Index Vol. 20 Included Free

Vol 20 No 12

JULY 1967

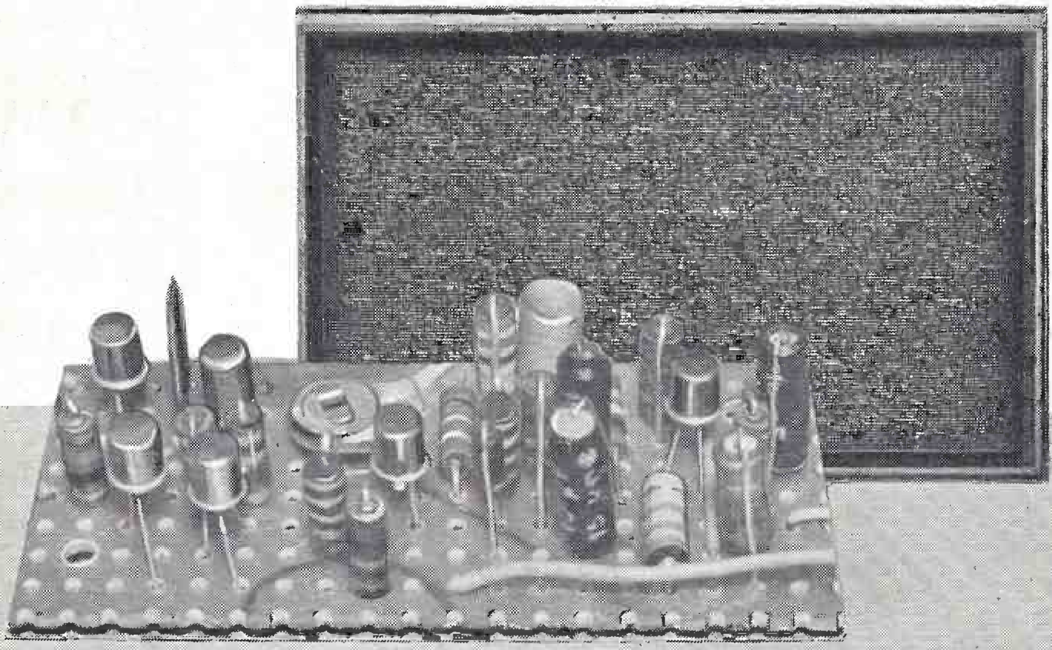
2/6

A DATA PUBLICATION

THE RADIO CONSTRUCTOR

RADIO · TELEVISION
ELECTRONICS · AUDIO

Miniature High Quality 1 Watt Amplifier



Model Control Receiver ★ Transistor Gain Tester ★ Basic Oscilloscope ★ Transistor Portable Receiver

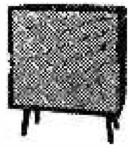
Build HEATHKIT models

Britain's Best in Electronic Kits

No previous experience needed to successfully build any Heathkit model

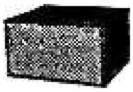
HI-FI—AUDIO

The World-famous COTSWOLD SPEAKER SYSTEM. 3 speakers cover 30–20,000 c/s. Can be driven by as little as 3 watts, handles up to 15 watts. Independent level controls for treble and mid-range speakers. Supplied in "the white". Easy to build. Assembled in a few hours.



Kit £25.12.0. Assembled £33.17.0.

AVON
Low-cost Mini Speaker

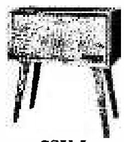


A compact system for bookshelf, wall mounting, etc. 6½" bass, 3¼" treble speakers. Inductor-capacitor cross-over unit. Strong construction, fully finished walnut veneered cabinet. Fast-easy-assembly. Gives best possible performance for 7¼"w x 13½"h x 8½"d size box. Supplied in two parts:

Total Price Kit £13.16.0 inc. P.T.

Loudspeaker System, SSU-1
Build-it-yourself in an evening, finish it to match your own furnishings. Two specially designed speakers. Use vertical or horizontal. Dims: 11½"h x 23"w x 11¾"d.

Kit £11.17.6 inc. P.T.
Set of legs (7" or 15") 14/6 extra.



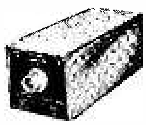
SSU-1

3+3W Transistor Stereo Amplifier, TS-23.
Has all the essential features for quality sound reproduction from records, radio and other sources. 16 transistor, 4 diode circuit. Good frequency response. 3 watts (15 ohms) output per channel. 6 position selector switch. P.C.B. construction. Separate bass, treble, balance and volume controls. Modern styling.
Kit £17.15.0
Beautiful walnut veneered cabinet £2 extra.

Valve FM TUNER, FM-4U
7 valve circuit. Self-powered. Fly-wheel tuning. Comprises pre-assembled RF Unit (£2.15.0 inc. P.T.) IF Amplifier, power supply, valves, case, etc. £13.13.0. For free standing or cabinet mounting.

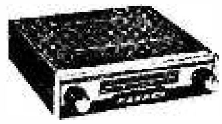
Total Price Kit £16.8.0.

STEREO DECODER, SD-1
Converts Heathkit or similar tuners to stereo.
Kit £8.10.0. Assembled £12.5.0.



TRANSISTOR RADIOS

Complete your motoring pleasure with this outstanding CAR RADIO, Model CR-1



8 latest semi-conductors for 12 volt positive or negative earth systems. Powerful 4 watts output. Pre-assembled and aligned tuning unit. Push-button tone and LW, MW selection. Printed circuit assembly. Tastefully styled—will harmonise with any car colour scheme. Output stage will operate up to two loudspeakers. Dim: 6¾"w x 2¼"h x 6¼"d. Available for your convenience in two units. RF Amplifier kit CR-IT £1.13.6 inc. P.T. IF/AF Amp kit CR-IA £11.3.6. **Total Price Kit £12.17.0** inc. P.T.
6" x 4" Loudspeaker £1.4.5 extra.

OXFORD LUXURY PORTABLE, UXR-2
10 semi-conductors. Large 7" x 4" speaker for big-set sound. Battery economiser circuit. Push-button L/M wave and tone selection. Pre-aligned I.F. transformers. Leather case and handle.
Kit £14.18.0 inc. P.T.

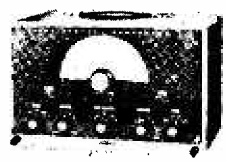
UXR-2

Low-cost Portable, UXR-1
7 semi-conductors. L/M wave coverage. Leather case. **Kit £12.11.0** inc. P.T.

Junior Transistor Radio, UJR-1
For earphone operation (optional extra) external aerial, etc., **Kit £2.7.6** inc. P.T.

TEST INSTRUMENTS

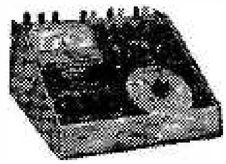
Sine/Sq GENERATOR, IG-82U
20 c/s–1 Mc/s in 5 bands <0.5% sine wave distortion. <0.15 μsec. square wave rise time. Sine and sq. wave outputs available simultaneously. Modern attractive styling. Dimensions 13"w x 8½"h x 7"d.
Kit £25.15.0. Assembled £37.15.0.



IG-82U

Multimeter, MM-1U
Sensitive 50μA 4½" meter. 22 voltage, current and resistance ranges. 20,000 ohm/volt d.c., 5,000 ohm/volt a.c. sensitivities.

Kit £12.18.0. Assembled £18.11.6 inc. test leads.



Transistor Tester, IM-30U
Provides complete dc analysis of PNP, NPN transistors, etc. Four lever switches for fast, easy, test selection.
Kit £23.18.0.
Assembled £36.10.0.

RF Signal Generator, RF-1U
Ideal for service workshop. 100 kc/s–200 Mc/s coverage.
Kit £13.18.0. Assembled £20.8.0.

SERVICE TOOL KIT, TK-2
Includes soldering iron, pliers, screwdrivers, etc. **£4.6.6**

Mail order prices quoted include Free delivery (UK)

Send for this Catalogue . . .
. . . it's FREE!
32 pages packed with Britain's largest selection of electronic Kits.
Mail coupon or write:
DAYSTROM LTD., Dept. RC-7 GLOUCESTER. Tel. 20217.

To **DAYSTROM LTD., GLOUCESTER**
Please send me **FREE BRITISH CATALOGUE** ☐
Please send me details of models ☐
....
NAME ....
ADDRESS ....
.... RC-7

Please send a Catalogue to my friend
Name ....
Address ....
.... RC-7

SEE HEATHKIT MODELS IN LONDON, 233 Tottenham Court Road, W.1. Tel. 01-636-73-49

BI-PAK SEMICONDUCTORS

8 RADNOR HOUSE
93/97 REGENT STREET
LONDON, W.1

TUNNEL DIODES 15/– EACH AEY11 IN3720

UNIJUNCTION TRANSISTORS 15/– EACH 2N2160 2N2646

6. 2N2926 SPECIAL OFFER 20/–

TRANSISTOR MANUAL BY G. E.
CIRCUITS, APPLICATIONS, CHARACTERISTICS, THEORY.
647 PAGES
30/- EACH P.P. 2/6

S.C.R. MANUAL BY G. E.
INC. L.A. S.C.R'S. G.T. SWITCHES, THEORY, RATINGS, APPLICATIONS.

FAIRCHILD
BRAND NEW FROM U.S.A.
8 LEAD — EPOXY CASE
RTμL MICROLOGIC

COMPLETE DATA AND CIRCUITS SEND 1/6. OR FREE WITH ALL IC ORDERS

μ L 900 "Buffer"	19/6
μ L 914 "Gate"	19/6
μ L 923 "J.K." (FLIP-FLOP)	35/–

THESE DEVICES OPEN UP A WHOLE NEW CONCEPT in the WORLD of ELECTRONICS
"INTEGRATED CIRCUITS"

Our vast stocks change daily with hundreds of Semiconductor bargains becoming available. Just send 2/6 to cover 3 months mailing of our latest stock lists, eqvt. charts, circuits, etc.

NEW TESTED VALUE PAKS

3 OC139 Trans. NPN Mullard	10/–
2 Drift Trans. 2N1225 100 M/Cs PNP	10/–
6 Matched Trans. OC44/45/81/81D	10/–
4 OA10 Diodes Mullard	10/–
15 Red Spot AF Trans. PNP	10/–
15 White Spot RF Trans. PNP	10/–
4 Sil. Rects. 3A 100/400 PIV	10/–
4 High Current Trans. OC42	10/–
2 Power Trans. OC26/35	10/–
5 Sil. Rects. 400 PIV 250mA	10/–
3 OC71 Trans. Mullard	10/–
3 OC75 Trans. Mullard	10/–
2 10 Amp. Sil. Rect. 50/100 PIV	10/–
8 Diodes OA70	10/–
1 5 AMP SCR 100 PIV	10/–
3 Sil. Trans. 2S303 PNP	10/–
5 GET884 Trans. eqvt. OC44	10/–
10 Assorted Computer Diodes	10/–
4 Zeners 5, 12 Volts. Mixed	10/–

FREE One 10/– Pack of your own choice free with orders valued £4 or over **FREE**

4 2G417 Trans. eqvt. AF116/117	10/–
2 200 M/Cs Sil. Trans. BSY26/27	10/–
5 OA47 Gold Bonded Diodes	10/–
4 OA202 Sil. Diodes Sub-Min.	10/–
3 OC77 Trans. Mullard	10/–
8 OA81 Diodes CV448	10/–
3 High volt. AF Trans. PNP ACY17	15/–
3 BSY95A Sil. Trans. STC	15/–
3 Sil. Trans. OC200 Mullard	15/–
2 Sil. Power Rect. 6 Amp. 200 PIV BYZ13	15/–
1 AF139 GERM. Trans. 1500 M/Cs	15/–
1 Sil. Power Trans. 100 M/Cs TK201A NPN	15/–
6 Zener Diodes 3–15 Volts. Mixed 400mW	15/–
5 OA5 Gold Bonded Diodes Mullard	15/–
1 2N1132 PNP PLANAR Trans. Sil	15/–
2 2N697 NPN PLANAR Trans. Sil	15/–
4 GERM. Power Trans. eqvt. OC16 Mullard	15/–
6 Sil. Rect. Type BY100 800 PIV 550mA	20/–
4 BC108 Sil. Trans.	20/–

Minimum Order 10/–. CASH WITH ORDER PLEASE Add 1/– postage and packing per Order. GUARANTEED by return postal service. Overseas add extra for Airmail.

★ — VALUE PAKS — ★
★ EXTENDED RANGE ★
★ NEW — UNTESTED ★

120	GERM. SUB-MIN.	DIODES	10/-
50	MIXED	TRANSISTORS	10/-
16	SILICON 750mA TOP-HAT	RECTIFIERS	10/-
20	ALL TYPES MIXED VOLTS	ZENERS	10/-
25	SIL. NPN 200 Mc/s	TRANSISTORS	10/-
10	STUD. 2 AMP	SILICON RECT.	10/-
30	NPN MIXED SILICON	TRANSISTORS	10/-
60	SILICON 200 mA	DIODES	10/-
40	ZENERS RECTIFIERS MIXED	TOP HAT	10/-
20	1 AMP GERM. UP TO 300 PIV	RECTIFIERS	10/-
40	LIKE OC81 AC128	TRANSISTORS	10/-
10	50-400 PIV 1 AMP	SCR's	20/-

Fast Mail Order for the Amateur Radio Enthusiast!

AERIAL EQUIPMENT

TWIN FEEDER. 300 ohm twin ribbon feeder similar K25, **8d.** per yard. 75 ohm twin feeder, **6d.** per yard. Post on above feeders and cable, 2/- any length.

COPPER WIRE. 14G, H/D, 140 ft., 30/-; 70ft., 16/-. Post and packing 3/3. Other lengths pro rata.

FEEDER SPREADERS. 6" Ceramic type F.S., **10d.** each. Postage 2/6 up to 12.

CERAMIC CENTRE PIECE for dipoles, Type AT, **1/6** each. P. & P. 1/-.

2 METRE BEAM, 5 ELEMENT W.S. YAGI. Complete in box with 1" to 2½" masthead bracket. Price **56/-**. P. & P. 4/-.

SUPER AERAXIAL. 70/80 ohm coax. 300 watt very low loss, **2/3** per yard. 50 ohm 300 watt, **2/6** per yard. P. & P. 2/6.

TOUGH POLYTHENE LINE, type ML1 (100lb.), **2d.** per yd. or **12/6** per 100 yds. Type ML2 (220lb.), **4d.** per yd. or **25/-** per 100 yds., ML4 (400lb.), **6d.** per yd. ideal for Guys, L.W. Supports, Halyards, etc. Postage 1/6 on all line.

MIDLAND AGENTS FOR

EDDYSTONE

Receivers & Components

Transmitters, Receivers and Sundry Equipment by

- **KW ELECTRONICS**
- **GREEN E.C.E.**
- **T.W. ELECTRONICS**
- **CODAR RADIO**
- **C.S.E.**

NEW BOXED VALVES
3/6 each, 4 for 10/-. P. & P. 2/-.

TYPES

6N7GT	6SF7	6AB7	6SH7
6AC7	6F7	6SK7	956
6K7			

ABSORPTION WAVEMETERS, 3.00 to 35.00 Mc/s in 3 Switched Bands. 3.5, 7, 14, 21 and 28 Mc/s. Ham Bands marked on scale. Complete with indicator bulb. A MUST for any Ham Shack. ONLY **25/-** EACH. Post free.

SHADED POLE MOTORS. Suitable for fans or blowers, 240 volts 50 c/s. **12/6** each. P. & P. 3/–.

VARIABLE CONDENSERS. All brass with ceramic end plates and ball race bearings. 50pF, **5/9**; 100, **6/6**; 160, **7/6**; 240, **8/6**. Extension for ganging. P. & P. 2/-.

SEALED RELAYS, 12v. 105Ω Coil Type A. 4 Pole, C.O. **15/-**. Type B.2 Pole, C.O. + 2 Pole Norm. on, **12/6**. P. & P. 1/6.

AMATEUR RADIO
CHAS. H. YOUNG LTD.

At your service **G2AK, G3LAY, G3VFV**
Please print your address. No. C.O.D. under £1.

The Widest Range in the Midlands
★ **HIRE PURCHASE**
★ **PART EXCHANGE**

'phone 021-236 1635

Chas. H. YOUNG Ltd.
170-172 Corporation Street, Birmingham 4

ARE YOU A PRO — HAM—OR—DABBLER?

NO MATTER WHICH—WE CAN HELP YOU!

LOOK — 100's of Bargain Packs to choose from

LARGE RANGE—LOW PRICE
SILICON CONTROLLED RECTIFIERS. SEND FOR FULL RANGE AND CIRCUIT DIAGRAMS.
FREE OF CHARGE

No.		PRICE
A1.	6—Silicon rectifiers BY100 type ...	20/–
A2.	10—Relays, mixed types and voltages ...	20/–
A3.	20—Mixed, marked and tested trans. ...	20/–
A7.	1—500 Mc/s epitaxial mesa. PNP 2N700	20/–
A8.	6—Sub. min zeners, 3.6–15V, 400mW	20/–
A9.	1—2N174 real power trans. 80V, 150W	20/–
A12.	1—High power, high volts, 2S024, 100V, 100W	20/–
A13.	25—Assorted trans. and diodes, all new	20/–
A14.	4—2N601 p/trans. germ. 30V, 10 Mc/s	20/–
B1.	50—Unmarked, untested, trans. new ...	10/–
B2.	4—Solar cells, inc. Book of ins. ...	10/–
B3.	4—OA5 gold bonded diodes, Mullard	10/–
B5.	7—Matched set, OC44/45/81D/81 + diode	10/–
B8.	2—Power trans. OC26/35 type ...	10/–
B9.	1—Light sensitive cell, ORP12 type ...	9/–
B11.	2—Comp. air, AC128, AC176	10/–
B13.	7—BA115 G.B. diodes T.V. video ...	10/–
B15.	8—Bi-directional trans., ASY66 ...	10/–
B20.	4—Assorted NPN trans., TO-5, TO-18	10/–
B32.	4—1 amp. recs. 200/300PIV	10/–
B33.	10—Germ diodes, assorted types ...	10/–
B34.	8—Silicon diodes, assorted types ...	10/–
B35.	2—2 zener diodes 1½W., 7 and 10 volts	10/–
B36.	10—Gold bonded, diodes, assorted ...	10/–
B41.	3—2G339A NPN audio, texas	10/–
B42.	5—TK22C germ. switching trans. ...	10/–
B43.	4—IS100 sil. recs. 100 PIV, ¾ amp ...	10/–
B44.	1—Tunnel diode AEY11, 1050 Mc/s, 5mA	10/–

FANTASTIC! Bargains of the Year

OC45 IF TRANSISTOR **1/9** **OA9** EQUAL TO OA5 **2/-**
OC44 OSCILLATOR TRANSISTOR **1/11** **OC36** POWER TRANSISTOR **7/6** MUCH BETTER THAN OC35
GENUINE TRANS. NOT REMARKS

FREE PACKS OF YOUR OWN CHOICE UP TO THE VALUE OF 10/– WITH ALL ORDERS OVER £4

FREE A WRITTEN GUARANTEE WITH ALL OUR SEMICONDUCTORS

SCOOP PURCHASE!

Pre-assembled logic elements. 2 input gates 2/–. 3 input gates 2/9. Flip Flops and others 5/– each. Send for more details.

FIRST EVER LOGIC KITS. Learn for yourself how computers work, even make one for yourself. Full instructions for a noughts and crosses machine, binary counters, timers, etc. L.1. **5 gns.** L.2. **10 gns.** No need to purchase both kits, you can start with L.2. which incorporates L.1. DETAILS FREE.

MAKE A REV. COUNTER FOR YOUR CAR. THE 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a perfectly linear and accurate rev. counter for any car. State 4 or 6 cylinder. **20/– each**

NO CONNECTION WITH ANY OTHER FIRM. MINIMUM ORDER 10/– CASH WITH ORDER PLEASE. Add 1/– post and packing per order. OVERSEAS ADD EXTRA FOR AIRMAIL.

SEND FOR OUR **FREE** LISTS AND CATALOGUE OF OUR PRODUCTS. CHECK YOUR OWN EQUIVALENTS WITH OUR FREE SUBSTITUTION CHART.

No.		PRICE
C1.	15—50 volt. trans., germ, switching ...	15/–
C2.	1—Uni junction, 2N2160 or equiv. ...	15/–
C3.	5—Audio kit, NKT278/275/271/173 + diode	15/–
C4.	2—RF. power trans., OC22 and BUY11	15/–
C5.	2—Sil. power recs. 200PIV, 6 amp ...	15/–
C6.	5—Sil. recs., ¾ amp, 100/200PIV ...	15/–
C9.	2—100/60V, sil, trans., 200 Mc/s, ZT84/86	15/–
C14.	2—3 watt planar, 2N1613, 2N1893 ...	15/–
C15.	4—Sil. trans., in the 2S300 series ...	15/–
C16.	1—Sil. power 85 watts, 2S721 series ...	15/–
C17.	2—60v. 160 Mc/s TO-18, 2S103/4 ...	15/–
C18.	1—2N1132 sil. plana, pnp trans. ...	15/–
C20.	3—Germ. NPN trans., 2N1302/4/8 ...	15/–
C21.	3—Germ. pnp trans., 2N1303/5/7/9 ...	15/–
C22.	1—300 Mc/s trans. ASZ21, Mullard ...	15/–
C23.	1—35 amp sil. rec., 100PIV, stud ...	15/–
C25.	2—Power trans., germ., OC28/29 type	15/–
C27.	4—800PIV, 500mA, sil. recs., STC ...	15/–
C28.	5—Sil. recs., 400PIV, ½ amp	15/–
C29.	1—200 Mc/s low noise trans., AFZ12 ...	15/–
C30.	2—Sil. trans., narrow gain spread BCZ11	15/–
C31.	4—Sil. recs. 800 PIV, ¾ amp	15/–
D1.	25—½W hi-stab, resistors mixed ...	5/–
D3.	3—Germ. diodes, OA70, OA79, OA81	5/–
D4.	2—Sil. recs., Sub. min., 400/600PIV 400mA	5/–
D7.	2—Zener diodes, 5 1V, 250mW ...	5/–
D9.	10—Assorted capacitors, all types ...	5/–
D10.	20—Transistor heat sinks	5/–
D14.	3—Low imp. earphones, less plugs ...	5/–
E1.	2—2N458 matched power trans., 150V, 80W	30/–

TRANSISTORS	PRICE
AC107	6/–
AC126	2/6
AC127	2/6
AC128	3/–
ACY17	5/–
AF114	4/–
AF115	3/–
AF116	3/–
AF117	4/–
AF118	3/6
AF119	3/6
AF178	10/–
ASY66	2/–
BCZ11	5/–
BFY50	15/–
BSY25	10/–
BSY26	5/–
BSY27	5/–
BSY28	5/–
BSY29	5/–
BSY95A	5/–
OC41	2/6
OC71	2/6
OC72	2/6
OC73	5/–
OC81	2/6
OC81D	2/6
OC83	4/–
OC139	2/6
OC140	5/–
OC170	2/6
OC171	4/–

TRANSISTORS	PRICE
OC200	5/–
OC201	8/–
2G301	2/6
2G303	2/6
2N697	5/–
2N706	5/–
2N711	10/–
2N1302	4/–
2N1303	4/–
2N1304	5/–
2N1305	5/–
2N1306	6/–
2N1307	6/–
2N1308	8/–
2N1309	7/6
2S303	2/6
POWER TRANSISTORS	
OC20	10/–
OC23	10/–
OC25	8/–
OC26	5/–
OC28	5/–
OC35	5/–
DIODES	
AAY42	2/–
OA10	2/–
OA70	1/9
OA79	1/9
OA81	1/9
OA182	2/–
IN914	1/6

EXCITING NEW PACKS!

B45.	1—Power trans. ADY22/TK400A VCB60 IC 8 amps. PNP	10/–
B47.	10—Sil stud recs. 3 amps unmarked, untested	10/–
B49.	2—Power trans. GET 9 VCB64 IC 8 amps. germ. PNP	10/–
B50.	2—Light sensitive cells ORP60 type	10/–
B52.	30—Trans. all new, factory tested but unmarked	10/–
C31.	4—Sil. recs. 800 PIV ¾ amp. top hat ...	15/–
C32.	2—Power trans. TK400A/NKT404 VCB64 IC 8 amps.	15/–
A17.	3—Sil. stud recs. 6 amps. 400 PIV. BYZ12	20/–
A18.	2—Sil. stud recs. 10 amp. 800 PIV. ...	20/–
A20.	1—AUY10 VHF power trans. 60 Mc/s 70V	20/–

PRE-PAK SEMICONDUCTORS

DISTRIBUTED EXCLUSIVELY BY

DAVIS & WHITWORTH LTD., DEPT. E.
222-224 WEST ROAD, WESTCLIFF-ON-SEA, ESSEX
PHONE: SOUTHEND (0702) 46344

SUPPLIERS TO SCHOOLS—H.M. GOVT. INSTITUTES AND FACTORS

THE **Radio Constructor**

Incorporating THE RADIO AMATEUR

JULY 1967

Vol. 20, No. 12

Published Monthly (1st of month)

Editorial and Advertising Offices
57 MAIDA VALE LONDON W9

Telephone CUNningham 6141

Telegrams Databux, London

Annual Subscription 36s. (U.S.A. and Canada $5) including postage. Remittances should be made payable to "Data Publications Ltd". Overseas readers please pay by cheque or International Money Order.

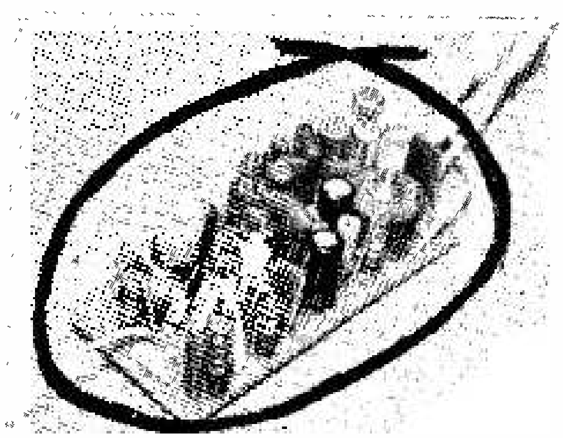
Queries. We regret that we are unable to answer queries other than those arising from articles appearing in this magazine nor can we advise on modifications to equipment described. Queries should be submitted in writing and accompanied by a stamped addressed envelope for reply.

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

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

Production.—Letterpress/contact litho.

Published in Great Britain by the Proprietors and Publishers
Data Publications Ltd. 57 Maida Vale London W9
Printed by A. Quick & Co. (Printers) Ltd.
Clacton-on-Sea England



The SCT/RR1 Super-Regenerative Model Control Receiver

This article gives full constructional details of a super-regenerative receiver designed for model control in conjunction with the single channel tone transmitter described last month. A future issue will feature a superhet receiver employing transfilters which may also be used with the transmitter.

FOLLOWING THE DESCRIPTION OF THE SCT/T1 single channel tone transmitter, we deal now with the first of two alternative receiver systems, which have been specially designed for use in conjunction with the SCT/T1. This month's receiver is of the super-regenerative type, and features high sensitivity, good interference rejection, a tuned filter relay-less output stage, and a five transistor circuit. A future issue will describe the alternative superhet circuit, which employs transfilter i.f. stages and thus presents no lining up problems.

Circuit Of The SCT/RR1

The full circuit diagram of the SCT/RR1 is shown in Fig. 1. Dealing with the circuit in detail, the super-regenerative detector section is made up of TR_1 in conjunction with the biasing network given by R_1, R_2, R_3 and C_2, the tuned collector circuit L_1, C_3, and the feedback components C_5, C_6 and the r.f. choke. The input signal from the antenna (aerial) is fed to TR_1 collector via C_4[1].

The detector circuit is maintained in a permanent state of oscillation at a fairly high frequency by the built-in feedback network, and this high frequency signal appears at large amplitude across R_3. In the absence of a carrier signal at the antenna the sensitivity of the circuit is very high and atmospheric "noise" is picked up and amplified by TR_1, this noise appearing in demodulated form across R_3 together with the high frequency signal. Thus, in the absence of a carrier signal, the signal across R_3 will comprise a large high frequency signal mixed with "noise" of smaller amplitude.

If, now, a fairly strong but unmodulated carrier signal is received at the L_1–C_3 tuned frequency (approx. 27 Mc/s), the sensitivity of the circuit will be reduced by a.g.c. action, while at the same time the carrier will be demodulated by the rectifying action of TR_1. Since sensitivity has been reduced and the detected carrier contains no a.f., the "noise" signal will cease to appear across R_3, leaving the high frequency signal only.

Finally, if the carrier *is* modulated, a.g.c. action will again eliminate the noise signal from appearing across R_3, but in this case the "noise" will be

[1] The "1 amp TV choke" specified in the Components List for the r.f. choke is a small Radiospares component (0.56in long by 0.18in diameter) intended for TV suppression, and it has a nominal inductance of 5μH and a natural resonant frequency of 55–65 Mc/s It should be noted, incidentally, that Radiospares components may only be obtained through retailers.—Editor.

Basic Radio Control (6)

by F. L. Thurston

COMPONENTS

Resistors
(All $\frac{1}{4}$ watt 5%)

R_1	22kΩ
R_2	6.8kΩ
R_3	6.8kΩ
R_4	12kΩ
R_5	5.6kΩ
R_6	5.6kΩ
R_7	2.2kΩ
R_8	10kΩ
R_9	470Ω
R_{10}	27kΩ
R_{11}	10kΩ
R_{12}	330Ω
R_{13}	1kΩ

Inductors

L_1 =$9\frac{1}{2}$ turns 24 s.w.g. e.c.w. on Radiospares 0.27in dia. former with iron-dust core
L_2 =FX2236 pot core with wound bobbin (Teleradio)
R.F.C. =1 amp TV choke or small r.f. choke

Capacitors
(All sub-miniature types, 12V wkg. or greater)

C_1	16μF electrolytic
C_2	1μF electrolytic
C_3	33pF silver mica, 1%
C_4	12pF polystyrene
C_5	12pF polystyrene
C_6	0.002μF Mylar
C_7	0.01μF Mylar
C_8	8μF electrolytic
C_9	0.05μF Mylar
C_{10}	0.005μF Mylar
C_{11}	16μF electrolytic
C_{12}	1μF electrolytic
C_{13}	0.02μF Mylar, *not* ceramic (see text)
C_{14}	0.05μF Mylar
C_{15}	1μF electrolytic

Semiconductors

TR_1, TR_2, TR_3=ST141 (Sinclair)
TR_4, TR_5=2G381 (Texas) or NKT218
D_1=0A200 or 1S940, silicon

Miscellaneous

Veroboard panel ($1\frac{1}{8} \times 2\frac{5}{16}$in or greater) with 0.1in matrix (11 strips by 25 holes or more)
30in flexible antenna (aerial) wire
Radiospares 0.27in dia. coil former with iron dust core
9-volt battery
Connecting wire, insulated sleeving, battery connectors, etc.

Note: All components are available from Teleradio Electronics, 325/7 Fore St., London, N.9
Teleradio Electronics is making available a complete kit of components for this receiver

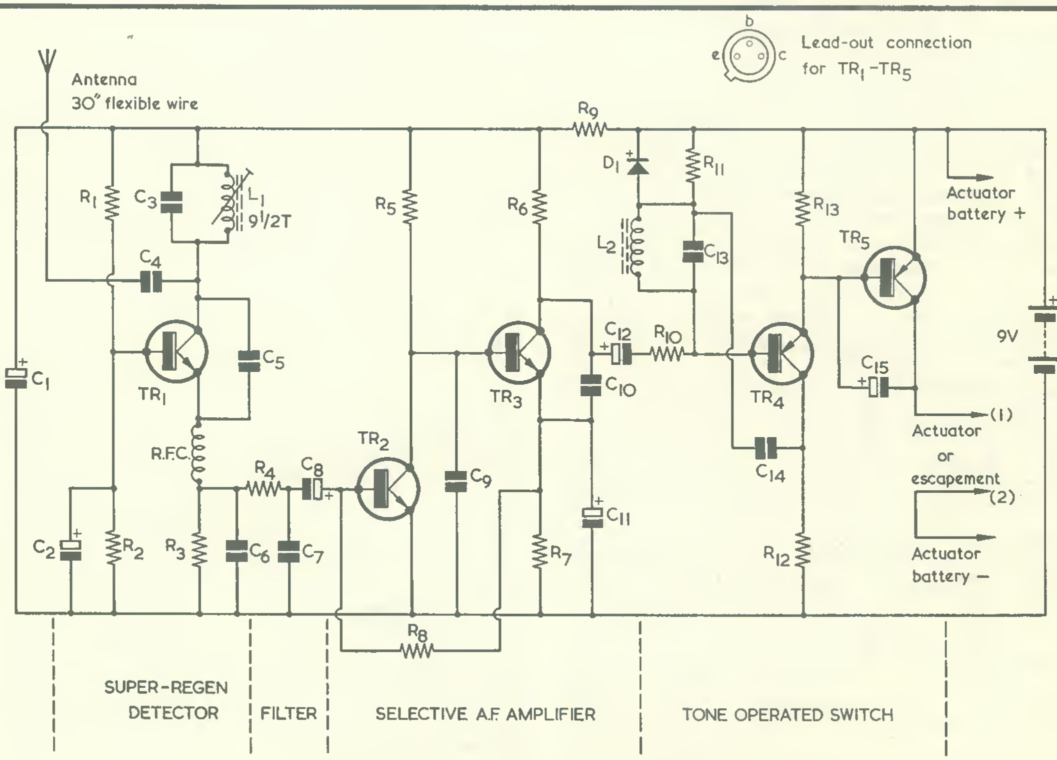


Fig. 1. The circuit of the SCT/RR1 super-regenerative receiver

replaced by the a.f. signal resulting from demodulation of the carrier, this a.f. being of small amplitude relative to the high frequency signal.

Now, of the different signals that appear across R_3, the high frequency signal is of large amplitude but is not wanted, while the a.f. tone signal is of small amplitude but *is* wanted. (The "noise" signal can be ignored.) Our design problem, then, is to amplify the a.f. up to a level at which it is useful, whilst at the same time eliminating the unwanted high frequency component. In Fig. 1 this is achieved by first passing the complex signal from R_3 through the filter network given by R_4 and C_7, which attenuates the high frequency but not the a.f. signal, and then passing the modified signal on to the direct coupled amplifier (TR_2 and TR_3) via C_8.

TR_2 and TR_3 give a high degree of amplification to the a.f. part of the modified input signal, but at high frequencies the amplifier gain is greatly reduced by the collector bypass capacitors C_9 and C_{10}, so that the high frequency part of the signal is virtually eliminated. The a.f. signal finally appearing at TR_3 collector is therefore a faithful reproduction of the a.f. tone modulation signal applied at the transmitter. This a.f. tone signal is used to operate the electronic switch circuit given by TR_4 and TR_5, via C_{12} and R_{10}.

The operation of the tone switch is fairly involved, and is best explained in stages. L_2 and C_{13} form a parallel tuned circuit operating at the tone modulation frequency; this tuned circuit presents a high impedance at its operating frequency and a low impedance at all other frequencies. The tuned circuit is effectively wired in series with R_{10}, which has a fairly high value, and the input audio signal from TR_3 collector is applied across this series combination. At the same time, the junction of R_{10} and the tuned circuit is connected to the base of TR_4, so that the series circuit forms a frequency sensitive voltage divider network with its output taken to TR_4 base. Thus, at the tuned frequency the impedance of the tuned circuit will be high and almost the full input signal will be applied to TR_4 base, while at all other frequencies the tuned circuit will present a low impedance so that, through potential divider action, only a negligible part of the input signal will reach TR_4 base.

TR_4 is connected in the common emitter configuration, but has its base clamped to "ground" (the positive supply line) via the d.c. path given by L_2 and R_{11}, so that the transistor is normally biased off. When, however, the input tone signal is presented to its base (at the tuned frequency) the transistor is made to conduct by the negative-going parts of the input signal; amplifying action takes place, and an amplified version of the signal then appears at TR_4 collector. This amplified signal is fed back via C_{14} to the junction of the tuned circuit and D_1–R_{11}, and the diode then rectifies this signal, with the result that a d.c. negative bias appears across D_1–R_{11}. This bias is fed via the d.c. path of L_2 to the base of TR_4, thereby biasing TR_4 on as far as d.c. is concerned and consequently improving the amplifying action of the transistor. As a result of the improved amplifying action of the circuit, a larger signal appears at TR_4 collector, and is fed back to D_1, thereby increasing the d.c. bias even more and giving even greater amplifying action. As may be seen, a semi-regenerative action takes place, and TR_4 is driven sharply on at the tuned frequency of L_2 and C_{13}.

Once TR_4 has switched on, a fairly large d.c. potential appears across R_{13}, together with an a.c. signal. This d.c. potential is fed to the base of TR_5, which is wired in the common emitter configuration, and drives this transistor hard on. An external escapement may be connected as the collector load of TR_5. A certain amount of amplification of the a.c. input signal also tends to take place. Any a.c. signal appearing at TR_5 collector is, however, fed back to TR_5 base via C_{15}. So far as TR_5 is concerned, the a.c. feedback signal is negative and degenerative, so that only a negligible a.c. appears in fact at TR_5 collector, and the transistor acts almost purely as a d.c. switch. The TR_5 output transistor is fed by its own battery supply, which is selected to suit the particular escapement in use, and can handle currents up to 0.5A for very brief periods, 300mA for moderately long periods, or 100mA for indefinite periods.

The major part of the receiver is powered by its own 9-volt supply, R_9 and C_1 being used to decouple TR_4 from TR_1, TR_2 and TR_3. TR_1, TR_2 and TR_3 are silicon planar n.p.n. type transistors, while TR_4 and TR_5 are p.n.p. germanium types.

Construction

The receiver, which measures $2\frac{9}{16}$ x $1\frac{1}{8}$ x $\frac{1}{4}$in, is built on a small piece of Veroboard with 0.1in hole spacing. It is important to note that this is a far smaller matrix than is normally used.

Start construction by cutting the panel to size, as shown in Fig. 2, and then drill the two holes where indicated; the larger of these two holes (B) should be a tight fit on the L_1 coil former. Next, break the copper strips on the copper side of the panel with the aid of a small drill or a sharp penknife, exactly in the positions shown.

Assembly of the components on the Veroboard panel should now proceed by numbers, in the following manner.

(1). Secure the L_1 coil former in place. This can be accomplished either by cutting off the base of the former, pushing the body into the hole and securing it in place with glue or, as in the case of the prototype, by merely pushing the complete former into the hole from the copper side of the panel, relying on friction to hold it in place. Now wind the coil on to the former using 24 s.w.g. enamelled copper wire. Start by cleaning one end and soldering this into hole 4b, then close-wind $9\frac{1}{2}$ turns clockwise, from the base upwards, finishing off by soldering the remaining end of the wire (after cleaning) into hole 4e. The winding should be kept well down and close to the surface of the Veroboard panel. A piece of cotton or thin rubber band should now be passed through the centre of the coil former and the iron-dust core screwed in place, ensuring that the core is sufficiently free for tuning adjustments to be made but not so

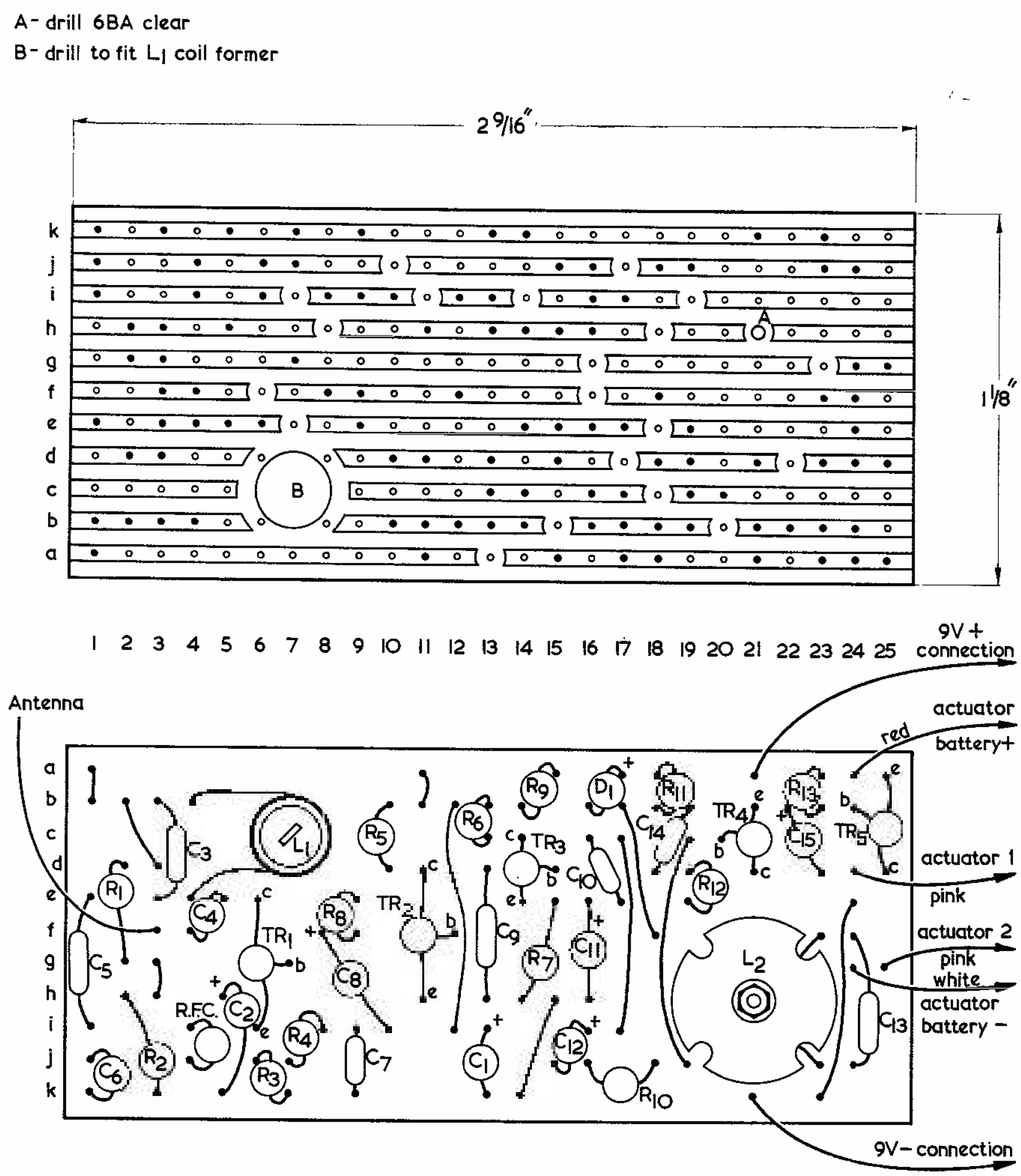


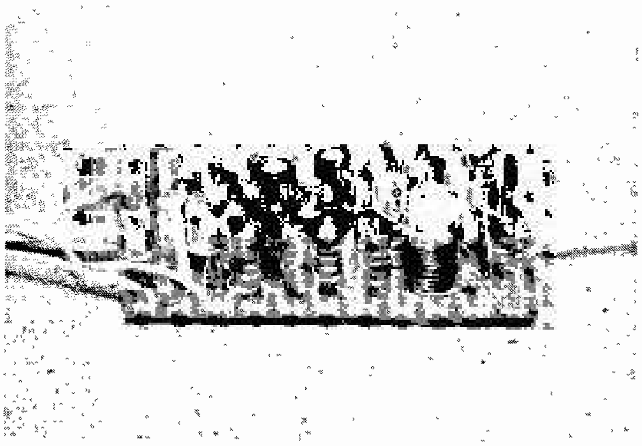
Fig. 2. The copper and component sides of the Veroboard panel

free that it can be shaken out of adjustment by prolonged vibration.

(2). Wire shorting links, using bare 32 s.w.g. tinned copper wire, as follows; 1a to 1b, 2b to 3d, 3g to 3h, 11a to 11b, and 15h to 14k. Connect a shorting link, using sleeved 32 s.w.g. wire, between 12b and 12i.

(3). Solder the following components in position (see Fig. 2), noting that all components fitted now and in later steps (except C_5) are mounted vertically, and that insulated sleeving should be used where there is any danger of components short-circuiting against one another. Remember that the cases of TR_1, TR_2 and TR_3 are internally connected to their collectors. Connect C_1 with positive to hole 13i and negative to 13k, R_1 between 2d and 2g, R_2 between 2h and 3k, the r.f. choke between 4i and 4j, C_2 between 5h and 5k (positive to 5h), C_4 between 5e and 4f, C_3 between 3b and 3e, C_5 (mounted horizontally) between 1e and 1i, C_6 between 1j and 1k, and R_3 between 6j and 7k. Solder TR_1 in place with its emitter to 6i, its base to 7g, and its collector to 6e, mounting the transistor fairly close to the panel. Solder the antenna (aerial), which is a 30-inch length of ordinary insulated multi-strand wire, to hole 3f. Solder R_9 between 15a and 14b. Finally, connect the 9-volt receiver battery connectors (PP3 type) with positive to hole 21a and negative to 21k. This completes the assembly of the super-regenerative detector stage of the receiver.

(4). The circuit can be given a functional check at this stage, if desired. Check visually that there are no short-circuits between the copper strips on the rear of the panel, and if satisfactory connect a *crystal* earpiece across R_3. Connect the 9-volt (PP3) battery to its connectors, and check that a



Side view of the completed receiver. The resistors shown here are ½ watt types, but sub-miniature ¼ watt components, as specified in the Components List, may alternatively be fitted

slight hissing noise is heard in the earpiece, indicating that the TR_1 stage is functioning. Next, either switch on the carrier at the transmitter (described last month) in which case the hissing should disappear, or switch on carrier and tone together in which case the hissing should be replaced by the transmitter tone signal. If the hissing does not disappear, try adjusting the core of L_1. Once this check has been completed satisfactorily, remove the earpiece and battery from the circuit.

(5). Solder TR_2 in place with its emitter to 11h, its base to 12f, and its collector to 11d. Solder TR_3 in place with its emitter to 14e, its base to 15d, and its collector to 14c. Solder R_8 between 9e and 9f, solder C_8 between 8f and 10i (positive to 8f), R_4 between 8i and 7j, C_7 between 9i and 9k, C_9 between 13d and 13h, R_7 between 15e and 14h, C_{11} between 16e and 16h (positive to 16e), C_{10} between 16c and 17e, R_5 between 10b and 10d, and R_6 between 13b and 13c. This completes the wiring of the filter and selective a.f. amplifier stages.

(6). At this stage the circuit can be given a second functional check, using the same procedure as given in step 4 but with the crystal earpiece connected between TR_3 collector (case) and the negative supply line. The volume in the earpiece should be considerably greater than in the earlier test.

(7). Connect shorting links, using 32 s.w.g. sleeved wire, between 17c and 17i, and between 17b and 18f. Assemble the pre-wound L_2 bobbin in the pot-core, as shown in Fig. 3, and then bolt the assembly in position on the Veroboard panel. Solder the L_2 leads to holes 23f and 23j; the pot-core should be locked in position by brushing a dab of paint over the securing nut and bolt. Now wire a sleeved link between 19j and 19c, and another between 23k and 24e. Solder C_{12} between 16i and 15j (positive to 16i), R_{10} between 16j and 18j, and R_{12} between 19d and 19e. Solder TR_4 in position, with emitter to 21b, base to 20c, and collector to 21d, and TR_5 with emitter to 25a, base to 24b, and collector to 25d, using heat shunts during the soldering operations for both transistors. Solder C_{13} between 24f and 24j, C_{14} between 19b and 18d, R_{11} between 18a and 18b, D_1 between 17a and 16b (positive to 17a), R_{13} between 23a and 23b, and C_{15} between 22b and 23d (positive to 22b). Finally, solder the following leads in place: actuator positive lead (red) with battery terminal clip to hole 24a, actuator lead 1 (pink) to hole 24d, actuator lead 2 (pink) to hole 25g, and actuator battery negative lead (white) to hole 24g. The assembly of the receiver circuit is now complete.

(8). The receiver can be given a final test in the following manner. Check the reverse side of the board visually to make sure that there are no short-circuits between the copper strips, and then connect the crystal earpiece between the receiver negative line and TR_3 collector (case). Connect the 9-volt receiver battery, but do *not* connect an actuator or the actuator battery at this stage. A strong hiss should be heard in the earpiece. Now switch the transmitter carrier and tone on together, and check that the hiss is replaced by the tone signal, adjusting the core of L_1 if necessary. Retract the transmitter antenna, and move the transmitter well away from the receiver until the tone signal in the earpiece falls in strength (it may be necessary to move a distance of 100yds. or so!) and adjust L_1 core for maximum strength. Switch the transmitter off, and remove the receiver battery.

Connect an actuator or escapement (an Elmic "CONQUEST" escapement was used on the prototype) in series with a 1 amp d.c. ammeter and connect the combination between the two pink leads on the receiver. Connect the actuator battery (4.5 volts was used on the prototype) and the 9-volt receiver battery in place, and check that, with no tone signal being transmitted, the actuator draws negligible current. Now remove the back of the transmitter case and switch on carrier and tone together; the actuator current should rise sharply on "tone" (to 300mA in the case of the prototype). If the current does not rise to a high level, adjust RV_1 in the transmitter, checking at the same time that a tone variation is heard in the earpiece, RV_1 should be adjusted for maximum actuator current. When the equipment is correctly adjusted, maximum current should be obtained with RV_1 in the centre position, and negligible current should be obtained with RV_1 at the extreme ends of its travel. Check that TR_5 does not become excessively warm under high current conditions, and that the current returns to a negligible value when tone is switched off. If these tests are satisfactory, the transmitter and receiver are now ready for use.[2]

It is possible (but unlikely) that the tone frequency of the transmitter will not be correctly matched to that of the receiver, whereupon a high actuator current rise cannot be obtained. In this case, proceed as follows; replace the 1 amp meter in series with the actuator with a multi-range current meter, and then connect the receiver supplies and switch on the

[2] Should it be possible to "peak" the current reading with RV_1 but not to obtain a sufficiently high level, the value of R_{10} can be reduced to increase the drive to TR_4 and so increase the actuator current. The value of R_{10} should not be reduced below 12kΩ.

transmitter. Adjust the multimeter until a reasonable reading is obtained, and then adjust RV_1 in the transmitter to give an increase in the reading, while at the same time monitoring the tone signal with the earpiece. If the increase in current comes with a *rise* in tone, it can be assumed that the receiver tuned circuit is set to too high a frequency, and the value of C_{13} should be increased. If the increase in current comes with a *fall* in tone, C_{13} should be reduced. If such a modification is necessary, the value of C_{13} should be altered by trial and error by small amounts at a time, fine adjustment being obtained by wiring an additional capacitor in parallel with the capacitor in the C_{13} position, it being fitted between holes 25f and 25j.

Operating Instructions

The receiver should be well packed in sponge rubber when installed in the model, the actuator or escapement being wired between the two pink leads.

Before making a first flight, a full range check should be made in the following manner. Fully erect the special centre-loaded transmitter antenna and adjust its tuning slug for maximum reading on a field strength meter. With the receiver equipment installed in the model and switched on, check that the control surfaces function correctly then, while a colleague operates the transmitter, walk away from the transmitter with the model held about four feet above the ground. When operation of the control surfaces becomes erratic, adjust the core of L_1 until an improvement is noticed. Continue this operation, moving steadily away from the transmitter, until control is finally lost. The distance between the transmitter and receiver at this point is referred to as the "ground range", and should be approximately 600 to 800 yards with this equipment. The "ground-to-air" control range is usually double the ground range, so a flying range of ½ mile or so can be expected from the equipment.

Transmitter/Receiver Modifications

Because of the high degree of interference rejection that is offered by the sharply tuned tone "switch" of this receiver, it is possible to operate three or more sets of super-regen equipment at the same time and on the same flying field, providing that each set is tuned to operate at a different frequency. In such a case, a group of modellers should get together and select their operating frequencies amongst themselves, one using a low tone frequency, a second a medium frequency, and the third a high tone frequency; the precise frequencies being sorted out by trial and error so that no one operator's transmitter causes interference with the other operators' receivers.

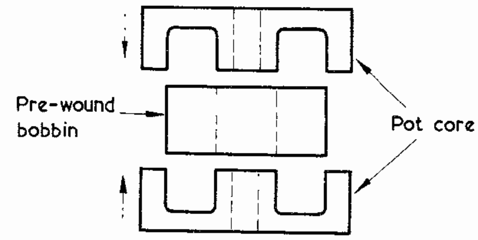


Fig. 3. Showing how L_2 is assembled

In the transmitter, the values of C_9 and C_{10} (which are of equal value) can be changed to give a coarse control of frequency, while R_7 and R_8 (also of equal value) can be varied between the limits 10kΩ to 33kΩ to give a fine control of frequency. In the receiver, the tone frequency of operation can be altered by changing the value of C_{13}. In all cases, a reduction in component value gives an increase in tone frequency, and an increase in component value gives a reduction in frequency.

Using the component values shown for the transmitter and receiver in this and the preceding issues, the frequency of tone operation is approximately 1.5 kc/s. The current drawn from its 9-volt battery by the prototype SCT/RR1 receiver was 2.2mA in the absence of a carrier and 18mA on receipt of a carrier plus tone.

Editor's Note

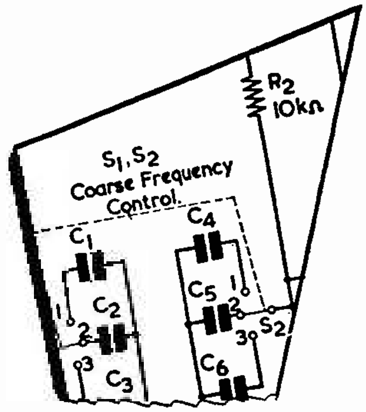
It should be appreciated that the escapement coil operated by the output transistor is intended to be energised for brief periods in normal use, as is standard practice in single channel work. A light escapement will draw a current of some 300mA when energised. This current must *not* be allowed to flow for other than intermittent periods or the output transistor will become damaged, and it is important to bear this in mind when testing and setting up. If the output transistor is allowed to pass a current of some 300mA for several seconds, then it should be allowed to cool for several seconds before being made to pass current again. A restriction of this nature is common with relayless miniature control receivers.

If short pulse currents of between 300 and 600mA are to be handled, the output transistor could be replaced by two 2G381 or two NKT218 transistors in parallel, i.e. connected emitter to emitter, base to base and collector to collector. This will result in only a small increase in the overall size of the unit. ✱

EMI Radar for Maritime Comet

The HS801 maritime Comet, Britain's latest Coastal Command aircraft, is to be equipped with an improved version of ASV-21 radar developed by EMI Electronics Ltd. ASV-21 is an air-to-surface search radar with its aerial scanner located in a radome beneath the aircraft. It is capable of locating submarine periscopes and snorkels and has been the means of saving many lives at sea in peacetime air/sea rescue operations.

Regarded by many countries as the best equipment of its type in the world, earlier versions of ASV-21 radar have been used for many years in the Shackletons of R.A.F. Coastal Command. It is also fitted to the maritime aircraft of Commonwealth and certain foreign air forces.



Muting Circuits for TV Receivers

SUGGESTED CIRCUIT No. 200

by G. A. FRENCH

It is customary practice in most households for the television receiver to be switched on for at least part of each evening, with the sound volume control set for a comfortable listening level. Quite often, however, it is desirable to turn the volume down for a short period, this being due to a number of reasons. It may, for instance, be desired to reduce volume level during advertisement periods, or because an unexpectedly loud signal is being broadcast, or because it is thought that a baby or a sick person is calling for attention. There must be few viewers who have not, at some time or another, had to rush to turn down the television volume control when some minor domestic crisis has arisen. If the room is fairly crowded with people or furniture, this sudden action may often precipitate a second domestic crisis!

The solution to this problem consists of providing a small control box at the viewing position which, by merely touching a switch or a push-button, temporarily reduces the volume from the TV receiver to a low level. Unfortunately, such a control box has to be coupled into the TV receiver circuits by way of a length of flex, and this flex will inevitably suffer rough usage because it has to pass over the floor of the room. Since mains-driven TV receivers have a chassis which is connected to one side of the mains, this length of flex could not be used to couple the control unit directly to the a.f. circuits of the set to provide the muting facility, because the flex would then be carrying mains potential. The consequent risk of shock would be too great to allow such a method of operation to be used in practice.

In this month's "Suggested Circuit" article the author discusses several simple means of obtaining remote control muting of the sound channel of a TV receiver, the coupling flex and the control unit being completely isolated from the receiver chassis. Two simple methods of obtaining muting will first be dealt with, after which a more sophisticated scheme will be described which allows control to be achieved with push-buttons. This last system incorporates a neon lamp bistable circuit of the type described by the author in last month's issue.

It must be emphasised that, whilst the circuits involved are relatively simple, some skill and experience of TV circuitry is required of the reader who takes advantage of them. **The circuits automatically provide electrical isolation from the receiver circuits, but the constructor using them must ensure that the actual insulation provided between the control unit circuitry and that in the receiver is of a high order and is suitable for mains voltages.**

Receiver Modification

In all the circuits which follow, muting is achieved with the aid of a photoconductive cell type ORP12, advantage being taken of the fact that this cell exhibits a high resistance in the dark condition, and a low resistance when illuminated. The dark resistance of an ORP12 is $10M\Omega$ or more, whilst its lowest resistance is 300 to 75Ω when fully illuminated.

It is suggested that a modification be made in the grid circuit of the sound output valve of the TV receiver to enable the ORP12 to exert control. Fig. 1 (*a*) shows the basic elements of a typical TV sound output stage, in which cathode bias is employed and the grid leak of the output valve is returned to chassis. The required modification at the grid circuit is illustrated in Fig. 1 (*b*), in which diagram a $100k\Omega$ resistor is inserted between the a.f. coupling capacitor and the grid leak, and a length of screened cable is added so that its centre conductor connects to the output grid and its braiding to any nearby chassis point. It should be possible to incorporate this modification quite easily in most TV receivers employing printed circuits. The grid end of the a.f. coupling capacitor may be unsoldered from its printed circuit conductor, and the corresponding capacitor lead pulled out of the board. One end of the additional $100k\Omega$ resistor may then be inserted into, and soldered at, the hole in the board previously used by the capacitor lead, the other end of the resistor connecting to the now-free lead of the coupling capacitor to form a "mid-air joint". See Fig. 1 (*c*). The screened cable may be connected up at any convenient circuit points. The $100k\Omega$ resistor need only be an $\frac{1}{8}$ watt component, and the grid of the output stage is recommended as a suitable point for the modification because hum pick-up will not normally be troublesome here. The insertion of the $100k\Omega$ resistor will cause a small drop in overall a.f. gain, but this will not raise any difficulties if the receiver has plenty of sound gain in reserve, as is usually the case.

Screened cable is used for the modification because it enables the muting components to be positioned, at the other end of the cable, at any convenient point inside the TV cabinet. The length of the screened cable is unimportant, and it should be a narrow-diameter flexible insulated type. The muting components must not be positioned outside the cabinet because they are at chassis

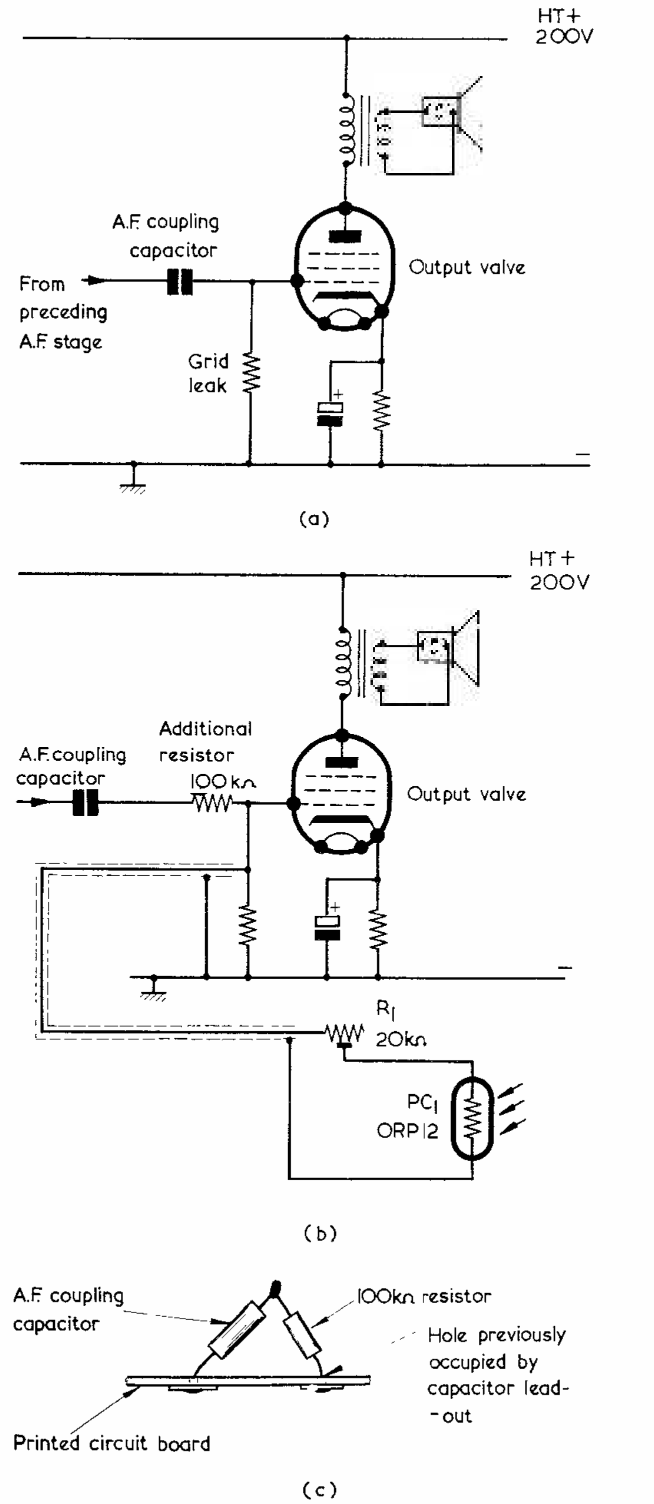


Fig. 1 (a). The TV sound output stage before modification
(b). Adding the 100KΩ resistor and screened lead which connects to the muting components
(c). The 100KΩ resistor may, normally, be added quite readily to printed circuit board layouts

and, hence, "live" potential. In Fig. 1 (*b*) the remote end of the screened cable is terminated by the 20kΩ preset variable resistor, R_1, and the ORP12 photoconductive cell, PC_1. The resistance of the latter is varied by means which will shortly be described. As may be seen by inspection of the circuit, the a.f. signal applied to the grid of the output valve will reduce as ORP12 resistance decreases.

Simple Control Circuits

The first control circuit to be described is shown in Fig. 2 (*a*). This is very simple and is by no means original, but it is included to provide a full picture of the various methods of control which can be employed.

In Fig. 2 (*a*) the control unit comprises a 6 volt battery and an on-off switch, this unit being situated, at the end of a 2-way flex, at the viewing position. The flex couples to two sockets at the receiver, the circuitry to the right of these sockets in this diagram (and in succeeding diagrams) being enclosed inside the cabinet of the TV receiver. The control leads connect to a Radiospares 6 volt 0.06 amp pilot light (Home Radio Cat. No. PL7) which is enclosed, with photoconductive cell PC_1, in a small light-proof box. PC_1 and R_1 are the similarly identified components of Fig. 1 (*b*), and carry out the functions indicated in that diagram.

The operation of the circuit of Fig. 2 (*a*) is extremely simple. When switch S_1 at the remote control unit is in the "Normal" position, pilot lamp PL_1 is extinguished. As a result, PC_1 is in the dark condition and exhibits maximum resistance, thereby causing no significant drop in a.f. gain in the receiver. When S_1 is thrown to the "Mute" position, pilot lamp PL_1 lights up, the photoconductive cell exhibits low resistance and the a.f. gain of the receiver drops in consequence. Variable resistor R_1 is adjusted to give the required drop in volume when S_1 is in the "Mute" position. If desired, R_1 can be replaced by a fixed resistor of the appropriate value after the requisite setting has been found.

As may be seen, the control unit can consist of a small box housing S_1 and the 6-volt battery, the latter being any convenient small type. The light-proof box housing PL_1 and PC_1 may be about the size of a match-box or smaller, the spacing between the pilot lamp and the light-sensitive surface of the ORP12 being approximately half an inch. It will probably be unnecessary to screen this box and R_1 if these two parts are positioned well away from mains circuits or the vertical time-base of the receiver. If screening is required, the light-proof box could be made of metal, with R_1 (as a fixed resistor) fitted inside. However, it will more probably be found possible to use the muting circuit without screening, if care is taken in finding a suitable position for it.

An obvious variation on the circuit

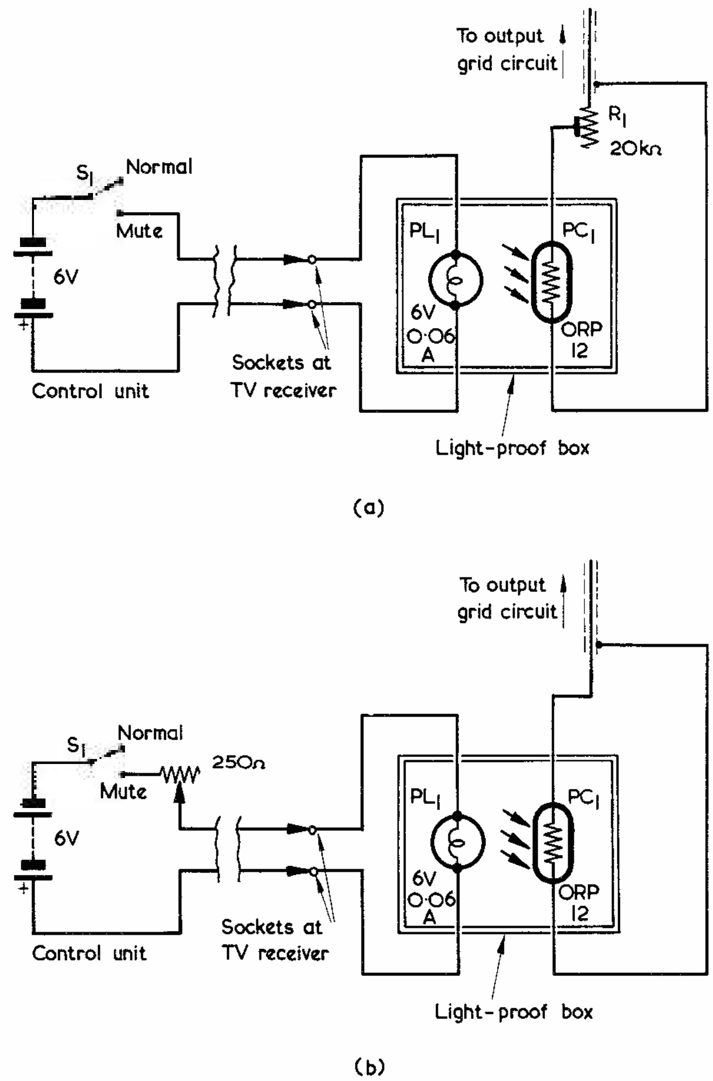


Fig. 2 (a). A simple means of obtaining remote muting
(b). An alternative method, by means of which muting level is controlled at the remote point

of Fig. 2 (*a*) is illustrated in Fig. 2 (*b*). This is the same as Fig. 2 (*a*) except that R_1 is not now required, the ORP12 connecting directly across the screened cable from the grid circuit of Fig. 1 (*b*). Also, in Fig. 2 (*b*) the amount of a.f. attenuation given when S_1 is in the "Mute" position is controlled from the remote point by means of a 250Ω variable resistor. When S_1 is set to "Mute", this variable resistor is adjusted to vary the light emitter by PL_1 and, hence, the resistance offered by PC_1 in the illuminated condition. The 250Ω variable resistor may be a knob-operated component, whereupon it can be used to give a panel control of the volume offered at the "Mute" setting of S_1. The effect on volume as the resistor is adjusted will be both non-linear and a little "sluggish", the latter being due to thermal inertia in the pilot lamp filament. Also the variable resistor will have to be a rather large wirewound type capable of passing currents up to 60mA.

An alternative approach is to set the 250Ω variable resistor to the value which gives the required muting level, and then to replace it with a fixed resistor. If it is found that the voltage dropped across the resistor is more than 1.5 or more than 3 volts, the 6-volt battery shown should be replaced by a 4.5 volt or a 3 volt battery as applicable, and the procedure repeated. This approach is desirable since there would, of course, be little point in using a 6-volt battery at the control unit if a 4.5 or 3-volt battery with a series resistance of lower value could be employed instead. These are factors which can be checked experimentally before finalising the design. Unfortunately, the writer cannot give any hard-and-fast recommendations here as there will be wide variations in the results given with different TV receivers.

In both Figs. 2 (*a*) and 2 (*b*), care should be taken to ensure that the insulation between the pilot lamp circuit and the ORP12 circuit is completely reliable and satisfactory for mains voltages. The socket connections indicated in these diagrams could be given in practice by a 2-way mains-type socket and plug, such as the flat Bulgin P.29 socket and P.28 plug, the socket being secured to the back of the TV receiver.

Bistable Circuit

The circuits of Figs. 2 (*a*) and 2 (*b*) are extremely simple. They suffer, however, from the disadvantage that current is always drawn from the battery at the remote position when "Mute" is selected. Even though a low-consumption 0.06A pilot lamp is specified, battery life will still be short if the "Mute" facility is selected for long periods of time.

An alternative approach is given in Fig. 3, this ensuring that current is only drawn from the remote battery for a short instant when changing over from "Normal" to "Mute", and vice versa. The circuit is based on the neon bistable discussed in last month's "Suggested Circuit", and readers requiring a full description of the bistable should consult that article.

In Fig. 3, the bistable circuit proper is given by NE_1, PC_2, NE_2, PC_3, R_2 and R_3. The circuit is a true bistable because it can only exist in one of two states: either NE_1 is illuminated and PC_2 offers low resistance (thereby keeping NE_2 extinguished), or NE_2 is illuminated and PC_3 offers low resistance (thereby keeping NE_1 extinguished). PC_2 and PC_3 are photoconductive cells type ORP12, whilst NE_1 and NE_2 are small inexpensive wire-ended neon bulbs. Suitable types are the Cat. No. PL32A available from Home Radio, or the Hivac type 16L or 34L available from Henry's Radio. The bistable obtains an h.t. voltage of around 200 from the TV receiver h.t. positive line, the current drain being of the order of 2mA only. An h.t. negative connection is picked up from the braiding of the screened cable which couples to the output grid circuit.

The bistable is triggered from one state to the other in the following manner. Let us assume that NE_2 is alight and NE_1 is extinguished. At the control unit we press the "Mute" push-button, S_2, with the result that the 6 volt battery is applied to pilot lamp PL_1. Pilot lamp PL_1 lights up and illuminates PC_2, whereupon this cell exhibits low resistance. The low resistance in PC_2 causes NE_2 to extinguish and PC_3 to offer a high resistance. Neon bulb NE_1 then lights up, and it stays illuminated after the "Mute" button has been released and PL_1 has become extinguished. The reason why neon NE_1 stays illuminated is because it causes PC_2 to retain the low resistance initially instigated by PL_1 and therefore prevents NE_2 from lighting up. The circuit is in one of its two stable states.

To bring the circuit to its previous state, the "Normal" push-button, S_1, is pressed. This illuminates PL_2, with the result that PC_3 exhibits low resistance and neon NE_1 extinguishes. Photoconductive cell PC_2 then offers a high resistance, NE_2 lights up and the circuit returns to its previous stable state. Neon bulb NE_2 remains illuminated, in consequence, after the "Normal" push-button is released.

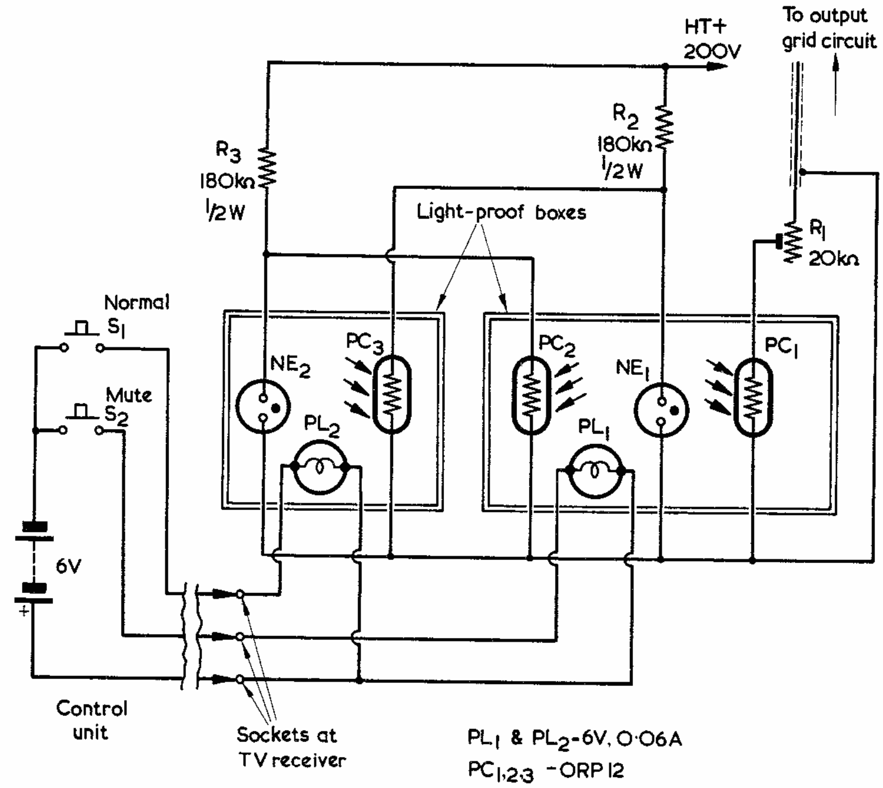


Fig. 3. Using a neon bistable circuit ensures that only momentary current demands are made of the remote battery

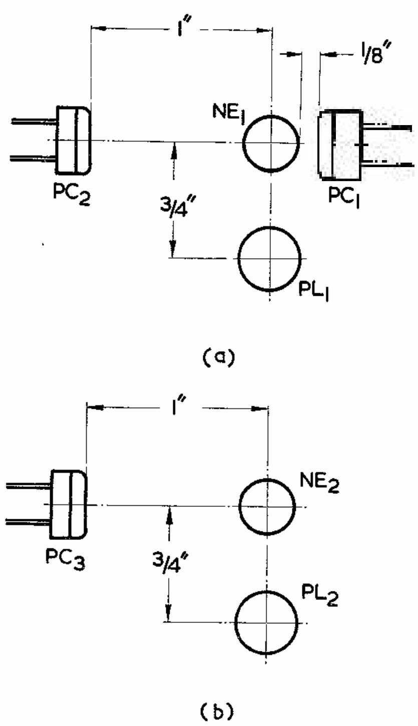


Fig. 4 (a). Spacing between components in the right-hand light-proof box of Fig. 3.
(b). A similar type of spacing is required in the left-hand light-proof box

As just mentioned, the bistable remains stable in its new state after actuation by S_1 or S_2, and further closing of the push-button which instigates the changeover has no effect. The circuit can only be triggered to the alternate state by pressing the *opposite* button. A very short pressure on the desired push-button is all that is needed in practice to bring about the changeover, and the 6 volt battery has, in consequence, a long life.

A point not yet referred to is that, when NE_1 lights up (after pressing the "Mute" button) it illuminates photoconductive cell PC_1. In conjunction with R_1, PC_1 carries out the same function as did the similarly identified components in Fig. 2 (*a*). Thus, pressing the "Mute" button reduces receiver volume, this being returned to normal by pressing the "Normal" button.

Should screening of PC_1 and R_1 be necessary, only the right-hand light-proof box of Fig. 3 is affected and the remainder of the circuit need not be screened. It might, at first sight, be thought that PC_1 is superfluous and that its function could be carried out by one of the photoconductive cells in the bistable itself (i.e. PC_2 or PC_3) since these cells similarly change from high to low resistance, or vice versa, as the bistable changes over. However, when either PC_2 or PC_3 is in the high resistance state it is shunted by an illuminated neon bulb which, itself, exhibits a low impedance.

The components in the right-hand light-proof box of Fig. 3 may be spaced from each other as shown in Fig. 4 (*a*). This diagram gives a top view of the neon bulb and pilot lamp, with the sensitive surfaces of the two photoconductive cells directed towards the neon bulb. PC_1 needs to be close to NE_1 as it is desirable for this cell to exhibit a resistance of some 2kΩ or less when the neon bulb is illuminated. If necessary, the cell can touch the neon bulb envelope. The siting of PL_1 is not critical since the light this bulb offers is far greater than that from the neon. The components in the left-hand box may take up the positions shown in Fig. 4 (*b*), these being similar to those, in the right-hand box, for PC_2, NE_1 and PL_1.

The circuit of Fig. 3 should be checked out in experimental form before finally fitting it into position permanently in the TV cabinet. Again, insulation suitable for mains voltages *must* be provided between the pilot lamp circuit and the bistable and PC_1 circuits. After initial checking, R_1 may be replaced by a fixed resistor of appropriate value, as with Fig. 2 (*a*). A small 3-way mains socket may provide the sockets shown in Fig. 3, this being mounted at the rear of the TV receiver. A 3-way flex, terminated in a corresponding plug, then couples to the control unit.

The circuit of Fig. 3 is more complex than those of Figs. 2 (*a*) and (*b*), but all the components are small and take up little space. For those who are interested in the more unusual type of device, the operation of the present circuit is, in practice, quite fascinating. The circuit may, of course, be employed for the remote volume control of any other item of a.f. equipment as well as the a.f. stages of a TV receiver. It should be remembered that, when the television receiver is first switched on, the bistable may take up either the "Mute" or "Normal" state, and that it may be necessary to initially press the "Normal" button to latch the bistable over to the condition which gives normal volume level.

The Photoconductive Cells

Some final points need to be made concerning the photoconductive cells themselves.

Connections to the cell lead-outs should be made quickly with, preferably, a heat shunt clipped to the lead-out while soldering. During experimental and constructional work with Fig. 3, *always* make certain that NE_1 is connected across PC_3 and that NE_2 is connected across PC_2 before power is applied. If either of the cells is not shunted by the appropriate neon bulb, the voltage across the cell will rise above its maximum rating of 110 volts and it may suffer damage.

Finally, the photoconductive cells should not be used at ambient temperatures above 50°C. This necessitates fitting the control circuit in a cool part of the TV receiver cabinet, well away from heat-dissipating components. It is normally found that the coolest points are along the bottom of the cabinet near the rear.

Transistor Gain Tester

by P. Rigby

A simple and robust piece of equipment which measures transistor gain under practical conditions. A good correlation is given with beta measurements taken by conventional means.

There are a great number of characteristics which are used to define the performance of transistors, but many of these are useless to the average amateur who does not want to become tied up in the mathematics of circuit design.

There is, however, one characteristic which is of universal importance, and this is the gain. From this characteristic we can usually sum up whether a transistor is good or bad. The tester to be described gives a measure of the common emitter current gain.

Circuit Description

The circuit, shown in Fig. 1, is that of an amplifier with positive feedback. If we adjust RV_1 for maximum feedback then the circuit will oscillate, this being indicated by a howl in the loudspeaker across the transformer winding in the collector circuit of the transistor under test. By slowly reducing the setting of RV_1 we will reach a position where the oscillations cease, and this position will depend upon the gain of the transistor.

The bias, and hence the collector current, may be set by RV_1 to a suitable value for the transistor being checked.

Transformer T_1 is a small intervalve type with a ratio of 1:1. However, this component is not at all critical and almost any small low-ratio transformer may be used. Many small transformers were tried in the prototype with complete success.

An unusual feature is the use of electrolytic capacitors connected back to back. This avoids the use of a switch to reverse the capacitors when

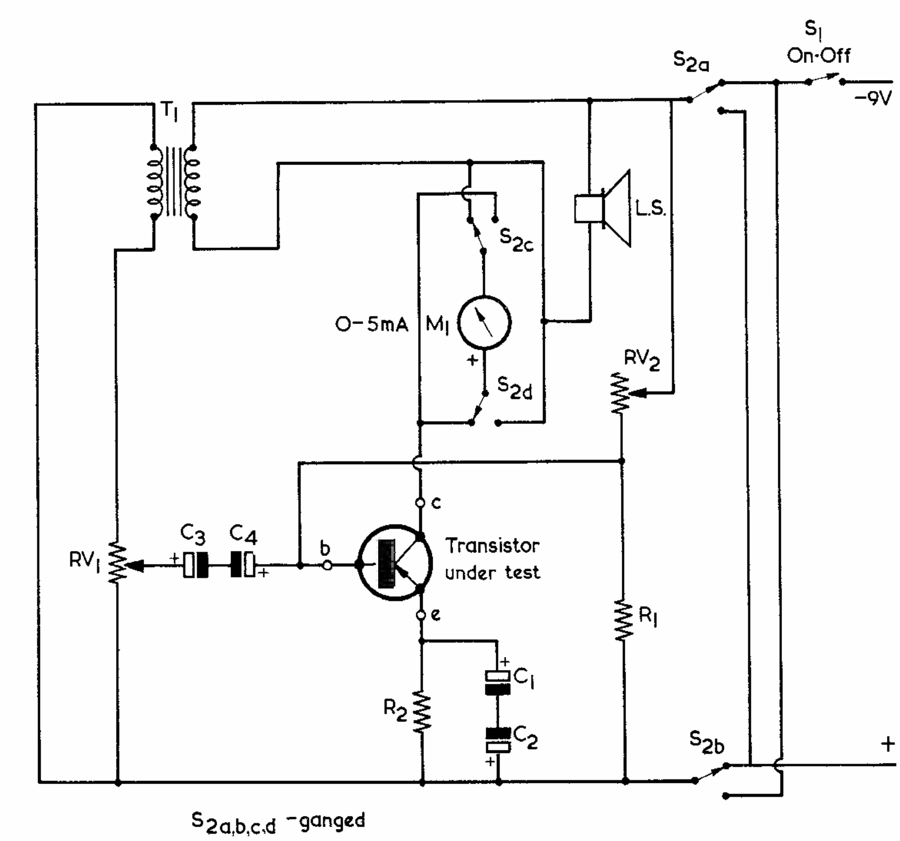


Fig. 1. The circuit of the transistor gain tester. Switch S_2 is shown adjusted for testing p.n.p. transistors, with a p.n.p. transistor in the test position. The alternative position of S_2 allows the instrument to check n.p.n. transistors

COMPONENTS

Resistors
- R_1 3.3kΩ ¼ watt 20%
- R_2 1.5kΩ ¼ watt 20%
- RV_1 2kΩ potentiometer, linear
- RV_2 25kΩ potentiometer, linear

Capacitors
- C_1 50μF electrolytic, 12V wkg.
- C_2 50μF electrolytic, 12V wkg.
- C_3 25μF electrolytic, 12V wkg.
- C_4 25μF electrolytic, 12V wkg.

Switches
- S_1 s.p.s.t. toggle
- S_2 4-pole, 2-way, wafer

Meter
- M_1 moving-coil, 0–5mA

Transformer
- T_1 intervalve transformer (see text)

Loudspeaker
Balanced amature unit (see text)

Miscellaneous
Supply battery,
Transistor test terminals,
Instrument case etc.

the supply is reversed by the p.n.p./n.p.n. switch S_2. In Fig. 1, this switch is in the p.n.p. position, and a p.n.p. transistor is shown connected to the test terminals. The alternative position of S_2 reverses the supply polarity and the connections to the meter, enabling n.p.n. transistors to be checked.

In the prototype, a balanced armature headphone with a d.c. resistance of 28Ω was used as the loudspeaker. This particular type is that employed in sound powered telephones. Since it gave adequate volume it was mounted on the front panel of the instrument. Alternative phones may also be used. For instance, a normal pair of 2,000Ω headphones can be employed, these being worn on the head and plugged into a jack on the front panel of the instrument. A crystal earphone, in series with a 1MΩ variable resistor to control volume, may similarly be used.

The supply potential in Fig. 1 is 9 volts. If the reader wishes to apply lower voltages to transistors under test, a 6 volt supply may be used, at which voltage the tester will work equally well. But the tester should be calibrated and operated at one supply voltage only. If, for instance, it is calibrated at 9 volts and then operated at 6 volts, the error in gain readings will be around 5%.

Construction

The layout is not at all critical and is left to the constructor's discretion. Either an internal or external meter may be employed. If the circuit will not oscillate when completed, it is probable that the transformer is supplying negative instead of positive feedback. This is remedied by reversing the connections to one of its windings.

Operation and Calibration

Set the p.n.p./n.p.n. switch to the requisite position and connect a transistor to the instrument. Switch on by means of S_1 and set RV_1 for maximum feedback (the control should be wired so that this corresponds to the fully anticlockwise position). Adjust RV_2 for the required collector current. Slowly advance RV_1 whilst adjusting RV_2 to maintain the same collector current. It will be found that the pitch of the howl tends to rise as RV_1 is advanced, but this is unimportant. When the oscillations cease, RV_1 will indicate the gain of the transistor.

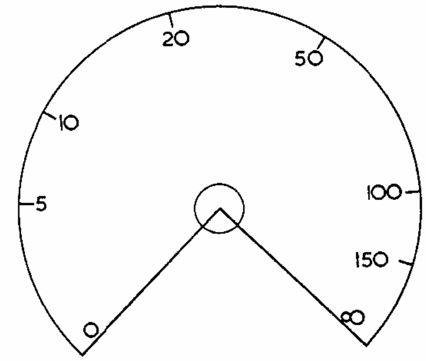


Fig. 2. The scale of RV_1 after calibration will be non-linear, as shown here. (This particular scale is intended to demonstrate non-linearity only, and should not be copied)

Calibration of RV_1 should be carried out with transistors whose gains have been found on another tester.* For calibration purposes, reliance must not be placed on the gains quoted for different transistors by the manufacturers since these have a very wide tolerance range. The scale of RV_1 will not be linear but will take up a form similar to that shown in Fig. 2.

*In the absence of another tester, an approximate measure of gain for individual transistors can be obtained by dividing collector current by base current under d.c. conditions. Work to a collector current of several milliamps at 1.5 or 3 volts, and avoid using transistors which have a high leakage current with the base open circuit.—Editor.

CAN ANYONE HELP ?

Requests for information are inserted in this feature free of charge, subject to space being available. Users of this service undertake to acknowledge all letters, etc., received and to reimburse all reasonable expenses incurred by correspondents. Circuits, manuals, service sheets, etc., lent by readers must be returned in good condition within a reasonable period of time

Jason JR1 Stereo Tape Recorder.—W. Norrie, 3 Ryders Wynd, Richmond, Yorks.—circuit and data required. Also circuit for Jason Valve Voltmeter.

* * *

Geloso G209 Receiver.—H. Douglass, 40 Alston Gardens, Throckley, Newcastle upon Tyne 5—circuit diagram, purchase or loan.

* * *

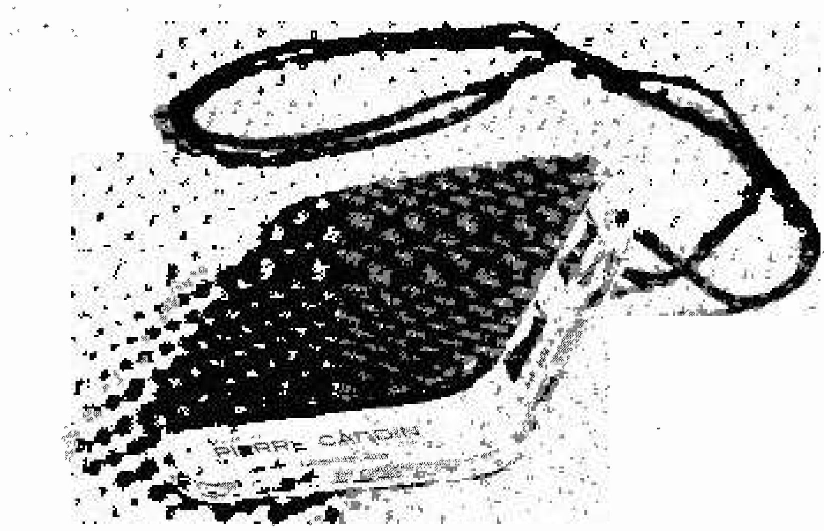
Wireless Set ZC1 Mk.I.—M. J. Reeves, 99 Longhurst Road, London, S.E.13—circuit diagram of this New Zealand Army equipment.

K.B. Receiver Model FB10.—R. Green, 3 Brecon Road, Enfield, Middx.—information on drive cord repair for this receiver.

* * *

Receiver Circuit.—R. Wibberley, 234 Radford Boulevard, Nottingham—circuit required for a.c. operated a.m. receiver (valved), 3 watts output, tuning indicator, covering Long, Medium and Short waves.

NEWS . . . AND .



A Pierre Cardin Design

If an Italian dress designer can design motor car bodies why should not something similar happen to radio cabinet design?

It has, and illustrated above is a transistor portable with a neat and elegant case designed by Pierre Cardin the French couturier. This new portable—the *Civic*—is made to be worn rather than carried. In green and gold, little chromium, and a space for the owner's initials, the *Civic* is intended to complement today's flowing fashion line and to get away from the traditional square-cut lines associated with radio.

As may be expected from a high priest of Paris fashion, the appearance is intended particularly to appeal to the ladies and a shoulder cord enables it to be worn as a fashion accessory from a belt or lapel.

The circuit is a 7 transistor superhet, range 520–1605 kc/s, output 160mW. The set weighs 7oz., is 3⅛in square by 1¼in deep and is obtainable from Civic Stores Ltd., of Putney, London.

There is no reason why radio equipment should not delight the eye, in fact a pleasing appearance can be evidence of a well designed and constructed circuit, conversely a poor appearance can mean that there is a lash-up underneath.

Electronics Ahead

The biggest boost for years to the British electronics industry seems to be the general impression gained by exhibitors to the British Radio and Electronic Component Show, which closed its doors after 59,247 visitors from all over the world had either placed orders or initiated deals worth at least £25 million. This, the Organisers say, is a most conservative figure.

Attendance figures were up by 10%, including 2,482 buyers from 60 countries.

Mr. Arthur Bulgin, O.B.E., M.I.E.R.E., Chairman of the Exhibition Committee, said: "It looks like a pretty prosperous year for the whole electronic component industry.

"In this year of Quality and Reliability, our firms—the backbone of the electronics industry—have shown that we can beat the world, even the state-subsidised industries of America, Japan and Russia, when it comes to quality and price.

"It is the most successful electronics show I have been associated with for twenty years. It is quite obvious that the component industry will be increasing considerably its £50 million a year export contribution to the country's economy for the next several years."

One of the big features of the show was the longest demonstration of colour television ever put out by the B.B.C. Of this, Mr. Arthur Bulgin commented: "The B.B.C. did a wonderful job for us by eight hours of transmission a day through the week. This has enabled many firms to demonstrate their ability to supply colour components to the international market."

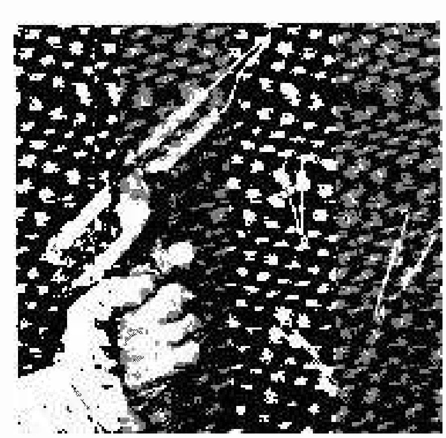
Unique 2-heat Soldering Gun

The soldering irons used in most radio constructor's workshops are 1-heat, sole purpose, tools but there is now available from Headquarters & General Supplies Ltd., a real luxury multi-purpose gun.

The model illustrated herewith is a dual heat gun which gives instant high or low soldering temperatures at the touch of a trigger and, when in use, twin spotlights are automatically switched on. Smoothing and cutting tips are included in the plastic carrying case.

Obviously such a heat gun can be used for many purposes other than radio. It is suitable for a variety of metal work and repairs, jewellery making and repairs, cutting floor tiles, repairing thermoplastic toys and utensils, gardening equipment, etc.

The price of this "Rolls Royce" of soldering irons is 5 guineas and is available direct from Headquarters & General Supplies Ltd., Coldharbour Lane, London, S.E.5. (postage 5s.) It may also be obtained from their other stores.



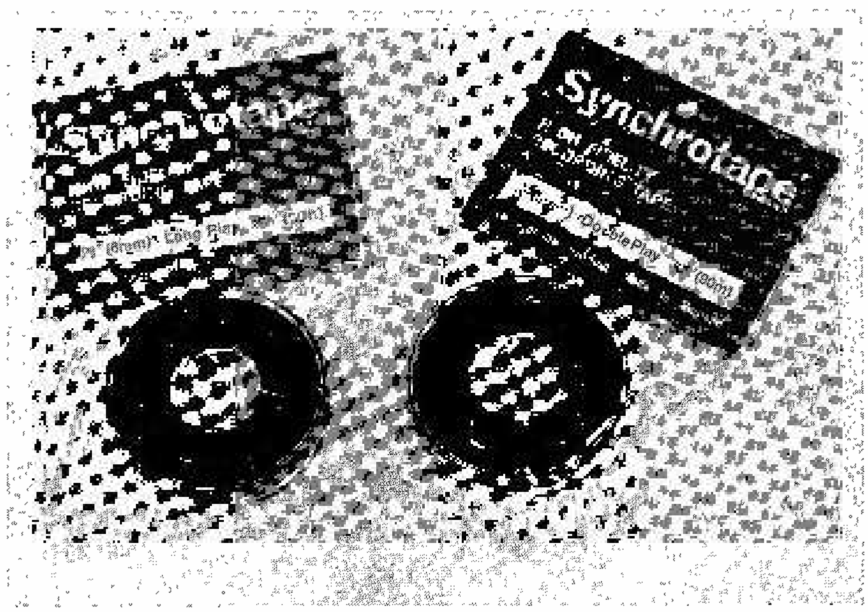
COMMENT

Radio Licences

In the two preceding issues of this magazine we have dealt with Pirate Radio Ships and Walkie-Talkie sets. When writing about the former we said that although the radio amateur realises the need for registration and regulations, this did not mean that he necessarily agreed with every regulation.

We have recently learned that the Post Office has been demanding the licence fee of 25s. a year from children who take their transistor radios with them to boarding school. In the past most Head Postmasters have interpreted the regulations so that boarders were considered members of their housemaster's household and covered by his radio licence—a sensible arrangement it seems to us.

The situation seems to be well summed up by Mr. Paul Griffin, headmaster of Aldenham School speaking to a *Times* journalist. "My staff were up in arms about it. It must have seemed very pleasant to the Postmaster General to have his revenue from boarding schools multiplied by twenty—but can anyone explain why a boarder should need a special licence for his transistor when any day boy may wander the length of his homeland, the Tijuana brass blaring from his hip, and not pay a penny for the privilege?"



Synchrotape's New $2\frac{3}{8}$ in Reels

Just released by SYNCHROTAPE, new $2\frac{3}{8}$in reels in Long and Double Play lengths should meet the Summer demand now created by users of portable Tape Recorders. The Long Play $2\frac{3}{8}$in SYNCHROTAPE has 200ft of P.V.C. Tape retailing at 5s. 9d. whilst the 300ft Double Play version retails at 8s. 9d. Both reels are in new "see-through" hanging packs with colour coded headers.

The unique SYNCHROTAPE "Free Insurance up to £25" Scheme given with every 5in, $5\frac{3}{4}$in and 7in reel introduced last autumn will continue for at least the rest of 1967, say Adastra Electronics Ltd. of 167 Finchley Road, London, N.W.3.

SYNCHROTAPE is suitable for use at speeds from $1\frac{7}{8}$in/sec to 15in/sec inclusive (4.75–38.1 cm/sec), and under normal working conditions can satisfactorily replace similar tapes in use, particularly in respect of high frequency response at low speeds. At $7\frac{1}{2}$in/sec (19.05 cm/sec), half-track, when biased to give maximum output at 1 kc/s, with DIN 70 microsecond playback equalisation. All SYNCHROTAPE reels are packed in Polythene bags, and the colour-coded boxes film sealed in Propathene.

Quotes

● "Almost 25,000 colour television sets have been ordered from G.E.C., the only maker yet to declare for the 19in sets rather than 25in. The order must be worth more than £2,500,000 in total.

"Numbers of big rental chains are taking the sets, possibly even some linked with other set manufacturers. G.E.C. is about the only major TV manufacturer in Britain without a rental subsidiary."

From *The Times* newspaper.

● "Why is it the less a radio amateur has to say the longer it takes him to say it?"

From *Mobile News*, the journal of The Amateur Radio Mobile Society.

"Name?"

"Smith, Sir."

"Age?"

"Nineteen, Sir."

"Religion?"

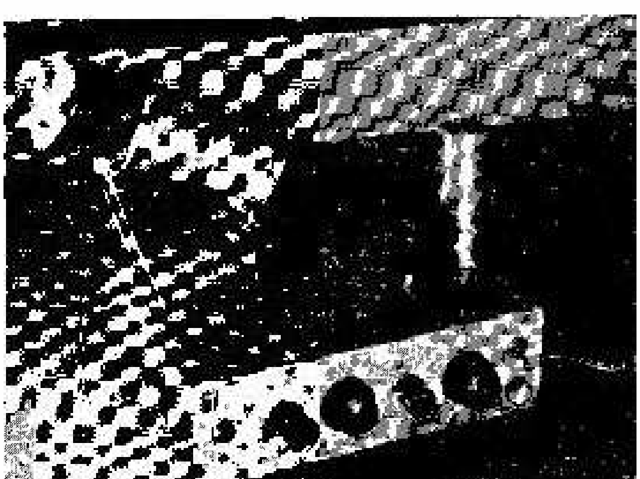
"Cathode Follower, Sir."

Basic Oscilloscope

Arthur C. Gee, G2UK

For the experimenter and amateur transmitting enthusiast there are many applications for a low-cost oscilloscope without a Y amplifier or a timebase. The instrument then becomes, quite simply, a c.r.t. having the requisite power supply and control circuits, together with open inputs leading directly to the X and Y plates. In the unit described here, provision is also made for feeding heater and h.t. positive voltages to ancillary equipment.

FOR A NUMBER OF PURPOSES, PARTICULARLY around the amateur radio station, a very simple oscilloscope can prove a most useful test instrument. For such applications as checking a.m. modulation, comparing audio frequencies in r.t.t.y. installations and lining up s.s.b. equipment, there is no real necessity for such refinements as X and Y amplifiers, nor even for a timebase. In any event, these can always be added at a later date if required, provided room is left on the chassis for their associated valves and components. Another point is that it is useful to have a basic oscilloscope available, the circuitry of which can be readily altered so that particular circuits can be set up for specific purposes.



The circuit may be readily assembled on any conveniently sized chassis. Here, the four controls and the on-off switch are mounted on one of the chassis side panels

The Components

The unit described here was built more or less from components on hand. The cathode ray tube used, a VCR139A, is one of the older surplus types, but quantities of this tube are still available, both as surplus or from private spares boxes. At the time of writing, the VCR139A can be obtained from Z And I Aero Services Ltd., 44a Westbourne Grove, London, W.2. The author has had a VCR-139A on hand for possible use in an application such as the present one for quite a number of years, and he felt that it would be well worth-while devoting an article to this unit as many other readers may be in a similar position.

The VCR139A requires a heater supply of 4 volts at 1.1 amps, and it will perform well on e.h.t. voltages of 500 or so. This means that a mains transformer salvaged from an old broadcast receiver could be pressed into service as the basis of the power supply. A 4 volt heater winding (which would have been originally used for the receiver rectifier) is a bit "old hat" these days, however. Nevertheless, if the reader has not already got an old mains transformer with a 4 volt winding in stock, he may be able to find one at his favourite radio service depot. Transformers of this type are frequently taken out of old mains receivers and retained. Indeed, it may well be possible to obtain a suitable transformer from an old radio that would otherwise have been consigned to the dustbin.

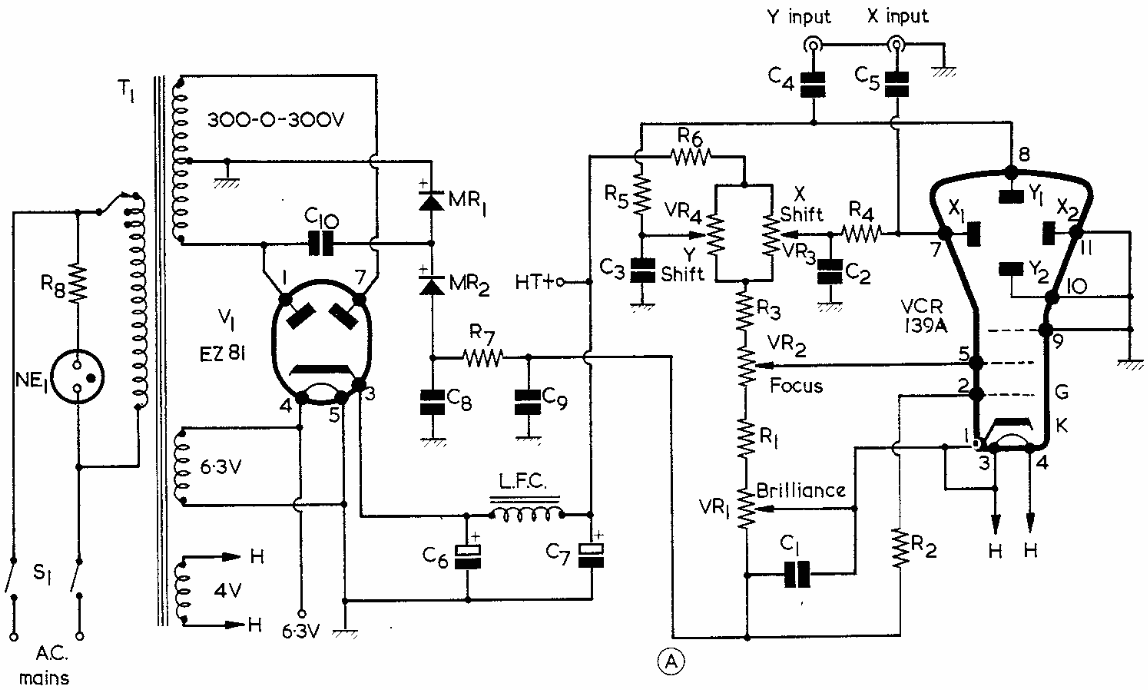
The 5 volt winding on a more modern transformer could also be employed here for the c.r.t. heater, it being merely necessary to insert a resistor in series with one of the heater leads. The calculated value of the series resistor is 0.9Ω and suitable resistance wire could be obtained from an old electric fire element or similar. Reduce the length of resistance wire inserted in series with the c.r.t. heater until the heater voltage is 4, as indicated by an a.c. voltmeter.

Circuit Operation

As may be seen from the accompanying circuit diagram, the mains transformer recommended has an h.t. secondary of 300–0–300 volts, together with the 4 volt heater winding just referred to. There is also a 6.3 volt winding, which feeds the heater of an EZ81 rectifier.

The 300–0–300 volt secondary is applied to the EZ81 which functions as a full-wave h.t. rectifier in normal fashion, the rectified positive voltage at its cathode being fed to the smoothing filter given by C_6, C_7 and the l.f. choke. The smoothed positive supply is then passed to the positive end of the shift, focus and brilliance chain which appears across the c.r.t.

Connected across one half of the 300–0–300 volt h.t. secondary is the voltage doubler circuit given by MR_1 and MR_2. This causes a negative



The circuit of the basic oscilloscope. This provides all control functions as well as h.t. and heater outlets for ancillary equipment

COMPONENTS

Resistors

(All fixed values ½ watt, 10%. All potentiometers carbon linear)

R_1	100kΩ
R_2	47kΩ
R_3	470kΩ
R_4	2.7MΩ
R_5	2.7MΩ
R_6	470kΩ
R_7	270Ω
R_8	Part of NE_1 assembly
VR_1	100kΩ potentiometer
VR_2	1MΩ potentiometer
VR_3	2MΩ potentiometer
VR_4	2MΩ potentiometer

Capacitors

C_1	0.01μF 250V wkg.
C_2	0.01μF 450V wkg.
C_3	0.01μF 450V wkg.
C_4	0.25μF 450V wkg.
C_5	0.25μF 450V wkg.
C_6	8μF electrolytic 450V wkg.
C_7	16μF electrolytic 450V wkg.
C_8	0.1μF 750V wkg.
C_9	0.25μF 750V wkg.
C_{10}	0.1μF 750V wkg.

Inductors

T_1 Mains transformer. Secondaries 300–0–300V, 6.3V, 4V. (See text concerning secondary currents and source)

L.F.C. 10 henry smoothing-choke, current as required. (See text)

Valve

V_1 EZ81

Tube

Cathode Ray tube type VCR139A

Rectifiers

MR_1, MR_2 Rectifiers type K3/25 (S.T.C.)

Neon

NE_1 250 volt neon signal lamp with built-in resistor

Switch

S_1 d.p.s.t. toggle

Miscellaneous

Chassis, knobs, B9A valveholder, etc.

voltage, smoothed by C_8, C_9 and R_7, to be applied to the negative end of the chain across the c.r.t. Thus, a negative e.h.t. voltage is applied to the cathode of the c.r.t., whilst the final anode and deflector plates are conveniently at, or close to, chassis potential.

The present circuit is intended to provide an h.t. positive output for ancillary equipment at the point marked "H.T.+". The voltage here is of the order of 300 to 400 according to the current drawn by the ancillary equipment. The maximum current which may be drawn is limited by the current rating of the transformer h.t. secondary or the smoothing choke. (The current drawn by the c.r.t. chain is negligibly low.) If the current drawn by the ancillary equipment will be around 30mA or less, the l.f. choke could be replaced by a smoothing resistor of 1 or 2kΩ.

A 6.3 volt output for the heaters in ancillary equipment is also available. The maximum current which may be drawn here is the current rating of the 6.3 volt winding of the mains transformer less the 1 amp taken by the EZ81 heater. The other side of the 6.3 volt output, and the h.t. negative connection for ancillary equipment, can be taken from the chassis of the unit.

This power supply circuit is based on the designs published in *The Radio Constructor* for February and March 1964; appearing in the articles by J. Hillman under the title "An Interchangeable Oscilloscope".

Construction

Little comment is necessary concerning constructional details. The writer used an existing chassis, measuring 10½ x 8 x 3in, which was already well provided with holes for valves, switches and potentiometers, etc., since it had previously been used for an audio amplifier unit. A few spare holes for the future addition of valves, potentiometers and other components is an advantage. Many of the holes can be temporarily filled by plastic plugs of the type which can now be bought specifically for filling spare holes on chassis or panels.

It is advisable to mount the mains transformer immediately behind the c.r.t. as shown, and if a mu-metal screen can be found for the tube, this too, is a help against trouble from magnetic deflection due to the field around the transformer.

The controls provide for X and Y shift, focus and brilliance, and there is also a mains on-off switch. Coaxial sockets are provided for the inputs to the X and Y plates.

The four potentiometers are mounted for convenience along one side of the chassis, as shown in the photograph. A pilot lamp to indicate when the unit is on is a useful addition. This can be of the neon type with its own built-in series resistor, connected across the mains input to the transformer.

With the prototype the negative e.h.t. voltage obtained at point "A" was 600, which allowed a satisfactory display to be given on the c.r.t. screen. The positive voltage at the h.t. positive outlet, with no ancillary equipment connected, was 420.

THE "EXPLORER IV" RECEIVER

Part 2

The drilling details for this receiver, the tools required and the fitting of the main components to the chassis were all described last month. In this concluding instalment, details of wiring-up, together with testing and operating procedures, are presented, whereupon the beginner should have no difficulty in completing this quality 1-valve short wave receiver.

Assuming the instructions given in part 1 (published in last month's issue) have been completed, beginners will now have their "Explorer" receiver at the stage where all the main components are secured to the chassis and the front panel.

Operations are resumed with the wiring-up process, a full description of which now follows. Beginners should ensure that each operation is carried out as described and in that order. In this manner the completion of the receiver will be carried out as simply and as easily as possible. Care should be taken with the soldering of each joint to make sure that no "dry joints" exist.

The point-to-point diagram of Fig. 3 illustrates the wiring for all components but it should be borne in mind that this drawing has been "exploded" for purposes of clarity, and that the components have shorter wires than appear in Fig. 3. All wiring must, in practice, be as short and direct as possible,

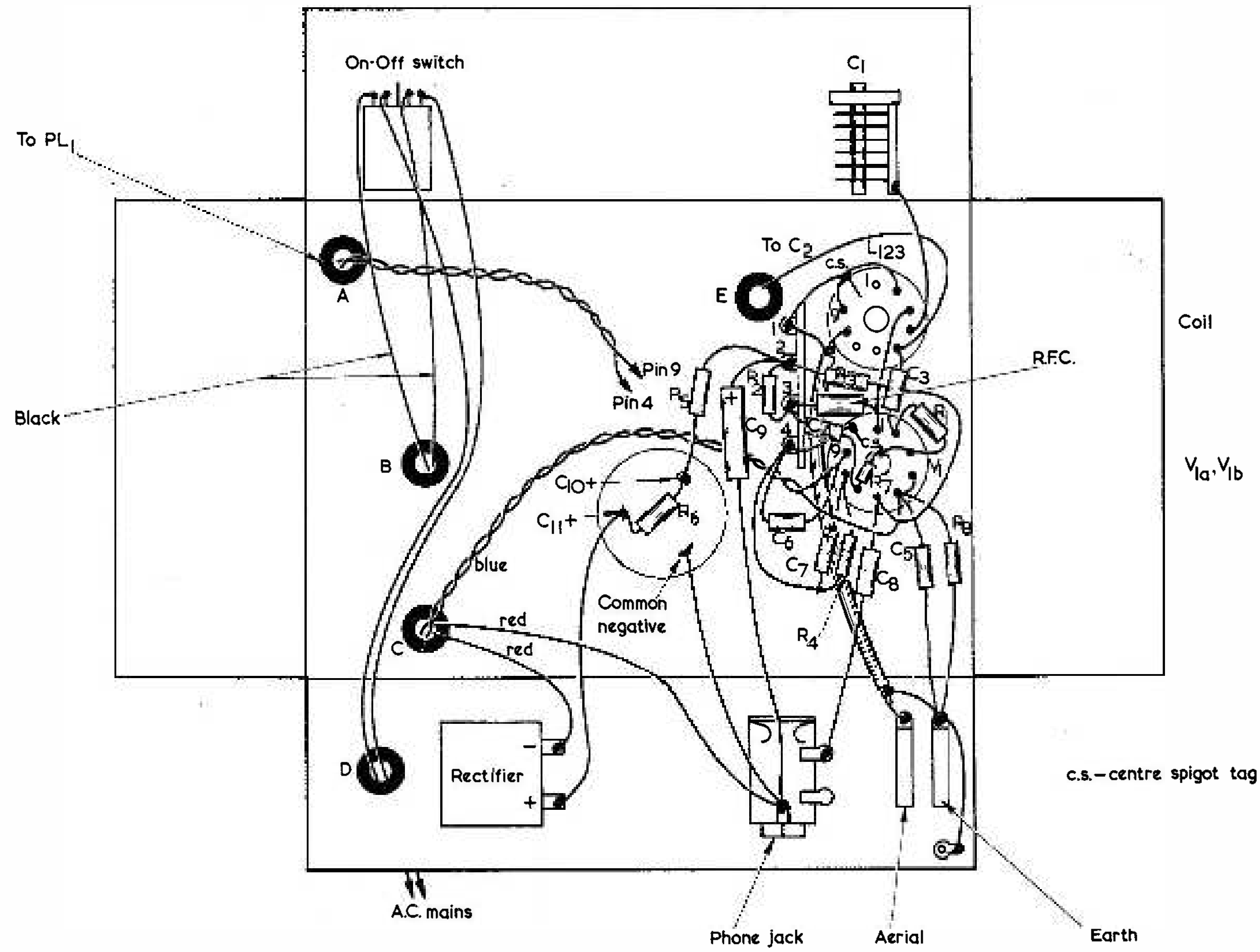


Fig. 3. Point-to-point wiring diagram of the receiver. Note that the wiring is shown in "exploded" form for purposes of clarity

the exception to this being the valve heater leads which should be positioned approximately as shown in the illustration of the below-chassis view.

Wiring Up

To facilitate wiring up, capacitor C_1 is initially removed. The front panel is then held only by the securing nut for the On-Off switch and care should be taken to ensure that it does not swivel on the bush of this switch. During the first wiring steps, the chassis should be rested on blocks (e.g. books, etc.) to prevent any undue pressure being placed on the panel.

Coilholder

Dealing firstly with the coilholder, and using a short bare length of wire, join pins 2 and 9 to the central metal spigot tag and thence to tag 1 of the 4-way tagstrip.

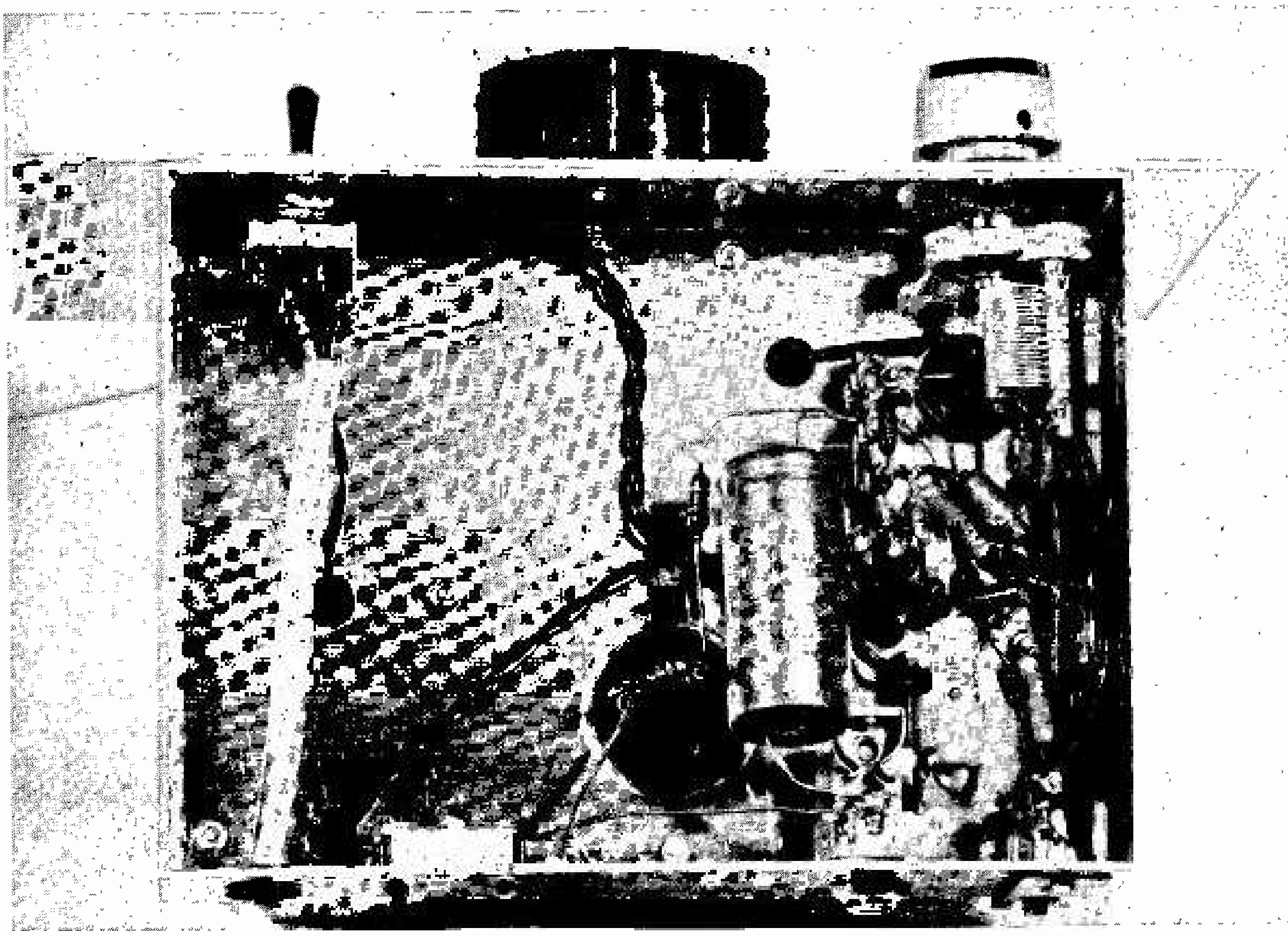
To pin 4 solder one end of a short length of p.v.c. covered wire of sufficient length to reach the adjacent fixed vane solder tag of C_1 when this is later mounted into position.

To pin 3 solder a short length of p.v.c. covered wire, the other end of which is soldered to pin 1 of the valveholder.

When the tuning capacitor, C_2, was fitted, a 4in length of insulated wire was connected to its fixed vane tag, this being fed through the grommet at hole E. Shortening as necessary, now connect this wire to pin 5 of the coilholder. Take up C_3, and connect one of its lead-out wires to pin 5 of the coilholder. Connect the other end of C_3 to pin 2 of the valveholder.

To the aerial input socket on the rear apron of the chassis solder the central wire of a short length of coaxial cable. Solder the braiding of the cable to the earth socket. Shortening the cable as necessary, connect the centre conductor at the other end to pin 8 of the coilholder, the braiding at this end end being soldered to tag 1 of the 4-way tagstrip. Using a short length of bare wire, connect the earth input socket at the rear apron to the adjacent chassis tag.

This completes the wiring-up at the coilholder with the exception of the connection to the reaction



Below-chassis view showing the actual location of components — compare with the diagram of Fig. 3

capacitor, C_1. This capacitor may be finally mounted in position, the wire previously fitted to pin 4 of the coilholder now being connected to its fixed vane tag. Note the orientation of C_1, as shown in the photograph of the chassis underside. With C_1 in position, the panel is securely held to the chassis and there is no further necessity, of course, to take any precautions against its swivelling on the switch bush.

Power Supply

Refer to Fig. 3 and wire-up the On/Off switch as shown, the black wires from the mains transformer (grommet B) being soldered to the left hand tag of each section of the switch. Shorten the wires as necessary. The a.c. mains input lead should now be fed through grommet D on the rear apron of the chassis and the wires soldered to the remaining two tags of the switch.

The two thin red wires from the transformer (grommet C) should now be suitably cut to length and connected in the following manner. One wire (it does not matter which one) to the negative tag (–) of the metal rectifier and the other wire to the tag of the phone jack nearer the rear apron. (This tag provides a chassis connection.) To the positive tag of the metal rectifier (+) solder one end of a short length of p.v.c. covered wire, the other end being soldered to the positive tag of capacitor C_{11} (8μF).

To C_{11} positive tag, also solder one end of resistor R_6, the other end of this resistor being connected to the positive tag of C_{10} (16μF) having firstly suitably cut the wire ends of R_6 to the correct length.

To the common negative tag of this dual capacitor (C_{10}, C_{11}) solder one end of a short length of wire and connect the other end to the tag of the headphone jack nearer the rear apron.

To the positive tag of C_{10} solder one end of resistor R_5, the other end of which connects to tag 2 of the 4-way tagstrip. To this latter tag also solder the positive end (+) of the electrolytic capacitor C_9, the other end of which is connected to the tag of the headphone jack nearer the rear apron.

The blue wires from the mains transformer (grommet C) should now be twisted together, cut to a suitable length, and the enamel covering removed from the copper wire by scraping with a penknife. Solder one wire end to pin 9 of the valveholder and the other wire end to pins 4 and 5 of the valveholder.

To valve pins 4 and 9 solder two lengths of p.v.c. covered wire, twist these together and feed through grommet A (see Fig. 3). The other ends connect to the panel lamp assembly PL_1 mounted on the front panel.

The wiring-up of the power supply section is now complete.

Valveholder

To tag 2 of the 4-way tagstrip solder one end of the resistor R_2, the other end connecting to tag 3 of the 4-way tagstrip.

To tag 3 of the 4-way tagstrip solder one end of the r.f. choke, having firstly suitably cut the wire ends of this component to length. Connect the other end of the r.f. choke to pin 1 of the valveholder.

Using a short length of bare wire, solder one end to pin 3 of the valveholder and the other end to the central metal spigot of the valveholder. Similarly using bare wire, connect the centre spigot tag to tag 4 of the 4-way tagstrip.

To pin 2 of the valveholder connect one end of R_1, the other end connecting to pin 3 of the valveholder.

To the centre spigot of the valveholder solder one end of the resistor R_7, the other end of this resistor connecting to pin 7 of the valveholder.

To pin 5 of the valveholder solder one end of the components R_8 and C_5. The other ends of R_8 and C_5 are soldered to the earth input tag on the rear apron of the chassis.

To pin 6 of the valveholder solder one end of the capacitor C_8, the other end of which connects to the phone jack solder tag nearer the valveholder. Also to pin 6 of the valveholder connect one end of resistor R_3, the other end of which connects to tag 2 of the 4-way tagstrip.

To tag 3 of the 4-way tagstrip solder one end of C_4, the other end of which connects to pin 7 of the valveholder.

To pin 8 of the valveholder solder one end of the components R_4 and C_7, taking care that the positive end of C_7 is connected to pin 8. The other ends of these two components are connected to tag 4 of the 4-way tagstrip.

To pin 9 of the valveholder connect one end of the capacitor C_6, the other end of C_6 connecting to tag 4 of the 4-way tagstrip.

This completes the wiring-up of the valveholder and of the receiver.

Checking

It is a great temptation for the beginner to rush the construction of his first receiver in order to get it working as soon as possible. More often than not, it will then be found that some mistake has been made in the wiring-up process due to the hasty method adopted. This invariably means that, upon switching on the receiver, it does not work at all or, even worse, expensive burning odours start to rise!

The very first thing to do is to check that all the correct connections have been made. Check with the circuit diagram (published last month), the point-to-point diagram of Fig. 3 and the foregoing textual instructions. Ascertain that no wires are touching one another in unwanted places. Are all the soldered connections correctly made with good sound joints? Take a little time to ensure that all is correct.

Voltage Table

Junction R_2, R.F.C.	100V
Pin 6 $V_{1(b)}$	80V
Junction R_5, C_9	310V
Junction R_5, R_6	325V

Plug in the valve and the selected coil (Range 3 will suffice). Connect the aerial, the earth, the headphones and the mains supply. Place the receiver on the bench such that the underside is uppermost and switch on, whereupon the panel lamp PL_1 should light up. If a meter is available, the voltage table will give an indication of the approximate voltages which should be obtained at various points in the circuit.

If all is well, it will be found that a signal should be apparent in the headphones once the reaction capacitor C_1 is set into a position just short of the oscillation point. A gentle breathing sound will be heard when oscillation occurs, and C_1 should be reduced in capacitance until the breathing sound just ceases, this being the most sensitive setting for the receiver. Rotation of the tuning capacitor C_2, whilst keeping the reaction control just short of the oscillation point, will bring in many transmissions throughout the tuning range.

Once the circuit has been tested and found to be in working order, the writer would suggest that the tags of the On/Off switch be covered with insulation tape several layers thick by wrapping the tape around the switch body several times. Protected thus, there will be little risk of shock should the operator accidentally handle the chassis and the switch tags at the same time. Alternatively, of course, the switch could be secured in a final position such that the On/Off motion is from side to side and not, as in the prototype, up and down.

Operation

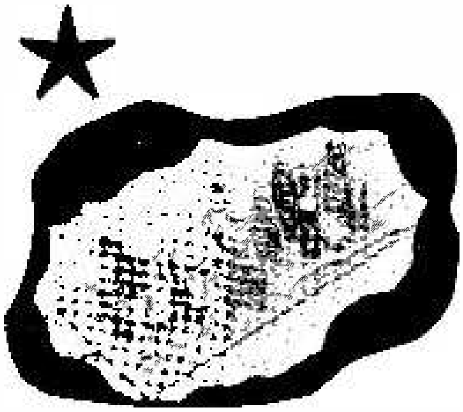
The operation of this receiver depends, for first class results, on the aerial and earth employed. The latter may consist of a copper rod or pipe, driven as far as possible into the soil, connection to the receiver being by way of a short length of copper wire secured to the top of the earth rod by a Jubilee clip or similar. The aerial should be sited as far from earthed objects such as trees, metal guttering, etc., and as high as possible.

The earth connection should not be taken from the house water pipe system if plastic pipes are fitted.

The type of aerial used with this receiver will greatly affect the performance and some beginners may like to experiment with the effect produced by inserting a silver mica capacitor in series with the aerial input such a capacitor having a value between 10 and 100pF.

For the reception of c.w. (Morse) signals, the receiver should be operated with the reaction control positioned just over the oscillation point.

If desired, the front panel of the completed receiver may be either painted or cellulose sprayed to give a final finish.



Miniature 1 Watt

Employing low-cost Sinclair n.p.n. silicon planar transistors, this miniature a.f. amplifier offers a high quality at powers up to 1 watt.

THIS HANDY LITTLE AMPLIFIER, WHICH USES A total of seven semiconductors in a transformerless circuit, measures a mere $2\frac{7}{8} \times 1\frac{1}{4} \times 1$in, yet it gives an output of 1 watt music power when using an 18 volt supply and a 15Ω speaker. Total building cost can be less than 50 shillings.

The design is unique in that the power supply may be varied over the range 7 to 20 volts without need for readjustment of component settings and with no appreciable change in either the quality or the quiescent current. The unit is thus ideal for direct incorporation in a wide range of radios, record players, and tape recorders, etc., or for use on its own as a general purpose power amplifier.

The performance of the amplifier is up to high quality standards, as is shown by the following list of characteristics.

Max. Output Power:
1 watt (music), 700mW (r.m.s.).
Frequency Response: (15Ω load)
60 c/s to 120 kc/s ± 3dB. (C_3=50μF).
10 c/s to 120 kc/s ± 3dB. (C_3=400μF).
Sensitivity For 1 Watt Output: (15Ω load)
150mV. into 1kΩ.
Distortion: (15Ω load)
1 watt music=less than 10%.
0.5 watt music=less than 1%.
Quiescent Current:
15mA at 18 volts.
8mA at 9 volts.
Size: $2\frac{7}{8} \times 1\frac{1}{4} \times 1$in
Power Supply: 7 to 20 volts.

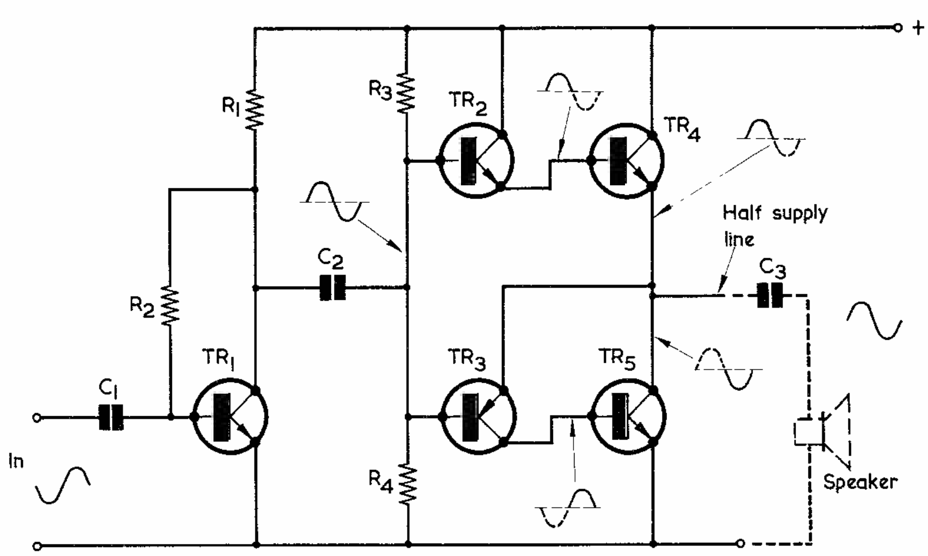


Fig. 1. Simplified diagram, illustrating the basic operation of the amplifier

High Quality Amplifier

Cover Feature

by W. Kemp

Basic Principles Of Operation

The full circuit diagram of the amplifier is shown in Fig. 2, but the operation of this unit is rather complex and a little difficult to explain working from the final circuit, so an introduction to the basic principles of operation is best made by referring first to the simplified diagram shown in Fig. 1.

Here, an input signal is applied via C_1 to the base of TR_1, which is wired as a simple common emitter amplifier with R_1 as its collector load. An amplified version of the input signal appears at TR_1 collector, but is in anti-phase (180° phase shift) to the original input signal. This amplified signal is fed via C_2 to the bases of TR_2 and TR_3, as shown.

The bases of TR_2 and TR_3 are joined together and connected to the junction of R_3 and R_4; these two resistors are of equal value and are connected between the two supply rails, so that this common point will be held at a mean level of half supply potential and the signal from C_2 will swing about this level. Due to basic transistor action, the potential of a transistor's emitter is held very close to that of its base, so that the line connecting TR_3 and TR_4 emitters will also be held at approximately half supply potential, as indicated.

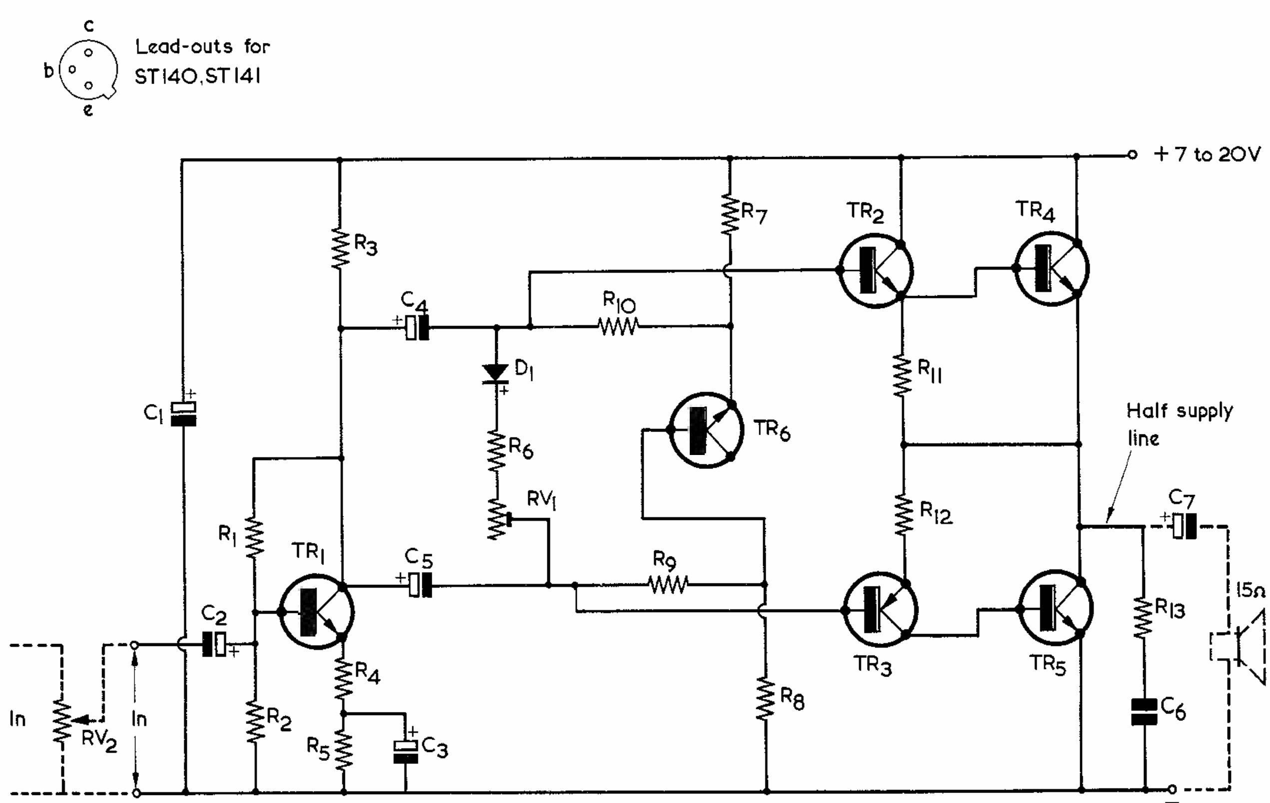
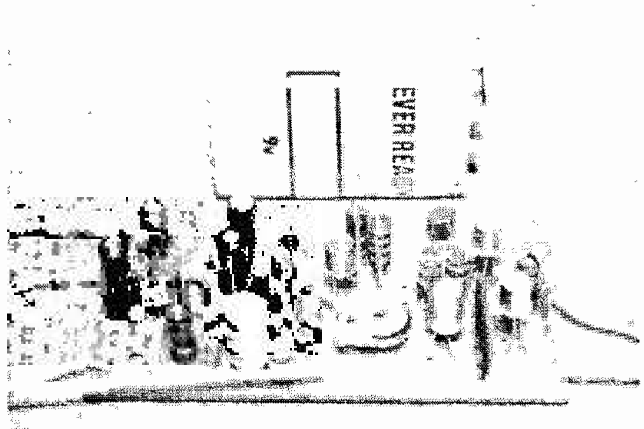


Fig. 2. The complete circuit of the miniature 1 watt amplifier



Another view of the amplifier. The PP3 battery gives an indication of the small size of the unit

Remembering that the signal from C_2 swings about the half supply potential, we may next consider the effect of this signal on the TR_2 to TR_5 stages.

TR_2 is connected as an emitter follower with its emitter connected directly to the base of TR_4, which is also wired in the emitter follower mode. These two transistors can thus be regarded as a single compound transistor having a very high gain, it being connected as an emitter follower and thus giving unity voltage gain and zero phase shift at TR_4 emitter. When the C_2 signal swings in a *positive* direction about the half supply potential, TR_2 and TR_4 will be driven on, and TR_4 emitter (and thus the half supply line) will "follow" the signal. When, however, the C_2 signal swings in a *negative* direction about the half supply potential, TR_2 and TR_4 will both be reverse biased and become cut off, whereupon they will contribute no part of the half supply line output waveform.

TR_3 is connected as a p.n.p. common emitter amplifier, with its collector current taken directly from the base of TR_5. TR_5 is connected as an n.p.n. common emitter amplifier with its collector connected to TR_3 emitter; both of these transistors thus operate with 100% voltage negative feedback and provide unity voltage gain. We have seen that a common emitter amplifier gives 180° phase shift between base and collector, and it follows that any signal at TR_3 collector will be in anti-phase to that at its base. The collector of TR_3 is connected to TR_5 base, however, so that the signal at TR_5 collector will, in its turn, be in anti-phase to the anti-phase signal at TR_3 collector, so that the TR_5 collector signal will be *in phase* with that at TR_3 base. TR_5 collector is connected to the half supply line and, since there is unity voltage gain and zero phase shift between TR_5 collector and TR_3 base, the signal on this line will tend to "follow" that on TR_3 base. When the signal at TR_3 base (from C_2) swings in a negative direction about the half supply potential, TR_3 is driven on (since it is a p.n.p. type) and in turn causes TR_5 to conduct whereupon the half supply line follows the C_2 signal. When the C_2 signal swings in a positive direction, TR_3 will be reverse biased and both TR_3 and TR_5 will be cut off, so that they contribute no part of the output signal at the half supply line.

To summarise, on positive-going parts of the C_2 signal, TR_2 and TR_4 conduct, but TR_3 and TR_5 are cut off. On negative-going parts of the C_2 signal TR_3 and TR_5 conduct and TR_2 and TR_4 are cut off. These four transistors thus act as a Class-B push-pull amplifier. In consequence, the waveform appearing on the half supply line is of the same form as that at TR_1 collector but is at a very low impedance level; this low impedance signal drives an external speaker via C_3.

Now, while the circuit of Fig. 1 is adequate for explaining the basic principles of this type of amplifier, it is of little practical value in its present form. This is because the base of TR_2 is wired direct to that of TR_3 and no base-bias can therefore be applied to either of these transistors, with the result that severe cross-over distortion would be experienced on the output signal.

This snag is overcome in the practical version of the final amplifier, which is shown in Fig. 2.

The Practical Circuit

Referring to Fig. 2, an input signal can be connected either directly or via an external volume control (RV_2) to the input terminals of the amplifier, and this signal is then fed via C_2 to the base of TR_1. TR_1 is wired as a common emitter amplifier with collector load R_3, but has series and shunt negative feedback provided by way of R_4 and R_1 to ensure a wide frequency response and low distortion, while at the same time stabilising the d.c. working points against wide variation in supply rail potential and transistor characteristics. An amplified version of the input signal appears at TR_1 collector, and is fed equally to the bases of TR_2 and TR_3 via C_4 and C_5 respectively.

TR_2 to TR_5 work in the manner already outlined, with the exceptions that R_{11} and R_{12} stabilise the circuit against variations in leakage currents, and that a sophisticated base-bias stabilisation network is provided. The output signal at the half supply line is fed to the 15Ω external speaker via the large value capacitor, C_7, which is also external to the amplifier panel. It should be noted that the impedance of the speaker must *not* be lower than 15Ω.

The frequency response of the Sinclair transistors used in the amplifier extends to so high a figure that it becomes necessary to limit the upper frequency response of the amplifier by artificial means, and this is achieved by wiring R_{13} and C_6 across TR_5, as shown. If this limiting network were not included, the amplifier would tend to act as a self-activating oscillator operating in the high r.f. range, and possible damage would result in TR_4 and TR_5.

The base-bias network of the amplifier operates in the following manner. R_7 and R_8 are of the same value and are wired in series with a 6 volt "Zener diode" (actually the base-emitter junction of TR_6), the combination being connected between the positive and negative supply rails as shown. A constant potential of 6 volts appears across the "Zener diode", even though the supply rail potential may be varied over the range 7—20 volts. One of the unique features of the ST140 and ST141 range of transistors is that, by using only the emitter and base connections, they can be made to function as very low impedance 6 volt Zener diodes, and TR_6 (ST140) is in fact used as the "Zener diode" in this circuit.

The voltage across the "Zener diode" is fed to a voltage divider network comprising R_9, RV_1, R_6, D_1 and R_{10}, the base of TR_2 being connected to the junction of D_1 and R_{10}, and the base of TR_3 being connected to the junction of R_9 and RV_1. The value of RV_1 is adjusted to set the correct degree of base-bias for TR_2 and TR_3.

Since R_7 is symmetrical with R_8, and R_9 is symmetrical with R_{10}, the bases of both TR_2 and TR_3 will automatically be held at approximately half supply potential, irrespective of variations in the actual supply voltage. Similarly, since the base-bias potentials are derived from the Zener-stabilised 6 volts, rather than from the supply lines, the base-bias potentials will remain substantially constant, once set, irrespective of supply line variations.

Finally, the base-bias potentials are stabilised against changes in ambient temperature by the series compensating diode, D_1.

It should be added that TR_3 may be any small-signal p.n.p. type having a beta of greater than 40. An OC202 is suitable.

This completes the description of the amplifier circuit.

Construction

The unit is wired up on a small piece of Veroboard panel with 0.15in hole spacing. Start construction by cutting the panel to size, as shown in Fig. 3, and then drill the two mounting holes to clear 6BA screws. Cut back the copper from around these holes, as shown. Now break the copper strips, with the aid of a small drill or the special cutting tool that is available, as indicated in Fig. 3.

Next solder all components in position on the Veroboard panel, as shown also in Fig. 3, taking care to fix all leads and components in exactly the positions indicated. Note that all components

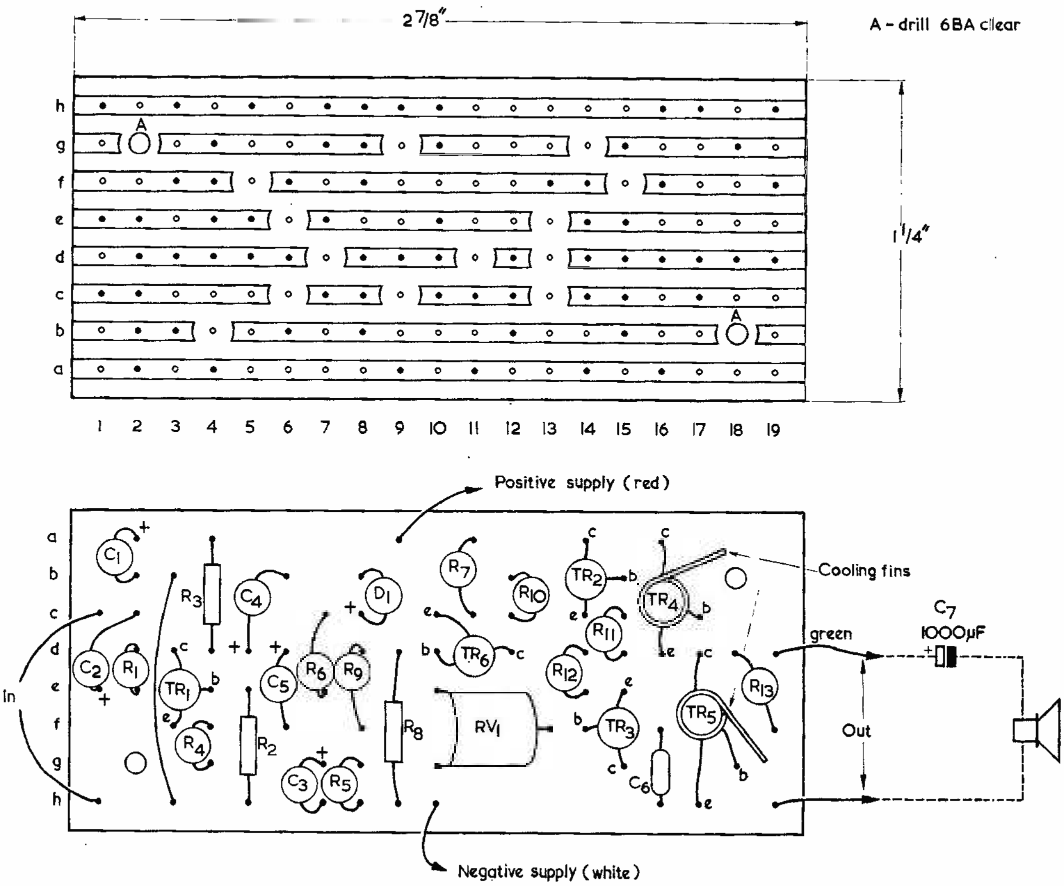


Fig. 3. The copper and component sides of the Veroboard on which the amplifier is assembled

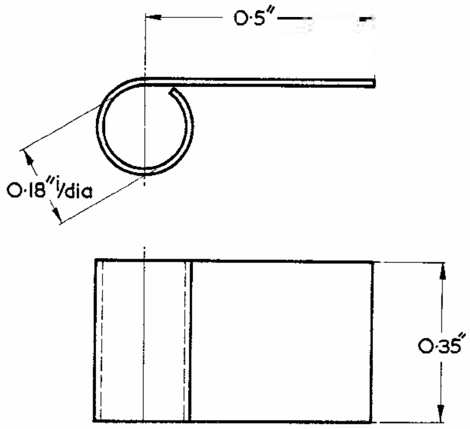


Fig. 4 Although not essential, cooling fins can be fitted to TR_4 and TR_5 to provide an operating margin. These may have the approximate dimensions shown here

other than R_2, R_3, R_8 and RV_1 are mounted vertically and as close to the surface of the panel as possible. Insulated sleeving should be used where there is any danger of components short-circuiting against one another, and in this respect it should be noted that the cases of the n.p.n. transistors are "live" since they are internally connected to the transistor collectors.

The output transistors TR_4 and TR_5 work within their rated dissipations without the necessity for a heat sink but it is still, nevertheless, worth-while fitting them with small cooling fins to provide an operating margin. The fins can be made from any thin metal which may be conveniently bent into shape. Dimensions are not critical and those shown in Fig. 4 may be followed approximately. The curved section of each fin can be initially bent around a 2BA bolt or the shank of a No. 15 drill. Since these cooling fins are in electrical contact with the transistor collectors they should not touch any other component or wire. Cooling fins were not fitted when the photographs were taken, but they appear in the layout diagram of Fig. 3.

Particular care should be taken to ensure that all electrolytic capacitors and semiconductors are mounted with the polarities, or connections, shown in the diagram. It may be necessary to file the tags of RV_1 to make them fit the Veroboard holes.

When assembly is complete, double-check all wiring and make sure that there are no short-circuits between the copper strips on the rear of the panel. When satisfactory, the circuit can be given a functional check.

Set RV_1 for minimum resistance (slider closest to hole 10e), short-circuit the input leads together and, with a d.c. current meter wired in series with a 9-volt battery, connect the battery to the amplifier power supply lines, a current reading of less than 5mA should be obtained.* If satisfactory, break the power supply connection, connect a 15Ω speaker between the output leads via a 1000μF capacitor (C_7) as shown in Fig. 3 and re-connect the supply. There should be no significant increase

* If a current reading substantially greater than 5mA is given, reduce the value of R_6 to 560Ω.

COMPONENTS

Resistors
(All fixed values $\frac{1}{2}$ watt)

- R_1 27kΩ 10%
- R_2 10kΩ 10%
- R_3 2.2kΩ 10%
- R_4 22Ω 10%
- R_5 220Ω 10%
- R_6 1kΩ 10% (see text)
- R_7 1kΩ 5% hi-stab
- R_8 1kΩ 5% hi-stab
- R_9 2.2kΩ 5% hi-stab
- R_{10} 2.2kΩ 5% hi-stab
- R_{11} 330Ω 10%
- R_{12} 330Ω 10%
- R_{13} 22Ω 10%
- RV_1 1kΩ linear potentiometer, sub-miniature preset
- RV_2 5kΩ log potentiometer (optional—mounted external to panel)

Capacitors
(All sub-miniature types)

- C_1 8μF electrolytic 25V wkg.
- C_2 16μF electrolytic 15V wkg.
- C_3 50μF electrolytic 6V wkg. (60 c/s—120 kc/s) or 400μF electrolytic 2.5V wkg. (10 c/s—120 kc/s)—see Amplifier Characteristics
- C_4 16μF electrolytic 15V wkg.
- C_5 16μF electrolytic 15V wkg.
- C_6 0.05μF
- C_7 1,000μF or greater, electrolytic 15V wkg. (mounted external to panel)

Semiconductors

- TR_1 ST140 (Sinclair)
- TR_2 ST141 (Sinclair)
- TR_3 OC202
- TR_4 ST141 (Sinclair)
- TR_5 ST141 (Sinclair)
- TR_6 ST140 (Sinclair)
- D_1 OA200 or OA202

Miscellaneous

Veroboard, 0.15in hole matrix, $2\frac{7}{8} \times 1\frac{1}{4}$in (8 strips × 19 holes)
15Ω speaker
Cooling fins (for TR_4 and TR_5)
Wire, sleeving, etc.
Battery, as appropriate

in the current reading. Now connect the output from a tuner unit or the output socket of a transistor radio to the input terminals of the amplifier; set the volume at a fairly low level and adjust RV_1 to give minimum quiescent current (approximately 8mA) consistent with good sound quality. Next run the amplifier at fairly high volume for a few minutes, so that the output transistors (TR_4 and TR_5) reach a fairly high temperature, and then check that the quiescent current returns to a low level when the volume is reduced to zero. If this does not occur, ensure that RV_1 has been correctly adjusted and make entirely certain that the speaker has the correct impedance of 15Ω or greater. Finally, replace the 9-volt supply with an 18-volt supply and re-check the amplifier for quality. RV_1 should require little, if any, readjustment, although quiescent current will rise to about 15mA.

The amplifier is now complete and ready for use.

Using The Amplifier

The amplifier may be used with any supply voltage in the range 7 to 20 volts. It is intended for use with a speaker impedance of 15Ω or greater, and clearly, the maximum output power will be reduced below 1 watt as the supply voltage is reduced below 18 volts.

A volume control can be fitted at the front of the amplifier, as shown in Fig. 2, if required, a 5kΩ variable resistor (RV_2) being employed for this purpose. If a long input lead is to be used, this should consist of screened wire with the braiding connecting to hole 1h of the Veroboard. C_7 (the output capacitor) is mounted external to the main amplifier panel.

The amplifier is primarily intended to be driven from a tuner unit or similar source of fairly high level input signals, and the sensitivity of the unit is thus not particularly high, an input of 150mV being required for maximum output. In consequence, the amplifier is *not* suitable for direct drive from a microphone or other very low level signal source. In such cases a pre-amplifier will be required, and it is hoped to describe a suitable unit, incorporating tone controls, in a future issue.

Transistor Portable for Beginners

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

A simple medium and long wave receiver which may be constructed at low cost.

A PLEASANT RESULT OF WRITING articles for *The Radio Constructor* is the letters which come in from readers. From some of these it would seem that the various designs using the Spontaflex circuit have interested many beginners, some of whom, however, have felt that they have had insufficient practical detail given to them. So this article is primarily for the beginner, and constructional detail will be fuller than is the author's usual practice. The receiver to be described uses a modified form of the Spontaflex circuit with an arrangement for boosting the bass frequencies. The circuit has not been previously published so the beginner will be able to feel that he is building something new.

So far as components are concerned, it must be emphasised that TR_1, TR_2, D_1, T_1 and T_2 must be as specified. The speaker should be of fairly high flux density, 10,000 to 12,000 gauss being suitable. C_3 is not a generally available type, but the suppliers quoted in the Components List have informed the author that good stocks are held. If the dual capacitor specified cannot be obtained, two separate capacitors can be substituted, but it must be pointed out that one of these may not be eventually required. As is explained later in the article, the value required in C_3 may be either 2,000, 4,000 or 6,000μF according to the characteristics of the particular semiconductors employed, the value giving best results being found by experiment.

Construction

It is suggested that the frame aerial be made first. Two pieces of plywood, about ¼in thick, are cut as shown in Fig. 2 (*a*), as also are two pieces as shown in Fig. 2 (*b*). The first two pieces have 9 slots cut in each end with a hacksaw. The slots should be ¼in deep. The first is cut ¼in from one side, and 6 more are cut at ¼in intervals. There is then a gap of ¾in, and 2 more cuts are made, the second of which should be ¼in from the far side.

The other two pieces of plywood have no cuts but one of them should have pencil lines drawn at the same intervals as the slots in the other two pieces. These pencil lines are indicated in Fig. 2 (*c*), which also shows the positions of eight small holes (diameter about $\frac{1}{16}$in) which need to be drilled. The holes should be numbered, as shown, on both sides of the wood. The relative position of these holes may be judged from the axis X—X, which appears also in the diagram of the completed assembly in Fig. 2 (*d*). The frame is then made by passing panel pins through the sides shown in Fig. 2 (*a*) into the ends of the sides shown in Fig. 2 (*b*). The result should look like Fig. 2 (*d*).

The frame should now be held with the side having the holes on top, and with hole No. 1 towards the constructor. 32 s.w.g. enamelled wire is passed through hole No. 1, leaving about 6in protruding inside the frame, the wire being locked by pushing a wedge into the hole from the outside. (A sharpened match stick will provide an adequate wedge). Winding is in an anti-clockwise direction—all windings are done thus—and 3 turns are put in each of the first 6 sets of slots so that a continuous winding of 18 turns results. This winding can now be cut, about 6in of wire being passed through hole No. 2 and locked. The next winding consists of 3 turns only in the one set of slots, starting at hole No. 3, ending at hole No. 4, and with 6in of free wire at each end. The third coil consists of 40 turns of 38 s.w.g. enamelled wire, all wound

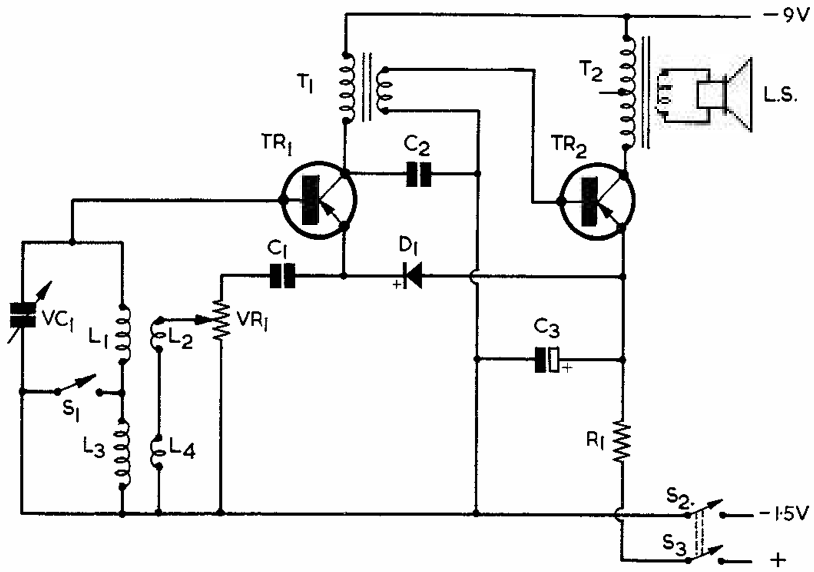


Fig. 1. The circuit of the receiver

in the one set of slots (the last set but one), the winding starting at hole No. 5 and ending at hole No. 6. Lengths of wire, 6in long, are again left inside the frame at each end of the winding. The fourth and last coil consists of 3 turns of 32 s.w.g. enamelled wire starting at hole No. 7 and ending at hole No. 8. Once more, 6in of free wire are left at each end. The frame is now complete and, for the time being, should be placed on one side. Fig. 3 shows, in diagrammatic form, the manner in which the coils appear on the frame.

Next, a piece of ¼in plywood is cut, to measure 11 x 11in. The 6-way tagboard is cut as shown in Fig. 4. A fret saw is the best tool to use here.

The exact position of the components should be ascertained by laying them out on the 11 x 11in panel, taking up the positions shown in Fig. 5. This approach is necessary, as it is impossible to anticipate where the holes will be drilled for the speaker. One of these holes is used to fix the clip for TR_2, and hence decides the exact position of the tagboard. This, in its turn, determines the position of the volume control and, in the interests of a neat layout, the wavechange switch S_1, and the tuning capacitor VC_1. However, it will not take long to mark positions and cut out a suitable hole for the speaker. The three holes for VC_1, VR_1 and S_1 should be made using a ⅜in drill. Components can then be mounted as shown in Fig. 5. A suitable clip for fixing C_3 can be made from tinplate, 5in long by ¾in wide, two holes spaced 4in from each other being drilled at the two ends. The lid of a tobacco tin offers suitable material. The strip will wrap round C_3 which can then be held securely to the board by one screw passing through the two holes. If two separate capacitors are eventually employed (after initial tests) instead of the dual component, the clip may be devised so that one is above (i.e. farther away from the board than) the other. T_2 has one of its feet bent through a right angle. It is fixed to the board by a screw passing through this one foot in such a way that its windings are kept at right angles to the windings of the frame aerial. The tagboard should have two washers, or a strip of thick Paxolin or similar, underneath its two fixing holes, so that it stands clear of the panel.

Wiring

The tags for S_2 and S_3 shown in Fig. 5 correspond in position to those fitted to the Morganite potentiometer specified in the Components List and, for this reason, it is desirable that this particular component be employed. Should another potentiometer and switch assembly be used, the switch tags may take up a different position and it will be necessary to identify, with the aid of a continuity tester or ohmmeter, which tags correspond to each switch. As a guide, the two tags marked A in Fig. 5 correspond to S_2, whilst those marked B correspond to S_3.

T_1 should be fitted in the slot in the tagboard in such a way that its leads stand upwards. These leads should be the first to be soldered into position, and should be held reasonably tight, while soldering, so that the component is held firmly in the slot once connections have been made. The rest of the wiring should now be carried out, leaving the transistors, diodes and frame aerial leads to the last. The semiconductor leads should be held with pliers while they are being soldered into position to avoid damage due to heat. Finally, the frame aerial should be fixed in position. See Fig. 6. The side with the holes in it should be at the top, and hole No. 1 should be closest to the panel. Adhesive may be used to fix the frame to the panel, or small screws, in which case care must be observed not to split the plywood or damage the windings. The 8 leads from the frame can then be cut to suitable lengths to enable them to reach their respective wiring points. The enamel should be carefully cleaned from the ends, and the wire tinned, before soldering to the wiring points. It will be seen from Fig. 5 that leads

COMPONENTS

Resistors
- R_1 82Ω ¼ watt 10%
- VR_1 5kΩ potentiometer, linear track, with 2-pole switch, Morganite (T.R.S. Radio)

Capacitors
- C_1 0.01μF paper
- C_2 560pF ceramic or silver-mica
- C_3 4,000μF plus 2,000μF, 6V wkg.—see text (T.R.S. Radio)
- VC_1 500pF variable, Dilecon (Jackson Bros.)

Inductors
- $L_{1,2,3,4}$ See text
- T_1 Transformer type QX1P (Osmor)
- T_2 Transformer type TT5 (Repanco)

Semiconductors
- TR_1 MAT101 or MAT121
- TR_2 OC81
- D_1 GEX64 (CV2310) (Henry's Radio, Ltd.)

Switch
- S_1 Single pole, on-off, toggle
- $S_{2,3}$ Fitted to VR_1

Speaker
- 3Ω 8 x 5in (see text)

Battery
- See text

Miscellaneous
- Tagboard, 6-way "Standard" (Radiospares)
- 2 knobs
- Transistor clip
- Plywood, screws, wire, panel pins, etc.

(N.B. Radiospares components may only be obtained through retailers.)

Nos. 4 and 7 are soldered to each other only, and not to any component.

A 9 volt battery is required with a tapping 1.5 volts from the positive end. If the receiver will not be used for long periods at a time, two batteries of the 1289 type are suitable. One of these should have the cardboard strip at the top removed, exposing the top cap (in the centre) of the centre cell. This should be cleaned of bitumen and the 1.5 volt lead from the receiver soldered to it. The positive lead goes to the short brass strip of this battery, and the long brass strip is then soldered to the short brass strip of the second battery. The negative 9 volt connection is then taken from the long brass strip of the second battery. If the receiver is to have heavy use, two batteries of the 126 type will prove more economical. The top of one of these should be opened and the 1.5 volt lead from the receiver soldered to the top cap of the central cell. The positive lead of the receiver is screwed to the positive terminal of this battery, and the negative lead to the negative terminal of the other battery, The negative terminal of the first battery is joined to the positive terminal of the second battery by means of a short length of wire.

Testing

The receiver may now be tested. The wavechange switch, S_1, should be put into its upwards position for medium waves, and VR_1 switched on and turned clockwise over most of its movement until a hiss or whistle is heard. It can then be set back a little, and VC_1 adjusted until the local station is received. The receiver is directional, and should be rotated for best results. The local station will probably be much too loud and VR_1 will need to be turned anti-clockwise to reduce the volume. VR_1 will need to be turned anti-clockwise to reduce the volume. More distant stations will require VR_1 to be verv near the point where the hiss or whistle starts.

It is possible that, as soon as VR_1 is turned far enough to operate the battery switch, a deep howl, or a motor-boating type sound is heard from the speaker. If this should happen, the tag on C_3 marked 4000μF should be connected to the tag marked 2000μF. If, as is more probable, the howl does not manifest itself, the lead soldered to the 4000μF tag should be removed and taken instead to the 2000μF tag, without joining these two tags together. The low howl may now start up, but if it does not the constructor will know that he is obtaining the maximum bass boost available. The exact characteristics of the semiconductors determine whether the optimum value for C_3 (i.e. that sufficient to prevent the howl) is 2,000, 4,000 or 6,000μF.

The receiver should give good volume and quality from local stations and, in most areas, a considerable variety of stations after dark. At the author's home in South Devon, he obtains a choice of 18 programmes at a strength quite powerful enough for bedroom use. This receiver is much more than a local station set.

The frame aerial used is equally suitable for any of the single tuned circuit Spontaflex designs which have been previously published in this magazine, including the super-

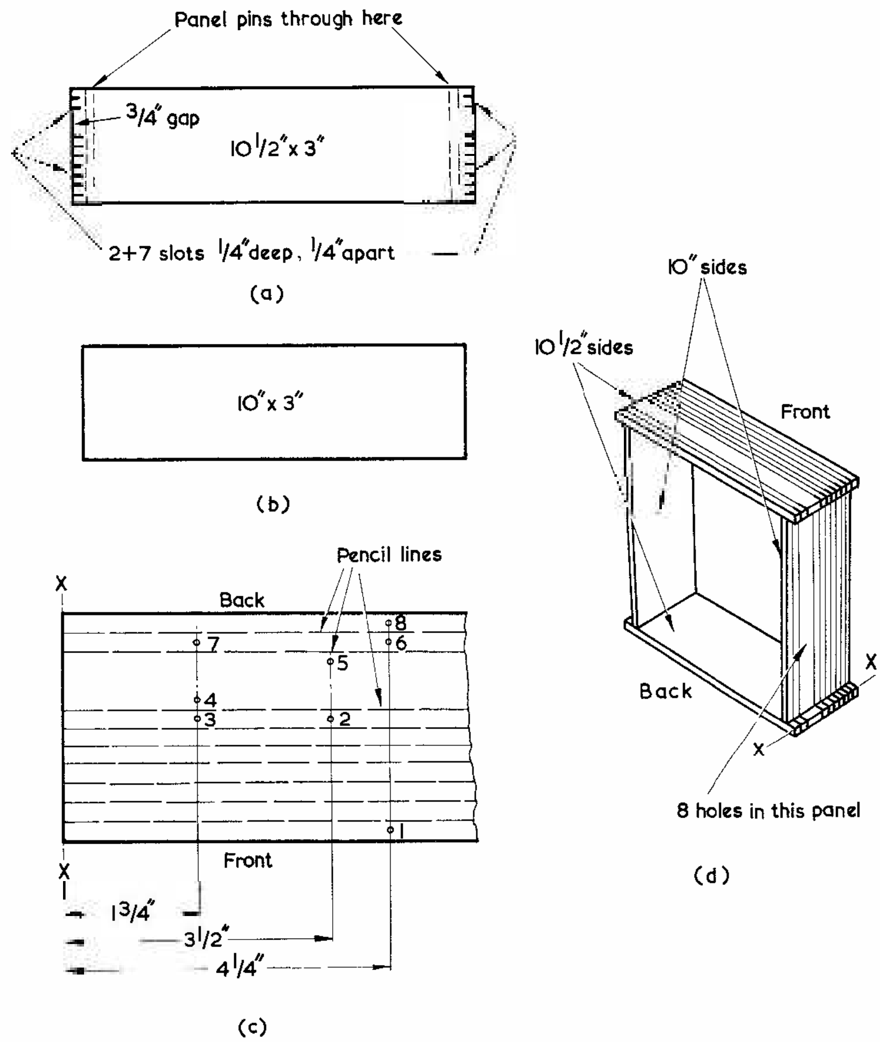


Fig. 2 (a). The two slotted sections of the frame aerial assembly
(b). The unslotted sections
(c). One of the unslotted sections is marked up and drilled as shown here
(d). The frame aerial complete

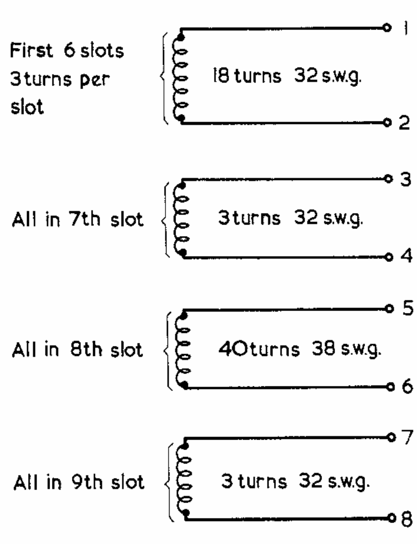


Fig. 3. The layout of windings on the frame aerial

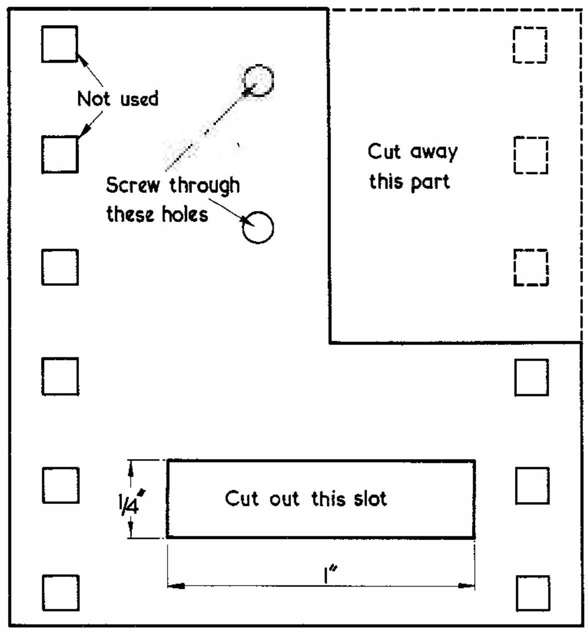


Fig. 4. How the 6-way tagboard is modified

regenerative version*, though in the case of this circuit it may prove useful to decrease C_6, shown in Fig. 1 of the article in question, to 0.01μF and increase VC_2 by shunting a fixed capacitor of from 300 to 600pF across it. The receiver described in the present article can therefore form a useful starting off point for beginners who wish to build more ambitious designs as they gain experience and confidence.

The author leaves the matter of a suitable case for the receiver to the ingenuity of the constructor, who is also left to make a suitable tuning scale. Sufficient stations should be capable of identification, after dark, to enable wavelengths to be identified. it is suggested that it should be fairly easy to remove the receiver from its case—not because frequent battery renewal will be called for, but because the constructor is likely to be asked, on many occasions, to prove that he is only using two transistors!

Circuit Operation

A few paragraphs giving a theoretical description of circuit operation may be of interest. The circuit may be said to be a development of the original 2-transistor design described in the June 1964 issue—developed so as to obtain greater efficiency with fewer components.

If Fig. 1 is examined it will be seen that TR_1 is a micro alloy transistor connected to employ the Spontaflex principle. That is to say, the whole of a tuned circuit is applied between base and emitter and amplification of radio frequency takes place by the common collector mode. The amplified signal appears across D_1 and is demodulated. D_1 then forms the input load for a common base audio frequency amplifier, and the amplified a.f. signal appears across the primary of T_1 which has a very high inductance (of about 600H) so that amplification of voltage is very large. T_1 has a step-down ratio of 30:1 so that its secondary is well matched to the input of TR_2, which performs as a common emitter power amplifier. The output appears across the primary of T_2, which has a ratio of 15:1 and feeds a 3Ω loudspeaker. TR_2 will pass about 16mA with a new battery, but this will soon settle down to about 12 to 13mA.

It will be seen that the battery is tapped at 1.5 volts from the positive end and that the bases of TR_1 and TR_2 are coupled to this point. Stabilisation for TR_2 is provided by R_1 and TR_1 obtains its emitter bias from the top of R_1. There is, of course, a voltage drop across D_1 and this has to be a special type

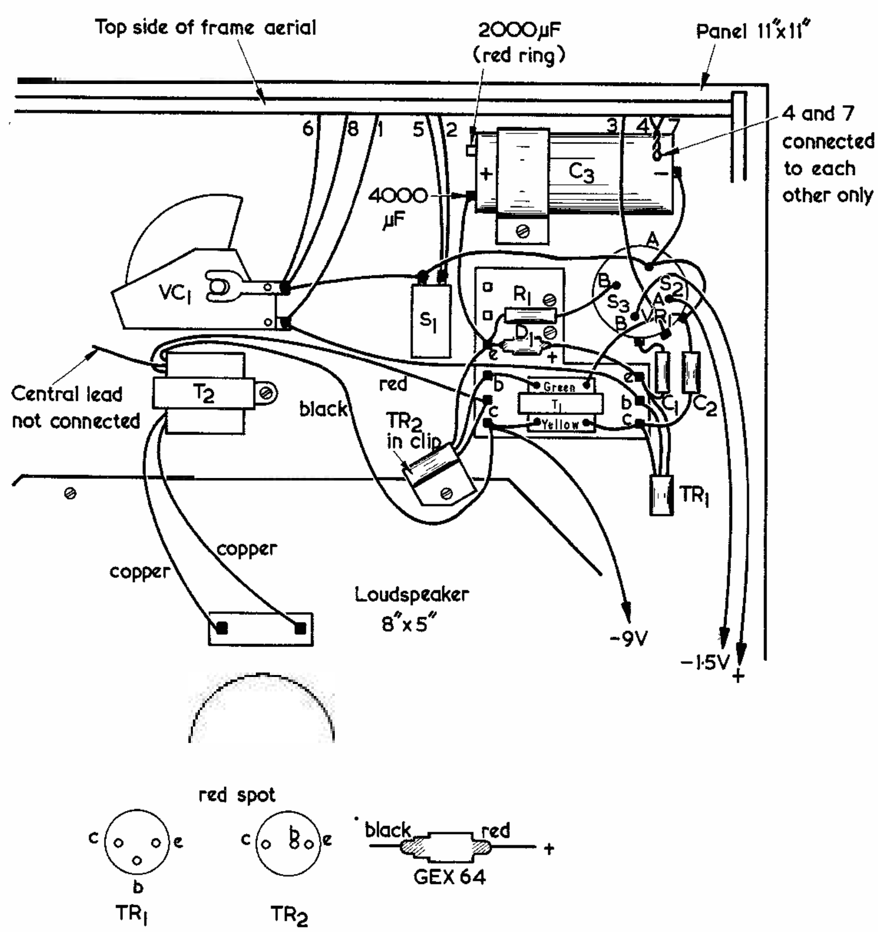


Fig. 5. Details of wiring and component layout

* See Editor's Note at end for references to previous articles.

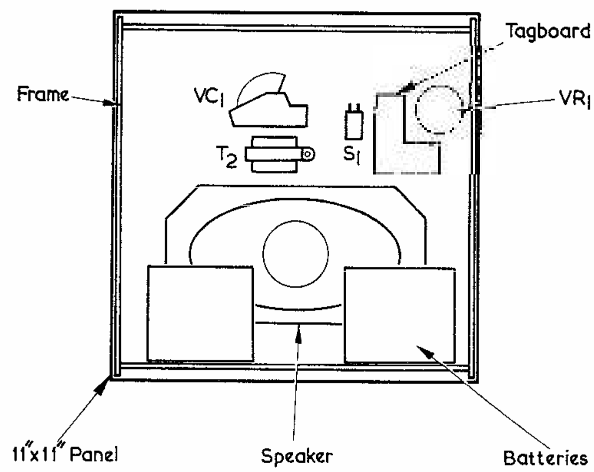


Fig. 6. Rear view of the receiver, showing how the loudspeaker and batteries are positioned inside the frame

with a very low forward resistance in order for TR_1 to pass enough current to function properly. The more normal type of diode, such as the OA81, will not enable TR_1 to function well with a fixed resistor in the R_1 position. The specified type is available from Henry's Radio, Ltd., emitter as GEX64 or CV2310.

D.C. stabilisation is excellent, but the presence of T_1, connected so as to introduce a phase change, offers a degree of positive feedback of the signal. This is held in check by the large electrolytic capacitor, C_3, which has a value which prevents oscillation or distortion at very low frequencies, but nevertheless allows a useful boost of these frequencies. It will be found that if the direction of one of the windings of T_1 is reversed, the good bass response will disappear as the small positive feedback is exchanged for a small negative feedback of the lowest audio frequencies.

TR_2 is provided with a cooling clip which is fitted to the chassis of the speaker. Although TR_2 is operating within its limits without a heat sink, the clip is necessary to prevent any heating of this transistor, with a consequent effect on the emitter bias of TR_1. An increase in ambient temperature affects the diode and TR_1 equally with TR_2, and therefore does not upset biasing.

Reaction is taken from the emitter of TR_1, and VR_1 acts as a true volume control since it damps the tuned circuit as it is turned towards minimum.

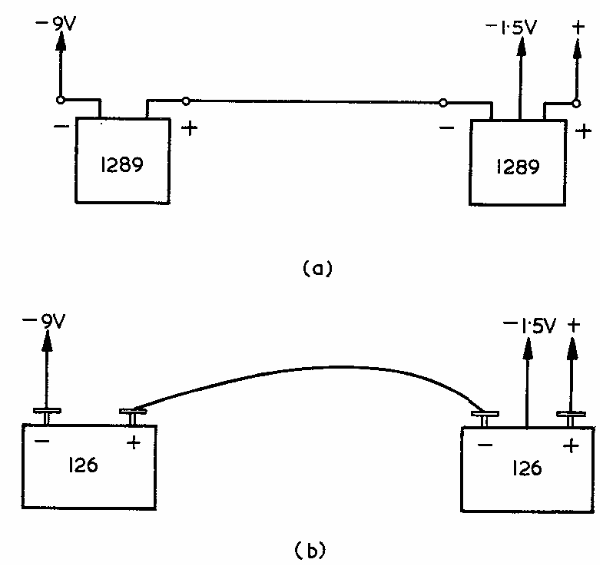


Fig. 7. How the batteries are connected. Either Ever Ready type 1289 or type 126 may be used

Alternative Diode

Since the above was written it has occurred to the author that some constructors might experience difficulties or delays in obtaining the rather unusual GEX64 diode. If the following modification is carried out, any common r.f. diode such as the OA81 may be used in its place. It is necessary to obtain a 100Ω pre-set potentiometer, the Radiospares "Slider" type being suitable. This takes the place of R_1 and its two ends are connected as are those of R_1 in Fig. 5. The negative end of D_1 is connected to the slider of the potentiometer instead of as shown in Fig. 5, and the slider is set about $\frac{1}{3}$ of the way from the left hand side of the potentiometer. Once the correct connection for C_3 has been found, as already described, the slider may be moved slightly in either direction until volume, quality and smooth volume control are all as good as possible. If the slider is too much to the left, volume control will be erratic and sensitivity poor. if it is too far to the right volume will be poor and the output will sound thin.

Editor's Note

The Spontaflex circuit was introduced by Sir Douglas Hall in *The Radio Constructor* of June 1964. (The article published then used a name other than "Spontaflex which was found, later, to be also a trade name.) Subsequent designs based on the Spontaflex principle were: "6-Stage 3-Transistor Short Wave Reflex Receiver, August 1964; "The 'Single Span' Mains Driven Receiver", October 1964; "Super-regenerative Transistor Circuit" for Medium and Long Waves, May 1965 (referred to above); "The 'Spontaflex R.D.4' Transistor Portable", March 1966; and "Comprehensive Volume Control Circuit", August 1966.

UNDERSTANDING RADIO

Parallel and Push-Pull Output Valves

by W. G. Morley

In last month's issue we discussed the operation of the output valve in a radio receiver, showing that the impedance to which the anode is matched is that which provides maximum output at an acceptable level of distortion. We also examined Class A_1 operation (in which no grid current flows) and Class A_2 operation (in which grid current flows during part of the input cycle). We now turn to output stages employing two valves.

Parallel And Push-Pull Operation

In order to obtain a higher output than is offered by a single valve on its own it is possible to connect two output valves in parallel, as shown in Fig. 1 (*a*). Both valves should, of course, be of the same type (e.g. two 6BW6's) and should be fairly well matched. Adequate matching would be given if, for example, two new valves by the same maker were used.

The two valves in parallel provide twice the output power that is offered by a single valve, and for the same grid input signal voltage. The impedance presented to the anodes by the output transformer should be half the optimum impedance for a single valve. The overall r_a is half that of a single valve, and the total anode current will be twice that for a single valve.

In Fig. 1 (*a*) it is assumed that cathode bias is employed, both cathodes sharing a single bias resistor and bypass capacitor. The bias resistor should have half the value that would be required for a single valve because twice the current is now flowing through it. This enables the bias voltage applied to both valves to be the same as for a single valve. Alternatively, the cathodes may have separate cathode bias resistors and bypass capacitors, each resistor having the same value as for a single valve.

In Fig. 1 (*b*) we have two output valves in push-pull. The input signal to these two valves is provided by the centre-tapped secondary of a transformer, with the result that, when one grid goes positive, the other grid goes negative. Thus, the two signals at the grid are in antiphase. The amplified signals at the anodes are similarly in antiphase and are recombined in the centre-tapped primary of the output transformer, whose secondary couples to the loudspeaker in normal manner.

For normal Class A_1 operation, each valve of Fig. 1 (*b*) may have the same bias voltage and anode load impedance (presented by the half of the output transformer primary between the centre-tap and the anode) as for a single valve, whereupon the output power is twice that for a single valve. The grid-to-grid input signal voltage (i.e. the signal voltage across the entire secondary of the input transformer) is twice that which would be required by a single valve. As the anode current of one valve increases during the input signal cycle the anode current of the other valve decreases, and it is from this method of operation that the term "push-pull" derives.

The push-pull output circuit has a number of important advantages. When an output valve is employed on its own it can provide an output which is a distorted version of the input signal applied to its grid. If the input signal is a sine wave, the distorted output signal will consist of the original sine wave plus harmonics of the sine wave, the latter having been generated due to the distortion introduced by the valve. To give an example, Fig. 2 (*a*) shows a sine wave with a second harmonic, and it will be readily observed that this second harmonic has twice the frequency of the original sine wave. In Fig. 2 (*b*) we see two sine waves which are in antiphase, both having the same second harmonic. Such signals could be present at the anodes of the push-pull amplifier of Fig. 1 (*b*), and it should be noted that the second harmonic has the same phase relationship to the original sine wave in both instances. At point A in the upper waveform the second harmonic starts to go positive at the same instant as does the sine wave, and the same occurs at point B in the lower waveform.

As was just mentioned, the waveforms of Fig. 2 (*b*) could appear at the anodes of the push-pull amplifier of Fig. 1 (*b*). The two sine waves are in antiphase (one goes positive when the other goes negative) which is the desired condition for feeding to the ends of the centre-tapped output transformer primary. At the same time the two second harmonic signals are *in phase* (one goes positive when the other goes positive). Thus, on application to the ends of the centre-tapped output transformer primary they cancel each other out, and no second harmonic signal appears in the output transformer secondary.

The push-pull output circuit has the advantage, therefore, that any second harmonics introduced by distortion in the output valves are cancelled out in the output transformer. By following a similar procedure to that illustrated in Fig. 2 (*b*), it can be shown that any further even harmonics (4th, 6th, etc.) which may be introduced by the output valves are also cancelled out in the output transformer. Unfortunately, the phase relationship given with even harmonics does not apply to the odd harmonics (3rd, 5th, etc.). These are not cancelled out and they appear in the output transformer secondary.

It should be added that, for good cancellation of even harmonics, both output valves should be nearly identical in characteristics and there should be a tight inductive coupling between the two halves of the primary.

Another advantage resulting from push-pull operation is due to the fact that the d.c. component of the anode currents of the two valves flows in opposing directions through the two halves of the output transformer primary. In consequence, the magnetic fields set up by the two halves of the primary due to this d.c. component are equal and opposite, and they cancel out. The d.c. component of the anode currents exerts, therefore, no magnetising force on the iron core of the output transformer. This is quite a different state of affairs to that given when a single output valve (or two output valves in parallel—as in Fig. 1 (*a*)) is coupled to an output transformer. With the single valve there is always a d.c. component flowing in one direction through the primary of the output transformer, and a significant magnetising force is exerted on the transformer core in consequence.

Output transformers intended for operation from a single output valve usually have the laminations which form the core *butt-jointed*, with a gap to break the magnetic circuit. A typical example is given in Fig. 3 (*a*) in which E and I laminations are shown. All the E laminations are on one side of the assembly, and all the I laminations are on the other side, a piece of thin card or similar non-magnetic material being inserted between the sets of laminations to prevent a complete magnetic circuit being set up.[1] The gap in the magnetic circuit keeps at a relatively low level the flux density in the core which results from the d.c. component of the anode current, and it thereby prevents the core approaching saturation during the output half-cycles when the a.c. component of the anode current adds to the d.c. component. The butt-jointed type of assembly may also be used with U and T laminations, as illustrated in Fig. 3 (*b*). Here, all the U laminations are on one side and all the T laminations are on the other side, with thin card or similar material interposed as shown in the diagram.

With a Class A_1 or A_2 push-pull output stage,

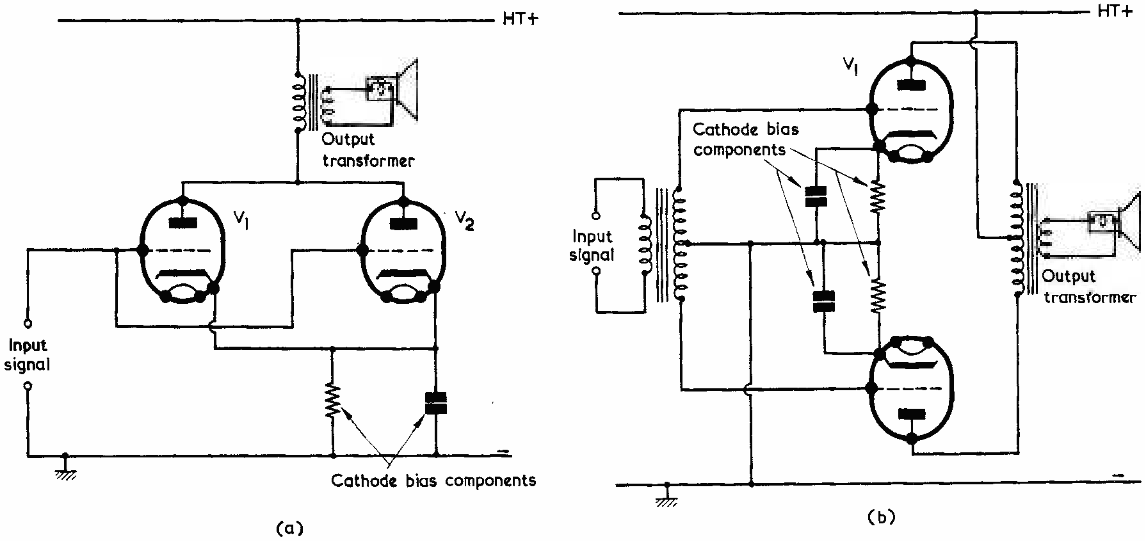


Fig. 1 (a). Two output valves may be connected in parallel to provide twice the output power which can be given by a single valve. As was explained last month, triode valves are shown for reasons of clarity, and the valves could alternatively be beam tetrodes or pentodes

(b). Two output valves may also be connected in push-pull, as shown here

[1] In some butt-jointed transformers, no card or similar material may be inserted between the sets of laminations, an effective gap resulting from the relatively rough lamination edge surfaces which butt together. Also, the two end laminations may be fitted the other way round to ease assembly problems.

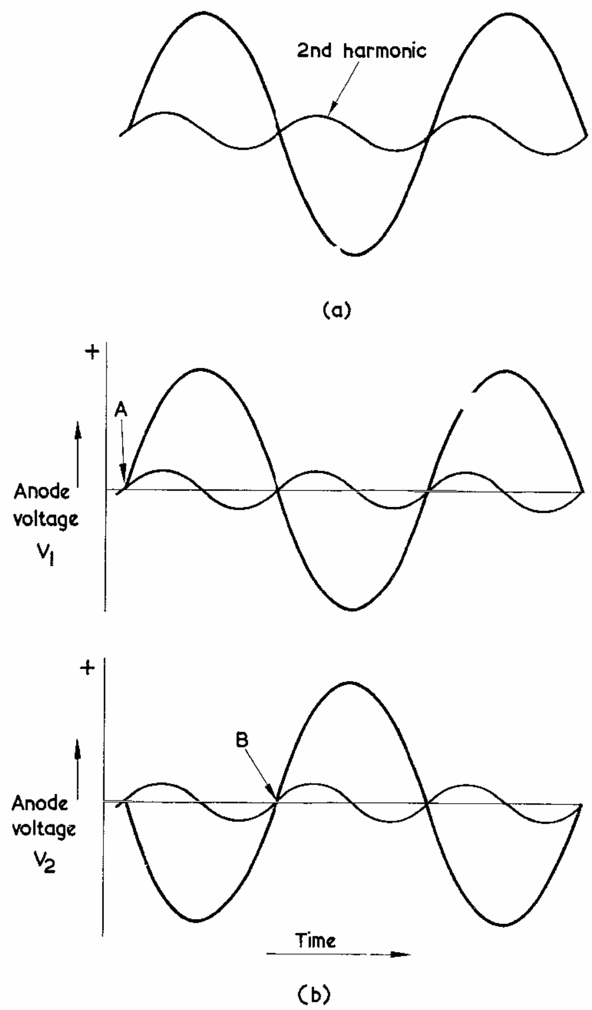


Fig. 2 (a). A sine wave accompanied by a second harmonic signal
(b). The two waveforms shown here could be present at the anodes of Fig. 1 (b). This diagram shows that, whilst the original sine waves are in antiphase, the second harmonic signals are in phase

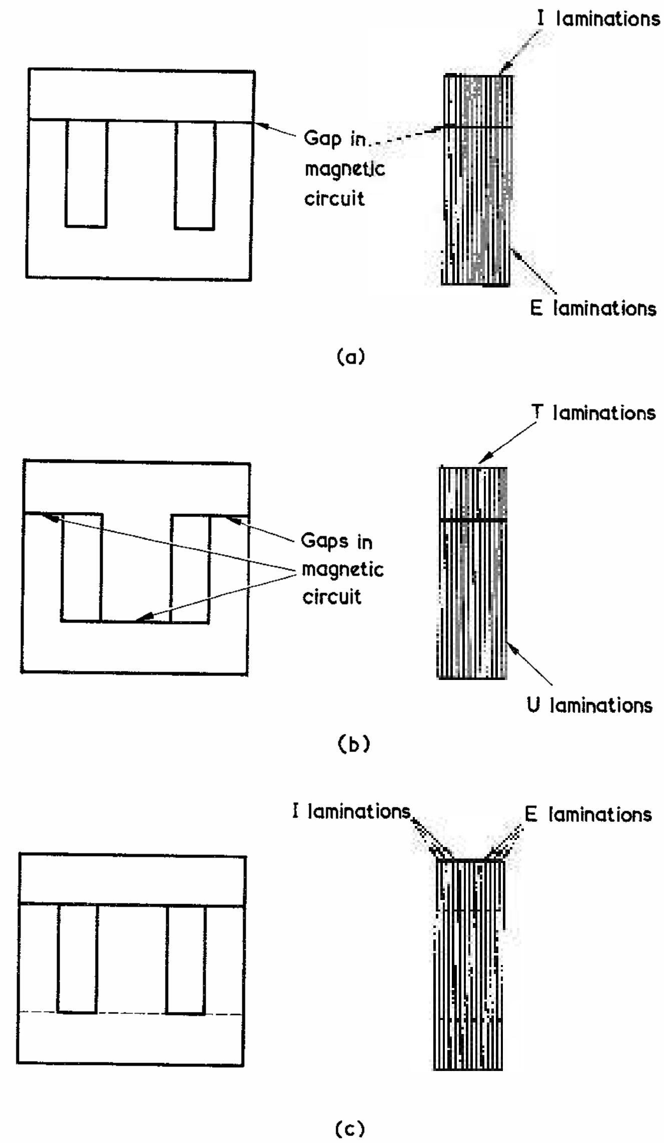


Fig. 3 (a). Output transformer laminations in a butt-jointed assembly
(b). A butt-jointed assembly with U and T laminations
(c). E and I laminations in an interleaved assembly

there is no magnetising force due to the d.c. component of the anode current, and it is not necessary for the laminations in a push-pull output transformer to be butt-jointed. They can, instead, be *interleaved*, as shown in Fig. 3 (*c*). Here there are alternate E and I laminations (or U and T laminations) on either side of the assembly with no gap in the magnetic circuit.[2]

Since the laminations in a push-pull output transformer are interleaved, they offer a higher permeability than does a butt-jointed assembly of similar dimensions. Because of this, the push-pull output transformer can have a greater efficiency than a single valve output transformer of the same size. In practice, this would result in the push-pull output transformer introducing less distortion than the single valve output transformer.

Yet another advantage conferred by the use of a push-pull output stage is that, if both halves of the circuit are identical and the valves work in Class A_1 or A_2, a constant current is drawn from the h.t. positive supply rail. As the current drawn by one valve increases during the input signal cycle, the current from the other valve decreases by a similar amount. Since no currents at signal frequency flow in the h.t. supply applied to the output circuit, h.t. bypass and decoupling requirements become eased.

Summing up, it may be seen that we can use two valves to obtain twice the output power that would be given by one by either connecting them in parallel or in Class A_1 or A_2 push-pull. Connecting the valves in push-pull has the advantages that even harmonics are cancelled out (thereby reducing distortion), that a more efficient output transformer may be employed (again reducing distortion) and that h.t. bypass and decoupling requirements are less stringent. The advantages conferred by push-pull operation makes this the preferred choice when two output valves are to be used.

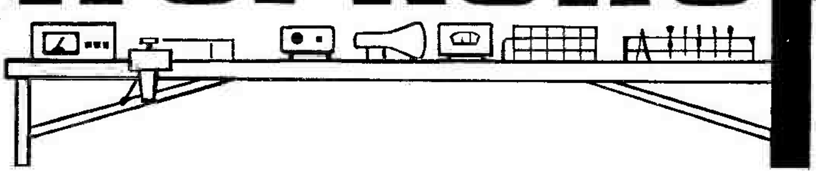
[2] The subject of transformer laminations, and the reasons for using butt-jointed and interleaved assemblies, was discussed in greater detail in "Understanding Radio" in the June 1963 issue.

In Fig. 1 (*b*) the two grids of the push-pull output stage are supplied with antiphase signals by way of a transformer having a centre-tapped secondary. In most cases, it is preferable to employ a valve rather than a transformer to provide the antiphase grid signals, and we shall be discussing the circuits generally employed in a later article.

Next Month

In next month's issue we shall examine other classes of operation. ✱

In your workshop



This month Smithy the Serviceman, aided as always by his able assistant, Dick, investigates a component whose two operating currents flow in completely opposite directions in the same length of wire!

QUESTION: IF DURING NORMAL TV servicing you encounter an open-circuit heater chain, which heater is the one most likely to have burnt out?

Answer: The heater of the last valve you check.

This First Rule of Television Servicing was well known to Dick, and he frowned as he peered into the cabinet whose back he had just removed. The mains input fuse was satisfactory and a full h.t. voltage was being given by the silicon h.t. rectifier. On the other hand, the valve heaters remained obstinately unlit. Obviously, the mains supply was reaching the h.t. rectifier, and it seemed a pretty safe guess that one of the valve heaters had become open-circuit.

Find The Valve

Dick grunted, switched off the set and pulled its plug from the socket at the rear of his bench.

"Hey, Smithy," he called out, "have you got the Heater Checker Box?"

"Have I got what?"

"The Heater Checker Box."

"It's knocking around over here somewhere," replied the preoccupied Serviceman. "Ah, there it is, at the back of my bench."

Dick walked over, picked up the item of equipment in question, and returned with it to his bench. It may be mentioned that the Heater Checker Box in question consisted of a small battered wooden case containing nothing more than a PP3 9-volt battery, a B7G valveholder, a B9A valveholder, a B10B valveholder, a 910Ω fixed resistor, and a 0–10mA meter which bore on its scale the proud insignia of the Air Ministry. (Fig. 1). This simple continuity-testing device had been originally assembled some years ago by Smithy during a quiet hour, and had repaid itself in time saved many times over. The B10B valveholder represented a recent modification carried out by Dick shortly after the PFL200 double pentode made its début in British TV receivers, and the new base occupied a splinter-edged hole which had previously taken an octal valveholder, one mounting hole of the B10B base being secured direct to an original octal mounting hole and the other to the remaining octal hole by way of an oddment of metal having the necessary two holes with more or less the requisite spacing. Such are the humble tools with which the servicemen of England keep the home heater wires burning.

Dick set to work systematically with the Heater Checker Box, removing each valve from the printed circuit board in turn, plugging it quickly into the Box, then re-

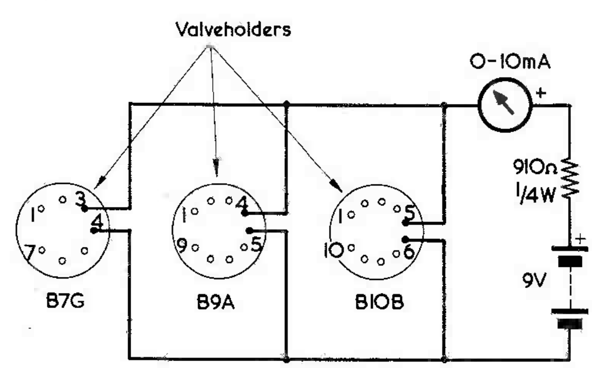


Fig. 1. Smithy's 'Heater Checker Box', one of those simple servicing aids which can save a lot of time in routine testing. Valves in an open-circuit heater chain can have their heaters quickly checked for continuity by plugging into the appropriate valveholder. The B10B valveholder takes valves of the PFL200 class, which have recently been introduced. In Smithy's version, the 0–10mA meter was a low-cost surplus item. This meter is mounted on the front panel of the box in company with the valveholders, the battery and series resistor being fitted inside

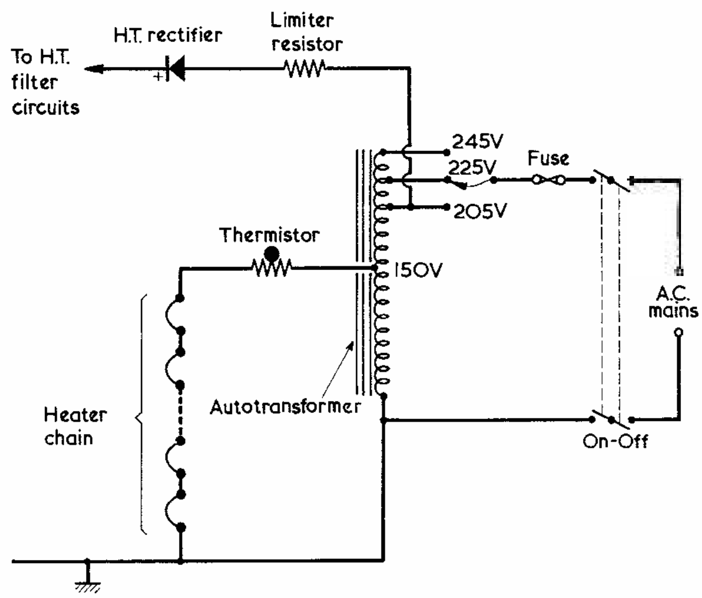


Fig. 2. Employing an autotransformer in a television receiver to feed the heater chain and provide a low impedance a.c. feed at the required voltage for the h.t. rectifier. A circuit of this type is used in the Thorn 900 and 950 Series receivers, in which the autotransformer has a total winding resistance of 75Ω

turning it to the set. Much to his gratification (and to show that there are exceptions even to so inviolable a maxim as that First Rule) Dick found that the fourth valve he checked, an EF183, caused no movement in the needle of the 0–10 mA meter.

On a hunch, Dick switched his testmeter to a resistance range, connected one test lead to the chassis of the receiver on his bench and applied the other to pin 4 of the B9A valveholder which had recently taken the defunct EF183. The testmeter indicated a resistance of approximately 450Ω. Dick frowned, and transferred the test lead to pin 5. This time the resistance to chassis was of the order of 60Ω.

"Smithy!"

"Hallo!"

"I've got a really queer one here," called out Dick. "Both ends of the heater chain seem to go straight down to deck!"

Smithy turned round and glanced at the receiver on Dick's bench.

"I'm not surprised," he remarked briefly. "Still, I suppose I might as well listen to how you arrive at this earth-shattering conclusion."

"Well," said Dick, "I first of all found the open-circuit valve in this heater chain almost immediately. Since I'd located it so quickly I thought it mightn't be a bad idea to have a quick prod between the heater pin sockets of the valveholder and chassis just to make certain that there weren't any further breaks in the heater chain below it. Normally, you'd get a low resistance between chassis and one heater pin socket only, this being the socket which connects to the next heater down. The first I checked gave me 450Ω, which seemed a bit high to me; and the second gave me 60Ω. So what do I do now?"

"You go to the spares cupboard," replied Smithy resignedly, "and get out a replacement valve. You then go to the filing cabinet and pick up the service manual for this set. All right?"

"Okeydokey," replied Dick obligingly, as he got up from his stool.

He quickly returned with the new valve and the service manual, then looked expectantly at the Serviceman.

"Pop that new valve in," commanded Smithy shortly, "and switch on."

It took Dick very little time to insert the new EF183, reconnect the set to the mains and switch on. Very soon, all the valves in the set were glowing away at their normal brightness. A puzzled Dick switched the receiver off again.

"After having got *that* little job done," continued Smithy, "I would suggest that you next open up the service manual and have a quick shufti at the heater circuit for that set."

Again, Dick carried out Smithy's bidding.

"Why, it's obvious," he exclaimed, after a moment. "The heater chain's run from an autotransformer!"

"Of course it's obvious, you steaming great twit," snorted Smithy. "If you'd looked at that circuit in the first place instead of wasting my time, you'd have seen that the autotransformer has a 150 volt tapping which feeds the heater chain with a thermistor in series. (Fig. 2). Your 60Ω reading was given by the heaters below the valve you took out, whilst the 450Ω reading was given by the heaters above plus the thermistor in its cold state and the 150 volt winding of the autotransformer. This whole episode," concluded Smithy severely, "only emphasises once again that, whenever you encounter what seem to be peculiar symptoms on a radio or TV chassis, you should always sit and think for a moment before jumping to conclusions. And if the service sheet is available, *always* take a look at that before going further."

"I suppose I did rather rush at things just now," admitted Dick ruefully. "Still, how did *you* know that the set had an autotransformer?"

"I recognised the model," replied Smithy promptly. "And I must say that I like the autotransformer idea for a heater supply, too. Not only does the autotransformer provide exactly the right voltage for the heater chain without dissipating a great deal of heat in the process but it also enables the a.c. passed on to the h.t. rectifier to be fed from a low impedance source instead of by way of mains voltage tap resistors."

Autotransformer Resistance

"I see what you mean," remarked Dick, as he examined the service manual circuit again. "Wait a minute, though. There's something else here that's queer, too!"

"What's that?"

"The resistance shown for the autotransformer winding," replied Dick. "The total winding resistance is given as 75Ω."

"That seems," pronounced Smithy, "to be a very reasonable resistance figure for an autotransformer of this type."

"But it *can't* be right," objected Dick. "A couple of days ago I was checking a mains transformer which gave 250–0–250 volts at 60mA plus the usual 6.3 and 5 volt heater outputs, and its total primary resistance was 30Ω only. The transformer in this TV set is bashing out 150 volts at no less than 300mA for that heater chain, and yet its winding resistance is two and a half times that for the other transformer."

"What you forget," explained Smithy patiently, "is that the transformer in that set is an autotransformer. In an autotransformer the primary and secondary currents flow in opposite directions in the common section, and the wire in that section only has to carry the difference between them."

"Oh."

"The common section," added Smithy helpfully, "also has to carry the magnetising current. But this is normally quite small, of course."

"Of course."

Smithy turned to look at his assistant, whereupon his irritation at having been interrupted completely vanished at the sight of the hopelessly baffled expression which now graced that young man's face.

"You haven't," he chuckled, "the faintest *clue* on what I'm talking about, have you?"

"To be completely frank," admitted Dick, "I haven't! Apart from this magnetising current business, how on earth can the primary and secondary currents flow in opposite directions? If they did that, the secondary voltage in the common section of the winding would be out of phase with the primary voltage. And that's impossible, because they're both sharing the same bit of wire!"

Smithy grinned.

"It can be a bit difficult to see how the current opposition takes place," he conceded, "and I suppose that the only way to understand it properly is to get down to basic principles."

He twisted round and switched off the receiver on which he had been working.

"I don't expect it will hurt," he remarked, picking up his stool and carrying it over to Dick's bench, "if I spend the next fifteen minutes or so telling you how this current opposition business comes about. But first of all I'll explain the magnetising current bit. Magnetising current is merely the current which flows from the mains into the primary of a mains transformer when all the secondaries are not connected to any load. It's the current needed to overcome the losses in the transformer given by eddy currents, hysteresis effects in the laminations and so on, together with the current which flows against the inductive reactance of the primary. Indeed, one of the tests usually given to a mains transformer before it leaves the works is to check its magnetising current. If this is too high there may be something wrong with the laminations or the windings, and the transformer is then rejected."

"Well, *that*," remarked Dick in a relieved tone of voice, "seems simple enough to me. What about this primary and secondary current business, though?"

"To deal with that," said Smithy, "I'll have to start with a spot of elementary theory. As you know, if we connect an alternating supply to a mains transformer primary we cause a changing magnetic field to be produced which, in turn, induces an alternating voltage in all the windings of the transformer. O.K.?"

"Sure."

"Right," said Smithy. "Now, one of the windings in which an alternating voltage is induced is the primary itself. If there are no loads on the secondaries the voltage induced in the primary opposes the applied alternating voltage and, therefore, opposes the flow of current in the primary. This induced voltage is the back e.m.f., and it is the presence of this back e.m.f. which causes *any* inductor to oppose changes in the current which flows through it. With the secondaries unloaded the transformer primary behaves, in fact, in much the same manner as does an iron-cored choke."

"I think I understand what you're getting at," said Dick. "Would this back e.m.f. thing be the reason why iron-cored h.t. smoothing chokes oppose ripple currents from an h.t. rectifier, whilst offering no opposition to the direct current?"

"That's it," confirmed Smithy. "Now, if we connect a resistor across one of the transformer secondaries to form a load, the situation becomes more involved. As I've already mentioned, the changing magnetic field caused by the primary induces an alternating voltage in the secondary, and what you have to bear in mind here is that this is the same changing magnetic field that produced the back e.m.f. in the primary. So the alternating voltage induced in the secondary will be in phase with the back e.m.f. in the primary. Since we have added a resistor across the secondary a current must now flow in this secondary. This current will be in phase with the back e.m.f. which opposes the alternating voltage applied to the primary, and it sets up, in its turn, a second changing field which opposes the original changing magnetic field produced by the primary."

"I'm still with you, Smithy," said Dick. "But only just!"

"We're nearly over the hard part," replied Smithy encouragingly. "This second field, in opposing the original field, reduces the back e.m.f. in the primary, whereupon an increased primary current has to flow to ensure that the original field cancels out that produced by the secondary. And you can now stand at ease, mate!"

"Is it all over?"

"It is," replied Smithy. "To sum the whole process up, we can say that if the a.c. mains is applied to the primary of a mains transformer with no connections to the secondaries, the current that flows in the primary is just magnetising current. If we load one or more of the secondaries, the resulting current causes a field to be built up which opposes that due to the primary, and the primary current has to increase to cancel this opposing field. I hardly need to remind you that this process is well borne out in practice. You are bound to have observed at some time that the mains current flowing in the primary of a mains transformer increases if you draw increased current from any of its secondaries."

Winding Polarities

"Well, stap me," exclaimed Dick. "Do you know, Smithy, I've always accepted that as one of the facts of life without ever wondering why it happens! I can see what you're getting at now. When secondary current increases, the primary current *has* to go up so that the primary field can cancel the increased opposing field produced in the transformer by the secondary current."

Dick's face, lit for a brief moment by sudden enlightenment, clouded over again.

"I'm still in trouble, though," he continued. "If the secondary field opposes the primary field it means that the current flowing in the secondary is out of phase with the current flowing in the primary."

"So it is," replied Smithy. "In fact, I've already pointed out that it's in phase with the back e.m.f."

"But," protested Dick, "the secondary current *can't* be out of phase with the primary current. Look, I'll show you!"

Dick picked up his pen and scribbled a sketch in the margin of the service manual. (Fig. 3 (*a*)).

"Let's say," he went on, "that we've got an imaginary mains tranny like the one I've drawn here. This is a very simple transformer in which the primary and secondary consist of a few turns of wire on a long straight iron core. The upper winding is the primary, and it has twice as many turns as the lower winding, which is the secondary. If I apply 20 volts a.c. to the upper winding I'll get 10 volts out of the lower winding, won't I?"

"You will," agreed Smithy.

"But," said Dick excitedly, "if I now join the bottom end of the upper winding to the top end of the lower winding (Fig. 3 (*b*)) I'll find that the two voltages *add up*. I'll still get 20 volts across the upper winding and 10 volts across the lower winding but, what is more, I'll also

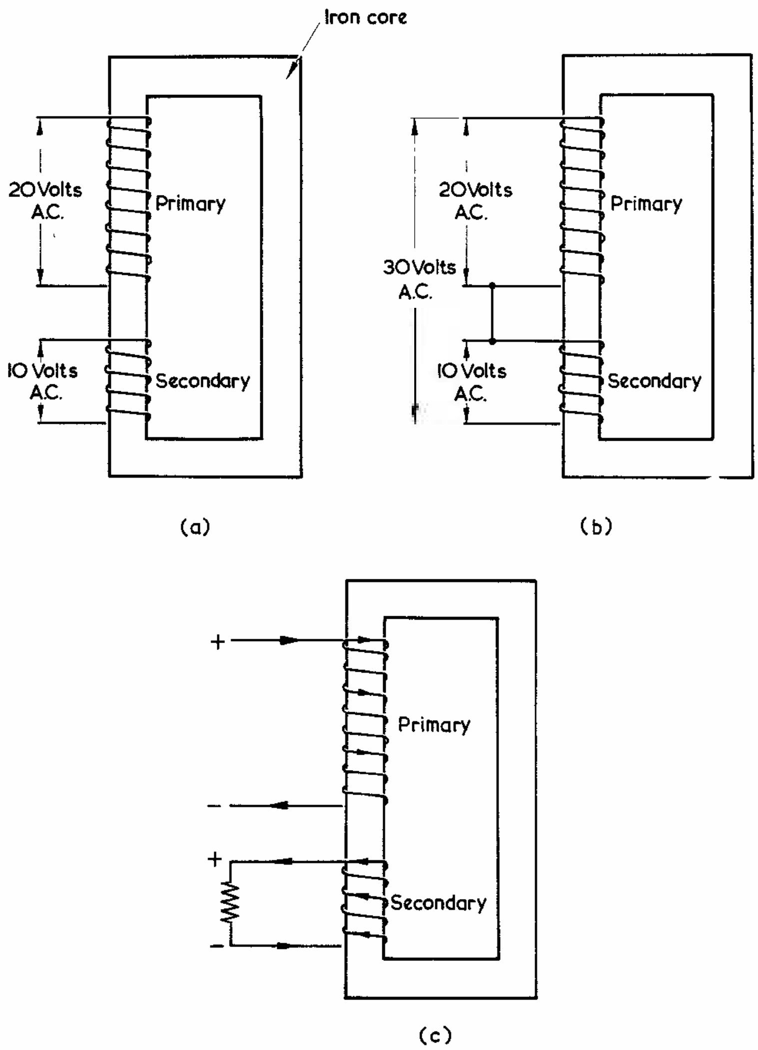


Fig. 3 (a). A simple transformer in which the primary has twice as many turns as the secondary

(b). If the primary and secondary are connected together as shown here, a total of 30 volts appears across the two windings in series

(c). Although, so far as the external circuit is concerned, the two windings appear to be in phase for voltage, the currents in the primary and secondary actually flow in opposite directions

get 30 volts across the lot. This can only mean that the voltages across the windings are in phase. And, if that's the case, what you say about the currents being out of phase just cannot be true!"

"Yes it can," chuckled Smithy, taking Dick's pen from him. "Let's take a look at your transformer at an instant during the input half-cycle when the top of the upper winding is positive and the bottom of the upper winding is negative. I'll now add a few arrows to your sketch to indicate the flow of conventional current. This is, from positive to negative."

"The way the transistor holes go?"

"Don't be facetious," reproved Smithy sternly. "Now, you can see that the arrows I'm adding to the upper winding are exactly correct for primary current flowing from positive to negative. (Fig. 3 (*c*)). No current will flow in the lower winding unless it's loaded, and so I'll have to add a resistor across it. The current which then flows in the secondary winding is, as I said just now, opposite in direction to that in the primary and so I'll add further arrows to indicate this. Whereupon—hey presto—what do we find?"

"Blimey," said Dick, unbelievingly. "So far as the external circuit is concerned, the top end of the lower winding is positive, too!"

"And so it is," agreed Smithy, "and you get the familiar in-phase voltage additive effect which you always find in transformer windings when you connect them up in series. I do appreciate, though, that this current direction business can be a bit of a shaker at first. As an alternative approach, it's not a bad idea to think of the secondary as though it were an a.c. generator. If I were to replace the lower winding in your sketch by an a.c. generator, you could then see that the current which flows through it has *got* to be opposite to that flowing through the upper winding if you're going to get the in-phase additive effect for voltage."

"In other words," said Dick, "the direction of current in a transformer can be explained by looking upon the primary as a load and by looking upon the secondary as a generator."

"That's a reasonably close approximation," confirmed Smithy. "Although I must hasten to add that it's more accurate to work in terms of opposing fields. Anyway, we now come to the autotransformer."

Smithy scribbled a further sketch in the margin of the service manual. (Fig. 4 (*a*)).

"And here we have the basic autotransformer which started this whole discussion off," he said, "and in which one section carries both primary and secondary currents. Let's assume for a moment that our autotransformer is a perfect component with no losses, so that the power consumed by the secondary load will be equal to the power taken by the primary from the a.c. supply. To take an example to explain autotransformer operation, we could start by assuming that the voltage applied to the primary is 200 volts, that the secondary voltage across the common winding is 50 and that the secondary current is 4 amps. (Fig. 4 (*b*)). Thus, 200 watts are supplied by the secondary, and 200 watts are in consequence taken from the input supply by the primary. The primary current is, therefore, 1 amp. The primary and secondary currents in the common 50 volt section oppose each other, which means that you have 1 amp going in one direction and 4 amps going in the other direction. In consequence, only 3 amps actually flows in the common section and so the transformer can be made with wire capable of carrying 1 amp for the top bit and 3 amps for the common bit lower down."

"Blimey," remarked Dick, impressed. "That's a lot less expensive than the equivalent double-wound transformer, isn't it?"

"Definitely," said Smithy. "The equivalent double-wound transformer would need a primary capable of carrying 1 amp and a separate secondary capable of carrying 4 amps. Not only do we save 50 volts-worth of primary, but the secondary winding is replaced by wire which has to carry 3 amps instead of 4 amps. The only snag is the obvious one. You don't get the secondary circuit isolated from the mains, as you do with the double-wound mains transformer."

"If the secondary voltage is closer to the primary voltage," remarked Dick, "the primary and secondary currents will get closer too, won't they?"

"They will," agreed Smithy. "As secondary voltage approaches primary voltage in an autotransformer the actual current in the common winding becomes lower and lower. If the secondary output in my example had been, say, 150 volts at 4 amps, the corresponding primary current would have been 3 amps at 200 volts. (Fig. 4 (*c*)). The current in the common section would, then, have been 1 amp only. The greatest economy is given, of course, when the secondary voltage is equal to the primary voltage. Assuming a perfect transformer, the two currents then cancel out and the current in the common section becomes zero."

All The Way Through

"Gosh," said Dick innocently, "that's a *fantastic* saving, isn't it?"

"I was pulling your leg there," laughed Smithy. "If the secondary voltage is equal to the primary voltage you wouldn't need an autotransformer anyway. All such an autotransformer would consist of is a single inductor connected across an a.c. supply circuit which was working quite happily without it! But this ultimate instance does illustrate very clearly how the current in the common winding of an autotransformer reduces as the secondary and primary voltages approach each other. Incidentally, we've been talking about step-down auto-transformers up to now, but you can just as readily have a step-up autotransformer. This time the common section functions as primary and part of the secondary. You still have a current equal to the difference between the primary and secondary currents flowing in the common section, as before."

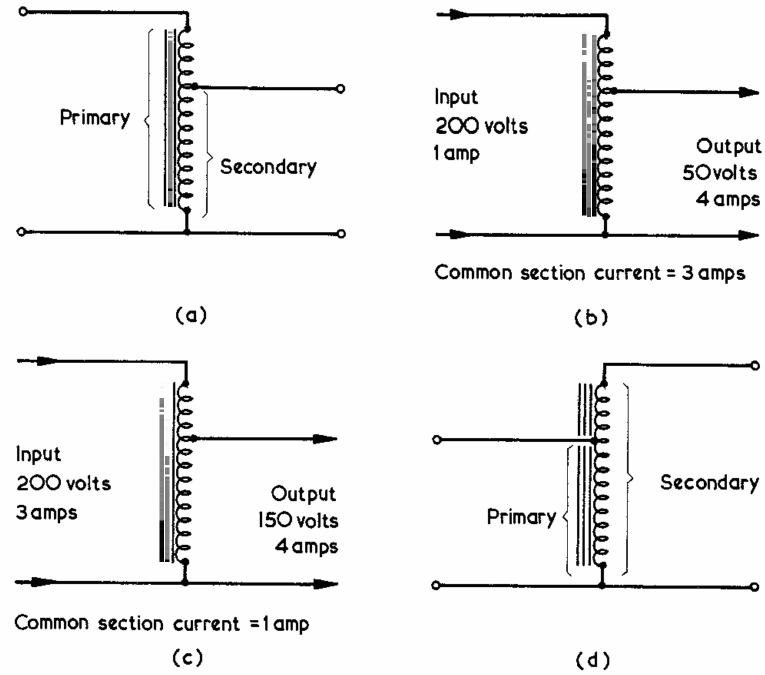


Fig. 4 (a). A step-down autotransformer
(b). Typical voltages and currents in a 'perfect' 4:1 autotransformer
(c). A 4:3 autotransformer. Since the primary and secondary currents are closer, a proportionately lower current flows in the common winding

(d). A step-up autotransformer. As with the step-down autotransformer, the current in the common winding is the difference between the primary and secondary currents

Smithy scribbled out the circuit symbol for the step-up autotransformer (Fig. 4 (*d*)), then rose from his stool and carried it back to his bench.

"And that," he remarked, "is quite enough about autotransformers for today! You'll now be able to understand why the autotransformer in that TV set of yours had a higher winding resistance than you'd expect from, say, the primary of a double-wound transformer doing the same job. Ignoring magnetising current, the common section up to 150 volts has to carry the difference between the primary and secondary currents only, whereupon it can be wound with thinner wire than if it had to carry the full secondary current."

A sudden thought occurred to the Serviceman.

"Seeing that I've shown you how to calculate the currents which flow in the windings of an autotransformer," he added, "you could finish things off by working out the currents in the two sections in a 2:1 step-down autotransformer and in a 1:2 step-up autotransformer. You can choose any voltages and currents you like for the calculations."

There was silence for some moments as Dick concentrated on these two little problems.

"I'm dashed," he remarked, surprised. "The current in both sections is the same in a 2:1 autotransformer; and it is, too, in a 1:2 autotransformer."

"That's quite correct," confirmed Smithy. "A 2:1 autotransformer, or a 1:2 autotransformer, is like a stick of Blackpool rock. It's the same all the way through!"

NEXT MONTH . . .

★ **Model Control Transistor Superhet**
★ **Windscreen Wiper Programmer**
★ **10 Watt P.A. Amplifier**

Electricity Hazards

by Gordon J. King,
Assoc.Brit.I.R.E., M.T.S., M.I.P.R.E.

The domestic mains supply is a killer. This fact should never be forgotten by those who work with radio and electricity and who, through over familiarity, may tend to become careless and ignore the very real dangers that are never absent from work of this nature

This article outlines many of the common-sense procedures and precautions which may be taken to prevent shock; but it must be emphasised that if the recipient of a shock is well-versed in electricity the responsibility for the shock rests only with him

We repeat, the domestic mains supply is a killer

We often tend to take electricity too much for granted and forget that it can be as hazardous out of control as it can be useful under control. Every year a number of people die as the result of electric shock in the home, a smaller number die from electrocution or burns resulting from static electricity and lightning, while a great number of people suffer from non-fatal shock due to similar causes.

Most of the personal damage is due to lack of clear thought before playing around with electrical circuits or equipment. Some, of course, is due to poor or faulty electrical installations and appliances, and a small proportion of personal damage results from almost unavoidable accidents, such as being struck by lightning.

Apart from personal damage, uncontrolled electricity is responsible for the yearly loss of quite a lot of electrical and electronic equipment. For example, a flash of lightning, while not actually causing a strike, can induce very heavy currents in an aerial downlead and ruin valves, coils or transistors. Similarly, the connection of an "earthed" accessory to a "live chassis" receiver can result in serious damage to the equipment concerned and also represent a personal hazard. In this article it is proposed to investigate electricity hazards as they apply to both person and equipment.

Supply Circuits

The biggest danger of electric shock exists on the mains power supply fed into almost every house. Electricity is brought in on two conductors: a "live" conductor, coded red, and a "neutral" conductor, coded black. On power circuits—for electric fires, machines, and so forth—it is required by law that a third "earth" conductor be run. This may be a bare, tinned copper conductor or it may be an insulated conductor with a green covering.[1] The earth conductor does not normally pass electricity. It simply acts as a safety device to bypass currents which may occur due to a fault condition in a connected appliance. The fault current would then blow a fuse and remove the supply from the current-carrying conductors.

The neutral circuit from the distribution transformer is always efficiently earthed at source. The live circuit must, of course, always be adequately insulated from earth to avoid leakage currents. The real earth circuit (that is, the earth conductor at the house) is derived either from an earth point in or near the house or from an earth terminal provided by the Electricity Board, the general idea being depicted in Fig. 1.

Normally, it is impossible to touch any of the bare mains conductors or metal connecting sockets, since these are adequately insulated and isolated from the consumer. However, in our line of hobby

[1]The coding, red for live, black for neutral and green for earth, applies to British house wiring and appliances. However, it should always be remembered that the supply wires on some imported electrical equipment may employ a colour code that differs from the British version. If any doubt exists, it is always advisable to check the mains lead colour coding on imported electrical equipment by continuity checks or by visual examination.—Editor.

or profession we obviously have to make connections from the mains to exposed instruments, equipment, sets and so on, whereupon there is an immediate risk of shock.

If we happen to touch a circuit which is connected to the live side of the mains, we may or may not get a shock. A shock results only when there is a connection, through the body, across the supply. This would happen if we put one hand on the live circuit and the other hand on the neutral circuit *or on anything which is earthed.* Electricity would then flow through our body.

Although we may not be aware of the fact, we might in some way be connected to earth. Thus, on touching a live circuit with just one hand current can flow through our body to the point where it is connected to earth. We could then get a bad shock. The earth connection to our body could be via a stone, brick or concrete floor, through leather shoes and the feet. Wooden and plastic floors and rubber and plastic shoes (without nails) act as good insulators, and with these conditions existing we would probably feel no shock at all on touching a live circuit.

In our den, however, we may have an earthed electric heater of some sort. It need not be switched on, but if we are in contact with it whilst dealing with any exposed mains circuits we are certainly asking for trouble! Indeed, we should keep well clear of anything that is earthed when working on mains equipment, and to prevent the possibility of earth leakages through the floor to the feet, it is a good idea to stand on a dry rubber mat or to put the bench stool or chair on such a mat.

Live Chassis

Another great shock hazard these days is given by live-chassis equipment. The majority of TV sets, for instance, have the metal chassis, or negative supply line and screens, connected to one side of the mains supply. The correct procedure during installation is to connect the mains to the set so that the chassis is always connected to the neutral conductor. Thus the risk is diminished if inadvertent personal contact is made to the chassis.

It cannot be guaranteed that the chassis of all live-chassis equipment is connected to the neutral side of the mains and many installations will be encountered in which the chassis is connected to the live side. Under normal conditions this does not matter too much, for the chassis should be arranged in the cabinet in such a manner that it is impossible for even the smallest finger to make contact with the electrical parts. At one time a shock source with radio and TV equipment was the grub screws clamping on the control knobs. This danger is now completely removed by the use of spring-loaded knobs with no exposed metal parts at all.

However, there is a real danger of extending the live chassis circuit outside the cabinet by connecting, say, an extension speaker, baby alarm circuit, pick-up, remote control or, in fact, anything whose wiring is brought out through the cabinet. Many experimenters are well aware of this danger and take steps to isolate external circuits which are so connected.

There are two essential ways of achieving the necessary isolation. One is by the use of isolating and coupling capacitors and the other is by the employment of an isolating transformer. Unfortunately, isolating capacitors tend to introduce hum problems when audio is being applied to or taken from a live-chassis type of set. It is often found that by deleting the capacitor and making a direct connection to the chassis on the earthy side of the external circuit the hum is removed. Unfortunately, the circuit is sometimes left in this condition by experimenters. *This is a highly dangerous practice even with the live chassis at neutral potential, for if the mains input to the set is reversed for some reason the external connections and equipment are in direct connection with the live side of the mains, representing a potential death-trap to the users of the equipment and infants.*[2]

Transformer Isolation

The use of isolating transformers often impairs the quality of the audio being fed in or taken out of the receiver, that is when an isolating transformer is connected in the signal circuits. However, an isolating transformer can be used, alternatively, between the mains supply and the live-chassis set. With such a transformer the mains supply circuits are completely isolated from the set, the chassis of which can then be connected to a good earth point. Under this condition it is perfectly safe to connect external circuits and equipment direct to the chassis without fear of electric shock, the arrangement being shown in Fig. 2.

[2]With audio frequency circuits, the sum of the values of the two isolating capacitors must not exceed 0.02μF, and the capacitors should each have a working voltage rating of at least 300 volts a.c. Isolating transformers should have insulation capable of withstanding mains voltage between primary and secondary, and it must be emphasised that many inter-valve and inter-transistor transistors may *not* have such insulation (for the obvious reason that they are not designed to provide mains isolation) and should not be relied on for this purpose. Suitable mains and a.f. isolating transformers and circuits were described in "Radio Topics" in the May 1965 issue.—EDITOR.

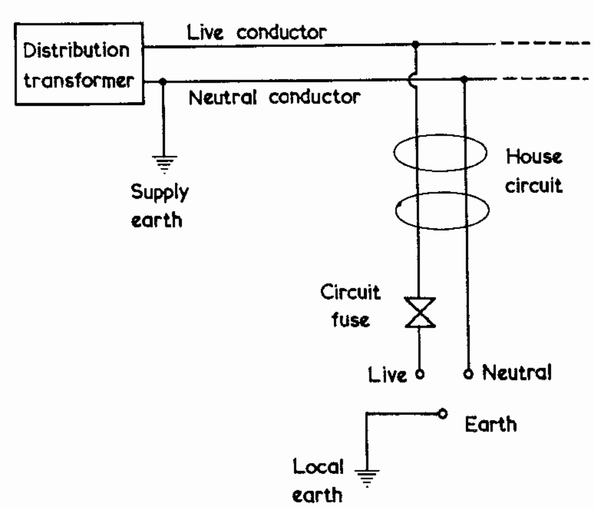


Fig. 1. Basic domestic power supply circuit

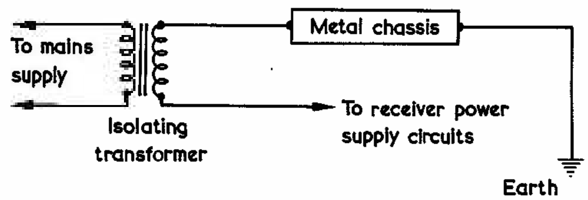


Fig. 2. By the use of a mains isolating transformer the metal chassis of a live-chassis type receiver can be connected to earth and external connections rendered safe

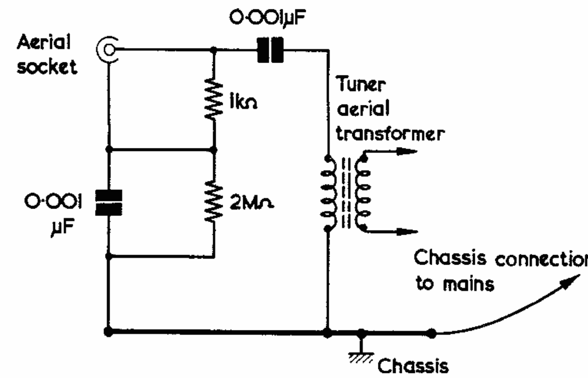


Fig. 3. The capacitors in the aerial circuit isolate the aerial from the mains supply in the event of the chassis of the set being connected to the live side of the mains. The resistors prevent the capacitors developing a static charge, as explained in the text

The transformer must be capable of carrying the full power input required by the receiver. Various types of isolating transformers of this kind are available, these ranging from 75-watt types for radio equipment to 200-watt types for television sets and more powerful radios.

The manufacturer of the live-chassis type of set has to take precautions to ensure that direct connection to the chassis cannot be made via the aerial input. With TV sets the outer and inner conductors of the coaxial aerial circuit are isolated by capacitors, as shown in Fig. 3.[3] The parallel resistors, being of very high value, do not detract from this isolation, and they are included to prevent the build-up of static electricity on the aerial and will be discussed later.

Capacitor Isolation

The value of the aerial isolating capacitors is chosen to avoid attenuation of the aerial signal while offering a very high impedance to the 50 c/s mains power. A typical value is 0.001µF. At 200 Mc/s this has a reactance of less than 1Ω, while at 50 c/s its reactance is around 3MΩ. At mains voltages a single 0.001µF capacitor would thus pass a current in the order of 80µA, which is too small to do any bodily damage.

Should one of these isolating capacitors short-circuit, then there is a real shock hazard at the aerial, for the aerial, coaxial cable and coaxial socket and plug will be at live mains potential above earth if the set is connected to the mains so that the chassis is on the live side.

This means that anyone with inadequate shoe insulation standing outside on the moist earth and touching the braiding of the coaxial cable or the exposed metal of an associated plug or socket would almost certainly receive a very nasty shock which could prove fatal. If the shoes happen to be dry and have rubber or other good insulant soles, one might then be reasonably well protected, but the risk is still very high.

Live Aerial

A similar risk would exist at the aerial itself, of course, and more than one aerial erector has met his untimely death by a "live" aerial when making adjustments for best picture. There are two hazards here, one electrocution pure and simple, and the other the possibility of being flung off the roof due to involuntary action because of the shock.

These hazards, and others like them, can be largely eliminated by ensuring that the set is always connected to the mains so that the chassis is at neutral potential. A short-circuit in an isolating component would not, then, cause the live mains to be connected to an external circuit.[4]

It is a relatively simple matter to check a chassis for a live mains connection. One way is to hold a neon-test screwdriver on the chassis with the set on. If the neon glows the chassis is live and the mains supply wires should be reversed. Another way is with an ordinary a.c. voltmeter set to 250 volts. If a mains voltage reading is obtained with one test prod on the chassis and the other on an earth point the chassis is live, and the supply wires should similarly be reversed.

During wet weather the aerial system effectively earths. Now if, during such conditions, a spark occurs when the aerial plug is pushed in and pulled out of its socket on the set it means that the mains is connected for a live chassis. If the spark is excessive it could also mean that an isolating capacitor in the set is either completely short-circuited or has poor insulation. These possibilities should be checked immediately. A small spark is normal with a live chassis and earthed aerial due to the small 50 c/s current flowing through the capacitor.

Now that transistor aerial booster amplifiers are becoming popular leakage effect at the aerial can be important, for each time the set is switched on and off current and voltage transient pulses occur, and these could ruin the transistor in a booster connected in series with an earthed aerial and a set with a live chassis. Some boosters have protection

[3] The leakage current which can flow to earth from the aerial terminal or group of terminals should not exceed 0.3mA (B.S. 415:1961, "Safety Requirements for Radio or Other Electronic Apparatus"). Assuming a mains voltage of 250, this requires a minimum isolating impedance (given by capacitors and parallel resistors) of 830kΩ.—EDITOR.

[4] Do not, however, place too much reliance on the fact that a chassis is at neutral potential. It only requires an open-circuit in the neutral supply line, due to such things as a blown fuse or a faulty switch contact, for the chassis to assume live potential via the heater chain or other power supply components. *Never*, whilst in contact with earth, handle conductors at neutral potential on the assumption that such a connection makes them entirely safe.—EDITOR.

against this hazard, however, including the current model of the "King Telebooster", which has an input/output isolation of about 16MΩ.

Shock Current

Just how much bodily damage results from an electric shock depends upon the magnitude of *current* flowing through the body. The current is limited by the skin resistance. A healthy person has a skin resistance under normal conditions of between 3,000 and 5,000Ω. Of course, a person with damp hands or a person perspiring badly will have a much lower resistance. A person working under damp conditions, around a sink or in a bath may have a skin resistance of only a few hundreds of ohms.

From Ohm's Law we know that the current flowing is equal to the voltage divided by the resistance. Thus, the current is increased as the voltage is increased and as the resistance is reduced. The skin resistance of a person near or in water may be so low as to allow the passage of almost an ampere of current at mains voltage! Such a person would not live. Even a light, high resistance contact at a high voltage may yield several killing milliamperes. In addition, the high voltage may instigate arcing and result in electrical burns.

Non-lethal E.H.T. Voltages

Fortunately, it usually happens that the high voltages we are concerned with, such as in TV sets, have a very low current yield. This means that if the resistance of the body applied across the source is relatively low (that is, compared with the source resistance), the voltage automatically drops to a low value. Some people have the ability to stop a car engine by placing a hand flat upon the e.h.t. terminals of the spark plugs! Although the voltage here is very high (many thousands of volts) the current is remarkably small. The body (or hand) then simply acts as an almost complete short-circuit to this small current and the voltage falls to nearly zero, thereby stopping the engine. This is not to say that the performer fails to receive an electric shock, and the exercise is not one that can be recommended.

TV and radio sets are more lethal on the mains side than on the h.t. or e.h.t. side, for the mains has a very high current capacity. Early TV sets had very lethal e.h.t. voltage systems, since the voltage was derived from a mains transformer with a 5 or 6kV secondary. Such transformers could provide many milliamperes at thousands of volts for a short period.

First Aid

Should one unfortunately find a colleague in an apparent state of electrocution it is just as well to know what to do. Firstly, of course, the offending power supply should be switched off or removed. If a simple switch-off is impossible do not attempt to remove the circuit with the bare hands. Use a length of wood or other non-conducting and dry material to push away the electrical circuit. If this is not possible, throw a piece of metal or other solid

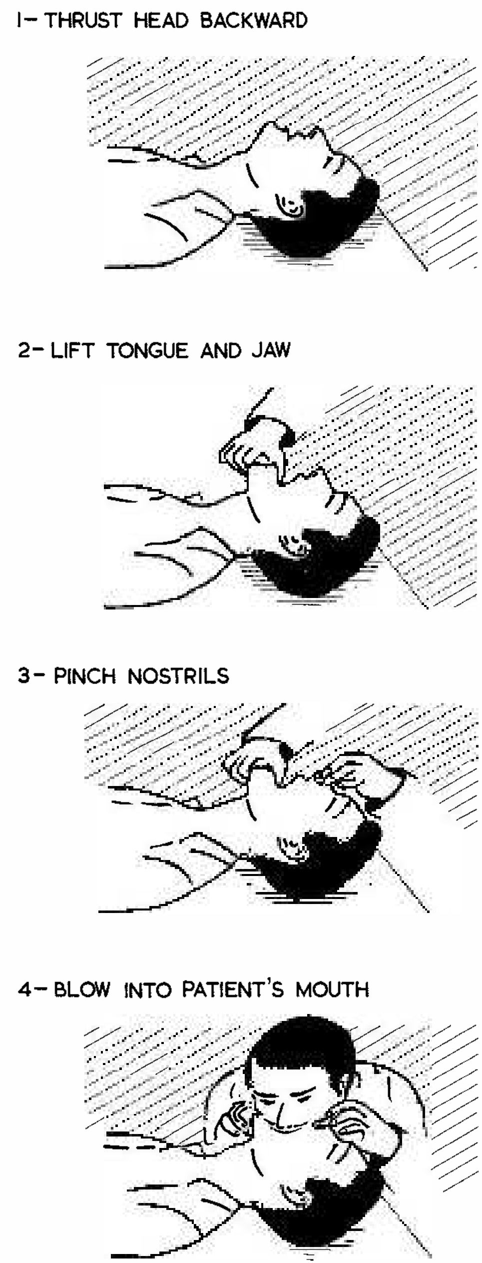


Fig. 4. Illustrating the "kiss of life". This is a form of artificial respiration which can be used to revive a patient suffering from electric shock

conductor across the electrical circuit to blow a fuse.

As soon as electrical contact has been broken and if the person is unconscious a form of artificial respiration should be commenced. The "kiss of life" or mouth-to-mouth method is simple to apply and has been proved many times as highly successful. This process is shown in Fig. 4.

An ambulance should, of course, be summoned and if necessary the artificial respiration should be continued without break during the trip to the hospital. Note that life has been restored after nine hours' of artificial respiration! Revival in the majority of cases occurs within a few minutes, 60% of such patients have recovered within 30 minutes and 15% within 60 minutes.[5]

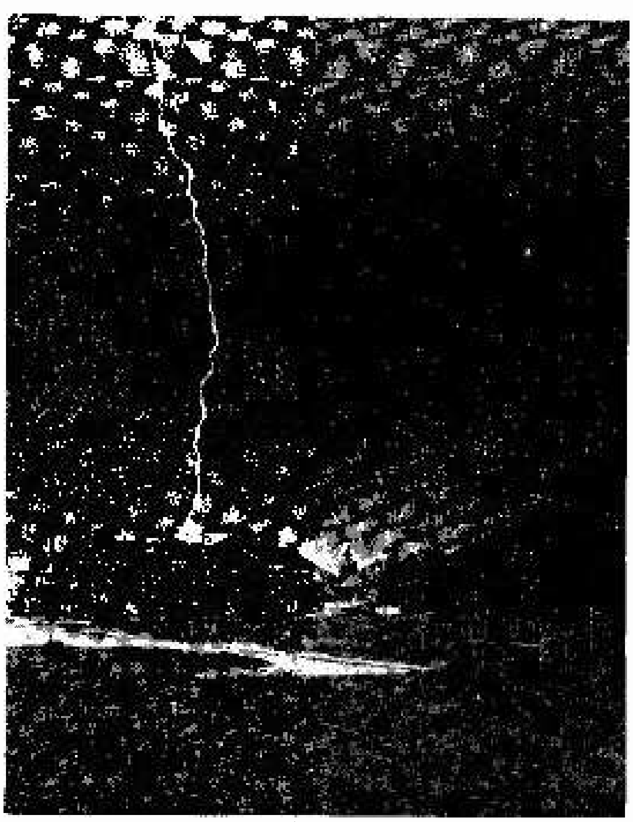
Lightning

Another big electrical hazard is lightning. This, of course, cannot be controlled in the same way as "domestic" electricity, but there are steps that can be taken to reduce the possibility of a strike or damage to person and equipment. The worst place to be during a bad thunder storm is in an open field. If there is no shelter in the form or caves, buildings or dense woods, etc., the best thing to do is to lie flat on the ground until the storm diminishes. The safest place is in a building but it is best to keep away from the fireplace when the storm is at its height. Out of doors a car or bus offers good protection, but trees in isolation are dangerous since lightning often strikes the highest point, particularly in isolated and sparsely built-up areas.

Lightning is an electrical discharge which takes place when the potential between a cloud and earth or between two clouds rises to such a high level that the insulation of the air collapses. Ionisation then occurs and this is followed almost immediately by the flash or discharge. Thunder is simply the air pouring back into the partial vacuum created by the discharge.

The discharge carries many thousands of amperes of electricity and is thus extremely potent. Cloud-to-earth discharges represent the greatest danger to person and equipment, but during the main discharge small discharges may occur between clouds, as shown in the illustration.

[5] Fig. 4, and the facts in this paragraph, are from "Electrical Injuries", by a Doctor of Medicine, *Irish Radio and Electrical Journal*, September 1963.



A major electrical discharge from cloud to earth, together with small inter-cloud discharges

One thing that we are never quite sure about during a thunder storm is whether to disconnect the radio or television aerial. And we often wonder whether the TV aerial represents a risk to property and life. One can be assured that there is no extra risk of lightning striking by the presence of an aerial on the chimney. Indeed, there is probably less risk when the installation is adequately earthed, for then it works on the principle of the so-called lighting conductor.

The principle of the lightning conductor is to drain away to earth, slowly and consistently, any charge in proximity to the building. By this means a build-up of a high charge which may incite a major discharge is less likely. The lightning conductor consists of a metal spike at the highest point bonded efficiently to earth through a very heavy conductor. A television aerial which is well earthed has similar characteristics.

In the early days of long-wire aerials it was a common usage to employ an aerial switch which was operated during a thunder storm, to connect the aerial to earth. Although this idea represented sound principle, it is no longer used. Not all present-day television or f.m. radio aerials are earthed. Thus, the only discharge path for static is through the coaxial cable, through the discharge resistors shown in Fig. 3 and then to earth through the mains via the chassis of the set. The discharge resistors mentioned are not designed to pass high values of static discharge current, their purpose being mainly to avoid the isolating capacitors themselves acquiring a high static charge.

However, the aerial system, even if not directly bonded to earth through a separate conductor, has a fairly low resistance earth return path, particularly when it is raining. A drain for static though not very efficient, nevertheless does exist. The best idea is to ensure that the aerial mast (if metal) and cross boom, directors and reflector are earthed through a separate conductor.

During a mild thunder storm there is little point in removing the aerial from the set, for the discharge resistors in the tuner will handle small charges. However, there is some merit in disconnecting the aerial when the storm is severe, but to be really prudent the cable end should not be left indoors It should be pushed out through the window and earthed if possible.

If the aerial is connected to the set through a transistor booster, it should definitely be disconnected, for lightning flashes near the house induce spikey transient currents into the aerial downlead and no small-signal v.h.f. or u.h.f. transistors can survive high amplitude waveforms of this nature. The same applies when the set itself, or the tuner, incorporates transistors. There are ways of protecting transistor equipment against lightning hazards, but these are costly and have not yet been incorporated in domestic equipment.

Radio Topics

By Recorder

HAVE YOU EVER EXPERIENCED the infuriating situation when, after having carefully scheduled several spare hours out of a busy day for the repair of a radio, you find, on initially examining it, that the very first thing you require is a component you haven't got on hand and which will take at least a day to obtain?

This is exactly what happened to me a week or so before I sat down to write these notes. Since the way I got round the problem may be of general interest, I shall now relate the story in all its drama.

Heater Dropper

The set in question was a rather old medium and long wave a.c./d.c. valve radio which had been gradually deteriorating in performance over the years and which had finally gone completely dead. When I plugged the set into the mains and switched on I soon found that its 910Ω 10 watt heater dropper resistor had gone open-circuit. This was obviously the fault which had caused the set to finally pack in and I would have to replace the resistor, if only with a temporary component, before I could get down to clearing up the more interesting snags which were lurking around in the signal-carrying circuits.

Whereupon, I had a look in the spares box to find a resistor which would take the place of the defunct dropper. But could I find one? Search as I might I couldn't find *anything* that would even act as a temporary substitute—not even two or three resistors which could be used together in series or in parallel to make up the desired value and wattage.

It was just when my language was dropping to B.B.C. TV level that I spotted my heavy-duty soldering iron lying innocently on its rest at the corner of my bench. This doughty instrument is rated at 240 volts 55 watts, which meant that—rough check—it should pass slightly less than quarter of an amp when connected to the mains. And quarter of an amp at 240 volts corresponds to a resistance of 960Ω! I quickly checked the resistance of the soldering iron and found it to be 1kΩ in practice. As this was near enough to 910Ω, I temporarily hooked the iron across the burnt-out dropper and was able to get the valves alight and proceed with the more serious fault-finding in that set. For the record I should add that the only things wrong were that the 0.01μF coupling capacitor to the grid of the output valve had become leaky and that the 10kΩ common feed resistor to the screen-grids of the frequency-changer and i.f. pentode had gone high. With these components replaced and a final touch-up on the i.f. cores, the set played as well as it did when it left the factory. Several days later, when I'd obtained a replacement dropper resistor, I was able to fit this in place in the receiver, secure in the knowledge that all the other snags had been cleared up.

If nothing else, this little episode does show that if you're pushed for a high wattage resistor a soldering iron can make an excellent temporary substitute. After fixing the set I calculated more carefully the resistance to be expected from a 240 volt 55 watt iron, to find that this is very slightly more than 1kΩ. This figure agrees nicely with the resistance check I'd made. I then checked the resistance of the iron at its full working temperature and found that this was similarly 1kΩ. Becoming intrigued, I checked several other soldering irons, and I could observe no significant difference between their cold and hot resistances. Furthermore, all the soldering iron resistances were very close to those which would be expected from their voltage and wattage ratings. For example, a 240 volt 10 watt iron (calculated resistance 5.8kΩ) measured up as 5.6kΩ, and a 240 volt 25 watt iron (calculated resistance 2.3kΩ) measured up as 2.4kΩ.

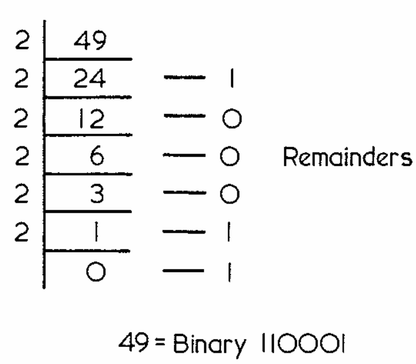
So, if ever you want a temporary high wattage resistor in a hurry, try using a soldering iron. Not only does this have a good temperature coefficient of resistance but it is also a close-tolerance component. Furthermore, it has its maximum wattage rating printed on the handle!

Decimal To Binary

Dick and Smithy's excursion into the field of binary calculations in "In Your Workshop" in the March issue seems to have received general approval. One reader, J. R. Handford of London S.W.1., wrote to us almost immediately after the article appeared to describe an alternative method of converting decimal to binary. An example of this appears in the accompanying diagram.

You take your decimal number and continually divide by 2, noting the remainder (or difference), which will be either a 0 or a 1, on the right hand side. It is important to keep dividing down until the bottom figure in the division column is a zero. The binary equivalent of the decimal number is then obtained by reading the remainders upwards. In the diagram, 49 is thus shown to be equal to binary 110001. This is certainly a very quick method of converting decimal to binary.

Another reader who also describes the same method of changing decimal to binary is J. McRobert of Co. Down, Northern Ireland, who adds that "this conversion suggests a very simple electronic converter, namely a series of simple flip-flops designed so that the odd (and final, if any) pulse lights a lamp and the even pulse puts out the light but passes a pulse to the next flip-flop. At each stage a lighted lamp will indicate a difference of 1 and an unlighted lamp a difference of 0, the lamps being arranged in reverse order".



A simple method of converting decimal numbers to their binary equivalents

My thanks are due to Mr. Handford and Mr. McRobert for passing on this information.

P.T.C. Thermistors

There is certainly nothing static with electronic devices these days. As soon as we get used to devices which work in one way the manufacturers introduce another version which works in precisely the opposite manner! With colour television now upon us, let me introduce to you a new "opposite-working" device, this being the P.T.C. thermistor.

The ordinary sort of thermistor we have become accustomed to is the N.T.C. (negative temperature coefficient) type, whose resistance decreases as its temperature increases. This makes it the ideal component for insertion in series with a valve heater chain, where the initial current flow on switching on from cold would otherwise be excessively high. The P.T.C. thermistor has a positive temperature coefficient, which means that its resistance *increases* with temperature increase.

In colour TV receivers, P.T.C. thermistors are employed in degaussing circuits for the shadow-mask picture tube. With this tube it is, of course, necessary for the three electron beams to converge with the correct angles at the shadow-mask at all times during horizontal and vertical deflection within the frame, this requirement being met by the convergence and purity adjustments. So critical is the operation of the tube that these adjustments have to take into account the Earth's magnetic field. Also, the adjustments can be upset by gradual magnetisation of any magnetic materials in the tube or around it. In the past, colour TV receivers in the U.S.A. used to be degaussed whenever it was thought that magnetisation had occurred or whenever the location of the receiver was altered, the degaussing procedure consisting of applying an alternating field which gradually decreased in intensity. In practice, a large flat coil of wire connected to the a.c. mains was slowly moved around the tube and receiver metalwork, then slowly moved away to a distance of

6ft or so and the supply switched off.

British colour TV receivers have a degaussing coil built into the cabinet, this being automatically brought into use every time the set is switched on or off or when some other switching operation takes place. For each degaussing process a high alternating current is initially passed through the coil, this slowly tailing off in amplitude until the degaussing operation is complete. The result is that the tube and the set are always well and truly degaussed, and one possible cause of trouble is eliminated before it can occur.

And this is where the P.T.C. thermistor comes in. An excellent method of causing the alternating current in the degaussing coil to tail off gradually is to insert a P.T.C. thermistor in series with the supply to the coil. When the alternating current is initially applied the P.T.C. thermistor offers a low resistance and allows a high current to flow. The P.T.C. thermistor then begins to heat up, whereupon its resistance increases and less current flows. The final result is that, when the P.T.C. thermistor is at maximum temperature, it offers a very high resistance and the current in the degaussing coil is negligibly low.

Actual degaussing circuits tend to be a wee bit more complicated than a degaussing coil and a P.T.C. thermistor in series. But in many, if not all, sets it is a P.T.C. thermistor which provides the gradual tail-off of alternating current which is essential for correct degaussing.

Transistor Operated Bulbs

If, like me, you get a kick out of knocking up transistor circuits which cause small pilot bulbs to become illuminated by collector current, here's a little dodge which can keep transistor dissipation down by quite an appreciable amount.

In most circuits of this nature it is usual to connect the transistor in the common emitter mode and insert the bulb between the collector and the negative supply line (or positive supply line if an n.p.n. transistor is being used). When the transistor becomes conductive, due to base current from another part of the device, the bulb then lights up. One snag with this set-up is that, when the bulb becomes illuminated, initial collector current can be very high because the cold resistance of the bulb will be much lower than its resistance at operating temperature. For instance, a 6.3 volt 0.15 amp pilot lamp can have a cold resistance of 5Ω or even less, whereas its hot resistance (after consultation of the Law of our good friend Mr. Ohm) works out at 42Ω.

The dodge consists of connecting a fixed resistor across the emitter and collector of the transistor to cause a small standing current to flow in the bulb even when the transistor is non-conductive. The value of the resistor is such that the standing current in the bulb is not quite sufficient to cause it to glow. The result is that, when the transistor becomes conductive, the bulb presents a resistance which is considerably higher than its cold resistance and the initial collector current is significantly reduced.

Another point to bear in mind is, of course, that minimum dissipation in the transistor occurs when it is cut-off or bottomed, and that maximum dissipation occurs (with a linear collector load resistor) when half the supply voltage appears across the transistor. So, it's always a good plan with circuits of this nature, and if small transistors are being used, to ensure that the transistor which controls the bulb spends nearly all its time either hard on or fully cut-off, and a minimum amount of time in the in-between state.

FERRANTI HIGH FIDELITY AUDIO DESIGNS

Currently available from Ferranti Ltd. is an attractive 47-page brochure giving full circuit diagrams and technical details for a wide range of pre-amplifiers, main amplifiers and stabilised power supplies. All amplifiers are in the high fidelity category, and the main amplifiers have output powers of 7, 15, 30 and 150 watts. Further sections in the brochure describe a comprehensive phase-shift oscillator and an f.m. tuner.

All these designs employ Ferranti n.p.n. and p.n.p. silicon planar epitaxial transistors, and a feature of the power amplifiers is the complete elimination of transformers in the signal circuits. The brochure will be of particular interest and value to the home constructor.

Readers may obtain copies of the brochure free of charge by writing to Ferranti Ltd., Electronics Department, Gem Mill, Chadderton, Oldham, Lancs. The transistors specified in the circuits may also, if desired, be purchased direct from Ferranti Ltd. at Gem Mill.

SMALL ADVERTISEMENTS

Rate: 9d. per word. Minimum charge 12/–.
Box No. 2/– extra.

Advertisements must be prepaid and all copy must be received by the 4th of the month for insertion in the following month's issue. The Publishers cannot be held liable in any way for printing errors or omissions, nor can they accept responsibility for the *bona fides* of advertisers. (Replies to Box numbers should be addressed to: Box No.—, *The Radio Constructor*, 57 Maida Vale, London, W.9.)

SERVICE SHEETS, 1925–1967. From 1s. Catalogue 6,000 models, 2s. 6d. S.A.E. enquiries.—Hamilton Radio, 13 Western Road, St. Leonards, Sussex.

100 PAGE ILLUSTRATED CATALOGUE NO. 17 of Government and manufacturers' electronic and mechanical surplus, also a complete new section of the latest semi-conductors and miniature components, includes a credit voucher for 2s. 6d. Send for your copy now. Price 3s. post free. Arthur Sallis (Radio Control) Ltd., 93 North Road, Brighton, Sussex.

FOR SALE. Oscilloscopes—Galvanometers—Evershed & Vignolles Meggers—Relays—Uniselector Switches—Solenoids. Also other items and components. Free list. Stamp please.—R. & E. Mart, Box 9 G.P.O., Tunbridge Wells, Kent.

TELEPRINTERS 7B complete from £10. Also Auto-transmitters, Reperforators, Signalling Rectifiers, etc., from William Batey & Co. (Exports) Ltd., Gaiety Works, Akeman Street, Tring, Herts. Please ring Tring 3476.

A SUPER BARGAIN. 4 transistor push-pull 3 watt gram amplifier and mains power pack, volume and tone controls, all wired and assembled on chassis 9½ x 3 x 3in, complete with 7 x 4in speaker and mains lead, all for £5 12s. 6d. Post and packing 6s.—Wavemechs, 771A High Road, London, N.17.

TORIOD COILS for sale. Suitable RTTY, etc. Mostly 88mH but some values above and below. S.A.E. for details. 7s. 6d. each. Box No. F289.

FOR SALE. STROBOSCOPES No. 2, (643 rpm) and No. 4 (666.6 rpm), at 7s. 6d. 0–12 oz., tension gauge at 7s. 6d. Box No. F290.

14/0076 SINGLE P.V.C. COVERED WIRE on 100 yd. reels, red or green 8/4d. post 4/6d. 3 reels post 6/– Polyproplene twine 6/– 100 yds. coil. S.A.E. for samples. Better quality mixed parcels radio parts etc., 5½ lbs. approx., 12/6d. G. Hart, The Bungalow, Lings Lane, Chelmondiston, Ipswich, Suffolk.

TRANSFORMERS REWOUND. Specials made to order. Reasonable charges. S.A.E. enquiries. Ratcliffe, 27 Station Road, Holmfirth, Yorks.

FOR SALE. Rectifier Units, Type 43A. 50s. plus carriage. Box No. F292.

continued on page 762

BENTLEY ACOUSTIC CORPORATION LTD.

38 Chalcot Road, Chalk Farm,
LONDON, N.W.1.
PRImrose 9090

47 Norfolk Road,
LITTLEHAMPTON, Sussex.
Littlehampton 2043

Please forward all mail orders to Littlehampton

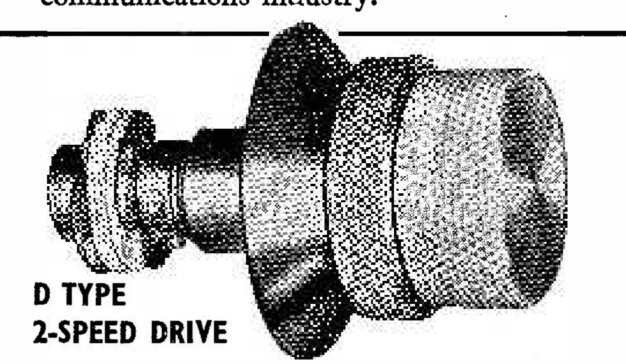
1R5	4/9	10C2	12/–	AZ31	7/9	ECL82	6/3	EZ41	6/6	PY88	7/3
1S5	3/3	10F1	9/9	DAF96	6/–	ECL83	9/–	EZ80	3/9	PY800	6/–
1T4	2/6	10F18	9/–	DF96	6/–	ECL85	11/–	EZ81	4/3	PY801	6/–
3Q4	5/3	10LD11	10/–	DK40	10/6	ECL86	7/9	GZ34	10/–	U25	11/–
3S4	4/9	10P13	12/–	DK92	7/6	EF36	3/–	HABC80	9/3	U26	8/6
3V4	5/6	10P14	13/–	DK96	6/6	EF37A	7/–	KT66	16/6	U191	10/–
5Y3GT	5/–	12AT6	4/6	DL96	6/–	EF39	5/–	PABC80	7/6	U301	12/6
5Z4	7/6	12AU6	4/9	DM70	6/–	EF41	9/–	PC86	8/6	U329	9/–
6AQ5	4/9	12AV6	5/9	DY87	5/9	EF80	4/6	PC88	8/6	U404	6/–
6AT6	3/9	12BA6	5/–	E88CC	12/–	EF85	4/6	PC95	6/9	U801	18/–
6AU6	5/6	12BE6	5/3	EABC80	5/9	EF86	6/3	PC97	5/9	UABC80	5/3
6AV6	5/–	12BH7	6/–	EAF42	7/6	EF89	4/9	PC900	8/6	UAF42	7/9
6BA6	4/6	19AQ5	7/3	EB91	2/3	EF91	3/3	PCC84	5/6	UBC41	6/6
6BE6	4/3	20D1	10/–	EBC41	7/3	EF92	2/6	PCC85	6/9	UBC81	6/6
6BH6	6/6	20F2	11/6	EBC81	6/3	EF97	8/–	PCC88	10/6	UBF80	5/6
6BJ6	7/–	20L1	13/–	EBF80	5/9	EF98	9/–	PCC89	9/9	UBF89	5/9
6BQ7A	7/–	20P3	15/–	EBF83	7/–	EF183	6/3	PCC189	8/3	UBL21	9/–
6BR7	9/–	20P4	16/–	EBF89	5/9	EF184	5/9	PCF80	6/3	UC92	5/6
6BW6	7/–	20P5	16/–	EBL21	10/3	EH90	7/6	PCF82	6/–	UCC84	8/–
6BZ6	6/–	30C15	10/6	EC86	11/6	EL33	12/–	PCF84	8/–	UCC85	6/6
6CD6G	19/6	30C17	11/6	EC88	10/6	EL41	8/–	PCF86	8/–	UCF80	8/3
6CH6	6/–	30C18	9/6	EC92	6/6	EL42	7/6	PCF801	8/6	UCH21	9/–
6F1	9/6	30F5	9/9	ECC40	9/6	EL84	4/6	PCF802	9/6	UCH42	8/6
6F23	8/–	30FL1	13/–	ECC81	3/6	EL85	7/6	PCL82	6/3	UCH81	6/–
6F24	10/–	30FL12	13/–	ECC82	4/6	EL86	8/–	PCL83	8/6	UCL82	7/–
6J7G	4/9	30FL14	11/–	ECC83	4/6	EL95	5/–	PCL84	7/–	UCL83	8/9
6K7G	1/3	30L15	12/–	ECC84	5/6	ELL80	13/–	PCL85	8/3	UF41	7/9
6K8G	3/–	30L17	12/–	ECC85	5/–	EM71	14/–	PCL86	8/–	UF42	4/9
6L6	7/6	30P4	11/6	ECC88	7/–	EM80	5/9	PFL200	13/6	UF80	6/9
6L18	7/6	30P4MR	13/–	ECC189	9/–	EM81	6/9	PL36	9/–	UF85	7/3
6LD20	6/6	30P12	9/–	ECF80	7/–	EM84	6/–	PL81	6/9	UF86	9/–
6Q7G	5/–	30P19	10/–	ECF82	6/9	EM85	11/–	PL82	5/9	UF89	5/6
6SN7	4/6	30PL1	12/9	ECF86	8/6	EM87	6/6	PL83	6/–	UL41	8/9
6V6G	3/6	30PL13	13/3	ECH21	9/6	EY51	5/6	PL84	6/3	UL84	5/6
6X4	3/6	30PL14	13/3	ECH35	6/–	EY81	7/–	PL500	13/6	UM80	5/–
6X5	5/3	30PL15	13/6	ECH42	8/9	EY83	9/–	PY33	8/6	UY21	9/–
6/30L2	9/6	35W4	4/6	ECH81	5/–	EY84	9/6	PY80	5/–	UY41	5/6
7Y4	6/6	85A2	6/6	ECH83	7/–	EY86	5/9	PY81	5/–	UY85	4/9
9D7	7/6	807	11/9	ECH84	6/6	EY88	7/6	PY82	5/–	VP4B	11/–
10C1	9/–	5763	10/–	ECL80	6/–	EZ40	6/–	PY83	5/6	X41	10/–

Terms of business: Cash with order only. No C.O.D. Post/packing 6d. per item. Orders over £5 post free. All orders despatched same day as received Complete catalogue including transistor section and components with terms of business 6d. Any parcel insured against damage in transit for 6d. extra.
We are open for personal shoppers 9 a.m.–5 p.m. Saturdays 9 a.m.–1 p.m.

JACKSON

the big name in PRECISION components

Precision built radio components are an important contribution to the radio and communications industry.



D TYPE
2-SPEED DRIVE

★ 1½ inches diameter satin anodised aluminium
★ Mounts on outside of panel
★ Always at correct height
★ Smooth precise powerful 4½ : 1 and direct
★ Knobs available separately to match
★ Smart appearance

JACKSON BROS. (LONDON) LIMITED
Dept. RC, KINGSWAY-WADDON, CROYDON, CR9 4DG
Phone Croydon 2754–5 (01–688). *Grams* Walfilco, Croydon

SMALL ADVERTISEMENTS

continued from page 761

TECHNICAL DRAWINGS, Artwork, etc. Electronic and Radio Circuits a speciality. Moderate charges. —B. P. Meaney, 43 Forest Road, Worthing, Sussex.

HIGH GRADE SWISS AND ENGLISH LEVER WATCHES OVERHAULED, REPAIRED. Chronographs and electric watches. 12 months guarantee. Estimates free. Write for details and prices or send registered to: B. Thornton, C.M.B.H.I., Kimtarn, Clay Hill, Beenham, Reading. Berks.

CIRCUITS FOR EVERY POSSIBLE APPLICATION. 7/6d. each. C.W.O. Otherways 10s. 0d. R. Pearce, 4 New Road, Tiptree, Essex.

JOIN BRITAIN'S LEADING DX CLUB by joining The World Communication Club, Great Britain. Details from: S. Green, 26 Tolhouse Street, Great Yarmouth, Norfolk.

BRIGHTEN UP YOUR ADVERTISING! Break the ice with a cartoon, "tailor made" for your product. Reasonable charges. Box No. F294.

"MEDIUM WAVE NEWS" Monthly during DX season—Details from: B. J. C. Brown, 60 White Street, Derby.

JOIN THE INTERNATIONAL S.W. LEAGUE. Free Services to members including Q.S.L. Bureau. Amateur and Broadcast Translation. Technical and Identification Dept.—both Broadcast and Fixed Stations, DX Certificates, contests and activities for the SWL and transmitting members. Monthly magazine, *Monitor*, containing articles of general interest to Broadcast and Amateur SWLs, Transmitter Section and League affairs, etc. League supplies such as badges, headed notepaper and envelopes. QSL cards, etc., are available at reasonable cost. Send for League particulars. Membership including monthly magazine, etc., 35s. per annum.—Secretary, ISWL, 60 White Street, Derby.

FOR SALE. B.P.L. Signal generator (mains) £3, (cost £21). 53 assorted valves £2. Hemingway, 9 Hitherwood, Cranleigh, Surrey.

WANTED. 8 and 10 way socket connectors for SCR522 transceiver. Will pay reasonable price. D. Scott, 8 Clayfarm Road, London S.E.9.

BOOKS FOR SALE. *Hi-Fi Projects for the Hobbyist*, Fieldman, 10s. *Transmitting Valves*, Heyboer & Zijlstra, 10s. 6d. *Radio Operating Questions & Answers*, Nilson, 5s. 6d. *Television Receiver Design*, Neeteson, 7s. 6d. *Electronic Valves in A.F. Amplifiers*, Rodenhuis, 3s. 6d. *Tubes for Computers*, Philips, 5s. 6d. *Industrial Rectifying Tubes*, Philips, 5s. 6d. *U.H.F. Tubes for Communication and Measuring Equipment*, 5s. 6d. *Instructions to Radio Constructors*, Warring, 7s. 6d. All post free. Box No. F297.

continued on page 763

SMALL ADVERTISEMENTS

continued from page 762

WANTED. Alco/Sirius steam portable generator, made by Lyons Co., as used in WW2 for battery charging by troops in Burma.—Box No. F299.

FOR SALE. Japanese dynamic microphone and stand. Small, neat unit. Hand held mic. Piezo make, £3. —Box No. F300.

ESSEX GARDENERS. Buy your bedding and rock plants, shrubs, etc., also cacti, from May's Nurseries, 608 Rayleigh Road, Hutton, Brentwood, Essex. Callers only, Monday to Saturday.

ARE YOU A MOTORING ENTHUSIAST? The Seven Fifty Motor Club caters for all types of motor sport—racing, rallies, hill climbs, etc. Monthly Bulletin free to members. For full details write to: The General Secretary, Colin Peck, "Dancer's End," St. Winifred's Road, Biggin Hill, Kent.

POSTAL ADVERTISING? This is the Holborn Service. Mailing lists, addressing, enclosing, wrappering, facsimile letters, automatic typing, copy service campaign planning, design and artwork, printing and stationery. Please ask for price list.—The Holborn Direct Mail Company, 2 Mount Pleasant, London, W.C.1. Telephone: TERminus 0588.

MESSERSCHMITT Four wheel TG 500 sports car. Enthusiast seeks damaged or part vehicles, spares etc. Details to C. E. Jaques, 33 Middleton Road, Shenfield, Essex.

PROPERTIES for sale and to let in London and suburbs. Apply to Maggs & Stephens, Estate Agents, 229 Maida Vale, London, W.9. MAIda Vale 8123.

MICRO ELECTRONIC BUGS. Train ticket size, 8 gns. Also diagram, module, pea size microphone to build. 5 gns. Box No. F305.

FOR SALE. Crystal controlled Holme Moss F.M. tuner less valves £4. 5. 0d. o.n.o. or crystals 35s. Modified Mullard tape pre-amp. £4. 5. 0d. o.n.o. with EF86's £5 o.n.o. Elstone OT8 trans. 20s. Matched EL41's 10s. Details s.a.e. Box No. F306.

YOUR KITS EXPERTLY ASSEMBLED. Radios, amplifiers, test gear of every description. For estimate simply send price and type of kit to: W. Thomas, No. 6 North Avenue, Ruabon, Nr. Wrexham.

MICRO TRANSMITTER MK V
(SUB-MIN WIRELESS-MICROPHONE TRANSMITTER)
COSTS LESS THAN **25/-** TO BUILD ON 1" x 1" BOARD.

G. A. BOBKER, ELECTRONICS, DESIGN & EXPERIMENTAL. CIRCUIT & DETAILS **5/-** 64, CHOIR STREET, SALFORD, 7, LANCS.

Value in the Shops 80'9

THE RADIO CONSTRUCTOR
SPECIAL PRIVILEGE PRICE OF

THE NEW TOLTEC HAIR DRYER

52/6 Add 4/6 for postage

SPECIFICATION

Moulded in beautiful symmetrical pastel blue impact resisting thermoplastic casing.
Quiet in operation.
Hot or cold air.
No radio or T.V. Interference—meets British standard specification.
Fitted with safety cut-out.
12 months & money refund guarantee. 230-250 volts A.C. only.

Value 80/9 in the shops

Send the coupon below with the sum of only 57/- (this includes 4/6d to cover postage, packing and insurance, unless you are collecting personally).

Please send me one Toltec Hair Dryer at the special privilege price as advertised in *The Radio Constructor.*

I enclose cheque/postal order value ....

Name...

Address...

....

(*Block Capitals please*)

To: **Toltec Electronic & Trading Co. Ltd. Hatton House, Hurst Green, Etchingham, Sussex**

THE RADIO CONSTRUCTOR

ANNUAL SUBSCRIPTIONS to this magazine may be obtained direct from the publishers

ONLY 36/— per year, post free

Please send remittance with name and address and commencing issue required to:

DATA PUBLICATIONS LTD 57 MAIDA VALE LONDON W9

Please mention **THE RADIO CONSTRUCTOR** when writing to advertisers

THE

Radio Constructor

Incorporating THE RADIO AMATEUR

Index

To Volume Twenty

August 1966–July 1967

EMI Tube Probes Into Dark

Important new areas of research have been opened up by the 4-stage Image Intensifier tube, developed by EMI electronics, when used in conjunction with AEI electron microscopes.

Certain specimens, such as polymers, crystals and some biological tissues, are known to undergo a change of state when exposed to radiation from an electron beam. To reduce this effect, current densities giving light levels at the output phosphor of 10^{-4} Lux or less are necessary. This light level, approximately that of the darkest night, is the lowest at which the unaided eye can see after prolonged dark adaption of an hour or more.

The Image Intensifier's ability to multiply light levels by a factor of a million enables current densities of 10^{-14} amp/sq cm, equivalent to 10^{-6} Lux, to be detected.

Photography at this level would normally require an exposure in excess of 4000 seconds using 50 ASA film. With the Image Intensifier, an exposure of only 8 seconds is necessary, without significant loss of quality.

With the EMI image intensifier dark adaption is unnecessary. The output of the intensifier can be viewed either directly, or through a television camera for group viewing. The results of an experiment in which changes take place can be recorded on video tape and replayed almost immediately or stored for future reference.

The Image Intensifier is conveniently located beneath the camera chamber of the microscope and can be removed without exposing either the microscope column or the camera to atmosphere.

NEW REVISED AND ENLARGED EDITION

DB5 TV Fault Finding
124 pages. Price **8/6,** postage 8d.
Profusely illustrated with photographs taken from a television screen depicting the faults under discussion and containing a wealth of technical information, with circuits, enabling those faults to be eradicated. Now includes B.B.C.II as well as B.B.C.I and I.T.A.
". . . A book that should be in every television dealer's service workshop, and in every home-constructor's, for that matter."—*Journal of the Television Society.*

DB6 The Radio Amateur Operator's Handbook
64 pages. Price **5/-,** postage 5d.
Contains Amateur Prefixes, Radio Zone Boundaries, Amateur Band Frequency Allocations, Call Areas, Charts and Maps, Areas, Codes, Mileage Tables, Prefixes/Directional Bearings, Post Office Regulations, and much other useful operating data. For the beginner there are notes on how to use the mass of information given to obtain the greatest satisfaction from the hobby.
". . . For concise knowledge in this field a few shillings well worth spending."—*Electronics* (Australia).

DB14 Short Wave Receivers for the Beginner
72 pages. Price **6/-,** postage 6d.
Contains a selection of both battery and mains operated short wave receivers, circuits, point-to-point wiring diagrams and many illustrations. Introductory chapter gives much information on the Short Wave Spectrum, Clubs, QSL'ing, Aerials, Amateur and Broadcast Band Listening, Frequencies, etc.
This book has been specially prepared for the beginner interested in short wave receiver construction and operation.

DB15 Twenty Suggested Circuits
48 pages. Price **3/6,** postage 5d.
By G. A. French. Covers subjects ranging from electronic laboratory equipment to the simplest of periodic switches. Includes: simple and inexpensive two-valve capacity bridge, short wave regeneration preselector, one-valve speech operated switching circuit, transformer ratio analyser, series noise limiter, receiver remote mains on-off control, and many other circuits.

DB16 Radio Control for Models
192 pages. Price **15/-,** postage 9d.
By F. C. Judd. Contains both theory and practical designs of simple and advanced transmitters and receivers; basic concepts, aerials, uses of radio components, transistorised receivers, multi-channel operation, etc. Sections on servo-mechanisms by Raymond F. Stock.
More than 200 illustrations. Circuits, photographs, tables and working diagrams.

DB17 Understanding Television
512 pages. Price **37/6,** postage 3/-.
By J. R. Davies. This book, which deals with the principles of 625 line reception as fully as 405 line reception, fully explains: the nature of the television signal; the cathode ray tube; receiver tuner units; receiver i.f. amplifiers; a.f. and video amplifiers; vertical and horizontal timebases; deflector coil assemblies; synchronising; automatic gain and contrast control; power supplies and receiver aerials. Also includes a comprehensive introduction to colour television.
". . . one of the best books that aims to explain television in simple language. . . ." R.S.G.B. Bulletin.

I enclose Postal Order/Cheque for..............................in payment for..............................

NAME ....

ADDRESS ....

....

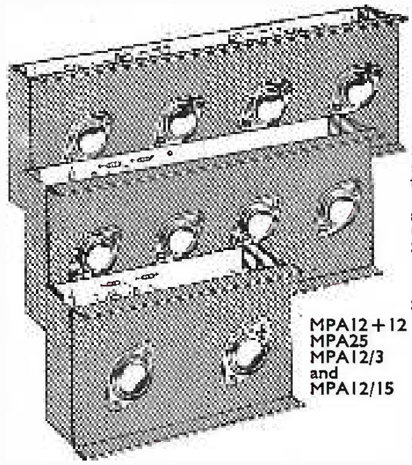
(Please use Block Capitals for both name and address)

Postal Orders should be crossed and made payable to Data Publications Ltd.
Overseas customers please pay by International Money Order
All publications are obtainable from your local bookseller

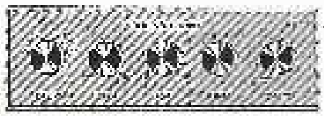
Data Publications Ltd., 57 Maida Vale, London W.9

NEW SOLID STATE HIGH FIDELITY EQUIPMENT ★★★★

IMPROVED PERFORMANCE—NEW STYLING—NEW MODELS—MONO & STEREO

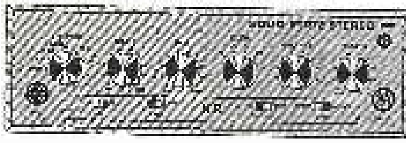


MPA12+12
MPA25
MPA12/3
and
MPA12/15



◀ MP3

SP6-2 ▼



MP3. Mono preamplifier. All silicon low noise zener stabilised circuit. Full range of controls—fully equalised inputs for xtal pu, dyn/xtal mic, radio tuners, tape head and preamp. replay. Supplied built and tested on metal chassis complete with grey/silver front panel, alu. knobs and handbook. Output 250mV. Supply 12 to 60 volts 3mA. Overall size $9\frac{3}{8} \times 1\frac{3}{8} \times 1\frac{7}{8}$in.
MP3 Price £6.19.6, P.P. 3/-

SP6–2. Mono/stereo preamplifier. Uses 8 silicon/germanium devices. Zener stabilised. Completely new low noise design. Full range of controls and filters. Inputs for magnetic/xtal/ceramic cartridges, radio tuners, tape preamp, microphones, tape head, etc. Record output socket. Supplied built and tested on metal chassis with grey/silver front panel and matching knobs. Complete with input sockets and handbook. Output 250mV per channel. Supply 9 to 60 volts 4mA. Overall size $12 \times 3\frac{1}{2} \times 3\frac{1}{4}$in.
SP6–2 Price £14.19.6, P.P. 5/-

SP4. Mono/stereo preamplifier as previously advertised. Complete with front panel and knobs. Size $9 \times 3\frac{1}{4} \times 1\frac{3}{8}$in. **SP4 Price £10.19.6, P.P. 3/6**

MPA12/3 and MPA12/15. 12 watt power amplifiers for use with above preamplifiers. Improved response and performance with even lower distortion levels. MPA12/3 for 3 to 5 ohm speakers, 24/28 volt supply MPA12/15 for 10 to 16 ohm speakers, 40/45 volt supply, uses 8 silicon and germanium devices. Inputs 100mV for 12 watts, response ± 1dB, 30 c/s to 20 kc/s. THD 0.2% at 12 watts. High gain stable push-pull output designs. Built on to metal chassis as illustrated. Overall size 5 x 2 x 3in. Complete with handbook.
MPA12/3 Price £4.10.0, P.P. 2/6 **MPA12/15 Price £5.5.0, P.P. 2/6**

MPA12+12. Twin amplifier for mono/stereo use with above preamplifiers. Consists of two matched MPA12/15 amplifiers (see above) on single chassis. Output for 10 to 16 ohm speakers. 40/45 volts supply. Overall size $10 \times 2 \times 3\frac{1}{4}$in.
MPA12+12 Price £9.19.6, P.P. 4/-

MPA25. 25/30 watt power amplifier for use with above preamplifiers. New design and layout with improved response and overall performance. Output for $7\frac{1}{2}$ to 16 ohm speaker systems. Input 180mV for full output. Push-pull circuit. Uses 10 silicon and germanium devices. Supply 50/60 volts. Overall size $8 \times 2 \times 3\frac{1}{4}$in. **MPA25 Price £7.10.0, P.P. 3/6**

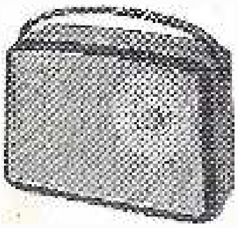
CHOICE OF PREAMPLIFIERS POWER AMPLIFIERS MAINS UNITS

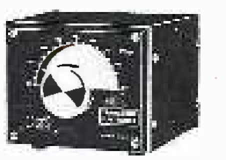
MAINS UNITS
110/240 volt 50/60 c/s input. AC/DC fused. Fully smoothed and isolated. MU series has additional choke/capacitor filtering and panel voltage selectors. All types on metal chassis. **PS24/40.** Output 24 and 45 volts 1 amp. For use with 1 or 2 MPA12/3, MPA12/15, or 1 MPA12+12. **Price 70/-, P.P. 3/-**
MU24/40. Choke smoothed. Output 24 and 45 volts 1 amp. For use with 1 or 2 MPA12/3 and MPA12/15 or 1 MPA12+12. Price 87/6, P.P. 3/6.
MU60. Choke smoothed. Output 50 volts 1 amp. For use with 1 or 2 MPA25. Price 95/-, P.P. 4/-

RECOMMENDED SYSTEMS
MP3+MPA12/15+PS40 **£14.12.6, P.P. 6/6**
MP3+MPA12/3+PS24 **£13.17.6, P.P. 6/6**
MP3+MPA25+MU60 **£18.5.0, P.P. 8/-**
SP6–2+MPA12+12 or 2 MPA12/15 + MU40 **£28.5.0, P.P. 10/-**
SP6–2+2 MPA12/3+MU24 **£26.15.0, P.P. 10/-**
SP6–2+2 MPA25+MU60 **£33.5.0, P.P. 10/6**
SP4+2 MPA12/15+PS40 **£24.0.0, P.P. 9/-**
SP4+2 MPA12/3+PS24 **£22.15.0, P.P. 9/-**
MP3+2 MPA12/15+MU40 **£20.17.6, P.P. 8/-**
MP3+2 MPA12/3+MU24 **£19.7.6, P.P. 8/-**

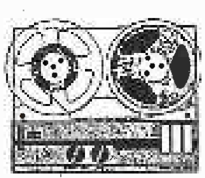
THE FINEST VALUE IN HIGH FIDELITY–FULLY GUARANTEED
CHOOSE A SYSTEM TO SUIT YOUR NEEDS & SAVE POUNDS

COMPLETE BROCHURE FREE ON REQUEST





STEREO DECODER KIT
For use with all F.M. tuners
£5.19.6. P.P. 2/6



WE CAN SUPPLY FROM STOCK MOST OF THE PARTS SPECIFIED ON CIRCUITS IN THIS MAGAZINE. SEND LIST FOR QUOTATION. OR BETTER STILL—BUY THE NEW 1967 CATALOGUE. EVERYTHING YOU NEED IS LISTED AND AVAILABLE FROM STOCK.

7-TRANSISTOR MW-LW SUPERHET PORTABLE TO BUILD **NEW!**
New printed circuit design with ½ watt full power output. Fully tunable on both MW/LW Bands. 7 transistors plus diode. Push-pull circuit Fitted 3 ohm Speaker, large ferrite aerial and Mullard transistors easy to build with terrific results. All local pirate and continental stations. Handbook free on request.
Total cost to build **£6.19.6** **P.P. 3/6**

TOURMASTER TRANSISTOR CAR RADIO British Made
7-Transistor MW/LW Car Radio. 12 volt operated. 3 watt output. Push-button wavechange. RF stage. Supplied built, boxed, ready to use with Speaker and Baffle. Car fixing kit and manufacturers' current guarantee. Special Bargain Offer. Buy Now!
LIST PRICE 15 GNS. **£7.19.6** **P.P. 4/6**

VHF FM TUNER TO BUILD
87/105 Mc/s Transistor Superhet. Geared tuning. Terrific quality and sensitivity. For valve or transistor amplifiers. $4 \times 3\frac{1}{2} \times 2\frac{1}{4}$in. Complete with dial plate. 5 Mullard Transistors, Plus 4 Diodes. (Cabinet Assembly 20/- extra). Leaflet on request.
TOTAL COST TO BUILD **£6.19.6** **P.P. 2/6**

BUILD A QUALITY 2 OR 4 TRACK TAPE RECORDER
3-speed version using '363' decks
★TWO-TRACK. Deck **£10.10.0.** Martin Amplifier. **£14.19.6.** Cabinet and speaker **7gns.** Complete kits with FREE 7in. 1,200ft. tape, spare spool. Today's Value £45. **27 gns.** **P.P. 15/-**
★FOUR-TRACK. Deck **£13.10.0.** Martin Amplifier **£15.19.6.** Cabinet and speaker **7 gns.** Complete kits with FREE 7in. 1,200ft. tape, spare spool. Today's value £50. **30 gns.** **P.P. 15/-**

27 Mc/s B'ND RADIO CONTROL
Sub-miniature crystals 17/6 each
Matched pairs for superhet 35/- pair
(State 455 kc/s or 470 kc/s I.F.)

Mayfair Portable Electronic Organ

NOW AVAILABLE AS:
● **COMPLETE KIT OF PARTS** ● **BUILT AND TESTED** ● **PRE-BUILT ASSEMBLIES.**
REVERBERATION UNITS AND RECOMMENDED SPEAKERS AND AMPLIFIERS IN STOCK.
Designed by L. W. ROCHE

STRAIGHT FORWARD TO BUILD AND TUNE—EASY TO PLAY—FULLY GUARANTEED. ALL PARTS AVAILABLE SEPARATELY—ASTOUNDING VALUE AND PERFORMANCE.
● Plug-in printed circuits ● 170 transistors and devices ● 10 selected tone colours ● Fully sprung keyboard ● Vibrato ● 6 Octaves of generators ● Simple locked-in tuning ● 110/250 volt mains unit ● Cabinet size $30\frac{1}{4}$in x 15in x $9\frac{1}{2}$in ● Weight 35 lb. Cabinet with detachable legs, music stand and foot swell pedal ● Fully detailed building manual with photos, drawings and full circuits.
Complete range of organ parts in stock. H.P. facilities available. Trade/Export supplied. Fully detailed leaflet and Price List on request. Call for demonstration and play the Mayfair.

RELAYS, MOTORS, SWITCHES, MINIATURE COMPONENTS, TRANSISTORS AND DEVICES
Complete range in stock all types for every purpose. Also panel and multimeters, precision components, radio control crystals and parts, transistors, tunnel diodes, thyristors, LDR's, zeners, rectifiers and diodes. Everything you need for amateur and professional applications—see 1967 catalogue. The largest range in the country. Suppliers of quality components and equipment for over 20 years.

LISTS AVAILABLE
(incorporated in full catalogue)
★Transistors/Rectifiers/SCR's/Valves/Crystals/Zeners, etc. 24 pages, 1/-.
★4-page hi-fi stock list with discounts. All popular makes. Free on request.
★Car radio and tape recorders. Free.
★Organs and components lists. Free.

HENRY'S RADIO LTD.

303 Edgware Road, London, W.2 PADdington 1008/9 (STD 01-723 1008) Open Mon. to Sat. 9-6. Thurs. 1 p.m. Open all day Saturday.

1967 CATALOGUE
Have you a copy? Fully detailed and illustrated. Over 200 pages of components, equipment, etc. Over 5,000 stock items. FULLY DETAILED AND ILLUSTRATED. Price 8/6, post paid. 5 Free discount vouchers, value 10/- with every catalogue.
200 PAGES—PLUS!