new channel of **7038** (42.62m) in place of **12175**. The new channel carries the External service from 1725 until 2130. Parallel channels for the Home Service are **3780** (79.32m), **7065** (42.46m) and 15085 (19.89m), according to BADX.

● **ROUMANIA**
The English broadcasts from Radio Bucharest to Europe are now from 1300 to 1330 on **11940** (25.13m) 120/240kW, **15250** (19.67m) 18/120kW, and on **17710** (16.94m) 120kW. From 1930 to 2030 on **9510** (31.55m) 18/120kW and on **11940**. From 2100 to 2130 on **7195** (41.70m) 18/100kW and on **9690** (30.96m) 50/120kW. To Africa from 1100 to 1130 on **11920** (25.17m) 18kW, **15250** (19.67m) 18/120kW and **17850** (16.81m) 100/120kW. To Asia from 1500 to 1530 on **11920, 15250** and on **17760** (16.89m) 18/120kW. To the Pacific from 0654 to 0815 on **11940, 15250** and on **17760.** To North America from 0130 to 0230, from 0300 to 0330 and from 0430 to 0500 on **5985** (50.13m) 100kW, **6190** (48.87m) 120kW, **9570** (31.35m) 240kW, **11810** (25.40m) 18/120kW, **11940** and on **15250**.

● **MAURITIUS**
Forest Side has been heard using **4870** (61.60m) instead of the listed **4850** channel, when broadcasting the BBC news in English. Mauritius is a small island of 720 square miles situated in the Indian Ocean and is one of the Mascarene Islands. The capital is Port Louis, the volcanic island being surrounded by coral reefs. The official language is English but most of the islanders speak a French patois. Forest Side has a power of 10kW and the address is – Mauritius Broadcasting Corporation, Broadcasting House, Forest Side.

● **LEBANON**
The French transmission to North America from Radio Lebanon is from 0130 to 0200, in Arabic from 0200 to 0230 and in English from 0230 to 0300 on the reactivated channel of **9545** (31.43m) 100kW. Radio Lebanon can also be heard, in English, from 1830 until 1900 on **11705** (25.63m) 100kW.

● **MEXICO**
Radio Mexico has dropped the **21705** outlet and currently uses **9705** (30.91m) 20kW, **11770** (25.49m) 100kW and **17835** (16.82m) 100kW. The last mentioned channel is the most often reported in the SWL press and offers the best chance of reception here in the U.K. The address of XERMX is – Apartado 20-620, Mexico 20.

● **EGYPT**
The schedule for the Voice of the Arabs programme, in Arabic, is as follows – from 0300 to 0600 on **7050** (42.55m) and on **9850** (30.46m) both 100kW. From 0600 to 1445 on **15475** (19.38m) 50/100kW, **17625** (17.03m) 50/100kW and on **17905** (16.75m) 50/100kW. From 1445 to 1630 on **15475** and on **17905**. From 1630 to 1700 on **7050, 9850, 15475** and on **17905.** From 1700 to 0030 on **7050** and on **9850**, according to BADX journal 'Bandspread'.

● **AFGHANISTAN**
Radio Afghanistan broadcasts to Europe, in English, from 1800 to 1830 daily on **9530** (31.48m) 100kW and on **11785** (25.46m) 100kW. Kabul may also be heard, in English, from 1400 to 1430 on **4775** (62.84m) 100kW according to the schedule but reception would be difficult on this channel for the average listener in the U.K. The address is – P.O. Box 544, Kabul.

● **AFRICA**
This continent can be heard almost the whole year round here in the U.K. on the lower frequency bands. A good 'marker station' indicating the prevailing reception conditions for Africa is Omdurman, Sudan, on **4994** (60.08m) 20kW, at least for the average listener. The 'dyed-in-the-wool' Dxer would, no doubt, choose a low-powered Angolan station for his 'marker'. If Omdurman can be heard with a very strong signal then the chances are that conditions are good for general African reception.

Some of the African stations recently logged indicate just what may be heard when using a makeshift indoor aerial.

3336 1939 (89.95m) 4kW Ziguinchor, Senegal, with a programme of light music and announcements in French.

3380 1936 (88.76m) 20/100kW Blantyre, Malawi, news in English.
4795 2146 (62.57m) 10kW CR6RG Radio Commercial de Angola, Sa da Bandeira, light music with announcements in Portuguese.
4875 1928 (61.54m) 20kW SABC Johannesburg, South Africa, record selections with announcements in Afrikaans.
4890 2154 (61.35m) 25kW Dakar, Senegal, light music with songs and announcements in French.
4976 1902 (60.29m) 7.5kW Kampala, Uganda, heard with a talk in English on the subject of Ugandan economics.
5047 1906 (59.43m) 100kW Lome, Togo, discussion in French.
5050 1908 (59.41m) 20kW Dar-es-Salaam, Tanzania, newscast in Swahili.

● SOUTH AMERICA

The 'season' for Latin American reception will shortly be upon us although, of course, LA's can be heard the whole year round. Those stations recently logged and which may interest readers are listed here.

4780 0009 (62.76m) 1kW YVLA La Voz de Carabobo, Valencia, Venezuela, songs in Spanish.
4825 2350 (62.18m) 3kW HIFA Voz de las Feurzas Armadas, S. Domingo, Dominican Republic, LA music and identification.
4870 2347 (61.60m) 5kW YVKP Radio Tropical, Caracas, Venezuela, LA music and songs in Spanish.
4890 2339 (61.35m) 5kW YVKB Nueva Radio Dif, Caracas, Venezuela, talk in Spanish.
4980 2315 (60.25m) 10kW YVOC Ecos del Torbes, San Cristobal, Venezuela, LA music and advertisements in Spanish.
6000 0055 (50.00m) 25kW PRK5 Radio Inconfidencia, Belo Horizonte, Brazil, identification and LA songs.
6095 0045 (49.22m) 7.5kW ZYB7 Radio Dif, Sao Paulo, Brazil, sports commentary and identification.
6160 0030 (48.70m) 10kW HJKJ Emisora Nueva Granada, Bogota, Colombia, LA music and full identification.
6185 0026 (48.50m) 10kW ZYR77 Radio Bandeirantes, Sao Paulo, Brazil, sports commentary in Portuguese.
9585 0058 (31.30m) 10kW ZYR56 Radio Excelsior, Sao Paulo, Brazil, discussion in Portuguese.
9685 0105 (30.98m) 7.5kW ZYR227 Radio Gazeta, Sao Paulo, Brazil, commentary in Portuguese.

Listen out for the LA transmitters on the LF bands in the coming weeks, signal strengths will slowly build up as we go from Spring into Summer. If the static associated with the latter season of the year and commercial QRM (interference) allow, we should all have some success with our LA sessions.

● A READER'S LOG

Julian Moss of Rayleigh, Essex, uses a Meridian 10-transistor portable receiver for his short wave roamings and requests that we include 'more down-to-earth loggings as a regular feature'. JM continues 'There must be as much excitement in tracking down the Lebanon on a transistor portable as in receiving some obscure LA (Latin American) transmitters on some £200 communications receiver'. Well JM, only a very few Dxers are equipped with such high-priced receivers, most have either 'surplus' equipment or relatively cheaper sets. However, that is another story, but I would be pleased to include readers loggings in this feature subject to available space; just send them along to the Editorial Office – the address is on the Contents page of this issue. Here are the loggings of JM.

5960 0815 HCJB Quito, Ecuador, English programme.
6025 2130 R. Portugal, English programme.
6170 2045 Kol Yisrael, Jerusalem, English programme.
7235 1535 R. Australia, English programme.
9460 2100 R. Pakistan, news in English.
9525 2245 RSA Johannesburg, programme in English.
9530 2230 VOA Monrovia, Liberia, signing-off.
9545 2045 R. Ghana, Accra, English programme.
9560 1020 NHK Tokyo, English programme.
9570 0735 R. Australia, Dx news.
9605 2130 CBC Montreal, in English.
9605 1945 R. Athens, Greece, in English.
9690 2000 WNYW New York, in English.
9745 2045 R. Baghdad, Iraq, German programme.
9805 2245 R. Cairo, in English.
11705 1905 R. Lebanon, in English.
11765 0735 R. Australia, in English.
11780 2000 HCJB Quito, in English.
11890 2030 WNYW New York, in English.
11910 1930 ETLF Addis Ababa, in English.
11950 1730 FEBA Seychelles, in English
11970 2238 RSA Johannesburg, news in English.

All of which goes to show just what can be achieved on the short waves with a 'domestic' receiver – well done JM!

SUPER DX

Over the past few months, super Dx in the form of reception in the U.K. of signals from Papua and New Guinea, has been achieved and reported in the BADX journal 'Bandspread', to which due acknowledgements are made. Recently, reception of such stations as VL9BC on **3335** at 2000, when Radio Wewak was heard with drums and choral songs; VL8BD Radio Daru on **3305** at 2024 with light choral songs and Port Moresby on **4890** at around 2000 were made. Considering the low powers of these stations and the frequencies on which they operate, the reception of such transmissions in the U.K. equals super Dx by any standard.

LAST LOOK ROUND

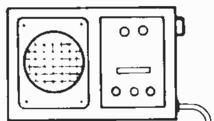
1972 WORLD RADIO-TV HANDBOOK

The 26th edition of this directory of the world's radio and television stations is undoubtedly the most comprehensive yet produced. Priced at £2.80, a very reasonable sum when one considers the vast amount of research and collation necessary to produce such a publication, the 384 page Handbook represents good value for money.

Of great importance and interest to SWL's, WRH – as it has become known over the years – is accepted all over the world as the 'bible' of those interested in short wave listening, not to mention the similar interests of medium wave and TV enthusiasts. The Short Wave Stations of the World list, some 23 pages in all, without which many SWL's would be lost when identifying stations, is the most complete available to the average listener.

All the usual features and listings have been brought up to date.

In your workshop



Regular readers will recall that, in last month's episode, Smithy reviewed the f.m. 'front-ends' employed in current a.m.–f.m. transistor radios, dealing also with automatic frequency control. He now returns to the subject of these radios and initiates his assistant, Dick, into the mysteries of a.m.–f.m. i.f. stages and the more modern versions of the f.m. ratio discriminator stage.

"A MAN OF HONOUR," COMPLAINED Dick bitterly, "would *keep* his promise."

"For goodness' sake," snorted Smithy irately, "don't keep on all the time."

"Well, it isn't fair," continued Dick. "You promised me ages ago that we would have a gen-session on the i.f. stages of transistor a.m.-f.m. radios, and yet you keep putting me off all the time."

"For a start," Smithy corrected him wearily, "it wasn't ages ago. It was just last month, after I'd finished telling you all about the f.m. front-ends in these receivers. Since that time, as it might have been noticeable to even someone as myopic as yourself, I've been snowed under with urgent work."

A.M.-F.M. I.F. STAGES

"You aren't," Dick pointed out quickly, "snowed under now."

Helplessly, the serviceman looked around him. What Dick said was perfectly true. After a long run of heavy unremitting labour, the pressure of work had, that afternoon, suddenly ceased. Smithy glanced at his watch. There was at least an hour to go before he was due to lock up and go home.

"Oh, very well then," he remarked, shrugging his shoulders resignedly. "We'll have a go at those a.m.-f.m. i.f. stages then. You'd better come over to my bench, as I'll have to show you a few circuits and things."

"Good old Smithy," responded Dick enthusiastically, as he carried his stool over to Smithy's side of the workshop. "I *knew* you were a man of honour."

"And don't keep on about my honour," grunted Smithy tetchily. "That happens to be something I hold in high esteem. It is not to be lightly bandied about."

"All right, all right," replied Dick soothingly. "I shan't mention it again."

"Fair enough," said Smithy. "Now, if you can remember our last technical rag-chew, I told you that the f.m. front-end design of a.m.-f.m. transistor radios has become pretty stabilized over the years, and that a typical front-end consists of two grounded-base transistors, one operating as r.f. amplifier and the other as mixer-oscillator. When we come to the i.f. stages of these sets, however, we find that circuit design is not quite as highly standardised. Nevertheless, all receivers of this type have i.f. amplifier circuits with a.m. i.f. and f.m. i.f. transformers connected in series, and the main differences lie in the more minor details."

"What's this business of having a.m. i.f. and f.m. i.f. transformers in series?"

"Connecting i.f. transformers in series is a common practice," said Smithy, "and it dates from the old valve a.m.-f.m. sets. I'll show you the sort of thing I mean."

Smithy pulled his note-pad towards him and sketched out several circuits.

"Here we are," he remarked, putting his pen back on the bench. "I've drawn a few examples of the sort of i.f. transformer circuits you're likely to encounter in transistor a.m.-f.m. receivers. In the first of these circuits there are two double-tuned i.f. transformers in series, the primaries being in the collector circuit of the first transistor, and the secondaries being in the base circuit of the following transistor."

Smithy pointed at the sketch of the two i.f. transformers in question. (Fig. 1(a).)

"Here," he went on, "the f.m. i.f. transformer is the one that's closer to both the collector and the following base, and it's tuned to 10.7MHz. The a.m. i.f. transformer follows it and is tuned to an intermediate frequency in the range of 450 to 475kHz, according to the make and design of the receiver. To make things easier in our discussion today, let's assume from now on that all the a.m. i.f. transformers we talk about are tuned to 470kHz, which is in fact one of the more common figures used."

"As you like," said Dick agreeably, as he settled himself more comfortably on his stool. "When you have i.f. transformers in series like the ones you've drawn, isn't the tuning of one going to upset the tuning of the other?"

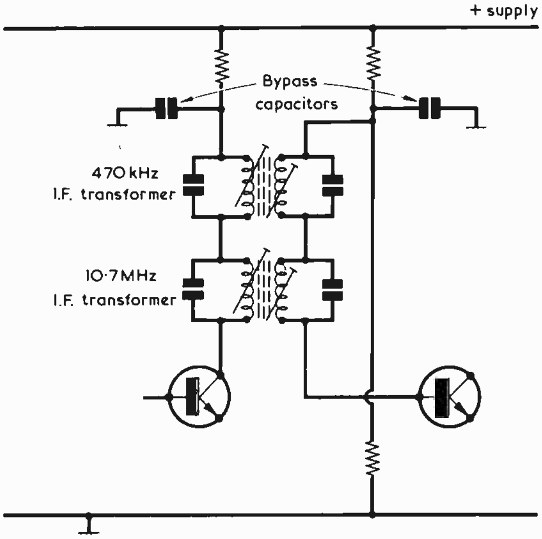
"Not to any significant degree," replied Smithy. "The beauty of the system is that the few turns of wire in the 10.7MHz i.f. transformer represent what is nearly a dead short to frequencies around 470kHz. At the same time, the fixed tuning capacitors across the windings in the 470kHz i.f. transformer are usually of the order of 200pF, and these offer quite a low reactance at 10.7MHz, the reactance being around 80Ω or so. Each of the tuned circuits is complete with its own parallel capacitor, and adjustments in one transformer do not then noticeably upset the tuning of the other. A rather fascinating aspect of the circuit is that, if you connect a signal generator to the base of the first transistor and some form of signal output level indicator to the collector of the second transistor, you'll get one band-pass peak as you take the signal generator through 470 kHz and another as you take it through 10.7MHz. The circuit allows either i.f. transformer to function as if it were in circuit on its own."

"What stops the circuit from amplifying any 470kHz signals which may be present when you're receiving f.m., and any 10.7MHz signals which may be present when you're receiving a.m.?"

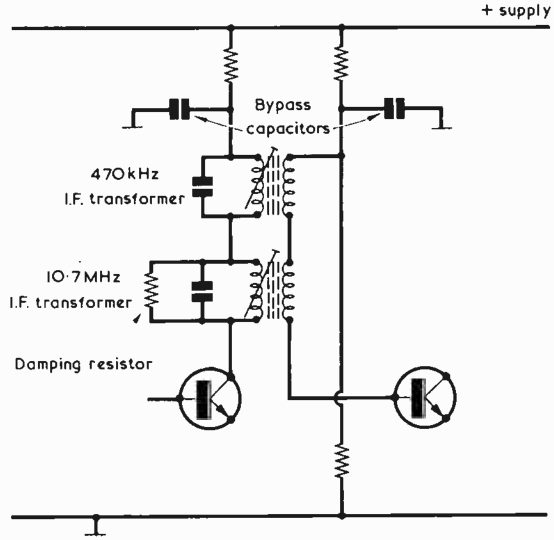
"The normal approach," said Smithy, "is to have a single 10.7MHz i.f. transformer on its own immediately following the f.m. front-end circuit, and this is sufficient to keep any 470kHz signals that may be present out of the i.f. stages when receiving f.m. signals. Most sets also have a single 470kHz i.f. transformer on its own immediately following the a.m. front-end, and this does the same thing to any 10.7MHz signals that may be knocking around. A further safeguard against breakthrough of the wrong i.f. is given by the fact that the outputs of the a.m. detector and the f.m. discriminator are switched before going into the a.f. stages of the set."

"I see," said Dick thoughtfully, "Let's get back to those other i.f. transformer circuits you've drawn."

"All right," replied Smithy. "Well now these alternative circuits represent variations in the basic theme given by the two double-tuned i.f. transformers



(a)



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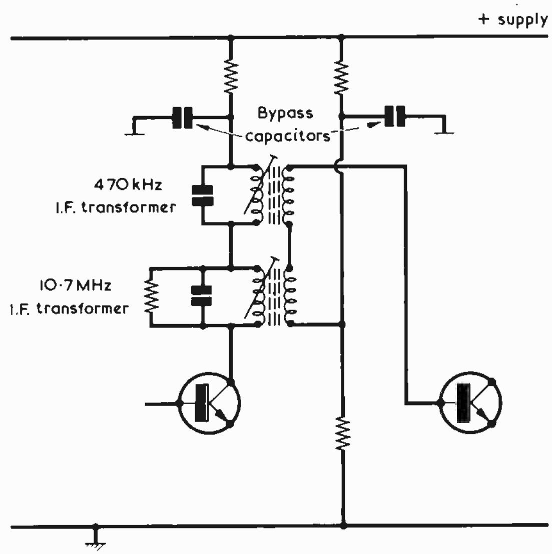


(c)

Fig. 1. Three basic methods of connecting in series the f.m. and a.m. i.f. transformers between i.f. transistors in a.m.-f.m. receivers. The circuit in (a) tends to appear in earlier receivers, and those in (b) and (c) in more recent sets. Frequently, connections may be made to part of a tuned winding via a tap instead of to the complete winding. (It should be noted that a number of receivers have the positive supply line connected to chassis instead of the negative line, as is assumed, for ease of explanation, in these and subsequent diagrams)

in series. A common practice nowadays consists of having a single tuned primary circuit in either one or both of the i.f. transformers with, usually, a damping resistor of some 2.5 to 6kΩ across the 10.7MHz primary."

Smithy indicated the second of his drawings (Fig. 1 (b)), then pointed to the third (Fig. 1 (c)).

"And here," he added, "is another variation, in which the primary of the 10.7MHz transformer is, as with the other circuits, closer to the collector of the first transistor, whilst the secondary of the 470kHz transformer is closer to the base of the second transistor."

F.M. OVERLOAD DIODE

"Do these alternative circuits work in just the same way?" asked Dick.

"Oh yes," said Smithy. "The untuned secondary of the 10.7MHz transformer offers negligible impedance to 470kHz signals. On the other hand, the inductance of the untuned secondary on the 470kHz transformer *can* offer an appreciable reactance at 10.7MHz. However, its self-capacitance helps to bring its overall impedance down to a sufficiently low level for the circuit to function satisfactorily in practice at 10.7MHz."

"Are there any further variations on these circuits?"

"There are a few minor ones," replied Smithy. "For instance, as I mentioned just now, you may have one of the transformers in a pair single-tuned and the other double-tuned, and things like that. Also, some of the i.f. transformers may consist of a tuned primary and a tuned secondary in separate cans, these being joined by a low-value capacitor or an inductive link. But you'll find that the basic idea of having two i.f. transformers in series remains the same. One thing I haven't shown is that there is nearly

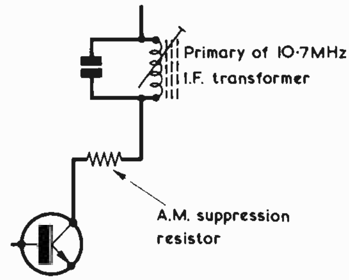


Fig. 2. It is common practice to insert a series resistor immediately after the collector of i.f. transistors in order to reduce the effect of a.m. interference

always a series fixed resistor immediately following the collector which feeds the i.f. transformers, this having a value of the order of 100Ω to 1kΩ."

Smithy scribbled in the resistor on his first circuit diagram. (Fig. 2.)

"What does that resistor do?"

"It reduces the effect of a.m. interference when you're on f.m.," replied Smithy. "It can be helpful, for instance, with impulsive interference such as is given by poorly suppressed car ignition systems. Another dodge you'll encounter occasionally is given by the addition of a point-contact germanium diode across a 10.7MHz i.f. transformer primary in an early i.f. stage of the receiver."

Smithy sketched out a circuit incorporating the diode. (Fig. 3).

"That diode," he continued, "is included to prevent f.m. overload. If a very strong f.m. signal is received it causes the diode to conduct and to limit the amplitude of the signal."

Smithy stopped and turned to look at his assistant.

"All right so far?" he asked.

"Oh, definitely," replied Dick promptly. "I can see quite clearly now how an i.f. amplifier stage can handle both the 470kHz and 10.7MHz intermediate frequencies. I'm not too certain, though, about the overall stage line-up of the complete a.m.-f.m. receiver."

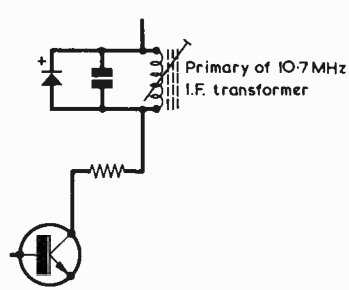


Fig. 3. In some receivers a germanium point-contact diode is connected across the primary of an early 10.7MHz i.f. transformer. The diode prevents overloading by strong f.m. signals

"Then we'll deal with that next." pronounced Smithy, "with the aid of a few block diagrams. After having understood the points we've been talking about up to now you should be able to picture quite easily what each block stands for."

The Serviceman paused for a moment to collect his thoughts, then picked up his pen again.

"It's a little difficult to know where to start here," he confessed. "As I said at the beginning there is rather a wide variance in design between manufacturers of a.m.-f.m. receivers so far as the stage sequences they use for the i.f. section are concerned. I think my best plan will be to show you the two most frequently employed line-ups you're likely to encounter, and these will give you a good insight into the whole business. Here's the first line-up."

Smithy completed a drawing he had started whilst he was talking. (Fig. 4 (a).)

"This will do to commence with," he announced. "At the left hand end of the drawing you have the f.m. front-end, which obtains a supply from the receiver battery on f.m. only. It has an output at 10.7MHz which goes through a 10.7MHz i.f. transformer and, via a second section of the receiver a.m.-f.m. switch, to the a.m. mixer-oscillator transistor. On f.m. this transistor is uncoupled from the a.m. aerial and oscillator tuned circuits, and it functions as the first 10.7MHz i.f. amplifier, its output feeding into the 10.7MHz i.f. transformer which follows it. When the set is switched to a.m., the transistor is disconnected from the first 10.7MHz i.f. transformer and couples into the a.m. aerial and oscillator circuits, which will include the usual ferrite rod aerial coil or coils. The transistor then passes a 470kHz output into the first 470kHz i.f. transformer. The secondaries of the 10.7MHz and 470 kHz i.f. transformers are in series, and these couple into the i.f. amplifier transistor which follows them. This transistor, in turn, works into another pair of series-connected 10.7MHz and 470kHz i.f. transformers. These couple to a further i.f. amplifier transistor, which then feeds into the 10.7MHz ratio discriminator and 470kHz a.m. detector circuits. The outputs of these are selected by another section of the overall a.m.-f.m. switch and are then passed to the a.f. stages of the receiver."

ALTERNATIVE LINE-UP

"There's quite a bit of gubbins in that lot, isn't there?" remarked Dick.

"There is," agreed Smithy. "In fact, a fairly respectable bit of circuitry is involved. Now, let me show you a different approach."

He bent over his note-pad and

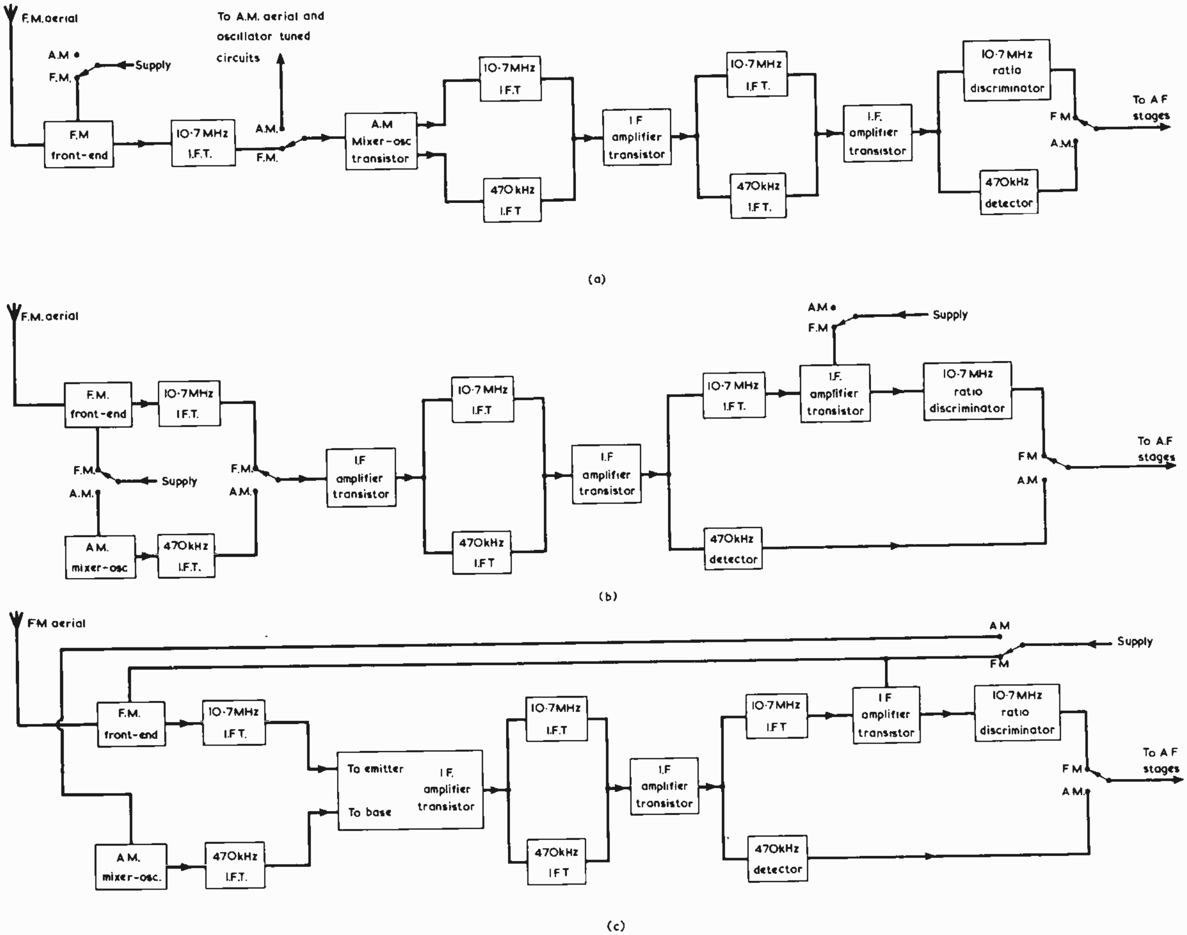


Fig. 4 (a) A common stage line-up employed in a.m.-f.m. receivers
(b) Another frequently used line-up
(c) A line-up, incorporated in some Pye receivers, which requires very simple a.m.-f.m. switching circuits

produced a further sketch. (Fig. 4 (b).)

"This is another basic line-up," he remarked, pointing to the drawing. "Once again we have the f.m. front-end at the left, this working into the first 10.7MHz i.f. transformer. The a.m. mixer-oscillator is also at the left, and this feeds into the first 470kHz i.f. transformer. Either the f.m. front-end or the a.m. mixer-oscillator is brought into operation by applying the supply to it via a section of the receiver a.m.-f.m. switch. Another section of the a.m.-f.m. switch selects the outputs of the 10.7MHz and 470kHz i.f. transformers and applies them to the first i.f. amplifier transistor. This couples into a pair of series-connected 10.7MHz and 470kHz i.f. transformers which, in turn, couple into the next i.f. amplifier transistor. This feeds into a 10.7MHz i.f. transformer and into the 470kHz detector circuit. The 10.7MHz i.f. transformer works into a further i.f. amplifier transistor, which is only switched into circuit on f.m., and thence into a 10.7MHz ratio discriminator circuit. The outputs of the 470kHz detector circuit and the 10.7MHz ratio discriminator circuit are, as before, selected by a section of the a.m.-f.m. switch, and they then pass on to the receiver a.f. stages."

"I see," said Dick, gazing closely at Smithy's drawings. "I note, incidentally, that in both cases there are three transistors in the 10.7MHz i.f. amplifier chain and only two in the 465kHz i.f. amplifier chain."

"That's right," agreed Smithy. "You need a bit more i.f. gain with the 10.7MHz signal than you do with the 470kHz one. Incidentally, I've been talking all the time about sections of the receiver a.m.-f.m. switch. Actually, there won't be a separate a.m.-f.m. switch as such, and the a.m.-f.m. switching will be controlled by the wave-change buttons. These will, in most instances, simply select long waves, medium waves and v.h.f."

Smithy looked again at the two block diagrams he had drawn.

"Most of the a.m.-f.m. sets you'll encounter," he went on, "will have a stage line-up similar to one of the two I've just shown you. There's one interesting variant on the second one, incidentally, and it goes like this."

Smithy tore the top sheet from his pad and drew out a further diagram. (Fig. 4 (c).)

"This is much the same as the second one I showed you," he said, "but there is a difference in the manner in which the f.m. front-end and the a.m. mixer-oscillator couple into the first common i.f. amplifier. Both have their separate first i.f. transformer, and the 10.7MHz one couples into the emitter of the first common i.f. amplifier transistor whilst the 470kHz one

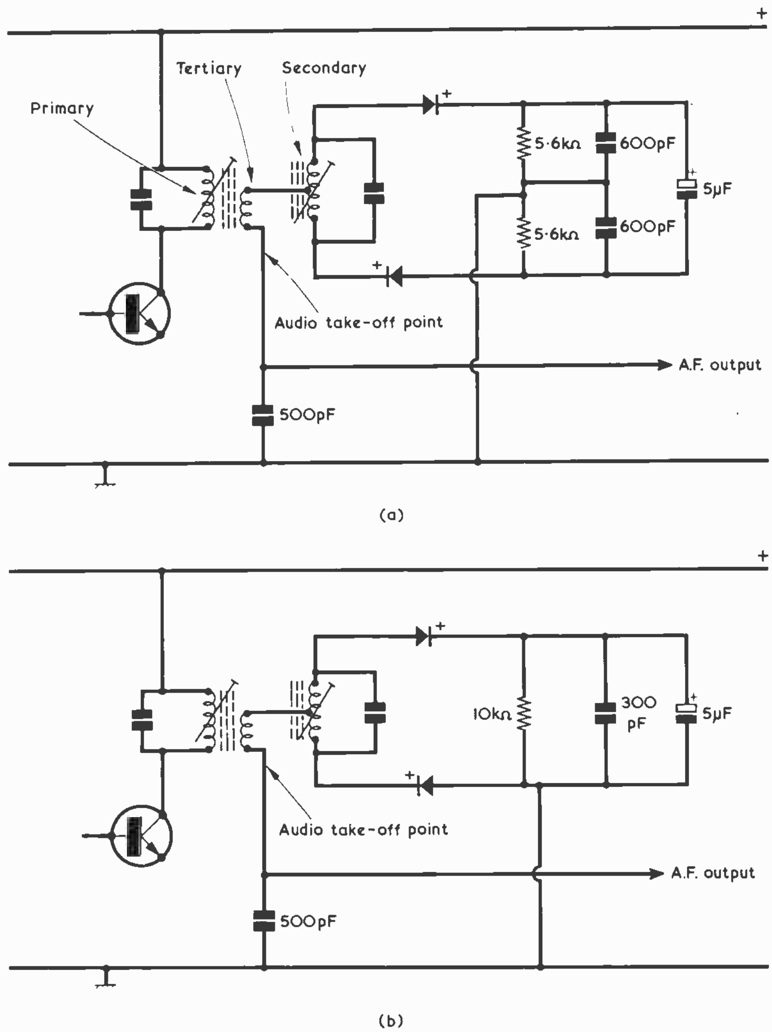


Fig. 5 (a) The basic balanced f.m. ratio discriminator circuit with representative component values
(b) The unbalanced version of the ratio discriminator. Component values are again representative

couples into the base of that transistor. The result is that the f.m.-a.m. switching is delightfully simple. All that is needed is one switch pole to switch the supply between the f.m. front-end and the a.m. mixer-oscillator, and another switch pole to select the output of the f.m. ratio discriminator or the a.m. detector. There is no necessity for the f.m.-a.m. switching to enter the i.f. signal circuits at all."

RATIO DISCRIMINATOR

"Blimey," remarked Dick, impressed. "That *is* neat. Incidentally, you haven't dealt with the a.m. detector and f.m. discriminator circuits yet. How about those?"

"Well," replied Smithy, "the a.m. detector section in these sets is pretty straightforward and uses a single diode in normal fashion. However, the ratio discriminator circuit in more recent receivers is rather different from the earlier ones we used to play with in the past and it mightn't be a bad idea to make this the next subject to deal with."

"The main thing I remember about f.m. ratio discriminators," remarked Dick, "is that the discriminator transformer has what is described as a tertiary winding. That word 'tertiary' used to worry me no end until someone told me that it was only a posh word meaning 'third'!"

Smithy chuckled.

"Some of the terms in electronics *can* be a bit off-putting at first," he agreed. "At any event, and to do a bit of recapping, we need to remember that the basic type of ratio discriminator transformer used to have a primary winding, a secondary winding and that tertiary winding which puzzled you, and it appear in a circuit like this."

Smithy drew out a ratio discriminator circuit on his note-pad. (Fig. 5 (a).)

"Here are your three windings," he remarked. "The primary, the secondary and the tertiary. You'll notice that the signal voltage causes the electrolytic capacitor following the diodes to charge up and this is what gives the ratio detector its inherent a.m. limiting action. If the signal voltage goes up, further current has to flow into the electrolytic capacitor to charge it to the increased voltage. This causes damping of the tuned windings with the result that the increase in signal voltage becomes largely nullified. Similarly, if signal voltage goes down, less charging current has to flow into the electrolytic capacitor and the tuned windings exhibit a higher effective Q, thereby largely compensating for the drop in signal voltage."

"I get it," exclaimed Dick. "Really, I suppose, the tuned windings are damped all the time by the resistance connected across the electrolytic capacitor. If signal voltage goes up, the windings are further damped by the charging current which flows in the electrolytic capacitor, and if signal voltage goes down the windings are less damped."

"That's the idea," said Smithy. "When a ratio detector circuit is set up accurately it gives a surprisingly high level of a.m. limiting. The circuit I've just shown you, by the way, is known as the 'balanced' type of ratio discriminator because of the chassis centre-tap into the resistance across the electrolytic capacitor. When the signal fed to this type of discriminator is at the centre frequency, the output voltage at the audio take-off point is at chassis potential. If the signal frequency is changed in one direction the audio take-off point goes positive of chassis, and if the signal frequency is changed in the other direction the audio take-off point goes negative of chassis. Which is, of course, the result of the circuit's ability to convert changes of frequency to changes of voltage."

"If," put in Dick, "there is a balanced ratio discriminator, can you have an unbalanced one, too?"

"Oh yes," confirmed Smithy. "I'll show you a simple version of the unbalanced ratio discriminator next."

Smithy busied himself once more with his pen, and produced the new circuit. (Fig. 5 (b).)

"Here we are," he remarked. "This is basically the same as the balanced circuit, but the chassis now connects to one end of the electrolytic capacitor and the resistance across it. Since there is no resistive centre-tap, the circuit saves a resistor. It also saves one of the two low-value capacitors across the electrolytic since, for symmetry in the balanced circuit, two equal low-value capacitors were placed across the electrolytic with their junction coupling to chassis."

"Do you really need the single low-value capacitor across the electrolytic in the unbalanced version? Wouldn't the electrolytic be sufficient on its own?"

"You *could* use it on its own," replied Smithy, "but it would be better to leave the lower value capacitor in circuit as well. The latter will normally be a mica or a ceramic component and it will offer a better performance at signal frequency. The unbalanced f.m. discriminator functions in the same manner as the balanced type with the exception that, at centre frequency, the audio take-off point is not at chassis potential but is at a potential which is half of that developed across the electrolytic capacitor. The audio take-off point then goes positive and negative of that potential as the signal frequency varies on either side of the centre frequency."

"Are the more recent ratio discriminator circuits you mentioned just now balanced or unbalanced?"

"You get both types," said Smithy. "It will probably be easier if I start off by showing you an unbalanced type, so here goes."

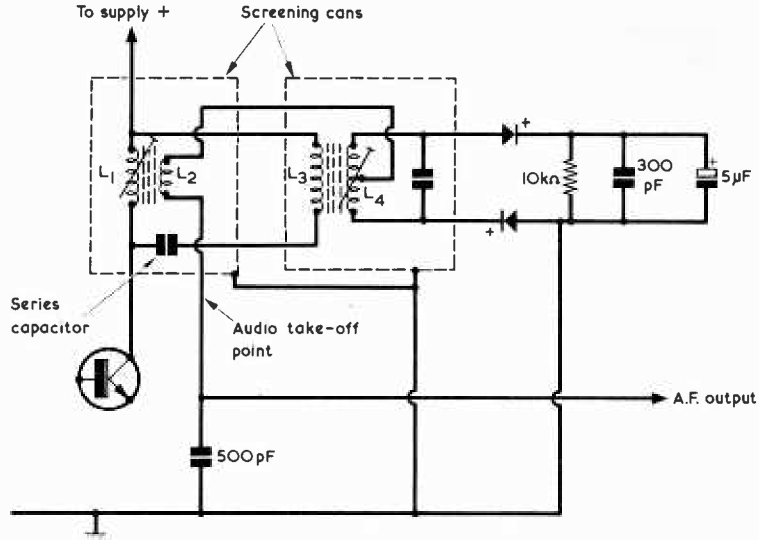
Yet again, Smithy's pen moved briskly over his pad as he sketched out a further circuit. (Fig. 6 (a).)

"It looks," remarked Dick, as he examined Smithy's sketch, "as though the discriminator transformer in this new version of the circuit is split up into two separate sections."

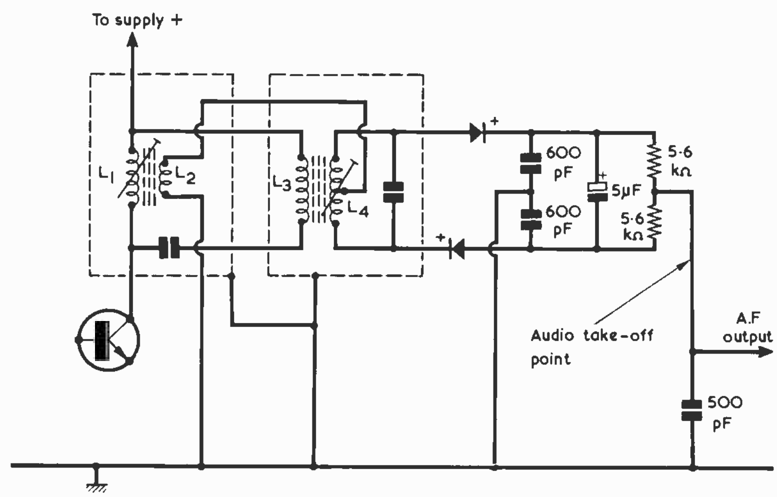
"It is," confirmed Smithy. "What you now have is the primary in one screening can and the secondary in a second screening can. I've marked the individual windings L1 to L4 and, if you examine the circuit, you'll see that it's a fairly obvious development from the earlier type of unbalanced ratio detector. Winding L1 is the same as the original primary and it couples via the series capacitor and L3 to L4, the latter being the same as the original secondary. The centre-tap in L4 connects back to L2, which is the same as the old tertiary winding. The audio take-off point is then given at the lower end of L2."

"This new circuit," remarked Dick, "seems to be pretty well the same as the old one. All that's happened is that the primary and secondary windings have been shifted into separate cans."

"Exactly," confirmed Smithy. "Apart from any other advantages the new circuit may have, it makes it possible to control the inductive coupling between the primary and secondary a little more precisely than in the earlier circuit, where all the windings were on one former. When, in the later circuit, you set up the cores in L1 and L4, the core in L1 is adjusted for maximum voltage across the electrolytic capacitor at the centre signal frequency, and the core in L4 is adjusted so that the potential at the



(a)



(b)

Fig. 6 (a) A modern version of the unbalanced ratio discriminator of Fig. 5(b). Here, and in (b), components have the same representative values as their counterparts in Fig. 5

Fig. 6 (b) A commonly-encountered version of the basic balanced discriminator circuit. In some circuits, the junction of the two equal-value resistors across the electrolytic capacitor connects to chassis, and the audio take-off point appears at the lower end of L2

audio take-off point is half that across the electrolytic capacitor."

"That all seems fair enough," remarked Dick. "Now, what about the new version of the balanced ratio discriminator?"

"I'm drawing it out for you right now," replied Smithy. "I'll be able to show it to you in a jiffy."

Several moments later, Smithy indicated the balanced ratio discriminator circuit to Dick. (Fig. 6 (b).)

"There's something fishy here," said Dick suspiciously. "For a start, the old audio take-off point is now going to chassis."

"Forget that for the moment," advised Smithy, "and just compare the circuit with the one for the unbalanced discriminator. We have the same

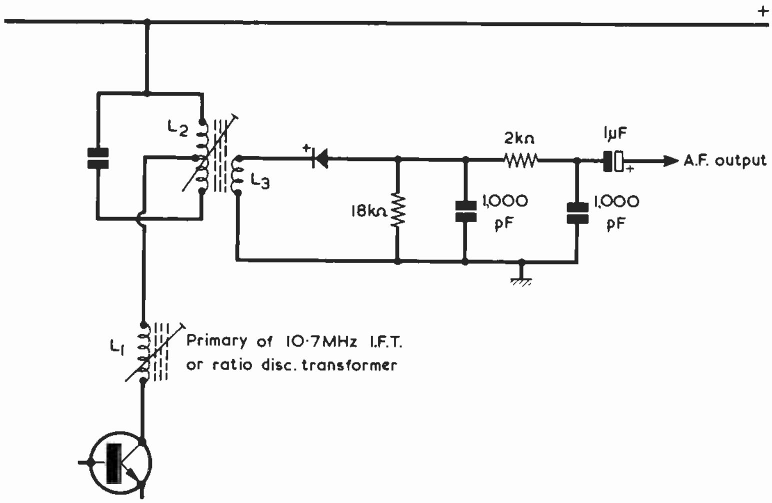


Fig. 7 Simplified circuit illustrating the a.m. detector stage of an a.m.-f.m. receiver

arrangement with windings L1, L2, L3 and L4, and since this is now a balanced discriminator circuit, the electrolytic capacitor has two equal value resistors connected across it to give a resistive centre-tap. Now, as with the earlier balanced ratio discriminator, this centre-tap could connect to chassis and you could get an audio take-off from the lower end of L2. Indeed, this arrangement is used in quite a few sets. But it is more common practice to connect the lower end of L2 to chassis and to take the audio from the resistive centre-tap. All you're doing, then, is to move the reference chassis connection from the resistive centre-tap to the lower end of L2. Got it?"

"Yes, I see what you mean," said Dick, frowning. "I assume that, when this particular circuit is set up, the audio take-off point from the resistive centre-tap is still at chassis potential when the input is at centre frequency."

"It is," confirmed Smithy. "You set up L1 for maximum voltage across the electrolytic capacitor and L4 for chassis potential at the new audio take-off point when a central input frequency is injected. The balanced version of the discriminator circuit is always employed in receivers having automatic frequency control, because the control voltage then swings positive or negative of chassis as receiver tuning is taken either side of the correct position. You'll remember we talked quite a bit about automatic frequency control during our last session."

"Do you," asked Dick, "get any variations in practice from the two discriminator circuits you've just shown me?"

"You'll find a few minor ones," replied Smithy. "For instance, the series capacitor between L1 and L3 is sometimes omitted, and L3 connects directly across part of L1. Or, again, L1 and L3 are in series. But these are simply variations on a readily recognisable basic circuit."

A.M. DETECTOR

"Well, that's fine," said Dick enthusiastically. "There's only one point on these a.m.-f.m. receivers you haven't covered, and that's the a.m. detector circuit itself."

"The a.m. detector circuit won't take long to deal with," commented Smithy. "This part of the set is pretty simple."

For the last time that day, Smithy busied himself at his note-pad to produce his final circuit diagram. (Fig. 7.)

"This is the a.m. detector bit," he announced, pointing at the drawing. "If the receiver has the stage line-up I showed you in the first of my block diagrams, coil L1 here is the primary of the ratio discriminator transformer. And, if the receiver line-up is the same as my second block diagram, coil L1 is the primary of the last 10.7MHz i.f. transformer. The collector of the transistor couples via L1 to a tap in L2, which is tuned to 470kHz. The coupling coil L3 then feeds the a.m. detector diode which, in most receivers, also produces an a.g.c. voltage for a.m. operation as well. And that's all there is to it!"

"Blimey, Smithy," said Dick appreciatively. "You've really given me some useful gen on these a.m.-f.m. sets today. I shan't even ask you any more questions about them!"

"Is that a promise?"

"Only for the time being," said Dick cheerfully. "I wouldn't be at all surprised to find that I have a few questions to ask you on something quite different in the very near future!"

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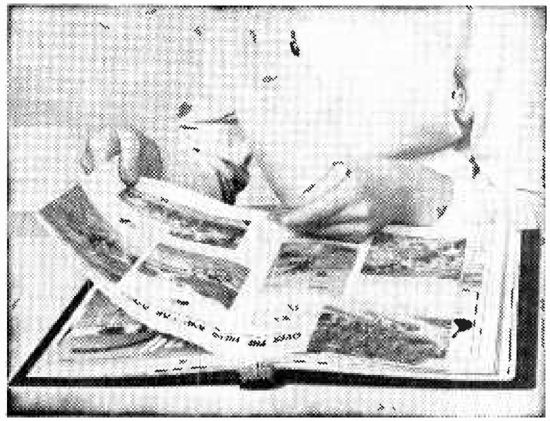

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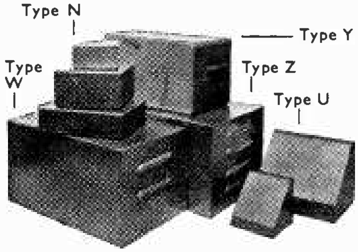

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Millimetre-Inch Table I

Continuing the metrication series, the Table lists inch equivalents to 'round number' millimetre values from 0.5 to 40mm. Inches are given to four significant figures.

mm.	*in.*	*mm.*	*in.*	*mm.*	*in.*	*mm.*	*in.*
0.5	0.01969	8.0	0.3150	15.5	0.6102	26.0	1.024
1.0	0.03937	8.5	0.3347	16.0	0.6299	27.0	1.063
1.5	0.05906	9.0	0.3543	16.5	0.6496	28.0	1.102
2.0	0.07874	9.5	0.3740	17.0	0.6693	29.0	1.142
2.5	0.09843	10.0	0.3937	17.5	0.6890	30.0	1.181
3.0	0.1181	10.5	0.4134	18.0	0.7087	31.0	1.220
3.5	0.1378	11.0	0.4331	18.5	0.7284	32.0	1.260
4.0	0.1575	11.5	0.4528	19.0	0.7480	33.0	1.299
4.5	0.1772	12.0	0.4724	19.5	0.7677	34.0	1.339
5.0	0.1969	12.5	0.4921	20.0	0.7874	35.0	1.378
5.5	0.2165	13.0	0.5118	21.0	0.8268	36.0	1.417
6.0	0.2362	13.5	0.5315	22.0	0.8661	37.0	1.457
6.5	0.2559	14.0	0.5512	23.0	0.9055	38.0	1.496
7.0	0.2756	14.5	0.5709	24.0	0.9449	39.0	1.535
7.5	0.2953	15.0	0.5906	25.0	0.9843	40.0	1.575